Appendix 49

Whale Tail 2019 Fish Habitat Offset Monitoring Report

AGNICO EAGLE

MEADOWBANK GOLD MINE

WHALE TAIL PIT

2019 FISH HABITAT OFFSET MONITORING REPORT

In Accordance with

DFO Fisheries Authorization 16-HCAA-00370

Prepared by:
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EXECUTIVE SUMMARY

According to Fisheries and Oceans Canada (DFO) Authorization 16-HCAA-00370, Agnico Eagle maintains a Fish Habitat Offset Monitoring Plan (FHOMP; March, 2018) to determine the effectiveness of fish habitat offsetting features.

In order to ensure that offsets are functioning fish habitat as projected, assessment of the structure and successful utilization of these features by fish are the primary goals of the monitoring program for habitat enhancement/creation offsets. These offsets include a set of constructed shoals and an elevated water level (approx. 1 m) throughout Whale Tail Lake. Based on the schedule described in the FHOMP, monitoring of these constructed offsetting features will generally occur 1, 3, 5 and 10 years post-construction.

In addition to the constructed habitat offsetting features, a portion of offsetting for Whale Tail Pit is provided through a suite of complementary measures (research projects). No physical monitoring is conducted in relation to research projects. However, progress monitoring is conducted to document annual activities, and results are summarized here to determine when criteria for success have been met.

In 2019, no monitoring was required to be conducted in relation to habitat enhancement features, because construction of the offsets is not yet complete.

Six research studies are underway as complementary measures for Whale Tail Pit offsetting (Table 1). All studies are on track for completion according to original timelines as described in signed research agreements with the academic partners. In 2019, field programs and laboratory analyses entered year one or two for five of these projects. One will be complete in 2020, and the remaining four will continue with additional field studies this summer. One study is not proposed to begin until re-flooding of Vault and Phaser Lakes is complete, beyond 2026. Agnico is also looking for an alternate suitable study site and industry partner for that study, to allow it to be completed in the nearer term.

Table 1. Whale Tail Pit complementary measures (research projects).

Study	Lead Researcher	Study Period
Study 1: Assessment of changes in aquatic productivity and fish populations due to flooding of Whale Tail South and downstream lakes during operations	H. Swanson	2018 – 2022
Study 2: Assessment of impacts of the Baker Lake wastewater outflow on aquatic systems including fish and fish habitat	H. Swanson	2019 – 2024
Study 3: Literature review and field validation of northern lake fish habitat preferences	S. Doka	2018 – 2020

Study	Lead Researcher	Study Period
Study 4: Arctic Grayling occupancy modelling	H. Swanson	2018 – 2021
Study 5: End pit lake habitat use	TBD	2027 – 2034 (est.)
Study 6: eDNA methods development	J. Stetefeld	2018 - 2023

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SECTION 1 • INTRODUCTION

1.1 BACKGROUND

In accordance with Fisheries and Oceans Canada (DFO) Authorization 16-HCAA-00370, Agnico Eagle maintains a Fish Habitat Offset Monitoring Plan (FHOMP; March 2018) to ensure that fish habitat offsetting described in the Fish Habitat Offsetting Plan for Whale Tail Pit (March, 2018; Appendix C – May 2018) is constructed and functioning as intended. This program is carried out as a targeted monitoring plan under the Meadowbank Aquatic Effects Monitoring Program (AEMP).

1.2 SUMMARY OF OFFSETTING FEATURES

A series of in-water constructed features will create or enhance fish habitat to offset losses occurring in the North Basin of Whale Tail Lake. Acting as complementary offsetting measures, a suite of research projects has also been developed to address knowledge gaps in Northern fish habitat use and monitoring methods.

Further details for each are provided in the Fish Habitat Offsetting Plan for Whale Tail Pit (March, 2018; Appendix C – May 2018).

1.2.1 Constructed Offsets

1.2.1.1 Rock Shoals

Placement of rock material to change lake basin substrate from fine or mixed to coarse (i.e. the creation of rock shoals) is a commonly used fish habitat enhancement technique. This offsetting measure will occur in the dewatered area of Whale Tail Lake – North Basin outside of the pit, with the work conducted prior to reflooding.

Roads, jetties and other features will be scarified or converted to coarse substrate as necessary, prior to closure. A pit sill cap of coarse rock material will also convert fine substrate to coarse in areas where coarse substrate did not already exist. In addition, a network of shoals (termed grid shoals based on their conceptual design pattern) will convert half of the southern area of the North Basin to higher-value habitat.

1.2.1.2 Constructed Sill and Elevated Water Level

During the operations period when Whale Tail Lake – North Basin is dry, a permanent water control structure (sill) will be constructed just upstream of Mammoth Dike. Once the Whale Tail Dike is breached and flows resume its natural direction through Mammoth Lake, this feature will ensure that water levels in Whale Tail Lake and connecting channels remain at 1

m higher than baseline conditions. It is estimated that a 1 m increase in water levels upstream of the Mammoth Dike would create approximately 46.6 ha of new aquatic habitat.

