CUMBERLAND
RESOURCES LTD.

MEADOWBANK GOLD PROJECT

NO-NET-LOSS PLAN (NNLP)

NOVEMBER 2006

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EXECUTIVE SUMMARY

Cumberland Resources Ltd. (Cumberland) is proposing to develop a gold mine on its Meadowbank property in the Kivalliq region approximately 70 km north of the Hamlet of Baker Lake on Inuit-owned surface lands. Cumberland has been actively exploring the Meadowbank area since 1995. Engineering, environmental baseline studies, and community consultations have paralleled these exploration programs and have been integrated to form the basis of current project design.

Cumberland has nearly completed a comprehensive, multi-year environmental impact assessment (EIA) process involving many regulatory agencies, stakeholder groups, and the public. A key step in this process was the receipt of conditional approval for the project from the Nunavut Impact Review Board (NIRB) after hearings were conducted involving all interested parties.

Proposed mine development plans will result in encroachment into fish-bearing lakes (e.g., creation of dikes, mining activity, waste impoundment, and habitat enhancement) and streams (all-weather private access road crossings). The harmful alteration, degradation, or destruction (HADD) of fish habitat is addressed under Section 35 of the *Fisheries Act* and requires an Authorization administered by Fisheries and Oceans Canada (FOC). In addition to its inclusion in the Section 35 Authorization, the planned tailings impoundment area (TIA) falls under the purview of Section 36(3) of the *Fisheries Act* (tailings are considered a “deleterious substance”) and will require scheduling under Section 5 of the *Metal Mining Effluent Regulations* (MMER). Environment Canada handles both Section 36(3) and the process for listing the Meadowbank TIA on MMER Schedule 2. This No-Net-Loss Plan (NNLP) addresses the requirements of these regulations by quantifying habitat losses/gains during operations and closure stages, detailing fish habitat compensation measures, and providing an adaptive-management-based monitoring plan to verify compliance with the NNLP. NNLP implementation engineering plans (e.g., compensation structure construction plans, implementation schedules, and associated budgeting to satisfy bond requirements) are provided separately by Cumberland.

The total number of Habitat Units[1] (HUs) for the project area lakes is 17,570. Similar to most projects of this nature, a net loss of productive capacity is expected in the project lakes during the construction and operation stages of the Meadowbank Gold project. Short-term fish habitat losses during these stages are 1,761 HUs. Redesigning the Finger dike habitat enhancement feature in the past year resulted in a doubling of habitat productivity during operations to 206 HUs.

At post-closure, a considerable amount of temporarily lost habitat will be recovered from habitat enhancements in the impounded lake areas and associated dikes, new pit-associated lake areas gained from mining former terrestrial areas, and substantial increases in three-dimensional surface area and volume of the deep pit areas. The long-term (i.e., post-closure) habitat balance sheet for various mine components is presented below:

Project Component	***HUs Lost***	***HUs Gained***	***Net HUs***	***NNL Ratio***
Mine Site (excluding TIA)	1,390	1,402	+12	1:1
Tailings Impoundment Area	370	749	+379	2:1
All-Weather Private Access Road	0.5	0.8	+0.3	1.6:1

[1] Habitat unit (HU) is a standardized measurement that integrates both the spatial extent and quality of fish habitat.

Overall, the project achieves a long-term gain of 390 HUs, all within the project area lakes. This represents an overall increase of 22% in the predicted productive capacity for the area within the mine's footprint compared to the pre-mining baseline.

Implementation of the NNLP for the TIA will achieve a 2:1 compensation-to-loss ratio (see Tailings Impoundment Area Summary for more details), which will be fully realized at mine closure.

The All-Weather Private Access Road (AWPAR) NNLP (Appendix A) also achieves a net surplus in productive capacity upon implementation of the compensation strategy. Cumberland's commitment to install bridges over each of the 10 fish-bearing watercourses has significantly minimized encroachment into fish habitat. Minor habitat losses (0.53 HUs in total) are only predicted to occur at 5 of the 21 AWPAR crossings. Implementation of the compensation strategy would result in a net gain in productive capacity of habitat from the AWPAR project (i.e., enhancement minus losses) of 0.27 HUs (i.e., 0.80 HUs – 0.53 HUs), or 51%.

TAILINGS IMPOUNDMENT AREA SUMMARY

The northwest arm of Second Portage Lake has been proposed as a tailings impoundment area (TIA) for the Meadowbank Gold Project. In addition to the no-net-loss (NNL) requirements of Section 35 of the *Fisheries Act,* the planned TIA falls under the purview of Section 36(3) of the *Fisheries Act* (tailings are considered a “deleterious substance”) and will require scheduling under Section 5 of the *Metal Mining Effluent Regulations* (MMER). This No-Net-Loss Plan (NNLP) addresses the requirements of these regulations by quantifying habitat losses/gains during operations and closure stages, detailing fish habitat compensation measures, and providing an adaptive-management-based monitoring plan to verify compliance with the NNLP.

Tailing Impoundment Area Habitat Summary

Project Component	*HUs Lost*	*HUs Gained Operations*	*HUs Gained Post-closure*	*Total Hus Gained*	*NNL Ratio*
Tailings Impoundment Area	370	206	543	749	2:1

Construction/Operations Stages

The East dike will impound 144 ha of Second Portage Lake and is proposed for Year –1 of the development (see Figure 4.1 of main report). This is approximately 35% of the surface area of Second Portage Lake. Of this total, 89.5 ha is situated behind the West dike, which isolates the northwest arm of Second Portage Lake and will initially contain the attenuation ponds and eventually, the TIA. The total number of habitat units permanently lost to the TIA is calculated as 370.5 (see TIA Habitat Summary table below).

Enhancement activities conducted during the construction/operations stage will result in the creation of 206 HUs, which partially offsets the TIA-related losses. These gains in the productive capacity of fish habitat come from modification of the East, Goose Island and Vault dike faces and the creation of the Finger dike habitat enhancement area. These are permanent gains in habitat that will extend indefinitely.

Post-Closure Stage

At post-closure, a considerable amount of temporarily lost habitat will be recovered from habitat enhancements in the impounded lake areas and associated dikes, a new pit-associated lake area gained from mining former terrestrial areas, and substantial increases in three-dimensional surface area and volume of the deep pit areas (see Figure 5.3 of main report). An additional 543 HUs of fish habitat will be gained during this stage of the project upon full implementation of the NNLP.

Summary

Constructing the TIA will result in the loss of 370 HUs. This is 24% of total pre-mining habitat in Second Portage Lake (1,505 HUs) and only 3% of habitat (11,978 HUs) in Third Portage Lake considering that this area will be absorbed into Third Portage Lake at closure. Operational and post-closure habitat enhancement activities will result in the addition of 749 HUs, for a compensation-to-loss ratio of slightly more than 2:1.

DESCRIPTION OF SUPPORTING DOCUMENTATION

Cumberland Resources Ltd. (Cumberland) is proposing to develop a mine on the Meadowbank property. The property is located in the Kivalliq region approximately 70 km north of the Hamlet of Baker Lake on Inuit-owned surface lands. Cumberland has been actively exploring the Meadowbank area since 1995. Engineering, environmental baseline studies, and community consultations have paralleled these exploration programs and have been integrated to form the basis of current project design.

The Meadowbank project is subject to the environmental review and related licensing and permitting processes established by Part 5 of the Nunavut Land Claims Agreement. To complete an environmental impact assessment (EIA) for the Meadowbank Gold project, Cumberland followed the steps listed below:

1. Determined the VECs (air quality, noise, water quality, surface water quantity and distribution, permafrost, fish populations, fish habitat, ungulates, predatory mammals, small mammals, raptors, waterbirds, and other breeding birds) and VSECs (employment, training and business opportunities; traditional ways of life; individual and community wellness; infrastructure and social services; and sites of heritage significance) based on discussions with stakeholders, public meetings, traditional knowledge, and the experience of other mines in the north.

2. Conducted baseline studies for each VEC and compared / contrasted the results with the information gained through traditional knowledge studies (see Columns 1 and 2 on the following page for a list of baseline reports).

3. Used the baseline and traditional knowledge studies to determine the key potential project interactions and impacts for each VEC (see Column 3 for a list of EIA reports).

4. Developed preliminary mitigation strategies for key potential interactions and proposed contingency plans to mitigate unforeseen impacts by applying the precautionary principle (see Columns 4 and 5 for a list of management plans).

5. Developed long-term monitoring programs to identify residual effects and areas in which mitigation measures are non-compliant and require further refinement. These mitigation and monitoring procedures will be integrated into all stages of project development and will assist in identifying how natural changes in the environment can be distinguished from project-related impacts (monitoring plans are also included in Columns 4 and 5).

6. Produced and submitted an EIS report to Nunavut Impact Review Board (NIRB).

As shown on the following page, this report is part of the documentation series that has been produced during this six-stage EIA process.

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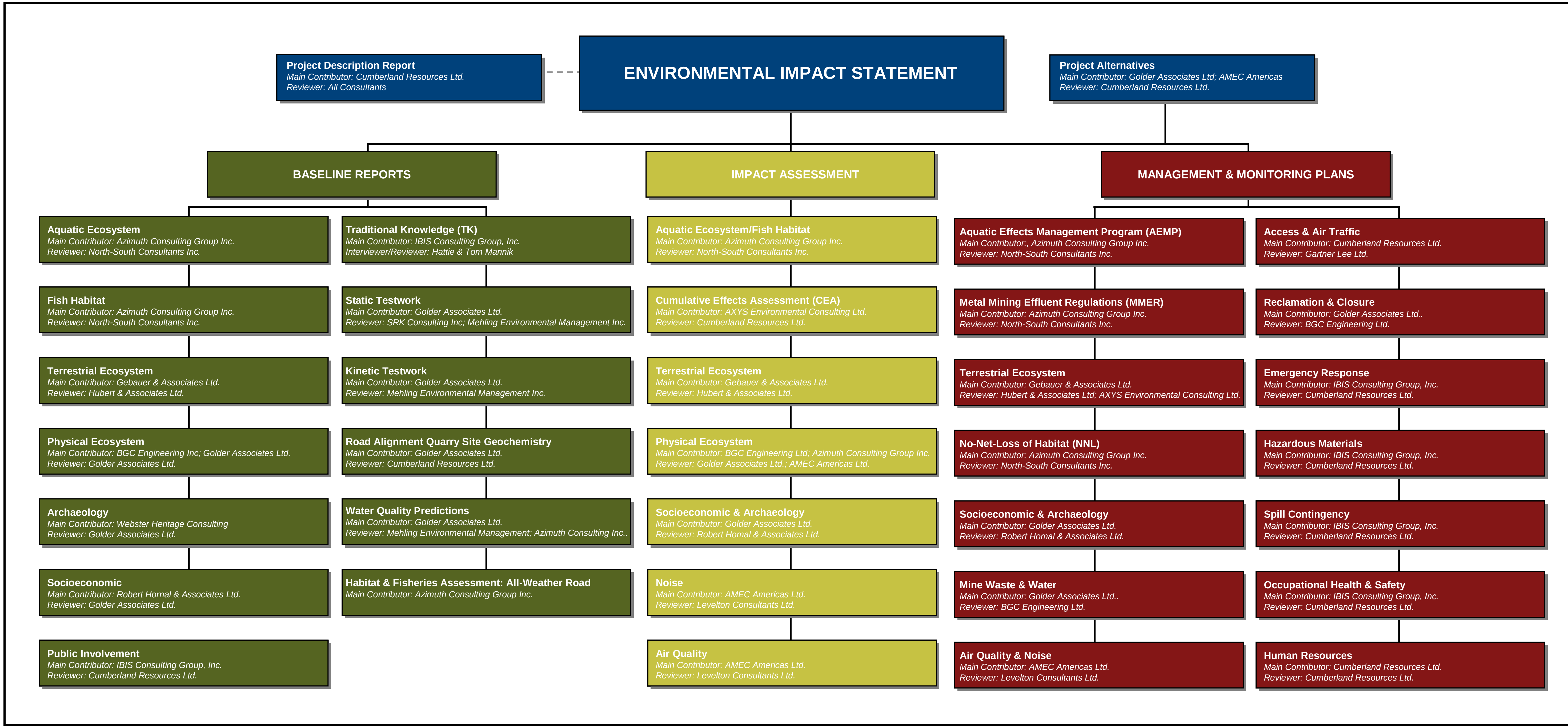
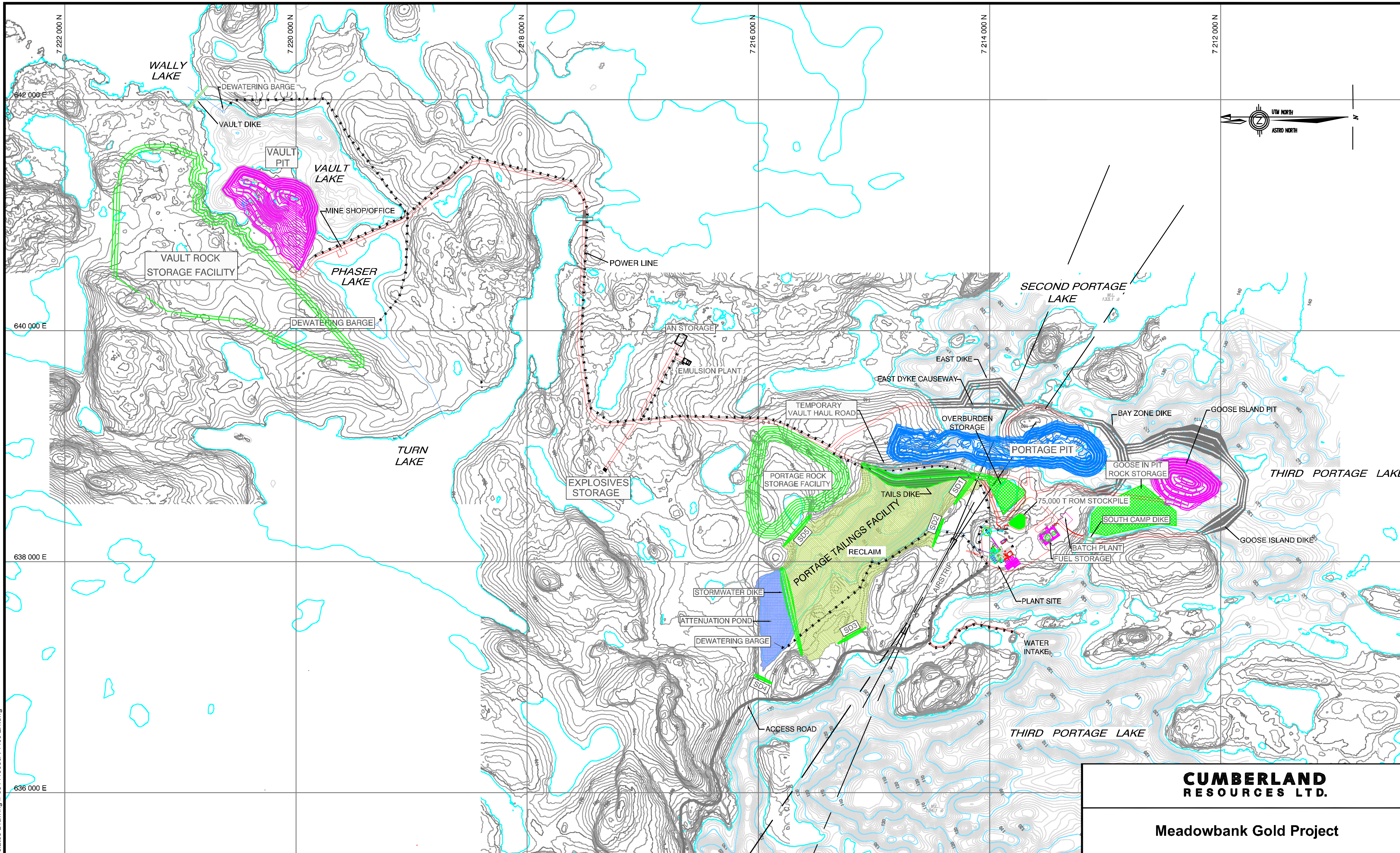
EIA DOCUMENTATION ORGANIZATION CHART



Date: November 2006

PROJECT LOCATION MAP



Source:Golder Associates Drawing # 05141303A-1400-2.1.dwg

NOTES

1) Topographic contour interval 2m.
2) Bathymetric contour interval 1m.
3) Scale As shown.

LEGEND

SD: SADDLE DAM

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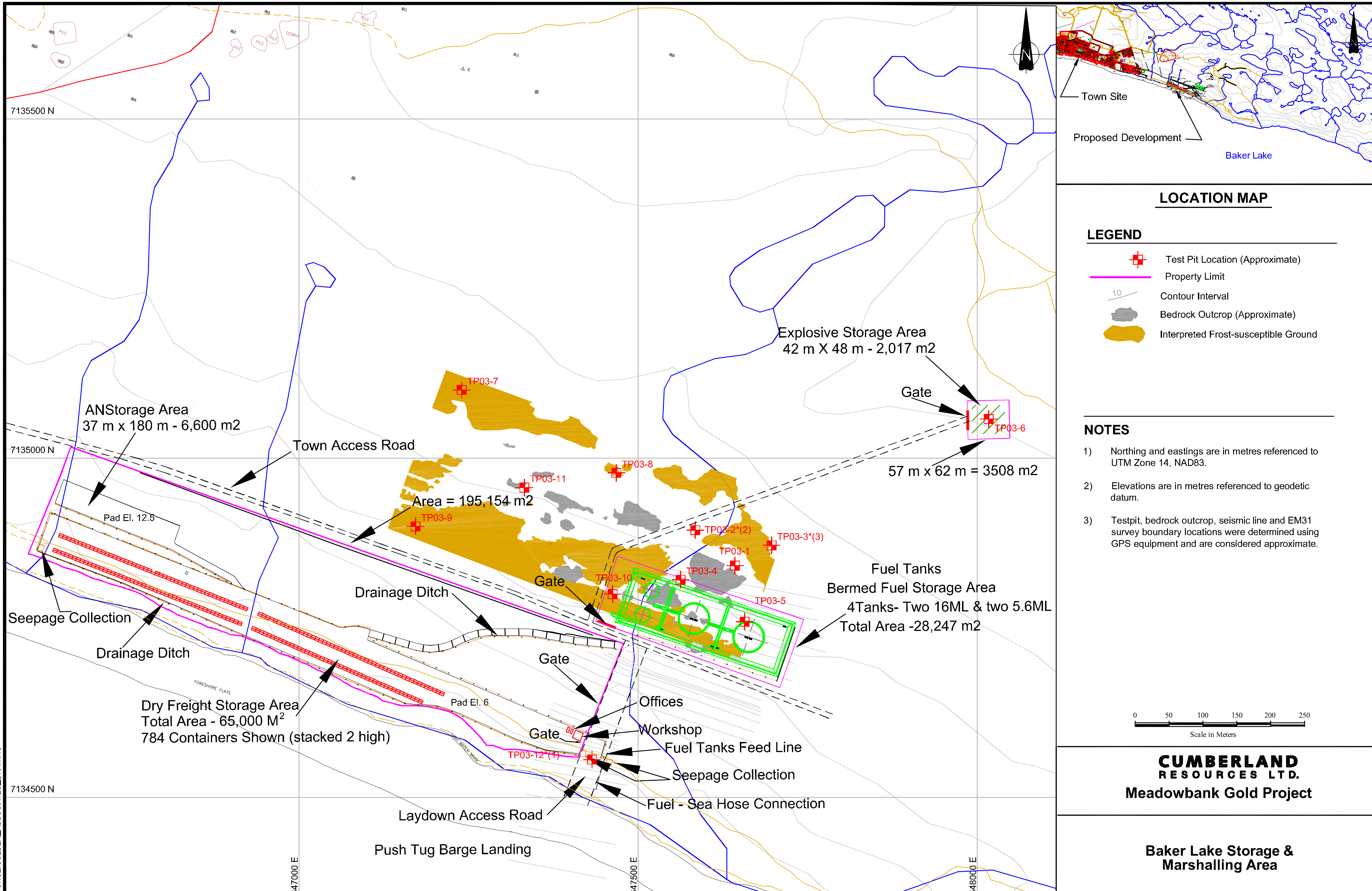
Meadowbank Gold Project

General Site Plan



SOURCE:GOLDER_ASSOCIATES_DRAWING

SECTION 1 • INTRODUCTION

1.1 BACKGROUND

Cumberland is evaluating the feasibility of establishing a gold mine at its Meadowbank property near Baker Lake, Nunavut. A 115-km long All-Weather Private Access Road (AWPAR) has also been proposed to connect the Hamlet of Baker with the property. This road will cross a number of ephemeral streams and rivers. All fish-bearing streams will be crossed with bridges, most of which are clear-span and will not affect habitat. A complete and independent No Net Loss of Habitat Plan (NNLP) related to the AWPAR is provided within this document as Appendix A.

The Meadowbank project, about 75 km north of the Hamlet of Baker Lake, is situated on the headwaters of several ultra-oligotrophic, fish-bearing lakes. Second Portage, Third Portage, and Vault/Wally lakes are located directly within the boundaries of the mineral zones being explored on the Meadowbank property and drain into Tehek Lake. Tehek Lake is a large lake (455 km^2) that flows via the Quoich River system into the western end of Chesterfield Inlet and, eventually, into Hudson Bay. The surrounding terrain is typically barren-ground subarctic, dominated by many small lakes and ponds with indistinct and complex drainage patterns.

Supporting documents relating to the aquatic environment for an environmental impact assessment (EIA) of the Meadowbank project include the following:

- Baseline Aquatic Environment Assessment Report (BAEAR, 2005) – This report summarizes the baseline studies conducted between 1996 and 2005 of the physical, chemical, and aquatic ecological characteristics of the Meadowbank project lakes and connecting channels.

- Framework for the Application of Metal Mining Effluent Regulations report (MMER, 2005) – This report presents a study design to comply with and implement studies required under the Metal Mining Effluent Regulations (MMER) and Environmental Effects Monitoring (EEM) program.

- Aquatic Environmental Management Program (AEMP, 2005) report – This report presents a framework for environmental monitoring of the aquatic environment of project lakes during mine construction and operation.

- Baseline Fish Habitat Assessment Report (BFAR, 2005). This report describes and quantitatively maps the spatial distribution and relative abundance of fish habitat within Second Portage, Third Portage, Wally, and Vault lakes (project lakes). The specific objectives were to describe the nature, quantity, and distribution of habitat types, and quantitatively map the relative abundance and value of fish habitat.

The purpose of this No-Net-Loss Plan (NNLP) is to quantify and assess impacts to fish habitat in the project lakes related to activities undertaken during construction, operation, and post-closure of the Meadowbank project and present options to compensate for this loss of fish habitat. This is necessary to achieve the goal of no net loss (NNL) of fish habitat as stipulated under the Fisheries and Oceans Canada (FOC; previously known as Department of Fisheries and Oceans [DFO]) *Fisheries Act*.

A key component of the NNLP is designation of the northwest arm of Second Portage Lake as a tailings impoundment area (TIA). To ultimately achieve no net loss over the long-term, this NNLP attempts to create significantly more habitat than is destroyed to compensate for the permanent habitat loss associated with the TIA in Second Portage Lake.

1.2 REGULATORY CONTEXT

The federal *Fisheries Act* describes fish habitat as, "spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly to carry out their life processes." Fish habitat is comprised of physical (e.g., substrate type and structure, water velocity), chemical (e.g., nutrients, temperature), and biological (e.g., plankton, insects) attributes that combine to create conditions affecting the productivity of fish populations in a lake or stream. The federal no net habitat loss principle described in the FOC Policy for the Management of Fish Habitat (FOC, 1986) strives to avoid a net loss of productive capacity of fish habitat as a result of a development project by following a set of guidelines or a hierarchy of options. In order of preference, these are:

- relocation or physically moving a project or part of the project to eliminate the potential for adverse effects
- redesign of a project to avoid adverse impacts
- mitigation of impacts in cases where relocation or redesign of a project is not possible—an example is installation of erosion control measures or materials to minimize effects of introduced sediments on habitats.

Compensation involves replacing harmfully altered, disrupted, or lost habitat with newly created habitat or enhancement of existing habitat. This is only considered when relocation, redesign, or mitigation measures fail to avoid harmful alteration, disruption, or destruction of fish habitat. There is also a hierarchy of compensation measures ranging from the creation of similar habitat at or near the development (i.e., like for like), to the least preferred option, increasing productive capacity of fish habitat of a different species (or stock) away from or off-site.

Major project activities (e.g., dike construction and operation) will result in the harmful alteration, disruption, or destruction (HADD) of fish habitat. FOC (1998) defines HADD as, "any meaningful change in one or more habitat components that can reasonably be expected to cause a real reduction in the capacity of the habitat to support the life requisites of fish." A HADD occurs when the physical, chemical, or biological feature of a water body is sufficiently altered such that habitat becomes less suitable for one or more life history process (e.g., spawning, feeding) By definition, HADD can involve alteration (i.e., an indefinite change in capacity of habitat to support fish that does not eliminate habitat), disruption (i.e., temporary changes to habitat that cause a reduction in capacity to support fish), or destruction (i.e., permanent change in habitat that eliminates capacity to support fish).

Major project activities will alter or destroy fish habitat, despite reasonable attempts to avoid impacts, because of the nature of certain activities. Thus, this NNLP presents a range of possible options to mitigate and compensate, to the extent possible, impacts to fish habitat in the project lakes. If impacts cannot be fully mitigated and a HADD is likely to occur, it is within the discretion of FOC to issue an authorization under Section 35(2) of the *Fisheries Act*, allowing for habitat alteration, disruption, or destruction (FOC, 1998), provided that full compensation of the HADD can be achieved, either through on-site and/or off-site measures to create or improve existing habitat. A full explanation of the hierarchy and decision framework for the determination and authorization of HADD can be found in FOC (1986 and 1998).

Consideration is also given to the spatial and temporal context of impacts to habitat and the relative value of affected habitat. Project activities that affect large areas of low value habitat may have lesser impacts than activities that affect small areas of high value habitat. In addition, project activities that cause impacts of short duration will have less overall impact than activities that cause long-term or permanent HADD (FOC, 1998). Therefore, this NNL assessment will consider differences in temporal duration, spatial extent, and magnitude of impact relative to habitat value. That is, greater emphasis will be placed on impact assessment and compensation of medium and high value habitat (e.g., spawning shoals, complex platform, and apron habitat providing shelter and feeding) and less on low value habitat (e.g., deep-water, low-complexity habitat). Impacts with the potential to affect habitat for longer time periods (decades) than brief time periods (months/years) will also be given greater emphasis.

Finally, lakes that do not contain fish and do not provide resources to sustain fish in adjacent lakes are not considered productive fish habitat (FOC, 1998) and will not be accounted for under the NNLP presented here. Lakes that are isolated, are limited by lack of overwintering habitat and contain few fish will also be given less consideration than large, productive lakes. For example, shallow (<3 m depth) lakes or ponds that are not connected to larger water bodies and have insufficient depth to support overwintering by fish have no potential to support a fishery and are not considered productive fish habitat.

The northwest portion of Second Portage Lake has been proposed as a tailings impoundment area (TIA) and as such will require designation under Schedule 2 of the *Metal Mining Effluent Regulations* (MMER). Prior to its designation, an acceptable habitat compensation plan must be developed and accepted by FOC. This NNLP is an integral part of the application process for designation of the northwest arm of Second Portage Lake as a TIA under Schedule 2 of the MMER.

1.3 UNDERSTANDING HABITAT FEATURES OF PROJECT LAKES

Fish habitat is generally classified according to five major categories: spawning/nursery; rearing; feeding; overwintering; and migratory. Migratory habitat is important in systems where stream habitat provides life history functions for particular species, such as spawning and feeding by Arctic grayling, or to connect lakes, acting as migratory corridors. Because of the headwater nature of the project lakes, there is negligible stream habitat. Project lakes are connected to one another by small, ephemeral connecting channels that freeze during winter. Arctic grayling (*Thymallus arcticus*) are not present within the project lakes and watershed boundaries. Consequently, this habitat assessment focuses on lacustrine habitats because of the near absence of stream habitat within the project area (BAEAR, 2005).

Fish habitat, as it pertains to importance and utilization by different fish species at particular life history stages (e.g., larvae, juvenile, adult) in the project lakes, is a complex mixture of physical, chemical, and biological features.

- Physical features include the type, size, shape, distribution, and slope of bottom sediment, ranging in size from fine material (clay, silt, and sand) to coarse material (gravel, cobble, and boulder). Water depth, exposure to wind forces, currents, ice scour, temperature, oxygen concentration, and proximity to sediment sources and tributary streams also affect physical habitat quality and utilization by fish. The project lakes are ice-bound for much of the year (October through June), which has a strong influence on fish species composition, distribution, and productivity.
- Chemical features include pH, nutrient concentration, organic carbon content of sediment, and contaminants (e.g., metals, hydrocarbons). The project lakes are very nutrient-poor (ultra-oligotrophic), with naturally low productivity.
- Biological features include abundance of food sources (algae, zooplankton, and benthic invertebrates), predators, and competing species. Project lakes are dominated by lake trout (*Salvelinus namaycush*), which exert a strong influence over other species present because of their piscivorous diet and abundance.

Understanding the relative abundance and spatial distribution of physical features and structure of habitat in lakes is important to determine the quality of habitat, which is reflected ultimately in the abundance (i.e., biomass), productivity, and diversity of fish. Abundance of fish differs between lakes as a result of a complex interaction between quality and abundance of available habitat, quantity of critical habitats such as spawning, availability and abundance of food resources (as dictated by lake productivity) and immigration or emigration by fish. Large-scale geographic or climatic effects also dictate distribution and abundance of fish, independent of habitat features.

1.4 OBJECTIVES

The primary objective of this NNLP is to quantitatively assess the distribution, abundance, and value of fish habitat within Second and Third Portage lakes and Vault Lake that may be adversely affected by mine development, relative to areas of these lakes that are unaffected, and to propose options to mitigate or compensate for HADD during mine life and beyond. The proposed NNLP will completely compensate for all habitat losses, both temporary (i.e., during construction/operation) and permanent (i.e., from dikes and tailings impoundment) in the post-closure environment through on-site enhancement of existing habitat and creation of new habitat.

The northwest arm of Second Portage Lake is being proposed as a TIA. To designate a lake or a portion of its area as a TIA requires special recognition under the MMER of the *Fisheries Act*. Habitat loss within the TIA is permanent and must be compensated for. To specifically address the TIA in this NNLP we have strived to incorporate FOC's guiding principal of a roughly 2:1 gain-to-loss ratio of habitat compensation. Because of the permanent nature of habitat loss from a TIA, this document specifically identifies habitat compensation areas that will balance habitat loss with habitat gain and proposes a monitoring program to ensure that this objective is met.

Quantification of lacustrine habitat in the project lakes was accomplished through a combination of quantitative assessment and mapping techniques (e.g., bathymetry, air photo interpretation, underwater video, GIS), field study results, previous studies in northern lakes (e.g., Diavik, Snap Lake), published scientific literature and professional experience. An adaptive management strategy will also be adopted to take advantage of results of field monitoring on site, as well as results of monitoring studies conducted at other northern mines to optimize habitat compensation measures to ensure no net loss.

A secondary objective of this NNLP is to quantify and assess impacts to fish habitat in watercourses crossed by the proposed all-weather private access road (AWPAR) and to present options for compensating for the loss of fish habitat (Appendix A). Cumberland is proposing an all-weather road to provide year-round ground access to the Meadowbank site. Golder Associates (Golder) has identified the optimal route for the AWPAR based on a number of parameters including suitability of terrain, ease of construction, availability of borrow material for construction, and minimal stream crossings. Strong emphasis on the latter has resulted in the 115 km AWPAR having no more than 21 stream crossings in the current design.

Bridges have been proposed to cross all fish-bearing streams to minimize impacts to habitat and fisheries resources. The AWPAR crossing designs incorporated guidance from the Habitat Management Program of FOC to avoid or minimize impacts to fish or fish habitat (FOC, 2005). Residual habitat loss from non-clear span bridges and abutments to riverine habitat has been assessed and compensated for in a similar manner as for lacustrine habitat to ensure there is a net gain in productive capacity of habitat.

SECTION 2 • ENVIRONMENTAL SETTING

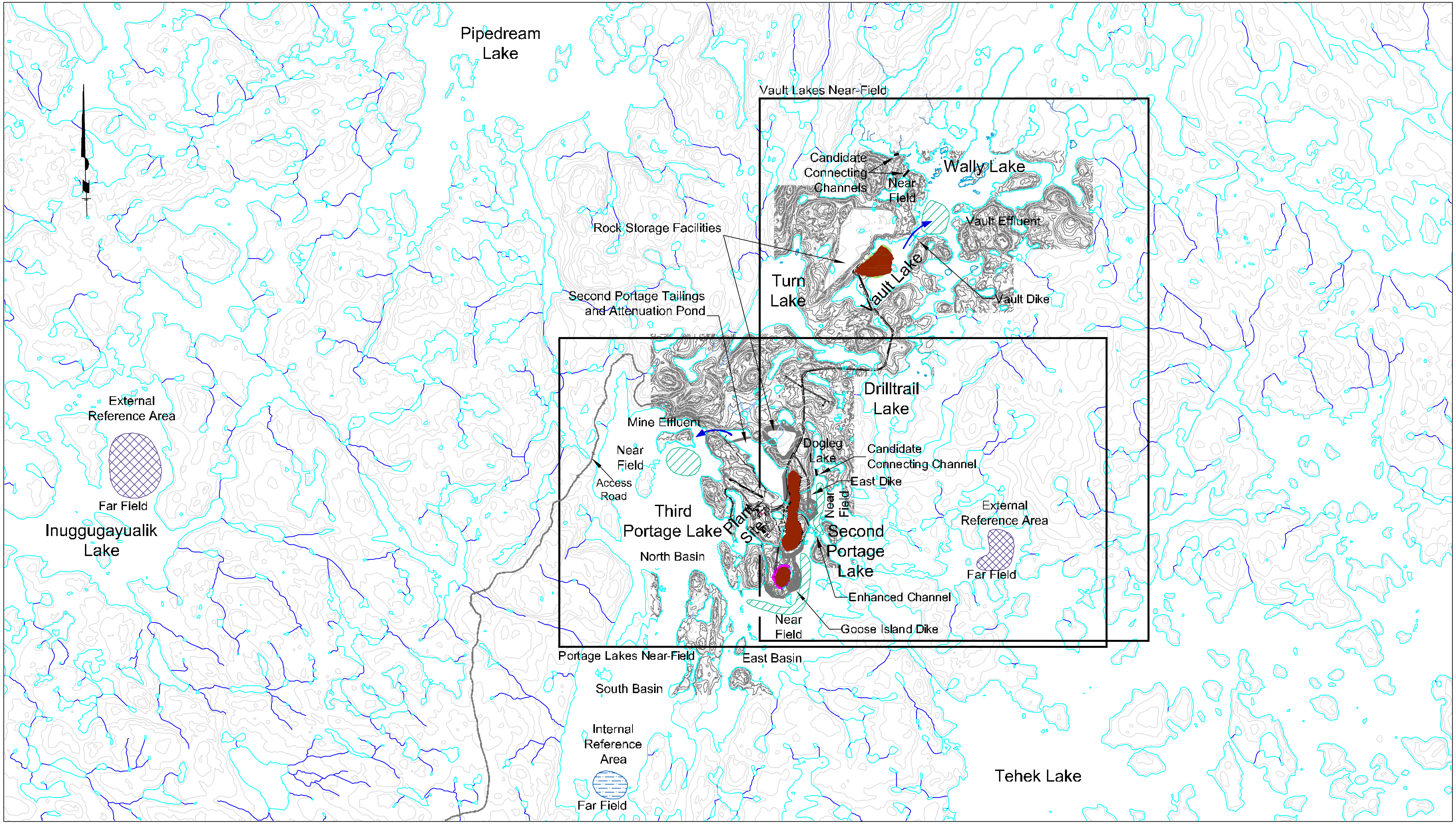
Understanding the environmental setting of the Meadowbank project lakes is critical to applying the principals of no net loss of habitat. Ecological studies conducted in the project lakes between 1996 and 2006 have provided the necessary insight into the nature of the fish populations in project, reference and regional lakes and their relationship with important habitats.

The local climate and the physical/chemical characteristics of lakes in this region of the Arctic have a profound influence on the habitat productivity, species composition, and biomass of aquatic organisms. The project lakes are situated in the extreme headwaters of the watershed boundary that separate two main drainages—the Arctic and Hudson Bay drainages. Only a short distance north of Second and Third Portage lakes, water flows north to the Arctic Ocean via the Meadowbank/Back River system. The project lakes fall entirely within the Quoich River system that flows south through Tehek Lake into Chesterfield Inlet and eventually into Hudson Bay. A falls near the mouth of the river prevents upstream access by fish, including anadromous species. Because of the headwater nature of the project lakes, the drainage area relative to surface area is very small and the lakes experience only local inflow from the immediately surrounding terrain. All project lakes are connected by small, ephemeral channels that are frozen during winter and in some cases, only allow limited movement by fish between lakes for a brief period during spring freshet (Figure 2.1). Even where there is excellent hydraulic connectivity between lakes, for example between Second Portage Lake and Tehek Lake, movements by fish are small and random and not associated with life history demands such as migration to spawning or overwintering areas.

Three species dominate the fish community in all project lakes. Lake trout (*Salvelinus namaycush*) was the most abundant, comprising between 60% and 100% of all enumerated fish in surveyed lakes. Round whitefish (*Prosopium cylindraceum*) was the next most abundant species, comprising 15 to 25% of fish, with landlocked Arctic char (*S. alpinus*) comprising the remainder (10 to 15%). Only one burbot (*Lota lota*) has been captured from Tehek Lake. Ninespine stickleback (*Pungitius pungitius*) and slimy sculpin (*Cottus cognatus*) were the only other species present and were found in small numbers. No other spring spawning species such as suckers (*Catostomus* sp.) or Arctic grayling (*Thymallus arcticus*) are present in reference or project lakes or connecting channels. Arctic grayling are, however, the dominant species in stream channels crossed by the proposed AWPAR within the Prince River watershed south of the Quoich watershed that drains the project lakes.

2.1 SPECIES HABITAT PREFERENCES

There is a considerable body of literature that has evaluated preferred habitat preferences for spawning/nursery areas, rearing, feeding and overwintering by fish. However, much of the literature and observations have been made for temperate lakes, such as the Great Lakes, and especially for lake trout. For example, in temperate lakes oxygen and temperature regimes, lake stratification and seasonal limnological differences dictate habitat utilization by lake trout. Habitat suitability indices have been developed for lake trout based on these parameters. However, these are irrelevant in the project lakes because all project lakes are unstratified with uniform vertical oxygen (high) and temperature (cold) regimes year-round. These parameters are less important drivers of habitat utilization in project lakes than for trout in southern Canadian lakes.



Source: Azimuth Consulting Group drawing

Legend

External Reference Area
Pit
Near Field Monitoring Area
Internal Reference Area
Road

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Meadowbank Gold Project

Figure 2.1
Meadowbank Study Area Lakes & Dike Locations

Relatively few studies have specifically examined habitat preference of Arctic fish species. We have drawn information from several common sources, such as Scott and Crossman (1979), McPhail and Lindsey (1970) and Richardson et al, (2001). These authors summarized habitat preferences compiled or observed by other researchers, and the end result is that the range in habitat preferences stated for depth, grain size, morphology or other habitat features for each species is broad and non-specific. To augment these general sources, we have explored relevant literature to attempt to acquire more specific habitat preference information for fish in Arctic lakes (Table 2.1). This met with limited success, because most authors' observations of habitat preferences were also relatively general in nature. This is because habitat preference by fish is often general, or difficult to define, especially for broad categories like "spawning" or "foraging."

Lake trout spawn over large, coarse substrates on sloped shoals and platforms with interstitial spaces that allow oxygenation of eggs. Ice thickness and the depth to which this type of rocky habitat can be found dictate depth of spawning. In the project lakes this is between 2 and 6 m. There is an abundance of this kind of habitat and it is widespread throughout the project lakes.

Arctic char and round whitefish also prefer this general habitat type, although optimal grain size for these two species may be slightly smaller than for lake trout. Thus, within the same shoal, it is likely that all three species will use this habitat for spawning/rearing according to intra-specific micro-habitat preference. It is difficult to map or quantify habitat on such a fine scale, therefore, this habitat feature will necessarily receive the same habitat classification or value and be deemed as "suitable for spawning" by lake trout, char and whitefish.

Arctic grayling are not found within the watershed area of the project lakes, but they are the dominant species in large streams crossed by the proposed AWPAR within the Prince River drainage area south of the Quoich drainage. Habitat preference for this species is also presented here, but is not related to project lakes.

The sections below provide a literature review and assessment of habitat preference for spawning/nursery, rearing, foraging and overwintering for important species, namely lake trout, round whitefish and Arctic char from lakes and Arctic grayling from streams. Collectively, these species comprise at least 99.9% of the fish biomass in the project lakes. Nevertheless, we also present habitat preference information for ninespine stickleback, slimy sculpin and burbot, which have been found in small numbers in project lakes (BAEAR, 2005). All species are considered in NNLP.

2.1.1 Lake Trout (*Salvelinus namaycush*)

Lake trout prefer shallow shoreline sites with clean, silt-free, boulder and cobble for spawning, rearing and feeding (McPhail and Lindsey, 1970; Dumont et al, 1982; Goodyear et al, 1982; Marcus et al, 1984; Kelso et al, 1995; Ford et al, 1995). Spawning occurs in the fall just before or just after freeze-up, usually in depths ranging from 0.12 to 10 m over boulder and cobble (Dumont et al, 1982; Goodyear et al, 1982; Marcus et al, 1984) (Table 2.1). In the project lakes, spawning occurs at a depth of at least 2 m because of ice cover.

Table 2.1: Summary of Habitat Requirements for Relevant Project Lake Fish Species

Species	Life Stage	Spawning/Nursery					Rearing/ Foraging		Overwintering	References/Region
		Timing	Frequency	Location	Substrate	Depth	Substrate	Depth	Substrate/Depth	
Lake trout	Adult	FALL (Sept, Oct, Nov)	2 or 3 yrs	Shallow inshore areas of lakes. Eggs typically fall between crevices, incubate for 5 mths and hatch in March or April				All depths, with seasonal movement		MacPhail and Lindsey 1970; Scott and Crossman 1973; Richardson et al, 2001 / General
					Cobble, gravel, interspersed with boulders, free of fine sediment (sand, silt and clay)	Typically 0.12 to 10 m, have been found to have a range of 0.12 to 55 m	Unstratified lakes, random, throughout lakes	0 to 50 m	pelagic zone, below freeze zone; >10 m	Dumount et al, 1982, Goodyear et al, 1982, Ford et al, 1995 / General
					< 5 m boulder and cobble sloping contour	3 to 80 m in Great Lakes				Mardsen et al, 1995 / Great Lakes ON
				Variety of sloping and steep shorelines and shoals	Variation of coarse grained material	1.8 to 12 m	Boulder and Cobble, with varied grades			Fitzsimons 1996 / Great Lakes ON
					0.8 to 3 m diameter with interstitial space required					Gunn 1995/ N.ON
							Along rocky shorelines			Wong and Willans 1973/ NT
				Sloping within 5 to 30 m from shore	Mixed rounded and angular materials	1 to 6.3 m but typically between 3.5 and 6.3 m				Kelso et al, 1995/ Lake Superior ON
				Near shore (<10 m from shore)	Clean, coarse substrates	< 2 m				Gunn and Sein 2004 / N.ON
				Off shore	Clean coarse grained, clean angular rubble	6 to 15 m				Thibodeau and Kelso, 1990 / Great Lakes ON
						0.20 to 1.5 m				McAughty and Gunn 1995 / Sudbury, N.ON
				Shoals and shorelines	Mixture of large boulder and cobble, free of silt with many interstitial spaces	2 to 5 m in sloping shorelines				Golder 1998/ Lac de Gras NT
Lake trout	Young-of-the-year						Cobble, and boulder in the vicinity their former incubation site	Shallow inshore areas	Boulders and cobble	MacPhail and Lindsey 1970; Scott and Crossman 1973, Richardson et al, 2001 / General
							Cobble, and boulder where incubated, remain in spawning area for several weeks, move to sand	Shallow inshore areas	Boulders and cobble	Dumount et al, 1982; Goodyear et al, 1982; Ford et al, 1995/ general
						< 3.0 m from the bottom		Shallow inshore areas, feeding on invertebrates, primarily zooplankton	2 to 8 m. Utilize near shore refugia, avoid ice cover	MacDonald et al, 1992/ Alaska
							Off shore areas with soft sediments and near rocky shore areas			Wong and Willans 1993 / NT

Table 2.1 – Continued

Species	Life Stage	Spawning/Nursery					Rearing/ Foraging		Overwintering	References/Region
		Timing	Frequency	Location	Substrate	Depth	Substrate	Depth	Substrate/Depth	
Lake trout	Juvenile						Shelter in Cobble, and boulder		3 to 8 m	Dumount et al 1982; Goodyear et al 1982; Ford et al 1995 / General
							Cobble and boulder			MacPhail and Lindsey 1970; Scott and Crossman 1973, Richardson et al, 2001 / General
								3.0 to 8.0 m interface of boulder and soft substrate. For Protection and feeding (chironomids & zooplankton etc.)	Structured and soft sediment interface	MacDonald et al,1992 /Alaska
							Silt clouds observed , implying near silt substrate, possibly at interface b/n boulder/cobble and silt	2.5 to 40 m along the bottom of the lake		Davis et al, 1997 / Central ON. (Algonquin)
							Shallow, sheltered bays (presumably boulder and cobble)	0 to 4 m		Golder 1998/ Lac de Gras NT
Round whitefish	Adults	FALL (Oct, Nov)	Not all females spawn every year	Inshore, shallow areas in lakes	Gravel shallow areas		Bottom feeding (benthic invertebrates), also prefer areas with currents	7 to 22 m		McPhail and Lindsay 1970; Scott and Crossman 1973, Richardson et al, 2001 / General
					Gravel (periodically over sand and silt); rocky areas					Harper, 1948 / Keewatin region
				Shallow waters						Goodyear et al, 1982 / General
					Gravel and cobble substrates	Typically <1 m, but also 5 to 10 m	Rock, sand and gravel	1.5 to 4.5		Normandeau 1969; Bryan and Kato 1975 / General; Yukon
				Shallow waters of lakes	Gravel substrate in lake shallows	1 to 5 m				Bodaly 1986 / general
				Inshore areas of lakes	Eggs settle into rocks and gravel					Morrow 1980/ Alaska
Round whitefish	Young-of-the-year						Boulder, gravel	1.5 to 4.5 m		Normandeau 1969; Goodyear et al, 1982 / General; Yukon
							Stay in spawning areas 2 to 3 wks post hatch			Morrow 1980/ Alaska
Round whitefish	Juvenile						Boulders, bottom feeders			Scott and Crossman 1973; Richardson et al, 2001
								7 to 22 m		Becker 1983 / Wisconsin
							Schooling in shallow inshore bays			Golder 1998/ Lac de Gras NT

Table 2.1 – Continued

Species	Life Stage	Spawning/Nursery					Rearing/ Foraging		Overwintering	References/Region
		Timing	Frequency	Location	Substrate	Depth	Substrate	Depth	Substrate/Depth	
Arctic char	Adult	FALL (Sept, Oct)	2 to 3 yrs	Spawn in shallow waters	Rocky and gravel shoals	1.0 to 4.5 m				McPhail and Lindsey 1970; Scott and Crossman 1973, Richardson et al, 2001 / General
									Benthic and littoral areas; 5 to10 m	L'Abee Lund et al, 1992 / Norway
					Prefer gravel and cobble	2 to 10 m				Rubin and Buttiker 1992 / Switzerland
					Periodically in vegetated littoral zones					Skulason et al, 1989 / Norway
							Over boulder and cobble substrate. Pelagic zone of lakes feeding primarily zooplankton with seasonal shifts to benthic/littoral areas in the fall	<5 m		Sandlund et al, 1987;L'Abee Lund et al, 1992 / Norway
							Shoreline zone and outlet zone, on cobble and boulder			Parker and Johnson 1991 / Nunavut
							Arctic char were found predominantly in deeper areas with cobble and gravel, and periodically in littoral zones in an oligo Norwegian lake	>11 m		Saksgard and Hesthagen 2004 / Norway
Arctic char	Young-of-the-year						Gravel and Cobble where incubated, hatch in March to April, Cobble and Boulders for cover	<1 m in near shore, shallow water areas		L'Abee Lund et al, 1992 / Norway
Arctic char	Juvenile						Cobble and boulders for protection. As juveniles mature they move from benthic to pelagic zones for feeding	>5 m to avoid predation		L'Abee Lund et al, 1992 / Norway
Burbot	Adult	SPRING (Jan to April, under the ice)		Shallow depths, in lakes, rivers, and streams	Sand and gravel	0.5 to 3.0 m	Seek shelter in boulder, shallow waters during the day	<1 to 10 m		McPhail and Lindsey 1970; Scott and Crossman 1973, Richardson et al, 2001 / General
				Shallow depths in lakes	Sand and gravel	0.5 to 3.0 m	Feed, at night, and seek shelter in boulder, shallow waters during the day. Known to move to hypolimnion	<1 to 10 m		Goodyear et al, 1982, Ford et al, 1995/ General
				Not precisely determined, near shore littoral zones		<4 m	Boulder or sunken trees for protection in N Ont. Lake,	<4 m		Ryder and Pesendorfer, 1992 / N.ON
Burbot	Young-of-the-year						Shallow boulder shoal	<4 m		Ryder and Pesendorfer, 1992 / N.ON
							Over sand and cobble in the pelagic zone	<1 m		McPhail 1997; Richardson et al 2001 / General

Table 2.1 – Continued

Species	Life Stage	Spawning/Nursery					Rearing/ Foraging		Overwintering	References/Region
		Timing	Frequency	Location	Substrate	Depth	Substrate	Depth	Substrate/Depth	
Burbot	Juvenile						In shallow water in boulders, cobble for protection during the day once nocturnal	<1 to 10 m	5 to 10 m	McPhail 1997; Richardson et al 2001 / General
Ninespine stickleback	Adult	SPRING/ SUMMER (April to Aug)	Annually		Weedy,vegetated, muddy	0.1 to 0.15 m off the bottom 2 to 40 m	Dense vegetation, sand and gravel beaches	10 to 70 m	Move to deep areas to in fall to overwinter	McPhail and Lindsay 1970;Scott and Crossman 1973, Richardson et al, 2001 / General
					Weedy,vegetated, muddy	0.1 to 0.15 m off the bottom 2 to 40 m				Goodyear et al, 1983 / General
				Marginal waters	Rocky bottomed areas					Hubbs and Lagler 1958 / Great Lakes ON
				Within 3 to 12 m of the shoreline	Nests built under boulders, protected from turbulence. Boulder and cobble and boulder and gravel	0.25 to 80 cm	Forage in area of nests, boulder and cobble, but also found in open water			Mackenzie and Keenleyside 1970 / Central ON.
Ninespine stickleback	Young-of-the-year						Remain in nursery of mud and orgainc debris	0.1 to 0.15 m		McPhail and Lindsey 1970, Richardson et al, 2001 / General
							Scatter among boulders and cobbles			McPhail and Lindsey 1970, Richardson et al, 2001 / General
Ninespine stickleback	Juvenile						Dense vegetation, sand and gravel beaches	0.1 to 2 m	Deepwater areas	McPhail and Lindsey 1970, Richardson et al, 2001 / General
Slimy Sculpin	Adult	SPRING (May)	Annually	Typically found in rivers, streams, creeks, less frequently in lakes	Shallow rocky shorelines or shoals	< 1.5 m	Gravel, cobble and boulder, however prefer shallow soft sediment	0.5 to 2.10 m		McPhail and Lindsay 1970;Scott and Crossman, 1973, Richardson et al, 2001 / General
					Boulder, cobble, gravel and sand		Gravel, cobble and boulder,prefer shallow soft sediment	<5 to 210 m, most abundant >20 m in Lake Superior		Selgeby 1988 / Lake Superior ON
							Gravel, cobble and boulder	0.5 to 2.10 m	Metaliminion	Mohr 1984 / N.ON
							Higher percentage found in boulder and cobble littoral zone than bare sediments of deeper water			Hanson et al,1992 / Alaska
					Boulder, cobble and gravel, low affinity for sand and silt	0 to 5+ m deep	Associated with gravel or sand, with a lower affinity for boulder and cobble			Lane et al, 1996 / Great Lakes ON
				Shallow littoral zones	Boulders	<8 m		>8 m		Mousseau and Collins 1987 / N.ON
							Below cobble near spawning and rearing areas (<11m displacement range)			Gray 2004 / N.B.
				Littoral zone	Slope of the boulder and cobble shoreline	Greatest density of biomass found at 3.5 m	High density of biomass at the rock/ soft sediment interface			McDonald et al, 1982 / Alaska

Table 2.1 – Continued

Species	Life Stage	Spawning/Nursery					Rearing/ Foraging		Overwintering	References/Region
		Timing	Frequency	Location	Substrate	Depth	Substrate	Depth	Substrate/Depth	
Slimy Sculpin	Young-of-the-year						Gravel and sand	0.5 to 1.5 m		Mohr 1984 / N.ON
							Nests associated with boulder and cobble			Scott and Crossman 1973; Richardson et al, 2001 / General
Slimy Sculpin	Juvenile						Use rocks for protection, associated with nests			Lane et al, 1996 / Great Lakes ON
							Gravel and rocky	0.5 to 2.10 m		Mohr 1984 / N.ON
		Spawning/Nursery					Rearing/ Foraging			
Species	**Life Stage**	Timing	Frequency	Location	Substrate	Depth	Substrate	Depth		

Young-of-the-year forage in shallow complex habitat, and gain protection in boulder and cobble dominated areas. Development and growth of lake trout young-of-the-year is greatly dependant on availability of zooplankton, their primary food source. As juveniles they feed on benthic organisms and zooplankton in the interface between angular substrate and fine sediment (3 to 8 m depths) within 0.3 m from the bottom (Davis et al, 1997; MacDonald et al, 1992). In unstratified lakes, such as the project lakes, adult lake trout feed at a variety of depths (0 to 35 m), along shallow shorelines as well as throughout the pelagic zone. They are primarily cannibalistic, feeding on young-of-the-year and juveniles, as well as opportunistically on juvenile Arctic char, round whitefish and slimy sculpin, and ninespine stickleback. The diet of lake trout from project lakes consisted mostly of other lake trout.

Lake trout was by far the most abundant fish collected in the project lakes (BAEAR, 2005) and corresponding emphasis was placed on habitat abundance and preference of this species. Literature suggests that successful recruitment of lake trout depends on availability of rearing habitat and nutrient availability. Evans et al (1991) concluded that availability of rearing habitat controls natural recruitment in lake trout populations in unstratified lakes, as predators are not limited within a thermal boundary. In the project lakes, this rearing zone is between 0 to 8 m depths above the fine sediment. Along with habitat, ultimately biological characteristics of the species in project lakes (i.e., slow growth rate, late maturity, and low reproduction potential) and the unproductive nature of the water (low nutrient concentration, cold temperatures, short growing season) dictate productivity of lake trout (Oliver et al, 2004)

Recent studies (McAughey and Gunn, 1995; Gunn et al, 1996) indicate that if lake trout are displaced from known spawning habitat, lake trout are extremely adaptable and respond to the loss of habitat by selecting alternate spawning sites without affecting recruitment, so long as boulder and cobble areas are clean of silt and fine sediment.

2.1.2 Round Whitefish (*Prosopium cylindraceum*)

In the north, round whitefish spawn primarily in shallow inshore areas of lakes and periodically in rivers (McPhail and Lindsey, 1970; Scott and Crossman, 1973). Substrate preferences for spawning are variable, ranging from boulder substrates to gravel in both rivers and lakes (Harper, 1948; Normandeau, 1969; Bryan and Kato, 1975; Morrow, 1980; Richardson et al, 2001). There is essentially no stream habitat in the project area. Spawning takes place in lakes at least 2 m depth over heterogeneous boulder cobble/gravel substrate with little to no fines along shorelines and on submerged reefs and shoals.

Young-of-the-year remain in the vicinity of their spawning grounds and seek shelter in boulder and cobbles (depth ranging from 1.5 to 4.5 m) (Normandeau, 1969; Goodyear et al, 1982). Juveniles and adults feed primarily on benthic invertebrates but also on fish and fish eggs (Bodaly 1986). Feeding occurs along the margins of slopes at the intersection of rocky, coarse substrate and fine sediment substrate at depths of 6 to 10 m where chironomid larvae are more abundant. Juvenile fish will utilize habitat nearer to coarse cover substrate than adults, which range over a wider range of depths and substrates, being less vulnerable to predation than juveniles. Adults typically inhabit areas with high boulder substrate (Normandeau, 1969; McPhail and Lindsey, 1970). Round whitefish captured in gill nets from project lakes were usually found over coarse, rocky substrate in nearshore areas (platforms, shoals) in depths from 3 to 10 m. They were seldom captured in deeper water far from cover habitat. Despite their relative abundance in Arctic lakes, relatively little is known about habitat preference of lacustrine dwelling round whitefish.

2.1.3 Arctic Char (*Salvelinus alpinus*)

Arctic char spawn in lakes during fall primarily over gravel and cobble substrate at a range of depths (2 to 10 m) (McPhail and Lindsey, 1970; Sandlund et al, 1987; Rubin and Buttiker, 1992). They have also been found to spawn in vegetated littoral zones of silt and muddy substrate, habitat not found in any of the project lakes (Skulason et al, 1989). Spawning habitat for Arctic char in the project lakes is very similar to that of lake trout and round whitefish. Char are much less abundant in the lakes that either whitefish or lake trout and are not constrained by lack of habitat. Spawning occurs within a similar depth range and morphology as lake trout, although grain size preference is smaller, with a higher proportion of gravel and cobble than boulder. This habitat occurs at slightly deeper depths, from 3 to 6 m.

Young-of-the-year prefer near-shore shallow areas in boulders and cobble substrate which is an important source for cover (L'Abee-Lund et al, 1992). This is similar to habitat preference of round whitefish and lake trout. The coarse, productive shallow environment (0 to 3 m depth) is important for protective cover as well as for foraging. Young of the year and juveniles feed on benthic invertebrates in the littoral zone, but transition to deeper portions of the lake with cover habitat as juveniles to escape high predation areas, where they feed in the pelagic zone on zooplankton (Sandlund et al, 1987; L'Abee-Lund et al, 1992).

Arctic char occupy a wide range of depths, more so than round whitefish, opportunistically feeding on a wide variety of organisms including zooplankton, insects, and small fish (McPhail and Lindsey, 1970). In a Norwegian lake, adult char dominated deeper epibenthic and pelagic areas of the lake (Jansen et al, 2001; Saksgard and Hesthagen, 2004). Pelagic fish were also significantly larger than epibenthic or nearshore fish.

Diet of char in project lakes was found to mostly consist of zooplankton, and when available, Notostraca (tadpole shrimp). Zooplankton abundance and biomass in project lakes was reasonably high and individual zooplankters were quite large. Given the low abundance of char in the lakes and the lack of another predator that focuses on zooplankton, char have access to a relatively abundant food source without much competition, either within or between species. This might account for the relatively large size of Arctic char found in the project lakes, with each of Second Portage, Third Portage and Inuggugayualik lakes containing landlocked char of at least 3 kg. Although this size is unusual for non-anadromous fish, large char are not uncommon in the lakes. Once adult char reach a large size (>2 kg), they are less likely to be predated upon by lake trout and have an advantage over smaller fish and access to a relatively unexploited food source. It is likely that predation of juvenile char suppresses abundance of char in project lakes.

Tallman et al (1996) found that growth rate of landlocked char was similar to anadromous char where lack of predation and sufficient food source allowed landlocked char to grow larger. The size at age relationship of project lake char was similar to char from western Hudson Bay near Rankin Inlet (BAEAR, 2005).

2.1.4 Burbot (*Lota lota*)

Burbot inhabit lakes, rivers and streams throughout their geographic range in the north (Scott and Crossman, 1973; Goodyear et al, 1982; Ford et al, 1995). In project lakes only one individual was captured from Tehek Lake and this species is considered uncommon. Although capture methods for burbot were appropriate and deep water habitat was fished, it is possible that they occur in the other project lakes, however, given that approximately 2,000 fish have been captured, they are likely quite rare.

