Area Mining Impact Overview Report
Smith Creek Area Structure Plan

Three Sisters Mountain Village
Canmore, AB
Wood File: CG09130

Prepared for:

Three Sisters Mountain Village Properties Limited c/o QuantumPlace Developments Limited

1026 16 AV NW, Suite 203 Calgary, AB T2M 0K6

13-Nov-20

Area Mining Impact Overview Report Smith Creek Area Structure Plan

Three Sisters Mountain Village

Wood File: CG09130

Prepared for:

Three Sisters Mountain Village Properties Limited c/o QuantumPlace Developments Limited
1026 16 AV NW, Suite 203 Calgary, AB T2M 0K6

Prepared by:

Wood Environment & Infrastructure Americas
a Division of Wood Canada Limited
#401, 1925 – 18th Avenue NE
Calgary, Alberta, T2E 7T8
Canada
T: 403-248-4331

13-Nov-20

Copyright and non-disclosure notice

Third-party disclaimer

Form 1
Compliance Certificate

Pursuant to the Canmore Undermining Review Regulation (AR 34/2020), a review of the land described in ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** dated **13 November 2020** was carried out to determine whether the area is suitable for the intended development, ***Smith Creek Area Structure Plan***, having regard to undermining and related conditions. The review was made in accordance with the guidelines established by order of the Minister and accepted professional practice and accordingly includes the investigations considered necessary in the circumstances.

In my opinion, the land described in the above report is considered suitable for the intended development, subject to any mitigative measures outlined in the ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** with respect to the undermining and related conditions.

PROFESSIONAL ENGINEER ALBERTA

2020-11-13

Professional Seal

Municipality: Mississauga
Date: 13 November 2020

PERMIT TO PRACTICE
Wood Environment & Infrastructure Solutions,
A Division of Wood Canada Limited
Signature
Date 13 November 2020
PERMIT NUMBER: P 4546
The Association of Professional
Engineers and Geoscientists of Alberta

THREE SISTERS mountain village

FountainStone Solutions Inc.
Collaborative Solutions For Your Environment

Form 2
Compliance Review Certificate

Pursuant to the Canmore Undermining Review Regulation (AR 34/2020), I have made a review of the ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** dated **13 November 2020** to determine whether the report complies with the guidelines established by order of the Minister and whether the review of the land described in the report was made in accordance with accepted professional practice and accordingly included the investigations necessary in the circumstances.

In my opinion, the ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** complies with the guidelines established by order of the Minister.

In my opinion, the review of the land described in the ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** was made in accordance with accepted professional practice and accordingly included the investigations necessary in the circumstances.

I certify that I did not assist in the preparation of the ***Area Mining Impact Overview Report Smith Creek Area Structure Plan*** and I am not associated with or employed by the individuals or firm that prepared the undermining report.

PROFESSIONAL ENGINEER OF ALBERTA
2020-11-13

Professional Seal

Municipality: Cochrane, Alberta
Date: November 13, 2020

PERMIT TO PRACTICE
FOUNTAINSTONE SOLUTIONS INC.
RM SIGNATURE:
RM APEGA ID#: M54055
DATE: 2020-11-13
PERMIT NUMBER: P13007
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Executive Summary

This Area Mining Impact Overview Report has been undertaken by Wood Environment & Infrastructure Americas, a Division of Wood Canada Limited (Wood) for Three Sisters Mountain Village Properties Limited (TSMVPL), care of QuantumPlace Developments Limited (QPD) as required by *Alberta Regulation 34/2020*. The work includes assessing the proposed Smith Creek Area Structure Plan (ASP) for undermining considerations and is the first stage in the development process. The proposed Smith Creek ASP is located in Canmore, Alberta.

Due to the history of coal mining in and around Canmore, the Province of Alberta had previously published *Alberta Regulation 114/97*. QPD advised that as a part of the review of the Municipal Government Act undertaken by the Province of Alberta between 2012 and 2020, TSMVPL had requested that the 114/97 regulations and associated guidelines be updated to reflect over 20 years of experience accumulated within the regulated area, and to better align the regulations with the stages of planning approvals to provide improved clarity of process to TSMVPL and the public. QPD, the Town of Canmore and the Province of Alberta worked to prepare new guidelines and regulations which led to the Province of Alberta publishing the new *Alberta Regulation 34/2020* dated 17 March 2020 (AR 34/2020) concerning development on undermined lands so that risks from surface and underground mines can properly be considered and mitigated as appropriate. In addition to the Regulations, a new set of guidelines titled "*2020 Guidelines to Evaluate Proposed Development Over Designated Undermined Lands in the Town of Canmore, Alberta* dated 01 April 2020" (the Guidelines) that reflected current practice and modern risk considerations was also approved by the Province for use. This Area Mining Impact Overview Report has been prepared using the 2020 Regulations and Guidelines.

The work included reviewing the following items: LiDAR, orthophotos, Canmore coal mine plans and boreholes in the Alberta Energy Regulator database, Canmore bedrock geology maps, proposed land uses and conceptual roads and buildings locations for Smith Creek ASP, boreholes, surveys completed for TSMVPL and others throughout the ASP area, and existing undermining and inspection reports for the area written by others spanning back for over 20 years.

Using data from multiple sources a simple internal model for the underground mine workings was created by Wood, which allowed for the mine workings to be reviewed quickly in relation to observed features. This model could be updated for modelling at more detailed stages of undermining reports as outlined in AR 34/2020.

Areas of interest, based on previous mining, previous work by other consultants, LiDAR review and orthophotos were visited on the ground as part of a two-day site reconnaissance program. During the site visit, over 35 km were walked across the site by Wood personnel trained and experienced in identifying ground surficial expressions of potential impacts of undermining and condition assessments of former portals, shafts, exploration works and other mining features. Photographs, GPS points and tracks, along with notes on potential subsidence features were collected.

Historical documentation and the site reconnaissance both indicate that there are no known surface or underground coal mines within the Smith Creek ASP area. The entire ASP area has been classified as Zone 1 based on the potential for subsidence or sinkholes and associated potential damage to structures. Zone 1 is defined as:

- Zone 1 Green: no structural or ground mitigation required for development. These are areas that have not been undermined or are located above the midpoint of broad de-pillared areas with expected uniform settlement.

In the case of the Smith Creek ASP area, the former applies, as no undermining has taken place beneath the ASP area.

While zone classification or boundaries in undermined areas can change location or hazard rating as additional investigations are conducted and more information is available, no change is anticipated within the Smith Creek ASP, and no additional undermining investigation is required for this area..

There are hazards within the 500 m public safety assessment area, including undermining and portals. The planned wildlife fence which will surround the ASP area will serve to keep wildlife from entering the ASP area, and keep humans away from safety risks that may be present from undermining hazards south of the Smith Creek ASP area.

During more detailed planning stages such as conceptual scheme, land use or subdivision applications, changes to the preliminary hazard zone assessment map for the Smith Creek ASP area are not anticipated based on the information presented herein. Subject to more detailed work within future Project Undermining reports, development within Zone 1 may generally proceed without need for ground or structural mitigation to address undermining considerations.

At three locations, there are proposed pedestrian access gates leading to proposed designated trails. Due to proximity to undermined works, Project Undermining Reports are recommended for two of the trails to assess potential risks and possible mitigation for safe public trail use.

A compliance certificate in accordance with AR 34/2020 is enclosed within this report.

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

Wood Environment & Infrastructure Americas, a Division of Wood Canada Limited (Wood), is pleased to submit this report to Three Sisters Mountain Village Properties Limited (TSMVPL), care of QuantumPlace Developments Limited (QPD). This work was completed in fulfillment of the Work Order countersigned on 23 September 2020, supported by the Master Services Agreement dated 18 June 2020.

It is understood that TSMVPL has prepared for Smith Creek a draft Area Structure Plan (ASP) to provide guiding policy for future development within the ASP area. The location of the Smith Creek ASP is south of the Trans-Canada Highway (Highway 1) as shown in **Figure 1**. This figure also shows the proposed site in relation to Canmore and nearby surrounding development. The proposed development plan incorporates a variety of structures and usages, including:

- Residential areas;
- Open space and recreation areas;
- Flex commercial – industrial district;
- Stormwater ponds;
- Sediment retention area; and
- Various connecting roads and utilities.

The Land Use Map for the Smith Creek ASP is shown in **Figure 2**. **Figure 3** and **Figure 4** show the conceptually proposed development overlain on orthophoto and LiDAR backgrounds, respectively.

This report is intended as a preliminary assessment of potential undermining hazards associated with the area structure plan and is the first of many reports that are required by the Guidelines prior to site development. During more detailed planning stages such as conceptual scheme, land use or subdivision applications, the preliminary hazard zone assessment map will be updated and refined as needed, as outlined in the Guidelines. More detailed work within the future Subdivision Mining Impact Assessment Reports or Project Undermining reports can include planning with respect to hazards, surface water ponds, as well as borehole drilling, gas detection, and mitigation work, as necessary.

2.0 Background

Coal mining in Canmore began in the late 1800's to support the steam powered transcontinental Canadian Pacific Railway that ran through the Bow Valley. Semi-anthracite and bituminous coal were mined to produce steam for the trains and coke for smelting, respectively, and the production of coal expanded through the First and Second World Wars. In the 1950's the railway began using diesel power instead of steam, lowering the local demand for coal. International demand kept the mines operating until 1979, when the price of coal dropped due to competition and reduced demand, leading to the closure of all coal mines in Canmore.

Due to the history of surface and underground coal mining in and around Canmore, the Province of Alberta had previously published Alberta Regulation 114/97, the Canmore Undermining Review Regulation. QPD advised that as a part of the review of the Municipal Government Act undertaken by the Province of Alberta between 2012 and 2020, TMVPL had requested that the 114/97 regulations and associated guidelines be updated to reflect over 20 years of experience accumulated within the regulated

area, and to better align the regulations with the stages of planning approvals to provide improved clarity of process to TSMV and the public. QPD, the Town of Canmore and the Province of Alberta worked to prepare new guidelines and regulations which led to the Province of Alberta publishing the new *Alberta Regulation 34/2020* dated 17 March 2020 (AR 34/2020) concerning development on undermined lands so that risks from surface and underground mines can properly be considered and mitigated as appropriate. In addition to the Regulations, there a new set of guidelines titled "*2020 Guidelines to Evaluate Proposed Development Over Designated Undermined Lands in the Town of Canmore, Alberta* dated 01 April 2020" (the Guidelines) that reflected current practice and modern risk considerations was also approved by the Province for use. This Area Mining Impact Overview Report has been prepared using the 2020 Regulations and *Guidelines*.

3.0 Scope of Work

The purpose of this project is to develop an Area Mining Impact Overview report for the Smith Creek development according to the *Guidelines*.

The steps outlined in Section B.1 of the aforenamed document specifies the technical evaluation process appropriate for an Area Mining Impact Overview Report, which is to consist of the following:

- Research sources of technical information;
- Geological model and base map preparation;
- Preliminary site reconnaissance and map verification; and
- Preparation of a preliminary hazard zone assessment map.

Subsequent steps to refine the preliminary mapping, where necessary, are outlined in Section B.2 of the Guidelines but are not included within the scope of this report, as they are undertaken during more detailed planning stages such as conceptual scheme, land use or subdivision applications.

4.0 Desktop Study

The desktop portion of this assessment consisted of a review of numerous sources of data provided by QPD and acquired via public sources.

The following reviewed sources are within public domain or were purchased for this specific project:

- LiDAR and Orthophotos from the Town of Canmore, flown in June 2013;
- Canmore Coal Mine Plans from the Alberta Energy Regulator database;
- Canmore Boreholes from the Alberta Energy Regulator database; and
- Canmore Bedrock Geology Map, Geological Survey of Canada, Map 1266A, Scale 1:50,000, dated 1970.

The following sources were provided by QPD:

- Copies of coal mine line work and scans of mine plans from the Alberta Energy Regulator database and Canmore Museum;
- Line work of proposed land uses and conceptual road layouts;
- Borehole logs completed by others;

- Borehole videos and surveys by others; and
- Existing undermining and inspection reports prepared by others for the current site and surrounding areas.

4.1 Surficial and Bedrock Geology

4.1.1 Bedrock Geology

The Canmore area is located in the northern portion of the Cascade Coal Basin, a northwest trending zone that extends approximately 80 km within the Front Ranges of the Rocky Mountains of Alberta. Bedrock at the site consists primarily of the Kootenay Group, a Lower Cretaceous to Upper Jurassic age coal-bearing formation.

Stratigraphically from the bottom up, the Kootenay Group consists of the Morrisey (Weary Ridge, Moose Mtn), Mist Mountain, and the Elk formations. These sedimentary units were deposited within a broad coastal plain environment associated with the Columbia Orogeny. The Mist Mountain Formation, which is up to 1000 m thick, underlies the study area, is comprised of interbedded sandstone, siltstone, mudstone and coal. These units are interpreted as deltaic and/or fluvial/alluvial/plain deposits. Economic coal seams are present throughout the stratigraphic sequence in seams up to 18 m thick (Mossop, 1994).

Within the Mist Mountain Formation, the bedrock units are folded into asymmetric syncline/anticline pairs with fold axes that plunge approximately 10° to the southeast. The northeast syncline limbs generally dip to the southwest at between 10° and 35°, while the southwest limbs of the synclines range from near vertical to overturned. These seams have been repeated by thrust faulting, shear faults, and late-stage extensional faulting. Extensive shearing, structural thinning and thickening have occurred within the core of the folds and act as natural boundaries to the mineable reserves. The repeating seams associated with the faulting have also brought the coal units in the formation within mineable depths from the ground surface.

In general, the coals in the Mist Mountain Formation vary between medium and low volatile bituminous coal and a firm coherent coke. However, in the vicinity of Canmore, high geothermal conditions associated with intrusive activity resulted in high volatile bituminous and semi-anthracitic coals in this area (Mossop, 1994). The general geology of the Canmore area is shown in plan and section on **Figure 5**.

4.1.2 Surficial Geology

Bedrock at the site is overlain by a mix of glacial, alluvial and colluvial deposits, with thicknesses ranging typically between 5 and 30 m. The lowermost layer at the site is glacial till, generally described as competent material consisting of a mixture of clay, silt, sand, gravel, cobbles, and boulders. This is overlain by colluvial materials at or near the base of natural slopes and consists of a mix of materials including till and other sediments, as well as rock debris. The alluvial deposits are typical fan-type highly permeable sands and gravels and are generally located adjacent to active mountain streams.

4.1.3 Groundwater

Groundwater conditions have not been explicitly assessed as part of this study. The groundwater profile generally follows the orientation of the ground surface towards the Bow River. However, local groundwater flow is generally controlled by the underground workings, with multiple studies indicating that the groundwater level typically fluctuates between 1310 and 1316 masl (Jacques Whitford, 2006) at nearby sites.

As there is no mining underlying the Smith Creek ASP area, ground water levels are expected to follow the ground surface and will be confirmed in subsequent phases, as necessary.

4.2 Existing Boreholes

4.2.1 Alberta Energy Regulator Library Boreholes

Boreholes in the Alberta Energy Regulator (AER) Library were drilled between 1967 and 1980 by private companies, often for exploration purposes, and later handed over to the AER library. A total of 12 AER boreholes exist within the study area, which includes the 500 m public safety assessment area around the Smith Creek ASP boundaries. The minimum, maximum and average length of the 12 boreholes was 16.8 m, 161.5 m and 51.4 m, respectively. The locations of the AER boreholes are shown on **Figure 6**; the AER boreholes are all located upslope and to the southwest or just west of the northern portion of the Smith Creek ASP boundary

These boreholes report overburden to range from 3.0 to 29.3 m depth across the site. The overburden is described as clay or clay and gravel.

4.2.2 Other Existing Boreholes

Another 70 boreholes, undertaken for undermining assessment purposes, exist within the ASP study area. The minimum, maximum and average borehole lengths are 10.6 m, 46.7 m and 15.28 m, respectively. These boreholes are also shown on **Figure 6**, and were drilled between 1997 and 2008. These boreholes are also located upslope and to the southwest or just east of the northern portion of the Smith Creek ASP boundary.

These boreholes indicate overburden ranging from zero to 15.9 m thick upslope (*i.e.* southwest) and to the west of the northern ASP area. Little information regarding the thickness of the overburden is known in the south east region of the ASP which has no adjacent borings. Most of the boreholes do not have the overburden descriptor broken down by actual soil type since it is understood that this was not the purpose of these holes; these holes were advanced for the purposes of ground truthing the site, to verify the accuracy of the plans and the seam limits, and to clarify the ground conditions associated with observed hazards.

4.3 Previously Mapped Features

Regular monitoring within the study area and in surrounding areas has been performed on an ongoing basis by other consultants. A total of 884 undermining-related features have been identified within the entire database for the Three Sisters Mountain Village Properties, and 56 of these features are located within the current ASP study area. **Figure 7** shows the location of all features mapped by others within the ASP area and public safety assessment area.

The 56 features within the ASP study are identified as prospect (47), possible prospect (2), surface debris (4), excavation (2) or not identified (1). These terms are described as follows:

- Prospects are areas where a shallow hole or shallow trench was dug to look for coal. In most cases, this shallow hole or trench is less than 1.0 m deep, less than 1 m wide and less than 5 m long (although some are up to 25 m long).
- Possible prospects are depressions in the ground that may be prospects or natural features.
- Surface debris are often locations with potential mining associated debris, such as logs or metal debris.
- The observed excavation is a trench 1.5 m deep, 3 m wide and 6 m long.

- Not identified features are areas identified by others, but no notes are provided as to their source. The not-identified feature is believed to be surface debris due to the identified feature number; the feature location was visited during the site reconnaissance, but nothing of note was observed.

Note that most of these previously mapped features are located outside of the ASP area, and most are not on the TSMVPL property, as shown on Figure 7. Many are also outside of the "designated lands" as identified in Alberta Regulations 34/2020 (as indicated in Schedule 1 / Part 1).

4.4 LiDAR Data and Orthophotos

LiDAR and orthophotos, collected in June 2013, were acquired from the Town of Canmore at the commencement of this investigation. The LiDAR was flown over a total area of 53 km^2 using a helicopter flying at approximately 110 km/h at a height of 500 m on 28 June 2013. The average point density of the LiDAR point cloud was 5.8 points/m^2. The resolution of the orthophoto mosaic was 0.1 m pixels.

The Smith Creek ASP and safety zone was screened for features of note or which might be indicative of undermining or mining activities. Each feature was categorized as features to visit, man-made mounds or depressions. Features related to current infrastructure (i.e. golf course, Thunderstone Quarry, roads, subdivisions), were excluded from the assessment. Generally, the man-man mounds were waste rock piles from mining upslope and outside of the ASP area. Many of the depression areas are prospect areas, portal entrances, or surface mines. Many of these features were visited on the ground as part of the ground reconnaissance for verification, clarification, and categorization. Most of these features are located, as expected, outside of the ASP and on the southwest side of the site where mine workings exist (*i.e.* upslope of the ASP area, and some of which are off of the TSMVPL property).

The results of the preliminary screening work are shown on **Figure 8**.

4.5 Mine Workings

Mining in the Canmore area began in 1886 and continued until the closure of the last mine in 1979, followed by reclamation activities in the region. No known coal mines have been exploited beneath the Smith Creek ASP area. Within the 500 m public safety assessment area, however, there are six mines, as summarized in **Table 1**.

Table 1: Mines Underlying the 500 m Public Safety Assessment Area

Mine Name	Mining Dates	Average Mined Height (m)
Cairnes	1895 – 1974**	2.3
Upper Marsh and Big Seam	1895 – 1974**	2.7
Lower Marsh	1895 – 1974**	2.1
Seam 6	1895 – 1974**	unknown*
Seam 4	1937-1949	2.0
Wilson	1961-1979	3.8

* Mine thickness not legible on various copies of mine drawings.

** Mining dates not known at this time. General dates for Canmore mines shown.

Figure 9 shows a plan view of the individual mined areas relative to the proposed development.

Mining in the region was generally conducted via the room and pillar method, which typically consists of two phases. The first is the development phase, in which a grid of tunnels is created (rooms) separated by a network of pillars. During this phase, the extraction ratio (areal ratio of extracted coal to the initial in situ coal in a seam) ranges from 20 to 40 percent and the pillars are large.

The second phase in room and pillar mining is pillar recovery or the de-pillaring phase, which begins when the development has reached its ultimate minable extent in the seam or area of interest. During this phase, the initial pillars are reduced in size to remove as much coal as practicable. The extent of de-pillaring is a function of the quality of the coal, the rock/mine (*i.e.* roof) conditions, and general economics. De-pillaring can increase the overall extraction ratio to between 50 and 75%. De-pillared areas are more susceptible to subsidence as pillars fail and allow gradual failure and subsidence of the strata above. As no undermining identified is immediately adjacent to the ASP this is not expected to be a concern within the ASP.

4.6 Mine Modelling

For internal purposes, Wood created a simple linework model of the mine workings in the surrounding 500 m public safety assessment area. The model was created using Deswik, a 3-D mine modeling package that permits export to various other software packages. The existing mine scans and mosaics were used to establish the mine linework.

The mine scans were aligned and scaled to the Alberta Township System (ATS) Grid in Deswick. The simple mine linework was then exported as dxf files for use in other packages and in report figures. The 3D model software allows for cross and long sections to be located in plan view, with the software generating the sections automatically.

4.7 Overlap with Existing Developments

Within the 500 m safety public safety assessment area around the ASP there are occupied lands or lands used for utilities and roads. These include:

- Stewart Creek Golf Course
- Hamlet of Dead Man's Flats (Gas Station, Motel, Houses, Businesses, etc.)
- Trans-Canada Highway
- AltaLink Powerline Right-of-Way
- George Biggy Sr Road

It is understood that there are existing controls in these areas against undermining hazards, if applicable. For example, within the Stewart Creek Golf Course, several mine subsidence occurrences are fenced off and demarcated with "no trespassing" signs.

Note that Thunderstone Quarries is also located within the ASP area.

5.0 Field Reconnaissance

5.1 Safety

Prior to accessing the site for the field reconnaissance, a Health and Safety Plan was completed and each day prior to work a Safety Toolbox Talk was completed. The purpose of these two documents is to identify potential hazards and mitigation methods both in advance and on the day of the work, respectively. In

addition, daily COVID-19 declaration assessments were undertaken and submitted to QPD prior to site access.

No safety issues or incidents occurred during the site visits.

5.2 Site Observations from Field Reconnaissance

The purpose of the field reconnaissance was to observe surface features identified during earlier investigations, to visit features identified from the LiDAR, and to identify any new or previously unrecorded surface features observed during the reconnaissance. Surface features were identified in earlier work by Norwest, UMA and Golder, who have previously performed field reconnaissance work within this area.

The Stewart Creek Golf Course and Thunderstone Quarry were both accessed as part of this work to complete the field reconnaissance for these areas. Permission from the operator for access was given in both cases.

Surface features associated with undermining activities can include mine portals, areas of cracking or possible subsidence, mining debris, rock waste piles and exploratory test pits. Mine portals were used as human and equipment entrances to mines, fresh air supply, hauling of supplies, and removal of coal. Portals were surface openings into tunnels called slopes which were inclined, often following the dip of the rock strata. In the field, these features can be readily observed as openings in the ground if they have not been mitigated. Within the ASP there were no observed open shafts or open portals during the field work. It is understood that the portals and shafts within the 500 m public safety assessment area boundary have been mitigated by others, often by placing soil or concrete into the openings. All of the portals that were visited during the site reconnaissance had been mitigated by backfilling the openings. A select few portals showed subsidence behind the backfilled portal entrance with small open voids observed. An example of a larger subsidence occurrence behind a backfilled portal is shown in Photograph 005 in Appendix A, located within the 500 m buffer zone behind the mine portal entrance on the Stewart Creek Golf Course (Feature R19).

Surface expressions that may be related to mining-related subsidence include the presence of depressions, voids or cracks. Features of this type were not observed within the ASP area; however, several were observed within the 500 m public safety assessment area.

Mining debris, rock waste piles and exploratory test pits do not pose an undermining risk to development. There are several exploratory test pits with the ASP area that were visited as part of the field work.

Prior to the fieldwork, Wood representatives had loaded linework showing previously noted features, proposed road alignments, LiDAR and mine plans loaded onto a handheld GPS, which were used to guide the reconnaissance. The GPS tracks of the site reconnaissance are shown on **Figure 10**. Specific notes on significant locations visited and related photographs are provided in **Appendix A**.

Where bedrock outcrops were encountered, the dip and dip direction of the strata were recorded to aid in understanding and mapping the local geology as the mine developments followed the coal seams.

6.0 Assessment

6.1 Surface Hazards

Historical documentation and the site reconnaissance both indicate that there are no known surface coal mines within the ASP area. As such, there are no risks associated with surface hazards due to coal mining within the ASP area.

6.2 Development of Subsidence

Historical documentation and the site reconnaissance both indicate that there are no known underground coal mines within the ASP area. As such, there is no risk of ground subsidence due to coal undermining within the ASP area.

6.3 Preliminary Hazard Mapping

The entire ASP area has been classified as Zone 1 based on the potential for subsidence or sinkholes, and associated potential damage to structures. The preliminary area Hazard Map is shown as **Figure 11**. On the map, Zone 1 is defined as follows:

Zone 1 Green: no structural or ground mitigation required for development. These are areas that have not been undermined or are located above the midpoint of broad de-pillared areas with expected uniform settlement. In the case of the Smith Creek area ASP, the former applies as no undermining has taken place beneath the ASP area.

While zone classification or boundaries in undermined areas can change location or hazard rating as additional investigations are conducted and more information is available, no change is anticipated within the Smith Creek ASP, and no additional undermining investigation is required.

