of the berm should have a minimum width of 2.0 m. The available borrow materials at FOX-C for berm construction are erodible. It is therefore recommended that the surface of the berms be covered with a 0.5 m thick layer of gravel and cobbles.

To reduce settlement and ground subsidence, the debris should be placed in 0.5 m thick lifts with a prescribed non frost susceptible intermediate fill (see Section 6.0) graded over each lift of debris to fill the voids. The intermediate fill should be a minimum of 0.15 m thick and worked into the underlying debris. The maximum debris thickness (sum of all debris lifts) in the landfill should not exceed 3.0 m.

The landfill should be capped with a layer of fill compacted to 95% of the maximum density determined in the laboratory using standard effort (ASTM D698). The surface of the landfill should be graded to a slope between 2% and 4%. The landfill should be contoured to blend in with the surrounding terrain.

Most of the available fills for landfill covers are relatively pervious, however, using the available materials, landfill freezeback can be achieved using a thermally designed thickness of landfill cover. A freezeback design would significantly reduce the risk of moisture migration into and out of the landfill. Typically a landfill cap 1.0 m to 2.0 m thick is required. EBA can carry out the analysis for a freezeback cover design upon request.

Environmental assessment of the debris materials is being carried out by others. Provided the environmental risk of leachate products escaping the landfill is deemed acceptable, a cover thickness less than that required for complete freezeback can be used.

5.1.3 Potential New Debris Landfill Locations

During the 2004 investigation, four sites (Figure 1) were investigated as potential debris landfill sites. Debris Landfill Location 1 is located at the Midstation Dump. Locations 2 and 3 are located off Lake Road. Location 4 is located off of the Beach Road. The following sections describe each location in detail.

A fifth location for a landfill that may be contemplated is at Borrow Area 1, described in Section 6.2.1. A landfill at Borrow Area 1 would reduce the need to haul fills upslope to Midstation.

Potential Debris Landfill Location 1

A new landfill could be constructed on the existing pad area of the Midstation Dump and adjacent area, if required. The area is a relatively large and flat area which is accessed directly from the upper station road as shown on Figure 3 and Photo 9. The surface area of the existing pad is approximately 1800 m^2. The landfill could also be extended to the north if a larger area is required. The landfill could be constructed up against the mountain slope on the east side to blend into the natural topography of the area and reduce granular fill quantities. The landfill could also be extended to the west, but access to the Midstation Dump will have to be maintained until it is cleaned up.

The existing pad drains north, eventually into the Ekalugad Fjord.

The proposed area contains surface debris and some stained soil. The debris would have to be removed prior to landfill construction. The stained soil may impact landfill monitoring results. A thorough baseline sampling program is recommended.

Surface materials were dominantly boulders and bedrock outcrop, therefore, no testpits were excavated. Borrow sources for landfill are discussed in Section 6.0. The nearest borrow source (Borrow Area 1) is located downgradient of the site at a distance of approximately 2 km.

Potential Debris Landfill Location 2

Potential Debris Landfill Location 2 (Figure 9 and Photo 16) is situated in a terraced area north of the Lake Road roughly half way between Lake, Beach and Station Road Junction and the freshwater lake. There is presently a barrel cache located on the west portion of the site. The area has minor relief, from the northeast to the southwest side. The area is undisturbed and is accessed from the Lake road. The east landfill berm could be constructed into a natural slope and be blended into the natural topography of the area thus reducing granular fill quantities.

Three testpits (TP-32 to TP-34) were excavated in the proposed landfill area in 2004. All three testpits were terminated on frozen ground at a depth between 1.2 and 1.3 m. A damp to wet, fine to medium grained sand with trace to some silt and occasional

cobbles was encountered in all the testpits. Moisture contents were 18.7% and 9.9%. The sand is overlain by 100 mm of organics. Several boulders were present at ground surface in the area. A small amount of ponded water was present on the ground surface in the vicinity of TP-32 during the investigation. Testpit logs are present in Appendix B and laboratory results are presented in Appendix C.

The proposed landfill site drains south toward the mouth of the glacier river into the freshwater lake. The freshwater lake discharges into Ekalugad Fjord.

