Area Mining Impact Overview Report Resort Village Area Structure Plan_Rev2

Three Sisters Mountain Village
Canmore, AB
Wood File: CG09125

Prepared for:

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

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

16-Nov-20

Area Mining Impact Overview Report Resort Village Area Structure Plan_Rev2

Three Sisters Mountain Village

Wood File: CG09125

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

16-Nov-20

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 Resort Village Area Structure Plan_Rev2*** dated **16 November 2020** was carried out to determine whether the area is suitable for the intended development, ***Resort Village 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 Resort Village Area Structure Plan_Rev2*** with respect to the undermining and related conditions.

PROFESSIONAL ENGINEER ALBERTA
JAMES ... 2020-11-16

Professional Seal

Municipality: Mississauga
Date: 16 November 2020

PERMIT TO PRACTICE
Wood Environment & Infrastructure Solutions, A Division of Wood Canada Limited
Signature [signature]
Date 16 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

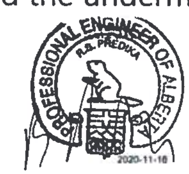
Form 2
Compliance Review Certificate

Pursuant to the Canmore Undermining Review Regulation (AR 34/2020), I have made a review of the ***Area Mining Impact Overview Report Resort Village Area Structure Plan_Rev2*** dated **16 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 Resort Village Area Structure Plan_Rev2*** 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 Resort Village Area Structure Plan_Rev2*** 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 Resort Village Area Structure Plan_Rev2*** and I am not associated with or employed by the individuals or firm that prepared the undermining report.



Professional Seal

Municipality: Cochrane, Alberta
Date: November 16, 2020

PERMIT TO PRACTICE
FOUNTAINSTONE SOLUTIONS INC.
RM SIGNATURE: [signature]
RM APEGA ID#: M54055
DATE: 2020-11-16
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 Resort Village Area Structure Plan (ASP) for undermining considerations and is the first stage in the development process. The proposed Resort Village 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 the Resort Village ASP, boreholes, videos and 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 various pieces of data an internal three-dimensional model for the underground mine workings was created. This model allowed for specific sections to be cut in areas of interest, and will be used for modelling at more detailed stages of undermining reports as outlined in AR 34/2020. A total of five mines were found to directly underly the proposed Resort Village ASP at a variety of depths and locations.

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 three-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.

A preliminary hazard zone assessment map based on the potential impact from undermining below the ASP was completed. The map identifies zones based on the potential risk of subsidence and associated possible damage to structures if not appropriately mitigated or addressed. The breakdown of the zones is 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;

- Zone 2 Yellow: development possible with ground mitigation. These are associated with near-surface workings with the potential for sinkhole formation;
- Zone 3 Orange: development possible with ground and structural mitigation, as necessary. These are associated with areas that are undermined by more than one de-pillared seam;
- Zone 4 Magenta: development possible, but higher ground strains are possible. These zones are associated with the margins above the edges of de-pillared areas where the strains, tilt and curvature are expected to be locally higher; and
- Zone 5 Red: steeply dipping or sub-vertical workings. These areas have potential for sinkhole or trough development; the potential for development is considered low as the potential costs for mitigation are considered high.

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. Subject to more detailed work within future Subdivision Mining Impact Assessment Reports or Project Undermining Reports, development within Zone 1 may generally proceed without need for ground or structural mitigation to address undermining considerations. Zones 2 through 4 will likely require varying degrees of ground and/or structural mitigation for development to proceed in accordance with the Guidelines, and will require further detailed work at future planning stages.

Zone 5 contains known steeply dipping or sub-vertical workings that are unlikely to be feasible for development due to the high cost of mitigation. Some of the features in Zone 5 have already been addressed for public safety consideration in previous work by others, however, review of these measures is recommended when development proceeds within 500 m of these features. Wood recommends avoidance of the development of structures within Zone 5 as a primary means of mitigation at this time, and that ASP policy be written to reflect avoidance at this time.

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

Table of Contents

1.0 Introduction 7
2.0 Background 7
3.0 Scope of Work 8
4.0 Desktop Study 8
4.1 Surficial and Bedrock Geology 9
4.1.1 Bedrock Geology 9
4.1.2 Surficial Geology 9
4.1.3 Groundwater 10
4.2 Existing Boreholes 10
4.2.1 Alberta Energy Regulator Library Boreholes 10
4.2.2 Other Existing Boreholes 10
4.3 Previously Mapped Features 10
4.4 LiDAR Data and Orthophotos 10
4.5 Mine Workings 11
4.5.1 Riverside Mine 12
4.5.2 No. 2 Mine, Stewart Seam 12
4.5.3 No. 2 Mine, Sedlock Seam 12
4.5.4 No. 2 Mine, Carey Seam 12
4.5.5 Morris Seam 13
4.6 Three-Dimensional Modelling 13
4.7 Areas with Existing Mitigation for Golf Course Use 14
5.0 Field Reconnaissance 15
5.1 Safety 15
5.2 Site Observations from Field Reconnaissance 15
6.0 Assessment 16
6.1 Surface Hazards 16
6.2 Development of Subsidence 16
6.3 Preliminary Hazard Mapping for Development 18
6.4 Preliminary Hazard Mapping for Recreational Use 19
6.5 Features and Characteristics for Future Study 20
6.6 Future Work 21
7.0 Closure 22
8.0 References 23

List of Figures

Figure 1: Site Location
Figure 2: Land Use Map
Figure 3: Site Overview with Orthophoto
Figure 4: Site Overview with LiDAR
Figure 5: Bedrock Geology
Figure 6: Existing Boreholes
Figure 7: Features Mapped by Others
Figure 8: Wood Mapped Features
Figure 9: Stewart Mine
Figure 10: Sedlock Mine
Figure 11: Carey Mine
Figure 12: Morris No. 1 Mine
Figure 13: Riverside Mine
Figure 14: All Mines in ASP
Figure 15: Analyzed Mine Sectors
Figure 16: Previously Mitigated Areas for Golf Course Use
Figure 17: Wood GPS Tracks
Figure 18: Surface Mine and Shafts within ASP
Figure 19: Preliminary Hazard Zone Map – Development Areas
Figure 20: Preliminary Hazard Zone Map – Recreation Areas

List of Tables

Table 1: Mines underlying the Study Area 11
Table 2: Shafts Mitigated for Public Safety Purposes within the ASP Study Area 14
Table 3: Portals Mitigated for Public Safety Purposes within the ASP Study Area 15

List of Appendices

Appendix A Site Reconnaissance Features by Others, Visited by Wood
Site Reconnaissance Waypoints
Site Reconnaissance Select Photographs
Appendix B 3D Model Plans and Sections
Appendix C Key Persons Resumes
Appendix D Limitations to Geotechnical Reports

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 Professional Services Agreement signed on 30 April 2020.

It is understood that TSMVPL is preparing the Resort Village Area Structure Plan (ASP) to provide guiding policy for future development within the ASP area. The location of the Resort Village ASP is generally south of the Three Sisters Parkway as shown in **Figure 1**, which 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:

- Spa & boutique hotels;
- Innovation district;
- Village center;
- Low density residential housing;
- Medium density residential housing;
- Tourist homes;
- Indoor recreation; and
- Various connecting roads and utilities.

The Land Use Map with the named districts within the 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 will 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, 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 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 Resort Village Area Structure Plan 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 are outlined in Section B.2 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. It is anticipated that the preliminary hazard zone assessment map contained in this report will be updated and refined as needed as outlined in the Guidelines during more detailed work within future Subdivision Mining Impact Assessment Reports or Project Undermining Reports.

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, conceptual road layouts, and potential building footprint areas;
- 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 coal seam sequence 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, but locally up to 44 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. However, a significant amount of information and monitoring data is available based on previous work performed at the site by others. Historically, the surficial geology for parts of the site identified some areas as swamp; however, the groundwater regime was changed due to the underground mining, resulting in drainage of the swampy areas. 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)

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 1979 by private companies, often for exploration purposes, and later handed over to the AER library. A total of 42 AER boreholes exist within the study area, which includes the 500 m public safety assessment area around the Resort Village ASP area boundaries. Two of these boreholes could not be located by the AER within their database, and the logs for two other boreholes were not legible. The minimum, maximum and average length of the 38 useful boreholes was 16.8 m, 278.9 m and 87.5 m, respectively. The locations of the AER boreholes are shown on **Figure 6**.

4.2.2 Other Existing Boreholes

Another 441 boreholes, undertaken for undermining assessment purposes, exist within the entire study area. The minimum, maximum and average borehole lengths are 6.0 m, 230.0 m and 42.8 m, respectively. These boreholes are also shown on **Figure 6.**

Based on the borehole data, the overburden is noted to range between zero and 44 m thick across the entire site. 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; rather, the intended focus of the holes was bedrock identification and the assessment of mine conditions. These boreholes were drilled between 1997 and 2008 for the purposes of ground truthing the site, to verify the accuracy of the plans and the seam limits, to clarify the ground conditions associated with observed hazards, to stabilize voids through the injection of paste or to observe the extent of paste migration performed as part of previous site mitigation work.

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; approximately 120 of these features are located within the current ASP area, and an additional 376 features within the 500 m boundary zone around the ASP area. **Figure 7** shows the location of all features mapped by others, which were visited in the field by Wood personnel on 25 June, 02 July and 29 September 2020. Further discussion regarding significant mapped features, is presented in Section 5.

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 Resort Village area was screened for features of note or which might be indicative of undermining impacts or mining activities. Each feature was identified with an individual number and categorized as features to visit, man-made mounds and man-made flat or depression areas. In general, the man-made flat or depression areas were golf course features (i.e. tee boxes, putting greens, sand traps) or other associated infrastructure. Man-made mounds are likely associated with construction of the roads, AltaLink's power transmission line or the golf course. Features flagged to visit were areas that required reconnaissance on the ground for verification, clarification, and categorization.

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. Several coal seams have been exploited beneath the current ASP study area, as summarized in **Table 1**. **Figures 9** through **13** show the relation between the individual mined areas relative to the proposed development; **Figure 14** shows all five mines together with the proposed development area.

Table 1: Mines underlying the Study Area

Mine Name	Mining Dates	Average Mined Height (m)	Depth Range below ASP (m)	Stratigraphic Sequence (from top down)
Stewart	1914-1952	2.1	17 - 172	1
Sedlock	1903-1915	1.8	19 - 88	2*
Morris No.1	1924-1941	1.5	23 - 99	2*
Carey	1916-1934	2.75	55 - 211	3
Riverside	1976-1979	1.8	100 – 300	4

* Morris and Sedlock seams are the same stratigraphic unit.

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 mineable 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 conditions of the ground around the coal (*i.e.* the mine roof, in particular), and general economics. De-pillaring can increase the overall extraction ratio to between 50 and 75%.

Within the study area, not all of the mines or seams were de-pillared. To assess the impact of mining and potential for surface impact, each mined seam was subdivided into sectors based on seam orientation, depth, and whether de-pillaring had been undertaken. De-pillared areas were conservatively assumed to have an extraction ratio of 75%. For areas that were not de-pillared, the extraction ratio was determined based on the ratio of area mined relative to the area of the remaining pillars. Additional information for each sector, such as length, width and depth were also recorded. This information was used in preparation of the hazard map in **Figure 19** and will be used in future studies to assess the detailed potential for surface subsidence, as discussed in Section 6. The sectors determined for each seam are shown on **Figure 15**. The characteristics of each mining seam, as well as their mining histories are provided in the following subsections.

4.5.1 Riverside Mine

The Riverside Mine, located at the northeast end of the ASP area, was mined between 1972 and 1979. The seam that was mined had a thickness ranging between 3.0 and 3.75 m and dipped at approximately 19° towards the southwest. For this mine, only the initial room and pillar development was completed, leaving large pillars between the development workings; no de-pillaring was undertaken in this mine. Within the ASP area, the mining depth ranges from 100 m near the northeastern limit to more than 300 m below surface at the lower reaches.

Within the ASP limits there are no known open shafts or portals to this mine.

4.5.2 No. 2 Mine, Stewart Seam

The Stewart Seam is the uppermost seam stratigraphically within the ASP, and was mined from 1914 to 1952, with an average mined height of 2.1 m. The seam is folded into the shape of a syncline with the northeastern limb dipping between 10 and 25 degrees to the southwest, at depths of between 15 and 170 m below the ground surface. The southwest limb is near vertical and approaches within 35 m below the ground surface. Within the ASP the total area of the mined seam is approximately 613,000 m^2, of which over 587,000 m^2 was de-pillared (*i.e.* 96% of the seam within the ASP area). This seam was mined up to the subcrop (bedrock surface) along the northeastern limits.

Within the ASP limits there are known to be three shafts to this mine and three portals for the Stewart seam.

4.5.3 No. 2 Mine, Sedlock Seam

The Sedlock Seam underlies the Stewart Seam in the northern portions of the ASP. This seam was mined from 1903 to 1915, with an average mined height of 1.8 m. This seam is folded into the shape of a syncline with a fold axis that trends towards the northwest and plunges shallowly to the southeast, with an anticline on the southwest limb with a similar fold axis trend. There is also some undulation observed along the fold axis.

The northeast limb dips between 3° and 19°, with the shallower dips more common in the northern portion, becoming steeper to the south. The southwest limb becomes vertical before rolling over the anticline axis, where it dips shallowly to the southwest. Within the ASP area, Wood subdivided the mine into 22 sectors based on orientation, extraction ratio and de-pillaring. Of these, 12 of the sectors, representing an area of approximately 108,000 m^2 of the total seam area of 308,000 m^2 within the ASP area (*i.e.* 35 percent of the total area) have been depillared. The depth to the workings of this seam range between 20 and 90 m below the ground surface within the ASP area.

Within the ASP limits there are known to be four shafts to this mine and no portals.

4.5.4 No. 2 Mine, Carey Seam

The Carey Seam underlies the Sedlock seam, and was mined between 1916 and 1934, with an average mined height of 2.75 m. This seam has also been folded into a syncline with a fold axis that trends to the northwest and dips shallowly to the southeast, as well as a tighter-folded anticline on the southeast limb. In general, the northeast limb dips shallowly (*i.e.* less than 10°) within the ASP area, locally steepening up to near 20° near the fold axis in the southern portion of the seam. The southwestern limb dips much more steeply at between 20° and 30°, with vertical dips.

This mine was subdivided into 26 sectors based on orientation, extraction ratio, and de-pillaring. Of these 26 sectors, 11 are depillared, with the majority of depillaring occurring on the southwest fold limb. The total area of the sectors is over 718,000 m^2 and the depillared area is approximately 232,000 m^2, indicating that 32 percent of the seam has been depillared. The roof of this mine is located between 55 and 210 m below ground surface within the analyzed sectors.

Within the ASP limits there are no known shafts or portals to this mine.

4.5.5 Morris Seam

The Morris Seam represents the same geological unit as the Sedlock Seam to the west. The Number 1 and Number 2 Morris Seams are the same stratigraphically but are separated by a thrust fault. The seam on the hanging wall side of the fault is the Number 1 Morris Seam and the seam on the footwall side is the Number 2 Morris Seam. Both Morris Seams were mined to the subcrop along the northeast edge of the mines as confirmed by mine plans, which indicate that gravel was encountered along the northeast edge of both Morris Seams.

The Morris Seam was mined from 1924 to 1941, with an average mined height of 1.5 m. Within the ASP, the mined portions of the seam dip between 10 to 25 degrees toward the southwest. This mine was separated into 10 sectors based on extraction ratio, orientation, and depillaring. Of these 10 sectors, 7 are depillared. The total area of the sectors is over 209,000 m^2 and the depillared area is over 99,000 m^2, representing 47 percent of the seam within the ASP area. The roof of this mine is located between 25 and 100 m below ground surface within the analyzed sectors.

Within the ASP limits there is known to be one shaft to this mine and three portals.

4.6 Three-Dimensional Modelling

Wood created a 3D model of the mine workings within the ASP area and surrounding 500 m buffer. 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 and survey elevations, which was then carefully reviewed with Lidar topography and detailed borehole data to confirm the model, or to make minor adjustments as needed to account for current topography and mine conditions.

The mine scans were aligned and scaled to the Alberta Township System (ATS) Grid in Deswick. Linework was completed within the project area based on the historical mine scans and existing QPD data sources. Seam elevations were taken from the historic mine scans and adjusted to the elevation datum offset of 53 feet based on a note on scan "Carey_aban_vs2-3" dated 1935. Seam elevations were also determined from applicable borehole logs and combined with the seam elevations from the mine scans. Surfaces were generated using the elevations from the mine scans and borehole logs and re-limited to the outline of each mine's linework. The surfaces were then extruded to their corresponding seam thicknesses, resulting in 3D solids. The pillars for each mine were generated based on the linework created based on the above work and then cut from the solid of the applicable mine. The mine solids were then exported as dxf files for use in other packages.

The 3D model allows for cross and long sections to be located in plan view, with the software generating the sections automatically. Appendix B shows examples of various sections that have been cut through the model.

4.7 Areas with Existing Mitigation for Golf Course Use

Some hazards identified within the ASP area were mitigated using geogrid and paste backfill during construction of the unfinished golf course that currently occupies the site. The locations of the mitigation works are shown on **Figure 16** in relation to the proposed development. Most of the mitigation work focused on the subcrop areas of the Sedlock seam, as well as shafts and portals. The level of mitigation, which included excavation/backfilling with geogrid and local paste fill injection, was only undertaken to address public safety for recreational land use, and would need additional assessment, analysis, design, and mitigation for building construction.

It is understood that the known shafts and portals with the ASP have all been mitigated as per **Table 2** and **Table 3** below.

Table 2: Shafts Mitigated for Public Safety Purposes within the ASP Study Area

Shaft #	Mine Name	Mitigation
#63	Sedlock	Inspected by Golder (2007), mitigated for TSCGR 500m public safety zone.
S14	Sedlock	Mitigated by Golder Associates (2002). Excavated to 6 m depth, backfilled with compacted till, crowned, placed topsoil and removed fence.
S15	Sedlock	Mitigated by Golder Associates (2002). Excavated to 6 m depth, backfilled with compacted till, crowned, placed topsoil and removed fence.
B111	Sedlock	Mitigated by Golder Associates (2001). Excavated to expose previously placed backfill, added 100 m^3 of compacted gravel pit run and graded surface.
B39	Stewart	Mitigated by Golder Associates (2002). Inspected and backfilled.
B38	Stewart	Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Excavated to heading in seam. Heading plugged with 77 m^3 of concrete. Backfilled.
S17	Stewart	Mitigated during Stewart Creek Golf Course Development (Norwest, 2000). Large rock and concrete plug placed over shaft. Total of 10.5 m^3 of 15 MPa concrete used to form a plug 4 m in diameter. Backfilled.
B87	Morris	Mitigated during Stewart Creek Golf Course Development (Norwest, 1998). 1.5 m of large rock/concrete blocks placed in the bottom of the excavation. 6 m^3 of 15 MPa concrete was poured into the rocks. Process was repeated, total of 12 m^3 of concrete used forming a concrete plug at 5 m depth. Backfilled.

Table 3: Portals Mitigated for Public Safety Purposes within the ASP Study Area

Portal #	Mine Name	Mitigation
B41	Stewart	Mitigated by Golder (2007). Excavated and backfilled with paste during TSCGR mitigation program.
B42	Stewart	Mitigated by Golder (2007). Excavated and backfilled with paste during TSCGR mitigation program.
B40	Stewart	Mitigated by Golder Associates (2003). Excavated and backfilled with 100m^3 of local gravel. Site graded.
B107	Morris	Excavated and temporarily backfilled with local materials during Parkway construction (Norwest, 2001).
UMA9	Morris	Reclaimed portal - gravel pushed inside and over top. Previously excavated and backfilled with local materials (Norwest, 2001).
B99	Morris	Backfilled portal. No movement as of last inspections in 2017 (Golder) and 2020 (Wood).

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

A site reconnaissance was conducted by Wood representatives B. Brodland P.Eng and N. Khan G.I.T. on 25 June, 02 July 2020 and 29 September 2020. The purpose of the field reconnaissance was to observe surface features identified during previous investigations, to visit features identified from the LiDAR, and to identify any new or previously unrecorded surface features. Surface features were previously identified by Norwest, UMA and Golder, who have previously performed field reconnaissance work within this area.

Surface features within the ASP include mine portals, mine shafts, areas of cracking or possible subsidence, former water conveyance trenches, mine buildings/infrastructure, mining debris, rock waste piles and exploratory test pits. Mine portals and shafts were used as personnel and equipment entrances to mines, fresh air supply, hauling of supplies, and removal of coal. Shafts were typically sub-vertical and driven from the workings up to the surface. 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 area there were no observed open shafts or open portals during the field work; however, subsidence features were noted to correspond with several of these locations. It is understood that the portals and shafts within the ASP boundary have been mitigated for public safety purposes by others, often by placing soil or concrete into the openings to prevent access, as discussed in the previous section.

Within the ASP, surface expressions that may be related to mining-related subsidence include the presence of depressions, voids or cracks. Features of this type were observed and are shown on **Figure 7** and summarized in **Table 1** of **Appendix A**. These features were taken into consideration when creating the Hazard Zone Assessment Map.

Water conveyance trenches, mine buildings/infrastructure, mining debris, rock waste piles and exploratory test pits do not pose an undermining risk to development but are present across the ASP area, which is a former industrial site (*i.e.* brownfield site), and were visited as part of the field work.

During the field visit the Wood representatives had linework showing previously noted features, proposed road alignments, LiDAR and mine plans loaded onto a handheld GPS. The GPS tracks of the site reconnaissance are shown on **Figure 17**. Specific notes on significant locations visited and relevant photographs are provided in **Appendix A**. Note that many of the surface features within the ASP area initially observed by others were mitigated or addressed as part of the preparation of the site for use as a golf course in the early 2000's.

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

Within the ASP area, coal was generally mined using underground methods. Several known shafts and portals were identified within the study area, as shown on **Figure 18**. The associated mine workings for each of these portals and shafts are indicated in **Table 2** and **Table 3**.

A historical surface coal mine "surface cut" is also shown on **Figure 17**. This surface cut partly underlies an existing manmade and lined pond and overlies the Carey and Stewart seams. While it is understood that this mine was backfilled upon completion of coal extraction, the type of backfill and level of compaction of the fill material was not documented. Within the borehole database discussed in Section 4.3, over 50 boreholes were advanced through the surface mine area to assess backfill and mine conditions. It is noted that no building development is planned above this area.

6.2 Development of Subsidence

The undermined areas in southeast Canmore are susceptible to two different types of subsidence: sinkhole development, and surface troughs or sags. These mechanisms can be described as follows:

Sinkhole development is possible where the underground workings approach the top of the bedrock surface (subcrop), and generally involve limited surface area. In these cases, the gradual collapse of the roof of the mine working causes the void to migrate upwards toward the ground surface. At the same time, the failed material increases in volume via bulking as it settles on the floor of the mine workings. These sinkholes can coalesce, forming steep sided troughs at the ground surface, as can be observed between Quarry Lake and Three Sisters Drive. Sinkhole development in the Canmore area is usually associated with shallow mining at or near the subcrop, or with shafts or portals for the underground workings.

Previous work on the Three Sisters site indicates that the minimum bulking factor observed for failed or collapsed material is 1.143, meaning that the collapsed material from the mine roof has a 14% increase in volume relative to in situ / intact volume (Golder, 2019). At this bulking factor, failure of the mine roof can potentially chimney up to eight (8) times the height of the original mine workings before the failed material expands enough to completely fill the void. Consequently, workings within approximately 20 m of the ground surface have the potential for sinkhole development. Note that if the failed material is washed away by water flow into or through the underground workings, or if the floor of the underlying void is sufficiently inclined (*i.e.* steeper than the angle of repose of the collapsed material), this vertical chimneying distance increases as the bulked material is washed away or migrates along the inclined floor of the mine workings. The steeper the incline, the further the void can migrate upwards.

Panel sags or troughs tend to form above wider mined panels with higher extraction ratios and can form due to mining at any depth. In the Canmore area, panel subsidence is associated primarily with the de-pillared areas of the mines, where the extraction ratio (ratio of mined to unmined area) is approximately 75% or more, like the mined-out No. 2 Mine Stewart Seam. The undersized pillars left behind in the de-pillared areas gradually collapse and the rock mass in the immediate roof of the panel fails into the void similar to the mechanism described for sinkhole formation. This failed material is more compressible, allowing gradual relaxation of the beds above the mined-out voids. This sagging and bed separation can extend to surface and form a dish or trough-shaped depression on surface (Hartman, 1992).

The size and shape of the subsidence trough is a function of the make-up of the rock mass overlying the coal seam, as well as the depth of the mine workings; as the depth to the workings increases, the surface expression of panel subsidence decreases in magnitude until it becomes almost immeasurable or negligible. The trough shape and magnitude/depth tend to be characteristic of a given region or rock mass and need to be determined via observation and/or measurement. It is understood that, prior to this initial review towards a different primary site use, previous studies of this site had been performed by others, which will be further investigated during the next phases of the undermining review.

The main components of subsidence include:

- Vertical displacement of the material overlying the mined-out void;
- Horizontal displacement of materials along the perimeter of the subsidence trough;
- Sloping ground in the transition zone between the original / undisturbed ground surface beyond the undermined area and the base of the subsidence trough;
- Horizontal strain associated with the horizontal displacement; and
- Vertical curvature associated with the change in ground slope.

The maximum vertical movement of the ground surface over these panels is greatest at the center of the panel and is a function of the seam height, the extraction ratio, and a subsidence factor. The subsidence factor is an empirical value based on the panel width and the depth of mining, based on observed ground deformations, and can range between 0.22 and 0.81 (Marino, 1997). It is important to note that subsidence factors vary by region and are specific to the geological and mining conditions in the area of interest.

In general, the vertical ground deformation is not the critical parameter influencing the potential for development of structures at the ground surface. Rather, the horizontal strains and the tilt or curvature associated with the edges of the subsidence troughs have the potential to constrain development as they have the greatest impact on structures developed within the margins of the subsidence trough. The surface horizontal displacements and the associated strains, tilt and curvature due to the profile of the subsidence are least at the centre and edges of the trough and are a maximum at or near the inside limit of the edge of the mined area. The limits of the subsidence trough are defined by the draw or limit angle measured from the edge of the de-pillared area to the ground surface on the outside, and the line from the edge of the de-pillared area to the point where maximum subsidence is reached and where the bottom of the subsidence trough becomes flat.

The draw or limit angle of 71° (after Peng *et al,* 1994) was used to define the outer edge of the subsidence trough. While conservative, this angle allows for wider de-pillared zones associated with potential failure of the barrier pillars. The inside angle was determined via assessing the subsidence profile for a typical de-pillared zone at approximately 125 m depth. The inflection point is the point where the reverse-S shaped subsidence profile transitions from concave to convex, and is located to the inside of the edge of the de-pillared zone. The offset of the inflection point of the subsidence curve from the panel edge was calculated using the relation $d = h(0.305069 * 0.99104^{3.28h})$, where d is the offset into the inside edge of the de-pillared zone and h is the depth to the top of the mined seam. The shape of the subsidence curve was determined using the Budryk-Knothe influence function, as per the SME Handbook (Hartman, 1992). Based on this curve and the offset of the inflection point, a line was drawn from the top of the seam edge to the inside limit of the subsidence profile (i.e. near the bottom of the subsidence profile), which was measured at 78°. This was used as the inside limit for the subsidence curve where the tilt/strain/curvature are higher.

6.3 Preliminary Hazard Mapping for Development

To assess the hazards associated with the historic mining activities within the ASP area, each mined seam was evaluated and subdivided into sectors as discussed in Section 4.6. Each seam was assessed for de-pillaring, orientation, and proximity to surface, and areas that were undermined by multiple seams were identified.

The ASP area has been divided into zones based on the potential for subsidence or sinkholes, and associated potential damage to structures. The breakdown of the zones is 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.
- Zone 2 Yellow: development possible with ground mitigation. These are associated with near-surface workings with the potential for sinkhole formation.
- Zone 3 Orange: development possible with ground and structural mitigation, as necessary. These are associated with areas that are undermined by more than one de-pillared seam.
- Zone 4 Magenta: development possible, but higher ground strains are possible. These zones are associated with the margins above the edges of de-pillared areas where the strains, tilt and curvature are expected to be locally highest.
- Zone 5 Red: steeply dipping or sub-vertical workings. These areas have potential for sinkhole or trough development; the potential for development is considered low as the potential costs for mitigation are considered high.

The distribution of these zones for the Three Sisters Resort Village are shown on **Figure 19**. Note that these boundaries are approximate and can vary in location or hazard rating as additional investigations are conducted and more information is available.

The zone boundaries were established as follows:

- The Zone 1 boundaries were considered as the inside limit of broad de-pillared zones for the seams closer to surface (where the maximum subsidence is anticipated), or for areas that are not undermined.
- For the Zone 2 workings, the concern is for the development of sinkholes associated with shallow workings. For these, the subcrop limit was used as the upper boundary and the bedrock thickness of

8 times the working thickness was used for the lower boundary, with a 20 m offset applied to each to account for uncertainty and time effects. Where shallow workings exist for more than one seam, such as for the Sedlock and Stewart seams, (on the northeast side of the ASP), these zones were considered together.

- The Zone 3 considered areas that overlies de-pillared zones from the deeper seams, or where there was overlap between de-pillared zones from more than one seam. The boundaries used were the outer limits as of the de-pillared zones, projected to surface at the draw angle.
- The Zone 4 boundaries are the zones with potential structural issues, associated with the limits of the de-pillared zones. For these, the outer and inner limits of the subsidence profile were determined as described above using angles of 71° and 78°, respectively from the edge of the de-pillared area. These limits were projected onto the ground surface for each de-pillared zone for each seam and coalesced where there was overlap.
- The Zone 5 boundaries are related to known locations of subvertical or steeply dipping seams and workings, with offsets included for uncertainty.

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. Subject to more detailed work within the future Subdivision Mining Impact Assessment Reports or Project Undermining reports, development within Zone 1 may generally proceed without need for ground or structural mitigation to address undermining considerations. Zones 2 through 4 will likely require varying degrees of ground and/or structural mitigation for development to proceed in accordance with the Guidelines and will require further detailed work at future planning stages. Wood acknowledges that the boundaries and offsets selected may be conservative; however, they are considered appropriate for the level of study, the potential change in site usage, and Wood's current level of understanding for the site. The zone boundaries and offsets will be revisited and refined during subsequent studies.

Zone 5 contains known steeply dipping or subvertical workings that are unlikely to be feasible for development due to the high cost of mitigation. Some of the features in Zone 5 areas have already been addressed for public safety considerations in previous work by others; however, review of these measures is recommended when development proceeds within 500 m of these features. Wood recommends avoidance of the development of structures within Zone 5 as a primary means of mitigation at this time, and that ASP policy be written to reflect avoidance in Zone 5 areas only.

6.4 Preliminary Hazard Mapping for Recreational Use

The preparation of the Hazard Map in Figure 19 assumed that development would take place across the ASP area, including infrastructure and building construction. If there is no development planned, and the land within the ASP area is only to be used for recreational purposes, the Hazard Map can be redrawn for recreational use only, as shown on **Figure 20**. In determining the zone classifications, the same methodology as described in Section 6.3 was applied, and can be described as follows:

- Zone A (Green): Areas classified as Zones 1 and 3 re-classify as Zone A (green) and are permissible for recreation areas where no static ground loads will be applied.
- Zone B (Orange) encompasses all of the areas classified as Zone 4 and are suitable for recreational use although investigation and possibly mitigation may be required for development of access or infrastructure as the potential for higher ground strains still exists.

- Zone C (Yellow): has the same boundaries as Zone 2 and has the potential for sinkhole development due to shallow workings. Recreation uses in this zone require further assessment and likely localized mitigation for public use.
- Zone D (Red): has the same boundaries as Zone 5 and is associated with subvertical workings. Recreation uses in this zone require further assessment and likely localized mitigation for public use.

