Appendix V5-6V

Conceptual Freshwater Fisheries Offsetting Approach for Phase 2

Memorandum

Date: December 20, 2016

To: John Roberts and Oliver Curran; TMAC Resources Inc.

From: Kathryn Kuchapski and Michael McGurk; ERM Consultants Canada Ltd.

Subject: **Conceptual Freshwater Fisheries Offsetting Approach for Phase 2**

The purpose of this memorandum is to identify a procedural framework and potential offset options for completing a Freshwater Fisheries Offsetting Plan, if deemed necessary by Fisheries and Oceans Canada (DFO), for the Phase 2 Project.

1. INTRODUCTION

Three mechanisms of fish habitat loss may result from Phase 2 Project activities:

- Habitat loss in streams and lakes resulting from water withdrawal, specifically reduced discharge in lake outflow streams and reduced lake surface elevation.
- Habitat loss in lakes at the locations of water intakes and discharge pipelines, specifically the area below the high water mark that may be lost to (underlie) this infrastructure.
- Habitat loss at road crossings of fish-bearing streams, specifically the areas under culverts or bridge support structures.

As a consequence, fish habitat and fish populations may be adversely impacted in affected waterbodies resulting in the potential for *serious harm* to fisheries productivity. According to the *Fisheries Protection Policy Statement* (DFO 2013a), if a project is likely to cause *serious harm to fish* after the application of avoidance and mitigation measures, then the proponent must develop a plan to undertake offsetting measures to counterbalance the unavoidable residual *serious harm* to fish. These offsetting measures, also known as offsets, are implemented with the goal of maintaining or improving the productivity of commercial, recreational or Aboriginal (CRA) fisheries (DFO 2013b).

2. REGULATORY AND POLICY FRAMEWORK

The *Fisheries Protection Policy Statement* (DFO 2013a) supports the 2012 updates made to the *Fisheries Act*. The *Fisheries Protection Policy Statement* replaces Fisheries and Oceans Canada's (DFO) no net loss guiding principle for fish habitat within the *Policy for the Management of Fish Habitat* (DFO 1991). The changes to the *Fisheries Act* include a prohibition against causing *serious harm to fish* that are part of, or support, a CRA fishery (section 35 of the *Fisheries Act*); provisions for flow and passage (sections 20 and 21 of the *Fisheries Act*); and a framework for regulatory decision-making (sections 6 and 6.1 of the *Fisheries Act*). These provisions guide the Minister's decision-making process in order to provide for sustainable and productive fisheries.

The amendments center on the prohibition against *serious harm to fish* and apply to fish and fish habitat that are part of or support CRA fisheries. Proponents are responsible for avoiding and mitigating *serious harm to fish* that form part of or support CRA fisheries. When proponents are unable to completely avoid or mitigate *serious harm to fish*, their projects will normally require authorization under subsection 35(2) of the *Fisheries Act* in order for the project to proceed without contravening the Act.

DFO interprets *serious harm to fish* as:

- The death of fish.
- A permanent alteration to fish habitat of a spatial scale, duration, or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, nursery, rearing, food supply areas, migration corridors, or any other area in order to carry out one or more of their life processes. The destruction of fish habitat of a spatial scale, duration, or intensity that results in fish no longer being able to rely on such habitats for use as spawning grounds, nursery, rearing, food supply areas, migration corridor, or any other area in order to carry out one or more of their life processes.

After efforts have been made to avoid and mitigate impacts, any residual *serious harm to fish* is required to be offset. An offset measure is one that counterbalances unavoidable *serious harm to fish* resulting from a project with the goal of maintaining or improving the productivity of the CRA fishery. Where possible, offset measures should support available fisheries' management objectives and local restoration priorities.

3. FISHERIES OFFSETTING APPROACH

A procedural approach is proposed for developing a Freshwater Fisheries Offsetting Plan (the Offsetting Plan) for Phase 2, if deemed necessary by DFO. This approach is proposed to satisfy the *Fisheries Protection Policy Statement* (DFO 2013a) and the federal *Fisheries Act*, and to allow for flexibility in finding a solution to offsetting Project-related effects.

The proposed approach for the development of an Offsetting Plan is identified below and will be discussed in the following five sections:

- Assessment of fish habitat;
- Assessment of fish populations and their abundance;
- Habitat evaluation procedure;
- Identification of offsetting options; and
- Assessment of offsetting options.

The proposed approach was developed based upon the guidance provided in the *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (DFO 2013b). The approach was also based upon the review of existing fisheries and fish habitat information for Phase 2. Based upon this review a number of preliminary offsetting options were identified and are discussed in the following sections.

The *Fisheries Protection Policy Statement* (DFO 2013a), the *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (DFO 2013b), and the federal *Fisheries Act* refer to fish productivity as the metric for offsetting. Since fish productivity, defined as the number of kilograms of fish tissue estimated per m^2 of stream habitat or per hectare of lake habitat per year, is difficult to measure in practice, fish habitat continues to be used as a practical surrogate for productivity.