Potential Demolition Debris Landfill Location 2 is a suitable location for debris landfill and/or soil disposal facility. Fill quantities can be reduced by taking advantage of the natural topography of the area.

Proposed Debris Landfill Location 3

Proposed Debris Landfill Location 3 (Figure 9 and Photo 17) is situated in a terraced area north of Lake road approximately 200 m east of the freshwater lake. The area is undisturbed and is accessed from Lake Road. The east landfill berm could be constructed into a natural slope, thus reducing the granular fill quantities.

Four testpits (TP-28 to TP-31) were excavated in the proposed landfill site in 2004. All four testpits met refusal on frozen ground at a depth between 1.2 and 1.4 m. The east portion of the area (TP-30 and TP-31) is comprised of fine to medium grained sand with some silt. This material is also present in the west portion of the site (TP-28 and TP-29) to a depth of 0.2 and 1.1 m, respectively. At Testpits TP-28 and TP-29 the underlying soils were sand and gravel with trace silt. The entire area is overlain by 100 to 200 mm of organics. Moisture contents for the fine to medium grained sand for the area were 3.1%, 10.3% and 10.2%. Testpit logs are present in Appendix B and laboratory results are presented in Appendix C.

The potential landfill site drains towards the freshwater lake approximately 200 m west, which then discharges to Ekalugad Fjord.

Proposed Demolition Debris Landfill Location 4

Proposed Debris Landfill Location 4 (Figure 11 and Photos 18 and 19) is a large relatively flat area on the west side of the Beach Road adjacent to Borrow Area 3. This area is also feasible as a Soil Disposal Facility or Landfarm. It is an undisturbed area that slopes towards the southwest. The area drains approximately 250 m southwest into a river which flows into Ekalugad Fjord.

Four testpits were excavated at the proposed site (TP-07 and TP-19 through TP-21). All testpits terminated in frozen ground with depths ranging between 1.0 and 1.2 m. The surficial soils ranged from fine to medium grained sand with some silt to sand and silt. The silty sand present in TP-20 is underlain by a layer of coarse-grained sand at 0.8 m to an undetermined depth. Moisture contents were 17.4%, 10.5%, 11.8% and 23.9%. Seepage was observed in all four testpits, with depth of seepage between 0.8 and 1.1 m. Testpit logs are presented in Appendix B and laboratory results are presented in Appendix C.

5.2 Soil Disposal Facility

5.2.1 Design Considerations

It is understood that there are soils on site that are contaminated with PCB's and heavy metals. Hazardous contaminated soil must be shipped off site. Non-hazardous contaminated soils can be landfilled on site using a lined containment system. The lined system should encapsulate the non hazardous contaminated soil and covered with material so that it freezes back and remains in a frozen condition.

A leachate collection and monitoring system is not generally incorporated into high arctic landfills, as they do not function well in a permafrost environment. A combination of freezeback of the landfilled material and a geomembrane cover and base liner will result in little to no moisture migration into or out of the landfill.

Thermal analyses have not been carried out for the proposed developments. If a soil disposal facility is required at FOX-C it is recommended that a climate analysis and thermal analysis be carried out to determine the design parameters.

5.2.2 Potential Soil Disposal Facility Location 1

Soil Disposal Facility Location 1 was investigated for the specific purpose of a soil disposal facility. Other sites deemed suitable for a soil disposal facility include Landfill 2 and 4 (Section 5.1.3) provided these sites are not needed for landfill purposes.

Soil Disposal Facility Location 1 (Figure 11 and Photos 20) is a relatively flat area on the east side of Beach Road approximately 950 m south of the main beach area. The identified area is approximately 19,500 m^2. The area is undisturbed and slopes towards the northeast. The site drains to a creek which is 115 m away. The creek flows for approximately 850 m to the northwest and drains into Ekalugad Fjord. The west berm for Soil Disposal Facility Location 1 could be constructed into a natural slope, thereby reducing the granular fill quantities.

Four testpits were excavated in the area (TP-04, TP-12, TP-13 and TP-14). All testpits terminated in frozen ground at depths between 0.85 and 1.10 m. The surficial soils were predominantly clayey silt. Moisture contents were 19.8%, 24.3%, 22.7%, and 16.4%. Ice was present in the frozen soil in the base of TP-14 and stratified ice and soil (V_s = 20 to 40%) was present in two of the other testpits. Testpit logs and laboratory results are found in Appendix B and C, respectively.