1.2.2 Complementary Measures

The approved suite of complementary measures (research projects) includes six studies aimed at closing knowledge gaps regarding the biology and habitat requirements of northern fish species, developing tools and validating methods to facilitate and advance ongoing monitoring, and/or characterizing responses of fish-bearing aquatic systems to direct anthropogenic manipulations. These studies are:

1. Assessment of changes in aquatic productivity and fish populations due to flooding of Whale Tail South and downstream lakes during operations

2. Assessment of impacts of the Baker Lake wastewater outflow on aquatic systems including fish and fish habitat

3. Literature review and field validation of northern lake fish habitat preferences

4. Arctic grayling occupancy modeling

5. Pit lake habitat use assessment

6. eDNA methods development

1.3 OBJECTIVES

1.3.1 Constructed Offsets

As described above, the majority of habitat gains for Whale Tail Pit offsetting are planned to be achieved through habitat creation and enhancement efforts. These include:

- re-flooding of the de-watered Whale Tail Lake - North Basin following construction of habitat enhancement features (shoals);

  and

- maintaining an elevated water level in Whale Tail Lake compared to baseline conditions;

In order to ensure that offsets are functioning fish habitat as intended and projected, assessment of the structure and successful utilization of these features by fish are the primary goals of the monitoring program for habitat enhancement/creation offsets.

The overall objectives of this report are:

a. To describe results of the physical and ecological monitoring programs conducted in relation to constructed offsetting features, as detailed in the FHOMP;
b. To determine when the criteria for success identified in the FHOMP have been met.

1.3.2 Complementary Measures

No physical monitoring is conducted in relation to research projects. However, progress monitoring is conducted to document annual activities, and results are described here to determine when criteria for success have been met.

1.4 SCHEDULE OF MONITORING

The complete schedule for monitoring of offsets is described in the FHOMP, Table 4 (March, 2018). That plan will be updated as necessary to reflect any changes in scheduled monitoring events. Generally, monitoring for constructed offsets is planned to occur 1, 3, 5, and 10 years post-construction. Progress updates for complementary measures will be provided annually.

SECTION 2 • MONITORING METHODS

2.1 CONSTRUCTED OFFSETS

The assessment of constructed habitat features includes monitoring methods with quantitative criteria for success (physical structure, interstitial water quality), as well as complementary "qualitative" tools (periphyton growth and fish use). All lines of evidence will then be integrated in a weight-of-evidence approach to make the final determination regarding habitat feature functionality.

A complete description of scheduled monitoring methods to assess the structure, water quality, periphyton, and fish use of the offsetting features is provided in the FHOMP. Details of monitoring completed in a given year will be provided here, including dates, locations, and any adjustments to standard methods.

In 2019, no monitoring was required to be conducted in relation to habitat enhancement features, because construction of the offsets is not yet complete.

2.2 COMPLEMENTARY MEASURES

As required by Fisheries Act Authorization HCAA-16-00370, complete annual progress reports on complementary measures are provided to DFO by May 31 of the following year, including preliminary results and analyses.

An interim update is provided in this report for each project, along with a description of activities of the Meadowbank Fisheries Research Advisory Group (MFRAG) in the preceding year. Until research studies are complete and published, these interim updates will focus on general activities and methods, and do not include results and analyses.

SECTION 3 • RESULTS

3.1 CONSTRUCTED OFFSETS

In 2019, no monitoring was required to be conducted in relation to habitat enhancement features, because construction of the offsets is not yet complete.

3.2 COMPLEMENTARY MEASURES

An update is provided here on activities of the Meadowbank Fisheries Research Advisory Group (MFRAG) and each research study in 2019.

3.2.1 Activities of the MFRAG

As part of the Fish Habitat Offsetting Plan for Whale Tail Pit (March, 2018), the Meadowbank Fisheries Research Advisory Group (MFRAG) was conceptualized to provide a forum for input from key stakeholders. The MFRAG meets annually to review project progress reports, propose and approve or reject new projects or project components, and assess whether criteria for success have been met.

In 2019, Agnico Eagle confirmed interest in MFRAG participation by DFO, the Kivalliq Inuit Association (KIA), and the Baker Lake Hunters and Trappers Organization. As planned in the Fish Habitat Offsetting Plan for Whale Tail Pit, Appendix C (May, 2018), Agnico also identified a third party external advisor (Dr. Kelly Munkittrick, University of Calgary) who will participate in all MFRAG activities. A draft Memorandum of Understanding and Terms of Reference were developed by Agnico, and reviewed by all parties. The initial meeting of the MFRAG was held on December 12, 2019 in Montreal, Quebec. Representatives from all member groups were in attendance. The group received presentations by lead researchers involved in each study, and had the opportunity for questions, comments, and open discussion. Each MFRAG member group has been requested to provide written comments, if any, by February 28, 2020. Written comments will be distributed to research study leads for consideration.

The participant list, agenda, and notes from the inaugural 2019 MFRAG meeting are provided in Appendix A.

3.2.2 Study 1 - Assessment of changes in aquatic productivity and fish populations due to flooding

3.2.2.1 Research Team

Dr. Heidi Swanson, University of Waterloo

Jared Ellenor, University of Waterloo

3.2.2.2 Research Objectives

This research study aims to understand changes in fish population productivity and habitat use during and after flooding occurs, as determined through relative abundance and/or biomass and condition factor within the resident fish population.

Since flooding activities are planned to occur over a relatively short term (2-3 years), the study will specifically include a focus on small-bodied fish, which are expected to react first to changes in nutrient profiles.

Changes in productivity will be related to water quality variables and changes in lake morphometry (especially area). Use of newly flooded habitats will be assessed and related to habitat characteristics.

3.2.2.3 Research Methods

Assessments of fish population metrics will take place annually over four field seasons both prior to and after flooding (2018, 2019, 2020, 2021) during two-week (approximate) field visits in late July and August.

The following field survey methods are planned to be included as part of this study:

- Shoreline electrofishing and/or visual surveys, both before and after flooding.
- Collection of small-bodied fishes (via electrofishing) for analysis of trophic ecology and growth parameters, both before and after flooding.
- Presence-only surveys, after flooding.

