Appendix 45

Meadowbank 2021 Habitat Compensation Monitoring Report

MEADOWBANK COMPLEX

2021 HABITAT COMPENSATION MONITORING REPORT

In Accordance with

DFO Fisheries Authorizations NU-0190, NU-03-0191.3, NU-03-0191.4 and 14-HCAA-01046

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Complex

March, 2022

EXECUTIVE SUMMARY

According to Fisheries and Oceans Canada (DFO) *Fisheries Act* Authorizations (FAAs) NU-0190, NU-03-0191.3, NU-03-0191.4 and 14-HCAA-01046, Agnico Eagle maintains a Habitat Compensation Monitoring Plan (HCMP; Version 4, February, 2017) to demonstrate whether fish habitat compensation features at the Meadowbank site are constructed and functioning as intended.

In 2021, monitoring according to the HCMP was conducted for the constructed spawning pads feature, located at stream crossing R02 along the all-weather access road (AWAR) to Baker Lake (FAA NU-0190), as well as for the onsite habitat compensation features constructed to date (East Dike exterior, Bay-Goose Dike exterior, Dogleg Ponds – FAA NU-03-0191.3).

AWAR Spawning Pads - *NU-0190*

Habitat compensation monitoring methods for the spawning pads constructed in 2009 at AWAR crossing R02 include a visual assessment of spawning pad stability, as well biological monitoring to confirm adult fish presence and reproduction in this watercourse using hoopnets and drift traps. In 2021, the constructed spawning pads were visually confirmed to be stable as designed. For the adult fish population, condition factors, population size distributions and timing of migration were within the range of values seen in previous years, confirming continued use of this area by Arctic Grayling (*Thymallus arcticus*) without significant changes in population structure. Rates of collection of fish larvae in drift traps continue to exceed those observed prior to construction of the spawning pads. While these traps are useful to assess spawning rates upstream of the R02 AWAR crossing generally, Agnico anticipates reviewing HCMP methods prior to the next (2023) monitoring event to better assess successful utilization of the constructed spawning pads specifically. Any updated plans will be provided to DFO for review prior to implementation. Currently, monitoring of this compensation feature is scheduled to continue every other year until decommissioning of the AWAR (est. 2031).

Dewatering Dike Faces (Exterior) - *NU-03-0191.3*

Habitat compensation monitoring for the exterior of dewatering dike faces (East Dike and Bay-Goose Dike) in 2021 included a final assessment of interstitial water quality, periphyton growth and fish use. These features were constructed in 2009 and 2011, and monitoring was prescribed in the HCMP for a minimum period of 10 years. A historical review was performed to facilitate a weight-of-evidence evaluation and confirm criteria for success for these compensation features have been met.

Overall, while periphyton growth has been slow and average biomass has not yet reached reference levels, diverse communities are present. Dewatering dike faces were constructed as designed in the NNLP and are stable as fish habitat (Section 2.2.4.2), with suitable water quality for aquatic life (Section 3.2.1.2), and have recorded fish presence at rates no lower

than reference areas (Section 3.2.3.2). Since periphyton communities are considered healthy and there is no reason to believe that biomass will not eventually reach reference levels, the weight of evidence indicates that dike faces are functioning as fish habitat, as assumed in the NNLP. As a result, criteria for success are considered to be met and no further compensation-related monitoring for these features is planned, but this will be confirmed in consultation with DFO prior to the next potential monitoring season (2023)

Dogleg Ponds - *NU-03-0191.3*

In 2021, monitoring for the Dogleg Ponds included structural assessments (surface area and connectivity), and evaluation of fish presence through angling and underwater camera.

Complete bathymetric surveys indicated that changes in surface area have occurred as assumed in the NNLP (+5 – 15%). Visual assessments of connectivity indicated channels are passable to fish during freshet, with potential access upstream to Dogleg Pond and NP-1 for small-bodied species throughout the season. Fish were identified by underwater camera within both Dogleg Pond and NP-1, which supports NNLP assumptions of access enhancements in this area. Final follow-up monitoring will be conducted along with historical review in 2025 according to the HCMP, prior to determining success of this compensation feature.

Vault Area - NU-03-0191.4, 14-HCAA-01046

Mining operations have now ceased in the Vault and Phaser Pits, and initial habitat monitoring events (substrate assessments in the dry) were planned to be conducted in 2020, prior to significant reflooding of the lake basins. These assessments have been delayed to 2022. No additional flooding of the Vault and Phaser basins is planned to occur over this time period (2020 – 2023) as pits are filling with natural inflows, so this delay does not impact substrate assessment methods or results.

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1.1 BACKGROUND

In accordance with *Fisheries Act* Authorizations (FAAs) NU-03-0190, NU-03-0191.3, NU-03-0191.4, and 14-HCAA-01046, Agnico Eagle maintains a Habitat Compensation Monitoring Plan (HCMP; February, 2017) for the Meadowbank site to ensure that fish habitat compensation described in the site's No Net Loss and Fish Habitat Offsetting Plans is constructed and functioning as intended. The HCMP pertains to fish habitat compensation for losses associated with the Meadowbank site, including Second Portage Lake, Third Portage Lake, Phaser Lake, Vault Lake, and AWAR stream crossings, as described in the following plans:

FAA NU-03-0190: Meadowbank Gold Project No-Net-Loss-Plan (NNLP), prepared by Azimuth Consulting Group Inc. – November 2006

- Losses and compensation for the AWAR stream crossings

FAAs NU-03-0191.3 and NU-03-0191.4: Agnico-Eagle Mines: Meadowbank Division No Net Loss Plan (NNLP) – October 15, 2012

- Losses and compensation for Second Portage Lake, Third Portage Lake, and Vault Lake

FAA 14-HCAA-01046: Agnico Eagle Mines: Meadowbank Division Fish Habitat Offsetting Plan: Phaser Lake – February, 2016 (draft)

- Losses and offsetting for Phaser Lake

The success of fish habitat offsetting for the Whale Tail site is monitored and reported separately under the Fish Habitat Offsets Monitoring Plan for the Whale Tail Site (V2 June, 2021; under review), and is not discussed here.

1.2 SUMMARY OF COMPENSATION FEATURES

A brief description of habitat compensation features for each FAA is provided below. Further details are available in the most recent Habitat Compensation Monitoring Plan (Version 4, February, 2017).

1.2.1 AWAR Compensation (NU-03-0190)

Construction of the 110 km All Weather Access Road (AWAR) between the Hamlet of Baker Lake and the Meadowbank Mine was completed in the spring of 2008, under DFO Authorization NU-03-0190. Four AWAR crossings were found to impact fish-bearing streams, so habitat compensation was required by DFO to account for any potential reductions in productivity.

In 2009, a habitat compensation project consisting of four gravel spawning pads was constructed at crossing R02 according to design specifications that met biological criteria aimed at enhancing Arctic Grayling (*Thymallus arcticus*) productivity (Figure 1). The construction focused on creating high value spawning and nursery habitat to compensate for the loss of the low and medium value habitat affected by bridge abutment construction at the four crossings.

Per Condition 5 of Fisheries Act Authorization NU-03-0190, monitoring studies have been conducted to evaluate fish migrations at the four AWAR crossings where "harmful alteration, disruption or destruction" (HADD) of fish habitat occurred (R02, R06, R09, and R15), and where compensation was implemented (R02). The details of this program are described in the original HCMP (Azimuth, 2007). In 2013, Agnico Eagle and DFO reviewed the information collected to date, and determined that conditions of the Authorization pertaining to monitoring of HADD sites were fulfilled, and that further monitoring would focus on the habitat compensation features. Updates to the scheduled monitoring activities at R02 were made beginning in 2013 (HCMP Version 2 - Agnico Eagle, 2014).

Figure 1. Arctic Grayling spawning pads constructed at Meadowbank all weather road crossing R02.

1.2.2 Portage Area Compensation (NU-03-0191.3)

Fish habitat losses in the Portage area are largely due to the dewatering of a portion of Second Portage Lake for the mine's tailings storage facility (TSF) and Portage Pit, and the Bay-Goose Basin of Third Portage Lake for construction of the Portage and Goose Island pits (Figure 2). These areas were impounded from the rest of their lakes using dewatering dikes constructed from material quarried onsite.

Habitat compensation features in the Portage Pit area are as follows.

1.2.2.1 Bay-Goose Basin Re-Flooding & Dewatering Dike Faces

While the TSF area in Second Portage Lake represents a permanent loss of fish habitat, the impounded Goose and Portage Pit areas and surrounding former lake basins were planned to be re-flooded after mining operations ceased. This re-flooded area formed a significant part of the site's original fish habitat compensation under Fisheries Act Authorization NU-03-0191.3. However, since in-pit deposition of tailings material was permitted within the dewatered area in 2019, Agnico is working with DFO to adapt the habitat offsetting plan for NU-03-0191.3 as necessary. An addendum to the 2012 No Net Loss Plan for the Meadowbank Site which describes proposed changes in habitat compensation related to in-pit deposition of tailings material was submitted to DFO in December, 2020, and Agnico is awaiting final review. Proposed changes do not impact the compensation monitoring that was required in 2021 under the HCMP schedule, so this addendum is not discussed further here.

The exterior faces of the dewatering dikes (East Dike and Bay Goose Dike) are currently in place as constructed habitat compensation features, and monitoring was conducted for these dike faces in 2021.

1.2.2.2 Dogleg Pond Enhancements

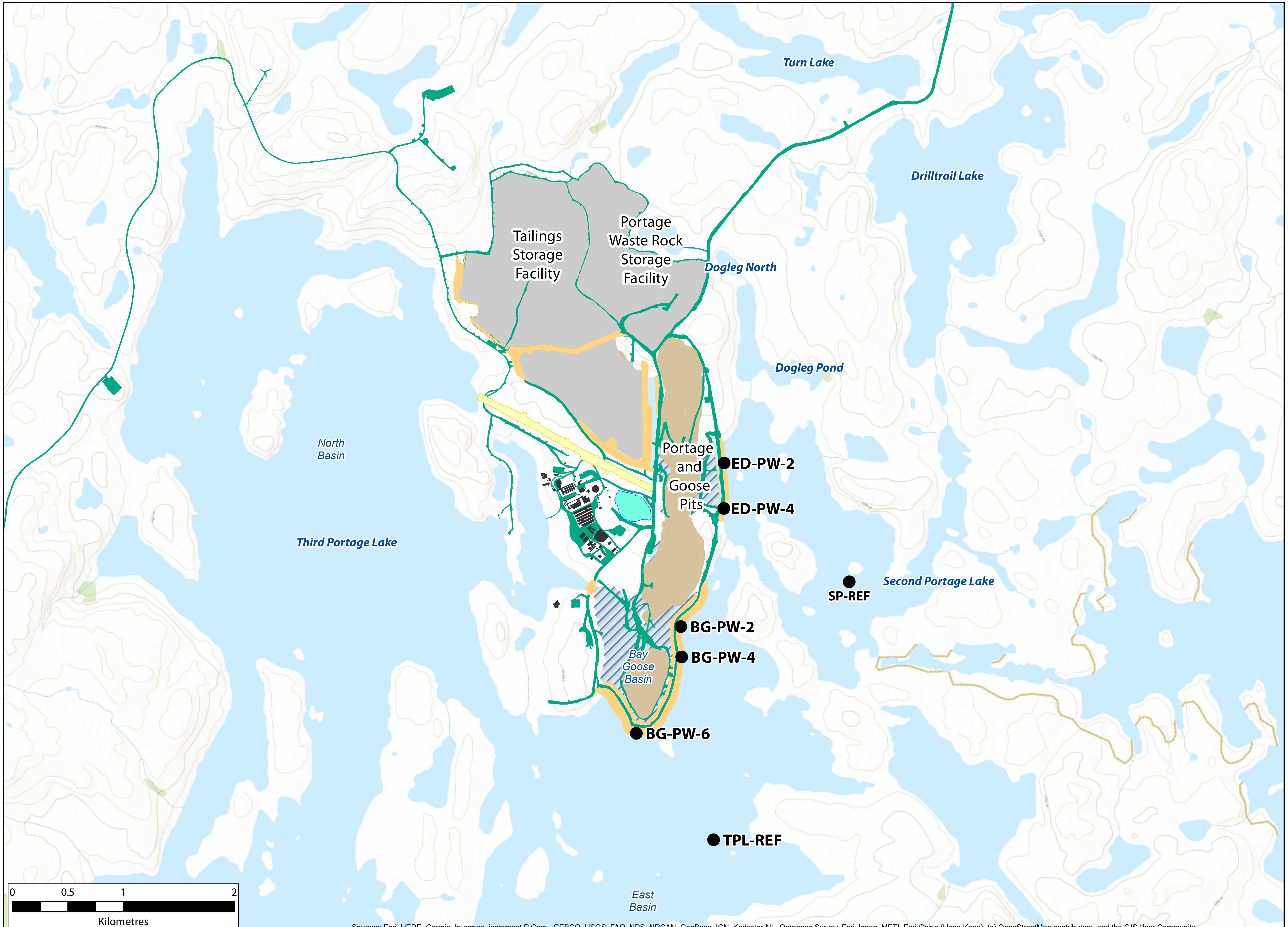
Dogleg Pond and the "North Portage" ponds, Dogleg North Pond (also called NP-1) and NP-2, were isolated ponds located near the waste rock area, just north of Second Portage Lake. Since drainage of NP-2 into Second Portage Lake became blocked by the waste rock pile on the northern edge of the TSF, a connecting channel was excavated (2013) to direct flow from NP-2 to Dogleg North Pond, effectively increasing the drainage area of Dogleg and Dogleg North Pond. The accompanying increase in wetted area was estimated at 5% for Dogleg Pond, 15% for Dogleg North Pond (NP-1), and 5% for NP-2. Through construction of a diversion channel, connectivity between the ponds has been improved, and previously inaccessible habitat in Dogleg North Pond has become available for use by fish inhabiting Dogleg Pond.

Monitoring of fish presence/absence and surface area was conducted for the Dogleg Ponds in 2021.

1.2.2.3 Finger Dikes

As described in the 2012 NNLP for the Meadowbank Site, finger dikes are also planned to be constructed on the Bay-Goose Dike extending into Third Portage Lake. These features will provide additional "shoreline" habitat that is used by most species for spawning and will have a total area of 1 ha at their base.

The finger dikes are not yet constructed so no monitoring was required in 2021.



Legend

● Habitat Monitoring Location

Mine Plan

- Dewatered Lake
- Roads
- Pits
- Airstrip
- Dikes
- Facilities
- Waste Rock & Tailing Storage Facility
- Stormwater Management Pond

Habitat Compensation Monitoring Locations

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CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N
W E
S
UTM Zone 14 NAD83

DATE: JANUARY 2022

SCALE: 1:32,000

DRAWN BY: LC, JS

CHECKED BY:

FIGURE:

2

The information displayed on this map has been compiled from various sources. While every effort has been made to accurately depict the information, this map should not be relied on as being a precise indicator of locations, features, or roads, nor as a guide to navigation. MNR data provided by Queen's Printer of Ontario. Use of the data in any derivative product does not constitute an endorsement by the MNR or the Ontario Government of such products.

1.2.3 Vault Area Compensation (NU-03-0191.4, 14-HCAA-1046)

Vault Lake and Phaser Lake, located north of the Portage area, drained to the adjacent Wally Lake prior to construction activity, but the connection was not passable to fish. To allow construction of the Vault and Phaser pits, Vault Lake was separated from Wally Lake with the Vault Dike and both Vault and Phaser Lakes were dewatered.

Post-closure, Vault Lake will connect to Phaser Lake through the BB Phaser Pit. Both areas will be re-flooded and the connection to Wally Lake re-established with a deeper channel to permit better fish passage. Vault and Phaser Lakes will also be expanded by construction of the Vault and Phaser pits, a portion of which is in a terrestrial zone. Alterations of the de-watered basin area outside the pit will improve habitat through the development of shoals and mixed substrate areas.

Initial monitoring events for Vault area compensation (substrate surveys in the dry for Vault and Phaser Lake basins) were originally planned for 2019 but have been delayed to 2022 (Section 2.3). Re-flooding of the pits in this area is ongoing through natural inflows, and no change to the flood status of the lake basins is anticipated prior to 2023.

1.3 OBJECTIVES

The following sections describe the monitoring objectives for compensation features by location. These objectives are fulfilled according to the methods and schedule described in detail in Section 2, below, and in the HCMP.

1.3.1 AWAR Monitoring Objectives

Based on Condition 5.2 of DFO Authorization NU-03-0190, the objectives of the AWAR monitoring program are as follows:

- Assess the stability and successful utilization of all compensation features during the spawning and nursery period for Arctic Grayling (Condition 5.2.1)

Additional Conditions pertaining to monitoring of HADD sites were no longer required as per the 2014 HCMP Version 3 update (that was designed in consultation with DFO).

1.3.2 Portage and Vault Area Monitoring Objectives

Based on Condition 6 of DFO Authorizations NU-03-0190.3, NU-03-0191.4, and 14-HCAA-1046, the objectives of the Portage area monitoring program are as follows:

- Assess the stability and successful utilization of all fish habitat compensation features according to the methodology and schedule detailed in the Habitat Compensation Monitoring Plan

- Provide a photographic record before, during and after construction, during decommissioning and post-restoration to indicate that all works and undertakings have been completed according to the conditions of the Authorization and the NNLP

1.4 SCHEDULE OF MONITORING

The complete schedule of monitoring events is detailed in the HCMP (Version 4; February, 2017). Monitoring activities conducted in 2021 generally followed the schedule therein, with minor alterations as described in Section 2, below.

SECTION 2 • CURRENT-YEAR MONITORING METHODOLOGY

As per the HCMP schedule, monitoring was conducted in 2021 for the AWAR compensation feature (FAA NU-0190; Condition 5.2.1) and for the Portage area compensation features (FAA NU-0191.3; Condition 6). Initial monitoring events for the Vault area compensation features (FAA NU-0191.4 and 14-HCAA-01046; Condition 6) were originally scheduled for 2019, but have been delayed to 2022 as further described in Section 2.3.

A description of the methods used to assess function and structure of each habitat compensation feature according to the objectives of the FAAs is provided in the HCMP. Specific details (e.g. dates, locations) and any adjustments to standard methods in the reporting year's monitoring events are described below.

2.1 AWAR MONITORING

2.1.1 Stability

The compensation features were visually assessed to determine general stability in comparison to previous years. In particular, signs of any significant movement of the berm material or spawning bed material were noted. Significant movement would be identified as any changes prohibiting the berms from functioning as intended to reduce water flow rates and improve spawning habitat in the constructed gravel area between the berms.

2.1.2 Larval Drift Traps

To demonstrate ongoing reproduction within the R02 reach, drift trap monitoring proceeded in a manner similar to previous years. In total, 12 larval drift traps (DT) were set at R02 from June 20/21 through July 16, 2021 (UTM coordinates provided in Table 1; locations shown in Figure 3). Four traps (DT A1 to A4) were upstream of the R02 habitat compensation area. Four traps (DT B1 – B4) were immediately downstream of the R02 habitat compensation, and four traps (DT C1 – C4) were set further downstream, slightly upstream of the bridge in locations identical to previous monitoring events. Five of the larval drift traps consisted of a square sided metal cone with a rigid frame (~47 x 30 cm) that funnelled into a 0.5 mm nitex mesh bag. Attached at the back of the nitex bag was a Nalgene®-type container where the drift was collected. Seven traps consisted of a ~60cm x 30 cm square frame which has a 0.5 mm nitex mesh bag, attached to a hard plastic container where the drift was collected. The frames were submerged at least halfway under water (as water levels permitted) and secured by poles on each side. Drift traps were checked at least every three days, but most commonly every day until the second last day of monitoring when drift had declined to near zero, and they were left unchecked for one week. Larval drift was enumerated in the field and released.

Table 1. UTM coordinates for drift traps at R02 in 2021.

Drift Trap ID	Date In	Date Out	UTM Coordinates (Zone 14)	
A1	June 21	July 16	643461	7143399
A2	June 21	July 16	643451	7143402
A3	June 21	July 16	643442	7143404
A4	June 21	July 16	643436	7143413
B1	June 20	July 16	643585	7143509
B2	June 20	July 16	643584	7143522
B3	June 20	July 16	643580	7143531
B4	June 20	July 16	643572	7143541
C1	June 20	July 16	643744	7143416
C2	June 20	July 16	643750	7143419
C3	June 20	July 16	643763	7143425
C4	June 20	July 16	643774	7143430

2.1.3 Angling

To confirm presence of adult fish within the constructed spawning pads, angling and underwater camera methods were used.

Consistent with previous years, minimal angling was conducted at R02 in 2021. Attempts were made for 30 – 90 min periods on July 2, 4, and 6 by casting with small lures with barbless hooks, focussing on the spawning pads area (in and around the berms). Locations and durations are provided in Section 3.1.3 (Results).

2.1.4 Underwater Camera

In 2021, the focus areas for the underwater video cameras were between the spawning berms. Cameras were set for 1.5 – 2.5 h on either July 4 or 6 between each set of berms (3 recordings total), and 6h22m of footage were recorded. Locations and durations are provided in Section 3.1.4 (Results).

The cameras were mounted on a ½" x 12" L shaped piece of rebar which was welded to a 4" x 12" steel "C" beam. The "C" beam acted as a base for the camera mount. A rope with a buoy at one end was attached to the rebar and lowered into the water. The buoy was used as a locator once the camera was deployed under water.

2.1.5 Hoopnets

To document adult population metrics within the R02 reach, migrating fish were captured using hoopnets set upstream of the AWAR bridge and culvert crossings (Figure 3). Without jeopardizing the safety of the field personnel, the nets were placed in the thalweg of the streams depending on ice-flow conditions and stream velocities, to ensure the maximum effort to capture migrating fish. Nets consisted of either a 4 ft (1.22 m) or 3 ft (0.9 m) diameter front hoop, with interior hoops and traps that prevent fish from escaping but provide enough space for fish to survive. Wings were attached to the front hoop to direct fish into the net. The captured fish were gently removed by field technicians, placed in large tubs filled on location with stream water for biological processing and then placed in a recovery tub. The fish were released up or downstream of the hoopnets, depending on the fish's migration direction. The Animal Use Protocol Report for this work is provided in Appendix A.

Biological processing included:

- measurement of fork length
- measurement of weight using a Pesola field scale (+/-2 to 5 g)
- classification of maturity by gently palpitating the abdomen and visually identifying distinguishable male or female features

For the purposes of population surveys, nets were set once water conditions were safe, between June 19 and July 1 (depending on location) and were removed on July 6, 2021.

Hoopnet locations (Figure 3, Table 2) were selected upstream (R02A) and downstream (R02B) of the constructed spawning pads as in previous years. A third group of nets (R02C) was also set in a side channel, upstream of the road crossing culvert, adjacent to the bridge.

Table 2. Hoopnet locations, net orientation (upstream-moving fish, US; downstream-moving fish, DS), dates of deployment and approximate stream coverage at crossing R02 in 2021 (*coverage may equal more than 100% as wings overlapped)

Location	GPS Coordinates	Start Date	End Date	Soak Time (days)	% Coverage*
R02A-US	14W 643508 7143443	6/21/21	7/6/21	15	25
R02A-DS	14W 643512 7143454	6/23/21	7/6/21	13	50
R02A-US	14W 643496 7143455	6/27/21	7/6/21	9	80
R02B-US	14W 643740 7143430	6/15/21	6/17/21	2	30
R02B-DS	14W 643744 7143437	6/15/21	6/17/21	2	30
R02B-US	14W 643450 7143439	6/19/21	7/06/21	17	30
R02B-DS	14W 643750 7143446	6/19/21	7/06/21	17	40
R02C-US	14W 643923 7143420	1/07/21	7/6/21	5	100
R02C-DS	14W 643831 7143431	1/07/21	7/6/21	5	100

Figure 3. Locations of cameras, hoopnets, and larval drift traps in 2021 at the R02 habitat compensation feature.

2.1.6 Water Temperature

Water temperature measurements were recorded daily using a standard digital thermometer. Although these are not a component of compensation monitoring, they help to provide a record of the environmental setting under which migrations are occurring.

2.2 PORTAGE AREA MONITORING

2.2.1 Interstitial Water Quality

Modeling during the Environmental Impact Assessment process indicated that metals leaching from quarried rock used in dike construction would not significantly impact the aquatic environment. Nevertheless, interstitial water quality of constructed habitat compensation features is assessed through the HCMP to verify predictions.

In order to collect a representative sample from the bioactive zone between the rocks, an electric diaphragm pump with food-grade silicon tubing was used. Samples were collected at depths between 1 and 2 m at previously established locations (Table 3, Figure 2), and analyzed for total suspended solids, phosphorus, hardness, and total and dissolved metals. Results are compared to CCME Water Quality Guidelines for the Protection of Aquatic Life (Freshwater, Long Term) (CCME, 2022).

In all previous monitoring events (2011, 2015, 2017) no exceedances of CCME guidelines occurred except for total phosphorus (2011 only, all stations including reference), and occasional exceedances of TSS (2015, 2017) in individual samples where the dike material was likely disturbed by the sampler.

Table 3. UTM coordinates for dike interstitial water (pore water) monitoring locations. These are also the approximate locations of underwater video monitoring and angling.

Location	Station ID	UTM Coordinates	Depth
East Dike	ED-PW-2*	14W 0639382 7214257	1.8 m
	ED-PW-4	14W 0639381 7213846	1.5 m
Bay Goose Dike	BG-PW-2	14W 0638993 7212783	1.9 m
	BG-PW-4	14W 0639001 7212509	1.6 m
	BG-PW-6	14W 0638592 7211820	1.7 m
Third Portage Lake Reference Station	TPL-REF	14W 0639289 7210860	1.9 m
Second Portage Lake Reference Station	SP-REF	14W 0640510 7213187	1.7 m

**Note that in the 2015 report, this location was misidentified as PW-1, but coordinates are the same*.

2.2.2 Periphyton Growth

Periphyton monitoring was conducted by Azimuth Consulting Group in 2021 to assess growth (density and biomass) and community composition on the dewatering dike faces compared to reference areas. Methods for this component are summarized here, and details are provided in Appendix B.

Periphyton samples were collected between August 7 and 17 in the following areas (Appendix B Figure 2-1):

East Dike HCF (Second Portage Lake)

- East Dike (SP-ED)
- Drilltrail Arm reference area (SP-DT)

Bay-Goose Dike HCF (Third Portage Lake – East basin)

- Bay-Goose Dike – North section (TPE-BGN)
- Bay-Goose Dike – South section (TPE-BGS)
- Bay-Goose reference area (TPE-G)

Five replicate samples were collected from each area and analyzed independently. Periphyton samples were preserved in the field with a small amount of Lugol's solution and sent to Plankton R Us Inc. (Winnipeg, MB) for taxonomic identification and biomass (µg/cm^2) estimation.

2.2.3 Fish Use

Both angling and underwater motion camera monitoring took place in and around the interstitial water sampling locations, as shown on Figure 2. Catch and effort were recorded for each location and are presented in Section 3.2.3 (Results). The Animal Use Protocol Report for this work is provided in Appendix A.

2.2.3.1 Angling

Summertime angling was performed by Agnico Eagle technicians between August 6 and September 2. Ice fishing was performed on October 2, November 27, and December 19. A total angling effort of 36.5 line hours (h) was completed (15.3 h in the Dogleg Ponds; 21.2 h in Portage Lakes).