Note that in all cases, known shafts and portals should also be avoided. Recreational use is understood to include activities similar to walking trails, biking trails, open fields, soccer fields, baseball diamonds, and natural areas,

6.5 Features and Characteristics for Future Study

In general terms, there are many factors that can affect the degree of surface subsidence and the shape of the deformation profile, which in turn can impact the risk associated with development above undermined areas. These factors, as described by Hartman (1992) include, but are not limited to, the following:

- Multiple seam mining – the interaction between the seams and the resulting surface expression of subsidence may result in a higher degree of deformation (this will be assessed in analysis for subsequent more detailed studies);
- Seam dip – the dip of the seam can skew the shape of the subsidence profile, steepening the influence angle on the up-dip side and flattening it on the down-dip side above de-pillared areas;
- Degree of extraction – lower extraction ratios have been found to delay or reduce subsidence; as the rooms are widened during extraction/depillaring, the pillar size is reduced (increasing the extraction ratio), making them more prone to failure and accelerating the collapse of the roof into the workings;
- Surface topography – sloping ground has an impact on the downward movements due to the effect of gravity. Consequently, tensile strains are higher on hill crests and are subdued in valley bottoms, impacting the surface expression of subsidence;
- Groundwater – at the site, the original groundwater flow patterns have been greatly impacted by the undermining to the point that flow is mainly contained within the underground workings, with the water level stable at or near elevation 1310 m (Jacques Whitford 2006). However, the flow of surface water through cracks and into the mine workings can accelerate the formation of sinkholes or troughs as fine materials in existing cracks are washed away;
- Mined area – for maximum subsidence to be achieved, a critical width must be exceeded on both lateral and longitudinal axes; smaller areas can tend to bridge and decrease subsidence, even for long narrow mined panels; and
- Time – the surface expression of subsidence due to undermining is a function of the time since mining was completed. This time includes the time for the remaining pillars in a de-pillared area to fail, the time for the roof to collapse, and the time for the sag of the overlying beds to migrate to surface. In many cases, this migration can take decades.

While the above list appears onerous, a significant body of work has already been completed within the ASP area associated with the development of the Three Sisters golf course and other areas owned by TSMVPL. The surface features observed and photographed by others over decades provides an extensive source of data for the conditions at the site and any changes that have occurred, including hazards that have been mitigated and areas that have been cleared. The observation record also indicates that many of the features have not changed or have only changed minimally since the beginning of development on the site, despite decades that have elapsed since the closure of the mines.

The extensive borehole database discussed in Section 4.3, which includes over 480 boreholes across the ASP provides a wealth of information regarding the existing subsurface conditions and potential for future ground movement. Further, many of the existing boreholes have plastic conduit installed so that the boreholes remain accessible. This will potentially allow for future camera and/or downhole survey work to occur to assess the changes in ground movement or void migration that have occurred to date, in addition to data from new boreholes advanced during future studies.

As mentioned above, subsequent steps undertaken during more detailed planning stages such as conceptual scheme, land use or subdivision applications as a part of more detailed work within future Subdivision Mining Impact Assessment Reports or Project Undermining Reports will also serve to address the impact of the aforementioned factors. The existing boreholes contain information regarding the limits of mining and confirmation of the accuracy of mine records, presence of pillars, thickness of collapsed materials, presence of voids, rubble, and bed separations, etc., which can be analyzed to estimate the amount of subsidence that has already occurred across the ASP area, and the potential for future surface impact. It is assumed that additional boreholes will be advanced during additional phases of work to close any gaps in the data that may exist and to further the understanding of the current conditions at the site. This information will be used to give an accurate profile of the potential for surface impacts due to the undermining, the risks associated with development, and the mitigative measures that can be applied to reduce the risk.

6.6 Future Work

The impact of the undermining will need to be assessed for each non-green zone on the map for subsequent stages of development. These assessments, which are part of the more detailed planning stages, will include:

- Pillar dimension and depth calculations to assess stability of remnant pillars and determine panel sizes;
- Estimates of maximum subsidence values and ranges;
- Assessment of subsidence profiles and curves to evaluate tilt and strain for the various seams and sectors, and determine the location where limits are exceeded for each de-pillared area;
- Assessment of the interaction of subsidence profiles from the multiple seams to determine ultimate tilt, strain and subsidence at ground surface; and
- Determination of areas that will require further investigation to verify existing ground conditions, mining geometry and to assess the potential for application of ground or structural mitigation strategies.

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:

PROFESSIONAL ENGINEER ALBERTA
JAMES TOD
2020-11-16

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

Blake Brodland

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 16 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, withing 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

Golder Associates, 2019. *Three Sisters Mountain Village, Undermining Report, South Bow Water Main, Tipple Site*, report prepared for Epcor Water Services, October.

Hartman, H.L. 1992. Mining Engineering Handbook, 2nd Edition, Seeley W. Mudd Memorial Fund of AIME Society for Mining, Metallurgy and Exploration.

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

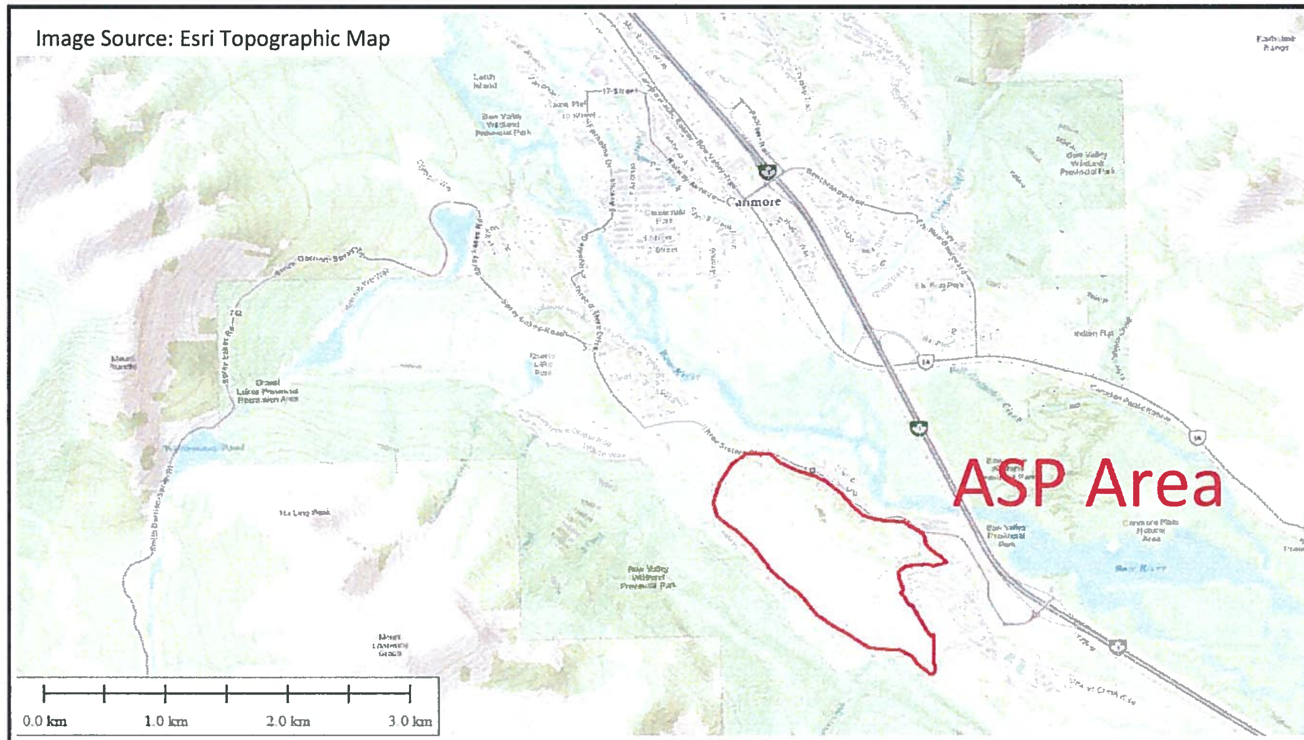
Marino, G.G. 1998. The Siting of a Prison Complex Above an Abandoned Underground Coal Mine, Journal of Geotechnical and Geoenvironmental Engineering, October.

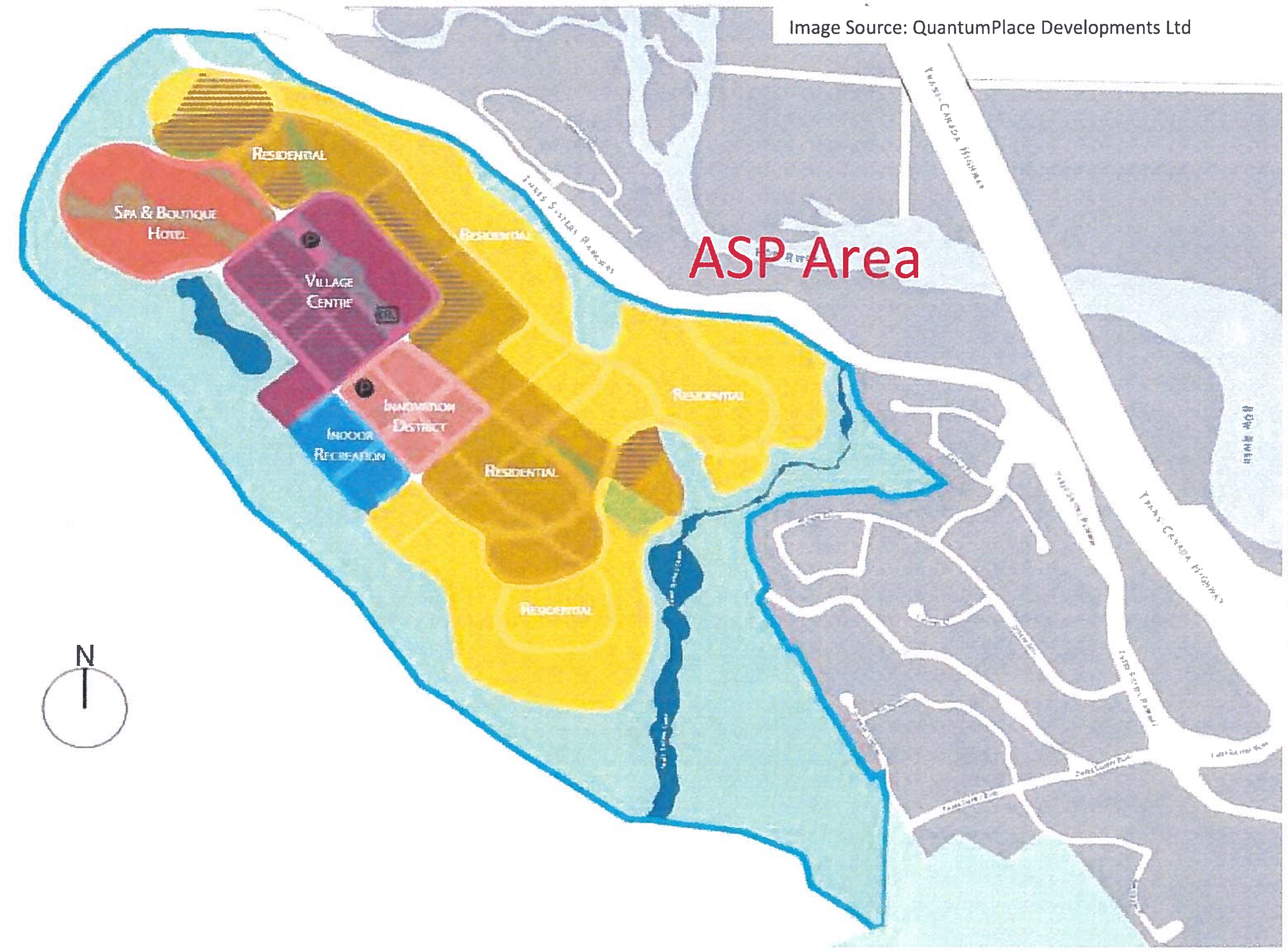
Mossop, G.D. 1994. Geological atlas of the western Canada Sedimentary Basin, joint publication by the Canadian Society of Petroleum Geologists and the Alberta Research Council, 510 pp.

Peng, S.S., C.T. Holland and Y. Luo. 1994. A new method for designing support area to protect surface structures over underground coal mining areas, SME, Trans. Vol 294, pp. 1927 – 1932.

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.

Figures





Linework: QuantumPlace Developments 21 July 2020

	PROJECT NAME	PROJECT NUMBER
wood.	Resort Village ASP	CG09125
		FIGURE NUMBER
		1
THREE SISTERS mountain village	SHEET TITLE	ISSUE/REVISION
	Site Location	Rev2

ASP Area

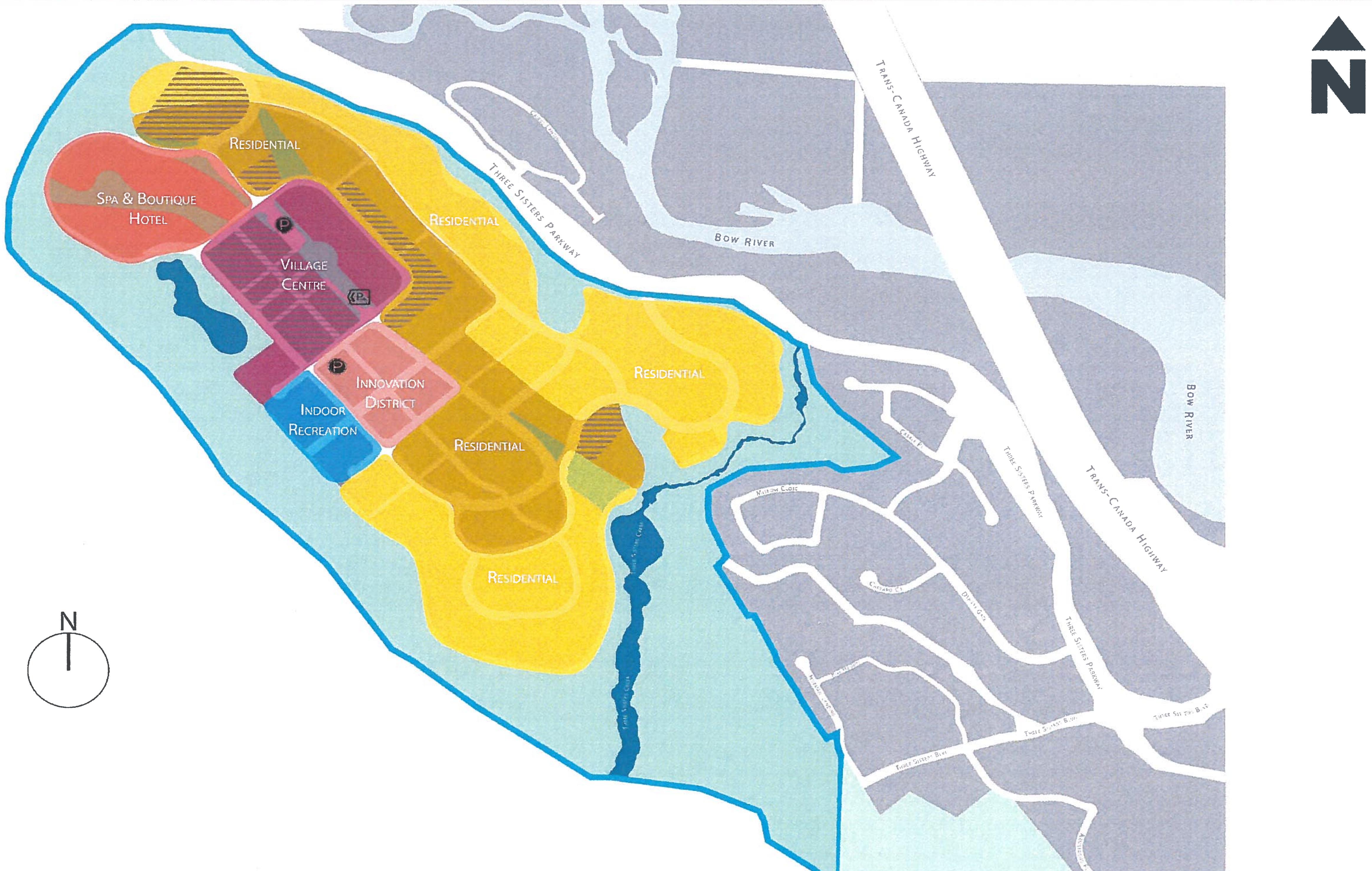
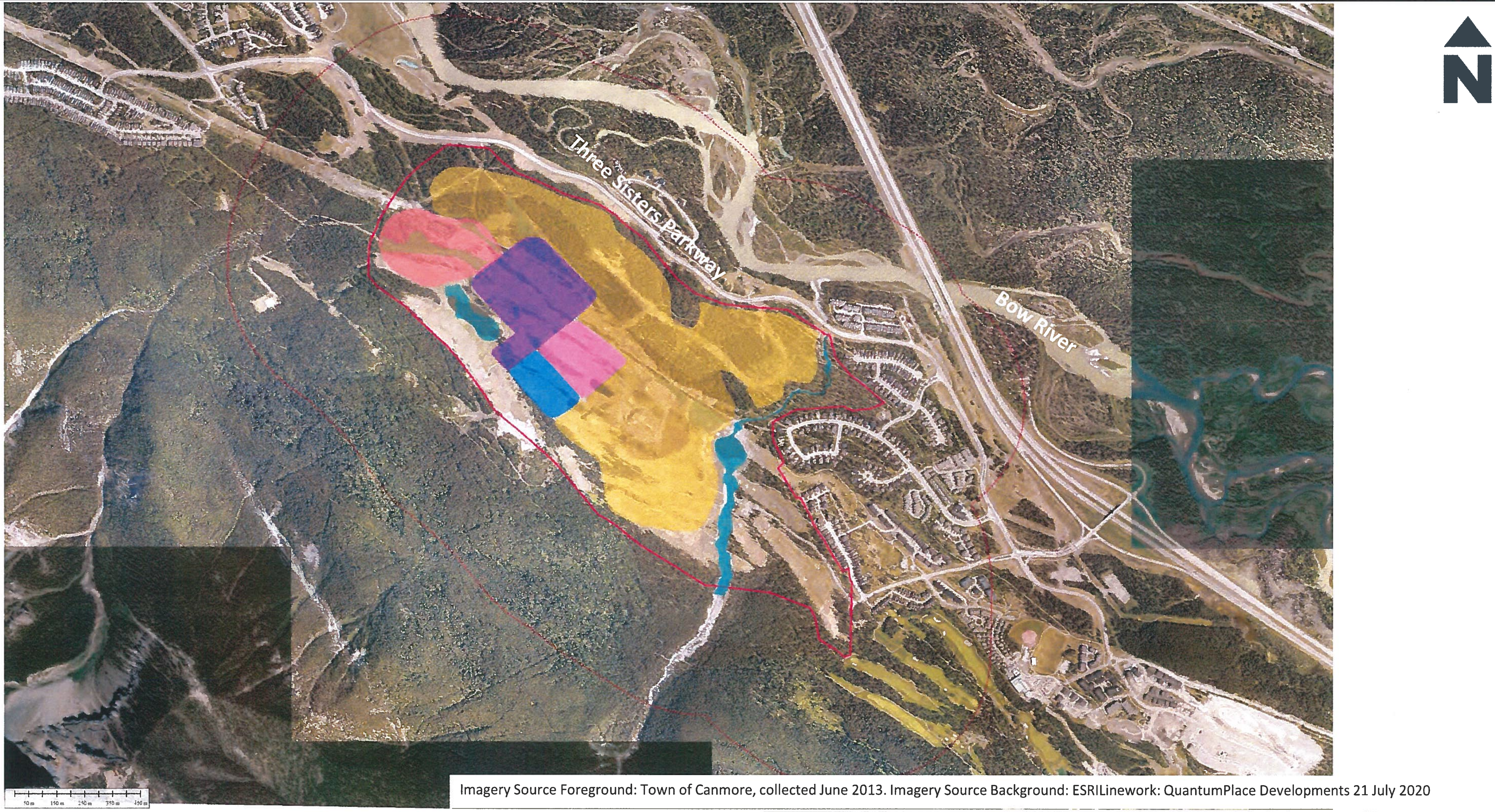


Image Source: QuantumPlace Developments Ltd

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125 FIGURE NUMBER 2
THREE SISTERS mountain village	SHEET TITLE Land Use Map	ISSUE/REVISION Rev2

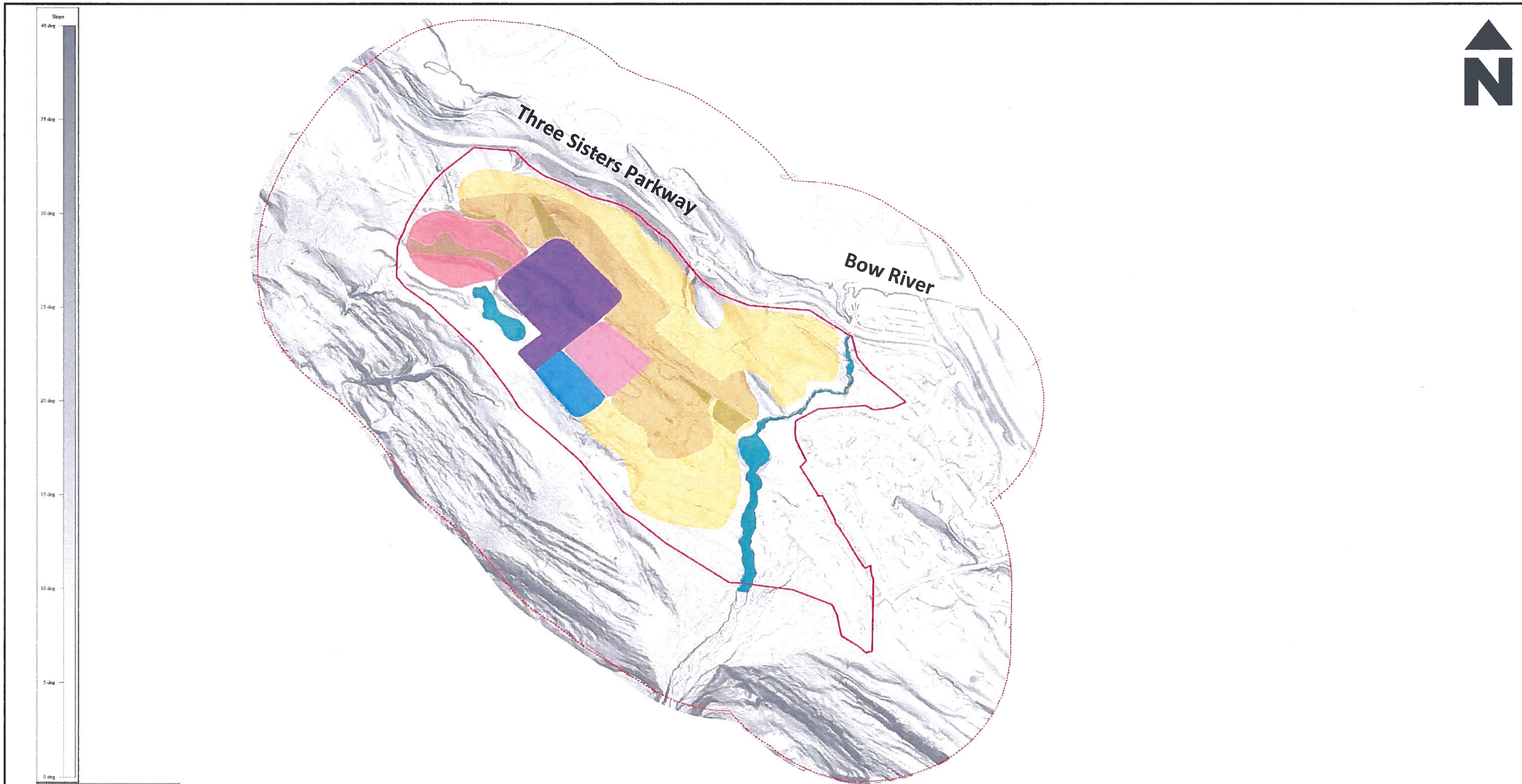


Imagery Source Foreground: Town of Canmore, collected June 2013. Imagery Source Background: ESRILinework: QuantumPlace Developments 21 July 2020

Legend

- ASP Boundary
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 3
THREE SISTERS mountain village	SHEET TITLE Site Overview with Orthophoto	ISSUE/REVISION Rev2

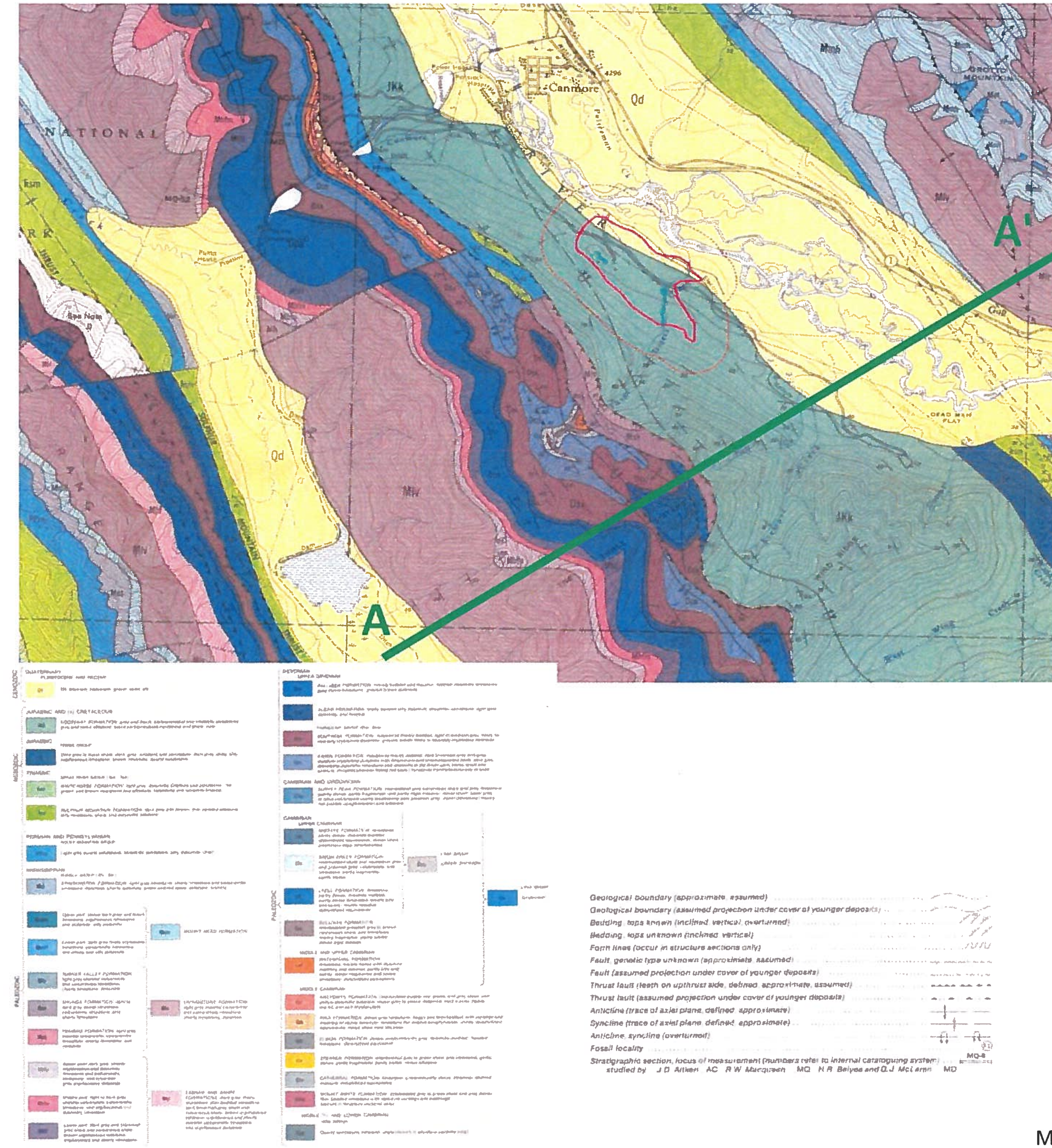


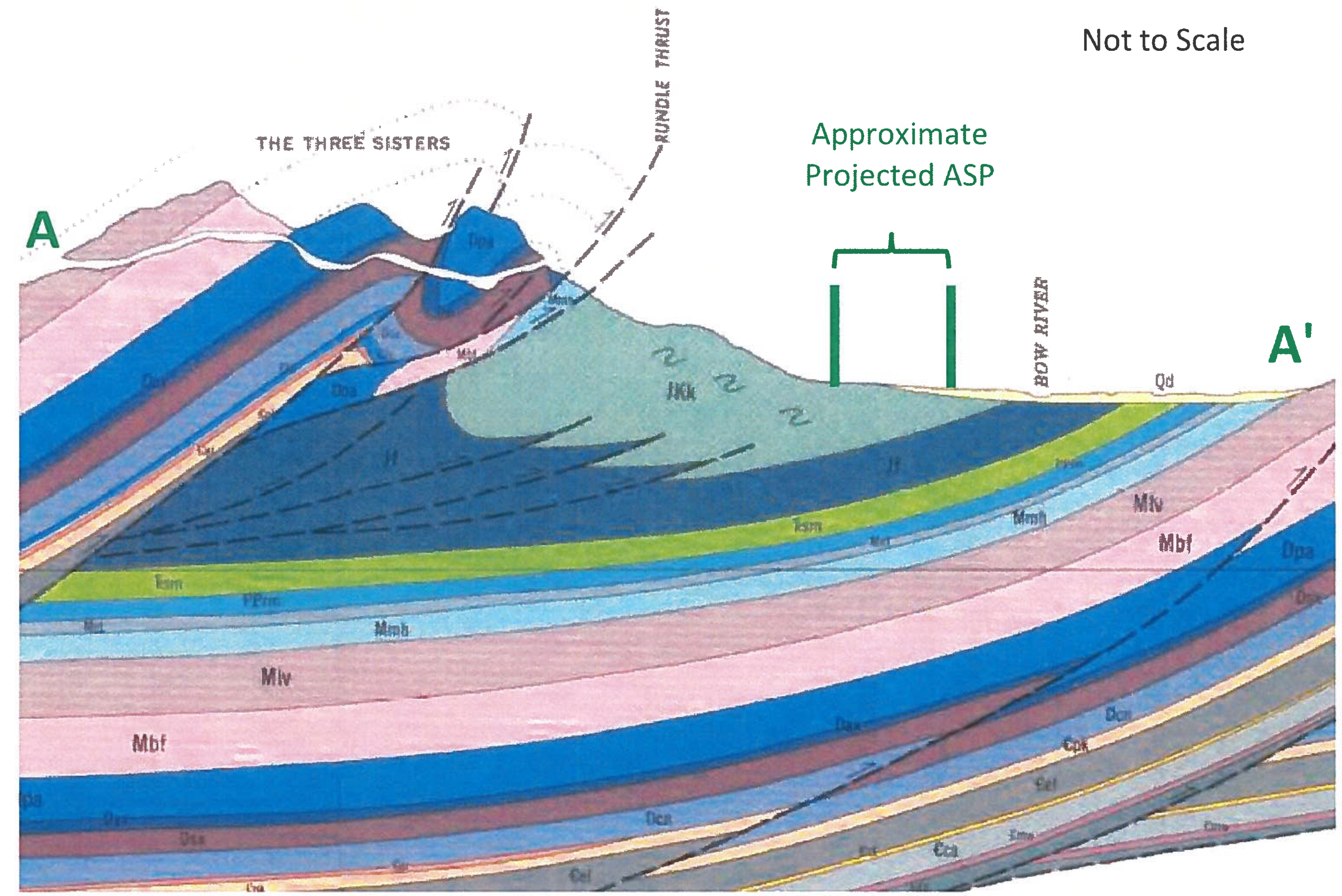
LiDAR Source: Town of Canmore, collected June 2013. Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Boundary
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 4
THREE SISTERS mountain village	SHEET TITLE Site Overview with LiDAR	ISSUE/REVISION Rev2





Not to Scale

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

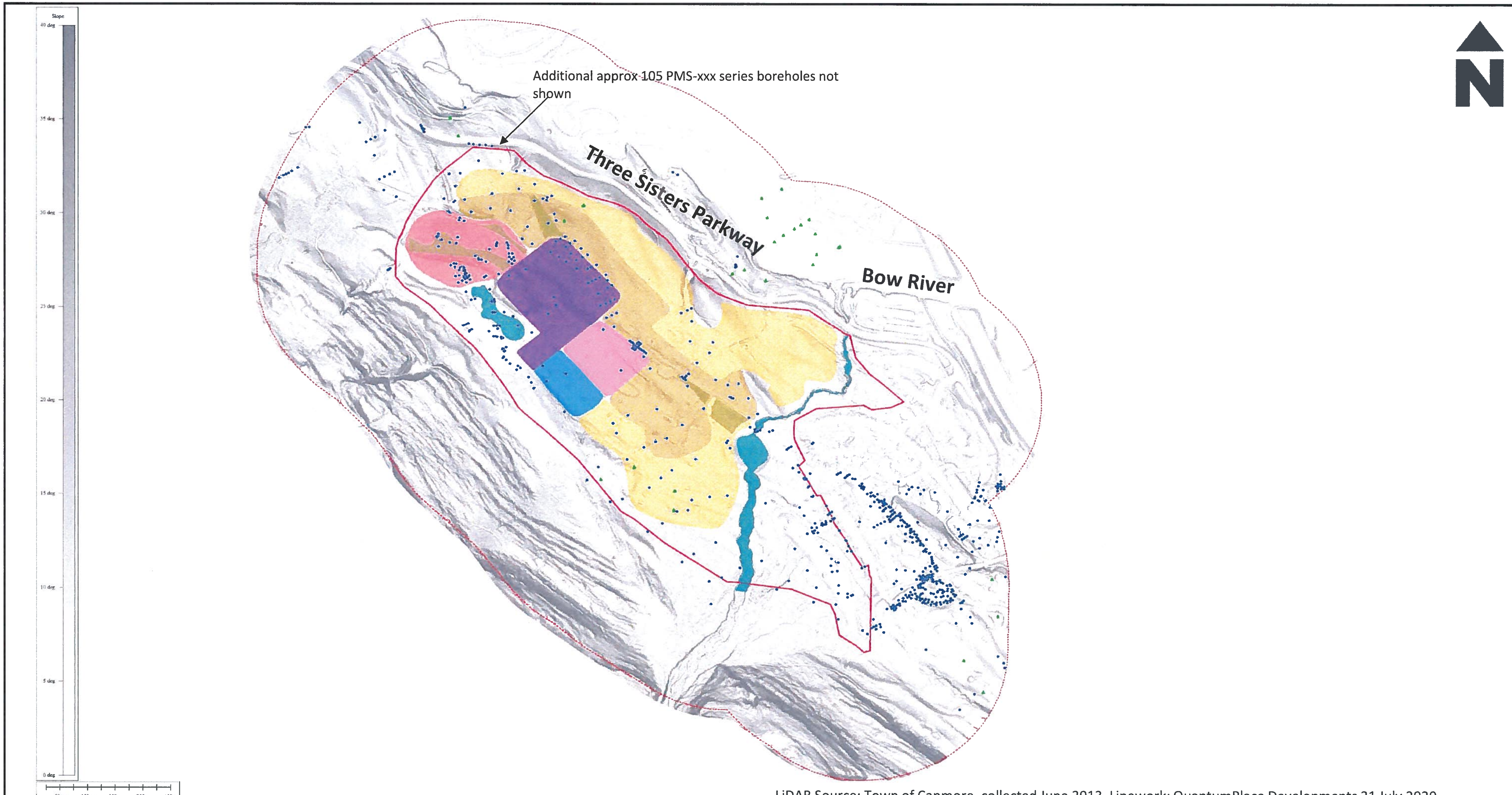
Legend

ASP Area

wood.