Burbot are unusual in that they spawn under ice between January and April in shallow water (2 to 5 m depth) (Scott and Crossman, 1973; Goodyear et al, 1982; Ford et al, 1995). Upon hatching fry are found in the pelagic zone and congregate over sand and rubble substrate. McPhail (1997) found that fingerlings change habitat preference when moving from crepuscular to nocturnal activity pattern, as juveniles seek shelter in boulder and cobble substrate during the day. Juveniles are typically found over boulders and cobbles along shorelines (Ford et al, 1995; Ryder and Pisendorfer, 1992). Adults typically inhabit deeper waters with periodic night feeding in shallow areas, as they are sensitive to subsurface illumination (McPhail and Lindsey, 1970; Ryder and Pisendorfer, 1996). Adults are found over boulder, cobble and sand substrates at varying depths (0 to 10 m) (Scott and Crossman 1973, Ford et al, 1995; Fischer and Eckmann, 1997). Burbot were rare in the project lakes with only one adult collected from Tehek Lake.

2.1.5 Ninespine Stickleback (*Pungitius pungitius*)

The ninespine stickleback are found throughout Nunavut. They inhabit slow streams, shallow bays in lakes and tundra ponds (McPhail and Lindsey, 1970; Scott and Crossman, 1973). Stickleback are commonly found in shallow water in boulder and cobble habitat that is wave swept (McKenzie and Keenleyside, 1970). They are highly dependant on vegetation for protection and are commonly found in weedy, cool, and quiet waters (McPhail and Lindsey, 1970; Goodyear et al, 1982). This habitat type does not exist in the project lakes. As with all members of the family Gasterosteidae, ninespine stickleback construct and defend a territory before building a nest for egg deposition (McPhail and Lindsey, 1970; Goodyear et al, 1982). They prefer to nest in shallow water during spring at depths from 0.5 to 2.5 m and current speeds less than 0.3 m/sec (Worgan and FitzGerald, 1981). Once the nest is built the male entices one or more females to deposit eggs in the nest. Eggs incubate for 14 to 21 days at a water temperature of 5 to 6°C. Fry remain in the nest until they are able to swim, at which time they move into open water where they congregate in shallow, sandy, areas with good cover where they are protected from predatory fish (McPhail and Lindsey, 1970; Goodyear et al, 1982).

Stickleback were commonly found in small ephemeral streams along the all-weather road, but were rarely captured in minnow traps in the project lakes. Stickleback have occasionally been observed near shore along rocky shelves with coarse, shallow cover habitat.

2.1.6 Slimy Sculpin (*Cottus cognatus*)

Adult slimy sculpin are typically found in cool, clear lakes and frequent gravel, cobble and boulder substrate with very small home ranges (<50 m) (Selgby, 1988; Gray et al, 2004). They are seldom found in lakes and information on slimy sculpin in both lacustrine and riverine habitats in the north is limited. Spawning occurs in early spring over sand, gravel and cobble substrates in shallow waters of lakes (<1.5 m) (Scott and Crossman, 1973; Selgby, 1988). The male selects a protected site under a rock or ledge, gathers a female, who deposits adhesive eggs on the ceiling that the male fertilizes (Goodyear et al, 1982; Mousseau and Collins, 1987). Eggs require four weeks to hatch depending on water temperature. After hatching, fry drop to the bottom of the nest where they absorb the yolk sack and then leave the nest. Young-of-the-year and juvenile slimy sculpin prefer gravel and cobble substrate (Mohr, 1984). Slimy sculpin gradually shift from shallow water habitat to deepwater habitat as they mature (0.5 to 2.1 m) (Mohr, 1984; Selgeby, 1988). Adult fish in the Arctic have very small home ranges in gravel/boulder substrate in nearshore habitat of lakes (Scott and Crossman, 1973; Mohr, 1984; Selgeby, 1988). Few slimy sculpin were found in the project lakes and were seldom observed in the gut contents of fish.

2.1.7 Arctic Grayling (*Thymallus arcticus*)

Arctic grayling are found throughout Nunavut in rivers, streams, and lakes with clear cold waters (Evans et al, 2002). They are common in the lower Prince River, Thelon River, and Kazan River entering Baker Lake, but are not present in the project area lakes or connecting channels between lakes. Arctic grayling undertake spawning migrations from overwintering habitat (usually lakes) in the early spring prior to or at ice break-up, moving into smaller streams between mid-May and early June. Arctic grayling prefer to spawn over gravel or rocky bottoms with a small percentage of sandy bottom (<15% to 20%). Arctic grayling spawn in areas with surface current velocities less than 1.4 m/s, varying water depths and relatively small, unembedded gravels about 2.5 cm in diameter. A post-spawning run of Arctic grayling from small streams to adjoining rivers and lakes occurs in late June following spawning (Chang-Kue and Cameron, 1980). Arctic grayling have been found to summer feed, after spawning, in rubble and gravel, fine-grained and coarse-grained substrates. Evans et al (2002) have documented spawning migrations by Arctic grayling of up to 320 km from overwintering habitat.

Arctic grayling can mature as early as age 2 or as late as 9 years of age (Evans et al, 2002). Once mature, Arctic grayling typically spawn each year. Within our study region we observed many mature grayling that were resting and did not spawn each year. Spawning takes place over a 2- to 3-week period (Ford et al, 1995), young hatch within 16 to 18 days at 9°C, newly hatched alevin spend 3 to 5 days under substrate and fry are first collected from late June to early July (Evans et al, 2002). Fry reside in semi-deep pools and side channels over boulder, cobble, silt, and sand substrates and water velocities less than 0.8 m/s. Young of the year remain in their natal stream for up to 15 months, where ice conditions permit, and leave in mid-September to move downstream to overwinter in larger lakes or streams.

2.2 OVERVIEW OF HABITAT REQUIREMENTS OF LACUSTRINE FISH IN PROJECT LAKES

2.2.1 Spawning/Nursery Habitat

Lake trout, round whitefish and Arctic char spawn during fall over coarse, rocky substrates with heterogeneous grain size and adequate slope and aspect that resists sedimentation and has good circulation to ensure oxygenation of incubating eggs. In the project lakes, this habitat can be found between 2 and 6 m depth, below the bottom of the ice and above the transition zone between coarse substrates and the transition to silt/clay draped over coarse substrates between 6 to 8 m. According to the literature gathered and summarized in Table 2.1, there is very little to separate spawning habitat preference of the three major or important species. Lake trout likely select larger grain size substrates than do Arctic char and larger still than round whitefish. This kind of habitat is found predominantly within shoal and apron habitat with discernable slopes in water depths greater than 2 m, below the ice scour zone. Spawning habitat features are also important for nursery areas where young-of-the-year fish can absorb their yolk-sac and be afforded protection from predation during the transition to active feeding.

Relatively little is known about spawning habitat preference by burbot and the forage species, ninespine stickleback and sculpin (Table 2.1). Burbot also spawn in shallow areas but do so in mid-winter over sand and gravel areas. In project areas lakes, this may be slightly deeper near transition zones to sediment basin habitat. Stickleback and sculpin will spawn in habitat that is generally similar to what is preferred by char and whitefish in coarse substrates near shore associated with slopes.

Habitat features (e.g., depth, morphology, substrate) most suitable for spawning/rearing were quantitatively mapped (BFAR, 2005) and were appropriately weighted when determining habitat suitability. It is likely that all important species use this kind of habitat for spawning, although discrete areas within these habitat polygons are selected by different species according to subtle features in discrete areas (e.g., patches of smaller grain size material) that cannot be mapped. It is assumed that habitat types with suitable depth and slope with a wide variety of grain size material will be suitable for spawning/rearing by lake trout, round whitefish and Arctic char (Table 2.1).

2.2.2 Rearing/Foraging Habitat

In addition to spawning habitat, shallow, boulder/cobble substrate areas are important to overall productivity of the project lakes because they provide shelter and protection for young-of-the-year and juveniles for all project lake species. These habitats also provide productive areas where periphyton grows and grazing invertebrates colonize. Protection from predation is especially important in unstratified, nutrient poor systems where predators reside at all depths. Additionally the interface between the boulder-cobble shoreline and soft sediment serves as an important feature for rearing and survival of young-of-the-year and juvenile fish. These areas provide protection from predation and soft sand/silt sediment habitat that provide food for maturing fish feeding on chironomids and other invertebrates. The information gathered from the literature (Table 2.1) was quite general with respect to habitat preference by lake trout with wide depth range (shallow to 50 m), rocky, cobble shorelines with fine sediments, sheltered and interface habitats, and a variety of food sources, including zooplankton, benthos and fish. Similar habitat preference is displayed for round whitefish, except that they range over a narrower, generally shallower depth range than lake trout, owing to their smaller size and vulnerability to predation.

Round whitefish are omnivorous, feeding on a wide range of organisms including zooplankton, chironomid larvae, larvae of other aquatic insects and tadpole shrimp. Whitefish will be more closely associated with bottom substrates than lake trout and Arctic char. Thus they are more likely to be found near the coarse bottom/fine sediment interface within depth ranges of 6 to 10 m in project lakes, especially as juveniles. Adults may venture out into deeper water and feed over a wider depth range, although risk of predation is higher.

Arctic char juveniles feed on zooplankton and opportunistically on benthic invertebrates, especially chironomid larvae. There is a gradual shift from nearshore, benthic habitat with plenty of cover to pelagic habitat as fish get larger and focus more on zooplankton. Adult char from the project lakes fed almost exclusively on zooplankton, although other groups such as Notostraca were observed in gut contents. Adults feed opportunistically on seasonally abundant food sources as they become available. Arctic char grow to a relatively large size (>3 kg) in all of the project and reference lakes. We speculate that with a seasonally abundant zooplankton community in the lakes, and no inter-species competition for this food source, char can achieve greater than typical size, provided they are not predated upon.

Lake trout will forage over a wide range of habitat types, areas and depths, given their predatory nature. They feed primarily on fish, especially as larger juveniles and adults, when they target other trout, as well as whitefish and probably char, although few char were identified from gut contents. Round whitefish will tend to forage in moderate depths usually nearshore, although larger fish may be found in deeper waters away from cover habitat. Char also prefer nearshore waters as juveniles, but are more common in the pelagic zone than whitefish as they target open, littoral areas where zooplankton are more abundant.

Thus, the range in habitat suitability for each species is broader than for spawning habitat and there are inter-specific differences in habitat preference for major species. These preferences have been accounted for within the habitat suitability weightings according to habitat type and value within the project lakes. For example, platform and apron habitat types that are slightly deeper and have a greater proportion of fine substrate veneer and transitional habitat are more suitable for rearing/foraging than spawning and is reflected in the weighting between high value and moderate value habitat (BHAR, 2005).

Burbot typically feed in deeper water and usually at night or dawn/dusk. During the daytime they will seek out nearshore areas with cover. Burbot usually feed on larger invertebrates and fish, especially as adults. Thus, habitat preference covers a wide range of depths, substrate size and morphometry of habitat. Stickleback and sculpin are small species that are always vulnerable to predation and inhabit shallow water over coarse substrates where there is ample cover habitat. The home range of these species is quite small and there is a good correlation between spawning/nursery habitat and rearing/foraging habitat. Sculpin tend to rear and forage in coarse rocky habitat while stickleback prefer vegetation. Given that the project lakes contain no macrophytes stickleback will seek out similar shelter habitat as other species, associated with transition zones from coarse material to finer sediments with a greater abundance of benthic invertebrates.

2.2.3 Overwintering Habitat

Overwintering by all species occurs in water depth of 2 m or greater because maximum ice thickness within project lakes has been measured between 1.8 and 2 m. Despite a continuous ice-cover between the end of September or early October and July, oxygen concentrations in the water column remain high throughout the lakes with little or no oxygen depletion, even near the bottom. Thus, the only habitat that all species are excluded from is very shallow, coarse boulder habitat that is less than 2 m depth because of ice cover.

It is difficult to precisely determine subtle differences in overwintering habitat, depth and location within and between species because of ice cover. According to the literature, overwintering by lake trout occurs over boulder cobble habitat, usually in shallow water (up to 8 m), especially for juveniles that require cover. Adults will overwinter and roam over larger areas in deeper water with less habitat (Table 2.1). Very little information exists for overwintering by round whitefish and Arctic char, although presumably they have the same habitat preference as lake trout, choosing coarse substrates of moderate depth that provide adequate cover. Adult char may spend more time in the pelagic zone than whitefish, taking advantage of greater habitat abundance and food resources in open water.

Burbot will also inhabit deeper water than other species, but juveniles will still be associated with coarse substrates in transition zones. Stickleback and sculpin purportedly move to slightly deeper water, away from the ice-water interface and will inhabit transition zone habitat near the margins of sediment basin habitat type. Again, very little specific information exists for these species from any region of the country (Table 2.1).

In terms of preference of habitat type during overwintering, juveniles of all species will select platform, apron or shoal habitat, while adult lake trout and Arctic char may select sediment basin habitat that is >8 m depth and may forage opportunistically in this area. In terms or relative abundance of overwintering habitat, all project lakes, except small shallow lakes (e.g., Phaser Lake) have an abundance of this habitat. For example, 75% of the area of Third Portage Lake consists of deep, sediment basin habitat that is suitable for lake trout, which comprises the vast majority of the population and biomass of the fish populations in the project lakes.

2.3 OVERVIEW OF CONNECTING CHANNEL HABITAT BETWEEN PROJECT LAKES

Field investigations conducted between 1997 and 2005 evaluated the possibility, timing, species composition, and magnitude of movement by fish between project lakes. Movement by fish between lakes is a function of habitat features (e.g., stream discharge, water depth, and substrate composition) and biological imperative (e.g., spawning migrations, movement out of shallow lakes into deeper lakes to overwinter).

Study results have demonstrated that there are no dedicated migrations by any fish species between any of the project lakes via their connecting channels. Rather, movements by lacustrine fish between lakes are random, small and opportunistic and are not related to life history requirements such as spawning, foraging or overwintering. Although water depth, substrate, and discharge between lakes is adequate for movement by fish between some of the larger lakes (i.e., between Third and Second Portage; Vault and Wally; Second Portage and Tehek lakes), only small numbers of fish have been captured in hoop nets and in similar proportions as they have been found from gill net surveys of the project lakes.

The absence of movement or migrations by fish between the lakes is not unexpected. Lake trout and round whitefish are common lake-dwelling species that do not typically move between lakes. The project lakes are large and provide all necessary habitats (spawning, rearing, foraging, overwintering) these species require to survive. Thus, there is no biological imperative to move between lakes. This is not to say that movements by fish related to spawning or overwintering do not occur within lakes. Certainly lake trout, Arctic char and round whitefish will move within the lakes to seek out suitable habitat during fall for spawning.

No migrations by Arctic char between the project lakes have been observed. Char in the system are landlocked and non-anadromous. Char do not move or migrate between lakes with any greater frequency or in greater abundance than lake trout, choosing to remain within their natal lakes.

Arctic grayling are not present within the project lakes. Although grayling are present in the Quoich River downstream of Tehek Lake, their presence in Tehek Lake or upstream lakes has not been demonstrated. Concerted effort within lakes and connecting channels, especially between Tehek and Second Portage lakes has failed to discover grayling. Grayling were not captured in gill nets from project lakes (1997 to 2005). Arctic grayling were commonly observed, however, in all major streams along the proposed all-weather road throughout the open water season. However, all of the streams containing grayling were within the Prince River drainage. The absence of Arctic grayling from the project lakes and their connecting channels is due to the lack of spawning habitat for this species. Connecting channels are short, late thawing and have ephemeral flow. Lawrence and Davies (1977) suggested that poor habitat conditions due to cold water temperatures and inadequate flow conditions prevent spawning by grayling in the upper watershed of this system. Bottom substrate of most channels is very coarse, consisting of large boulders with very little cobble or gravely/rocky parts of main rivers that is favoured for spawning by grayling (Scott and Crossman, 1979).

Lake cisco (*Coregonus artedii*) have also not been collected within or moving between project lakes. Cisco have been collected in small numbers from streams draining to the Prince River system along the proposed all-weather private access road. The absence of lake cisco from the project lakes indicates that they are likely absent from at least the upper reaches of Tehek Lake. Many of the channels are wide and boulder strewn, making movements by fish between lakes difficult.

SECTION 3 • FISH HABITAT ASSESSMENT

3.1 GENERAL APPROACH

Understanding the structure, abundance and spatial distribution of physical features of lacustrine habitat is necessary to determine habitat quality of habitat and its importance for key life history stages of fish, for spawning/nursery, rearing, foraging and overwintering. The species composition, abundance (i.e., biomass) and diversity of fish in project lakes is a function of habitat structure and quality. Four key features dictate the structure, function and overall quality of fish habitat and ultimately, its utilization by fish. These are:

- substrate (grain size) composition
- water (and ice) depth (m)
- morphology (e.g., shoal, platform, sediment basin)
- complexity and slope.

The general approach to defining and mapping habitat at Meadowbank was similar in principal to mapping exercises carried out by mine companies at other northern developments such as Diavik Diamond mines (Golder, 1998), Snap Lake diamond mine (Golder, 2002), Doris North Gold project (RL&L and Golder, 2003), Tahera Diamond (2004) and Fisheries and Oceans Canada (FOC) for Newfoundland and Labrador (Bradbury et al, 2001) and in general by Minns (1995). Consultants for each of these projects follow the basic principals of the Habitat Evaluation Procedure (HEP), first established by the US Fish and Wildlife Service (USFWS, 1981). This procedure is based on calculating a dimensionless unit called a Habitat Unit. Habitat Units are derived from area-weighted sums of habitat type (ha) multiplied by a habitat suitability index (HSI). The HSI is a subjective metric of the relative importance of a habitat type to different life history stages of fish. The product of different habitat areas and their relative importance or suitability (HSI) are represented as Habitat Units and are used to achieve no net loss of habitat.

Certain activities, such as draining parts of lakes will result in the loss of habitat. According to the principals of the no-net-loss policy of the *Fisheries Act*, this habitat must be replaced with similar habitat, with similar productive capacity. Only by understanding what has been lost can one understand what must be replaced to achieve no net loss. Therefore, the approach by mines has been to quantify habitat lost during construction and operation activities and compensate for this loss during operation and post-closure.

The basic procedures followed by Diavik (Golder, 1998), Snap Lake (Golder, 2002) and Miramar's Doris North Gold project (RL&L and Golder, 2003) roughly follow the modified HEP to quantify fish habitat. The basic steps of this procedure are:

- Determine the areal quantity and distribution of particular habitat types (in hectares). Habitat types were defined based on combinations of (e.g., nearshore, deep) and substrate type (e.g., boulder; boulder/cobble). In the case of Diavik, five substrate types were identified along shorelines within discrete depth ranges. A similar exercise was conducted for shoal habitat, unconnected to shorelines. Thus, an areal quantity of depth/substrate combinations is acquired over local/regional areas and areas potentially affected by mining.

- Habitat types are then subjectively ranked or scored according to its perceived suitability for each major life history stage of fish (i.e., spawning, rearing, foraging, overwintering). A high score indicates greater suitability for a particular habitat type than a low score. For example, nearshore boulder/cobble habitat ranked higher for foraging than for spawning of fish. This value is the Habitat Suitability Index or HSI. HSIs are assigned based on professional judgement.

- This exercise is repeated for each life history stage of each species for each habitat type (i.e., depth x substrate combination).

- Areal habitat quantity (ha) of each the depth x substrate habitat type is multiplied by the HSI to determine total Habitat Units. A Habitat Unit is a dimensionless number that connotes the relative suitability of a habitat feature.

- Habitat Units (HUs) are summed over life history stage and weighted by species to arrive at an overall total number of HUs.

Thus, the total HU potentially affected within a region is determined and provides a basis for compensating for, or replacing lost HUs through an enhancement. The ultimate goal is to balance the number of habitat units gained against those lost to achieve a net gain, or no net loss.

3.2 APPROACH AT NWT & NUNAVUT MINES

The following sections present a brief overview of what has been conducted at Snap Lake, Diavik, Miramar, and Tahera, as well as the approach recommended for Newfoundland and Labrador by FOC (Bradbury et al, 2001).

3.2.1 Habitat Assessment at Snap Lake, NWT

Several assumptions made by Golder (2002) were also followed at Meadowbank. These included a focus on “important” fish species (species with domestic, sport, commercial, ecological value), avoidance of development near productive habitat and focus mapping on shallow, coarse substrates such as shoals, and nearshore littoral areas.

Golder (2002) used a simple approach to quantify the effects of the proposed project on fish productivity at Snap Lake. Physical habitat features were separated into three major categories: near-shore (< 4 m), deep-water (> 4 m) and shoal areas (0 to 6 m). Near-shore habitat was subdivided into seven habitat types: boulder/cobble (Bo/Co), bedrock/boulder (Bd/Bo), inundated vegetation/boulder (IV/Bo), bedrock/cobble and inundated vegetation (IV). Shoal habitat was broken down into two categories: primary and secondary, defined by a specific percentage of boulder and cobble. No subcategories were used for deep water. Golder (2002) delineated and mapped these categories in the project area. Topographic maps were reviewed to incorporate bathymetric data and to quantify inshore and deep water by measuring maximum depths of the rocky substrate in the field. GIS was used to calculate area in hectares.

Habitat Suitability Indices (HSI) were calculated by comparing physical features to four distinct classes of habitat requirements for the fish species life stages: spawning, nursery, rearing and foraging. A five-point scale (1.0, 0.75, 0.50, 0.25, and 0) was used to score the physical habitat requirements per life stage of each species. The table below provides an example of the HSI units assigned for lake trout (Golder 2002).

Habitat Type		Spawning	Rearing	Foraging	Nursery
Nearshore	Bo/Co	0.25	0.75	1	0.25
	Bd	0	0.25	0.25	0
	Bd/Bo	0	0.50	0.25	0
	Bo	0.25	0.75	0.75	0.25
	IV/Bo	0	0.25	0.25	0
	Bd/Co	0	0.25	0.25	0
	IV	0	0.25	0.25	0
Shoal	Primary	0	0.50	0.75	0
	Secondary	0.75	0.25	0.50	0.75
Deep water		0.50	0.25	0.50	0

HSI values for each species were multiplied by the area (ha) of the specific physical habitat type to compute a relative habitat unit (HU) per species, per life stage (Golder, 2002).

Example calculation for lake spawning in Bo/Co: 290.5 ha x 0.25 (HSI) = 72.6 (HU)

This calculation was repeated for all habitat types for pre-construction. For example, the total Habitat Units of lake trout spawning habitat in pre-construction was determined to be 99.4.

Using the same subdivision of physical habitat features, habitat area (ha) lost to construction, and gained through enhancement/mitigation are calculated. The areas are multiplied by the developed HSI values to compute HUs. The sum of the habitat units lost and gained were calculated for construction, operation and post-closure.

Following HU calculations for pre-construction, construction and operations, per species, per life stage, an arbitrary exploitation and specific abundance weighting was assigned to each species. Golder (2002) assigned an “exploitation weighting” for domestic/commercial (0.4), sport (0.2) and forage species (0.07). If one species fulfilled all of these qualities, a mean of the values was assigned (i.e., 0.33 for lake trout). The species abundance weighting was determined based on relative proportion of catch-per-unit-effort from 1999 data.

Lastly, the net change in HUs was determined for each species, and life history stage to determine the relative amount of habitat lost to construction/operation and gained during operation and post-closure. Of course, the objective is to achieve no net loss of habitat, measured as Habitat Units.

3.2.2 Habitat Assessment at Diavik Diamond Mine, NWT

The methodology used by Golder (2002) at Snap Lake was similar to the approach at Diavik (Golder 1998). The situation at Diavik is very similar to Meadowbank, in that a large area of a lake is diked off and the interior drained to allow mining. When mining is finished, the pit will be re-filled, the dike breached and the two waterbodies allowed to mix. Habitat within the diked area includes shorelines, shoals, shallow and deep areas. Opportunities for habitat enhancement in the lacustrine environment of Lac de Gras focused on enhancement of dike exteriors, to provide optimal habitat for spawning and rearing of important species.

Physical habitat types and areal coverage (ha) were determined from bathymetric maps. Scanned aerial photos were overlaid with bathymetric information and total area calculated using GIS. This exact same approach was followed at Meadowbank.

Physical feature types for the project included: shoreline, shoal, shallow and deep water, small lakes and streams, which is a smaller suite of parameters than was followed in this study. Physical habitat attributes were surveyed using a boat (slope, depth, erosion potential and substrate composition of shoals) and photographed from a helicopter. Field surveyed UTM coordinates were input using GIS. In addition, a camera was mounted on a remotely operated vehicle (ROV) to describe the substrate composition, complexity, morphology and depth. Similar processes were used for the small isolated or interior project lakes. Streams were surveyed based on size, channel characteristics, velocity, and other stream characteristics.

Physical shoreline habitat was divided into 6 subcategories based on depth and substrate composition (e.g., shallow, boulder/cobble, etc.). Shoal habitat was divided into 5 subcategories; clean boulder near deep water with optimal slope; clean boulder not adjacent to deep water with interstitial spaces; gravel interstitial spaces of inadequate size, clean and optimum exposure; gravel, sedimented, sand/gravel, interstitial spaces of inadequate size, not adjacent to deep water. Both physical shoal and shoreline subcategories incorporated slope, morphology, substrate, and complexity. These categories were also used at Meadowbank, so basic mapping techniques were relatively similar.

Previously developed HSI models were consulted. Golder (2002) noted that the HSI developed for lake trout, the most abundant species in the study area, were not appropriate. This is because the HSIs developed for lake trout by Marcus et al (1984) are only applicable to lakes that thermally stratify in summer and where there are temperature/oxygen gradients in the water column. This situation does not exist in most Arctic lakes, and therefore does not apply. HSIs were subjectively developed for each species following a literature review, Delphi exercise (soliciting ideas and opinions from outside researchers and laypersons) and field observations. HSI values were ranked using a five-point scale, (0.0 to 1.0) for each project lake species during spawning, nursery, rearing and foraging. Species-specific HSIs were developed according to the categories for shoreline type, shoal type and depth. HUs were again calculated by multiplying HSI values by the area (ha) of the associated physical habitat subcategory for Lac de Gras and for the interior project lakes (see Snap Lake example calculations).

3.2.3 Habitat Assessment at Doris North, Nunavut

Miramar Hope Bay Ltd. Is proposing a gold project east of Bathurst Inlet, 160 km southeast of Cambridge Bay in Nunavut. According to the development plan, part of a small (~ 76 ha) lake (Tails Lake) is proposed to be used for disposal of mine tailings. Based on relatively simple mapping, 19 habitat types were identified associated with the nearshore littoral zone. Habitat sections were based primarily on substrate with depth as a minor component. Only two sections were comprised of cobble/boulder substrate, with the remainder consisting of silty sand. RL&L and Golder (2003) only identified the coarse substrate as being of good quality habitat. Each habitat section was ranked as per its suitability as spawning, nursery, rearing and foraging. Nearshore boulder/cobble was deemed suitable for multiple life history stages and requirements by fish, as was the approach taken by other mine development projects. Habitat units were calculated based on the product of surface area (ha) and habitat suitability indices. The HSI values ranged between 0 and 1.0 and were assigned to three habitat types (nearshore fines, nearshore large cobble, deep water) for each of spawning, nursery, rearing and foraging for lake trout. Overwintering habitat suitability was not considered. HSI assignments for Tails Lake were similar to those used at Diavik and Snap Lake mine projects.

Tails Lake contained only lake trout, so habitat units were not weighted according to species abundance or utilization. However, weighting according to importance as domestic/commercial and ecological value was conducted, to derive a value of 0.9.

Miramar Hope Bay Ltd. consultants RL&L and Golder (2003) followed a similar procedure at Doris North as for Diavik (Lac de Gras) and Snap Lake, because Golder has been involved in each of these projects.

3.2.4 Habitat Assessment at Jericho Diamond Project, NWT

Mainstream Aquatics (2004) recently developed a no-net-loss plan for the Jericho Diamond project on behalf of Tahera Diamond Corporation. Relatively small amounts of aquatic habitat will be affected by this project. Nevertheless, no net loss calculations were made for all project components with aquatic impacts including a water intake causeway, a discharge pipe, small stream diversion and a kimberlite containment area. The kimberlite containment area is forecast to permanently affect a small lake (10.3 ha Long Lake) that contains only burbot and slimy sculpin.

As with other northern mine development projects, habitat of Long Lake was classified according to four habitat types based on simple depth/substrate combinations. These were multiplied by HSI indices ranging from 0 (unsuitable habitat) to 1.0 (excellent habitat) for each life history stage, similar to those used by Golder at Snap Lake and Diavik. Following this calculation, importance weightings were applied according to the ecological niche and domestic / recreational / ecological value of each species to determine an overall weighting, termed Weighted Habitat Units (WHU). WHUs were determined for habitats adversely affected or lost by each development activity during operation and closure.

A rock reef is proposed to compensate for lost habitat. This 1,207 m^2 structure will consist of coarse rocky substrate that extends to about 5 m depth and is intended to provide high quality habitat for one or more of spawning, nursery, foraging and wintering habitats (Mainstream Aquatics, 2004). Excavation and causeway construction and improved access to critical habitats in a stream are forecast to create more WHUs than is lost during mine operations, resulting in a net gain. However, this gain is not realized until closure.

3.2.5 Lacustrine Habitat Standard Methods Guide – Newfoundland & Labrador

FOC established a standard methods guide (Bradbury et al, 2001) for Newfoundland and Labrador for quantifying the *HADD* of fish, but may also be used to assist in the *no net loss* of productive fish habitat. Although standard methods for quantifying habitat in the Northwest Territories and Nunavut does not exist, very similar approaches have been taken at other developments to achieve no net loss of habitat, as described above. Although Bradbury et al (2001) emphasized species and physical habitat features that are not found in the Meadowbank project lake area, it was useful to compare the methodology specifically outlined in a region with lake systems partially comparable to the Arctic.

The general steps outlined by Bradbury et al (2001) consisted of the following steps: identify all fish species; collect habitat requirements information for computing composite Habitat Suitability Indices (HSI); characterize the physical habitat; and determine habitat equivalent units (HEI).

Physical habitat mapping types were separated into littoral and non-littoral zones. The littoral zone was further divided into two categories: no vegetation and vegetation, with subcategories of coarse, medium and fine substrate for both categories. Similarly, non-littoral zone habitat was separated into coarse (boulder), medium (cobble/gravel) and fine substrates (sand/silt). HSI values were developed for each species per life stage: spawning, young of the year, juvenile and adult. Required habitat features per life stage, were separated into depth, substrate and vegetative cover. A four point rank scale (1.0, 0.67, 0.33, 0) was used to rank the importance of the subcategories for depth (0 to 1 m, 1 to 2 m, 5 to 10 m, 10+ m), substrate and vegetation cover (submergents and emergents).

Depth and substrate ranking values were combined (calculated as a mean of the ranking values) and separated per life stage for each species. The greatest mean ranking value was divided into littoral, and non-littoral physical features and the associated subcategories. Golder (1998, 2002) HSI values remained separate for each species per life stage throughout the process, FOC (2001) took a different approach by assigning the highest value from each life stage (presumably for conservative measures), therefore, only one value for each species per substrate category was employed. Finally, the area of aquatic habitat (ha) was multiplied by the HSI value for each species to derive Habitat Unit values.

3.3 HABITAT ASSESSMENT AT MEADOWBANK GOLD PROJECT

3.3.1 Overview

Golder (2002 and 1998) and FOC (2001) used a similar framework and approach to subjectively determine the relative value of areal habitat features (ha) and their relative suitability as spawning/nursery, rearing and foraging habitat for important and forage species.

Our general approach to achieve no net loss at Meadowbank used the same principles as those used by Golder at Diavik and Snap Lake, although the specific approach differs in two key ways. First, habitat attributes (and their subcategories; i.e., four depth ranges) at Meadowbank were quantitatively assessed at a much finer, less subjective scale than other studies, using a more complex set of metrics including depth, ice scour, substrate, slope, morphology and complexity. These features were used to identify repeatable “habitat types” that were distinguishable based on the combination of habitat attributes. The end result was that 627 individual habitat polygons were identified for each of the above metrics (BFAR, 2005). Each habitat polygon consisted of a unique combination of depth, substrate, slope, morphology and complexity. Depending on the combination of these, each polygon has greater or lesser value to fish – for spawning, rearing, etc. To determine the relative habitat value of each polygon, a scoring system was devised to determine the overall habitat value. The total score of the areal habitat (ha) physical attribute determined whether a polygon was ranked as having a habitat value score that was high, medium or low. All high, medium and low polygons were mapped and quantified (ha) using GIS. This scoring of habitat attributes was less subjective than other methods because assessment of areal habitat value incorporated more metrics that were more precisely derived from bathymetry, detailed aerial photographic analysis and groundtruthed using underwater video and professional experience.

Second, the areal quantity (ha) of high, medium, and low value habitat scores were multiplied by HSI values. These were subjectively determined for all life history stages (i.e., spawning, rearing), as well as overwintering habitat requirements. HSI values were determined using professional experience, an independent, internal exercise and by comparison to other studies (e.g., Golder, 1998 & 2002).

The product of high, medium and low habitat area values (ha) and HSI values is equivalent to Habitat Units. These are dimensionless units that ultimately are used to determine habitat lost and habitat gained and has been the standard means other northern mines have used to address no net loss. Calculation of Habitat Units incorporates all species, including forage species. Finally, results were weighted according to the relative abundance of species from seven years of fisheries study results. Lake trout, round whitefish and Arctic char comprised 99% of species abundance, with burbot, stickleback and sculpin comprising less than 1% combined.

As described, the same elements have been incorporated as in other assessments of HUs. However, this approach included more physical habitat features and was more quantitative and less subjective than other studies. For example, overwintering habitat value was considered in this study; this was not done in other studies. Furthermore, emphasis was placed on a wider variety of habitat attributes than simply depth and substrate. Here we also assessed morphology, slope and ice scour to assist in ranking and determining relative value of habitat at different life history stages.

The following sections provide more specific detail on assessment and quantification of habitat attributes, scoring habitat polygons, determining habitat suitability indices and calculating HUs.

3.3.2 Habitat Attribute Classification

The following subsections specifically describe how each habitat attribute contributed to overall habitat quality in the project lakes. Six physical habitat attributes were used to delineate polygon boundaries and to describe visible features of each polygon. This was accomplished based on interpretation and GIS mapping of 1:10,000 stereo aerial photographs groundtruthed with underwater video imagery. The six attributes were substrate type, morphology, water depth, habitat complexity, ice scour and slope. Definitions of each are as follows:

- Morphology – The general form of the polygon feature (shape, approximate slope and dimensions, and connectivity to shorelines, shoals, and profundal habitat).
- Substrate – An estimate of the substrate composition and grain size (e.g., silt, gravel, cobble, boulder).
- Depth – An estimate of depth (m) based on empirical bathymetry data and air photo interpretation and spot depths from video imagery.
- Complexity – A qualitative estimate about the composition and spatial heterogeneity of the habitat.
- Ice-scour – Shallow (generally < 2m) coarse boulder habitat with evidence of ice scour resulting in a lower ranking (i.e., high to medium score).
- Slope – Habitat polygons with steep slope were ranked higher because they tend to be deeper and have less build-up of finer sediments and are favoured for spawning by all species.

Aerial photograph interpretation identified a total of 627 unique, identifiable polygons in Vault Lake (24 polygons), Wally Lake (112 polygons), Second Portage Lake (66 polygons, 14 of which were identified within the proposed Portage pit area and tailings impoundment area), and Third Portage Lake (425 polygons, 208 of which were identified within the Goose Island pit area).

The circumference (m) and area (m^2) of each individual polygon was measured using GIS and examined to define habitat features according to the four main attributes above. The relative contribution of each habitat attribute, as it contributes to overall quality of habitat for fish, is discussed below. Features of the six habitat attribute categories are described below.

3.3.2.1 Morphology

Morphology of habitat is a term used to describe large, discrete units of substrate features (i.e., polygons) than can be delineated and quantified and are distinct from adjacent units. For example, a visible offshore shoal surrounded by deeper, indistinct sediment is captured and measured as a discrete unit and quantified with GIS.

The four morphology classes are:

- *Platform* – A continuous, low-slope polygon, usually adjacent to the shoreline. General characteristics of platform habitat are predominantly coarse, boulder substrate, but occasionally may include a discontinuous veneer of boulder cobble over bedrock. Complexity is moderate to high.
- *Apron* – Aprons occur lakeward of platforms or shoals and generally have a steeper slope than platforms. Substrate of aprons is finer than platforms or shoals and represent transitional habitat between shallow littoral areas and deep (>6 m) zones of the lake with fine (sand or silt/clay) sediments.
- *Shoal* – Shoals may or may not be associated with platforms; offshore width may be as wide as alongshore length. Shoals are most commonly not attached to land and are found at depths from 2 m and deeper. Substrate typically consists of a mixture of coarse material (boulder, cobble), but may have a veneer of fine sediment draped over the surface. Complexity is usually moderate.

- *Sediment basin* – Represented by large, low slope continuous polygons offshore of aprons, shoals, and platforms. Generally characterized by deep depths (>8 m) with predominantly fine substrates (silt/clay) with some occasional boulder or cobble patches in discrete areas. Complexity is low and uniform.

Morphology can influence habitat quality in terms of proximity to food sources such as periphyton and insects; these food sources are more commonly associated with platforms. Morphology is also an indicator of lakebed complexity. Greater complexity is associated with platforms while less complexity is associated with aprons and deep, sediment basin habitats.

3.3.3 Substrate

Lakebed substrate is a key habitat attribute that dictates habitat function (e.g., spawning, rearing, feeding) and extent to which fish utilize particular habitats.

Substrate is an important factor in determining habitat utilization and value. In general, coarse, heterogeneous sediment mixtures have a higher habitat value because of greater diversity and structure. Coarse sediment is required for spawning, nursery, and shelter habitat by fish. Sediment composed of an even mixture of fine substrates with little or no complexity is very common, but has lesser value than heterogeneous substrate. Fine substrate habitat is used for feeding by some species but does not provide good, direct habitat for other life history needs of fish.

Substrate of each habitat polygon was classified according to one of four classes: boulder-dominated substrate; boulder/cobble; sediment-dominated with cobble/boulder; and fine-sediment-dominated. Lakebed imagery collected from drop-camera stations provided insight into grain size and depth when combined with colour gradations visible from the aerial photographs. General descriptions of the four substrate classes are as follows:

- *Boulder* – Predominantly boulder and cobble substrates. These may be ice-scoured in very shallow platforms and have light to heavy periphyton coverage. This substrate type was most common in shallow water.
- *Boulder/cobble* – A heterogeneous mixture of boulder-cobble substrate interspersed with some fine sediment patches. Boulders and cobbles are sometimes pressed into fines. This substrate type is also more common in shallow water and has a covering of periphyton.
- *Sediment with boulder/cobble* – A heterogeneous mixture of sediment (i.e., sands and silt-clay) with occasional boulder-cobble coverage (between 10% and 50%). Boulders and cobble may have a light veneer of fines draped over the surface. This substrate occurs primarily in the transition zone between shallow boulder cover and deeper fine sediments at depths of 2 to 6 m.
- *Sediment fines* (silt-clay) – Predominantly silt-clay sediment (90%) with some sand (<5%) and occasional patchy boulder/cobble (<10%). Most common in water depths >6 m.

3.3.4 Depth

Depth was assigned to lake areas from which depth polygons were derived and quantified using GIS. Depth was estimated from features that could be distinguished from air photos and empirical bathymetry data, and groundtruthed from depths measured in the field using underwater video photography.

Classifying depth is important in ranking habitat quality because of the influence of ice, wind-driven currents, and wave action on nearshore and shoal habitat features. For example, ice can scour shallow, littoral zones to a depth of 2 m, minimizing colonization by benthic invertebrates and attached algae. Fish do not spawn successfully within several metres of the water surface because of the risk of freezing of eggs. Wave action and exposure determines sediment grain size and sedimentation rate in shallower waters.

Four depth classes were identified.

- *Shallow* – Less than 2 m depth. Shallow areas were typically found adjacent to shoreline and were associated with platforms and sometimes, shoals. Boulders and/or cobbles may pierce the water's surface and are assumed to freeze to the lakebed in winter.
- *Moderate* – From 2 to 4 m depth. Moderate depth areas provide optimum depth for spawning because of favourable substrate size and distribution. Shoals and aprons typically have moderate depth. Recent studies (e.g., Diavik, Snap Lake) indicate that this depth is preferentially used by lake trout for spawning.
- *Deep* – From 4 to 6 m depth. Deep areas are found lakeward of platform habitat and are most often associated with aprons and shoals. The 6 m lower limit of this class frequently corresponded to the outer edge of platforms.
- *Very deep* – Greater than 6 m depth. Bottom substrate features at depths greater than 6 m could not be clearly distinguished from air photos. Based on underwater video survey results and sediment sampling from previous field studies (BAEAR, 2005), substrate at these depths and greater consist almost exclusively of fine (clay-silt) sediment.

3.3.5 Complexity

Complexity of substrate describes the relative diversity, roughness, and heterogeneity of bottom substrate. There is a positive correlation between substrate complexity and habitat quality. Complex, three-dimensional habitats have a large surface area, which provides for optimal conditions for spawning, nursery, rearing, and shelter habitat for fish because of the diversity of microhabitats. Soft sediment with uniform slope and grain size has low diversity and very little microhabitat diversity.

Three classes of habitat complexity were identified:

- *Complex* – Polygons shows considerable surface roughness (e.g., boulder veneer on bedrock) and a diversity of microhabitats. Complex habitats were more frequently observed at shallow to moderate depths (0 to 4 m) and were associated with platform and shoal habitats.
- *Moderately complex* – Polygon shows some (25% to 50% of area) surface roughness with moderate microhabitat diversity. Usually found at depths greater than 3 or 4 m, associated with shoal and apron habitat.

- *Uniform* – Polygons with little or no surface roughness and low diversity of microhabitats. Usually associated with fine sediment in deeper (>8 m) depths and shallow, sloping bedrock or bedrock controlled shorelines with little or no boulder veneer and low complexity habitat.

3.3.5.1 Ice Scour

If, based on aerial photographs, shallow habitat polygons were determined to have significant ice scour, it was assumed that these polygons were less than 2 m depth and thus received a lower ranking score. That is, if the habitat polygon scored as high value for all other features (e.g., substrate, complexity, morphology), it was automatically ranked as medium value because of the lack of suitability as spawning/nursery habitat because ice cover and risk of freezing prevents survival of eggs.

3.3.5.2 Slope

Habitats that dropped steeply into the water column as seen from aerial photographs or bathymetry, were deemed to have higher value because steep slope areas resist deposition of fine sediments and have great value as spawning/rearing and foraging areas. Although the surface area of steep slope areas less than 10 m depth in the project lakes was small, these polygons were assumed to have high habitat value because of coarse grain size, adequate depth, high complexity and high value morphology.

3.3.6 Determination of Habitat Type

Habitat attributes described above were grouped within identifiable units (i.e., polygons) based on unique combinations of habitat attribute (i.e., substrate, complexity, morphology, and depth) and class (within attribute features) that were mapped and quantified (ha) using GIS.

Six discrete, repeatable habitat types were identified in nearshore littoral zones, shoals, and offshore areas in the project lakes, as distinguished from aerial photograph interpretation and groundtruthed during field surveys (BAEAR, 2005) and with underwater video. The six habitat types are:

- *Boulder platform* – Situated adjacent to shorelines, substrate is typically very coarse, dominated by large boulders (<75%) and cobble, shallow depth (<2 m), and high complexity.
- *Boulder shoal* – Situated offshore of landforms, unconnected to shorelines. Substrate is very heterogeneous and comprised of boulders (75%) with mixed sediment, including cobble and coarse gravel. Depth ranges from shallow (2 m) to moderate depth (2 to 4 m) with high complexity.
- *Boulder apron* – Transition habitat between platforms or shoals and deep sediment basin habitat in deeper water. Substrate typically composed of a moderately complex mixture of boulder and cobble (>70%). Depth is usually shallow to moderate (2 to 4 m), although some polygons were deeper (6 m) with moderate to high complexity.
- *Mixed sediment apron* – Transition habitat consisting predominantly of fine sediments (sand, silt, clay >50%) with occasional boulder and cobble embedded in the sediment with moderate complexity and moderate depth (2 to 4 m).

- *Sediment apron* – Transition habitat with small amounts of coarse substrate (boulder/cobble <25%) and moderate to low complexity. Transition to higher amounts of fines (silt/clay) and reduced complexity with increased depth. Moderate to uniform complexity typically at depths of 4 to 6 m.
- *Sediment basin* – Inferred from field and video data where substrate is dominated by fines (>90%) with few, occasional boulders or small cobble patches. Morphology is flat with uniform complexity and depth is greater than 6 to 8 m.

Habitat type of each polygon was identified and mapped in the Portage lakes and Vault/Wally Lake as depicted in Figures 3.1 and 3.2, respectively. Surface area of each habitat was also quantified using GIS to determine total and relative abundance of each habitat type across project lakes (see Table 3.1).

Note that shallow sandy beach and boulder shoal habitat at deeper depths (6 to 8 m) do not exist in the project lakes. That is, there were no areas identified where fine sediments dominated grain size in shallow water, nor were there areas where very coarse sediments dominated grain size in deep (>6 m) areas. There was a consistent, inverse relationship between sediment grain size and increasing depth. Ice scouring, wind, and wave erosion cause very coarse materials to dominate along shorelines in shallow waters. Fine grain sediment (silt/clay) is found in transition and profundal (i.e., sediment basin habitat) areas. The headwater nature and absence of stream habitat and consequent inputs of sediment from upstream tributaries is a contributing factor to the six habitat types described here, which encompass the range of habitat types observed.

3.3.7 Distribution & Abundance of Habitat Types

The spatial distribution of all six habitat types (i.e., boulder platform, boulder shoal, boulder apron, mixed sediment apron, sediment apron, and sediment basin) were quantified by area using GIS, mapped, and assigned a unique colour to allow easy visual interpretation for Second and Third Portage lakes (see Figure 3.1) and for Vault/Wally Lake (see Figure 3.2). The same procedure was followed for habitat attributes: morphology (platform, shoal, apron, profundal basin), depth (shallow, moderate, deep), substrate (boulder, boulder-sediment, sediment-boulder, fine sediment), and complexity.

Figure 3.1: Distribution of Habitat Types in Second & Third Portage Lakes

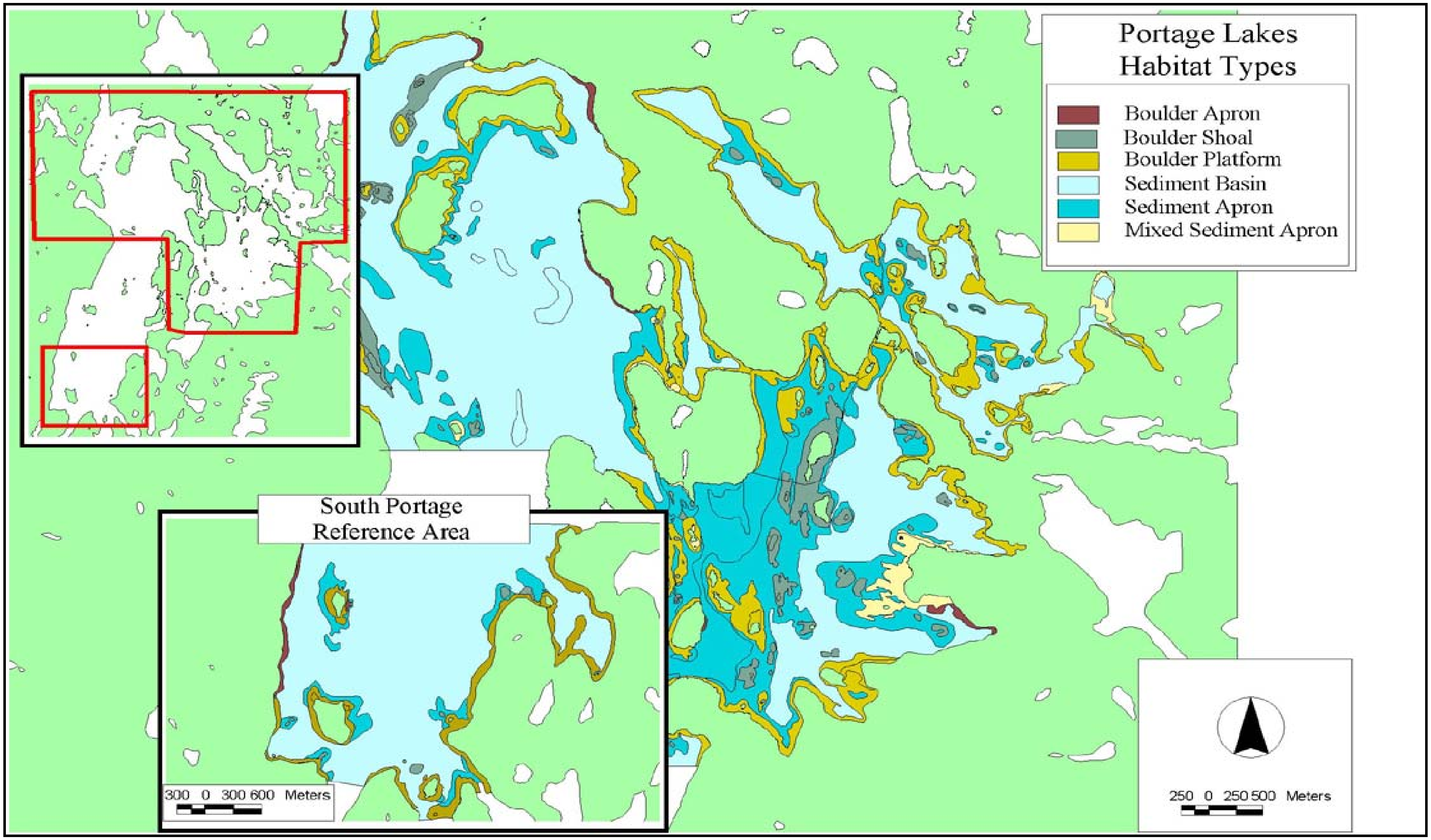


Figure 3.2: Distribution of Habitat Types in Vault & Wally Lakes

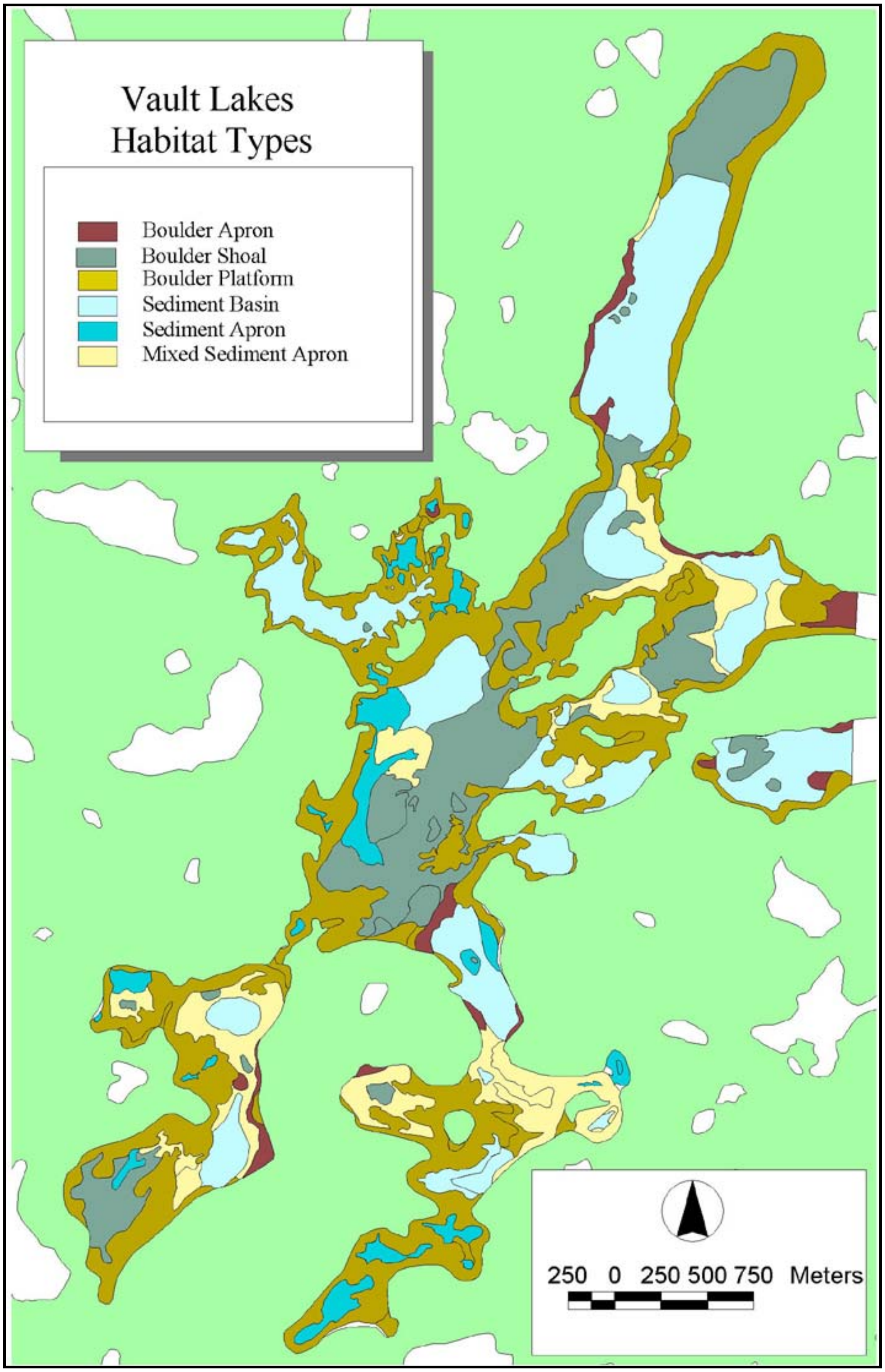


Table 3.1: Total Area (ha) & Relative Abundance of Habitat Types within Project Area Lakes

Sum of Hectares Habitat Type	Second Portage Lake		Third Portage Lake		Vault Lake		Wally Lake	
	Total Area (ha)	**Percentage of Total**	**Total Area (ha)**	**Percentage of Total**	**Total Area (ha)**	**Percentage of Total**	**Total Area (ha)**	**Percentage of Total**
Boulder Platform	103.4	27.0	316.1	12.2	47.4	48.3	217.0	36.2
Boulder Shoal	6.4	1.7	104.1	4.0	12.9	12.7	118.7	19.8
Boulder Apron	0.0	0.0	20.2	0.8	3.1	3.0	14.5	2.4
Mixed Sediment Apron	6.6	1.7	33.0	1.3	20.8	20.4	57.1	9.5
Sediment Apron	36.3	9.5	496.3	19.1	3.8	3.7	29.1	4.9
Sediment Basin	229.7	60.0	1,623.5	62.6	11.0	10.8	162.4	27.1
Grand Total	383.0	100.0	2,593.0	100.0	98.1	100.0	598.8	100.0

3.3.8 Habitat Distribution in Project Lakes

3.3.8.1 Second Portage Lake

The majority of lake area in Second Portage is deeper than 6 to 8 m, the visual limit of resolution of air photos. Maximum depth of the north arm is 38 m and the bottom slopes steeply away from the shoreline and is composed primarily of bedrock and or bedrock with heavy boulder veneer. Sixty percent of the total area of Second Portage Lake consists of profundal basin sediment, greater than 6 m deep. This habitat type dominates the area occupied by the Portage pit and tailings impoundment area (see Figure 3.1).

South of the north arm, lake habitat complexity is more diverse, with many boulder platforms and shallow shoals, and submerged shoals and platforms extending from islands and shorelines. This habitat is preferred for spawning by lake trout, round whitefish, and Arctic char.

Sediment basin habitat (> 6 m deep), consisting of low complexity fine sediment habitat was the dominant feature in Second Portage Lake, composing almost 230 ha or 60% of total lake area. Boulder platform habitat (103 ha) was the next most abundant habitat type in less than 4 m depth, composing 27% of the total lake area (see Table 3.1). Sediment apron (9.5%), mixed sediment apron (6.6%), and boulder shoal habitat (6.4%) composed the remainder of habitat in Second Portage Lake.

3.3.8.2 Third Portage Lake

The relative proportions of habitat in Third Portage Lake were similar to those of Second Portage Lake. There are several large, deep (>30 m) basins in Third Portage Lake, which composed 62.6% of the total area mapped (75% of total lake area). Sediment apron habitat composed 19% of the lake by surface area and was found predominantly in the east basin, west and south of Goose Island. This habitat is moderately deep (2 to 4 m), with abundant mixed boulder/cobble shoals interspersed with fine sediment. Boulder platform habitat was the next most abundant type (12.2%), with smaller amounts of boulder apron, boulder shoal (especially around Goose Island and in the North Basin), and mixed sediment apron habitats (see Table 3.1).

3.3.8.3 Vault/Wally Lake

Vault (98 ha) and Wally (598 ha) lakes are headwater lakes with very complex shorelines and great spatial diversity in depth, substrate type, and morphology. Within Vault Lake, deep sediment basin habitat is rare and composes a small area of the overall habitat (11%), but is proportionally more abundant in Wally Lake (27%; Table 3.1). It is possible that paucity of overwintering habitat may limit productivity of fish in Wally Lake and Vault Lake in particular. Boulder platform habitat dominates nearshore habitat in both lakes, followed by boulder shoal habitat, contributing to the relatively high habitat value in these lakes. Boulder apron and sediment apron habitat each composed less than 5% of habitat by area in Vault and Wally lakes. The complex spatial distribution of habitat types, substrates, and depths contribute to the high overall spatial complexity and value of habitat within these lakes.

3.4 HABITAT VALUE & SUITABILITY (HSI)

Habitat value was calculated based on the cumulative contribution of morphology, substrate, depth, complexity, ice scour and slope for each polygon. The suitability of high, medium, and low value habitat to support life history functions, namely spawning/nursery, rearing, feeding, and overwintering was determined based on the scoring system described below.

Not all habitat is created equal. The value of habitat polygons that scored higher value for each habitat attribute (e.g., slope, depth, substrate) is greater than habitat polygons that scored low. Therefore, a ranking system using a Habitat Suitability Index was used to determine the relative worth of habitat that scored high, medium or low. Total number of hectares of high, medium or low habitat score or value was multiplied by the appropriate Habitat Suitability Index (HSI) to derive HUs.

HSI values were derived for each species for each of four major life history stages: spawning/nursery; rearing; foraging and overwintering. The ranking or scoring system of HSI was similar to what has been used at other northern mines, except the total score ranged from 0 to 10, rather than 0 to 1.0. That is, perfect habitat that was ideally suited to all life history stages of fish would score a 10 (equivalent to excellent habitat; Golder, 1998; 2002). Habitat that was unsuitable for any or all life history stages would be scored progressively lower, depending on how unsuitable it was.

3.4.1 Scoring Habitat Attributes

All 627 polygons identified from air photos were assigned a habitat type and individually evaluated for a suite of physical habitat attributes (BFAR, 2005). A system was devised to score physical attributes using a weighting and ranking system (see Table 3.2), whereby the relative quality of each attribute to provide for basic fish life history requirements was assessed. The rationale for weighting and scoring of habitat attributes was based on our understanding of fish habitat requirements and local conditions, professional judgment and experience, and the scientific literature (see Section 2.0).

To determine the value of habitat polygons, the relative importance of each of the major habitat attributes (substrate, morphology, depth, ice scour, slope and complexity) within each polygon were weighted and the features within attributes (classes) were ranked from one (low value) to three or four (high value). Ice scour and slope were ranked slightly differently. The rationale for scoring habitat features within each habitat attribute is described below and summarized in Table 3.2 below.