All fish were caught using a jigging method with a small jigging spoon with barbless hooks. All fish caught by angling were recorded, and the majority were weighed, measured, floy-tagged below the dorsal fin (unless they were lost during capture), and released. To minimize stress, each fish was processed quickly and then released, by holding underwater until it was able to swim away on its own. No mortalities occurred.

2.2.3.2 Underwater Camera

Underwater motion camera monitoring was performed by Agnico Eagle technicians between August 6 and 24, 2021. A total effort of 22 h of video footage was collected across all locations (dike faces and Dogleg Ponds). Cameras were attached to custom-made heavy metal stands and lowered by rope. Cameras were collected approximately 2 – 4 h later and reviewed (due to the cold water temperatures, the battery life on the underwater motion cameras was restricted to about 1.5 h). Observations of fish within the video frame were recorded, along with species if feasible.

2.2.4 Structure & Stability

2.2.4.1 Portage Pit Area

Under the 2017 HCMP, structure monitoring for compensation features within the dewatered Portage area (basin, pits, boulder garden, roads/shoals) is planned to occur prior to re-flooding using air photos and/or field survey to document substrate types throughout this area for eventual comparison with NNLP post-construction habitat type assumptions. However, since this area is no longer considered by DFO to be a viable option for habitat compensation due to in-pit deposition of tailings material, structure monitoring for habitat compensation purposes is no longer scheduled. It is anticipated that the HCMP will be updated in 2022 pending DFO approval of the December 2020 Addendum to the 2012 NNLP for the Meadowbank Site, which identifies the replacement habitat compensation option and associated monitoring plan.

2.2.4.2 Dewatering Dikes – Exterior Faces

Final designs (as-builts) of the East and Bay-Goose Dikes were incorporated into the 2012 NNLP calculations (Agnico Eagle, 2012a). Stability was assessed in the 2011 Habitat Compensation Monitoring Report (Agnico Eagle, 2012b). No additional structure or stability monitoring is planned for this location in the HCMP. Photos of the dikes in 2021 are provided below.

Figure 4. East Dike, looking north.

Figure 5. East Dike, looking south.

Figure 6. Bay-Goose Dike, looking east.

2.2.4.3 Dogleg Ponds

Design intent of the surface area changes and access improvements for the Dogleg system are monitored to confirm whether construction of the diversion channel from NP-2 to Dogleg North Pond (NP-1) is increasing the wetted area of these ponds as assumed, and to confirm the potential for fish movement, especially between Dogleg Pond and Dogleg North Pond (NP-1).

Monitoring includes bathymetric surveys to determine water depth and area of each pond, and an assessment of water depth in connecting channels (visual). Both bathymetric surveys of the ponds and visual surveys of connecting channels were conducted in 2021 (June - August).

2.3 VAULT AREA MONITORING

According to the HCMP, assessments of structure (particularly substrate types) within the dewatered Vault and Phaser Lake basins will occur prior to significant flooding of these areas. Since mining operations have now ceased in the Vault and Portage pits, habitat structure assessments were initially planned to be conducted in 2019, but have been delayed to 2022. Pits are currently re-filling with natural in-flows, and no additional flooding of the adjoining Vault and Phaser Lake basins is planned to occur prior to 2023, so this delay does not impact the substrate assessment.

Substrate assessments in 2022 will aim to document whether changes to post-flooding habitat type areas within these basins are complete as designed in the NNL Plans for Vault and Phaser Lakes. The assessments prior to significant re-flooding will focus on mapping substrate types, while final surface area and depth zones will be determined after flooding is complete, along with analyses of water quality and fish use.

The current reflooding status in Vault and Phaser Lakes is shown in Figure 7 (photo from 2020 – since that time pit flood level has increased but lake basin flood levels remain the same).

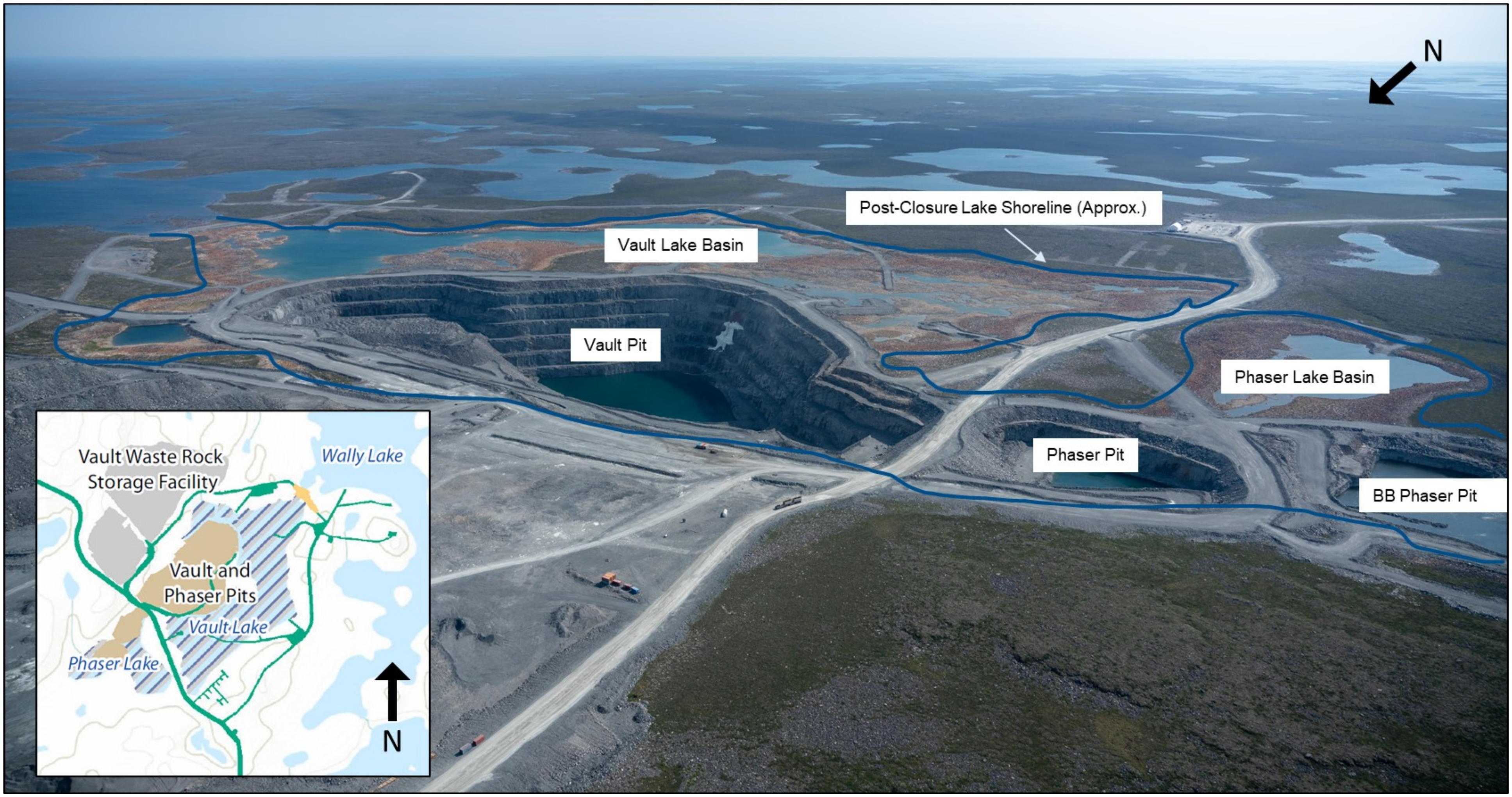

Figure 7. Vault and Phaser Lakes area, showing current status of lake basin flooding (August 2020), and mine plan (inset) for reference.

SECTION 3 • RESULTS

3.1 AWAR MONITORING

3.1.1 Stability

Visual observations indicated little to no movement of the spawning berm material. The berms appear to be functioning as intended to reduce water flow rates and depths. Gravel substrate and cobble U-berms on the downstream side of each berm remain intact.

Figure 8. R02 spawning pad berms (blue arrows) just after full ice off (June 22) in 2021.

3.1.2 Larval Drift Traps

3.1.2.1 Current Year Results

In 2021, 2176 larvae were collected in the R02 reach studied. Of these, 736 larvae were collected in traps A1 – A4, which were placed just upstream of the compensation area and downstream of natural spawning habitat (Table 4). In total, 1022 larvae were collected in traps

B1 – B4, which were located just downstream of the habitat compensation area. Drift traps C1 – C4 were placed further downstream, and collected a total of 579 larvae.

Table 4. Total, daily average and daily maximum catch of fish larvae in drift traps at R02 in 2021.

Drift Trap ID	Total	Average	Max
A1	137	10.5	36
A2	203	15.6	47
A3	159	12.2	32
A4	237	18.2	47
Total	736	-	-
B1	59	4.2	13
B2	290	20.7	93
B3	375	26.8	86
B4	298	21.3	106
Total	1022	-	-
C1	21	1.5	9
C2	177	12.6	42
C3	198	15.2	49
C4	183	13.1	37
Total	579	-	-

Arctic Grayling are spring spawners that migrate from lakes and large rivers to smaller streams to spawn over gravel or rocky bottoms (Evans et al. 2002). The literature suggests that spawning occurs between 7 and 10°C (Evans et al. 2002, McPhail and Lindsey, 1970; Scott and Crossman, 1973). Young are thought to hatch within 16-18 days at water temperatures of 9°C or within 8 to 32 days of water temperature of 15.5°C (McPhail and Lindsey, 1970; Krueger, 1981).

In 2021, peak drift trap catch occurred between June 27 and July 1, just when water temperatures jumped from 5°C to 10-11°C (Figure 9). In previous years, peak catch has occurred slightly earlier (June 13 – 24), at water temperatures of 2 – 6°C. These results were taken to suggest that fish caught in drift traps in recent years, and particularly 2019, may have included YOY of fall spawners (e.g., lake trout or round whitefish), which hatch in late spring in this region. While this may still be the case, spent adult Arctic Grayling (females and males) were identified in hoopnets from the initiation of monitoring in 2021 (June 22 – Appendix C), suggesting that Arctic Grayling spawning did occur prior to June 22 when water temperatures were less than 2 – 4°C.

In 2006 – 2007 (Azimuth, 2007; 2008a), taxonomic ID of drift trap catch was formally performed by a consulting laboratory. In 2006, 4 of 56 YOY were identified as Arctic Grayling, while the remainder were small-bodied fish (Slimy Sculpin or Stickleback). In 2007, 89% of the 327 fish were determined to be Arctic Grayling. In 2008 (Agnico Eagle, 2009), taxonomic ID was performed by the consulting laboratory, but only total numbers of Arctic Grayling were reported. In 2009 (Agnico Eagle, 2010), fish larvae identification was confirmed at a University of Guelph laboratory by an Agnico environmental biologist using a suitable larval taxonomic key (Auer 1982). Since that time (Agnico Eagle, 2011, 2013, 2015, 2017, 2019) field ID has been performed, and only total Arctic Grayling catch has been reported (except in 2010, when 2 Ninespine Stickleback (*Pungitius pungitius*) were reported among 1136 Arctic Grayling). However, based on the very early presence of larval drift catch in 2019 (June 13 at water temperatures of 2°C), it is likely that alternate (fall-spawning) species are in fact present and these may have been misidentified in the field as Arctic Grayling in recent years. Historical results (Section 3.1.2.2) are interpreted in that context. Total drift trap catch is assessed, rather than Arctic Grayling only.

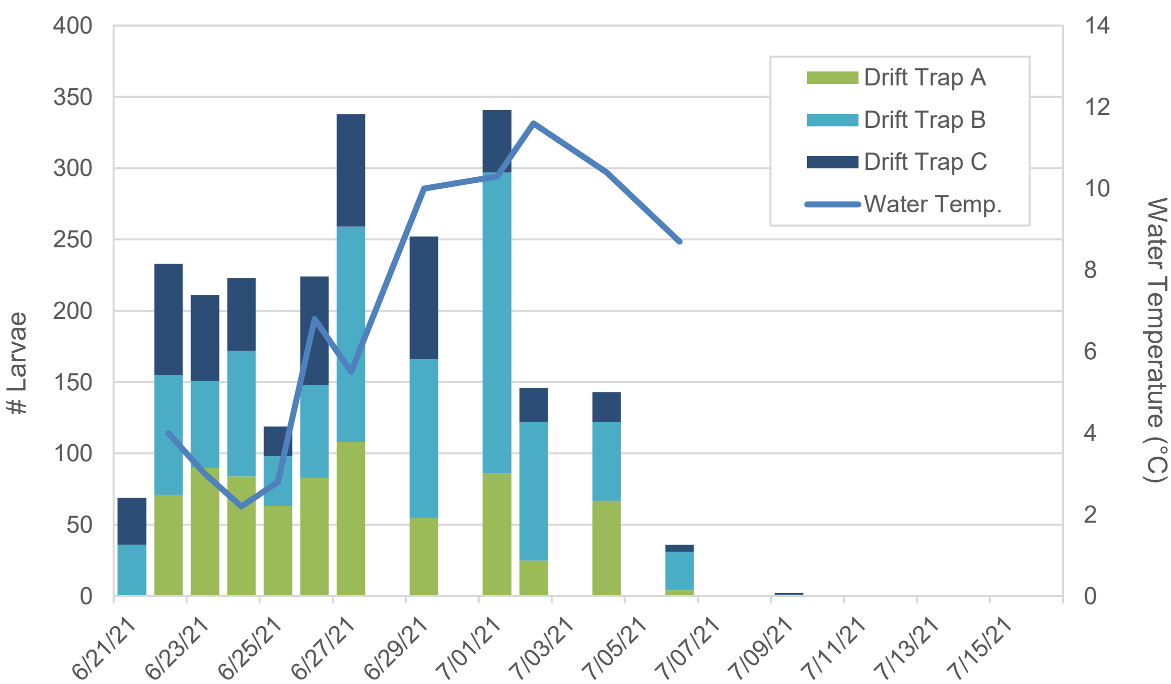

Figure 9. Water temperature and total number of fish larvae collected at drift trap areas A, B and C from June 21 – July 16, 2021.

3.1.2.2 Historical Results

Since 2005, the number of drift traps and dates of monitoring have varied at R02 (Table 5). Therefore, the year-over-year change in drift trap collection observed in annual monitoring programs is more effectively compared if values are standardized to the number of traps and number of days monitored (i.e. catch per unit effort (CPUE); soak time = 24 h/day). The trapping period in 2021 was near average, with traps set for 25 - 26 days from mid-June to mid- July. In 2007, 2009 and 2010, the trapping period was extended to late July or early August (37 – 45 days). In late July of each year, larval drift was essentially reduced to nil. To provide a preliminary comparison of standardized counts, the first 24 days of each monitoring period are examined (for 2017, only 23 days are available) in Figure 10. Although the first date in has varied by up to 14 d over the years (Table 5), this date typically corresponds with ice-off, so comparing catch for the first 24 d each year also provides a rough standardization by temperature and flow conditions.

In 2005, no larvae were collected at R02, likely because only one drift trap was set. This is not considered to be a representative sample, so is excluded from the comparison.

Table 5. Summary of larval drift trap sets at R02 from 2005 to 2021.

Year	Earliest Date In	Last Date Out	Max # Traps	Total # Trap Days
2005	29-Jun	17-Jul	1	19
2006	24-Jun	19-Jul	2	52
2007	23-Jun	29-Jul	7	259
2008	21-Jun	16-Jul	8	160
2009	24-Jun	07-Aug	9	405
2010	24-Jun	01-Aug	12	468
2011	22-Jun	17-Jul	12	288
2013	14-Jun	29-Jun	9	117
2015	18-Jun	17-Jul	12	348
2017	10-Jun	02-Jul	11	253
2019	13-Jun	15-Jul	12	380
2021	20-Jun	16-Jul	12	308

Total catch per trap day was relatively low in 2017 compared to other post-construction years, but was similar to values observed in 2009 (Figure 10). This was likely due to low water levels overall, and warmer water temperatures occurring earlier in the season than other recent years. In 2021, drift trap catch per trap day was similar to 2019, and temperatures of 8-10°C (when drift typically peaks and then tails off) were similarly reached between June 28 – July 4.

Larval catch per trap day was highest at station B in 2021, but there is no clear trend between drift trap locations year-over-year. Overall these results demonstrate that greater numbers of larvae continue to be caught in the R02 reach since construction of the spawning pads.

A more specific examination of Arctic Grayling larval production within the R02 area was conducted in April 2020 in support of the December 2020 *Addendum to the 2012 No Net Loss*

Plan for the Meadowbank Site: Implementation of Contingency Option 3 – Construction of Arctic Grayling Spawning Pads. This assessment is attached as Appendix E. Briefly, using data collected through 2019, results indicated that densities of Arctic Grayling larvae (based on larvae collected after a calculated emergence date) collected in drift traps downstream of the spawning pads increased on average 4x in years post-construction compared to the years pre-construction.

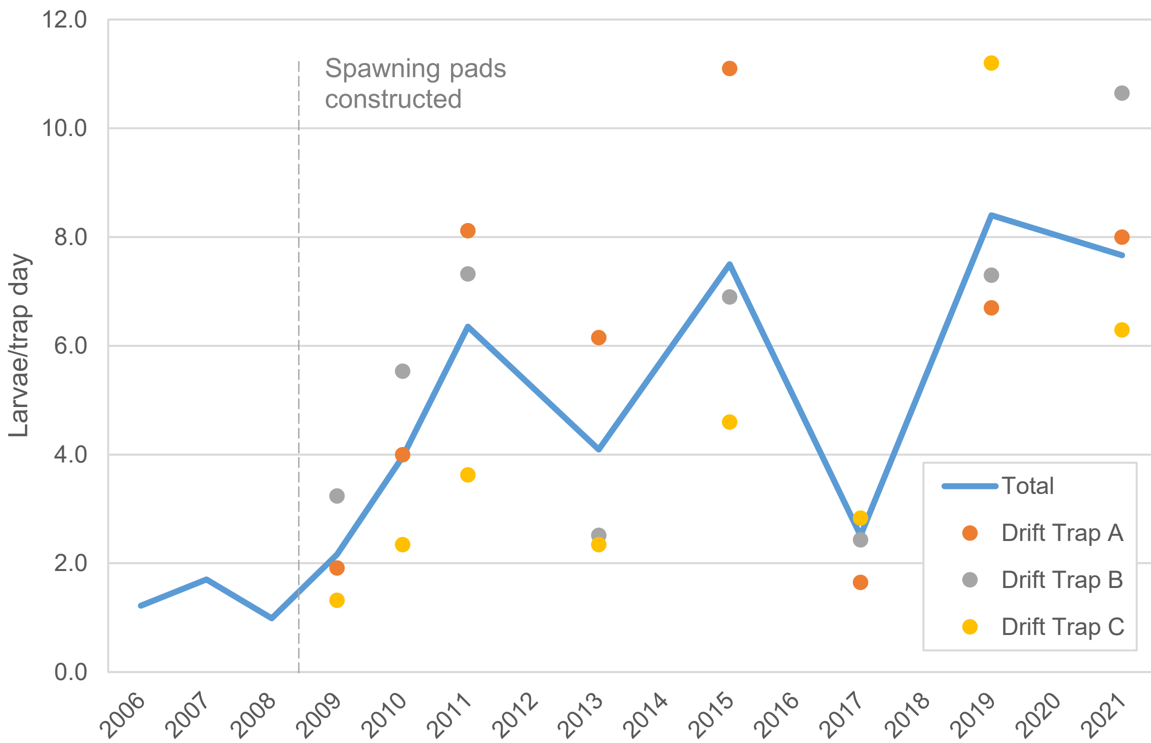

Figure 10. Total CPUE (larvae/trap day) for drift trap catch for the first 24 study days from 2006 to 2021, and catch by trap location (A, B, C). For 2006 – 2008, only total values are shown since spawning pads were not yet constructed and trap locations varied within the reach.

3.1.3 Angling

In total, three fish were caught through angling on the spawning pads, including one Round Whitefish (*Prosopium cylindraceum*) and two Arctic Grayling (spent females, F4 - Table 6).

Table 6. Fish captured through angling at R02 in 2021.

Date	# Anglers	Total Line Time (min)	Species	Length (mm)	Weight (g)	Sex/Maturity
7/02/21	2	60	None	-	-	-
7/04/21	2	120	RNWH	- (fish lost)	-	-
7/06/21	1	90	ARGR	250	230	F4
7/06/21	1	90	ARGR	288	260	F4

3.1.4 Underwater Video

As described in Section 2.1.4, cameras were set on July 4 and 6, and 1.5 – 2.5 h of footage were recorded per spawning pad.

In total 11 observations of Arctic Grayling were recorded on July 4, and two observations of unknown fish were recorded on July 6 (Table 7).

Table 7. Underwater video sessions and recorded observations at R02 in 2021.

Location	Date	Duration of Video	Species	# Observations (Fish)
Between berms 1 and 2	Jul. 4	1h31	ARGR	2
Between berms 2 and 3	Jul. 4	2h25	ARGR	9*
Between berms 3 and 4	Jul. 6	2h26	Unknown	2

**Of these 9 observations, one group of 5 fish and one group of 2 fish were recorded together.*

3.1.5 Hoopnets

3.1.5.1 Total Catch

All records of hoopnet catch are provided in Appendix C.

As in the past, the predominant species of adult fish collected in 2021 along the AWAR was Arctic Grayling (222 fish). In addition, 17 Round Whitefish, 3 Lake Trout (*Salvelinus namaycush*), and one Ninespine Stickleback were also caught (Table 8). Since Arctic Grayling are the primary species of concern in this study, the majority of the data analysis includes only individuals of that species (as indicated).

Table 8. Total number of fish collected by species in R02 hoopnets in 2021.

Species	Total Catch
Arctic Grayling	222
Lake Trout	3
Round Whitefish	17
Ninespine Stickleback	1
Total	*243*

By standardizing the catch to the number of nets and number of days fished, a cursory comparison of inter-annual trends can be performed. It should be noted, however, that many factors can affect the how well hoopnet catches represent the true population. For example, longer study periods involve a greater proportion of days on which fewer fish are migrating. If the study continues beyond the actual migration period, the total number of fish per unit effort is reduced when compared with shorter studies. Studies at R02 have been initiated immediately once ice conditions are safe for work, but those conditions can vary significantly from year to year, resulting in study initiation dates ranging by 19 days (June 10 – June 29; Table 9). Another factor affecting total catch and catch per unit effort in both 2017 and 2019 was significantly warmer water temperatures (2017) and/or lower water levels (2017 and 2019) than observed previously. By the end of the study period in those years, hoopnets were not able to be submerged to their full width, reducing catch efficiency.

Nevertheless, historical catch per unit effort (CPUE as fish per net-day, all species) is presented in Figure 11. The elevated catch per unit effort in 2005, 2006 and 2021 compared to other years is likely a result of lower effort, which increases catch efficiency (2005 and 2006 saw only two nets deployed for about three weeks, and 2021 saw 7 nets deployed for 2 – 17 days each for a total of 85 net days (Table 9)). With this in mind, no significant trend in total CPUE is apparent since construction of the spawning pads.

Table 9. Summary of dates and number of nets (upstream and downstream) used at R02 from 2005 to 2019.

Hoop Nets	First Date In	Last Date Out	Max # Nets	Total # Net Days
2005	29-Jun	18-Jul	2	42
2006	24-Jun	19-Jul	2	50
2007	24-Jun	20-Jul	5	132
2008	17-Jun	16-Jul	4	124
2009	26-Jun	02-Aug	9	234
2010	25-Jun	01-Aug	7	227
2011	24-Jun	19-Jul	9	219
2013	14-Jun	29-Jun	10	122
2015	17-Jun	17-Jul	10	237
2017	10-Jun	07-Jul	8	212
2019	11-Jun	12-Jul	8	181
2021	19-Jun	06-Jul	7	85

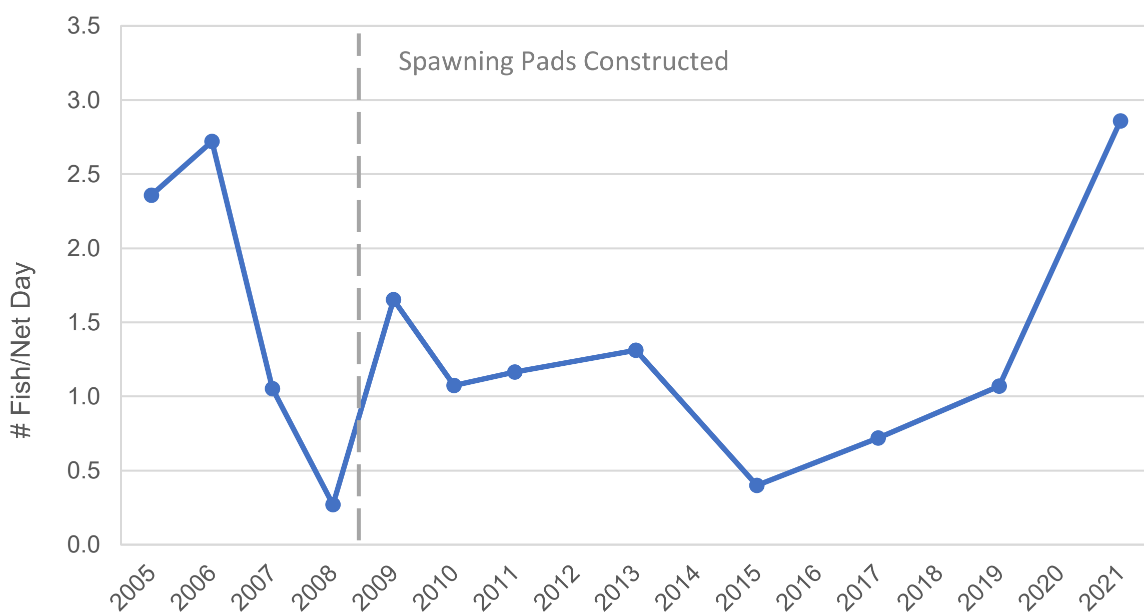

Figure 11. Number of fish (all species) captured per unit effort (# fish/net day) at R02.

3.1.5.2 Movements

A total of 212 Arctic Grayling were captured moving upstream and 10 moving downstream (Figure 12). Fish were first caught on June 22, when water temperatures were 4°C.

As in previous years, peak larval drift (June 27 – July 1; Section 3.1.2) occurred prior to the observed peak adult Arctic Grayling upstream migration (July 2). These data suggest that either actual peak upstream migration is occurring earlier than hoopnet installation (e.g., under the ice, as suggested in earlier years of this report), or that drift trap catch early in the monitoring period includes some YOY of fall spawning species, as discussed in Section 3.1.2.

