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Dear Jim,

Re: Kudz Ze Kayah Project – Findings of Terrain Analysis

Summary

This report details the findings of terrain analysis undertaken for the Kudz Ze Kayah (KZK) Project. The terrain analysis was undertaken to develop geomorphic and geological models for the site, provide a preliminary overview of the geohazards at the site and aid the planning of future borrow area assessments. The scope of work included:

- A desk top study review of published mapping and the logs of test pits undertaken at the site in previous site investigation programs.
- Geomorphic mapping by interpreting a Bare Earth Digital Elevation Model (DEM) in 3D after applying the 'slope shader' function within the *Global Mapper* software package. This analysis allowed a range of glacial landforms, including kames, kettles, eskers, glaciofluvial terraces and meltwater channels to be delineated, which, in turn, facilitated a preliminary characterization of the surficial geology of the site.
- Ground-proofing the surficial geology interpretation using the findings of the previous test pitting investigations.

The majority of the site area has a blanket of glacial soils. The predominantly hummocky nature of the glaciated topography and the absence of glacial flutings (low linear ridges) suggest that Ablation Till is much more common within the Study Area than Lodgement (Basal) Till, at least within the near-surface overburden stratigraphy. The Ablation Till is associated with ice-contact glaciofluvial deposits characterized by kame complexes. Both of these geological materials were deposited when glacier ice stagnated and melted. The Ablation Till and kames predominantly comprise cohesionless soils, which nonetheless, have some fines. The Ablation Till has a more variable particle size distribution locally predominantly comprises silt. The 1995/96 test pits provide fairly widespread evidence of glacial lacustrine deposits in the vicinity of the site of the proposed Lower Water Management Pond. The soils encountered comprised soft to firm clayey silt with trace sand and loose to compact silts and fine sands, locally with trace gravel. A few small eskers were identified at the site of the proposed Open Pit, and a glaciofluvial terrace was also identified at the north margin. These units are expected to comprise sands and gravels with only minor fines and are potential sources of construction aggregate. Three Pro-glacial meltwater corridors were delineated in the mapping, a north-south corridor along Geona Creek and two west-northwest oriented corridors, which intersect the Geona Creek Corridor from the east. Pro-glacial Meltwater Corridors are complexes of meltwater channels that formed in front of a retreating ice sheet. It is interpreted that glaciofluvial sands and gravels occur along these corridors.

Along the Geona Creek Meltwater Corridor, the glaciofluvial deposits are overlain by lake deposits and organic swamp deposits as well as alluvium deposited by Geona Creek. Lake deposits occur at the sites of the Lower Water Management Pond in the north part of the Study Area and the Open Pit in the south part. The lake deposits encountered in tests pits comprised sand and silt with trace fine gravel to clayey silt, locally with sand. The alluvial deposits along Geona Creek predominantly comprise fine-grained flood plain deposits (organic silts and sands with trace gravel) along with subordinate coarse channel deposits (sands with some gravel and trace to some silt). Three alluvial fans have developed at the confluences of tributary drainage lines with Geona Creek. The fluvial fan

deposits were found to comprise cohesionless soils ranging from loose to compact silty sand with some gravel and trace cobbles to sandy gravel with many cobbles. These fluvial fan deposits are another potential source of aggregate.

The terrain analysis highlighted local geohazards at the site despite the terrain being predominantly gently inclined. Debris slides have occurred, locally, on moderate natural slopes either side of Geona Creek. It is possible that these landslides were caused, at least in part, by permafrost degradation. There is an active fan at the confluence of Fault Creek and Geona Creek in the south part of the footprint area of the proposed Open Pit. The 1995 ortho-imagery shows evidence of a recent debris flood on the fan. Recent debris slides have been identified on the incised gully side slopes adjacent to Fault Creek and are a possible source of enhanced sediment load that could initiate debris floods.

The terrain analysis highlighted permafrost and periglacial processes to be widespread across the Study Area. The permafrost distribution is partly controlled by slope aspect with the sheltered north-facing slopes being the most prone to permafrost accumulation. In addition, the fine-grained soil types at the site are more likely to contain permafrost. The 1995/96 site investigations found permafrost to be more extensive along the portion of the Geona Creek drainage line in the north part of the Study Area where the valley floor has a northerly aspect. Stripes have developed locally on the upper slopes as a result of the downslope creep of patterned ground. These features are likely to be preferential flow paths for near-surface water. Stripes extend down slope into the footprint area of the proposed Overburden Stockpile. Thaw lakes on the Geona Creek Valley floor and thermal erosion on the lower slopes on the west side of the valley are evidence of local permafrost degradation.

Extensive areas of solifluction were mapped on the upper slopes. The footprints of the proposed Open Pit, the three proposed waste storage facilities and the proposed road, which follows the western limits of the footprints of the proposed facilities, all extend across areas of solifluction. The terrain in these areas should be assumed to be unstable with respect to development and mitigation measures will needed to prevent slope instability.

1 – INTRODUCTION

The Kudz Ze Kayah Project is a proposed copper-zinc-lead-gold mine that BMC Minerals (No.1) Ltd. (BMC) is currently developing to a Pre-Feasibility Study (PFS) level. The project is located in the Saint Cyr Range area of the Pelly Mountains approximately 250 km northeast of Whitehorse, Yukon. The topography of the area consists of rolling hills with lakes occupying valley bottoms.

The Study Area is shown on Drawing G0001. The elevation of the site ranges from approximately 1,400 meters above sea level (masl) at the valley floor to approximately 1,700 masl at the hill tops. The valley floor is occupied by a small creek known as Geona Creek. Geona Creek flows towards the north. Fault Creek joins Geona Creek from the west in the south part of the Study Area. North Lakes Creek flows southwards from the confluence of Fault Creek with Geona Creek. Two west-northwest trending drainage lines join Geona Creek from the east. The site is located within an area of extensive discontinuous permafrost (50 to 90%) close to the boundary of an area of sporadic discontinuous permafrost (10 to 50%), (Heginbottom et al, 1992).

The layout of the proposed mine facilities is shown on Drawing G0001. The site of the proposed Open Pit is located in the headwaters of the Geona Creek Watershed. Three waste storage facilities are proposed, two on the west side of the Geona Creek Valley and a third in a tributary valley to the east. It is proposed to develop an Overburden Stockpile on the east side of the Geona Creek Valley. It is proposed to site the mill on the slopes to the west of Geona Creek between and down slope from the sites of the proposed Class A and Class B Storage Facilities. Two Water Management Ponds are proposed along the Geona Creek Drainage Line.

This report presents the findings of a terrain analysis undertaken for the KZK Project. The key aims of the study were to:

- Develop geomorphic and geological models for the site to facilitate the planning of future site investigation programs and geotechnical and hydrogeological interpretation

- Provide a preliminary overview of the geohazards at the site, and
- Aid the planning of future borrow area assessments.

2 – SCOPE OF WORK

The Study Area is shown on Drawing G0001 and includes the full extent of the area of natural terrain upslope from the main facilities.

