Clinton Creek Remediation Project

Closure of Post 10% Design Services Data Gaps
Project # VE52705K.002

DRAFT

Prepared for:

Government of Yukon-Energy, Mines and Resources
Assessment and Abandoned Mines
2C – 4114 4th Avenue, Whitehorse, Yukon, Y1A 4N7

January 2022

Clinton Creek Remediation Project

Closure of Post 10% Design Services Data Gaps
Project # VE52705K.002

Prepared for:

Government of Yukon-Energy, Mines and Resources Assessment and Abandoned Mines
2C – 4114 4th Avenue, Whitehorse, Yukon, Y1A 4N7

Prepared by:

Wood Environment & Infrastructure Solutions
400, 111 Dunsmuir Street
Vancouver, BC V6B 5W3
Canada
T: 604-294-3811

January 2022

DRAFT

Third-party disclaimer

This report is for the use of the Government of Yukon, ("YG") and its authorized consultants, contractors, and representatives, First Nations, the federal government, and regulatory agencies.

The reports are made available for third party review for informational purposes only in relation to this Project or for the purposes upon which the report was requested. YG and Wood make no representation or warranty nor assume any liability with respect to any reliance by a third party on this report and the work referred to in this report. If site conditions or applicable standards change or if additional information becomes available, modifications to the findings and conclusions of this report may be necessary.

Table of Contents

1.0 Project Background, Scope and Development Status 1
1.1 Site Description 1
1.2 Closure Planning Activities and Inputs 4
1.2.1 Precedents to Current Scope 4
1.2.1.1 Pre 10% Design Development 4
1.2.1.2 10% Design Development Scope 4
1. Project Partners 4
2. 10% Design Definition 4
3. Original Wood Scope 5
4. Alternative Design Development 5
5. Ongoing Monitoring Programs 6
1.2.2 Candidate Options 6
1.2.2.1 Base Case Designs 6
1.2.2.2 Alternative Designs 6
1.3 Current Post 10% Design Services Scope 7
1.3.1 Objectives 7
1.3.2 Data Gaps 7
1.3.2.1 Dam Breach 7
1.3.2.2 Site Access 7
1.3.2.3 Failure Movements 7
1.3.2.4 Seismic Data Collection 8
1.3.2.5 Common Elements – Pits and Borrow 8
1.3.2.6 Lake Drawdown – Fish and Fish Habitat 8
1.3.3 Conceptual Site Model Update with Recent Data 8
1.3.4 Options Integration Assessment 8
1.4 Closure Planning Status and Timelines 9
1.5 Document Structure 9
2.0 Dam Breach Assessment 12
2.1 Introduction 12
2.2 Breach Scenarios 12
2.3 Summary of Results 13
2.4 Suggested Dam Classifications 14
2.5 Dam Safety Review Requirements 15
2.6 Recommendations 15
3.0 Seismic Runout Assessment 16
3.1 Introduction 16
3.2 Objectives and Methodology 16
3.2.1 Objectives 16
3.2.2 Methodology 16
3.2.3 Scenarios and Results 16
3.2.3.1 Clinton Creek Existing Topography Runout Assessment 16
3.2.3.2 Clinton Creek Alternative Spillway Design Runout Assessment 17
3.2.3.3 Wolverine Creek Existing Topography Runout Assessment 17
4.0 Seismic Assessment 19
4.1 Introduction 19
4.2 Scope and Background 19
4.3 Seismic Monitoring Proposal 19

DRAFT

5.0 Site Characterization Update 21
5.1 Introduction 21
5.2 Sources of Information 21
5.3 Conclusions and Recommendations 21
6.0 Borrow Assessment 22
6.1 Introduction and Background 22
6.2 Scope 23
6.3 Assessment Outcomes and Conclusions 23
7.0 Lake Drawdown Assessment 25
7.1 Background 25
7.2 Drawdown Assumptions 25
7.3 Conclusions and Recommendations 25
8.0 Pit Closure Assessment 27
8.1 Background and Scope 27
8.2 Option Assessments and Designs 27
8.3 Cost Estimates for Pit Closure Options 28
8.4 Closure Options Comparative Assessment 28
8.5 Summary Comments and Observations 28
9.0 Access Limits Assessment 30
9.1 Background and Scope 30
9.2 Method Overview 30
9.3 Event Scenarios 31
9.4 Event Impacts 31
9.4.1 Seismic 31
9.4.2 Hydrotechnical 32
9.5 Risk Calculations and Benchmarks 32
9.6 Summary Comments and Observations 32
9.6.1 Influence of HHERA Conclusions 33
9.6.2 Pit Access Limits 34
9.6.3 Seiche Events 34
9.7 Land Access Cost Benefit Assessment 34
10.0 Options Integration Assessment 36
10.1 Background and Scope 36
10.2 Methodology 36
10.3 Summary Comments and Observations 36
10.4 Additional Issues/Considerations 37
10.4.1 Lake Drawdowns 37
10.4.2 Alternative Designs 38
11.0 Concluding Observations 39
12.0 Closure 40
13.0 References 41

DRAFT

List of Figures

Figure 1-1: Site Location Plan 2
Figure 1-2: Site Layout 3
Figure 1-3: Options Evaluation and Selection Process Design 10
Figure 1-4: Project Timeline 2021-2035 11

Table of Contents (cont'd)

List of Tables

Table 2-1: Dam Breach Consequence Summary Table....13
Table 8-1: Pit Closure Cost Summary ($CAD million) 28

List of Appendices

Appendix A: Closure and Reclamation Planning Bibliographies
Appendix B: General Arrangement Drawings for 10% Designs (Base Case) and Alternate Designs
Appendix C: Dam Breach Assessment
Appendix D: Seismic Runout Assessment
Appendix E: Seismic Assessment
Appendix F: Site Characterization Update
Appendix G: Borrow Assessment
Appendix H: Lake Drawdown Assessment
Appendix I: Pit Closure Assessment
Appendix J: Access Limits Assessment
Appendix K: Options Integration Assessment

DRAFT

List of Acronyms and Abbreviations

AACE	American Association of Cost Engineers
AAM	Assessment and Abandoned Mines (Yukon Government)
BCMOE	British Columbia Ministry of the Environment
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CCRP	Clinton Creek Remediation Project
CDA	Canadian Dam Association
DBA	Dam Breach Assessment
DBM	Design Basis Memorandum
ERT	Electrical Resistivity Tomography
IDF	Inflow Design Flood
IPRP	Independent Project Review Panel
LCCA	Life Cycle Cost Analysis
masl	metres above sea level
PMF	Probable Maximum Flood
TH	Tr'ondëk Hwëch'in
WC	Wolverine Creek
Wood	Wood Environment & Infrastructure Solutions, a Division of Wood Canada
YG	Yukon Government

1.0 Project Background, Scope and Development Status

1.1 Site Description

The Clinton Creek Mine Site (the Site) is a former asbestos mine that was operated between 1968 and 1978. The site is located approximately 100 km northwest of Dawson City, Yukon, near the confluence of Fortymile River and the Yukon River (Figure 1-1). Major elements of the site are shown on Figure 1-2. During mine operations, material was removed from three ore sources, the Porcupine Pit (the largest), Horseshoe Pit and the Creek Pit. Waste was placed in the following locations:

1. Clinton Creek Waste Dump, where waste was placed along the south valley wall of the Clinton Creek valley. It is estimated that 60 million tonnes of waste were placed in the Clinton Creek Waste Dump;
2. Porcupine Creek Waste Dump, where waste was placed into the Porcupine Creek valley (Porcupine Creek Waste Dump); and
3. Snowshoe Pit Waste Dump, where waste was placed on the north side of the Snowshoe Pit along the top of the south Clinton Creek valley wall.

During mining operations, ore was transported via an aerial tramway from the south side of the Clinton Creek valley to the Mill Site at the top of the west valley wall of Wolverine Creek. The ore, a serpentine rock containing chrysotile asbestos, was processed in the mill and the waste material, or tailings, were transported via conveyor to two piles along the steep west slope of Wolverine Creek, one pile located north of the other. Approximately 12 million tonnes of tailings were deposited in these two piles.

In 1974, waste material placed on the south slope of the Clinton Creek valley, the Clinton Creek Waste Dump, failed, apparently several times and possibly at different locations, which blocked the Clinton Creek flow path. The failure created a landslide dam, which impounded water upstream, producing what is now known as Hudgeon Lake. Currently, water discharging from Hudgeon Lake travels southeast via Clinton Creek to Fortymile River, approximately 8 km downstream, initially through four gabion drop structures (DS1, DS2, DS3 and DS4), originally constructed between 2002 and 2004, and then down a lower gradient channel.

The south tailings lobe also failed in 1974, blocking Wolverine Creek. It is understood that the initial failure of the tailings was relatively rapid, and there was considerable mobility of the initially steep tailings cone down the slope, blocking Wolverine Creek, and then down the Wolverine Creek valley following the breach of the temporary landslide dam. At some time post mine-closure, the north tailings pile also blocked Wolverine Creek. At present, there are two ponds which have formed along Wolverine Creek, one upstream of the north tailings lobe and one between the two tailings lobes, referred to as North and South Ponds, respectively. The North Pond discharges into the South Pond and flows from the South Pond is conveyed south via Wolverine Creek, finally discharging into Clinton Creek near the site gate.

Additional locations of interest on the Site, referred to as the Common Elements, include the following locations and/or features:

- Former mill site;
- Air strip (outside of OIC boundary);
- Clinton Creek access road;
- Clinton Creek site roads;
- Clinton Creek ford crossings;

DRAFT

wood.
Environment & Infrastructure Solutions
a Division of Wood Canada Limited
#600 - 4445 Lougheed Highway
Burnaby, BC V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

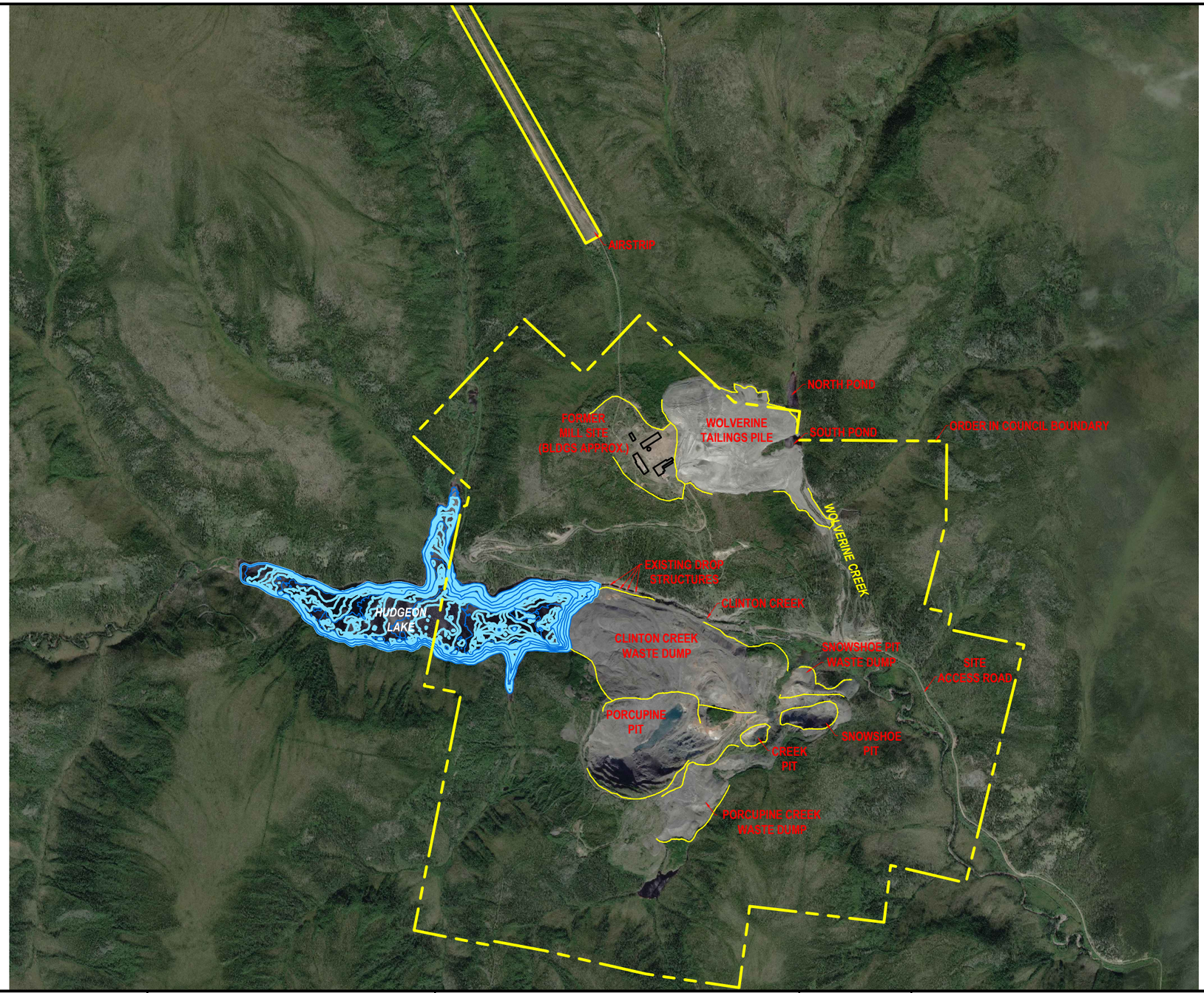
DWN BY:	KL
CHK'D BY:	GG
DATUM:	NAD 83
PROJECTION:	UTM Zone 7
SCALE:	AS SHOWN

CLIENT □PROJECT:
CLINTON CREEK MINE
REMEDIATION PROJECT

TITLE:
SITE LOCATION PLAN

DATE:	NOV 2019
PROJECT NO:	VE52705E
REV. NO:	A
FIGURE NO:	1-1

P:\CAD\CIV\2018 Site Investigation\Figure-2.1.dwg – November 13, 2019 – Lin, Kevin



0m 200 400 600 400 1000

1 : 25000

wood.

Environment & Infrastructure Solutions
a Division of Wood Canada Limited

CLIENT:

DWN BY:	MK
CHK'D BY:	GG
DATUM:	NAD 83
PROJECTION:	UTM Zone 7
SCALE:	AS SHOWN

PROJECT: CLINTON CREEK MINE REMEDIATION PROJECT

TITLE: SITE LAYOUT

DATE:	JAN 2022
PROJECT NO:	VE52705K
REV. NO:	A
FIGURE NO:	1.2

P:\CAD\CIV\Figure-1.2.dwg – FIG 1.2 – Jan. 24, 2022 3:14pm – mark.kramer

- Hudgeon Lake outlet abutments, log boom and drop structures;
- Ore piles;
- Miscellaneous borrow areas; and
- Miscellaneous infrastructure, equipment and waste.

There are no buildings remaining at the Site; however, large, heavily reinforced concrete foundations are present at the former mill site, the crusher building, and the former Tram Tower #3.

1.2 Closure Planning Activities and Inputs

1.2.1 Precedents to Current Scope

1.2.1.1 Pre 10% Design Development

Closure planning assessments and investigations were initiated shortly before regular mining and processing operations on the Clinton property ceased operations in 1978. Planning activities continued sporadically throughout the period between shut down and the commencement of the current 10% design development scope. This work was undertaken by a number of parties (both property owners and governments) and addressed various closure issues including the stability of the waste dump and tailings structures, the flow of surface waters over these structures, local surface water and lake water qualities, contaminant conditions on the property, the state of the local fishery, and the health and ecological risks posed by the site. A bibliography of the relevant reports generated during this period is included in Appendix A.

1.2.1.2 10% Design Development Scope

In 2016, Wood was contracted by the Government of Yukon to progress closure planning to what was referenced as the 10% stage of design development.

1. Project Partners

The 10% design development work was overseen and guided by the following Project Partners:

- the Government of Yukon, Energy, Mines and Resources, Assessment and Abandoned Mines (Wood's client);
- Crown Indigenous Relations and Northern Affairs Canada (CIRNAC); and
- the Tr'ondëk Hwëch'in (TH) Government.

In addition, the Project Partners, through CIRNAC, maintain an Independent Peer Review Panel (IPRP) that provides independent technical oversight and advice at key junctures of project development.

2. 10% Design Definition

The IPRP recommended the following guidance for defining and establishing the 10% design phase objectives (IPRP, 2018):

> *It is recommended that designs be developed …… with sufficient field data to prepare designs that meet the design bases and criteria with reasonable certainty and to reasonably assure there are no fatal flaws. The field data base can be supplemented by reasonable engineering assumptions based on experienced professional judgement, and it must be possible to deal with design uncertainties using reasonable worst case assumptions and cost contingencies.*

DRAFT

Wood interpreted this to mean that the 10% design development stage would involve advancing concepts to the degree that a single base case concept could be selected with a low probability that fatal flaws in the selected concept would be encountered thereafter. It was concluded that fatal flaws would include technical conditions or constraints that preclude application of the concept, insurmountable regulatory burdens and/or prescriptions, and/or "exotic" (i.e., economically implausible) costs.

3. Original Wood Scope

Wood was initially retained in the fall of 2016 to:

- conduct a review of the available information;
- develop a data gap and a site investigation plan to collect the missing information (e.g., Human Health Ecological Risk Assessment (HHERA), geotechnical studies) to complete the remediation design to 10%, and to develop a cost estimate for each concept, as well as address the common elements;
- conduct site investigations, including gathering field data (e.g., geotechnical investigation on the waste dump and tailings piles, field data for HHERA) to ensure all information that was required was available to develop the design and cost estimate for each concept; and
- develop a 10% design and an AACE (American Association for Cost Engineers) Class 4 Life Cycle Costs Analysis (LCCA) for each concept and the common elements.

The intent of the 10% design development was to advance the design of the closure concepts to a level that would allow the Project Parties to select a single remedial option to advance for the site.

The site investigations conducted under this scope were completed in two phases (one in the fall of 2016 and a second in the summer of 2018) with a period of data interpretation and assessment completed in the interregnum. This initial phase of the 10% design development work concluded with the production of a design report (Wood, 2019) and an associated cost estimate (Wood, 2019a).

4. Alternative Design Development

Following review of the design report and associated cost estimate report, a follow-up assessment was requested to study an alternate design approach that focused on meeting the seismic design standards for Closure – Active Care of a CDA Low classification structure rather than the Passive Care guidelines for a CDA Significant classification structure that had been adopted for the initial phase of the work. This was premised on the expectation that elements of the terrain threatened by seismic induced failures would be posted to eliminate threat to life. The expectation was that this offered the potential for lower capital costs with the understanding that costs in the event of failure would be passed on as operational expenses. The underlying philosophy was to consider a design approach that could control risks to a reasonable degree and that would be repairable within the limits imposed by uncertainty. This approach was underpinned by the relevant observation that, whilst both Clinton Creek Valley and Wolverine Creek Valley were impacted by slope failures in the 1970s and 1980s, there has been minimal long term environmental impact to the downstream environment.

The alternative design study then made the assumption that the mine would remain indefinitely in Closure – Active Care with measures taken to control site access. A key requirement of this alternative approach is that the owner normally has resources on-site that are able to respond to problems and possible emergencies that may develop. The design criteria required under CDA guidelines for seismic loadings significantly reduced from the Passive Care initial designs. Hydrotechnical designs, except as specifically noted, maintained the use of Passive Care and a Significant Classification .

The Alternative Design assessment concluded with a report (Wood, 2020) describing possible alternates and/or modifications to the "base case" designs, and providing cost estimates for those alternates.

DRAFT

5. Ongoing Monitoring Programs

In recent years, the Government of Yukon has undertaken monitoring programs on the Clinton property in support of both site management and design development. These programs have included monitoring of surface water flows and qualities on and around the property, and assessments of the physical integrity of various earth structures (e.g., waste dumps and tailings structures). Recent examples of these monitoring efforts are provided by way of EDI (2021) and Tetra Tech (2021).

1.2.2 Candidate Options

The base case and alternate closure design development activity considered the candidate options described below. General arrangement drawings for each of these options are provided in Appendix B and the associated cost estimates are summarized in Table AL-3 of Appendix J. Reference to Wood (2019, 2019a, 2020) should be made for complete descriptions of the bases, scope, components, anticipated performance outcomes and costs of these closure options. A listing of all the Wood investigative and assessment reports that supported the development of these design documents is included in the project bibliography in Appendix A.

1.2.2.1 Base Case Designs

Clinton Creek Side Closure Concepts

CC1 – Water Passage and Catastrophic Failure Mitigation – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure of the pile and construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek.

CC2 – Water Passage, Catastrophic Failure Mitigation and Lower Lake – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure, construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek, and lower Hudgeon Lake as part of that concept.

CC3 – Water Passage with Reduction of the Lake Level, Eliminating the Dam, and Mitigating Catastrophic Failure – Conduct sufficient work on the waste rock pile to prevent it from acting as a Dam (i.e., as defined by the Canadian Dam Association) on Clinton Creek and to mitigate a catastrophic failure of the waste rock pile. Construct a water conveyance channel to provide water passage through the site.

Wolverine Creek Side Closure Concepts

WC1 – Sediment Control Only – Construct a sediment control structure downstream of the rock-lined channel in Wolverine Creek – no work on the tailings pile or the channel is required.

WC2 – Water Passage and Stability Improvement – Conduct sufficient work at the base of the tailings pile to minimize the tailings movement and provide a semi-stable surface to construct a water conveyance channel.

WC3 – Isolate the Asbestos – Stabilize tailings pile to allow a cover to be placed or relocate the tailings pile.

1.2.2.2 Alternative Designs

Alternative Designs were developed for options CC1, CC2 and WC2 (alternates for the other options were not feasible and/or relevant given the operative assumptions applied to the Alternative Designs assessment). The basic design characteristics and objectives for these alternates are as described above for the base case designs. As noted in Section 1.2.1.2.4, the differences reflected in these designs come from the modified design bases and criteria applied to their development. These bases and criteria

DRAFT

provide for lower costs, but produce outcomes with lower resilience to seismic and flooding events. The alternate designs assume that the risks generated by this reduced resilience to extreme events will be mitigated by limits to the use and access of Clinton property and increased maintenance.

1.3 Current Post 10% Design Services Scope

Wood's scope of work for the outcomes and deliverables presented in this document were specified in Yukon (2020). A paraphrased summary scope description follows.

1.3.1 Objectives

The data gaps scope objectives were as follows:

- to build on the submitted 10% designs to close information gaps (Section 3.2) identified by the Project Parties (Yukon Government, Tr'ondëk Hwëch'in First Nation, and Crown-Indigenous Relations and Northern Affairs Canada) required to advance to an Options Evaluation process;
- to review recently collected data to update the Conceptual Site Model where needed (Section 3.8); and
- to provide Consultant representation during the options evaluation and selection process.

1.3.2 Data Gaps

1.3.2.1 Dam Breach

The Dam Breach Analysis completed in support of the submitted 10% Designs was applicable only to current conditions (and by extension CC1). The Dam Breach Analysis should be extended to the other closure concepts contemplated in the 10% Design submission and should include flood mapping for failure events, sediment displacement quantity estimates, and evaluation of the proposed dam classifications per Canadian Dam Association guidance.

DRAFT

1.3.2.2 Site Access

A clear understanding of access restrictions imposed under each closure concept and current conditions is required. To support these understandings, the Consultant shall:

- present access restrictions for closure and current conditions graphically in map format, clearly showing access restrictions which may include off-limit areas, bypasses, signage, gates, fencing, seasonal restrictions, etc.;
- evaluate site risks to visitors based on exposure duration (occasional, frequent, and continuous) and activity (for example, through travel, recreating, working, hunting/gathering); and
- evaluate seasonal risk differences for occasional site users under the current site conditions.

1.3.2.3 Failure Movements

A screening level stability analysis was completed in support of the submitted 10% designs which returned factors of safety below 1.0 under certain conditions (seismic and drawdown triggered liquefaction). A settlement analysis should be completed to estimate failure movements. Movement estimates can also be incorporated into the Dam Breach and Site Access work described above.

1.3.2.4 Seismic Data Collection

One of the recommendations from the March 2020 IPRP technical review was to install a seismograph at the Clinton Creek site to better understand how/if detectable ground motions correlate with movements observed in the slope indicators installed at site. A review of the available seismic information, design assumptions related to liquefaction potential and triggering seismic events, and slope indicator data and monitoring practices is required. A recommendation on whether or not to install a seismograph at site is requested.

1.3.2.5 Common Elements – Pits and Borrow

The submitted 10% Designs did not include closure concepts for the Common Elements identified in Wood's 2016 Scope of Work. Pit closure design is a priority on the Common Elements list and should be advanced with a range of options including no further action, closure as a lake, partial backfill to drain, and complete backfilling. This should include an understanding of closure waste material storage capacities and stability.

A desktop study should be conducted to evaluate borrow potential near the Clinton Creek Mine Site. This study should not be restricted to existing locations or access routes, incorporate extensive terrain mapping, and include an optional field component to confirm potential borrow locations and material properties. A technical memorandum shall be prepared to present the results from this desktop study. The technical memorandum will potentially be used by others to plan borrow source field investigations for 2021.

1.3.2.6 Lake Drawdown – Fish and Fish Habitat

The current assumption in the submitted 10% Designs is that geotechnical stability governs the allowable drawdown rate for Hudgeon Lake. An understanding of the timing and max/min flow conditions during drawdown for the protection of downstream fish and fish habitat should be determined. If the assumed (geotechnical) drawdown rate requires adjusting to remain protective of fish and/or fish habitat (due to sediment loading, water quality, overall flow conditions, etc.), impacts to project schedule and costs could be significant.

DRAFT

1.3.3 Conceptual Site Model Update with Recent Data

The Consultant shall review recently collected GPS, InSAR, and inclinometer data to validate previous assumptions for site conditions and to update the Conceptual Site Model where needed.

1.3.4 Options Integration Assessment

For the most part, the 10% design phase concepts were developed and assessed as stand-alone closure scopes; there was no detailed consideration of the integration of options for the Clinton and Wolverine valleys into a consolidated closure scope for the property. The Project Parties concluded that integrating options from the two sides will influence the extent to which project closure objectives are met and therefore evaluation outcomes. It was determined that a consideration of integration issues was necessary prior to entering the Options Evaluation and Selection process. The objective of this assessment then was to integrate conceptual design options for the Clinton Creek and Wolverine Creek sides of the Clinton Creek Mine Site, to assess their compatibility and determine whether there are advantages, efficiencies and drawbacks associated with integration that may have implications on option evaluations against closure objectives.

This Options Integration scope was an addition to the original data gaps scope. The detailed Terms of Reference for the scope were outlined in Yukon (2021).

1.4 Closure Planning Status and Timelines

The closure planning work completed to date, including the current data gaps scope, has been undertaken in support of the Partners' efforts to select a preferred closure option. This option select effort is one of the early steps in the broader closure planning and execution process. The steps in that process and the CCRP's current state of development are illustrated on Figure 1-3. Note that this figure was part of the information presented to the public in community meetings held at Dawson City in October 2021 (Stratos, 2021). A more detailed outline of the option selection process is illustrated in Figure 1-4, again, excerpted from information presented in the community meetings.

1.5 Document Structure

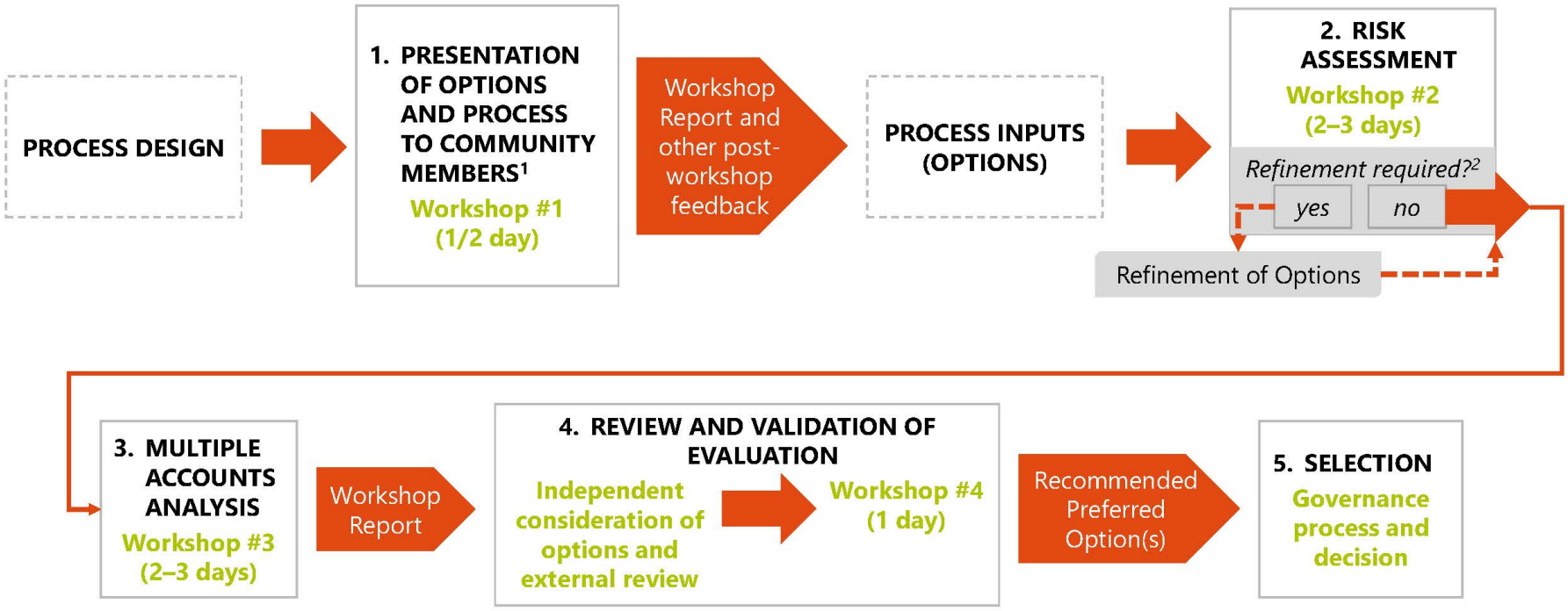
The primary deliverables under this scope are presented as a series of appendices to this document. For each deliverable, the document text provides a summary of the scope, methods and central outcomes (i.e., in effect, the document text provides an executive summary of the appendices). Finally, the text concludes with some of Wood's general observations relating to the current state of closure planning and how work undertaken to date is likely to influence the process of selecting a closure concept.

The order of the key deliverable appendices is as follows (note that this order varies somewhat from the listing of deliverables in the scope, largely to better represent how initial scope outcomes support other deliverables that rely on these outcomes).

- Appendix C – Dam Breach Assessment;
- Appendix D – Seismic Runout Assessment;
- Appendix E – Seismic Assessment
- Appendix F – Site Characterization Update
- Appendix G – Borrow Assessment;
- Appendix H – Lake Drawdown Assessment;
- Appendix I – Pit Closure Assessment; and
- Appendix J – Access Limits Assessment
- Appendix K – Options Integration Assessment

DRAFT

Options Evaluation and Selection Process Design

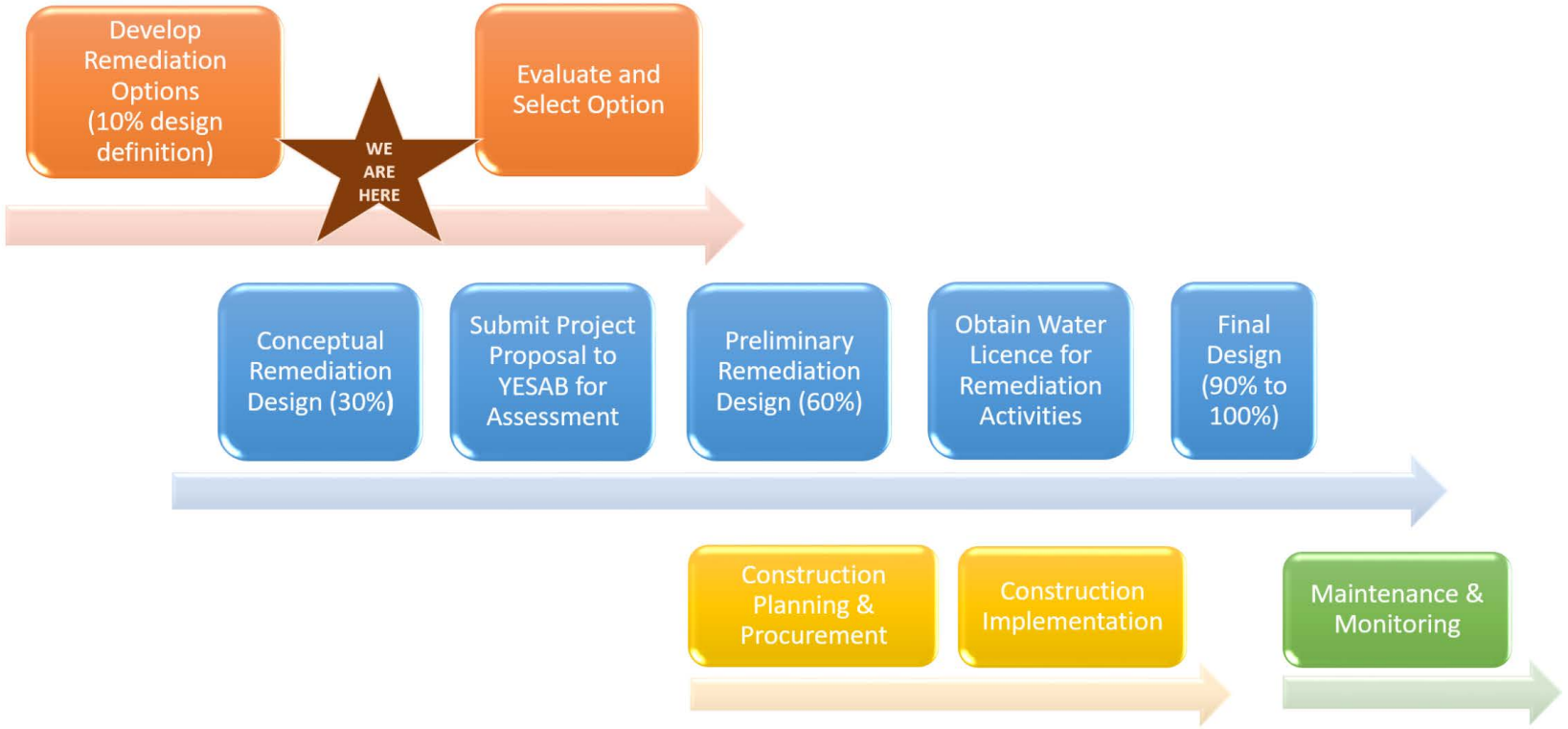


Notes:
1. Additional consultation and engagement with TH government and community may occur throughout this process
2. Refinement refers to updating the closure option(s) as needed

Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada

wood.		Clinton Creek Remediation Project		
Yukon Government Depart of Mines & Resources	Yukon	Options Evaluation and Selection Process Design (from Stratos (2021))		
		Date: November 2021	Project No.: VE52705K.002	Figure: 1-3

Project Timeline 2021-2035



Yukon Crown-Indigenous Relations and Northern Affairs Canada / Relations Couronne-Autochtones et Affaires du Nord Canada

wood.		**Clinton Creek Remediation Project**
Yukon Government Depart of Mines & Resources	Yukon	**Project Timeline 2021-2035 (from Stratos (2021))**
		Date: November 2021 | Project No.: VE52705K.002 | **Figure: 1-4**

2.0 Dam Breach Assessment

2.1 Introduction

During the 10% design phase, Wood undertook a preliminary dam breach assessment (DBA) to provide an indication of the dam classification of the landslide dam impounding Hudgeon Lake. The dam classification was then used to establish initial hydrotechnical and geotechnical design criteria for each option under the Canadian Dam Association (CDA) guidelines. These design criteria were then used to undertake the 10% design. To close data gaps for the options selection process, AAM requested that the scope of the 10% design phase DBA be extended to include:

- Flood mapping for failure events.
- Sediment displacement estimates; and
- Evaluation of dam classification per CDA guidelines.

Understanding the consequences of a breach of the impoundment of Hudgeon Lake, in whatever form the reclamation of the Clinton Creek side takes, is fundamental to confirming final hydrotechnical and geotechnical design criteria for the reclamation option. DBA is also necessary to manage post closure health and safety and environmental risks at the site and for assessing limits to site utility, if required, in the post reclamation landscape.

The DBA is not a risk assessment because it does not consider the likelihood of a failure, only the consequences. It is understood that the Project Partners will be undertaking a risk assessment for each closure option during the options select process. Appendix J – Access Limits Assessment provides some commentary on risk at the site and contextualizes the balance between exposure time to hazards that could be encountered without warning, on site activities and comparisons with other hazards experienced in the normal course of life in the Yukon.

DRAFT

Wood undertook the DBA by estimating breach parameters (primarily breach depth, width and time of formation) and developing a one-dimensional hydraulic model in US Army Corps of Engineers software HEC-RAS (Version 5.0.7). Theoretical breach scenarios were developed that would represent credible failure mechanisms on both Clinton Creek and Wolverine Creek.

2.2 Breach Scenarios

Taking into consideration the transient nature of site use, which will likely continue into the future, dam breach scenarios were developed based on the following factors:

- Whether there would be any potential to warn users of the site of a likely hazard developing. For example, exceptionally severe rainfall. Wood considered that flood induced failures would come with a warning; whereas, seismic or other sunny day failures would not.
- Whether the dam failed due to overtopping in a flood (Flood Induced) or failure from some other mechanism such as piping (Sunny Day); and
- How high a seismically induced new landslide dam could fill before action could be taken by the Owner to mitigate the risk.

For Clinton Creek scenarios were chosen to represent:

- Failure of CC1 under flood and sunny day conditions.
- The failure of slide slopes of CC1 alternatives resulting in a new landslide impoundment and subsequent overtopping failure of that impoundment.

- Failure of CC2 under flood and sunny day conditions.
- Failure of slide slopes of CC2 alternatives resulting in a new landslide impoundment and subsequent overtopping failure of that impoundment.

For Wolverine Creek, modelled scenarios were related to failure of the existing south tailings piles (simulates potential for dam breach under WC1) and for a failure of the existing impoundment.

2.3 Summary of Results

Flood maps were produced from the model results. These are provided in Appendix C. Many of the modelled scenarios produced similar peak flow rates and inundation zones. To avoid an unmanageable number of maps, scenarios for mapping were chosen that would:

- provide a "no breach" base case scenario against which breach model runs could be measured;
- provide an analogue for other events where the flood wave peak discharge is similar to other scenarios; and
- book end the highest rare, but credible, breach flow.

Consequence of a breach is described for each concept in Table 2-1.

Table 2-1: Dam Breach Consequence Summary Table

Option	Summary
CC1	Failure of CC1 under either flood or sunny day conditions would result in moderate consequences for the Clinton Creek valley. There would be several sections of the access road flooded. Significant quantities of sediment would be deposited down the valley up to 5 m deep in places.
CC1 Alternative	The failure of a seismically induced secondary landslide dam downstream of CC1 would result in moderate to major consequences for the Clinton Creek valley depending on response time of the owner to mitigate the situation. Flood depths would be greater than the failure of the base case CC1
CC2	Failure of CC2 under either flood or sunny day conditions would result in minor consequences for the Clinton Creek valley. Some erosion of the creek banks could be expected but the outflows from the breach are similar to what could be experienced during an extreme flood in excess of a 1 in 1000 year event.
CC2 Alternative	The failure of a seismically induced secondary landslide dam downstream of CC2 would result in minor to major consequences for the Clinton Creek valley depending on the size and height of the failure and most significantly, the response time of the Owner to mitigate the situation.
Wolverine Creek	Downstream consequences of a breach of the existing impoundments on Wolverine Creek would be similar to those experienced from a 1 in 10 AEP flood in the catchment. Long term impacts would be minor. If the existing tailings piles were to fail and block the valley (for example if WC1 were selected as the preferred option), and the Owner did not act to stop water from impounding behind the slide, there is the potential for more significant impact to the downstream environment.

2.4 Suggested Dam Classifications

It is the responsibility of the owner to agree an appropriate dam classification with the regulator. The regulatory bodies involved depend on the circumstances. The *Waters Act* requires a water licence for most dams and depending on the type and purpose of the dam, it may fall under other legislation such as the *Quartz Mining Act.* Licencing starts with an application to the Yukon Environmental and Socio-economic Assessment Board (YESAB) and it seems likely that any dam on Clinton Creek would require a Type "A" licence under the *Waters Regulation* (*Waters Act)* for major undertakings.

The CDA guidelines recommend a classification system based on assessment of consequences. Consequences of a dam failure may include loss of life, property and environmental damage, and general disruption of the lives of the population in the inundated area. In Clinton Creek, the release of anoxic lake water, hydrogen sulphide (H_2S), accumulated silt or eroded waste rock could also have detrimental environmental effects, including impacts on aquatic habitat.

Wood's recommendations for dam classification can only be made in this scope of work for CC1 and CC2. Other reclamation options either result in the removal of impoundments or, as is the case for WC1, in failure modes that relate to new, seismic induced landslide dams.

Based on the analysis undertaken and CDA Table 2-1, Wood recommends that a dam classification of "Significant" be adopted for CC1 for the following reasons:

- Long sections of the access road would be inundated to a considerable depth if CC1 were to breach. There would likely be considerable damage to this infrequently used transportation route.
- Except for infrequent transits of the site via the access road, there is no identifiable population at risk in the flooded area. Given the short transit times through the inundation zone, loss of life could be considered to be through "unforeseeable misadventure".
- The habitat at risk is marginal and restoration is possible.
- Access to the former Clinton Creek townsite would be temporarily cut-off with possible damage to the ford across Clinton Creek.

For hydrotechnical design Wood recommends that a dam classification of "Low" is adopted for CC2 for the following reason:

- Only very short sections of the access road are flooded. These should be easily avoidable in flood conditions. Access to the former town site would be temporarily cut-off with potential damage to the ford but there would be only minor damage to sections of flooded access road.
- The CC2 outlet channel is designed at a slack gradient intended to mimic as far as possible, the natural outlet of a lake. Failure of the channel would progress at a slow rate and anyone recreating in the area should be able to leave the danger area. Except for infrequent transits of the site via the access road, there is no identifiable population at risk in the flooded area. Given the very short transit times through the inundation zone, loss of life could be considered to be through "unforeseeable misadventure".
- The incremental difference in flow rate and flood inundation between the inflow design flood (IDF) with no breach and the IDF with a breach is only approximately 25% immediately downstream of the lake.

DRAFT

2.5 Dam Safety Review Requirements

A Dam Safety Review (DSR) is a systematic review and evaluation of all aspects of design, construction, maintenance, operation, processes and systems affecting a dam's safety including the dam safety management system.

Under CDA guidelines, and based on the proposed dam classifications, CC1 would require a formal DSR every 10 years and CC2 would not require a DSR unless the dam classification or site conditions were to change.

2.6 Recommendations

The following dam classification recommendations should be considered interim:

- For options select purposes and for hydrotechnical design, Wood recommends that CC1 be given a classification of "Significant" under CDA guidelines.
- For options select purposes and for hydrotechnical design, Wood recommends that CC2 be given a classification of "Low" under CDA guidelines.
- Yukon Government should obtain a complete LiDAR dataset for the Clinton Creek valley.
- At the 30% design stage, the DBA should be revisited with the complete LiDAR dataset and the mapping results should be confirmed with the more accurate complete dataset.
- Future changes in site use not contemplated at this time may necessitate the re-evaluation of consequence.

DRAFT

3.0 Seismic Runout Assessment

3.1 Introduction

Wood previously completed closure concepts of 10% design level on the Clinton Creek Remediation Project located in Yukon (Wood, 2019a, 2020). To build on the submitted 10% Designs to close information gaps required to advance to evaluation process, a runout assessment was carried out for Clinton Creek waste pile, and Wolverine Creek tailings dump. This memo summarizes the runout assessment methodology, parameters, and results that are presented in detail in Appendix D.

3.2 Objectives and Methodology

3.2.1 Objectives

The objectives of the runout assessment include the following:

1. Provide indications of runout distances, immediately following a design seismic event consistent with a closure time frame.
2. Provide estimate of elevations of triggered landslide dams in Clinton Creek and Wolverine Creek.
3. Provide estimate of runout extent for an extreme runout (very low probability) event from Wolverine Creek Tailings Dump.

3.2.2 Methodology

Previous design analysis primarily focused on defining a stable, no significant movement for the design slopes. This was accomplished by assigning liquefied strength parameters to potentially liquefiable stratigraphical components of both the Clinton Creek landslide dam as well as the asbestos tailings in Wolverine Creek. In order to execute the analysis undrained strength ratios were adopted and the slope conditions suitable for a factor of safety (FoS) of unity determined. The intention at this stage of design was to basically eliminate the threat of seismically induced slope movements. Therefore, the flatter slopes for these design options are not studied herein. Rather, steeper slopes are considered in order to inform possible option selections which might accept the consequences of liquefaction failures.

For this study, post failure motion modelling software "Dan-W" formulated by Hungr (1995) and HGR (2010) was used to model the runout in a two-dimensional (2D) configuration. This model does not consider the runout potential if a water body lies behind the failed slope and the resulting runouts during reservoir breach.

3.2.3 Scenarios and Results

The following runout model scenarios were assessed:

- Clinton Creek waste pile existing topography.
- Clinton Creek waste pile mitigation options 2020 alternative spillway design.
- Wolverine Creek tailings dump existing topography.

3.2.3.1 Clinton Creek Existing Topography Runout Assessment

Several sections were cut through the waste pile existing topography and four sections were selected for the runout modelling. The modelling results indicated:

DRAFT

- the runout distances range from 39 to 352 m depending on slope location, mobility, failure block volume, and slope shapes;
- the resulted landslide dam elevations range from 372 to 428 m depending on section locations with minimum dam heights of 8 to 26 m; and
- the runout upslope elevations on the north slopes range from 395 to 433 m.

3.2.3.2 Clinton Creek Alternative Spillway Design Runout Assessment

The 2020 alternative designs for the Clinton waste dumps considered 4H:1V spillway slopes with and without blast densification. The purpose of blast densification was introduced as a method a controlling static liquefaction during construction. Therefore the 4H:1V slopes of the alternative design are potentially susceptible to instability during the events more severe than the design seismic event, and a runout may occur. The runout modelling results for this scenario indicated:

- the runout distances range from 75 to 84 m depending on mobility, failure block volume, and slope shapes;
- the resulted landslide dam elevations range from 415 to 427 m depending on section locations with minimum dam heights of 13 to 17 m; and
- the runout upslope elevations on the north slopes range from 423 to 436 m.

3.2.3.3 Wolverine Creek Existing Topography Runout Assessment

A section at the South Lobe of the Wolverine Creek Tailings Dump was selected for the runout modelling. There are two major lobes facing east towards Wolverine Creek and a third section of the asbestos lobe facing approximately north west. All, or one of these lobes may fail either by static loading or seismic.

The results of analysis conducted on these lobes suggest the following possible scenarios:

- One lobe or more lobes could fail with the runout may block the Wolverine Creek and form a landslide dam which would then impound water upstream of the dam. The elevation of the new dam would depend on the mass moving. However, it would take time for the dam to be overtopped or for internal erosion of the tailings to occur.
- It is also possible that the south most tailings lobe could runout down Wolverine Creek. The runout distances range from 135 to 190 m and upslope elevations on the east slope range from 452 to 480 m depending on the likely mobility;
- Generally, the resulted landslide dam elevations range from 436 to 460 m, with a minimum dam height of 30 m;
- The runout may travel along the Wolverine Creek and form deposits in the creek, the runout distance is estimated to be 884 m from dump toe with a runout surface grading of about 5.4%;
- With an exceedingly unlikely mobility case, the 2D model indicates that the runout could travel through Wolverine Creek and enter Clinton Creek.

In conclusion, it is considered extremely unlikely that a design seismic event would cause tailings to reach Clinton Creek immediately post event. However, a landslide dam could form and if control measures were not taken, then an overtopping breach would likely cause asbestos tailings to reach Clinton Creek. Slope deposits could be in the order of 15 to 20 m high near the current slope flattening somewhat with distance.

DRAFT

A no-warning static stability event of the current slope after a wet period (for example) could impact as little as 200 m beyond the current tailings. A no-warning seismic event could impact in the order of 900 m down Wolverine Creek to near the confluence. Slope deposits could be in the order of 20 m high near the current slope flattening somewhat with distance.

DRAFT

4.0 Seismic Assessment

4.1 Introduction

To close information gaps required to advance to the evaluation of closure options for the Clinton Creek property, an assessment of seismic monitoring concepts was carried out for Clinton Creek waste pile, and Wolverine Creek tailings dump. This memo summarizes the assessment methodology and outcomes that are detailed in Appendix E.

4.2 Scope and Background

A key factor in evaluating options for site closure at the Clinton property is whether the foundation subsoils are susceptible to seismically induced liquefaction. The Project's Independent Project Review Panel (IPRP) has recommended that the potential benefits of installing seismic monitoring equipment (including triaxial accelerometers and pore pressure monitoring equipment) at the site be assessed. The installation would complement data available from the GSC site at Dawson YK. The idea would be to use site specific seismic ground motion and pore pressure data to better define the liquefaction susceptibility of the looser foundation soils and the general aspects of the site's seismic response (e.g., potential amplification of input "firm ground" base motions considering two dimensional geometries of the waste dumps, variable soil profiles, and sloping ground conditions). The purpose of this seismic assessment is to consider the usefulness of a seismic monitoring station at site.

4.3 Seismic Monitoring Proposal

If seismic monitoring equipment were installed it is anticipated that monitoring would be undertaken over a period of perhaps 5 to 10 years to support the development of closure designs. Wood's assessments of this concept (Appendix E) indicate that over a 5-to-10-year period, the likelihood of capturing a seismic event strong enough to trigger soil liquefaction is very small. From this point of view, the benefit of installing seismic monitoring equipment to record future liquefaction triggering events over a relatively short time frame is believed to be small.

Based on the anticipated limited PGA levels that would be recorded over a 5-to-10-year time frame, Wood concluded that the proposed monitoring equipment and regime would have a very low likelihood of recording seismic shaking sufficient to trigger significant levels of excess pore pressure in the waste dump materials or granular soil foundations. Such instrumentation is likely to record low level seismic excitation which would only serve to calibrate a quasi-elastic seismic response of the waste dumps, which would be of limited benefit to the closure design.

In addition, there are several fundamentally different sites on the property with varying aspects relative to likely source zones, that would in any event need consideration if seismic monitoring installation(s) were considered, specifically the:

- Clinton Creek Landslide Dam;
- Wolverine Creek Asbestos Tailings;
- Porcupine Creek Pit Rock Slopes;
- North Bedrock Slope of Clinton Creek opposite spillway; and
- Other waste dumps in Porcupine Creek, and east of the main Clinton Creek landslide dam.

DRAFT

This is significant in that the potential design input requirements are likely to be highly site specific.

In summary, Wood has concluded that the probability of getting a design significant seismic event for closure designs in the available design time period is low. On-going GSC/NRC seismic predictions for this site, which are conditioned by a monitoring station at Dawson are likely to be sufficient.

DRAFT

5.0 Site Characterization Update

5.1 Introduction

In August 2019, Wood submitted the "Geological and Geotechnical Site Characterization Report" (Characterization Report) which endeavored to provide a synthesis of the available geological and geotechnical information, including the data collected as a part of the site investigation programs undertaken in 2016 and 2018, in order to document the geotechnical characteristics at the mine site (Wood, 2019).

The characterization relied largely on review of available historical information, drill logs, data from instrumentation, survey of monitoring stations and InSAR data in the vicinity of the Clinton Creek waste dump, Wolverine Creek tailing dump and Porcupine Creek waste dump. This section summarizes the characterization update detailed in Appendix F. The update is based on data that has been collected subsequent to the August 2019 report with the objective of noting any changing trends or revised interpretations.

5.2 Sources of Information

The following sources of information were used in the preparation of the update.

1. Slope indicator (SI) readings collected by Tetra Tech. Additional readings since the issue of the Characterization Report include those collected September 2019, July and September 2020.
2. Vibrating wire piezometer (VWP) and thermistor data from selected boreholes drilled in the waste dumps and tailings. These instruments record data at 12-hour interval via dataloggers, with the latest data download completed in September 2020. Instrumentation data plots have been updated and reviewed relative to the interpretations in the Characterization Report.
3. Tetra Tech's 2020 Annual Monitoring Report for their long-term performance monitoring program (Tetra Tech, 2021). This report included presentation and interpretation of the results of monitoring station surveys completed in September 2020 and the 2020 InSAR data.

DRAFT

5.3 Conclusions and Recommendations

The geotechnical, hydrotechnical and thermal trends observed in recent data are generally consistent with those reported in August 2019. Recent instrumentation data has provided additional insight into some of the hydrogeological conditions and ongoing movements of the waste piles.

Additional understanding of the secondary creep in the ice rich permafrost would be beneficial to characterize the area. For example:

- The creep response of the ice rich permafrost zone in BH18-03 near the headwater of the current spillway is associated with the colluvial slope that has been covered by waste rock fills. Given the changes in thermal boundary conditions it is expected that this permafrost will eventually thaw and continue to creep. Slopes excavated in this ice-rich permafrost could also fail in creep rupture. Any of the options (the original 2×3 Base Cases (CC1, CC2, CC3) or the latter Alternative Designs) will need to account for both settlement and slope stability issues.
- For the buried valley wall at BH18-04, options CC1, CC2 and CC3 all reduce the cover over ice rich permafrost at this location and settlement and possibly slope instability could be an issue here as well.

- It would be valuable to obtain temperature data in SI18-03 and SI18-04 to better understand the thermal regime at these locations. This could be accomplished by lowering a thermistor string down the SI casing.
- Clearly, there is insufficient areal information on the distribution of ice rich permafrost considered to be derived in the slow buildup of colluvial debris over potentially several millennia. The original objective for BH18-03 and BH18-04 was to test the characteristics of the valley walls. This has been accomplished at a 10% design level. However, extensive additional site information will be required, the specific details of which would be determined after a decision is taken as to the selected option.

Within the Clinton Creek valley, the apparent hydraulic and thermal connectivity of the alluvial layers at depth with the spillway is expressed in some of the boreholes with seasonal variation in both pressures and temperatures. It appears that the spillway is a "losing stream" where water infiltrates down into the spillway substrate materials and moves laterally (as reflected in the variations observed in nearby boreholes) possibly along the alluvial / bedrock interface. There may also be groundwater inputs and interactions with other surface bodies such as Hudgeon Lake, Porcupine Pit or other sources that are not yet understood.

Further characterization of the groundwater within the Clinton Creek waste dump has implications with respect to the closure selection. Proposed excavations below the water table will face difficulties with respect to seepage and slope stability, largely as a function of permeability and storage within the waste dump and its source(s). Assuming a "downward" groundwater table extending from the spillway for some distance, excavations proposed laterally at the spillway elevation or higher should be dry until encountering regional groundwater table towards the valley walls. Any additional excavation will require a drawdown of the water table prior to construction, which may be affected by Hudgeon Lake levels and/or Porcupine Pit lake levels. Further work is recommended to better characterize groundwater conditions in the Clinton Creek waste dump, possibly including the installation of pumping wells and conducting pumping tests to assess hydraulic connectivity, conductivity, and storage parameters. Tracer testing or additional geochemical testing of the water may be beneficial in determining the source of some of the seeps.

DRAFT

6.0 Borrow Assessment

6.1 Introduction and Background

The closure designs developed to date (Wood, 2019, 2020) will require varying amounts of granular aggregate and riprap of suitable quality. Chilkoot Geological Engineers Ltd. (Chilkoot) prepared a borrow source assessment in 2015 (Chilkoot, 2016) which shortlisted sites identified as harbouring potential aggregate and riprap resources which may be suitable for structural applications associated with the mine closure. The current assessment is a "desk-top" assessment of borrow sources closer to the Clinton Creek mine, leveraging the previous work by Chilkoot. The assessment provides comments and considerations for further evaluation of potential borrow sources for the mine closure concepts including a discussion of the activities and methods that could be used going forward to better define borrow sources (granular materials and rip rap). A scaled back evaluation of additional sites that could be considered by YG is also presented based on a desktop assessment expanded from the 2015 Chilkoot work, which was focused solely on the mine site and along the Clinton Creek Road.

The following sections summarize the assessment work and outcomes that are detailed in Appendix G.

6.2 Scope

The borrow assessment scope of work included the following:

- a desktop review of additional potential borrow sources;
- a discussion on durability parameters for riprap;
- an assessment of the sensitivity of total project costs to borrow haul distance; and
- the identification of additional borrow resources that show some potential for development in support of the CCRP.

6.3 Assessment Outcomes and Conclusions

The borrow assessment outcomes and conclusions detailed in Appendix G are summarized as follows:

- The desktop review identified five additional areas as potential sources for granular borrow or riprap. These are:
    - Potential rip rap source in host outcrops of resistant bedload found in Clinton and Wolverine Creek.
    - Potential rip rap source in shallow rock near the airfield.
    - Possible source of granular material on alluvial terraces and fans near the Fortymile River crossing (Clinton Creek Road km 33).
    - Potential rip rap source in areas of benched shallow rock near the Clinton Creek Road between km 0 to 16.
    - Potential rip rap source in additional plutonic stocks of the Prospector Mountain Suite.

  These sites may be added to the seven sites shortlisted by Chilkoot for further work and reprioritized as warranted for the detailed geotechnical investigations needed to confirm volumes and material qualities, and to check for adverse geotechnical conditions such as shallow groundwater, permafrost or geohazards (e.g., flooding or mass wasting).
- Initial work should include ground-based reconnaissance to verify the desktop interpretations and to collect samples for laboratory testing. For granular deposits, observations should be made with respect to soil classification, stratigraphic relationships, and potential for shallow groundwater. For potential quarry sites, observations with respect to lithology, mechanical properties and structure, including joint spacing will be important.
- With respect to durability testing for riprap, the more stringent of the pass/fail criteria from the three agencies described in Appendix G is recommended, given the severity of the climate and application with respect to long term closure. Specific gravity, absorption and magnesium sulphate should form the backbone of the testing program alongside micro deval, accelerated freeze thaw and LA abrasion.
- Field work should be completed by qualified professionals experienced with bedrock and engineering geology. Execution and interpretation of laboratory materials testing would be undertaken by experienced materials testing professionals. ML/ARD testing should also be completed at all sites where quarrying or additional excavation in rock is anticipated.
- All of this additional testing should be completed on both the newly identified and previously identified quarry locations along with reviews and resolution of any land use conflicts or dispositions.

DRAFT

- Borrow haul expenses as a percentage of total option costs are relatively low. Generally, option selection is not likely to be driven by issues surrounding haul distance. Borrow locations and characteristics will be more important however for the detailed design, costing and execution planning of the selected closure option.

DRAFT

7.0 Lake Drawdown Assessment

7.1 Background

One of the significant data gaps from the 10% design phase was insufficient data on the hydraulic conductivity of the Clinton Creek waste rock pile to determine safe drawdown rates for Hudgeon Lake from a geotechnical perspective. Although all closure concepts for Clinton Creek side require some lake drawdown for construction, the rate of lake drawdown is a significant factor in overall project costs, particularly for closure concepts CC2 and CC3, due to the amount of drawdown required to implement either of those options.

The Project Partners identified that the introduction of significant quantities of water from Hudgeon Lake may have a deleterious effect on the downstream creek environment and may affect the downstream fish population. The Project Partners requested that Wood develop an understanding of the timing and max/min flow conditions during drawdown for the protection of downstream fish and fish habitat; because this could be the determining factor for lake drawdown rates instead of geotechnical constraints.

7.2 Drawdown Assumptions

Each option to drawdown Hudgeon Lake requires substantial effort and some may not be effective and/or feasible for all candidate options. Pumping was selected as the preferred drawdown method for the purposes of 10% design phase because it offers flexibility in controlling drawdown rates and therefore relative certainty in outcomes.

For the 10% design, it was assumed that:

- the lake would be lowered by 5 m each construction season;
- the drawdown would be achievable in a 1-month period after freshet (June); and
- spare capacity is required to maintain the drawdown after rainfall and summer storms.

Pumping rates would vary depending on the inflows from the catchment headwaters; however the pumps would have a maximum capacity of 3.6 m^3/s. This would have the effect of artificially extending the freshet flows by up to one month each year.

Drawdown requirements will depend on the final design and construction methods. For the 10% design assumptions were made about the amount of drawdown that would be required for construction. Option CC1 would require a total temporary drawdown of approximately 10 m for the period of construction, from 412 to 402 m. Option CC2, would require a permanent drawdown from 412 to 400 m and a temporary drawdown of an additional 5 m. For option CC3, the lake is removed completely, a drawdown of approximately 27 m; though there may be upstream ponds and sediment control incorporated into the design.

7.3 Conclusions and Recommendations

A number of aspects of how the Clinton Creek aquatic ecosystem might respond to the temporary additional water introduced into the system by lowering of the lake have a high degree of uncertainty at this time. The slow lowering of the water level of the lake over up to six years is likely to mitigate many of the potential adverse effects; however, how the dynamics of the lake change over the years as the depth of the lake is decreased is difficult to assess

DRAFT

The assessment of potential effects from the drawdown has been based on the proposed options and a drawdown rate of up to 3.6 m^3/s over approximately one month each year, over a span of up to six years. At this rate, there will be a substantial increase in discharge in the lower reaches of Clinton Creek during the drawdown, and potential adverse effects to fish habitat. In general, the lower the drawdown rate the less likelihood there will be adverse effects in the lower reaches; however, the drawdown for construction must be achieved within a reasonable time frame, and the proposed drawdown rate up to 3.6 m^3/s is likely an acceptable compromise.

Wood concludes that the assumptions made for the 10% design for drawdown rates and methods are reasonable and do not supersede the assumption that geotechnical constraints are the dominant factor. The drawdown and resulting increased discharge in Clinton Creek will likely have some short-term adverse effects for example, increased turbidity, flow and velocities in the stream; however, these will be short in duration, lasting less than a month each year.

DRAFT

8.0 Pit Closure Assessment

This section summarizes the work detailed in Appendix I relating to the assessment of options for pit closure at the former Clinton Creek mine site.

8.1 Background and Scope

The closure designs for the former mine pits (Porcupine, Snowshoe and Creek Pits) reflected in Wood, 2019, 2019a were not advanced in any detail because pit closure actions were viewed as unlikely to drive selection of the broader closure strategy adopted for the property. The closure concept assessment for the pits that is summarized in this section and detailed in Appendix I, makes the assumption that the broader property closure plan is not integrated with closure requirements for the pits, and does not significantly influence those requirements (i.e., that pit closure actions will be largely stand-alone activities). In practice, pit plans will be integrated to at least some degree with the broader property plan. However, assessing these 'stand-alone' concepts for the pits establishes a baseline that provides context for the likely scope and cost influences of pit closure, while avoiding the need to consider an unwieldy number of permutations and combinations of potential pit and property closure concepts.

The closure options considered for the pits were as follows:

- No Action: involves defining and maintaining those limits to public access needed to protect public safety, with appropriate signage, road and trail blocks, and potentially pit crest safety berms.
- Removal of Pit Lake: involves those actions necessary to provide safe, unencumbered public access to a pit area that does not incorporate a water inventory at the pit base.
- Maintenance of Pit Lake: involves those actions necessary to provide safe, unencumbered public access to a pit area that incorporates a self sustaining and accessible water inventory at the pit base.
- Complete Backfilling: providing safe, unencumbered public access to pit areas by restoring local slopes and contours to conditions broadly consistent with pre-development conditions

In this context, Wood has assumed that the term 'safe, unencumbered public access" refers to conditions that are consistent with the risks associated with undisturbed, natural landscapes in the Clinton Creek area (i.e., risks are not eliminated, but lowered to those consistent with accessing local undisturbed lands).

Given the paucity of geotechnical (including rock mechanics) data for these pits and as-built geometry, closure concepts have been based on judgements about the configurations needed to sustain physical integrity and/or stability (i.e., concepts are indicative of potential requirements, not designs validated by the requisite characterization data).

8.2 Option Assessments and Designs

The options for pit closure were presented by way of a discussion that mirrored that outlined in the broader 10% design development report (Wood, 2019). That report considered the following items or issues for each alternative:

- Scope Elements: a presentation of the key components required to address the closure scope associated with an option.
- Materials Management Concept: a discussion reflecting the importance of earth movements for most of the options and providing an outline of how these movements will be executed.
- Anticipated Performance Outcomes: a discussion of Wood's judgements regarding the post closure outcomes that the options will deliver.

DRAFT

- Constructability/Execution Issues: an outline of key constructability/execution issues that are particular features of an option (i.e., intended to highlight differentiating execution challenges; not as an exhaustive schedule of more routine execution requirements).
- Key Risks and Uncertainties: a discussion of the key risks and uncertainties that apply to the design concept at this design stage (i.e., prior to execution), and for the closure landscape following execution of an option (i.e., the long-term liabilities that must be retained by the Project Partners).
- Associated Closure Criteria: a description of the closure and reclamation criteria that have been assumed for the design or are defined by the fundamental characteristics of the option. This section refers broadly to the general Project Partner objectives established for CCRP (Table P2) and also describes more specific criteria that, in Wood's view, will be associated with an option.

8.3 Cost Estimates for Pit Closure Options

Estimates for the pit closure options were developed using the estimating platform applied for both the 10% design phase candidate options (Wood, 2019a) and the subsequent Alternate Design options (Wood, 2020). The resulting estimates for pit closure are summarized in Table 8-1 and detailed in Appendix I, Table P3.

Table 8-1: Pit Closure Cost Summary ($CAD million)

Option	No Action	Removal of Pit Lake	Maintenance of Pit Lake	Complete Backfilling
Porcupine Pit	$2.8	$114	$119	$137
Snowshoe and Creek Pit	$1.8	$18	$16	$46

8.4 Closure Options Comparative Assessment

Appendix I includes a summary assessment of the pit closure options in a tabular, comparative evaluation relative to a common set of objectives and criteria (Table P5). The objectives/criteria were developed from the Project Partners' general objectives supplemented by more specific criteria derived from Wood's understanding of project requirements and constraints, and the outcomes of discussions with the Project Partners.

8.5 Summary Comments and Observations

The following general comments and observations can be offered based on the outcomes of the pit closure assessments and cost estimates described in Appendix I.

- All of the Porcupine Pit active closure options (i.e., other than no action) involve substantial capital expenditures either because of the significant rock blasting scopes or, in the case of the Complete Backfilling option, the large movements of dump materials into the pits.
- The more modest costs for the Snowshoe/Creek active closure options, excepting perhaps the Complete Backfilling option, reflect the smaller scale of closure requirements generally, and the proximate availability of local dump fills.
- Caution should be exercised in making distinctions between those options exhibiting small cost differentials (e.g., between PP2 and PP3). The indicative nature of the concepts presented, driven in turn by the lack of characterization data for the pits generally, means that there is a comparatively high degree of uncertainty relating the closure scopes. In addition, the estimates particularly those for

the Porcupine Pit, are sensitive to assumptions relating to a small number of costing inputs (the blasting unit price in particular) that have not yet been defined with site specific resolution.

- Pursuant to the overriding assumptions applied for this assessment, the cost estimates reflect requirements for pit closure as stand-alone activity (i.e., separate from, and incremental to, broader property closure activity). As pit closure plans are integrated with the broader property closure scope as options are selected, pit closure costs will decline from those presented herein, largely as a function of the quantities of dump and tailings spoils generated by the preferred options for the Clinton and Wolverine sides of the property (e.g., selecting CC3 and WC3 (complete dump and tails removal) takes incremental closure costs for the Porcupine Pit close to zero).
- Not surprisingly, the No Action alternatives for pit closure offer costs one to two orders of magnitude lower than the active closure options, a difference that highlights the economic implications of accepting limits to the utility of pit areas post closure and the associated need for ongoing institutional controls.
- The requirements, costs and relative appeal of pit closure options will be strongly influenced by the options selected for the Clinton and Wolverine Creek sides of the property; this probably limits the utility of progressing the indicative pit closure designs presented herein any further in advance of those broader closure decisions for the property.

DRAFT

9.0 Access Limits Assessment

This section summarizes the work detailed in Appendix J relating to the assessment of potential land use and/or site access restrictions associated with the status quo and some of the candidate closure options for the former Clinton Creek mine site.

9.1 Background and Scope

Many of the candidate closure concepts developed to date for the CCRP, particularly the Alternate Designs, retain some level of residual risk and discussions to date have noted access may need to be limited. It was also noted that a greater understanding of these risks would support the Partners' concept select deliberations. The Access Limits scope was undertaken to:

- present access restrictions for closure and current conditions graphically in map format, clearly showing access restrictions which may include off-limit areas, bypasses, signage, gates, fencing, seasonal restrictions, etc.;
- evaluate site risks to visitors based on exposure duration (occasional, frequent, and continuous) and activity (for example, through travel, recreating, working, hunting/gathering); and
- evaluate seasonal risk differences for occasional site users under the current site conditions.

9.2 Method Overview

There are a variety of approaches that have been applied to the assessment of risks associated with mining structures. Given the particular requirements and focus of the Clinton access limits assessment, and the limitations of the data available to support it, Wood applied a hybrid approach that borrows from various methods and relies on a liberal application of professional judgement to arrive at general illustrations of the risks that various publics using or visiting the property may be subject to. These are not definitive measures of risk, but rather are intended to initiate and inform a risk assessment and management process that is likely to be ongoing through the closure planning and execution process for the site.

DRAFT

Wood's hybrid approach was informed by the risk management guidance provided in the 2013 revisions to Section 6 of the CDA's Dam Safety Guidelines (CDA, 2013). For the individual risks that are particularly relevant for the access limits assessment at Clinton, CDA offers the following formula for calculating risk:

$$P_{LOL} = P_{Event} \times P_{Failure/Event} \times P_{Fatality/Failure}$$

where: P_{LOL} = Probability of Loss of Life; the unconditional probability of fatality for maximally exposed individual from a hazardous event

P_{Event} = Unconditional probability that a hazardous event of specified type and magnitude range will occur

$P_{Failure/Event}$ = Conditional probability that the structure will actually fail, given the event

$P_{Fatality/Failure}$ = Conditional probability of loss of life, given structure failure

The risks calculated by the above formula need to be aggregated over all failure initiating events in order to obtain the total risk to the individual. It is important to note that while this equation refers exclusively to probabilities, in fact, it combines probability terms (P_{Event}) with measures of consequence (P_{Fail}, $P_{Fatality}$) to predict the risk to individuals (P_{LOL}) posed by particular events.

Wood applied this general formula and compared outcomes both to criteria recommended by the CDA and other risk benchmarks that may have particular relevance for users of and/or visitors to the Site. The range of comparative benchmarks offered was a reflection of the lack of any specific definition of the

levels of risk that are acceptable for the particular circumstances at Clinton. The approach taken is to provide general comparative characterizations of risks that the Partners can consider in defining the nature and scale of land use restrictions that are likely to apply to different closure options for the property.

9.3 Event Scenarios

For the purposes of this access limits assessment, there are two broad categories of hazardous events that were considered, specifically seismically induced failures of the Clinton Creek waste dump or the Wolverine Creek tailings inventory, and hydrotechnical events resulting in breaches of dump and/or tailings structures, either as a result of flooding, or as a secondary consequence of seismic events. The probabilities of these events and the physical consequences that they could generate are the subject of the geotechnical and hydrotechnical discussions presented in the Dam Breach and Runout Assessment Appendices of this report (i.e., Appendices C and D). These appendices include maps or drawings illustrating the areal limits of the physical consequences of the events in question. These maps/drawings can also be considered to judge how these limits of impact might vary amongst the candidate closure options. The intent is to provide some indication of how varying levels of closure investment influence the final utility of the reclaimed landscape (i.e., a preliminary quantitation of the relationship between cost and post closure risks to local publics).

The assessment draws a distinction drawn between the seismic and hydro events that will likely have a significant bearing on how the associated risks are managed post closure. Seismic events are not predictable in any practical sense, which means that the only way to mitigate the impacts of their physical consequences on local publics is to limit the use and occupancy of the affected lands. These are considered to be no-warning events. However, most of the hydrotechnical events described in Appendix C would be preceded by events that would provide degrees of warning for those breach events carrying the potential to cause injury or death. That is because the particular hydrotechnical events referenced are caused by flooding that would take some time to compromise the physical integrity of dam structures, or they are the secondary effects of seismically induced spillway failures that will, again, involve time lags for the build-up of potentially compromising water levels. The duration of these "with-warning" events on the hydrotechnical side varies, but in most cases, would be long enough to affect evacuations of potentially impacted areas if appropriate monitoring and notification systems in conjunction with on-demand evacuation resources, were to be developed and reliably sustained. This use of monitoring and evacuation as a primary risk management tool for hydrotechnical events could be applied to limit the required number and scope of limits required for access and use of the lands.

9.4 Event Impacts

9.4.1 Seismic

The representations of event boundaries for seismic events provided in Appendix D (Attachment B) reflect the outcomes of analyses described in the Appendix, supplemented with Wood's judgements about the influence of the Alternate Designs on these event boundaries. For the Clinton Creek valley, Figure AL-2 of Appendix D shows the estimated slide hazard area for the status quo, and the approximate reduction in that area that would be offered by the Alternate Designs.

On the Wolverine Creek side, Figure AL-3 of Appendix D shows two event boundaries, one of the status quo (and for WC1 which approximates the status quo), and a second for the WC2 Alternate Design (i.e., Option WC2-A).

DRAFT

9.4.2 Hydrotechnical

All of the relevant hydrotechnical event boundaries are included in the figures included in the Dam Breach Appendix (i.e., Appendix C).

9.5 Risk Calculations and Benchmarks

Combining the probabilities of subject events with the representations of the physical consequences of these events to produce preliminary characterizations of risks to individuals on or proximate to impacted areas was done by applying the basic risk equation described above in Section 9.2. Wood's application of this formula to the events of interest is detailed in Table AL-2 of Appendix J. The significance of the Table AL-2 calculations was characterized via comparisons to three risk benchmarks. The relevance of these benchmarks to the Clinton scope has not been established at this stage. They were applied simply to provide some readily understood comparisons to the predictions of risk associated with temporary occupations of the Clinton property.

1. CDA Guideline for Individual Risk
   Section 6 of CDA (2013) notes that in dam safety decisions, individual risk should be considered in terms of the "maximally exposed individual" that is permanently resident downstream of the dam. Typically, the maximally exposed individual is exposed to the hazard significantly more than 50% of the time. The maximum level of individual risk is generally given as less than 10^{-4}/year.

2. Aircraft Travel
   Statistics outlined in PCI (2021) describe a fatality rate of 6.1 per million flight hours for what is referenced as a commuter airline (judged by Wood to be a reasonable representation of the comparatively small aircraft servicing regional flights in the Yukon). This would translate into a fatality risk of 1.4×10^{-5} (i.e., 2.3/1,000,000 x 6.1) for a roughly 2.3 hour return (in and outbound total) flight between Whitehorse and Dawson City.

3. Vehicle Travel
   A reference on vehicle fatalities in Yukon describes a fatality rate for the territory of 0.6 per million vehicle kilometres (Yukon, 2019). Given that the road distance between Dawson City and the Site is about 102 km, a return drive to the site would result in a fatality rate of 1.21×10^{-4} (i.e., 0.6 x ((102 x 2)/1,000,000)).

9.6 Summary Comments and Observations

Summary comments and observations relating to the application of limits to site access for both the status quo and select candidate closure options are provided below.

- The nature of breach events is such that areas of impact are much larger than those for seismically induced dump and tailings runouts. However, the warnings that precede these breach events offer opportunities for applying monitoring and evacuation protocols as alternatives to broadly scoped access limits for mitigating the associated event risks.
- The findings of this preliminary risk assessment underscore the general conclusion that land uses involving full time occupancy on and downstream of the Clinton property would not be appropriate for both the property as it stands (i.e., a no action closure scenario) or the Alternate Designs. This conclusion aligns with the basic design premise upon which the Alternate Design concepts were developed.

DRAFT

- The assessment also suggests that transient movements across the site (i.e., using the property to access other areas) do not generate risks to individuals or small groups that are inconsistent with CDA guidelines for individual risk, or markedly different from the risks that individuals typically assume when moving over large distances (e.g., driving and flying).
- Mitigating the potential for serious injury or death caused by seismically driven failures of the current Clinton Creek waste dumps for the Alternate Closure designs will require limits on the durations of individual or small group occupancies (e.g., small hunting parties) to days or a small number of weeks depending, in part, on the number of people involved. This reduces exposure periods, but does not eliminate overall risk, considered as the product of likelihood and consequence.
- The higher potential for seismic liquefaction failures on the Wolverine Creek tailings reduces those acceptable occupancies to a few days at most. The lower probabilities associated with the relatively extensive event tailings runout scenarios allow for longer occupancies, but over larger areas of impact (i.e., larger areas of limited access).
- Hydrological breaches of the Clinton Creek waste dump and Wolverine tailings generate somewhat lower individual risks, but over considerably larger areas. Again, these risks could be mitigated via the application of access restrictions, similar to those described for seismic liquefaction dump/tailings failures, or via the application of monitoring and evacuation protocols.
- Reminders as to what can precede "with-warning" events presented on signage could be considered to facilitate personal risk management. At the same time, signage would need to stress the lack of warnings for seismically triggered events.
- It is worth noting that while most of the Base Case, 10% designs were developed to mitigate the risk of seismic liquefaction failures, this is not the case for Base Case design WC1 on Wolverine Creek (this is essentially the status quo with some sediment control). This means that any of the Base Case designs for Clinton Creek would still require the property access restrictions described for WC1 (i.e., Figure AL-3) if combined with that option for Wolverine Creek.

There is a high level of uncertainty in all of the key components of this preliminary access limits assessment, specifically in the characterizations of the physical consequences of seismic, flood and breach events, and in the assumptions and judgements applied to predict the likelihood these events will cause serious injury or death. More robust and refined analyses of the preferred closure option(s) will likely be required to fully develop any access restrictions ultimately applied for the property. That said, Wood believes this current analysis provides a general representation of the nature and scale of land use and access limits that would likely apply to closure plans or concepts that don't fully mitigate all failure risks in the basic design concept.

9.6.1 Influence of HHERA Conclusions

The Human Health and Ecological Risk Assessment (HHERA) that was updated for the Clinton property in 2019 estimated the risks associated with temporary occupancies of the site created by the asbestos that is present in the Wolverine tailings. Among other findings, the HHERA concluded that:

- Incremental Excess Lifeline Concern Risks (IELCRs) for exposure to asbestos fibres in air exceed the target IELCR for the hunter/gatherer and camper receptor groups based on personal and area sampling results indicating that unacceptable risks due to airborne asbestos exposure are predicted for these receptors under current Site conditions; and

DRAFT

- IELCRs for exposure to asbestos fibres in air for the occasional visitor are less than the essentially negligible target risk of 1 x 10^{-5} for all sample results indicating that unacceptable risks due to airborne asbestos exposure are not predicted for this receptor under current conditions.

It is useful to note that the HHERA considered long term, chronic exposures to asbestos in air in the Wolverine Creek valley as it currently exists, not the short-term exposures that might be associated with failures of the tailings structures. Seismic events would generate exposure scenarios that depart from the long term, chronic exposures modelled by the HHERA. A seismically driven failure of the tailings would likely produce a substantial and temporary increase in asbestos levels in air.

It seems unlikely that the asbestos content of the tailings would impose the need for limits to access and/or land utility incremental to those needed to mitigate the seismically driven physical safety risks to individuals.

9.6.2 Pit Access Limits

Unrestricted access to the former Porcupine, Snowshoe and Creek pits on the Clinton property cannot be provided because of the lack of geotechnical data and assessment relating to the over-steepened slopes associated with these pits. Attachment B of Appendix J describes closure options that could be applied for these pits to remove access restrictions. These options assume pit closure is undertaken as stand-alone activity (i.e., separate from and incremental to, closure activity on the balance of the property). In practice, pit and property closure plans will ultimately be integrated and the extent to which dedicated pit closure actions would be needed to eliminate or reduce access restrictions will depend on the options selected for the Clinton and Wolverine sides of the property.

9.6.3 Seiche Events

Seiches are sudden and significant changes in lake levels, in this case caused by slope failures, particularly those resulting from seismic events. Seiches on Hudgeon Lake could produce:

- risks to the safety of persons on, or immediately proximate to the lake during a seismic event; and/or
- risks to anyone downstream of Hudgeon Lake during an event, or later should the seiche undermine the long-term integrity of the dump and/or associated spillway structures.

The significance of these risks will depend of course on the size of the seiche produced, and on the scale of any subsequent damage to dump structures. Those factors will in turn will have a relationship to seismic event return periods that Wood has not attempted to quantify in this exercise. Wood has concluded that it is unlikely that the incremental risks posed by seiche events would require an expansion of the access limit boundaries.

While the incremental risks associated with seiche events are unlikely to be determining issues for the concept select phase of project development, they may require more considered and quantitative assessments as design development of a preferred closure concept is progressed.

9.7 Land Access Cost Benefit Assessment

One of the key objectives of the current work was to provide more clarity on the specific nature and scope of limits to land use that would be associated with both the status quo and some of the candidate closure options. As part of concept select deliberations, it will be useful to contrast these limits in land utility against the economies in closure costs that they may provide. This will allow for at least a preliminary assessment of the land utility cost benefits associated with the current schedule of candidate closure options.

DRAFT

Table AL-3 of Appendix J provides a representation of that cost benefit evaluation based on the results of the access limits assessment developed under this scope and the cost estimates for the candidate options prepared previously (Wood, 2019a, 2020). The following general observations can be offered based on the content of this Appendix J table:

- The table reiterates previous conclusions that the base case designs (excluding WC1, which is largely the status quo) provide for more or less unlimited access to the Clinton lands, but at substantial costs. Indeed, this was the finding that precipitated development and consideration of the Alternate Designs.
- The Alternate Designs provide modest improvements to land utility and access that could be described as incremental at best. It seems unlikely that these modest, incremental benefits would in themselves justify the still substantial costs associated with the Alternate Designs.
- The limited land utility and access benefits that the Alternate Designs provide do not diminish the other beneficial characteristics and features of these options. While these designs do not offer complete mitigation of seismic impacts, they do provide more robust slopes and hydrotechnical features that will reduce long term monitoring and maintenance liabilities related to the property.

DRAFT

10.0 Options Integration Assessment

This section summarizes the work detailed in Appendix K relating to the integration of Clinton Creek and Wolverine Creek closure options for the former Clinton Creek mine site.

10.1 Background and Scope

The 10% design phase for the Clinton Creek Remediation Project considered three closure concepts for the Clinton Creek side of the property and three for the Wolverine Creek side. These designs and their associated cost estimates were described in Wood (2019) and Wood (2019a), respectively. For the most part, these concepts were developed and assessed as stand-alone closure scopes; there was no detailed consideration of the integration of options for the Clinton and Wolverine valleys into a consolidated closure scope for the property.

The Project Parties concluded that integrating options from the two sides will influence the extent to which project closure objectives are met and therefore evaluation outcomes. It was determined that a consideration of integration issues was necessary prior to entering the Options Evaluation and Selection process. The objective of this assessment then was to integrate conceptual design options for the Clinton Creek and Wolverine Creek sides of the Clinton Creek Mine Site, to assess their compatibility and determine whether there are advantages, efficiencies and drawbacks associated with integration that may have implications on option evaluations against closure objectives.

10.2 Methodology

The Options Integration Assessment was undertaken using a matrix to evaluate the various potential option combinations against the criteria and/or issues likely to influence the relative appeal of those combinations. The matrix was developed by consolidating the assessment criteria and the key cost elements from the comparative assessments presented in the 10% design report and the 10% cost estimate, respectively (i.e., Table 8-1 of Wood (2019) and Table 2 of Wood (2019a)). The resulting matrix is presented as Table 1 of Appendix K. The construction and application of this table is described in the following:

- The matrix provides a qualitative categorization for each option combination against the range of scope elements and key project issues captured by the matrix.
- The qualitative categorizations have been assigned on the basis of Wood's judgement using a five point scale ranging from 'Significant Positive' to 'Significant Negative'.
- The rationales behind Wood's judgements are described by option and scope element/issue in the following sections. The numbering in these sections align with the numbering in the cells shown in Table 1.
- Generally, the matrix describes the impact of a combination on the characterization of individual options offered previously in the 10% design report and associated cost estimate (i.e., addresses whether or not the combination improves or detracts from how individual closure options were described previously).

10.3 Summary Comments and Observations

The following summary comments and observations can be offered on the basis of the integration outcomes outlined on Table 1 of Appendix K and the associated commentary in the appendix:

DRAFT

- One key issue for the development of an integrated property execution plan will be the extent to which options on the Clinton Creek side of the property are run concurrently with those on the Wolverine Creek side. The relative appeal of concurrent versus consecutive operations will be influenced by the required equipment and staff resources, the ability to service those resource requirements locally or regionally, the associated impacts on opportunities for First Nations participation, the locations selected for the disposition of relocated tailings, the need to sequence operations in ways that sequester tailings below relocated waste dump materials, and the influence of asbestos abatement protocols on overall execution efficiencies and costs.
- This issue will be most pronounced if WC3 is selected for the Wolverine Creek valley because of the scale of the associated tailings relocation scope. Table 1 demonstrates that, not surprisingly, concurrent operations for the WC3 option combinations offer a reduced execution timeline but potentially at the expense of local and First Nations socio-economic opportunities, given that resource demands may exceed local capacities and because of the reduced time window for project participation. Table 1 suggests a minor cost benefit offered by a more consecutive execution strategy. However, the resolution provided by the current level of execution planning definition is not sufficient to reliably characterize the cost differences between concurrent and consecutive operations.
- Table 1 suggests that concurrent execution strategies for combinations involving WC2 (the operative assumption for most of this assessment) offer similar benefits and trade-offs (i.e., reduced timelines but more limited local and First Nations socio-economic benefits).
- Integration issues are not as significant for the combinations involving WC1, largely because the very limited WC1 scope could be readily integrated within the much larger Clinton scopes. The categorizations offered in Table 1 for the WC1 combinations should be interpreted with this comparative insignificance in mind (i.e., a slight Positive for a WC1 combination will not be as relevant as the same categorization for combinations and options involving larger materials movements).
- Generally, this first iteration of an Options Integration Assessment for the CCRP offers limited resolution for most of the key execution issues which, in turn, is a reflection of the conceptual nature of the current designs, execution plans/assumptions and their associated cost estimates. The key issues identified in this assessment will require progressive definition and assessment as post 10% project development proceeds.

10.4 Additional Issues/Considerations

10.4.1 Lake Drawdowns

While the lake drawdowns required on the Clinton side of the property will clearly influence the overall execution schedule, it is less evident that they will have a determining influence on option integration issues. Executing Clinton drawdowns concurrently with works on the Wolverine Creek side could be considered to reduce the overall schedule. However, the concurrent vs. consecutive execution determinations are more likely to be driven by the costs and logistics of the materials management operation rather than any constraints imposed by the Clinton drawdowns. In addition, if any material drawdown constraints did emerge, they could likely be mitigated by scheduling the bulk of drawdown activity prior to the initiation of materials management operations. Again, this would extend the overall execution schedule but that may not be a significant concern if it delivers the key execution benefits of the preferred approach to integration of the Clinton and Wolverine materials management scope.

DRAFT

10.4.2 Alternative Designs

The scope of work for this integration assessment did not call for consideration of the Alternative Designs in the Table 1 comparative assessment. However, the following general comments about the potential influence of the alternates on integration considerations are offered.

Among other things, the alternates are distinguished from their respective base design options by the lower materials management scopes that they call for. The CC1 alternate volumes are about one-fifth of the CC1 base design, CC2 alternates are about one to two-thirds of base and the WC2 alternate no more than one-half of the base design. These reductions make it more likely that concurrent execution schedules (i.e., undertaking work on the Clinton and Wolverine sides of the property at the same time) can be developed without over-taxing the resource and logistical constraints imposed by local contracting capabilities and/or the physical limitations of the property itself. Concurrent schedules offer the obvious benefit of an expedited delivery of closure outcomes, and at least the potential for some cost efficiencies via economies of scale. These potential benefits are particularly pronounced for the CC1 alternates; a combination of CC1 and WC2-A would invoke a total project materials management scope little more than about two-thirds of the base CC1 scope alone. The possible benefits for the CC2 alternates are less obvious, simply because the materials management scopes are larger than the CC1 alternates. Nevertheless, these CC2 alternate volumes still represent substantial reductions from the base design which, in turn, increase the potential that concurrent operations would be viable, particularly if combined with the alternate for WC2.

One additional comment relating to the potential impact of options integration on post closure land utility can be offered. Combining any of the base designs options on the Clinton side with the alternate for WC2 offers the benefit of limiting post closure site access restrictions (see discussion in Wood 2021 to that side of the property (i.e., the Wolverine tailings) that, by its nature, offers more limited opportunities for post closure land occupation and/or use. Whether this is an integration issue or a concept select consideration is perhaps debatable, but Wood offers the observation nonetheless.

DRAFT

11.0 Concluding Observations

The Project Partners will be considering the closure design development work completed to date, along with the work described in this Data Gaps report, in light of the project objectives and various other considerations particular to each Partner's requirements and constraints. These considerations will lead to the selection of a preferred concept that will then be developed further in subsequent design activity. Wood recognizes that the selection of a preferred closure concept involves the consideration by the Project Partners of a variety of issues and trade-offs that go beyond Wood's remit. The following comments and observations reflect conclusions formed by Wood during the conduct of the work and are offered simply to provide support to the Project Partners' deliberations as the candidate options are reviewed.

- The data gaps scope has improved the definition of the performance outcomes offered by the various candidate options, and in particular, their relative capabilities in providing public access to the lands following closure.
- It is clear that providing unrestricted public access following closure will involve substantial expenditures. Alternate closure designs that reduce costs are available, but generally involving accepting significant land access and/or use penalties. In that respect, most alternates may provide limited benefits over acceptance of the status quo.
- It seems likely that the significance of the cost issue will have an important influence on the Partners, and the public's, option select deliberations. Wood would note that the cost differential between alternates that come with restrictions, and the associated base case designs that do not, varies considerably. The cost benefit evaluation of this issue that is offered in the Access Limits discussion Table AL-3 (Appendix J) may offer some assistance to the Partners in the consideration of this issue.
- Community perspectives on the relative significance of access/use limitations between the two valleys on the site may also influence the option select considerations. Eliminating restrictions in the Wolverine Creek Valley will likely be more difficult and costly than in the Clinton Creek Valley, arguably the more consequent of the two from the perspective of potential post closure land utility. This might increase the appeal of the one alternate design available on the Wolverine side if it provides at least some benefits (improved resistance to extreme events, better aesthetics, mitigation of asbestos contact risks) while limiting access/use restrictions to the least productive component of the larger property.
- While the status quo is not among the candidate options for either side of the property, the work completed to date provides more clarity on the implications of accepting current conditions and the costs and benefits of departing from them. These definitions of the status quo offer baselines that should facilitate the Partners' option select deliberations and will go some distance in addressing questions that will likely emerge from some public stakeholders about the imperatives for action, given the considerable costs involved in executing closure options.
- This clarity comes from the representations offered for the core benefits of closure action, specifically, and among others, mitigation of the safety risks generated by the potentials for unpredictable and uncontrolled failures of dump and/or tailings structures, an improved aesthetic for the property generally, and mitigation of the chronic health risks posed by exposed tailings.
- One of the more useful outcomes of the Options Integration Assessment was to highlight the need for advancing execution planning as the project moves into the 30% design development phase. While integration issues may have a limited influence on option select deliberations, they will have important bearing on cost, schedule and procurement requirements for the selected closure concepts.

DRAFT

12.0 Closure

This report is for the use of the Government of Yukon, ("YG") and its authorized consultants, contractors, and representatives, First Nations, the federal government, and regulatory agencies.

The reports are made available for third party review for informational purposes only in relation to this Project or for the purposes upon which the report was requested. YG and Wood make no representation or warranty nor assume any liability with respect to any reliance by a third party on this report and the work referred to in this report. If site conditions or applicable standards change or if additional information becomes available, modifications to the findings and conclusions of this report may be necessary.

For and on behalf of:

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Note: The technical content of this report has been professionality authenticated (i.e., affixed with professional stamps and Wood's Yukon Permit to Practice) under each individual appendix. The following signatures relate only to the content of the main text of this report.

DRAFT

R. Brian Geddes, P.Eng.
Principal Engineer

Geoff Graham, P.Eng.
Associate Water Resources Engineer & Project Manager

Reviewed by:

Dr. E.C. McRoberts, Ph.D., P.Eng.
Principal Geotechnical Engineer

RBG/GG/ECM/jm

13.0 References

Note: These references are for the main document only; references for the Appendices are included separately in each individual Appendix. A single, consolidated references section will be developed for the final version of this document.

Canadian Dam Association (CDA). 2013. *Dam Safety Guidelines 2007 (Revised 2013).* Section 6, Analysis and Assessment.

Environmental Dynamics Inc. (EDI). 2021. *Clinton Creek Surface Water Quality and Hydrological Investigations Quarterly Report: August 2021*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. September 2021.

Government of Yukon (Yukon). 2020. *Scope of Work for Clinton Creek Post 10% Design Services*. Prepared by Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. 2 November 2020.

Government of Yukon (Yukon). 2021. *Scope of Work for Integration of Clinton Creek and Wolverine Creek Options.* Prepared by Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. 14 May 2021.

Independent Peer Review Panel (IPRP). 2018. *Technical Memorandum Re: Clinton Creek Mine Closure – Status Update Meeting (April 2018)*. Submitted to Michael Nahir, Director of Engineering, NAO-CSP Impacted Sites Program Indigenous and Northern Affairs Canada. 30 July 2018.

PlaneCrashInfo (PCI). 2021. *Odds of being involved in a fatal accident.* Downloaded from Accident statistics (planecrashinfo.com). June 2021.

Stratos. 2021. *Site Closure Options Community Meetings, Clinton Creek Remediation Project*. PowerPoint presentation prepared for the Government of Canada, Crown-Indigenous Relations and Northern Affairs Canada and the Government of Yukon Energy, Mines and Resources Assessment and Abandoned Mines. October 2021.

Tetra Tech. 2021. *2020 Annual Report Long-Term Performance Monitoring Program Clinton Creek Mine, Yukon*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. January 2021.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project 10% Design Phase Report.* Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions (Wood). 2019a. *Clinton Creek Remediation Project, 10% Design Phase Cost Estimate*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions (Wood). 2020. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

DRAFT

Appendix A
Closure and Reclamation Planning Bibliographies

DRAFT

References - compiled by INAC Jan 1, 2018

YEAR	REPORT NAME	AUTHOR	INAC Server (CIDM #)
Unknown	Historical Photos of the Clinton Creek Project	Unknown	327177
Unknown	Historical Photos of Wolverine Creek	Unknown	327179
Unknown	Various Historical Photos of the Clinton Creek Mine Site	Unknown	327180
Jan-73	Summary of the application for an industrial water use licence for the Cassiar Asbestos mine at Clinton Creek	DIAND	no copy
Aug-74	Report to the Department of Indian Affairs and Northern Development on waste disposal Clinton Creek Mines	Golder Browner Associates	301460
Jun-74	Inspection of Clinton Mine Operations	Dawson City Resource Management	327142
Apr-77	Stabilization Measures for Mine Closure	Golder Associates	297556
Dec-77	Requirements for Development of a Rehabilitation Plan	Hardy Associates	327144
Jan-78	The feasibility of using sealants for stabilizing asbestos tailings piles	Hardy Associates	no copy
Jan-78	Cassiar Asbestos Corporation Mine - Review of waste dump and tailings pile behaviours	Hardy Associates	no copy
Jan-78	An environmental assessment of the effects of Cassiar Asbestos Corporation on Clinton Creek, Yukon Territory	Environmental Protection Service Pacific Region	301464
Jan-78	Report on possible asbestos contamination of the Cassiar access road	Williamson, A.	no copy
Jul-78	Mine Waste Dump and Tailings Pile Clinton Creek Operations	Golder Associates	297541
Oct-78	Stabilization and Reclamation, Clinton Creek Mine	Hardy Associates	301462
Feb-80	Cassiar Asbestos Mine Review of Waste Dump and Tailings Pile Behaviours	Hardy Associates	297560
Aug-80	Clinton Creek Waste Dump and Channel Closure Movement Monitor Data	Golder Associates	297546
Jan-81	Assessment of the effects of the Clinton Creek Mine waste dump and tailings	EVS Consultants Ltd.	301465
Jun-81	Cassiar Asbestos Mine, Waste Dump and Tailings Pile Stability	Hardy Associates	297558
Dec-81	Clinton Creek Site Photos 1975-1981	Cassiar Asbestos	327143
Jul-82	Cassiar Asbestos Mine, Waste Dump and Tailings Pile Stability	Hardy Associates	297559
Aug-83	Report on Mine Waste Dumps	Klohn Leonoff Consulting Engineers	327145
Nov-83	Report on 1983 Remedial Works	Klohn Leonoff Consulting Engineers	327153
Jan-84	Report on Wolverine Creek Tailings Piles	Klohn Leonoff Consulting Engineers	327154
Jun-84	Wolverine Creek Tailings Piles Clinton Creek Asbestos Mine Review of Rehabilitation Measures	Hardy Associates	297557
Aug-84	Report on 1984 Site Visit	Klohn Leonoff Consulting Engineers	327160
Jan-85	Cassiar Asbestos Corporation Mine - Review of waste dump and tailings pile areas	Hardy Associates	301468
Jun-86	Abandonment Plan for Waste Dumps and Tailings Piles	Klohn Leonoff Consulting Engineers	297270
Sep-86	Abandonment Plan for Clinton Creek Asbestos Mine	Klohn Leonoff Consulting Engineers	327161
Nov-86	Cassiar Asbestos Mine Results of Annual Inspection	Geo-Engineering	327162
Dec-86	Clinton Creek Asbestos Mine Abandonment Plan	Geo-Engineering	327163
Jan-87	Proceedings of the public hearing related to the Cassiar Mining Corporation	J.G. Moore and Associates	301469
Jul-87	Report on 1987 Annual Inspection	Geo-Engineering	327164
Dec-87	Downstream Hazard Assessment	Klohn Leonoff Consulting Engineers	297176
Jan-88	Salmon Presence in the Fortymile River	Jaremovic, L. And A. Von Finster	no copy
Nov-88	Report on 1988 Site Inspection	Geo-Engineering	327166
Jun-91	Abandoned Clinton Creek Asbestos Mine Report On 1990 Site Inspection	Geo-Engineering	hard copy
Jan-92	Landslide Dams at Clinton Creek	Stepanek, M. And H.F. McAlpine	301467
May-93	Report on Site Inspection	Geo-Engineering	327168
Jan-98	Account of sampling, Hudgeon Lake and Clinton Creek	W.R. Ricks Consulting	no copy
Jan-98	Abandoned Clinton Creek Asbestos Mine, A Water Contaminants Evaluation	Patrick Roach	194277
Jul-98	1997 and 1998 Site Inspections	Geo-Engineering	327181
Jan-99	Fisheries Observations Hudgeon Lake, Clinton Creek Mine Site	W.R. Ricks Consulting	no copy
Jan-99	Fish Habitat in Hudgeon Lake	Northern Affairs Contaminants Program	no copy
Jan-99	Clinton Creek - Recent Water Sampling	von Finster, A.	no copy
Jan-99	Fish and Habitat Quality Survey in Clinton Creek	von Finster, A.	297493
Mar-99	An Environmental Review of the Clinton Creek Abandoned Asbestos Mine, Yukon, Canada	Royal Roads University	197477
Apr-99	Clinton Creek Asbestos Mine 1998 Site Reconnaissance	UMA Engineering Ltd.	199387, 199110
Apr-00	Abandoned Clinton Creek Asbestos Mine Risk Assessment Report	UMA Engineering Ltd.	193975
Aug-00	Abandoned Clinton Creek Asbestos Mine Report on June and July 2000 Site Inspections	Geo-Engineering	194013
Nov-00	Abandoned Clinton Creek Asbestos Mine Conceptual Design Report	UMA Engineering Ltd.	193980
May-02	Site Visit Report	Pat Roach	327170
May-02	Environmental Liability Report	UMA Engineering Ltd.	193748
Jun-02	Abandoned Clinton Creek Asbestos Mine Conceptual Design Report	UMA Engineering Ltd.	297552
Aug-02	Specifications for Clinton Creek Channel Stabilization	UMA Engineering Ltd.	193743
Jan-03	Abandoned Clinton Creek Asbestos Mine Fish Salvage July 31 - August 02, under Licence 03-19	Northern Affairs Contaminants Program	301472
Apr-03	Clinton Creek Channel Stabilization (Stage 1) Construction Report	UMA Engineering Ltd.	297167

References - compiled by INAC Jan 1, 2018

YEAR	REPORT NAME	AUTHOR	INAC Server (CIDM #)
Jun-03	Abandoned Clinton Creek Asbestos Mine Site Visit June 2003	Northern Affairs Contaminants Program	301471
Dec-03	Clinton Creek Channel Stabilization (Stage 2) Construction Report	UMA Engineering Ltd.	hard copy
Jan-04	Report on Operations Under License to Collect Fish 04-17 Clinton Creek	Government of Yukon Energy, Mines and Resources, Assessment and Abandoned Mines	297495
Jan-05	Active-layer detachments following the summer 2004 forest fires near Dawson City, Yukon	Yukon Geological Survey	no copy
Jan-05	Clinton Creek, tributary to the Fortymile River, Yukon River North Mainstem sub-basin - Record of 2005 sampling	von Finster, A.	297498
Feb-05	Clinton Creek Channel Stabilization (Stage 3) Construction Report	UMA Engineering Ltd.	297519
Jan-06	Spawning and Rearing Access Restoration	Dawson Renewable Resources Council	no copy
Jan-06	Clinton Creek, tributary to the Fortymile River, Yukon River North Mainstem sub-basin - Record of 2006 sampling	von Finster, A.	297499
Mar-06	Summary of 2004 Hazard Mitigation Work, Monitoring and a Screening Level Risk Assessment for Airborne Asbestos	UMA Engineering Ltd.	297525
Jan-07	Clinton Creek, tributary to the Fortymile River, Yukon River North Mainstem sub-basin - Record of 2007 sampling	von Finster, A.	297500
Jan-07	Rearing and Overwintering Access Restoration	Dawson Renewable Resources Council	301473
Jan-08	Report on Operations Under License to Collect Fish #CL07-19 Clinton Creek	Government of Yukon Energy, Mines and Resources, Assessment and Abandoned Mines	301474
Jan-08	Rearing and Overwintering Access Restoration 2008	Dawson Renewable Resources Council	301475
Jan-08	Clinton Creek Mine Site Fisheries and Invertebrate Assessment Monitoring	White Mountain Environmental Consultants	65937
Apr-08	Former Clinton Creek Asbestos Mine Review of Suggested Improvements to Hudgeon Lake	UMA Engineering Ltd.	61012
Jan-09	Former Clinton Creek Asbestos Mine 2009 Site Inspection	AECOM Canada Ltd.	301476
Jan-09	Yukon River North Mainstem Stewardship	DDRRC	301477
Jan-09	Clinton Creek, tributary to the Fortymile River, Yukon River North Mainstem sub-basin - Record of 2008 sampling	von Finster, A.	297502
Jun-09	Former Clinton Creek Asbestos Mine Long Term Performance Monitoring - 2008	AECOM Canada Ltd.	297555
Jul-09	Former Clinton Creek Asbestos Mine Overview Report	AECOM Canada Ltd.	105804
Nov-09	Assessment of Existing Chemical and Biological Data for Clinton Creek Mine, Yukon	Minnow Environmental Inc.	103427
Jan-10	Former Clinton Creek Asbestos Mine 2009 Site Inspection	AECOM Canada Ltd.	no copy
Jan-10	Hydrogen Sulphide in Hudgeon Lake Yukon: Evaluation and Remediation Options	Werner Liebau	301548
Jan-10	Yukon River North Mainstem Stewardship	DDRRC	301478
Feb-10	Clinton Creek Mine Risk Review 2009	SRK Consulting	105097
Feb-10	Clinton Creek Mine Options Workshop	SRK Consulting	129947
Sep-10	Site Inspection on August 23, 2010	AECOM	122102
Oct-10	Water Resources Inspection Report on Gabion Structure Damage and Channel Washout	Yukon Environment - Water Resources Branch	122105
Oct-10	Clinton Creek Juvenile Chinook Salmon Genetics - DFO Memo	DFO	142009
Mar-11	Former Clinton Creek Asbestos Mine 2010 Site	AECOM Canada Ltd.	297553
Mar-11	Former Clinton Creek Asbestos Mine Long Term Performance Monitoring - 2010	AECOM Canada Ltd.	297554
Feb-13	Surface Water Quality and Hydrology Monitoring Programs - 2012	Laberge	253471
Dec-13	Long Term Performance Monitoring	Associated Engineering	237536
Jan-14	Health Assessment of Slimy Sculpin in Three Yukon Streams	DFO	229403
Mar-14	Lifecycle Cost Analysis for Remediation Options - Clinton Creek Site	WorleyParsons	230781
Mar-14	2013 Clinton Creek Surface Water Quality and Hydrological Monitoring Program	ELR	253473
Mar-15	Clinton Creek Engineering Review and Assessment - Part 1	WorleyParsons	250673
Mar-15	Clinton Creek Engineering Review and Assessment - Patr 2	WorleyParsons	257487
Jan-16	Geotechnical Evaluation - Borrow Source Assessment - Clinton Creek Area	Chilkoot Geological Engineers Ltd.	278822
Feb-16	Existing Geotechnical Subsurface and Monitoring Data Summary Report	TetraTech EBA	284939
Mar-16	Data Gap Assumption Report	TetraTech EBA	285403
Mar-16	Evaluation of Existing Movement Data Including Correlation to Seasonality	TetraTech EBA	285799
Mar-16	Geotechnical Stability Analysis and Dam Breach Update	TetraTech EBA	286698
Mar-16	Geotechnical Monitoring Program Review	TetraTech EBA	286701
Mar-16	Geotechnical Investigation Program Recommendations	TetraTech EBA	286702
Mar-16	Fish Passage Memo	TetraTech EBA	287512
Mar-16	Fish Utilization and Passage	Al von Finster, AvF R&D	290144
Mar-16	Preliminary Dam Classification - Mine Waste Structures	TetraTech EBA	290224
Aug-16	Data Gap Memo and Site Investigation Plan - Draft	AMEC Foster Wheeler	295733
Sep-16	Gap Analysis Report	AMEC Foster Wheeler	297988
Nov-16	Field Investigation Plan for Drilling and Sampling Memo	AMEC Foster Wheeler	308200
Dec-16	Design Refinement Memo - Draft	AMEC Foster Wheeler	300778
Dec-16	Design Decision Log Draft	AMEC Foster Wheeler	301051
Jan-17	Preliminary Review of Requirements for Tailings Cover	AMEC Foster Wheeler	308222
Jan-17	Borehole Logs for 10% Design	AMEC Foster Wheeler	301697
Mar-17	Project Parties Meeting Minutes and Presentation	AMEC Foster Wheeler	308910
Mar-17	Field Program Summary Report - Draft	AMEC Foster Wheeler	307203
Mar-17	Clinton Creek Cultural Research and Oral History Project	Midnight Arts and Crowberry Consulting and Communications	hard copy
Apr-17	Design Basis Memo	AMEC Foster Wheeler	302621
Apr-17	HHERA Draft Report	AMEC Foster Wheeler	308283

References - compiled by INAC Jan 1, 2018

YEAR	REPORT NAME	AUTHOR	INAC Server (CIDM #)
Apr-17	Hydrotechnical Design Criteria Memo - Draft	AMEC Foster Wheeler	308199
May-17	Wolverine Creek Tailings Pile Deck for Technical Workshop	AMEC Foster Wheeler	311466
May-17	Clinton Creek Waste Rock Deck for Technical Workshop	AMEC Foster Wheeler	311417
Dec-17	Aerial Photos of Clinton Creek Mine Site - 1951-2016	INAC	327182

2.0 BIBLIOGRAPHY OF WOOD PROJECT DELIVERABLES AND RELATED DOCUMENTS

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2017. *Draft Field Program Summary Report*. Submitted to Yukon Government, Energy, Mines and Resources, Assessment and Abandoned Mines Branch. February 2017.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2017a. *Gap Analysis Report for Task Authorization (TAR) #3: Gap Analysis & Site Investigation Plan Clinton Creek Remediation Preliminary Design (10%)*. Submitted to Yukon Government, Energy, Mines and Resources, Assessment and Abandoned Mines Branch. February 2017.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2017b. *Clinton Creek Mine Remediation Preliminary Design (10%) Factual Geotechnical Report*. Project TE161009. Submitted to Yukon Government Energy, Mines and Resources, Assessment and Abandoned Mines Branch. February 2017. R1 DRAFT.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2017c. *Human Health and Ecological Risk Assessment Report for TA #5: Develop (10% Designs and Cost Estimates, Clinton Creek Remediation Preliminary Design (10% (DRAFT)*. Submitted to Yukon Government, Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2017.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2017d. *Project Update and Design Refinement Report for Task Authorization #5: Develop 10% Designs and Cost Estimates, Clinton Creek Remediation Preliminary Design (10%) Update to "Section 4.0 – Design Update"*. Submitted for Project Parties Meeting #2. Submitted to Yukon Government, Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2017.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2018. *Clinton Creek Mine, Geotechnical Data Gaps*. Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2018.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2018a. *Clinton Creek Mine, Geotechnical Design Gaps.* Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2018.

Amec Environment & Infrastructure (Amec Foster Wheeler). 2018b. *Clinton Creek Remediation Project General Site Characterization and Data Gap Assessment.* Project VE52695.100.05. March 2018.

Independent Peer Review Panel (IPRP). 2017. TECHNICAL MEMORANDUM Re: Clinton Creek Closure Project – Comments and Recommendations on AMEC and TetraTech EBA Engineering Reports. Submitted to Michael Nahir, Director of Engineering, NAO-CSP Aboriginal Affairs and Northern Development Canada (AANDC). March 21, 2017.

Independent Peer Review Panel (IPRP). 2017a. TECHNICAL MEMORANDUM Re: Clinton Creek Closure Project – Remediation Preliminary Design – Technical Review Workshop (Appendix A) Submitted to Michael Nahir, Director of Engineering, NAO-CSP Aboriginal Affairs and Northern Development Canada (AANDC). August 9, 2017.

Independent Peer Review Panel (IPRP). 2018. TECHNICAL MEMORANDUM Re: Clinton Creek Mine Closure – Status Update Meeting (April 2018). Submitted to Michael Nahir, Director of Engineering, NAO-CSP Impacted Sites Program Indigenous and Northern Affairs Canada (AANDC). July 30, 2018.

Independent Peer Review Panel (IPRP). 2020. TECHNICAL MEMORANDUM Re: Clinton Creek Mine Closure– Review of 10% Design Phase Report and Supporting Documentation. Submitted to Jason Berkers and Justin Pigage, Crown Indigenous Relations and Northern Affairs Canada (CIRNAC). March 9, 2020.

Wood Environment & Infrastructure Solutions. 2019. *Clinton Creek Remediation Project 10% Design Phase Report.* Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2019a. *Clinton Creek Remediation Project 2018 Site Investigation Report*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. July 2019.

Wood Environment & Infrastructure Solutions. 2019b. *Clinton Creek Remediation Project Human Health and Ecological Risk Assessment Update*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. July 2019.

Wood Environment & Infrastructure Solutions. 2019c. *Clinton Creek Remediation Project Geotechnical Summary*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. August 2019.

Wood Environment & Infrastructure Solutions. 2019d. *Clinton Creek Remediation Project Meeting Notes, Workshop #2 - Site Investigation/Characterization Report and Design Development Review*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. January 2019.

Wood Environment & Infrastructure Solutions. 2019e. *Geological and Geotechnical Site Characterization and Model - Clinton Creek Remediation Project*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. August 2019.

Wood Environment & Infrastructure Solutions. 2019f. *Clinton Creek Remediation Project Meeting Notes, Workshop #3 - Site Characterization and Design Development Review*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. May 2019.

Wood Environment & Infrastructure Solutions. 2019g. Memo re: *Wood Response to IPRP Comments, Suggestions and Recommendations During CCRP Workshop #3*. Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. 5 June 2019.

Wood Environment & Infrastructure Solutions. 2019h. *Clinton Creek Remediation Project, Dam Breach Assessment*. Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2019i. *Clinton Creek Remediation Project Environmental Site Characterization Update*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. June 2019.

Wood Environment & Infrastructure Solutions. 2019j. *Clinton Creek Remediation Project, 10% Design Phase Cost Estimate*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2019k. *Clinton Creek Remediation Project Meeting Notes, Partner Review Meeting*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. 12 December 2019.

Wood Environment & Infrastructure Solutions. 2020. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

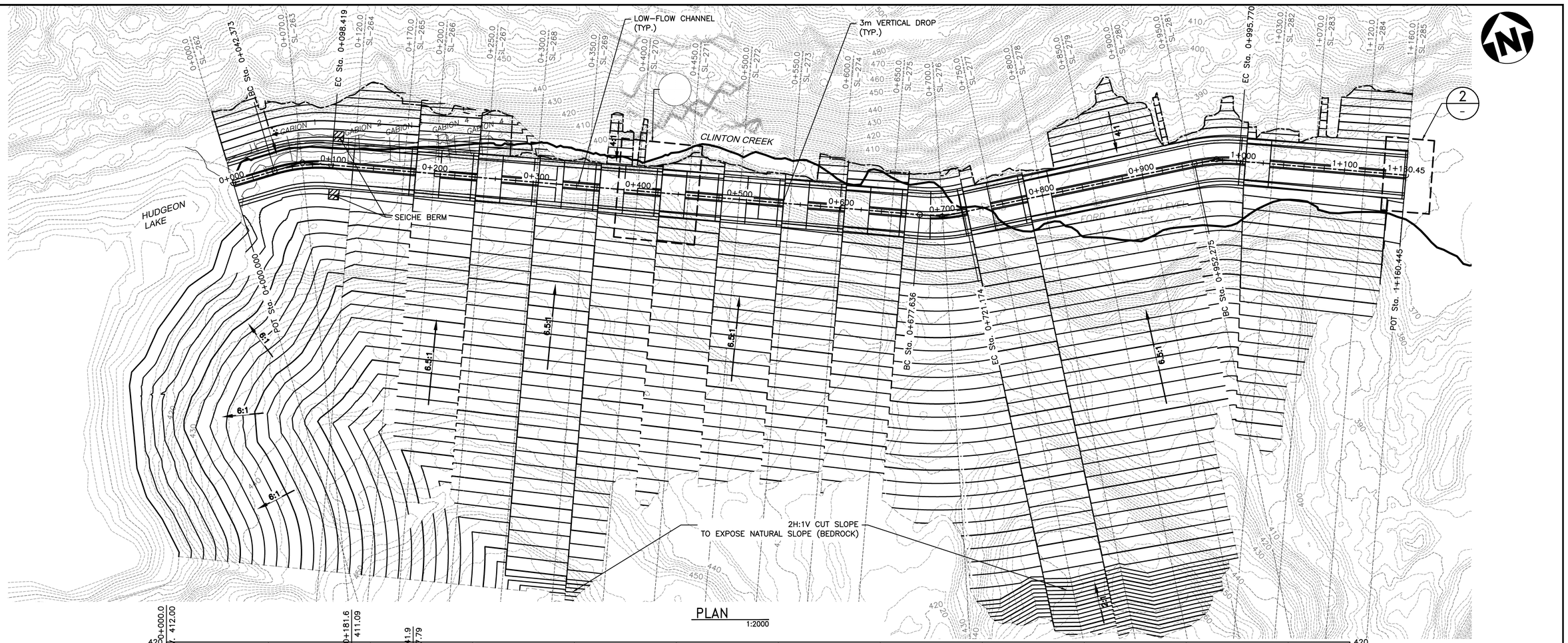
Wood Environment & Infrastructure Solutions. 2020a. *Clinton Creek Remediation Project, Meeting Notes, IPRP Review Meeting*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. 18/19 March 2020.

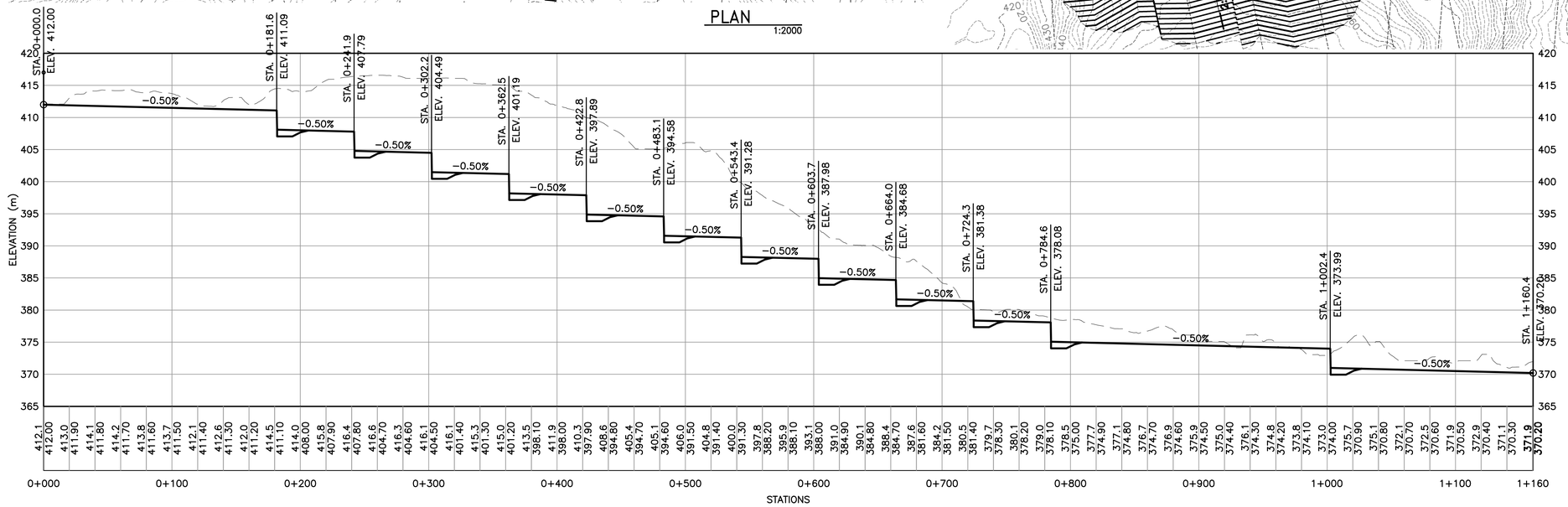
Appendix B
General Arrangement Drawings for 10% Designs (Base Case) and Alternate Designs

DRAFT

Base Designs

DRAFT





PROFILE VIEW
HORZ 1:2000/ VERT 1:400

NOT FOR CONSTRUCTION

0m 4 8 12 16 20
1:400

0m 20 40 60 80 100
1:2000

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	20JUN2019	ISSUED FOR REVIEW	LB	MH				

REF	NUMBER	TITLE
3	VE52705E.CC1.4	CROSS SECTIONS - SHEET 2 OF 2
2	VE52705E.CC1.3	CROSS SECTIONS - SHEET 1 OF 2
1	VE52705E.CC1.2	SECTIONS & DETAILS

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: AS SHOWN

	BY	DDMMMYY
DES	KB	24JUN2019
DRN	LB	24JUN2019
CHK	MH	24JUN2019
APP		

Yukon

wood.

SUBJECT: CLINTON CREEK REMEDIATION PROJECT
OPTION CC1 (LAKE RETENTION)
PLAN AND PROFILE

AREA:

CLIENT DWG NO.:

DRAWING NO.: VE52705E.CC1.1

REV: A

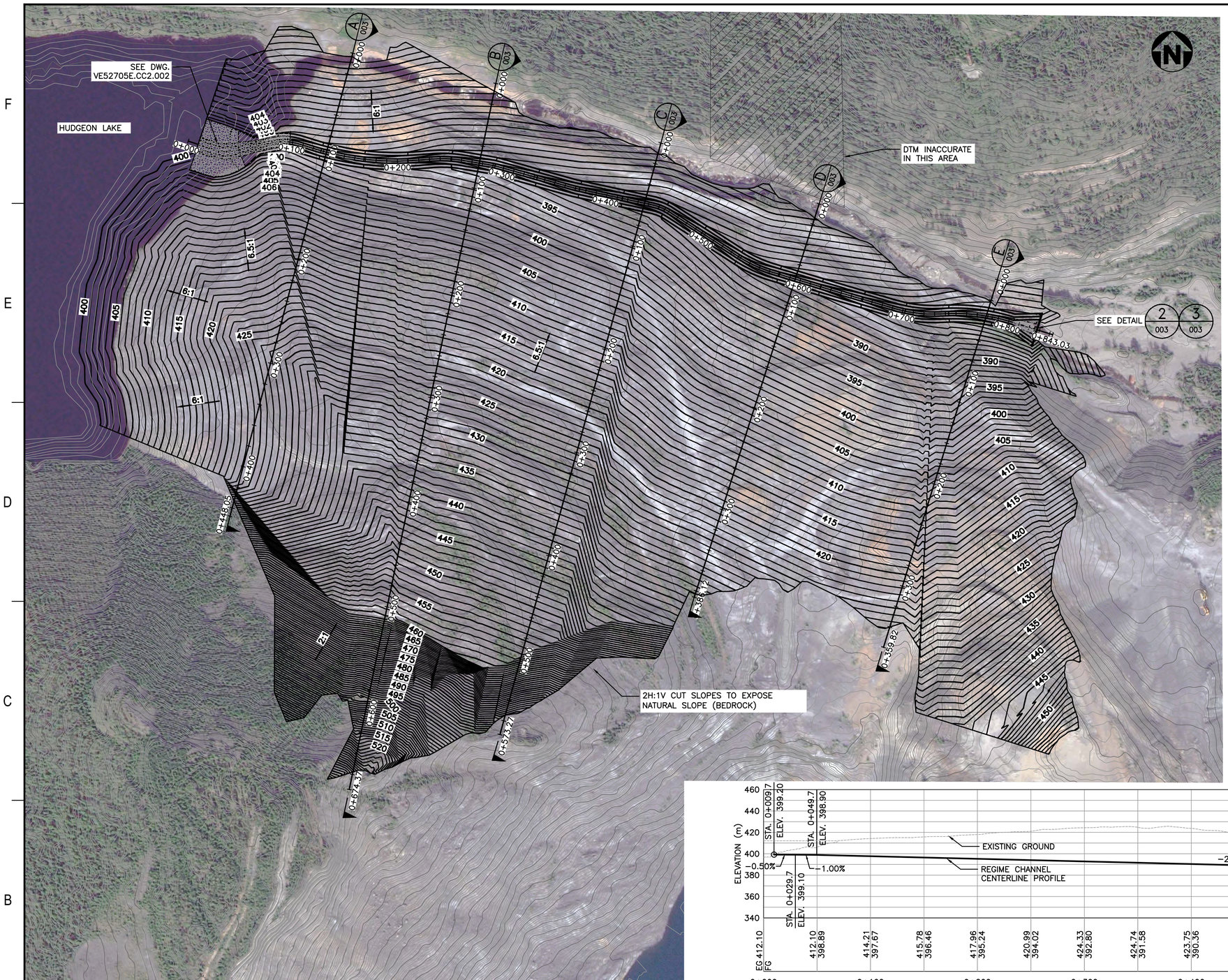
CAD FILE: \\BGP-FS1\BGP-EE-ENV\PROJECTS\3000\VE52705.SERES\VES02500 - DGN\YUKON - CLINTONCREEKREMEDIATION\MOD - WORK IN PROGRESS\344\WATER\42 EPA1\ALO\CIVIL\DGN\FILLWAY - MODEL\2019-JUN04-2.DWG

SAVED: 26-Aug-19 1:21 PM PLOTTED: 15-Nov-19 11:42 AM USER: LIN, KEVIN

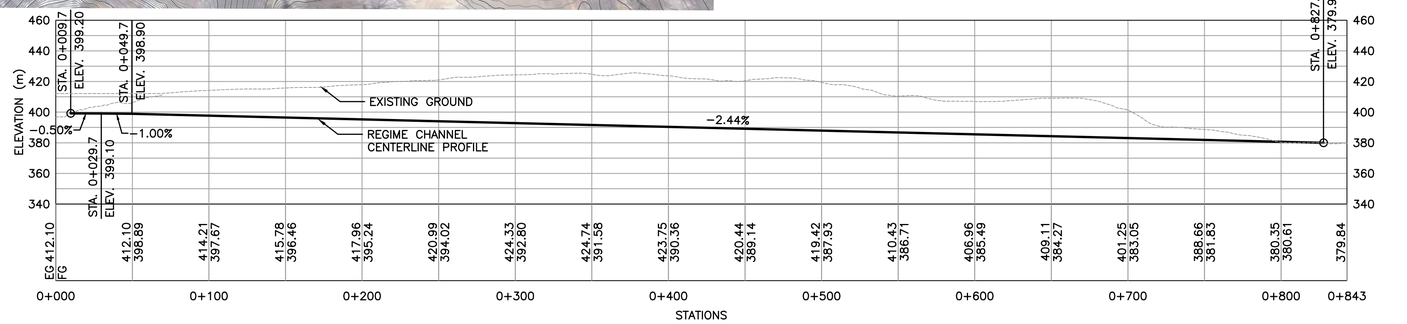
ISO A1 594x841

8 7 6 5 4 3 2 1

A B C D E F



PLAN
1:2000



PROFILE
1:2000H 1:2000V

NOT FOR CONSTRUCTION

0m 20 40 60 80 100
1:2000

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	03NOV19	ISSUED FOR CONSTRUCTION	JM	GG	GG			
1	15NOV19	ISSUED FOR CONSTRUCTION	JM	GG	GG			

REF	NUMBER	TITLE
2	VE52705E.CC2.3	SECTIONS & DETAILS
1	VE52705E.CC2.2	REGIME CHANNEL INTAKE

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED, AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: 1:2000

	BY	DDMMMYY
DES	GG	10JUL19
DRN	JM	10JUL19
CHK	GG	10JUL19
APP		

Yukon

wood.

SUBJECT
CLINTON CREEK REMEDIATION PROJECT
OPTION CC2
(LOWER LAKE WITH REGIME CHANNEL)
PLAN AND PROFILE

AREA

CLIENT DWG NO.

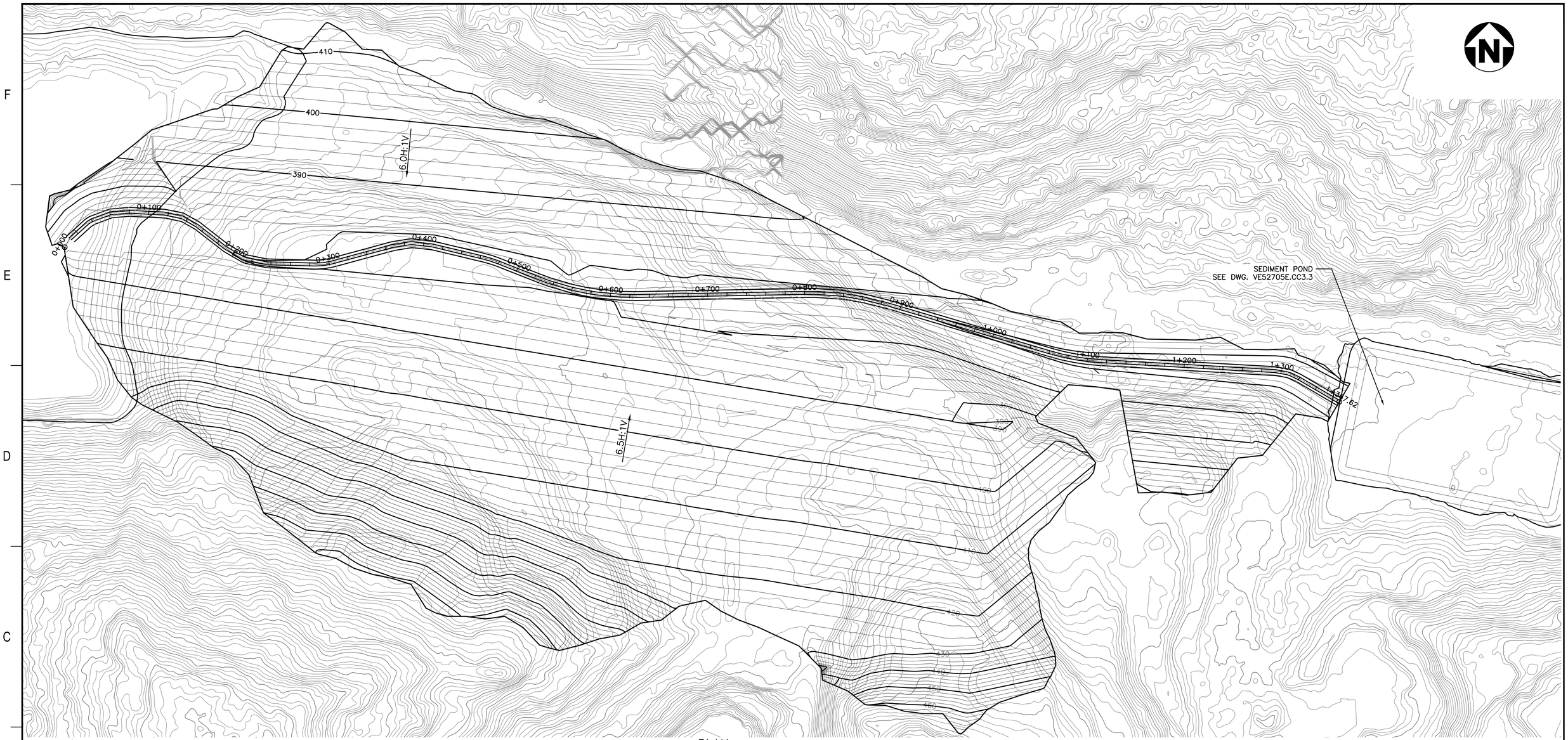
DRAWING NO.: VE52705E.CC2.1

REV

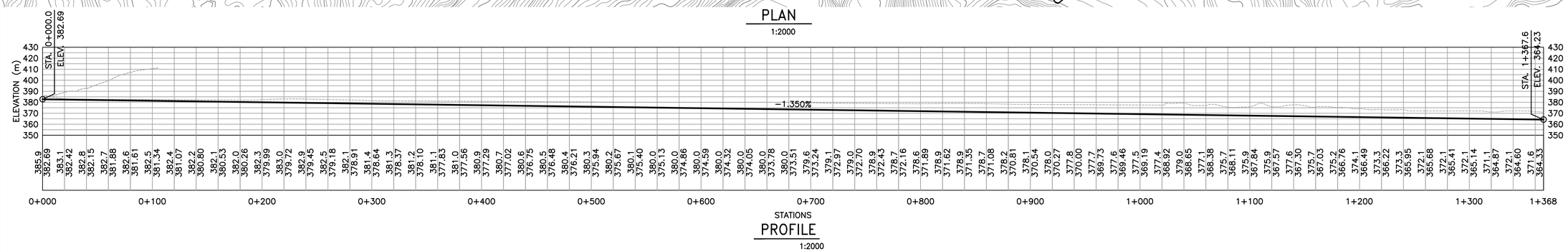
CAD FILE: PCAD\DWGS\CC2-REGIME CHANNEL\CLINTON CREEK - REGIME CHANNEL-INVAKE 2018.DWG

SAVED: 03-Sep-19 9:20 AM PLOTTED: 15-Nov-19 12:07 PM USER: LIN, KEVIN

ISO A1 594x841



PLAN
1:2000



PROFILE
1:2000

0m 20 40 60 80 100
1:2000

NOT FOR CONSTRUCTION

COPYRIGHT © 2018

REF	NUMBER	TITLE
4	VE52705E.CC3.5	SEDIMENT POND SECTIONS & DETAILS
3	VE52705E.CC3.4	SEDIMENT POND PROFILE
2	VE52705E.CC3.3	SEDIMENT POND PLAN
1	VE52705E.CC3.1	PLAN

REFERENCES

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (I) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: AS NOTED

	BY	DDMMMYY
DES	GG	10JUL19
DRN	JM	10JUL19
CHK	GG	10JUL19
APP		

Yukon

wood.

SUBJECT: CLINTON CREEK REMEDIATION PROJECT
OPTION CC3 (REMOVAL OF LAKE)
RESTORED CHANNEL PLAN AND PROFILE

AREA:

CLIENT DWG NO.:

DRAWING NO.: VE52705E.CC3.2

REV:

CAD FILE: P:\CAD\CC\CC3 RESTORATION CHANNEL NO LAKE\CLINTON CREEK RESTORATION CHANNEL - CC3.DWG

SAVED: 03-Sep-19 10:21 AM PLOTTED: 15-Nov-19 12:32 PM USER: LIN, KEVIN

ISO A1 (594x841)

8 7 6 5 4 3 2 1

A B C D E F

PLAN
1:2500

0m 25 50 75 100 125
1:2500

NOT FOR CONSTRUCTION

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	05/JUN/19	ISSUED FOR REVIEW						

REF	NUMBER	TITLE
3	VE52705E.WC1.4	SEDIMENT POND SECTIONS & DETAILS
2	VE52705E.WC1.3	SEDIMENT POND PROFILES
1	VE52705E.WC1.2	SEDIMENT POND PLAN

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED, AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: 1:2500

	BY	DDMMMYY
DES	SM	10JULY19
DRN	JM	10JULY19
CHK	SM	10JULY19
APP		

Yukon

wood.

SUBJECT: CLINTON CREEK REMEDIATION PROJECT
OPTION WC1 (SEDIMENT CONTROL ONLY)
SEDIMENT POND GENERAL ARRANGEMENT

AREA:

CLIENT DWG NO.:

DRAWING NO.: VE52705E.WC1.1

REV:

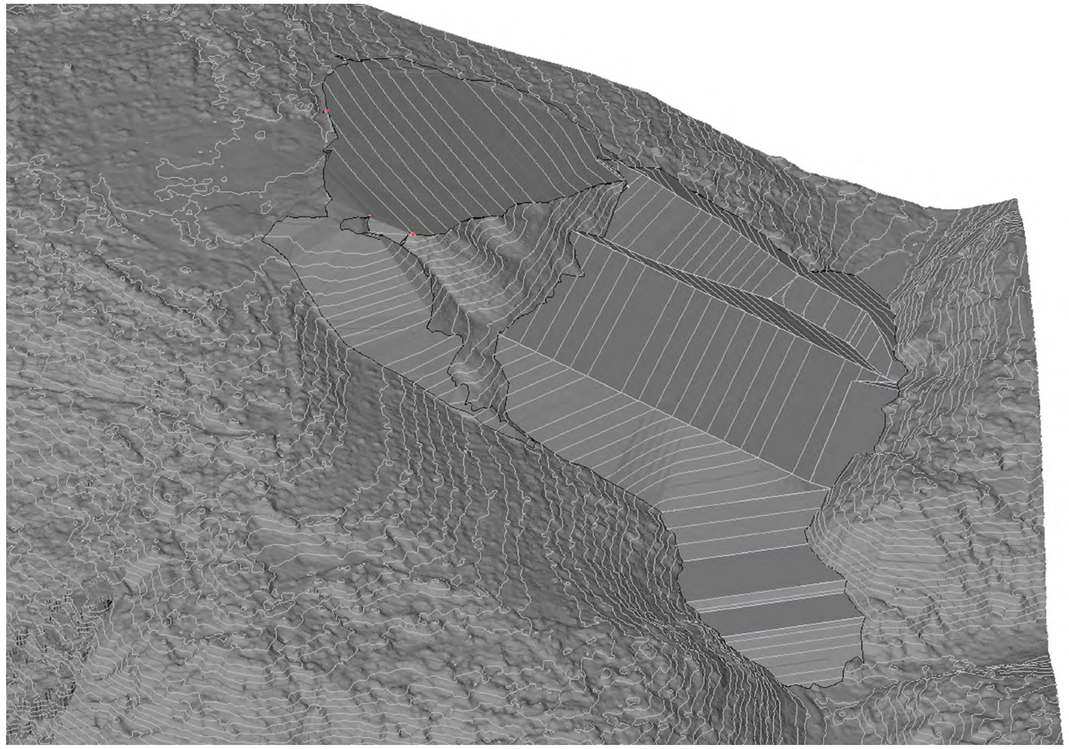
CAD FILE: P:\CAD\DWG\WC1-001\GENERAL ARRANGEMENT.DWG

SAVED: 15-Aug-19 2:38 PM PLOTTED: 15-Nov-19 1:28 PM USER: LIN, KEVIN

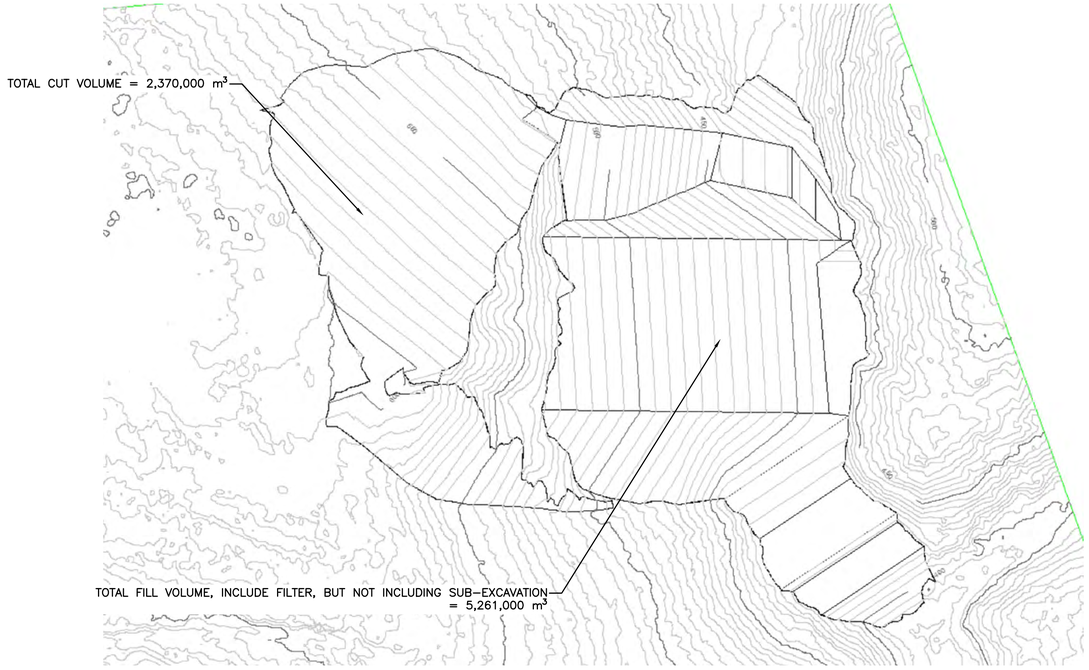
ISO A1 594x841

F E D C B A

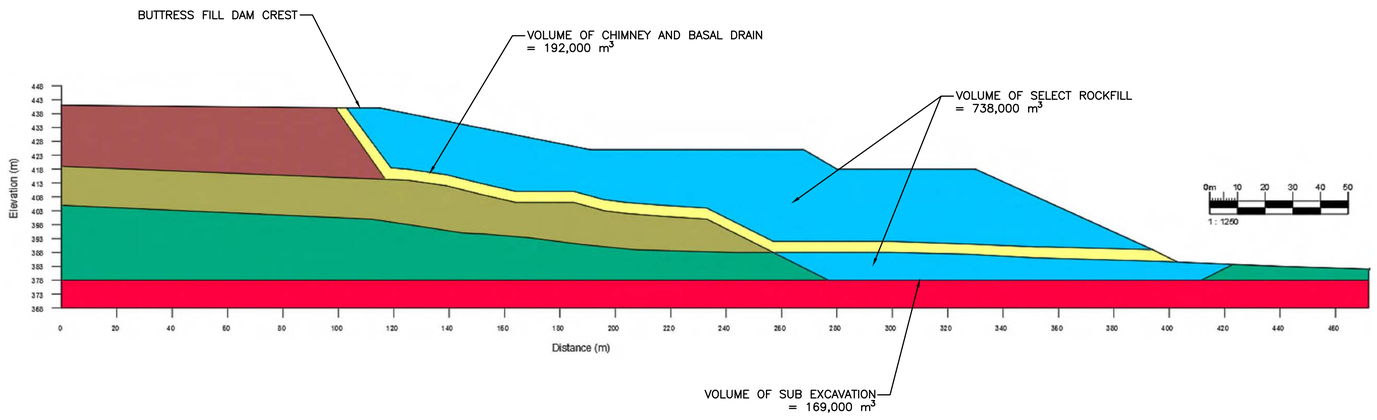
8 7 6 5 4 3 2 1



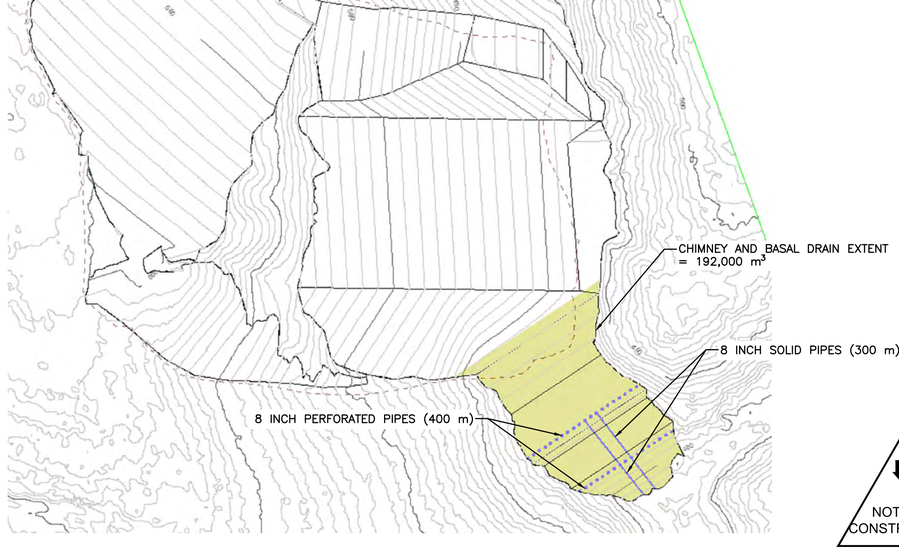
GENERAL ARRANGEMENT OF WC2 CONCEPT LOOKING NORTH



PLAN VIEW – TAILINGS CUTS, BUTTRESS FILL DAM, AND TOE BERM EXTENT



PROFILE VIEW – BUTTRESS FILL DAM



PLAN VIEW – CHIMNEY AND BASAL DRAIN AND 8 INCH DRAIN PIPES EXTENT

NOT FOR CONSTRUCTION

REF	NUMBER	TITLE
6	VE52705E.WC2.7	SPILLWAY SECTIONS, SHEET 3 OF 3
5	VE52705E.WC2.6	SPILLWAY SECTIONS, SHEET 2 OF 3
4	VE52705E.WC2.5	SPILLWAY SECTIONS, SHEET 1 OF 3
3	VE52705E.WC2.4	SPILLWAY SECTIONS & DETAILS
2	VE52705E.WC2.3	PROFILE
1	VE52705E.WC2.2	PLAN

REFERENCES

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (I) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: VARIES

	BY	DDMMMYY
DES	EM	10JUL19
DRN	JM	10JUL19
CHK	EM	10JUL19
APP		

Yukon

SUBJECT: CLINTON CREEK REMEDIATION PROJECT OPTION WC2 (IN PLACE STABILIZATION) GENERAL ARRANGEMENT AND ILLUSTRATION OF CONCEPT

wood.

AREA

CLIENT DWG NO.

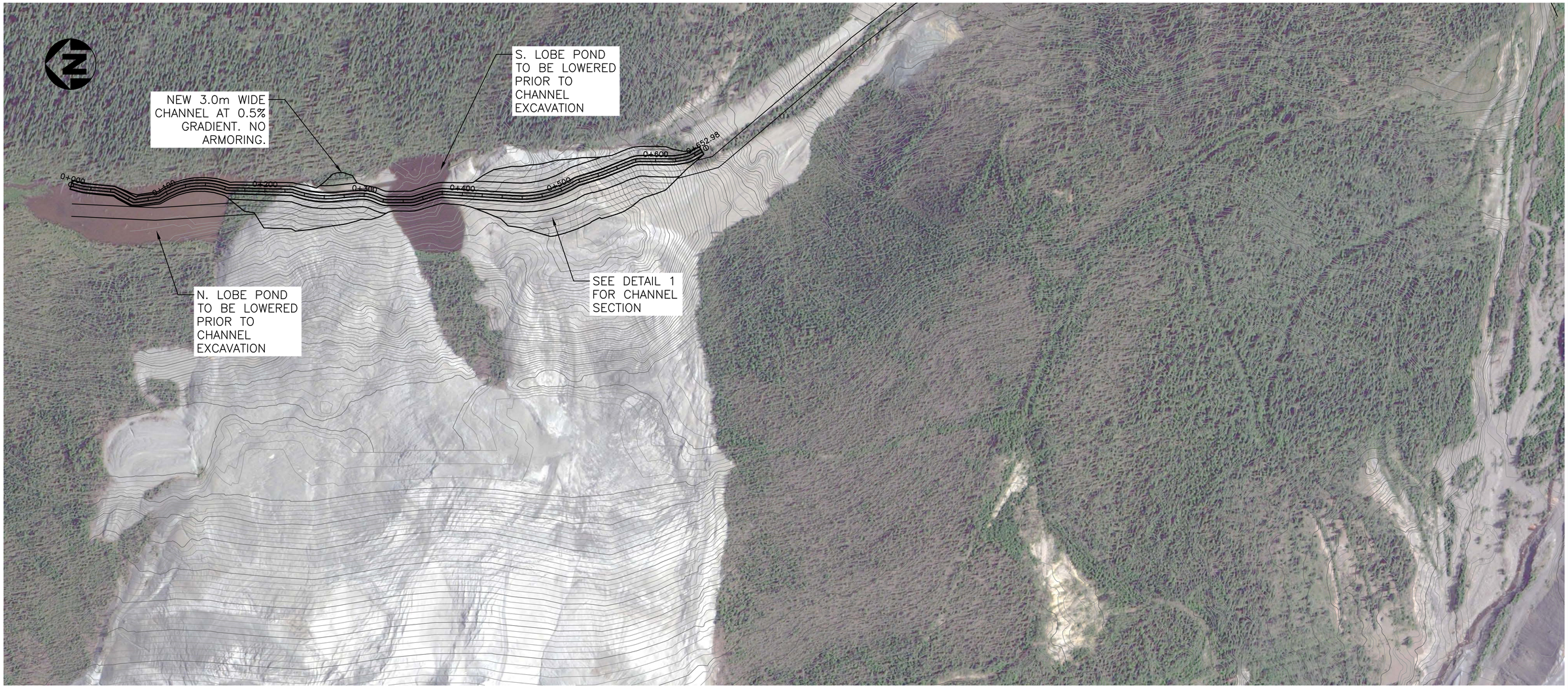
DRAWING NO.: VE52705E.WC2.1

REV

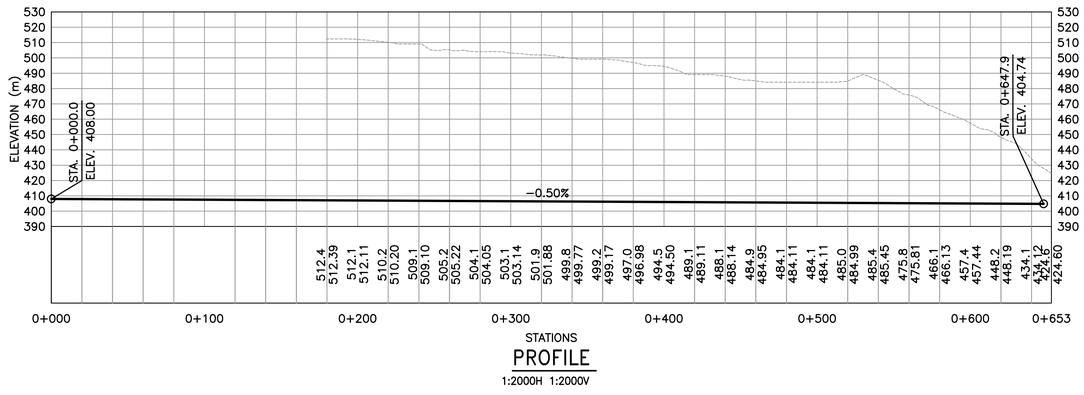
COPYRIGHT © 2018

CAD FILE: P:\CAD\DWG\VE52705E.WC2.1.DWG

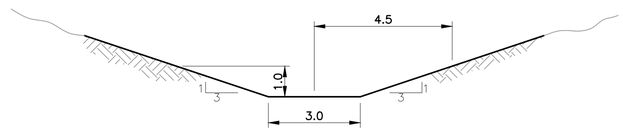
ISO A1 594x841



PLAN
1:2000



PROFILE
1:2000H 1:2000V



TYPICAL SECTION

DETAIL 1
1:100

0m 1 2 3 4 5
1:100

0m 20 40 60 80 100
1:2000

NOT FOR CONSTRUCTION

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

REF	NUMBER	TITLE
1	VE52705E.WC3.2	HAUL ROAD PLAN PROFILE & DETAILS

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (I) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% DESIGN

PROJECT NO.: VE52705E.100.2

SCALE: VARIES

	BY	DDMMMYY
DES	GG	12JUL19
DRN	JM	12JUL19
CHK	GG	12JUL19
APP		

Yukon

wood.

SUBJECT
CLINTON CREEK REMEDIATION PROJECT
OPTION WC3
(TAILINGS ISOLATION VIA RELOCATION)
PLAN, PROFILE AND SECTION

AREA

CLIENT DWG NO.

DRAWING NO.: VE52705E.WC3.1

REV

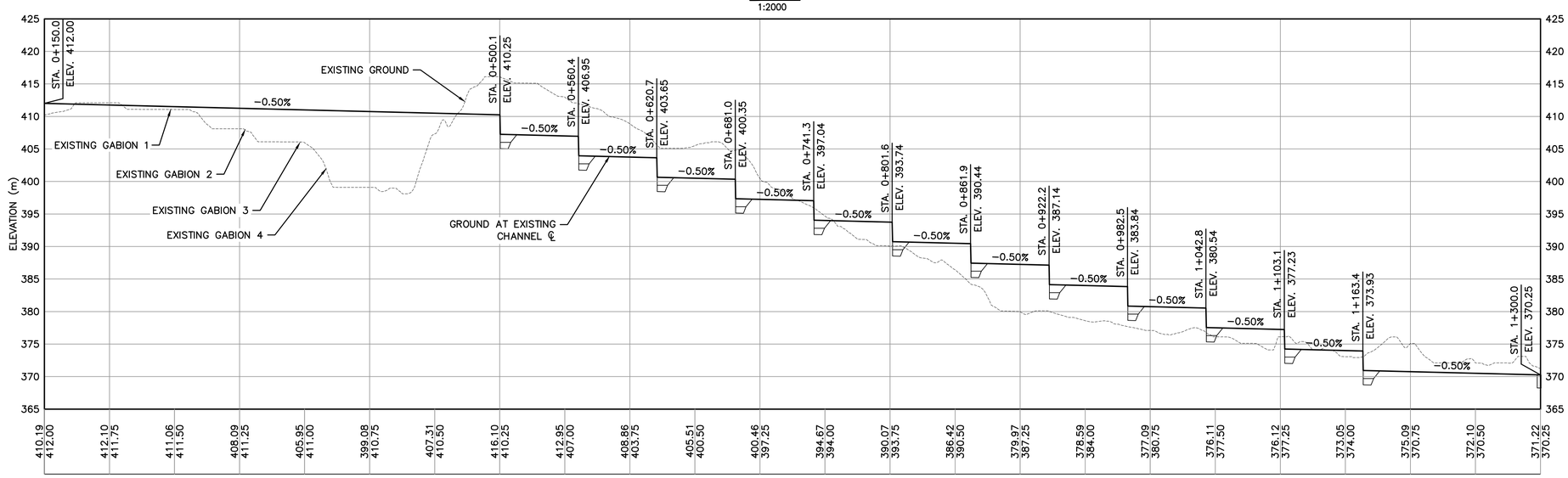
ISO A1 594x841

SAVED: 29-Aug-19 8:11 AM PLOTTED: 15-Nov-19 3:00 PM USER: LIN, KEVIN

Alternate Designs

DRAFT

PLAN
1:2000



PROFILE VIEW
SCALE: H=1:2000 / V=1:400

NOTES:

1. THE TOPOGRAPHY BASED ON 2018 LIDAR DATA PROVIDED BY YUKON GOVERNMENT.
2. ALL DIMENSIONS AND COORDINATES ARE IN METERS. DATUM: NAD83, UTM ZONE 7.

LEGEND:

◆ BOREHOLES LOCATIONS

0m 4 8 12 16 20
1:400
0m 20 40 60 80 100
1:2000

COPYRIGHT © 2018

REF	NUMBER	TITLE
4	VE52705G.CC1A-B.5	CROSS SECTIONS - SHEET 3 OF 3
3	VE52705G.CC1A-B.4	CROSS SECTIONS - SHEET 2 OF 3
2	VE52705G.CC1A-B.3	CROSS SECTIONS - SHEET 1 OF 3
1	VE52705G.CC1A-B.2	SECTIONS & DETAILS

REFERENCES

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	13MAR20	ISSUED FOR REVIEW	PE	GG				

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED, AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

NOT FOR CONSTRUCTION

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% ALTERNATIVE DESIGN

PROJECT NO.: VE52705G

SCALE: AS SHOWN

	BY	DDMMMYY
DES	GG	13MAR20
DRN	PE	13MAR20
CHK	GG	13MAR20
APP		

Yukon

wood.

SUBJECT: CLINTON CREEK REMEDIATION PROJECT
OPTION CC1A (LAKE RETENTION)
OPTION 1 - PLAN AND PROFILE

AREA:

CLIENT DWG NO.:

DRAWING NO.: VE52705G.CC1A 1.1

REV: A

CAD FILE: PW:\ADM\VE52705G.CC1A 1.1.DWG

ISO 13568-1

SAVED: 12-Mar-20 3:00 PM PLOTTED: 13-Mar-20 9:50 AM USER: ENCARNACION, PERSY

8 7 6 5 4 3 2 1

A B C D E F

NOTES:

1. THE TOPOGRAPHY BASED ON 2018 LIDAR DATA PROVIDED BY YUKON GOVERNMENT.
2. ALL DIMENSIONS AND COORDINATES ARE IN METERS. DATUM: NAD83, UTM ZONE 7.

LEGEND:

◆ BOREHOLES LOCATIONS

0m 4 8 12 16 20
1:400

0m 20 40 60 80 100
1:2000

COPYRIGHT © 2018

REF	NUMBER	TITLE
4	VE52705G.CC1A-B.5	CROSS SECTIONS - SHEET 3 OF 3
3	VE52705G.CC1A-B.4	CROSS SECTIONS - SHEET 2 OF 3
2	VE52705G.CC1A-B.3	CROSS SECTIONS - SHEET 1 OF 3
1	VE52705G.CC1A-B.2	SECTIONS & DETAILS

REFERENCES

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP
A	13MAR20	ISSUED FOR REVIEW	PE	GG	

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

NOT FOR CONSTRUCTION

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% ALTERNATIVE DESIGN

PROJECT NO.: VE52705G

SCALE: AS SHOWN

	BY	DDMMMYY
DES	GG	13MAR20
DRN	PE	13MAR20
CHK	GG	13MAR20
APP		

Yukon

wood.

SUBJECT: CLINTON CREEK REMEDIATION PROJECT OPTION CC1-B (LAKE RETENTION) PLAN AND PROFILE

AREA:

CLIENT DWG NO.:

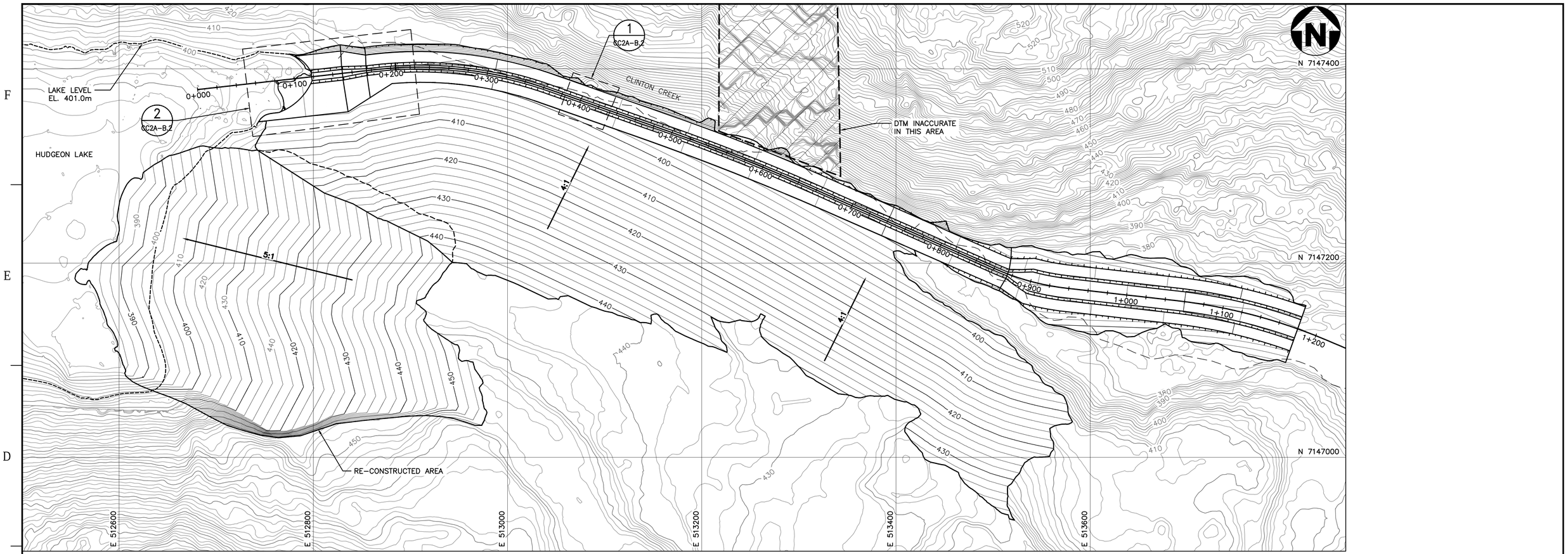
DRAWING NO.: VE52705G.CC1B 1.2

REV: A

CAD FILE: PW:\ENG\VE52705G.CC1B 1.2.DWG

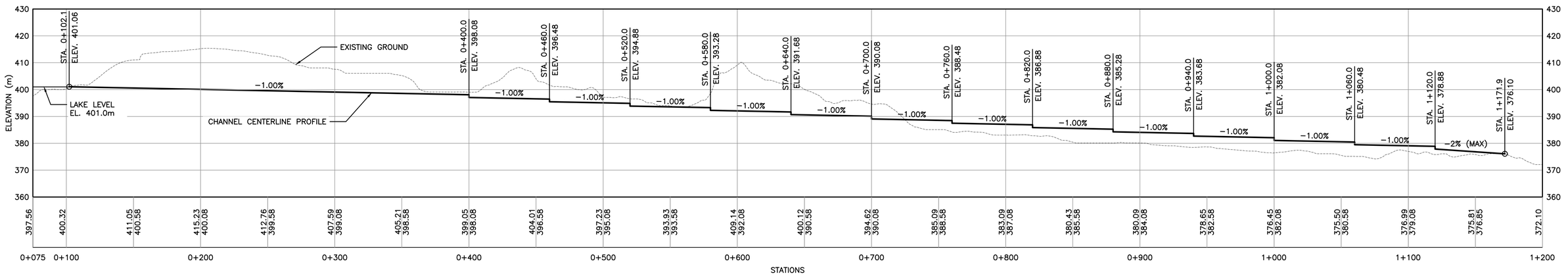
SAVED: 13-Mar-20 9:51 AM PLOTTED: 02-Apr-20 2:18 PM USER: ENCARNACION, PERSY

ISO A1 (594x841 mm)



PLAN

SCALE 1:2000



PROFILE

SCALE H=1:1500 / V=1:750

NOTES:

1. THE TOPOGRAPHY BASED ON 2018 LIDAR DATA PROVIDED BY YUKON GOVERNMENT.
2. ALL DIMENSIONS AND COORDINATES ARE IN METERS. DATUM: NAD83, UTM ZONE 7.

0m 10 20 30 40 1:750

0m 15 30 45 60 75 1:1500

0m 20 40 60 80 100 1:2000

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	13MAR20	ISSUED FOR REVIEW	PE	GG				

REF	NUMBER	TITLE
2	VE52705G.CC2A-B 3	CROSS SECTIONS
1	VE52705G.CC2A-B 2	DETAILS

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (I) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

NOT FOR CONSTRUCTION

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE: 10% ALTERNATIVE DESIGN

PROJECT NO.: VE52705G

SCALE: AS SHOWN

		BY	DDMMMYY
DES	GG		13MAR20
DRN	PE		13MAR20
CHK	GG		13MAR20
APP			

Yukon

wood.

SUBJECT

CLINTON CREEK REMEDIATION PROJECT
OPTION CC2-A (LOWER LAKE CHANNEL)
PLAN AND PROFILE

AREA

CLIENT DWG NO.

DRAWING NO.: VE52705G.CC2A 1.1

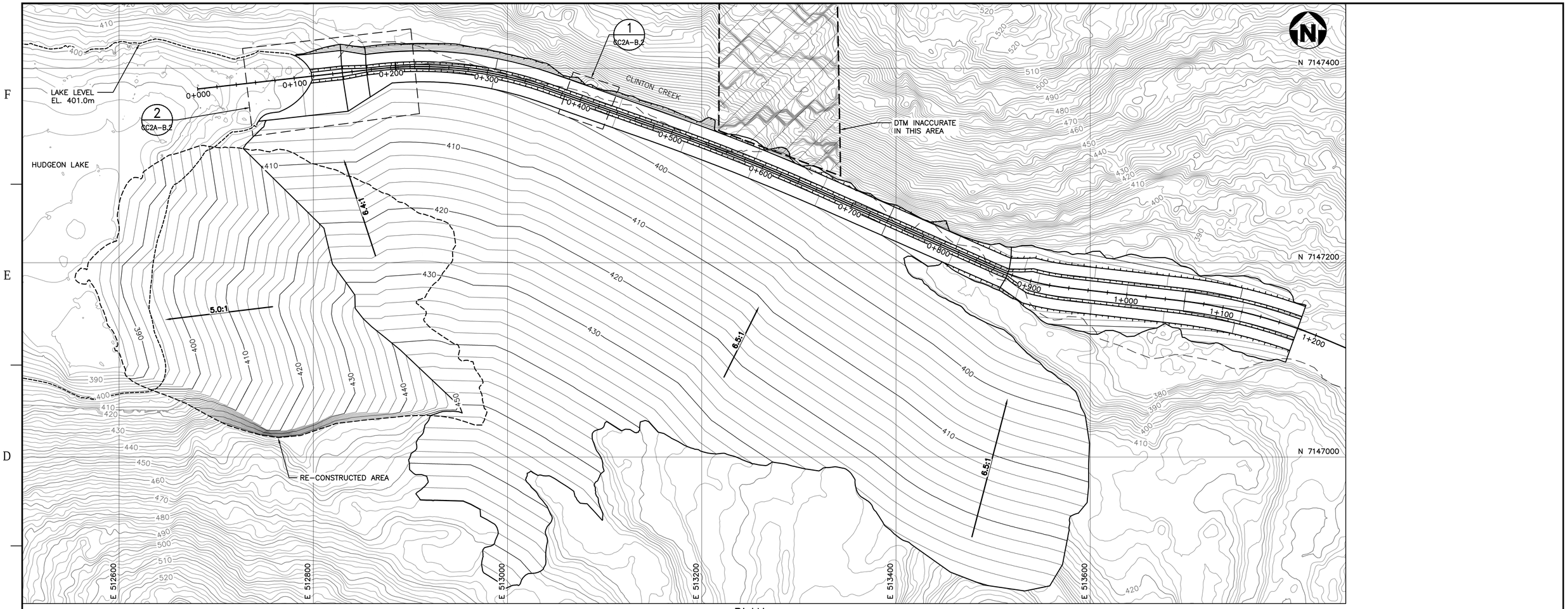
REV: A

CAD FILE: PCIC\DGN\VE52705G-CC2A 1.1.DWG

SAVED: 12-Mar-20 3:24 PM PLOTTED: 02-Apr-20 2:30 PM USER: ENCARNACION, PERSY

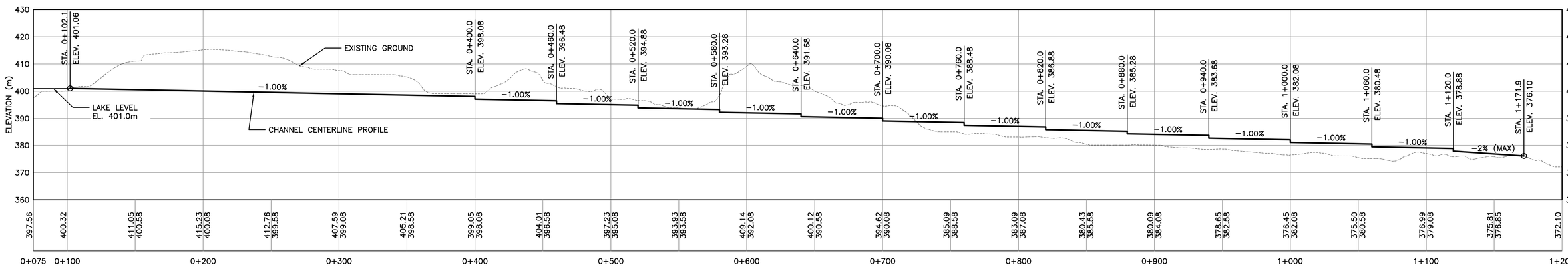
SIZE: A1 (594x841)

8 7 6 5 4 3 2 1



PLAN

SCALE 1:2000



PROFILE

SCALE H=1:1500 / V=1:750

NOTES:

1. THE TOPOGRAPHY BASED ON 2018 LIDAR DATA PROVIDED BY YUKON GOVERNMENT.
2. ALL DIMENSIONS AND COORDINATES ARE IN METERS. DATUM: NAD83, UTM ZONE 7.

0m 10 20 30 40 — 1:750

0m 15 30 45 60 75 — 1:1500

0m 20 40 60 80 100 — 1:2000

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

REF	NUMBER	TITLE
2	VE52705G.CC2A-B 3	CROSS SECTIONS
1	VE52705G.CC2A-B 2	DETAILS

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (I) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED, AND (II) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

NOT FOR CONSTRUCTION

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

10% ALTERNATIVE DESIGN

PROJECT NO.

VE52705G

SCALE

AS SHOWN

	BY	DDMMMYY
DES	GG	13MAR20
DRN	PE	13MAR20
CHK	GG	13MAR20
APP		

Yukon

wood.

SUBJECT

CLINTON CREEK REMEDIATION PROJECT
OPTION CC2-B (LOWER LAKE CHANNEL)
PLAN AND PROFILE

AREA

CLIENT DWG NO.

DRAWING NO.

VE52705G.CC2B 1.2

REV

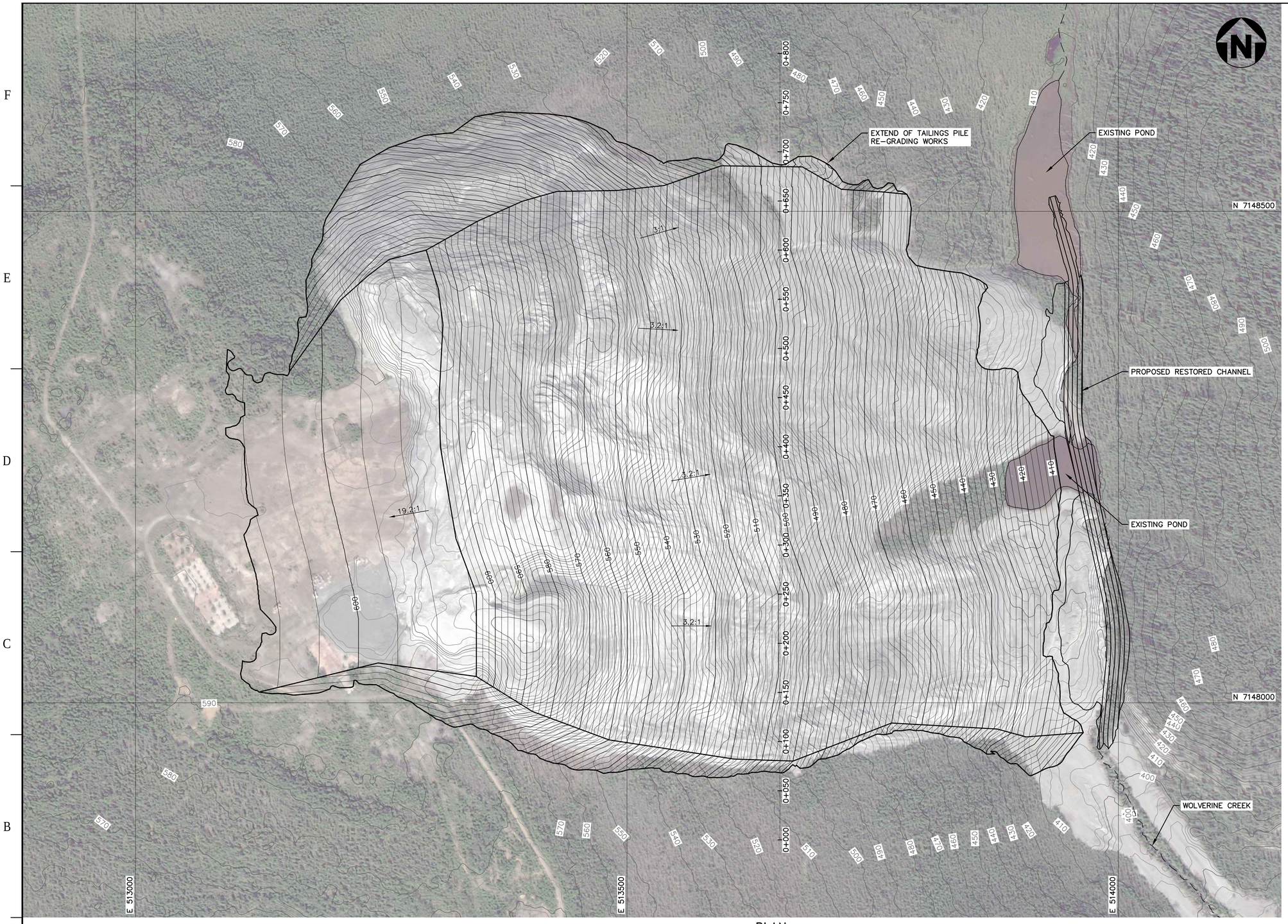
A

CAD FILE: P:\CAD\VE52705G.CC2B 1.2.DWG

SAVED: 12-Mar-20 3:25 PM PLOTTED: 02-Apr-20 2:31 PM USER: ENCARNACION, PERSY

ISO A1 594x841

8 7 6 5 4 3 2 1



PLAN
1:2000

0m 20 40 60 80 100
1:2000

NOTES:

1. THE TOPOGRAPHY BASED ON 2018 LIDAR DATA PROVIDED BY YUKON GOVERNMENT.
2. ALL DIMENSIONS AND COORDINATES ARE IN METERS. DATUM: NAD83, UTM ZONE 7.

COPYRIGHT © 2018

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	13MAR20	ISSUED FOR REVIEW	PE	GG				

REF	NUMBER	TITLE
3	VE52705G.WC2A.4	CROSS SECTIONS
2	VE52705G.WC2A.3	PLAN, PROFILE AND TYPICAL SECTION
1	VE52705G.WC2A.2	GENL ARGT AND ILLUSTRATION OF CUT /FILL AREAS

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN WOOD CANADA LIMITED AND ITS CLIENT, THIS DOCUMENT: (i) CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (ii) MAY BE USED BY THE CLIENT ONLY IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT WAS INTENDED. ANY USE OF, OR RELIANCE ON, THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK.

NOT FOR CONSTRUCTION

APPROVED FOR _____

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE
10% ALTERNATIVE DESIGN

PROJECT NO.
VE52705G

SCALE
AS SHOWN

	BY	DDMMMYY
DES	GG	13MAR20
DRN	PE	13MAR20
CHK	GG	13MAR20
APP		

Yukon

wood.

SUBJECT
CLINTON CREEK REMEDIATION PROJECT
OPTION WC2A (IN PLACE STABILIZATION)
GENERAL ARRANGEMENT
AND ILLUSTRATION OF CONCEPT

AREA

CLIENT DWG NO.

DRAWING NO.
VE52705G.WC2A.1

REV
A

CAD FILE P:\CAD\DGN\VE52705G.WC2A.1.DWG

SIGNATURE

Appendix C
Dam Breach Assessment

DRAFT

400, 111 Dunsmuir Street
Vancouver, BC V6B 5W3
T: + 604-664-4315
www.woodplc.com

Memo

To: Yukon Government, Assessment and Abandoned Mines

From: Geoff Graham, P.Eng., Timothy Ambler, M.Eng, C.Eng. (UK)

Review: Lloyd Madge, P.Eng.

Date: 24 September 2021

Ref No.: VE52705K

Re: **Clinton Creek Post 10% Design Services – Task 1 Data Gaps Report – Dam Breach Assessment (DRAFT - Issued for Information)**

DRAFT

1.0 Introduction

This dam breach assessment was undertaken for the Clinton Creek abandoned mine site under Contract No C000057538 Clinton Creek Post 10% Design Services. The work was undertaken to fill data gaps in relation to the consequences of a dam breach on either Clinton Creek or Wolverine Creek. This memo should be read in conjunction with the previous dam breach assessment undertaken by Wood in November 2019 (Wood, 2019). Supporting information including hydrology context, calculations and methodology and a bibliography of research reviewed on landslide dams is presented in that report.

In 2020 Wood completed a 10% design phase for reclamation concepts proposed by the Project Partners for the Clinton Creek abandoned mine site (Wood 2019a, 2020). The 10% design phase included "design alternatives" that were developed to provide a reasonable balance between reclamation cost and potential public access restrictions that might be required for the design alternatives which do not fully mitigate risk to health and safety at the site.

Risk management at the site requires consideration of both hydrotechnical (flood) and geotechnical considerations (seismic). There are also strong linkages between these technical factors, especially for alternative designs which contemplate site access restrictions. For example, seismic failure of a dump slope, creates an immediate local runout threat, followed by the creation of a new landslide dam, which when breached poses a flooding threat. This memorandum focusses on hydrotechnical issues. Seismically induced runout modelling is considered in Appendix *TBD*. Overall risk management issues are summarized in Appendix *TBD*.

1.1 Site Overview

The Clinton Creek Mine Site (the Site) is a former asbestos mine that was operated between 1968 and 1978. The site is located approximately 100 km northwest of Dawson City, Yukon near the confluence of the Fortymile River and Yukon River.

Major elements of the site are shown in

Figure 1. During mine operations, material was removed from three ore sources: the Porcupine Pit (the largest pit), Snowshoe Pit and the Creek Pit. Waste was placed in the following locations:

1. The Clinton Creek Waste Dump, where waste was placed along the south valley wall of the Clinton Creek valley. It is estimated that 60 million tonnes of waste were placed in the Clinton Creek Waste Dump.
2. The Porcupine Creek Waste Dump, where waste was placed into the Porcupine Creek valley (Porcupine Creek Waste Dump); and
3. The Snowshoe Pit Waste Dump, where waste was placed on the north side of the Snowshoe Pit along the upper edge of the south Clinton Creek valley wall.

During mining operations, ore was transported from the south side of the Clinton Creek valley to the mill site located on high ground on the north side of Clinton Creek and along the upper edge of the west valley wall of Wolverine Creek via an aerial tramway. The ore, a serpentine rock containing chrysotile asbestos, was processed in the mill while the waste material or tailings were transported via conveyor to two piles positioned along the steep western slope of Wolverine Creek with one pile located north of the other. Approximately 12 million tonnes of tailings were deposited into these two piles.

In 1974, waste material deposited onto the south slope of the Clinton Creek valley, forming the Clinton Creek Waste Dump, is believed to have failed, blocking the Clinton Creek flow path. It should be noted that by the time of the failure, Clinton Creek had already been diverted north of the creek's natural path, which flowed along the toe of the south slope of the Clinton Creek valley. The failure created a landslide dam, which impounded water upstream, producing what is now known as Hudgeon Lake. It is currently believed that only a portion of the Clinton Creek Waste Dump failed and that efforts were made to stabilize the resulting landslide dam. Currently, water discharging from Hudgeon Lake flows in Clinton Creek southeast approximately 8 km downstream to Fortymile River. There are several small tributaries in the reach between Hudgeon Lake and the confluence with Fortymile River. The outlet from Hudgeon Lake was constructed between 2002 and 2004 and consists of four gabion drop structures (DS1 to DS4).

DRAFT

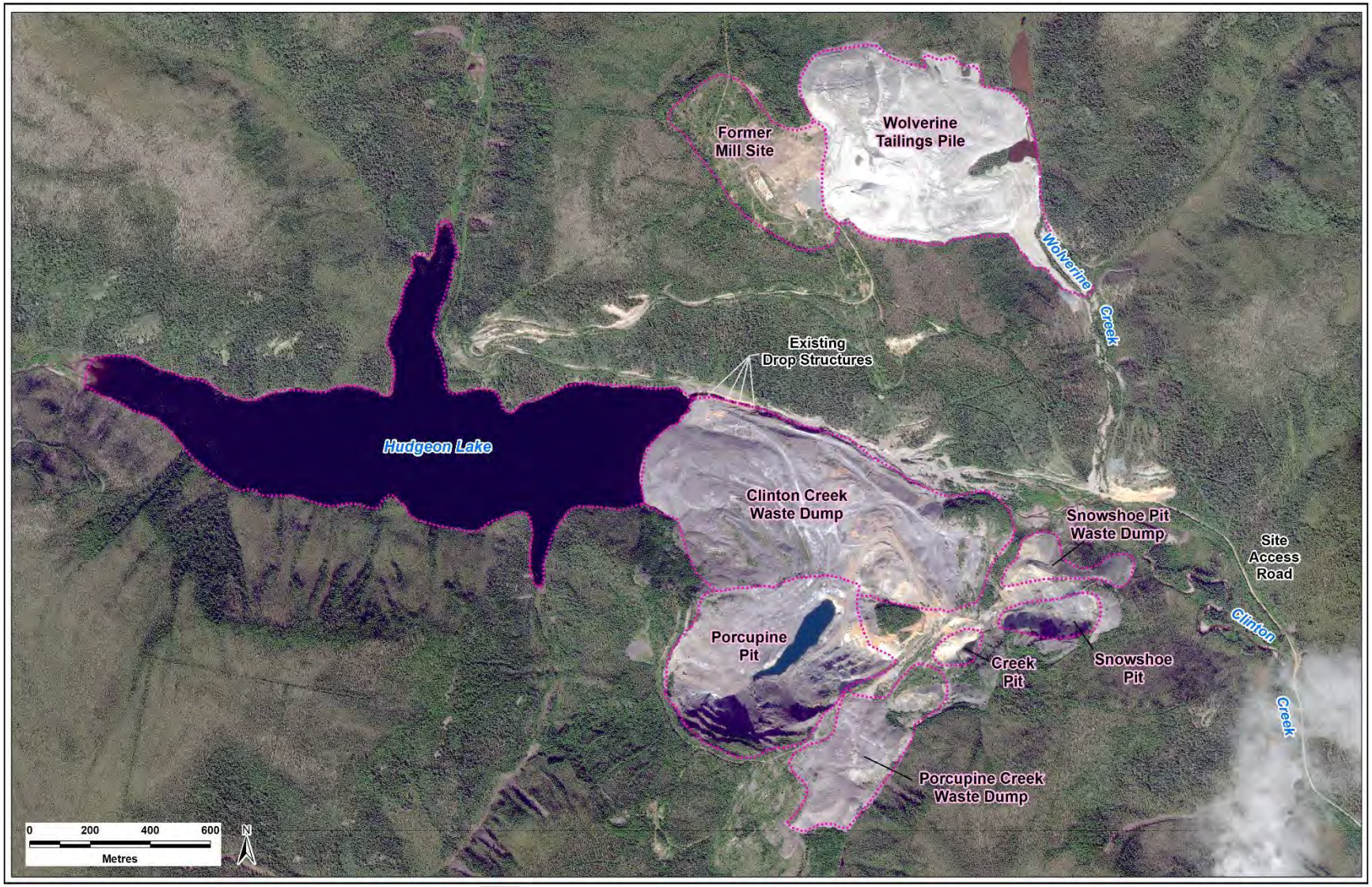


Figure 1 Site Layout

1.2 Closure Concepts

The following closure concepts were developed to a 10% design level in the previous work undertaken by Wood:

Clinton Creek

CC1 – Water Passage and Catastrophic Failure Mitigation (LCCA Option D3, I2) – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure of the pile and construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek.