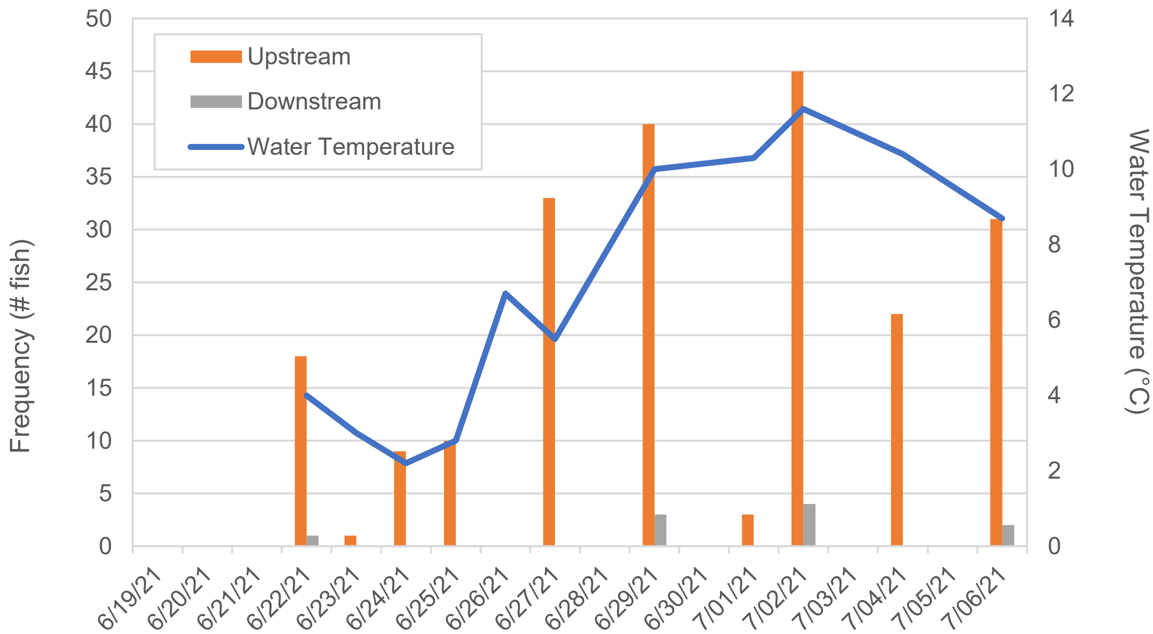

Figure 12. Upstream and downstream movements of Arctic grayling at R02 in 2021.

The R02 nets were set in three locations in 2021 - just upstream (R02A) and downstream of the habitat compensation area (R02B), and just upstream of the culvert beside the R02 bridge (R02C). Hoopnets were set historically to confirm adult passage upstream of the AWAR bridge, and data is used now to generally assess the population structure, more than local movements between the A, B, and C locations. However, as in previous years, many more fish (156) were collected at R02A than R02B (43) (Table 10), likely due to the higher proportion of stream coverage at this location (100 vs 70% in 2021; Section 2.1.5, but historically this has varied significantly) and generally lower water depths at R02B. Hoopnets have not been set at R02C since 2011 because assessment of fish passage through the culvert is no longer required. However, the data collected in 2021 serve to demonstrate that this culvert remains passable to migrating fish.

Table 10. Upstream and downstream movements of Arctic grayling by net location since 2010.

R02 Hoopnet ID	Fish Movement	2010	2011	2013	2015	2017	2019	2021
A	US	61	175	81	19	138	144	156
	DS	58	13	41	32	6	13	2
B	US	103	25	33	8	2	6	43
	DS	8	16	5	14	1	30	7
C	US	3	1	-	-	-	-	13
	DS	11	25	-	-	-	-	1
Total	US	167	201	114	27	140	149	212
	DS	77	54	46	46	7	44	10

3.1.5.3 Condition Factor

Table 11 provides a summary of the average, maximum and minimum length and weight, and the average condition factor of Arctic Grayling collected. Distributions of lengths and weights are similar to previous years. The average condition factor (K) was greater than 1.00, which demonstrates a healthy population. Six Arctic Grayling were lost in transfer prior to recording length or weight data, resulting in a sample size of 169 fish.

Table 11. Average, maximum and minimum Arctic Grayling length, weight and average condition factor (K).

n	Length (mm)			Weight (g)			K*
	Avg	Max	Min	Avg	Max	Min	Avg
222	290	525	40	296	2000	2	1.17

* K = (weight/((length/10)3)) x 100

Condition factors for years 2006 – 2021 are shown in Figure 13. Condition factor and variability (standard deviation) are similar to previous years.

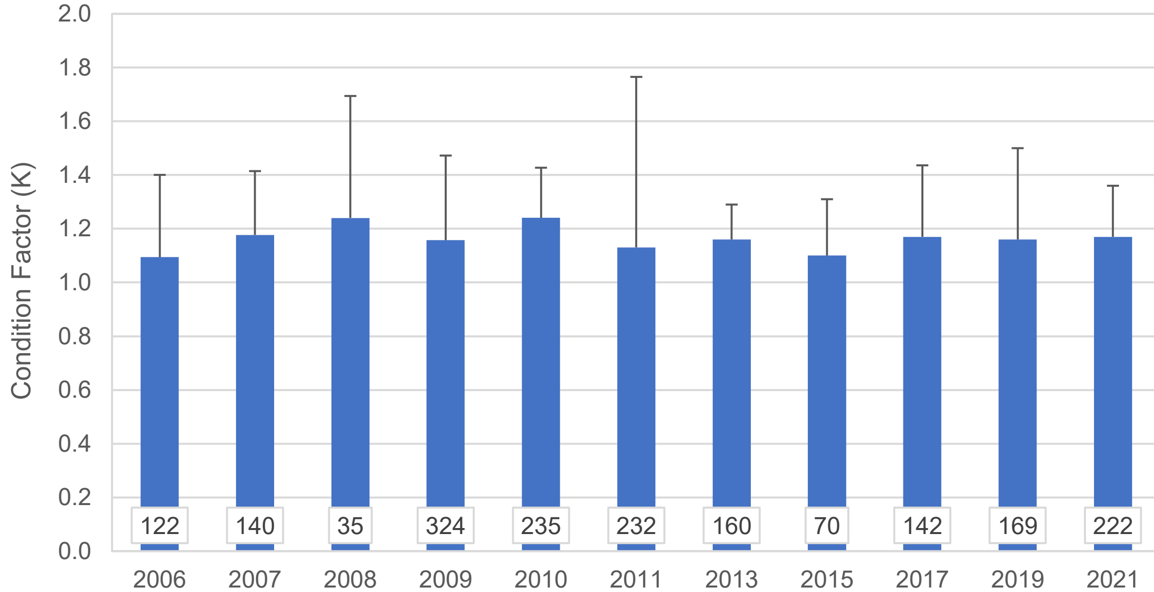

Figure 13. Average condition factor of Arctic Grayling captured at R02. Error bars indicate standard deviation. Values indicate total number of fish.

3.1.5.4 Size Distribution and Maturity

As in the past, the length-frequency distribution (Figure 14) of fish collected at R02 is approximately normally distributed with the largest number of fish collected in the 280-300 mm size class (72 fish). This data demonstrates that recruitment is occurring as would be expected within this population.

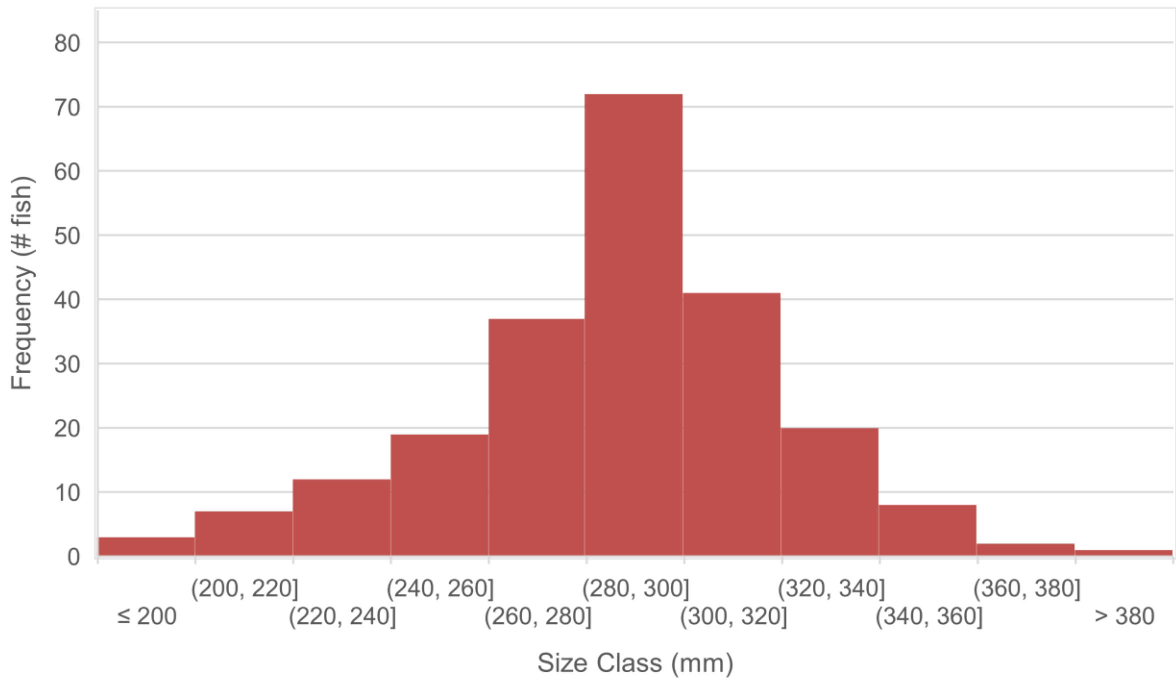

Figure 14. Length-frequency distribution of Arctic grayling captured at R02 in 2021.

The total numbers of male and female fish captured by spawning classification are shown in Table 12. In 2021, more male fish were captured than female fish, and overall an unusually large proportion of ready-to-spawn males was identified. Typically immature fish form the largest proportion of catch.

Table 12. Number of fish by spawning classification caught at R02 in 2021.

Classification	Catch
Immature (F1/M6)	49
Female	
Ready (F2)	18
Waiting (F3)	28
Spent (F4)	14
Male	
Ready (M7)	68
Waiting (M8)	29
Spent (M9)	13
Unknown (F5/M10)	3

3.1.5.5 Current Year Recaptures

Floy tags were used to assist in tracking the activities of migrating fish. Table 13 provides the results of the current year tagging program, or “recaptures”. In 2021, 4 fish were re-captured at R02 (all Arctic Grayling).

Table 13. Arctic Grayling captured and re-captured in the current year at R02.

Fish	Date Collected	Net	US/DS	Tag #	Length	Weight	Sex/ Maturity
1	2021-06-22	R02A	US	996	299	310	M7
	2021-06-25	R02A			396	300	M7
2	2021-06-22	R02A	US	700	310	360	M7
	2021-06-29	R02A			340	310	M7
	2021-07-02	R02B			300	350	M7
3	2021-06-24	R02A	US	348	272	260	F5
	2021-07-02	R02B			270	240	F2
4	2021-06-22	R02A	US	433	350	540	M7
	2021-06-23	R02A			348	520	M7

3.1.5.6 Previous Year Recaptures

In 2021, one fish tagged in a previous year was recaptured.

Table 14. Arctic Grayling recaptured from previous years at R02.

Fish	Date Collected	Net	US/DS	Tag #	Length	Weight	Sex/ Maturity
1	2019-06-23	R02A	US	747	240	160	F1 or M6
	2021-07-04	R02A			310	291	M

3.2 PORTAGE AREA MONITORING

3.2.1 Interstitial Water Quality

3.2.1.1 Current Year Results

Analytical results of the interstitial water quality sampling are provided in Appendix D with CCME Water Quality Guidelines for the Protection of Aquatic Life (Freshwater, Long Term) (CCME, 2022).

All results were below CCME guidelines, and overall, water quality measured at dike stations was similar to reference stations.

3.2.1.2 Historical Summary

Interstitial water quality sampling occurred for all dike and reference stations in 2011, 2015, 2017, and 2021. Throughout this time, very few samples have exceeded data analysis criteria (CCME Water Quality Guidelines for the Protection of Aquatic Life). A summary of all results exceeding these guidelines is as follows.

- In 2011, the total phosphorus guideline for ultra-oligotrophic lakes was exceeded at all stations, including reference stations, indicating this was not caused by dike material.
- In 2015 and 2017, TSS results for a single Bay-Goose station (a different one each year) exceeded the CCME guideline. Since previous results for these stations were less than the guideline, it is assumed that sediment was disturbed during sampling, so the elevated TSS was not a long-term event.

Along with results from 2021 (Section 3.2.1.1), these data indicate that water quality in the interstitial spaces along the exterior faces of the East Dike and Bay-Goose Dike is suitable as fish habitat, and has remained that way over the 10 year monitoring period.

3.2.1.3 QA/QC

All laboratory analyses were completed by a suitable accredited laboratory (ALS Laboratories, Vancouver, B.C.).

During the interstitial water quality sampling, one duplicate sample was taken at BG-PW-6. According to Core Receiving Environment Monitoring Program (CREMP) methods (Azimuth, 2020), data quality objective for field duplicates were 1.5x the laboratory reported duplicate limit, which was either 2x the detection limit or 20% (relative percent difference). Duplicate difference is calculated when both the sample and duplicate exceed the laboratory detection limit.

All duplicate sample results met these data quality objectives (Appendix D).

3.2.2 Periphyton Growth

Periphyton monitoring under the HCMP tracks the development of attached algal communities on the faces of the East Dike HCF (since 2009) and Bay-Goose Dike HCF (since 2011). Full results for this monitoring component in 2021 are provided in Appendix B and summarized here with some additional historical comparisons.

3.2.2.1 East Dike

The periphyton community has changed substantially at East Dike stations since it was constructed. In 2021, total biomass decreased at both the dike and reference areas in Second Portage Lake (i.e., SP-ED and SP-DT) compared to 2019, suggesting this may be attributed to natural variability. While average total biomass at the dike remains lower than the reference area, the range among dike samples (46 – 184 µg/cm^2) does overlap the range among reference area samples (182 – 463 µg/cm^2), indicating some dike face habitat hosts the same amount (biomass) of periphyton as some reference areas.

In contrast to the observed difference in average biomass, species composition trends show that the community at the East Dike has progressively evolved to become quite similar to the community at the reference area.

3.2.2.2 Bay Goose Dike

The periphyton community at the Bay-Goose Dike has also evolved substantially, but at a much slower rate than seen at the East Dike. Biomass results for the Bay-Goose Dike continue to be substantially lower than the reference area, with little progress to reducing the gap made between 2019 and 2021. The southern portion of the dike has higher biomass than the northern portion, potentially due to aspect (i.e., favorable growing conditions due to more sunlight), but other factors could also be at play as the pattern is not consistent in each event.

Along with lower biomass, some differences in community composition compared to reference areas were observed. The periphyton community at the Bay-Goose Dike appeared to be less diverse than the reference area as indicated by lower Simpson's diversity scores and fewer taxa. While proportions of cyanobacteria and diatoms were similar between dike and reference stations, the proportion of chlorophytes was higher at the reference station. Nevertheless, historical results show progress along the Bay-Goose Dike towards a more heterogeneous periphyton community comprised of species similar to the reference area.

3.2.2.3 Historical Trends

Overall, the presence of a structurally similar periphyton community at the dike stations relative to reference areas indicates a healthy periphyton community is developing on the dike faces.

Despite healthy communities, it is apparent that periphyton biomass takes time to develop, and that a decade is not enough time for full colonization of new barren rock surfaces to the levels found at the selected unimpacted reference areas. Currently, it is unknown how much of the observed difference in biomass between dike and reference stations may be attributed to the region's high natural variability in periphyton growth (as shown by the variability amongst individual replicates). For example, the range in total biomass among Second Portage reference station replicates collected just a few meters apart was 182 – 463 µg/cm^2, and the range for Third Portage was 241 – 592 µg/cm^2. Since reference stations have remained consistent to facilitate analysis of inter-annual variation, spatial variation within the Second Portage and Third Portage basins is relatively unknown, and it is possible that the selected locations trend towards higher productivity than other reference areas.

While in-depth analysis of the multitude of factors controlling periphyton growth is beyond the scope of this assessment, the sizeable difference in average biomass between dike face and reference stations tends to suggest that regardless of possible natural variation, full community biomass development on newly submerged substrate in these lakes takes more than 10 -12 years. Twelve years post-construction, periphyton biomass on the East Dike appears to be beginning to overlap the observed range of reference station biomass (Figure 15). Growth on the younger Bay-Goose Dike has historically seen some overlap for south-facing locations (BGS - Figure 16), but not in 2019 or 2021. Results of interstitial water sampling (Section 3.2.1) strongly indicate that water quality near the dike face is just as suitable for periphyton growth as reference areas, so slow periphyton development rates are assumed to be a result of the natural ultra-low nutrient concentrations, low light levels, and cold temperatures in these Arctic lakes.

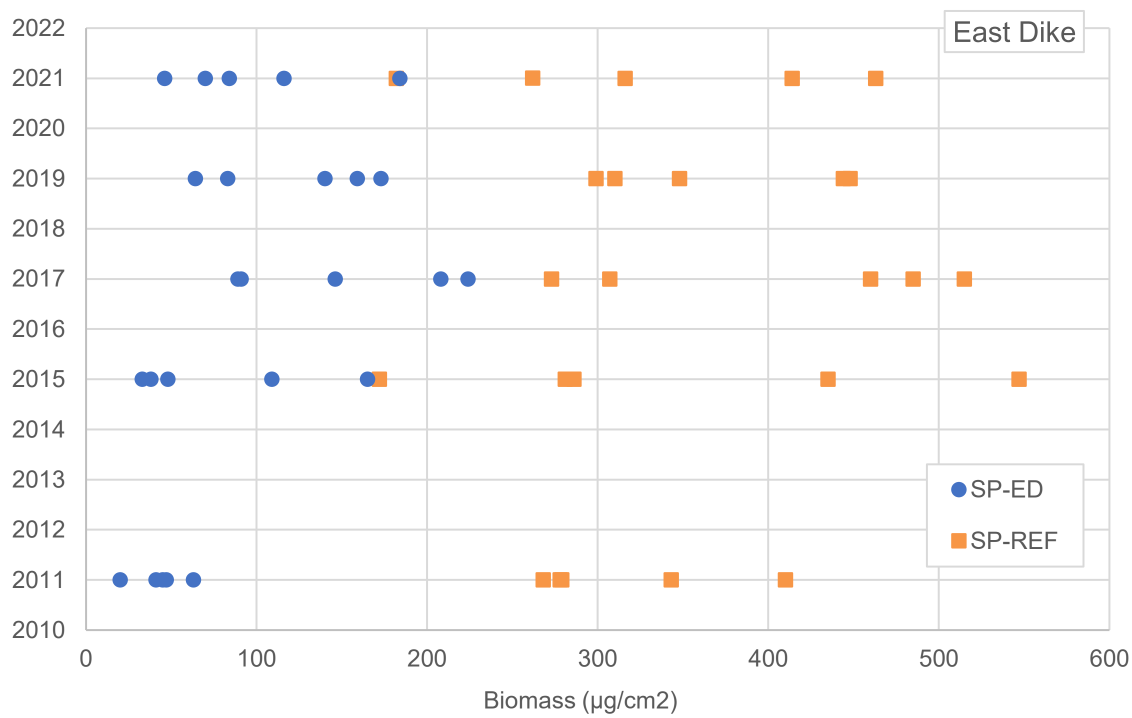

Figure 15. Biomass (µg/cm^2) of major periphyton taxa groups measured at East Dike (SP-ED) and East Dike reference (SP-REF) locations.

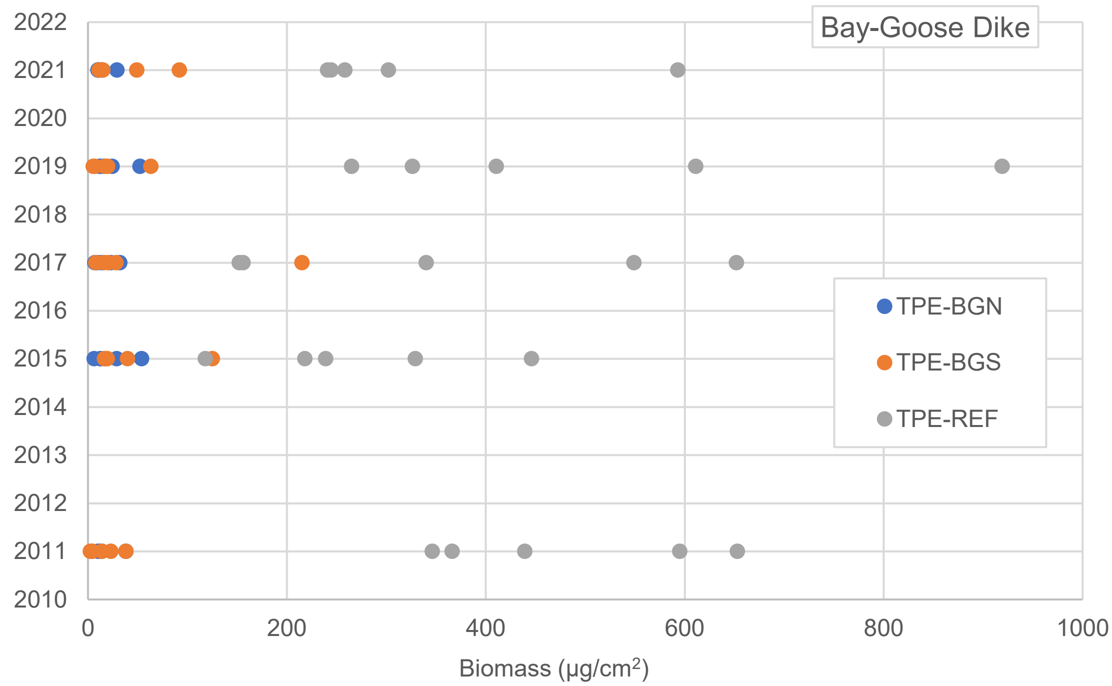

Figure 16. Biomass (µg/cm²) of major periphyton taxa groups measured at Bay-Goose Dike (TPE-BGN, TPE-BGS) and Bay-Goose Dike reference (TPE-REF) locations.

3.2.3 Fish Use

As in 2015, 2017, and 2019, analysis of fish use of the habitat compensation features constructed to date (dike faces and Dogleg Ponds) was assessed through the minimally invasive techniques of angling and underwater motion video prescribed in the 2017 HCMP. These have proven to be a successful non-lethal program to demonstrate continued fish presence in and around the study areas. In 2011, gill nets were used instead of angling.

3.2.3.1 Angling

The complete angling effort and catch for habitat compensation features is provided in Table 15. Between zero and five fish were caught per station in 1.5 – 5 h of effort.

The focus of this assessment was on dike stations, in order to demonstrate presence of fish in the area (21.2 line h in the Portage Lakes). During each full dike face angling session (1-2 x 120-150 min) between 1 – 3 fish were captured. During the reference station angling sessions (one per reference station, 90 – 120 min), no fish were captured. However, reference station angling occurred through ice, in October and December, whereas dike station angling occurred in August or early September.

For the Dogleg Ponds more than 15 line h of angling effort were performed (August and November), and no fish were captured, which is similar to results in 2019. Fish were however captured in these ponds in previous years (including one Arctic Char in 2015), and were observed by underwater camera in 2021 (Section 3.2.3.3).

With the overall low catch, data on fish size metrics was limited in 2021, but available results indicate that as in previous years, fish across a range of size classes are frequenting the area around dike faces (195 – 711 mm).

Table 15. Angling effort and fish capture for East Dike (ED), Bay Goose Dike (BG), Dogleg Ponds and reference locations (REF). LKTR = lake trout. ARCH = Arctic char. Sex/maturity was unknown or not recorded for all fish.

Location	Date DD/MM	# Anglers	Time (line min)	Total Catch	Fish #	Species	Tag	Fork Length (mm)	Weight (g)
Second Portage Lake									
ED-PW-2	08/08	2	120	1	1	LKTR	-	-	-
	17/08	2	120	3	1	LKTR	45	450	1134
					2	LKTR	80	711	4536
					3	LKTR	81	505	1361
ED-PW-4	08/08	2	120	1	1	LKTR	-	-	-
	17/08	2	120	3	1	(no info)	-	-	-
					2	(no info)	-	-	-
					3	(no info)	-	-	-
SP-REF	19/12	2	90	0	-	-	-	-	-
Third Portage Lake									
BG-PW-2	02/09	2	140	3	1	LKTR	-	195	80
					2	LKTR	-	-	-
					3	LKTR	-	-	-
BG-PW-4	15/08	2	150	2	1	LKTR	-	-	-
					2	LKTR	-	-	-
BG-PW-6	07/08	2	130	3	1	LKTR	78	490	1580
					2	ARCH	53	470	1360
					3	LKTR	79	270	680
	14/08	2	130	2	1	LKTR	-	-	-
					2	LKTR	-	-	-
	24/08	2	30	0	-	-	-	-	-
TPL-REF	02/10	1	120	0	-	-	-	-	-
Dogleg Ponds									
Dogleg	07/08	2	120	0	-	-	-	-	-
	8/08	3	270	0	-	-	-	-	-

Location	Date DD/MM	# Anglers	Time (line min)	Total Catch	Fish #	Species	Tag	Fork Length (mm)	Weight (g)
NP-1	06/08	2	120	0	-	-	-	-	-
	07/08	2	180	0	-	-	-	-	-
NP-2	27/11	3	225	0	-	-	-	-	-

3.2.3.2 Underwater Camera

For each underwater camera location in 2021, between 1 and 47 observations of fish were recorded in 47 – 234 min of video (Table 16). Underwater video monitoring was not conducted at Second and Third Portage Lake reference stations or NP-2. Nevertheless, results supplement angling observations for fish presence around dike faces, and demonstrate fish presence within the Dogleg Ponds.

Of note, pond NP-1 was fishless prior to the 2013 construction of the channel between NP-2 and NP-1. Fish were observed on underwater camera in that pond in 2017, and again in 2021, which supports assumptions of the 2012 NNLP that access for fish would be created.

Table 16. Underwater video observations for dike face stations and Dogleg Ponds in 2021. ARCH = Arctic Char; RNWH = Round Whitefish; LKTR = Lake Trout.

Location	Date	Duration of Video (min)	Species	# Observations (Fish)
ED-PW-2	Aug. 17	(did not record)	-	-
ED-PW-4	Aug. 17	78	ARCH	1
BG-PW-2	Sept. 2	82	ARCH	1
		47	RNWH	2
BG-PW-4	Aug. 15	185	LKTR	2
			Unknown	1
BG-PW-6	Aug. 14	134	Unknown	3
	Aug. 24	90	Unknown	1
Dogleg Pond	Aug. 7	234	LKTR	6
			Unknown	1
	Aug. 8	126	-	0
NP-1	Aug. 6	160	Unknown**	47*

**Of these observations, several groups of 2 – 4 fish were recorded together.*
***Small-bodied fish*

3.2.3.3 Historical Trends

Angling

While overall angling catch was low in 2021, CPUE was calculated to facilitate historical comparisons (Table 17). The available data indicates that fish are continuing to frequent the dike face area, and rates are no lower than reference stations (in the absence of potential seasonal influences, since reference station fishing in 2021 was under-ice). In previous years when catch was higher and perhaps more representative with summer-only sampling (2011 and 2015), catch per unit effort (CPUE) was also similar across dike and reference stations, or slightly higher at dike stations. CPUE could not be assessed in 2017 or 2019 because station ID and/or effort per station was not recorded.