Assessments of changes in fish populations will take into account relationships with the following water quality parameters, some of which are planned to be collected through compliance monitoring programs, and some of which are supplementary:

- Quantity and quality of dissolved organic carbon;
- Total and dissolved concentrations of nitrogen and phosphorus;
- TSS;
- Chlorophyll-a;
- Major anions and cations;

- Total and dissolved metals;
- Stable isotope ratios on dissolved inorganic carbon; and
- Total and methyl mercury.

Some or all of the above assessments will be conducted in the following lakes: Whale Tail Lake (A17), A63, A65, A20, Mammoth Lake (A16), A76 (as feasible), and additional reference systems.

3.2.2.4 Summary of Activities

In 2018 and 2019, the study focused on the collection of baseline data (2018) and flooding year 1 data (2019) for small bodied fish species (slimy sculpin, ninespine stickleback) within the Whale Tail South area. Jared Ellenor completed shoreline electrofishing for small bodied fish in 6 waterbodies in the area of Whale Tail Lake: Whale Tail Lake, Mammoth Lake, A63, A20, A65 and reference site Lake 8 (refer to Figure 1). Monitoring endpoints that were selected for analysis included abundance, length, weight, condition, age, catch per unit effort, and weight-at-age.

Furthermore, the University of Waterloo team collected baseline water quality data at Whale Tail Lake, Mammoth Lake, A63, A20, A65 and Lake 8, which will be used to support the interpretation of fish population data. Additional water and sediment quality data collected under compliance monitoring programs will similarly be used in this assessment.

Finally, Agnico Eagle contracted hydroacoustic surveys in Whale Tail Lake, Mammoth Lake, Lake 8 and A20, which in the future will be used to assess changes in habitat characteristics post flooding.

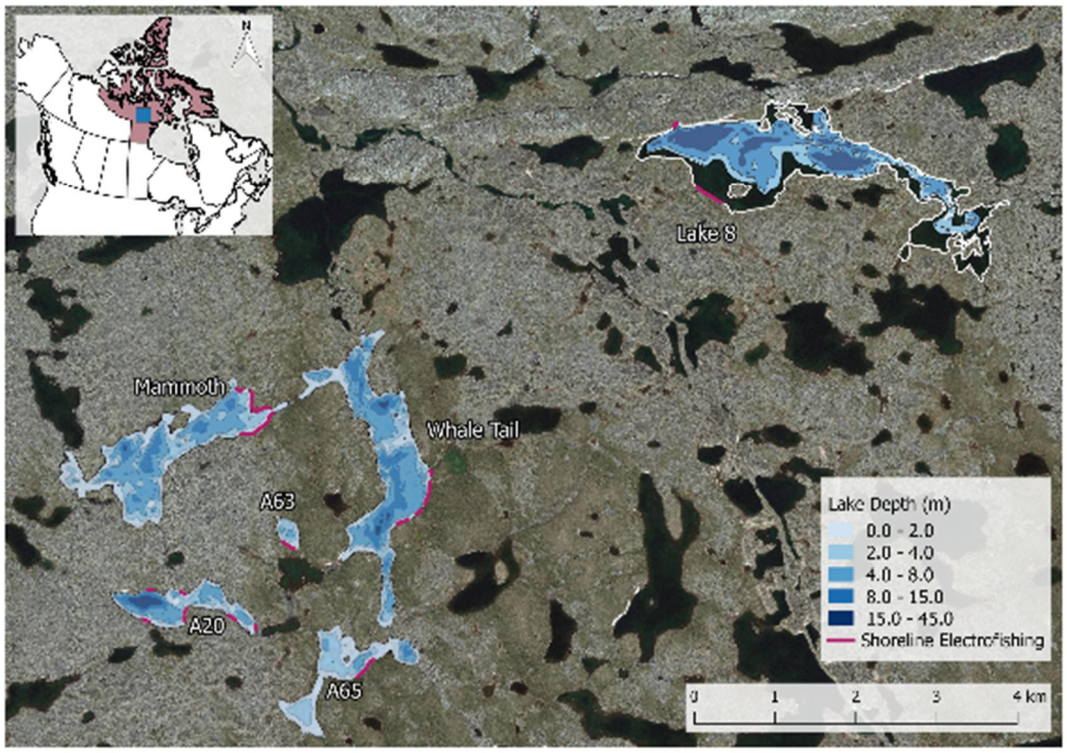

Figure 1. Productivity study area – electrofishing locations (J. Ellenor).

3.2.3 Study 2 – Assessment of impacts of the Baker Lake wastewater outflow on fish productivity and fish habitat

3.2.3.1 Research Team

Dr. Heidi Swanson, University of Waterloo

Jared Ellenor, University of Waterloo

Bronte McPhedran, University of Waterloo

3.2.3.2 Research Objectives

A 5-year research program lead by Dr. Rob Jamieson (Dalhousie University) is underway to assess the current status of the wastewater treatment system in the hamlet of Baker Lake and develop designs for upgrades. As part of this holistic assessment, key questions related to understanding fish health, fish habitat, nutrient status and fish productivity are included as offsetting for the Whale Tail Pit project. The fish and fish habitat portion of the study is being conducted by Dr. Heidi Swanson, from the University of Waterloo.

The following objectives specific to fish and fish habitat have been developed:

1. Quantify the current fish habitat, fish health and fish productivity in the Arctic wastewater system.

2. Quantify changes in fish habitat, fish health and fish productivity associated with Arctic wastewater treatment system upgrades.

3.2.3.3 Research Methods

General study methods will follow Environmental Effects Monitoring (EEM) protocols to assess changes in large-bodied fish population health and habitat that occur as a result of wastewater treatment upgrades. Supplemental methods similar to those employed in Study 1 will be used to further assess changes in productivity in small-bodied fish, which may occur under shorter time frames. Specific target lakes will include those within the current wastewater flow path, as well as a reference system.