3.4.1.1 Substrate

Substrate features largely dictate the function and contribute significantly to overall habitat function and quality. To recognize the contribution of substrate to habitat value, a range of scores was assigned depending on sediment composition. Heterogeneous mixtures of coarse sediment (boulder, cobble, and gravel) were assigned a maximum score of 4. Sediment dominated exclusively by boulders, generally found in shallow water (<2 m) was ranked lower (3) because of the lower diversity and surface area. As sediment grain size becomes increasingly smaller and more uniform in composition, overall value is diminished and assigned a score of 2 or 1, in the case of silt/clay sediment, found at deeper depths or bedrock-controlled shorelines at shallow depths.

Table 3.2: Scores Assigned to Habitat Classes Described from Project Lakes

Habitat Attribute	Weighting[1]	Class	Rank[2]	Feature Score[3]
Substrate	2	Boulder	3	6
	2	Boulder/Cobble	4	8
	2	Boulder/Cobble/Fines	2	4
	2	>90% Fines	1	2
Complexity	2	Uniform	1	2
	2	Moderate	2	4
	2	Complex	3	6
Ice Scour	1	Ice Scoured	2	- 2
Slope	1	Flat slope	1	0
	1	Steep slope	2	2
Morphology	1	Apron	2	2
	1	Shoal	3	3
	1	Platform	4	4
	1	Sediment Basin	1	1
Depth	1	Shallow (0 to 2 m)	1	1
	1	Moderate (2 to 4 m)	4	4
	1	Deep (4 to 6 m)	3	3
	1	Very Deep (>6m)	2	2

Notes: **1.** Weighting indicates the relative importance of each habitat attribute as a determinant of habitat value. **2.** Ranking indicates relative importance of features within habitat attributes. **3.** Feature score is the product of Weight x Rank (except ice scour), and indicates the relative importance of habitat attributes as they contribute to overall habitat value.

3.4.1.2 Complexity

Polygons with complex habitat attributes characterized by high surface roughness, substrate heterogeneity, slope, and dimensionality due to variable depth received the highest rank (3). Polygons displaying intermediate complexity attributes were scored as moderate (2). Polygons displaying low spatial and vertical complexity and uniformity in sediment grain size, slope, and depth received the lowest rank (1).

3.4.1.3 Ice Scour

Where habitat was obviously ice-scoured from aerial photographs and groundtruthing, a penalty score was applied to avoid scoring this as high value habitat. Shallow, complex habitat (shoals or platforms) with coarse substrate ranks relatively high but is not used successfully for spawning or rearing by fish. Therefore, a correction factor was applied when ice cover was documented to ensure that the habitat was not scored incorrectly (i.e., too high).

3.4.1.4 Slope

Habitat with steep slope was given a score of 1; otherwise, no additional points were awarded. This recognizes the value of steep slope habitat that resists sedimentation and is favoured by fish for spawning/rearing. This habitat feature was difficult to distinguish from aerial photographs and comprised only a small amount of available habitat. Nevertheless, where present, it increased relative value of habitat polygons.

3.4.1.5 Morphology

The shape, topography, and slope of individual polygons determine the particular life history function that the polygon provides to fish, such as feeding, overwintering, or spawning. Shoals are particularly important as spawning areas while nearshore platforms are important as feeding and rearing areas. Platforms and shoals consisting of heterogeneous substrates were ranked higher (3 or 4) than aprons because of good light penetration, low ice scour and sediment deposition, and good water circulation. Aprons represent transitional habitats consisting of lesser periphyton growth, reduced circulation, and lower diversity substrates (boulder/cobble <50%; rank 2) or predominantly fines (rank 1). Platforms and shoals have a steeper slope, less accumulated sediment on the rock surfaces, and a greater abundance of periphyton growth than aprons and are therefore scored higher. Deep sediment basin polygons (aprons and profundal areas) consisting predominantly of fine sediments with low diversity, low slope, and no cover were ranked lowest (1).

3.4.1.6 *Depth*

Depth has a strong, direct influence on habitat value, primarily because of the relationship between ice scour, light penetration, biological productivity (e.g., periphyton growth and benthic community), water circulation, sedimentation, currents, and exposure. Habitat polygons in moderate depth (2 to 4 m) ranked higher (4) than habitats deeper than 4 m (rank 3) because of greater light penetration, periphyton growth, water mixing, and exposure to nutrients. Deep sediment basin habitats provide good foraging and overwintering habitat, but there is no cover habitat for spawning or nursery areas and thus received a lower rank (2). Shallow habitat at depths of 2 m or less is ice-scoured, exposed, subject to high wave energy, and ice-free only 8 to 9 months received the lowest rank (1).

3.4.2 Determining Polygon Habitat Value

Habitat value of individual polygons was determined by multiplying the numeric rank value within each habitat attribute by a weighting factor to achieve a feature score (see Table 3.2). Two of the habitat attributes, substrate and complexity, were assigned a weighting factor of 2, reflecting the greater relative importance of these attributes to overall habitat quality, compared to morphology and depth, which were assigned a weighting of 1. Feature scores were summed to derive a total score that is a reflection of habitat value.

Scores were calculated for all 627 identifiable polygons in Second Portage Lake (66 polygons), Third Portage Lake (425 polygons), Vault Lake (24 polygons), and Wally Lake (112 polygons). For example, the total score or value of a particular habitat polygon, such as a boulder shoal found at moderate depth was determined according to its unique composition of substrate type (e.g., boulder/cobble = 8), complexity (e.g., moderate = 4), morphology (e.g., shoal = 3), and depth (e.g., moderate = 4) to produce a total score of 19.

Based on the scoring system, the highest possible score was 22. To simplify the classification system, habitat types with a total score of 18 to 22 were assigned a value of “high,” scores of 13 to 17 a value of “moderate,” and a score of 12 or less, a value of “low.” High (red), moderate (orange), and low (yellow) value habitat polygons were classified, quantified, and mapped using GIS and are presented in Figures 3.3 and 3.4 for Second/Third Portage lakes and Vault/Wally Lake, respectively.

The defining features of high, moderate, and low value habitat polygons are as follows:

- *High Value* – High value habitat polygons are characterized by complex, heterogeneous boulder or boulder/cobble substrate with few fines situated in moderate depth (2 m to 4 or 5 m) below the ice scour zone, but above the transition zone to fine silt/clay. High value polygons were usually associated with shoals or platforms with good exposure and discernable slope. These polygons combined many of the habitat features sought by fish and are best suited for multiple life history requirements, including spawning/nursery, rearing, shelter, and feeding.
- *Moderate Value* – Moderate value habitat polygons are typically found within two depth ranges; 0 to 2 m and 4 m to 6 or 8 m. Moderate value polygons in shallow (<2 m) water are characterized by large boulder or, infrequently, boulder/cobble habitat with no fines, shallow slope and are usually attached to shorelines (platforms). Substrate is usually ice-scoured and unavailable for spawning, but does provide excellent rearing and foraging habitat. Moderate value polygons are frequently found nearshore and their distribution is strongly related to depth. Overwintering habitat value is nil in water depth less than 2 m. At mid-range depths (> 4 m), moderate value polygons consist of a mixture of coarse substrates on shoals or aprons in transition areas. Coarse substrates in these areas are sometimes draped by fine sediments and are important transition areas between coarse and fine substrate. This habitat offers good protection for all fish species, especially juveniles, and is less important for spawning/nursery, but is very important as rearing and feeding habitat. Overwintering is also important in this depth / substrate zone. HSI values determined in Table 3.3 reflect this diversity of habitat, stratified by depth.
- *Low Value* – Low value habitat polygons consist primarily of uniform fine substrate, of low complexity in deep water (> 8 m) providing feeding and overwintering habitat. The importance of this habitat varies according to species. Juveniles and round whitefish of all ages forage for chironomid larvae near transition zones where there is adequate shelter. Arctic char, especially adults, forage in mid-water feeding on zooplankton, and are commonly found above this habitat type in the pelagic environment (Jansen et al, 2001, Saksgard and Hesthagen 2004). This combination of habitat features is most common, especially in Second and Third Portage lakes. Some low value habitat is also found very near shore in Second and Third Portage lakes and Vault/Wally lakes and is characterized as sloping bedrock or broken rock slabs extending from shore to depths of several meters. These shorelines are flat with low complexity and low diversity in structure and habitat value.

There is no established, widely recognized procedure or protocol for mapping and valuing fish habitat in Arctic lakes. The same basic principals have been applied for Meadowbank as were applied in environmental assessments of other northern mining projects (e.g., Diavik, Snap Lake, Jericho) as described in Section 3.2. In this assessment, HSIs were applied to high, moderate, and low value habitat polygons to determine overall HUs. Figures 3.3 and 3.4 present the spatial distribution of these polygons in the Portage lakes and Vault and Wally lakes, respectively. These images illustrate the distribution, abundance, and relative context of important habitats in the project lakes. The maps clearly indicate the location of important habitats, especially shoals, platforms, and complex habitat types that are most important for spawning/nursery, rearing and foraging areas. Large areas of Second and Third Portage lakes consist of deep-water, low complexity silt/clay habitat.

Figure 3.3: Baseline Habitat Quality – Second & Third Portage Lakes

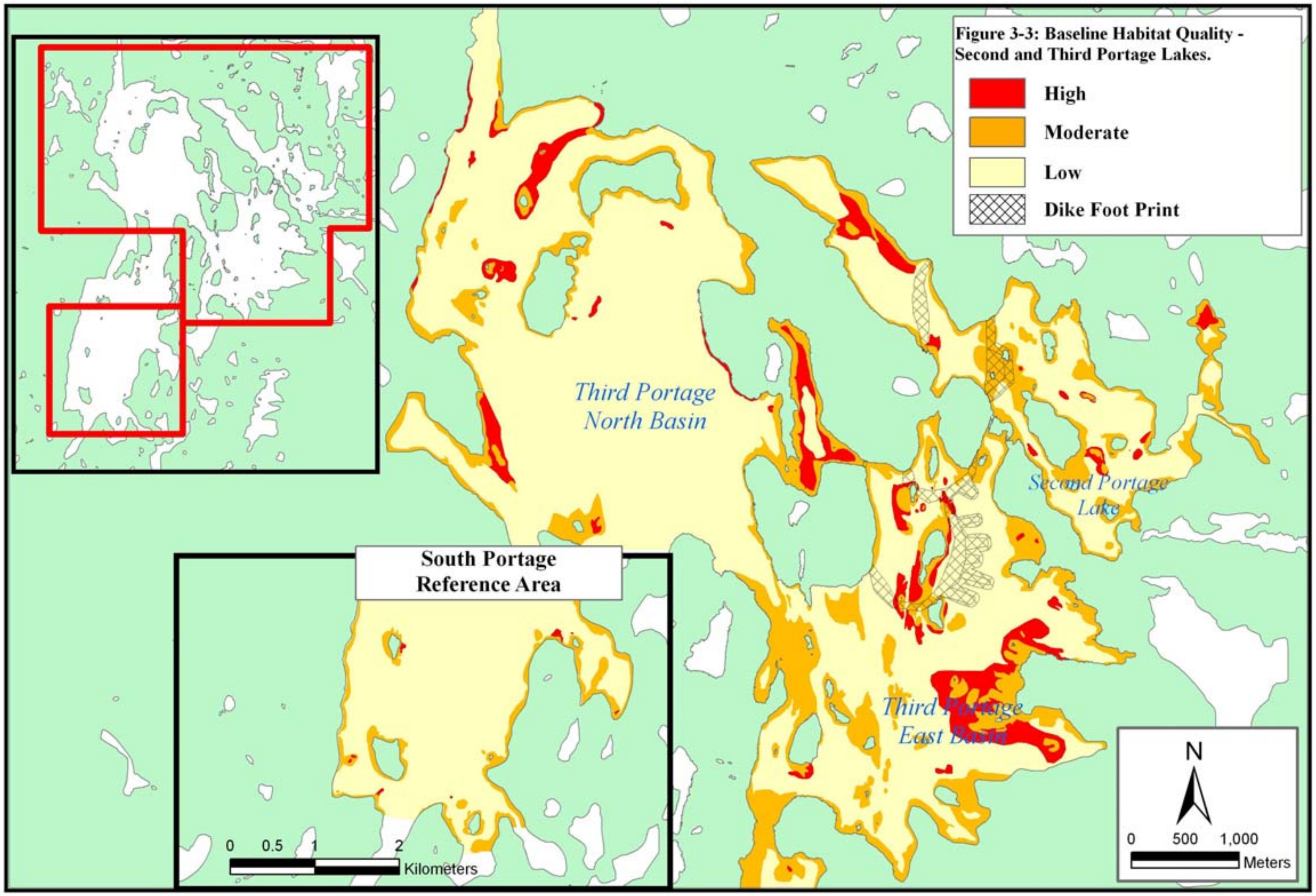


Figure 3.4: Baseline Habitat Quality – Vault & Wally Lakes

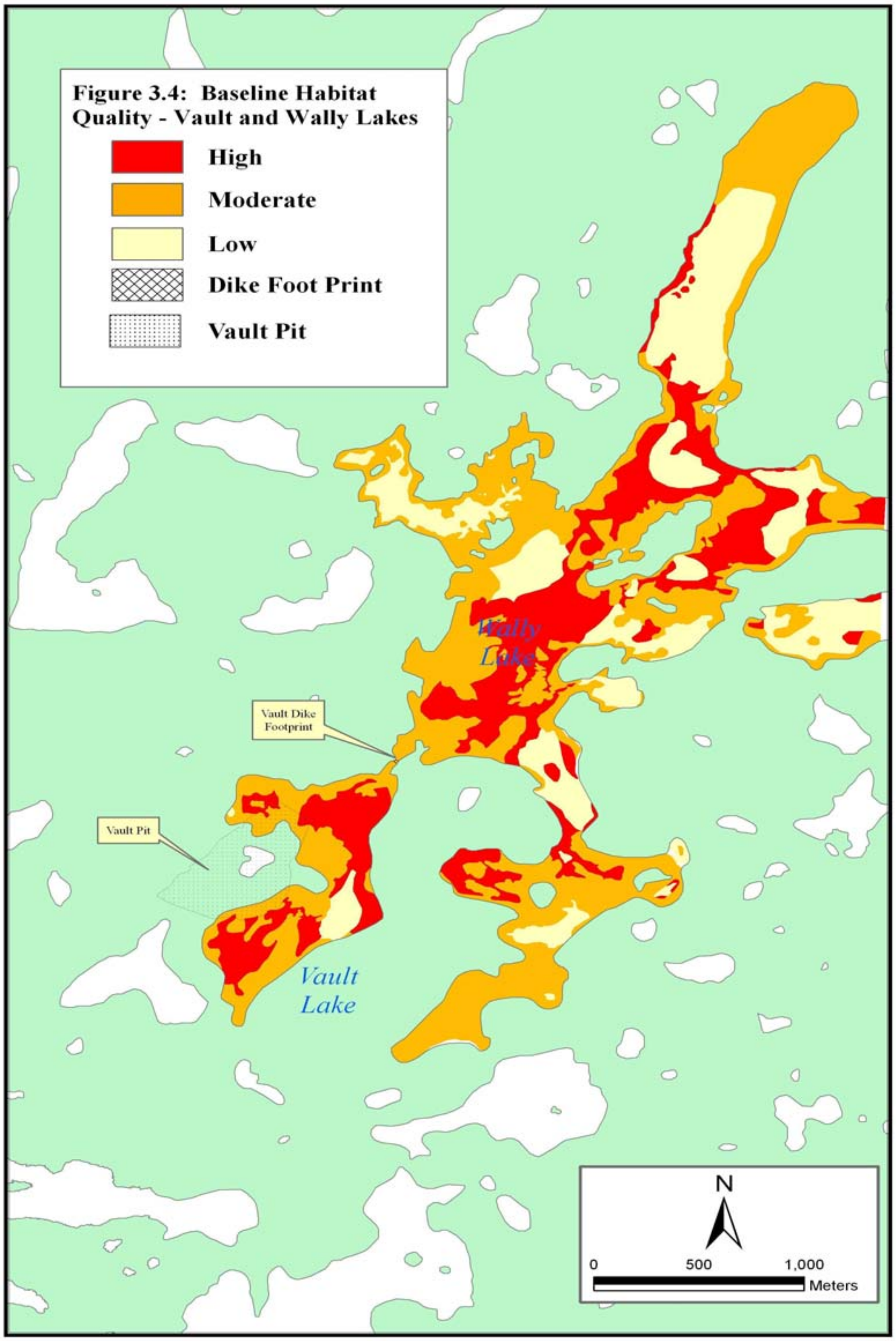


Table 3.3: Habitat Suitability Indices (HS I) per Species per Life Stage for High, Medium & Low Areas

		Spawning/ Nursery (4)	Rearing (2)	Foraging (3)	Overwintering (1)	Total Score (10)
Lake trout	High	4	1.75	2.5	1	9.25
	Medium	1	2	2.5	0.5	6
	Low	0	0.5	1	0.75	2.25
Round whitefish	High	3	1.5	2	1	7.5
	Medium	2	2	2.5	0.5	7
	Low	0	0.5	1.5	0.5	2.5
Arctic char	High	3.5	1.5	2.5	1	8.5
	Medium	1	1.5	2	0.5	5
	Low	0	0.5	1.5	0.75	2.75
Burbot	High	3	1.5	2	0.5	7
	Medium	2	1.5	2	0.25	5.75
	Low	1	0.5	2	1	4.5
Slimy sculpin	High	2	1.5	2	0.75	6.25
	Medium	1	2	2.5	0.25	5.75
	Low	0.5	1	1.5	0.5	3.5
Ninespine stickleback	High	2	2	2	1	7
	Medium	1	2	2.5	0.5	6
	Low	0	0	0.5	0	0.5

3.5 HABITAT UNIT DERIVATION IN PROJECT LAKES

HUs are calculated from the product of habitat area (ha) and habitat suitability (HSI) for each life history stage. The HU is then weighted according to species abundance or importance in the project lakes. The specific procedure followed to determine HUs for project lakes is described as follows.

3.5.1 Habitat Suitability Index

Habitat suitability indices (HSI) for major species (lake trout, round whitefish and Arctic char), burbot and forage species (ninespine stickleback and slimy sculpin) are presented in Table 3.3. The scoring system used here was similar as for other northern mines, except that a scale from 0 to 10 was used instead of 0 to 1.0. Perfect habitat would receive a score of 10 and would completely satisfy habitat for all life history stages of each species. Four life history stages were ranked:

- Spawning/nursery was combined because of the necessarily strong relationship between the locations where eggs are laid and when hatching and early nursery and yolk-sac absorption and swim-up occur. This is arguably the most important life history stage and was weighted to recognize this with a score of 4. High value habitat polygons are used for spawning/nursery by fish and their distribution is restricted.

- Rearing habitat for juvenile fish (young-of-the-year and immature fish) was given a score of 2. Rearing habitat is relatively widespread and abundant in the project lakes because of the abundance of habitat associated with shorelines, shoals, platforms and aprons that provide coarse, complex substrates where fish shelter.
- Foraging habitat (all ages) was given a score of 3 in recognition of the nutrient limited status of the lakes. During winter a considerable portion of the useable habitat of the lake is bound by ice; the majority of the project lake habitat consists of low value profundal sediment basin habitat that is less important for juvenile fish as foraging habitat. Lake trout and adult round whitefish and Arctic char utilize profundal habitat far more than juveniles.
- Overwintering habitat is very abundant in the project lakes and is not limiting except perhaps in Vault Lake and was given a score of 1.

HSI values were determined for all species, including burbot and forage species for the above life history stages, for each of high, medium and low habitat polygons. The habitat polygons, ranked by relative value, incorporate individual scoring based on morphology, depth, substrate, complexity, slope, and ice cover and their subcategories (e.g., 4 depth zones, 6 morphology types, etc.). This ranking system is simple and has relatively little bias or subjectivity. As discussed above in Section 3.4.2, high value habitat incorporates features that are suitable or satisfy many different life history requirements. Medium value habitat is less complex, contains shallow, ice-scoured habitat and does not provide the same habitat quality as high value polygons. The overall scoring of HSI values between high, medium, and low value polygons within species is consistent, with sum totals reflecting habitat features within high, medium, and low value habitat polygons. However, inter-species differences in habitat preference and life history are reflected by the values. For example, habitat suitability indices between lake trout, burbot, and slimy sculpin were consistently different and reflected differences in life history. Burbot and sculpin are more closely associated with benthic habitats and may range over a wider range of substrates and depths trout, especially juveniles.

HSI values for lake trout, round whitefish and Arctic char were relatively similar, among life history stage as well as within habitat value polygon. This is because spawning habitat preference of these species (Table 2.1) is relatively similar, with only subtle differences in grain size distribution. High value habitat polygons are likely selected by all species for multiple life history functions such as spawning/nursery, rearing and foraging. The similarity in HIS scores is a reflection of the similarity in life history strategies of these species. There are differences in habitat preference at different life history stage of each species, however, and this is reflected in HSI values (Table 3.3). For example, as adults, Arctic char may adopt a more pelagic life style foraging on zooplankton over low value habitat polygons (score 1.5). Lake trout also spend time in open water, but spend more time in shallower water targeting prey that are more closely associated with high and moderate value polygons (score 2.5).

3.5.2 Species Weighting

The result of this weighting exercise above is that high, medium and low value polygons received individual scores for each species according to life history requirements. For example, high value polygons rated more highly for lake trout (HSI of 9.25) than for round whitefish (HSI of 7.5) slimy sculpin (HSI of 6.25). In other studies of northern mines (Golder, 1998; 2002; Mainstream Aquatics, 2004) each species was subjectively ranked according to its perceived importance as domestic, commercial or ecological value. This is a subjective, anthropomorphic approach that places value on a natural resource based on perception; this approach was not applied at Meadowbank.

Instead, to achieve an overall HU rating for habitat polygons, HSI values were weighted by species abundance based on fisheries studies conducted between 1997 and 2005 (BAEAR, 2005). Surveys conducted since 1997 have used the same index gill nets. Relative abundance (and biomass) of species differed somewhat among lakes, although lake trout was consistently most abundant, followed by round whitefish and then Arctic char. Very small numbers of ninespine stickleback and slimy sculpin have been captured and only one burbot has been caught from Tehek Lake.

Fish captured during all surveys were totalled and the percent relative abundance of species, pooled over all project lakes was determined to derive an abundance weighting (Table 3.4). Average abundance of lake trout pooled over lakes and years was 75%. Round whitefish (15%) and Arctic char (9%) were next most abundant. To be conservative, it was assumed that burbot were slightly more abundant than net surveys suggested and an abundance weighting of 0.5% was used. A similar assumption was made for ninespine stickleback and slimy sculpin, each using a weighting factor of 0.25%. Although the actual abundance was lower, these species are not vulnerable to gill nets and this value reflects their likely abundance or biomass (Table 3.4).

Table 3.4: Weighted Mean Habitat Suitability Indices (HSI)

Polygon Value	**Species**	**HS I**	**Species Abundance Weighting**	**Final HS I**
High	Lake trout	9.25	0.75	6.94
	Round whitefish	7.5	0.15	1.13
	Arctic char	8.5	0.09	0.77
	Burbot	7	0.005	0.04
	Slimy sculpin	6.25	0.0025	0.02
	Ninespine stickleback	7	0.0025	0.02
			SUM	**8.90**
Medium	Lake trout	6	0.75	4.50
	Round whitefish	7	0.15	1.05
	Arctic char	5	0.09	0.45
	Burbot	5.75	0.005	0.03
	Slimy sculpin	5.75	0.0025	0.01
	Ninespine stickleback	6	0.0025	0.02
			SUM	**6.06**
Low	Lake trout	2.25	0.75	1.69
	Round whitefish	2.5	0.15	0.38
	Arctic char	2.75	0.09	0.25
	Burbot	4.5	0.005	0.02
	Slimy sculpin	3.5	0.0025	0.01
	Ninespine stickleback	0.5	0.0025	0.00
			SUM	**2.34**

Species weighting scores were multiplied by the HSI score and then summed to derive a species weighted score for project lakes for high, medium and low value polygons. The overall score for each polygon value was similar to the value for lake trout because of their great abundance, but is an unbiased reflection of the contributions made by other species to Habitat Units. Thus, HUs incorporate habitat suitability of uncommon and forage species in overall assessment of no net loss for all species.

- The species weighted HSI value for high value habitat polygons is 8.90.
- The species weighted HSI value for medium value habitat polygons is 6.06.
- The species weighted HSI value for low value habitat polygons is 2.34.

The product of these values multiplied by the spatial area (ha) of high, medium and low value polygons is an unbiased estimate of Habitat Units. HUs derived in this manner were used to determine habitat loss and gain during construction/operation and post-closure at the Meadowbank Gold project.

3.5.3 Habitat Mapping

A total of 383 ha was mapped in Second Portage Lake, over all habitat types combined (Table 3.5). This included all habitats within the proposed Portage pit and tailings impoundment area (see Figure 3.1) extending from the north end of Second Portage Lake to the outlet into Tehek Lake. This does not include surface area of Drilltrail Lake (Figure 3.2).

Table 3.5: Total Area of Project Area Lakes Relative to Area Classified for Fish Habitat

	Total Area (ha)	Total Classified Area (ha)	% Area Classified
Second Portage	383	383	100
Third Portage	3,600	2,593	72
Vault/Wally Lakes	732	697	95

Third Portage Lake is much larger than the other lakes, totalling about 3,600 ha. Approximately 2,593 ha of Third Portage Lake habitat was quantified, which is nearly three quarters (72%) of the total area of Third Portage Lake (Table 3.5). Because of its very large size, the entire lake was not mapped. Mapping focused on the northern basin (effluent discharge site during Years 1 to 4 and because of the existence of empirical bathymetry data), the southern basin (which serves as the internal reference area) and the east basin (where the majority of mine development is occurring) were mapped. Note that areas presented here are plan-view areas and do not incorporate the effect of slope on actual area. That is, the area of high quality habitat along shorelines may actually be slightly higher than estimated from air photos (two dimensions) because of the slope of lakebed; however, this difference is consistent for all of the lakes and represents only a small difference.

Vault, Wally, and Drilltrail lakes flow in a north-south direction, eventually connecting with Second Portage just upstream of its outlet to Tehek Lake (Figure 2.1). Vault Lake is a small lake (98 ha) adjacent to the Vault deposit, while Wally Lake is a large (598 ha), convoluted lake that lies immediately adjacent to Vault Lake and is connected via a small (10 m) channel. Wally Lake connects to Second Portage Lake via a small connecting lake (Figure 2.1). Vault and Wally lakes have a combined surface area of 732 ha, of which 697 ha (95%) were mapped.

3.5.4 Third Portage Lake

High (173 ha) and moderate (649 ha) value habitat polygons (Table 3.6) in Third Portage Lake are strongly associated with boulder platform and boulder shoal habitat because of ideal substrate, complexity, and depth for feeding and spawning/nursery and rearing habitat for lake trout, round whitefish, and Arctic char. The east basin contains proportionally more moderate and high value habitat than the north and south basins, which are dominated by large, deep basins with few islands and shallow shoals. Low value polygons comprise 77% of the lake surface area because of the deeper depth and predominance of low value, fine-sediment basin habitat. Fine sediments with little or no boulder/cobble and very low complexity characterize low value habitat, although areas of intermediate depth (4 to 12 m) provide good feeding habitat for round whitefish because of abundant benthic invertebrate populations (BAEAR, 2005). Note that the hectares in Table 3.5 for Third Portage Lake are corrected for total area of Third Portage Lake (3,600 ha).

3.5.5 Second Portage Lake

Second Portage Lake (383 ha) contained proportionately more high (21 ha) and moderate (126 ha) value polygons (5% and 33% respectively; Table 3.6) than low value polygons (62%) compared to Third Portage Lake, because of shallower depth and greater abundance of boulder platform and boulder shoal habitat of shallow to moderate depth and high complexity (see Table 2.1). The smaller lake area and large number of islands and submerged shoals contribute to greater complexity and diversity of habitat.

A relatively small area of moderate value polygons exists in Second Portage Lake, especially the north basin because of the steep sloping shorelines and deep depth of the basin, with the exception of a shallow (8 m) sill that separates the planned attenuation pond from the tailings impoundment area. South of this area, near the proposed location of the East dike, habitat complexity and value is high because of ideal depth and substrate characteristics. Abundant boulder/cobble substrate over platform and shoal habitat in moderate depth water contributes to this high value. High and moderate value habitat is strongly associated with islands, where platform and shoal habitat exists windward and in the lee of the strong prevailing northwest wind direction.

3.5.6 Vault/Wally Lake

A large proportion (92%) of the polygons in Vault Lake (98 ha) were classified as high (39 ha) and moderate value habitat (51 ha) (Table 3.6). A similar proportion of Wally Lake (599 ha) polygons were rated as high (23%) or moderate value (49%) habitat that is abundant and distributed evenly throughout the lake system, especially in the central region of Vault and Wally lakes (Table 3.2). Again, high value habitat polygons were typically associated with boulder platforms with heterogeneous substrates, shallow to moderate depth, and high complexity.

Table 3.6: Total Area (ha) & Number of Habitat Units (HU) from High, Moderate & Low Value Polygons in Project Area Lakes

Habitat Polygon	HS I	Second Portage		Third Portage		Vault Lake		Wally Lake	
		Total Area (ha)	Total HU	Total Area (ha)	Total HU	Total Area (ha)	Total HU	Total Area (ha)	Total HU
High	8.90	21.3	189.2	173	1,538.9	39.7	353.5	138.3	1,229.6
Moderate	6.06	126.4	765.9	649	3,931.7	50.7	307.0	294.7	1,785.9
Low	2.34	234.9	550.2	2,778	6,507.5	11.0	25.8	164.0	384.1
Total HU			**1,505.3**		**11,978.8**		**686.3**		**3,399.6**

Note: Total area and HU of Third Portage Lake are pro-rated based on actual total lake area (3,600 ha).

The total area of moderate value polygons in Vault (50.7 ha) and Wally lakes (295 ha) was 49% of mapped surface area, and was considerably more than the area and proportion of moderate value polygons than in the Portage lakes. Moderate value habitat is associated with boulder apron and mixed sediment apron, and is dominated by coarse substrates in water of shallow-to-moderate depth and moderate complexity. Similar to the Portage lakes, use of moderate habitat by fish for spawning is probably very site-specific. Given the abundance of high and moderate habitat polygons in the Vault lakes, this area is not limited by physical habitat attributes.

Low value polygons associated with overwintering habitat in Vault Lake (11 ha, 12%) and Wally Lake (164 ha, 27%) was relatively less abundant than low value habitat in the Portage lakes because of the generally shallow nature of the Vault/Wally lake basins. It is possible that deep water, overwintering habitat may be limiting productive capacity of Vault and Wally lakes.

SECTION 4 • HABITAT LOSS DURING MINE DEVELOPMENT

4.1 CONTEXT

The project lakes are situated in the extreme headwaters of the Quoich River system and are nutrient-poor with low productivity and low diversity of fish species. Quantifying habitat loss is complex and depends on a number of factors that influence how habitat and ultimately, fish biomass is affected during the course of mine life. The absolute and relative value (based on Habitat Units) of fish habitat potentially affected by mine development activities was based on a rigorous habitat assessment using information gathered from aerial photographs, underwater video imagery, field studies, and professional experience. Three major factors considered in this assessment are:

- The project lakes are isolated and have not been fished by community members from Baker Lake, except on rare occasions. The project lakes do not support domestic or sport fisheries.
- High and moderate value habitat polygons are abundant and widely distributed throughout the project lakes. There does not appear to be a limitation in productive habitat in the lakes. Habitat altered or destroyed within lake areas affected by the proposed mine development does not disproportionately affect key habitat types that do not exist elsewhere in the project lakes.
- The project lakes are ultra-oligotrophic and severely nutrient-limited. Production of fish biomass in project lakes is limited by lack of nutrients and not due to deficiencies, limitations, or distribution of physical habitat types.

Certain mine development activities during construction and operation will result in the unavoidable alteration, disruption, or destruction of fish habitat because certain activities cannot be relocated or mitigated.

Avoidance of disruption, alteration or destruction of fish habitat has been exercised at Meadowbank where possible.

- Dike footprints and set back from pits has been minimized as much as possible.
- The Portage/Goose Island waste rock dump has been reduced in size to avoid impacting small fish-bearing lakes to the north of the dump.
- Orientation of the runway has been altered to prevent its incursion into Third Portage Lake.
- Phaser Lake will not be drawn down. Rather, elevation will be maintained by a water retention berm and discharge will be directed to Turn Lake to avoid loss of overwintering habitat in Phaser Lake.
- Water intake pipe and effluent pipe will avoid high value habitat polygons.
- Bridges will be installed across all fish-bearing streams along the proposed AWPAR.

Dike construction and the creation of open pits within the bounds of Second Portage Lake, Third Portage Lake, and Vault Lake will eliminate or alter habitat despite reasonable attempts to avoid impacts. This section of the NNL quantifies the amount (ha) and value of HUs altered, disrupted, or destroyed from minor and major development activities. Options to compensate for loss of fish habitat in the project lakes during operation and post-closure are presented.

4.2 HABITAT LOSS FROM MINOR PROJECT ACTIVITIES

Minor project activities are those activities that are routine where proven engineered mitigation techniques exist, affect only small amounts of habitat (<1.0 ha) and whose effects can largely be mitigated through proper construction practices or on-site habitat enhancement. Detailed descriptions of construction methods and mitigation during installation and operation of each of these activities is provided within the EIA and supporting documents. Furthermore, direct impacts on fish due to worker fishing, consumptive water use, blasting, noise and disturbance from dike construction, and effluent discharge are described in detail in the EIA and are not quantified here.

The following proposed minor project activities have the potential to alter, disrupt, or destroy fish habitat within project lakes:

- elimination of one of three channels that connect Second Portage and Third Portage lakes as a result of construction of the East and Bay Zone dikes
- alteration of habitat from construction and installation of a water intake pipe in Third Portage Lake and effluent discharge pipe in Third Portage Lake and Wally Lake
- diversion of Phaser Lake outflow from Vault Lake to Turn Lake
- installation and operation of the Turn Lake Road crossing
- construction and operation of a marine barge landing facility at Baker Lake.

4.2.1 Portage Lakes Connecting Channel

Construction of the Bay Zone and East dikes will eliminate the westernmost of the three channels connecting Second and Third Portage lakes (Figure 2.1). Normally, fish passage via this channel is difficult during the open-water season with the exception of peak spring freshet. The channels are shallow and consist of boulder cobble with most water flow between or beneath the large substrate at all times except freshet. Movement by fish between the lakes is impossible during winter (October to June) because the channels are frozen. Monitoring of fish movement between Second and Portage lakes detected very small (<10 fish) movements of fish over the course freshet between the lakes (BAEAR, 2005). No fish movements were detected at base flows in August.

The connecting channels are short and are not used as migratory routes by Arctic char or any other species. Spawning, nursery habitat, and rearing by juvenile fish does not occur in this connecting channel.

To compensate for the loss of the connecting channel, the easternmost channel may need to be widened slightly to facilitate greater flow that must now pass via two channels and not three. A decision as to whether the channel needs to be modified is pending a detailed engineering survey of the central and eastern channels. A detailed assessment of the impact on water quantity as a result of dewatering of a portion of Second Portage Lake is presented in the Aquatic Environment Impact Assessment (2005). Of the two remaining channels, this easternmost channel is the furthest from mine operations and less likely to be affected by noise or disturbance, such as blasting (note: FOC's peak particle velocity (PPV) and overpressure (mm/s) criteria (Wright and Hopky 1998) will not be exceeded beyond the dike exteriors. Substrate consists of very coarse boulder/cobble substrate, and is not subject to erosion.

Improving fish passage between Second and Third Portage lakes may have benefits to fish species composition in Third Portage Lake. Currently, the relative abundance and biomass of Arctic char in Third Portage Lake is low (7%) relative to abundance in Second Portage Lake (18%) and Tehek Lake (16%; BAEAR 2005). Establishing a reliable hydraulic connection between Second and Third Portage lakes might permit movement by Arctic char into Third Portage Lake. This could be viewed as a viable means of compensating for habitat loss.

4.2.2 Intake & Effluent Pipe Installation & Operation

Three pipelines will be constructed in the project lakes:

- a water intake pipe situated west of the plant site on the western shore of the small, south-facing peninsula in Third Portage Lake
- a water effluent pipe extending from the north end of the Second Portage Lake attenuation pond into Third Portage Lake, discharging between the mainland and the most northerly island
- a water effluent pipe extending from the Vault Lake attenuation pond into Wally Lake.

The freshwater intake pipe will extend from shore and run along the lake bottom, extending from nearshore, rocky habitat to sediment basin habitat approximately 75 m offshore at a depth of 10 to 12 m. The intake will be fitted with an appropriately sized screen to minimize entrainment of small fish, calculated using the FOC (1995) guidance to minimize entrainment of fish in the intake, based on intake volume, screen size, intake velocity, and swimming ability of local fish species.

The intake pipe will be 1 m in diameter and constructed of heavy-duty, insulated polyvinyl chloride (PVC). During installation, care will be taken to minimize disturbance of coarse, nearshore substrate to seat the pipe along the bottom. Coarse material will be placed on either side of the pipe to anchor it to the bottom. At depths deeper than 4 to 6 m there is a transition to fine silt/clay sediment; therefore, the pipe will improve habitat complexity, especially in the sediment basin habitat by providing vertical structure and increasing available shelter habitat. Surface area occupied by the pipes during operation is small (0.007 ha), and the amount of benthic area lost will be more than compensated for by the riprap material used to anchor the pipe and by the dimensions of the pipe itself.

Effluent will be discharged to each of the receiving environments (Wally and Third Portage lakes) via a 0.5 m HDPE pipe. The pipe will extend at least 50 m offshore of the nearest coarse substrate in at least 10 m of water. The end of the pipe will have a diffuser to maximize dilution of effluent into the receiving environment. Effluent will be directed away from any sensitive habitats. Similar mitigation measures will be implemented as for the intake pipes to minimize disturbance and increase habitat complexity near the effluent pipe.

4.2.3 Turn Lake Road Crossing

The access road between the plant site and the Vault development will require that twin culverts be placed across a narrow constriction in the lake. The proposed crossing is 70 m wide and approximately 100 m upstream of the discharge point to Drilltrail Lake. The crossing will require two 75 m long, 2.5 m diameter round culverts with a sideslope ratio of 3H:1V for protection of habitat. Culverts will be installed in the dry during winter and embedded 0.8 m into the existing lake bottom to provide lateral structural stability.

Culverts are used regularly where roads cross water bodies and there are well-established mitigation measures to ensure that the crossing does not impair fish passage or pose a potential chronic source of sediment. The measures below will be implemented.

- Standard construction practices will be employed during culvert installation.
- Shorelines will be rip rapped to prevent exposure of permafrost and prevent soil erosion.
- Coarse substrate will be placed inside the culverts and at the approaches to both ends to encourage fish movements and provide compensatory fish habitat with greater complexity than the uniform, fine sediment bottom where the culverts will be installed.
- Installation will be carried out during winter to avoid sensitive time periods for movements and feeding by fish.

Culvert diameter is sized to accommodate a 1:100 freshet. Under normal, freshet conditions, discharge velocity within the culvert will not exceed 0.6 m/s and will allow upstream movement by fish. A quantitative assessment of the Turn Lake to Drilltrail Lake connection channel was undertaken during spring freshet in the vicinity of the planned crossing (BAEAR, 2005). Wetted width was 30 m but maximum water depth was only 20 cm. The channel, although wide, is very shallow and substrate consists of large boulders that likely prevent movement of fish between the two lakes. Consistent with all other channels in the project lakes, movements by fish between channels is uncommon. Thus, migratory habitat is not adversely affected because there is no migration by fish.

Riprap will be used to ensure the protection of shoreline banks from erosion and to provide complexity to habitat. In addition, a layer of coarse gravel and stone will be placed inside the entire length of the culverts to a depth of 0.5 m. This will provide sufficient cover habitat within the bottom of the culverts to reduce avoidance by fish passing through the culverts. A layer of very coarse material will also be placed at the approaches to the culverts to provide similar habitat as inside the culverts to facilitate fish movement and improve conditions for movement than currently exist. Placement of riprap along the bottom and approaches to the culverts will increase habitat complexity and mitigate habitat alteration due to culvert operation.

4.2.4 Baker Lake Marine Barge Landing Facility

A marine barge facility will be constructed at Baker Lake to allow barges carrying mine supplies to access local roads and the winter ice road. A ramp will be constructed of a geotextile material, extending from the nearshore to 1 m depth about 10 m offshore. This ramp will allow shallow draft marine barges to land without causing disturbance and erosion of the nearshore environment. The approximate area of the barge landing facility is 0.02 ha. The geotextile material and ramp will alter a small amount of the shoreline that is normally ice-scoured or frozen in winter. Thus, a very small area of low value benthic habitat may be temporarily altered.

There are no streams or watercourses of any kind within the footprint area or between the staging area and Baker Lake, thus there is no impact to fish habitat.

4.2.5 Diversion of Phaser Lake Outflow

Phaser Lake is a small (26 ha), shallow lake (4 to 5 m maximum depth) that contains a small, isolated population (~100) of lake trout and round whitefish. Phaser is connected to Vault Lake via a small rocky channel that is impassable by fish. Flow between the two lakes is either subsurface or flows between a large boulder field. Although this lake has a reasonable quantity of high and moderate polygon values, productivity is limited by lack of overwintering habitat, as there is only one small area of the lake (1 to 2 ha) where water depth exceeds 3 m.

Phaser Lake normally discharges to Vault Lake during freshet. However, once Vault Lake is isolated and dewatered, water discharged from Phaser Lake will have to be re-directed to Phaser Lake via a connecting channel to avoid flooding of Vault pit. In Year 4 a water retention berm will be constructed across the mouth of the connecting channel between Phaser Lake and Vault Lake to maintain lake elevation and overwintering habitat in the lake. This will avoid a drawdown on Phaser Lake, which would have compromised overwintering survival of the small fish population. Given that the water level of Phaser Lake will remain unchanged and discharge will be directed to Turn Lake and Drilltrail Lake, there is no net difference in water balance in the system and no impact to fish habitat.

4.2.6 Summary

There is no net HADD of habitat expected as a result of construction and operation of minor project activities. Adherence to proper construction practices and mitigation measures (e.g., winter culvert installation, sediment control, intake screen, etc.), and use of riprap to stabilize shorelines and anchor pipes will ensure that productive capacity of habitat is not diminished during mine life.

- Isolation of Phaser Lake from Vault Lake during mine operations will not result in a loss of habitat because lake elevation will be maintained.
- Elimination of the westernmost connecting channel between Second Portage and Third Portage lakes will be balanced by enhancement of the easternmost channel (if necessary) to ensure that net discharge between the lakes will remain unchanged. A net gain in habitat may be realized if channel enhancement improves opportunities for fish movement between the lakes, which currently is very difficult.
- Construction and installation of a water intake pipe and effluent discharge pipe in Third Portage Lake and Wally Lake will not alter shoreline habitat. The pipes will increase habitat complexity by providing cover for small fish.
- Installation and operation of the Turn Lake Road crossing will not affect or may improve opportunities for movement of fish between Turn and Drilltrail lakes.
- Operation of a marine barge landing facility at Baker Lake within the ice-scoured upper 2 m of a small shoreline area near the marshalling facility will not diminish productive capacity of habit

4.3 HABITAT LOSS FROM MAJOR PROJECT ACTIVITIES

Major project activities are those activities that have the potential to harmfully alter, disturb, or destroy larger amounts of habitat (>1.0 ha) and whose effects cannot be entirely mitigated through proper construction practices or on-site habitat enhancement. Major project activities include:

- dike construction to impound lake areas
- impoundment dewatering and creation of pits
- impoundment of the northwest arm of Second Portage Lake to create a TIA.

Development at Meadowbank will require construction of dikes that will impound discrete areas of project lakes, which will be developed as pits. Pit size and depth will increase over the life of the mine as ore is extracted, for either processing or disposal in the TIA of Second Portage Lake or as waste rock. The net impact to the project lakes is directly related to the loss of habitat within the pit areas and beneath dike footprints (see Figures 4.1 and 4.2). This section describes and evaluates the quantity and quality of habitat altered or destroyed within each project lake and specifically describes habitat loss associated with the TIA and habitat compensation to achieve no net loss.

Table 4.1 provides details of net habitat loss during construction and operation of the Meadowbank Gold project. Major mine components including dikes, basins, pits, and the TIA are each accounted for separately to provide a full accounting of habitat loss associated with each component.

4.3.1 Second Portage Lake – Dikes, Basins, Pits & TIA

The East dike will impound 144 ha of Second Portage Lake and is proposed for Year –1 of the development. This is approximately 35% of the surface area of Second Portage Lake. Of this total, 89.5 ha is situated behind the West dike, which isolates the northwest arm of Second Portage Lake and will contain the attenuation ponds and eventually, the TIA. The total number of habitat units permanently lost to the TIA is calculated as 370.5 (Table 4.1). Section 5 provides a full description of the compensation plan for this lost habitat, incorporating the goal of a 2:1 ratio of habitat gain to loss for the TIA.

Lake area east of the West dike, partly occupied by the Portage pit will be re-flooded upon mine closure and will be reoccupied by fish as part of Third Portage Lake. At post-closure, pit development will increase water volume by 15.8 Mm^3 because of pit depth. In addition, overall surface area of the lake will be increased, because the flooded lake bottom will include former terrestrial areas that will be developed and enhanced to provide productive fish habitat. Thus, re-flooding of the former lake basin will result in a net increase in surface area and volume of the lake (see Section 5.4).

A plan view of underlying habitat affected by mine development in Second Portage Lake is depicted in Figure 4.1. Because of the deep depth of the northwest basin within the proposed TIA, more low value polygon sediment basin habitat will be destroyed than all other habitat types combined. The most abundant moderate or high value habitat destroyed is represented by boulder platform (31.9 ha) and transition sediment apron habitat (18.3 ha).

Figure 4.1: Development Footprint – Second & Third Portage Lakes Area

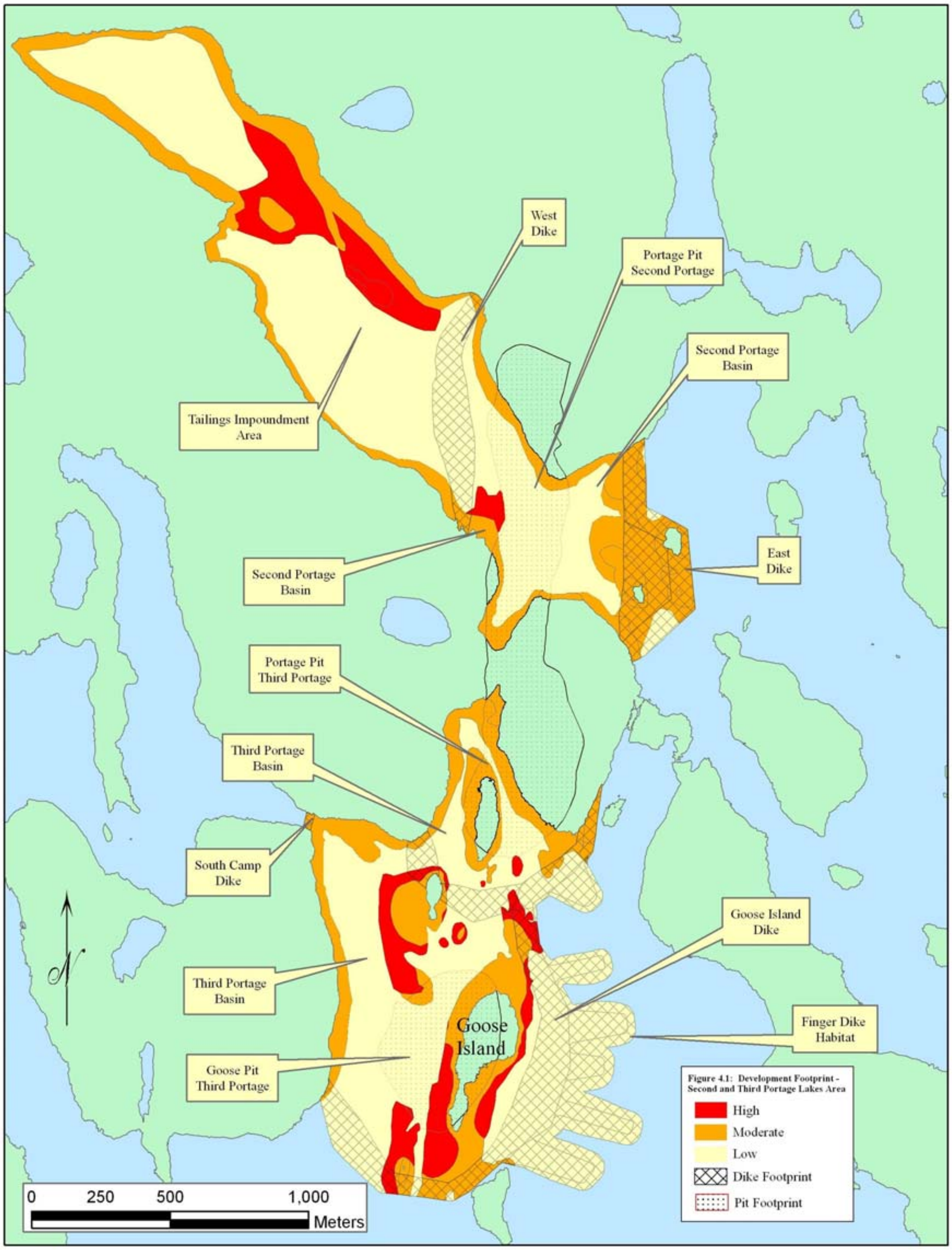


Figure 4.2: Development Footprint – Vault Lake Area

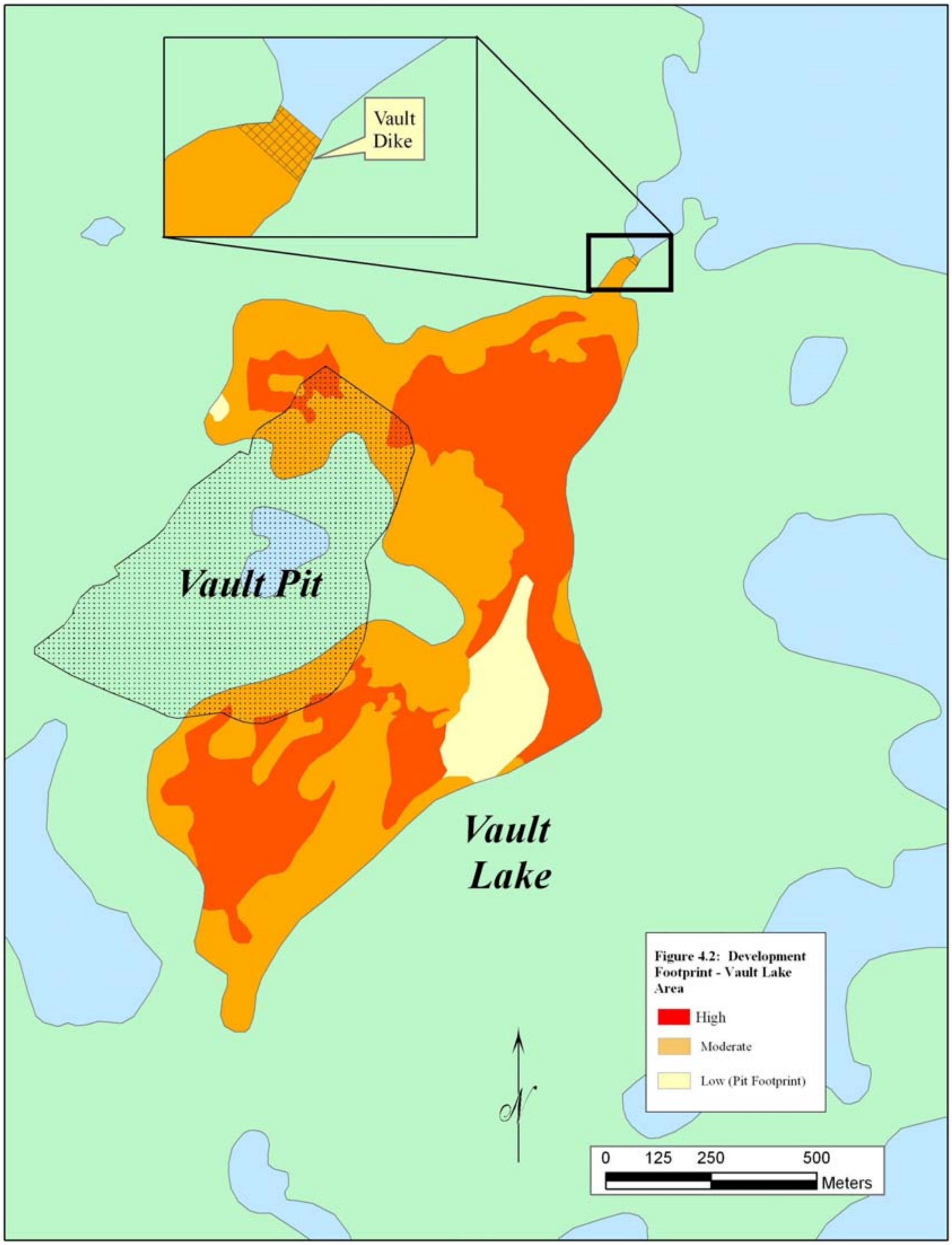


Table 4.1: Total Habitat Units (HU) Altered, Disturbed, or Destroyed by the Meadowbank Gold Project

	Mine Component	High			Medium			Low			Total HUs	
		HS I	*ha*	*HU*	*HS I*	*ha*	*HU*	*HS I*	*ha*	*HU*	*Mine Site*	*TIA*
Second Portage Lake	*Tailings Impoundment Area*	8.90	12.70	**112.99**	6.06	20.95	**126.92**	2.34	55.75	**130.59**		**370.50**
Second Portage Lake	*East Dike Footprint*	8.90	0.00	0.00	6.06	5.99	36.26	2.34	1.29	3.02	39.28	
	West Dike Footprint	8.90	0.03	0.24	6.06	0.64	3.88	2.34	7.75	18.15	22.27	
	*Second Portage - Basin**	8.90	1.13	10.05	6.06	12.87	77.94	2.34	9.95	23.31	111.30	
	*Portage Pit - Second Portage Lake**	8.90	0.004	0.04	6.06	3.55	21.52	2.34	12.03	28.18	49.75	
	Total			**10.3**			**139.6**			**72.7**	**222.6**	**0.0**
Third Portage Lake	*Goose Island Dike Footprint*	8.90	1.34	11.88	6.06	4.24	25.69	2.34	15.32	35.89	73.46	
	South Camp Dike Footprint	8.90	0.00	0.00	6.06	0.17	1.00	2.34	0.00	0.00	1.00	
	*Third Portage - Basin**	8.90	10.37	92.20	6.06	20.75	125.70	2.34	35.49	83.14	301.04	
	*Goose Pit - Third Portage Lake**	8.90	2.00	17.77	6.06	3.70	22.43	2.34	8.91	20.87	61.07	
	*Portage Pit - Third Portage Lake**	8.90	0.01	0.07	6.06	4.87	29.50	2.34	2.39	5.59	35.16	
	*Finger Dike Habitat Footprint**	8.90	0.10	0.85	6.06	0.10	0.58	2.34	19.44	45.53	46.95	
	Total			**122.8**			**204.9**			**191.0**	**518.7**	**0.0**
Vault Lake	*Vault Dike Footprint**	8.90	0.00	0.00	6.06	0.00	0.00	2.34	0.04	0.09	0.09	
	Vault Pit - Vault Lake	8.90	0.65	5.79	6.06	7.79	47.18	2.34	0.00	0.00	52.97	
	Vault - Basin	8.90	34.89	310.38	6.06	42.90	259.87	2.34	11.02	25.82	596.07	
	Total			**316.2**			**307.1**			**25.9**	**649.1**	**0.0**
Total HADD (HUs)											**1390.4**	**370.5**

Note: * Component habitat loss temporary; future habitat quality may vary (changed or enhanced) from baseline conditions.

- Habitat lost under the Eas dike and West dike footprints total approximately 15.7 ha or 61.6 HUs.
- The Portage pit footprint in Second Portage Lake will result in the loss of approximately 50 HUs; upon mine closure the extremely deep pit and surrounding basin will be flooded, returning habitat back to productive use by fish (see Section 5 for details).
- TIA development will result in the permanent loss of fish habitat totalling 89.4 ha representing 370 HUs (Table 4.1). This is approximately 25% of the total HUs available to fish in Second Portage Lake (1505 HUs; Table 3.6).
- Low and medium quality habitat losses account for 469 HUs, comprising the majority of the cumulative HADD (79%) in Second Portage Lake.

Note that some of this habitat will be regained during post-closure and recovered as high or medium value habitat when it is re-flooded. This habitat will become part of Third Portage Lake because the East dike is a permanent structure that is required to maintain the 1 m water elevation difference between Third Portage and Second Portage lakes. A full description of habitat modification prior to flooding is provided in Section 5, for post-closure remediation activities.

4.3.2 Third Portage Lake – Dikes, Basins & Pits

In Year –1 the Bay Zone dike will be constructed and impound 19.9 ha of Third Portage Lake, or 0.5% of the total surface area of Third Portage Lake. In Year 1, the Goose Island dike will replace the Bay Zone dike and expand the affected area to allow development of the Goose Island pit (Figure 4.1). The Goose Island dike will impound approximately 109 ha of Third Portage Lake, which is 3% of the total surface area of Third Portage Lake (~3,600 ha).

Total area and HUs of altered or destroyed by dike footprints, dewatered habitat and development of Goose Island pit are presented in Table 4.1. The lake area impounded by the Goose Island dike is relatively shallow (except for the southeast corner) and contains relatively higher proportions of high and medium value polygons relative to the rest of the lake (Figure 4.1). Note that much of this habitat will be recovered, except for the surface area of the pit development itself, when mining is finished and the dike is breached (Section 5) once water quality is acceptable.

Southeast of the Goose Island dike, lake depth ranges from 16 to 20 m and consists largely of low value sediment basin habitat. To compensate for habitat loss during mine operation, a series of “dike fingers” will be constructed off of the southeast corner of Goose Island dike. These rocky fingers will extend offshore of the Goose Island dike into deep, low value sediment basin habitat polygons. Construction of dike fingers will occur in Year 2, the year following construction of Goose Island dike, and will employ the same mitigation features (e.g., silt curtains) as for dike construction. Although the footprint area of Goose Island dike will be expanded into Third Portage Lake, there will be a net gain in HUs because the surface area of the dike face will replace low habitat value polygons and will be designed to function as high or moderate value habitat.

Dike face material between 0 and 2 m will be considered to have a medium value HSI because of freezing during winter and unsuitability as spawning/nursery habitat. Habitat between 2 and 10 m is considered of high value because it will have suitable depth, aspect, slope, substrate size and morphology to satisfy multiple life history requirements (spawning, rearing, foraging) for all important species (lake trout, round whitefish and Arctic char). Dike face material at depths greater than 10 m is considered moderate value because of its high surface area and complexity, providing deep shelter habitat for many species.

The dike face below the water surface will be constructed from low metal leaching iron formation rock. Similar to the rest of the dikes, the dike will be capped with ultramafic rock above the water surface to minimize the potential for metals leaching. Following is a summary of total habitat loss during construction and operation of the Goose Island dike and pit impoundment:

- Total HADD in Third Portage Lake is 519 HUs (Table 4.1).
- Goose Island dike footprint will result in a HADD of 73.5 HUs.Goose Island finger dike habitat footprint will result in a HADD of 47 HUs, but will result in the creation of higher quality habitat (see Section 5).
- The Goose Island pit and Portage pit (the portion falling within the baseline boundaries of Third Portage Lake) footprints result in a loss of 96 HUs.
- The majority of HADD (301 HUs) results from dewatering the Third Portage Basin; this loss is temporary.
- Low and medium quality habitat losses account for 396 HUs, or 76% of the total HADD in Third Portage Lake.
- The majority of habitat losses are temporary (444 HUs or 86% of the lake's total HADD) and account for less than 4% of total available HUs in the lake (11,979 HUs).

Re-flooding of this habitat area during post-closure will result in a net increase in surface area and volume of Third Portage Lake (partly at the expense of Second Portage Lake) because the entire area north of Goose Island dike will become part of Third Portage Lake. The East dike will remain in place to maintain the 1 m elevation difference between the two lakes.