Table 17. CPUE by monitoring station (all species). In 2011, fish presence was assessed by gill nets, while in 2015 – 2021 angling was used, so CPUE is not directly comparable between those years. In 2017 and 2019 only subtotals by area were recorded. *Ice-fishing.

Station	2011	2015	2017	2019	2021
	fish/150m net/day	fish/line h	fish/line h	fish/line h	fish/line h
BG-2	7.5	2.5	-	-	1.2
BG-4	6.6	1.8	-	-	0.4
BG-6	5.0	2.2	-	-	2.1
TPL-REF	3.2	0	-	-	0*
BG & TPL Total	-	-	*2.0*	*0.6*	-
ED-1	16.6	-	-	-	-
ED-2	8.5	2.3	-	-	1.0
ED-4	7.0	3.3	-	-	1.0
SP-REF	3.7	2.7	-	-	0*
ED & SP Total	-	-	*2.2*	*1.9*	-

Underwater Camera

As a supporting line of evidence, underwater camera results are summarized briefly by year, below. Underwater video was only recorded at reference stations in 2015, so CPUE was not calculated. These results serve to demonstrate continued fish presence around the dike faces.

2015 –

- Effort: 28 h in Second Portage Lake (including East Dike stations and reference), 40 h in Third Portage Lake (including the Bay-Goose Dike stations and reference),

- Catch: 4 fish at ED-2, 2 fish at ED-4, 3 fish at ED-REF, 4 fish at BG-2, 16 fish at BG-4, 3 fish at BG-6, 0 fish at TPL-REF.

2017 –

- Effort: 11.2 h in East Dike stations (total), 9.4 h in Bay-Goose Dike stations (total)

- Catch: 11 fish at ED-2, 5 fish at ED-4, 2 fish at BG-2, 1 fish at BG-4

2019 - A single lake trout sighting was captured on camera around the East Dike during the underwater motion camera monitoring program (3 h of footage in this area between July 25 – July 31).

2021 –

- Effort: 1.3 h in East Dike stations (total); 8.9 h in Bay-Goose Dike Stations (total)
- Catch: 0 – 4 fish per station

3.2.4 Structure

3.2.4.1 Dogleg Ponds

3.2.4.1.1 Surface Area

The NNLP for the Meadowbank site (2012) identified projected increases in wetted area of 5% for Dogleg Pond, 15% for Dogleg North Pond (NP-1), and 5% for NP-2. The area used in baseline calculations and the projected increase in area for each pond is described in Table 18. Baseline areas were initially determined from bathymetric surveys conducted by Agnico engineering technicians in August 2010 and 2011 and used in conjunction with air photos (unknown date) by a GIS consultant (Dougan & Associates) to map baseline pond areas.

In 2017, 2019, and 2021, bathymetric surveys were conducted to confirm whether construction of the diversion channel from NP-2 to Dogleg North (NP-1) is increasing the wetted area of these ponds as assumed in the 2012 NNLP, and to confirm the potential for fish movement, especially between Dogleg Pond and NP-1 (which was previously determined to be fishless).

However, bathymetric surveys conducted by boat by Meadowbank engineering technicians in these shallow ponds in 2017 and 2019 omitted a significant portion of shallow shoreline area, and thus under-reported total surface area. Results of surveys in 2017 and 2019 were reported in the 2019 HCMP Report but are excluded here on this basis. Surveys in 2021 were conducted by a consulting bathymetry firm (Trout Hydrography Inc.) and are considered fully representative of pond wetted area at the time of surveys. Surveys were conducted on July 13 (NP-1), July 14 (NP-2), and August 4 (Dogleg Pond).

Surveys in 2021 indicate that all three ponds have experienced an increase in surface area in line with NNLP assumptions. While this assessment cannot account for inter-annual variability in either baseline or post-construction water levels, 2021 surveys and baseline measurements were conducted at a similar time of year (near end of freshet).

The Dogleg Ponds are planned to be monitored again in 2025 prior to determination of habitat compensation success, and surface area measurements will be confirmed at that time which will help assess inter-annual variability in water levels.

Table 18. Baseline, predicted (2012 NNLP), and measured surface area for the Dogleg Ponds.

Location	Metric	Baseline	Predicted (NNLP)	2021
Dogleg Pond	Area (ha)	21.2	22.2 (+5%)	22.3
	Max. Depth (m)	11	-	11.3
	Shoreline Elevation (masl)	-	-	133.5
NP-1 (Dogleg North Pond)	Area (ha)	3.2	3.7 (+15%)	3.8
	Max. Depth (m)	3.8	-	4.3
	Shoreline Elevation (masl)	-	-	135.4
NP-2	Area (ha)	8.7	9.1 (+5%)	10.2
	Max. Depth (m)	5	-	6.5
	Shoreline Elevation (masl)	-	-	139.9

3.2.4.1.2 Connectivity

In addition to surface area, connectivity of the ponds was assessed to determine whether connecting channels are passable to fish.

Second Portage Lake to Dogleg Pond

In 2015, Arctic Char were first caught in Dogleg Pond. Access for that species was conservatively excluded from habitat compensation calculations in 2012. However, it was suggested that Arctic Char may eventually access this area from Second Portage Lake due to changes in water levels as a result of construction of the channel from NP-2. Since Arctic Char were captured in Dogleg Pond in 2015 and 2017, the channel connecting Dogleg Pond to Second Portage Lake was assessed in 2021 to determine whether fish passage is now possible and Arctic Char may be accessing the Dogleg system via this route. Results of this assessment indicated that water levels during freshet appeared sufficiently deep to allow fish passage (from mid-May to mid-July). The channel connecting Dogleg Pond to Second Portage consists of a block field substrate of approximately 170 m wide. During the assessment in early August, the water junction between the lakes was still present, with a water depth between 10 cm and 30 cm.

Figure 17. Channel from Second Portage Lake to Dogleg Pond (in background) – August 8, 2021.

Dogleg Pond to NP-1

NP-1 Pond was fishless prior to construction activity in this area, and fish access was assumed as part of the 2012 NNLP. In 2021, fish were observed in this pond by underwater camera. Visual assessment of the channel in early August indicated sufficient connectivity for potential passage of small bodied fish, with better access during freshet (mid-May – mid-July).

Figure 18. Overview of connecting channels between NP-1 (foreground), Dogleg Pond (middle), and Second Portage Lake (background) on June 18, 2021. Connecting channels in red circles.

NP-1 to NP-2

The channel connecting NP-1 to NP-2 consists of three sections: a diversion ditch of 230 m, a culvert of 35 m and a natural boulder channel of 45 m. Access for fish between NP-1 and NP-2 was visually assessed in 2021, and results indicated that during freshet the water level is sufficient to allow fish passage. In early August, however, the connection is dry.

Figure 19. Inlet to NP-1 (behind camera) from NP-2 (behind culvert) on August 7, 2021.

SECTION 4 • SUMMARY

4.1 AWAR MONITORING

The intent of the constructed spawning pad feature was to provide optimal conditions (flow rates, substrate) for Arctic Grayling spawning in the R02 reach.

Monitoring of this feature occurs every two years, and according to the 2017 HCMP, includes assessments of: stability (visual observations), adult fish population metrics (hoopnets), adult presence on the spawning pads (underwater video, angling), and evidence of reproduction (larval drift traps).

Stability of the feature was visually confirmed in 2021, with minor shifting of material since construction, as anticipated.

Adult fish population data collected in 2021 indicate that fish migrating at R02 continue to have a well distributed population (range of sizes, sexes, maturity) and are generally in good body weight (K > 1). No significant trends in adult fish CPUE (fish/net day) over time are apparent. Overall, these data confirm continued use of the R02 reach by Arctic Grayling without major changes in population structure.

While spawning behaviours were not specifically identified by the field crew, adult fish presence between the spawning pad berms (including spent females) was demonstrated through underwater camera and angling results.

Results of drift trap catch indicate ongoing reproduction within the R02 reach. In addition, YOY CPUE for a standardized study period in June-July has increased since construction of the spawning pads. The early timing of peak catch with very low water temperatures in recent years (and particularly 2019) was taken to suggest that YOY of fall-spawning species may have formed a large portion of catch in recent years (along with Arctic Grayling larvae), since laboratory ID ceased in 2009. While this may still be the case, identification of spent adult Artic Grayling at study initiation in 2021 (June 22) does indicate that spawning runs are occurring at water temperatures of 2 – 4 °C or less, which is earlier than common literature suggests (7 - 10°C; Evans et al. 2002, McPhail and Lindsey, 1970, & Scott and Crossman, 1973).

In the HCMP, no specific criteria for success of the spawning pads are associated with fish use metrics (hoopnet catch, larval drift). However, 12 years post-construction it is clear that these features continue to be stable as designed, and to support fish productivity within the R02 watercourse. Currently, monitoring is planned to continue every other year until decommissioning of the AWAR crossing, according to Condition 5.2 of the FAA (NU-03-0190). Since the timeline for road decommissioning (est. 2031) is now significantly extended compared to NNLP assumptions (est. 2018-2020), Agnico anticipates working with DFO to revise this monitoring schedule with potential adjustments to methods moving forward (see Section 5.1).

4.2 PORTAGE AREA MONITORING

4.2.1 Dewatering Dike Faces

As described in Meadowbank's 2012 NNLP, outer faces of the dewatering dikes (Bay Goose and East Dike) are assumed to provide simulated reef habitat for fish in Second and Third Portage Lakes. Monitoring for these features as described in the HCMP includes assessment of interstitial water quality, periphyton growth and fish use every two years until 2021, at which point success of the features will be determined using a weight-of-evidence approach which includes a review of historical results.

As described in Section 3.2.1.2, interstitial water quality monitoring over a 10-year period strongly indicates water quality within the dike faces is similar to local reference stations, and suitable for freshwater life, including fish egg incubation and periphyton growth. Criteria for success according to the 2017 HCMP are therefore met for this monitoring component.

While periphyton development on the 12-year-old East Dike is approaching reference conditions, both growth (biomass, density) and community diversity on the 10-year-old Bay-Goose Dike is lagging behind (Section 3.2.2.3). Since interstitial water quality continues to meet guidelines, this slow growth is assumed to be a result of natural environmental conditions in these lakes (low nutrients, low light, and cold temperatures). There are no quantitative criteria for success for periphyton.

Similarly, no specific criteria for success are associated with fish use of the dike faces (HCMP, February, 2017), but generally fish presence in this area should be demonstrated, and ideally, at rates no lower than reference areas to confirm success of this habitat. Fish presence around dike faces has been recorded throughout multiple rounds of monitoring over 10 years, at rates similar to or higher than reference areas (Section 3.2.3.3). While this was best demonstrated through gill net use in 2011 and intensive angling effort in 2015 (34 h), angling and underwater camera data collected in 2021 support these conclusions.

Overall, while periphyton growth is slow and has not yet reached reference levels (Section 3.2.3.3), dewatering dike faces were constructed as designed in the NNLP and are stable as fish habitat (Section 2.2.4.2), with suitable water quality for aquatic life (Section 3.2.1.2), and have recorded fish presence at rates no lower than reference areas (Section 3.2.3.3). Since periphyton communities are considered healthy and there is no reason to believe that biomass will not eventually reach reference levels, the weight of evidence indicates that dike faces are functioning as fish habitat, as assumed in the NNLP.

As a result, no further compensation-related monitoring for these features is planned, but this will be confirmed in consultation with DFO prior to 2023 (next potential monitoring year).

4.2.2 Dogleg Ponds

Construction of the diversion channel between NP-2 and NP-1 was planned to result in slightly increased water levels, improved connectivity between these ponds, and especially to open previously inaccessible habitat in Dogleg North Pond (NP-1).

Fish use of NP-1 was confirmed in 2017 and 2021 through underwater camera surveys. Bathymetric surveys were completed, and show that the assumed increase in surface are has occurred. Visual assessment of connectivity indicated that in general these channels would be accessible to fish during freshet, and with potential access upstream to Dogleg Pond and NP-1 throughout the season.

Monitoring for the Dogleg Ponds will be conducted again 2025, according to the 2017 HCMP, after which time success will be determined.

SECTION 5 • ACTIONS

5.1 AWAR MONITORING

The following actions were planned for 2021. Agnico's responses are indicated below each action along with any plans for actions prior to or during the next monitoring event.

- Prior to the 2021 monitoring event, Agnico will look to update the HCMP to better evaluate successful utilization of the constructed spawning pads. Any updated plans will be provided to DFO for review and approval prior to implementation.
    - Delayed to 2022. According to Condition 5.2 of the FAA (NU-03-0190), monitoring of stability and successful utilization of the spawning pads is required until decommissioning of the AWAR crossing. At the time of issue of the FAA (2007), the life of mine was projected as 8 – 10 years. Currently, AWAR decommissioning is projected for 2031 (2017 HCMP). Since monitoring over more than 10 years has demonstrated stability of the spawning pads, healthy adult populations, and reproduction within the R02 reach, Agnico will look to discuss amendments to this condition with DFO.

5.2 PORTAGE AREA MONITORING

The following actions were planned in conjunction with the 2021 monitoring event, and Agnico's response to each is indicated below along with any plans for actions prior to or during the next monitoring event:

- Air photo interpretation combined with bathymetric surveys will be conducted in 2021 for the Dogleg Ponds area to better compare results with baseline mapping.
    - Complete - Adjusted bathymetric survey methods were used and surface area measurements were complete without the need for additional air photo interpretation.
- Visually assess flow in connecting channels within the Dogleg system to confirm potential for improved fish passage (including channels between NP-2 and NP-1, NP-1 and Dogleg Pond, and Dogleg Pond to Second Portage Lake).
    - Complete
- Develop updated HCMP SOPs to clarify angling and underwater video camera monitoring methods.
    - Complete. Records for all monitoring events were complete in 2021.

No actions are specified for the next monitoring event (2025).

5.3 VAULT AREA MONITORING

The following actions were planned for Vault and Phaser Lakes HCMP monitoring in 2021, and Agnico's response is indicated below along with any plans for actions prior to or during the next monitoring event:

- Substrate mapping will be conducted for the dewatered basins of Vault and Phaser Lakes and compared to requirements of the accepted NNL and Offsetting plans for these areas.
    - Delayed to 2022 (as described in Section 2.3).

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APPENDIX A

Animal Use Protocol Report

Freshwater Institute Animal Care Committee
Animal Use Protocol Report Form

AUP #:	**FWI-ACC-2021 -28**
Project Title:	Meadowbank Mine: Fisheries Habitat Compensation Monitoring All-Weather Access Road (AWAR) and Mine Site Authorization Monitoring
Was this project new or a renewal?	Renewal
Last Year's AUP # (if applicable):	FWI-ACC-2019 -27
Project Lead: **Phone** **E-mail**	Eric Haley 819-759-3555 ext.4606491 819-651-1010 eric.haley@agnicoeagle.com
Contact Person: **Phone** **E-mail**	Eric Haley 819-759-3555 ext.4606491 819-651-1010 eric.haley@agnicoeagle.com
Project end date:	2021-12-31

Please highlight Yes or No for each answer and provide further information if required.

1. **Did the project deviate from the approved AUP? If yes, please describe.**
   Yes / No The project did not deviate from the approved AUP

2. **Fill the chart out below, per species**

	Numbers Approved in AUP		**Actual Numbers**			
Species: Common & Scientific names	**Live sampled and released**	**Euthanized as intended for study**	**Live sampled and released**	**Euthanized as intended for study**	**Accidental mortalities**	**Euthanized due to injury from capture**
Arctic Grayling	AWAR - ~ 200 (mostly ARGR) Mine Site - ~ 200	AWAR - 20 (Near-Zero mortality) Mine Site - ~ 50	223	0	0	0
Lake Trout			9	0	0	0
Arctic Char			1	0	0	0
Round Whitefish			17	0	0	0
Slimy Sculpin			0	0	0	0
Ninespine stickleback			1	0	0	0

3. **Were any non-target species captured?**
   Yes / No
   a. **what species were captured?**
   b. **what was done with the non-target species?**
   c. **what methods could be changed to decrease the capture of non-target species?**

4. Were there any difficulties encountered?
(These may include: problems with tanks or water systems, water quality issues, problems with methods, problems with equipment used, problems with field staff, weather issues etc).

Yes / No

a. Describe what happened.
The established targets could not be achieved due to a combination of factors related to the restrictions put in place to manage the covid-19 pandemic. We faced operational constraints and a reduction in personnel, which restrain our capture effort.

b. Can anything be done to mitigate these issues for future projects?
This exceptional situation was difficult to predict, although for future projects the possibility of restrictions due to the pandemic will be taken into consideration to mitigate these incidents

5. How could your methods be changed to reduce pain, injury and suffering of animals? (3 R's and endpoints)

The nature of this project requires Agnico Eagle to capture fish to determine presence/absence in the environment. Fish cannot be replaced by a non-animal alternative.

Agnico Eagle, to reduce the number of fish being used during the monitoring studies, is and will continue to increase the use of underwater cameras to verify presence/absence of fish habitat usage in the environment.

Agnico Eagle, to minimize pain and/or distress to fish will continue to use best management practices. Smaller hoops with smaller mesh size will continue to be used in future programs along the AWAR. This will optimize net deployment and contribute to a lower number of small fish getting caught in the nets. Also, Agnico Eagle will continue to ensure that all hoop nets placed by field staff are not deployed in shallow sections of the stream or in areas where fast moving water is present.

6. Were there any injuries to animals, or any unexpected mortalities?

Yes / No

If yes, an Incident Report must be completed. Please send completed form to the FWI-ACC chair at: XCA-FWISL-ACC@DFO-MPO.GC.CA as soon as possible

Eric Haley

Project Lead

2022-01-28

Date

APPENDIX B

2021 Periphyton Report

Habitat Compensation Monitoring Program 2021: East Dike and Bay-Goose Dike Periphyton

Meadowbank Complex

Prepared for:

Agnico Eagle Mines Ltd
Meadowbank Complex
Baker Lake, NU X0C 0A0

FINAL

March 2022

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218-2902 West Broadway
Vancouver, B.C., V6K 2G8

Report Version

Version	Date	Distribution
Draft (revision 0)	December 17, 2021	Agnico Eagle (e-copy)
Final	March 9, 2022	Agnico Eagle (e-copy)

PLAIN LANGUAGE SUMMARY

This report provides information on periphyton monitoring conducted on the East Dike and Bay-Goose Dike from 2007 to 2021 as part of the habitat compensation monitoring program (HCMP) for the Meadowbank Mine. The focus of the HCMP is to document the functionality of habitat compensation features (HCFs) constructed to offset habitat losses associated with the development of the Meadowbank Mine.

Periphyton are unicellular and colonial aquatic algae species that grow on rocks and other hard substrates beneath the water surface. Periphyton provides an important food source for certain benthic invertebrate species and, together with phytoplankton, forms the base of the aquatic food web. The periphyton monitoring aspect of the HCMP tracks the development of attached algal communities on the faces of the East Dike HCF (since 2009) and Bay-Goose Dike HCF (since 2011). Periphyton biomass and measures of diversity were used to compare periphyton between stations and among years.

Density and Biomass

At the East Dike HCF, periphyton density and biomass were highly variable within locations. Total biomass was lower at both stations compared to 2019, whereas density increased slightly at the reference station and decreased on the East Dike. Similar to previous years, total biomass and density were lower at the East Dike HCF compared to the reference area. The proportion of cell densities and of biomass by major taxa group (e.g., cyanobacteria, diatoms) was similar between the East Dike and the reference area.

At the Bay-Goose Dike HCFs, similar to previous years, the total biomass and cell density were approximately 6 to 7-fold lower than the reference area. Cyanobacteria and diatoms were dominant in terms of biomass at the Bay-Goose Dike HCFs and the reference area. The proportion of biomass for chlorophytes was higher at the reference area than the Bay-Goose Dike HCFs.

Diversity

Periphyton richness and community composition at the East Dike and Bay-Goose Dike HCFs in 2021 are similar to reference areas and similar to results from 2019.

Trends

In the post-dike construction phase up until 2017, biomass steadily increased at the dike HCFs. Since then, total biomass on the dikes continues to be lower than the total biomass at the reference areas. The observed difference has remained larger at the Bay-Goose Dike HCFs compared to the East Dike HCFs.

In earlier monitoring years, diatoms dominated the periphyton communities at the HCFs. Since then, the community structure appears to have shifted to a more diverse mix of taxa. Species composition within major taxa groups is now similar between the HCFs and reference areas.

Overall, the progress at the Bay-Goose Dike towards a heterogenous periphyton community has been slower than what has been observed for SP-ED. However, some progress was made in 2021 at the Bay-Goose Dike HCFs as shown by increases in diversity and biomass.

Conclusions

Based on the 2021 results and historical trends, it is apparent that periphyton communities take time to develop and that a decade is not enough time for full colonization of new barren rock surfaces to levels of biomass found at unimpacted reference areas. The presence of a structurally similar periphyton community at each of the HCFs relative to their respective reference areas indicates a healthy periphyton community. Though total biomass growth is still expected as periphyton community succession progresses, there may be variation from year to year. Alternatively, differences between stations may be attributed to the high natural variability in periphyton data as shown by the variability amongst individual replicates.

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ACRONYMS

CREMP	Core Receiving Environment Monitoring Program
DQO	Data quality objectives
GPS	Global Positioning System
HCF	Habitat compensation feature
HCMP	Habitat Compensation Monitoring Program
QAQC	Quality assurance quality control
RPD	Relative percent difference
SOP	Standard operating procedure
SP	Second Portage Lake
SP-DT	Second Portage Lake – Drilltrail arm reference area
SP-ED	Second Portage Lake – East dike
TPE	Third Portage Lake – East basin
TPE-BGN	Third Portage Lake – East basin – Bay-Goose dike – North section
TPE-BGS	Third Portage Lake – East basin – Bay-Goose dike – South section
TPE-G	Third Portage Lake – East basin – Bay-Goose dike – reference area
UTM	Universal Transverse Mercator

1 INTRODUCTION

1.1 Overview and Objectives

Under terms of the Department of Fisheries and Oceans Canada *Fisheries Act* Authorization (NU-03-0191), long-term monitoring following the Habitat Compensation Monitoring Program (HCMP) is required to document the effectiveness of habitat compensation features (HCFs) constructed to offset habitat losses associated with development of the Meadowbank Mine. The HCFs were designed to serve as productive habitat for Lake Trout, Arctic Char and Round Whitefish by providing spawning, nursery and foraging habitat.

The *Habitat Compensation Monitoring Plan* (Agnico Eagle, 2017) describes the physical and ecological monitoring requirements, the schedule for implementing the monitoring program, and criteria for evaluating the success of HCF functionality.

The habitat compensation monitoring strategy integrates monitoring methods, specific quantitative success criteria (physical structure and interstitial water quality), and complementary qualitative tools (periphyton growth and fish use) to assess habitat compensation features. Porewater chemistry and toxicity testing are classified as *quantitative* monitoring tools because they are sufficiently accurate and precise to identify any ecological constraints to HCF function and inform decision-making. Periphyton community and fish usage components of the HCMP are *qualitative* tools that complement porewater chemistry and toxicity testing results but are not used on their own for decision-making. The results of these studies are considered in a weight-of-evidence assessment to determine if the HCFs are functioning as intended.

1.2 Objectives

The objective of the periphyton community component of the HCMP is to document periphyton community colonization and development on the dike face HCFs. The periphyton community is a group of microorganisms, including algae, that grow attached or close to submerged substrate. Periphyton are ecologically important because they form the base of the hard-bottom benthic food chain, which ultimately leads up to fish. Periphyton species composition and biomass are indirect indicators of lake productivity, reflecting nutrient concentrations in the lake, and may sometimes indicate the presence of contaminants. As described in the HCMP (Agnico Eagle, 2017), success criteria for periphyton monitoring focus on the capability of HCFs to function as fish habitat. The HCFs are expected to provide good substrate for periphyton to colonize.

This report summarizes the 2021 periphyton community results compared to the historical data. The 2021 data are compared to the baseline community data and reference sites to determine whether there are any gross differences in composition. The periphyton community was directly sampled (i.e., scraped off the rocks) and analyzed for density (cells/cm^2) and biomass (µg/cm^2); with a greater emphasis placed on biomass as it is more ecologically relevant and is derived from the density counts (See Methods [**Section 2**]).

2 METHODS

2.1 Periphyton Community Sampling

Periphyton community sampling was completed by Azimuth over an 11-day period between August 7th and August 17th. Periphyton samples were collected in the following areas in relation to each dike HCF (sampling locations are shown in **Figure 2-1**):

- East Dike (Second Portage Lake)
    - East Dike HCF (SP-ED)
    - Drilltrail Arm reference area (SP-DT) – this is a reference station located on the west shore of Second Portage Lake about half way up the Drilltrail Arm.
- Bay-Goose Dike (Third Portage Lake – East basin)
    - North section of the Bay-Goose Dike HCF (TPE-BGN)
    - South section of the Bay-Goose Dike HCF (TPE-BGS)
    - Third Portage Lake reference area (TPE-G) – this area is located on a small island approximately 1 km southwest of the southern tip of the Bay-Goose Dike.

Five replicate samples were collected from each area and analyzed independently. Universal Transverse Mercator (UTM) coordinates were collected at each replicate station and are reported in **Table 2-1**. Sampling locations were selected according to the following criteria; 1) a sufficient number of large, flat rocks from areas where the water is less than 1 m deep, 2) rocks with a flat surface facing upwards as much as possible, and 3) with uniform algal coverage, not particularly dense or sparse. Periphyton growth is naturally variable due to differences in wave action, aspect to sun, water depth and clarity, nutrient availability, rock type, water temperature and other factors. Rocks with similar characteristics (e.g., large, flat, with uniform algal coverage) were preferentially selected among the various sampling areas to the extent possible given the inherent differences in habitat between the dike faces and reference areas.