The EEM-style fish population health analysis will include investigation of the following effect indicators and endpoints pre- and post-construction, targeting two large-bodied fish species (Lake trout, Round whitefish, Burbot and/or Arctic grayling):

- Growth (energy use) – determined through size-at-age analysis
- Reproduction (energy use) – determined through relative gonad size (GSI)
- Condition (energy storage) – determined through weight-to-length ratio (condition factor; K) and relative liver weight (LSI)
- Survival – age distribution
- Fish tissue survey – concentrations of contaminants of local concern will be assessed in fish tissue

The EEM-style fish habitat analysis will include an assessment of impacts to the benthic invertebrate community, based on the following effect indicators and endpoints pre- and post-construction:

- Total benthic invertebrate density – number of animals per unit area
- Diversity index – Simpson's diversity index
- Taxa richness – number of taxa
- Community structure – Bray-Curtis similarity index

Further, to align with Study 1 methods, analysis of changes in fish population productivity will be assessed through:

- Hydroacoustics surveys (as feasible, depth-dependent) - kg fish/hectare
- Electrofishing and/or minnow trap surveys for small-bodied fish – growth parameters

Indicators of exposure to contaminants will also be assessed through exploration of two novel methods (however, these methods are not included in the proposed budget for the complementary measure):

- Proteomics analysis of sensitive fish tissue (e.g. liver) to assess potential markers of contaminant exposure.
- Otolith analysis via laser-ablation ICP-MS to determine concentrations of trace elements, and exploration of this method for tracking history of exposure, and comparing to reference systems.

Assessments of changes in fish populations will take into account relationships with the following water quality parameters, some of which are planned to be collected through engineering-based objectives and some of which are specific to fish-related objectives:

- Dissolved organic carbon
- Total and dissolved concentrations of nitrogen
- Total and dissolved concentrations of phosphorus
- TSS
- Chlorophyll-a
- Major anions and cations

3.2.3.4 Summary of Activities

As shown in Figure 2, this study is focusing on:

- Finger Lake,
- Lagoon Lake,
- Airplane Lake,
- Baker Lake,
- the connecting streams, and
- reference lakes.

Figure 2. Baker Lake wastewater study lakes and reference lakes (2018).

In 2018 & 2019, the University of Waterloo completed field reconnaissance and collected water quality, sediment samples, fish tissue samples, and conducted presence/absence surveys.

2018:

- Reconnaissance year
- Collected water samples and sampled fish in Finger Lake and Airplane Lake
- Evaluated potential reference sites

2019:

- Selection of reference lakes
- Shoreline electrofishing, minnow trapping, gill netting in 5 waterbodies (Lagoon, Finger, Airplane lake, R1 and R2)
- Fish presence/ absence
- Collected ninespine stickleback and Arctic Grayling for health indicators, otoliths, and tissue
- Working in collaboration with UofM and Dalhousie, collected water quality samples and submitted for analysis.

3.2.4 Study 3 – Literature review and field validation of northern lake fish habitat preferences

3.2.4.1 Research Team

The research team is lead by Dr. Mike Rennie (Lakehead University) and Dr. Susan Doka (DFO Science) and includes Dr. Nandakumar Kanavillil (Lakehead University), Dr. Brian Shuter (OMNRF emeritus & Lakehead U), Ken Minns (DFO Science Emeritus & University of Toronto). Dr. Kevin Hedges, Mr. Neil Mochnacz and Dr. Paul Blanchfield (DFO Science) are part of an extended support team as well the graduate student undertaking the literature review.

3.2.4.2 Research Objectives

Habitat preferences of northern fish species are not well understood, which causes significant uncertainty in habitat-based offset calculations. This study aims to characterize habitat associations of Meadowbank-area lake fishes such as Lake Trout, Arctic Char, and Round Whitefish.

3.2.4.3 Research Methods

This study will be conducted over two years, from 2018 – 2020. Field surveys occurred in 2018 and 2019. Methods include a literature review, data gap analysis, and field programs to assess various sampling techniques for identifying fish habitat associations.

3.2.4.4 Summary of Activities

Literature Review and Gap Analysis

Following closely the Centre of Environmental Evidence guidelines for systematic literature review, a graduate student with Lakehead University under the co-supervision of Dr. Mike Rennie and Dr. Susan Doka reviewed primary and grey literature sources as well as unpublished data (e.g. Golder & Associates 2016, DFO FishOut database) on 11 northern species, including Lake trout (*Salvelinus namaycush*) Burbot (*Lota lota*), Lake whitefish (*Coregonus clupeaformis*), Lake cisco (*Coregonus artedi*), Round whitefish (*Prosopium cylindraceum*), Arctic char (*Salvelinus alpinus*), Arctic grayling (*Thymallus arcticus*), Slimy sculpin (*Cottus cognatus*), Ninespine stickleback (*Pungitius pungitius*), Dolly varden (*Salvelinus malma*) and Bull trout (*Salvelinus confluentus*) with current fish distributions in lakes of Nunavut and the Northwest Territories (Mandrak, et al. in review) and expert input from individuals that have been in the field in recent years (Portt 2015).

The data extracted from the review has been analyzed using appropriate statistical methods to synthesize the information by life stage (3 stages: spawning, nursery, juvenile/adult habitats) for the 11 northern fish species. Habitat variables of interest include: substrate associations, thermal tolerances and preferences, timing windows, depth associations at

different seasons, turbidity tolerances, species-species associations, flows and lake order, cover associations, pH and dissolved oxygen tolerances.