CC1A/B – Alternative Water Passage and Catastrophic Failure Mitigation – A design alternative to CC1 that takes a less conservative approach to side slopes on the reprofiled conveyance channel accepting that there remains some risk of slope failure into the lake or outlet from Hudgeon Lake.

CC2 – Water Passage, Catastrophic Failure Mitigation and Lowering Lake (LCCA Option E3) – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure, construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek, and lower Hudgeon Lake as part of that concept.

CC2A/B – Alternative Water Passage, Catastrophic Failure Mitigation and Lowering Lake – A design alternative to CC21 that takes a less conservative approach to side slopes on the reprofiled conveyance channel accepting that there remains some risk of slope failure into the lake or outlet from Hudgeon Lake.

CC3 – Water Passage with Reduction of the Lake Level, Eliminating the Dam, and Mitigating Catastrophic Failure (LCCA Option F) – Conduct sufficient work on the waste rock pile to prevent it from acting as a Dam (i.e. as defined by the Canadian Dam Association) on Clinton Creek and to mitigate a catastrophic failure of the waste rock pile. Construct a water conveyance channel to provide water passage through the site.

Wolverine Creek Concepts

WC1 – Sediment Control Only (Not in the LCCA) – Construct a sediment control structure downstream of the rock-lined channel in Wolverine Creek – no work on the tailings pile or the channel is required.

WC2 – Water Passage and Stability Improvement (LCCA Option B, C, D, D2) – Conduct sufficient work at the base of the tailings pile to minimize the tailings movement and provide a semi-stable surface to construct a water conveyance channel.

WC2A – Alternative Water Passage and Stability Improvement – A design alternative to WC2 that takes a less conservative approach to the side slopes for the reprofiled tailings piles.

This option includes realignment of Wolverine Creek to accommodate the reprofiling of the tailings pile.

WC3 – Isolate the Asbestos (LCCA Option E, E2) – Stabilize tailings pile to allow a cover to be placed or relocate the tailings pile.

Wood understands that the project partners require additional clarity about the specific nature and geographic reach of the land use and access restrictions that will be associated with the reclamation options under consideration. This dam breach assessment is intended to provide information on the consequences of failure of:

- the impounding structure (current and proposed) of Hudgeon Lake causing a flood wave into Clinton Creek;
- a theoretical blockage and subsequent failure into Wolverine Creek.

The analysis includes estimates of the volume and location of material deposited downstream as a result of a breach.

This memo should be read in conjunction with the previous dam breach assessment undertaken by Wood (Wood 2019b) where further details on hydrology, site descriptions, landslide dam research and the analysis previously undertaken can be found.

Note that small figures are embedded in the document and flood and sediment transport maps produced from the assessment are included in Attachment A at the end of this memo.

2.0 Objectives and Methodology

2.1 Objectives

The previous dam breach assessment (DBA) that was undertaken by Wood for the 10% design was intended to provide an indication of the likely dam classification of the landslide dam impounding Hudgeon Lake. The dam classification was then used to establish initial design criteria for each option under the Canadian Dam Association (CDA) guidelines. To close data gaps for options select, AAM has requested that the scope of the DBA be extended to include:

- Flood mapping for failure events;
- Sediment displacement estimates; and
- Evaluation of dam classification per CDA guidelines.

Understanding the consequences of a breach of the impoundment of Hudgeon Lake, in whatever form the reclamation of the Clinton Creek side takes, is fundamental to the integration of access restrictions into the post reclamation landscape.

2.2 Methodology

2.2.1 Software

Various hydraulic modelling packages are available for undertaking DBAs. Two commonly used models are US Army Corps of Engineers HEC-RAS and FLO-2D. HEC-RAS was used for the flood inundation mapping and Flo-2D was used to model mudflow for the various modelling scenarios. These two models are described further below.

2.2.1.1 HEC-RAS

Hydraulic modelling of the dam breach scenarios was undertaken using US Army Corps of Engineers HEC-RAS v5.0.6. The HEC-RAS system includes river analysis components for: (1) steady flow water surface profile computation; (2) one- and two-dimensional unsteady flow simulation; (3) movable boundary sediment transport computation; and (4) water quality analysis. As a key feature, all four components use common geometric data representation and geometric and hydraulic computation routines. In addition to these river analysis components, the system offers several hydraulic design features that can be invoked once basic water surface profiles are computed. It is possible to model dam breaches using an inline weir structure. As an expansive floodplain is not present, a 1-D model was deemed appropriate for modelling the various breach scenarios.

The dam breach capabilities in HEC-RAS includes a breach parameter estimator that calculates breach parameters using five different commonly used methodologies.

2.2.1.2 FLO-2D

The FLO-2D model was conceptualized in 1986 to predict mudflow hydraulics. It is one of the most widely used flood models commercially available. FLO-2D was selected for the mudflow/debris flow analysis due to the greater simulation capabilities within the model over HEC-RAS sediment transport modules.

2.2.2 Topographic Base

The topographic base for the dam breach modelling was created by amalgamating data from four different sources:

- 2018 LiDAR data captured by Yukon Government Highways & Public Works (green hatching in Figure 2).
    - Typically, LiDAR data has a vertical accuracy of ±5 to ±15 cm and horizontal accuracy of ±30 cm depending on the data retrieval specifications.

DRAFT

- 2016 bathymetric survey of Hudgeon Lake (blue shading)
  - The provenance or accuracy of this data is unknown; however, reasonable variations will not have a significant effect on the results of this study.
- Digital Elevation Model (DEM) produced by Yukon Government from satellite imagery (yellow hatching)
  - This DEM was produced from overlapping satellite images. These images include 50 cm GeoEye (captured on 26 Jul 2012), and 60 cm Quickbird (captured on 01 Sep 2008). 2018 lidar data for the Clinton Creek mine access road was used to improve the accuracy of the DEM. Elevations in this dataset are Orthometric.[1]
- University of Minnesota ArcticDEM (red hatching)
  - ArcticDEM is a high-resolution, high quality, digital surface model (DSM) produced by the Polar Geospatial Center at the University of Minnesota. It was produced using optical stereo imagery, high-performance computing, and open-source photogrammetry software. The current ArcticDEM Release 7 has DEM strips in 2 m grid resolution covering all land in the Arctic north of 60□N latitude. This data is the least accurate of the datasets and was only used where other data were not available in the middle stretch of Clinton Creek (Figure 2).
  - The ArcticDEM data use the WGS84 Ellipsoid as the datum. As described above, the elevations for the Clinton Creek DEM developed from satellite imagery are Orthometric and therefore, the ArcticDEM elevation data were adjusted by -10.55 m to convert the data to Orthometric elevations.

[1] Email communication from Underhill Geomatics and Yukon Government, 5 Feb 2021.

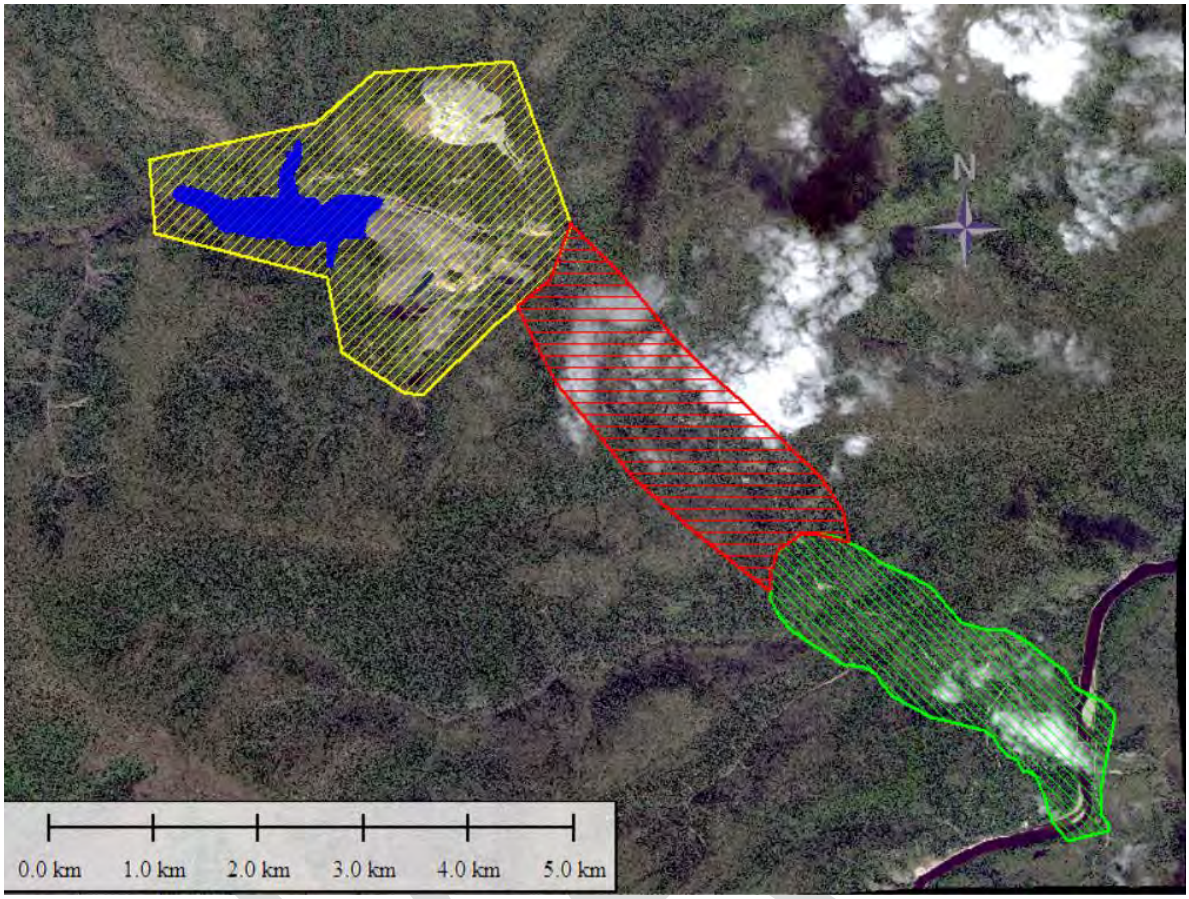


Figure 2: Topographic Data Zones

The highest quality topographic data is shown in green hatching. Because of the difference in data quality, the model was split at this location to enable future updates for higher quality topographic data for the upper model to be easily incorporated.

2.3 Development of Breach Scenarios

2.3.1 Overview

This section presents descriptions of the scenarios and results. Scenarios were developed based on the following factors:

- Warning/No warning to potential users of the site;
- Flood Induced (overtopping due to flood) or Sunny Day (failure from some other mechanism such as piping); and
- Filling times behind by seismically induced landslide impoundments.

Each of these are discussed in further detail below.

2.3.2 Flood Induced/Sunny Day

Analysis of flood induced (overtopping) and sunny day (for example piping) failures are standard practice outlined in CDA guidelines for dam breach assessments. This also embraces the concept that a major flood event and a major seismic event will not occur at the same time.

2.3.3 Warning/No Warning

This factor focused on the potential for users of the site to be warned prior to the failure of the dam. This is not to say that the warning systems are currently in place. Rather, that the owner of the site has an opportunity to develop a system or protocol that can warn users of the site, or temporarily close the site due to an increasing or developing hazard. For example, if a seismic event were to be sufficiently severe as to cause failure of the side slopes on Clinton Creek, or of the tailings piles in Wolverine Creek valley blocking the creek valley. The ground accelerations required to cause a slide would be observed at the Dawson seismograph and action could be taken by the owner to attend site and or alert users to the developing risk. This scenario is considered as a warning scenario. Typically, no-warning scenarios are the Sunny Day failures where the developing risk would probably go unobserved by either the general public or professionals not actively studying the failure mechanism; for example, increasing rates of seepage that would indicate a developing problem with internal erosion or piping; or a breach caused by seismic action with very little warning. An example of a no-warning event would be the threat posed by a landslide triggered by an earthquake to people either on the dump or tailings or in close proximity downslope in the runout zone. This is considered elsewhere.

The potential for flood warning is indicated in Table 1 with an indication of the likely possible warning for each scenario. The actual lead time available would depend on a number of factors including seasonality, on-site cameras functioning, frequency and timing of site visits, and users observing and then notifying the owner of changes in the site conditions.

2.3.4 Filling Times Behind a Seismically Induced Landslide Impoundment

2.3.4.1 Downstream Blockages

While the original base-case concepts were designed to mitigate seismic action, the alternative designs CC1A/B, CC2A/B and WC1 do not fully mitigate the risk of seismic failure of the conveyance channel side slopes in Clinton Creek or tailings piles in Wolverine Creek. Scenarios based on downstream landslide blockages are intended to inform the Project Partners of the hydrotechnical consequences of inaction by the owner; should a seismically induced failure occur. Geotechnical risks from seismic induced failures are discussed in Appendix *TBD* (Access Limits Assessment).

DRAFT

On the Clinton Creek side, the 2020 alternative design considered 4H:1V spillway slopes with and without blast densification (Wood, 2020). Blast densification was introduced as a method of controlling static liquefaction during construction. However, the 4H:1V slopes remain susceptible to instability during the 1:2,475-year (2% chance of occurring in a 50 year design life) earthquake (PGA 0.27g).

There is an important distinction between the hydrotechnical design criteria adopted for flow conveyance and the geotechnical criteria for slope stability. Whereas the hydrotechnical criteria were based on a dam classification of "Significant" for CC1 and "Low" for CC2, the criteria for geotechnical design were based on "Significant" dam classification for all options to mitigate seismic response at the significant level. This is because the failure of side slopes on any option in Clinton Creek, including CC3 where the lake is removed in its entirety, could result in a landslide impoundment that may result in a breach analogous to the failure of the existing drop structures which is considered by previous studies to be a Significant consequence dam.

A runout assessment was undertaken by Wood (Wood, 2019) to understand the consequences of failure of these concepts. The assessment considered the consequences of slope failure of the existing waste rock pile and the consequences of failure of the reprofiled waste rock pile under CC1A and CC2A. The analysis found in summary that:

- Under existing conditions, the waste rock pile could fail blocking the downstream channel to an elevation up to 428 m.
- under CC1A, the waste rock pile could fail downstream of the lake outlet and block the channel to an elevation of between 423 m to 427 m.
- Under CC2A, the slopes could fail blocking the channel to a level of between 417 m to 420 m.

On the Wolverine Creek side, the existing channel has an elevation of approximately 406 m. Under closure concept WC1, a liquefaction failure of the existing tailings lobes could block the channel to an elevation of between 450 m to 460 m depending on how much of the tailings pile slides. It should be noted that in the most significant geotechnical failure, runup on the opposite valley wall could be much higher, up to 470 m, but would result in a lower section (436 m to 444 m) in the centre of the dam.

2.3.4.2 Filling Time

The rate of filling behind a seismically induced downstream blockage was considered in the analysis. The basic concept is that landslide dams typically fail from overtopping within a short period of time (See Figure 3-1, Wood 2019b). In the Canadian Cordillera, 90% of landslide dams

fail within a few days. Under this type of scenario, the head of water would build up behind the landslide dam until it overtops and fails, causing a large downstream flood.

Yukon Government (YG) has indicated that a response plan is in place and contractors can be mobilized to site within a few days. A reasonable assumption might be that two weeks might be required to identify the problem and visit the site, mobilize a contractor and equipment to site, consult with engineers on short term emergency measures and then undertake mitigation measures to prevent a breach. An alternative scenario might occur if, in the immediate aftermath of a seismic event, AAM staff or contractors were not immediately available to attend site. Wood considered a month delay in undertaking mitigative measures in this case.

A seismic event has no correlation to precipitation, so rather than using flood conditions to study filling times, typical monthly precipitation was analyzed from Environment Canada precipitation data at Dawson City and compared against recorded precipitation at the site (shorter data record). A conservative assumption was made that the seismic event and subsequent blockage occurs during the freshet; usually around May.

The runoff generated by melting snowpack and average freshet precipitation was estimated using the basic relationship of:

$$V = P * A * c$$

Where: V = total volume of runoff in a month.

P = average monthly precipitation accumulated in the basin and stored as snow in between November and April plus the average monthly rainfall in May.

c = runoff coefficient; assumed to be 0.5 to account for snowpack losses due to sublimation and spring evaporation; some ponding in the basin and a small amount of infiltration.

In the absence of calibration data (accurate rainfall hyetographs and runoff hydrographs) runoff rates calculated using this method were compared against observed historical monthly flow rates at the drop structures on Clinton Creek and a reasonable correlation was found.

From these data, approximate filling times behind a landslide dam were calculated based on the storage elevation curve for Hudgeon Lake and the upper Wolverine Creek valley. For each, the water level that would be reached after two weeks filling, and one month filling, were calculated and used as the dam failure height.

For example, assuming a starting water elevation of approximately 412 m the water level in Hudgeon Lake would rise to a level of approximately 416 m within 2 weeks and approximately 420.5 m in one month.

DRAFT

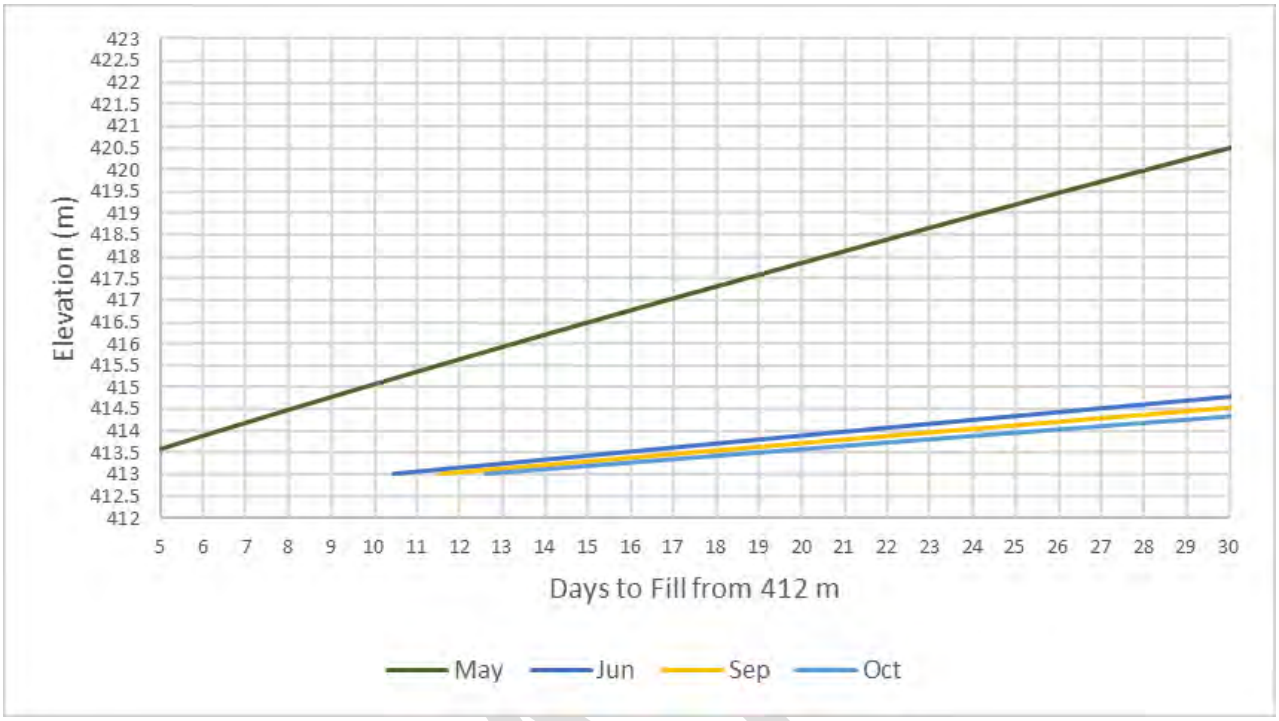


Figure 3: Hudgeon Lake – Days to Fill from 412 m After a Landslide Blockage

2.3.5 Dam Breach Scenarios

The selected dam breach scenarios for Clinton Creek are shown in Table 1 and the selected breach scenarios for Wolverine Creek are shown in Table 2.

DRAFT

Table 1: Description of Modelled Breach Scenarios on Clinton Creek

Scenario	Reclamation Option	Spillway and Inflow Condition	Breach Elevation (m)	Description	Warning Possible?
1	None	No breach. IDF.	None	Simulation to provide the base case for comparing the breach scenarios. Assuming a Significant classification dam and Passive Care phase, the IDF is 1/3 between the 1000-year event and the Probable Maximum Flood[2]. Since the PMF has no associated return period, the probability of this event is undetermined. However, based on an extrapolated flood frequency curve for Clinton Creek, an indicative return period for this event is once every 50,000 years or thereabouts.	Yes. Likely less than 2 days.
2	CC1	Flood induced breach of CC1.	412	Breach of CC1 occurs during an IDF event. Timing of the breach synchronized with the peak of the hydrograph.	Yes. Likely less than 2 days.
3	CC1	Sunny Day breach of CC1.	412	Breach of CC1 occurs on a sunny day.	No.
4	CC1A	Sunny Day. Seismic induced secondary dam caused by landslide downstream of CC1A inlet.	420.5	Large seismic induced failure of the side slopes by overtopping at 420.5 m. Assumes sunny day conditions since the likelihood of a seismic event and a flood occurring at the same time is not credible. Highest blockage scenario modelled. Though some slope failure model runs produced slightly higher elevations, this scenario assumes Owner does nothing to mitigate the buildup of water ponding behind the landslide and the landslide	Yes. Up to one month.

[2] For Passive Care IDF for a Significant class dam is 1/3 between the 1/1000 year event and the PMF which is currently estimated to be 357 m^3/s. For Active care, the IDF is from 1/100 year (currently estimated to be 59.9 m^3/s) to 1/1000 (currently estimated to be 87.2 m^3/s) year event based on agreement with the regulator.

Scenario	Reclamation Option	Spillway and Inflow Condition	Breach Elevation (m)	Description	Warning Possible?
				eventually overtops. This would take around a month during a typical freshet and several months during normal baseflow conditions.	
5	CC1A	Sunny Day. Seismic induced secondary dam caused by landslide downstream of CC1A inlet.	416	Smaller seismic induced landslide with a blockage to 416 m. Based on the rate of rise of Hudgeon Lake under freshet conditions, this is a credible level to which the lake could rise from about 412 m before mitigative action might be taken by the Owner (a two-week mobilization/mitigation window).	Yes. Up to 14 days.
6	CC2	Flood induced breach of CC2.	401	Breach of CC2 occurs during a IDF event. Timing of the breach synchronized with the peak of the hydrograph.	Yes. Likely less than 2 days.
7	CC2	Sunny day breach of CC2.	401	Breach of CC2 occurs on a sunny day.	No.
8	CC2A	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	417	Large seismic induced failure of the side slopes with a resultant blockage to 417 m. Assumes sunny day conditions since the likelihood of a seismic event and a flood occurring at the same time is not credible. Highest blockage scenario modelled. Though some slope failure model runs produced slightly higher elevations, this scenario assumes Owner does nothing to mitigate the buildup of water ponding behind the landslide and the landslide eventually overtops. This would take around a month during a typical freshet and several months during normal baseflow conditions.	Yes. Up to one month.

Scenario	Reclamation Option	Spillway and Inflow Condition	Breach Elevation (m)	Description	Warning Possible?
9	CC2A	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	407	Smaller seismic induced landslide with a blockage to 407 m. Based on the rate of rise of Hudgeon Lake under freshet conditions, this is a credible level to which the lake could rise from a starting level of 401 m before mitigative action might be taken by the owner (a two-week mobilization and mitigation window).	Yes. Up to 14 days.
10	Existing channel and spillway	No breach. 1 in 1000 year (0.1% AEP).	None	Simulation intended to provide context and an additional baseline to compare breach scenarios against. A flood event with an annual probability of 1 in 1000 (or 0.1%). This event has a 7.4% chance of occurring within the normal average lifespan of a Yukoner (77 years).	Yes. Likely less than 2 days.

DRAFT

Table 2: Description of Modelled Breach Scenarios on Wolverine Creek

Scenario	Reclamation Option	Spillway and Inflow Condition	Breach Elevation (m)	Description	Warning Possible?
1	None	Sunny day.	430	Slope failure of South Lobe of the Wolverine Creek tailings Dump, caused by either static loading or a seismic event. Runout across Wolverine Creek, forming landslide dam with crest elevation of 430 m. Filling of reservoir to 430 m under freshet conditions, which is a credible level to which the lake could rise from a starting level of 408.2 m before mitigative action might be taken by the Owner (a two week mobilization and mitigation window)..	Yes, up to 2 weeks
2	None	Sunny day.	435	Slope failure of South Lobe of the Wolverine Creek tailings Dump, caused by either static loading or a seismic event. Runout across Wolverine Creek, forming landslide dam with crest elevation of 435 m. Filling of reservoir to 435 m under freshet conditions, which would take around a month during a typical freshet and several months during normal baseflow conditions.	Yes, up to 1 month
3	None	IDF or Sunny day.	408.2	Existing landslide dam at south lobe fails, leading to a breach wave downstream. Failure may be flood induced or sunny day. No warning provided in this scenario.	No

2.3.6 Clinton Creek Breach Parameters

Breach parameters were calculated within the HEC-RAS breach module which compares five different methods for calculating breach parameters. These methods are:

- MacDonald et al (1984)[3];
- Froehlich (1995)[4];
- Froehlich (2008)[5];
- Von Thun & Gillette (1990)[6]; and
- Xu & Zhang[7].

It should be noted that the regression equations presented in the above documents are based on constructed earth or rockfill dams which have a crest width far less than the current landslide impoundment of Hudgeon Lake or any of the options under consideration for reclamation. Research on the failure of landslide dams was presented in the previous DBA study (Wood, 2019b).

Froehlich (1995) and Froehlich (2008) produced consistent results that were considered reasonable across all scenarios. Other methods produced unreasonable results for some scenarios and were therefore discarded. The method by Froehlich (2008) produced results that were generally larger than Froehlich (1995) and as the more recent Froehlich publication, was adopted for all scenarios to maintain comparative consistency.

Table 3 shows the adopted dam breach parameters along with the top of dam elevation and impoundment volume. The impoundment volumes were calculated based on assumed failure elevation, lake bathymetry and the Clinton Creek DEM described above.

DRAFT

[3] MacDonald, T.C. and J Langridge-Monopolis "*Breaching Characteristics of Dam Failures*" Journal of Hydraulic Engineering, vol 110, no. 5, P. 567 to 586. 1984.

[4] Froehlich, D.C. "*Embankment Dam Breach Parameters Revisited*" Water Resources Engineering, Proceedings of the 1995 ASCE Conference on Water Resources Engineering, San Antonio, Texas, August 14-18, 1995.

[5] Froehlich, D.C. "*Embankment Dam Breach Parameters and Their Uncertainties*" Journal of Hydraulic Engineering Volume 134, Issue 12, December 2008.

[6] Von Thun, J.L. and D.R. Gillette "*Guidance on Breach Parameters*" unpublished internal document, U.S. Bureau of Reclamation, Denver, Colorado, March 13, 1990.

[7] Xu, Y. and L.M. Zhang "*Breaching Parameters for Earth and Rockfill Dams*" Journal of Geotechnical and Geoenvironmental Engineering Volume 135, Issue 12. December 2009.

Table 3: Clinton Creek Dam Breach Assessment – Adopted Breach Parameters (based on Froehlich, 2008)

Scenario	Top of "Dam" Elevation (m)	Breach Bottom El. (m)	Failure Mode	Pool Volume at Failure (1,000 m^3)	Breach Bottom Width (m)	Side Slopes (H:V)	Breach Formation Time (hours)
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	412	399.68	Flood	10,736	57	1	1.49
3	412	399.68	Sunny Day	10,003	43	0.7	1.44
4	420.5	399.68	Sunny Day	17,000	64	1	1.20
5	416	399.68	Sunny Day	13,094	58	1	1.24
6	401	397.69	Flood	3,516	42	1	3.18
7	401	397.69	Sunny Day	3,516	33	0.7	3.18
8	417	397.69	Sunny Day	13,927	57	1	1.08
9	407	397.69	Sunny Day	6,678	49	1	1.56

2.3.7 Wolverine Creek Breach Parameters

Table 4: Wolverine Creek Dam Breach Assessment – Adopted Breach Parameters (based on Froehlich, 2008)

Scenario	Top of "Dam" Elevation (m)	Breach Bottom El. (m)	Failure Mode	Pool Volume at Failure (1,000 m^3)	Breach Bottom Width	Side Slopes (H:V)	Breach Formation Time (hours)
1	430	405.8	Sunny day	831	9	1	0.21
2	435	405.8	Sunny day	1,800	14	1	0.26
3	408.2	405.8	Flood/ Sunny day	215	19	1	1.08

For the Wolverine Creek model, peak breach flows were based on Froehlich (2016)[8], which builds on the Froehlich (1995) and Froehlich (2008) methodology. Model inflow hydrographs were developed by creating a triangular breach flow hydrograph using the breach volume and peak

[8] Froehlich, D.C. "Predicting Peak Discharge from Gradually Breached Embankment Dams". Journal of Hydrologic Engineering, Vol 21, Issue 11, November 2016.

flows. Peak flow was assumed to occur at 1/3 of the total hydrograph duration, as typically dam breach hydrographs have a steeper rising limb than failing limb.

3.0 Hydraulic Model Development

3.1 Clinton Creek

Due to the differing qualities of topographic base, the HEC-RAS model was split into two sections. The upper model covered from upstream of Hudgeon Lake to the downstream boundary where LiDAR data were available (blue, yellow, and red hatching in Figure 2). The downstream model was developed for the zone covered by LiDAR (green hatching in Figure 2).

The upper model was run for each scenario and for each, a flow hydrograph was extracted at the downstream boundary. The flow hydrograph was then entered as the upstream inflow boundary for the lower model for each scenario. The geometry for the lower model was consistent across all events.

The FLO-2D model, for the sediment transport modelling, used a composite of the different base maps, and was run as a single model.

3.1.1 Inflow Design Flood

The estimated design flows for various dam classifications on Clinton Creek were presented in Table 5-3 of Wood 2019b. To enable a "like for like" comparison of options, this study adopted the same inflow design flood (IDF) for all flood scenarios. The IDF for a Significant consequence dam was adopted. The design flood flow for a Significant dam is specified under the CDA Dam Safety Guidelines for Closure – Passive Care as 1/3 between the 1000-year return period flood flow and PMF. The adopted hydrograph for the flood induced scenarios is shown in Figure 4.

DRAFT

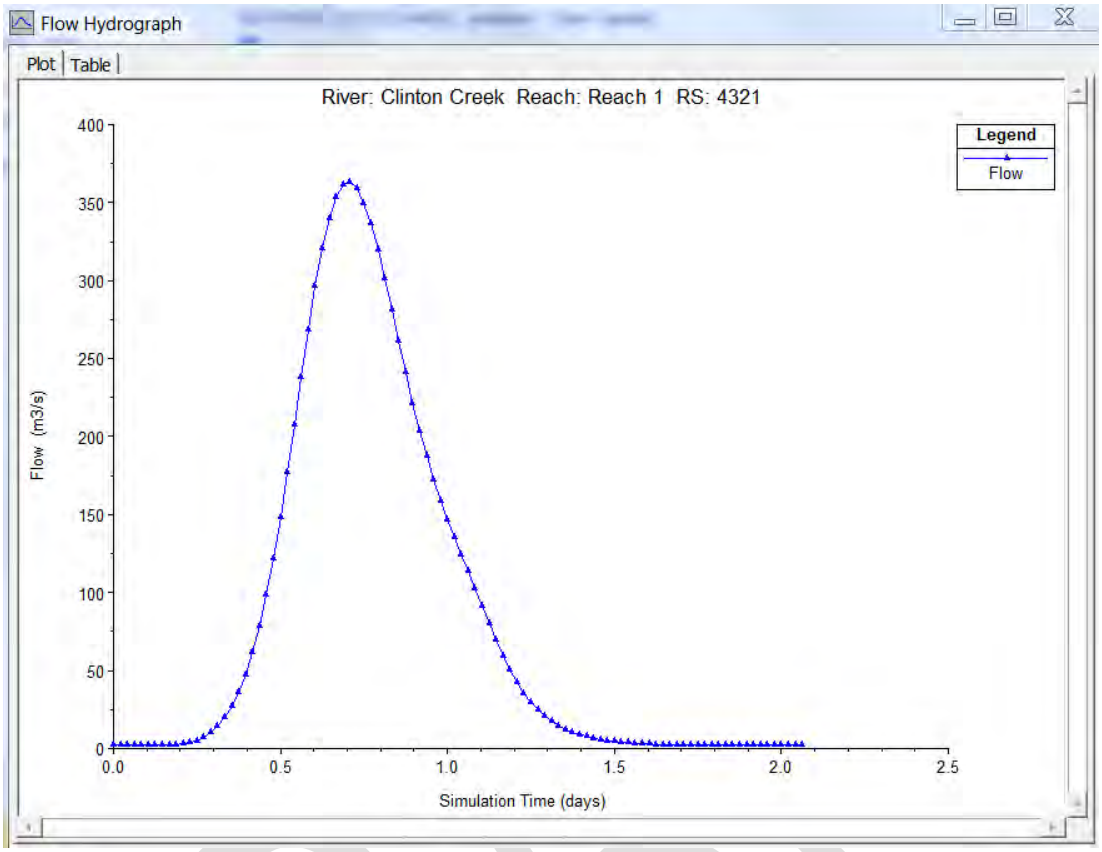


Figure 4: IDF Hydrograph for Clinton Creek Flood Induced Scenarios

For sunny day scenarios, a base flow of up to 20 m^3/s was added to the baseflow to enable the model to initially run. Thought this flow is much greater than might be expected on a sunny day, the additional flow was deemed insignificant compared to the peak resulting from the breach.

3.1.2 Model Sections

The 1D hydraulic model cross section locations and section chainages are shown in Figure 5 and Figure 6.

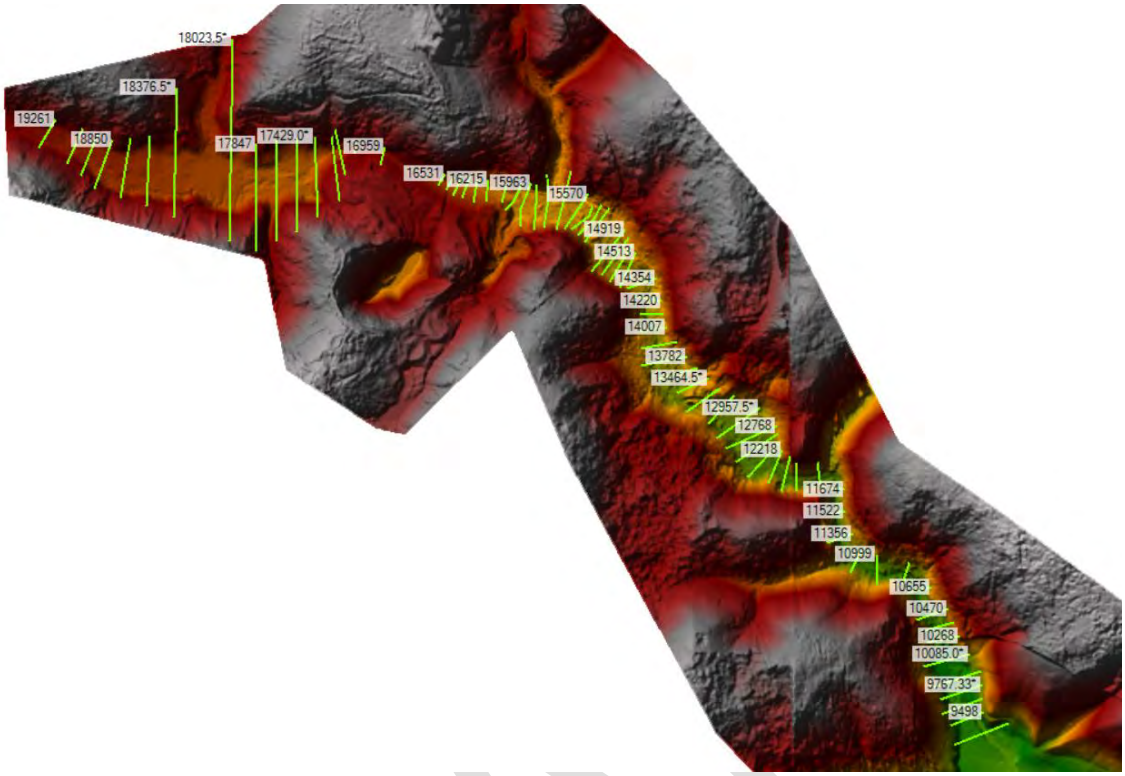


Figure 5: Extent of Upper HEC-RAS Model for Clinton Creek

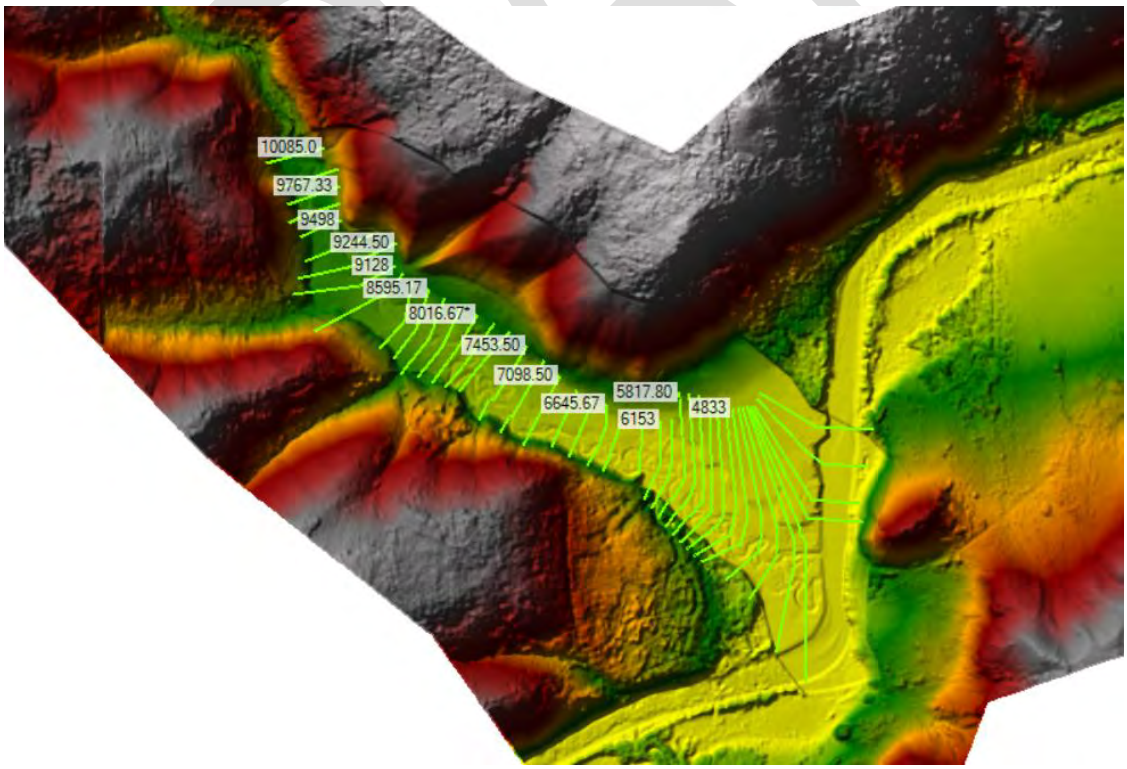


Figure 6: Extent of Lower HEC-RAS Model for Clinton Creek

To assess downstream sediment deposition, a FLO-2D model was developed for Clinton Creek. Inflow hydrographs for the model were identical to those used in the HEC-RAS model but included sediment inflows as well as water inflows. The model was set up with a 15 m × 15 m grid size, selected as a balance between resolution of results and computational time.

During a hypothetical breach of Clinton Creek dam, water passing through the breach will erode and transport dam material downstream, further enlarging the breach. This was considered the primary source of sediment in the model. Additional sediment loading from erosion of the Clinton Creek channel downstream of the dam was considered to be small compared to the volume of material in the breach. Though some lake sediment would be drawn through the breach, significant volumes of sediment from the bed of Hudgeon Lake were not anticipated to flow through the breach since the estimated breach depth would not be below the elevation of sediment as shown on the bathymetry data.

Total breach sediment volumes were calculated by estimating the total volume of material within the breach geometry, assuming a trapezoidal breach shape. Sediment concentration was applied to the inflow hydrograph and was treated as a constant concentration for the duration of the breach event. Typically, higher flows through a breach will result in higher velocities and higher erosion rates, so sediment flow rate will increase with increasing water flow rate. A constant sediment concentration is therefore considered suitable, noting that modelling results are not anticipated to be sensitive to the temporal distribution of sediment concentration.

Key scenarios were selected to undergo sediment transport modelling. These were scenarios 2, 4, 5 and 7, in order to give a range of possible downstream sediment impacts.

Sediment properties were estimated as part of the geotechnical assessments. For Clinton Creek, the sediment properties for transport modelling are shown in Table 5.

DRAFT

Table 5: Clinton Creek Sediment Parameters for Sediment Transport Modelling

Sediment Property	Value
Dry unit weight	19,000 N/m^2
Specific gravity	2.7
Sediment D_{50}	1.1 mm
Sediment D_{84}	12.2 mm
Sediment D_{16}	0.1 mm
FLO-2D Sediment gradation coefficient[9]	11.2
Sediment transport equation	Zeller and Fullerton

3.2 Wolverine Creek

The Wolverine Creek breach study used the composite topographic map developed for the Clinton Creek study.

3.2.1 Hydrology

The two scenarios modelled for Wolverine Creek were both Sunny Day failures, so predictions of extreme flood events in the Wolverine Creek valley were not required as part of this analysis.

Downstream of the Wolverine Creek-Clinton Creek confluence, the impacts of the baseline (no-breach) flood event will be identical to those in the Clinton Creek study, as the contributing catchment is the same.

3.2.2 Hydraulic Modelling

A 2D model was developed for Wolverine Creek, to model both downstream inundation extents and sediment transport. The model was developed in FLO-2D using the QGIS plug-in and is an adapted version of the FLO-2D model used for Clinton Creek. Sediment transport and downstream inundation modelling was carried out for Scenarios 1 and 2 only.

Scenario 3 was excluded from modelling, as the calculated peak breach flow was in the order of 15 m^3/s. As this flow is similar in magnitude to typical (e.g. 1 in 10 AEP) storm event flow in Wolverine Creek, the benefits of modelling this Scenario were minor.

Sediment properties were estimated as part of the geotechnical assessments. For Clinton Creek, the sediment properties for transport modelling are shown in Table 6.

[9] The gradation coefficient used in FLO-2D is equal to $0.5*(D_{84}/D_{50} + D_{50}/D_{16})$.

Table 6: Wolverine Creek Dam Breach sediment parameters for sediment transport modelling

Sediment Property	Value
Dry unit weight	19,000 N/m^2
Specific gravity	2.7
Sediment D_{50}	1.4 mm
Sediment D_{84}	7.4 mm
Sediment D_{16}	0.3 mm
FLO-2D Sediment gradation coefficient[101]	5.3
Sediment transport equation	Zeller and Fullerton

4.0 Results

4.1 Mapping Overview

Results from the hydraulic and sediment transport modelling are provided in Table 7, Table 8 and Figure A to Figure H in Attachment A of this memo. HEC-RAS automatically outputs flood inundation maps and depth grids. The outputs were checked, and the profiles were hand edited to remove small islands and to provide an interpretation of flood inundation in areas where the topographic data base was suspect. These suspect areas were generally at the interface between topographic datasets as described in Section 2.2.2 and at a few locations where it was evident that the University of Minnesota ArcticDEM does not accurately represent the terrain. In this case, air photos taken from various site visits by Wood and Yukon Government were used to edit the flood maps.

After running the various breach scenarios, it became clear that many produced similar inundation results. To avoid an unmanageable number of maps, scenarios for mapping were chosen that would:

- Provide a "no breach" base case scenario against which breach model runs could be measured (Scenario 1);
- Provide an analogue for other events where the flood wave peak discharge is similar to other scenarios (Scenario 2); and
- Book end the highest rare, but credible, breach flow (Scenario 4).

[10] The gradation coefficient used in FLO-2D is equal to 0.5*(D84/D50+D50/D16)

Flood depth maps are also provided for Scenarios 2 and 4 to facilitate decision making with respect to access restrictions.

The following map sets are provided in Attachment A:

- Clinton Creek
  - Figure A: Flood Inundation Extent Maps – Scenarios 1, 2 & 4.
  - Figure B: Flood Depth Maps – Scenario 2.
  - Figure C: Flood Depth Maps – Scenario 4.
  - Figure D: Sediment Transport Maps – Scenario 2.
  - Figure E: Sediment Transport Maps – Scenario 4.
- Wolverine Creek
  - Figure F: Flood Inundation Extent Maps – Scenarios 1 & 2.
  - Figure G: Sediment Transport Maps Scenario 1.
  - Figure H: Sediment Transport Maps Scenario 2.

4.2 Results

4.2.1 Peak Flow Rates

Table 7 and Table 8 provide peak modelled breach flows for the various scenarios at 3 points along the watercourse. Immediately downstream of the breach location, at the upper and lower model boundary and finally at the confluence of Clinton Creek with Fortymile River. As Wolverine Creek was modelled as a single model, no model boundary results were produced.

Table 7 shows that there is considerable flood attenuation as the flood wave progresses down the valley. The most significant attenuation occurs in the “red zone” where only the ArcticDEM was available for modelling and mapping. For this reason, the model may be overestimating flood attenuation especially for higher events. It is expected however, that there will be significant attenuation for higher events as flood water is stored in the upstream floodplain and as the hydrograph passes through the incised section of Clinton Creek.

DRAFT

Table 7: Clinton Creek Breach Peak Flows

Scenario	Spillway and Inflow Condition	Peak Flow Rate (m^3/s)		
		Immediately D/S of Drop Structures	Upper/Lower Model Boundary	Confluence with Fortymile River
1	No breach. IDF.	365	364	311
2	Flood induced breach of CC1.	1,110	977	915
3	Sunny Day breach of CC1	774	625	583
4	Sunny Day. Seismic induced secondary dam caused by landslide downstream of CC1A inlet.	3,520	1,741	1,521
5	Sunny Day. Seismic induced secondary dam caused by landslide downstream of CC1A inlet.	1,130	849	707
6	Flood induced breach of CC2.	450	375	372
7	Sunny day breach of CC2.	140	132	124
8	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	1,080	880	835
9	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	475	406	377
10	No breach. 1 in 1000 year (0.1% AEP) (Steady state model does not account for hydrograph attenuation).	87.2 (at Hudgeon Lake outlet) 103 (d/s of Wolverine Creek)	103	103

For Wolverine Creek flows, shown in Table 8, attenuation is much more significant. This is primarily due to the significantly lower total breach volumes in the Wolverine Creek breach Scenarios. Wolverine Creek breach volumes were typically 5 to 10 times lower than similar scenarios for Clinton Creek, despite similar peak breach flows.

Table 8: Wolverine Creek Breach Peak Flows

Scenario	Spillway and Inflow Condition	Peak Flow Rate (m^3/s)	
		Immediately D/S of Breach	Confluence with Fortymile River
1	Lake water level at 430 m. Sunny day failure.	1,310	87
2	Lake water level at 435 m. Sunny day failure.	2,560	270
3	Lake at normal water level. Sunny day or flood failure.	15 (plus flood event flow)	N/A

4.2.2 Likelihood and Consequence

4.2.2.1 Qualitative Assessment of Likelihood

Since the DBA is intended to understand the consequences of a dam breach, the assessment of risk is beyond the scope of this study. However, it is useful to put into context the likelihood of various scenarios discussed in Section 2.3.5 and in Table 11 and Table 12.

Wood developed a matrix describing Wood's interpretation of the likelihood of events occurring. This matrix was then used along with the probabilities of certain independent events occurring (flood or seismic) to make a qualitative assessment of the likelihood of an event occurring between the various scenarios.

Table 9 provides qualitative description of likelihood regarding a scenario being realized, ranked from Non-Credible/Very Rare to Almost Certain, taking into account historic occurrences, local conditions and event probability. The table is intended to put into context Wood's interpretation of the likelihood of a scenario occurring within a reasonable assumed design life.

Table 9: Contextual Description of Likelihood

Likelihood	Description
Almost Certain	Will undoubtedly happen or recur, possibly frequently.
Likely	Will probably happen or recur, but it is not a persisting issue or circumstance.
Unlikely	Might happen or recur occasionally.
Rare	Do not expect it to happen or recur but it is possible it may do so.
Non-Credible/Very Rare	This will probably never happen or occur.

4.2.2.2 Assessment of Consequence

The assessment of consequence is also a subjective exercise that relies on the judgement of the assessor. The consequences depend on receptors being in the area affected by a hazard being realized. Table 10 is based on CDA guidelines for assessing dam classification. The consequences of a failure are related to loss of life, environmental and cultural values and infrastructure and economics. The descriptive language used in Table 11 is based on Table 10.

Table 10: Description of Consequence (based on CDA)

Severity	Dam Class	Loss of Life*	Environmental and Cultural Values	Infrastructure and Economics
Severe	Extreme	>100	Major loss of critical habitat and/or impact on cultural values. Permanent loss of traditional use.	Major loss of site use, economic impact of recovery prohibitive.
Major	Very High	<100	Significant loss of habitat or traditional use. Restoration or compensation unlikely.	Permanent loss of some aspects of site use. High cost of recovery or restoration.
Moderate	High	<10	Permanent loss of some fish habitat. Restoration not certain. Potential cultural impact.	Short term loss of site use, economic impact of restoration significant.
Minor	Significant	Unspecified	No significant impact on fish, wildlife or cultural. Restoration highly likely.	Short term loss of site use, economic impact of restoration minor.
Negligible	Low	None	No environmental or cultural impact.	No impact to local infrastructure, minor economic impact.

Note:* **None** – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Unspecified – the level of safety required at a dam where people are temporarily at risk depends on the number of people, exposure time, nature of their activity and other conditions. The design requirements depend on whether the population are likely to be present during the flood season.

In relation to loss of life, under current site conditions, the consequence of a breach would fit the description for **None** given that there is no identifiable population in the potential inundation zone and loss of life could be considered through unforeseeable misadventure. This study assumes that there will be no substantial changes to exposure time after reclamation

and that loss of live would only be through unforeseeable misadventure. Future changes in site use not contemplated at this time may necessitate a re-evaluation of this assumption.

DRAFT

Table 11: Consequence Assessment – Clinton Creek

Scenario	Reclamation Option	Spillway and Inflow Condition	Commentary on Likelihood	Consequence
1	None	No breach. IDF.	This event has a 0.15% chance of occurring during the lifespan of an average Yukoner[11] (77 years – StatsCan). The application of the flood frequency curve to the IDF return period is tenuous but does provide an indication of the frequency of such an exceptional flood event. The conclusion is that this is a **rare** or **unlikely** event. Other scenarios are classified based on this benchmark.	The inundation zone for Scenario 1 is shown on Figures A1 to A4 in Attachment A. This flood would result in **minor**, localized flooding of the Clinton Creek access road and would temporarily cut off access to properties at the old Clinton Creek townsite. Impact to the environment would be dependent on the size of localized bank failures during the event. Erosion and transportation of natural bed material is considered low consequence since it is a natural process. The conclusion is that even though this event is rare or unlikely, it has only **minor consequences**. Other scenarios are classified based on this benchmark.
2	CC1	Flood induced breach of CC1.	The design standard for CC1 flows is the IDF. As such, the probability of this event occurring is even less than the IDF which has an annual probability somewhere in the region of 1 in 50,000. The conclusion is that this is a **non-credible** or **very rare** event.	The inundation zone for Scenario 2 is shown on Figures A1 to A4 and the flood depth, including flooding along the road is shown on Figures B1 to B4 in Attachment A. This scenario would result in the loss of the spillway, downcutting through the spillway foundation to an uncertain depth. Depth of flooding on the road would likely be sufficient to cause significant erosion. It would likely result in loss of **marginal** habitat. Restoration of Hudgeon Lake would be **possible** at a very high cost. Restoration of the channel downstream is possible. Sediment, shown on Figure D1 to D4 in Attachment A, will be deposited in a number of areas, including some lengths of access road. In some localized areas, significant deposition of sediment will result in sediment depths greater than 5 m in places, which will be expensive to excavate. In locations where the area of inundation is wider, sediment may be deposited over a 150 m wide area. Rapid drawdown of Hudgeon Lake could potentially cause slope instabilities in the surrounding hillsides and the remaining waste rock pile. For this reason, this event is considered to have **moderate consequences**.
3	CC1	Sunny Day breach of CC1.	The likelihood of this occurring is considered **non-credible** or **very rare** since the whole design intent of this option is to stabilize the impoundment, side slopes and to prevent this from occurring.	This scenario would result in the loss of the spillway, downcutting through the spillway foundation to an uncertain depth. Depth of flooding on the road would likely be sufficient to cause **significant** erosion. It would likely result in loss of **marginal** habitat and restoration of Hudgeon Lake would be unlikely or come at a very high cost. Rapid drawdown of Hudgeon Lake could potentially cause slope instabilities in the surrounding hillsides and the remaining waste rock pile. For this reason, this event is considered to have **moderate** consequences.
4	CC1A	Sunny Day. Seismic induced secondary dam caused by landslide downstream of CC1A inlet.	This side slope failure assumes ground acceleration from a 1 in 2,475 earthquake at the site. This event has a 2% chance of occurring in a 50-year period and is the consistent with the seismic design standard in the National Building Code of Canada. This event has a 3% chance of occurring during the lifespan of an average Yukoner. Given the frequency of monitoring trips to the site, the on site, remote access cameras and the likely response time for a response team to get to site (YG advised less than a week), the conclusion is that this scenario is a **rare** event.	The inundation zone for this scenario is shown in Figures A1 to A4 and the flood depth, including flooding along the road is shown on Figures C1 to C4 in Attachment A. This scenario would result in the loss of the spillway, downcutting through the spillway foundation to an uncertain depth. Depth of flooding on the road would likely be sufficient to cause significant erosion. It would likely result in **significant loss of habitat or traditional use** and restoration of Hudgeon Lake would be unlikely or come at a very high cost. Sediment, shown on Figure E1 to E4 in Attachment A, will be deposited in a number of areas, including some lengths of access road. In some areas, significant deposition of sediment will result in sediment depths in the 5 to 20 m range, which will be expensive to excavate. In locations where the area of inundation is wider, sediment may be deposited over a 200 m wide area. Rapid drawdown of Hudgeon Lake could potentially cause slope instabilities in the surrounding hillsides and the remaining waste rock pile. For this reason, this event is considered to have **major consequences**. Assuming that mitigative measures were not applied after the landslide dam occurred, which could then reduce consequences.
5	CC1A	Sunny Day. Seismic induced secondary dam caused by landslide	This scenario simulates a smaller seismic induced landslide which could overtop before YG are able to undertake mitigative measures to prevent an uncontrolled breach. It assumes two weeks of filling behind a landslide dam in May (freshet) before	Similar peak flow rates and consequences to Scenario 2. Considered to also have **moderate** consequences for the Clinton Creek valley. Sediment deposition is to Scenario 2, although the reduction in total flow volume in this Scenario results in less sediment being transported as far as the confluence with Fortymile River.

[11] https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310040901.

Scenario	Reclamation Option	Spillway and Inflow Condition	Commentary on Likelihood	Consequence
		downstream of CC1A inlet.	overtopping. This has an estimated chance of occurring of 1 in 30,000 in a given year (1/2425/12). On this basis, the conclusion is that this is an **unlikely** event.	
6	CC2	Flood induced breach of CC2.	The design standard for CC2 flows was the IDF. As such, the probability of this event occurring is even less than the IDF. The conclusion is that this is a **non-credible** or **very rare** event.	The extent of damage for this breach would be slightly more than Scenario 1. This flood would result in **minor, localized flooding** of the Clinton Creek access road and would temporarily cut off access to properties at the old Clinton Creek townsite. The flood induced failure of CC2 would require a flood in excess of the IDF and as such, it is unlikely that there would be recreationists in the area due to the extreme weather. Loss of life would be the result of an unforeseeable misadventure. Depending on the transport of material underlying the displaced riprap, there could be permanent loss of some habitat areas immediately downstream of the failure unless significant sums of money are spent to remove the debris and restore the channel. For this reason, the failure is considered to have **minor** consequences.
7	CC2	Sunny day breach of CC2.	The design concept of the channel was to practically eliminate the potential for a dam breach by lowering the lake outlet to 401 m and armouring the channel with riprap. The resultant downstream channel gradient was reduced sufficiently to create a stable outlet channel to Hudgeon Lake. The conclusion is that this scenario is a **non-credible** or very **rare event**.	This scenario is similar in flood magnitude to the 1 in 1000-year event. The impact of losing the constructed channel is mainly economic. Considering the infrequent and transitory nature of site use, loss of life would be through unforeseeable misadventure. There may be minor flooding in the lowest areas of the road, but it is considered site access could quickly be restored. Some erosion of the banks and channel could be expected but would be relatively **minor** compared to other scenarios. Typically, sediment deposition would occur on the banks of Clinton Creek. Sediment depths are typically under 1 m but may be up to 5 m in some localized locations. Though the optics of the failure of the constructed channel would not be good, the consequences of this failure are considered to be **minor**.
8	CC2A	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	This side slope failure assumes ground acceleration from a 1 in 2475 earthquake at the site. This event has a 2% chance of occurring in a 50-year period and is the consistent with the seismic design standard in the National Building Code of Canada. This event has a 3% chance of occurring during the lifespan of an average Yukoner. Given the frequency of monitoring trips to the site, the on-site, remote access cameras and the likely response time for a response team to get to site (YG advised less than a week), the conclusion is that this scenario is a **rare** event.	Similar consequences to Scenarios 2 and 5. A failure similar to this scenario could have **major** consequences for the Clinton Creek valley.
9	CC2A	Sunny day. Seismic induced secondary dam caused by landslide downstream of CC2A inlet.	This scenario simulates a smaller seismic induced landslide which could overtop before YG are able to undertake mitigative measures to prevent an uncontrolled breach. It assumes two weeks of filling behind a landslide dam in May (freshet) before overtopping. This has an estimated chance of occurring of 1 in 30,000 in a given year (1/2475/12). On this basis, the conclusion is that this is an **unlikely** event.	Consequences from this scenario would be similar to Scenario 6. This flood would result in **minor, localized flooding** of the Clinton Creek access road and would temporarily cut off access to properties at the old Clinton Creek townsite. In terms of risk to life, this scenario requires a major seismic event and at least two weeks without intervention by Yukon Government to mitigate the risk. It is therefore concluded the consequences to life from this breach scenario would be **low**. Depending on the transport of material underlying the displaced riprap, there could be permanent loss of some habitat areas immediately downstream of the failure unless significant sums of money are spent to remove the debris and restore the channel. For this reason, the failure is considered to have **minor** consequences.
10	Existing channel and spillway	No breach. 1 in 1000 year (0.1% AEP).	The probability of this event occurring in a given year is 0.1% (1 in 1000); however, consideration needs to be given to the seasonal nature of fluvial flooding at the site. During winter months this flood could be considered **non-credible/very rare** due to very	No significant impact to infrastructure, fish or other wildlife. Part of the natural flood cycle in Clinton Creek except for elevated sediment transport from erosion of the waste rock pile which is an unnatural feature. This scenario is considered to have **minor** consequences.

Scenario	Reclamation Option	Spillway and Inflow Condition	Commentary on Likelihood	Consequence
			cold winter temperatures. The event is most likely during summer months when access to the site is most likely in demand. This event is considered **unlikely** to **likely**; depending on the exposure time at the site.	

Table 12: Consequence Assessment – Wolverine Creek

Scenario	Reclamation Option	Spillway and Inflow Condition	Commentary on Likelihood	Consequence
1	None	Sunny day.	This scenario simulates a seismic or static failure landslide of the South Tailings pile, blocking Wolverine Creek. Given the frequency of monitoring trips to the site, the on-site, remote access cameras and the likely response time for a response team to get to site (YG advised less than a week), the conclusion is that this scenario is a **rare** event.	The inundation zone for Scenario 1 is shown on Figures F1 to F4 in Attachment A. The dam breach would result in localized flooding of the access road in two or three locations, with flood depths at the peak of the flood wave being below 0.5 m is most locations, except in one location where depths of 2-4 m may occur. Sediment deposition would primarily occur at the confluence of Wolverine Creek with Clinton Creek, with sediment depths of in the 5 m to 20 m range in some places. Sediment deposition, shown in Figure G1 to G4 in Attachment A, would occur in the Clinton Creek valley within the area of inundation, although sediment depths are anticipated to be below 1 m in most locations. Tailings may be transported as far downstream as the Yukon River, in relatively small quantities Habitat loss in the area of sediment deposition is likely, unless restoration efforts are undertaken to remove the debris. Rapid drawdown of the water level in Wolverine Creek may result in instability of the surrounding hillsides, or of the Wolverine Creek Tailings Dump. Since this is a theoretical landslide dam, no recommendations are given for dam classification in Section 5.
2	None	Sunny day.	This scenario simulates a seismic or static failure landslide of the South Tailings pile, blocking Wolverine Creek. Given the frequency of monitoring trips to the site, the on-site, remote access cameras and the likely response time for a response team to get to site (YG advised less than a week), the conclusion is that this scenario is a **rare** event. Although the formation of a larger landslide dam is possible, up to 450 to 460 m, filling scenarios where time of filling is greater than one month have been excluded as they are considered to be 'non-credible'. This is because it would be a product of a series of low probability events: a slope failure would need to occur, with the landslide completely blocking valley, remaining undetected for a long period of time). In addition, even if no intervention occurred, failure of a 460 m dam may occur due to internal erosion, well before the reservoir water level reaches the dam crest.	The inundation zone for Scenario 1 is shown on Figures F1 to F4 in Attachment A. The dam breach would result in localized flooding of the access road in a handful of locations, Flow depths over the road are anticipated to be below 0.5 m during the peak of the flood wave, although depths of 2-4 m may occur in one location. Sediment deposition would primarily occur at the confluence of Wolverine Creek with Clinton Creek, with sediment depths in the 5 m to 20 m range in some places. Sediment deposition, shown in Figure H1 to H4 in Attachment A, would occur in the Clinton Creek valley within the area of inundation, continuing to the confluence with Fortymile River, although sediment depths are anticipated to be below 1 m in most locations. Tailings may be transported as far downstream as the Yukon River, in relatively small quantities. Habitat loss in the area of sediment deposition is likely, unless restoration efforts are undertaken to remove the debris. Left for this length of time, rapid drawdown of the water level in Wolverine Creek may result in instability of the surrounding hillsides, or of the Wolverine Creek Tailings Dump. Since this is a theoretical landslide dam, no recommendations are given for dam classification in Section 5.

Scenario	Reclamation Option	Spillway and Inflow Condition	Commentary on Likelihood	Consequence
3	None	IDF or Sunny day.	In the event of an IDF flood, the breach of this small impoundment is considered likely under current conditions. A breach under sunny day conditions is considered a rare event. The existing dam is formed from a landslide and has not undergone any design or stabilization, so may be vulnerable to either static or seismic failure.	Height of the existing landslide dam is low, around 2 or 3 m high, and storage volume is in the order of 200,000 m^3 (for comparison, this is equal to about 3 or 4 days of freshet inflow from the Wolverine Creek catchment area. Downstream consequences of a breach of the existing landslide would be similar to those experienced from a 1 in 10 AEP storm event in Wolverine Creek, or from a more regular storm event in Clinton Creek. Given the volumes of water involved, sediment erosion and downstream transportation of sediment would be **minor**.

DRAFT

5.0 Proposed Dam Classification

5.1 Proposed Dam Classification

It is the responsibility of the owner to agree an appropriate dam classification with the regulator. The CDA guidelines recommend a classification system based on assessment of consequences. Consequences of a dam failure may include loss of life, property and environmental damage, and general disruption of the lives of the population in the inundated area. In Clinton Creek, the release of anoxic lake water, hydrogen sulfide (H_2S), accumulated silt or eroded waste rock could also have detrimental environmental effects, including impacts on aquatic habitat. Table 10 describes the CDA guidelines for dam classification based on failure consequence.

Previous studies by TetraTech EBA (Tetra Tech EBA, 2016) and Wood (Wood, 2019) concluded that the existing landslide dam that impounds Hudgeon Lake should be classified as a "Significant" dam under CDA guidelines based on the following assumptions:

- There is no permanent population at risk;
- The habitat at risk is marginal and could be restored; and
- Only recreational facilities, seasonal workplaces, and infrequently used transportation routes are at risk.

Under this study, Wood modelled a number of scenarios that were intended to simulate what might happen if seismic events caused new landslide dams that overtopped and failed without the Owner taking action to mitigate the risk. These scenarios were related to alternative designs on Clinton Creek and for the Wolverine Creek tailings lobes. For these scenarios, Wood does not provide a recommendation on dam classification.

Wood's recommendations for dam classification can only be made in this scope of work for CC1 and CC2. Other reclamation options either result in the removal of impoundments or, as is the case for WC1, in failure modes that relate to new, seismic induced landslide dams.

Based on the analysis undertaken and CDA Table 2-1, Wood recommends that a dam classification of "Significant" be adopted for CC1 for the following reasons:

- Long sections of the access road would be inundated to a considerable depth if CC1 were to breach as shown in Scenario 2 - Figures B1 to B4. There would likely be considerable damage to this infrequently used transportation route.
- Except for infrequent transits of the site via the access road, there is no identifiable population at risk in the flooded area. Given the short transit times through the

inundation zone, loss of life could be considered to be through "unforeseeable misadventure".

- The habitat at risk is marginal and restoration is possible
- Access to the former Clinton Creek townsite would be temporarily cut-off

For hydrotechnical design Wood recommends that a dam classification of "Low" is adopted for CC2 for the following reason:

- Only very short sections of the access road are flooded as shown in Figure A3 and Figure A4. These should be easily avoidable in flood conditions. Access to the former town site would be temporarily cut-off with potential damage to the ford but there would be only minor damage to sections of flooded access road.
- Except for infrequent transits of the site via the access road, there is no identifiable population at risk in the flooded area. Given the very short transit times through the inundation zone, loss of life could be considered to be through "unforeseeable misadventure".
- The incremental difference in flow rate between Scenario 1 (IDF no breach) and a breach of CC2 is only approximately 25% immediately downstream of the lake.

5.2 Dam Safety Review Requirements

A Dam Safety Review (DSR) is a systematic review and evaluation of all aspects of design, construction, maintenance, operation, processes and systems affecting a dam's safety including the dam safety management system. The frequency of DSR depends on the consequences of failure, the presence of, or changes in, external hazards, the results of surveillance (inspections) and demonstrated performance. The associated DSR frequency for CC1 and CC2 is given in Table 13.

DRAFT

Table 13: Proposed Dam Classification and Associated Inflow Design Flood

Closure Option	Proposed Dam Classification	CDA Inflow Design Flood (Passive Care)	Passive Care IDF (m^3/s)	CDA Inflow Design Flood (Active Care)	Active Care IDF (m^3/s)	DSR Frequency (years)
CC1	Significant	1/3 between 1/1000 and PMF	357	Between 1/100 and 1/1000	59.9 to 87.2	10
CC2	Low	Between 1/100 and 1/1000	59.9 to 87.2	1/100	59.9	Not required[12]

6.0 Recommendations

Dam classification is an evolutionary process that depends on consequence factors as described in Table 10. The present study is not intended to be the final word on dam classification for reclamation options at the site. It is meant to inform the decision-making process for concept select. The following dam classification recommendations should therefore be considered interim:

- For options select purposes and for hydrotechnical design, Wood recommends that CC1 be given a classification of "Significant" under CDA guidelines.
- For options select purposes and for hydrotechnical design, Wood recommends that CC2 be given a classification of "Low" under CDA guidelines.
- Yukon Government should obtain a complete LiDAR dataset for the Clinton Creek valley.
- At the 30% design stage, the DBA should be revisited with the complete LiDAR dataset and the mapping results should be confirmed with the more accurate complete dataset.
- Future changes in site use not contemplated at this time may necessitate the re-evaluation of consequence.

7.0 Closure

This memo has been prepared for the exclusive use of the Government of Yukon for specific application to the area covered by this memo. Any use that a third party makes of this memo and any reliance on, or decisions made based on it are the responsibility of such third parties. Wood accepts no responsibility for damages, if any, suffered by any third party as a result of

[12] A DSR is required if the consequence classification changes due to downstream development

decisions made or actions taken based on this memo. The report has been prepared in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

Geoff Graham, P.Eng.
Associate Water Resources Engineer

Reviewed by:

Lloyd Madge, P.Eng.
Associate Water Resources Engineer

Timothy Ambler, M.Eng. C.Eng. (UK)
Water Resources Specialist

List of Attachments

Attachment A –Figures

Clinton Creek
Figure A: Flood Inundation Extent Maps - Scenarios 1, 2 & 4
Figure B: Flood Depth Maps – Scenario 2
Figure C: Flood Depth Maps – Scenario 4
Figure D: Sediment Transport Maps – Scenario 2
Figure E: Sediment Transport Maps – Scenario 4

Wolverine Creek
Figure F: Flood Inundation Extent Maps - Scenarios 1 & 2
Figure G: Sediment Transport Maps Scenario 1
Figure H: Sediment Transport Maps Scenario 2

DRAFT

8.0 References

Wood, 2019. *Clinton Creek Remediation Project - Dam Breach Assessment*. November 2019.
Wood, 2019a. *Clinton Creek Remediation Project – 10% Design Phase Report*. November 2019.

DRAFT

Attachment A

Figures

DRAFT

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Scenario 1
Scenario 2
Scenario 4
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Extents Scenarios 1, 2 and 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure A-1

R:\General\PROJECT\VE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig A.4maps S1-2-4.mxd 21-06-01 3:23:22 PM ANALYST: trevor.robertson

516000

517000

518000

7144000

Clinton Creek

Clinton Creek Site Access Road

Scenario 1
Scenario 2
Scenario 4
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Extents Scenarios 1, 2 and 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure A-2

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig A.4maps S1-2-4.mxd ANALYST: trevor.robertson 21-06-01 3:23:28 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Scenario 1
Scenario 2
Scenario 4
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Extents Scenarios 1, 2 and 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure A-3

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig A-4maps S1-2-4.mxd ANALYST: trevor.robertson 21-06-01 3:23:32 PM

513000

514000

515000

7147000

7146000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Scenario 1
Scenario 2
Scenario 4
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Extents Scenarios 1, 2 and 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure A-4

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig A-4maps S1-2-4.mxd 21-06-01 3:23:35 PM ANALYST: trevor.robertson

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Roads

Scenario 2
Inundation Extent

Road Corridor Flood Depth (m)

>0 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth Scenario 2 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure B-1

R:\General\PROJECT\VE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig B 4maps FIDep2.mxd ANALYST: trevor.robertson 21-06-02 12:13:39 PM

516000 517000 518000

7144000

Clinton Creek

Clinton Creek Site Access Road

Roads
Scenario 2
Inundation Extent
Road Corridor Flood Depth (m)
>0 - 1
>1 - 5
>5

516000 517000 518000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth Scenario 2 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure B-2

R:\General\PROJECTS\EVE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig B 4maps FlDep2.mxd ANALYST: trevor.robertson 21-06-02 12:13:53 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Roads
Scenario 2
Inundation Extent
Road Corridor Flood Depth (m)
>0 - 1
>1 - 5
>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth
Scenario 2
Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June
2021

Figure B-3

R:\General\PROJECTVE\E52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig B 4maps FlDep2.mxd ANALYST: trevor.robertson 21-06-02 12:14:01 PM

513000 514000 515000

7147000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

7146000

Roads
Scenario 2
Inundation Extent
Road Corridor Flood Depth (m)
>0 - 1
>1 - 5
>5

513000 514000 515000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth Scenario 2 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure B-4

R:\General\PROJECT\EVE527705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig B 4maps FlDep2.mxd 21-06-02 12:14:45 PM ANALYST: trevor.robertson

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Roads

Scenario 4
Inundation Extent

Road Corridor Flood Depth (m)

>0 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth
Scenario 4
Clinton Creek

0 100 200

Metres
1:7,000

N

wood.

June
2021

Figure C-1

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig C 4maps FlDep4.mxd ANALYST: trevor.robertson 21-06-02 2:47:14 PM

516000 517000 518000

7144000

Clinton Creek

Clinton Creek Site Access Road

Roads
Scenario 4
Inundation Extent
Road Corridor Flood Depth (m)
>0 - 1
>1 - 5
>5

516000 517000 518000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth
Scenario 4
Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure C-2

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig C 4maps FlDep4.mxd ANALYST: trevor.robertson 21-06-02 2:47:31 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Roads
Scenario 4
Inundation Extent
Road Corridor Flood Depth (m)
>0 - 1
>1 - 5
>5

R:\General\PROJECTVELVE\52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig C 4maps FlDep4.mxd ANALYST: trevor.robertson 21-06-02 2:47:43 PM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth Scenario 4 Clinton Creek

0 100 200 Metres 1:7,000

N

wood.

June 2021

Figure C-3

513000

514000

515000

7147000

7146000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Roads

Scenario 4
Inundation Extent

Road Corridor Flood Depth (m)

>0 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Depth Scenario 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure C-4

R:\General\PROJECT\EVE527705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig C-4maps FlDep4.mxd ANALYST: trevor.robertson 21-06-02 2:48:50 PM

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 2
Clinton Creek

0 100 200 Metres 1:7,000

N

wood.

June 2021

Figure D-1

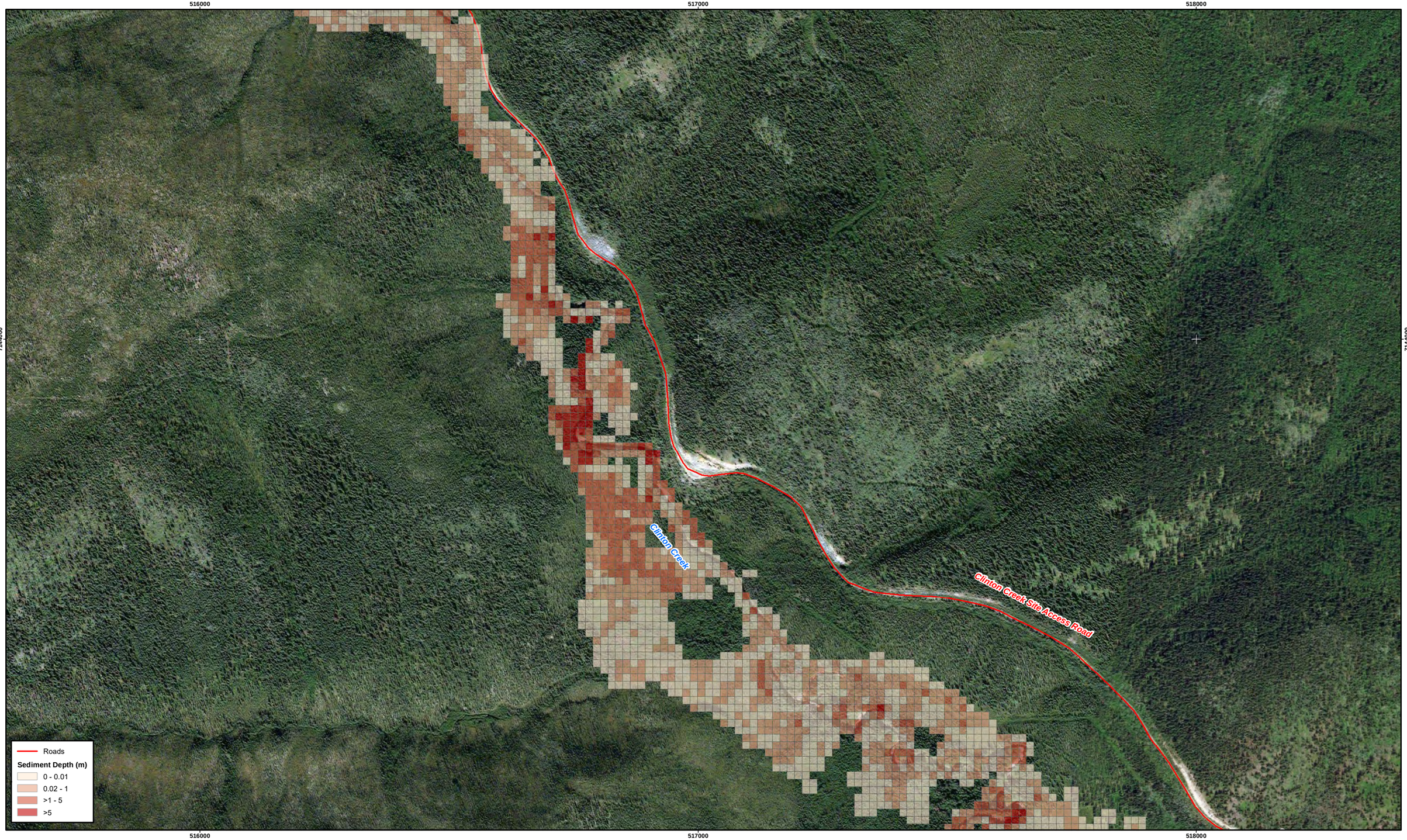
R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig D 4maps SedT2.mxd ANALYST: trevor.robertson 21-06-01 3:26:39 PM

516000

517000

518000

7144000



516000

517000

518000

7144000

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig D 4maps SedT2.mxd ANALYST: trevor.robertson 21-06-01 3:26:52 PM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 2 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure D-2

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 2 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure D-3

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig D 4maps SedTr2.mxd ANALYST: trevor.robertson 21-06-01 3:27:04 PM

513000 514000 515000

7147000

7146000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 2
Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June
2021

Figure D-4

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig D 4maps SedT2.mxd ANALYST: trevor.robertson 21-06-01 3:27:15 PM

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 4 Clinton Creek

0 100 200

Metres
1:7,000

N

wood.

June 2021

Figure E-1

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig E 4maps SedT4.mxd ANALYST: trevor.robertson 21-06-01 3:32:03 PM

516000

517000

518000

7144000

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure E-2

R:\General\PROJECTVEVE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig E 4maps SedTr4.mxd ANALYST: trevor.robertson 21-06-01 3:32:17 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 4 Clinton Creek

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure E-3

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig E 4maps SedT4.mxd ANALYST: trevor.robertson 21-06-01 3:32:30 PM

513000 514000 515000

7147000

7146000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 4 Clinton Creek

0 100 200
Metres
1:7,000

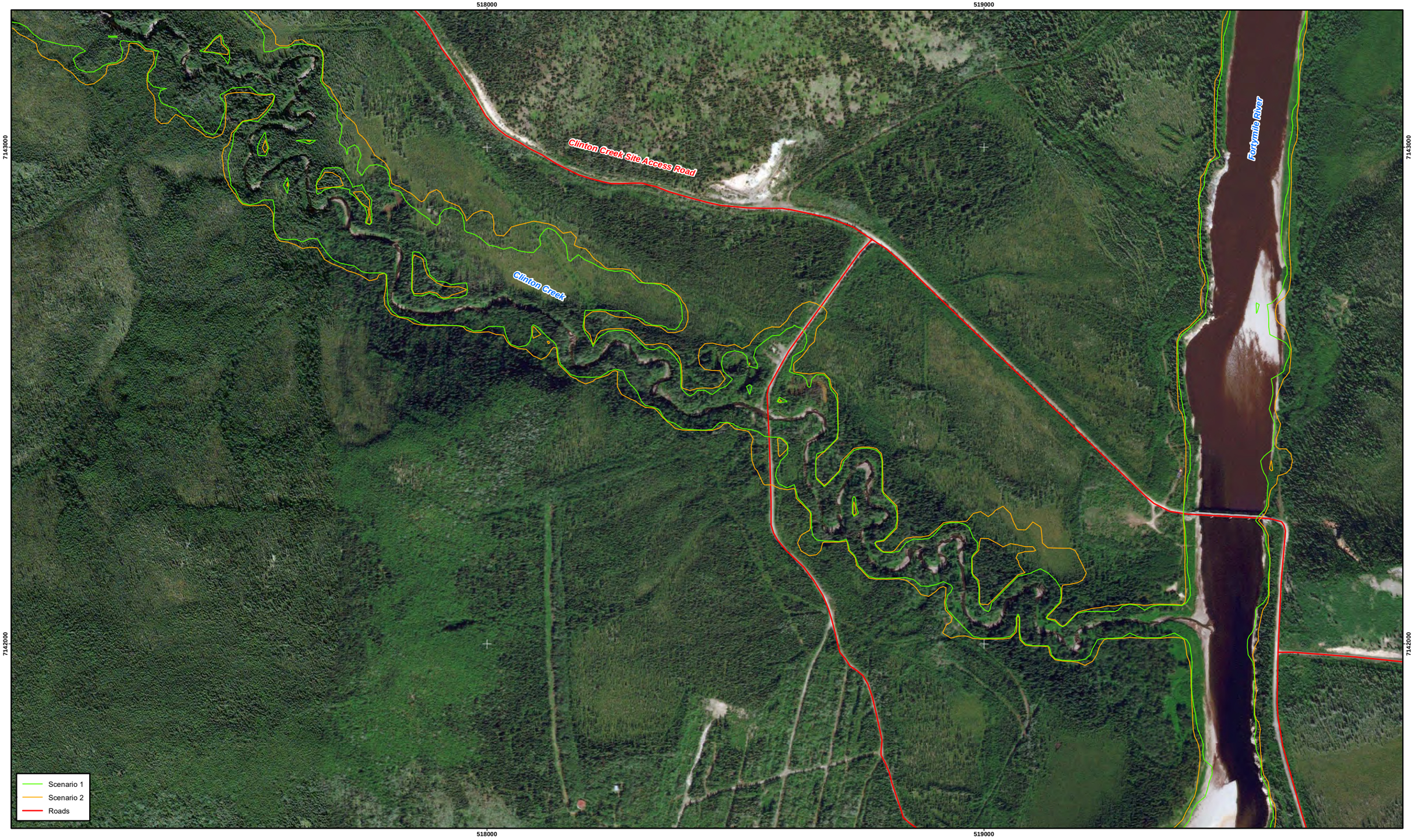
N

wood.

June 2021

Figure E-4

R:\General\PROJECT\EVE527705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig E 4maps SedTr4.mxd 21-06-01 3:32:41 PM ANALYST: trevor.robertson



R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig F 5maps W S1-2.mxd ANALYST: trevor.robertson 21-06-01 3:40:14 PM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Exents Scenarios 1 and 2 Wolverine Creek Breach

0 100 200 Metres 1:7,000

N

wood.

June 2021

Figure F-1

516000

517000

518000

7144000

Clinton Creek

Clinton Creek Site Access Road

Scenario 1
Scenario 2
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Exents Scenarios 1 and 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure F-2

R:\General\PROJECT\EVE\27705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig F 5maps W S1-2.mxd ANALYST: trevor.robertson 21-06-01 3:40:26 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Scenario 1
Scenario 2
Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Exents Scenarios 1 and 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure F-3

R:\General\PROJECTVELVE\52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig F 5maps W S1-2.mxd ANALYST: trevor.robertson 21-06-01 3:40:30 PM

513000 514000 515000

7147000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

7146000

Scenario 1
Scenario 2
Roads

513000 514000 515000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Exents Scenarios 1 and 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure F-4

R:\General\PROJECT\EVE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig F 5maps W S1-2.mxd ANALYST: trevor.robertson 21-06-01 3:40:33 PM

513000

514000

7148000

513000

514000

7148000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Flood Inundation Map Exents Scenarios 1 and 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure F-5

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig F 5maps W S1-2.mxd ANALYST: trevor.robertson 21-06-01 3:40:37 PM

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 1
Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

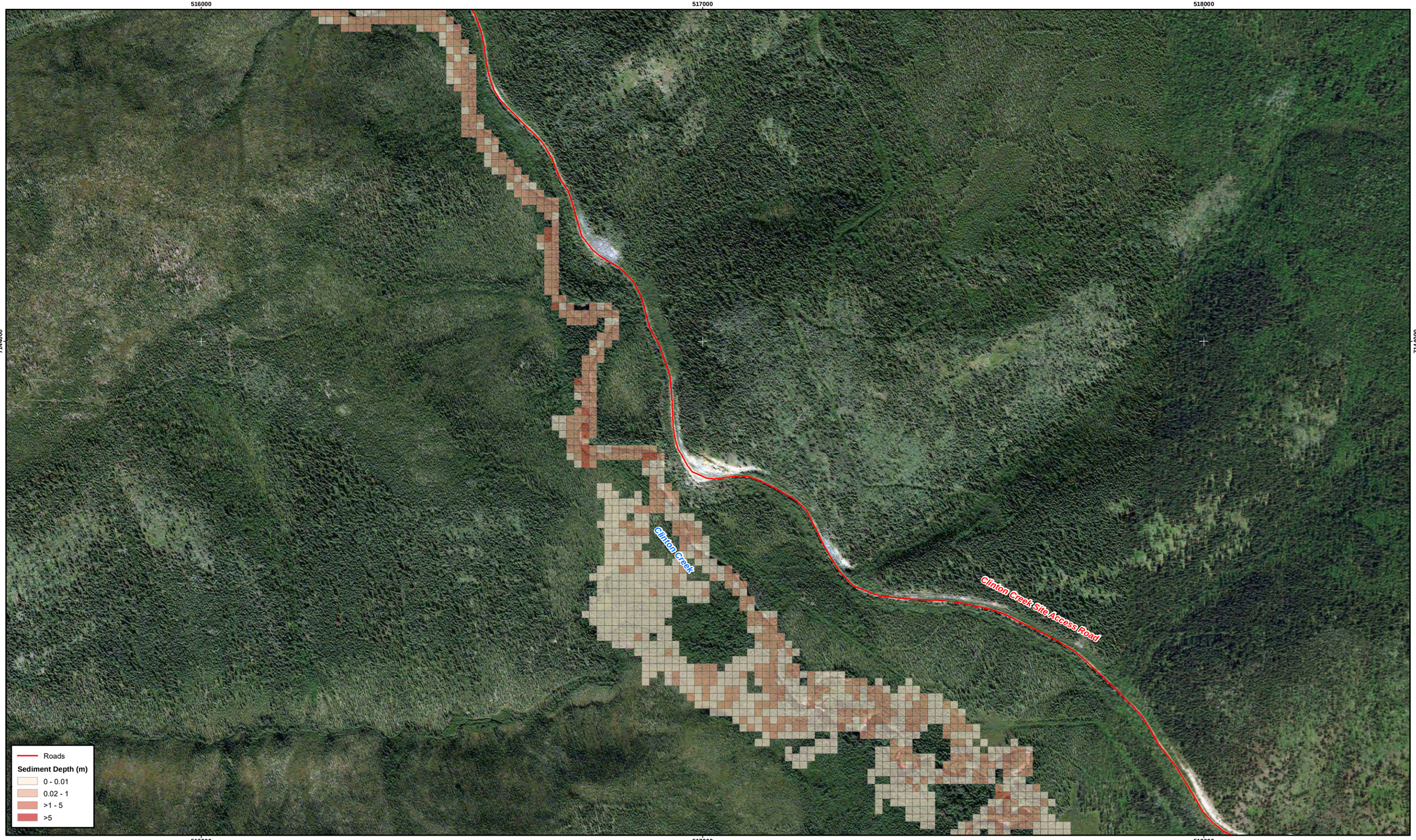
June 2021

Figure G-1

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig G 5maps W SedTr1.mxd ANALYST: trevor.robertson 21-06-01 3:54:22 PM

516000 517000 518000

7144000



516000 517000 518000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 1
Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure G-2

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig G.5maps W SedTr1.mxd ANALYST: trevor.robertson 21-06-01 3:54:28 PM

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 1 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure G-3

R:\General\PROJECTS\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig G 5maps W SedTr1.mxd ANALYST: trevor.robertson 21-06-01 3:54:35 PM

513000

514000

515000

7147000

7146000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Roads

Sediment Depth (m)

0 - 0.01

0.02 - 1

>1 - 5

>5

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 1 Wolverine Creek Breach

0 100 200

Metres
1:7,000

N

wood.

June 2021

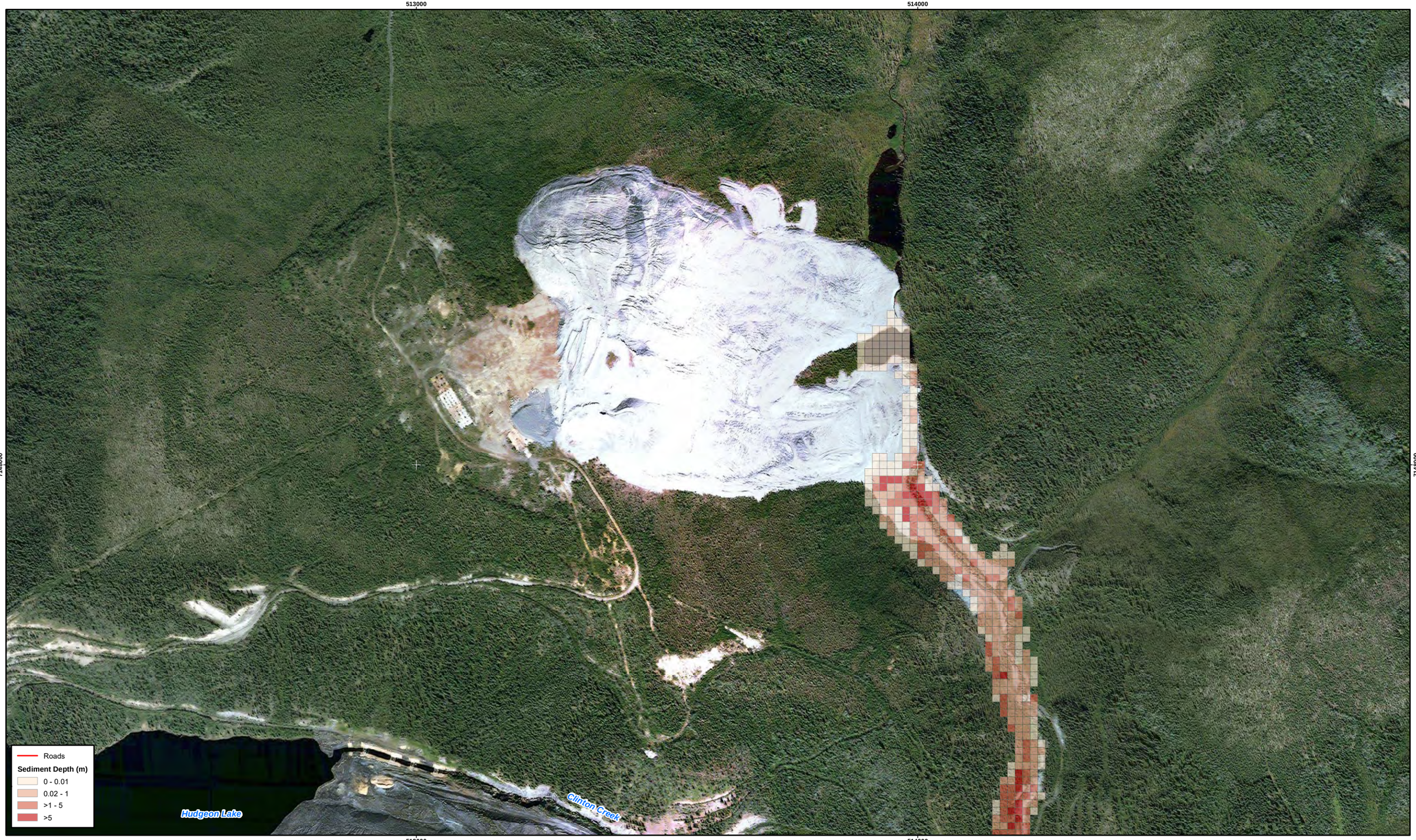
Figure G-4

R:\General\PROJECT\EVE527705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig G 5maps W SedTr1.mxd 21-06-01 3:54:42 PM ANALYST: trevor.robertson

513000

514000

7148000



513000

514000

7148000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 1 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure G-5

R:\General\PROJECT\VE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig G.5maps W SedTr1.mxd ANALYST: trevor.robertson 21-06-01 3:54:49 PM

518000

519000

7143000

7142000

Clinton Creek Site Access Road

Clinton Creek

Fortymile River

Sediment Depth (m)

- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5
- Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 2
Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

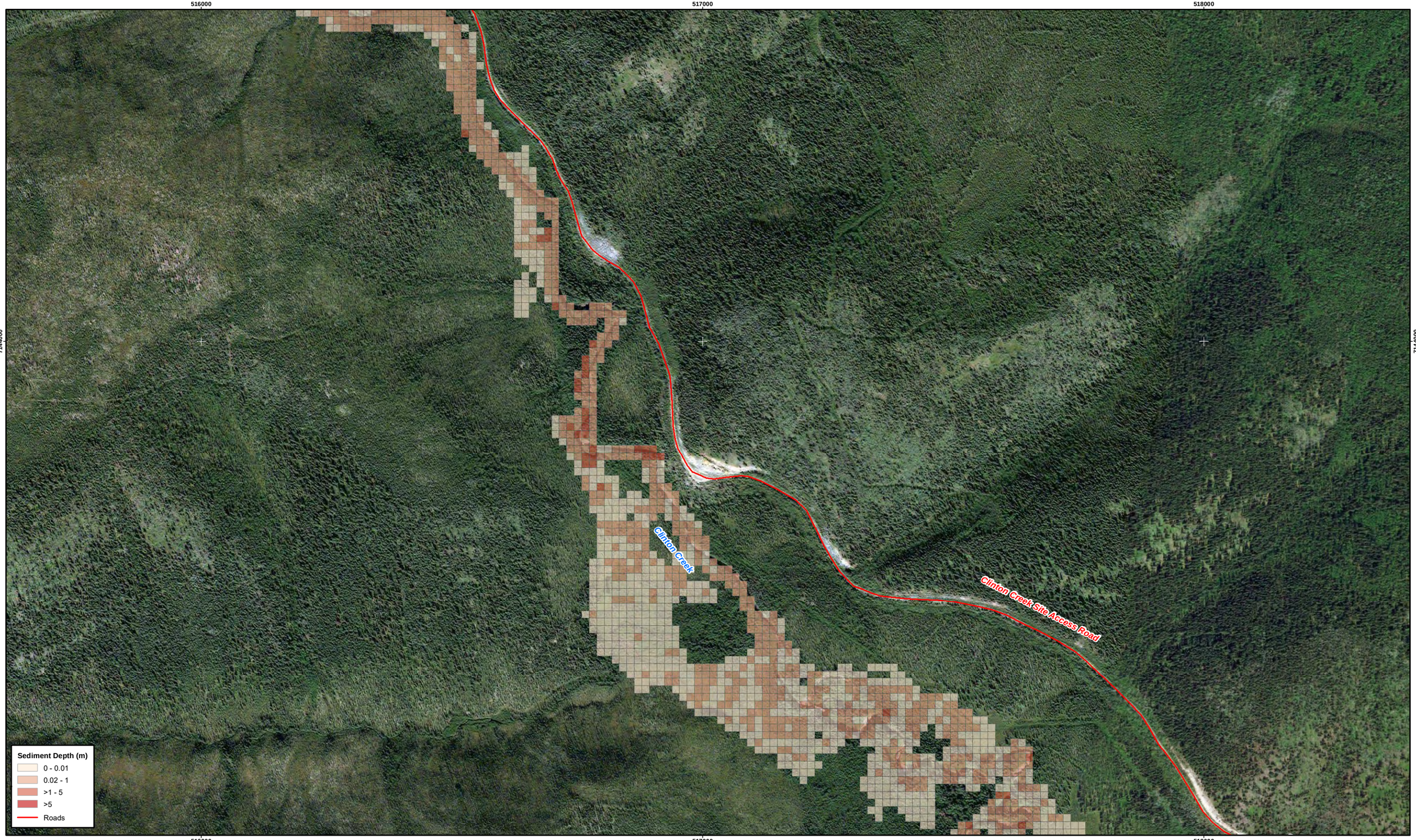
June
2021

Figure H-1

R:\General\PROJECTS\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig H.5maps W Sed Tr2.mxd ANALYST: trevor.robertson 21-06-01 4:03:53 PM

516000 517000 518000

7144000



516000 517000 518000

7144000

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig H 5maps W SedTr2.mxd ANALYST: trevor.robertson 21-06-01 4:04:02 PM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure H-2

515000 516000 517000

7146000

7145000

Clinton Creek

Clinton Creek Site Access Road

Sediment Depth (m)
- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5
- Roads

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

Figure H-3

R:\General\PROJECTVE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig H 5maps W SedT2.mxd ANALYST: trevor.robertson 21-06-01 4:04:11 PM

513000 514000 515000

7147000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Sediment Depth (m)
- 0 - 0.01
- 0.02 - 1
- >1 - 5
- >5
- Roads

7146000

513000 514000 515000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport Scenario 2 Wolverine Creek Breach

0 100 200
Metres
1:7,000

N

wood.

June 2021

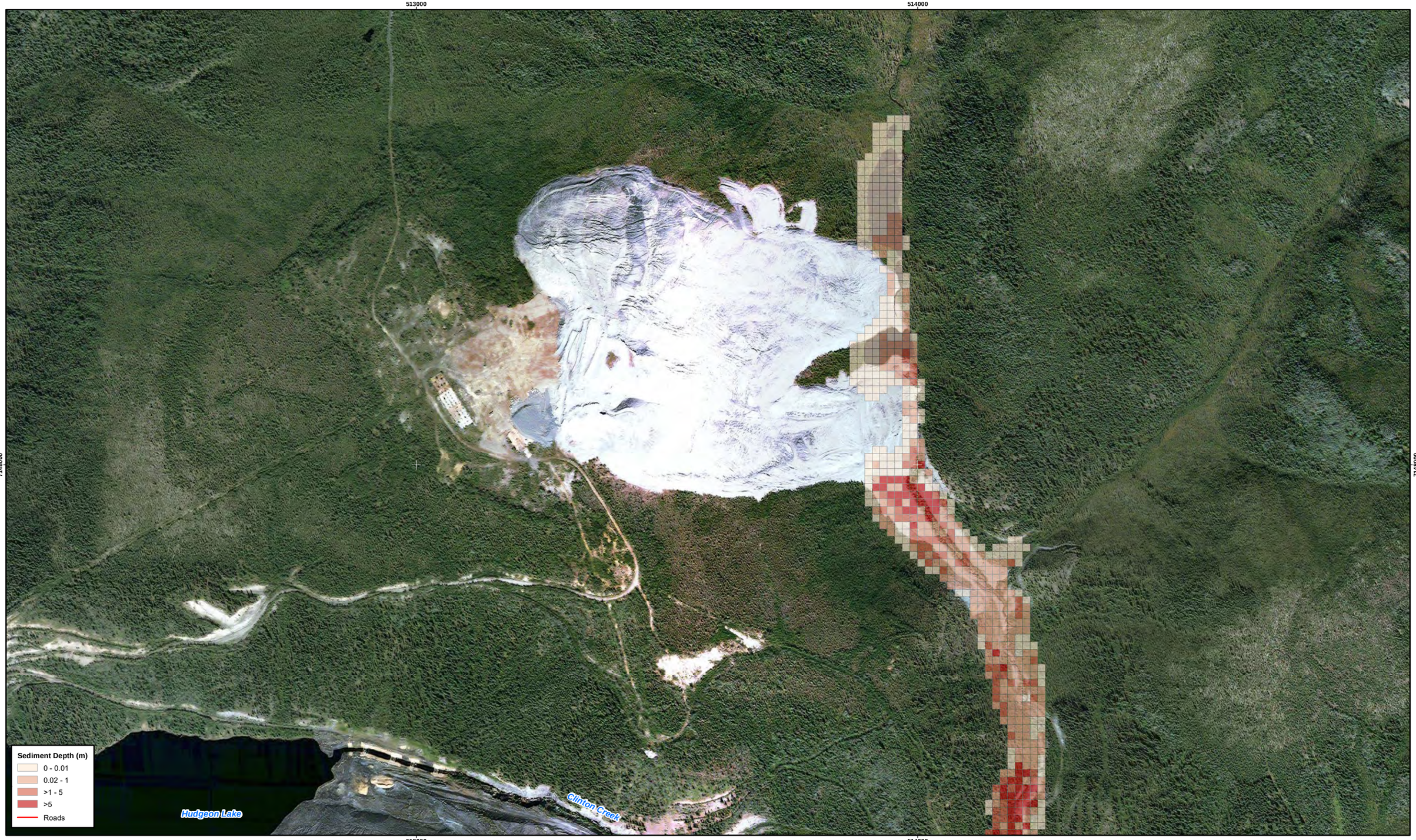
Figure H-4

R:\General\PROJECT\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig H 5maps W SedTr2.mxd ANALYST: trevor.robertson 21-06-01 4:04:20 PM

513000

514000

7148000



513000

514000

7148000

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Index

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

Sediment Transport
Scenario 2
Wolverine Creek Breach

0 100 200 Metres 1:7,000

N

wood.

June 2021

Figure H-5

R:\General\PROJECTS\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\ReportMaps\Fig H 5maps W SedTr2.mxd ANALYST: trevor.robertson 21-06-01 4:04:28 PM

Appendix D
Seismic Runout Assessment

DRAFT

Memo

To:	Yukon Government, Assessment and Abandoned Mines
From:	Jason Chen, P.Eng.
Reviewer:	Ed McRoberts, P.Eng.
Date:	16 September 2021
Ref No.:	VE52705K
Re:	**Clinton Creek Post 10% Design Services – Task 1 Data Gaps Report – Runout Assessment**

DRAFT

1.0 Introduction

Wood previously completed closure concepts of 10% design level on the Clinton Creek Remediation Project located in Yukon (Wood 2019a, 2020). To build on the submitted 10% Designs to close information gaps required to advance to evaluation process, a runout assessment was carried out for Clinton Creek waste pile, and Wolverine Creek tailings dump. This memo summarizes the runout assessment methodology, parameters, and results.

Note that all figures prepared for this study are attached as Attachment A, to this memo in a PowerPoint format and are referred to by the slide numbers.

2.0 Objectives and Methodology

2.1 Objectives

The objectives of the runout assessment include the following:

1. Provide indications of runout distances, immediately following a design seismic event consistent with a closure time frame.
2. Provide estimate of elevations of triggered landslide dams in Clinton Creek and Wolverine Creek.
3. Provide estimate of runout extent for an extreme runout (very low probability) event from Wolverine Creek Tailings Dump.

2.2 Methodology

Previous design analysis primarily focused on defining a stable, no significant movement for the design slopes. This was accomplished by assigning liquefied strength parameters to potentially liquefiable stratigraphical components of both the Clinton Creek landslide dam as well as the asbestos tailings in Wolverine Creek. In order to execute the analysis undrained strength ratios were adopted and the slope conditions suitable for a factor of safety (FoS) of unity determined. The intention at this stage of design was to basically eliminate the threat of seismically induced slope movements. Therefore, the flatter slopes for these design options are not studied herein. Rather, steeper slopes are considered in order to inform possible option selections which might accept the consequences of liquefaction failures. In this regard it is also noted that excavation of steeper slopes might in fact trigger static liquefaction during the construction process.

Modelling of post triggering movements of seismically induced liquefied slopes requires specialized software. For this study, post failure motion modelling software "Dan-W" formulated by Hungr (1995) and HGR (2010) was used to model the runout in a two-dimensional (2D) configuration. This model does not consider the runout potential if a water body lies behind the failed slope and the resulting runouts during reservoir breach. The consequences of reservoir breach runout are presented in Appendix A, to the main cover report.

Representatively steep sections at different locations were selected for the runout modelling. The runout block size of each section was assumed based on previous stability analyses carried out for Clinton Creek Project (Wood 2019b, 2020).

Tables 1 and 2 summarize the adopted materials properties for Clinton Creek and Wolverine Creek runout models, respectively. These model parameters were assumed based on literature review and previous project experience (Slides 3 and 4 of Attachment A). The Hungr (1995) model of frictional rheology requires input of effective dynamic friction angle and pore pressure in the runout mass. The analyses adopted an effective dynamic friction angle of 5.7 degrees for Clinton Creek waste and 4.6 degrees for Wolverine Creek tailings, equivalent to liquefied undrained strength ratios of 0.1 and 0.08, respectively, which were used in the previous stability analyses (Wood 2019b). Based on the material conditions and site conditions, it is considered reasonable that these strength parameters were lower than these obtained from the Elk Valley waste rock back calculation in Hungr et al. (2002). The material properties are required to be assigned in the runout model along the runout for both the dump and the foundation in the toe area. For input to the model, pore pressure ratios (Ru value, defined as the ratio of pore pressure to total overburden stress) were also selected for the runout model. For high mobility runout cases, higher pore pressure ratios of 0.4 to 0.7 were assumed.

Under high mobility cases on certain slope conditions, theoretically runout could run upslope and then migrate back to form landslide dams. Therefore, the maximum runout upslope elevations were shown to demonstrate the maximum limit of potential runout impact area. These model results will help assess the impact to the use of current access roads on the valley slope or near the valley floor. The landslide dams were referring to the final configuration at rest after runout traveling and back migration if any. For the

extreme runout (very low probability) event for the Wolverine Creek, volumetric modelling of assumed runout volume was used, instead of 2D Dan-W modeling to estimate the runout extent in both creeks.

Table 1: Clinton Creek Runout - Adopted Material Properties

Materials	Unit Weight kN/m³	Effective Dynamic Friction Angle, ϕ' (deg)	Pore Pressure Ratio, Ru	Bulk Friction Angle, ϕ (deg)	Internal Friction Angle (deg)
Waste	20	5.7	0.1	5.1	25
Foundation	20	5.7	0.1	5.1	25
Foundation (high mobility)	20	5.7	0.4 and 0.7	3.4 and 1.7	25

Table 2: Wolverine Creek Runout - Adopted Material Properties

Materials	Unit Weight kN/m³	Effective Dynamic Friction Angle, ϕ' (deg)	Pore Pressure Ratio, Ru	Bulk Friction Angle, ϕ (deg)	Internal Friction Angle (deg)
Upper Dump (not liquefied)	20	25	0.1	22.8	33
Upper Dump (high mobility-liquefied)	20	4.6	0.1	4.1	25
Lower Dump and Foundation	20	4.6	0.1	4.1	25

3.0 Scenarios and Results

The following runout model scenarios were assessed:

- Clinton Creek waste pile existing topography.
- Clinton Creek waste pile mitigation options 2020 alternative spillway design.
- Wolverine Creek tailings dump existing topography.

This section presents descriptions of the scenarios and results.

3.1 Clinton Creek Existing Topography Runout Assessment

Several sections were cut through the waste pile existing topography as shown in Slide 5 of Attachment A. Four sections were selected for the runout modelling. The model results are summarized in Table 3 and Slides 1 to 33 of Attachment A. The results indicated:

- the runout distances range from 39 to 352 m depending on slope location, mobility, failure block volume, and slope shapes;
- The resulted landslide dam elevations range from 372 to 428 m depending on section locations with minimum dam heights of 8 to 26 m; and
- the runout upslope elevations on the north slopes range from 395 to 433 m.

3.2 Clinton Creek Alternative Spillway Design Runout Assessment

The Clinton Creek remediation project 10% design (Wood 2019a) selected a peak ground acceleration (PGA) of 0.27 g for the design closure seismic event of 2% in 50 years considering CDA guidance for Closure - Passive Care at a Significant consequence classification. The 2020 alternative design (Wood 2020) follows CDA guidance for Operations at a Low consequence classification with a design PGA of 0.037 g. This Operation Case anticipates that seismic induced failures can occur. The risks of such failures are managed by limitation on site access. The 2020 alternative design considered 4H:1V spillway slopes with and without blast densification. The purpose of blast densification was introduced as a method a controlling static liquefaction during construction. Therefore the 4H:1V slopes of the alternative design are maybe susceptible to instability during the closure seismic event that has a PGA higher than 0.037 g, and a runout event may occur. The runout model results are summarized in Table 4 and Slides 34 to 41 of Attachment A. The results indicated:

- the runout distances range from 75 to 84 m depending on mobility, failure block volume, and slope shapes;
- the resulted landslide dam elevations range from 415 to 427 m depending on section locations with minimum dam heights of 13 to 17 m; and
- the runout upslope elevations on the north slopes range from 423 to 436 m.

3.3 Wolverine Creek Existing Topography Runout Assessment

A section at the South Lobe of the Wolverine Creek Tailings Dump was selected for the runout modelling. The model results are summarized in Table 5 and Slides 42 to 61 of Attachment A. There are two major lobes facing east towards Wolverine Creek and a third section of the asbestos lobe facing approximately north west. All, or one of these lobes may fail either by static loading or seismic. The current FoS under current loading is near unity and shear movements are being observed just below the tailings / insitu ground contact.

DRAFT

In assigning parameters for the analysis, it is considered that most of the tailings will be "dry" during failure and if liquefaction occurs this would be near the contact just above insitu ground. Thus, the mobility of the tailings would be low. And as the current pond impounded by the tailings dam is very small this will have little impact on the runout.

The results of the analysis suggest the following possible scenarios:

- One lobe or more lobes could fail with the runout may block the Wolverine Creek and form a landslide dam which would then impound water upstream of the dam. The elevation of the new dam would depend on the mass moving. However, it would take time for the dam to be overtopped or for internal erosion of the tailings to occur. Therefore, the safety consequences would be limited to a person on the tailings slope.
- It is also possible that the south most tailings lobe could runout down Wolverine Creek. The runout distances range from 135 to 190 m and upslope elevations on the east slope range from 452 to 480 m depending on the likely mobility;
- Generally, the resulted landslide dam elevations range from 436 to 460 m, with a minimum dam height of 30 m;
- The runout may travel along the Wolverine Creek and form deposits in the creek, the runout distance is estimated to be 884 m from dump toe with a runout surface grading of about 5.4%;
- With an exceedingly unlikely mobility case, the 2D model indicates that the runout can travel through Wolverine Creek and enter Clinton Creek. It is emphasized that this is an extreme runout event with very low probability. It would require the entire tailings slope to be saturated, which is considered unlikely as the slopes would have already long since failed in the past, given that the current FoS is slightly above unity. The runout extent on both creeks was estimated for the extreme event, assuming a volume of about 3 million m^3 tailings sourced from the South Lobe of the dump (Slides 57 to 61 of Attachment A).

In conclusion, it is considered extremely unlikely that a design seismic event of closure would cause tailings to reach Clinton Creek immediately post event. However, a landslide dam would form and if control measures were not taken, then an overtopping breach would likely cause asbestos tailings to reach Clinton Creek. Slope deposits could be in the order of 15 to 20 m high near the current slope flattening somewhat with distance.

A no-warning static stability event of the current slope after a wet period (for example) could impact as little as 200 m beyond the current tailings. A no-warning seismic event could impact in the order of 900 m down Wolverine Creek to near the confluence. Slope deposits could be in the order of 20 m high near the current slope flattening somewhat with distance.

Based on the runout assessment, the no-warning runout hazard areas were interpreted for access limits assessment, and are presented separately in the memo titled "Clinton Creek Remediation Project – Risk Management – Access Limits Assessment".

DRAFT

Table 3: Summary of Runout Assessment Results for Clinton Creek

Area	Section	Pore pressure ratio, Ru	Crest Elevation (m)	Dump height (m)	Block Volume (m^3/m)	Pre-runout Base elevation (m)	Landslide Dam Elevation (m)	Max. Run out Distance (m)	Max. Upslope Elevation on north slope (m)
Clinton Creek (existing topo)	1	0.1	448	85	1950	364	372 to 382	299	412
		0.4					372 to 380	322	421
		0.7					372 to 378	352	432
	4	0.1	410	40	1490	370	375 to 384	134	395
	4 (larger block)	0.1	410	40	3100	370	384 to 391	141	401
		0.4					385 to 389	148	407
		0.7					386 to 392	154	412
	7	0.1	424	47	5230	380	397 to 407	100	403
		0.4					397 to 406	104	404
		0.7					397 to 405	110	407
	9	0.1	443	45	2220	398	417 to 422	39	422
	9 (larger block)	0.1	445	47	4520	398	423 to 428	44	428
		0.4					423 to 428	48	432
		0.7					424 to 428	49	433

Table 4: Summary of Runout Assessment Results for Clinton Creek Alternative Closure Design

Area	Section	Pore pressure ratio, Ru	Crest Elevation (m)	Dump height (m)	Block Volume (m^3/m)	Pre-runout Base elevation (m)	Landslide Dam Elevation (m)	Max. Run out Distance (m)	Max. Upslope Elevation on north slope (m)
Clinton Creek (alternative spillway design 4H:1V)	Option CC1-A Sta.0+350	0.1	445	35	2630	410	423 to 427	76	423
		0.7					425 to 427	84	425
	Option CC2-A Sta. 0+400	0.1	445	45	3270	400	417 to 420	75	432
		0.7					415 to 424	80	436

DRAFT

Table 5: Summary of Runout Assessment Results for Wolverine Creek

Area	Section	Pore pressure ratio, Ru	Crest Elevation (m)	Dump height (m)	Block Volume (m^3/m)	Pre-runout Base elevation (m)	Landslide Dam Elevation (m)	Max. Run out Distance (m)	Max. Upslope Elevation on north slope (m)
Wolverine Creek (existing topo)	TS1-liquefied lower portion	0.1	613	187	13800	406	436 to 460	135	452
	TS1 – liquefied entirely							190	480
	TS1 combined with profile	0.1	613	208	13400	368 to 405	468 to 420 (Surface grad. 5.4%)	884	NA
	Extreme Runout (very low probability) Event	Runout expected to travel to Clinton Creek. Assumed 3 million m^3 runout from South Lobe and modelled volumetrically for distribution in Wolverine and Clinton Creeks.							

4.0 Closure

This memo has been prepared for the exclusive use of the Government of Yukon Energy, Mines and Resource Assessment and Abandoned Mines, for the specific application described herein. Any use which a third party makes of this report, or any reliance on or decisions made based on it are the responsibility of such third parties. Wood Environment & Infrastructure Solutions accepts no responsibility for damages suffered by any third party as a result of decisions made or actions based on this memo. It has been prepared in accordance with generally accepted engineering practices. No other warranty, express or implied is made.

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

Jianfeng (Jason) Chen, M.Sc. P.Eng.
Senior Geotechnical Engineer

Reviewed by:

Ed McRoberts, Ph.D., P.Eng.
Principal Geotechnical Engineer

List of Attachments:

Attachment A – Runout Assessment Figures

DRAFT

5.0 References

Hungr Geotechnical Research Inc. (HGR), 2010. DAN-W Release 10. *Dynamic Analysis of Landslides*. User's Manual.

Hungr, O. 1995. *A model for the runout analysis of rapid flow slides, debris flows, and avalanches*. Canadian Geotechnical Journal, 32: 610-623.

Hungr, O., Dawson, R., Kent, A., Campbell, and D., Morgenstern, N.R., 2002. *Rapid flow slides of coal mine waste in British Columbia, Canada*. In: Evans, S.G., DeGraff, J.V. (Eds.), Catastrophic Landslides: Effects, Occurrence and Mechanisms, vol. 15. Geological Society of America, Reviews in Engineering Geology, pp. 191–208.

Wood 2019a. *Clinton Creek Remediation Project, 10% Design Phase Report*. November 2019.

Wood 2019b. *Geotechnical Summary, Clinton Creek Remediation Project, Clinton Creek, Yukon*. December 2019.

Wood 2020. *Clinton Creek Remediation Project, 10% Design Phase – Alternative Designs*. March 2020

DRAFT

Attachment A

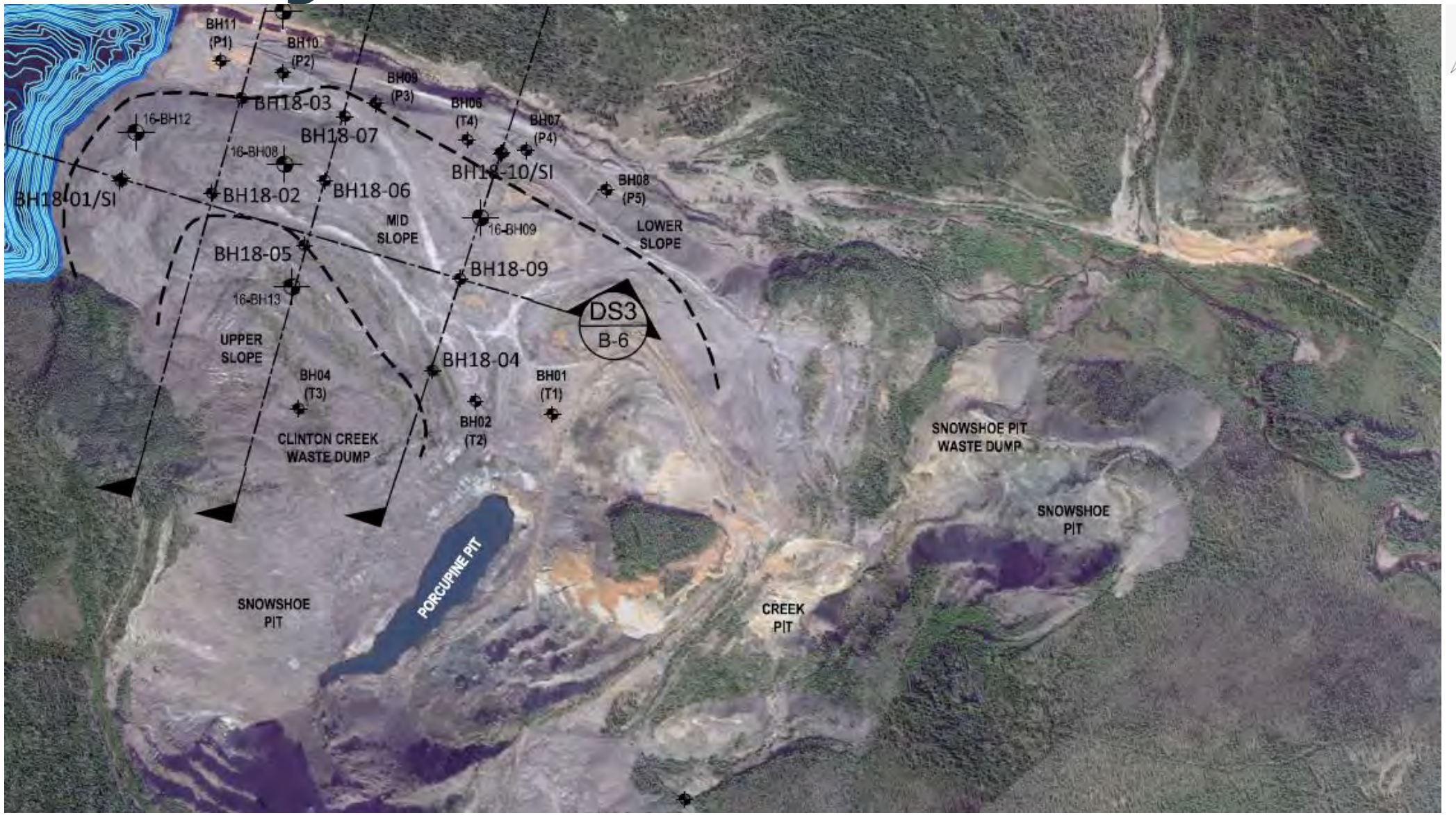
Runout Assessment Figures

DRAFT

Clinton Creek Waste Pile
Existing Topography

wood.

Aerial Image



Elk Valley Coal Mine Waste Dumps
Significant Case Record Used for Calibration by Hungr, et al. 2002

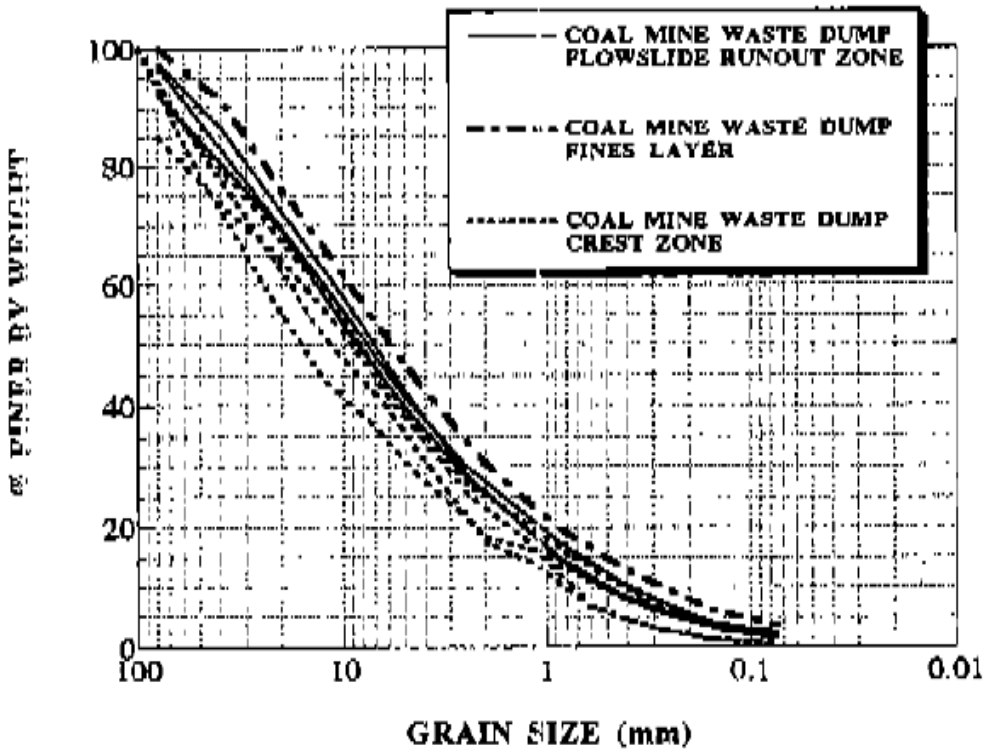


Figure 3. Typical grain-size distribution curves of soil-like coal-mining waste from segregated fine zones in waste pile and from base of flow slide deposits (Dawson and Morgenstern, 1995).

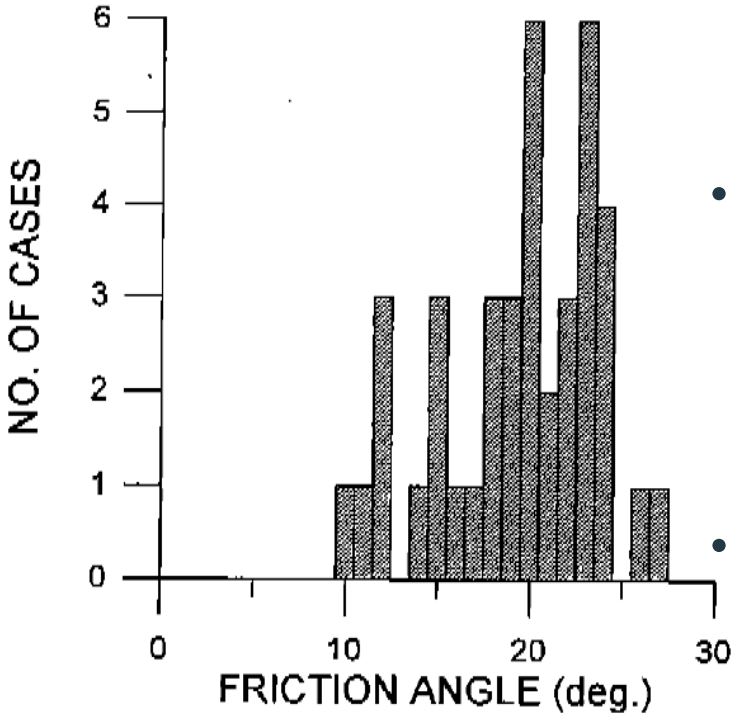


Figure 20. Distribution of bulk friction angles obtained by back calculation, using frictional model.

- Hungr's case record calibrated shows a range of bulk friction angle of 10 to 27 degrees.
- The bulk friction angle, ϕ, is related to the effective dynamic friction angle, ϕ', and pore pressure ratio Ru, as: $\phi=\text{atan}[\tan\phi'(1-Ru)]$.
- In Hungr, et al. 2002, no pore pressure ratio was considered in the back analysis, i.e. Ru=0, and $\phi=\phi'$

wood.

Clinton Creek Waste Pile Material Gradation

Approximate Elk Valley Coal Mine Waste Dump Material Gradation Envelop (Hungr, et al. 2002)

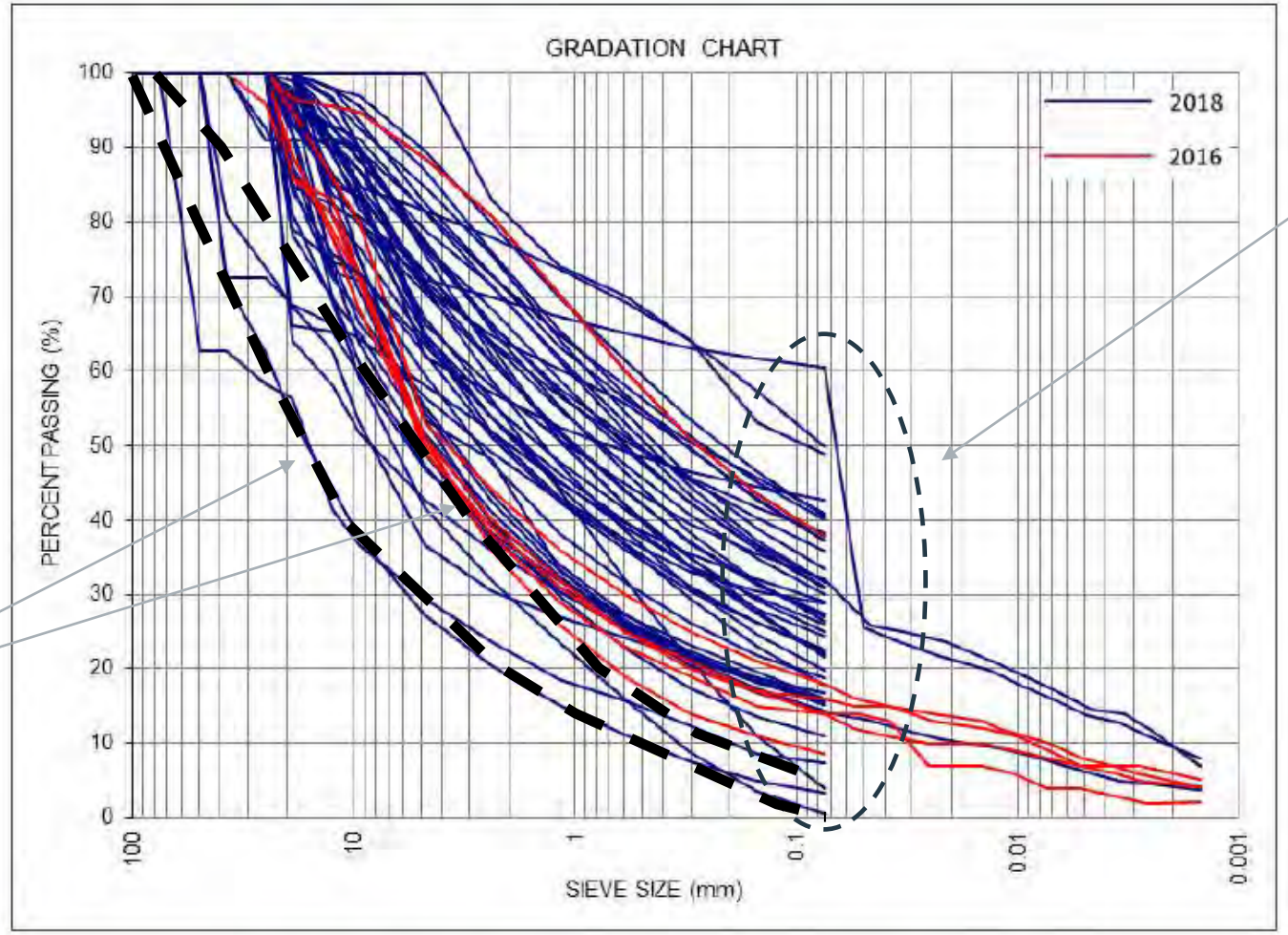


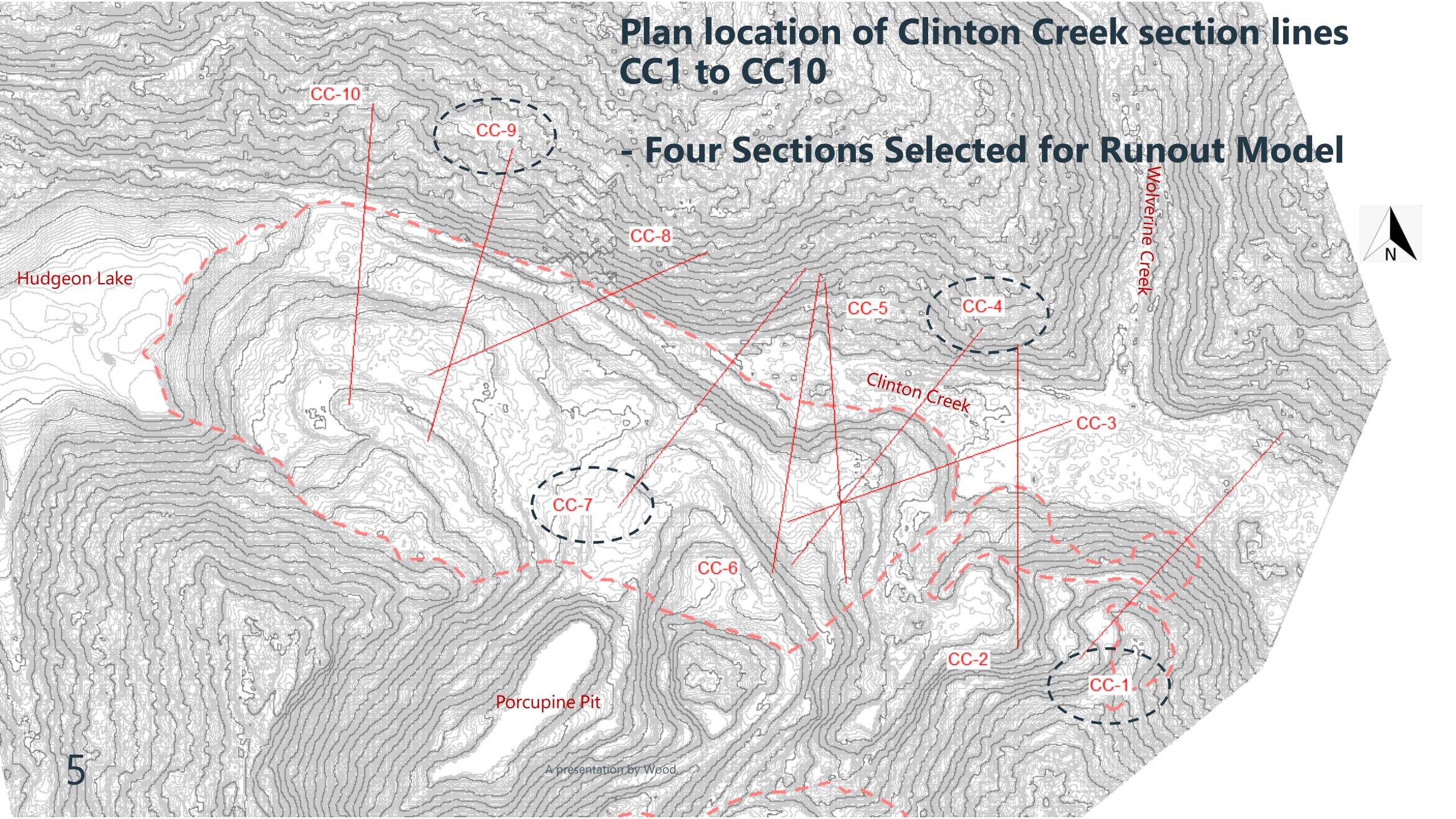
Figure 1: *Grain-size distribution curves from 2016 and 2018 site investigation programs in the Clinton Creek Waste Rock dump.*

- More fines at Clinton Creek Waste Pile
- Dynamic friction angles expected to be lower than coal mine waste in Hungr, et al. 2002, and pore pressure ratio needs to be considered.
- Previous stability assessment used strength ratio of 0.1 for liquefied waste.

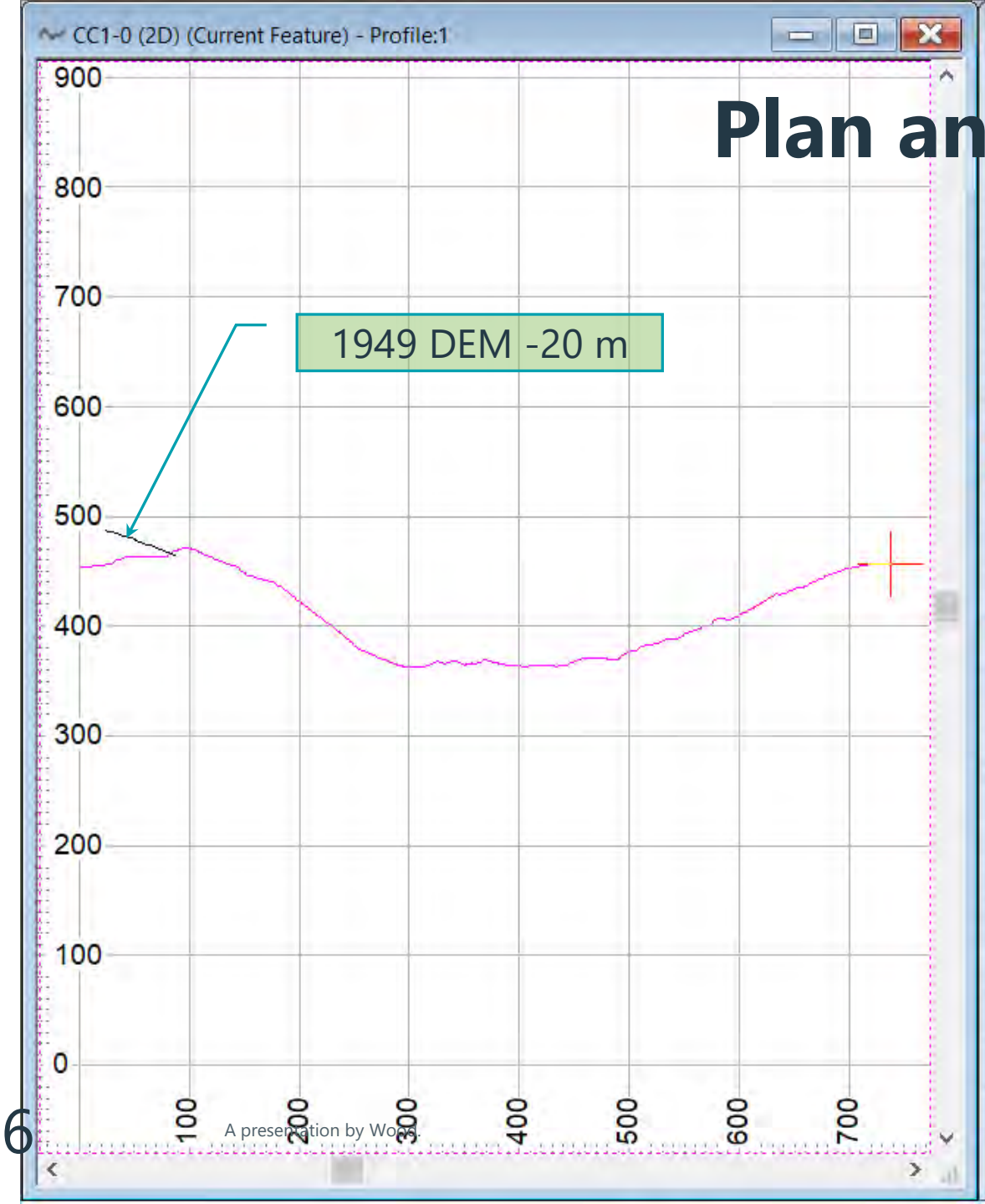
wood.

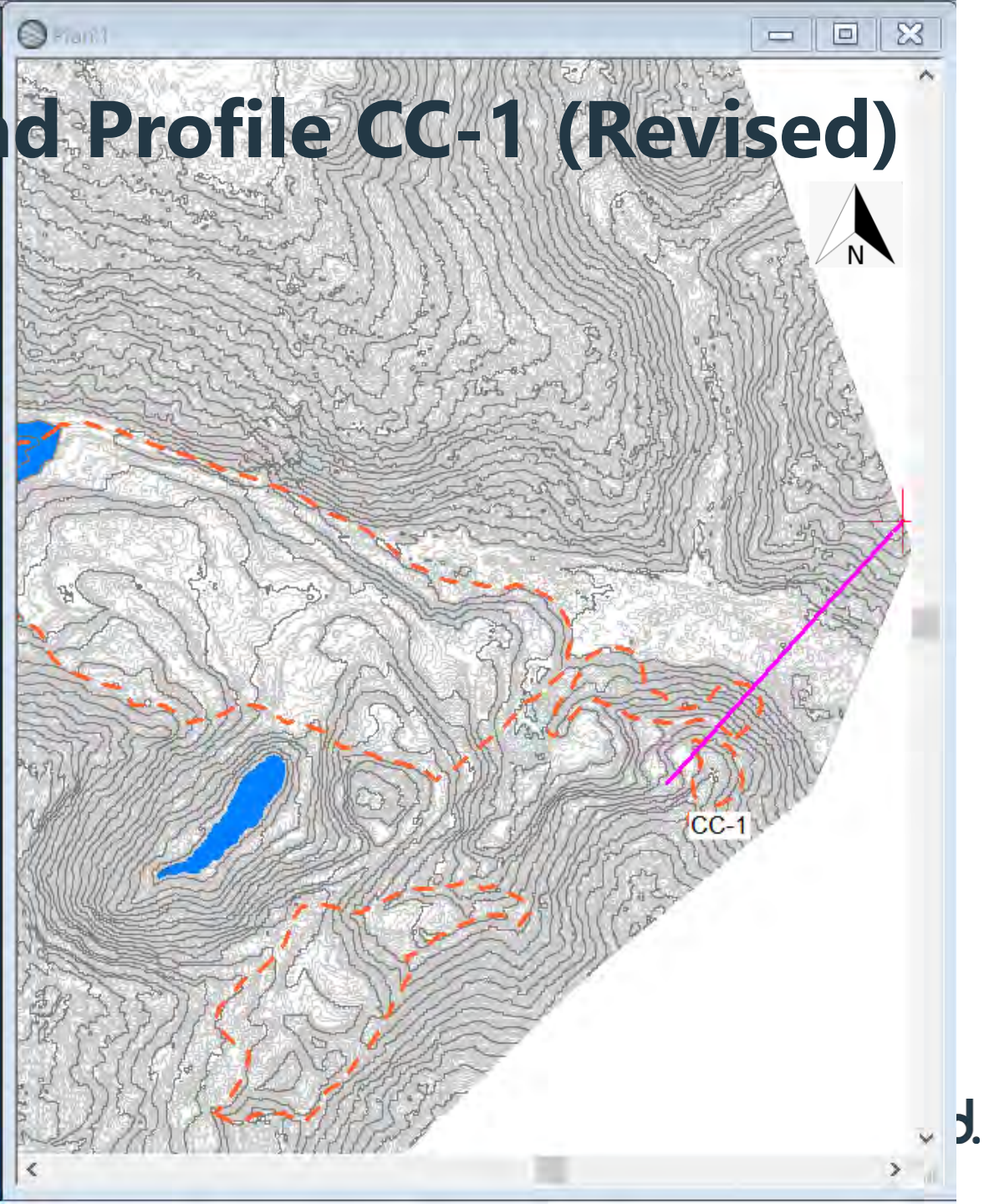
Plan location of Clinton Creek section lines CC1 to CC10

- Four Sections Selected for Runout Model



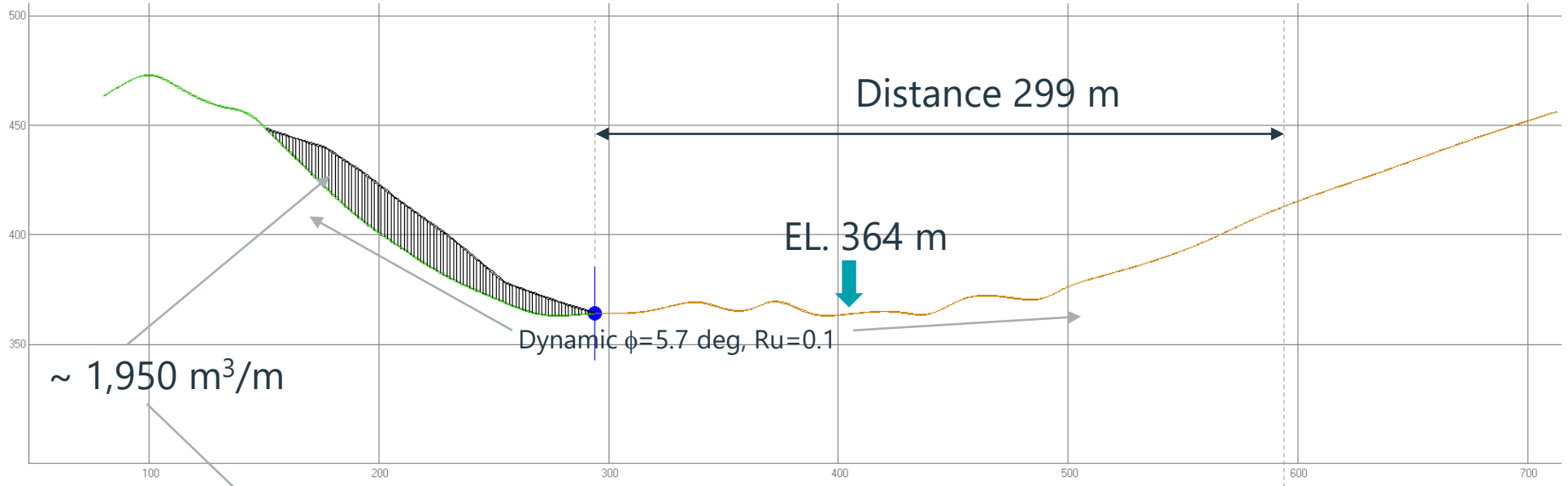
Plan and Profile CC-1 (Revised)



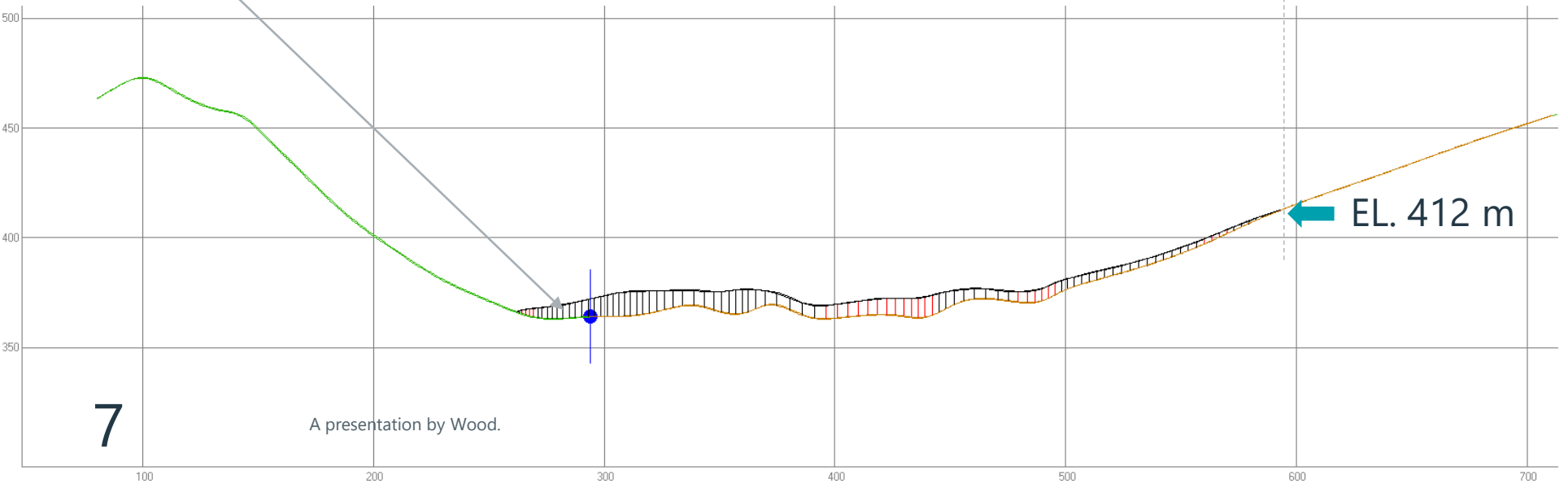


A presentation by Woo

Section CC-1 (assuming in situ Ru of 0.1)



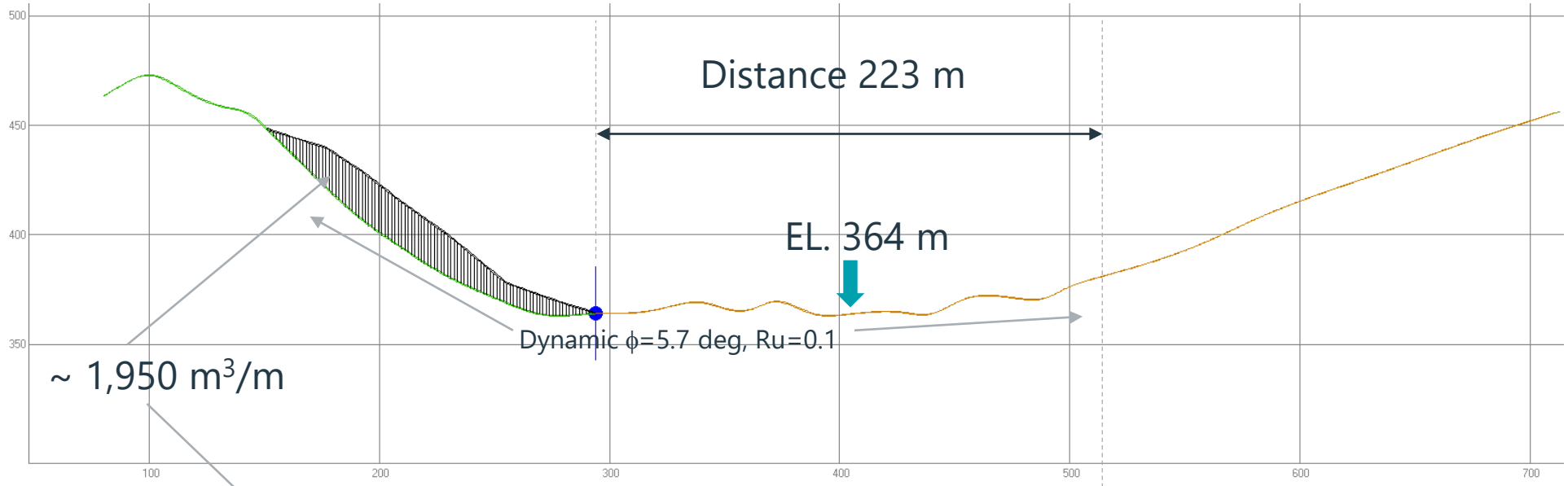
Pre-runout



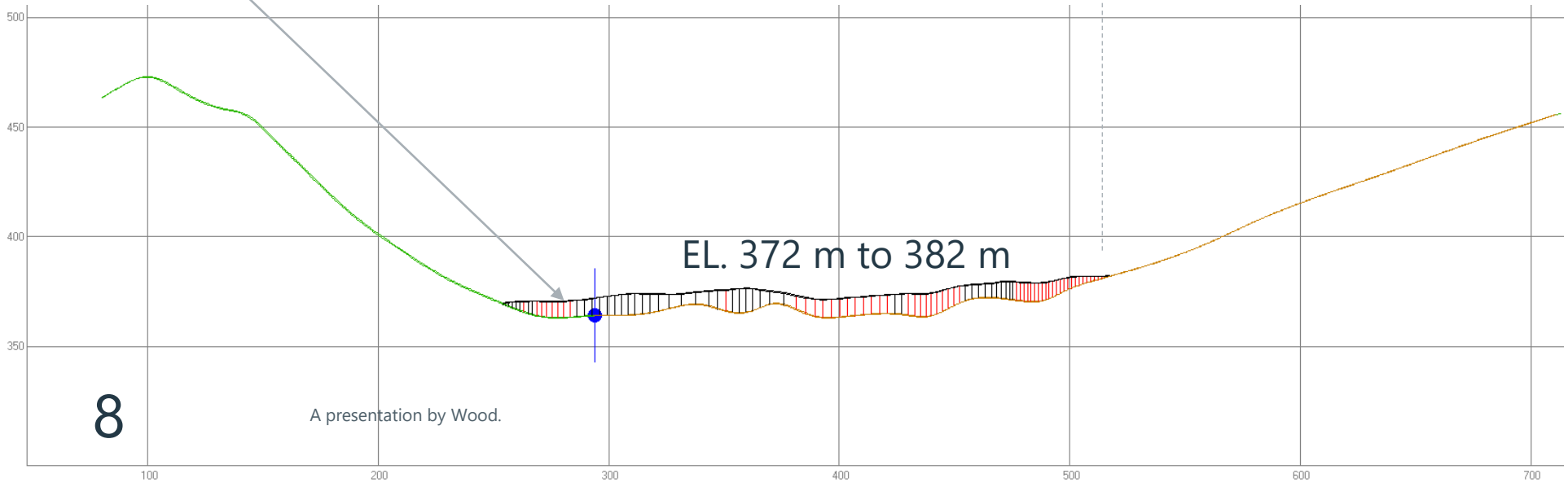
Maximum Distance and Upslope Elevation

wood.

Section CC-1 (assuming in situ Ru of 0.1)



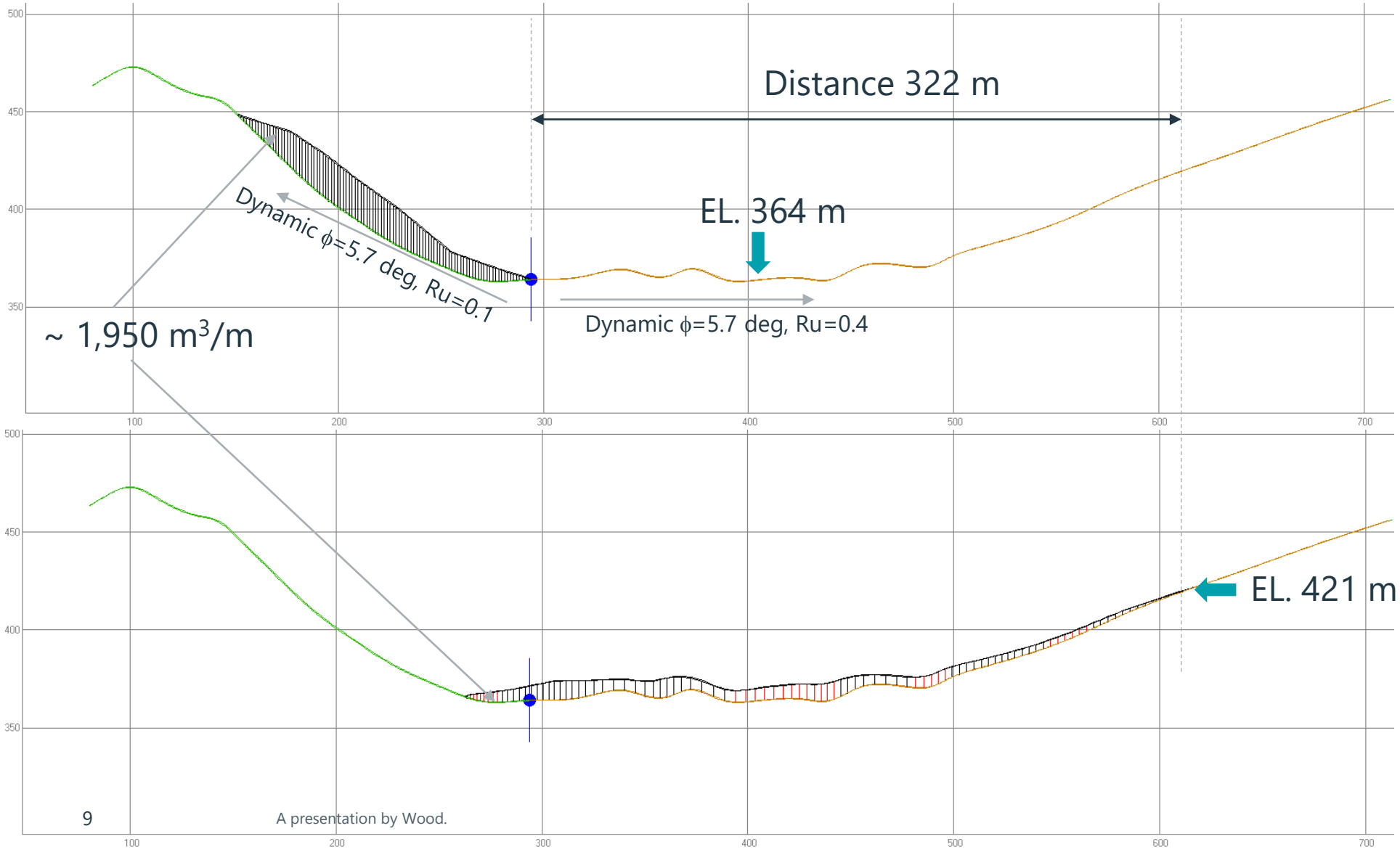
Pre-runout



Landslide Dam
Surface Elevations

wood.

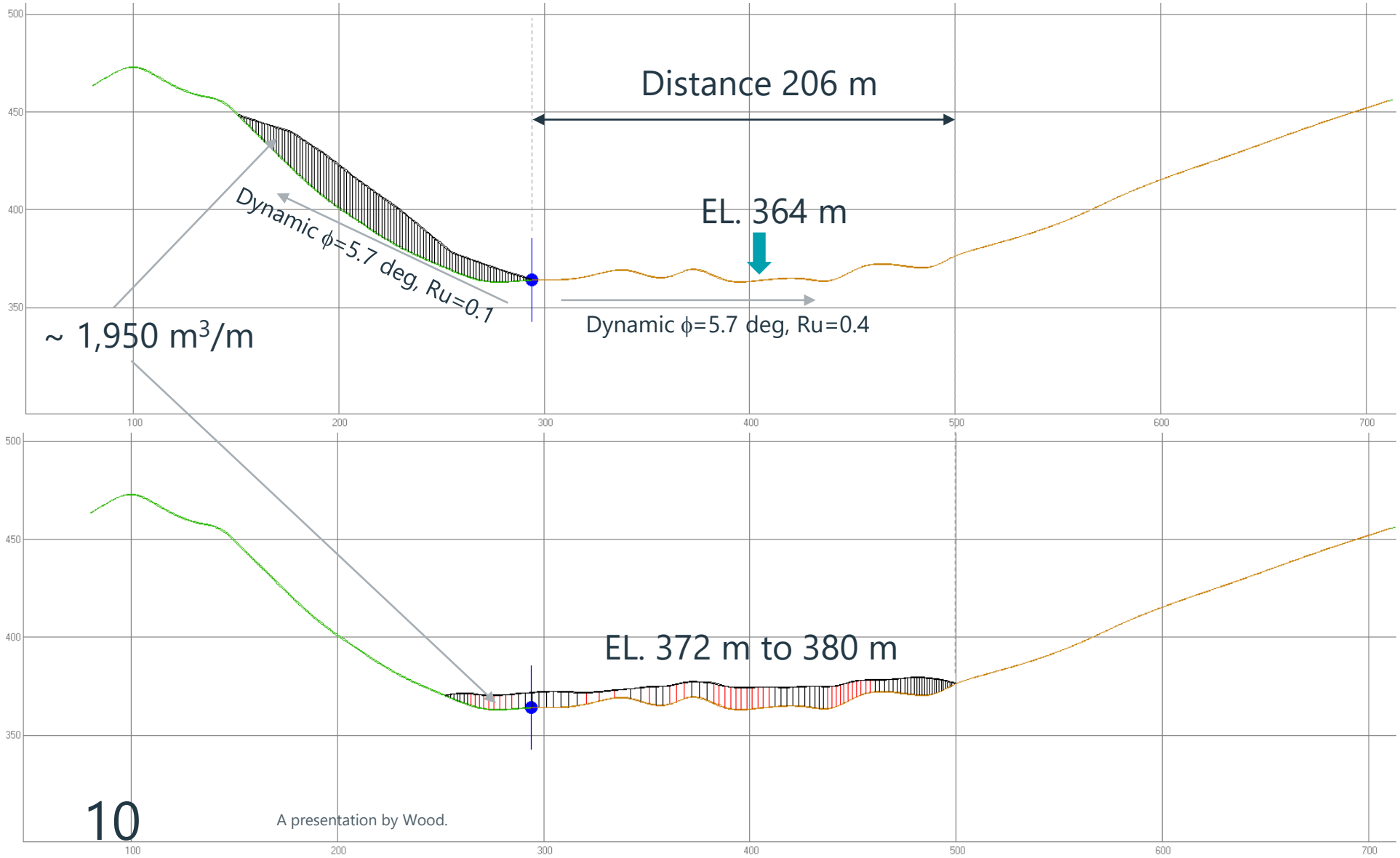
Section CC-1 (high mobility with high Ru=0.4)



Pre-runout

Maximum Distance and Upslope Elevation

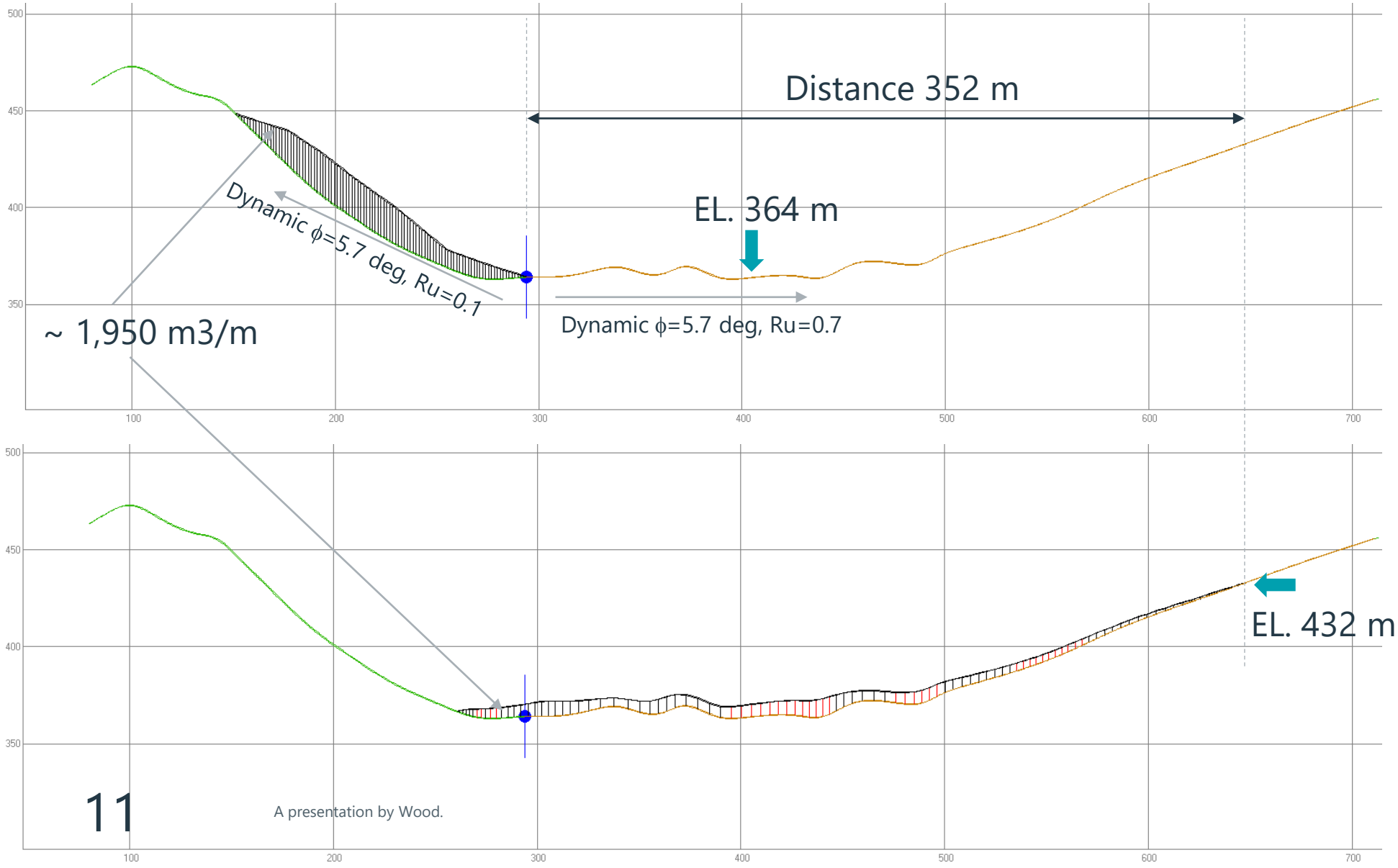
Section CC-1 (high mobility with high Ru=0.4)



Pre-runout

Landslide Dam Surface Elevations

Section CC-1 (high mobility with high Ru=0.7)

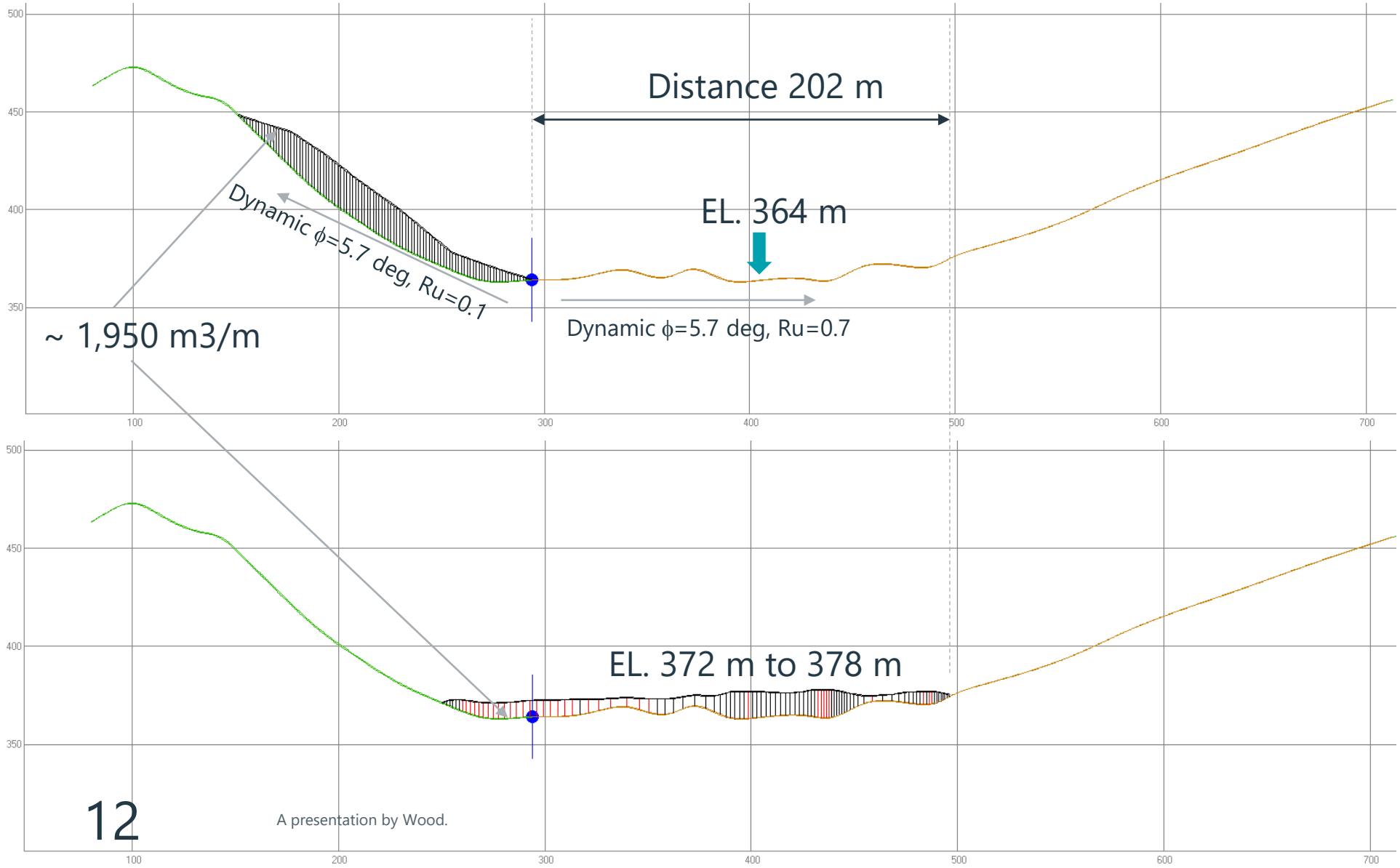


Pre-runout

Maximum Distance and Upslope Elevation

wood.

Section CC-1 (high mobility with high Ru=0.7)

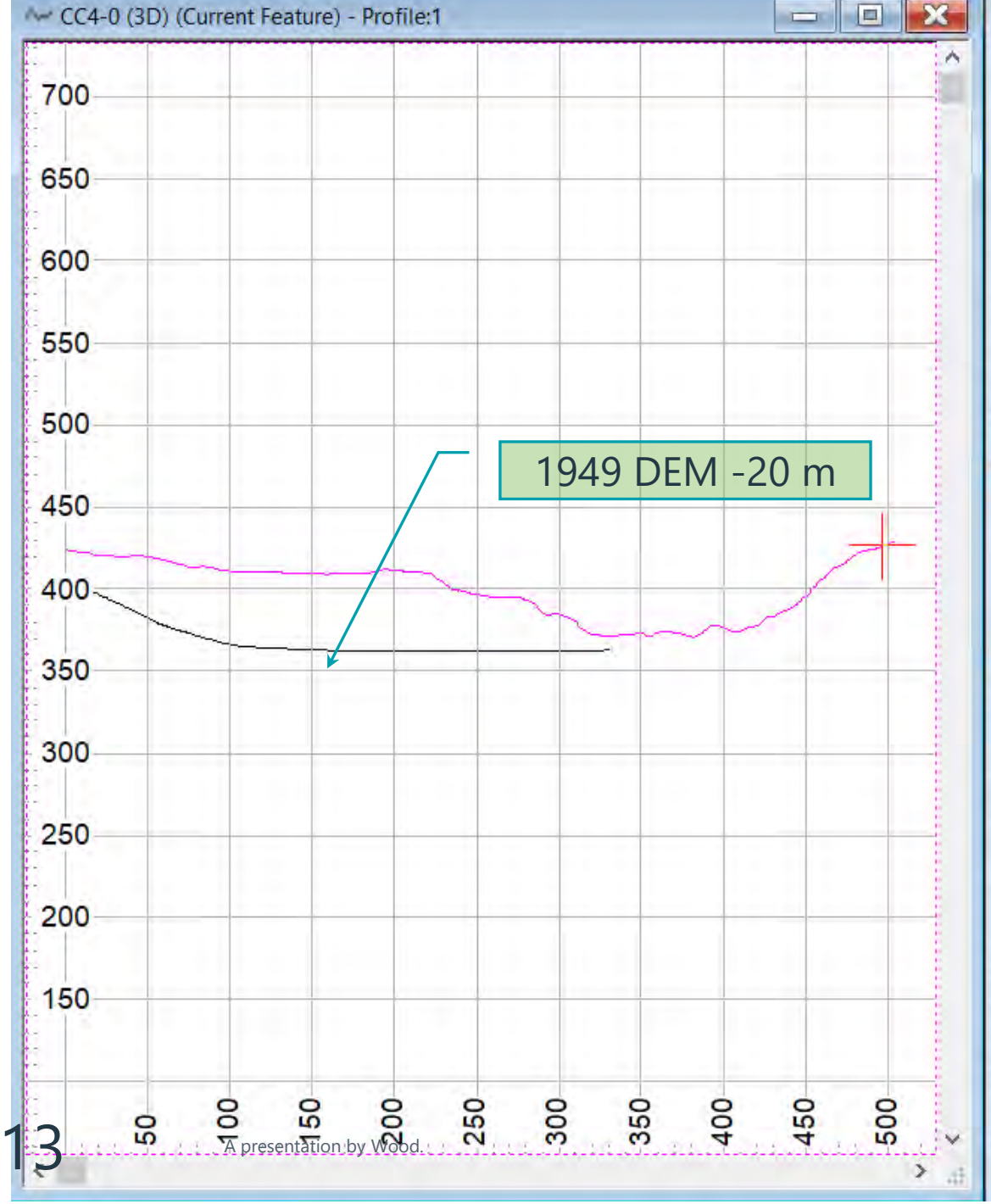


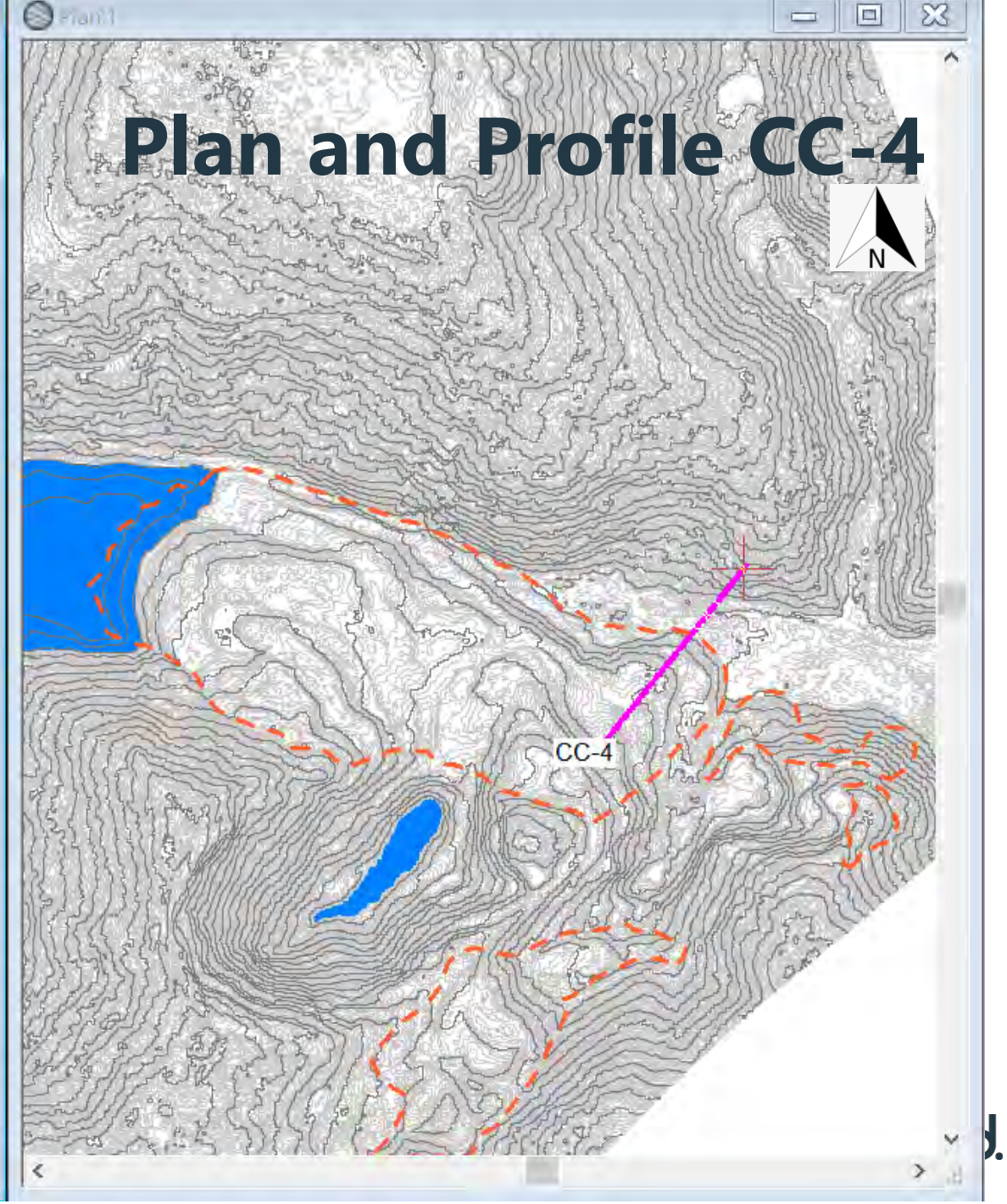
Pre-runout

Landslide Dam
Surface Elevations

wood.

Plan and Profile CC-4





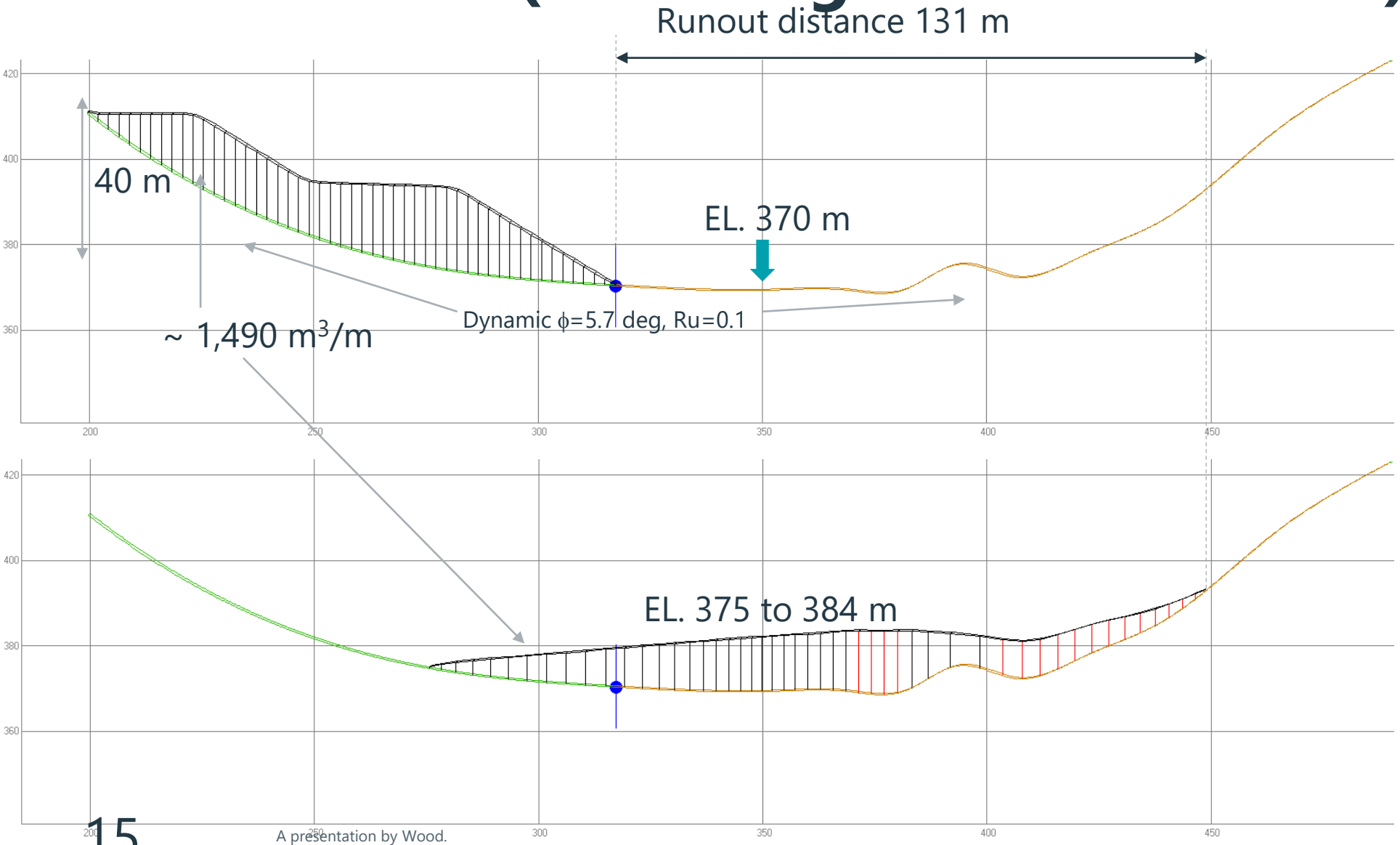
Section CC-4 (assuming in situ Ru of 0.1)

Pre-runout

Maximum Distance and Upslope Elevation

wood.

Section CC-4 (assuming in situ Ru of 0.1)

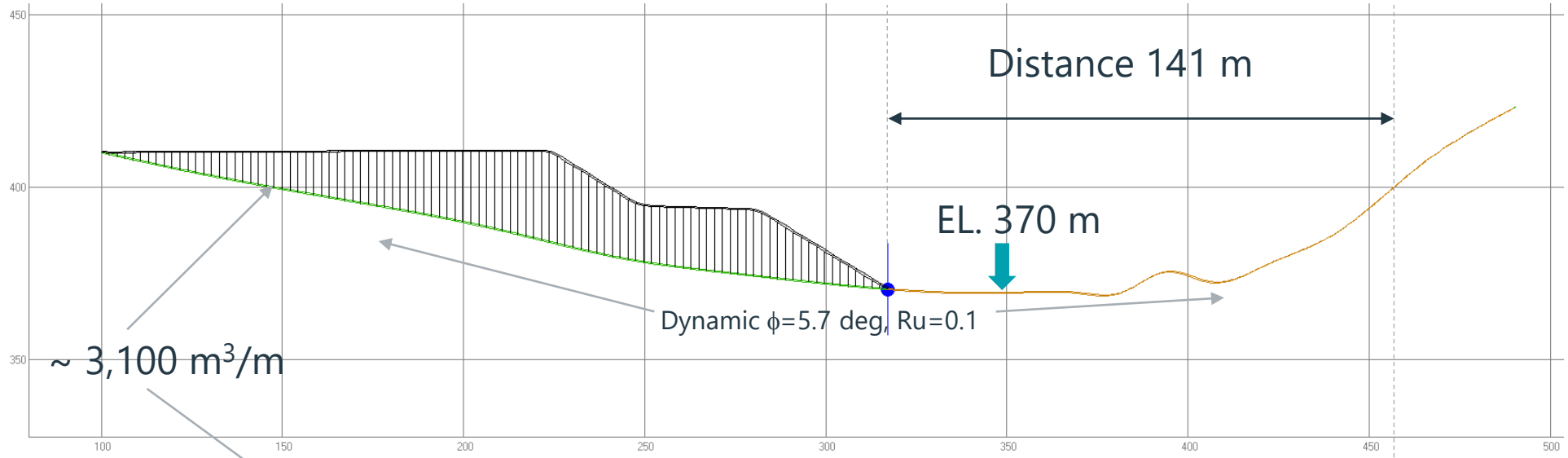


Pre-runout

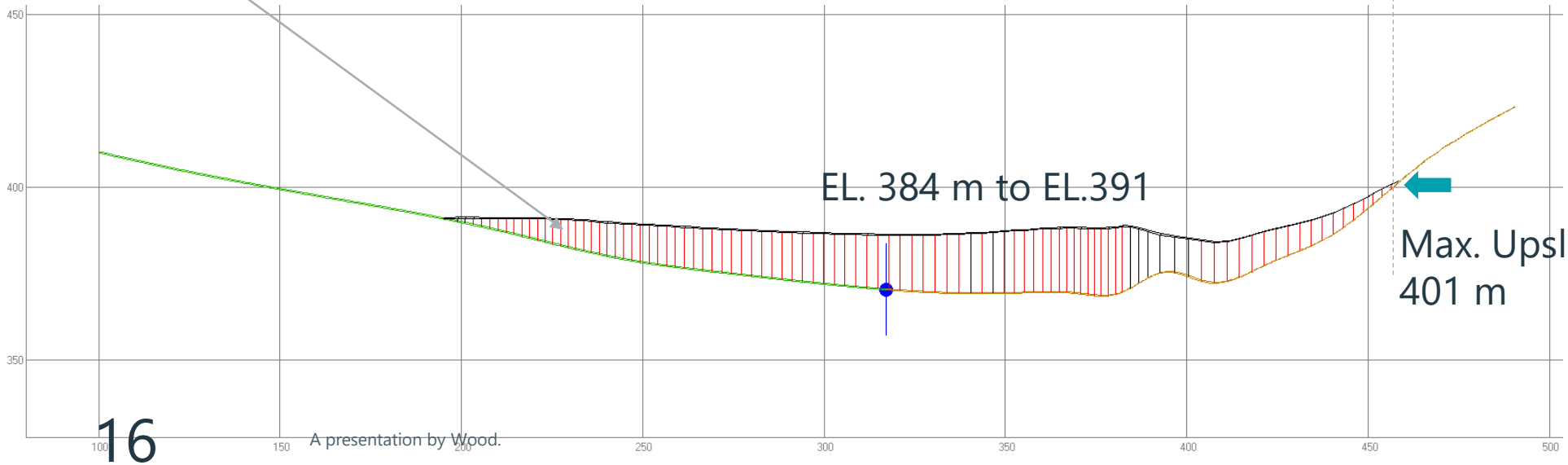
Landslide Dam Surface Elevations

wood.