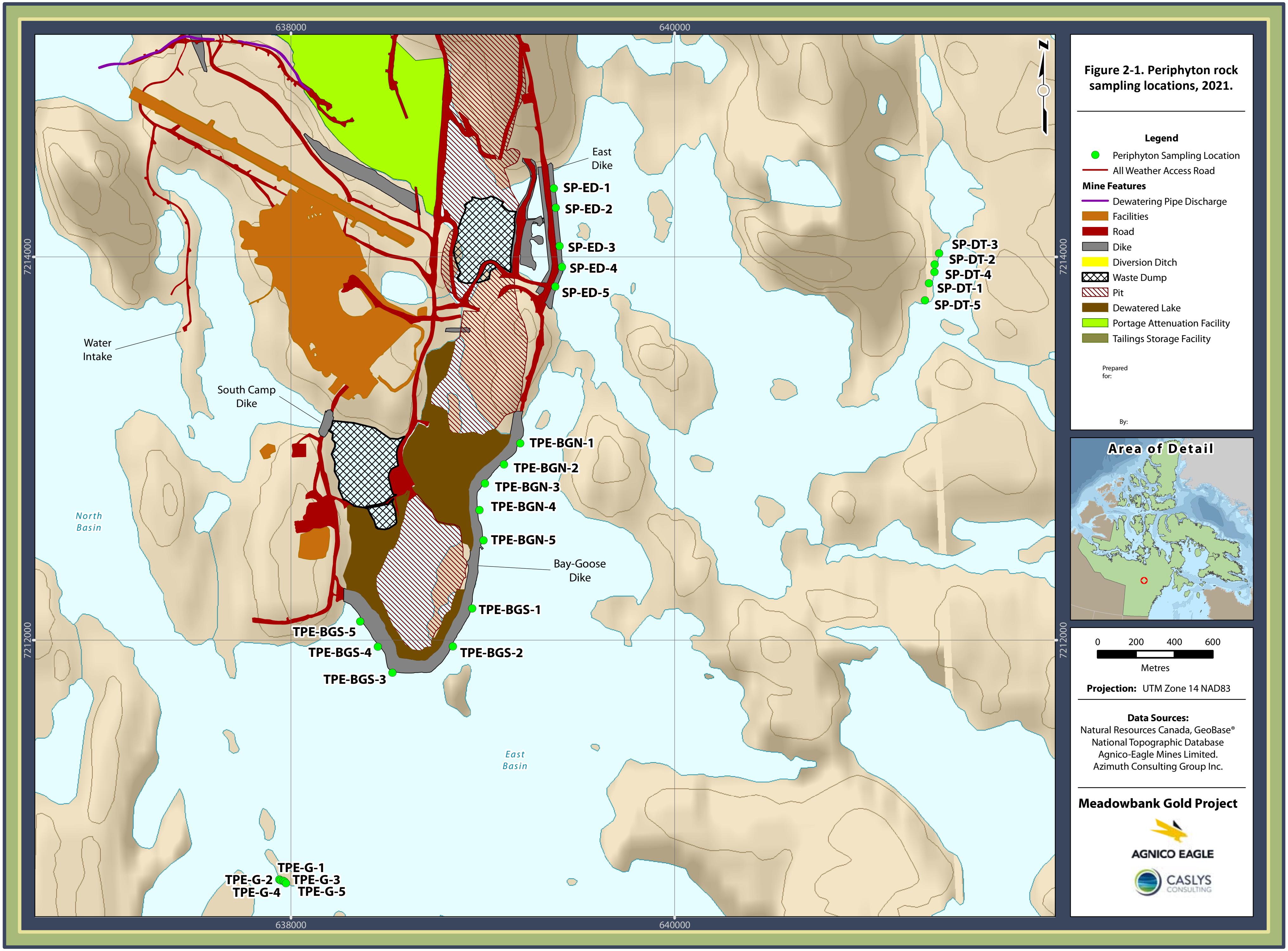


Figure 2-1. Periphyton rock sampling locations, 2021.

Table 2-1. Periphyton rock sampling locations, 2021.

Lake	Sampling Area (ID)	Designation	Date	Replicate	UTM Coordinates	
					Easting	Northing
Second Portage Lake	East Dike (SP-ED)	Impact	9-Aug-21	1	14W 0639368	7214371
				2	14W 0639379	7214248
				3	14W 0639400	7214055
				4	14W 0639411	7213933
				5	14W 0639384	7213857
	Drilltrail Arm Reference Area (SP-DT)	Control	9-Aug-21	1	15W 0358702	7213954
				2	15W 0358688	7213927
				3	15W 0358728	7214014
			17-Aug-21	4	14W 0641321	7213854
				5	14W 0641310	7213784
Third Portage Lake - East Basin	Bay-Goose Dike North section (TPE-BGN)	Impact	8-Aug-21	1	14W 0639194	7213018
				2	14W 0639114	7212921
				3	14W 0639017	7212823
				4	14W 0638977	7212682
				5	14W 0639003	7212508
	Bay-Goose Dike South section (TPE-BGS)	Impact	13-Aug-21	1	14W 0638944	7212142
				2	14W 0638839	7211950
				3	14W 0638545	7211828
				4	14W 0638454	7211965
				5	14W 0638363	7212093
	Reference Area (TPE-G)	Control	7-Aug-21	1	14W 0637974	7210734
				2	14W 0637968	7210740
				3	14W 0637960	7210747
				4	14W 0637950	7210748
				5	14W 0637942	7210752

Periphyton samples were collected using a specially-designed algae 'scrubber' (**Figure 2-2**). The scrubbers were used to remove and retain periphyton from a 20 cm^2 area on each rock; three rocks were composited for each replicate sample (i.e., each of the five replicates at a sampling area consisted of three rocks). Periphyton samples were preserved in the field with a small amount of Lugol's solution and sent to Plankton R Us Inc. (Winnipeg, MB) for taxonomic identification and biomass ($\mu g/cm^2$) estimation.

The standard operating procedure for collecting periphyton is described in **Appendix B**.

Figure 2-2. Periphyton sampling device and rocks selected for sampling.

2.2 Laboratory Methods

In the laboratory, each periphyton sample was well mixed and 2 mL sub-samples of suspension were sonicated for 10 to 20 seconds using a Sonifer Cell Disruptor (model w140) and gravity settled for 24 hours in an Ütermohl chamber (Findlay et al., 1999). Counts were performed on an inverted microscope at magnifications of 125X, 400X, and 1200X with phase contrast illumination. Cells were identified, counted and measured from random fields until 100 cells of the dominant species were found. Cell counts were converted to wet weight biomass by approximating cell volume. Estimates of cell volume for each species were obtained by measurements of up to 50 cells of an individual species and applying the geometric formula best fitted to the shape of the cell (Vollenweider, 1968; Rott, 1981).

2.3 Data Analysis

Periphyton community metrics for 2021 were qualitatively compared to previous years to determine whether there are any gross differences in composition. Species density (cells/cm^2) and biomass (µg/cm^2) at the level of major taxa group are the key metrics used to compare between stations and among years. The periphyton community is comprised four taxonomic groups: Cyanophytes (blue-green algae), Chlorophytes (green algae), Chrysophytes (golden algae), and Bacillariophytes (diatoms). Species richness was determined at the lowest practical level of identification, typically genus. The laboratory data are included in **Appendix C**.

Simpson's diversity index was calculated for each replicate sample to quantify periphyton species diversity among areas and replicates (Washington, 1984). Simpson's diversity index takes into account both the abundance patterns and taxonomic richness of the community. It measures the probability that two individuals randomly selected from a sample will belong to the same species. This is calculated by determining, for each taxonomic group at a site, the proportion of individuals that it contributes to the total number of individuals at the site. This diversity index can range from 0 to 1, with a value of 1 representing the highest diversity. Simpson's diversity index (D) is calculated as follows:

$$\mathrm{D} = 1 - \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

where:
N is the total number of organisms per replicate sample;
n_i is the total number of organisms of the i^{th} taxa per replicate sample.

2.4 Quality Assurance / Quality Control

Field sampling was carried out by qualified scientists according to the standard operating procedure (SOP). The 'scrubber' and the other sampling equipment were rinsed with lake water and inspected between replicates and stations to ensure that no debris remained in the bristles. Containers were labelled and each sample was given an internal waterproof label.

Laboratory quality control measures involved replicate counts on 10% of the samples to estimate the variability in the subsampling and enumeration method described above. Laboratory replicate samples were chosen at random and processed at different times from the original analysis to reduce biases. The laboratory duplicate is a new aliquot (10 ml) from the sample jar and is counted from the start in the same manner as the original aliquot (10 ml) taken from the jar. The data quality objective (DQO) for the laboratory replicates is a relative percent difference (RPD) of less than 25% for total density, total biomass, taxa richness, and Simpson's diversity.

3 RESULTS

A total of 53 species were identified in the East Dike and Bay-Goose Dike HCFs. The periphyton community in Third Portage Lake and Second Portage Lake is dominated by cyanophytes, diatoms and, to a lesser extent, chlorophytes (**Figure 3-1** – **Figure 3-4**). A complete list of the periphyton species in the samples collected from each location is provided in the presence/absence matrix in **Appendix D**. Results for the East Dike study are discussed in **Section 3.2.** Results for Bay-Goose Dike study are discussed in **Section 3.3**.

3.1 Quality Assurance / Quality Control

The RPDs for total density, total biomass, taxa richness and Simpson's diversity were below the 25% RPD DQO for laboratory duplicates (**Table 3-1**). Overall data quality is considered acceptable for the purposes of this study.

3.2 East Dike HCF

Periphyton samples were collected from rock surfaces at five locations each along the East Dike face (SP-ED) and the reference location (SP-DT). The 2021 study was the sixth cycle of habitat compensation monitoring at this area, which has been conducted every two years since 2009 (except for 2013).

As observed in previous years, density and biomass were highly variable within each location and the mean estimates of cell density and biomass were approximately 2-fold and 3-fold lower at SP-ED compared to SP-DT, respectively (**Table 3-2**, **Figure 3-1** and **Figure 3-2**). In 2021, total cell density decreased by approximately 15% at SP-ED (i.e., from 448,925 in 2019 to 381,682 cells/cm^2 in 2021). At the reference station (SP-DT) total cell density increased slightly in 2021 compared to 2019 (i.e., from 821,793 to 860,694 cells/cm^2). Mean biomass decreased at both SP-ED (24%) and SP-DT (13%) in 2021 compared to 2019, a trend that extends back to 2017 at both sites.

Relative major taxa group biomass and density were similar between SP-ED and SP-DT in 2021 (**Table 3-2**, **Figure 3-1** and **Figure 3-2**). From a biomass perspective, the communities at both sites are dominated by cyanobacteria and diatoms, followed by chlorophytes, which generally comprised about 5 to 20% of the community across the years (**Table 3-2**).

Community diversity indices (i.e., Simpson's diversity and taxa richness) were very similar at both sampling areas in 2021 (**Table 3-2**). The mean number of taxa was 15 at SP-ED and 16 at SP-DT, similar to the mean number of taxa observed in 2019 (Azimuth, 2020). The mean Simpson's diversity was similar between the two areas; 0.72 at SP-ED and 0.74 at SP-DT (**Table 3-2**).

Table 3-1. QA/QC results for the laboratory duplicate periphyton samples.

Metrics	Laboratory Duplicates								
	SP-DT-2 09-Aug-21	Lab Duplicate	RPD (%)	SP-ED-2 09-Aug-21	Lab Duplicate	RPD (%)	TPE-BGN-4 08-Aug-21	Lab Duplicate	RPD (%)
Total Density	876,707	812,620	7.6	307,617	331,970	-7.6	98,494	100,887	-2.4
Total Biomass	463	460	0.5	70	74	-5.2	11	10	6.5
# Taxa	19	18	5.4	14	14	0.0	12	14	-15
Simpsons Diversity	0.82	0.77	6.5	0.74	0.72	2.3	0.62	0.65	-4.0

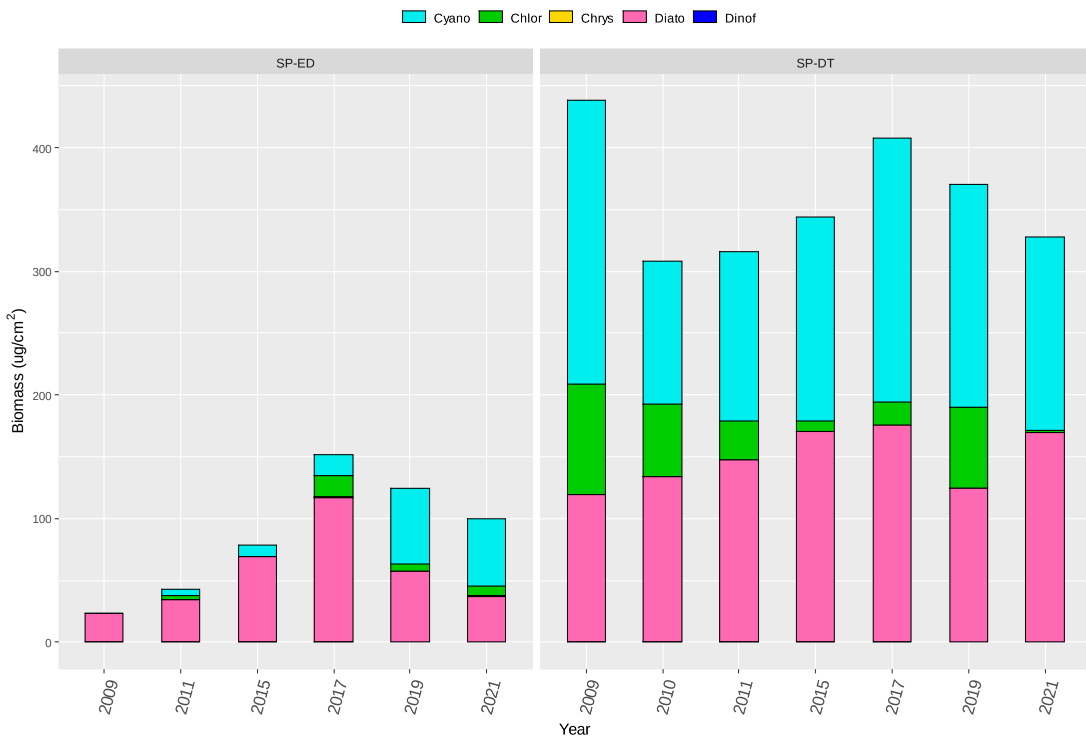
Notes:

RPD = Relative Percent Difference (%) = ((original - duplicate) / (original + duplicate)/2) x 100.

Shaded RPDs exceed 25% (lab duplicates).

NA = Not Applicable for rare species.

Figure 3-1. **Mean and relative periphyton biomass (µg/cm^2) for major taxa groups at East Dike HCF sampling areas.**



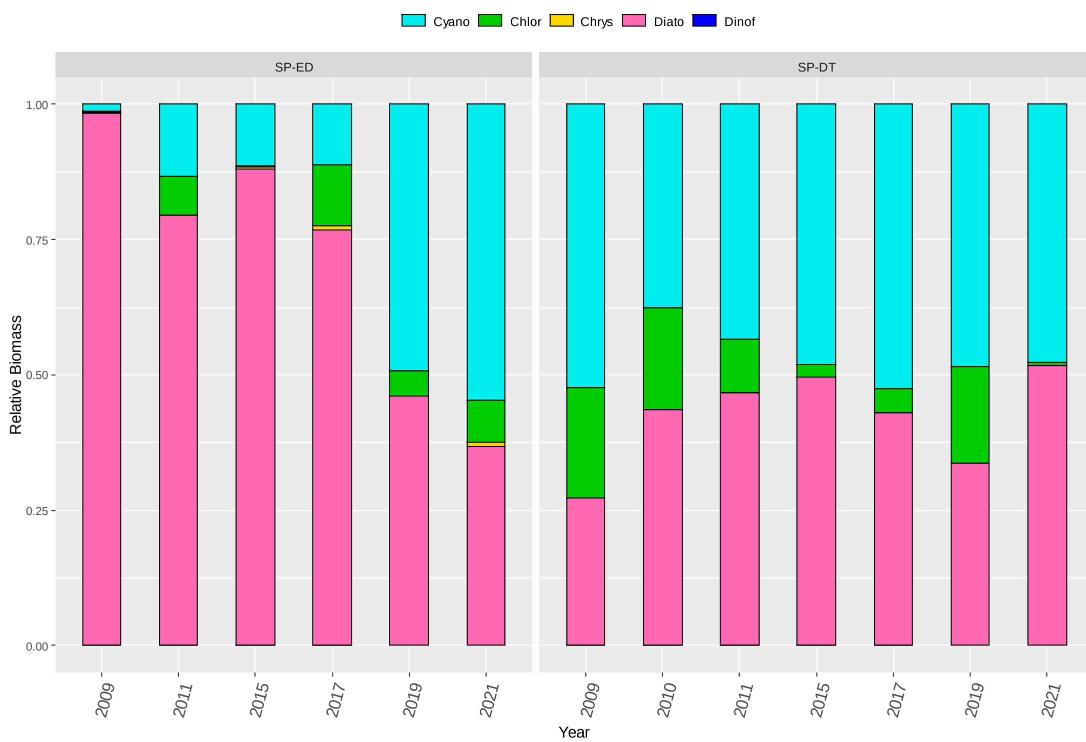
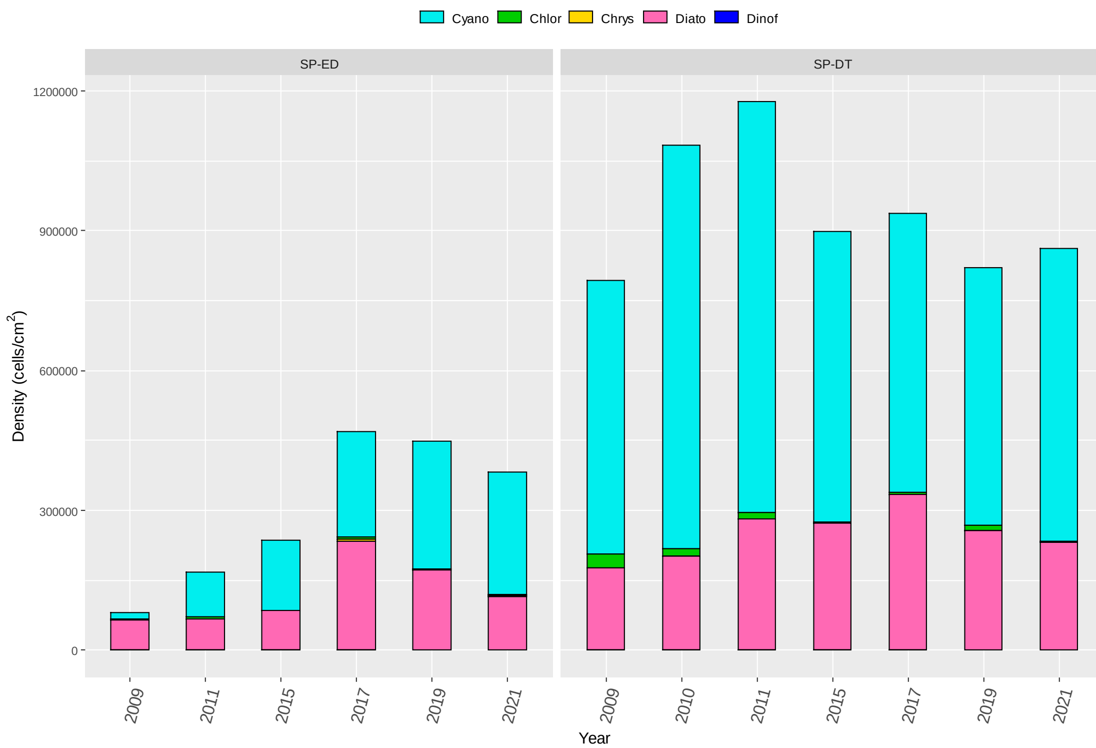


Figure 3-2. **Mean and relative periphyton density (cells/cm^2) for major taxa groups at East Dike HCF sampling areas.**



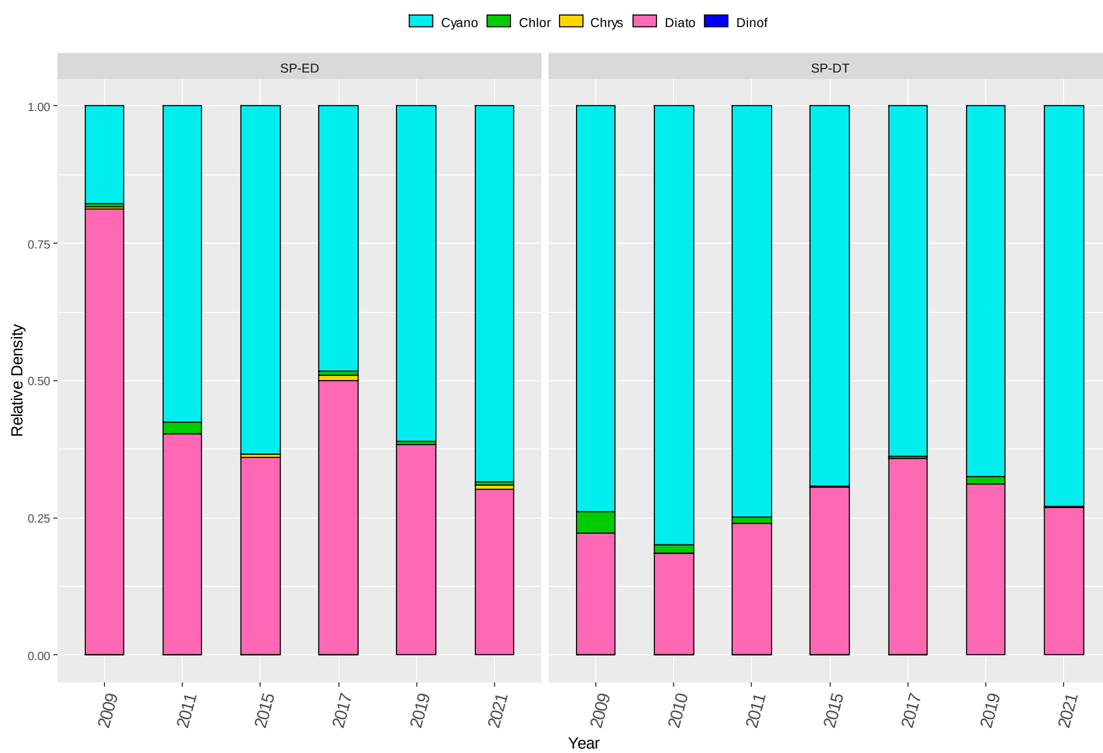


Table 3-2. Density (cells/cm²), diversity, and biomass (µg/cm²) of major periphyton taxa groups for East Dike HCF sampling areas.

Area-Replicate ID	Date	Periphyton Density (cells/cm²)					# Taxa	Simpson's Diversity
		Cyanobacteria	Chlorophyte	Chrysophyte	Diatom	Total		
Second Portage - East Dike								
SP-ED-1	09-Aug-21	237,762	11,963	14,954	97,198	361,877	16	0.76
SP-ED-2	09-Aug-21	228,149	0	0	79,468	307,617	14	0.74
SP-ED-3	09-Aug-21	446,813	0	0	75,366	522,179	13	0.74
SP-ED-4	09-Aug-21	202,909	0	0	150,456	353,365	15	0.68
SP-ED-5	09-Aug-21	191,406	0	0	171,966	363,372	15	0.66
Station Mean		***261,408***	***2,393***	***2,991***	***114,891***	***381,682***	***15***	***0.72***
	as %	***68%***	***1%***	***1%***	***30%***			
Second Portage - Drilltrail Arm Reference Area								
SP-DT-1	09-Aug-21	897,215	0	0	139,966	1,037,181	15	0.69
SP-DT-2	09-Aug-21	410,155	0	0	466,552	876,707	19	0.82
SP-DT-3	09-Aug-21	622,924	12,817	0	117,920	753,661	16	0.70
SP-DT-4	17-Aug-21	511,413	2,991	0	215,332	729,735	17	0.71
SP-DT-5	17-Aug-21	693,846	0	0	212,341	906,187	15	0.80
Station Mean		***627,111***	***3,162***	***0***	***230,422***	***860,694***	***16***	***0.74***
	as %	***73%***	***<1%***	***0%***	***27%***			

Area-Replicate ID	Date	Periphyton Biomass (µg/cm²)				
		Cyanobacteria	Chlorophyte	Chrysophyte	Diatom	Total
Second Portage - East Dike						
SP-ED-1	09-Aug-21	31	38.5	3.4	44	116
SP-ED-2	09-Aug-21	43	0	0.0	26	70
SP-ED-3	09-Aug-21	167.6	0.0	0.0	17	184
SP-ED-4	09-Aug-21	18.0	0.0	0.0	66	84
SP-ED-5	09-Aug-21	14.0	0.0	0.0	32	46
Station Mean		***54.7***	***7.7***	***0.7***	***37***	***100***
	as %	***55%***	***8%***	***1%***	***37%***	
Second Portage - Drilltrail Arm Reference Area						
SP-DT-1	09-Aug-21	243	0.0	0.0	72	316
SP-DT-2	09-Aug-21	161	0.0	0.0	302	463
SP-DT-3	09-Aug-21	39	6.5	0.0	137	182
SP-DT-4	17-Aug-21	77	2.7	0.0	182	262
SP-DT-5	17-Aug-21	262	0.0	0.0	152	414
Station Mean		***156***	***1.8***	***0***	***169***	***327***
	as %	***48%***	***1%***	***0%***	***52%***	

3.3 Bay-Goose Dike HCFs

Periphyton samples were collected from rock surfaces at five locations each along the north and south sections of the Bay-Goose Dike (i.e., TPE-BGN and TPE-BGS) and at the reference location TPE-G (**Table 3-3**, **Figure 3-3** and **Figure 3-4**). The 2021 study was the fifth cycle of habitat compensation monitoring along the Bay-Goose Dike, which has been conducted every two years since 2011 except for 2013.

In 2021, mean cell density at the north and south Bay-Goose Dike monitoring areas were approximately 6 to 7-fold lower than the reference area (TPE-G), which is a slightly lower ratio than that observed in historical sampling events (**Figure 3-4**). Periphyton density was dominated by cyanobacteria, followed by diatoms at both Bay-Goose Dike areas and the reference area TPE-G. Similar to 2019, there was a slightly higher proportion of cyanobacteria in terms of cell density at TPE-G (i.e., 75%) compared to 60% and 54% at the impact monitoring areas TPE-BGN and TPE-BGS, respectively (**Table 3-3**).

In 2021, the biomass was dominated by cyanobacteria and diatoms at all stations. Compared to 2019, the mean total biomass increased at TPE-BGS and decreased at TPE-G and TPE-BGN. Similar to previous years, the mean total biomass was much higher at the reference area TPE-G than at the impact areas TPE-BGN and TPE-BGS. Furthermore, biomass at TPE-G was fairly evenly distributed between cyanobacteria, chlorophytes, and diatoms whereas most of the biomass was attributed to cyanobacteria and diatoms at TPE-BGS and TPE-BGN (see **Table 3-3**, and **Figure 3-3**).

The proportion of biomass observed in 2021 for cyanobacteria and diatoms was similar across stations; however, the proportion of biomass for chlorophytes was higher at TPE-G than the impact stations TPE-BGN and TPE-BGS (**Figure 3-3**). The biomass of chlorophytes at TPE-BGS was heavily influenced by one replicate (replicate 5) which highlights the within-station variability in the periphyton community assemblage (**Table 3-3**).

Overall, TPE-BGN and TPE-BGS were similar in terms of Simpson’s diversity, taxa richness, and biomass in 2021. Similar to 2019, the periphyton community at the Bay-Goose Dike appeared to be less diverse than the reference area as indicated by lower Simpson’s diversity scores and fewer taxa (**Table 3-3**).

Relative to SP-ED, the patterns of colonization and succession seen at TPE-BGN and TPE-BGS have been generally slower and more variable. Since 2015 the relative biomass and density at TPE-G has been dominated by cyanobacteria (**Figure 3-3** and **Figure 3-4**). Historical results show progress along the Bay-Goose Dike towards a more heterogeneous periphyton community comprised of cyanobacteria and diatom species similar to the reference area (**Appendix A**). The total number of taxa increased or remained the same while Simpson’s diversity increased at all at all Bay-Goose Dike stations relative to 2019 (**Table 3-3**).

Figure 3-3. Mean and relative periphyton biomass (µg/cm²) for major taxa groups at Bay-Goose Dike HCF sampling areas.