3.1 Assessment of Fish Habitat

The first step in developing an offsetting plan is to quantify the amount and quality of habitat that will be lost to development after avoidance and mitigation measures have been applied. Avoidance and mitigation measures are planned during Phase 2 activities such that potential serious harm through habitat loss will be minimized. These measures include mitigation by design, best management practices (including DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat*; DFO 2013c), monitoring, and adaptive management (Volume 5, Section 6.5.3 in TMAC 2016).

Habitat data will form the basis of quantifying the potential serious harm to fisheries required to be offset, validate the habitat-based approach to offsetting, and support future monitoring (a federal requirement of Offsetting Plans). Streams and lakes are treated separately because different methods are used to measure habitat in streams than in lakes.

A large database on fish habitat currently exists for streams and lakes of the Hope Bay Greenstone Belt. Surveys of fish populations and fish habitat began in 1993 and continued to 2016. Surveys were conducted in 22 of those 24 years; no surveys were conducted in the years 1999 and 2001. Information collected from 1993 to 2008 was used for planning, permitting, and development at Doris. Sampling covered the Doris area, the Madrid and Boston areas, and selected lakes and streams outside the Project Development Area (PDA) such as the Roberts drainage and Reference Lakes A, B, C, and D and their inflow and outflow streams. Baseline aquatic studies for Phase 2 were conducted in 2009 and 2010. Additional studies in support of the Doris Aquatic Effects Monitoring Program (AEMP) and other environmental compliance programs were conducted from 2010 to 2016. In 2016, a reconnaissance program looking for potential offsetting sites was completed. Although focused on Doris, this baseline information is relevant to Phase 2.

3.1.1 Streams

From 1993 to 2016, multiple fish habitat survey methods were conducted on streams, as follows:

- Aerial surveys by helicopter (41 streams from 1995 to 2006);
- Reconnaissance surveys on foot (14 streams from 1995 to 2016);
- Habitat assessment (45 streams from 1995 to 2016);
- Fish Habitat Assessment Procedure (FHAP; Johnston and Slaney (1996); 56 streams from 2009 to 2016); and

- Sensitive Habitat Inventory Mapping (SHIM; Mason and Knight 2001; 23 streams in 2010).

All of the data collected by these methods was geo-referenced and is useful in assessing the quantity and quality of fish habitat. However, data collected using FHAP and SHIM will be most relevant to quantifying stream habitat because both methods divide streams up into habitat units (pools, riffles, glides, and cascades), provide areas (in m^2) for each unit, and characterize the quality of fish habitat in each habitat unit as good, fair, poor, or none. FHAP was applied to discrete sections of streams under the assumption that data collected in one or more sections could be extrapolated over an entire stream. In contrast, SHIM was applied to the whole lengths of streams.

Incremental changes in the Phase 2 Project have occurred since these surveys were conducted, potentially resulting in additional habitat surveys required to provide complete coverage of all streams that may either be affected by Phase 2 development or be used for offsetting projects. In addition, potential changes in stream depth and width resulting from Phase 2 activities will have to be modelled to predict Project-related effects on fish habitat resulting from decreased discharge at lake outflows.

3.1.2 Lakes

From 1993 to 2015, multiple fish habitat survey methods were conducted in lakes and ponds, as follows:

- Aerial surveys by helicopter (3 lakes from 1995 to 2006);
- Reconnaissance surveys of the shorelines and littoral zones on foot or by small boat (24 lakes from 1995 to 2014);
- Bathymetric surveys using hydroacoustic methods (16 lakes from 1993 to 2010);
- Habitat assessment of littoral zones (20 lakes and 26 ponds from 1995 to 2015);
- Estimation of surface area and maximum depth of small headwater lakes of the Roberts Watershed (20 lakes in 2006);
- Snorkel surveys of littoral lake habitat of Windy Lake from 2010 to 2014; and
- Hydroacoustic and underwater video surveys of deep-water lake substrate (3 lakes from 2009 to 2010).

As with stream data, all lake data is geo-referenced and is useful for assessing the quantity and quality of fish habitat in lakes. The major changes in lake habitat that are anticipated with Phase 2 are potential changes in lake volume and surface elevation due to water withdrawals. The area of habitat that will be gained or lost in each affected lake as a result of withdrawals will be modelled and the quality of that habitat will be assigned based on available baseline data.

Should there be a need to calculate the depths and areas of habitat features of special concern such as shoals on which Lake Trout spawn, then specific surveys using hydroacoustic equipment and/or video cameras may be required.

3.2 Assessment of Fish Populations and Their Abundance

An associated step in developing an offsetting plan is to map the distribution of fish species across the landscape and assess the relative or absolute numbers of fish in specific streams and lakes. Information on fish habitat alone is not sufficient for development of an offsetting plan because some fish species such as Arctic Char and Lake Trout have higher cultural value than other species because they are prized as food fish. Also, productivity varies among fish species due to variation in growth and reproduction. Therefore, habitat quantity and quality must also be linked to the distribution of fish species across the landscape and to the abundance of fish species. As with habitat, streams and lakes are treated separately because different methods are used to measure fish population abundance in streams than in lakes. However, an offsetting plan will combine these data sets for species with anadromous or adfluvial life histories.