During more detailed planning stages such as conceptual scheme, land use or subdivision applications, changes to the preliminary hazard zone assessment map are not anticipated based on the information presented herein. Subject to more detailed work within future Project Undermining reports, development within Zone 1 may generally proceed without need for ground or structural mitigation to address undermining considerations.

6.4 Hiking Trails

Hiking trails around the Smith Creek ASP will be developed for access to the wilderness areas. These trails will encroach on undermined areas within the 500 m buffer zone around the ASP area. However, it is understood that surrounding the Smith Creek ASP area a continuous Wildlife Fence is planned, which is a boundary to the adjacent Wildlife Corridor. The primary purpose of this fence is to keep wildlife from entering the ASP area, but also serves to keep humans within the ASP area and outside the wildlife corridors. The fence also has the benefit of keeping humans away from safety risks that may be present from undermining hazards south of the Smith Creek ASP area.

At three locations there will be pedestrian access gates to allow humans to pass from the ASP area into the 500 m public safety assessment area along designated trails. Within the 500 m public safety assessment area there are noted to be underground mines. It is understood that there will be three designated trails that will be clearly posted with signs warning humans to remain on the marked trails. None of these three designated hiking trails cross over undermined land. The closest distance between any of the proposed trails and the nearest undermined land is approximately 30 m. A Project Undermining Report is recommended for two of the three identified potential trails to assess potential risks and possible mitigation for safe public trail use. Mitigative measures could include realignment, geotechnical measures or relocation of the trail(s).

Figure 12 shows the wildlife fence, access gates, known underground mines and proposed trails within the 500 m public safety assessment area. The areas recommended for future Project Undermining Report prior to the construction of the proposed trails are also shown.

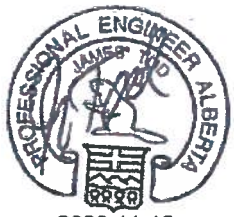
7.0 Closure

This document was prepared for the exclusive use of Three Sisters Mountain Village Properties Limited and QuantumPlace Developments Limited for the specific application described within. It is understood that the ASP is a high-level planning document with a multi-year life span and this report applies for the intent and lifespan of this ASP. It was prepared in accordance with generally accepted engineering practices in the geotechnical consulting industry. No other warranty, express or implied, is made.

Sincerely,

Wood Environment & Infrastructure Americas
a Division of Wood Canada Limited

Per:



2020-11-13

James (Jim) Tod, M.Sc.(Eng), P.Eng.
Associate Rock Mechanics Engineer
Tel: 905-568-2929
Email: james.tod@woodplc.com

Blake Brodland, P.Eng.
Geological Engineer
Tel: 403-387-1981
Email: blake.brodland@woodplc.com

Review by:

Adam Coulson, Ph.D., P.Eng.
Principal Rock Mechanics Engineer
Tel: 905-568-2929
Email: adam.coulson@woodplc.com

PERMIT TO PRACTICE
Wood Environment & Infrastructure Solutions,
A Division of Wood Canada Limited
Signature
Date 13 November 2020
PERMIT NUMBER: P 4546
The Association of Professional
Engineers and Geoscientists of Alberta

8.0 References

Alberta Energy Regulator (AER), Boreholes from various years, within LSD 024-10w5

Alberta Energy Regulator (AER), Mine Plans for Canmore area, file names *CL_MP,2 and CL_MP,1775*

Geological Survey of Canada, Map 1266A, Scale 1:50,000, Published 1970

Jacques Whitford, 2006. *Three Sisters Mountain Village Hydrogeological Assessment, Report No. ABC62520* report prepared for Three Sisters Mountain Village Ltd, May 29, 2006

Mossop, G.D. 1994. Geological atlas of the western Canada Sedimentary Basin, joint publication by the Canadian Society of Petroleum Geologists and the Alberta Research Council, 510 pp.

Town of Canmore. LiDAR and Orthophotos, collected and processed by LiDAR Services International Inc. (LSI), flown June 2013. LiDAR Survey Report issued 12 July 2013.

Numerous internal TSMVPL records, files, are reports by others.

Figures

Image Source: Esri Topographic Map

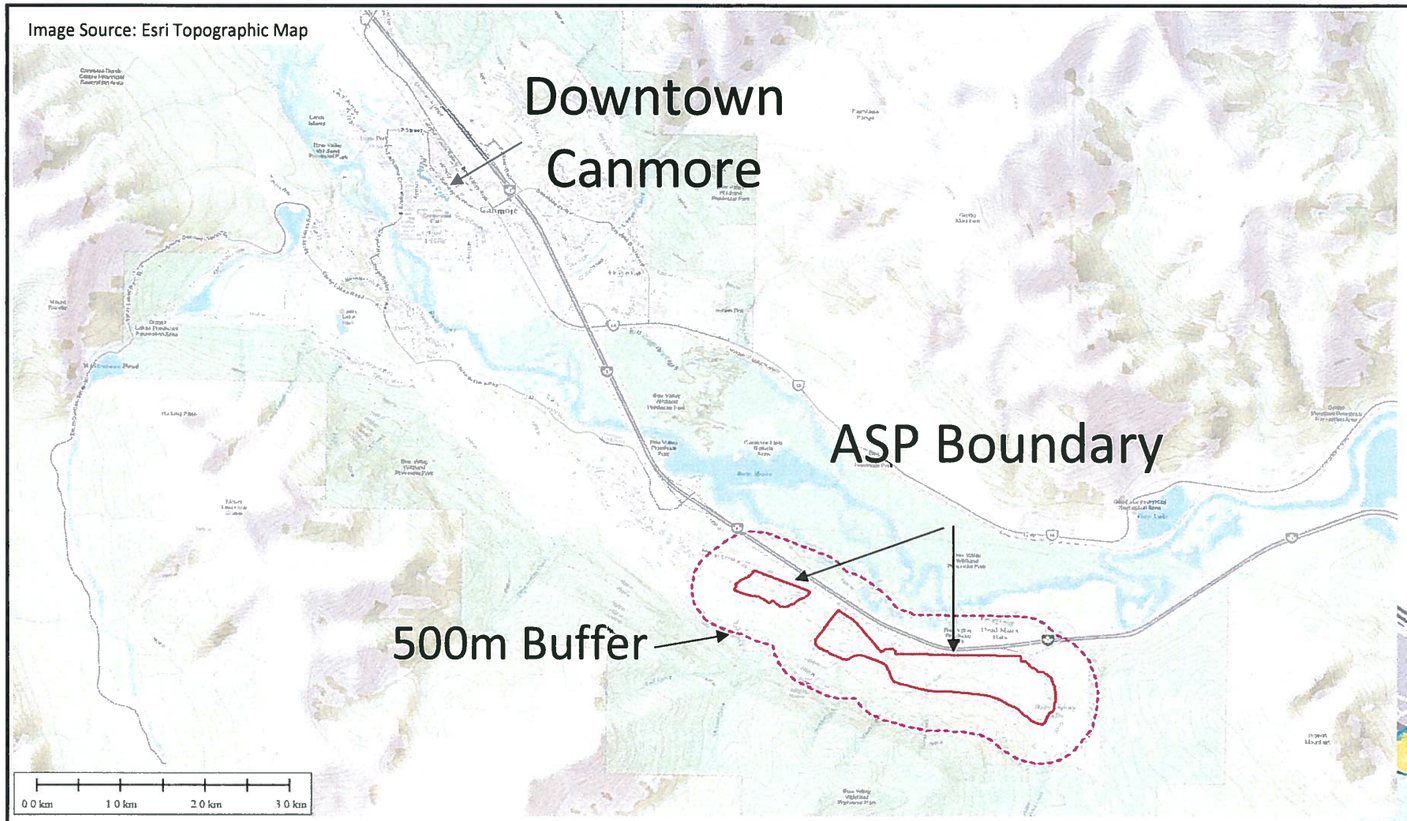
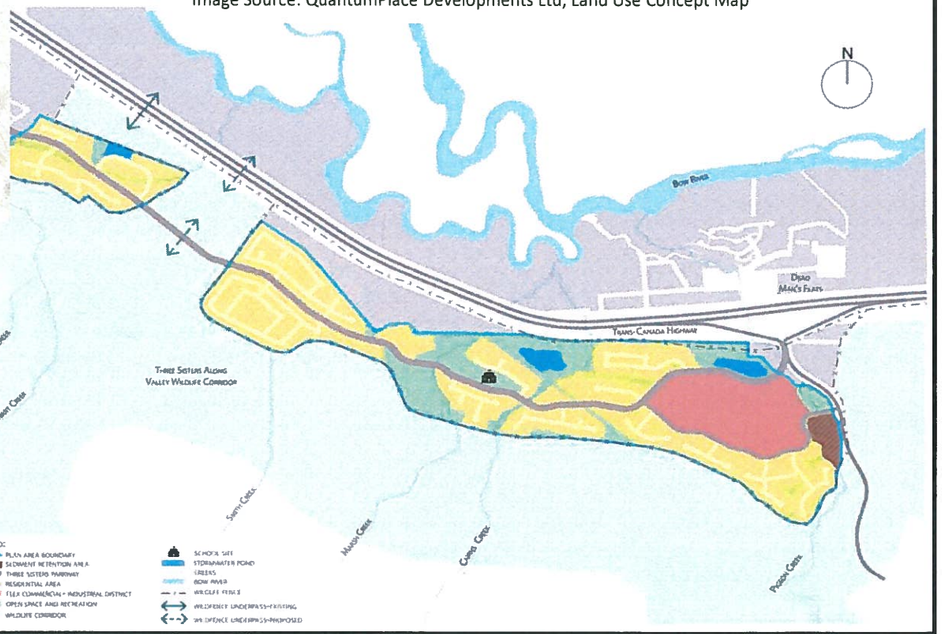


Image Source: QuantumPlace Developments Ltd, Land Use Concept Map



Linework: QuantumPlace Developments 15 September 2020

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Site Location
PROJECT NUMBER	CG09130
FIGURE NUMBER	1
ISSUE/REVISION	1

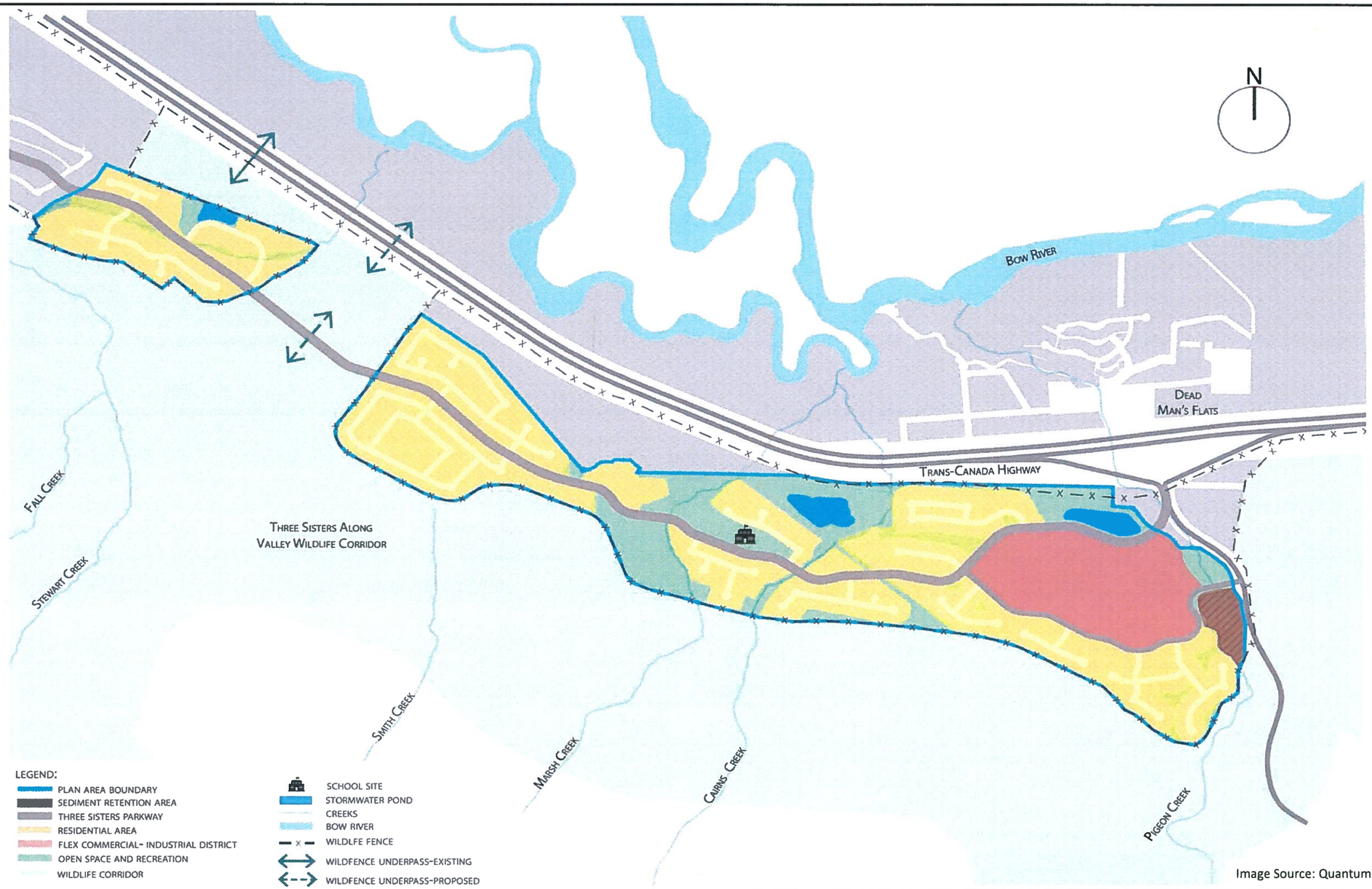
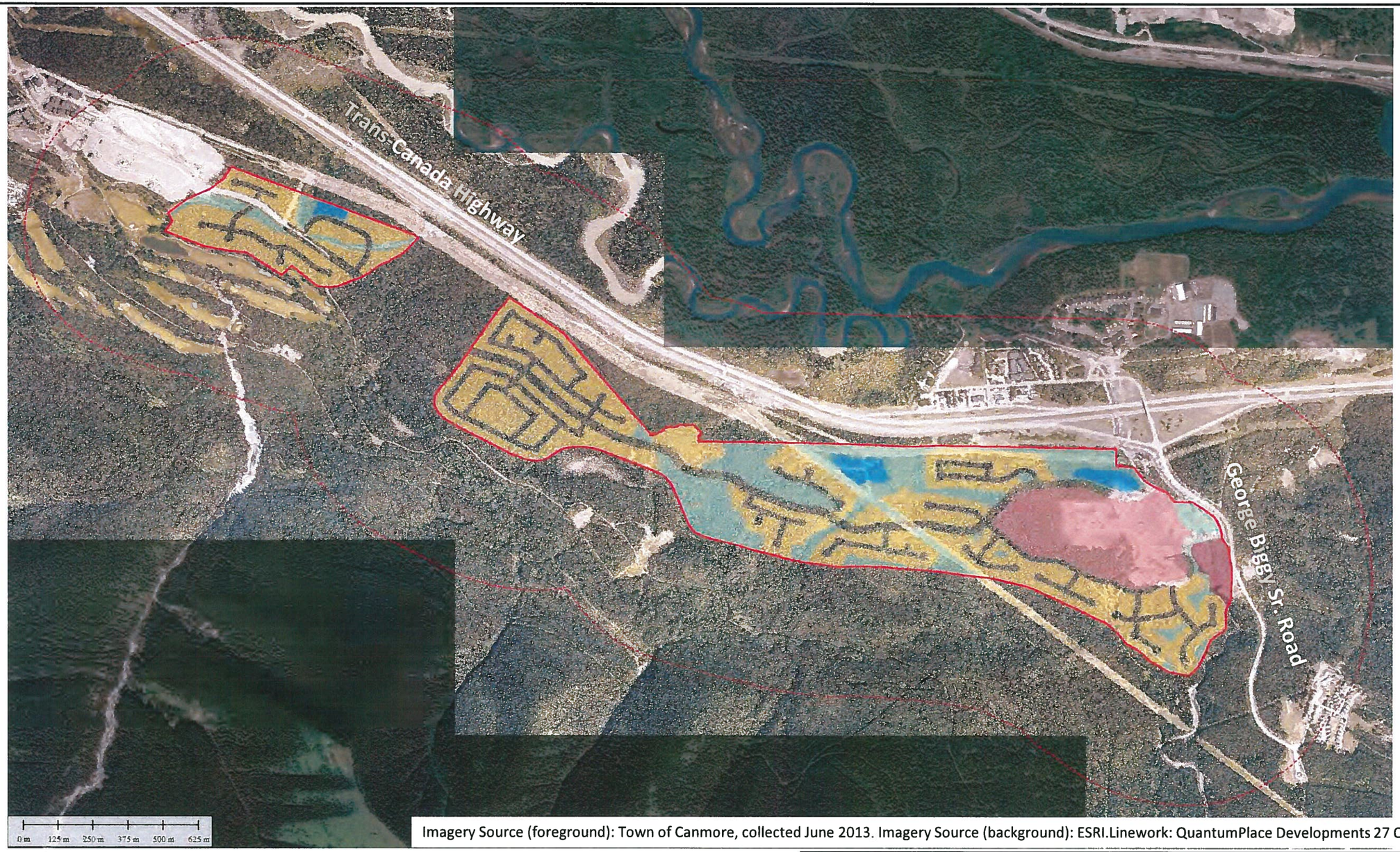


Image Source: QuantumPlace Developments Ltd

wood.	PROJECT NAME: Area Mining Impact Overview Smith Creek ASP	PROJECT NUMBER: CG09130
THREE SISTERS mountain village	SHEET TITLE: Land Use Map	FIGURE NUMBER: 2
		ISSUE/REVISION: 1



N

Imagery Source (foreground): Town of Canmore, collected June 2013. Imagery Source (background): ESRI.Linework: QuantumPlace Developments 27 October 2020

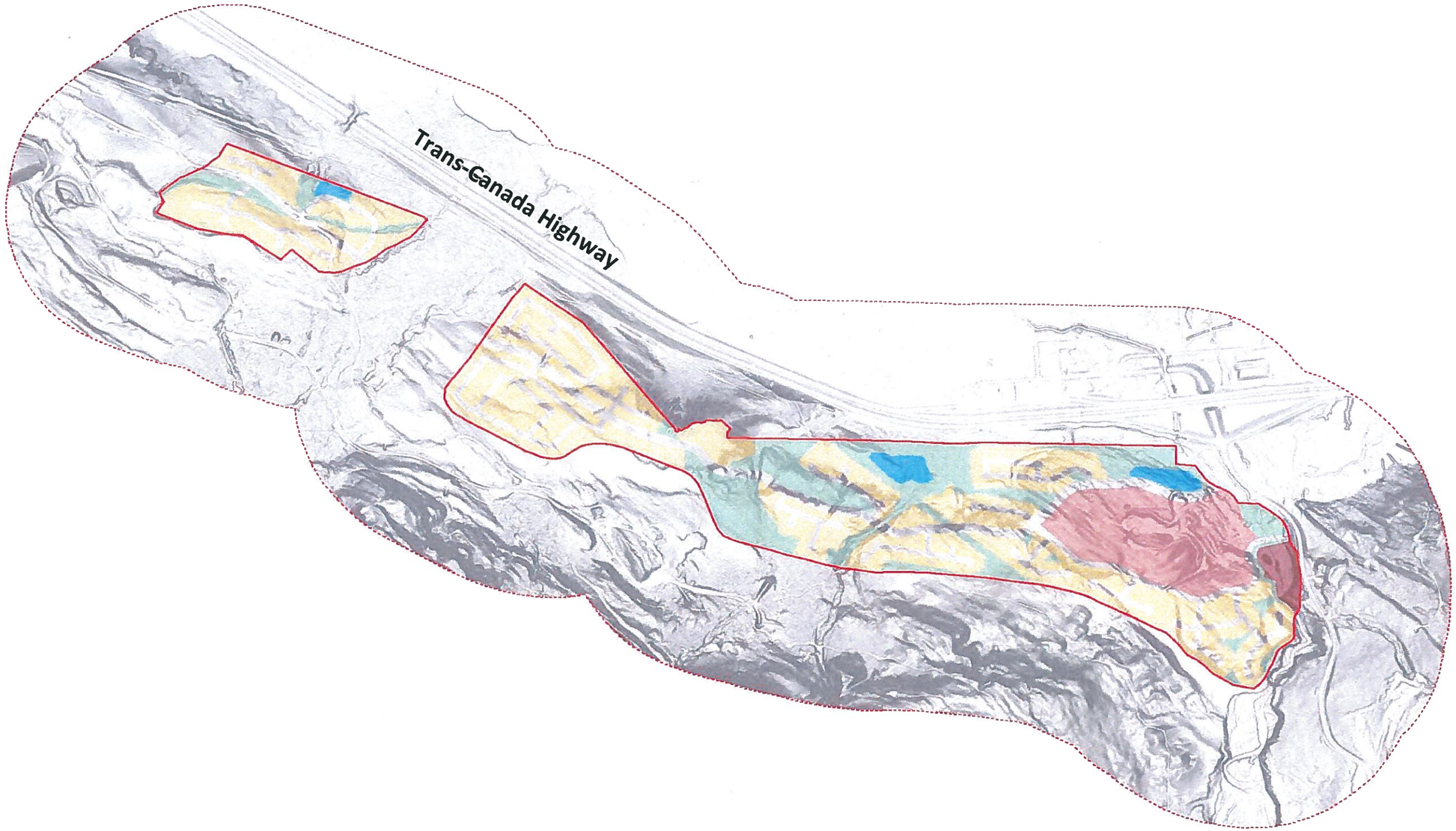
Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- 500m Safety Zone

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Site Overview with Orthophoto
PROJECT NUMBER	CG09130
FIGURE NUMBER	3
ISSUE/REVISION	1



N

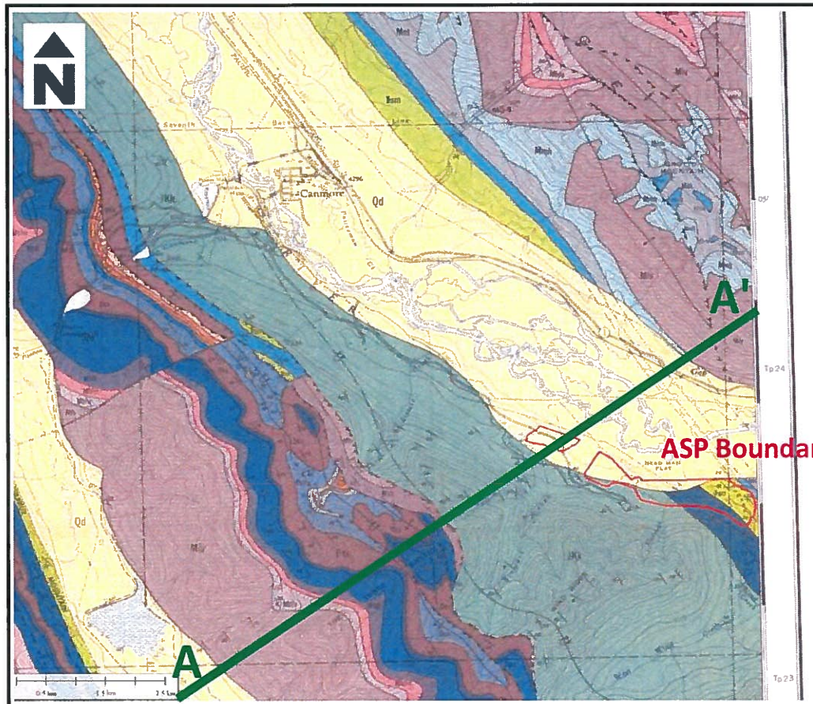
0 m 125 m 250 m 375 m 500 m 625 m

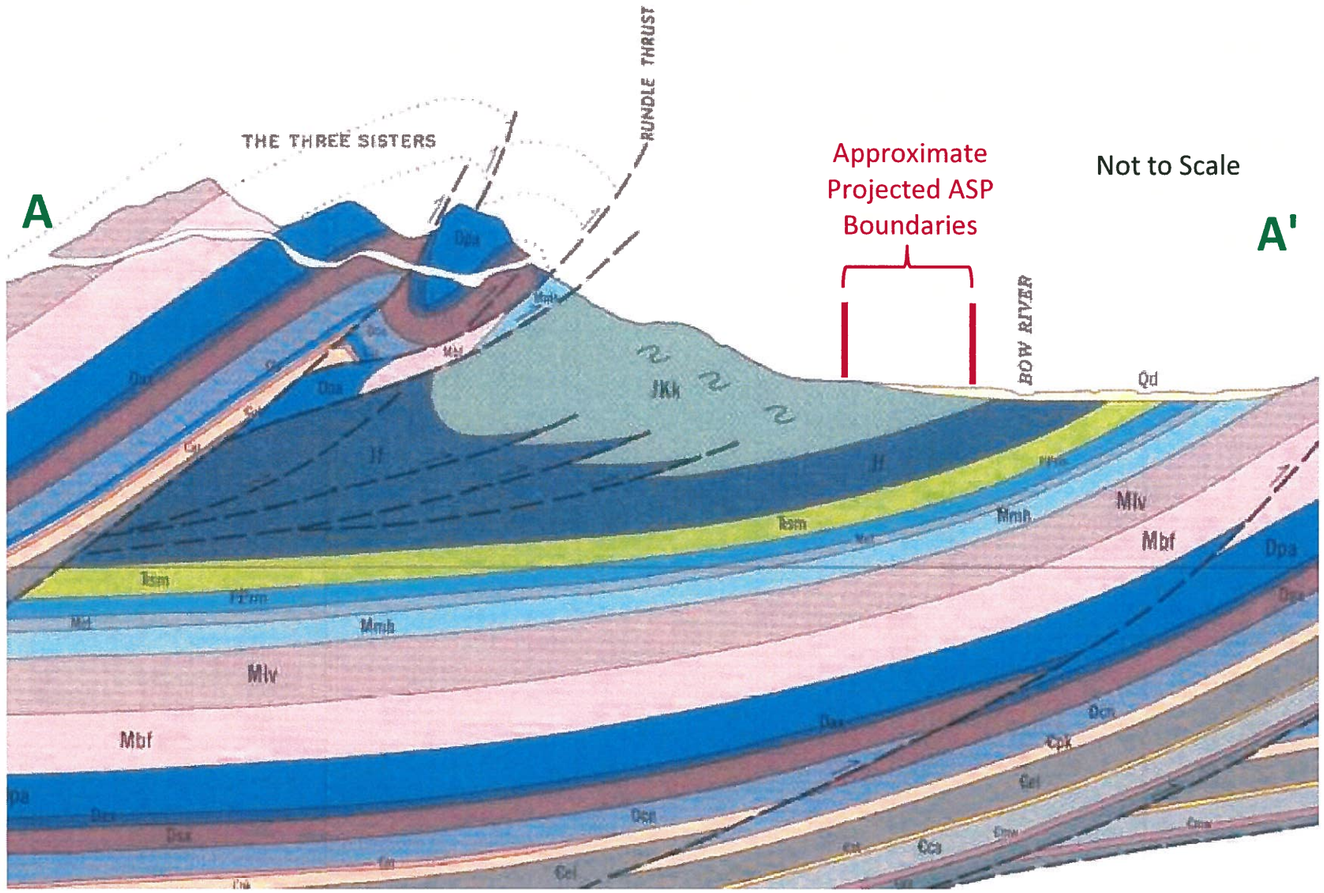
Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- 500m Safety Zone