THREE SISTERS mountain village

PROJECT NAME	PROJECT NUMBER
Resort Village ASP	CG09125
	FIGURE NUMBER
	5
SHEET TITLE	ISSUE/REVISION
Bedrock Geology	Rev2

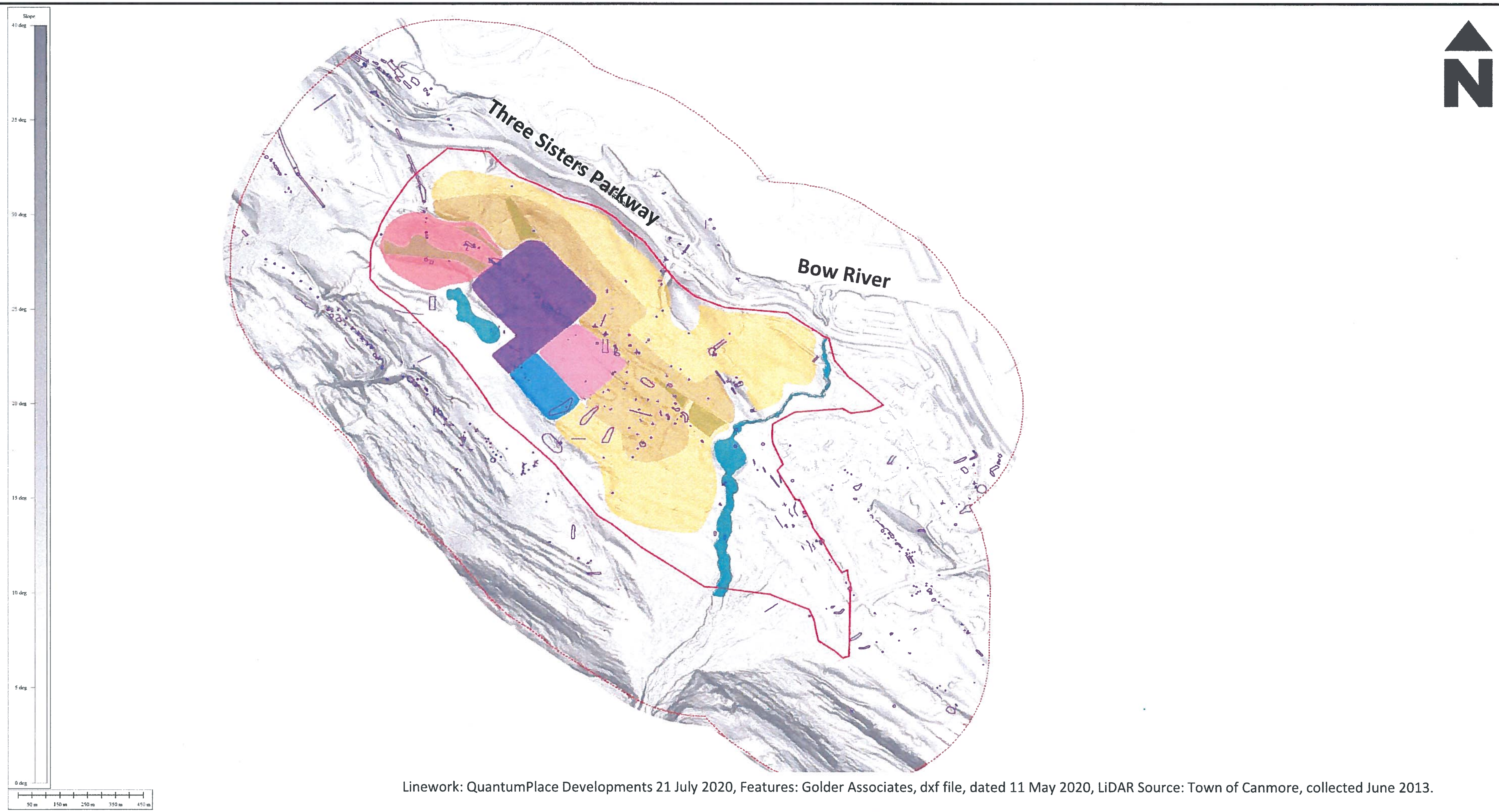


LiDAR Source: Town of Canmore, collected June 2013. Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- AER Boreholes
- TSMV Existing Boreholes

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 6
THREE SISTERS mountain village	SHEET TITLE Existing Boreholes	ISSUE/REVISION Rev2



Linework: QuantumPlace Developments 21 July 2020, Features: Golder Associates, dxf file, dated 11 May 2020, LiDAR Source: Town of Canmore, collected June 2013.

Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- Features Mapped by Others

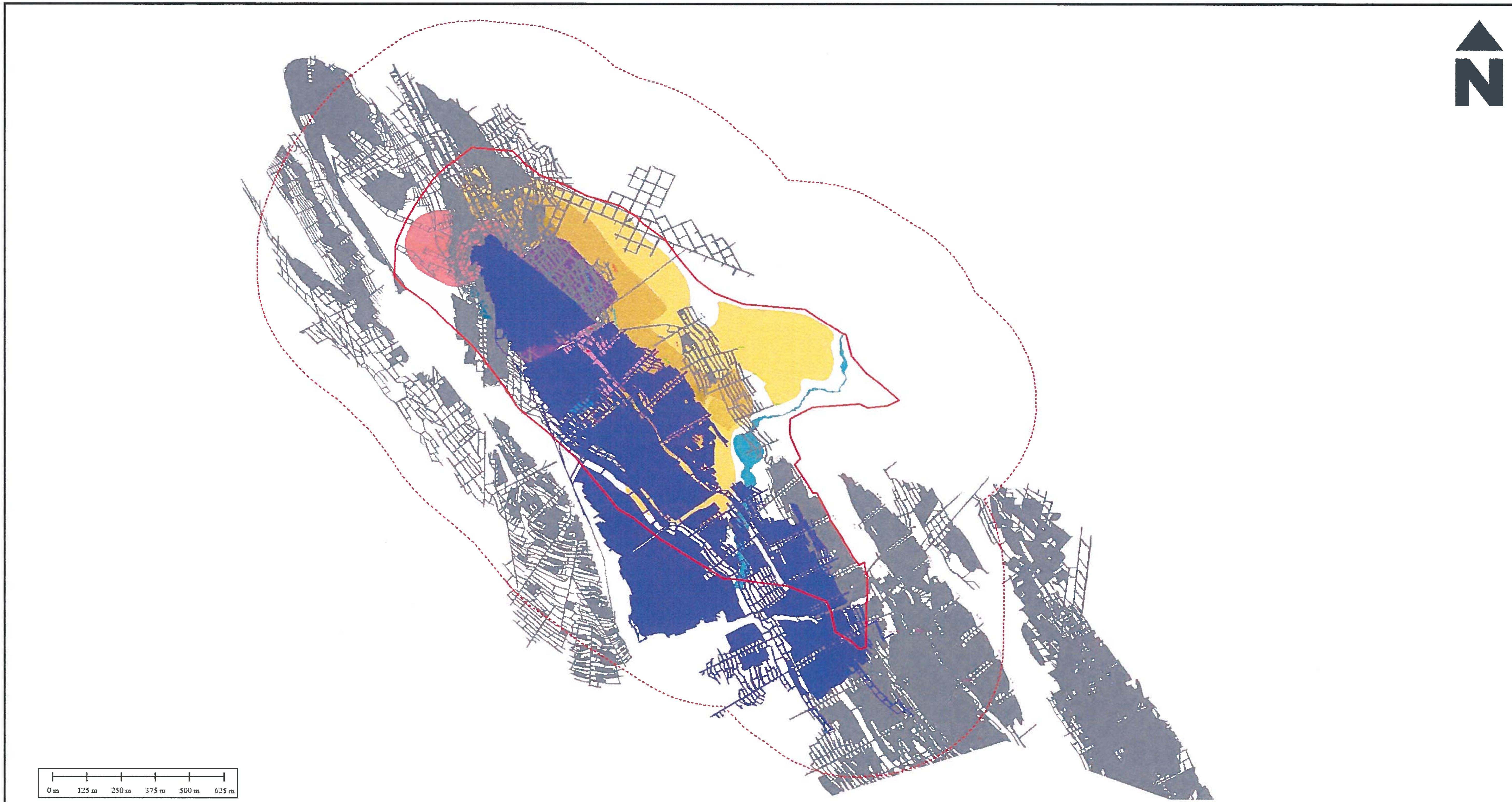
wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 7
THREE SISTERS mountain village	SHEET TITLE Features Mapped by Others	ISSUE/REVISION Rev2

Linework: QuantumPlace Developments 21 July 2020, LiDAR Source: Town of Canmore, collected June 2013.

Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- Noteworthy Features
- Man-Made Mounds
- Man-Made Flat or Depression Areas

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 8
THREE SISTERS mountain village	SHEET TITLE Wood Mapped Features	ISSUE/REVISION Rev2



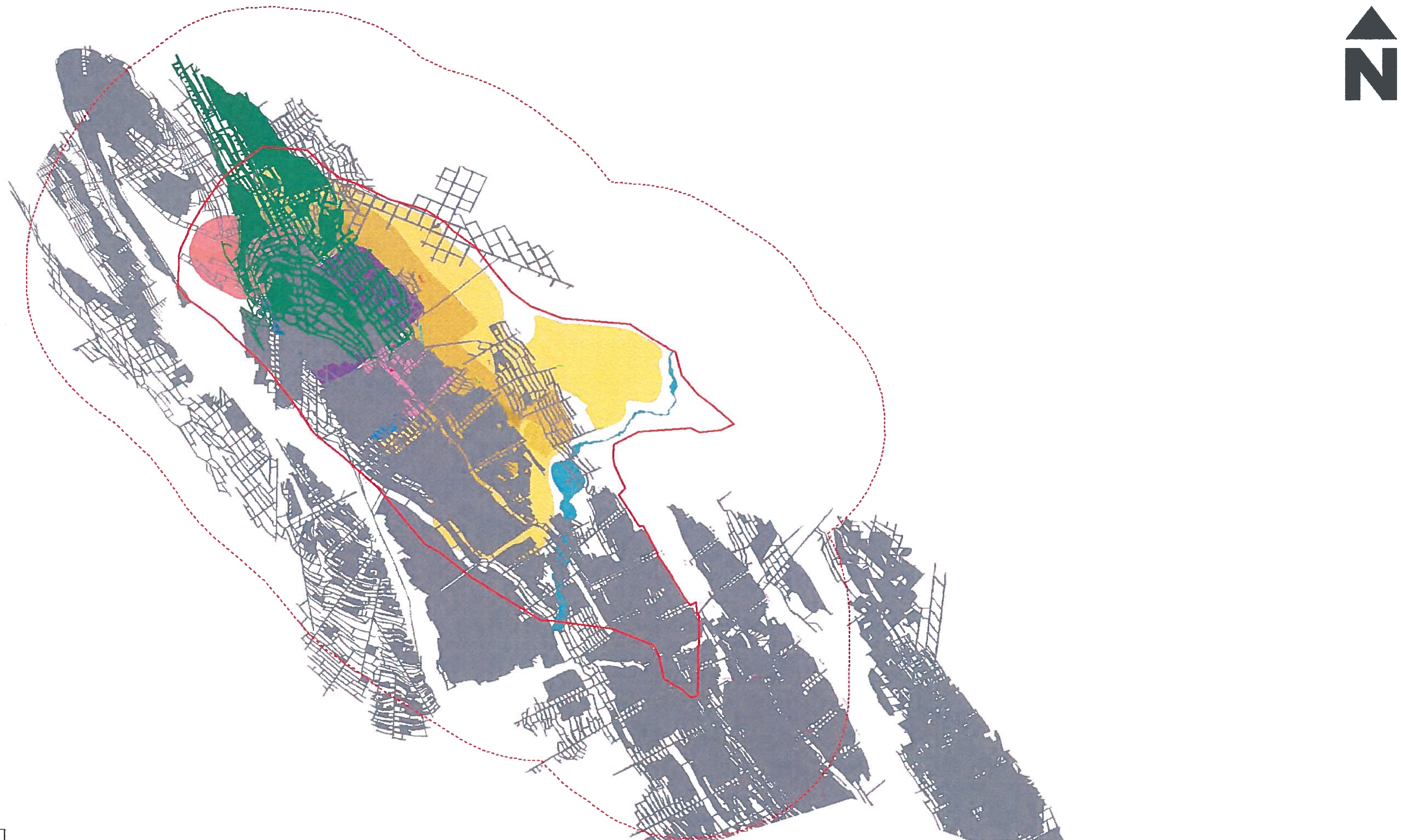
Legend

- ASP Area
- 500m Safety Zone
- Stewart Mine
- Other Mines

wood.

THREE SISTERS mountain village

PROJECT NAME	Resort Village ASP
SHEET TITLE	Stewart Mine
PROJECT NUMBER	CG09125
FIGURE NUMBER	9
ISSUE/REVISION	Rev2



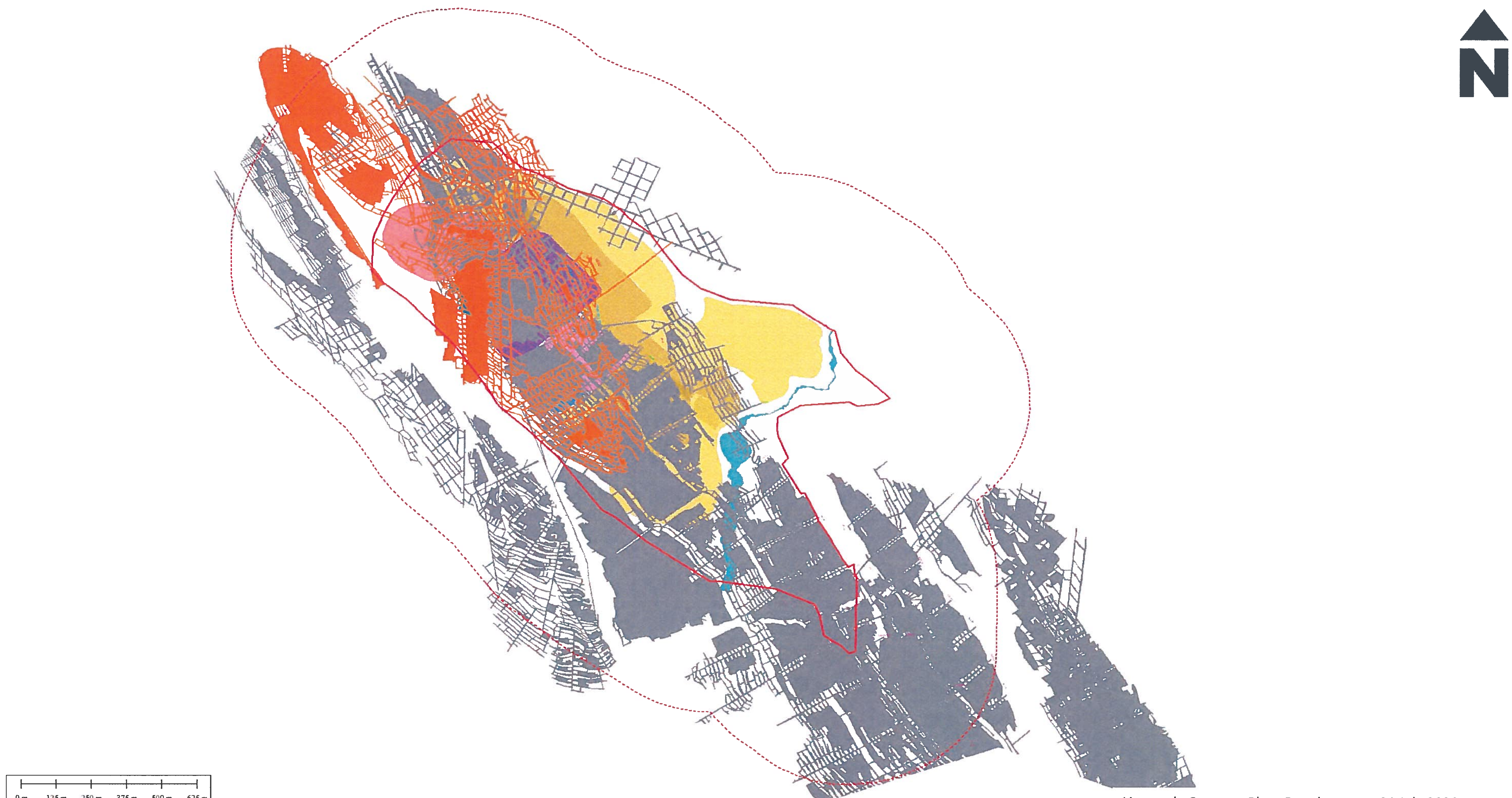
0 m 125 m 250 m 375 m 500 m 625 m

Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Area
- 500m Safety Zone
- Sedlock Mine
- Other Mines

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125	FIGURE NUMBER 10
THREE SISTERS mountain village	SHEET TITLE Sedlock Mine	ISSUE/REVISION Rev2	

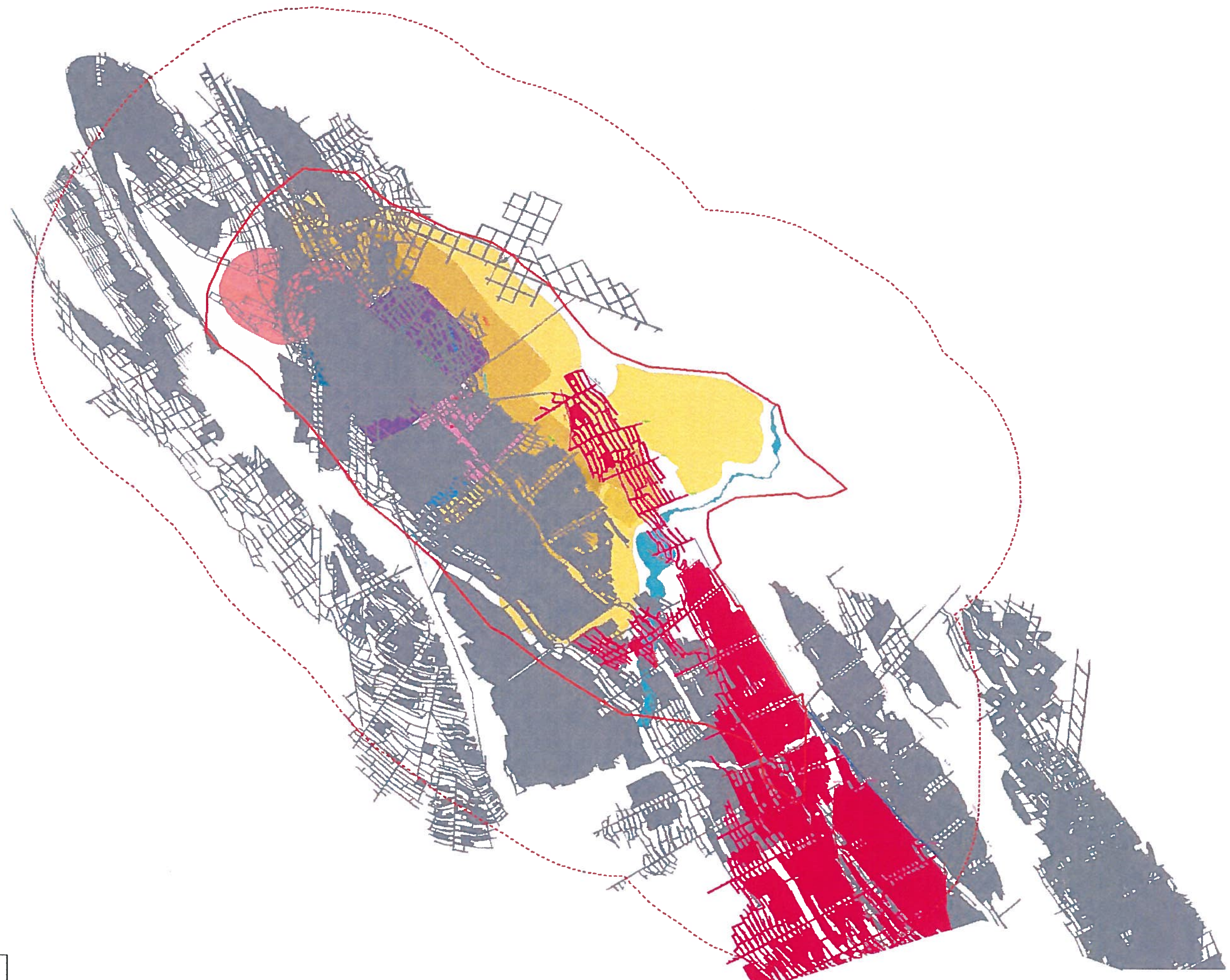


Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Area
- 500m Safety Zone
- Carey Mine
- Other Mines

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 11
THREE SISTERS mountain village	SHEET TITLE Carey Mine	ISSUE/REVISION Rev2



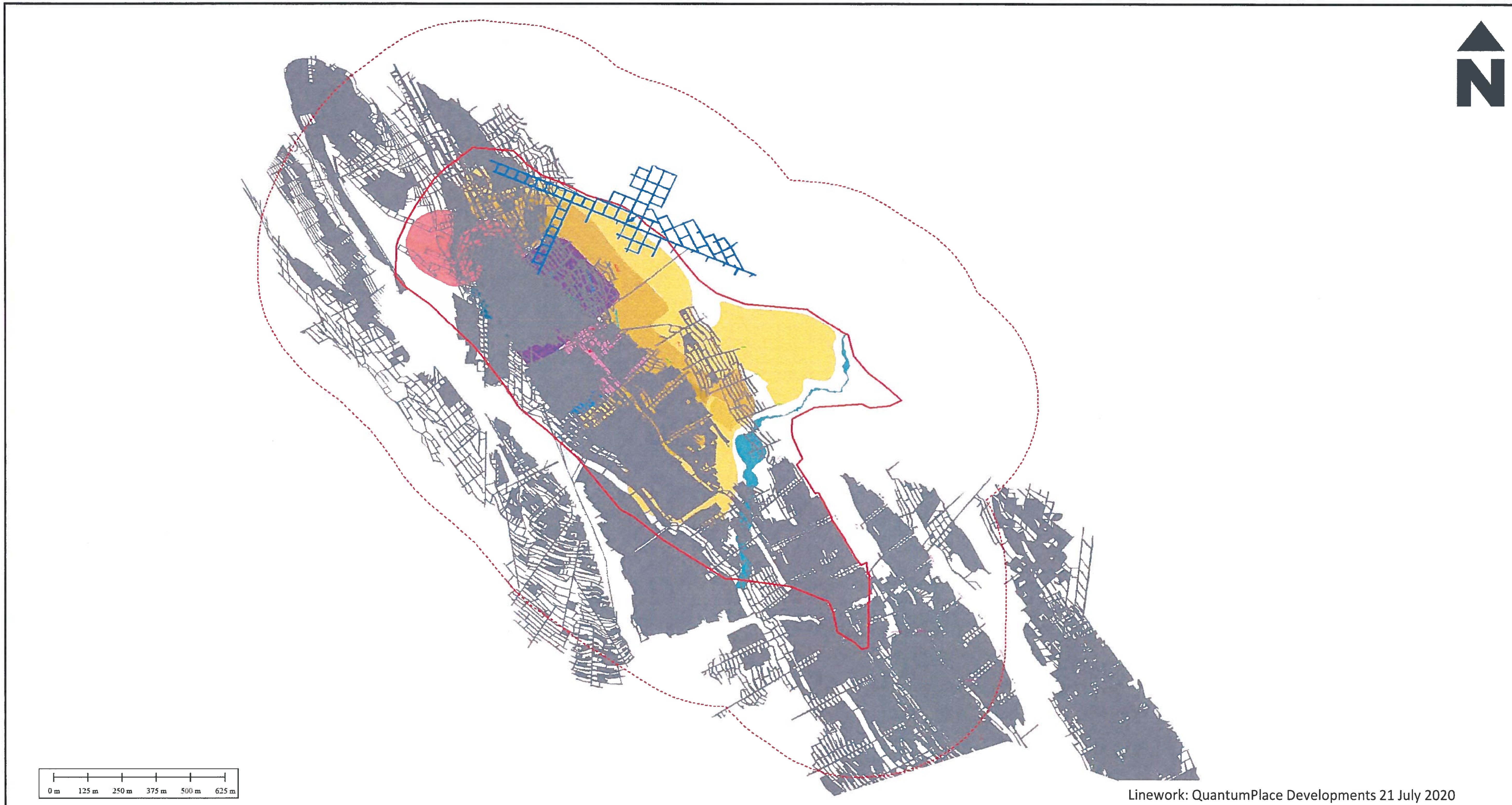
0 m | 125 m | 250 m | 375 m | 500 m | 625 m

Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Area
- 500m Safety Zone
- Morris No. 1 Mine
- Other Mines

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 12
THREE SISTERS mountain village	SHEET TITLE Morris No. 1 Mine	ISSUE/REVISION Rev2

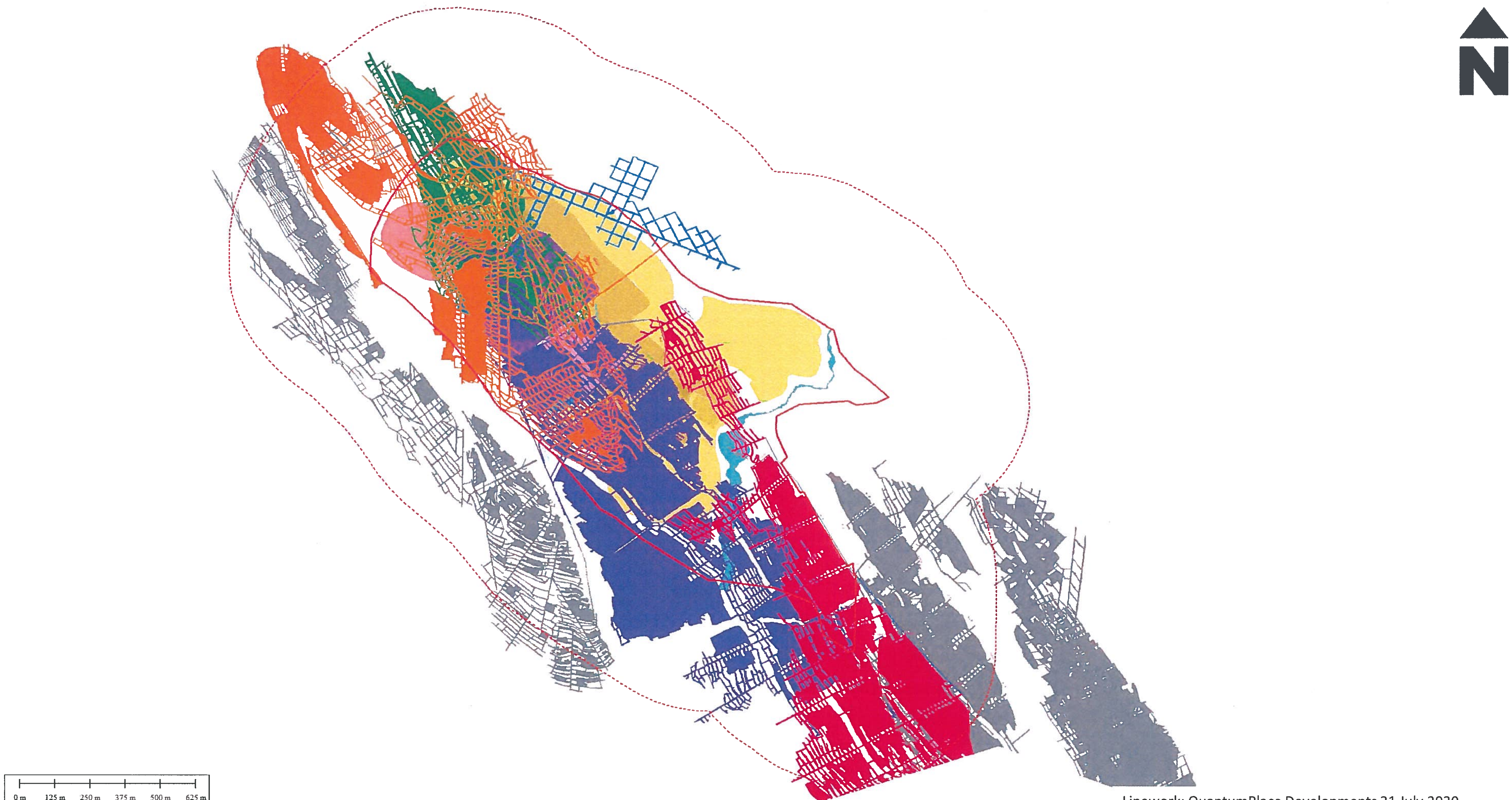


Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Area
- 500m Safety Zone
- Riverside Mine
- Other Mines