4.3.3 Vault Lake – Dikes, Basins & Pits

The Vault dike will be constructed in Year 4 across the small channel that connects Vault to Wally Lake, isolating Vault and Phaser lakes from Wally Lake during the final four years of mine life. Few fish have been captured moving between Vault and Wally lakes, despite the good hydraulic connection between the two lakes that permits fish movement throughout the summer (BAEAR, 2005).

Wally Lake contains 379 ha of moderate and high value habitat that is widely distributed throughout the lake. The lake is relatively shallow and is dominated by boulder platform (217 ha) and boulder shoal habitat (119 ha; Table 3.1). Boulder apron, sediment apron, and mixed sediment apron habitat is also relatively abundant in Wally Lake. Deep, sediment basin habitat (162 ha) constitutes 27% of total available habitat and is considerably less abundant in Wally than in Second (60%) and Third Portage (63%) lakes. Wally Lake is also continuous with Drilltrail Lake and this lake system connects directly with Second Portage Lake, just upstream of its outlet to Tehek Lake via a wide, deep channel.

The majority of Vault Lake will be drained and discharged to Wally Lake, except for two deep (>6 m) depressions that will serve as attenuation ponds. Development of the Vault Lake pit will temporarily alter 74 ha of moderate and high value habitat polygons during operation. Note that pit development has very little encroachment into the main body of the lake (Figure 4.2) and the majority of the original lake habitat will be gained back at end of mine life, after the pit has been flooded. The pit will provide additional surface area and volume relative to pre-mine conditions. Thus, there is expected to be a significant net gain in area and habitat value of Vault Lake during post-closure.

Vault Lake is relatively shallow and overwintering habitat may be limiting. Therefore, there is some uncertainty as to the relative value of this lake to fish on a year-round basis. Because of shallow depth and lack of overwintering habitat, the productive capacity of this lake may be lower than the HUs calculated for the lake would suggest. Temporary habitat loss from installation of Vault dike and impoundment and draining of Vault Lake was determined from HUs based on high, medium and low value habitat polygons (see Figure 4.2 and Table 4.1). Habitat lost during construction and operation of Vault pit is as follows:

- Vault dike footprint is very small and will result in the temporary loss of 0.09 HUs.
- Habitat loss in Vault pit is 686 HUs because of the relatively large amount of high and medium value habitat polygons. Loss of low value habitat situated primarily in deep areas (11 ha) is only 26 HUs or less than 4% of habitat value. Because of the lack of deep, overwintering habitat, the effective habitat loss may be substantially less than the 686 HUs estimated by the model.

At mine closure, Vault dike will be breached and the Vault pit gradually flooded, increasing volume from approximately 2 to 19.6 Mm^3. Thus, the combined lake volume of Vault Lake will be increased considerably from current conditions after mine closure. With the addition of deeper overwintering habitat, this may improve the overall productive capacity of Vault and Wally lakes over the long term.

4.3.4 Summary

Major project activities will result in a total HADD during construction and operation of 1,760 HUs (Table 4.1). The tailings impoundment area (TIA) accounts for 370 HUs. The remaining 1,370 HUs are comprised of pits/impoundments/dikes in Second Portage Lake (223 HUs), Third Portage Lake (519 HUs), and Vault Lake (649 HUs).

Measures to compensate for, enhance, or replace temporary and permanent habitat loss from dike footprints and the TIA in particular, are described in detail in Section 5.0. A wide variety of habitat compensation options have been considered and investigated and were developed based on field investigations, scientific literature, experience at other northern mines, professional experience, and discussions with FOC. The principals of adaptive management have also been incorporated into our compensation planning and monitoring programs; however, nothing is permanent. As this project and other northern projects proceed and evolve, more information will become available and we will learn what works and what doesn’t work. This information will be applied to optimize our attempts to ensure that there is no net loss of habitat within the project lakes and that long-term productive capacity is not diminished.

SECTION 5 • HABITAT COMPENSATION

5.1 PHILOSOPHY

The NNL of habitat principle strives to avoid loss of productive capacity of fish habitat as a result of a development project. This NNLP has quantified the loss of productive habitat within the Meadowbank project lakes projected to occur for those activities that cannot be relocated, redesigned, or mitigated and will result in the HADD of fish habitat. The challenge is to try to compensate for this loss of habitat through on-site compensation. However the options for effective on-site compensation are typically quite limited, especially during the operations period.

The FOC (1998) decision framework document recognizes this by stating, “on-site compensation is an option where site rehabilitation can be successfully undertaken. Compensation can also take place off-site and is normally the only option when there are long-term impacts to habitat or it is simply destroyed on site.” Furthermore, this document goes on to state that, “the relationship between the quantity and quality of fish habitat and fish production is not well understood…and that compensation measures may not completely offset a HADD of fish habitat resulting from a project development.” FOC managers are encouraged to, “seek compensation which is at least equivalent with respect to quantity and quality of habitat” and that “the goal of NNL of productive capacity is thus applied not as a rigid quantitative rule, but as a guiding principle.”

This NNLP incorporates this philosophy by recognizing the natural limitations of on-site habitat compensation when such a relatively large area is altered or destroyed, and balances the significance of habitat loss from the perspective of the risk to the local and regional fish population and the local resource user. Nevertheless, our entire compensation and enhancement program is focused on site, although the majority of benefits will not be realized until post-closure, after re-flooding of dewatered areas.

In applying the NNL principle to a project, a number of factors must be considered to assess whether an authorization for HADD of fish habitat should be issued. FOC (1998) lists these considerations, which are paraphrased below. The left-hand column lists the FOC considerations, while the right-hand column describes their specific application to the Meadowbank project, where appropriate (see Table 5.1).

This assessment attempts to put local site conditions in perspective with the principle of application of NNL. For example, productive capacity of project lakes is limited by nutrient availability and not by physical habitat features. There is considerably more physical habitat available in the project lakes than required by the current biomass of fish (BFAR, 2005; BAEAR, 2005). For this reason, it is not proposed that large amounts of physical habitat in project lakes be constructed during operations within existing lake areas where there is already an abundance of physical habitat. Furthermore, there is no precedent that in non-habitat limiting systems, creating new habitat will result in increased productivity of fish.

Table 5.1: Factors Considered by FOC when Issuing a HADD Authorization

FOC Considerations	Site-Specific Considerations
The acceptability of the HADD.	To be determined through consultation with FOC, and community members of Baker Lake.
Fisheries population or management objectives.	There are no specific management objectives, due to the remote nature of the area and the existence of large areas of similar habitat.
Does the habitat support an active fishery – if not, there is flexibility in timing and implementation of compensation.	The lakes do not support commercial or sport fishing activities because they are remote. Domestic fishing is rare.
Importance of the habitat – is the habitat in low supply or does it have high value to fish production?	Habitat value has been quantified and is not in low supply and is not limiting to fish production.
Is the HADD temporary or permanent?	Certain aspects of the project (e.g., TIA) will result in a permanent HADD. All other HADDs are temporary and can be compensated for after closure.
Does the HADD cause a significant change in the capacity of the habitat to produce fish?	During operation the HADD will cause a reduction in the capacity of the habitat to produce fish. At closure, there will be a net gain in productive capacity.
The availability of technically feasible habitat compensation options, and evidence of past success in efforts to compensate for habitat loss of this type and magnitude.	Few technically feasible options are available. There is some evidence that on-site compensation to replace large areas of habitat lost is successful in restoring productive capacity. Adaptive management will be used to optimize habitat enhancement.
Compatibility with the hierarchy of preference for compensation options.	On-site opportunities for compensation are very limited during operation. Net habitat gain at post-closure is preferred.
Does this authorization set a precedent that could lead to future cumulative impacts?	Unlikely. This is the only mine development within a very large area.

5.2 PRECEDENT

There have been several NNL plans recently developed as part of environmental impact assessments for Arctic mines including Diavik (Golder, 1998), Snap Lake (Golder, 2002), Doris North (RL&L and Golder, 2003) and Jericho (Mainstream Aquatics, 2004).

The Diavik NNL report (1998) proposed the following habitat compensation projects:

- modification of the external surface of containment dikes during operation and internal surfaces at closure

- creation of shallow reefs and other habitat features constructed on the shallow shelf between the dike interior and the open pit, after closure and breaching of the dike
- filling of deep areas of three small shallow lakes with coarse material to provide foraging habitat
- excavation of one shallow lake to provide overwintering habitat
- improvement of existing stream habitat to compensate for stream habitat loss.

The Snap Lake project will affect only a very small area of Snap Lake due to installation and operation of water intake and mine water outlet structures. Proposed habitat mitigation consists of using a coarse boulder/cobble mixture to increase habitat diversity in the immediate area of the pipes (Snap Lake, 2002). No other habitat compensation outside of the immediate areas affected is proposed for Snap Lake.

The NNL plan for the proposed underground gold project (Doris North) by Miramar Hope Bay Ltd. proposed compensation measures for impoundment of a portion of a lake (Tails Lake), alteration of marine habitat from construction of a jetty, and other minor project activities (stream crossing, water intake, and floating dock). RL&L and Golder (2003) stated that, “the tailings containment area could not be relocated or redesigned to avoid impacts,” and did not recommend habitat enhancement within Tails Lake. Instead, they proposed that enhancement of a stream channel of a nearby lake (Roberts Lake) to facilitate upstream and downstream movement by Arctic char for spawning purposes would provide the necessary compensation; however, FOC subsequently requested (FOC, 2004) that Miramar Hope Bay provide additional mitigation/compensation options to fully compensate for habitat loss in Tails Lake. RL&L and Golder (2004) responded by proposing that rearing habitat, which is purported to be limiting in Doris Lake just west of Tails Lake, be created in shallow, sandy areas at five locations. Placement of habitat in Tails Lake was not proposed.

In summary, no recent mine developments have proposed that extensive areas of new habitat be created within natural lakes during mine operations where habitat does not appear to be limiting. Given the abundance of habitat of all types in the project lakes, opportunities for on-site mitigation and compensation during mine operation are limited. During post-closure, because of newly flooded land areas, there is expected to be a net gain in productive capacity in the project lakes.

This section describes several options intended to compensate for habitat that is harmfully altered, disrupted, or lost, with newly created habitat or enhancement of existing habitat during operation and at post-closure. Total number of HUs lost (HADD) in the post-closure environment such as dike footprints and the tailings impoundment area are counted as residual habitat loss (Table 5.2). There are also “net” changes to re-flooded lacustrine habitat that is altered (i.e., improved where possible) and it is our intent to enhance or improve habitat that is “lost” during operations so that there is a net gain in the post-closure environment. This is contrasted against habitat gain considering all enhancement options described below.

Table 5.2: Total Habitat Units (HUs) Gained During Construction & Operation at Meadowbank Gold Project

		High			Medium			Low			Total HUs	
	Mine Component	***HS I***	***ha***	***HU***	***HS I***	***ha***	***HU***	***HS I***	***ha***	***HU***	***Mine Site***	***TIA***
Second Portage Lake	*East Dike - Exterior*	8.90	0.24	2.1	6.06	0.35	2.1	2.34	0.00	0.00	**0**	**4.25**
Third Portage Lake	*Goose Island Dike - Exterior*	8.90	1.9	16.9	6.06	1.8	10.7	2.34	0.00	0.00		27. 6
	Finger Dike Habitat	8.90	19.5	173.9	6.06	0.00	0.00	2.34	0.00	0.00		173.9
	Total			**192.9**			**12.8**			**0.0**	**0**	**201.5**
Vault Lake	*Vault Dike - Exterior*	8.90	0.00	0.00	6.06	0.10	0.6	2.34	0.00	0.00		0.61
	Total			**0.0**			**0.6**			**0.0**	**0**	**0.6**
Habitat Gained (HUs)											**0.0**	**206.3**

5.3 CANDIDATE HABITAT COMPENSATION OPTIONS INVESTIGATION

5.3.1 Background

Construction and operation of the Meadowbank Gold mine requires that parts of three lakes be diked and drained of water. Given the magnitude of disturbance to the affected waterbodies, this will cause an unavoidable HADD of fish habitat that cannot be completely compensated for during mine operations. Comprehensive compensation for lost habitat can only be achieved after mine operations have ceased and post-closure compensation measures have been implemented.

Sections 5.3.2 and 5.3.3 below summarize our assessment of several on-site compensation plans to compensate for habitat loss during mine operations and at post-closure, respectively. When the draft NNL was first reviewed, FOC Iqaluit asked Cumberland to investigate other options to replace lost habitat during operations because of the significant net loss of habitat during operation. During a meeting on February 10, 2006 (See March 6, 2006 Technical Memorandum to FOC; Appendix B) Azimuth and FOC agreed to a list of candidate options that would be investigated during 2006. This section summarizes results of our investigation of these candidate habitat compensation options that were outlined in the memo to FOC. A full description of the results is provided in Appendix C.

It was agreed that an “A” list and a “B” list of options would be evaluated. The A-list describes candidate *on-site* habitat compensation options. The B-list focuses on *off-site* compensation options near Baker Lake as a contingency plan, in the event that viable on-site compensation options are deemed unfeasible.

On-site candidate habitat compensation options included the following:

- Improve connecting channel between Third Portage and Second Portage lakes to facilitate movement by fish between the lakes, especially Arctic char.
- Develop shoal habitat in areas of Second or Third Portage lakes away from the mine site. A similar effort can be made in Wally Lake, although shoal habitat is much less limiting in this lake than in other lakes.
- Improve connecting channels between project area lakes, specifically Wally to Drilltrail; Drilltrail to Second Portage; and Turn to Drilltrail.
- Create connecting channels between lakes where none currently exist (e.g., Dogleg to Second Portage; unnamed lakes to Wally Lake, unnamed lake to Tehek Lake).

Off-site candidate compensation options included the following:

- East of town there is an unnamed stream with a hanging culvert that prevents upstream movement by fish. This stream drains Airplane Lake.
- Halt dumping of raw sewage to the small stream west of Baker Lake that ultimately feeds Airplane Lake.
- Improve connecting channels between Prince River or Thelon River and tributary streams or off channel lakes.

- Construct a causeway into Baker Lake to provide a breakwater and spawning/rearing shoal and habitat for lake trout, whitefish, and char.
- Investigate potential of creating pit lakes from quarries along the all-weather road.
- Determine if there are known areas where Arctic char spawn within the Prince/Thelon rivers and attempt enhancement.

The following sections describe our assessment of on-site and off-site habitat compensation options from 2006 field investigations.

5.3.2 On-Site Habitat Compensation Options

Portage Lakes Connecting Channel Improvement

Construction of the Goose Island and East dikes will eliminate the westernmost of the three channels that connect Second and Third Portage lakes. Shallow water depth within nearly all channels prevents movement by fish except perhaps during peak freshet. Improving access between the two lakes by modifying the easternmost channel may allow char to move from Second into Third Portage Lake and occupy mid-water, profundal habitat that is currently underutilized. Increasing abundance of char in Third Portage may significantly add to productive capacity over the long-term. However, because of the difficulty in measuring increased productive capacity and the lengthy time required to realize the benefit, this option has a **low** likelihood of benefit during operations.

Creation of Artificial Shoal Habitat

This option has large technical and safety challenges and would have a great cost relative to the amount of habitat created. This option has a **negligible** benefit of success during mine operations and is not recommended.

Creation of shoal habitat elsewhere in Second and Third Portage lakes can be done by truck during winter by dumping waste rock on the ice to increase habitat value from low to high. However, given the technical challenges, safety issues, uncontrolled release of fine sediments, and low benefit to cost ratio, this option is not viable.

Improve Project Lake Connecting Channels

Modifications to existing connecting channels between lakes are unlikely to provide significant benefits to local fish populations as no additional habitat is actually created. This option has a **negligible** benefit of success during mine operations and is not recommended.

The dominant fish species in all of the project lakes are non-migratory and not strongly motivated to move between lakes. Several years of study have failed to demonstrate that any species undertakes anything but random movements. Furthermore, habitat assessments of all connecting channels revealed that most channels are impassable to fish, even during freshet. Deepening channels without lowering the inverse elevation and not exposing permafrost also pose technical challenges that are not warranted.

Create New Connecting Channels

The creation of new connecting channels between lakes where impassable channels currently exist was evaluated at six locations (Figure 5.1). This option has **negligible** benefit and is not recommended as no new habitat is actually created. Furthermore, most of the channels considered connect relatively small lakes to larger lakes that have very small watershed areas, with insufficient flow to support fish movements. Cost and technical challenges associated with channel deepening to prevent erosion of permafrost are also difficult to justify given the very small accrual of fish habitat.

5.3.3 Off-Site Habitat Compensation Options

Hanging Culvert near Baker Lake

This option has **negligible** benefit and is not recommended. It is unlikely that fish could access the culvert from Baker Lake leading to Airplane Lake because of the steep gradient between the lake and the culvert. Furthermore, we have heard that Airplane Lake is contaminated (presumably by sewage and other wastes) and it is not desirable to provide access by fish from Baker Lake to this lake.

Halt Sewage Disposal to Airplane Lake Basin

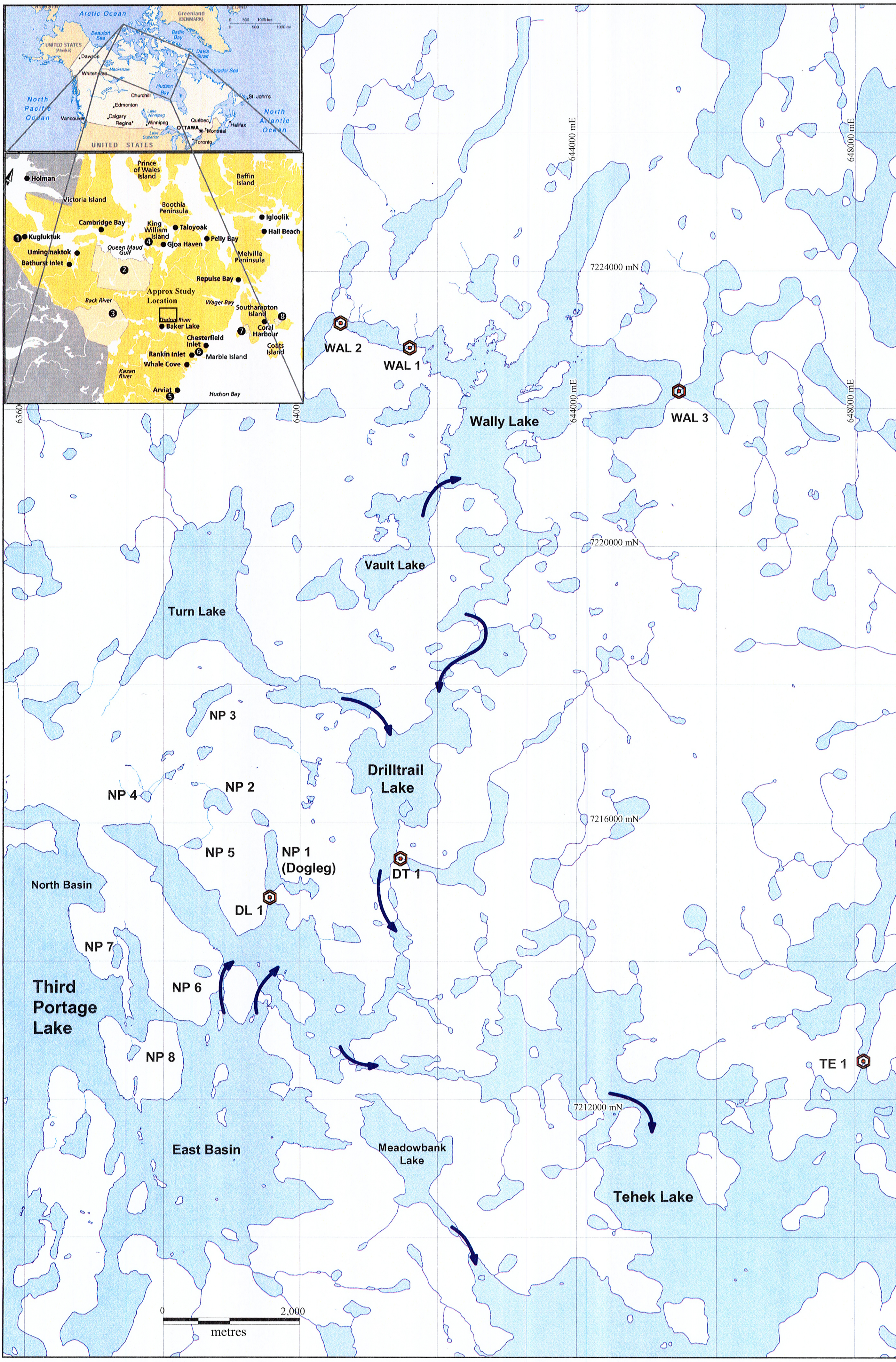
This option is not within the purview of investigations by Cumberland Resources and is the responsibility of the Government of Nunavut.

Improve Tributary Stream Connections Within Prince & Thelon Rivers

This option has **negligible** benefit and is not recommended.

On 11 July 2006 the Prince River was surveyed between its mouth at Baker Lake and upstream to the Majuqtuqsiurvik rapids, a popular fishing spot for residents of Baker Lake. South of the rapids to Baker Lake there are no large tributary streams or lake systems that enter the Prince River that might provide off-channel overwintering habitat for fish, particularly Arctic char. We did not identify any deficiencies in habitat or in connectivity to off-channel areas that would be suitable candidates for off-site habitat compensation.

The Thelon River is a very large river that also has no off-channel habitat, tributary streams, or off-channel. It would be logistically very difficult and expensive with uncertain benefits to local residents to attempt any such habitat enhancement. We could not identify any obvious location to attempt this.



LEGEND

Flow Direction

Connecting Channels

AZIMUTH

Azimuth Consulting Group Inc.
218-2902 West Broadway
Vancouver, BC, V6K 2G8

CUMBERLAND RESOURCES LTD.

Meadowbank Baseline Study

Project Lakes, Ponds, and Candidate Connecting Channel Enhancement Areas

Scale:	1:50,000	N.T.S.:	66H/1 & 56E/4	Date:	Oct / 06
Drawn by:	J T K	Checked by:	RB	Fig No.	
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Baker Lake Causeway

This option requires a great deal of rock that is not readily available, expensive to transport, creates a potential navigation hazard and has negligible benefit. It is **not** recommended. To minimize or eliminate the navigational hazard that a causeway may pose, it would have to be installed in water that is too deep to provide useful habitat for fish.

Create Pit Lakes from AWPAR Quarries

This option has **nil** benefit and is not recommended. New lake habitat cannot be created from the 10 candidate quarries situated along the proposed all-weather road because they are shallow and situated on high ground away from nearby waterbodies.

Identify Spawning Areas on the Prince/Thelon Rivers

This off-site compensation option has **negligible** benefit and is not recommended. There is no anecdotal or formal traditional knowledge that indicates if local elders or hunters are familiar with spawning areas by fish within the Thelon and Prince rivers. Given the lack of traditional knowledge about spawning areas, uncertainty about habitat quality, and the uncertain benefits to local people, this is not a viable option.

5.3.4 Summary

None of the habitat enhancement options evaluated were deemed to effectively offset the net loss of productivity during the mine operation stage. Significant, but long-term and difficult-to-measure benefits may accrue to productive capacity in Third Portage Lake if a larger population of Arctic char can be established by improving the connecting channel between Second Portage and Third Portage lakes.

Given the lack of viable habitat compensation alternatives, we have refocused our efforts on optimizing enhancement opportunities directly associated with mine-related activities. Indeed, the proposed revisions to the draft NNLP during the past year have resulted in significant improvements to on-site habitat creation during the operations period. An important new development is submerging the Goose Island finger dikes entirely below the water surface (-3 m) to approximately double HUs created during operation that will persist in perpetuity. Key components of the habitat enhancement strategy for the Meadowbank project are described in the following sections for the operations and post-closure periods, respectively.

5.4 HABITAT ENHANCEMENT – OPERATIONS

Opportunities for habitat enhancement during the construction and operation of the Meadowbank mine are limited, as is the case for other northern mine developments. We have not recommended that pristine lake habitat be altered to try to recover or enhance habitat productivity. Habitat enhancement activities have targeted areas deemed to pose the greatest net benefit for effort expended. This includes improvements of existing structures, such as dike faces, and improving adjacent habitat to dikes, such as the Goose Island finger dike habitat. This additional habitat complexity in an area of low complexity will help offset habitat losses during operations and will eventually contribute to achieving a no net loss of fish habitat over the long term.

The main components of the NNLP for the operations period are dike enhancement and finger dike habitat. Details of these two enhancement opportunities are discussed in the following sections. The main change to the NNLP resulting from this past year's reassessment is the approximate doubling of productive habitat associated with the Goose Island finger dike habitat area.

Total permanent habitat productivity gained from enhancement activities during operations is 206 HUs. This is more than double the originally-proposed (i.e., October 2005) total of 100 HUs (factoring out the airstrip extension into Third Portage Lake, which was an overall net loss of habitat and is no longer part of the proposed development). While these gains do not come close to offsetting the operational HADD losses documented in Section 4, it is a significant increase relative to the previous plan. It is important to note that this imbalance is only temporary as implementation of more comprehensive enhancement opportunities upon mine closure ultimately results in a net gain in productive habitat in the project area (details in Section 5.5).

The revised accounting for productive habitat gained during the operations phase is presented in Table 5.2. All the operations stage enhancements have been allocated to the TIA portion of the table as partial compensation for the permanent loss of that area.

5.4.1 Dike Enhancement

Dikes will be designed to ensure that they are stable over the very long-term, considering the possible locations and types of flood control structures that may be required. Dike exterior and interior (at closure) habitats will be designed to provide good quality habitat. That is, dike face material between 0 and 2 m will be considered to have a medium value HSI because it freezes during winter and is unsuitable as spawning/nursery habitat. Habitat between 2 and 10 m is considered of high value HSI because it will have suitable depth, aspect, slope, substrate size and morphology to satisfy multiple life history requirements (spawning, rearing, foraging) for all important species (lake trout, round whitefish and Arctic char). All dike faces (interior and exterior) below the water surface will be constructed from low metal leaching iron formation rock. Above the water surface the dike will be capped with ultramafic rock, similar to the rest of the dikes.

Dewatering dikes (East dike, Goose Island dike, West dike) will remain intact during the controlled flooding of both Portage and Vault pit areas, in order to isolate flooded pit waters from surrounding lakes. Pits will be filled gradually over the course of several years (described in Physical Environmental Impact Assessment, 2005). Once the water levels have stabilized within the flooded pits and water quality is considered acceptable for mixing with Third Portage Lake, parts of dikes will be decommissioned during closure activities to allow circulation of pit water and lake water. At least two sections of the Goose Island dike will be taken down by 6 m to allow Third Portage and the flooded pits to mix. Similarly, the Vault dike will be dismantled, to allow water from Wally Lake and Vault Lake and Vault pit to mix.

The Second Portage East dike will remain, preserving the 1 m difference in elevation between Third Portage and Second Portage lakes. Similarly, the West dike will remain to contain the stored frozen mine tailings. The remaining portions of Goose Island dike and the finger dikes exterior to Goose

Island dike will continue to provide high quality fish habitat during post-closure. The new habitat created along dike walls will be of greater surface area and equal or greater quality (coarse substrate providing shelter, and varying depth available along wall from pit ledges) relative to current pre-mine conditions. Total number of HUs gained from dike faces at post-closure are presented in Table 5.2.

5.4.2 Goose Island Finger Dike Habitat

As discussed earlier, southeast of the Goose Island dike, lake depth ranges from 16 to 20 m and consists largely of low value sediment basin habitat (Figure 4.1). Construction of a series of “dike fingers” off the southeast corner of Goose Island dike into low value habitat polygons will increase net habitat value during operations and post-closure.

Expansion of the footprint area of Goose Island dike to incorporate the fingers will result in a loss of low value habitat totalling about 47 HUs. The design originally proposed (October 2005) focused on enhancing the dike face to provide medium or high quality habitat polygons, resulting in an estimated 67 HUs of habitat, and a net gain of 20 HUs (for both operational and post-closure periods). However, the top of the dike fingers were above the water level, providing no additional habitat productivity benefits. A significant additional gain in habitat can be achieved by lowering the elevation of the dike fingers to at least 3 m below current lake elevation. The revised design will start as per the original design. However, once the fingers have been completed, the top of the dike will be lowered by 3 m below the lake surface level, working from the finger tips back to the Goose Island dike. This will also eliminate the need to cap the dikes with low metal leaching iron formation rock and will further reduce the potential for acid generation. The net result is a transformation of the entire finger dike habitat area into high value habitat and results in a gain in productivity of 174 HUs (or a net gain of 127 HUs once the loss of the footprint is factored into the equation) (see Tables 4.1 and 5.2).

5.5 HABITAT ENHANCEMENT – CLOSURE

There are many habitat enhancement options available at post-closure. Prior to closure and flooding of impounded areas, habitat structures can be engineered to provide features that have good substrate/grain size quality, complexity, depth and other parameters. Deep (>10 m) areas can be built up to form reefs or shoals and shorelines can be engineered to provide high value habitat in a similar fashion as for dike faces. The entire contiguous area from the Goose Island pit north will become part of Third Portage Lake and will be 1 m in elevation higher than Second Portage Lake on the east side of the East dike. Prior to post-closure, habitat within the pits and setback areas (sills) between the pit crest and the toe of each dike will be contoured to provide optimal fish habitat. Decisions as to exactly what and how habitat will be enhanced at closure is speculative at this time, however, we present several options as to how habitat enhancement can result in a net gain in HUs at post-closure (see Tables 4.1 and 5.3).

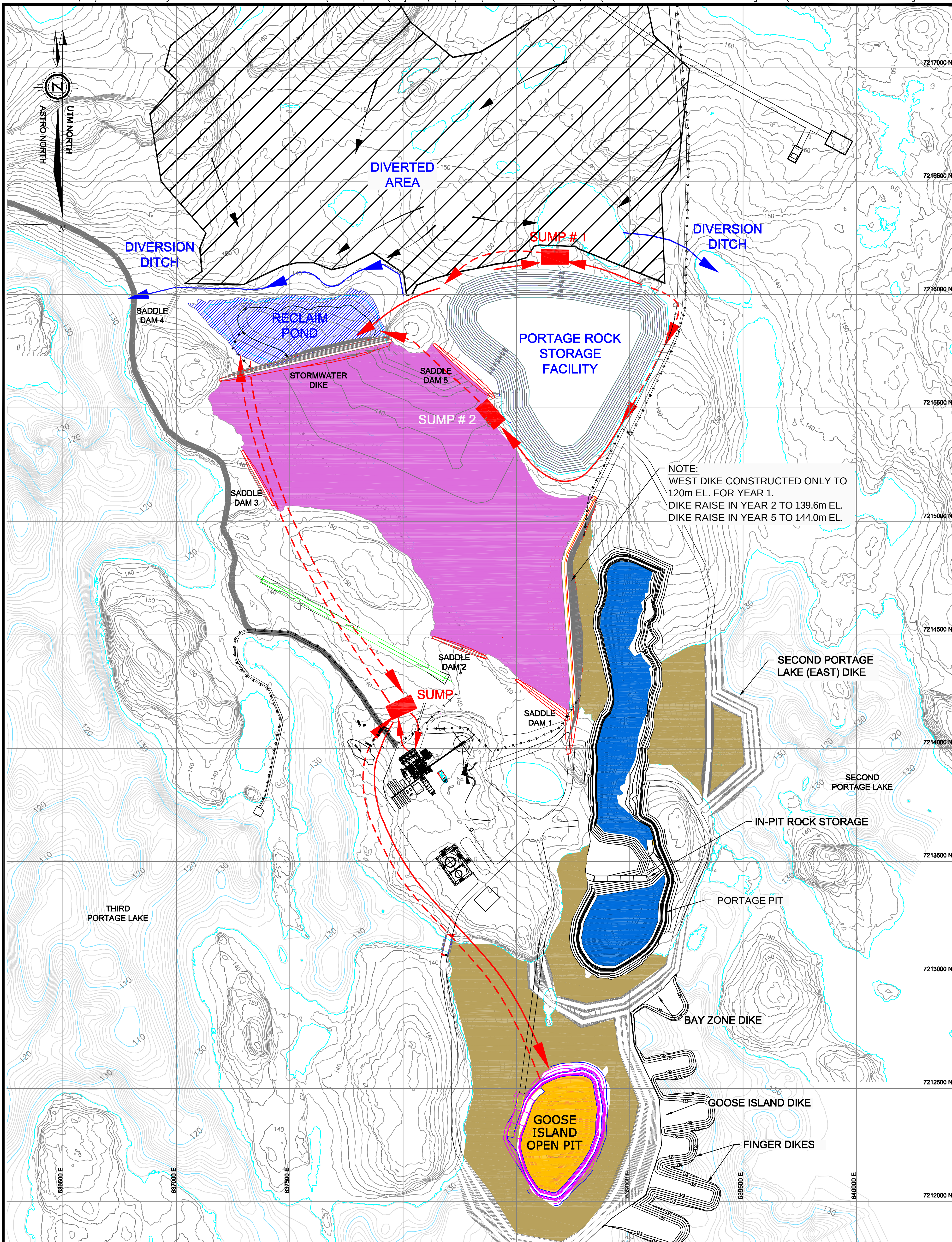
Figure 5.2 illustrates what the mine development will look like in Year 8, just before filling of the pits and re-flooding of the lake bottom. Habitat enhancement and restoration will take place at this time. Just prior to closure, the Portage and Goose Island pits and Vault pit will gradually be filled, followed by the former lake bottom and former terrestrial areas that will be submerged in the post-closure environment. Once the impoundment area has been completely filled and water quality is acceptable, breaches will be made in the south end of Goose Island dike and the two water bodies allowed to mix.

Table 5.3: Total Habitat Units (HUs) Gained after Closure of Mining Operations at Meadowbank Gold Project

	Mine Component	High			Medium			Low			Total HUs	
		HS I	***ha***	***HU***	***HS I***	***ha***	***HU***	***HS I***	***ha***	***HU***	***Mine Site***	***TIA***
Second Portage Lake	*East Dike - Exterior*	8.90	0.24	2.13	6.06	0.35	2.12	2.34	0.00	0.00		4.3
	*East Dike - Interior**	8.90	0.04	0.36	6.06	0.34	2.06	2.34	0.00	0.00		2.4
	*West Dike - Exterior**	8.90	1.04	9.25	6.06	0.83	5.03	2.34	0.00	0.00		14.3
	*Second Portage - Basin**	8.90	23.95	213.0	6.06	0.00	0.00	2.34	0.00	0.00	213.0	
	*Portage Pit - Second Portage Lake**	8.90	2.27	20.15	6.06	0.19	1.14	2.34	20.47	47.9		69.2
	*Portage Pit - 2P Land to Lake**	8.90	3.81	33.87	6.06	0.32	1.91	2.34	34.42	80.6		116.4
	Total			**278.8**			**12.3**			**128.6**	**213.0**	**206.6**
Third Portage Lake	*Goose Island Dike - Exterior*	8.90	1.90	16.87	6.06	1.76	10.69	2.34	0.00	0.00		27.6
	Goose Island Dike - Interior	8.90	0.89	7.92	6.06	0.59	3.57	2.34	0.00	0.00		11.5
	Goose Island Dike - Restored	8.90	2.99	26.58	6.06	0.00	0.00	2.34	0.00	0.00	26.6	
	Finger Dike Habitat	8.90	19.6	174.6	6.06	0.00	0.00	2.34	0.00	0.00		174.6
	Third Portage - Basin	8.90	56.8	505.6	6.06	9.89	59.94	2.34	0.00	0.00	565.6	
	Goose Pit - Third Portage Lake	8.90	1.49	13.30	6.06	0.69	4.18	2.34	17.67	41.4		58.9
	Portage Pit - Third Portage Lake	8.90	1.97	17.57	6.06	0.16	0.99	2.34	17.85	41.8		60.4
	Goose Pit - 3P Land to Lake	8.90	0.98	8.68	6.06	0.45	2.73	2.34	11.53	27.0		38.4
	Total			**771.2**			**82.1**			**110.2**	**592.2**	**371.3**
Vault Lake	*Vault - Basin*	8.90	34.9	310.4	6.06	42.9	259.9	2.34	11.02	25.8	596.1	
	Vault Dike - Restored	8.90	0.04	0.36	6.06	0.00	0.00	2.34	0.00	0.00	0.4	
	Vault Pit - Vault Lake	8.90	1.13	10.01	6.06	0.15	0.92	2.34	11.42	26.8		37.7
	Vault Pit - Vault Land to Lake	8.90	4.0	35.53	6.06	0.54	3.26	2.34	40.54	95.0		133.8
	Total			**356.3**			**264.0**			**147.5**	**596.4**	**171.4**
Habitat Gain (HUs)											**1401.6**	**749.3**

Note: * Habitat components will actually be in Third Portage Lake drainage, but are shown here for accounting purposes.

REVISION DATE: 06/11/14 09:36AM By: NVeloso CADD FILE: N:\Bur-Graphics\Projects\2005\1413\05-1413-036A\1050\CAD\1100 Mine Waste and Water Management\051413036A-1100-SK21.dwg



LEGEND

- ATTENUATION POND
- RECLAIMED TAILINGS
- RECLAIMED TAILINGS POND
- PIT LAKE DEWATERED AREA
- PIT RE-WATERING
- NON-CONTACT WATER DIVERSION
- PUMPED CONTACT WATER
- PIPED/DIVERTED CONTACT WATER

NOTES

1) Topographic contour interval 2m.
2) Bathymetric contour interval 1m.

REFERENCES

1) Amec Americas Ltd., Drawing Number A1-131395-100-C-0001 (100- C-0001.DWG), Meadowbank Feasibility Study, April 2005.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

Pre-Flood Mine Plan - Portage/Goose YEAR 8

Golder Associates

PROJECT No.	05-1413-036A	FILE No.	051413036A-1100-SK09
DESIGN	AS	23SEP05	SCALE AS SHOWN	REV. 0
CADD	NV	23SEP05	
CHECK	AS	23SEP05	
REVIEW	CJC	18OCT05	

FIGURE 5.2

Figures 5.3 and 5.4 show post-closure habitat quality after implementation of habitat enhancements. Figure 5.5 is an engineering diagram that shows the elevation (i.e., depth) contours for Portage/Goose Island pit and lake bottom after mining has been completed. Figure 5.6 illustrates what the post-closure aquatic environment will look like from a plan view with the two breaches in the Goose Island dike and the pit areas re-flooded. In addition to former lake habitat, some terrestrial areas, such as islands and the peninsula that separated Second and Third Portage lakes will be submerged, resulting in a net gain in surface area of the lake.

With the exception of the deep pits, most of the re-flooded habitat will be 10 m depth or less and will provide good quality habitat. Similar to what was assumed for dike face habitat, polygons between 0 and 2 m is frozen during winter and is medium value habitat. At depths between 2 and 10 m, habitat features will be engineered to provide at least medium to high value habitat. Habitat greater than 10 m, including pits, is considered low value.

Figure 5.7 illustrates a similar scenario for Vault Lake. Once the pit has been re-flooded and the lake re-filled, the dike separating Wally Lake from Vault Lake will be removed (assuming water quality is acceptable). Much of the original, undisturbed habitat will be returned to Vault Lake, except for a small portion of the western part of the lake that has been altered by the pit itself. The perimeters of the flooded pit and setbacks from the land will be engineered to provide high and medium value habitat.

Habitat structures (reefs, boulder gardens, and shoals) will be constructed on the former lake bottom and setbacks prior to flooding where appropriate, to create fish habitat on the sill areas and pit walls. Figures 5.8, 5.9, and 5.10 provide conceptual views of how fish habitat can be improved within the continuous Portage/Goose Island area from a plan view (Figure 5.8) and cross-sectional views (Figures 5.9 and 5.10). Increasing the complexity and diversity of habitat prior to flooding will ensure that habitat values and productivity can be maximized. The benefits of habitat enhancement and compensation measures undertaken during construction/operation will persist through post-closure into the foreseeable future.

5.5.1 Portage & Goose Island Pits

Mining activity in the Portage pit will eventually result in increased surface area (i.e., 26 ha due to mined terrestrial areas that become part of the lake upon post-closure flooding) and much greater volume (i.e., increased depth results in a projected pit volume of 29.8 Mm^3 and an increase in bottom surface area with the steep walls). The Goose Island pit will similarly add new lake area (4 ha) and depth (projected pit volume is 10.2 Mm^3).

Flooding the pits after mine closure will ultimately result in more than a two-fold gain in habitat productivity relative to the original pit footprints on Second and Third Portage lakes (343 HUs vs. 159 HUs). Habitat quality in the pits is primarily low, with some moderate and high value areas around the upper perimeters. It is anticipated that the deep zones will be used primarily for overwintering, especially in Vault Lake where this type of habitat is lacking. Note that water quality and habitat suitability of the pits, even deep portions, is predicted to be suitable for fish in the long-term (i.e., >25 years).

Figure 5.3: Post-Closure Habitat Quality – Second & Third Portage Lakes

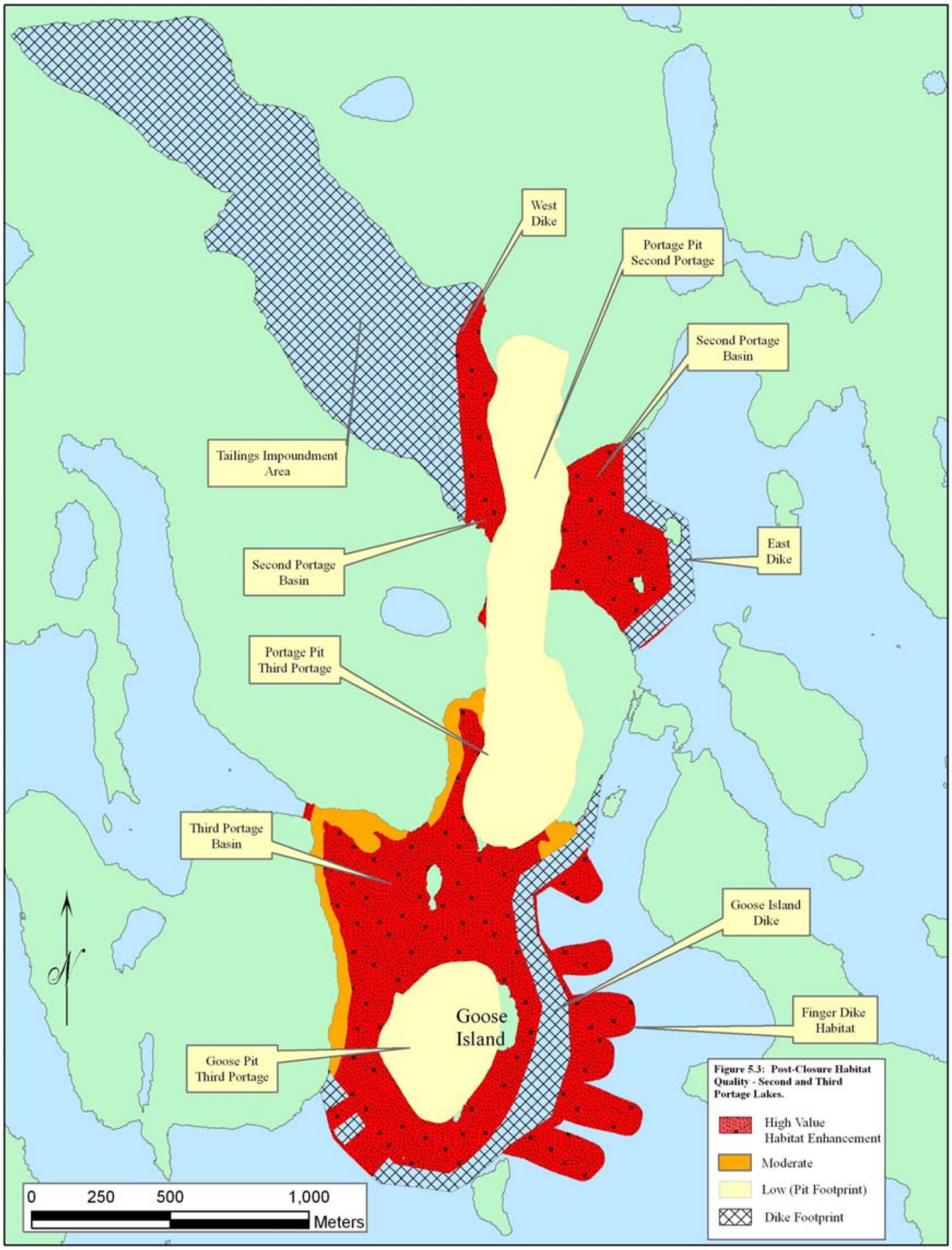
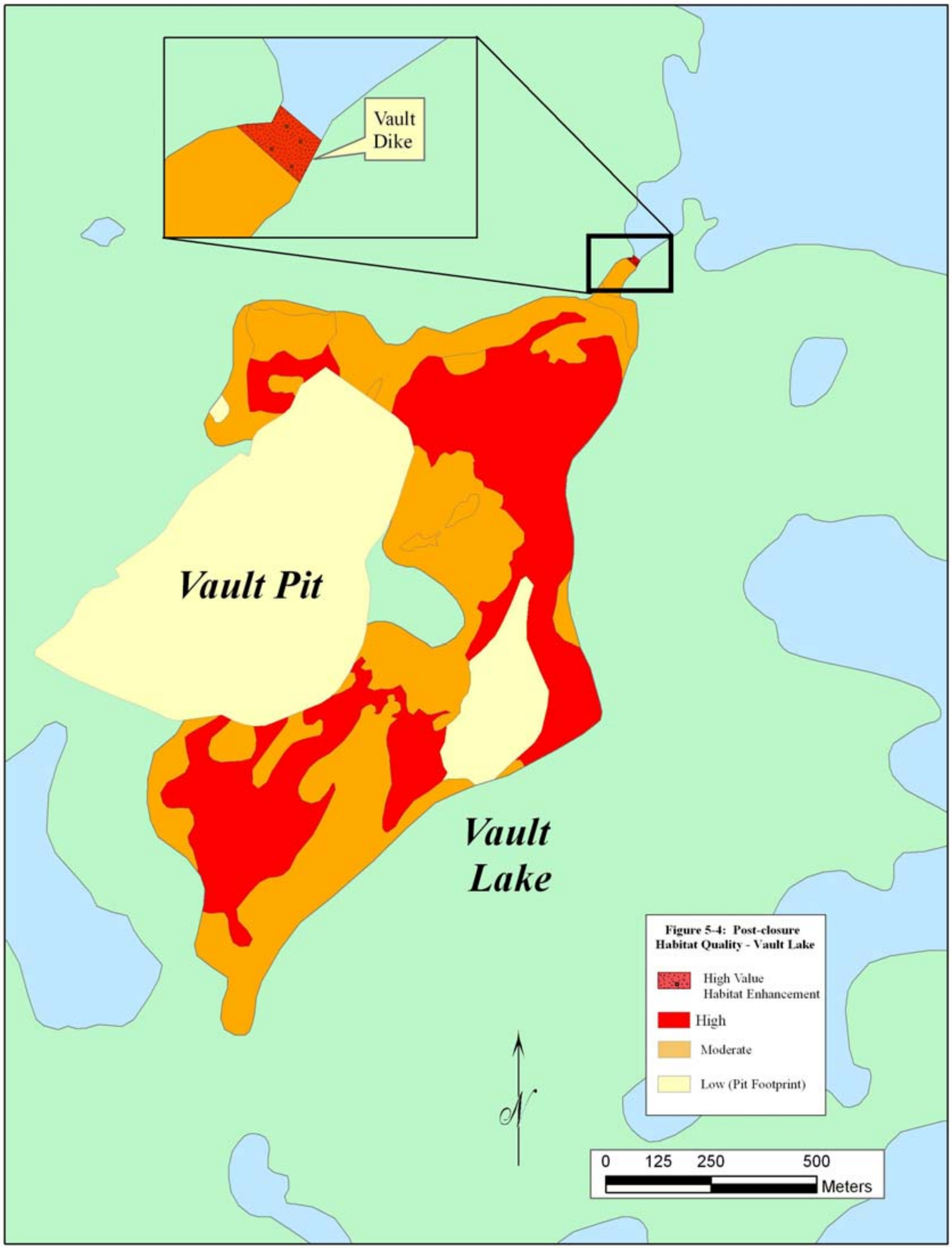
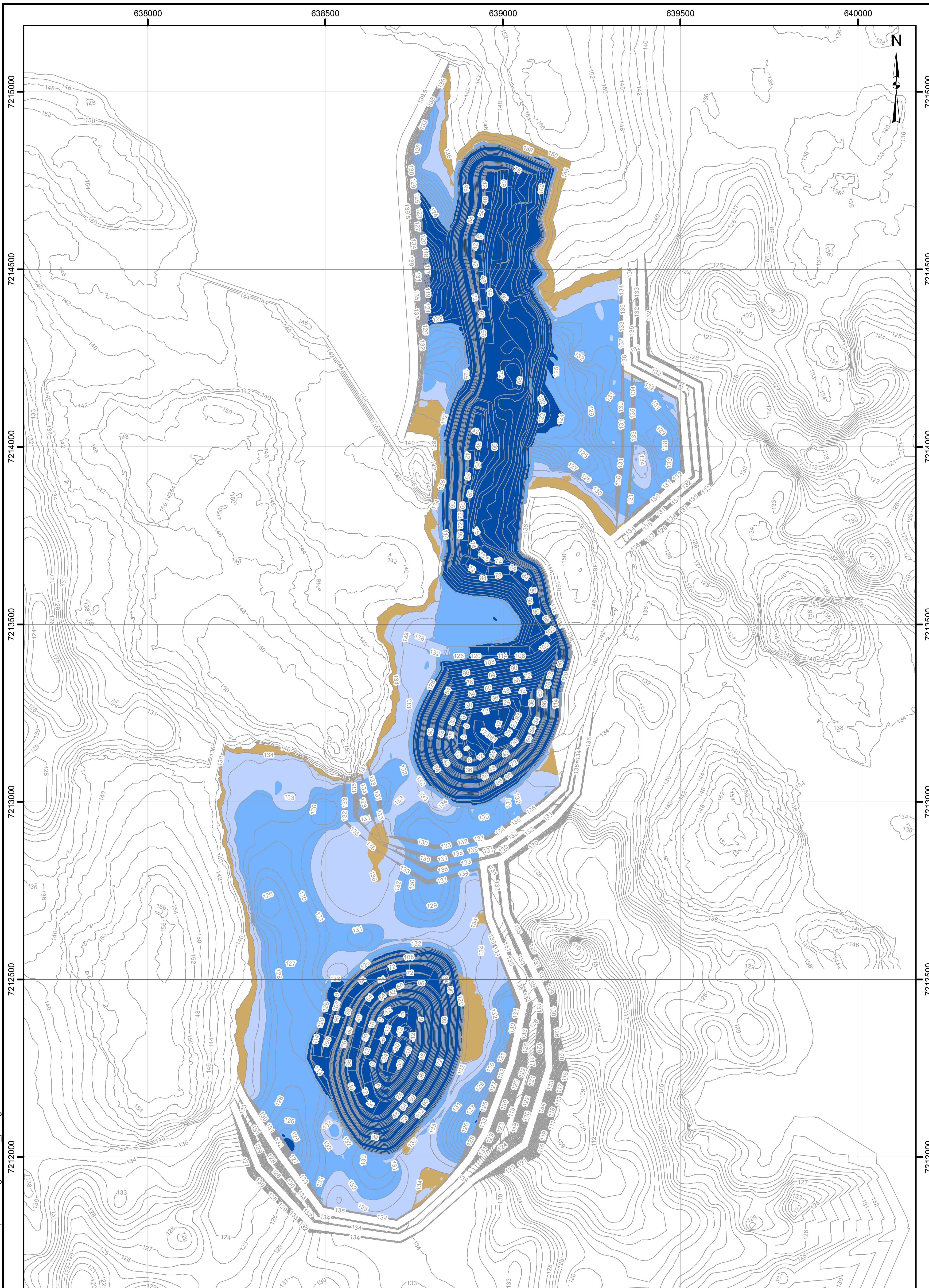


Figure 5.4: Post-Closure Habitat Quality – Vault Lake





LEGEND

Topographic Contour (2 m interval)

Bathymetric Contour (1 m interval)

Water Depth (m)

- > 10 (medium value)
- 2 - 10 (high value)
- 0 - 2 (medium value)
- Islands and Shorelines

*Water depth interpolated from best available bathymetric data. Islands may not appear as shown.

200 100 0 200 Metres

Scale - 1:10,000

REFERENCE

Cumberland Resources Ltd.

Datum: NAD 83 Projection: UTM Zone 14

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

BATHYMETRY AND HABITAT VALUES PORTAGE AREA POST CLOSURE

Golder Associates, Burnaby, B.C.

PROJECT No. 05-1413-036A			SCALE AS SHOWN	REV. 0
DESIGN	CJC	28 Oct. 2005	**FIGURE 5.5**	
GIS	CDB	28 Oct. 2005		
CHECK				
REVIEW				

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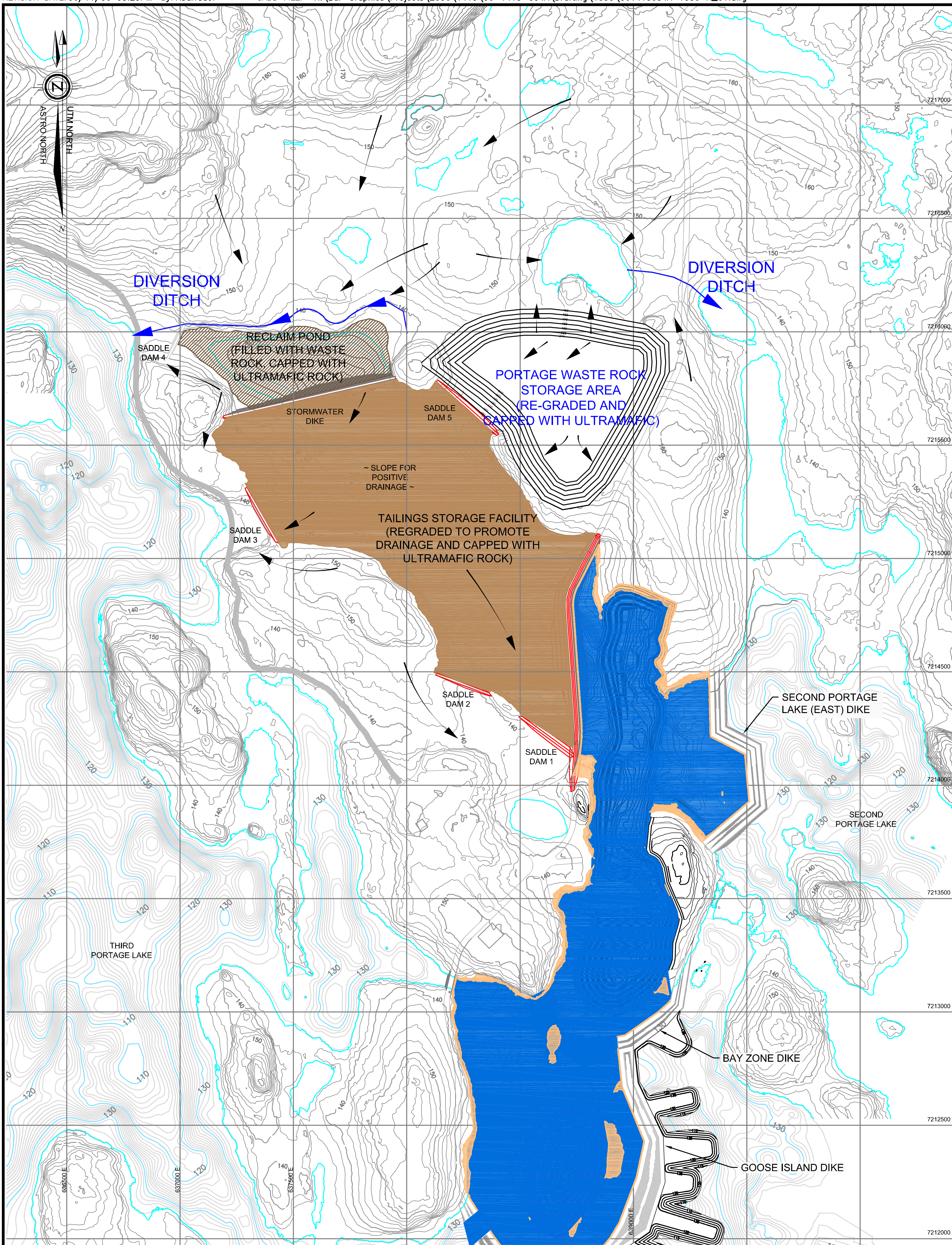
REVISION DATE: 06/11/06 05:23PM By: ASalvador CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034A\Drafting\1050\061413034A-1050-A_01.dwg



LEGEND

- ATTENUATION POND
- RECLAIMED TAILINGS
- RECLAIMED TAILINGS POND
- PIT LAKE REWATERED AREA
- ISLANDS AND SHORELINES
- NON-CONTACT WATER DIVERSION

NOTES

1) Topographic contour interval 2m.
2) Bathymetric contour interval 1m.
3) Water depth interpolated from best available bathymetric data. Islands may not appear as shown.

REFERENCES

1) Amec Americas Ltd., Drawing Number A1-131395-100-C-0001 (100- C-0001.DWG), Meadowbank Feasibility Study, April 2005.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

PORTAGE / GOOSE IMPOUNDMENT RE-FLOODING SCENARIO POST-CLOSURE

Golder Associates

PROJECT No.	06-1413-034A		FILE No.	061413034A-1050-A_01	
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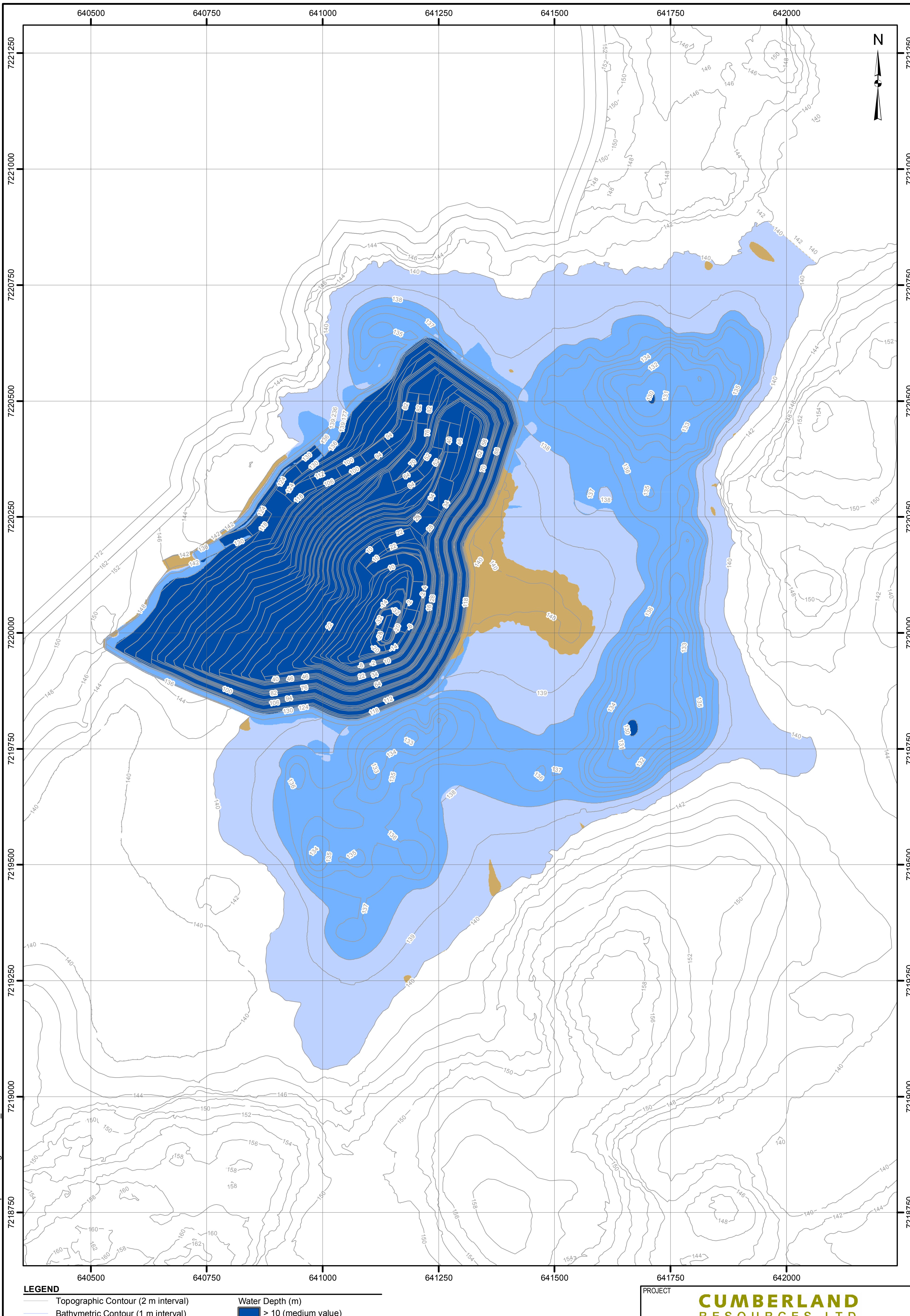
CADD	AS	06NOV06			
CHECK					
REVIEW					

FIGURE 5.6



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LEGEND

Topographic Contour (2 m interval)

Bathymetric Contour (1 m interval)

Water Depth (m)

- > 10 (medium value)
- 2 - 10 (high value)
- 0 - 2 (medium value)
- Islands and Shorelines

*Water depth interpolated from best available bathymetric data. Islands may not appear as shown.