Soil Disposal Facility Location 1 is considered an acceptable location disposal of non-hazardous contaminated soils; however, constructability issues may arise from the high natural moisture content of the material and the presence of ice rich permafrost. Excavation of active layer should be minimized to reduce the risk of thaw settlement of the underlying ice rich permafrost.

6.0 GRANULAR BORROW MATERIAL

An assortment of granular fill types are required for the construction of new landfills/soil disposal sites, remediation of existing debris areas, backfill of excavation areas and access road reconstruction. Characteristic particle distributions have been prescribed for six granular fill types for the following applications:

- Type 1 Granular Fill – coarse gravel, cobbles and boulders for erosion protection;
- Type 2 Granular Fill – gravel and sand for landfill cover;
- Type 3 Granular Fill – general fill for excavation backfill;
- Type 4 Granular Fill – silt and sand for landfill berms;
- Type 5 Granular Fill – sand for geomembrane bedding; and
- Type 6 Granular Fill – sand and gravel for intermediate landfill debris cover.

Section 6.1 describes the applications of these materials and characteristics of the above materials in more detail. Section 6.2 describes prospective borrow materials at FOX-C.

6.1 Granular Material Specifications

Type 1 Granular Fill is generally a well-graded gravel and cobbles with a trace of sand. It is typically used for erosion protection of landfills and as riprap for small drainage courses. The gradation requirements for Type 1 Granular Fill may vary significantly depending on the specific application. The gradation requirements should be evaluated once the specific application of Type 1 Granular Fill is known.

Type 2 Granular Fill is typically gravel and sand and is generally used for construction of landfill berms and covers and regrading requirements. Type 2 Granular Fill should have a particle size distribution within the limits presented on Table 1.

TABLE 1
TYPE 2 GRANULAR FILL
PARTICLE SIZE DISTRIBUTION LIMITS

Particle Size (mm)	% Passing
200	100
50	60 to 90
5	30 to 75
0.425	10 to 30
0.08	5 to 20

Type 3 Granular Fill is any sand and gravel material with a maximum particle size not exceeding 200 mm that is obtained from excavations or other approved sources. Type 3 is generally used for regrading, backfill of contaminated soil excavations and general site grading requirements. Type 2 Granular Fill is acceptable for Type 3 Granular Fill.

Type 4 Granular Fill is a non-saline, silt and sand material used for construction of containment berms and backfill of the key trench excavations for the Soil Disposal Facility. The water content of the Type 4 Granular Fill must be adjusted to achieve a minimum degree of saturation of 90%. It may be necessary to air-dry the material so that it can be placed and compacted according to the specifications. Type 4 Granular fill should have a particle size distribution within the limits presented on Table 2.

TABLE 2
TYPE 4 GRANULAR FILL
PARTICLE SIZE DISTRIBUTION LIMITS

Particle Size (mm)	% Passing
100	100
50	80 to 100
12.5	55 to 95
5	45 to 90
2	35 to 80
0.425	25 to 70
0.08	20 to 40

Type 5 Granular Fill is used as an embedment material for geosynthetic liners and should be comprised of rounded particles and free from angular particles, stones larger than 25 mm in diameter, waste or other deleterious materials. Type 5 Granular Fill should have a particle size distribution within the limits presented on Table 3.

TABLE 3
TYPE 5 GRANULAR FILL
PARTICLE SIZE DISTRIBUTION LIMITS

Particle Size (mm)	% Passing
25	100
12.5	75 to 100
5	50 to 100
2	30 to 60
0.425	10 to 40
0.08	0 to 8

Type 6 Granular Fill is generally used as an intermediate cover within landfills and is obtained from excavations or other sources generally consisting of gravel or sand in an unfrozen state and free of deleterious material. The maximum particle size of the material should be less than 150 mm with less than 8% of the material, by weight,

passing the 0.08 mm sieve. Some Type 2 and Type 3 Granular Fills, depending on the specific particle size distribution of the material, may be acceptable as Type 6 Granular Fill.