From 1993 to 2016, fish communities of streams and lakes of the Hope Bay Belt were sampled using eight fishing methods, as follows:

- Backpack electrofishing in streams and along the shorelines of lakes (106 streams, 26 lakes, and 18 ponds from 1993 to 2016);
- Minnow traps in streams and ponds and along the shorelines of lakes (24 streams, 28 lakes, and 24 ponds from 1994 to 2016);
- Gillnets in lakes, ponds, and large streams (3 streams and 40 lakes from 1993 to 2015).
- Angling in lakes and large streams (5 streams and 18 lakes from 1995 to 2015);
- Beach seining on lake shorelines and large streams (4 streams and 16 lakes from 1996 to 2008);
- Fyke nets in lakes and large streams (4 streams and 9 lakes from 2002 to 2012);
- Fish fence on Roberts Outflow or Little Roberts Outflow from 2002 to 2015; and
- Hydroacoustic techniques to estimate number and density of fish in lakes (3 lakes from 2009 to 2015).

The extensive fish sampling provides a large database from which the spatial distribution of fish presence in freshwater systems of the Hope Bay Belt has been mapped (Figures 6.2-16 and 6.2-17 in Volume 5, Section 6, TMAC 2016).

These data have also allowed an assessment of the relative abundance of each species among streams and lakes, and estimates of absolute numbers of fish and their densities (number/m^2 for streams and number/ha for lakes) for a subset of those waterbodies. More surveys of fish abundance in some streams, particularly potential offsetting sites, may be required for development of an offsetting plan.

3.2.1 Streams

A total of fourteen species of fish were captured in the freshwater stream and river samples: Ninespine Stickleback, Lake Trout, Lake Whitefish, Cisco, Arctic Char, Least Cisco, Arctic Grayling, Broad Whitefish, Slimy Sculpin, Burbot, Arctic Flounder, Fourhorn Sculpin, Greenland

Cod, and Starry Flounder. The latter four species reside in the sea, but are able to tolerate brackish water and move short distances up rivers and streams. Arctic Flounder, Fourhorn Sculpin, and Greenland Cod were found in the Koignuk River and Arctic Flounder and Fourhorn Sculpin were found in Little Roberts Outflow. Starry Flounder was found in Glenn Outflow; each of these waterbodies are connected directly to the ocean. None of the species captured are designated as threatened or endangered by COSEWIC or listed through the *Species at Risk Act* (2002).

Backpack electrofishing was the predominant method of sampling fish populations in streams of the Hope Bay Belt over the last 23 years, followed by minnow traps. The other five methods were used on only a few large streams.

Two types of electrofishing surveys were used. Reconnaissance-level electrofishing was used to sample the fish community and estimate catch-per-unit-effort (CPUE, number of fish per electrofishing second) that could be compared among streams. Elevated variability is associated with these CPUE estimates because the surveyed stream section was not usually blocked off with nets, thereby allowing fish to leave and enter the section during sampling. Also, only one pass of the section was usually conducted. This methodology allows rapid reconnaissance-level screening of streams for comparison to other streams surveyed with the same methodology, but cannot be used as a direct estimate of fish community productivity.

The three-pass electrofishing method employed blocking nets and used the depletion method to provide estimates of absolute fish number (with confidence limits). Fish numbers can be converted to fish densities (number/m^2) by dividing number by the survey area. This method is standard for quantitative fish studies in small streams (Johnston et al. 2007). The three-pass method was done on fewer streams than the reconnaissance-level method because it requires more time and effort to conduct.

Electrofishing CPUE and density are measures of standing stock, the abundance of fish at a particular time and place, rather than of productivity. Also, since all streams in the Hope Bay Belt freeze to the bottom in winter, they are estimates of standing stock during summer and of a fish community dominated by juveniles. However, they are valuable for the purpose of developing an offsetting plan because standing stock is assumed to vary directly with habitat quality; good habitat is assumed to support more fish than poor habitat, assuming other factors such as distance to overwintering or spawning habitats are equal. In this way, electrofishing CPUE and densities can confirm assessments of fish habitat quality. A statistical comparison of electrofishing CPUE and densities with habitat quality should be part of the background support for the offsetting plan. A comparison of electrofishing CPUE and densities with minnow trap CPUE for streams in which both methods were used should also be part of the background support.

Extrapolating estimates of CPUE or density from a few sampling sites over an entire stream can only be done if a sufficient number of sites over a broad range of habitat quality were sampled because within a stream there is typically high spatial variation in fish abundance due to spawning distribution, geomorphic influences (Kruse et al. 1997), habitat variability (Newman and Waters 1989), and species competition (Bohlin 1978). Therefore, to develop the offsetting plan additional three-pass electrofishing surveys may be required for some streams potentially affected by Phase 2 activities or assessed as potential offsetting habitat for which no electrofishing has been conducted, for which only reconnaissance-level data are available, or for streams in which the spatial coverage by three-pass sampling is judged to be inadequate.