The scope of work included:

- A desk top study review of the regional published geological mapping as well as the reported findings of test pitting undertaken at the site in 1995, 1996 and 2016.
- Development and interpretation of a slope angle map of the Study Area. The slope angle map was prepared using the *ArcView* software package with the *3d Analyst* extension.
- Interpretation of a Bare Earth Digital Elevation Model (DEM) within the *Global Mapper* software package by applying the 'slope shader' function and exaggerating the vertical scale to accentuate the landforms. This analysis allowed a range of glacial landforms, including kames, kettles, eskers, glaciofluvial terraces and meltwater corridors to be delineated. The morphological features were digitized within *Global Mapper* and then exported to *ArcMap* to produce the final maps.
- Additional interpretation of the terrain, terrain hazards and surficial geology was undertaken using the 1m contours from the 1995 topographic survey and ortho-imagery from 1995.
- Ground-proofing the surficial geology interpretation using the findings of the test pitting investigations undertaken in 1995, 1996 and 2016.

3 – DESK STUDY

3.1 PUBLISHED GEOLOGY

The Geological Survey of Canada has mapped the surficial geology in the region of the project at a scale of 1:100,000 (Jackson, L.E., Jr., 1993). Morainal (Till) deposits and colluvial aprons are mapped on the lower slopes of the north-trending Geona Creek Valley. The morainal deposits are described as silty sandy gravels with cobbles and minor boulders. The colluvial apron soils are described as granular soils with particles up to boulder size. Glaciofluvial Complex sediments are mapped along the floor of the west-northwest trending valley in the northeast part of the Study Area and are shown to extend into the north-trending valley. These 'ice-contact' deposits are described as sands and gravels with minor silt and are indicated to be greater than 5 m-thick. An alluvial fan is mapped at the confluence of Fault Creek and the main north-south oriented drainage line at the site of the proposed Open Pit. Bedrock is mapped on the hilltops.

3.2 PREVIOUS SITE INVESTIGATIONS

Site investigations, comprising test pitting and boreholes, were carried out at the site in 1995, 1996 and 2016. The test pit and borehole locations are shown on Figures 1 and 2 and the test pit locations are reproduced on Drawing G0002. A preliminary geotechnical site characterization (KP, 2016a) was prepared from the findings of the 1995/96 site investigations and further work undertaken in 2013. An additional report (KP, 2016b) summarizes the findings of the 2016 site investigation program.

The site investigations confirmed the presence of morainal deposits, glaciofluvial deposits and colluvial apron deposits on the valley side slopes. Glacial lacustrine deposits were also encountered, locally. Alluvium and organic soils were encountered along the Geona Creek drainage line. Permafrost was encountered in many test pits. The findings of the 1995, 1996 and 2016 test pits were used in this study in order to field truth the terrain analysis.

4 – FINDINGS OF TERRAIN ANALYSIS

4.1 GEOMORPHIC INTERPRETATION

The slope angle map for the Study Area is presented in Drawing G0001. It can be seen from Drawing G0001 that slope angles in the Study Area are generally gentle. There is a band of moderate slopes at the toe of the east side of the Geona Creek Valley. The steepest terrain is in the southwest part of the Study Area where the slopes are predominantly moderately inclined and locally moderately steep. Moderately steep to steep slopes occur along two gullies upslope from the site of the proposed Open Pit.

The findings of the terrain analysis are presented on Drawing G0002. The following landforms were identified in the mapping:

- Hummocky Moraine.
- Kames.
- Kettles.
- Eskers.
- Pro-glacial Meltwater Corridors.
- Glaciofluvial terrace.
- Solifluction Lobes.
- Patterned Ground (Stripes).
- Thaw Lakes.

The predominantly hummocky nature of the glaciated topography and the absence of glacial flutings (low linear ridges) suggest that Ablation Till is much more common within the Study Area than Lodgement (Basal) Till, at least within the near-surface overburden stratigraphy. The Ablation Till is associated with ice-contact glaciofluvial deposits characterized by kames and kettles. Both of these geological materials were deposited when glacier ice stagnated and melted. Ablation Till is characterized by soils that have a lower consistency or relative density compared to Lodgement Till, which has been overridden and consolidated by a large thickness of ice. Another important difference in the geotechnical properties of the two types of Till is that Lodgement Tills, as well as the underlying overburden can be overconsolidated. Kames are mounds of gravel and sand with trace to some silt. They formed where streams deposited coarse sediment in cavities in the ice sheet. The kames commonly occur in groups, referred to as kame complexes. This classification of glaciofluvial soils as ice-contact kames can be of particular importance for hydrogeological modelling and seepage analyses as kame deposits tend to have a significant proportion of silt and therefore are inferred to have lower permeability's than channel deposits. Kettles are closed depressions that occur locally within the kame complexes. They formed when detached blocks of ice melted at the end of the last glaciation. Their floors are commonly below the water table, thus kettles are commonly occupied by ponds or lakes. A few small eskers were identified in the vicinity of the site of the proposed Open Pit. Eskers are sinuous ridges that consist of sands and gravels with some cobbles deposited in sub-glacial channels.

Three pro-glacial meltwater corridors were delineated in the mapping, a north-south corridor along Geona Creek and two west-northwest oriented corridors, which intersect the Geona Creek corridor from the east. Pro-glacial Meltwater Corridors are complexes of meltwater channels that formed in front of the retreating ice sheet. The margins of the meltwater corridors are defined by the maximum lateral extents of the incised slopes adjacent to the main drainage lines. Pro-glacial Meltwater Corridors are expected to have a continuous extent of granular deposits.

There is evidence of periglacial and permafrost processes within the Study Area. Stripes have developed locally on the upper slopes as a result of the downslope creep of patterned ground. These features are likely to be preferential flow paths for near-surface water. Solifluction is widespread within the upper and middle slopes. Solifluction comprises seasonal downslope creep of the active layer. Colluvial aprons have developed locally at the toes of the valley side slopes. These are wedges of sediment with a prominent concave slope break at the upslope margin. It is interpreted that the colluvial aprons consist mainly of sheetwash sediment mixed with

re-transported surficial organic soils that have been carried down slope by water seeping above the permafrost table. Thaw lakes were mapped on the valley floor and there are thermal erosion features on the lower slopes on the west side of the Geona Creek Valley. These features are the product of permafrost degradation.

4.2 SURFICIAL GEOLOGY

The surficial geology within the Study Area is interpreted to predominantly comprise Ablation Till and ice-contact glaciofluvial deposits. There is possible local evidence of Basal Till from test pits undertaken on the lower valley slopes in the vicinity of the site of the proposed Lower Water Management Pond. Test Pit TP96-D7 encountered dense silty gravelly sand with cobbles and Test Pit TP96-D4 encountered dense grey silt with trace sand and some gravel and cobbles. The 1995/96 test pits provide fairly widespread evidence of glacial lacustrine deposits in the vicinity of the site of the proposed Lower Water Management Pond. The soils encountered comprised soft to firm clayey silt with trace sand and loose to compact silts and fine sands, locally with trace gravel. It is interpreted that glaciofluvial sands and gravels occur along the meltwater corridors and are overlain, locally, by lake deposits organic swamp deposits and alluvium. Small esker deposits occur along the Geona Creek Meltwater Corridor between the sites of the proposed Open Pit and the Class B Storage Facility. A small glaciofluvial terrace was mapped on the east side of the Geona Creek Valley floor immediately to the north of the footprint of the proposed Open Pit. An approximately 0.1 to 0.2 m-thick band of volcanic ash was encountered above the glacial deposits in some test pits undertaken on the lower side slopes of the Geona Creek Valley (e.g. TP 16-35).