6.2 Granular Borrow Areas

Three existing borrow areas (Areas 1, 2, 3,) and four new Borrow Areas (Areas 4, 5, 6, and 7) were identified at the FOX-C site during the 2004 site investigation. The locations are shown in Figure 1. For new landfill and/or borrow pits, a 50 m setback between landfills and borrow areas is required.

Individual borrow areas are discussed in Section 6.2 and summarized in Section 6.3.

A John Deer 4600 tractor with a backhoe attachment was used to excavate testpits along Lake Road between Borrow Area 2 and Borrow Area 6. Due to impassable road conditions on Beach Road and Station Road, testpits were hand excavated. Soil samples were collected for laboratory index testing. Testpit logs are presented in Appendix B and laboratory test results are presented in Appendix C.

6.2.1 Proposed Borrow Area 1

Borrow Area 1 (Figures 1 and 5 and Photos 21 and 22) is located on the south side of Station Road approximately 1 flight km south of Midstation. The borrow area is predominantly sand and gravel with some silt and varying amounts of cobbles and boulders. A portion of the area has been depleted during previous borrow activities. The remaining undisturbed area has surface layer of boulders and cobbles.

A total of four shallow testpits were hand excavated in the area (TP-41 through TP-44). Testpit depths were between 0.3 and 0.6 m with two of the testpits meeting refusal on cobbles. Moisture contents were 7.7%, 7.6% and 9.3%. Testpit logs are presented in Appendix B, and laboratory results are presented in Appendix C. Particle size analysis size indicated the sample tested consisted of 36% gravel, 47% sand and 17% silt/clay. The sample contained 50 mm maximum particle sizes; however, particles up to 1.2 m are present in the borrow area. Refer to the testpit logs and photos for additional information.

With some sorting to remove boulders and oversize cobbles, the granular materials in Borrow Area 1 are considered suitable for Type 2 and Type 3 Granular Fill. Type 1 granular fill may be present in certain portions of the borrow area but no specific areas were identified during the investigation. The total identified area shown on Figure 5 is approximately 49,000 m^2. The disturbed area is approximately 26,000 m^2. An estimated volume of 49,000 m^3 would be available, assuming an average excavation thickness of 1.0 m. Additional material may be available at greater depth, but the material may be frozen and extraction would require a thaw and strip operation.

At the time of the 2004 investigation, ponded water was present in the disturbed portion of the borrow area. Control of surface drainage will be required during development as the borrow material will become difficult to work with if it becomes wet.

6.2.2 Proposed Borrow Area 2

Borrow Area 2 (Figures 1 and 10 and Photo 23) is located at the (Lake Road, Beach Road Station Road) Junction and contains a range of materials suitable for Type 1, Type 2, Type 3, Type 5, and Type 6 applications. A stockpile of sand and gravel and a partially developed area has exposed fine to medium grained sand. It appears that the stockpile was area derived from the respective borrow site.

A total of four shallow testpits were excavated in the area with one on the top of the stockpile (TP-40) and three around the perimeter (TP-37 through TP-39). Testpit depths were between 1.15 and 1.8 m with all testpits meeting refusal on frozen ground. Testpit logs are presented in Appendix B. A sample of the material consisted of 36% gravel, 64% sand, and 0% silt/clay. Laboratory results are presented in Appendix C. The sample contained 25 mm maximum particle sizes; however, particles up to 200 mm are present in the borrow area. Refer to the testpit logs and photos for additional information.

The stockpile contains approximately 20,000 m^3 of material. The material at depth is frozen; therefore, extraction of the entire pile will require a thaw and strip operation.

A disturbed area located north of the stockpile exposes fine to medium grained sand suitable as Type 5 Granular Fill. The identified Type 5 area is approximately 7,300 m^2. An estimated volume of 7,300 m^3 may be available, assuming an excavation thickness

of 1.0 m. Additional material would be available at greater depth, but the material may be frozen and extraction would require a thaw and strip operation.