REFERENCE

Cumberland Resources Ltd.

Datum: NAD 83 Projection: UTM Zone 14

150 75 0 150 Metres

Scale - 1:7,500

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

BATHYMETRY AND HABITAT VALUE VAULT AREA POST CLOSURE

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-036A			SCALE AS SHOWN	REV. 0
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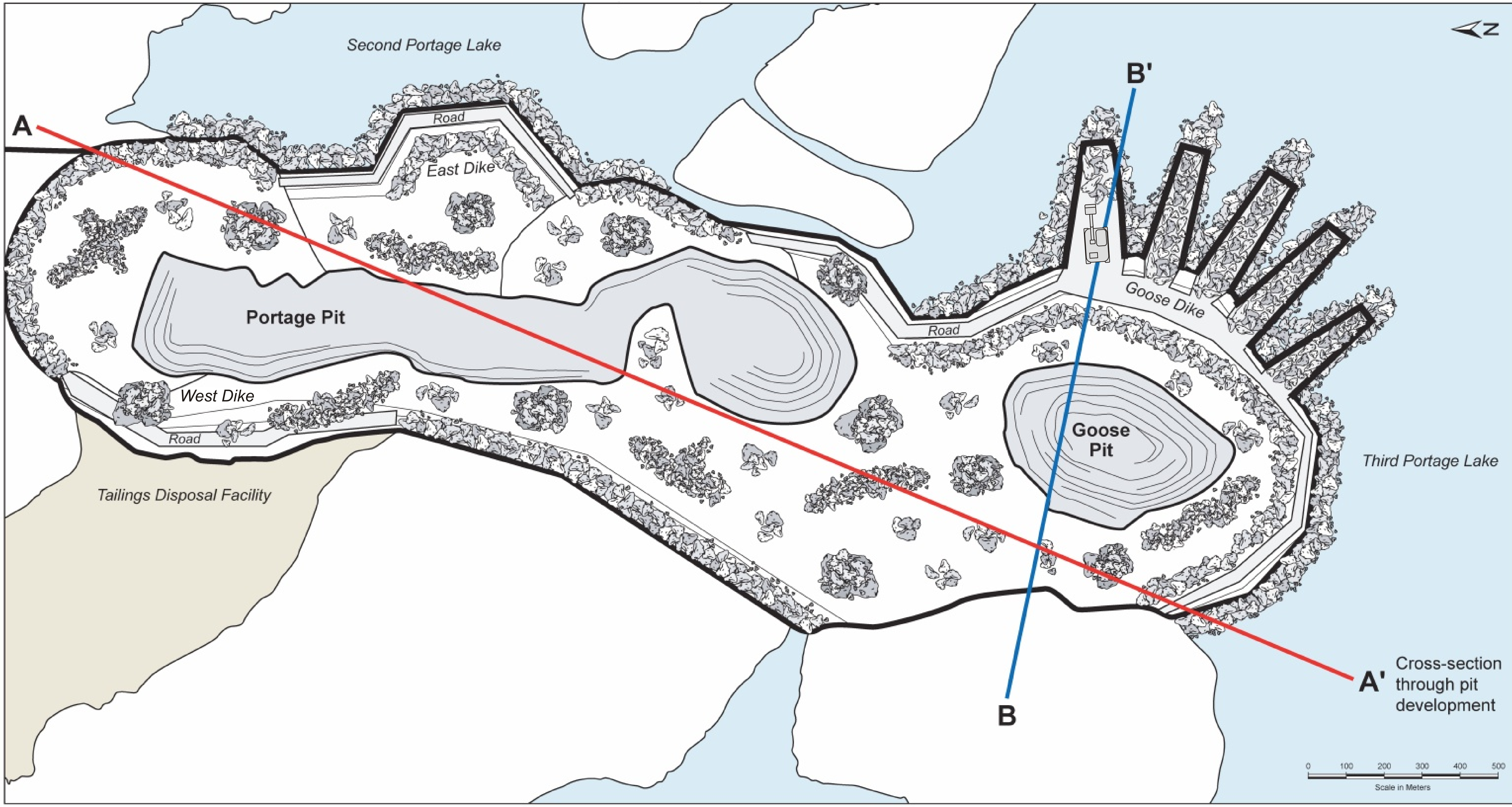
GIS	CDB	28 Oct. 2005		
CHECK				
REVIEW				



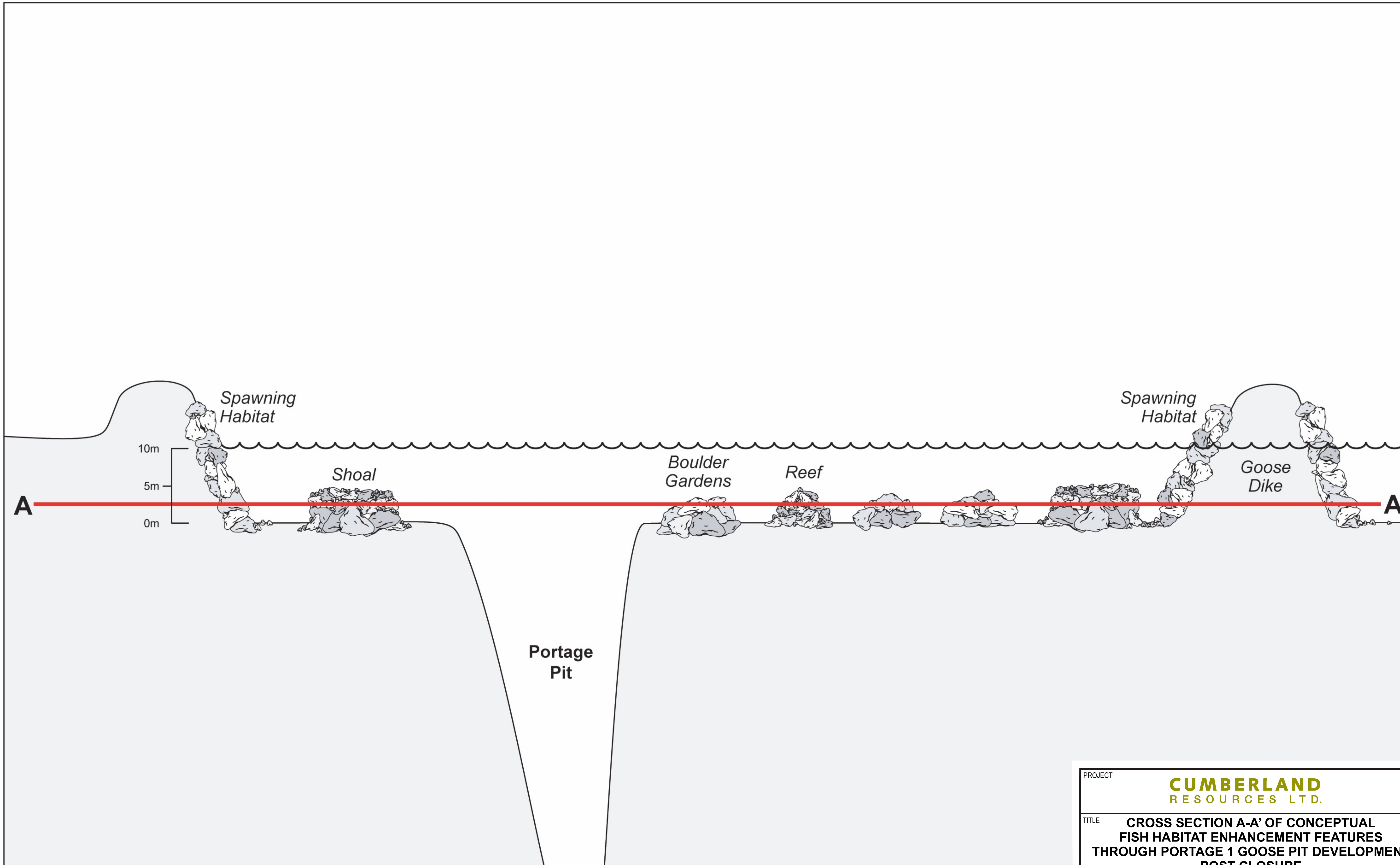
Fish Habitat Features

Boulder Gardens | Reefs | Shoals | Dike Face Spawning Habitat

PROJECT	CUMBERLAND RESOURCES LTD.
TITLE	PLAN VIEW OF CONCEPTUAL FISH HABITAT ENHANCEMENT FEATURES THROUGH PORTAGE 1 GOOSE PIT DEVELOPMENT POST-CLOSURE

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	
DESIGN	KD	24OCT06	SCALE AS SHOWN	REV.
CADD	GG	24OCT06	FIGURE 5.8	
CHECK				
REVIEW				



PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

CROSS SECTION A-A' OF CONCEPTUAL FISH HABITAT ENHANCEMENT FEATURES THROUGH PORTAGE 1 GOOSE PIT DEVELOPMENT POST-CLOSURE

Golder Associates

PROJECT No.	06-1413-034A		FILE No.	
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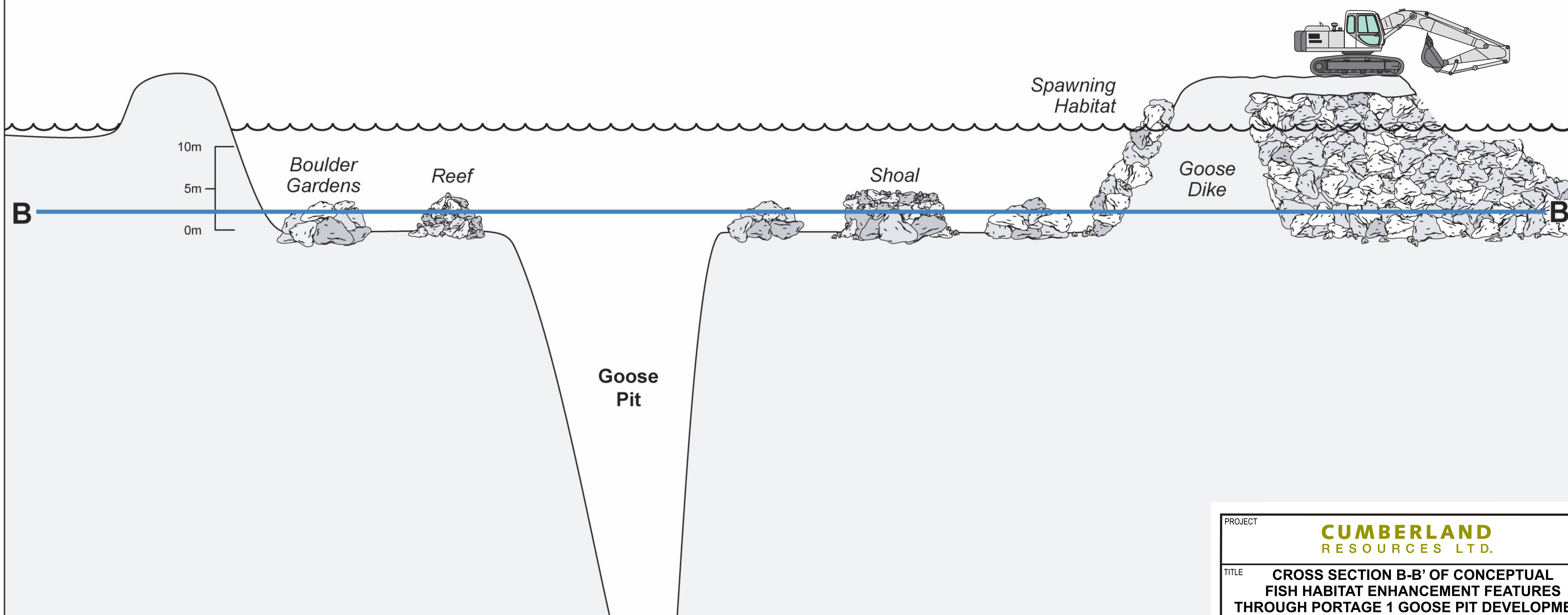
CHECK	KD	24OCT06		
REVIEW				



PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

CROSS SECTION B-B' OF CONCEPTUAL FISH HABITAT ENHANCEMENT FEATURES THROUGH PORTAGE 1 GOOSE PIT DEVELOPMENT POST-CLOSURE

Golder Associates

PROJECT No. 06-1413-034A			FILE No.
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CADD	GG	24OCT06	**FIGURE 5.10**
CHECK	KD	24OCT06	
REVIEW			

DRAWING DATE: 24-Oct-06 COREL FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034A\Drafting\1050\061413034A-1050-A_01-03.cdr

5.5.2 Second & Third Portage Basins

At closure, the pits will be flooded and the dike interior, setback area or sills, and pit face will be contoured to provide medium (0 to 2 m and >10 m) and high (2 to 10 m) value habitat polygons. More importantly, much of the original impounded basin area outside the pit footprints will be enhanced and upgraded to high value habitat through the addition of reefs, shoals, and boulder gardens. Table 5.3 summarizes habitat units gained from each residual structure (e.g., dike faces) or enhancement (e.g., flooded lake bottom). Key results are as follows:

- The East dike interior and exterior dike faces will incorporate habitat design features to provide spawning / nursery (>2 m depth), foraging, and rearing areas for fish, amounting to 7.7 HUs.
- Goose Island dike interior and exterior, as well as the restored habitat in the two breach zones, will create 66 HUs.
- West dike exterior will create 14 HUs.
- The East dike, West dike, and most of the Goose Island dike will remain in place in perpetuity, resulting in the permanent net loss of 48 HUs (i.e., 135 HUs lost for combined footprints; 60 HUs gained for dike faces, and 27 HUs gained in enhanced breach zones).
- Post-closure habitat enhancements in the Second and Third Portage basins (i.e., those areas within the impoundment areas, but outside the pits) will result in a net gain of 366 HUs (i.e., 1,375 HUs post-closure compared to 1,009 HUs baseline value).

5.5.3 Tailings Impoundment Area

There is net HADD related to the tailings impoundment area (TIA) amounting to 370 HUs (Tables 4.1 and 5.3). This is 24% of total available habitat in Second Portage Lake (1,505 HUs) and only 3% of available habitat (11,978 HUs) in Third Portage Lake, considering that this area will be absorbed into Third Portage Lake at closure. Operational and post-closure habitat enhancement will result in a net gain-to-loss ratio of slightly more than 2:1.

5.5.4 Vault Impoundment & Vault Pit

Vault Lake will be diked and drained in Year 4 of operation and will be mined until Year 8. Vault pit will encroach into Vault Lake by about 20% of the surface area of the lake (Figure 4.2). The majority of the lake will be unaffected by mine development. Unlike the other impounded basins, we are not recommending additional enhancements for the Vault basin because much of the habitat quality in the area is already rated as high or moderate. Deep areas of the lake are low in abundance and overwintering habitat may be limiting productivity of this lake. Thus, creation of a deep pit may enhance overall productivity of the lake by providing formerly limiting habitat type.

After mine development at Vault has been completed in Year 8, the pit will gradually be filled, which is estimated to require several years. Pit depth is predicted to be 160 m with a volume estimated to be 21.5 Mm^3. This is ten times the former volume of Vault Lake (2 Mm^3) and more than half the combined volume of Vault and Wally lakes. This represents a significant increase in volume and surface area of the lake, especially to Vault Lake alone. It is likely that in post-closure, Vault Lake will become more productive than it is now.

At closure, the Vault dike will be breached and the Vault pit gradually be allowed to fill. Estimated habitat productivity upon implementation of the closure plan is presented in Table 5.3. Most of the habitat gains are related to flooding the lake basin, returning productivity lost during the operations period. The major change from baseline conditions is the addition of the Vault pit, which adds a net gain of 119 HUs, mostly as deep water habitat (i.e., primarily low value). The value of the new habitat for overwintering in Vault Lake may make a significant difference in local productivity.

5.5.5 Summary

A net loss of productive capacity is expected in the project lakes during construction and operation of the Meadowbank Gold project. Despite redesigning the Finger dike habitat enhancement feature in the past year to double permanent habitat productivity gains during this phase to 206 HUs, a net loss of 1,555 HUs is predicted which cannot be recovered or replaced during mine operations.

At post-closure, a considerable amount of temporarily lost habitat will be recovered from habitat enhancements in the impounded lake areas and associated dikes, a new pit-associated lake area gained from mining former terrestrial areas, and substantial increases in three-dimensional surface area and volume of the deep pit areas. An accounting of the long-term no-net-loss balance sheet for the project is presented in Table 5.4. Overall, the project achieves a long-term gain of 390 HUs, all within the project area lakes. This represents a 22% increase in the predicted productive capacity for the area within the mine’s footprint compared to the pre-mining baseline. The net gain in habitat productivity represents a greater than 2-to-1 compensation-to-loss ratio for the permanent loss of the tailings impoundment area.

Table 5.4: Post-closure No-Net-Loss Balance Sheet for Meadowbank Gold Project

Project Component	*HUs Lost*	*HUs Gained*	*Net HUs*	*NNL Ratio*
Mine Site (excluding TIA)	1,390	1,402	+12	1:1
Tailings Impoundment Area	370	749	+379	2:1

Note: NNL Ratio = HUs Gained:HUs Lost.

SECTION 6 • NNLP MONITORING

Consistent with the environmental management approach for the project as a whole, monitoring will play an important role in successful implementation of the NNLP. The AEMP (2005) documents the comprehensive monitoring and management strategy through all project aspects and phases. While addressing NNLP Monitoring, the AEMP concluded that the specific program could only be prepared once a framework for monitoring and assessment has been agreed to by all parties including the KIA, Baker Lake, Cumberland, and FOC. Once the NNLP has been agreed to in principle, a Sampling and Analysis Plan (SAP) will be prepared to outline all monitoring of fish habitat as required to meet the terms of the FOC habitat authorization. In general, there will be two components to the NNLP Monitoring: Pre-implementation and Post-enhancement Monitoring. As with the AEMP, the strategy of adaptive management is an integral part of the monitoring of NNL enhancement features in the project lakes. Monitoring results will be used to provide feedback on NNLP implementation to maximize overall benefits to fish productivity and avoid significant impacts.

6.1 PRE-IMPLEMENTATION & OPERATIONAL MONITORING

Targeted monitoring of high value habitat areas within the development footprint over the last few years has allowed us to understand and quantify habitat areas that are being used most intensely by fish, such as for spawning or foraging. This has been achieved by using aerial photography, bathymetry, short-set gillnetting and groundtruthing using underwater video. The combined results provide detailed visual information on the habitats most used by fish.

We have completely and quantitatively mapped in great detail (FHAP, 2005) all habitats being dewatered within the project lakes. Once the areas are dewatered, these high value locations will be completely visible and can be verified against what was mapped, groundtruthed and used as “models” for planned enhancement activities. Ultimately, key elements of these features will be incorporated into the appropriate post-closure enhancement area designs.

A central component of the NNLP is upgrading low quality or value fish habitat to high quality habitat. Although many enhancement opportunities were identified for this project, very few of these are cost-effective or viable during operations. Operational improvements or enhancement programs are primarily associated with dike faces and the Goose Island finger dikes. These planned activities associated with developing the Meadowbank Gold project will provide us with a valuable opportunity to refine our understanding of the key features that combine to make high quality fish habitat and utilization by fish. Several years of habitat assessment and monitoring experience will be gained prior to undertaking the bulk of habitat enhancement that will take place at post-closure. Thus, adaptive management will allow for optimization of habitat features prior to re-flooding and recovery of large amounts of habitat.

6.2 POST-ENHANCEMENT MONITORING

Performance monitoring of NNLP enhancement areas will be necessary to show they are functioning as intended. The staging of enhancement implementation (i.e., some during operations and others post-closure) provides a great opportunity for adaptive management. For example, once the East and

Goose Island dikes are operational, they will provide direct habitat for periphyton and benthic communities, as well for spawning and rearing habitat by fish. These dike exteriors are designed to provide optimal habitat for fish during the life of the mine, as well as beyond mine life. Furthermore, success of the engineered finger dikes as high value enhancement feature will be monitored during the operational period to provide direct feedback, along with the results of pre-implementation monitoring, to final design of post-closure enhancement features.

Although design specifications can meet life history requirements for fish, other factors must also be satisfied if the dike exteriors are to function as productive habitat for plants, invertebrates, and fish. For example, metals leached from dikes into overlying pore waters could adversely affect periphyton growth, establishment of a benthic community, and egg survival and/or development of fish larvae during the initial flush shortly after dike construction. Thus, a targeted study has been designed to address utilization of spawning habitat by lake trout after dike construction (AEMP, 2005). To verify that dikes will function as designed, pore water from the interstitial spaces within East dike and Goose Island dike will be sampled for dissolved metals concentrations up to four times during the first year of operation. The sampling method would be a hose inserted into spaces within the dike, with water withdrawn through an in-line filter and using a pump.

A targeted monitoring program will also be conducted to evaluate the effects of metals potentially leaching from dikes on periphyton colonization. Species composition, abundance, and biomass of periphyton communities will be measured at discrete locations on the East dike and Goose Island dike and compared with periphyton data from reference areas. This will indicate whether the dikes are functioning as productive fish habitat by determining whether algal growth is impaired to any degree by metals leached from the rock material used to construct the dikes. Sampling will be conducted once annually in late summer during the height of periphyton growth from rock surfaces with similar attributes (e.g., depth, exposure to sun, aspect) to minimize inherent variation in periphyton biomass. Further details will be incorporated into the SAP.

A targeted study is also proposed to determine the extent to which dikes are used for spawning by lake trout. Similar methods, such as short-set gill nets during fall and underwater video will document whether fish are utilizing dike faces and finger dike habitat for spawning. Sampling for eggs under the ice, or for larvae during early spring at break-up will be used to provide direct evidence of spawning and egg survival. If necessary, fish can be spawned artificially and egg traps placed within the dike face material to determine egg survival and survival of fry prior to emergence and swim-up. These targeted studies will verify if dike face habitat is functioning as designed using the principals of adaptive management. Furthermore, results from other northern mine developments and attempts to create habitat will be used to optimize habitat features and design parameters at Meadowbank.

It is important to be aware that the colonization of newly enhanced habitat by algae and benthic invertebrates will likely take several seasons and affect the degree of usage of these areas by fish. Furthermore, these lakes are not habitat limited. If, during the first few years, little or no activity is observed, this does not mean that this is not productive habitat.

Cumberland will work closely with FOC and other parties to ensure the development of an appropriate monitoring framework that addresses key concerns of all stakeholders.

SECTION 7 • REFERENCES

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APPENDIX A

No-Net-Loss Plan: All-Weather Private Access Road

APPENDIX A

MEADOWBANK GOLD PROJECT

NO-NET-LOSS PLAN:
ALL-WEATHER PRIVATE ACCESS ROAD

NOVEMBER 2006

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SECTION 1 • INTRODUCTION

1.1 BACKGROUND

Cumberland Resources Ltd. (Cumberland) is evaluating the feasibility of establishing a gold mine at its Meadowbank property, located about 75 km north of the Hamlet of Baker Lake, Nunavut. The surrounding terrain is typical of the barren-ground subarctic, dominated by many small lakes and ponds with indistinct and complex drainage patterns. Ground access to the site is currently restricted to a winter-only road. Cumberland is proposing an all-weather, private access road (AWPAR) to provide year-round ground access to the site.

Golder Associates (Golder) identified the optimal route for the AWPAR based on a number of parameters including suitability of terrain, ease of construction, availability of borrow material for construction, and minimal stream crossings. Strong emphasis on the latter has resulted in the 115-km AWPAR having only 21 crossings in the current design (see Figure 2-1). Azimuth Consulting Group Inc. (Azimuth) conducted a baseline assessment of fish habitat and habitat usage patterns (i.e., magnitude and timing) for each of the proposed crossings; results of this baseline work is summarized in the *Habitat & Fisheries Assessment: All-Weather Road* (HFA-AWPAR, 2005). Azimuth recommended specific crossing structures (i.e., bridge or rounded culvert) to minimize impacts to habitat and fisheries resources. In addition to minimizing the number of stream crossings, the AWPAR crossing designs incorporated guidance from the Habitat Management Program of Canada Fisheries and Oceans (FOC; previously known as Department of Fisheries and Oceans [DFO]) to avoid or minimize impacts to fish or fish habitat (FOC, 2005). Indeed, most of the crossings discussed herein are clear spans and do not result in the harmful alteration, disruption, or destruction (HADD) of fish or fish habitat.

Azimuth conducted additional follow-up investigations in 2006 to minimize uncertainties in the 2005 study. While not fully completed, available results from 2006 will be included where possible.

The purpose of this No-Net-Loss Plan (NNLP) is to quantify and assess impacts to fish habitat in watercourses crossed by the AWPAR and to present options for compensating for the loss of fish habitat. This is necessary to achieve the no net loss of fish habitat as stipulated under the *Fisheries Act* (see Section 1.2 of the main report for a more detailed description of regulatory context).

1.2 UNDERSTANDING HABITAT FEATURES OF AWPAR WATERCOURSES

Fish habitat is generally classified according to five major categories: spawning/nursery; rearing; feeding; overwintering; and migratory. Migratory habitat is important in systems where stream habitat provides life history functions for particular species, such as spawning and feeding by Arctic grayling (*Thymallus arcticus*), or to connect lakes, acting as migratory corridors.

Fish habitat, as it pertains to importance and utilization by different fish species at particular life history stages (e.g., larvae, juvenile, adult) in the AWPAR watercourses, is a complex mixture of physical, chemical, and biological features.

- Physical features include watercourse morphology (e.g., channel width and depth), substrate type and size (e.g., homogenous or mixed beds of gravel, cobble, or boulder), flow rates, oxygen concentration, and temperature. These small streams and channels are frozen solid for much of the year and typically only flow for short periods each summer, peaking just after snowmelt (i.e., freshet). Consequently, their importance to fish varies largely on how they are used as spring/summer habitat (e.g., as migration corridors or for spawning). Furthermore, installation of crossing structures may affect physical dynamics and be detrimental to fish or fish habitat.
- Chemical features include pH, nutrient concentration, organic carbon content of sediment, and contaminants (e.g., metals, hydrocarbons). Aquatic systems in this region are known as being nutrient-poor (ultra-oligotrophic), with naturally low productivity.
- Biological features include abundance of food sources (algae, zooplankton, and benthic invertebrates), predators, and competing species. Some of the AWPAR watercourses serve as important fish habitat, primarily for Arctic grayling spawning and rearing.

Ultimately, the interaction of these features dictates the importance of AWPAR watercourses to fish and their susceptibility to adverse effects related to the installation of crossing structures. These will be explored in greater detail for each proposed AWPAR crossing.

1.3 OBJECTIVES

The ultimate objectives of this AWPAR NNLP are to:

- describe baseline conditions for fish habitat and fish habitat usage for each of the proposed AWPAR watercourse crossings
- determine whether proposed crossing structures encroach the watercourse margins and adversely impact fish habitat (i.e., result in a HADD)
- quantify any proposed habitat losses in terms of area and value (i.e., high, medium, or low for fish species using watercourse)
- propose compensation measures for each HADD.

SECTION 2 • ENVIRONMENTAL SETTING

Understanding the environmental setting of the AWPAR watercourses is critical to applying the principals of no net loss of habitat. Ecological studies conducted in the AWPAR watercourses in 2005 and 2006 have provided the necessary insight into the nature of fish habitats and their utilization by fish.

2.1 INVESTIGATION METHODS

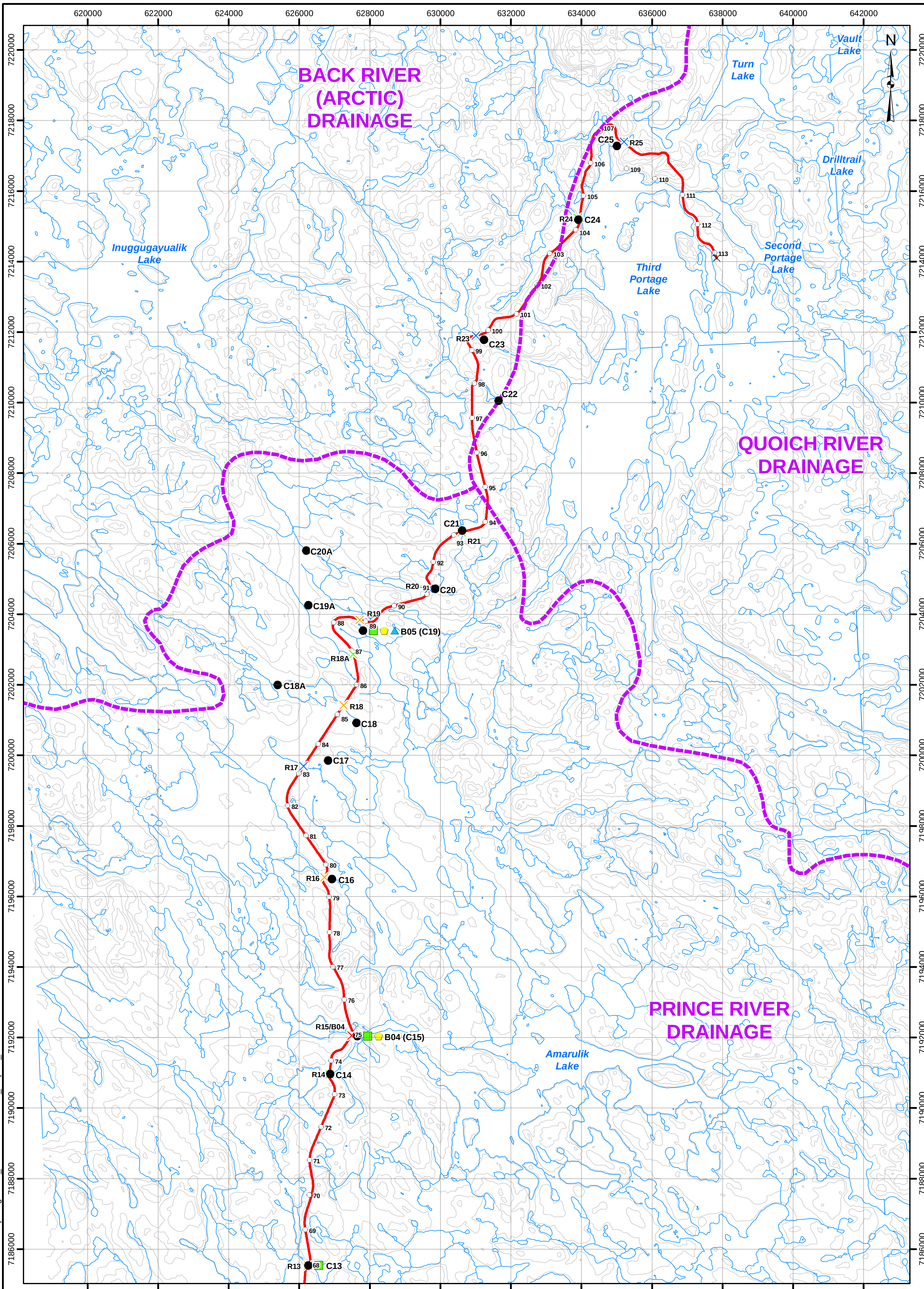
Watercourse flow dynamics, and hence fish use, show considerable seasonal variability. Consequently, the full range of field investigations were planned to include spring/summer (i.e., late June/early July) and late summer/early fall (August). In addition, we visited sites at ice break-up (June) and in the fall (September) to more fully appreciate the range of conditions possible; these conditions can be seen in the photos presented in Appendix AB.

Crossings were numbered from C01 to C25 in the HFA-AWPAR (2005) and bridge identifiers were also used. The system Golder has been using replaces the “C” with an “R” and does not have specific bridge identifiers. This document will conform to Golder’s system to avoid further confusion. The AWPAR route from Baker Lake to the Meadowbank mine site and all watercourse crossings are shown in Figure 2.1.

2.1.1 Fish Habitat Characterization

Each watercourse crossing was evaluated based on the following criteria to determine the relative importance of the watercourse with respect to fish habitat and utilization:

- significance of the watercourse with respect to local setting
- connectivity to upstream and downstream ponds and lakes
- over-wintering potential of upstream and downstream lakes
- substrate composition; stream depth, width, and discharge
- overall importance of habitat to fish from a life history perspective (i.e., spawning, rearing, migratory, feeding).



LEGEND

- Meadowbank Project
- Kilometre Marker
- Proposed Route
- Watercourse
- Waterbody
- Contour (10 m interval)
- Habitat Assessment (Spring and Fall)
- Hoop Net (Spring)
- Hoop Net (Fall)
- Larval Drift Trap
- Minnow Trap
- Watershed Boundary
- Stream Crossing (30 m bridge)
- Stream Crossing (12 m bridge)
- Stream Crossing (multiple culverts at bottom)
- Stream Crossing (single culvert at bottom)

2,000 1,000 0 2,000 Metres

Scale - 1:100,000

REFERENCE

Cumberland Resources Ltd.

Datum: NAD 83 Projection: UTM Zone 14

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD
STREAM CROSSINGS SHOWING LOCATIONS OF HABITAT
ASSESSMENT AND FISHING GEAR DEPLOYMENT
1:100,000 Mapsheet 1 of 3

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 1
DESIGN	KD	23 Oct. 2006		
GIS	CDB	23 Oct. 2006		
CHECK	CJC	23 Oct. 2006		
REVIEW				

FIGURE 2.1

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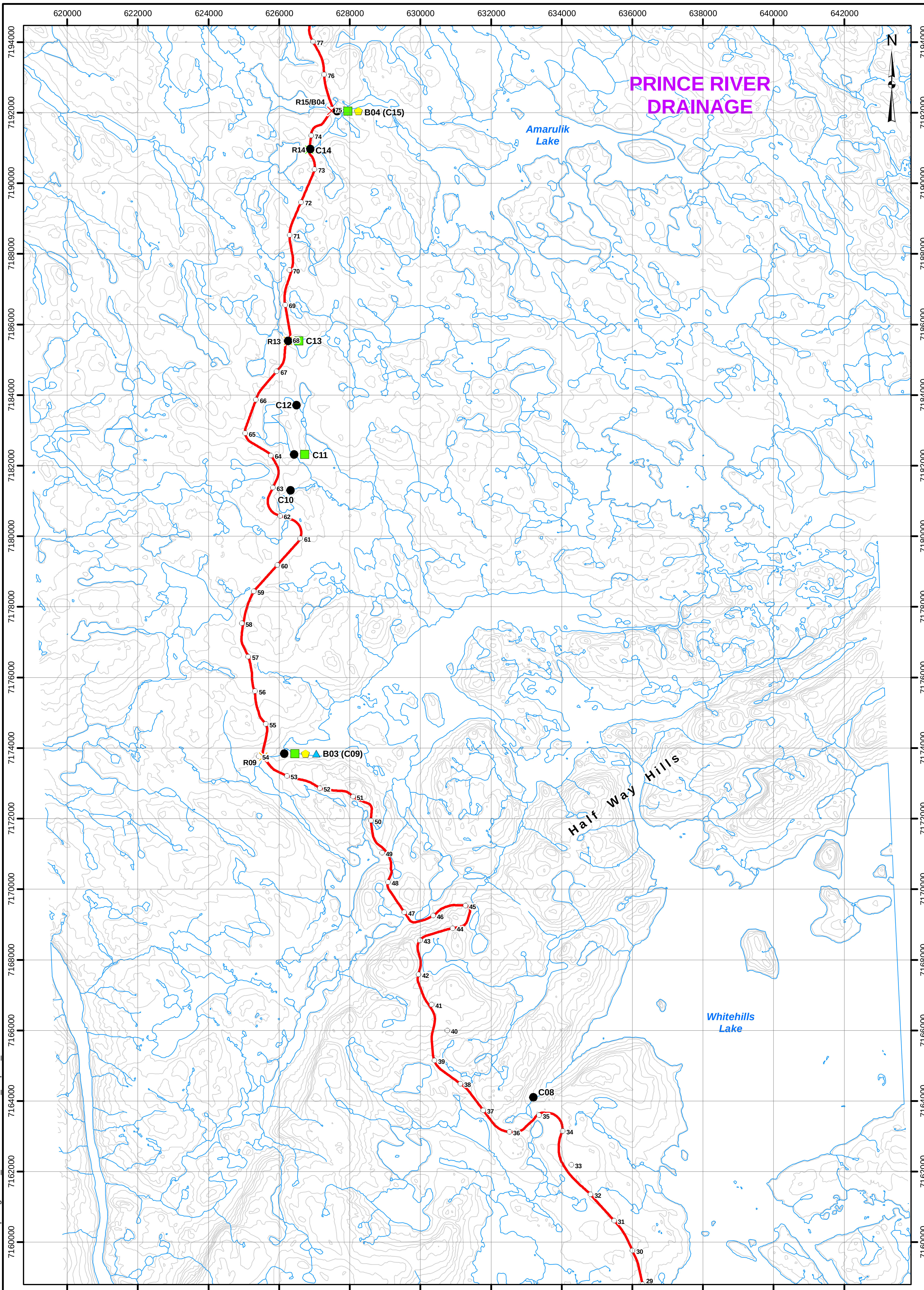

LEGEND

Meadowbank Project	Habitat Assessment (Spring and Fall)	Stream Crossing (30 m bridge)
Kilometre Marker	Hoop Net (Spring)	Stream Crossing (12 m bridge)
Proposed Route	Hoop Net (Fall)	Stream Crossing (multiple culverts at bottom)
Watercourse	Larval Drift Trap	Stream Crossing (single culvert at bottom)
Waterbody	Minnow Trap	
Contour (10 m interval)	Watershed Boundary	

2,000 1,000 0 2,000 Metres

Scale - 1:100,000

REFERENCE

Cumberland Resources Ltd.

Datum: NAD 83 Projection: UTM Zone 14

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD
STREAM CROSSINGS SHOWING LOCATIONS OF HABITAT ASSESSMENT AND FISHING GEAR DEPLOYMENT
1:100,000 Mapsheet 2 of 3

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 1
DESIGN	KD	23 Oct. 2006		
GIS	CDB	23 Oct. 2006		
CHECK	CJC	23 Oct. 2006		
REVIEW				

FIGURE 2.1

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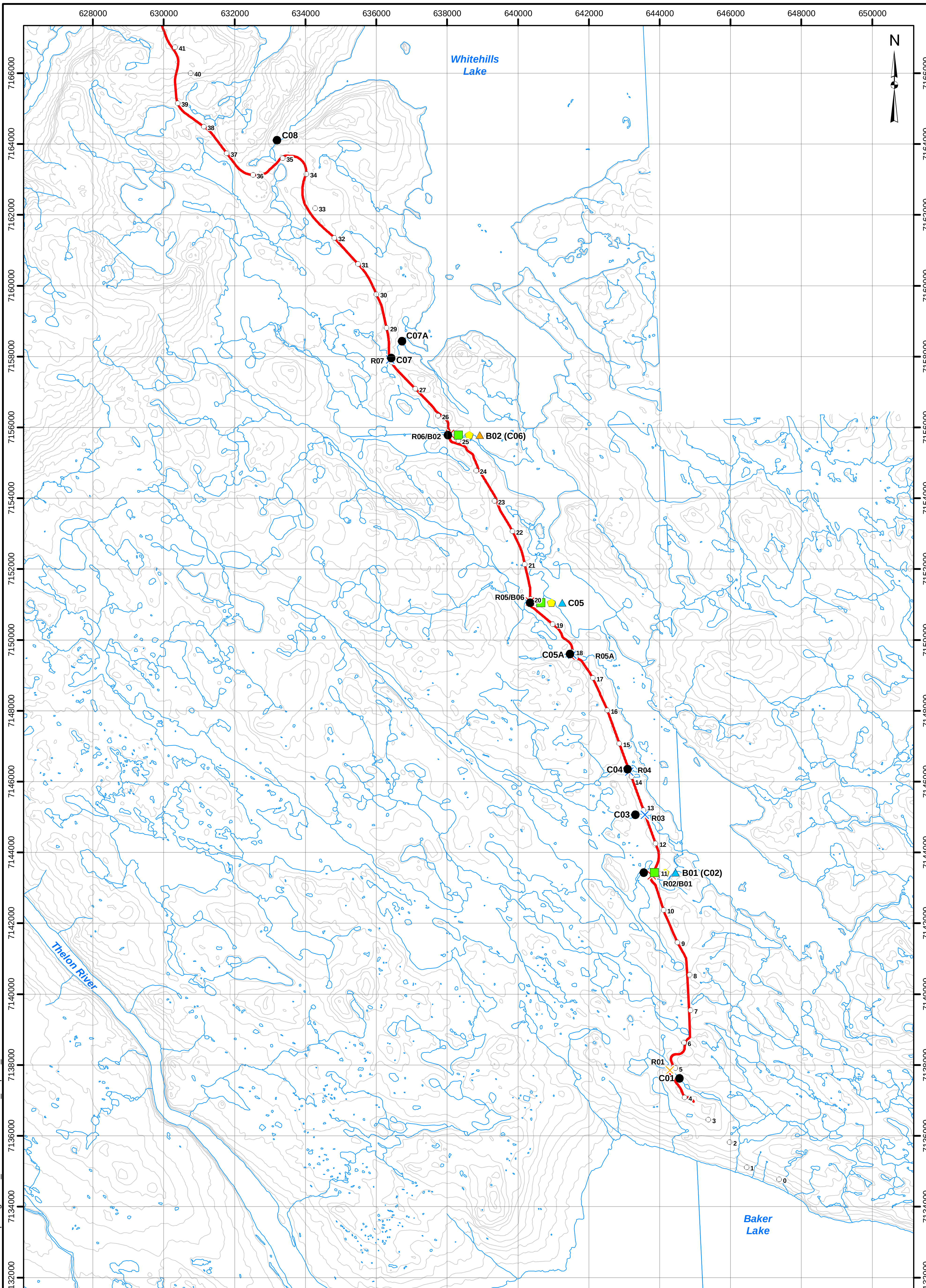

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LEGEND

- Meadowbank Project
- Kilometre Marker
- Proposed Route
- Watercourse
- Waterbody
- Contour (10 m interval)
- Habitat Assessment (Spring and Fall)
- Hoop Net (Spring)
- Hoop Net (Fall)
- Larval Drift Trap
- Minnow Trap
- Watershed Boundary
- Stream Crossing (30 m bridge)
- Stream Crossing (12 m bridge)
- Stream Crossing (multiple culverts at bottom)
- Stream Crossing (single culvert at bottom)

2,000 1,000 0 2,000 Metres

Scale - 1:100,000

REFERENCE

Cumberland Resources Ltd.
Datum: NAD 83 Projection: UTM Zone 14

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD
STREAM CROSSINGS SHOWING LOCATIONS OF HABITAT ASSESSMENT AND FISHING GEAR DEPLOYMENT
1:100,000 Mapsheet 3 of 3

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 1
DESIGN	KD	23 Oct. 2006	FIGURE 2.1	
GIS	CDB	23 Oct. 2006		
CHECK	CJC	23 Oct. 2006		
REVIEW				

All watercourse crossings were visited during the early stages of the spring/summer survey and prioritized to focus monitoring efforts based on preliminary habitat assessment criteria. Aerial photos, ground photos, and evaluations were completed at all of the watercourse crossings. Detailed components of the evaluation included:

- stream depth (m), wetted width (m) and bankfull (m), if applicable, and discharge (m^3/s).
- channel flow characterization according to relative proportions of pool (<0.25 m/s), chute or run (>0.25 to 0.5 m/sec), riffle (>0.5-1.0 m/sec), and rapid (>1.0 m/sec) (Portt et al., 1999)
- percent substrate characterization (boulder, cobble, gravel, fines, grass, and other)
- completing a reach plan in the field, where applicable
- describing physical channel features and making general observations relating to potential for access and passage by fish, fish presence, fish habitat, and overall fish-bearing capacity.

Crossings that had high fish-bearing capacity with respect to the evaluation criteria and required focused monitoring efforts included crossings R02, R05, R06, R09, R15, R16, and R19 (Figure 2.1). Habitat mapping and evaluation were conducted at all crossings in 2005, even those where habitat did not have the capacity to support fish or where fish were not present because access to the watercourse was not possible (e.g., fishless ponds upstream and/or downstream; barriers).

2.1.2 Fishing Methods

Hoop nets, larval drift traps, and minnow traps were set in all suspected fish-bearing watercourses and visited almost daily (see Figure 2-1 for specific locations). Hoop nets were used to firstly determine overall movement of fish, and secondly to determine direction (up- and downstream) movement of fish. Hoop nets consisted of either 4 ft (1.22 m) or 3 ft (0.9 m) diameter front hoop dimensions, 17 ft (4.9 m) long with a total width, including wings of either 9 m or 15 m. All of the hoop nets used in the monitoring consisted of a series of 7 hoops with 25 cm^2 size (1") mesh. Attached to the hoops are mesh extension “wings” that extended with variable length, outside of the front hoop. Hoop nets were set with aluminium poles and wings extended in a V-shape to span the width of channel to maximize degree of fish capture. Fish are trapped within the hoop nets and retained alive as they move up- or downstream depending on the way the net is oriented to capture fish.

Where stream width was so narrow as to only accommodate one hoop net, a 1.92 cm (1.5") stretch mesh gill-net was set behind the hoop net, after arriving at the stream crossing. The gill net served to trap and collect fish impeded by the hoop net attempting to migrate in the opposite direction of hoop net (either up or downstream, depending on the orientation of the hoop net). To maximize collection, the hoop nets were redirected in response to the direction of the highest abundance of migrating fish.

Fish were removed from hoop nets at least every second day, depending on helicopter availability, identified to species, measured for fork length (mm) and examined for external health and spawning condition by gentle palpitation of the belly. Periodic autopsies on a small sample of fish were conducted to determine gender ratio, state of sexual maturity, internal condition, and diet.

Larval drift traps were set at crossings R02, R06, R09, R15, R16, and R19. Traps were set near the hoop nets within constricted, riffle portions of the stream to collect passively drifting fish eggs and newly hatched fry. Larval drift traps consist of 0.5 mm Nitex mesh traps attached to the back of a square, cone-shaped frame constructed of aluminium. The frame with trailing net and collection vessel was submerged into the stream and anchored between two aluminium rods driven into the sediment. These traps are very effective at collecting fish and invertebrates drifting downstream. The volume of water samples is directly related to the surface area of the trap (m^2) and stream velocity (m/s). Drift traps were checked at least every second day and fish eggs or larvae were removed and preserved in a dilute formalin solution for taxonomic identification by North/South Consultants, Winnipeg. Invertebrate species collected in the larval drift traps were also identified at least to order.

Standard baited Gee minnow traps were deployed at crossings R02, R05, R06, R09, R11, R13, R16, and R19 based on suspected fish presence. Minnow traps were set in standing water pools or back eddies and monitored and cleaned on a near daily basis. Minnow traps were placed in select streams where it was assumed that larger fish could not access because of very shallow water or poor habitat, but which might be accessible by small fish. All fish captured were identified to species and returned to the stream.

2.2 RELEVANT FISH SPECIES RIVERINE BIOLOGY

2.2.1 Arctic Grayling (*Thymallus arcticus*)

Arctic grayling are found throughout Nunavut in rivers, streams and lakes with clear cold waters (Evans et al., 2002). Their life history is riverine, adfluvial, and lacustrine, and they frequent clear streams, rivers and lakes in the East Arctic eco-region, including Baker Lake. They are common in the lower Prince River, Thelon River, and Kazan River, entering Baker Lake. It is important to note that no Arctic grayling have been found within the project area lakes watershed from Tehek to Second Portage or the connecting channels between project lakes. Arctic grayling undertake spawning migrations from over-wintering habitat (usually lakes), in the early spring prior to or at ice break-up, moving into smaller streams between mid-May and early June. Arctic grayling prefer to spawn over gravel or rocky bottoms with a small percentage of sandy bottom (<15% to 20%). Arctic grayling spawn in areas with surface current velocities less than 1.4 m/s, varying water depths and relatively small, unembedded gravels about 2.5 cm in diameter. A post-spawning run of Arctic grayling from small streams to adjoining rivers and lakes occurs in late June following spawning (Chang-Kue and Cameron, 1980). Arctic grayling have been found to summer feed, after spawning, in rubble and gravel, fine-grained and coarse-grained substrates. Evans et al., (2002) have documented spawning migrations by Arctic grayling of up to 320 km from overwintering habitat.

Arctic grayling can mature as early as age two or as late as nine years of age (Evans et al., 2002). Once mature, Arctic grayling typically spawn each year. Within our study region we observed many mature grayling that were resting and did not spawn each year. Spawning takes place over a two- to three-week period (Ford et al., 1995), young hatch within 16 to 18 days at 9°C, newly hatched alevin spend three to five days under substrate and fry are first collected from late June to early July (Evans et al., 2002). Fry reside in semi-deep pools and side channels over boulder, cobble, silt, and sand substrates and water velocities less than 0.8 m/s. Young-of-the-year remain in their natal stream for up to 15 months, where ice conditions permit, and leave in mid-September to move downstream to overwinter in larger lakes or streams.

2.2.2 Arctic Char (*Salvelinus alpinus*)

Arctic char exhibit both anadromous and non-anadromous life histories. Anadromous char spend at least part of their adult lives feeding in marine water and making migrations into freshwater lakes to overwinter and reproduce. Arctic char spawn in fall every two to four years over gravel/cobble substrate at depths of 3 m or more in lakes that do not freeze to the bottom. Arctic char do not spawn in streams and only periodically have been found to spawn in areas of large rivers that provide open water (i.e., deep, fast-flowing portions, downstream from a lake or near falls). In general, channels, streams, and rivers are mainly used as migratory corridors for Arctic char (Evans et al., 2002).

During spawning, females construct redds (spawning nests) in shallow heterogeneous substrates (mixture of sand, gravel, and boulders), but have also been found to spawn in boulder rubble substrate without constructing redds (Evans et al., 2002). Eggs hatch in the late winter, and fry emerge from the gravel in July when planktonic food is abundant. Young-of-the-year have been observed predominantly along shorelines of lakes and find refuge and protection by hiding in stones. Anadromous juveniles remain in fresh water for 3 to 8 years before their first migration to sea. They leave following ice break between May and July. First-time migrants and repeat migrants voyage to the marine environment, with larger char tending to leave fresh water first. Older fish tend to migrate further from their natal territory, and migrate distances averaging 70 km, and up to 180 km in one summer. Following opportunistic feeding along coastal regions in the summer, Arctic char return to fresh water in late July, August, and into September where they pass through shallow riffle areas and have been known to ascend rapids with water velocities of 2.5 to 3.0 m/s (Moore, 1975). Char seek deep lakes to spawn and/or overwinter.

2.2.3 Lake Trout (*Salvelinus namaycush*)

Lake trout are found throughout the north (Scott and Crossman, 1973). Although they occur primarily in large deep lakes, they occasionally inhabit large clear rivers. The extent to which lake trout dwell in riverine habitat is unknown. Lake trout prefer to spawn in deep areas of lakes over substrate consisting of gravel, rubble, and boulders up to 46 cm in diameter. Spawning rarely takes place in large rivers and is thought to occur periodically in the wide and slow sections of the Back River and the Thelon, north and west of the project area. Lake trout are present in the Prince River system.

2.2.4 Round Whitefish (*Prosopium cylindraceum*)

Round whitefish are common in northern Canada and are found in shallows of lakes, ponds, slow-flowing rivers, streams, and brackish waters (Evans et al., 2002). They are common throughout the project area lakes and periodically collected along the proposed all-weather road. Spawning occurs mainly in lakes but on occasion round whitefish will spawn in rivers and clear streams. In the local study area round whitefish spawn in late fall (October) in lakes with gravel and rubble substrate free of sand and silt. Eggs overwinter under the ice and hatch in April and May, after 123 to 140 days of incubation (Scott and Crossman, 1973). Young-of-the-year use boulders, shoals, and other forms of habitat features as protective cover. As round whitefish grow they tend to move into deeper and faster water (Lee, 1985). Maturation is from three to six years of age (MacKay and Power, 1968).

2.2.5 Lake Cisco (*Coregonus artedii*)

Lake cisco are distributed extensively throughout the north (Scott and Crossman, 1973) and are predominantly found in lacustrine habitat and periodically in large rivers in Nunavut (Evan et al., 2002). Little is known about the use of riverine systems by lake cisco. Lake cisco have been caught at the mouth of the Thelon River in river pools upstream from Baker Lake. Lake cisco have not been captured or observed within the project area lakes. No additional information on riverine-dwelling lake cisco was available.

2.2.6 Ninespine Stickleback (*Pungitius pungitius*)

The ninespine stickleback is found throughout Nunavut (Evans et al., 2002). They inhabit slow streams, shallow bays in lakes, tundra ponds in brackish pools and inshore coastal waters. Ninespine stickleback exhibit riverine and lacustrine life histories, preferring stream habitat with a heterogeneous substrate of mud and sand, depths from 0.5 to 2.5 m, and current speeds less than 0.3 m/sec (Worgan and FitzGerald, 1981). Stickleback are rare in the project lakes and are found in shallow water over boulder cobble habitat.

Ninespine stickleback are commonly found in weedy, cool, quiet waters. Similar to all of the family Gasterosteidae, ninespine stickleback construct and defend a territory before building a nest. Once the nest is built, the male entices one or more females to deposit eggs in the nest (Evans et al., 2002). Eggs incubate for 6 to 7 days at a water temperature of 15°C to 16°C, and fry stay in the nest until they are able to swim and move into open water where they congregate in shallow, sandy areas, where they are protected from predatory fish.

2.2.7 Slimy Sculpin *(Cottus cognatus)*

Slimy sculpin are present throughout the East Arctic ecoregion. They are typically found in cool, clear, or muddy waters in rivers, streams and creeks with rocky or gravel substrate (Evans et al 2002). They are seldom found in lakes; however, they do exhibit both lacustrine and riverine life history types. Unfortunately, information on slimy sculpin in the north is limited. Spawning occurs in early spring beneath the ice as the male selects a protected site under a rock or ledge and gathers a female, who deposits adhesive eggs on the ceiling that the male fertilizes (Evans et al., 2002). Eggs require four weeks to hatch depending on water temperature. After hatching, fry drop to the bottom of the nest where they absorb the yolk sack and then leave the nest. Young-of-the-year and juvenile slimy sculpin prefer rivers or streams with cobble and boulder substrate and low velocity currents (0.2 to 0.4 m/s). Slimy sculpin mature by age two or three. Adult fish in the Arctic have very small home ranges in gravelly streams or nearshore habitat of lakes.

SECTION 3 • FISH HABITAT ASSESSMENT

3.1 GENERAL APPROACH

A number of key attributes, including physical structure, abundance, and spatial distribution, determine habitat quality. Habitat characterization at the AWPAR watercourse crossings was conducted using the field methods described in Section 2.1. Habitat suitability for each target species was determined with consideration of species-specific habitat requirements for various life history stages; this relied on general knowledge and published information of the biology and ecology of each species as summarized in Section 2.2 and on site-specific data on habitat utilization by fish. Similar to the approach used for the lakes in the vicinity of the mine site (see main report), this information was integrated into a habitat quality ranking system to provide an objective means of quantitatively determining the overall loss of habitat (i.e., associated with stream channel encroachment at the AWPAR crossings) and habitat gains related to compensatory habitat.

3.2 HABITAT VALUE & SUITABILITY

The system used to quantify habitat quality for the AWPAR crossings was based on the scoring of two main attributes (by attribute class):

- *Substrate Type* – Substrate size (classes present are boulder, boulder/cobble, boulder/cobble/gravel, cobble, cobble/gravel, and gravel) plays a key role in how fish use habitat. For example, most local fish species prefer gravel or cobble/gravel substrate for spawning. Boulders present with other substrate can locally reduce flow velocity and provide important refuge. However, a homogenous field reduces surface area for primary productivity and can limit fish migration. Consequently, homogenous boulder fields received a low score while higher scores were given to the other substrate types.
- *Stream Morphology* – Channel shape, water depth, and seasonal flow patterns strongly influence the suitability of habitat for fish use. For example, high stream velocities or impassable channels limit the use of habitat by fish. Scoring classes were “good” (easily passable channel throughout open water period; resting/refuge habitat present),”moderate” (passable channel during higher flow periods but lacks refuge pools), and “poor” (impassable channel for most of the season).

Scores for individual attribute features are presented in Table 3.1. The attributes were weighted according to their overall importance in driving habitat quality. For example, a substrate type suitable for spawning would be useless in a portion of the channel with subsurface flow. The range of possible scores is from 4 to 100; habitat quality categories were assigned as follows: high (67-100), medium (34-66), and low (4-33).

Table 3.1: Scores Assigned to Habitat Features at AWPAR Crossings.

Attribute	Class	Weighting	Rank	Feature Score
Substrate	B	1	2	2
	B/C	1	5	5
	B/C/G	1	5	5
	C	1	5	5
	C/G	1	5	5
	G	1	5	5
Morphology	Good	2	10	20
	Moderate	2	5	10
	Poor	2	1	2

Notes: **B** = Boulder, **C** = Cobble, **G** = Gravel; see text for descriptions.

The habitat quality categories identified above can be generally summarized as follows:

- *High* – Channel structure provides for migration throughout the open water season (i.e., water depth and current velocities adequate); substrate types present provide ideal areas for spawning, rearing, and foraging.
- *Medium* – Channel structure contains sufficient water for some migration most of the open season; pockets of suitable substrate available amongst larger areas of marginal habitat (e.g., boulder fields). The area may be part of the main channel, a portion of a side channel or pool providing refuge for migrating fish.
- *Low* – Channel provides limited to no passage, except during high water; potentially adequate substrate may be unsuitable for key life history stages due to low flows and/or shallow depths (i.e., exposed surfaces).

Information from the field studies and literature-based studies that is specific to species and life history stage was used to develop a habitat-suitability index (HSI) for the target fish species in each of the habitat value categories (Table 3.2). The index reflects inter-specific differences in habitat preferences for various life history stages. The HSI was then weighted by the relative abundance of each target species (2005 fish surveys) to create a final index (Final HSI) that accounts for actual fish usage patterns at the AWPAR crossings (Table 3.3). For example, Arctic grayling represented 85% of the fish caught in 2005 (i.e., 594 of 697 fish). Round whitefish (8.3%) and lake trout (5.3%) were the next most abundant fish in the 2005 AWPAR study. Weighting the original HSI by relative abundance ensures that final index is highly relevant to the AWPAR.

3.3 HABITAT UNIT DERIVATION AT AWPAR CROSSINGS

The HU derivation process is explained in detail in Section 3.5 of the main report. That process was modified slightly for this AWPAR NNLP due to the linear nature of the proposed development. Rather than mapping baseline habitat for the entire stream, HUs were formally derived only for habitat areas in watercourses where encroachment of the stream channel is proposed (see Section 4 for more details). Note that habitat quality over a much broader portion of the watercourses was quantitatively and qualitatively documented (see HFA-AWPAR, 2005). This information will be reported as required in Section 4 to place any habitat losses into context and to support the development of appropriate compensation strategies. Use of HUs provides an objective accounting system for habitat loss/gain that consistently incorporates habitat quality.