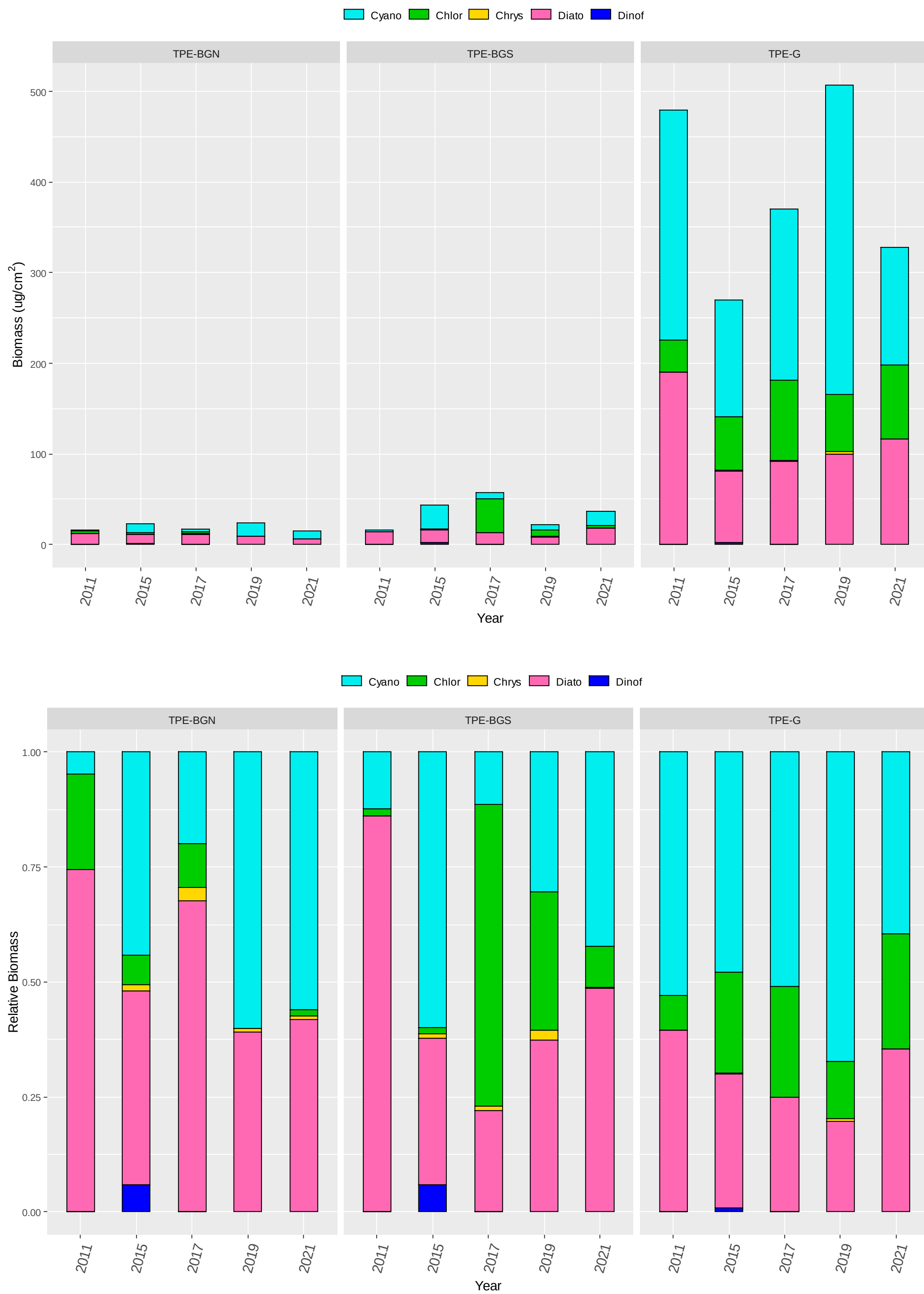


Figure 3-4. Mean and relative periphyton density (cells/cm^2) for major taxa groups at Bay-Goose Dike HCF sampling areas.

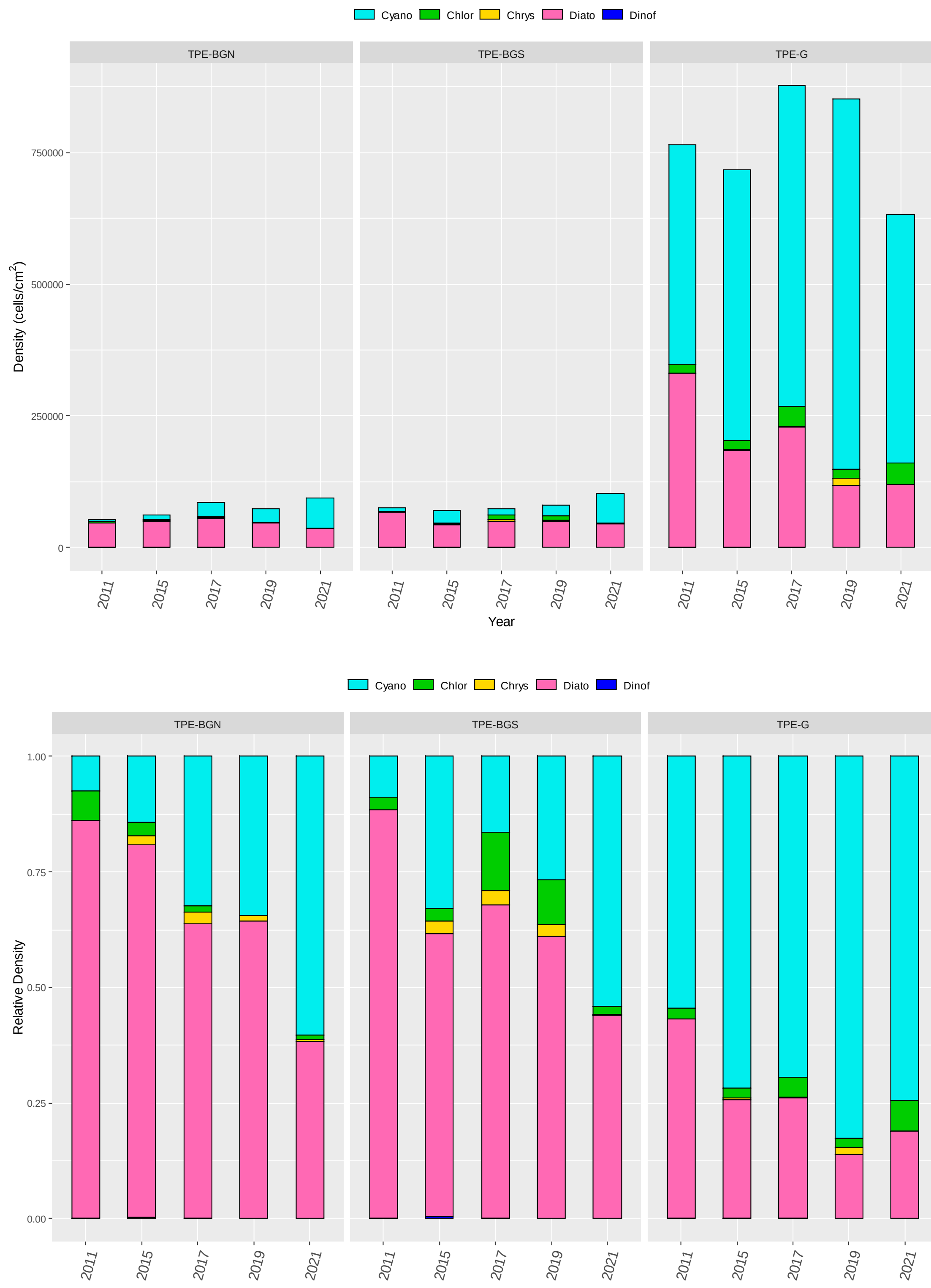


Table 3-3. Density (cells/cm²), diversity, and biomass (µg/cm²) of major periphyton taxa groups for Bay-Goose Dike HCF sampling areas.

Area-Replicate ID	Date	Periphyton Density (cells/cm²) Cyanobacteria	Chlorophyte	Chrysophyte	Diatom	Total	# Taxa	Simpson's Diversity
Bay-Goose Dike – North section (TPE-BGN)								
TPE-BGN-1	08-Aug-21	60,213	3,988	0	11,963	76,164	10	0.63
TPE-BGN-2	08-Aug-21	41,631	0	0	33,018	74,648	10	0.62
TPE-BGN-3	08-Aug-21	70,880	0	2,692	44,861	118,432	11	0.72
TPE-BGN-4	08-Aug-21	52,238	0	0	46,256	98,494	12	0.62
TPE-BGN-5	08-Aug-21	56,704	0	0	42,349	99,053	12	0.72
Station Mean		***56,333***	***798***	***538***	***35,689***	***93,358***	***11***	***0.66***
	as %	***60%***	***1%***	***1%***	***38%***			
Bay-Goose Dike – South section (TPE-BGS)								
TPE-BGS-1	13-Aug-21	73,106	0	0	105007	178114	11	0.74
TPE-BGS-2	13-Aug-21	57422	0	0	25122	82544	13	0.71
TPE-BGS-3	13-Aug-21	15432	0	0	55627	71059	11	0.43
TPE-BGS-4	13-Aug-21	50962	0	718	12561	64241	14	0.45
TPE-BGS-5	13-Aug-21	82185	8613	0	28352	119150	15	0.81
Station Mean		***55821***	***1723***	***144***	***45334***	***103022***	***13***	***0.63***
	as %	***54%***	***2%***	***<1%***	***44%***			
Bay-Goose Dike – Reference (TPE-G)								
TPE-G-1	07-Aug-21	328381	32300	0	86133	446813	15	0.74
TPE-G-2	07-Aug-21	450851	0	0	82992	533843	17	0.74
TPE-G-3	07-Aug-21	717772	129199	0	236865	1083836	19	0.77
TPE-G-4	07-Aug-21	428420	17944	0	130096	576461	20	0.77
TPE-G-5	07-Aug-21	433227	30762	0	58960	522948	18	0.67
Station Mean		***471730***	***42041***	***0***	***119009***	***632780***	***18***	***0.74***
	as %	***75%***	***7%***	***0%***	***19%***			

Area-Replicate ID	Date	Periphyton Biomass (µg/cm²) Cyanobacteria	Chlorophyte	Chrysophyte	Diatom	Total
Bay-Goose Dike – North section (TPE-BGN)						
TPE-BGN-1	08-Aug-21	3	1	0	6	10
TPE-BGN-2	08-Aug-21	7	0	0	3	10
TPE-BGN-3	08-Aug-21	21	0	0.6	7	29
TPE-BGN-4	08-Aug-21	3	0	0	8	11
TPE-BGN-5	08-Aug-21	8	0	0	6	14
Station Mean		***8.4***	***0.2***	***0.1***	***6.3***	***15***
	as %	***56%***	***1%***	***<1%***	***42%***	
Bay-Goose Dike – South section (TPE-BGS)						
TPE-BGS-1	13-Aug-21	43	0	0	49	92
TPE-BGS-2	13-Aug-21	9	0	0	5	14
TPE-BGS-3	13-Aug-21	4	0	0	8	11
TPE-BGS-4	13-Aug-21	8	0	0	7	15
TPE-BGS-5	13-Aug-21	13	16	0	20	49
Station Mean		***15.3***	***3.3***	***0***	***17.7***	***36***
	as %	***42%***	***9%***	***0%***	***49%***	
Bay-Goose Dike – Reference (TPE-G)						
TPE-G-1	07-Aug-21	59.7	53.3	0.0	127.9	241.0
TPE-G-2	07-Aug-21	198.7	0.0	0.0	45.6	244.3
TPE-G-3	07-Aug-21	98.6	247.7	0.0	246.5	592.9
TPE-G-4	07-Aug-21	168.8	37.3	0.0	96.0	302.2
TPE-G-5	07-Aug-21	122.4	72.5	0.0	63.3	258.3
Station Mean		***129.6***	***82.2***	***0***	***115.9***	***327.7***
	as %	***40%***	***25%***	***0%***	***35%***	

4 DISCUSSION AND CONCLUSIONS

Periphyton monitoring under the HCMP tracks the development of attached algal communities on the faces of the East Dike HCF (since 2009) and Bay-Goose Dike HCF (since 2011). Periphyton community development is dependent on several factors, including nutrient availability (Bonilla et al., 2005), light (Kiffney et al., 2003) and the capacity of different taxa to colonize, grow, compete, tolerate stress, and resist loss processes (Cox, 1990). Diatoms were the dominant major taxon in the early-stage periphyton communities along the East Dike and Bay-Goose Dike HCFs. In the ensuing years, the community structure has shifted to a more heterogeneous mix of cyanobacteria, diatoms, and to a lesser extent, chlorophyte taxa at both the East Dike and Bay-Goose Dike HCFs.

4.1 East Dike HCF

The periphyton community has changed substantially at the East Dike HCF since it was constructed. In 2021, community (total) biomass decreased at the impact and reference areas in Second Portage Lake (i.e., SP-ED and SP-DT) compared to 2019, but these changes were also seen at the reference area, suggesting they may be attributed to natural variability. Notwithstanding, community biomass at the HCF remains lower than the reference area; it is not clear how much of this difference is due to habitat differences between the two areas (e.g., substrate size/stability, aspect and other physical differences). In contrast, species composition trend results show that the community at SP-ED has progressively evolved to become quite similar to the community at reference area SP-DT (**Figure 3-1** and **Figure 3-2**).

4.2 Bay-Goose Dike HCFs

The periphyton community has also changed substantially at the Bay-Goose Dike HCF, but at a much slower rate than seen at the East Dike HCF. In Third Portage Lake, biomass results for the Bay-Goose HCFs continue to be substantially lower than the reference area, with little progress to reducing the gap made between 2019 and 2021. Interestingly, the southern portion of the dike has higher biomass than the northern portion, potentially due to aspect (i.e., favorable growing conditions due to more sunlight), but other factors could also be at play as the pattern is not consistent in each event. It is unclear why biomass results remain low on the dike faces. From a community composition perspective, year-to-year results are variable, but the proportion of cyanobacteria relative to diatoms continues to trend towards being similar to the reference area. Overall, biomass remains low relative to the reference area, but community composition is fairly similar.

4.3 Conclusions

The presence of a structurally similar periphyton community at each of the HCFs relative to their respective reference areas indicates a healthy periphyton community. While total biomass growth is still expected as periphyton community succession progresses, there may be variation from year to year, due to aforementioned factors.

The next cycle of the HCMP is scheduled for August 2023.

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APPENDICES

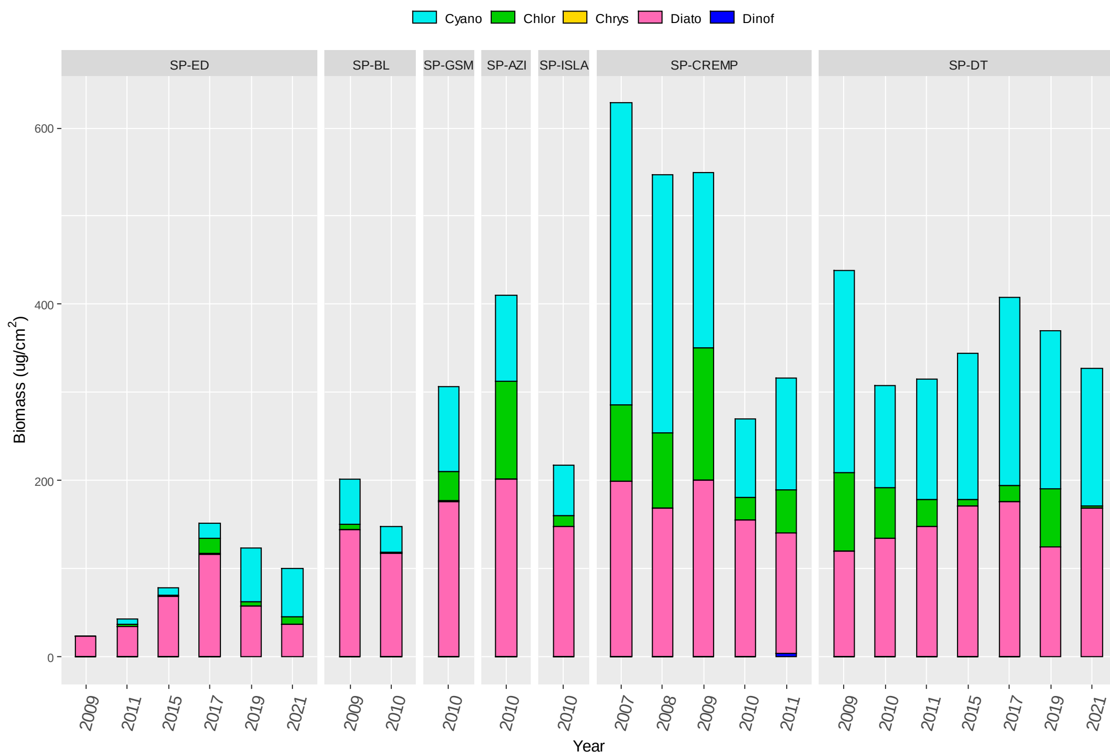
APPENDIX A
HISTORICAL PERIPHYTON RESULTS

LIST OF FIGURES – APPENDIX A

Periphyton Monitoring Areas from the Effects Assessment Studies (not included in the HCMP)

- *Second Portage Lake Boat Launch (SP-BL)* – this is a near-field station located just outside (east) of the area that was enclosed by turbidity barriers in 2008; this station would have been exposed to relatively high TSS concentrations in 2008. Sampled in 2009 and 2010 as part of targeted Effects Assessment Studies (Azimuth, 2011), but is not included in the HCMP.
- *Second Portage new near-field (SP-GSM)* – this is a near-field station located on the north shore of the lake about 0.5 km east of the dike. This area was last sampled in 2010 as part of targeted Effects Assessment Studies for construction of the East Dike (Azimuth, 2012).
- *Second Portage new far-field (SP-AZI)* – this is a far-field station located in a flat area at the base of a steep slope on the north shore of the lake about 1.0 km east of the dike.
- *Second Portage new far-field (SP-ISLA)* – this is a far-field station located on the south side of an island about 1.4 km southeast of the dike.
- *Second Portage CREMP location (SP-CREMP)* – this is a far-field station located on the north shore of the lake about 1.8 km southeast of the dike, at the south tip of the entrance to the Drilltrail Arm; this area was likely exposed to slightly elevated TSS in 2008. Monitoring was last conducted in 2011 as part of the Effects Assessment Study for construction of the East Dike (Azimuth, 2012).
- *Third Portage Lake CREMP location (TPE-CREMP)* – this area is located in the southeast corner of the east basin of Third Portage Lake. The area was originally monitored in 2007 and 2008 as part of the CREMP. Monitoring was last conducted in 2011 as part of the Effects Assessment Study for construction of the Bay-Goose dike (Azimuth, 2012).

Figure A-1. Mean and relative periphyton biomass (µg/cm²) for major taxa groups at East Dike HCF sampling areas, 2007-2021.



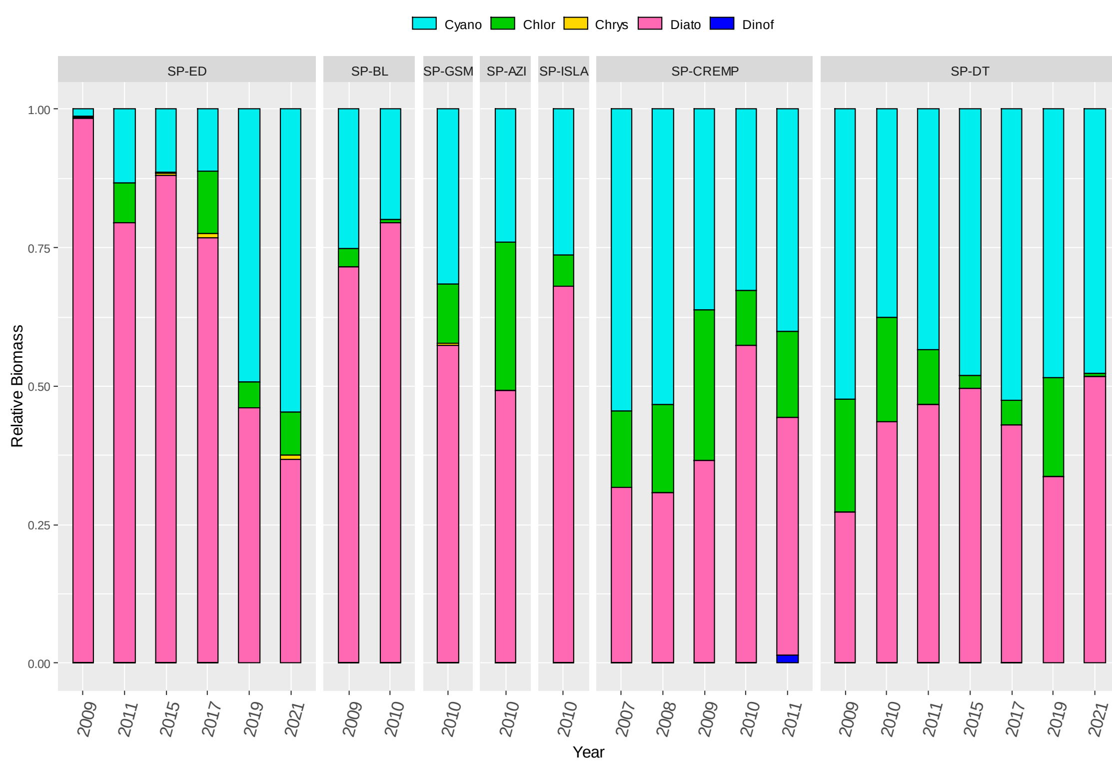
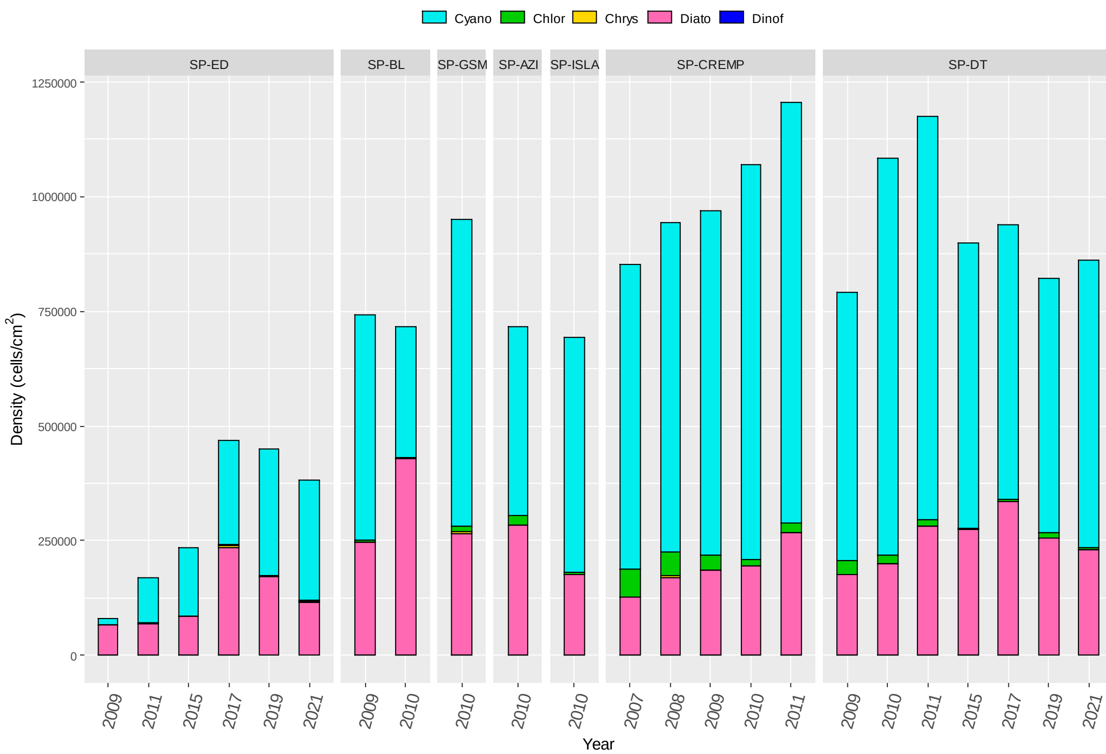


Figure A-2. Mean and relative periphyton density (cells/cm²) for major taxa groups at East Dike HCF sampling areas, 2007-2021.



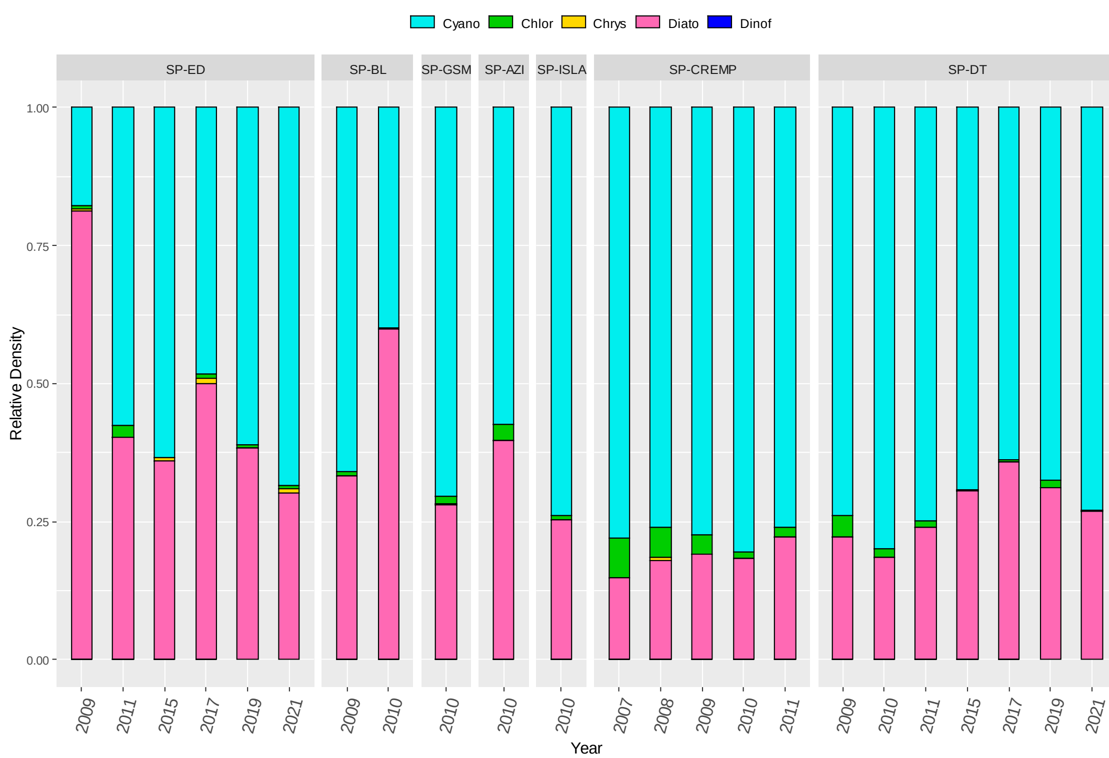
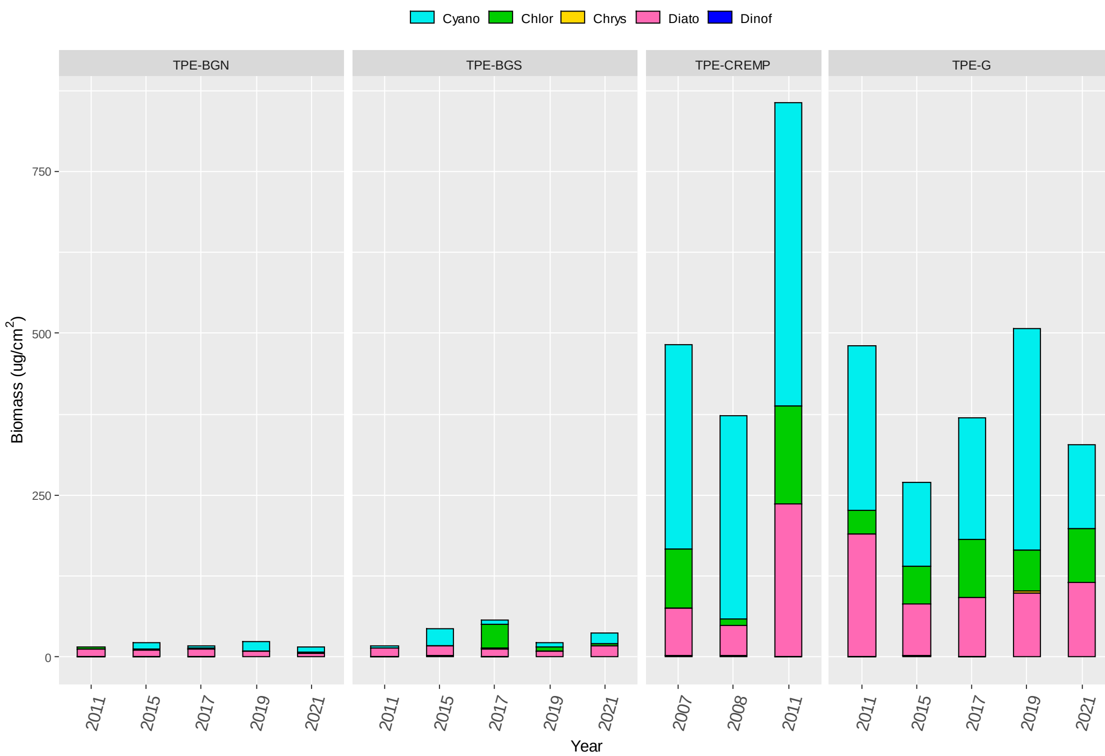


Figure A-3. Mean and relative periphyton biomass (µg/cm²) for major taxa groups at Bay-Goose Dike HCF sampling areas, 2007-2021.