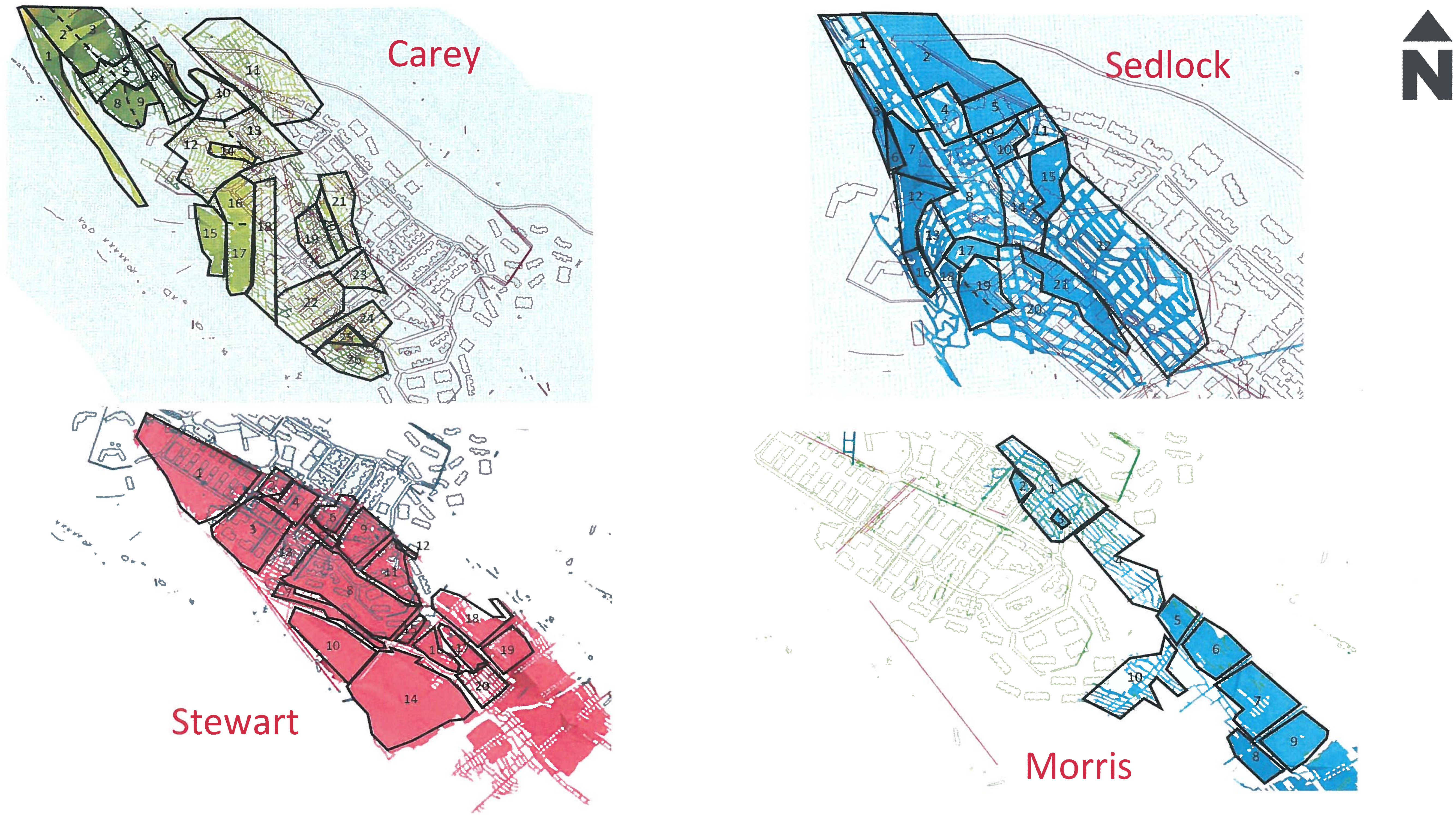
wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 13
THREE SISTERS mountain village	SHEET TITLE Riverside Mine	ISSUE/REVISION Rev2



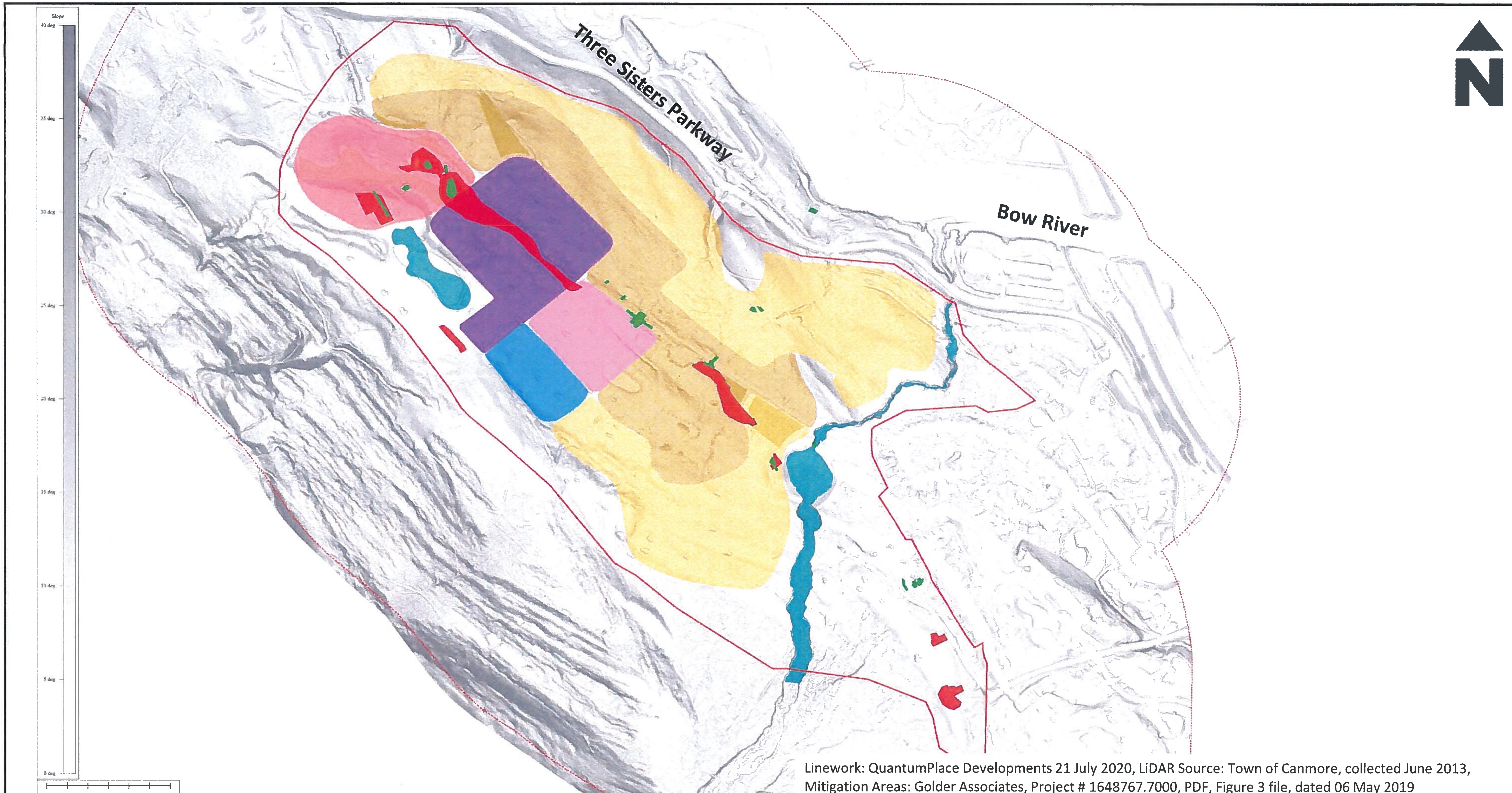
Legend

- ASP Area
- 500m Safety Zone
- Stewart Mine
- Sedlock Mine
- Carey Mine
- Morris No. 1 Mine
- Riverside Mine
- Other Mines

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125	
		FIGURE NUMBER 14	
THREE SISTERS mountain village	SHEET TITLE All Mines in ASP	ISSUE/REVISION Rev2	



wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 15
THREE SISTERS mountain village	SHEET TITLE Analysed Mine Sectors	ISSUE/REVISION Rev2



Linework: QuantumPlace Developments 21 July 2020, LiDAR Source: Town of Canmore, collected June 2013, Mitigation Areas: Golder Associates, Project # 1648767.7000, PDF, Figure 3 file, dated 06 May 2019

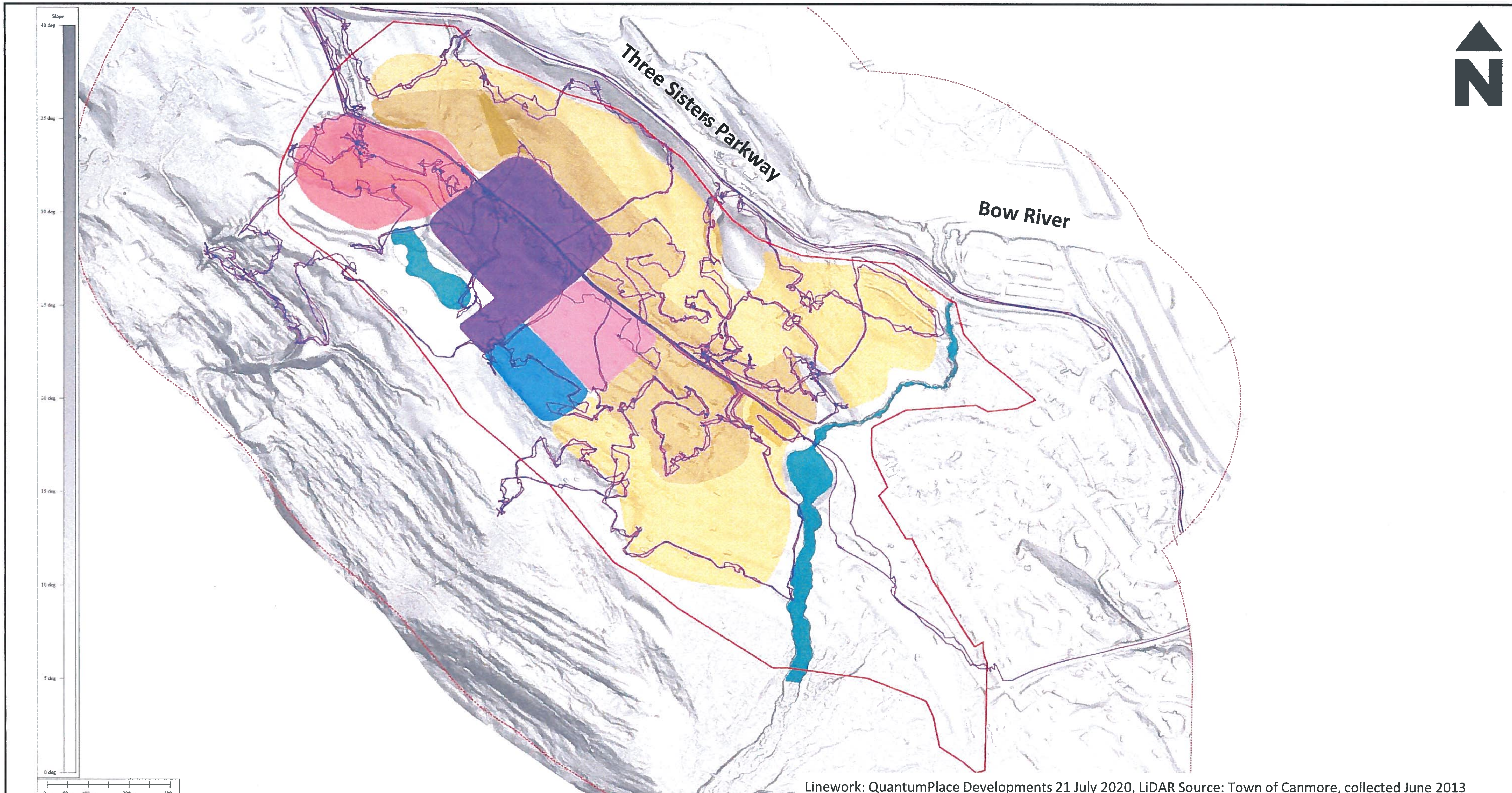
Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- Existing Geogrid Mitigation
- Existing Paste Mitigation

wood.

THREE SISTERS mountain village

PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
	FIGURE NUMBER 16
SHEET TITLE Previously Mitigated Areas For Golf Course Use	ISSUE/REVISION Rev2

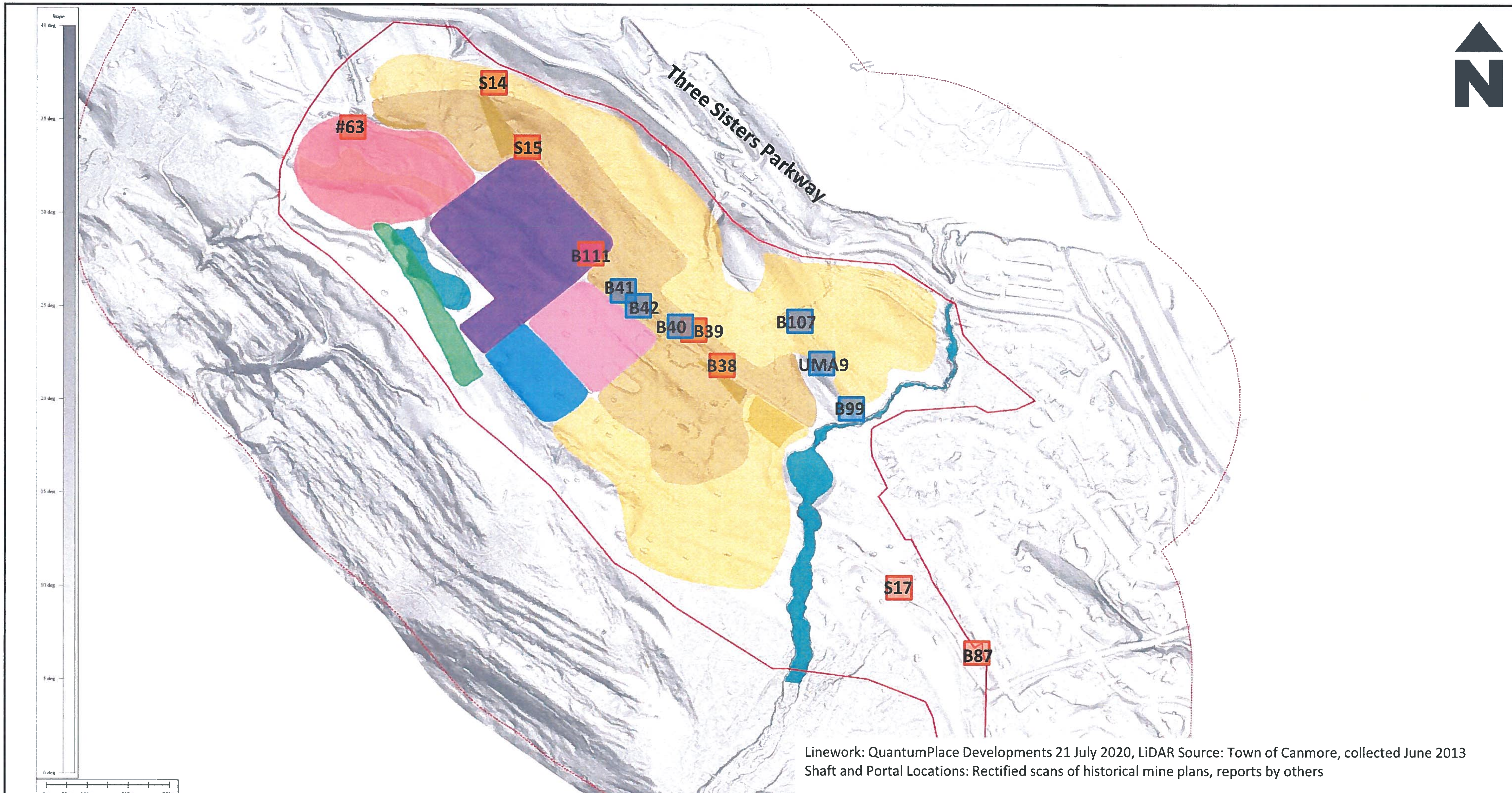


Linework: QuantumPlace Developments 21 July 2020, LiDAR Source: Town of Canmore, collected June 2013

Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- Wood E&IS GPS Tracks

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 17
THREE SISTERS mountain village	SHEET TITLE Wood GPS Tracks	ISSUE/REVISION Rev2

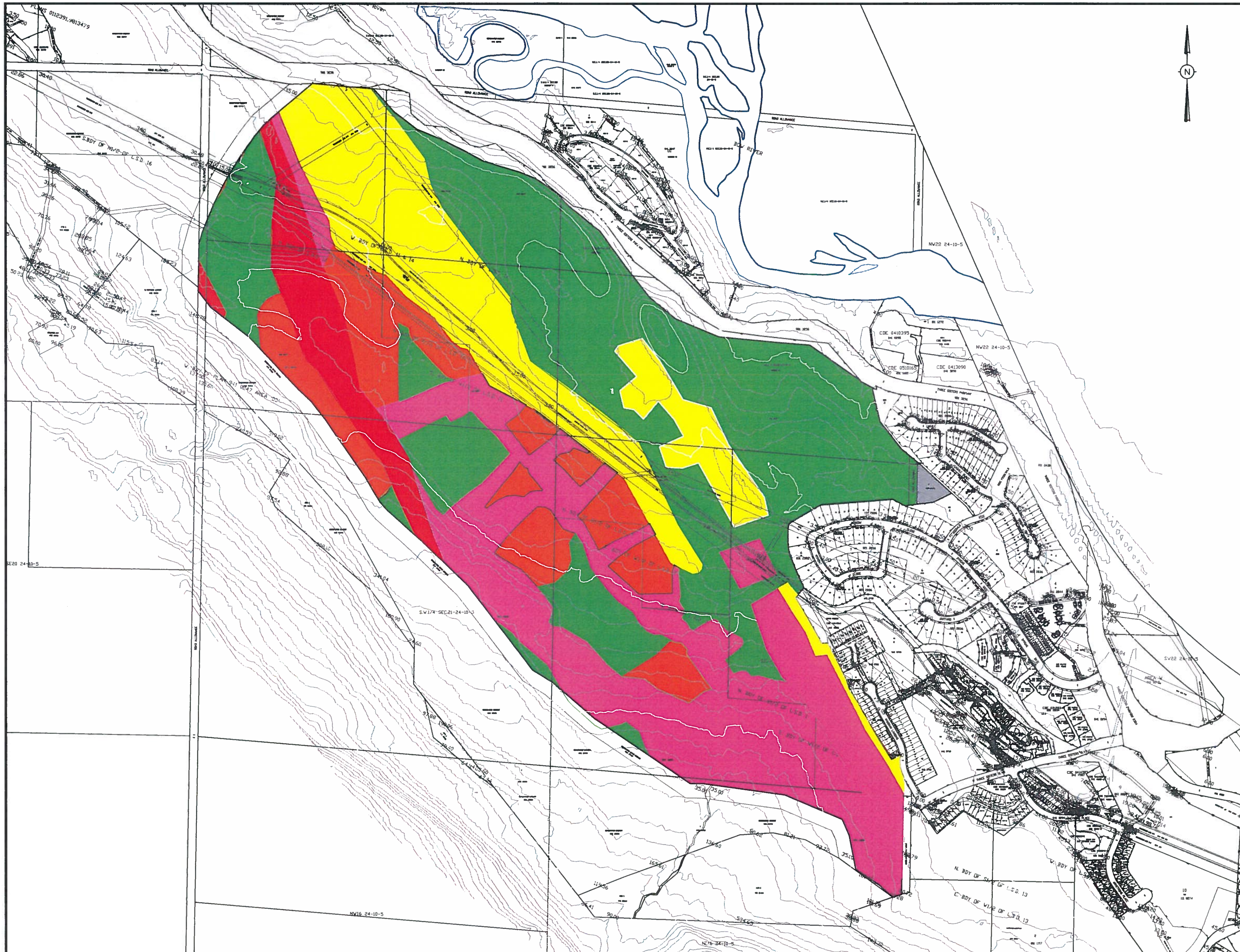


Linework: QuantumPlace Developments 21 July 2020, LiDAR Source: Town of Canmore, collected June 2013
Shaft and Portal Locations: Rectified scans of historical mine plans, reports by others

Legend

- ASP Area
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential
- Surface Coal Mine Extents
- Former Shaft
- Former Portal

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125
		FIGURE NUMBER 18
THREE SISTERS mountain village	SHEET TITLE Former Surface Mine, Shafts and Portals within ASP	ISSUE/REVISION Rev2



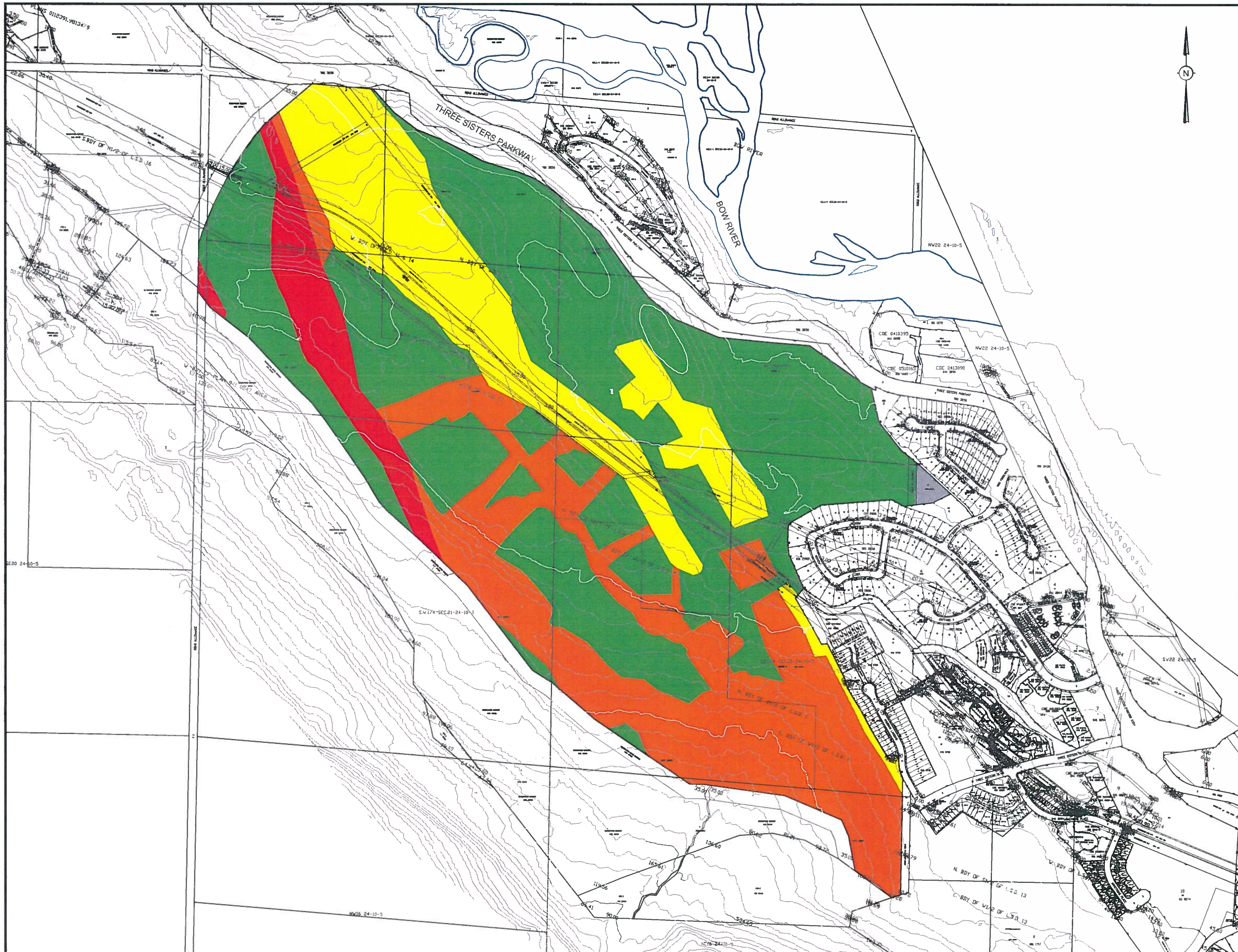
LEGEND:

- ZONE 1 (GREEN): NO STRUCTURAL OR GROUND MITIGATION REQUIRED FOR DEVELOPMENT. THESE ARE AREAS THAT HAVEN'T BEEN UNDERMINED, OR ARE LOCATED ABOVE THE MIDPOINT OF BROAD DE-PILLARED AREAS WITH EXPECTED UNIFORM SETTLEMENT.
- ZONE 2 (YELLOW): DEVELOPMENT POSSIBLE WITH GROUND MITIGATION. THESE ARE ASSOCIATED WITH NEAR-SURFACE WORKINGS WITH THE POTENTIAL FOR SINKHOLE FORMATION.
- ZONE 3 (ORANGE): DEVELOPMENT POSSIBLE WITH GROUND AND STRUCTURAL MITIGATION, AS NECESSARY. THESE ARE ASSOCIATED WITH AREAS THAT ARE UNDERMINED BY MORE THAN ONE DE-PILLARED SEAM, OR THE POTENTIAL FOR DIFFERENTIAL SETTLEMENT DUE TO UNDERLYING PILLARS AND DE-PILLARED AREAS.
- ZONE 4 (MAGENTA): DEVELOPMENT POSSIBLE, BUT HIGHER GROUND STRAINS POSSIBLE. THESE ZONES ARE ASSOCIATED WITH THE MARGINS ABOVE THE EDGES OF DE-PILLARED AREAS WHERE THE STRAINS, TILT AND CURVATURE ARE EXPECTED TO BE LOCALLY HIGHER.
- ZONE 5 (RED): STEEPLY DIPPING OR SUBVERTICAL WORKINGS. THESE AREAS HAVE POTENTIAL FOR SINKHOLE OR TROUGH DEVELOPMENT; THE POTENTIAL FOR DEVELOPMENT IS CONSIDERED LOW AS THE POTENTIAL COSTS FOR MITIGATION ARE CONSIDERED HIGH.

0 100 200 400m
1:7500 SCALE

CLIENT LOGO	CLIENT:		COMPANY LOGO	PROJECT	
THREE SISTERS mountain village	THREE SISTERS MOUNTAIN VILLAGE PROPERTIES LTD.	DWN BY: GG CHK'D BY: JT	wood.	THREE SISTERS MOUNTAIN VILLAGE RESORT VILLAGE ASP AREA	DATE: NOVEMBER 2020 PROJECT NO: CG09125
	Wood Environment & Infrastructure Solutions #401, 1925 - 18th Ave. NE Calgary, Alberta, Canada T2E 7T8	DATUM: N/A PROJECTION: N/A SCALE: AS SHOWN		TITLE PRELIMINARY HAZARD ZONE-DEVELOPMENT	REV NO.: A FIGURE No 19

C:\Users\greg.gwynne\Desktop\CG09125 Three Sisters Undermining\03_Figures\001 - 06-10-2020- Three Sisters Hazard\Figure 19_Preliminary Hazard Map.dwg - Layout1 - Nov. 16, 2020 6:01pm - greg.gwynne



LEGEND:

- ZONE A (GREEN): PERMISSIBLE FOR RECREATION AREAS WHERE NO STATIC GROUND LOADS WILL BE APPLIED.
- ZONE B (ORANGE): SUITABLE FOR RECREATIONAL USE ALTHOUGH INVESTIGATION AND POSSIBLY MITIGATION MAY BE REQUIRED FOR DEVELOPMENT OF ACCESS OR INFRASTRUCTURE AS THE POTENTIAL FOR HIGHER GROUND STRAINS STILL EXISTS
- ZONE C (YELLOW): POTENTIAL FOR SINKHOLE DEVELOPMENT DUE TO SHALLOW WORKINGS. RECREATION USES IN THIS ZONE REQUIRE FURTHER ASSESSMENT AND LIKELY LOCALIZED MITIGATION FOR PUBLIC USE.
- ZONE D (RED): ASSOCIATED WITH SUBVERTICAL WORKINGS. RECREATION WITHIN THIS ZONE REQUIRE FURTHER ASSESSMENT AND LIKELY LOCALIZED MITIGATION FOR PUBLIC USE.

0 100 200 400m
1:7500 SCALE

CLIENT LOGO: THREE SISTERS mountain village	CLIENT: THREE SISTERS MOUNTAIN VILLAGE PROPERTIES LTD.	DWN BY: GG	PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT VILLAGE ASP AREA
	Wood Environment & Infrastructure Solutions #401, 1925 - 18th Ave. NE Calgary, Alberta, Canada T2E 7T8	CHK'D BY: JT	DATE: NOVEMBER 2020
		DATUM: N/A	PROJECT NO: CG09125
	COMPANY LOGO: wood.	PROJECTION: N/A	TITLE: PRELIMINARY HAZARD ZONE-RECREATION
		SCALE: AS SHOWN	REV. NO.: A
			FIGURE No: 20

Appendix A

Site Reconnaissance Features by Others, Visited by Wood

Site Reconnaissance Waypoints and Map

Site Reconnaissance Select Photographs

Previously Mapped Features which Wood Visited and Comments

wood.