Colluvial aprons were mapped at the toes of the valley side slopes adjacent to Geona Creek, particularly on the east side of the valley. The colluvial aprons predominantly comprise organic sits and sands, which are locally frozen. It is interpreted that the aprons developed in areas where ice-contact glaciofluvial deposits extend onto the lower valley side slopes. Sheetwash within the active layer is expected to mobilize the finer sediment component of the ice-contact deposits in such settings forming relatively fine-grained cohesionless soils with a component of organic material.

Along the Geona Creek Meltwater Corridor, the glaciofluvial deposits are overlain by lake deposits and organic swamp deposits as well as alluvium deposited by Geona Creek. Lake deposits occur at the sites of the Lower Water Management Pond in the north part of the Study Area and the Open Pit in the south part. The lake deposits encountered in tests pits comprised sand and silt with trace fine gravel to clayey silt, locally with sand. The alluvial deposits along Geona Creek predominantly comprise fine-grained flood plain deposits (organic silts and sands with trace gravel) along with subordinate coarse channel deposits (sands with some gravel and trace to some silt). Three alluvial fans have developed at the confluences of tributary drainage lines with Geona Creek. The fluvial fan deposits were found to comprise cohesionless soils ranging from loose to compact silty sand with some gravel and trace cobbles to sandy gravel with many cobbles. Bedrock outcrops are mainly restricted to hill-top settings.

4.3 GEOHAZARDS

The terrain analysis identified 4 debris slides on moderate slopes adjacent to Geona Creek. It is possible that these landslides were caused, at least in part, by permafrost degradation. One relict debris slide and four recent debris slides were mapped on the moderate to moderately steep side slopes of the gully in the southwest part of the Study Area. This gully terminates in a broad (approximately 700 m–wide) alluvial fan. The 1995 ortho-imagery shows evidence from bare soil deposits and the nature of the vegetation cover of a recent debris flood on this fan. The fan and the recent debris flood deposit extend into the footprint area of the proposed Open Pit. The approximate extent of the flood deposit is shown on Drawing G0002.

4.4 GROUND CONDITIONS AT SITES OF PROPOSED FACILITIES

4.4.1 Open Pit

A pro-glacial meltwater corridor oriented towards the north passes through the central portion of the footprint of the proposed Open Pit. It is interpreted that glaciofluvial sands and gravels occur along this corridor. The glaciofluvial deposits are overlain by lake deposits and organic swamp deposits, locally, as well as alluvium

deposited by Geona Creek. The lake deposits are expected to comprise silts and fine sands. The organic swamp deposits were found to be up to approximately 1.0 m-thick. They generally comprise organic silt, locally with some gravel. Test Pit TP95B-21 encountered black organic silty sand with interbedded lenses of silt to approximately 1.0 m-depth. The alluvial deposits can be subdivided into channel deposits and overbank flood plain deposits. It is interpreted that a channel deposit, comprising loose to compact sand, some gravel, trace to some silt and trace cobbles was encountered in Test Pit TP95G-01 and a flood plain deposit comprising soft grey silt with trace sand and trace organics was encountered in Test Pit TP96-B20.

An active fluvial fan intersects the meltwater corridor in the south part of the footprint of the proposed Open Pit. The fluvial fan deposits were found to comprise cohesionless soils ranging from loose to compact silty sand with some gravel and trace cobbles to sandy gravel with many cobbles. The 1995 ortho-imagery shows evidence of a recent debris flood on the fan. The mapped extent of the debris flood deposit is shown on Drawing G0002.

The surficial geology on the valley side slopes at the site of the proposed Open Pit is interpreted to predominantly comprise Ablation Till. The Ablation Till encountered in the site investigations ranged from silt and sand with some gravel and trace cobbles and boulders to sand and gravel with some silt and trace cobbles and boulders. Three small eskers were mapped along the toe slopes of the valley in the vicinity of the site of the proposed Open Pit. A glaciofluvial terrace was mapped on the valley floor immediately to the north of the footprint of the proposed Open Pit. One of the eskers was sampled in Test Pit TP95P-04. The material encountered comprised sand and gravel with some silt and cobbles and boulders. The glaciofluvial terrace was previously investigated in Test Pit TP95B-24. The material encountered comprised loose to compact gravelly sand to sandy gravel with trace to some silt and cobbles. Colluvial apron deposits have been identified at the toes of the valley side slopes at the site of the proposed Open Pit. The material encountered in the site investigation test pits included loose to compact organic silty sand to sandy silt and silty sand to sandy silt with trace to some gravel, trace cobbles and trace to some organics.

Permafrost was encountered in the 1995/96 site investigations especially in the finer grained alluvial, organic swamp and colluvial apron soils. Ice lenses with a width of approximately 25 cm and a thickness of approximately 10 cm were observed in an alluvial flood plain deposit comprising organic silt and sand with trace gravel. Several thaw lakes were identified in an organic swamp on the north side of the footprint of the proposed Open Pit. A possible thermal erosion feature was mapped in the vicinity of the west margin of the footprint area of the proposed Open Pit. These thaw lakes and thermal erosion features are interpreted as local evidence of permafrost degradation.

An area of solifluction was mapped on the slopes in the east part of the footprint area of the proposed Open Pit. Test Pits TP16-43 and TP16-45 encountered partly frozen cohesionless soil to approximately 1.0 m depth, interpreted as a solifluction deposit. The material encountered ranged from silty gravel with some sand and trace cobbles to organic silt and cobbles with trace sand and gravel. Test Pit TP16-41, undertaken in the north part of the footprint of the proposed Open Pit, encountered partly frozen organic silt with some sand and trace cobbles to 0.5 m depth. This material is also a possible solifluction deposit. The west margin of the proposed Open Pit footprint also extends into an area of soliflucted slopes.

4.4.2 Overburden Stockpile

It is interpreted from the terrain analysis that the surficial geology at the site of the proposed Overburden Stockpile predominantly comprises Ablation Till. There is limited available site investigation information to field truth this interpretation. Test Pits TP95-03C, 4C and 5C encountered clayey silt and sand with gravel and minor cobbles and boulders, which is interpreted to be Ablation Till.

Permafrost was encountered in 3 of the 4 test pits undertaken in the vicinity of the site of the proposed facility in the 1995 site investigation. Upslope from the site of the proposed Overburden Stockpile site, there is a bedrock knoll at an elevation of approximately 1,700 masl. The terrain analysis identified a narrow band of solifluction in the upper colluvial slopes. Stripes extend down slope from the toe area of the soliflucted slopes and extend across

much of the footprint area of the proposed facility. Stripes typically comprise loose very coarse soils and can be seasonal preferential flow paths for near-surface water within the active layer.

4.4.3 Class C Storage Facility

The terrain analysis shows the surficial geology at the site of the proposed Class C Storage Facility predominantly comprises Ablation Till. There is limited existing site investigation information to confirm this interpretation. Test Pits TP95-01C and TP95-02 C encountered silty sand with gravel and minor cobbles and boulders, interpreted as Ablation Till.

A meltwater corridor oriented towards the west-northwest crosses the footprint of the proposed facility. It is interpreted that glaciofluvial sands and gravels occur along this corridor and that the glaciofluvial sands and gravels extend beneath the footprint of the proposed Seepage Collection Pond. These deposits have not been ground-proofed in the previous site investigations. Abundant kames and kettles were mapped on the lower slopes adjacent to the drainage line especially on the south side of the valley. These landforms are characteristic of ice-contact glaciofluvial deposits. The particle size distribution of these soils is likely to be somewhat similar to that of the Ablation Till.