3.2.2 Lakes

A total of nine species of fish were captured in the freshwater lake samples. The species, in descending order of common occurrence is: Ninespine Stickleback (captured in 63% of lakes), Lake Trout (46%), Lake Whitefish (33%), Cisco (33%), Arctic Char (24%), Least Cisco (19%), Arctic Grayling (7%), Broad Whitefish (7%), and Slimy Sculpin (7%). None are designated as threatened or endangered by COSEWIC or listed through the *Species at Risk Act* (2002).

Gillnets were the predominant method of sampling fish populations of lakes in the Hope Bay belt (40 lakes), followed by minnow traps (28 lakes), shoreline electrofishing (26 lakes), angling (18 lakes), beach seining (16 lakes), fyke nets (9 lakes), and hydroacoustic methods (3 lakes).

Gillnet CPUE (number of fish/100 m^2 of net/hour fishing) provides an estimate of relative abundance of lake-resident fish, although comparisons among lakes are complicated by the different mesh sizes, net areas, and soak times that were used over the last 23 years. A statistical comparison of gillnet CPUE and with lake habitat quality is expected to be part of the background support for the offsetting plan.

That analysis will require an index of habitat quality of lakes. One candidate is lake surface area, which has been shown to be positively correlated with fish species richness (i.e., the number of fish species) in the Hope Bay Belt. A regression of log(fish species richness) on log(lake surface area) for 25 lakes was highly significant ($P<0.001$) and explained 50% of the variance in log(fish species richness). Similar results have been reported from many lake and stream systems around the world. Examples include Ontario (Eadie et al. 1986) and large lakes around the globe (Vadeboncoeur et al. 2011).

Another candidate is lake trophic status as indicated by Total Phosphorus (TP) trigger ranges shown in *Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems* (CCME 2004). There are six classes: ultra-oligotrophic (TP<0.004 mg/L), oligotrophic (TP = 0.004-0.01 mg/L), mesotrophic (TP = 0.01-0.02 mg/L), meso-eutrophic (TP = 0.02-0.035 mg/L), eutrophic (TP = 0.035-0.1 mg/L), and hyper eutrophic (TP>0.1 mg/L).

Statistical comparisons of gillnet CPUE and CPUE of the other five fishing methods for lakes in which more than one method of catching fish were used is also expected to be part of the background support of the offsetting plan.

Absolute estimates of fish population number for lakes in the Hope bay Belt were conducted with two methods: mark-recapture and hydroacoustic. In 2002, a mark-recapture study of Lake Trout in Tail Lake (converted into the Tailings Impoundment Area in 2011) was conducted using the numbers of tagged trout and the numbers of recovered tagged and untagged trout, all caught by gillnets. A population of 2,360 trout (with 95% confidence limits (CL) of 1,313 to 4,275) was calculated with the Peterson method and a population of 2,362 (95% CL: 1,725 to 5,511) was calculated with the Schnabel method. Using the estimate of Tail Lake surface area of 76.6 ha measured in 2000 gave a Lake Trout density of 34 fish/ha.

In 2007, a mark-recapture study of Lake Trout in Patch Lake of the LSA North was conducted using MARK to calculate a population of 1,159 trout (95% CL: 825 to 1,680). The surface area of Patch Lake is 567.4 ha so Lake Trout density was 2.0 fish/ha.

In 2009, surveys of fish number in Doris and Patch lakes were conducted with hydroacoustic gear. The total number of fish in Doris Lake was estimated to be 55,806 (95% CL: 41,982 to 69,629). The surface area of Doris Lake is 337.8 ha so total fish density was 165.2 fish/ha. Gillnet sampling conducted before and after the hydroacoustic survey showed that the three major fish species made up the following percentages of the catch: Lake Trout (6.1%), Lake Whitefish (28.3%), and Cisco (65.5%). Therefore, numbers and densities were as follows: Lake Trout (3,408 and 10.1 fish/ha), Lake Whitefish (15,183 and 46.8 fish/ha), and Cisco (36,584 and 108.3 fish/ha).

The total number of fish in Patch Lake estimated by the 2009 hydroacoustics survey was 33,619 (95% CL: 17,499 to 49,740), which gave a total fish density of 59.3 fish/ha. Gillnet sampling showed that the three major fish species made up the following percentages of the catch: Lake Trout (54.3%), Lake Whitefish (42.1%), and Cisco (3.6%). Therefore, numbers and densities were as follows: Lake Trout (18,258 and 32.2 fish/ha), Lake Whitefish (14,142 and 24.9 fish/ha), and Cisco (1,218 and 2.1 fish/ha).