Section CC-4 (Larger Block - assuming in situ Ru of 0.1)

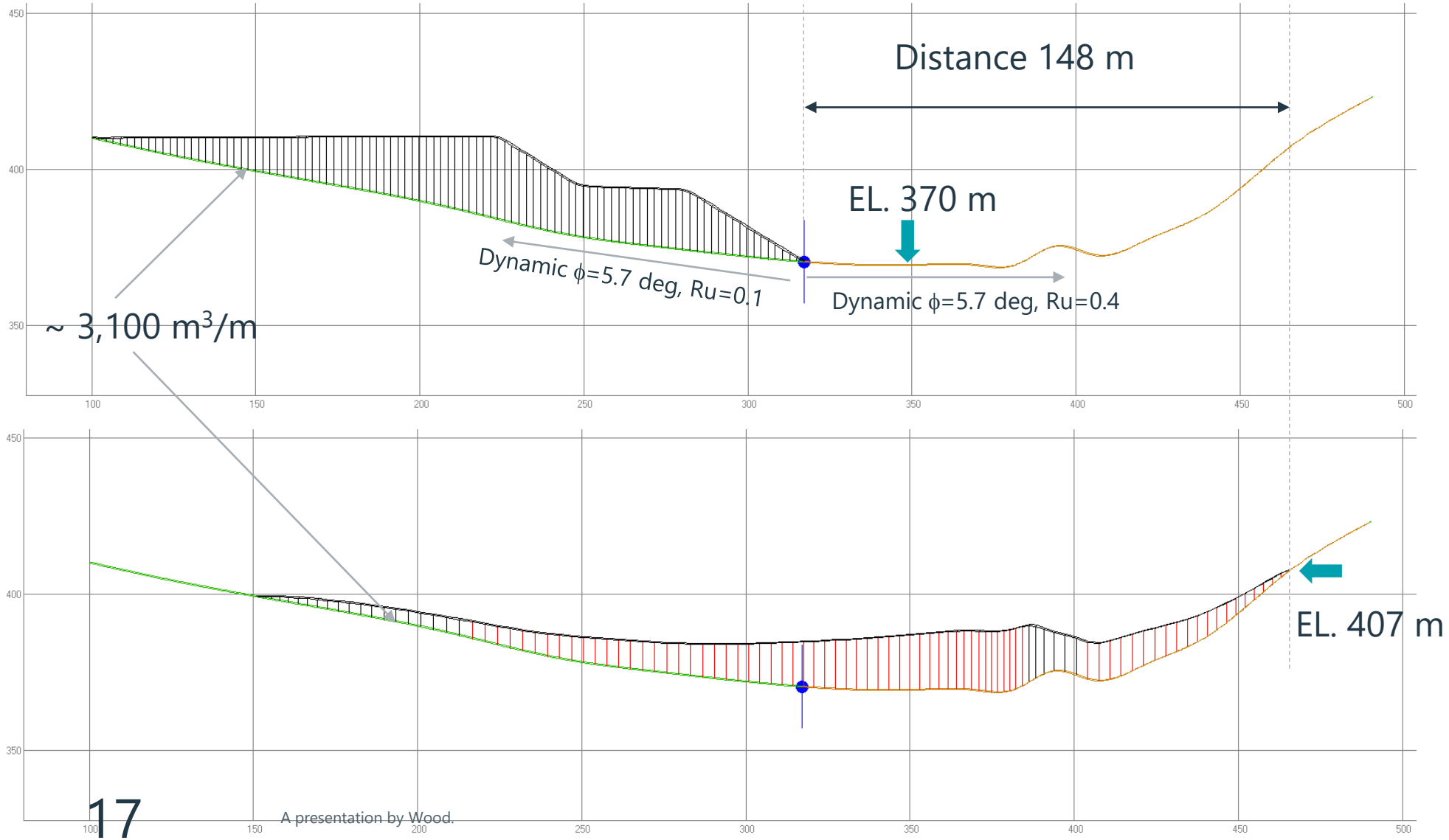


Pre-runout



Landslide Dam
Surface Elevations

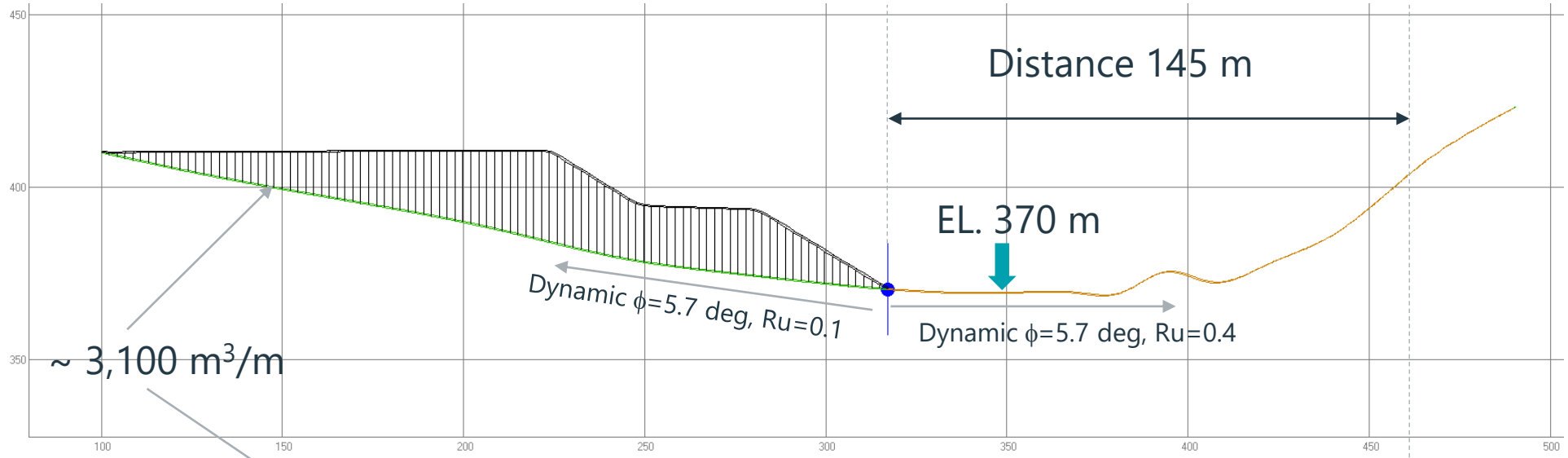
Section CC-4 (Larger Block – with high Ru of 0.4)



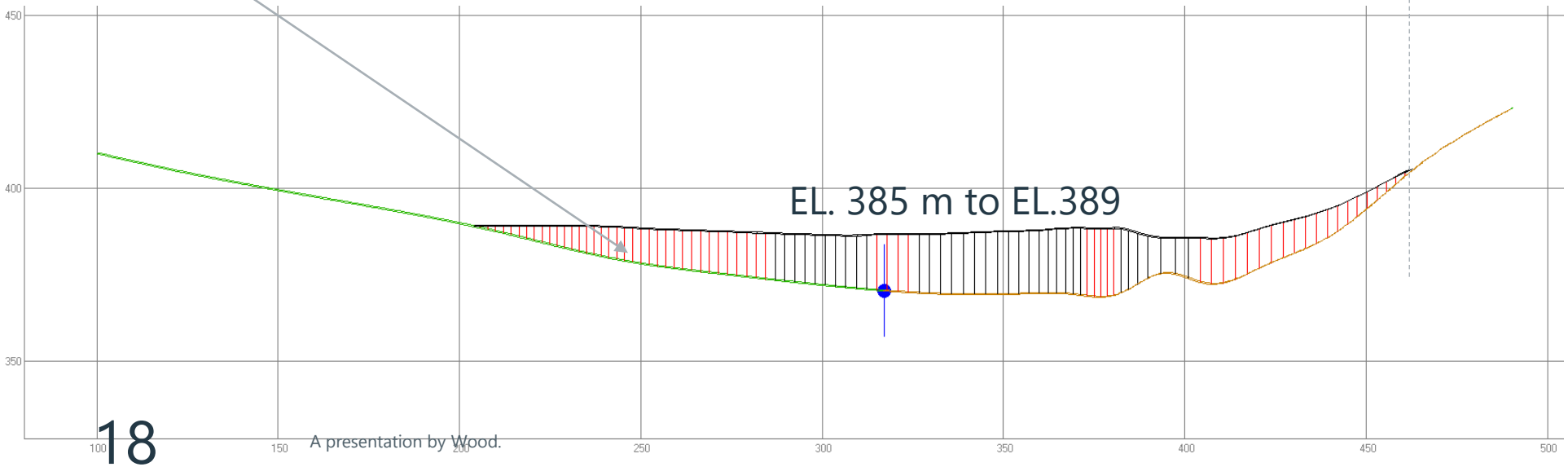
Pre-runout

Maximum Distance and Upslope Elevation

Section CC-4 (Larger Block – with high Ru of 0.4)



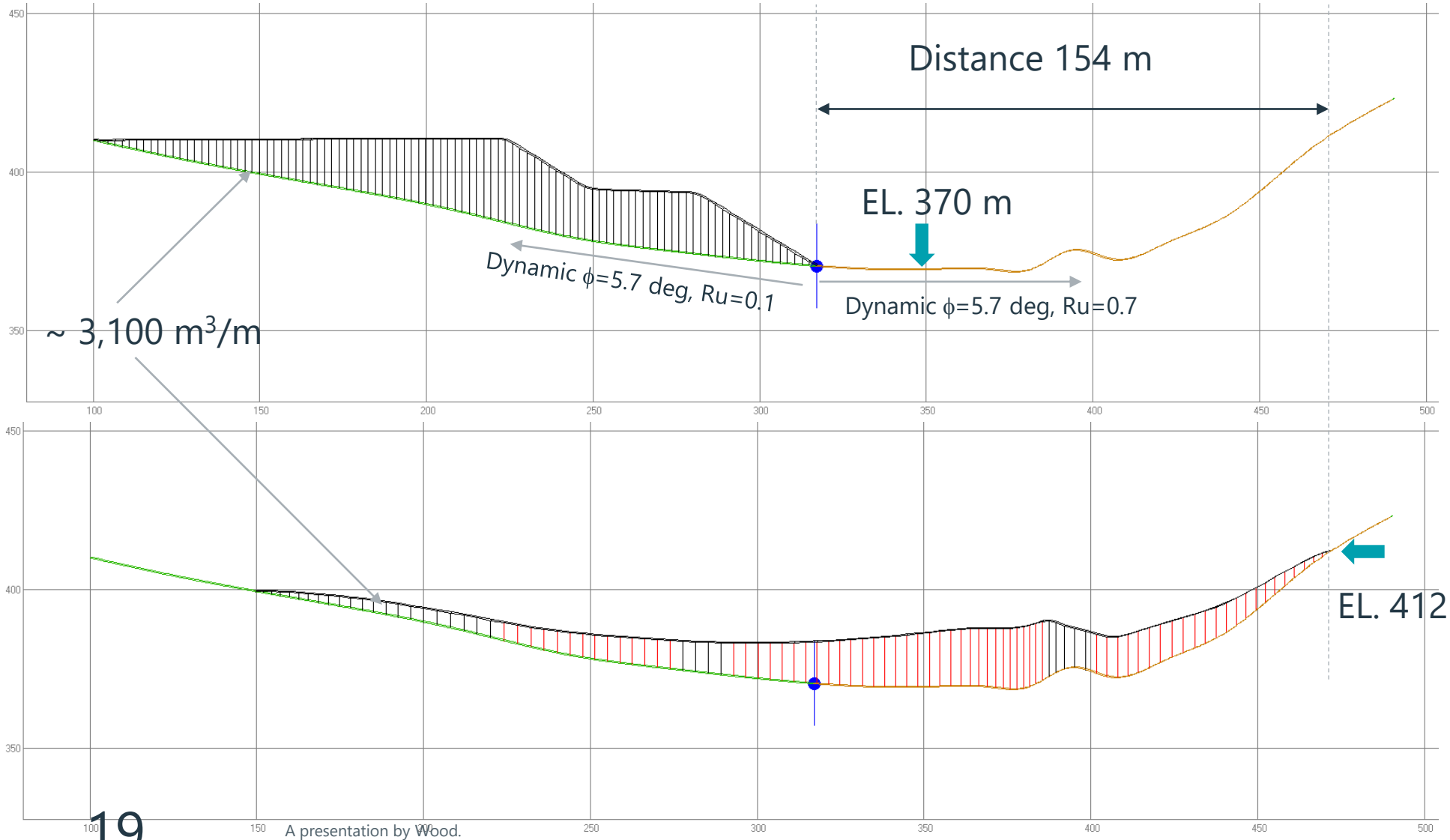
Pre-runout



Landslide Dam
Surface Elevations

wood.

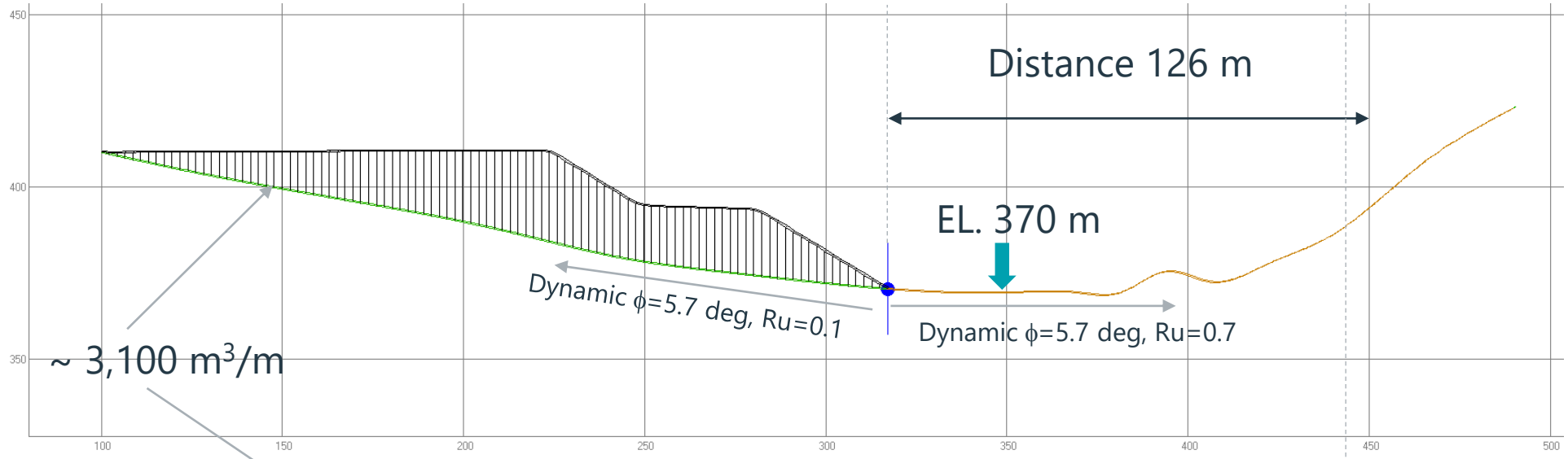
Section CC-4 (Larger Block – with high Ru of 0.7)



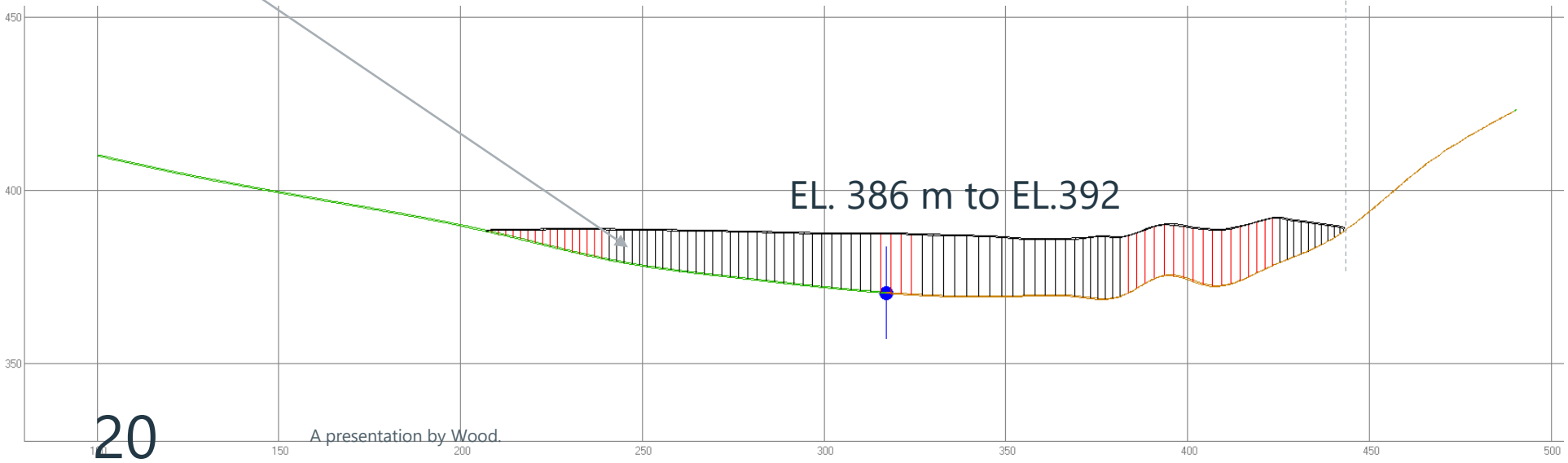
Pre-runout

Maximum Distance and Upslope Elevation

Section CC-4 (Larger Block – with high Ru of 0.7)

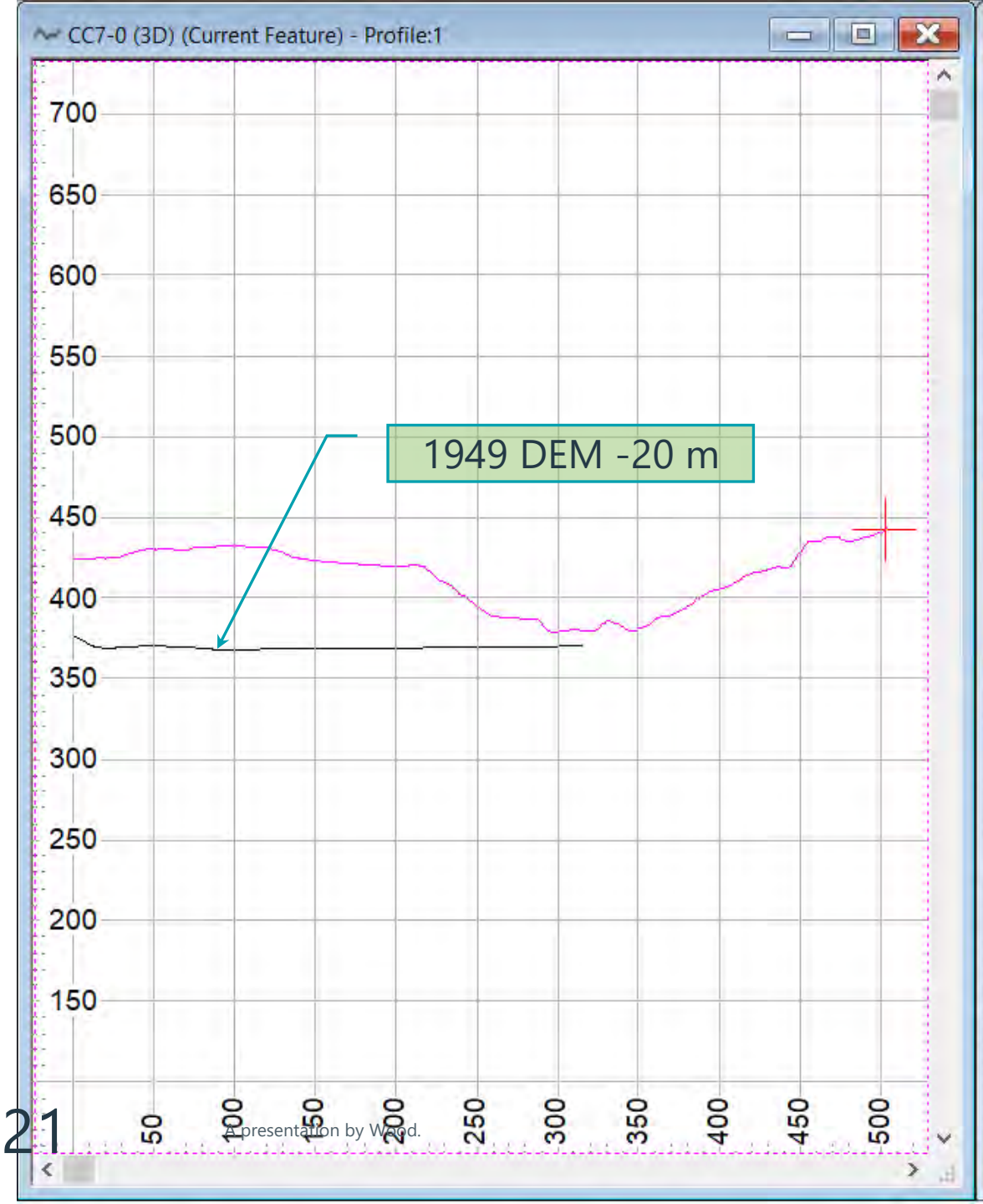


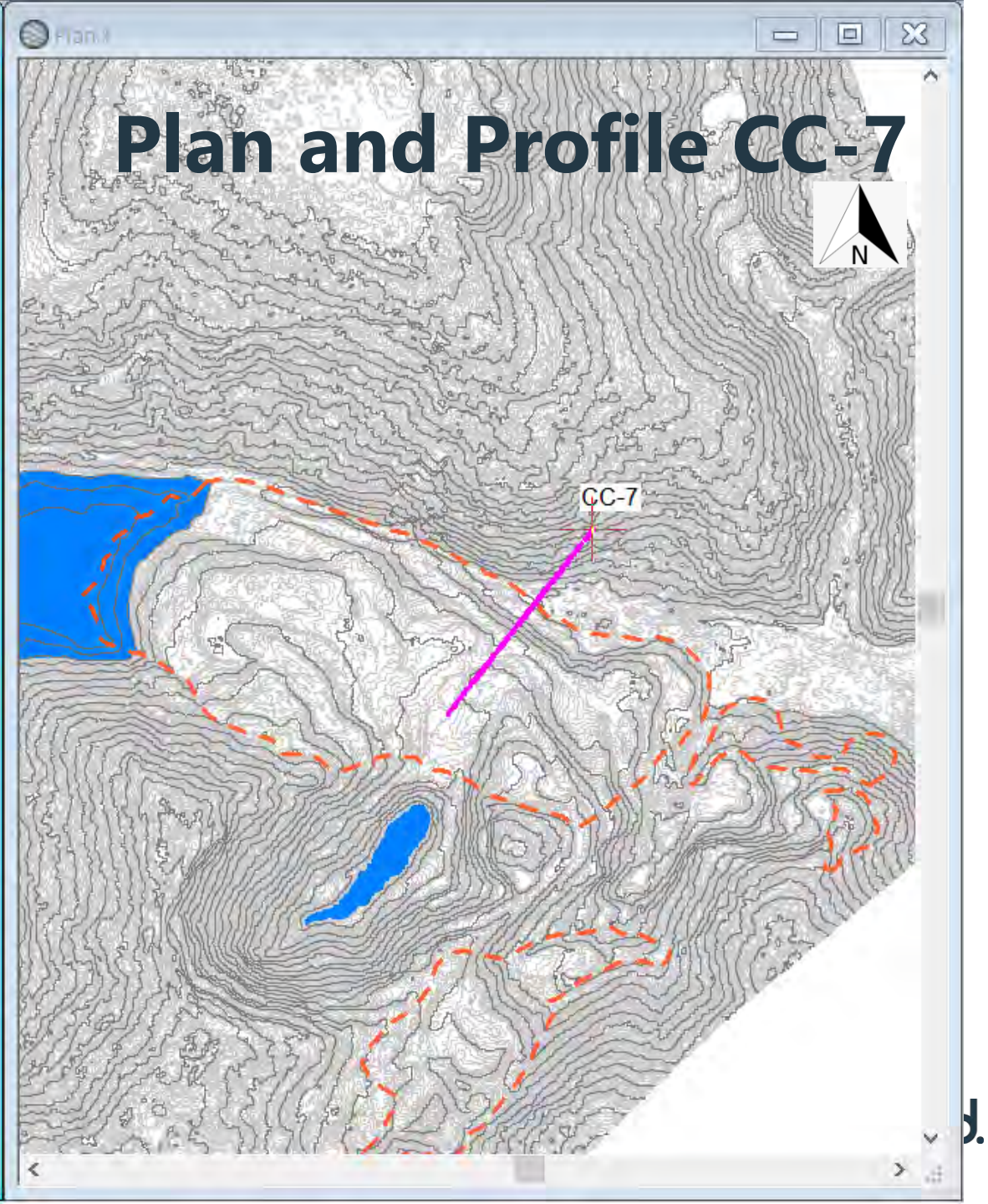
Pre-runout



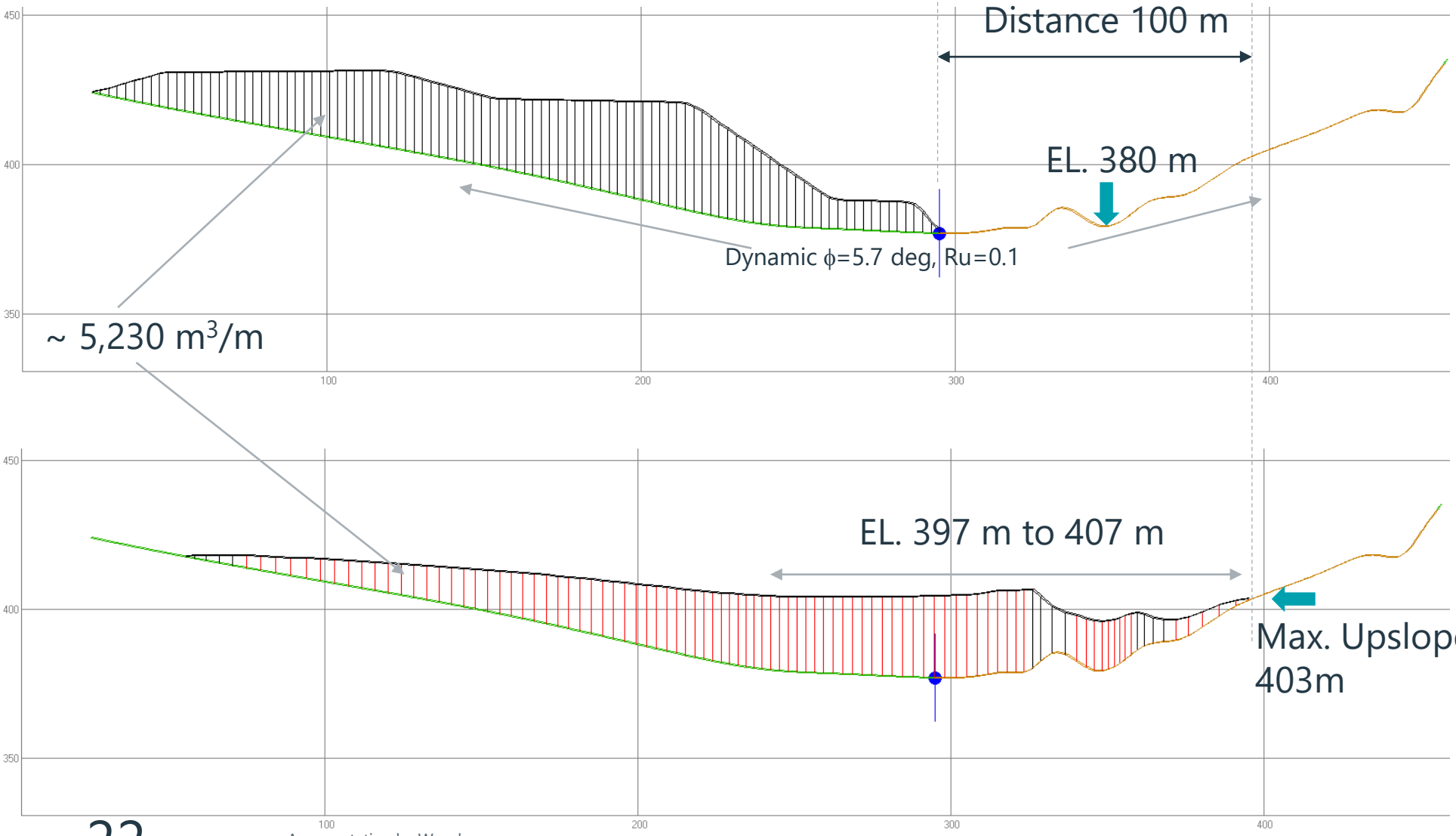
Landslide Dam
Surface Elevations

wood.


CC7-0 (3D) (Current Feature) - Profile:1
700
650
600
550
500
450
400
350
300
250
200
150
50
100
150
200
250
300
350
400
450
500
1949 DEM -20 m


Plan and Profile CC-7
N
CC-7

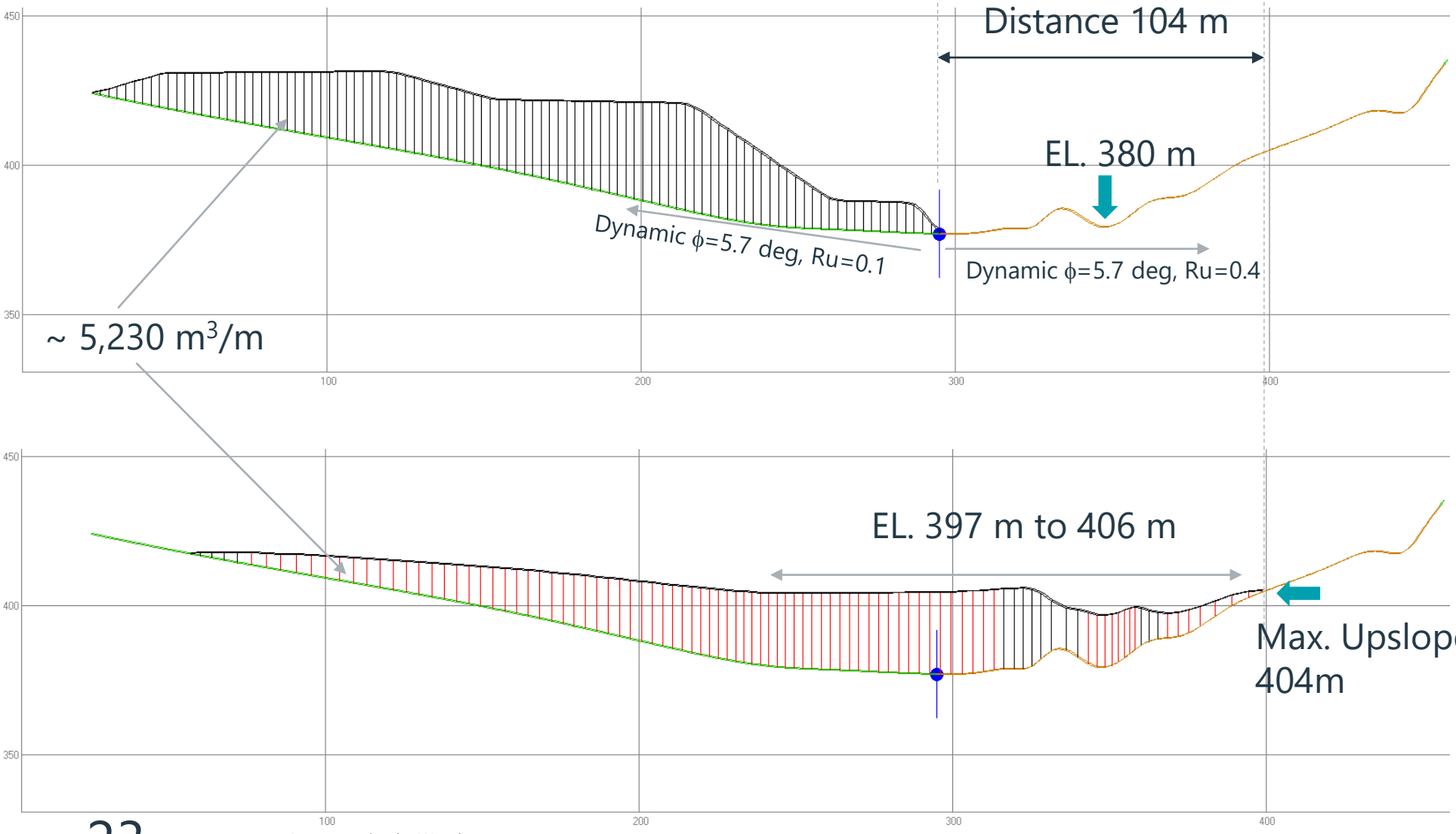
Section CC-7 (assuming in situ Ru of 0.1)



Pre-runout

Landslide Dam Surface Elevations

Section CC-7 (high mobility with high Ru of 0.4)

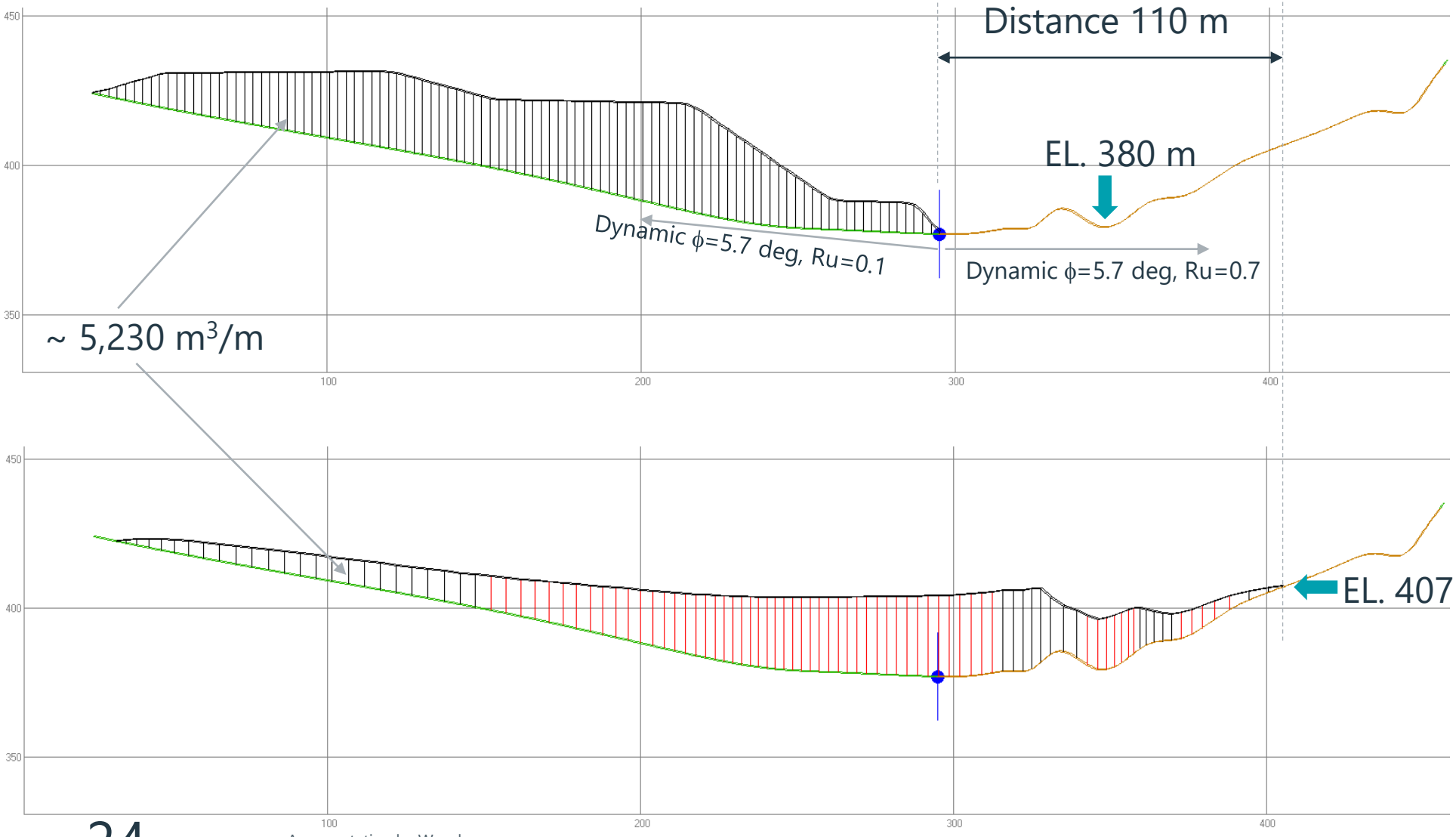


Pre-runout

Landslide Dam Surface Elevations

wood.

Section CC-7 (high mobility with high Ru of 0.7)

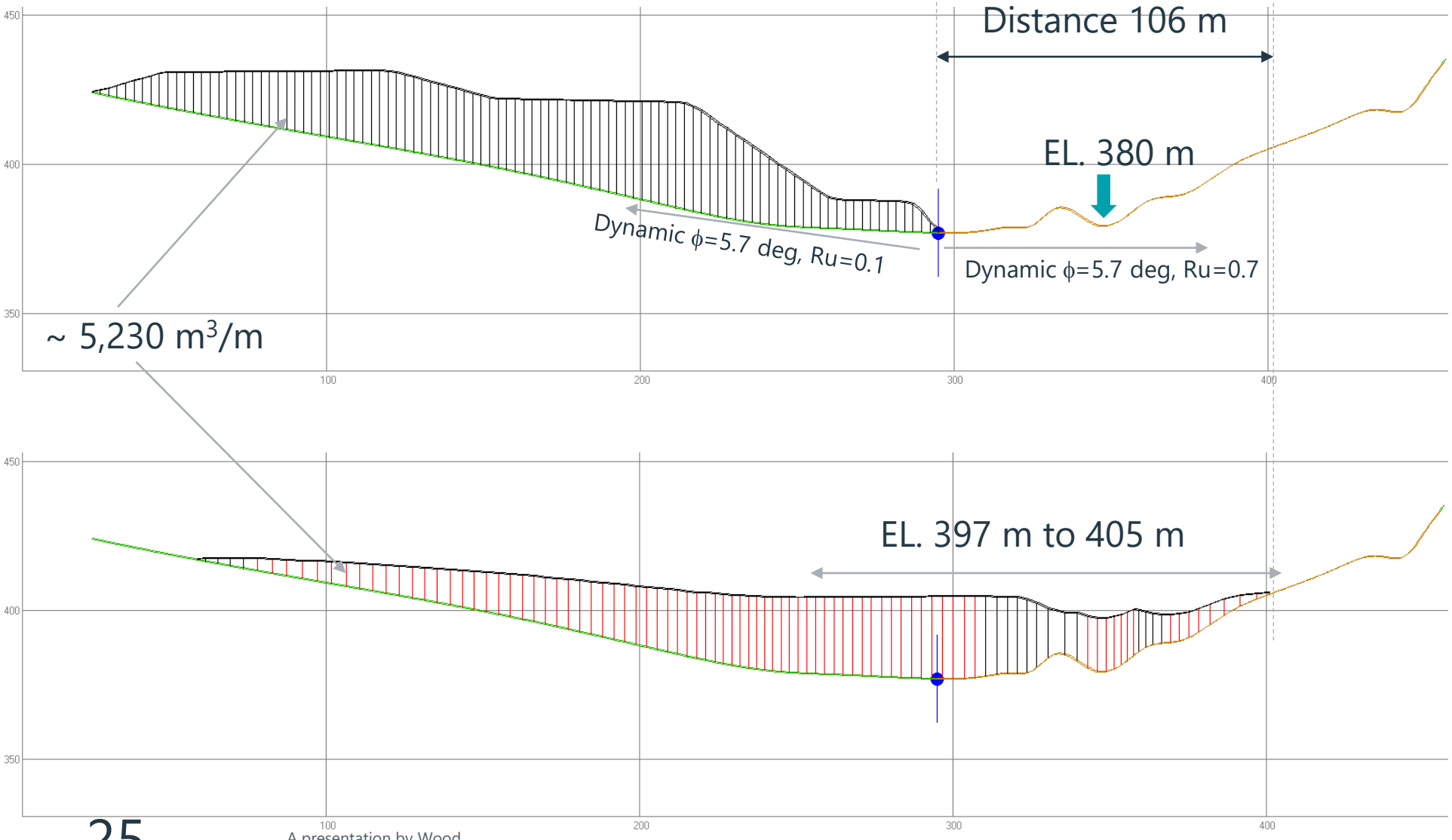


Pre-runout

Maximum Distance and Upslope Elevation

wood.

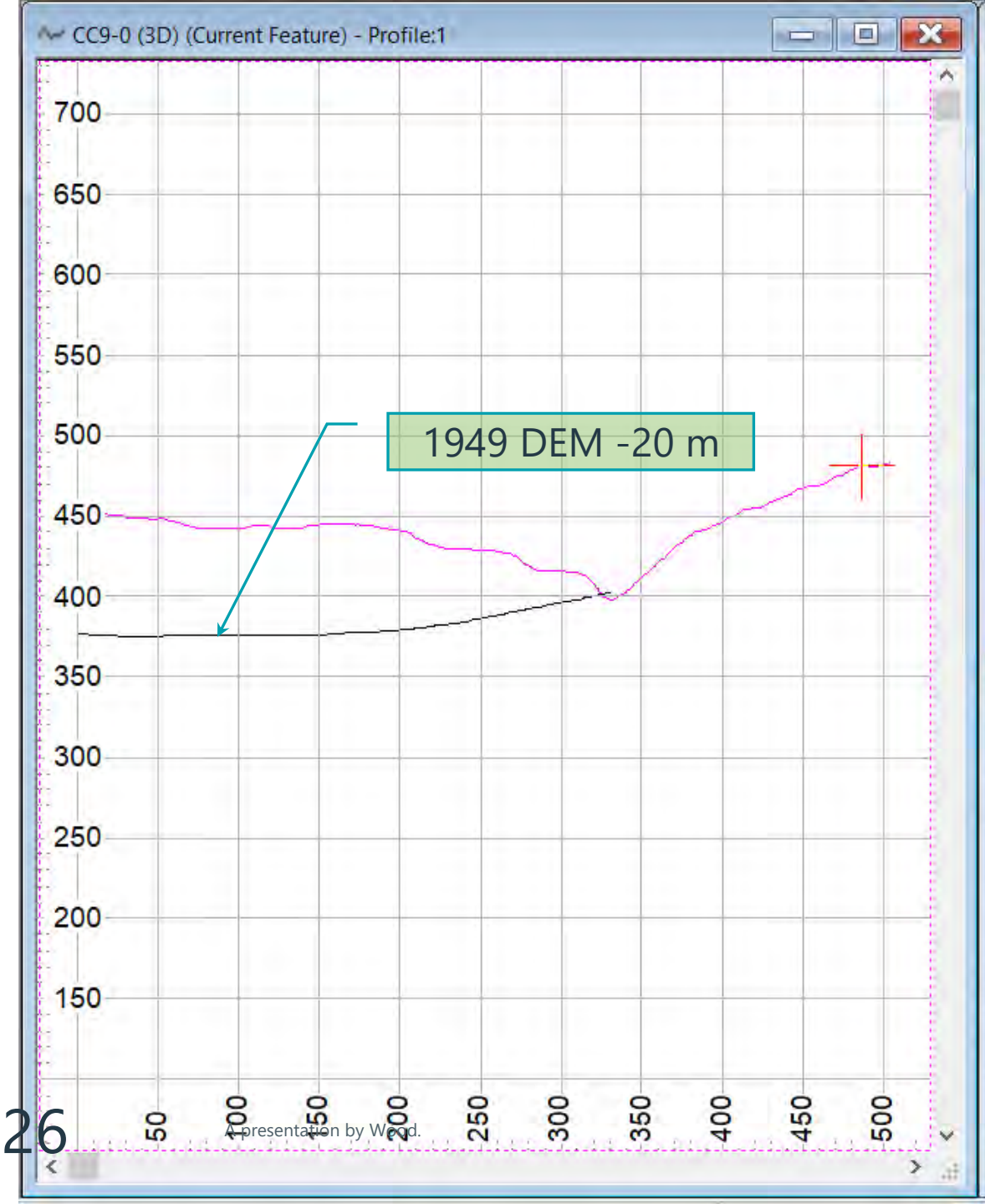
Section CC-7 (high mobility with high Ru of 0.7)

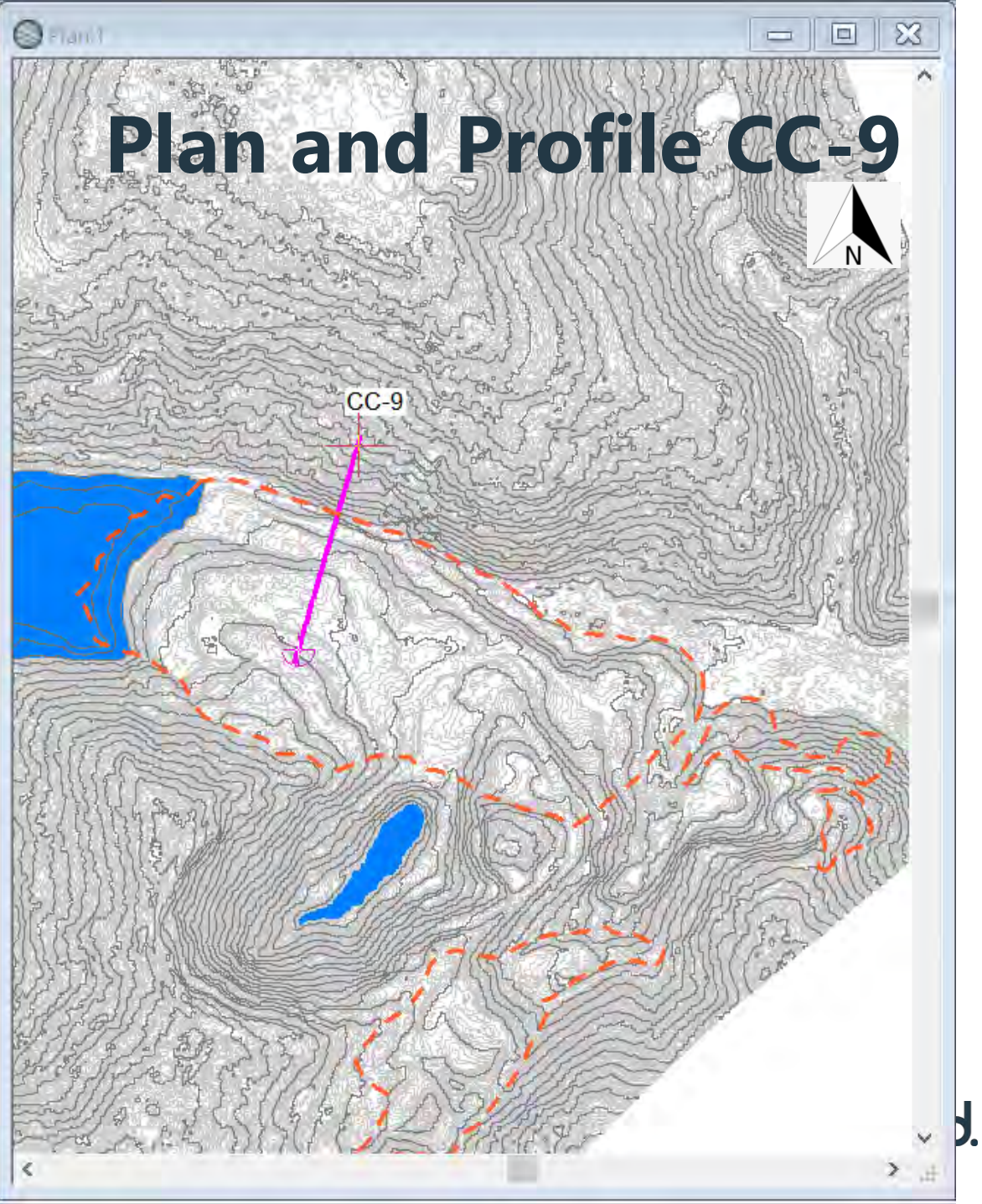


Pre-runout

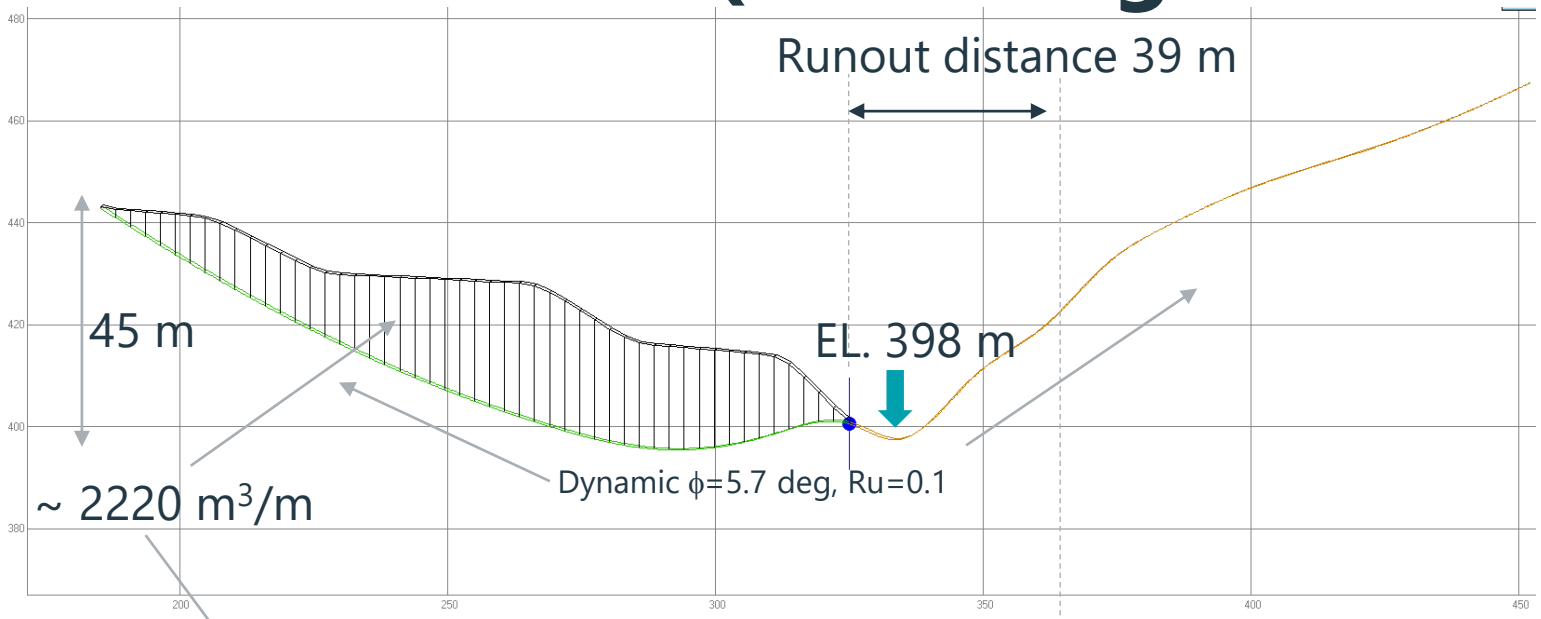
Landslide Dam Surface Elevations

wood.

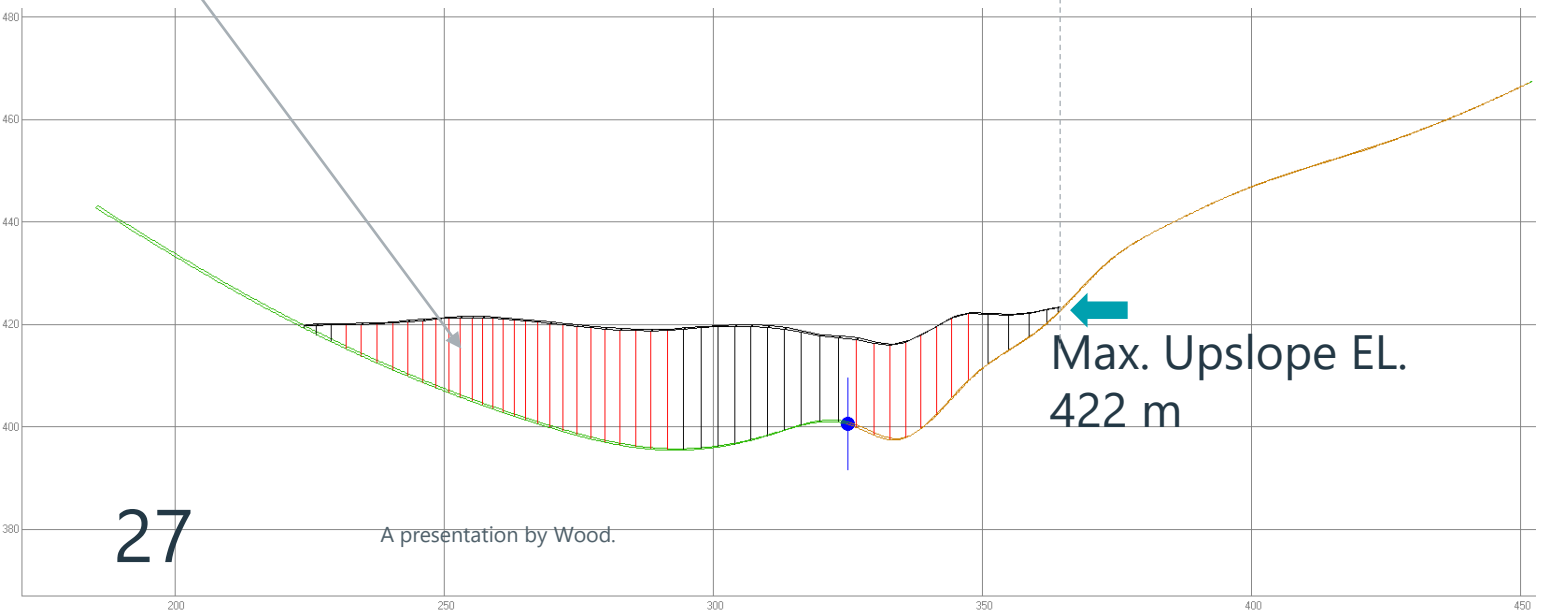

CC9-0 (3D) (Current Feature) - Profile:1
700
650
600
550
500
450
400
350
300
250
200
150
50
100
150
200
250
300
350
400
450
500
1949 DEM -20 m


Plan:1
Plan and Profile CC-9
N
CC-9

Section CC-9 (assuming in situ Ru of 0.1)



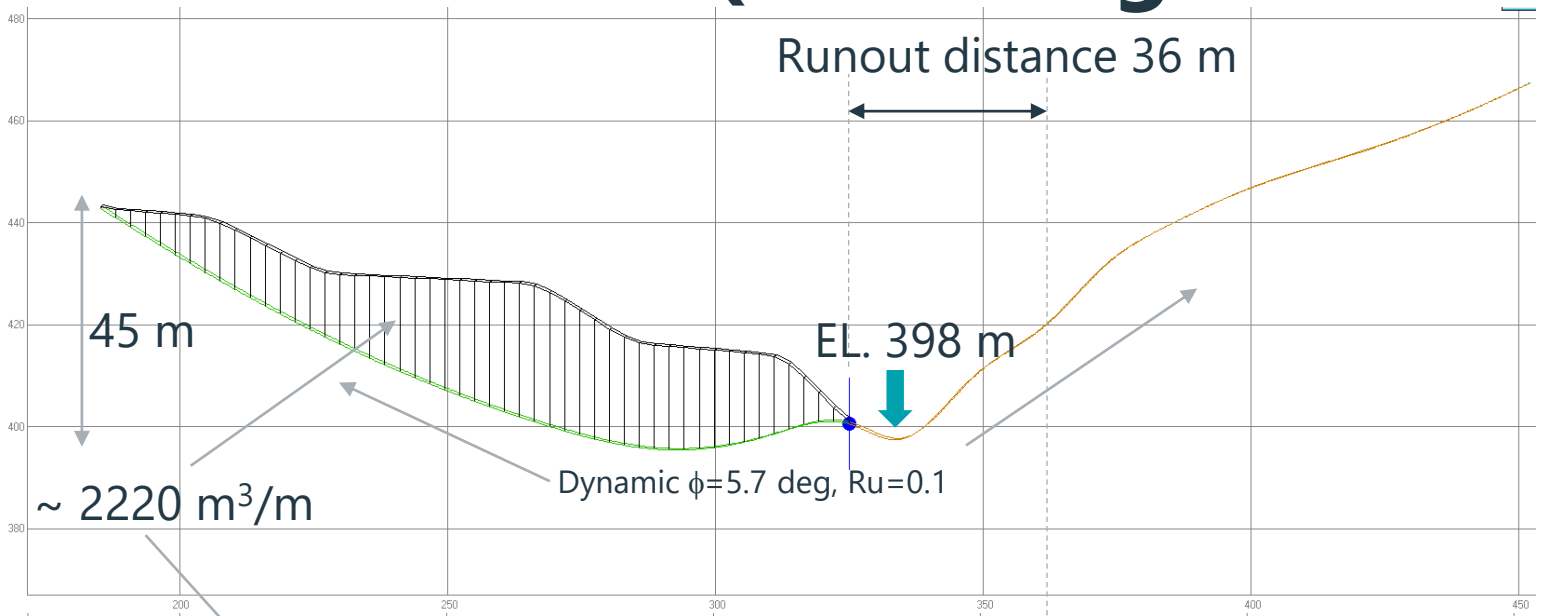
Pre-runout



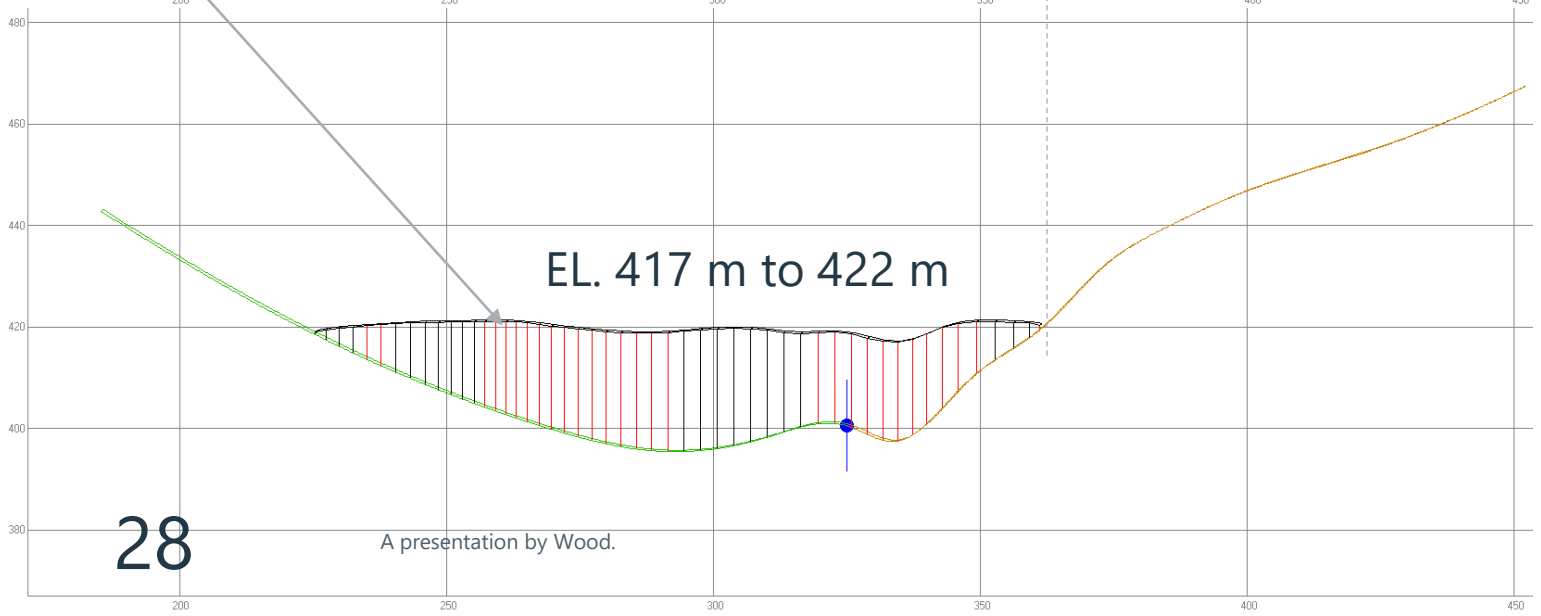
Maximum Distance and Upslope Elevation

wood.

Section CC-9 (assuming in situ Ru of 0.1)



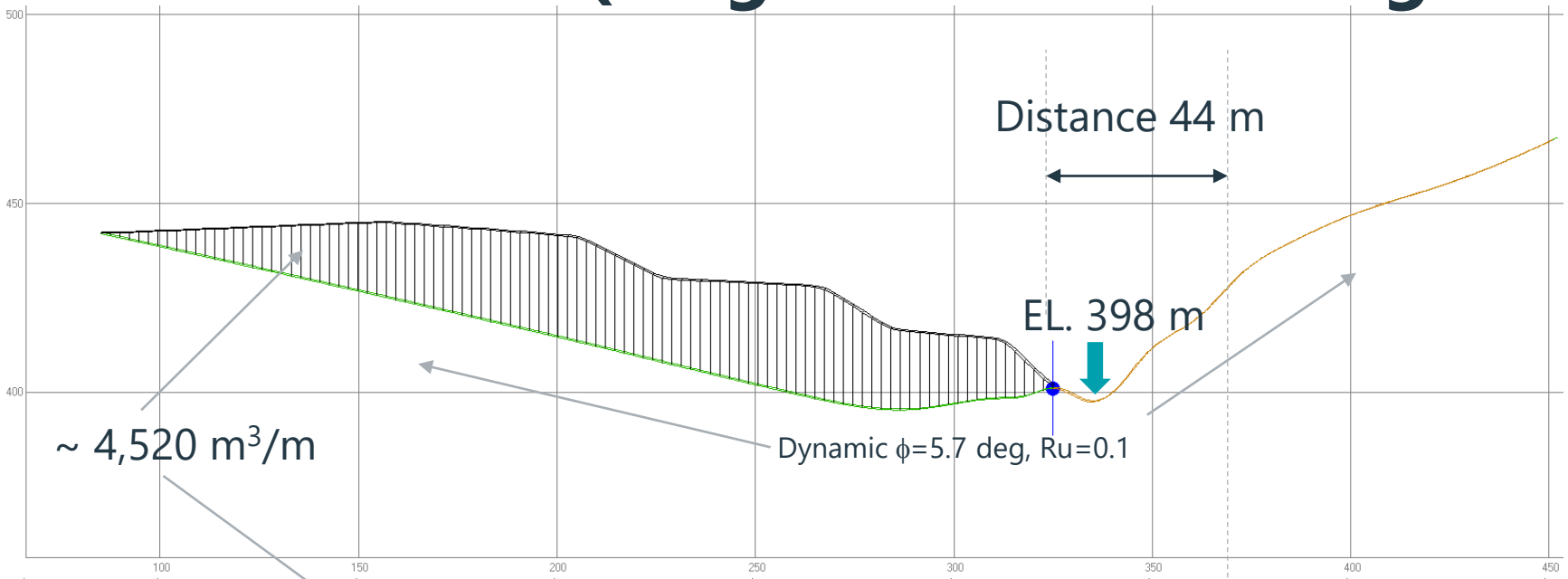
Pre-runout



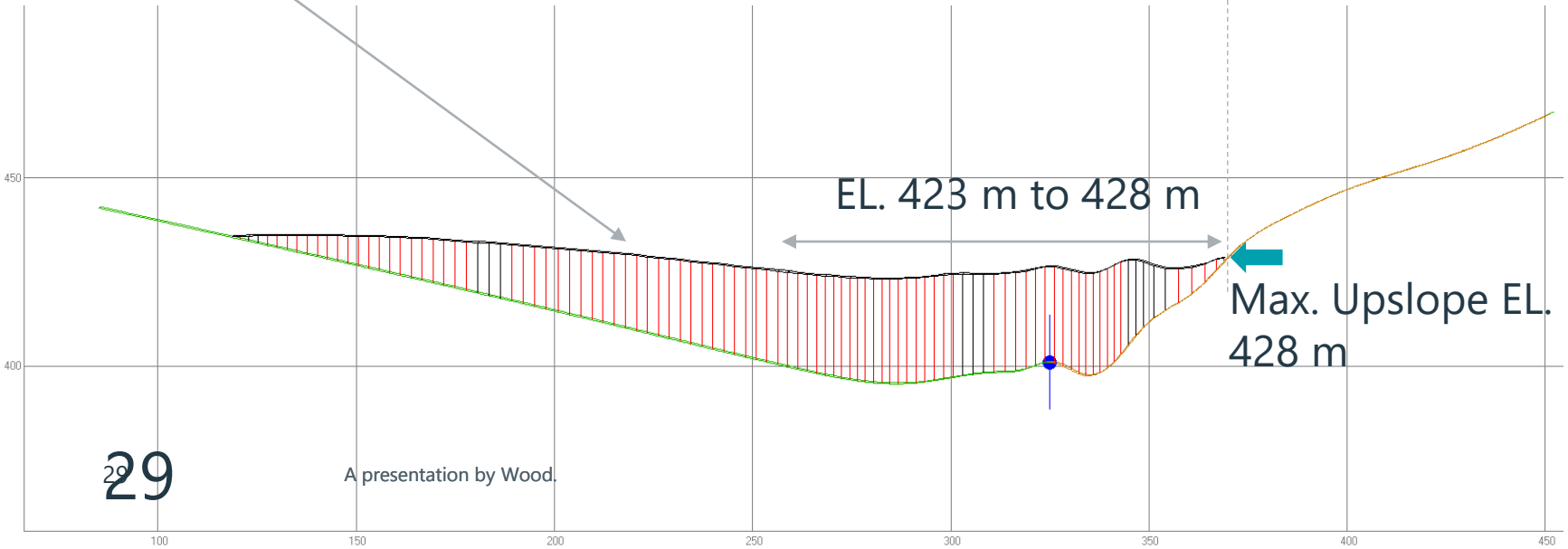
Landslide Dam
Surface Elevations

wood.

Section CC-9 (Larger Block assuming in situ Ru of 0.1)



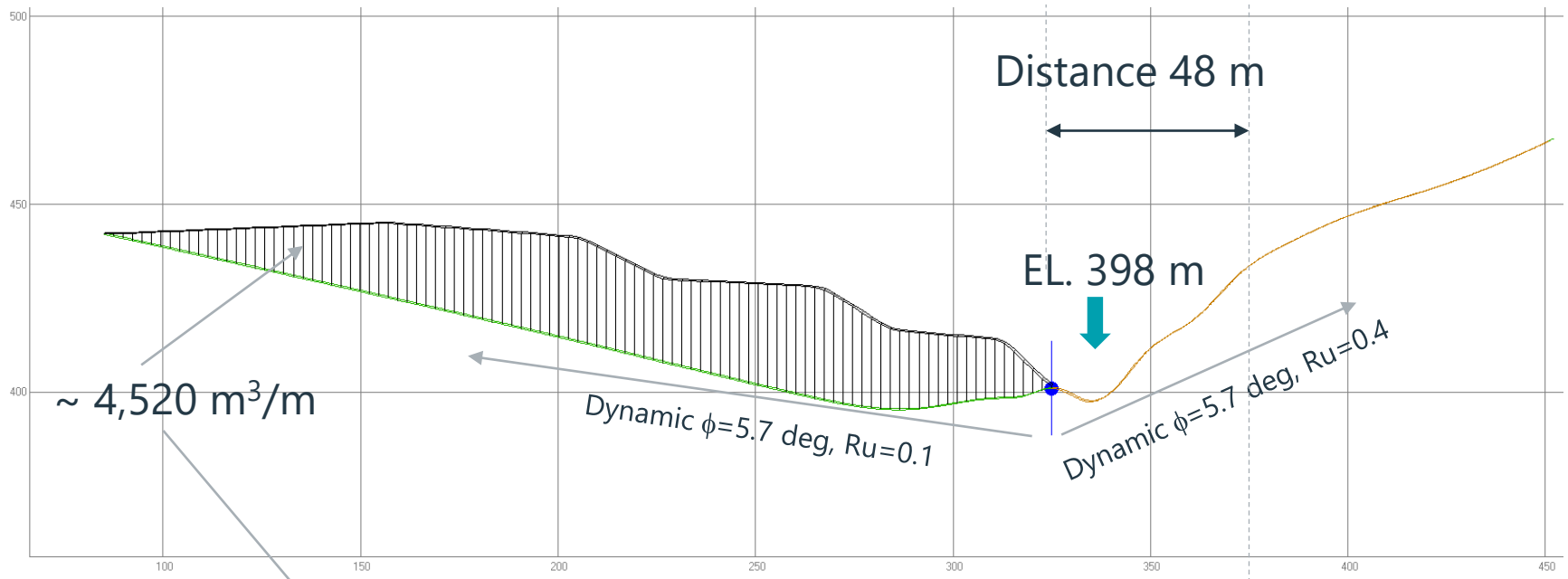
Pre-runout



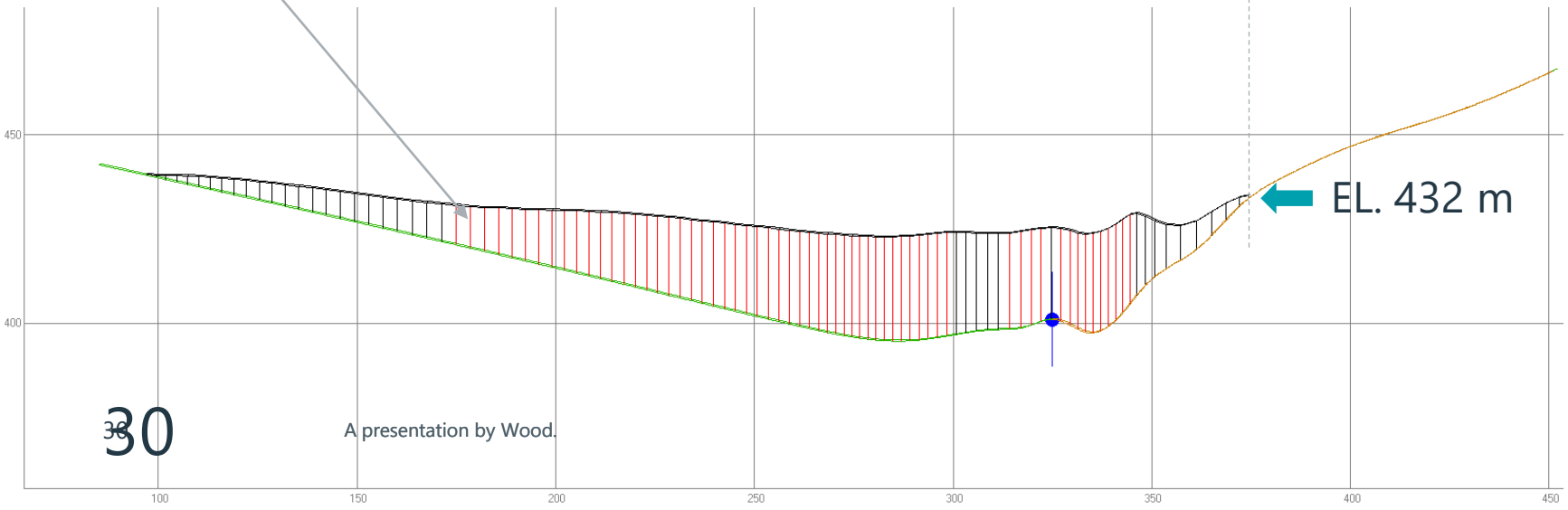
Landslide Dam Surface Elevations

29

Section CC-9 (Larger Block with high Ru of 0.4)

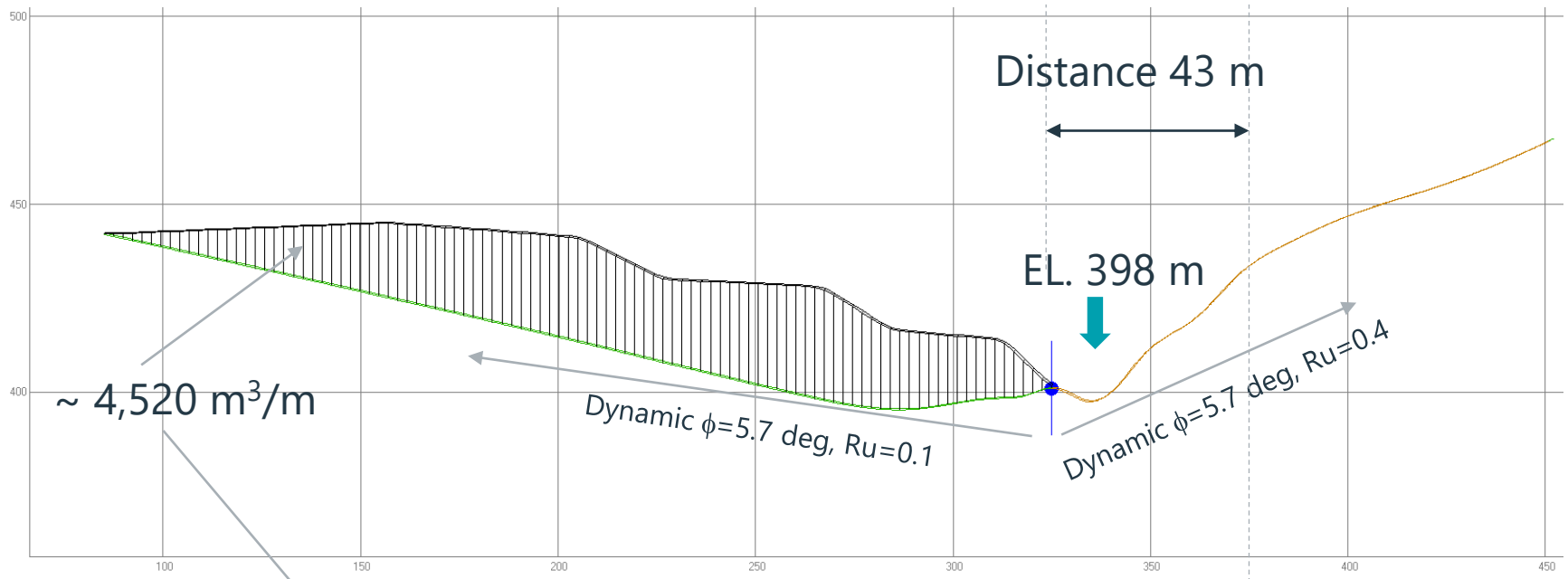


Pre-runout

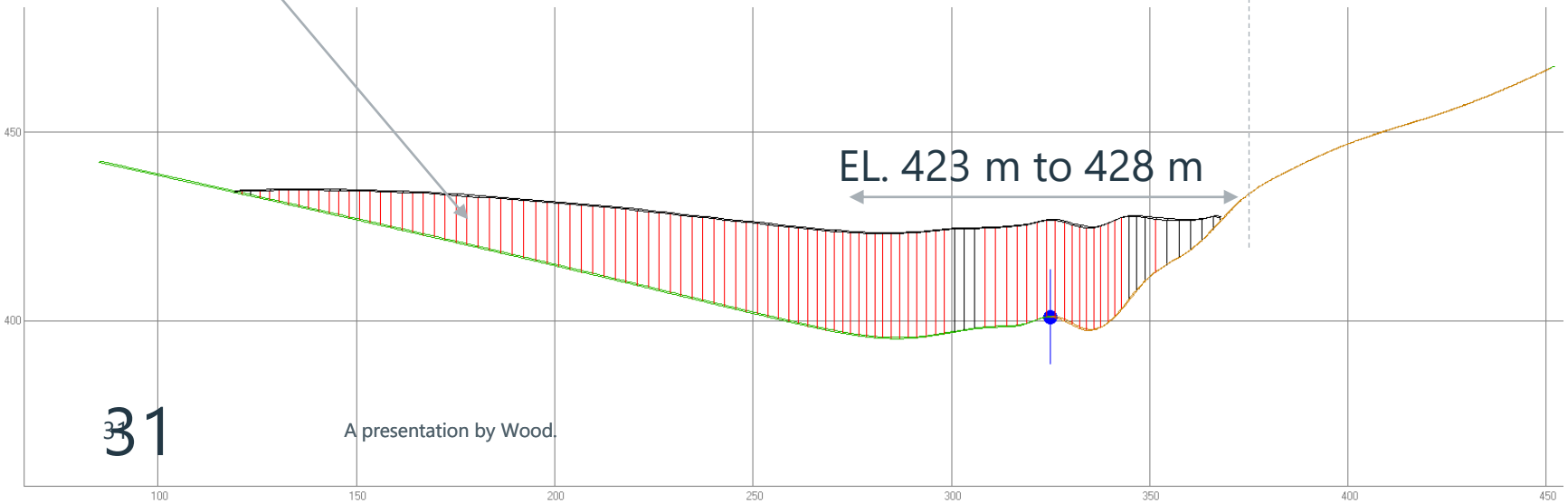


Maximum Distance and Upslope Elevation

Section CC-9 (Larger Block with high Ru of 0.4)

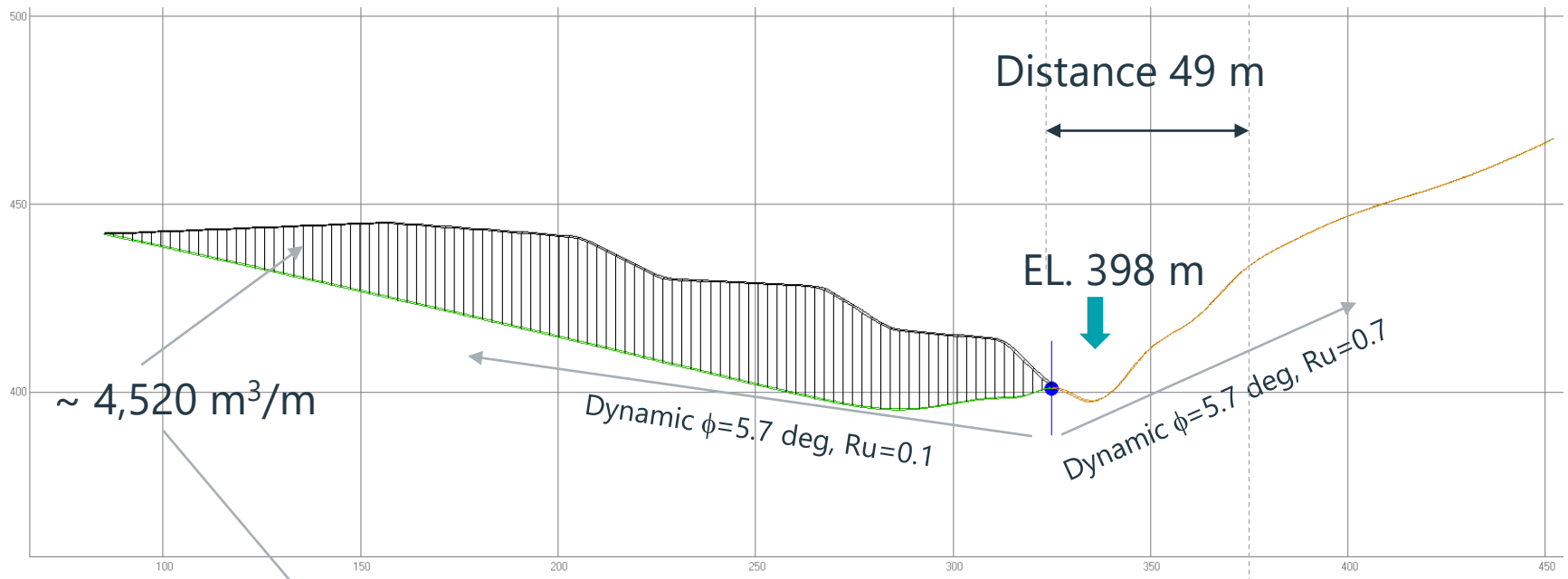


Pre-runout

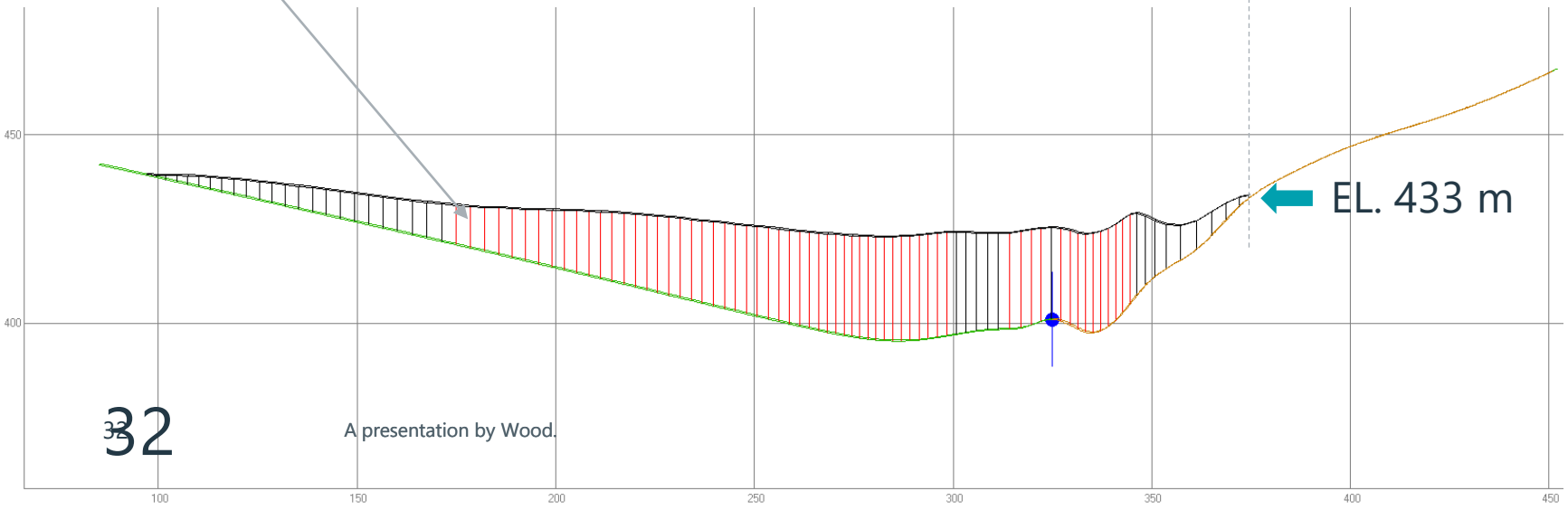


Landslide Dam Surface Elevations

Section CC-9 (Larger Block with high Ru of 0.7)

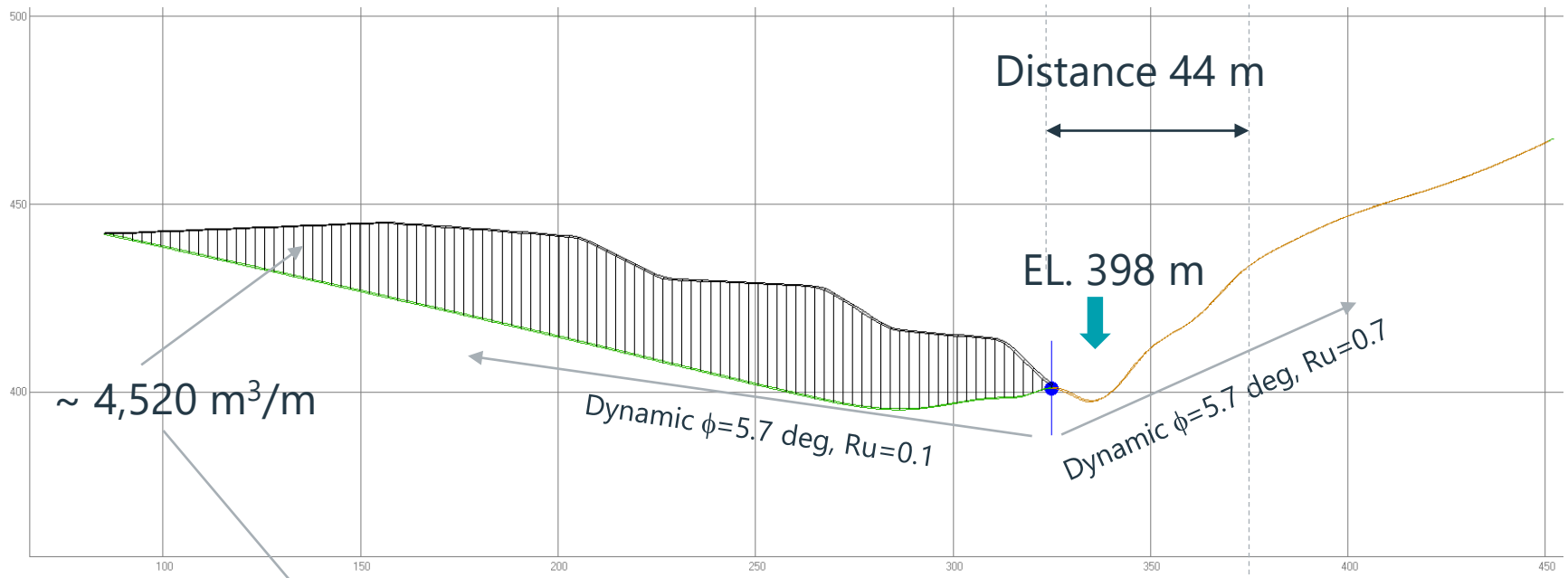


Pre-runout

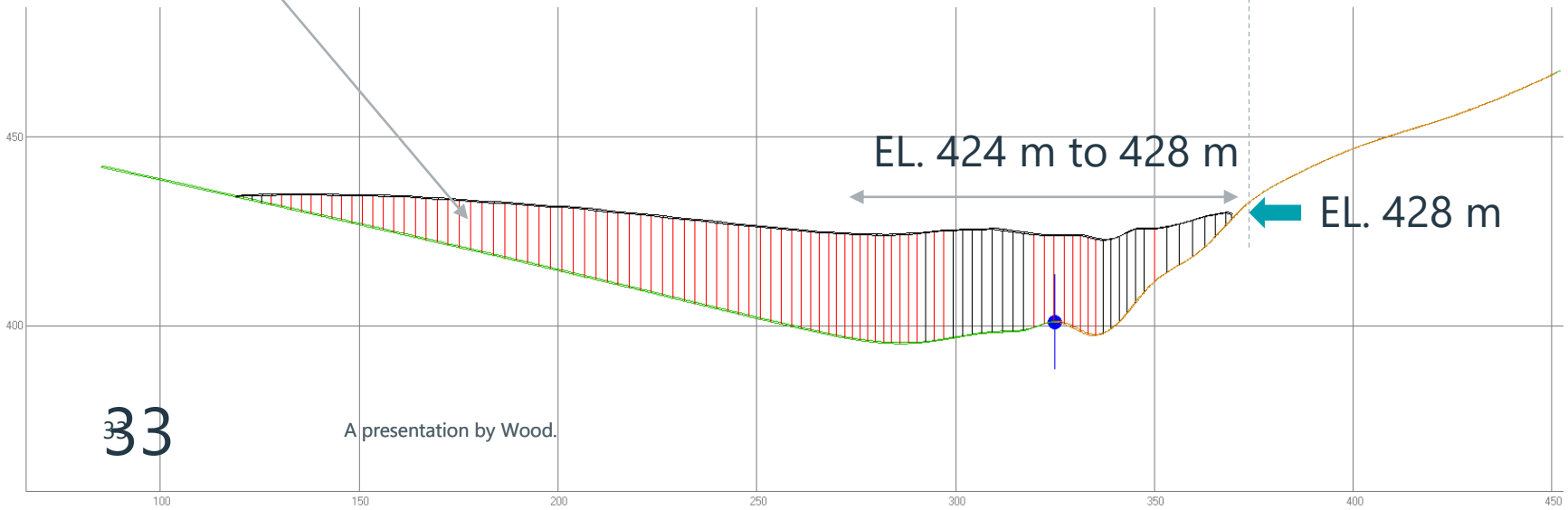


Maximum Distance and Upslope Elevation

Section CC-9 (Larger Block with high Ru of 0.7)



Pre-runout

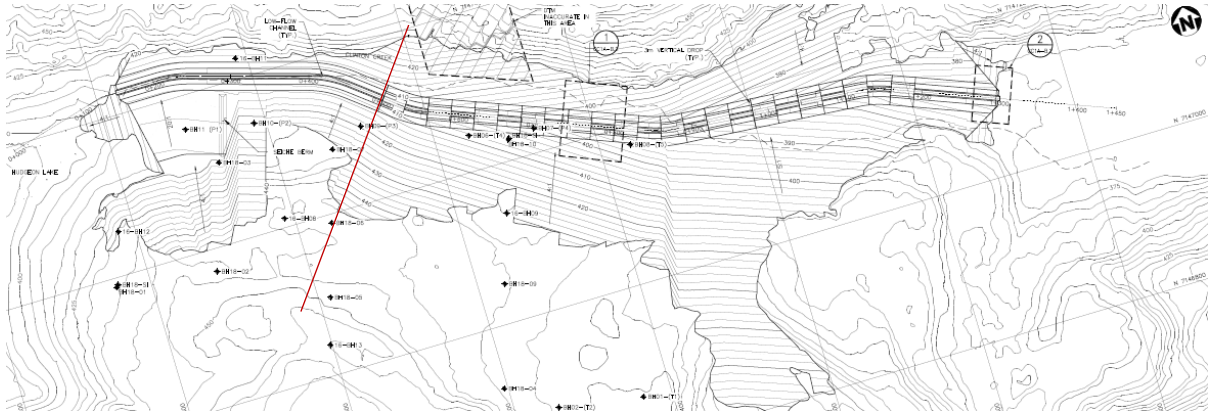


Landslide Dam Surface Elevations

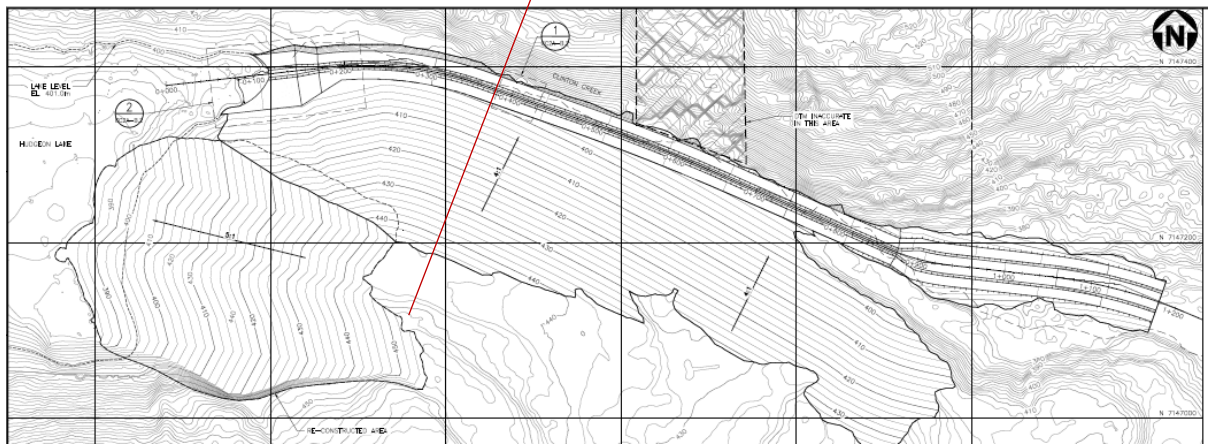
Clinton Creek Waste Pile Mitigation Options-2020 Alternative Spillway Design (Wood 2020)

2020 Alternative Spillway Design

Option CC1-A: Lake retention at El. 412 m, 4H:1V spillway slope cut.

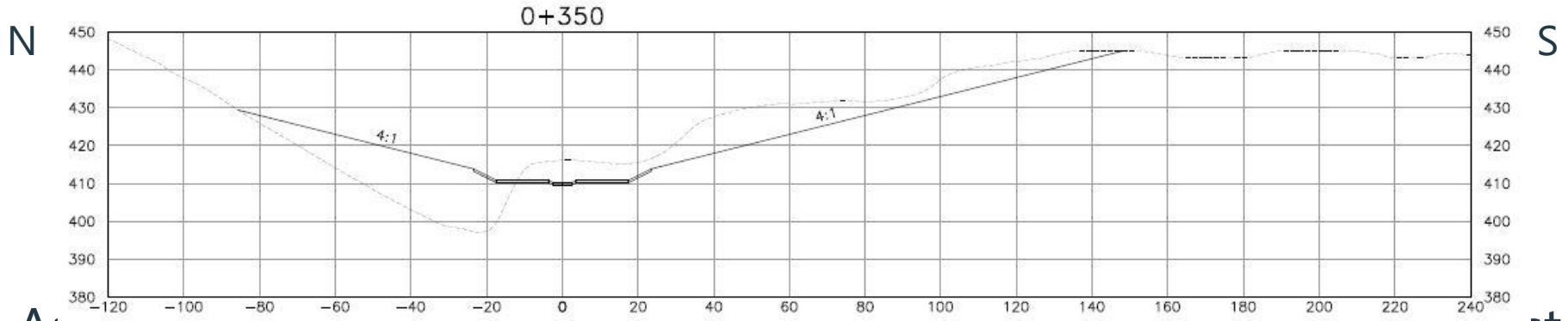


Option CC2-A: Lake lowered to El.401 m, 4H:1V spillway slope cut.

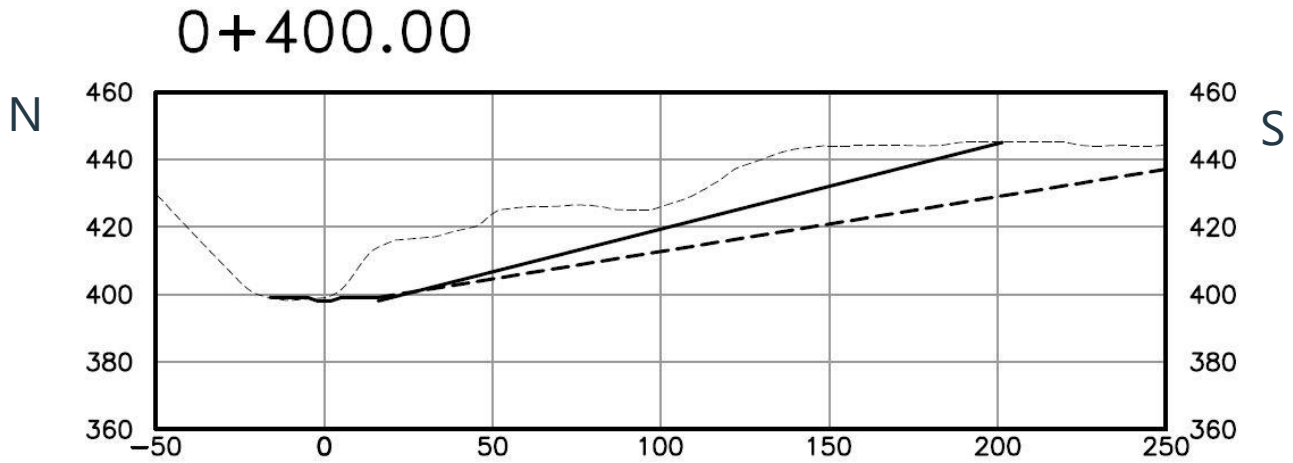


Sections Selected from 2020 Alternative

Option CC1-A: Lake at El. 412 m, 4H:1V spillway slope cut with blast densification.

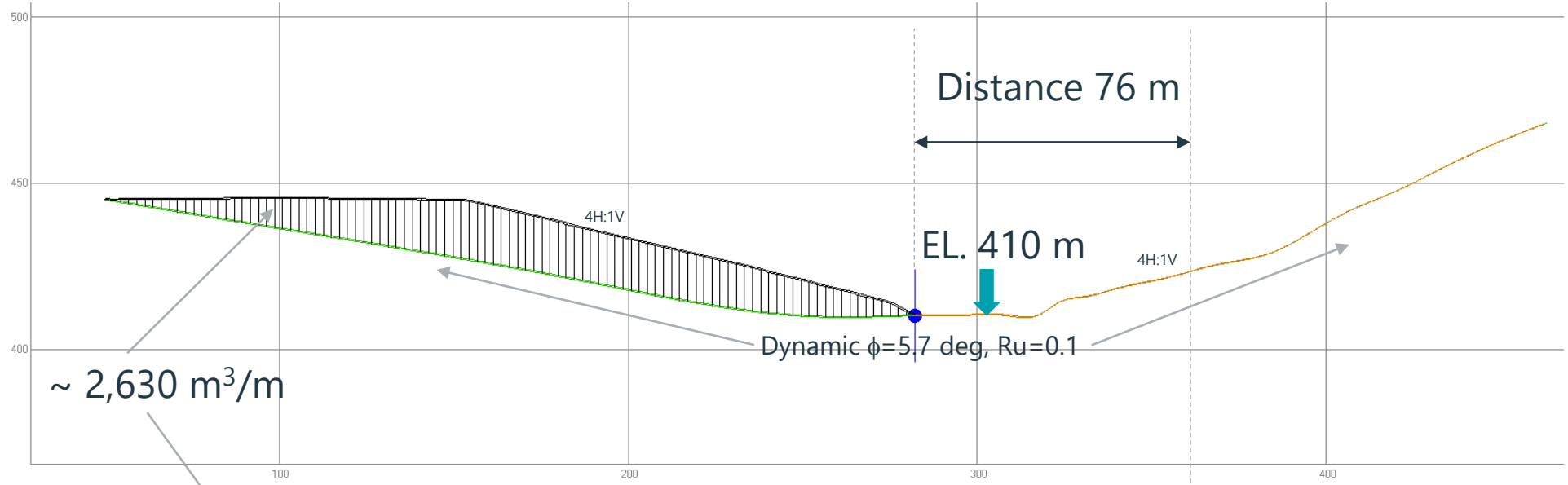


Option CC2-A: Lake lowered to El.401 m, 4H:1V spillway slope cut with blast densification.

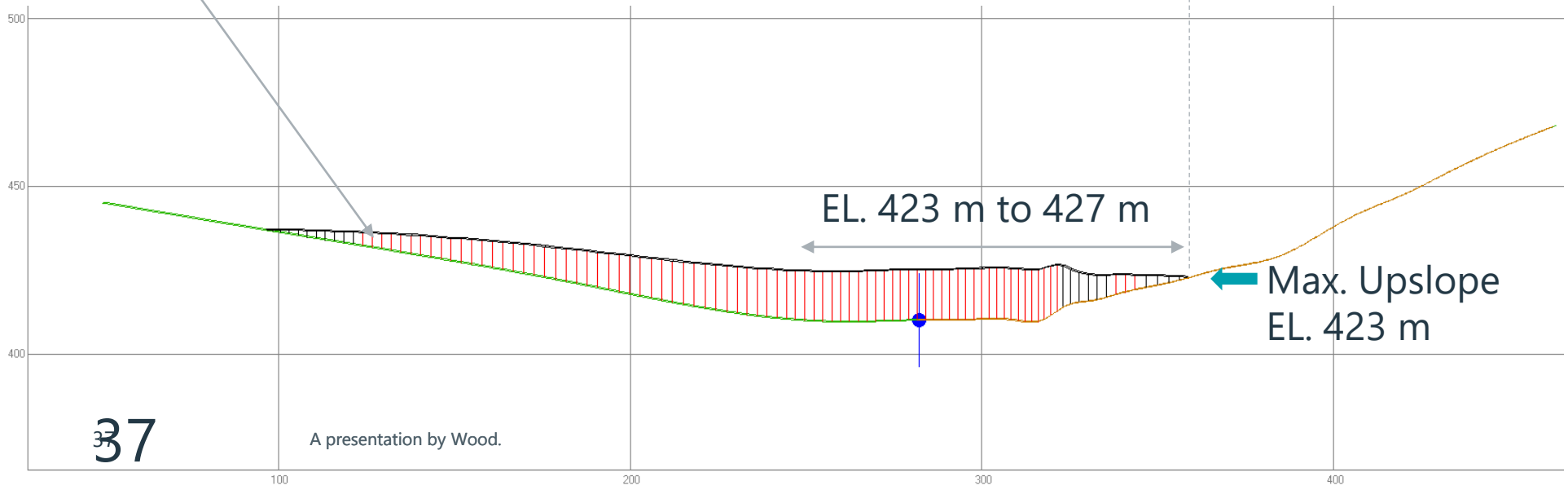


wood.

Option CC1-A(Lake at El. 412) 4H:1V Slope (assuming in situ Ru of 0.1)



Pre-runout

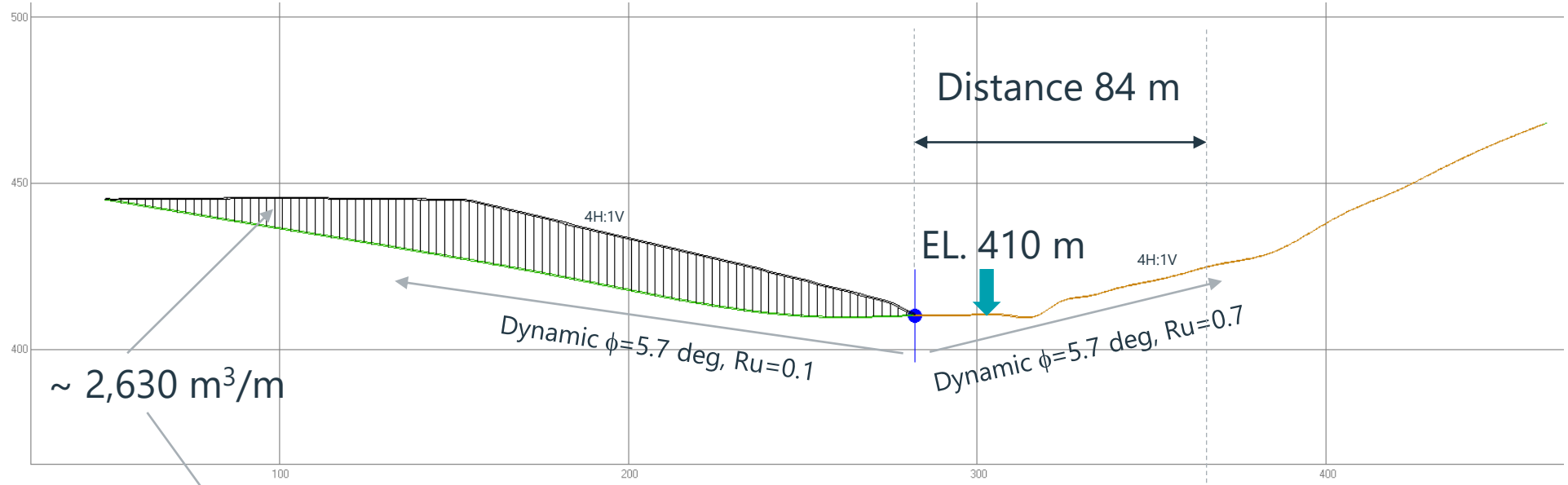


Landslide Dam
Surface Elevations

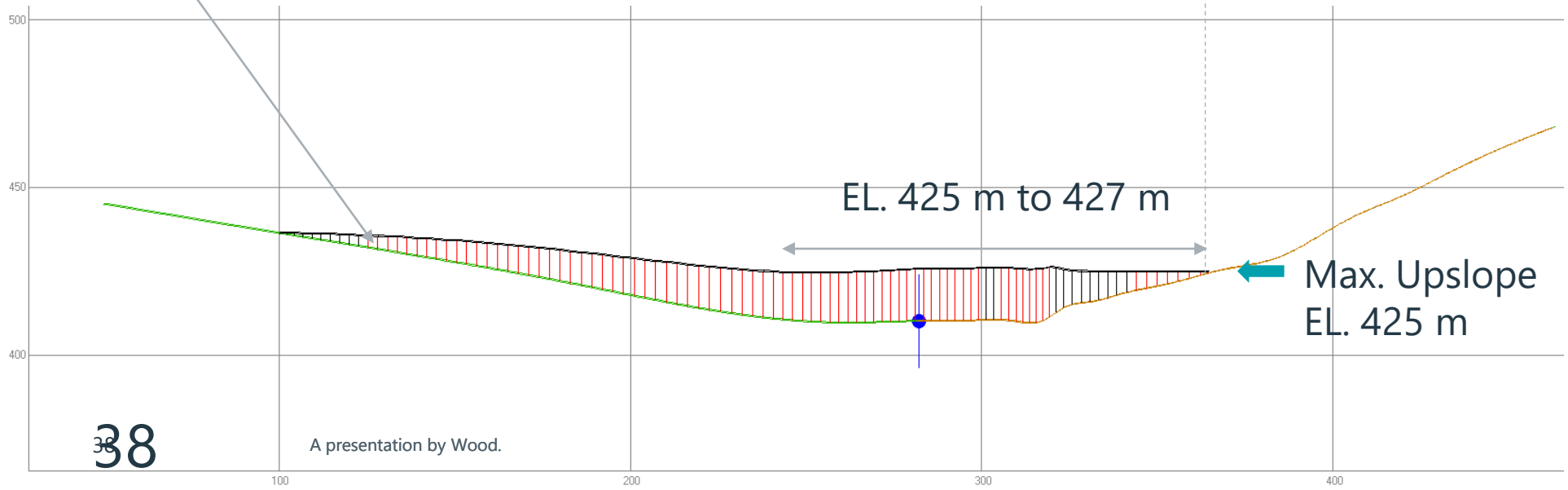
A presentation by Wood.

wood.

Option CC1-A(Lake at El. 412 m) 4H:1V Slope (High Mobility with Ru of 0.7)



Pre-runout

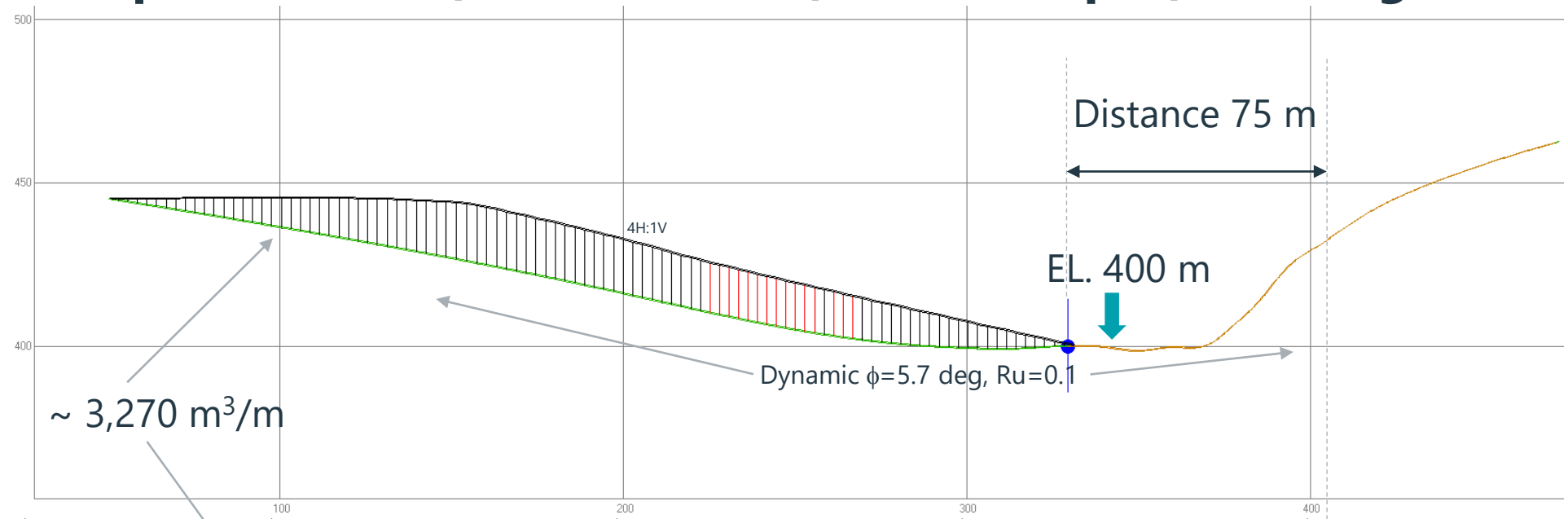


Landslide Dam
Surface Elevations

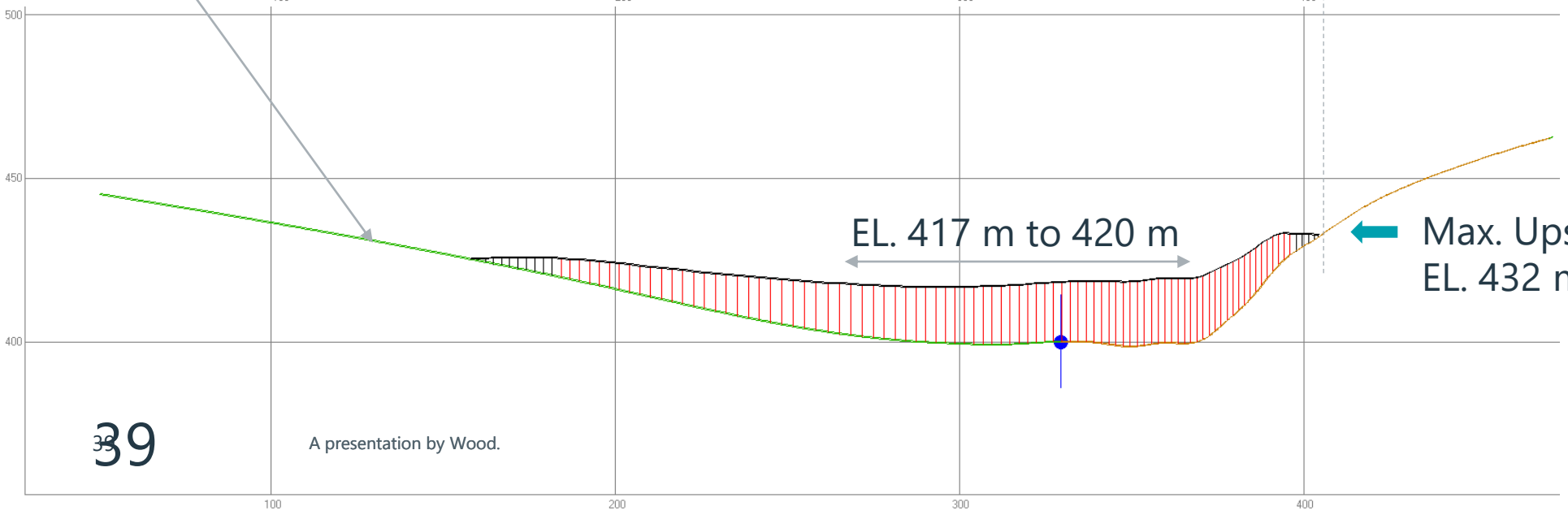
A presentation by Wood.

wood.

Option CC2-A (Lake at El. 401) 4H:1V Slope (assuming in situ Ru of 0.1)



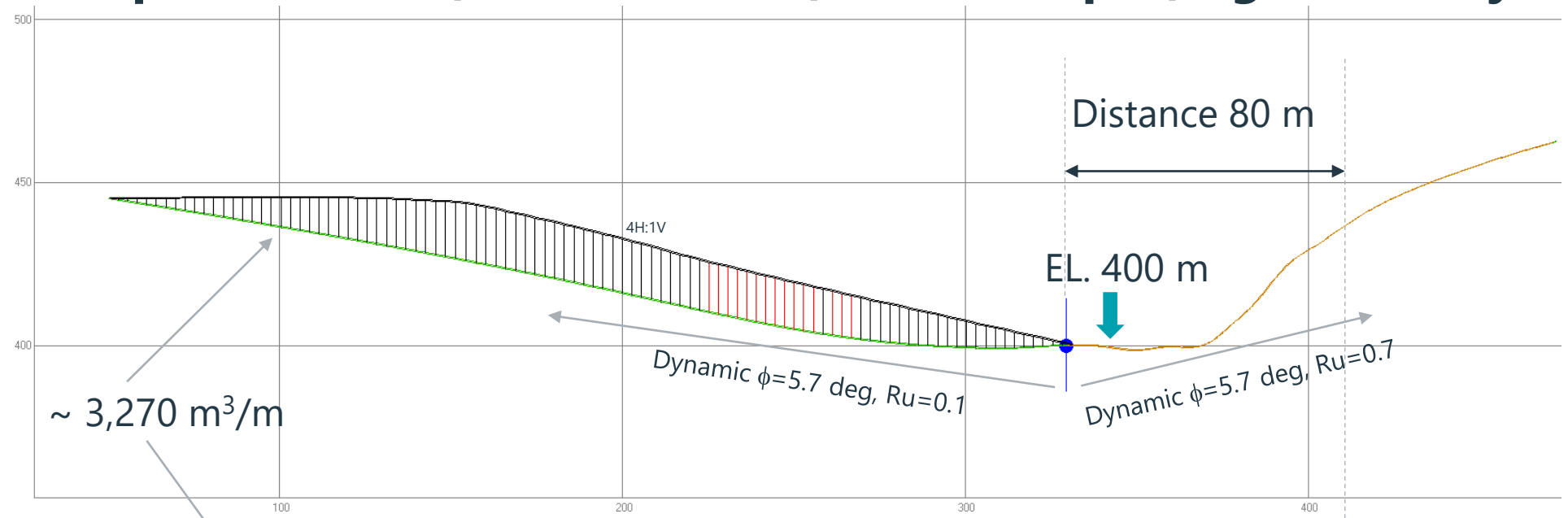
Pre-runout



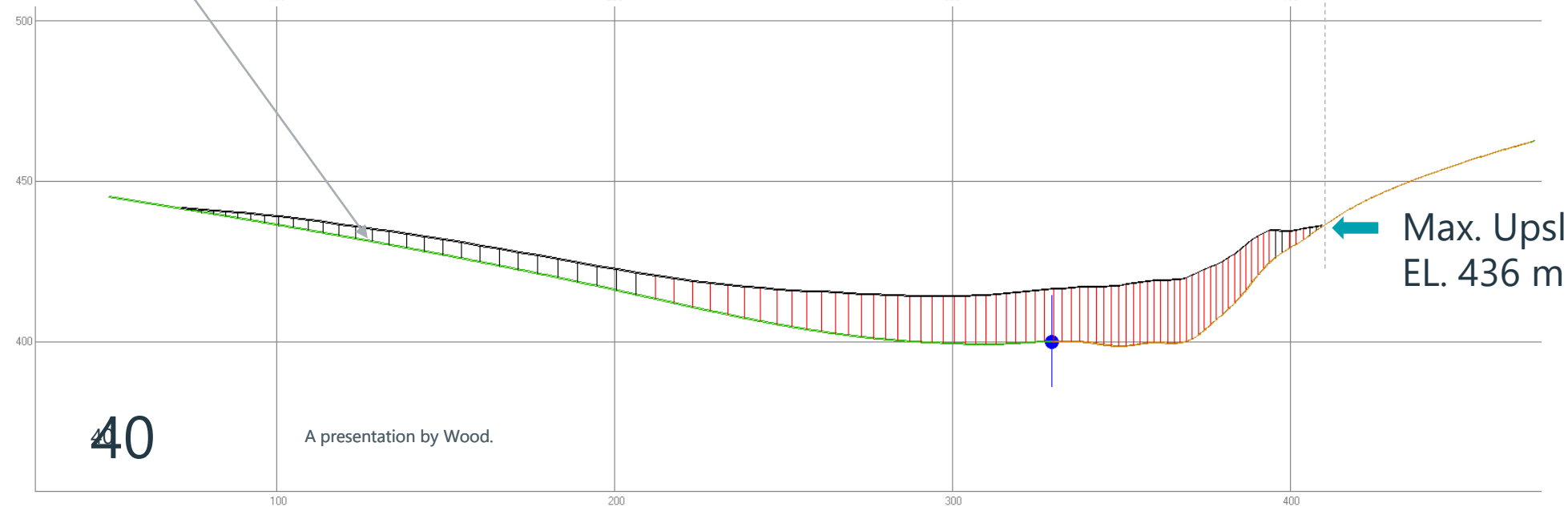
Landslide Dam
Surface Elevations

A presentation by Wood.

Option CC2-A (Lake at El. 401) 4H:1V Slope (High Mobility with Ru of 0.7)



Pre-runout

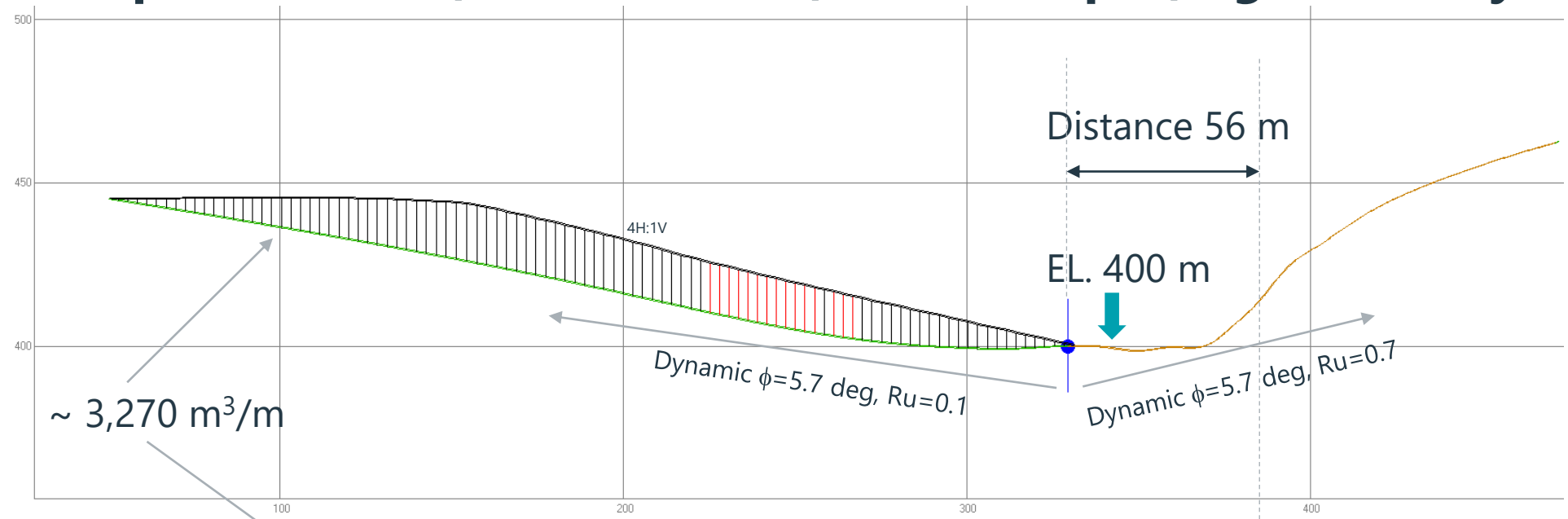


Maximum Distance and Upslope Elevation

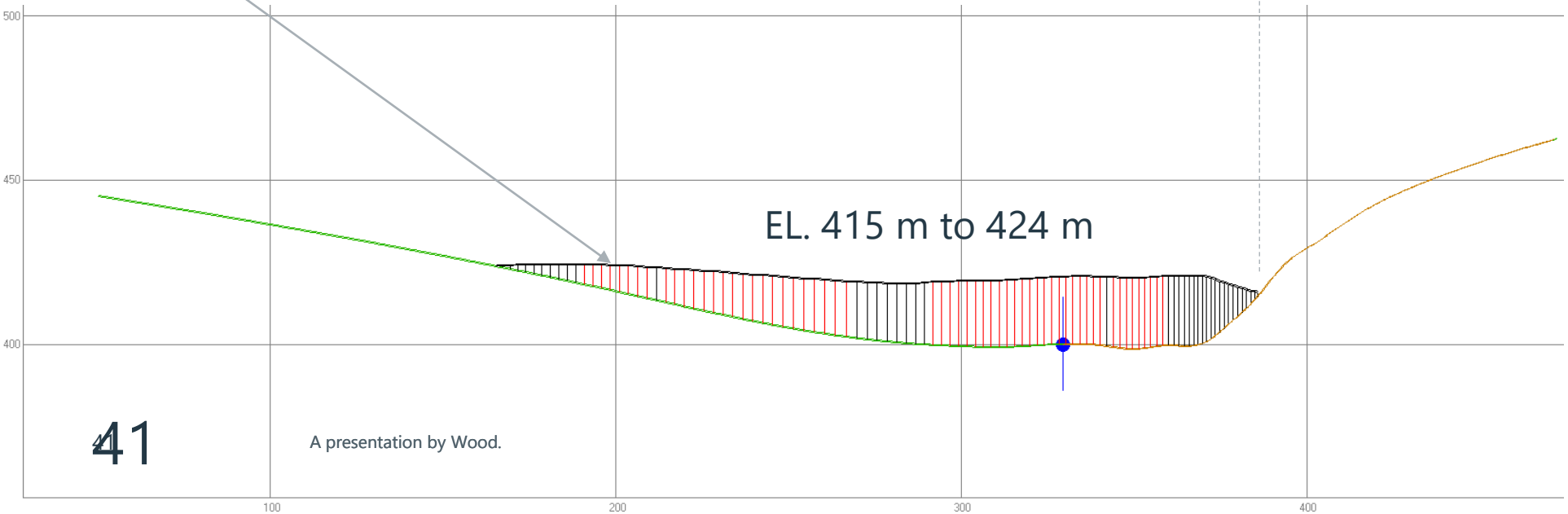
A presentation by Wood.

wood.

Option CC2-A (Lake at El. 401) 4H:1V Slope (High Mobility with Ru of 0.7)



Pre-runout



Landslide Dam Surface Elevations

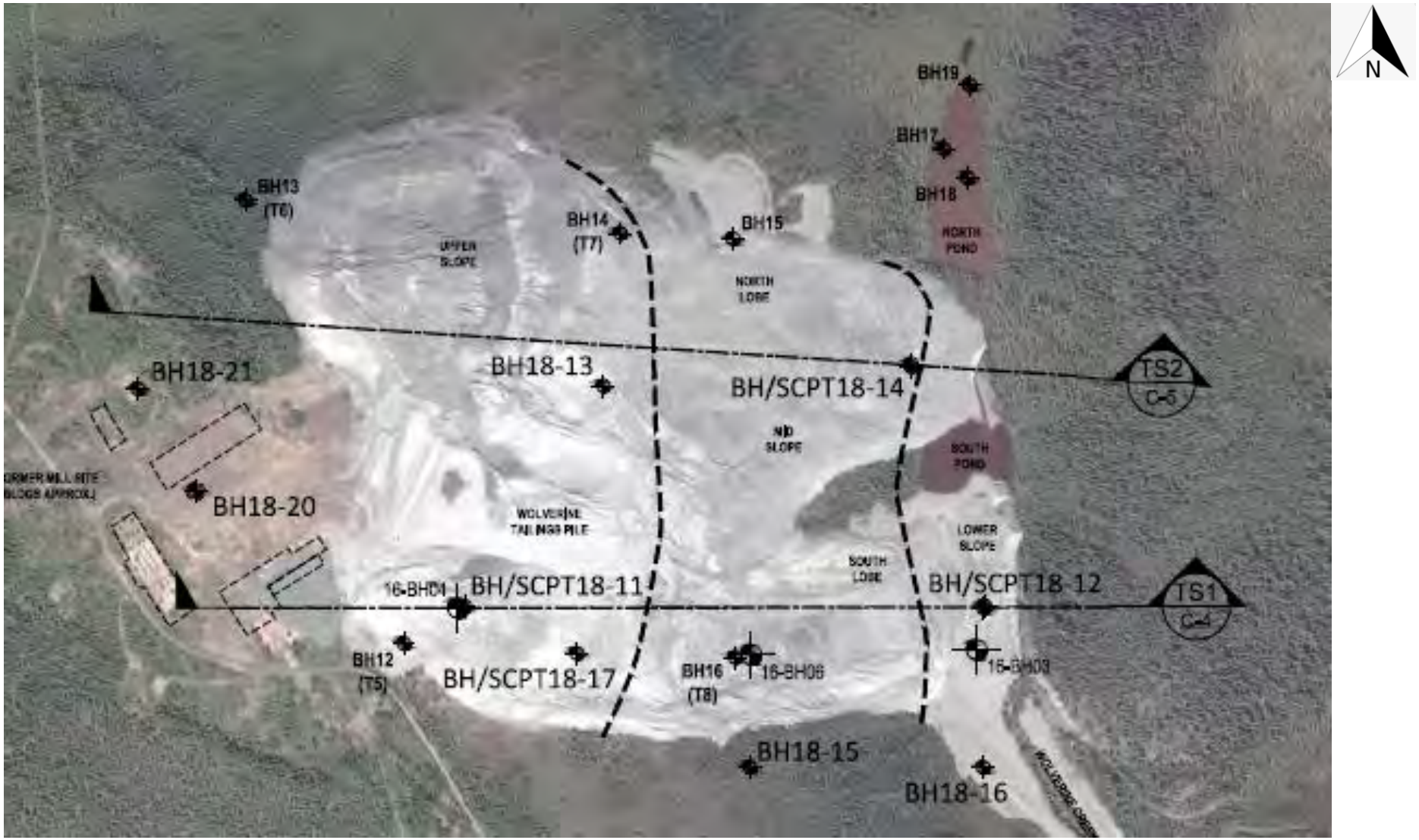
A presentation by Wood.

wood.

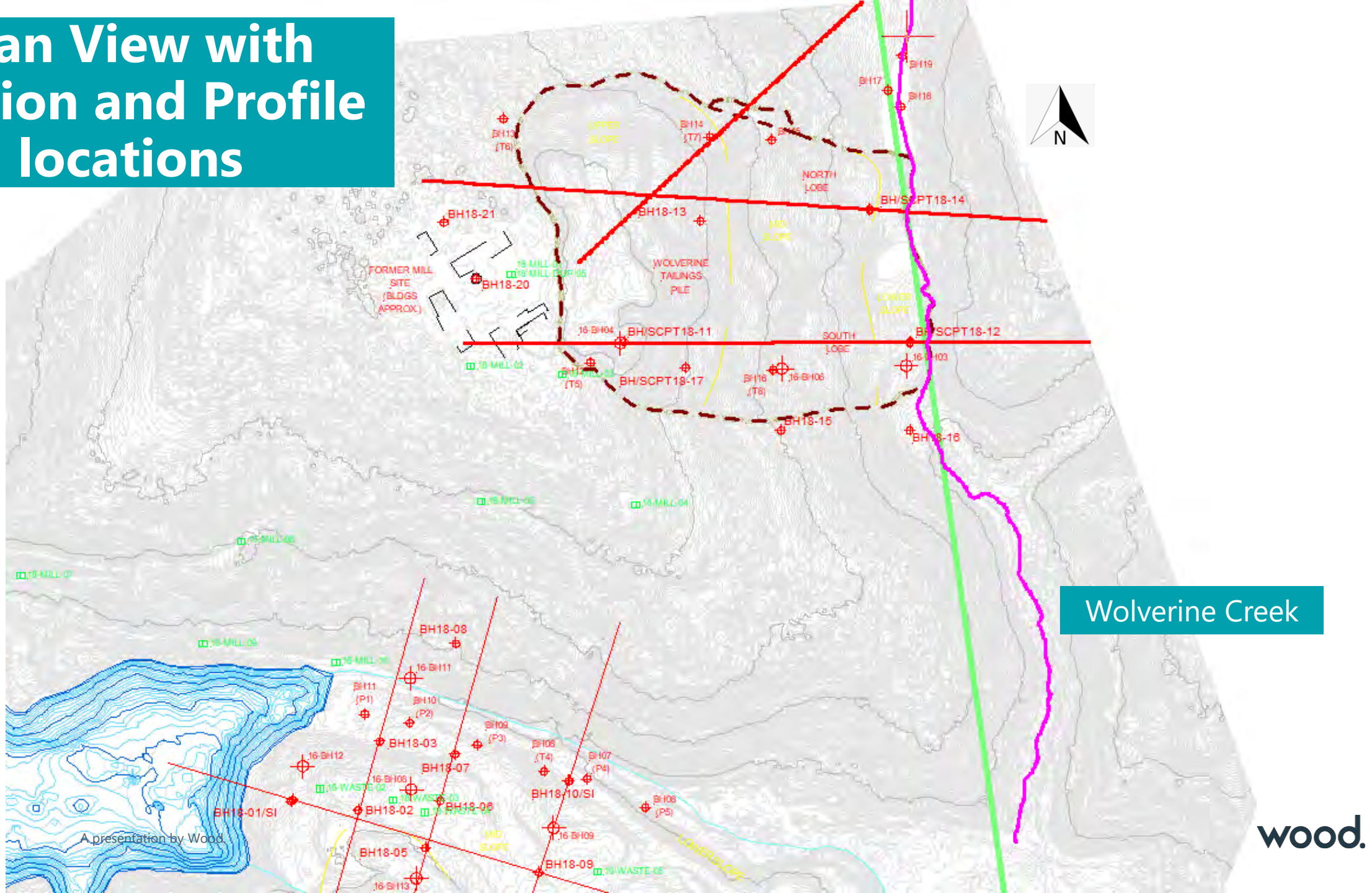
Wolverine Creek Tailings Dump
Existing Topography

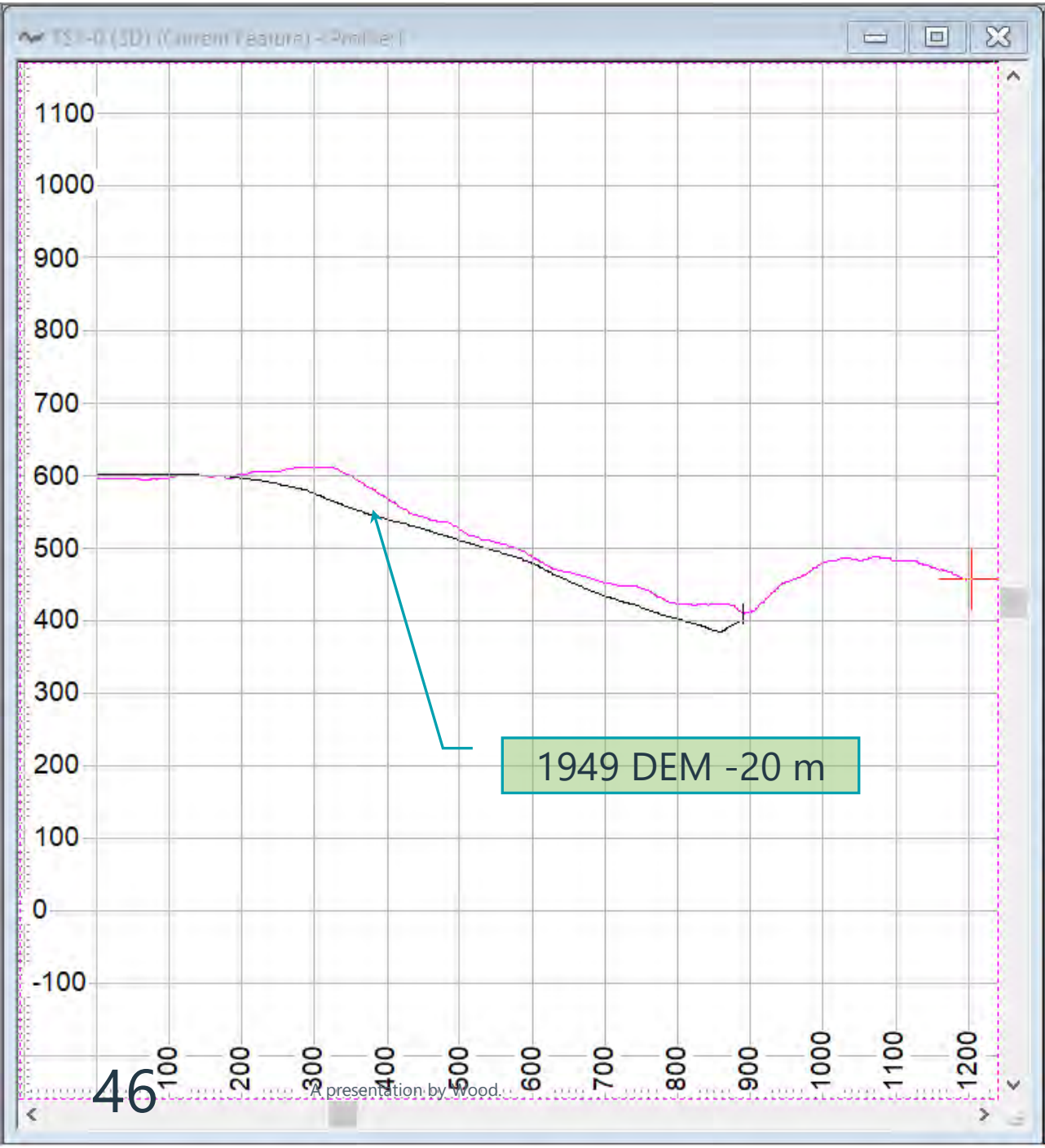
Aerial Image

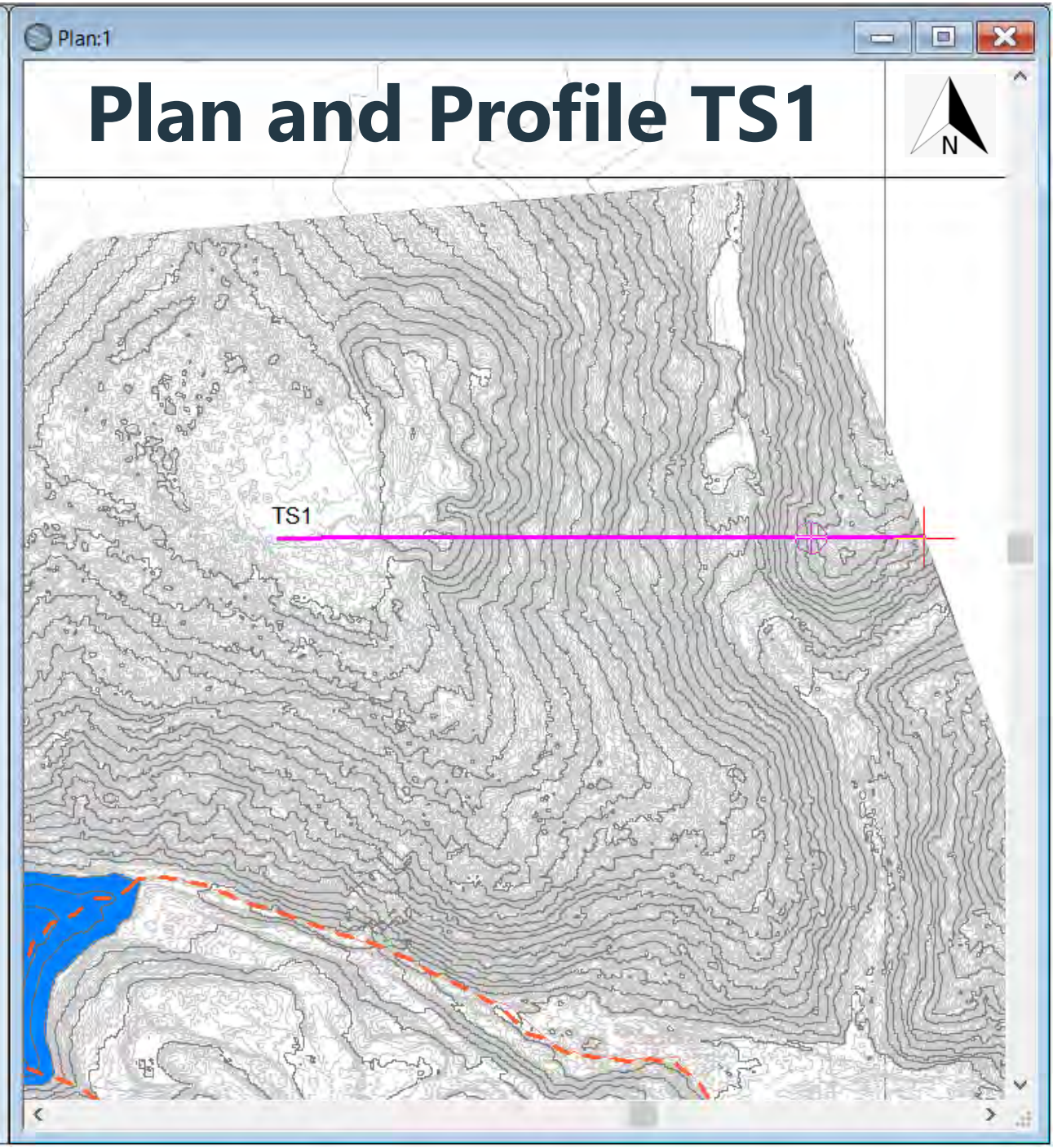
Tailings Dump Plan Aerial View

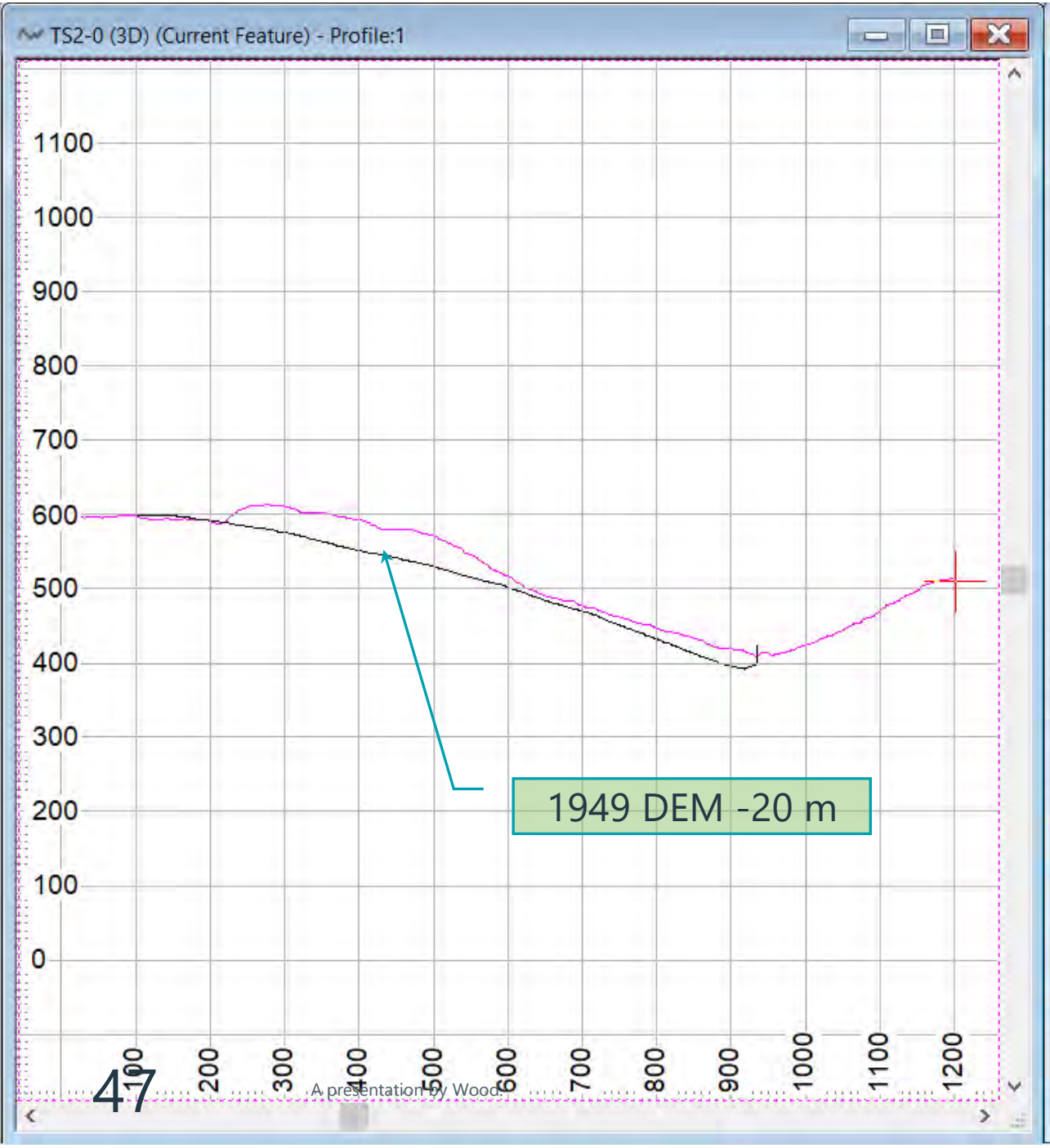


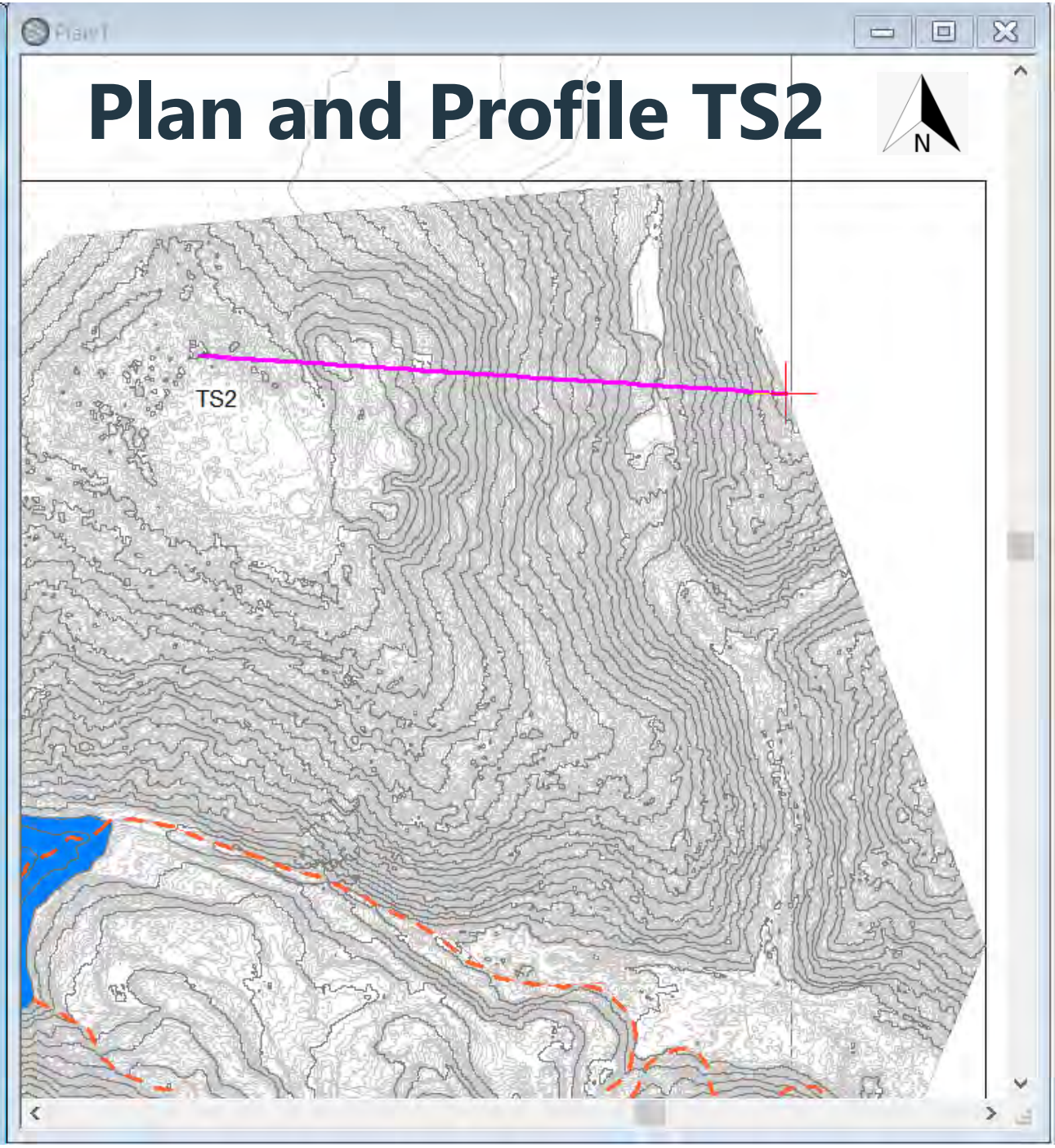
Plan View with Section and Profile locations

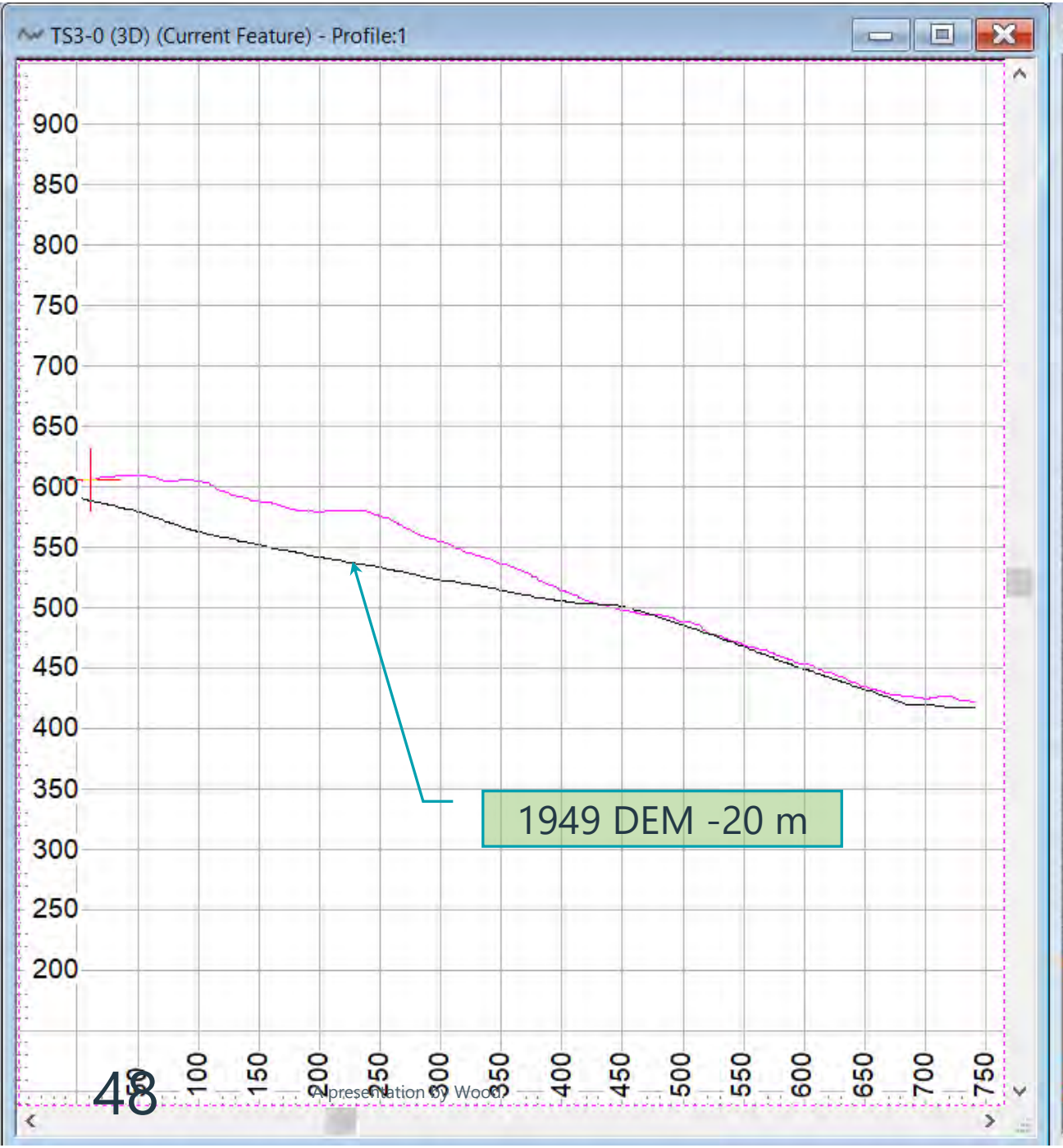


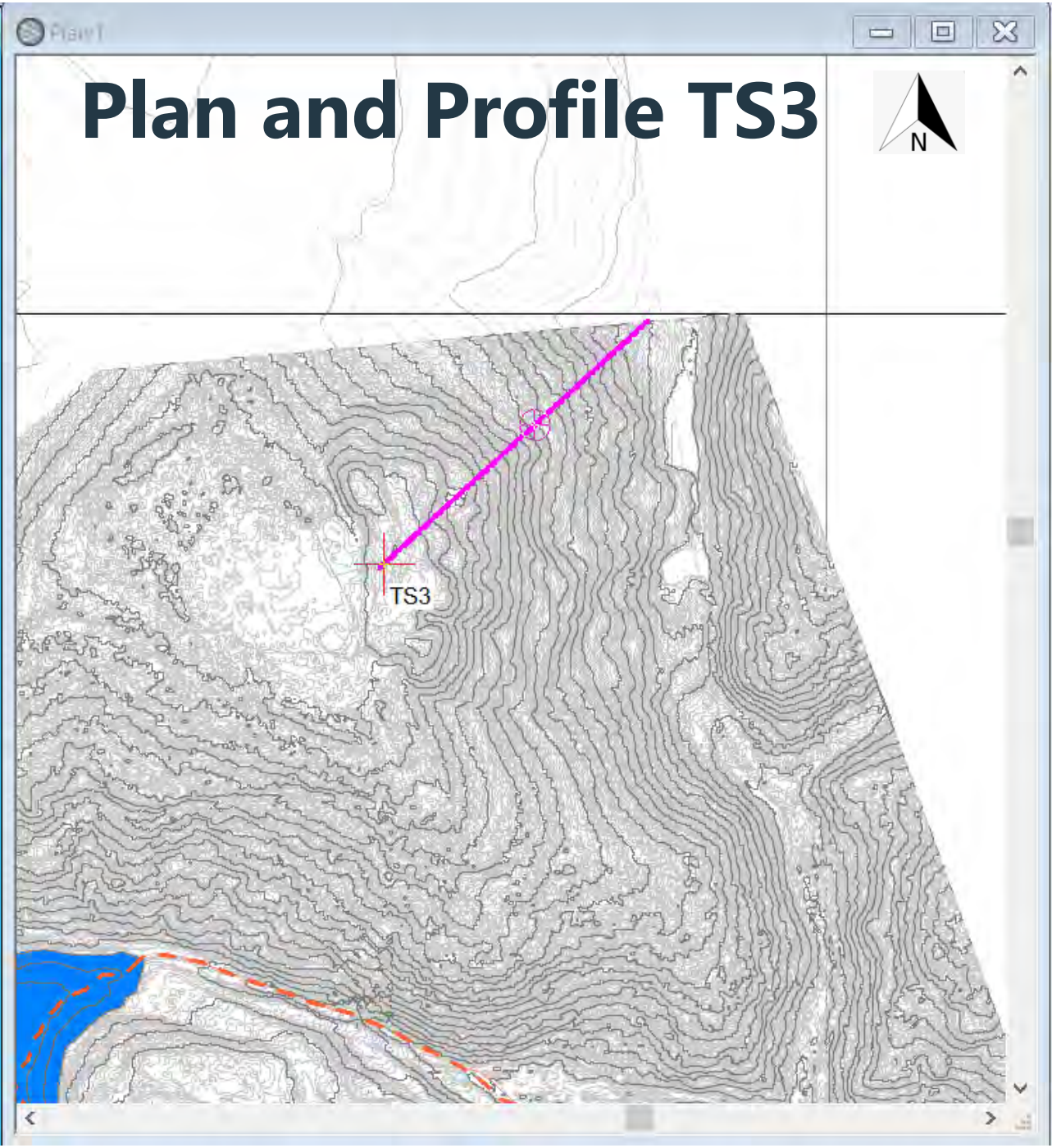

1100
1000
900
800
700
600
500
400
300
200
100
0
-100
100
200
300
400
500
600
700
800
900
1000
1100
1200
1949 DEM -20 m


Plan:1
Plan and Profile TS1
N
TS1

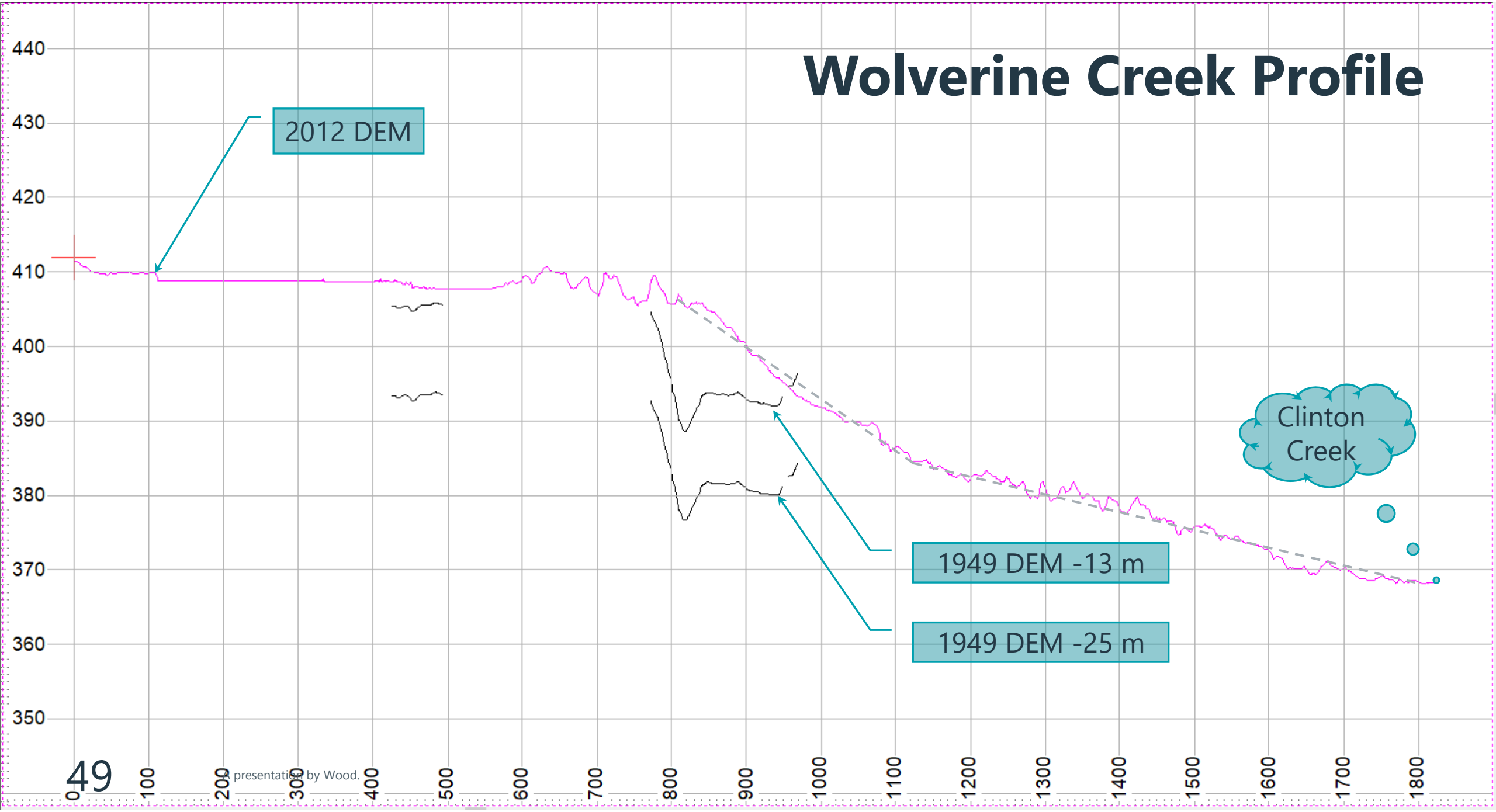

TS2-0 (3D) (Current Feature) - Profile:1
1100
1000
900
800
700
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1949 DEM -20 m


Plan and Profile TS2
N
TS2


TS3-0 (3D) (Current Feature) - Profile:1
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
1949 DEM -20 m

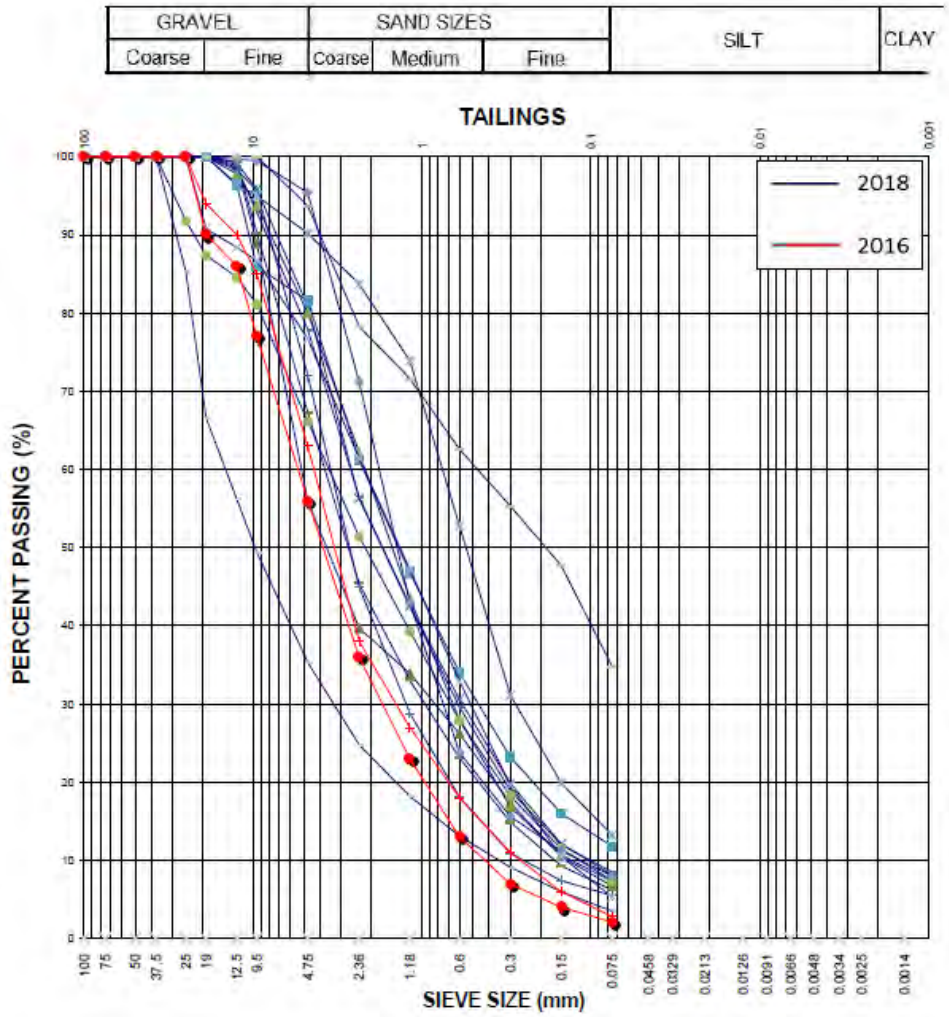

Plan 1
Plan and Profile TS3
N
TS3

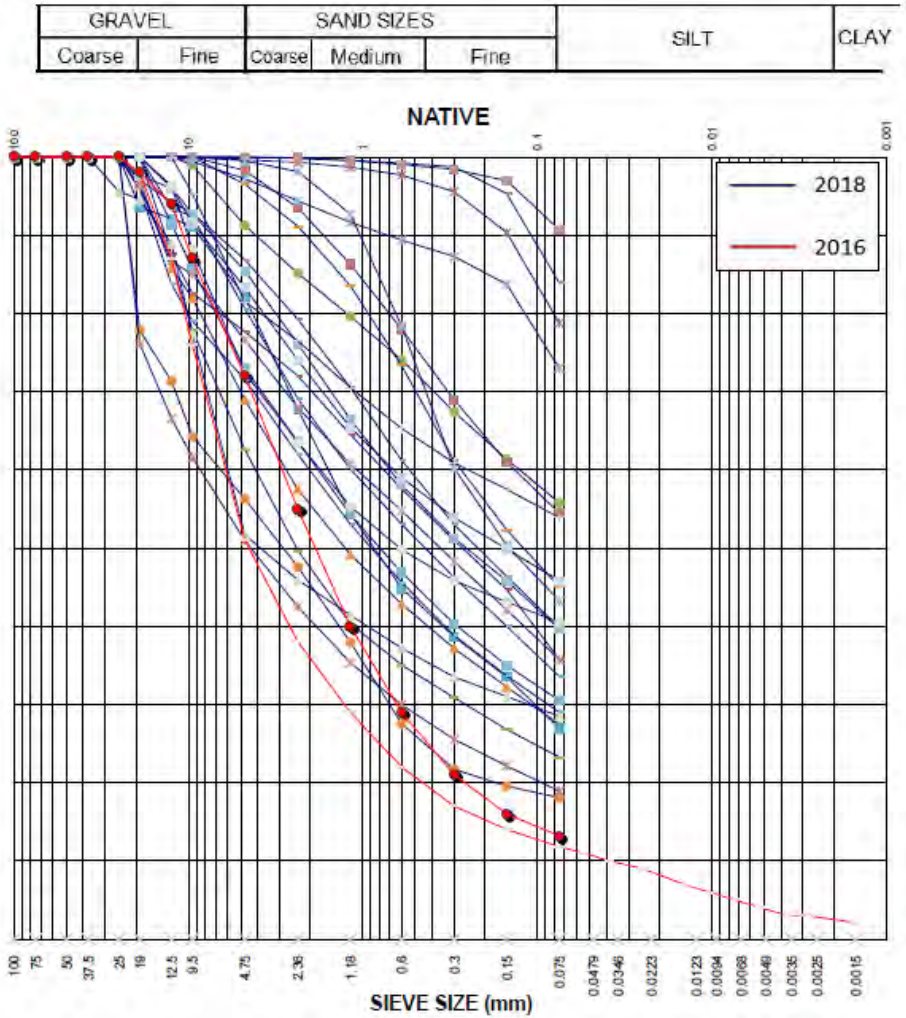
Wolverine Creek Profile



A presentation by Wood.

Wolverine Creek Tailings and Native Material Gradations



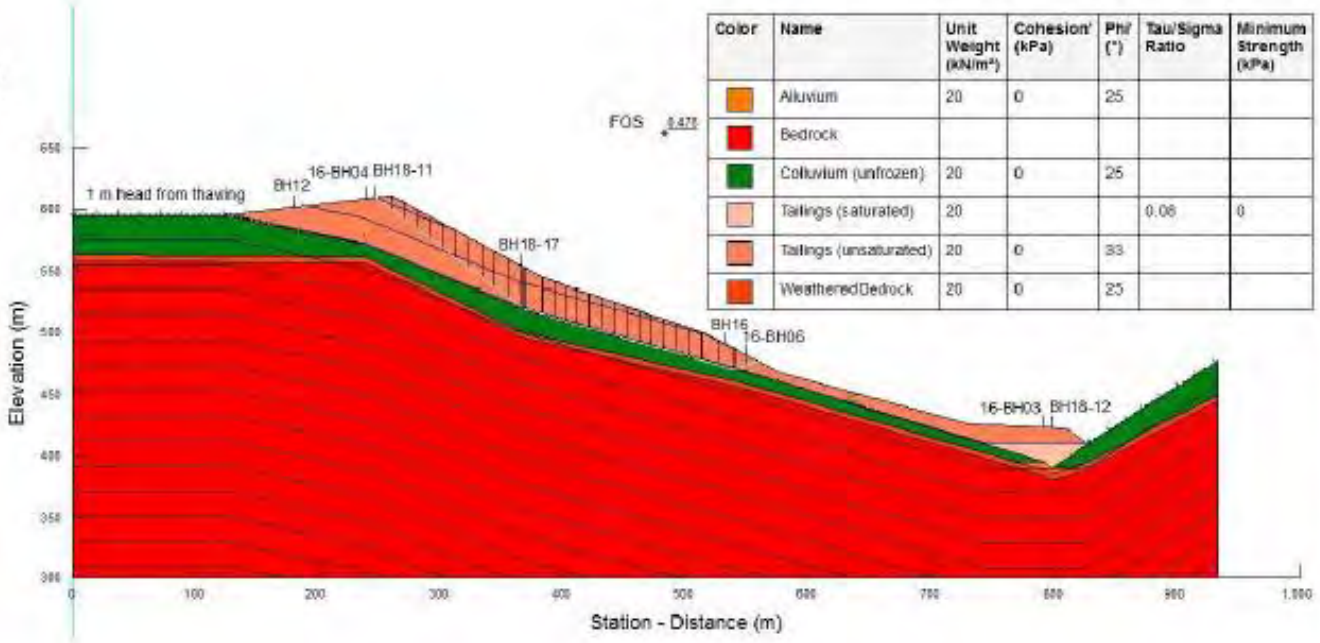


Previous Stability for South Lobe (Wood 2019) – Liquefied strength 0.08 for tailings and FoS less than 1

TS1 – Liquefaction in Tailings

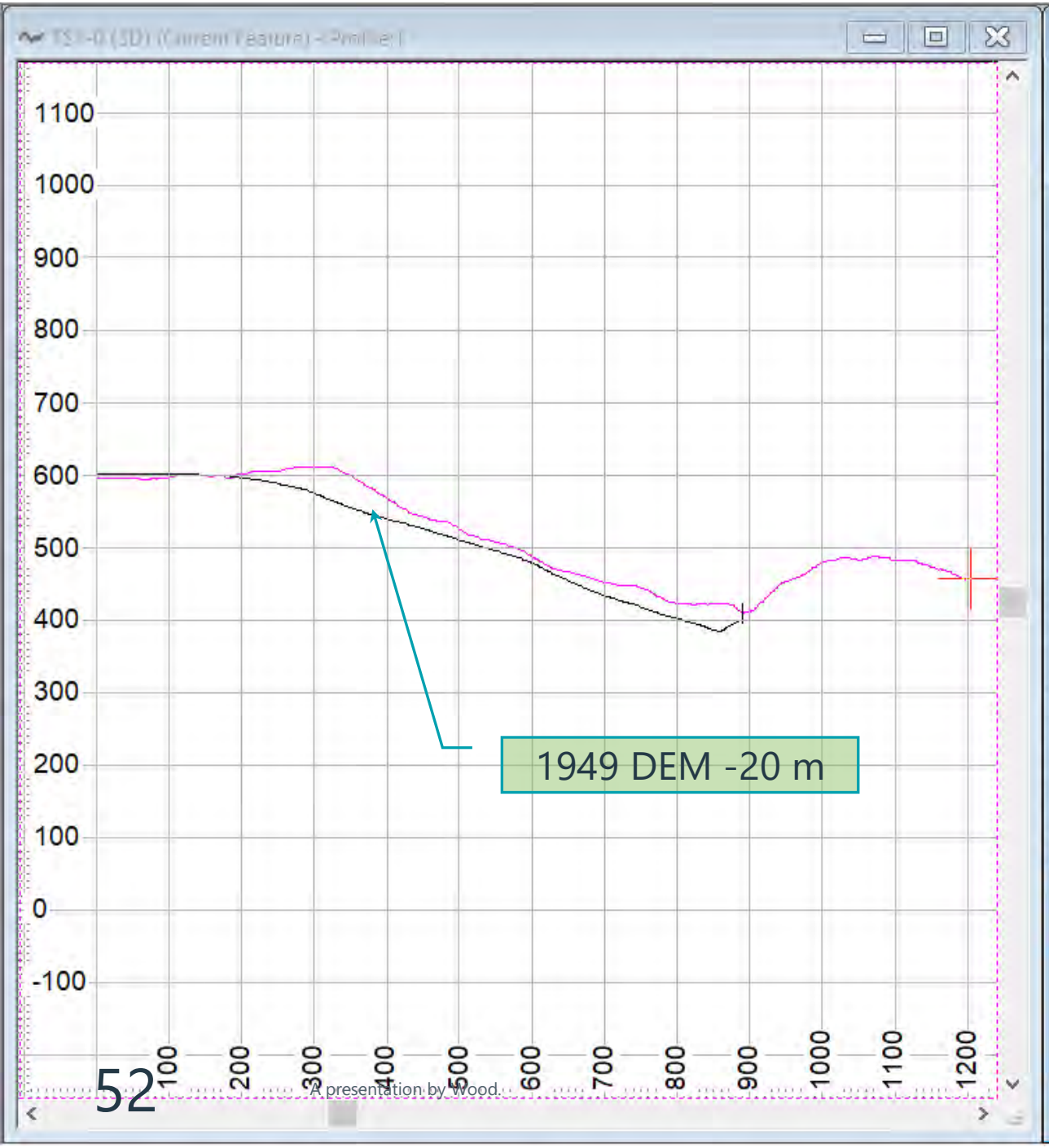
- Liquefied tailings use c/p' = 0.08
- Tailings (unsaturated) use ϕ=33°
- Phreatic surface 1 m above tailings/colluvium boundary

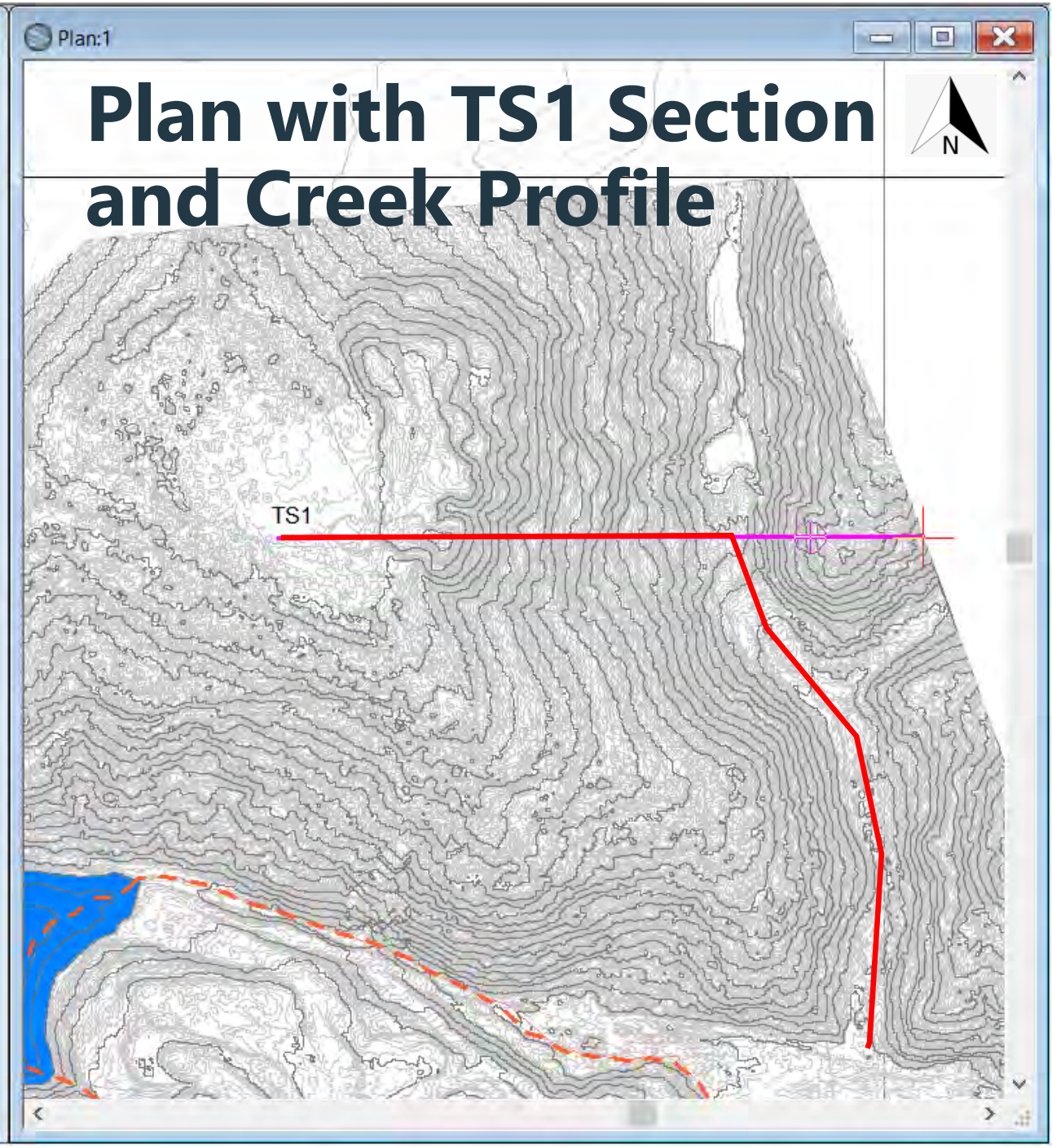
FoS = 0.48



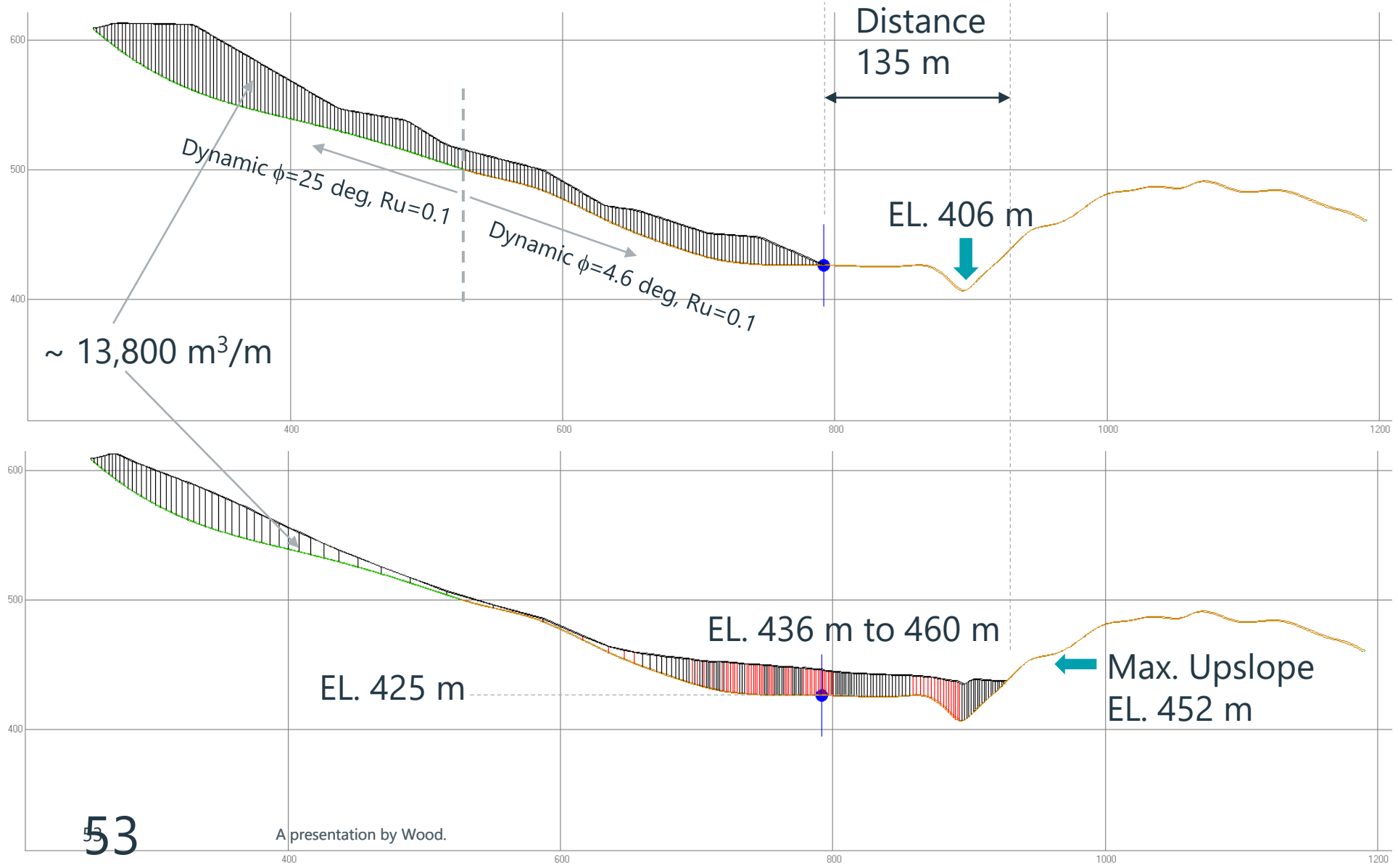
Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Tau/Sigma Ratio	Minimum Strength (kPa)
	Alluvium	20	0	25		
	Bedrock					
	Colluvium (unfrozen)	20	0	25		
	Tailings (saturated)	20			0.08	0
	Tailings (unsaturated)	20	0	33		
	WeatheredBedrock	20	0	25		

wood.