The two previous test pits undertaken at the footprint of the proposed facility did not encounter permafrost. Test pits undertaken in Ablation Till soils to the northwest did, however, encounter permafrost. It is interpreted that slope aspect has a significant control on the permafrost distribution and it is expected that permafrost is more widespread on north-facing slopes in the south part of the footprint of the proposed facility.

An extensive area of solifluction was mapped on the upper north-facing slopes in the vicinity of the site of the proposed facility. The area of solifluction extends into the proposed footprint, in particular in the west portion.

4.4.4 Class A and Class B Storage Facilities

The terrain analysis shows the surficial geology at the sites of the proposed Class A and Class B Storage Facilities and the intervening Topsoil Stockpile Areas predominantly comprises Ablation Till. Kames were mapped, locally across the footprint areas. These landforms are indicative of the presence of ice-contact glaciofluvial deposits. The Ablation Till encountered in the site investigations generally ranged from a sand and gravel with some silt and with cobbles to a sandy silt with trace to some gravel and cobbles. Boulders were occasionally encountered. Test Pits TP95B-14 and TP95-08, undertaken in the footprint of the proposed Class A Storage Facility, encountered firm silt with trace sand, trace to some gravel and trace cobbles. The Ablation Till was found to be locally frozen in test pits undertaken in the toe area of the north part of the footprint of the proposed Class A Storage Facility.

The glacial soils in the footprint areas of the two Seepage Collection Ponds, which are proposed to be sited down slope from the Class B Storage Facility, have been found to include slightly less fines. The soils encountered in the test pits undertaken in this area comprised sands with trace to some gravel and trace silt and cobbles. Local kame deposits were identified at the site of the proposed southern Seepage Collection Pond. It is interpreted that Test Pit TP 95G-09 was excavated into a kame. The south part of the footprint of the proposed southern Seepage Collection Pond impinges on an organic swamp.

Weathered argillite bedrock was encountered at approximately 0.5 m depth in Test Pits TP16-17, TP16-20 and TP16-24, undertaken in the south part of the footprint of the proposed Class A Storage Facility. Test Pits TP16-49 and TP16-51, undertaken in the north part of the footprint of the proposed Class A Storage Facility, also encountered weathered bedrock within 1 m of ground surface. The material encountered comprised weak highly weathered volcanic rock. Highly weathered bedrock was encountered within 1 m of ground surface, locally, in previous test pits undertaken at the sites of the proposed Seepage Collection ponds down slope from the site of the proposed Class B Storage Facility.

The terrain analysis identified soliflucted slopes in the upslope (west) part of the footprint of the proposed Class B Storage Facility. Two solifluction lobes impinge on the southwest part of the footprint of the proposed Class A Storage Facility. Test Pit TP16-18 was undertaken into the toe of one of these solifluction lobes. The material

encountered comprised sand and gravel with some clay and trace cobbles and boulders. The upslope portion of the footprint of the proposed southern Topsoil Stockpile Area crosses a solifluction lobe. Possible thermal erosion features were mapped down slope and to the east of the site of the proposed Class A Storage Facility. Gully erosion was mapped, locally, in the south part of the footprint of the proposed Class B Storage Facility.

4.4.5 Water Management Ponds

The Water Management Ponds are to be located on the Geona Creek valley floor, which is interpreted to be a pro-glacial meltwater corridor. Glaciofluvial sands and gravels occur along this corridor. Previous site investigation test pits have mainly been undertaken in the vicinity of the site of the proposed Lower Water Management Pond embankment. The glaciofluvial deposits encountered in the 1995/96 test pitting investigations comprised silty sand with some gravel and trace cobbles. The glaciofluvial deposits are overlain by organic swamp deposits and alluvium deposited by Geona Creek. At the site of the proposed Lower Water Management Pond, the organic swamp deposits were found to be up to approximately 5.4 m-thick (Test Pit TP106). This test pit encountered black organic silt with gravel lenses and some cobbles, trace wood fragments and ice lenses. An alluvial flood plain deposit comprising silty fine sand with trace fine gravel and ice lenses was encountered in Test Pit TP102.

The terrain analysis shows that the surficial geology on the valley side slopes in the vicinity of the sites of the proposed Water Management Ponds generally comprises Ablation Till. Colluvial Aprons have been mapped at the toe of the east side of the valley.

Permafrost was encountered in the majority of the 1995/96 tests pits undertaken on the valley floor in the vicinity of the sites of the proposed Water Management Ponds. Ice lenses were identified in the finer-grained organic swamp and flood plain soils. The extensive presence of permafrost in this area is attributed to the presence of fine-grained sediments and to the valley floor having a northerly aspect in this part of the site. Possible thaw lakes were identified in the footprint areas of both the Lower and Upper Water Management Ponds.

4.4.6 Mill Site

The terrain analysis shows the surficial geology at the site of the proposed Mill predominantly comprises Ablation Till. The material encountered in the test pits generally ranged from silty sand with some gravel to sand and gravel with some silt and trace cobbles. Boulders were encountered, locally, in the test pits. Permafrost was generally not encountered in the overburden soils in the test pits undertaken at the site of the proposed Mill. However, frozen silty sand to sandy silt with some gravel that included approximately 1 to 2 mm-thick ice lenses was encountered in Test Pit TP 96-B18. A possible thaw lake was mapped in the northeast corner of the footprint of the proposed Mill Site. Possible thermal erosion features extend down slope from the northeast corner of the footprint of the proposed Mill Site towards Geona Creek.

Weathered bedrock was encountered in most of the test pits undertaken at the site of the proposed Mill. It is interpreted that bedrock is shallowest in the northwest part of the footprint where weak to very weak highly weathered bedrock was encountered at 1.2 to 1.8 m depth.

4.4.7 Proposed Roads in the West part of the Site

In the west part of the site, it is proposed to construct parallel roads on the upslope and down slope sides of the Class A and Class B Storage Facilities. The surficial geology along the down slope alignment is expected to predominantly comprise Ablation Till, ranging from silty sand with trace gravel to sand and gravel with some silt and some cobbles. Test pitting has yet to be undertaken along the upslope alignment. Bedrock is expected to be relatively shallow along the upslope alignment. It is anticipated that the surficial geology predominantly comprises Ablation Till with local kame deposits along the north portion of the upslope alignment and predominantly comprises solifluction deposits along the south part.

4.5 POSSIBLE SOURCES OF FILL MATERIALS AND AGGREGATE

Ablation Till and ice-contact glaciofluvial deposits are the predominant surficial deposits at the site. Both these material types contain some fines and are potential sources of 'general' construction fill. Sources of suitable fine-grained fill are expected to be quite limited. This will likely be exacerbated by the propensity for permafrost accumulation in finer-grained soils. The 1995/96 test pits did, however identify local occurrences of cohesive till. Test Pits TP95B-14 and TP95-08, undertaken in the footprint of the proposed Class A Storage Facility, encountered a firm silt with trace sand trace to some gravel and occasional cobbles. Permafrost was not encountered in the cohesive till in these two test pits.