LiDAR Source: Town of Canmore, collected June 2013. Linework: QuantumPlace Developments 27 October 2020

wood.	PROJECT NAME: Area Mining Impact Overview Smith Creek ASP	PROJECT NUMBER: CG09130
THREE SISTERS mountain village	SHEET TITLE: Site Overview with LiDAR	FIGURE NUMBER: 4
		ISSUE/REVISION: 1



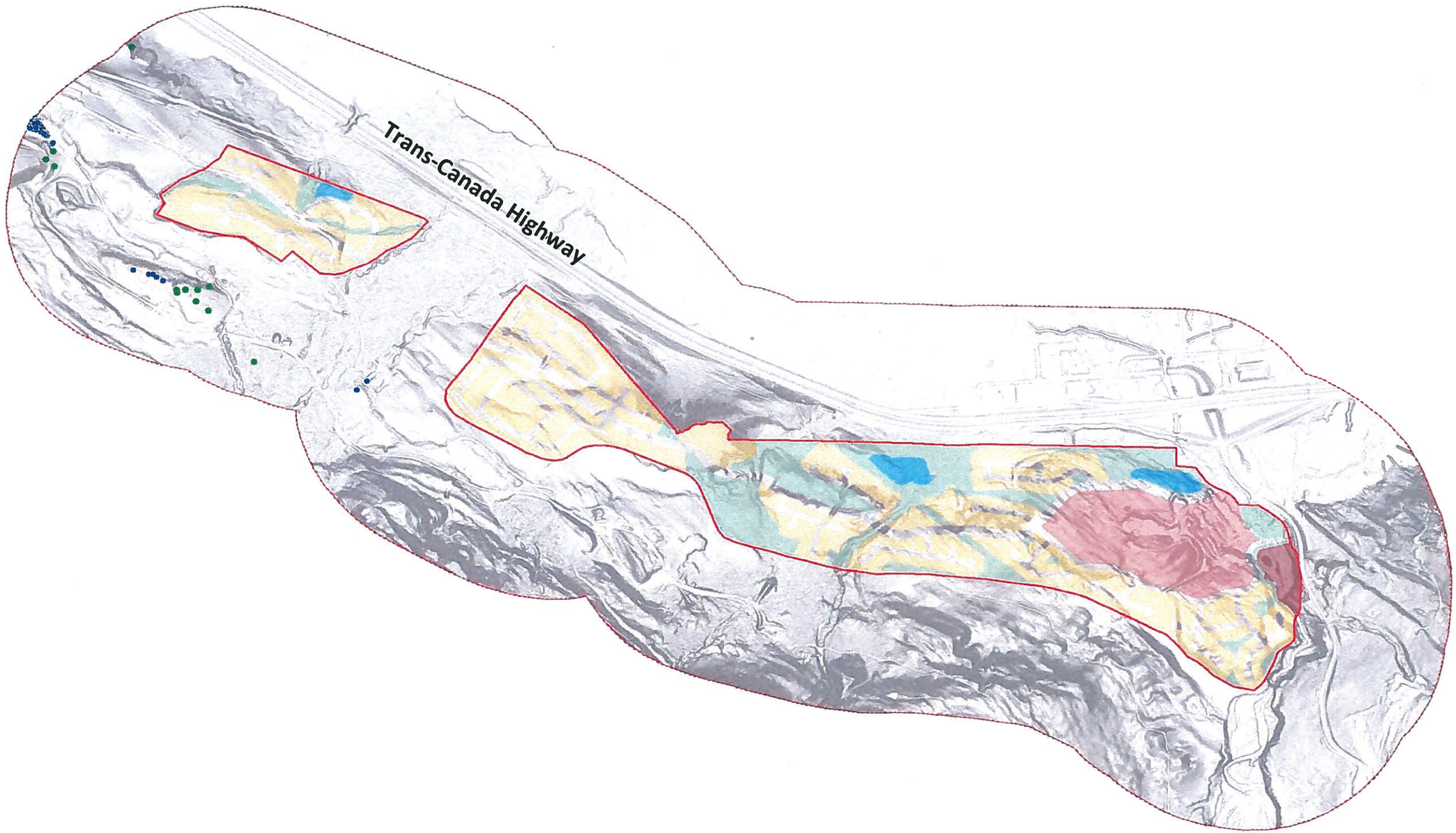


Map and Section Modified from: Geological Survey of Canada, Map 1266A, Canmore, Scale 1:50,000, Published 1970

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
PROJECT NUMBER	CG09130
FIGURE NUMBER	5
SHEET TITLE	Bedrock Geology
ISSUE/REVISION	1



N

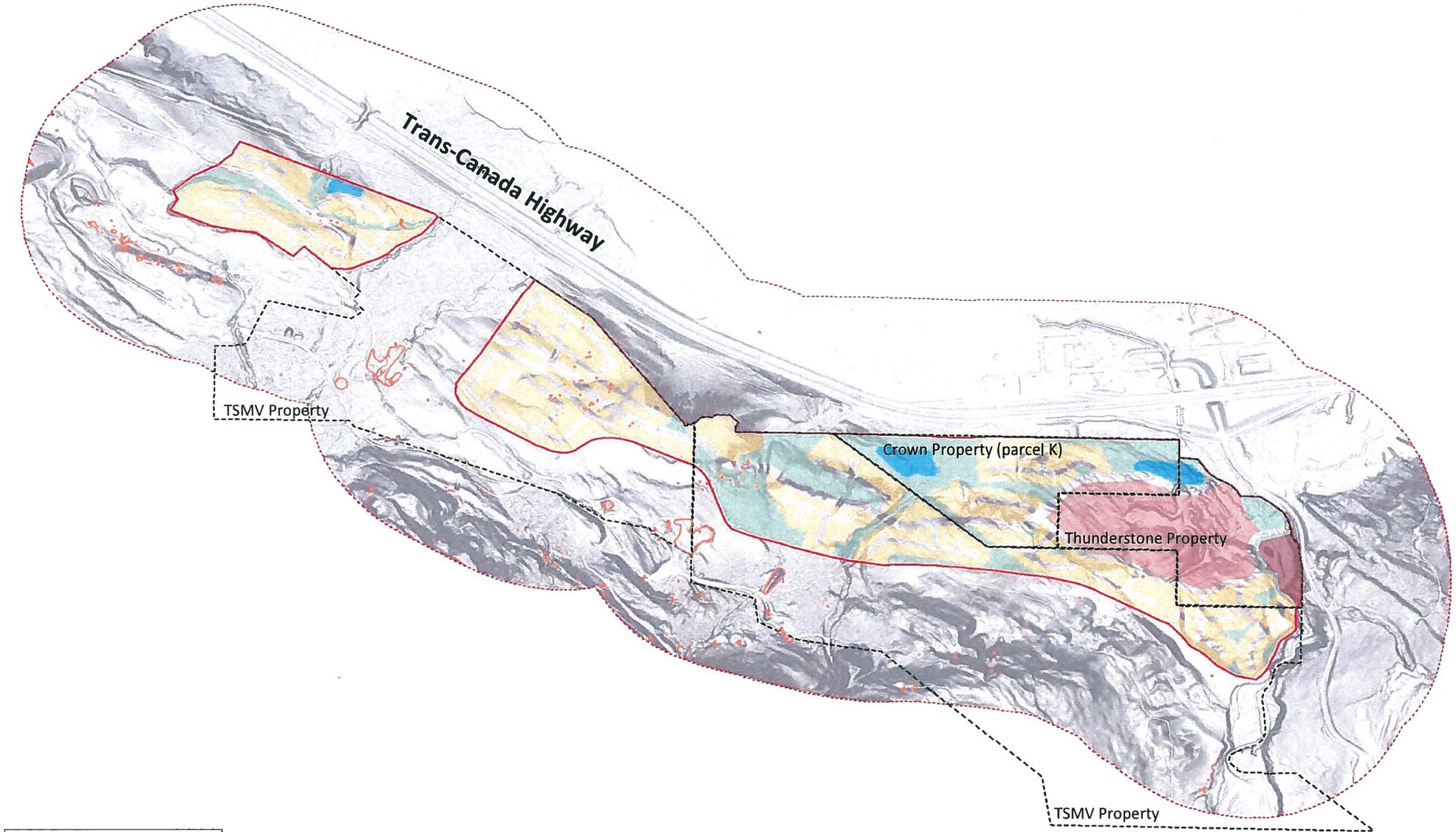
0 m 125 m 250 m 375 m 500 m 625 m

Legend

- ASP Area
- Residential
- Open Space
- Storm Water Ponds
- Flex Commercial
- Sedimentation Area
- AER Library Boreholes
- TSMV Existing Boreholes
- 500m Safety Zone

LiDAR Source: Town of Canmore, collected June 2013. Linework: QuantumPlace Developments 27 October 2020

wood.	PROJECT NAME: Area Mining Impact Overview Smith Creek ASP	PROJECT NUMBER: CG09130
THREE SISTERS mountain village	SHEET TITLE: Existing Boreholes	FIGURE NUMBER: 6
		ISSUE/REVISION: 1



N

0 m 125 m 250 m 375 m 500 m 625 m

Linework: QuantumPlace Developments 27 October 2020, Features: Golder Associates, dxf file, dated 11 May 2020, LiDAR Source: Town of Canmore, collected June 2013.

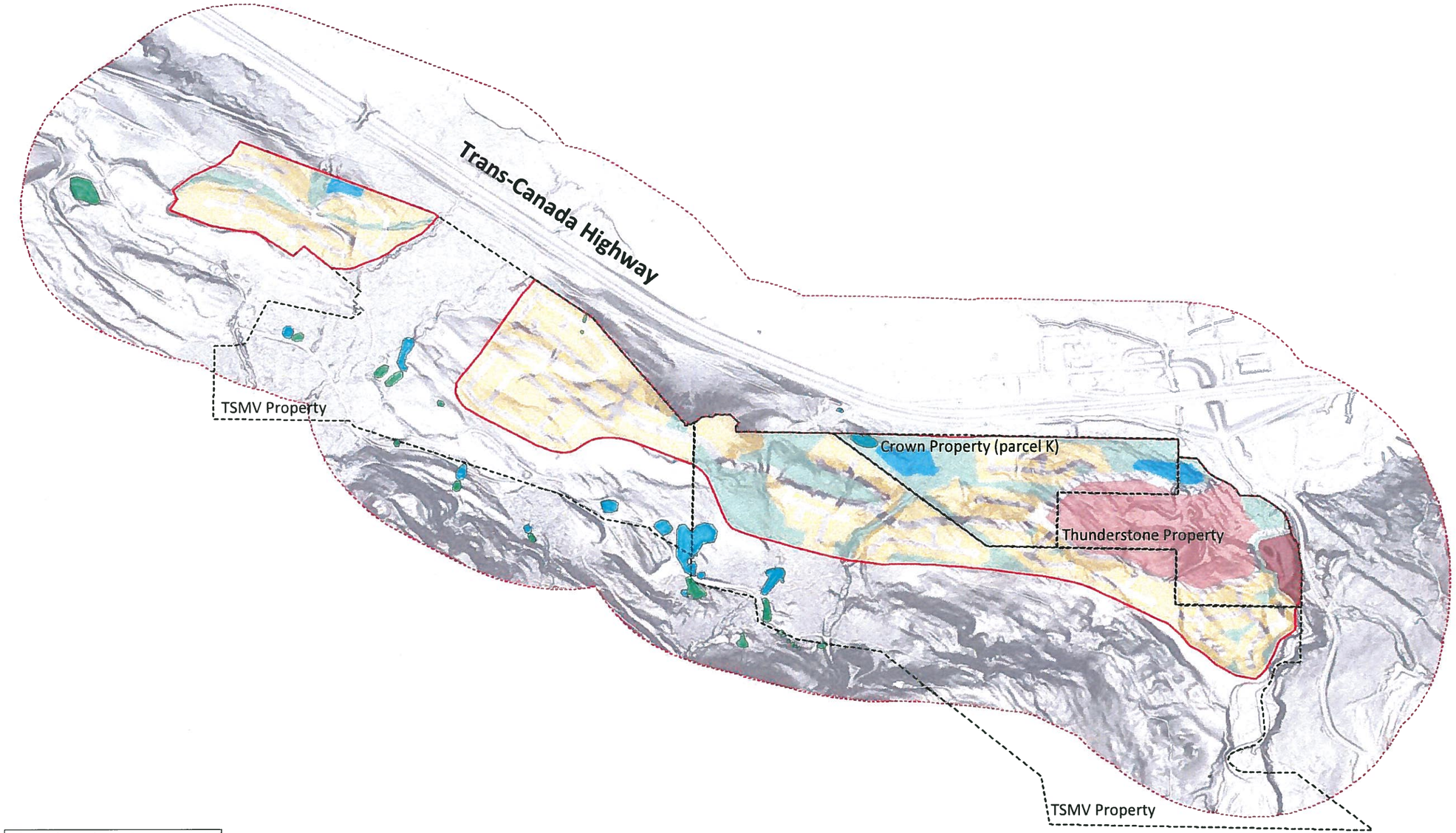
Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- Features Mapped by Others
- 500m Safety Zone

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Features Mapped by Others
PROJECT NUMBER	CG09130
FIGURE NUMBER	7
ISSUE/REVISION	1



Linework: QuantumPlace Developments 27 October 2020, LiDAR Source: Town of Canmore, collected June 2013.

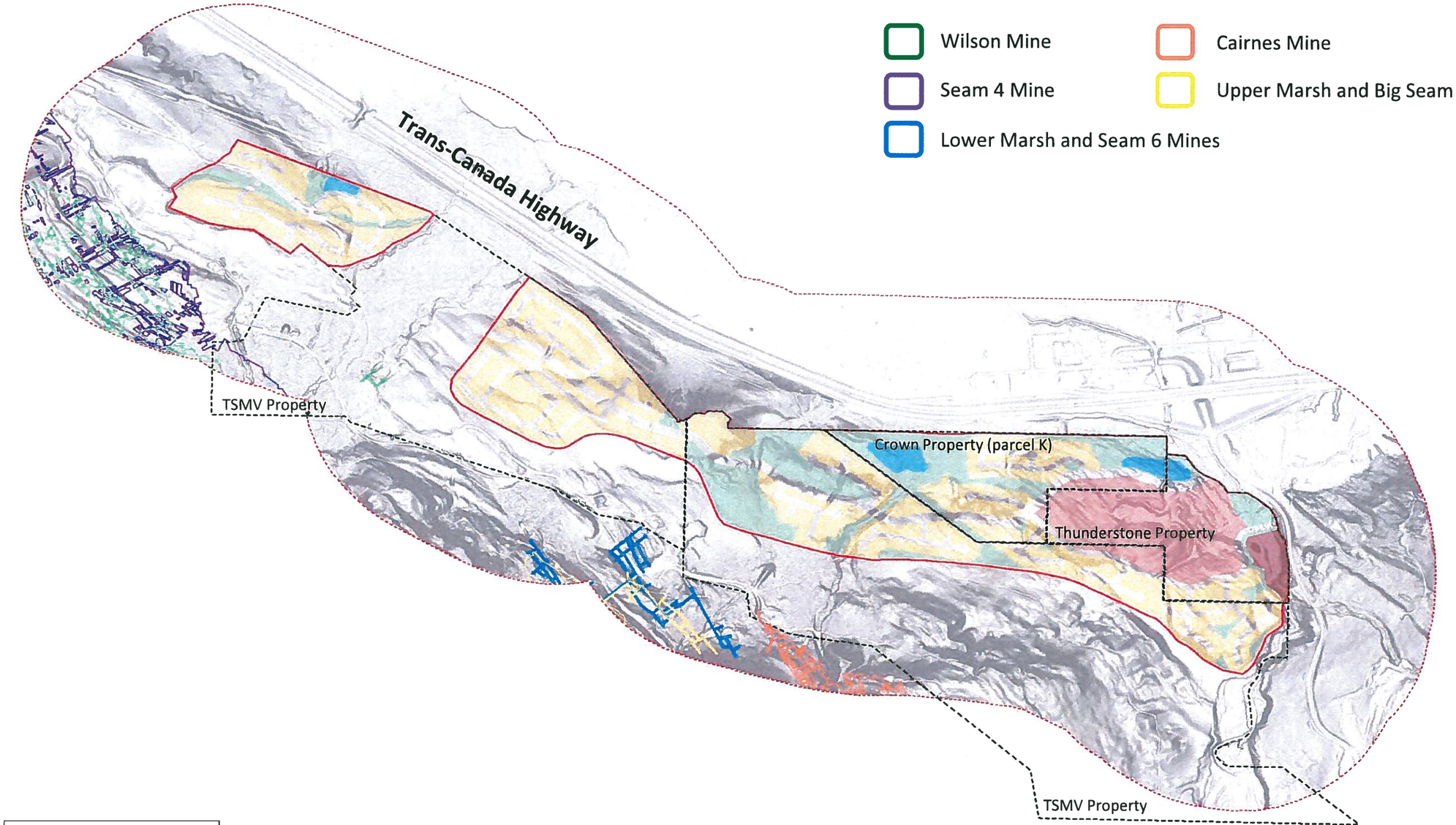
Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- 500m Safety Zone
- Man-Made Mounds
- Man-Made Flat or Depression Areas

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Wood Mapped Features
PROJECT NUMBER	CG09130
FIGURE NUMBER	8
ISSUE/REVISION	1



Linework: QuantumPlace Developments 27 October 2020, LiDAR Source: Town of Canmore, collected June 2013.

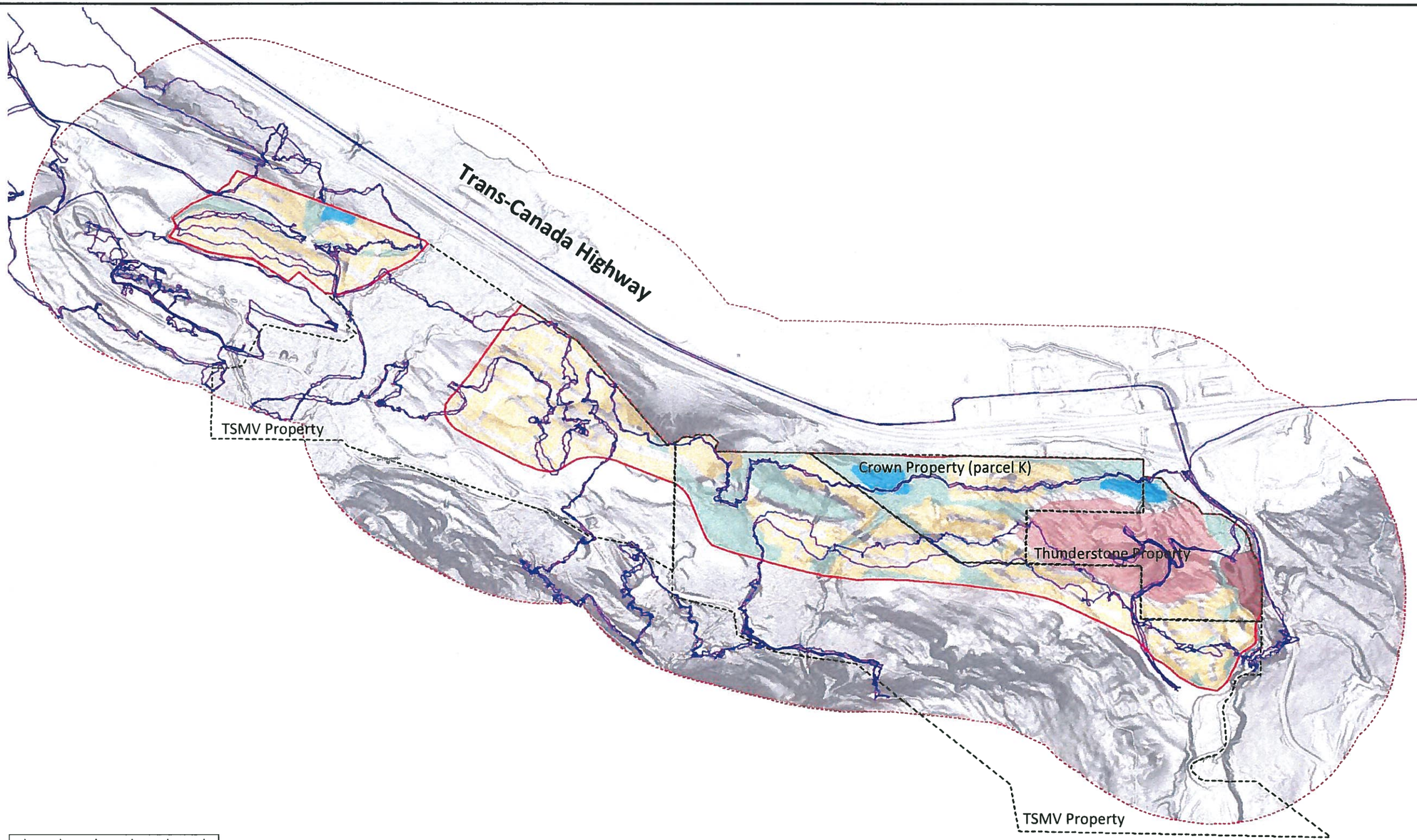
Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- 500m Safety Zone

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Mined Areas Inside 500m Safety Zone
PROJECT NUMBER	CG09130
FIGURE NUMBER	9
ISSUE/REVISION	1



Linework: QuantumPlace Developments 27 October 2020, LiDAR Source: Town of Canmore, collected June 2013

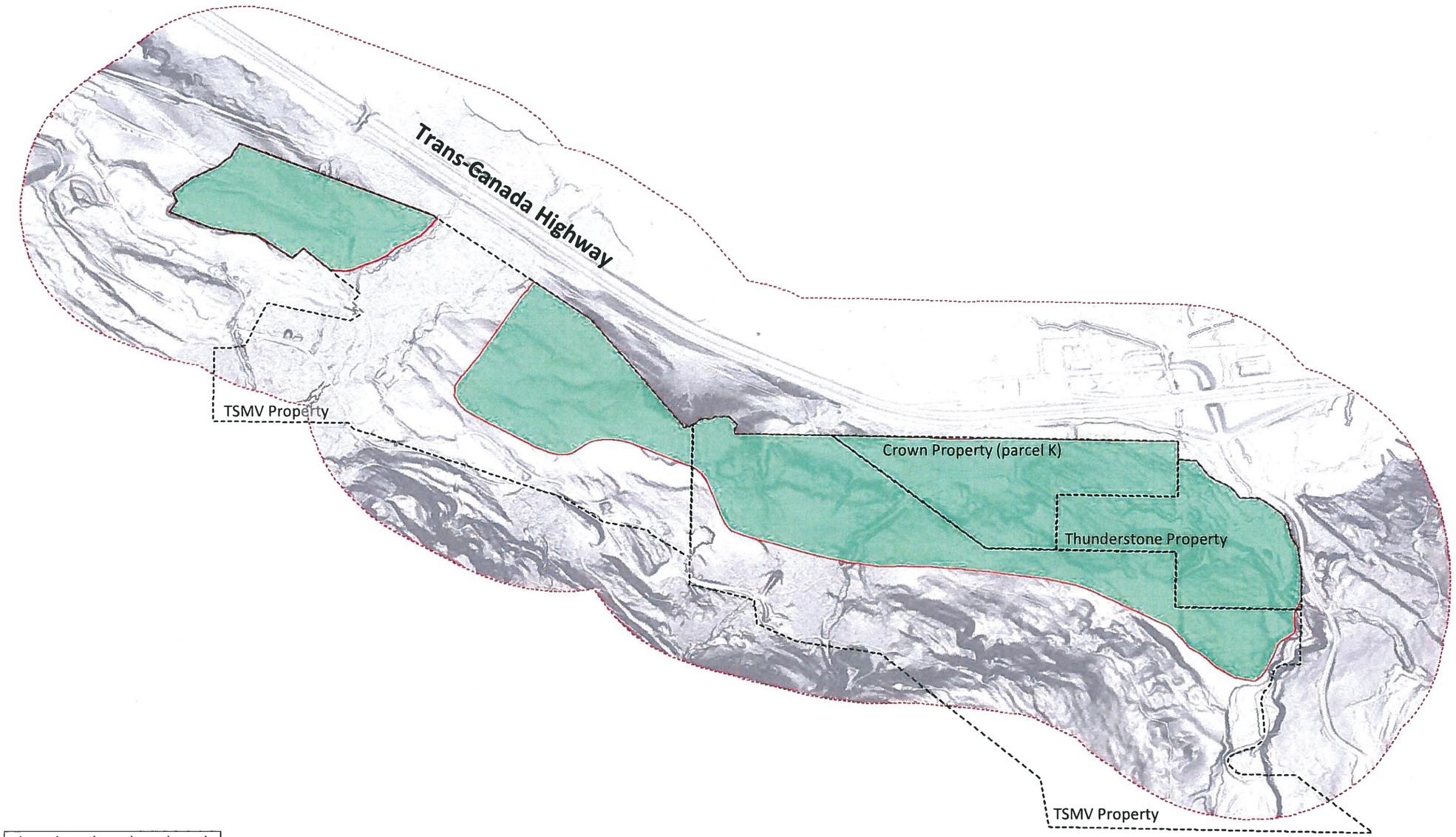
Legend

- ASP Area
- Residential
- Open Spaces
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- Wood E&IS GPS Tracks
- 500m Safety Zone