1100
1000
900
800
700
600
500
400
300
200
100
0
-100
100
200
300
400
500
600
700
800
900
1000
1100
1200
1949 DEM -20 m


Plan:1
Plan with TS1 Section and Creek Profile
N
TS1

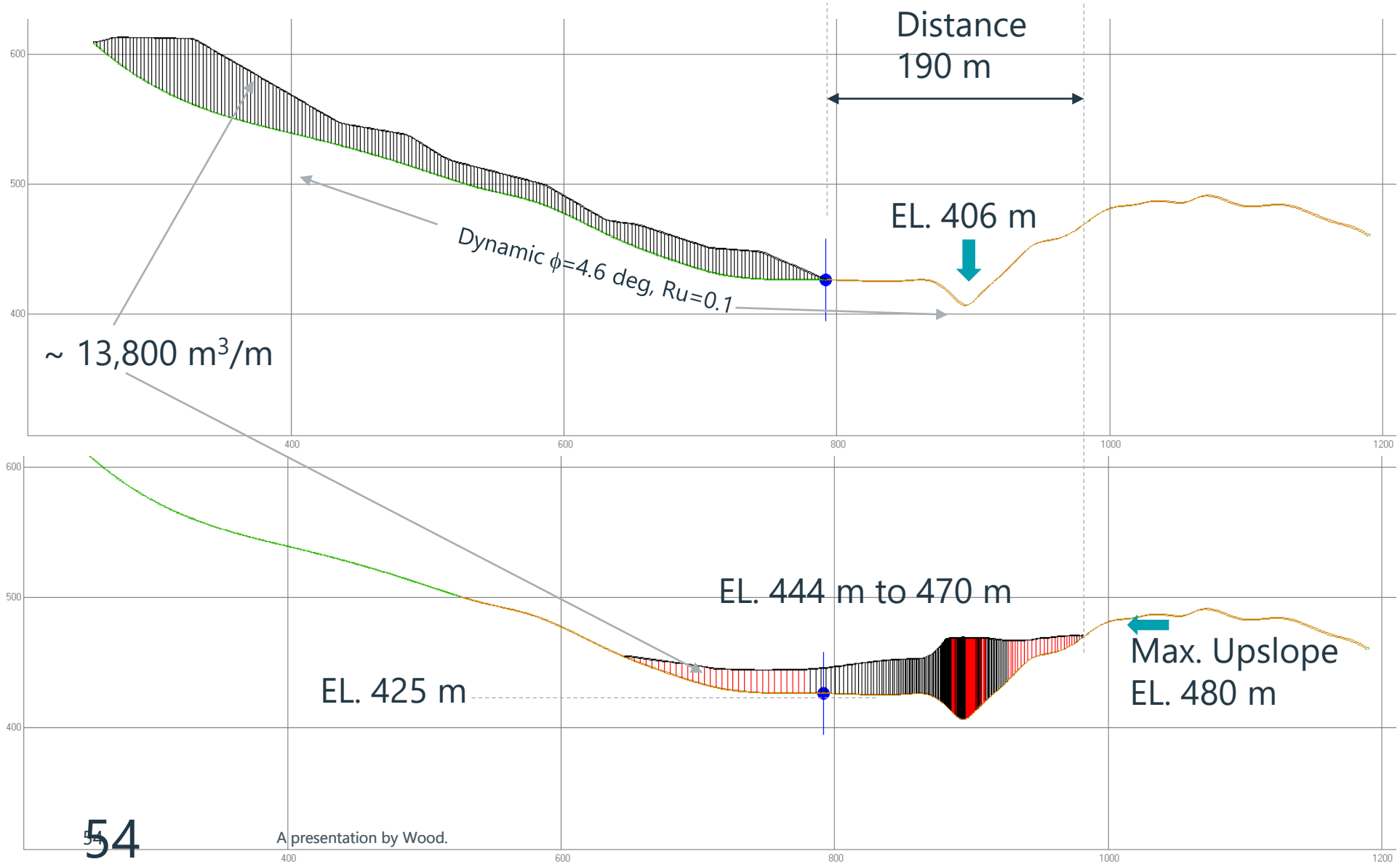
Section TS1 (Liquefied Tailings below EL. 500 m) - Likely Runout South Lobe Event with Dam



Pre-runout

Landslide Dam
Surface Elevations

Section TS1 (Liquefied tailings for Entire Slope) - Likely Runout South Lobe with High Dam Event



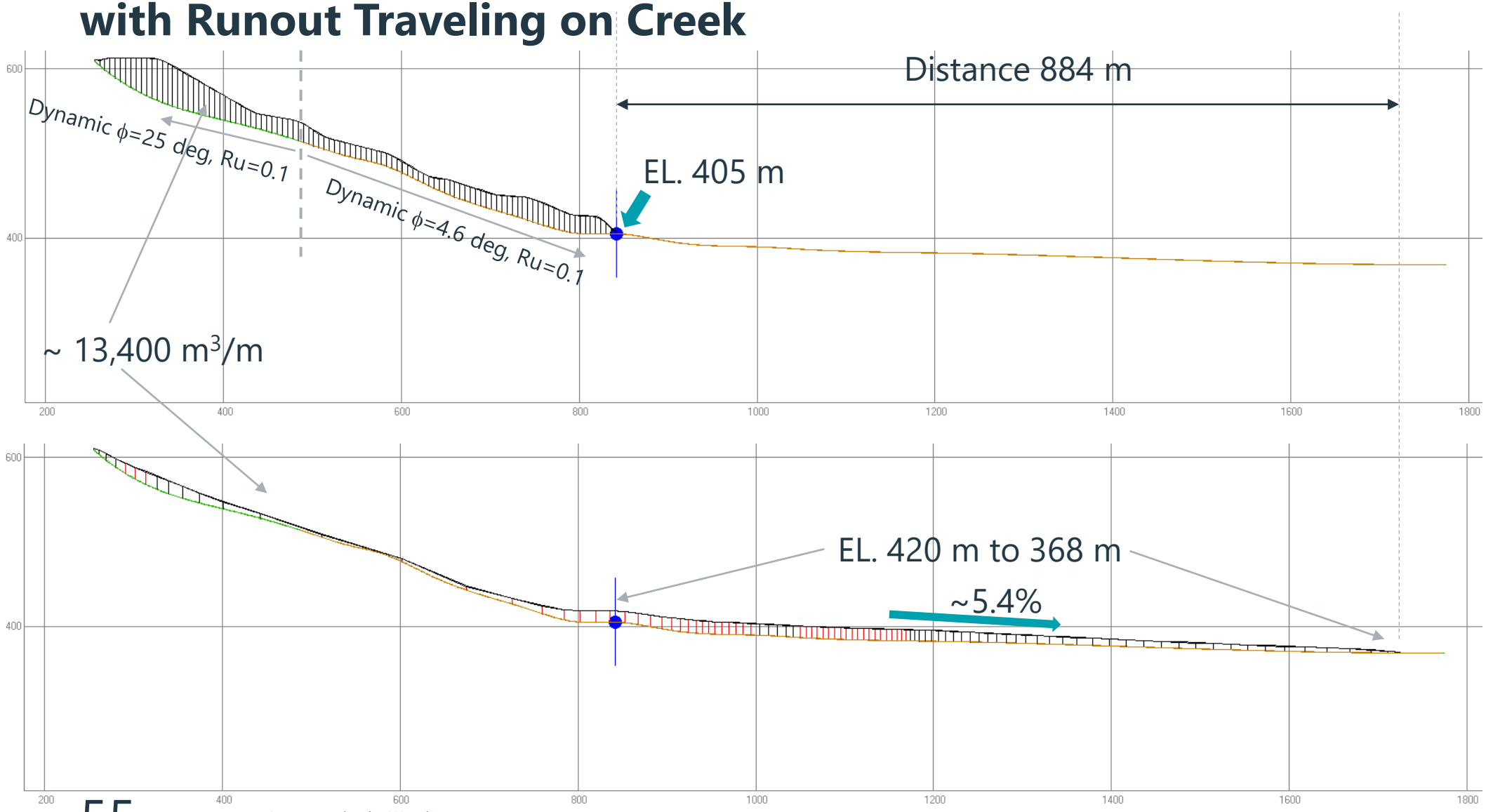
Pre-runout

Landslide Dam
Surface Elevations

54

wood.

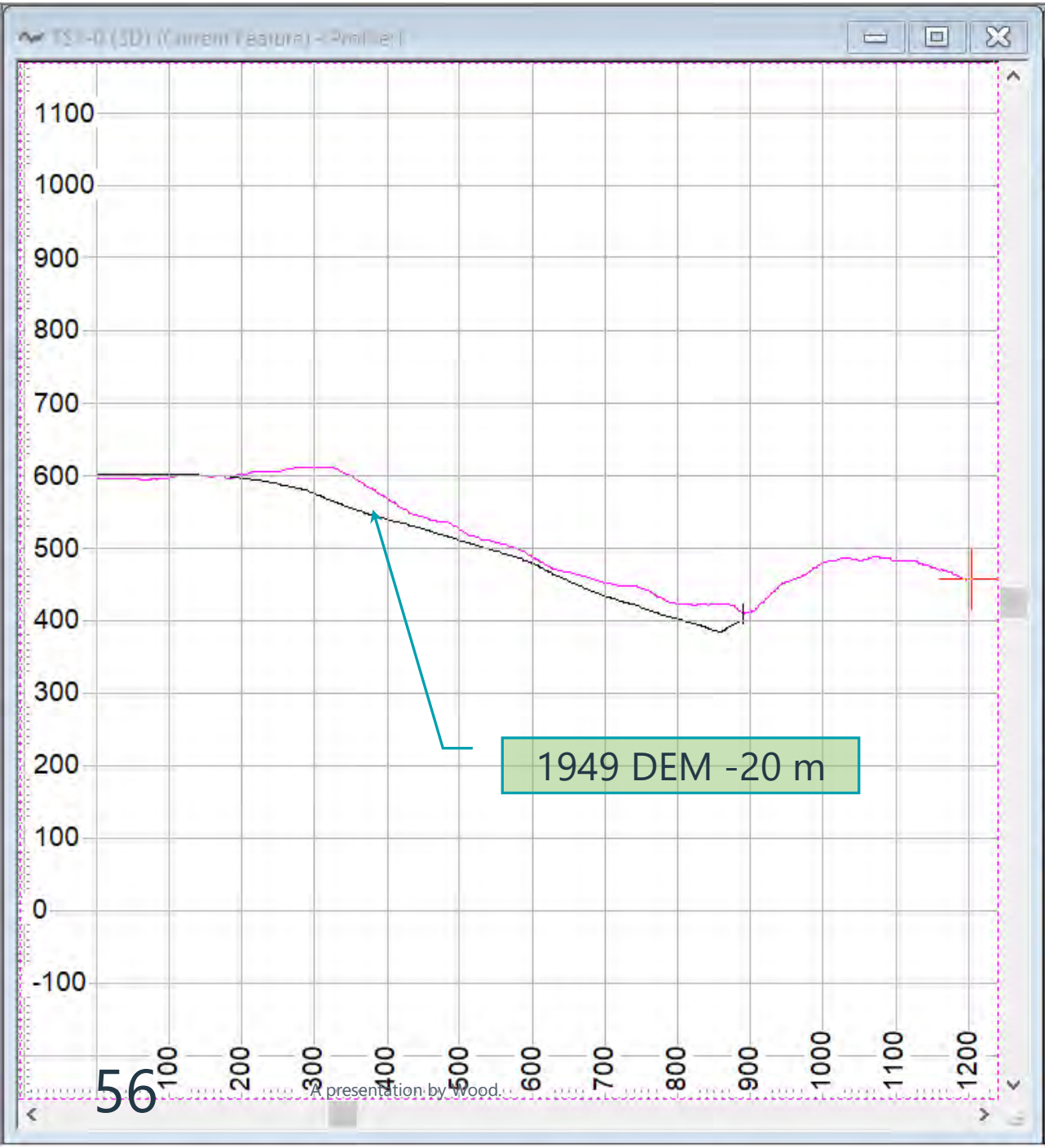
Section TS1 Combined with Creek Profile - Likely Runout South Lobe Event with Runout Traveling on Creek

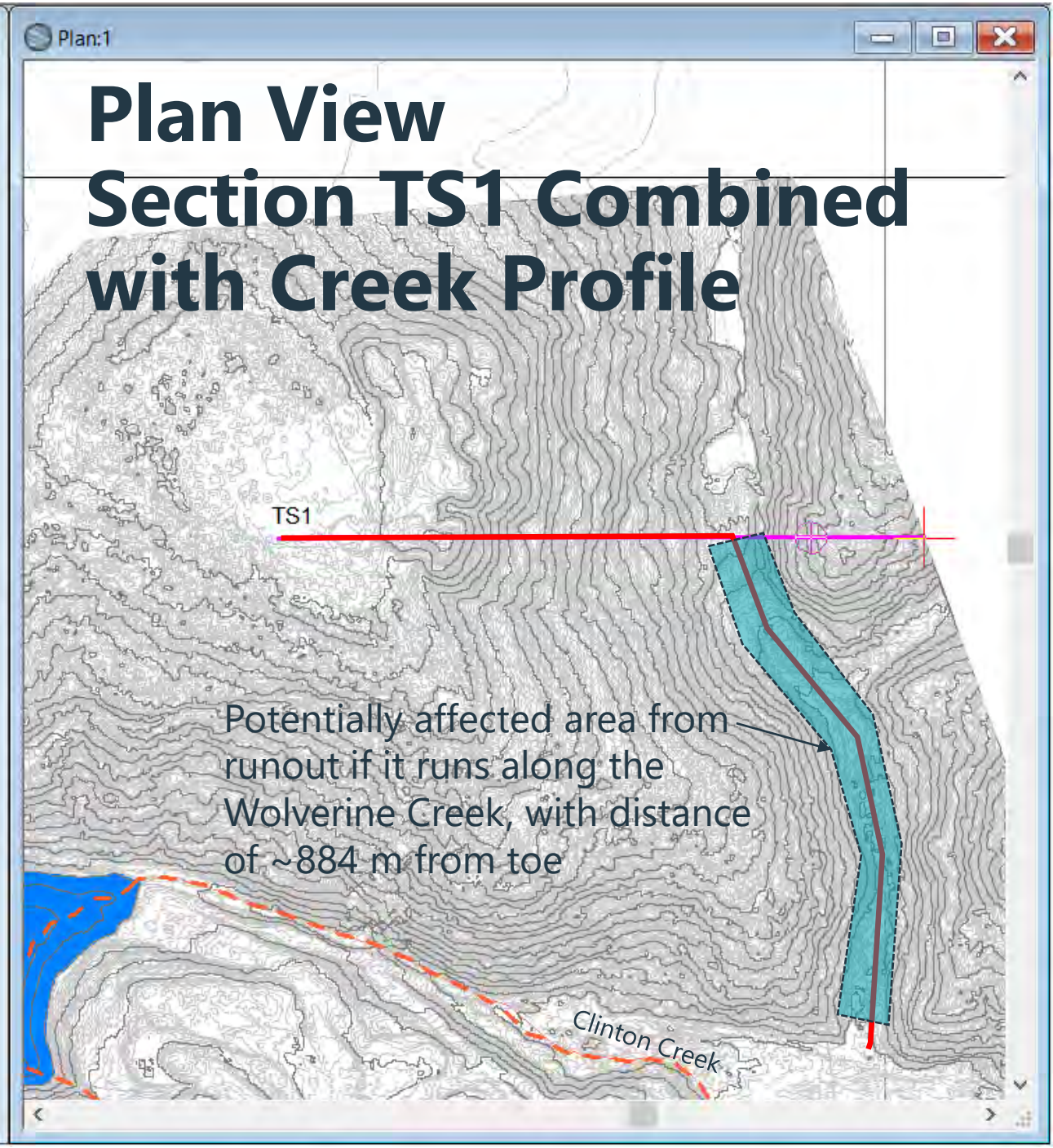


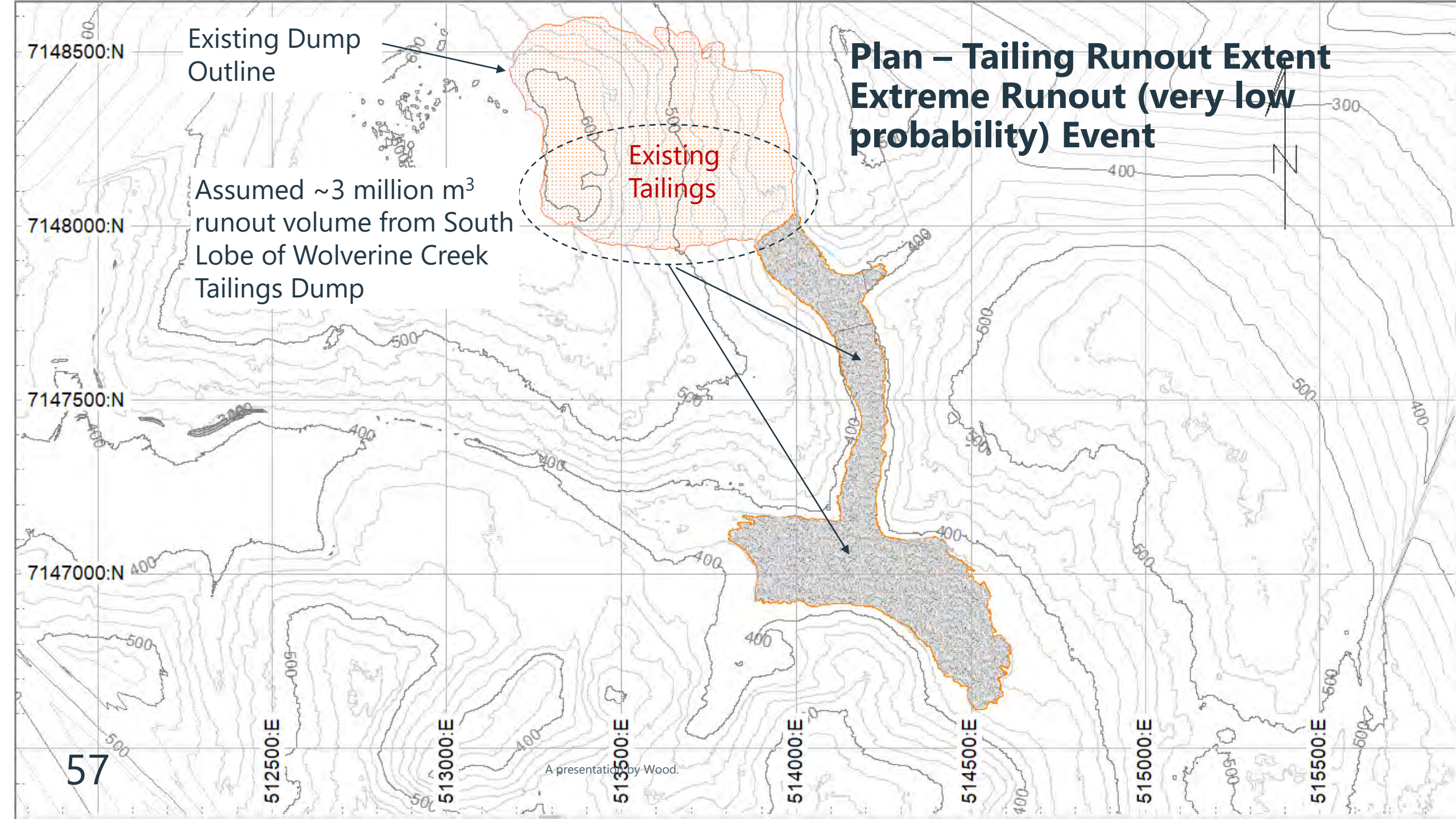
Pre-runout

Runout Surface Elevations

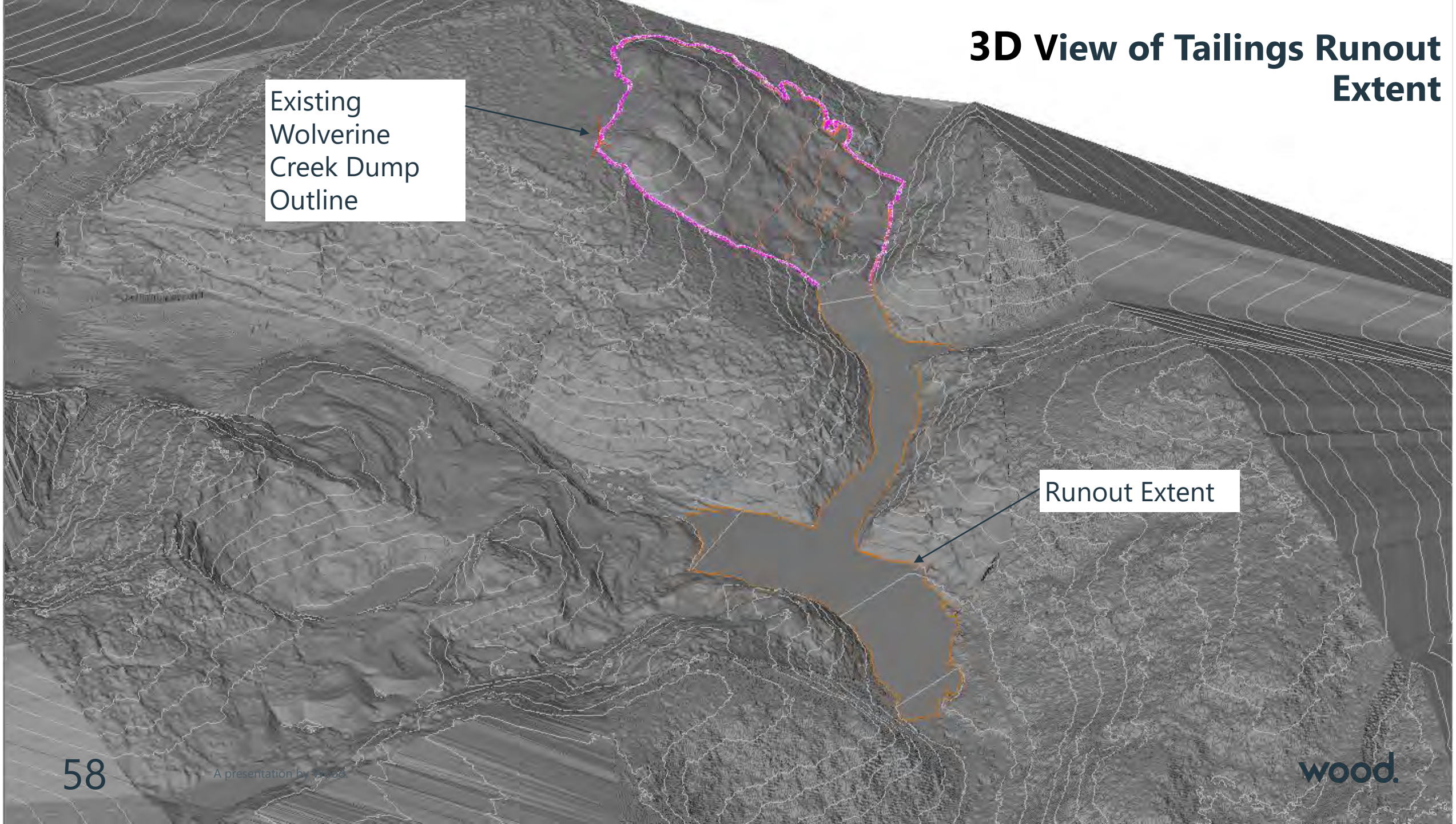
wood.


1100
1000
900
800
700
600
500
400
300
200
100
0
-100
100
200
300
400
500
600
700
800
900
1000
1100
1200
1949 DEM -20 m

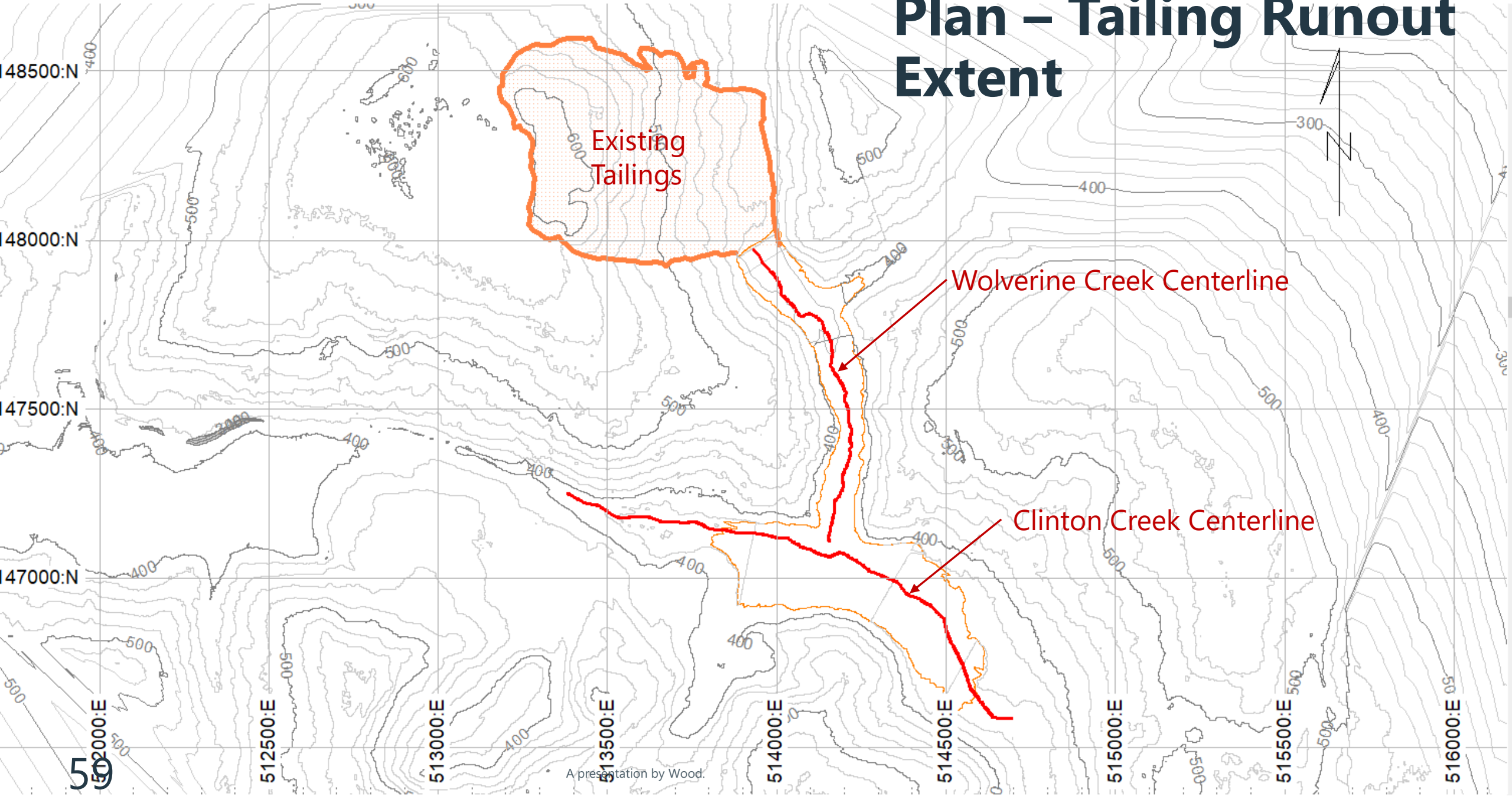

Plan:1
Plan View
Section TS1 Combined with Creek Profile
TS1
Potentially affected area from runout if it runs along the Wolverine Creek, with distance of ~884 m from toe
Clinton Creek


Existing Dump Outline
Assumed ~3 million m3 runout volume from South Lobe of Wolverine Creek Tailings Dump
Existing Tailings
Plan – Tailing Runout Extent Extreme Runout (very low probability) Event
7148500:N
7148000:N
7147500:N
7147000:N
512500:E
513000:E
513500:E
514000:E
514500:E
515000:E
515500:E

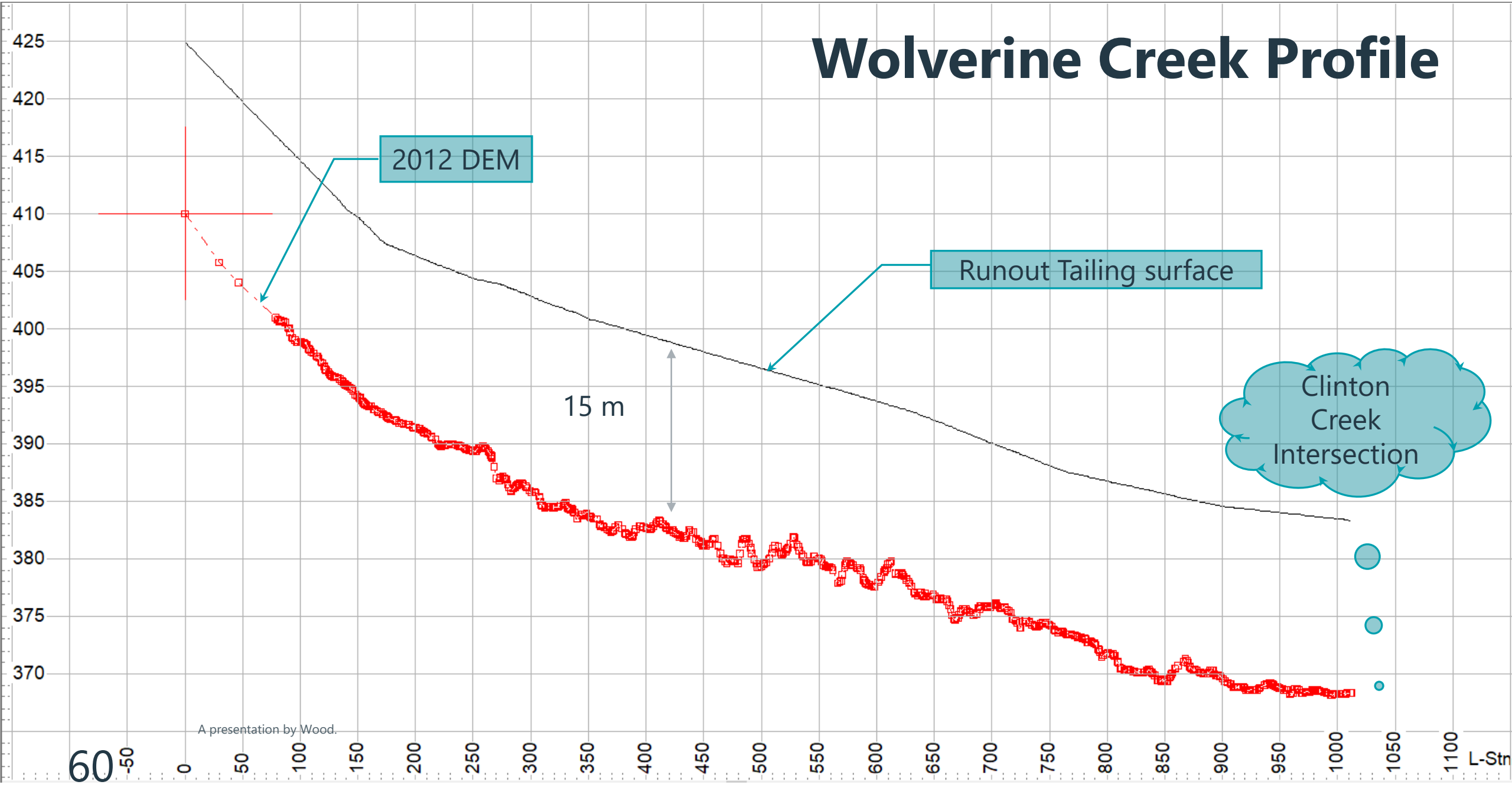
3D View of Tailings Runout Extent



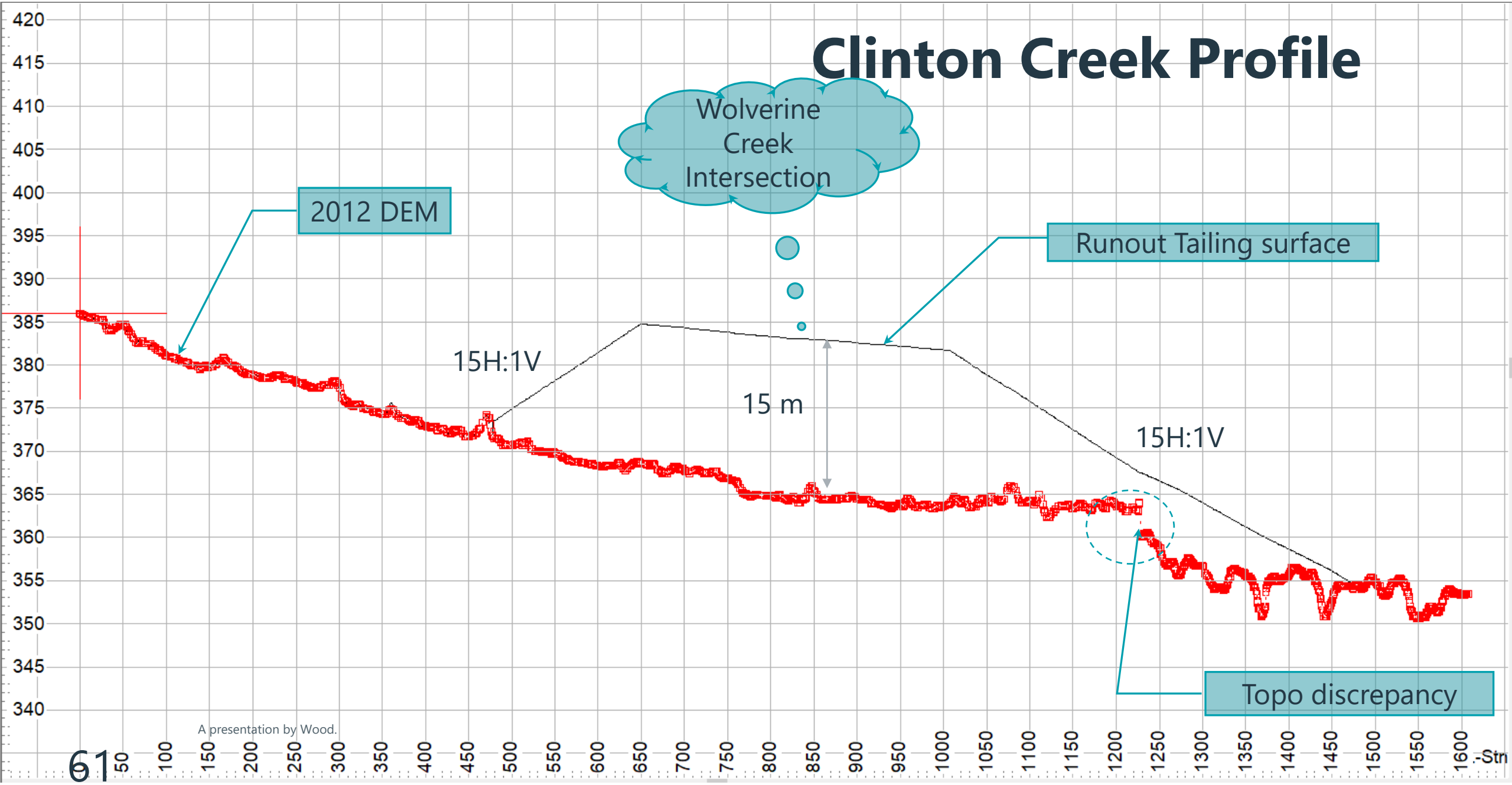
Plan – Tailing Runout Extent



Wolverine Creek Profile



Clinton Creek Profile



Appendix E
Seismic Assessment

DRAFT

Memo

To: File

From: Blair Gohl, Ph.D, P.Eng (BC) **Reviewer:** Ed McRoberts, Ph.D., P.Eng. (YT)

cc. Geoff Graham, P.Eng.

Date: 30 April 2021

Ref No.: VE52705K.04

Re: **General Commentary on Recommendation for Installation of Seismic Monitoring Equipment - Clinton Creek Asbestos Mine**

ISSUE FOR REVIEW

1.0 INTRODUCTION

A proposal dated November 18, 2020 has been prepared by Wood Environment and Infrastructure Solutions (Wood) to provide ongoing design services related to remediation of the abandoned Clinton Creek asbestos mine. These design services would build on earlier 10% design work to close information gaps identified by the Project Parties required to advance options for site remediation, to review recently collected data to update the Conceptual Site Model, and to provide consultant representation during the options evaluation. A key factor in evaluating options for site remediation is whether the foundation subsoils are susceptible to seismically induced liquefaction. The latter results from seismic shaking of looser saturated granular soils present in the foundations of the waste dumps at the site and corresponding excess (positive) pore pressure generation in the looser soils.

External reviewers for the project appointed by the Yukon Government have proposed the benefit of installing seismic monitoring equipment (including triaxial accelerometers and pore pressure monitoring equipment) at the mine site. The installation would complement data available from the GSC site at Dawson YK. This would be used to obtain site specific seismic ground motion and pore pressure data that could potentially be used to examine the liquefaction susceptibility of the looser foundation soils and general aspects of seismic site response (e.g. potential amplification of input "firm ground" base motions considering two dimensional geometries of the waste dumps, variable soil profiles, and sloping ground conditions). This monitoring is proposed over the next 5 to 10 years to facilitate mine closure design. A key assumption in this monitoring proposal is that ground motion levels would be

high enough over this relatively limited time frame of monitoring to result in significant nonlinear response of the foundation soils and positive excess pore pressure generation.

As requested by the Project Partners the purpose of this Memorandum is to consider the usefulness of a seismic monitoring station at site.

2.0 GENERAL BACKGROUND INFORMATION

Preliminary evaluations of seismic liquefaction triggering potential within the waste dump foundation subsoils have been made during the 10% design work. The assumptions made in this evaluation include:

- Use of a 2% probability of exceedance in 50 years of peak ground acceleration (PGA) for Site Class C soil conditions (e.g. dense glaciated materials or soft rock), corresponding to a PGA of 0.27 g. The latter ground motion level has a probability of exceedance per annum (p_a) equal to 0.000404 or an average return period (inverse of p_a) of 2475 years.
- Use of a design earthquake moment magnitude of M6.2 in liquefaction triggering evaluations. This design magnitude represents a mean value and was based on magnitude – distance de-aggregation data provided by Natural Resources Canada using the 5th Generation Seismic Hazard Model developed for the 2015 National Building Code of Canada. The seismic hazard model provides a probabilistic framework for calculation of ground motion levels having a specified probability of exceedance over a 50 year time frame. It is noted that earthquakes having a range of magnitudes (M4.75 to M8) and epicentral distances of up to 120 km were considered to dominate seismic hazard for the site. Thus, higher earthquake magnitudes than the M6.2 design magnitude considered in the liquefaction evaluation could potentially occur. These higher magnitudes would have a lower percentage contribution to the overall risk of creating a PGA of 0.27 g compared to lower magnitude earthquake, but would result in longer duration shaking and higher liquefaction triggering risk. Earthquake magnitudes lower than M4.75 have limited durations of shaking (number of shaking cycles) and therefore will be unlikely to trigger soil liquefaction. This latter topic is discussed later.

The current design for liquefaction susceptibility of Clinton Creek waste dumps is based on a limited series of SPT testing, while CPT testing is available for the Wolverine Creek asbestos tailings. The following summary of these data is:

- Adoption of a design, stress level corrected, Standard Penetration Test $N_{1,60}$ of 5 to 8 in the native waste rock and native granular soils near the base of waste dumps in the Clinton Creek Valley where previous waste dump failures have occurred. The $N_{1,60}$ values were collected during 2016 site investigation and show considerable scatter due to variation in

ISSUE FOR REVIEW

soil relative density and gradation, and soil particle size. It is also noted that lower $N_{1,60}$ values may also exist at higher elevations within the waste dumps, not just near the base.

- An allowance for soil fines content (percent passing a U.S. no. 200 sieve size corresponding to silt and clay size particles) in evaluation of soil liquefaction triggering potential, resulting in use of an "equivalent clean sand" $N_{1,60,cs}$ of 8 to 13 using a fines content in the range of 15 to 30%. Methods of fines content correction have been presented by Idriss and Boulanger (2014).
- Using "state of practice" liquefaction triggering curves for sand-like soils recommended by Idriss and Boulanger (2014) relating cyclic resistance ratio (CRR = ratio of constant amplitude cyclic shear stress to vertical effective overburden pressure) to $N_{1,60,cs}$ for a magnitude M7.5 earthquake. This gave $CRR_{M7.5}$ values in the range of 0.11 to 0.14. It is noted that these liquefaction triggering curves have been calculated for various earthquake events around the world in sand-like subsoils using an equation CRR = 0.65 τ_{max}/σ'_{vo} where τ_{max} is the peak cyclic shear stress on the horizontal plane at the soil depth under consideration generated by a particular earthquake motion, and σ'_{vo} is the vertical effective stress. The factor of 0.65 is used to convert an irregular cyclic shear stress time history resulting from a random earthquake ground motion to an effective, constant amplitude shear stress for N equivalent cycles of shaking. Considering an irregular cyclic shear stress time history, the equivalent number of cycles (N) depends on the design earthquake magnitude (which influences duration of shaking) and the relation of constant amplitude shear stress ratio (CRR) to number of loading cycles (N) to trigger soil liquefaction. The latter is termed a liquefaction triggering curve and provides a weighting function to convert irregular amplitudes of cyclic shear stress ratio (or CSR) to an effective constant amplitude of 0.65 τ_{max}/σ'_{vo}. This approach was originally suggested by Seed and Idriss (1971) in development of simplified methods of evaluating sand-like soil liquefaction potential due to seismic shaking. By adopting a representative average weighting curve, Seed et al (1975) have made a statistical study of the representative number of cycles for different earthquake magnitudes based on an effective shear stress amplitude of 0.65 τ_{max}/σ'_{vo}. This, in turn, has led to recommendations for adjustment of CRR to earthquake magnitude.
- Using a design earthquake magnitude M6.2 (rather than the standard M7.5 value used in the Idriss and Boulanger correlations) and correcting for the influence of earthquake magnitude to shaking duration (which is related to number of effective shaking cycles) gave $CRR_{M6.2}$ of 0.12 to 0.15. This indicates that lower magnitude earthquakes have a reduced tendency to trigger soil liquefaction compared to higher magnitude earthquakes.
- Considering potential slip surfaces near the base of waste dumps on Hudgeon Lake at about the 60 m depth and adopting additional corrections (reductions) in CRR due to suppression

ISSUE FOR REVIEW

of soil dilation tendencies during cyclic shearing for higher effective overburden stresses, gave $CRR_{M6.2}$ as low as 0.10 to 0.12 (or $CRR_{M6.2}$ values of 0.12 to 0.15 at shallower depths with limited overburden stress correction). It is noted that due to the potential presence of lower $N_{1,60,cs}$ zones at higher elevations within the waste dumps, liquefaction triggering need not be confined to zones near the base of the waste dumps, depending on the magnitude of seismically induced cyclic shear stresses at various elevations.

- Considering "sloping ground" effects under the downstream slopes of waste dumps due to shear stresses acting on potential slip planes, the ratio of static shear stress to vertical effective stress was estimated to be 0.15 considering a potential slip surface at 60 m depth for the Hudgeon Lake waste dump. This static shear stress ratio reduced $CRR_{M6.2}$ values to as low as 0.09 to 0.11 (or 0.12 to 0.15 at shallower depths with limited overburden stress correction and no static shear stress correction). It is noted that the static shear stress correction factor varies with the waste dump geometry and depth of potential slip surface.
- To evaluate seismically induced, cyclic shear stress demand on the native granular or waste dump materials relative to the CRR "resistance" and thus determine a factor of safety against liquefaction triggering, the peak shear stress τ_{max} on the horizontal plane for a particular soil element at a specified depth is calculated as $(A_{max}/g)\ \sigma_{vo}\ R_d$ where A_{max} is the peak horizontal ground acceleration at the ground surface, g is the gravitational constant, σ_{vo} is the total vertical overburden stress, and R_d is a stress reduction factor. The latter will depend on the 2D geometry of the waste dumps. One dimensional (1D) methods of evaluating R_d are not appropriate. The effective "driving" CSR = $0.65\ \tau_{max}/\sigma'_{vo} = 0.65\ (A_{max}/g)\ (\sigma_{vo}/\sigma'_{vo})\ R_d$. Limit equilibrium, 2D slope stability analysis carried out for typical waste dump cross-sections at Hudgeon Lake considering a soil element at 60 m depth indicates $\sigma_{vo}/\sigma'_{vo} = 1.4$. This stress ratio will vary along potential slip surfaces and for completely submerged portions of the slope, the stress ratio will have a value of approximately 2.
- Preliminary evaluation of liquefaction triggering potential assumed $A_{max} = 0.27$ g (no amplification of seismic input motions up from dense Site Class C foundation soils through the waste dump materials) and R_d values in the range of 0.5 to 1.0. Thus, the factor of safety against liquefaction triggering FSL = CRR/CSR = (0.09 to 0.11)/(0.245 R_d) or FSL values at or below 0.9 considering deep soil elements. For shallower soil elements near the toe of waste dumps (which are submerged) having CRR values in the range of 0.12 to 0.15 and σ_{vo}/σ'_{vo} = 2, FSL = (0.12 to 0.15)/(0.35 R_d) or FSL values again well below 1.0. Thus, seismic liquefaction triggering was predicted for typical waste dump slopes under design levels of earthquake shaking.

ISSUE FOR REVIEW

- CPT data collected at the Wolverine Creek tailings with testing results expressed as a normalized Qtn parameter also predict instability under the 2% in 50yr event if the tailings are saturated.

Details of seismic wave propagation and the potential for alteration of the input base motions (amplification or de-amplification) through the waste dumps due to soil nonlinearity have not been examined in the preliminary 10% design stage. It is recommended that these effects be considered during future detailed design using appropriate 2D dynamic analyses. But given the relatively low design $N_{1,60,cs}$ values and the high input PGA (=0.27 g) for a design M6.2 earthquake event (and possibly higher), more detailed 2D seismic site response analysis is not likely to change the overall conclusion.

Using 2D seismic analysis methods for slopes presented by Martin and Lew (1999) we have calculated the effective CSR at the base of the waste dumps using the following parameters:

- Depth of slide mass (H) below waste dump crest = 70 m
- average shear wave velocity (Vs,avg) of waste dump = 400 m/sec
- Fundamental (small strain) period of waste dump = 4H/Vs,avg = 0.70 sec (the latter definition of fundamental site period is used in the Martin and Lew procedure based on the depth H of the slide mass)
- Average period of input (firm ground) earthquake motions = 1.0 second (derived from the Uniform Hazard Response Spectrum provided by Natural Resources Canada for the 2475 year return period seismic event
- Firm ground PGA = 0.27 g
- Stress ratio SR = σ_{vo}/σ'_{vo} = 1.4

The calculations give an effective CSR at the base of the waste dump of 0.19, within the range of values calculated in the preliminary evaluation.

We have also checked the above effective CSR against a method proposed by Kavazanjian (2013) using charts presented by Makdisi and Seed (1978) for triangular embankments. The latter give effective maximum horizontal equivalent accelerations (MHEA) at the centre of gravity of the slide mass versus normalized depth (z/H) of the slide mass expressed as a fraction of the peak acceleration at the crest of the embankment. Thus, an average maximum shear stress at the depth z is given as τ_{max} = MHEA x σ_{v0} where σ_{v0} is the total vertical stress at the depth under consideration and MHEA is expressed as a fraction of unit gravity. One must estimate the peak ground acceleration at the crest of the embankment (A_{max}) in order to use the Makdisi and Seed charts. Thus, the effective CSR at the base of the slide mass is given as CSR = 0.65 τ_{max}/σ'_{v0} = 0.65 MHEA σ_{v0}/σ'_{vo} = 0.65 x MHEA x SR. Kavazanjian presents charts to permit estimating A_{max}

ISSUE FOR REVIEW

for slopes as a function of input base acceleration (PGA), considering topographic amplification effects. Using PGA = 0.27 g, Amax = 0.6 g, SR = 1.4 and MHEA = 0.35 (average of range presented by Makdisi and Seed) gives an effective CSR = 0.19, in close agreement with the results using the Martin and Lew method.

The above simplified methods used to estimate effective CSR at the base of waste dumps should be checked during later, more detailed design stages using appropriate 2D dynamic finite element analyses.

3.0 SEISMIC LIQUEFACTION TRIGGERING LEVELS

Considering the occurrence of a design M6.2 earthquake event and CRR values in the range of 0.09 to 0.15 (depending on soil depth and whether static shear stress correction is applied), the approximate ground acceleration level A_p at a particular soil depth required to trigger liquefaction is given by the equation

CRR = 0.65 (A_p/g) σ_{vo}/σ'_{vo}. Here $A_p = A_{max}$ R_d and the ground surface acceleration A_{max} is a multiple of the input PGA at firm ground level (e.g. $A_{max} = \beta$ PGA). The Martin and Lew procedure has been used to calculate the critical PGA to trigger soil liquefaction. For deeper soil elements with imposed static shear stress, a CRR value of 0.09 to 0.11 and $\sigma_{vo}/\sigma'_{vo} = 1.4$, resulting in a critical PGA required to trigger soil liquefaction = 0.11 g to 0.13 g. For shallower soil elements with no static shear stress correction, a CRR value of 0.12 to 0.15 and $\sigma_{vo}/\sigma'_{vo} = 2.0$, resulting in a critical PGA level required to trigger liquefaction = 0.10 g to 0.12 g.

It is generally considered that lower magnitude earthquakes below an M5 level will not trigger seismic liquefaction due to the short duration of the earthquake shaking and the limited number of effective shaking cycles (Idriss and Boulanger, 2014). Considering a threshold triggering magnitude M5 event, this would increase slightly the above estimated CRR values for deeper soil elements with the influence of static shear from 0.09 to 0.11 for an M6.2 event, to 0.10 to 0.12 for an M5 event using the Idriss and Boulanger magnitude scaling factors. Similarly, for shallower soil elements with no static shear effect, CRR values would increase from 0.12 to 0.15 for an M6.2 event to 0.13 to 0.16 for an M5 event. This would increase the critical PGA level for liquefaction triggering for deeper soil elements from 0.12 g to 0.14 g, and for shallower soil elements from 0.11 g to 0.13 g.

4.0 PROPOSAL FOR SEISMIC MONITORING

It has been suggested that the Yukon Government consider installing seismic monitoring equipment (triaxial accelerometers and pore pressure transducers) for purposes of assessing soil liquefaction triggering potential under moderate to strong seismic shaking levels. The above assessment indicates horizontal ground acceleration (PGA) levels in the range of 0.11 to 0.14 g

ISSUE FOR REVIEW

would need to occur for M5 events and 0.10 to 0.13 g for an M6.2 event to trigger soil liquefaction. It is anticipated that the seismic monitoring equipment would be installed for a period of 5 to 10 years to facilitate mine closure design as it pertains to seismic response of the waste dumps.

The probabilistic seismic hazard analysis (PSHA) provided by Natural Resources Canada for the Clinton Creek Mine is provided in Appendix A. As stated previously, this PSHA is based on the 5th Generation Seismic Hazard

Model developed for 2015 NBCC and considers the influence of earthquakes with magnitudes in the range of M4.75 to M8. Earthquakes of lower magnitudes are considered of no significant consequence to liquefaction triggering. However, the neglect of the influence of lower magnitude, near field earthquakes with magnitudes in the range of M2 to M4.75 in the PSHA model is likely to result in an under prediction of PGA values for higher per annum probability events (i.e. shorter return period events) based on analyses presented by Halchuk and Adams (2010).

A plot of the NRCan PSHA model results is presented in terms of PGA versus per annum probability of exceedance p_a using a logarithmic scale in Figure 1. This indicates an approximately linear trend line using log – log axes. Considering the "expected" PGA level at a 50% probability of exceedance in a 5 to 10 year period gives a per annum rate of exceedance in the range of 0.067 to 0.129 assuming a Poisson probability process. The extrapolated NRCan PSHA model results indicate an expected PGA of 0.01 g or less for these probability levels and no likelihood of triggering soil liquefaction. These expected PGA levels are considered low due to the reasons discussed above.

ISSUE FOR REVIEW

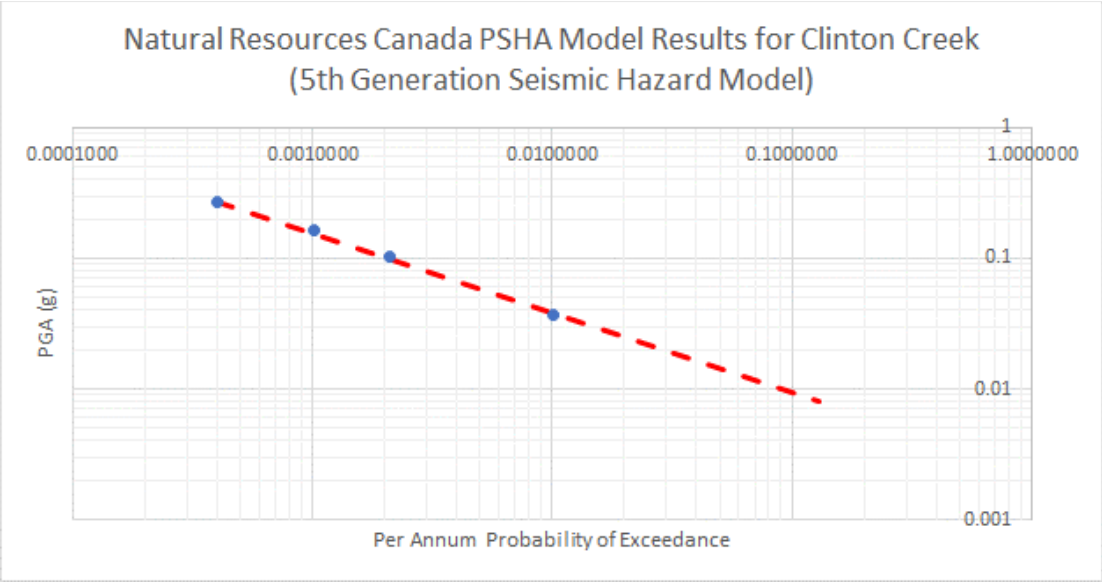


Figure 1 Natural Resources Canada PSHA model results for Clinton Creek using 5th Generation Seismic Hazard Model

The previous liquefaction triggering analysis indicates PGA levels of approximately 0.11 g to 0.14 g would be necessary to trigger soil liquefaction for lower magnitude (M5) events. The PSHA plot shown in Figure 1, while it includes contributions from M4.75 to M8 earthquakes, indicates a PGA of approximately 0.11 g would occur at a per annum probability of 0.0013 (770 year return period or 6.5% probability of exceedance in 50 years). In a 5 to 10 year period of proposed monitoring, this PGA level would have a 0.6 to 1.3% probability of exceedance, respectively. Thus, the likelihood of seeing the occurrence of a strong enough seismic event (M5 or greater) to trigger soil liquefaction over a 5 to 10 year period of monitoring is very small. From this point of view, the benefit of installing seismic monitoring equipment to record future liquefaction triggering events over a relatively short time frame is believed to be small.

Seismic monitoring carried out in the Clinton Creek area between 1985 and 2020 provided by Natural Resources Canada is shown plotted in Figure 2 and indicates epicentral locations of various low magnitude earthquakes (<M2 to M4). From this information, it is anticipated that if seismic monitoring equipment was installed, it would record very low level shaking from M2 to M4 earthquakes. Using earthquake attenuation relations for shallow crustal earthquakes adopted in the 5th Generation Seismic Hazard model (Boore and Atkinson, 2008; Atkinson and Boore, 2010), estimated mean PGA levels for different magnitude earthquakes (M2 to M4 range) occurring at a 10 km distance from the site are computed to be 0.01 g (M2), 0.03 g (M3) and 0.08 g (M4). The "expected" PGA level would be from a M3 event based on the 1985 – 2020 seismic monitoring in the region. These PGA values are less than those calculated previously to trigger liquefaction considering a higher M5 seismic event.

ISSUE FOR REVIEW

Based on the anticipated limited PGA levels that would be recorded over a 5 to 10 year time frame at the site, it is concluded that installation of seismic monitoring equipment (triaxial accelerometers and pore pressure transducers) would have a very low likelihood of recording strong enough seismic shaking to trigger significant levels of excess pore pressure in the waste dump materials or granular soil foundations. Such instrumentation is likely to record low level seismic excitation which would only serve to calibrate quasi-elastic seismic response of the waste dumps. This would be of limited benefit to seismic design aspects of mine closure.

It can also be noted that there are fundamentally several different sites with varying aspects relative to likely source zones, that would in any event need consideration if seismic monitoring installation(s) were considered.

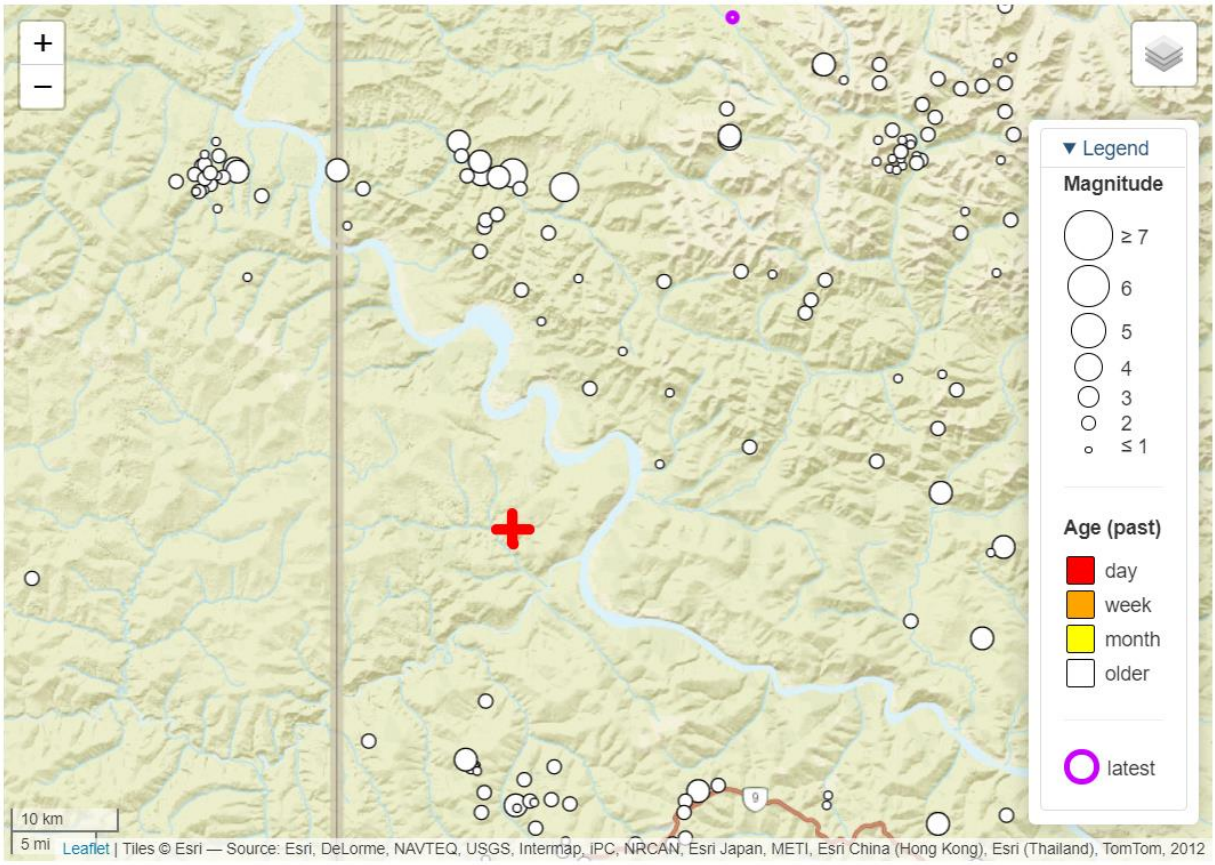
- Clinton Creek Landslide Dam
- Wolverine Creek Asbestos Tailings
- Porcupine Creek Pit Rock Slopes
- North Bedrock Slope of Clinton Creek opposite spillway
- Various other waste dumps in Porcupine Creek, and east of the main Clinton Creek landslide dam.

This is significant in that the potential requirements for site specific data per recommendations are extensive.

ISSUE FOR REVIEW

5.0 Conclusion

It is concluded that the probability of getting a design significant seismic event for closure designs in the available design time period is low. On-going GSC/NRC seismic predictions for this site, which are conditioned by a monitoring station at Dawson are sufficient.



Summary

Magnitude	< 2	2	3	4	5	≥ 6
Total	47	87	18	2	0	0

Figure 2: Seismic activity recorded in Clinton Creek area from 1985 to 2020 provided by Natural Resources Canada. The Clinton Creek mine site is shown with a red cross.

6.0 References

Atkinson, G., and Boore, D. (2011), "Modifications to Existing Ground-Motion Prediction Equations in Light of New Data", Bulletin of the Seismological Society of America, vol. 101, pp. 1121–1135

Boore, D.M. and Atkinson, G.M. (2008), "Ground-motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods Between 0.01 s and 10.0 s", Earthquake. Spectra, Vol. 24, No. 1, pp. 99–138

Halchuk, S. and J. Adams (2010), "M_{min} – Implications of Its Choice for Canadian Seismic Hazard and Seismic Risk", proc. 9th U.S. National and 10th Canadian Conference on Earthquake Engineering, July 25-29, 2010, paper no. 439

Idriss I. and Boulanger R. (2014) CPT and SPT Liquefaction Triggering Procedures. Report UCD/CGN-14/01. University of California at Davis.

Kavazanjian, E. (2013), "Evaluating the Seismic Coefficient for Slope Stability Analysis", lecture notes, Arizona State University, Oct. 22, 2013

Makdisi, F.I. and Seed, H.B. (1978), "Simplified Procedure for Estimating Dam and Embankment Earthquake Induced Deformations", ASCE, Journal of the Geotechnical Engineering Division, vol. 104, no. GT7, pp. 849-867

Seed, H.B. and Idriss, I.M. (1971), "Simplified Procedure for Evaluating Soil Liquefaction Potential", Journal of the Soil Mechanics and Foundations Division, ASCE, vol. 107, no. SM9, pp. 1249-1274

Seed, H.B., et al (1977), "Representation of Irregular Stress Time Histories by Equivalent Uniform Stress Series in Liquefaction Analyses", Report No. EERC75-29, EERC, University of California, Berkeley, Oct. 1975

ISSUE FOR REVIEW

APPENDIX A

PROBABILISTIC SEISMIC HAZARD ANALYSIS PROVIDED BY NATURAL RESOURCES CANADA FOR CLINTON CREEK MINE

ISSUE FOR REVIEW

Appendix F
Site Characterization Update

DRAFT

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited
400 – 111 Dunsmuir Street
Vancouver, BC V6B 5W3
Canada
T: +1 604-664-4315

www.woodplc.com

Memo – Rev 0

To:

From: Chris Davidson, M.Sc., P.Geo.
Karen Hincks, M.Sc., P.Geo.

Reviewer: Ed McRoberts, Ph.D, P.Eng.

cc:

Wood File No.: VE52705K

Date: 27 September 2021

Yukon Government No.:

Re: **Update to Geological and Geotechnical Site Characterization Report – 2021 – Clinton Creek Mine, Yukon – Rev 0**

1.0 Introduction

Wood Environment & Infrastructure Solutions (Wood) has been retained by the Government of Yukon represented by the Ministry of Energy Mines and Resources (YG) to provide engineering services for the "Clinton Creek Post 10% Design Services" (Project) for the Clinton Creek abandoned mine site approximately 80 kilometers northwest of Dawson City, Yukon.

In August 2019, Wood submitted the "Geological and Geotechnical Site Characterization Report" (Characterization Report) which endeavored to provide a synthesis of the available geological and geotechnical information, including the data collected as a part of the site investigation programs undertaken in 2016 and 2018, in order to document the geotechnical characteristics at the mine site (Wood, 2019).

The characterization relied largely on review of available historical information, drill logs, data from instrumentation, survey of monitoring stations and InSAR data in the vicinity of the Clinton Creek waste dump, Wolverine Creek tailing dump and Porcupine Creek waste dump. The scope of this memo is to provide an update based on data that has been collected subsequent to the August 2019 report with the objective of noting any changing trends or revised interpretations.

2.0 Sources of Information

The following sources of information were used in the preparation of this memo.

1. Slope indicator (SI) readings collected by TetraTech. Additional readings since the issue of the Characterization Report include those collected September 2019, July and September 2020.
2. Vibrating wire piezometer (VWP) and thermistor data from selected boreholes drilled in the waste dumps and tailings. These instruments record data at 12-hour interval via dataloggers, with the latest data download completed in September 2020. Instrumentation data plots have been updated and reviewed relative to the interpretations in the Characterization Report.

DRAFT

'Wood' is a trading name for John Wood Group PLC and its subsidiaries
Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited
Registered in Canada No. 1260467-1; GST: 899879050; DUNS: 25-362-6642

3. TetraTech's 2020 Annual Monitoring Report for their long-term performance monitoring program (TetraTech, 2021). This report included presentation and interpretation of the results of monitoring station surveys completed in September 2020 and the 2020 InSAR data. Wood did not have access to the raw monitoring and InSAR data; in some cases, differentiating between vertical and horizontal displacement components was not possible.

3.0 Comments on Recent Data

Wood has reviewed the aforementioned data sources and updated applicable plots. A PowerPoint slide deck has been provided to YG which provides updated information at each of the instrumented boreholes and is included in Appendix A. A summary of the observed trends is presented below, focussed on changes from those previously discussed in the Characterization Report.

1. Displacement patterns and rates in slope indicators remains similar to those previously reported. Downslope creep in the waste material continues in many of the instruments installed in the Clinton Creek waste dump and Wolverine Creek tailings dump with downslope tilt of the SI throughout the waste materials. Enhanced creep may occur in the upper zone (relative to deeper strata) thought to coincide with the active layer.
2. Distinct shear zones are generally absent (as previously reported) aside from possibly at BH18-07 (Clinton Creek Waste Dump) originating at the mixed waste / colluvium boundary and definitively in BH18-17 (Wolverine Creek tailings dump) along a movement plane just below the tailing / colluvium contact and frozen/unfrozen boundary.
3. Slope indicator data suggests that settlement type movement (possibly consolidation) continues to occur BH18-06, BH18-07, BH18-09, BH18-10 in the SI's installed in the Clinton Creek waste dump and in BH18-13 in the Wolverine Creek tailings dump.
4. Movements attributed to secondary creep in ice rich permafrost continue to be detected in BH18-03 and BH18-04 in the ice rich colluvium. This permafrost is interpreted to represent the original ground buried below mixed waste and colluvium. Enhanced deformation in these ice-rich zones is attributed to shear stress imparted by the overlying mine waste (which in itself is being transported to some extent on the underlying deformed zone). Rates of movement in the zone of plastic flow are remarkably consistent. Figure 1 below presents cumulative displacement over time in Zone 1 of BH18-03 between 37.8 and 39.8 m depth, which represents the lowest 1 m zone of ice-rich colluvium. Unfortunately, there is no temperature data for these SIs.

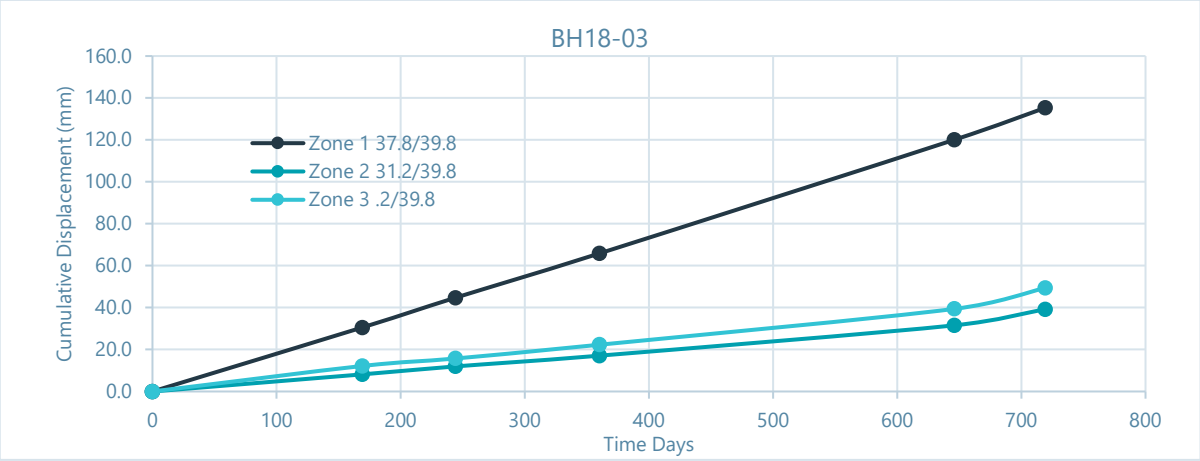


Figure 1: Cumulative Displacement with Time in BH18-03 Within the Interval Zones Specified

DRAFT

5. The SI data generally corroborates with the trends noted in the survey monitoring and InSAR data both in terms of direction and magnitude of displacement. Where settlement is anticipated based on SI data, it is normally reflected in the InSAR line of sight deformation rates at least in terms of settlement vs. uplift, similarly with surveyed results from monitoring stations. BH18-01, for example, shows some indications of settlement on the SI plot and has a resolved SI movement direction almost due west at about 20 mm/year. Monitoring station data at the nearest point to the borehole indicated 28 mm/year lateral displacement NNW and negative rates of displacement projected onto the ascending and descending orbits, indicating settlement.
6. TetraTech 2021 notes that the movement patterns and rates observed at monitoring points in the Clinton Creek waste dump and Wolverine Creek tailings dump are generally consistent with established trends with no evidence of new slope movement or acceleration observed in the 2020 field visit or data. Decreasing movement rates have been detected on the Wolverine Creek tailings dump south lobe and some portions of the north lobe.
7. With review of recent VWP data, the hydraulic connectivity with surface water, particularly within the buried alluvium, has become more apparent. Measured pressures, although with different total heads, mimic the seasonal changes in lake elevation, particularly the spike in lake elevation in May 2020, which was observed in VWPs installed in alluvium in BH18-02, BH18-07 and BH18-09. Seasonal variability is also noted in some cases in VWPs installed in waste material, or bedrock (BH18-06, 16-BH08, BH18-10, 16-BH09) however variability can be muted relative to responses observed in the alluvium, presumably due to reduced hydraulic conductivity.
8. Seasonal temperature variations are also detected in BH18-07, BH18-10 and 16-BH09 at depths greater than 30 m, presumably due to influx of surface water, likely from the spillway channel. Slopes rise steeply onto the waste dump and in many cases the elevation of the alluvium is similar to or lower than that of the spillway. Alluvium is over the bedrock and the creek roughly seated on the bedrock, so this is likely the warm water flowing laterally along the bedrock/alluvium contact. Water in the spillway can get to temperatures of greater than 10 C as the spillway decants water from the warmer surface layer in the lake. Deep seepage water from Hudgeon Lake is much colder.
9. Thermistor and temperature sensors in VWPs typically experienced relatively rapid initial cooling following installation while coming into equilibrium with possible minor cooling afterwards.

4.0 Conclusions and Recommendations

The geotechnical, hydrotechnical and thermal trends observed in recent data are generally consistent with those reported in August 2019. Additional instrumentation data has provided additional insight into some of the hydrogeological conditions and ongoing movements of the waste piles.

Additional understanding of the secondary creep in the ice rich permafrost would be beneficial to characterize the area. For example:

- The creep response the ice rich permafrost zone in BH18-03 near the headwater of the current spillway is associated with the colluvial slope that has been covered by waste rock fills. Given the changes in thermal boundary conditions it is expected that this permafrost will eventually thaw and continue to creep. Slopes excavated in this ice-rich permafrost could also fail in creep rupture. Any of the options (the original 2×3 Base Cases (CC1, CC2, CC3) or the latter Alternative Designs) will need to account for both settlement and slope stability issues. For option CC1 it will likely be necessary to pre-thaw the permafrost if a relatively rigid permanent spillway is selected. It is possible that on-going thaw settlement in this area has been a

DRAFT

contributing factor to current poor spillway performance. For option CC2, by removing approximately 10 m of cover at this location for the construction of the new, lower elevation spillway, changes to the thermal regime could result in an increased rate of settlement which would have a more rapid effect. For option CC3, where Clinton Creek would be restored to the original bed grade, even less cover would be present on the restored valley wall slope at this location.

- For the buried valley wall at BH18-04, options CC1, CC2 and CC3 all reduce the cover over ice rich permafrost at this location and settlement and possibly slope instability could be an issue here as well.
- It would be valuable to obtain temperature data in SI18-03 and SI18-04 to better understand the thermal regime at these locations. This could be accomplished by lowering a thermistor string down the SI casing. It would be necessary to provide partial plugs on the string to eliminate air convection in the annulus and to allow time for the air temperatures to equilibrate after the SI readings and string deployment. Or alternatively install thermistor string adjacent to the SI casings.
- Clearly, there is insufficient areal information on the distribution of ice rich permafrost considered to be derived in the slow buildup of colluvial debris over potentially several millennia. The original objective for BH18-03 and BH18-04 was to test the characteristics of the valley walls. This has been accomplished at a 10% design level. However, extensive additional site information will be required, the specific details of which would be determined after a decision is taken as to the selected option.

Within the Clinton Creek valley, the apparent hydraulic and thermal connectivity of the alluvial layers at depth with the spillway is expressed in some of the boreholes with seasonal variation in both pressures and temperatures. It appears that the spillway is a "losing stream" where water infiltrates down into the spillway substrate materials and moves laterally (as reflected in the variations observed in nearby boreholes) possibly along the alluvial / bedrock interface. There may also be groundwater inputs and interactions with other surface bodies such as Hudgeon Lake, Porcupine Pit or other sources that are not yet understood.

Further characterization of the groundwater within the Clinton Creek waste dump has implications with respect to the closure selection. Proposed excavations below the water table will face difficulties with respect to seepage and slope stability, largely as a function of permeability and storage within the waste dump and its source(s). Assuming a "downward" groundwater table extending from the spillway for some distance, excavations proposed laterally at the spillway elevation or higher should be dry until encountering regional groundwater table towards the valley walls. Any additional excavation will require a drawdown of the water table prior to construction, which may be affected by Hudgeon Lake levels and/or Porcupine Pit lake levels Further work is recommended to better characterize groundwater conditions in the Clinton Creek waste dump, possibly including the installation of pumping wells and conducting pumping tests to assess hydraulic connectivity, conductivity, and storage parameters. Tracer testing or additional geochemical testing of the water may be beneficial in determining the source of some of the seeps.

Depending on the Project Partners path forward decision Wolverine Creek tailings additional site data would be useful to refine design details.

DRAFT

The significant uncertainty for Porcupine Pit is the seepage pathways that appear to be controlling a more-or-less stable water level. Monitoring of water levels in this pit, and water quality information is required. It may be possible to acquire such data with a drone-based access, at considerably less cost than constructing a safe surface access pathway. A site inspection by rock mechanics specialist would also be useful.

5.0 Closure

This memo is subject to the Limitations in Appendix B.

Sincerely,
Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

Chris Davidson, M.Sc., P.Geo.
Senior Engineering Geologist

Karen Hincks, M.Sc., P.Geo.
Associate Engineering Geologist

Reviewed by:

Ed McRoberts, Ph.D, P.Eng.
Principal Engineer

Attachments
Attachment A – Site Characterization Slide Deck
Attachment B – Limitations

DRAFT

6.0 References

Tetra Tech. 2021. *2020 Annual Report Long-Term Performance Monitoring Program Clinton Creek Mine, Yukon.* Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. January 2021.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Geological and Geotechnical Site Characterization and Model*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. August 2019.

DRAFT

Attachment A – Site Characterization Slide Deck

DRAFT

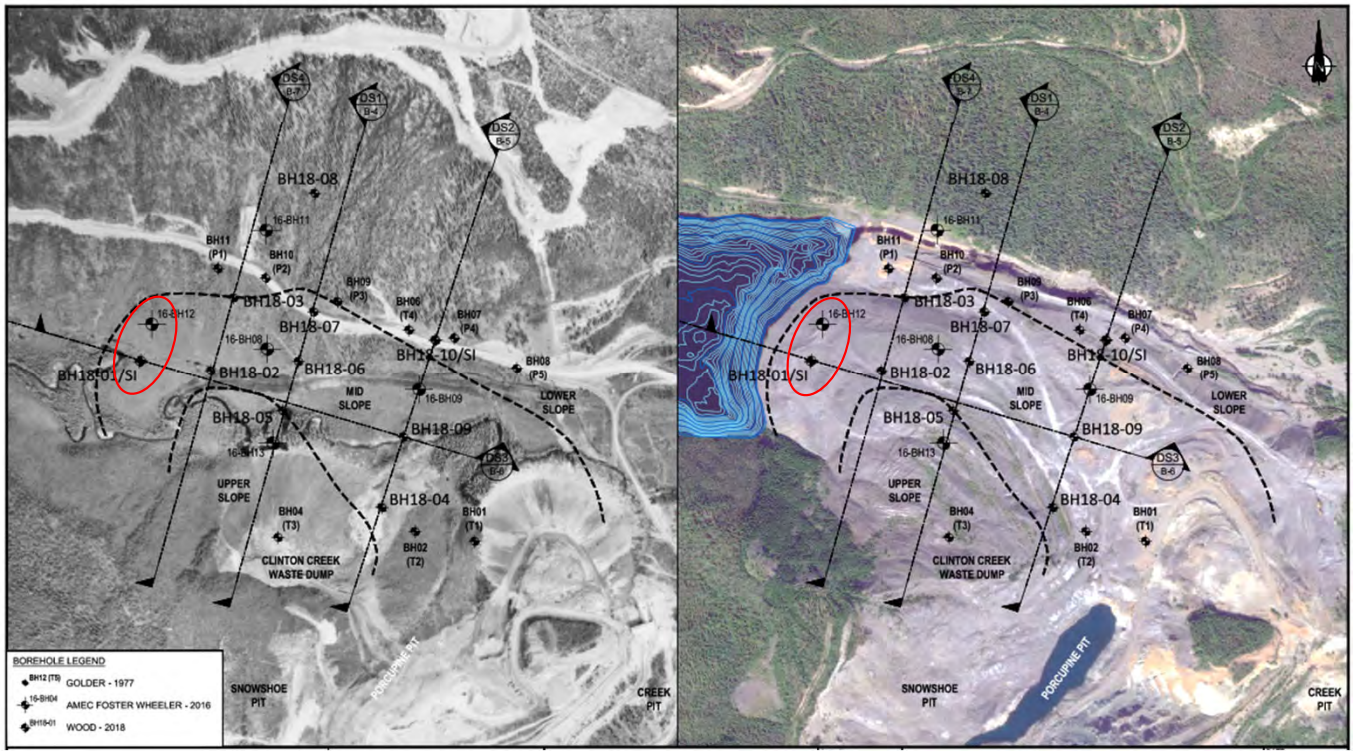
wood.

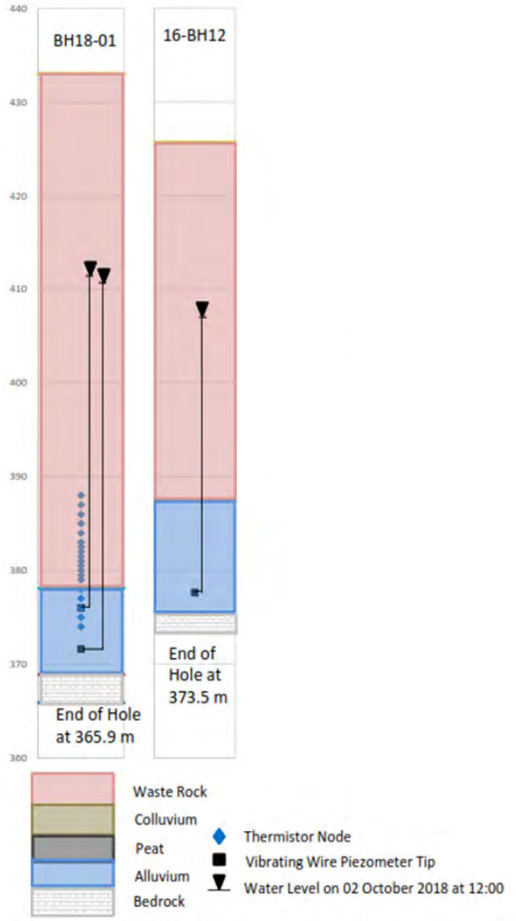
Site Characterization

Updated to September 2020

Clinton Creek Waste Dump

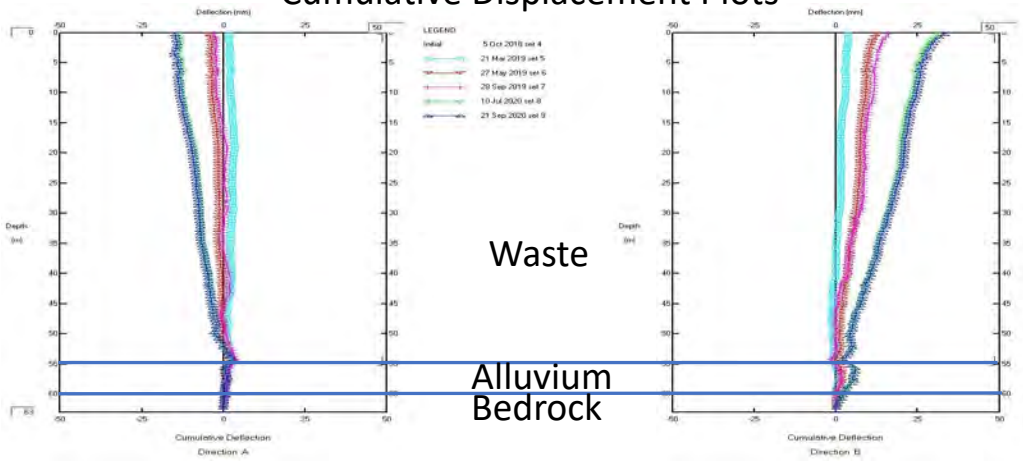
BH18-01/SI and 16-BH12

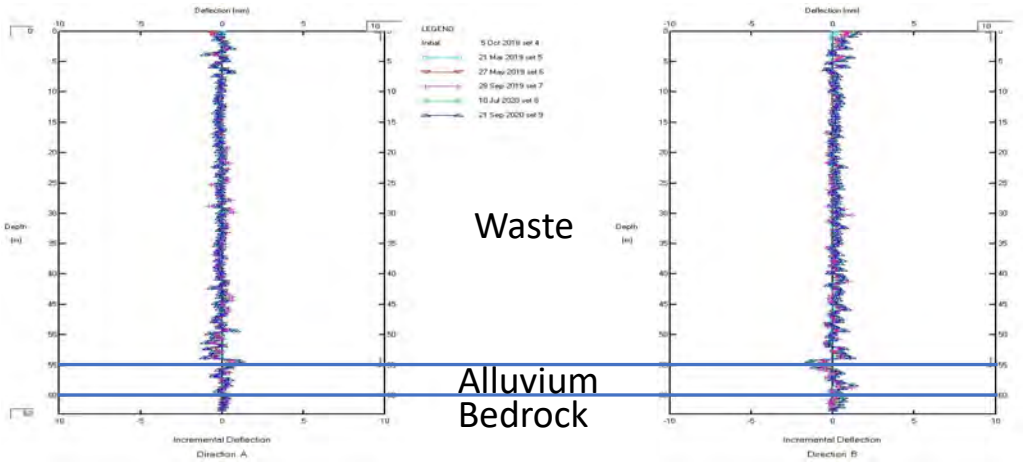




SI18-01

Cumulative Displacement Plots

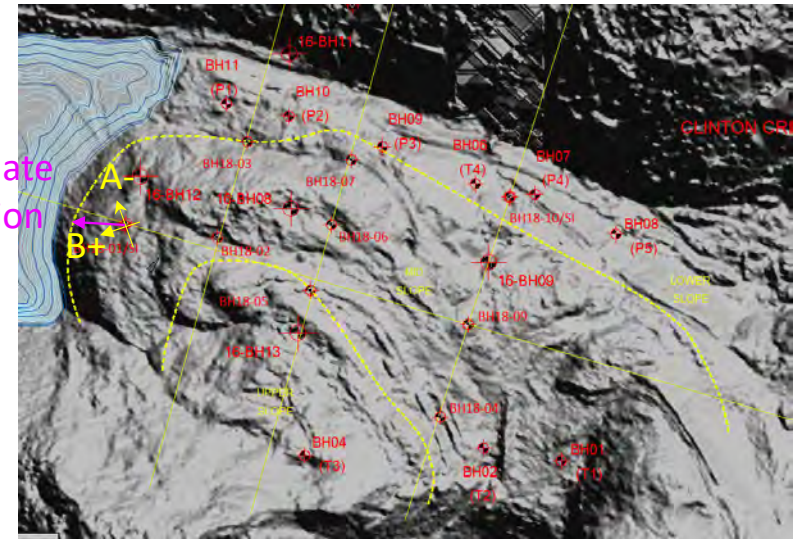




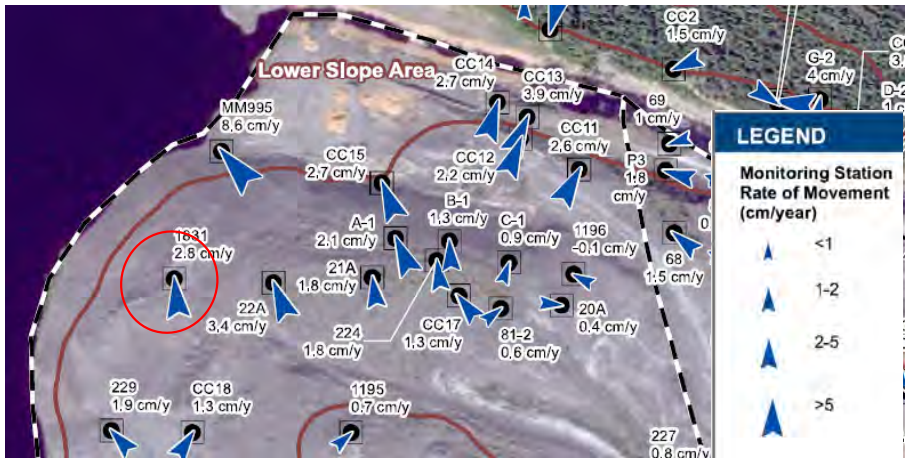
Incremental Displacement Plots

- Some indication of settlement at the alluvium / waste boundary
- Downslope tilt within the waste dump materials towards Hudgeon Lake
- Cumulative movement of 32 mm at rate between 8.5 and 20 mm/year.
- Consistent with slow and gradual creep of the waste dump toward Hudgeon Lake.

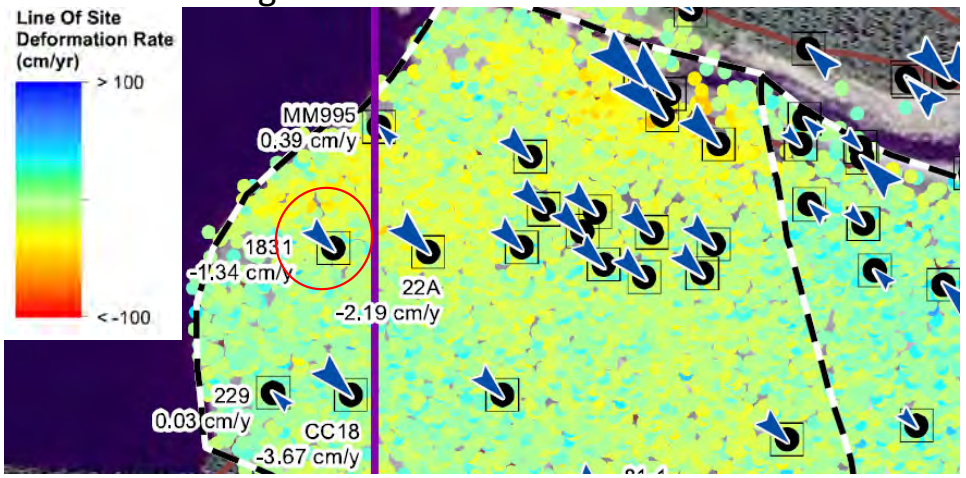
Approximate tilt direction



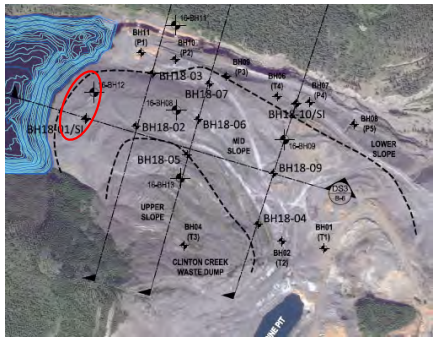
BH18-01/SI and 16-BH12 – Monitoring and InSAR



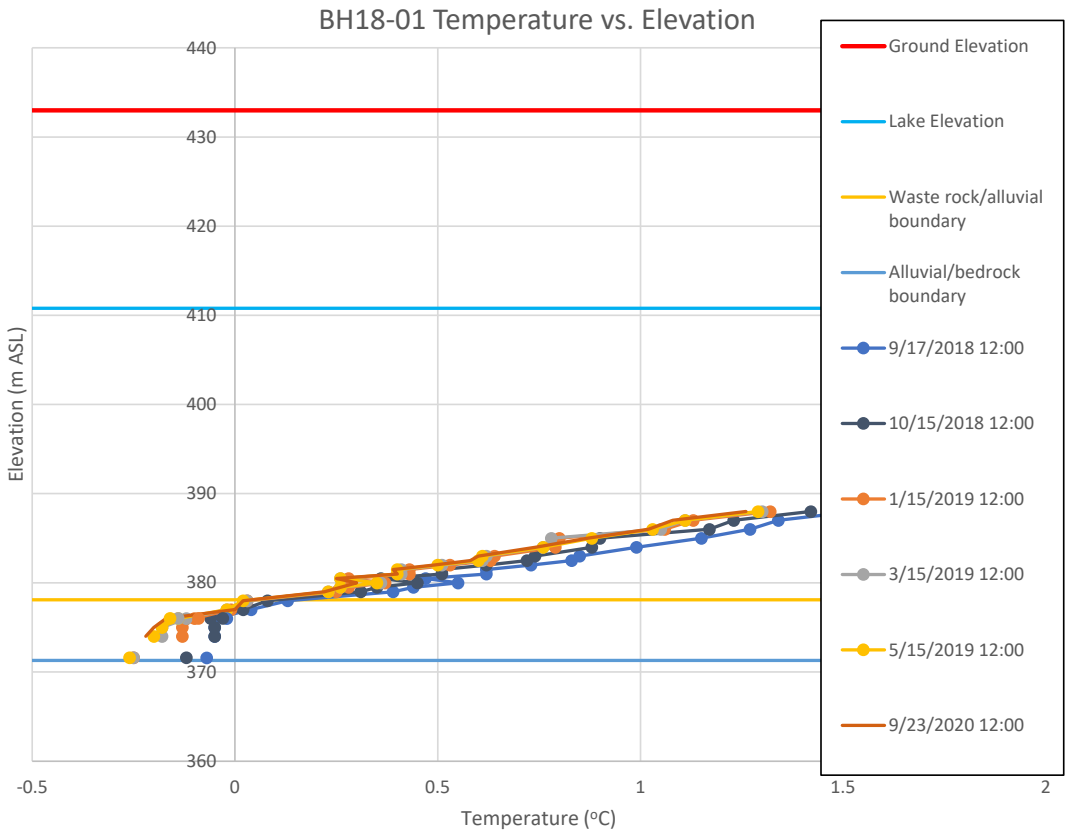
InSAR ascending orbit



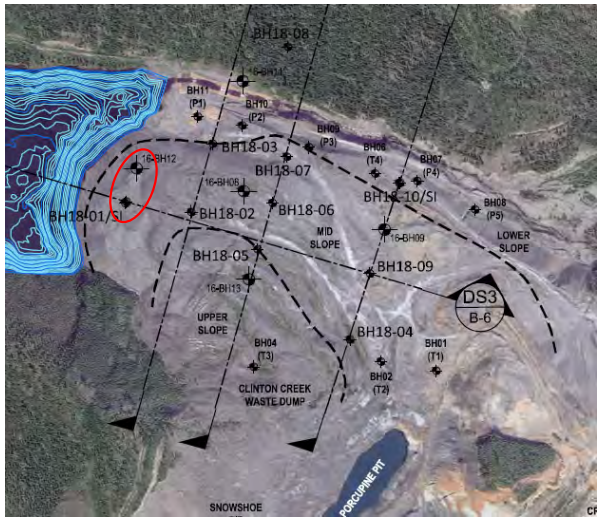
- Monitoring station 1831 is nearest point
  - 28 mm/year horizontal movement
  - -13.4 and -17.6 mm/year projected onto LOS for ascending and descending orbits suggest settlement
  - Data from 2018 -2020
- Mild settlement reflected in InSAR data
- In general, the InSAR and survey data correlate with the data from the SI – some settlement of the waste and some movement toward Hudgeon Lake



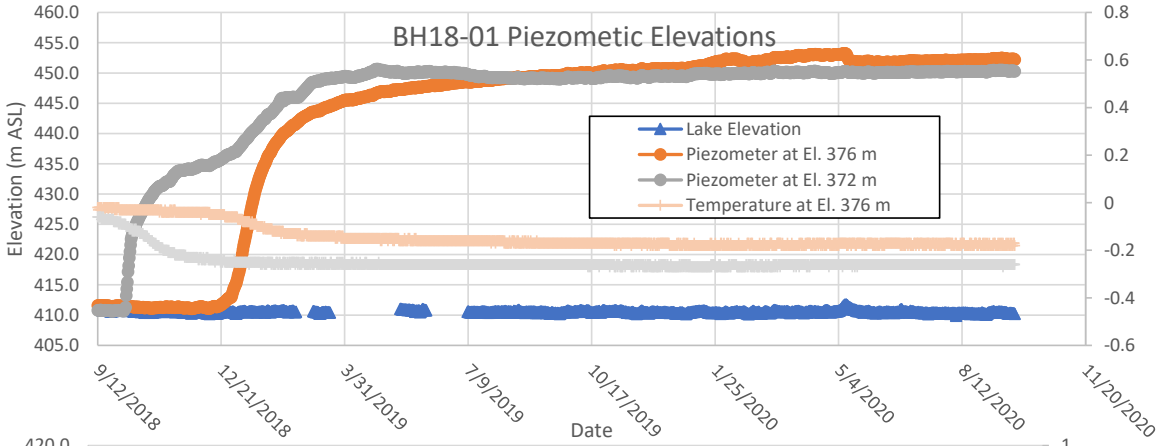
BH18-01 – Thermistor

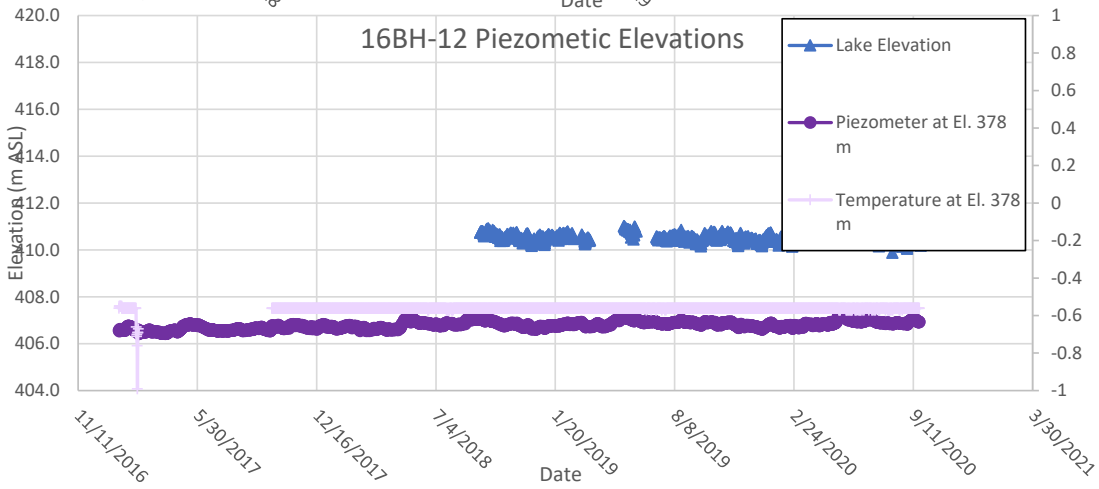


- Freezing point approximately corresponds with waste rock/alluvium boundary
- Single node of increased warming near 380 m, slightly above the alluvium/waste rock boundary
  - possible seepage layer of water from lake?
- General trend in all nodes is decreasing temperature between 2018 and 2019; generally stable temperatures between 2019 and 2020.
  - Consistent with time required for instruments to equilibrate to in situ conditions

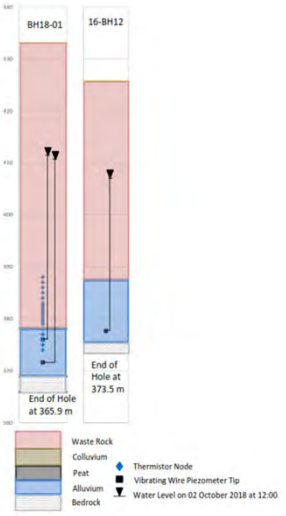


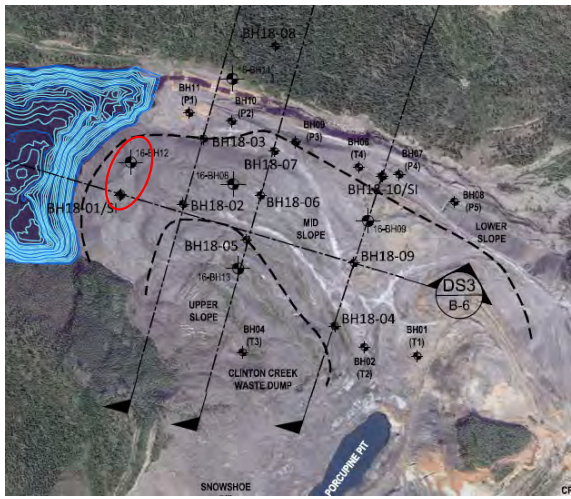
BH18-01 / 16-BH12 – Piezometers



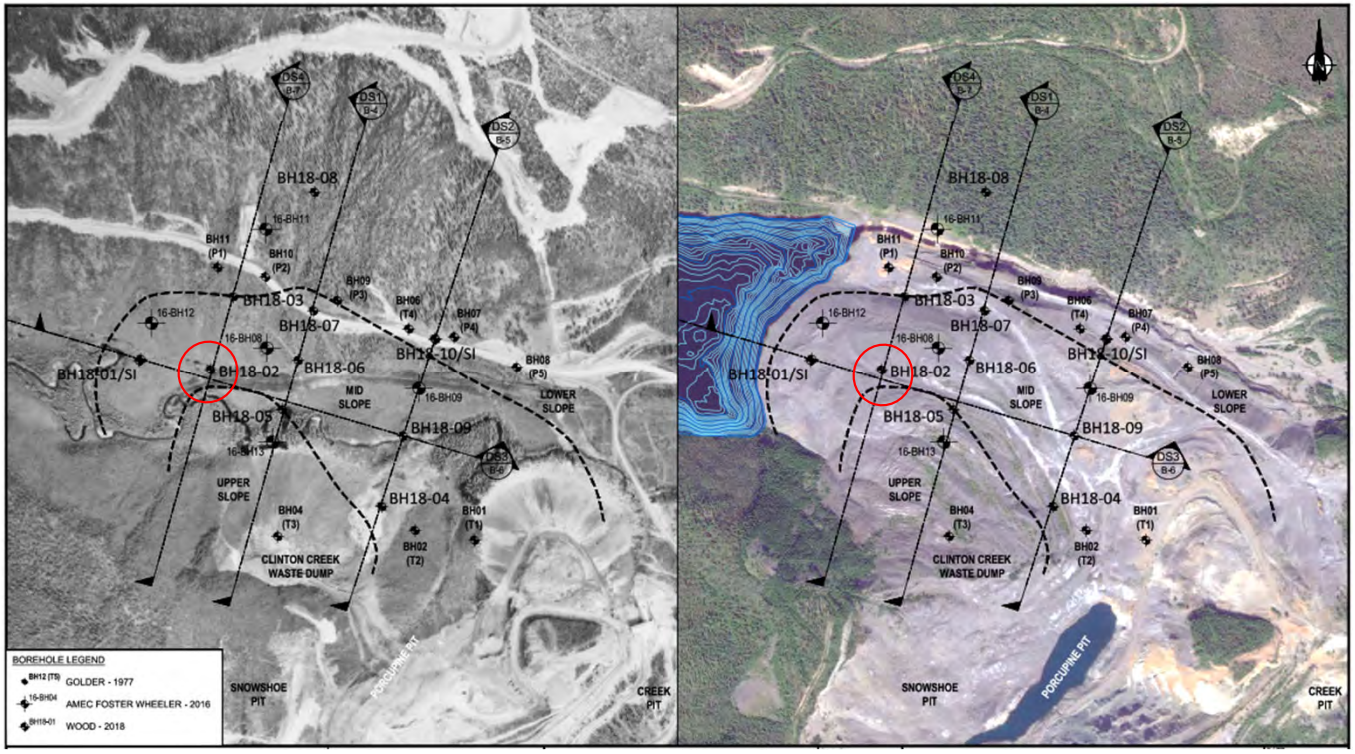


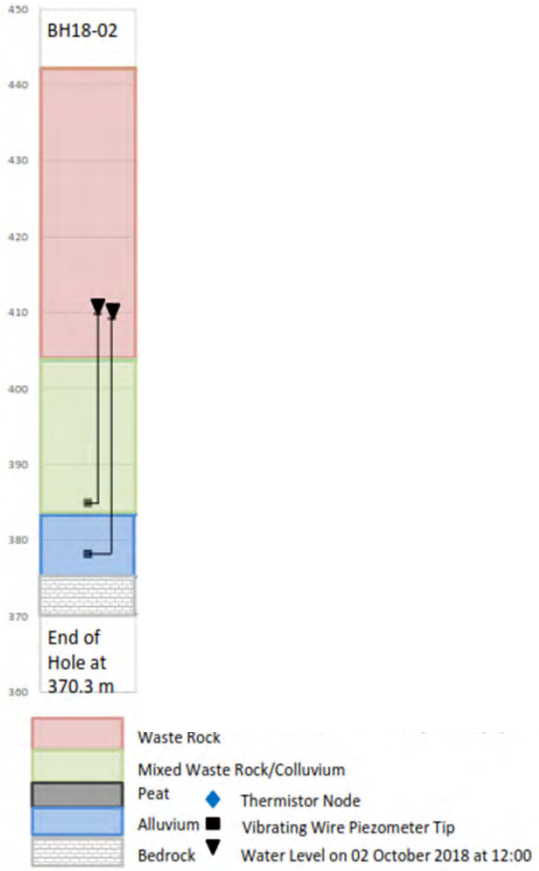
- BH18-01
  - Pressure heads in piezometers (both installed in alluvium) were initially close to lake elevation
  - Sharp increase in pressures attributed to freezing of tips - temperatures dropped significantly in late 2018 into early 2019, then generally stabilize.
  - Generally consistent with thermistor data
- 16BH-12
  - Slow increase in water pressure over time? Tip may also be frozen based on temperatures





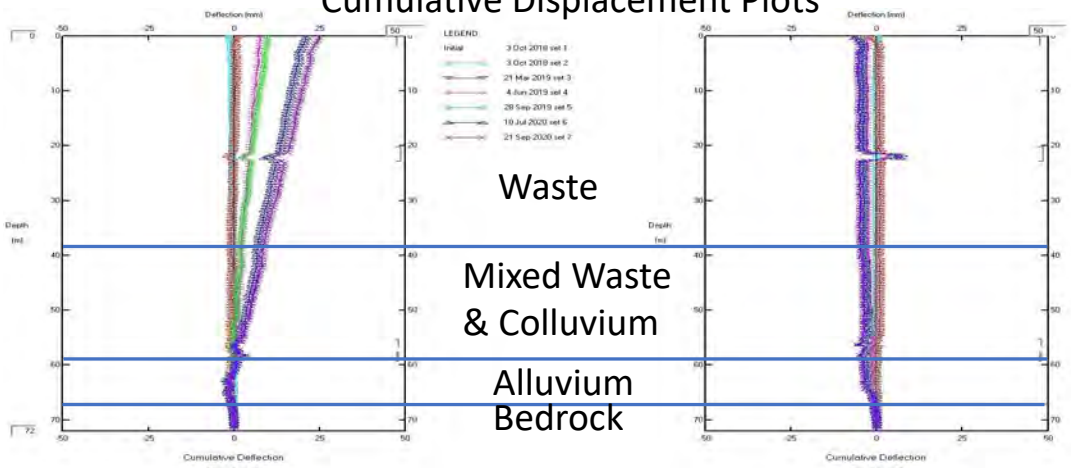
BH18-02

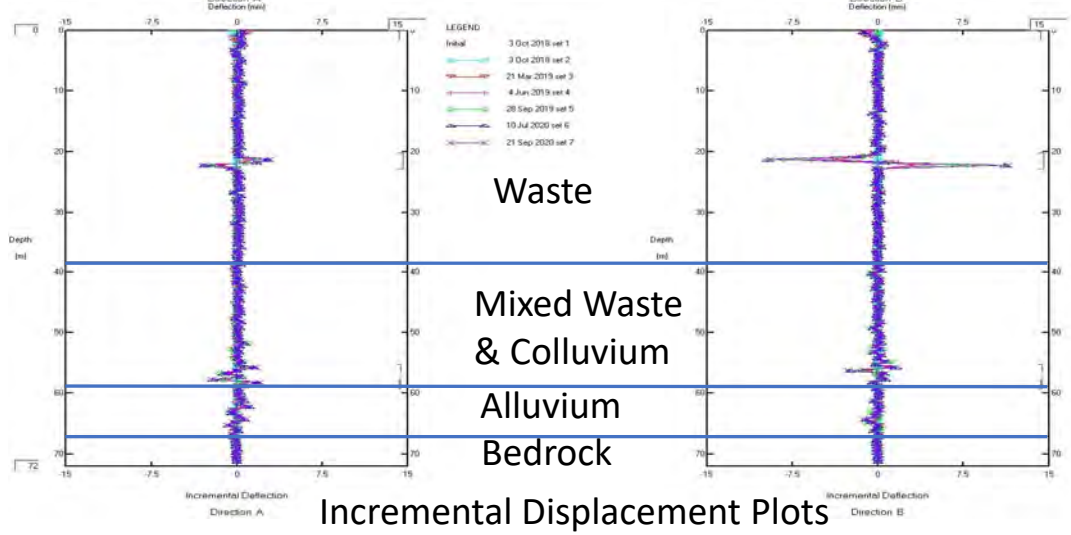

BH18-08
16-BH11
BH11 (P1)
BH10 (P2)
BH09 (P3)
BH18-03
16-BH12
BH18-07
BH06 (T4)
BH07 (P4)
16-BH08
BH18-10/SI
BH08 (P5)
BH18-01/SI
BH18-02
BH18-06
MID SLOPE
16-BH09
LOWER SLOPE
BH18-05
BH18-09
16-BH13
UPPER SLOPE
BH18-04
BH04 (T3)
BH01 (T1)
BH02 (T2)
CLINTON CREEK WASTE DUMP
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018


BH18-02
450
440
430
420
410
400
390
380
370
360
End of Hole at 370.3 m
Waste Rock
Mixed Waste Rock/Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

BH18-02 – SI

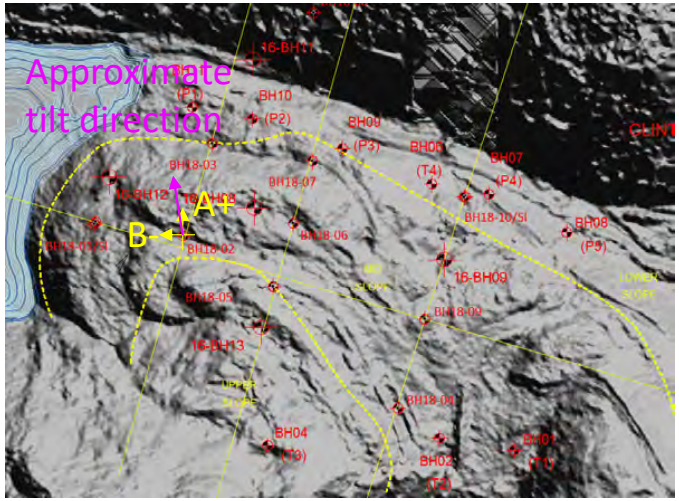
Cumulative Displacement Plots





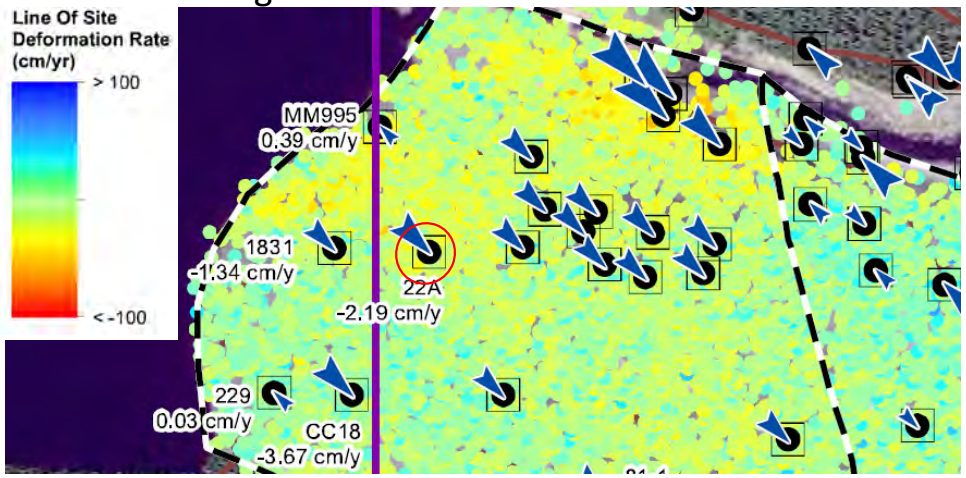
Incremental Displacement Plots

- Downslope tilt within the waste dump materials towards Hudgeon Lake/spillway inlet
- Cumulative movement in the waste dump (between 0.2 and 59.2 m depth) of 28.2 mm at an average rate of 13.7 mm/year between March 2019 and September 2020.
- Some apparent settlement near the mixed waste and colluvium/alluvium boundary.
- Consistent with slow and gradual creep of the waste dump toward Hudgeon Lake.
- Some anomalous incremental displacement near 20 m; may be due to casing deformation and shows no indication of change

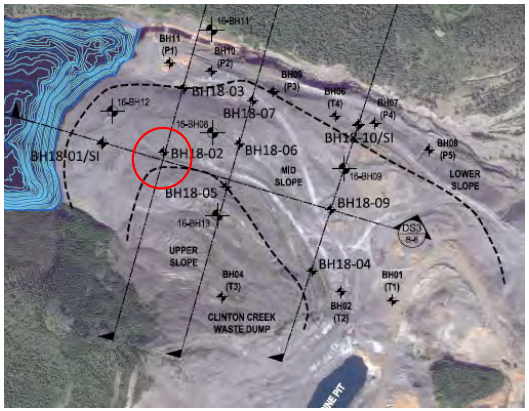


BH18-02 – Monitoring and InSAR

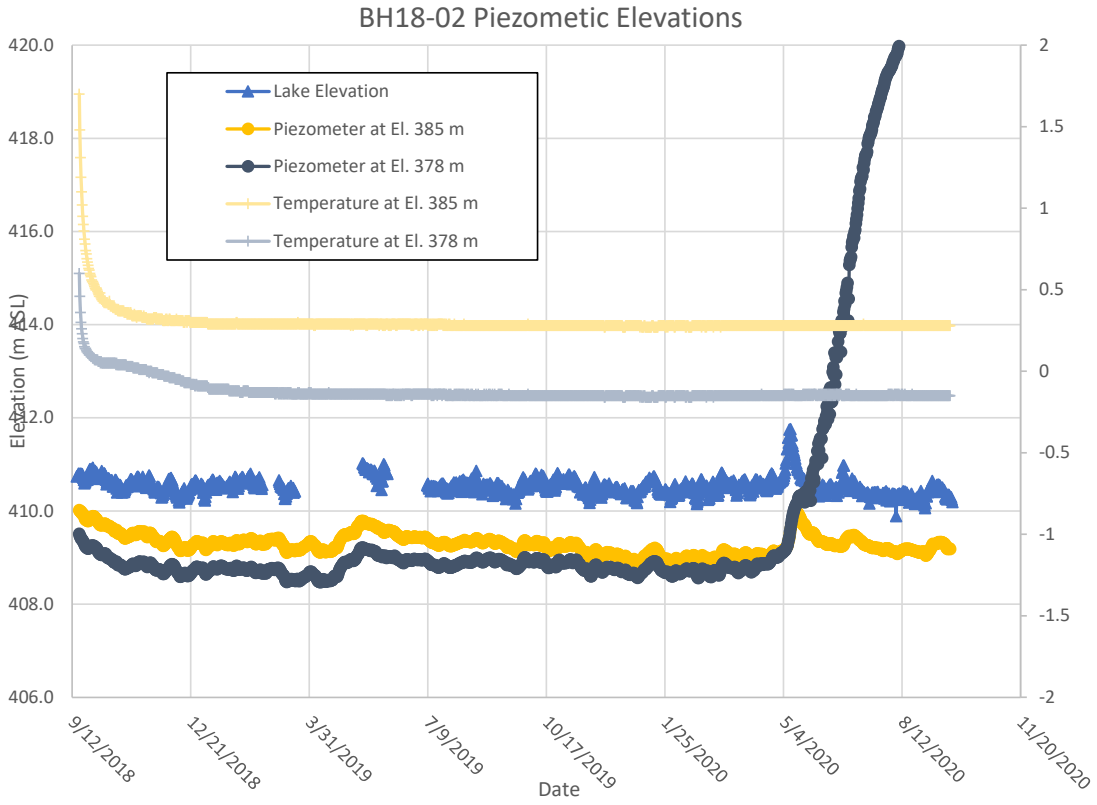
InSAR ascending orbit



- Monitoring station 22A is nearest point
  - 34 mm/year horizontal movement
  - -21.9 and -38.9 mm/year projected onto LOS for ascending and descending orbits suggest settlement
  - Data from 2018 -2020
- Mild settlement reflected in InSAR
- In general, the InSAR and survey data correlate with the data from the SI – some settlement of the waste and some movement toward Hudgeon Lake

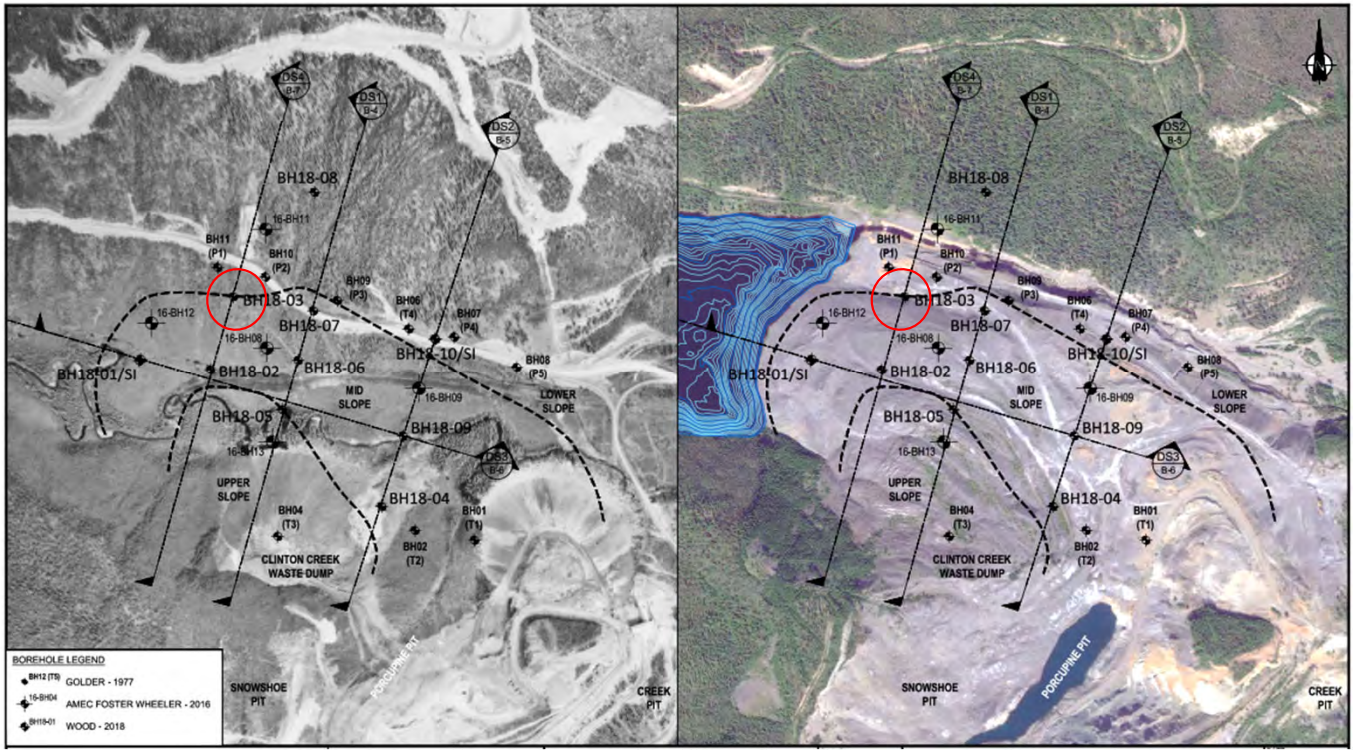


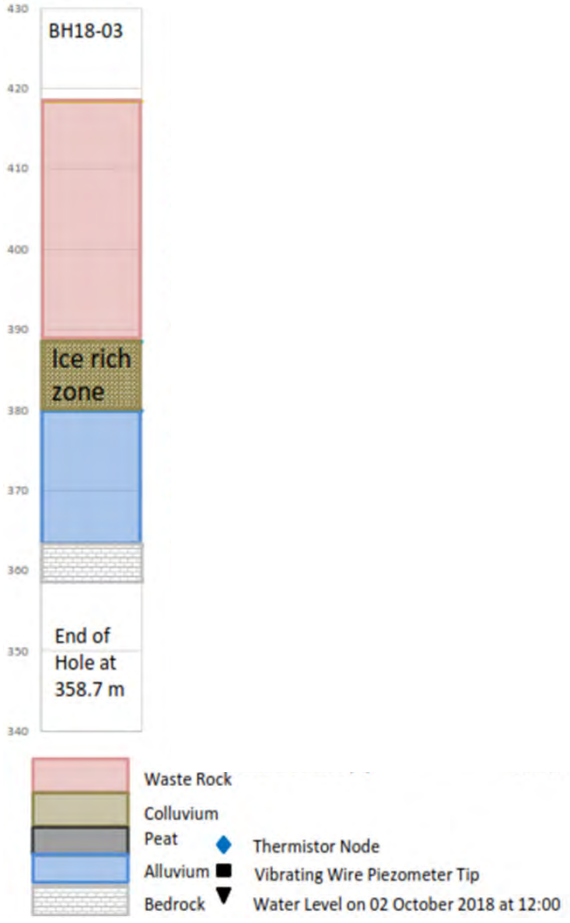
BH18-02 – Piezometers



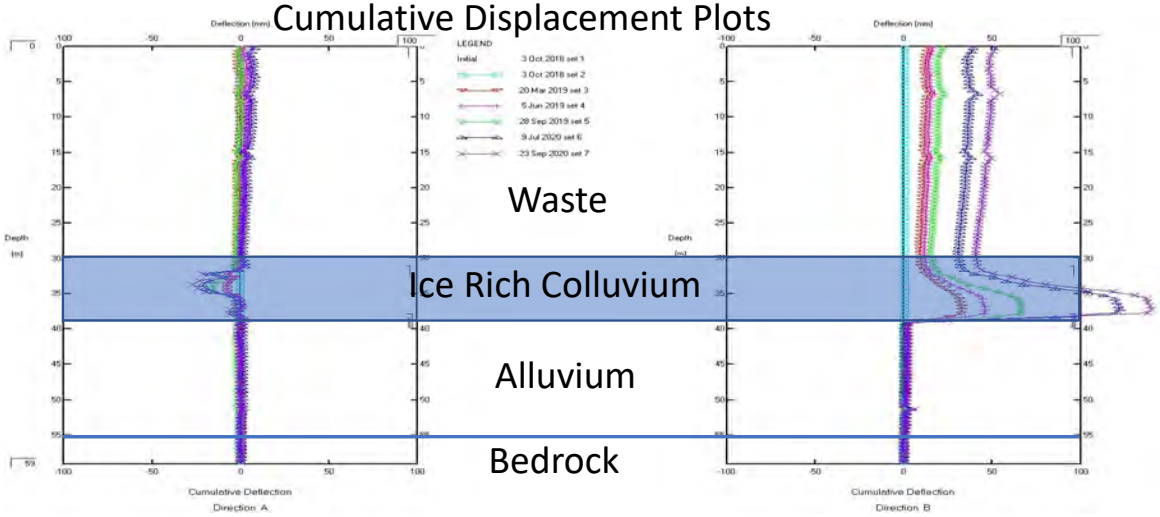
- Piezometer pressures follow similar trend as changes in lake elevation but different pressure heads – may be hydraulically connected to lake via the 1974 CC diversion channel
- Pressures between 378 & 385 were initially parallel but different; pressures equalized in May 2020 with increase in lake elevation
- Dramatic rise in pore pressures in piezo installed at 378 ; tip has been reading temperatures <0°C since late 2018 – possible ice crystal formation on membrane

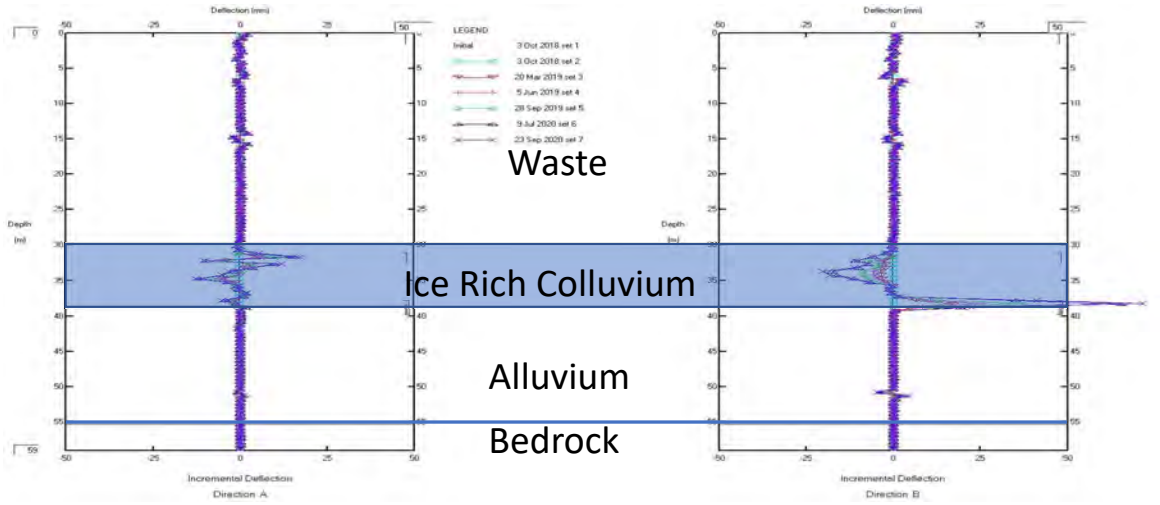
BH18-03


BH18-08
16-BH11
BH11 (P1)
BH10 (P2)
BH09 (P3)
BH18-03
16-BH12
BH18-07
BH06 (T4)
BH07 (P4)
16-BH08
BH18-10/SI
BH08 (P5)
BH18-01/SI
BH18-02
BH18-06
MID SLOPE
16-BH09
LOWER SLOPE
BH18-05
BH18-09
16-BH13
UPPER SLOPE
BH18-04
BH04 (T3)
BH01 (T1)
BH02 (T2)
CLINTON CREEK WASTE DUMP
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018


BH18-03
Ice rich zone
End of Hole at 358.7 m
430
420
410
400
390
380
370
360
350
340
Waste Rock
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

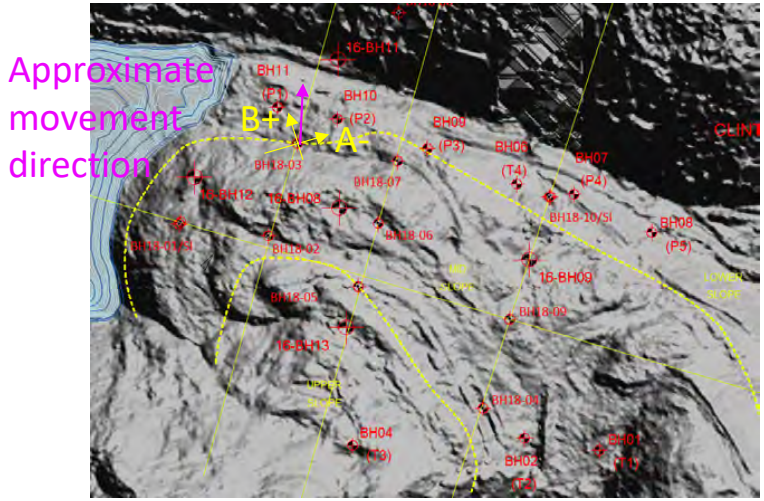
BH18-03 – SI



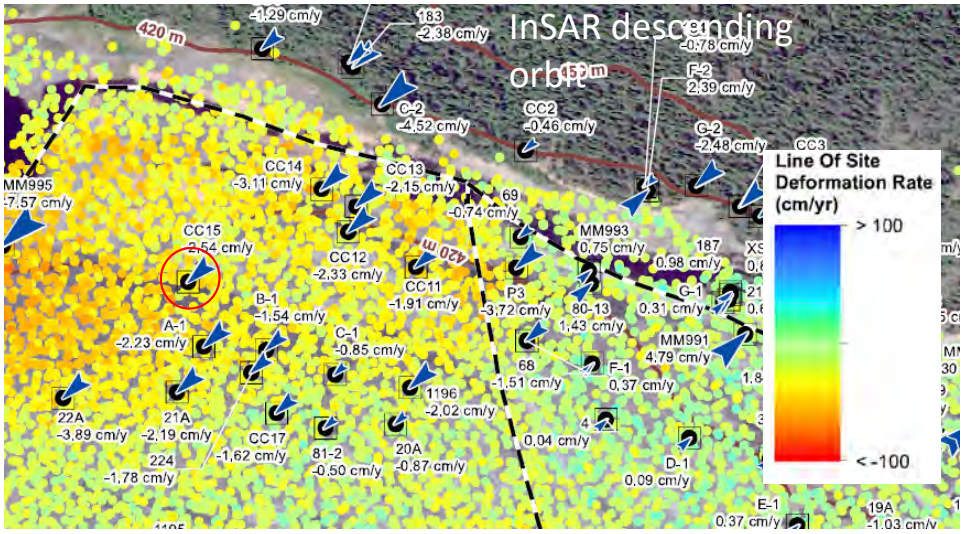


Incremental Displacement Plots

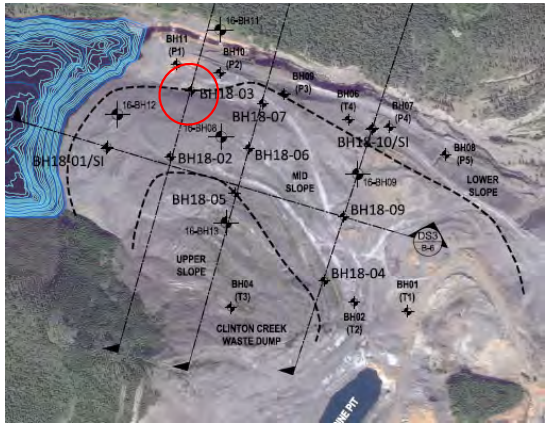
- Deformation in the ice rich colluvium zone attributed to a combination of settlement and creep towards Clinton Creek.
  - Cumulative movement at the base of the ice rich layer (between 37.8 and 39.8 m depth) of 135.3 mm at an average rate of 67.2 mm/year.
- Displacement of overlying waste rock on creeping ice rich colluvium, cumulative movement of 49.3 mm at an average rate of 23.9 mm/year



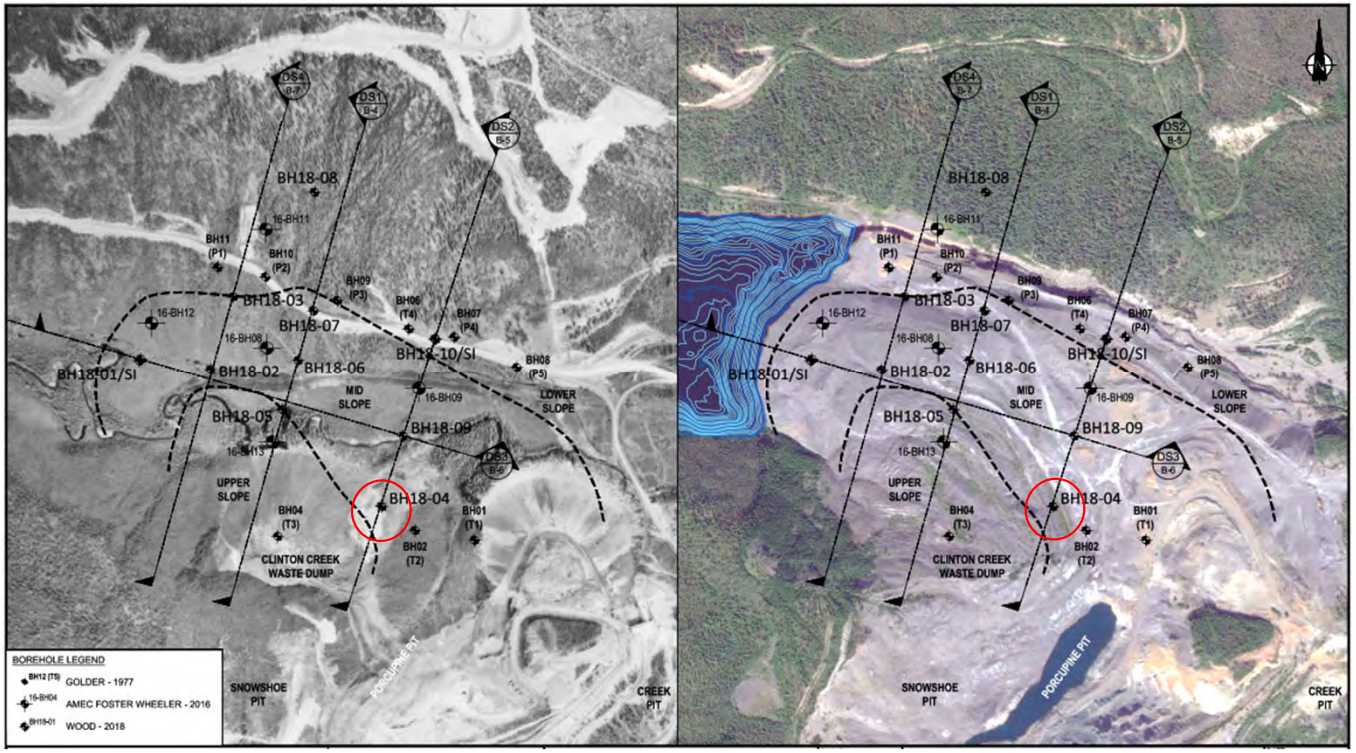
BH18-03 – Monitoring and InSAR

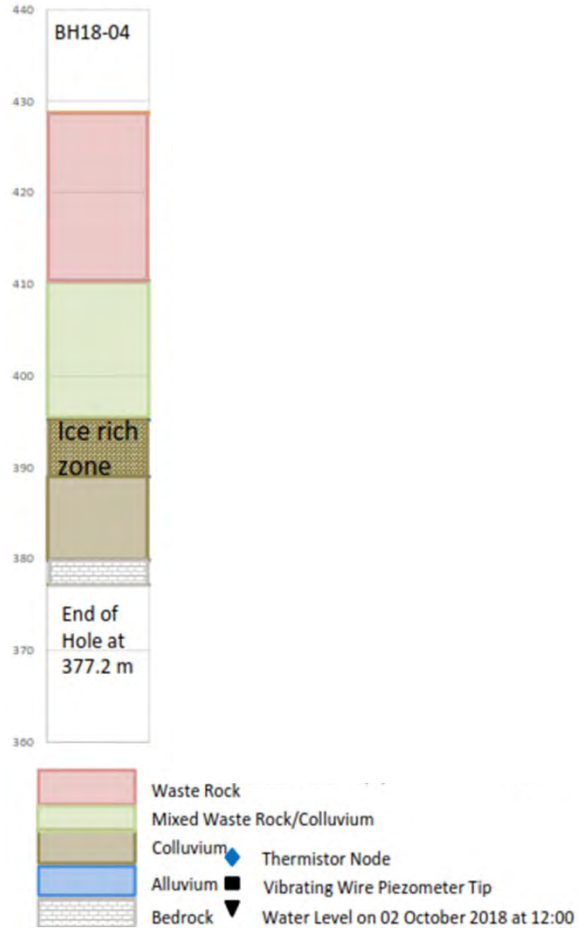


- Monitoring station CC15 is nearest point
  - 27 mm/year horizontal movement
  - -11.3 and -25.4 mm/year projected onto LOS for ascending and descending orbits suggest settlement
  - Data from 2018-2020
- InSAR suggests movements near this location have a higher portion of settlement than horizontal movements, consistent with the SI data



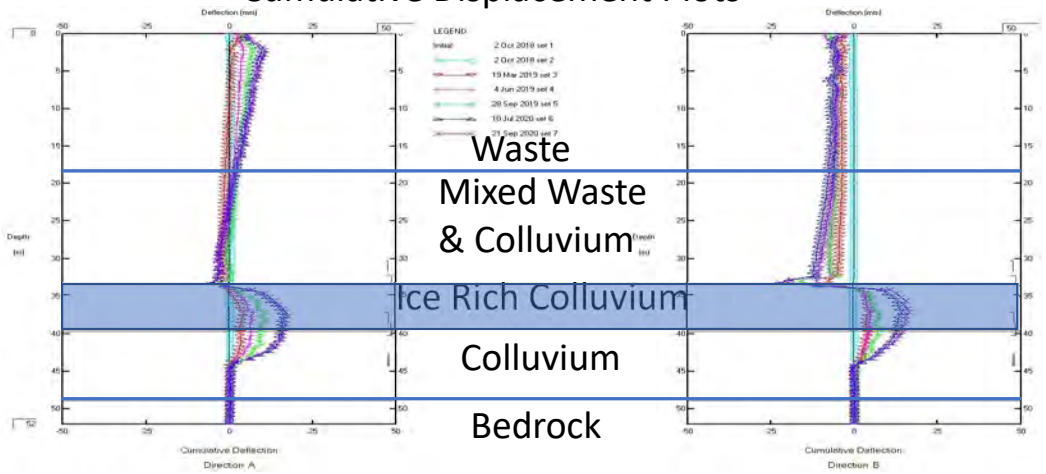
BH18-04

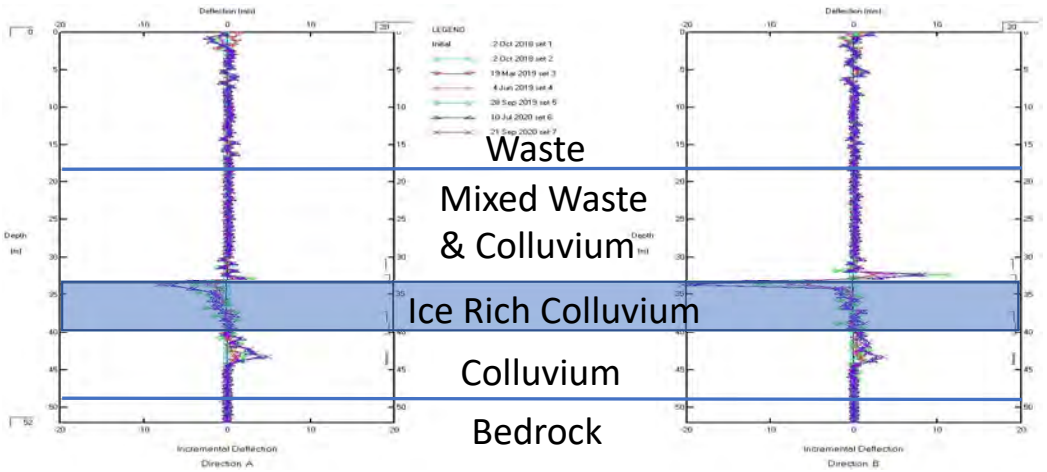

BH18-08
16-BH11
BH11 (P1)
BH10 (P2)
BH09 (P3)
BH18-03
16-BH12
BH06 (T4)
BH07 (P4)
BH18-07
16-BH08
BH18-10/SI
BH08 (P5)
BH18-01/SI
BH18-02
BH18-06
MID SLOPE
16-BH09
LOWER SLOPE
BH18-05
BH18-09
16-BH13
UPPER SLOPE
BH18-04
BH04 (T3)
BH01 (T1)
BH02 (T2)
CLINTON CREEK WASTE DUMP
DS1 B-4
DS2 B-5
DS3 B-6
DS4 B-7
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT


BH18-04
440
430
420
410
400
390
380
370
360
Ice rich zone
End of Hole at 377.2 m
Waste Rock
Mixed Waste Rock/Colluvium
Colluvium
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

BH18-04 – SI

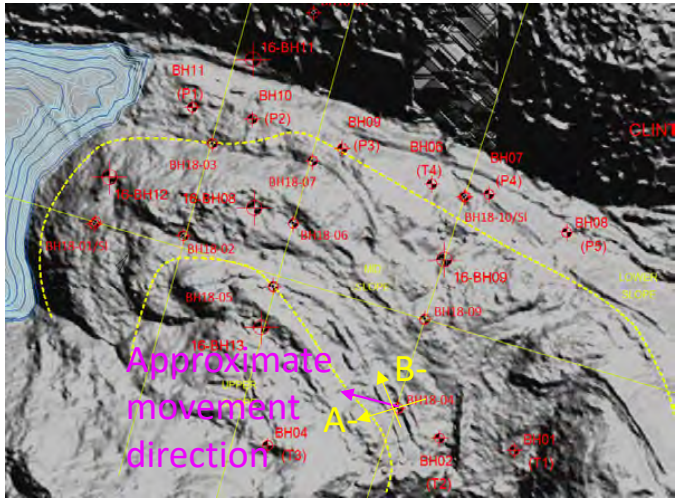
Cumulative Displacement Plots





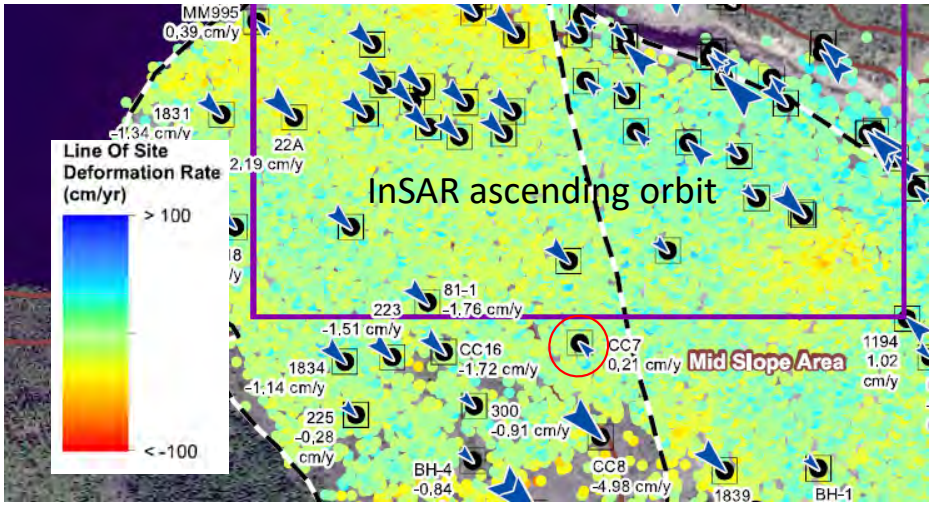
Incremental Displacement Plots

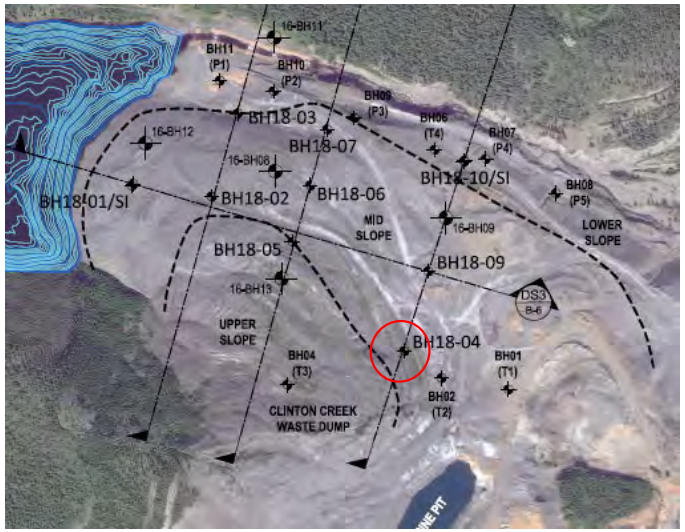
- The SI installed in this borehole has detected movements in the ice-rich colluvium (33.5 to 39.6 m depth) and in the colluvial material above and below
- Movement between 32.3 and 40.2 m – about 31 mm cumulative movement at rates between 22.3 and 15.8 mm per year slowing progressively between each reading
- Based on 2019/2020 data, it appears as though the SI may be experiencing backtilting above the ice rich layer – possibly settlement of the waste dump



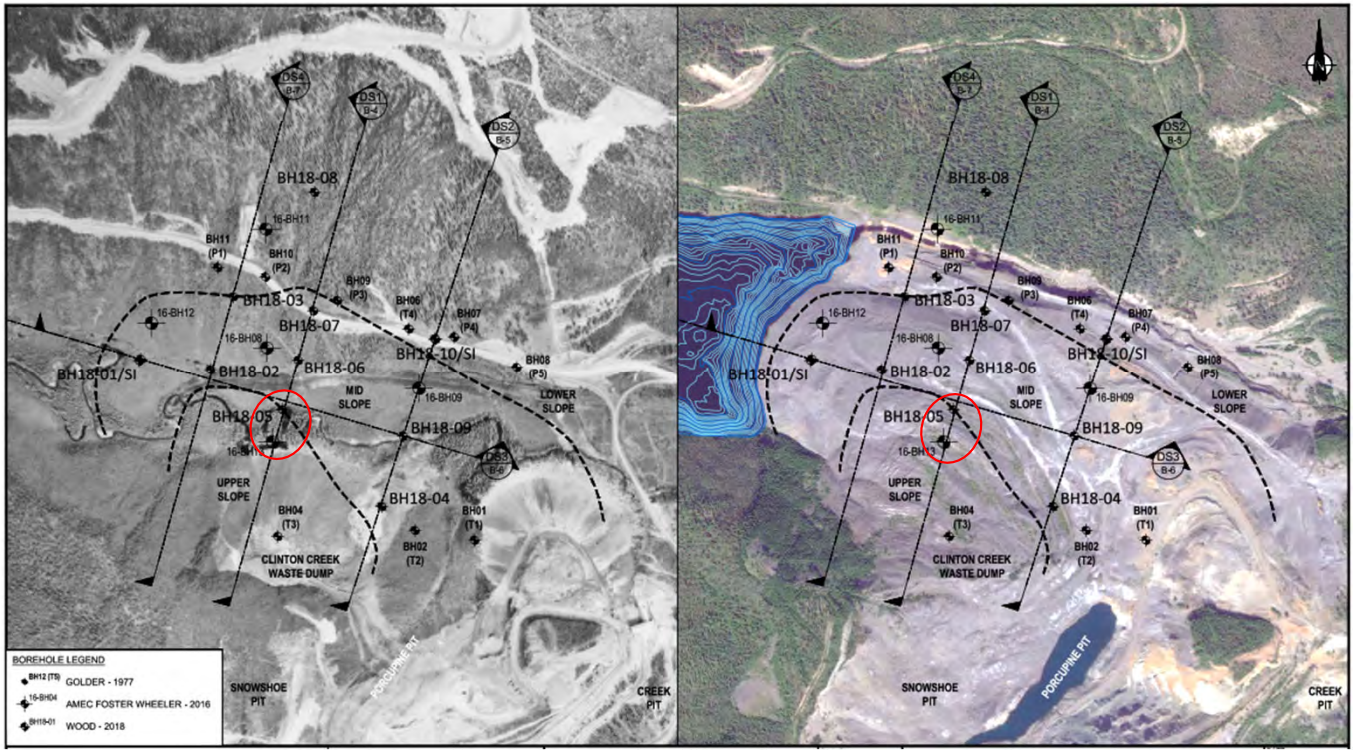
BH18-04 – Monitoring and InSAR

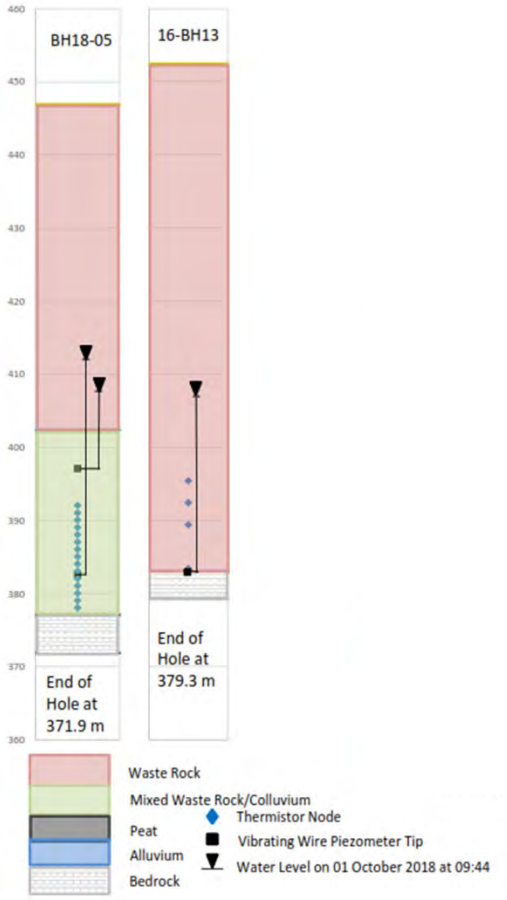
- Monitoring point CC7 is nearest point
  - 6 mm/year lateral movement
  - +2.1 and +6.2 mm/year projected onto LOS for ascending and descending orbits suggest mild uplift
  - Data from 2018 -2020
- No net movement reflected in InSAR



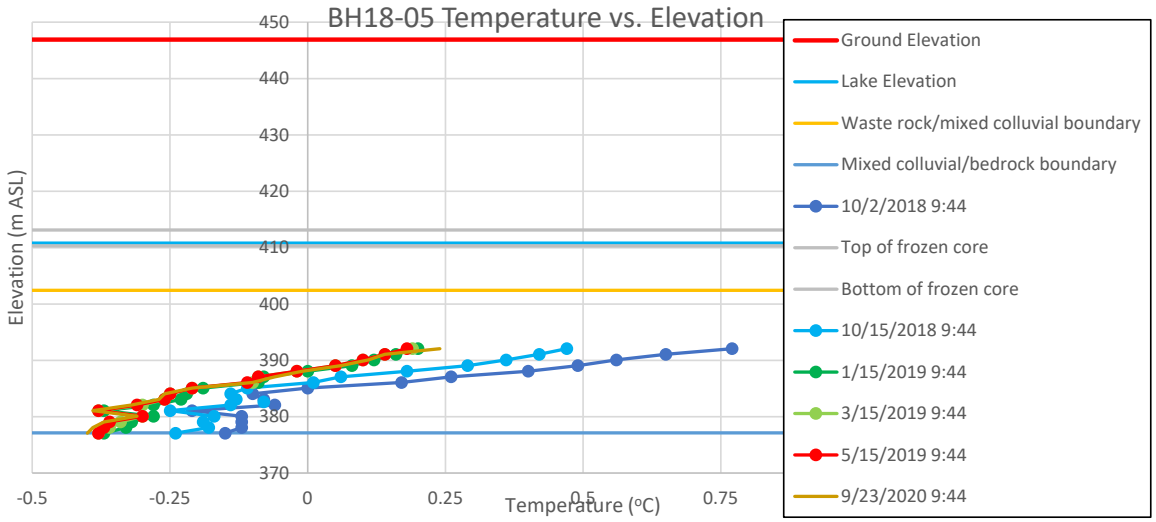


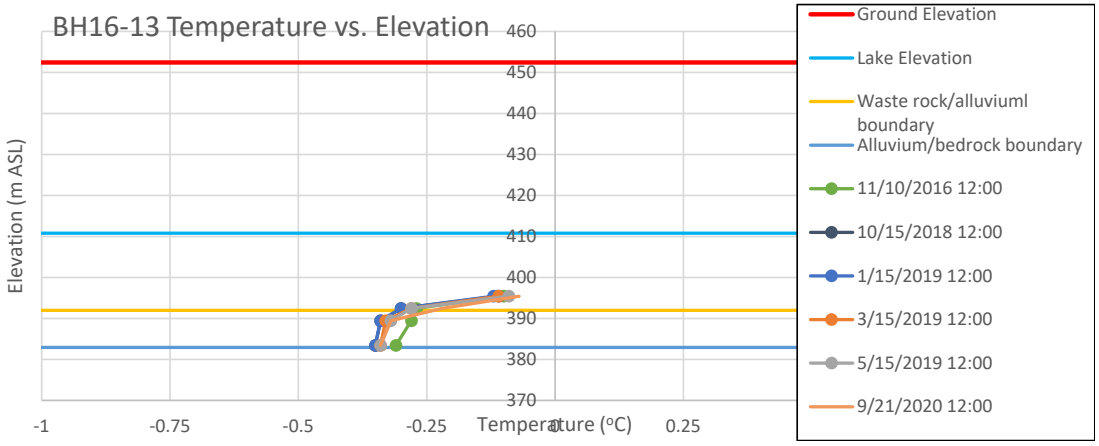
BH18-05 and 16-BH13



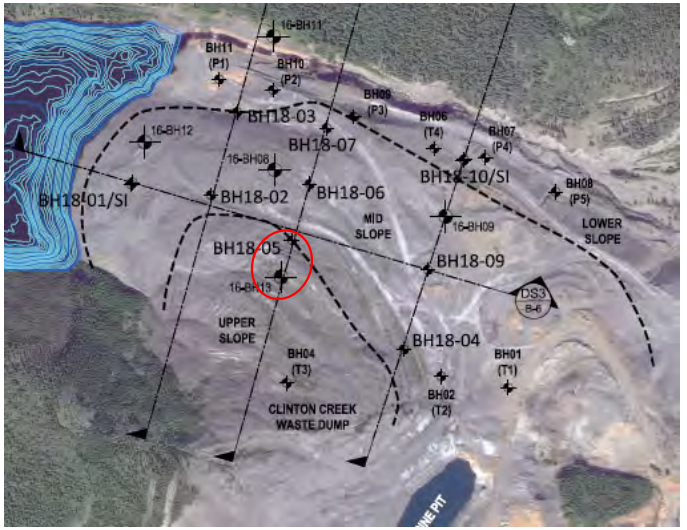


BH18-05 and 16-BH13 – Thermistors

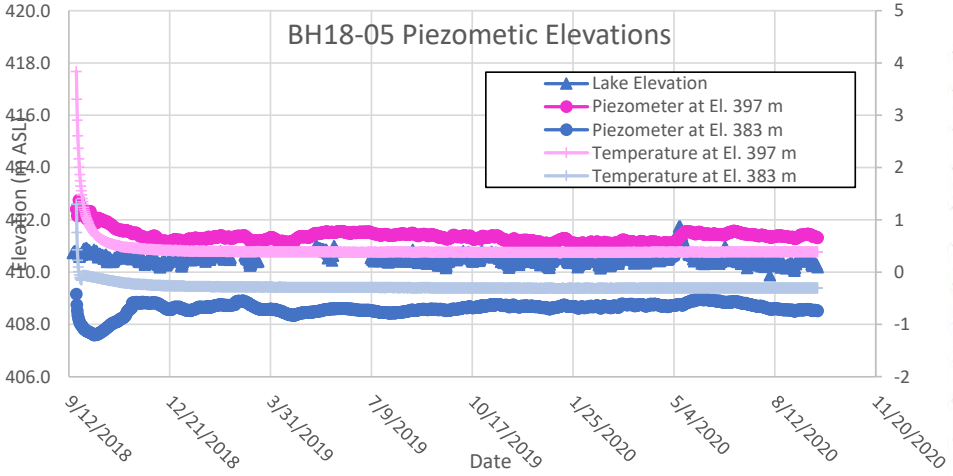


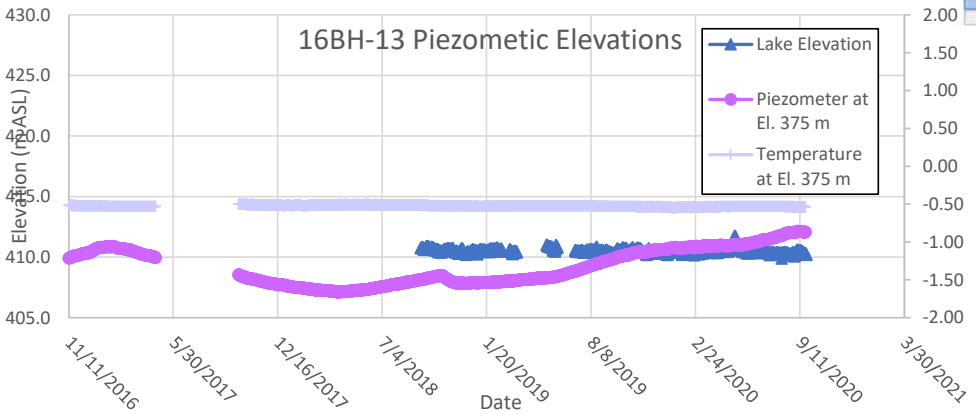


- BH18-05
  - Zero-degree boundary is partway within the mixed waste rock and colluvial material
  - Rapid cooling initially in 2018 while coming to equilibrium. Conditions have remained static with possible minor cooling since early 2019
  - Slight warming at nodes installed near 381 m
  - This borehole was drilled in what appears to be the original Clinton Creek channel
- 16B-BH13
  - Lower part of waste rock and alluvium below zero
  - Cooling between 2016 and 2018

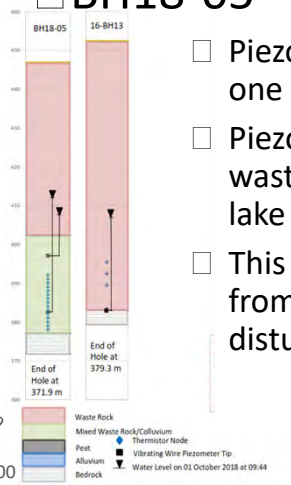


BH18-05 and 16-BH13 – Piezometers





BH18-05

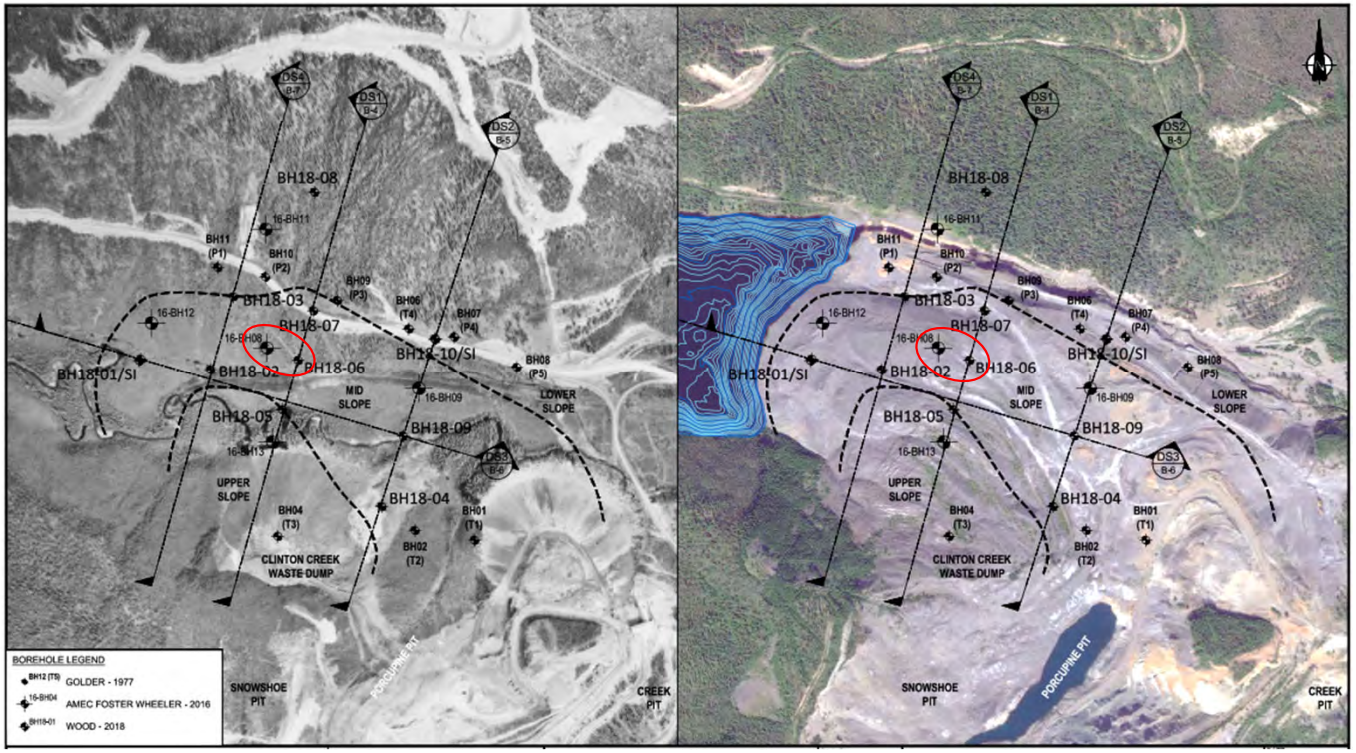


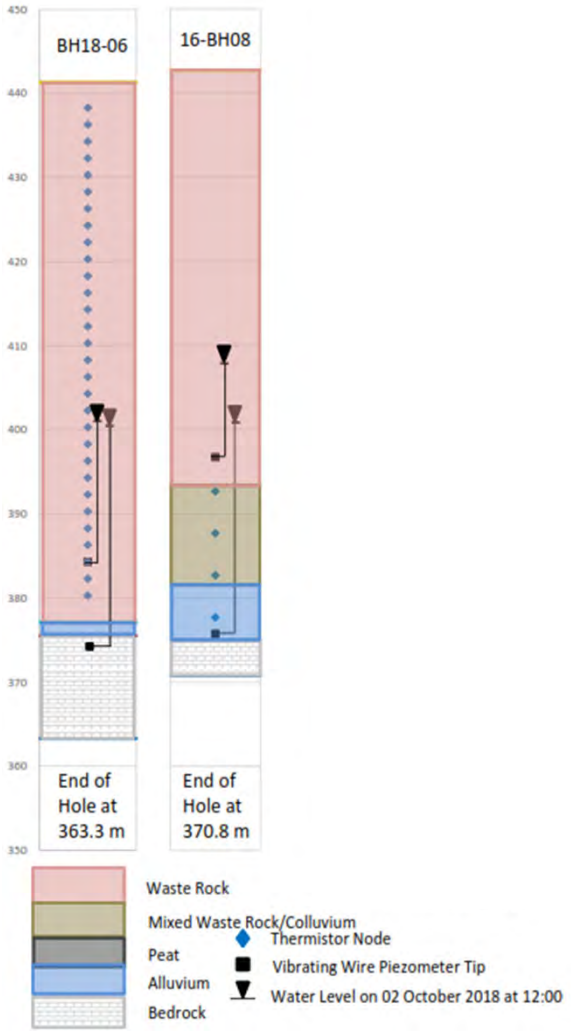
- Piezometer data follows same trends as lake and one another but different heads
- Piezometers are installed in waste rock or mixed waste rock and alluvium and respond to increased lake elevations with a muted response
- This supports the assumption that the alluvium from the original Clinton Creek Channel was likely disturbed during the failure of the waste dump

16BH-13

- Installed in the waste rock/bedrock boundary
- Changes in pressure independent of lake or piezometers in overlying materials in BH18-05

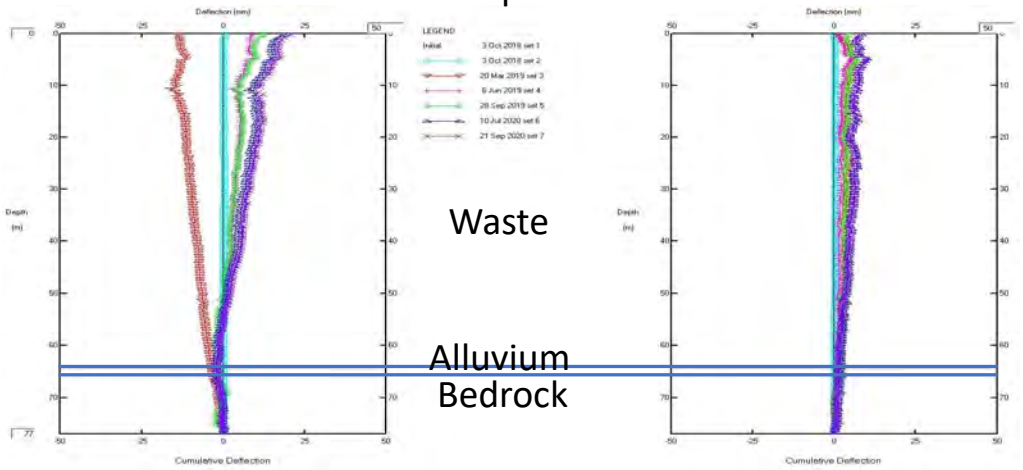
BH18-06 and 16BH-08

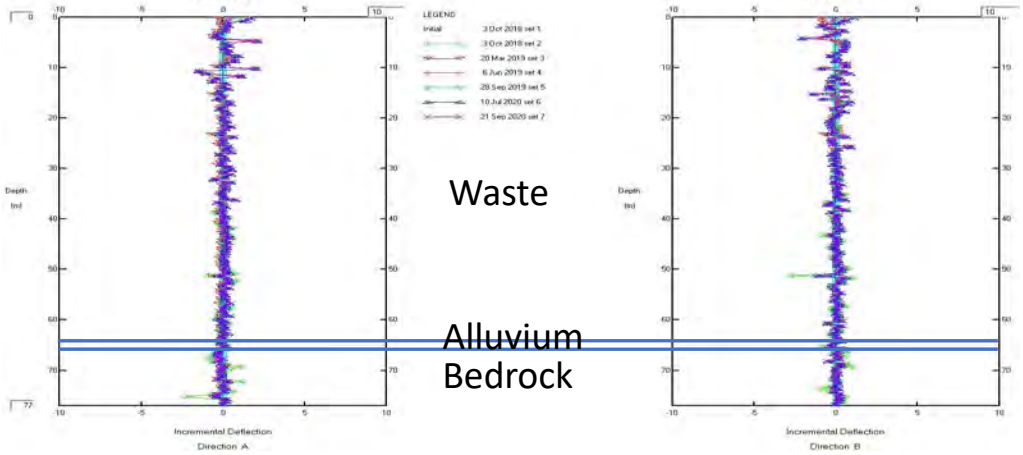




BH18-06 and 16-BH08 SI

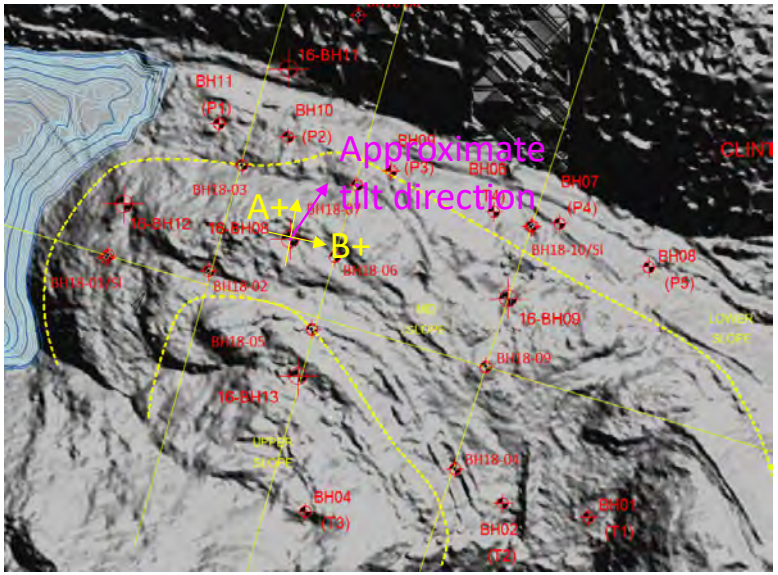
Cumulative Displacement Plots



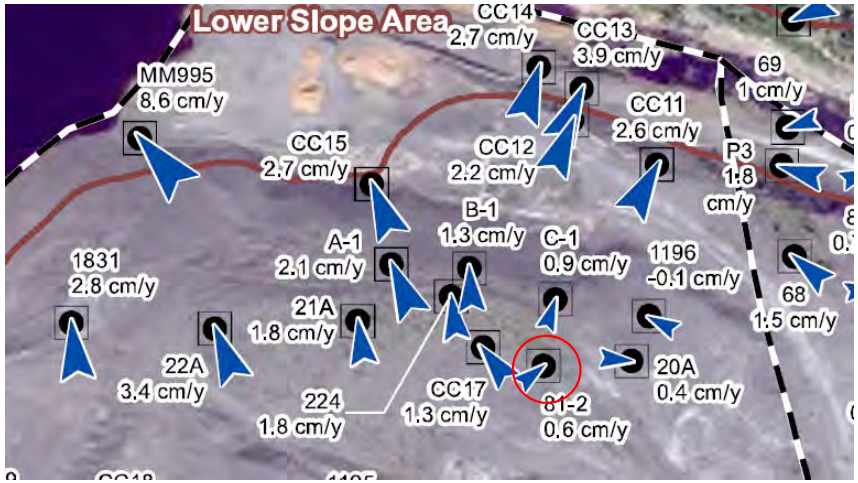


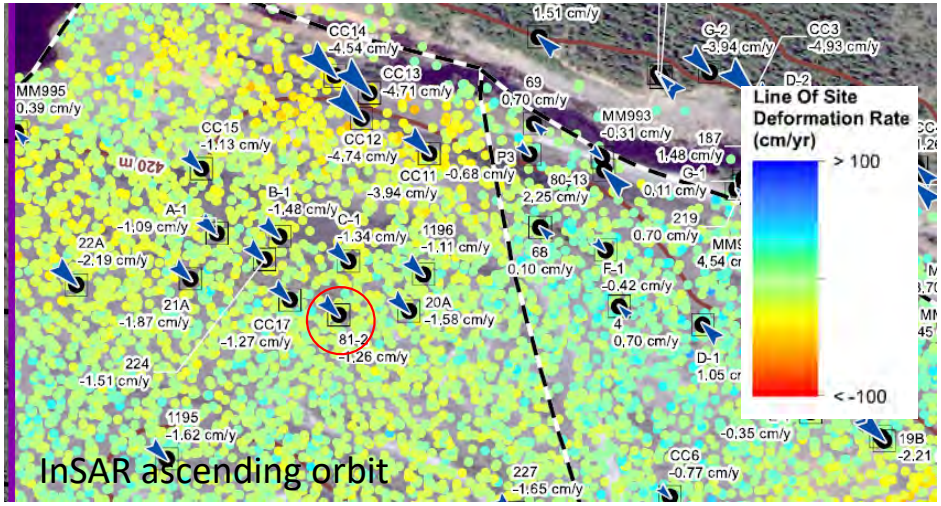
Incremental Displacement Plots

- Poor quality reading in March 2019
- General downslope creep in the waste material. Cumulative tilt movement of 21.9 mm at a rate between 26.3 and 11.14 mm, slowing between each measurement
- Possible indication of settlement through the waste dump

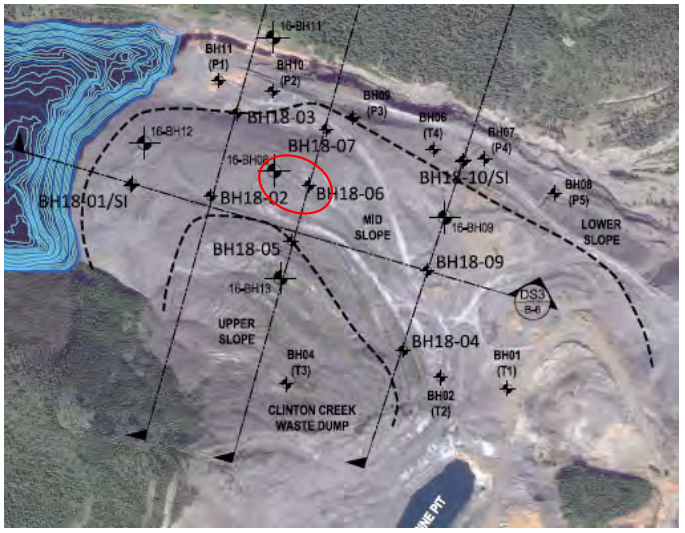


BH18-06 / 16-BH08 – Monitoring and InSAR

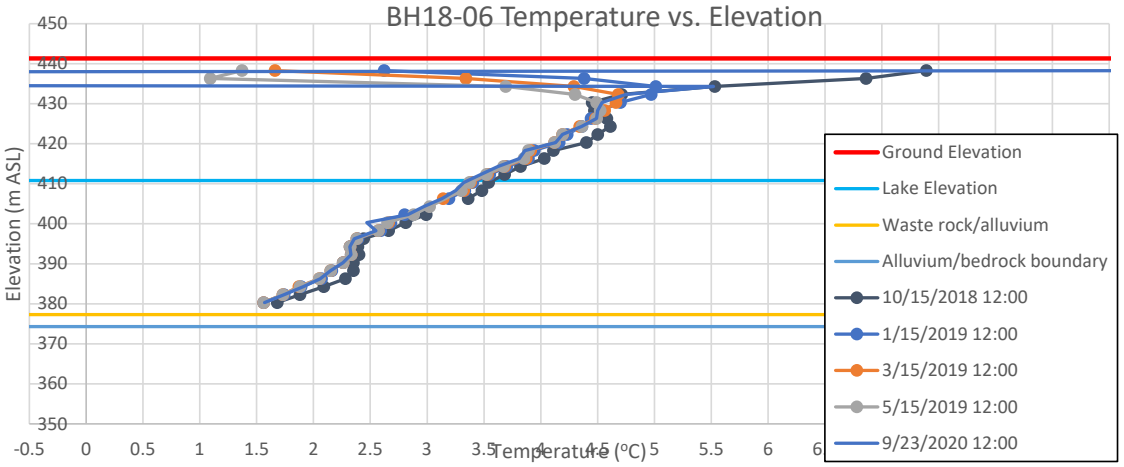


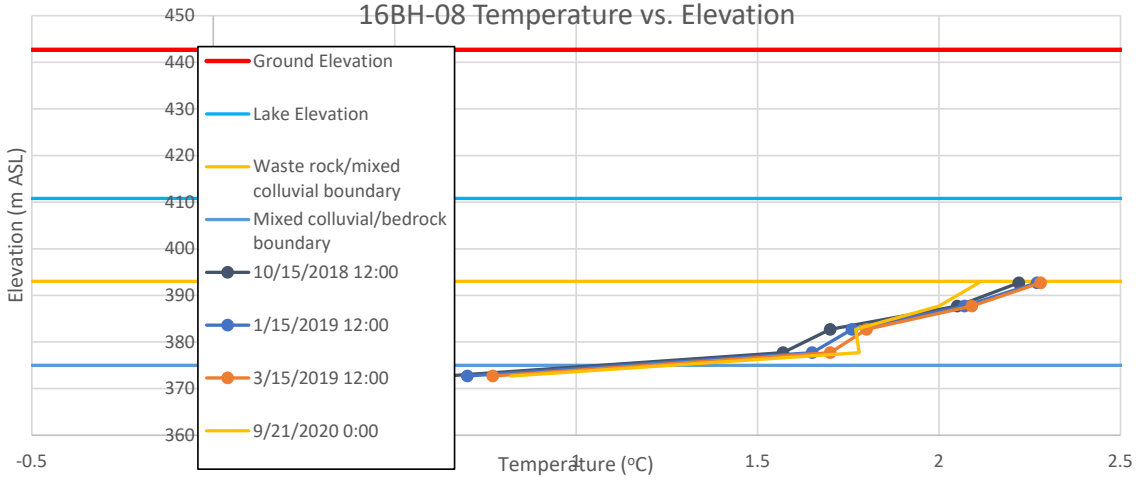


- Monitoring point 81-2 is nearest point
  - 6 mm/year lateral movement in the same direction as SI
  - -12.6 and -5 mm/year for projected onto LOS for ascending and descending orbits suggest mild settlement
  - Data from 2018 -2020
- Some settlement reflected in InSAR

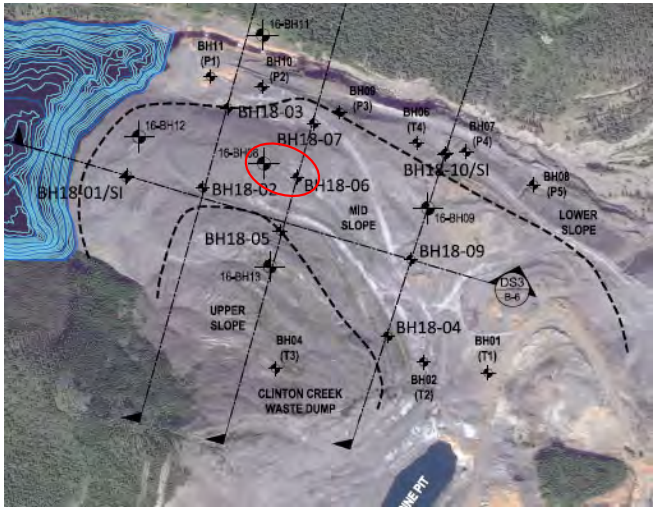


BH18-06 / 16BH-08 – Thermistors

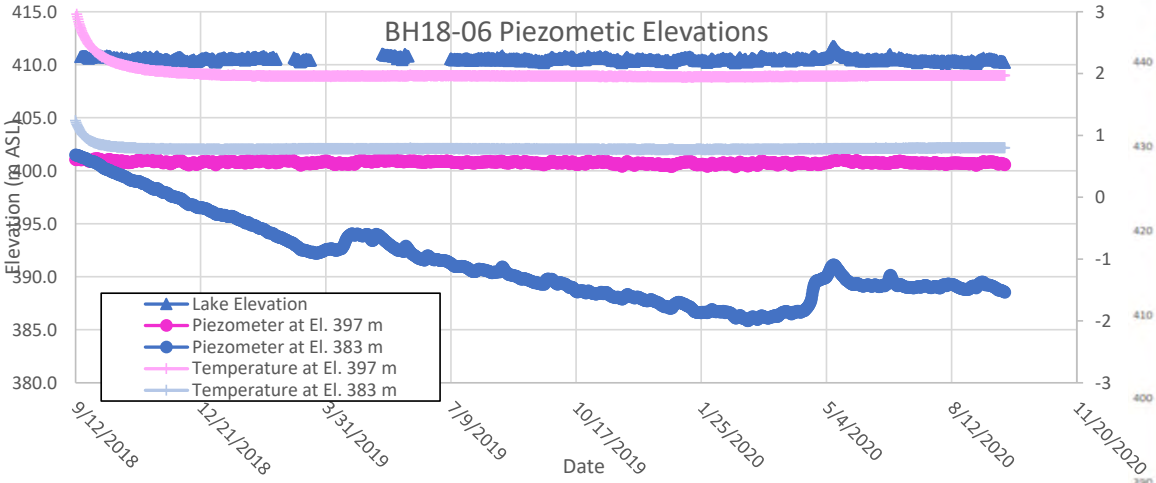


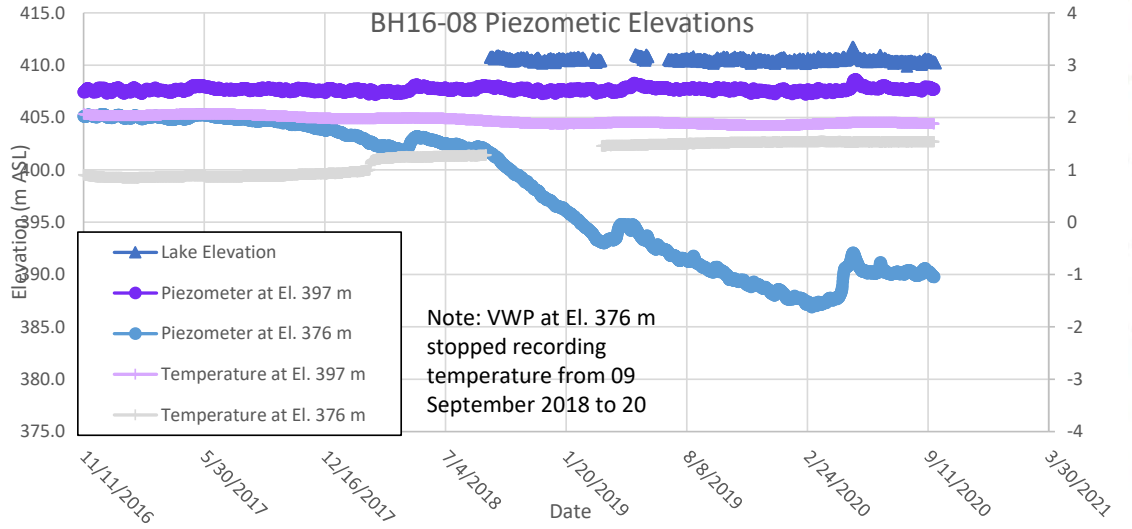


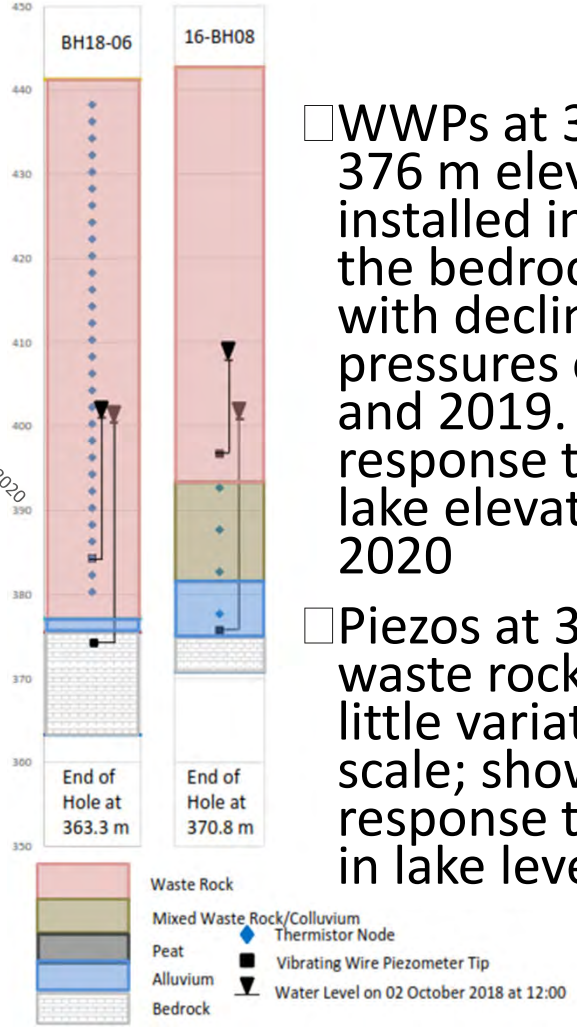
- BH18-06
  - Active layer in upper 10 m subject to freeze thaw
  - Permafrost not encountered in thermistor; waste rock all thawed.
  - Taken time to reach equilibrium but temperature has been stable in deeper portions of the thermistor since Jan 2019
- 16BH-08
  - Installed deeper relative to BH18-06 in mixed colluvium
  - Permafrost not encountered
  - Possible slight warming of nodes over time