6.2.3 Proposed Borrow Area 3

Borrow Area 3 (Figures 1 and 11) is an old borrow area located at the east side of Beach Road directly north of Potential Debris Landfill Location 4. The soils in the area are sands with trace of gravel to gravelly and trace silt to silty. Varying amounts of cobbles and boulders are present in both materials. A total of six testpits were excavated in the area (TP-05, TP-06, TP-15, TP-16, TP-17 and TP-18). One sample of material from the borrow area contained 6% gravel, 71% sand, and 23% silt/clay (Type 4), while another contained 25% gravel, 74% sand and 1% silt/clay (Type 5). Testpit logs are presented in Appendix B, and particle size distribution curves are presented in Appendix C.

Borrow Area 3 materials are considered suitable for Type 5 and/or Type 6 Granular Fill if carefully sorted. The identified area is approximately 13,000 m^2 in size. Assuming an average excavation thickness of 1.5 m, an estimated volume of 19,500 m^3 would be available. Additional material may be available at greater depth, but the material may be frozen and extraction would require a thaw and strip operation.

6.2.4 Proposed Borrow Area 4

Borrow Area 4 (Figure 12 and Photo 24) is located on the west side of Beach Road and approximately 600 m southwest of the Beach Area (Figure 1). Most of the proposed area is undisturbed; however, a barrel cache is present along the north perimeter.

Four testpits were excavated in the area (TP-02, TP-09, TP-10 and TP-11). All testpits were terminated in frozen ground at depths ranging between 0.7 and 1.2 m. The surficial soils are varied but include discontinuous clayey silts (Clay and Silt) and at depth included ICE+Soil (TP-11). Moisture contents select were determined to be 20.7%, 11.8%, 25.9%, 33.7% and 12.0%. No Moistures were carried out on the ICE+Soil. Testpit logs are presented in Appendix B and laboratory results are presented in Appendix C.

The material in Borrow 4 is finer grained than the Type 4 specification in Section 6.1. The material would be acceptable for Type 4 Granular Fill if the moisture content at the time of construction is adequate to produce a workable material. Drying and blending with a granular material may be required. Selective excavation with some sorting to remove boulders and cobbles greater than 100 mm diameter would also be required to make the material suitable for Type 4 Granular Fill. The identified area shown on Figure 12 is approximately 25,000 m^2. Assuming an average excavation thickness of 0.5 m, and a selective sourcing, an estimated volume of 8,000 m^3 of Type 4 Granular Fill would be available. Additional material may be available at greater depth or the area could be expanded to the south.

The feasibility of developing this borrow source will be influenced by the weather, management of the pit drainage and moisture content of the material. If the material becomes wet, rubber tired equipment may have difficulty accessing the borrow area. Tracked vehicles may be required. It may also be necessary to air dry the material or blend wet material with suitable dry material.

6.2.5 Proposed Borrow Area 5 (Proposed Debris Landfill Location)

Borrow Area 5 (Figure 9A and Photo 17) is a large relatively flat undisturbed area off Lake Road approximately 200 m east of the freshwater lake, as shown on Figure 9A and Photos 17. Potential Debris Landfill Location 3 is located within the area.

Four testpits (TP-28 to TP-31) were excavated to refusal on frozen material of 1.2 to 1.4 m depth. The entire area is overlain by 100 to 200 mm of organics. The east portion of the area (TP-30 and TP-31) is comprised of fine to medium grained sand with some silt. This material is also present in the west portion of the site, TP-28 and TP-29, to a depth of 0.2 and 1.1 m, respectively and is then underlain by sand and gravel with trace silt to the maximum depth of excavation. Moisture contents for the fine to medium grained sand found in the area were 3.1%, 10.3% and 10.2%. Testpit logs are present in Appendix B and laboratory results are presented in Appendix C.

The sand and gravel present in TP-28 and TP-29 is suitable for Type 2 and Type 3 Granular Fill; however, there appears to be limited quantities. The sand is suitable for Type 5 Granular Fill. The identified area shown on Figure 9 is approximately 10,500 m^2 in size. An estimated volume of 10,500 m^3 would be available, assuming an average

excavation thickness of 1.0 m. Additional material may be available at greater depth, but the material may be frozen and extraction would require a thaw and strip operation.

6.2.6 Proposed Borrow Area 6

Borrow Area 6 (Figures 1 and 8) is a large relatively flat undisturbed area off Lake Road approximately 130 m east of the freshwater lake, as shown in Figures 1 and 8.

