Appendix D Evaluation of Potential Borrow Pits

1 EVALUATION OF POTENTIAL BORROW PITS

1.1 Km 0.55 – BP1 – Siltstone Colluvium

This potential borrow source has already been developed in past and has been partially depleted in the building of the water storage pond adjacent to the mine site. The material is loose colluvium siltstone from an exposed slope along the east side of the roadway. The material is fairly fissile and the exposed debris slope consists of relatively fine fragments of broken material. This material appears suitable for subgrade construction, but is not likely suitable for road surfacing material as it appears to have little strength and would probably break down quickly under wheel loads. The previously excavated areas of this material are currently being used for mine site monitoring wells, so future development of this source would have to avoid those areas. While this is a readily available and easily developed source, the materials appear to be of fairly poor quality and the next potential source down the road at KP 2.7 is likely a better option for long-term development in this area.

Figure 1: BP1 colluvium source material

1.2 Km 2.72 – BP2 – Mudstone Bedrock

The potential borrow source at BP 2 consists of crumbling bedrock that has been used in past by Canadian Zinc for miscellaneous roadway improvements. This source is identified as a calcareous mudstone that appears very competent in comparison to the previous siltstone source at 0.55 km. Based on the materials developed here to date, it appears that this rock source readily fragments under the blade of a bulldozer, although this favourable trait may decrease with bedrock depth. In past, the use of a grizzly screening unit at the site removed any oversized materials prior to loading the materials into trucks for movement. The apparent hardness and blocky fracture properties of this material may make it suitable for crushing for surfacing material, and it seems to pack into a very dense state. One limitation for a crushing operation is the proximity to Prairie Creek would constrain the amount of area for the crushing and stockpiling of any large amounts of materials.

Figure 2: BP2 materials pushed from a higher rock face for screening with a grizzly.

Figure 3: Close up of the BP2 mudstone with sparry calcite cementing.

Figure 4: BP2 viewed from the north and showing the limited processing area available.

1.3 Km 4.01 – BP4A – Limestone/Mudstone Face Exposure

While the rock source at 4.01 km is not a preferred material source, there may be a large quantity of this material removed as waste rock in the building of the final road along this section. The material consists of a tall face of limestone/mudstone that may present a rockfall hazard to the present road location. In the event that this rock face has to be excavated back further, large amounts of waste rock will be generated and this material could be used to supply any anticipated borrow needs in the general area. It is anticipated that this material is more suited for subgrade construction that for surfacing material as it fractures quite easily and doesn't appear to be very durable in nature. Again, the close proximity of Prairie Creek will be a constraint to any processing or load out operations proposed here.

Figure 5: The rockfall hazard at 4.01 km may generate a large quantity of waste rock that could be used to supply subgrade borrow needs elsewhere nearby.

1.4 Km 4.49 – BP4B – Limestone/Mudstone Colluvium

Slightly further up the road route from the BP4A location is the site of a developed colluvial limestone/mudstone source that has been designated BP4B. This is basically a large talus slope that abuts to the current roadway, presenting a perfect natural source of shattered rock materials. It appears to result from the same parent rock as in BP4A, but the fragment sizes are much smaller in the colluvial slope. Again, this material seems more appropriate for subgrade construction material than for surfacing material due to its weak plane structure. In terms of ease of development for a talus source in the general area, the BP4B source is very straight forward operation – basically it appears ready to load out as it currently sits. However, if the slopes in the area of BP4A need to trimmed back due to rockfall issues, then it makes sense to use the BP4A material for borrow instead since it will already be loaded into trucks for removal.

Figure 6: The currently developed face of the colluvium talus slope at BP4B.

1.5 Km 6.78 – BP6 –Mudstone Bedrock/Colluvium

BP 6 is another case where rock face crowding the current road corridor presents an opportunity for a borrow pit due to economics. Any excavated material here will likely have to be hauled out for disposal. Once loaded into a truck it could be used to supply borrow needs elsewhere in the general area. This material appears to consist of mudstone and as such would be more suited for subgrade construction material than for surfacing material.

Figure 7: View from the north of the rock face (BP6) at 6.78 km

1.6 Km 10.02 – BP10 – Argillite Colluvium

Bp10 is a potential source of black argillite colluvium exposed in a slope alongside the roadway at 10.02 km. This material evidently extends for several hundred meters along the road here, but permafrost might be a strong possibility in the slopes as they are located on a northern aspect. Based on the material evident in the surface exposure, any permafrost in this slope may be ice poor, but it may still be a stability factor due to slow creep within the steep slope. The material in the slope does contain some competent looking large fragments that may serve as light to medium sized riprap. Riprap will be needed in this section of the road route, and along adjacent sections as well, to help manage stream flow adjacent to the roadway. This source contains some of the largest and most competent fragments noted on the western end of the road route. Planning for permafrost prior to any development is recommended.

Figure 8: BP10 material showing a wide size gradation. Also note some evidence of creep along the slope – this is assumed to be related to permafrost.

Figure 9: Some of the potential light riprap material noted in the BP10 slope.

1.7 Km 14.88 – BP14 – Limestone Colluvium

Bp14 appears to consist primarily of a limestone talus slope along the road corridor in a high mountain pass at 14.88 km. The gradation of the material is generally toward fragments of less than 0.3m, but some occasional embedded boulders within the matrix could be used for medium to large sized riprap. This talus slope is derived from limestone bedrock, making it an ideal construction material as it poses no risk of acid drainage – it is actually an acid neutralizing material. At this location, the potential borrow pit material is best suited for either subgrade fill or riprap, as the ground is too steep to accommodate a crushing operation for road surfacing material. BP 16 may offer better opportunities for setting up a crushing plant if required. This rock would likely create a superior surfacing material for the new road as it should be quite durable in nature and pack extremely well. The light color of this rock helps reduce solar heat absorption as well, making it a preferred choice if there is a need for filling over permafrost areas to help keep the ground insulated.

Figure 10: The limestone talus slope at 14.88 km (BP14).

1.8 Km 15.8 – BP 16 - Glacialfluvial Gravel

A large esker like deposit of limestone gravel left behind from the glaciers. Appears to be a large quantity and quality should provide enough room to accommodate a crush plant but it may be tight.

Figure 11: Large esker like deposit of glacial-fluvial gravel at 15.8 km.