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Wood GPS Tracks
PROJECT NUMBER	CG09130
FIGURE NUMBER	10
ISSUE/REVISION	1



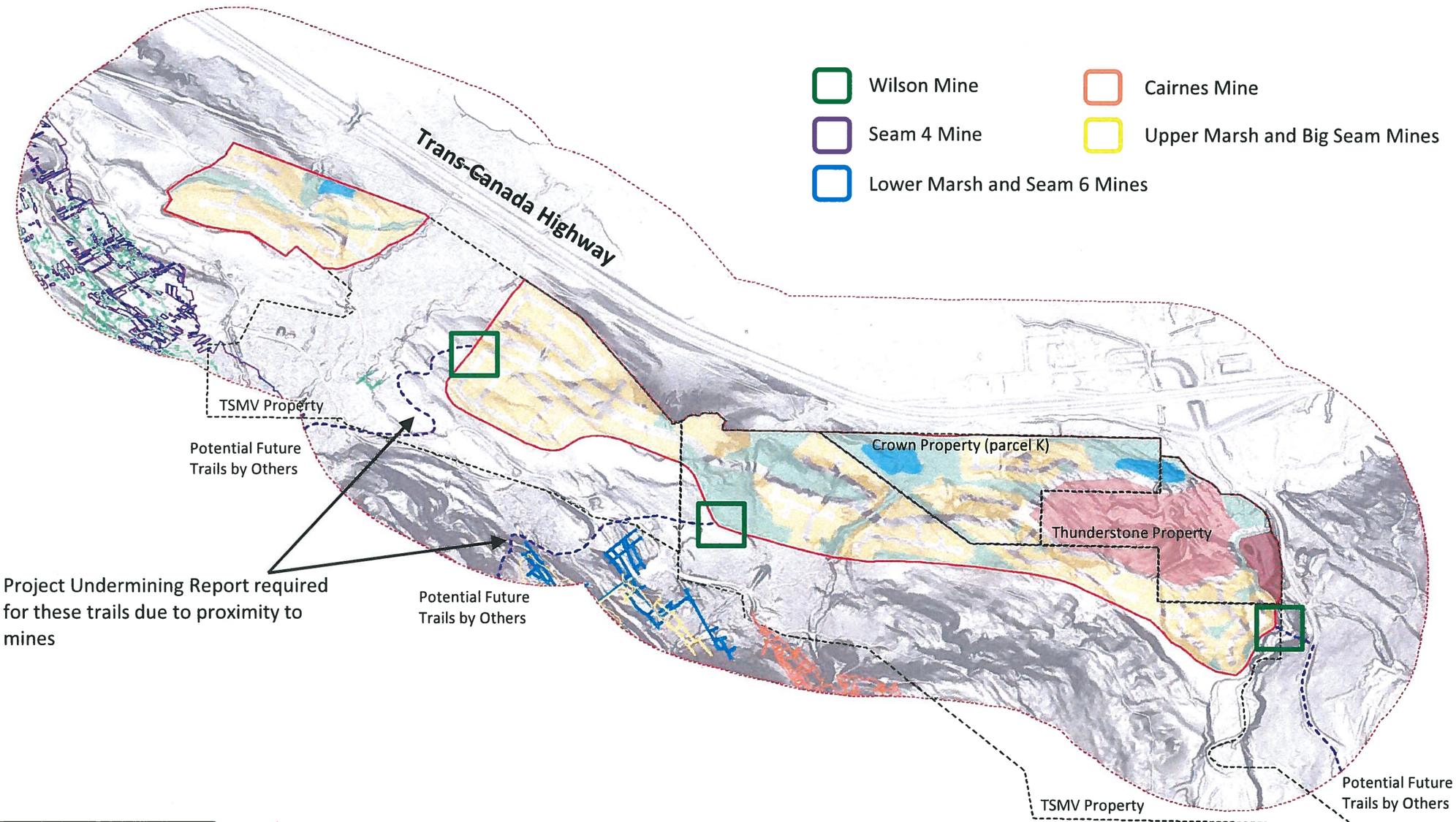
0 m 125 m 250 m 375 m 500 m 625 m

Legend

- Zone 1 (Green)
- ASP Area
- 500m Safety Zone

Linework: QuantumPlace Developments 27 October 2020, Legal Map Source: Town of Canmore 2017

wood.	PROJECT NAME: Area Mining Impact Overview Smith Creek ASP	PROJECT NUMBER: CG09130
THREE SISTERS mountain village	SHEET TITLE: Preliminary Hazard Zones	FIGURE NUMBER: 11
		ISSUE/REVISION: 1



0 m 125 m 250 m 375 m 500 m 625 m

500m Safety Zone

LiDAR Source: Town of Canmore, collected June 2013. Linework: QuantumPlace Developments 27 October 2020

Legend

- ASP Area
- Residential
- Open Space
- Stormwater Ponds
- Flex Commercial
- Sedimentation Area
- Potential Gate for Trail Access
- Approximate Trail Alignment

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Gate Access and Trails
PROJECT NUMBER	CG09130
FIGURE NUMBER	12
ISSUE/REVISION	1

Appendix A

Site Reconnaissance Features by Others Visited

Site Reconnaissance Waypoints

Site Reconnaissance Select Photographs

Previously Mapped Features which Wood Visited and Comments

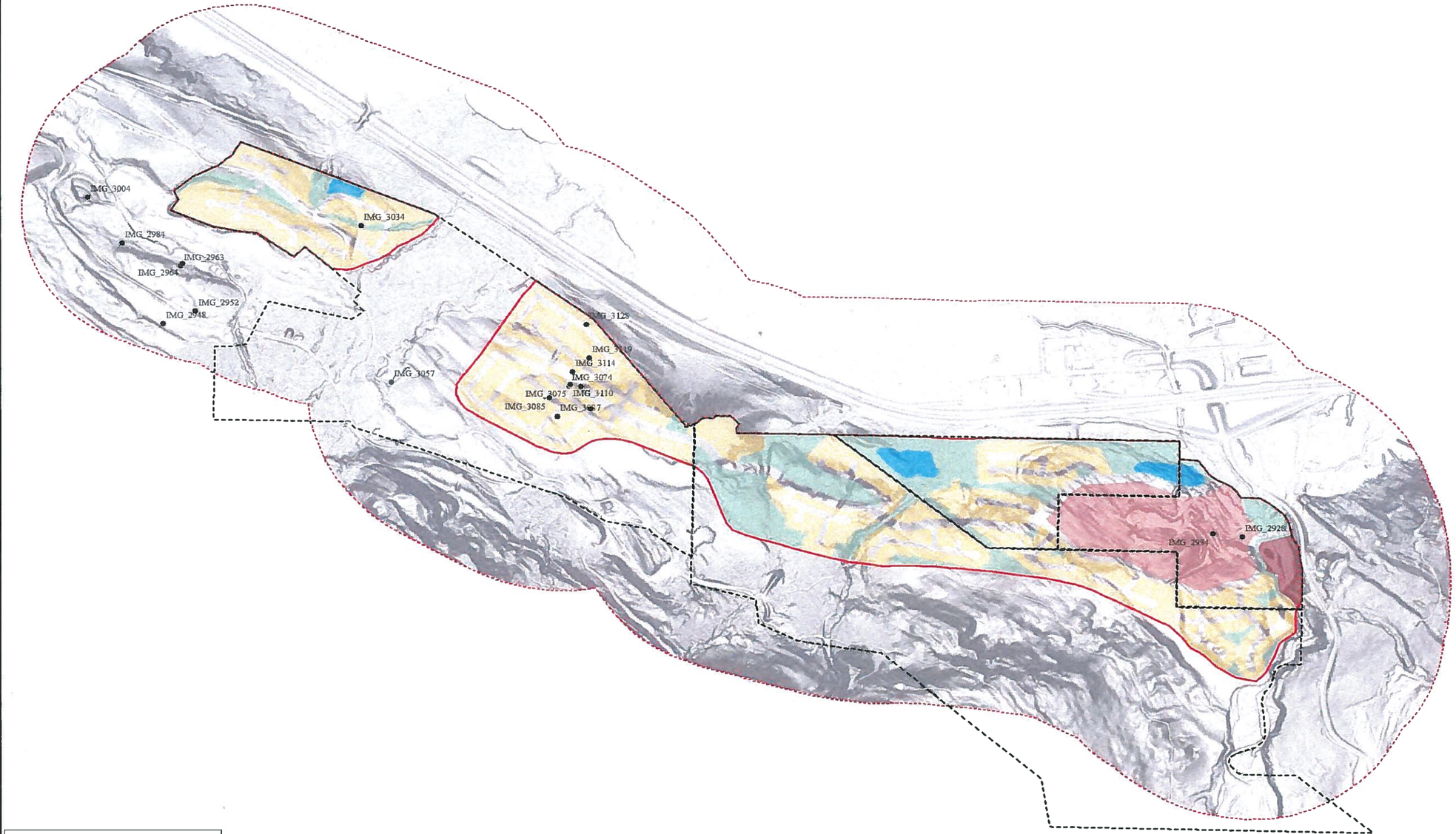
Feature Reference	Feature Type	Feature Description	2017 Feature notes	Mitigated (Y/N)	Mitigation Details	Wood Comments / Notes	Location
CP-10	Mine Entrance	Fan shaft into workings at 58 m depth.	Nothing seen	Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated and backfilled with large pieces of rock and 6 m^3 of 15 MPa concrete.	No obvious issues noted	500m Buffer
G004	Surface Debris	Clearing, 40m diameter, with signs of disturbance: dead trees, some fill and dozer work. (No photograph)		N	Mitigation not required. Not considered hazardous at the time of this report.	Depression noted, adjacent to road, likely mitigation from creek channel	500m Buffer
G005						No obvious issues noted	500m Buffer
G006						No obvious issues noted	ASP
G007a	Prospect	Possible prospect. Timbers lie horizontally along embankment of main haul road and close to a secondary road. Timbers are rotting away. Cleared trees are present nearby. Possibly related to the Wilson Seam subcrop.		N	Further inspection and mitigation recommended. Could be potentially hazardous given the amount of travel over the A-Gangway.	Major creek erosion in this area, exposed geotextile	ASP
G007b	Prospect	Possible prospect. Cleared area on side of slope which is an embankment of main haul road and close to a secondary road. May be timbered. Timbers are rotting away. Cleared trees are present nearby. Possibly related to the Wilson Seam subcrop.		N	Further inspection and mitigation recommended. Could be potentially hazardous given the amount of travel over the A-Gangway.	Major creek erosion in this area, exposed geotextile	ASP
G007c	Prospect	Possible prospect. Timbers present in excavation along embankment of main haul road and close to a secondary road. Timbers are rotting away. Cleared trees are present nearby. Possibly related to the Wilson Seam subcrop.		N	Further inspection and mitigation recommended. Could be potentially hazardous given the amount of travel over the A-Gangway.	Major creek erosion in this area, exposed geotextile	ASP
G007d	Surface Debris	Metal debris (cable, remains of gate and other) across from G7a through G7c on the main haul road.		N	Further inspection and mitigation recommended.	Major creek erosion in this area, exposed geotextile	ASP
G010	Surface Debris	Surface excavation, 0.5 to 1.5 m deep, 2 m wide and 25 m long. Plus cable and associated mining debris.		N	Mitigation not required. Not considered hazardous at the time of this report.	Depression remains. Metal and wood debris noted.	ASP
G011	Surface Debris	Surface excavation, 1m deep, 1.5m wide and 10m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	Major creek erosion in this area, no feature noted	ASP
G012	Prospect	Surface excavation, 5 m long, 1 m wide and 0.5 m deep.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	500m Buffer
G013	Prospect	Surface excavation, 1 m deep, 0.5 - 1 m wide and 25 m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	500m Buffer
G014	Prospect	Surface excavation, 0.7 m deep, 1 m wide and 7 m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G015	Surface Debris	Coal waste pile 12 m long and 5 m wide associated with Wilson Seam Prospect Headings.		N	Mitigation not required. Not considered hazardous at the time of this report.	Overgrown with moss and trees. Feature observed on LiDAR	500m Buffer
G017	Prospect	Surface excavation, 1m deep, 0.5m to 1m wide and 5m long. Bedrock exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G018	Prospect	Surface excavations (2), up to 1m deep, 1m wide and 7m long. These excavations have a 2m wide undisturbed strip between them. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G019	Prospect	Surface excavation, up to 1m deep, 1m wide and 3m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G020	Surface Debris	Clearing, as shown on site plan. Some waste piles and debris present. Material has been removed, creating slopes. Associated with the Wilson Seam prospect headings, G29 and G37.		N	Mitigation not required. Not considered hazardous at the time of this report.	Overgrown with moss and trees. Feature observed on LiDAR	500m Buffer
G021	Surface Debris	Dug-out area and clearing. Piles of material are present at the side of the pit. (No photograph)		N	Mitigation not required. Not considered hazardous at the time of this report.	Tree clearing, wet ground. No piles of material noted.	500m Buffer
G022	Prospect	Surface excavation, 0.7m deep, 0.5m to 1m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G023	Prospect	Surface excavations (2), 0.7m deep and 0.5m to 1.5m wide, 5m long and 7m long. These excavations have a 2m wide undisturbed strip in between them. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G024	Surface Debris	Pile of boulders 5m in diameter.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	500m Buffer
G025	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 4m long. Bedrock exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G026	Prospect	Surface excavation, 0.5m to 1m deep, 0.7m wide and 5m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G027	Prospect	Surface excavation, 0.5m to 1m deep, 0.7m wide and 4m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G028	Surface Debris	Depression, 5m diameter, with mounds of material on one side. Appears to be at the edge of a mine waste pile associated with the Wilson Seam Prospect Headings.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	500m Buffer
G029	Portal	Prospect heading into Wilson Seam. Backfilled, mounded, with a pipe protruding from fill.	Prospect heading into Wilson Seam. Has been backfilled and resembles a mine waste pile./collapsed mine entry, that has been packed down, no evidence of change	N	Mitigation not required. Not considered hazardous at the time of this report.	Portal opening has been mitigated	500m Buffer
G030	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 20m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G031	Prospect	Surface excavation, 0.5m to 1m deep, up to 4m wide and 7m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G032	Prospect	Surface excavation, 0.7m deep, 1.5m wide and 3m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G033	Prospect	Surface excavation, 0.7m deep, 1.5m wide and 4m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G034	Prospect	Surface excavation, 0.5m deep, 0.5m to 1m wide and 3m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G035	Prospect	Surface excavation, 0.5 m to 1 m deep, 1 m wide and 4m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G036	Prospect	Surface excavation, 1m deep, 1m wide and 5m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G037	Portal	Prospect heading into Wilson Seam. Has been backfilled and resembles a mine waste pile.	Prospect heading into Wilson Seam. Has been backfilled and resembles a mine waste pile./collapsed mine entry, that has been packed down, no evidence of change	N	Mitigation not required. Not considered hazardous at the time of this report.	Portal opening has been mitigated	500m Buffer
G038	Prospect	Surface excavation, 0.5m deep, 2m wide and 3m long. Some coal present. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G039	Prospect	Surface excavation, 1m deep, 2m to 3m wide and 4m long. Some coal present. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G040	Prospect	Surface excavation, 0.7m deep, 0.5m wide and 4m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G041	Prospect	Surface excavation, 0.5m deep, 0.5m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G042	Prospect	Surface excavations (2), "L" shaped, with 2m space between. Both 0.5m deep, up to 1m wide and 7m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G043	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G044	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 3m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G045	Prospect	Surface excavation, 0.5m deep, 0.5m wide and 7m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G046	Surface Debris	Series of small holes, 1 m in diameter, 0.5 m deep		N	Mitigation not required. Not considered hazardous at the time of this report.	Numerous depression and holes in vegetation within this area. Not deemed to be undermining related	500m Buffer
G047	Prospect	Surface excavation, 1m deep, 1.5m wide and 5m long. Bedrock is exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP

Previously Mapped Features which Wood Visited and Comments

Feature Reference	Feature Type	Feature Description	2017 Feature notes	Mitigated (Y/N)	Mitigation Details	Wood Comments / Notes	Location
G048	Prospect	Surface excavation, 0.5m deep, 1m wide and 6m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G049	Prospect	Surface excavation, 0.7m deep, 0.5m wide and 3m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G050	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G051	Prospect	Surface excavation, 0.5m deep, 0.7m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G052	Prospect	Surface excavation, 1m deep, 2.5m wide and 5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G053	Prospect	Surface excavation, 0.5m deep, 0.5m to 1m wide and 7m long with a 1m strip in the middle.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G054	Prospect	Surface excavation, 0.5m deep, 1m wide and 1.5m long.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted.	ASP
G058	Portal	Portal into the No. 6 Seam. Backfilled at surface. Resembles a mine waste pile. Not within Site 7 boundary.		N	Mitigation not required. Not considered hazardous at the time of this report.	Portal has been mitigated. Area with cuts to portal entrance, some small voids (~10cm dia) observed, possibly related to mitigation settlement	500m Buffer
G058	Mine Entrance	Portal into Seam No. 6 workings. Has been backfilled. Resembles a mine waste pile.	Portal into Seam No. 6 workings. Has been backfilled. Resembles a mine waste pile. A few 10cm holes with not airflow	N	Mitigation not required. Not considered hazardous at the time of this report.	Portal has been mitigated. Area with cuts to portal entrance, some small voids (~10cm dia) observed, possibly related to mitigation settlement	500m Buffer
G059	Portal	Portal into the No. 6 Seam. Backfilled at surface. Resembles a mine waste pile.	Portal into the No. 6 Seam. Backfilled at surface. Resembles a mine waste pile.	N	Mitigation not required. Not considered hazardous at the time of this report.	Portal has been mitigated. Heavily overgrown with brush. No evidence of portal remains, except trace mining debris.	500m Buffer
G064	Mine Entrance	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Has water pooled and pipes installed in front of it.	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Has water pooled and pipes installed in front of it.	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. One small hole (~10cm dia) into portal area. Evidence of water seepage with water pooled in cut to portal entrance.	500m Buffer
G070	Mine Entrance	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Has coal waste pile in front of it.	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Has coal waste pile in front of it.	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. One small hole (~10cm dia) into portal area. Evidence of water seepage with water pooled in cut to portal entrance.	500m Buffer
G071	Surface Debris	Surface depression, 5 m long, 0.5 m to 1 m wide, 0.1 m to 0.5 m deep. West of G72.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G072	Mine Entrance	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Bedrock of outcrop exposed.	Portal into No. 3 Mine, Cairnes Seam workings. Has been backfilled. Bedrock of outcrop exposed.	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
G073	Mine Entrance	Portal into No. 3 Mine, No. 6 Seam workings. Has been backfilled. Surrounded by deadfall and new growth.	Portal into No. 3 Mine, No. 6 Seam workings. Has been backfilled. Surrounded by deadfall and new growth. 4m x1m depression near back part of it	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
G074	Mine Entrance	Portal into No. 3 Mine, Big Seam. Has been backfilled. Surrounded by deadfall and new growth. Has coal waste pile in front of it.	Portal into No. 3 Mine, Big Seam. Has been backfilled. Surrounded by deadfall and new growth. Has coal waste pile in front of it. Minor slope instability on back slope	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
G079	Mine Entrance	Portal into the Upper Marsh Seam workings. Has not been backfilled except by some rocks and timbers. Can feel cold air flowing from opening. Sulphur smell present.	Portal into the Upper Marsh Seam workings. Has not been backfilled except by some rocks and timbers. Can feel cold air flowing from opening. Sulphur smell present.	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
G081	Surface Debris	Wooden platform with associated wooden debris. No photograph.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G082	Mine Entrance	Air shaft into the Lower Marsh Seam workings. Has been backfilled, but there is an opening of approximately 0.2 m diameter that cold air is flowing out of.	Air shaft into the Lower Marsh Seam workings. Has been backfilled, but there is an opening of approximately 0.2 m diameter that cold air is flowing out of.	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
G084	Surface Disturbance	Possible sinkhole over Upper and Lower Marsh workings approximately 30 m deep. Depression 3 m in diameter and 1 m deep. Appears fairly recent.	Depression 3 m in diameter and 1.5m deep. Has been there since 2008	N	Mitigation not required. Not considered hazardous at the time of inspection.	No change or obvious issues noted.	500m Buffer
G086	Prospect	Surface excavations (2) 3 m long, 1.5 m wide and 0.5 m deep with a 2 m bridge in between. No photograph.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G087	Surface Debris	Cleared area 10 m long and 3 m wide.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G088	Prospect	Surface excavation on a slope, 5 m long, 2 m wide and 1 m deep. Bedrock and coal seam exposed.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G090	Mine Entrance	Portal into Big Seam workings. Poorly backfilled with rocks and trees.	Portal into Big Seam workings. Poorly backfilled with rocks and trees. Pipe installed Noth of it with water flowing out. Historic description of G090 and G091 may be reversed	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal mitigated. No clear evidence of location. Heavy vegetation. Lots of mining debris.	500m Buffer
G091	Mine Entrance	Portal into Big Seam workings. Has been backfilled with mine waste. Has mine waste pile in front of it. Drainage pipe installed north of it.	Very deep hole ~8m deep, 60 degree angle into slope, opening ~3m diameter	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal mitigation appears to have partly settled. Opening is ~3m deep and ~3m diameter. Orange fencing present.	500m Buffer
G092	Mine Entrance	Portal into No. 6 Seam workings. Poorly backfilled with logs and trees. Bedrock is exposed. Sulphur smell present. No photograph.	Portal into No. 6 Seam workings. Bedrock is exposed on upper crest. Sulphur smell present. Previous comments say poorly backfilled with rocks and trees but slope appears well graded	N	Mitigation not required. Not considered hazardous at the time of inspection.	Portal has been mitigated. One small (~10cm dia) opening which may indicate fill settlement.	500m Buffer
G101	Prospect	Resembles a portal. Along outcrop ith coal seams present. Has been backfilled with coal waste and coal waste pile in front of it.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G102	Prospect	Surface excavation. Has been backfilled with rocks. Sulphur smell present.		N	Mitigation not required. Not considered hazardous at the time of inspection.	No obvious issues noted.	500m Buffer
G163	Waste Pile	Large coal waste pile is over 100 m long, 10 m wide and ~10 m high. Gravel sized coal at top of pile and larger cobble sized pieces at bottom. No trees on top of the pile but dense trees at sides. Top is flat and sides slope approximately 70 degrees.		N		Large spoil pile, Measured from LiDAR to be ~45m wide at greatest, over 100m long and 8m high	500m Buffer
G217	Surface Depression	6 m diameter and 0.5 to 1 m depth. No visible rock. Not on top of recorded mining.	6 m diameter and 0.5 to 1 m depth. No visible rock. Not on top of recorded mining.		Mitigation not required. Not considered hazardous at the time of reporting.	No obvious issues noted.	500m Buffer
G415	Possible prospect	Excavation is 2 m x 0.75 m and 0.3 to 1 m deep. Moss covered, pulling away on west side exposing overburden.	Remote feature, didn't visit	N		No obvious issues noted.	ASP
G417	Possible prospect	A series of downslope excavations (0.5 to 1 m deep) approximately 25 m long in total with lots of deadfall. Moss covered.		N		No obvious issues noted.	ASP
G418	Prospect	Small excavation 1.5 x 0.5 m wide and up to 0.75 m deep. Moss covered.		N		No obvious issues noted.	ASP
G419	Prospect	Excavation 1.5 x 0.5 m wide and ~0.3 m deep. Moss covered with bedrock exposed on west side. North side covered with deadfall		N		No obvious issues noted.	ASP
G420	Prospect	Excavation 2.5 x 1 to 1.5 m wide and ~0.5 to 1 m deep. Moss covered with some bedrock exposed on south side.		N		No obvious issues noted.	ASP
G421	Prospect	Excavation 2 x 0.5 m wide and 0.75 to 1 m deep. Moss covered.		N		No obvious issues noted.	ASP
G422	Prospect	2 long depressions: 3.5 m x 1-1.5 m and 0.5 - 1 m deep (each) separated by a tree, aligned downslope and moss covered.		N		No obvious issues noted.	ASP
G427	Excavation	Excavation in track 6m x 3m and 1.5 m deep. Covered with moss and leaves, some overburden exposed. Several small logs lie at bottom	Appears to be filled in, do not visit	N		No obvious issues noted.	ASP
G-428	Excavation	Excavation near intersect of two tracks. Material piled on west side. 8m x 6m ~1-2m deep. Walls slope on east and west sides. Overburden exposed on north and south walls. Grass covered. Lots of cobble present.		N		No obvious issues noted.	ASP
G436	Prospect	Rectangular depression. Grass covered. 5 x 2 m, 0.3 m deep. Uniform depth. Appears to be an imprint of a large item.		N		No obvious issues noted.	500m Buffer
G907	Possible tension crack	New feature 2017. 1m wide, 8-10 m long and 0.5 to 1.0 m deep in area of R30 and R34	New feature 2017. 1m wide, 8-10 m long and 0.5 to 1.0 m deep in area of R30 and R34	N		Appears to related to ground movement, likely associated with undermining.	500m Buffer (Golf Course)