A few small eskers were identified within the footprint of the proposed Open Pit and a glaciofluvial terrace was mapped on the north side of the footprint. It is anticipated that these units comprise sands and gravels with only minor fines and are potential sources of aggregate and structural fill. Test Pit TP95B-24 was undertaken on the glaciofluvial terrace on the north side of the footprint of the proposed Open Pit. This test pit encountered sand and gravel with cobbles and trace to some silt. However, the glaciofluvial terrace was found to extend to 2.2 m depth, only. The fluvial fan deposits at the site are another potential source of aggregate and structural fill. The glaciofluvial deposits that occur along the meltwater corridors also provide possible local sources of aggregate and structural fill; however, the soils in these settings may need additional processing to remove fines and organics and there would be an increased likelihood of the suitability of potential borrow sites being affected by the presence of permafrost from the permitting perspective.

5 – LIMITATIONS AND UNCERTAINTIES

Terrain analysis mainly provides insight into the surficial geomorphic processes and surficial geology. Some surficial geological materials have clearer surface expression than others. Ablation Till, the surficial soil type that is interpreted to be the most widespread at the site, is generally characterized by hummocky topography although it does not always develop such morphology and such topography is not entirely unique to this geological material type. Some geological materials can be difficult to detect because they do not have clear surface expression (e.g. glaciolacustrine deposits) or because they are only present at depth. The findings of test pits undertaken at the site in 1995/96 and in 2016 provided a valuable source of ground-truthing as well as sub-surface geological information.

6 – CONCLUSIONS AND DISCUSSION

Terrain analysis has been undertaken for the KZK Project. The mapping was completed with the aid of a Bare Earth Digital Elevation Model that facilitated the identification of glacial landforms and periglacial and permafrost processes.

The majority of the site area has a blanket of glacial soils. The predominantly hummocky nature of the glaciated topography and the absence of glacial flutings (low linear ridges) suggest that Ablation Till is much more common within the Study Area than Lodgement (Basal) Till, at least within the near-surface overburden stratigraphy. The Ablation Till is associated with ice-contact glaciofluvial deposits characterized by kame complexes. Both of these geological materials were deposited when glacier ice stagnated and melted. The Ablation Till and kames predominantly comprise cohesionless soils that, nonetheless, have some fines. The Ablation Till has a more variable particle size distribution and is predominantly comprises silt. The 1995/96 test pits provide fairly widespread evidence of glacial lacustrine deposits in the vicinity of the site of the proposed Lower Water Management Pond. The soils encountered comprised soft to firm clayey silt with trace sand and loose to compact silts and fine sands, locally with trace gravel. A few small eskers were identified within the footprint area of the proposed Open Pit, and a glaciofluvial terrace was mapped on the north side of the proposed footprint. These units are expected to comprise sands and gravels with only minor fines and are potential sources of construction aggregate. Three Pro-glacial meltwater corridors were delineated in the mapping, a north-south corridor along Geona Creek and two west northwest oriented corridors, which intersect the Geona Creek corridor from the east.

Pro-glacial Meltwater Corridors are complexes of meltwater channels that formed in front of a retreating ice sheet. Glaciofluvial sands and gravels occur along these corridors.

Along the Geona Creek Meltwater Corridor, the glaciofluvial deposits are overlain by lake deposits and organic swamp deposits as well as alluvium deposited by Geona Creek. Lake deposits occur at the sites of the Lower Water Management Pond in the north part of the Study Area and the Open Pit in the south part. The lake deposits encountered in tests pits comprised sand and silt with trace fine gravel to clayey silt, locally with sand. The alluvial deposits along Geona Creek predominantly comprise fine-grained flood plain deposits (organic silts and sands with trace gravel) along with subordinate coarse channel deposits (sands with some gravel and trace to some silt). Three alluvial fans have developed at the confluences of tributary drainage lines with Geona Creek. The fluvial fan deposits were found to comprise cohesionless soils ranging from loose to compact silty sand with some gravel and trace cobbles to sandy gravel with many cobbles.

The terrain analysis highlighted local geohazards at the site despite the terrain being predominantly gently inclined. Debris slides have occurred, locally, on moderate natural slopes either side of Geona Creek. It is possible that these landslides were caused, at least in part, by permafrost degradation. There is an active fan at the confluence of Fault Creek and Geona Creek in the south part of the footprint area of the proposed Open Pit. The 1995 ortho-imagery shows evidence of a recent debris flood on the fan. Recent debris slides have been identified on the incised gully side slopes adjacent to Fault Creek and are a possible source of enhanced sediment load that could initiate debris floods.

The terrain analysis highlighted permafrost and periglacial processes to be widespread across the Study Area. The permafrost distribution is partly controlled by slope aspect with the sheltered north-facing slopes being the most prone to permafrost accumulation. In addition, the fine-grained soil types at the site are more likely to contain permafrost. The 1995/96 site investigations found permafrost to be more extensive along the portion of the Geona Creek drainage line in the north part of the Study Area where the valley floor has a northerly aspect. Stripes extend down slope into the footprint area of the proposed Overburden Stockpile. These features are likely to be preferential flow paths for near-surface water. Thaw lakes on the Geona Creek Valley floor and thermal erosion on the lower slopes on the west side of the valley are evidence of local permafrost degradation.

Extensive areas of solifluction were mapped on the upper slopes. The footprints of the proposed Open Pit, the three proposed waste storage facilities and the proposed road, which follows the western limits of the footprints of the proposed facilities, all extend across areas of solifluction. The terrain in these areas should be assumed to be unstable with respect to development and mitigation measures will needed to prevent slope instability.

There are inevitably remnant uncertainties with the geomorphic and geological models that should be addressed in future site investigation programs. These include:

- The extent and nature of glaciofluvial deposits along the Meltwater Corridor at the site of the proposed Class C Storage Facility.
- The overburden geology and permafrost conditions at the sites of the proposed Water Management Ponds.
- The sub-surface extents of glaciolacustrine soils and Basal Till at the sites of the proposed facilities.
- The possible presence of overconsolidated soils at depth beneath local deposits of Basal Till.
- The nature of the solifluction deposits especially in the south part of the footprint of the proposed Class C Storage Facility and along the proposed road alignment, which follows the western limits of the footprints of the proposed facilities.

This study highlights several geotechnical considerations to be addressed further:

- The possibility of permafrost degradation along the Geona Creek Valley floor in the north part of the Study Area being exacerbated by the development of the Water Management Ponds.
- The debris flood hazard in the south part of the footprint of the proposed Open Pit. It is recommended that consideration be given to developing a deflection berm on the south part of the fan in order to protect the open

pit and the proposed road, which follows the western limits of the footprints of the proposed facilities, from debris floods.

- The possibility of terrain instability occurring in the areas of solifluction as a result of construction activities. Terrain stability will need to be considered in this respect for proposed roads as well as for the proposed Open Pit and storage facilities.

It is recommended that reconnaissance terrain and terrain stability mapping of the project site be undertaken to provide baseline soils and terrain data to support on-going project development.

Please do not hesitate to contact the undersigned, should you have any questions regarding this report.