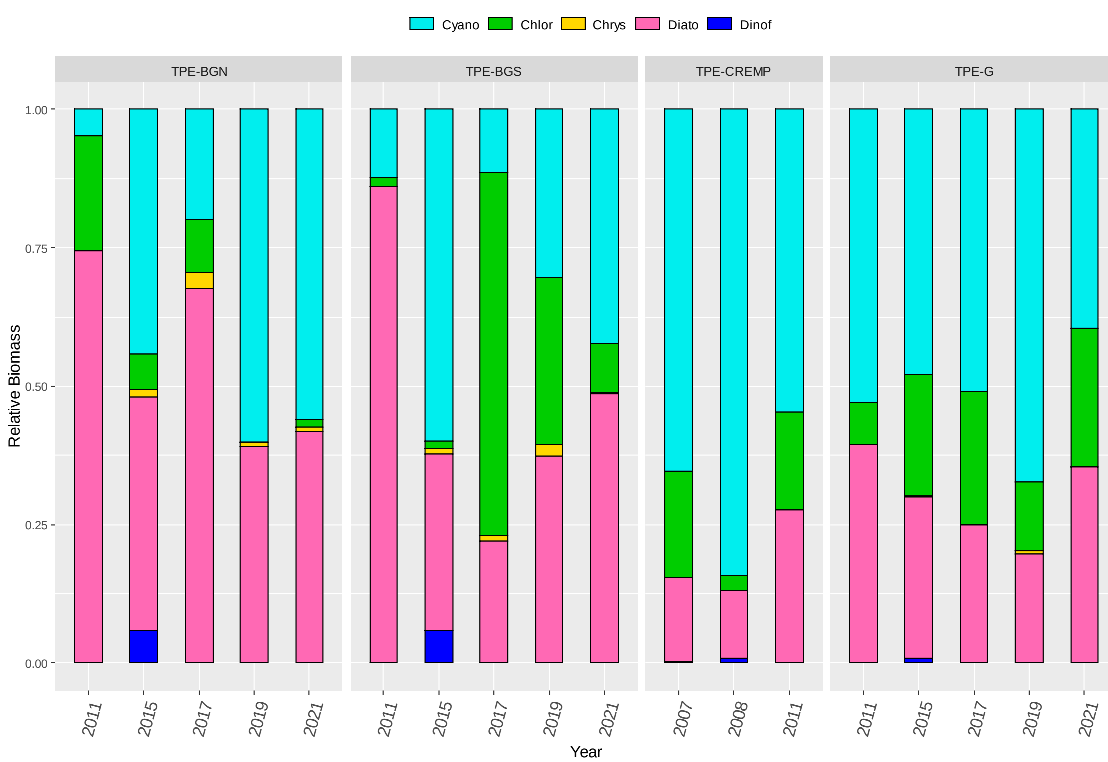
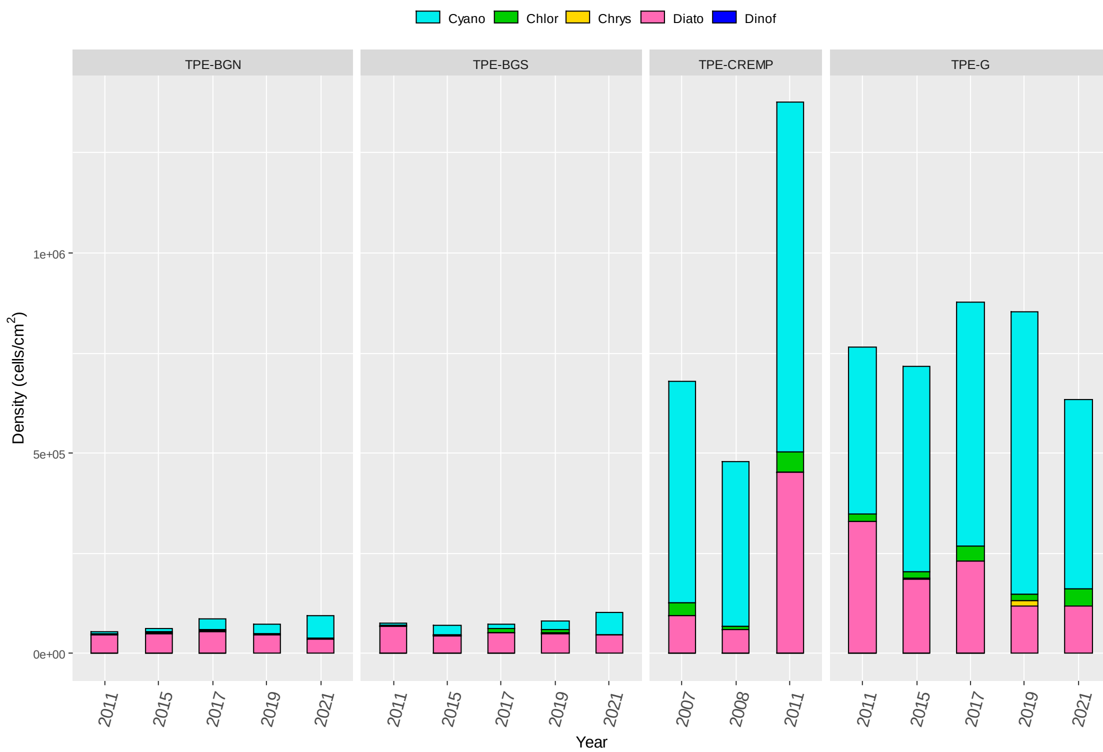
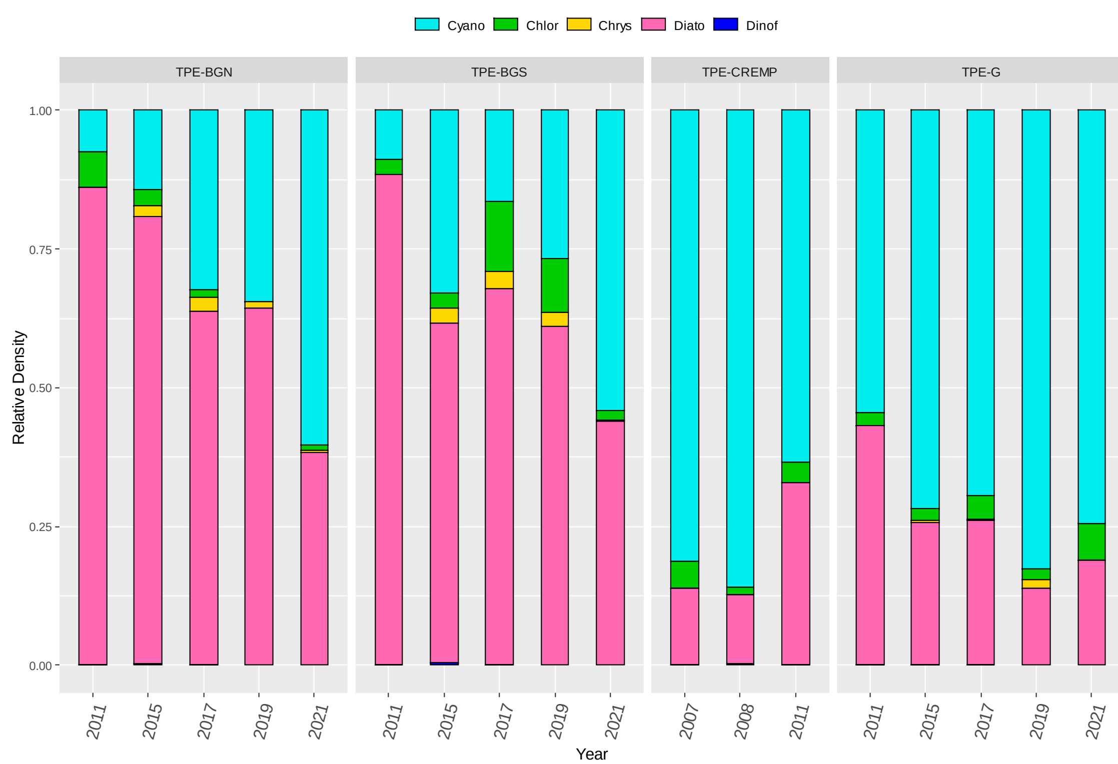


Figure A-4. Mean and relative periphyton density (cells/cm²) for major taxa groups at Bay-Goose Dike HCF sampling areas, 2007-2021.





APPENDIX B
PERIPHYTON SAMPLING – STANDARD OPERATING PROCEDURES

<u>Standard Operating Procedure</u>
Meadowbank Lakes Project
HCM Periphyton Sampling

Equipment

- Field collection data forms (printed on waterproof paper), pencils, waterproof markers & clipboard
- GPS unit, batteries
- Periphyton sampler, syringes & plastic tubes
- Binder clips (to pinch tubes on periphyton sampler)
- Shoulder gloves (with 5 cm increments marked from fingertip to shoulder)
- Large tote
- Field sample bottles & preservative (per replicate):
- 1 – 500 mL plastic jar
- 1 syringe & Lugol's solution
- Cooler(s) or action packer(s) (for storing and shipping samples)
- Address labels for cooler(s)/action packer(s)
- Chain-of-custody forms
- Large Ziploc bag (for sending chain-of-custody form in cooler)
- Packing tape (for sealing cooler)

General Procedures

Before going into the field, label all sampling containers. Using a permanent waterproof marker, print the following information directly onto both the jar and jar lid:

- Azimuth company name
- Station abbreviation (e.g., SP-ED) and replicate number (e.g., SP-ED -1, SP-ED-2)
- Date of sample collection

Before and during sampling, fill in the requested information on the field data form using a lead pencil or Rite-in-the-rain pen.

Access to the area may be by boat or foot; in either event, ensure the sampling area is not impacted by boat (launch) or other anthropogenic activities. Record the UTM coordinates for each sampling station, measured using a GPS unit in NAD 83, on the field data form. In future sampling events, sample periphyton from the same locations.

Select a rock with a flat surface, **no more than 0.5 meter below the water surface**, with the following criteria:

- Facing up as much as possible; if not, with a small slope[1]
- Uniform algal coverage, not uniformly dense or sparse

The periphyton sampler is a specially designed scrubber, consisting of a plexiglass tube with a plunger that fits snugly inside and a distal wire brush that comes in direct contact with the rock surface. Press the tube against the rock to form a tight seal. To detach the periphyton colonies, depress the plunger and twist for approximately 30 half turns. The periphyton mixture is suspended by opening the plunger approximately ¼ of the device volume and drawn into a syringe that is attached to the tube. Pinch intake tube closed when drawing suspension into syringe. Empty the syringe, pinch output tube closed prior to detaching the syringe, into the pre-labeled replicate 1 sampling container (i.e., TPE-CREMP-1). Continue scraping and syringing (approximately two times: another 20 half turns of the sampler, then 10 half turns, then a final rinse of sampler) until all visible periphyton are completely removed from the rock surface. This procedure works well with two people; one to scrub the rocks and clamp the intake tube, the other to operate the syringe and clamp the output tube. The number of turns in this SOP is conservative and may be too many for the average sampling site. Use discretion and examine each sampled rock to ensure it has been fully cleaned where the scrubber was used.

Repeat rock selection and scrubbing steps two more times, selecting undisturbed flat rocks in less than 0.5 meter of water. Put the collected periphyton samples from each rock into the same pre-labeled replicate 1 sampling container (i.e., TPE-1) as above. These three rocks are composited into one replicate sample; approximately 500 mL of water/periphyton are collected in total.

Repeat above steps for each replicate required at the station. For every 125 mL of periphyton mixture in each sampling container, add 1 mL of Lugol's solution to preserve the sample (the sample should look the colour of weak tea). Seal the sampling containers and store in a cooler at room temperature.

Fill out a chain-of-custody form completely and place into a sealed Ziploc plastic bag inside the shipping container. If using digital COC form, print two copies of the document in the field, one copy for the laboratory and one for Azimuth. Questions about COCs can be directed to Eric Franz.

[1] Along the dike face it may be necessary to set up a tote to receive the rock. If the aspect of the dike face is too steep to safely or properly sample in-situ place the rock in the tote in the boat. It must hold enough water to cover the sampled rock so that the plunger works properly. Make sure the tote is clean after each sample.

Meadowbank HCM Periphyton Scrubbing

- Collect periphyton scrubbing samples from 5 stations within SP and TPE
- Revisit the following SP stations: SP-DT and SP-ED
- Include the following TPE stations: TPE-BGN, TPE-BGS and TPE-G (reference site)
- Each station consists of 5 replicate samples (four stations are close together and the two dike stations are close together more spread out)
- Each sample replicate will consist of scrubbings from three rocks and will be placed in a 500 mL jar and preserved with Lugol's solution
- Ship samples and COC to David Findlay at Plankton R Us

  Plankton R Us Inc.
  39 Alburg Drive
  Winnipeg, MB, R2N 1M1
  Tel: 204-254-7952

APPENDIX C
2021 PERIPHYTON TAXONOMY DATA

Table C-1. Periphyton Taxonomy Results, 2021.

Notes:
1st number in species code = group 1=Cyanobacteria 2=Chlorophyte 5=Diatoms 7=Dinoflagellates
Total daily biomass is sum of all species on a given date
Replicates ending in "R" specifies a replicate count for QA/QC

Area	Replicate	Date	Species Code	Species name	Density	Biomass	Length	Width	Cell Volume
					cells/cm²	μg/cm²	μ	μ	μ³
SP - DT	1	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	64599	8.26	113.0	1.2	127.80
SP - DT	1	9-Aug-21	1084	Gloeocapsa punctata	509618	17.07	4.0	4.0	33.50
SP - DT	1	9-Aug-21	1086	Calothrix sp.	61011	196.27	96.0	8.0	3217.00
SP - DT	1	9-Aug-21	1131	Heteroleibeinia profunda Komarek	247631	15.25	19.6	2.0	61.60
SP - DT	1	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	14355	6.58	57.0	3.2	458.40
SP - DT	1	9-Aug-21	5311	Cymbella minuta Kutzing	3589	1.40	15.5	8.0	389.60
SP - DT	1	9-Aug-21	5513	Tabellaria fenestrata (Lyngbye) Kutzing	10767	8.52	84.0	6.0	791.70
SP - DT	1	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	17944	23.94	26.0	14.0	1334.10
SP - DT	1	9-Aug-21	5518	Synedra acus Kutzing	28711	3.61	120.0	2.0	125.70
SP - DT	1	9-Aug-21	5702	Achnanthes minutissima Kutzing	53833	4.42	19.6	4.0	82.10
SP - DT	1	9-Aug-21	5726	Eucocconeis sp.	3589	15.78	42.0	20.0	4398.20
SP - DT	1	9-Aug-21	5728	Epithemia argus Kutzing	3589	4.87	36.0	12.0	1357.20
SP - DT	1	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	3589	4.23	30.0	10.0	1178.10
SP - DT	1	9-Aug-21	5873	Gomphonema minutum	7178	3.01	25.0	8.0	418.90
SP - DT	1	9-Aug-21	5882	Anomoenies vitrea Ross	7178	2.44	36.0	6.0	339.30
SP - DT	2	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	38452	4.74	109.0	1.2	123.30
SP - DT	2	9-Aug-21	1084	Gloeocapsa punctata	143554	4.81	4.0	4.0	33.50
SP - DT	2	9-Aug-21	1086	Calothrix sp.	43579	139.62	91.0	8.2	3203.80
SP - DT	2	9-Aug-21	1131	Heteroleibeinia profunda Komarek	184570	11.37	19.6	2.0	61.60
SP - DT	2	9-Aug-21	5311	Cymbella minuta Kutzing	12817	5.03	15.6	8.0	392.10
SP - DT	2	9-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	2563	8.05	20.0	20.0	3141.60
SP - DT	2	9-Aug-21	5509	Cyclotella ocellata Pant.	2563	0.64	8.6	8.6	249.80
SP - DT	2	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	53833	77.35	28.0	14.0	1436.80
SP - DT	2	9-Aug-21	5518	Synedra acus Kutzing	20508	2.36	110.0	2.0	115.20
SP - DT	2	9-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	2563	5.80	240.0	6.0	2261.90
SP - DT	2	9-Aug-21	5702	Achnanthes minutissima Kutzing	271728	22.31	19.6	4.0	82.10
SP - DT	2	9-Aug-21	5726	Eucocconeis sp.	10254	42.95	40.0	20.0	4188.80
SP - DT	2	9-Aug-21	5767	Nitzschia fonticola Grunow	2563	0.16	15.0	4.0	62.80
SP - DT	2	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	5127	6.04	30.0	10.0	1178.10
SP - DT	2	9-Aug-21	5860	Diatoma vulgare Bory	5127	1.21	25.0	6.0	235.60
SP - DT	2	9-Aug-21	5865	Cymbella prostrata (Berkeley) Cleve	5127	116.94	120.0	22.0	22808.00
SP - DT	2	9-Aug-21	5870	Navicula radiosa Kutzing	2563	3.09	72.0	8.0	1206.40
SP - DT	2	9-Aug-21	5873	Gomphonema minutum	64087	8.59	8.0	8.0	134.00
SP - DT	2	9-Aug-21	5882	Anomoenies vitrea Ross	5127	1.69	35.0	6.0	329.90
SP - DT	2R	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	23071	2.84	109.0	1.2	123.30
SP - DT	2R	9-Aug-21	1084	Gloeocapsa punctata	110229	3.69	4.0	4.0	33.50
SP - DT	2R	9-Aug-21	1086	Calothrix sp.	43579	139.62	91.0	8.2	3203.80
SP - DT	2R	9-Aug-21	1131	Heteroleibeinia profunda Komarek	220459	13.58	19.6	2.0	61.60
SP - DT	2R	9-Aug-21	5306	Navicula minima Grunow	5127	0.22	10.2	4.0	42.70
SP - DT	2R	9-Aug-21	5311	Cymbella minuta Kutzing	2563	1.01	15.6	8.0	392.10
SP - DT	2R	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	43579	62.61	28.0	14.0	1436.80
SP - DT	2R	9-Aug-21	5518	Synedra acus Kutzing	12817	1.48	110.0	2.0	115.20
SP - DT	2R	9-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	5127	11.60	240.0	6.0	2261.90
SP - DT	2R	9-Aug-21	5702	Achnanthes minutissima Kutzing	297363	24.41	19.6	4.0	82.10
SP - DT	2R	9-Aug-21	5726	Eucocconeis sp.	15381	64.43	40.0	20.0	4188.80
SP - DT	2R	9-Aug-21	5767	Nitzschia fonticola Grunow	2563	0.16	15.0	4.0	62.80
SP - DT	2R	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	7690	9.06	30.0	10.0	1178.10
SP - DT	2R	9-Aug-21	5860	Diatoma vulgare Bory	2563	0.60	25.0	6.0	235.60
SP - DT	2R	9-Aug-21	5865	Cymbella prostrata (Berkeley) Cleve	5127	116.94	120.0	22.0	22808.00
SP - DT	2R	9-Aug-21	5870	Navicula radiosa Kutzing	2563	3.09	72.0	8.0	1206.40
SP - DT	2R	9-Aug-21	5873	Gomphonema minutum	7690	3.22	25.0	8.0	418.90
SP - DT	2R	9-Aug-21	5882	Anomoenies vitrea Ross	5127	1.69	35.0	6.0	329.90
SP - DT	3	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	33325	4.34	115.0	1.2	130.10
SP - DT	3	9-Aug-21	1086	Calothrix sp.	2563	6.61	77.0	8.0	2580.30
SP - DT	3	9-Aug-21	1102	Gloeothece sp.	297363	1.43	2.1	2.1	4.80
SP - DT	3	9-Aug-21	1131	Heteroleibeinia profunda Komarek	271728	17.06	20.0	2.0	62.80
SP - DT	3	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	17944	9.09	63.0	3.2	506.70
SP - DT	3	9-Aug-21	2228	Oedogonium sp.	12817	6.52	18.0	6.0	508.90
SP - DT	3	9-Aug-21	5509	Cyclotella ocellata Pant.	10254	2.14	8.1	8.1	208.70
SP - DT	3	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	5127	6.84	26.0	14.0	1334.10
SP - DT	3	9-Aug-21	5546	Gyrosigma sp	5127	5.22	72.0	6.0	1017.90
SP - DT	3	9-Aug-21	5702	Achnanthes minutissima Kutzing	74341	6.23	20.0	4.0	83.80
SP - DT	3	9-Aug-21	5720	Cyclotella bodanica Eulenst.	2563	39.57	34.0	34.0	15434.60
SP - DT	3	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2563	3.02	30.0	10.0	1178.10
SP - DT	3	9-Aug-21	5865	Cymbella prostrata (Berkeley) Cleve	5127	67.50	116.0	17.0	13164.80
SP - DT	3	9-Aug-21	5882	Anomoenies vitrea Ross	7690	2.61	36.0	6.0	339.30
SP - DT	3	9-Aug-21	5884	Gomphonema angustum Agardh	2563	2.75	41.0	10.0	1073.40
SP - DT	3	9-Aug-21	5901	Denticula sp	2563	1.41	21.0	10.0	549.80
SP - DT	4	17-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	41870	6.15	130.0	1.2	147.00
SP - DT	4	17-Aug-21	1086	Calothrix sp.	11963	44.14	91.0	8.8	3689.80
SP - DT	4	17-Aug-21	1102	Gloeothece sp.	92712	0.45	2.1	2.1	4.80
SP - DT	4	17-Aug-21	1131	Heteroleibeinia profunda Komarek	364867	25.91	22.6	2.0	71.00
SP - DT	4	17-Aug-21	2205	Mougeotia sp.	2991	2.71	30.0	6.2	905.70
SP - DT	4	17-Aug-21	5306	Navicula minima Grunow	5981	0.30	12.0	4.0	50.30
SP - DT	4	17-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	2991	7.93	18.9	18.9	2651.20
SP - DT	4	17-Aug-21	5513	Tabellaria fenestrata (Lyngbye) Kutzing	5981	4.96	88.0	6.0	829.40
SP - DT	4	17-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	92712	123.69	26.0	14.0	1334.10
SP - DT	4	17-Aug-21	5518	Synedra acus Kutzing	2991	0.38	120.0	2.0	125.70
SP - DT	4	17-Aug-21	5546	Gyrosigma sp	2991	1.78	63.0	4.9	594.00
SP - DT	4	17-Aug-21	5547	Frustulia rhomboides (Ehrenberg) de Toni	2991	8.93	76.0	10.0	2984.50
SP - DT	4	17-Aug-21	5702	Achnanthes minutissima Kutzing	56824	4.76	20.0	4.0	83.80
SP - DT	4	17-Aug-21	5726	Eucocconeis sp.	2991	12.84	41.0	20.0	4293.50
SP - DT	4	17-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2991	3.52	30.0	10.0	1178.10
SP - DT	4	17-Aug-21	5873	Gomphonema minutum	8972	3.91	26.0	8.0	435.60
SP - DT	4	17-Aug-21	5882	Anomoenies vitrea Ross	26916	9.39	37.0	6.0	348.70
SP - DT	5	17-Aug-21	1028	Merismopedia glauca (Ehrenberg) Kutzing	59814	1.34	3.5	3.5	22.40
SP - DT	5	17-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	47851	6.28	116.0	1.2	131.20
SP - DT	5	17-Aug-21	1070	Anabaenopsis sp.	47851	0.27	2.2	2.2	5.60
SP - DT	5	17-Aug-21	1086	Calothrix sp.	77759	231.91	89.0	8.0	2982.40
SP - DT	5	17-Aug-21	1102	Gloeothece sp.	116638	0.56	2.1	2.1	4.80
SP - DT	5	17-Aug-21	1131	Heteroleibeinia profunda Komarek	343932	21.60	20.0	2.0	62.80
SP - DT	5	17-Aug-21	5311	Cymbella minuta Kutzing	8972	3.50	15.5	8.0	389.60
SP - DT	5	17-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	26916	35.91	26.0	14.0	1334.10
SP - DT	5	17-Aug-21	5702	Achnanthes minutissima Kutzing	107666	8.84	19.6	4.0	82.10