BH18-06 / 16BH-08 – Piezometers

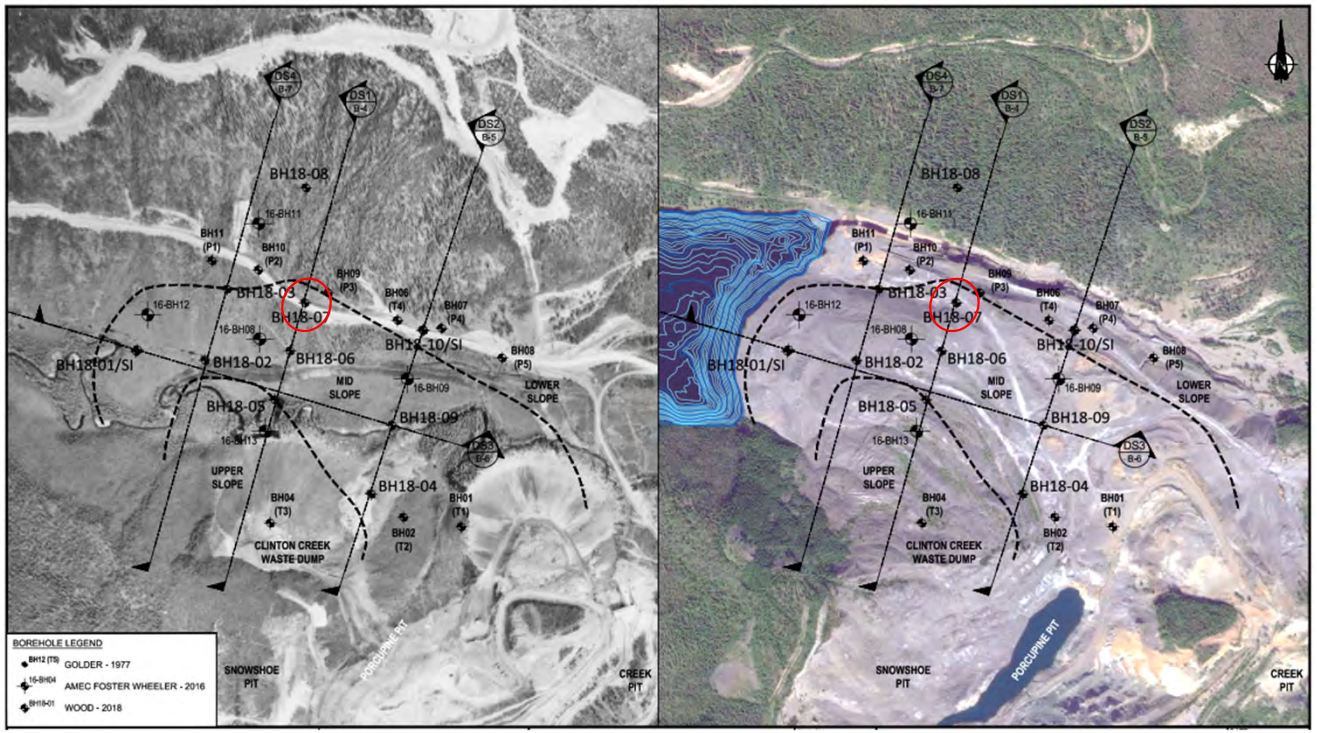


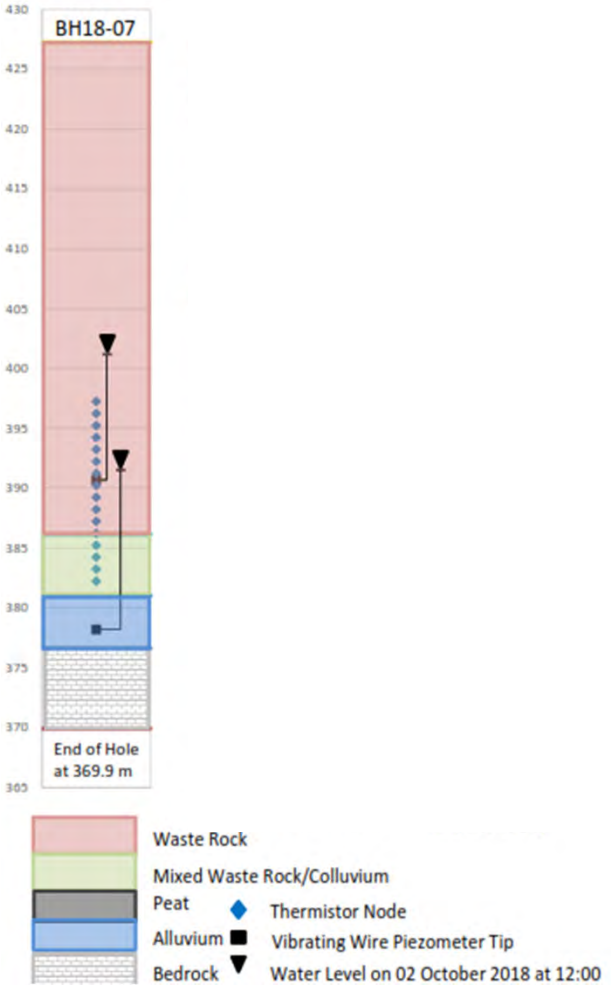




- WWPs at 383 m and 376 m elevation is installed in or near the bedrock; piezo with declining pressures over 2018 and 2019. Shows a response to increased lake elevation in May 2020
- Piezos at 397 m in waste rock shows little variation at this scale; shows some response to increases in lake level

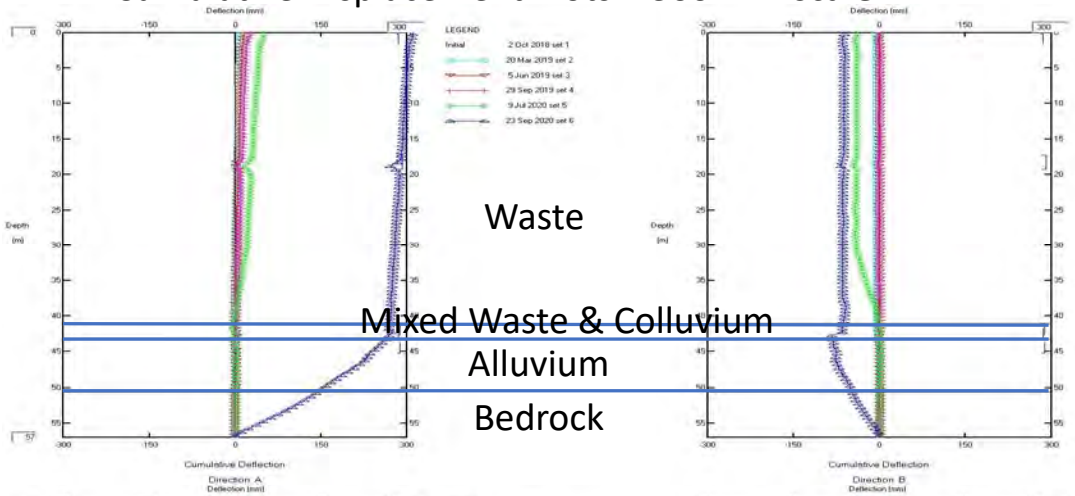
BH18-07

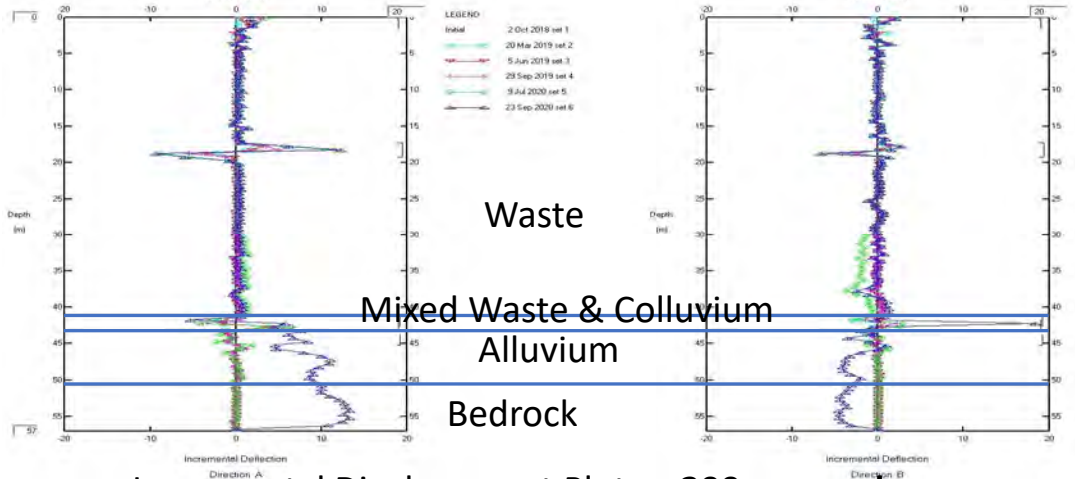

BH18-08
16-BH11
BH11 (P1)
BH10 (P2)
BH18-03
BH09 (P3)
BH06 (T4)
BH07 (P4)
16-BH12
BH18-07
16-BH08
BH18-10/SI
BH08 (P5)
BH18-01/SI
BH18-02
BH18-06
MID SLOPE
16-BH09
LOWER SLOPE
BH18-05
BH18-09
16-BH13
UPPER SLOPE
BH18-04
BH04 (T3)
BH01 (T1)
BH02 (T2)
CLINTON CREEK WASTE DUMP
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT


BH18-07
430
425
420
415
410
405
400
395
390
385
380
375
370
365
End of Hole at 369.9 m
Waste Rock
Mixed Waste Rock/Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

BH18-07 – SI

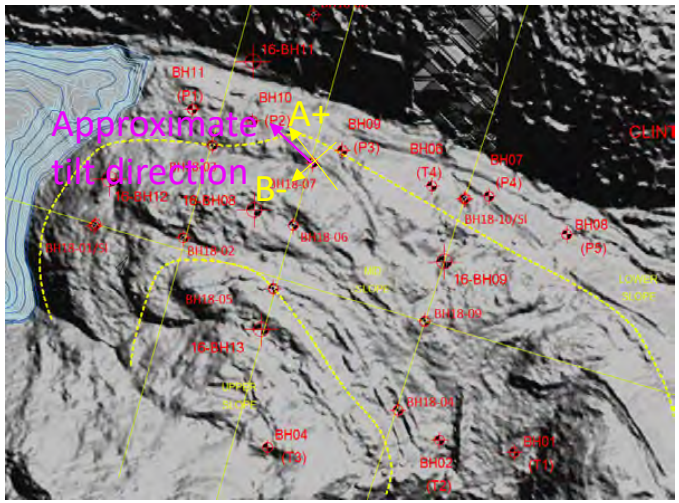
Cumulative Displacement Plots – **300 mm scale**





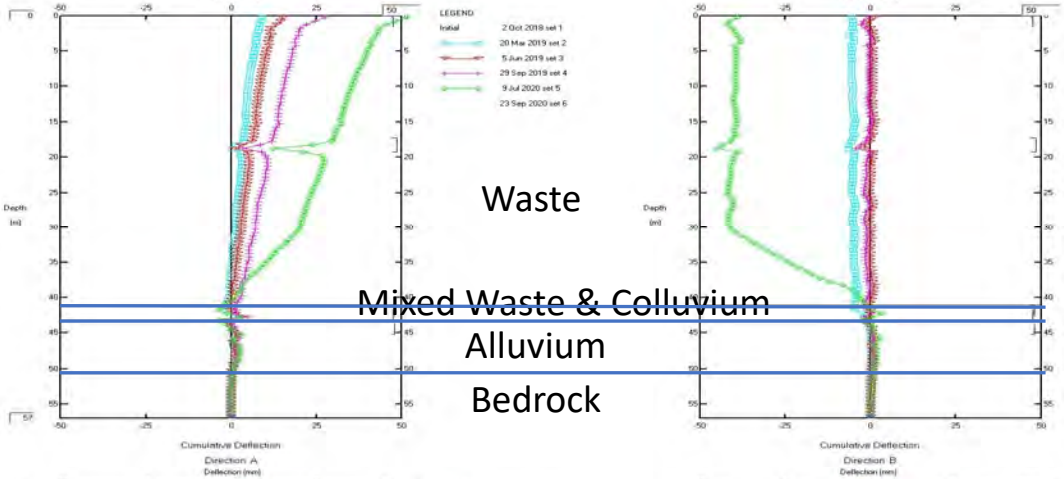
Incremental Displacement Plots – **300 mm scale**

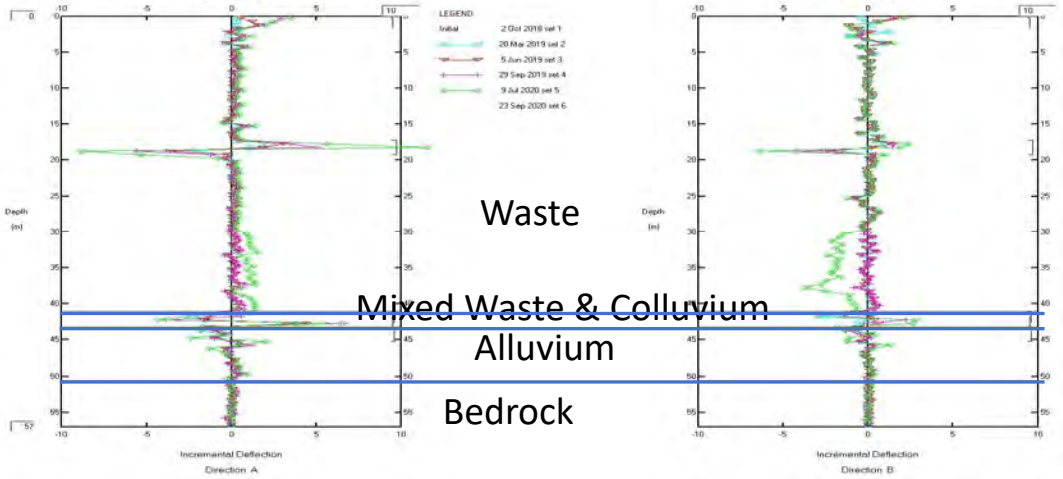
- September 2020 readings are questionable, in particular, the readings in the bottom of the SI are inconsistent.
- Readings are removed on the next slide



SI18-07 – SI

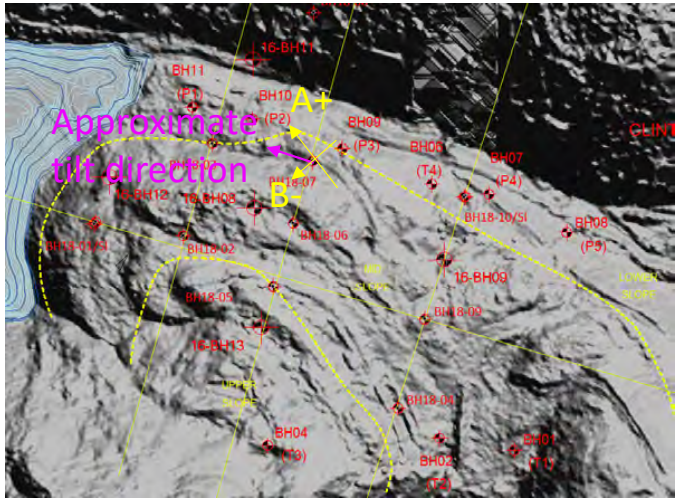
Cumulative Displacement Plots – **50 mm scale**



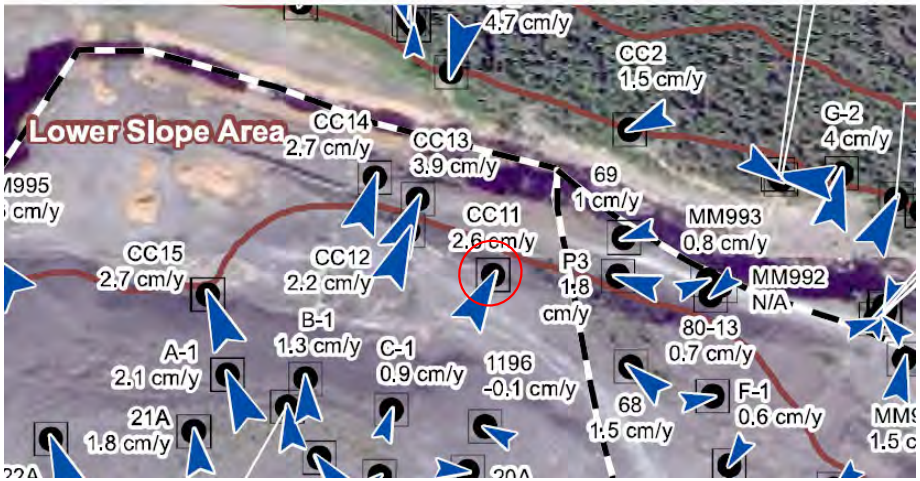


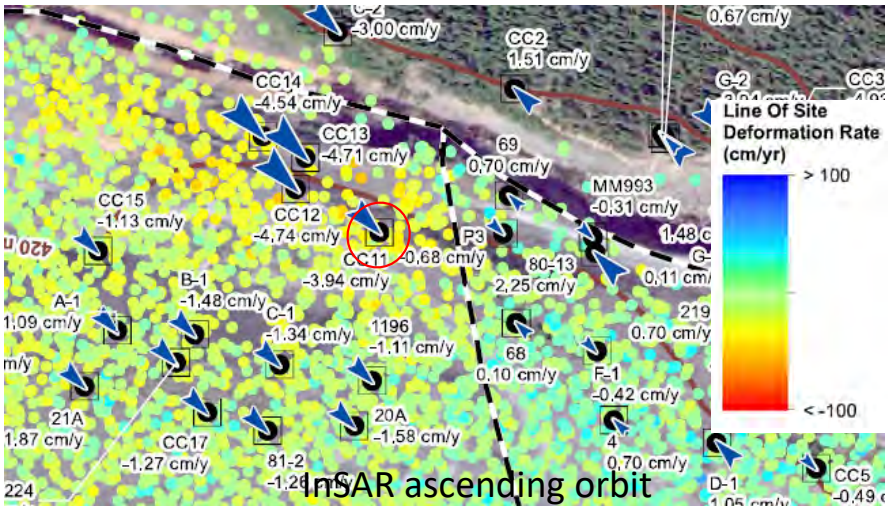
Incremental Displacement Plots – **50 mm scale**

- Overall downslope movement between 0 and 43.2 m of 76 mm with an average movement rater of 29 mm/year (excl Sept 2020), accelerating between each measurement from 24 to 37 mm/year from 2019 to July 2020.
- Downslope movement generally confined to mixed waste and waste dump materials
- Indication of settlement in the upper alluvium into the mixed waste and colluvium

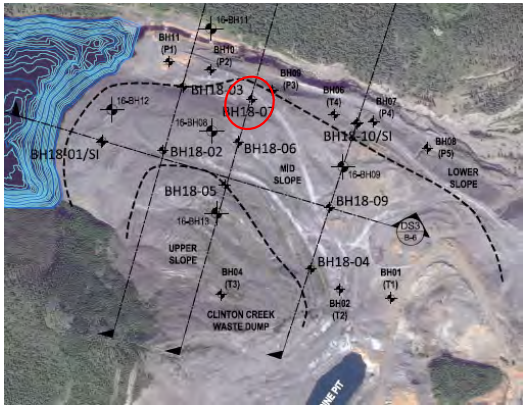


BH18-07 – Monitoring and InSAR

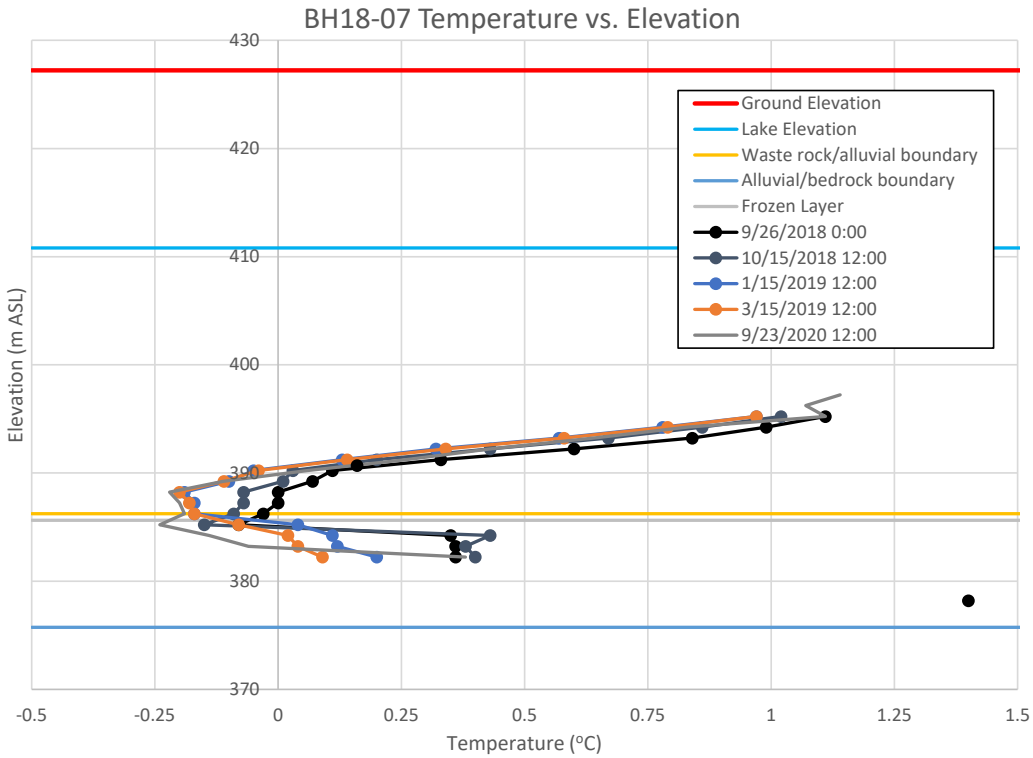




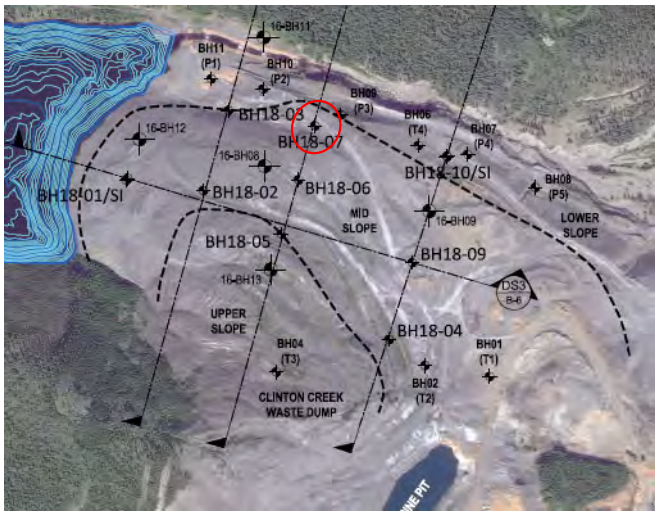
- Monitoring point CC-11 is nearest point
  - 26 mm/year lateral movement towards the spillway.
  - -39.4 and -19.1 mm/year onto LOS for ascending and descending orbits
  - Data from 2018 -2020
- InSAR suggests higher rate of settlement than monitoring station
- Generally, in agreement with SI data



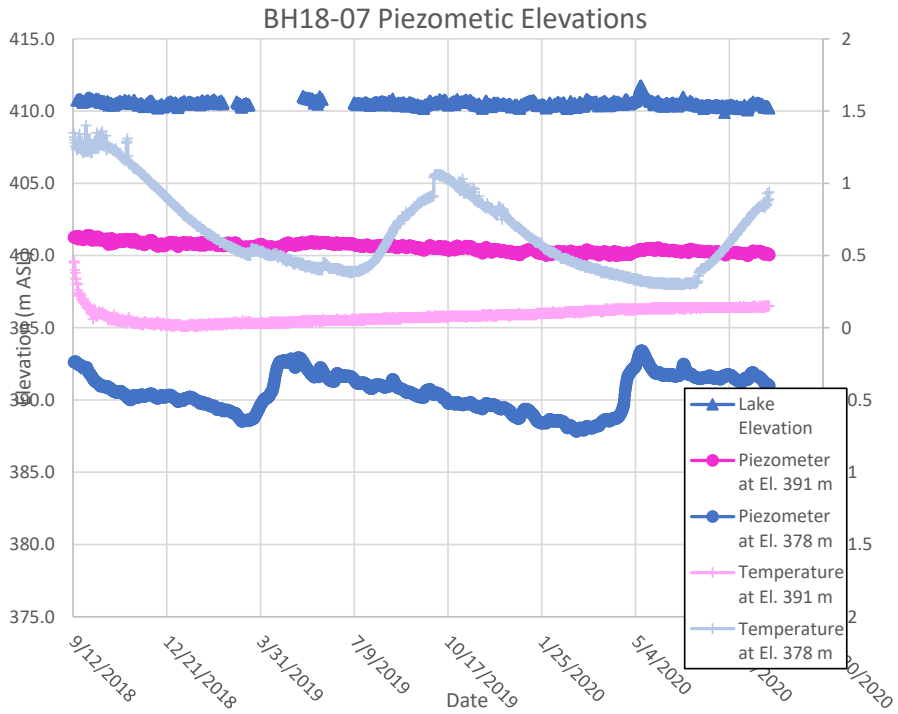
BH18-07 – Thermistor

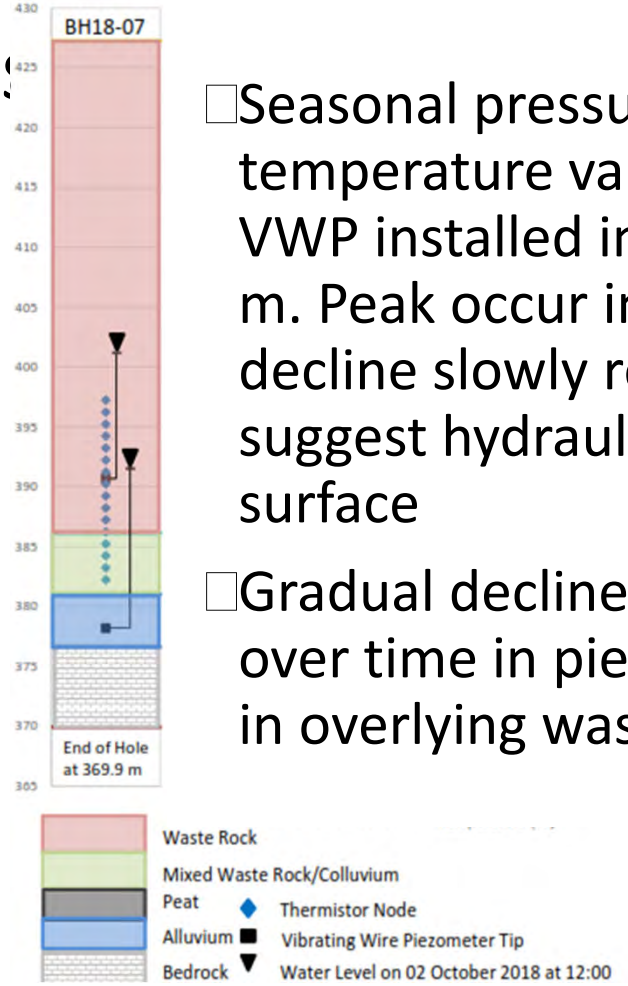


- Lower portion of waste rock is frozen
- Unusual trend of warming to above zero once down into the native alluvium – possible influence of current Clinton Creek spillway
- Cooling in the alluvium from installation through 2019, with an increase in the temperature of the bottom node in September 2020



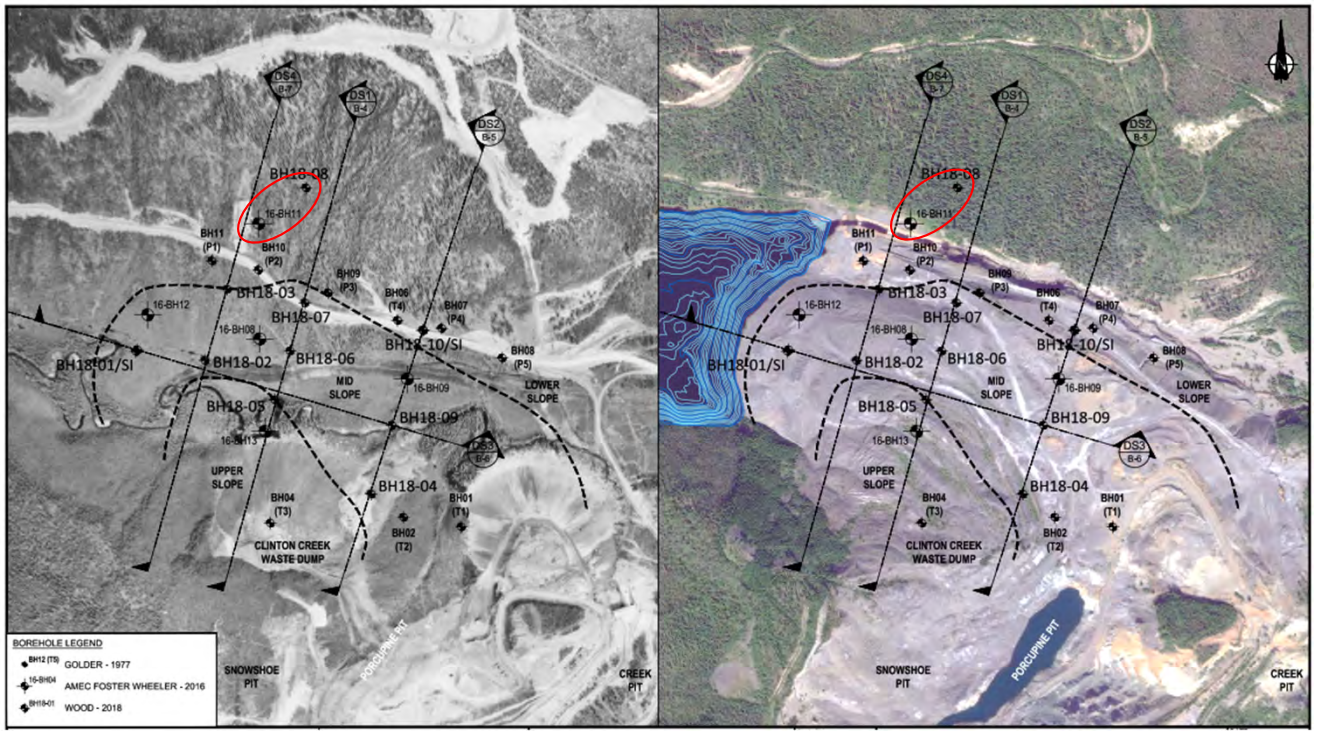
BH18-07 – Piezometers

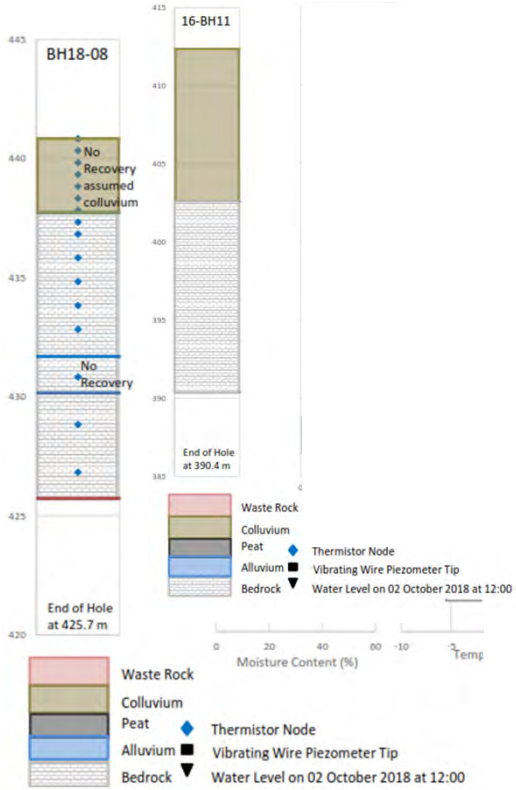




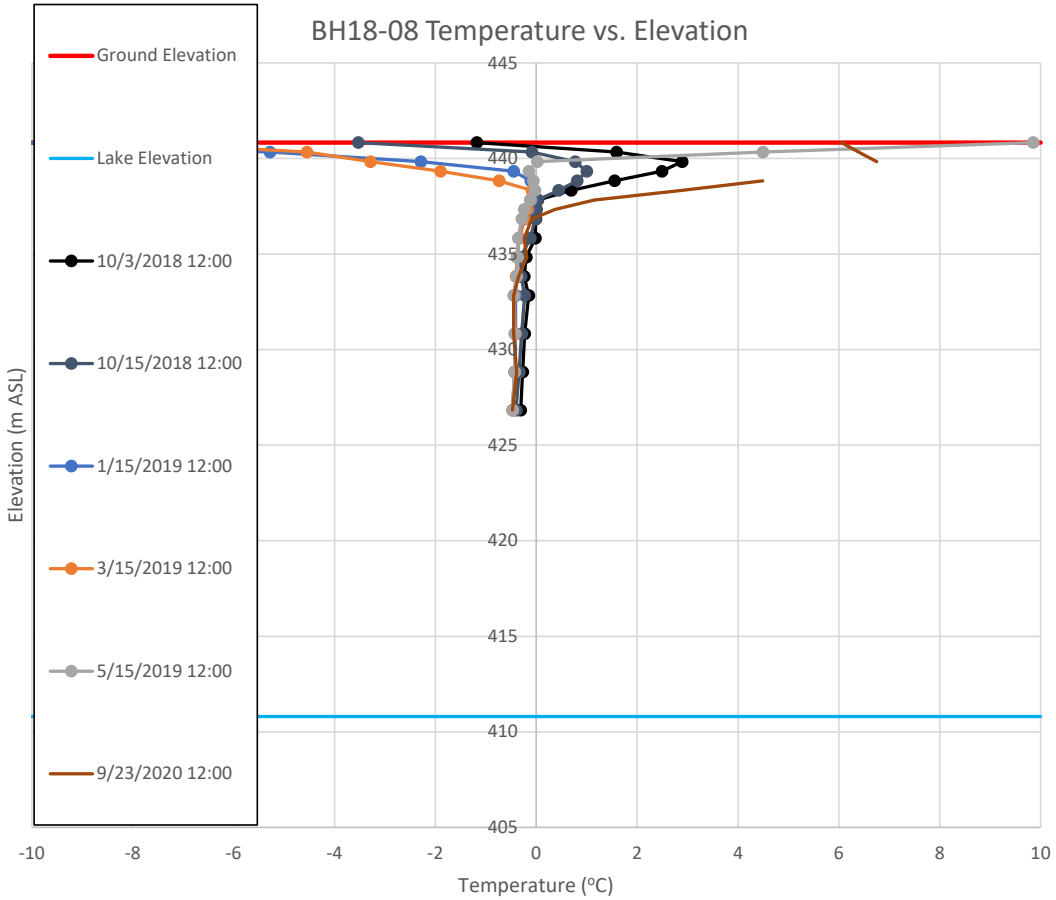
- Seasonal pressure and temperature variations in deep VWP installed in alluvium at 378 m. Peak occur in May and decline slowly rest of year – suggest hydraulic conductivity to surface
- Gradual decline in pressures over time in piezometer installed in overlying waste rock at 391 m

BH18-08 and 16-BH11

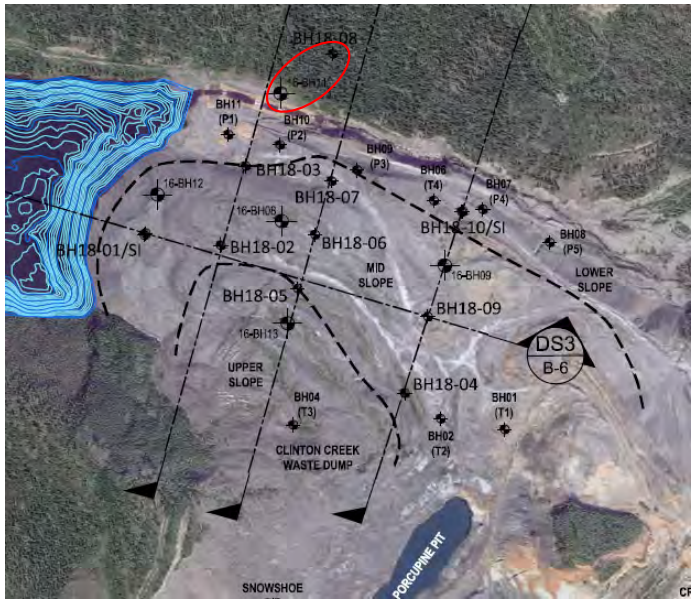




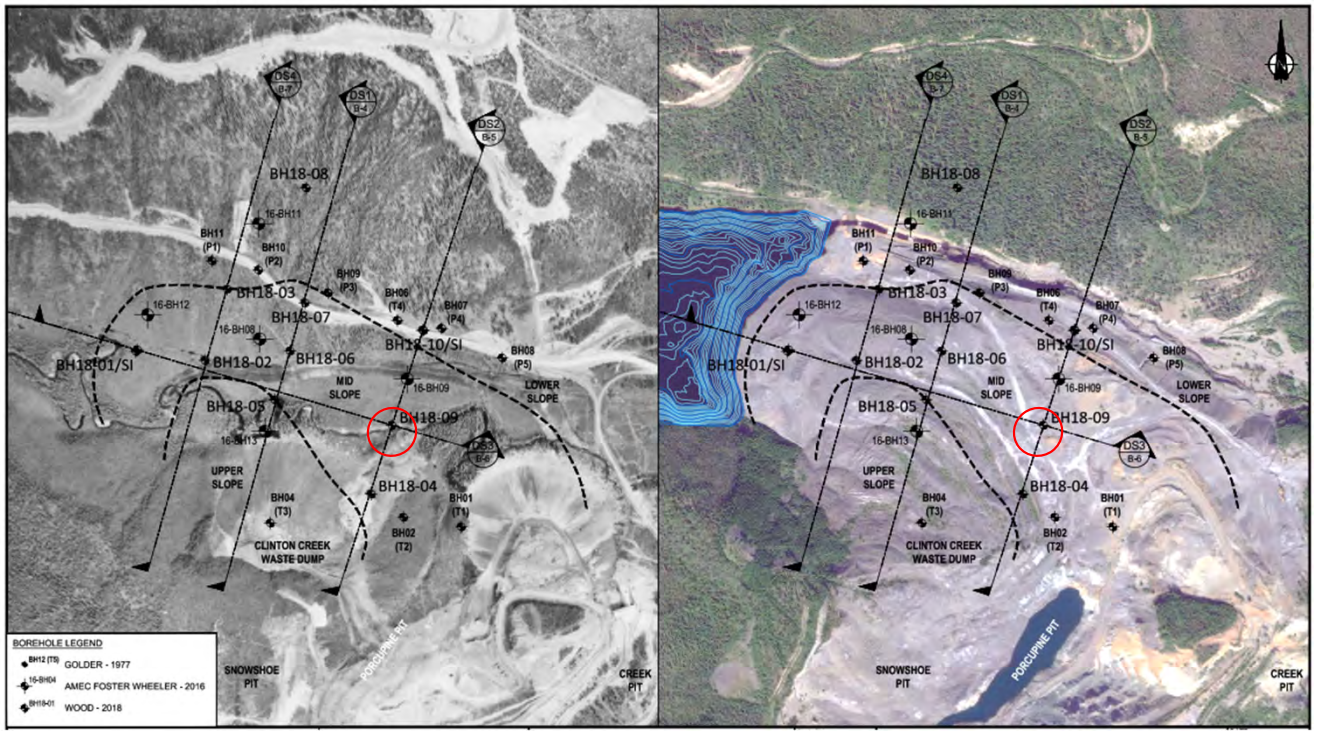
BH18-08 – Thermistors

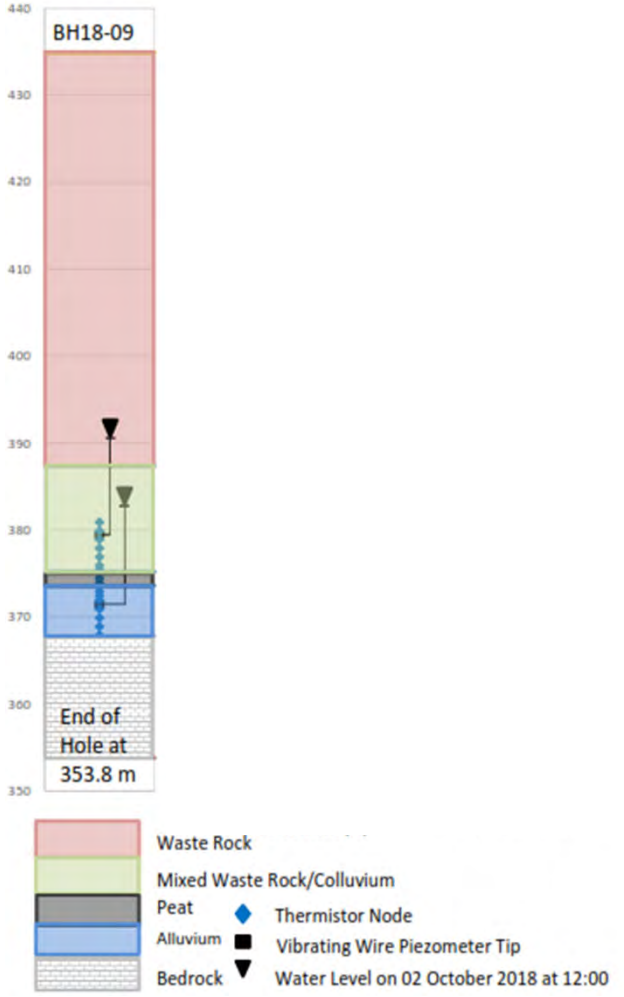


- Located on north slope in generally undisturbed area
- Seasonal variations in air temperature reflected in near surface thermistors
- Effects become subdued with depth, active zone <3m below surface



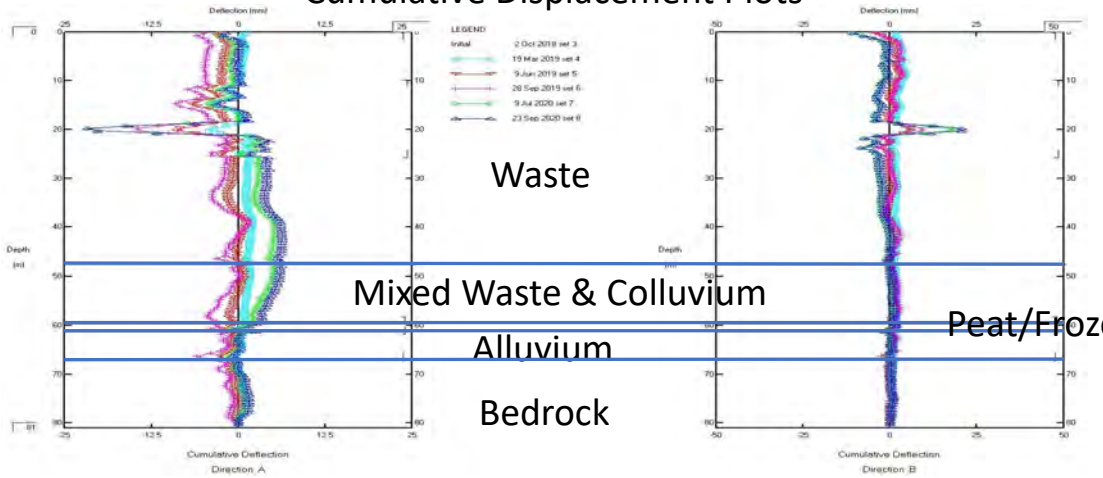
BH18-09

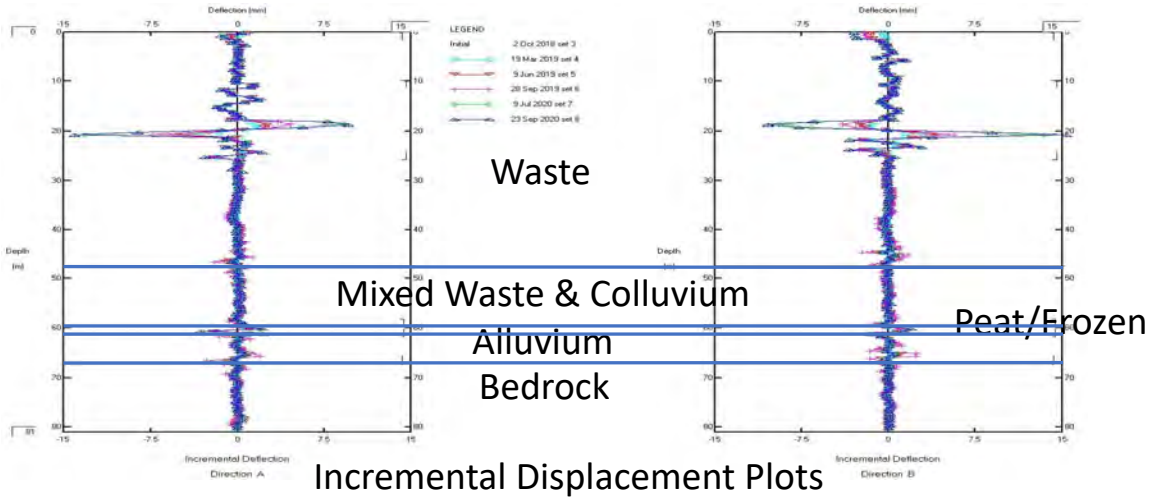

BH18-08
BH18-03
BH18-07
BH18-10/SI
BH18-01/SI
BH18-02
BH18-06
BH18-05
BH18-09
BH18-04
MID SLOPE
LOWER SLOPE
UPPER SLOPE
CLINTON CREEK WASTE DUMP
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018


BH18-09
440
430
420
410
400
390
380
370
360
350
End of Hole at 353.8 m
Waste Rock
Mixed Waste Rock/Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

BH18-09

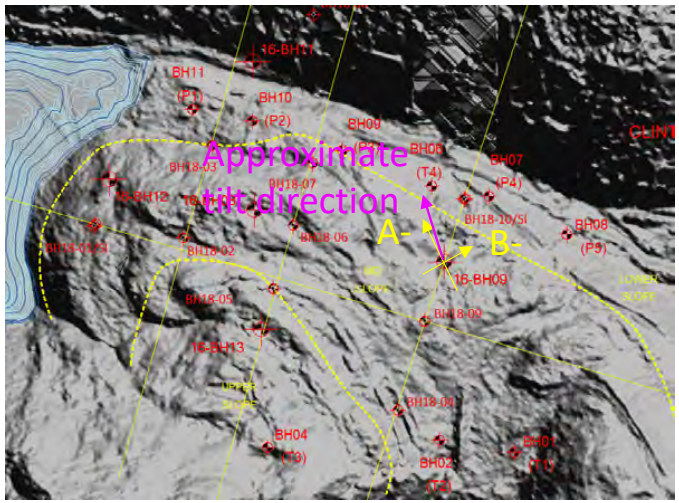
Cumulative Displacement Plots



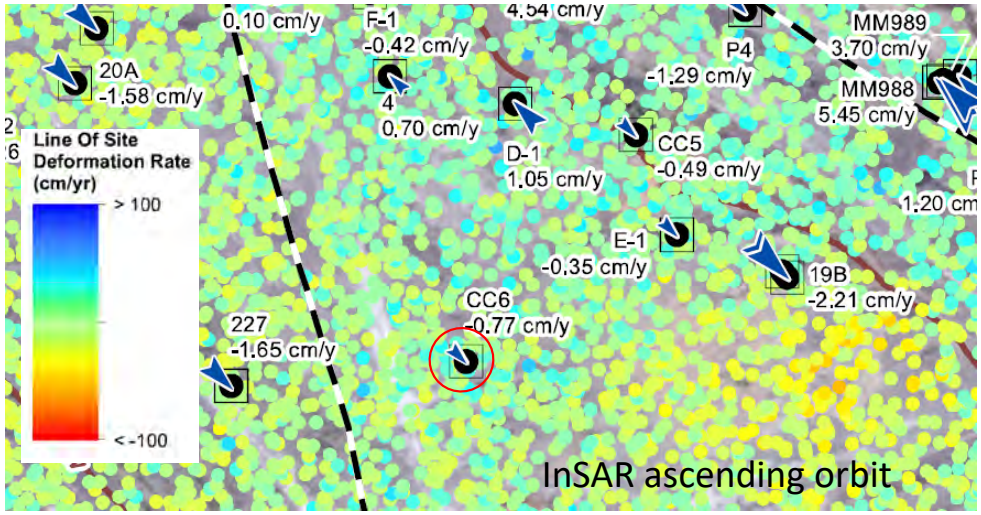


Incremental Displacement Plots

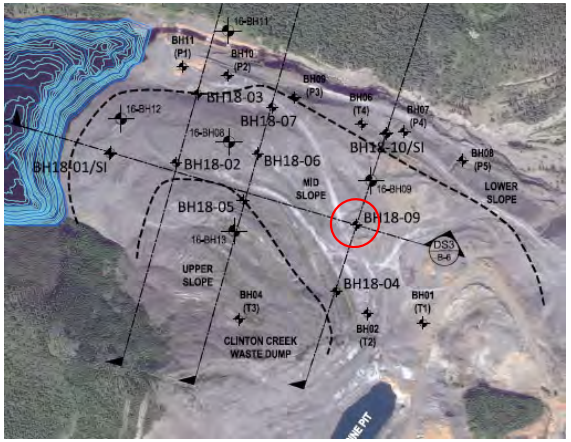
- Appears that there are several potential areas of settlement:
  - Alluvium
  - Frozen peat layer
  - Above the mixed waste/colluvium boundary with the waste
  - Possible settlement zone around 20 m depth



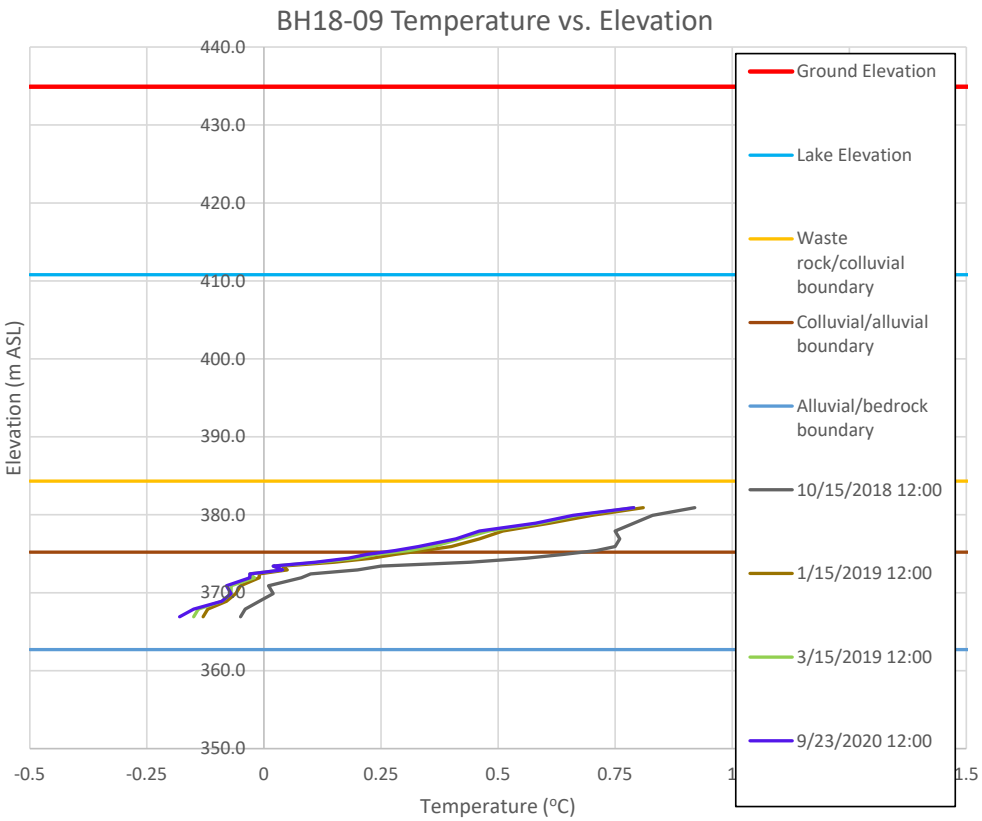
BH18-09 – Monitoring and InSAR



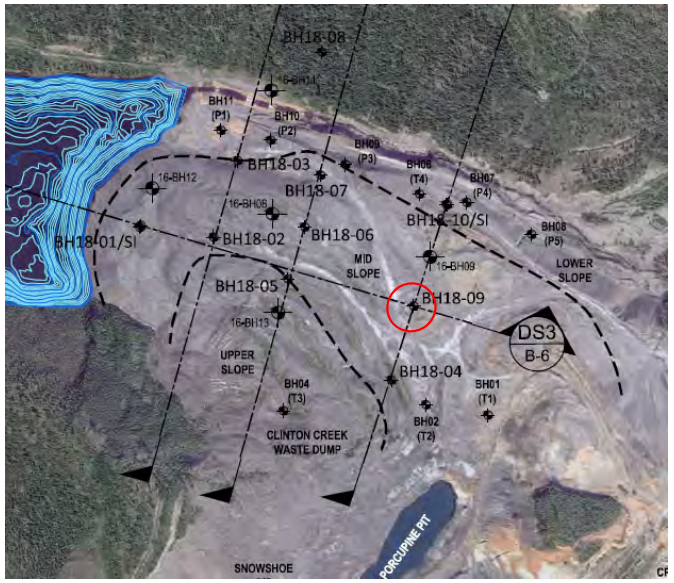
- Monitoring point CC6 is nearest point
  - 11 mm/year lateral movement in the same direction as SI
  - -7.7 and -9.4 mm/year onto LOS for ascending and descending orbits
  - Data from 2018 -2020
- InSAR possibly shows minor uplift however movement away from the satellite indicates settlement



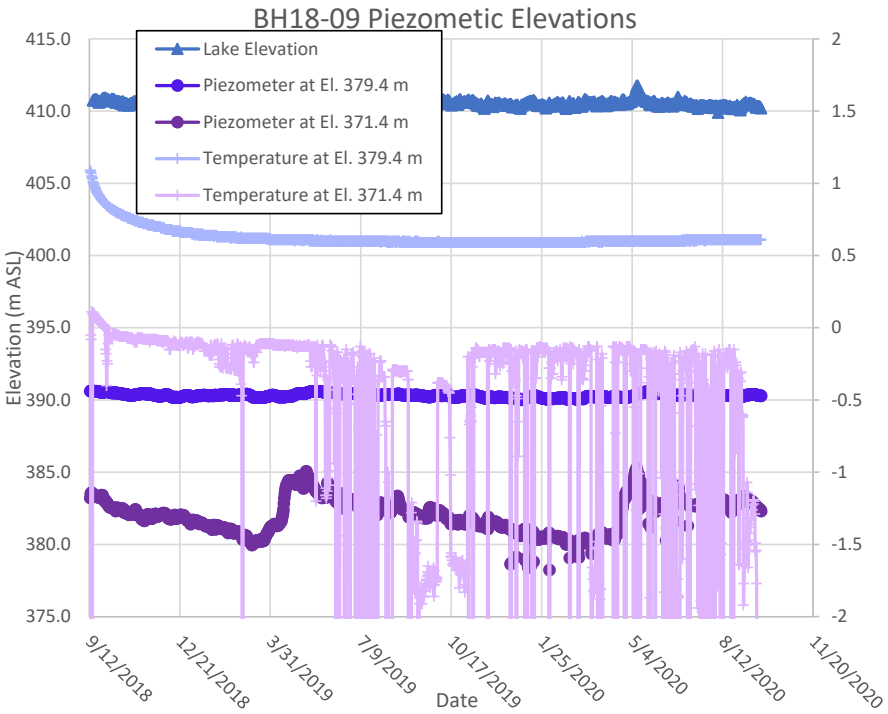
BH18-09 – Thermistors



- Native alluvium is partially frozen (previously reported)
- Temperature profiles have remained relatively consistent after equilibrating following initial installation

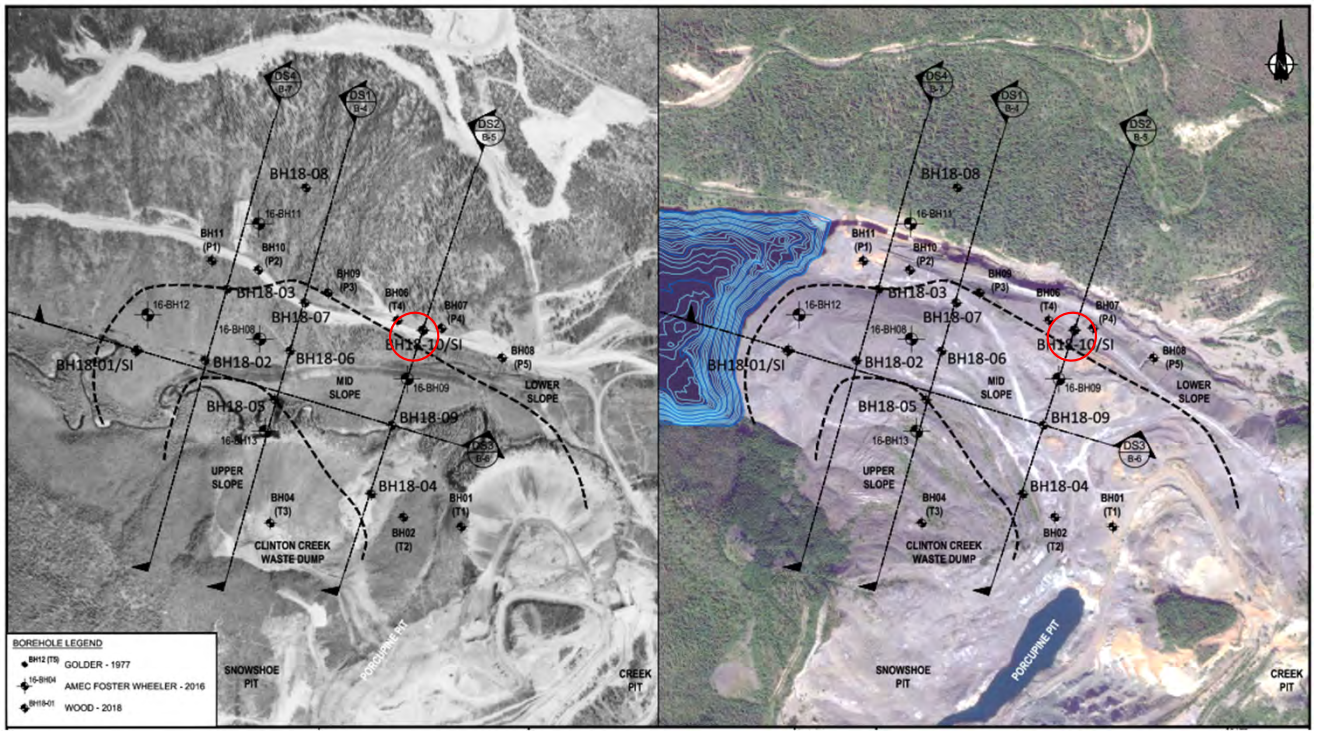


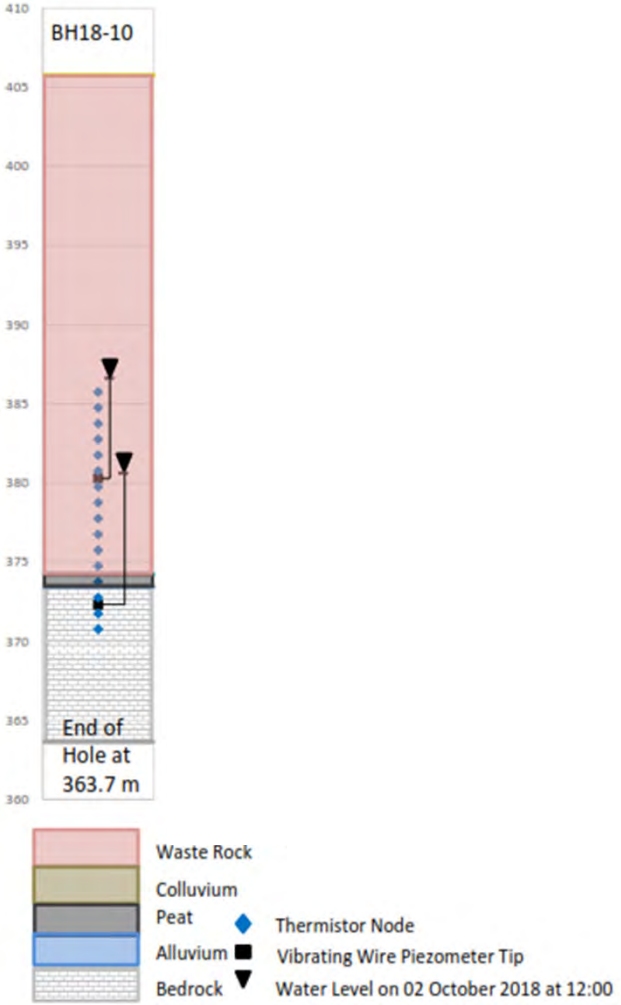
BH18-09 – Piezometers



- Seasonal fluctuations in pressure heads measured in piezo at 371.4 m; tip is installed in the alluvium of the pre-construction Clinton Creek channel. Temperature all below 0°C – possible malfunction of thermistor.
- Piezo at 379.4 m (installed in mixed waste/colluvium) has pressure heads around 380 m - not much water? Alluvium partially saturated?

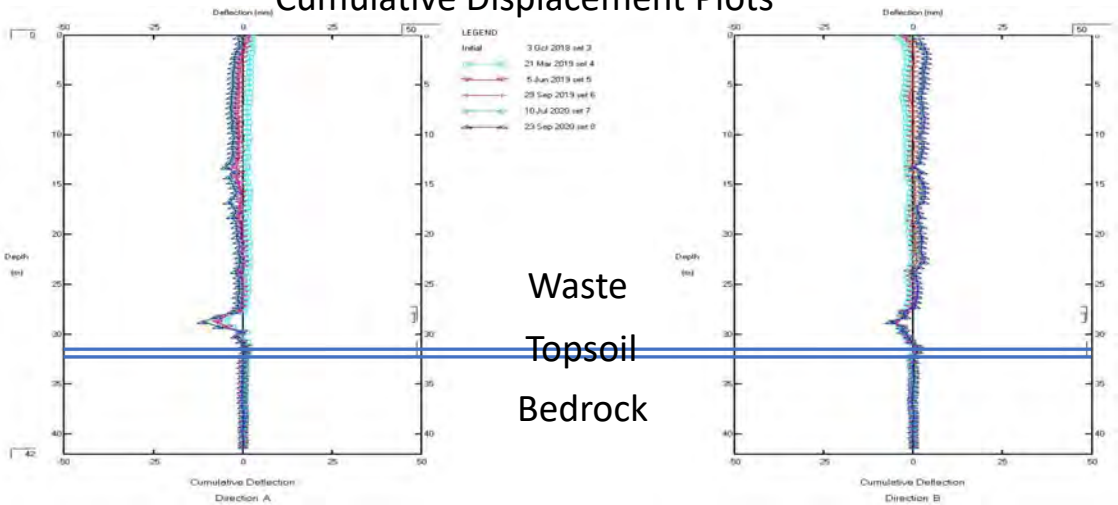
BH18-10/SI

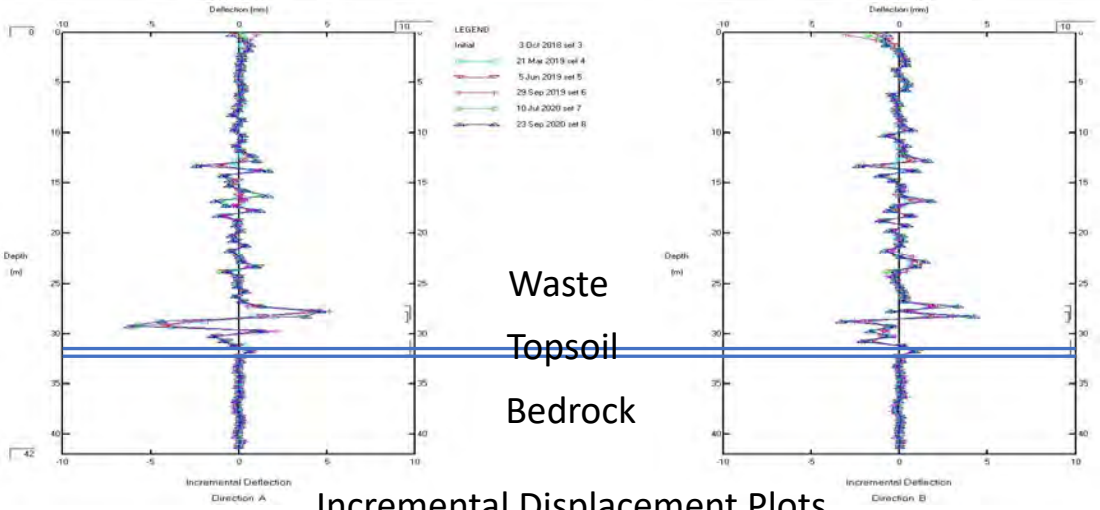

BH18-08
BH18-03
BH18-07
BH18-10/SI
BH18-01/SI
BH18-02
BH18-06
BH18-05
BH18-09
BH18-04
MID SLOPE
LOWER SLOPE
UPPER SLOPE
CLINTON CREEK WASTE DUMP
SNOWSHOE PIT
PORCUPINE PIT
CREEK PIT
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018


BH18-10
410
405
400
395
390
385
380
375
370
365
360
End of Hole at 363.7 m
Waste Rock
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

SI18-10

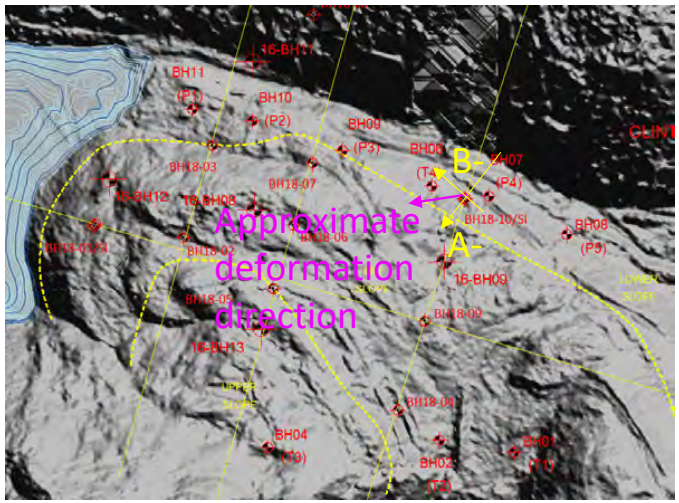
Cumulative Displacement Plots



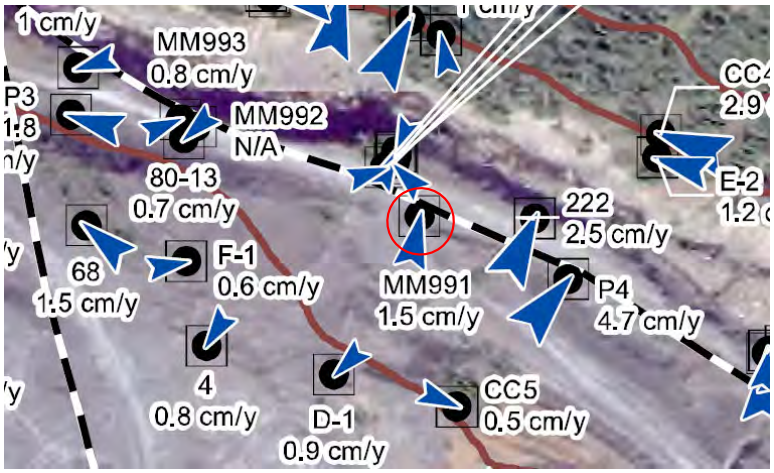


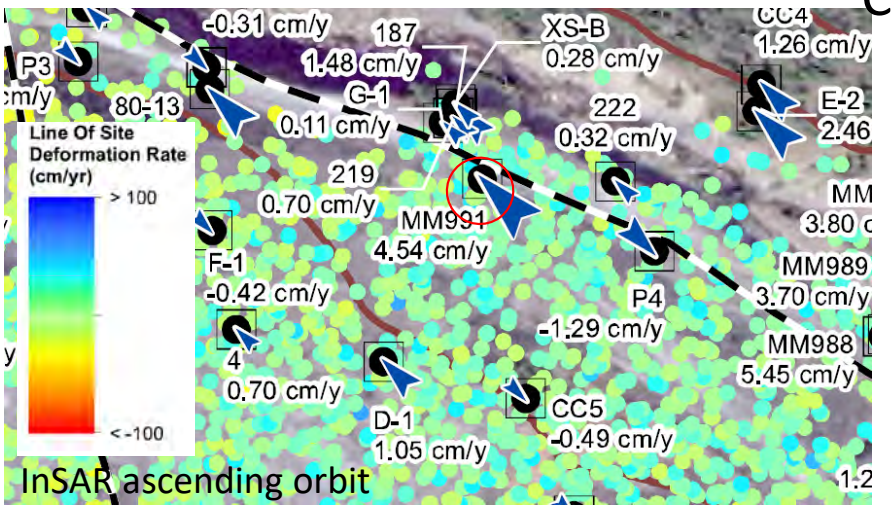
Incremental Displacement Plots

- Settlement through the waste dump materials
  - Largest magnitude between 27 and 32 m depth
  - Minor settlement through the waste above, through the whole waste dump

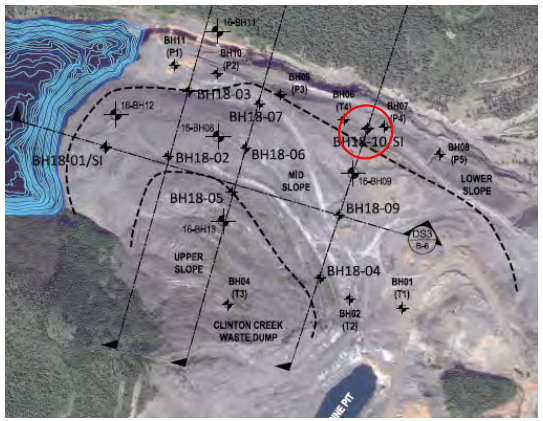


BH18-10/SI – Monitoring and InSAR

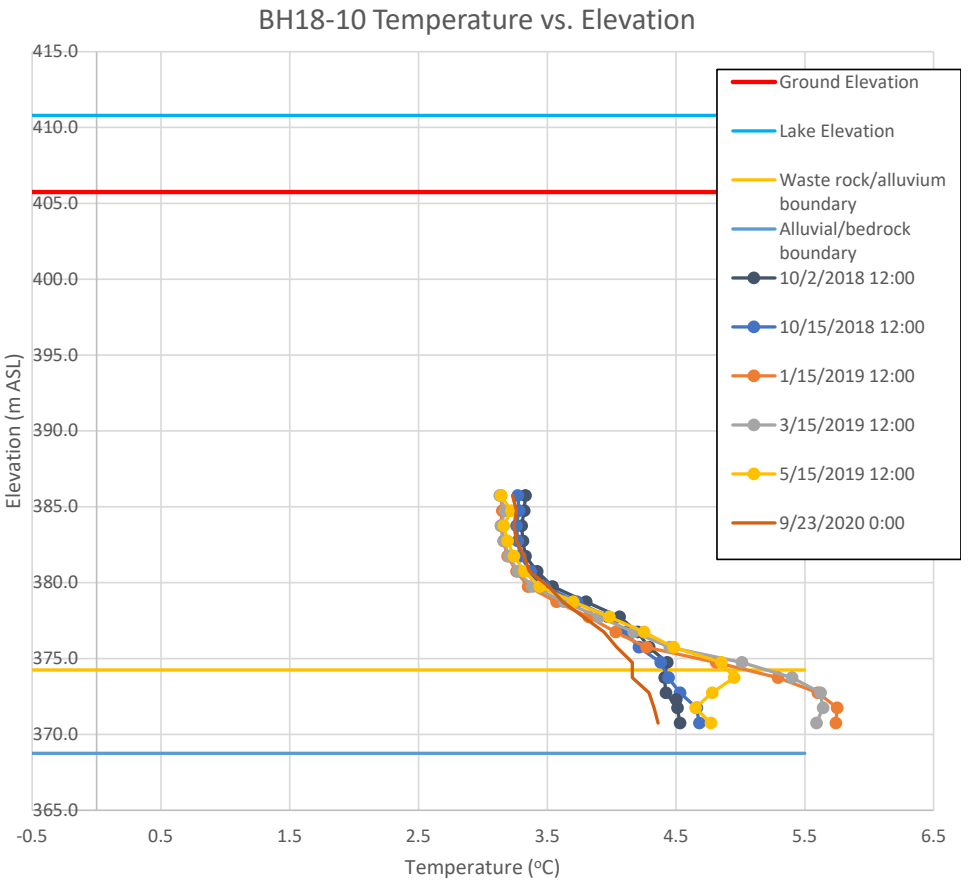




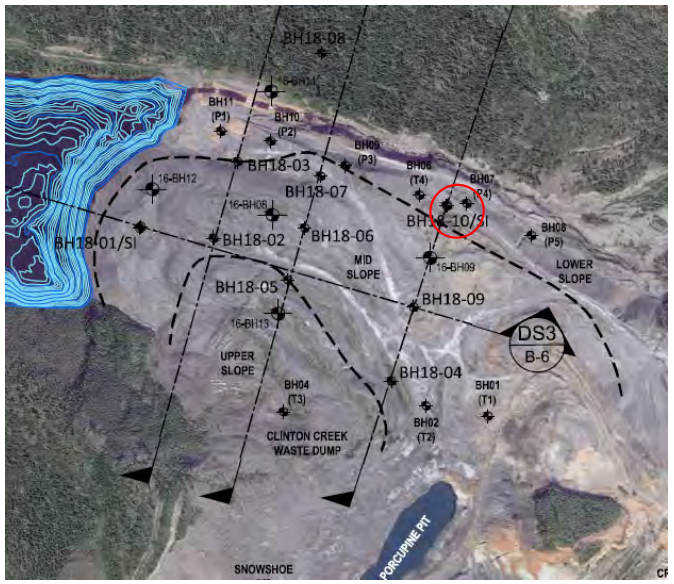
- Monitoring station MM991 is nearest point
  - 15 mm/year lateral movement toward the Clinton Creek channel
  - +45.4 and +47.9 mm/year onto LOS for ascending and descending orbits indicating uplift
  - Data from 2018 -2020
- InSAR shows minor uplift – possible uplift closer to the toe of the pile with movement toward Clinton Creek



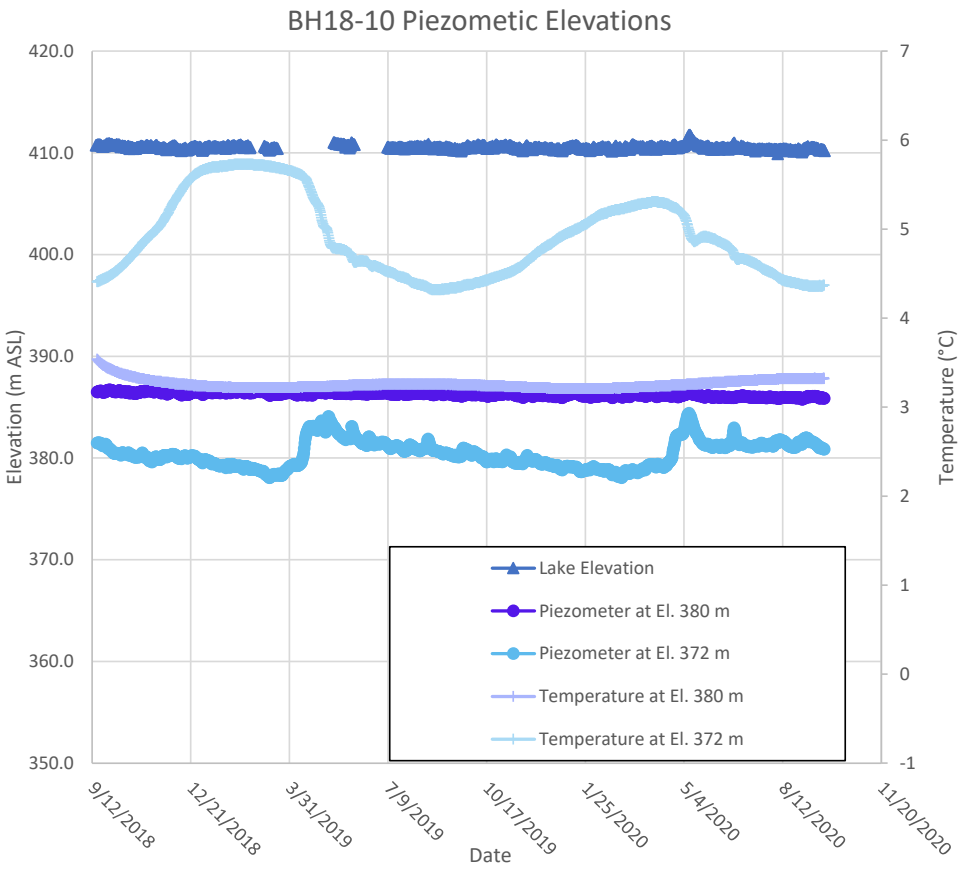
BH18-10 – Thermistor

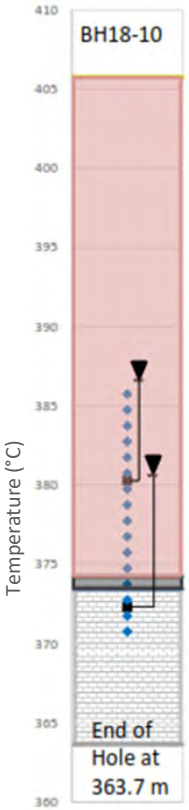


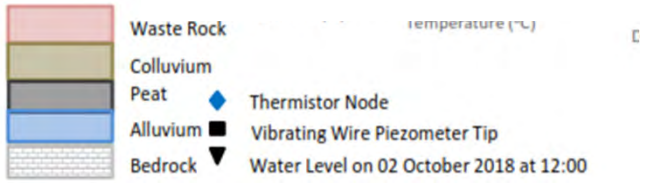
- Soils above zero degrees – previously reported
- Unusual trend of warming with depth
- Native alluvium is well above zero, possibly due to thermal influence from lake/spillway
- Cooling trend in deeper sediments over time based on thermistor plots



BH18-10 – Piezometer

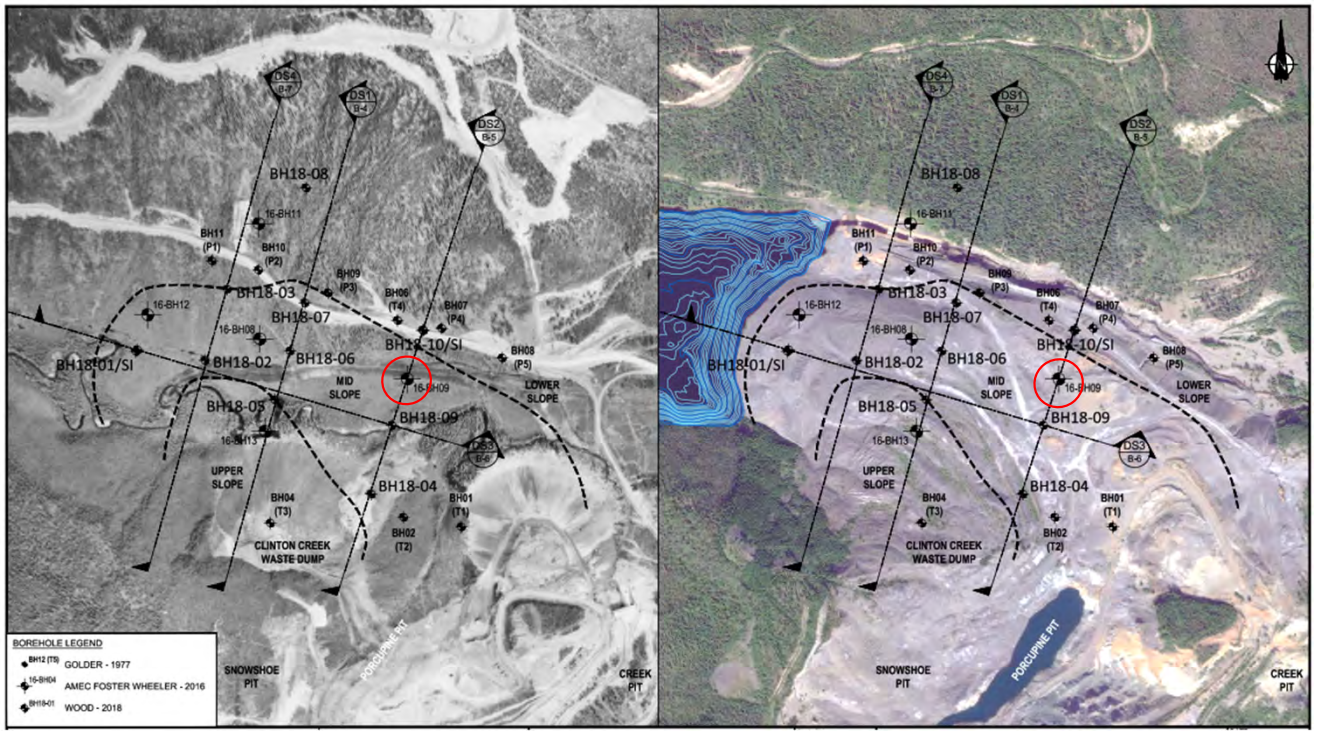


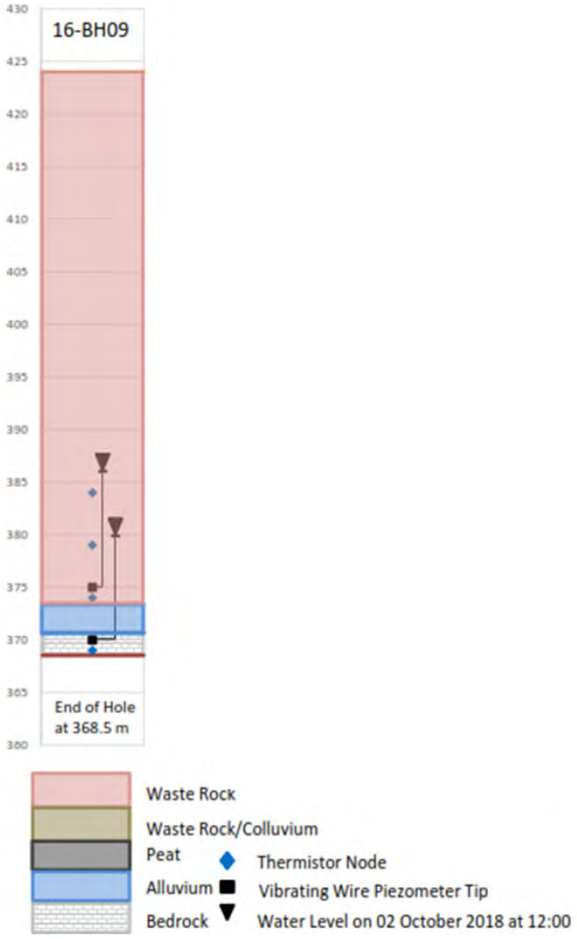




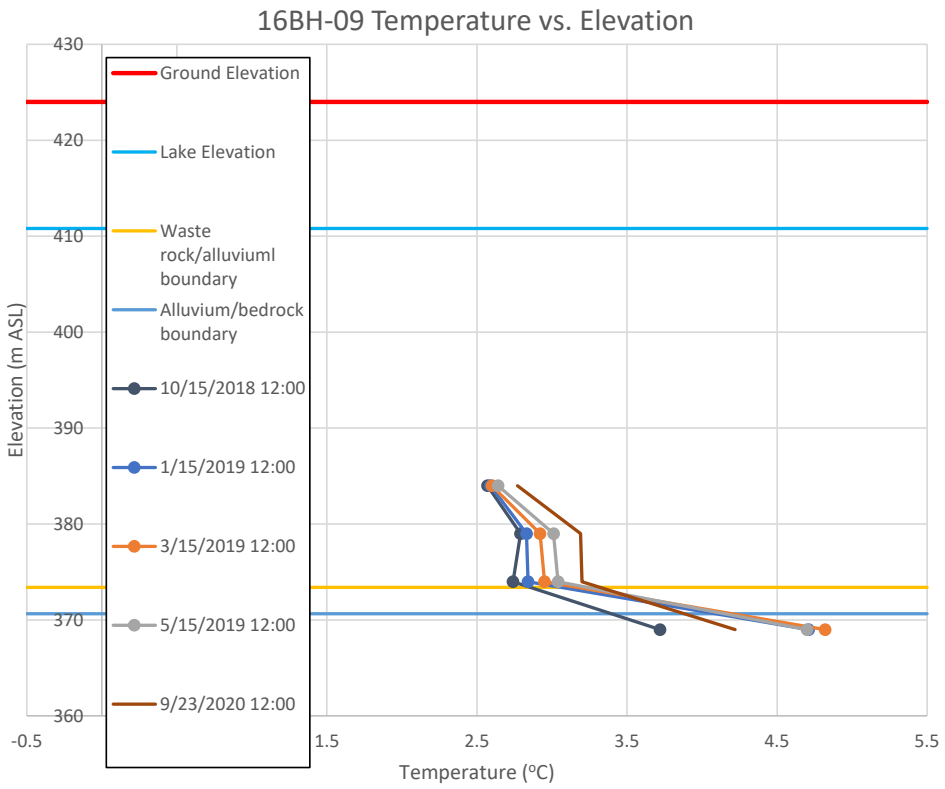
- **Seasonal fluctuations in pressure heads measured in piezo 372 m (installed in bedrock)** with peaks around 385 m during the spring followed by gradual decrease – hydraulically connected to the surface. Appears to have thermal impacts from spillway?
- Piezo at 380 m (installed in mine waste) has consistent pressure heads around 387 m suggest low hydraulic conductivity of mine waste relative to bedrock

16-BH09

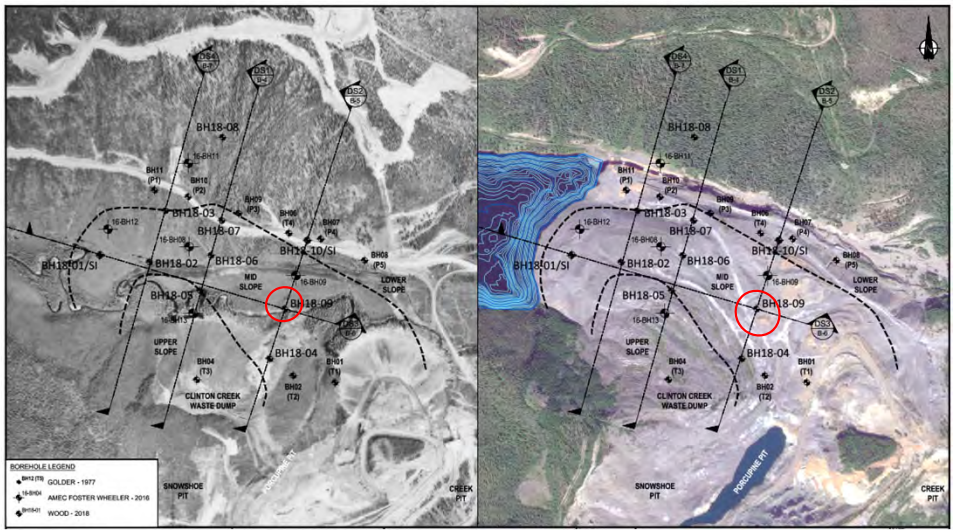

DS4
B-7
DS1
B-4
DS2
B-5
BH18-08
16-BH11
BH11
(P1)
BH10
(P2)
BH09
(P3)
BH18-03
16-BH12
BH18-07
BH06
(T4)
BH07
(P4)
16-BH08
BH18-10/SI
BH08
(P5)
BH18-01/SI
BH18-02
BH18-06
MID
SLOPE
16-BH09
LOWER
SLOPE
BH18-05
BH18-09
16-BH13
DS3
B-6
UPPER
SLOPE
BH18-04
BH04
(T3)
BH01
(T1)
BH02
(T2)
CLINTON CREEK
WASTE DUMP
SNOWSHOE
PIT
PORCUPINE PIT
CREEK
PIT
BOREHOLE LEGEND
BH12 (T5) GOLDER - 1977
16-BH04 AMEC FOSTER WHEELER - 2016
BH18-01 WOOD - 2018


16-BH09
430
425
420
415
410
405
400
395
390
385
380
375
370
365
360
End of Hole
at 368.5 m
Waste Rock
Waste Rock/Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 02 October 2018 at 12:00

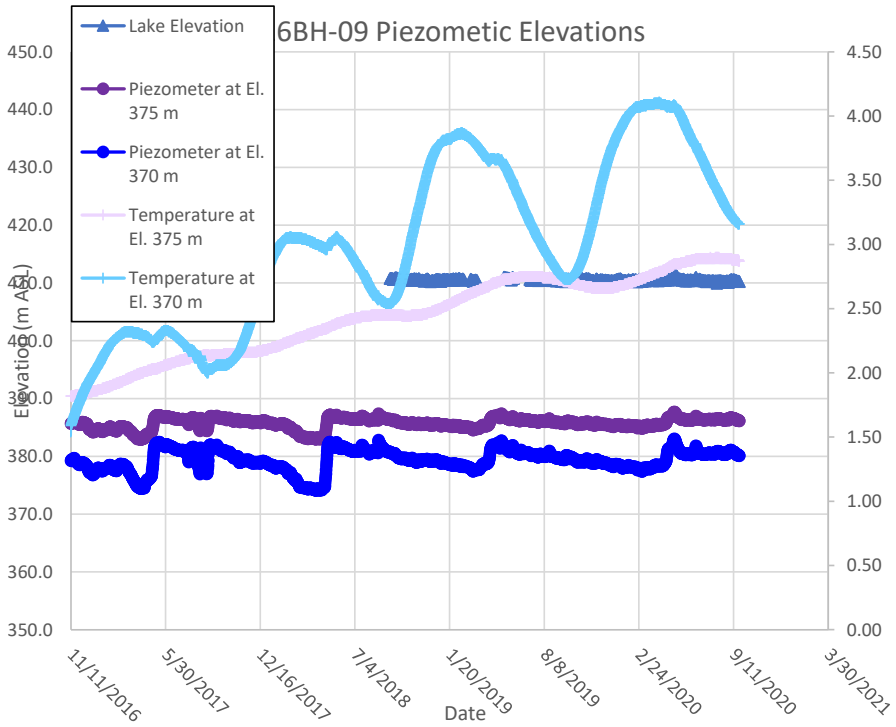
16-BH09 – Thermistors

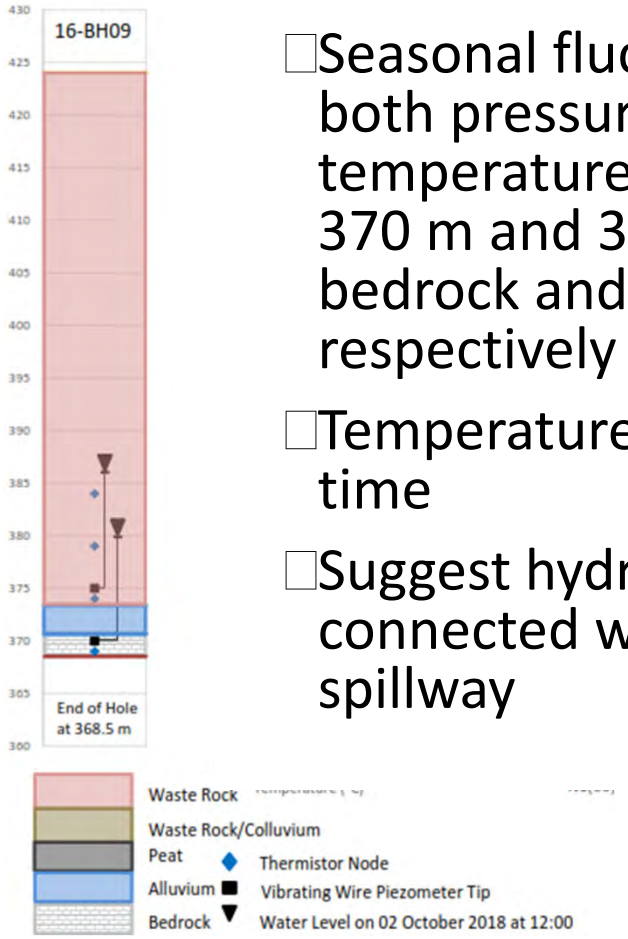


- Thermistors in lower waste rock and underlying alluvium
- All greater zero degrees
- Warming trend with depth and with time



16-BH09 – Piezometers

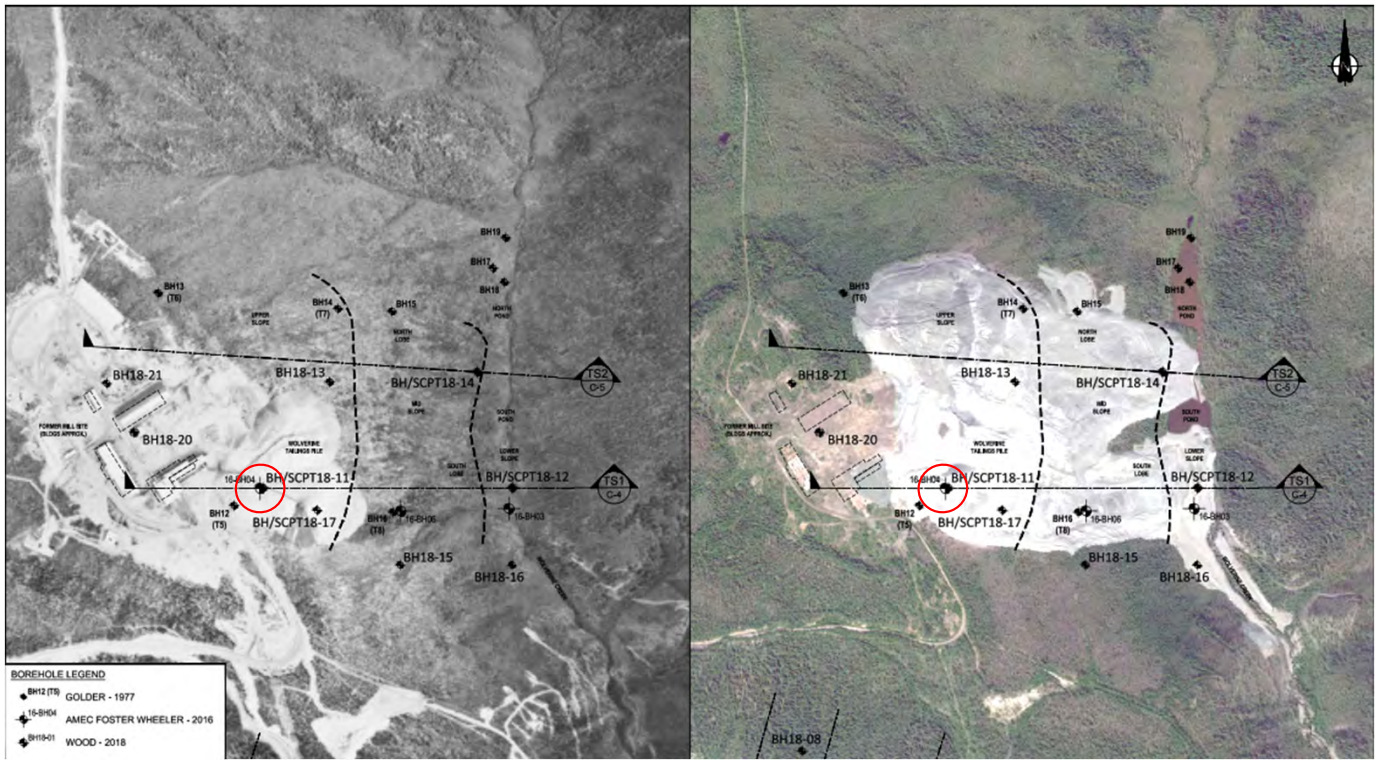


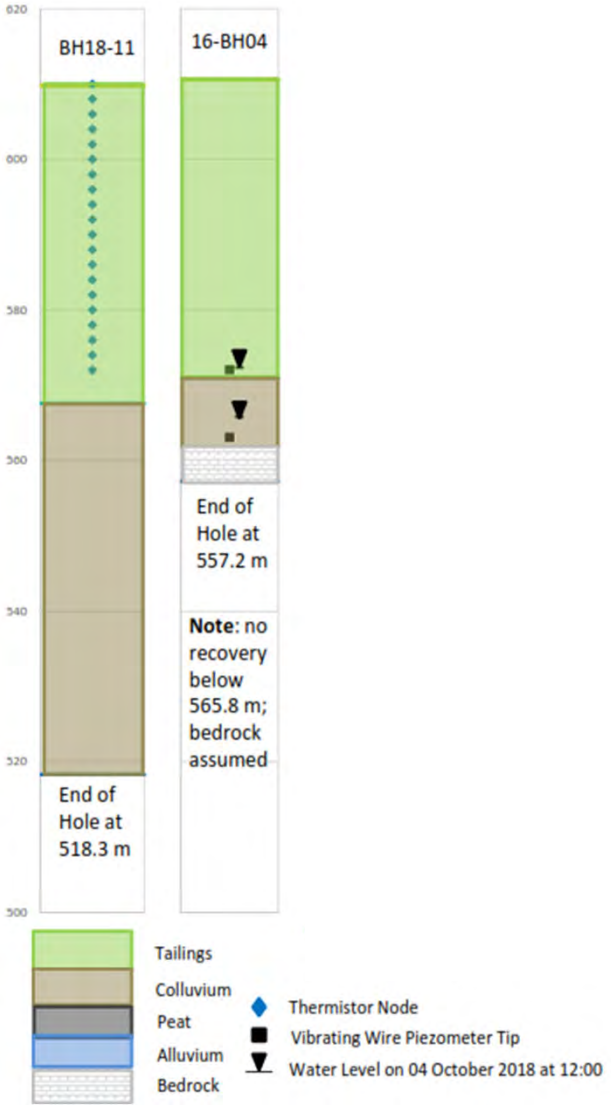


- Seasonal fluctuations in both pressure and temperatures for VWP at 370 m and 375 m in bedrock and waste rock respectively
- Temperature is rising with time
- Suggest hydraulically connected with lake / spillway

Wolverine Creek Tailings

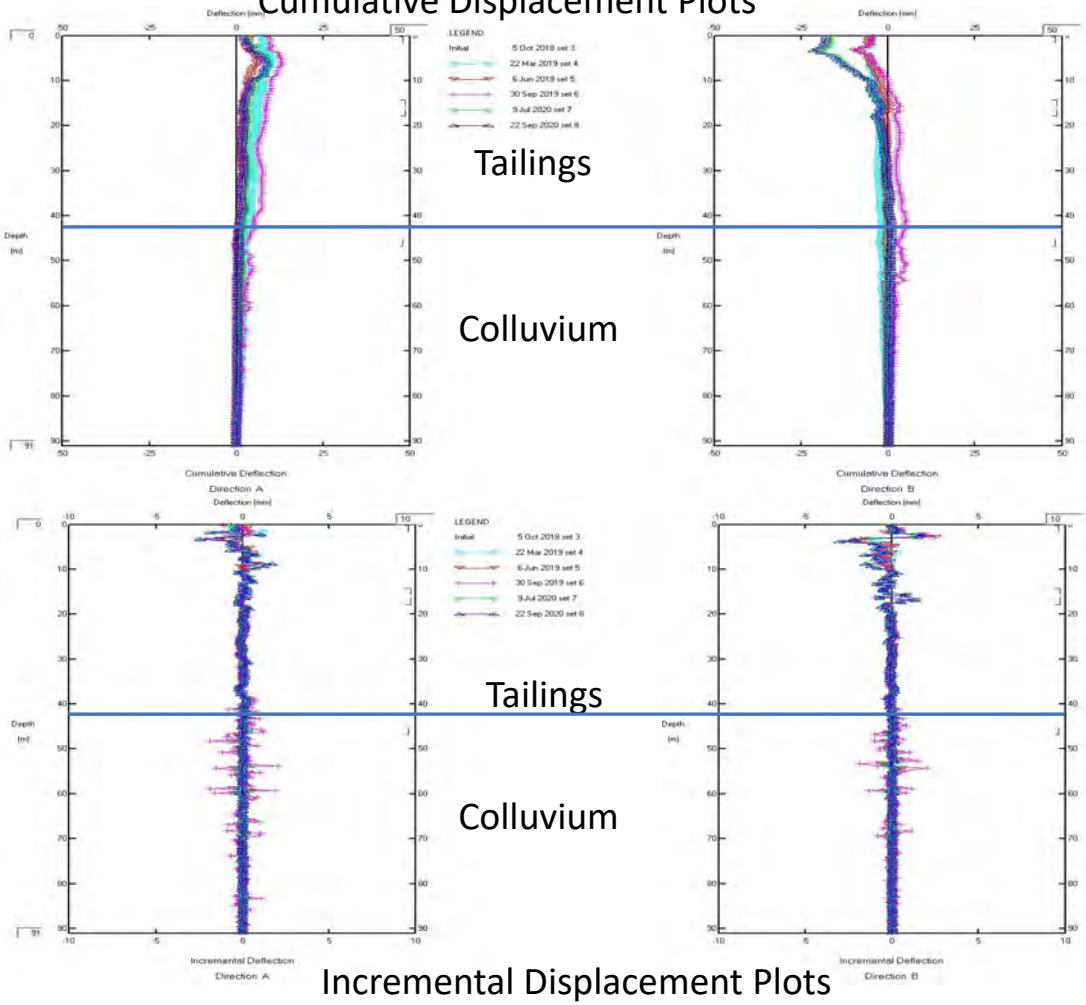
BH18-11 / 16BH-04





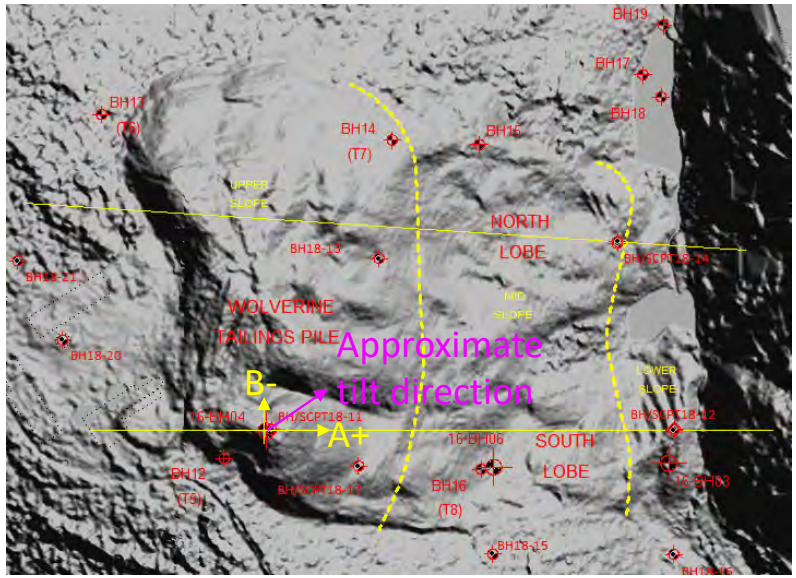
BH18-11 / 16BH-04 – SI

Cumulative Displacement Plots

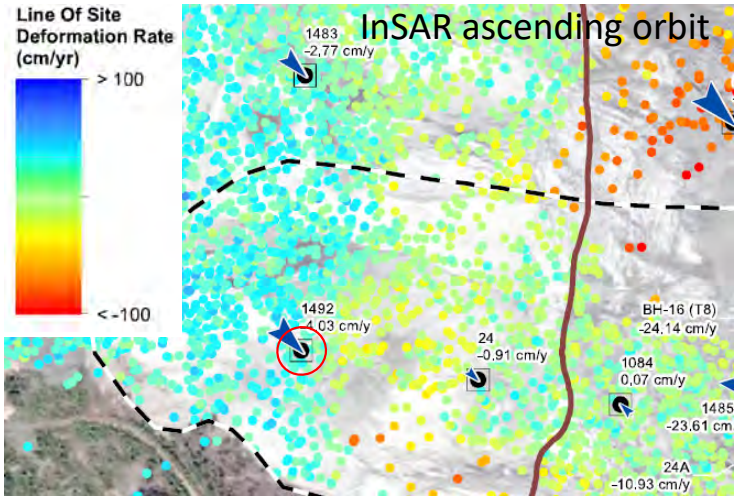


Incremental Displacement Plots

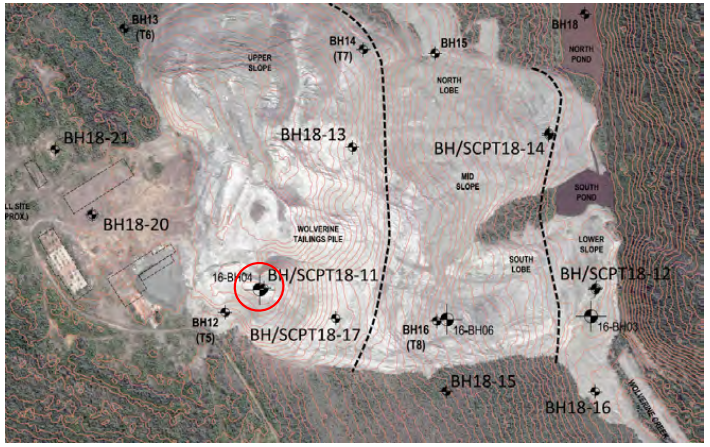
- Indication of tilt between surface and 46.8 m depth with 18.9 mm cumulative movement at average movement rate of 10.5 mm/year
- Previous reporting noted downslope creep in tailings
- Enhanced recent creep in upper ~10 m



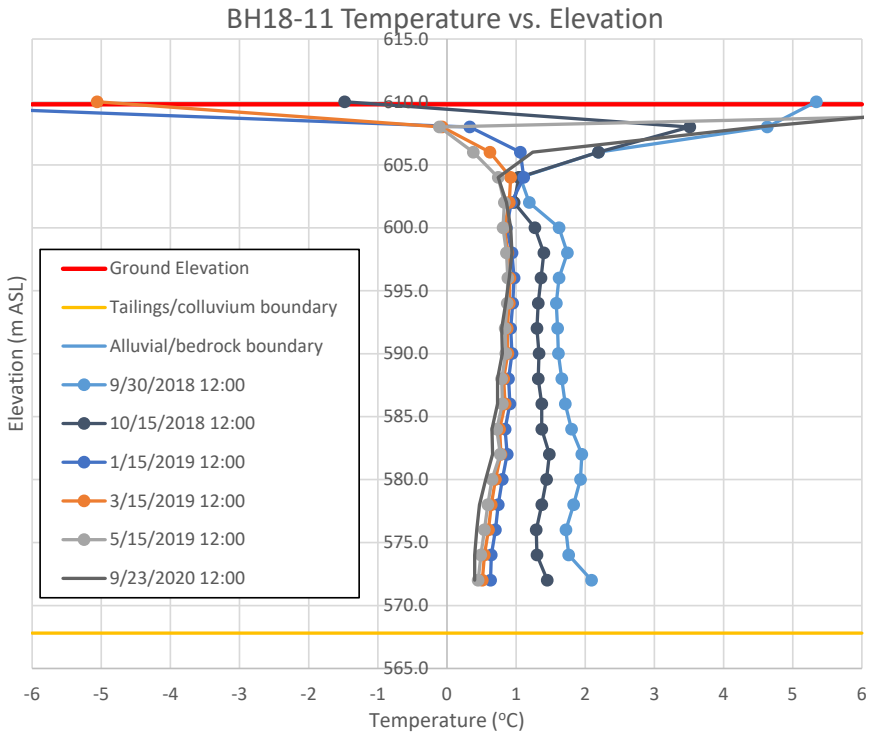
BH18-11 / 16BH-04 – Monitoring and InSAR



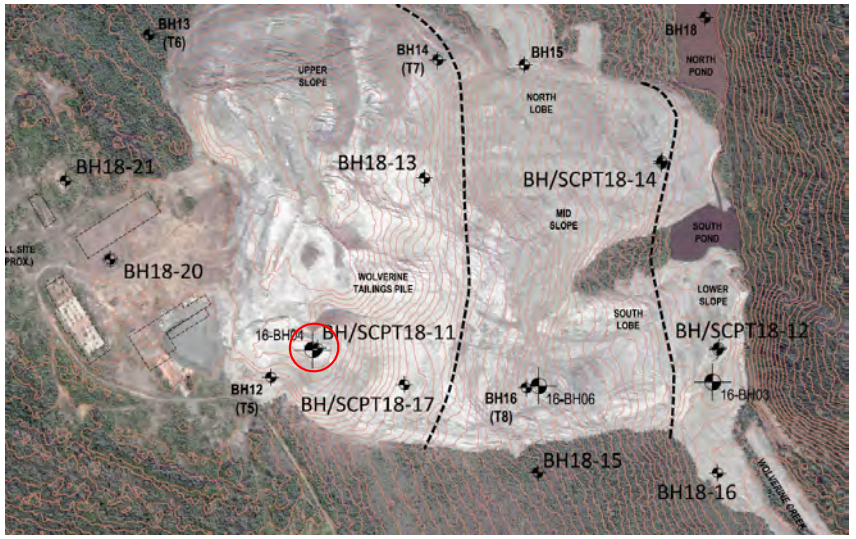
- Monitoring station 1492 is nearest point
  - 44 mm/year lateral movement
  - -40.3 and +23.4 mm/year for onto LOS for ascending and descending orbits (lateral movements)
  - Data from 2018 -2020
- InSAR shows some uplift at the location, but settlement/decrease in elevation just downslope of instrument location



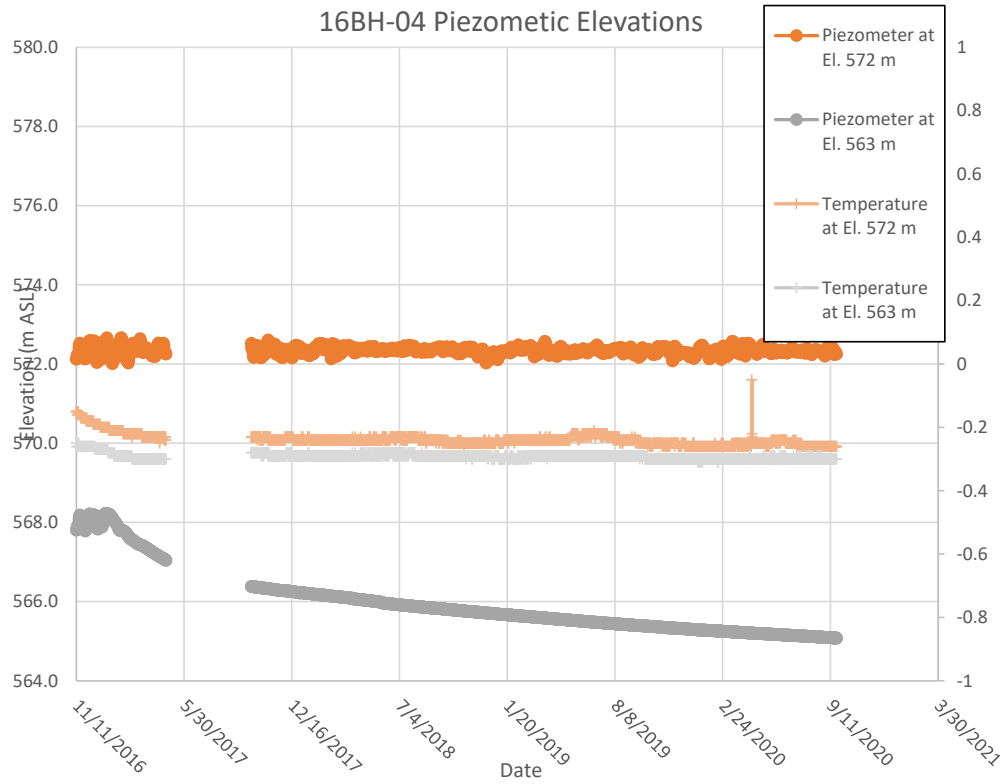
BH18-11 / 16BH-04 – Thermistor

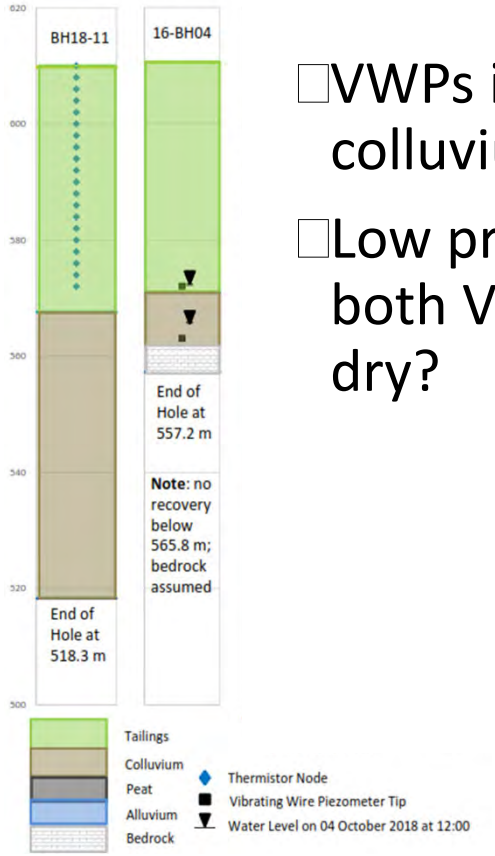


- Active zone in upper ~6 m
- Tailings are un-frozen
- Thermistors appeared to take several months to equilibrate but have remained fairly stable following equilibration period



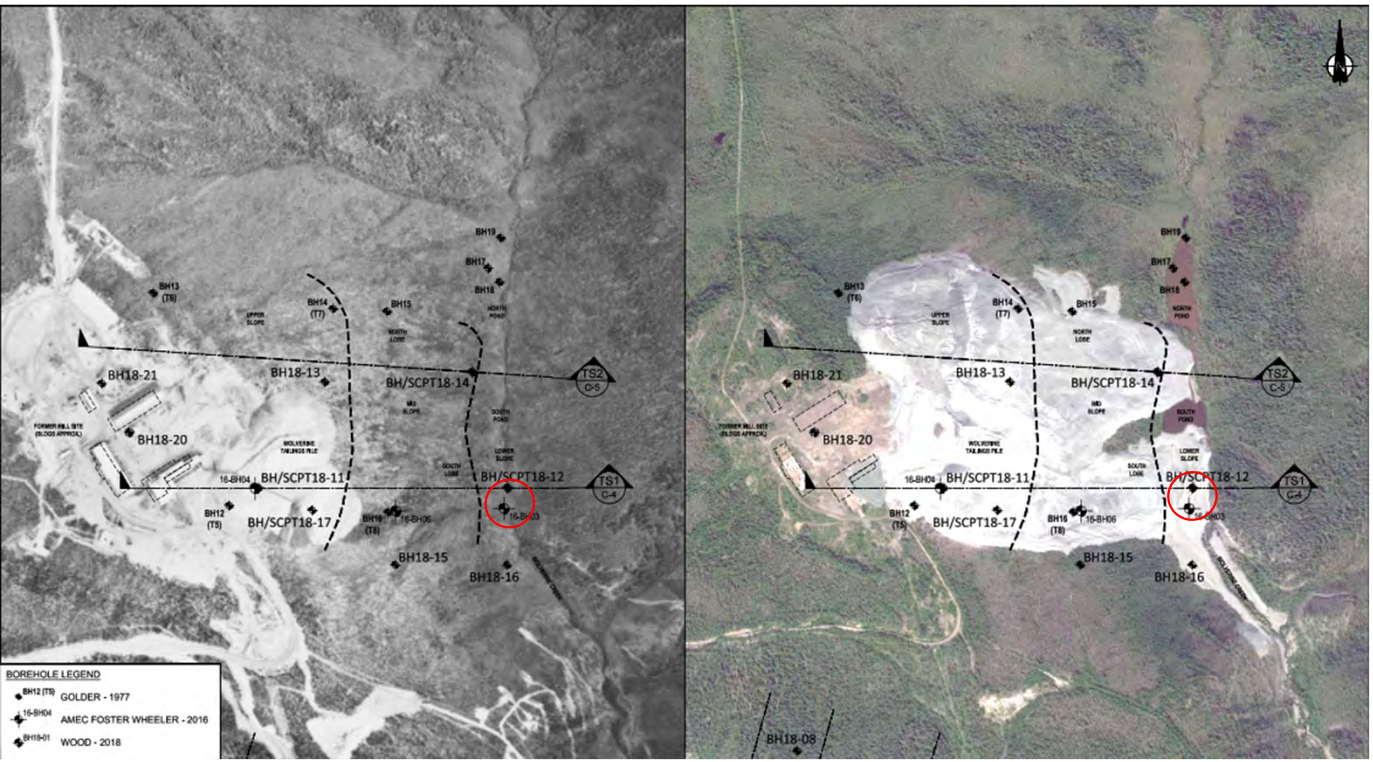
BH18-11 / 16BH-04 – Piezometers

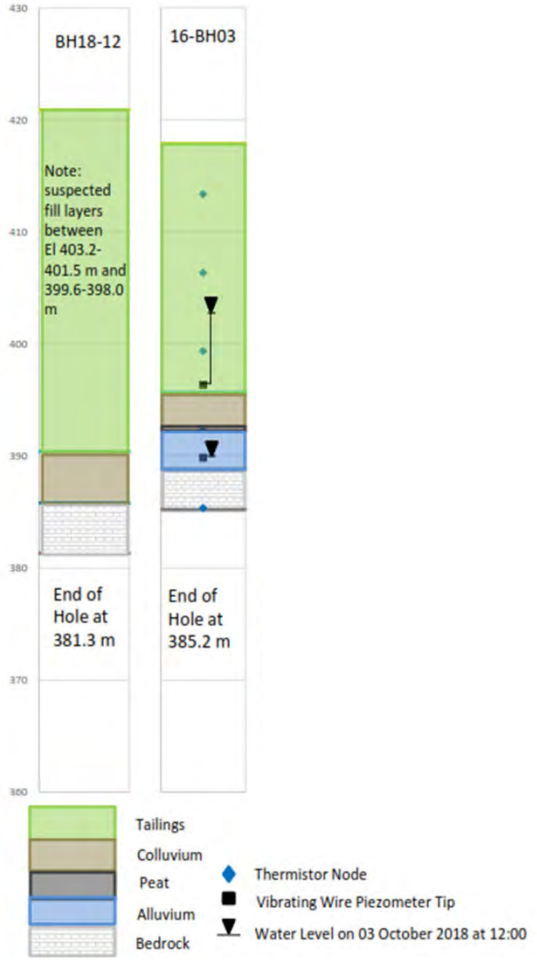




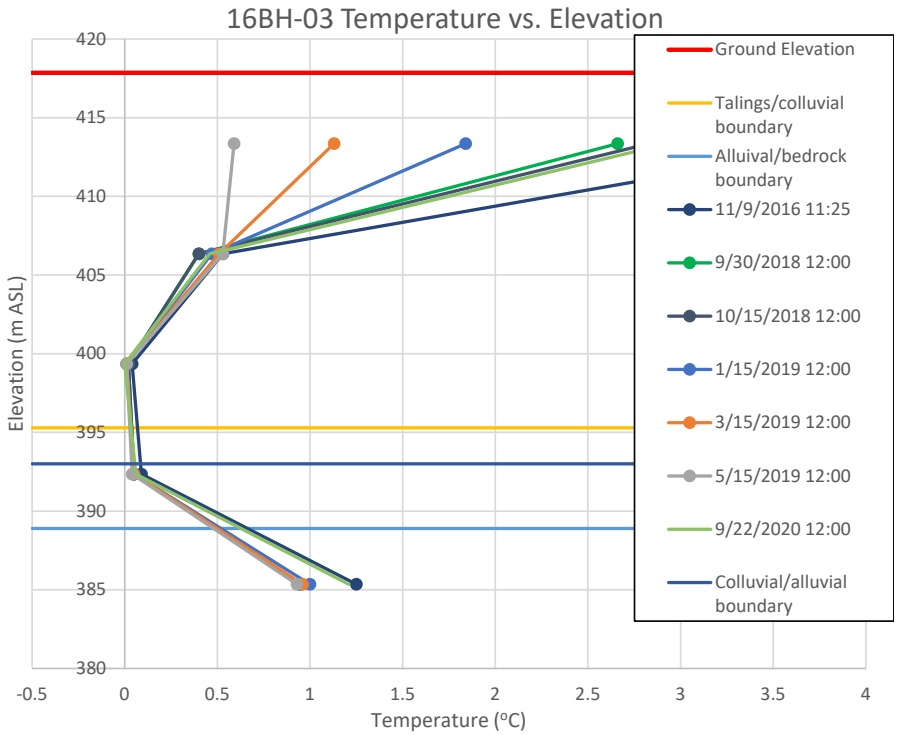
- VWPs installed in colluvium and tailings
- Low pressure heads in both VWPs – frozen or dry?

BH18-12 / 16BH-03

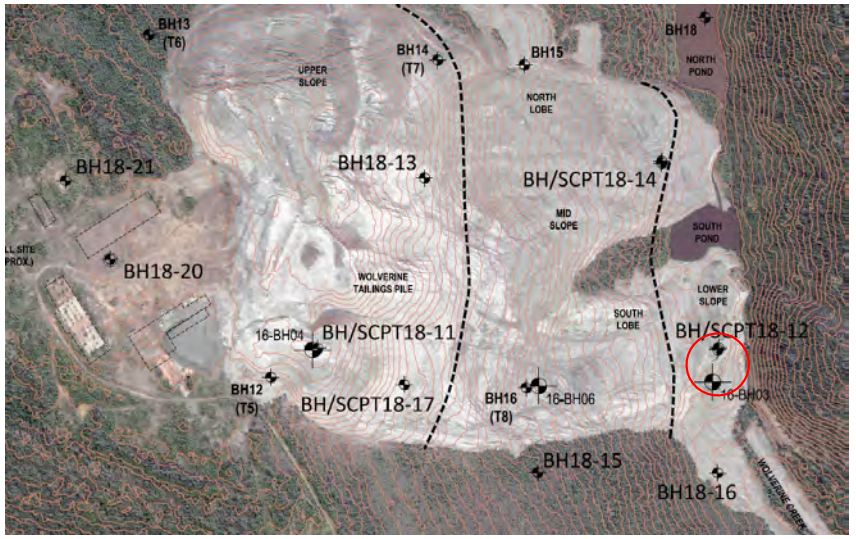




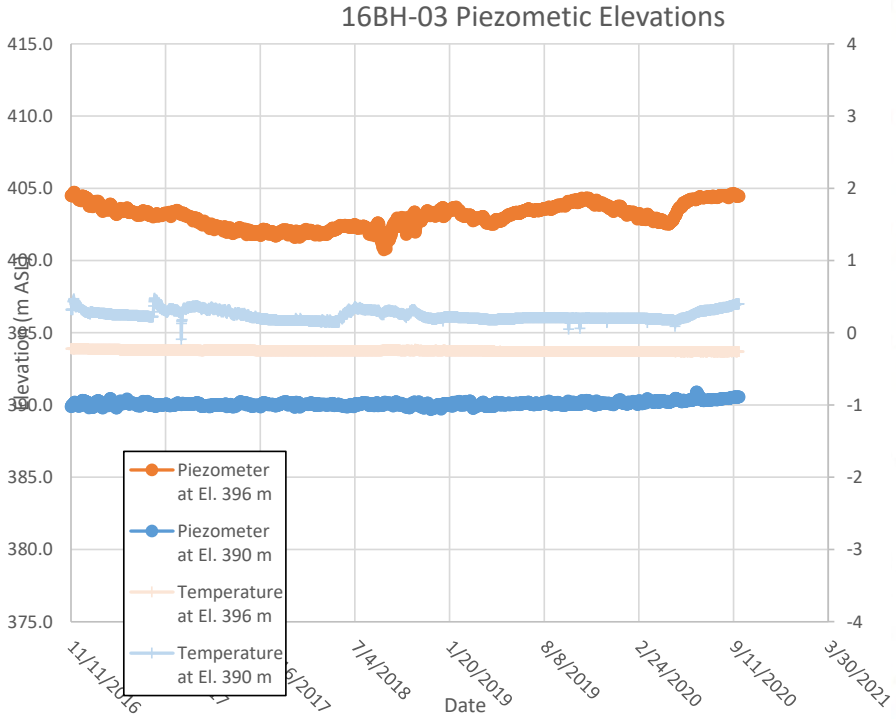
BH18-12 / 16BH-03 – Thermistor

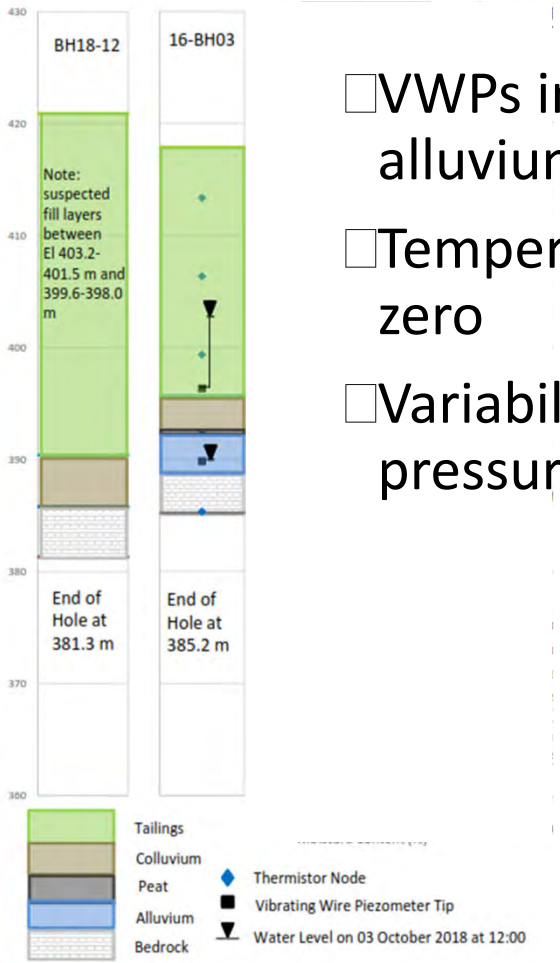


- Active zone in upper ~11 m
- Tailings are unfrozen
- Unusual warming trend with depth, likely due to thaw bulb below historic Wolverine Creek or seepage of water



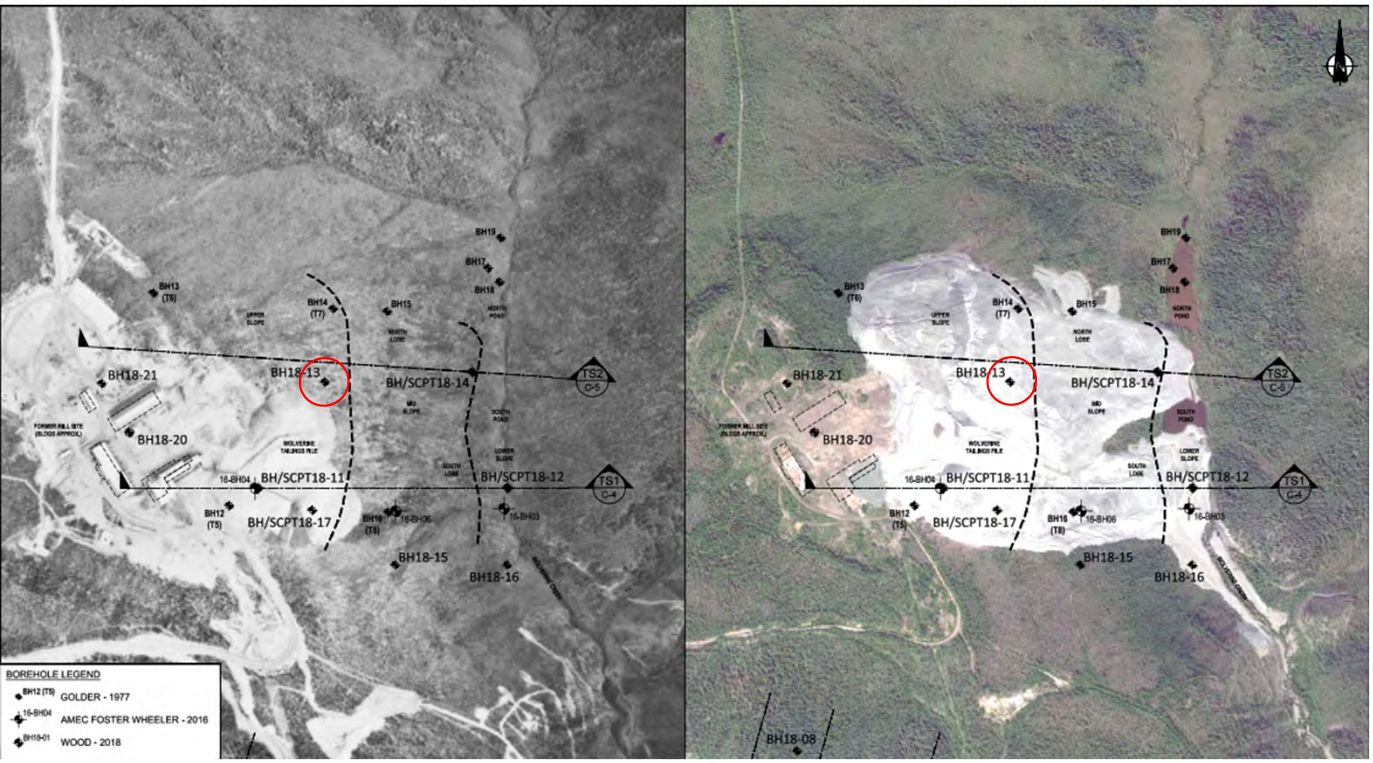
BH18-12 / 16BH-03 – Piezometers



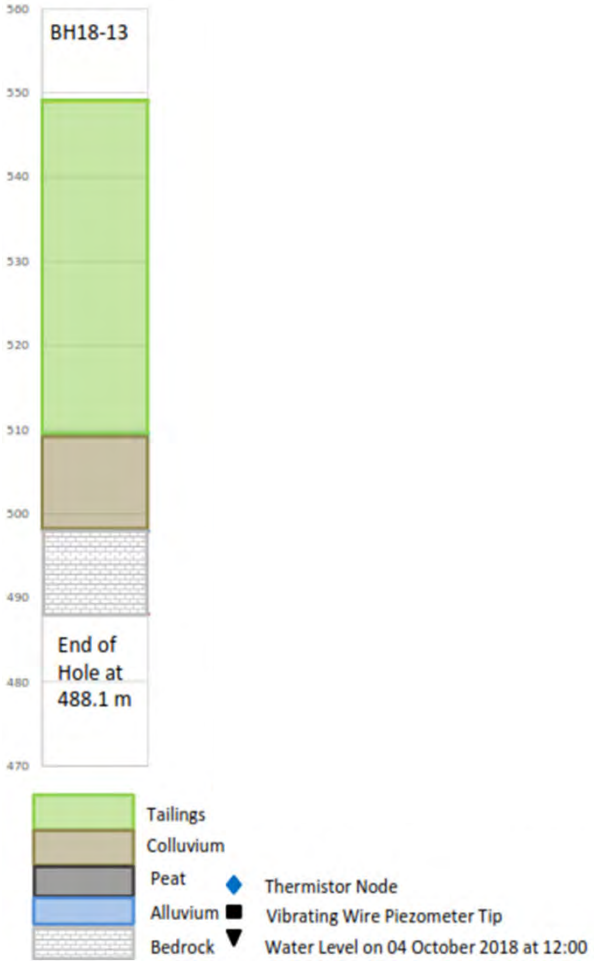


- VWPs installed in alluvium and tailings
- Temperatures below zero
- Variability in water pressures

BH18-13

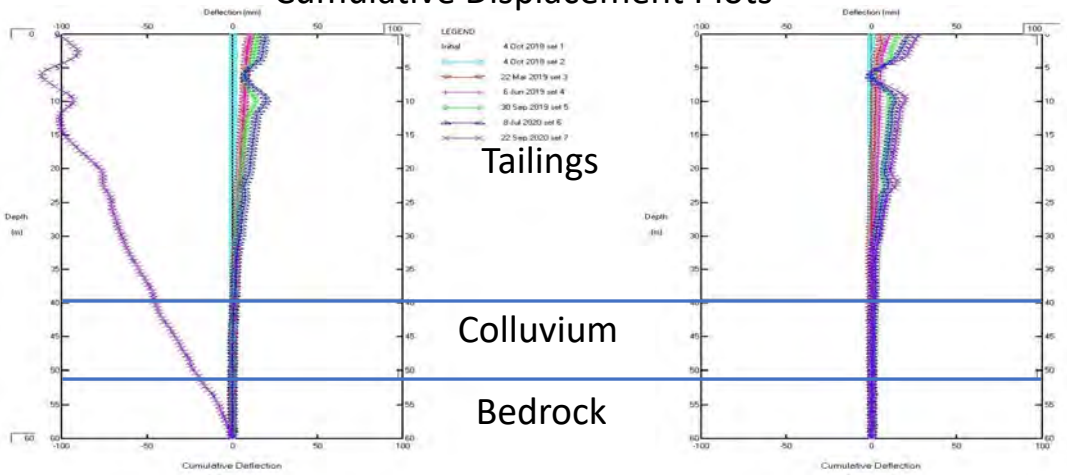

BH18-21
BH18-13
BH/SCPT18-14
TS2
BH18-20
BH/SCPT18-11
BH/SCPT18-12
TS1
BH/SCPT18-17
BH18-15
BH18-16
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018

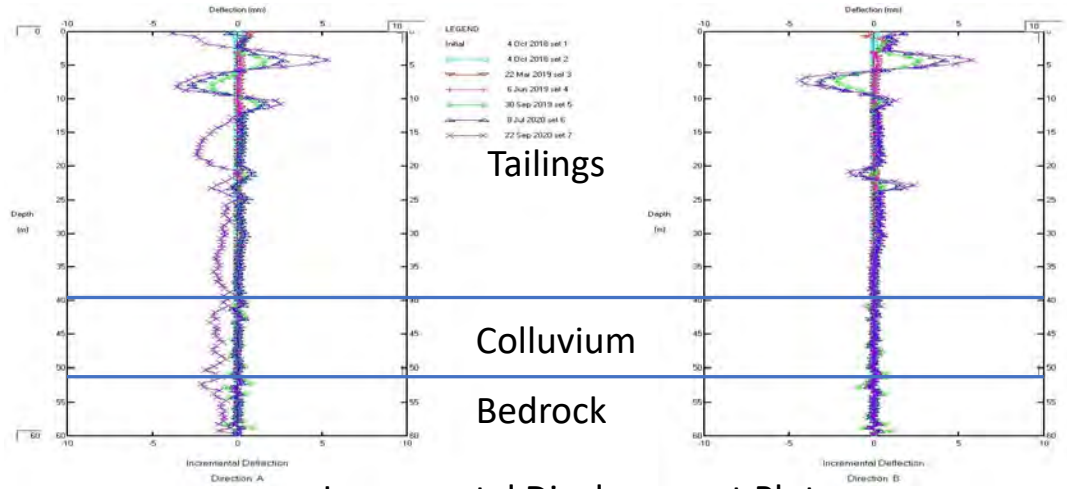
BH18-21
BH18-13
BH/SCPT18-14
TS2
BH18-20
BH/SCPT18-11
BH/SCPT18-12
TS1
BH/SCPT18-17
BH18-15
BH18-16
BH18-08


BH18-13
560
550
540
530
520
510
500
490
480
470
End of Hole at 488.1 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 12:00

BH18-13 – SI

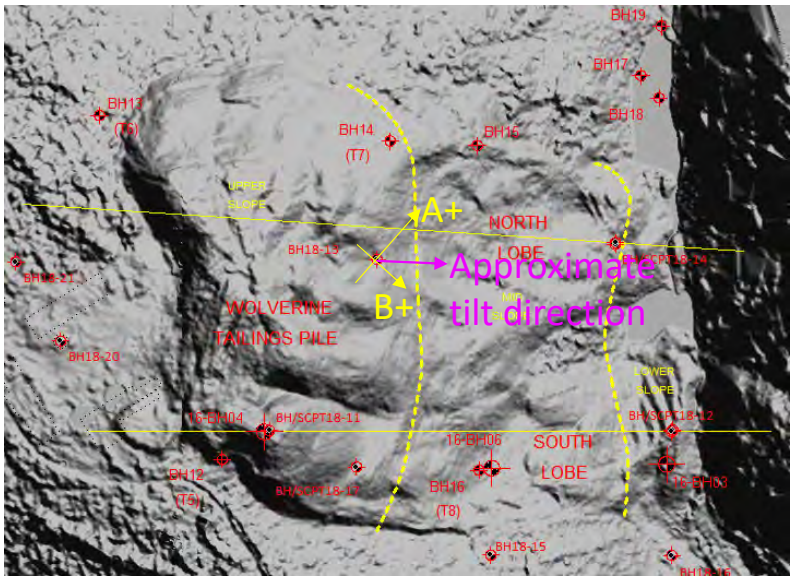
Cumulative Displacement Plots



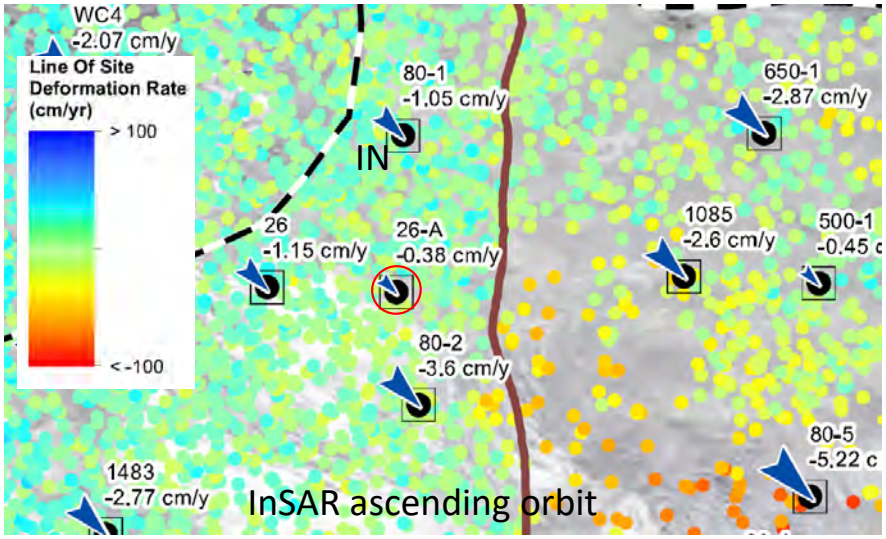


Incremental Displacement Plots

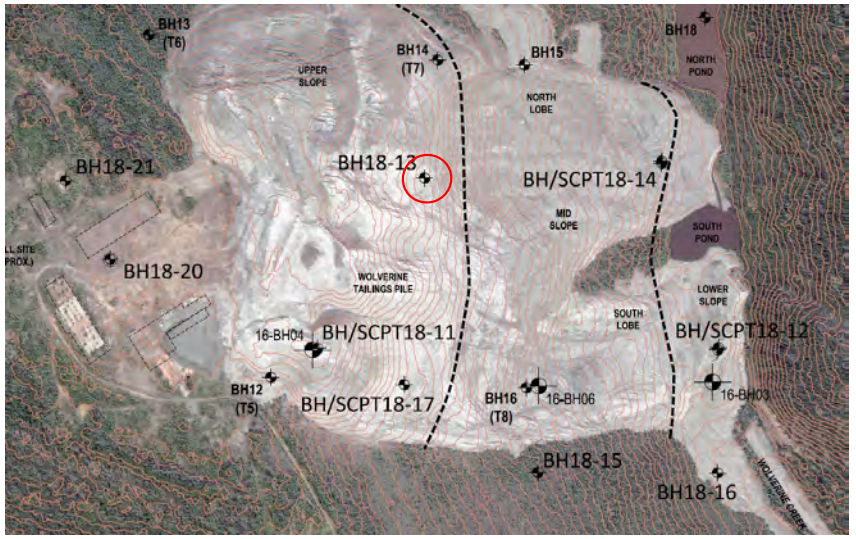
- Previous reporting noted downslope creep in the tailings
- Settlement also possible based on deflections noted starting in Sept 2019
- Large anomalous displacement in A-direction measured in Sept 2020 reading – suspect data
- Cumulative tilt between grade and 55.2 m is 28.5 mm at rates between 16.2 and 25 mm/year (excluding Sept 2020 data)



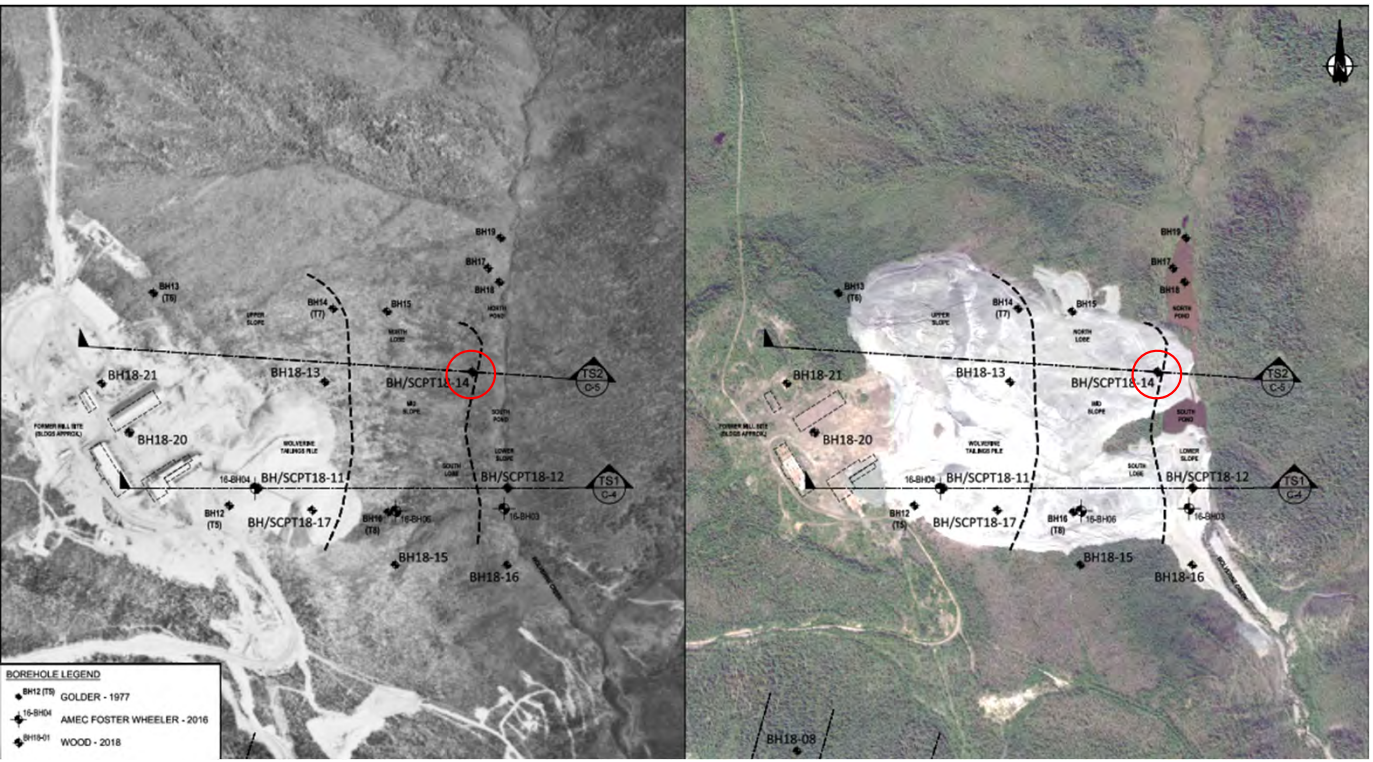
BH18-13 – Monitoring and InSAR

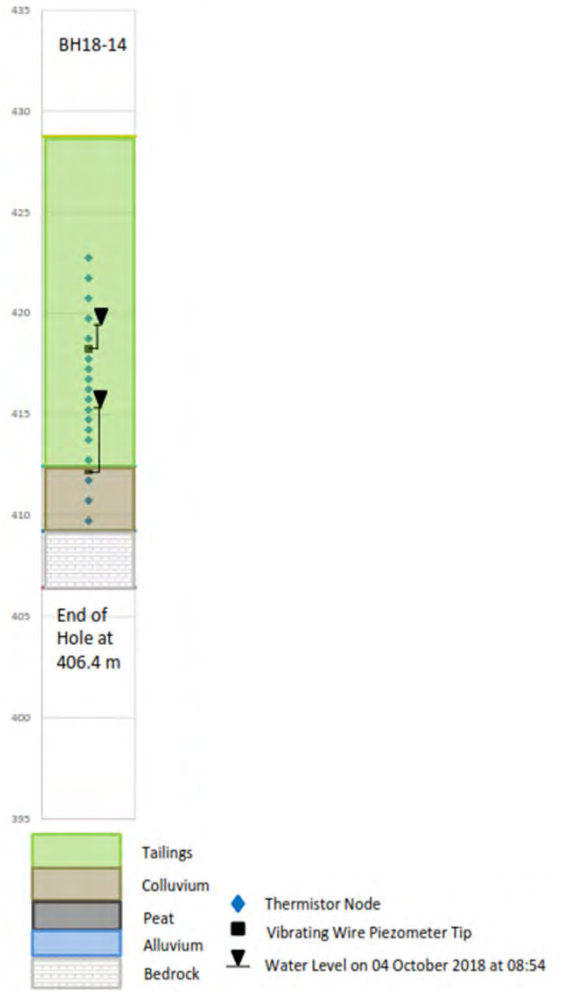


- Monitoring station 26-A is nearest point
  - 8 mm/year lateral movement
  - -3.8 and +4 mm/year for ascending and descending orbits (lateral movements interpreted)
- InSAR shows minor uplift

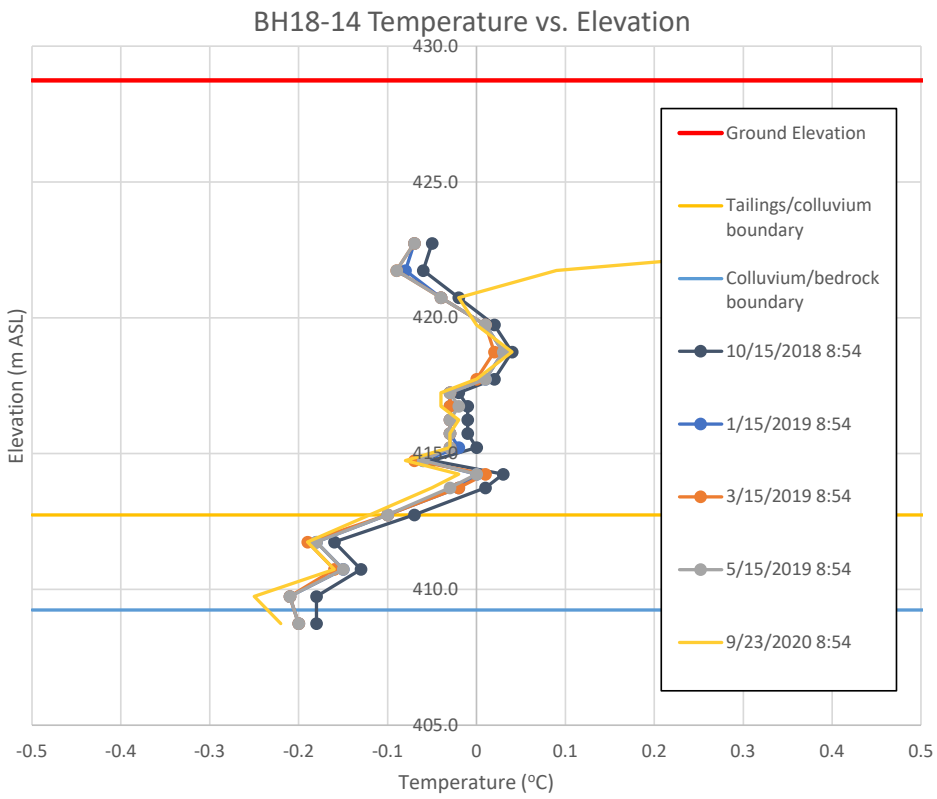


BH18-14

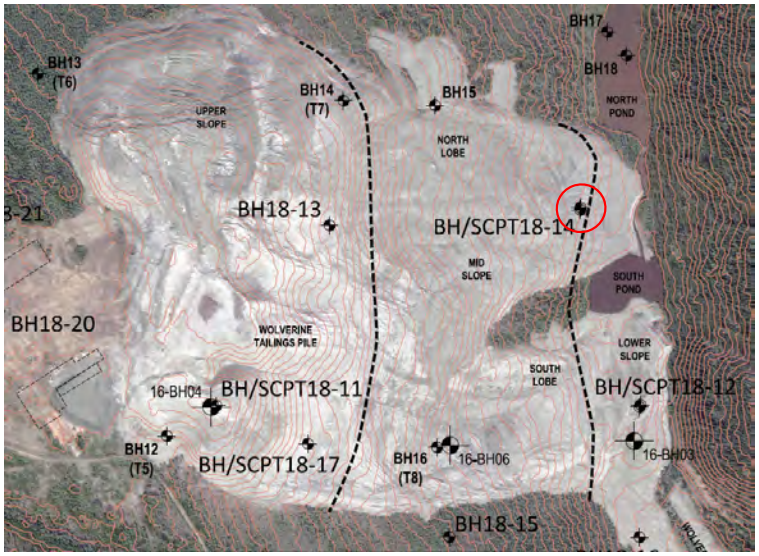

BH18-21
BH18-13
BH/SCPT18-14
TS2
C-5
BH18-20
16-BH04
BH/SCPT18-11
BH/SCPT18-12
TS1
C-4
BH12 (T9)
BH/SCPT18-17
BH16 (T8)
16-BH06
16-BH03
BH18-15
BH18-16
BH18-08
BOREHOLE LEGEND
BH12 (T9) GOLDER - 1977
16-BH04 AMEC FOSTER WHEELER - 2016
BH19-01 WOOD - 2018


435
430
425
420
415
410
405
400
395
BH18-14
End of Hole at 406.4 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 08:54

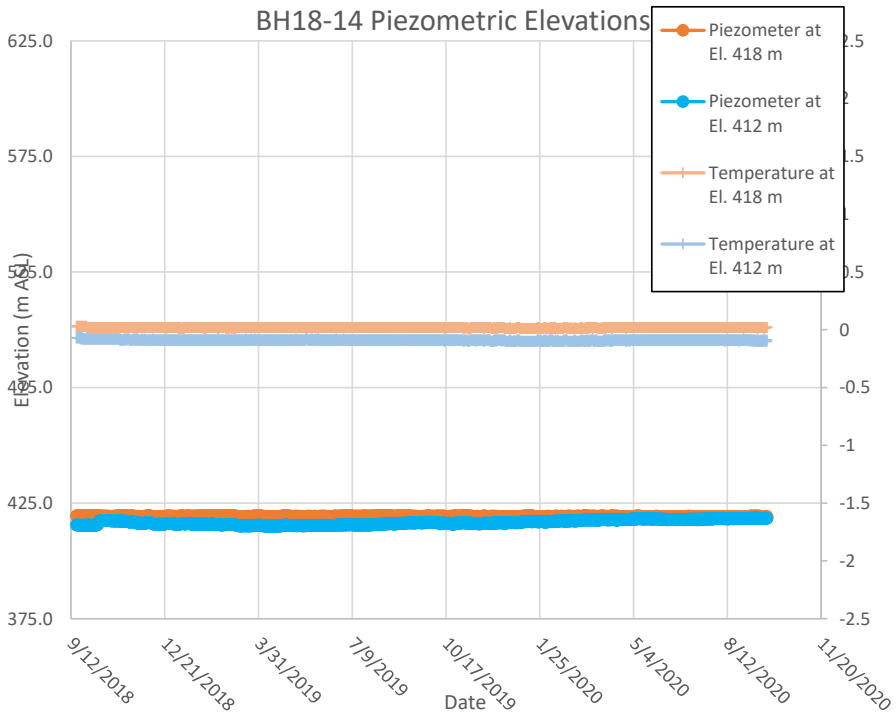
BH18-14 – Thermistor

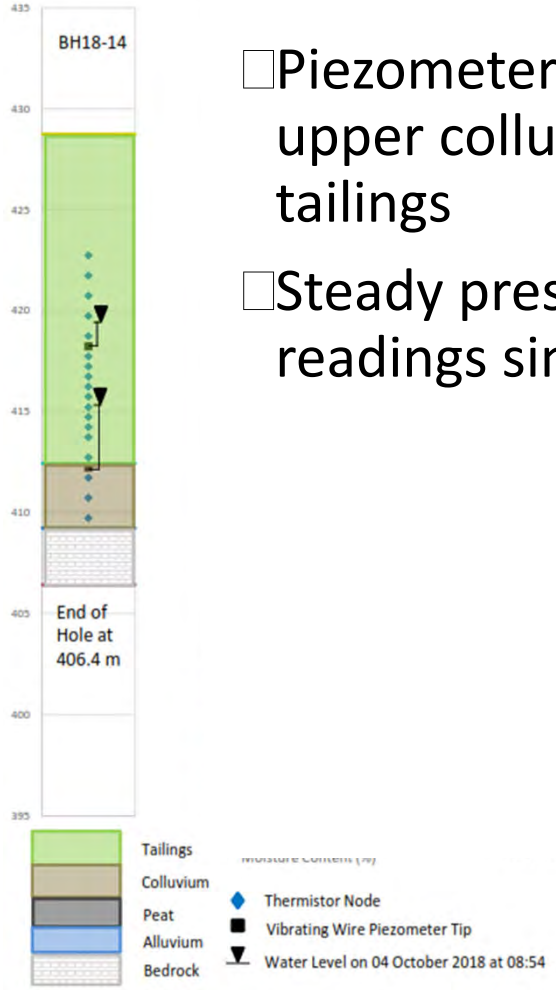


- Tailings near zero degrees
- Colluvium and bedrock frozen
- Possible slight cooling over time



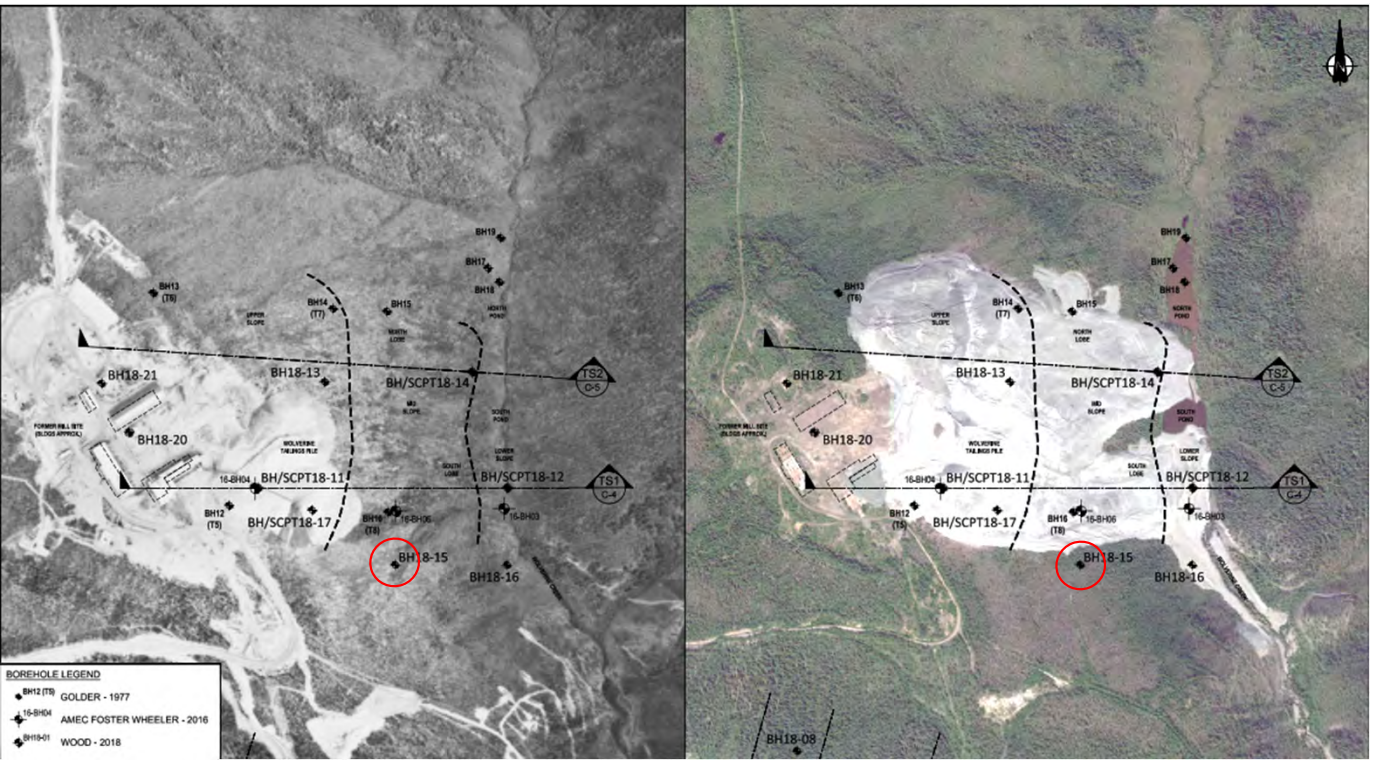
BH18-14 – Piezometers

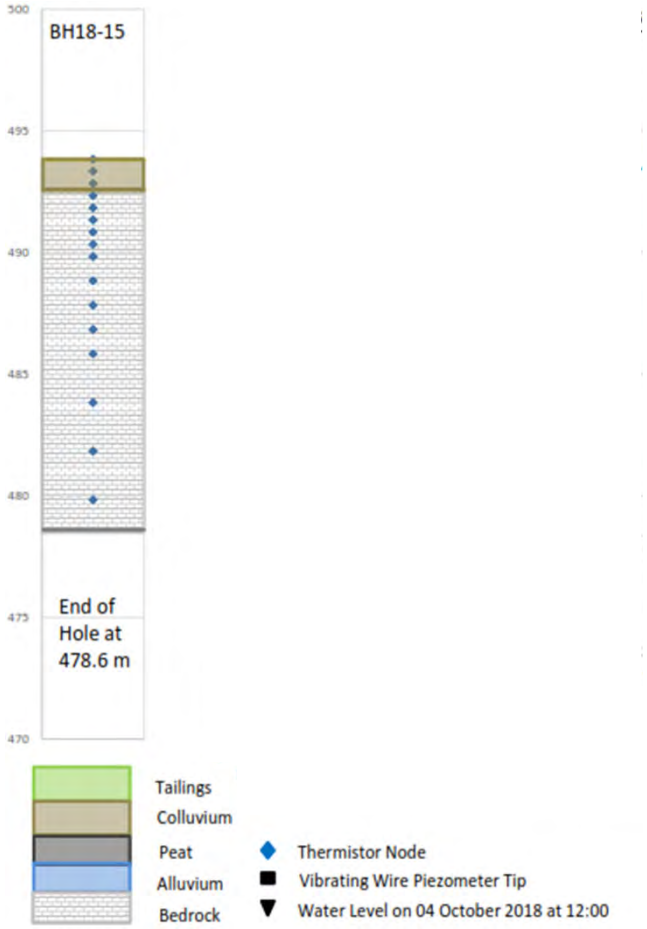




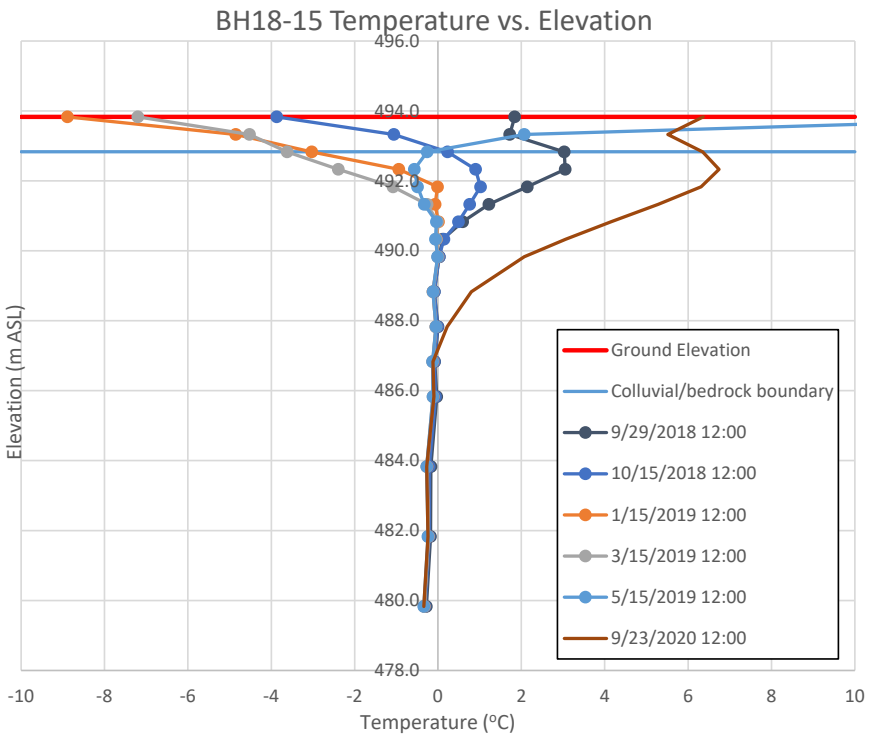
- Piezometers installed in upper colluvium and tailings
- Steady pressure readings since install

BH18-15

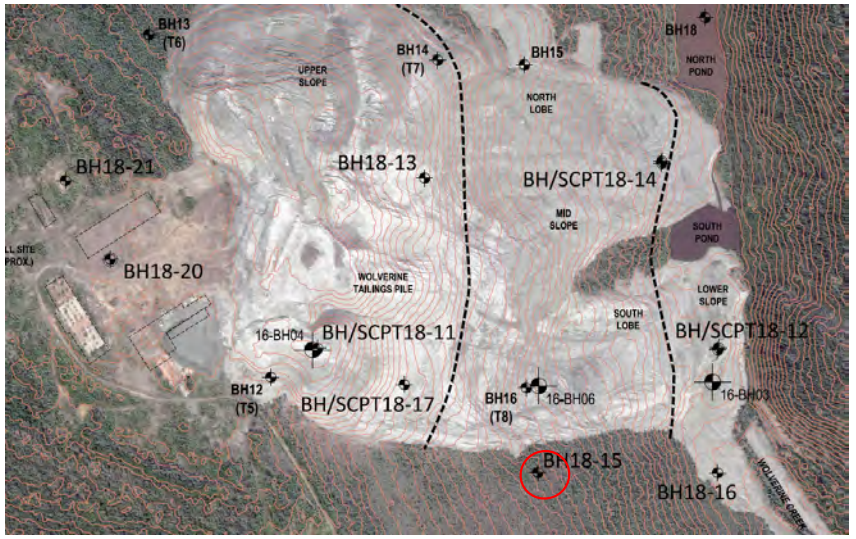

BH18-21
BH18-13
BH/SCPT18-14
TS2
C-5
BH18-20
16-BH04
BH/SCPT18-11
BH/SCPT18-12
TS1
C-4
BH12 (T9)
BH/SCPT18-17
BH16 (T8)
16-BH06
16-BH03
BH18-15
BH18-16
BH18-08
BOREHOLE LEGEND
BH12 (T9) GOLDER - 1977
16-BH04 AMEC FOSTER WHEELER - 2016
BH19-01 WOOD - 2018


BH18-15
500
495
490
485
480
475
470
End of Hole at 478.6 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 12:00

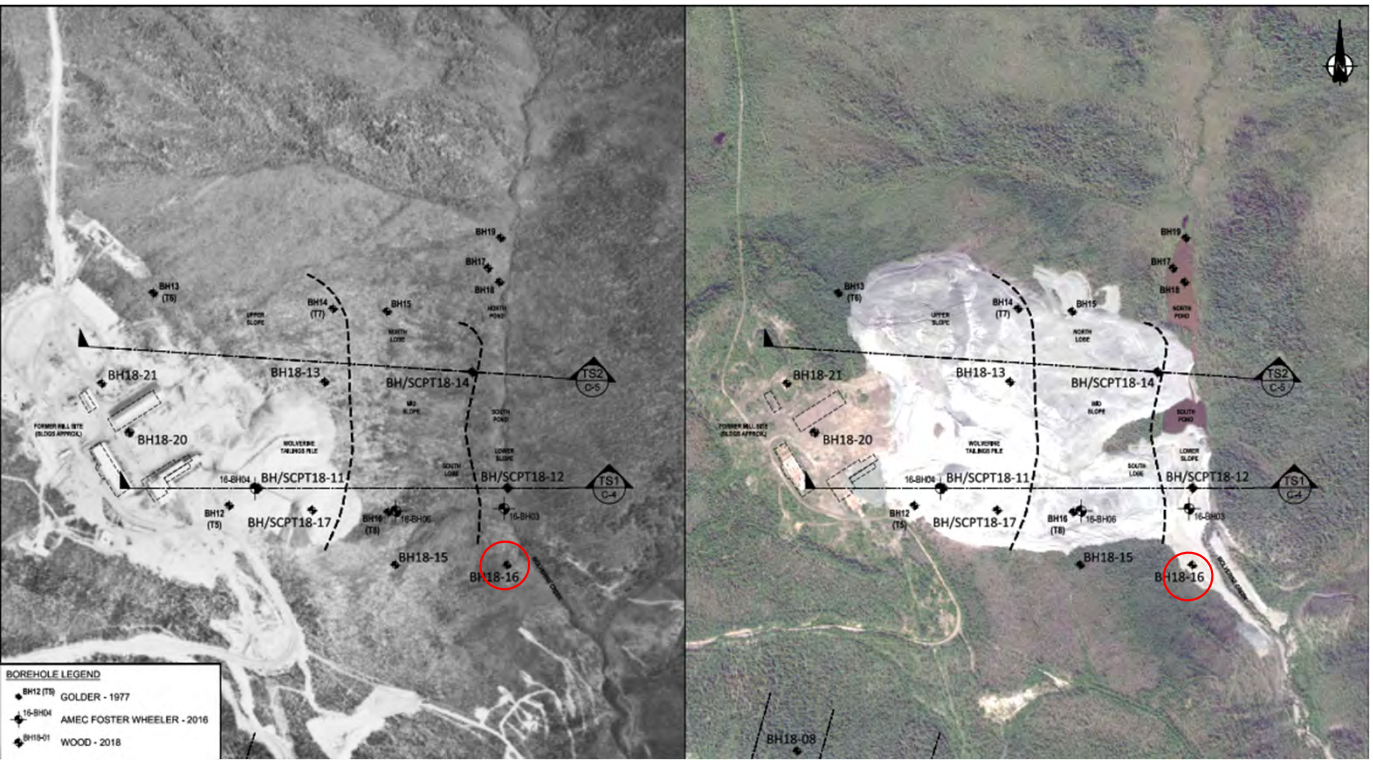
BH18-15 – Thermistor

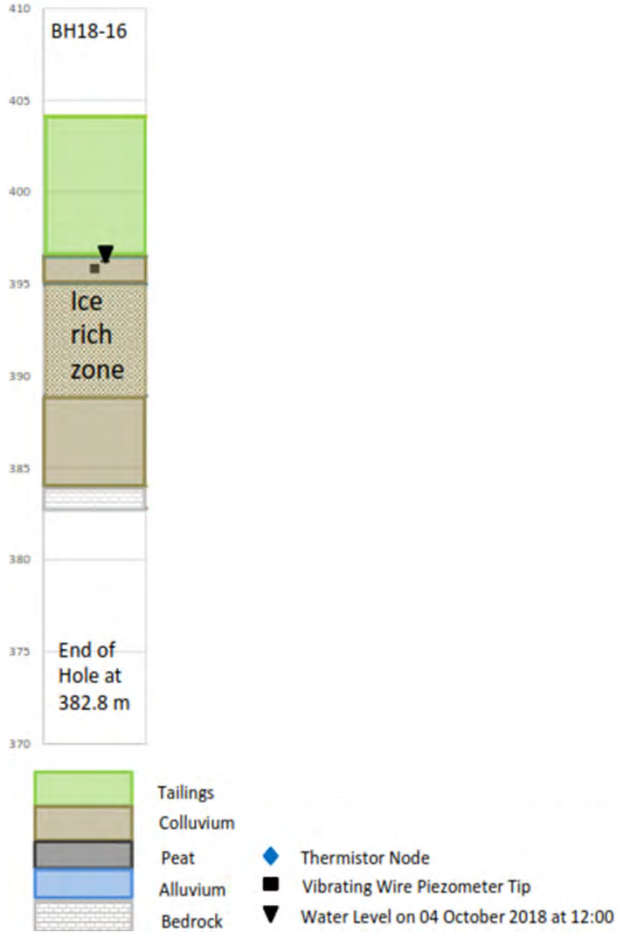


- The September 2020 data shows a much deeper active layer than previous data would suggest to about 7 m below grade
- Colluvium within the active layer
- Bedrock is frozen at about 8 m below ground surface

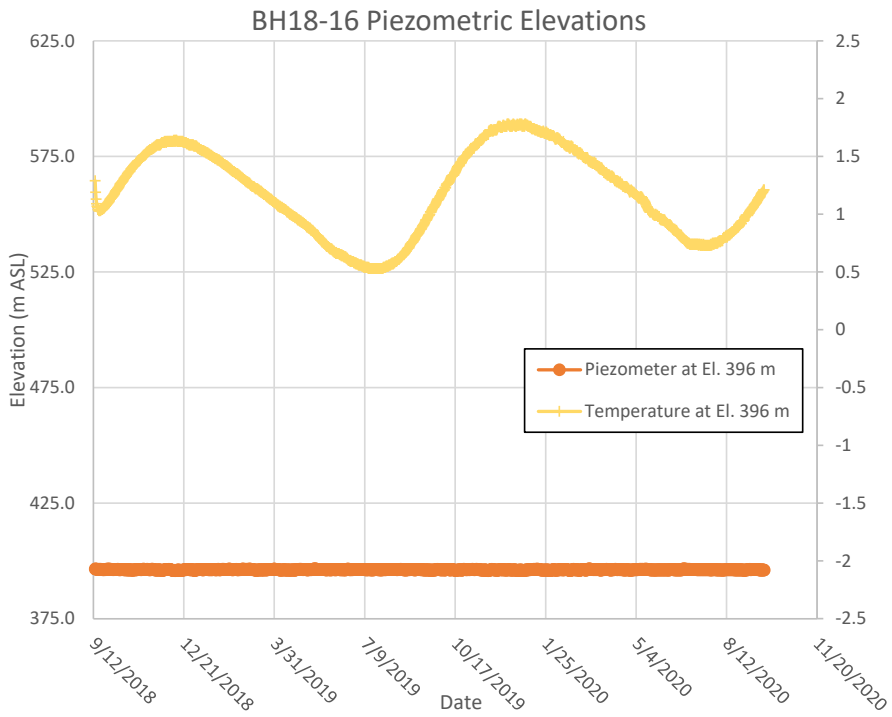


BH18-16

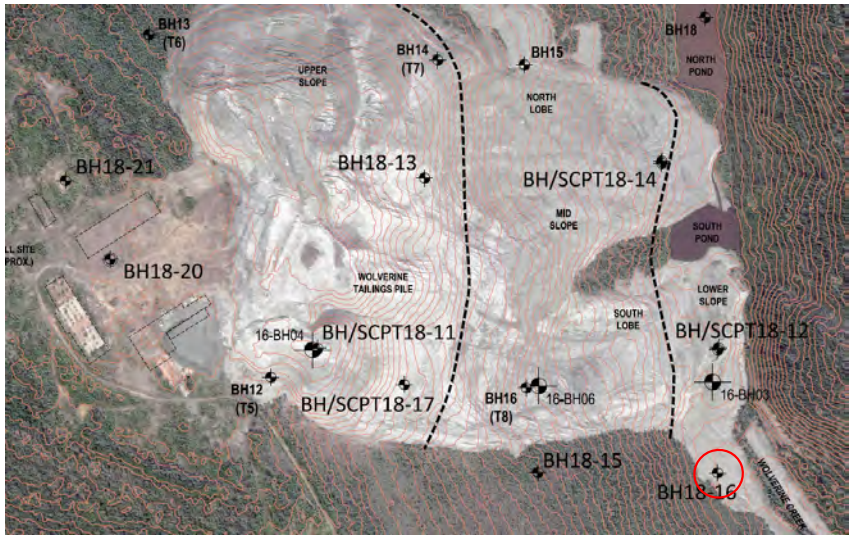

BH18-21
BH18-13
BH/SCPT18-14
TS2
C-5
BH18-20
16-BH04
BH/SCPT18-11
BH/SCPT18-12
TS1
C-4
BH12 (T9)
BH/SCPT18-17
BH16 (T8)
16-BH06
16-BH03
BH18-15
BH18-16
BH18-08
BOREHOLE LEGEND
BH12 (T9) GOLDER - 1977
16-BH04 AMEC FOSTER WHEELER - 2016
BH18-01 WOOD - 2018


BH18-16
410
405
400
395
390
385
380
375
370
Ice rich zone
End of Hole at 382.8 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 12:00

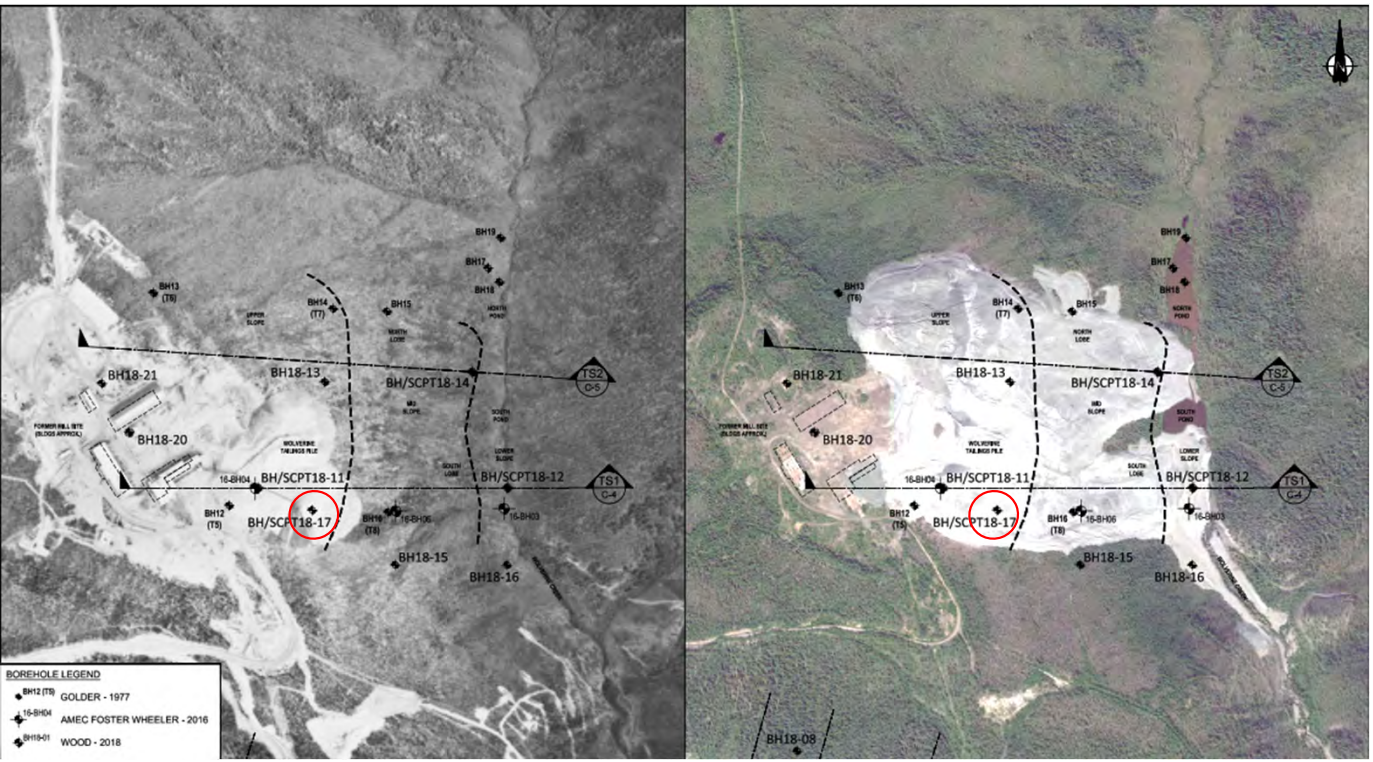
BH18-16 – Piezometer

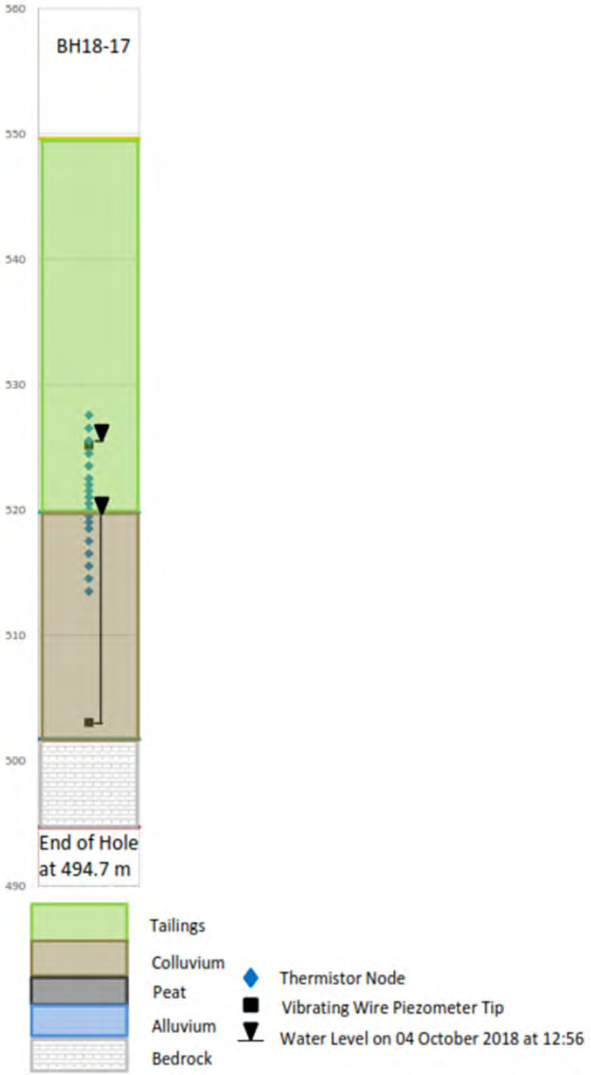


- Piezometer is installed in the native colluvium about 10 m below grade
- No change is pressures (near install depth at 396 m) over time – likely dry
- Highest temperatures recorded in December and January, with lowest temperatures in July and August



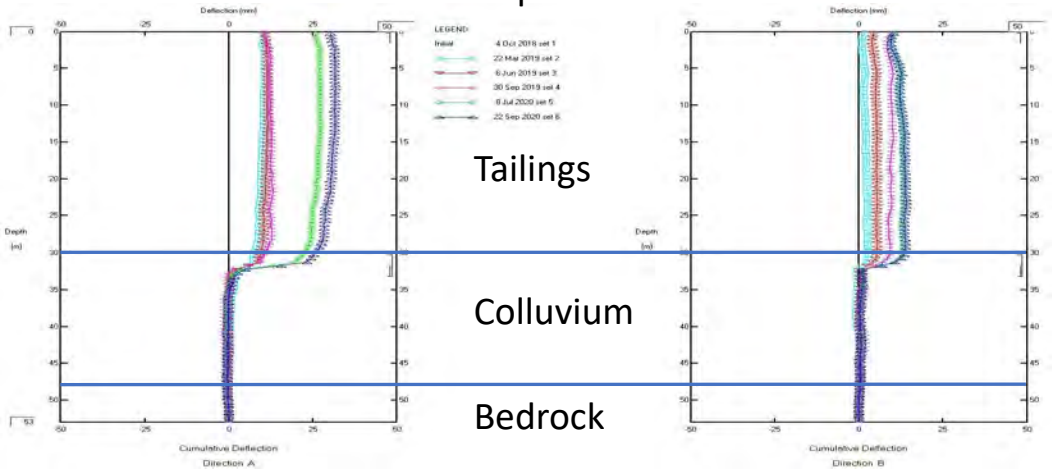
BH18-17

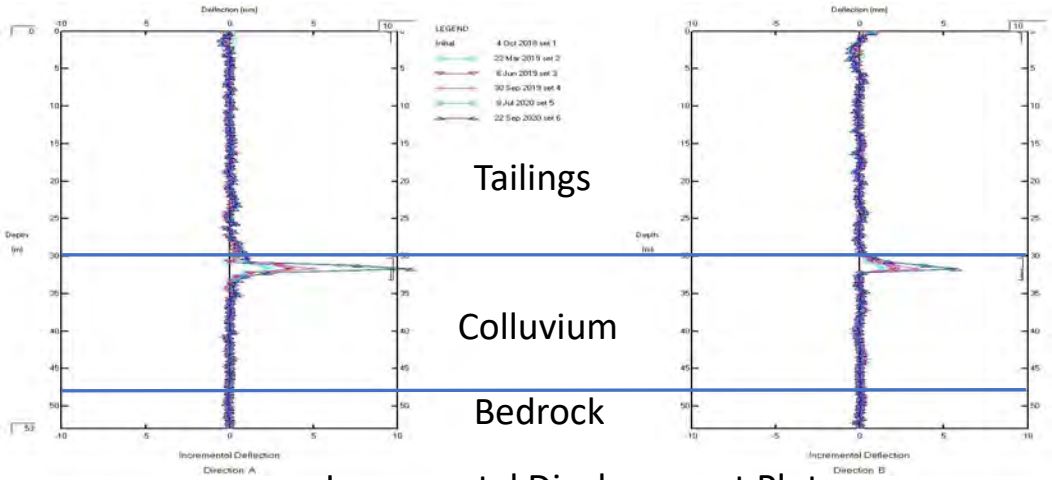

BH18-21
BH18-13
BH/SCPT18-14
TS2
C-5
BH18-20
16-BH04
BH/SCPT18-11
BH/SCPT18-12
TS1
C-4
BH12 (T9)
BH/SCPT18-17
BH16 (T8)
16-BH06
16-BH03
BH18-15
BH18-16
BH18-08
BOREHOLE LEGEND
BH12 (T9) GOLDER - 1977
16-BH04 AMEC FOSTER WHEELER - 2016
BH18-01 WOOD - 2018