1.9 Km 25.5 – BP 25 – Glacial-fluvial Gravel

A large esker like deposit of limestone gravel left behind from the glaciers. Appears to be a large quantity and quality. If required, should have adequate room for a crush plant.

Figure 12: Large esker like deposit of glacial-fluvial gravel at 15.8 km.

1.10 Km 33.5, 34.5, 35.5, 37.5, 38.3 – BP 33, 34, 35, 37, 38 – Large Fragmented Talus Rock

All similar large fragmented talus rock deposit found along the lower Sundog Creek parallel to the proposed road location. Will work well for the proposed road construction approach along the lower sections of lower sundog.

Figure 13: Large talus rock deposits along a number of locations of the lower Sundog Creek between Km 33 to 39.

1.11 Km 39.20 – BP39 – Alluvial Floodplain Cobble/Gravel – Carbonates

Bp39 lies on a meander along the southern margin an old alluvial floodplain along Sundog Creek. This section of the alluvial plain will become isolated from the main stem of the creek when the permanent access road is constructed. Once the road is constructed, this fringe margin of the old floodplain will no longer be subjected to the spring floods that have overtopped the dry gravel bar here infrequently in past. With the removal of the risk of flooding on this area, the deposited gravel materials here could potentially be extracted for road construction because it is located outside the active high water levels. This area could be one of the most important potential borrow sites along the planned roadway, as it contains washed carbonate materials (limestone/limy siltstone) that make for a preferable construction material. This light colored, durable, and non-acidic cobble and gravel would be a preferred material for use at many places within the project area because of it properties. It could be processed by crushing and screening into a highly durable, long-term road surfacing material for construction and maintenance purposes. The material is extremely free draining and its light color would not absorb much solar heating so it would assist in insulating fill material over permafrost zones (if required). Because it is situated on the fringe of an old alluvial wash channel, there is a good likelihood that this material is free of permafrost as well. The large flat here is also advantageous for operating a crushing plant and for stockpiling crushed materials until they can be applied to the road. Since the area may be subject to a fluctuating water table (as controlled by seepage from nearby Sundog Creek), any gravel excavation would need to be carried out during periods with a low water table.

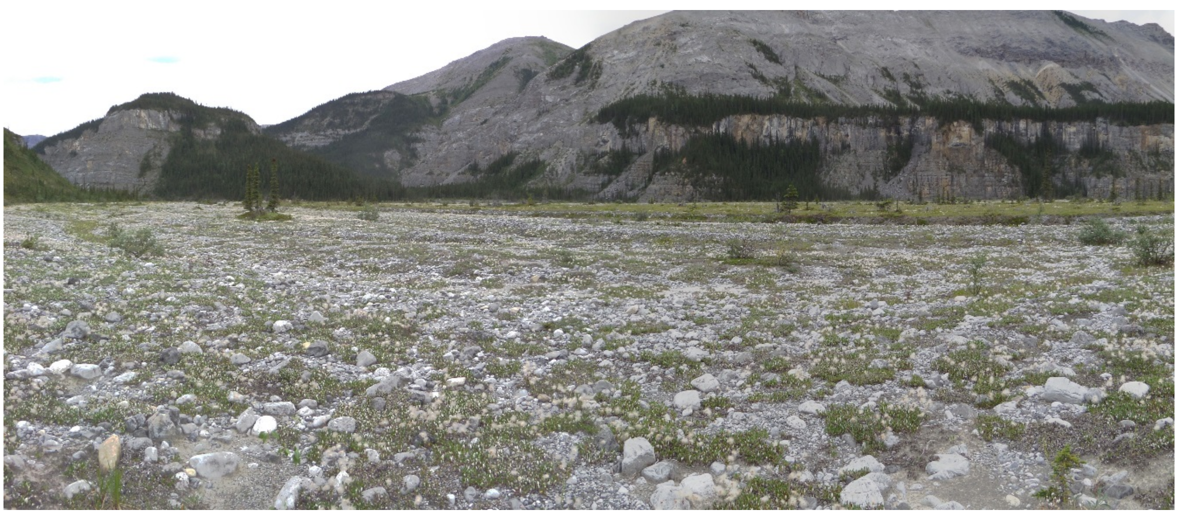

Figure 14: This dry alluvial flood plain at 39.20 km will become isolated from the main stem of Sundog Creek during road construction, providing opportunity to develop it as a crushed gravel source – BP39.

Figure 15: Typical gravel and cobble material available at BP39. This material consists primarily of Paleozoic carbonate rocks as evidenced by the abundance of fossilized coral fragments throughout the aggregates.

1.12 Km 40.0 – BP 40A - Alluvium Gravel/Cobble

Similar deposit as identified at BP 39, an old floodplain of Sundog Creek. Perhaps more attractive than BP 39 because closer proximity (1 km) to the intended destination. Expect it to be a shallow depth as to not compromise the water table. If required, ample room for crushing plant.

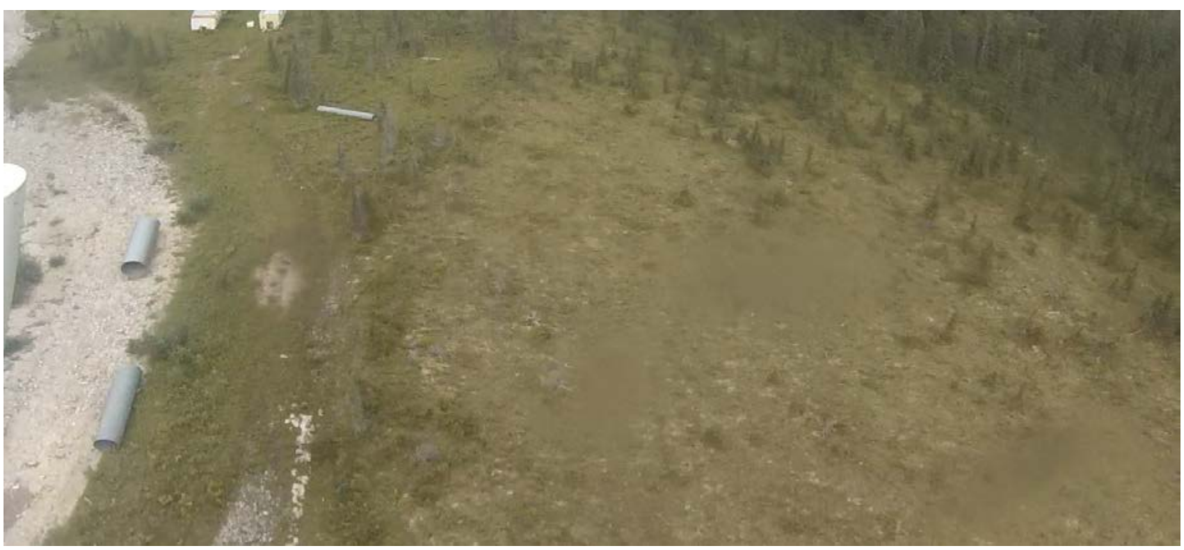

Figure 16: Old flood plain of Sundog Creek utilized as a camp/laydown area (Cat Camp) from the 1980 winter road construction.