Six testpits (TP-22 through TP-27) were excavated to refusal at depths of 1.4 to 1.8 m. Typically, the area is comprised of 0 to 200 mm of fine to medium grained sand with some silt underlain by sand and gravel with trace silt to the maximum depth of excavation. TP-24 consisted of fine to medium grained sand with some silt to an undetermined depth. Particle size distribution analyses for two samples had gravel contents of 42% and 19%, sand contents of 55% and 78%, and silt/clay contents of 3% and 3%, respectively. Testpit logs are present in Appendix B and laboratory results are presented in Appendix C. The sample contained 25 mm maximum particle sizes; however, particles up to 250 mm are present in the borrow area.

The granular materials in Borrow Area 6 are considered suitable for Type 2, Type 3 and Type 6 Granular Fill. Type 1 and 5 Granular Fill may be available if the material was screened. Should any material be used as Type 2 or 3 Granular Fill, the use of a Type 1 Granular Fill cover may be required. The identified area shown on Figure 8 is approximately 20,000 m^2. Assuming an average excavation thickness of 1.0 m, an estimated volume of 20,000 m^3 would be available. Additional material may be available at greater depth, but the material may be frozen and extraction would require a thaw and strip operation. Additional material may also be available to the north as the topography is similar to that of Borrow Area 6; however, field confirmation is required.

6.2.7 Proposed Borrow Area 7

Borrow Area 7 (Figure 6 and Photos 25 through 28) is a large relatively flat, terraced area off Station Road approximately 350 m east of the junction of the access roads. The area is on the south side of the glacier fed river and is predominantly undisturbed.

No testpits were excavated in the area; however, the slopes of the terraced area were examined. The area is comprised of varying layers of sand and sand and gravel typical of an outwash area.

The granular materials in Borrow Area 7 are suitable for Type 2, Type 3 and Type 6 Granular Fill. Type 1 and 5 Granular Fill may be available if the material was screened. Should any material be used as Type 2 or 3 Granular Fill, the use of a Type 1 Granular Fill cover may be required. There is an old river channel present in the borrow area containing cobbles and gravel. This material would be suitable for Type 1 Granular Fill.

The identified area shown on Figure 8 is approximately 110,000 m^2 in size. Assuming an average excavation thickness of 1.0 m, an estimated volume of 110,000 m^3 would be available. Additional material is available to the west of the shown area, if required.

6.3 Summary of Granular Borrow Resources

All of the required Granular Borrow Types described in Section 6.0 were found at FOX-C. Table 4 summarizes the estimated borrow materials available at FOX-C. There is no requirement for crushing granular materials, but there may be a requirement for sorting and screening granular materials and blending materials to achieve the gradation requirements.

There is limited quantity of Type 1 material on the site.

Type 2 Granular Fill identified in Borrow Areas 2, 5, 6 and 7 is sandy and, therefore, easily eroded. Depending on the use of the Type 2 material, a cover layer of Type 1 Granular Fill may be required.

Type 4 Granular Fill was encountered in Borrow Area 4 within 0.5 m of the surface. At Borrow Area 4 the Type 4 Granular fill will become wetter with depth limiting the volume that can be removed. Developing the pit using proper drainage practices will be necessary.

Type 5 and Type 6 Granular Fill were available in Borrow Areas 2, 3, 5, 6, and 7.

Most of the borrow sources are located at the west end of FOX-C in the vicinity of Lake Road and Beach Road.

Borrow Area 1 is approximately 2.5 km and 2.0 km distance by road (and down-gradient) from Upper Station and Midstation, respectively. The next closest borrow sources to these sites is Borrow Area 7 which is roughly 6 kilometres away (south of the Junction).