Previously Mapped Features which Wood Visited and Comments

Feature Reference	Feature Type	Feature Description	2017 Feature notes	Mitigated (Y/N)	Mitigation Details	Wood Comments / Notes	Location
PR-36	Prospect	Prospect				No obvious issues noted.	500m Buffer
PR-52	Prospect	Prospect				No obvious issues noted.	500m Buffer
PR-64	Prospect	Prospect				No obvious issues noted.	500m Buffer
R03	Mine Entrance	Probable mine portal into No. 4 Mine, No. 4 Seam, 5 m by 8 m and 0.3 m deep. Has been previously covered and seeded, but fill has subsided. Associated with R27.	Near cart path (which is fenced). ~3m wide by 10 m long, 1.5 m deep	Y	Mitigated during Stewart Creek Golf Course Development (Norwest 1998). Excavated and backfilled. Mitigated along with R3.	Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R04	Mine Entrance	Possible vent shaft into No. 4 Mine, No. 4 Seam, 3 m diameter, 1.5 m deep, and partially filled with old mine timbers and fallen trees. Mine rock piled around collar. No visible void. No photograph.	Possible vent shaft into No. 4 Mine, No. 4 Seam, 3 m diameter, 1.5 m deep, and partially filled with old mine timbers and fallen trees. Mine rock piled around collar. No visible void.		Fenced off during SCGC development, (Norwest 2000)	Appears similar to prospect site, but may be mine subsidence in this area due to shallow workings.	500m Buffer (Golf Course)
R05	Surface Disturbance	Probable subsided area 7 m long, 5 m wide and 0.5 m deep, over No. 4 Mine workings 25 - 30 m deep. Trees have fallen or are tilted. No photograph.	Probable subsided area 7 m long, 5 m wide and 0.5 m deep, over No. 4 Mine workings 25 - 30 m deep. Trees have fallen or are tilted.		Fenced off during SCGC development, (Norwest 2000)	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R06	Surface Disturbance	Probable subsided area, 7 m long, 5 m wide and 0.5 m deep, over No. 4 Mine workings 25 - 30 m deep. Trees have fallen or are tilted. No photograph.	Probable subsided area, 7 m long, 5 m wide and 0.5 m deep, over No. 4 Mine workings 25 - 30 m deep. Trees have fallen or are tilted.		Fenced off during SCGC development, (Norwest 2000)	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R07	Surface Disturbance	Subsided area, 15 m diameter, 1.8 m deep, over No. 4 Mine workings 20 m deep. Filled with trees. No photograph. Associated with R8.	Subsided area, 15 m diameter, 1.8 m deep, over No. 4 Mine workings 20 m deep. Filled with trees. Possibly Associated with R8.		Fenced off during SCGC development, (Norwest 2000)	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R08	Surface Disturbance	Subsided area, 15 m diameter, 1.8 m deep, over No. 4 Mine workings 20 m deep. Filled with trees. No photograph. Associated with R7.	Subsided area, 15 m diameter, 1.8 m deep, over No. 4 Mine workings 20 m deep. Filled with trees. Associated with R7.		Fenced off during SCGC development, (Norwest 2000)	Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R09	Prospect	Test pit, 10 m long, 4 m wide and 1.8 m deep. One slump evident over prospect where it had collapsed. Associated with R10.		Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated and backfilled.	No obvious issues noted.	500m Buffer (Golf Course)
R10				Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated and backfilled.	No obvious issues noted.	500m Buffer (Golf Course)
R11	Surface Disturbance	Subsided area, 20 m diameter and 2 m deep, over No. 4 Mine workings 25 m deep. No visible void. No photograph.	Subsided area, 20 m diameter and 2 m deep, over No. 4 Mine workings 25 m deep. No visible void. New waypoint created, two fence openings right near top scarp, should be closed		Fenced off during SCGC development, (Norwest 2000)	Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R12	Surface Disturbance	Subsided area, 3 m diameter and 1 m deep, over No. 4 Mine workings 15 m deep. No visible void. No photograph.	Subsided area, 3 m diameter and 1 m deep with steep back scarp, over No. 4 Mine workings 15 m deep. No visible void.		Fenced off during SCGC development, (Norwest 2000)	Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R13	Surface Disturbance	Subsided area, 5 m diameter and 1 m deep, over No. 4 Mine workings 15 m deep. No visible void. Filled with trees that have been specifically cut. No photograph.	Subsided area, 5 m diameter and 1 m deep, over No. 4 Mine workings 15 m deep. No visible void. Filled with trees that have been specifically cut.		Fenced off during SCGC development, (Norwest 2000)	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R14	Surface Disturbance	Subsided area with 2 fissures, 12 m long and 3 m wide, over No. 4 Mine workings 25 m deep. No photograph.	Noth'ng seen		Fenced off during SCGC development, (Norwest 2000)	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R15	Surface Disturbance	Subsided area, 7 m diameter and 3 m deep over No. 4 Mine workings 20 m deep. Associated with R18.	Mitigated nothing seen	Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated, geogridded and backfilled.	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R16	Surface Disturbance	Subsided area, 4 m long, 1.5 m wide and 1 m deep, over No. 4 Mine workings 12 m deep. No photograph.	Subsided area, 4 m long, 1.5 m wide and 1 m deep, over No. 4 Mine workings 12 m deep.			Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R17	Surface Disturbance	Subsided area, 2 m diameter and 1 m deep, over No. 4 Mine workings 5 m to 10 m deep. No photograph.	Subsided area, 2 m diameter and 1 m deep, over No. 4 Mine workings 5 m to 10 m deep. Continuation seen downslope			Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R18	Surface Disturbance	Subsided area, 6 m diameter and 3 m deep, over No. 4 Mine workings 15 m deep. Associated with R15.	Mitigated, nothing seen	Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated, geogridded and backfilled.	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R19	Mine Entrance	Portal into No. 4 Mine workings. Starts at the No. 4 Seam subcrop and descends at 10° to reach the level of the "A Gangway".	Main feature has not changed, but is still in plain site from the fairway, potentially very hazardous for curious onlookers. There is still a fence around it in good shape. Potential associated sinkhole about 1m diameter and 0.3m deep on south side up slop. Potentially new tension crack on east side of feature, about 6-8m, 0-20cm wide	Y	Portal reconstructed during Stewart Creek Golf Course Development (1998).	Portal entrance includes wooden timbers. Portal has collapsed upslope of entrance, leaving large void (~5m dia), depth able to be measured.	500m Buffer (Golf Course)
R20	Prospect	Depressions, 2 m long, 1 m wide and 0.8 m deep, and 1 m square, 0.5 m deep. Dirt heaped around 1 of 2 depressions. No photograph.				Depression remains. Fenced from Golf Course.	500m Buffer (Golf Course)
R21	Surface Disturbance	Subsided area, 15 m long, 3 m wide and 0.5 m deep, over No. 4 Mine workings 12 m deep. No photograph.	Subsided area, 15 m long, 3 m wide and 0.5 m deep, over No. 4 Mine workings 12 m deep.			Depression remains, estimated to be closer to 0.5m wide in places. Fenced from Golf Course.	500m Buffer (Golf Course)
R22	Non-mining Related	Subsided area or prospect at bottom of natural gully, 3 m in diameter and 1.5 m deep.		Y	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). Excavated and backfilled.	No obvious issues noted.	500m Buffer (Golf Course)
R27	Cave Subsidence	Elongated subsided area, 15 m long, 2 m wide, 1.5 m deep. Aligned with natural water course. Possible subsidence into rise entry? Associated with R-3.	Elongated subsided area, 15 m long, 2 m wide, 1.5 m deep. Aligned with natural water course. Possible subsidence into rise entry? Associated with R-3.	Y	Mitigated during Stewart Creek Golf Course Development (Norwest 1998). Excavated and backfilled. Mitigated along with R27.	Depression remains, perpendicular to slope fall line. Likely mine subsidence. Fenced from Golf Course.	500m Buffer (Golf Course)
R28	Prospect	Possible prospect, 5 m long and 3 m wide. Has been filled in and reclaimed. Mitigated by Norwest in 1997.		Y	Mitigated during Stewart Creek Golf Course Development (Norwest 1998). Excavated, geogridded and backfilled. Mitigated along with R29.	No obvious issues noted.	500m Buffer (Golf Course)
R29	Surface Disturbance	Subsided area, 3 m long, 2 m wide and 1 m deep, over No. 4 Mine workings 6 m deep. Mitigated by Norwest in 1997.	Probably built cart path over it	Y	Mitigated during Stewart Creek Golf Course Development (Norwest 1998). Excavated, geogridded and backfilled. Mitigated along with R28.	No obvious issues noted.	500m Buffer (Golf Course)
R30	Surface Disturbance	Shallow subsided area. 6m x6m, 0.5m deep	Shallow subsided area. 6m x6m, 0.5m deep	N	investigate and mitigate as required	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R31	Surface Disturbance	Subsided area. Some backfilling has been done.	Subsided area. 6m x 4m, 0.5m deep	N	investigate and mitigate as required	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R32	Prospect	Pit with timber tripod and hoist loop. Has been filled in. 3m x 1.5m, 1.5m deep.		N	investigate and mitigate as required	No obvious issues noted.	500m Buffer (Golf Course)
R34	Cave Subsidence	Subsided previously reclaimed hole. 3m dia., 0.3m deep.	Subsided previously reclaimed hole. 3m dia., up to 1.5m deep., potential hazard, not too near paths or roads	N	Surveillance	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
R35	Cave Subsidence	Reclaimed subsided area. 10m x 5m, 0.3m deep	Reclaimed subsided area. 10m x 5m, 0.3m deep	N	Surveillance	No obvious issues noted at this particular location, however mine subsidence present adjacent to this area.	500m Buffer (Golf Course)
N/A	Portal	Portal to Cairnes Mine				Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer
N/A	Portal	Portal to Cairnes Mine				Portal has been mitigated. Area with cuts to portal entrance.	500m Buffer



0 m 125 m 250 m 375 m 500 m 625 m

Linework: QuantumPlace Developments 15 September 2020

wood.

THREE SISTERS mountain village

PROJECT NAME	Area Mining Impact Overview Smith Creek ASP
SHEET TITLE	Select Photo Locations
PROJECT NUMBER	CG09130
FIGURE NUMBER	1
ISSUE/REVISION	0

Photograph 1: Thunderstone Quarry
Overview of rock quality, orientation and overburden

Photograph 2: Thunderstone Quarry
Overview of rock quality, orientation and overburden

wood.

CLIENT:

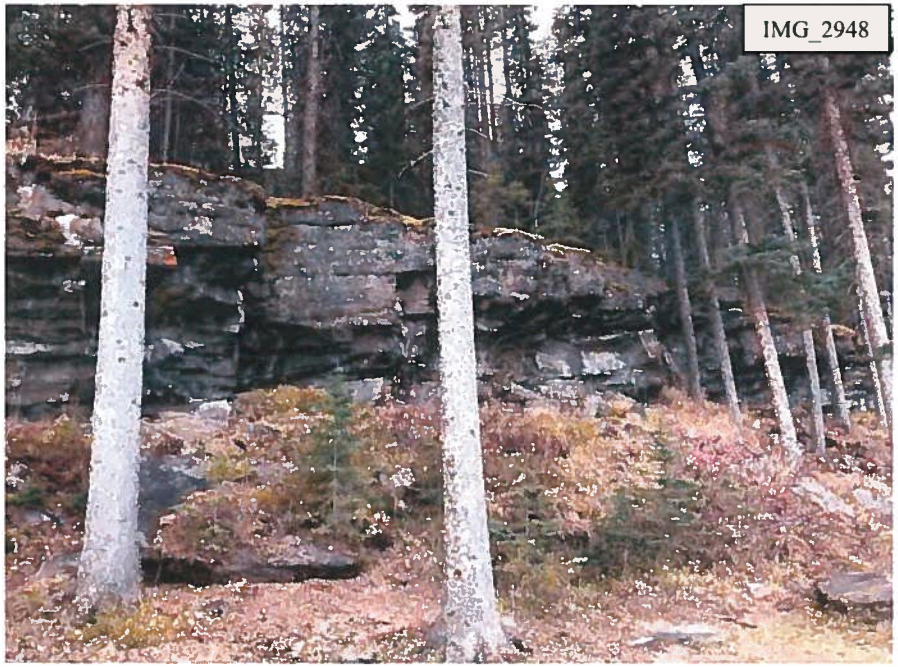
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020



Photograph 3: Stewart Creek Golf Course
Overview of rock quality, orientation and overburden

Photograph 4: Stewart Creek Golf Course
Example of mine waste

wood.

CLIENT:
THREE SISTERS mountain village

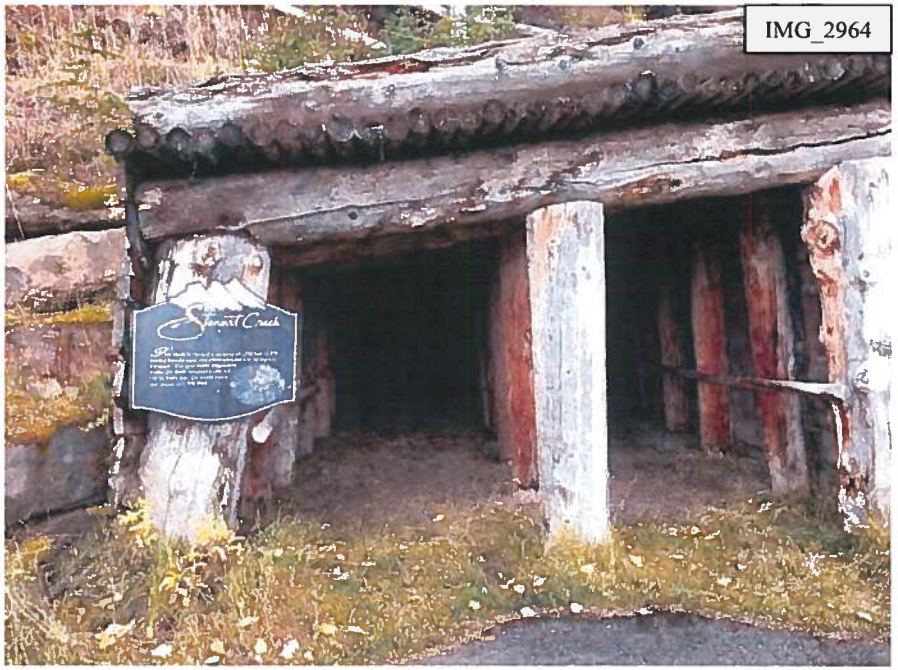
Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 5: Stewart Creek Golf Course
Collapsed Portal Entrance Area (R19)



Photograph 6: Stewart Creek Golf Course
Mine Portal Entrance (R19)

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 7: Stewart Creek Golf Course
Suspected subsidence (near R3 portal)

Photograph 8: Stewart Creek Golf Course
Surface Coal Mine (known to be backfilled as a municipal waste landfill in the past

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 9: ASP Area
Mine waste or exploratory borehole (feature G6)

Photograph 10: 500m Public Safety Assessment Area
Mitigated portal (Portal G37)

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 11: ASP Area
Prospect G30 (excavation to assess potential for mining)

Photograph 12: ASP Area
Prospect G31 (excavation to assess potential for mining)

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 13: ASP Area
Prospect G38 (excavation to assess potential for mining)

Photograph 14: ASP Area
Prospect G40 (excavation to assess potential for mining)

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 15: ASP Area
Mining Debris, near G49

Photograph 16: ASP Area
Prospect G26 (excavation to assess potential for mining)

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 17: ASP Area
Prospect G31 (excavation to assess potential for mining)

Photograph 18: ASP Area
Prospect G23 (excavation to assess potential for mining)

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Photograph 17: ASP Area
Prospect G19 (excavation to assess potential for mining)

Photograph 18: ASP Area
Prospect G14 (excavation to assess potential for mining)

wood.

CLIENT:
THREE SISTERS mountain village

Reconnaissance Photographs

Area Mining Impact Overview
Smith Creek ASP

CG09130

November 2020

Appendix B

Key Personnel CVs

Adam Coulson, Ph.D., P.Eng.

Principal Rock Mechanics Specialist

Professional Summary

Adam Coulson is a rock mechanics engineer with over 30 years of experience in the mining industry specializing mainly in underground and open pit mine design, and a range of rock mechanics aspects. He has been involved in leading, coordinating and conducting detailed rock mechanics mining scoping, pre/feasibility studies and detailed design/evaluation/ review/monitoring of underground excavations at existing operations in Canada and internationally. His additional responsibilities have included managing, coordinating and establishing project teams and liaison with multidisciplinary teams. He has been the lead for rock mechanics investigations of numerous underground and open pit mining projects and some technically challenging projects involving facilitation of qualitative risk assessment with project stake holders. During his time at Noranda Inc., Adam was also the Noranda representative on a number of international and Canadian rock mechanics projects/ committees, such as the Executive Steering Committee of the International Caving Study (ICS I), Industrial Review Committee for the Mitigation of Violent Failure Processes in Deep Underground Mining (MIRACO) and has sat on the Industrial Committee for Canadian Mining Industry Research Organization, (CAMIRO).

Dr. Coulson, as well as previously being an adjunct professor at the University of Toronto who has lectured in the Design and Support of Underground Excavations and Introduction to the Mining Industry, has given a number of short courses to industrial practitioners on topics of rock mechanics as well as short courses on the mining industry to non-practitioners.

Qualifications

Education

- Ph.D., Rock Mechanics, Civil Engineering, University of Toronto, 2009
- M.Sc. (Eng), Rock Mechanics, Mining Engineering, Queens University, 1996
- B.Eng., Mining Engineering, Camborne School of Mines, Exeter University, 1990

Professional History

- Wood Environment & Infrastructure Solutions, Principal Rock Mechanics Specialist and Eastern Canada Rock Mechanics Team

Years of Experience
30 (12 with Wood)

Office of Employment
Mississauga, Ontario

Languages
- English

Professional Associations
- Professional Engineers of Ontario, 2002
- APEG BC Professional Engineer, 2017
- (Eligible for Professional Engineers and Geoscientists of Newfoundland & Labrador)
- (Eligible for Temporary Ordre des ingénieurs du Quebec)
- Canadian Institute of Mining and Metallurgy (CIM)
- Canadian Rock Mechanics Association (CARMA)
- Canadian Geotechnical Society (CGS)
- Associate of the Camborne School of Mines, 1990

Leader, Global Mining Rock Mechanics Coordinator (2008-Present)
- University of Toronto, Adjunct/Special Lecturer (2002-2008)
- Sole Practitioner, Rock Mechanics Consultant (2001-2008)
- Noranda Inc., Rock Mechanics Engineer (1997-2001)
- Noranda Technology Centre, Rock Mechanics Scientist (1995-1997)
- Engineering Seismology Group (ESG) Canada Inc., Field Mine Seismologist Consultant (1994-1995)
- Queen's University, Research Assistant, Geotechnical Mine Design Research Group (1990-1994)
- Camborne School of Mines Geothermal Site, Research Assistant, Underground Project Supervisor (1990)
- Anglo American Corporation, Free State Saiplaas Mine, Junior (Project) Engineer (1989)

Core Skill Summary

Geomechanical Site Investigation

Developing, coordinating, managing multi-million dollar site investigation programs for open pit and underground mining deposits, involving multiple drill rigs, multiple core orientation techniques, differing hydrogeological packer testing and well testing techniques, camera and televiewer surveys, geomechanical logging for multiple classification methods. Many project have involved diamond drilling and directional drilling to greater than 1,000 m with continuous QA/QC for hole attitude, deviation and rock mechanics data quality.

Design and support of underground tunnels and mine excavations

Evaluation of excavation support requirements using empirical and numerical methods, for both low and high stress environments. Evaluation of support quality control, in situ and laboratory testing for various support types.

Underground Open Stope and Pillar Mine Design

Using numerical and empirical techniques such as the Canadian Stability Graph Method, and the Pillar Stability method, based on underground data collection of rock mass quality and laboratory testing combined with, numerical modelling to design, monitor and evaluate underground mining activity, and evaluation of Crown Pillar Stability and remediation methods for closure.

Block caving evaluation and mine design

Using numerical and empirical techniques such as the Laubschers Cave Mining Stability Graph Method, combined with underground and surface mapping, including data from diamond drill holes to evaluate the potential for block cave mining of large low grade deposits in Canada and internationally.

Microseismic monitoring and rock burst evaluation for high stress mining

Evaluation of mine microseismic systems, array optimization, and analysis of microseismic data. Investigation of rock burst incidents and ground failures caused by high stress mining, support and monitoring recommendations.

Open pit and waste dump design

Assessment of open pit wall stability using kinematic, limit equilibrium and numerical modelling methods; use of ground freezing to retain saturated overburdens, and evaluation of waste dump stability.

Laboratory testing of hard rock

Uniaxial and triaxial strength rock and grout testing, Brazilian strength testing, point load testing and determination of elastic constants.

In situ stress measurement and monitoring

Performing overcoring stress measurement using CSIRO hollow inclusion cell, and USBM 3 component deformation gauge, biaxial testing to obtain elastic constants. Installation of CSIRO cells for long term monitoring, and evaluation of various stress cell type response. Borehole camera, extensometer, TDR, and other displacement monitoring.

Representative projects

Underground mine design, closure and tunnelling pertaining to "Undermining"

Teck-Glencore, Louvem Mine, Crown Pillar Investigation and Water Management Review (2020)
Lead Rock Mechanics Engineer for the subsidence assessment for a number of near surface stope of the old Louvem Mine (Undermining Study), adjacent to the Louvicourt Mine in Quebec. This mine has been closed for a number of years is has undergone rehabilitation with the intention of treating the water from the underground mine. Placement of the water treatment plant was evaluated for safe accesses and following commissioning evaluation of potential instability through dewatering of waste rock fill in a glory hole has been evaluated with recommendations for pumping and a path forward.

MERN-Agnico Eagle Mines, Manitou Mine Crown Pillar Stability Evaluation (2020)
Senior review the crown pillar stability evaluation of historical Manitou Mine, located below Agnico Eagles Goldex Tailings pond. Evaluation involves construction of a 3D model of the mine and preliminary empirical crown pillar stability evaluations (Undermining Study) and 2D FEM modelling of a number of the crowns in critical positions.

Twin Metals Minnesota, Maturi Deposit Rock Mechanics Subsidence and Crown Pillar Stability Assessment (2018 - 2019)
Subsidence modelling and crown pillar stability review (Undermining Study) of the Maturi Deposit. Performed non-linear three dimensional numerical deformation modelling to simulate the open stope mining from 150m below surface to depth of around 800m over a large area 5 km along strike by 2 km down dip. This proposed mine lies below the start of the boundary waters for the Mississippi and a scenic highway. The mining method developed employs a system of large open stopes separated by pillars optimally designed to yield with an increase in the extraction ratio, with overall stability maintained through backfilling of stopes. In addition non-linear and linear elastic analysis were performed including empirical stability analysis of the crown pillar stability.

BHP Selbaie Mine, Rock Mechanics Review of the Stability of the Underground B-zone and Selbaie Pit walls (2017 - 2020)
As part of the overall water treatment plan for upgraded closure, one of the options looks at batch cleaning significant quantities of water for release to the environment, where by it will be required to draw down the pit lake by 15 to 20 m. Review of old mine plans and construction of a 3D model to assess the impact of pit dewatering on stability of the near surface mining of the B-zone, subsidence potential (Undermining Study) and stability of the pit wall with adjacent stoping near surface stopes.

Barrick Gold, Turquoise Ridge Joint Venture, Nevada. Underground Mine Design Scoping Level Study and Rock Mechanics Data Collection Review (2017 - 2018)
Assisted in the development of scoping level mine design concepts of various mining methods to determine optimized mining for the underground gold deposit. The Carlin trend ore bodies are typically of poor quality rock masses being highly faulted and altered such that standard hard rock mining is not performed but underhand cut and fill mining under an engineered stable backfill instead. In order to optimize the mine design and streamline the economics in better quality ground various mining methods,

opening size and ground support requirements were reviewed. Included in these options where full extraction and caving methods, that required subsidence analysis (Undermining Study) to be performed to assess potentially affected areas.

Teck-Glencore, Louvem Mine, Quebec Crown Pillar and Subsidence Review (2017)
Review and analysis of near surface stopes and their potential impact on a proposed water treatment plant. Empirical review and assessment of potential subsidence zones (undermining study) was performed with recommendation for site investigation work and siting of the plant.

MNDM, South Bay Mine Crown Pillar Investigation (2015)
Rock mechanics lead and project manager for characterization through diamond drilling of 4 stope crown pillars at the South Bay Mine. The project involved development of a 3D Model of the mine, which could also be run for stress analysis, to layout the boreholes to investigate the rock mass conditions of the crown pillars and stop hangingwall, backfill level and type, and void size (Undermining Study). The objective is to provide an analysis of the stability in relation to Mine Rehabilitation Code, Mining Act, Schedule 1, O. Reg. 240/000, Part 3, and to recommend mitigation procedures for stabilization if required.

Ojuelas Deposit la Encantada Mine Mexico, First Majestic, Prefeasibility Study – Rock Mechanics Review (2015)
Based on a site visit for underground mapping, review of exploration core and assessment of the geotechnical and exploration logging database, determine the viability and requirements for inclined block caving of the Ojuelas Deposit. Evaluation also considered optimum hydraulic radii for caving, draw rates, drawpoint spacing, fragmentation size, ground support requirements, sequencing strategies and surface subsidence estimates and impacts (Undermining Study).