1.13 Km 40.9, 41 – BP 40B, 41 - Silty Sand

Not field confirmed but expecting similar material type that was consistently observed in the surrounding area. Should provide adequate base material for subgrade material for expected localized overland sections. Expect shallow pit depths of 2 m.

Figure 17: An aerial view of an elevated "hump" of expected silty sand which should provide adequate base material to support overland sections.

1.14 Km 43.15 – BP43A – Fine Sand – Esker Deposit

At 43.15 km a small esker of fine sand (BP43A) is crossed by the road route. This esker runs in a westerly direction from roadway, and could be developed as a long-term source of sand for winter road sanding and for pipe bedding material during construction. During construction, this sand deposit could also be used for free draining road fill across lowlands.

Figure 18: View of the existing cut for the past winter road across the end of the esker at 43.15 km.

Figure 19: Example of the fine sand in the esker source designated as BP43.

1.15 Km 43.65 – BP43B – Medium Sand Deposit

BP43B is situated at 43.65 km and covers an area containing an existing borrow pit of medium sand from the original winter road construction era. While this particular area has been designated as the borrow site, the sand deposit itself runs from approximately 43.5 km to 45.75 km. As with the BP43A site, this sand has potential for pipe bedding, winter road sanding, and for subgrade fill across lowland areas. The material in BP43B grades a little coarser than the material in BP43A, so if may be a bit more appropriate for lowland fills where the pumping of groundwater into the subgrade may be a concern.

Figure 20: View of the sand material in the original construction borrow at 43.65 km.

1.16 Km 47.00 – BP47A – Limestone Bedrock

BP47A is situated about 300 m south of 47 km, and consists of a large rock face along a seasonal side drainage that enters from the south and parallels the route to the east. While this side valley is off the planned corridor construction footprint, it does contain two potential sources of important construction materials, and could be readily accessed with a short access road and crossing over a small stream. This rock face, and the scree slope situated below it, offers a source of both colluvium and solid rock limestone for road development needs. These raw materials could be used to generate construction materials ranging from crushed surfacing materials and subgrade rock fill, to riprap for armouring. Geologically, this area consists extensively of carbonate based bedrock so all the materials available for borrow here should be acid neutralizing materials.

Figure 21: View of BP47A limestone bedrock face.

Figure 22: The small stream that would need to be crossed to access BP47A and BP47B.

1.17 Km 47.00 – BP47B – Alluvial Floodplain Deposit - Carbonates

BP47B is also situated to the south of 47 km and requires the same short access road and creek crossing as BP47A would in order to develop it. This potential borrow source consists of alluvial gravel deposits (carbonate based) situated along the west side of a valley entering from the south. The stream within the valley is seasonal and appears to be dry except for during the higher spring runoff periods when it briefly avulses and deposits gravels across the broader floodplain. As such, this deposit is similar to that of BP39, in that material excavation would likely be possible during the drier summer, fall, and winter months, and the depth of excavation could be controlled by a fluctuating water table. There is also a possibility that the low level water flows are carried underground in subterranean channels within the limestone bedrock. Shallow gravel excavations carried out further back from the seasonal channel would be practical, but would require additional planning.

Figure 23: View of BP47B alluvial deposit area.

Figure 24: Typical BP47B alluvial deposit materials derived from carbonate parent rock.

1.18 Km 47.7 – BP 47C - Colluvium and Bedrock Limestone

Assumed a similar rock formation as identified in BP 47A however is adjacent to the proposed road location so more accessible.

Figure 25: Exposed rock face adjacent to the proposed road at KM 47.7.

1.19 Km 50.2 – BP 50B – Fine Sand

Could be easily expanded and would provide adequate material for localized overland sections.

Figure 26: An example of the fine sand material found near BP 50B.

1.20 Km 50.88 – BP50 – Fine Sand

BP50 is part of a broad area of fine sand found between 50.88 and 51.75 km that could be used for subgrade fill over the wetter lowlands in the area. These lowlands present relatively deep organics and potentially permafrost at depth. This material provides free draining borrow, but it is also quite fine and it would have to be capped with coarser materials to protect it from potential surface erosion after construction.

Figure 27: The fine sand in BP50 is potential fill for crossing over nearby lowlands.

1.21 Km 51.70 – BP51 – Fine Sand

BP51 is part of the same broad sand deposit that BP50 is situated on, but BP51 is located strategically on the west end of a wide lowland with deep organics that the road must cross. This lowland area, possibly with permafrost under it at depth, must be crossed using overland construction techniques to build the subgrade. Overland construction involves "floating" a roadway across areas with deep organics by leaving the organics undisturbed and covering them with a thick layer of imported free-draining material taken from suitable borrow sources. BP51 would provide a suitable borrow source on the western end of the long overland section running from about 51.75 km to 52.95 km. As with BP50, this sand is quite fine and would have to be capped with coarser material to control the potential for surface erosion.

Figure 28: The fine sand in BP51 is a potential overland subgrade borrow source on the west side of a section of deep organic lowland running from 51.75 km to 52.95 km.

Figure 29: Aerial view of the BP51 source area – burned area (grey) indicates the sand.

1.22 Km 53.40 – BP53 – Fine Sand with minor Gravel

BP53 is located at 53.4 km, slightly beyond the eastern end of the wide lowland area that the road must cross between 51.75 km to 52.95 km with overland construction. BP53 is located on the nose of some benched terrain that juts out on its east side toward Poljie Creek and is bordered by an ancient paleo-channel of Polje Creek on the north. The upper bench level consists primarily of the same fine sand as was noted in BP50 and BP51, while the lower bench has some slightly coarser sand with some minor gravel and shale fragments. All this material is free-draining and suitable for the overland fill required between 51.75 km to 52.95

km. As with the previous borrow sites in this area, this sand is quite fine and would have to be capped with coarser material to control the potential for surface erosion. Previous subsurface geotechnical drilling at nearby Poljie Creek also indicated some gravel deposition at depth in this general area, so the lower levels of this borrow area have some limited potential for glaciofluvial gravel deposits as well.