Field Programs

In 2018 Fisheries and Oceans in partnership with Lakehead University conducted ten days of sampling (August 20-30, 2018) in the vicinity of the Amaruq mine camp. The objective of this work was to perform reconnaissance sampling to test efficiencies and logistical challenges of using conventional methods used by scientific consultants and government researchers in the south to assess habitat and fish communities. A variety of equipment was used to meet this objective including, a multi-probe water quality sonde (EXO), passive and active fish sampling gears in both lakes and connecting channels (e.g. minnow traps, GoPro video footage, backpack electrofishing and drift nets) and hydroacoustic surveys (BioSonics MX) for physical habitat mapping (e.g. depth and substrate). The latter was conducted to complement hydroacoustic fish distribution data collected by Milne Technologies (mid-July 2018). Troubleshooting these methods in the field during 2018 informed how to standardize methods for fish habitat sampling in the North (Arctic Region) and how to proceed with habitat and fish assessment surveys during the 2019 field season.

Based on year one field tests and literature review results, field work in year two (2019) focussed on filling data gaps around habitat associations for small-bodied fishes, while assessing alternative sampling approaches. The 2019 field program consisted of an analysis of VIE tagging methods (mark recapture) to evaluate stream habitat preferences, as well as deep water electrofishing, near-shore electrofishing, and netting techniques. Those programs were conducted over two study periods, in late June and August/September.

3.2.5 Study 4 – Arctic grayling occupancy modelling

3.2.5.1 Research Team

Dr. Heidi Swanson, University of Waterloo

Jared Ellenor, University of Waterloo

3.2.5.2 Research Objectives

Understanding the potential for occupancy of fluvial systems by fish species based on readily measurable habitat characteristics could facilitate and improve the accuracy of environmental impact assessment and offset planning. Objectives of this work are the development of occupancy models for Arctic grayling in the Meadowbank region, and a comparison of habitat predictors in this area with those observed in the NWT.

3.2.5.3 Research Methods

This three-year study will be conducted from 2018 – 2021, with one reconnaissance field season (2018), a complete field season (2019) and a possible validation field season (2020 or 2021).

This study will involve characterizing occupancy of Arctic grayling young-of-the-year in relation to stream habitat characteristics, consistent with methods developed previously in the Northwest Territories (Baker, 2017[1]). Methods will include presence-absence surveys for rearing young-of-year (visual, electrofishing) and assessment of habitat characteristics (e.g., stream width, depth, velocity, vegetation cover, bank formation, distance to overwintering habitat) for 50-m stream segments. Study sites will include impacted as well as reference systems. Impacted streams may include those in the Baker Lake wastewater flow path, streams associated with the all-weather road, and/or the R02 stream where habitat compensation features were constructed by Agnico Eagle in 2009. Reference systems in the surrounding region will be selected based on both suitability and ease of access.

3.2.5.4 Summary of Activities

In 2018, initial reconnaissance and habitat characterization was conducted on four streams in Baker Lake, as well as three systems along the all-weather access road to Meadowbank (R02, R05, and R09). The purpose of the reconnaissance work was to:

- Develop a general understanding of the lake/river systems within the region;
- Test and refine habitat variable data collection/sampling methodology; and,
- Identify systems/streams suitable for occupancy modeling (i.e., connectivity throughout summer and access to overwintering habitat).

In 2019, a complete presence-absence survey and analysis of habitat characteristics was conducted for 49 streams in the area between Baker Lake and the Amaruq mine site (Figure 3). Surveys were conducted over 23 days from mid-July to August, 2019. Predictive relationships between habitat characteristics and presence-absence of Arctic grayling YOY were developed.

[1] Baker, L.F., Artym, K.J., Swanson, H.K., 2017. Optimal sampling methods for modelling the occupancy of Arctic grayling (Thymallus arcticus) in the Canadian Barrenlands. Canadian Journal of Fisheries and Aquatic Sciences 74, 1564-1574.