BH18-17
560
550
540
530
520
510
500
490
End of Hole at 494.7 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 12:56

BH18-17 – SI

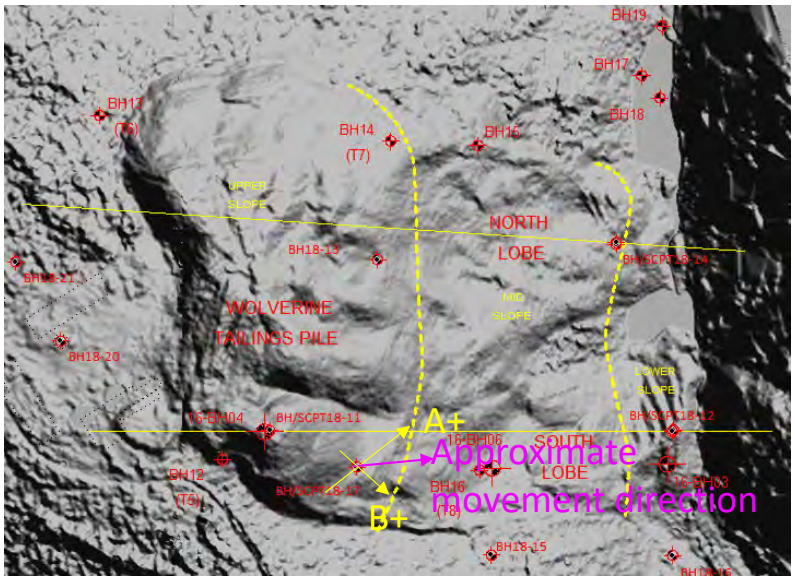
Cumulative Displacement Plots





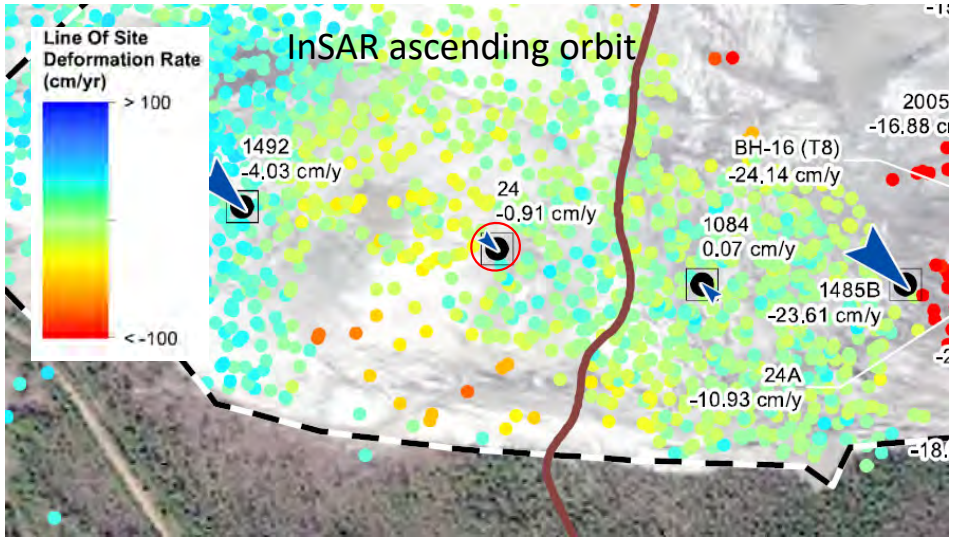
Incremental Displacement Plots

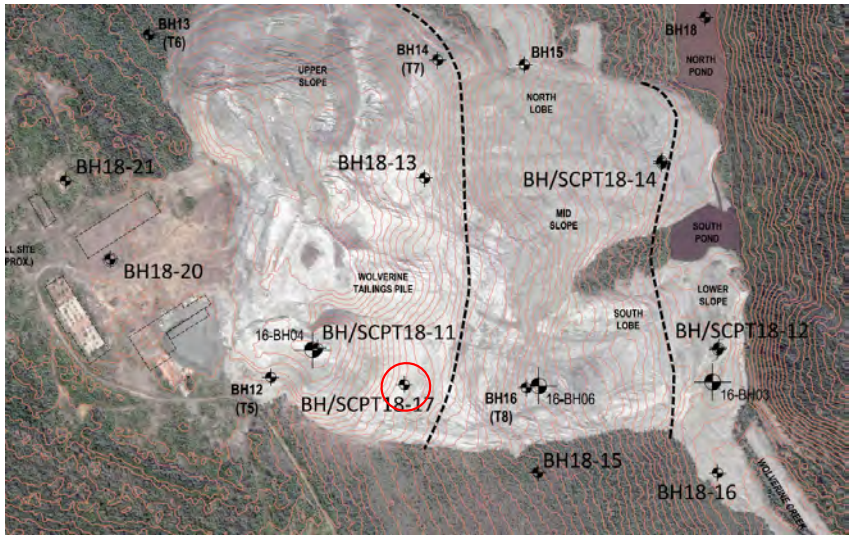
- The SI in BH18-17 is measuring a distinct movement plane just below the tailings/colluvium contact, approximately corresponding to the frozen/unfrozen boundary as measured by the thermistor.
- The cumulative downslope movement of approximately 30 mm at an average rate of 16 mm/year



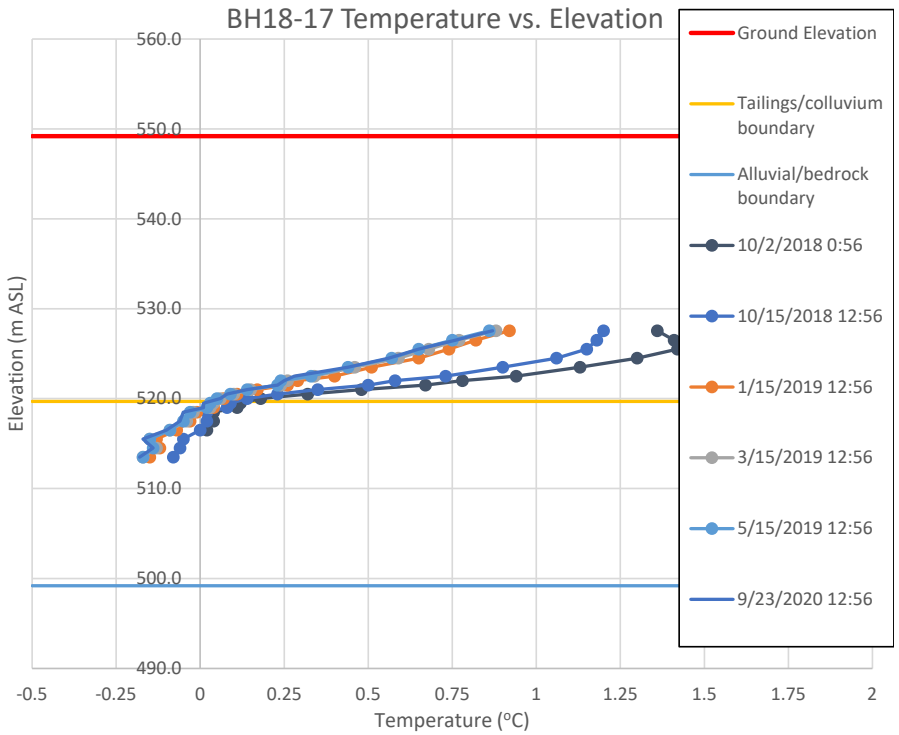
BH18-17 – Monitoring and InSAR

- Monitoring station 24 is nearest location
  - 18 mm/year lateral movement (corresponds very well with SI data)
  - -9.1 and +8.2 mm/year onto LOS for ascending and descending orbits (lateral movements)
  - Data from 2018 -2020
- InSAR shows minor decrease (settlement) on upslope side and increase (accumulation) on downslope side

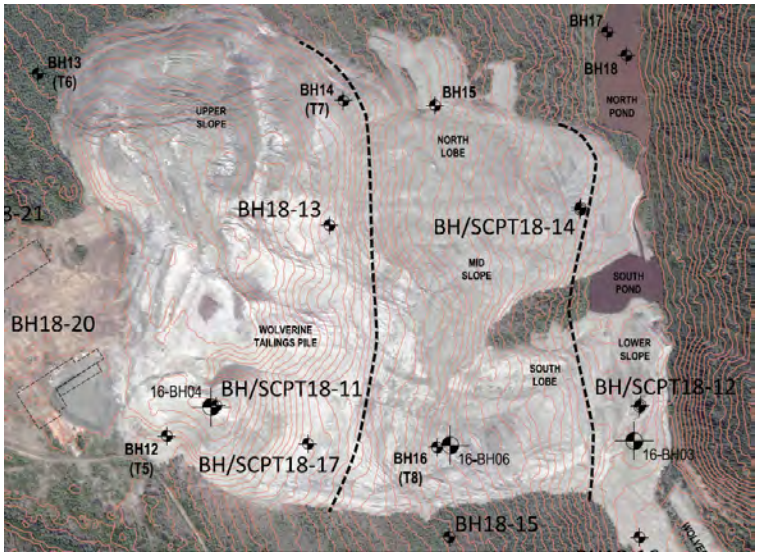




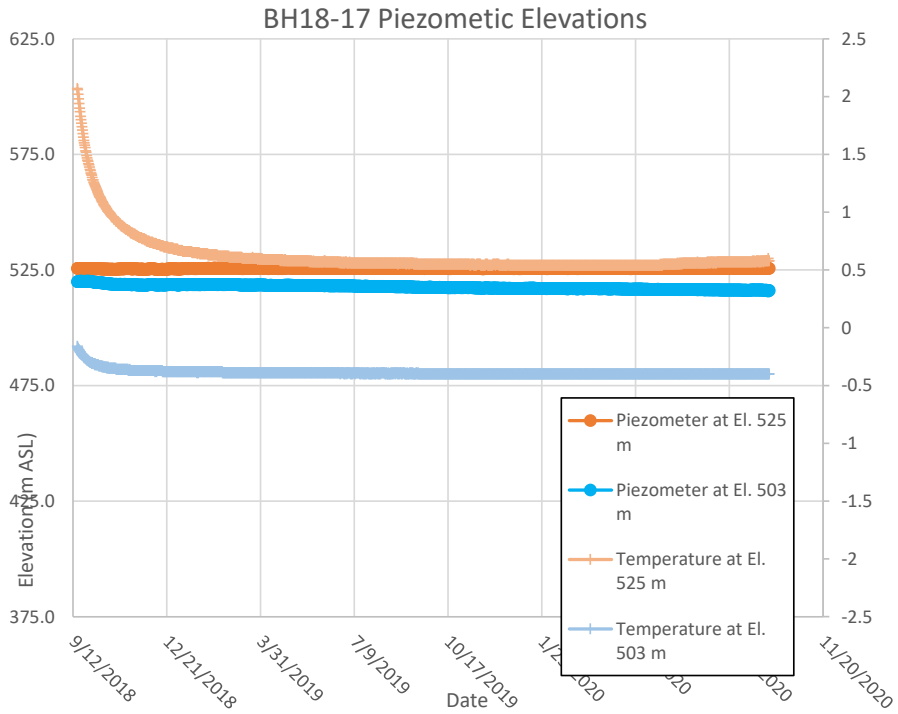
BH18-17 – Thermistor

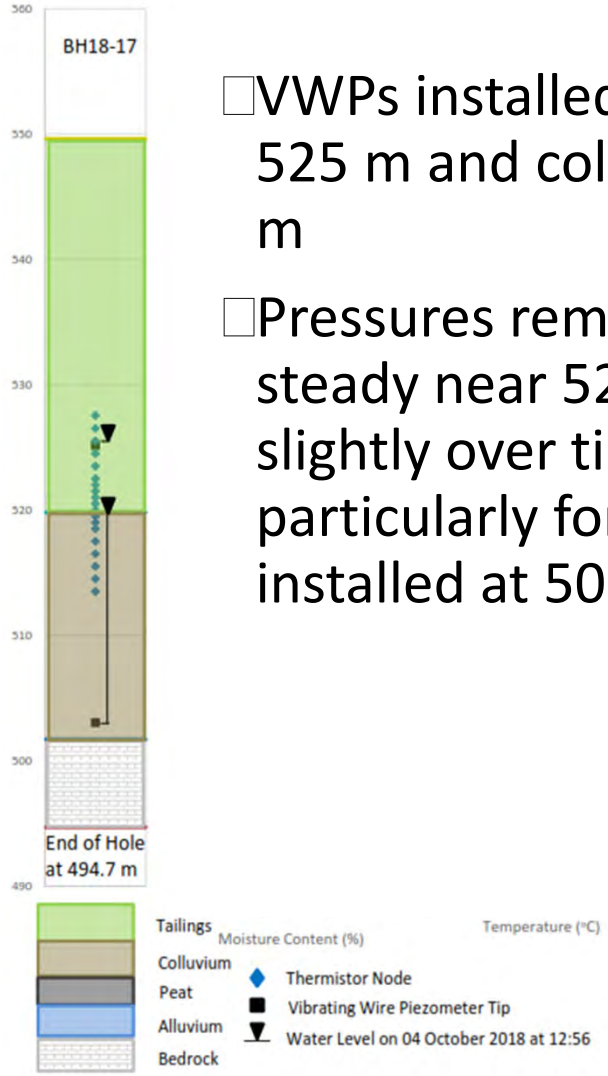


- Tailings/colluvium contact is about the frozen/unfrozen boundary
- After equilibrating temperature profiles have remained steady



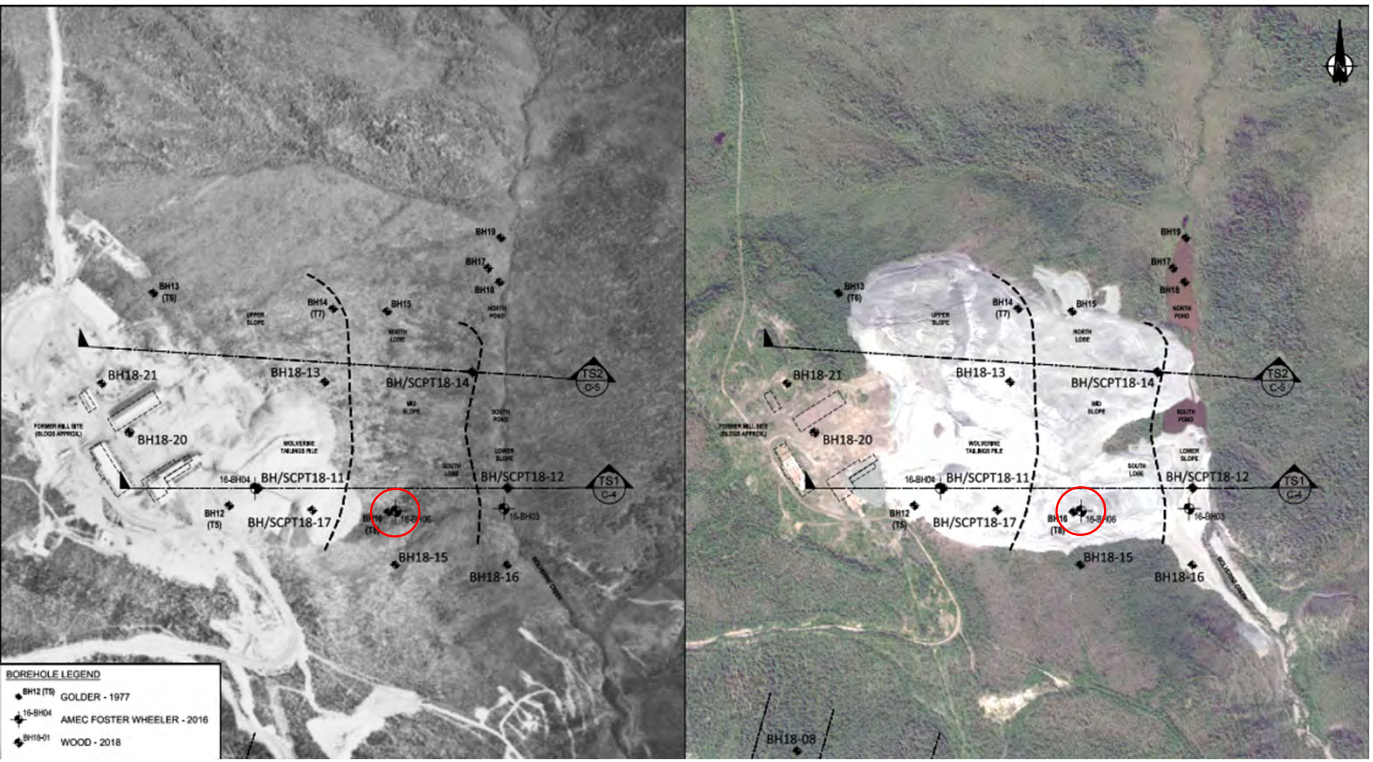
BH18-17 – Piezometers

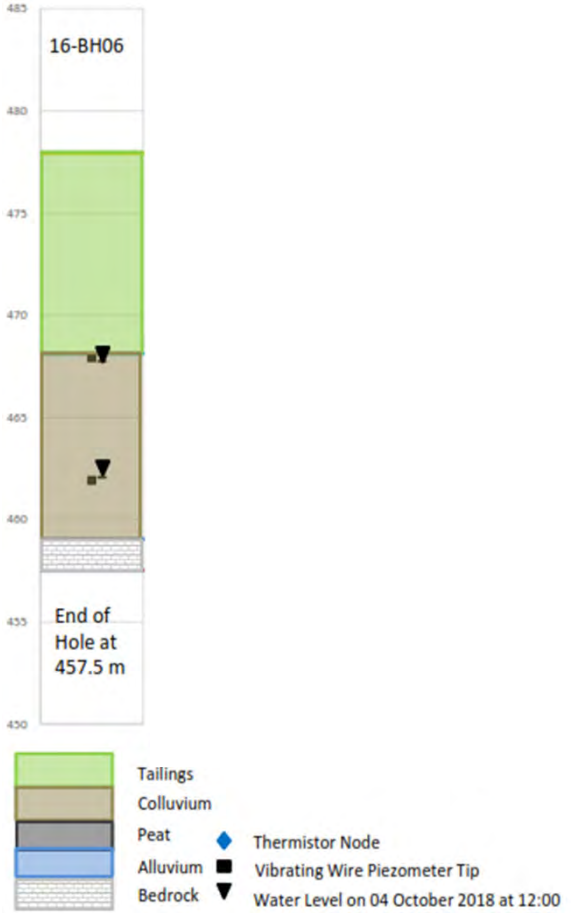




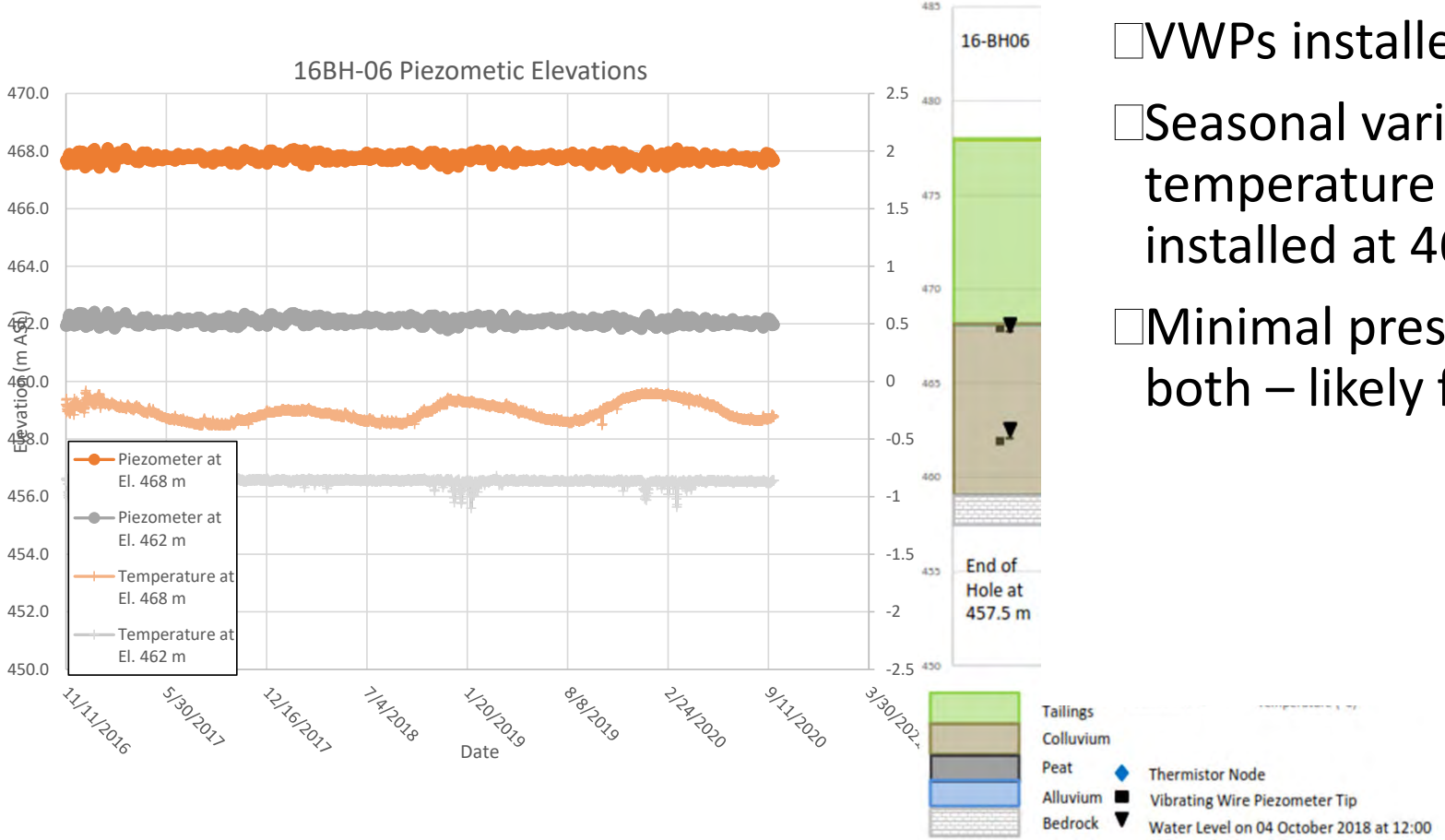
- VWPs installed in tailings at 525 m and colluvium at 503 m
- Pressures remained fairly steady near 525 m dropping slightly over time particularly for the VWP installed at 503 m

16-BH06


BH18-21
BH18-13
BH/SCPT18-14
TS2
C-5
BH18-20
16-BH04
BH/SCPT18-11
BH/SCPT18-12
TS1
C-4
BH12
(T9)
BH/SCPT18-17
16-BH06
16-BH03
BH18-15
BH18-16
BH18-08
BOREHOLE LEGEND
GOLDER - 1977
AMEC FOSTER WHEELER - 2016
WOOD - 2018


485
480
475
470
465
460
455
450
16-BH06
End of Hole at 457.5 m
Tailings
Colluvium
Peat
Alluvium
Bedrock
Thermistor Node
Vibrating Wire Piezometer Tip
Water Level on 04 October 2018 at 12:00

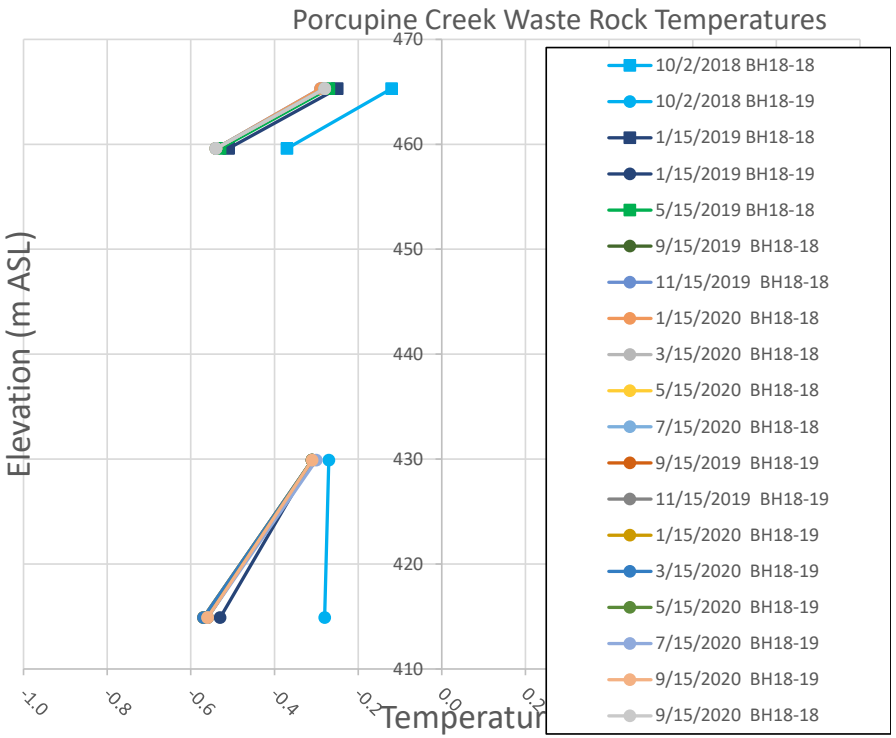
16-BH06 – Piezometers



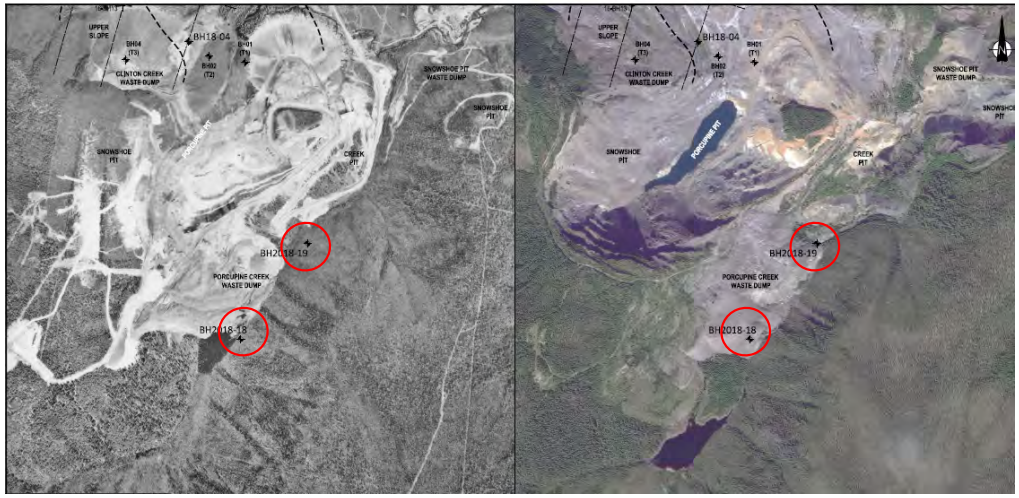
- VWPs installed in colluvium
- Seasonal variation in temperature for VWP installed at 468 m
- Minimal pressure heads in both – likely frozen ground

Porcupine Creek Waste Dump

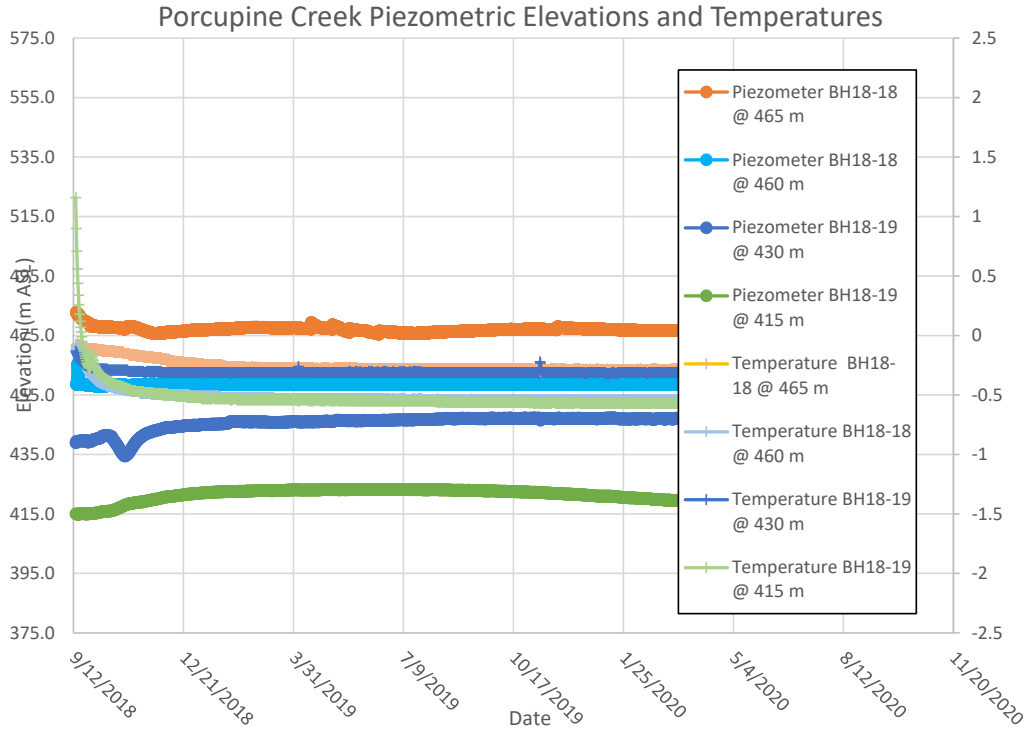
BH18-18 and BH18-19 – Temperatures

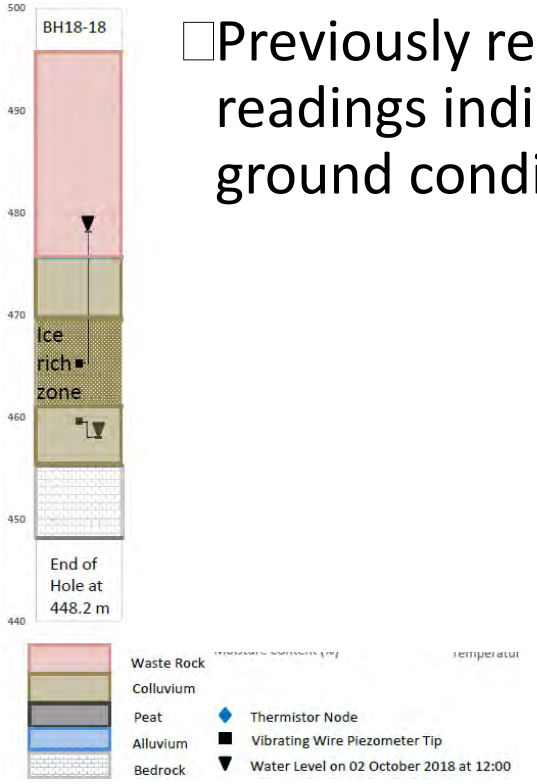


- Temperatures monitored in VWPs only – no thermistors
- Below zero degrees and cooling with time



BH18-18 and BH18-19 – Piezometers





- Previously reported that all readings indicate frozen ground conditions

Attachment B – Limitations

DRAFT

Limitations

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:
   a) The contract between Wood and the Client, including any subsequent written amendment or Change Order duly signed by the parties (hereinafter together referred as the "Contract");
   b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by Wood to the Client in connection to the Contract; and
   c) The limitations stated herein.
2. **Standard of care:** Wood has prepared this report in a manner consistent with the level of skill and are ordinarily exercised by reputable members of Wood's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guaranty, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.
3. **Limited locations:** The information contained in this report is restricted to the site and structures evaluated by Wood and to the topics specifically discussed in it, and is not applicable to any other aspects, areas, or locations.
4. **Information utilized:** The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions, and qualifications/limitations set forth in this report.
5. **Accuracy of information:** No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). Wood cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.
6. **Report interpretation:** This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by Wood.
7. **No legal representations:** Wood makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.
8. **Decrease in property value:** Wood shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.
9. **No third-party reliance:** This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or Contract. Any use or reproduction which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. Wood does not represent or warrant

DRAFT

the accuracy, completeness, merchantability, fitness for purpose or usefulness of this document, or any information contained in this document, for use or consideration by any third party. Wood accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on this report or anything set out therein. including without limitation, any indirect, special, incidental, punitive, or consequential loss, liability or damage of any kind.

10. **Assumptions:** Where design recommendations are given in this report, they apply only if the project contemplated by the Client is constructed substantially in accordance with the details stated in this report. It is the sole responsibility of the Client to provide to Wood changes made in the project, including but not limited to, details in the design, conditions, engineering, or construction that could in any manner whatsoever impact the validity of the recommendations made in the report. Wood shall be entitled to additional compensation from Client to review and assess the effect of such changes to the project.
11. **Time dependence:** If the project contemplated by the Client is not undertaken within a period of 18 months following the submission of this report, or within the time frame understood by Wood to be contemplated by the Client at the commencement of Wood's assignment, and/or, if any changes are made, for example, to the elevation, design or nature of any development on the site, its size and configuration, the location of any development on the site and its orientation, the use of the site, performance criteria and the location of any physical infrastructure, the conclusions and recommendations presented herein should not be considered valid unless the impact of the said changes is evaluated by Wood, and the conclusions of the report are amended or are validated in writing accordingly.

    Advancements in the practice of geotechnical engineering, engineering geology and hydrogeology and changes in applicable regulations, standards, codes or criteria could impact the contents of the report, in which case, a supplementary report may be required. The requirements for such a review remain the sole responsibility of the Client or their agents.

    Wood will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.
12. **Limitations of visual inspections:** Where conclusions and recommendations are given based on a visual inspection conducted by Wood, they relate only to the natural or man-made structures, slopes, etc. inspected at the time the site visit was performed. These conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in Wood's opinion, for direct observation.
13. **Limitations of site investigations:** Site exploration identifies specific subsurface conditions only at those points from which samples have been taken and only at the time of the site investigation. Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions.

    The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite this investigation, conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

    Final sub-surface/bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports.

DRAFT

Bedrock, soil properties and groundwater conditions can be significantly altered by environmental remediation and/or construction activities such as the use of heavy equipment or machinery, excavation, blasting, pile-driving or draining or other activities conducted either directly on site or on adjacent terrain. These properties can also be indirectly affected by exposure to unfavorable natural events or weather conditions, including freezing, drought, precipitation and snowmelt.

During construction, excavation is frequently undertaken which exposes the actual subsurface and groundwater conditions between and beyond the test locations, which may differ from those encountered at the test locations. It is recommended that Wood be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered at the test locations, that construction work has no negative impact on the geotechnical aspects of the design, to adjust recommendations in accordance with conditions as additional site information is gained, and to deal quickly with geotechnical considerations if they arise.

Interpretations and recommendations presented herein may not be valid if an adequate level of review or inspection by Wood is not provided during construction.

14. **Factors that may affect construction methods, costs and scheduling:** The performance of rock and soil materials during construction is greatly influenced by the means and methods of construction. Where comments are made relating to possible methods of construction, construction costs, construction techniques, sequencing, equipment or scheduling, they are intended only for the guidance of the project design professionals, and those responsible for construction monitoring. The number of test holes may not be sufficient to determine the local underground conditions between test locations that may affect construction costs, construction techniques, sequencing, equipment, scheduling, operational planning, etc.

    Any contractors bidding on or undertaking the works should draw their own conclusions as to how the subsurface and groundwater conditions may affect their work, based on their own investigations and interpretations of the factual soil data, groundwater observations, and other factual information.

15. **Groundwater and Dewatering:** Wood will accept no responsibility for the effects of drainage and/or dewatering measures if Wood has not been specifically consulted and involved in the design and monitoring of the drainage and/or dewatering system.

16. **Environmental and Hazardous Materials Aspects:** Unless otherwise stated, the information contained in this report in no way reflects on the environmental aspects of this project, since this aspect is beyond the Scope of Work and the Contract. Unless expressly included in the Scope of Work, this report specifically excludes the identification or interpretation of environmental conditions such as contamination, hazardous materials, wild life conditions, rare plants or archeology conditions that may affect use or design at the site. This report specifically excludes the investigation, detection, prevention or assessment of conditions that can contribute to moisture, mould or other microbial contaminant growth and/or other moisture related deterioration, such as corrosion, decay, rot in buildings or their surroundings. Any statements in this report or on the boring logs regarding odours, colours, and unusual or suspicious items or conditions are strictly for informational purposes.

17. **Sample Disposal:** Wood will dispose of all uncontaminated soil and rock samples after 30 days following the release of the final geotechnical report. Should the Client request that the samples be retained for a longer time, the Client will be billed for such storage at an agreed upon rate. Contaminated samples of soil, rock or groundwater are the property of the Client, and the Client will be responsible for the proper disposal of these samples, unless previously arranged for with Wood or a third party.

DRAFT

Appendix G
Borrow Assessment

DRAFT

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited
400 – 111 Dunsmuir Street
Vancouver, BC V6B 5W3
Canada
T: +1 604-664-4315

www.woodplc.com

Memo

To:	File		
From:	Chris Davidson, MSc, PGeo	**Reviewer:**	Dr. Ed McRoberts, PhD, PEng
cc:		**Wood File No.:**	VE52705K
Date:	23 September 2021	**Yukon Government No.:**	
Re:	**Riprap and Borrow Sources – Comments and Considerations for Sourcing and Development – 2021 – Clinton Creek Mine, Yukon - Rev 0**		

DRAFT

1.0 Introduction

1.1 Background

Wood Environment & Infrastructure Solutions (Wood) has been retained by the Government of Yukon represented by the Ministry of Energy Mines and Resources (YG) to provide engineering services for the "Clinton Creek Post 10% Design Services" (Project) for the Clinton Creek abandoned mine site about 80 kilometers northwest of Dawson City, Yukon.

In November 2019, Wood concluded the 10% designs and Class 4 cost analyses for three closure concepts for the Clinton Creek side and three closure concepts for the Wolverine Creek side. These closure concepts involved several mitigation options which will require varying amounts of granular aggregate and riprap of suitable quality.

Chilkoot Geological Engineers Ltd. (Chilkoot) prepared a borrow source assessment in 2015 (Chilkoot, 2016) which shortlisted seven sites identified as harbouring potential aggregate and riprap resources which may be suitable for structural applications associated with the mine closure. Of the potential rock quarries, only one site, located on the Top of the World Highway 44 kilometers from the mine entrance, would yield Class III-sized riprap. Similarly, for sand and gravel, only one site, located 14 kilometers from the mine entrance, was considered to have suitable quality and quantity for long term development.

YG identified the significant haul-distance as a potential concern in the request for proposal (RFP) for this work and has requested that Wood provide a "desk-top" assessment of borrow sources closer to the Clinton Creek mine, leveraging the previous work by Chilkoot. The scope has evolved to some extent following the award. Based on evaluation of costs, the borrow issue, while an important design consideration, was found to have limited relevance for the ultimate selection of closure concept and could potentially be deferred, at least in part, in priority of other work and rather Wood was to provide a "path forward" for further evaluation.

'Wood' is a trading name for John Wood Group PLC and its subsidiaries
Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited
Registered in Canada No. 1260467-1; GST: 899879050; DUNS: 25-362-6642

This memo primarily provides comments and considerations for further evaluation of potential borrow sources for the mine closure concepts including a discussion of the activities and methods that could be used going forward to better define borrow sources (granular materials and rip rap). A scaled back evaluation of additional sites that could be considered by YG is also presented based on a desktop assessment expanded from the 2015 Chilkoot work, which was focused solely on the mine site and along the Clinton Creek Road.

1.2 Chilkoot Assessment

The most recent and comprehensive assessment of potential borrow sources was completed by Chilkoot in 2015 (Chilkoot, 2016). They completed a desktop assessment including a literature review of past reports pertaining to the mine and any reports specific to borrow assessment in the area. They also completed review of air photos in the vicinity of the mine and Clinton Creek Road. Chilkoot spent seven days in the field to evaluate the potential sources they identified during the desktop phase and submitted samples from shortlisted quarry/borrow sites for laboratory analysis for moisture, index, durability testing (LA abrasion, absorption and specific gravity) and reaction to concrete (Sulphate analysis).

Chilkoot concluded that because the site remained unglaciated during the last ice age, near surface bedrock tends to be deeply weathered since it was not scoured by ice. In addition, the asbestos/serpentine ore body itself is inherently weak and fractured as are the surrounding ultramafics and argillites within the mine site.
An assemblage of intermediate strength quartzite and schists was described to encompass the weaker rocks in the vicinity of the mine site. The strongest rock Chilkoot identified was at a localized granodiorite stock part of the Prospector Mountain Suite located near Swede Dome along the Top of the World Highway at kilometer 63. Chilkoot identified two other potential quarry areas, one in a 30 m thick layer of quartzite at the entrance of the mine (entrance pit) and a muscovite schist at kilometer 46 of the Top of the World Highway.

DRAFT

Chilkoot comments that the absence of glaciation contributes to difficulties sourcing suitable granular borrow materials, which are often glacially derived elsewhere in western Canada. They identified, however, a number of potential colluvial and fluvial deposits within the mine site and along Clinton Creek Road with four sites being recommended for further assessment. Chilkoot notes that some may be subject to placer claims or other land dispositions.

The locations recommended by Chilkoot for granular borrow and riprap are shown in Figure 1, appended and listed in Section 5.

With respect to the anticipated quantities of materials at that time, Chilkoot noted the absence of large cobbles in the fluvial deposits which would make it difficult to fulfill the "cobble" size requirement. For blast rock and riprap, relatively closely spaced joints in the quartzite at the entrance pit preclude larger sized clasts and the limited extent and awkward geometry of the outcrop will limit volumes. The granodiorite at Top of the World highway, kilometer 63, located 44 kilometers south of the mine entrance, was recommended.

Chilkoot recommended that site specific geotechnical evaluations be carried out at the seven recommended locations to "verify the composition, quality and quantity of the specific borrow sources and identify geotechnical liabilities (i.e. groundwater, permafrost, overburden thickness etc.) and that pit development plans be developed".

1.3 Site History and Updated Borrow Requirements

Portions of the mine tailings and waste rock at the Clinton Creek Mine site failed in the 1970's and created landslide dams in the Clinton Creek and Wolverine Creek valleys, Porcupine Creek valley was blocked by the construction of waste piles. The blockage of Clinton Creek resulted in the creation of the largest reservoir of the three impoundments known as Hudgeon Lake. The spillway from Hudgeon Lake provides an outlet for Clinton Creek, but at a gradient far steeper than the original vertical alignment. On-going poor performance of the spillway has required several repairs. As some options require a steeper gradient a good source of riprap will be an essential requirement for closure design.

Wood has developed closure concepts for both Clinton and Wolverine Creeks as possible long-term solutions to allow for mine closure (Wood, 2019, 2020). Depending on the concept selected, significant quantities of granular material and riprap may be required. Requirements vary between each of the closure concepts and are summarized in Table 1-1 appended.

1.4 Scope of Work

The assessment and comments provided in this memo are intended to build-off the previous work from Chilkoot and fill some of the gaps, including assessment of areas not directly in the mine/along the road that are closer to the mine, and provide a potential path forward for YG in terms of borrow evaluation with respect to the closure requirements. The specific scope of work included the following:

1. Desktop review of additional potential borrow sources. Stereo pair air photos were reviewed in about a 12 km by 12 km area centered on the mine bounded by the Yukon River to the east and Fortymile River to the south to check for borrow sources closer to the mine and along the Clinton Creek Mine Road. Note that airphoto review was aimed at providing a cursory review of major features that are in proximity of the mine and should not be regarded as full-fledged terrain mapping. This desktop scope also included review of the Chilkoot report and the geology thesis by Htoon (1979) for opportunities for additional sources. Areas of potential interest identified by Wood are shown on Figure 1.
2. Discussion on durability parameters for riprap. Wood has completed a literature search to provide guidance for durability evaluation of riprap which was not discussed in detail in the Chilkoot report. The discussion provided is intended to help provide a framework for YG and the Geotechnical Engineer for future phases to assess suitability quality of materials.
3. Sensitivity to haul distance. Wood has undertaken cost analysis as part of other scopes of work to review the impact of haul distance of materials on cost. A summary of this information is provided for overall context.

Sites where there may be potential for additional borrow resources not previously identified are put forward in this memo. These do not consider costs for any new access development or consider land restrictions such as placer claims, private property, or other land dispositions.

DRAFT

2.0 Review of Additional Borrow Sources

Wood has completed desktop review of aerial photographs and available geological reports to identify additional potential borrow sources. Potential sites are shown on the appended Figure 1 and discussed in the following sections.

2.1 Airphoto Review

The terrain surrounding the mine site is an un-glaciated ancient plateau where streams have down cut to form V-shaped valleys between upland areas and ridges, (with Clinton Creek being an exception to this with a relatively broad valley bottom). Elevations normally range from about 300 – 450 m in the valleys to up to 1,000 m at the crest of the ridges with valley slopes around 10 – 20 degrees. The drainages form dendritic pattern of erosion likely reflecting relatively weak rock and that the landscape was not sculpted by glaciers during the last ice age. Htoon (1979) remarks that outcrops make up less than 5% of the area likely for the same reasons. Fortymile River, crossed at kilometer 32 of the Clinton Creek Mine Road, and the Yukon River, about 15 kilometers east of the mine site, are the major drainages in the region.

Airphotos (A21626 Photo 81 to 136, A21627 Photo 1 to 53 and A27995 Photo 63 to 101) were reviewed in stereo to check for the presence of landforms such as terraces and fans indicative of potential granular borrow or escarpments, shelves or other prominences that provide an indication of resistant bedrock, which may be suitable for further checks on quarry potential. Features of potential interest have been delineated and digitized are shown on the appended Figure 1. A summary of the sites identified is listed below.

1. For large parts of the study area, bedrock appears to outcrop along ridge lines or crests of slopes at margins of plateaus with planar slopes mantled in colluvium with an overall dendritic drainage pattern. This type of terrain is interpreted to reflect weathered and/or inherently weak bedrock lithologies.

   Alongside the Clinton Creek Mine road near kilometer 0 to 16 the terrain expression differs, where shelves, knobs and benches are interpreted as shallow rock under a veneer of soil. The distinct expression of these features suggests a more resistant/durable lithology and are delineated on the appended Figure 1 as potential targets for further quarry development assessment.

   Knobby terrain and terrain where the underlying rock has more control on the drainage patterns was noted several kilometers east of the Clinton Creek Road in an area mapped as the intermediate strength schist. Given the distance from available access this location may have limited development potential.

2. Typically, in glaciated terranes, alluvial fans rich in sand and gravel are often deposited at the margins of the U-shaped, glacially sculpted valleys deposited from glacial meltwater and modern stream flows. Drainages within the valley bottom can rework sediment downcutting in areas leaving sand and gravel terraces. There is an absence of these features within the V-shaped valleys within the Clinton Creek area. However, some of the larger valleys do have distinguishable river terraces and alluvial fan deposits from tributary streams. The most accessible location for further assessment is near the crossing of the Fortymile River and townsite where some larger fans and alluvial terraces are located, as shown on the appended Figure 1. An alluvial fan noted along Fish Road located about 2 kilometers east of the Fortymile bridge warrants further checks.

   Chilkoot noted in their report that many of the areas near the river are subject to placer claims and that low lying areas may be predominantly silty with shallow groundwater. They identified three fluvial sites 12, 13, 14a and one colluvial site, 14b, in this area. Site 14b is shown on the appended maps. These are apparently

DRAFT

away from the placer claims but in some cases were observed to have shallow groundwater or shallow rock, which would further limit potential.

It could also be noted that stripping of overburden to get at deeper granulars could make borrow pit development now attractive for placer operations. Some degree of secrecy may be required in borrow investigations.

2.2 Additional Potential Sources

Based on review of the Chilkoot report and the thesis by Htoon, Wood has identified the following sites as potential areas of interest with respect to additional borrow sources:

1. Resistant bedload in creeks. Bedload and rounded boulders near and within Clinton and Porcupine Creeks would have presumably been subject to mechanical abrasion, impact, weathering and freeze thaw as a result of being at the surface and transported within the channel. These rocks are a proxy for resistant rock types eroded from local outcrop or transported by fluvial or colluvial processes from upstream reaches / upslope banks. That is to say, if larger boulders in Clinton Creek have survived continuous mechanical and thermal agitation then the specific source of such more resistant rock may be a potential borrow source. Any assessment of boulder durability in Clinton Creek should not be construed by the Project Partners as a recommendation that boulders in the creek should be mined for riprap.

   Chilkoot noted an approximately 500 m^3 stockpile of rounded boulders between 1.3 – 1.5 m diameter near the outlet of Hudgeon Lake, interpreted to have been sourced from the creek. These were apparently composed of higher-grade serpentine and shale with discontinuity spacings between 0.1 – 0.3 m or less.

   Serpentine and shale are typically low quality and not suitable for aggregate or riprap. The boulders which Chilkoot describe may represent locally resistant portions within a weaker mass and therefore not a viable source of material, depending on volume requirements, as very selective mining of host outcrop would be necessary. Regardless, further work is recommended to assess and characterize the transported materials found in and nearby the creeks which may provide an indication of the geology of the resistant rock types, which could be used to look for the geological source as a potential quarry location.

2. Airfield. Chilkoot noted a thin veneer of overburden of fractured chloritic schist near the airfield. Although there are no further details on the rock or its quality, the fact that the rock is shallow, close to the mine, on a topographic high (favorable geometry for excavation) and along an existing access may warrant further investigation. The airfield is also located near several geologic contacts and isolated outcropping of a subgroup of the ore body assemblage. While the listed rock types are generally considered unsuitable for riprap, it may be worth further ground review or possibly site investigation in the area to further assess its potential. Checks should include areas near the south end of the airstrip where the published mapping shows quartzite as one of the major bedrock lithologies which is endorsed by Chilkoot at the entrance pit.

3. Areas mapped as strong lithologies. Htoon (1979), describes four distinct plutonic events that affected the Clinton Creek area resulting in intrusions of diorites, monzonites and alaskites between the late Triassic and mid Cretaceous. Two large stocks are located 15 kilometers north west and 25 kilometers east of Hudgeon Lake with two other smaller bodies located closer to the mine site. These smaller bodies occur 7 km west of Hudgeon Lake and about 6 km east of kilometer 16 of the Clinton Creek Mine Road and are part of the same Prospector Mountain Suite at Top of the World Highway kilometer 63. The locations of these intrusive bodies are shown on the appended Figure 1.

DRAFT

3.0 Durability Parameters

One of the topics which was not discussed in detail in the Chilkoot report was the physical properties and recommended tests for durability of riprap. This requirement is underscored for long term closure performance. There are a number of durability tests that can be considered when evaluating a potential riprap source which are presented here for information and guidance for future work:

1. Specific Gravity is a dimensionless quantity comparing dry and submerged weight of a sample that is used extensively to evaluate suitability of riprap as it is a fundamental property for erosion control applications. Riprap must be significantly denser than water to remain stable under hydraulic loading. Specific gravity is also considered an indicator of the quality of the rock.
2. Absorption of a rock is measured based on the increase of mass due to water infiltrating the pore spaces within a sample. Water that absorbs significant amounts of water, may be prone to breakdown from freeze thaw or salt crystallization.
3. LA Abrasion is a measure of a materials resistance to abrasion after being subject to attrition, impact and grinding in a steel drum containing steel balls for a certain number of revolutions. While this test is widely used to evaluate aggregates resistance to abrasion; National Cooperative Highway Research Program (NCHRP, 2006) comments this test was developed for concrete aggregates and correlates poorly to performance of larger sized clasts. Conversely, specific gravity and absorption are endorsed as reliable indicators of field performance.
4. Micro Deval is a measure of a materials resistance to abrasion and grinding with steel balls in the presence of water. Some rock types become more prone to degradation when wetted/submerged particularly those with a clay/silt component.
5. Sodium or Magnesium Sulphate Soundness provides an indication of durability relative to accelerated weathering and freeze thaw by subjecting the sample to cycles of immersion then drying in a sodium or magnesium sulphate solution. Crystallization of the salts within the pores and cracks of the specimen lead to degradation of the sample. The magnesium sulphate test is reported to be more severe.
6. Accelerated Freeze Thaw determines the degradation of the rock based on a sample's exposure to multiple freeze thaw cycles in a specialized chamber. The result provides an indication of the rock's resistance to freeze thaw. NCHRP 2006 noted that while this test provided a good indication of performance relative to freeze thaw, sulphate and absorption tests are reliable and less expensive surrogates.

"Pass-fail" thresholds for these tests may be provided in agency guidelines or specified by the design engineer. Table 3-1 below provides a comparison of recommended test results from several agencies which could be helpful to guide the design engineer as part of future work.

DRAFT

Table 3-1: Comparison of Agency Riprap Specifications

Test	BC MoTI Specification (2020)	NCHRP Report 568 (2006)	Yukon Government (personal comm. 2021)
Specific Gravity	>2.5 (ASTM D6473)	>2.5 (AASHTO T 85)	
Absorption	<2% (ASTM D6473)	<1.0% (AASHTO T 85)	
LA Abrasion			<35%
Micro Deval	<20% ASTM 6928-10	<30% Mild Application <20% Moderate <10% Severe or Permanent	
Sodium Sulphate			
Magnesium Sulphate	<10% following 5 cycles (ASTM D5240)	<17.5%	
Accelerated Freeze Thaw		<0.5% (AASHTO T 103 – 25 cycles)	

DRAFT

The rock being considered for riprap should be dense and durable and resistant to breakdown over time within the given environment and application. Given the long-term closure timescales and relatively severe climate/application, it is preferrable to meet more stringent criteria, if possible. This might not be possible, and the selection may devolve to the best available combination considering the options, with the consequences being inevitable replacement as weathering in a severe climate degrades the "best available choice". Material availability, economics, and risk tolerance are considerations. The material must meet the required gradation, not have metal leaching and acid rock drainage (ML/ARD) and demonstrate some degree of competency. Rocks with any significant clay content (e.g. shale or argillite) are not recommended.

The results from the tests completed on rock samples submitted from the sites sampled by Chilkoot are presented in Table 3-2 below. For the tests completed, all are within the recommended thresholds presented in Table 3-1 aside from the absorption for the serpentine sample collected from the mine entrance pit.

The results from a durability perspective are encouraging but more testing with additional test types is recommended to adequately characterize the rock.

Table 3-2: Summary of Results Chilkoot Durability Testing

Sample No.	Location	Rock Type	LA Abrasion	Relative Density	Absorption
1	Top of World Highway – km 63	Granodiorite	14.7	2.719	0.39
2	Top of World Highway – km 46	Muscovite Schist	18.2	2.647	0.31
3	Mine – Entrance Pit	Quartzite	22.6	2.899	0.91
4	Mine – Entrance Pit	Serpentine	Not tested due to health concerns relative to asbestos	2.630	1.72

4.0 Sensitivity to Haul Distance

Table 4-1 was developed to assess the potential influence of granular source locations on the relative costs of the various candidate closure options (both the 10% Base Case Designs (Wood, 2019) and the Alternative Design Concepts (Wood, 2020)). The table was developed from the estimating workbook prepared to support the Alternative Designs Concepts (Wood, 2020) and presents the change in total estimate that results from reductions in the haul distances assumed in the original estimate. The revised average haul distances used (i.e. 5 km and 2 km) are not intended to reflect likely outcomes of future borrow source investigations, but rather to bracket optimistic assumptions about what these future assessments and investigations might deliver.

Table 4-1 predicts that more proximate granular sources would generate comparatively modest cost reductions for most of the candidate closure options. The maximum cost benefit reaches 15% for the most fill intensive closure option on Wolverine Creek (i.e. WC2). However, even in this case, WC2 remains the most costly alternative for the Wolverine side of the property. Wood concludes from this assessment that the cost of granular fill sources, while important considerations for detailed closure designs and execution planning, are not likely to have significant influences on the concept select, phase of Partner deliberations. Of more importance is the long-term durability of rip/rap given the extreme environment.

DRAFT

5.0 Conclusions

Based on the desktop review completed by Wood, five additional areas have been identified as potential sources for granular borrow or riprap. These are listed below along with the Chilkoot recommended sites for reference and are shown on Figure 1:

Table 5-1: Summary of Wood Potential Site and Chilkoot (2016) Recommended Sites

Site	Location	Type
Wood #1	Host outcrops of resistant bedload found in Clinton and Wolverine Creek.	Potential rip rap source
Wood #2	Shallow rock near the airfield.	Potential rip rap source
Wood #3	Alluvial terraces and fans near the Fortymile River crossing (Clinton Creek Road km 33).	Possible source of granular material
Wood #4	Areas of benched shallow rock near the Clinton Creek Road between km 0 to 16.	Potential rip rap source
Wood #5	Additional plutonic stocks of the Prospector Mountain Suite.	Potential rip rap source
Chilkoot Mine Site 1	Existing quarry at the entrance to the mine site. Serpentine over quartzite.	Existing rock quarry
Chilkoot Mine Site 5	Former granular quarry on the mine site south of the road that leads to the tailings and former mill area.	Existing granular borrow source
Chilkoot Site 10	Fluvial materials located near km 24.9 of the Clinton Creek Road consisting of poorly graded gravelly sand.	Existing granular borrow source
Chilkoot Site 11	Fluvial terrace located near km 26.6 of the Clinton Creek Road	Existing granular borrow source
Chilkoot Site 14b	Fluvial deposit near the former town site at Fortymile River near Km 33.2 of the Clinton Creek Road.	Existing granular borrow source
Chilkoot Top of World Highway	Existing rock quarry located at km 46 of top of world highway.	Existing rock quarry
Chilkoot Top of World Highway	Existing rock quarry located at km 63 of top of world highway.	Existing rock quarry

In conclusion it can be noted that:

The haul distance costs as a percentage of total option cost may not be high. Of more importance within a closure time frame is long term durability and/or an option less reliant on rip/rap durability.

Based on the economics discussed in Section 4, overall concept selection is not likely to be driven by issues surrounding haul distance; however, it is important for detailed design. Further work is required to verify desktop observations and characterize the deposits to evaluate if they offer benefit from those previously identified by Chilkoot.

Initial work should include ground-based reconnaissance to verify the desktop interpretations and to collect samples for laboratory testing. For granular deposits, observations should be made with respect to soil classification, stratigraphic relationships, and potential for shallow groundwater. For potential quarry sites, observations with respect to lithology, mechanical properties and structure, including joint spacing, are important.

With respect to durability testing for riprap, the more stringent of the pass/fail criteria from the three agencies presented is recommended, given the severity of the climate and application with respect to long term closure. Specific gravity, absorption and magnesium sulphate should form the backbone of the testing program alongside micro deval, accelerated freeze thaw and LA abrasion. Wood notes that while highway design requires durable granular material replacement with time is part of operational cost for roads. But closure embodies much longer time frames and the bar should be set as high as possible.

Additional testing should be completed on both the newly identified and previously identified quarry locations.

Further review and resolution of any land use conflicts or dispositions is required.

Field work should be completed by a qualified professional experienced with bedrock and engineering geology. Execution and interpretation of laboratory materials testing would be undertaken by experienced materials testing professionals. ML/ARD testing should also be completed at all sites where quarrying or additional excavation in rock is anticipated.

Where warranted, sites from the five listed above may be added to the seven sites shortlisted by Chilkoot for further work and reprioritized as necessary for detailed geotechnical investigation. Subsurface investigation including test pitting, drilling and geophysics may be required at the direction of the qualified professional. In general, checks should be made to confirm volumes and suitable quality as well to check for adverse geotechnical conditions such as shallow groundwater, permafrost or geohazards such as flooding or mass wasting.

DRAFT

6.0 Closure

This memo is based on desktop review of the sources referenced intended to provide guidance to the Project's Geotechnical Engineer for consideration with respect to future borrow evaluations. The final determination of feasibility, practicality, and suitability of potential borrow sources from a geotechnical point-of-view will be subject to the outcome of additional geotechnical site investigation and design.

This memo is subject to the attached Limitations.

Sincerely,
Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

Chris Davidson, MSc, PGeo
Senior Engineering Geologist

Reviewed by:

Ed McRoberts, PhD, PEng
Principal Engineer

DRAFT

Attachments
Tables
Figure 1
Limitations

7.0 References

Chilkoot Geological Engineers, Ltd. (CGE). 2016. *Geotechnical Evaluation, Borrow Source Assessment - Clinton Creek Area, Dawson, Yukon*. Prepared for Yukon Government, Energy, Mines and Resources, Assessment and Abandoned Mines.

Htoon, Myat. 1979. *Geology of the Clinton Creek Asbestos Deposit, Yukon Territory*. A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science, University of British Columbia. March 1979.

National Cooperative Highway Research Program (NCHRP). 2006. *Riprap Design Criteria, Recommended Specifications, and Quality Control.* Report 568. Transportation Research Board.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project, 10% Design Phase Report*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

DRAFT

Tables

Table 1-1: Granular Requirements by Candidate Closure Option

Option	Task	Subtask	Item	Description	Unit	Total Qty
CC1	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	19,000
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	33,000
	Flow Conveyance	Spillway	Spillway and Channel Construction	Select Granular Supply for Densifications	m^3	115,000
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
CC1-A	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	2,120
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	21,500
	Flow Conveyance	Spillway	Spillway and Channel Construction	Select Granular Supply for Densifications	m^3	0
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
CC1-B	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	2,120
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	21,500
	Flow Conveyance	Spillway	Spillway and Channel Construction	Select Granular Supply for Densifications	m^3	0
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
CC2	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	37,020
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	10,200
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=175mm	m^3	4,670
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
CC2-A	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	37,020
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	10,200
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=175mm	m^3	4,670
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
CC2-B	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=500mm	m^3	37,020
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	10,200
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=175mm	m^3	4,670
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
CC3	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	5,700
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	6,150
WC1	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
	Flow Conveyance	Sediment Pond	Wolverine Creek Diversion	Wolverine Riprap for diversion channel armouring	m^3	600
WC2	Materials Management	Earthmoving - Load & Haul	Tailings Dump	Compacted Granular Fill (Berm)	-	358,000
	Materials Management	Earthmoving - Load & Haul	Buttress Fill Dam	Select Rockfill Shell and Backfill Volume	-	192,000
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=200mm	m^3	2,085
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	2,270
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=450mm	m^3	2,470
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=800mm	m^3	11,640
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=1000mm	m^3	5,290
	Flow Conveyance	Spillway	Spillway and Channel Construction	Bedding Gravel	m^3	1,135
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
WC2-A	Materials Management	Earthmoving - Load & Haul	Tailings Dump	Compacted Granular Fill (Berm)	-	3,310
	Materials Management	Earthmoving - Load & Haul	Tailings Dump	Compacted Granular Fill (Berm)	-	358,000
	Materials Management	Earthmoving - Load & Haul	Buttress Fill Dam	Select Rockfill Shell and Backfill Volume	-	0
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=200mm	m^3	0
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=300mm	m^3	0
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=450mm	m^3	3,310
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=800mm	m^3	0
	Flow Conveyance	Spillway	Spillway and Channel Construction	Riprap d50=1000mm	m^3	0
	Flow Conveyance	Spillway	Spillway and Channel Construction	Bedding Gravel	m^3	0
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950
WC3	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Bedding gravel	m^3	8,200
	Flow Conveyance	Sediment Pond	Sediment Pond Earthworks	Rip Rap Pond Dikes inside and outside Placed	m^3	9,500
	Flow Conveyance	Sediment Pond	Clinton Creek Diversion	Clinton Riprap for diversion channel armouring	m^3	2,950

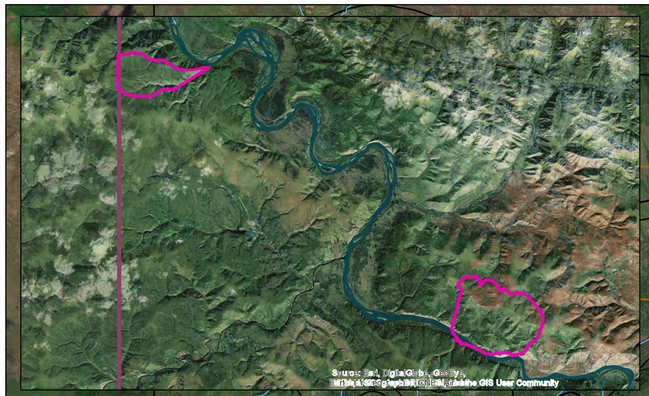
DRAFT

Table 4-1: Influence of Granular & Rip Rap Source on Total Estimate

	Base Estimate (11 & 64 Km Hauls)		5 Km ave Haul (Airstrip Source)				2 Km ave Haul (Local Sources)			
Option	Total	Total (Rounded)	Total	Total (Rounded)	Savings		Total	Total (Rounded)	Savings	
					$	%			$	%
CC1	$307,415,050	$310,000,000	$298,407,670	$300,000,000	$9,007,380	3%	$296,397,326	$300,000,000	$11,017,724	4%
CC1-A	$133,652,729	$130,000,000	$128,102,562	$130,000,000	$5,550,167	4%	$127,267,548	$130,000,000	$6,385,182	5%
CC1-B	$130,848,792	$130,000,000	$125,296,631	$130,000,000	$5,552,160	4%	$124,460,620	$120,000,000	$6,388,171	5%
CC2	$196,700,417	$197,000,000	$189,564,939	$190,000,000	$7,135,478	4%	$188,486,330	$188,000,000	$8,214,087	4%
CC2-A	$150,040,955	$150,000,000	$139,690,321	$140,000,000	$10,350,634	7%	$138,178,403	$140,000,000	$11,862,552	9%
CC2-B	$177,454,650	$180,000,000	$167,080,307	$170,000,000	$10,374,343	6%	$165,556,535	$170,000,000	$11,898,116	7%
CC3	$289,973,701	$290,000,000	$289,073,063	$289,000,000	$900,638	0%	$288,858,472	$289,000,000	$1,115,229	0%
WC1	$49,653,572	$50,000,000	$48,110,809	$50,000,000	$1,542,764	3%	$47,839,629	$50,000,000	$1,813,943	4%
WC2	$309,478,289	$310,000,000	$280,987,803	$280,000,000	$28,490,486	9%	$268,153,284	$270,000,000	$41,325,006	15%
WC2-A	$126,541,300	$130,000,000	$124,219,650	$120,000,000	$2,321,650	2%	$123,810,741	$120,000,000	$2,730,560	2%
WC3	$261,053,732	$260,000,000	$259,433,967	$260,000,000	$1,619,765	1%	$259,124,287	$260,000,000	$1,929,445	1%

DRAFT

Figure 1



Prospector Mountain Suite

Areas of Knobby Terrain

Airfield

Mine Site 5 – Granular Borrow Area

Mine Site 1 – Entrance Pit - Rock Quarry

CCR Site 14 – Km 33.2 - Granular Borrow Area

CCR Site 11 – Km 25.6 - Granular Borrow Area

CCR Site 10 – Km 24.9 - Granular Borrow Area

Clinton Creek

Clinton Creek Road

Fish Road

Wetlands

Terrain

DMF1 DMF3 DMF4 DMF5 CPSM2 CPSM4 TrJ1 LKgP

N

0 1 km

Legend

Chilkoot 2016

Recommended Borrow Site

Wood 2021

Indicator or Reclaimed Road

Indicator or Planned Road

Air Photo Location

Air Photo Line

Contour - 10 - Current

CPSM Monzodiorite/diorite to Porphyritic Granite

CPSM Monzodiorite/diorite to Porphyritic Granite

CPSM Monzonite/Peridotite to Granite/Granitic Dike

CPSM Monzonite/Peridotite to Granite/Granitic Dike

DMF1 Hornfelsed Sedimentary Rock

DMF3 Hornfelsed Sedimentary Rock

DMF4 Hornfelsed Sedimentary Rock

DMF5 Hornfelsed Sedimentary Rock

TrJ1 Granite/Granodiorite to Monzonite

TrJ1 Granite/Granodiorite to Monzonite

References: Geology from Geological Survey of Canada

CLIENT: KONKOMA ENERGY MINERAL AND RESOURCE

Wood
Environment & Infrastructure Solutions
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9

DATUM: NAD 83

PROJECTION: UTM Zone 8

SCALE: 1:10,000

PROJECT: CLINTON CREEK POST 10 DESIGN SERVICES
CLINTON CREEK YUKON

TITLE: RIPRAP AND BORROW SOURCE

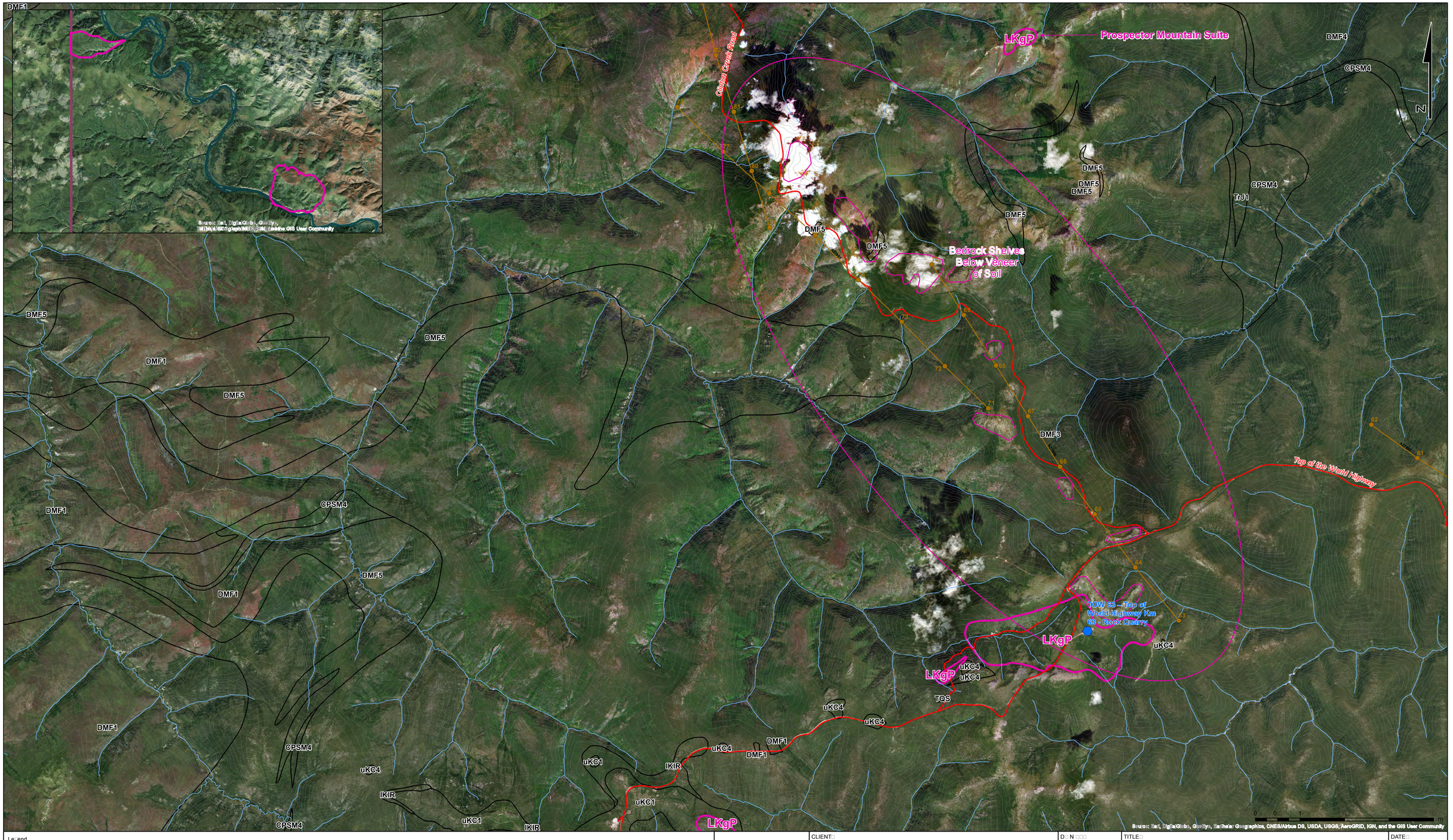
DATE: SEPTEMBER 2021

PROJECT NO: VE10K

REV NO: 0

SHEET 1 OF 1

Title: Proposed Borrow Sources 00 Sheet 0 of 0 Clinton Creek Site Reclamation 0.00 - Initial Plan Drawing created in Colour



Le□end

Chilkoot 2016

- Re□ommended □orro□ □ite□
- Air P□oto Lo□tion□
- Air P□oto Line□
- Conto□r□ - □0□ - C□n□e□

Wood 2021

- Indi□tor o□Re□i□t□nt Ro□□
- Indi□tor o□□r□n□l□r De□o□it

- CP□M□□d□nite□eridotite□□r□□□r□ite□di□□□e□er□entinite
- DM□1□□-□-i-□□□i□t□m□□i□olite□□-□nei□□□□-□-□-i-i-□□i□t□□-□-□-i-□□□i□t□□□lite□□□rt□ite□ltr□m□i□□
- DM□□□□□rt□ite□r-□□□rt□ite□t-m-□-i-□□□i□t
- DM□□□□□rt□ite□r-□□□rt□ite□t-m-□-i-□□□i□t
- DM□□□m□r□le
- T□□□□□□lt□t□□□re□i□
- TrJ1□□r□illite□□nd□tone□lime□tone
- IKIR□□e□□le to □o□□le□on□lomer□te
- □KC1□□□□lt□re□i□□nde□ite□or□□r□d□□ite□tr□□□te
- □KC□□□□le□□nd□tone□on□lo□t□□□o□l

References:

□eolo□□□□r □□oto lo□tion□□nd li□□t line□□o□r□ed □om □eo□□□on □tt□□□m□□er□i□e□□o□□□□□□eo□□□on□

CLIENT□ □□KON ENER□ □□MINE□ AND RE□O□RCE□	D□ N □□□ □□ C□K D □□□ CD	TITLE□ RIPRAP AND □ORRO□ □O□RCE□	DATE□ □EPTEM□ER □0□1
□ ood En□ironment □ In□r□□tr□□t□re □ol□tion□ 3456 Opie Crescent Prince George, BC, CANADA V2N 2P9	DAT□M□ NAD □□ PROJECTION□ □TM □one □ □CALE□ 1□□0 000	PROJECT□ CLINTON CREEK PO□T 10□ DE□I□N □ER□ICE□ CLINTON CREEK□□□KON	PROJECT NO.□ □E□□0□K RE□ NO□□ 0 □I□□RE 1 □□EET □O□ □

□□□ I□Pro□e□t□□□E□□E□□□00□□E□□□0□□□o□t□□□on□Clinton□Cree□□E□□□0□K 00□-□i□1-□itePl□n-□0□m□d

T□□dr□□in□□□□ ori□in□l□□rod□□ed in □olo□r□

Limitations

Limitations

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:
   a) The contract between Wood and the Client, including any subsequent written amendment or Change Order duly signed by the parties (hereinafter together referred as the "Contract");
   b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by Wood to the Client in connection to the Contract; and
   c) The limitations stated herein.
2. **Standard of care:** Wood has prepared this report in a manner consistent with the level of skill and are ordinarily exercised by reputable members of Wood's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guaranty, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.
3. **Limited locations:** The information contained in this report is restricted to the site and structures evaluated by Wood and to the topics specifically discussed in it, and is not applicable to any other aspects, areas, or locations.
4. **Information utilized:** The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions, and qualifications/limitations set forth in this report.
5. **Accuracy of information:** No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). Wood cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.
6. **Report interpretation:** This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by Wood.
7. **No legal representations:** Wood makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.
8. **Decrease in property value:** Wood shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.
9. **No third-party reliance:** This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or Contract. Any use or reproduction which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. Wood does not represent or warrant

DRAFT

the accuracy, completeness, merchantability, fitness for purpose or usefulness of this document, or any information contained in this document, for use or consideration by any third party. Wood accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on this report or anything set out therein. including without limitation, any indirect, special, incidental, punitive, or consequential loss, liability or damage of any kind.

10. **Assumptions:** Where design recommendations are given in this report, they apply only if the project contemplated by the Client is constructed substantially in accordance with the details stated in this report. It is the sole responsibility of the Client to provide to Wood changes made in the project, including but not limited to, details in the design, conditions, engineering, or construction that could in any manner whatsoever impact the validity of the recommendations made in the report. Wood shall be entitled to additional compensation from Client to review and assess the effect of such changes to the project.
11. **Time dependence:** If the project contemplated by the Client is not undertaken within a period of 18 months following the submission of this report, or within the time frame understood by Wood to be contemplated by the Client at the commencement of Wood's assignment, and/or, if any changes are made, for example, to the elevation, design or nature of any development on the site, its size and configuration, the location of any development on the site and its orientation, the use of the site, performance criteria and the location of any physical infrastructure, the conclusions and recommendations presented herein should not be considered valid unless the impact of the said changes is evaluated by Wood, and the conclusions of the report are amended or are validated in writing accordingly.

    Advancements in the practice of geotechnical engineering, engineering geology and hydrogeology and changes in applicable regulations, standards, codes or criteria could impact the contents of the report, in which case, a supplementary report may be required. The requirements for such a review remain the sole responsibility of the Client or their agents.

    Wood will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.
12. **Limitations of visual inspections:** Where conclusions and recommendations are given based on a visual inspection conducted by Wood, they relate only to the natural or man-made structures, slopes, etc. inspected at the time the site visit was performed. These conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in Wood's opinion, for direct observation.
13. **Limitations of site investigations:** Site exploration identifies specific subsurface conditions only at those points from which samples have been taken and only at the time of the site investigation. Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions.

    The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite this investigation, conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

    Final sub-surface/bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports.

DRAFT

Bedrock, soil properties and groundwater conditions can be significantly altered by environmental remediation and/or construction activities such as the use of heavy equipment or machinery, excavation, blasting, pile-driving or draining or other activities conducted either directly on site or on adjacent terrain. These properties can also be indirectly affected by exposure to unfavorable natural events or weather conditions, including freezing, drought, precipitation and snowmelt.

During construction, excavation is frequently undertaken which exposes the actual subsurface and groundwater conditions between and beyond the test locations, which may differ from those encountered at the test locations. It is recommended that Wood be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered at the test locations, that construction work has no negative impact on the geotechnical aspects of the design, to adjust recommendations in accordance with conditions as additional site information is gained, and to deal quickly with geotechnical considerations if they arise.

Interpretations and recommendations presented herein may not be valid if an adequate level of review or inspection by Wood is not provided during construction.

14. **Factors that may affect construction methods, costs and scheduling:** The performance of rock and soil materials during construction is greatly influenced by the means and methods of construction. Where comments are made relating to possible methods of construction, construction costs, construction techniques, sequencing, equipment or scheduling, they are intended only for the guidance of the project design professionals, and those responsible for construction monitoring. The number of test holes may not be sufficient to determine the local underground conditions between test locations that may affect construction costs, construction techniques, sequencing, equipment, scheduling, operational planning, etc.

    Any contractors bidding on or undertaking the works should draw their own conclusions as to how the subsurface and groundwater conditions may affect their work, based on their own investigations and interpretations of the factual soil data, groundwater observations, and other factual information.

15. **Groundwater and Dewatering:** Wood will accept no responsibility for the effects of drainage and/or dewatering measures if Wood has not been specifically consulted and involved in the design and monitoring of the drainage and/or dewatering system.

16. **Environmental and Hazardous Materials Aspects:** Unless otherwise stated, the information contained in this report in no way reflects on the environmental aspects of this project, since this aspect is beyond the Scope of Work and the Contract. Unless expressly included in the Scope of Work, this report specifically excludes the identification or interpretation of environmental conditions such as contamination, hazardous materials, wild life conditions, rare plants or archeology conditions that may affect use or design at the site. This report specifically excludes the investigation, detection, prevention or assessment of conditions that can contribute to moisture, mould or other microbial contaminant growth and/or other moisture related deterioration, such as corrosion, decay, rot in buildings or their surroundings. Any statements in this report or on the boring logs regarding odours, colours, and unusual or suspicious items or conditions are strictly for informational purposes.

17. **Sample Disposal:** Wood will dispose of all uncontaminated soil and rock samples after 30 days following the release of the final geotechnical report. Should the Client request that the samples be retained for a longer time, the Client will be billed for such storage at an agreed upon rate. Contaminated samples of soil, rock or groundwater are the property of the Client, and the Client will be responsible for the proper disposal of these samples, unless previously arranged for with Wood or a third party.

DRAFT

Appendix H
Lake Drawdown Assessment

DRAFT

Memo

To:	Yukon Government, Assessment and Abandoned Mines		
From:	Duncan Hendricks, R.P.Bio	**Reviewer:**	Louise Porto, R.P.Bio.
cc:		**Wood File No.:**	VE52705K
Date:	22 October 2021		
Re:	**Assessment of the Drawdown of Hudgeon Lake on Downstream Aquatic Ecosystem of Clinton Creek**		

1.0 Introduction

The Clinton Creek Mine is a former asbestos mine that was operated between 1968 and 1978. The mine is located approximately 100 km northwest of Dawson City, Yukon, near the confluence of Fortymile River and the Yukon River. In 1974, waste material placed on the south slope of the Clinton Creek valley failed, blocking the Clinton Creek channel. The failure created a landslide dam, which impounded water upstream, producing what is now known as Hudgeon Lake. The south tailings lobe also failed in 1974, blocking Wolverine Creek, a tributary to Clinton Creek downstream of Hudgeon Lake.

Three options are being considered by the Project Partners for the remediation of the Clinton Creek side of the former mine site. These are:

- **CC1 - Water Passage and Catastrophic Failure Mitigation (LCCA Option D3, I2)** – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure of the pile and construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek. Under this option, the lake level would remain at approximately 412 m; the present day level. Drawdown of the lake would be required for construction.
- **CC2 - Water Passage, Catastrophic Failure Mitigation and Lowering Lake (LCCA Option E3)** – Conduct sufficient work on the waste rock pile to mitigate a catastrophic failure, construct a water conveyance channel to provide water passage from Hudgeon Lake to Clinton Creek, and lower Hudgeon Lake as part of that concept. Under this option the lake level would be reduced by 12 m to 13 m. For construction the water level would require temporary further lowering.
- **CC3 - Water Passage with Reduction of the Lake Level, Eliminating the Dam, and Mitigating Catastrophic Failure (LCCA Option F)** – Conduct sufficient work on the waste rock pile to prevent it from acting as a Dam (i.e., as defined by the Canadian Dam Association) on Clinton Creek and to mitigate a catastrophic failure of the waste rock pile. Construct a water conveyance channel to provide water passage through the site. Under this option, the lake would be substantially removed.

Alternative designs are also being considered for CC1 and CC2. The channel vertical and horizontal alignment is substantially unchanged in these designs; however, the side slopes are steepened to reduce excavation and the channels are designed to accommodate a smaller design flood.

As described above, several potential options were reviewed, including modifications that retained the existing lake, partial drawdown of the lake to lower its level, and complete removal of the lake (Wood 2020).

DRAFT

This memo provides a preliminary assessment of whether these three options could be constructed without adverse effects to fish and fish habitat resulting from the process of drawing down the lake to assist in option selection. This memo does not provide a detailed effects assessment of any of the options, nor does it provide a detailed mitigation or monitoring plan for construction of a preferred option. It is expected that an environmental assessment and environmental management plan would need to be prepared upon selection of a preferred option.

2.0 Existing Conditions

Clinton Creek is a tributary of the Fortymile River, which flows into the Yukon River approximately 4.6 km downstream of the confluence of Clinton Creek and the Fortymile River. The watershed has an area of approximately 205 km^2. Currently, water discharging from Hudgeon Lake flows southeast via Clinton Creek to Fortymile River, approximately 8 km downstream. There are four gabion drop structures located in Clinton Creek downstream of the lake (DS1, DS2, DS3 and DS4), constructed between 2002 and 2004. The downstream drop structure (DS4) was upgraded and repaired in 2015, following damage sustained in 2010. Damage to DS4 was noted in the field following the spring freshet in 2018, and additional damage was caused to the drop structure during a flood event in August 2018. Supplementary repairs to DS4 were then completed in the fall of 2018 (TetraTech 2018).

At some time post mine-closure, the north tailings pile also blocked Wolverine Creek. At present, there are two ponds which have formed along Wolverine Creek, one upstream of the north tailings lobe and one between the two tailings lobes, referred to as North and South Ponds, respectively. The North Pond discharges into the South Pond and flows from the South Pond is conveyed south via a constructed channel into Wolverine Creek, finally discharging into Clinton Creek near the site gate.

Numerous studies have been conducted on the Clinton Creek watershed since the impoundment of Hudgeon Lake in 1974 (von Finster 2012). These studies have included assessments of water quality, invertebrate community, fish habitat, and fish populations. The following sections draw on these previous studies to provide a description of the existing conditions in Clinton Creek downstream of the lake.

2.1 Clinton Creek

2.1.1 Stream Water Quality

Water quality parameters in Clinton Creek have been assessed during a number of studies. These studies have shown that concentrations for a number of parameters were elevated relative to background levels. In Clinton Creek, boron, manganese, and nickel were often elevated relative to background levels, and in Wolverine Creek, antimony, boron, and nickel were often elevated relative to background levels. These results are generally consistent with the observation that metals such as nickel, cobalt, chromium, and manganese are often released from materials rich in chrysotile asbestos (Schreier et al. 1987).

In a study by Minnow (2010), concentrations of sulphate, cadmium, and chromium were occasionally above both background levels and water quality guidelines for protection of aquatic life in samples collected in Clinton Creek and Wolverine Creek, indicating limited potential for adverse effects to biota.

Wood (2020) reviewed existing water quality data for background upstream and down stream, and Hudgeon Lake and compared them with the CCME's protection of Aquatic Life guideline criteria. The maximum total selenium concentration in the Hudgeon Lake is lower than that analyzed in the upstream water bodies but higher than that recorded for the downstream water bodies. However, for the dissolved selenium concentration,

DRAFT

the Hudgeon Lake's level is slightly higher than that observed in the upstream and the downstream water bodies. For both total and dissolved selenium, the recorded concentrations are higher (except the upstream average concentration) than the CCME FAL guidelines.

For total and dissolved arsenic, the average Hudgeon Lake's recorded concentrations levels are lower than the CCME FAL criteria but higher for the maximum recorded values. Both dissolved and total arsenic average and maximum levels are higher in the lake when compared with the upstream and the downstream recorded concentrations.

Sulphide levels in Clinton Creek downstream of the lake are acceptably low and oxygen levels sufficiently high for aquatic life (DFO 2007). Overall, water quality sampling indicates a wide range of substances occur at concentrations above background levels, but guidelines for protection of aquatic life were rarely exceeded (Minnow 2010; Wood 2020).

Asbestos fibre concentrations downstream of the mine are elevated in comparison with background levels. However, the effects of asbestos fibre exposure on fish populations in Clinton Creek is unclear (Fisheries and Environment Canada 1977, RRU 1999).

2.1.2 Macroinvertebrate Community

Benthic macroinvertebrate communities are important components of aquatic ecosystem, and they are good indicators of water quality conditions. As a result, benthic invertebrates are useful for monitoring the effects of disturbances on aquatic ecosystems. A number of studies have characterized the benthic community in Clinton Creek, primarily with goal of determining potential adverse effects from the mining operations.

Fisheries and Environment Canada (1977) determined that invertebrate communities had been adversely affected by mining operations. Similarly, analysis by Minnow (2010) indicated that benthic invertebrate communities in mine-exposed areas were distinct from the reference communities sampled. Benthic macroinvertebrate communities in the mine-exposed areas of the Clinton Creek watershed had more chironomids and fewer Plecoptera than reference areas (Minnow 2010). Although the benthic invertebrate community structure in Clinton Creek was different than reference sites, Minnow (2010) found the benthic macroinvertebrate community in the Fortymile River downstream of Clinton Creek was similar to the reference communities. Similarly, WMEC (2008) found a preference for low oxygen and pollution tolerant species at the lake outflow location.

Overall, Minnow (2010) found that data indicated that there were mine-related effects on the benthic macroinvertebrate communities downstream of the Clinton Creek Mine; however, these communities were not definitively outside the range of conditions found in reference streams, with the exception of Wolverine Creek. Mine influence was most evident in Wolverine Creek. There was no evidence of mine-related effects in the Fortymile River (Minnow 2010).

2.1.3 Fish and Fish Habitat

Numerous fish surveys have been conducted in the Clinton Creek watershed as well as well as within Fortymile River since the formation of Hudgeon Lake (Fisheries and Environment Canada 1977, Delaney et al. 1981, RRU 1999, von Finster 2012). There is minimal information on fish distribution prior to lake formation. The species of fish captured in Clinton Creek include Arctic Grayling (*Thymallus arcticus*), Chinook Salmon (*Oncorhynchus tshawytscha*), Longnose Sucker (*Catostomus catostomus*), Burbot (*Lota lota*), Slimy Sculpin (*Cottus cognatus*), Lake Chub (*Couesius plumbeus*), Lake Whitefish (*Coregonus clupeaformis*), and Round Whitefish (*Prosopium cylindraceum*; Fisheries and Environment Canada 1977, von Finster 2005, 2012, Minnow 2009a, 2009b). Arctic

DRAFT

Grayling have been captured in Hudgeon Lake, and it is assumed that Clinton Creek within the current footprint of the lake, and upstream, was used by fish on a seasonal basis (Delaney et al. 1981, von Finster 2012). The gabion drop structures at the outlet of Hudgeon Lake prevent upstream fish movement. Consequently, the lake and areas upstream are now considered fishless, with no fish captured in recent studies.

Downstream of Hudgeon Lake, Clinton Creek provides good rearing and overwintering habitat for juvenile Chinook Salmon and Arctic Grayling (Delaney et al. 1981, von Finster 2012). The lack of deep pool habitat was noted by WMEC (2008, 2009); however, juvenile Chinook Salmon do not require pools for overwintering. In addition, Arctic Grayling migrate out of Clinton Creek in the autumn, and do not overwinter in the stream.

Numerous studies (e.g., Fisheries and Environment Canada 1977, Delaney et al. 1981, RRU 1999, von Finster 2012) have reported the capture of juvenile Chinook Salmon in this part of Clinton Creek. Genetic studies indicate that these Chinook Salmon are from stocks that spawn in the Yukon River and tributaries (including the Teslin, Big Salmon, and Nordenskiol rivers) upstream from Fortymile River (Mackenzie-Grieve 2010).

Beaver activity in Clinton Creek has apparently increased markedly in recent decades, resulting in changes to fish habitat in the lower reaches of the stream and potentially affecting Chinook Salmon movement and habitat use (von Finster 2012). The beaver dams present barriers to fish movement within the stream, at least during some flow conditions (Netro 2008). To address beaver activity and impoundments, a program managed by Dawson District Renewable Resources Council since 2006 has moved Chinook Salmon from the mouth of Clinton Creek to the upper reaches (e.g., Smart 2007).

Fish distribution and habitat use in the lower reaches of Clinton Creek can vary considerably from year to year (von Finster 2012), with beaver impoundments playing a large role in distribution. In particular, adult Arctic Grayling distribution has varied markedly between years. Clinton Creek provides suitable habitat for Arctic Grayling spawning, and it appears that Arctic Grayling have spawned within Clinton Creek in some years (Delaney et al. 1981, von Finster 2012). Arctic Grayling use of Clinton Creek is seasonal, with Arctic Grayling moving into Clinton Creek in spring and migrating out in the autumn. Adult Chinook Salmon have not been captured in Clinton Creek, and there is no evidence that salmon spawn in the stream. This is likely because flows in Clinton Creek are not sufficient during the upstream migration and spawning period for Chinook Salmon (von Finster 2012).

Groundwater discharges in Clinton Creek immediately downstream of the mine site provide high-quality fish habitat, including providing overwintering habitat for juvenile Chinook Salmon. Open-water conditions have been observed at the mouth of Wolverine Creek as a result of these groundwater flows (A. von Finster, Pers. Comm., 2021). These groundwater flows may be related to alterations to the groundwater flow from mining activities (von Finster 2012).

Royal Roads University Applied Research Division (1999) suggested that there has been an increase in Chinook Salmon population in Clinton Creek and a shift in composition from Artic Grayling to Chinook Salmon from 1980 to 1999. However, it should be noted that this is speculative in nature, and there is insufficient data to draw a conclusion on any shifts in species composition.

The tributaries to Clinton Creek appear to provide moderate quality fish habitat, although they are generally shallow (Fisheries and Environment Canada 1977). Wolverine Creek does not currently support fish, likely as a result of an impassable culvert at the confluence with Clinton Creek. Fish use of Wolverine Creek prior to mining activities is not known (Marty et al. 2013).

DRAFT

2.2 Hudgeon Lake

Hudgeon Lake has a surface area of approximately 65 Ha and a volume of 6.7 x 10^6 m^3, with a maximum depth of 27 m (Liebau 2010). Hudgeon Lake is classified as a meromictic lake, meaning that the lake only mixes partially on an annual basis. This is in contrast to most inland freshwater lakes that are holomictic and mix completely (Kalff 2002) or dimictic, mixing twice per year (during spring warm-up and autumn cool-down). Because there is no mixing of waters within the lake, the lake remains continuously stratified. In a meromictic lake, the mixolimnion is the upper layer that is subject to mixing and temperature stratification. The monimolimnion is the higher density layer that is not mixed and is anoxic. The layer in between the mixolimnion and the monimolimnion is a layer where salinity and other water quality parameters change, known as the chemocline or halocline. In Hudgeon Lake, the chemocline is between 7 and 9 m (Liebau 2010).

Below 5 m, salinity and total dissolved solids increase markedly and are considered brackish to slightly saline at the bottom. During the summer, dissolved oxygen decreases below 5 m, with the water becoming anoxic at approximately 10 m. Sulfide concentrations increase substantially below 9 m (as oxygen concentrations decrease), reaching concentrations of 1.5 mg/L near the bottom of the lake (Liebau 2010). The entire lake becomes anoxic during winter when the lake is ice covered (von Finster 2012). Although fish have been captured in Hudgeon Lake, the anoxic conditions limit available fish habitat and likely prevent overwintering in the lake (UMA 2008).

The surface layer of the lake warms considerably during summer months, reaching over 20 °C in some years (Liebau 2010). The warming of the lake has substantial effects on productivity in the lake and downstream in Clinton Creek (Liebau 2010). The water temperatures of Hudgeon Lake decrease to approximately 0 °C at depth. This is due to the presence of permafrost in the basin that now contains the lake before inundation. This is unlike the typical northern lake where there is an unfrozen zone below the lake.

3.0 Proposed Lake Drawdown

Each option to drawdown Hudgeon Lake requires substantial effort and some may not be effective and/or feasible for all candidate options. The specific method for drawing down Hudgeon Lake will be the subject of additional assessment and optimization following option selection and subsequent design development activity. Pumping was selected as the preferred drawdown method for the purposes of 10% design phase because it offers flexibility in controlling drawdown rates and therefore relative certainty in outcomes.

For the 10% design, it was assumed that:

- the lake would be lowered by 5 m each construction season;
- the drawdown would be achievable in a 1-month period after freshet (June); and
- spare capacity is required to maintain the drawdown after rainfall and summer storms.

As the lake level lowers, the volume of water required to be pumped reduces for a given 5 m interval. Taking into consideration summer storms, pump downtime and other uncertainties, during the 10% design phase a system was selected that has a maximum pumping rate of 3.6 m^3/s to a head of up to 8 m.

The drawdown process for all three options would be similar, although the total drawdown depth would vary depending on the option. For the 10% design, an assumption was made that Option CC1 would require a total temporary drawdown of approximately 10 m for the period of construction, from 412 to 402 m, to allow for the civil works proposed in this option, including spillway construction. The drawdown process would be conducted

DRAFT

for a period of 10 to 20 days each summer at variable pumping rates depending on inflows (up to 3.6 m^3/s), with a reduction in lake depth of approximately 5 m each year. The lake drawdown of 10 m would be achieved over 2 year period. After construction, lake levels would gradually be allowed to return to 412 m while always ensuring adequate flow in the stream to support the aquatic environment.

Option CC2, would require a permanent drawdown from 412 to 400 m, with an additional drawdown of 5 m depending on site conditions and construction methods (to approximately 395 m) to allow for the civil works. Similar to CC1, the rate of drawdown would be approximately 5 m per year, with the total required drawdown being achieved in 4 years. After construction, lake levels would return to 400 m.

For option CC3, the drawdown process would be conducted for a period of 10 to 20 days each summer over 6 years, at a rate of approximately 5 m per year, to achieve a total drawdown of 27 m. The drawdown would be staged to allow for the reconstruction of temporary spillways each year to allow passage of freshet. Concept CC3 includes a dedicated sediment control structure because the exposure of previously submerged valley slopes is expected to generate significant sediment loads during execution. Monitoring and managing sediments will likely be a significant issue during execution that may also require the application of observationally driven, supplementary mitigative measures (e.g., targeted removal of select, exposed lake sediment accumulations seen to be contributing disproportionately to sediment discharges).

4.0 Effects Assessment

Drawdown of Hudgeon Lake, and the associated removal of the drop structures downstream of the lake in Clinton Creek may have a number of effects on aquatics resources. These include the following:

- Decreased likelihood of major flood event related to breach of the impoundment.
- Improved access to upstream fish habitat after drawdown.
- Decreased buffering effect of the lake on high flows, including during snow melt.
- Increased discharge and associated effects on fish habitat in Clinton Creek during drawdown.
- Increased sediment load in Clinton Creek.
- Potential effects to water temperature and quality downstream during drawdown.
- Long-term effects to water temperature and productivity downstream after drawdown.

The effects of lake drawdown and removal have not been widely studied. The most comparable event that has been studied is the removal of dams and the resulting reservoir on impounded systems; however, these studies were in very dissimilar lakes compared with Hudgeon Lake (which is meromictic). As a result, it is difficult to look to other studies to predict the effects on Clinton Creek. The potential effects of lake drawdown are discussed in more detail in the sections below.

4.1 Impoundment Failure

All reclamation options will reduce or eliminate the potential for a failure of the dam and flood event in Clinton Creek. The high-water event resulting from failure could alter habitat considerably through flooding and smothering with sediments and have a direct effect on the primary productivity, the invertebrate community, and the fish community in Clinton Creek. This risk was identified by Royal Roads University Applied Research Division (1999). A flood event could also potentially release large quantities of poor-quality water, including potentially high levels of H_2S (Liebau 2010). Such an event would likely have a temporarily devastating effect on the aquatic

DRAFT

community in Clinton Creek, including juvenile Chinook Salmon rearing habitat. Consequently, the lake drawdown could provide considerable benefit by reducing this risk (Liebau 2010).

4.2 Fish Movement

Currently, both the water quality of Hudgeon Lake and the drop structures at its outlet present a barrier to upstream fish movement. Option CC1 will not result in improved fish passage upstream into the lake, and the dam will remain a barrier to fish movement. Both Options CC2 and CC3 would restore access to the upper reaches of Clinton Creek and its tributaries for seasonal fish use. Option CC2 would include the construction of new channel from the lake to the existing Clinton Creek channel, at a gradient that would allow fish passage upstream into the lake and its tributaries. CC3 will allow for fish passage once sediment loading from the upstream environment has stabilised and the sediment pond is removed. Access to the upper reaches would likely benefit Arctic Grayling, which have historically been found in Hudgeon Lake, and potentially Chinook Salmon as well.

4.3 Downstream Fish Habitat

The drawdown of the lake proposed under all three options will result in short-term increases in flow in Clinton Creek downstream of the lake for up to six years. The proposed discharge rate up to 3.6 m^3/s is in the region of typical freshet flows out of Hudgeon Lake and would represent a substantial increase compared with the average flow during much of the year. The drawdown would effectively increase the duration of the freshet by up to a month each year until the desired lake level is attained.

Water depths would generally increase in the stream, potentially creating more pool habitat. Water velocities in the stream would also increase, potentially decreasing habitat quality for rearing juvenile fish. However, these changes to fish habitat would be short in duration, lasting approximately one month each year. There would likely be no long-term effects to fish habitat from this temporary increase in discharge in Clinton Creek below the dam as a result of increased flows during drawdown. The increased flows may decrease habitat suitability for juvenile fish, such as the Chinook Salmon that utilize the stream, as water velocities will likely increase in the stream. A detailed assessment of the effects of this flow increase on fish habitat would need to be conducted to better assess effects on habitat suitability in Clinton Creek.

4.4 Water Quality

The water quality in Hudgeon Lake has the potential to affect the aquatic community downstream of the lake during the drawdown process. Water quality parameters of importance include dissolved oxygen concentrations, water temperature, as well as metals, sulphide, and asbestos concentrations.

All three options proposed would require a temporary or permanent drawdown of the lake to some extent, varying from 10 to 27 m. The hydrodynamics of Hudgeon Lake during the potential drawdowns are poorly understood. Hudgeon Lake is unusual because it is both meromictic and within a permafrost basin, with bottom water temperatures of approximately 0 °C. The potential effects on lake mixing from wind and water withdrawals is complex and is poorly understood, even in more commonly studied dimictic lakes (Bocaniov et al. 2014). UMA (2008) suggest that lowering the lake level would not result in seasonal turnover of the lake from either wind-driven energy inputs or through density-driven effects. Lowering the lake level would result in a lower surface area and reduced exposure to the wind, potentially decreasing wind energy input (UMA 2008). Partial lowering of the lake under option CC2 will probably not result in a change from the lake's meromictic state and turnover of

DRAFT

the lake (UMA 2008). In addition, the lake will continue to experience anoxic conditions during the winter ice-covered period.

As the lake level drops in preparation for construction, the surface mixing of the lake should continue, oxygenating the lower portions of the lake. This mixing should maintain a surface mixolimnion of approximately 5 m, but it is not known at this time. At some point during complete lake drawdown proposed in option CC3, the lake may become shallow enough for wind-induced mixing and stream inflow to turnover the lake, oxygenating the entire volume of water.

Oxygen levels within the lake discharge water is an important consideration in assessing the potential effects on the downstream aquatic community. Based on limnological studies of Hudgeon Lake, the upper 5 m of the lake remain oxygenated during summer months. Because water will be drawn from the surface of the lake, it will draw oxygenated water and discharge it into the stream. Given the rate of drawdown of the lake, it is anticipated that the drawdown intake will remain within the oxygenated portion of the lake at all times. This is supported by the UMA (2008) suggestion that the oxygenated zone (approximately 5 m in depth) will remain intact during the lowering of the lake level. However, mixing within the lake during drawdown is not understood at this point. The draw of water at the surface may pull less oxygenated water from deeper parts of the lake. Aeration of the discharge water will occur at the energy dissipation structure at the outlet; however, at the 10% design phase it was assumed that the water would be otherwise untreated. Aeration of the lake itself has been proposed by others as a method to improve water quality in the lake (Liebau 2010). This approach could be explored as a method of improving water quality prior to discharge to mitigate any potential adverse effects resulting from poor water quality.

The surface water of Hudgeon Lake can warm substantially during the summer, and the increased discharge of large quantities of warmer water into the stream downstream of the lake may result in an increased mean water temperature during the drawdown period. At this time, no modelling has been completed to determine the potential changes in temperatures within Clinton Creek downstream of the lake. Any increase in temperature will likely have a temporary beneficial effect on productivity in Clinton Creek. An assumption was made in the 10% design phase that the plan to lower the lake each year post-freshet would not result in harmful water quality of high temperatures downstream. Because the drawdown period each year is proposed to be just after the freshet and for a period of less than one month, the potential adverse effects to the aquatic ecosystem from any potential variation in temperature is expected to be negligible.

Sulphide levels in lake water need to be considered as part of the lake drawdown process. Although sulphides are not present in the water near the drawdown intake, sulphides are present in the anoxic deeper portions of the lake. The effects of the drawdown process on lake mixing are not known, and consequently, there is the possibility that sulphides could be discharged during lake drawdown. At this point in the design process, it has been assumed that natural aeration at the outlet energy dissipator is the only treatment required.

Based on several studies that have been conducted since the formation of Hudgeon Lake, a number of water quality parameters in Clinton Creek are above CCME guidelines. However, the discharge of surface water from Hudgeon Lake during drawdown should not result in any increases in the concentration of these parameters, simply a temporary increase in overall discharge. There should be no adverse effects to the aquatic community from metals or asbestos fibres as a result of lake drawdown process.

After drawdown, there will be some sediment movement downstream as the channel cuts through sediments deposited since 1974. It is expected that this will result in higher initial sediment loads in Clinton Creek because

wood.

of the erosion of this material. The design proposed in Wood (2020) incorporates a sediment pond, which should reduce movement of larger sediment into lower Clinton Creek. It is acknowledged that mitigating the movement of finer sediment will be challenging. The potential adverse effects of sediment movement following lake drawdown is partially mitigated through the design, however, it is likley that some of the unknown fine sediments that will come out of the lake could remain suspended through the sediment ponds and discharge into the downstream environment as turbid water. This turbid water may discharge into Fortymile River; however, the effects would be negligible given the low discharge rates compared to the discharge in the downstream receiving streams where freshet water levels will likely remain high during the discharge period.

5.0 Conclusions and Recommendations

A number of aspects of the Clinton Creek aquatic ecosystem have a high degree of uncertainty at this time. As a meromictic lake in a permafrost zone, Hudgeon Lake has unusual water quality characteristics. Although the lake has been extensively studied, the effects of lowering the lake level on characteristics of the lake, such as the chemocline and water chemistry is uncertain. The slow lowering of the water level of the lake over up to six years is likely to mitigate many of the potential adverse effects; however, how the dynamics of the lake change over the years as the depth of the lake is decreased is difficult to assess. Water quality in the deeper waters of the lake is currently not suitable for aquatic life, but this is anticipated to change markedly with drawdown and potential mixing of the monimolimnion. The nature of changes in water quality in the lake are highly uncertain at this time.

It is highly likely that overall temperatures in Clinton Creek will decrease with the removal of Hudgeon Lake. The reduction in temperature may have potentially adverse effects on productivity in Clinton Creek as the temperature regime will be restored to pre-impoundment conditions. In turn, this may result in changes to the fish community.

The assessment of potential effects from the drawdown has been based on the proposed options and a drawdown rate of up to 3.6 m^3/s over approximately one month each year, over a span of up to 6 years. At this rate, there will be a substantial increase in discharge in the lower reaches of Clinton Creek during the drawdown, and potential adverse effects to fish habitat. In general, reducing the drawdown rate will decrease potential adverse effects in the lower reaches; however, it is recognized that the drawdown must be achieved within a reasonable time frame, and the proposed drawdown rate is likely an acceptable compromise.

While quantifying effects is beyond the scope of this memo, Wood concludes that the assumptions made for the 10% design for drawdown rates and methods are reasonable and do not supersede the assumption that geotechnical constraints are the dominant factor. The drawdown and resulting increased discharge in Clinton Creek will likely have some short-term adverse effects; however, these will be short in duration, lasting less than a month each year.

If planning for lake drawdown proceeds, a number of recommendations can be made at this time to better understand the ecosystem and monitor the effects.

- Model increased flow in Clinton Creek resulting from the discharge during drawdown to better understand potential effects on water temperature and fish habitat at various flows.
- Model lake dynamics under withdrawal conditions, if feasible, to assess water quality in discharge water.
- Assess the potential of lake aeration as a means to improve water quality in Hudgeon Lake to determine if it would be beneficial.

DRAFT

It is anticipated that the development of a detailed monitoring plan would be required as part of the regulatory approval process for any instream works. This plan would include monitoring of key water quality parameters in the lake, discharge water, and Clinton Creek during drawdown to ensure water quality remains acceptable and to better understand changes in the lake as lake levels decrease. In addition, the plan would likely include monitoring of fish populations during and after drawdown in Clinton Creek to understand potential changes in the fish community.

DRAFT

6.0 Closure

Sincerely,
Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

Duncan Hendricks, R.P.Bio
Senior Aquatic Biologist

Reviewed by:

Louise Porto, R.P.Bio
Senior Aquatic Biologist

7.0 References

Bocaniova, Serghei, C. Ullmanna, K. Rinkea, K.G. Lambb, B. Boehrer. 2014. Internal waves and mixing in a stratified reservoir: Insights from three-dimensional modeling. Limnologica 49 (2014) 52-67.

Boehrer B., U. Kiwel, K. Rahn, M. Schultze. 2014. Limnologica 44 (2014) 81-89.

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. (plus updates).

Delaney, P.W., R. Stewart, D. Konasewich and G.A. Vigers. 1981. Assessment of the Effects of the Clinton Creek Mine Waste Dump and Tailings, Yukon Territory. EVS Consultants. Prepared for Cassiar Resources Ltd. 65 p. & Appendices.

Environment Canada. 2009. August 2009 – Clinton Creek Mine Site Visit (Type II). Memo to Rachel Pugh, Yukon Government from Martin Guilbeault, Environment Canada November 24, 2009.

Fisheries and Environment Canada. 1977. An Environmental Assessment of the Effects of Cassiar Asbestos Corporation on Clinton Creek, Yukon Territories. Surveillance Report. EPS 5-PR-77-3. 38 p.

Kalff, J. 2002. Limnology: inland water ecosystems. Prentice Hall, Upper Saddle River, New Jersey.

Laberge Environmental Services. 2009. Summary of Environmental Monitoring Activities at the Abandoned Clinton Creek Asbestos Mine, 2009. January 2010.

Liebau, W.H.O. 2010. Hydrogen Sulphide in Hudgeon Lake, Yukon: Evaluation and Remediation Options. MSc. Thesis. 91 p.

Mackenzie-Grieve, J. October 26, 2010. Clinton Creek jcs Genetics. Memo to file. DFO OHEB. 18 pp.

DRAFT

Marty, G.D., J. Mackenzie-Grieve, J. Miller and M. Guilbeault. 2013. Health Assessment of Slimy Sculpin in Three Yukon Streams. Aquatic Health Centre, Fisheries and Oceans and Environment Canada. 68 pp.

Minnow Environmental Inc. 2010. Assessment of 2009 Aquatic Data for Clinton Creek Mine, July 2010, Project No. 2315.

Minnow Environmental Inc. 2009a. Assessment of Existing Chemical and Biological Data for Clinton Creek Mine, Yukon. November 2009, Project No. 2298.

Minnow Environmental Inc. 2009b. 2009 Study Recommendations (for the Clinton Creek Mine closure process). July 15, 2009, 4 pp.

Netro, G. 2008. Rearing and Overwintering Access Restoration 2008. Prepared for the Yukon River Panel by Dawson Renewable Resources Council. 30 pp.

Risley, J, S.J. Brewer, R.W. Perry. 2010. Simulated effects of dam removal on water temperatures along the Klamath River, Oregon and California, using 2010 Biological Opinion flow requirements. USGS.

Roach, P., and R. Ricks. 2003. Abandoned Clinton Creek Asbestos Mine - Fish Salvage July 31-August 02, 2003. License 03-19. Northern Affairs Program. 9 p.

Royal Roads University Applied Research Division (RRU). 1999. An Environmental Review of the Clinton Creek Abandoned Asbestos Mine, Yukon, Canada. Prepared for Indian and Northern Affairs Canada. 100 p. & Appendices.

Schreier, H., T.G. Northcote, and K. Hall. 1987. Trace metals in fish exposed to asbestos rich sediments. Water, Air, and Soil Pollution 35(1987): 279-291.

Smart, C. 2007. Rearing and overwintering access restoration. Dawson District Renewable Resources Council. 29 pp.

UMA Engineering Ltd. 2008. Former Clinton Creek Asbestos Mine: Review of Suggested Improvements to Hudgeon Lake. UMA Project 6029 009 00 (4.6.1). April 2008.

von Finster, A. 2012. Distribution and Habitat Utilisation of Clinton Creek by Fish: State of Knowledge to March, 2012. Prepared for Government of Yukon Energy, Mines and Resources, Assessment and Abandoned Mines. AvF R&D. 31 p.

Wood. 2020. Clinton Creek Remediation Project 10% Design Phase Report. 102 pp. plus appendices.

WMEC (White Mountain Environmental Consulting). 2008. Clinton Creek Mine Site Fisheries and Benthic Invertebrate Assessment Monitoring, 2007.

WMEC (White Mountain Environmental Consulting). 2009. Clinton Creek, Fish Community Survey September, 2009. November 2009.

DRAFT

Appendix I
Pit Closure Assessment

DRAFT

#600 – 4445 Lougheed Highway
Burnaby, BC, V5C 0E4
T: +1 604-294-3811
www.woodplc.com

Memo

To:	Project File: VE52705K.002
Company:	Government of Yukon-Energy, Mines and Resources Assessment and Abandoned Mines
From:	Brian Geddes
Date:	30 September 2021
CC:	**Wood**: Geoff Graham, Ed McRoberts, Karen Hincks **Yukon:** Carrie Gillis, Senior Project Manager – Type II Mines
Ref:	VE52705K.002
Re:	**Clinton Creek Remediation Project - 2021 Data Gaps Report – Pit Closure Assessment**

DRAFT

This memorandum presents the work undertaken to-date under Wood's current Post 10% Design Services scope relating to the assessment of options for pit closure at the former Clinton Creek mine site. This memorandum will ultimately form a component of the 2021 Data Gaps Report that is currently in preparation. The Table of Contents for this memorandum is presented herein as Attachment A.

This document incorporates comments on a 31 May 2021 draft received by Wood from the Project Partners. This version is issued as a draft for review by the project's Independent Peer Review Panel (IPRP).

This assessment is entirely restricted to the Porcupine, Snowshoe, and Creek Pits from a safety perspective. It has been assumed that pit water qualities are such that unacceptable environmental impacts and/or risks will not be associated with, or created by, ongoing groundwater seepage and/or pit surface water discharges in the post closure landscape. Wood considers these site characterization related assumptions as reasonable in light of current understandings of general conditions on the Clinton property. However, pit specific data validating these assumptions is not available and will be required to support any future advancement of these concepts.

1.0 Pit Closure Assessment

1.1 Background

1.1.1 Scope Development

The Clinton property's Common Elements were discussed in the Environmental Characterization Update Report (Wood, 2019i), but closure designs, particularly for the former mine pits (Porcupine, Snowshoe and Creek Pits) were not advanced in any detail because closure actions were viewed as likely to be influenced or defined by the broader closure strategy adopted for the property (e.g., utilization of pits for storing spoil generated by many of the candidate options). The closure concept assessment for the pits that is described in this section, makes the assumption that the broader property closure plan is not integrated with closure requirements for the pits, and does not significantly influence those requirements (i.e., that pit closure actions will be largely stand-alone activities). In practice, pit plans will be integrated to at least some degree with the broader property plan. However, assessing these 'stand-alone' concepts for the pits

establishes a baseline that provides context for the likely scope and cost influences of pit closure, while avoiding the need to consider an unwieldy number of permutations and combinations of potential pit and property closure concepts.

The closure options considered for the pits will include those identified in Yukon's scope of work (Section 1.3), specifically:

- no action (beyond potentially imposing access restrictions);
- maintenance of a lake (presumably at levels that can be sustained passively);
- backfilling as needed to eliminate water accumulations; and
- complete pit backfilling.

Given the paucity of geotechnical (including rock mechanics) data for these pits and as-built geometry, closure concepts have been based on judgements about the configurations needed to sustain physical integrity and/or stability (i.e., concepts are indicative of potential requirements, not designs validated by the requisite characterization data).

1.2 Pit Descriptions and Characterizations

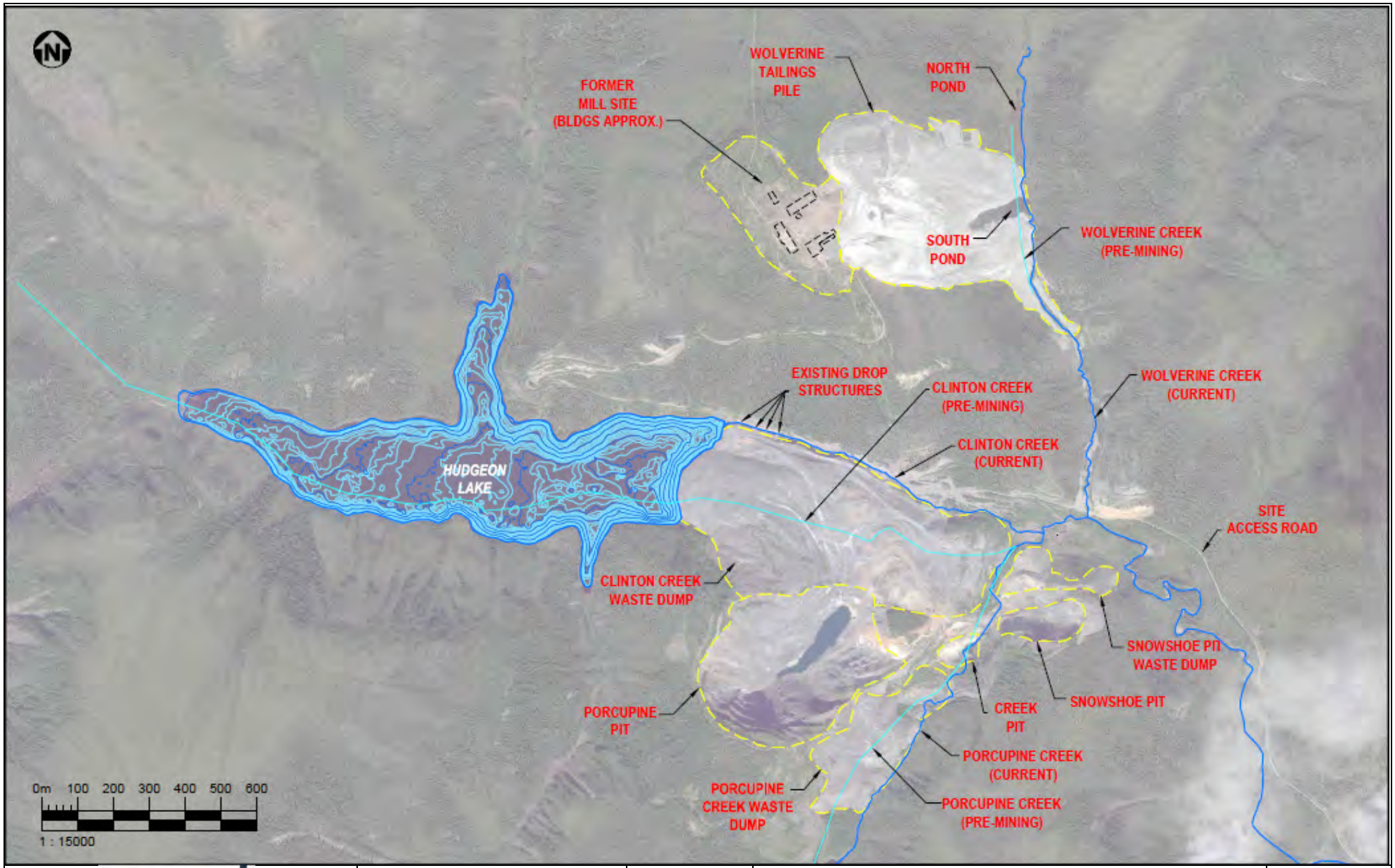
This assessment considers closure options for the three pits, shown on Figure P1, specifically the Porcupine, Snowshoe and Creek pits.

1.2.1 Development History

Amec Foster Wheeler (2018a) provides the following overview of pit and dump development, prepared from a review of aerial photographs, one oblique aerial photograph, a bedrock geology report (Htoon, 1979) and consultant reports (Golder, 1978; Hardy, 1977).

> *While the schedule for the operations is not clear, it appears overburden soils were stripped from the pit area and was deposited into both Porcupine Creek, as well as off the south Clinton Creek valley wall. As a practical matter, the direction of dumping would be determined by shortest haul as well as the condition of the haul roads.*
>
> *Golder (1978) provided the following comments with regards to Porcupine Creek:*
>
> - *West bank dumping has led to instability interrupting drainage course.*
> - *Argillite dumps have forced the creek to the east (or right).*
> - *In areas where Serpentine rock dump dominated, the creek disappeared into the waste dump and flowed beneath the surface.*
>
> *It is also commented on by Hardy (1977) that water was percolating under the spoil piles. This also appears to be the case as seen in the 1993 aerials.*
>
> *The evidence in a 1993 photo suggests less slope instability than reported by Golder. This may be due to the dumps stabilizing against the east valley wall. There is some evidence that wet finer grained overburden spoil was placed in the upper portion of the valley bottom, and that the spoil flowed to a relatively flat angle. Then a waste rock dump was advanced over this material with the dump appearing stable.*
>
> *The gradient from the small ponded area up-creek to the Creek Pit is about 100 m drop over 1 km.*
>
> *The gradient from the creek towards the Porcupine Pit is about 100 m in 500 m. There is no obvious impact of this gradient on Porcupine Pit stability.*

DRAFT



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□ A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT	DATE□ M□□□□0□1
C□K□D □□□ □□		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ □ormer Clinton Cree□ Mine □ite □ □ener□l Arr□n□ement	RE□□NO□1
PROJETION□ NAD □□		RE□□DATE□ □e□t□□0□1
□CALE□ A□ □□O□ N		□I□□RE NO□ P1

1.2.2 Bedrock Stability and Seepage

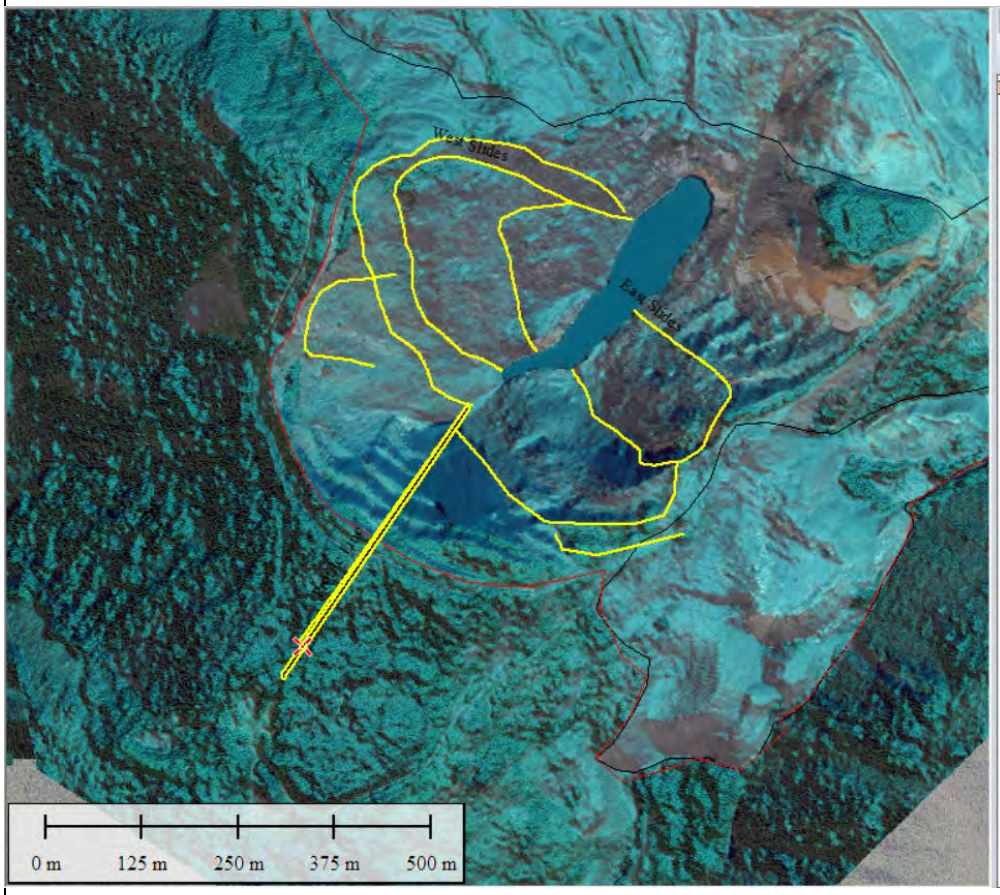
While noting that there has been little emphasis on bedrock properties in site investigations conducted on the property to date, Wood (2019e) offered the following overview of bedrock stability and seepage characteristics in the pit area:

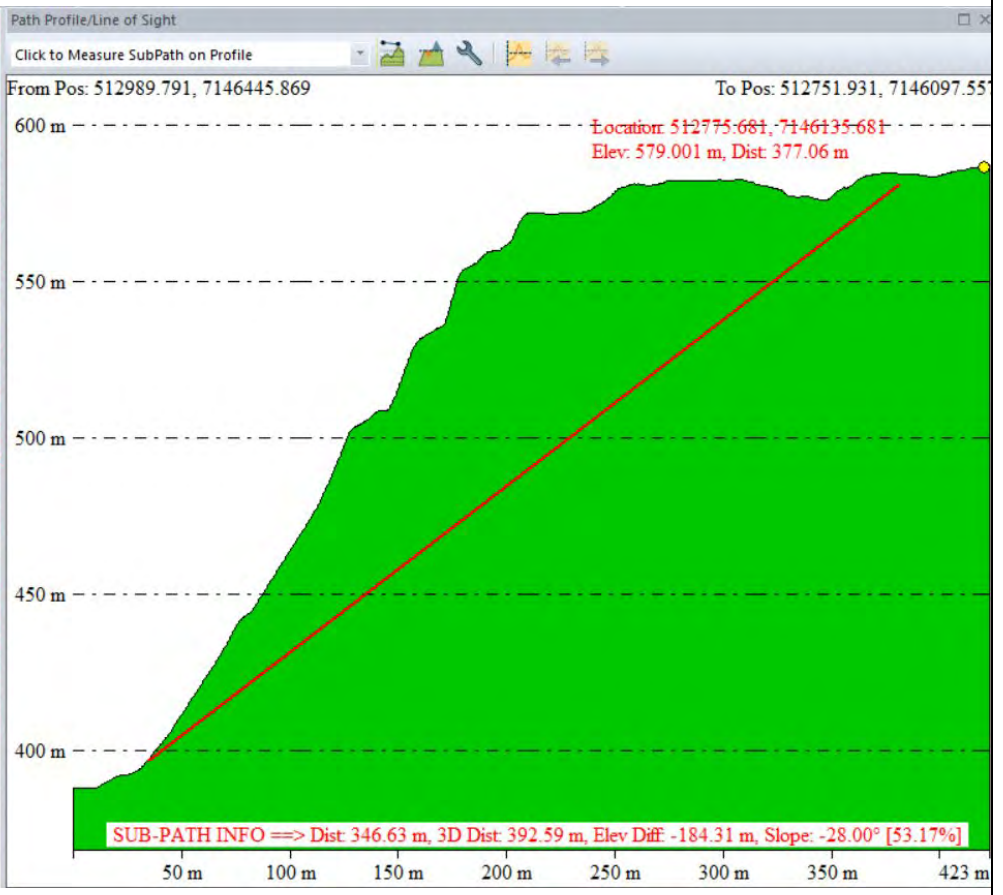
> *Aerial photograph review of Porcupine Pit indicates that some pit segments, seated in argillite dominated bedrock are prone to weathering. These fall down slopes are in the order of 26 to 27 degrees (2H:1V). Unfailed pit slope segments in the quartzite are at about 45° (1 H:1 V) and what fall down slopes that can be identified in the quartzite are about 35° (1.4H:1V). Serpentine rock may give rise to lower frictional strengths creating small scale failures. One of the photographs presented in Figure 4-1 shows the condition of the pit walls as of June 2019.*
>
> *The bedrock assemblages are highly folded, jointed, and faulted. Stepanek and McAlpine (1992) discuss the Yukon Cataclastic Complex of two main assemblages, the first a sheared assemblage with ultramafic, metamorphosed and igneous rocks including serpentinite, diorite, amphibolite, and schist and the second assemblage a weakly deformed assemblage including shale, siltstone and sandstone with some local phyllite and phyllonite of Mid to upper Triassic age. The ore was cross-fibre chrysolite asbestos veinlets cutting jade-green serpentine. Overall the bedrock at the site is criss-crossed by steep normal faults and thrust faults. The normal faults are near-vertical and tend to bound the ore body, while the thrust faults are low angle and tend to occur along the contact of the two assemblages.*
>
> *As far as can be determined, the water level in the Porcupine Pit is about the same as Clinton Creek at the confluence with Porcupine Creek and appears to have maintained this level for several decades (at elevation 375 masl). This suggests some degree of faulting providing pathways in a north/south direction and is consistent with Htoon (1979). This is an important premise as option development may require significant infilling of Porcupine Pit with wastes. Given the current understanding, it is conceptualized that placing wastes back into the pit will not result in a significant rise in the water table in the pit.*
>
> *Snowshoe Lake (which we interpret as what was Creek Pit) exhibits differential lake levels; however, survey data of the differing lake levels is not available in the provided EDI reports (EDI, 2018). The EDI reports do indicate that in July 2018, the newly installed staff gauge was dry, while in September 2018, the staff gauge was completely underwater, indicating large water fluctuations. EDI has commented that both Upper Snowshoe Lake and Lower Snowshoe Lake, both located within the Porcupine Creek valley in the vicinity of the former Creek Pit, have high water fluctuations, and that the mechanism of how water moves into and out of these lakes is unknown. However, based on Htoon (1979), the Porcupine Creek valley appears to be bounded on both sides by faults, which could be providing a highly fractured zone which could result in fracture flow of groundwater, which daylights in this area of the site.*

DRAFT

1.2.3 Porcupine Pit Slide Areas

An examination of LiDAR images for the Porcupine Pit shows evidence of slides in the northwest and southeast sections of the pit (see Figure P2). The specific failure mechanisms that produced these slides have not been identified or assessed in any detail. The influence that material movements in these areas will have on slope stabilities is therefore particularly uncertain. In this early evaluation of pit closure options, this additional uncertainty will likely require mitigation via limiting the materials movements prescribed in slide areas and/or by the conservative targeting of stabilizing measures (e.g., placement of buttressing fills over slide toes).





Note: □lide □re□□ □re deline□ted in □ello□

wood. En□ironment □ In□□tr□□t□re □ol□tion□ □ Di□i□ion o□□ ood C□n□d□ Limited 1□□□□ □ □□A□en□e □□rre□□□C □□N □P□ Tel□□0□-□□□-□□□□	Client□ Yukon	D□ N □□□ □□ C□K□D □□□ □□ DAT□M□ NAD □□ PROJETION□ NAD □□ □CALE□ A□ □□O□ N	PROJECT□ CLINTON CREEK REMEDIATION PROJECT TITLE□ Por□□□ine Pit □lide Are□□	DATE□ M□□□□0□1 Pro□e□t no□ □E□□□0□K□00□ RE□□NO□ RE□□DATE□ □I□□RE NO□ P□

1.2.4 Pit Contours and Storage Capacities

1.2.4.1 Topographic Data

Two Digital Elevation Models (DEM) surfaces, a 1949 DEM (with three different vertical adjustments), and a 2012 DEM, and an Arctic DEM were used to describe pit contours and calculate storage volumes. The contours generated using these data are shown for the Clinton property generally on Figure P3 and for the pits area in particular on Figures P4 and P5.

1.2.5 Storage Capacities

Appendix G of Wood (2019c) provided the following summary of storage volume estimates for the three Clinton pits.

1.2.5.1 Porcupine Pit

The elevation of the standing water in the pit is approximately 376 m and the elevation of the lowest portions of the pit rim is at 418 m. The overall geometry of this pit is somewhat atypical with the highest pit slopes to the south and the north pit wall being a lower elevation pillar of in-situ overburden and bedrock between the pit and Clinton Creek valley.

Assuming that a partial shell with an overall 3H:1V slope is constructed from the low point of the pit rim, the overall storage capacity of the Porcupine Pit, not including volumes below the existing water level, would be some 23.9 M m^3 (see Figure 5.2 of Wood (2019c), Appendix G).

1.2.5.2 Snowshoe and Creek Pits

The geometry of the Snowshoe Pit is also atypical (i.e., side cut into a hill), and the pit does not have a closed rim. This limits the option of increasing storage capacity via the kind of constructed perimeter shell assumed for the Porcupine Pit. Given this, the overall storage capacity of the Snowshoe Pit was estimated to be about 800,000 m^3.

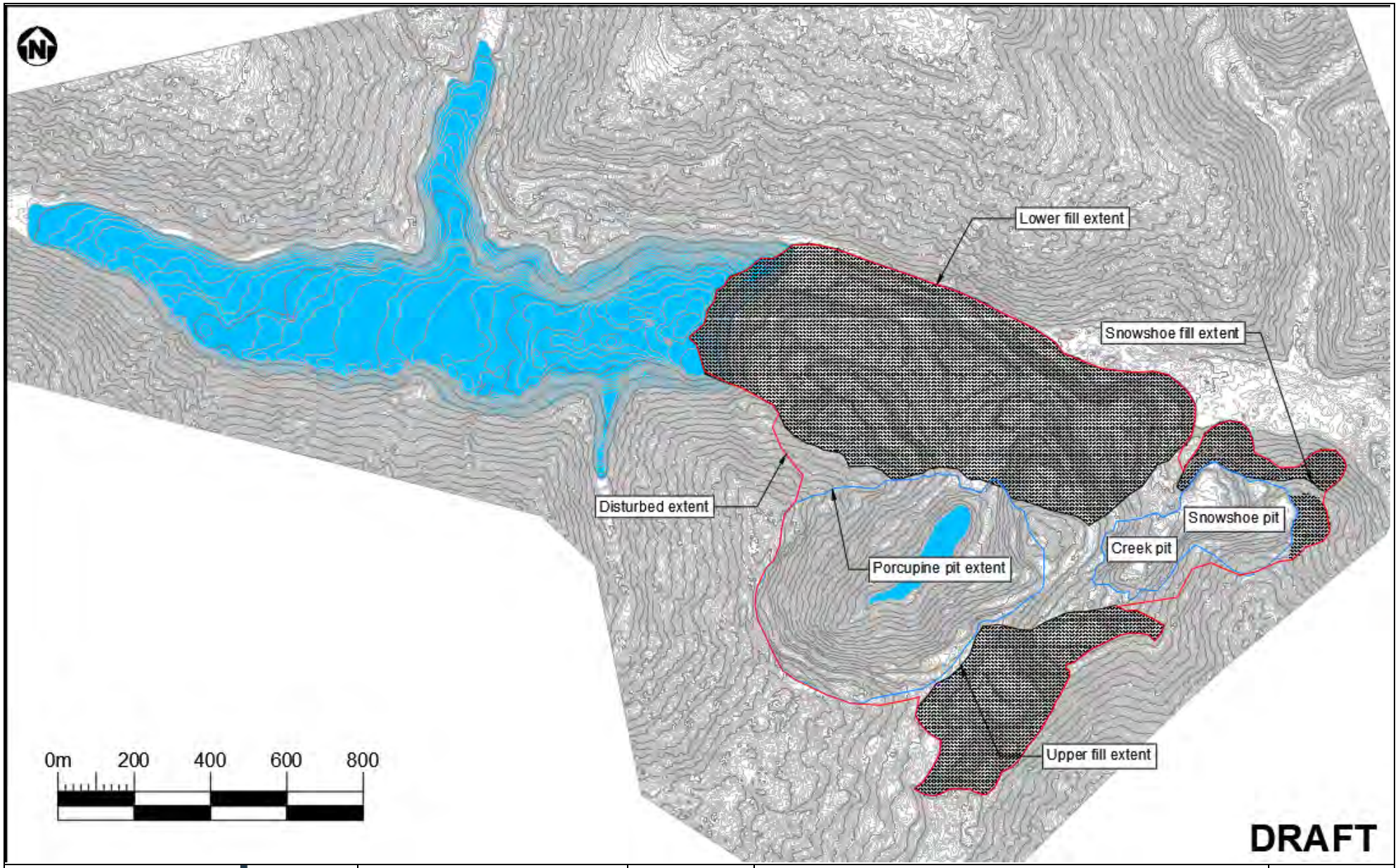
The available storage volume in Creek Pit was not calculated because of the lack of data on the geometry of the pit below the current water surface.

DRAFT

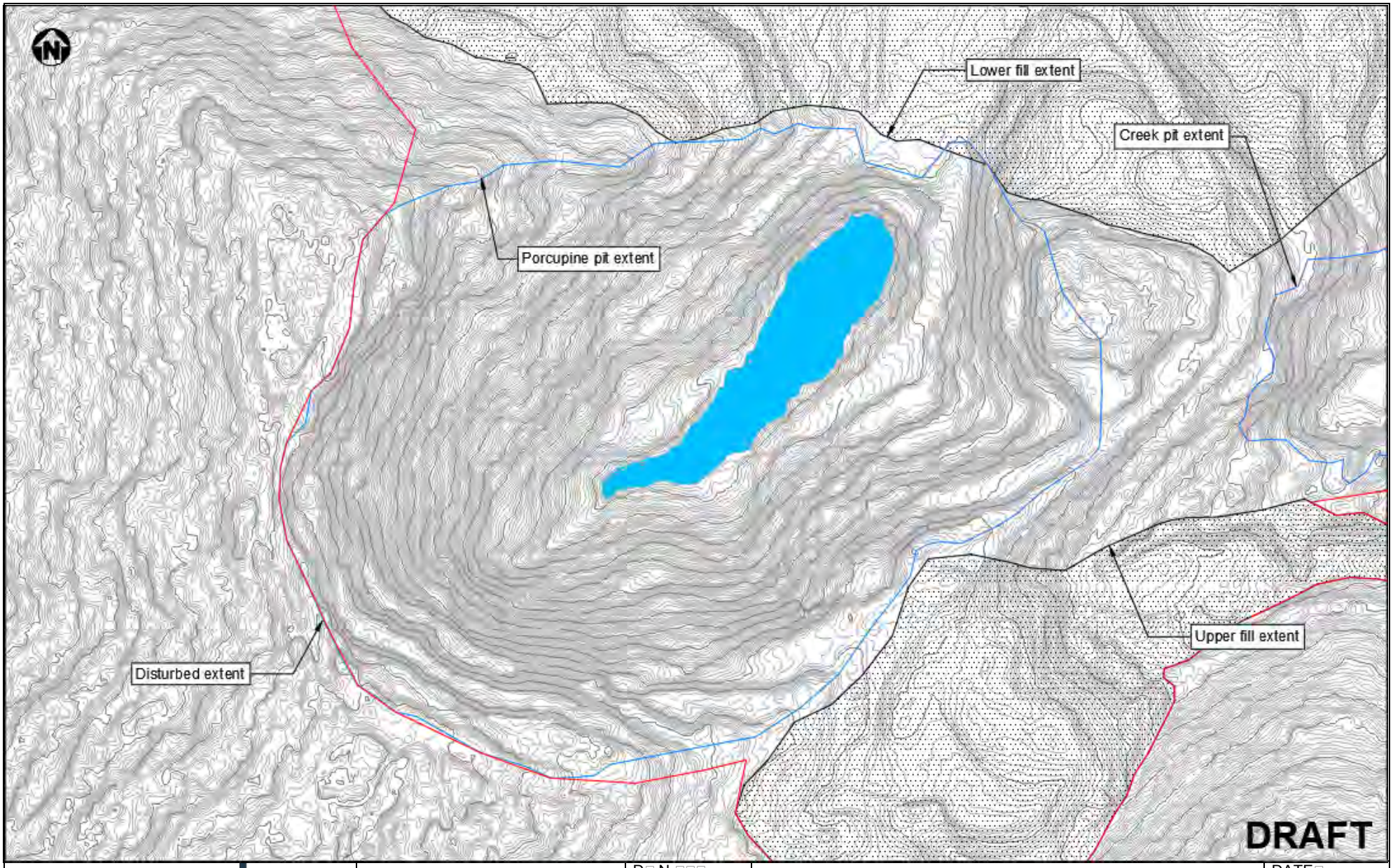
1.2.6 Pit Water Volumes

Detailed information on the surface water regimes in the pits is not available, partly because investigative efforts have tended to focus elsewhere, and partly because of safety constraints on access. The potential benefits of bathymetric surveys to quantify water volumes will be assessed as future investigative programs are scoped (detailed designs may not require certainty on these volumes, or at least it may not be critical enough to justify the cost and risk involved in acquiring the data; incorporating flexibility in the design concept may be more feasible).

The following discussions of pit water volumes, balances and qualities are representations developed or approximated for the purposes of this assessment.



wood. En□ironment □ In□□tr□□t□re □ol□tion□ □ Di□i□ion o□□ ood C□n□d□ Limited 1□□□□ □ □□A□en□e □□rre□□□C □□N □P□ Tel□□0□-□□□-□□□□	Client□ Yukon	D□ N □□□ □□ C□K□D □□□ □□ DAT□M□ NAD □□ PROJETION□ NAD □□ □CALE□ A□ □□O□ N	PROJECT□ CLINTON CREEK REMEDIATION PROJECT TITLE□ Clinton Are□ To□o□r□□□□	DATE□ M□□□□0□1 Pro□e□t no□ □E□□□0□K□00□ RE□□NO□ RE□□DATE□ □I□□RE NO□ P□



wood.

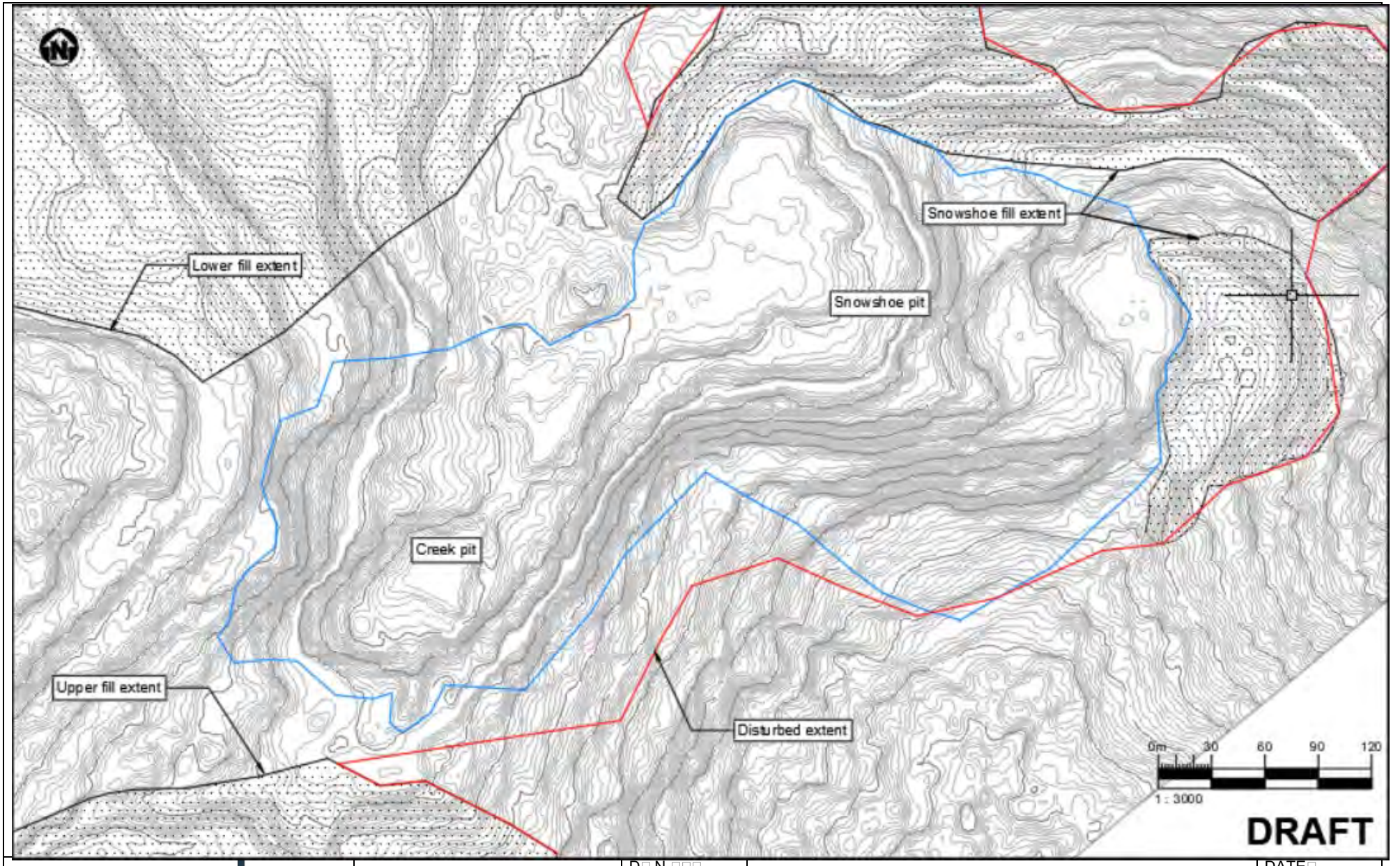
En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT
C□K□D □□□ □□	
DAT□M□ NAD □□	TITLE□ Por□□□ine Pit Are□ To□o□r□□□□
PROJETION□ NAD □□	
□CALE□ A□ □□O□ N	

DATE□ M□□□□0□1
Pro□e□t no□ □E□□□0□K□00□
RE□□NO□
RE□□DATE□
□I□□RE NO□ P□



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□		DATE□ M□□□□0□1
C□K□D □□□ □□	CLINTON CREEK REMEDIATION PROJECT		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□		RE□□NO□
PROJETION□ NAD □□	□no□□□oe□Cree□Pit Are□ To□o□r□□□□		RE□□DATE□
□CALE□ A□ □□O□ N			□I□□RE NO□ P□

1.2.6.1 Porcupine Pit

1. Volumes

The approximation of the Porcupine Pit water volume that is represented on Figure P6 was based on the following estimating assumptions (applied to mitigate the lack of hard data on pit topography below the current water level):

- pit walls below water level (El. 376) are sloped at 37°;
- the maximum water depth is then about 15 m; and
- a flat pit bottom about 30 m wide sloping up towards the south end is assumed and all water storage is assumed confined to this south end (again, this is a representation selected to facilitate estimating; it is not intended as a realistic interpretation of actual below water pit topography).

These assumptions produce an estimate for total current pit water volume of about 170,000 m^3 and a pond surface area of about 24,000 m^3 (see Figure P6).

2. Water Balance

A comparison of water inflow to evaporation was undertaken to give some preliminary support to the operative assumption that Porcupine Pit is naturally drained (see Section 1.2.2). A total annual surplus inflow to the pit of over 700,000 m^3 was approximated from the following inputs:

- average annual precipitation: 324 mm (from Canada, 2021);
- average annual evaporation: 225 mm (from Meteo Whitehorse, 2021);
- pit catchment area: 318 ha (calculated from DEM data);
- runoff coefficient: 0.70 (Section 4.1 of Wood, 2019); and
- pit water surface area: 24,000 m^2 (from Figure P6).

This substantial incoming water surplus, combined with the observation that pit water levels have been more or less constant over time, suggests that there is a natural pit outflow structure, through the pit walls.

3. Quality

Analytical data for the Porcupine Pit waters is limited, largely because ongoing concerns about pit wall stability has constrained access. Data for a monitoring event in 2013 was provided in Table W5 of the Environmental Site Characterization Update Report (Wood, 2019i). These data indicated levels of arsenic and boron above aquatic guidelines and in the case of arsenic, above drinking water guidelines. These excursions were not evident in the receiving environments downstream of the pit lakes. While these limited data suggest that pit water qualities will not be a determining issue for closure designs, that assumption will require additional data, assessment and validation during future phases of closure planning. It is possible that waters contacting freshly exposed rock surfaces may exhibit higher contaminant loadings and/or that more fully characterized downstream impacts will demonstrate requirements for mitigation of some sort.

1.2.6.2 Snowshoe and Creek Pits

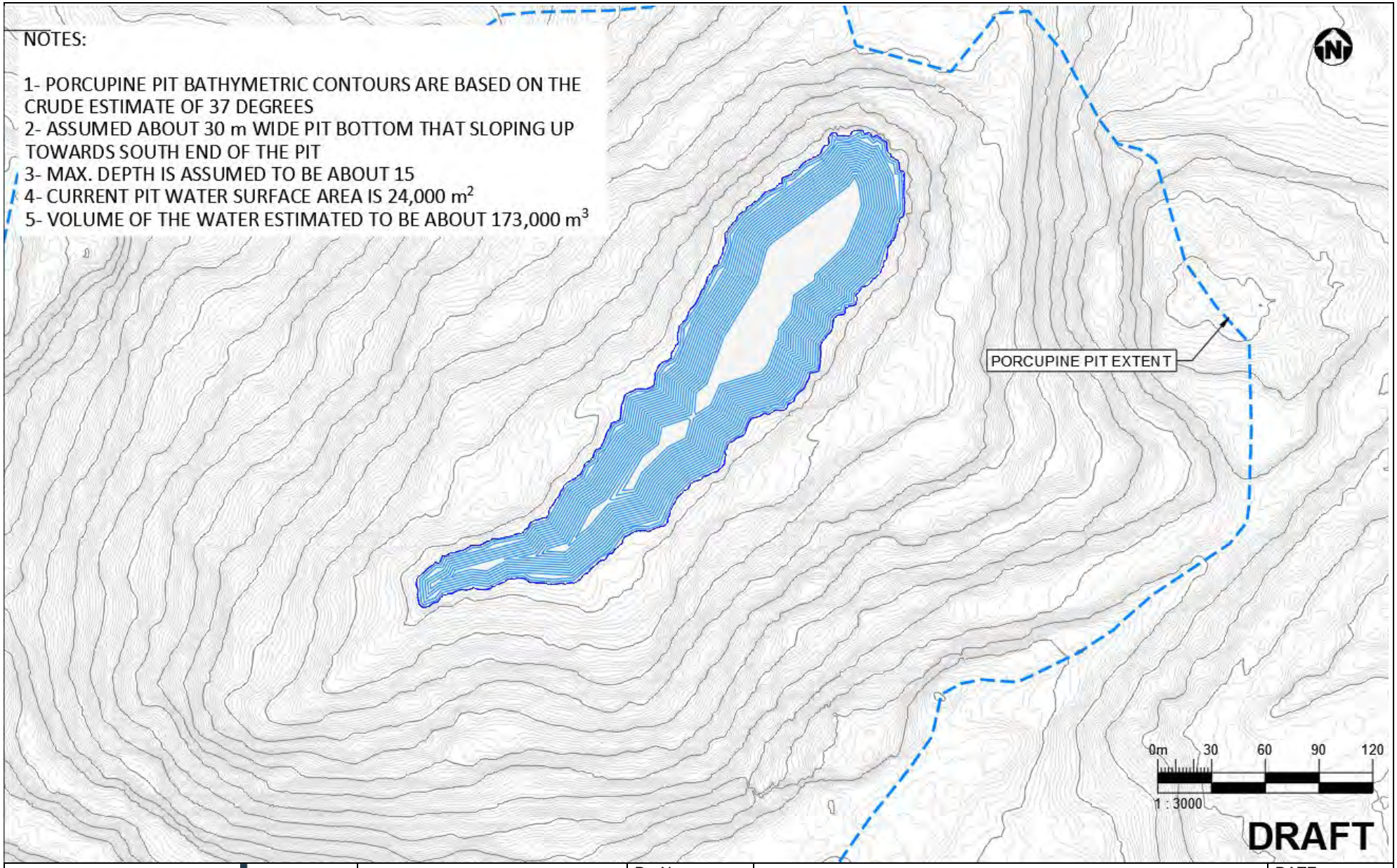
1. Volumes

Ponded water volumes and surface areas in the Creek Pit are shown on Figure P7 (i.e., about 1,700 m^3 and 1,600 m^2, respectively). There are no ponded water volumes associated with the Snowshoe Pit.

DRAFT

NOTES:

1- PORCUPINE PIT BATHYMETRIC CONTOURS ARE BASED ON THE CRUDE ESTIMATE OF 37 DEGREES
2- ASSUMED ABOUT 30 m WIDE PIT BOTTOM THAT SLOPING UP TOWARDS SOUTH END OF THE PIT
3- MAX. DEPTH IS ASSUMED TO BE ABOUT 15
4- CURRENT PIT WATER SURFACE AREA IS 24,000 m^2
5- VOLUME OF THE WATER ESTIMATED TO BE ABOUT 173,000 m^3



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

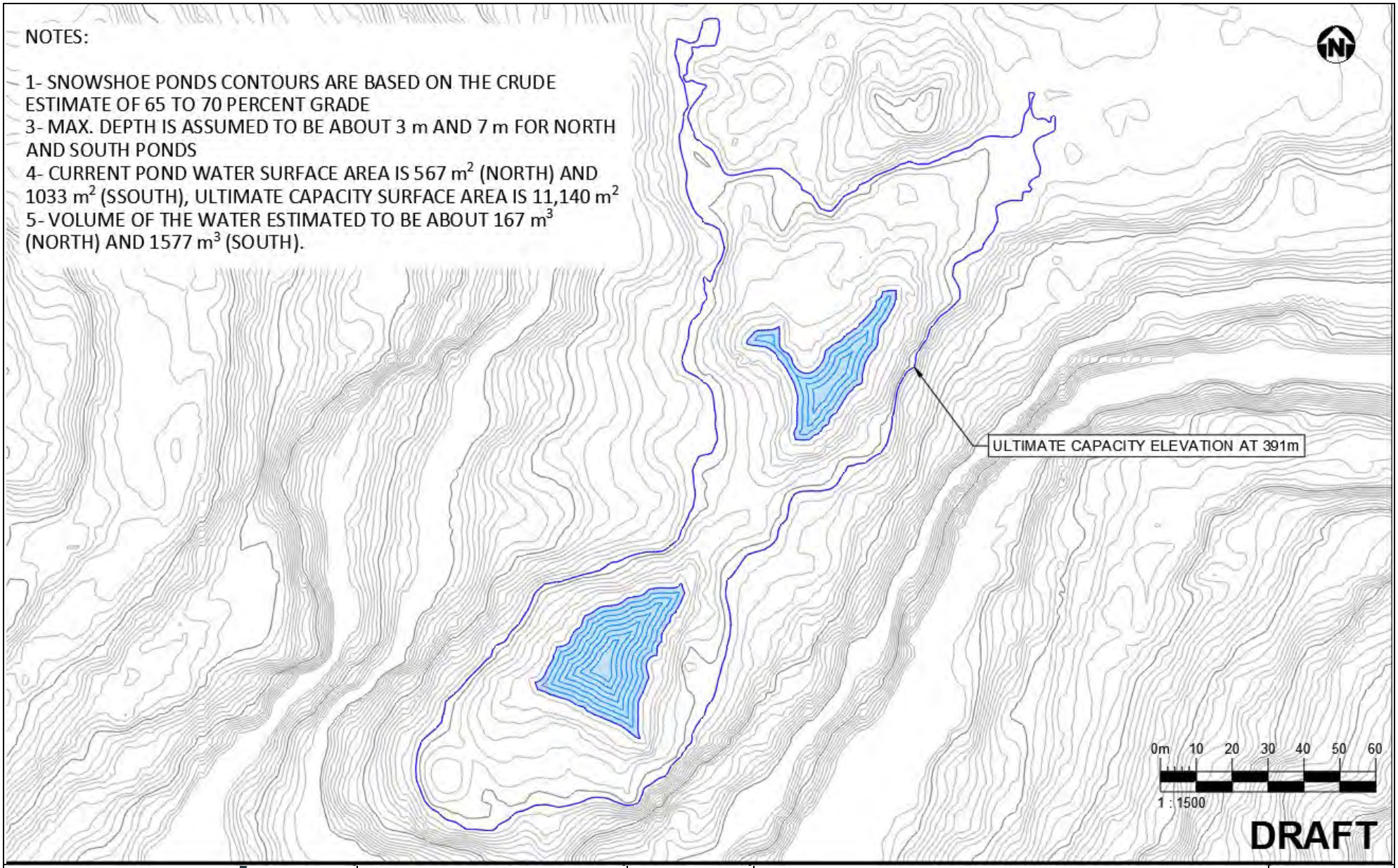
Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT	DATE□ M□□□□0□1
C□K□D □□□ □□		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ Por□□□ine Pit □ □ter □ol□me	RE□□NO□
PROJETION□ NAD □□		RE□□DATE□
□CALE□ A□ □□O□ N		□I□□RE NO□ P□

NOTES:

1- SNOWSHOE PONDS CONTOURS ARE BASED ON THE CRUDE ESTIMATE OF 65 TO 70 PERCENT GRADE
3- MAX. DEPTH IS ASSUMED TO BE ABOUT 3 m AND 7 m FOR NORTH AND SOUTH PONDS
4- CURRENT POND WATER SURFACE AREA IS 567 m^2 (NORTH) AND 1033 m^2 (SSOUTH), ULTIMATE CAPACITY SURFACE AREA IS 11,140 m^2
5- VOLUME OF THE WATER ESTIMATED TO BE ABOUT 167 m^3 (NORTH) AND 1577 m^3 (SOUTH).



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□
□□
C□K□D □□□
□□
DAT□M□
NAD □□
PROJETION□
NAD □□
□CALE□
A□ □□O□ N

PROJECT□
CLINTON CREEK REMEDIATION PROJECT

TITLE□
Cree□ Pit □ □ter □ol□me

DATE□
M□□□□0□1
Pro□e□t no□
□E□□□0□K□00□
RE□□NO□
RE□□DATE□
□I□□RE NO□
P□

2. Water Balance

A water balance calculation specific to the Snowshoe/Creek Pit areas was not attempted. For the purposes of this assessment, the general conclusions described above for the Porcupine Pit (i.e., that natural pit outflows drain the excess of inflows over evaporation) was assumed.

3. Quality

Recent data for the pit ponded water (Table W5 of Wood (2019i)) indicates a pattern of metal excursions similar to that outlined above for the Porcupine Pit Lake (with he exception of boron levels which are not elevated above aquatic criteria). Arsenic is elevated in all of the sampling results; however, these excursions do not appear in sampling sites downstream (see results for E2 in Table W2 of Wood (2019i)).

1.3 Closure Option Descriptions

Yukon's scope of work described the following options for pit closure:

- no action;
- backfilling to eliminate water accumulations;
- maintenance of a lake; and
- complete backfilling.

For the purposes of this assessment, Wood has expanded on, and/or interpreted these descriptions as follows:

- No Action: involves defining and maintaining those limits to public access needed to protect public safety, with appropriate signage, road and trail blocks, and potentially pit crest safety berms.
- Removal of Pit Lake: involves those actions necessary to provide safe, unencumbered public access to a pit area that does not incorporate a water inventory at the pit base. Wood has assumed this will be accomplished by pit backfilling above the equilibrium lake level plus some safety margin (i.e., it will not be done by pumping out current lakes) None of the options will involve removing existing lakes while maintaining pit topographies more or less consistent with the status quo. To do so would require the development of drains that may not be feasible given the elevation differences between current pit bottoms and the available drain discharge options in the creek valleys.).
- Maintenance of Pit Lake: involves those actions necessary to provide safe, unencumbered public access to a pit area that incorporates a self sustaining and accessible water inventory at the pit base.
- Complete Backfilling: providing safe, unencumbered public access to pit areas by restoring local slopes and contours to conditions broadly consistent with pre-development conditions

In this context, Wood has assumed that the term 'safe, unencumbered public access" refers to conditions that are consistent with the risks associated with undisturbed, natural landscapes in the Clinton Creek area (i.e., risks are not eliminated, but lowered to those consistent with accessing local undisturbed lands).

More complete descriptions of these options are provided by way of closure option designs in the following section.

DRAFT

1.4 Pit Closure Option Designs – Clinton Creek

1.4.1 Common Assumptions

1.4.1.1 Final Pit Slopes

The characterization data summarized in Section 1.2 notes that there is insufficient, site specific information, and rock mechanics data in particular, to define stable post closure slopes for the pit escarpments. Absent this data, and solely for the purposes of this assessment, a "design slope" for the pit rock slopes was established by reviewing and cataloguing the slopes of apparently stable, undisturbed rock surfaces in the Clinton area. The thinking was that the upper range of natural stable rock slopes is a reasonable, and likely conservative, proxy for a data driven design slope for the Clinton pits.

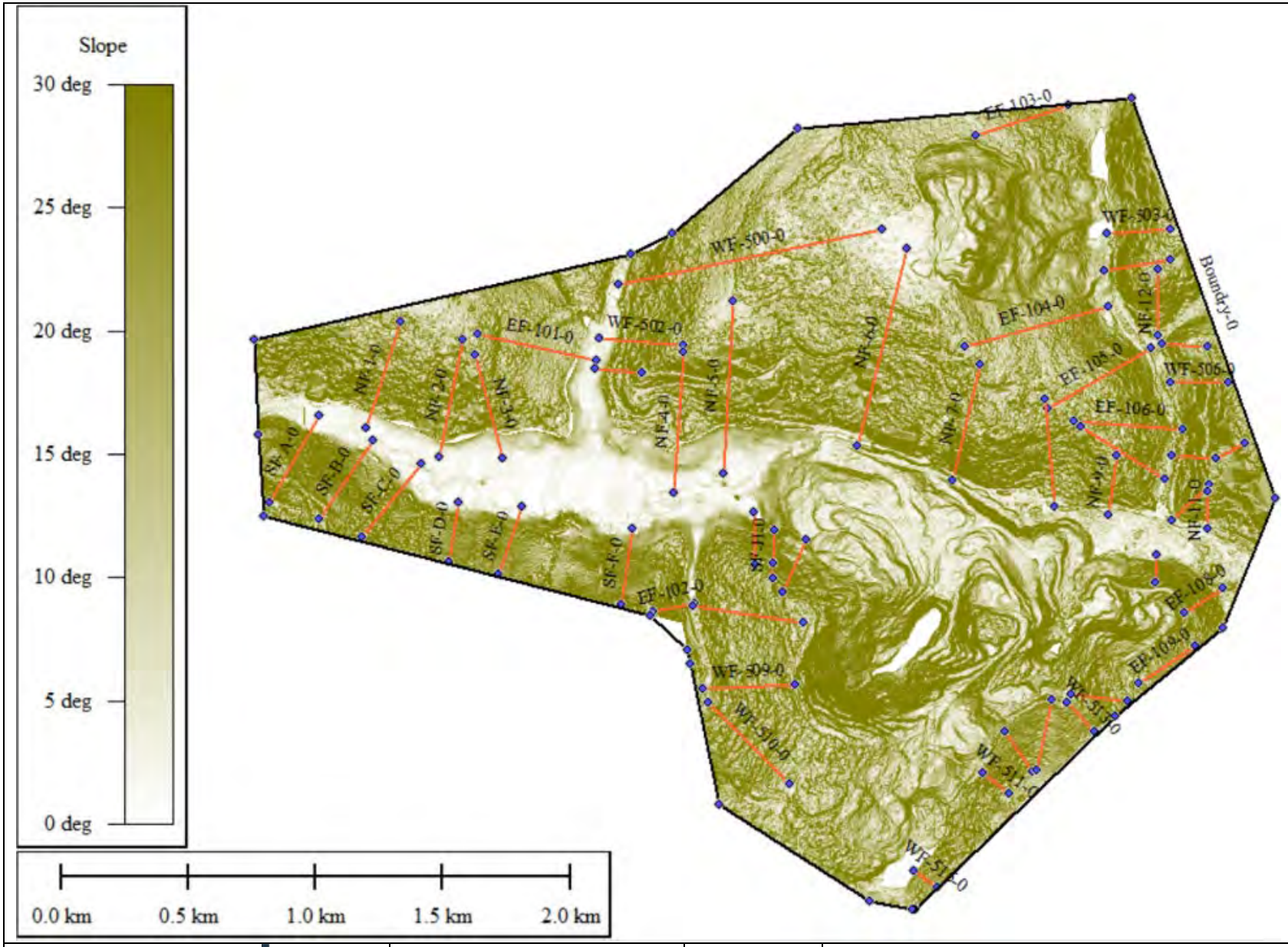
The DEM data described in Section 1.2.4.1 was used to identify potentially representative, undisturbed rock sections and their associated profiles. The inventory of sections reviewed is shown on Figure P8. Table P1 summarizes the slope data assembled from these profiles. This table also identifies the subset of those profiles that Wood considered in determining a representative upper bound for stable, undisturbed rock slopes in the area. This subset intentionally excluded, as a matter of judgement, comparatively shallow slopes that would have produced an overly conservative representation of a maximum stable slope. Wood has considered the Table P1 outcomes to conclude that a slope of 27° (i.e., 2H:1V) would be a reasonable representation of acceptable post closure rock slopes for the Porcupine, Snowshoe and Creek Pits. This is also consistent with the observations of fall down slopes in argillite dominated bedrock (prone to weathering) in the order of 26 to 27 degrees (2H:1V) noted in Section 1.2.2 (Wood, 2019e). It may be possible to utilize steeper slopes in some pit wall segments dominated by somewhat more stable bedrock. However, flatter slopes might be found to be necessary for argillite dominated pit walls. Therefore, the 2H:1V slope is considered reasonable at this time.

DRAFT

1.4.1.2 General Assumptions

The following assumptions were applied broadly to the pit closure option assessments.

- Stand Alone Activity: it has been assumed that the general property closure plan is not integrated with closure requirements for the pits, and does not significantly influence those requirements (i.e., that pit closure actions will be largely stand-alone activities depending on option selected). In practice, pit plans will be integrated to at least some degree with the broader property plan. However, assessing these 'stand-alone' concepts for the pits will establish a baseline that provides some context for the likely scope and cost influences of pit closure, while avoiding the need to consider an unworkable number of permutations and combinations of potential pit and property closure concepts.
- Integrated Execution: notwithstanding the above, it will be assumed that any work on the pits will be undertaken concurrently with the broader property closure plan (i.e., even if the scope of plans is not integrated, their execution will make use of common logistical and contracting resources).
- Available Fill: the existing fill stockpile inventories associated with each pit will be assumed available as backfill. This assumption is considered reasonable for this exercise given that the broader property closure concepts will either leave these fills intact or relocate them to pit storage as part of dump/tails slope reduction plans. The latter scenario, in effect, prescribes the pit closure option (i.e., via the backfilling option). Depending on the option selected then pit infilling costs would be borne by the pit mitigation decision.
- Access: it has been assumed that existing site and dump roads/tracks will provide sufficient access to execute closure plans without significant new road/access construction.



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT	DATE□ M□□□□0□1
C□K□D □□□ □□		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ N□t□r□l □lo□e □□r□e□- Pl□n o□□e□tion Line□ O□er LiDAR	RE□□NO□
PROJETION□ NAD □□		RE□□DATE□
□CALE□ A□ □□O□ N		□I□□RE NO□ P□

Table P1 - Clinton Area Natural Slope Survey - Section Slopes

wood.

South facing slopes

Section Name	Min slope (degrees)	Max slope (degrees)	Overall slope (degrees)
NF-A	19	35	30
NF-B	24	34	34
NF-C	11	35	24
NF-D	18	27	24
NF-E	22	24	25
NF-F	28	45	28
NF-G	23	42	30
NF-H	21	54	31
NF-K	21	37	30
NF-L	15	23	19
NF-M	35	50	38
Average	**22**	**37**	**28**

North facing slopes

Section Name	Min slope (degrees)	Max slope (degrees)	Overall slope (degrees)
SF-1	19	25	25
SF-2	15	37	19
SF-3	20	40	24
SF-4	19	43	26
SF-5	18	31	24
SF-6	21	41	20
SF-7	11	31	40
SF-8	14	27	25
SF-9	20	57	27
SF-10	23	60	30
SF-11	22	62	30
SF-12	20	35	30
Average	**19**	**41**	**27**

West facing slopes

Section Name	Min slope (degrees)	Max slope (degrees)	Overall slope (degrees)
WF-500	19	37	25
WF-501	16	32	25
WF-502	20	30	29
WF-503	25	30	27
WF-504	26	46	43
WF-505	16	44	26
WF-506	14	43	32
WF-507	20	46	34
WF-508	18	51	23
WF-509	19	36	26
WF-510	23	40	21
WF-511	22	56	29
WF-512	24	27	26
WF-513	17	26	22
WF-514	15	30	28
WF-515	15	27	23
Average	**19**	**38**	**27**

East facing slopes

Section Name	Min slope (degrees)	Max slope (degrees)	Overall slope (degrees)
EF-101	5	41	15
EF-102	24	38	36
EF-103	14	20	20
EF-104	11	20	20
EF-105	24	41	30
EF-106	18	53	26
EF-107	14	49	28
EF-108	31	46	38
EF-109	15	24	22
Average	**17**	**37**	**26**

Overall	Min slope (degrees)	Max slope (degrees)	Overall slope (degrees)
Min =	5	20	15
Max =	35	62	43
Mean =	19	38	**27**
Stdev=	5	11	6

- Pit Drainage: per the discussion in Section 1.2.2, it has been assumed that the pits are currently drained via the natural hydrologic and/or hydrogeological characteristics of the individual pits.
- Seepage and Surface Water Impacts: per the discussion on water qualities in Section 1.2.6, it has been assumed that pit water qualities are such that unacceptable environmental impacts and/or risks will not be associated with, or created by, ongoing groundwater seepage and/or pit surface water discharges in the post closure landscape.

Wood considers the last two, site characterization related assumptions as reasonable in light of current understandings of general conditions on the Clinton property. However, pit specific data validating these assumptions is not available and will be required to support any future advancement of these concepts.

1.4.2 Option Assessments and Designs

This section describes the assessment and/or design development activity and outcomes for each of the candidate pit closures. The discussion mirrors that outlined in the broader 10% design development report (Wood, 2019) that considered the following items or issues for each alternative:

- Scope Elements: a presentation of the key components required to address the closure scope associated with an option.
- Materials Management Concept: a discussion reflecting the importance of earth movements for most of the options and providing an outline of how these movements will be executed.
- Anticipated Performance Outcomes: a discussion of Wood's judgements regarding the post closure outcomes that the options will deliver.
- Constructability/Execution Issues: an outline of key constructability/execution issues that are particular features of an option (i.e., intended to highlight differentiating execution challenges; not as an exhaustive schedule of more routine execution requirements).
- Key Risks and Uncertainties: a discussion of the key risks and uncertainties that apply to the design concept at this design stage (i.e., prior to execution), and for the closure landscape following execution of an option (i.e., the long-term liabilities that must be retained by the Project Partners).
- Associated Closure Criteria: a description of the closure and reclamation criteria that have been assumed for the design or are defined by the fundamental characteristics of the option. This section refers broadly to the general Project Partner objectives established for CCRP (Table P2) and also describes more specific criteria that, in Wood's view, will be associated with an option.

DRAFT

Table P2: Clinton Creek Remediation Project Objectives

1. Protect human health and safety	• Reduce or eliminate risks to worker health and safety. • Prevent, minimize or mitigate any adverse effects on the health and safety of people accessing the site. • Animals, plants and berries around the mine site are safe for humans to harvest.
2. Protect the environment, including land, air, water, fish, and wildlife	• Prevent, minimize or mitigate adverse effects on the aquatic environment including fish and fish habitat. • Prevent, minimize or mitigate adverse effects on the terrestrial environment. • Protect, and to the extent possible, restore aquatic and terrestrial habitats using methods conductive to natural regeneration.
3. Return and/or retain the site to a state that supports community and traditional land uses	• Maximize access for public use. • Reclaim disturbed areas to support community and traditional land use. • Water flowing from the mine site will be safe for recreational use.
4. Maximize local, First Nation and Yukon socio-economic benefits from the Clinton Creek Project	• Maximize project-related benefits through training, employment and business opportunities for Tr'ondëk Hwëch'in citizens. • Maximize project-related benefits through training, employment and business opportunities for local residents and Yukoners, in a manner that is consistent with the Devolution Transfer Agreement. • Maximize opportunities for capacity building for locals, Tr'ondëk Hwëch'in and Yukoners.
5. Minimize project related liability, risk and costs	• Minimize implementation and post-closure risks associated with the project. • Minimize post-closure residual liabilities. • Minimize project implementation costs. • Minimize post-closure operations and maintenance costs.

DRAFT

Notes:
1. Restore - it is understood that the 'measure' as to whether the environment is restored is not necessarily to pre-mining conditions, but rather will be to a stable, improved or self-sustaining state.

1.4.3 No Action (PP1 and SCP1)

1.4.3.1 Scope Elements

This option would involve leaving the pits and their associated water impoundments as they currently stand, and mitigating the public safety risks generated by the potential instabilities in rock surfaces via restrictions and/or controls on access to the areas involved. The specific nature and extent of the access restrictions required would depend on the outcomes of future geotechnical data efforts (see Section 1.5.1), but would likely involve a combination of signage and physical markers/barriers that would be integrated with whatever access controls are applied over the balance of the property (i.e., the discussion in Access Limits section of the Data Gaps report).

Sustaining these controls would involve an ongoing and indefinite requirement for physical maintenance of the features involved and monitoring/assessment of their effectiveness in light of public interactions with the areas in question. There would also be ongoing requirements for describing and defending these controls to and with the public and for maintaining the institutional resources and memory needed to manage post closure requirements. These requirements produce the costs for this No Action alternative that are described in Section 1.5 (i.e., 'No Action' does not mean zero cost).

1.4.3.2 Materials Management Concept

The No Action concept assumes there are no major materials movements (i.e., safety berms, ditches excepted) undertaken for pit closure. Note that the premise for the concept also assumes that closure plans for the balance of the property do not produce changes in the physical status of the pits (i.e., they are not used for spoil storage).

1.4.3.3 Anticipated Performance Outcomes

The No Action alternative is the low effort/ higher potential consequence (relative to other pit closure options) bookend for closure of the Clinton pits. The limited closure effort required is offset by significant limits to the utility of the post closure landscape.

1.4.3.4 Constructability/Execution Issues

There are no constructability/execution issues of any significance related to the No Action option.

1.4.3.5 Key Risks and Uncertainties

1. Pre-Execution

As noted in Section 1.2, there are no site specific rock mechanics or other geotechnical data available for the three pit sites. Absent any new data, the geographic reach of access limits applied to limit public safety risks would, therefore, need to be conservatively defined. Any new investigative data (note that the cost estimate (Section 1.5) includes an investigative scope) that are compiled could influence the nature or scale of the No Action alternative in a range of ways, specifically:

- it is possible, if unlikely, that additional data would demonstrate that the pit areas could be safely accessed without any modification to current slopes; and
- additional data would likely support refined definitions to the areal extent of exclusion zones and/or the risks associated with specific area use scenarios (e.g., particular sporadic, time limited access).

Generally speaking, the wide range of potential outcomes resulting from new data suggest that the current assessments and conclusions relating to the No Action alternative are at least moderately sensitive to the outcomes of future investigative activity.

2. Post Execution

The post execution risks and/or uncertainties related to the No Action option would be a function of the uncertainties associated with any future investigative outcomes (i.e., any investigative conclusions will carry at least some residual uncertainty), and the level of conservatism that is applied to the definition of access limits and controls. In addition, the robustness of post closure monitoring and maintenance of any access limits will strongly influence their long-term effectiveness. Applying controls without the ongoing institutional support, resources and memory needed to sustain them will limit the temporal reach of their effectiveness.

1.4.3.6 Associated Closure Criteria

Key closure criteria associated with the No Action option are as follows:

- reduces public safety risks by limiting access to areas deemed to present higher consequences, higher likelihood and therefore higher relative risks.
- does not return and/or retain the site to a state that supports community and traditional land uses;
- produces no significant local, First Nation or Yukon socio-economic benefits; and
- reduces project related liability, risks and costs.

DRAFT

1.4.4 Removal of Pit Lake (PP2 and SCP2)

This option is intended to provide safe, unencumbered public access to pit areas that do not incorporate a water inventory at the pit base.

1.4.4.1 Scope Elements

This option would involve the following:

- reducing those upper portions of current pit slopes outside of slide areas (see Section 1.2.3) that exceed the assumed design rock slope of 2 horizontal to 1 vertical (i.e., the 27° described in Section 1.4.1.1) via blasting; and
- leaving the entire inventory of blasted spoil at the base of the pits and supplementing with imported dump fill as necessary to stabilize slide areas and/or to bring pit bases above the current water (i.e., lake) elevations in the pits.

Given the overriding assumption that current pit water levels are controlled by existing drainage features, the above approach would involve some temporary displacement of the pit water inventory. However, that inventory would eventually equilibrate below the final spoil surface at the current water elevation. It is not anticipated that the gradation of blasted materials will be fine enough to compromise pit drainage and/or produce perched accumulations of water. However future investigative and design development activity can be scoped to validate these assumptions.

1.4.4.2 Materials Management Concept

1. Blasting

Blasting operations would progress via a ramp running down the escarpment that would access a series of pads constructed parallel to the escarpment slope. Holes would be drilled along these pads to depths of perhaps 20 m to place the blasting explosives. The specific drilling/blasting locations and patterns would be established on the basis of a detailed blasting plan driven in part by the outcomes of future rock mechanics investigations conducted on the pit slopes. The ramp would be extended and pads constructed in a series of stages working down the escarpment. Blasted spoil would be allowed to accumulate at the pit base, and wherever necessary, pushed downslope via the ramp/pads as the program progresses. The ramp would ultimately provide safe access to the base of the pit that would then facilitate contouring of final spoil elevations above current water levels at the base of the pits.

2. Cut/Fill Balance

2a Porcupine Pit

Figure P9 provides a representation of the post closure contours for the Porcupine Pit. The materials management concept shown includes the following key elements:

- blasting of the comparatively steep undisturbed rock slopes in the northeast and southwest sections of the pit to a slope of 2H:1V; and
- construction of a fill bench at the base of the pit up to elevation 420 to stabilize the slide areas in the northwest and southeast sections of the pit.

Note that Figure P9 is a general representation that doesn't illustrate all of the detail that would be associated with the specific ramp and pad configurations that would be used to facilitate blasting. Specific elements of the Figure P9 concept are as follows:

- work would likely be initiated with blasting operations on the northeast escarpment and operations here would utilize the ramp into the pit that currently exists in this area;

DRAFT

- the blasting spoil would be used to address a portion of the fill inventory required to build the buttressing fill to el. 420;
- dump fill would be imported as needed to progress the buttress fill towards the southwest;
- blasting operations on the southwest escarpment would incorporate a ramp running perpendicular to the slope at 2H:1V with sideslopes extending from the ramp up to grade at the same 2H:1V slope;
- the southwest blasting spoil would also contribute to the total fill required to construct the buttress fill to El. 420; and
- total blasted material volumes in Figure P9 amount to about 2.4 Mm^3 (or about 2.64 Mm^3 bulked) and the total fill requirement for the El. 420 bench is 2.7 Mm^3 (i.e., about 60,000 m^3 of the buttress fill will be comprised of imported dump material).
- Most of the blasted spoil would require re-handling to place and contour the buttress bench to El. 420 (for the purposes of the cost estimate it was assumed that 2.5 Mm^3 of the blast spoil would require rehandling).

2b. Snowshoe and Creek Pits

Figure P10 provides representations of the cut and fill balances for the Snowshoe and Creek Pits. The modelling for this balance considered the two pits together; given their proximity, the materials management concept and effort would likely be integrated. Again, this is a general representation that doesn't show the detail associated with blasting ramp and pad configurations.

The Snowshoe/Creek slope modification plan varies from the Porcupine Pit approach in that it relies less on blasting and more on conventional cut and fill operations. This is partly because of the configuration of the disturbed rock slopes in these pits, and partly because of the local proximity of dump fills (i.e., dump fills are immediately adjacent to the north, east and west sides of the pit perimeter). The blasting scope on the relatively steep southern side of the pit was limited to avoid encroaching on the undisturbed slopes to the south. While they are somewhat steeper than the 2:1 "design slope", disturbing these long stable natural slopes was judged to be unnecessary and/or counterproductive. Utilizing cut and fill operations rather than blasting in other areas is feasible because of the limited and local nature of over steepened sections of the rock slope, and/or the local availability of fills for achieving the desired slope reductions.