TABLE 4
SUMMARY OF FOX-C DEW LINE SITE GRANULAR BORROW SOURCES

Borrow Area	Available Granular Fill Type	Quantity Estimate			Comments
		Area (m^2)	Excavation Depth (m)	Volume (m^3)	
Borrow Area 1	Types 2 and 3	49,000	1.0	49,000	Partially Developed area and Undeveloped area.
Borrow Area 2	Types 2, 3 and 6	20,000	1.0	20,000	Partially Developed area
	Type 5	7,300 (Type 5)		7,300 (Type 5)	
Borrow Area 3	Type 5 and 6	13,000	1.5	19,500	Partially Developed area
Borrow Area 4	Types 4	25,000	0.5	8,000	Undeveloped area.
Borrow Area 5	Types 5 and 6	10,500	1.0	10,500	Undeveloped area
Borrow Area 6	Types 2, 3 and 6	21,500	1.0	21,500	Undeveloped area.
Borrow Area 7	Types 2, 3 and 6 Limited Type 1	110,000	1.0	110,000	Undeveloped area.

7.0 ACCESS ROAD EVALUATION

7.1 Beach Road

Beach Road (Figures 1, 10, 11, 12 and 13A and Photos 29 to 39) is approximately 2.2 km long. The existing road width (shoulder to shoulder) ranges from approximately 2.3 to 4.5 m and is typically 3 m.

The amount of regrading of the road surface prior to any significant vehicle traffic will depend on site development and the type of hauling equipment being used. With the exception of river crossings, the majority of road is still passable with a 4 x 4 pickup truck and with some fill placement and/or grading, it would be suitable for heavy equipment traffic. If two-way haul traffic is needed construction of pull out sections will be required.

All existing culverts on the Beach road were constructed out of 45 gallon barrels welded together. Breaks in the road where the road would be impassable by haul trucks exist at drainage crossings where the either culverts have failed (BR Crossings 1, 2 and 3) or where the road appear to have washed out because no culverts were installed (BR Crossing 4).

The POL Tanks are located in the Beach Debris Area and mark the end of Beach Road. Between the POL tanks and BR Crossing 1, the road has been eroded by cross drainage. At this section the road embankment materials appear to have been derived by cut and fill. The local soils are fine-grained and highly erodible. The erosion is discontinuous over a distance of about 350 m along the road. Welded barrel culverts are present. Although water passes through the culverts, it appears to flow beneath the existing culverts. It is expected that under the weight of heavy equipment these culverts and road above them will fail. Culvert crossing should therefore should be upgraded. Where the road has been breached and eroded, road fill will be required to resurface the road and provide a width passable by haul trucks. Most of the required fill may be salvaged locally and the remainder will need to be imported.

Between BR Crossing 1 and the Junction there are at least two additional culvert crossings that may require replacement as the existing culverts are no longer structurally sound. All existing culvert crossings should be assessed at the time of construction with the aid of heavy equipment.

Regular road maintenance during hauling will likely be required.

7.2 Lake Road

Lake Road is approximately 1.1 km long (Figure 1, Photos 41 and 42). The road surface width ranges from approximately 2.3 to 5.5 m and is typically 3 m. The road has been constructed from the granular material obtained from near the roadway. The soils range from sand to sand and gravel. No culvert crossings are present on the Lake Road. Generally the road is trafficable and in satisfactory condition for light traffic. Some grading is required over the extent of the roadway prior to any haul traffic. Approximate 240 m length of the road located on cross-sloped terrain requires reconstruction due erosion.

If two-way haul traffic is needed construction of pull out sections will be required. Regular grading during hauling will likely be required.

7.3 Station Road

Station Road from the Junction to the end of the road at the Upper Station is approximately 5.9 km long. The existing road surface width (shoulder to shoulder) between Kilometre 0 (Junction) and Kilometre 3.0 of Station Road ranges from approximately 2.5 to 5.5 m, but is typically 3 to 4 m. The general condition of the roadway to Kilometre 3.0 (approximately Crossing 2) is shown in Photos 49 to 54. A substantial amount of road structure remains that is in satisfactory condition for heavy equipment traffic, however, many sections will require varying amounts of surface preparation requiring fills resourced locally from the road right-of-way and/or from imported borrow. Road impasses in the first 3.0 kilometres include one failed road section, two river crossings (Crossing 1 and Crossing 2) and five washouts (Washouts 1 to 5).