Gillnet and hydroacoustic assessment data collected in 2009 showed that Lake Trout and Cisco relative abundance and density increased with depth, while Lake Whitefish relative abundance was highest in shallow locations (0 to 5 m). Fish abundance increased with depth, particularly in the northwest portion of Patch Lake.

In 2010, hydroacoustic surveys were conducted at two areas of Aimaokatalok Lake: the Ore Body area and the Reference area. Fish density at the Ore Body area was 12.0 fish/ha during the day and 2.0 fish/ha at dusk. Fish Density at the Reference area was 48.0 fish/ha during the day. The mean density for both areas was 20.7 fish/ha.

In summary, there are two unbiased estimates of whole-lake fish density: 59.3 fish/ha for Patch Lake and 165.2 fish/ha for Doris Lake. A third estimate of whole-lake fish density of 20.7 fish/ha is available for Aimaokatalok Lake, but only if one assumes that surveys of the Ore Body and References areas are representative of the entire lake. These three estimates of fish density agree with the ranking of trophic status of lakes as indexed by TP trigger ranges (CCME 2004). Aimaokatalok and Patch lakes, which have the lowest estimates of fish density, are both classified as oligotrophic-mesotrophic. Doris Lake, which has the highest fish density, is classified as oligotrophic-eutrophic. Additional estimates of lake fish population number may be considered as part of the offsetting plan. If so, the estimates should be obtained by hydroacoustic techniques combined with gillnetting.

3.3 Habitat Evaluation Procedure

A habitat evaluation procedure (HEP) will be used to construct a habitat budget for the offsetting plan should one be deemed necessary by DFO. HEP is a generalized procedure for assessing habitat suitability in streams and lakes. It was developed by the US Fish and Wildlife Service more than 35 years ago (USFWS 1980), and has been widely used throughout Canada and North America since then. It is a standard tool for developing habitat budgets for offsetting planning in Canada (e.g., Diavik 1998; BHP Billiton 2002; RL&L/Golder 2003; Rescan 2005, 2007, 2012).

The HEP approach has two advantages. First, it provides an objective method to characterize the quality or importance of affected habitats to fish species and aquatic resources. Second, it allows standardization of habitat quality ratings relative to other habitats that have different physical characteristics (e.g., lakes versus streams). This facilitates comparisons among habitat types and ultimately allows affected habitats to be evaluated as a single group for the offsetting calculation.

HEP is an appropriate tool for offsetting fisheries effects in Canada. As identified by DFO in *Science Advice to Support Development of a Fisheries Protection Policy for Canada* (DFO 2013d), a pragmatic approach based on habitat quality is an appropriate first step for offsetting (i.e., budgeting) fisheries productivity. Due to difficulties in directly measuring fish productivity, surrogates such as biological indices (e.g., fish biomass, salmonid smolt yield, production/biomass, vital rates) or habitat variables (e.g., habitat suitability indices or estimates of primary or secondary production), can be used to indirectly evaluate project-related impacts to fish productivity (Randall et al. 2013; Minns et al. 2011). However, it is recognized that data collection and monitoring of biological indices (e.g., fish biomass) will be required to validate a habitat-based approach to offsetting (Randall et al. 2013).

Where the Project has the potential to cause *serious harm to fish*, as concluded by DFO, affected habitats will be quantified and characterized in terms of their importance to each fish's life history stage. The HEP produces habitat units (HU, m^2) that are indices of both habitat quantity and quality for the affected habitats. This is calculated by multiplying habitat area (measured in m^2) by a habitat suitability index (HSI). As a result, HU are the currency of offset budgeting and planning.

This is the stage at which the following analyses may be useful for evaluating the quality of fish habitat by cross-checking with available fish CPUE data:

- A statistical comparison of electrofishing CPUE and fish densities with stream habitat quality assessments.
- A comparison of electrofishing CPUE and fish densities with minnow trap CPUE for streams in which both methods were used.
- A statistical comparison of gillnet CPUE with lake habitat quality.
- A statistical comparison of gillnet CPUE and CPUE of other fishing methods used in lakes for those lakes in which more than one method was used.

The HEP model relies upon HSI curves for depth, velocity, substrate, cover, water quality, and other attributes. Relevant Arctic Char, Lake Trout, and Arctic Grayling HSI curves will be researched, collated, and reviewed for applicability to the Project area. HSI for Arctic Char and Lake Trout spawning and rearing (nursery) habitat were developed in the original Doris North No Net Loss Plan (Golder 2007).

Modelling of lake surface elevations and of discharge rates in streams may be required to calculate the loss of HUs in some lakes and streams as a result of Phase 2 activities. Once the number of HUs for the affected habitats is known, the identification and budgeting of offsetting options can commence. The objective is to create at least an equal number of offsetting HUs.

3.4 Identification of Offsetting Options

Identification of offsetting options is an iterative process requiring knowledge of local Inuit fisheries and community interest/priorities, fish distribution, fish population abundance, and habitat quality within the Project area. It requires a combination of stakeholder engagement/consultation, desktop analysis of available data, field-based assessment, and sound professional judgement.