Table 3.2: Habitat Suitability Indices (HS I) per Species and Life Stage for High, Medium & Low Areas

Species	Habitat Rank	Spawning/ Nursery(4)	Rearing(2)	Foraging(2)	Migration(2)	Total Score(10)
Arctic	High	4	2	2	2	10
Grayling	Medium	2.5	1	1	1	5.5
	Low	0	0.5	0	0	0.5
Arctic	High	0	1	1	2	4
Char	Medium	0	0.5	0.5	0.5	1.5
	Low	0	0	0	0	0
Lake	High	0	1	1	2	4
Trout	Medium	0	0.5	0.5	0.5	1.5
	Low	0	0	0	0	0
Round	High	2	1	1.5	2	6.5
Whitefish	Medium	1	0.5	0.5	0.5	2.5
	Low	0	0	0	0	0
Lake	High	1	1	1	2	5
Cisco	Medium	0	0.5	0.5	0.5	1.5
	Low	0	0	0	0	0
Ninespine	High	4	2	2	2	10
Stickleback	Medium	3	1.5	1.5	1.5	7.5
	Low	0	0.5	0	0	0.5
Slimy	High	4	2	2	2	10
Sculpin	Medium	3	1.5	1.5	1.5	7.5
	Low	0	0.5	0	0	0.5

Table 3.3: Final Habitat Suitability Index (HSI) Derivation

Habitat Rank	Species	HS I	Weighting	Final HSI
High	Arctic grayling	10	0.852	8.52
	Arctic char	4	0.004	0.02
	Lake trout	4	0.053	0.21
	Round whitefish	6.5	0.083	0.54
	Lake cisco	5	0.004	0.02
	Ninespine stickleback	10	0.000	0.00
	Slimy sculpin	10	0.003	0.03
			SUM	**9.34**
Medium	Arctic grayling	5.5	0.852	4.69
	Arctic char	1.5	0.004	0.01
	Lake trout	1.5	0.053	0.08
	Round whitefish	2.5	0.083	0.21
	Lake cisco	1.5	0.004	0.01
	Ninespine stickleback	7.5	0.000	0.00
	Slimy sculpin	7.5	0.003	0.02
			SUM	**5.01**
Low	Arctic grayling	0.5	0.852	0.43
	Arctic char	0	0.004	0.00
	Lake trout	0	0.053	0.00
	Round whitefish	0	0.083	0.00
	Lake cisco	0	0.004	0.00
	Ninespine stickleback	0.5	0.000	0.00
	Slimy sculpin	0.5	0.003	0.00
			SUM	0.43

SECTION 4 • HABITAT LOSS RELATED TO AWPAR

4.1 CONTEXT

The AWPAR was designed to minimize both the number of crossings and the degree of encroachment into fish-bearing waters at each of the crossings. Specifically, baseline fish and fish habitat surveys (HFA-AWPAR, 2005) were used to determine appropriate engineered structures (e.g., culverts for non-fish-bearing streams; bridges for fish-bearing watercourses) for each crossing. Where practical, bridges were designed as clear spans to completely avoid encroachment of the stream channel. However, this was not possible at all locations, resulting in the harmful alteration, disruption, or destruction (i.e., HADD) of fish habitat. HADD occurrences will be quantified in terms of HUs; compensation options will be provided in Section 5.

4.2 HABITAT LOSS FROM AWPAR PROJECT ACTIVITIES

The proposed 120 km AWPAR from the Hamlet of Baker Lake to the Meadowbank property contains only 21 crossings of ephemeral or seasonal streams (see Figure 2.1). Of the 21 watercourses crossed, 11 were found to be non-fish-bearing streams[1] (HFA-AWPAR, 2005) and have been planned with culverts; these do not warrant further discussion (i.e., no possibility for HADD). The remaining 10 crossings contain fish and are proposed to be either 12 m or 30 m bridges to minimize encroachment of the watercourse channels. Only 6 of the 10 contain fish other than ninespine stickleback or slimy sculpin. The status of each fish-bearing crossing is discussed in the following sections to identify and quantify any HADD occurrences.

4.2.1 Crossing R01

This is the first crossing on the AWPAR and is immediately north of the Hamlet of Baker Lake, approximately 3.6 km along the proposed road west of the sewage outflow adjacent to the Hamlet dump (see Appendix AB for photos). This watercourse connects three isolated lakes north of Baker Lake to a series of smaller downstream lakes and ponds that ultimately discharge directly into the lower Prince River system and into Baker Lake. One of these downstream lakes, Airplane Lake, receives inputs from sewage disposal from Baker Lake.

Arctic grayling were observed in the 2005 survey swimming in protected clear water pools and darting downstream through the central channel. However, due to the shallow stream depth, the importance of the small stream for migration between the two lakes was deemed low. The current AWPAR design (Figure 4.1) consists of 12 m bridge (final base width of 7.9 m) that avoids any encroachment of the 1 m wide channel (i.e., no HADD).

Recent discussions regarding AWPAR routing may result in starting on the existing Prince River road, which would avoid this crossing location altogether. Since there is no HADD at this crossing, these design changes, if approved, would not affect this NNLP.

[1] Non-fish-bearing streams were typically characterized by shallow, braided channels with little direct connectivity to larger, more important waterbodies. Highly ephemeral in nature, the substrates usually consisted of terrestrial vegetation that is inundated for a short time during freshet.

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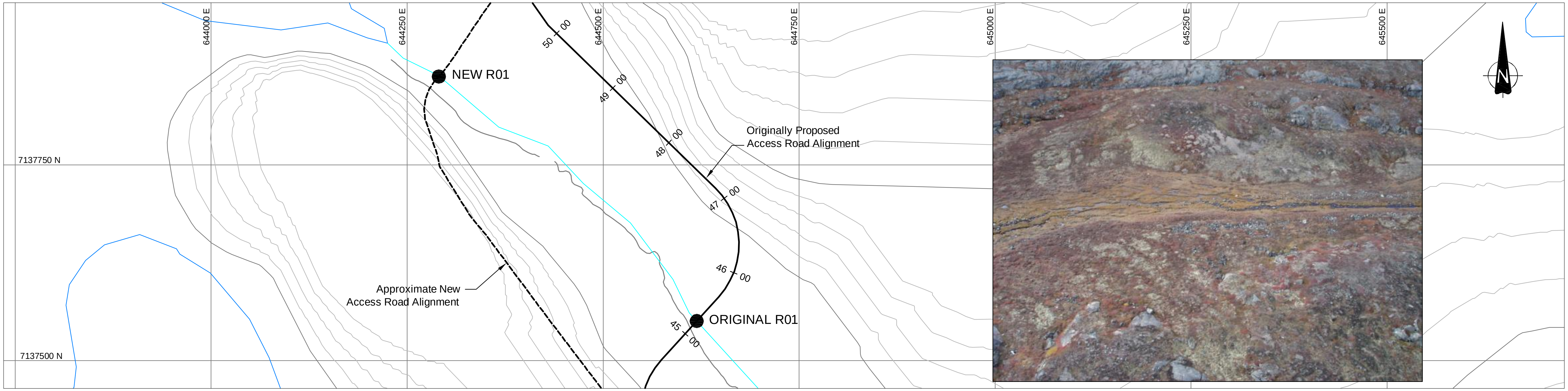
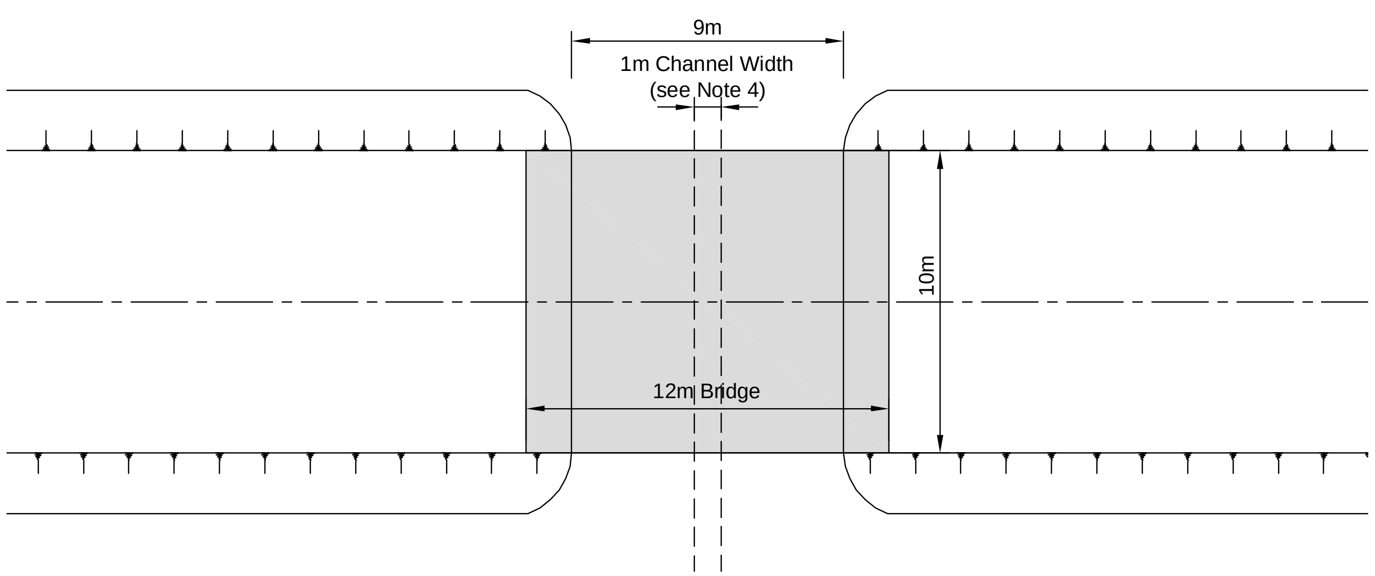


PLAN

0 50 100 150 200 250
Scale in Meters

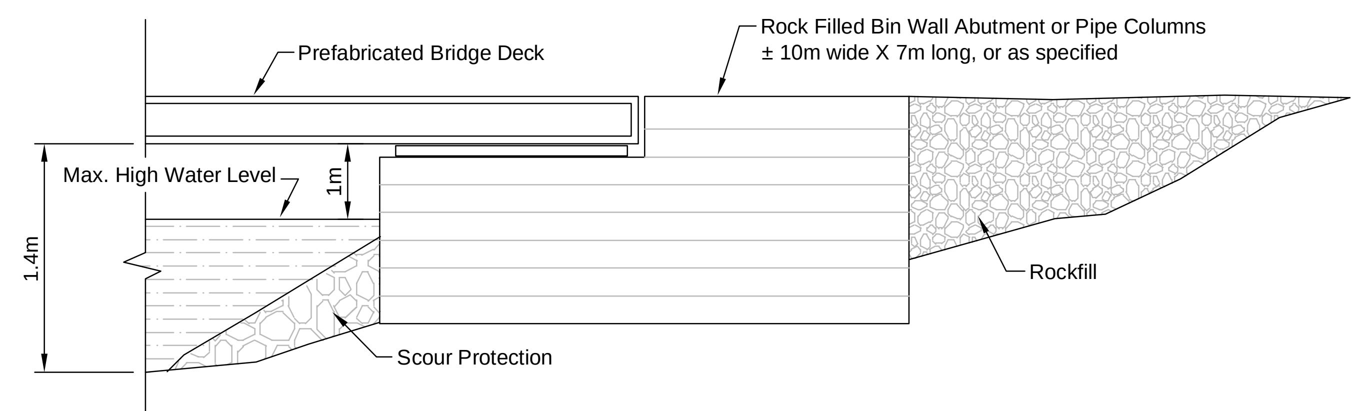
NOTES
1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

REFERENCE
1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



PROPOSED BRIDGE R01 PLAN (12m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS

NVeloso

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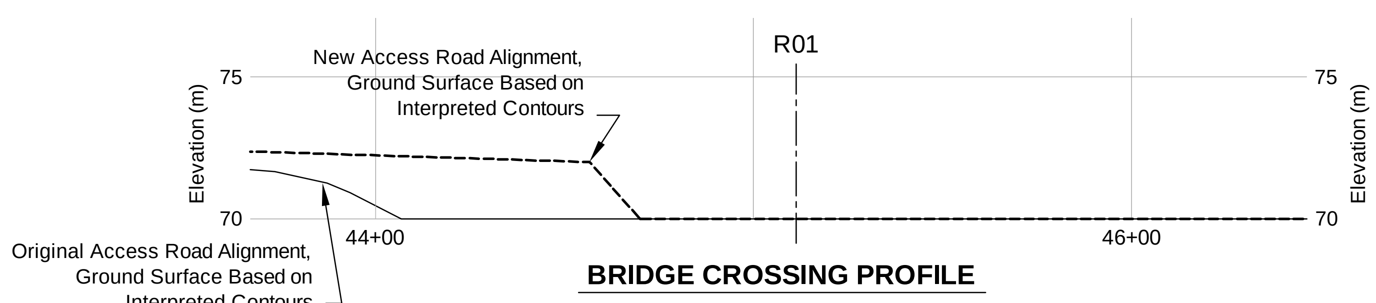


BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R01 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE	NTS REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06	FIGURE 4.1	
REVIEW				

4.2.2 Crossing R02

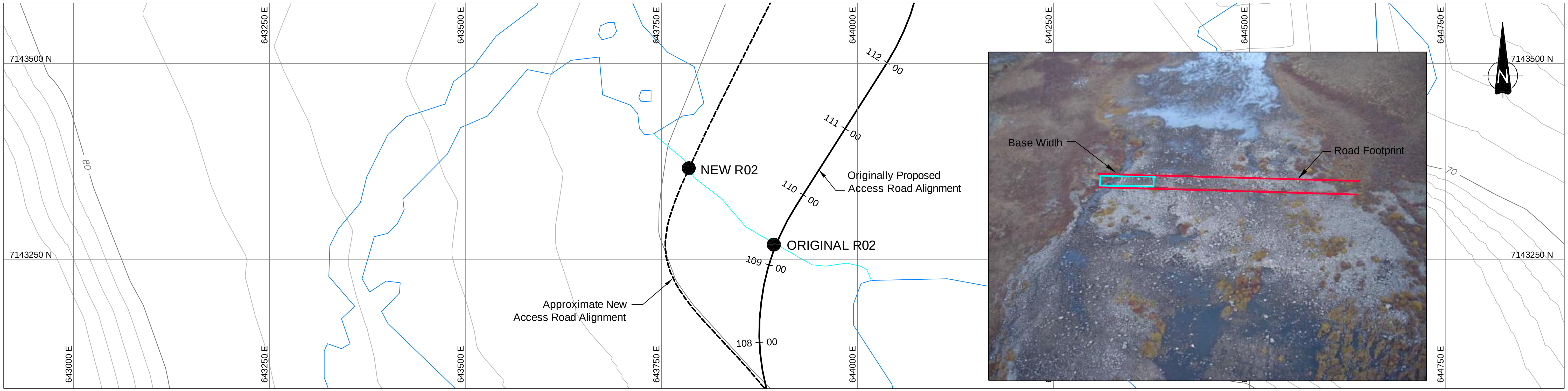
Crossing R02 is situated 10.2 km north along the proposed AWPAR (see Appendix AB for photos). The watercourse is the largest crossed by the AWPAR and contains significant fisheries resources (HFA-AWPAR, 2005). The 113.5 m wide channel contains its deepest portion bordering the southern bank, and is more confined and distinctive than the remaining watercourse, which flows through a dense boulder/cobble field. Fish sampling (using hoop nets and larval drift traps) conducted just upstream of the crossing location in 2005 showed that Arctic grayling is the dominant species (n=129), followed by round whitefish (n=45). While the exact magnitude of channel use at the crossing location is not known, the close proximity of the hoop net locations suggests that it is an important migration route to nearby spawning, rearing, and feeding areas.

The bridge size and location have been chosen to minimize encroachment onto high-value fish habitat. The planned 30 m bridge will have an estimated final base width of 17.5 m (Figure 4.2) and will be situated to span the main channel (i.e., principle migratory corridor) along the south shoreline. The southern abutment will be located on the shore and will not encroach the stream. The northern abutment and approach will be constructed on top of a boulder-dominated bar that is naturally elevated within the channel and extends across to the north shoreline (i.e., fish passage in this area is only likely during freshet). The encroachment into the channel will result in a HADD that requires quantification.

The encroachment footprint was calculated to be 0.24 ha using bridge design parameters provided by Golder (see Appendix AC for details). This estimate takes bridge elevation, conservative slope estimates for road and approach margins and the overall encroachment length into consideration. Crossing locations were re-surveyed in 2006 to provide higher resolution habitat quality information on the area potentially affected by bridge construction (Table 4.1). Survey results were scaled to predicted high water levels to account for optimal habitat potential (i.e., areas not accessible to fish at the time of the survey were assessed as if water levels were higher). The majority of the proposed impact area consists of low value habitat of little direct or indirect value to fish. Except during freshet, this channel is dry or water flows beneath or between the large boulders embedded in the stream channel. These factors were considered when determining the final crossing locations. HUs for the HADD are presented in Table 4.2. Compensation options are discussed in Section 5.

4.2.3 Crossing R05

Crossing R05 is located approximately 19 km along the AWPAR (see Figure 2.1). The channel is well defined, connecting two small lakes that discharge to the Prince River. The HFA-AWPAR (2005) concluded that the stream contains high value fishery resources, particularly in the spring when Arctic grayling are migrating. A 30 m bridge with a final base width of 23.3 m will fully span the 12.7 m wide stream near the discharge point (Figure 4.3), thus avoiding any HADD.



PLAN

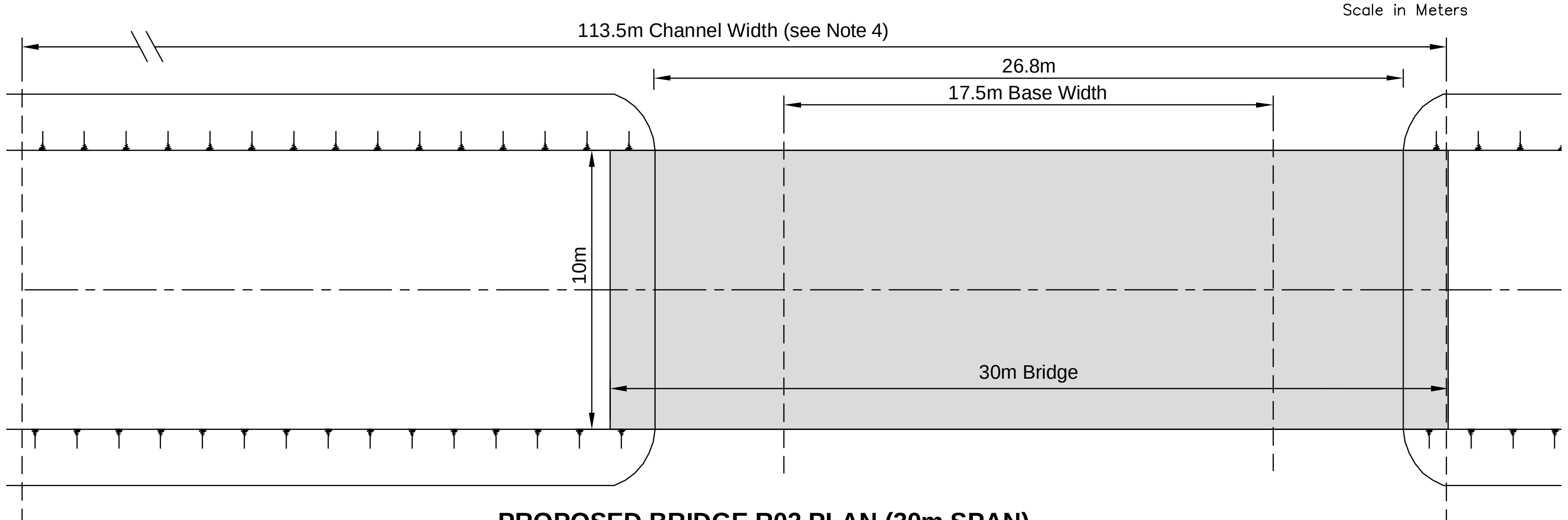
0 50 100 150 200 250
Scale in Meters

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

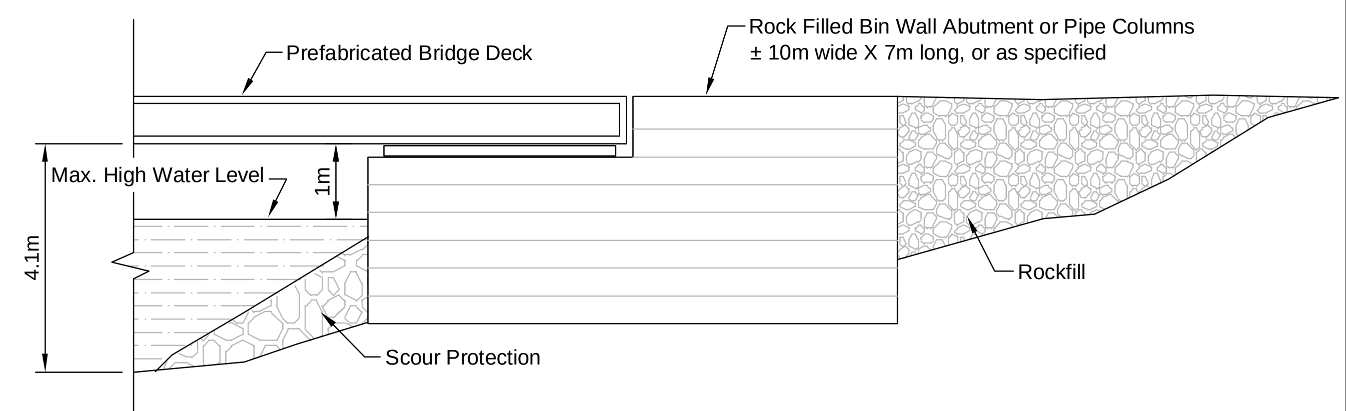
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



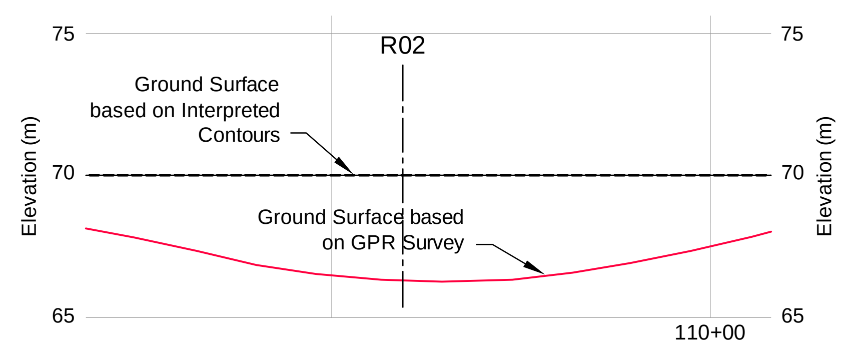
PROPOSED BRIDGE R02 PLAN (30m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

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REVISION DATE: 06/10/25 04:42PM By: NVeloso

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R02 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No. 061413034-02	
DESIGN	PA	27SEP06	SCALE NTS	REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06		
REVIEW				

FIGURE 4.2

4.2.4 Crossing R06

Crossing R06 (19 km along AWPAR) is proposed to span a well-defined channel that connects a small lake that discharges to the Prince River. The exact location is characterized by a narrowing channel with natural topographic features on each shore that will provide armoured banks during peak water flow (Figure 4.4).

The 2005 survey showed usage of this channel as a migratory channel for Arctic grayling; no grayling spawning areas have been identified within this reach. The channel is also opportunistically used throughout the open water season by lake trout and round whitefish, but to a much lesser degree than by grayling. The channel opens up downstream into a pool that is likely used as a feeding and refuge area during spring grayling migration. Grayling spawning habitat (confirmed with larval drift traps in 2006) has been identified in a rifle run area approximately 1 km downstream from the proposed crossing location.

Table 4.1: Habitat Characterization & Ranking for Crossing R02

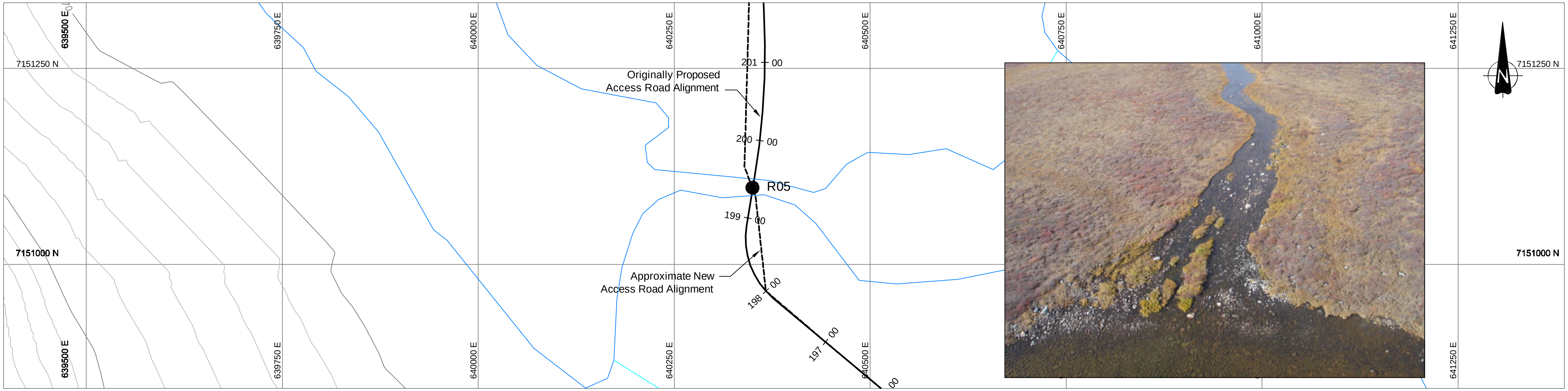
Chain Distance		Meters	Area %	Substrate		Morphology		Habitat Score	Habitat Rank
From	To			Class	Score	Class	Score		
0	17.5	NA	NA	NA	NA	NA	NA	NA	NA
17.5	25	7.5	0.08	B/C/G	5	M	10	50	M
25	30	5	0.05	B/C	5	P	2	10	L
30	35	5	0.05	B/C	5	P	2	10	L
35	40	5	0.05	B/C	5	P	2	10	L
40	45	5	0.05	B/C/G	5	P	2	10	L
45	50	5	0.05	B/C	5	P	2	10	L
50	55	5	0.05	B/C	5	P	2	10	L
55	60	5	0.05	B/C/G	5	P	2	10	L
60	65	5	0.05	B/C/G	5	P	2	10	L
65	70	5	0.05	B/C	5	P	2	10	L
70	75	5	0.05	B/C	5	M	10	50	M
75	80	5	0.05	B/C	5	M	10	50	M
80	85	5	0.05	B/C	5	M	10	50	M
85	90	5	0.05	B/C	5	P	2	10	L
90	95	5	0.05	B/C	5	P	2	10	L
95	100	5	0.05	B/C	5	P	2	10	L
100	105	5	0.05	B/C	5	M	10	50	M
105	110	5	0.05	B/C	5	P	2	10	L
110	113.5	3.5	0.04	B/C	5	P	2	10	L

Notes: Substrate: B = Boulder, C = Cobble, G = Gravel. Morphology: G = Good, M = Moderate, P = Poor. Habitat Rank: H = High, M = Medium, L = Low.

Table 4.2: Habitat Unit (HU) Calculation for Crossing R02 HADD

Habitat Rank	Final HS I	Area (ha)	HUs
High	9.34	0	0.00
Medium	5.01	0.07	0.35
Low	0.43	0.17	0.07
		Total HUs	**0.43**

Note: HS I = Habitat Suitability Index, HU = Habitat Unit.



PLAN

0 50 100 150 200 250
Scale in Meters

NOTES
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2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
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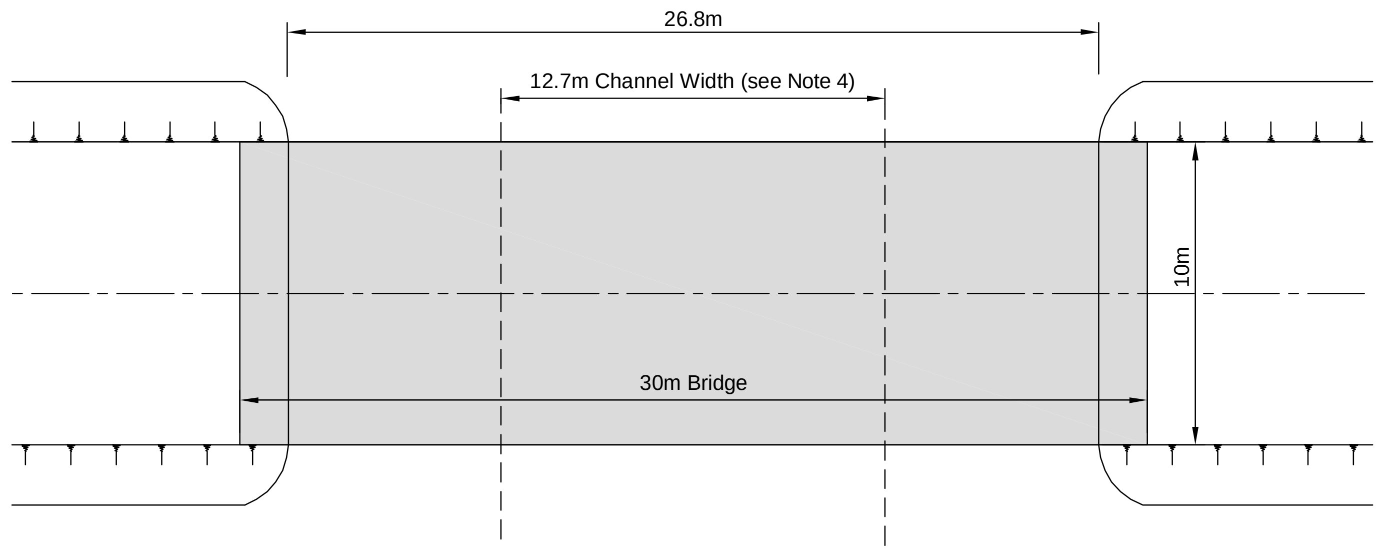
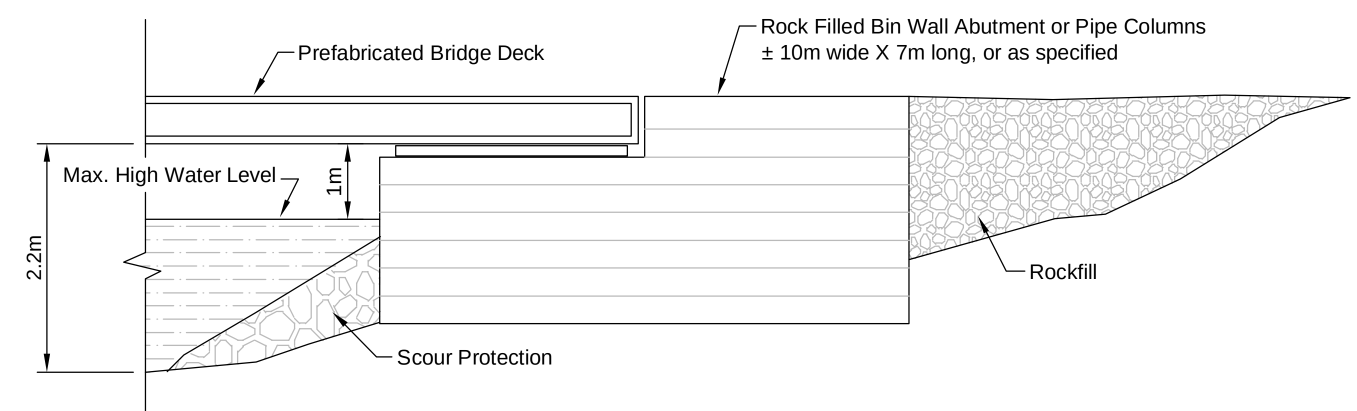
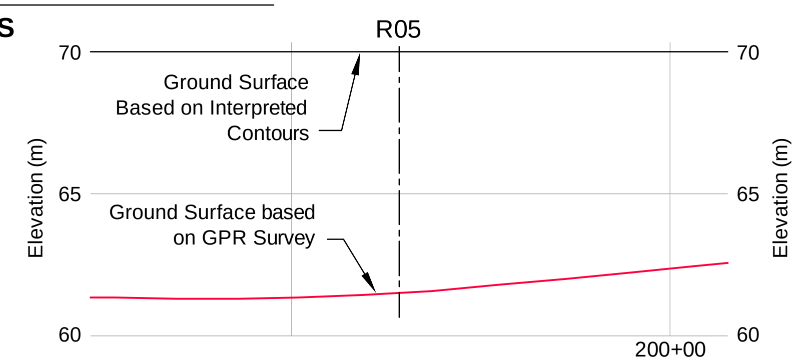


PROPOSED BRIDGE R05 PLAN (30m SPAN)
NTS



TYPICAL ROAD SECTION AT ABUTMENT
NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

NOTE
Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R05 AND ABUTMENT DETAILS

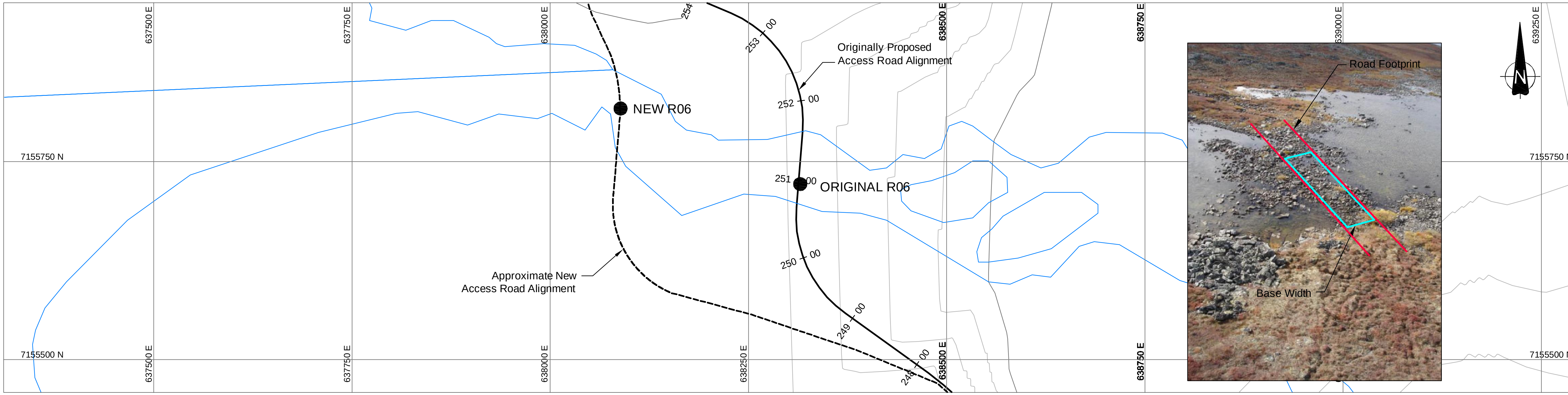
Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE NTS	REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06	FIGURE 4.3	
REVIEW				

REVISION DATE: 06/10/25 04:42PM By: NVeloso CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

REVISION DATE: 06/10/25 04:42PM By: NVeloso



PLAN

0 50 100 150 200 250

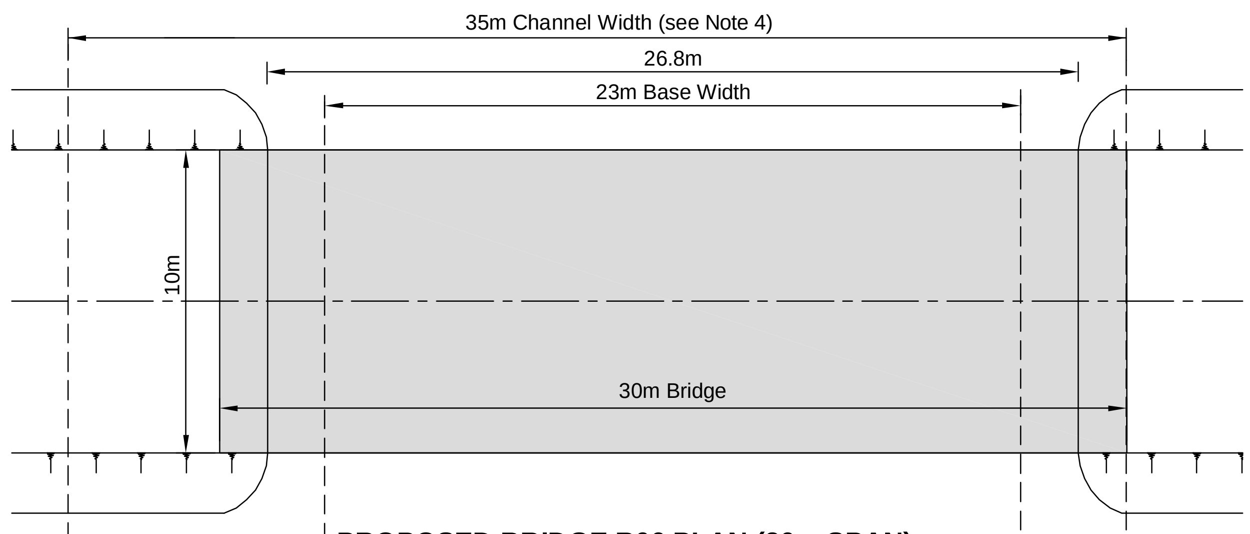
Scale in Meters

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

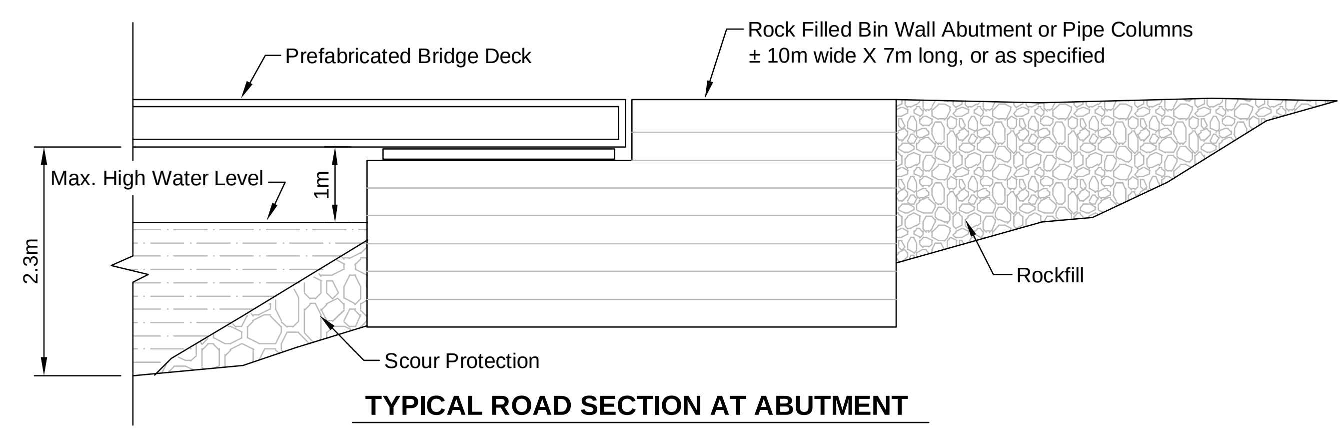
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



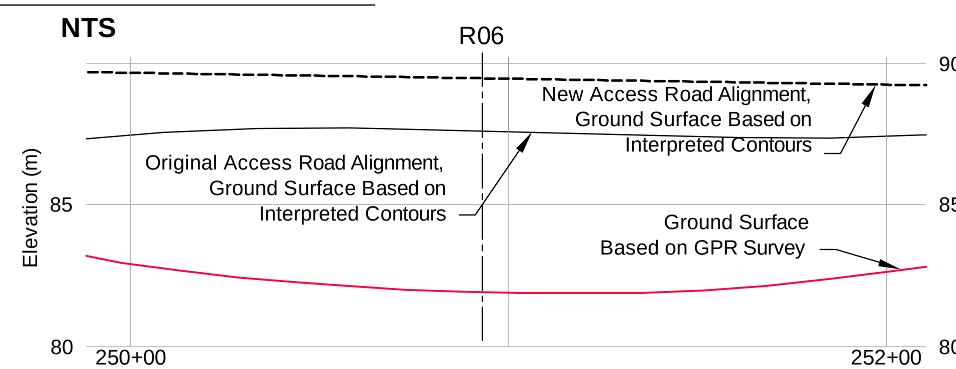
PROPOSED BRIDGE R06 PLAN (30m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5

Vertical Scale in Meters

0 20 40 60 80 100

Horizontal Scale in Meters

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R06 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE NTS	REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06	FIGURE 4.4	
REVIEW				

The crossing has been designed (i.e., bridge size and location) to minimize encroachment onto high-value fish habitat. The planned 30 m bridge will have an estimated final base width of 23 m (Figure 4.4). The main portion of the 35 m wide channel is located on the north side, with a secondary channel to the south. Consequently, the bridge will be located to avoid encroachment of the northern portion of the channel. The magnitude of the HADD for the southern portion of the channel is quantified below.

The encroachment footprint was calculated to be 0.022 ha using bridge design parameters provided by Golder (see Appendix AC for details). This estimate takes bridge elevation, conservative slope estimates for road and approach margins and the overall encroachment length into consideration. Crossing locations were re-surveyed in 2006 to provide higher resolution habitat quality information on the area potentially affected by bridge construction (Table 4.3). Survey results were scaled to predicted high water levels to account for optimal habitat *potential* (i.e., areas not accessible to fish at the time of the survey were assessed as if water levels were higher). The majority of the proposed impact area consists of low value habitat of little direct or indirect value to fish. This is expected since minimizing impacts to valued fish resources was a core factor determining final crossing locations. HUs for the R06 HADD are presented in Table 4.4. Compensation options are discussed in Section 5.

Table 4.3: Habitat Characterization & Ranking for Crossing R06

Chain Distance		Meters	Area %	Substrate		Morphology		Habitat Score	Habitat Rank
From	To			Class	Score	Class	Score		
0	23	NA	NA	NA	NA	NA	NA	NA	NA
23	28	5	0.42	B/C	5	P	2	10	L
28	30	2	0.17	B/C	5	M	10	50	M
30	32	2	0.17	B/C	5	M	10	50	M
32	34	2	0.17	B/C	5	M	10	50	M
34	35	1	0.08	B/C	5	P	2	10	L

Notes: Substrate: B = Boulder, C = Cobble, G = Gravel. Morphology: G = Good, M = Moderate, P = Poor. Habitat Rank: H = High, M = Medium, L = Low.

Table 4.4: Habitat Unit (HU) Calculation for Crossing R06 HADD

Habitat Rank	Final HS I	Area (ha)	HUs
High	9.34	0	0.00
Medium	5.01	0.01	0.05
Low	0.43	0.01	0.01
		Total HUs	**0.06**

Note: HS I = Habitat Suitability Index, HU = Habitat Unit.

4.2.5 Crossing R09

Crossing 09 is located 54 km along the proposed AWPAR, north of Halfway Hills (Figure 2.1). The watercourse connects two isolated lakes with the northern basin of Whitehills Lake. The portion to be crossed is a riffle/run comprised primarily of boulders and cobble.

Fisheries survey results show the importance of this channel for spring migration by Arctic grayling, and opportunistic utilization of the stream in the summer and fall by lake trout, round whitefish, lake cisco, and Arctic char. Arctic char may spawn in the upstream lake, given that a larval fish was identified in the drift trap in spring. Potential grayling spawning sites have been identified immediately upstream and downstream of the crossing location.

A 12 m bridge with a base width of 3.5 m is planned for this crossing; actual channel width is approximately 7.5 m (Figure 4.5). The orientation of the abutments will encroach slightly on the south side of the channel and between 2 to 4 m on the north side, resulting in a HADD. Quantification of HADD magnitude is presented below.

The northern encroachment area contains a riffle/run that accommodates moderate discharge throughout the open water season. Two grassy hummocks are situated in the stream, which may provide refuge during fish migration. A small back eddy and pool with ideal substrate and adequate flow will be encroached on the northeast portion of the abutment. The south side has similar characteristics as the north side, but accommodates a greater amount of discharge as the stream bends slightly northeast and downstream of the crossing. Based on substrate type (boulder cobble) and stream morphology (moderate) in the encroachment areas, habitat in the HADD is of medium value. The estimated HADD area (see Appendix AC) is 0.004 ha (40 m^2); HUs are shown in Table 4.5. Compensation strategies are discussed in Section 5.

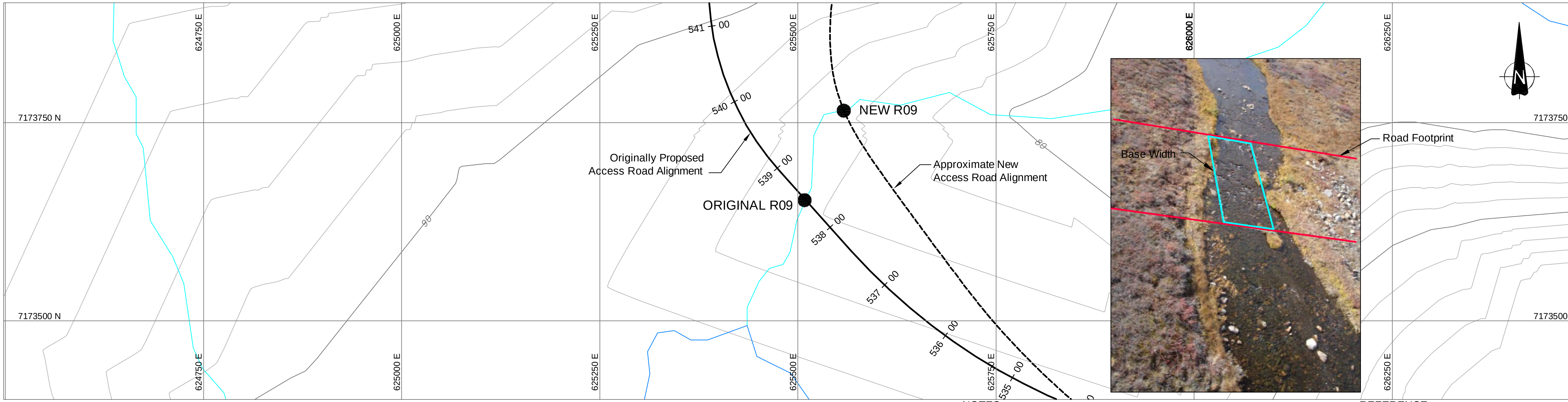
Table 4.5: Habitat Unit (HU) Calculation for Crossing R09 HADD

Habitat Rank	Final HS I	Area (ha)	HUs
High	9.34	0	0.00
Medium	5.01	0.004	0.02
Low	0.43	0	0.00
		Total HUs	0.02

Note: HS I = Habitat Suitability Index, HU = Habitat Unit.

4.2.6 Crossing R13

Crossing R13 is located approximately 68 km along the proposed AWPAR north of Baker Lake. The channel is narrow (3 m), deep (0.7 m) and connects a narrow upstream lake to a network of lakes and ponds that ultimately discharge into the western basin of Amarulik Lake (HFA-AWPAR, 2005; Figure 2.1).



PLAN

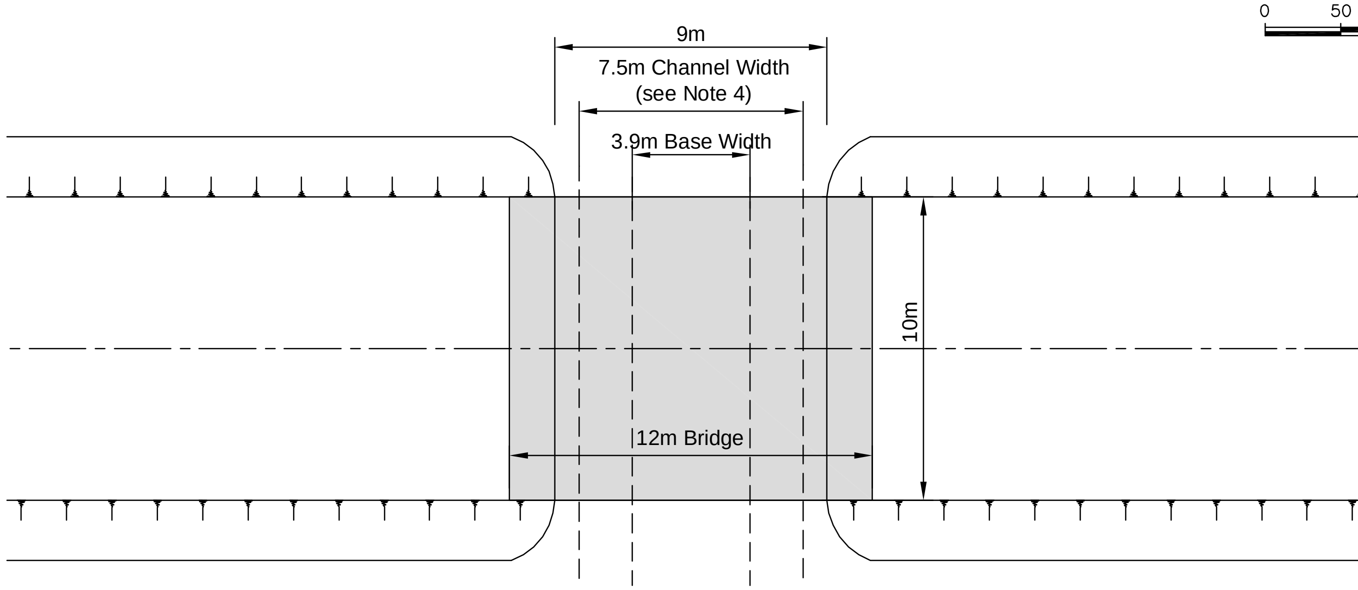
Scale in Meters: 0 50 100 150 200 250

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

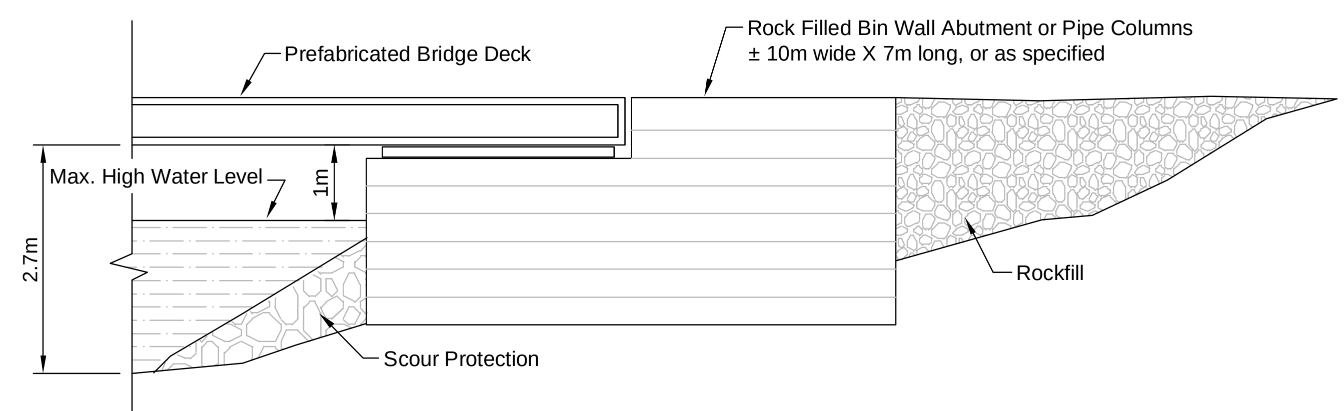
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



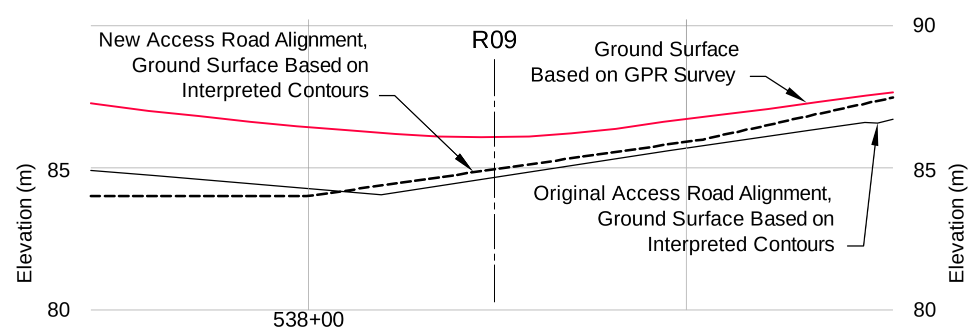
PROPOSED BRIDGE R09 PLAN (12m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

Vertical Scale in Meters: 0 2.5 5 7.5 10 12.5

Horizontal Scale in Meters: 0 20 40 60 80 100

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

REVISION DATE: 06/10/25 04:42PM By: NVeloso

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R09 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A		
DESIGN	PA	27SEP06
CADD	NV	27SEP06
CHECK	PA	27SEP06
REVIEW		

FILE No. 061413034-02

SCALE NTS REV. A

FIGURE 4.5

This channel passes through a wetland, with variable substrate predominated by grass upstream and exposed boulders and cobbles downstream. Various small ponds and pools are located in the upstream portion. Due to the poor substrate composition and negligible connectivity, habitat utilization is limited to small numbers of ninespine stickleback in standing pools both upstream and downstream of the crossing location.

A 12 m bridge with a final base width of 7.2 m will fully span the 3 m wide stream (Figure 4.6; see photos in Appendix AB), thus avoiding any HADD.

4.2.7 Crossing R15

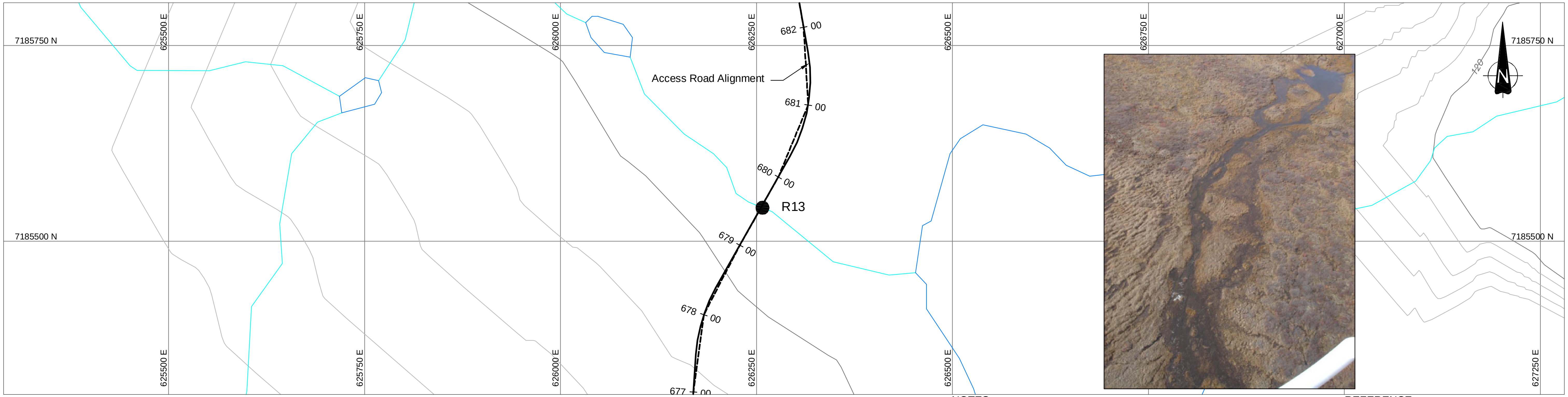
Crossing R15 is located 75 km along the proposed AWPAR (Figure 2.1). The watercourse is well connected to the western basin of Amarulik Lake and connects a network of overwintering lakes upstream of Amarulik Lake.

Stream flow was characterized by a riffle/run (50/50%) sequence with a significant elevation change from the upstream lake to downstream pools. Stream channel width at the crossing location is 27 m. Substrate in the general location consisted of boulder/cobble and some gravel. The wide, shallow boulder/cobble fields that directed stream flow around boulders and above cobbles during high water level periods become impassable by fish as water levels decrease through July and August.

Although connectivity and potential for fish passage were ranked as good, only a few Arctic grayling were captured during the 2005 and 2006 surveys (HFA-AWPAR, 2005; preliminary data for 2006). Potential spawning habitat has been identified 500 m downstream of the crossing locations; larval grayling were caught in drift traps in 2005. Given the proximity and connectivity of this crossing to Amarulik Lake, and possible upstream overwintering habitat, fish activity was less prominent than expected. It may be that the upstream and downstream boulder and cobble fields act as barriers throughout the majority of the open-water season, and that fish movement and activity was limited to peak freshet (2 to 3 weeks), if at all.

A 30 m bridge is proposed with a final base width of 23.4 m, which nearly spans the 27 m wide channel at the specific crossing location (Figure 4.7). While the bridge nearly spans the channel, a small zone of encroachment will occur on the north side. The HADD is quantified below.

The channel is shallow and diffuse at the crossing location, comprised predominantly of boulder (80%) and cobble (20%) with a few pockets of gravel substrate. This habitat is dry at all times of the year except at peak freshet. Based on substrate type (mostly boulder with some cobble) and stream morphology (moderate) in the encroachment area, habitat in the HADD is of low value. The area of the HADD was calculated to be 0.004 ha (see Appendix AC); HUs are shown in Table 4.6. Compensation strategies are discussed in Section 5.