Figure 30: Fine sand with minor gravel and shale showings in the lower bench of BP53.

1.23 Km 54.60 – BP54 – Rock Knob - Carbonates

At 54.60 km the road route passes in close proximity to the northern end of a chain of carbonate rock protrusions along the east side of Poljie Creek. The protrusions forming BP54 consist of two low, timbered, rock outcrops on the north end of a chain of carbonate exposures that become visually impressive further south where they form karst cliffs and pinnacles overlooking Poljie Creek. While physically connected to this same chain of karst exposures, the BP54 outcrop knobs are very subdued outlying outcrops, with very little aesthetic value evident. They do however provide a good potential source of carbonate rock that could be developed into a needed source of riprap and ballast for construction within the general area. Depending on the depth of the material that can be developed here, there may be enough volume in these exposures to justify a small rock crushing operation to develop superior surfacing for the road and for the proposed airstrip nearby. This rock would also form an excellent capping material for the sand fill proposed for overland construction in the section from 51.75 km to 52.95 km to the west. It would armour the sand fill from erosion and provide a light colored reflective surface to prevent solar heat absorption into the fill should permafrost be present at depth.

Figure 31: Aerial view (looking east) of the carbonate rock exposures proposed for BP54.

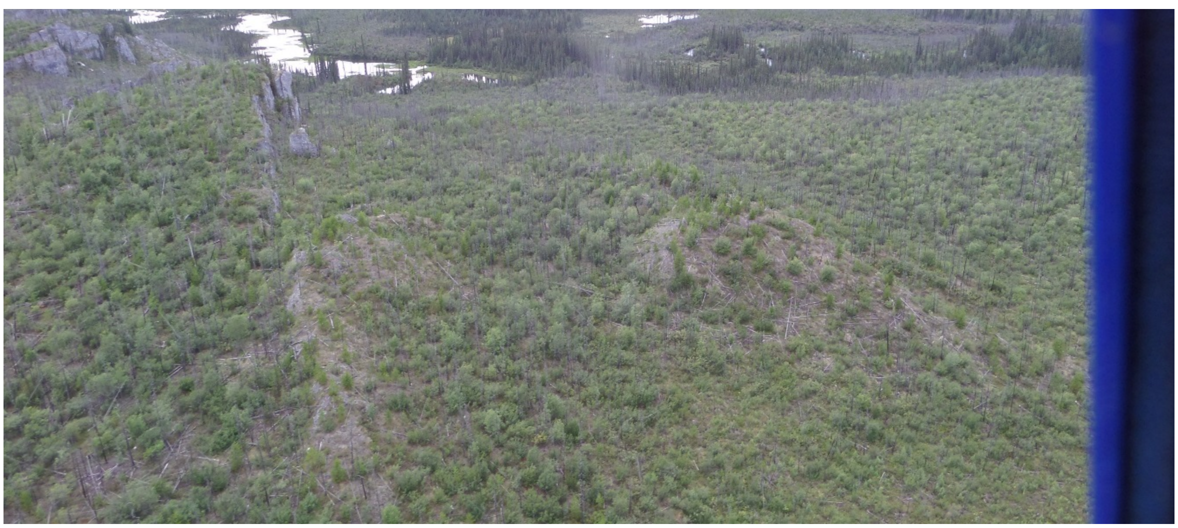

Figure 32: Aerial view (looking southwest) of the timbered carbonate rock knobs (lower center) proposed for BP54. The more exotic karst formations (upper left) that start further south along Poljie Creek, are not part of the proposed BP54 borrow area.

1.24 KM 55.3 – BP 55 – Shale Rock Knobs

Shale rock knobs comparable to BP 54 however the road passes thru them. Could be utilized for excellent subgrade base over overland sections and/or possibly surfacing.

Figure 33: The fragmented shale rock knob the road passes thru at km 55.3.

1.25 KM 55.9 – BP 56 – Exposed Shale Rock Knob

Exposed shale rock knob located along the upper cut-slope of the proposed road. Could provide excellent subgrade material and possibly for surfacing.

Figure 34: A large exposed shale rock sideslope near KM 55.9.

1.26 KM 56.5 – BP 56B – Shale Rock Knob

Exposed shale rock knob located in close proximity to road location. Could provide excellent subgrade material and possibly for surfacing.

Figure 35: An example of the shale rock found at Km 56.5.

1.27 Km 59.41 – BP59 – Sub-rounded Sedimentary Gravels & Sand

BP59 consists of a shale based gravel deposit exposed in a constructed cut at 59.41 km along the old winter road. The material is fairly sandy but is still one of the better looking glaciofluvial gravel materials noted within the general area. It could be used as a lower durability pit-run gravel source, or for fill for the road or the nearby proposed airstrip. This gravelly material appears in exposures along the old winter road right up to about 59.90 km.

Figure 36: Shale based sandy gravel noted along the old winter road at 59.41 km (BP59)

Figure 37: Similar looking material found along winter road at 59.90 km.

1.28 Km 61.40 – BP61 – Siltstone Exposure

BP61 consists of a siltstone outcrop exposed in a cut along the old winter road at 61.40 km. The material is quite fissile and likely of low durability, but is one of the best construction materials found in this section of finer grained moraine deposits with occasional seepage zones. This material can be used to firm up areas of soft ground and to repair some ditch and shoulder erosion that has occurred on a few steep grades along the old winter road west of this location.

Figure 38: Fissile siltstone exposure.

1.29 Km 64.87 – BP64 – Glaciofluvial Gravel - Eskers

BP64 constitutes but a small portion of a very large glaciofluvial kame/kettle deposit that is several kilometers in size and situated south of Mosquito Lake. The material contains sub-rounded sedimentary rock fragments in a matrix of silty sand that would pack well for road surfacing and may even have some natural dust control properties. The potential gravels here are quite deep and additional sampling at depth would be needed if it is necessary to confirm suitable gradation throughout. The BP64 location is situated about 400 m west of the planned road route, and has the best looking gravel from multiple sampling locations taken along the nearby esker chains. This area could be developed for gravel pit purposes with a short section of easily constructed access road across well drained soils. If however, the quantity of materials at BP65 is proven out by deeper test excavations, then it would be simpler to develop that material directly along the roadway.