Feature Reference	Feature Type	Feature Description	2017 Feature notes	Mitigated (Y/N)	Mitigation Details	Wood Comments / Notes	Wood Site Visit Date
#61	Cave Subsidence	Slump on east side of trail. From slump, a 30 m depression/crack. Associated with TF11		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002) Cleared of large vegetation, backfilled with 150m³ of gravel pit run and graded. Mitigated together with feature TF11	No issues noted, however rebar noticed	25-Jun-20
#63 (G500)+A77	Shaft	Near location of shaft shown on mine plans with steep seam. Subsidence depression at shaft location.	No new observations	N	Inspected by Golder Associates (2007). No movement. To be mitigated during TSCGR 500m safety zone program	No obvious depression, appears to be a natural feature, area is treed	25-Jun-20
#65	Non-mining related	Not near ming workings		N	Mitigation not required. Not considered hazardous at time of report.	Feature was not seen however slight depression in the area was noted, likely water related	25-Jun-20
#66 (Grass sinkhole)	Cave Subsidence	Slumps into outcrop	No new observations	N	Regular inspections recommended	No evidence of feature noted	29-Sep-20
#66A	Cave Subsidence	Cave in west side of gully, approximally 3m long by 2m wide. Cave has been backfilled by rocks, trees and coal waste.	Surrounded by downed fencing	N	Regular inspections recommended	No obvious issues noted	29-Sep-20
#66P1	Portal	Portal	Grassy opening	Y	May have been previously backfilled by Alberta Environment	No evidence of feature noted but ~30 m from WPT 152. Several voids over distance of ~12m in alignment to 160/340, largest hole is 1.5m long, 1.0m deep and 0.5m wide)	29-Sep-20
#66P2	Portal	Portal	Along outcrop, probably filled in	Y	May have been previously backfilled by Alberta Environment	No evidence of feature noted	29-Sep-20
#66P3	Portal	Fan Portal	Along outcrop, probably filled in	Y	May have been previously backfilled by Alberta Environment	No evidence of feature noted	29-Sep-20
#66P4	Portal	Portal	Along outcrop, probably filled in	Y	May have been previously backfilled by Alberta Environment	No evidence of feature noted	29-Sep-20
#66P5	Portal	Portal	Along outcrop, probably filled in	Y	May have been previously backfilled by Alberta Environment	WPT 153. Portal where mitigation soil has collapsed leaving open access. Orange fencing surrounds	29-Sep-20
#68S	Cave Subsidence	Southern end of trench slump approx. 15 m across and 8 m deep. Numerous large trees (0.2 to 0.25 m diameter) and saplings inside of trench.	Southern end of trench slump approx. 15 m across and 8 m deep. Numerous large trees (0.2 to 0.25 m diameter) and saplings inside of trench. Fence is in need of repair	Y	Inspected by Golder (2007). Fenced off, fence in need of repair. Regular inspection required.	No evidence of feature noted	29-Sep-20
#73	Cave Subsidence	Sinkhole 5m diameter and 1m deep in center. Located on the side of hill from 16th Fairway of TSCGR	Sinkhole 5m diameter and 1m deep in center. Located on the side of hill from 16th Fairway of TSCGR, fence needs fixing.	N	Inspected by Golder (2007). No movement noted. Area to be fenced during the development of the TSCGR	Subsidence feature 10 m wide, 15 m long, 1.5 m deep	25-Jun-20
#74	Cave Subsidence	Feature is approximately 6m in diameter and 4m deep. Cone shaped, instability around edges	6m diameter, .75 m deep, fence down needs to be fixed	N	High current hazard, may increase in future. Fence currently in place, recommend mitigation before opening of TSCGR	Subsidence feature, 0.75 m deep, ~6 m daimeter, circular / rectangular shape. Den noticed on SW side, ~0.5 m diameter, pm in center	25-Jun-20
#75	Cave Subsidence	Feature is approximatly 3m in diameter and 1.5m deep.	Fence around needs to be fixed	N	High current hazard, may increase in future. Fence currently in place, recommend mitigation before opening of TSCGR.	Subsidence feature, 3 m x 3 m, 1.5 m deep if counting scarp, if not counting scarp, 30 cm deep. Does not appear active	25-Jun-20
B025	Surface Disturbance	Smooth pile of gravel by the Three Sisters Creek. Appears like gravel pushed from creek to cover subsidence. Grassed, small trees. No recent movement.	Smooth pile of gravel by the Three Sisters Creek. Appears like gravel pushed from creek to cover subsidence. Grassed, small trees. No recent movement.	N	Inspected by Golder, (2004). Mitigation not required.	No evidence of feature noted	29-Sep-20
B026	Surface Disturbance	Depression along Three Sisters Creek. No recent movement	Covered by river gravel graded for flood mitigation	N	Inspected by Golder, (2004). Mitigation not required	No evidence of feature noted	29-Sep-20
B027	Surface Disturbance	Depression 3 m to 5 m wide and irregular depth of 1 m to 1.5 m. No recent movement. Some trees and moss ...	Mitigated	N	No Mitigation Required. Feature washed away by Three Sisters Creek	No evidence of feature noted	29-Sep-20
B028	Subcrop	Depression 10 m wide, 3 m deep (middle), side sloping at 45 - 50°	Depression 10 m wide, 3 m deep (middle), side sloping at 45 - 50°	Y	Area mitigated by TSCGR paste program (2007). Mitigated by Golder Associates Ltd. (2002) during Three Sisters Creek Subdivision development.Feature was excavated and backfilled with approx. 200 m³ of material.	No evidence of feature noted	29-Sep-20
B030	Subcrop	5 m diameter depression, 4 m deep, steep sides.	Likely mitigated during golf course	Y	Area mitigated by TSCGR paste program (2007). Mitigated by Golder Associates Ltd. (2002) during Three Sisters Creek Subdivision 500 m Mitigation Program. Feature was excavated and backfilled with approx. 80 m³ of material.	No evidence of feature noted	29-Sep-20
B031	Subcrop	Depression 4 m diameter, 1.5 m deep. No recent movement. Grassed and small trees.	Depression 4 m diameter, 1.5 m deep. No recent movement. Grassed and small trees.	N	Mitigation not required.	WPT 133: Depression 1.5m deep, 4m across, extending to WPT 134 for approximately 35m, becoming only 1m deep	29-Sep-20
B032	Watercourse	Channel 5 m to 10 m wide, up to 1.5 m deep. No recent movement. Thin growth. Shallow workings. Possible continuation of B31	Channel 5 m to 10 m wide, up to 1.5 m deep. No recent movement. Thin growth. Shallow workings. Possible continuation of B31.	N	Mitigation not required.	No evidence of feature noted	29-Sep-20
B033	Cave Subsidence	Depression 10 m diameter, 1.5 m deep, steep along east side and north side, large trees, shrubs and grass.	Under quarry road	Y	Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Feature was excavated and backfilled with approx. 125 m³ of material.	Under gravel stockpile	29-Sep-20
B034	Cave Subsidence	5 m - 7 m diameter depression, 1 m - 2 m deep. Some trees, cone shaped depression with hole in the middle.		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Feature was excavated and backfilled with approx. 50 m³ of material.	Under gravel stockpile	29-Sep-20
B035	Watercourse	Channel like depression, with gently sloping sides 5 m wide, 1 m deep, shallows towards west. No recent movement.		N	Mitigation not required.	No evidence of feature noted	29-Sep-20
B036	Watercourse	Small Depression. 1.5 m diameter, 1 m deep. Ditch like depression, approx. 100 m long. Probably a crack eroded by water over the years. Bottom filled. Moss growth.	Under quarry	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision development. Feature was excavated and backfilled with approx. 5 m³ of material.	Under gravel stockpile	29-Sep-20
B037	Cave Subsidence	Square shaped depression, 15 m long, 7 m wide, 1 m deep, sharp edges, grass and small trees.		Y	Mitigated by Golder Associates Ltd. during Three Sisters Creek Subdivision 500 m Mitigation Program (2001). Feature was excavated and backfilled with approx. 100 m³ of material.	No evidence of feature noted	29-Sep-20
B038	Shaft	Site of No. 2 Stewart air shaft in gravel about 7 m deep to seam with 16° dip.		Y	Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Excavated to heading in seam. Heading plugged with 77 m³ of concrete. Backfilled.	No obvious issues noted	02-Jul-20
B039	Shaft	Site of No. 2 Stewart air shaft in gravel.		Y	Mitigated by Golder Associates (2002). Inspected and backfilled.	No obvious issues noted	02-Jul-20
B040	Portal	Site of portal access into No. 2 Stewart workings to 16° seam.		Y	Mitigated by Golder Associates (2003). Excavated and backfilled with 100m3 of local gravel. Site graded.	No obvious issues noted	02-Jul-20
B041	Portal	Blocked portal access into No. 2 Stewart workings to depillared area with 15° slope. Sharp drop (3 m) above portal.	No change observed	Y	Mitigated by Golder (2007). Excavated and backfilled with paste during TSCGR mitigation program.	No obvious issues noted	25-Jun-20
B042	Portal	Backfilled portal access into No. 2 Stewart workings to depillared area with 15° slope. Some cracks present 0.6 to 0.8 m wide, filled with debris. Area is wooded.	Under gravel pit	Y	Mitigated by Golder (2007). Excavated and backfilled with paste during TSCGR mitigation program.	Sand pile	25-Jun-20
B043	Cave Subsidence	Depression 15m long 6m wide 0.7 m deep over No. 2 Stewart workings. Above 30 m deep depillared workings.		Y	Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 100m³ of gravel pit run and graded.	No evidence of feature noted	25-Jun-20
B044	Possible scarp	Feature 50 m long over No. 2 Stewart workings. Could be block failure. Possible borrow pit for filling B43 and B45 in shallow subsidence area.		N	Inspected. No mitigation required.	No obvious issues noted	25-Jun-20
B045	Non-mining Related	Linear depression over No. 2 Stewart workings. 0.5 m deep.		N	Inspected. No mitigation required.	Near depression from Wood E&IS maping, no subsidence feature noted	25-Jun-20
B046	Cave Subsidence	Depression over No. 2 Stewart workings. 15 m long, 15 m wide and 3 m deep. Has extension 3 m by 5 m by 2 m deep	Mitigated in the past. No displacements observed	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 200 m³ of gravel pit run and graded.	No evidence of feature noted, appears as a hill	25-Jun-20
B047	Cave Subsidence	Depression over Stewart No. 2 workings 3 m across, 2 m deep. Over 6m deep depillared workings.	Mitigated in the past. No displacements observed	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 10 m³ of gravel pit run and graded.	No evidence of feature noted	25-Jun-20
B048	Cave Subsidence	Depression over Stewart No. 2 workings 5 m wide, 20 m long and 2 m deep. Over 10 m deep depillared workings.	Slight subsidence near slope edge	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 250 m³ of gravel pit run and graded. Mitigated together with B49.	Slight depression 20 m x 30 m, not believed to be subsidence, ditch at fill area & hill, likely caused by fill	25-Jun-20
B049	Cave Subsidence	Depression over Stewart No. 2 workings 4 m across. Over 10 m deep depillared workings.		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 250 m³ of gravel pit run and graded. Mitigated together with B48.	No evidence of feature noted	25-Jun-20
B050	Cave Subsidence	Depression over Stewart No. 2 workings 6 - 8 m wide, 15 m long and 3 m deep. Over 10m deep depillared workings.		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 150 m³ of gravel pit run and graded.	No evidence of feature noted, sprinkler in middle of feature area	25-Jun-20
B051	Cave Subsidence	Depression over Stewart No. 2 workings 10 mlong, 3 m wide and 2 m deep. Over 14 m deep depillared workings.		Y	Regraded during TSCGR development, (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 70 m³ of gravel pit run and graded	No evidence of feature noted	25-Jun-20
B052	Cave Subsidence	Depression over Stewart No. 2 workings 5 m wide, 8 m long and 2.5 m deep. Over 20 m deep depillared workings.	Mitigated in the past. No displacements observed	Y	Regraded during TSCGR development, (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 80 m³ of gravel pit run and graded	No evidence of feature noted	25-Jun-20
B060 (G337)	Shaft	Small depression above old air shaft, 2 m diameter, 1.25 m deep. No recent movement. Not sure if shaft has been backfilled.	Small depression above old air shaft, 2 m diameter, 1.25 m deep. No recent movement. Not sure if shaft has been backfilled	Y	See G337 for mitigation details	No evidence of feature noted	29-Sep-20
B061 (G368)	Drill Hole	Small depression above old slope, 2 m diameter, 0.7 m deep. Drill hole down to Musgrove slope (40 m, 8.6 m gravel). No danger. No recent movement.		Y	See G368 for mitigation details	No evidence of feature noted	29-Sep-20
B067	Subcrop Subsidence	Irregular sink hole 5 m long and 10 m wide, with max depth of 1.2 m. There are two distinct holes inside this depression. 0.5 m diameter, 1 m deep with vertical sides. Grass and trees. 8 m gravel cover over workings		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Feature was excavated and backfilled with approx. 50 m³ of material.	Under gravel stockpile	29-Sep-20
B068	Subcrop Subsidence	3 m diameter hole, 1.5 m deep with steep edges along south and southwest sides. 8 m gravel cover over workings. Grass and trees. No recent movement. No danger		Y	Regraded during TSCGR development, (2007). Mitigated by Golder Associates Ltd. (2001) during Three Sisters Creek Subdivision 500 m Mitigation Program. Feature was incorporated into feature B67	Under gravel stockpile	29-Sep-20
B070	Prospect	Depression 5 m long, 3 m wide and 2 m deep. Steep edges. Growth of grass and trees. Mine plans indicate possible prospect location.		Y	Regraded during TSCGR development, (2007). Mitigated during the construction of water pipeline (2001). Not considered hazardous at time of report.	No evidence of feature noted	25-Jun-20
B071	Prospect	Excavation. 5 m long, 3 m wide and 1.5 m deep. Attempt to find No. 2 Seam (over Stewart workings). Resembles a portal		Y	Mitigated by Golder in 2002. Cleared of large vegetation, backfilled with 30m³ of gravel pit run and graded. Mitigated together with B72	No evidence of feature noted	25-Jun-20
B072	Prospect	Exploratory trench with material built up on either side. Attempt to find No. 2 Seam (over Stewart workings).		Y	Mitigated by Golder in 2002. Cleared of large vegetation, backfilled with 30m3 of gravel pit run and graded. Mitigated together with B71.	No evidence of feature noted	25-Jun-20
B073	Shallow Mining	Long, depression with gently sloping sides, treed and grassed approx. 50 m long and 5 m - 10 m wide.	Under quarry road	N	Mitigation not required	No evidence of feature noted	29-Sep-20
B099	Portal	Reclaimed portal - gravel pushed inside and over top.	Reclaimed portal - gravel pushed inside and over top	Y	Backfilled portal. No movement as of last inspection	No subsidence feature noted	02-Jul-20
B100	Portal	Small depression, 2 m diameter, 0.5 m deep. Small shrub and grass growing. Depression over slope from B99 portal.	Small depression, 2 m diameter, 0.5 m deep. Small shrub and grass growing. Depression over slope from B99 portal	N	Inspected. Indistinguishable from native ground	No subsidence feature noted	02-Jul-20
B101	Prospect	Probably prospect. Possibly portal to 15° slope. This feature has material built up on either side of it and looks like a channel without debris at the bottom of it. Numerous small depressions, 0.3 - 0.6 m deep. Remains of prospects PR38 and PR39		Y	Opened up and temporarily backfilled with local materials during Parkway construction (Norwest, 2001).	No obvious issues noted	02-Jul-20
B102	Surface Debris	Trench like watercourse depression 20 m long, 1 m across and 0.7 m deep. Flat vertical sides. Possible surface excavation.		N	Inspected. No mitigation required	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
B103	Surface Debris	Drainage ditch above shallow workings. 30 - 50 m long, 1 m wide, 0.5 - 0.7 m deep with flat bottom and vertical sides.		N	Inspected. No mitigation required	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
B104	Non-mining Related	Round 3 m diameter depression with some mining debris. Possibly remains of a large pulley wheel installation and/or portal shed.		N	Inspected. No mitigation required.	No obvious issues noted	02-Jul-20
B105	Non-mining Related	Probably hoist foundation for main B40 Portal. Concrete foundations of porbalby hoist room some steel roads in concrete. Lots of mining debris. No subsidence.		N	Inspected. No mitigation required.	No obvious issues noted	02-Jul-20
B106	Watercourse	Approx. 50 m long depression. Could be of natural origin. Narrow at the west and, 1 m wide and 1 m deep, progressively wider and deeper towards west where it is 10 m wide and 5 m deep. Some water seeping from the sides and floor at the west forming a stream. Possibly remains of borrow pits supplying gravel to block off adjacent to No. 1 Morris Portal.		N	Inspected. No mitigation required.	No subsidence feature noted	02-Jul-20

Previously Mapped Features which Wood Visited and Comments

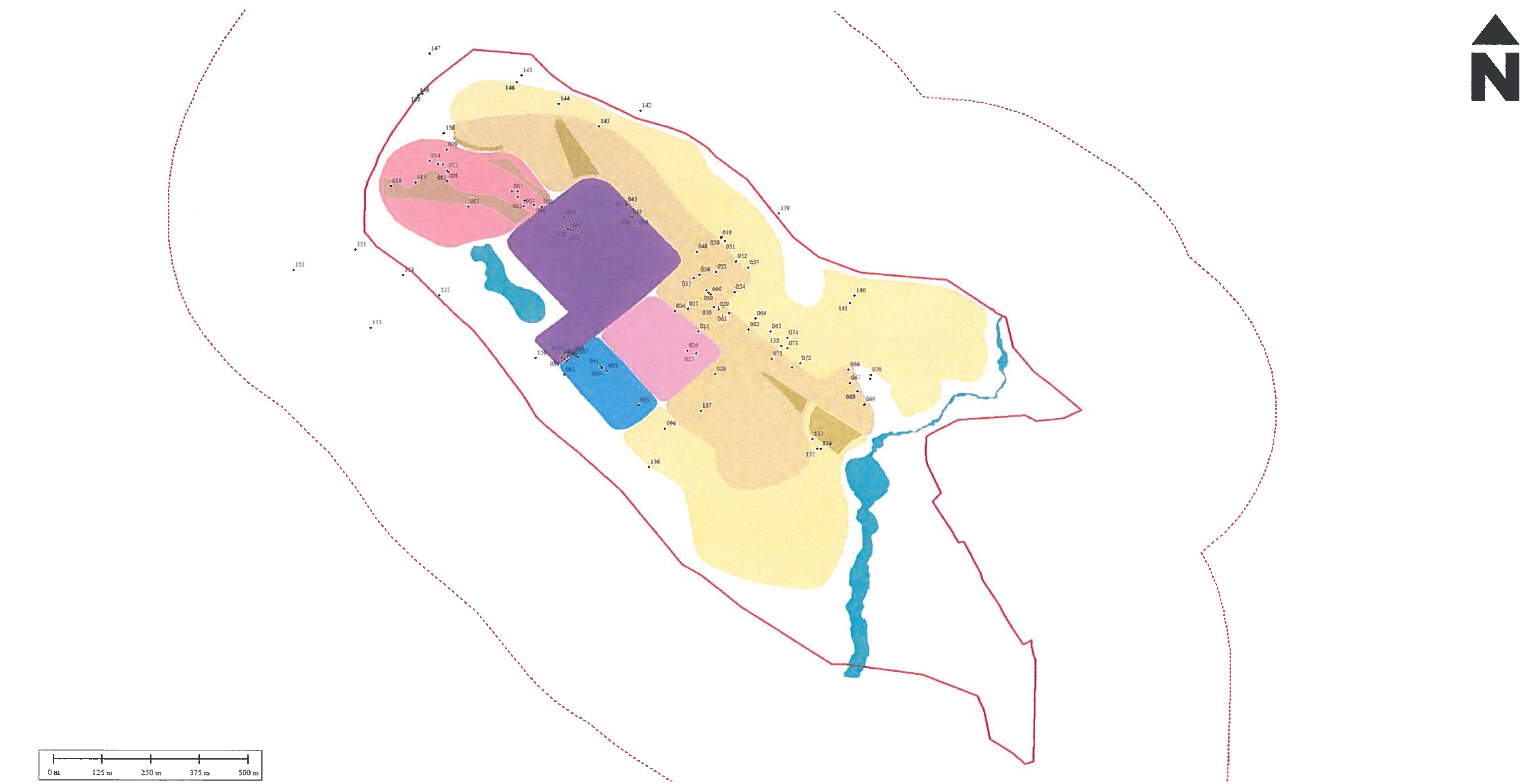
wood.

Feature Reference	Feature Type	Feature Description	2017 Feature notes	Mitigated (Y/N)	Mitigation Details	Wood Comments / Notes	Wood Site Visit Date
B107	Portal	Portal access to depillared area of No. 2, No. 1 Morris workings, 15° slope. Possible location of reclaimed portal. Area wooded with small trees. No sign of subsidence, only some coal and shale, mining debris.	Portal access to depillared area of No. 2, No. 1 Morris workings, 15° slope. Possible location of reclaimed portal. Area wooded with small trees. No sign of subsidence, only some coal and shale, mining debris.	Y	Excavated and temporarily backfilled with local materials during Parkway construction (Norwest, 2001).	No subsidence feature noted	02-Jul-20
B109	Surface Debris	Air shaft areas. Pile of gravel material in place, approx. 3 m high. Mine plans indicate boreholes used for passage of main and tail haulage ropes.		N	Inspected. No mitigation required. No signs of movement and no apparent danger	No evidence of feature noted	25-Jun-20
B110	Boreholes	Depression 2 m in diameter and 1 m deep with steep sides. Holes for passage of haulage main and tail ropes.		N	Inspected. No mitigation required.	2 steel casings ~ 6"	25-Jun-20
B112	Subcrop Subsidence	Depression over No. 2 Sedlock workings, 10m across and 0.7 m deep. Above 15 m deep workings	Did not find anything	N	Inspected. No mitigation required.	Slight depression, 0.2 - 0.3 m, natural, outside mining limits	02-Jul-20
B113	Subcrop Subsidence	Ditch 1 m wide 0.75 m deep. Above 15m deep workings.	Ditch 1 m wide 0.75 m deep. Above 15m deep workings.	N	Inspected. No mitigation required.	Depression ~1 m wide, 0.4 -0.6 m deep, has 90 degree angle, less defined toward WPT 43, coincidence with mining limit, B113 in this area, shallow workings	02-Jul-20
DW-02	Cave Subsidence	Hole in side of bank. Allowed access into mine workings.		Y	Mitigated by Norwest Resource Consultants Ltd. (2000) along with DW-3 and DW-5. Mitigation included breaking the overlying rock, removing it and replacing it. Area sloped to be consistent with surrounding ground.	No evidence of feature noted	29-Sep-20
DW-03	Cave Subsidence	Large collapse into mine workings. Allowed access into mine workings.		Y	Mitigated by Norwest Resource Consultants Ltd. (2000) along with DW-2 and DW-5. Mitigation included breaking the overlying rock, removing it and replacing it. Area sloped to be consistent with surrounding ground.	No evidence of feature noted	29-Sep-20
DW-05	Cave Subsidence	Large collapse into mine workings. Allowed access into mine workings.		Y	Mitigated by Norwest Resource Consultants Ltd. (2000) along with DW-2 and DW-3. Mitigation included breaking the overlying rock, removing it and replacing it. Area sloped to be consistent with surrounding ground.	No evidence of feature noted	29-Sep-20
DW-06	Cave Subsidence	Large collapse into mine workings	Approximately 2m diameter opening into workings. Near bike path, high hazard	Y	Mitigated by Norwest Resource Consultants Ltd. (2000) along with DW-7. Mitigation included breaking the overlying rock, removing it until no voids remained and replacing it. Area sloped to be consistent with surrounding ground.	No evidence of feature noted	29-Sep-20
DW-07	Cave Subsidence	Large collapse into mine workings	Sapplings growing, no sign of displacement	Y	Mitigated by Norwest Resource Consultants Ltd. (2000). Along with DW-6. Mitigation included breaking the overlying rock, removing it until no voids remained and replacing it. Area sloped to be consistent with surrounding ground.	No evidence of feature noted	29-Sep-20
DW-10	Depression	Depression	Depression	N	Mitigation not required. Investigated using a backhoe by Norwest Resource Consultants Ltd. (2000) and no hazardous conditions were found	No evidence of feature noted	29-Sep-20
DW-11 (66-P3)	Portal	Fan Portal		Y	May have been previously backfilled by Alberta Environment	No evidence of feature noted	29-Sep-20
DW-12	Cave Subsidence	Collapse into depillared mine workings. Could possibly be the same feature as #66A		Y	Mitigated by Norwest Resource Consultants Ltd. (2000). Excavated and backfilled. Area sloped to provide good drainage.	No evidence of feature noted	29-Sep-20
DW-24	Portal	Backfilled portal.	Mitigated area, no displacements observed	Y	Mitigated by Norwest Resource Consultants Ltd. (2000). Excavated to form wedge-shaped roof and sides and rock or concrete plug or compacted backfill installed to close entrance. Plug covered with native material from adjacent area and sloped to be consistent with the surrounding ground.	No evidence of feature noted	29-Sep-20
G136	Surface Debris	Cleared area 100 m long, 20 m wide with depression in center and slumped sides. New growth present.		N	Mitigation not required. Not considered hazardous at the time of inspection	2 m deep depression, steep edges in area (rounded elsewhere)	02-Jul-20
G137	Surface Debris	Trench system with one main branch and several smaller branches, quite possibly used for drainage. Wood was found in the trench at a point.		N	Mitigation not required. Not considered hazardous at the time of inspection	Under stockpile	29-Sep-20
G138	Prospect	Surface excavation, 5 m long, 1.5 m wide and 1 m deep. Material piled up on sides.		N	Regraded during TSCGR development, (2007). Mitigation not required	Under gravel stockpile	29-Sep-20
G139	Prospect	Surface excavation into rock, 5 m long, 1.5 m wide and 1.5 m deep with some overhang. There is a clearing, 20 m in diameter with new growth around this prospect.		N	Mitigation not required	Under gravel stockpile	29-Sep-20
G140	Prospect	Surface excavations (2), 2 to 2.5 m long, 0.5 to 0.7 m wide and 0.5 m deep. Bedrock exposed.		N	Mitigation not required	No evidence of feature noted	29-Sep-20
G144	Surface Disturbance	Tension crack. Runs close to G135 (15 m long, 0.5 m wide, 1 m deep).	Under dirt pile as part of quarry/development	N	Mitigation not required. Not considered hazardous at the time of this report.	Under stockpile	29-Sep-20
G145	Surface Debris	Clearing, 20 m diameter, with surface excavation and dirt piles. G139 is at the edge of this clearing.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted, GPS marker partially under gravel stockpile	29-Sep-20
G146	Prospect	Surface excavation, 2 m diameter and 0.5 m deep. Bedrock exposed.		N	Mitigation not required. Not considered hazardous at the time of this report.	Under stockpile	29-Sep-20
G147	Surface Disturbance	Possible tension crack (5 m long, 0.3 m wide, 0.5 m deep).	Under dirt pile as part of quarry/development	N	Mitigation not required. Not considered hazardous at the time of this report.	Under stockpile	29-Sep-20
G149	Surface Debris	Cleared area with signs of disturbance (excavation). New growth present.		N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted	29-Sep-20
G150	Surface Disturbance	Possible tension crack (5 m long, 0.2 m wide, 0.3 m deep).	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G151	Surface Disturbance	Possible tension crack. More likely natural (moss and root cover, animal burrow, etc.)(10 m long, 0.3 m wide, 0.3 m deep).	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G153	Surface Disturbance	Possible tension crack, 5 m long, 0.1 m wide and 0.5 m deep. Runs near G137	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted but ~10 m from WPT 137 Depression (1.5m diameter, 0.4m deep)	29-Sep-20
G154	Prospect	Surface excavation, 4 m long, 1 m wide and 1 m deep.		N	Regraded during TSCGR development, (2007). Mitigation not required	Under stockpile	29-Sep-20
G155	Surface Disturbance	Disturbed outcrop, possible vertical displacement. Opening 3 m long, 0.2 m wide and 0.5 m deep.	Outcrop, no displacement observed	N	Regraded during TSCGR development, (2007). Mitigation not required	Under gravel stockpile	29-Sep-20
G156	Surface Debris	Trench, probably for drainage. 20 m long, 0.7 m deep and 1 m wide. Trench curves around near outcrop G155		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted, GPS marker partially under gravel stockpile	29-Sep-20
G157	Surface Disturbance	Possible tension crack, 5 m long, 0.2 m wide and 0.3 m deep. More likely natural (moss and root cover, animal burrow, etc.).	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G158	Prospect	Cleared area off the side of a road that has been excavated and dirt piles are present. There are at least 3 prospects, 2 m long, 0.7 m wide and 0.5 m deep on average.		N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted	29-Sep-20
G159	Surface Disturbance	Possible tension crack, 5 m long, 0.2 m wide and 0.3 m deep. More likely natural (moss and root cover, animal burrow, etc.).	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted but ~20 m from WPT 137 Depression (1.5m diameter, 0.4m deep)	29-Sep-20
G160	Surface Debris	Mine waste pile in clearing, 70 m long and 40 m wide with steep sides. Metal debris present. Large area (as per site plan contours) with differencial settlement and/or slumping.		N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted	29-Sep-20
G161	Surface Debris	Depression with slump on sides, 6 m wide and 10 m long. Could possibly be from drainage of G160, as it tails off down a slope.		N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted	29-Sep-20
G162	Surface Debris	Trench, probably for drainage, 50 m long, 1 m wide and 0.3 m deep. Meets up with G136.		N	Mitigation not required. Not considered hazardous at the time of this report.	No evidence of feature noted	29-Sep-20
G164	Surface Disturbance	Possible tension cracks (2). 1.5 m long, 0.1 m wide and 0.2 m deep at close to right angles to each other.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G165	Surface Disturbance	Tension crack, 10 m long, 0.3 m wide and 0.5 m deep. May have additional disturbance by animal burrows.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G167	Surface Disturbance	Tension crack, 15 m long, 0.1 m wide and 0.4 m deep. Strike 350o. May have additional disturbance by animal burrows.	No displacement observed	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G168	Surface Disturbance	Possible tension crack, 0.3 m long, 0.2 m wide and 0.3 m deep. Strike 030o. Possibly connects to what may or may not be an animal burrow, if so, length is 10 m	Possible tension crack. 0.3 m long, 0.2 m wide and 0.3 m deep. Strike 030o. Possibly connects to what may or may not be an animal burrow. If so, length is 10 m	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G169	Surface Disturbance	Tension crack, 0.2 m long, 0.1 m wide and 0.4 m deep. Strike 032o.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G170	Surface Disturbance	Tension crack, 15 m long, 0.3 m wide and 0.3 m deep.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G171	Surface Disturbance	Tension crack, 5 m long, 0.1 m wide and 0.5 m deep.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G172	Surface Debris	Trench, probably for drainage, at least 50 m long, 1 m wide, 0.5 m deep. Strike 276o. Possible tension cracks in trench 0.1 m long, 0.1 m wide and 0.2 m deep.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G173	Surface Debris	Cleared area, oddly shaped 20 m diameter. Signs of disturbance including pile of metal debris, surface excavation and dirt piles.		N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G174	Surface Disturbance	Tension crack, 5 m long, 0.2 m wide and 0.3 m deep.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G175	Surface Disturbance	Tension crack, 8 m long, 0.3 m wide and 0.5 m deep.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G177	Surface Disturbance	Possible tension crack, 3 m long, 0.1 m wide and 0.4 m deep.	Nothing seen	N	Mitigation not required. Not considered hazardous at the time of this report.	No obvious issues noted	02-Jul-20
G212	Sinkhole	Sinkhole into vertical Sedlock Mine in a row with73, #74 and #75. Dimensions approximately 5 m in diameter and 5 m deep		Y	Mitigated by Golder (2007), injected with paste backfill during TSCGR mitigation program. Sinkhole backfilled by Kidco Construction	No subsidence evidence noted, different vegetation in area was noticed, subsidence feature was mitigated	25-Jun-20
G312	Tension Crack	Possible tension crack resembling a step, 0.3 m high and 3 m long.	Gravel quarry on top	N	Inspected by Golder Associates (2004). Mitigation not required, not considered hazardous.	No evidence of feature noted	29-Sep-20
G313	Sinkhole	Bowl shaped disturbance about 3 m in diameter and 0.2 m deep adjacent to a road	Gravel quarry on top	N	Inspected by Golder Associates (2004). Mitigation not required, not considered hazardous.	No evidence of feature noted	29-Sep-20
G314	Surface Debris	Large pile of logs and logging waste. Not mining related		N	Inspected by Golder Associates (2004). General cleanup and disposal of debris is recommended. Mitigation not required. Not considered hazardous at time of report.	Pile of bush and logs	02-Jul-20
G315	Sinkhole	Potentially hazardous hole about 2m deep and 3m diameter. Appears partially dug-up by hoe. Close to dirt road and power lines	No evidence of hole, area has been altered due to gravel quarry, likely gone	N	Inspected by Golder (2007). To be mitigated during TSCGR 500m zone mitigation	No obvious issues noted	02-Jul-20
G316	Surface Debris	Wood structure, interpreted to be a drainage structure used during mining.		N	Inspected by Golder Associates (2004). May recover as an artifact. Mitigation not required. Not considered hazardous at time of report.	No evidence of feature noted	29-Sep-20
G317	Prospect	Shallow, square depression 0.8 m long, 0.5 m wide and 0.5 m deep. Notable rock present on sides.		N	Inspected by Golder Associates (2004). May regrade prior to development. Mitigation not required. Not considered hazardous at time of report.	No obvious issues noted	02-Jul-20
G322	Prospect	Set of 3 depressions in the bearing of 040/220. In line with G63		N	(2007) Regraded during TSCGR development. Mitigation not required.	Under gravel stockpile	29-Sep-20
G323	Prospect	Set of 3 depressions in the bearing of N-S. In line with G140 with dimensions of 2 m long, 0.5 m wide and 0.5 m deep.		N	(2007) Regraded during TSCGR development. Mitigation not required.	No evidence of feature noted	29-Sep-20
G327	Prospect	Set of 2 excavations, both about 2 m long, 1 m wide and 0.5 - 0.75 m deep.		N	Inspected by Golder Associates (2004). Mitigation not required. Not considered hazardous	No evidence of feature noted	29-Sep-20
G332	Possible Tension Crack	Ground separation 2.5m long and 0.1 m wide. Uncertain if mining related because of the undulating terrain and abundance of burrows.	No observation. Under golf course	N	(2007) Regraded during TSCGR development.	No obvious issues noted	02-Jul-20
G333	Prospect	Possible series of four prospects each spaced 1.5 m apart and are 1 m wide and 1 m long. Uncertainty due to mossy terrain.		N	Inspected by Golder Associates (2004). Mitigation not required. Not considered hazardous.	No obvious issues noted	02-Jul-20
G334	Prospect	Hole resembling possible prospect but may be recent due to surrounding drilling activity. 1.5m x 3m x1.5m deep and not marked in GPS (616285E, 5657461N)		N	Mitigation not required	No obvious issues noted	02-Jul-20
G337	Surface Depression	Depression 3 m in diameter and 1.5 m deep. Associated with Musgrove slope	No signs of recent displacement	Y	Mitigated by Golder, (2007). Excavated as part of the Musgrove slope trench investigation; mine workings were uncovered and collapsed. The area was backfilled and debris laid over the feature.	No evidence of feature noted	29-Sep-20
G339	Tension Crack	20m long step-like bed separation with a height of 10-20cm running approx. E-W	Graded over by golf course, no signs of displacement	N	(2007) Regraded during TSCGR development.	No obvious issues noted	02-Jul-20
G343	Surface Debris	Surface excavation, 10 m long, 2 m wide and 0. 5 m deep. Soil appears recently submerged and is now cracked from drying. Little vegetation and sharp edges. Presumed to be a drainage trench.		N	(2007) Regraded during TSCGR development	No obvious issues noted	02-Jul-20
G348	Possible Tension Crack	Ground separation 0.1 m wide divided into two smaller pieces about 4 m apart, running in the N-S direction.	Under golf course, regraded	N	(2007) Regraded during TSCGR development	No obvious issues noted	02-Jul-20
G349	Possible Tension Crack	Series of smaller cracks and burrows running for about 0.1 to 0.15 m. Could be a natural feature of the terrain, runs in the N-S direction	Under golf course, regraded	N	Further inspection recommended.	No obvious issues noted	02-Jul-20
G359	Surface Disturbance	Excavation 50 m long, 20 m wide and 3 m deep with flat bottom. Possibly on contours, might be associated with gravel pits, possible regrading of surface	Under golf course, regraded	N	(2007) Regraded during TSCGR development.	No obvious issues noted	25-Jun-20
G362	Surface Debris	Excavation running E-W with a cross-section dimension of 1 m by 1 m. Presumed to be a drainage trench		N	May want to regrade prior to development.	WPT 154: Continuation of WPT 151 Trench (3-4m wide, 2m deep, orientated 102/282) to current WPT 154 Trench (orientated 112/292, 1m wide 0.5m deep), ~100 m to WPT 155 and ~150 m to WPT 151	29-Sep-20

Previously Mapped Features which Wood Visited and Comments

wood.