A general desktop approach that will be conducted to aid in the identification of potential fisheries offsetting options may include:

- Engagement with the local Hunters and Trappers Organization (HTO) and TMAC's Inuit Environmental Advisory Committee.
- Review and analysis of available data on fish and fish habitat for watersheds within and outside of the Phase 2 boundaries.
- Literature review of species-specific habitat limiting factors based upon peer-reviewed documents and professional knowledge.
- Identification of factors limiting fish productivity within and outside of Project area watersheds. For example, identification of species and life history stages present, identification of known key habitats (e.g., over-wintering and spawning areas), and identification of anthropogenic impacts within watersheds.
- Identification of previously assessed fisheries offsetting options provided in background literature (e.g., environmental consultant reports for the Project area).
- Identification of potential options through remote satellite imagery analysis (e.g., Google Earth).

Once the identification of potential sites is finalized, field reconnaissance and ground-truthing of the preliminary offsetting options will be conducted. Field reconnaissance also provides an opportunity to identify additional offsetting options. Offsetting options will be visited to refine site objectives, assess value to fishery, site-specific constraints and opportunities, biological relevance, stability, permanence, target species, target habitat, and target life history stage. Assessment of site-specific constraints and opportunities include:

- connectivity to critical habitats (e.g., overwintering, spawning habitats);
- water supply magnitude and dependability;
- water and sediment quality;
- fluvial geomorphology (stability, flood risk, sediment supply, gradient); and
- construction considerations (access, construction costs, stability and durability of instream structures, and time to full functionality of site).

A qualitative feasibility assessment, based upon professional experience, will be conducted for each preliminary offsetting option. This assessment will be conducted by a fisheries biologist and water resources engineer to determine the technical feasibility of the options. Through an iterative process of elimination and refinement, a technically feasible offsetting option(s) will be identified.

3.5 Assessment of Offsetting Options

Additional data will be gathered to support the selected technically feasible offsetting options. Additional data may include biological, hydrological, and topographical data; however the specific data requirements will ultimately depend upon the offsetting option objectives and design. These data requirements will be determined by the fisheries biologist and water resources engineer, in consultation with regulatory agencies and stakeholder groups.

This is the stage at which the following field data collection at offsetting stream and lake sites may be useful:

- FHAP or SHIM surveys of fish habitat quantity and quality in previously un-surveyed streams;
- Three-pass electrofishing surveys of fish number and density in previously un-surveyed streams; and
- Hydroacoustic estimates of fish population numbers in previously un-surveyed lakes accompanied by gillnetting to determine fish species composition.

The HUs for each offsetting option will be calculated and compared to HUs for the impacted streams and lakes. The ratio of offsetting HUs to impacted HUs will be least 1.0 and may be higher based on the fisheries value of the impacted area as well as the fisheries value of the offsetting area. For example, high quality habitat may require additional offsetting area in order to ensure no net loss of fish productivity. Alternatively, low quality habitat may be replaced with a smaller area of higher quality habitat.

4. PRELIMINARY OFFSETTING OPTIONS

In advance of the predicted effects associated with the Phase 2 Project, several options have been identified that could offset potential serious harm to fisheries, as defined by the *Fisheries Act* (1985) and concluded by DFO.

The following section presents three preliminary offsetting options in the vicinity of the Hope Bay Project, and then discusses the potential for off-site offsetting. Both stream and lake options are discussed as both may be required to offset for potential Phase 2 project effects. Based on the effects assessment (TMAC 2016), impacts to fish habitats in streams and lakes may result from water withdrawal, from the construction of water intakes and discharge pipelines, and from the construction of road crossings over fish-bearing streams.

4.1 Project Vicinity Options

As described in Section 3, extensive fieldwork has been completed within the Project area that will help identify potential offsetting options around the Hope Bay Project. In 2016, preliminary site assessments were completed at several stream and lake sites to determine their suitability as potential offsetting locations.

4.1.1 Option 1- Enhance the Quality of Existing Juvenile Stream Rearing Habitats

Increasing the abundance of preferred habitats for rearing juveniles could increase the overall productivity of those streams. A fish sampling program completed in Doris, Roberts, and Little Roberts outflows in 2016 found that juvenile Arctic Char density was statistically higher in riffles and cascades when compared to glides, but glides were the predominant habitat type within those streams. Glides in those streams had a U-shaped cross-section (steep banks and a flat bottom) with little structural complexity, laminar flow, little cover for predator avoidance, and poor quality substrate for rearing salmonids (primarily fine sediments). Riffles and cascades had higher quality habitats for rearing because they were structurally complex, were well oxygenated, provided quality food sources, and provided refuge from predators.

To offset for potential reductions in productivity of stream habitats, more productive habitat types (i.e., riffles and cascades) could be constructed in less productive areas (poor quality glides). This would provide a greater quantity of productive habitats to juvenile fish. A key factor in this type of enhancement would be ensuring that fish passage is not impeded by the new habitat features, particularly in streams used by anadromous fish.