Figure 39: Overview of major glaciofluvial deposits south of Mosquito Lake (background)

Figure 40: Sub-rounded gravel present in the BP64 sample area

1.30 Km 65.15 – BP65 – Glaciofluvial Gravel

BP65 also falls on the large glaciofluvial kame/kettle deposit previously noted for the BP64 site, but this borrow site falls along the existing roadway and doesn't require additional access road to develop it. BP65 appears to fall along the southern edge of the deposit area, and the depth of deposition will likely be substantially shallower in comparison to the esker deposit at BP64. As evidence of the potential for a shallow deposit here is the rock knob of primarily fissile shale that protrudes up through the area on the west side of the road. The base of this hill may contain more shale than gravel. This shale, in itself, is a potential borrow material for subgrade construction and the rock knob here appears to contain a substantial amount of it. The gravel materials sampled along the road here also appear fairly variable in composition over short distances. That, taken in combination with potentially shallow gravel deposition in this area, indicates a need for additional investigation to a greater depth to confirm materials prior to any large pit development. A low ridge formation (esker?) protruding out into the wetland on the southeast side also may contain gravels, but this formation wasn't sampled during the field reconnaissance. Should further testing in this area indicate a limited gravel volume, the use of BP64 would be the preferred alternative due to the volume available there.

Figure 41: Test pit with well-rounded gravel at BP65. Another test nearby revealed more angular shale gravel content, so the area is somewhat variable for gravel composition.

Figure 42: Exposed face with both blocky and fine fissile shale was noted in a rock knob about 200 m southwest of BP65. This material likely extends back close to the road

1.31 Km 67.52 – BP67 – Shale Colluvium

At 67.52 km the road route runs along the toe of a steep (70%) hillside that is covered in fine shale talus. Shale colluvium is apparent along the entire hillside above the road here up to about 67.8 km, but this location has the cleanest exposed talus material noted in the area. This material would be suitable for overland fills and for firming up areas of soft ground, but wouldn't be a very good surfacing material due to its fractures and sharp fragments. There is also some potential for ice poor permafrost in this hillside, due to the northern aspect of this talus face, so additional investigation would be prudent before any development is carried out.

Figure 43: Surface talus exposure of fine shale at 67.52 km (BP67).

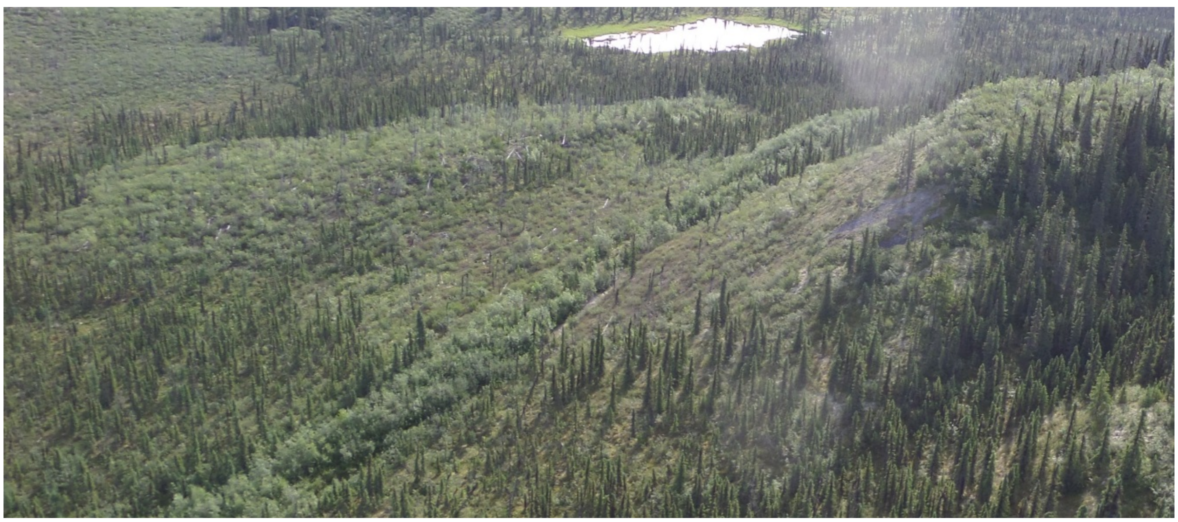

Figure 44: BP67 talus sidehill (center right) with old road running diagonally across view.

1.32 Km 70.75 – BP70 – Fine Sand

The route crosses a sidehill with an old cut slope showing fine sand material intermixed with minor colluvium shale at about 70.75 km. This material (BP70) is free draining and good for subgrade fills in overland sections. There are several small lowland sections requiring overland fills within the general area.

Figure 45: Fine sand material at 70.75 km (BP70)

Figure 46: The existing cut slope at BP70. The weathered face appears to be colluvium shale because of the residual fragments left in place, but the slope is in sandy materials.

1.33 Km 72.86 – BP72 – Fine Sand

The current route cuts through a low knob of sand at 72.86 km, which is directly adjacent to a wetland crossing that requires an overland fill that was not constructed as part of the original winter road. The wetland crossing is approximately 130 m long, and it will need an appreciable volume of fill material to build a new subgrade across it. The sand knob here (BP72) is strategically located for supplying the needed subgrade fill volume for the crossing, and the existing cleared road footprint can be re-utilised to reduce new ground disturbance as well.

Figure 47: Sandy material in a low hump at 72.86 km (BP72) can be used in a wetland fill.

1.34 Km 76.23 – BP76 – Fine Sand

In an almost mirror image of the BP72 situation, this small hump of sand at 76.23 km (BP76) is strategically located next to a wetland crossing that will need to be built up with fill as well. Again, the existing road footprint can be re-utilised to reduce new ground disturbance at the borrow site.

Figure 48: Another small sand hump at 76.23 km can provide fill for a wetland crossing.

1.35 Km 77.22 – BP77A – Sandy Till

Between 77 km and 78 km a broad lowland area must be crossed by the road, and additional borrow to build overland subgrade fills will be needed. This lowland area only presents a few opportunities for borrowing nearby material, and these areas consist of long low glacial deposition ridges left within the lowland margin area itself. As the existing winter road crosses these low ridges, it is advantageous to borrow the drier materials found in these areas for constructing the subgrade fills across the lowland. Any additional materials required to complete the fills will have to be imported from borrow sources further away.