Yours truly,
Knight Piésold Ltd.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
J. E. HALEY
33730

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Reviewed:
Les Galbraith, P.Eng.
Specialist Engineer | Associate

Approval that this document adheres to Knight Piésold Quality Systems:

Attachments:

Drawing G001 Rev 0	Slope Angle Map
Drawing G002 Rev 0	Terrain Analysis
Figure 1 Rev 0	Historic Site Investigations
Figure 2 Rev 0	2016 Geotechnical Site Investigation

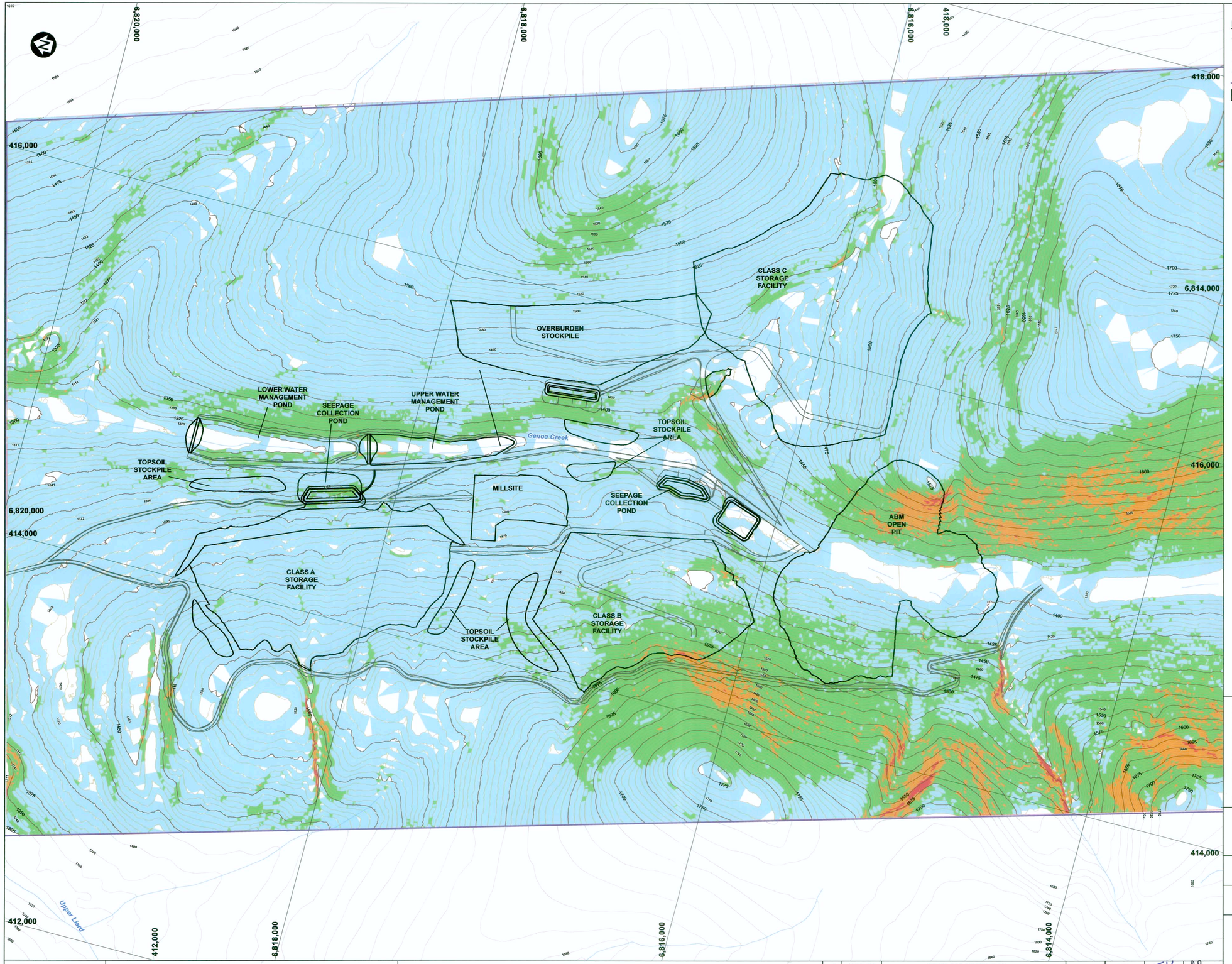
References:

Heginbottom, J.A. and Radburn, L.K. (1992). Permafrost and ground ice conditions of north-western Canada, Map 1691A, Scale 1:1000,000.

Jackson, L.E., Jr. (1993). Surficial Geology, Rainbow Creek, Yukon Territory; Geological Survey of Canada, Map 1797A, Scale 1:100, 000)

KP (2016a). Kudz Ze Kayah Pre-Feasibility Study – Geotechnical Site Characterization Summary

KP (2016b). Kudz Ze Kayah Project – 2016 Geotechnical Site Investigation Data Report



LEGEND

GENERAL

- CONTOUR (5 M)
- CONTOUR (20 M)
- RIVER/CREEK
- STUDY AREA
- PROPOSED MINE FACILITIES

SLOPE ANGLE

- 0 - 5% (PLAIN: 0 - 3 DEGREES)
- 6 - 26% (GENTLE: 4 - 15 DEGREES)
- 27 - 49% (MODERATE: 16 - 26 DEGREES)
- 50 - 70% (MODERATELY STEEP: 27 - 35 DEGREES)
- >70% (STEEP: >35 DEGREES)

ISSUED FOR INFORMATION

NOTES:

1. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 9N.

2. THE CONTOUR DATA IS 5 METRES LIDAR CONTOURS INSIDE THE STUDY AREA AND 20 METRES GEOYUKON CONTOURS OUTSIDE THE STUDY AREA. (HTTP://MAPSERVICES.GOV.YK.CA/GEOYUKON).

3. THIS MAP IS PRODUCED AT A NOMINAL SCALE OF 1:10,000 FOR 24X36 ("D" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

4. FACILITIES TAKEN FROM A PROJECT GENERATED ARRANGEMENT PLAN DATED NOVEMBER 16, 2016.

300 150 0 300 600 900 m

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. E. HALEY # 33730
Nov. 17, 2016

Knight Piésold CONSULTING

BMC MINERALS (NO.1) LTD

KUDZ ZE KAYAH PROJECT

SLOPE ANGLE MAP

P/A NO.	DRAWING NO.	REVISION
VA101-640/2	G0001	0

REFERENCE DRAWINGS		REVISIONS						REVISIONS					
DRG. NO.	DESCRIPTION	REV	DATE		DESIGN	DRAWN	CHK'D	APP'D	REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEWED	APPROVED
-	-								0	16NOV'16	ISSUED FOR INFORMATION	JEH	KK	JHH	BB