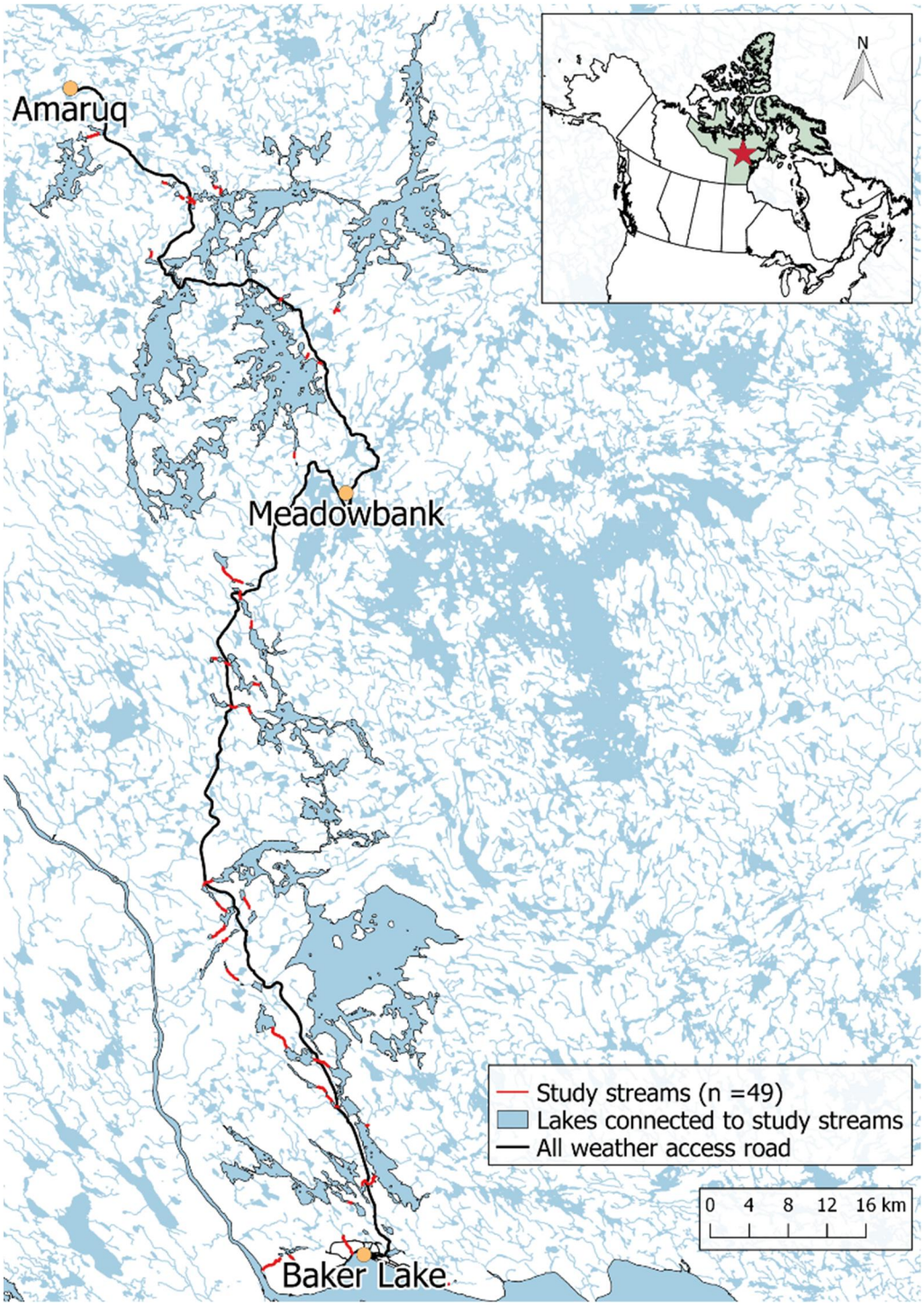

Figure 3. Arctic grayling occupancy study streams (2019).

3.2.6 Study 5 – End-pit lake habitat suitability assessment

3.2.6.1 Research Objectives

Fish use of re-flooded pit areas with good connectivity to natural systems is not well understood, yet these areas may represent a significant opportunity for fish habitat offsetting. Since multiple pits of various sizes at the Meadowbank site are planned to be reflooded in the relatively near term (2027 – 2029), there is an opportunity to thoroughly characterize fish use of pit lake habitat and population growth in re-flooded lakes through a research program. This study will aim to characterize fish use of new pit lake habitat in relation to habitat and water quality variables, and particularly in relation to reference systems. The research team and program details will be developed by the MFRAG prior to study initiation (est. 2026).

3.2.6.2 Summary of Activities

In accordance with Condition 4.2.1.3 of the FAA for Whale Tail Pit (16-HCAA-00370), Agnico Eagle submitted to DFO a literature review and study outline regarding end pit lake habitat assessment in March, 2019.

As described in the 2018 study plan for this project (see Fish Habitat Offsetting Plan for Whale Tail Pit, Appendix C), flooding of pits at the Meadowbank site is currently planned to be complete in between 2027 - 2029 (Phaser, Vault, and Whale Tail Pits), after which time field studies could begin. Initial literature reviews and methods development will occur in the years prior to pit reflooding.

Alternatively, Agnico will collaborate with other industry partners if appropriate sites are available in other locations in the nearer term. To this end, Agnico has begun to seek out potential partner sites through conversations with environment representatives at other metal mine, diamond mine, and oil sands sites throughout 2019. To date, no appropriate study lakes or interested industry research partners have been identified. However, Agnico continues to pursue this option.

3.2.7 Study 6 – eDNA Methods Development

3.2.7.1 Research Team

The Principal Investigator for this project is Jörg Stetefeld (Centre for Oil and Gas Research and Development, University of Manitoba). The lead Field Scientist is Matt McDougall, assisted by Fabian Heide and Olga Francisco (COGRAD, University of Manitoba).

3.2.7.2 Research Objectives

Traditional fish population monitoring techniques which rely on field catches remain challenging particularly in remote Northern locations due to non-standardized sampling

methods, high costs, labour intensity, and their invasive nature. eDNA methods present a potentially useful tool for rapid and non-invasive assessments of fish communities but have not been significantly developed or validated for Arctic systems. The main goal of this project is to develop and optimize monitoring tools based on eDNA metabarcoding technology to assess fish species assemblages (presence/absence and relative abundance) in the Kivalliq region.

Objectives are:

1. Development and optimization of the eDNA metabarcoding technique adapted for the arctic environment as a substitute for current fish species determination approaches.

2. Producing guidelines for handling and analyzing of samples and deliver the method and provide training to the local community.

3. Produce long-term reliable and precise baseline data on the distribution of aquatic associated fish species in the Amaruq mine site lakes using developed eDNA technology.

4. Producing data on the physiochemical properties of the lake water including dissolved mineral content to understand if any changes in stated parameters affect the eDNA/fish assemblage results.

5. Examine the impact of flooding Whale Tail Lake South Basin with the coincident changes in physiochemical properties of the aquatic area (e.g., increase in turbidity, dissolved solids) on the fish population using developed eDNA technique.

6. Collecting baseline eDNA and water quality data on lakes nearby Amaruq mine site outside the mining activity (potential candidates include B3 or DS1) and use them as a control for population changes.