Figure 49: A low ridge of higher sandy till (BP77A) crosses over the road route laterally at 77.22 km. This source of drier material could be used to build some of the overland fills that will be required to cross the wetland.

1.36 Km 77.70 – BP77B – Sandy Till

At 77.70 km, another low relief ridge of dry sandy till (BP77B) lies on the south side of the existing road. This source, in conjunction with BP77A, could be used to supply some fill for the overland subgrade crossing of the lowland to the west of this location.

Figure 50: A small hump of higher sandy till (BP77B) lies on the southern side of the road at 77.70 km. This source of drier material could also be used to construct some of the overland fills that will be required to cross the nearby lowland area.

1.37 Km 78.52 – BP78 – Sandy Till

The nose of a ridge crossed at 78.52 km provides another source of dry sandy till (BP78) for constructing overland fills in this area of low ground.

Figure 51: A small ridge of sandy till (BP78) lies under the road route at 78.52 km. The drier material here could be used to construct adjacent overland fills.

1.38 Km 84.2 – BP 84 – Sandy Till

Similar to PB 78, expected sandy till type material to be utilized for localized overland sections.

Figure 52: The road passes through the center of this aspen patch and the borrow area parallels the road.

1.39 Km 86.35 – BP86A – Medium Sand

A soil exposure on an existing cut face along the original winter road reveals a source of medium sized sand at 86.36 km (BP86A). The material appears to be very free draining and suitable for pipe bedding or overland fill material.

Figure 53: Sand material found in an existing cut slope at 86.35 km. This is some of the cleanest sand noted in the area and could be used for pipe bedding and overland fills.

Figure 54: Existing cut slope exposing the BP86A sand material. Large timber growing on the site indicates the area is likely permafrost free.

1.40 Km 86.52 – BP86B – Medium Gravelly Sand

Another nearby soil exposure along an existing winter road cut face at 86.52 km (BP86B) reveals medium sized gravelly sand within the slope. This material could be utilized as road fill for construction over an adjacent lowland area, and for overland construction across other lowland sections to the northwest.

Figure 55: Medium grain sized gravelly sand material found in an existing cut slope at 86.52 km.

Figure 56: Aerial view of the BP86B site (right of center) showing the ridge containing gravelly sand.

1.41 Km 87.52 – BP87 – Alluvial Cobble and Gravels - Carbonates

At about 87.4 km, the Tetcela River is crossed by the route, and the planned road continues eastward across a flat plain which appears to be the site of several relict river channels from past millennia. As such, much of this area is comprised of old river beds and there is substantial subsurface gravel and cobble deposition under this currently forested plain. Hand excavated test holes were almost impossible to carry out to any depth here as the subsurface material consists of large embedded cobbles and gravels in a coarse matrix that is practicably impenetrable to shovels. The composition of the materials deposited here is assumed to be similar in texture to that of the current day active channel nearby – coarse mixtures of gravels and cobbles. This area could provide a critical supply of durable gravel aggregate that could be crushed for making superior surfacing materials. Materials of this nature could be used for road surfacing and grade construction for tens of kilometers in either direction from this site. The presence of innumerable Paleozoic coral fossils within the gravels throughout the Tetcela River system also indicate that the resulting gravels here are derived from carbonate based bedrock and are non-acidic.

Deeper investigation needs to be carried out in the coarse material here to determine the full depth and gradation of the deposited materials, and to ascertain if the water table would present a problem to development of a borrow pit. There is ample area well back of the river near the BP87 site that is suitable for the establishment of a crushing plant and for stockpiling material.

Figure 57: The bed composition of the current day Tetcela River is assumed to be indicative of the materials that should underlie the BP87 site, which is situated well back of the river here, in the timber on the left hand side.

Figure 58: View of some of the material deposited within the existing river bank to the west of the proposed BP87 location. This material is assumed to be typical of the deposition in the borrow area and it would need to be crushed for road surfacing.

1.42 Km 90.5, 91.5, 93.0, 93.6 - BP 90, 92, 93A, 93B, 93C, 94 – Silt / Sand Mixture

Borrow volume required for localized overland sections. Area and volume could be easily expanded. Not field verified but similar material found in the surrounding area.

Figure 59: Aerial view of the landscape from KP 90 to 95. Patches/islands of dry, esker type terrain covered with lodgepole pine/aspen. These humps will provide borrow material to overland the lower, depressed permafrost (likely ice-rich) sections in between.

1.43 Km 96.0 – BP 96 – Silty Sand

Borrow volume required for localized overland sections. Area and volume could be easily expanded. Not field verified but similar material found in the surrounding area.

Figure 60: Aerial view of the landscape near KP 96. Borrow to be extracted from elevated dry humps covered mainly with aspen and lodgepole pine.

1.44 Km 102 – BP 102- Fine Sand

Borrow volume required for localized overland sections. Area and volume could be easily expanded.

Figure 61: Dry sand type material at Wolverine Pass which should supply the large volume demands required for the overland construction approach within the switchbacks.

1.45 Km 102.3 – BP 102B – Silty Sand

Borrow volume required for localized overland sections. Requires a short 175 m access road. Area and volume could be easily expanded. Not field verified but similar material found in the surrounding area.

Figure 62: Dry elevated "humps" covered with lodgepole pine and aspen should provide adequate silty sand type material for overland sections, particularly in the proposed switchback section KP 97 to 102.

1.46 Km 103.7 – BP 103 - Clay till Overburden/Carbonate Rock

Large elevated knob with potential clay till type material overlying a carbonate rock layer underneath. The clay could be utilized for subgrade overland base material, the rock could be blasted/crushed and utilized for road surfacing.

Figure 63: One of many large, elevated rock knob "humps" in a south to north linear line which the proposed road parallels. Exposed rock outcrops are common along a number of these knob features and we expect this particular one to offer the same material.

1.47 Km 104 – BP 104 – Clay till Overburden/Carbonate Rock

Large elevated knob with potential clay till type material overlying a carbonate layer underneath. The clay could be utilized for subgrade overland base material, the rock could be blasted/crushed and utilized for road surfacing. Future test pits will determine the precise shape and size (probably less than 2.5 ha).