Xstrata Raglan Mine, Quebec, Crown pillar stability evaluation and open stope and rib pillar dimensioning (2011)
Empirical and numerical evaluation of the required crown pillar dimension and maximum stope dimension for the extraction of the 3T zone at Raglan mines. This area was potentially very sensitive as the main mine road and ramp access lay adjacent to this zone (Undermining Study).

MERN, Mine Principale Crown Pillar Assessment for Site Rehabilitation (2015 – Present)
Rock mechanics lead investigator for the crown pillar stability and underground mine site rehabilitation assessment for the abandoned Mine Principale Mine site in northern Quebec. This site has three abandoned mines, with over 30 near surface stopes requiring assessment through site investigation geomechanical drilling and analysis of the stability of the crowns using empirical and numerical modelling techniques (Undermining Study). Further work includes determining the most economic and appropriate method for assessing the best way to stabilize any unstable crowns and stopes walls. Stabilization via blasting and backfilling, backfilling failed zones, and stabilization through backfilling voids via boreholes.

Northgate Minerals, Young-Davidson Project Rock Mechanics Lead for EPCM of an Open Pit and Underground Mine Design (2010 - 2012)
Coordination of geomechanical requirements for the construction of an open pit and underground mining operation down to 1,400 m bgs. Detailed design using empirical and numerical stress modelling methods for underground stope and pillar dimensioning, and ground support requirements. Detailed rock mechanics optimization for shrinkage, sublevel caving and room and pillar mining. Review of progress and optimisation of open pit slope stability and ongoing investigations into historic crown pillar stability, subsidence potential and stabilization methods (Undermining Studies).

Apollo Gold Corporation, Stock Mine Crown Pillar Assessment (2008 - 2010)
Identification and development of an action plan to determine the crown pillar stability and potential remediation measures during operation and closure. Site investigation and crown pillar stability analysis, back analysis and subsidence review of caved zones adjacent to critical infrastructure (Undermining Study).

Other Underground mine design, closure and tunnelling

NWMO, Nuclear Waster Management, Phase 2 Site Characterization Ignace-Hornepayne (2019-present)
Lead Rock Mechanics Engineer for the drilling up to seventeen (17) 1,000 m deep boreholes for the geomechanical, geomorphology, hydrogeology, geochemistry and groundwater monitoring of a potential Deep Underground Nuclear Repository. This project involves the integration of many disciplines requiring complex testing and high levels of QA/QC in every aspect of the drilling and testing.

EPA, Copper Bluffs UG Mine Stabilization and Rehabilitation (2019-present)
Copper Bluffs mine is an abandoned small copper mine in Norther California. The Mine is a source of acid mine drainage 9ARD) and requires the mine to first be stabilized and then rehabilitated to allow for the processing of water prior to entering the environment. Wood is working in combination with EA Group and Harrison Western Contracting and Construction (HarWest) to define the requirements to stabilize the mine and then rehabilitate. This project involves construction of a 3D model of the complex mine geometry for historical drawings and then the geomechanical evaluation of surface and underground, such that HarWest can effectively re-support and stabilize the mine for further ARD remediation.

South32 and Arizona Mining, Paste Backfill Strength Requirements for the Hermosa Project at the PFS Level (2019)
Assessment of backfill stability for multiple longhole open stope mining zone for the flat lying Hermosa Deposit. Assessment included review of mine sequence, lift heights, and mining geometry to determine stress and support requirements to define optimum factors of safety. Using a modified limit equilibrium technique after Mitchell and comparison to existing operations, assessment of the required fill strength for primary, secondary and tertiary stopes was assessed for the various mining zones.

Vale – J.R. Richardson, Inspection of the 150m long Stop Log Tunnel (2018)
Project manager and lead for the review of a short tunnel between tailings facilities and the Frood Mine tailings waste disposal facility. This tunnel is exposed to significant acid mine drainage from the tailings dams, and the tunnel supported with a combination of conventional galvanised rebar bolts and fibreglass resin rebar in order to stabilise the blocky ground of the tunnel. Performed planning and overview of the mapping of the tunnel and developed a photo library for future surveys. Made recommendation for additional ground support in places where support had corroded or was not evident and required based on rock mass quality classification and wedge analysis.

Minera Tres Valles, PFS Mining Geomechanics for the PPM Massive Deposit (2018)
Senior rock mechanics reviewer for the prefeasibility block cave study for the MTV's Papomono Massivo Project, located near the centre of the Papomono orebody. The PFS included compilation of rock mass classification and structural data, for the block caving evaluation of the deposit, including recommendations for caving sequence drawpoint spacing, draw control, subsicdence and infrastructure placement.

Rio Tinto, Third Party DGO Deposit feasibility review (2018)
Third party rock mechanics design and reserve estimation due diligence review of a potential open stope ore zone below the Kennecott Bingham Canyon Pit known as the drainage gallery ore (DGO).

Twin Metals Minnesota, Maturi Deposit Rock Mechanics Ramp Design (2018 - 2019)
Rock Mechanics design and review of the ramp placement for the business case of the Maturi Deposit. Performed numerical stress modelling to ascertain the number of stopes to be sterilized due to access through the orebody, including assessment of ground support requirements and potential deformation on the conveyor system.

Waterberg project, South Africa, Due Diligence Review of Underground PFS Mine Design (2016-17)
Rock Mechanics design and reserve estimation due diligence review for a confidential client.

Twin Metals Minnesota, Maturi Deposit Rock Mechanics Design Update at the PFS Level for the TMM Business Case (2016 - Present)
Rock mechanics update and design criteria confirmation for the TMM Business Case. Site confirmation geomechanical core logging of over 6,000 m of core to evaluation the consistency and influence on the ground support requirements for the updated PFS.

Centerra Gold (AuRico Gold), Kemess Mine, Surface Infrastructure Project Feasibility and Detailed Engineering, (2016 - Present)
Rock Mechanics investigation, design and senior review of 3 mine portals cuts for a conveyor decline and a triple access decline. This infrastructure is required for access from the existing plant site to the underground block cave of the Kemess Mine.

Codelco, El Teniente, New Mine Level Review and Recommendations for the Materials Handling System (2016)

Senior Rock Mechanics review of the geomechanical evaluation of the constructability of the main materials access drive TAP/TC. The evaluation involved the compilation of geomechanical and seismic data and reviews from other consultants and the development of strategies such as destress blasting, yielding ground support, instrumentation and pre-conditioning using hydraulic fracturing.

Twin Metals Minnesota, Maturi Deposit Prefeasibility Ground Support Assessment and Stability Review for the TMM Business Case (2016)
Rock mechanics assessment on the influence of mining on infrastructure development, required to assess the ground support recommendations for the TMM Business Case. Construct 3D PFS stope and pillar design criteria into the orebody shape and perform numerical stress analysis to assess stress damage on infrastructure and stability of pillars to validate the design criteria when incorporated into the actual orebody. Based on this modelling and empirical evaluations provide ground support design criteria for costing and scheduling purposes to support the TMM Business Case.

City of Toronto, Don Valley Water Management Diversion Tunnel Geotechnical Investigation (Phase 5) (2016)
Management of the rock mechanics aspects of the site investigation for the approximately 22 km of tunnel. Rock mechanics characterization was performed for 39 boreholes down to approximately 60 m depth. The main focus of this investigation was for the proposed 6 m TBM tunnel to be located around a depth of 50 m in the shale unit underlying Toronto. As part of this characterization the following task were performed: overcoring USBM stress measurements in 6 boreholes, rock mass geomechanical logging of all shale cores, packer testing, acoustic televiewer surveys, rock mechanics strength and swell testing.

Minera Frontera Del Oro, Los Helados PEA Update Study (2015)
Senior rock mechanics review for the geomechanical block cave evaluation for the Los Helados Deposit. Review of the evaluation of caveability, drawpoint configuration, draw control, preconditioning using hydrofracturing, ground support requirements and subsidence potential.

Orisyvo Project Mexico, Fresnillo plc., Geotechnical and Backfill (high level) Review and Assessment (PEA- level) to Support Mine Design and Mining Method Evaluations (2015)
Desktop review of the geotechnical/exploration database to confirm proposed stope dimensions, and development of a sequencing strategy for longhole open stoping with backfill. Evaluation of backfill strength requirements for paste backfill option. Recommendation for ground support requirements and future work.

Twin Metals Minnesota, Maturi Deposit Prefeasibility Geomechanical Assessment for the TMM Business Case (2015 - 2016)
Rock mechanics lead for the review and update of the Maturi mine design criteria based on modification of the mining method to improve productivity and recovery for the TMM Business case frame work. A full review of the geomechanical data gathered at the site was performed with redefinition of structural domains and recommendation for future work to provide information to a feasibility level. Assessment of stable stoping and pillar geometries was performed and combined with sequencing and linear elastic and non-linear numerical modelling to optimize the mining plan. Wood worked closely with the client to develop mining procedures and recommendation that are practical in nature to fully exploit this challenging deposit.

Confidential Client. Mine Tunnel Plug Assessment (2015 - Present)
Senior rock mechanics review and advisor for the assessment of a 40 plus year old tunnel plug at the abandoned Mine. Aided in the development of a geomechanical and hydrogeological drilling and instrumentation plan, including performing on site mapping of the exposed tunnel surfaces and outcrops and assessment of the tunnel plug state. Work continues performing laboratory testing and assessment of stability based on linear elastic and non-linear stress and displacement modelling, to aid in stability and remediation measure recommendations.

Glencore, Mine Raglan Donaldson Prefeasibility Site Investigations and Instrumentation (2015)
Rock mechanics lead and geomechanical site investigation and instrumentation advisor for the geomechanical characterization of two underground deposits, Donaldson (5 Lenses) and Z13-Z14. The project involved geomechanical rock mass characterization of 13 boreholes up to 740 m long, concentrating on the main ore zone. As part of the characterization review of televiewer data was performed to understand the structural fabric. Additionally, the site is contained within a 650 to 550 m thick permafrost zone. Techniques were developed and implemented to install multiple thermistor strings and deep piezometers to monitor the permafrost and artesian conditions. These installation are the deepest performed down to 750 m and have been used to identify the depth of the permafrost in the mining region. Additionally, hydrogeological characterization has been performed using the IPI Water Inflation packer system down to a depth of 750 m.

Vale, Voisey's Bay Underground Mine Project FEL3 (2013 - 2015)
Rock mechanics lead and geomechanical project manager for the rock mechanics design of two underground deposits, Reid Brook and Eastern Deeps. The project involved working closely with the client's operational team. Site investigations for the verification / validation of data, assessment of portal locations, and open pit bench mapping. For both the underground deposits, design has entailed cut and

fill, post pillar cut and fill, drift and fill and bulk mining methods. Rock mass and joint structure evaluations, development of optimum stope sizes, 3D stress analysis to determine infrastructure placement and ground support requirements. Development of sequencing methodology for bulk mining, assessment of backfill strength requirements and backfill options, assessment of dilution. Determination of crown pillar stability through empirical, linear elastic and non-linear modelling. Development of recommendations for future geomechanical programs.

New Gold Inc., Rainy River Project Underground Mining Feasibility Update Study Site Investigation and Design (2013 - 2014)
Rock mechanics lead, geomechanical project manager, Qualified Person (QP : NI 43-101) for site investigations (geomechanical) and design for the newly discovered Interpid zone for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core, outcrop mapping and using empirical and numerical methods to evaluate underground opening stability including the evaluation of the narrow vein mining, cut and fill mining and open stope stability dimensioning, backfill strength and testing and ground support requirements through the proposed mine.

Rainy River Resources Ltd, Ontario, Underground Mining Feasibility Study Site Investigation and Design (2012 - 2013)
Rock mechanics lead, geomechanical project manager, Qualified Person (QP : NI 43-101) for site investigations (geomechanical) and design of large 500 m deep open pit, to interact with a 850 m deep underground mine for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core, hydrogeological investigations and using empirical and numerical methods to evaluate underground opening stability including the evaluation of the narrow vein mining, cut and fill mining and open stope stability dimensioning, backfill strength and testing and ground support requirements through the proposed mine.

Northgate Minerals, Davidson Creek Diversion Tunnel ROV Inspection and Stability Review (2011)
Review and coordination of geomechanical requirements for inspection of a 400m long small diameter drill and blast water diversion tunnel inspection. The inspection was performed in combination with ASI Group using at an ROV "Seaeye Falcon" with an above waterline laser scanner, below waterline scanning Sonar, and above and below waterline video cameras. The survey developed sections ever 10m and pints of interest, to determine volume capacity and stability issue of the unsupported tunnel on average 2.25 m wide and 2.8 m high. A blockage was identified in the tunnel (due to a beaver dam) which required removal. The geomechanical review indicated stable back conditions for man entry.

Newmont Mining Ltd., Leeville Mine, Evaluation of Required Paste Backfill Strength (2011 - 2012)
Empirical and numerical evaluation of the required paste backfill strength for transverse open stoping and sill matt strength for cut and fill mining. Recommendations for future studies and backfill testing.

Vale Thompson Mine, 1D Rationalization Project, Manitoba, Geomechanical/Geotechnical FEL2 (prefeasibility) study (2011 - 2012)
Compilation of previous studies, evaluation of data and gap analysis assessment for the present study and the proposed Feasibility study (FEL3). The study involved the empirical and numerical evaluation of open stope dimensioning, sequencing, impact on infrastructure, ground support requirements, backfill strength requirements, risk analysis assessment and recommendations for future studies.

Magma Metals Inc., Thunder Bay North Ontario, Open stope and pillar dimensioning (2010 - 2011)
Site level geotechnical investigation to scoping study standard and design of open stope and pillar dimensioning for underground transverse open stoping and cut and fill mining to scope study level.

Ariab Mining Company (La Mancha), Sudan, Open stope and pillar dimensioning (2010 - 2011)
Site level geotechnical investigation to scoping study (PEA) standard and design of open stope and pillar dimensioning for underground sub-level open stoping to scope study level. Acted as, Qualified Person (QP – NI 43-101) for the PEA submission with reference to geomechanical mine design.

Orosur Mining Inc, Arenal Deeps Project, Uruguay, Underground Mine Design (2010)
Design using empirical and numerical stress modelling methods for underground stope and pillar dimensioning for room and pillar, cut and fill, and sub-level open stoping mining methods to a bankable feasibility study level. Acted as, Qualified Person (QP – NI 43-101) for the PEA submission with reference to geomechanical mine design.

Xstrata Copper, Mines Gaspe Mont Porphyre, Rock Mechanics Review and Recommendations (2010)
Provided a detail rock mechanics review of the all the available data making recommendations for further work and data collection to take this challenging ore body with the potential for block caving, through the next stage gates of scoping level to a feasibility level study. Additionally, provided a review of the state of the art in competent block cave mining and design, and recommendations for potential improvements in production and undercut design.

Silver Standard, La Pitarilla Project, Conceptual Design Study for Block Caving (Internal Report to Client) (2009)
Provided rock mechanics design review to a conceptual and scoping level of the caveability of an underground silver deposit in Mexico. Review of selected geotechnical borehole logs and rock mass assessment were used to assess potential undercut requirements to promote cave initiation, support recommendations and draw rate. Provided recommendations for site investigation work to develop the project to a prefeasibility level.

and observation ongoing for closure.

Aurora Gold Project, Guyana Goldfields (2009 - 2012)
Rock mechanics lead, and Qualified Person (QP – NI 43-101), for site investigation and design of open pits and underground operations for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core, hydrogeological packer testing and using empirical and numerical methods to evaluate pit wall slope stability and underground open stope dimensioning and design. Project involved 5 open pits, and a numerous underground deposit, the main deposit was open at depth below 1,500 m and controlled drilling down to 800 m was required for the geomechanical underground program.

Northgate Minerals, Young-Davidson Project, Underground Stope and Pillar Dimensioning feasibility Study (2008 - 2009)
Site investigation of deep boreholes using oriented core techniques down to 1,400 m bgs. Design using empirical and numerical stress modelling methods for underground stope and pillar dimensioning for longitudinal retreat, room and pillar, sub-level open stoping, large shrinkage stope, sub-level caving mining methods to a bankable feasibility study level.

David Bell Mine, Teck Corona, Operating Corporation, Ground Control Review of Cable Bolting Quality Control and Rock Mechanics Objectives (2006)
Review and recommendations of cable bolting practices, and cable bolt pipe tests, conducted at David Bell Mine. Also, conducted an underground site review of ground support standards and advised on a number of ground control objectives relating to stable stope extraction and sequencing.

Noranda Inc., Montreal, International Caving Study Co-ordination Meeting (1999-2001)
Noranda representative on the executive steering committee, for the International Caving Study, a group developed to research, collaborate and exchange technical developments for block cave mining. Sponsoring companies included, BHP, Codelco, De Beers Consolidated, P.T. Freeport Indonesia, Newcrest Mining, Noranda Inc., North Limited, Rio Tinto PLC and TVX Hellas. Coordination of site visits and exchange to Jeffery Mine, Quebéc. During the 3 years of the project detailed site visits for internal data collection and collaboration were made, to Northparkes Mine, Australia; Freeport Indonesia (Grasberg, IOZ, DOZ); Palabora, SA; Premier Mine, SA.

Open pit, Slopes and waste dump design

Campania Minera Zafranal - Teck, Senior Reviewer for the Zafranal Feasibility Level Site Investigation and Open Pit Rock Mechanics Design (2017 – 2018)
Rock mechanics senior reviewer for the feasibility level site investigation and the development of updated design criteria and stability analysis at the feasibility level for the 425 m deep Zafranal Pit. A large low grade porphyry copper deposit which is in the Peruvian Andes and structurally complex.

IAMGOLD, Cote Gold Project, Open Pit Optimization and Geotechnical Design Criteria for Feasibility Study Level (2017 – 2018)
Rock mechanics senior lead for the development of updated design criteria and stability analysis at the feasibility level for the 450 m deep Cote Gold Project. A large low grade gold deposit where slight changes to the pit slope inclination make large changes to the NPV of the project. Review of all data and design was performed with recommendations for the design and analysis going forward.

Graymont, Hicksville Quarry, New Brunswick, Open Pit Stability Site investigation and Pit Slope Design Criteria (Stability Assessment) (2017)
Rock mechanics lead for the site investigation for the stability and pit slope optimization of a 2 km long, 70 m deep Limestone Quarry. This study includes drilling of triple tube oriented cores and geomechanical logging with rock and soft rock laboratory strength testing, bench mapping of existing limestone waste rock cuts. Design criteria will be based on optimum bench face angles and bench widths based on kinematic analysis, combined with inter-ramp and overall slope stability to minimize the waste removal in the high grade Lime rich content dipping at 25 degrees and 30 m thick.

Regional Municipality of Halton, Dundas Street West of Brant Street, Outcrop Stability Review, Risk Identification, Mitigation Measures and Follow Up on Manual Scaling (2016 to 2017 ongoing)
Rock mechanics senior reviewer of the stability and risk identification of a 140 m long outcrop on average 10 m high adjacent to the Dundas Highway. Development of mitigation recommendations for the region of Holton following the Ministry of Ontario guidelines. Following enactment of manual scaling by Wood, review of the risk was performed and followed up with further recommendations.

IAMGOLD, Cote Gold Project, Open Pit Third Party Review for Updated PFS study (2016 – 2017)
Rock mechanics senior reviewer for a third party review of previous rock mechanics investigations and design for the 450 m deep Cote Gold Project. A large low grade gold deposit where slight changes to the pit slope inclination make large changes to the NPV of the project. Review of all data and design was performed with recommendations for the design and analysis going forward.

MERN Mine Principale, Quebec, Open Pit Stability Review for Closure and Rehabilitation (2015 – 2016)
Rock mechanics lead and geomechanical project manager, for the evaluation of the stability and closure requirements of the historic site Mine Merrill, part of the Mine Principale rehabilitation and closure Project with MERN and WSP. Performed geomechanical bench mapping, review of historic core and geomechanical core logging. Performed and reviewed kinematic analysis and slide.

Rainy River Resources Ltd, Ontario, Open Pit Slope Stability Feasibility Study Site Investigation and Design (2012 – 2014)
Rock mechanics lead and geomechanical project manager, Qualified Person (QP : NI 43-101) for site investigations (geomechanical) and design of large 500 m deep open pit, for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core, hydrogeological investigations and using empirical and numerical methods to evaluate pit wall slope stability. Additionally, design and investigation of the underground deposit through the evaluation of the narrow vein mining and open stope stability dimensioning.

Ariab Mining Company (La Mancha), Sudan, Africa, Open Pit Slope Stability Recommendations (2010 - 2012)
Site level geotechnical investigation of open pits and core to scoping study (PEA) standard and design of pit wall slopes at two open pits to scoping study level. Acted as Qualified Person (QP : NI 43-101) for the open pit geomechanical design.

Aurora Gold Project, Guyana Goldfields, SA (2009 - 2012)
Rock mechanics lead and Qualified Person (QP : NI 43-101) for site investigation and design of open pits and underground operations, for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core and using empirical and numerical methods to evaluate pit wall slope stability and underground open stope dimensioning and design. The pits 5 in total were technically challenging being located in both hard rock and weather rock (saprolite residual soil/clay) an adjacent to a large river the Cuyuni River. The interaction of the pit and the river were critical and hydrogeology was incorporated into the geotechnical investigations. A geotechnical designed River Dyke was required to prevent flood waters from entering one of the main pits. This required a close working relationship between the rock, geotechnical, hydrogeological and mining engineers as well as the client to provide practical and economic solutions.

AcerlorMittal, Liberia Western Range Iron Ore Project, Africa (2010 - 2012)
Rock mechanics senior review for the feasibility level and detailed engineering for the slope stability assessment of the Tokadeh, Gangra and Yuelliton direct shipping ore (DSO) and concentrator open pits. Performed a site review and reconnaissance of the site prior to site investigation work to help define the requirements of the geomechanical studies with the lead rock mechanics engineer. These three pits are located in a remote region of Liberia, in the mountains requiring consideration of stability of saprolites/laterites and soft non-economic ore and well as a structural understanding of the iron ore formations and the basal gneiss.

Lundin Mining, Touro Open Pits, Spain, Scoping Study Evaluation of Existing Open Pit Operation for Expansion and Mining of 3 New Deposits (2012)
Rock mechanics lead for the evaluation based on existing data and site visit to perform scoping level pit bench face mapping and evaluation of exploration core. Scoping level stability design of criteria developed for pits slopes of 5 open pits, using preliminary kinematic stability analysis and limit equilibrium modelling.

Trelawney Mining and Exploration Inc., Cote Lake, Ontario, Open Pit Slope Stability Scoping Study (2011 - 2012)
Site level geotechnical investigation of core to scoping study standard and analysis and design of pit wall slopes for a potential > 500 m deep super pit.

Trelawney Mining and Exploration Inc., Cote Lake, Ontario, Open Pit Slope Stability Review and Gap Analysis Evaluation for Scoping study to Feasibility Level Design (2011)
Rock mechanics review of site investigations for the Cote Lake open pit. The pit has the potential to be > 500 m deep and is open at depth. Evaluation of data and review of core led to the development of recommendation for a scoping to feasibility level data requirement.

Rainy River Resources Ltd, Ontario, Open Pit Slope Stability Review and Gap Analysis Evaluation for a Feasibility level design (2011)
Rock mechanics review of site investigations and previous design studies for the Rainy River open pit. The pit has the potential to be 500 m deep and is overlain by 35 m of clays. Evaluation of the studies led to recommendations for future investigations and studies and potential optimizations for design.

Quest Rare Mineral Ltd, Strange Lake Quebec, Open Pit Slope Stability Feasibility Study Design (2011 -2013)
Rock mechanics lead, project manager, Qualified Person (QP : NI 43-101) for site investigations (Geomechanical and geotechnical) and design of large 50 year potential open pits, for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core, hydrogeological investigations and using empirical and numerical methods to evaluate pit wall slope stability.

Quest Rare Mineral Ltd, Strange Lake Quebec, Open Pit Slope Stability Prefeasibility Study Design Recommendations (2010-2011)
Site level geotechnical investigation of open pits and exploration core to prefeasibility study standard and design of pit wall slopes. Acted as Qualified Person (QP: NI 43-101), for development of the Prefeasibility pit Design. Recommendations for further studies.

Magma Metals Inc., Thunder bay North, Ontario, Open Pit Slope Stability Scoping Study Recommendations (2010 - 2011)
Site level geotechnical investigation to scoping study standard and design of open pit slopes, including recommendations site investigations and further studies to move the project to a pre and feasibility level.

Baffinland Iron Mine Corporation, Mary River Project, Baffinland, Open Pit Slope Stability Review and Gap Analysis Evaluation for a Feasibility level design (2010)
Rock mechanics review of site investigations and previous design studies for the Mary River open pit. The pit has the potential to be 500 m deep. Evaluation of the studies led to recommendations for future investigations and studies and potential optimizations for design.

Northgate Minerals, Young-Davidson Project Rock Mechanics Lead for EPCM of an Open Pit and Underground Mine Design (2010 - 2012)
Coordination of geomechanical requirements for the construction of an open pit and underground mining operation down to 1,400 m bgs. Detailed design using empirical and numerical stress modelling methods for underground stope and pillar dimensioning, and ground support requirements. Detailed rock mechanics optimization for shrinkage, sublevel caving and room and pillar mining. Review of progress and optimisation of open pit slope stability and ongoing investigations into historic crown pillar stability.

Duck Pond Operations, Boundary Pit Feasibility Study (2010 - 2011)
Rock mechanics lead for the development of field investigations using oriented core, hydrogeological studies for the analysis and design of two small open pits to feasibility study level.