3.2.7.3 Research Methods

This study involves a 5-year plan to develop and utilize an eDNA metabarcoding approach to measure fish assemblages in the Amaruq area. Environmental DNA metabarcoding technology will be developed and optimized to detect fish species including Arctic Char, Arctic Grayling, Lake Trout, Round Whitefish, Burbot, Slimy Sculpin, Ninespine Stickleback, Hybridized Lake Trout/Arctic Char and analyze their relative abundances. For water quality data, temperature, pressure, dissolve oxygen, pH, salinity, conductivity, and dissolved metals including Cu/ Zn/ Cd/Fe/Hg/Mn will be measured (some metrics may be obtained through regular compliance monitoring programs).

The first two rounds of sampling were completed before significant in-water construction (July 2017). The second round of sampling was done in August, 2018, during construction of the Whale Tail Dike. Additional sampling will be completed during and after flooding of the Whale

Tail Pit area (2019, 2021). The results will be used to assess the influence of mining activity on changes in fish species populations, as measured through eDNA methods.

3.2.7.4 Summary of Activities

In 2017, one week of preliminary field investigations were conducted, to collect water samples for laboratory analysis using previously published, conventional methods (Whatman GF/C filters).

In August 2018 and 2019, Matt McDougall and Fabian Heide visited the Amaruq mine site and, assisted by Jeff Hart of the Kivalliq Inuit Association, collected 211 eDNA samples from 9 lakes. Various filter types were tested for eDNA yield; sample volumes were determined by balancing the need for higher sampling with time per sample. Though the turbidity of the lakes is very low, finer particulates quickly clog all filters tested. Filters tested were: Whatman glass microfiber GF/C with a nominal porosity of 1.2µm, Whatman glass microfiber GF/F with a nominal porosity of 0.7µm, Millipore Isopore polycarbonate PC 0.4µm, and Millipore Isopore polycarbonate PC 0.2µm. eDNA filters were stored in 95% ethanol. At each eDNA sampling site, water samples were collected for elemental analysis and water chemistry parameters were recorded.

In 2019, laboratory methods for sample processing were refined, including validation of new primers. A publication on the complete methods for sampling and processing of Arctic lake fish eDNA samples is expected to be produced in 2020.

In furthering the training objectives of this project, the first eDNA sampling workshop was held at the University of Manitoba in February, 2019, with 4 members of the Kivalliq Inuit community in attendance. The 3 day workshop featured of number of lecturers in the eDNA community, as well as a hands-on DNA extraction laboratory.

The eDNA workshop in February 2019 has laid the foundation for further involvement of the Inuit community in eDNA sampling. In the 2019 season, 2 of the trainees from the program assisted in sample collection. This field training will set the stage for sampling independent of the University of Manitoba.

SECTION 4 • ASSESSMENT OF SUCCESS

4.1 CONSTRUCTED OFFSETS

No monitoring has yet been conducted for constructed offsets, so success can not yet be evaluated.

Initial monitoring is expected to occur in 2026, after construction of the Mammoth Sill, grid shoals, and road scarification, and prior to flooding of the former lake basin in Whale Tail North.

4.2 COMPLEMENTARY MEASURES

Criteria for success for each research project are focussed on publication of study results in the peer-reviewed literature, or similar primary sources. None of the research programs have reached this stage, but all are on track to meet originally targeted timelines according to research agreements (Table 2). With the exception of Study 2 (delayed one year), all studies were initiated according to the timeline proposed in the Fish Habitat Offsetting Plan for Whale Tail Pit, Appendix C (May, 2018).

In the interim, several studies have been presented at academic conferences.

Table 2. Target study publication dates and conference presentation references. *Wastewater study initiation was delayed one year compared to dates proposed in the Fish Habitat Offsetting Plan for Whale Tail Pit, Appendix C (May, 2018), so publication dates are adjusted accordingly.

Study	Study Period	Target Publication Date		Conference Presentations
		Original	Current	
Study 1: Productivity	2018 – 2022	2022	2022	Ellenor, J., Portt, C., and Swanson, H.K. 2019. Variation in Slimy Sculpin (*Cottus cognatus*) monitoring endpoints at six Barrenland lakes in central Nunavut. Poster presentation. Canadian Conference for Fisheries Research on January 3-6, 2019.
Study 2: Wastewater	2019 – 2024	2021/2024*	2021/2024	
Study 3: Habitat Preferences	2018 – 2020	2020	2020	
Study 4: Arctic Grayling Occupancy	2018 – 2021	2021	2021	Ellenor J., Swanson, H. K., 2019. Factors influencing how Arctic Grayling (*Thymallus arcticus*) use Barrenland streams near Baker Lake, Nunavut. Platform presentation. ArcticNet Annual Scientific

Study	Study Period	Target Publication Date		Conference Presentations
		Original	Current	
				Meeting on December 2-5, 2019.
Study 5: End Pit Lake Habitat Use	2027 – 2034 (est.)	2030-2034	2030-2034	
Study 6: eDNA Study	2018 - 2023	2020, 2022	2020, 2022	

SECTION 5 • ACTIONS

5.1 CONSTRUCTED OFFSETS

According to the Fish Habitat Offset Monitoring Plan (Table 4), no monitoring is planned in relation to constructed offsets for Whale Tail Pit in 2020.

5.2 COMPLEMENTARY MEASURES

In 2020, field programs, laboratory assessments, and data analysis will continue for studies 1, 2, and 6 as feasible. Delays in 2020 field programs may arise due to site travel restrictions under COVID-19.

Study 3 (literature review and field validation of northern lake fish habitat preferences) is planned to be completed, and manuscripts are expected to be submitted for publication.

Study 4 (Arctic grayling occupancy) objectives will be substantially completed in 2020, with a presentation made at Arctic Net in 2019 and manuscripts expected to be submitted for publication in 2020. Supplemental field programs for model validation may be completed as feasible in 2020 or 2021.