Figure 64: One of many large, elevated rock knob "humps" in a south to north linear line which the proposed road parallels. Exposed rock outcrops are common along a number of these knob features. We expect this particular one to offer the same material.

1.48 Km 106.8 – BP 107 – Carbonate Rock

Large elevated knob with potential clay till type material overlying a carbonate layer underneath. The clay could be utilized for subgrade overland base material, the rock could be blasted/crushed and utilized for road surfacing.

Figure 65: One of many large, elevated rock knob "humps" in a south to north linear line which the proposed road parallels. Exposed rock outcrops are common along a number of these knob features. We expect this particular one to offer the same material.

1.49 Km 111.7 – BP 111 – Carbonate Rock

Part of the same geological formation as BP 104. Any overburden material (clay/silt/sand) Could provide borrow for overland subgrade base material and a rock quarry for crushing/surfacing.

Figure 66: Aerial view of a potential large exposed shale rock outcrop near KP 112.

1.50 Km 116 – BP 116 – Shale Rock Quarry

Part of the same geological formation as BP 104 and 111. Overburden material (clay/silt/sand) could serve as borrow for overland subgrade base material and a rock quarry for crushing/surfacing.

Figure 67: An aerial view of a large, exposed shale rock outcrop a few hundred meteres above the proposed road location. It is assumed this rock feature extends down to the road location and could provide an excellent source of blasted/crush surfacing material.

1.51 Km 117 – BP 117 – Potential shale/gravel deposit

An exposed and *visible from the air* "shale rock" looking deposit the road location passes through.

Figure 68: A low level fly over identified this potential shale rock deposit. The proposed road is located through this feature.

1.52 Km 123.68 – BP123A – Alluvial Cobble and Gravels - Carbonates

Where the route passes through the gap in the Front Range Mountains, known locally as Grainger Gap, there is a substantial potential for developing a crushed natural gravel source that can be used surfacing material over large sections of the road. In the area of 123.68 km, the Grainger River (or an unnamed major tributary of it) has changed its channel in recent decades, and has left a large deposition channel abandoned to annual runoff. The current annual runoff avulsion channel flows directly south now, leaving a 500 m section of old channel that had flowed eastward abandoned. Based on all available visual evidence in the field, this relict channel hasn't received any appreciable water flow since the time the original winter road was constructed back in the early 1980's – there isn't any evidence of flows across that roadway since then. The dry relict channel (BP123A) holds promise for supplying all the material required for a large crushing operation producing surfacing aggregate, as well as other products for road construction. As with much of the other alluvial cobble noted along the route, the Grainger Gap gravels appear to originate from competent carbonate bedrock, making them an environmentally friendly and preferred construction material.

The large relict channel provides a flat plain with ample room for setting up a crushing plant, and for holding stockpiled materials. This area has potential to be a long-term source of maintenance aggregate as well.

Figure 69: Aerial view (from west) of the dry relict channel left behind when an avulsing streambed changed course at least 35 years ago. The lower part of the photo shows the present day avulsion channel's course, while the upper left side shows the abandoned channel proposed for use by BP123A.

Figure 70: Typical gravel materials found in the abandoned channel at BP123A.

Figure 71: Aerial view of the east end of the relict channel where BP123A is proposed. The proposed road route would cross over it along the area at the bottom of the photo.

1.53 Km 123.68 – BP123B – Limestone Bedrock

Directly adjacent to the relict avulsion channel at BP123A, is a limestone bedrock knob that juts up about 10 m in height from the alluvial plain. This rock knob is readily accessible from flat ground on all sides, making it a simple candidate for developing a blasted rock source in this area. While the eroded rock surface is fairly fractured, there is potential for producing larger shot rock and riprap from interior sections of the rock knob via controlled blasting. The limestone rock would be an environmentally friendly material for stream crossing works.

Figure 72: View of the isolated limestone rock knob (BP123B) protruding from the BP123A relict channel plain. This knob has level access on all sides of it making it a very simple location to develop for a source of blasted rock.

Figure 73: Closer view of the limestone bedrock available in BP123B.

1.54 Km 124.8 – BP 125A, 125B - Limestone Bedrock / Limestone Rockslide

An exposed outcrop of limestone bedrock with talus at the base (125B) would make an excellent rock quarry. The northern tip of BP 125A is in close proximity to the proposed road while BP 125B requires a short 400m access road but offers loose talus rock deposit at the base of the face. Both pits would provide excellent base material for overland construction from KP 124.8 to 127.2.

Figure 74: A view of the exposed rock face of BP 125A. The proposed road is located on the right side of photo at the base of the slope on the historic flood plain of Grainger River.

Figure 75: At view of BP 125B with exposed bedrock and talus rock deposit at the base.

1.55 Km 126.40 – BP126 – Limestone Rockslide (Rock Glacier?)

What appears to be a large limestone rockslide above the road at 126.40 km presents an opportunity to access naturally broken rock in a wide range of sizes, varying from large riprap down to fine rubble. The toe of this slide is about 250 m above the road, and it extends another 500 m uphill toward the originating bedrock cliffs. There is an extensive supply of broken rock in this formation, and it doesn't require expensive blasting to produce it – just sorting of the material and loading it out in trucks. It would require an access trail of about 550 m in length to connect this source to the proposed road route in order to utilise it.

When viewed in the field, this formation has all the appearances of a run-out zone from a large past rockslide, but when viewed on satellite photos the toe of the slide seems to have some appearance of "flowing" material. This raised the question of whether this ruble formation is actually a rockslide deposit or a rock covered glacial remnant, and a subsequent field inspection of the surface debris failed to provide a clear answer to that question. It would be necessary to conduct some subsurface excavation to determine if there is ice present in, or under the ruble. If the formation is the remnant of a glacier, the lower toe of the formation may still provide ample thawed rubble material that has resulted from past ice retreat from subsequent melting.

If the formation is just rockslide debris, there is potential to save the substantial costs of drilling and blasting nearby bedrock to generate riprap sources for the many stream crossings within economic haul range. The finer rubble would also be idea for subgrade construction across the many lowland areas nearby, especially over areas of permafrost due to its light, solar reflecting color. If, during the construction of the new winter road, there is an opportunity to probe this location, it would provide a definitive answer as to the material core properties of this formation, and indicate its suitability for providing construction materials.

Figure 76: View of the top end of ruble source and the near vertical limestone cliff it originated from.