Aurora Gold Project, Guyana Goldfields (2009 - 2011)
Rock mechanics lead and Qualified Person (QP : NI 43-101) for site investigation and design of open pits and underground operations, for a bankable feasibility study. Design and implementation of the site investigation through diamond drilling using oriented core and using empirical and numerical methods to evaluate pit wall slope stability and underground open stope dimensioning and design.

Northgate Minerals, Young-Davidson Project: Analysis of Geotechnical Data and Design for Open Pit Slope Stability (2008 - 2009)
Review and analysis of oriented core data and laboratory testing for the evaluation of open pit slope stability based on kinematic stability analysis, plane and wedge failure, and limit equilibrium analysis for overall slope stability.

Verglas Project, Rouyn Noranda, Quebec, Technical and operational post audit review of the Verglas Project Phase I (2001)
Facilitating and identification of technical and operation problems developed through the completion of the Verglas Project Phase I. A technically challenging project amalgamating state of the art ground freezing technology to stabilise thirty meters of saturated clays and creating the largest ever circular cofferdam, in order to mine a rich crown pillar via open pit mining. The goal of this audit was not only to identify all the issues and technical problems that had arisen, but also to analyse the mitigation measure taken and evaluate the risks for a future project concluding with recommendations.

Gallon Open Pit Mine, Rouyn Noranda, Quebec, Review and Design of Alternate Pit Access to Achieve Optimum End of Pit Life Extraction (2000)
Review and site inspection of the existing pit and wall stability in regard to proposing an alternate push dumped waste rock ramp to allow for mining of the existing ramp and high grade lens contained in pit walls. Project was successful in achieving maximization of mining the in-pit resource.

Verglas East Phase I, Rouyn, Quebec, Design and Economic Modelling from Construction to Production (2000)
Supervision of detailed engineering and design of small open pit, to mine a high grade remnant crown pillar, utilising ground freezing of the largest ever cofferdam to be constructed. Cost evaluation, economic modelling and acquisition request proposal development and presentation. Contract negotiation and organisation. Evaluation of monitoring requirements, and technical advice during construction and implementation of project.

Antamina, Peru, Reclamation Plan - Waste Dump Design Review (1998)
Review of Waste Dump design for a major open pit, selecting and co-ordinating expert consultation for design of large waste dumps located in the high altitude and precipitation regions of the Andes.

Redefinition of the reclamation plan as part of the detailed engineering study. Research into the geomorphic stability of large waste dumps based on historical waste dump construction of similar waste dumps and expected material properties. Successful defence of the design led to financing of the project.

Shaft evaluations

Cardiff South Incline, Hudbay, Ontario, Geotechnical Review for Shaft Capping (2009)
Review of the geotechnical conditions around the shaft collar of an inclined adit, in order to place and engineered steel reinforced shaft cap, pinned to competent rock.

Golden Giant Mine, Ontario, Shaft Pillar Extraction Review (1999)
Review of geotechnical conditions, mining sequence, and performing numerical stress modelling and recommendations of alternative mining strategies for the potential mining of the shaft pillar before the end of mine life. Recommendation of the detress slot option led to the eventual successful mining of the shaft pillar.

Golden Giant Mine, Ontario, Numerical Modelling Study on the Effects of Adjacent Property Mining on the Golden Giant Shaft (1999)
Review of geotechnical conditions in the golden giant shaft and infrastructure, calibrating numerical stress modelling to observations, and modelling of different mining options and the effects of mining by an adjacent operation.

Norita Mine, Quebec, Geotechnical Shaft Inspection and Shaft Infrastructure Evaluation (1996)
Geotechnical investigations and inspection of timber lined shaft infrastructure with full shaft mapping for support recommendations required for final stage mining of stopes past the shaft location.

Golden Giant Mine, Ontario, Shaft Review of Support Strategies (1996)
Review and inspection of support work carried out in the Golden Giant shaft and numerical stress modelling of effects of future mining.

Golden Giant Mine, Ontario, Canada, Geomechanical Evaluation and Investigation of the Golden Giant Shaft (1995)
Geotechnical investigation and structural inspection of the Golden Giant timber lined shaft following a flurry of seismic activity that temporarily closed the shaft and the mine. Mapping performed as part of a team of mine site and NTC personnel and an external consultant. Review of seismic activity and effects of mining induced stress using numerical stress modelling was performed and calibrated to borehole camera work and complete shaft mapping of the affected area. Making recommendations for ground support and monitoring instrumentation.

Microseismic analysis and rock burst evaluation

Williams Mine, Ontario, Williams Mine Sill Pillar Response to Mining (2001 - 2008)
As part of Dr. Coulson's PhD research, analysis of mine induced microseismic data using spatial and temporal techniques of event locations alone, combined with analysis of conventional displacement monitoring instrumentation was performed. Through the calibration of 3D linear elastic numerical modelling and 2D non-linear modelling, led to insights into the strength state of the rock mass going from pre to a post peak brittle strength, defining the gradual failure a confined rock mass over 100's of metres.

Golden Giant Mine, Ontario, Shaft Pillar Evaluation (2009)
As part of Dr. Coulson's PhD research analysis of mine induced microseismic data using full waveform records was performed to determine changes in the source parameters, during the gradual failure of a confined rock mass in the region of the Golden Giant Mine shaft pillar. Notable changes in these source parameters were observed during the point of yield of the rock mass, and fault plane solutions determined from first motion studies were found to correlate to the stress regime and formation of a macrofracture shear structure. Calibration with 3D linear elastic modelling, indicates the potential for determining areas of hard rock mines that will become seismic and fail.

Brunswick Mine, New Brunswick, Risk Assessment for the 1000 South Bulk Ore Zone Mass Blast (2001)
Back analysis and forward modelling to evaluate the risk potential of ground reaction related to mining a de-stress blast to shield the main 1000 South Bulk Ore zone from a high stress environment. This project required the planning, organisation and implementation of qualitative risk analysis tools to evaluate the mining of a substantial volume of ground in a short time frame. Facilitating and structuring of risk analysis brainstorming sessions with project members at the mine and Noranda's technology centre was performed to develop a risk analysis framework. Through back analysis of existing of openings damage likelihood criteria where developed and correlated to mining during the progression of extraction, such that mitigation and project planning could be achieved for the duration and post duration of the project. This project required not only analysis and development of extended analysis techniques beyond current practice, but the communication and drawing together of information to all stakeholders at all levels of seniority.

Brunswick Mine, New Brunswick, Rock Burst Response Team (2000)
Geotechnical investigation and mine planning to alleviate the potential for large magnitude rock burst events. Review and recommendation of mine sequence; co-ordination of study using numerical, analytical and empirical techniques, following a significant fall of ground in a sensitive area.

Brunswick Mine, New Brunswick, High Stress Mining Project (2000)
Risk evaluation of effects of high stress on the stability and burst potential of secondary pillar stopes, and stope wall stability, based on induced stress, seismic, geotechnical/ geological, falls of ground and pillar deterioration histories. Production of calibrated design charts and tools for assessing the risk for stope and pillar failure under high stress and bursting potential, for use with 3D linear elastic modelling. This being based on over 50 pillar case histories, and stope wall failures. This project was ongoing for over 3 years.

Golden Giant Mine, Ontario, Microseismic Shaft Activity Evaluation (1996)
Analysis of the development of microseismicity in relation to mining activity and stress behaviour around a portion of the highly stress shaft development.

Heath Steele Mine, New Brunswick, Microseismicity and System Evaluation (1996)
Following a major rock burst and fall of ground incident, evaluation of the after shock location and interpretation of cause. Review and recommendation of proposed seismic system installation.

Creighton Mine, Ontario, Canada, Evaluation of Seismicity in Highly Stress Ground (1990 - 1993)
Detailed geotechnical review of ground conditions, microseismic system evaluation, microseismic and ground monitoring analysis. Researching through numerical and empirical techniques the propagation of seismic trends relative to mining of a highly stresses sill pillar, as part of the Canadian Rockburst Research Project.

Other Project Experience

(Many More Projects prior to 2006)

Additional Qualifications

Publications / Presentations

- Cabot, E, Coulson, A., Tod, J., McNicoll, S., Delattre, S., Rasmussen, H. and Gautier, C. (2019). "Hazard identification, stability assessment and risk mitigation overview of near-surface openings and pillars at the former Mine Principale, in Chibougamau, Quebec". In proc. Of 72nd Canadian Geotechnical Society Annual Conference, Geo St. John's - Under Land and Sea, Sept 29 to Oct 2, 2019, Paper #428.
- Coulson, A., Cabot, E., Vlachopoulos, N., and Mohsen, N (2018). "Practical Aspects of Core Logging for Engineering Purposes" Workshop given at the 71st Canadian Geotechnical Society Annual Conference, Geo Edmonton, Sept 23, 2018.
- Altwegg, P., Cabot, E., Maloney, S., Coulson, A., Malla, S., and Goodman, S. (2017). " *In Situ* Stress Measurements at the Coxwell Bypass Tunnel along the Inner Harbour East and Lower Don River, Toronto, Ontario." Proc. of the 70th Canadian Geotechnical Conference and the 12th Joint CGS/IAH-CNC Groundwater Conference, GeoOttawa, Ontario Canada, Oct 1 to Oct 4, 2017. Paper #295.
- Cabot, E., Guatrey, S., Coulson, A., Choquet, F., Anderson, M., Drob, T., Caumartin, R. and Thivierge, S.E. (2016). "*In Situ* Characterization and Deep Borehole Instrumentation to Identify Permafrost Zones at the Raglan Mine, Nunavik, QC, Canada." Proc of the 69th Canadian Geotechnical Conference, GeoVancouver 2016 Oct 3 to Oct 5, 2016. Paper #003918.
- Coulson, A.L., and Bawden, W.F. (2010), "Characterising the state of failure of a confined rock mass from the pre to post peak strength state, using microseismicity and conventional displacement instrumentation – A case study William Mine, Sill Pillar, Canada", in Proc. of the Fifth International seminar on Deep and High Stress Mining, 6-8 Oct, 2010, Santiago, Chile. pp 45.
- Coulson, A.L., (2009), "Investigation into the Pre to Post Peak Strength State and Behaviour of Confined Rock Masses Using Mine Induce Seismicity". PhD Thesis Department of Civil Engineering, Lassonde Institute, University of Toronto, Canada, 457 pp.
- Coulson, A.L., and Bawden, W.F. (2008), "Observation of the Spatial and Temporal Changes of Microseismic Source Parameters and Locations, Used to Identify the State of the Rock Mass in relation to the Peak and Post-Peak Strength Conditions", in Proc. 42th U.S. and 2nd US-Canada Rock Mechanics Symposium, San Francisco, June 29 - July 2, 2008. ARMA #08-101: 19 pp.
- Coulson, A.L., Bawden, W.F. and Crowder, J.J. (2007), "Estimation of the Peak and Post-Peak Behaviour of Fractured Rock Masses Using Spatial and Temporal Analysis of Mine Induced Microseismicity", in Rock Mechanics, Meeting Society's Challenges and Demands, Proceedings of the 1st Canada-US Rock Mechanics Symposium, Vancouver, Canada, 27-31 May, 2007.
- Crowder, J.J, Coulson, A.L. and Bawden, W.F. (2006), "The Field-Scale Laboratory: Estimation of Post-Peak Parameters and Behaviour of Fracture Rock Masses", ARMA, Golden Rocks 2006, Colorado School of Mines, Golden, Colorado, USA. June 17th –21st, 2006.
- Crowder, J.J., Coulson, A.L. and Bawden, W.F. (2006), "Innovative use of SMART Cable Bolt Data through Numerical Back Analysis for the Interpretation of Post Failure Rock Mass Properties", CIM Vancouver 2006, Vancouver, Canada, May14th – 17th, 2006.
- Coulson, A. L (2005). " An Introduction to the Mining Industry Exploration to Reclamation – Mining 101" Presented to the Federal Trade Officers Training Workshop, Novotel, Toronto, Canada, March 2005 and incorporated into short course for Engineering for Educators Workshop, University of Toronto, Dec 2005.
- Coulson, A. L., Diederichs, M.S., Falmagne, V., Rizkalla, M. and Simser, B. (2002), "Qualitative Risk Assessment for Mine Openings in Varying Stress Conditions", NARMS, Toronto, Canada. July 7th 10th, 2002.

James (Jim) Tod, M.Sc.(Eng), P.Eng

Associate Rock Mechanics Engineer
Team Lead

Professional Summary

Jim is a rock mechanics engineer with over 30 years' experience in mining and geotechnical engineering in Canada and internationally. His primary focus has been rock mechanics and rock mass characterization, with the aim of obtaining a proper understanding of the geology so the correct engineering solution can be applied. He has coordinated and conducted rock mechanics studies at the scoping and pre/feasibility levels for both open pit and underground projects, and has performed reviews for internal and external studies, and audits for existing operations.

For open pit mining operations, Jim has helped to prepare Ground Control Management Plans, implemented monitoring and data collection systems, and created systems for documenting ground instabilities and communicating hazards to the workforce and management, and has done numerous studies for open pit designs for both hard and soft rock. For underground mining, he has been involved in the selection of appropriate mining methods and stope and pillar sizes and has performed or led crown pillar and mine sequencing studies using numerical, empirical and analytical methods. He has also conducted ground support audits, instrumentation program design and interpretation, and the interpretation of microseismic data in relation to mining.

Multiple studies in the last several years have focussed subsidence potential above new or existing operations, or on the stability of the rock mass above the existing excavations. These studies have addressed the stability of the crown pillars, as well as the potential for propagation of chimney/caving failures, and the long-term response of the rock mass above the operation, including on the ground surface

Throughout his career, Jim has excelled in simplifying complex ideas so they can be more easily understood by those unfamiliar with rock mechanics and mining. This has served him well in advocating for clients and employers with stakeholders and government ministries, and as an Adjunct Professor and occasional guest lecturer in rock mechanics at Queen's university.

Years of Experience
32 (2 with Wood)

Office of Employment
Mississauga, Ontario

Languages
- English

Professional Associations
- Professional Engineers Ontario
- Engineers & Geoscientists British Columbia
- Association of Professional Engineers and Geoscientists of Alberta
- Canadian Institute of Mining (CIM)
- International Society for Rock Mechanics (ISRM)

Qualifications

Education

- M.Sc.(Eng), Rock Mechanics, Mining Engineering, Queens University, 1996
- B.A.Sc., Geological Engineering (Geotechnical Option), University of British Columbia, 1988

Registrations / Certifications / Licenses

- Professional Engineers Ontario (PEO), 90518275
- Engineers and Geoscientists British Columbia, 18148
- Association of Professional Engineers and Geoscientists of Alberta, 276339

Professional History

- Wood Environment & Infrastructure Solutions, Associate Rock Mechanics Engineer, Central Canada Rock Mechanics Team Lead (2018 – Present)
- Detour Gold Corp, Detour Lake Mine, Senior Geotechnical Engineer, James Bay area, Ontario (2015 to 2018)
- Queen's University at Kingston, Adjunct Professor – Stability Analysis in Mine Design, Kingston, Ontario (Fall Term, 2015)
- BGC Engineering, Rock Mechanics Engineer, Toronto and Kingston, Ontario (2014 to 2015)
- Golder Associates Limited, Geological / Rock Mechanics Engineer, Montreal, Quebec and Kingston, Ontario (2010-2014)
- Mine Design Technologies Inc., Senior Engineer, Kingston, Ontario (2000 to 2010)
- Engineering Seismology Group (ESG) Canada, Rock Mechanics Engineer / Programmer, Kingston, Ontario (1996 to 2000)
- Bharti Associates Engineering Ltd, Rock Mechanics Engineer, Sudbury, Ontario and Kingston, Ontario (1994 to 1995)
- Piteau Associates Engineering Ltd, Junior / Intermediate Geological Engineer, Vancouver, British Columbia (1988 to 1992)
- Thurber Consultants Limited, Slope Monitor – Syncrude Mildred Lake Mine Site, Fort McMurray, Alberta (1988)

Crown Pillar and Subsidence Studies

Twin Metals Minnesota, Maturi Deposit Rock Mechanics Subsidence and Crown Pillar Summary Report (2018 - 2019)

Prepared report summarizing potential for subsidence and crown pillar stability above TMM's proposed Maturi project in Minnesota for release to regulators (2019). Report was based on technical report prepared by Wood, but reframed in less technical language.

MERN, Mine Principale Crown Pillar Assessment for Site Rehabilitation (2018 – Present)

Performed slope stability assessment and technical support for field work for crown pillar stability and underground mine site rehabilitation for the abandoned Mine Principale mine site located near Chibougamou, QC.

BHP Selbaie Mine, Rock Mechanics Review of the Stability of the Underground B-Zone and Selbaie Pit walls (2019 - 2020)

Prepared final report documenting the geomechanics assessment for slope stability and crown pillar failure, and determination of propagation limits above stope crowns in support of closure and remediation for Mine Selbaie, James Bay region, Quebec.

Vezza Project – Crown pillar assessment (2011)
Project manager for crown pillar design study for narrow vein open stopes at the Vezza Mine, near Matagami, Quebec. Work involved selection of geotechnical drill hole locations, preparation of laboratory test program, quality assurance and compilation of site investigation data, characterization of the rock mass, design of the crown pillar, and preparation of the final report.

Wood Experience

NWMO, Nuclear Waster Management, Phase 2 Site Characterization Ignace-Hornepayne (2019-present)
Technical reviewer and support for drilling, core logging and data collection, and reporting for the NWMO's field investigation for a potential underground waste repository near Ignace, ON.

Twin Metals Minnesota, Maturi Deposit Rock Mechanics Feasibility Readiness Assessment (2019-2020)
Lead Engineer in preparation of path forward for geomechanics field and testing program to advance TMM's Maturi Underground Project in Minnesota towards full feasibility. Areas of discussion included location of drillholes for main deposit and ramp access, in-situ stress testing, hydrogeology, and scheduling.

Vale – Central Tailings Area Inspection of Seepage Collection Area No. 2 Tunnel (2019)
Performed visual inspection from of ground support and tunnel conditions from video footage taken from the inlet and outlets for the No. 2 tunnel, taken from a remote-controlled boat mounted with a video camera.

Vale – J.R. Richardson, Inspection of the 150m long Stop Log Tunnel (2018)
Senior review for review of a short tunnel between tailings waste disposal facility and tailings facilities at Frood Mine. Review consisted of inspection of galvanized rebar and fiberglass resin rebar in blocky ground under corrosive conditions, recommendations for additional ground support where affected by corrosion, and creating a photo library baseline for future surveys.

IAMGOLD, Cote Gold Project, Tailings Storage Facility Rock Mass Characterization Study (2019)
Design and implementation of field program and analysis of data for rock mechanics assessment of ground conditions in support of hydrogeological / hydrological assessment of tailings management facility for IAMGOLD's Côté Gold project, Gogama, ON (2019).

Peer Technical Review - Various Clients (2018 – present)
Internal peer reviewer for technical reports for pre-feasibility and feasibility level open pit designs, site investigations, crown pillar designs, subsidence investigations.

External technical review – Various Clients (2018 – present)
High level third-party review of geomechanics for operations in Canada, South America, India, Indonesia (ongoing).

Selected Experience – Underground

Nova Scotia Power – Inspection and design of remediation for Wreck Cove tailrace tunnel (2015)
Site inspection and design of remedial ground support for a rockfall in the tailrace tunnel at Nova Scotia Power's Wreck Cove generating station, Cape Breton, Nova Scotia. Project involvement also included assistance in preparation of construction specifications, and selection of contractors, training of staff for QA of ground support installation.

Mines Abcourt – Pillar classification and remediation for Elder Mine (2014)
Site inspection and pillar classification / pillar remediation for underground room and pillar mine (Elder Mine) near Rouyn-Noranda. Successfully advocated for the client with La Commission de la santé et de la sécurité du travail (CSST) to resume operations.

Graymont – Instrumentation program design (2014)
Design of an instrumentation program for Graymont's Pleasant Gap underground limestone quarry in Pennsylvania.

Geomega – Conceptual study for underground rare earth project (2013)
Technical lead for conceptual study for an underground rare earth project. Duties included site assessment, preliminary rock mass characterization, stope and crown pillar dimensioning, and preparation of a summary geomechanics report, Lebel-sur-Quevillion, Quebec.

Paguanta – Underground pre- and feasibility geomechanics study (2012)
Technical lead for preparation of a pre-feasibility / feasibility level geomechanics report for the Paguanta project in northern Chile. Tasks involved quality assurance and compilation of site investigation data, characterization of the rock mass, assessment of stope stability, recommendations for stope dimensions based on multiple mining methods, crown pillar design, ground support recommendations, and preparation of the geomechanics design report.

Iamgold Mouska Mine – Numerical modelling study (2011)
Numerical modelling study to assess proposed extraction sequence for a deep underground zone at Iamgold's Mouska Mine, Cadillac, Quebec. The extraction sequence was based on stresses and strains developed in the orebody, impact of mining on the haulage drifts, pillars shaft and ramp. Provided recommendations regarding ground support and extraction sequences, and prepared summary report.

Minera Cosala Nuestra Senora Mine site audit review (2011).
Provided rock mechanics support for a site audit for the Nuestra Senora Mine in Cosala, Mexico. Duties involved collection of underground geotechnical data, stability assessment for proposed open stopes, and preparation of summary report.

Serra Pelada Project – Rock mass assessment (2011)
Site investigation for the evaluation of support performance and rock mass characterization for underground deposit in saprolite / saprock at Collossus Mineral's Serra Pelada project, located in the Para province in Brazil. Evaluated the existing support design and installation methods, and made recommendations for changes to support type, pattern design, and installation. Provided characterization for the underground rock mass.

Mine Raglan – Back Analysis of fall of ground (2011)
Carried out back analysis of a large fall of ground in permafrost at the Raglan Mine in northern Quebec. Back analysis was performed based on site investigation, geological data, historical mining data, and numerical modelling. Created calibrated numerical model and developed design criteria for remaining stopes and blocks within the zone (2011).

Numerical Modeling – Various (2000 – 2010)
Provided numerical modelling support to various operations using boundary element packages (*examine*^{3d}, Map3d) for assessment of extraction sequences. Operations included Williams, David Bell, Golden Giant, and Lac des Iles (Ontario), Cayeli Mine (Turkey), and Leeville Mine (Nevada, USA). Also provided numerical modelling training for engineering staff at Cayeli Mine (Turkey).

Instrumentation – Various (1996 – 2010)
Provided support for SMART instrumentation for operations around the world. Also configured and installed proprietary data acquisition systems at Andina (Chile), Cayeli (Turkey), Williams, Kidd Creek and Goldex Mines (Canada) and the Olkiluoto nuclear power plant site (Finland). Installed and configured microseismic systems and operations in Canada and Australia.

Big Gossan – PEA level rock mechanics and stope sizing (1994)
Rock mechanics engineer for the preliminary economic assessment for Freeport's Big Gossan deposit, located in Irian Jaya province of Indonesia. Duties included site visit and collection of available data, rock mass and engineering geology characterization, preliminary stope designs and mining sequences, plus preparation and presentation of final report.

Selected Experience – Open Pit

Detour Gold – Geotechnical Engineering for Pit Slopes (2015 – 2018)
Founded Geotechnical department for Detour Lake Mine (Detour Gold), focussing on implementing systems and strategies, creating a Ground Control Management Plan (GCMP), characterization of the rock mass via photogrammetric modelling, documenting the as-built pit profile and reconciling with the original pit design parameters, mining through historic underground workings, preparation of a geotechnical assessment for the life-of-mine pit phases, building a fault model for the pit, implementing a drone program, and training staff in geotechnical data collection, James Bay Area, Ontario.

Geotechnical slope design reviews – various (2014-2015)
Performed internal technical reviews for slope designs and rock mechanics reports for mines in British Columbia (Gibralter Mine), Eritrea (Bisha Mine), and Brazil (Volta Grande Project).

Patterson Lake South – open pit / underground rock mechanics (2015)
Prepared rock mechanics portion of complex open pit / underground scoping level study for a potential uranium mine (Fission Uranium Corp.).

Quarry floor pop-up study (2015)
Performed internal technical review and completed technical report for potential quarry bottom pop-up study for the Miller Braeside Quarry, Ontario.

Hardrock Project – open pit slope kinematics assessment (2014)
Prepared a kinematic slope re-assessment for the proposed Hardrock open pit near Geraldton, Ontario (2014).

Kipawa Project – pre-feasibility/feasibility level study (2013)
Technical lead for pre-feasibility / feasibility level open pit slope design for Matamec's Kipawa rare earth project near Temiscaming, Quebec. Work involved selection of geotechnical drillhole locations, preparation of laboratory test program, quality assurance and compilation of site investigation data, characterization of the rock mass, assessment of slope stability, pit design, and preparation of the pit slope design report.

Casa Berardi – open pit slope design (2012)
Project director and technical lead for a conceptual level open pit slope design for the Casa Berardi mine near La Sarre, Quebec. Work involved selection of geotechnical drillhole locations, preparation of a laboratory test program, quality assurance and compilation of site investigation data, characterization of the rock mass, assessment of slope stability, pit design, and preparation of pit slope design report (2012).

Bouskour Mine – feasibility level open pit slope design (2012)
Technical lead for feasibility level open pit slope design for the Bouskour Mine in Morocco. Involved in quality assurance and compilation of site investigation data, characterization of the rock mass, assessment of slope stability, pit slope design and preparation of pit slope design report (2012).