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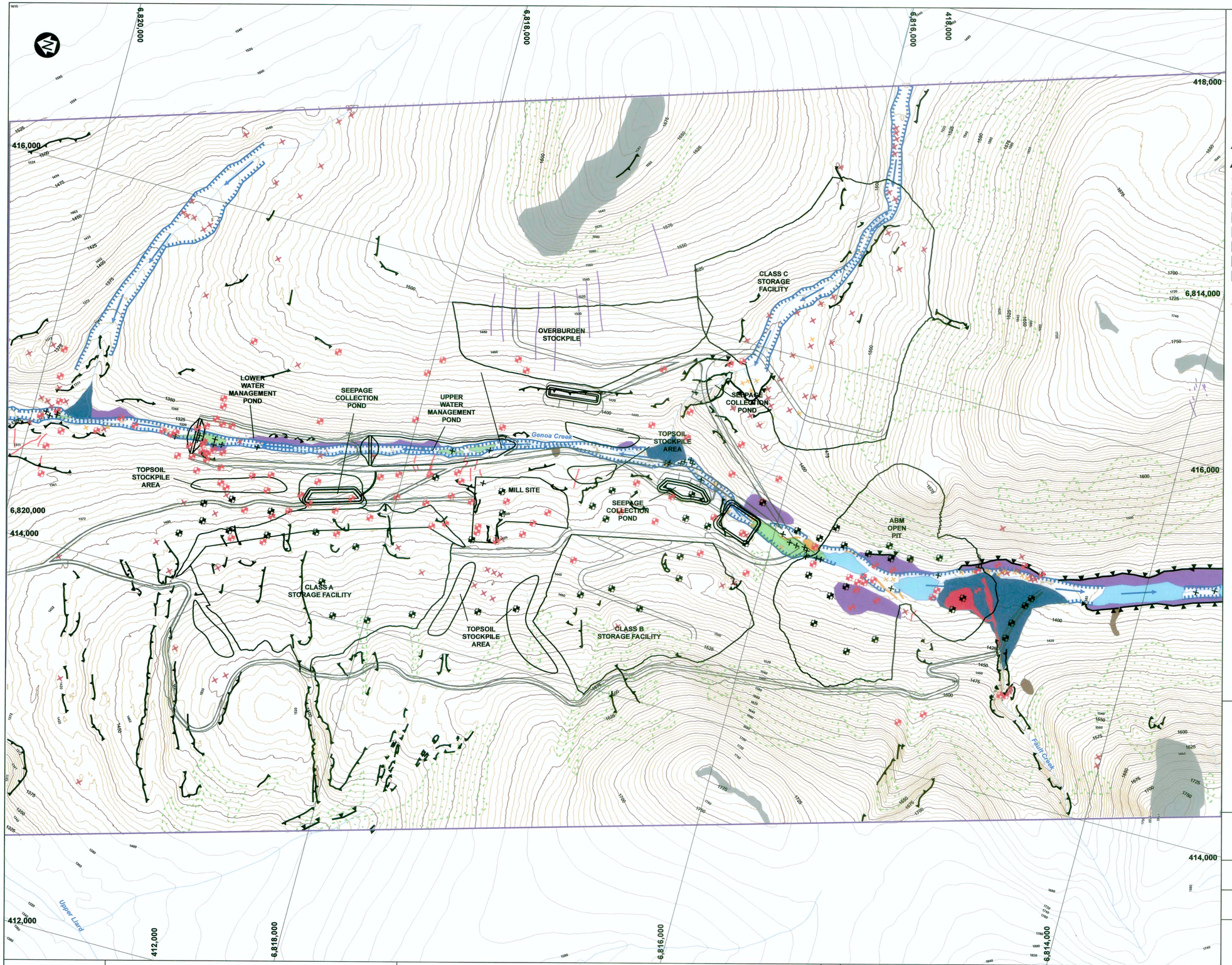

LEGEND

GENERAL
- TESTPIT 2016
- TESTPIT PRIOR TO 2016
- CONTOUR (5 M)
- CONTOUR (20 M)
- RIVER/CREEK
- STUDY AREA
- PROPOSED MINE FACILITIES

TERRAIN FEATURES
- CONVEX SLOPE BREAK
- CONCAVE SLOPE BREAK
- STRIPES
- MELTWATER CORRIDOR
- ORGANIC SWAMP
- ALLUVIAL FAN
- LAKE DEPOSIT
- COLLUVIAL APRON
- GLACIOFLUVIAL TERRACE
- BEDROCK KNOLL OR RIDGE

LANDFORMS
- ESKER
- KAME
- KETTLE

TERRAIN HAZARDS
- GULLY EROSION
- RECENT DEBRIS FLOOD DEPOSIT
- RECENT DEBRIS SLIDE
- DEBRIS SLIDE
- THERMAL EROSION
- THAW LAKE
- SOLIFLUCTED SLOPE

ISSUED FOR INFORMATION

NOTES:

1. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 9N.

2. THE CONTOUR DATA IS 5 METRES LIDAR CONTOURS INSIDE THE STUDY AREA AND 20 METRES GEOYUKON CONTOURS OUTSIDE THE STUDY AREA. (HTTP://MAPSERVICES.GOV.YK.CA/GEOYUKON).

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300 150 0 300 600 900 m

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — J. E. HALEY # 33730 — J.Haley NOV. 17, 2016

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KUDZ ZE KAYAH PROJECT

TERRAIN ANALYSIS

P/A NO.	DRAWING NO.	REVISION
VA101-640/2	G0002	0

REFERENCE DRAWINGS		
DRG. NO.	DESCRIPTION	
-	-	

REVISIONS						
REV	DATE	DESCRIPTION	DESIGN	DRAWN	CHK'D	APP'D
0	16NOV'16	ISSUED FOR INFORMATION	JEH	KK	JH	BB

REVISIONS				
REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEWED	APPROVED

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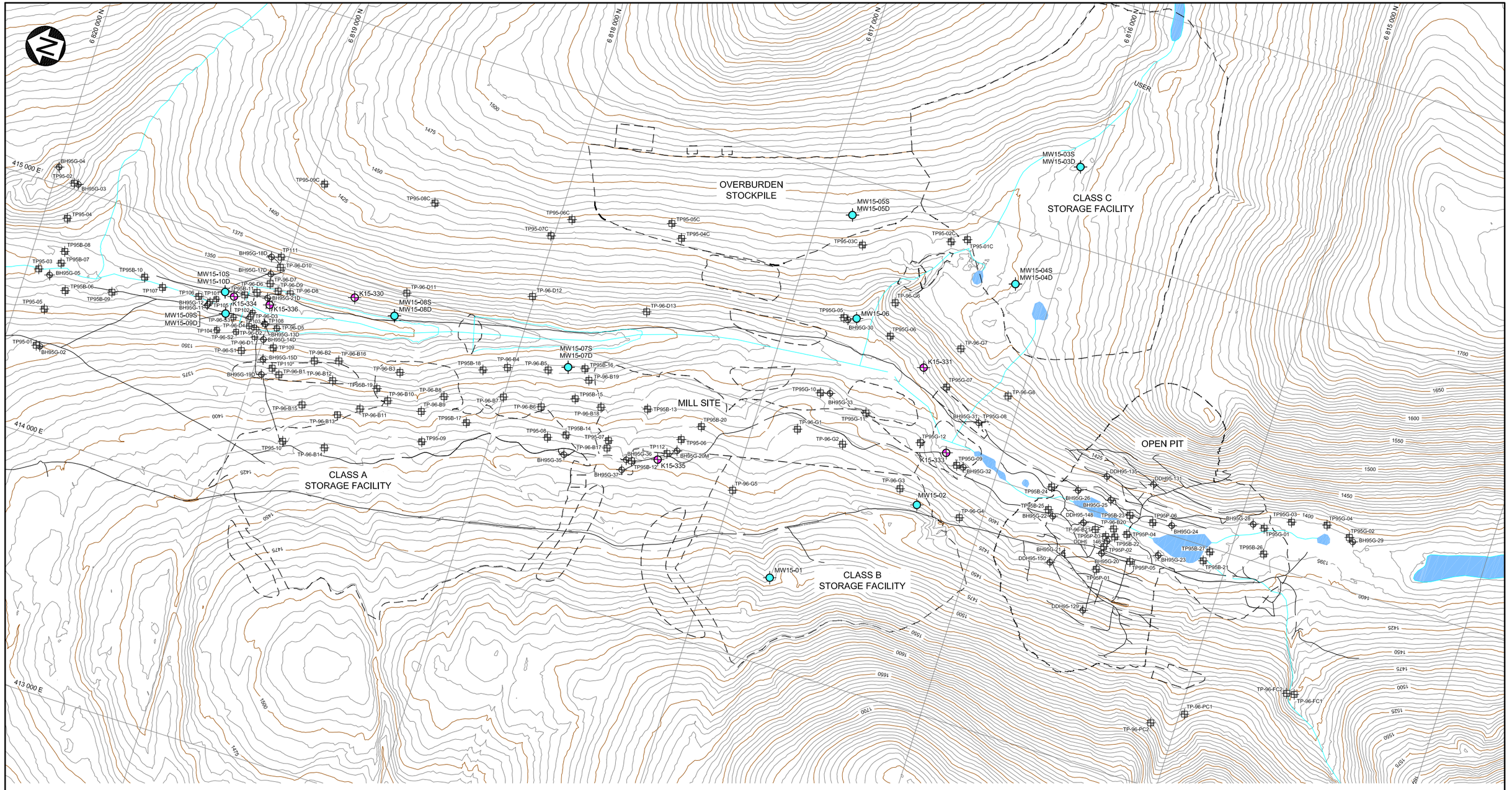