Feature Reference	Feature Type					Wood Comments / Notes	Wood Site Visit Date
	Surface Debris	Excavation running close to E-W, 1.5 m wide by 0.7 m deep. Presumed to be a drainage trench.		N	May want to regrade prior to development.	WPT 155: End of WPT 151 Trench (3-4m wide, 2m deep, orientated 102/282), ~100 m to WPT 154 and ~250 m to WPT 151	29-Sep-20
	Portal	Large clearing close to portals and roads. Lots of waste and dead trees. Evidence of slope failure.	Large clearing close to portals and roads. Lots of waste and dead trees. Evidence of slope failure.	Y	Mitigation completed by others.	No evidence of feature noted	29-Sep-20
	Tension Crack	Edge of vertical mining, N-S bearing, 15 m long, vertical offset of 0.2 m, close proximity to sinkholes.	Nothing seen	N	Inspected by Golder Associates (2007). Feature to be mitigated during TSCGR 500m zone mitigation		25-Jun-20
		Sinkhole in the process of forming above Musgrove Slope. Approx. 3 m diameter and 0.7 m deep in middle. Tension cracks running around perimeter. Few trees exist in this area.		Y	Mitigated by Golder (2007). Excavated as part of the Musgrove Slope trench excavation where mine workings were uncovered and collapsed. The area was backfilled and contoured with a 1 m mound over feature, trees and debris were layed across the feature. Regular inspections recommended.		29-Sep-20
	Surface Depression	Small tension crack around outside of depression approximately 1 m long. Depression is approximately 5 m in diameter above the Musgrove Slope. Could be same feature as B61.	Mitigated, no evidence	Y	Mitigated by Golder (2007). Excavated as part of the Musgrove Slope trench excavation where mine workings were uncovered and collapsed. The area was backfilled and contoured with a 1 m mound over feature, trees and debris were layed across the feature. Regular inspections recommended.		29-Sep-20
	Surface Depression	Rectangular depression approx. 1 m long, 0.7 m wide and 0.5 m deep along outside of what appears to be a backfilled area approximately 5 m in diameter above the Musgrove Slope.	Rectangular depression approx. 1 m long, 0.7 m wide and 0.5 m deep along outside of what appears to be a backfilled area approximately 5 m in diameter above the Musgrove Slope.	Y	Mitigated by Golder (2007). Excavated and backfilled with spoil material and an additional 72 m^3 of fill. Area was contoured with a 1 m mound over feature, trees and debris were layed across the feature.		29-Sep-20
	Surface Debris	Trench running approx. E-W and is about 0.4 m wide by about 0.5 m deep. Presumed to be a drainage trench.		N	May regrade prior to development.	Linear feature, 0.5 m wide, 0.5 m deep, some trees ~0.3 in diameter growing in it are straight, pit or circular depression at WPT 57, end of feature (WPT55-WPT57), G388	02-Jul-20
	Surface Debris	Trench 1.5 m wide by 1 m deep. Bearing 170/350 and is overgrown with spruce trees. Presumed to be a drainage trench.		N	May regrade prior to development.	Linear features, likely drainage ditches	02-Jul-20
	Surface Debris	Trench 1.5 m wide by 1 m deep. Bearing 40/220. Sides littered by old wooden culvert debris.		N	May regrade prior to development.	Wooden pipes, in line with WPT 71, this is likely an old ditch	02-Jul-20
	Prospect	Set of prospects about 1.5 m long, 1 m wide and 0.75 m deep Both excavations continue below rock layer and southern excavation is noted by a metal pipe protruding from surface, possibly an air vent.		N	(2007) Regraded during TSCGR development.	No obvious issues noted	25-Jun-20
	Prospect	Set of prospects about 1.5 m long, 1 m wide and 0.75 m deep Both excavations continue below rock layer and southern excavation is noted by a metal pipe protruding from surface, possibly an air vent.		N	(2007) Regraded during TSCGR development.		25-Jun-20
	Possible sinkhole	Depression 2 - 3 m diameter and 0.3 m deep between #74 and #75 sinkholes. Possible recent movement (slight cracking in surrounding soil).	No new observations	N	Inspected by Golder Associates (2007). High hazard due to steep mining conditions and magnitude of surrounding features. Will be mitigated during TSCGR 500m zone mitigation.	T 013	25-Jun-20
	Surface Depression	Oblong shaped depression 2 m by 3 m across, 2 m deep, apparently fresh and active	Multiple circular depression about a meter wide, 40 cm deep	Y	Mitigated by Golder (2007). Excavated as part of the Musgrove Slope trench where mine workings were uncovered and collapsed. The area was backfilled and contoured with a 1 m mound over feature, trees and debris were layed across the feature. Regular inspections recommended.		29-Sep-20
	Surface Depression	Circular depression 1m in diameter and 0.3m deep.	Multiple circular depression about a meter wide, 40 cm deep	Y	Mitigated by Golder (2007). Excavated as part of the Musgrove Slope trench excavation where mine workings were uncovered and collapsed. The area was backfilled and contoured with a 1 m mound over feature, trees and debris were layed across the feature. Regular inspections recommended.		29-Sep-20
	Sinkhole	Sinkhole 3mX4m and 3m deep. Becoming wider with depth	Sinkhole 3mX4m and 3m deep. Becoming wider with depth. Fence needs fixing, hazardous, should be mitigated	N	Investigated by Golder Associates, (2007). Several boreholes have been drilled in the vicinity to investigate. Boreholes backfilled with 1MPa concrete. Permanent mitigation required.	Depression feature is 5 m in diameter, 1 - 2 m deep on average, 2.5 - 3.0 m deep on west side, vertical sides, dense gravelly till material	25-Jun-20
	Prospect shaft	Square shaped depression approx 1m squared by 0.4m deep. Possible prospect into the No. 2 Morris seam. Steel anchors and guy wires surrounding the feature. Small trees growing in feature.	Square shaped depression approx 1m squared by 0.4m deep	N	Inspected by Golder Associates (2007). Investigate and mitigate for TSCGR 500m safety zone.	No obvious issues noted	02-Jul-20
	Tension Crack	Feature over No. 2 Stewart workings 15m long extending east of TF10.	Under golf course, regraded	Y	Regraded during TSCGR development (2007). Mitigated by Golder (2003). Excavated to determine extent and backfilled with local material. Mitigated together with feature TF11.	No evidence of feature noted	25-Jun-20
	Tension Crack	Feature over No. 2 Stewart workings starts south of B49 and continues to B48 approximately 20m long.	Under golf course, regraded	Y	Regraded during TSCGR development(2007). Mitigated by Golder (2003) together with features GTC3, B48 and B49.	Slope, but no cracks noted	25-Jun-20
	Tension Crack	Feature over No. 2 Stewart workings runs parallel to GTC2 at a point. Similar to GTC2.	Under golf course, regraded	Y	Regraded during TSCGR development (2007). Mitigated by Golder (2007) together with features GTC2, B48 and B49.	Slope, but no cracks noted	25-Jun-20
	Portal	Portal (reclaimed area) located from site plans.	Portal (reclaimed area) located from site plans. No sign of surface disturbance	Y	Mitigated by Golder (2007). Excavated as part of the Musgrove Slope trench. The area was backfilled and contoured with a 1 m mound over feature, trees and debris were layed across the feature. Regular inspections recommended.	No evidence of feature noted	29-Sep-20
P-06 Stewart	Portal	Site of Wilson Plane Portal. Area reclaimed, location from plans.	Site of Wilson Plane Portal. Area reclaimed, location from plans. No surface disturbance noted	N	Investigated by Golder (2007), drilled into workings. Mitigation not required at this time as the feature does not pose a threat to public safety.	No evidence of feature noted	29-Sep-20
P-07	Portal	Portal site into Musgrove slope, location from plans, not seen at surface.	Portal site into Musgrove slope, location from plans. No sign of displacement on surface	N	Investigated by Golder (2007). Mitigation not required at this time as the feature does not pose a threat to public safety.	No evidence of feature noted	29-Sep-20
PR-04	Prospect	Prospect drivage as shown on mine plans. Drivage is approximately 5 m wide, 30 m long and 1.7 m high with a maximum dip of 47°.		Y	Excavated, concrete plug installed and backfilled during Parkway construction (Norwest, 2001).	No evidence of feature noted	29-Sep-20
PR-06	Prospect	Prospect		Y	Inspected by Golder (2004), could not distinguish from surrounding ground.	No evidence of feature noted	29-Sep-20
PR-06A	Prospect	Probably prospect. Not over recorded workings.		Y	Inspected by Golder (2004), could not distinguish from existing ground. Further mitigation not required. Excavated and backfilled previously (Norwest, 2001).	No evidence of feature noted	29-Sep-20
PR-06B	Prospect	Probably prospect. Not over recorded workings.		Y	Inspected by Golder (2004), could not distinguish from existing ground. Further mitigation not required. Excavated and backfilled previously (Norwest, 2001).	No evidence of feature noted	29-Sep-20
PR-07	Prospect	Prospect		Y	Inspected by Golder (2004), could not distinguish from existing ground. Further mitigation not required. Excavated and confirmed limited prospect (Norwest, 2001).	No evidence of feature noted	29-Sep-20
PR-38	Prospect	Possibly seeking Morris Seam subcrop.		Y	Mitigated by Golder Associates (2001). Cleared of large vegetation, backfilled with 30 m^3 of gravel pit run and graded. Mitigated together with PR-39.	No obvious issues noted	02-Jul-20
PR-39	Prospect	Small hole into water filled prospect.		Y	Mitigated by Golder Associates (2001). Cleared of large vegetation, backfilled with 30 m^3 of gravel pit run and graded. Mitigated together with PR-38.	No obvious issues noted	02-Jul-20
PR-54	Prospect	Probably prospect. Not over recorded workings. Possibly seeking No. 1 Morris Seam.		Y	Could not locate - probably opened up into portal (see B107) (Norwest, 2001).	No obvious issues noted	02-Jul-20
S-14	Mine Entrance	Air shaft into No. 2 Sedlock workings , 20m deep to 5° slope.	Fence surround capped mine shaft needs fixing. No signs of displacement	Y	Mitigated by Golder Associates (2002). Excavated to 6 m depth, backfilled with compacted till, crowned, placed topsoil and removed fence.	Known shaft location. Filled with soil, with outline being approx 8m diameter and 0.3m settlement at edges	29-Sep-20
S-15	Mine Entrance	Air shaft into No. 2 Sedlock workings, 20m deep to 15° heading.	Wind fence surrounding entrance, back filled, mitigated. No signs of displacement	Y	Mitigated by Golder Associates (2002). Excavated to 6 m depth, backfilled with compacted till, crowned, placed topsoil and removed fence.	Proven shaft site, airshaft #2, orange fence, mounded, mitigated in 2002, no obvious subsidence	02-Jul-20
TF06	Cave Subsidence	Feature over No. 2 Stewart 3m diameter by 0.5 m deep.	Under golf course, nothing found	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 20 m^3 of gravel pit run and graded.	No obvious issues noted	25-Jun-20
TF07	Cave Subsidence	Feature over No. 2 Stewart 8 m diameter by 4 m deep.	Under golf course, nothing found	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 150 m^3 of gravel pit run and graded.	No evidence of feature noted	25-Jun-20
TF08	Cave Subsidence	Feature over No. 2 Stewart 5-8m diameter by 1-2m.	Under golf course, nothing found	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 120 m^3 of gravel pit run and graded.	Rumpled area, possible linear feature ~10 - 15 m long, 20 cm wide	25-Jun-20
TF09	Cave Subsidence	Feature over No. 2 Stewart 4m diameter by 2-3m.	Under golf course, nothing found	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 50 m^3 of gravel pit run and graded.	No evidence of feature noted	25-Jun-20
TF10	Cave Subsidence	Feature associated with No. 2 Stewart workings 20 m by 10 m by 2 m deep.	Under golf course, nothing found	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 300 m^3 of gravel pit run and graded.	No evidence of feature noted	25-Jun-20
TF11	Cave Subsidence	Shallow workings of No. 2 Stewart.	Under golf course nothing found	Y	Mitigated by Golder (2007) injected with paste backfill during the TSCGR mitigation program. Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 150 m^3 of gravel pit run and graded. Mitigated together with feature #61.	No issues noted, however rebar noticed	25-Jun-20
TF12	Cave Subsidence	Shallow workings of No. 2 Stewart.	Mitigated slightly hummocky	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 150 m^3 of gravel pit run and graded.	Forested area, sloped, no issues observed	25-Jun-20
TF13	Cave Subsidence	Shallow workings of No. 2 Stewart.	Mitigated	Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 8 m^3 of gravel pit run and graded.	Forested area, sloped, no issues observed	25-Jun-20
TF14	Cave Subsidence	Shallow workings associated with #61 crack.		Y	Regraded during TSCGR development (2007). Mitigated by Golder Associates (2002). Cleared of large vegetation, backfilled with 11 m^3 of gravel pit run and graded.	No obvious issues noted	25-Jun-20
TF17	Cave Subsidence	Shallow vertical workings	Area fenced off, fence needs repair	N	Mitigation not required.	No evidence of feature noted but possible crack (0.2m deep, 0.3m wide, 4m long, orientated 132/312) noted near TF17, WPT 150	29-Sep-20
TF18	Cave Subsidence	Depression 3 m long, 2 m wide and 1.5 m deep.	No signs of recent surface disturbance	N	Inspected by Golder (2007), will be mitigated during TSCGR 500m public safety zone. Feature is fenced, showing little movement.	Does not appear active, wire fence around feature, subtle depression ~2 m x 3 m, ~20 cm deep	25-Jun-20
TF20	Surface debris	Mud pit on top of shallow workings of No. 2 Stewart.		N	Mitigation not required.	Depression feature – 4 m wide, 30 cm high edges, old road?	25-Jun-20
TW1	Non-mining Related	Excavated pit 5 m long, 3 m wide and 0.5 m deep. Not over recorded workings.		N	Mitigation not required	Pile of soil / rock @ 70°, 1 m high	02-Jul-20
TW2	Subcrop	Material bulldozed into collapse over corner of shallow, depillared workings.	Potential scarp on edge of creek channel, may also be result of regrading	N	Mitigation not required.	No evidence of feature noted	29-Sep-20
UMA1	Non-mining Related	Probably mud pit for DDH-38. Not over recorded workings.		Y	Mitigated by Golder (2003). Excavated to determine extent and backfilled with local material.	Building remains	02-Jul-20
UMA2	Non-mining Related	Probably mud pit for DDH-37. Not over recorded workings.		N	Mitigation not required.	2 pits noted, one has steel pipe (AER hole)	02-Jul-20
UMA3	Prospect	Probably prospect prior to P-6. Depression 15 m by 8 m. Not over recorded workings. Possibly part of mud system for DDH-36.		Y	Mitigated by Golder (2003). Excavated to determine extent and backfilled with local material.	No evidence of feature noted	29-Sep-20
UMA4	Non-mining Related	Planked excavation 2 m diameter and 1.5 m deep. Probably mud pit for DDH-42. Not over recorded workings.		N	Inspected. Mitigation not required.	No evidence of feature noted	29-Sep-20
UMA5	Surface Infrastructure	Timbers that are remains of old buildings/pipeline. Not over recorded workings.		N	Inspected. Mitigation not required.	No obvious issues noted	25-Jun-20
UMA6	Cave Subsidence	Depression 2 m (8 m?) in diameter in hillside over No. 2 Stewart Workings. Outcrop nearby.	Under golfe course, nothing seen	N	Mitigated by Golder Associates, (2007). Paste backfill injected during TSCGR mitigation program. Mitigated by Golder Associates (2003). Cleared of large vegetation, backfilled with 50 m^3 of gravel pit run and graded.	No obvious issues noted	25-Jun-20
UMA7	Non-mining related	Depression 3 m across and 1m deep, near subcrop but not over workings. Probably related to surface equipment.		N	Inspected. Mitigation not required.	No obvious issues noted	02-Jul-20
UMA9	Portal	Portal access to depillared area of No. 2, No. 1 Morris workings, 15° slope. Not over recorded workings.	A series of small holes with airflow coming out of them	Y	Reclaimed portal - gravel pushed inside and over top. Further mitigation not required. Previously excavated and backfilled with local materials (Norwest, 2001).	Air flowing from holes in portal fill, 5 holes ~ 50 cm in diameter	02-Jul-20
G900	Sinkhole	New feature 2017. ~2m wide, 0.5 m deep depression in area of G147	New feature 2017. ~2m wide, 0.5 m deep depression in area of G147	N		No evidence of feature noted	29-Sep-20
G901	Possible Sinkhole	New feature 2017. ~2m wide, 1.0 m deep depression in area of G177	New feature 2017. ~2m wide, 1.0 m deep depression in area of G177	N		Depression feature ~8 m long, 0.8 m deep, 2 m wide (at deepest and widest)	02-Jul-20
G902	Possible Sinkhole	New feature 2017. Possible animal burrow, 0.2 m wide but appears to have been partly capped with cement?	New feature 2017. Possible animal burrow, 0.2 m wide but appears to have been partly capped with cement?	N		Partially covered hole with concrete panel, 0.4 x 0.5 m, 0.7 m deep at an angle (~45°)	02-Jul-20
G903	Possible Sinkhole	New feature 2017. 1.2 m wide by 0.4 m deep in grassy area north of the green.	New feature 2017. 1.2 m wide by 0.4 m deep in grassy area north of the green.	N		4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
G904	Possible Sinkholes	New feature 2017. Group of three small holes, approximately 1 m across and 0.3 m deep	New feature 2017. Group of three small holes, approximately 1 m across and 0.3 m deep	N		4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
G905	Possible Sinkholes	New feature 2017. Possible animal burrows. 0.1 to 0.3 m wide holes at base of tree	New feature 2017. Possible animal burrows. 0.1 to 0.3 m wide holes at base of tree	N		Hole feature between tree roots noted, 0.2 m wide, 0.4 m long, 0.2+ m deep	02-Jul-20
G906	Possible Sinkhole	New feature 2017. 10 m diameter, 1.5m deep depression with flat bottom in wood chip backfill in clearing near P-06. Possible material was removed and this is a stockpile	New feature 2017. 10 m diameter, 1.5m deep depression with flat bottom in wood chip backfill in clearing near P-06. Possible material was removed and this is a stockpile	N		No evidence of feature noted	29-Sep-20



Linework: QuantumPlace Developments 21 July 2020

Legend

- ASP Boundary
- Spa & Boutique Hotel
- Village Centre
- Indoor Recreation
- Innovation District
- Residential

wood.	PROJECT NAME Resort Village ASP	PROJECT NUMBER CG09125 FIGURE NUMBER n/a
THREE SISTERS mountain village	SHEET TITLE GPS Waypoints	ISSUE/REVISION 1

Wood Waypoints Noted During Site Reconnaissance

wood.

Waypoint #	Description	Date
WPT 001	Weeping tile noted	25-Jun-20
WPT 002	Vertical weeping tile noted	25-Jun-20
WPT 003	Vertical pipe (12" I.D.), two weeping tiles enter at 180°	25-Jun-20
WPT 004	Horizontal weeping tile, series of rebar pins	25-Jun-20
WPT 005	Well vegetated, west extent	25-Jun-20
WPT 006	Well vegetated, east extent	25-Jun-20
WPT 007	Depression 2-3 m diameter, 20 cm deep (adjacent to black pipe with red valve)	25-Jun-20
WPT 008	Depression noted, 2 m long, 1 m wide, 30 cm deep, outside of fenced area (possible new feature)	25-Jun-20
WPT 009	Powerline vault	25-Jun-20
WPT 010	Old powerpole, cut & disbanded	25-Jun-20
WPT 011	Depression 2 m x 2 m , 30 cm deep	25-Jun-20
WPT 012	Linear scarp, ~0.6 m high, relatively continous, visible on LiDAR, likely old road cut, #75 could be same, possibly G393 feature	25-Jun-20
WPT 013	Linear scarp, ~0.6 m high, relatively continous, visible on LiDAR, likely old road cut, #75 could be same, possibly G393 feature	25-Jun-20
WPT 014	Potential outcrop - Limestone / Dolostone	25-Jun-20
WPT 015	20 cm deep depression, 2 m wide x 1 m	25-Jun-20
WPT 016	Manhole cover	25-Jun-20
WPT 017	Concrete path ~ 100 m on hill - Phil said structural joints @ 3-5 m, no cracks or seperation noted	25-Jun-20
WPT 018	Powerline vault & pedestal	25-Jun-20
WPT 019	Powerline manhole x4	25-Jun-20
WPT 020	Steel pipe G391?	25-Jun-20
WPT 021	1" steel bars, possible depression in between, area is rumpled	25-Jun-20
WPT 022	1" steel bars, possible depression in between, area is rumpled	25-Jun-20
WPT 023		25-Jun-20
WPT 024	AltaLink vault	25-Jun-20
WPT 025	Altalink vault, 1.0 - 1.5 m deep depressions, 3 m long, 2 m wide	25-Jun-20
WPT 026	Limestone outcrop, 2 m high	25-Jun-20
WPT 027	1 m wide gully, 0.5m deep (likely water gulley)	25-Jun-20
WPT 028	Limestone outcrop, highly deformed and fissile, steeply dipping	25-Jun-20
WPT 029	Fire hydrant & 2 valves	25-Jun-20
WPT 030	Black HDPE pipe, ~8" ID, 8.5" OD	25-Jun-20
WPT 031	Limestone / mudstone outcrop	25-Jun-20
WPT 043	Depression feature ~5 m long, 2 m wide, 1 m deep, outside of mining footprint	02-Jul-20
WPT 044	Depression ~1 m wide, 0.4 -0.6 m deep, has 90 degree angle, less definded toward WPT 43, coincidence with mining limit, B113 in this area, shallow workings	02-Jul-20
WPT 045	Depression ~1 m wide, 0.4 -0.6 m deep, has 90 degree angle, less definded toward WPT 43, coincidence with mining limit, B113 in this area, shallow workings	02-Jul-20
WPT 046	Depression ~1 m wide, 0.4 -0.6 m deep, has 90 degree angle, less definded toward WPT 43, coincidence with mining limit, B113 in this area, shallow workings	02-Jul-20
WPT 047	Depression ~1 m wide, 0.4 -0.6 m deep, has 90 degree angle, less definded toward WPT 43, coincidence with mining limit, B113 in this area, shallow workings	02-Jul-20
WPT 048	Building remains (UMA1)	02-Jul-20
WPT 049	Pit feature is ~3 m in diameter, 1.5 m deep	02-Jul-20
WPT 050	Pit feature is ~3 m in diameter, 1.5 m deep	02-Jul-20
WPT 051	Pit feature is ~1 m in diameter, 0.8 m deep, outside mining footprint	02-Jul-20
WPT 052	2 depressions ~1 m in diameter, 0.5 m deep, cleared area with timbers pulled	02-Jul-20
WPT 053	Feature is 3 m long, 0.5 m wide, and 0.5 m deep	02-Jul-20
WPT 054	3 pit features observed, 1 m in diameter, 0.5 deep	02-Jul-20
WPT 055	Linear feature, 0.5 m wide, 0.5 m deep, some trees ~0.3 in diameter growing in it are straight, pit or circular depression at WPT 57, end of feature (WPT55-WPT57), G388	02-Jul-20
WPT 056	Linear feature, 0.5 m wide, 0.5 m deep, some trees ~0.3 in diameter growing in it are straight, pit or circular depression at WPT 57, end of feature (WPT55-WPT57), G388	02-Jul-20
WPT 057	Linear feature, 0.5 m wide, 0.5 m deep, some trees ~0.3 in diameter growing in it are straight, pit or circular depression at WPT 57, end of feature (WPT55-WPT57), G388	02-Jul-20
WPT 058	Feature is 0.8 m in diameter, 0.4 deep, square shaped	02-Jul-20
WPT 059	5 circular pits noted, ~0.8 m in diameter, 0.2 m deep	02-Jul-20
WPT 060	Pit feature, 0.8 m in diameter, 0.3 m deep	02-Jul-20
WPT 061	Depression feature, 4 m in diameter, 0.5 m deep	02-Jul-20
WPT 062	Depression feature, 3 - 5 m wide, 0.5 - 0.8 m deep, visible on LiDAR, some felled trees noted	02-Jul-20
WPT 063	Depression feature, 3 - 5 m wide, 0.5 - 0.8 m deep, visible on LiDAR, some felled trees noted	02-Jul-20
WPT 064	2 concrete pads, wood frames, bricks, cable, broken gear	02-Jul-20
WPT 065	Linear depression along fill line, 0.8 m wide, 0.4 m deep, 10 m long	02-Jul-20
WPT 066	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
WPT 067	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
WPT 068	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
WPT 069	Linear feature, ~1.5 - 0.3 wide, 0.5 deep, traced with WPTs, ~50 m long (B103?)	02-Jul-20
WPT 070	Air flowing from holes in portal fill, 5 holes ~ 50 cm in diameter	02-Jul-20
WPT 071	Likely creek, forest litter, very straight, ~1 m wide, 0.5 m deep	02-Jul-20
WPT 072	Wooden pipes, in line with WPT 71, this is likely an old ditch	02-Jul-20
WPT 073	Linear features, likely drainage ditches	02-Jul-20
WPT 074	Linear features, likely drainage ditches	02-Jul-20
WPT 075	Limestone outcrop, attitude measured	02-Jul-20
WPT 076	Hole in vegetation, 25 cm x 15 cm, 75 cm deep	02-Jul-20
WPT 077	Circular hole, 0.5 m x 0.8 m, 0.9 m deep	02-Jul-20
WPT 078	Hole, 0.35 x 0.6 m, 0.35 m deep	02-Jul-20
WPT 079	Hole with 0.3 m diameter	02-Jul-20
WPT 080	Numerous small holes appear to be in line	02-Jul-20
WPT 081	Numerous small holes appear to be in line	02-Jul-20
WPT 082	Depression feature ~8 m long, 0.8 m deep, 2 m wide (at deepest and widest)	02-Jul-20
WPT 083	Partailly covered hole with concrete panel, 0.4 x 0.5 m, 0.7 m deep at an angle (~45°)	02-Jul-20
WPT 084	4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
WPT 085	4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
WPT 086	4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
WPT 087	4 circular depressions, ~1.5 m in diameter, 0.4 m deep	02-Jul-20
WPT 088	4 circular depressions, well vegetated, ~1.5 m in diameter, 0.6 m deep	02-Jul-20
WPT 089	4 circular depressions, well vegetated, ~1.5 m in diameter, 0.6 m deep	02-Jul-20
WPT 090	4 circular depressions, well vegetated, ~1.5 m in diameter, 0.6 m deep	02-Jul-20
WPT 091	4 circular depressions, well vegetated, ~1.5 m in diameter, 0.6 m deep	02-Jul-20
WPT 092	Crack in pathway, ~10 cm wide, 30 - 40 m long	02-Jul-20
WPT 093	Depression and crack in pathway, ~10 m in diamter, 0.2 m depth	02-Jul-20
WPT 094	2 m deep depression, steep edges in area (rounded elsewhere)	02-Jul-20
WPT 133	Depression 1.5m deep, 4m across, extending to WPT 134 for approximately 30m, becoming only 1m deep	29-Sep-20
WPT 134	End of WPT 133 feature	29-Sep-20
WPT 135	Three holes in a line, spaced 2m and 1.5m apart. Holes are approx 10cm in diameter, could be animal burrows	29-Sep-20
WPT 136	Clearing on slope, flat, no trees, possibly a drill pad	29-Sep-20
WPT 137	Depression, 1.5m diameter, 0.4m deep	29-Sep-20

Wood Waypoints Noted During Site Reconnissance

Waypoint #	Description	Date
WPT 138	Two ditches running approx 155 and 162 orientation. 0.5 to 1.0m deep and wide. Suspected to be man-made	29-Sep-20
WPT 139	Bedrock outcrop, mudstone and siltstone	29-Sep-20
WPT 140	Steel pipe, approx 3 inch diameter, appears old as is mostly buried and heavily rusted	29-Sep-20
WPT 141	End of steel pipe in WTP 140	29-Sep-20
WPT 142	Linear feature, orientated approx 240. 2m long, 0.4m deep, 0.7m wide followed by 8m long, up to 0.5m deep, 0.7m wide	29-Sep-20
WPT 143	Square wooden crib structure 5m x 5m, 4 logs tall, 0.8m high	29-Sep-20
WPT 144	Known shaft location. Filled with soil, with outline being approx 8m diameter and 0.3m settlement at edges	29-Sep-20
WPT 145	Large concrete block approx 1 x 2.5 . 2.5 m	29-Sep-20
WPT 146	Large concrete block approx 2 x 1 x 3 m	29-Sep-20
WPT 147	Concrete pad 4 x 5 m, 0.5m high with approx 15 vertical threaded bars	29-Sep-20
WPT 148	Top of ditch	29-Sep-20
WPT 149	Bottom of ditch 0.8 x 0.8 m	29-Sep-20
WPT 150	Possible crack, 0.2m deep, 0.3m wide, 4m long. Orientated 132, could be TF17	29-Sep-20
WPT 151	Trench 3-4m wide, 2m deep orientated 102, continues to WPT 154 and WPT 155	29-Sep-20
WPT 152	Several voids over distance of 12m in alignment to 160. Largest hole is 1.5m long, 1.0m deep and 0.5m wide.	29-Sep-20
WPT 153	Portal where mitigation soil has collapsed leaving open access. Orange fencing surrounds.	29-Sep-20
WPT 154	Continuation of WPT 151, orientated 112, 1m wide 0.5m deep	29-Sep-20
WPT 155	End of trench marked by WPTs 151 and 154	29-Sep-20
WPT 156	Three concrete panels on golf cart track, approx 20m long. Believed to be mitigation.	29-Sep-20
WPT 157	Asphalt crack orientated 237, approx 20m long	29-Sep-20

2020 Wood E&IS Photograph

Photograph 1: Feature #74, June 2020

2017 Golder Associates Photograph

Photograph 1A: Feature #74, October 2017

NOTE: Photograph obtained from Golder Associates Ltd. report "Three Sisters Mountain Village Properties Ltd. Fall 2017 Site Reconnaissance Program, June 2018"

wood.

CLIENT:

THREE SISTERS mountain village

Surface Feature Comparison

No. 2 Mine, Sedlock Seam, Feature #74

CG09125

October 2020

2020 Wood E&IS Photograph

Photograph 2: Feature #73, June 2020

2017 Golder Associates Photograph

Photograph 2A: Feature #73, October 2017

NOTE: Photograph obtained from Golder Associates Ltd. report "Three Sisters Mountain Village Properties Ltd. Fall 2017 Site Reconnaissance Program, June 2018"

wood.

CLIENT:

THREE SISTERS mountain village

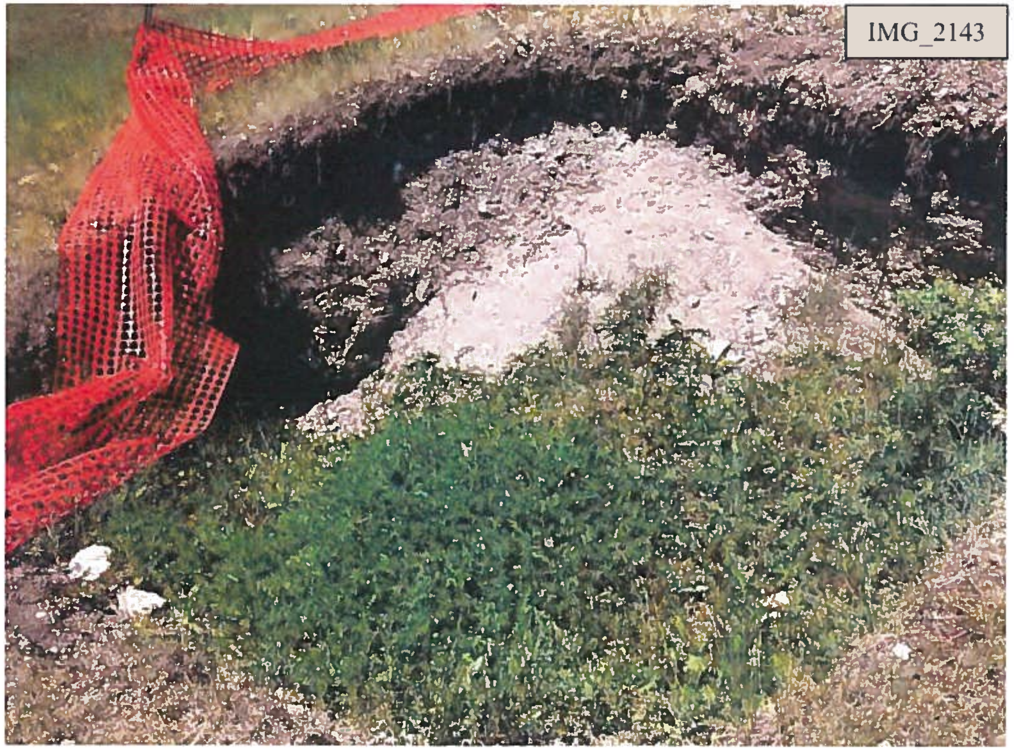
Surface Feature Comparison

No. 2 Mine, Sedlock Seam, Feature #73

CG09125

October 2020

2020 Wood E&IS Photograph



Photograph 3: Feature G404, June 2020

2017 Golder Associates Photograph

Photograph 3A: Feature G404, October 2017

NOTE: Photograph obtained from Golder Associates Ltd. report "Three Sisters Mountain Village Properties Ltd. Fall 2017 Site Reconnaissance Program, June 2018"

wood.