Additional Qualifications

Training

- Joint Health and Safety Committee Certification (Part 1), 2018
- Practical Calibration of Numerical Models for Meaningful Prediction of Ground Behaviour, short course given by W.F. Bawden and K. Kalenchuk, Montreal, May 2014
- Short Course on Rockfall Protection Techniques, given by Daniele Piela, Queen's University, August 2013

Publications / Presentations

- Cabot, E., A. Coulson,J. Tod, S. McNicoll, S. Delattre, H. Rasmussen, and C. Gauthier, 2019. Hazard identification, stability assessment and risk mitigation overview of near-surface openings and pillars at the former Mine Principale, in Chibougamau, Quebec. Paper presented at the 72nd Canadian Geotechnical Conference, St. John's, NFLD, Sept. 29 – Oct. 2, 2019.
- Bawden, W.F., Tod, J., Lausch, P. and Davison, G. 2002. The use of geomechanical instrumentation in cost control in underground mining, 1st Deep and High Stress Mining Seminar, Perth, W. Australia, October.
- Tod, J.D. and Peter Lausch. 2003. Interpreting and troubleshooting SMART instrumentation. 18th AMQ Ground Control Colloque. Val-d'Or, Canada.
- Tod, J.D. and W.F. Bawden. 1997. Validation of Far Field Overcore Stress Measurement Data using an Integrated Geomechanical Analysis. Rock Stress., Japan.
- Urbancic, T.I., W.F. Bawden and J.D. Tod. 1996. Seismic Validation of Numerical Models Using Stress Inversion Techniques. 2nd North American Rock Mechanics Symposium. Montreal, Quebec.
- Hawley, P.M., J.D. Tod and B. Thiele. 1991. Construction and Operation of the Tailings Disposal Facility for the Samatosum Mine, British Columbia. CIM 93rd AGM. Vancouver, Canada.
- Hawley, P.M., A.F. Stewart, J.D. Tod and L.A. Wolff. 1991. Rock Mechanics and Slope Design Investigations for the South Pit of the Kennecott Ridgeway Mine, South Carolina. SME Annual General Meeting. Denver, Colorado, USA. Martin, D.C. and J.D. Tod. 1990. Engineering Geology and Geotechnical Assessment of the Muddy Lake Landslides, Northwestern British Columbia. GAC Annual General Meeting. Vancouver, Canada.
  Awards

Blake Brodland, B.A.Sc., P.Eng.

Senior Geological Engineer

Professional Summary

Mr. Brodland has over ten years of geotechnical experience, ranging from construction contracting to engineering consulting. He has experience with site investigations, field mapping, permafrost monitoring and investigations, terrain assessment, LiDAR and orthophoto review, instrument installation and remote monitoring systems, surveying, tunnel boring machines, soil and core logging, helicopter work, sewer and water main construction, geothermal modelling, slope stability, site supervision, geohazards, linear infrastructure, and project management. He has practical experience in Ontario, Alberta, Northwest Territories and Nunavut.

Qualifications

Education

- Coursework, International Short Course on Permafrost Engineering, University of Alberta, 2013
- Bachelor of Applied Science, Geological Engineering (Honours), University of Waterloo, 2011

Registrations / Certifications / Licenses

- Professional Engineer (Canada), AB, 136722
- Professional Engineer (Canada), NT, L3282
- Professional Engineer (Canada), NU, L3282

Certifications and Training

- Standard First Aid- AED and CPR-C, including BC
- Workplace Hazardous Materials Information System (WHMIS)
- Leadership for Safety Excellence
- Ground Disturbance Level II
- H2S Alive
- Construction Safety Training System and Pipeline Construction Safety Training
- ATV training, Energy Sector Driver Improvement Program, Bear Aware
- Leadership Excellence Training

Wood Experience

Project Manager and Lead Project Engineer

Enbridge Pipelines (NW) Inc., NT & AB (2011 to Present). Analyzed and reported on monthly instrument readings along an 868 km long pipeline in the Northwest Territories and northern Alberta. Data sets include thermistors, slope inclinometers, piezometers and shape accel arrays. Lead twice annual visual reconnaissance trips, preparing annual reports and annual meeting summarizing all geotechnical data along the pipeline. Work included coordinating with the client, various proposals, modelling, analyzing seismic risk, coordinating field crews, managing field work, thaw probing, logging soils, and supervising instrument repairs.

Years of Experience

11 (9 with Wood)

Office of Employment

Western Canada - Calgary, AB

Languages

- English

Professional Associations

- Member, Association of Professional Engineers and Geoscientists of Alberta
- Member, Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists (NAPEG)

Areas of Expertise

- Project managing large (>$1M) and technically challenging, complex projects. Working with tight timelines and budgets, while managing clients and subcontractor expectations
- Extensive experience with field investigations, site characterization, field mapping, permafrost monitoring and investigations, terrain assessment, LiDAR and orthophotos, instrument installation and remote monitoring systems, surveying, tunnel boring machines, soil and core logging, and helicopter work
- Arctic and southern experience in pipelines, foundations, slope stability, and site investigations including contractor supervision and planning

Project Manager and Lead Project Engineer

Enbridge Pipelines (NW) Inc. Installation Program, NT & AB (2011 to Present). Managed and participated in annually instrument installation and repairs program at select sites based on data from previous years. Installation work included thermistors, slope inclinometers, piezometers and shape accel arrays. Many of the instruments were connected to satellite monitoring systems, equipped with automatic alarm systems. Work included being on site for installation (2012, 2013, 2014) and later training other workers and managing the project from the office (2016, 2017, 2019, 2020).

Project Manager and Project Engineer

Three Sisters Mountain Village, Undermining Work at Various Sites, Canmore, AB (2020 to Present). Reviewed existing reports, mine drawings, boreholes for accuracy and to aid in assessment of suitability for proposed developments. Additional work involved review of LiDAR for subsidence features and ground truthing. Assisted with the development of a 3D model to show the mine based on historical drawings and boreholes. Borehole investigation plan was developed in relation to proposed commercial and residential developments at one site.

Project Engineer

Teck Resources Limited, Elkview Operations, near Sparwood, BC (2019 to Present). Reviewed existing reports, new test pit information, LiDAR and orthophotos to identify potential geohazards in proximity to the proposed road and pipeline alignment. Work also included a site visit, slope stability modelling and instrumentation plan for new fill placement. Reported on findings and attended client meetings.

Project Engineer

Teck Resources Limited, Fording River Operations, near Elkford, BC (2019 to Present). Reviewed LiDAR, orthophotos, previous reports, new test pits and new boreholes to identify potential geohazards in proximity to the proposed development. Reported on findings and attended client meetings.

Project Manager and Lead Project Engineer

Government of the Northwest Territories, Granular and Bedrock Resource Investigation, near Tulita, NT (2019 to Present). Reviewed LiDAR, orthophotos and historical data to prepare for field mapping of nine potential borrow sites by helicopter. Field mapping work included extensive field mapping of bedrock outcrops, along with hand augers and hand test pits of granular sources to identify areas for further detailed investigation. Additional investigation included rock coring boreholes accessed by helicopter. Subsequent laboratory testing included physical properties and screening for Acid Rock Drainage and Metal Leaching potential. Work included liaising with land permit issuers, tree clearing crews and numerous subcontractors.

Project Manager and Lead Project Engineer

Government of the Northwest Territories, Edie Lake Quarry, Norman Wells, NT (2020 to Present). Reviewed existing information for the quarry, directed a site visit and sample collection. Subsequent work included ordering laboratory testing for physical properties and Acid Rock Drainage and Metal Leaching potential.

Project Engineer

Parks Canada, TransCanada Highway Twinning near Golden, BC (2017 to 2019). Analyzed and reported on geohazards in near proximity to the highway corridor. Work included reviewing historical reports, reviewing and ground truthing LiDAR, helicopter reconnaissance, all with consideration to proposed highway corridor widening and re-alignment. Work also included screening for Acid Rock Drainage and Metal Leaching potential based on rock cores which were drilled.

Project Engineer

Parks Canada, Waterton National Park, AB (2018). Helicopter and ground reconnaissance to review recent rock fall in areas impacted by the 2017 Kenow Wildfire. Work included client meeting, report and subsequent recommendations.

Project Manager and Project Engineer

Horizontal Directional Drill Investigation, Enbridge Pipelines (NW) Inc., NT (2016 & 2017). Managed, coordinated and reported on a multi-million-dollar geotechnical investigation for a proposed horizontal directional drill. Work included managing up to 6 subcontractors and over 50 workers, supporting borehole drilling to over 180 m depths in remote winter conditions. Boreholes were drilled on slopes requiring cribbing and others were drilled on the Mackenzie River pack ice. Reporting included site history, geological model based on borehole program, site-specific risks for the horizontal directional drill, laboratory index testing and landslide hazards.

Project Engineer

Clinton Creek Mine Reclamation, YK (2017). Reviewed historical reports for an old asbestos mine which has been experiencing tailings slope instability. Work included reviewing LiDAR, climate, historical air photos, lake levels, lake chemistry, historical boreholes and operations. Planned for a subsequent field program to acquire more information.

Project Engineer

FortisBC Liquefied Natural Gas, Squamish BC (2016). Performed remote bedrock mapping of igneous and sub-glacial volcanics for a proposed LNG pipeline. Subsequent work included site set-up and inclined borehole drilling with packer testing for a proposed tunnel in which the LNG pipeline would be operated.

Project Engineer

Confidential Oil Sands Client, Fort McMurray (2016). Looked at constructability and design parameters for a large structure in a tailing pond. Work included sub-aqueous foundation design based on various loading conditions and foundation locations.

Project Engineer

Transport Canada, NT (2015-2016). Prepared maintenance protocols along a highway through permafrost to address geotechnical issues arising from snow coverage, drainage and road repair. Geothermal modelling was done to compare various scenarios.

Project Engineer

Confidential Oil Sands Client, Fort McMurray (2016). Analyzed borehole and CPT data, including field and laboratory results for trends within zones of interest. Work also included analyzing LiDAR and air photos along the perimeter of tailings facility for areas of concern.

Project Engineer

Alberta Transportation, AB (2011 to 2016). Assisted with geotechnical investigations, field readings, proposals, cost estimates and report preparation.

Project Manager and Project Engineer

Pembina Pipeline Corporation, AB (2011 to 2015). Managed large re-inspection program and site-specific geotechnical investigations. Utilized air photos, LiDAR data, geological maps and field skills to identify hazards and quantify risk areas. Performed field readings and led several teams performing site inspections. Subsequent work involved managing the installation of in-place inclinometers, vibrating piezometers and slope inclinometers.

Project Engineer

Confidential Oil Sands Client, Fort McMurray (2015). Worked with existing tailings deposition plan to model geothermal effects over several seasons. Annual and seasonal trends were modelled and analyzed. Work also included processing field data from a major borehole program for design of future facilities.

Project Field Engineer

Northwest Territories Housing Corporation, Ulukhaktok, NT (2015). Recommended foundation types and requirements based on a desktop study which included reviewing air photos, geological maps and nearby site investigations.

Project Manager and Project Engineer

Inter Pipeline Ltd., Fort McMurray AB (2014). Assisted in performing a hydrotechnical investigation for a pipeline crossing through a wetland. Work included historical air photograph assessment and a site visit to record site conditions.

Project Field Engineer

Imperial Oil, Inuvik, NT (2013). Coordinated and supervised a borehole drilling program for a storage tank facility. Recommendations included placing insulation and gravel fill below to tanks to improve thermal stability.

Project Engineer

Teck Resources Limited, BC (2011-2013). Analyzed and compiled various data sets from weather stations, survey prisms, GPS monitors and piezometers. Assisted in preparing quarterly monitoring reports related to mine stability.

Project Manager and Project Engineer

Water Treatment Plant, Wrigley, NT (2013). Responsible for coordination, supervision, budget monitoring and field investigation. Reported on subsurface conditions including soils, ground water and permafrost. Provided recommendations for excavation, berm construction, seismic risk and other construction procedures.

Project Engineer

Fuel Tank Stability Investigation, Inuvik, NT (2013). Managed and coordinated with the client and drilling subcontractor to assess the geotechnical conditions near fuel tank. Reported on soil and site conditions, recommended foundation stabilization measures, with particular attention to site permafrost conditions.

Project Field Engineer

Water Treatment Plant, Inuvik, NT (2013). Supervised subcontractor's drilling and logged soils for geotechnical conditions. Reported on site conditions, soil temperatures and made recommendations on settlement pond excavation, building foundation, thermosyphons and water pipeline alignment.

Field Engineer

ATCO Electric, AB (2012-2013). Supervised borehole drilling and CPT testing at various sites. Responsible for daily reporting and logging soils. Assisted in coordinating pile load testing for final design.

Field Engineer

Aircraft Hangar, Inuvik, NT (2012). Responsible for coordination, supervision and budget monitoring. Reviewed field personnel's soil logs for geotechnical conditions. Reported on findings and made recommendations for foundation type, including thermosyphons and ad-freeze piles. Later reviewed construction drawings.

Field Engineer

Aurora College Piling Inspection, Inuvik, NT (2012). Managed budget, as well as scheduled and supervised subcontractor in the field. Duties included QA/QC and providing as-built specifications to the client on the ad-freeze piles.

Field Engineer

Aircraft Hangar, Inuvik, NT (2011). Coordinated and supervised subcontractor performing drilling work. Logged soils and sampled soils for both geotechnical and environmental conditions. Reported on findings and made recommendations for foundation type, including thermosyphons.

Field Engineer

Granular Borrow Source Characterization, Taloyoak, NT (2011). Supervised subcontractor's excavator and explored areas for granular source material as identified by desktop study. Reported on gravel sources and screening/washing options.

Field Engineer

Water Treatment Plant Footing Inspection, Jean Marie River, NT (2011). Inspected subgrade for bearing capacity. Reported findings and made recommendations for compacted gravel lifts based on field conditions.

Field Engineer

Snow Fence, Clyde River, NU (2011). Supervised drilling subcontractor while logging and sampling soils. Reported on findings and made recommendations for pile depths and alignment.

Other Experience

Projects Assessment Team Member

Syncrude, Aurora Mine, AB (2009). Worked with the project management team to perform cost-benefit analyzes for projects. Work included speaking with operations and bringing their concerns to high-level management. Work included weekly safety inspections and pump efficiency calculations.

Field Representative

Baffinland Iron Mine, Steensby Inlet, NU (2008). Supervised diamond drilling subcontractor, as well as characterizing and sampling frozen soils and metamorphic rock. Performed instrument readings, terrain mapping and assisted with hydrotechnical stream investigations.

Professional History

- Wood Environment & Infrastructure Solutions, Geological Engineer, Calgary, Alberta, 2011 to present
- AECOM, Civil Water Technologist, Markham, Ontario, (Co-op experience) 2009
- Syncrude Canada Ltd., Assistant Project Manager, Fort McMurray, Alberta, (Co-op experience) 2009
- Knight Piésold, Diamond Drill Supervisor, Mary River, Nunavut, (Co-op experience) 2008
- McNally International Inc., Shift Engineer, Toronto, Ontario, (Co-op experience) 2007
- McNally International Inc., Assistant Surveyor, Toronto, Ontario, (Co-op experience) 2007

Additional Qualifications

Publications / Presentations

- Remediation of a Settlement and Heave Anomaly on a pipeline in the Northern Region of Canada – an Update. Delegate presented at the Canadian Geotechnical Society, GeoEdmonton (2018)
- Settlement and Heave Anomaly on a Pipeline in the Northern Region of Canada,. Presented at the Canadian Geotechnical Society, GeoOttawa (2017)
- Presentation to Transport Canada on Permafrost Considerations based on reporting and conducted survey (2016)
- Monitoring a Pipeline Constructed Through 869 km of Canadian Permafrost. Presented at the Amec Technical Summit, Las Vegas (2014)

John Laxdal, P.Eng.
Principal Engineer

Professional Summary

John Laxdal, P. Eng., is a civil engineer with 38 years experience and has been involved in the geotechnical engineering aspects of a broad spectrum of projects including highway, freeway, dam, mass transit and power projects.

He has been involved in mining subsidence evaluation in Alberta for over 30 years.

He has been involved with bid stage engineering for several Public Private Partnership and Design Build transportation projects including the Broadway Subway in Vancouver, Champlain Bridge in Montreal, and Port Mann Highway 1, Golden Ears, Kicking Horse, Sea to Sky, and Sierra Yoyo Desan Road in BC. He was geotechnical Engineer of Record for the Golden Ears Bridge Western Connector in Surrey/Langley, BC.

Mr. Laxdal was the Team Leader responsible for geotechnical, environmental, and pavement design for the Deerfoot Trail Extension south of Calgary, Alberta, which received the Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) Summit Award for Excellence. This project was the forerunner for the large Alberta Transportation ring road projects in Calgary and Edmonton.

John is on the Transportation Association of Canada (TAC) Geotechnical/Materials standing committees.

Qualifications

Education

- BE, Civil Engineering, University of Saskatchewan, 1982

Registrations / Certifications / Licenses

- Registered Professional Engineer, British Columbia, and Yukon

Training

- Permafrost Short Course, University of Alberta, 2003
- Pavement Field Evaluation Short Course, American Society for Civil Engineering, Geo-Institute, Los Angeles, California, 2004
- Dynamic Analysis for Modelling Soil and Soil Structure Systems, Vancouver Geotechnical Society, 2007
- The Response Spectrum, Seismic Design for Structures, CSCE, 2007

Years of Experience
38 (23 with Wood)

Office of Employment
Burnaby, BC

Professional Associations

- American Concrete Institute
- American Society of Civil Engineering
- Canadian Geotechnical Society
- Canadian Society of Civil Engineering
- Canadian Technical Asphalt Association – Board Member
- Deep Foundations Institute
- Geo Institute of ASCE

Areas of Expertise

- Project Management
- Geotechnical and Materials Engineering

Representative Projects

Mining Subsidence Evaluation, Three Sisters Mountain Village, Canmore AB. Team member for mining subsidence studies for the Resort Centre and Stewart Creek Commercial sites mining subsidence evaluations in Canmore, AB.

Broadway Subway Project, Vancouver BC, Geotechnical Lead for the Aecon/Dragados/WSP/Hatch team. This project includes: five kilometer twin running tunnels; a 700 m length of elevated guideway; and six new underground stations.

Mining Subsidence Evaluation, Proposed Hospital, Drumheller, AB, Alberta Public Works Evaluated mining subsidence risks for several potential sited for a new hospital in Drumheller AB. Ultimately the provincial government chose a site which was not undermined in the valley bottom.

Mining Subsidence Evaluation, Proposed Subdivisions, Lethbridge, AB. Evaluated risks of construction of residential subdivisions over abandoned coal mine workings on both the east and west sides of Lethbridge. This included detailed review of the mining records, drilling boreholes to evaluate the condition of the abandoned workings, and calculation of potential differential settlement, ground strains, and the potential for voids to migrate to the surface.

Mining Subsidence Evaluation, Proposed Residential Subdivision, Medicine Hat, Alberta. Responsible for senior review of a mining subsidence study for a proposed new residential subdivision over abandoned coal mine workings in Medicine Hat, AB.

BC Hydro – Transmission and Distribution Projects, various locations, BC (2008 to present). Lead Geotechnical Engineer for over 250 BC Hydro electrical transmission and distribution projects throughout British Columbia. Typical project value would range from two to 250 million dollars. Projects have included new transmission lines, underground distribution duct banks, road, rail and river undercrossings, new electrical substations, and additions to existing substations. The projects often require detailed seismic analysis, slope stability, and detailed analysis of pile foundations. Provided geotechnical value engineering for the new 75 km long 500 kV transmission line from Site C to Peace Canyon generating station. Geotechnical review engineer for 500 kV transmission line realignment around a landslide near Telkwa BC.

Trans Mountain Expansion Project, Trans Canada Highway Realignment, Hope, BC (2017 to present). Responsible for coordinating geotechnical assessment of rockfall hazards, other geohazards, embankment geotechnical engineering and pavement design.

Oyu Tolgoi to Gashuun Sukhait Road, Maintenance and Transfer Study, Oyu Tolgoi LLC, Mongolia 2012. Mr. Laxdal was responsible for review of the pavement design and preparation of an estimate of life cycle maintenance and rehabilitation costs for this 110 km highway through the Gobi Desert in southern Mongolia. This road was built to link the new Oyu Tolgoi mine in Mongolia to China. The road is used for haul of the copper-gold concentrate from the mine site to China for processing. The Mongolian Government will take over this roadway in the future. The Oyu Tolgoi copper-gold mine is one of the world's largest. Like Cycle Costs were evaluated in accordance with the Worldbank procedures.

Port Mann Highway 1, Vancouver, BC Ferrovial/Cintra/SNC, Mr. Laxdal was responsible for geotechnical and pavement engineering aspects within a bid design team. This was a large and complex

project ($2.4 billion Capex) through difficult terrain including soft compressible peat and clay deposits in the BC Lower Mainland.

BC Hydro Site C, Aecon-Flatiron-Dragados-EBC Partnership, Generating Station and Spillways Civil Works, QC Laboratory, 2018 to present, responsible for planning, negotiating, setting up, and overseeing the QC materials testing laboratory and staff for the $1.6 billion civil works contract for the Site C Dam near Ft St John BC.

Public Works Government Services Canada – Geotechnical Engineering Standing Offer, 2010 to present: Senior Geotechnical Engineer and client point of contact. Call up assignments included:

- Huntingdon Addition, Canadian Border Service
- RCMP Detachment, 100 Mile House
- Kwikwexwhelp Institution (Kwi-Kwi)
- Mission Correction Facility
- Ferndale Correction Facility
- Matsqui Correction Facility
- Pacific Highway, Port of Entry, Canadian Border Service
- Pacific Institution/Regional Treatment Centre, Abbotsford , BC - New 96 Bed Living Unit
- Pacific Traverse Trail, Ucluelet to Tofino, Pacific Rim National Park – new 30 km recreational pathway with several bridges

Golden Ears Bridge, (2005 to 2010). Mr. Laxdal was Wood's project manager responsible for geotechnical engineering and was the Geotechnical Engineer of Record for the Western Approach roadway network, including several grade separation structures.

Sea to Sky Highway Improvement Project, Highway 99, Vancouver to Whistler, BC Mr. Laxdal coordinated geotechnical engineering and environmental work for this assignment during the bid engineering phase. Geotechnical conditions were challenging for the route including soft compressible soils, rockfall, and other geohazard issues in steep mountainous terrain.

Deerfoot Trail Extension, Calgary, Alberta, Alberta Transportation Team Leader responsible for environmental impact assessment, permitting, geotechnical and pavement design aspects of the CDN$100 million project including a new crossing of the Bow River and several grade separated interchanges.

TransCanada PipeLines – Pipeline No. 100-6, Alberta/Saskatchewan border to Manitoba/Ontario border. Conducted the geotechnical evaluation, which involved assessment of slope stability at major river crossings, assessment of the potential for horizontal boring at paved road and rail crossings, and an assessment of open cut feasibility at river crossings. Prepared generic and site specific foundation designs for valves.

Cowley Ridge Wind Power, Pincher Creek, Alberta, 1993 – geotechnical engineer for the first wind power development in Canada. This project required heavy foundations to resist overturning from wind loads.

Little Bow River Dam, Champion, AB, Canada. Managed geotechnical engineering for this $100 million new earthfill dam and associated service and emergency spillways. This project included an earthfill dam on a cretaceous clay shale bedrock foundation. The bedrock included bentonitic horizons and the embankment foundation design was based on the residual friction angle.

Oldman River Dam, Pincher Creek, AB, Canada. Managed instrumentation including extensometers, slope indicators, thermistors, piezometers. Prepared concrete mix designs for the spillway including detailed testing for adiabatic temperature rise in mass concrete and mix optimization for low heat of hydration. Oversaw materials QC program. Provided geotechnical services for the roadway realignment around the reservoir.

LNG Plant Site and Marine Terminal at Bish Cove, near Kitimat, BC, and Pipeline, PAC-RIM LNG Inc., BC, Canada. Conducted marine and terrestrial geotechnical site assessments at the Bish Cove plant site. Responsible for mapping and the geotechnical aspects of pipeline route selection for the natural gas pipeline from Prince George to Kitimat.

Metro Vancouver – Douglas Road Main 2 and Tilbury Junction Chamber Projects, Vancouver and Delta, BC. Corporate Sponsor and Geotechnical Senior Reviewer. The Douglas Road project includes construction of a 1,524 mm diameter steel water main as well as construction of line valve chamber, blow down and air relief chambers. The Tilbury Junction Chamber project involves installation of external piping and the tie-ins towards the three mains connecting into the new Tilbury Junction Chamber. The Tilbury site is in the Fraser River delta with liquefiable soils. This project will also include construction of two flow meter chambers with installation of the flow meters, final grading and surface drainage as well as fencing around the graded site.

Metro Vancouver – South Delta Main No. 1, Vancouver, BC (2014 to present). Corporate sponsor and senior geotechnical reviewer. Phase I environmental screening along the alignment. Joint geotechnical/environmental field investigations and staged environmental sampling focused on groundwater quality for excavation dewatering and disposal/treatment options. Geotechnical recommendations provided for project design and construction, including undercrossing of Highway 17, excavation, backfill, and seismic design.

Metro Vancouver – Gilbert Trunk No. 2 – Hollybridge Way Segment, Richmond, BC (2014 to present). Senior geotechnical reviewer. Joint geotechnical/environmental field investigations and media sampling focused on groundwater quality for excavation dewatering and disposal/treatment options. Geotechnical recommendations provided for project design and construction, including excavation, dewatering, shoring, backfill, and seismic design.

SkyTrain Millennium Line Elevated Guideway, Vancouver BC, SAR Transit, oversaw civil materials QC inspection and testing for sitework and precast. This 18 km long elevated guideway was designed and built in 18 months.

Skytrain Evergreen Line, SNC Lavalin, oversaw QC inspection and testing for guideway and stations from a management perspective.

Appendix D

Limitations to Geotechnical Reports

Limitations

1. The work performed in the preparation of this report and the conclusions presented herein are subject to the following:

    a) The contract between Wood and the Client, including any subsequent written amendment or Change Order dully signed by the parties (hereinafter together referred as the "Contract");

    b) Any and all time, 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 care 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, guarantee, 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 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.

    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.

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, wildlife 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, mold 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 60 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.