Potential sites for juvenile rearing enhancements were identified in Roberts Outflow, as well as in some other tributaries to Roberts Lake where this type of habitat enhancement could improve productivity. Suitable sites containing glide habitat that were sampled during fieldwork in 2016 could be sampled prior to enhancement to establish more robust baseline fish densities, and then sampled after enhancement to provide a measure of success.

4.1.2 Option 2- Improve access to the upper reaches of Stream E09

To partly compensate for the loss of fish and fish habitats in Tail Lake caused by the construction of the Tailings Impoundment Area (TIA), a No Net Loss Plan (NNLP; Golder 2007) proposed the construction of rearing habitat for juvenile Arctic Char in Stream E09, a tributary to Roberts Lake, by creating additional pool habitat. Two pools were constructed in 2012 approximately 350 m upstream from Roberts Lake.

Pre-enhancement sampling determined that most tributaries to Roberts Lake do not support juvenile Arctic Char due to low summer discharge and the presence of barriers to fish passage

(Golder 2007). Stream E09 was identified as the best candidate for enhancement as it has adequate baseline flow throughout the summer and it is used by rearing juvenile Arctic Char in low abundance.

However, post-enhancement monitoring results indicated that the enhancement was of limited success. It appears that fish use of the newly created pools is limited by a steep section of creek (gradient of 8%) approximately 100 m in length, between the enhancement site and Roberts Lake, where the stream morphology is step-pool with several chutes. This steep section of creek limits upstream migration by juveniles and upstream habitats have very low fish densities.

An offsetting program that improved access for juveniles in Roberts Lake upstream into the low-gradient reach where the existing enhancement pools are located may increase utilization not only of these pools, but of the entire stream. This section of stream has low gradient (less than 3%), and it exhibits the Arctic "beaded stream" morphology, where a series of relatively deep, natural pools are separated by sections of narrow, shallow creek. By selectively moving boulders within the step-pool section of the creek, the largest drops would be reduced making access from Roberts Lake easier.

4.1.3 Option 3- Increase the abundance of spawning and juvenile rearing habitats in lakes

Arctic aquatic ecosystems present a unique set of challenges to their inhabitants when compared to more southerly environs. Emergent juveniles must migrate from spawning beds to rearing habitats, and then make annual migrations between summer rearing habitats and overwintering locations. Throughout their juvenile life, these fish are exposed to predation pressure from species such as Lake Trout.

Juvenile Arctic Char in lakes such as Roberts Lake migrate in the spring from overwintering habitats in the lake to rearing habitats in inflows and the outflow. Large, piscivorous Lake Trout target these fish, congregating in locations where they are able to feed on them. On one occasion, a field crew observed 27 adult Lake Trout in Roberts Lake in the fall within a short distance of where Stream E14 enters the lake, presumably feeding on juveniles that had spent the summer rearing in the stream but had to re-enter the lake to seek overwintering habitats. There is high structural complexity within the creek where fish can use cover to avoid predation, but when re-entering the lake there is little structure, exposing them to awaiting predators.

Adding habitat features that provide cover for juveniles as they migrate between critical habitat areas (e.g., between summer rearing and overwintering habitats, or between spawning beds and rearing habitats) would help improve productivity by reducing predation pressure by Lake Trout. Habitat features, such as boulder clusters could be used in locations where juveniles are particularly exposed.

4.2 Off-Site Offsetting Options

Off-site offsetting may be a suitable alternative where enhancements would be constructed in or around a community in Nunavut, rather than near the mine site. Off-site offsetting (i.e., community-based offsetting) can provide a broader range of benefits than just improvements to fisheries. These benefits include:

- potential to rehabilitate human-impacted sites such as improperly installed culverts or over-fished populations;
- Increased engagement with local community directly through employment and indirectly through increased activity in the community;
- Transfer of knowledge by training community members in enhancement and monitoring methods; and,
- Potential to engage local educational institutions such as the Canadian High Arctic Research Station.

In addition to community consultations to identify options, biological, hydrological, topographical, and engineering investigations will be required to determine the technical feasibility of preliminary off-site offsetting options. The following biological data will be acquired to support the development of the Offsetting Plan:

- habitat assessment and mapping;
- fish passage assessments at potential restrictions; and
- fisheries community, demography, and abundance sampling (e.g., gillnetting, electrofishing, fish stranding enumeration) at potential sites.

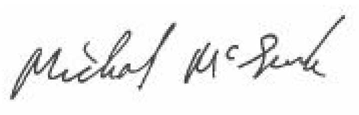
Hydrological, topographical, and engineering data requirements are site-specific and will be determined during a field investigation.