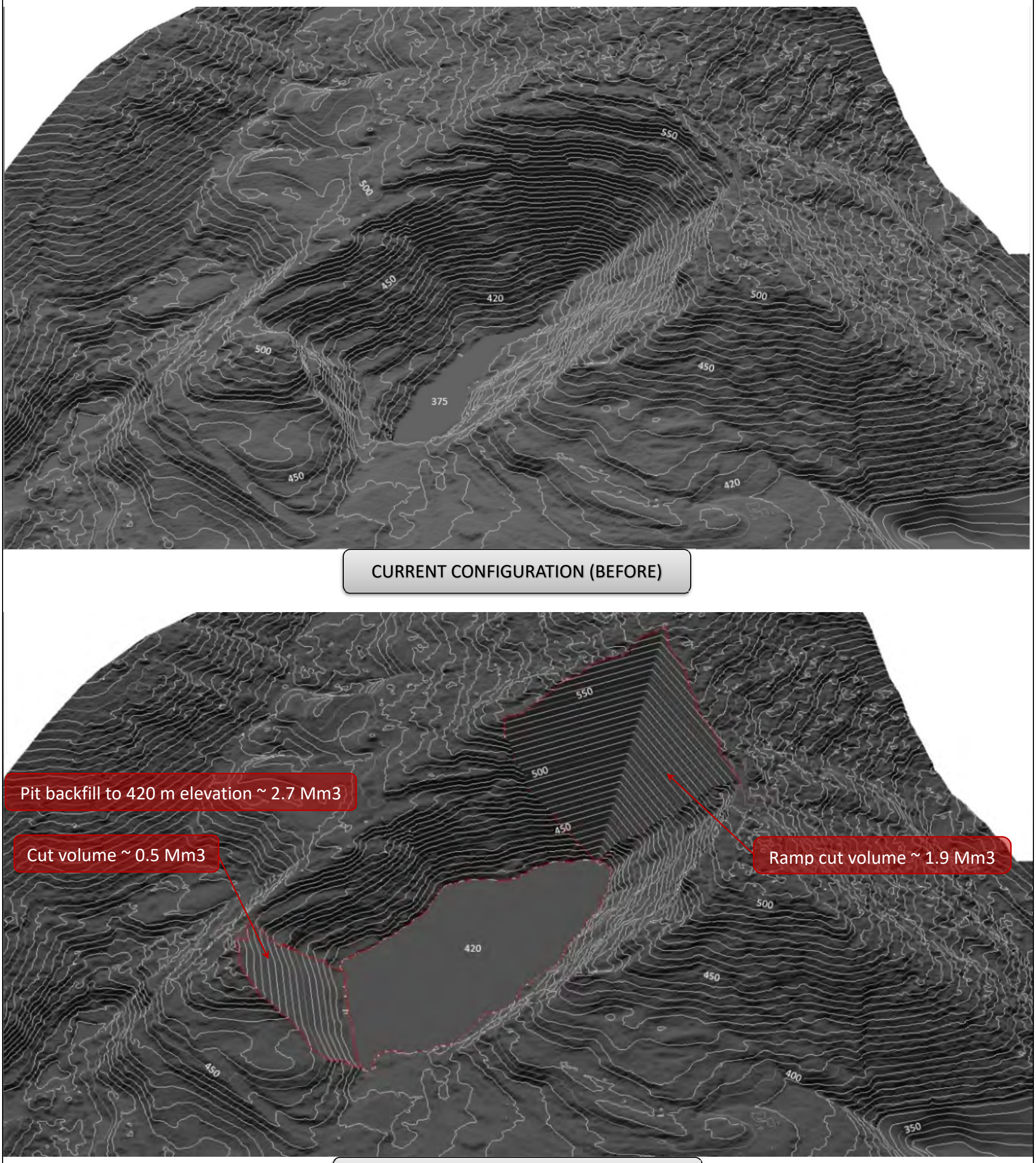
DRAFT

The Snowshoe/Creek isometrics in Figure P10 assumes fill slopes of 2:1 in those areas that are not blasted. This comparatively steep fill slope will require additional assessment and validation in any future phase of design and may prove to be unworkable. They were assumed in this assessment for two reasons:

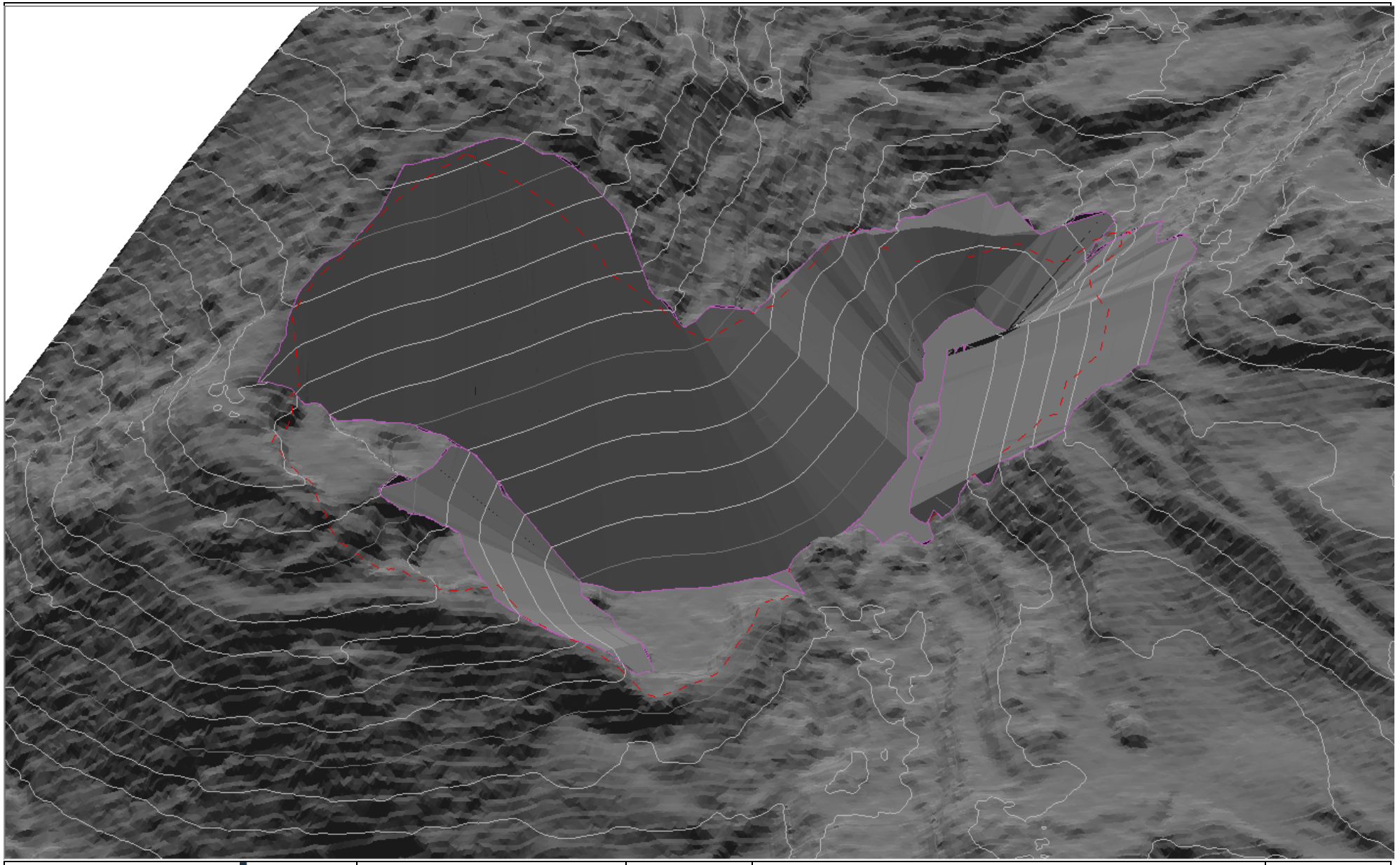
- shallower slopes would make consideration of a lake retention option difficult or impractical (i.e., shallower slopes will fill pit valley bottoms); and
- to create some separation between this option and the complete backfilling option described in Section 1.4.6 (i.e., shallower fill slopes for this option will produce outcomes very similar to the 3:1 slope concepts described in the complete backfilling option)

The general geographic distribution of conventional cut/fill and blasting operations for the Snowshoe/ Creek Pits is represented on Figure P11. Comments on the representations provided in Figures P10 and P11 are as follows:

- the total cut volume is about 174,000 m^3 of which approximately three quarters (130,000 m^3) is removed via blasting, mostly from the relatively steep southern escarpment southeast of the Creek Pit;



wood. En□ironment □ In□r□□tr□□t□re □ol□tion□ □ Di□i□ion o□□ ood C□n□d□ Limited 1□□□□ □ □□A□en□e □□rre□□□C □□N □P□ Tel□□0□-□□□-□□□□	Client□ Yukon	D□ N □□□ □□ C□K□D □□□ □□ DAT□M□ NAD □□ PROJETION□ NAD □□ □CALE□ A□ □□O□ N	PROJECT□ CLINTON CREEK REMEDIATION PROJECT TITLE□ Por□□□ine Cree□ Remo□□l o□L□□e l□ometri□	DATE□ M□□□□0□1 Pro□e□t no□ □E□□□0□K□00□ RE□□NO□1 RE□□DATE□ □e□t□□0□1 □l□ □RE NO□ P□



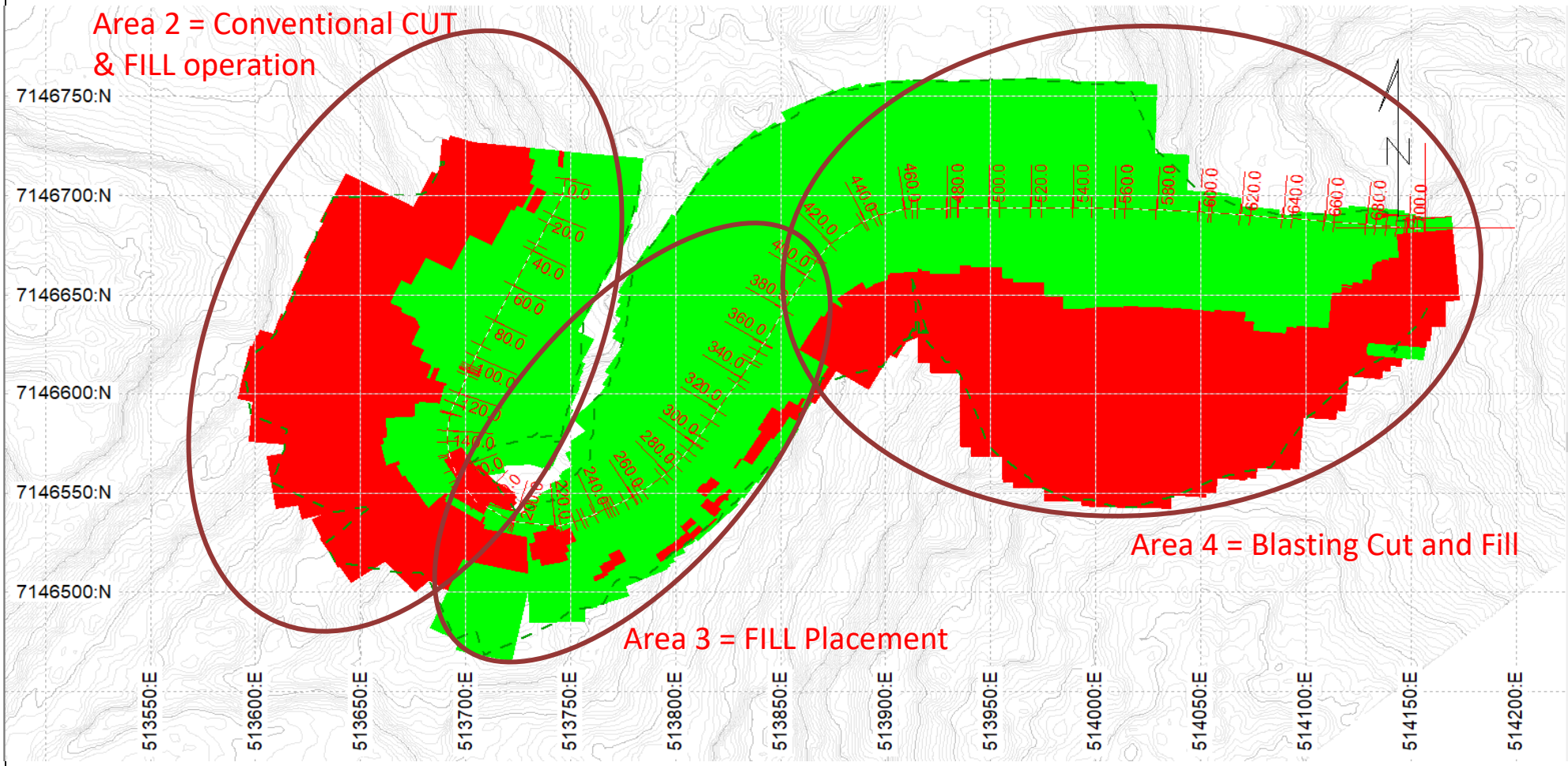
wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT	DATE□ M□□□□0□1
C□K□D □□□ □□		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ □no□□□oe □nd Cree□ Pit□ Remo□□l o□L□□e I□ometri□	RE□□NO□
PROJETION□ NAD □□		RE□□DATE□
□CALE□ A□ □□O□ N		□I□□RE NO□ P10



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT		DATE□ M□□□□0□1
C□K□D □□□ □□			Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ □no□ □□oe □nd Cree□ Pit□ □ M□teri□l□M□n□□ement Are□□		RE□□NO□
PROJETION□ NAD □□			RE□□DATE□
□CALE□ A□ □□O□ N			□I□□RE NO□ P11

- total fill volumes amount to about 520,000 m^3, of which 230,000 m^3 would be borrowed from local dump stockpiles (i.e., from the Snowshoe Pit dump to the east and Porcupine Pit dump to the west);
- blasting operations would likely be completed first on the escarpment southeast of the Creek Pit; some final slopes downslope of the lower blasting line may be steeper than the 2:1 shown on the isometric (i.e., approaching angles of repose), where detailed designs demonstrate that these steeper slopes can be accommodated;
- backfilling operations would likely be initiated by end dumping fill into the Creek valley bottom and then using that platform to place and build fills up the slope; and
- the isometric shown fills the Creek Pit valley bottom above the current water level with a slope of 1% that will drain surface flows.

1.4.4.3 Anticipated Performance Outcomes

The Lake Removal option for pit closure would provide the following performance outcomes:

- provision of reliably stable slopes in the post closure landscape; and
- this stability would, in turn, provide for unrestricted public access to the lands in question, at risks not materially different from those encountered in natural landscapes.

1.4.4.4 Constructability/Execution Issues

Blasting operations are not anticipated to generate any execution risks that are particular to the Clinton property. Any execution risks should be manageable at Clinton within the context of a properly developed and detailed design and execution plan.

Construction of 2:1 dump material fills in the Snowshoe/Creek Pits may be difficult for portions of the pit. Detailed execution planning may identify local areas requiring more shallow fills.

The Lake Removal option will involve the temporary displacement of current pit water inventories as blasted spoil and/or imported dump materials are added to the pit. The total storage capacity of the pits is likely sufficient to avoid the need to release these displaced waters directly during construction. Displaced waters retained in the pit would simply be allowed to drain via the existing pit outlets and equilibrate before completing final contouring operations at the base of the pit. Alternatively, if temporary water releases were judged necessary to expedite schedules, detailed planning could define the rate of displaced water releases that downstream watersheds could accommodate.

1.4.4.5 Key Project Execution Risks and Uncertainties

1. Pre-Execution

The design and execution of a slope reduction/closure plan for the pits will be influenced by the outcomes of the geotechnical and rock mechanics investigations that are a necessary precursor to more detailed planning. Given that little or no characterization data along these lines are currently available, the range of potential investigative outcomes and the associated design implications is wide. It is possible that final rock slopes well below the assumed 2H:1V will be needed in some pit wall segments and/or that the feasibility and scope of blasting as the primary slope reduction mechanism will be limited. Additional investigation of the stability of slide areas in the Porcupine Pit will be necessary to understand the interactions with, and limits to, blasting scopes, and to better define appropriate stabilization methods (e.g., to validate and/or refine the concept of a stabilizing bench constructed to El. 420). Further, it may be determined that the assumed 2H:1V waste dump fill slopes in the Snowshoe/Creek Pits will not be sufficiently stable.

DRAFT

The nature and number of design development gaps that future investigative activities would be intended to address indicate that the current assessments relating to the Lake Removal plan for pit closure are highly sensitive to the outcomes of future investigative activity. These gaps underscore one of the key, overriding premises of this pit closure assessment, specifically that the outcomes should be viewed as indicative of possible closure approaches, not representative of a typical 10% design concept.

2. Post Execution

It is possible that future investigative activity will demonstrate that a slope reduction operation for the pits may carry more uncertainty relating to final slope stabilities than has been assumed. This could require mitigation via temporal and/or geographic constraints to site access of some description, albeit to lesser extents than would be associated with the No Action option for pit closure.

1.4.4.6 Associated Closure Criteria

Key closure criteria associated with the Lake Removal option are as follows:

- mitigates public safety risks by stabilizing all slopes in the post closure pit landscape;
- returns the site to a state that supports community and traditional land uses;
- maximizes access for public use;
- offers the potential for creation of significant local First Nations or Yukon socio-economic benefits (i.e., via the participation in pit closure execution activity);
- substantially reduces project related liability and risks; and
- involves substantial execution costs but minimal post closure operations and maintenance costs.

DRAFT

1.4.5 Maintenance of Lake (PP3 and SCP3)

This option is intended to provide safe, unencumbered public access to pit areas that incorporate self sustaining and accessible water inventories.

1.4.5.1 Scope Elements

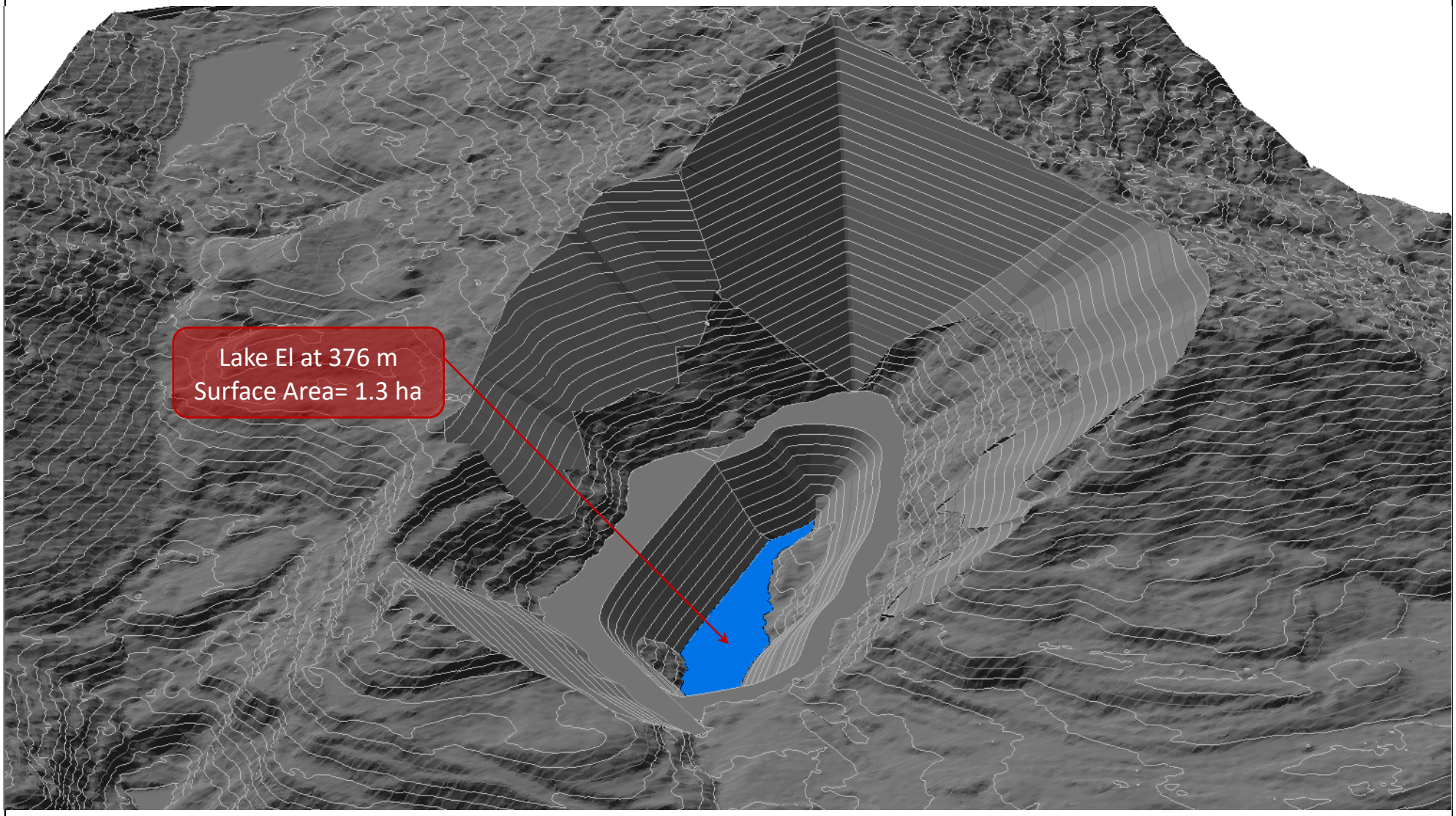
For the purposes of this assessment, the Maintenance of Lake option was assumed to incorporate the basic elements of the Lake Removal option, except that some proportion of the current water inventory would be restored in the pit bottoms by reductions in the scope of fill and/or blast spoil placements. The post closure pit landscape for this option would incorporate:

- blasted rock slopes (where applicable) no steeper than 2H:1V;
- water inventories that may be lower than the status quo, but sufficient to maintain ‘lakes’ of some description in the Porcupine and Creek Pits; and
- ramps that would extend from pit rims to the water’s surface (these ramps would be legacies of the basting and/or cut and fill operation).

1. Porcupine Pit

Figure P12 is a representation of a final Porcupine Pit isometric constructed along the lines described above, and as follows:

- the scope of fill placement for the bench to El. 420 is reduced in the portion of the pit bottom to provide retention of a portion of the current lake inventory;



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□		DATE□ M□□□□0□1
C□K□D □□□ □□	CLINTON CREEK REMEDIATION PROJECT		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□		RE□□NO□
PROJETION□ NAD □□	Por□□□ine Pit M□inten□n□e o□L□□e I□ometri□		RE□□DATE□
□CALE□ A□ □□O□ N			□I□□RE NO□ P1□

- slide area slopes on the west side of the pit will be reduced to a maximum of 2H:1V by removing materials from the upper portions of the slopes.

The lake surface area in this isometric is about 1.3 ha, about half of the current area.

2. Snowshoe and Creek Pits

Figure P13 is an isometric of the final Snowshoe and Creek Pit configurations. For the assumed blasting/ fill scenario, all of the post closure water inventory would be in the Creek Pit valley bottom; there would be no water in the Snowshoe Pit. The Creek Pit maximum water inventory in this scenario would be about 7,800 m^3, which is greater than the current pit water inventory (some 1,700 m^3 in Figure P6) but likely generally consistent with typical water volumes in the Creek Pit valley.

1.4.5.2 Materials Management Concept

The materials management plan for the Maintenance of Lake option would be largely as described for the Lake Removal option (Section 1.4.4.2) except that portions of surplus blast spoil would be hauled from the pit, and/or imported fill volumes reduced proportionate to the desired water inventory. In the case of the Snowshoe/Creek Pit imported fill, volumes are reduced by the same 7,800 m^3 represented by the water inventory.

1.4.5.3 Anticipated Performance Outcomes

The Maintenance of Pit Lake option would provide the same safe and unencumbered public access to the pit areas offered by the Lake Removal option with the potentially added benefit of 'lake' access. The significance of this potential benefit would depend on the Project Partners' perspectives on the character and utility of the pit lake following closure activity.

DRAFT

1.4.5.4 Constructability/Execution Issues

The constructability and execution issues related to the Maintenance of Pit Lake option would largely mirror those outlined in Section 1.4.4.4 for the Lake Removal option, except that issues associated with the temporary displacement of waters would be less significant for the former.

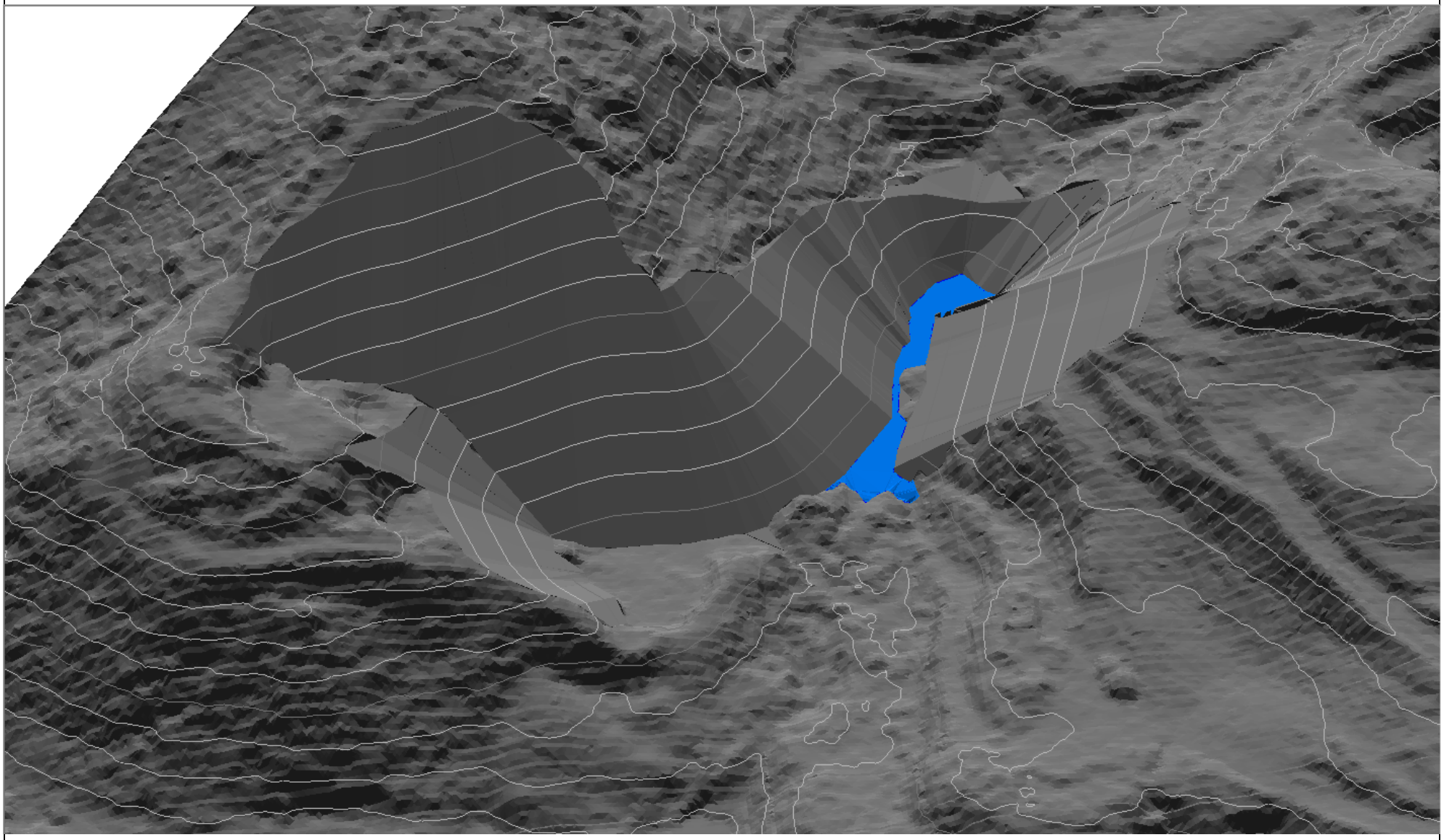
1.4.5.5 Key Risks and Uncertainties

The pre and post execution risks and uncertainties for the Maintenance of Lake option would be as described in Section 1.4.4.5 for the Lake Removal option. In addition, for the Porcupine Pit, the assumption that the limits of the bench to El. 420 can be reduced to provide some degree of lake retention without compromising the stability of slide areas in the pit requires significant supplemental data and design assessment. Again, the closure concepts presented should be viewed simply as indicative of potential approaches to closure, and subject to considerable change following additional characterization and design development.

1.4.5.6 Associated Closure Criteria

Key closure criteria associated with the Maintenance of Lake option are as follows:

- mitigates public safety risks by stabilizing all slopes in the post closure pit landscape;
- returns the site to a state that supports community and traditional land uses;
- maximizes access for public use;
- offers the potential for creation of significant local First Nations or Yukon socio-economic benefits (i.e., via the participation in pit closure execution activity);



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□		DATE□ M□□□□0□1
C□K□D □□□ □□	CLINTON CREEK REMEDIATION PROJECT		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□		RE□□NO□
PROJETION□ NAD □□	□no□□□oe □nd Cree□ Pit□ M□inten□n□e o□L□□e I□ometri□		RE□□DATE□
□CALE□ A□ □□O□ N			□I□□RE NO□ P1□

- substantially reduces project related liability and risks; and
- involves substantial execution costs but minimal post closure operations and maintenance costs.

1.4.6 Complete Backfilling (PP4 and SCP4)

The Yukon scope of work does not define a particular concept for the Complete Backfilling Pit Closure option. Wood has assumed that it would not literally involve re-establishment of pre-development pit contours, largely because there is insufficient dump and/or tails inventory to do this without pre-supposing the adoption of both CC3 and WC3 (i.e., complete removal of both the Hudgeon waste dump and entire Wolverine tailings inventory). Even in this circumstance, the available fill inventory would be sufficient only to completely backfill the Porcupine Pit. In any case, the presumption of particular property closure options as pre-requisites is inconsistent with the basic assumption of pit closure as stand-alone activity that has been adopted for this assessment. Further, it has been assumed that the possibility of opening new borrow sources to provide pit backfill can be self evidently discounted because it would simply shift the closure and reclamation liability from the Clinton pits to these new borrow sources.

1.4.6.1 Scope Elements

Given the above assumptions, and for the purposes of this pit closure assessment, Wood has interpreted the Complete Backfilling option as follows:

- pits would be backfilled at safe and stable long-term slopes, assumed to be 3H:1V for the purposes of this assessment;
- backfill sources would be the upper and Snowshoe fills and portions of the Hudgeon Lake Lower Dump Fills that can be removed without compromising the stability of those dumps;
- the pits would be backfilled to elevations that would keep all final dump surfaces in the dry (i.e., above the elevations of current water interfaces); and
- pit reclamation would be entirely via backfilling; there would be no blasting of rock slopes.

DRAFT

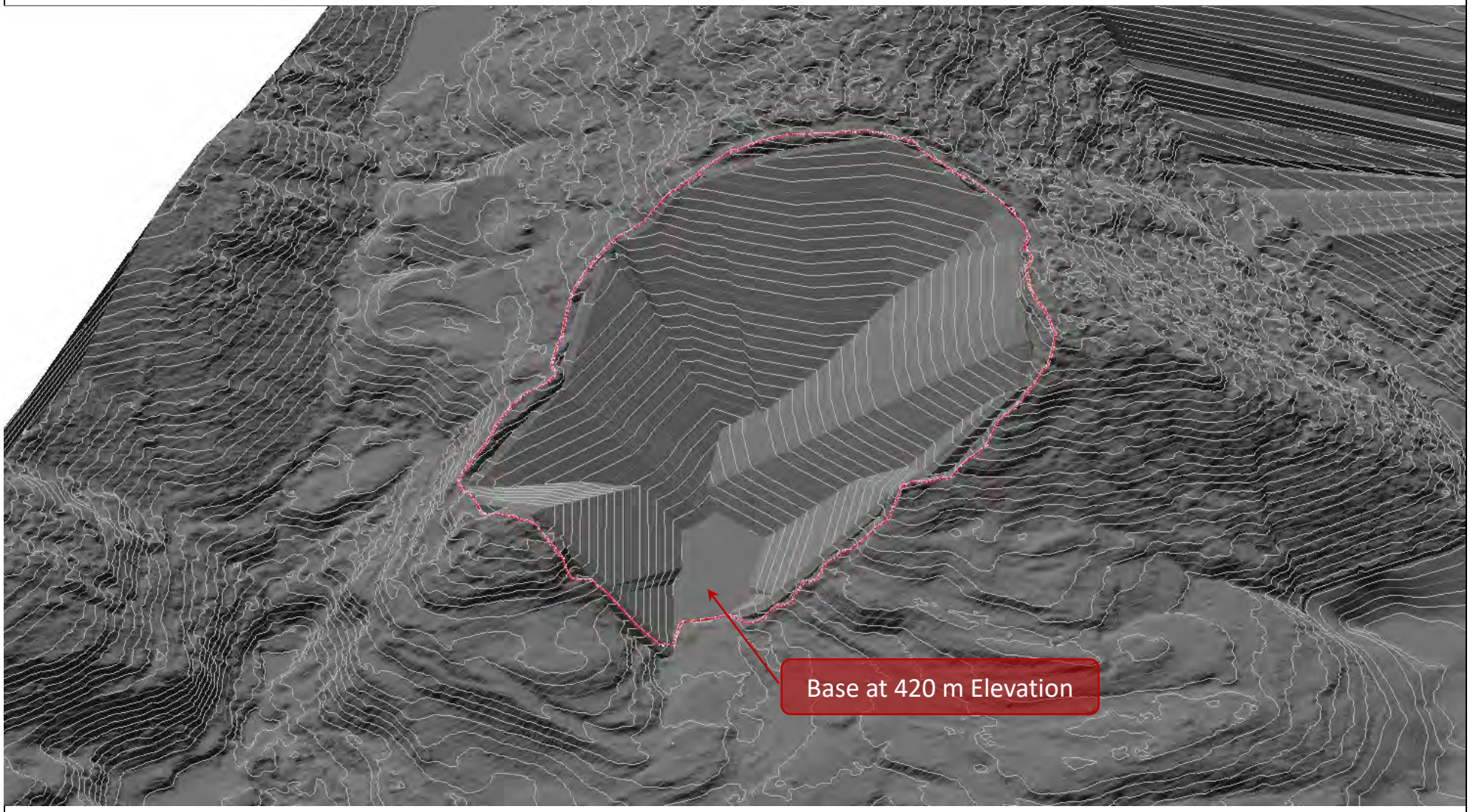
Isometrics of the backfilling concept for the Porcupine and Snowshoe/Creek Pits are shown on Figures P14 and P15, respectively. Elements of these concepts are as follows:

- the backfilled volume placed in the Porcupine Pit would be roughly 12,500,000 m^3, and about 3,800,000 m^3 in the Snowshoe and Creek Pits; and
- the pit bases have been contoured to elevations about well above the current water level in the pits.

1.4.6.2 Materials Management Concept

1. Porcupine Pit

Backfilling of the Porcupine Pit would start with the construction of a platform in the pit base that would extend up to about El. 420. The slopes would then be constructed up at 3H:1V to the pit rim. The total fill requirement of some 12.5 Mm^3 would be sourced from the Hudgeon Lake lower dump materials. For the purposes of this assessment, it has been assumed that this comparatively large fill requirement can be sourced from those Hudgeon Lake fills in ways that do not compromise that stability of dump structures that will remain in the Clinton Creek valley post closure. Additional assessment and design development would clearly be needed to validate this assumption should complete backfilling of Porcupine Pit be contemplated with a Clinton Creek option that does not generate significant dump soil volumes.



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

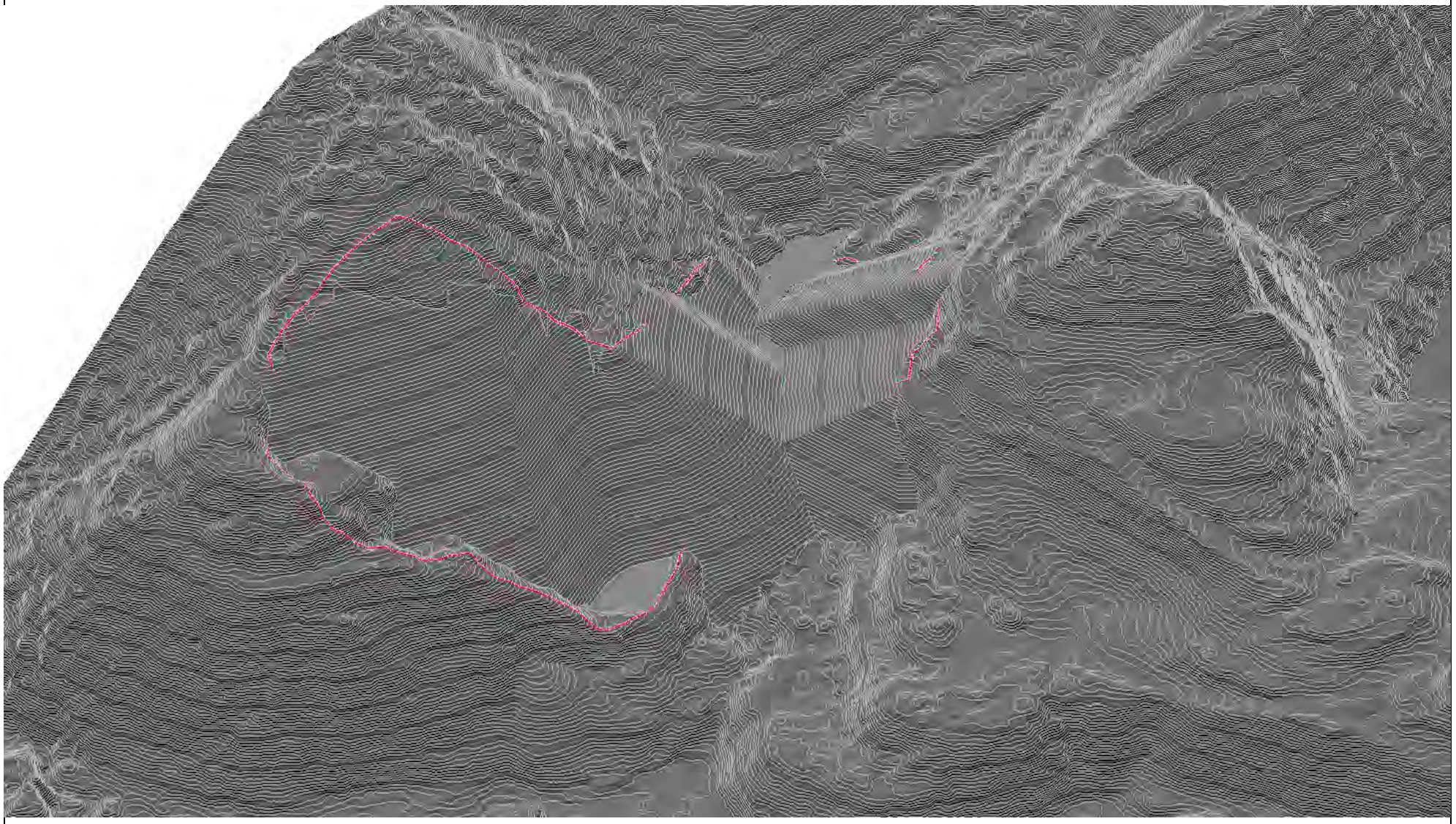
Yukon

D□ N □□□
□□
C□K□D □□□
□□
DAT□M□
NAD □□
PROJETION□
NAD □□
□CALE□
A□ □□O□ N

PROJECT□
CLINTON CREEK REMEDIATION PROJECT

TITLE□
Por□□□ine Pit Com□lete □□□□illin□ l□ometri□

DATE□
M□□□□0□1
Pro□e□t no□
□E□□□0□K□00□
RE□□NO□
RE□□DATE□
□l□□RE NO□
P1□



wood.

En□ironment □ In□□tr□□t□re □ol□tion□
□ Di□i□ion o□□ ood C□n□d□ Limited
1□□□□ □ □□A□en□e □□rre□□□C □□N □P□
Tel□□0□-□□□-□□□□

Client□

Yukon

D□ N □□□ □□	PROJECT□ CLINTON CREEK REMEDIATION PROJECT	DATE□ M□□□□0□1
C□K□D □□□ □□		Pro□e□t no□ □E□□□0□K□00□
DAT□M□ NAD □□	TITLE□ □no□ □□oe □nd Cree□ Pit□ Com□lete □□□□illin□ I□ometri□	RE□□NO□
PROJETION□ NAD □□		RE□□DATE□
□CALE□ A□ □□O□ N		□I□□RE NO□ P1□

2. Snowshoe/Creek Pits

Similar to the Porcupine Pit, backfilling of the Snowshoe/Creek Pits would be initiated by filling the Creek Pit valley bottom and then working the slope up both pit walls. The estimated fill requirement is greater than the available fill in the dumps east of Snowshoe Pit and southwest of the Creek Pit. This fill deficit would come from about 500,000 m^3 sourced from the Hudgeon Lake lower dump fills.

1.4.6.3 Anticipated Performance Outcomes

The Complete Backfilling option would provide safe and unencumbered access to the entire pits area in a landscape that would not incorporate any lakes.

1.4.6.4 Constructability/Execution Issues

The safe provision of access for backfilling operations will require plans based on the site-specific investigative data referenced in the following section. For this assessment, it has been assumed that access plans can be developed without requiring extraordinary preparatory measures and/or mitigations. Beyond concerns about access, constructability and/or execution constraints of significant consequence related to the Complete Backfilling option are not anticipated.

1.4.6.5 Key Risks and Uncertainties

1. Pre-Execution

As noted previously, geotechnical and rock mechanics investigations will be necessary precursors to any detailed planning effort for pit closure. These investigations could identify more comprehensive requirements for pit access and/or the need for different fill slopes than have been assumed in this assessment. Given the wide range of potential characterization outcomes, the current assessments of the Complete Backfilling option should be viewed as highly sensitive to the outcomes of future investigative activity.

DRAFT

2. Post Execution

It is possible that future investigative activity will demonstrate that a backfilling operation for the pits may carry more uncertainty relating to final slope stabilities than has been assumed. This could require mitigation via temporal and/or geographic constraints to site access of some description, albeit to lesser extents than would be associated with the No Action option for pit closure.

1.4.6.6 Associated Closure Criteria

Key closure criteria associated with the Complete Backfilling option are as follows:

- mitigates public safety risks by stabilizing all slopes in the post closure pit landscape;
- returns the site to a state that supports community and traditional land uses;
- maximizes access for public use;
- offers the potential for creation of significant local First Nations or Yukon socio-economic benefits (i.e., via the participation in pit closure execution activity);
- substantially reduces project related liability and risks; and
- involves substantial execution costs but minimal post closure operations and maintenance costs.

1.5 Cost Estimates for Pit Closure Options

Estimates for the pit closure options were developed using the estimating platform applied for both the 10% design phase candidate options (Wood, 2019j) and the subsequent Alternate Design options (Wood, 2020). The resulting estimates for pit closure are summarized in Table P3. The associated estimate detail is provided in the workbook presented in Attachment B.

1.5.1 Estimating Assumptions

Reference to Wood (2019j) and Wood (2020) should be made for a complete description of the estimating workbook that has been used for the pit estimates (i.e., Attachment B). In addition to these reference descriptions, the following estimating assumptions are reflected in the pit estimates.

- Given that pit closure activity is assumed to be co-incident with execution of the broader property closure plan, the pit estimates in Table P3 include no incremental costs for general project infrastructure (i.e., roads, bridges, site power, camp development).
- Incremental staff and equipment required for the pit scope are assumed to have been mobilized and demobilized separately from the property scope (i.e., it is assumed that maintenance of the broader execution schedule will require additional staff and equipment dedicated to any pit scope).
- The estimate assumed the pit scope will increase camp occupancy costs but not fixed camp development costs (i.e., it is assumed that spare camp capacity will be sufficient to accommodate pit staff execution requirements).
- The blasting and spill management costs in Table P3 apply an all-in unit rate that captures all drilling, access ramp/pad construction, blasting and local spoil management required to reduce pit rock slopes; supplementary grading/contouring and/or removal of blasting spoils required for some of the options are covered by equipment hours (i.e., Earthmoving – Load and Haul and Support Equipment (Dozers and Graders)) under the Materials Management column of Table P3.
- The blasting unit prices applied in the estimate (i.e., 25/m^3 for the comparatively large Porcupine blasting scope and $40/ m^3 for the relatively small Snowshoe/Creek scope) has been selected based on Wood's experience, and from a review of various materials management prices published in Alberta (2021). More site specific and reliable price developments incorporating inputs from contractors specializing in northern blasting operations has not been attempted for this exercise. The resulting estimate outcomes should be interpreted recognizing the relatively high uncertainty attached to the blasting unit prices used.
- The Extraordinary Field Investigations column covers costs for dedicated rock mechanics investigations for all pit options and the associated geotechnical assessment and design; it is assumed these investigations would also be required for the status quo options (i.e., PP1 and SCP1) to provide clarity on the required geographic limits on access restrictions. In addition, the other pit options would require geotechnical stability assessments for final pit slopes (i.e., blasting spoil and imported fill). The figures used for these requirements in the estimate are provisions rather than built up estimates, given the uncertainties currently associated with the various investigative and design scopes.
- Hydrologic, geotechnical and water quality monitoring requirements during closure activities for the pits are assumed to be similar to those applied for the Wolverine Creek options in the 10% design (i.e., not zero, but relatively modest).

DRAFT

Table P3 - Estimated Costs for Pit Closure Options

wood.

Option	MOB and Demob		Temporary Facilities and Controls (TF&C)											Civil Works							Mechanical Works			Post Closure Care and Maintenance						Extraordinary Field Investigations	EPCM	Contingency	Total	Total (Rounded)
				Site Access		On-Site Haul Roads		Fuel/Power Supply		H&S Controls				Materials Management				Flow Conveyance and Erosion Control																	
	Personnel	Equipment	Camp	Roads	Bridges	Roads	Bridges	Fuel Storage and Delivery	General Site Power	General Site H&S	Asbestos Abatement Controls	Incidental Temporary Facilities and Controls	Monitoring	Earthmoving Load & Haul	Blasting & Spoil Mgmt	Support Equipment - Dozers	Support Equipment - Graders	Spillway	Erosion Control	Sediment Pond	Ground Thawing	Lake Drawdowns	Blast Densification	Care & General Maintenance	Repair & Remediation	Monitoring	Partner Communications/Consultations	Owner's Project Management & Admin	Sediment Pond Cleanouts					
CC1	$1,261,353	$77,097	$8,900,390	$3,068,851	$1,203,770	$996,180	$891,675	$2,534,389	$2,199,949	$308,654	$5,027,136	$6,261,660	$1,508,825	$19,923,602		$8,585,013	$4,069,932	$35,592,092		$4,599,144	$77,705,000	$638,841		$13,360,489		$14,653,440	$1,077,459	$538,729		$9,450,000	$21,498,367.24	$61,483,010	**$307,415,050**	**$310,000,000**
CC1-A	$466,449	$63,080	$4,443,992	$1,221,084	$1,203,770	$198,188	$891,675	$1,571,878	$1,138,250	$119,958	$2,368,933	$2,580,905	$600,356	$3,534,073		$5,482,379	$1,619,410	$12,835,376		$4,599,144		$592,498	$4,110,000	$13,360,489	$9,339,561	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,861,107.58	$26,730,546	**$133,652,729**	**$130,000,000**
CC1-B	$515,774	$63,080	$4,728,729	$1,350,210	$1,203,770	$219,146	$891,675	$1,594,744	$1,212,444	$132,643	$2,530,736	$2,521,510	$663,841	$3,907,791		$6,062,125	$1,790,658	$12,835,376		$4,599,144		$592,498		$13,360,489	$9,525,836	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,657,184.84	$26,169,758	**$130,848,792**	**$130,000,000**
CC2	$2,047,067	$77,097	$13,353,611	$4,980,480	$1,403,770	$1,616,714	$891,675	$2,953,100	$3,298,342	$500,919	$7,636,081	$4,003,804	$2,448,692	$32,334,280		$13,932,732	$6,605,147	$12,399,214		$4,599,144		$682,515		$4,732,423		$15,014,097	$1,302,023	$651,012		$6,150,000	$13,746,394	$39,340,083	**$196,700,417**	**$197,000,000**
CC2-A	$682,452	$77,097	$5,619,328	$1,660,394	$1,203,770	$538,981	$891,675	$2,104,957	$1,390,671	$166,997	$3,104,907	$3,015,431	$816,346	$10,779,612		$4,644,898	$2,202,026	$12,399,214		$4,599,144		$638,841	$12,600,000	$4,732,423	$12,693,491	$15,014,097	$1,302,023	$651,012		$6,150,000	$10,352,979	$30,008,191	**$150,040,955**	**$150,000,000**
CC2-B	$1,313,849	$77,097	$9,197,926	$3,196,574	$1,403,770	$1,037,640	$891,675	$2,448,771	$2,273,336	$321,500	$5,201,449	$3,596,127	$1,571,620	$20,752,803		$8,942,313	$4,239,319	$12,399,214		$4,599,144		$638,841		$4,732,423	$17,664,493	$15,014,097	$1,302,023	$651,012		$6,150,000	$12,346,702	$35,490,930	**$177,454,650**	**$180,000,000**
CC3	$4,028,369	$77,097	$24,583,116	$9,800,955	$1,803,770	$3,181,489	$891,675	$4,008,948	$6,068,115	$985,746	$14,214,952	$5,979,584	$4,818,716	$63,629,781		$27,417,857	$12,998,095			$2,378,134		$696,795		$3,396,374		$9,799,197	$871,040	$435,520	$3,233,731	$6,150,000	$20,529,906	$57,994,740	**$289,973,701**	**$290,000,000**
WC1	$239,714	$23,364	$1,204,500	$1,077,986				$87,370	$459,199	$92,040	$584,100	$1,040,997	$170,000			$766,500	$420,480			$4,599,144				$8,188,687		$11,205,571	$1,077,459	$538,729	$3,965,048		$3,574,089	$9,828,744	**$49,143,722**	**$50,000,000**
WC2	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,403,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$6,333,182	$956,799	$108,657,228		$16,553,575	$4,733,114	$5,496,524		$4,599,144				$8,188,687		$5,861,376	$646,475	$323,238		$2,350,000	$21,743,923	$60,383,289	**$301,916,446**	**$300,000,000**
WC2-A	$908,564	$126,159	$6,642,981	$1,755,906	$1,203,770	$4,598,312	$891,675	$2,366,968	$1,445,550	$191,654	$3,954,521	$2,458,629	$276,909	$21,775,499		$7,762,316	$1,369,820	$764,511		$4,599,144				$8,188,687	$6,300,254	$5,861,376	$646,475	$323,238		$150,000	$8,441,292	$23,251,052	**$116,255,261**	**$120,000,000**
WC3	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,603,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$5,475,038	$956,799	$67,163,988		$33,107,150	$8,046,295		$7,500,000	$4,599,144				$2,081,649		$2,449,799	$871,040	$435,520			$18,797,631	$51,693,486	**$258,467,430**	**$260,000,000**
PP1												$45,253												$1,077,459			$215,492	$215,492		$500,000	$155,370	$552,266	**$2,761,331**	**$2,800,000**
PP2	$751,845	$72,425	$4,384,192					$448,127		$198,598	$1,572,548	$2,399,785	$322,645	$6,702,524	$60,000,000	$3,777,517	$641,844							$861,967			$129,295	$129,295		$600,000	$8,239,261	$22,807,967	**$114,039,834**	**$114,000,000**
PP3	$826,324	$63,080	$4,889,388					$519,891		$226,703	$1,686,986	$2,500,121	$374,315	$7,499,360	$60,000,000	$5,056,183	$859,104							$861,967		$215,492	$129,295	$129,295		$600,000	$8,583,750	$23,755,313	**$118,776,567**	**$119,000,000**
PP4	$1,682,728	$175,220	$8,873,547					$640,467		$332,826	$4,067,054	$2,886,211	$461,128	$48,719,018		$26,256,604	$3,877,899							$861,967			$129,295	$129,295		$600,000	$9,909,326	$27,400,646	**$137,003,230**	**$137,000,000**
SCP1												$31,031												$775,770			$129,295	$129,295		$300,000	$106,539	$367,983	**$1,839,913**	**$1,800,000**
SCP2	$271,856	$46,726	$1,735,212					$219,934		$89,645	$481,166	$373,063	$158,350	$1,673,493	$5,158,200	$1,301,154	$308,422							$646,475		$172,393	$86,197	$86,197		$400,000	$1,280,848	$3,622,333	**$18,111,664**	**$18,000,000**
SCP3	$233,856	$46,726	$1,492,664					$189,192		$77,114	$413,909	$325,773	$136,216	$1,168,499	$5,158,200	$908,517	$215,352							$646,475			$86,197	$86,197		$400,000	$1,118,489	$3,175,844	**$15,879,220**	**$16,000,000**
SCP4	$587,179	$126,159	$3,266,295					$289,095		$136,347	$1,320,087	$962,878	$208,145	$16,208,775		$7,384,566	$1,750,416							$646,475			$86,197	$86,197		$400,000	$3,305,881	$9,191,173	**$45,955,864**	**$46,000,000**

- The post closure costs for the pits are best viewed as judgement-based provisions rather than estimates, given the current uncertainties relating to post management scopes; while these annual costs are modest, they produce significant net present values because the associated requirements extend indefinitely following closure.

1.5.2 Estimating Outputs

1.5.2.1 Pit Closure Designs to Date

Pit closure was considered in the 10% design development work (i.e., the base 10% designs and the Alternative Designs) to the extent that pits were assumed as spoil storage structures for those options involving significant relocations of dump and/or tails materials. This largely addressed pit closure for these options because issues related to unstable rock slopes were mitigated via the stabilizing influence of pit infilling. Note that this applied only to the Porcupine Pit because the available storage in the Snowshoe and/or Creek pits was not needed to accommodate the maximum volumes of spoil potentially generated by the candidate closure options.

Table P4 summarizes the spoil volumes directed to storage for the closure options considered to date. Any combination of the Clinton and Wolverine options that produce spoil volumes exceeding the 12.5 Mm^3 fill requirement for the Complete Backfilling option for Porcupine Creek (see Section 1.4.6) would largely mitigate the need for incremental closure costs for this pit. Option combinations that produce spoil volumes less than this figure would generate incremental Porcupine Pit closure pits falling proportionately between the 10% closure design estimates (Wood, 2019, 2020) and the stand-alone pit closure estimates described herein (i.e., Table P3).

DRAFT

Table P4: Key Materials Movement Volumes for CCRP Closure Alternatives

Option	Creek	Estimated Waste Material or Tailings Removal Volume (m^3)	Waste Material Relocation / Tailings Area
CC1	Clinton	4,373,000	PPSS
CC1-A	Clinton	870,000	To Fill
CC1-B	Clinton	962,000	PPSS
CC2	Clinton	7,097,000	PPSS
CC2-A	Clinton	2,366,000	PPSS
CC2-B	Clinton	4,555,000	PPSS
CC3	Clinton	13,966,000	PPSS
WC1	Wolverine		
WC2	Wolverine	4,312,000	
WC2-A	Wolverine	2,225,000	Local Fill & PPSS
WC3	Wolverine	7,688,000	PPSS

1.5.2.2 Integration with Property Closure Plans

The pit closure cost estimates reflect the general assessment assumption that the broader property closure plan is not integrated with closure requirements for the pits (see Section 1.4.1.2), an assumption made to avoid consideration of an unworkable number of permutations and combinations of potential pit and property closure concepts. In practice, the extent to which pit closure is integrated with the larger Clinton closure scope will depend on the property closure options selected and the Partners' objectives

and preferences for the pits. This assessment and cost estimate could have made the assumption that the minimum dump spoil quantities generated by any of the candidate property closure plans would be directed to one of the pits. However, even this minimum volume would raise final grade levels at the pit bases above the current pit water levels, effectively precluding adoption of the 'lake retention' option for the pits. If pit lake retention was preferred, excess spoil from the Clinton dumps could be consolidated outside the pits in engineered landforms located proximate to the dump source(s). Further, the 'no action' scenario for the Clinton and Wolverine sides of the property has not yet been categorically discounted; it is conceivable that a final property closure plan would combine access limits for most of the property with some degree of active closure for the pits, hence the decision to start the consideration of potential pit closure costs as stand-alone activity.

All of the above said, most of the property closure options will generate excess dump and/or tailings volumes requiring disposition, and the pits are an obvious and practical candidate for these materials. This suggests that pit lake retention would need to be a compelling preference to preclude use of the pits, particularly the Porcupine Pit, for spoil disposition. The apparently limited utility of the current pit lakes would appear to reduce the likelihood of this scenario; more plausible are scenarios that would see at least the Porcupine Pit integrated with the broader property closure plan as a spoil disposition location. While the current schedule of cost estimates does not fully address the range of potential pit spoil disposition scenarios, the cost implications of these scenarios can be inferred generally from a consideration of the pit estimates offered (i.e., for Options PP1 through PP4 and SCP1 through SCP4, in Table P3), and those property closure options that do utilize the Porcupine Pit for varying degrees of spoil disposition.

Note that the pit estimates in Table P3 underestimate costs for the unlikely combination of 'no action' for both the Clinton and Wolverine valleys, with active closure operations for the pits. This is because the estimates assumed temporally co-incident property and pit closure execution, with the former activity scope capturing general project infrastructure costs.

DRAFT

1.6 Closure Options Comparative Assessment

The central purpose of this report is to describe designs for those candidate pit closure options that have been identified by the Project Partners. The Project Partners will be considering these designs, and the associated cost estimates, in light of the project objectives (Table P2), closure criteria supplementing these objectives and various other considerations particular to each Partner's requirements and constraints. These considerations will lead to the selection of a preferred concept to pit closure that will then be developed further in subsequent design activity. Wood recognizes and fully understands that this concept select process is driven by issues that are the Project Partners' alone to consider; issues that are not driven solely by the technical considerations that are the focus of this document. However, during the conduct of this phase of design development, Wood has formed opinions about the nature and utility of the options that may be useful input to the Project Partners' deliberations. This section is intended to capture and present those opinions.

1.6.1 Process/Format

Wood's interpretations of the pit closure options are presented in a tabular, comparative assessment relative to a common set of objectives and criteria. The objectives/criteria were developed from the Project Partners' general objectives (Table P2) supplemented by more specific criteria derived from Wood's understanding of project requirements and constraints, and the outcomes of discussions with the Project Partners. The resulting comparative assessment is presented in Table P4. Note that this table is a supplement to the comparative assessment for the general property closure options that was presented in the 10% Design Report (Wood, 2019).

It is worth noting that the ratings applied in this table are intentionally coarse (i.e., there are typically only three levels of differentiation considered under each criterion (e.g., low, medium, high)). It would not be appropriate to attempt more refined distinctions in a high-level comparative assessment like this, and the number of ratings applied were therefore limited.

1.6.2 Criteria Descriptions

The following sections describe each of the individual criteria considered in Table P5.

1.6.2.1 Protection of Human Health and Safety

These criteria refer to an option's ability to mitigate health and safety risks in the post closure landscape. Specific criteria descriptions are as follows:

- Catastrophic Slope Failure Risk: characterizes the extent to which an option mitigates the potential for large scale slope movements or failures that are likely to generate significant consequences in the post closure landscape.
- Asbestos Risks: characterizes the post closure risks to site visitors posed by asbestos in air.
- Other Contaminant Risks: characterizes the post closure risks to site visitors posed by other contaminants (principally metals) in site wastes, soils and/or rocks.
- Utility of Harvested Natural Produce and Wildlife: characterizes the post closure risks associated with harvesting natural produce (e.g., plants, berries) and/or wildlife from the Clinton property.

1.6.2.2 Protection of the Environment

These criteria refer to an option's ability to mitigate the impacts of environmental degradation in the post closure landscape. Specific criteria descriptions are as follows:

- Impacts on Fish Habitat: describes whether the option is likely to have a positive or negative impact on the character and status of the property's fish habitat prior to closure (i.e., the status quo).
- Impacts on Terrestrial Environment: describes whether an option is likely to have a beneficial impact on the existing capability and/or aesthetic of land ecosystems in the post closure environment.
- Impacts on Surface Water Quality: characterizes an option's likely impact on post closure surface water quality, and indirectly then, on the health of local aquatic ecosystems.

1.6.2.3 Uncertainties

1. Pre-Execution

Section 7 of the Design Report (Wood, 2019) noted that there is some potential that future investigative activity undertaken as part of post 10% design development efforts, could change perspectives on the relative appeal of the candidate options. This criterion qualitatively describes the sensitivity of the Table P4 representations of an option's characteristics and performance outcomes to future investigative outcomes that might fall outside of the range current assumptions.

DRAFT

Table P5
Clinton Creek Remediation Project
Comparative Assessment of Candidate Closure Options - Pit Closure Supplement

wood.

		Protect Human Health & Safety (Post Closure)				Protect the Environment (Post Closure)			Uncertainties				Post Closure Land Utility							
									Pre Execution (Design Development and/or Permitting)	Post Execution										
	Criterion	Catastrophic Slope Failure Risk	Asbestos Risks	Other Contaminant Risks	Utility of Harvested Natural Produce & Wildlife	Impacts on Fish Habitat	Impacts on Terrestrial Environment	Impacts on Surface Water Quality	Sensitivity of Current Option Assessments to Changes in Site Characterizations	Relating to Slope Failure Potentials	Relating to Environmental Outcomes	Relating to Human Health & Safety Outcomes	Access	Compatibility With Pre-development Land Uses	Recreational use of surface water bodies	Execution Challenges/Difficulty	Post Execution OPEX Liabilities (excl catastrophic failure remediation)	Permitting Challenges/Complexity	Compatibility with Maximization of First Nation & Yukon Socio-Economic Benefits	Costs (LCCA)
Option	*Ratings*	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Neutral, High	Negative, Neutral, Positive	Negative, Neutral, Positive	Negative, Neutral, Positive	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High	Restricted, Neutral, Unrestricted	Low, Medium, High	Restricted, Neutral, Unrestricted	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High	from Section 1.5 or Wood (2019j)
Clinton Creek																				
CC1 - Retention of Hudgeon Lake		Medium	Low	Low	Neutral	Neutral	Neutral	Neutral	High	Medium	Low	Medium	Unrestricted	Low	Unrestricted	High	Medium	High	Low	$310,000,000
CC2 - Lower Hudgeon Lake with Regime Channel		Medium	Low	Low	Neutral	Positive	Positive	Neutral	Medium	Low	Medium	Low	Unrestricted	Medium	Unrestricted	Medium	Low	Medium	High	$197,000,000
CC3 - Removal of Hudgeon Lake		Low	Low	Low	Neutral	Positive	Positive	Negative	Medium	Low	Medium	Low	Unrestricted	High	Unrestricted	Medium	Low	Low	High	$290,000,000
Wolverine Creek																				
WC1 - No Tailings Disturbance; Sediment Control Only		High	High	High	Low	Neutral	Negative	Neutral	Low	High	High	High	Restricted	Low	Restricted	Low	High	High	Low	$50,000,000
WC2 - In-Place Tails Stabilization and Surface Water Conveyance		Low	Low	Low	Neutral	Positive	Neutral	Positive	High	Medium	Low	Low	Unrestricted	Low	Unrestricted	Medium	Medium	High	High	$310,000,000
WC3 - Isolation via Relocation		Low	Low	Low	High	Positive	Positive	Positive	Medium	Low	Low	Low	Unrestricted	High	Unrestricted	Medium	Low	Low	High	$260,000,000
Porcupine, Snowshoe & Creek Pits																				
PP1 - Porcupine Pit - No Action		Medium	Low	Low	Neutral	Neutral	Neutral	Neutral	Medium	Low	Low	Low	Restricted	Low	Restricted	Low	Medium	Medium	Low	$2,800,000
PP2 - Porcupine Pit - Lake Removal		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	Medium	Unrestricted	Medium	Low	Low	High	$114,000,000
PP3 - Porcupine Pit - Lake Retention		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	Medium	Unrestricted	Medium	Low	Low	High	$119,000,000
PP4 - Porcupine Pit - Complete Backfilling		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	High	Unrestricted	Medium	Low	Low	High	$137,000,000
SCP1 - Snowshoe & Creek Pits - No Action		Medium	Low	Low	Neutral	Neutral	Neutral	Neutral	Medium	Low	Low	Low	Restricted	Low	Restricted	Low	Medium	Medium	Low	$1,800,000
SCP2 - Snowshoe & Creek Pits - Lake Removal		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	Medium	Unrestricted	Medium	Low	Low	High	$18,000,000
SCP3 - Snowshoe & Creek Pits - Lake Retention		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	Medium	Unrestricted	Medium	Low	Low	High	$16,000,000
SCP4 - Snowshoe & Creek Pits - Complete Backfilling		Low	Low	Low	Neutral	Neutral	Positive	Neutral	High	Low	Low	Low	Unrestricted	High	Unrestricted	Medium	Low	Low	High	$46,000,000

Color Legend

Best
Mid
Worst

2. Post Execution

These criteria characterize the reliability of predictions for the health, safety and environmental outcomes potentially offered by an option. Specific criteria descriptions are as follows:

- Slope Failure Potentials: characterizes uncertainties in predictions of stability, recognizing the practical limits to the geotechnical dataset that could be assembled for an option (i.e., that while the current datasets may be supplemented during detailed design, the inevitable limits to data compilation will produce uncertainties that must be accommodated in a closure plan).
- Health, Safety and Environmental Outcomes: similarly, the practical limits to site characterization datasets and risk analyses will produce residual uncertainties requiring consideration in any closure plan.

1.6.2.4 Post Closure Land Utility

These criteria characterize the degree of public access that an option will provide post closure and the compatibility of potential future land uses relative to similar undeveloped lands. Specific criteria descriptions are as follows:

- Access: characterizes the limits to public access that may be required under an option to mitigate post closure risks.
- Compatibility with Pre-development Land Uses: characterizes the ability of an option to provide for land uses consistent with those offered by undeveloped lands in the area. This criterion is applied with a long-term perspective (e.g., considering the capabilities of the property after spontaneous revegetation has occurred).
- Recreational Use of Surface Water Bodies: characterizes any limits to the public's access to local water bodies that may be required to mitigate post closure risks.

DRAFT

1.6.2.5 Other Criteria

Table P4 includes various other criteria focusing on the difficulty of executing options, the scale of post closure liabilities that may be associated with them, how difficult and/or complex the regulatory approvals process may be and the potential for options to deliver local socio-economic benefits. Specific criteria descriptions are as follows:

- Execution Challenges/Difficulties: characterizes any distinguishing procurement, construction and/or operating challenges that might be associated with executing an option in this remote northern setting.
- Post Execution Liabilities: characterizes the general scale of ongoing operating, monitoring and maintenance requirements that would be associated with an option.
- Permitting Challenges/Complexity: a broad and general characterization of any distinguishing consultation, permitting and approvals liabilities associated with an option.
- Compatibility with Maximization of First Nation and Yukon Socio-Economic Benefits: a characterization of any challenges and/or obstacles that an option might pose to utilizing local resources (e.g., extensive requirements for highly specialized equipment and/or expertise).

1.6.2.6 Costs

This column presents the total costs by option detailed in Section 1.5.

1.7 Summary Comments and Observations

The following general comments and observations can be offered based on the outcomes of the closure assessments and cost estimates described herein.

- All of the Porcupine Pit active closure options (i.e., other than no action) involve substantial capital expenditures either because of the significant rock blasting scopes or, in the case of the Complete Backfilling option, the large movements of dump materials into the pits.
- The more modest costs for the Snowshoe/Creek active closure options, excepting perhaps the Complete Backfilling option, reflect the smaller scale of closure requirements generally, and the proximate availability of local dump fills.
- Caution should be exercised in making distinctions between those options exhibiting small cost differentials (e.g., between PP2 and PP3). The indicative nature of the concepts presented, driven in turn by the lack of characterization data for the pits generally, means that there is a comparatively high degree of uncertainty relating the closure scopes. In addition, the estimates particularly those for the Porcupine Pit, are sensitive to assumptions relating to a small number of costing inputs (the blasting unit price in particular) that have not yet been defined with site specific resolution.
- Pursuant to the overriding assumptions applied for this assessment, the cost estimates reflect requirements for pit closure as stand-alone activity (i.e., separate from, and incremental to, broader property closure activity). As pit closure plans are integrated with the broader property closure scope as options are selected, pit closure costs will decline from those presented herein, largely as a function of the quantities of dump and tailings spoils generated by the preferred options for the Clinton and Wolverine sides of the property (e.g., selecting CC3 and WC3 (complete dump and tails removal) takes incremental closure costs for the Porcupine Pit close to zero).
- Not surprisingly, the No Action alternatives for pit closure offer costs one to two orders of magnitude lower than the active closure options, a difference that highlights the economic implications of accepting limits to the utility of pit areas post closure and the associated need for ongoing institutional controls.
- The requirements, costs and relative appeal of pit closure options will be strongly influenced by the options selected for the Clinton and Wolverine Creek sides of the property; this probably limits the utility of progressing the indicative pit closure designs presented herein any further in advance of those broader closure decisions for the property.

DRAFT

2.0 Closure

This report is based on circumstances and conditions available at the time of writing. Wood has performed its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing in Alberta and British Columbia at the time that the services were performed.

Wood trusts that this report meets your current needs. Should you have any questions or require further clarification, please contact the undersigned at your convenience.

Sincerely,

Wood Environment and Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

R. Brian Geddes, P.Eng.
Principal Engineer

Reviewed by:

Ed McRoberts, Ph.D., P.Eng.
Principal Geotechnical Engineer

DRAFT

3.0 References

Alberta. 2021. *Unit Price Averages Report*. Government of Alberta, Transportation Construction Tendering and Contracts. Downloaded from www.alberta.ca/unit-prices-and-cost-adjustments. 04 May 2021.

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler). 2018a. *Clinton Creek Mine, Geotechnical Design Gaps.* Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2018.

EDI Environmental Dynamics Inc. (EDI). 2018. *Clinton Creek Surface Water Quality and Hydrological Investigations 2018/19: Methodology*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. July 2018.

Golder Associates (Golder). 1978. Report to Cassiar Asbestos Corporation Ltd. Re *Mine Waste Dump and Tailing Pile Clinton Creek Operations*. Project V77016. July 1978.

Government of Canada (Canada). 2021. *Canadian Climate Normals 1981-2010 Station Data for Dawson A*. Environment and Climate Change Canada. Downloaded from weather.gc.ca. 02 March 2021.

Htoon, Myat. 1979. *Geology of the Clinton Creek Asbestos Deposit, Yukon Territory*. A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science, University of British Columbia. March 1979.

Meteo Whitehorse. 2021. *Evapotranspiration Seasonal Summary*. Downloaded from meteowhitehorse-yukon Canada-evapotranspiration. 02 March 2021.

R.M. Hardy & Associates Ltd. (Hardy). 1977. *Report on Requirements for Development of a Rehabilitation Plan, Clinton Creek Mine, Cassiar Asbestos Corporation*. Prepared for the Yukon Territory Water Board. December 1977.

Stepanek, M. and H.F. McAlpine. 1992. *Landslide Dams of Clinton Creek*. Geohazards '92. P 291-298.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project 10% Design Phase Report.* Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions (Wood). 2019a. *Clinton Creek Remediation Project 2018 Site Investigation Report*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. July 2019.

Wood Environment & Infrastructure Solutions. 2019c. *Clinton Creek Remediation Project Geotechnical Summary*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. December 2019.

Wood Environment & Infrastructure Solutions. 2019e. *Geological and Geotechnical Site Characterization and Model - Clinton Creek Remediation Project*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. August 2019.

Wood Environment & Infrastructure Solutions. 2019i. *Clinton Creek Remediation Project Environmental Site Characterization Update*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. June 2019.

Wood Environment & Infrastructure Solutions. 2019j. *Clinton Creek Remediation Project, 10% Design Phase Cost Estimate*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2020. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

DRAFT

Attachment A
Table of Contents

DRAFT

wood.

Table of Contents

1.0 Pit Closure Assessment 1
1.1 Background 1
1.1.1 Scope Development 1
1.2 Pit Descriptions and Characterizations 2
1.2.1 Development History 2
1.2.2 Bedrock Stability and Seepage 4
1.2.3 Porcupine Pit Slide Areas 4
1.2.4 Pit Contours and Storage Capacities 6
1.2.4.1 Topographic Data 6
1.2.5 Storage Capacities 6
1.2.5.1 Porcupine Pit 6
1.2.5.2 Snowshoe and Creek Pits 6
1.2.6 Pit Water Volumes 6
1.2.6.1 Porcupine Pit 10
1. Volumes 10
2. Water Balance 10
3. Quality 10
1.2.6.2 Snowshoe and Creek Pits 10
1. Volumes 10
2. Water Balance 13
3. Quality 13
1.3 Closure Option Descriptions 13
1.4 Pit Closure Option Designs – Clinton Creek 14
1.4.1 Common Assumptions 14
1.4.1.1 Final Pit Slopes 14
1.4.1.2 General Assumptions 14
1.4.2 Option Assessments and Designs 17
1.4.3 No Action (PP1 and SCP1) 18
1.4.3.1 Scope Elements 18
1.4.3.2 Materials Management Concept 19
1.4.3.3 Anticipated Performance Outcomes 19
1.4.3.4 Constructability/Execution Issues 19
1.4.3.5 Key Risks and Uncertainties 19
1. Pre-Execution 19
2. Post Execution 19
1.4.3.6 Associated Closure Criteria 19
1.4.4 Removal of Pit Lake (PP2 and SCP2) 20
1.4.4.1 Scope Elements 20
1.4.4.2 Materials Management Concept 20
1. Blasting 20
2. Cut/Fill Balance 20
2a Porcupine Pit 20
2b. Snowshoe and Creek Pits 21
1.4.4.3 Anticipated Performance Outcomes 25
1.4.4.4 Constructability/Execution Issues 25
1.4.4.5 Key Project Execution Risks and Uncertainties 25
1. Pre-Execution 25
2. Post Execution 26

DRAFT

Table of Contents (cont'd)

1.4.4.6 Associated Closure Criteria 26
1.4.5 Maintenance of Lake (PP3 and SCP3) 26
1.4.5.1 Scope Elements 26
1. Porcupine Pit 26
2. Snowshoe and Creek Pits 28
1.4.5.2 Materials Management Concept 28
1.4.5.3 Anticipated Performance Outcomes 28
1.4.5.4 Constructability/Execution Issues 28
1.4.5.5 Key Risks and Uncertainties 28
1.4.5.6 Associated Closure Criteria 28
1.4.6 Complete Backfilling (PP4 and SCP4) 30
1.4.6.1 Scope Elements 30
1.4.6.2 Materials Management Concept 30
1. Porcupine Pit 30
2. Snowshoe/Creek Pits 33
1.4.6.3 Anticipated Performance Outcomes 33
1.4.6.4 Constructability/Execution Issues 33
1.4.6.5 Key Risks and Uncertainties 33
1. Pre-Execution 33
2. Post Execution 33
1.4.6.6 Associated Closure Criteria 33
1.5 Cost Estimates for Pit Closure Options 34
1.5.1 Estimating Assumptions 34
1.5.2 Estimating Outputs 36
1.5.2.1 Pit Closure Designs to Date 36
1.5.2.2 Integration with Property Closure Plans 36
1.6 Closure Options Comparative Assessment 37
1.6.1 Process/Format 37
1.6.2 Criteria Descriptions 38
1.6.2.1 Protection of Human Health and Safety 38
1.6.2.2 Protection of the Environment 38
1.6.2.3 Uncertainties 38
1. Pre-Execution 38
2. Post Execution 40
1.6.2.4 Post Closure Land Utility 40
1.6.2.5 Other Criteria 40
1.6.2.6 Costs 40
1.7 Summary Comments and Observations 41
2.0 Closure 42
3.0 References 43

DRAFT

Table of Contents (cont'd)

List of Figures

Figure P1: Former Clinton Creek Mine Site – General Arrangement 3
Figure P2: Porcupine Pit Slide Areas 5
Figure P3: Clinton Area Topography 7
Figure P4: Porcupine Pit Area Topography 8
Figure P5: Snowshoe/Creek Pit Area Topography 9
Figure P6: Porcupine Pit Water Volume 11
Figure P7: Creek Pit Water Volume 12
Figure P8: Natural Slope Survey – Plan of Section Lines Over LiDAR 15
Figure P9: Porcupine Pit Removal of Lake Isometric 22
Figure P10: Snowshoe and Creek Pits Removal of Lake Isometric 23
Figure P11: Snowshoe and Creek Pits – Materials Management Areas 24
Figure P12: Porcupine Pit Maintenance of Lake Isometric 27
Figure P13: Snowshoe and Creek Pits Maintenance of Lake Isometric 29
Figure P14: Porcupine Pit Complete Backfilling Isometric 31
Figure P15: Snowshoe and Creek Pits Complete Backfilling Isometric 32

DRAFT

List of Tables

Table P1: Clinton Area Natural Slope Survey – Section Slopes 16
Table P2: Clinton Creek Remediation Project Objectives 18
Table P3: Estimated Costs for Pit Closure Options 35
Table P4: Key Materials Movement Volumes for CCRP Closure Alternatives 36
Table P5: Clinton Creek Remediation Project Comparative Assessment of Candidate Closure Options - Pit Closure Supplement 39

List of Attachments

Attachment A: Table of Contents
Attachment B: Pit Closure Options Estimating Workbook

Attachment B
Pit Closure Options Estimating Workbook

DRAFT

wood.

Clinton Creek Remediation Project - 10% Design Development Cost Estimate

Date: April 26, 2021

wood.

Navigation Dashboard (note: use buttons at right to access estimate content)

Estimate Summaries				*CCRP Cost Estimate Table W-2: Cost Summary by Option*
				Table W-3: Cost Summary by Activity
Estimate Detail				*CCRP Cost Estimate Table W-4: 2019 CC1 Estimate Detail*
				CCRP Cost Estimate Table W-4a: 2019 CC1-A Estimate Detail
				CCRP Cost Estimate Table W-4b: 2019 CC1-B Estimate Detail
				CCRP Cost Estimate Table W-5: 2019 CC2 Estimate Detail
				CCRP Cost Estimate Table W-5a: 2019 CC2-A Estimate Detail
				CCRP Cost Estimate Table W-5b: 2019 CC2-B Estimate Detail
				CCRP Cost Estimate Table W-6: 2019 CC3 Estimate Detail
				CCRP Cost Estimate Table W-7: 2019 WC1 Estimate Detail
				CCRP Cost Estimate Table W-8: 2019 WC2 Estimate Detail
				CCRP Cost Estimate Table W-8a: 2019 WC2-A Estimate Detail
				CCRP Cost Estimate Table W-9: 2019 WC3 Estimate Detail
				CCRP Cost Estimate Table W-10a: 2021 PP1 Estimate Detail
				CCRP Cost Estimate Table W-10b: 2021 PP2 Estimate Detail
				CCRP Cost Estimate Table W-10c: 2021 PP3 Estimate Detail
				CCRP Cost Estimate Table W-10d: 2021 PP4 Estimate Detail
				CCRP Cost Estimate Table W-11a: 2021 SCP1 Estimate Detail
				CCRP Cost Estimate Table W-11b: 2021 SCP2 Estimate Detail
				CCRP Cost Estimate Table W-11c: 2021 SCP3 Estimate Detail
				CCRP Cost Estimate Table W-11d: 2021 SCP4 Estimate Detail
				CCRP Cost Estimate Table W-12: 2019 Consolidated Estimate Detail
Volume & Equipment Metrics				*CCRP Cost Estimate Table W-13: 2019 Remediation Options - Earthmoving Metrics*
				CCRP Cost Estimate Table W-14: Key Equipment and Field Personnel Metrics
Equipment Specificiations & Unit Rates				*CCRP Cost Estimate Table W-15: Loading Equipment Specifications and Rates*
				CCRP Cost Estimate Table W-16: Hauling Equipment Specifications and Rates
				CCRP Cost Estimate Table W-17: Yukon Government Third Party Equipment Rental Rates
				CCRP Cost Estimate Table W-18: 2019 NWT Equipment Rates
Estimate Inputs	*Mobilization and Demobilization*			*CCRP Cost Estimate Table W-19: Mobilization and Demobilization of Equipment and Field Personnel*
	Temporary Facilities and Controls	*Camp*		*CCRP Cost Estimate Table W-20: Worker Camp Cost Estimate*
		Site Access / On-site Haul Roads	*Roads*	*CCRP Cost Estimate Table W-21: Access Road Improvement and Maintenance Estimate*
			Bridges	*CCRP Cost Estimate Table W-22: Water Crossing Cost Estimate*
		Fuel Power/Supply	*Fuel Storage and Delivery*	*CCRP Cost Estimate Table W-23: Fuel Storage Cost Estimate*
			General Site Power	*CCRP Cost Estimate Table W-24: Site Electrical Power Estimate*
		H&S Control	*General Site H&S*	*CCRP Cost Estimate Table W-25: Conventional Health & Safety Estimate*
			Asbestos Abatement Controls	*CCRP Cost Estimate Table W-26: Asbestos Abatement Estimate*
		Incidental Temporary Facilities and Controls		*CCRP Cost Estimate Table W-56: 2019 Estimate Factors and Assumptions*
		Monitoring		*CCRP Cost Estimate Table W-54a: Annual Post Closure Costs*
	Civil Works	*Materials Management*	*Earthmoving - Load & Haul*	*CCRP Cost Estimate Table W-27: Earth Moving Estimate - Option CC1*
				CCRP Cost Estimate Table W-28: Earth Moving Estimate - Option CC2
				CCRP Cost Estimate Table W-29: Earth Moving Estimate - Option CC3
				CCRP Cost Estimate Table W-30: WC2 Material Volumes and Disposition
				CCRP Cost Estimate Table W-31: Earth Moving Estimate - Option WC3
				CCRP Cost Estimate Table W-32: Earth Moving Estimate - Option PP1
				CCRP Cost Estimate Table W-33: Earth Moving Estimate - Option PP2
				CCRP Cost Estimate Table W-34: Earth Moving Estimate - Option PP3
				CCRP Cost Estimate Table W-35: Earth Moving Estimate - Option PP4
				CCRP Cost Estimate Table W-36: Earth Moving Estimate - Option SCP1
				CCRP Cost Estimate Table W-37: Earth Moving Estimate - Option SCP2
				CCRP Cost Estimate Table W-38: Earth Moving Estimate - Option SCP3
				CCRP Cost Estimate Table W-39: Earth Moving Estimate - Option SCP4
				CCRP Cost Estimate Table W-40: Haul Road Construction Estimate - Option WC3
				CCRP Cost Estimate Table W-41: Aggregate Load and Haul from Site 11 Estimate
				CCRP Cost Estimate Table W-42: Riprap Load and Haul from Km 63 Quarry Estimate
				CCRP Cost Estimate Table W-43: Haul Road Construction - Options CC1, CC2, and CC3
			Blasting & Spoil Management	*25*
			Support Equipment - Dozers	*CCRP Cost Estimate Table W-45: Dozing Equipment Estimate*
			Support Equipment - Graders	*CCRP Cost Estimate Table W-46: Grading and Road Maintenance Equipment*
		Flow Conveyance	*Aggregate*	*CCRP Cost Estimate Table W-47: Engineered Sands, Gravels, and Riprap Estimate*
			Spillway / Erosion Control	*CCRP Cost Estimate Table W-48: Flow Conveyance and Erosion Control Cost Estimates*
			Sediment Pond	*CCRP Cost Estimate Table W-49: Sediment Pond Cost Estimate*
				CCRP Cost Estimate Table W-50: Option CC3 Sediment Pond Cost Estimate
	Mechanical Works	*Ground Thawing*		*CCRP Cost Estimate Table W-51: Ground Thawing Cost Estimate*
		Lake Drawdown		*CCRP Cost Estimate Table W-52: Hudgeon Lake Drawdown Cost Estimate*
	Post Closure Care & Maintenance			*CCRP Cost Estimate Table W-54a: Annual Post Closure Costs*
				CCRP Cost Estimate Table W-54b: Annual Post Closure Costs - Pits
	Investigations			*CCRP Cost Estimate Table W-55: CCRP - Major, Supplementary Investigative Costs by Option*
Estimate Factors, Assumptions, and Indices				*CCRP Cost Estimate Table W-56: 2019 Estimate Factors and Assumptions*
				CCRP Cost Estimate Table W-57: Statistics Canada Price Indexes
				CCRP Cost Estimate Table W-58: Statistics Canada Average Hourly Earnings
				CCRP Cost Estimate Table W-59: Yukon Government Fair Wage Schedule

CCRP Cost Estimate Table W-2: Cost Summary by Option

wood.

Option	MOB and Demob		Temporary Facilities and Controls (TF&C)											Civil Works							Mechanical Works			Post Closure Care and Maintenance						Extraordinary Field Investigations	EPCM	Contingency	Total	Total (Rounded)
				Site Access		On-Site Haul Roads		Fuel/Power Supply		H&S Controls				Materials Management				Flow Conveyance and Erosion Control																	
	Personnel	Equipment	Camp	Roads	Bridges	Roads	Bridges	Fuel Storage and Delivery	General Site Power	General Site H&S	Asbestos Abatement Controls	Incidental Temporary Facilities and Controls	Monitoring	Earthmoving Load & Haul	Blasting & Spoil Mgmt	Support Equipment - Dozers	Support Equipment - Graders	Spillway	Erosion Control	Sediment Pond	Ground Thawing	Lake Drawdowns	Blast Densification	Care & General Maintenance	Repair & Remediation	Monitoring	Partner Communications/Consultations	Owner's Project Management & Admin	Sediment Pond Cleanouts					
CC1	$1,261,353	$77,097	$8,900,390	$3,068,851	$1,203,770	$996,180	$891,675	$2,534,389	$2,199,949	$308,654	$5,027,136	$6,261,660	$1,508,825	$19,923,602		$8,585,013	$4,069,932	$35,592,092		$4,599,144	$77,705,000	$638,841		$13,360,489		$14,653,440	$1,077,459	$538,729		$9,450,000	$21,498,367.24	$61,483,010	**$307,415,050**	**$310,000,000**
CC1-A	$466,449	$63,080	$4,443,992	$1,221,084	$1,203,770	$198,188	$891,675	$1,571,878	$1,138,250	$119,958	$2,368,933	$2,580,905	$600,356	$3,534,073		$5,482,379	$1,619,410	$12,835,376		$4,599,144		$592,498	$4,110,000	$13,360,489	$9,339,561	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,861,107.58	$26,730,546	**$133,652,729**	**$130,000,000**
CC1-B	$515,774	$63,080	$4,728,729	$1,350,210	$1,203,770	$219,146	$891,675	$1,594,744	$1,212,444	$132,643	$2,530,736	$2,521,510	$663,841	$3,907,791		$6,062,125	$1,790,658	$12,835,376		$4,599,144		$592,498		$13,360,489	$9,525,836	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,657,184.84	$26,169,758	**$130,848,792**	**$130,000,000**
CC2	$2,047,067	$77,097	$13,353,611	$4,980,480	$1,403,770	$1,616,714	$891,675	$2,953,100	$3,298,342	$500,919	$7,636,081	$4,003,804	$2,448,692	$32,334,280		$13,932,732	$6,605,147	$12,399,214		$4,599,144		$682,515		$4,732,423		$15,014,097	$1,302,023	$651,012		$6,150,000	$13,746,394	$39,340,083	**$196,700,417**	**$197,000,000**
CC2-A	$682,452	$77,097	$5,619,328	$1,660,394	$1,203,770	$538,981	$891,675	$2,104,957	$1,390,671	$166,997	$3,104,907	$3,015,431	$816,346	$10,779,612		$4,644,898	$2,202,026	$12,399,214		$4,599,144		$638,841	$12,600,000	$4,732,423	$12,693,491	$15,014,097	$1,302,023	$651,012		$6,150,000	$10,352,979	$30,008,191	**$150,040,955**	**$150,000,000**
CC2-B	$1,313,849	$77,097	$9,197,926	$3,196,574	$1,403,770	$1,037,640	$891,675	$2,448,771	$2,273,336	$321,500	$5,201,449	$3,596,127	$1,571,620	$20,752,803		$8,942,313	$4,239,319	$12,399,214		$4,599,144		$638,841		$4,732,423	$17,664,493	$15,014,097	$1,302,023	$651,012		$6,150,000	$12,346,702	$35,490,930	**$177,454,650**	**$180,000,000**
CC3	$4,028,369	$77,097	$24,583,116	$9,800,955	$1,803,770	$3,181,489	$891,675	$4,008,948	$6,068,115	$985,746	$14,214,952	$5,979,584	$4,818,716	$63,629,781		$27,417,857	$12,998,095			$2,378,134		$696,795		$3,396,374		$9,799,197	$871,040	$435,520	$3,233,731	$6,150,000	$20,529,906	$57,994,740	**$289,973,701**	**$290,000,000**
WC1	$239,714	$23,364	$1,204,500	$1,077,986				$87,370	$459,199	$92,040	$584,100	$1,040,997	$170,000			$766,500	$420,480			$4,599,144				$8,188,687		$11,205,571	$1,077,459	$538,729	$3,965,048		$3,574,089	$9,828,744	**$49,143,722**	**$50,000,000**
WC2	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,403,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$6,333,182	$956,799	$108,657,228		$16,553,575	$4,733,114	$5,496,524		$4,599,144				$8,188,687		$5,861,376	$646,475	$323,238		$2,350,000	$21,743,923	$60,383,289	**$301,916,446**	**$300,000,000**
WC2-A	$908,564	$126,159	$6,642,981	$1,755,906	$1,203,770	$4,598,312	$891,675	$2,366,968	$1,445,550	$191,654	$3,954,521	$2,458,629	$276,909	$21,775,499		$7,762,316	$1,369,820	$764,511		$4,599,144				$8,188,687	$6,300,254	$5,861,376	$646,475	$323,238		$150,000	$8,441,292	$23,251,052	**$116,255,261**	**$120,000,000**
WC3	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,603,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$5,475,038	$956,799	$67,163,988		$33,107,150	$8,046,295		$7,500,000	$4,599,144				$2,081,649		$2,449,799	$871,040	$435,520			$18,797,631	$51,693,486	**$258,467,430**	**$260,000,000**
PP1												$45,253												$1,077,459			$215,492	$215,492		$500,000	$155,370	$552,266	**$2,761,331**	**$2,800,000**
PP2	$751,845	$72,425	$4,384,192					$448,127		$198,598	$1,572,548	$2,399,785	$322,645	$6,702,524	$60,000,000	$3,777,517	$641,844							$861,967			$129,295	$129,295		$600,000	$8,239,261	$22,807,967	**$114,039,834**	**$114,000,000**
PP3	$826,324	$63,080	$4,889,388					$519,891		$226,703	$1,686,986	$2,500,121	$374,315	$7,499,360	$60,000,000	$5,056,183	$859,104							$861,967		$215,492	$129,295	$129,295		$600,000	$8,583,750	$23,755,313	**$118,776,567**	**$119,000,000**
PP4	$1,682,728	$175,220	$8,873,547					$640,467		$332,826	$4,067,054	$2,886,211	$461,128	$48,719,018		$26,256,604	$3,877,899							$861,967			$129,295	$129,295		$600,000	$9,909,326	$27,400,646	**$137,003,230**	**$137,000,000**
SCP1												$31,031												$775,770			$129,295	$129,295		$300,000	$106,539	$367,983	**$1,839,913**	**$1,800,000**
SCP2	$271,856	$46,726	$1,735,212					$219,934		$89,645	$481,166	$373,063	$158,350	$1,673,493	$5,158,200	$1,301,154	$308,422							$646,475		$172,393	$86,197	$86,197		$400,000	$1,280,848	$3,622,333	**$18,111,664**	**$18,000,000**
SCP3	$233,856	$46,726	$1,492,664					$189,192		$77,114	$413,909	$325,773	$136,216	$1,168,499	$5,158,200	$908,517	$215,352							$646,475			$86,197	$86,197		$400,000	$1,118,489	$3,175,844	**$15,879,220**	**$16,000,000**
SCP4	$587,179	$126,159	$3,266,295					$289,095		$136,347	$1,320,087	$962,878	$208,145	$16,208,775		$7,384,566	$1,750,416							$646,475			$86,197	$86,197		$400,000	$3,305,881	$9,191,173	**$45,955,864**	**$46,000,000**

CCRP Cost Estimate Table W-10a: 2021 PP1 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Day	Days / Month	Total Qty	Unit Price	Cost
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		-	year						-	-	-	$ 200,000	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		-	year						-	-	-	$ 40,000	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		-	year						-	-	-	$ 100,000	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		-	months		-				-	-	-	$ 12,500	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		-	months		-				-	-	-	$ 100	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		-	person/months		-				-	-	-	$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		-	months		-				-	-	-	$ 1,200	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		-	months		-						-	$ 2,000	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		-	months		-						-	$ 600	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		-	months		-						-	$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		-	%		-							$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		-	months		-						-	$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		-	lump sum		-						-	$ 32,960	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	-	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	PP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	-	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	PP1	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	-	person*shifts		-				-	-	-	$ 400	$ -
Wolverine	PP1	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	-	months	1.25					-	-	-	$ 20,833	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	-	each		-						-	$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	-	lump sum		-						-	$ 713,628	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	-	lump sum		-						-	$ 363,191	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	-	months		-						-	$ 52,555	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	-	person*days		-						-	$ 123	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	-	days		-						-	$ 4,560	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Setup		-	each						-	-	-	$ 1,733,343	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		-	months						-	-	-	$ 1,293.78	$ -
Wolverine	PP1	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		-	tonnes						-	-	-	$ 0.42	$ -
Wolverine	PP1	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		-	tonnes						-	-	-	$ 0.89	$ -
Wolverine	PP1	Civil Works	Materials Management	Blasting and Spoil Management			-									-	$ -	$ -
Wolverine	PP1	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		-	months			-			-	-	-	$ 320	$ -
Wolverine	PP1	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		-	months			-			-	-	-	$ 170	$ -
Wolverine	PP1	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		-	hours	-					-	-	-	$ 192	$ -
Wolverine	PP1	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	-	-						-	-	-	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 861,967	$ 861,967
Wolverine	PP1	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 215,492	$ 215,492
Wolverine	PP1	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	-	-								-	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	-	-								-	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	PP1	Post Closure Care and Maintenance	Partner Communications/Consultations	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 215,492	$ 215,492
Wolverine	PP1	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 215,492	$ 215,492
Wolverine	PP1	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	-	$ -	$ -
Wolverine	PP1	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		-	%						-	-	3%	$ 1,508,442	$ 45,253
Wolverine	PP1	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		-	lump sum								1.00	$ 500,000	$ 500,000
Wolverine	PP1	Factors	EPCM	N/A				%								10%		$ 155,370
Wolverine	PP1	Factors	Contingency	N/A				%								25%		$ 552,266

Subtotal	**$2,053,696**
EPCM	**$155,370**
Contingency	**$552,266**
Option Total	**$2,761,331**

CCRP Cost Estimate Table W-10b: 2021 PP2 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Day	Days / Month	Total Qty	Unit Price	Cost
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		0.9	year						-	-	0.95	$ 200,000	$ 189,791
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		0.9	year						-	-	0.95	$ 40,000	$ 37,958
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		0.9	year						-	-	0.95	$ 100,000	$ 94,896
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		11.4	months		-				-	-	11.39	$ 12,500	$ 142,344
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		11.4	months		-				-	-	11.39	$ 100	$ 1,139
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		11.4	person/months		52				-	-	11.39	$ 3,640	$ 41,450
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		11.4	months		-				-	-	11.39	$ 1,200	$ 13,665
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		11.4	months		52						592.15	$ 2,000	$ 1,184,299
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		11.4	months		52						592.15	$ 600	$ 355,290
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		11.4	months		52						-	$ -	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		11.4	%		52							$ 4,384,192	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		11.4	months		52						-	$ -	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		11.4	lump sum		52						1.00	$ 32,960	$ 32,960
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	11.4	hours			3		15.58	-	-	46.73	$ 300	$ 14,018
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	11.4	hours			7		15.58	-	-	109.03	$ 300	$ 32,708
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	11.4	hours			3		15.58	-	-	46.73	$ 300	$ 14,018
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	11.4	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	11.4	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	11.4	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	PP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	11.4	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	PP2	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	11.4	person*shifts		52				-	-	1,286.51	$ 400	$ 514,606
Wolverine	PP2	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	11.4	months	1.25					-	-	11.39	$ 20,833	$ 237,239
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	11.4	each		52						-	$ -	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	11.4	lump sum		52						-	$ 713,628	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	11.4	lump sum		52						-	$ 363,191	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	11.4	months		52						11.39	$ 52,555	$ 598,465
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	11.4	person*days		52						18,011.21	$ 123	$ 2,206,400
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	11.4	days		52						346.37	$ 4,560	$ 1,579,327
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Setup		11.4	each						-	-	-	$ 1,733,343	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		11.4	months						-	-	346.37	$ 1,293.78	$ 448,127
Wolverine	PP2	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		11.4	tonnes						-	-	5,120,000	$ 0.42	$ 2,163,749
Wolverine	PP2	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		11.4	tonnes						-	-	5,120,000	$ 0.89	$ 4,538,775
Wolverine	PP2	Civil Works	Materials Management	Blasting and Spoil Management			11.4									2,400,000	$ 25.00	$ 60,000,000
Wolverine	PP2	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		11.4	months			3			-	-	10,028.81	$ 320	$ 3,209,218
Wolverine	PP2	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		11.4	months			1			-	-	3,342.94	$ 170	$ 568,299
Wolverine	PP2	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		11.4	hours	1					-	-	3,342.94	$ 192	$ 641,844
Wolverine	PP2	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	11.4	-						-	-	-	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ 861,967	$ 861,967
Wolverine	PP2	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	11.4	-								-	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	11.4	-								-	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ -	$ -
Wolverine	PP2	Post Closure Care and Maintenance	Partner Communications/Consultations	N/A	N/A	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP2	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	11.4	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP2	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	11.4	-						-	-	-	$ -	$ -
Wolverine	PP2	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		11.4	%						-	-	3%	$ 79,992,821	$ 2,399,785
Wolverine	PP2	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		11.4	lump sum								1.00	$ 600,000	$ 600,000
Wolverine	PP2	Factors	EPCM	N/A				%								10%		$ 8,239,261
Wolverine	PP2	Factors	Contingency	N/A				%								25%		$ 22,807,967

Subtotal	**$82,992,606**
EPCM	**$8,239,261**
Contingency	**$22,807,967**
Option Total	**$114,039,833**

CCRP Cost Estimate Table W-10c: 2021 PP3 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Day	Days / Month	Total Qty	Unit Price	Cost
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		1.1	year						-	-	1.10	$ 200,000	$ 220,185
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		1.1	year						-	-	1.10	$ 40,000	$ 44,037
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		1.1	year						-	-	1.10	$ 100,000	$ 110,093
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		13.2	months		-				-	-	13.21	$ 12,500	$ 165,139
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		13.2	months		-				-	-	13.21	$ 100	$ 1,321
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		13.2	person/months		48				-	-	13.21	$ 3,360	$ 44,389
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		13.2	months		-				-	-	13.21	$ 1,200	$ 15,853
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		13.2	months		48						634.13	$ 2,000	$ 1,268,267
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		13.2	months		48						634.13	$ 600	$ 380,480
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		13.2	months		48						-	$ -	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		13.2	%		48							$ 4,889,388	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		13.2	months		48						-	$ -	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		13.2	lump sum		48						1.00	$ 38,238	$ 38,238
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	13.2	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	13.2	hours			6		15.58	-	-	93.45	$ 300	$ 28,035
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	13.2	hours			3		15.58	-	-	46.73	$ 300	$ 14,018
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	13.2	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	13.2	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	13.2	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	PP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	13.2	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	PP3	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	13.2	person*shifts		48				-	-	1,377.73	$ 400	$ 551,092
Wolverine	PP3	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	13.2	months	1.25					-	-	13.21	$ 20,833	$ 275,232
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	13.2	each		48						-	$ -	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	13.2	lump sum		48						-	$ 713,628	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	13.2	lump sum		48						-	$ 363,191	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	13.2	months		48						13.21	$ 52,555	$ 694,306
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	13.2	person*days		48						19,288.23	$ 123	$ 2,362,837
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	13.2	days		48						401.84	$ 4,560	$ 1,832,245
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		13.2	months						-	-	401.84	$ 1,293.78	$ 519,891
Wolverine	PP3	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		13.2	tonnes						-	-	4,800,000	$ 0.42	$ 2,028,515
Wolverine	PP3	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		13.2	tonnes						-	-	4,800,000	$ 1.14	$ 5,470,845
Wolverine	PP3	Civil Works	Materials Management	Blasting and Spoil Management			13.2									2,400,000	$ 25.00	$ 60,000,000
Wolverine	PP3	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		13.2	months			3			-	-	13,423.49	$ 320	$ 4,295,518
Wolverine	PP3	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		13.2	months			1			-	-	4,474.50	$ 170	$ 760,665
Wolverine	PP3	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		13.2	hours	1					-	-	4,474.50	$ 192	$ 859,104
Wolverine	PP3	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	13.2	-						-	-	-	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ 861,967	$ 861,967
Wolverine	PP3	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	13.2	-								-	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	13.2	-								-	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ 215,492	$ 215,492
Wolverine	PP3	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ -	$ -
Wolverine	PP3	Post Closure Care and Maintenance	Partner Communications/Coordinations	N/A	N/A	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP3	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	13.2	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP3	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	13.2	-						-	-	-	$ -	$ -
Wolverine	PP3	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		13.2	%						-	-	3%	$ 83,337,381	$ 2,500,121
Wolverine	PP3	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		13.2	lump sum								1.00	$ 600,000	$ 600,000
Wolverine	PP3	Factors	EPCM	N/A				%								10%		$ 8,583,750
Wolverine	PP3	Factors	Contingency	N/A				%								25%		$ 23,755,313

Subtotal	**$86,437,503**
EPCM	**$8,583,750**
Contingency	**$23,755,313**
Option Total	**$118,776,566**

CCRP Cost Estimate Table W-10d: 2021 PP4 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Da	Days / Month	Total Qty	Unit Price	Cost
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		1.4	year						-	-	1.36	$ 200,000	$ 271,252
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		1.4	year						-	-	1.36	$ 40,000	$ 54,250
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		1.4	year						-	-	1.36	$ 100,000	$ 135,626
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		16.3	months		-				-	-	16.28	$ 12,500	$ 203,439
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		16.3	months		-				-	-	16.28	$ 100	$ 1,628
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		16.3	person/months		95				-	-	16.28	$ 6,650	$ 108,229
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		16.3	months		-				-	-	16.28	$ 1,200	$ 19,530
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		16.3	months		95						1,546.13	$ 2,000	$ 3,092,267
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		16.3	months		95						1,546.13	$ 600	$ 927,680
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		16.3	months		95						-	$ -	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		16.3	%		95							$ 8,873,547	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		16.3	months		95						-	$ -	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		16.3	lump sum		95						1.00	$ 47,107	$ 47,107
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	16.3	hours			6		15.58	-	-	93.45	$ 300	$ 28,035
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	16.3	hours			17		15.58	-	-	264.78	$ 300	$ 79,433
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	16.3	hours			6		15.58	-	-	93.45	$ 300	$ 28,035
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	16.3	hours			4		15.58	-	-	62.30	$ 300	$ 18,690
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	16.3	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	16.3	hours			2		15.58	-	-	31.15	$ 150	$ 4,673
Wolverine	PP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	16.3	hours			3		15.58	-	-	46.73	$ 150	$ 7,009
Wolverine	PP4	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	16.3	person*shifts		95				-	-	3,359.16	$ 400	$ 1,343,664
Wolverine	PP4	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	16.3	months	1.25					-	-	16.28	$ 20,833	$ 339,064
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	16.3	each		95						-	$ -	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	16.3	lump sum		95						-	$ 713,628	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	16.3	lump sum		95						-	$ 363,191	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	16.3	months		95						16.28	$ 52,555	$ 855,332
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	16.3	person*days		95						47,028.23	$ 123	$ 5,761,029
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	16.3	days		95						495.03	$ 4,560	$ 2,257,187
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		16.3	months						-	-	495.03	$ 1,293.78	$ 640,467
Wolverine	PP4	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		16.3	tonnes						-	-	25,000,000	$ 0.55	$ 13,734,738
Wolverine	PP4	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		16.3	tonnes						-	-	25,000,000	$ 1.40	$ 34,984,280
Wolverine	PP4	Civil Works	Materials Management	Blasting and Spoil Management			16.3									-	$ -	$ -
Wolverine	PP4	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		16.3	months			6			-	-	60,592.16	$ 320	$ 19,389,493
Wolverine	PP4	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		16.3	months			4			-	-	40,394.78	$ 170	$ 6,867,112
Wolverine	PP4	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		16.3	hours	2					-	-	20,197.39	$ 192	$ 3,877,899
Wolverine	PP4	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	16.3	-						-	-	-	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ 861,967	$ 861,967
Wolverine	PP4	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	16.3	-								-	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	16.3	-								-	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ -	$ -
Wolverine	PP4	Post Closure Care and Maintenance	Partner Communications/Coordinations	N/A	N/A	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP4	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	16.3	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	PP4	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	16.3	-						-	-	-	$ -	$ -
Wolverine	PP4	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		16.3	%						-	-	3%	$ 96,207,046	$ 2,886,211
Wolverine	PP4	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		16.3	lump sum								1.00	$ 600,000	$ 600,000
Wolverine	PP4	Factors	EPCM	N/A				%								10%		$ 9,909,326
Wolverine	PP4	Factors	Contingency	N/A				%								25%		$ 27,400,646

Subtotal	**$99,693,257**
EPCM	**$9,909,326**
Contingency	**$27,400,646**
Option Total	**$137,003,229**

CCRP Cost Estimate Table W-11a: 2021 SCP1 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Day	Days / Month	Total Qty	Unit Price	Cost
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		-	year						-	-	-	$ 200,000	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		-	year						-	-	-	$ 40,000	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		-	year						-	-	-	$ 100,000	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		-	months		-				-	-	-	$ 12,500	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		-	months		-				-	-	-	$ 100	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		-	person/months		-				-	-	-	$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		-	months		-				-	-	-	$ 1,200	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		-	months		-						-	$ 2,000	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		-	months		-						-	$ 600	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		-	months		-						-	$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		-	%		-							$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		-	months		-						-	$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		-	lump sum		-						1.00	$ -	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	-	hours			-		15.58	-	-	-	$ 300	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	-	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	SCP1	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	-	hours			-		15.58	-	-	-	$ 150	$ -
Wolverine	SCP1	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	-	person*shifts		-				-	-	-	$ 400	$ -
Wolverine	SCP1	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	-	months	1.25					-	-	-	$ 20,833	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	-	each		-						-	$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	-	lump sum		-						-	$ 713,628	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	-	lump sum		-						-	$ 363,191	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	-	months		-						-	$ 52,555	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	-	person*days		-						-	$ 123	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	-	days		-						-	$ 4,560	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Setup		-	each						-	-	-	$ 1,733,343	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		-	months						-	-	-	$ 1,293.78	$ -
Wolverine	SCP1	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		-	tonnes						-	-	-	$ -	$ -
Wolverine	SCP1	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		-	tonnes						-	-	-	$ -	$ -
Wolverine	SCP1	Civil Works	Materials Management	Blasting and Spoil Management			-									-	$ -	$ -
Wolverine	SCP1	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		-	months			-			-	-	-	$ 320	$ -
Wolverine	SCP1	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		-	months			-			-	-	-	$ 170	$ -
Wolverine	SCP1	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		-	hours	-					-	-	-	$ 192	$ -
Wolverine	SCP1	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	-	-						-	-	-	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 646,475	$ 646,475
Wolverine	SCP1	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	SCP1	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	-	-								-	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	-	-								-	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ -	$ -
Wolverine	SCP1	Post Closure Care and Maintenance	Partner Communications/Consultations	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	SCP1	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	1.00	$ 129,295	$ 129,295
Wolverine	SCP1	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	-	-						-	-	-	$ -	$ -
Wolverine	SCP1	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		-	%						-	-	3%	$ 1,034,360	$ 31,031
Wolverine	SCP1	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		-	lump sum								1.00	$ 300,000	$ 300,000
Wolverine	SCP1	Factors	EPCM	N/A				%								10%		$ 106,539
Wolverine	SCP1	Factors	Contingency	N/A				%								25%		$ 367,983

Subtotal	**$1,365,391**
EPCM	**$106,539**
Contingency	**$367,983**
Option Total	**$1,839,913**

CCRP Cost Estimate Table W-11b: 2021 SCP2 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Day	Days / Month	Total Qty	Unit Price	Cost
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		0.5	year						-	-	0.47	$ 200,000	$ 93,147
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		0.5	year						-	-	0.47	$ 40,000	$ 18,629
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		0.5	year						-	-	0.47	$ 100,000	$ 46,574
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		5.6	months		-				-	-	5.59	$ 12,500	$ 69,860
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		5.6	months		-				-	-	5.59	$ 100	$ 559
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		5.6	person/months		32				-	-	5.59	$ 2,240	$ 12,519
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		5.6	months		-				-	-	5.59	$ 1,200	$ 6,707
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		5.6	months		32						178.84	$ 2,000	$ 357,685
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		5.6	months		32						178.84	$ 600	$ 107,305
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		5.6	months		32						-	$ -	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		5.6	%		32							$ 1,735,212	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		5.6	months		32						-	$ -	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		5.6	lump sum		32						1.00	$ 16,176	$ 16,176
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	5.6	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	5.6	hours			4		15.58	-	-	62.30	$ 300	$ 18,690
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	5.6	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	5.6	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	5.6	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	5.6	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	SCP2	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	5.6	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	SCP2	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	5.6	person*shifts		32				-	-	388.56	$ 400	$ 155,422
Wolverine	SCP2	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	5.6	months	1.25					-	-	5.59	$ 20,833	$ 116,434
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	5.6	each		32						-	$ -	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	5.6	lump sum		32						-	$ 713,628	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	5.6	lump sum		32						-	$ 363,191	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	5.6	months		32						5.59	$ 52,555	$ 293,718
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	5.6	person*days		32						5,439.79	$ 123	$ 666,382
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	5.6	days		32						169.99	$ 4,560	$ 775,112
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		5.6	months						-	-	169.99	$ 1,293.78	$ 219,934
Wolverine	SCP2	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		5.6	tonnes						-	-	662,777	$ 0.55	$ 364,123
Wolverine	SCP2	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		5.6	tonnes						-	-	662,777	$ 1.98	$ 1,309,370
Wolverine	SCP2	Civil Works	Materials Management	Blasting and Spoil Management			5.6									128,955	$ 40.00	$ 5,158,200
Wolverine	SCP2	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		5.6	months			2			-	-	3,212.73	$ 320	$ 1,028,072
Wolverine	SCP2	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		5.6	months			1			-	-	1,606.36	$ 170	$ 273,082
Wolverine	SCP2	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		5.6	hours	1					-	-	1,606.36	$ 192	$ 308,422
Wolverine	SCP2	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	5.6	-						-	-	-	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ 646,475	$ 646,475
Wolverine	SCP2	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	5.6	-								-	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	5.6	-								-	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ 172,393	$ 172,393
Wolverine	SCP2	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ -	$ -
Wolverine	SCP2	Post Closure Care and Maintenance	Partner Communications/Coordinations	N/A	N/A	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP2	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	5.6	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP2	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	5.6	-						-	-	-	$ -	$ -
Wolverine	SCP2	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		5.6	%						-	-	3%	$ 12,435,419	$ 373,063
Wolverine	SCP2	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		5.6	lump sum								1.00	$ 400,000	$ 400,000
Wolverine	SCP2	Factors	EPCM	N/A				%								10%		$ 1,280,848
Wolverine	SCP2	Factors	Contingency	N/A				%								25%		$ 3,622,333

Subtotal	**$13,208,482**
EPCM	**$1,280,848**
Contingency	**$3,622,333**
Option Total	**$18,111,663**

CCRP Cost Estimate Table W-11c: 2021 SCP3 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Da	Days / Month	Total Qty	Unit Price	Cost
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		0.4	year						-	-	0.40	$ 200,000	$ 80,127
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		0.4	year						-	-	0.40	$ 40,000	$ 16,025
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		0.4	year						-	-	0.40	$ 100,000	$ 40,063
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		4.8	months		-				-	-	4.81	$ 12,500	$ 60,095
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		4.8	months		-				-	-	4.81	$ 100	$ 481
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		4.8	person/months		32				-	-	4.81	$ 2,240	$ 10,769
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		4.8	months		-				-	-	4.81	$ 1,200	$ 5,769
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		4.8	months		32						153.84	$ 2,000	$ 307,687
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		4.8	months		32						153.84	$ 600	$ 92,306
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		4.8	months		32						-	$ -	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		4.8	%		32							$ 1,492,664	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		4.8	months		32						-	$ -	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		4.8	lump sum		32						1.00	$ 13,915	$ 13,915
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	4.8	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	4.8	hours			4		15.58	-	-	62.30	$ 300	$ 18,690
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	4.8	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	4.8	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	4.8	hours			1		15.58	-	-	15.58	$ 300	$ 4,673
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	4.8	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	SCP3	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	4.8	hours			1		15.58	-	-	15.58	$ 150	$ 2,336
Wolverine	SCP3	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	4.8	person*shifts		32				-	-	334.24	$ 400	$ 133,698
Wolverine	SCP3	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	4.8	months	1.25					-	-	4.81	$ 20,833	$ 100,159
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	4.8	each		32						-	$ -	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	4.8	lump sum		32						-	$ 713,628	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	4.8	lump sum		32						-	$ 363,191	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	4.8	months		32						4.81	$ 52,555	$ 252,663
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	4.8	person*days		32						4,679.41	$ 123	$ 573,235
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	4.8	days		32						146.23	$ 4,560	$ 666,767
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		4.8	months						-	-	146.23	$ 1,293.78	$ 189,192
Wolverine	SCP3	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		4.8	tonnes						-	-	462,777	$ 0.55	$ 254,245
Wolverine	SCP3	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		4.8	tonnes						-	-	462,777	$ 1.98	$ 914,254
Wolverine	SCP3	Civil Works	Materials Management	Blasting and Spoil Management			4.8									128,955	$ 40.00	$ 5,158,200
Wolverine	SCP3	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		4.8	months			2			-	-	2,243.25	$ 320	$ 717,841
Wolverine	SCP3	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		4.8	months			1			-	-	1,121.63	$ 170	$ 190,676
Wolverine	SCP3	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		4.8	hours	1					-	-	1,121.63	$ 192	$ 215,352
Wolverine	SCP3	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	4.8	-						-	-	-	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ 646,475	$ 646,475
Wolverine	SCP3	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	4.8	-								-	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	4.8	-								-	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ -	$ -
Wolverine	SCP3	Post Closure Care and Maintenance	Partner Communications/Consultations	N/A	N/A	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP3	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	4.8	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP3	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	4.8	-						-	-	-	$ -	$ -
Wolverine	SCP3	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		4.8	%						-	-	3%	$ 10,859,113	$ 325,773
Wolverine	SCP3	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		4.8	lump sum								1.00	$ 400,000	$ 400,000
Wolverine	SCP3	Factors	EPCM	N/A				%								10%		$ 1,118,489
Wolverine	SCP3	Factors	Contingency	N/A				%								25%		$ 3,175,844

Subtotal	**$11,584,886**
EPCM	**$1,118,489**
Contingency	**$3,175,844**
Option Total	**$15,879,219**

CCRP Cost Estimate Table W-11d: 2021 SCP4 Estimate Detail

Creek	Option	Activity	Task	Subtask	Item	Description	Task (Project) Duration (mo.)	Unit	Factor (Geographic / Escalation)	Personnel	Equipment / Vehicles / Units	Fuel / hr	Hours	Hrs / Da	Days / Month	Total Qty	Unit Price	Cost
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Water Quality		0.6	year						-	-	0.61	$ 200,000	$ 122,438
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Hydrotechnics		0.6	year						-	-	0.61	$ 40,000	$ 24,488
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Monitoring	N/A	Geotechnics		0.6	year						-	-	0.61	$ 100,000	$ 61,219
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	On-Site Medic		7.3	months		-				-	-	7.35	$ 12,500	$ 91,829
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Field Supplies		7.3	months		-				-	-	7.35	$ 100	$ 735
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Meetings		7.3	person/months		68				-	-	7.35	$ 4,760	$ 34,968
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	General Site H&S	Monthly Safety Reporting		7.3	months		-				-	-	7.35	$ 1,200	$ 8,816
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Tyvek Overalls, Respirators, and Standard PPE		7.3	months		68						499.55	$ 2,000	$ 999,096
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Air Quality Monitoring		7.3	months		68						499.55	$ 600	$ 299,729
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Equipment Filters		7.3	months		68						-	$ -	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Change and Wash Facility Supply and Maintenance		7.3	%		68							$ 3,266,295	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Controlled Work Perimeter		7.3	months		68						-	$ -	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	H&S Controls	Asbestos Abatement Controls	Vehicle Washdown Building and Pressure Washers		7.3	lump sum		68						1.00	$ 21,263	$ 21,263
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Excavators	7.3	hours			4		15.58	-	-	62.30	$ 300	$ 18,690
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Haul Trucks	7.3	hours			13		15.58	-	-	202.48	$ 300	$ 60,743
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Dozers	7.3	hours			4		15.58	-	-	62.30	$ 300	$ 18,690
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Compactors	7.3	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Graders	7.3	hours			2		15.58	-	-	31.15	$ 300	$ 9,345
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Water Trucks	7.3	hours			2		15.58	-	-	31.15	$ 150	$ 4,673
Wolverine	SCP4	Mobilization and Demobilization	Equipment	N/A	Mob / Demob	Support Trucks	7.3	hours			2		15.58	-	-	31.15	$ 150	$ 4,673
Wolverine	SCP4	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Airfare - Edmonton to Dawnson City	7.3	person*shifts		68				-	-	1,085.33	$ 400	$ 434,131
Wolverine	SCP4	Mobilization and Demobilization	Personnel	N/A	Mob / Demob	Bus Transportation - Dawson City to Site	7.3	months	1.25					-	-	7.35	$ 20,833	$ 153,048
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Site Preparation	Clearing & Surface Prep	7.3	each		68						-	$ -	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Mobilization	Mob Costs	7.3	lump sum		68						-	$ 713,628	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Demobilization	Demob Costs	7.3	lump sum		68						-	$ 363,191	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Rental	Camp Rental Costs	7.3	months		68						7.35	$ 52,555	$ 386,082
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Occupancy	Camp Occupancy Costs	7.3	person*days		68						15,194.58	$ 123	$ 1,861,359
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Camp	N/A	Camp Utilities	Utilities - Total Costs	7.3	days		68						223.45	$ 4,560	$ 1,018,855
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Fuel/Power Supply	Fuel Storage and Delivery	Fuel Storage - Rental		7.3	months						-	-	223.45	$ 1,293.78	$ 289,095
Wolverine	SCP4	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Loading		7.3	tonnes						-	-	7,523,042	$ 0.55	$ 4,133,080
Wolverine	SCP4	Civil Works	Materials Management	Earthmoving - Load & Haul	Earthmoving - Hauling		7.3	tonnes						-	-	7,523,042	$ 1.61	$ 12,075,694
Wolverine	SCP4	Civil Works	Materials Management	Blasting and Spoil Management			7.3									-	$ -	$ -
Wolverine	SCP4	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Dozing		7.3	months			4			-	-	18,233.50	$ 320	$ 5,834,719
Wolverine	SCP4	Civil Works	Materials Management	Support Equipment - Dozers	Earthmoving - Compaction		7.3	months			2			-	-	9,116.75	$ 170	$ 1,549,847
Wolverine	SCP4	Civil Works	Materials Management	Support Equipment - Graders	Earthmoving - Grading		7.3	hours	2					-	-	9,116.75	$ 192	$ 1,750,416
Wolverine	SCP4	Mobilization and Demobilization	TF&C	N/A	N/A	N/A	7.3	-						-	-	-	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Inspections	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ 646,475	$ 646,475
Wolverine	SCP4	Post Closure Care and Maintenance	Care & General Maintenance	N/A	Access	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Repair & Remediation	N/A	Repair Costs	Present Value	7.3	-								-	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Repair & Remediation	N/A	Remediation Costs	Present Value	7.3	-								-	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Monitoring	N/A	Water Quality	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Monitoring	N/A	Hydrotechnics	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Monitoring	N/A	Geotechnics	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ -	$ -
Wolverine	SCP4	Post Closure Care and Maintenance	Partner Communications/Consultations	N/A	N/A	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP4	Post Closure Care and Maintenance	Owner's Project Management & Admin	N/A	N/A	Baseline and Time Limited Premiums	7.3	-						-	-	1.00	$ 86,197	$ 86,197
Wolverine	SCP4	Post Closure Care and Maintenance	Sediment Pond Cleanouts	N/A	N/A	Baseline and Time Limited Premiums	7.3	-						-	-	-	$ -	$ -
Wolverine	SCP4	Temporary Facilities and Controls (TF&C)	Incidental Temporary Facilities and	N/A	N/A		7.3	%						-	-	3%	$ 32,095,931	$ 962,878
Wolverine	SCP4	Extraordinary Field Investigations	N/A	N/A	Rock Mechanics Investigations		7.3	lump sum								1.00	$ 400,000	$ 400,000
Wolverine	SCP4	Factors	EPCM	N/A				%								10%		$ 3,305,881
Wolverine	SCP4	Factors	Contingency	N/A				%								25%		$ 9,191,172

Subtotal	**$33,458,809**
EPCM	**$3,305,881**
Contingency	**$9,191,172**
Option Total	**$45,955,862**

CCRP Cost Estimate Table W-13: 2019 Remediation Options - Earthmoving Metrics

Option	Creek	Dump Material or Tailings Removal Volume (m3)1	Waste Material Relocation / Tailings Area	Haul Distance (one way) (km)	Average Current Haul/Work Slope (%)	Maximum Current Haul/Work Slope (%)	Maximum Digging Depth (m)	Design Slope (%)	Blasting Volume (bank m3)	Blasting Volume (bulked @ 10% m3)	Conventional Cut Volume (bank m3)	Conventional Cut Volume (bulked @ 10% m3)	Total Available Blast Spoil & Cut (bulked m3)	Total Fill Requirment (m3)	Blasting Spoil Excess (m3)	Blasting Spoil Excess Requiring Truck Shovel Movements (m3)	Fill from Stockpile Requirement (m3)	Lake Volume (m3)
CC1	Clinton	4,373,000	PPSS	0.4 to 1.	25	30	40	17										
CC1-A	Clinton	870,000	To Fill	0.2	25	30	40	17										
CC1-B	Clinton	962,000	PPSS	0.2	25	30	40	17										
CC2	Clinton	7,097,000	PPSS	0.4 to 1.	25	30	40	17 to 50										
CC2-A	Clinton	2,366,000	PPSS	0.4 to 1.	25	30	40	17 to 50										
CC2-B	Clinton	4,555,000	PPSS	0.4 to 1.	25	30	40	17 to 50										
CC3	Clinton	13,966,000	PPSS	0.4 to 1.	25	30	70	17										
WC1	Wolverine																	
WC2	Wolverine	4,312,000			30	40												
WC2-A	Wolverine	2,225,000	Local Fill & PPSS	2.7	27	40	13	27										
WC3	Wolverine	7,688,000	PPSS	2.7	27	40	13	27										
PP1	Porcupine Pit								-	-	-	-	-	-	0		0	
PP2	Porcupine Pit								2,400,000	2,640,000		-	2,640,000	2,700,000	0	2,500,000	60,000	
PP3	Porcupine Pit								2,400,000	2,640,000	800,000	880,000	3,520,000	1,000,000	2,520,000	2,400,000	0	
PP4	Porcupine Pit	12,500,000								-		-	-	12,500,000	0		12,500,000	
SCP1	Snowshoe & Creek Pits								-	-	-	-	-	-	0		0	
SCP2	Snowshoe & Creek Pits								128,955	141,851	45,481	50,029	191,880	523,268	0		331,388	
SCP3	Snowshoe & Creek Pits								128,955	141,851	45,481	50,029	191,880	423,268	0		231,388	100,000
SCP4	Snowshoe & Creek Pits													3,761,521	0		3,761,521	

[1]Wood. 5 April 2019. Clinton Creek - Storage and Excavation Volumes.

CCRP Cost Estimate Table W-14: Key Equipment and Field Personnel Metrics

Creek	Option	Tailings Volume (m3)	Material Volume (m3)	Number of Excavators	Number of Haul Trucks	Number of Dozers	Number of Compactors	Number of Graders	Number of Water Trucks	Number of Support Trucks	Total Equipment Operators	Total Support Personnel	Owners Team	Shifts per Day	Total Crew Count	Project Duration (Years)
Clinton	CC1		4,373,000	2	7	2	1	2	2	3	19	10	3	2	61	1.42
	CC1-A		870,000	1	3	3	2	2	2	3	16	10	3	2	55	0.57
	CC1-B		962,000	1	3	3	2	2	2	3	16	10	3	2	55	0.63
	CC2		7,097,000	2	7	2	1	2	2	3	19	10	3	2	61	2.31
	CC2-A		2,366,000	2	7	2	1	2	2	3	19	10	3	2	61	0.77
	CC2-B		4,555,000	2	7	2	1	2	2	3	19	10	3	2	61	1.48
	CC3		13,966,000	2	7	2	1	2	2	3	19	10	3	2	61	4.55
Wolverine	WC1			1	1	1		1	1	1	6	4	2	2	22	0.50
	WC2	2,370,000	1,942,000	2	16	3	1	2	3	3	30	10	3	2	83	2.81
	WC2-A	2,225,000		2	16	2	2	2	3	3	30	10	3	2	83	0.81
	WC3	7,688,000	-	2	16	3	1	2	3	3	30	10	3	2	83	2.81
Porcupine Pit	PP1															
	PP2			3	7	3	1	1		1	16	4	2	2	52	0.95
	PP3			2	6	3	1	1		1	14	4	2	2	48	1.10
	PP4			6	17	6	4	2	2	3	40	6	3	2	95	1.36
Snowshoe & Creek Pits	SCP1													2		
	SCP2			1	4	2	1	1	1	1	11	2	1	2	32	0.47
	SCP3			1	4	2	1	1	1	1	11	2	1	2	32	0.40
	SCP4			4	13	4	2	2	2	2	29	4	2	2	68	0.61

Equipment Mobilization

Distance from Edmonton to Dawson City:	2,521	km
Distance from Dawson City to Fortymile R. Bridge:	91	km
Distance from Fortymile R. Bridge to Site:	9	km
Total Mobilization + Demobilization Distance:	**5,224**	km

The George Black Ferry:	This ferry service crosses the Yukon River and provides access to the Top of the World Highway from the North Klondike Highway for motorists passing through Dawson City.
Yukon River Ice Bridge:	Yukon gov't gives up on attempt to build ice bridge in Dawson City. https://www.cbc.ca/news/canada/north/gov-halts-dawson-city-ice-bridge-1.5001387. https://yukon.ca/sites/yukon.ca/files/hpw/final_nrc_report_dawson_ice_bridge_2018_final.pdf
Fortymile River Bridge:	Weight restrictions not available. Built in 1966.

CCRP Cost Estimate Table W-15: Loading Equipment Specifications and Rates

Loaders	Manufacturer	Model	Bucket Capacity (m^3)	Rated Payload (tonnes)	Configuration	Machine Working Weight (t)	Tires	Gross Power (kW)	Fuel Consumption	Digging Force (KN)	Maximum Dumping Height (m)	Maximum Height of Cut (m)	Optimal Working Bench Height (m)	Comments	Rate/hr	Rate Source
Caterpillar 330F	Caterpillar	330F	1.5	2.8	Excavator		track								$ 228	ARHCA x 1.2
Caterpillar 385C	Caterpillar	385C	4.6	8.3	Excavator	84	track	390.0	68		8.1	12.5	9		$ 358	ARHCA x 1.2
Caterpillar 390F GP	Caterpillar	390F GP	4.6	9.7	Excavator	84	track	390.0			8.1	12.5	9		$ 560	ARHCA x 1.2
Caterpillar 6015 FS	Caterpillar	6015 FS	7.0	12.6	Hydr.Shovel	105	track	522.0	91	490	8.8	11.0	8	Also available as Excavator		
Caterpillar 6018 FS	Caterpillar	6018 FS	10.0	18.0	Hydr.Shovel	172	track	858.0	150	730	10.1	13.2	9	Also available as Excavator		
Caterpillar 6030 FS	Caterpillar	6030 FS	16.5	29.7	Hydr.Shovel	287	track	1,140.0	200	920	10.7	13.9	10	Also available as Excavator		
Caterpillar 6040 FS	Caterpillar	6040 FS	22.0	39.6	Hydr.Shovel	397	track	1,516.0	265	1,270	10.9	14.4	10	Also available as Excavator		
Caterpillar 6050 FS	Caterpillar	6050 FS	26.0	46.8	Hydr.Shovel	525	track	1,880.0	329	1,500	11.8	15.3	11	Also available as Excavator		
Caterpillar 6060 FS	Caterpillar	6060 FS	34.0	61.2	Hydr.Shovel	562	track	2,240.0	392	1,640	11.6	15.5	11	Also available as Excavator		
Caterpillar 6090 FS	Caterpillar	6090 FS	52.0	93.6	Hydr.Shovel	980	track	3,360.0	588	2,400	14.5	20.2	15	NOT available as Excavator		
Caterpillar 7395	Caterpillar	7395	35.0	63.5	Cable Shovel	1,179	track	3,106.0			10.0	16.7	15			
Caterpillar 7495 HD	Caterpillar	7495 HD	50.0	81.8	Cable Shovel	1,306	track	3,330.0			10.6	17.3	17			
Caterpillar 7495	Caterpillar	7495	56.0	100.0	Cable Shovel	1,382	track	3,706.0			10.1	17.8	17			
Caterpillar 7495 HF	Caterpillar	7495 HF	56.0	100.0	Cable Shovel	1,442	track	3,778.0			10.9	17.8	17	Oil sands model		
Caterpillar 988H	Caterpillar	988H	6.4	11.3	Loader	50	35/65R33	414.0		451	3.5	7.7	6	High Lift adds 0.4 m height	$ 389	ARHCA x 1.2
Caterpillar 990H	Caterpillar	990H	8.4	15.0	Loader	78	45/65-39	512.0		583	4.0	8.1	6	High Lift adds 0.6 m height	$ 485	ARHCA x 1.2
Caterpillar 992K	Caterpillar	992K	10.7	18.7	Loader	100	45/65-45	676.0		568	4.6	9.3	7	High Lift adds 0.6 m height	$ 485	ARHCA x 1.2
Caterpillar 993K	Caterpillar	993K	12.5	27.2	Loader	134	50/65-51	782.0		709	4.7	9.8	7	High Lift adds 0.6 m height		
Caterpillar 994K High lift	Caterpillar	994K High lift	19.0	35.0	Loader	194	53.5/85-57	1,176.0		989	5.6	10.9	8			
Caterpillar 994 STD	Caterpillar	994 STD	21.2	38.1	Loader											
Caterpillar 994High lift	Caterpillar	994High lift	18.0	32.0	Loader	197	53.5/85-57	1,176.0		1,020	6.0	11.0	8			
Caterpillar 994EXT lift	Caterpillar	994EXT lift	17.0	32.0	Loader	200	58/85-57	1,176.0		1,020	7.0	11.0	8			
Caterpillar 994Super lift	Caterpillar	994Super lift	36.0	32.0	Loader	212	53.5/85-57	1,176.0		693	7.3	16.4	12	Coal Only		
Hitachi EX1200-6	Hitachi	EX1200-6	5.9	10.6	Hydr.Shovel	114	track	567.0	99	577	8.8	12.4	9	Also available as Excavator		
Hitachi EX1900-6	Hitachi	EX1900-6	11.0	20.7	Hydr.Shovel	191	track	810.0	142	660	10.4	14.6	10	Also available as Excavator		
Hitachi EX2600-6	Hitachi	EX2600-6	15.0	27.0	Hydr.Shovel	252	track	1,119.0	196	907	10.4	15.0	11	Also available as Excavator		
Hitachi EX3600-6	Hitachi	EX3600-6	21.0	37.8	Hydr.Shovel	361	track	1,450.0	254	1,130	10.9	16.3	12	Also available as Excavator		
Hitachi EX5600-6	Hitachi	EX5600-6	29.0	52.2	Hydr.Shovel	533	track	2,238.0	392	1,570	13.1	18.9	14	Also available as Excavator		
Hitachi EX8000-6	Hitachi	EX8000-6	42.0	75.6	Hydr.Shovel	811	track	2,900.0	508	2,230	13.8	20.5	15	NOT available as Excavator		
Komatsu WA1200-6 std	Komatsu	WA1200-6 std	20.0	36.0	Loader	216	60/80 R57	1,411.0	178	1,275	6.3	12.2	9			
Komatsu WA1200-6 Hlift	Komatsu	WA1200-6 Hlift	18.0	32.4	Loader	218	60/80 R57	1,411.0	178	1,236	7.1	12.8	9			
Komatsu PC800	Komatsu	PC800	4.5	8.1	Excavator											
Komatsu PC1250LC-8	Komatsu	PC1250LC-8	5.0	9.0	Excavator	107	track	502.0	88			10.4	7			
Komatsu PC2000	Komatsu	PC2000	11.0	19.8	Hydr.Shovel	195	track	728.0	127	721	9.7	14.4	10	Also available as Excavator		
Komatsu PC3000	Komatsu	PC3000	15.0	27.0	Hydr.Shovel	252	track	940.0	165	1,000	10.2	15.1	11	Also available as Excavator		
Komatsu PC4000	Komatsu	PC4000	22.0	39.6	Hydr.Shovel	385	track	1,400.0	245	1,250	12.0	17.2	12	Also available as Excavator		
Komatsu PC5500	Komatsu	PC5500	29.0	52.2	Hydr.Shovel	533	track	1,880.0	329	1,865	13.3	19.5	14	Also available as Excavator		
Komatsu PC8000	Komatsu	PC8000	42.0	75.6	Hydr.Shovel	700	track	3,000.0	525	2,320	13.9	19.6	14	NOT available as Excavator		
LeTourneau L950	LeTourneau	L950	13.8	24.5	Loader	107	45/65-45	783.0		712	4.6	9.2	7			
LeTourneau L950 Hi Lift	LeTourneau	L950 Hi Lift	12.0	21.8	Loader	110	45/65-45	783.0		734	5.3	9.7	7			
LeTourneau L1150	LeTourneau	L1150	19.1	34.5	Loader	141	50/65-51	899.0		975	5.6	10.5	8			
LeTourneau L1150 Hi Lift	LeTourneau	L1150 Hi Lift	17.6	31.8	Loader	142	50/65-51	899.0		889	6.3	11.0	8			
LeTourneau L1350	LeTourneau	L1350	22.9	40.8	Loader	184	60/80 R57	1,193.0		961	6.4	11.4	8			
LeTourneau L1350 Hi Lift	LeTourneau	L1350 Hi Lift	21.4	38.1	Loader	186	60/80 R57	1,193.0		987	7.1	11.7	8			
LeTourneau L1850	LeTourneau	L1850	30.6	54.4	Loader	243	58/85-57	1,491.0	157	1,228	6.8	12.6	9			
LeTourneau L1850 Hi Lift	LeTourneau	L1850 Hi Lift	28.3	49.9	Loader	246	58/85-57	1,492.0	157	1,248	7.4	12.9	9			
LeTourneau L2350	LeTourneau	L2350	40.5	72.6	Loader	262	70/70-57	1,715.0		1,273	7.0	13.4	10			

CCRP Cost Estimate Table W-15: Loading Equipment Specifications and Rates

Loaders	Manufacturer	Model	Bucket Capacity (m^3)	Rated Payload (tonnes)	Configuration	Machine Working Weight (t)	Tires	Gross Power (kW)	Fuel Consumption	Digging Force (KN)	Maximum Dumping Height (m)	Maximum Height of Cut (m)	Optimal Working Bench Height (m)	Comments	Rate/hr	Rate Source
LeTourneau L2350 Hi Lift	LeTourneau	L2350 Hi Lift	38.2	68.0	Loader	272	70/70-57	1,715.0		1,290	8.0	13.9	10			
Liebherr R9100	Liebherr	R9100	7.0	12.6	Hydr.Shovel	114	track	565.0		544	8.1	10.3	7	Also available as Excavator		
Liebherr R984C	Liebherr	R984C	7.0	12.6	Hydr.Shovel	125	track	523.0		550	8.9	11.4	8	Also available as Excavator		
Liebherr R9250	Liebherr	R9250	15.0	27.0	Hydr.Shovel	254	track	960.0		935	11.0	15.2	11	Also available as Excavator		
Liebherr R9350	Liebherr	R9350	18.0	32.4	Hydr.Shovel	310	track	1,120.0		1,060	11.2	15.7	11	Also available as Excavator		
Liebherr R9400	Liebherr	R9400	22.0	39.6	Hydr.Shovel	353	track	1,250.0		1,290	11.2	16.0	11	Also available as Excavator		
Liebherr R995	Liebherr	R995	26.5	47.7	Hydr.Shovel	450	track	1,600.0		1,400	12.8	17.7	13	Also available as Excavator		
Liebherr R996B	Liebherr	R996B	34.0	61.2	Hydr.Shovel	676	track	2,240.0		1,905	12.9	18.0	13	Also available as Excavator		
Liebherr R9800	Liebherr	R9800	42.0	75.6	Hydr.Shovel	810	track	2,984.0		2,400	13.0	19.2	14	Also available as Excavator		
P&H 2300XPC	P&H	2300XPC	28.1	45.4	Cable Shovel	775	track	2,387.0			8.5	13.5	12			
P&H 2800XPC	P&H	2800XPC	36.6	59.0	Cable Shovel	1,078	track	3,089.0			9.1	16.6	17			
P&H 4100C	P&H	4100C	50.8	81.7	Cable Shovel	1,243	track	3,886.0			9.1	15.8	17			
P&H 4100XPC AC	P&H	4100XPC AC	67.6	108.9	Cable Shovel	1,532	track	5,113.0			9.5	16.8	17			
P&H 4100C BOSS	P&H	4100C BOSS	52.3	90.7	Cable Shovel	1,354	track	3,886.0			9.5	16.9	17	Oil sands model		

CCRP Cost Estimate Table W-16: Hauling Equipment Specifications and Rates

Trucks	Manufacturer	Model	Target Payload (tonnes)	Capacity Heaped (2:1) (m^3)	Overall Width (m)	Loading Height (m)	Gross Vehicle Weight (t)	Tires	Gross Power (kW)	Haul Road	Body	Rate/hr	Rate Source
Belaz 75137NA	Belaz	75137NA	136.0	80.0	7.00	4.80	244	33.00R51	1,194	24.5	rigid		
Belaz 75302NA	Belaz	75302NA	220.0	138.0	8.40	5.92	376	40.00R57	2,347	29.4	rigid		
Caterpillar 735B	Caterpillar	735B	32.7	19.7	4.20	2.98	65	26.5R25	337	14.7	articulated	$ 282	ARHCA x 1.2
Caterpillar 740B EJ	Caterpillar	740B EJ	38.0	24.0	4.20	3.20	74	29.5R25	365	14.7	articulated	$ 312	ARHCA x 1.2
Caterpillar 745C	Caterpillar	745C	41.0	73.8	4.20	3.20	74	29.5R25	365	14.7	articulated	$ 323	ARHCA x 1.2
Caterpillar 770G	Caterpillar	770G	35.0	25.1	4.78	3.23	71	18.00R33	381	16.7	rigid	$ 389	ARHCA x 1.2
Caterpillar 772G	Caterpillar	772G	43.8	31.3	4.78	3.64	82	21.00R33	446	16.7	rigid	$ 389	ARHCA x 1.2
Caterpillar 773G	Caterpillar	773G	52.8	35.2	5.67	3.77	103	24.00R35	578	19.8	rigid	$ 461	ARHCA x 1.2
Caterpillar 775G	Caterpillar	775G	61.7	41.7	5.67	3.97	112	24.00R35	615	19.8	rigid	$ 481	ARHCA x 1.2
Caterpillar 777G	Caterpillar	777G	91.0	60.2	6.10	4.39	165	27.00R49	765	21.4	rigid	$ 656	ARHCA x 1.2
Caterpillar 785D	Caterpillar	785D	132.9	78.0	7.06	4.97	249	33.00-R51	1,082	24.7	rigid		
Caterpillar 789C	Caterpillar	789C	180.7	105.0	7.67	5.21	317	37.00R57	1,417	26.8	rigid		
Caterpillar 793F	Caterpillar	793F	226.0	134.0	8.30	6.50	386	40.00-R57	1,976	29.1	rigid		
Caterpillar 795F AC	Caterpillar	795F AC	313.0	213.0	8.97	7.04	570	56/80 R63	2,535	31.4	rigid		
Caterpillar 797F	Caterpillar	797F	350.0	240.0	9.75	7.00	624	59/80 R63	2,983	34.1	rigid		
Hitachi EH1100-3	Hitachi	EH1100-3	59.0	38.7	4.44	3.76	111	24.00R35	567	15.5	rigid		
Hitachi EH1700-3	Hitachi	EH1700-3	95.2	60.4	6.25	4.26	163	27.00R49	783	21.9	rigid		
Hitachi EH3500ACII	Hitachi	EH3500ACII	185.0	111.0	8.01	5.63	325	37.00R57	1,491	28.0	rigid		
Hitachi EH4000ACII	Hitachi	EH4000ACII	222.0	134.0	9.54	5.71	384	46/90 R57	1,864	33.4	rigid		
Hitachi EH5000ACII	Hitachi	EH5000ACII	290.0	206.0	9.28	7.12	500	53/80 R63	2,014	32.5	rigid		
Komatsu HM400	Komatsu	HM400	36.5	22.3	3.45	2.97	74	29.50R25	338	12.1	articulated	$ 250	ARHCA x 1.2
Komatsu HD785-7	Komatsu	HD785-7	91.0	60.0	6.89	4.29	166	27.00R49	895	24.1	rigid	$ 656	ARHCA x 1.2
Komatsu HD1500-7	Komatsu	HD1500-7	144.1	78.0	6.09	4.97	249	33.00-R51	1,109	21.3	rigid		
Komatsu 730E	Komatsu	730E	183.7	111.0	7.54	5.61	324	37.00R57	1,492	26.4	rigid		
Komatsu 830E AC	Komatsu	830E AC	221.2	147.0	7.32	6.71	386	40.00-R57	1,865	25.6	rigid		
Komatsu 860E-1K	Komatsu	860E-1K	254.0	169.0	8.33	6.39	454	50/80 R57	2,014	29.2	rigid		
Komatsu 930E-4	Komatsu	930E-4	291.8	211.0	8.69	7.06	502	53/80 R63	2,014	30.4	rigid		
Komatsu 960E-2K	Komatsu	960E-2K	326.6	214.0	9.19	7.39	576	56/80 R63	2,610	32.2	rigid		
Liebherr T282C	Liebherr	T282C	363.0	220.0	9.68	7.43	600	56/80 R63	2,800	33.9	rigid		
Unit Rig MT3300	Unit Rig	MT3300	136.0				252	33.00-R51	1,193	-	rigid		
Unit Rig MT3700AC	Unit Rig	MT3700AC	186.0	123.0	7.30	6.20	336	40.00-R57	1,492	25.6	rigid		
Unit Rig MT4400AC	Unit Rig	MT4400AC	221.0	144.0	8.00	6.10	392	50/80 R57	2,014	28.0	rigid		
Unit Rig MT5500AC	Unit Rig	MT5500AC	326.0	218.0	9.45	6.86	543	56/80 R63	2,014	33.1	rigid		
Unit Rig MT6300AC	Unit Rig	MT6300AC	363.0	215.0	9.70	7.39	603	59/80 R63	2,796	34.0	rigid		
Caterpillar 730C2	Caterpillar	730C2	30.0									$ 285	YG
Komatsu HM350	Komatsu	HM350	35.0									$ 285	YG
Caterpillar 730E	Caterpillar	730E	30.0								articulated	$ 325	YG
Terex TA30	Terex	TA30	30.0								articulated	$ 295	YG
Volvo A30D	Volvo	A30D	30.0									$ 300	YG

wood.

Quantity

Component	Option	Number of Excavators	Number of Haul Trucks	Number of Dozers	Number of Compactors	Number of Graders	Number of Water Trucks	Number of Support Trucks	Camp Personnel	Total Equipment Operators	Total Support Personnel	Owners Team	Shifts per Day	Total Crew Count	Project Duration (Years)	Project Duration (Person.Days)
Clinton	CC1	2	7	2	1	2	2	3	included in the camp estimate	19	10	3	2	61	1.42	31,692
	CC1-A	1	3	3	2	2	2	3		16	10	3	2	55	0.57	11,370
	CC1-B	1	3	3	2	2	2	3		16	10	3	2	55	0.63	12,572
	CC2	2	7	2	1	2	2	3		19	10	3	2	61	2.31	51,434
	CC2-A	2	7	2	1	2	2	3		19	10	3	2	61	0.77	17,147
	CC2-B	2	7	2	1	2	2	3		19	10	3	2	61	1.48	33,011
	CC3	2	7	2	1	2	2	3		19	10	3	2	61	4.55	101,216
Wolverine	WC1	1	1	1	0	1	1	1		6	4	2	2	22	0.50	4,015
	WC2	2	16	3	1	2	3	3		30	10	3	2	83	2.81	85,254
	WC2-A	2	16	2	2	2	3	3		30	10	3	2	83	0.81	24,673
	WC3	2	16	3	1	2	3	3		30	10	3	2	83	2.81	85,254
Porcupine Pit	PP1	0	0	0	0	0	0	0		0	0	0	0	0	0.00	-
	PP2	3	7	3	1	1	0	1		16	4	2	2	52	0.95	18,011
	PP3	2	6	3	1	1	0	1		14	4	2	2	48	1.10	19,288
	PP4	6	17	6	4	2	2	3		40	6	3	2	95	1.36	47,028
Snowshoe Pit	SCP1	0	0	0	0	0	0	0		0	0	0	2	0	0.00	-
	SCP2	1	4	2	1	1	1	1		11	2	1	2	32	0.47	5,440
	SCP3	1	4	2	1	1	1	1		11	2	1	2	32	0.40	4,679
	SCP4	4	13	4	2	2	2	2		29	4	2	2	68	0.61	15,195

Equipment Mobilization (km)

Distance from Whitehorse to Dawson City:	532
Distance from Dawson City to Fortymile R. Bridge:	91
Distance from Fortymile R. Bridge to Site:	9
Total Mob + Demob Distance:	**1,246**

The George Black Ferry:	This ferry service crosses the Yukon River and provides access to the Top of the World Highway from the North Klondike Highway for motorists passing through Dawson City.
Yukon River Ice Bridge:	Yukon gov't gives up on attempt to build ice bridge in Dawson City. https://www.cbc.ca/news/canada/north/gov-halts-dawson-city-ice-bridge-1.5001387. https://yukon.ca/sites/yukon.ca/files/hpw/final_mc_report_dawson_ice_bridge_2018_final.pdf
Fortymile River Bridge:	Weight restrictions not available. Built in 1966.

Unit Price

Equipment Mob/Demob	$/t.km	
Equipment Mob/Demob km/hr	80	
Equipment Mob/Demob hours	16	
Equipment Mob + Demob Distance (km)	2492	

Equipment Mobilize and Demobilize Costs

Creek	Option	Excavators Mob/Demob	Haul Trucks Mob/Demob	Dozers Mob/Demob	Compactors Mob/Demob	Graders Mob/Demob	Water Trucks Mob/Demob	Support Trucks Mob/Demob	Factor	Total Mob + Demob
Mob/Demob Rate/hr		$ 300	$ 300	$ 300	$ 300	$ 300	$ 150	$ 150		
Clinton	CC1	$ 9,345	$ 32,708	$ 9,345	$ 4,673	$ 9,345	$ 4,673	$ 7,009	1	$ 77,097
	CC1-A	$ 4,673	$ 14,018	$ 14,018	$ 9,345	$ 9,345	$ 4,673	$ 7,009	1	$ 63,080
	CC1-B	$ 4,673	$ 14,018	$ 14,018	$ 9,345	$ 9,345	$ 4,673	$ 7,009	1	$ 63,080
	CC2	$ 9,345	$ 32,708	$ 9,345	$ 4,673	$ 9,345	$ 4,673	$ 7,009	1	$ 77,097
	CC2-A	$ 9,345	$ 32,708	$ 9,345	$ 4,673	$ 9,345	$ 4,673	$ 7,009	1	$ 77,097
	CC2-B	$ 9,345	$ 32,708	$ 9,345	$ 4,673	$ 9,345	$ 4,673	$ 7,009	1	$ 77,097
	CC3	$ 9,345	$ 32,708	$ 9,345	$ 4,673	$ 9,345	$ 4,673	$ 7,009	1	$ 77,097
Wolverine	WC1	$ 4,673	$ 4,673	$ 4,673	$ -	$ 4,673	$ 2,336	$ 2,336	1	$ 23,364
	WC2	$ 9,345	$ 74,760	$ 14,018	$ 4,673	$ 9,345	$ 7,009	$ 7,009	1	$ 126,159
	WC2-A	$ 9,345	$ 74,760	$ 9,345	$ 9,345	$ 9,345	$ 7,009	$ 7,009	1	$ 126,159
	WC3	$ 9,345	$ 74,760	$ 14,018	$ 4,673	$ 9,345	$ 7,009	$ 7,009	1	$ 126,159
Porcupine Pit	PP1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	1	$ 1
	PP2	$ 14,018	$ 32,708	$ 14,018	$ 4,673	$ 4,673	$ -	$ 2,336	1	$ 72,425
	PP3	$ 9,345	$ 28,035	$ 14,018	$ 4,673	$ 4,673	$ -	$ 2,336	1	$ 63,080
	PP4	$ 28,035	$ 79,433	$ 28,035	$ 18,690	$ 9,345	$ 4,673	$ 7,009	1	$ 175,220
Snowshoe Pit	SCP1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	1	$ 1
	SCP2	$ 4,673	$ 18,690	$ 9,345	$ 4,673	$ 4,673	$ 2,336	$ 2,336	1	$ 46,726
	SCP3	$ 4,673	$ 18,690	$ 9,345	$ 4,673	$ 4,673	$ 2,336	$ 2,336	1	$ 46,726
	SCP4	$ 18,690	$ 60,743	$ 18,690	$ 9,345	$ 9,345	$ 4,673	$ 4,673	1	$ 126,159

Mobilize and Demobilize Workers by Air to Dawson City and by Bus to Site

Airfare Whitehorse to Dawson City	Each Retu	Air No	$ 400

Creek	Option	Project Duration (Years)	Bus Operating Cost/Year	Worker Airfare	Total
Clinton	CC1	1.4	$ 250,000	$ 905,498	$ 1,261,353
	CC1-A	0.6	$ 250,000	$ 324,855	$ 466,449
	CC1-B	0.6	$ 250,000	$ 359,208	$ 515,774
	CC2	2.3	$ 250,000	$ 1,469,545	$ 2,047,067
	CC2-A	0.8	$ 250,000	$ 489,917	$ 682,452
	CC2-B	1.5	$ 250,000	$ 943,184	$ 1,313,849
	CC3	4.5	$ 250,000	$ 2,891,879	$ 4,028,369
Wolverine	WC1	0.5	$ 250,000	$ 114,714	$ 239,714
	WC2	2.8	$ 250,000	$ 2,435,817	$ 3,139,345
	WC2-A	0.8	$ 250,000	$ 704,955	$ 908,564
	WC3	2.8	$ 250,000	$ 2,435,817	$ 3,139,345
Porcupine Pit	PP1	0.0	$ 250,000	$ -	$ -
	PP2	0.9	$ 250,000	$ 514,606	$ 751,845
	PP3	1.1	$ 250,000	$ 551,092	$ 826,324
	PP4	1.4	$ 250,000	$ 1,343,664	$ 1,682,728
Snowshoe Pit	SCP1	0.0	$ 250,000	$ -	$ -
	SCP2	0.5	$ 250,000	$ 155,422	$ 271,856
	SCP3	0.4	$ 250,000	$ 133,698	$ 233,856
	SCP4	0.6	$ 250,000	$ 434,131	$ 587,179

Note: Bus operating cost includes driver and assumes 60 km/day on average with purchase of V6 diesel 30 passenger. Based on bus cost model prepared by the U.S. Department of Transportation. Assumes that ice bridge over the Yukon River is available.

CCRP Cost Estimate Table W-20: Worker Camp Cost Estimate

Fixed Duration Estimate

Description	Camp Duration (Years)	Number of People	Quantity	Unit	Unit Price	Unit Price Geographic Correction Factor	Total Base Cost	Reference
Camp Site Preparation - Clearing			2	Ha	$ 8,863	1.2	$ 21,270	Alberta Transportation 2019
Camp Site Preparation - Surface Preparation			20000	m2	$ 27	1.2	$ 653,280	Alberta Transportation 2019

Item	Camp Size	Quality	Unit	Half Full	Full
Mob Costs	60 Person	Better	LS	$ 713,628	$713,628
Demob Costs	60 Person	Better	LS	$ 363,191	$363,191
Camp Rental Costs	60 Person	Better	$/Month	$ 52,555	$ 52,555
Camp Occupancy Costs	60 Person	Better	$/Day	$ 5,020	$ 7,350
Utilities - Diesel	60 Person	Better	$/Day	$ 888.95	$1,777.89
Utilities - Propane	60 Person	Better	$/Day	$ 199.80	$ 399.60
Utilities - Water	60 Person	Better	$/Day	$ 378.00	$ 756.00
Utilities - Sewer	60 Person	Better	$/Day	$ 354.09	$ 708.17
Utilities - Garbage	60 Person	Better	$/Day	$ 111.00	$ 222.00
Utilities - Telecom	60 Person	Better	$/Day	$ 696.00	$ 696.00
Utilities - Total Costs	60 Person	Better	$/Day	$ 2,628	$ 4,560

60 Person Better Camp Costs Applied to the estimate.

Variable duration estimate based on budgetary pricing tables and project durations.

Option	Workers	Project Duration (years)	Occupancy Range (No. of Guests)	Site Prep	Mob	Demob	Camp Rental	Camp Occupancy	Utilities	Total
CC1	61	1.42	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 897,688	$ 3,882,371	$ 2,368,963	$ 8,900,390
CC1-A	55	0.57	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 357,186	$ 1,392,835	$ 942,601	$ 4,443,992
CC1-B	55	0.63	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 394,958	$ 1,540,123	$ 1,042,279	$ 4,728,729
CC2	61	2.31	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 1,456,869	$ 6,300,751	$ 3,844,621	#########
CC2-A	61	0.77	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 485,691	$ 2,100,546	$ 1,281,721	$ 5,619,328
CC2-B	61	1.48	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 935,048	$ 4,043,951	$ 2,467,557	$ 9,197,926
CC3	61	4.55	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 2,866,935	$12,399,083	$ 7,565,729	#########
WC1	22	0.50						$ 1,204,500		$ 1,204,500
WC2	83	2.81	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 1,774,737	$10,443,692	$ 4,683,462	#########
WC2-A	83	0.81	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 513,630	$ 3,022,530	$ 1,355,450	$ 6,642,981
WC3	83	2.81	Full 60	$ 674,550	$ 713,628	$ 363,191	$ 1,774,737	$10,443,692	$ 4,683,462	#########
PP1	0	0.00					$ -	$ -	$ -	$ -
PP2	52	0.95					$ 598,465	$ 2,206,400	$ 1,579,327	$ 4,384,192
PP3	48	1.10					$ 694,306	$ 2,362,837	$ 1,832,245	$ 4,889,388
PP4	95	1.36					$ 855,332	$ 5,761,029	$ 2,257,187	$ 8,873,547
SCP1	0	0.00					$ -	$ -	$ -	$ -
SCP2	32	0.47					$ 293,718	$ 666,382	$ 775,112	$ 1,735,212
SCP3	32	0.40					$ 252,663	$ 573,235	$ 666,767	$ 1,492,664
SCP4	68	0.61					$ 386,082	$ 1,861,359	$ 1,018,855	$ 3,266,295

□□□ed on ATCO □ronte□□□0 □e□tem□er□□01□

Budgetary prices above are based on the following proposed services:

SCOPE	SERVICE
CAMP EQUIPMENT	□ Transport & Installation □ Camp equipment rentals □ Site Service rentals □ Dismantle and demobilization
GENERAL OVERVIEW	□ Catering □ Housekeeping service □ Janitorial service □ Camp maintenance – Call Out Basis Only □ Laundry of linens/bedding/towels □ Drug and alcohol-free camp. Non-smoking rooms.
SPECIFIC - LODGE MANAGEMENT	□ Combined Chef-Manager to run the camp
SPECIFIC - PERSONNEL AND TRAINING	□ Lodge management personnel (non-union) □ Front desk personnel (non-union) □ Food service personnel (non-union) □ Housekeeping & janitorial personnel (non-union) □ Maintenance & grounds keeping personnel (non-union) □ All required training for personnel □ Catering & housekeeping services for ATCO staff □ Personnel transportation to/from site
SPECIFIC - SUPPLY & REPLACEMENT	□ Housekeeping & janitorial equipment, tools, and consumables □ Small kitchen equipment & tools □ Food, paper & consumables for catering services □ All office furniture for Lodge Management
SPECIFIC - FOOD SERVICES	□ Two hot meals per day as follows: 1 hour for breakfast and bagged lunch 1.5 hours for supper □ Hours can be set by client □ Catering Permit
SPECIFIC - HOUSEKEEPING & JANITORIAL	□ Cleaning of call camp rooms & washrooms □ Weekly linen change □ Daily cleaning of all camp common facilities □ Residents not allowed to wear boots in the lodge
SPECIFIC - LAUNDRY	□ Weekly Laundry of linens/bedding/towels □ Laundry of personnel clothing □ Towel change service every second day
SPECIFIC – UTILITIES	□ Natural gas □ Propane □ Water supply □ Waste water & sewage hauling
SPECIFIC - MAINTENANCE	□ Snow clearing from stairs and walkways □ Monthly call-outs for preventative & corrective maintenance □ Replacement of spare parts
SPECIFIC - ROOM MANAGEMENT	□ Bedroom allocation and occupancy reporting □ Check ins, check outs, and key management □ Board count reports □ Occupancy reports for emergency evacuation purposes □ Room management software
SPECIFIC – HSE & QA/QC	□ Project specific HSE plan □ Project specific ERP plan □ Project specific Crisis Management plan □ Food safety management & QA/QC Program per Food Services Management Guide □ On-site HSE coverage provided by lodge management

CCRP Cost Estimate Table W-21: Access Road Improvement and Maintenance Estimate

Road Improvement and Maintenance Cost Allocations

Road Segment	Length (km)	Total Annual Cost	Comment
Clinton Creek Camp to Mine Site	9	$ 107,432	Graders
Site 11 Pit to Clinton Creek Road	0	$ -	
Mike 63 Quarry to Clinton Creek Road	4	$ 47,747	Graders
On-Site	10	$ 810,568.42	Graders + Dozer
Dawson City to Fortymile Bridge	91	$ 1,086,253	The road is closed from mid-September until mid-May. Yukon Government. 2018. Top of the World Highway Draft Interpretive Plan. Snow clearing is required during these months for crew mobilization and demobilization.
		$ 2,052,000	

Road Segment	Task	Road Area (m2)	Gravel Volume	Gravel Cost	Annual Total
Clinton Creek Camp to Mine Site - (3 inches of annual gravel placement)	Gravel	□□000	□0□□	□ □1□□□	□ 10□□□1

Total Annual Cost **$ 2,155,971**

Road Improvement and Maintenance Total Cost

Option	Project Duration (Years)	Total
CC1	1.42	**$ 3,068,851**
CC1-A	0.57	**$ 1,221,084**
CC1-B	0.63	**$ 1,350,210**
CC2	2.31	**$ 4,980,480**
CC2-A	0.77	**$ 1,660,394**
CC2-B	1.48	**$ 3,196,574**
CC3	4.55	**$ 9,800,955**
WC1	0.50	**$ 1,077,986**
WC2	2.81	**$ 6,067,149**
WC2-A	0.81	**$ 1,755,906**
WC3	2.81	**$ 6,067,149**

Road Improvement and Maintenance Annual Cost

Grader Allocation	Task	Unit Price/hr	Annual Months	Anuual Hours	Annual Total
Cat 12H	Maintenance	$ 210	1□	□□□0	□ □0□□00
Cat 12H	Maintenance	$ 210	□	□1□0	□ □□□□00

$ 1,360,800

Dozer Allocation					
Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	Maintenance	$ 320	□	□1□0	□ □□1□□00

CCRP Cost Estimate Table W-22: Water Crossing Cost Estimate

Crossing	Location	Purpose	Existing Bridge?	Crossing Length (m)	Crossing Width (m)	Crossing Area (m2)	Proposed Use	Unit Price	Unit	Task	Unit Price Geographic Correction Factor	Reference	Total Cost	Haul road bridge required									Ice bridge required										
														CC1	CC1-A	CC1-B	CC2	CC2-A	CC2-B	CC3	WC1	WC2	WC2-A	WC3	CC1	CC1-A	CC1-B	CC2	CC2-A	CC2-B	CC3	WC1	WC2	WC2-A	WC3
Clinton Creek	**Former Clinton Creek Townsite**	Site Access	No	15	5	75	Worker camp access/egress.	$ 3,963	m2	Construct	1.2	Alberta Transportation Bridge Cost Data - Site 78210.	$ 356,670												Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Clinton Creek	**Wolverine Haul Road**	On-Site	No	15	12.5	187.5	Haul road from Wolverine to Porcupine.	$ 3,963	m2	Construct	1.2	Alberta Transportation Bridge Cost Data - Site 78210.	$ 891,675	No	No	No	No	No	No	No	No	Yes	Yes	Yes											
Clinton Creek	**West End of Site**	On-Site	No	15	12.5	187.5	Crossing for Clinton Creek Options	$ 3,963	m2	Construct	1.2	Alberta Transportation Bridge Cost Data - Site 78210.	$ 891,675	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No											
Fortymile River	**Fortymile River**	Site Access	Yes	150	5	750	Equipment Mobilization and demobilization.	$ 719	m2	Repair	1.2	Alberta Transportation Bridge Cost Data - rehab data - Bridge 74222.	$ 647,100												Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Yukon River	**Dawson City**	Site Access	Yes	400			Equipment mobilization. Seasonal ferry or winter road (when feasible).	$ 200,000	Each	Construct	1	Yukon Government communications , Highways and Public Works. 10/12/2018	$ 200,000												See "Years of Participation in Ice Bridge Cost" below.										

Assumes project pays entire cost of ice bridge.

Years of Participation in Ice Bridge Cost

Option	Years
CC1	**1.00**
CC1-A	**1.00**
CC1-B	**1.00**
CC2	**2.00**
CC2-A	**1.00**
CC2-B	**2.00**
CC3	**4.00**
WC1	**0.00**
WC2	**2.00**
WC2-A	**1.00**
WC3	**3.00**

Cost Estimate for Haul Road Bridges

Option	Haul Road Bridges	Access Road Bridges	Ice Bridge Construction Participation	Total
CC1	**$ 891,675**	**$ 1,003,770**	**$ 200,000**	**$2,095,445**
CC1-A	**$ 891,675**	**$ 1,003,770**	**$ 200,000**	**$2,095,445**
CC1-B	**$ 891,675**	**$ 1,003,770**	**$ 200,000**	**$2,095,445**
CC2	**$ 891,675**	**$ 1,003,770**	**$ 400,000**	**$2,295,445**
CC2-A	**$ 891,675**	**$ 1,003,770**	**$ 200,000**	**$2,095,445**
CC2-B	**$ 891,675**	**$ 1,003,770**	**$ 400,000**	**$2,295,445**
CC3	**$ 891,675**	**$ 1,003,770**	**$ 800,000**	**$2,695,445**
WC1	**$ -**	**$ -**	**$ -**	**$ -**
WC2	**$ 891,675**	**$ 1,003,770**	**$ 400,000**	**$2,295,445**
WC2-A	**$ 891,675**	**$ 1,003,770**	**$ 200,000**	**$2,095,445**
WC3	**$ 891,675**	**$ 1,003,770**	**$ 600,000**	**$2,495,445**

CCRP Cost Estimate Table W-23: Fuel Storage Cost Estimate

Quantity

Creek	Option	Number of Excavators	Number of Haul Trucks	Number of Dozers	Number of Graders	Number of Water Trucks	Number of Support Trucks	Shifts per Day	Project Duration (Years)
Clinton	CC1	2	7	2	2	2	3	2	1.42
	CC1-A	1	3	3	2	2	3	2	0.57
	CC1-B	1	3	3	2	2	3	2	0.63
	CC2	2	7	2	2	2	3	2	2.31
	CC2-A	2	7	2	2	2	3	2	0.77
	CC2-B	2	7	2	2	2	3	2	1.48
	CC3	2	7	2	2	2	3	2	4.55
Wolverine	WC1	1	1	1	1	1	1	2	0.50
	WC2	2	16	3	2	3	3	2	2.81
	WC2-A	2	16	2	2	3	3	2	0.81
	WC3	2	16	3	2	3	3	2	2.81
Porcupine Pit	PP1	0	0	0	0	0	0	0	0.00
	PP2	3	7	3	1	0	1	2	0.95
	PP3	2	6	3	1	0	1	2	1.10
	PP4	6	17	6	2	2	3	2	1.36
Snowshoe Pit	SCP1	0	0	0	0	0	0	2	0.00
	SCP2	1	4	2	1	1	1	2	0.47
	SCP3	1	4	2	1	1	1	2	0.40
	SCP4	4	13	4	2	2	2	2	0.61

Fuel Consumption (L/hr)

	Litres/Hour	Hours/Day	Litres/Day	
Excavator	67	20	1340	07 - CAT Handbook edition 48.pdf
Truck	27	20	540	07 - CAT Handbook edition 48.pdf
Dozer	39	20	780	07 - CAT Handbook edition 48.pdf
Grader	16	20	320	07 - CAT Handbook edition 48.pdf
Water Truck (12,500 L)	13	20	260	http://www.ezyquip.com.au/DownloadAttachment.ashx?AttachmentId=181385
Support Truck	5	20	100	assumed
Generators	20	20	400	

Emergency Stock (days)	180	George Black Ferry at Dawson City is open mid-May to mid-October, when it shuts down for the season. Ice bridge across the Yukon River has failed over the past few years. Assumed fuel storage required when the ferry is not operating.
Lead-Time for Supply (days)	6	
Total Storage Capacity (days)	**186**	

Fuel Consumption (L/Day)

Option	Excavators	Trucks	Dozers	Graders	Water Trucks	Support Trucks	Generators	Pumps
CC1	2680	3780	1560	640	520	300	1808	2353
CC1-A	1340	1620	2340	640	520	300	1808	2353
CC1-B	1340	1620	2340	640	520	300	1808	2353
CC2	2680	3780	1560	640	520	300	1808	2353
CC2-A	2680	3780	1560	640	520	300	1808	2353
CC2-B	2680	3780	1560	640	520	300	1808	2353
CC3	2680	3780	1560	640	520	300	1808	2353
WC1	1340	540	780	320	260	100	1108	
WC2	2680	8640	2340	640	780	300	1808	

CCRP Cost Estimate Table W-23: Fuel Storage Cost Estimate

WC2-A	2680	8640	1560	640	780	300	1808
WC3	2680	8640	2340	640	780	300	1808
PP1	0	0	0	0	0	0	0
PP2	4020	3780	2340	320	0	100	0
PP3	2680	3240	2340	320	0	100	0
PP4	8040	9180	4680	640	520	300	0
SCP1	0	0	0	0	0	0	0
SCP2	1340	2160	1560	320	260	100	0
SCP3	1340	2160	1560	320	260	100	0
SCP4	5360	7020	3120	640	520	200	0

Fuel Storage Estimate

http://totaloilfield.ca/wp-content/uploads/2016/06/400BBL-Tanks-Storage-TOR-Water-Management.pdf

Total Oilfield services tank quote Aug 2, 2019.pdf

Costs for fuel storage capacity of 1660 bbl (254,380 L) and 4000 bbl (635,950 L) provided by Total Oilfield Rentals

254,380 L Tank Farm Estimate

Rental Item	Qty	Rate/Day	Total/Day
400 bbl Sloped Bottom, Lined and Sour Service Tank	4	$ 20	$ 80
8' x 40' Rig Mat	3	$ 10	$ 30
Berm Block	28	$ 1	$ 28
Berm Crossing Stair	1	Included	Included
Tank Grounding Package	4	Included	Included
		Total	**$ 138**

Mob/Demob and Set-up

Mobilization and set-up	$ 93,425
Demobilization	$ 93,425
Permit	Cost + 10%
Yukon Power Lift (if required)	Cost + 10%
Cleaning, servicing, repairs & fluid/solid disposal charges are extra	Extra
Total	**$ 186,850**

Purchase Items

Secondary Containment Liner	**$ 2,000**

50,000 L Enviro Tank

50,000 L Enviro Tank Rental (Provided by Dall Contracting Ltd.)	**$ -**	No Charge (Dall Contracting Quote)
50,000 L Enviro Tank Mobilization - Estimated by Wood	**$ 23,356**	Assumed same as Total
50,000 L Enviro Tank Demobilization - Estimated by Wood	**$ 23,356**	Assumed same as Total

635,950 L Tank Farm Estimate

Rental Item	Qty	Rate/Day	Total/Day
400 bbl Sloped Bottom, Lined and Sour Service Tank	10	$ 20	$ 200
8' x 40' Rig Mat	8	$ 10	$ 80
Berm Block	36	$ 1	$ 36
Berm Crossing Stair	2	Included	Included
Tank Grounding Package	4	Included	Included
		Total	**$ 316**

Mob/Demob and Set-up

Mobilization and set-up	$ 183,345
Demobilization	$ 183,345
Permit	Cost + 10%
Yukon Power Lift (if required)	Cost + 10%
Cleaning, servicing, repairs & fluid/solid disposal charges are extra	Extra
Total	**$ 366,690**

Purchase Items

Secondary Containment Liner	**$ 4,500**

CCRP Cost Estimate Table W-23: Fuel Storage Cost Estimate

Fuel Storage Capacity Estimate

Option	Fuel (L) Storage Estimated Requirement	Storage Cost (Setup)	Storage Cost Daily Rental	Storage Cost Total Rental over Project Duration	Storage Cost Total	Storage Scenario Capacity (L)
CC1	**2,537,211**	**$ 1,862,207**	**$ 1,294**	**$ 672,182**	**$ 2,534,389**	**2,543,800**
CC1-A	**2,031,291**	**$ 1,355,643**	**$ 1,046**	**$ 216,236**	**$ 1,571,878**	**2,035,040**
CC1-B	**2,031,291**	**$ 1,355,643**	**$ 1,046**	**$ 239,102**	**$ 1,594,744**	**2,035,040**
CC2	**2,537,211**	**$ 1,862,207**	**$ 1,294**	**$ 1,090,894**	**$ 2,953,100**	**2,543,800**
CC2-A	**2,537,211**	**$ 1,733,343**	**$ 1,322**	**$ 371,614**	**$ 2,104,957**	**2,543,800**
CC2-B	**2,537,211**	**$ 1,733,343**	**$ 1,322**	**$ 715,428**	**$ 2,448,771**	**2,543,800**
CC3	**2,537,211**	**$ 1,862,207**	**$ 1,294**	**$ 2,146,741**	**$ 4,008,948**	**2,543,800**
WC1	**827,396**	**$ 87,370**	**$ 138**		**$ 87,370**	**890,330**
WC2	**3,196,951**	**$ 2,346,428**	**$ 1,630**	**$ 1,674,462**	**$ 4,020,890**	**3,306,940**
WC2-A	**3,051,871**	**$ 1,909,173**	**$ 1,540**	**$ 457,796**	**$ 2,366,968**	**3,052,560**
WC3	**3,196,951**	**$ 2,346,428**	**$ 1,630**	**$ 1,674,462**	**$ 4,020,890**	**3,306,940**
PP1	**-**		**$ 1,294**	**$ -**	**$ -**	
PP2	**1,964,160**		**$ 1,294**	**$ 448,127**	**$ 448,127**	**2,035,040**
PP3	**1,614,480**		**$ 1,294**	**$ 519,891**	**$ 519,891**	**1,653,470**
PP4	**4,344,960**		**$ 1,294**	**$ 640,467**	**$ 640,467**	**4,451,650**
SCP1	**-**		**$ 1,294**	**$ -**	**$ -**	
SCP2	**1,067,640**		**$ 1,294**	**$ 219,934**	**$ 219,934**	**1,144,710**
SCP3	**1,067,640**		**$ 1,294**	**$ 189,192**	**$ 189,192**	**1,144,710**
SCP4	**3,135,960**		**$ 1,294**	**$ 289,095**	**$ 289,095**	**3,179,750**

63,595 L Tank Farm Estimate - Wood Extrapolation of Total and Dal Estimates

Rental Item	Qty	Rate/Day	Total/Day
400 bbl Sloped Bottom, Lined and	1	$ 20	$ 20
8' x 40' Rig Mat	1	$ 10	$ 10
Berm Block	7	$ 1	$ 7
Berm Crossing Stair	1	Included	Included
Tank Grounding Package	1	Included	Included
		Total	**$ 37**

Mob/Demob and Set-up

Mobilization and set-up	$ 23,356
Demobilization	$ 23,356
Permit	Cost + 10%
Yukon Power Lift (if required)	Cost + 10%
Cleaning, servicing, repairs & fluid/solid disposal charges are extra	Extra
Total	**$ 46,713**

Purchase Items

Secondary Containment Liner	**$ 2,000**

50,000 L Enviro Tank

50,000 L Enviro Tank Rental (Provided by Dall Contracting Ltd.)	**$ -**	No Charge (Dall Contracting Quote)
50,000 L Enviro Tank Mobilization - Estimated by Wood	**$ 23,356**	Assumed same as Total
50,000 L Enviro Tank Demobilization - Estimated by Wood	**$ 23,356**	Assumed same as Total

50000	litres		$ 46,712.50	mob/demob
254380	litres	$ 138.00 day	$188,850.00	mob/demob
635950	litres	$ 316.00 day	$371,190.00	mob/demob

Scenario	Total Litres	Enviro Tank			Small Tank Farm				Large Tank Farm				Combined Pricing / Rates	
		Qty	Price	Cost	Qty	Total Litres	Setup	Day Rate	Qty	Total Litres	Setup	Day Rate	Setup	Day Rate
1	254,380	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	0	0	$ -	$ -	$ 235,562.50	$ 138.00
1	890,330	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	1	635950	$ 371,190.00	$ 316.00	$ 606,752.50	$ 454.00
2	1,144,710	1	$46,712.50	$46,712.50	2	508760	$ 377,700.00	$ 276.00	1	635950	$ 371,190.00	$ 316.00	$ 795,602.50	$ 592.00
3	1,399,090	1	$46,712.50	$46,712.50	3	763140	$ 566,550.00	$ 414.00	1	635950	$ 371,190.00	$ 316.00	$ 984,452.50	$ 730.00
4	1,526,280	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	2	1271900	$ 742,380.00	$ 632.00	$ 977,942.50	$ 770.00
5	1,653,470	1	$46,712.50	$46,712.50	4	1017520	$ 755,400.00	$ 552.00	1	635950	$ 371,190.00	$ 316.00	$ 1,173,302.50	$ 868.00
6	1,780,660	1	$46,712.50	$46,712.50	2	508760	$ 377,700.00	$ 276.00	2	1271900	$ 742,380.00	$ 632.00	$ 1,166,792.50	$ 908.00
7	1,907,850	1	$46,712.50	$46,712.50	5	1271900	$ 944,250.00	$ 690.00	1	635950	$ 371,190.00	$ 316.00	$ 1,362,152.50	$1,006.00
8	2,035,040	1	$46,712.50	$46,712.50	3	763140	$ 566,550.00	$ 414.00	2	1271900	$ 742,380.00	$ 632.00	$ 1,355,642.50	$1,046.00
9	2,162,230	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 1,349,132.50	$1,086.00
10	2,162,230	1	$46,712.50	$46,712.50	6	1526280	$ 1,133,100.00	$ 828.00	1	635950	$ 371,190.00	$ 316.00	$ 1,551,002.50	$1,144.00
11	2,289,420	1	$46,712.50	$46,712.50	4	1017520	$ 755,400.00	$ 552.00	2	1271900	$ 742,380.00	$ 632.00	$ 1,544,492.50	$1,184.00
12	2,416,610	1	$46,712.50	$46,712.50	2	508760	$ 377,700.00	$ 276.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 1,537,982.50	$1,224.00
13	2,416,610	1	$46,712.50	$46,712.50	7	1780660	$ 1,321,950.00	$ 966.00	1	635950	$ 371,190.00	$ 316.00	$ 1,739,852.50	$1,282.00
14	2,543,800	1	$46,712.50	$46,712.50	5	1271900	$ 944,250.00	$ 690.00	2	1271900	$ 742,380.00	$ 632.00	$ 1,733,342.50	$1,322.00
15	2,670,990	1	$46,712.50	$46,712.50	3	763140	$ 566,550.00	$ 414.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 1,726,832.50	$1,362.00
16	2,670,990	1	$46,712.50	$46,712.50	8	2035040	$ 1,510,800.00	$ 1,104.00	1	635950	$ 371,190.00	$ 316.00	$ 1,928,702.50	$1,420.00
17	2,798,180	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 1,720,322.50	$1,402.00
18	2,798,180	1	$46,712.50	$46,712.50	6	1526280	$ 1,133,100.00	$ 828.00	2	1271900	$ 742,380.00	$ 632.00	$ 1,922,192.50	$1,460.00
19	2,925,370	1	$46,712.50	$46,712.50	4	1017520	$ 755,400.00	$ 552.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 1,915,682.50	$1,500.00
20	2,925,370	1	$46,712.50	$46,712.50	9	2289420	$ 1,699,650.00	$ 1,242.00	1	635950	$ 371,190.00	$ 316.00	$ 2,117,552.50	$1,558.00
21	3,052,560	1	$46,712.50	$46,712.50	2	508760	$ 377,700.00	$ 276.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 1,909,172.50	$1,540.00
22	3,052,560	1	$46,712.50	$46,712.50	7	1780660	$ 1,321,950.00	$ 966.00	2	1271900	$ 742,380.00	$ 632.00	$ 2,111,042.50	$1,598.00
23	3,179,750	1	$46,712.50	$46,712.50	5	1271900	$ 944,250.00	$ 690.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 2,104,532.50	$1,638.00
24	3,179,750	1	$46,712.50	$46,712.50	10	2543800	$ 1,888,500.00	$ 1,380.00	1	635950	$ 371,190.00	$ 316.00	$ 2,306,402.50	$1,696.00
25	3,306,940	1	$46,712.50	$46,712.50	3	763140	$ 566,550.00	$ 414.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 2,098,022.50	$1,678.00
26	3,306,940	1	$46,712.50	$46,712.50	8	2035040	$ 1,510,800.00	$ 1,104.00	2	1271900	$ 742,380.00	$ 632.00	$ 2,299,892.50	$1,736.00
27	3,434,130	1	$46,712.50	$46,712.50	1	254380	$ 188,850.00	$ 138.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 2,091,512.50	$1,718.00
28	3,434,130	1	$46,712.50	$46,712.50	6	1526280	$ 1,133,100.00	$ 828.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 2,293,382.50	$1,776.00
29	3,434,130	1	$46,712.50	$46,712.50	11	2798180	$ 2,077,350.00	$ 1,518.00	1	635950	$ 371,190.00	$ 316.00	$ 2,495,252.50	$1,834.00
30	3,561,320	1	$46,712.50	$46,712.50	4	1017520	$ 755,400.00	$ 552.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 2,286,872.50	$1,816.00
31	3,561,320	1	$46,712.50	$46,712.50	9	2289420	$ 1,699,650.00	$ 1,242.00	2	1271900	$ 742,380.00	$ 632.00	$ 2,488,742.50	$1,874.00
32	3,688,510	1	$46,712.50	$46,712.50	2	508760	$ 377,700.00	$ 276.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 2,280,362.50	$1,856.00
33	3,688,510	1	$46,712.50	$46,712.50	7	1780660	$ 1,321,950.00	$ 966.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 2,482,232.50	$1,914.00
34	3,688,510	1	$46,712.50	$46,712.50	12	3052560	$ 2,266,200.00	$ 1,656.00	1	635950	$ 371,190.00	$ 316.00	$ 2,684,102.50	$1,972.00
35	3,815,700	1	$46,712.50	$46,712.50	5	1271900	$ 944,250.00	$ 690.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 2,475,722.50	$1,954.00
36	3,815,700	1	$46,712.50	$46,712.50	10	2543800	$ 1,888,500.00	$ 1,380.00	2	1271900	$ 742,380.00	$ 632.00	$ 2,677,592.50	$2,012.00
37	3,942,890	1	$46,712.50	$46,712.50	3	763140	$ 566,550.00	$ 414.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 2,469,212.50	$1,994.00
38	3,942,890	1	$46,712.50	$46,712.50	8	2035040	$ 1,510,800.00	$ 1,104.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 2,671,082.50	$2,052.00
39	3,942,890	1	$46,712.50	$46,712.50	13	3306940	$ 2,455,050.00	$ 1,794.00	1	635950	$ 371,190.00	$ 316.00	$ 2,872,952.50	$2,110.00
40	4,070,080	1	$46,712.50	$46,712.50	6	1526280	$ 1,133,100.00	$ 828.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 2,664,572.50	$2,092.00
41	4,070,080	1	$46,712.50	$46,712.50	11	2798180	$ 2,077,350.00	$ 1,518.00	2	1271900	$ 742,380.00	$ 632.00	$ 2,866,442.50	$2,150.00
42	4,197,270	1	$46,712.50	$46,712.50	4	1017520	$ 755,400.00	$ 552.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 2,658,062.50	$2,132.00
43	4,197,270	1	$46,712.50	$46,712.50	9	2289420	$ 1,699,650.00	$ 1,242.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 2,859,932.50	$2,190.00
44	4,197,270	1	$46,712.50	$46,712.50	14	3561320	$ 2,643,900.00	$ 1,932.00	1	635950	$ 371,190.00	$ 316.00	$ 3,061,802.50	$2,248.00
45	4,324,460	1	$46,712.50	$46,712.50	7	1780660	$ 1,321,950.00	$ 966.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 2,853,422.50	$2,230.00
46	4,324,460	1	$46,712.50	$46,712.50	12	3052560	$ 2,266,200.00	$ 1,656.00	2	1271900	$ 742,380.00	$ 632.00	$ 3,055,292.50	$2,288.00
47	4,451,650	1	$46,712.50	$46,712.50	5	1271900	$ 944,250.00	$ 690.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 2,846,912.50	$2,270.00
48	4,451,650	1	$46,712.50	$46,712.50	10	2543800	$ 1,888,500.00	$ 1,380.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 3,048,782.50	$2,328.00
49	4,451,650	1	$46,712.50	$46,712.50	15	3815700	$ 2,832,750.00	$ 2,070.00	1	635950	$ 371,190.00	$ 316.00	$ 3,250,652.50	$2,386.00
50	4,578,840	1	$46,712.50	$46,712.50	8	2035040	$ 1,510,800.00	$ 1,104.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 3,042,272.50	$2,368.00
51	4,578,840	1	$46,712.50	$46,712.50	13	3306940	$ 2,455,050.00	$ 1,794.00	2	1271900	$ 742,380.00	$ 632.00	$ 3,244,142.50	$2,426.00
52	4,706,030	1	$46,712.50	$46,712.50	6	1526280	$ 1,133,100.00	$ 828.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 3,035,762.50	$2,408.00
53	4,706,030	1	$46,712.50	$46,712.50	11	2798180	$ 2,077,350.00	$ 1,518.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 3,237,632.50	$2,466.00
54	4,706,030	1	$46,712.50	$46,712.50	16	4070080	$ 3,021,600.00	$ 2,208.00	1	635950	$ 371,190.00	$ 316.00	$ 3,439,502.50	$2,524.00
55	4,833,220	1	$46,712.50	$46,712.50	9	2289420	$ 1,699,650.00	$ 1,242.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 3,231,122.50	$2,506.00
56	4,833,220	1	$46,712.50	$46,712.50	14	3561320	$ 2,643,900.00	$ 1,932.00	2	1271900	$ 742,380.00	$ 632.00	$ 3,432,992.50	$2,564.00
57	4,960,410	1	$46,712.50	$46,712.50	7	1780660	$ 1,321,950.00	$ 966.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 3,224,612.50	$2,546.00
58	4,960,410	1	$46,712.50	$46,712.50	12	3052560	$ 2,266,200.00	$ 1,656.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 3,426,482.50	$2,604.00
59	4,960,410	1	$46,712.50	$46,712.50	17	4324460	$ 3,210,450.00	$ 2,346.00	1	635950	$ 371,190.00	$ 316.00	$ 3,628,352.50	$2,662.00
60	5,087,600	1	$46,712.50	$46,712.50	10	2543800	$ 1,888,500.00	$ 1,380.00	4	2543800	$ 1,484,760.00	$ 1,264.00	$ 3,419,972.50	$2,644.00
61	5,087,600	1	$46,712.50	$46,712.50	15	3815700	$ 2,832,750.00	$ 2,070.00	2	1271900	$ 742,380.00	$ 632.00	$ 3,621,842.50	$2,702.00
62	5,214,790	1	$46,712.50	$46,712.50	8	2035040	$ 1,510,800.00	$ 1,104.00	5	3179750	$ 1,855,950.00	$ 1,580.00	$ 3,413,462.50	$2,684.00
63	5,214,790	1	$46,712.50	$46,712.50	13	3306940	$ 2,455,050.00	$ 1,794.00	3	1907850	$ 1,113,570.00	$ 948.00	$ 3,615,332.50	$2,742.00
64	5,214,790	1	$46,712.50	$46,712.50	18	4578840	$ 3,399,300.00	$ 2,484.00	1	635950	$ 371,190.00	$ 316.00	$ 3,817,202.50	$2,800.00

50000	litres		$ 46,712.50	mob/demob
254380	litres	$ 138.00	day	$188,850.00 mob/demob
635950	litres	$ 316.00	day	$371,190.00 mob/demob

Scenario	Total Litres	Enviro Tank			Small Tank Farm				Large Tank Farm				Combined Pricing / Rates	
		Qty	Price	Cost	Qty	Total Litres	Setup	Day Rate	Qty	Total Litres	Setup	Day Rate	Setup	Day Rate
65	5,341,980	1	$46,712.50	$46,712.50	11	2798180	$2,077,350.00	$1,518.00	4	2543800	$1,484,760.00	$1,264.00	$3,608,822.50	$2,782.00
66	5,341,980	1	$46,712.50	$46,712.50	16	4070080	$3,021,600.00	$2,208.00	2	1271900	$ 742,380.00	$ 632.00	$3,810,692.50	$2,840.00
67	5,469,170	1	$46,712.50	$46,712.50	9	2289420	$1,699,650.00	$1,242.00	5	3179750	$1,855,950.00	$1,580.00	$3,602,312.50	$2,822.00
68	5,469,170	1	$46,712.50	$46,712.50	14	3561320	$2,643,900.00	$1,932.00	3	1907850	$1,113,570.00	$ 948.00	$3,804,182.50	$2,880.00
69	5,469,170	1	$46,712.50	$46,712.50	19	4833220	$3,588,150.00	$2,622.00	1	635950	$ 371,190.00	$ 316.00	$4,006,052.50	$2,938.00
70	5,596,360	1	$46,712.50	$46,712.50	12	3052560	$2,266,200.00	$1,656.00	4	2543800	$1,484,760.00	$1,264.00	$3,797,672.50	$2,920.00
71	5,596,360	1	$46,712.50	$46,712.50	17	4324460	$3,210,450.00	$2,346.00	2	1271900	$ 742,380.00	$ 632.00	$3,999,542.50	$2,978.00
72	5,723,550	1	$46,712.50	$46,712.50	10	2543800	$1,888,500.00	$1,380.00	5	3179750	$1,855,950.00	$1,580.00	$3,791,162.50	$2,960.00
73	5,723,550	1	$46,712.50	$46,712.50	15	3815700	$2,832,750.00	$2,070.00	3	1907850	$1,113,570.00	$ 948.00	$3,993,032.50	$3,018.00
74	5,723,550	1	$46,712.50	$46,712.50	20	5087600	$3,777,000.00	$2,760.00	1	635950	$ 371,190.00	$ 316.00	$4,194,902.50	$3,076.00
75	5,850,740	1	$46,712.50	$46,712.50	13	3306940	$2,455,050.00	$1,794.00	4	2543800	$1,484,760.00	$1,264.00	$3,986,522.50	$3,058.00
76	5,850,740	1	$46,712.50	$46,712.50	18	4578840	$3,399,300.00	$2,484.00	2	1271900	$ 742,380.00	$ 632.00	$4,188,392.50	$3,116.00
77	5,977,930	1	$46,712.50	$46,712.50	11	2798180	$2,077,350.00	$1,518.00	5	3179750	$1,855,950.00	$1,580.00	$3,980,012.50	$3,098.00
78	5,977,930	1	$46,712.50	$46,712.50	16	4070080	$3,021,600.00	$2,208.00	3	1907850	$1,113,570.00	$ 948.00	$4,181,882.50	$3,156.00
79	6,105,120	1	$46,712.50	$46,712.50	14	3561320	$2,643,900.00	$1,932.00	4	2543800	$1,484,760.00	$1,264.00	$4,175,372.50	$3,196.00
80	6,105,120	1	$46,712.50	$46,712.50	19	4833220	$3,588,150.00	$2,622.00	2	1271900	$ 742,380.00	$ 632.00	$4,377,242.50	$3,254.00
81	6,232,310	1	$46,712.50	$46,712.50	12	3052560	$2,266,200.00	$1,656.00	5	3179750	$1,855,950.00	$1,580.00	$4,168,862.50	$3,236.00
82	6,232,310	1	$46,712.50	$46,712.50	17	4324460	$3,210,450.00	$2,346.00	3	1907850	$1,113,570.00	$ 948.00	$4,370,732.50	$3,294.00
83	6,359,500	1	$46,712.50	$46,712.50	15	3815700	$2,832,750.00	$2,070.00	4	2543800	$1,484,760.00	$1,264.00	$4,364,222.50	$3,334.00
84	6,359,500	1	$46,712.50	$46,712.50	20	5087600	$3,777,000.00	$2,760.00	2	1271900	$ 742,380.00	$ 632.00	$4,566,092.50	$3,392.00
85	6,486,690	1	$46,712.50	$46,712.50	13	3306940	$2,455,050.00	$1,794.00	5	3179750	$1,855,950.00	$1,580.00	$4,357,712.50	$3,374.00
86	6,486,690	1	$46,712.50	$46,712.50	18	4578840	$3,399,300.00	$2,484.00	3	1907850	$1,113,570.00	$ 948.00	$4,559,582.50	$3,432.00
87	6,613,880	1	$46,712.50	$46,712.50	16	4070080	$3,021,600.00	$2,208.00	4	2543800	$1,484,760.00	$1,264.00	$4,553,072.50	$3,472.00
88	6,741,070	1	$46,712.50	$46,712.50	14	3561320	$2,643,900.00	$1,932.00	5	3179750	$1,855,950.00	$1,580.00	$4,546,562.50	$3,512.00
89	6,741,070	1	$46,712.50	$46,712.50	19	4833220	$3,588,150.00	$2,622.00	3	1907850	$1,113,570.00	$ 948.00	$4,748,432.50	$3,570.00
90	6,868,260	1	$46,712.50	$46,712.50	17	4324460	$3,210,450.00	$2,346.00	4	2543800	$1,484,760.00	$1,264.00	$4,741,922.50	$3,610.00
91	6,995,450	1	$46,712.50	$46,712.50	15	3815700	$2,832,750.00	$2,070.00	5	3179750	$1,855,950.00	$1,580.00	$4,735,412.50	$3,650.00
92	6,995,450	1	$46,712.50	$46,712.50	20	5087600	$3,777,000.00	$2,760.00	3	1907850	$1,113,570.00	$ 948.00	$4,937,282.50	$3,708.00
93	7,122,640	1	$46,712.50	$46,712.50	18	4578840	$3,399,300.00	$2,484.00	4	2543800	$1,484,760.00	$1,264.00	$4,930,772.50	$3,748.00
94	7,249,830	1	$46,712.50	$46,712.50	16	4070080	$3,021,600.00	$2,208.00	5	3179750	$1,855,950.00	$1,580.00	$4,924,262.50	$3,788.00
95	7,377,020	1	$46,712.50	$46,712.50	19	4833220	$3,588,150.00	$2,622.00	4	2543800	$1,484,760.00	$1,264.00	$5,119,622.50	$3,886.00
96	7,504,210	1	$46,712.50	$46,712.50	17	4324460	$3,210,450.00	$2,346.00	5	3179750	$1,855,950.00	$1,580.00	$5,113,112.50	$3,926.00
97	7,631,400	1	$46,712.50	$46,712.50	20	5087600	$3,777,000.00	$2,760.00	4	2543800	$1,484,760.00	$1,264.00	$5,308,472.50	$4,024.00
98	7,758,590	1	$46,712.50	$46,712.50	18	4578840	$3,399,300.00	$2,484.00	5	3179750	$1,855,950.00	$1,580.00	$5,301,962.50	$4,064.00
99	8,012,970	1	$46,712.50	$46,712.50	19	4833220	$3,588,150.00	$2,622.00	5	3179750	$1,855,950.00	$1,580.00	$5,490,812.50	$4,202.00
100	8,267,350	1	$46,712.50	$46,712.50	20	5087600	$3,777,000.00	$2,760.00	5	3179750	$1,855,950.00	$1,580.00	$5,679,662.50	$4,340.00

CCRP Cost Estimate Table W-25: Conventional Health & Safety Estimate

Creek	Option	Monthly Safety Reporting			On-Site Medic			Field Supplies			Monthly Safety Meetings			Total Cost	Reference / Assumptions
		Qty (months)	Unit Price	Cost	Qty (months)	Unit Price	Cost	Qty (months)	Unit Price	Cost	Qty (months)	Unit Price	Cost		
Clinton	CC1	17.1	$ 1,200	$ 20,497	17.1	$ 12,500	$ 213,513	17.1	$ 100	$ 1,708	17.1	$ 4,270	$ 72,936	**$ 308,654**	Assumes project duration based on haul years (from CC1) plus 2 months on either end of hauling. On-Site medic costs assumed at $150k per year with 20% additional fees from the service provider. http://neuvoo.ca/salary/?job=Field%20Medic https://simplerlife.com/collections/medical-kits-supplies-and-equipment/products/25-patient-deluxe-medical-kit-797-pieces Assumes on-site staff will attend monthly safety meetings to review plans, procedures, safe work practices, incidents etc.
	CC1-A	6.8	$ 1,200	$ 8,156	6.8	$ 12,500	$ 84,956	6.8	$ 100	$ 680	6.8	$ 3,850	$ 26,166	**$ 119,958**	
	CC1-B	7.5	$ 1,200	$ 9,018	7.5	$ 12,500	$ 93,940	7.5	$ 100	$ 752	7.5	$ 3,850	$ 28,933	**$ 132,643**	
	CC2	27.7	$ 1,200	$ 33,265	27.7	$ 12,500	$ 346,513	27.7	$ 100	$ 2,772	27.7	$ 4,270	$118,369	**$ 500,919**	
	CC2-A	9.2	$ 1,200	$ 11,090	9.2	$ 12,500	$ 115,521	9.2	$ 100	$ 924	9.2	$ 4,270	$ 39,462	**$ 166,997**	
	CC2-B	17.8	$ 1,200	$ 21,350	17.8	$ 12,500	$ 222,399	17.8	$ 100	$ 1,779	17.8	$ 4,270	$ 75,972	**$ 321,500**	
	CC3	54.6	$ 1,200	$ 65,462	54.6	$ 12,500	$ 681,894	54.6	$ 100	$ 5,455	54.6	$ 4,270	$232,935	**$ 985,746**	
Wolverine	WC1	6.0	$ 1,200	$ 7,200	6.0	$ 12,500	$ 75,000	6.0	$ 100	$ 600	6.0	$ 1,540	$ 9,240	**$ 92,040**	
	WC2	33.8	$ 1,200	$ 40,523	33.8	$ 12,500	$ 422,117	33.8	$ 100	$ 3,377	33.8	$ 5,810	$196,200	**$ 662,217**	
	WC2-A	9.8	$ 1,200	$ 11,728	9.8	$ 12,500	$ 122,166	9.8	$ 100	$ 977	9.8	$ 5,810	$ 56,783	**$ 191,654**	
	WC3	33.8	$ 1,200	$ 40,523	33.8	$ 12,500	$ 422,117	33.8	$ 100	$ 3,377	33.8	$ 5,810	$196,200	**$ 662,217**	
Porcupine Pit	PP1	-	$ 1,200	$ -	-	$ 12,500	$ -	-	$ 100	$ -	-	$ -	$ -	**$ -**	
	PP2	11.4	$ 1,200	$ 13,665	11.4	$ 12,500	$ 142,344	11.4	$ 100	$ 1,139	11.4	$ 3,640	$ 41,450	**$ 198,598**	
	PP3	13.2	$ 1,200	$ 15,853	13.2	$ 12,500	$ 165,139	13.2	$ 100	$ 1,321	13.2	$ 3,360	$ 44,389	**$ 226,703**	
	PP4	16.3	$ 1,200	$ 19,530	16.3	$ 12,500	$ 203,439	16.3	$ 100	$ 1,628	16.3	$ 6,650	$108,229	**$ 332,826**	
Snowshow & Creek Pits	SCP1	-	$ 1,200	$ -	-	$ 12,500	$ -	-	$ 100	$ -	-	$ -	$ -	**$ -**	
	SCP2	5.6	$ 1,200	$ 6,707	5.6	$ 12,500	$ 69,860	5.6	$ 100	$ 559	5.6	$ 2,240	$ 12,519	**$ 89,645**	
	SCP3	4.8	$ 1,200	$ 5,769	4.8	$ 12,500	$ 60,095	4.8	$ 100	$ 481	4.8	$ 2,240	$ 10,769	**$ 77,114**	
	SCP4	7.3	$ 1,200	$ 8,816	7.3	$ 12,500	$ 91,829	7.3	$ 100	$ 735	7.3	$ 4,760	$ 34,968	**$ 136,347**	

CCRP Cost Estimate Table W-26: Asbestos Abatement Estimate

wood.