PLAN
SCALE A

150 75 0 250 500 750 m
SCALE A

NOTES:

1. COORDINATE GRID IS UTM NAD 83 ZONE 9N.
2. TOPOGRAPHIC DETAIL BASED ON INFORMATION PROVIDED BY BMC MINERALS (NO.1) LTD. FEBRUARY 2, 2016.
3. PIT SHELLS PROVIDED BY BMC MINERALS (NO.1) LTD. APRIL 8, 2016.
4. CONTOUR INTERVAL IS 5 METRES.
5. ALL ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

LEGEND:

- GROUNDWATER MONITORING WELL (TETRA TECH)
- GEOTECHNICAL DRILLHOLE (KNIGHT PIESOLD)
- PREVIOUS DRILLHOLE (GOLDER)
- PREVIOUS TEST PIT (GOLDER)
- PREVIOUS TEST PIT (GOLDER 1995)
- FACILITY OUTLINE
- RIVER/STREAM/DRAINAGE
- EXISTING ACCESS ROAD / TRAIL

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	02DEC'16	ISSUED WITH LETTER	JAG	KJM	LJG

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KUDZ ZE KAYAH PROJECT

FINDINGS OF TERRAIN ANALYSIS HISTORIC SITE INVESTIGATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-640/2	VA16-01804

FIGURE 1 REV 0

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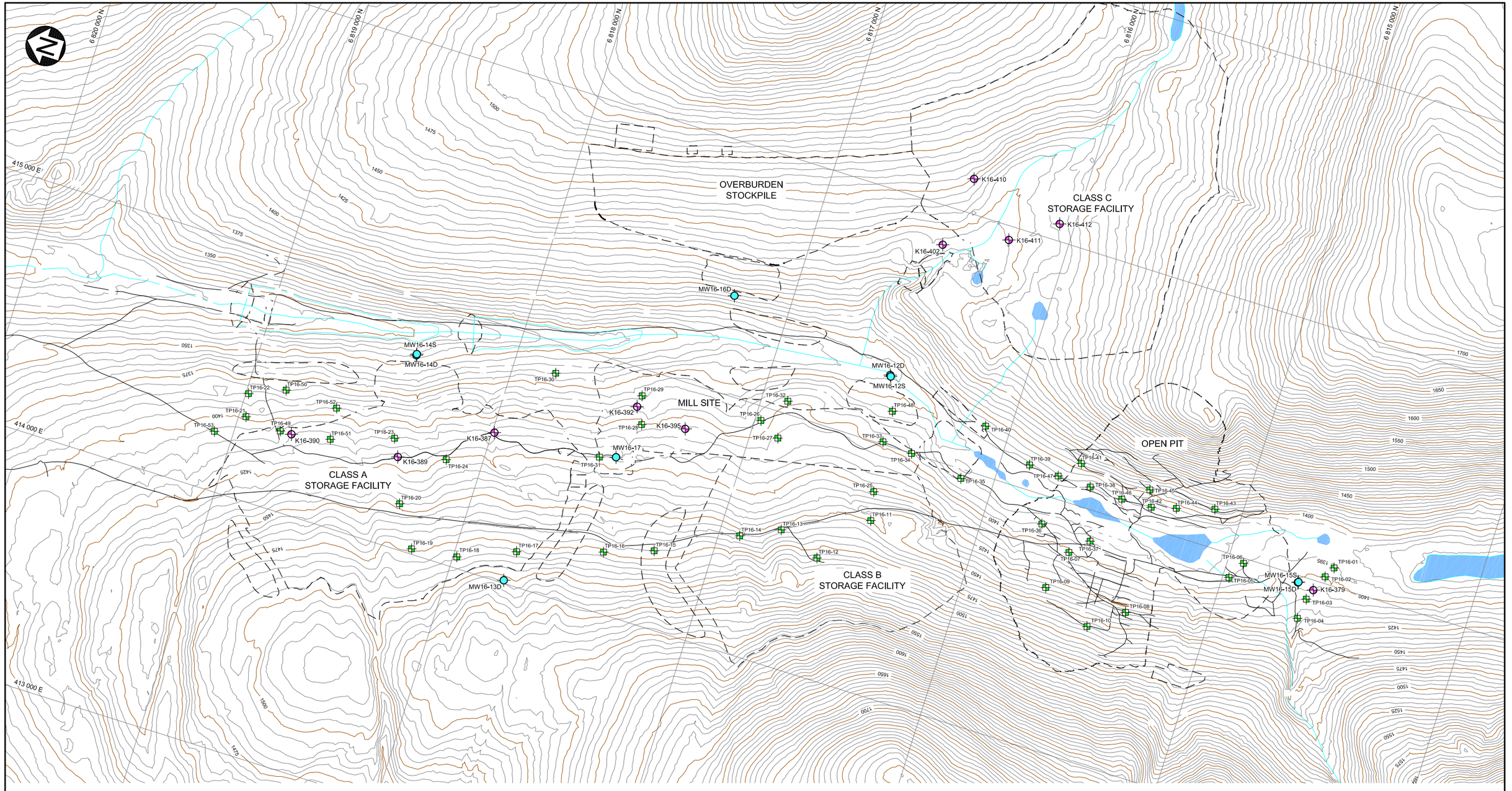

PLAN
SCALE A

SCALE A 150 75 0 250 500 750 m

NOTES:

1. COORDINATE GRID IS UTM NAD 83 ZONE 9N.
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LEGEND:

- GROUNDWATER MONITORING WELL
- GEOTECHNICAL DRILLHOLE
- TEST PIT
- FACILITY OUTLINE
- RIVER/STREAM/DRAINAGE
- EXISTING ACCESS ROAD / TRAIL

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	02DEC'16	ISSUED WITH LETTER	JAG	KJM	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

FINDINGS OF TERRAIN ANALYSIS
2016 GEOTECHNICAL SITE INVESTIGATION

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-640/2	VA16-01804

FIGURE 2 REV 0