From Kilometre 3.0 to the end of Station Road the road was constructed by placing fill over boulders and rock outcrops. The existing road surface width (shoulder to shoulder) throughout this section ranges from approximately 2.5 to 6.0 m, but is typically 4 to 6 m. The road conditions are shown in Photos 56 and 63. Approximately 1,000 m of the road located on cross sloped terrain requires resurfacing due to erosion and washouts. Construction of pull out sections may be required to facilitate two-way haul traffic.

Following are brief descriptions of impasses observed between the Junction and Kilometre 3.0 (Crossing 2).

Kilometre 0.1 Road Failure

A failed section of road (Figure 10 and Photo 43) approximately 140 m in length is located a distance about 100 m from the Junction (Station Road Kilometre 0). Failure at this road section appears to result from permafrost degradation coupled with deep erosion gullies across the road and undercutting by the glacier fed river.

Based on a visual assessment of the site it was deemed that for temporary access that it may be prudent to realign and build new road just upslope of the failed road section. A topographic survey was completed on the area to facilitate a redesign.

River Crossing 1

River Crossing 1 (Photos 48 and 49) was constructed in the 1960's using a culvert. The glacier fed river has washed out the crossing. Several options are available for reconstruction depending on the long term plan for the roadway and the specific use of the roadway. Construction of a properly sized culvert or a portable bridge are possibilities, but for cost estimating purposes, the installation of two large culverts, a boulder subbase and surface course has been assumed. Depending on the intended use of this road, it may be designed as a seasonal crossing to be removed each fall or as a longer term crossing.

River Crossing 2

River Crossing 2 (Photo 55) was also constructed in the 1960's using a culvert. The glacier fed river has washed out the crossing.

Several options are available for reconstruction depending on the long term plan for the roadway and the specific use of the roadway. Construction of a properly sized culvert or a portable bridge are possibilities, but for cost estimating purposes, the installation of two large culverts, a boulder subbase and surface course has been assumed. The boulders to be used for the subbase along with the surface course can be sourced from the area or Borrow Area 1. Depending on the intended use of this road, it may be designed as a seasonal crossing to be removed each fall or as a longer term crossing.

Washouts 1 through 5

Washouts (Figures 1, 6 and 7) have resulted from failed culverts and interference of the road with natural drainage paths. Washouts 1 through 5 are shown in Photos 44 to 47. The road at these sections is constructed out of sand and gravel or silt till obtained from the roadway right-of-way.

Washout No.	Length of Affected Road
1	Three existing culverts have been plugged, causing drainage to wash out the roadway at several locations. Approximately 80 m of affected roadway.
2	Approximately 60 m of affected roadway.
3	Approximately 100 m of affected roadway.
4	Roadway has been washed out in two main segments. A water course crosses the roadway. There is approximately 95 m of affected roadway.
5	Approximately 120 m of affected road.

Reconstruction would include installing culverts at the respective washouts and reconstructing the road and/or constructing armoured cross-ditches.

Approximately 200 m^3 and 140 m^3 of fill material will be required at Crossing 1 and 2, respectively.

- BR Crossing 3 is a segment of roadway that has been washed out from surface drainage.
  - A culvert will be installed in this location (or the area could be recontoured to promote drainage away from the roadway).
  - Approximately 140 m^3 of fill material from the roadway right of way or Borrow 3 will be used as fill material.

- BR Crossing 4 is a location where the existing culverts have been washed out.
  - A new culvert will be installed.
  - A hauling operation from Borrow Area 2 has been assumed.
  - It has been assumed that two articulated haul trucks and a loader will be used for the hauling operation and an excavator will be used to place the material.
  - Approximately 210 m^3 of fill material will be required.

The estimated equipment time and costs for the Beach Road repairs are listed in Table 5.

TABLE 5
COST ESTIMATE FOR THE BEACH ROAD

Description	Hours	Quantity	Unit Price	Cost
Excavator	20		$ 155	$ 3,100
Articulated Haul Trucks[1]	38		$ 135	$ 5,130
Dozer	28		$ 145	$ 4,060
Loader	14		$ 130	$ 1,820
Grader	10		$ 130	$ 1,300
Culverts		7	$ 1,000	$ 7,000
			Subtotal	$22,410
		Assume additional 20% for downtime, etc.		
				$26,200

Note: [1] 3 Articulated Haul Trucks assumed