For Study 5 (End-pit lake habitat suitability), Agnico will continue to look for an appropriate alternate study sites, academic and industry research partners.

A second meeting of the MFRAG is planned for November, 2020.

APPENDIX A

2019 MFRAG Meeting Agenda and Notes

AGNICO EAGLE

MEADOWBANK FISHERIES RESEARCH ADVISORY GROUP

December 12, 2019

Meeting notes in red

MFRAG MEETING

WELCOME

AGNICO EAGLE

- Background – What is the MFRAG?
  - In July 2018, DFO issued a Fisheries Act Authorization (FAA) for Agnico's Whale Tail Pit Project at the Meadowbank site (Baker Lake, Nunavut).
  - The accepted fish habitat offsetting for this project includes a suite of complementary measures (research projects) developed by Agnico in consultation with DFO.
  - As part of this program, Agnico and DFO conceptualized an advisory group to review project progress and provide a forum for input from key stakeholders.
  - Five of these projects are underway now at the Meadowbank site, and one is in the concept phase.

MFRAG MEETING

WELCOME

AGNICO EAGLE

- Project topics
  - Arctic grayling habitat occupancy modelling (2018 – 2020)
  - Change in fish population productivity related to terrestrial flooding (2018 – 2022)
  - Advancements in habitat suitability characterization for Arctic fish species (2018 – 2020)
  - Impacts of municipal wastewater discharge on fish health (2019 – 2023)
  - Characterization of fish habitat use in end pit lakes (est. 2027 – 2034)
  - Methods development in eDNA monitoring of Arctic fish populations (2017 – 2022)

- Today we will receive updates from the research teams on the progress of each project, and have an opportunity to ask questions, with a view towards ensuring that original project goals continue to be targeted, OR, discuss any changes in project goals.
- Recommendations for specific methods may be discussed with the researchers, but study design is not the intent.

MFRAG MEETING

WELCOME

AGNICO EAGLE

- Welcome and thank you to all MFRAG members and presenters

MFRAG Member Groups

- Fisheries and Oceans Canada
  - Boyan Tracz
  - Alasdair Beattie
  - José Audet-Lecouffe
  - Edyta Ratajczyk (online)
- Agnico Eagle
  - Nancy Duquet-Harvey
  - Robin Allard
  - Leilan Baxter
- Kivalliq Inuit Association
  - Jamie Kataluk
- Baker Lake Hunters and Trappers Organization
  - Richard Aksawnee
  - Harold Putumiraqtuq
- Appointed External Advisor
  - Kelly Munkittrick, University of Calgary (online)

MFRAG Presenters

- Heidi Swanson, University of Waterloo
- Sue Doka, DFO Science and Hannah Hancock, MSc Candidate
- Matthew McDougall, University of Manitoba

MFRAG MEETING

AGENDA

AGNICO EAGLE

9-9:45 am

Welcome

Review of comments received and signing of final MFRAG MOU/TOR

(~15 min break)

10 am – 12 pm

Research update presentations and question period (~ 30 min each)

(Lunch break)

1 – 2:45 pm

Research update presentations and question period (~ 30 min each)

(~15 min break)

3 – 4:30 pm

Summary and discussion of any preliminary recommendations for each project

(adjourned at 330 pm)

MFRAG MEETING

SIGNING OF THE MOU

AGNICO EAGLE

- Round table discussion of any final comments on the last version of the MOU/TOR
- After discussions, three comments require follow up by DFO/AEM, so the final version was not signed. However all members appear to be in agreement with the overall intent of the MFRAG, and the meeting will proceed as planned.
- The draft MOU/TOR from today will be sent out for further comment.

MFRAG MEETING

COFFEE BREAK

MFRAG MEETING

RESEARCH UPDATES

AGNICO EAGLE

- Presentation 4: Leilan Baxter – End Pit Lake Habitat Suitability
- Presentation 3: Susan Doka –Habitat Preferences of Northern Fish Species

LUNCH 

- Presentation 1: Heidi Swanson - Changes in Aquatic Productivity
- Presentation 2: Heidi Swanson – Baker Lake Wastewater Assessment
- Presentation 5: Heidi Swanson – Arctic Grayling Occupancy Modelling
- Presentation 6: Matthew McDougall – eDNA Methods Development

COFFEE BREAK 

MFRAG MEETING

DISCUSSION

AGNICO EAGLE

- Summary and discussion of any preliminary recommendations for each project, with intent to develop consensus in eventual written recommendations. Recommendations are to address any new/amended study objectives, methods, community engagement approaches, and eventually, confirmation that project deliverables/criteria for success have been met.

  Study 1: Heidi Swanson - Changes in Aquatic Productivity

  Study 2: Heidi Swanson – Baker Lake Wastewater Assessment

  Study 3: Susan Doka – Habitat Preferences of Northern Fish Species

  Study 4: Leilan Baxter – End Pit Lake Habitat Suitability

  Study 5: Heidi Swanson – Arctic Grayling Occupancy Modelling

  Study 6: Matthew McDougall – eDNA Methods Development

- No specific recommendations came up today; however the participants will have the opportunity to review all the presentations and provide written comments, if any.
- We reviewed the original project timelines and deliverables. All are proceeding as planned, with the exception of the Baker Lake wastewater study, for which the official start date was changed from 2018 to 2019, due to timing of applications for external funding by the research team.

MFRAG MEETING

CLOSING REMARKS

- Discuss submission date for written recommendations. DFO – end Feb
- Timing for next MFRAG meeting – ok with December 2020? Plan for Nov 2020
- Thanks all for your participation

AGNICO EAGLE

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