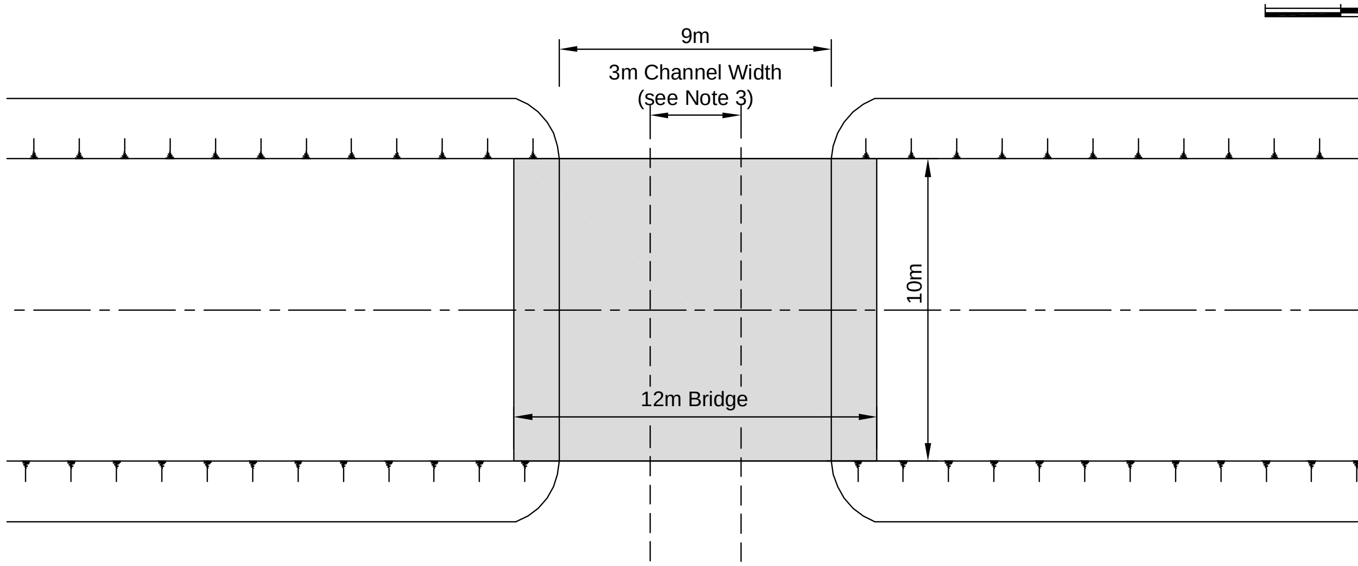
PLAN

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

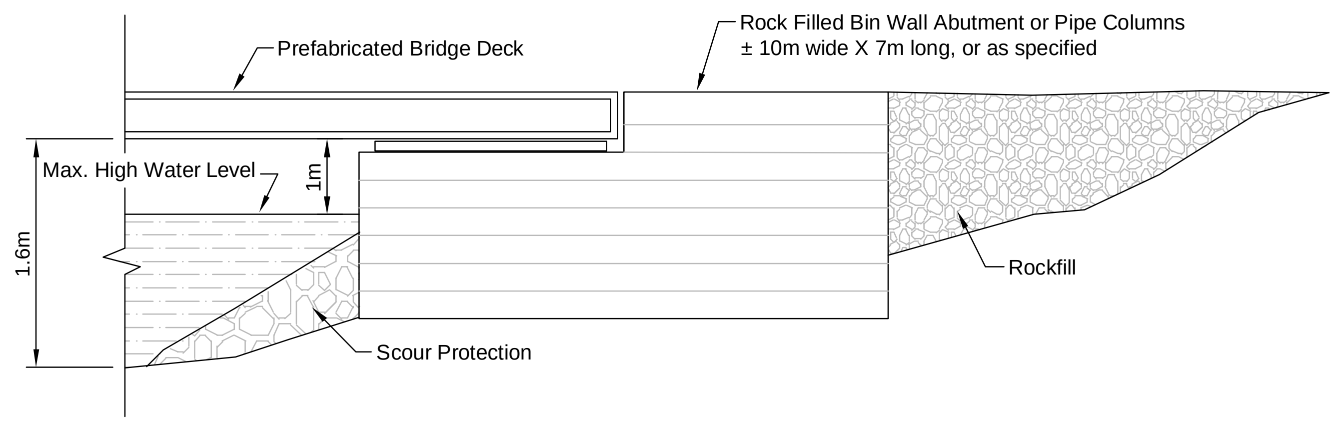
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



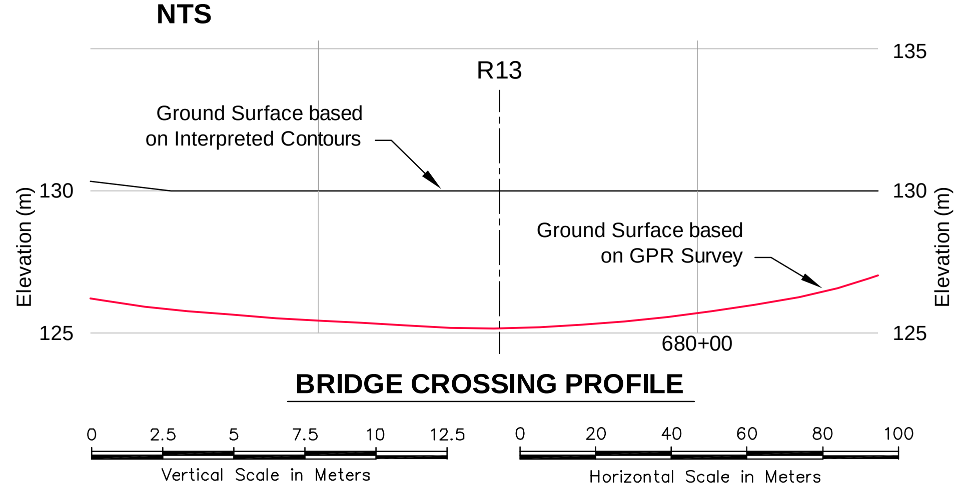
PROPOSED BRIDGE R13 PLAN (12m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R13 AND ABUTMENT DETAILS

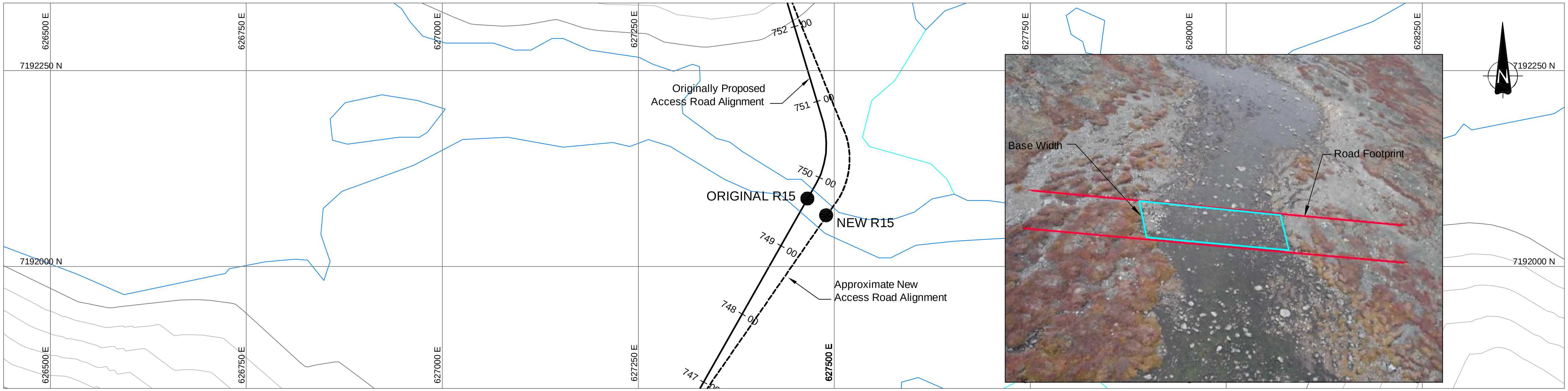
Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE NTS	REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06		
REVIEW				

FIGURE 4.6

CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

REVISION DATE: 06/10/25 04:42PM By: NVeloso



PLAN

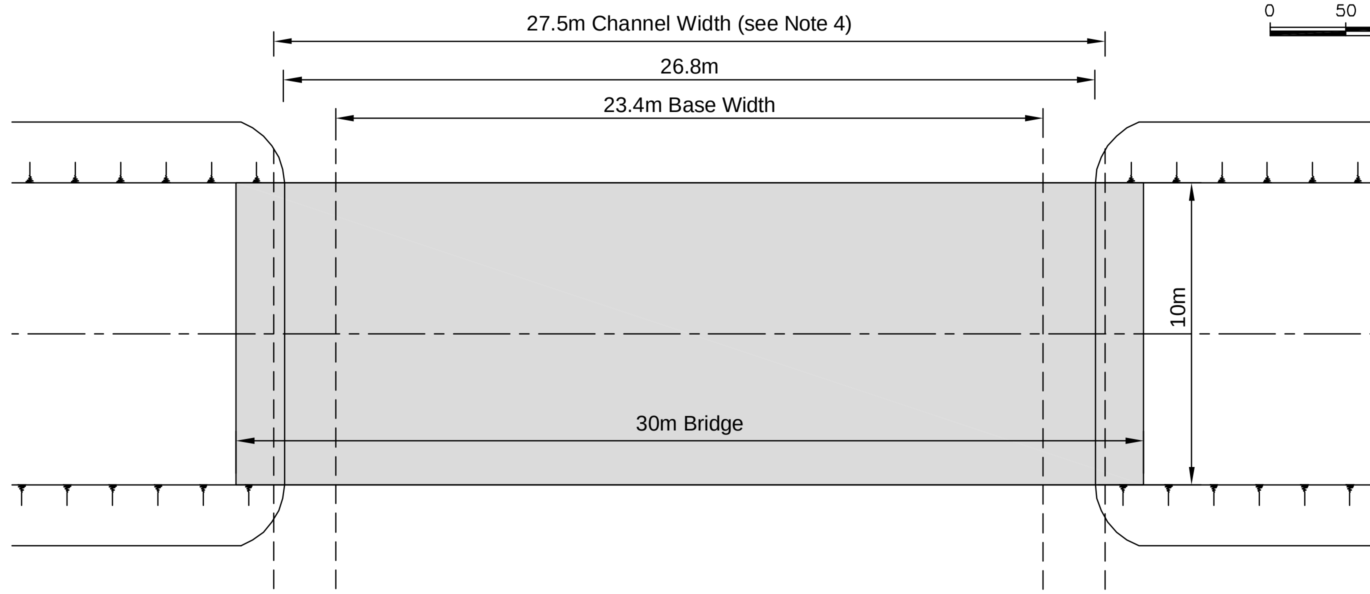
0 50 100 150 200 250
Scale in Meters

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

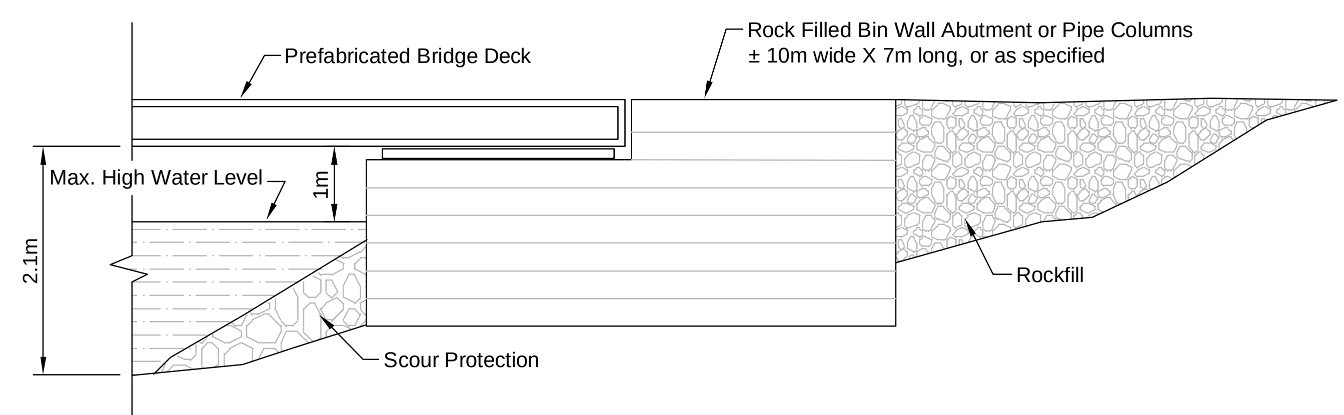
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



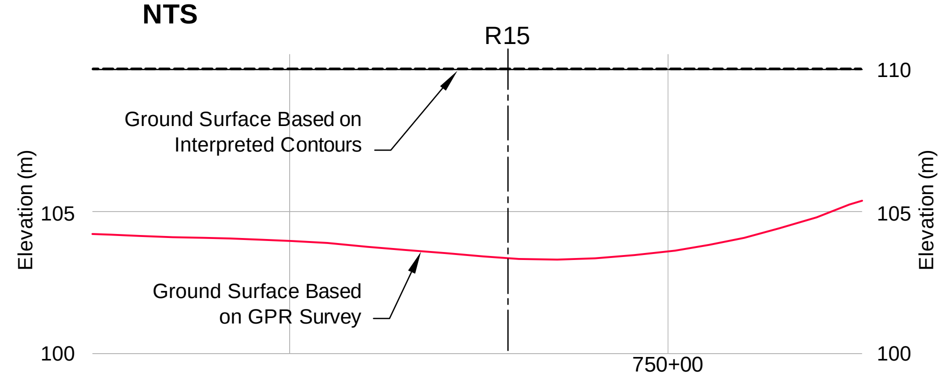
PROPOSED BRIDGE R15 PLAN (30m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

REVISION DATE: 06/10/25 04:42PM By: NVeloso

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R15 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE NTS	REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06	**FIGURE 4.7**	
REVIEW				

Table 4.6: Habitat Unit (HU) Calculation for Crossing R15 HADD

Habitat Rank	Final HS I	Area (ha)	HUs
High	9.34	0	0.00
Medium	5.01	0	0.00
Low	0.43	0.004	0.002
		Total HUs	0.002

Note: HS I = Habitat Suitability Index, HU = Habitat Unit.

4.2.8 Crossing R16

Crossing R16 is located 80 km along the AWPAR and is situated approximately 6 km northwest of Amarulik Lake. The crossed watercourse connects a large downstream lake that eventually discharges into Amarulik Lake, with a small upstream lake that is part of a series of small lakes and ponds.

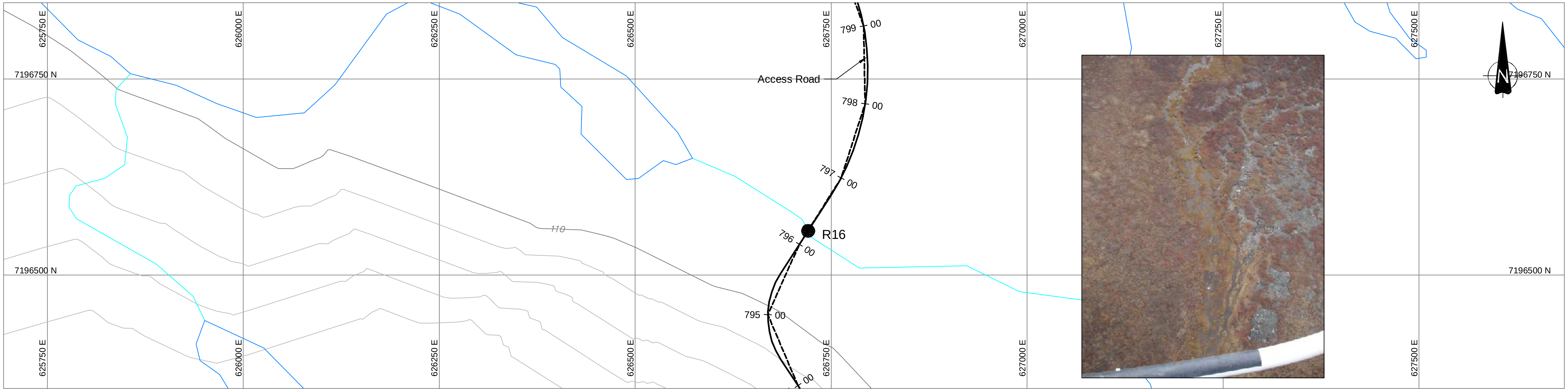
The stream is 1.3 m wide, shallow (0.28 m), and consists of a braided channel with grassy vegetation and mixed subsurface flow, descending to an alternating, riffle (50%), run (15%), and pool. Below a series of small pools, the stream connects to the outflow lake through a confined riffle/run channel. Substrate in riffle portions of the stream consisted of boulder (30%), cobble (45%), and variable substrate of gravel, exposed sediment, and grass. Substrate in pools consisted of fine sediment and grass.

Fish surveys (larval drift and minnow traps only; stream is too small for hoop nets) conducted in 2005 found juvenile ninespine stickleback in the watercourse. The shallow depth, upstream and downstream barriers, and poor substrate rank this stream as poor to nil habitat quality for Arctic grayling or other large species. However, the habitat is suitable for a small population of stickleback that inhabits the stream during summer. It is not known if the stickleback move out of the stream and survive the winter, as this watercourse is completely frozen for eight months of the year.

The proposed 12 m bridge has a final base width of 5.6 m, which easily spans the 1.3 m wide channel (Figure 4.8). Consequently, there is no HADD at this crossing.

4.2.9 Crossing R18

Crossing R18 is 85.5 km along the proposed AWPAR (Figure 2.1). The crossing location is downstream of a pond closely connected to a series of lakes to the west and northwest. The watercourse is a diffuse, braided stream with riffles and pools between boulders and undulating grassy hummocks. Channel width at the crossing location is 1 m. The substrate is predominantly boulder (70% to 90%) and cobble (30% to 10%), with greater abundance of boulders in the midstream boulder field. Flow transitions between subsurface flow and emergent flow in the midstream boulder field.



PLAN

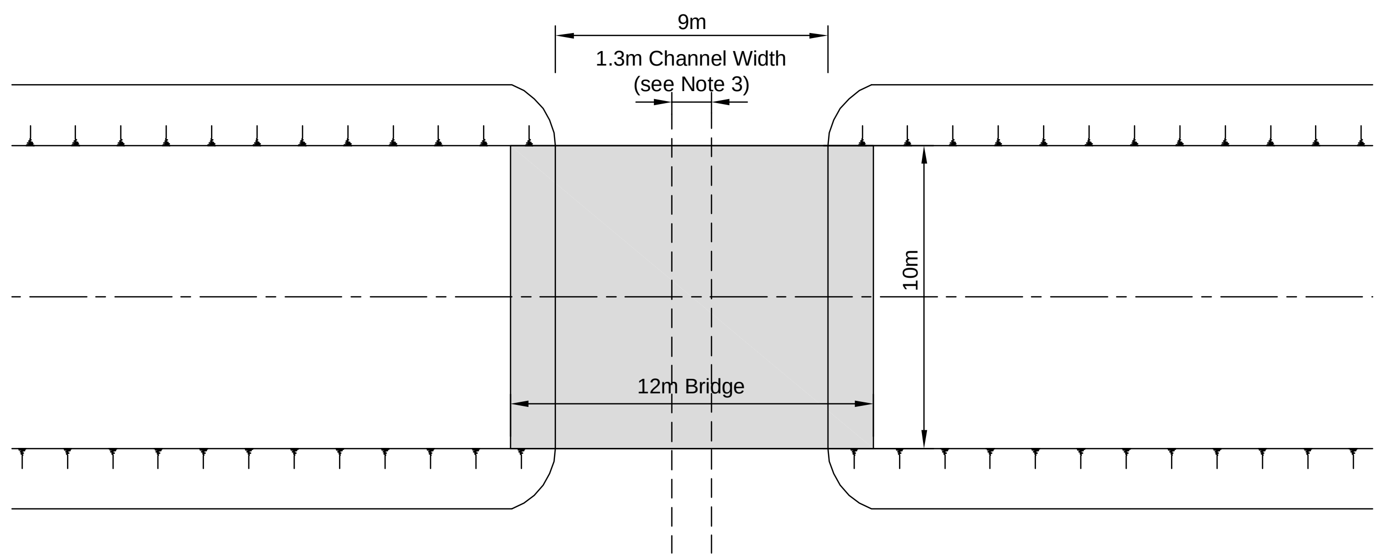
0 50 100 150 200 250
Scale in Meters

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

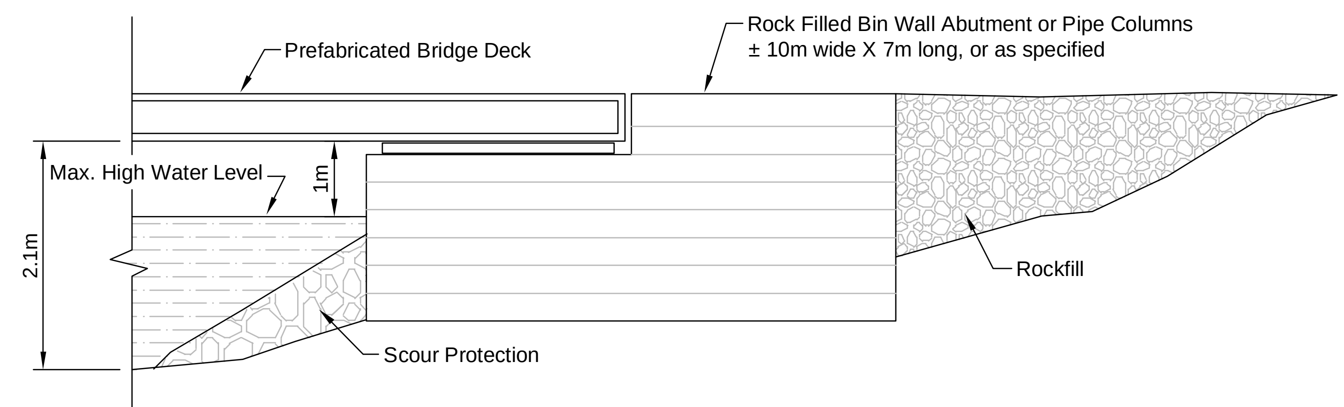
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



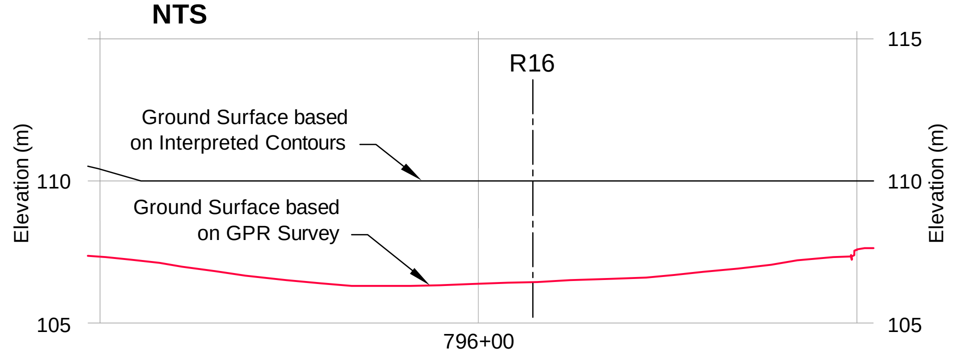
PROPOSED BRIDGE R16 PLAN (12m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R16 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02
DESIGN	PA	27SEP06	SCALE	NTS REV. A
CADD	NV	27SEP06		
CHECK	PA	27SEP06		
REVIEW				

FIGURE 4.8

Small fish have been observed (most likely ninespine stickleback), but the small stream is not suitable for migration or spawning by other species (e.g., Arctic grayling or round whitefish). Given the unfavourable substrate, negligible connectivity, and poor accessibility from upstream or downstream directions, stream habitat value and fish-bearing capacity in the vicinity of crossing R18 was ranked as low (HFA-AWPAR, 2005).

A 12 m bridge with a final base width of 5.9 m is planned for this 1 m wide channel crossing (Figure 4.9). Consequently, there is no HADD at this location.

4.2.10 Crossing R19

Crossing R19 is located at Km 89 along the proposed AWPAR. The stream at this crossing connects a small network of lakes with a small upstream lake that eventually discharges to the north basin of Amarulik Lake. The moderately wide channel is about 40 cm deep and well confined. Composition of substrate is primarily boulder and cobble, with small areas of interspersed gravel.

Fish survey work in 2005 and 2006 show high use of the watercourse for migration and spawning by Arctic grayling. Suitable grayling spawning habitat is located upstream of the proposed crossing. Lake trout, Arctic char, and round whitefish use the area to a much lesser degree. Unlike many other crossings, fish were present in the stream throughout the open water season.

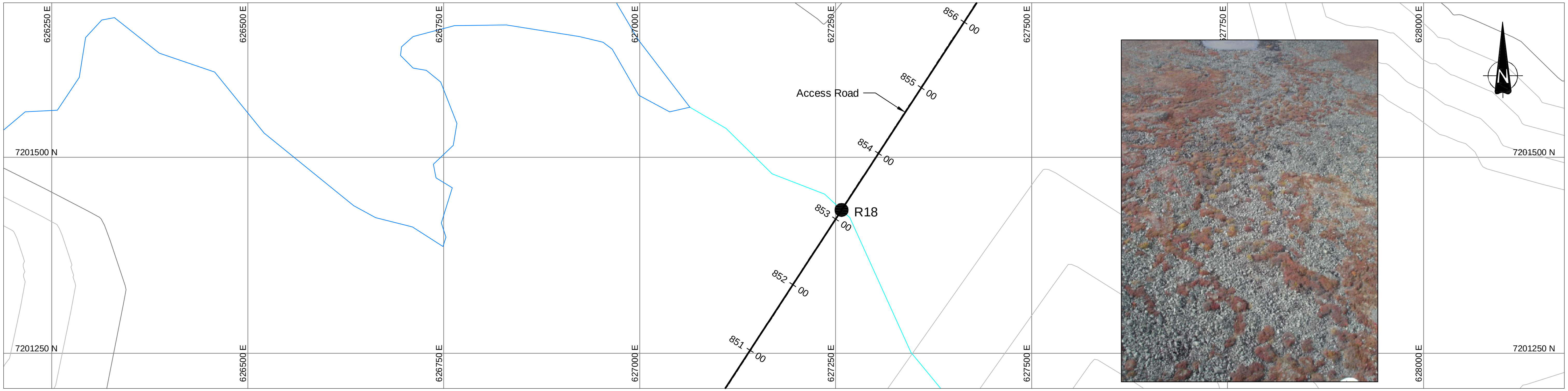
A 12 m bridge with a base width of 3.7 m is planned for this crossing; channel width is 8.7 m (Figure 4.10). Optimal orientation of the abutments to favour the eastern portion of the channel will result in encroachment of the western portion, resulting in a HADD. Quantification of HADD magnitude is presented below.

The stream runs north-south at the crossing location. The entire channel width facilitates discharge through open water with the deepest section on the east side of the channel. The substrate at this interval is homogeneous across the entire width of the stream and is characterized as riffle/run with boulder/cobble substrate. Based on substrate (mixed) and stream morphology (moderate), the value of the HADD habitat is considered medium. The area of the HADD was calculated to be 0.005 ha (Appendix AC); HUs are shown in Table 4.7. Compensation strategies are presented in Section 5.

Table 4.7: Habitat Unit (HU) Calculation for Crossing R19 HADD

Habitat Rank	Final HS I	Area (ha)	HUs
High	9.34	0	0.00
Medium	5.01	0.005	0.03
Low	0.43	0	0.00
		Total HUs	0.03

Note: HS I = Habitat Suitability Index, HU = Habitat Unit.

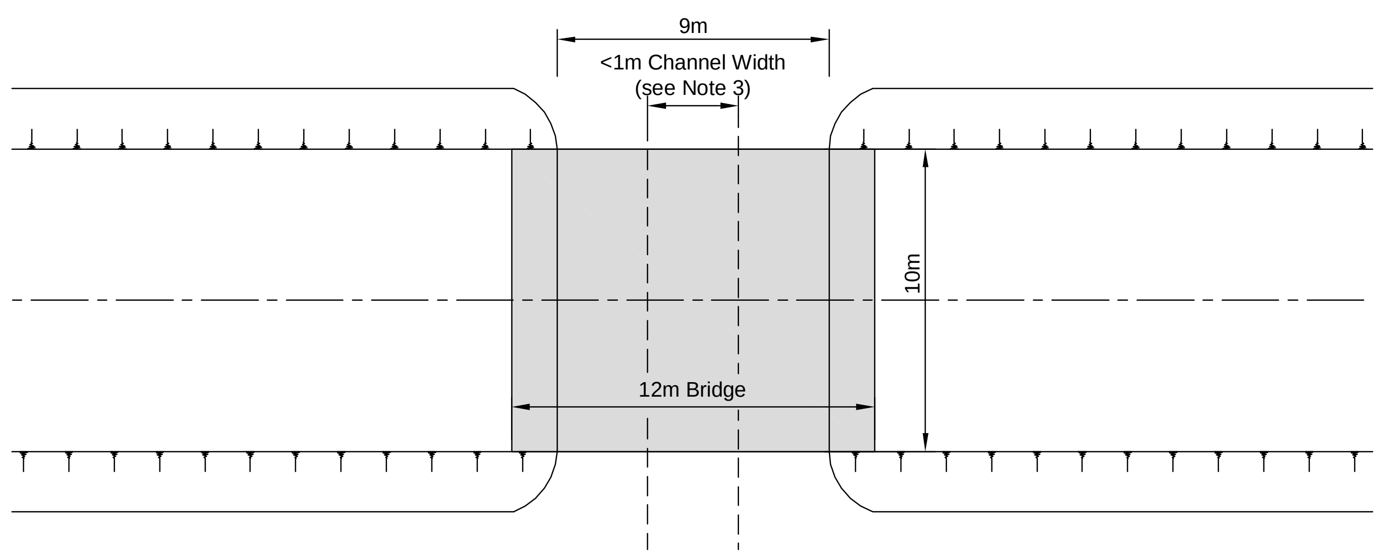


PLAN

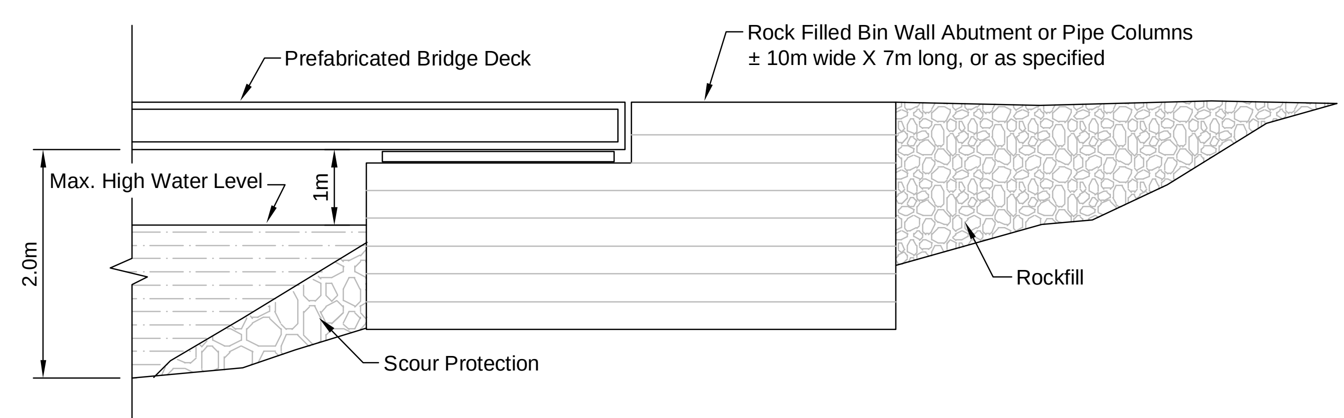
0 50 100 150 200 250
Scale in Meters

NOTES
1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

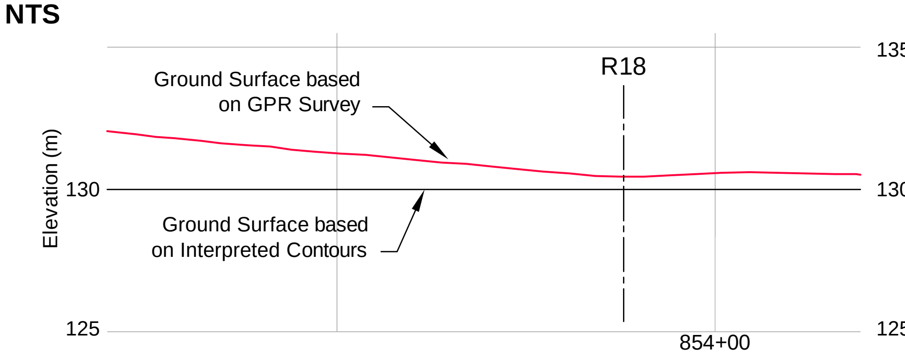
REFERENCE
1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



PROPOSED BRIDGE R18 PLAN (12m SPAN)
NTS



TYPICAL ROAD SECTION AT ABUTMENT
NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5
Vertical Scale in Meters

0 20 40 60 80 100
Horizontal Scale in Meters

NOTE
Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R18 AND ABUTMENT DETAILS

Golder Associates

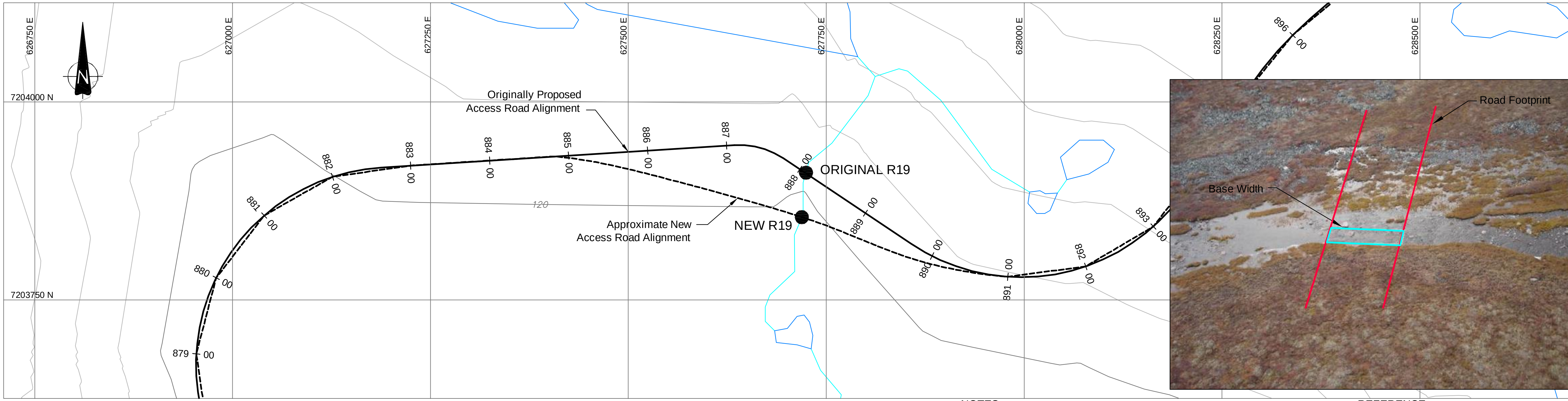
PROJECT No. 06-1413-034A		FILE No. 061413034-02
DESIGN	PA	27SEP06
CADD	NV	27SEP06
CHECK	PA	27SEP06
REVIEW		

SCALE NTS REV. A

FIGURE 4.9

CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

REVISION DATE: 06/10/25 04:42PM By: NVeloso



PLAN

0 50 100 150 200 250

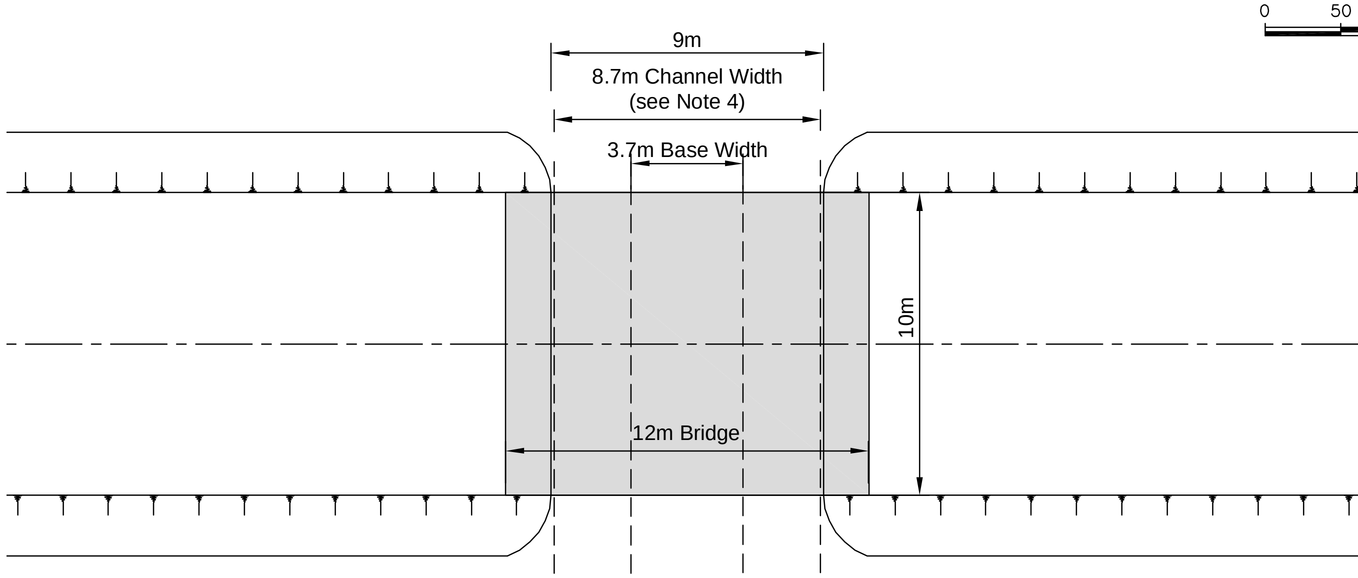
Scale in Meters

NOTES

1. The 2m contours have been inferred based on 10m contour interval reference maps. As such, variations should be anticipated between the topographic contours presented and actual ground elevations.
2. Bin wall abutment design for 30m (100ft) spans; pipe column abutment design for 12m (40ft) spans.
3. Road alignment and crossing location revised based on field observations.
4. Channel Width: Width of the stream that contains no terrestrial vegetation and is basically the rocky channel (Azimuth 2005).

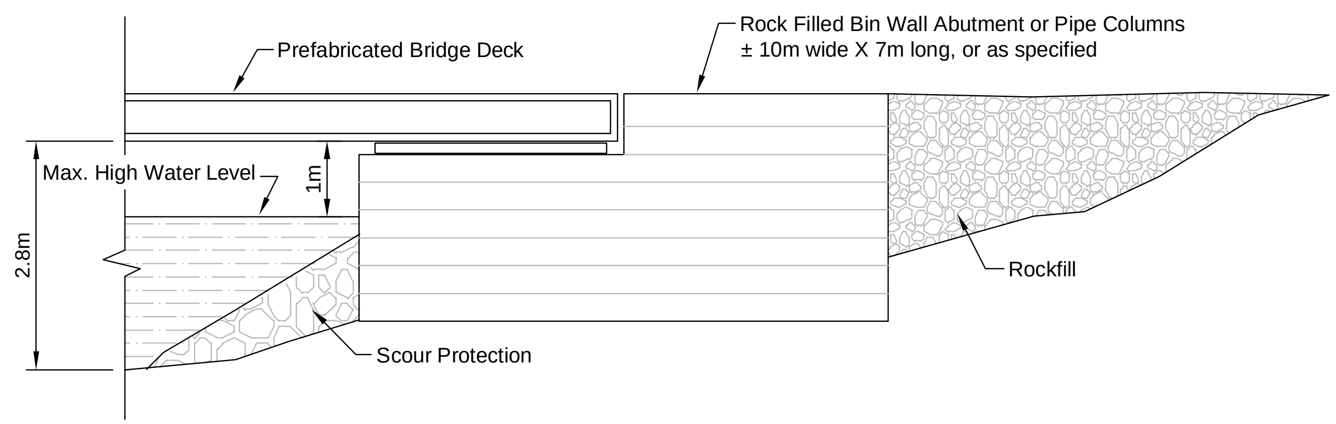
REFERENCE

1. Cumberland Resources Ltd. NAD83 Projection: UTM Zone 14
2. Photos taken by Azimuth in September 2006



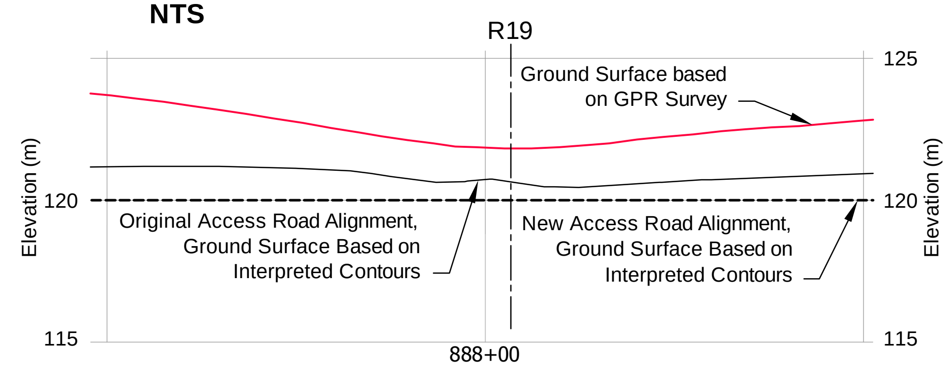
PROPOSED BRIDGE R19 PLAN (12m SPAN)

NTS



TYPICAL ROAD SECTION AT ABUTMENT

NTS



BRIDGE CROSSING PROFILE

0 2.5 5 7.5 10 12.5

Vertical Scale in Meters

0 20 40 60 80 100

Horizontal Scale in Meters

NOTE

Ground surface elevations collected during GPR survey are based on GPS data and should be considered approximate.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ALL-WEATHER PRIVATE ACCESS ROAD CONCEPTUAL BRIDGE CROSSING R19 AND ABUTMENT DETAILS

Golder Associates

PROJECT No. 06-1413-034A			FILE No.	061413034-02	
DESIGN	PA	27SEP06	SCALE	NTS	REV. A
CADD	NV	27SEP06			
CHECK	PA	27SEP06	**FIGURE 4.10**		
REVIEW					

REVISION DATE: 06/10/25 04:42PM By: NVeloso CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-034\Drafting\cad\061413034-02.dwg

SECTION 5 • HABITAT COMPENSATION

5.1 OVERVIEW

The general philosophy of the no-net-loss-of-habitat principle and precedents for northern mines are discussed in detail in Sections 5.1 and 5.2 of the main report. Minimizing impacts to fish habitat where practical was an integral factor in the overall design of the AWPAR. This is demonstrated by the low number of total crossings (21 overall) and relatively high number of bridges (10; planned for all fish-bearing watercourses). Notwithstanding these efforts to avoid or reduce impacts to fish-bearing waters, encroachments of the stream channel are identified in Section 4 of this appendix that will result in the loss of a small amount of productive habitat at only five of the 10 fish-bearing crossings along the AWPAR (Table 5.1). The total magnitude of HADD for the entire road is approximately 0.5 HUs. According to Golder, designers of the AWPAR, these crossing cannot be relocated, redesigned, or mitigated to avoid the HADD.

Table 5.1: HADD Summary for AWPAR.

Road Crossing	High Habitat Value			Medium Habitat Value			Low Habitat Value			Total HUs
	HS I	**ha**	**HU**	**HS I**	**ha**	**HU**	**HS I**	**ha**	**HU**	
R01	9.34	0	0	5.01	0	0	0.43	0	0	0
R02	9.34	0	0	5.01	-0.070	-0.351	0.43	-0.174	-0.074	-0.43
R05	9.34	0	0	5.01	0	0	0.43	0	0	0
R06	9.34	0	0	5.01	-0.011	-0.055	0.43	-0.011	-0.005	-0.06
R09	9.34	0	0	5.01	-0.004	-0.020	0.43	0	0	-0.020
R13	9.34	0	0	5.01	0	0	0.43	0	0	0
R15	9.34	0	0	5.01	0	0	0.43	-0.0041	-0.002	-0.002
R16	9.34	0	0	5.01	0	0	0.43	0	0	0
R18	9.34	0	0	5.01	0	0	0.43	0	0	0
R19	9.34	0	0	5.01	-0.005	-0.025	0.43	0	0	-0.03
Total Habitat Units (HUs) Lost for AWPAR Crossings HADD										**-0.53**

Note: Habitat losses shown as negative values; gains are shown as positive values.

The DFO (1998) decision framework document states that "…on-site compensation is an option where site rehabilitation can be successfully undertaken. Compensation can also take place off-site and is normally the only option when there are long-term impacts to habitat or it is simply destroyed on site." DFO managers are encouraged to "seek compensation which is at least equivalent with respect to quantity and quality of habitat" and that "the goal of NNL of productive capacity is thus applied not as a rigid quantitative rule, but as a guiding principle."

The AWPAR NNLP incorporates this philosophy by exploring on-site compensation strategies for each crossing with a potential HADD, but recognizing that there may be natural limitations to on-site habitat compensation in certain areas where off-site compensation provides greater benefits to regional fish populations.

In applying the NNL principle to a project, a number of factors must be considered to assess whether an authorization for HADD of fish habitat should be issued. DFO (1998) lists these considerations, which are paraphrased below in Table 5.2. The left-hand column lists the DFO considerations, while the right-hand column describes their specific application to the AWPAR project.

Table 5.2: Factors Considered by DFO when Issuing a HADD Authorization

DFO Considerations	Site-Specific Considerations
The acceptability of the HADD.	To be determined through consultation with DFO, and community members of Baker Lake.
Fisheries population or management objectives.	There are no specific management objectives, due to the remote nature of the area and the existence of large areas of similar habitat.
Does the habitat support an active fishery – if not, there is flexibility in timing and implementation of compensation.	The streams do not support commercial or sport fishing activities because they are remote or of lower fisheries value than nearby areas. Domestic fishing is rare.
Importance of the habitat – is the habitat in low supply or does it have high value to fish production?	Crossings were carefully located and designed to avoid high value habitat (e.g., spawning areas). HADD habitat is mostly of low value, with some moderate value present as well. The lost habitat is not in limited supply.
Is the HADD temporary or permanent?	Current plans are to decommission the road atter it is no longer needed to support mine closure. Bridge abutments will be re-contoured to local topography, their small footprint areas will remain as a permanent but small loss of habitat.
Does the HADD cause a significant change in the capacity of the habitat to produce fish?	HADD will not affect fish production in any of the watercourses; proposed compensation will seek to enhance local production or add to regional production where there do not appear to be benefits from enhancing local habitat. Overall, there is a net gain in HUs with the proposed compensation plan.
The availability of technically feasible habitat compensation options, and evidence of past success in efforts to compensate for habitat loss of this type and magnitude.	Unlike the project lakes, high value habitat for spawning and rearing in riverine environments may be lacking. Combined with the small magnitude of the overall HADD and good access by the AWPAR, enhancements of local habitat should successful in restoring productive capacity.
Compatibility with the hierarchy of preference for compensation options.	On-site opportunities for compensation are proposed where they provide maximum gain for resources expended; otherwise, off-site compensation is recommended to enhance regional productivity.
Does this authorization set a precedent that could lead to future cumulative impacts?	Unlikely. This is the only mine development within a very large area.

5.2 HABITAT COMPENSATION OPTIONS

Field studies were conducted during the open water seasons of 2005 and 2006 to assess fish habitat and fish usage patterns in the watercourses crossed by the AWPAR. The results of these investigations provide invaluable crossing-specific information to tailor a compensation strategy for all

AWPAR HADD areas. As discussed in Section 5.1, on-site (i.e., within the watercourse where a HADD is occurring) habitat enhancement is considered the preferred option for addressing HADDs, unless overall productivity would best be served through off-site compensation. Consequently, strategies are presented below for each of the HADD areas; where limitations to on-site compensation exist, options for off-site compensation are discussed.

In addition to direct habitat loss relating to the HADD areas, encroachment of the stream channel by bridge structures may result in local changes to flow regime. While normally much less of a concern for bridges (i.e., relative to culverts), increased current velocities can adversely affect fish migration through the establishment of flow barriers. Azimuth provided a conservative upper-bound current velocity recommendation of 0.7 m/s to Golder to support the design of bridge structures (width, encroachment, height) and avoid flow barriers to fish. The recommendation was based on the upstream migration of Arctic grayling to spawning areas. For the purposes of moving through areas of increased current velocities, fish swimming speeds can be classified into burst speed (i.e., highest speed attainable for less than 15 seconds) and prolonged speed (i.e., moderate speed maintained for up to 30 minutes). Burst speeds can be used when fish are well rested and flow barrier distances are small (e.g., 1 to 10 m); prolonged speeds are more suitable for covering moderate distances (e.g., 10s to 100s of meters). Katopodis and Gervais (1991) compiled a swimming performance database to determine burst and prolonged speeds for a range of fish sizes and body forms. For example, the estimated burst and prolonged speeds for a 30 cm long Arctic grayling are approximately 1.2 m/s (over 2.5 m distance) and 0.9 m/s (over 10 m distance) (see Figure 4 in Katopodis and Gervais, 1991). Given the planned bridge abutment widths of approximately 10 m, smaller adult Arctic grayling should be able to pass that distance in current velocities of 0.7 to 0.9 m/s. Where this is not possible without intervention (i.e., where Golder flow estimates exceed 0.9 m/s), channel modifications (e.g., adding boulders to create refuge habitat) will be implemented to mitigate the flow increases without affecting fish migration. Post-construction monitoring will be conducted to ensure that estimated flows are within the acceptable bounds and that fish migration is technically feasible.

5.2.1 Crossing R02

The R02 HADD is 0.43 HUs, representing 80% of the total AWPAR HADD. As discussed in Section 4.2.2, Arctic grayling are the predominant species present and best target for enhancing productivity. Grayling spawning areas have been identified upstream of the crossing location. While stream morphology in the potential spawning areas is relatively good, optimal substrate (i.e., unembedded gravels 2.5 cm in diameter; Evans et al., 2002) appears to be limiting overall and in the vicinity of the crossing. Consequently, the best compensation strategy would be to improve existing low-value habitat in these areas by adding optimal substrate material, resulting in the creation of high-value grayling spawning habitat. There is more than sufficient area available at the upstream location to offset the R02 HADD. HADD losses would be approximately balanced through the addition of 0.05 ha (500 m^2) of optimal substrate material in the upstream area (i.e., low-value habitat enhanced to create high-value spawning habitat). Details on the final recommendations of enhancement magnitude and location are provided in Section 5.3.

5.2.2 Crossing R06

The R06 HADD is 0.06 HUs, representing 11% of the total AWPAR HADD. Similar to R02, Arctic grayling are the dominant fish species present, representing approximately 90% of the fish population using the watercourse. Good grayling spawning habitat is considered limiting in the stream and represents a good opportunity for habitat enhancement. Consequently, we recommend improving the potential of the riffle/run area about 75 m upstream of the R06 HADD through the addition of optimal substrate material to facilitate grayling spawning. HADD losses would be approximately balanced through the addition of 0.007 ha (70 m^2) of good spawning substrate to the upstream area; there is more than enough area for this to be done on site. Details on the final recommendations of enhancement magnitude and location are provided in Section 5.3.

5.2.3 Crossing R09

The R09 HADD is 0.02 HUs, representing only 4% of the total AWPAR HADD. Arctic grayling are again the dominant species present in the stream and occur in relatively large numbers for the size of the watercourse. Neither grayling spawning habitat nor migratory connectivity (for lake trout and Arctic char) appear to be limiting in this stream. Furthermore, loss of the very small HADD area is unlikely to reduce local fish productivity. Consequently, we recommend targeting one of the other crossings to provide the greatest benefits to regional fish productivity. Details on the final recommendations of enhancement magnitude and location are provided in Section 5.3.

5.2.4 Crossing R15

The R15 HADD is 0.002 HUs, or less than 1% of the total AWPAR HADD. The HFA-AWPAR (2005) noted that fish access to this diffusely flowing stream is limited by boulder barriers at both the inflow and outflow areas, making the channel impassable for much of the open water season. Enhancing this location is not likely to improve local productivity. Consequently, we recommend targeting one of the other crossings to maximize benefits to regional fish productivity. Details on the final recommendations of enhancement magnitude and location are provided in Section 5.3.

5.2.5 Crossing R19

The R19 HADD is 0.03 HUs, or 5% of the total AWPAR HADD. Fish abundance was relatively high in the stream; over 30% of all the fish caught in the 2005 AWPAR crossings survey were from R19 (HFA-AWPAR, 2005). Baseline information shows that the stream already has relatively good habitat and connectivity (HFA-AWPAR, 2005). Furthermore, the small magnitude of the HADD is unlikely to reduce local productivity. Thus, enhancing this location would not likely result in significant benefit to local productivity. We recommend enhancing another crossing location to compensate for this HADD. Details on the final recommendations of enhancement magnitude and location are provided in Section 5.3.

5.3 NO NET LOSS STRATEGY

Options for habitat compensation for AWPAR-associated HADDs were discussed in Section 5.2. Stream crossings R02 and R06, which account for over 90% of the total HADD (i.e., 0.484 of 0.531 HUs), offer excellent opportunities for habitat enhancement. The remaining three (R09, R15, R19) have relatively small HADDs and offer less opportunities for local enhancement. Consequently, we recommend augmenting the enhancement at R02 and R06 to maximize benefits to regional fish productivity.

In addition to targeting local enhancement opportunities to offset HADD-related habitat losses, Cumberland is committed to providing a net gain in fish habitat productivity of over 50% for the AWPAR project (i.e., habitat enhancement will increase estimated productivity by slightly more than 1.5 times relative to HADD losses). Details of this compensation strategy and how it relates to each HADD crossing are provided in Table 5.3.

Crossings R02 and R06 have been identified as the best streams to implement compensation for HADD-related losses in productivity. The proposed strategy is to enhance 0.08 ha (800 m^2) at R02 and 0.01 ha (100 m^2) at R06 of existing low value habitat to create high value habitat suitable for Arctic grayling spawning habitat. The net benefit of enhancement activities (i.e., gain from high value habitat minus the loss of the low value habitat) is estimated at 0.80 HUs. The overall gain in productive capacity of habitat from the AWPAR project (i.e., enhancement minus losses) is a net gain of 0.27 HUs (i.e., 0.80 HUs – 0.53 HUs), or 51%.

Table 5.3: No-Net-Loss Compensation Strategy for AWPAR

Road Crossing	High Habitat Value			Medium Habitat Value			Low Habitat Value			Total HUs
	HS I	HA	HU	HS I	HA	HU	HS I	HA	HU	
Habitat Units Lost for AWPAR Crossings HADD (from Table 5.1)										
R01	9.34	0	0	5.01	0	0	0.43	0	0	0
R02	9.34	0	0	5.01	-0.07	-0.35	0.43	-0.17	-0.07	-0.43
R05	9.34	0	0	5.01	0	0	0.43	0	0	0
R06	9.34	0	0	5.01	-0.01	-0.06	0.43	-0.011	-0.01	-0.06
R09	9.34	0	0	5.01	-0.004	-0.02	0.43	0	0	-0.02
R13	9.34	0	0	5.01	0	0	0.43	0	0	0
R15	9.34	0	0	5.01	0	0	0.43	-0.004	-0.002	-0.002
R16	9.34	0	0	5.01	0	0	0.43	0	0	0
R18	9.34	0	0	5.01	0	0	0.43	0	0	0
R19	9.34	0	0	5.01	-0.005	-0.03	0.43	0	0	-0.03
Total Habitat Units (HUs) Lost for AWPAR Crossings HADD										**-0.53**
Habitat Units Gained with Proposed Enhancement Activities										
R01	9.34	0	0	5.01	0	0	0.43	0	0	0
R02	9.34	0.08	0.75	5.01	0	0	0.43	-0.08	-0.03	0.71
R05	9.34	0	0	5.01	0	0	0.43	0	0	0
R06	9.34	0.01	0.09	5.01	0	0	0.43	-0.01	-0.004	0.09
R09	9.34	0	0	5.01	0	0	0.43	0	0	0
R13	9.34	0	0	5.01	0	0	0.43	0	0	0
R15	9.34	0	0	5.01	0	0	0.43	0	0	0
R16	9.34	0	0	5.01	0	0	0.43	0	0	0
R18	9.34	0	0	5.01	0	0	0.43	0	0	0
R19	9.34	0	0	5.01	0	0	0.43	0	0	0
Habitat Units (HUs) Gained for Proposed Enhancements										**0.80**
Net Habitat Units (HUs) Summary for AWPAR Project										**0.27**
Relative Increase (%) in Habitat Units (HUs) for AWPAR Project										**51%**

Note: Habitat losses shown as negative values; gains are shown as positive values. Relative increase (%) shown as (Net Gain)/(Total HADD).

SECTION 6 • NO-NET-LOSS PLAN MONITORING

Consistent with the environmental management approach for the project as a whole, monitoring will play an important role in the successful implementation of the AWPAR NNLP. The *Aquatic Effects Management Program* (AEMP, 2005) documents the comprehensive monitoring and management strategy to mitigate adverse effects to aquatic resources through all aspects and phases of the project. While addressing monitoring for the NNLP as a whole, the AEMP concluded that the specific program could only be prepared once a framework for monitoring and assessment has been agreed to by all parties including the Kiggavik Inuvialuit Association, Baker Lake, Cumberland, and Department of Fisheries and Oceans. Once the AWPAR NNLP has been agreed to in principle, a Sampling and Analysis Plan (SAP) will be prepared that will outline all monitoring of fish habitat as required to meet the terms of the DFO habitat authorization.

In general, there will be two components to the NNLP monitoring: pre-implementation and post-enhancement monitoring. As with the AEMP, the proposed strategy is adaptive management. Monitoring will be used to provide feedback on NNLP implementation to maximize overall benefits to fish productivity and avoid significant impacts.

6.1 PRE-IMPLEMENTATION MONITORING

A central component of the AWPAR NNLP is upgrading fish habitat from lower quality to high quality. Pre-implementation monitoring has been ongoing throughout the 2005 and 2006 seasons (see Section 2.1 for details). Monitoring has targeted collecting data to address specific information requirements to support the design of the AWPAR and NNLP preparation. Additional information required includes continued monitoring of existing fisheries resources and more detailed descriptions of baseline habitat in the proposed compensation areas.

6.2 POST-ENHANCEMENT MONITORING

Performance monitoring of NNLP enhancement areas will be necessary to show that they are functioning as intended. Of primary importance in this program will be documenting that the installation of crossing structures, particularly those encroaching stream channels, has not adversely affected fish migration. Similar to the fish migration studies conducted for pre-implementation monitoring, installation of hoop nets upstream and downstream of the crossings will help address this issue. In addition, deployment of larval drift traps downstream of the enhancement areas will be used to show if these areas are being used for spawning as intended.

SECTION 7 • REFERENCES

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APPENDIX AA

Fisheries & Oceans Canada Crossing Recommendations

NUNAVUT OPERATIONAL STATEMENT
Habitat Management Program

CLEAR-SPAN BRIDGES

Version 2.0
Valid until March 31, 2007

This Operational Statement applies to the construction of only those small-scale bridge structures that completely span a watercourse without altering the stream bed or bank, and that are a maximum of two lanes wide. A clear-span bridge is often more preferred than a culvert as no structures are placed on the stream bed or banks.

Clear-span bridge construction has the potential to negatively affect riparian habitat. Riparian vegetation occurs adjacent to the watercourse and directly contributes to fish habitat by providing shade, cover, and spawning and food production areas. Only the vegetation required to be removed to meet operational and safety concerns for the crossing structure and the approaches should be removed.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under Section 35 of the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with Subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to be incorporated into the design and construction of small-scale, clear-span roadway or railway bridges in order to avoid negative impacts to fish habitat. **You may proceed with your Clear-Span Bridge project without a DFO review when you meet the following conditions:**

- the bridge is no greater than two lanes in width and does not encroach on the natural channel width by the placement of abutments, footings or armouring (e.g., rock and concrete) below the ordinary high water mark (see definition below) so that there is no restriction to natural channel processes,
- the work does not include realigning the watercourse,
- disturbance to riparian vegetation is minimized,
- the work does not involve dredging, infilling or excavating the bed or bank of the watercourse,
- this Operational Statement is posted at the work site and is readily available for reference by workers, and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Constructing*

Clear-Span Bridges listed below.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in a violation of Subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact the Nunavut DFO office, at the address below, if you wish to obtain DFO's opinion on the possible options you should consider to avoid contravention of the *Fisheries Act*.

This Operational Statement does not release you from the responsibility of obtaining any other permits or approvals that may be required under local, territorial and federal legislation (e.g., the *Navigable Waters Protection Act, Nunavut Waters and Surface Rights Tribunal Act, Territorial Lands Act and Regulations, Regional Inuit Association Land Use Permits,* etc.) that apply to the work being carried out in relation to this Operational Statement.

We ask that you notify DFO, preferably 10 working days before starting your work, by filling out and sending in, by mail or by fax, the Nunavut notification form to the DFO office in your area. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement.