CLIENT:

THREE SISTERS mountain village

Surface Feature Comparison

No. 2 Mine, Stewart Seam, Feature G404

CG09125

October 2020

2020 Wood E&IS Photograph

Photograph 4: Feature UMA9, July 2020

2017 Golder Associates Photograph

Photograph 4A: Feature UMA9, October 2017

NOTE: Photograph obtained from Golder Associates Ltd. report "Three Sisters Mountain Village Properties Ltd. Fall 2017 Site Reconnaissance Program, June 2018"

wood.	CLIENT: THREE SISTERS mountain village	**Surface Feature Comparison**	
		No. 2 Mine, No. 1 Morris Seam, Feature UMA9	CG09125 October 2020

Photograph 5: Crack in pathway, Waypoint 092 , July 2020

Photograph 6: Crack in pathway, Waypoint 092 , July 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 7: Slight crack in pathway near feature G903 (waypoints 076 – 083), July 2020

Photograph 8 : Slight crack in pathway near feature G903 (waypoints 076 – 083), July 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 9: Depression in area where G173 and G334 were observed in the past, Waypoint 093, July 2020

Photograph 10: 4 circular depressions, well vegetated, ~1.5 m in diameter, 0.6 m deep, Waypoints 088 - 091, July 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 11: Feature G901, Waypoint 082, July 2020

Photograph 12: Feature G902, Waypoint 083, July 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 13: Numerous small holes appear to be in line, Waypoints 076 – 081, near Features G165, G167, and G177, July 2020

Photograph 14: Numerous small holes appear to be in line, Waypoints 076 - 081, near Features G165, G167, and G177, July 2020

wood.	CLIENT: Three Sisters Mountain Village	Reconnaissance Photographs
		CG09125
		October 2020

Photograph 15: Depression in area where G136 was observed in the past, Waypoint 094, July 2020

Photograph 16: Photograph 10: Depression in area where G136 was observed in the past, Waypoint 094, July 2020

wood.	CLIENT: THREE SISTERS mountain village	**Reconnaissance Photographs**
		CG09125
		October 2020

Photograph 17: Feature G390, Waypoint 072, July 2020

Photograph 18: Feature G390, Waypoint 072, July 2020

wood.	CLIENT: Three Sisters mountain village	Reconnaissance Photographs	
			CG09125
			October 2020

Photograph 19: 3 pit features observed, 1 m in diameter, 0.5 deep, Waypoint 054, July 2020

Photograph 20: Linear features (likely drainage ditches), Waypoint 071, July 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 21: Depression with 90° turn, less defined toward Waypoint 43, coincidence with mining limit, B113 feature in this area, feature bounds waypoint 043-047, photo at waypoint 045, July 2020

Photograph 22: Depression with 90° turn, less defined toward Waypoint 43, coincidence with mining limit, B113 feature in this area, feature bounds waypoint 043-047, photo at waypoint 046, July 2020

Photograph 23: Feature S-15, July 2020

Photograph 24: Depression with 90° turn, less defined toward Waypoint 43, coincidence with mining limit, B113 feature in this area, feature bounds waypoint 043-047, photo at waypoint 043, July 2020

wood.	CLIENT: THREE SISTERS mountain village	**Reconnaissance Photographs**
		CG09125
		October 2020

Photograph 25: Linear scarp, relatively continuous, likely Feature G393, Waypoint 012, June 2020

Photograph 26: Feature #75 in fenced off area, Waypoint 010, June 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 27: Bedrock outcrop at Waypoint 31, next to Feature B42, June 2020

Photograph 28: Bedrock outcrop at Waypoint 28, June 2020

wood.

CLIENT:

THREE SISTERS mountainvillage

Reconnaissance Photographs

CG09125

October 2020

Photograph 29: Depression at Waypoint 133, September 2020

Photograph 30: Depression at Waypoint 134, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 31: Bedrock outcrop at Waypoint 139, September 2020

Photograph 32: Bedrock outcrop at Waypoint 139, September 2020

wood.

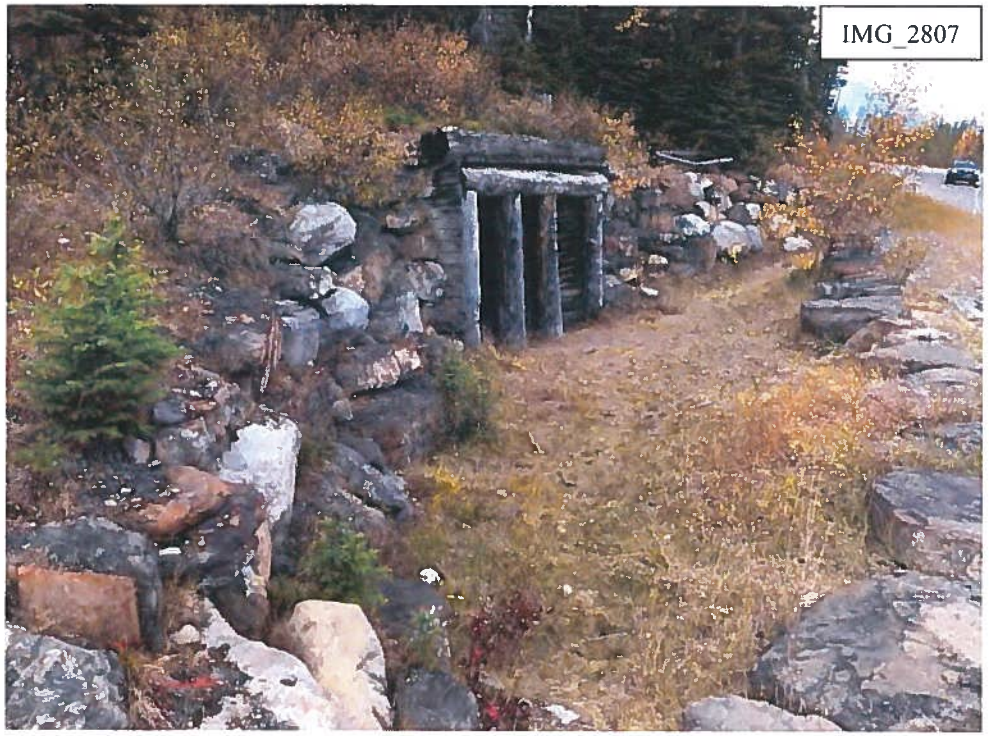
CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020



Photograph 33: Sealed mine portal at Three Sisters Parkway, September 2020

Photograph 34: Sealed mine portal at Three Sisters Parkway, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 35: Steel pipe at Waypoint 140 and 141, September 2020

Photograph 36: Wooden Reel, September 2020

wood.

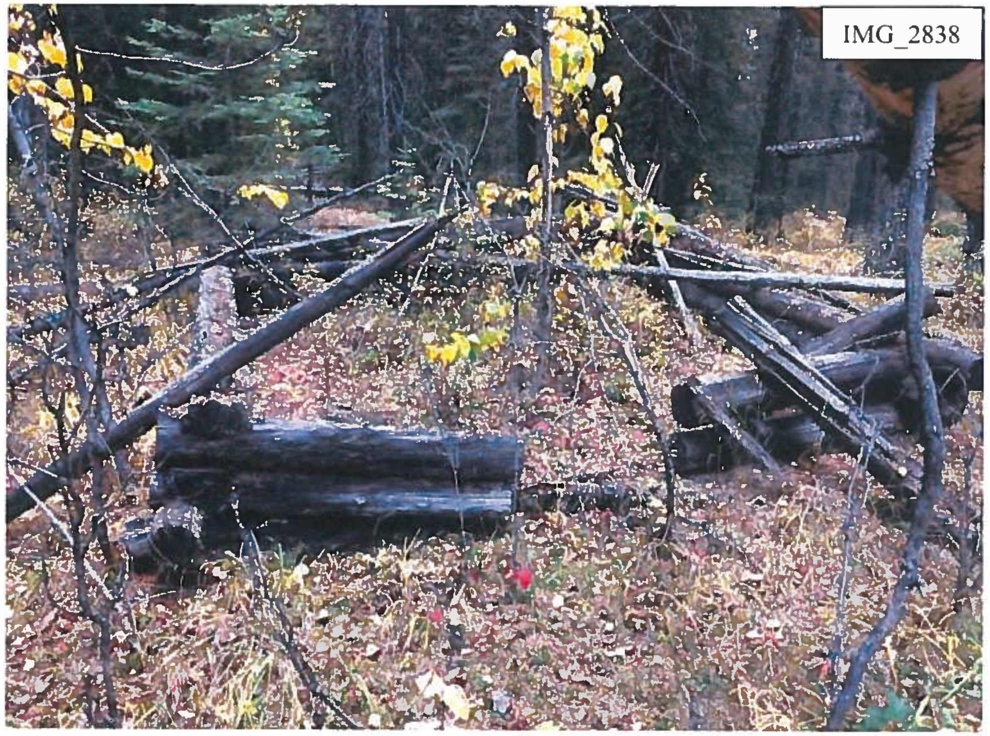
CLIENT:

THREE SISTERS mountainvillage

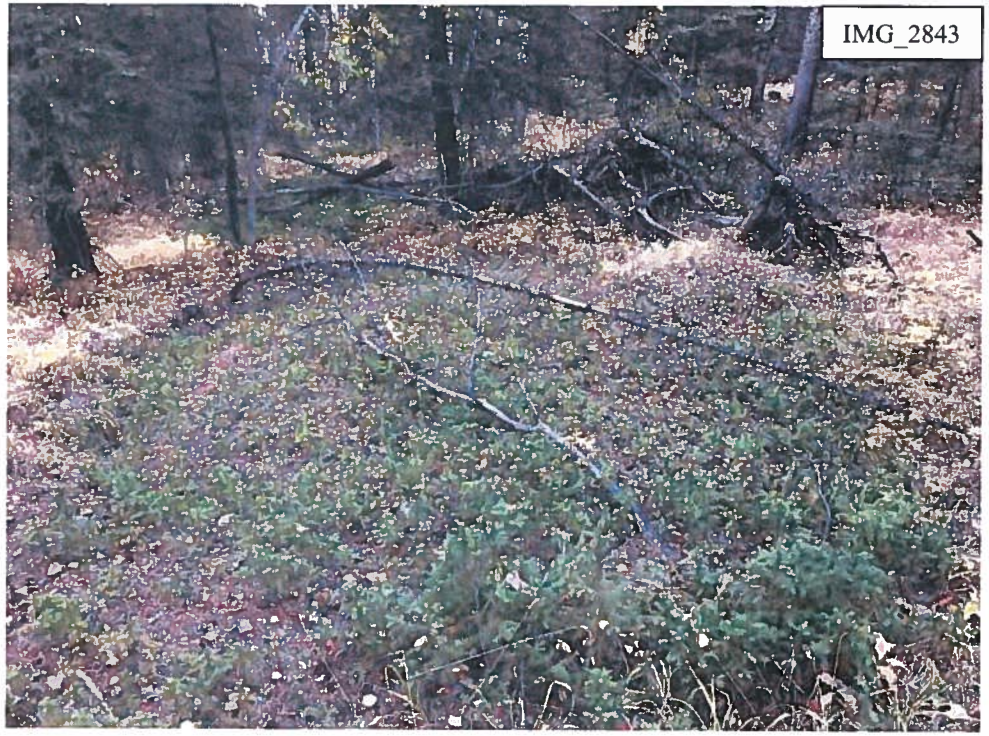
Reconnaissance Photographs

CG09125

October 2020



Photograph 37: Square wooden crib structure at Waypoint 143, September 2020



Photograph 38: Known shaft location with settlement at Waypoint 144, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 39: Known shaft location with settlement at Waypoint 144, September 2020

Photograph 40: Known shaft location with settlement at Waypoint 144, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 41: Concrete block at Waypoint 145, September 2020

Photograph 42: Concrete block at Waypoint 145, September 2020

wood.

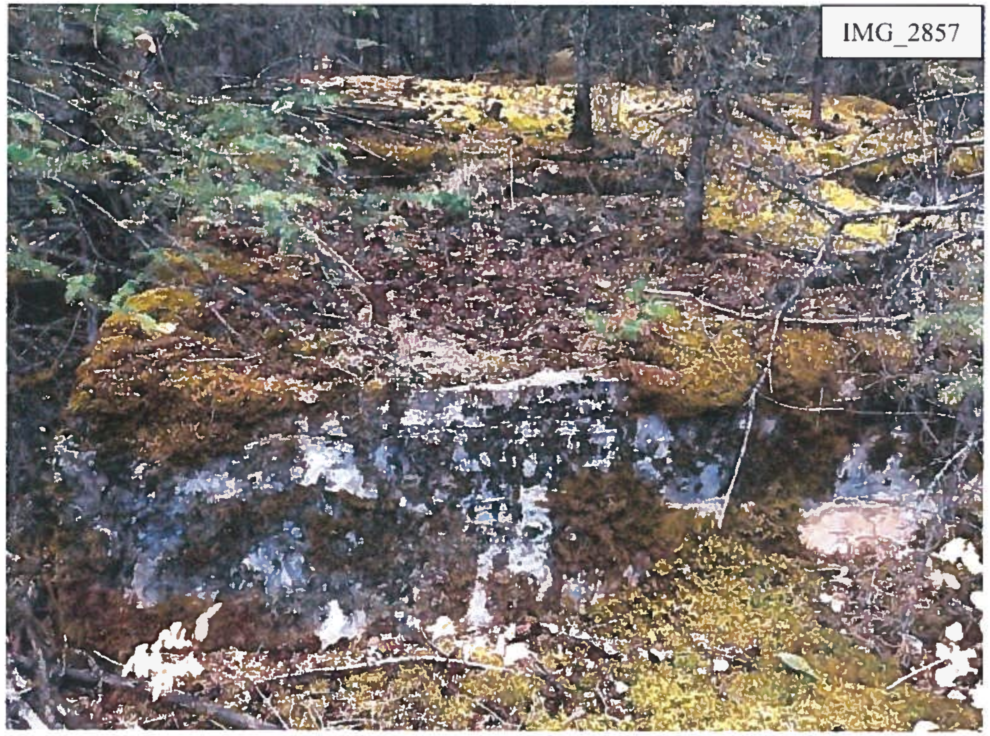
CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020



Photograph 43: Concrete foundation Waypoint 147, September 2020

Photograph 44: Concrete foundation Waypoint 147, September 2020

wood.

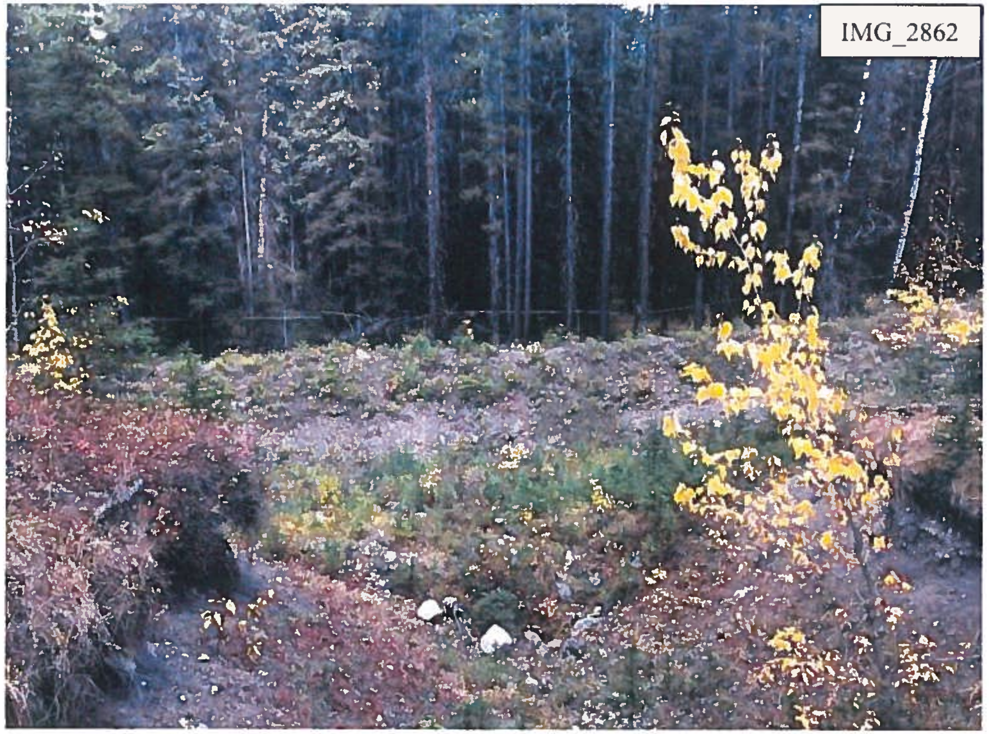
CLIENT:

THREE SISTERS mountainvillage

Reconnaissance Photographs

CG09125

October 2020



Photograph 45: Fenced area with ditch, near Waypoint 149, September 2020

Photograph 46: Ditch between Waypoint 148 and 149, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 47: Possible subsidence area Waypoint 150, September 2020

Photograph 48: Possible subsidence area Waypoint 150, September 2020

wood.

CLIENT:

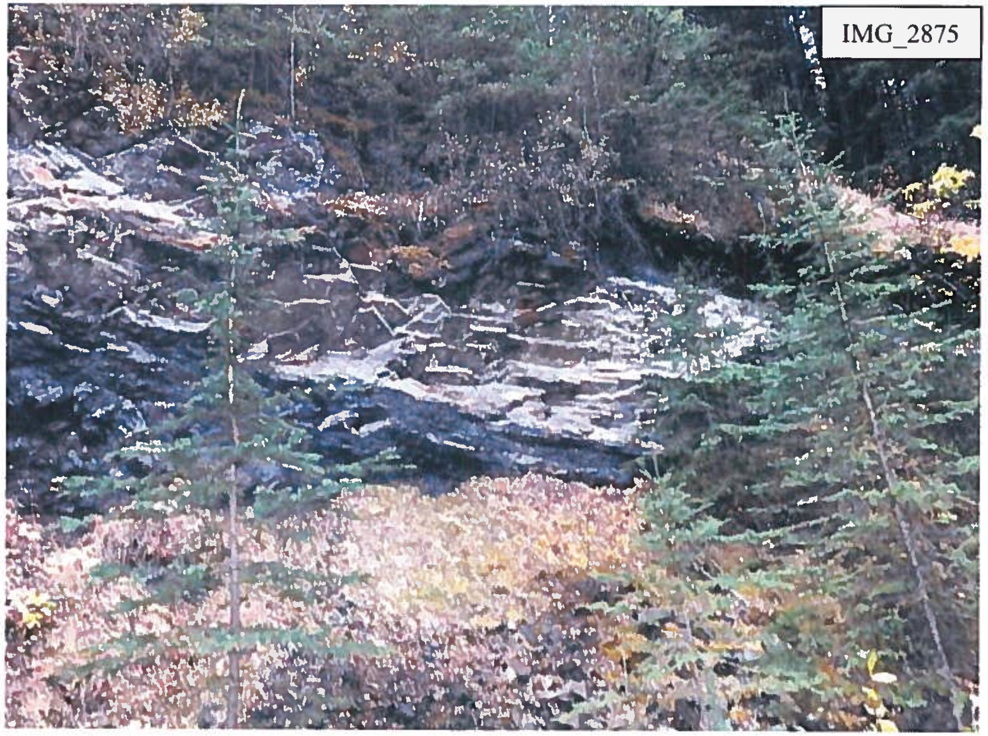
THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 47: Bedrock outcrop, near Waypoint 151, September 2020



Photograph 48: Bedrock outcrop, near Waypoint 151, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 49: Trench, Waypoint 151, 154, 155, September 2020

Photograph 50: Trench, Waypoint 151, 154, 155, September 2020

wood.

CLIENT:

THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 49: Trench, Waypoint 151, 154, 155, September 2020

Photograph 50: Trench, Waypoint 151, 154, 155, September 2020

CLIENT: THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 51: Voids, Waypoint 152, September 2020 (outside ASP Area)

Photograph 52: Voids, Waypoint 152, September 2020 (outside ASP Area)

wood.

CLIENT: THREE SISTERS mountain village

Reconnaissance Photographs

CG09125

October 2020

Photograph 53: Former Mining Portal, Waypoint 153, September 2020 (outside ASP Area)

Photograph 54: Former Mining Portal, Waypoint 153, September 2020 (outside ASP Area)

wood.

CLIENT:

THREE SISTERS mountain village

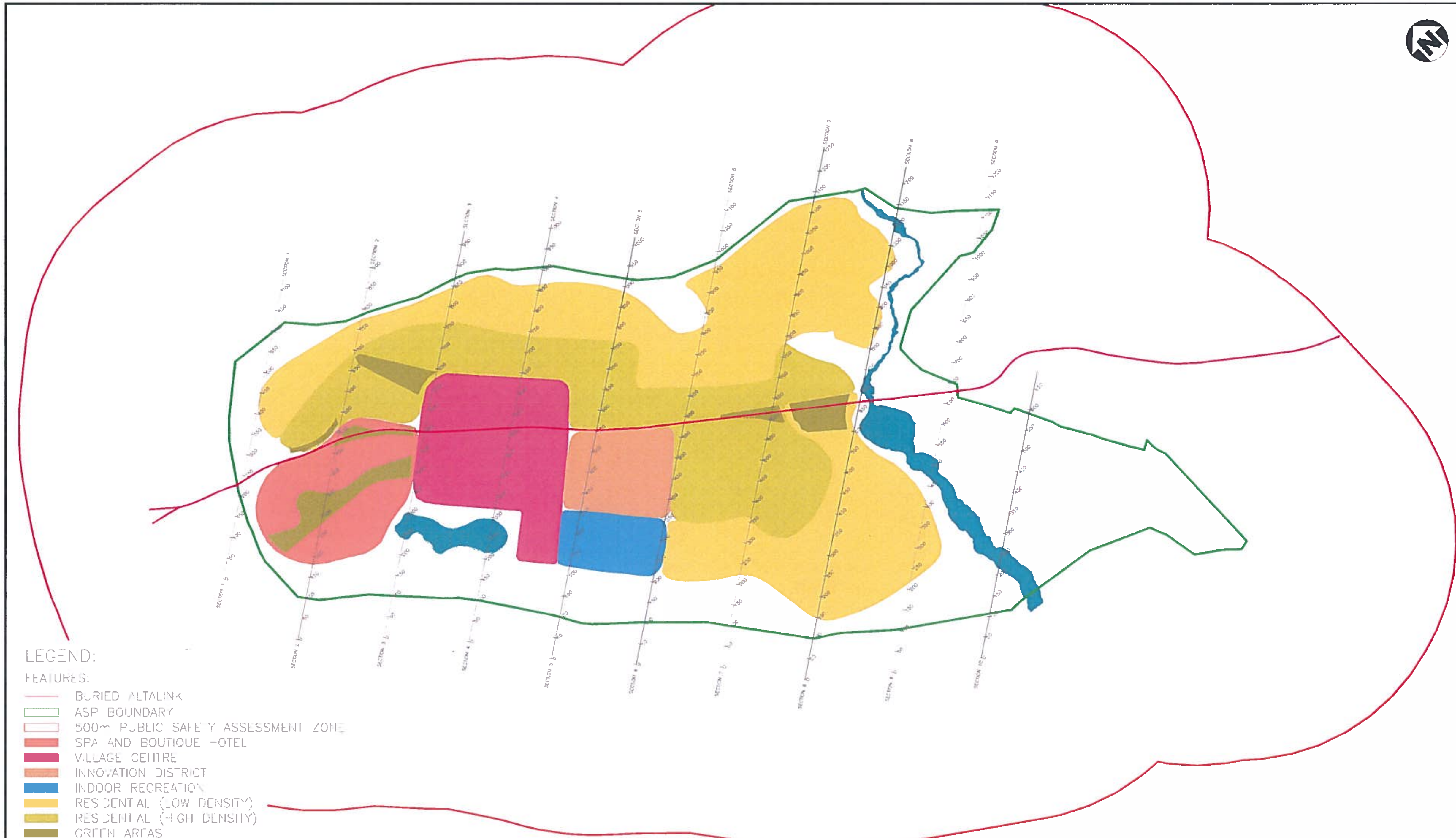
Reconnaissance Photographs

CG09125

October 2020

Appendix B

3D Model Plans and Sections



CAD FACSIMILE

THIS CAD FACSIMILE IS NOT THE ORGINAL VERSION OF THIS DRAWING. THE OFFICIAL VERSION HAS BEEN SIGNED AND STAMPED. CAD FACSIMILE IS FOR INFORMATION ONLY AND SHALL NOT BE RELIED UPON. WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS DOES NOT ASSUME LIABILITY FOR ITS USE BY OTHERS.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

wood.

DRAWN BY	BS
DESIGNED BY	
CHECKED BY	
REVIEWED BY	
APPROVED BY	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SITE PLAN

PROJECT NO	CG09130
REVISION NO	0
DATE	12NOV2020
SCALE	1:4000
DRAWING NO	245235-200

CAD FACSIMILE
THIS CAD FACSIMILE IS NOT THE ORIGINAL VERSION OF THIS DRAWING. THE OFFICIAL VERSION HAS BEEN SIGNED AND STAMPED. CAD FACSIMILE IS FOR INFORMATION ONLY AND SHALL NOT BE RELIED UPON. WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS DOES NOT ASSUME LIABILITY FOR ITS USE BY OTHERS.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

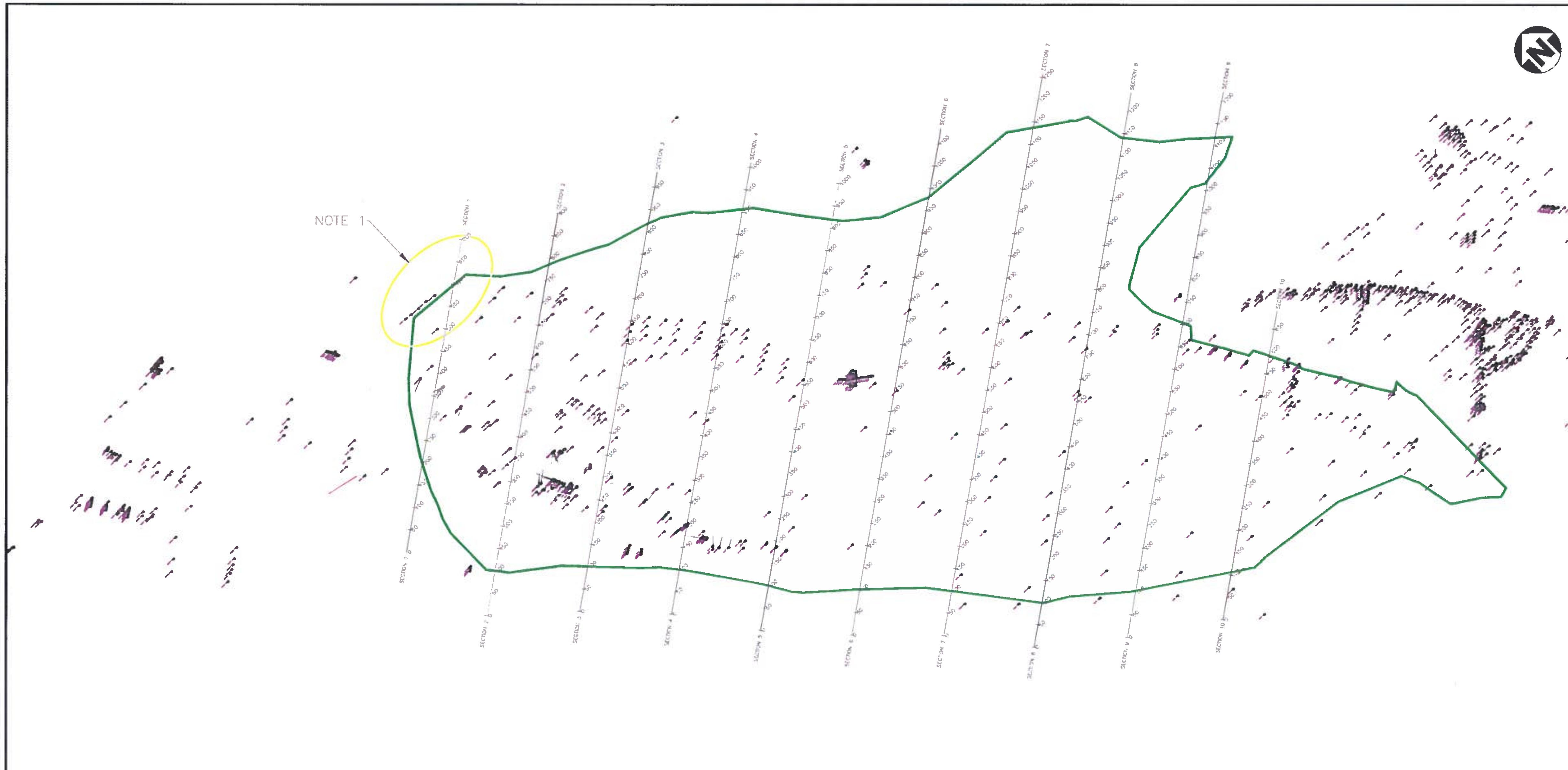
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP MINES

PROJECT NO.:	CG09130
REVISION NO.:	0
DATE:	12NOV2020
SCALE:	1:4000
DRAWING NO.:	245235-201



LEGEND:

FEATURES:

ASP BOUNDARY

NOTE 1: APPROXIMATELY 105 BOREHOLES NOT SHOWN WITHIN CIRCLED AREA AS PER THREE SISTER PARKWAY CONTRACTS 1 AND 2 UNDERMINING REPORT c2000 BY NORWEST RESOURCE CONSULTANTS LTD.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

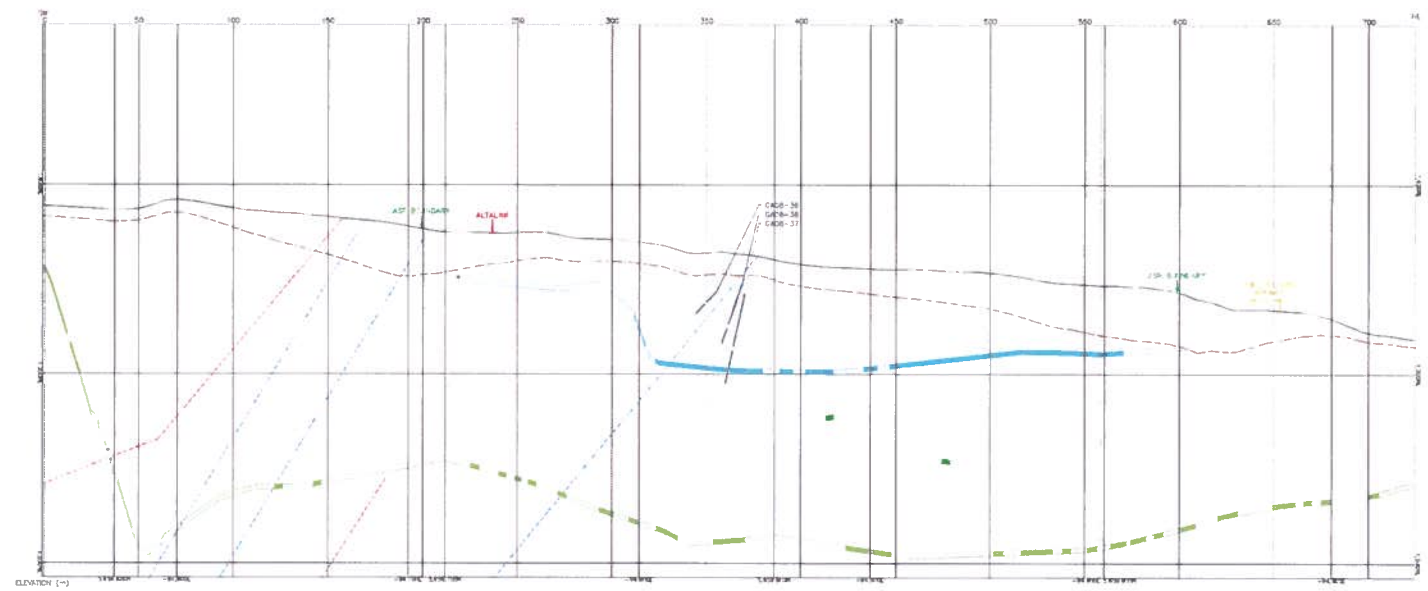
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP BOREHOLES

PROJECT NO:	CG09130
REVISION NO:	0
DATE:	12NOV2020
SCALE:	1:4000
DRAWING NO:	245235-202



LEGEND:

MINING:

PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SEDLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: three sisters mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