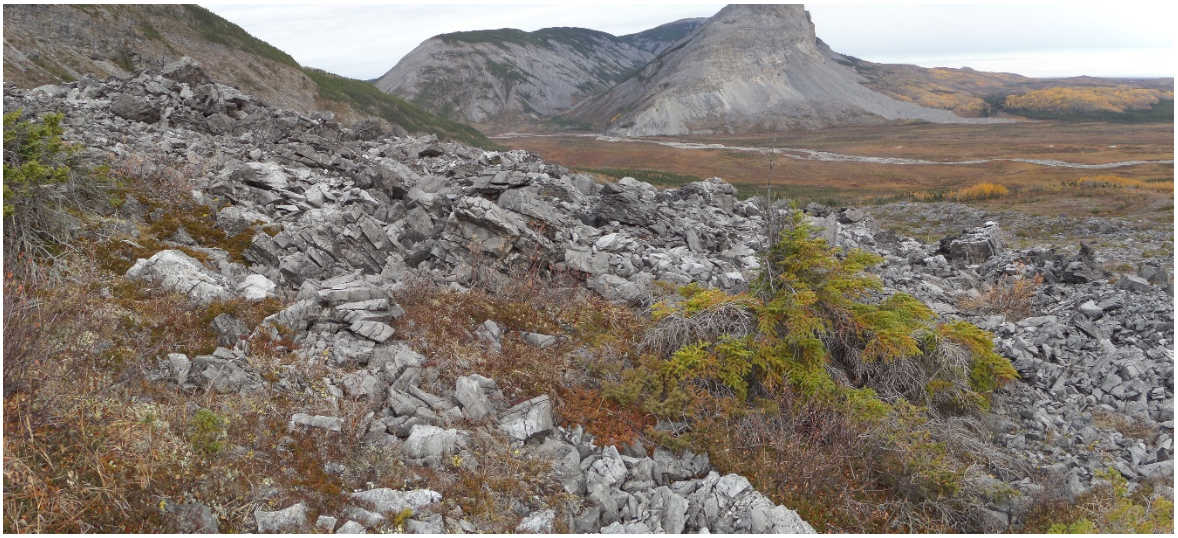

Figure 77: Limestone colluvium rock gradation available at the middle of the ruble slope.

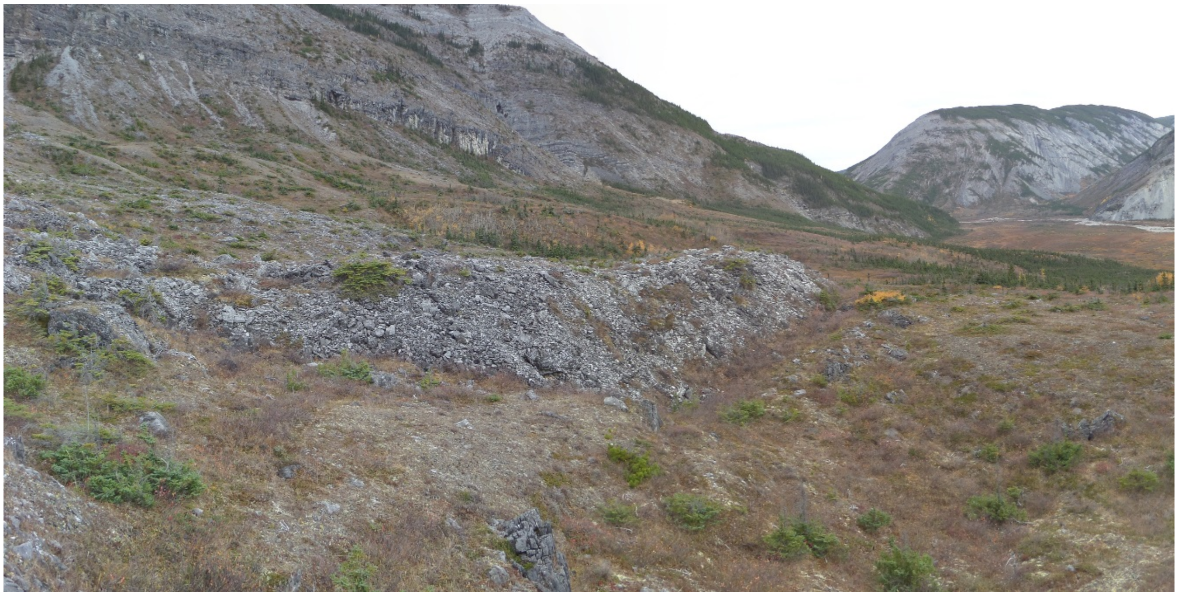

Figure 748: Finer material evident at the toe of the ruble slope. If the ruble pile is a rock glacier, this portion may be ice free now, as it is at the terminal end of the debris field.

1.56 Km 129 – BP 129 – Alluvial Cobble and Gravels

Potential good source of surfacing gravel. Close proximity to the proposed road location.

Figure79: An example of the gravels at BP 129.

1.57 Km 151.5 – BP 151A, 151B - Alluvial Cobble and Gravels

Must confirm depth and area but expect shallow source (2m deep) spread over a large fan. Some short access road(s) may be required to develop. A potential S3 seasonal stream divides the two defined patches. Probably requires crushing.

Figure 80: One example of the gravel type material at BP 151.

Figure 81: An aerial view of the large fan at BP 151, KP 151.5.

1.58 Km 158.2 – BP 158 - Limestone/Carbonate Talus rock deposit

Final area must be defined and will be much smaller. Excellent source of mixed talus rubble at the base of limestone/carbonate rock face. A very strategic aggregate source to supply surfacing requirements and rip rap from KP 155 to 184. Requires a 1.5 km access road.

Figure 82: An aerial view of large deposit of talus rock at BP 158.

1.59 Km 159.7 – BP 159 – Rock Debris Flow Fan

On the north side of the proposed Liard River landing/crossing exists a large debris/fan of rubble mix of limestone based rocks, gravel, mixed with clay. A detailed investigation to determine the potential and extent of the deposit must be completed. This source would be strategic location to serve aggregate requirements on both the north side and especially the south side of the Liard River where gravel sources are difficult to find.

Figure 83: An aerial view of the potential aggregate source just above the proposed north landing on the Liard River.

Figure 84: On the surface, the material looks attractive but only additional investigation will determine the true potential of the source.