Measures to Protect Fish and Fish Habitat when Constructing Clear-Span Bridges

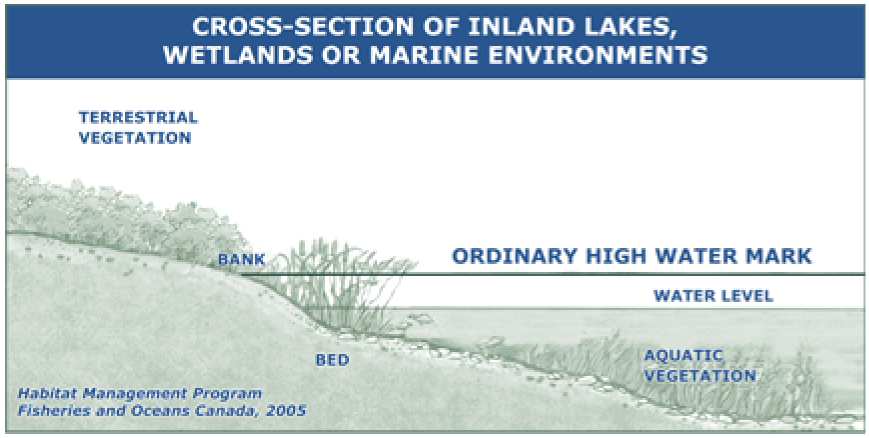
1. Avoid building on meander bends, braided streams, alluvial fans or any other area that is inherently unstable and may result in the erosion and scouring of the bridge structure.
2. Construct the bridge structure (including any approaches, abutments, armouring (rock and concrete) or footings) entirely above the ordinary high water mark (see definition below) and away from areas with eroding or unstable banks.
3. Construct the bridge structure with sufficient freeboard to pass floating objects at high flows.
4. Design the bridge so that stormwater runoff from the bridge deck, side slopes and approaches is directed to a collection basin or vegetated area having suitable features to remove suspended solids, dissipate velocity and prevent sediment and other deleterious substances from entering the watercourse. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.
5. Generally, there are no restrictions on timing for the construction of clear-span structures as they do not involve in-water work. However, if there are any activities with the potential to disrupt spawning fish, their incubating eggs and larval life stages (e.g., in-water crossing of watercourse by machinery), adhere to territorial fisheries timing windows (see the attached Nunavut In-Water Construction Timing Windows), or alternatively, carry out the project when the waterbody is frozen to the bottom or is dry.
6. Machinery fording the watercourse to bring equipment required for construction to the opposite side of the watercourse should be limited to a one-time event (over and back) and occur only if an existing crossing at another location cannot be used. If the stream bed and banks are highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation is likely to occur as a result of equipment crossing, then a temporary crossing structure or other practices should be used to protect these areas. The fording should be timed in accordance with Measure 5.
7. Install effective sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Pay particular attention to the ditches of road approaches. Inspect measures regularly

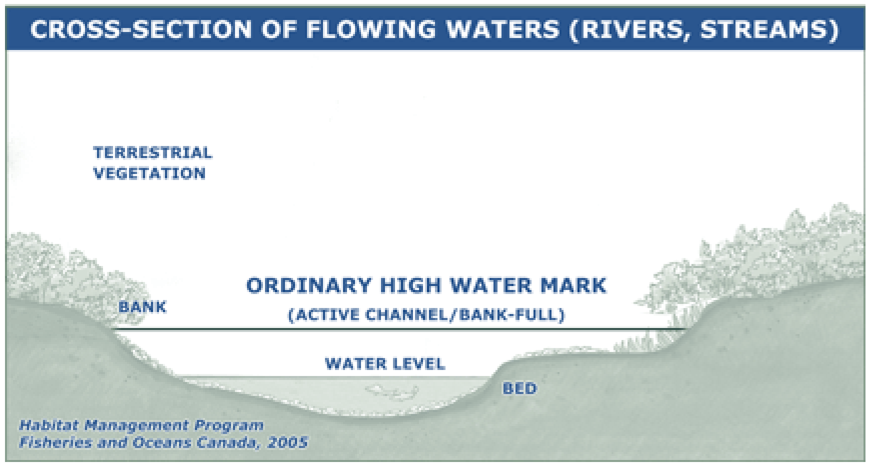
during the course of construction and until any required re-vegetation has established to ensure they are functioning properly. Make all necessary repairs if any damage is discovered or if these measures are not effective at controlling erosion and sedimentation.

8. Operate machinery from outside of the water and in a manner that minimizes disturbance to the banks of the watercourse.
    1. Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
    2. Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent deleterious substances from entering the water.
    3. Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
9. Use measures to prevent deleterious substances, such as new concrete (i.e., it is pre-cast, cured and dried before use near the watercourse), grout, paint, ditch sediment and preservatives from entering the watercourse.
10. While this Operational Statement does not apply to the clearing of riparian vegetation, the removal of select plants may be required to meet operational and/or safety concerns for the crossing structure and the approaches. This removal should be kept to a minimum and will not occur outside of the road right-of-way.
11. Stabilize any waste materials removed from the work site, above the ordinary high water mark (see definition below), to prevent them from entering any watercourse. Spoil piles could be contained with silt fence, flattened, covered with biodegradable mats or tarps, and/or planted with preferably native grass or shrubs.
12. Vegetate any disturbed areas by planting and seeding preferably native trees, shrubs or grasses and cover such areas with mulch to prevent soil erosion and to help seeds germinate. If there is insufficient time in the growing season remaining for the seeds to germinate, stabilize the site (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and then vegetate the following spring. If re-vegetation is not possible due to climatic extremes and/or lack of appropriate seed or stock, the site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.
13. Maintain effective sediment and erosion control measures until complete re-vegetation of disturbed areas is achieved or until such areas have been permanently stabilized by other effective sediment and erosion control measures, in the event that re-vegetation is not possible.

Definition:

Ordinary high water mark – The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams) this refers to the "active channel/bank-full level" which is often the 1:2 year flood flow return level. In inland lakes, wetlands or marine environments it refers to those parts of the water body bed and banks that are frequently flooded by water so as to leave a mark on the land and where the natural vegetation changes from predominately aquatic vegetation to terrestrial vegetation (excepting water tolerant species). For reservoirs this refers to normal high operating levels (Full Supply Level).





Aussi disponible en français.

DFO OFFICE LIST

TIMING WINDOWS

Notification Form (Adobe Acrobat Format)

Fisheries and Oceans Canada Pêches et Océans Canada Canada

CONTENTS

Last updated: 2006-08-16 Important Notices

APPENDIX AB

AWPAR Crossing Photos

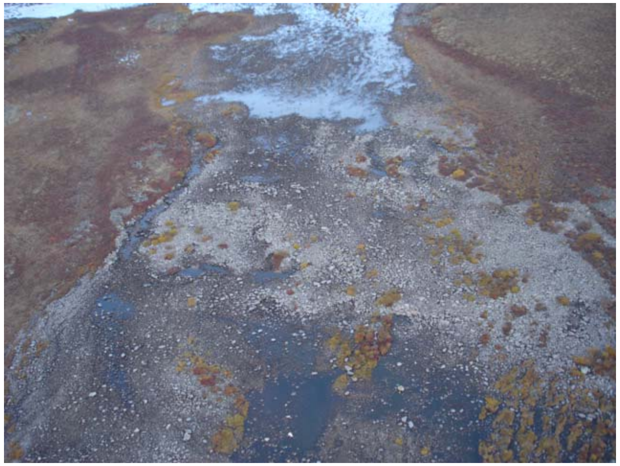
Crossing R01

Crossing R01 viewed from above.

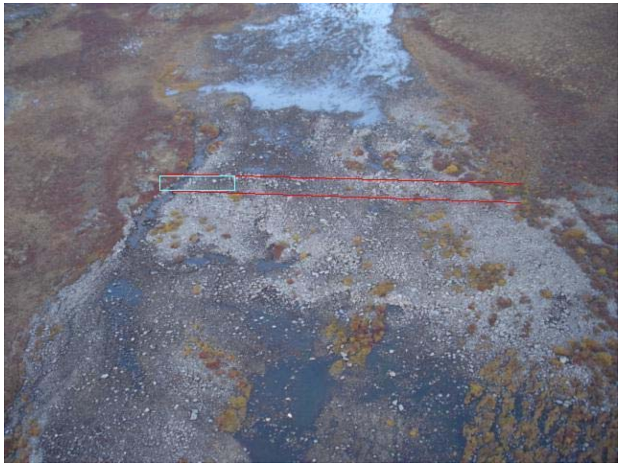
Slightly closer view of crossing location.

Crossing R02

Crossing R02 viewed from above.



Rough schematic of crossing location showing bridge placement.



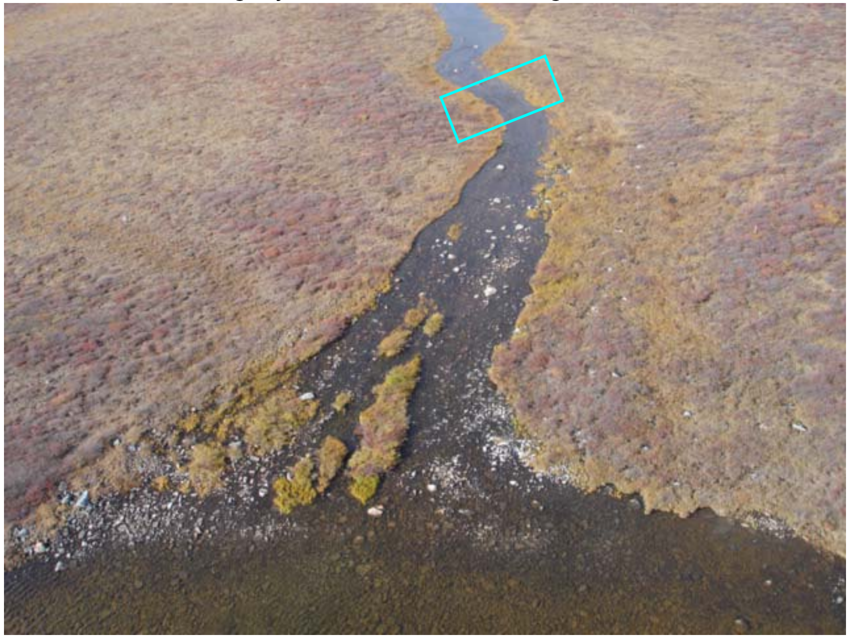
Typical substrate in encroachment area.

Close up of channel area to be spanned by bridge.

Crossing R05

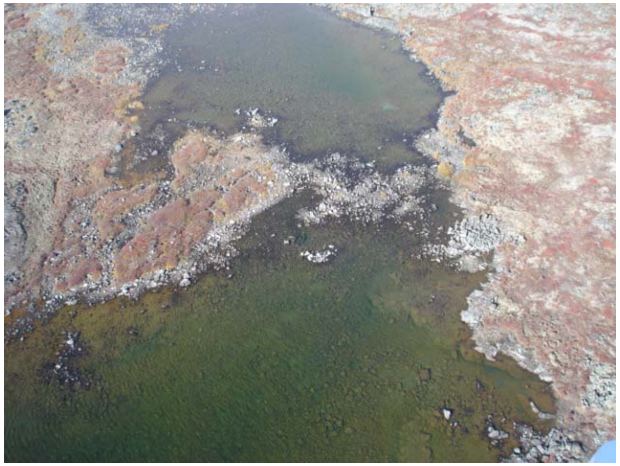
Crossing R05 viewed from above.

Slightly closer view of crossing location.



Crossing R06

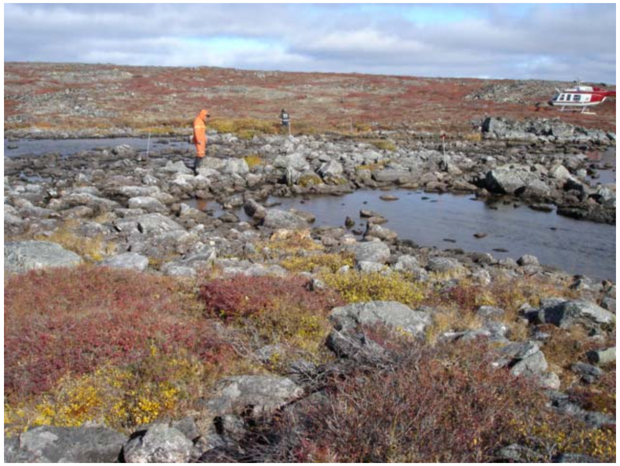
Crossing R06 viewed from above.



Slightly closer view of crossing location.

Typical substrate along crossing location.

Shallow rocky area at crossing location.

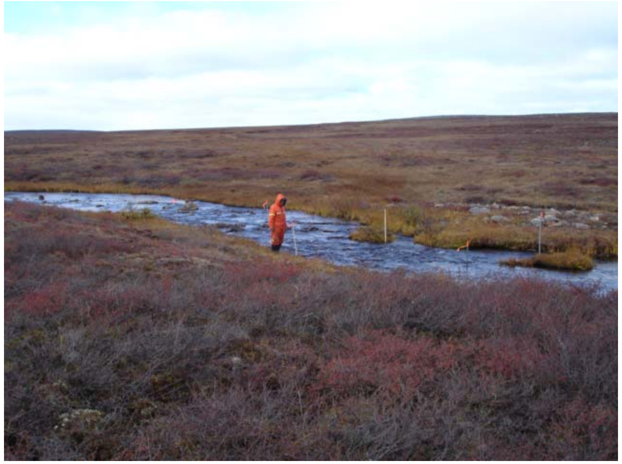


Crossing R09

Crossing R09 viewed from above.

Slightly closer view of crossing location.

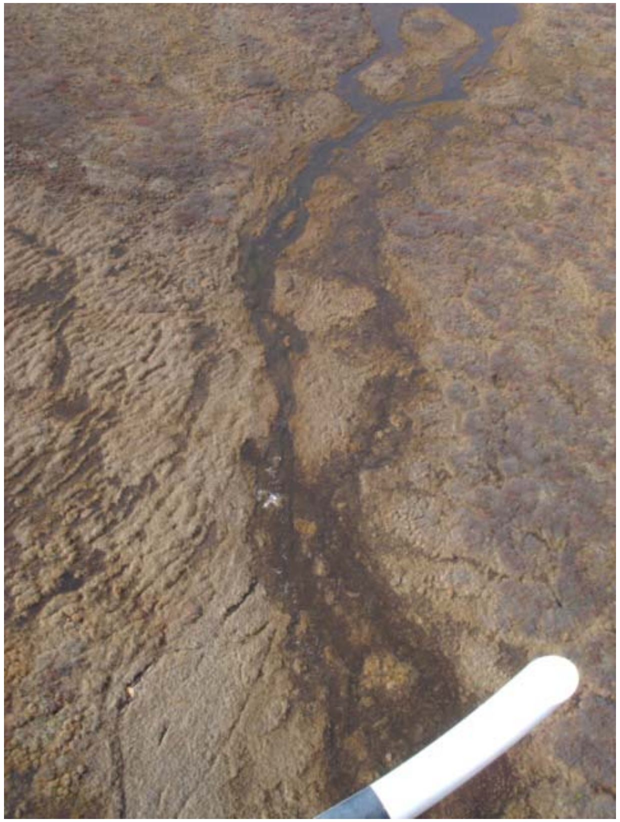
Crossing location staked with bridge position.



Encroachment area – NE portion.

Crossing R13

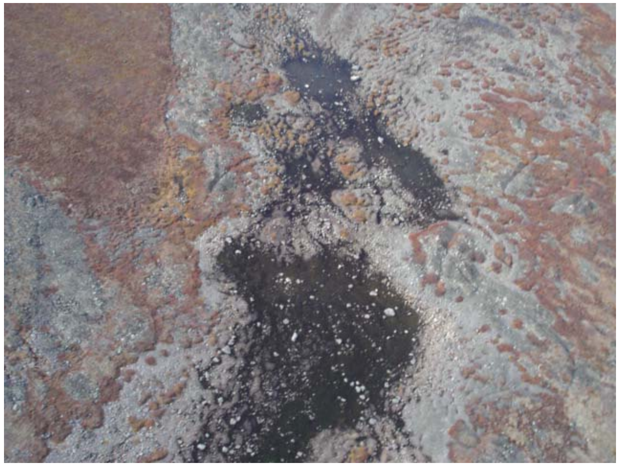
Crossing R13 viewed from above.



Crossing R15

Crossing R15 viewed from above.

Slightly closer view of crossing location.

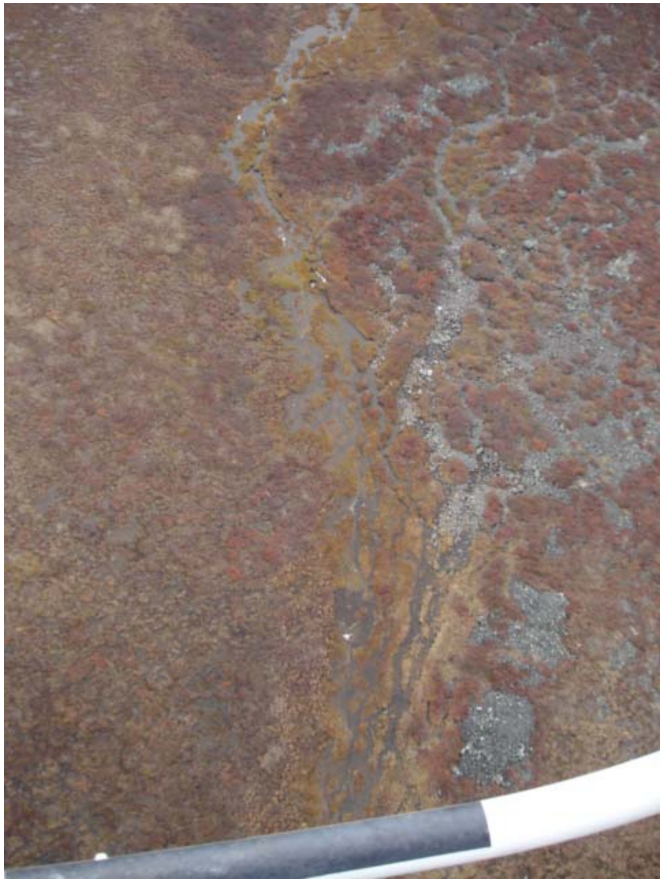


Crossing location being staked with bridge position.

Encroachment area on north bank.

Crossing R16

Crossing R16 viewed from above.



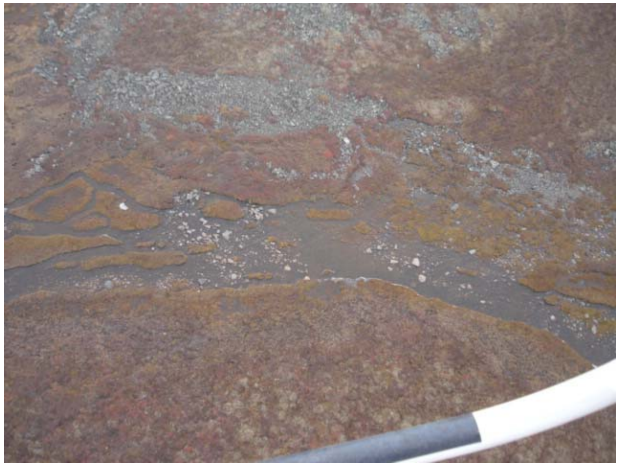
Crossing R18

Crossing R18 viewed from above; note lake upstream.

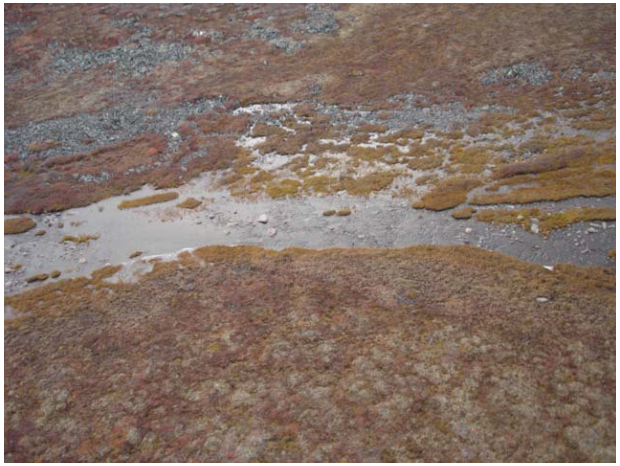
Slightly closer view of boulder field at crossing location.

Crossing R19

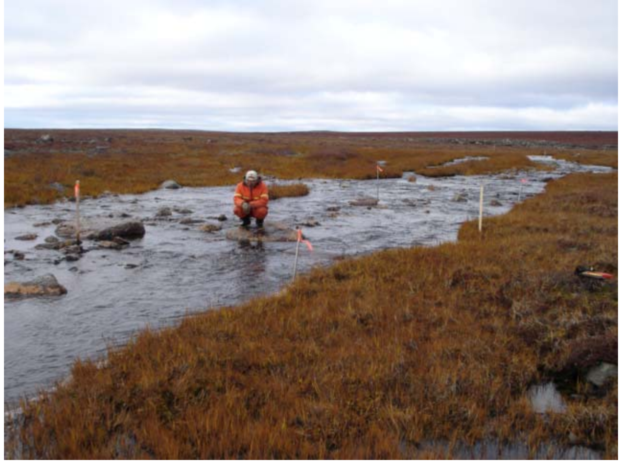
Crossing R19 viewed from above.



Slightly closer view of crossing location.



Cross section looking south to north (with bridge position stakes).



Encroachment area on west side of channel.

APPENDIX AC

AWPAR HADD Area Calculations

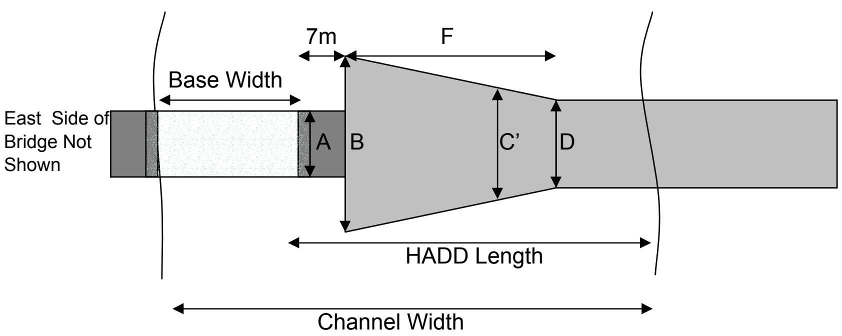
All-Weather Private Access Road
HADD Area Calculations

Crossing	Bridge Height	Channel Width	Base Width	HADD Length	Width A	Width B	Width D	Distance F	Slope	Length of road on Channel (constant width)	Width when road reach shore, C	Rect A	Trap B-D	Trap B-C	HADD Rect D	Area (m^2)
R01	1.8	1.0	7.9													
R02	4.5	113.5	17.5	96.0	10	45.9	19.6	41.1	0.32	47.9	19.6	70	2291.5	1568	806	2444
R05	2.6	12.7	23.3													
R06	2.7	35.0	23.0	12.0	10	31.3	19.6	18.3	0.32	-13.3	28.1	70	749.7	148	N/A	218
R09	3.1	7.5	3.5	4.0	10	22.4	14									40
R13	2.0	3.0	7.2													
R15	2.5	27.5	23.4	4.1	10	20.1	14									41
R16	2.5	1.3	5.6													
R18	2.4	1.0	5.9													
R19	3.2	8.7	3.7	5.0	10	35.3	19.6									50

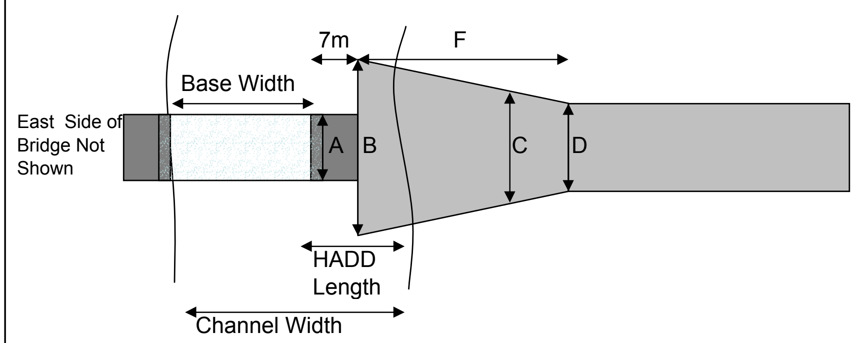
Notes: All units in meters (lengths and widths) or square meters (area).
Bridge height (incl. approx. bridge deck of 0.4m), base width, and widths A B C' D provided by Golder.
Channel width based on 18 September 2006 crossing assessment using latest GPS coordinates from Golder.
HADD Area calculated based on footprint of bridge abutments (and road where appropriate) over watercourse channel.
Width C for R06 calculated for 5m from abutment (HADD length = 12m).
Crossing R09, R15 and R19 have only minor encroachment by one bridge abutment.

A = Fixed width of 10m for each abutment; fixed length of 7m.
B = Variable width of abutment leadup.
C = Width of road at shoreline.
D = Road width based on permafrost requirements.
F = Distance from abutment to normal road width (D).

R02 CROSSING HADD AREA CALCULATIONS



R06 CROSSING HADD AREA CALCULATIONS



APPENDIX B

Azimuth Technical Memorandum: Supplementary Response to Fisheries & Oceans Canada Information Requests

Technical Memorandum

Date: 6/3/2006

To: **Derrick Moggy, Department of Fisheries and Oceans, Iqaluit NU**

Cc: **Craig Goodings, Cumberland Resources Vancouver**

From: **Randy Baker, Azimuth**

RE: **Supplementary Response to DFO Information Requests**

Following review of Cumberland Resources February 10 2006 response to Information Requests by the Department of Fisheries and Oceans (DFO) Iqaluit, DFO has requested clarification or reassessment of habitat impacts related to the following activities:

- Habitat loss from airstrip extension into Third Portage Lake
- Habitat loss from drawdown of Phaser Lake by 1 meter
- All-weather access road bridge crossing conceptual diagrams and habitat loss
- Intake Pipe
- Effluent pipe locations and design
- Clarification of habitat compensation options considered during mine operation to satisfy the NNL policy

Airstrip Extension

Issue: DFO requested that the airstrip not extend into the water or minimize extension into the water, to avoid further impacts to fish habitat during mine operations

Resolution: Cumberland has determined that the airstrip can be re-aligned so that an extension into Third Portage Lake is no longer required. There will be no impact of fish habitat in Third Portage Lake as a result of airstrip extension.

Phaser Lake Drawdown

Issue: It was proposed that water level of Phaser Lake would be drawn down by 1 meter and this volume directed to Turn Lake during mine operations. The purpose of this is ensure that water discharged from the lake during freshet does not flow to Vault Lake or Vault Pit and affect adversely pit integrity and worker safety. DFO had concerns that a drawdown of 1 m would compromise the already limiting overwintering habitat in the lake for the few fish existing in this lake. Two solutions were proposed to resolve this problem; 1) dig a deep (~6 m) hole to provide overwintering habitat or 2) construct a berm around the natural outlet of Phaser Lake to prevent outflow towards Vault Lake and maintain the existing water level.

Resolution: Golder Associates has recently issued a memo (Appendix A) that presents a third option. This option proposes that the road accessing Vault pit from the mill can be elevated, providing a physical barrier between Vault Lake and Phaser Lake. This road would provide a sufficient barrier between the two lakes to ensure that during freshet water does not exit Phaser Lake and enter Vault pit. Water will still be diverted or pumped to Turn Lake during mine life. This solution will satisfy both engineering concerns and prevent impacts to water level in Phaser Lake and will not result in a loss of fish habitat.

All-weather Road Bridge Crossings

Issue: No design criteria regarding stream crossings by the all-weather road have been provided to the regulatory agencies, especially DFO. DFO requested that conceptual plan view and cross-sectional drawings of each bridge crossing be provided in order that habitat compensation, if any, can be determined. Of the 25 planned crossings, only six crossings contain reasonable numbers of migrating fish, specifically Arctic grayling, as well as small numbers of Arctic char, Arctic cisco and lake trout. Five of these streams will be crossed with bridges while the sixth (crossing RO1 near Baker Lake) will be crossed with a large culvert.

Resolution: Plan view and cross-sectional drawings of each of the five proposed bridge crossings are provided in Appendix B. Bridge abutments of four of the five crossings will intrude into the stream bed and affect fish habitat at spring freshet water levels. Total habitat area impacted by bridge abutments encroaching into streambed habitat is summarized below:

Bridge Crossing	Surface Area Affected (m^2)
B01 (R02)	263 m^2
B02 (R06)	235 m^2
B03 (R09)	0 m^2
B04 (R15)	291 m^2
B05 (R19)	170 m^2
Total Area	**959 m^2**

The total stream habitat area intruded by bridge abutments in streams crossed by bridges affecting fish species other than stickleback is 959 m^2. This is the maximum area of habitat loss considering that mid-summer stream width for all streams except one (B02) is less than the bridge span (~13 m). Thus a quantifiable amount of habitat will be buried beneath the bridge abutment and needs to be compensated.

The stream channels in the vicinity of the stream crossings suffer from a shortage of small, suitably sized spawning gravel for Arctic grayling. Thus it is proposed that a habitat area at least equivalent to the surface area lost be installed with pea-size gravel. This grain size type is favored for spawning by grayling and should enhance local populations. Note also that the riprap exterior of the bridge abutments will also function as shelter habitat for juvenile fish, providing additional habitat.

Freshwater Intake Pipe

Issue: DFO has requested further information on the siting and deign of the freshwater intake pipe and whether there is a potential for impacts to fish habitat.

Resolution: The freshwater intake pipe will be seated on a gravel or small riprap bed that extends into Third Portage Lake along a steep rocky bank. The pipe will run along the bottom either directly on the fine sediment or on a gravel bed. Neither option will adversely affect fish habitat. The intake will be situated at least 1 m off of the bottom to avoid fish habitat and will be fitted with an appropriately sized screen to avoid entrainment of small fish (see the Aquatic EIA for further details).

Effluent Pipe Location and Design

Issue: Environment Canada expressed concern that there has been a lack of detail regarding the design and location of the effluent pipe from Second Portage Lake attenuation pond to Third Portage Lake north basin during Years 1 to 4. This information has been provided directly to Environment Canada and via this memo DFO is also apprised of this communication.

Resolution: Effluent will be discharged to Third Portage Lake from the Second Portage attenuation pond only during Years one to four or five of operation. Beyond Year 5 effluent will be directed to Goose Pit for *in situ* treatment, if necessary. Based on conservative predictions of water chemistry within the attenuation pond, all metals concentrations in effluent will be considerably lower for all metals prescribed in the Metal Mining Effluent Regulations. It is not anticipated that treatment will be required prior to discharge. Note that no water that comes into contact with mine tailings will be discharged to the receiving environment.

Cumberland Resources is committed to fulfilling all requirements of MMER, including environmental effects monitoring, specifically no acute toxicity to fish, investigations of sublethal toxicity of effluent, fish metals investigations and benthic invertebrate community surveys according to prescribed schedules.

Environment Canada expressed concern that while whole basin predictions of water quality have been made, there has been no evaluation of water quality of the lake area surrounding the discharge point. Given the relatively low metal loading predicted for the effluent and the large dilution capacity of the discharge point, we anticipate that impacts to the near-field mixing zone will be negligible. No exceedences of metals for which there are CCME guidelines will be exceeded in Third Portage Lake north basin, except for cadmium which for reasons explained earlier, is an artifact of the hardness derived guideline. Under MMER there is a requirement to conduct a plume delineation study to determine the actual zone of impact and to determine the spatial extent of the plume. Modeling to delineate the spatial extent of the plume will be conducted as part of detailed engineering design, once the location and design of the diffuser system has been determined.

To minimize impacts to the receiving environment, the following design features will be incorporated into the effluent discharge system:

- The effluent pipe will be seated along the bottom of Third Portage Lake north basin and extend directly offshore of the north end of Second Portage Lake opposite the attenuation pond.
- Effluent will only be discharged during the open water period and not under ice.
- The pipe will run along the bottom of the lake to a depth of at least 16 m. The shoreline along Third Portage at the discharge pipe location has a very steep drop off to water of about 20 m depth at about 80 – 100 m offshore.
- Effluent will be discharged far enough away from shore and productive fish habitat so as to have no direct impacts.
- The effluent pipe will be fitted with a diffuser to facilitate mixing.
- The diffuser head will be situated several meters above the lake bottom to ensure that sediment is not disturbed or entrained in the outflow.
- The location of effluent discharge pipe will be far enough offshore to take advantage of the prevailing north – south wind direction that will facilitate longitudinal and vertical mixing.

DFO and Environment Canada will be kept appraised of developments with respect to siting and final design of the effluent discharge system.

Fish Habitat Compensation

Issue: DFO has requested further clarification of specific habitat compensation measures to be undertaken at Meadowbank during and after mine development. The vast majority of habitat loss occurs during mine operation when lakes are diked and pits are dewatered. Recognizing that there is a net loss of habitat during operation that cannot be fully compensated for, DFO requests a 2:1 habitat replacement to loss ratio after closure to compensate for this temporary loss of habitat. DFO also wishes further clarification on how the principles of adaptive management will be used in the context of habitat loss.

Resolution: It is difficult to precisely ascribe workable, guaranteed solutions to compensate for habitat loss at this point in time, especially for operations when opportunities are limited. DFO has acknowledged that a definitive plan cannot be assured at this early state of development for two reasons. First, despite the presence of several relatively new mines in the NWT, no proven mitigation or compensation measure has emerged upon which efforts at Meadowbank can be based. Second, there are a variety of on-site and off-site options that require further evaluation or consideration before one or more of these options are chosen. DFO Iqaluit and Azimuth agree that this selection process would benefit from the participation of DFO Science to take advantage of the accumulated experience at the Freshwater Institute, Winnipeg. The candidate options, including some nearer the community of Baker Lake should also be presented before the Hunters and Trappers Organization (HTO) for consideration, given that they are the ultimate recipients of whatever compensatory actions are taken.

Tailings Disposal Area – Cumberland is committing to achieving a roughly 2:1 habitat compensation ratio of gains to losses, especially pertaining to permanent habitat loss such as the Tailings Disposal Area. In the February 10, 2006 from Cumberland to DFO, IR#16 proposed a near 2:1 plan. Approximately 400 habitat units (HUs) would be lost behind and beneath the Tailings Dike while approximately 800 HUs are proposed, gained primarily from flooded formerly terrestrial area, plus habitat improvements to the dewatered lake bottom between the East Dike and the Tailings Dike. Shoals, boulder gardens and other habitat features will be strategically placed within this basin prior to flooding to increase habitat value above current levels.

Habitat Replacement during Operations – There will be unavoidable loss of habitat during operations that will be difficult to completely compensate for with on-site options because of the size of impoundments behind the Vault, Goose Island and East dikes. This is only partially offset by the Goose Island finger dikes.

DFO and Azimuth have agreed that an "A" list and a "B" list of options should be developed. The A-list describes candidate on-site habitat compensation options. The B-list of compensation options proposed here focus on off-site compensation near Baker Lake as a contingency plan. B-list options would be explored if it becomes apparent that suitable A-list candidate options area will not provide adequate compensation.

Following is the list of candidate on-site compensation options that are proposed for evaluation during summer 2006 and in consultation with DFO and the Baker Lake HTO. Given that mine development will not affect project lakes for at least two years, there is time to assess and evaluate the proposed options to choose those that are best for this project. We would like to resolve this issue in 2006, following meetings with DFO and the HTO.

Table 1. On-Site Candidate Habitat Compensation Proposals ("A-List")

Candidate Compensation Option	Rationale and Advantages	Uncertainties
1) Improve connecting channel between Third Portage and Second Portage lakes to facilitate movement by fish, especially Arctic char.	Currently, movement by fish between 2PL and 3PL is difficult or impossible. The easternmost connecting channel will be modified to facilitate flow during dewatering and can be further modified to allow fish passage. Arctic char are two or three times more abundant in 2PL than 3PL. Increasing access by char from 2PL to 3PL may increase abundance of fish within this large lake without compromising abundance of lake trout because of the difference in diet. This may significantly add to productive capacity over the long-term.	It is uncertain how to measure the benefit over the long-term, especially in HUs. Opening up a 36 km^2 lake to more char will certainly be advantageous, although it may take many years for the full benefit of this effort to be realized. Like other compensation efforts, it is difficult to measure. DFO Science may have some perspective on this.
2) Develop shoal habitat in areas of Second or Third Portage Lake away from the mine site. A	Spawning or shallow foraging habitat can be created elsewhere in Second and/or Third Portage Lake that might increase productive capacity. Suitably sized gravel and cobble can be placed in moderate	Given that the lakes are not habitat limiting, the benefit of this kind of compensation is uncertain. Habitat will have to be destroyed or altered to

similar effort can be made in Wally Lake, although shoal habitat is less limiting here than in other lakes.	depths (6 – 8 m) to raise depth and improve habitat value (i.e., convert moderate to high value habitat). This can be done by truck during winter by dumping on the ice. An ancillary advantage is the subaqueous disposal of PAG materials, rather than on land.	increase its apparent value. This kind of mitigation could be quite costly, depending on the cost to crush and screen appropriately size materials, transport the materials and monitoring.
3) Improve connecting channels between project area lakes, specifically Wally – Drilltrail; Drilltrail – Second Portage; Turn Lake – Drilltrail Lake.	Some of the smaller lakes such as Drilltrail are relatively shallow and may be limited by overwintering habitat. Access to larger lakes such as Second Portage or Wally lakes may increase productive capacity of project area lakes.	It is uncertain if fish will move between lakes that currently have very poor connectivity. Difficult to measure the benefit of this in the long-term.
4) Create connecting channels where none currently exist.	Dogleg Lake contains an isolated fish population consisting only of lake trout. Creating an hydraulic connection capable of passing fish between Dogleg and Second Portage Lake may provide planktivorous species such as whitefish and char to move into this lake and increase biomass and productivity and provide an additional food source for lake trout. Similar investigations can be made for small isolated lakes in the Wally Lake drainage basin.	Uncertain if fish will move into Dogleg Lake and difficult to measure change in productive capacity. Care has to be taken when creating or enhancing channels to avoid exposing permafrost that could erode and introduce sediments.

In the event that on-site options are determined to have questionable or highly uncertain benefit, are not technically feasible, or prohibitively expensive, other off-site candidate options will be explored. These options will be investigated coincident with on-site options to assess all feasible options. The Baker Lake HTO will have to become formally involved in efforts to identify suitable areas that have good potential to increase local/regional benefits to fish populations.

Individual village elders were asked a series of questions in summer 2005 pertaining to the all-weather road and to identify areas they are familiar with that could be improved from a habitat perspective (Appendix C). None of the individuals interviewed could identify specific habitats or areas that could be enhanced (Traditional Ecological Knowledge report, 2005). However, as this is a relatively new concept for the local people, this issue will be pursued further in summer 2006. A combination of interviews and field surveys of popular fishing spots will be undertaken to visit specific areas and assess the potential for improvements to local fisheries. These options may provide greater long-term benefits to local people.

A list of candidate off-site options that will be investigated with DFO and the Baker Lake HTO are as follows:

Table 2. Off-Site Candidate Habitat Compensation Options ("B-List")

Candidate Compensation Option	Rationale and Advantages	Uncertainties
1) East of town there is a stream with a hanging culvert that prevents upstream movement by fish.	Repairing or replacing this culvert will have direct benefits in providing opportunities for up- or downstream movements by fish.	The importance of this stream to local fish populations is unknown.
2) Raw sewage is currently being dumped into a fish-bearing stream (R01). Treating the sewage or creating a holding pond away from the stream will reduce impacts.	Eliminating the direct impacts of sewage dumping to the stream will increase productive capacity of the stream. Primary treatment of creation of an off-channel holding pond would eliminate the direct impact, yet still contribute nutrients to the system.	Productive capacity of the stream in the absence of nutrients from sewage disposal is unknown.
3) Improve connecting channels between Prince River or Thelon River and tributary streams or off channel lakes.	If certain streams or lakes can be identified that have few fish or landlocked char populations and currently suffer from poor connectivity, productivity of such systems can be increased.	It is unknown if such systems exist on the Prince or Thelon rivers in the vicinity of Baker Lake. If opportunities lie too far way, it would be costly and of questionable benefit to undertake such options.
4) Construct a causeway into Baker Lake to provide a breakwater and spawning/rearing shoal and habitat.	Given the exposed nature of this coastline and the lack of complex habitat along the northern shoreline of Baker Lake, breakwaters or shoals created in water of intermediate depth (< 8 m) might provide spawning, rearing and foraging habitat for several species, including trout, char and whitefish.	Difficult to quantify or measure increase in productive capacity as habitat limiting features of Baker Lake are unknown.
5) Investigate potential of creating pit lakes from quarries along the all-weather road.	Creating pit lakes could increase productive capacity of lake systems along the all-weather road.	Pits would be very nutrient poor and have limited watersheds, making connectivity with adjacent lakes or stream difficult. Given the low runoff, movement of fish between pits and adjacent waterbodies would be difficult.
6) Determine if there are known areas where Arctic char spawn within the Prince/Thelon rivers and attempt enhancement.	Increasing spawning habitat, which may be limiting for char, will increase productive capacity in this region.	It is not known if local knowledge of spawning areas of char exists.

Adaptive Management – Throughout various documents supporting the Environmental Impact Assessment it is stated that the principles of *adaptive management* will be applied to optimize mitigation and compensation measures. At this time, it cannot be foreseen which of the above compensations measures will bear the most fruit, the fruit being increased productive capacity of fish habitat. It remains to be seen which options are most likely to increase the productive capacity based on activity at other northern mines. This is perhaps the best way to quickly identify those options that have the greatest likelihood of success or how they can be adapted to increase likelihood of success at Meadowbank. Notwithstanding this, we acknowledge that DFO is seeking some assurance that more than one compensation option is explored, to avoid placing all of one's eggs in the same basket.

We view this exercise as an iterative process. DFO suggests that candidate options be tested on a small scale. This can be done. The selection of the candidate options with the greatest likelihood of success will benefit this approach, based on a preliminary assessment and on the expertise of DFO Science Division. We also recognize the limitations and risks inherent in each of the compensation options listed above and appreciate the concerns of DFO. That being said, it is difficult at this time to identify specific candidate options that are most likely to be chosen for further evaluation. This is best done once reconnaissance studies are conducted in 2006 and in consultation with stakeholders, in particular DFO, Baker Lake and possibly the KIA.

Cumberland Resources is committed to identifying those options with the greatest likelihood of success and with the greatest potential benefit to fish or fisheries targeted by Baker Lake residents. We envisage this process as organic, with input from important stakeholders throughout the process. Fortunately we have at least a two-year window to conduct a proper assessment of candidate options and to learn from other experiences in the north before selecting a suite of compensation options specific to Meadowbank. Monitoring programs will be designed and developed with input from DFO to ensure that quantifiable goals of productive capacity can be measured and met. If it is determined that adaptations to a particular enhancement must be made mid-stream then this will be done, as per adaptive management principles.

We also appreciate that DFO may be seeking a more definitive approach at this time. However, given the uncertainty that exists with respect to habitat enhancement initiatives in Arctic lakes, it would be premature to presume that we can assemble a definitive plan without consulting other stakeholders. Careful evaluation of "A" and "B" list options over the next year or so will greatly assist in narrowing down those options considered for implementation if and when Meadowbank is developed. Rest assured that Azimuth and Cumberland are committed to working with DFO to identify habitat compensation options that satisfy the goals of No Net Loss of habitat while balancing the reality that the techniques to achieve no net loss in Arctic lakes is in its infancy and a great deal is yet to be learned.

APPENDIX A

GOLDER MEMO – Phaser Lake Compensation Option - Sent Separately; Under revised plan this is redundant

APPENDIX B

Cross-Section and Plan View Diagrams of AWR Bridge Crossings (see AWPAR NNLP)

APPENDIX C

Questionnaire Posed to Baker Lake Elders, Summer 2005

Figure 4.3: List of Questions Used as Guidelines during the 2005 Phase 3 Interviews

1. Did you ever live somewhere along this new proposed road access?

2. Do you do hunting around this area?

3. (a) Do you take this route when you are going hunting in the summer time and how far do you go?

   (b) What about in the winter time, how far do you go?

5. What was the route for migrating caribou?

6. Did you cache meat for the winter along this route?

7. When do people fish, how many fish of different species do people normally get?

8. What kinds of fish do you prefer when you go fishing?

9. What lakes do people fish at along the road to camp?

10. Show me on the map where you fished near lakes along the road?

11. Are people aware of any streams or rivers near the proposed road of Baker Lake that they know fish move or migrate in? (Whether you fish or not, this is important to understand what the impact of a road crossing on a stream might be).

12. Can you identify any lake, river, or stream near the community that you feel can be improved for fish?

13. Do you know of a lake that cannot be accessed by Arctic char moving upstream from Baker Lake because of a blockage or something else?

14. Are there areas you are aware of where Arctic char used to go to spawn or overwinter, but now cannot? Do you know why?

15. Are there any stream blockages along the road on the way to Prince River?

16. Where do graylings spawn?

17.. Do you know if there are any areas or islands where large numbers of geese or other birds nest along this route?

18. Do you collect eggs from this area on regular basis?

19. Can you tell me if there are any archaeological sites along this route?

20. What can you tell me about graves in the area?

21. What can you tell me about sites of spiritual significance or special sites in the area?

22. Do you have a cabin near or along this route where you normally go to in the spring and summer time?

23. How do you feel about a gravel road from Baker Lake to the camp?

24. Will the gravel road have any negative effects on the caribou? Will there be too much hunting?

25. How can we do better in doing wildlife surveys?

26. Is there anything I missed that you would like to add?

27. I have no more questions. Thank - you for your time.

APPENDIX C

Habitat Compensation Options

APPENDIX C

MEADOWBANK GOLD PROJECT

HABITAT COMPENSATION OPTIONS

NOVEMBER 2006

TABLE OF CONTENTS

SECTION 1 • CANDIDATE HABITAT COMPENSATION OPTIONS INVESTIGATION

1.1 BACKGROUND

Construction and operation of the Meadowbank Gold mine requires that parts of three lakes be diked and drained of water. Given the magnitude of disturbance to the affected waterbodies, this will cause an unavoidable HADD of fish habitat that cannot be completely compensated for during mine operations. Comprehensive compensation for lost habitat can only be achieved after mine operations have ceased and post-closure compensation measures have been implemented.

The sections below describe the candidate on-site compensation plans to compensate for habitat loss during mine operations and at post-closure, respectively as agreed to with FOC. During a meeting on 10 February 2006 (See 6 March 2006 Technical Memorandum to FOC; Appendix B) Azimuth agreed to investigate a list of candidate options during 2006. This section reports on results of the investigation of these habitat compensation options outlined in the aforementioned memo to FOC.

It was agreed that an “A” list and a “B” list of options would be investigated. The A-list describes candidate on-site habitat compensation options. The B-list focuses on off-site compensation options near Baker Lake as a contingency plan, in the event that viable on-site compensation options are deemed unfeasible.

On-site candidate habitat compensation options included the following:

- Improve connecting channel between Third Portage and Second Portage lakes to facilitate movement by fish between the lakes, especially Arctic char.
- Develop shoal habitat in areas of Second or Third Portage lakes away from the mine site. A similar effort can be made in Wally Lake, although shoal habitat is much less limiting in this lake than in other lakes.
- Improve connecting channels between project area lakes, specifically Wally to Drilltrail; Drilltrail to Second Portage; and Turn to Drilltrail.
- Create connecting channels between lakes where none currently exist (e.g., Dogleg to Second Portage; unnamed lakes to Wally Lake, unnamed lake to Tehek Lake).

- Off-site candidate compensation options included the following:
- East of town there is an unnamed stream with a hanging culvert that prevents upstream movement by fish. This stream drains Airplane Lake.
- Halt dumping of raw sewage to the small stream west of Baker Lake that ultimately feeds Airplane Lake.
- Improve connecting channels between Prince River or Thelon River and tributary streams or off channel lakes.

- Construct a causeway into Baker Lake to provide a breakwater and spawning/rearing shoal and habitat for lake trout, whitefish, and char.
- Investigate potential of creating pit lakes from quarries along the all-weather road.
- Determine if there are known areas where Arctic char spawn within the Prince/Thelon rivers and attempt enhancement.

The following sections describe our assessment of on-site and off-site habitat compensation options from 2006 field investigations.

1.2 ON-SITE HABITAT COMPENSATION OPTIONS

1.2.1 Portage Lakes Connecting Channel Improvement

Construction of the Goose Island and East dikes will eliminate the westernmost of the three channels that connect Second and Third Portage lakes. Based on several years of monitoring (BAEAR, 2005), the number of fish moving between these two lakes is very low because of shallow water, boulder substrate, and a lack of motivation by fish to move between lakes. Shallow water depth within nearly all channels prevents movement by fish except perhaps during peak freshet. Detailed engineering design will determine whether the easternmost connecting channel needs be modified to accommodate the annual discharge in the absence of the easternmost channel. However, there is considerable redundancy in discharge capacity from Third Portage Lake and modifications may not be necessary. Conditions for fish passage may improve because of increased water movement through the remaining channels. It is debatable whether facilitating movement of fish betweens lakes would constitute an increase in productive habitat.

Our rationale for this option is as follows: historic fisheries studies indicate that the relative and absolute abundance of Arctic char is lower in Second Portage Lake than in Third Portage Lake. If landlocked char can be encouraged to move from Second Portage Lake into Third Portage Lake, it may be that the total abundance of fish in Third Portage can be increased. We hypothesize that char could take advantage of the underutilized biomass of zooplankton in the project lakes (BAEAR, 2005). Landlocked Arctic char within the project and reference lakes can grow very large (up to 6 kg). We believe that once char reach this large size they are no longer vulnerable to predation by large lake trout. Large char can take advantage of open water profundal habitat in the mid-water column where risk of predation is low and an abundant food source of zooplankton exists. Other species, such as whitefish, are more vulnerable to predation from lake trout in open water and this habitat is probably underutilized.

Increasing abundance of char in Third Portage Lake may significantly add to productive capacity over the long-term. However, detecting the benefit of this during operation is unlikely. Because of our difficulty in measuring increased productive capacity and the lengthy time required to realize the benefit, this option has a **low** likelihood of benefit during operations. However, the true benefit of this option may be significant and positive in the long-term but very difficult to measure and quantify.

1.2.2 Creation of Artificial Shoal Habitat

Shoal habitat can be created elsewhere in Second and Third Portage lakes, away from the mine site. A similar effort can be made in Wally Lake, although shoal habitat is not limiting here and further pursuit of this option is not recommended. Suitably sized cobble and rock can be placed in moderate depths (8 to 10 m) to raise depth by about 4 m and improve habitat value (i.e., convert low or moderate to high value habitat). This can be done by truck during winter by dumping waste rock on the ice. Once the ice melts, the material would fall through the water column to fill a depression and build a reef over the original lake bottom. However, there are several drawbacks to this:

- Habitat in the remaining lake is not limiting and the benefit of this kind of compensation is uncertain and has not been proven elsewhere.
- Technical challenges in dropping the material over the correct place.
- Safety issues, such as a truck falling through the ice, must be considered when end-dumping rock.
- Habitat will have to be destroyed or altered to increase its apparent value. This kind of mitigation could be quite costly, depending on the cost to crush and screen appropriately sized materials, transport the materials, and long-term monitoring.
- Short-term impacts to water quality that cannot be controlled will occur from fine sediments being introduced into the water column.
- A very high cost may be associated with this exercise that is difficult to justify. For each net gain of 7 habitat units covering only one hectare, at least 50,000 m^3 of material would have to be placed on the lake bottom (assuming a 5 m decrease in depth).

This option has large technical and safety challenges and would have a great cost relative to the amount of habitat created. This option has a **negligible** benefit of success during mine operations and is not recommended.

1.2.3 Improve Project Lake Connecting Channels

Modifications to existing connecting channels between lakes are unlikely to provide significant benefits to local fish populations as no additional habitat is actually created. The dominant fish species in all of the project lakes is lake trout. This species is non-migratory and is not strongly motivated to move between lakes, even between lakes that have excellent hydraulic connectivity – such as between Tehek and Second Portage lakes (BAEAR, 2005). Several years of study have failed to demonstrate that lake trout, or indeed any other species, moves between lakes except on a very occasional basis, even when there is a good hydraulic connection.

All connecting channels between lakes are shallow, fairly wide, and very rocky with the majority of flow moving beneath and between large boulders, even during freshet. Because of the headwater nature of all of these lakes, discharge is low and adequate flow for fish passage either does not exist or is limited to a brief period during spring freshet. There are also technical issues to overcome such as deepening the channel without lowering the inverse elevation causing a drop in upstream water level, and not exposing permafrost that would cause erosion and sedimentation. Again, the dominant species is lake trout and they not motivated to move between lakes because there is no reason to do so.

This option has a **negligible** benefit of success during mine operations and is not recommended.

1.2.4 Create New Connecting Channels

The creation of new connecting channels between lakes where impassable channels currently exist was evaluated in summer 2006 at six locations (see Figure 5.1 of the main report):

- Two small lakes discharging to the northwest of Wally Lake (WAL-1 and -2) – These boulder dominated channels connect two unnamed lakes to the northwest side of Wally Lake. Connectivity of channels is low or nil during open water season and freshet and both channels provide poor value habitat with large boulder barriers. Alterations should not be considered at these channels.
- Large unnamed lake due east of Wally Lake (WAL-3) – Channel length is approximately 20 m with boulder and cobble dominated substrate with small portions of gravel. No pools were visible with riffle portions observed between exposed boulders. It is likely habitat for slimy sculpin and may allow fish to pass between lakes. Selective removal of boulders would improve connectivity and fish passage during freshet and possibly during summer.
- Small unnamed lake discharging to Drilltrail Lake from the east (DT-1) – A boulder field separates Drilltrail from this small lake. No connectivity was observed and we do not believe that fish passage would be possible even with channel alterations because of low flow.
- Dogleg Lake (NP-1) to Second Portage Lake (DL-1) – A long rocky channel with some elevation difference connects Dogleg to Second Portage Lake northeast of the planned East dike. There is insufficient surface water flow over a channel that is too long to consider improving the hydraulic connection between the two lakes. A fisheries investigation in 2004 revealed a healthy population of lake trout and round whitefish in Dogleg, so improving the connection between the two lakes would be of minor or negligible benefit.

Large unnamed lake discharging to Tehek Lake (TE-1) – This channel connects a moderate size lake on the north east side of Tehek with probable foraging and overwintering habitat. The channel is predominantly boulder with small pools, runs and riffles. Channel depth is adequate and would probably allow for dominant species to move between the lakes without improvements to the channel. Slimy sculpin were observed in the channel. Channel alterations may improve fish passage opportunities during freshet and the open water season.

Most of the channels considered for improvement connect relatively small lakes to larger lakes. All of the waterbodies have very small watershed areas, thus discharge volume is very low and insufficient to support fish movements, even if there was an unobstructed hydraulic connection. Cost and technical challenges associated with channel deepening to prevent erosion of permafrost are also difficult to justify given the very small accrual of fish habitat. Larger lakes also have their own fish populations, thus whether a net gain is realized is also doubtful. If small lakes do not have overwintering habitat, and assuming that fish were so motivated and could gain access to a small lake, they would be trapped in the lake and would likely die during winter because of insufficient water depth and oxygen. Thus there is a risk that the lakes would become a trap and detract from productive capacity of habitat. This option has **negligible** benefit and is not recommended.

1.3 OFF-SITE HABITAT COMPENSATION OPTIONS

1.3.1 Hanging Culvert near Baker Lake

There is a hanging culvert running beneath the Prince River road east of Baker Lake that leads to the town dump. This culvert passes a stream beneath the road that drains Airplane Lake, which is the recipient of sewage discharged to a stream upstream of the lake. Downstream of the culvert the stream has a very steep gradient and has a very high discharge and flow velocity during freshet. It is unlikely that fish from Baker Lake are able to access the culvert because of steep slope and high velocity and deepening or installing a larger culvert may not be the limiting factor to allow fish to access Airplane Lake. Furthermore, we have heard reports that Airplane Lake is contaminated (presumably by sewage and other wastes) and it is probably not desirable to provide access by fish from Baker Lake to this lake. This option has **negligible** benefit and is not recommended.

1.3.2 Halt Sewage Disposal

Northeast of the Hamlet of Baker Lake raw sewage is dumped onto the foreshore of a pond. This pond drains to Airplane Lake and ultimately discharges to Baker Lake via the aforementioned culvert, beneath the road to the town dump. It is presumed that fish do (or did) exist in Airplane Lake and the small tributary streams that discharge to it. Although the practice of dumping raw sewage should be halted, this option is not within the purview of Cumberland Resources responsibility and is not considered further.

1.3.3 Improve Tributary Stream Connections to Prince & Thelon Rivers

On 11 July 2006 the Prince River was surveyed between its mouth at Baker Lake and upstream to the Majuqtuqsiurvik rapids, a popular fishing spot for residents of Baker Lake. The Prince River drains the Whitehills Lake watershed and is a large, well-confined river with sufficient flow during the entire open water period to allow fish movements throughout its length. Numerous riffle/rapid sections separated by wide, diffuse boulder channel runs typify the river. The river channel undulates between small hills through tundra habitat northeast of Baker Lake as it runs in a southeast direction towards Baker Lake, entering the lake about 8 km east of the Hamlet. There is unrestricted access to the river system by fish from Baker Lake including lake trout, Artic char, round whitefish, and possibly lake cisco and Arctic grayling.

South of the Majuqtuqsiurvik rapids there are no large tributary streams or lake systems that enter the Prince River that might provide off-channel overwintering habitat for fish, particularly Arctic char. We did not identify any deficiencies in habitat or in connectivity to off-channel areas that would be suitable candidates for off-site habitat compensation. Furthermore, we did not identify any impassable barriers to fish migration along the mainstem of the river.

The Thelon River is a very large river that has no off-channel habitat, tributary streams, or off-channel lakes within tens of kilometers of its mouth at Baker Lake. It would be logistically very difficult and expensive with uncertain benefits to local residents to attempt any such habitat enhancement. We could not identify any obvious location to attempt this.

Notwithstanding the cost and logistical difficulties in working in pristine areas so far away from Baker Lake, it would be tremendously difficult to determine whether or not the habitat enhancement measures undertaken would be effective at increasing productive capacity. This option has **negligible** benefit and is not recommended.

1.3.4 Baker Lake Causeway

Fish habitat along the northern shoreline of Baker Lake east of the community consists of sloping gravel cobble substrate that gradually extends into the lake with no significant diversity features. Constructing a submerged causeway into the lake, perpendicular to shore, would increase surface area, complexity, and habitat diversity in an otherwise uniform environment.

A similar issue exists in Baker Lake as in the project lakes. That is, this large, ultra-oligotrophic lake is not habitat limited (BAEAR, 2005). Therefore, constructing a causeway into Baker Lake may not result in increased productive capacity of habitat in Baker Lake.

A large difficulty to overcome with this option is the navigation hazard that a causeway will present. This is especially problematic with the increased number of barges, some carrying hazardous goods that will be transporting materials to the marshalling area to support the mine. To minimize or eliminate the navigational hazard that a causeway may pose, it would have to be installed in water that is too deep to provide useful habitat for fish. Given this situation, this option also has **negligible** benefit and is not recommended.

1.3.5 Create Pit Lakes from AWPAR Quarries

New lake habitat cannot be created from the 10 candidate quarries that are situated along the proposed all-weather road between Baker Lake and the Meadowbank camp. According to the construction plan for the quarries along the proposed AWR, all of the quarries are situated on high ground and away from nearby waterbodies. Furthermore, the depth of each quarry is expected to be quite shallow, no more than 2 to 3 m deep. Even if the quarry was situated near a waterbody and could be filled, depth would be insufficient to support overwintering by fish. Given these logistical difficulties, this option has **nil** benefit and is not recommended.

1.3.6 Identify Spawning Areas on the Prince/Thelon Rivers

There is no anecdotal or formal traditional knowledge that indicates if local elders or hunters are familiar with spawning areas by fish within the Thelon and Prince rivers. Because the Baker Lake people have targeted caribou as a principal food source, less is known about fish spawning areas. Results from a questionnaire posed to elders asked to relate details about fisheries resources did not yield site-specific information related to habitat utilization by fish. In the absence of this information, it would be very difficult to determine where char might spawn in these rivers, if they do so at all. Given the lack of traditional knowledge about spawning areas, uncertainty about habitat quality, and the uncertain benefits to local people, this off-site compensation option has a **negligible** benefit and is not recommended.

1.4 SUMMARY

None of the habitat enhancement options evaluated were deemed to effectively offset the net loss of productivity during the mine operation stage. Significant, but long-term and difficult-to-measure benefits may accrue to productive capacity in Third Portage Lake if a larger population of Arctic char can be established by improving the connecting channel between Second Portage and Third Portage lakes.

Given the lack of viable habitat compensation alternatives, we have refocused our efforts on optimizing enhancement opportunities directly associated with mine-related activities. Indeed, the proposed revisions to the draft NNLP during the past year have resulted in significant improvements to on-site habitat creation during the operations period. An important new development is submerging the Goose Island finger dikes entirely below the water surface (-3 m) to approximately double HUs during operation. Key components of the habitat enhancement strategy for the Meadowbank project are described in sections 5.4 and 5.5 of the main document for the operations and post-closure periods, respectively.