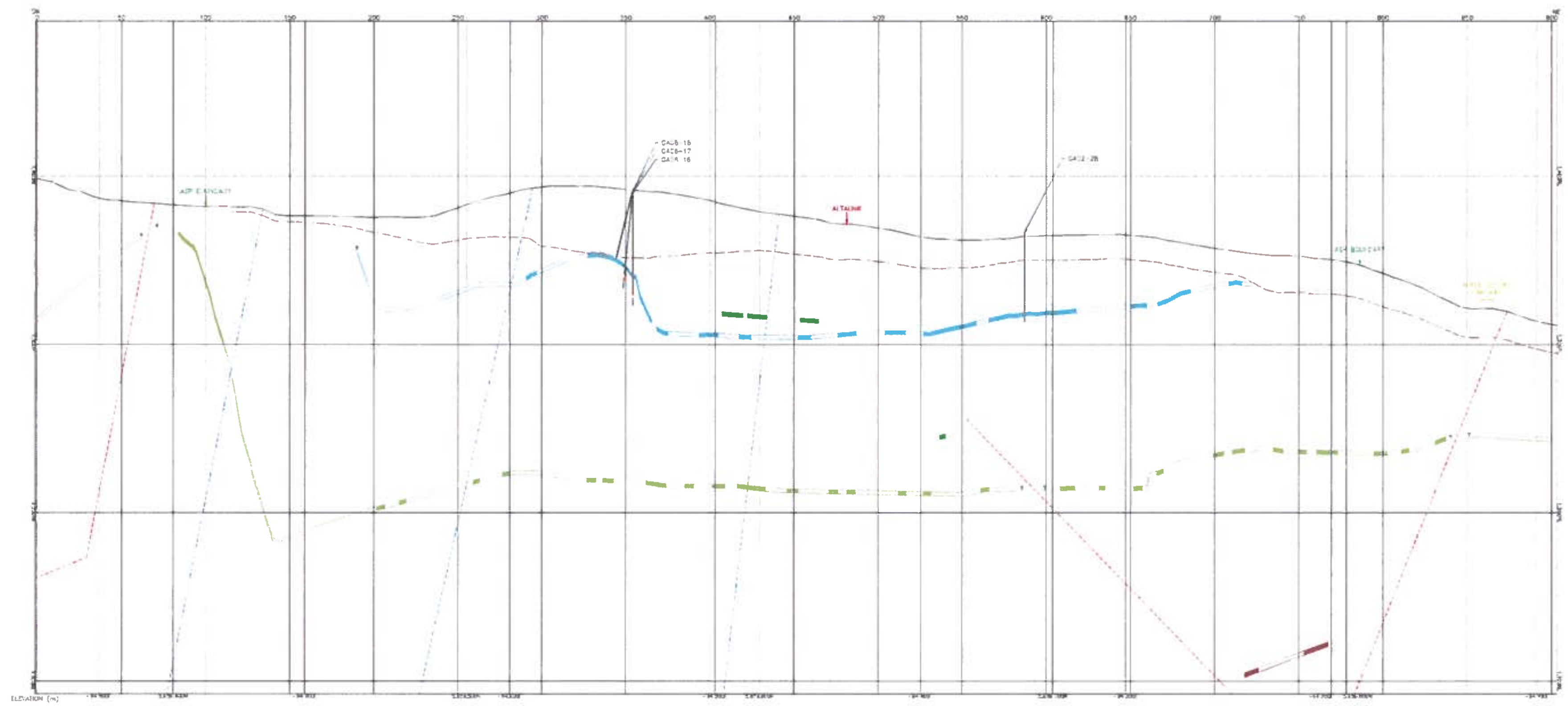
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 1

PROJECT NO:	CG09130
REVISION NO:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO:	245235-301



LEGEND:

MINING

PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SEDLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga Ontario Canada L4Z 3K7

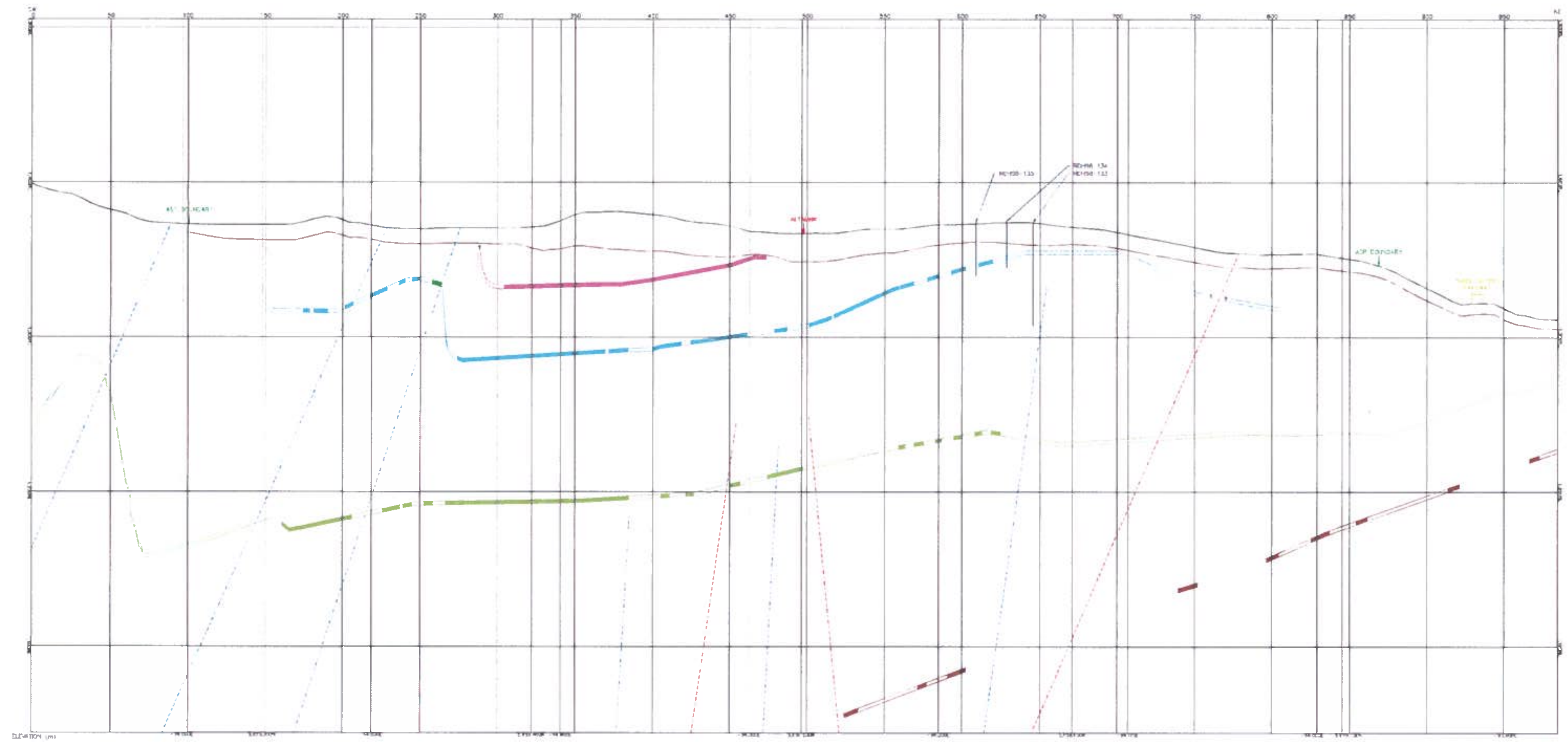
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 2

PROJECT NO:	CG09130
REVISION NO:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO:	245235-302



LEGEND:

MINING:
PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SEDLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- LIDAR TOPO
- BURIED ALTA LINK LOCATION
- APPROX. TOP OF BEDROCK
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- THREE SISTERS PARKWAY ROAD
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

CAD FACSIMILE
THIS CAD FACSIMILE IS NOT THE ORIGINAL VERSION OF THIS DRAWING. THE OFFICIAL VERSION HAS BEEN SIGNED AND STAMPED. CAD FACSIMILE IS FOR INFORMATION ONLY AND SHALL NOT BE RELIED UPON. WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS DOES NOT ASSUME LIABILITY FOR ITS USE BY OTHERS.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario Canada L4Z 3K7

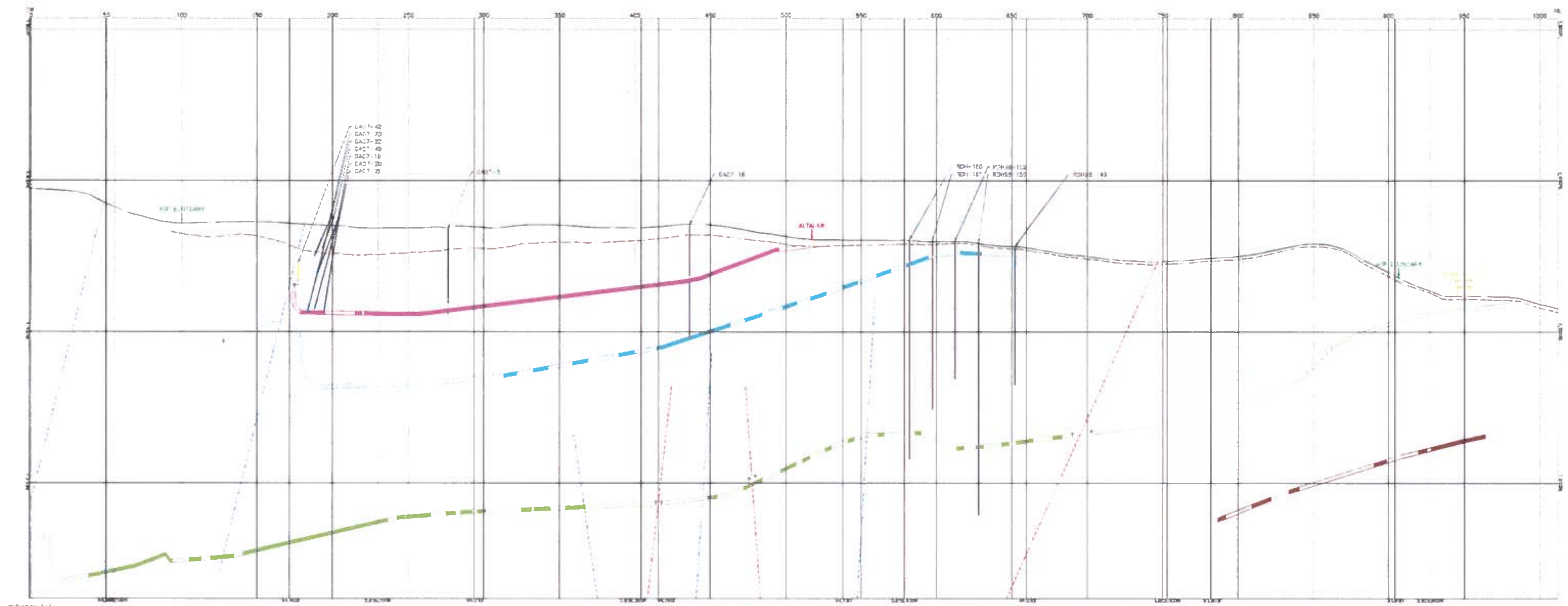
wood.

DRAWN BY	BS
DESIGNED BY	
CHECKED BY	
REVIEWED BY	
APPROVED BY	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 3

PROJECT NO.	CG09130
REVISION NO.	0
DATE	12NOV2020
SCALE	1:1500
DRAWING NO.	245235 303



LEGEND:

MINING

PILLAR/EXCAVATED

STEWART 2 MINE	RIVERSIDE MINE	SHAFT
SEDLOCK MINE	MORRIS 1 MINE	
CAREY 2 MINE	OTHER TUNNELS	

BOREHOLES

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: THREE SISTERS mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

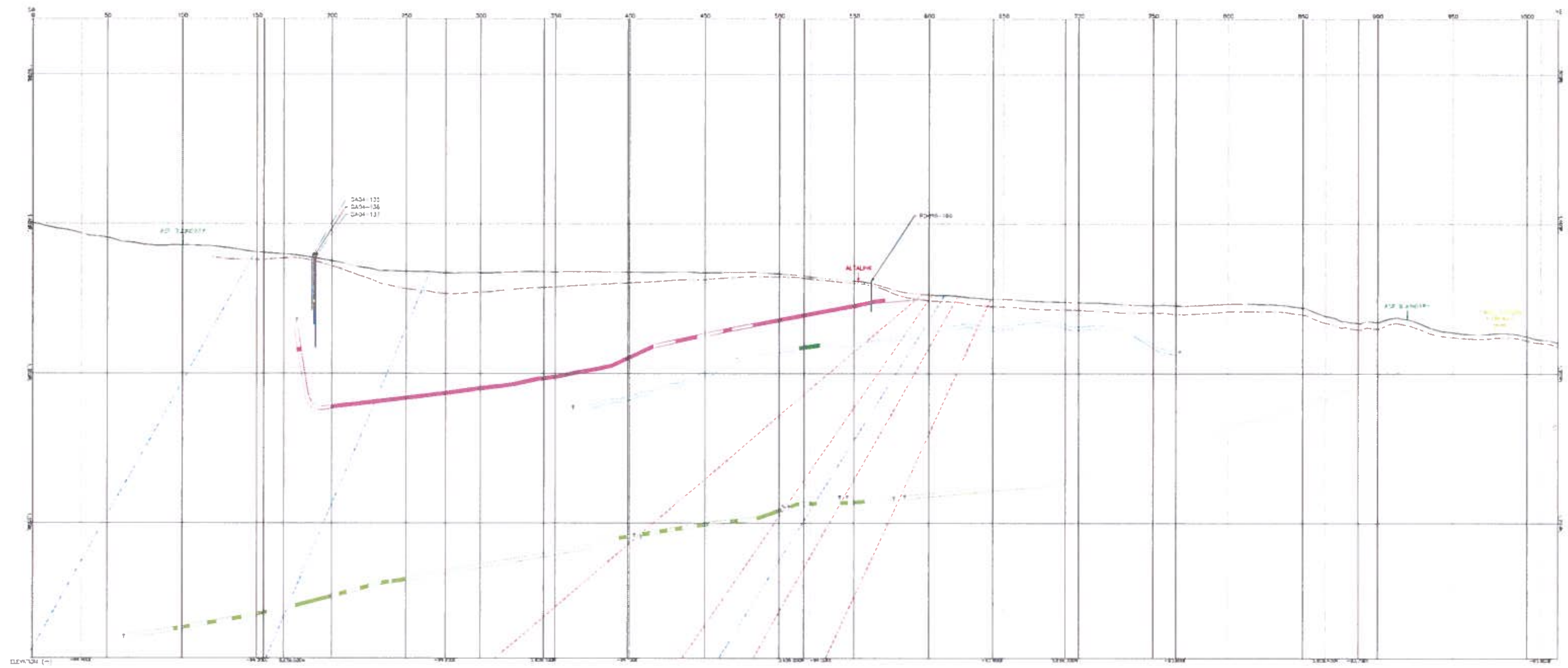
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 4

PROJECT NO.:	CG09130
REVISION NO.:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO.:	245235-304



LEGEND:

MINING:

PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SEBLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client logo.

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

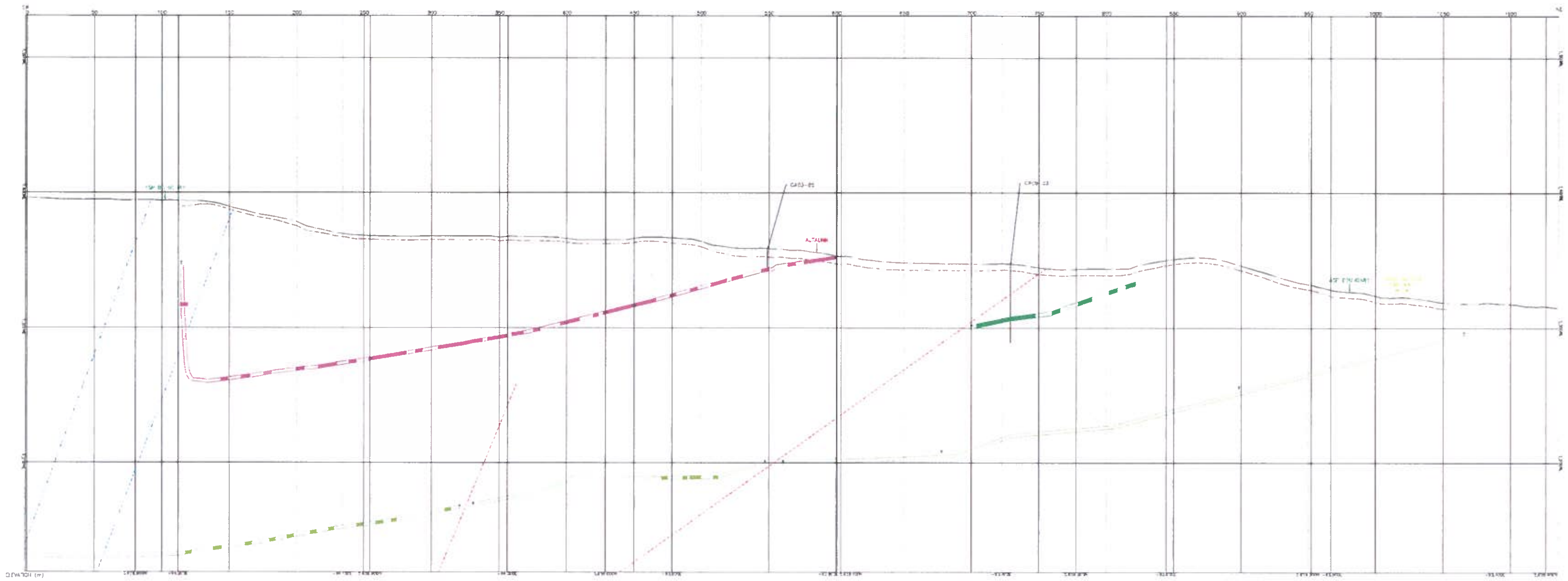
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 5

PROJECT NO:	CG39130
REVISION NO:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO:	245235-305



LEGEND:

MINING

PILLAR/EXCAVATED

STEWART 2 MINE	RIVERSIDE MINE	SHAFT
SEDLOCK MINE	MORRIS 1 MINE	
CAREY 2 MINE	OTHER TUNNELS	

BOREHOLES

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES

ASP BOUNDARY	LIDAR TOPO
BURIED ALTALINK LOCATION	APPROX. TOP OF BEDROCK
APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS	THREE SISTERS PARKWAY ROAD
APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS	

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
103 Traders Boulevard East
Mississauga Ontario Canada L4Z 3K7

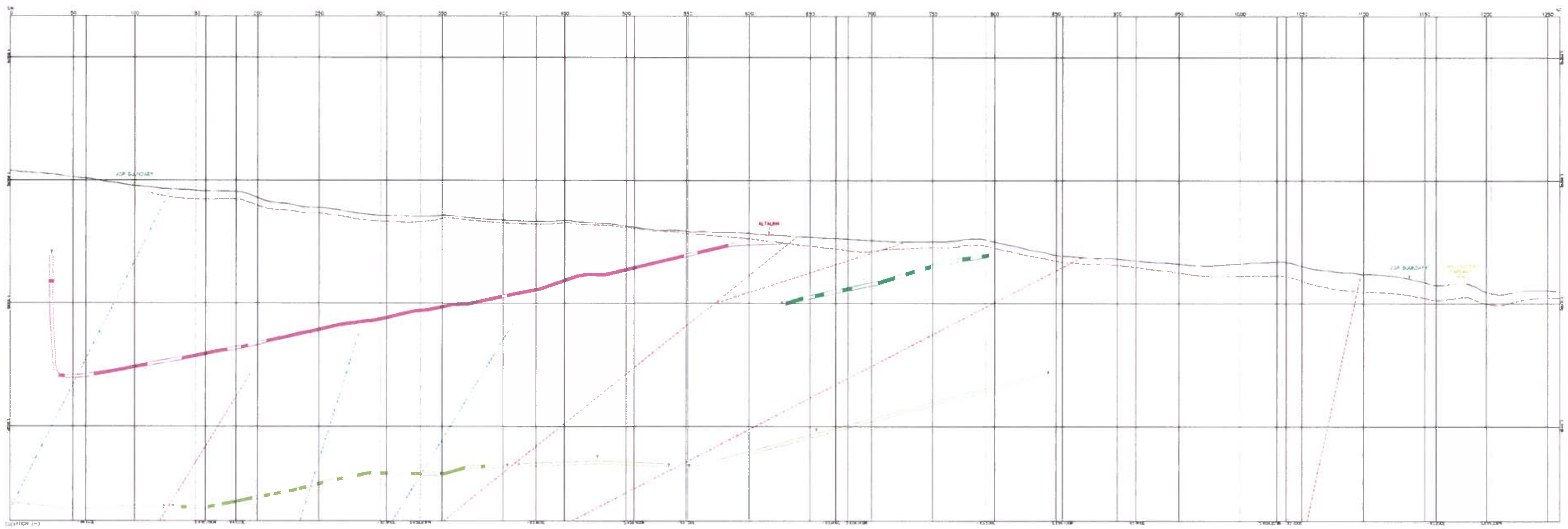
wood.

DRAWN BY	BS
DESIGNED BY	
CHECKED BY	
REVIEWED BY	
APPROVED BY	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 6

PROJECT NO.:	CG09130
REVISION NO.:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO.:	245235.306



LEGEND:

MINING:

PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SHERLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

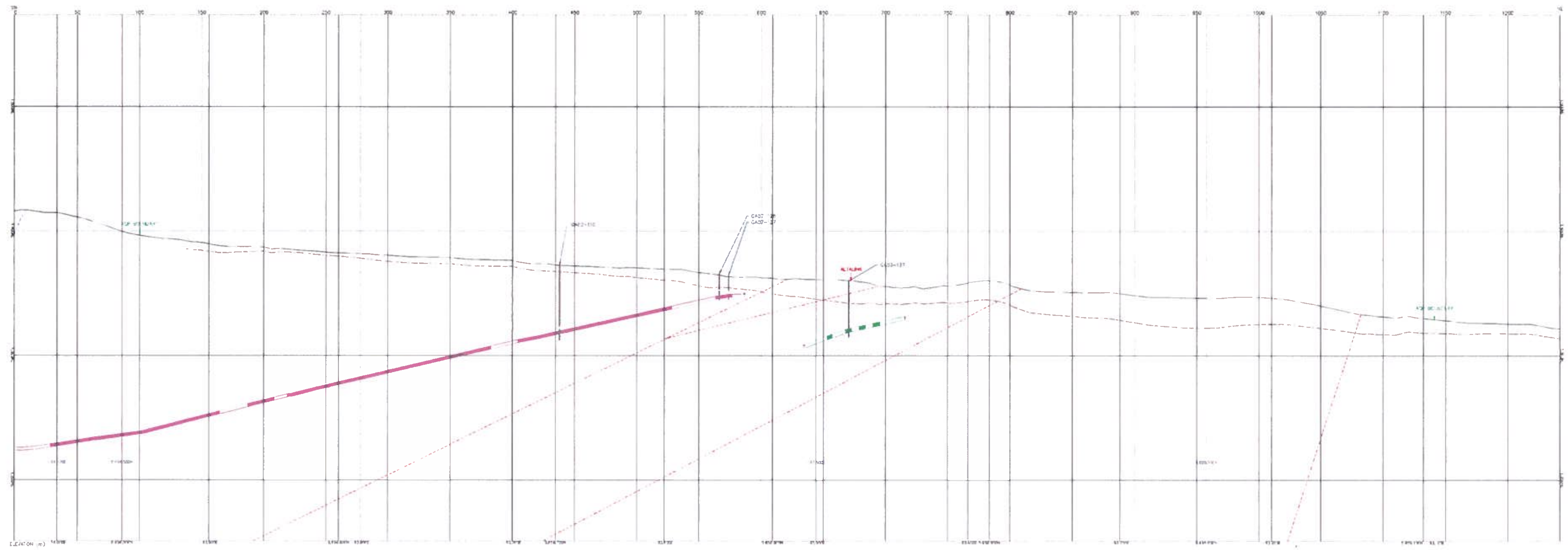
wood.

DRAWN BY	BS
DESIGNED BY	
CHECKED BY	
REVIEWED BY	
APPROVED BY	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 7

PROJECT NO.	CG09130
REVISION NO.	0
DATE	12NOV2020
SCALE	1:1500
DRAWING NO.	245235-307



LEGEND:

MINING

PILLAR/EXCAVATED

- STEWART 2 MINE
- RIVERSIDE MINE
- SHAFT
- SEDLOCK MINE
- MORRIS 1 MINE
- CAREY 2 MINE
- OTHER TUNNELS

BOREHOLES:

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES:

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

Client Logo: Three Sisters mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

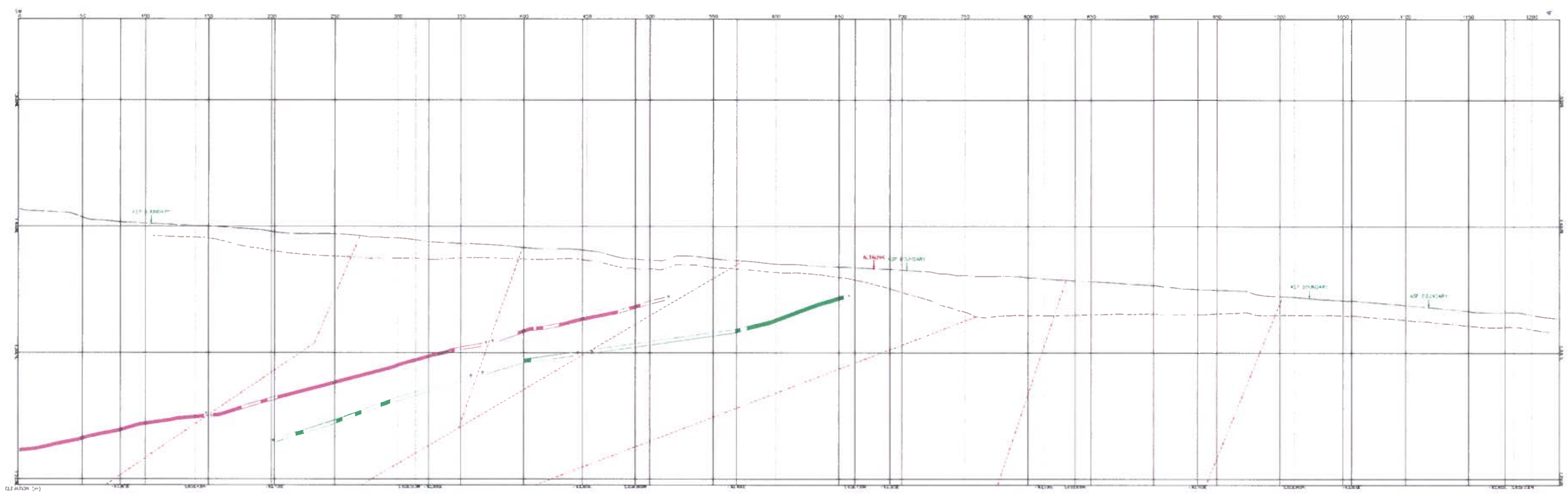
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 8

PROJECT NO.:	CG09130
REVISION NO.:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO.:	245235-308



LEGEND:

MINING

PILLAR/EXCAVATED

MINING			BOREHOLES	FEATURES:	
STEWART 2 MINE	RIVERSIDE MINE	SHAFT	OTHER STRATA	ASP BOUNDARY	LIDAR TOPO
SEDLOCK MINE	MORRIS 1 MINE		COAL	BURIED ALTALINK LOCATION	APPROX. TOP OF BEDROCK
CAREY 2 MINE	OTHER TUNNELS		VOID	APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS	THREE SISTERS PARKWAY ROAD
			RUBBLE	APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS	

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 50m OF SECTION LINES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountain village

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

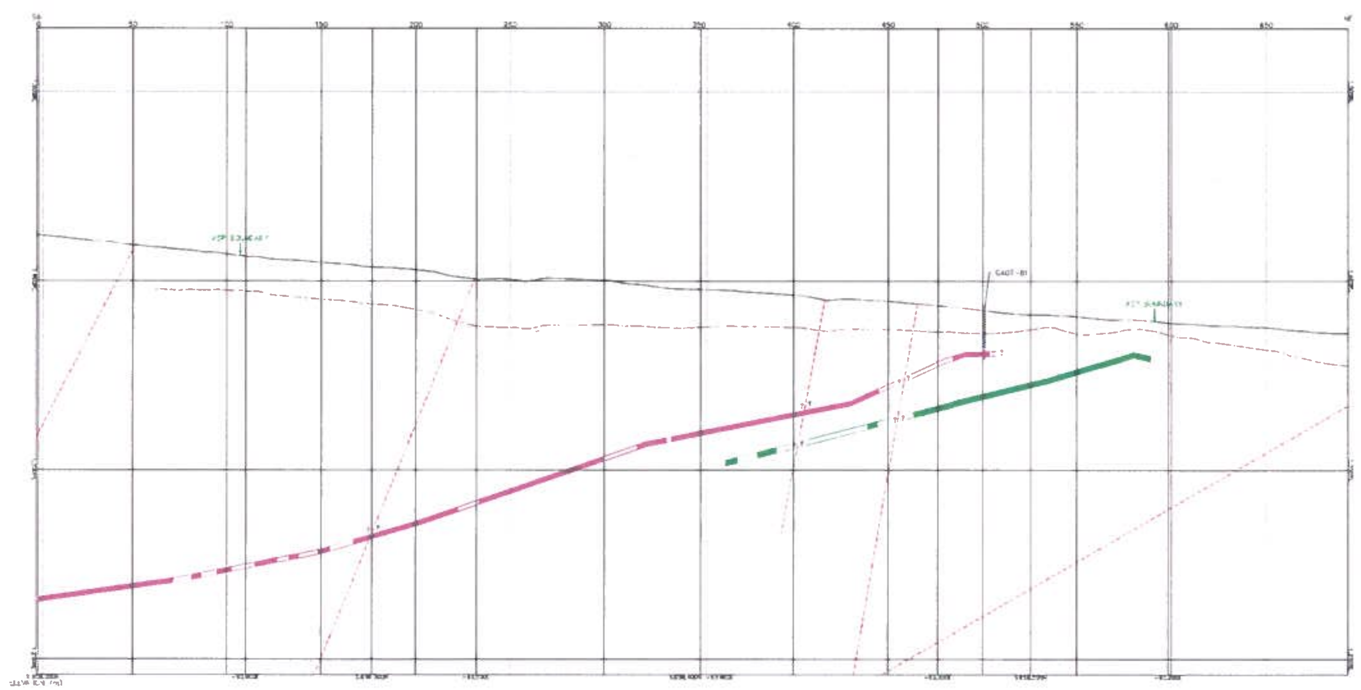
wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 9

PROJECT NO:	CG09130
REVISION NO:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO:	245235-309



LEGEND:

MINING
PILLAR/EXCAVATED

STEWART 2 MINE	RIVERSIDE MINE	SHAFT
SEDLOCK MINE	MORRIS 1 MINE	
CARLEY 2 MINE	OTHER TUNNELS	

BOREHOLES

- OTHER STRATA
- COAL
- VOID
- RUBBLE

FEATURES

- ASP BOUNDARY
- BURIED ALTALINK LOCATION
- APPROXIMATE FAULT LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- APPROXIMATE FOLD AXIS LOCATIONS AS PROJECTED FROM NORWEST SECTIONS
- LIDAR TOPO
- APPROX. TOP OF BEDROCK
- THREE SISTERS PARKWAY ROAD

NOTE: ONLY SELECT BOREHOLES SHOWN. BOREHOLES PROJECTED ONTO SECTION WITHIN +/- 10m OF SECTION LINES

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG	APPR

Client Logo: mountainvillage

Client: THREE SISTERS MOUNTAIN VILLAGE

Wood Environment & Infrastructure Solutions
160 Traders Boulevard East
Mississauga, Ontario, Canada L4Z 3K7

wood.

DRAWN BY:	BS
DESIGNED BY:	
CHECKED BY:	
REVIEWED BY:	
APPROVED BY:	

PROJECT: THREE SISTERS MOUNTAIN VILLAGE RESORT CENTER MINING SUBSIDENCE

TITLE: OVERVIEW REPORT RESORT VILLAGE ASP SECTION 10

PROJECT NO.:	CG09130
REVISION NO.:	0
DATE:	12NOV2020
SCALE:	1:1500
DRAWING NO.:	245235-310

Appendix C

Key Personnel CVs

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

Principal Rock Mechanics Specialist

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

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

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)

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

Associate Rock Mechanics Engineer

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

wood.

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)

wood.

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.

wood.

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.