				CC1	CC1-A	CC1-B	CC2	CC2-A	CC2-B	CC3	WC1	WC2	WC2-A	WC3	PP1	PP2	PP3	PP4	SCP1	SCP2	SCP3	SCP4
Tyvek Overalls, Respirators and Standard PPE	Project Duration	Months		17.1	6.8	7.5	27.7	9.2	17.8	54.6	6.0	33.8	9.8	33.8	0.0	11.4	13.2	16.3	0.0	5.6	4.8	7.3
	Quantity	Workers		61	55	55	61	61	61	61	22	83	83	83	-	52	48	95	-	32	32	68
	Unit Price	$/worker/month		$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000
		SubTotal		**$2,083,886**	**$ 747,613**	**$ 826,670**	**$3,381,967**	**$1,127,481**	**$2,170,615**	**$6,655,283**	**$ 264,000**	**$5,605,715**	**$1,622,362**	**$5,605,715**	**$ -**	**$1,184,299**	**$1,268,267**	**$3,092,267**	**$ -**	**$ 357,685**	**$ 307,687**	**$ 999,096**
Air Quality Monitoring	Project Duration	Months		17.1	6.8	7.5	27.7	9.2	17.8	54.6	6.0	33.8	9.8	33.8	0.0	11.4	13.2	16.3	0.0	5.6	4.8	7.3
	Quantity	Workers		61	55	55	61	61	61	61	22	83	83	83	-	52	48	95	-	32	32	68
	Unit Price	$/worker/month		$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600
		SubTotal		**$ 625,166**	**$ 224,284**	**$ 248,001**	**$1,014,590**	**$ 338,244**	**$ 651,185**	**$1,996,585**	**$ 79,200**	**$1,681,714**	**$ 486,708**	**$1,681,714**	**$ -**	**$ 355,290**	**$ 380,480**	**$ 927,680**	**$ -**	**$ 107,305**	**$ 92,306**	**$ 299,729**
Equipment Filter	Project Duration	Vehicle.month		171	68	75	277	92	178	546	24	338	98	338	-	46	53	98	-	11	10	29
	Unit Price		No significant cost impact beyond regular H&S	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		SubTotal		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Change and Wash Facility Supply and	Project Duration	Months		17.1	6.8	7.5	27.7	9.2	17.8	54.6	6.0	33.8	9.8	33.8	-	11.4	13.2	16.3	-	5.6	4.8	7.3
	Cost	Camp cost	Camp cost	$ 8,900,390	$ 4,443,992	$ 4,728,729	#####	$ 5,619,328	$ 9,197,926	#####	$ 1,204,500	#####	$ 6,642,981	#####	$ -	$ 4,384,192	$ 4,889,388	$ 8,873,547	$ -	$ 1,735,212	$ 1,492,664	$ 3,266,295
	Unit Price	Percent of Camp cost	20%	$ 1,780,078	$ 888,798	$ 945,746	$ 2,670,722	$ 1,123,866	$ 1,839,585	$ 4,916,623	$ 240,900	$ 3,730,652	$ 1,328,596	$ 3,730,652	$ -							
		SubTotal		**$1,780,078**	**$ 888,798**	**$ 945,746**	**$2,670,722**	**$1,123,866**	**$1,839,585**	**$4,916,623**	**$ 240,900**	**$3,730,652**	**$1,328,596**	**$3,730,652**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Controlled Work Perimeter	Project Duration	Months		17.1	6.8	7.5	27.7	9.2	17.8	54.6	6.0	33.8	9.8	33.8	0.0	11.4	13.2	16.3	0.0	5.6	4.8	7.3
	Unit Price		No significant cost impact beyond regular H&S	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		SubTotal		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Vehicle Washdown Building and Pressure Washers	Quantity	Months		17.1	6.8	7.5	27.7	9.2	17.8	54.6	6.0	33.8	9.8	33.8	0.0	11.4	13.2	16.3	0.0	5.6	4.8	7.3
	Cost	Washdown Building	Escalated from WorleyParsons 2014: 1ea - 80'x120' temprorary building , 300mm SOG, 4ea - 4.5 GPM pressure washers	$ 464,771	$ 464,771	$ 464,771	$ 464,771	$ 464,771	$ 464,771	$ 464,771	Not Applicable	$ 464,771	$ 464,771	$ 464,771								
	Cost	Pressure Washers	Escalated from WorleyParsons 2014	$ 23,796	$ 23,796	$ 23,796	$ 23,796	$ 23,796	$ 23,796	$ 23,796	Not Applicable	$ 23,796	$ 23,796	$ 23,796								
	Cost	Maintenance	4man hours / day	$ 49,439	$ 19,672	$ 21,752	$ 80,236	$ 26,749	$ 51,497	$ 157,894	Not Applicable	$ 97,742	$ 28,288	$ 97,742	$ -	$ 32,960	$ 38,238	$ 47,107	$ -	$ 16,176	$ 13,915	$ 21,263
		SubTotal		**$ 538,006**	**$ 508,239**	**$ 510,319**	**$ 568,803**	**$ 515,316**	**$ 540,064**	**$ 646,461**		**$ 586,309**	**$ 516,855**	**$ 586,309**	**$ -**	**$ 32,960**	**$ 38,238**	**$ 47,107**	**$ -**	**$ 16,176**	**$ 13,915**	**$ 21,263**
		Total		**$5,027,136**	**$2,368,933**	**$2,530,736**	**$7,636,081**	**$3,104,907**	**$5,201,449**	##### #####	**$ 584,100**	##### #####	**$3,954,521**	##### #####	**$ -**	**$1,572,548**	**$1,686,986**	**$4,067,054**	**$ -**	**$ 481,166**	**$ 413,909**	**$1,320,087**

wood.

CCRP Cost Estimate Table W-33: Earth Moving Estimate - Option PP2

	Load and Haul	Load	Haul
Load and Haul Cost	□□□0□□□□□	□□1□□□□□	□□□□□□□□
Rate/tonne	1□□1	0□□□	0□□□
Rate/m³	□□□□	0□□□	1□□□

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	11,404,205	
Caterpillar 385C	Loaders Required =	3.00	3.00
Caterpillar 745C	Trucks Required =	6.97	7.00
	Duration of Remediation =	0.45	years

Waste Material Volume (In Bank) m³	In-Situ Bulk Density t/m³	Waste Material Tonnage t
2,560,000	2.00	5,120,000

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
	Calendar Time (h/year)	**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
	Available Time (h/year)	**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

	Internal (h/shift)		min/day
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay	0.50	60
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,317	255
	Gross Operating Hours (h/year)	**6,129**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1636	269.00
	Net Operating Hours (h/year)	**4,492**	

Adjustment Factors min/cycle

	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1123	
	Adjusted Net Operating Hours (h/year)	**3,369**	

Metric

Loading Productivities and Truck Match

Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.00
Loose Density	t/m³	2.00
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	2.11
Tonnes/Pass	tonne	8.1
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		5.05
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	40.6
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		99%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	1,188
Maximum Productivity	(wet t/NOH)	891
Maximum Productivity	(wet t/GOH)	653
Maximum Productivity	**(dry t/GOH)**	**620**
Maximum Productivity	(wt/yr)	4,001,475
Maximum Productivity	(wt/day)	10,963
Maximum Productivity	**(dt/year)**	**3,801,402**
Maximum Productivity	**(dt/day)**	**10,415**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
	Calendar Time (h/year)	8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
	Available Time (h/year)	**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay	0.50	60
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,317	
	Gross Operating Hours (h/year)	**6,129**	82%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1655	
	Net Operating Hours (h/year)	**4,474**	

Truck Capacity	tonne	40.6
Travel Distance one way	km	0.35
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	2.28
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	6.33
Maximum Truck Loads per hour		9.49
Maximum Productivity	(wet t/NOH)	385
Maximum Productivity	(wet t/GOH)	281
Maximum Productivity	**(dry t/GOH)**	**267**
Maximum Productivity	(wt/year)	1,722,151
Maximum Productivity	(wt/day)	4,718
Maximum Productivity	**(dt/year)**	**1,636,043**
Maximum Productivity	**(dt/day)**	**4,482**

CCRP Cost Estimate Table W-34: Earth Moving Estimate - Option PP3

	Load and Haul	Load	Haul
Load and Haul Cost	□□□□□□□0	□0□□□1□	□□□0□□□
Rate/tonne	1□□□	0□□□	1□1□
Rate/m³	□1□	0□□□	□□□

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	7,987,667	
Caterpillar 385C	Loaders Required =	2.00	2.00
Caterpillar 745C	Trucks Required =	5.84	6.00
	Duration of Remediation =	0.60	years

Waste Material Volume (In Bank) m³	In-Situ Buk Density t/m³	Waste Material Tonnage t
2,400,000	2.00	4,800,000

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

	Internal (h/shift)		min/day
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	195
Gross Operating Hours (h/year)		**6,439**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1719	282.61
Net Operating Hours (h/year)		**4,720**	

Adjustment Factors min/cycle

	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1180	
Adjusted Net Operating Hours (h/year)		**3,540**	

Loading Productivities and Truck Match

		Metric
Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.00
Loose Density	t/m³	2.00
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	2.11
Tonnes/Pass	tonne	8.1
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		5.05
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	40.6
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		99%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	1,188
Maximum Productivity	(wet t/NOH)	891
Maximum Productivity	(wet t/GOH)	653
Maximum Productivity	**(dry t/GOH)**	**620**
Maximum Productivity	(wt/yr)	4,204,035
Maximum Productivity	(wt/day)	11,518
Maximum Productivity	**(dt/year)**	**3,993,833**
Maximum Productivity	**(dt/day)**	**10,942**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	
Gross Operating Hours (h/year)		**6,439**	86%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1739	
Net Operating Hours (h/year)		**4,701**	

Truck Capacity	tonne	40.6
Travel Distance one way	km	0.60
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	3.90
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	7.95
Maximum Truck Loads per hour		7.55
Maximum Productivity	(wet t/NOH)	306
Maximum Productivity	(wet t/GOH)	224
Maximum Productivity	**(dry t/GOH)**	**212**
Maximum Productivity	(wt/year)	1,439,497
Maximum Productivity	(wt/day)	3,944
Maximum Productivity	**(dt/year)**	**1,367,522**
Maximum Productivity	**(dt/day)**	**3,747**

wood.

CCRP Cost Estimate Table W-35: Earth Moving Estimate - Option PP4

		Load and Haul	Load	Haul
Load and Haul Cost	□	□□□1□01□	□ 1□□□□□□□	□□□□□□□□0
Rate/tonne	□	1□□□	□ 0□□□	□ 1□□0
Rate/m³	□	□□0	□ 1□10	□□□0

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	18,433,077		
Caterpillar 385C	Loaders Required =	6.00	6.00	
Caterpillar 745C	Trucks Required =	16.81	17.00	
	Duration of Remediation =	1.36	years	

Waste Material Volume (In Bank) m³	In-Situ Buk Density t/m³	Waste Material Tonnage t
12,500,000	2.00	25,000,000

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

	Internal (h/shift)		min/day
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	195
Gross Operating Hours (h/year)		**6,439**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1719	282.61
Net Operating Hours (h/year)		**4,720**	

Adjustment Factors min/cycle

	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1180	
Adjusted Net Operating Hours (h/year)		**3,540**	

Loading Productivities and Truck Match

		Metric
Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.30
Loose Density	t/m³	1.54
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	1.62
Tonnes/Pass	tonne	6.2
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		6.57
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	31.2
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		76%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	914
Maximum Productivity	(wet t/NOH)	685
Maximum Productivity	(wet t/GOH)	502
Maximum Productivity	**(dry t/GOH)**	**477**
Maximum Productivity	(wt/yr)	3,233,873
Maximum Productivity	(wt/day)	8,860
Maximum Productivity	**(dt/year)**	**3,072,179**
Maximum Productivity	**(dt/day)**	**8,417**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	
Gross Operating Hours (h/year)		**6,439**	86%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1739	
Net Operating Hours (h/year)		**4,701**	

Truck Capacity	tonne	31.2
Travel Distance one way	km	0.55
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	3.58
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	7.63
Maximum Truck Loads per hour		7.87
Maximum Productivity	(wet t/NOH)	246
Maximum Productivity	(wet t/GOH)	179
Maximum Productivity	**(dry t/GOH)**	**170**
Maximum Productivity	(wt/year)	1,154,502
Maximum Productivity	(wt/day)	3,163
Maximum Productivity	**(dt/year)**	**1,096,777**
Maximum Productivity	**(dt/day)**	**3,005**

CCRP Cost Estimate Table W-37: Earth Moving Estimate - Option SCP2

	Load and Haul	Load	Haul
Load and Haul Cost	1□□□□□□□	□□□1□□	□ 1□□0□□□0
Rate/tonne	□□□□	0□□□	1□□□
Rate/m³	□0□□	1□10	□□□□

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	3,072,179		
Caterpillar 385C	Loaders Required =	1.00	1.00	
Caterpillar 745C	Trucks Required =	3.28	4.00	
	Duration of Remediation =	0.22	years	

Waste Material Volume (In Bank) m³	In-Situ Buk Density t/m³	Waste Material Tonnage t
331,388	2.00	662,777

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

	Internal (h/shift)		min/day
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	195
Gross Operating Hours (h/year)		**6,439**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1719	282.61
Net Operating Hours (h/year)		**4,720**	

Adjustment Factors min/cycle

	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1180	
Adjusted Net Operating Hours (h/year)		**3,540**	

Loading Productivities and Truck Match

		Metric
Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.30
Loose Density	t/m³	1.54
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	1.62
Tonnes/Pass	tonne	6.2
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		6.57
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	31.2
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		76%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	914
Maximum Productivity	(wet t/NOH)	685
Maximum Productivity	(wet t/GOH)	502
Maximum Productivity	**(dry t/GOH)**	**477**
Maximum Productivity	(wt/yr)	3,233,873
Maximum Productivity	(wt/day)	8,860
Maximum Productivity	**(dt/year)**	**3,072,179**
Maximum Productivity	**(dt/day)**	**8,417**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	
Gross Operating Hours (h/year)		**6,439**	86%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1739	
Net Operating Hours (h/year)		**4,701**	

Truck Capacity	tonne	31.2
Travel Distance one way	km	0.75
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	4.88
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	8.93
Maximum Truck Loads per hour		6.72
Maximum Productivity	(wet t/NOH)	210
Maximum Productivity	(wet t/GOH)	153
Maximum Productivity	**(dry t/GOH)**	**146**
Maximum Productivity	(wt/year)	986,339
Maximum Productivity	(wt/day)	2,702
Maximum Productivity	**(dt/year)**	**937,022**
Maximum Productivity	**(dt/day)**	**2,567**

CCRP Cost Estimate Table W-38: Earth Moving Estimate - Option SCP3

	Load and Haul	Load	Haul
Load and Haul Cost	1□1□□□□□	□□□□□□□	□1□□□□
Rate/tonne	□□□□	0□□□	1□□□
Rate/m³	□0□□	1□10	□□□□

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	3,072,179		
Caterpillar 385C	Loaders Required =	1.00	1.00	
Caterpillar 745C	Trucks Required =	3.28	4.00	
	Duration of Remediation =	0.15	years	

Waste Material Volume (In Bank) m³	In-Situ Buk Density t/m³	Waste Material Tonnage t
231,388	2.00	462,777

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
	Calendar Time (h/year)	**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
	Available Time (h/year)	**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

			min/day
	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	195
	Gross Operating Hours (h/year)	**6,439**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1719	282.61
	Net Operating Hours (h/year)	**4,720**	

Adjustment Factors

			min/cycle
	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1180	
	Adjusted Net Operating Hours (h/year)	**3,540**	

Metric

Loading Productivities and Truck Match

Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.30
Loose Density	t/m³	1.54
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	1.62
Tonnes/Pass	tonne	6.2
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		6.57
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	31.2
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		76%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	914
Maximum Productivity	(wet t/NOH)	685
Maximum Productivity	(wet t/GOH)	502
Maximum Productivity	**(dry t/GOH)**	**477**
Maximum Productivity	(wt/yr)	3,233,873
Maximum Productivity	(wt/day)	8,860
Maximum Productivity	**(dt/year)**	**3,072,179**
Maximum Productivity	**(dt/day)**	**8,417**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
	Calendar Time (h/year)	8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
	Available Time (h/year)	**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	
	Gross Operating Hours (h/year)	**6,439**	86%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1739	
	Net Operating Hours (h/year)	**4,701**	

Truck Capacity	tonne	31.2
Travel Distance one way	km	0.75
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	4.88
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	8.93
Maximum Truck Loads per hour		6.72
Maximum Productivity	(wet t/NOH)	210
Maximum Productivity	(wet t/GOH)	153
Maximum Productivity	**(dry t/GOH)**	**146**
Maximum Productivity	(wt/year)	986,339
Maximum Productivity	(wt/day)	2,702
Maximum Productivity	**(dt/year)**	**937,022**
Maximum Productivity	**(dt/day)**	**2,567**

CCRP Cost Estimate Table W-39: Earth Moving Estimate - Option SCP4

		Load and Haul		Load		Haul
Load and Haul Cost	□	1□□0□□□□	□	□1□□0□0	□	□1□0□□□□
Rate/tonne	□	□1□	□	0□□□	□	1□1
Rate/m³	□	□□1	□	1□10	□	□□1

Note: Reductions in base materials management productivities that are related to asbestos abatement have been applied to this estimate (equipment utilization reduced by 10% to calculate net operating hours).

Production Target	Tonnes/year =	12,288,718		
Caterpillar 385C	Loaders Required =	4.00	4.00	
Caterpillar 745C	Trucks Required =	12.64	13.00	
	Duration of Remediation =	0.61	years	

Waste Material Volume (In Bank) m³	In-Situ Buk Density t/m³	Waste Material Tonnage t
3,761,521	2.00	7,523,042
1		

LOADER HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		**8,760**	

Available Time = Calendar Time - Down Time

	Availability	85.0%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	0.85

Gross Operating Time = Available Time - Operating Standby

Operating Standby

			min/day
	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	195
Gross Operating Hours (h/year)		**6,439**	

Net Operating Time Gross Operating Time - Operating Delay

	Utilization	73%	
	Operating Delay (h/year)	1719	282.61
Net Operating Hours (h/year)		**4,720**	

Adjustment Factors

			min/cycle
	Truck availability to shovel	75%	0.68
	Shovel Wait for Truck	1180	
Adjusted Net Operating Hours (h/year)		**3,540**	

Loading Productivities and Truck Match

		Metric
Loader		Caterpillar 385C
Truck		Caterpillar 745C
Bucket Capacity	m³	4.6
Bucket Capacity	tonne	8.3
Truck Capacity	m³	73.8
Truck Capacity	tonne	41.0
Insitu Bulk Density	t/m³	2.00
Bulk Factor		1.30
Loose Density	t/m³	1.54
Moisture	%	5.0%
Fill Factor		0.84
Effective Bucket Capacity	m³	3.85
Wet/Loose Density	t/m³	1.62
Tonnes/Pass	tonne	6.2
Theoretical Passes (Volume)		19.14
Theoretical Passes (Weight)		6.57
Actual Passes		5
Truck Load	m³	19.3
Truck Load	tonne	31.2
Truck Fill % (Volume)		26%
Truck Fill % (Weight)		76%
Loader Cycle Time	seconds	22
Loader Spot Time	seconds	35
Load Time per Truck	seconds	123
Maximum Truck Loads per hour		29.27
Maximum Productivity	(wet t/adj. NOH)	914
Maximum Productivity	(wet t/NOH)	685
Maximum Productivity	(wet t/GOH)	502
Maximum Productivity	**(dry t/GOH)**	**477**
Maximum Productivity	(wt/yr)	3,233,873
Maximum Productivity	(wt/day)	8,860
Maximum Productivity	**(dt/year)**	**3,072,179**
Maximum Productivity	**(dt/day)**	**8,417**

TRUCK HOURS

Calendar Time

	Days	365	
	Shifts per day	2	
	Shift Length	12	
Calendar Time (h/year)		8,760	

Available Time

	Availability	85%	
	Down Time (h/year)	1,314	
Available Time (h/year)		**7,446**	

Gross Operating Time

Operating Standby

	Internal (h/shift)		
	Lunch & Breaks	1.00	120
	Meeting	0.04	5
	Shift Change	0.17	20
No Blast =>	Blast Delay		-
	Fueling	0.25	30
	Operator Inspection		-
	External (h/year)		
	Industrial		-
	Weather	120	20
	No Power		-
	Operating Standby (h/year)	1,007	
Gross Operating Hours (h/year)		**6,439**	86%

Net Operating Time

	Utilization	73%	
	Operating Delay (h/year)	1739	
Net Operating Hours (h/year)		**4,701**	

Truck Capacity	tonne	31.2
Travel Distance one way	km	0.70
Loaded	km/h	12.00
Empty Return	km/h	40.00
Truck haul cycle time	min	4.55
Load Time	minutes	2.05
Queue Time	minutes	1.00
Dump Time	minutes	1.00
Total Cycle Time	minutes	8.60
Maximum Truck Loads per hour		6.98
Maximum Productivity	(wet t/NOH)	218
Maximum Productivity	(wet t/GOH)	159
Maximum Productivity	**(dry t/GOH)**	**151**
Maximum Productivity	(wt/year)	1,023,613
Maximum Productivity	(wt/day)	2,804
Maximum Productivity	**(dt/year)**	**972,433**
Maximum Productivity	**(dt/day)**	**2,664**

25

Option	Activity	Quantity Derivation	Quantity	Unit	Unit Price	Pricing Derivation	Unit Price Geographic Correction Factor	Total Cost	Staff Count	Blasting Duration (years)
PP1	Blasting (including ramp and pad construction, drilling, blasting & local spoil management)		-	m3 (bank) of rock removed			1	$ -		
PP2			2,400,000	m3 (bank) of rock removed	$ 25.00	Wood Estimate	1	$ 60,000,000	10	0.5
PP3			2,400,000	m3 (bank) of rock removed	$ 25.00	Wood Estimate	1	$ 60,000,000	10	0.5
PP4			-	m3 (bank) of rock removed			1	$ -		
SCP1	Blasting (including ramp and pad construction, drilling, blasting & local spoil management)		-	m3 (bank) of rock removed			1	$ -		
SCP2			128,955	m3 (bank) of rock removed	$ 40.00	Wood Estimate	1	$ 5,158,200	5	0.25
SCP3			128,955	m3 (bank) of rock removed	$ 40.00	Wood Estimate	1	$ 5,158,200	5	0.25
SCP4			-	m3 (bank) of rock removed			1	$ -		

CCRP Cost Estimate Table W-45: Dozing Equipment Estimate

2019 Option	Creek	Dump Material or Tailings Removal Volume (m3)1	Blasting Volume (m3)	Blasting Spoil Requiring Grading/Contouring (m3)	Blasting Spoil Excess Requiring Truck Shovel Movements (m3)	Shovel Support	Placement Support	Compaction Support	Shovel Support Volume (m3)	Placing Volume (m3)	Selected Dozer	Dozer Count	Total Hours	Compactor Rate/hr	Dozer Rate/hr	Total Cost
CC1	Clinton	4,373,000				1	1	1	4,373,000	4,373,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	10,599	$ 170	$ 320	$ 8,585,013
CC1-A	Clinton	870,000				1	1	2	870,000	870,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	3	4,217	$ 170	$ 320	$ 5,482,379
CC1-B	Clinton	962,000				1	1	2	962,000	962,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	3	4,663	$ 170	$ 320	$ 6,062,125
CC2	Clinton	7,097,000				1	1	1	7,097,000	7,097,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	17,201	$ 170	$ 320	$ 13,932,732
CC2-A	Clinton	2,366,000				1	1	1	2,366,000	2,366,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	5,734	$ 170	$ 320	$ 4,644,898
CC2-B	Clinton	4,555,000				1	1	1	4,555,000	4,555,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	11,040	$ 170	$ 320	$ 8,942,313
CC3	Clinton	13,966,000				1	1	1	13,966,000	13,966,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	33,849	$ 170	$ 320	$ 27,417,857
WC1	Wolverin	NA					1				Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	1	2,190		$ 350	$ 766,500
WC2	Wolverin	4,312,000				1	2	1	2,660,000	8,624,000	Caterpillar - D10	3	10,477	$ 170	$ 470	$ 16,553,575
WC2-A	Wolverin	2,225,000				1	1	2	2,225,000	2,225,000	Caterpillar - D10	2	6,064	$ 170	$ 470	$ 7,762,316
WC3	Wolverin	7,688,000				1	2	1	7,688,000	7,688,000	Caterpillar - D10	3	20,954	$ 170	$ 470	$ 33,107,150
PP1	Porcupin e Pit		-						-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	0	-	$ 170	$ 320	$ -
PP2	Porcupin e Pit	-	2,400,000	-	2,500,000	2	1	1	-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	3	3,343	$ 170	$ 320	$ 3,777,517
PP3	Porcupin e Pit					2	1	1	-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	3	4,474	$ 170	$ 320	$ 5,056,183
PP4	Porcupin e Pit	12,500,000	-			2	4	4	25,000,000	50,000,000	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	6	10,099	$ 170	$ 320	$ 26,256,604
SCP1	Snowsh oe & Creek	-	-						-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	0	-	$ 170	$ 320	$ -
SCP2	Snowsh oe & Creek	-	128,955			1	1	1	-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	1,606	$ 170	$ 320	$ 1,301,154
SCP3	Snowsh oe & Creek	-	128,955			1	1	1	-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	2	1,122	$ 170	$ 320	$ 908,517
SCP4	Snowsh oe & Creek	-	-			2	2	2	-	-	Caterpillar - D8K Angle Blade, Tilt Blade, Ripper	4	4,558	$ 170	$ 320	$ 7,384,566

CCRP Cost Estimate Table W-46: Grading and Road Maintenance Equipment

Option	Creek	Estimated Waste Material Removal Volume (m3)	Blasting Volume (m3)	Blasting Spoil Requiring Grading/Contouring (m3)	Blasting Spoil Excess Requiring Truck Shovel Movements (m3)	Selected Grader	Grader Count	Total Hours	Rate/hr	Total Cost
CC1	Clinton	4,373,000				Cat 12H	2	10599	$ 192	$ 4,069,932
CC1-A	Clinton	870,000				Cat 12H	2	4217	$ 192	$ 1,619,410
CC1-B	Clinton	962,000				Cat 12H	2	4663	$ 192	$ 1,790,658
CC2	Clinton	7,097,000				Cat 12H	2	17201	$ 192	$ 6,605,147
CC2-A	Clinton	2,366,000				Cat 12H	2	5734	$ 192	$ 2,202,026
CC2-B	Clinton	4,555,000				Cat 12H	2	11040	$ 192	$ 4,239,319
CC3	Clinton	13,966,000				Cat 12H	2	33849	$ 192	$ 12,998,095
WC1	Wolverine	NA				Cat 12H	1	2190	$ 192	$ 420,480
WC2	Wolverine	4,312,000				Cat 12H	2	12326	$ 192	$ 4,733,114
WC2-A	Wolverine	2,225,000				Cat 12H	2	3567	$ 192	$ 1,369,820
WC3	Wolverine	7,688,000				Cat 12H	2	20954	$ 192	$ 8,046,295
PP1	Porcupine Pit	-				Cat 12H		0	$ 192	$ -
PP2	Porcupine Pit		2,400,000	-	2,500,000	Cat 12H	1	3343	$ 192	$ 641,844
PP3	Porcupine Pit	-				Cat 12H	1	4474	$ 192	$ 859,104
PP4	Porcupine Pit	12,500,000				Cat 12H	2	10099	$ 192	$ 3,877,899
SCP1	Snowshoe & Creek Pits	-				Cat 12H		0	$ 192	$ -
SCP2	Snowshoe & Creek Pits	-				Cat 12H	1	1606	$ 192	$ 308,422
SCP3	Snowshoe & Creek Pits	-				Cat 12H	1	1122	$ 192	$ 215,352
SCP4	Snowshoe & Creek Pits	-				Cat 12H	2	4558	$ 192	$ 1,750,416

CCRP Cost Estimate Table W-54b: Annual Post Closure Costs - Pits

Post Closure Provisions		PP1			PP2			PP3			PP4			SCP1			SCP2			SCP3			SCP4		
		Curren	Cost	Comments/Rationales	Curr	Cost	Comments/Rationales	Curr	Cost	Comments/Rationales	Cu	Cost	Comments/Rationales	Cu	Cost	Comments/Rationales	Cu	Cost	Comments/Rationales	Cu	Cost	Comments/Rationales	Cu	Cost	Comments/Rationales
Baseline																									
Care & General Maintenance	Inspections		$20,000	Annual Inspection & Report		$20,000	Annual Inspection & Report		$20,000	Annual Inspection & Report		$20,000	Annual Inspection & Report		$15,000	Annual Inspection & Report		$15,000	Annual Inspection & Report		$15,000	Annual Inspection & Report		$15,000	Annual Inspection & Report
	Access		$5,000	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$3,000	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance
Monitoring	Water Quality		$0	Assumes access restrictions preclude testing of "Lake" water quality		$0	No surface waters requiring monitoring		$5,000	Annual Monitoring of "Lake" water quality		$0	No surface waters requiring monitoring		$0	Assumes access restrictions preclude testing of "Lake" water quality		$4,000	Annual Monitoring of "Lake" water quality		$0	No surface waters requiring monitoring		$0	No surface waters requiring monitoring
	Hydrotechnics		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report
	Geotechnics		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report
Partner Communications/Consultations			$5,000	Ongoing requirement to communicate need for access controls		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing requirement to communicate need for access controls		$2,000	Ongoing demands will decline as post closure protocols become routine		$2,000	Ongoing demands will decline as post closure protocols become routine		$2,000	Ongoing demands will decline as post closure protocols become routine
Owner's Project Management & Admin			$5,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$3,000	Ongoing demands will decline as post closure protocols become routine		$2,000	Ongoing demands will decline as post closure protocols become routine		$2,000	Ongoing demands will decline as post closure protocols become routine		$2,000	Ongoing demands will decline as post closure protocols become routine
Totals			$35,000			$26,000			$31,000			$26,000			$24,000			$23,000			$19,000			$19,000	
Totals (Rounded)			##########			##########			##########			##########			##########			##########			##########			##########	
Time Limited Premiums (i.e. for the 10 years following completion of closure activity)																									
Care & General Maintenance	Inspections													########				$0							
	Access													########				$0							
Monitoring	Water Quality													########				$0							
	Hydrotechnics																								
Partner														########				$0							
Owner's Project Management &														########				$0							
Totals			**$0**									**$0**			**$0**			**$0**			**$0**				
Totals (Rounded)			**$0**									**$0**			**$0**			**$0**			**$0**				
						$0	No surface waters requiring monitoring																		

CCRP Cost Estimate Table W-54b: Annual Post Closure Costs - Pits

Post Closure Provisions (NPV)		PP1			PP2			PP3			PP4			SCP1			SCP2			SCP3			SCP4		
		% Curren	Cost	Comments/Rationales	% Curr	Cost	Comments/Rationales	% Curr	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales
Baseline																									
Care & General Maintenance	Inspections	100%	##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report	########	##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report
	Access	100%	##########	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance	########	##########	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance
Monitoring	Water Qualit	25%	$0	Assumes access restrictions preclude testing of "Lake" water quality		$0	No surface waters requiring monitoring		##########	Annual Monitoring of "Lake" water quality		$0	No surface waters requiring monitoring	########	$0	Assumes access restrictions preclude testing of "Lake" water quality		##########	Annual Monitoring of "Lake" water quality		$0	No surface waters requiring monitoring		$0	No surface waters requiring monitoring
	Hydrotechnic	25%	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report	########	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report
	Geotechnics	100%	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report	########	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report
Partner Communications/Consultations		25%	##########	Ongoing requirement to communicate need for access controls		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine	########	##########	Ongoing requirement to communicate need for access controls		$86,197	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine
Owner's Project Management & Admin		25%	##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine	########	##########	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine
Totals			##########			##########			##########			##########			##########			##########			##########			##########	
Totals (Rounded)			##########			##########			##########			##########			##########			##########			##########			##########	
Time Limited Premiums (i.e. for the 10 years following completion of closure activity)																									
Care & General Maintenance	Inspections		$0									$0			$0			$0			$0			$0	
	Access		$0									$0			$0			$0			$0			$0	
Monitoring	Water Quality		$0									$0			$0			$0			$0			$0	
	Hydrotechnics		$0									$0			$0			$0			$0			$0	
Partner			$0									$0			$0			$0			$0			$0	
Owner's Project Management &			$0									$0			$0			$0			$0			$0	
Totals			**$0**									**$0**			**$0**			**$0**			**$0**				
Totals (Rounded)			**$0**			**$0**			**$0**			**$0**			**$0**			**$0**			**$0**			**$0**	

Post Closure Provisions (NPV)		PP1			PP2			PP3			PP4			SCP1			SCP2			SCP3			SCP4		
		% Curren	Cost	Comments/Rationales	% Curr	Cost	Comments/Rationales	% Curr	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales	% Cu	Cost	Comments/Rationales
Baseline And Time																									
Care & General Maintenance	Inspections	100%	##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report		##########	Annual Inspection & Report	########	##########	Annual Inspection & Report		##########	Annual Inspection & Report	########	##########	Annual Inspection & Report	########	##########	Annual Inspection & Report
	Access	100%	##########	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance		$0	No access restrictions requiring maintenance	########	##########	Maintenance of signs, fences, other access controls		$0	No access restrictions requiring maintenance	########	$0	No access restrictions requiring maintenance	########	$0	No access restrictions requiring maintenance
Monitoring	Water Qualit	25%	$0	Assumes access restrictions precludes testing of "Lake" water quality		$0	No surface waters requiring monitoring		##########	Annual Monitoring of "Lake" water quality		$0	No surface waters requiring monitoring	########	$0	Assumes access restrictions precludes testing of "Lake" water quality		##########	Annual Monitoring of "Lake" water quality	########	$0	No surface waters requiring monitoring	########	$0	No surface waters requiring monitoring
	Hydrotechnic	25%	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report	########	$0	Included in general inspection report		$0	Included in general inspection report	########	$0	Included in general inspection report	########	$0	Included in general inspection report
	Geotechnics	100%	$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report		$0	Included in general inspection report	########	$0	Included in general inspection report		$0	Included in general inspection report	0%	$0	Included in general inspection report	########	$0	Included in general inspection report
Partner Communications/Consultations		25%	##########	Ongoing requirement to communicate need for access controls		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine	########	##########	Ongoing requirement to communicate need for access controls		$86,197	Ongoing demands will decline as post closure protocols become routine	########	$86,197	Ongoing demands will decline as post closure protocols become routine	########	$86,197	Ongoing demands will decline as post closure protocols become routine
Owner's Project Management & Admin		25%	##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine		##########	Ongoing demands will decline as post closure protocols become routine	########	##########	Ongoing demands will decline as post closure protocols become routine		$86,197	Ongoing demands will decline as post closure protocols become routine	########	$86,197	Ongoing demands will decline as post closure protocols become routine	########	$86,197	Ongoing demands will decline as post closure protocols become routine
Totals			##########			##########			##########			##########			##########			##########			##########			##########	
Totals (Rounded)			##########			##########			##########			##########			##########			##########			##########			##########	

CCRP Cost Estimate Table W-55: CCRP - Major, Supplementary Investigative Costs by Option

Investigative Requirement	Hrs/Test Holes	Unit Cost ($/Hr or TH)	Cost	PP1	PP2	PP3	PP4	SCP1	SCP2	SCP3	SCP4
ERT											
Equipment Purchase			$50,000								
Field Time	300	200	$60,000								
Interpretation / Reporting Time	200	200	$40,000								
		Total	**$150,000**								
Dump Foundation Characterization	50	$110,000	$5,500,000								
Ice Rich PF Delineation											
CC1 Spillway Bedrock Data	30	$110,000	$3,300,000								
Pump Tests	25	$20,000	$500,000								
WC2 Buttress / Dam Investigation	20	$110,000	$2,200,000								
Rock Mechanics Investigations		Lump Sum		$500,000	$600,000	$600,000	$600,000	$300,000	$400,000	$400,000	$400,000
			Totals	**$500,000**	**$600,000**	**$600,000**	**$600,000**	**$300,000**	**$400,000**	**$400,000**	**$400,000**

Derived from 2018 Investigative Costs

Drilling/Sub Costs (i.e. TA 10)	$1,615,000
Wood Super Costs (i.e. TA 11)	$700,000
Total Cost	$2,315,000
Test Holes Completed	21
Unit Cost /TH	$110,238

CCRP Cost Estimate Table W-56: 2019 Estimate Factors and Assumptions

Soil Density

M□teri□l	Den□it□ □t□m□□	Re□eren□e
Waste Dump	2	Wood. June 11, 2019 email correspondence.
Tailings	2	Wood. June 11, 2019 email correspondence.

EPCM and Contingency

EPCM	Contin□en□□	In□ident□l Tem□or□r□ □□□ilitie□ □nd Control□
10%	25%	3%

General

□in□n□i□l Item	□□l□e	Re□eren□e
Discount Rate	2.00%	Bank of Canada. 2019. Yield Curves for Zero-Coupon Bonds. Downloaded on May 16, 2019 from https://bankofcanada.ca/rates/interest-rates/bond-yield-curves/.
Life Cycle Duration (years)	100	Post Closure Activities following completion of closure activity.
Life Cycle Duration (years)	10	Post Closure Activity Time Limited Premiums (i.e. for the 10 years following completion of closure activity).
Base Year Applied for Discount Rate	January 1, 2019	Wood. May 2019. Estimate Basis Memorandum.
Currency	Q2 2019 Canadian dollars	Wood. May 2019. Estimate Basis Memorandum.
Land rights-of-way have been established for construction		Wood. May 2019. Estimate Basis Memorandum.
All major works will be performed by a workforce from Whitehorse.		Wood. May 2019. Estimate Basis Memorandum.
A camp will be established at the Clinton Creek site to accommodate all on-site personnel. All camp facilities will be brought in from Edmonton, AB		Wood. May 2019. Estimate Basis Memorandum.
Sufficient site preparations (clearing, grubbing, topsoil stripping and subgrade preparation) will have been completed previously at the Clinton Creek site to accommodate camp and site facilities		Wood. May 2019. Estimate Basis Memorandum.
All on-site personnel will be on a “two weeks on, two weeks off” rotation schedule		Wood. May 2019. Estimate Basis Memorandum.
One grader will be allocated full-time for road maintenance during construction in the summer (May to September)		Wood. May 2019. Estimate Basis Memorandum.
Two graders and one dozer will be allocated full-time for snow removal and road maintenance during construction in the winter (October to April)		Wood. May 2019. Estimate Basis Memorandum.
diesel fuel costs $1.36/L plus the cost of transportation from Dawson City to site		Wood. May 2019. Estimate Basis Memorandum.
All heavy equipment, camps, facilities and materials will be compatible with transport across: - the Yukon River via the existing ferry or ice bridge; and ♦ the Fortymile River via the existing bridge.		Wood. May 2019. Estimate Basis Memorandum.

Table P3 - Estimated Costs for Pit Closure Options

Option	MOB and Demob		Temporary Facilities and Controls (TF&C)											Civil Works							Mechanical Works			Post Closure Care and Maintenance						Extraordinary Field Investigations	EPCM	Contingency	Total	Total (Rounded)
				Site Access		On-Site Haul Roads		Fuel/Power Supply		H&S Controls				Materials Management				Flow Conveyance and Erosion Control																	
	Personnel	Equipment	Camp	Roads	Bridges	Roads	Bridges	Fuel Storage and Delivery	General Site Power	General Site H&S	Asbestos Abatement Controls	Incidental Temporary Facilities and Controls	Monitoring	Earthmoving Load & Haul	Blasting & Spoil Mgmt	Support Equipment - Dozers	Support Equipment - Graders	Spillway	Erosion Control	Sediment Pond	Ground Thawing	Lake Drawdowns	Blast Densification	Care & General Maintenance	Repair & Remediation	Monitoring	Partner Communications/Consultations	Owner's Project Management & Admin	Sediment Pond Cleanouts					
CC1	$1,261,353	$77,097	$8,900,390	$3,068,851	$1,203,770	$996,180	$891,675	$2,534,389	$2,199,949	$308,654	$5,027,136	$6,261,660	$1,508,825	$19,923,602		$8,585,013	$4,069,932	$35,592,092		$4,599,144	$77,705,000	$638,841		$13,360,489		$14,653,440	$1,077,459	$538,729		$9,450,000	$21,498,367.24	$61,483,010	**$307,415,050**	**$310,000,000**
CC1-A	$466,449	$63,080	$4,443,992	$1,221,084	$1,203,770	$198,188	$891,675	$1,571,878	$1,138,250	$119,958	$2,368,933	$2,580,905	$600,356	$3,534,073		$5,482,379	$1,619,410	$12,835,376		$4,599,144		$592,498	$4,110,000	$13,360,489	$9,339,561	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,861,107.58	$26,730,546	**$133,652,729**	**$130,000,000**
CC1-B	$515,774	$63,080	$4,728,729	$1,350,210	$1,203,770	$219,146	$891,675	$1,594,744	$1,212,444	$132,643	$2,530,736	$2,521,510	$663,841	$3,907,791		$6,062,125	$1,790,658	$12,835,376		$4,599,144		$592,498		$13,360,489	$9,525,836	$14,653,440	$1,077,459	$538,729		$9,450,000	$8,657,184.84	$26,169,758	**$130,848,792**	**$130,000,000**
CC2	$2,047,067	$77,097	$13,353,611	$4,980,480	$1,403,770	$1,616,714	$891,675	$2,953,100	$3,298,342	$500,919	$7,636,081	$4,003,804	$2,448,692	$32,334,280		$13,932,732	$6,605,147	$12,399,214		$4,599,144		$682,515		$4,732,423		$15,014,097	$1,302,023	$651,012		$6,150,000	$13,746,394	$39,340,083	**$196,700,417**	**$197,000,000**
CC2-A	$682,452	$77,097	$5,619,328	$1,660,394	$1,203,770	$538,981	$891,675	$2,104,957	$1,390,671	$166,997	$3,104,907	$3,015,431	$816,346	$10,779,612		$4,644,898	$2,202,026	$12,399,214		$4,599,144		$638,841	$12,600,000	$4,732,423	$12,693,491	$15,014,097	$1,302,023	$651,012		$6,150,000	$10,352,979	$30,008,191	**$150,040,955**	**$150,000,000**
CC2-B	$1,313,849	$77,097	$9,197,926	$3,196,574	$1,403,770	$1,037,640	$891,675	$2,448,771	$2,273,336	$321,500	$5,201,449	$3,596,127	$1,571,620	$20,752,803		$8,942,313	$4,239,319	$12,399,214		$4,599,144		$638,841		$4,732,423	$17,664,493	$15,014,097	$1,302,023	$651,012		$6,150,000	$12,346,702	$35,490,930	**$177,454,650**	**$180,000,000**
CC3	$4,028,369	$77,097	$24,583,116	$9,800,955	$1,803,770	$3,181,489	$891,675	$4,008,948	$6,068,115	$985,746	$14,214,952	$5,979,584	$4,818,716	$63,629,781		$27,417,857	$12,998,095			$2,378,134		$696,795		$3,396,374		$9,799,197	$871,040	$435,520	$3,233,731	$6,150,000	$20,529,906	$57,994,740	**$289,973,701**	**$290,000,000**
WC1	$239,714	$23,364	$1,204,500	$1,077,986				$87,370	$459,199	$92,040	$584,100	$1,040,997	$170,000			$766,500	$420,480			$4,599,144				$8,188,687		$11,205,571	$1,077,459	$538,729	$3,965,048		$3,574,089	$9,828,744	**$49,143,722**	**$50,000,000**
WC2	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,403,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$6,333,182	$956,799	$108,657,228		$16,553,575	$4,733,114	$5,496,524		$4,599,144				$8,188,687		$5,861,376	$646,475	$323,238		$2,350,000	$21,743,923	$60,383,289	**$301,916,446**	**$300,000,000**
WC2-A	$908,564	$126,159	$6,642,981	$1,755,906	$1,203,770	$4,598,312	$891,675	$2,366,968	$1,445,550	$191,654	$3,954,521	$2,458,629	$276,909	$21,775,499		$7,762,316	$1,369,820	$764,511		$4,599,144				$8,188,687	$6,300,254	$5,861,376	$646,475	$323,238		$150,000	$8,441,292	$23,251,052	**$116,255,261**	**$120,000,000**
WC3	$3,139,345	$126,159	$18,653,260	$6,067,149	$1,603,770	$4,598,312	$891,675	$4,020,890	$3,922,725	$662,217	$11,604,390	$5,475,038	$956,799	$67,163,988		$33,107,150	$8,046,295		$7,500,000	$4,599,144				$2,081,649		$2,449,799	$871,040	$435,520			$18,797,631	$51,693,486	**$258,467,430**	**$260,000,000**
PP1												$45,253												$1,077,459			$215,492	$215,492		$500,000	$155,370	$552,266	**$2,761,331**	**$2,800,000**
PP2	$751,845	$72,425	$4,384,192					$448,127		$198,598	$1,572,548	$2,399,785	$322,645	$6,702,524	$60,000,000	$3,777,517	$641,844							$861,967			$129,295	$129,295		$600,000	$8,239,261	$22,807,967	**$114,039,834**	**$114,000,000**
PP3	$826,324	$63,080	$4,889,388					$519,891		$226,703	$1,686,986	$2,500,121	$374,315	$7,499,360	$60,000,000	$5,056,183	$859,104							$861,967		$215,492	$129,295	$129,295		$600,000	$8,583,750	$23,755,313	**$118,776,567**	**$119,000,000**
PP4	$1,682,728	$175,220	$8,873,547					$640,467		$332,826	$4,067,054	$2,886,211	$461,128	$48,719,018		$26,256,604	$3,877,899							$861,967			$129,295	$129,295		$600,000	$9,909,326	$27,400,646	**$137,003,230**	**$137,000,000**
SCP1												$31,031												$775,770			$129,295	$129,295		$300,000	$106,539	$367,983	**$1,839,913**	**$1,800,000**
SCP2	$271,856	$46,726	$1,735,212					$219,934		$89,645	$481,166	$373,063	$158,350	$1,673,493	$5,158,200	$1,301,154	$308,422							$646,475		$172,393	$86,197	$86,197		$400,000	$1,280,848	$3,622,333	**$18,111,664**	**$18,000,000**
SCP3	$233,856	$46,726	$1,492,664					$189,192		$77,114	$413,909	$325,773	$136,216	$1,168,499	$5,158,200	$908,517	$215,352							$646,475			$86,197	$86,197		$400,000	$1,118,489	$3,175,844	**$15,879,220**	**$16,000,000**
SCP4	$587,179	$126,159	$3,266,295					$289,095		$136,347	$1,320,087	$962,878	$208,145	$16,208,775		$7,384,566	$1,750,416							$646,475			$86,197	$86,197		$400,000	$3,305,881	$9,191,173	**$45,955,864**	**$46,000,000**

Appendix J
Access Limits Assessment

DRAFT

#600 – 4445 Lougheed Highway
Burnaby, BC, V5C 0E4
T: +1 604-294-3811
www.woodplc.com

Memo

To:	Project File: VE52705K.002
Company:	Government of Yukon-Energy, Mines and Resources Assessment and Abandoned Mines
From:	Brian Geddes
Date:	30 September 2021
CC:	**Wood**: Geoff Graham, Ed McRoberts, Karen Hincks **Yukon:** Carrie Gillis, Senior Project Manager – Type II Mines
Ref:	VE52705K.002
Re:	**Clinton Creek Remediation Project – Risk Management – Access Limits Assessment**

This memorandum presents the work undertaken to-date under Wood's current Post 10% Design Services scope relating to the assessment of potential land use and/or site access restrictions associated with the status quo and some of the candidate closure options for the former Clinton Creek mine site. This memorandum will ultimately form a component of the 2021 Data Gaps Report that is currently in preparation. The Table of Contents for this memorandum is presented herein as Attachment A. This document incorporates comments on a 15 July 2021 draft received by Wood from the Project Partners. This version is issued as a draft for review by the project's Independent Peer Review Panel (IPRP).

DRAFT

1.0 Introduction and Scope

1.1 Terms of Reference Scope

In the Yukon Government's (YG's) Post 10% Design Scope definition, it was noted that a better understanding of the access restrictions imposed under the closure concepts examined to date and the current conditions is required. Many of the candidate closure concepts, particularly the Alternate Designs developed subsequent to the 10% design scope, retain some level of residual risk and discussions to date have inferred access may need to be limited. It was also noted that a greater understanding of these risks would support the Partners' concept select deliberations. YG specified that an Access Limits scope should be undertaken to:

- present access restrictions for closure and current conditions graphically in map format, clearly showing access restrictions which may include off-limit areas, bypasses, signage, gates, fencing, seasonal restrictions, etc.;
- evaluate site risks to visitors based on exposure duration (occasional, frequent, and continuous) and activity (for example, through travel, recreating, working, hunting/gathering) similar to the existing Human Health and Ecological Risk Assessment; and
- evaluate seasonal risk differences for occasional site users under the current site conditions, including: summarizing and comparing slope stability and hydrotechnical risks under frozen and non-frozen conditions; and providing an opinion on whether or not there is reduced risk for motorized access using existing roads on the mine site in the colder months (snow machine) versus warmer months (ATV, UTV).

1.2 Scope Development

During discussions with YG during project initiation (e.g., the kick-off telecon (Wood, 2021)), additional context on the objectives for this component of the Post 10% Design Scope was provided. It was agreed that one key, overriding objective for the scope is to provide additional clarity about the specific nature and geographic reach of the land use and access restrictions that will be associated with what can be referred to as the "risk-on" alternates (i.e., the 2020 Alternate Measures concepts and/or the status quo). In this context, "risk-off" alternates are those 10% Base Case Designs in which the need for land use and/or access constraints has been largely mitigated by the nature of the designs and their associated design criteria (which would capture all of the Base Case designs with the exception of WC1, which retains the seismic liquefaction risk for the tailings, and the need for access restrictions).

It was also noted that a key objective of the dam breach scope, related to the Access Limits discussion, is to understand the limits of flooding and impacts on road access.

The definitions of access limits offered in the following sections are generally broad and semi-quantitative. The level of resolution possible at this stage of design development does not provide for highly specific definitions of restricted areas, access routes and/or the specific methods that may be used to enforce restrictions (i.e., signs vs fences or barriers). It has been assumed that this more detailed definition of the access limits scope and methodology will follow concept select and will be tailored to the specific nature and constraints of the preferred closure concept.

2.0 Risk Management Overview

DRAFT

Identifying the access limits that may be required for closure concepts is part of the broader process of risk management that will be an integral component of the closure planning process for the site. This assessment considers a particular element of that broader risk management scope, specifically, the health and safety risks that could be assumed by individuals using or visiting the site. The broader risk management process has, and will continue to consider other closure aspects that the Partners and public value (e.g., environmental, aesthetics, land utility). The comparatively focused discussion of risk and access limits that is presented herein should be considered and interpreted as a component of the risk management activity that will be ongoing during the project development process.

It is useful to reiterate that the term risk in this discussion refers to the product of the likelihood of a particular event and its consequences. The consequences of an event can, in turn, impact a variety of issues and attributes. For the purposes of this access limits assessment, the discussion focuses on two related consequences, specifically, the impacts of particular events (i.e., seismic and/or flood) and their associated potential to cause harm to people who may be on or proximate to the site. All of these key variables (i.e., probabilities of occurrence, physical impacts and their reach, harms to individuals) carry with them uncertainties that are both large and variable. Much of Wood's work to date, including the current scope, has tended to focus on the physical consequences of a particular event (e.g., slope failures, dam breaches). The other elements of the risk equation have not been considered or quantified with any rigor, and the outcomes of this discussion should be interpreted accordingly. Many judgements have been applied to the definition of these additional parameters with a view to illustrating their potential impacts on considerations of risk as they might relate to restrictions on access. These outcomes are not intended as a definitive or final recommendation on land management, but are viewed as general input to the Partner's concept select deliberations, and the definition of supplementary risk management scopes as project development proceeds.

It is also worth emphasizing the importance of distinguishing between risk, probability and consequence in the consideration of access limits for the site. There is often a tendency to conflate these terms in discussions of risk management, a tendency that is useful to avoid for Clinton in particular, because of the

large variations in our understanding of these terms. Again, there is a large gap between our relatively defined understanding of the physical consequences of certain events (although even these are qualified by the inevitable and substantial limits to characterization data) and what we currently understand of the range of potential safety consequences that could flow from these events. These variations in key risk parameter definitions should be acknowledged and considered as the access limits assessment is reviewed and subsequent actions defined.

Wood has also made a distinction between "no-warning" triggers of events such as seismic action versus "with-warning" events such as flood or breach which do have associated precursors which robustly contribute to risk reduction.

3.0 Access Limits Assessment

3.1 Method Overview

There are a variety of approaches that have been applied to the assessment of risks associated with mining structures. Given the particular requirements and focus of the Clinton access limits assessment, and the limitations of the data available to support it, Wood has applied a hybrid approach that borrows from various methods and relies on a liberal application of professional judgement to arrive at general illustrations of the risks that various publics using or visiting the property may be subject to. These are not definitive measures of risk, but rather are intended to initiate and inform a risk assessment and management process that is likely to be ongoing through the closure planning and execution process for the site.

DRAFT

Wood's hybrid approach has been informed by the risk management guidance provided in the 2013 revisions to Section 6 of the CDA's Dam Safety Guidelines (CDA, 2013). CDA describes both qualitative and quantitative methods for assessing risks. Qualitative assessment characterizes uncertainty in non-mathematic form and uses various schemes for indexing, scoring and ranking risk factors. For example, consequences might be scored or categorized at levels ranging from negligible to catastrophic on the basis of qualitative descriptions of event outcomes. Similarly, probabilities would be categorized on qualitative bases or using general indicators of event frequencies. The two factors (i.e., consequence and probability) are then combined in a matrix that assigns risk events ranging typically from nil to extreme. An example of this kind of approach is represented by the Hazard Identification and Risk Analysis undertaken recently by the City of Whitehorse (Calian, 2017). The advantage of these qualitative methods is their comparative simplicity and the flexibility available in assigning consequence and probability categories. They are limited however in their ability to translate final risk rankings to specific prescriptions on land use that have meaning for impacted publics (e.g., should someone access a site carrying 'moderate' risk, and, if so, for how long?).

The CDA notes that quantitative risk assessments seek to provide mathematical descriptions of uncertainty in calculated estimates of risk. Quantitative methods offer the advantage of more specific characterizations of the relationship between time spent on a site and the risk assumed. The disadvantage is their reliance on quantitative inputs that are, at best, less than fully understood at Clinton.

The CDA also distinguishes between individual and societal risk as follows:

- *Individual risk* relates to concerns of how individuals see the risk from a particular hazard affecting them. It is usually defined as the risk to a hypothetical member of the public occupying the zone that can be affected in the event that a hazard occurs. The criteria for individual risk depend on such factors as whether or not the exposure is voluntary, whether the individual derives benefit from accepting the risk, whether the individual has some control over the risk, and whether the risk engenders particular dread.

- *Societal risk* generally refers to hazards that, if realized, could impact society and thus cause socio-political response. Societal risk may be seen as a relationship between the frequency of a particular hazard and the number of casualties if the hazard is realized. In applications dealing with hazards from engineered installations where the predominant issue is life safety, societal risk is characterized by graphs showing frequency of events that could cause multiple fatalities.

For the individual risks that are particularly relevant for the access limits assessment at Clinton, CDA offers the following formula for calculating risk:

$$P_{LOL} = P_{Event} \times P_{Failure/Event} \times P_{Fatality/Failure}$$

where: P_{LOL} = Probability of Loss of Life; the unconditional probability of fatality for maximally exposed individual from a hazardous event

P_{Event} = Unconditional probability that a hazardous event of specified type and magnitude range will occur

$P_{Failure/Event}$ = Conditional probability that the structure will actually fail, given the event

$P_{Fatality/Failure}$ = Conditional probability of loss of life, given structure failure

The risks calculated by the above formula need to be aggregated over all failure initiating events in order to obtain the total risk to the individual. In considering this formula is useful to note that the term, *Annual Event Probability (AEP*) as it is generally used in this Memorandum, expresses the probability of an event occurring in any given year. An individual occupying the site for a short time period once in a year has a reduced likelihood of being exposed to seismic risk. The life-time likelihood resulting from one trip per year for a lifetime is clearly greater.

DRAFT

The conditional probabilities $P_{Failure/Event}$ that structures will fail, given an event, vary widely depending on the failure modes and the nature of the loadings. The actual value for a particular structure and event is typically difficult to determine precisely (and this is certainly the case for Clinton). Hence, in some cases where no additional information is available, valid decisions can often be made on the basis of relatively simple analyses by making the very conservative assumptions that $P_{Failure/Event} = 1$ and $P_{Fatality/Failure} = 1$.

It is important to note that while this equation refers exclusively to probabilities, in fact, it combines probability terms (P_{Event}) with measures of consequence (P_{Fail}, $P_{Fatality}$) to predict the risk to individuals (P_{LOL}) posed by particular events. If it was argued that depending on the exact location of an individual and reaction time one might think there was a 50/50 chance of escaping from and event, then the conditional probability $P_{Failure/Event}$ would be 1/2. In cases, for example, where one visit of say four days in a given year is considered the conditional annual probability of exposure, $P_{Fatality/Failure}$ would be 4/365 or 1/91.

Wood has applied this general formula using the inputs developed as described in the following sections. The resulting estimates of risk are then compared to criteria recommended by CDA and to the other risk benchmarks described in Section 3.7, that may have particular relevance for users of and/or visitors to the Site. The range of comparative benchmarks offered is a reflection of the lack of any specific definition of the levels of risk that are acceptable for the particular circumstances at Clinton. The approach taken is to provide general comparative characterizations of risks that the Partners can consider in defining the nature and scale of land use restrictions that are likely to apply to different closure options for the property.

3.2 Event Scenarios

For the purposes of this access limits assessment, there are two broad categories of hazardous events that have been considered, specifically seismically induced failures of the Clinton Creek waste dump or the Wolverine Creek tailings inventory, and hydrotechnical events resulting in breaches of dump and/or tailings structures, either as a result of flooding, or as a secondary consequence of seismic events. The probabilities of these events and the physical consequences that they could generate are the subject of the geotechnical and hydrotechnical discussions presented in the Dam Breach and Runout Assessment Appendices of this report. The following sections present, paraphrase, and/or interpret the outcomes of these appendices to arrive at judgements regarding appropriate inputs to the basic individual risk equation described above in Section 3.1.

The geotechnical and hydrotechnical appendices referenced above include maps or drawings illustrating the areal limits of the physical consequences of the events in question. These maps/drawings can also be considered to judge how these limits of impact might vary amongst the candidate closure options. The intent is to provide some indication of how varying levels of closure investment influence the final utility of the reclaimed landscape (i.e., a preliminary quantitation of the relationship between cost and post closure risks to local publics).

For the purpose of this assessment, it has been assumed that the nature of the event consequences to individuals within these defined limits, and the probabilities that these consequences will be realized, are constant throughout the areal limits that have been described. This is a simplifying assumption that could be refined as closure planning progresses. In reality, the probabilities of individual harm and the specific nature of these harms is likely to vary unless these restricted zones are defined and categorized very narrowly, something that would require considerably more site characterization data and analysis than is currently available, or that may never be justified by design development requirements.

DRAFT

3.3 Risk Scenarios

3.3.1 Event Categories

There is a distinction to be drawn between the risks associated with seismic and hydro events that will likely have a significant bearing on how these risks are managed post closure. The seismic events described in the Runout Appendix are not predictable in any practical sense, which means that the only way to mitigate the impacts of their physical consequences on local publics is to limit the use and occupancy of the affected lands. These are considered to be no-warning events. However, most of the hydrotechnical events described in the Dam Breach Appendix, and in particular, those in Tables 1 and 2 of the appendix, would be preceded by events that would provide degrees of warning for those breach events carrying the potential to cause injury or death. That is because the particular hydrotechnical events referenced are caused by flooding that would take some time to compromise the physical integrity of dam structures, or they are the secondary effects of seismically induced spillway failures that will, again, involve time lags for the build-up of potentially compromising water levels. The duration of these "with-warning" events on the hydrotechnical side varies, but in most cases, would be long enough to affect evacuations of potentially impacted areas if appropriate monitoring and notification systems in conjunction with on-demand evacuation resources, were to be developed and reliably sustained. This use of monitoring and evacuation as a primary risk management tool for hydrotechnical events could be applied to limit the required number and scope of limits required for access and use of the lands.

3.3.2 Risk Management for "With Warning" Events

Precursors to with-warning events would identify conditions that assist in risk reduction. For example, heavy periods of intense precipitation, major snow accumulations followed by a very rapid onset of spring, high flow levels in Clinton Creek and the general area, or unusually rapid rises in water levels would alert users to personal risk of proceeding. These of course would be common-sense to experienced users intimately familiar with living on the land.

In addition to signage on-site, a flood warning system could be developed and maintained to alert potential users to the site of periods of elevated risk on the site. In very simplistic terms, a flood warning system consists of some kind of trigger or alarm, followed by a notification, and then, critically, action to protect themselves and their property by the recipient of the warning.

An effective flood warning system should be simple, robust to the elements and reliable. The trigger would be a seismic event (monitored in accordance with an agreed and prescribed protocol), exceedance of a prescribed water level as recorded by satellite based telemetry, real time level sensor and/or a forecast weather scenario that would create hazardous conditions on the site. Direct notification (not relying on passive public engagement) of the occurrence, significance and potential consequences of a trigger event would be distributed via a predetermined protocol, designed to be relevant for local target publics. Due to the remote location of the site, people on the site at the time could not be reached through cellular phones or radios so it may be desirable to install a warning claxon at one or more locations on the site. The final phase of a successful flood warning system is for the recipients to act. This can be as simple as changing travel plans or as comprehensive as proactive execution of a previously defined evacuation plan.

DRAFT

With all of the above said, the maintenance of access restrictions will continue to be an option for mitigating hydrotechnical risks should the Partners conclude that the development and/or sustenance of monitoring systems and evacuation protocols is not feasible or desirable. This may be a particular consideration for those hydrotechnical events that provide more limited warning windows.

3.4 Access Limit Boundaries (Event Consequences)

The geographic limits of access restrictions would be set to establish:

- clearly delineated areas outside of which there are no material increases in land use risks beyond those associated with local or regional areas not impacted by the Clinton mining operation;
- boundaries within which any users or visitors would be at risk of significant injury or death if clearly defined limits on use and/or occupancy are not observed.

The maps for seismic events that are presented in Attachment B, and in the Dam Breach Appendix for the various hydrotechnical events are intended to illustrate the potential boundaries of these areas, for both the status quo and various closure options under consideration. These maps characterize, in effect, the limits of the physical consequences of the risk paradigm. The personal consequences of the subject events within the geographic limits have been assumed to fall into a single category, that being 'significant injury or death' (see discussion in Section 3.2). Again, this simplified view of the potential impacts of a physical event is taken to reflect the preliminary, indicative nature of this current access limits assessment.

3.4.1 Seismic Events

The representations of event boundaries for seismic events provided in Attachment B reflect the outcomes of analyses described in the Runout Assessment Appendix, supplemented with Wood's judgements about the influence of the Alternate Designs on these event boundaries. For the Clinton Creek valley, Figure AL-2 shows the estimated slide hazard area for the status quo, and the approximate reduction in that area that would be offered by the Alternate Designs. It should be noted that these alternates would also produce some changes to the event boundaries on the western reaches of the creek valley, but not of a scale or significance that were considered material to this assessment.

On the Wolverine Creek side, Figure AL-3 shows two event boundaries, one of the status quo (and for WC1 which approximates the status quo), and a second for the WC2 Alternate Design (i.e., Option WC2-A). Modelling of the Option WC2-A runout has not been attempted. However, the reduced event boundary shown for WC2-A is judged to be a reasonable representation of the mitigative benefit potentially offered by this design.

3.4.2 Hydrotechnical Events

All of the relevant hydrotechnical event boundaries are included in the figures included in the Dam Breach Appendix. They have not been appended herein because they have not been modified from the appendix's original figures.

3.5 Event Probabilities

This section discusses the probabilities associated with seismic and hydrotechnical events with the potential to cause significant injury or death to individuals on or proximate to the Site (i.e., within the boundaries discussed above). This discussion addresses the P_{Event} term in the risk equation presented in Section 3.1 (i.e., P_{Event} = unconditional probability that a hazardous event of a specified type and magnitude will occur).

DRAFT

3.5.1 Seismic

Project seismic and related design information is to be found in the following references:

1. Tetra Tech EBA Preliminary Dam Classification – Mine Waste Structures Clinton Creek Mine Site YT (2016)
2. Amec Foster Wheeler Clinton Creek Remediation Preliminary Design Report (March 2017)
3. Wood Geotechnical Summary Report (August 2019) Appendix A "Design Basis Memorandum"
4. Wood Alternative Designs Report (March 2020) Sub-appendix A "Seismic Triggering Analysis"
5. Wood Memorandum Appendix TBD April 2021 "General Commentary on Recommendations for Seismic Monitoring Equipment"

Setting seismic design criteria is fundamentally a risk-based decision. In Canadian practice, and absent provincial or territorial regulation Canadian Dam Association Guidelines are generally adopted. These guidelines are based on an assessment of consequences, from which the hazard level of a seismic event, referred to as the Annual Event Probability (AEP) is selected for design. The details of this procedure are reviewed in the Design Basis Memorandum Wood (2019).

Beginning with Tetra Tech EBA (2016), consultant recommendations have been to assign a "Significant" classification to a landslide dam that impounds Clinton creek for the "Passive Closure" case. In this regard, Wood notes that CDA guidelines make it clear that ultimately it is the "owner" (and implicitly with concurrence of regulators) that must make the decision as to consequence classification.

As the 10% Design by Wood progressed it was determined that seismic triggering of liquefaction was an issue for the main landslide dam on Clinton Creek. This determination had the effect of substantially impacting base case designs and the estimated costs for mitigation escalated substantially.

The design question then posed by the Project Partners was to consider alternative designs. Wood's premise was that as it was not possible to eliminate the seismic threat, but that consequences, especially loss of life could be greatly reduced by restrictions on site access. Wood also noted that substantially increased site investigation might possibly reduce the threat of overall liquefaction of potentially loose wastes in the Clinton creek valley; but on the other-hand equally such investigation could just confirm the problem. Wood concluded that with acceptance of site restrictions the CDA classification would revert to a "Low" classification for a structure that essentially remained in an "Operation" case (I.e. Active Care). Wood's alternative designs were based on this acceleration.

3.5.1.1 Clinton Creek

The base case passive closure options (i.e., concepts in the 10% design report Wood (2019)) were based on the Significant Classification. Structures were designed to withstand seismic liquefaction applied to a design event which carries a annual event return period, or AEP, of 1 in 2,475 years for a significant classification. This results in a design horizontal acceleration of 0.27g for a Significant Classification.

For an alternative design assigned a Low Classification for a structure that remains in active care the AEP is 1/100. This results in a 0.037g design acceleration (see Wood (2020)). Statistically, an AEP of 1/100 means there is a 1 in 100 chance of getting the event in a given year. But, over a 100 year period, there is about a 37% chance of NOT getting a 1/100 event, or expressed from a likelihood perspective, a 63% chance of getting a 1/100 event in 100 years. This is a statistical consequence of what is referred to as normally distributed random events. This statistical prediction applies to a 1/n AEP over n years.

DRAFT

It has been estimated that for closure options that are not intended to withstand seismic events (i.e., the status quo and the Alternative Designs (CC1 A&B, CC2 A&B)), liquefaction would be initiated at about 0.14g which translates to an event with an AEP of 1 in 750 years (see Figure AL-1 and supporting discussion in the Runout Appendix).

The best fit to NBC site prediction in Figure AL-1 is:

$$AEP = 3E\text{-}5(\%g/100)^{-1.933}$$

where AEP is expressed as 1/AEP.

An acceleration 14%g, or 0.14g is equivalent to a Factor of Safety against triggering liquefaction of FoS_{liq} of unity. See Wood (2020) for discussion of FoS_{liq} and the AEP associated with different values of FoS_{liq}. Because the design acceleration is 0.27g, and the triggering acceleration is less at 0.14g, it is clear that for passive care, the potential for liquefaction is a concern.

In other words, P_{Event} for seismic liquefaction at the Site for these closure scenarios would be 0.001333 (1/750). This is equivalent to a 13% chance of initiation of liquefaction in 100 years.

To put these numbers in perspective, we can see consider the following hierarchy of possible events for a 100 year period.

- The base case design for a Significant AEP level has a 3.6% chance of occurring in the next 100 years. If structures are designed to a 1/100 AEP (i.e. the Active Care loading), significant damage is likely (based on current site knowledge) in the long term.
- There is a 13% chance of actually triggering liquefaction in the next 100 years. Some damage can be expected for structures design at a Low Classification.

Predicted Peak acceleration to Initiate a Seismic Liquefaction event is 0.14 g

The annual probability of a 0.14g event at Clinton Creek is 1/750 or 0.00133

Note the Seismic Hazard at the site is 0.27g a 1/2475 event or 0.0004

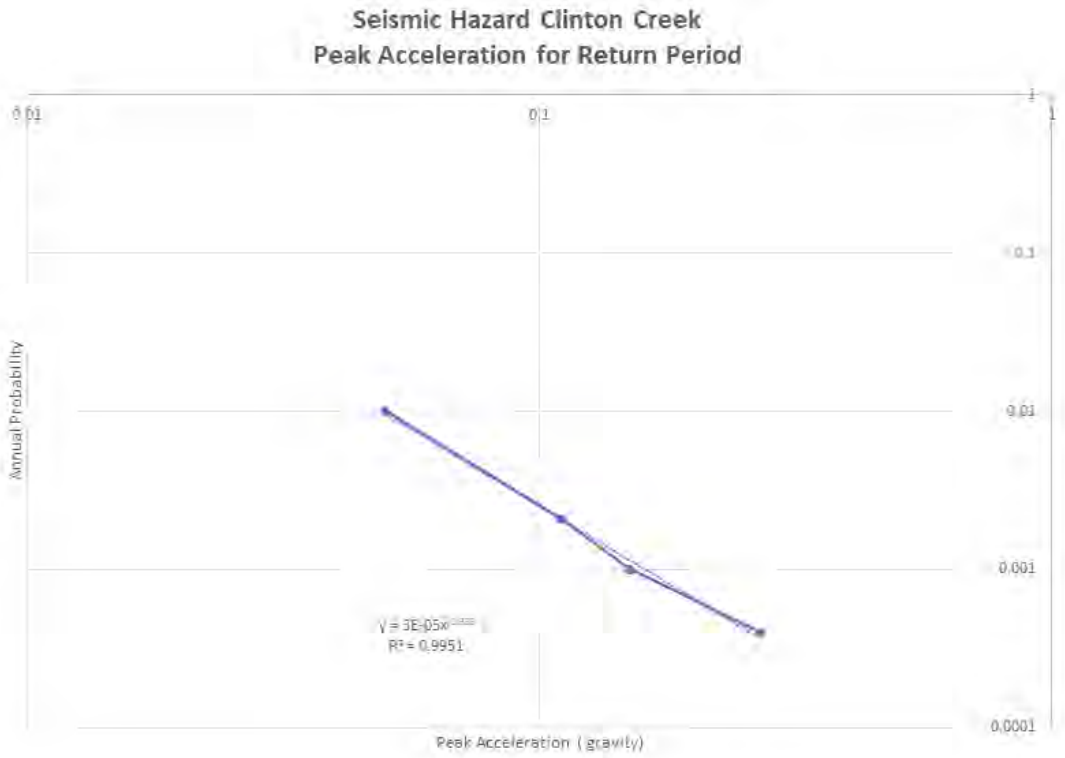


Figure AL-1: Seismic Hazard Clinton Creek Peak Acceleration for Return Period

- There is a 63% chance of getting the 1/100 event in the next 100 years but little to no damage from liquefaction is likely as a consequence of this event.

3.5.1.2 Wolverine Creek

The shear movements exhibited in the colluvium at the south lobe of the Wolverine Creek tailings coupled with previous back-analysis suggest a factor of safety near but above unity (i.e., a failure condition). For an essentially do-nothing approach per WC1, it would not take a major seismic event to cause outright failure and potentially trigger liquefaction depending on the hydrogeological regime near the tailings-colluvium contact. A seismic acceleration of 3%g applied as a pseudo-static acceleration is sufficient to degrade the exiting factor of safety by 10%. This would likely be sufficient to create a blockage of Wolverine Creek. If liquefaction of the tailings also occurred, there would be a rapid no-warning runout for some distance downstream. For a FOS degradation of 10%, a seismic acceleration of 3%g corresponds to an AEP of 0.026 or 1/38. (note: to characterize the sensitivity of this estimate: a 15% degradation would require a 5%g event corresponding to an AEP of 0.01 or 1/100). An annual event probability of 1/38 translates into a P_{Event} for the current condition on the Wolverine side of the property of 0.026. The 5%g event produces a corresponding P_{Event} of 0.01 (1/102). That is to say there is a reasonable chance of failure of the Wolverine Creek tailings.

The design objective for WC2-A was to flatten the tailings slope to achieve a static FoS of 1.2 to reduce the vulnerability to static loading, given the on-going slope indicator movements. This slope would still have some vulnerability to the design acceleration of 0.27g either overall or due to retrogressive movements beginning at the toe. Slope flattening was not intended to eliminate the potential for liquefaction. Any movement modes would be less severe that those predicted for WC1, and worst case movements are less likely to flow to Clinton Creek. A no-warning seismic threat would still exist for WC2-A, but of lesser areal extent.

DRAFT

3.5.1.3 Seismic Loadings Summary

The various seismic loadings applied for the 10% Base Case Designs, The Alternative Designs and for the Access Limits Assessment are summarized on Table AL-1 along with summary comments relating to the bases for these seismic loadings.

Table AL-1: Seismic Loading Summary by Design Scenario

Design Scenario	Seismic Loadings				Comments
	Clinton Creek Valley		Wolverine Creek Valley		
	Acceleration (%g)	AEP[a]	Acceleration (%g)	AEP	
10% Designs (Wood, 2019)	27	1/2,475	27	1/2,475	• Based on CDA[b] Significant Risk Classification and Passive Care • Requires no access restrictions
Alternate Designs	3.7	1/100	NA[c]	NA[c]	• Clinton side based on CDA Low Risk Classification and Active Care • Wolverine side assumes Active Care can be applied to mitigate the need to consider seismic triggering • Require access restrictions
Access Limits Assessment	14	1/750	3 5	1/38 1/102	• Intended to define the areal reach of access limits needed to safely manage structures not designed for seismic triggering (Wolverine Valley) or to standards that do not fully mitigate the liquefaction risk (Clinton Valley) (i.e., to define what might be a life-threatening event for these design scenarios) • The two Wolverine events are intended to bracket a plausible range of triggering events • All of these scenarios involve design scenarios that require access restrictions

DRAFT

3.5.2 Hydrotechnical

The following issues apply to the consideration of those hydrotechnical event scenarios that will be relevant to the access limits assessment:

- Clinton Creek Status Quo: the probabilities of flood induced breaches to the existing Clinton Waste Dump were assumed to be as described in Table 11 of the Dam Breach Appendix.
- Clinton Creek 10% Design Options: breach scenarios for the base case design options are not relevant for the access limits discussion because these designs mitigate the risks to a degree that limitations to site use and access are not necessary.
- Alternative Designs (Non-Seismic): the Clinton Alternate Designs applied the lower design flows that the CDA Guidelines provide for if the structure is maintained under an active versus passive post closure state (i.e., the operative assumption for the Alternate Designs). There is no change in CDA's treatment of the population at risk or loss of life criteria going from passive to active care if the dam classifications have not changed (which is the case for the Clinton designs). The premise is that any incremental risks resulting from lower design flows are mitigated by the more robust monitoring, maintenance and response protocols that are a feature of active care. However, this basic approach notwithstanding, the CDA acknowledges that "the appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of

their activity, and other conditions" (CDA, 2019). For this reason, and for the purposes of this assessment, Wood has assumed that the lower design flows applied for the Alternate Designs on Clinton may require limits on access and time spent on-site that need not be considered for the Base Case (10%) designs. While the physical consequences of the breach scenarios relevant for the Alternate Designs have not been modelled directly (see Table 1 of the Dam Breach Appendix), their physical consequences have been assumed similar to those for the base case designs (or the seismic induced breaches) for the purposes of this access limits discussion.

- Clinton Creek Alternate Designs (Seismic): seismically induced breaches to the Alternate Designs are assumed to carry the probability described in Section 3.5.1.1 for seismic events.
- Wolverine Creek Status Quo: IDF or Sunny Day breaches of the tailings lakes were not considered relevant to the access limits discussion because the volumes of retained water were judged unlikely to generate significant risks of downstream injury or death (or at least not high enough to justify the imposition of standing restrictions on use or access).
- Wolverine Creek Alternate Designs (Seismic); seismically induced breaches to the Alternate Designs are assumed to carry the probability described in Section 3.5.1.2 for seismic events.

These issues and assumptions produce the following probabilities used as inputs to the risk calculations described in Section 3.1 (i.e., the P_{Event} term in the calculations);

- Clinton Creek Status Quo: 2.0×10^{-5} (i.e., 1 in 50,000);
- Clinton Creek Alternate Designs (Non-Seismic): 0.01 (i.e., 1 in 100; reflecting the .01AEP IDF for this case);
- Clinton Alternate Design (Seismic): (i.e., CC1 A&B, CC2 A&B): 1.33×10^{-3}; and
- Wolverine Alternate Designs (Seismic): 0.010 to 0025.

Per the discussion in Section 3.3, these hydrotechnical event probabilities will only be relevant if the Partners choose to mitigate the risks of personal injury or death that might be associated with these events via the application of access limits, rather than using the warning periods offered by these events to implement monitoring and evacuation protocols.

DRAFT

3.6 Risk Calculations

Combining the probabilities of subject events with the representations of the physical consequences of these events (Attachment B and the Dam Breach Appendix figures), to produce preliminary characterizations of risks to individuals on or proximate to impacted areas was done by applying the basic risk equation presented initially in Section 3.1, summarized as:

$$P_{LOL} = P_{Event} \times P_{Failure} \times P_{Fatality;}$$

where P_{LOL} refers to the Probability of Loss of Life. Again, this equation appears to just refer to probabilities, but, in fact, combines probability terms (P_{Event}) with measures of consequence (P_{Fail}, $P_{Fatality}$) to predict the risk to individuals (P_{LOL}) posed by particular events, therefore it is a risk prediction.

Wood's application of this formula to the events of interest is outlined in Table AL-2. The content and features of this table are described as follows:

- Event Column: this column focuses on those specific failure events described above that are particularly relevant to the consideration of limits to site use or access. For the Wolverine seismic events, the table includes the range of potential triggering events described in Section 3.5.1.2 (i.e., 1/38 and 1/102 year events).

- P_{Event} Column: brings forward Wood's conclusions on judgements about the likelihood of the subject event occurring.
- Consequence Terms (i.e., $P_{Failure}$, $P_{Fatality}$): the values of these terms in Table AL-2 reflect Wood's judgements about the likelihood that events will produce failures with the geographic reach represented in the figures referenced above, and the likelihood that these failures would uniformly result in significant injury or death across an entire impacted area. It is useful to note that these terms represent one of the considerable points of uncertainty in the current, preliminary assessment, and areas where future considerations of risk are likely to focus as closure designs are developed. Again, the current assessment makes the simplifying, broad and conservative assumption that the presence of anyone within the predicted areas of impact will suffer the consequences reflected by the product of these terms.
- Occupancy Column: this column reflects the fact that individual risk is directly proportional to the time spent within the defined areas of impact. The three durations presented are intended to reflect a range that is representative of typical Clinton site uses (e.g., single days for site inspections and transient visitors, up to perhaps a month for campers or hunters).
- Individual Risk Column: this column combines the probability, consequence and occupancy terms to predict the risk to an individual, present within the defined areas of impact, that would be associated with the event of interest. It is important to note that this is a measure of individual risk, the collective risk to groups would be increased in direct proportion to the number of individuals involved (an issue that would be relevant for groups of hunters or campers, for example).
- Benchmarks: Table AL-1 references several risk benchmarks that are intended to provide some context for the individual risk calculations presented in the table. The derivations and sources of these benchmarks are described more fully in Section 3.7 (for example, the table can be used to compare the annual risk of one stay on-site per year of a particular duration to that associated with a flight between Whitehorse and Dawson City).
- Risk Benchmarks – Occupancy Equivalents: these columns simply back calculate how many days an individual could spend within defined areas of impact and be subject to an event risk consistent with the three benchmarks that Wood assumed might be particularly relevant (note however that this last assumption highlights the importance of perspective in determining what level of risk might be acceptable; judgements about appropriate benchmarks vary from one individual to another, and there are few risk benchmarks available that would be clearly and broadly viewed as directly relevant to the particular features of the Site and/or the events of interest).
- Background Shading: various background colours are used in Table AL-2 to represent the extent to which events will come with precedents that offer the potential for using a monitoring and evacuation strategy as an alternate to limiting access as the general approach to risk management.

DRAFT

Table AL-2 - Clinton Creek Data Gaps Scope - Access Limits Risk Predictions

Event	Relevant Closure Options	Representation of Impacted Area	Probability	Consequence		Individual Occupancy Within Impacted Area (days)	Individual Risk		Risk Benchmarks					
			P_{Event}	$P_{Failure}$	$P_{Fatality}$		Value	Return Period (yrs)	CDA Allowable Individual Risk	On-Site Occupancy Equivalent (days); see Note 1	Return Flight from Whitehorse to Dawson City	On-Site Occupancy Equivalent (days); see Note 1	Return Drive from Dawson City to Clinton Site	On-Site Occupancy Equivalent (days); see Note 1
Seismic failure of Clinton Waste Dump	Status Quo, CC1A&B, CC2A&B	Appendix B, Figure AL-2	0.00133	1.0	1.0	1	3.64E-06	274,436	1.00E-04	27	1.40E-05	4	1.21E-04	33
						10	3.64E-05	27,444						
						30	1.09E-04	9,148						
						Full Time	1.33E-03	752						
Seismic Failure of Wolverine Tailings - **3%g Event**	WC2-A	Appendix B, Figure AL-3	0.026	1.0	1.0	1	7.12E-05	14,038	1.00E-04	1	1.40E-05	0.2	1.21E-04	1.7
						10	7.12E-04	1,404						
						30	2.14E-03	468						
						Full Time	2.60E-02	38						
Seismic Failure of Wolverine Tailings - **3%g Event**	Status Quo	Appendix B, Figure AL-3	0.026	1.0	1.0	1	7.12E-05	14,038	1.00E-04	1	1.40E-05	0.2	1.21E-04	2
						10	7.12E-04	1,404						
						30	2.14E-03	468						
						Full Time	2.60E-02	38						
Seismic Failure of Wolverine Tailings - **5%g Event**	WC2-A	Appendix B, Figure AL-3	0.01	1.0	1.0	1	2.74E-05	36,500	1.00E-04	4	1.40E-05	0.5	1.21E-04	4.4
						10	2.74E-04	3,650						
						30	8.22E-04	1,217						
						Full Time	1.00E-02	100						
Seismic Failure of Wolverine Tailings - **5%g Event**	Status Quo	Appendix B, Figure AL-3	0.01	1.0	1.0	1	2.74E-05	36,500	1.00E-04	4	1.40E-05	0.5	1.21E-04	4
						10	2.74E-04	3,650						
						30	8.22E-04	1,217						
						Full Time	1.00E-02	100						
IDF on Clinton Dump (No Breach)	Status Quo	Dam Breach Appendix - Figures A1 to A4 (Scenario 1)	0.00002	1.0	0.1	1	5.48E-09	182,500,000	1.00E-04	No Limit	1.40E-05	No Limit	1.21E-04	No Limit
						10	5.48E-08	18,250,000						
						30	1.64E-07	6,083,333						
						Full Time	2.00E-06	500,000						
IDF Induced Breach on Clinton Dump	CC1A&B, CC2A&B	Dam Breach Appendix - Figures A1 to A4 (Scenario 1)	0.01	0.5	0.1	1	1.37E-06	730,000	1.00E-04	73	1.40E-05	10	1.21E-04	88
						10	1.37E-05	73,000						
						30	4.11E-05	24,333						
						Full Time	5.00E-04	2,000						
Seismically Induced Breaches of Clinton Dump	Status Quo, CC1A&B, CC2A&B	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	0.00133	1.0	0.5	1	1.82E-06	548,872	1.00E-04	55	1.40E-05	8	1.21E-04	66
						10	1.82E-05	54,887						
						30	5.47E-05	18,296						
						Full Time	6.65E-04	1,504						
Seismically Induced Breaches of Wolverine Tailings - **3%g Event**	Status Quo	Dam Breach Appendix - Figures F1 to F4 (Scenario 2)	0.026	1.0	0.3	1	2.14E-05	46,795	1.00E-04	5	1.40E-05	1	1.21E-04	6
						10	2.14E-04	4,679						
						30	6.41E-04	1,560						
						Full Time	7.80E-03	128						
Seismically Induced Breaches of Wolverine Tailings - **3%g Event**	WC2-A	Dam Breach Appendix - Figures F1 to F4 (Scenario 1)	0.026	0.3	0.2	1	4.27E-06	233,974	1.00E-04	23	1.40E-05	3	1.21E-04	28
						10	4.27E-05	23,397						
						30	1.28E-04	7,799						
						Full Time	1.56E-03	641						

Color Coding

	No Event Warning
	Short Event Warning (Days)
	Long Event Warning (Weeks)

Note 1: Time spent on site that generates an individual risk similar to that described for the benchmark in question.

3.7 Risk Benchmarks

Table AL-2 refers to three risk benchmarks that have been included to provide context to the preliminary risk calculations described above. The relevance of these benchmarks to the Clinton scope has not been established at this stage. They are offered simply to provide some readily understood comparisons to the predictions of risk associated with temporary occupations of the Clinton property.

1. CDA Guideline for Individual Risk
   Section 6 of CDA (2013) notes that in dam safety decisions, individual risk should be considered in terms of the "maximally exposed individual" that is permanently resident downstream of the dam. Typically, the maximally exposed individual is exposed to the hazard significantly more than 50% of the time. The maximum level of individual risk is generally given as less than 10^{-4}/year.

2. Aircraft Travel
   Statistics outlined in PCI (2021) describe a fatality rate of 6.1 per million flight hours for what is referenced as a commuter airline (judged by Wood to be a reasonable representation of the comparatively small aircraft servicing regional flights in the Yukon). This would translate into a fatality risk of 1.4×10^{-5} (i.e., 2.3/1,000,000 x 6.1) for a roughly 2.3 hour return (in and outbound total) flight between Whitehorse and Dawson City.

3. Vehicle Travel
   A reference on vehicle fatalities in Yukon describes a fatality rate for the territory of 0.6 per million vehicle kilometres (Yukon, 2019). Given that the road distance between Dawson City and the Site is about 102 km, a return drive to the site would result in a fatality rate of 1.21×10^{-4} (i.e., 0.6 x ((102 x 2)/1,000,000)).

4. Lifetime risks for site visits versus other benchmarks (for example death due to smoking), or other risk increasing human activities, could also be considered to expand on the benchmarking approach.

DRAFT

3.8 Seasonal Influences

The scope of work called for an evaluation of "seasonal risk differences for occasional site users under current site conditions" (Section 1.1). Wood would offer the following comments on the potential influence of seasonal variations on the descriptions of risk, and estimates of allowable site occupancies outlined in Table AL-2:

- The IDF flood event included in Table AL-2 would not occur during the winter period. However, this event does not produce limits on site occupancy in any case.
- The physical consequences of seismic events would not be materially different for the winter period. This, in turn, means there would be no seasonally driven changes to the occupancy limits for seismic events that are estimated in Table AL-2.
- Similarly, the occupancy limits estimated for seismically induced breach events would not be materially different for the winter months. However, because base winter flows would be comparatively low, the warning period following a seismic event would be longer in winter than summer (i.e., the delay between a seismic event and the associated flood induced breach would be extended).

In short, the critical events influencing on-site safety risks are not materially influenced by seasonal variations and frozen near surface ground conditions would not significantly change the estimates to allowable occupancies described in Table AL-2.

4.0 Access Limits

4.1 Summary Comments and Observations

Summary comments and observations relating to the application of limits to site access for both the status quo and select candidate closure options are provided below.

- The nature of breach events is such that areas of impact are much larger than those for seismically induced dump and tailings runouts. However, the warnings that precede these breach events offer opportunities for applying monitoring and evacuation protocols as alternatives to broadly scoped access limits for mitigating the associated event risks.
- The findings of this preliminary risk assessment underscore the general conclusion that land uses involving full time occupancy on and downstream of the Clinton property would not be appropriate for both the property as it stands (i.e., a no action closure scenario) or the Alternate Designs. This conclusion aligns with the basic design premise upon which the Alternate Design concepts were developed.
- The assessment also suggests that transient movements across the site (i.e., using the property to access other areas) do not generate risks to individuals or small groups that are inconsistent with CDA guidelines for individual risk, or markedly different from the risks that individuals typically assume when moving over large distances (e.g., driving and flying).
- Mitigating the potential for serious injury or death caused by seismically driven failures of the current Clinton Creek waste dumps for the Alternate Closure designs will require limits on the durations of individual or small group occupancies (e.g., small hunting parties) to days or a small number of weeks depending, in part, on the number of people involved. This reduces exposure periods, but does not eliminate overall risk, considered as the product of likelihood and consequence.
- The higher potential for seismic liquefaction failures on the Wolverine Creek tailings reduces those acceptable occupancies to a few days at most. The lower probabilities associated with the relatively extensive event tailings runout scenarios allow for longer occupancies, but over larger areas of impact (i.e., larger areas of limited access).
- Hydrological breaches of the Clinton Creek waste dump and Wolverine tailings generate somewhat lower individual risks, but over considerably larger areas. Again, these risks could be mitigated via the application of access restrictions, similar to those described for seismic liquefaction dump/tailings failures, or via the application of monitoring and evacuation protocols.
- Reminders as to what can precede “with-warning” events presented on signage could be considered to facilitate personal risk management. At the same time, signage would need to stress the lack of warnings for seismically triggered events.
- It is worth noting that while most of the Base Case, 10% designs were developed to mitigate the risk of seismic liquefaction failures, this is not the case for Base Case design WC1 on Wolverine Creek (this is essentially the status quo with some sediment control). This means that any of the Base Case designs for Clinton Creek would still require the property access restrictions described for WC1 (i.e., Figure AL-3) if combined with that option for Wolverine Creek.

There is a high level of uncertainty in all of the key components of this preliminary access limits assessment, specifically in the characterizations of the physical consequences of seismic, flood and breach events, and in the assumptions and judgements applied to predict the likelihood these events will cause serious injury or death. More robust and refined analyses of the preferred closure option(s) will likely be required to fully develop any access restrictions ultimately applied for the property. That said, Wood

DRAFT

believes this current analysis provides a general representation of the nature and scale of land use and access limits that would likely apply to closure plans or concepts that don't fully mitigate all failure risks in the basic design concept.

4.2 Influence of HHERA Conclusions

The Human Health and Ecological Risk Assessment (HHERA) that was updated for the Clinton property in 2019 (Wood, 2019b) estimated the risks associated with temporary occupancies of the site created by the asbestos that is present in the Wolverine tailings. Among other findings, the HHERA concluded that:

- Incremental Excess Lifeline Concern Risks (IELCRs) for exposure to asbestos fibres in air exceed the target IELCR for the hunter/gatherer and camper receptor groups based on personal and area sampling results indicating that unacceptable risks due to airborne asbestos exposure are predicted for these receptors under current Site conditions; and
- IELCRs for exposure to asbestos fibres in air for the occasional visitor are less than the essentially negligible target risk of 1×10^{-5} for all sample results indicating that unacceptable risks due to airborne asbestos exposure are not predicted for this receptor under current conditions.

These conclusions were based on the following occupancies on-site:

- Occasional Visitors: 10 hours/day, 1 day/month over 35 years;
- Hunters/Gatherers: 2 days/week, 6 months/year over 50 years
- Campers: 24 hours/day, 3 months/year.

It is useful to note that the HHERA considered long term, chronic exposures to asbestos in air in the Wolverine Creek valley as it currently exists, not the short term exposures that might be associated with failures of the tailings structures.

DRAFT

The minimum site occupancy that the above assumptions produce amounts to some 120 hours per year for occasional site visitors, well above the 24 hour annual allotment that is indicated in Table AL-2 to mitigate the physical risks generated by seismically driven failures of tailings structures. In short, the limits to site occupancy defined by the Table AL-2 outcomes are more critical than those predicted by the HHERA to mitigate long term risks generated by asbestos in air.

That said, seismic events would generate exposure scenarios that depart from the long term, chronic exposures modelled by the HHERA. The following observations can be offered relating to the potential significance of these event driven asbestos in air risks:

- a seismically driven failure of the tailings would likely produce a substantial and temporary increase in asbestos levels in air;
- quantifying the event driven asbestos in air levels would require a comprehensive predictive effort that is unlikely to be justified because:
  - for anyone on-site during a seismic event, the physical risks of harm would overwhelm those generated by exposures to asbestos in air;
  - following an event, there are opportunities for mitigating the asbestos in air risks via temporary site access controls, monitoring and/or the use of personal protective equipment (i.e., post event risk management would not likely require incremental long term access limits); and

- the long term, incremental asbestos risks generated by a seismic event (e.g., a potentially expanded footprint; more friable tailings surfaces) could be evaluated via characterization and assessment programs applied with site management protocols that could be developed appropriately to mitigate risks during the assessment process.

In short, it seems unlikely that the asbestos content of the tailings would impose the need for limits to access and/or land utility incremental to those needed to mitigate the seismically driven physical safety risks to individuals.

4.3 Pit Access Limits

Unrestricted access to the former Porcupine, Snowshoe and Creek pits on the Clinton property cannot be provided because of the lack of geotechnical data and assessment relating to the oversteepened slopes associated with these pits. Attachment B of this report describes closure options that could be applied for these pits to remove access restrictions. These options assume pit closure is undertaken as stand-alone activity (i.e., separate from and incremental to, closure activity on the balance of the property). In practice, pit and property closure plans will ultimately be integrated and the extent to which dedicated pit closure actions would be needed to eliminate or reduce access restrictions will depend on the options selected for the Clinton and Wolverine sides of the property. Excepting the status quo, many of the property closure option combinations will generate dump and/or tailings spoil volumes that when directed to the pits will reduce slopes, and at least partially mitigate the need for pit access restrictions. However, if the Alternate Designs, CC1 and/or WC1 are selected, there will likely be a need for either pit area access restrictions or dedicated pit closure options. The specific nature and scope of these pit restrictions will depend on the final dump and tails spoil volumes, the outcomes of geotechnical investigations and assessments focused on the pit areas, and Partner decisions about the efficacy and utility of dedicated pit closure actions.

DRAFT

The approximate boundaries of access limits applicable to the current pit conditions are delineated by the hazard areas shown on Figures AL-2 and 3. Note that these areas differ from those hazards shown for the Clinton and Wolverine Creek valleys in that they are not necessarily related only to seismic events. They have been conservatively defined absent any area specific geotechnical information relating to the stability of local slopes and/or the nature and scope of events that might trigger failures.

4.4 Seiche Events

The preceding discussions do not consider the risks that might be created by seiches generated by local failures of slopes along the perimeter of Hudgeon lake (both on the Clinton Creek waste dump and natural slopes elsewhere). Seiches are sudden and significant changes in lake levels, in this case caused by slope failures, particularly those resulting from seismic events. Seiches on Hudgeon Lake could produce:

- risks to the safety of persons on, or immediately proximate to the lake during a seismic event; and/or
- risks to anyone downstream of Hudgeon Lake during an event, or later should the seiche undermine the long-term integrity of the dump and/or associated spillway structures.

The significance of these risks will depend of course on the size of the seiche produced, and on the scale of any subsequent damage to dump structures. Those factors will in turn will have a relationship to seismic event return periods that Wood has not attempted to quantify in this exercise. The following general comments and/or observations about the potential significance of risks produced by seiche events are offered.

- It is unlikely that seiches produced by seismic events less severe than those resulting in the access limit boundaries shown on Figure AL-2, would produce catastrophic and immediate failures of the Clinton Creek waste dump.
- Less significant events could produce seiches that would compromise the functioning of spillway structures that could in turn undermine the integrity of the Clinton dump; however, these scenarios would unfold over extended timelines that would provide opportunities for risk mitigation via monitoring and evacuation.
- In short, it is unlikely that the incremental risks posed by seiche events would require an expansion of the access limit boundaries shown on Figure AL-2.

It is out of consideration of the seiche risks that the access limit boundaries shown on Figure AL-2 have been extended to cover the entire surface area of Hudgeon Lake. It is worth noting that the need for these restrictions to lake access could be mitigated, at least in part, by requiring that users of the lake observe recognized boating safety standards (i.e., the use of personal flotation devices). However, the lack of vehicles for enforcing compliance would limit the effectiveness of this approach.

While the incremental risks associated with seiche events are unlikely to be determining issues for the concept select phase of project development, they may require more considered and quantitative assessments as design development of a preferred closure concept is progressed.

4.5 Current and Anticipated Site Uses

Some perspectives on the relationships between the site access limits described above and the local community's current expectations for utilization of the property and adjacent lands can be derived from a consideration of a cultural research and oral history project completed recently by the Tr'ondëk Hwëch'in (Dobrowolsky and Winton, 2017).

DRAFT

4.5.1 Cultural Research and Oral History (CROH) Project Overview

The CROH project was commissioned by TH to compile information on past, current and anticipated future uses of the Clinton Creek Mine Site and local areas. This was done by interviewing some 14 people who worked at the Clinton Mine during operations, or who work or live in the area now. These interviews were supplemented by responses to survey questionnaires (in digital and paper formats) advertised and shared throughout the community of Dawson and emailed to selected interested parties outside of Dawson City. The survey was comprised of 17 questions, covering past and current uses of the Clinton Creek site; preferred access to the area; wildlife, vegetation and climate; and preferred future land uses. A total of 40 completed questionnaires (31 online and nine paper) were received (Dobrowolsky and Winton, 2017).

4.5.2 CROH Survey Findings

Section 4 of the CROH report provides graphical summaries of the responses to various questions posed in the survey, a number of which are particularly relevant to the issue of current and anticipated future use of the Clinton area lands. These include the following charts, all extracted directly from Dobrowolsky and Winton (2017).

Chart 1 – How often do you visit the Clinton Creek area?

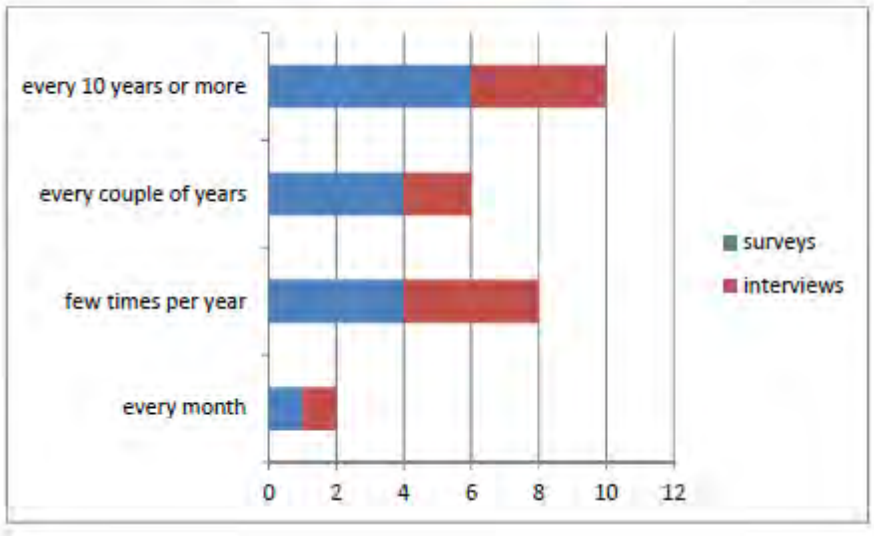


Chart 2 – Which spots do you visit? (Please select all that apply.)

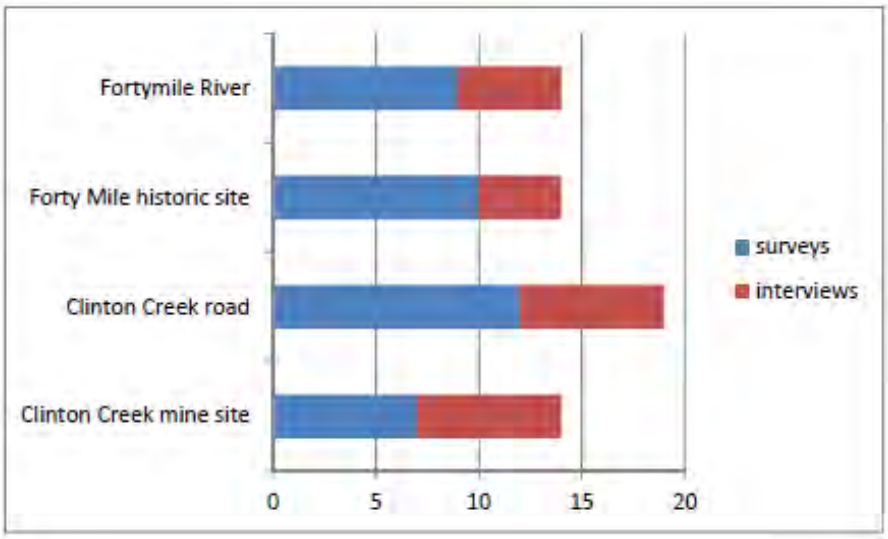


Chart 3 – What time of year do you visit? (Please select all that apply.)

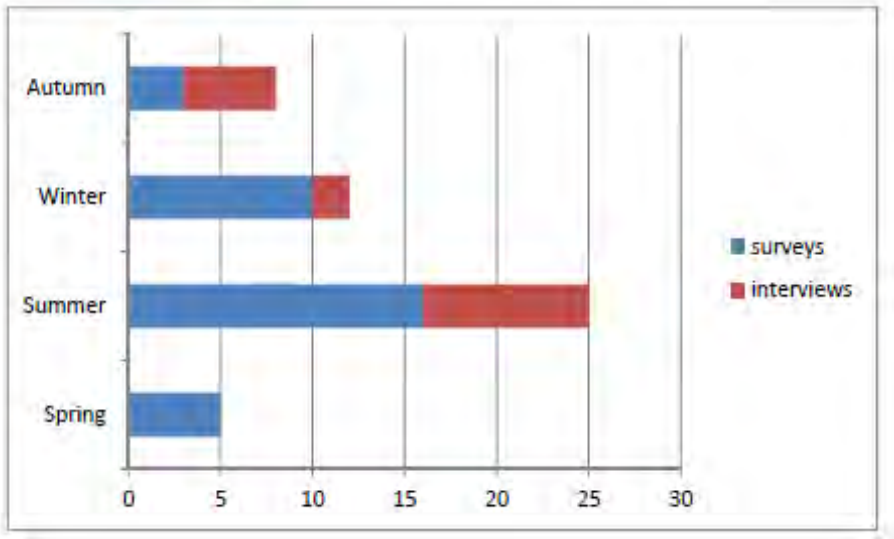


Chart 4 – Who do/did you visit in the Clinton Creek area? (Please select all that apply.)

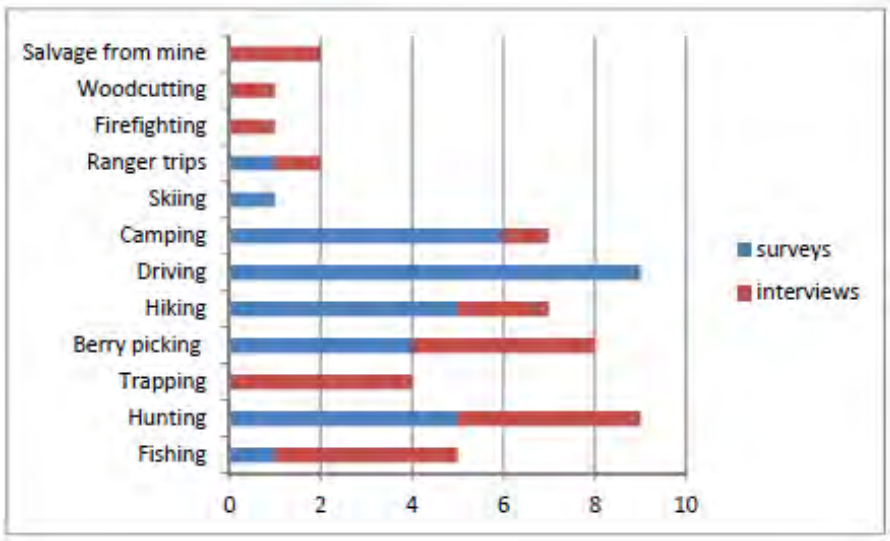


Chart 5 – How do you access the area? (Please select all that apply.)

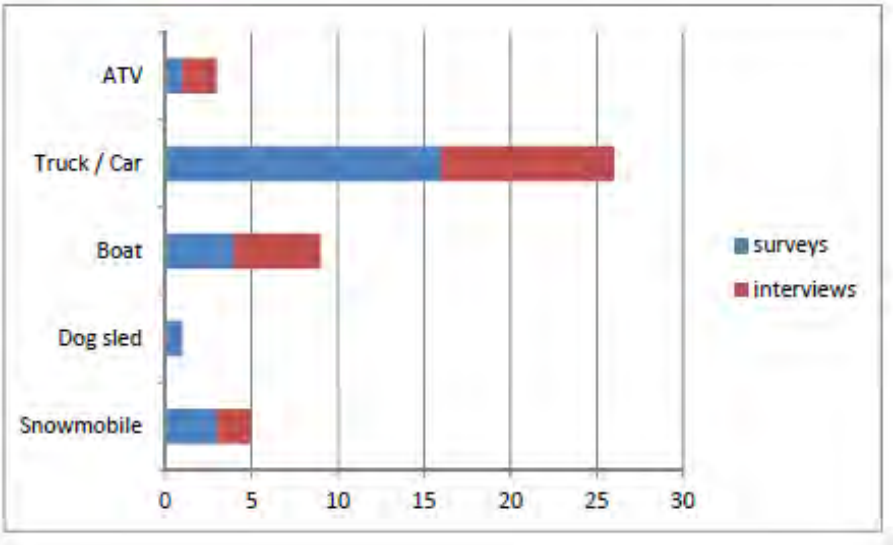
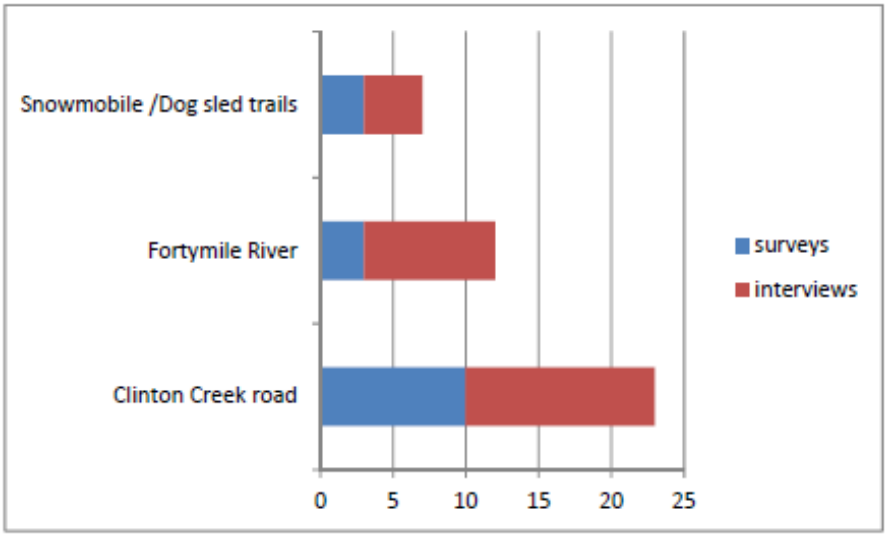


Chart 6 – Which routes do you access? (Please select all that apply.)



In addition, the following survey questions and responses are particularly relevant to the access limits issue:

14. How would you like to use the Clinton Creek site in the future? (from survey forms)

- Recreation, historical/cultural interpretation. Use of natural resources (hunting, fishing, foraging).
- The same as I am doing now just visit the area and enjoy the scenery it holds.
- Camping/hunting.
- I'd like to be able to continue to visit. I don't have any ideas for development.
- N/A.
- Not planning on it.

- Would like to walk around and see where we all lived.
- Stabilize Hudgeon Lake and let the rest grow back.
- Not sure.
- Same.
- Tourism, wilderness trips.
- Move back [in] the future.
- Would like to keep working at the [Forty Mile] Heritage Site and maybe overwinter some time.

15. How would you like to access the Clinton Creek site in the future? (from survey forms)

- Would like to clear out the Percy de Wolfe trails and put in a system of warming huts between Dawson and 40 Mile Road.
- Continued maintenance of roads and bridges.
- I hope to continue visiting and camping in Forty Mile.
- I enjoy the canoe trip, and the drive, and would like to try and visit by snowmobile and/or skiing at some point in the future.
- Same as now, just a casual Sunday drive.
- Road/river.
- By road.
- Road.
- Not applicable – if I did, it would be by road.
- Via road.
- It's important to keep Clinton Creek road open as well as the Fortymile Bridge.
- Road.
- By road.
- Road and Fortymile River.
- By road and land and rivers.

DRAFT

These survey outcomes lead to the following general observations on the relationships between the access limits described in Section 4.1 and current community perspectives on Clinton area land use.

- About a third of survey participants reported visiting the area as frequently as several times annually (i.e., 10 of 28).
- Use of the Clinton lands encompasses both the former mine site itself and adjacent local areas, specifically Fortymile River, the Fortymile historic site (former Town Site) and the Clinton Creek Road (i.e., mine site access road). Visits to the mine site proper were reported by about a half of responding participants (i.e., 14 of 28).

- The survey data does not identify which specific areas of the mine site are visited most often (i.e., Clinton vs. Wolverine sides of the property). However, the predominant on-site uses listed in Chart 4 describe activities that are more likely to be focused on the Clinton side of the property (i.e., these activities are generally not compatible with the current conditions and/or characteristics of the Wolverine tailings).
- The mine site access road is the predominant route for visiting the property.
- The large majority of area visits occur in the summer and shoulder frost free seasons.

It should be noted that the total number of visits recorded in the above charts do not capture the total count that could be visiting the Clinton area. However, the nature of the survey was such that participation was likely biased towards those with a need and/or desire to access the area, so the resulting counts likely provide some measure of the general range of regular visits. These overall numbers suggest that the total annual person-visits to the mine site itself are likely to be modest and focused predominantly on the Clinton side of the property, not directly on or adjacent to the Wolverine tailings. The survey results also suggest that current uses align broadly with Wood's observation (Section 4.1) that management of the site, in the absence of measures applied to mitigate liquefaction risks, will require highly restrictive limits to public access and occupancies on and immediately downgradient of the Wolverine tailings. Restrictions would also be required on the Clinton waste dump, but of a nature and scale that are not clearly disconnected to public expectations regarding future use of the dump areas.

4.6 Land Access Cost Benefit Assessment

One of the key objectives of the current work was to provide more clarity on the specific nature and scope of limits to land use that would be associated with both the status quo and some of the candidate closure options. As part of concept select deliberations, it will be useful to contrast these limits in land utility against the economies in closure costs that they may provide. This will allow for at least a preliminary assessment of the land utility cost benefits associated with the current schedule of candidate closure options.

DRAFT

Table AL-3 provides a representation of that cost benefit evaluation based on the results of the access limits assessment developed under this scope and the cost estimates for the candidate options prepared previously (Wood, 2019a, 2020). Descriptions of the columns and related content of this table are as follows:

- Options: the list of base case (i.e., 10%) and Alternate Designs described in Wood (2019) and Wood (2020), respectively.
- Access Limits: identifies the maps and/or figures in this document that show the areal limits to access associated with the status quo and the Alternate Designs. Recall that a key project assumption is that there will be no limits to access for the base case designs because their design criteria were specifically selected and/or defined to mitigate the need for these restrictions. Again, this does not mean that there are no safety risks associated with these options, but rather that the risks they carry fall below thresholds that would require restrictions.
- Allowable Occupancies: these columns bring forward the estimated limits to time spent within the limit boundaries that are presented in Table AL-2 and rationalized in Section 3.6, for both seismic and hydrotechnical events. Similar to Table AL-2, Table AL-3 distinguishes between events for which there would be no warning, and those which would be preceded by an indicative event or circumstance that would then offer the option of risk mitigation via evacuation.
- Estimated Cost: the most current cost estimate developed for each option as described in Wood (2020).

- Cost Benefit: highlights the reduction in costs over the base case designs that are offered by the Alternate Designs. These cost reduction benefits can be considered relative to the incremental limits to land use that they attract (i.e., in the form of expanded limit boundaries and/or reductions in the allowable time spent on-site).

The following general observations can be offered based on the content of Table AL-3:

- The table reiterates previous conclusions that the base case designs (excluding WC1, which is largely the status quo) provide for more or less unlimited access to the Clinton lands, but at substantial costs. Indeed, this was the finding that precipitated development and consideration of the Alternate Designs.
- The Alternate Designs provide modest improvements to land utility and access that could be described as incremental at best. It seems unlikely that these modest, incremental benefits would in themselves justify the still substantial costs associated with the Alternate Designs.
- The limited land utility and access benefits that the Alternate Designs provide do not diminish the other beneficial characteristics and features of these options. While these designs do not offer complete mitigation of seismic impacts, they do provide more robust slopes and hydrotechnical features that will reduce long term monitoring and maintenance liabilities related to the property.

DRAFT

Table AL-3 - Clinton Creek Data Gaps Scope - Comparative Land Access Cost Benefit Assessment

Option		Representation of Access Limit Boundary		Allowable Annual Individual Occupancy Within Limit Boundary (days)		Estimated Cost ($M)	Alternate Design Cost Benefit Relative to Base Case ($M)
Base Case (10% Design)	Alternative Designs	Seismic Events	Hydrotechnical Events	Seismic Events	Hydrotechnical Events		
Clinton							
Status Quo		Appendix B, Figure AL-2	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	27	55	Not Estimated	
CC1				No Limit	No Limit	$310,000,000	
	CC1-A	Appendix B, Figure AL-2	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	27	55	$130,000,000	$180,000,000
	CC1-B	Appendix B, Figure AL-2	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	27	55	$130,000,000	$180,000,000
CC2				No Limit	No Limit	$197,000,000	
	CC2-A	Appendix B, Figure AL-2	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	27	55	$150,000,000	$47,000,000
	CC2-B	Appendix B, Figure AL-2	Dam Breach Appendix - Figures A1 to A4 (Scenario 4)	27	55	$180,000,000	$17,000,000
CC3				No Limit	No Limit	$290,000,000	
Wolverine							
Status Quo		Appendix B, Figure AL-3	Dam Breach Appendix - Figures F1 to F4 (Scenario 2)	1-4	5	Not Estimated	
WC1		Appendix B, Figure AL-3	Dam Breach Appendix - Figures F1 to F4 (Scenario 2)	1-4	5	$50,000,000	
WC2				No Limit	No Limit	$300,000,000	
	WC2-A	Appendix B, Figure AL-3	Dam Breach Appendix - Figures F1 to F4 (Scenario 1)	1-4	24	$120,000,000	$180,000,000
WC3				No Limit	No Limit	$260,000,000	

Color Coding

No Event Warning
Short Event Warning (Days)
Long Event Warning (Weeks)

5.0 Closure

This report is based on circumstances and conditions available at the time of writing. Wood has performed its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing in Alberta and British Columbia at the time that the services were performed.

Wood trusts that this report meets your current needs. Should you have any questions or require further clarification, please contact the undersigned at your convenience.

Sincerely,

Wood Environment and Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

R. Brian Geddes, P.Eng.
Principal Engineer

Reviewed by:

DRAFT

Geoff Graham, P.Eng.
Associate Water Resources Engineer
(Hydrotechnical)

Ed McRoberts, Ph.D., P.Eng.
Principal Geotechnical Engineer
(Geotechnical)

6.0 References

Calian Emergency Management Solutions (Calian). 2017. *Hazard Identification and Risk Analysis*. Prepared for the City of Whitehorse. December 2017.

Canadian Dam Association (CDA). 2013. *Dam Safety Guidelines 2007 (Revised 2013).* Section 6, Analysis and Assessment.

Canadian Dam Association (CDA). 2019. Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2019 Edition.

Dobrowolsky, H and A. Winton. 2017. *Clinton Creek Cultural Research and Oral History Project*. Prepared for the Tr'ondëk Hwëch'in, Land and Resources Branch. March 2017.

Government of Yukon (Yukon). 2019. *Motor Vehicles in Yukon: A Public Health Perspective.* Office of the Chief Medical Officer of Health (2019).

PlaneCrashInfo (PCI). 2021. *Odds of being involved in a fatal accident.* Downloaded from Accident statistics (planecrashinfo.com). June 2021.

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project 10% Design Phase Report.* Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2019a. *Clinton Creek Remediation Project, 10% Design Phase Cost Estimate*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2020. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

Wood Environment & Infrastructure Solutions. 2021. *Clinton Creek Remediation Project (CCRP) Post 10% Design Services, Kick Off Meeting.* Meeting notes from MS Teams meeting to Discuss Objectives and Milestones for Scope of Work. 22 January 2021.

DRAFT

Attachment A
Table of Contents

DRAFT

wood.

Table of Contents

1.0 Introduction and Scope 1
1.1 Terms of Reference Scope 1
1.2 Scope Development 2
2.0 Risk Management Overview 2
3.0 Access Limits Assessment 3
3.1 Method Overview 3
3.2 Event Scenarios 5
3.3 Risk Scenarios 5
3.3.1 Event Categories 5
3.3.2 Risk Management for "With Warning" Events 6
3.4 Access Limit Boundaries (Event Consequences) 6
3.4.1 Seismic Events 7
3.4.2 Hydrotechnical Events 7
3.5 Event Probabilities 7
3.5.1 Seismic 7
3.5.1.1 Clinton Creek 8
3.5.1.2 Wolverine Creek 10
3.5.1.3 Seismic Loadings Summary 10
3.5.2 Hydrotechnical 11
3.6 Risk Calculations 12
3.7 Risk Benchmarks 15
3.8 Seasonal Influences 15
4.0 Access Limits 16
4.1 Summary Comments and Observations 16
4.2 Influence of HHERA Conclusions 17
4.3 Pit Access Limits 18
4.4 Seiche Events 18
4.5 Current and Anticipated Site Uses 19
4.5.1 Cultural Research and Oral History (CROH) Project Overview 19
4.5.2 CROH Survey Findings 19
4.6 Land Access Cost Benefit Assessment 24
5.0 Closure 27
6.0 References 28

DRAFT

List of Figures

Figure AL-1: Seismic Hazard Clinton Creek Peak Acceleration for Return Period 9
Figure AL-2: No Warning Zones for Seismic Triggering of Clinton Creek Waste Rock Dumps
Figure AL-3: No Warning Zones for Seismic Triggering of Wolverine Creek Tailings Piles

List of Tables

Table AL-1: Seismic Loading Summary by Design Scenario 11
Table AL-2: Clinton Creek Data Gaps Scope – Access Limits Risk Predictions 14
Table AL-3: Clinton Creek Data Gaps Scope - Comparative Land Access Cost Benefit Assessment 26

Table of Contents (cont'd)

List of Attachments

Attachment A: Table of Contents
Attachment B: Seismic Event Boundaries

DRAFT

Attachment B
Seismic Event Boundaries

DRAFT

wood.

511000 512000 513000 514000

7148000

7147000

7146000

Hudgeon Lake

Clinton Creek Site Access Road

Clinton Creek

Snowshoe Pit

Creek Pit

Porcupine Pit

Existing Slide Hazard Area
Residual Hazard Area (Options CC1A/B, CC2A/B)
Existing (Status Quo) Pit Hazard Areas
Roads

R:\General\PROJECT\VE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig AL-2 CC HA.mxd ANALYST: trevor.robertson 21-09-27 5:39:16 PM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Note: Pit Hazard Area triggers have not been identified and are not necessarily limited to seismic events.

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

No Warning Zones for Seismic Triggering of Clinton Creek Waste Rock Dumps

0 100 200
Metres
1:10,000

N

wood.

September 2021

Figure AL-2

513000

514000

515000

7148000

7147000

Hudgeon Lake

Clinton Creek

Clinton Creek Site Access Road

Porcupine Pit

Creek Pit

Snowshoe Pit

Impact Area Assumed for Status Quo and WC1

Impact Area Assumed for WC2-A

Existing (Status Quo) Pit Hazard Areas

Roads

R:\General\PROJECT\VE\VE52705K - Clinton Creek Post 10% Design Service\13 GIS\Mapping\ArcGIS\Report\Maps\Fig AL-3 WC HA.mxd ANALYST: trevor.robertson 21-09-07 10:39:17 AM

Projection: NAD 1983 UTM Zone 7N
QA/QC: KW TR GG
Sources: Centre for Cadastral Management, Geomatics Canada
- Contains information licensed under the Open Government licence – Yukon, Canada.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Note: Pit Hazard Area triggers have not been identified and are not necessarily limited to seismic events.

Yukon

Yukon Government
Assessment and Abandoned Mines
Clinton Creek Post 10% Design Services

No Warning Zones for Seismic Triggering of Wolverine Creek Tailings Piles

0 100 200
Metres
1:9,000

N

wood.

September 2021

Figure AL-3

Appendix K
Options Integration Assessment

DRAFT

#600 – 4445 Lougheed Highway
Burnaby, BC, V5C 0E4
T: +1 604-294-3811
www.woodplc.com

Memo

To:	Carrie Gillis, Senior Project Manager – Type II Mines
Company:	Government of Yukon-Energy, Mines and Resources Assessment and Abandoned Mines
From:	Brian Geddes
Date:	22 October 2021
CC:	**Wood**: Geoff Graham, Ed McRoberts, Karen Hincks
Ref:	VE52705K.002
Re:	**Clinton Creek Remediation Project – Options Integration Assessment**

This memorandum presents the work undertaken to-date under Wood's scope of work for integration of Clinton Creek and Wolverine Creek options undertaken as an adjunct to the Post 10% Design Services Scope. The Table of Contents for this memorandum is presented herein as Appendix A.

This document incorporates comments on an 11 August 2021 draft received by Wood from the Project Partners. This version is issued as a draft for review by the project's Independent Peer Review Panel (IPRP).

DRAFT

1.0 Introduction and Scope

1.1 Background

The 10% design phase for the Clinton Creek Remediation Project considered three closure concepts for the Clinton Creek side of the property and three for the Wolverine Creek side. These designs and their associated cost estimates were described in Wood (2019) and Wood (2019a), respectively. For the most part as per scope, these concepts were developed and assessed as stand alone closure scopes; there was no detailed consideration of the integration of options for the Clinton and Wolverine valleys into a consolidated closure scope for the property.

The Project Parties concluded that integrating options from the two sides will influence the extent to which project closure objectives are met and therefore evaluation outcomes. Therefore it was determined that integration will require consideration prior to entering the Options Evaluation and Selection process.

1.2 Objectives

Yukon's 14 May 2021 Terms of Reference noted that the objective of this assessment was to integrate conceptual design options for the Clinton Creek and Wolverine Creek sides of the Clinton Creek Mine Site, to assess their compatibility and determine whether there are advantages, efficiencies and drawbacks associated with integration that may have implications on option evaluations against closure objectives.

The work was intended to assist the Project Parties (Tr'ondëk Hwëch'in First Nation (TH), Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), and the Government of Yukon (YG)) gain a more holistic view of mine site closure prior to entering the Options Evaluation and Selection Process.

1.3 Scope of Work

Integrating all three Clinton Creek (CC1, CC2, CC3) options with the three Wolverine Creek (WC1, WC2, WC3) options results in nine possible option combinations, each of which may have its own advantages, efficiencies and drawbacks that could impact evaluations against closure objectives. It may be possible that the integration of particular options results in no advantages or efficiencies; however, this work was not intended to be used to discount or eliminate the combination of options or individual options, or to generate new options. This work was only to assess the implications of combining the current existing options as they are.

Yukon's Terms of Reference specified the following scope tasks:

- Combine Clinton Creek side closure options with Wolverine Creek side closure options for a 3 x 3 matrix or nine different integrated option combinations.
- Assess each combination of options (each "integrated option") for compatibility and to determine whether integrating options results in advantages, efficiencies, or drawbacks that could influence evaluation of the options against the closure objectives. This may include, for example:
    1. Examining how an option selected on one side could influence an option selected on the other side considering, but not limited to: schedule, maintenance requirements, health and safety risks of implementation, materials movement, relative costs, common infrastructure, camp considerations, major construction order considerations, execution considerations, optimization, socio-economics (e.g., job opportunities), etc.
    2. Examining how interactions of the two drainages could influence the selection of a conceptual option through the options evaluation and selection process.
- The matrix shall highlight key advantages, efficiencies, or drawbacks and be supported by a memo that provides supporting details, justification, and reasoning behind the opinions presented in the matrix.

DRAFT

For clarification, the scope does not include:

- Evaluation of the options against the closure objectives.
- Comparison of ranking of integrated options.
- Pre-selection or discounting options prior to the Project Parties' options evaluation and selection process.
- Further definition for the current conceptual options or refinement of cost estimates.
- Detailed execution planning.

While there are nine combinations, the question of whether or nor CC3 is undertaken concurrent with WC3 or essentially consecutively requires specific consideration. In addition, for consecutive execution, there is a significant difference if WC3 essentially precedes CC3 or if WC3 follows CC3.

Note that in addition to the six candidate options described above, there have been variations to these concepts considered as well (Wood 2020). These alternate designs have not been assessed directly in this scope. However, Section 5 of this document provides general comments on how the Alternate Designs would influence options integration issues.

Note as well that this document does not provide descriptions of the nature and scope of the base designs and the alternates. The respective design reports (i.e., Wood 2019 and Wood 2020) should be referenced for these descriptions.

2.0 Methodology

The Options Integration Assessment was undertaken using a matrix to evaluate the various potential option combinations against the criteria specified in the Terms of Reference, and other project criteria and/or issues likely to influence the relative appeal of those combinations. The matrix was developed by consolidating the assessment criteria and the key cost elements from the comparative assessments presented in the 10% design report and the 10% cost estimate, respectively (i.e., Table 8-1 of Wood (2019) and Table 2 of Wood (2019a)) (note that both of these 10% designations refer to the degree of design development, not the variance on the cost estimate). The resulting matrix is presented in Table 1. The construction and application of this table is described in the following:

- The matrix provides a qualitative categorization for each option combination against the range of scope elements and key project issues captured by the matrix.
- The qualitative categorizations have been assigned on the basis of Wood's judgement using a five point scale ranging from 'Significant Positive' to 'Significant Negative'.
- The rationales behind Wood's judgements are described by option and scope element/issue in the following sections. The numbering in these sections align with the numbering in the cells shown in Table 1.
- Generally, the matrix describes the impact of a combination on the characterization of individual options offered previously in the 10% design report and associated cost estimate (i.e., addresses whether or not the combination improves or detracts from how individual closure options were described previously). Those few departures from this general approach to categorization (i.e., those criteria/issues for which the categorization characterizes the combination rather than the individual closure options) are identified in the following text. Typically, these departures apply to the schedule impacts for combinations under which a concurrent execution schedule (i.e., Clinton and Wolverine scopes completed at the same time) reduces the overall timeline for closure operations.

DRAFT

3.0 Categorization Descriptions/Rationalizations

The following sections outline the judgements that Wood applied in assigning the categorizations appearing in Table 1. The numbers under each of the following sections align with those included in Table 1 under each option combination.

3.1 Clinton Options+WC1

Integration issues for combinations involving WC1 will be much less significant than for other options on the Wolverine Creek valley because of the comparatively minor scope of WC1. The civil works associated with development of the WC1 sediment pad (the only significant WC1 scope element) could be readily integrated within an execution plan for the much larger works associated with any of the Clinton options.

3.1.1 CC1 + WC1

1. Categorized as a Minor Positive for WC1 because the relatively short execution schedule required for construction of the WC1 sediment pond could likely be integrated within the longer execution schedule required for the CC1 dump material removal and relocation. The combination would not have a material impact on the overall CC1 execution schedule.

Table 1 - Options Integration Assessment Matrix

Option Combination	Project Execution Elements								Post Closure Performance Outcomes				Post Closure Care and Maintenance			First Nation & Yukon Socio-Economic Benefits	Cost
	Schedule	Mob and Demob	Temporary Facilities and Controls			Civil Works		Mechanical Works	Geotechnical	Hydrotechnical	Environmental	Land Access/Utility	Care & General Maintenance	Repair & Remediation	Monitoring		
			Camp	Access, Roads, Fuel/Power	H&S Controls	Materials Management	Flow Conveyance										
CC1+WC1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CC1																	
WC1																	
CC2+WC1	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
CC2																	
WC1																	
CC3+WC1	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
CC3																	
WC1																	
CC1+WC2	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
CC1																	
WC2																	
CC2+WC2	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
CC2																	
WC2																	
CC3+WC2	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
CC3																	
WC2																	
CC1+WC3 (**Consecutive** Tails/Dump Materials Relocation)	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
CC1																	
WC3																	
CC2+WC3 (**Consecutive** Tails/Dump Materials Relocation)	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
CC2																	
WC3																	
CC3+WC3 (**Concurrent** Tails/Dump Materials Relocation, with WC3 Preceding CC3)	154	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12A	13A	14A	15A	16A	17A
CC3																	
WC3																	
CC3+WC3 (**Consecutive** Tails/Dump Materials Relocation, with WC3 Preceding CC3)	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153
CC3																	
WC3																	
CC3 (First)+WC3 (**Consecutive** Tails/Dump Materials Relocation, with CC3 Preceding WC3)	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153
CC3																	
WC3																	

Legend

- Significant Positive
- Minor Positive
- Neutral
- Minor Negative
- Significant Negative

2. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC1 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC1 scope).
3. Categorized as Neutral because the 10% design and estimate for WC1 assumed that the required camp facility would be developed on-site for other options. This means there is no incremental camp benefit deriving from a combination of CC1 and WC1.
4. Categorized as a Minor Positive for WC1 because concurrent execution with CC1 would produce some efficiencies in the maintenance requirements for on-site roads.
5. Categorized as a Minor Positive for WC1 because concurrent execution with CC1 would produce some efficiencies in the application of general site H&S controls.
6. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC1 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC1 scope).
7. Categorized as Neutral because the combination has no significant impact on the flow conveyance scope for either option.
8. Categorized as Neutral because the combination has no significant impact on the mechanical scopes for CC1.
9. Categorized as Neutral because the combination has no significant impact on the geotechnical outcomes for either option.
10. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC1 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
11. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC1 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
12. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either option.
13. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
14. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC1 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
15. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.
16. Categorized as Neutral because the combination has no significant impact on the local socio-economic benefits offered by either option.

DRAFT

17. Categorized as Neutral because the combination has no significant impact on the estimated cost of either option.

3.1.2 CC2 + WC1

The integration assessment outcomes for the combination of CC2 and WC1 are not materially different from these for the CC1 and WC1 combination. For this reason, the following responses largely follow those provided for the CC1 + WC1 combination.

18. Categorized as a Minor Positive for WC1 because the relatively short execution schedule required for construction of the WC1 sediment pond could likely be integrated within the longer execution schedule required for the CC2 dump material removal and relocation. The combination would not have a material impact on the overall CC2 execution schedule.
19. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC2 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC2 scope).
20. Categorized as Neutral because the 10% design and estimate for WC1 assumed that the required camp facility would be developed on-site for other options. This means there is no incremental camp benefit deriving from a combination of CC2 and WC1.
21. Categorized as a Minor Positive for WC1 because concurrent execution with CC2 would produce some efficiencies in the maintenance requirements for on-site roads.
22. Categorized as a Minor Positive for WC1 because concurrent execution with CC2 would produce some efficiencies in the application of general site H&S controls.
23. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC2 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC2 scope).
24. Categorized as Neutral because the combination has no significant impact on the flow conveyance scope for either option.
25. Categorized as Neutral because the there is no impact on the mechanical scope for CC2.
26. Categorized as Neutral because the combination has no significant impact on the geotechnical outcomes for either option.
27. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC2 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
28. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC2 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
29. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either option.

DRAFT

30. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
31. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC2 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
32. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.
33. Categorized as Neutral because the combination has no significant impact on the local socio-economic benefits offered by either option.
34. Categorized as Neutral because the combination has no significant impact on the estimated cost of either option.

3.1.3 CC3 + WC1

The integration assessment outcomes for the combination of CC3 and WC1 are not materially different from those for the CC2 + WC1 combination. For this reason, the following responses largely follow those provided for the CC2 + WC1 combination.

35. Categorized as a Minor Positive for WC1 because the relatively short execution schedule required for construction of the WC1 sediment pond could likely be integrated within the longer execution schedule required for the CC3 dump material removal and relocation. The combination would not have a material impact on the overall CC3 execution schedule.
36. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC3 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC3 scope).
37. Categorized as Neutral because the 10% design and estimate for WC1 assumed that the required camp facility would be developed on-site for other options. This means there is no incremental camp benefit deriving from a combination of CC3 and WC1.
38. Categorized as a Minor Positive for WC1 because concurrent execution with CC3 would produce some efficiencies in the maintenance requirements for on-site roads.
39. Categorized as a Minor Positive for WC1 because concurrent execution with CC3 would produce some efficiencies in the application of general site H&S controls.
40. Categorized as a Minor Positive for WC1 because the comparatively minor equipment demands for WC1's sediment pond construction could probably be satisfied via efficient management of equipment mobilized primarily for the much larger materials management scope associated with CC3 (i.e., the relatively small WC1 materials management scope could likely be rolled largely within the larger CC3 scope).
41. Categorized as Neutral because the combination has no significant impact on the flow conveyance scope for either option.
42. Categorized as Neutral because the there is no impact on the mechanical scope for CC3.
43. Categorized as Neutral because the combination has no significant impact on the geotechnical outcomes for either option.

DRAFT

44. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC3 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
45. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC3 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
46. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either option.
47. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
48. Categorized as a Minor Positive for WC1 because the stabilization of the waste dumps under CC2 reduces the potential for dump failures and/or spillway degradation to compromise the structural integrity and/or performance of the Wolverine Creek sediment pond.
49. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.
50. Categorized as Neutral because the combination has no significant impact on the local socio-economic benefits offered by either option.
51. Categorized as Neutral because the combination has no significant impact on the estimated cost of either option.

3.2 Clinton Options+WC2

WC2 involves the development of a buttress fill supported by a buttress fill dam and the flow conveyance and drainage structures needed to maintain the structure's integrity and stability. The scope will involve the local relocation (i.e., within the Wolverine Creek valley) of some 2.4 Mm^3 of tailings, the incorporation of about 2.0 Mm^3 of waste dump material into the buttress fill and final tailings cover, and the importation of some 1.5 Mm^3 of select granular materials. Most of the dump material (i.e., about 1.6 Mm^3) will be used in the buttress fill and it has been assumed for this Options Integration assessment that this could be done more or less concurrently with the broader WC2 execution schedule. This would involve redirecting a portion of the dump inventory slated for the PPSS to the Wolverine Creek side of the property. For CC2 and CC3, these proportions are a comparatively small proportion of the dump relocation scope and even for CC1, it represents no more than about a third of the relocated total. It has been assumed therefore that detailed execution planning can produce a largely concurrent schedule that accommodates any specific sequencing requirements in the placement of tails and dump materials in the buttress fill. Further, the tailings cover inventory is only about 0.4 Mm^3 and it was assumed that the requirement for this movement to follow tailings placement will not compromise the general viability of a concurrent schedule.

3.2.1 CC1 + WC2

52. Categorized as a Significant Positive because of the schedule efficiencies inherent in a concurrent execution schedule. The rating for this criterion varies from others in that it reflects outcomes of the combination for the two options collectively. Concurrent options will not materially impact the execution schedules for the individual options but will shorten the project's schedule because the two key work scopes will be completed more or less simultaneously. This categorization assumes that a

DRAFT

concurrent operation does not impose a significant schedule burden on the relocation of waste dump materials from application of the extraordinary asbestos abatement protocols likely required for the tails movements.

53. Categorized as Neutral because there would be a need to simultaneously mobilize equipment fleets to address both the Clinton and Wolverine sides of the property. There would be some operational efficiencies offered by the economies of scale in a larger project fleet but not of a scale that could be reliably predicted as material at this point.
54. Categorized as Neutral because a larger camp sized to accommodate both the Clinton and Wolverine staff/equipment fleets would be necessary. Again, there may be some economies of scale offered by a combined operation but not of a scale likely to be material at this level of project definition.
55. Categorized as a Minor Positive because there would be some minor efficiencies in the development and operation of access infrastructure for a concurrent CC1 + WC2 combination because of the common elements of that infrastructure scope.
56. Categorized as a Minor Negative for CC1 because of the potential for co-application of the relatively intensive tailings asbestos abatement protocols to that portion of the waste dump materials directed to Wolverine Creek rather than the PPSS.
57. Categorized as a Minor Positive because of the potential for realizing operational efficiencies with a larger equipment fleet on-site.
58. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently.
59. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).
60. Categorized as Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
61. Categorized as Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
62. Categorized as Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
63. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).
64. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
65. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.
66. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.

DRAFT

67. Categorized as a Minor Negative because the comparatively high equipment/resource demands of a concurrent schedule may be less compatible with local resource constraints. The reduced execution schedule also means whatever benefits are available would extend over a shorter period. This option combination is not anticipated to have any impact on any of the post closure socio-economic benefits offered by either option.
68. Categorized as Neutral because at this stage of design, estimate and execution planning development is unclear if any cost efficiencies from a shorter schedule and/or larger equipment fleet would be countered by the logistical constraints imposed by the scope and/or the site itself, and/or the larger physical application of the comparatively robust asbestos abatement protocols that a concurrent schedule may required.

3.2.2 CC2 + WC2

69. Categorized as a Significant Positive because of the schedule efficiencies inherent in a concurrent execution schedule. The rating for this criterion varies from others in that it reflects outcomes of the combination for the two options collectively. Concurrent options will not materially impact the execution schedules for the individual options but will shorten the project's schedule because the two key work scopes will be completed more or less simultaneously. This categorization assumes that a concurrent operation does not impose a significant schedule burden on the relocation of waste dump materials from application of the extraordinary asbestos abatement protocols likely required for the tails movements.
70. Categorized as Neutral because there would be a need to simultaneously mobilize equipment fleets to address both the Clinton and Wolverine sides of the property. There would be some operational efficiencies offered by the economies of scale in a larger project fleet but not of a scale that could be reliably predicted as material at this point.
71. Categorized as Neutral because a larger camp sized to accommodate both the Clinton and Wolverine staff/equipment fleets would be necessary. Again, there may be some economies of scale offered by a combined operation but not of a scale likely to be material at this level of project definition.
72. There would be some minor efficiencies in the development and operation of access infrastructure for a concurrent CC2 + WC2 combination because of the common elements of that infrastructure scope.
73. Categorized as a Minor Negative for CC2 because of the potential for co-application of the relatively intensive tailings asbestos abatement protocols to that portion of the waste dump materials directed to Wolverine Creek rather than the PPSS.
74. Categorized as a Minor Positive because of the potential for realizing operational efficiencies with a larger equipment fleet on-site.
75. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently
76. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).
77. Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

DRAFT

78. Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
79. Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
80. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).
81. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
82. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.
83. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.
84. Categorized as a Minor Negative because the comparatively high equipment/resource demands of a concurrent schedule may be less compatible with local resource constraints. The reduced execution schedule also means whatever benefits are available would extend over a shorter period. This option combination is not anticipated to have any impact on any of the post closure socio-economic benefits offered by either option.
85. Categorized as Neutral because at this stage of design, estimate and execution planning development is unclear if any cost efficiencies from a shorter schedule and/or larger equipment fleet would be countered by the logistical constraints imposed by the scope and/or the site itself, and/or the larger physical application of the comparatively robust asbestos abatement protocols that a concurrent schedule may required.

DRAFT

3.2.3 CC3 + WC2

86. Categorized as a Significant Positive because of the schedule efficiencies inherent in a concurrent execution schedule. The rating for this criterion varies from others in that it reflects outcomes of the combination for the two options collectively. Concurrent options will not materially impact the execution schedules for the individual options but will shorten the project's schedule because the two key work scopes will be completed more or less simultaneously. This categorization assumes that a concurrent operation does not impose a significant schedule burden on the relocation of waste dump materials from application of the extraordinary asbestos abatement protocols likely required for the tails movements.
87. Categorized as Neutral because there would be a need to simultaneously mobilize equipment fleets to address both the Clinton and Wolverine sides of the property. There would be some operational efficiencies offered by the economies of scale in a larger project fleet but not of a scale that could be reliably predicted as material at this point.
88. Categorized as Neutral because a larger camp sized to accommodate both the Clinton and Wolverine staff/equipment fleets would be necessary. Again, there may be some economies of scale offered by a combined operation but not of a scale likely to be material at this level of project definition.

89. There would be some minor efficiencies in the development and operation of access infrastructure for a concurrent CC3 + WC2 combination because of the common elements of that infrastructure scope.

90. Categorized as a Minor Negative for CC3 because of the potential for co-application of the relatively intensive tailings asbestos abatement protocols to that portion of the waste dump materials directed to Wolverine Creek rather than the PPSS.

91. Categorized as a Minor Positive because of the potential for realizing operational efficiencies with a larger equipment fleet on-site.

92. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently.

93. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).

94. Categorized as Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

95. Categorized as Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

96. Categorized as Minor positive because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

97. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).

98. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.

99. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.

100. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.

101. Categorized as a Minor Negative because the comparatively high equipment/resource demands of a concurrent schedule may be less compatible with local resource constraints. The reduced execution schedule also means whatever benefits are available would extend over a shorter period. This option combination is not anticipated to have any impact on any of the post closure socio-economic benefits offered by either option.

102. Categorized as Neutral because at this stage of design, estimate and execution planning development is unclear if any cost efficiencies from a shorter schedule and/or larger equipment fleet would be countered by the logistical constraints imposed by the scope and/or the site itself, and/or the larger physical application of the comparatively robust asbestos abatement protocols that a concurrent schedule may required.

DRAFT

3.3 Clinton Options + WC3

The complete restoration option for the Wolverine Creek Valley (i.e., WC3) is the one option that involves the removal and relocation of substantial volumes of tailings material. There are a variety of issues and/or factors that will influence how this tailings relocation operation might be integrated with the Clinton options, all of which involve the relocation of significant volumes of waste dump materials. How these issues are defined and assessed during detailed execution planning will determine if the Wolverine and Clinton relocations are done largely concurrently or consecutively. The key issues and/or factors in this determination will likely be as follows:

- Materials Management Scopes: While the Hudgeon Lake drawdown requirements will influence relocation execution schedules, the critical schedule driver will be the equipment resources required to affect the substantial materials movements involved. The 10% design phase cost estimates assumed substantial equipment fleets that would require multiple years on both creek valleys to complete the required relocations. Execution schedules could be expedited with concurrent relocation options. However, it is not clear that the required scale of the materials management fleet could be efficiently and cost effectively managed given the nature of the respective materials and scopes, and the physical and logistical constraints imposed by the site.
- Tails Disposition Location: The tailings removed from the Wolverine Creek valley could be directed to a dedicated structure developed on the former plant site area west of the valley, a Porcupine Pit Storage Structure (PPSS) or some combination of the two. The 10% design phase estimate assumed all tailings removals are directed to a PPSS and the same assumption has been applied for this Options Integration assessment. This approach seems reasonable given that a second plant site disposition location would increase the footprint of the post closure landscape dedicated to waste disposal, and would create another long term monitoring and maintenance liability. That said, there may be economies offered by the shorter haul distances to the plant site location that merit examination as more detailed execution planning is undertaken.
- Tailings Containment: Wherever the tailings are located, they will need to be sequestered from the environment, both to eliminate the potential for airborne release of asbestos and potentially, to minimize the potential for the movement of fibres and/or tailings contaminants (i.e., metals) via groundwater. In practice, this means that the tailings will need to be placed below, if not all of the waste dump materials, then at least a significant portion of the dump inventory sufficient to create and sustain a stable cover.
- Asbestos Abatement Protocols: Mass movements of the tailings will require the application of robust asbestos monitoring and control protocols throughout the relocation process. These protocols will have significant influences on execution costs and schedules. Asbestos abatement will also be an issue for dump material relocations, but to a lesser extent. There may be some cost and/or schedule penalties associated with concurrent dump and tailings material relocations if, as a consequence, the more elaborate tailings requirements must also be applied to the dump material movements (e.g., for common operations at the PPSS).

At the current level of project and estimate definition, the manner in which these issues will play out as execution planning evolves is not necessarily self evident (i.e., the relative appeal of largely concurrent vs. largely consecutive tailings/dump materials movement operations is not obvious). For the purposes of this Options Integration assessment, it has generally been assumed that materials movements for options involving WC3 will be largely consecutive, with work on the Wolverine side preceding that on the Clinton side.

DRAFT

Two departures from these general assumptions have also been considered. To provide some representation of how concurrent options would impact the outcome, the assessment for the CC3 + WC3 combination has been repeated. Wood would anticipate that the differences presented between consecutive and concurrent materials movement operations for the CC3 +WC3 combination would apply, at least for the most part, to the other Clinton + WC3 combinations. Finally, the scenario in which work on the Clinton side of the property is done before the Wolverine side is considered and included in the Table 1 assessment matrix. Discussion of all of these CC3 +WC3 variants follows.

3.3.1 CC1 + WC3

The CC1 + WC3 combination is similar in many respects to the larger CC3 + WC3 combination in that both involve substantial materials management scopes undertaken consecutively on both sides of the property. This combination differs in that the Clinton portion of the total materials management scope drops to about half of that for the tailings on Wolverine. The comparatively small proportion of dump materials may require careful consideration in detailed execution planning to ensure that adequate dump volumes are available over the course of the schedule to provide adequate cover/containment of the tailings materials at the PPSS. Categorization rationales for this combination are as follows.

103. Categorized as neutral because a largely consecutive materials movement plan for a CC1 + WC3 combination would have a total executive schedule that is essentially the sum of those for each option (i.e., the total execution schedule would extend over a number of years, defined more specially on the basis of more refined lake drawdown plans and the outcomes of more detailed execution planning generally).

104. Categorized as a Minor Positive for CC1 because there would be some minor equipment mobilization efficiencies associated with the CC1 + WC3 combination because equipment used for the Wolverine work could be transitioned directly over to the Clinton scope (i.e., no need for separate Clinton equipment mob/demob).

105. Categorized as a Minor Positive because there would be some minor camp mobilization and occupancy efficiencies related to a CC1 + WC3 combination because there would be no need for a separate camp mobilization for the Clinton work and because of some efficiencies in staff utilization that would come from the small portions of the Clinton and work scopes that could be done concurrently.

106. Categorized as a Minor Positive because there would be some minor efficiencies in the provision of access for a CC1 + WC3 combination because the general site access infrastructure developed for the early Wolverine work would also be used for the Clinton scope.

107. Categorized as Neutral because H&S requirements are largely a function of project duration and a consecutive materials relocation plan will not materially reduce the execution schedule concurrently.

108. Categorized as Neutral because the materials management scopes for the Clinton and Wolverine scopes would be executed more or less independently.

109. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently

110. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).

111. Categorized as a Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

DRAFT

112. Categorized as a Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

113. Categorized as a Minor Positive for CC1 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

114. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).

115. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.

116. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.

117. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.

118. Categorized as a Minor Positive because the consecutive (i.e., not concurrent) execution of these options would produce a comparatively extended schedule that would likely offer greater and/or more extended opportunities for local First Nations contracting resources. This option combination is not anticipated to have any impact on any post closure socio-economic benefits offered by either option.

119. Categorized as a Minor Positive because of the modest efficiencies in equipment mob/demob, camp and site infrastructure costs that the combination would offer. However, these efficiencies would be very modest and would not likely generate economies that could be considered material relative to the combined cost of the options.

DRAFT

3.3.2 CC2 + WC3

The integration assessment outcomes for a CC2 + WC3 combination are similar to those described for the other Clinton + WC3 combinations. The waste dump volumes requiring relocation under CC2 are about half those for CC3; however, the dump relocation scope is still large (roughly comparable to the tailings relocation scope under WC3) and this combination involves the integration of two large materials management scopes. Categorization rationales for this combination are as follows.

120. Categorized as neutral because a largely consecutive materials movement plan for a CC2 + WC3 combination would have a total executive schedule that is essentially the sum of those for each option (i.e., the total execution schedule would extend over a number of years, defined more specially on the basis of more refined lake drawdown plans and the outcomes of more detailed execution planning generally).

121. Categorized as a Minor Positive for CC1 because there would be some minor equipment mobilization efficiencies associated with the CC2 + WC3 combination because equipment used for the Wolverine work could be transitioned directly over to the Clinton scope (i.e., no need for separate Clinton equipment mob/demob).

122. Categorized as a Minor Positive because there would be some minor camp mobilization and occupancy efficiencies related to a CC2 + WC3 combination because there would be no need for a separate camp mobilization for the Clinton work and because of some efficiencies in staff utilization that would come from the small portions of the Clinton and work scopes that could be done concurrently.
123. Categorized as a Minor Positive because there would be some minor efficiencies in the provision of access for a CC2 + WC3 combination because the general site access infrastructure developed for the early Wolverine work would also be used for the Clinton scope.
124. Categorized as Neutral because H&S requirements are largely a function of project duration and a consecutive materials relocation plan will not materially reduce the execution schedule concurrently.
125. Categorized as Neutral because the materials management scopes for the Clinton and Wolverine scopes would be executed more or less independently.
126. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently
127. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).
128. Categorized as a Minor Positive for CC2 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
129. Categorized as a Minor Positive for CC2 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
130. Categorized as a Minor Positive for CC2 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).
131. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).
132. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.
133. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.
134. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.
135. Categorized as a Minor Positive because the consecutive (i.e., not concurrent) execution of these options would produce a comparatively extended schedule that would likely offer greater and/or more extended opportunities for local First Nations contracting resources. This option combination is not anticipated to have any impact on any post closure socio-economic benefits offered by either option.

DRAFT

136. Categorized as a Minor Positive because of the modest efficiencies in equipment mob/demob, camp and site infrastructure costs that the combination would offer. However, these efficiencies would be very modest and would not likely generate economies that could be considered material relative to the combined cost of the options.

3.3.3 CC3 + WC3 (Consecutive Execution)

137. Categorized as neutral because a largely consecutive materials movement plan for a CC3 + WC3 combination would have a total executive schedule that is essentially the sum of those for each option (i.e., the total execution schedule would extend over a number of years, defined more specially on the basis of more refined lake drawdown plans and the outcomes of more detailed execution planning generally).

138. Categorized as a Minor Positive for CC3 There would be some minor equipment mobilization efficiencies associated with the CC3 + WC3 combination because equipment used for the Wolverine work could be transitioned directly over to the Clinton scope (i.e., no need for separate Clinton equipment mob/demob).

139. Categorized as a Minor Positive because there would be some minor camp mobilization and occupancy efficiencies related to a CC3 + WC3 combination because there would be no need for a separate camp mobilization for the Clinton work and because of some efficiencies in staff utilization that would come from the small portions of the Clinton and work scopes that could be done concurrently.

140. Categorized as a Minor Positive because there would be some minor efficiencies in the provision of access for a CC3 + WC3 combination because the general site access infrastructure developed for the early Wolverine work would also be used for the Clinton scope.

141. Categorized as Neutral because H&S requirements are largely a function of project duration and a consecutive materials relocation plan will not materially reduce the execution schedule concurrently.

142. Categorized as Neutral because the materials management scopes for the Clinton and Wolverine scopes would be executed more or less independently.

143. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently.

144. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).

145. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

146. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

147. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

148. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).

DRAFT

149. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.

150. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.

151. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.

152. Categorized as a Minor Positive because the consecutive (i.e., not concurrent) execution of these options would produce a comparatively extended schedule that would likely offer greater and/or more extended opportunities for local First Nations contracting resources. This option combination is not anticipated to have any impact on any post closure socio-economic benefits offered by either option.

153. Categorized as a Minor Positive because of the modest efficiencies in equipment mob/demob, camp and site infrastructure costs that the combination would offer. However, these efficiencies would be very modest and would not likely generate economies that could be considered material relative to the combined cost of the options.

3.3.4 CC3 + WC3 (Concurrent Execution)

154. Categorized as a Significant Positive because of the schedule efficiencies inherent in a concurrent execution schedule. The rating for this criterion varies from others in that it reflects outcomes of the combination for the two options collectively. Concurrent options will not materially impact the execution schedules for the individual options but will shorten the project's schedule because the two key work scopes will be completed more or less simultaneously. This categorization assumes that a concurrent operation does not impose a significant schedule burden on the relocation of waste dump materials from application of the extraordinary asbestos abatement protocols likely required for the tails movements.

DRAFT

155. Categorized as Neutral because there would be a need to simultaneously mobilize equipment fleets to address both the Clinton and Wolverine sides of the property. There would be some operational efficiencies offered by the economies of scale in a larger project fleet but not of a scale that could be reliably predicted as material at this point.

156. Categorized as Neutral because a larger camp sized to accommodate both the Clinton and Wolverine staff/equipment fleets would be necessary. Again, there may be some economies of scale offered by a combined operation but not of a scale likely to be material at this level of project definition.

157. Categorized as a Minor Positive because there would be some minor efficiencies in the development and operation of access infrastructure for a concurrent CC3 + WC3 combination because of the common elements of that infrastructure scope.

158. Categorized as a Minor Negative for CC3 because of the potential for co-application of the relatively intensive tailings asbestos abatement protocols to some or all of the waste dump relocation scope.

159. Categorized as a Minor Positive because of the potential for realizing operational efficiencies with a larger equipment fleet on-site.

160. Categorized as Neutral because the flow conveyance scopes for the Clinton and Wolverine scopes would be executed more or less independently

161. Categorized as Neutral because the combination has no significant impact on the mechanical scope for the Clinton side (there is no Mechanical scope on the Wolverine side).

162. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

163. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

164. Categorized as a Minor Positive for CC3 because the combination eliminates the potential that a post closure failure on the Wolverine side would impact the landscape on the Clinton side (e.g., via failure of the tails that backs up the restored Clinton Creek valley).

165. Categorized as Neutral because the combination has no significant impact on the post closure land utility for either system (i.e., neither side of the property would require any restrictions on land access).

166. Categorized as Neutral because the combination has no significant impact on the post closure care and general maintenance liability for either option.

167. Categorized as Neutral because the design premise for both options assumes no significant post closure repair and remediation liability.

168. Categorized as Neutral because the combination has no significant impact on the post closure monitoring liability for either option.

169. Categorized as a Minor Negative because the comparatively high equipment/resource demands of a concurrent schedule may be less compatible with local resource constraints. The reduced execution schedule also means whatever benefits are available would extend over a shorter period. This option combination is not anticipated to have any impact on any of the post closure socio-economic benefits offered by either option.

170. Categorized as Neutral because at this stage of design, estimate and execution planning development is unclear if any cost efficiencies from a shorter schedule and/or larger equipment fleet would be countered by the logistical constraints imposed by the scope and/or the site itself, and/or the larger physical application of the comparatively robust asbestos abatement protocols that a concurrent schedule may required.

DRAFT

3.3.5 CC3 + WC3 with Clinton Side First

The final entry in Table 1 repeats the consecutive CC3 + WC3 combination but assumes work is done on the Clinton side before that on Wolverine. For most of the matrix criteria and/or scope elements, this does not change the outcomes. However, early work on the Clinton side, and this would largely apply to CC1 and CC2 as well as CC3, does provide relatively expeditious mitigation of one of the most likely, if somewhat less significant risks, that being the potential for degradation of the upper spillway and its associated consequences. On the negative side, doing Clinton first would exacerbate the challenges of ensuring the tailings are properly sequestered and potentially increase the monitoring effort required to ensure this happens. In addition, WC3 requires tailings transport over the Clinton dump materials (unless the current haul road concept is changed substantially. This means that final work on the Clinton side would need to be follow tailings relocations with the attendant inefficiencies in materials management and general project execution infrastructure scopes.

4.0 Summary Comments and Observations

The following summary comments and observations can be offered on the basis of the integration outcomes outlined in the preceding sections.

- One key issue for the development of an integrated property execution plan will be the extent to which options on the Clinton Creek side of the property are run concurrently with those on the Wolverine Creek side. The relative appeal of concurrent versus consecutive operations will be influenced by the required equipment and staff resources, the ability to service those resource requirements locally or regionally, the associated impacts on opportunities for First Nations participation, the locations selected for the disposition of relocated tailings, the need to sequence operations in ways that sequester tailings below relocated waste dump materials, and the influence of asbestos abatement protocols on overall execution efficiencies and costs.
- This issue will be most pronounced if WC3 is selected for the Wolverine Creek valley because of the scale of the associated tailings relocation scope. Table 1 demonstrates that, not surprisingly, concurrent operations for the WC3 option combinations offer a reduced execution timeline but potentially at the expense of local and First Nations socio-economic opportunities, given that resource demands may exceed local capacities and because of the reduced time window for project participation. Table 1 suggests a minor cost benefit offered by a more consecutive execution strategy. However, the resolution provided by the current level of execution planning definition is not sufficient to reliably characterize the cost differences between concurrent and consecutive operations.
- Table 1 suggests that concurrent execution strategies for combinations involving WC2 (the operative assumption for most of this assessment) offer similar benefits and trade-offs (i.e., reduced timelines but more limited local and First Nations socio-economic benefits).
- Integration issues are not as significant for the combinations involving WC1, largely because the very limited WC1 scope could be readily integrated within the much larger Clinton scopes. The categorizations offered in Table 1 for the WC1 combinations should be interpreted with this comparative insignificance in mind (i.e., a slight Positive for a WC1 combination will not be as relevant as the same categorization for combinations and options involving larger materials movements).
- Generally, this first iteration of an Options Integration Assessment for the CCRP offers limited resolution for most of the key execution issues which, in turn, is a reflection of the conceptual nature of the current designs, execution plans/assumptions and their associated cost estimates. The key issues identified in this assessment will require progressive definition and assessment as post 10% project development proceeds.

5.0 Additional Issues/Considerations

5.1 Lake Drawdowns

While the lake drawdowns required on the Clinton side of the property will clearly influence the overall execution schedule, it is less evident that they will have a determining influence on option integration issues. Executing Clinton drawdowns concurrently with works on the Wolverine Creek side could be considered to reduce the overall schedule. However, the concurrent vs. consecutive execution determinations are more likely to be driven by the costs and logistics of the materials management operation rather than any constraints imposed by the Clinton drawdowns. In addition, if any material drawdown constraints did emerge, they could likely be mitigated by scheduling the bulk of drawdown activity prior to the initiation of materials management operations. Again, this would extend the overall execution schedule but that may not be a significant concern if it delivers the key execution benefits of the preferred approach to integration of the Clinton and Wolverine materials management scope.

DRAFT

5.2 Alternative Designs

As noted in Section 1.3, various alternates to the candidate designs were considered for some of the candidate options , specifically CC1, CC2 and WC2. The scope of work for this integration assessment did not call for consideration of these alternates in the Table 1 comparative assessment. However, the following general comments about the potential influence of the alternates on integration considerations are offered.

Among other things, the alternates are distinguished from their respective base design options by the lower materials management scopes that they call for. Summary tabulations of this scope for all of the base and alternate designs are provided in Table 2.

Table 2: Key Materials Movement Volumes for CCRP Closure Alternatives

Option	Creek	Estimated Waste Material or Tailings Removal Volume (m^3)	Waste Material Relocation/Tailings Area
CC1	Clinton	4,373,000	PPSS
CC1-A	Clinton	870,000	To Fill
CC1-B	Clinton	962,000	PPSS
CC2	Clinton	7,097,000	PPSS
CC2-A	Clinton	2,366,000	PPSS
CC2-B	Clinton	4,555,000	PPSS
CC3	Clinton	13,966,000	PPSS
WC1	Wolverine		
WC2	Wolverine	4,312,000	
WC2-A	Wolverine	2,225,000	Local Fill & PPSS
WC3	Wolverine	7,688,000	PPSS

DRAFT

The CC1 alternate volumes are about one-fifth of the CC1 base design, CC2 alternates are about one to two-thirds of base and the WC2 alternate no more than one-half of the base design. These reductions make it more likely that concurrent execution schedules (i.e., undertaking work on the Clinton and Wolverine sides of the property at the same time) can be developed without over-taxing the resource and logistical constraints imposed by local contracting capabilities and/or the physical limitations of the property itself. Concurrent schedules offer the obvious benefit of an expedited delivery of closure outcomes, and at least the potential for some cost efficiencies via economies of scale. These potential benefits are particularly pronounced for the CC1 alternates; a combination of CC1 and WC2-A would invoke a total project materials management scope little more than about two-thirds of the base CC1 scope alone. The possible benefits for the CC2 alternates are less obvious, simply because the materials management scopes are larger than the CC1 alternates. Nevertheless, these CC2 alternate volumes still represent substantial reductions from the base design which, in turn, increase the potential that concurrent operations would be viable, particularly if combined with the alternate for WC2.

One additional comment relating to the potential impact of options integration on post closure land utility can be offered. Combining any of the base designs options on the Clinton side with the alternate for WC2 offers the benefit of limiting post closure site access restrictions (see discussion in Wood 2021 to that side of the property (i.e., the Wolverine tailings) that, by its nature, offers more limited opportunities for post closure land occupation and/or use. Whether this is an integration issue or a concept select consideration is perhaps debatable, but Wood offers the observation nonetheless.

6.0 Closure

This report is based on circumstances and conditions available at the time of writing. Wood has performed its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing in Yukon at the time that the services were performed.

Wood trusts that this report meets your current needs. Should you have any questions or require further clarification, please contact the undersigned at your convenience.

Sincerely,

Wood Environment and Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

R. Brian Geddes, P.Eng.
Principal Engineer

Reviewed by:

Geoff Graham, P.Eng.
Associate Water Resources Engineer
(Hydrotechnical)

DRAFT

Ed McRoberts, Ph.D., P.Eng.
Principal Geotechnical Engineer
(Geotechnical)

7.0 References

Wood Environment & Infrastructure Solutions (Wood). 2019. *Clinton Creek Remediation Project 10% Design Phase Report*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2019a. *Clinton Creek Remediation Project, 10% Design Phase Cost Estimate*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. November 2019.

Wood Environment & Infrastructure Solutions. 2020. *Clinton Creek Remediation Project, 10% Design Phase Alternative Designs*. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. March 2020.

Wood Environment & Infrastructure Solutions. 2021. Memorandum re: *Clinton Creek Remediation Project, Risk Management – Access Limits Assessment*. Submitted to Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. September 2021.

DRAFT

Appendix A
Table of Contents

DRAFT

Table of Contents

1.0 Introduction and Scope 1
1.1 Background 1
1.2 Objectives 1
1.3 Scope of Work 2
2.0 Methodology 3
3.0 Categorization Descriptions/Rationalizations 3
3.1 Clinton Options+WC1 3
3.1.1 CC1 + WC1 3
3.1.2 CC2 + WC1 6
3.1.3 CC3 + WC1 7
3.2 Clinton Options+WC2 8
3.2.1 CC1 + WC2 8
3.2.2 CC2 + WC2 10
3.2.3 CC3 + WC2 11
3.3 Clinton Options + WC3 13
3.3.1 CC1 + WC3 14
3.3.2 CC2 + WC3 15
3.3.3 CC3 + WC3 (Consecutive Execution) 17
3.3.4 CC3 + WC3 (Concurrent Execution) 18
3.3.5 CC3 + WC3 with Clinton Side First 19
4.0 Summary Comments and Observations 20
5.0 Additional Issues/Considerations 20
5.1 Lake Drawdowns 20
5.2 Alternative Designs 21
6.0 Closure 22
7.0 References 23

DRAFT

List of Tables

Table 1: Options Integration Assessment Matrix 4
Table 2: Key Materials Movement Volumes for CCRP Closure Alternatives 21

List of Appendices

Appendix A: Table of Contents