5. SUMMARY

A conceptual fisheries offsetting plan, if deemed necessary by DFO, will be developed to identify and compensate for potential serious harm in accordance with the *Fisheries Act*, the *Fisheries Protection Policy Statement* and *the Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting*. The approach to offsetting will include quantification of habitat and productivity losses, identification of offset habitats and a quantification of habitat and productivity gains relative to losses. This process may involve engagement with the local Hunters and Trappers Organization, TMAC's Inuit Environmental Advisory Committee and DFO to align offsetting goals with local and regional sustainability objectives throughout the Draft and Final Environmental Impact Statements and any required application for a Fisheries Act Authorization.

Prepared by:

Kathryn Kuchapski, Consultant, M.Sc. P.Biol.
ERM



Michael McGurk, Principal Consultant, Ph.D., R.P.Bio.
ERM

REFERENCES

1985. *Fisheries Act*, RSC, C. F-14.

BHP Billiton. 2002. *EKATI Diamond Mine: Sable, Pigeon and Beartooth no net loss plan*. Prepared for BHP Billiton Diamonds Inc. by Dillon Consulting Ltd.

Bohlin, T. 1978. Temporal changes in the spatial distribution of juvenile sea-trout *Salmo trutta* in a small stream. *Oikos* 30:114-120.

CCME. 2004. Canadian water quality guidelines for the protection of aquatic life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: *Canadian environmental quality guidelines, 2004*, Canadian Council of Ministers of the Environment, Winnipeg.

Eadie, J.M., T.A. Hurley, .R.D. Montgomery, and K.L. Teather. 1986. Lakes and rivers as islands: species-area relationships in the fish fauna of Ontario. *Environmental Biology of Fishes* 15: 81-89.

DFO. 1991. *The Department of Fisheries and Oceans: Policy for the management of fish habitat.* Department of Fisheries and Oceans: Ottawa, Ontario.

DFO. 2013a. *Fisheries protection policy statement.* http://www.dfo-mpo.gc.ca/pnw-ppe/pol/index-eng.html. (accessed December 2016)

DFO. 2013b. *Fisheries productivity investment policy: A proponent's guide to offsetting*. http://www.dfo-mpo.gc.ca/pnw-ppe/offsetting-guide-compensation/index-eng.html. (accessed December 2016).

DFO. 2013c. *Measures to Avoid Causing Harm to Fish and Fish Habitat*. http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html. (accessed December 2016)

DFO. 2013d. *Science advice to support development of a fisheries protection policy for Canada*. Canadian Science Advisory Secretariat, Science Advisory Report 2012/063: Ottawa, Ontario.

Diavik Diamond Mines Inc. (Diavik). 1998. *"No net loss" plan*.

Golder. 2007. *Doris North Project "no net loss" plan.* Prepared for Miramar Hope Bay Ltd. By Golder Associates Ltd.: Edmonton, Alberta.

Johnson, D. H., B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons. 2007. *Salmonid field protocols handbook: Techniques for assessing status and trends in salmon and trout populations*. Maryland: American Fisheries Society.

Johnston, N.T. and P.A. Slaney. 1996. *Fish habitat assessment procedures*. British Columbia Ministry of Environment, Lands and Parks. Watershed Restoration Technical Circular No. 8.

Kruse, C. G., W. A. Hubert, and F. J. Rahel. 1997. Geomorphic influences on the distribution of Yellowstone cutthroat trout in the Absaroka Mountains, Wyoming. *Transactions of the American Fisheries Society* 126: 418-427.

Mason, B., and R. Knight. 2001. *Sensitive habitat inventory and mapping*. Community Mapping Network. Vancouver, BC.

Newman, R. M. and T. F. Waters. 1989. Differences in brown trout (*Salmo trutta*) production among contiguous sections of an entire stream. *Canadian Journal of Fish and Aquatic Sciences* 46: 203-213.

Randall, R. G., M. J. Bradford, K. D. Clarke, and J. C. Rice. 2013. *A science-based interpretation of ongoing productivity of commercial, recreational or Aboriginal fisheries*. DFO Canadian Science Advisory Secretariat Research Document 2012/112: Ottawa, Ontario.

Rescan. 2005. *Twin Lakes Diversion Project conceptual no net loss fish habitat compensation plan*. Prepared for BHP Billiton Base Metals by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

Rescan. 2007. *Galore Creek Project: Fish habitat compensation plan*. Prepared for Novagold Canada Inc. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

Rescan. 2012. *KSM Project: HADD fish habitat compensation plan*. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

RL&L/Golder. 2003. Doris North Project no net loss plan. Prepared for Miramar Hope Bay Ltd. by RL&L Environmental Services Ltd./Golder Associates Ltd.TMAC. 2016. *Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement.* Submitted to the Nunavut Impact Review Board. December 2016.

US Fish and Wildlife Service (USFWS). 1980. *Habitat evaluation procedures (HEP) ESM 102*. US Department of Interior. Washington, DC.

Vadeboncoeur, Y., P.B. McIntyre, and M.J. Vander Zanden. 2011. Borders of biodiversity: life at the edge of the world's largest lakes. *Bioscience* 61: 526-537.