Area	Replicate	Date	Species Code	Species name	Density cells/cm²	Biomass µg/cm²	Length µ	Width µ	Cell Volume µ³
SP - DT	5	17-Aug-21	5768	Nitzschia linearis W. Smith	2991	2.09	74.0	6.0	697.40
SP - DT	5	17-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	11963	14.09	30.0	10.0	1178.10
SP - DT	5	17-Aug-21	5865	Cymbella prostrata (Berkeley) Cleve	2991	68.78	121.0	22.0	22998.00
SP - DT	5	17-Aug-21	5873	Gomphonema minutum	5981	2.71	27.0	8.0	452.40
SP - DT	5	17-Aug-21	5882	Anomoenies vitrea Ross	38879	12.83	35.0	6.0	329.90
SP - DT	5	17-Aug-21	5916	Fragilaria capucina Grunow	5981	3.72	66.0	6.0	622.00
SP - ED	1	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	19440	3.21	146.0	1.2	165.10
SP - ED	1	9-Aug-21	1077	Pseudanabaena sp.	1495	0.19	40.0	2.0	125.70
SP - ED	1	9-Aug-21	1084	Gloeocapsa punctata	29907	1.00	4.0	4.0	33.50
SP - ED	1	9-Aug-21	1131	Heteroleibeinia profunda Komarek	158508	13.44	27.0	2.0	84.80
SP - ED	1	9-Aug-21	1223	Chamaesiphon incrustans Smith	10468	0.39	6.9	3.2	37.00
SP - ED	1	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	17944	12.41	86.0	3.2	691.70
SP - ED	1	9-Aug-21	2205	Mougeotia sp.	11963	38.52	41.0	10.0	3220.10
SP - ED	1	9-Aug-21	4388	Dinobryon sertularia Ehrenberg	14954	3.38	12.0	6.0	226.20
SP - ED	1	9-Aug-21	5509	Cyclotella ocellata Pant.	4486	1.42	9.3	9.3	315.90
SP - ED	1	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	16449	22.96	27.2	14.0	1395.70
SP - ED	1	9-Aug-21	5515	Fragilaria crotonensis Kitton	4486	1.48	79.0	4.0	330.90
SP - ED	1	9-Aug-21	5702	Achnanthes minutissima Kutzing	64300	5.39	20.0	4.0	83.80
SP - ED	1	9-Aug-21	5726	Eucocconeis sp.	1495	6.26	40.0	20.0	4188.80
SP - ED	1	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2991	3.52	30.0	10.0	1178.10
SP - ED	1	9-Aug-21	5875	Cocconies disculus Schum.	1495	2.30	30.0	14.0	1539.40
SP - ED	1	9-Aug-21	5916	Fragilaria capucina Grunow	1495	0.41	65.0	4.0	272.30
SP - ED	2	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	19226	2.52	116.0	1.2	131.20
SP - ED	2	9-Aug-21	1131	Heteroleibeinia profunda Komarek	135864	10.50	24.6	2.0	77.30
SP - ED	2	9-Aug-21	1223	Chamaesiphon incrustans Smith	33325	1.23	6.9	3.2	37.00
SP - ED	2	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	39734	29.08	91.0	3.2	731.90
SP - ED	2	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	3845	5.13	26.0	14.0	1334.10
SP - ED	2	9-Aug-21	5546	Gyrosigma sp	2563	1.41	66.0	4.6	548.40
SP - ED	2	9-Aug-21	5702	Achnanthes minutissima Kutzing	58960	4.94	20.0	4.0	83.80
SP - ED	2	9-Aug-21	5726	Eucocconeis sp.	1282	5.64	42.0	20.0	4398.20
SP - ED	2	9-Aug-21	5728	Epithemia argus Kutzing	1282	1.54	46.0	10.0	1204.30
SP - ED	2	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	1282	1.51	30.0	10.0	1178.10
SP - ED	2	9-Aug-21	5860	Diatoma vulgare Bory	2563	0.60	25.0	6.0	235.60
SP - ED	2	9-Aug-21	5882	Anomoenies vitrea Ross	2563	0.92	38.0	6.0	358.10
SP - ED	2	9-Aug-21	5884	Gomphonema angustum Agardh	3845	4.43	44.0	10.0	1151.90
SP - ED	2	9-Aug-21	5916	Fragilaria capucina Grunow	1282	0.38	70.0	4.0	293.20
SP - ED	2R	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	11536	1.51	116.0	1.2	131.20
SP - ED	2R	9-Aug-21	1131	Heteroleibeinia profunda Komarek	152527	11.79	24.6	2.0	77.30
SP - ED	2R	9-Aug-21	1223	Chamaesiphon incrustans Smith	44861	1.66	6.9	3.2	37.00
SP - ED	2R	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	33325	24.39	91.0	3.2	731.90
SP - ED	2R	9-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	1282	4.66	21.0	21.0	3636.80
SP - ED	2R	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	6409	8.55	26.0	14.0	1334.10
SP - ED	2R	9-Aug-21	5702	Achnanthes minutissima Kutzing	66650	5.59	20.0	4.0	83.80
SP - ED	2R	9-Aug-21	5726	Eucocconeis sp.	1282	5.64	42.0	20.0	4398.20
SP - ED	2R	9-Aug-21	5728	Epithemia argus Kutzing	2563	3.09	46.0	10.0	1204.30
SP - ED	2R	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2563	3.02	30.0	10.0	1178.10
SP - ED	2R	9-Aug-21	5860	Diatoma vulgare Bory	2563	0.60	25.0	6.0	235.60
SP - ED	2R	9-Aug-21	5882	Anomoenies vitrea Ross	1282	0.46	38.0	6.0	358.10
SP - ED	2R	9-Aug-21	5884	Gomphonema angustum Agardh	1282	1.48	44.0	10.0	1151.90
SP - ED	2R	9-Aug-21	5916	Fragilaria capucina Grunow	3845	1.13	70.0	4.0	293.20
SP - ED	3	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	87927	15.62	157.0	1.2	177.60
SP - ED	3	9-Aug-21	1077	Pseudanabaena sp.	1794	0.22	35.0	2.1	121.20
SP - ED	3	9-Aug-21	1086	Calothrix sp.	7178	21.83	75.0	8.8	3041.10
SP - ED	3	9-Aug-21	1131	Heteroleibeinia profunda Komarek	190210	14.34	24.0	2.0	75.40
SP - ED	3	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	159704	115.59	90.0	3.2	723.80
SP - ED	3	9-Aug-21	5306	Navicula minima Grunow	1794	0.08	10.0	4.2	46.20
SP - ED	3	9-Aug-21	5513	Tabellaria fenestrata (Lyngbye) Kutzing	7178	5.55	82.0	6.0	772.80
SP - ED	3	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	1794	2.39	26.0	14.0	1334.10
SP - ED	3	9-Aug-21	5518	Synedra acus Kutzing	8972	1.03	110.0	2.0	115.20
SP - ED	3	9-Aug-21	5702	Achnanthes minutissima Kutzing	44861	3.76	20.0	4.0	83.80
SP - ED	3	9-Aug-21	5753	Navicula sp.	1794	1.74	58.0	8.0	971.80
SP - ED	3	9-Aug-21	5873	Gomphonema minutum	1794	0.78	26.0	8.0	435.60
SP - ED	3	9-Aug-21	5881	Diatoma elongatum Agardh	7178	1.32	44.0	4.0	184.30
SP - ED	4	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	42790	6.83	141.0	1.2	159.50
SP - ED	4	9-Aug-21	1077	Pseudanabaena sp.	1380	0.13	30.0	2.0	94.20
SP - ED	4	9-Aug-21	1131	Heteroleibeinia profunda Komarek	157358	10.39	21.0	2.0	66.00
SP - ED	4	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	1380	0.67	60.0	3.2	482.50
SP - ED	4	9-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	6902	28.86	22.0	22.0	4181.50
SP - ED	4	9-Aug-21	5509	Cyclotella ocellata Pant.	12423	3.10	8.6	8.6	249.80
SP - ED	4	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	4141	5.52	26.0	14.0	1334.10
SP - ED	4	9-Aug-21	5518	Synedra acus Kutzing	5521	0.58	100.0	2.0	104.70
SP - ED	4	9-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	1380	2.86	220.0	6.0	2073.50
SP - ED	4	9-Aug-21	5547	Frustulia rhomboides (Ehrenberg) de Toni	1380	4.39	81.0	10.0	3180.90
SP - ED	4	9-Aug-21	5702	Achnanthes minutissima Kutzing	111807	9.37	20.0	4.0	83.80
SP - ED	4	9-Aug-21	5726	Eucocconeis sp.	1380	6.07	42.0	20.0	4398.20
SP - ED	4	9-Aug-21	5728	Epithemia argus Kutzing	1380	2.28	63.0	10.0	1649.30
SP - ED	4	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	1380	1.63	30.0	10.0	1178.10
SP - ED	4	9-Aug-21	5882	Anomoenies vitrea Ross	2761	0.91	35.0	6.0	329.90
SP - ED	5	9-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	2991	0.36	106.0	1.2	119.90
SP - ED	5	9-Aug-21	1077	Pseudanabaena sp.	8972	0.99	35.0	2.0	110.00
SP - ED	5	9-Aug-21	1131	Heteroleibeinia profunda Komarek	160003	10.56	21.0	2.0	66.00
SP - ED	5	9-Aug-21	1223	Chamaesiphon incrustans Smith	16449	0.57	6.5	3.2	34.90
SP - ED	5	9-Aug-21	1239	Homoeothrix varians Komarek & Kalina	2991	1.56	65.0	3.2	522.80
SP - ED	5	9-Aug-21	5306	Navicula minima Grunow	2991	0.17	12.0	4.2	55.40
SP - ED	5	9-Aug-21	5509	Cyclotella ocellata Pant.	5981	1.60	8.8	8.8	267.60
SP - ED	5	9-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	2991	3.99	26.0	14.0	1334.10
SP - ED	5	9-Aug-21	5518	Synedra acus Kutzing	10468	1.10	100.0	2.0	104.70
SP - ED	5	9-Aug-21	5546	Gyrosigma sp	1495	0.83	73.0	4.4	555.00
SP - ED	5	9-Aug-21	5702	Achnanthes minutissima Kutzing	134582	11.28	20.0	4.0	83.80
SP - ED	5	9-Aug-21	5726	Eucocconeis sp.	1495	6.58	42.0	20.0	4398.20
SP - ED	5	9-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2991	3.52	30.0	10.0	1178.10
SP - ED	5	9-Aug-21	5860	Diatoma vulgare Bory	2991	0.73	26.0	6.0	245.00
SP - ED	5	9-Aug-21	5882	Anomoenies vitrea Ross	5981	1.92	34.0	6.0	320.40
TPE - BGN	1	8-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	1196	0.09	64.0	1.2	72.40
TPE - BGN	1	8-Aug-21	1131	Heteroleibeinia profunda Komarek	42269	2.56	19.3	2.0	60.60
TPE - BGN	1	8-Aug-21	1223	Chamaesiphon incrustans Smith	16748	0.51	6.4	3.0	30.20
TPE - BGN	1	8-Aug-21	2228	Oedogonium sp.	3988	1.04	18.0	4.3	261.40
TPE - BGN	1	8-Aug-21	5311	Cymbella minuta Kutzing	1196	0.48	16.0	8.0	402.10
TPE - BGN	1	8-Aug-21	5513	Tabellaria fenestrata (Lyngbye) Kutzing	1196	0.99	88.0	6.0	829.40
TPE - BGN	1	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	2393	3.19	26.0	14.0	1334.10
TPE - BGN	1	8-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	399	0.79	210.0	6.0	1979.20

Area	Replicate	Date	Species Code	Species name	Density cells/cm²	Biomass µg/cm²	Length µ	Width µ	Cell Volume µ³
TPE - BGN	1	8-Aug-21	5702	Achnanthes minutissima Kutzing	6380	0.13	20.0	2.0	20.90
TPE - BGN	1	8-Aug-21	5875	Cocconies disculus Schum.	399	0.57	28.0	14.0	1436.80
TPE - BGN	2	8-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	718	0.07	88.0	1.2	99.50
TPE - BGN	2	8-Aug-21	1086	Calothrix sp.	718	1.66	69.0	8.0	2312.20
TPE - BGN	2	8-Aug-21	1124	Petalonema alatum Berk	1077	2.68	88.0	6.0	2488.10
TPE - BGN	2	8-Aug-21	1131	Heteroleibeinia profunda Komarek	33376	2.06	19.6	2.0	61.60
TPE - BGN	2	8-Aug-21	1223	Chamaesiphon incrustans Smith	5742	0.17	6.2	3.0	29.20
TPE - BGN	2	8-Aug-21	5306	Navicula minima Grunow	359	0.02	12.0	4.0	50.30
TPE - BGN	2	8-Aug-21	5311	Cymbella minuta Kutzing	718	0.29	16.0	8.0	402.10
TPE - BGN	2	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	359	0.48	26.0	14.0	1334.10
TPE - BGN	2	8-Aug-21	5702	Achnanthes minutissima Kutzing	31223	2.49	19.0	4.0	79.60
TPE - BGN	2	8-Aug-21	5882	Anomoenies vitrea Ross	359	0.12	36.0	6.0	339.30
TPE - BGN	3	8-Aug-21	1084	Gloeocapsa punctata	11664	0.39	4.0	4.0	33.50
TPE - BGN	3	8-Aug-21	1086	Calothrix sp.	4486	11.88	79.0	8.0	2647.30
TPE - BGN	3	8-Aug-21	1124	Petalonema alatum Berk	1346	3.08	81.0	6.0	2290.20
TPE - BGN	3	8-Aug-21	1131	Heteroleibeinia profunda Komarek	46207	2.81	19.4	2.0	60.90
TPE - BGN	3	8-Aug-21	1239	Homoeothrix varians Komarek & Kalina	7178	3.17	55.0	3.2	442.30
TPE - BGN	3	8-Aug-21	4388	Dinobryon sertularia Ehrenberg	2692	0.61	12.0	6.0	226.20
TPE - BGN	3	8-Aug-21	5306	Navicula minima Grunow	449	0.02	11.0	4.0	46.10
TPE - BGN	3	8-Aug-21	5509	Cyclotella ocellata Pant.	449	0.12	8.9	8.9	276.80
TPE - BGN	3	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	2692	3.31	24.0	14.0	1231.50
TPE - BGN	3	8-Aug-21	5702	Achnanthes minutissima Kutzing	39477	3.16	19.1	4.0	80.00
TPE - BGN	3	8-Aug-21	5882	Anomoenies vitrea Ross	1794	0.64	38.0	6.0	358.10
TPE - BGN	4	8-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	798	0.08	86.0	1.2	97.30
TPE - BGN	4	8-Aug-21	1131	Heteroleibeinia profunda Komarek	46256	2.82	19.4	2.0	60.90
TPE - BGN	4	8-Aug-21	1223	Chamaesiphon incrustans Smith	5184	0.16	6.4	3.0	30.20
TPE - BGN	4	8-Aug-21	5306	Navicula minima Grunow	1595	0.08	12.0	4.0	50.30
TPE - BGN	4	8-Aug-21	5311	Cymbella minuta Kutzing	798	0.31	15.3	8.0	384.50
TPE - BGN	4	8-Aug-21	5509	Cyclotella ocellata Pant.	399	0.09	8.3	8.3	224.50
TPE - BGN	4	8-Aug-21	5513	Tabellaria fenestrata (Lyngbye) Kutzing	399	0.30	81.0	6.0	763.40
TPE - BGN	4	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	2393	3.19	26.0	14.0	1334.10
TPE - BGN	4	8-Aug-21	5546	Gyrosigma sp	399	0.36	64.0	6.0	904.80
TPE - BGN	4	8-Aug-21	5702	Achnanthes minutissima Kutzing	38281	2.94	18.3	4.0	76.70
TPE - BGN	4	8-Aug-21	5873	Gomphonema minutum	798	0.36	27.0	8.0	452.40
TPE - BGN	4	8-Aug-21	5916	Fragilaria capucina Grunow	1196	0.34	67.0	4.0	280.60
TPE - BGN	4R	8-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	399	0.04	86.0	1.2	97.30
TPE - BGN	4R	8-Aug-21	1131	Heteroleibeinia profunda Komarek	42269	2.57	19.4	2.0	60.90
TPE - BGN	4R	8-Aug-21	1223	Chamaesiphon incrustans Smith	9172	0.28	6.4	3.0	30.20
TPE - BGN	4R	8-Aug-21	1239	Homoeothrix varians Komarek & Kalina	798	0.34	53.0	3.2	426.30
TPE - BGN	4R	8-Aug-21	5306	Navicula minima Grunow	798	0.04	12.0	4.0	50.30
TPE - BGN	4R	8-Aug-21	5311	Cymbella minuta Kutzing	1595	0.61	15.3	8.0	384.50
TPE - BGN	4R	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	1196	1.60	26.0	14.0	1334.10
TPE - BGN	4R	8-Aug-21	5518	Synedra acus Kutzing	399	0.04	96.0	2.0	100.50
TPE - BGN	4R	8-Aug-21	5546	Gyrosigma sp	399	0.36	64.0	6.0	904.80
TPE - BGN	4R	8-Aug-21	5702	Achnanthes minutissima Kutzing	41073	3.15	18.3	4.0	76.70
TPE - BGN	4R	8-Aug-21	5860	Diatoma vulgare Bory	798	0.19	25.0	6.0	235.60
TPE - BGN	4R	8-Aug-21	5873	Gomphonema minutum	399	0.18	27.0	8.0	452.40
TPE - BGN	4R	8-Aug-21	5875	Cocconies disculus Schum.	399	0.59	29.0	14.0	1488.10
TPE - BGN	4R	8-Aug-21	5916	Fragilaria capucina Grunow	1196	0.34	67.0	4.0	280.60
TPE - BGN	5	8-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	7537	0.52	61.0	1.2	69.00
TPE - BGN	5	8-Aug-21	1084	Gloeocapsa punctata	9331	0.31	4.0	4.0	33.50
TPE - BGN	5	8-Aug-21	1124	Petalonema alatum Berk	1794	4.62	91.0	6.0	2573.00
TPE - BGN	5	8-Aug-21	1131	Heteroleibeinia profunda Komarek	34453	2.16	20.0	2.0	62.80
TPE - BGN	5	8-Aug-21	1223	Chamaesiphon incrustans Smith	3589	0.12	6.9	3.0	32.50
TPE - BGN	5	8-Aug-21	5306	Navicula minima Grunow	1077	0.05	12.0	4.0	50.30
TPE - BGN	5	8-Aug-21	5509	Cyclotella ocellata Pant.	718	0.15	8.1	8.1	208.70
TPE - BGN	5	8-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	1436	1.92	26.0	14.0	1334.10
TPE - BGN	5	8-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	359	0.81	240.0	6.0	2261.90
TPE - BGN	5	8-Aug-21	5702	Achnanthes minutissima Kutzing	36965	3.03	19.6	4.0	82.10
TPE - BGN	5	8-Aug-21	5882	Anomoenies vitrea Ross	718	0.24	36.0	6.0	339.30
TPE - BGN	5	8-Aug-21	5916	Fragilaria capucina Grunow	1077	0.27	60.0	4.0	251.30
TPE - BGS	1	13-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	11298	1.48	116.0	1.2	131.20
TPE - BGS	1	13-Aug-21	1086	Calothrix sp.	15286	36.88	72.0	8.0	2412.70
TPE - BGS	1	13-Aug-21	1131	Heteroleibeinia profunda Komarek	46522	4.82	33.0	2.0	103.70
TPE - BGS	1	13-Aug-21	5311	Cymbella minuta Kutzing	665	0.21	15.0	7.3	313.90
TPE - BGS	1	13-Aug-21	5509	Cyclotella ocellata Pant.	665	0.18	8.8	8.8	267.60
TPE - BGS	1	13-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	30572	40.79	26.0	14.0	1334.10
TPE - BGS	1	13-Aug-21	5518	Synedra acus Kutzing	665	0.08	110.0	2.0	115.20
TPE - BGS	1	13-Aug-21	5546	Gyrosigma sp	665	0.67	71.0	6.0	1003.70
TPE - BGS	1	13-Aug-21	5702	Achnanthes minutissima Kutzing	69783	5.93	20.3	4.0	85.00
TPE - BGS	1	13-Aug-21	5768	Nitzschia linearis W. Smith	1329	0.86	69.0	6.0	650.30
TPE - BGS	1	13-Aug-21	5882	Anomoenies vitrea Ross	665	0.22	35.0	6.0	329.90
TPE - BGS	2	13-Aug-21	1084	Gloeocapsa punctata	11125	0.37	4.0	4.0	33.50
TPE - BGS	2	13-Aug-21	1086	Calothrix sp.	1436	3.42	71.0	8.0	2379.20
TPE - BGS	2	13-Aug-21	1124	Petalonema alatum Berk	359	0.95	94.0	6.0	2657.80
TPE - BGS	2	13-Aug-21	1131	Heteroleibeinia profunda Komarek	36965	3.60	31.0	2.0	97.40
TPE - BGS	2	13-Aug-21	1223	Chamaesiphon incrustans Smith	7537	0.24	6.9	3.0	32.50
TPE - BGS	2	13-Aug-21	5311	Cymbella minuta Kutzing	359	0.11	15.9	7.0	306.00
TPE - BGS	2	13-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	718	0.96	26.0	14.0	1334.10
TPE - BGS	2	13-Aug-21	5546	Gyrosigma sp	359	0.30	59.0	6.0	834.10
TPE - BGS	2	13-Aug-21	5702	Achnanthes minutissima Kutzing	20815	1.71	19.6	4.0	82.10
TPE - BGS	2	13-Aug-21	5767	Nitzschia fonticola Grunow	359	0.03	27.0	3.2	72.40
TPE - BGS	2	13-Aug-21	5768	Nitzschia linearis W. Smith	718	0.48	71.0	6.0	669.20
TPE - BGS	2	13-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	1436	1.69	30.0	10.0	1178.10
TPE - BGS	2	13-Aug-21	5882	Anomoenies vitrea Ross	359	0.12	35.0	6.0	329.90
TPE - BGS	3	13-Aug-21	1084	Gloeocapsa punctata	3589	0.12	4.0	4.0	33.50
TPE - BGS	3	13-Aug-21	1124	Petalonema alatum Berk	1077	2.77	91.0	6.0	2573.00
TPE - BGS	3	13-Aug-21	1131	Heteroleibeinia profunda Komarek	10049	0.82	26.0	2.0	81.70
TPE - BGS	3	13-Aug-21	1223	Chamaesiphon incrustans Smith	718	0.02	6.1	3.0	28.70
TPE - BGS	3	13-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	359	1.63	22.6	22.6	4533.00
TPE - BGS	3	13-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	359	0.48	26.0	14.0	1334.10
TPE - BGS	3	13-Aug-21	5702	Achnanthes minutissima Kutzing	52756	4.42	20.0	4.0	83.80
TPE - BGS	3	13-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	359	0.42	30.0	10.0	1178.10
TPE - BGS	3	13-Aug-21	5860	Diatoma vulgare Bory	718	0.17	25.0	6.0	235.60
TPE - BGS	3	13-Aug-21	5882	Anomoenies vitrea Ross	359	0.13	37.0	6.0	348.70
TPE - BGS	3	13-Aug-21	5916	Fragilaria capucina Grunow	718	0.41	61.0	6.0	574.90
TPE - BGS	4	13-Aug-21	1084	Gloeocapsa punctata	2871	0.10	4.0	4.0	33.50
TPE - BGS	4	13-Aug-21	1122	Phormidium autumnale Agardh	359	3.15	310.0	6.0	8765.00
TPE - BGS	4	13-Aug-21	1131	Heteroleibeinia profunda Komarek	47014	4.58	31.0	2.0	97.40
TPE - BGS	4	13-Aug-21	1223	Chamaesiphon incrustans Smith	359	0.01	6.3	3.0	29.70
TPE - BGS	4	13-Aug-21	1239	Homoeothrix varians Komarek & Kalina	359	0.16	55.0	3.2	442.30

Area	Replicate	Date	Species Code	Species name	Density cells/cm²	Biomass µg/cm²	Length µ	Width µ	Cell Volume µ³
TPE - BGS	4	13-Aug-21	4388	Dinobryon sertularia Ehrenberg	718	0.16	12.0	6.0	226.20
TPE - BGS	4	13-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	359	1.71	23.0	23.0	4778.00
TPE - BGS	4	13-Aug-21	5509	Cyclotella ocellata Pant.	718	0.15	8.1	8.1	208.70
TPE - BGS	4	13-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	359	0.48	26.0	14.0	1334.10
TPE - BGS	4	13-Aug-21	5702	Achnanthes minutissima Kutzing	4307	0.35	19.6	4.0	82.10
TPE - BGS	4	13-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2153	2.54	30.0	10.0	1178.10
TPE - BGS	4	13-Aug-21	5870	Navicula radiosa Kutzing	359	0.67	71.0	10.0	1858.80
TPE - BGS	4	13-Aug-21	5882	Anomoenies vitrea Ross	718	0.24	35.0	6.0	329.90
TPE - BGS	4	13-Aug-21	5916	Fragilaria capucina Grunow	3589	0.68	20.0	6.0	188.50
TPE - BGS	5	13-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	6460	0.70	96.0	1.2	108.60
TPE - BGS	5	13-Aug-21	1084	Gloeocapsa punctata	27275	0.91	4.0	4.0	33.50
TPE - BGS	5	13-Aug-21	1086	Calothrix sp.	1436	3.80	79.0	8.0	2647.30
TPE - BGS	5	13-Aug-21	1124	Petalonema alatum Berk	1077	2.71	89.0	6.0	2516.40
TPE - BGS	5	13-Aug-21	1131	Heteroleibeinia profunda Komarek	39477	3.85	31.0	2.0	97.40
TPE - BGS	5	13-Aug-21	1223	Chamaesiphon incrustans Smith	4307	0.12	6.1	3.0	28.70
TPE - BGS	5	13-Aug-21	1239	Homoeothrix varians Komarek & Kalina	2153	0.95	55.0	3.2	442.30
TPE - BGS	5	13-Aug-21	2205	Mougeotia sp.	5742	14.88	33.0	10.0	2591.80
TPE - BGS	5	13-Aug-21	2226	Ulothrix sp.	2871	1.46	18.0	6.0	508.90
TPE - BGS	5	13-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	1436	6.00	22.0	22.0	4181.50
TPE - BGS	5	13-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	7895	10.53	26.0	14.0	1334.10
TPE - BGS	5	13-Aug-21	5702	Achnanthes minutissima Kutzing	15791	1.32	20.0	4.0	83.80
TPE - BGS	5	13-Aug-21	5768	Nitzschia linearis W. Smith	359	0.24	71.0	6.0	669.20
TPE - BGS	5	13-Aug-21	5860	Diatoma vulgare Bory	1436	0.34	25.0	6.0	235.60
TPE - BGS	5	13-Aug-21	5916	Fragilaria capucina Grunow	1436	1.10	81.0	6.0	763.40
TPE - G	1	7-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	17944	1.28	63.0	1.2	71.30
TPE - G	1	7-Aug-21	1086	Calothrix sp.	16150	38.42	71.0	8.0	2379.20
TPE - G	1	7-Aug-21	1102	Gloeothece sp.	82544	0.40	2.1	2.1	4.80
TPE - G	1	7-Aug-21	1131	Heteroleibeinia profunda Komarek	199182	13.15	21.0	2.0	66.00
TPE - G	1	7-Aug-21	1239	Homoeothrix varians Komarek & Kalina	12561	6.47	64.0	3.2	514.70
TPE - G	1	7-Aug-21	2205	Mougeotia sp.	3589	10.57	31.0	11.0	2946.00
TPE - G	1	7-Aug-21	2216	Zygnema sp.	17944	32.47	16.0	12.0	1809.60
TPE - G	1	7-Aug-21	2231	Bulbochaete sp.	10767	10.28	19.0	8.0	955.00
TPE - G	1	7-Aug-21	5509	Cyclotella ocellata Pant.	5383	1.44	8.8	8.8	267.60
TPE - G	1	7-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	69983	93.36	26.0	14.0	1334.10
TPE - G	1	7-Aug-21	5547	Frustulia rhomboides (Ehrenberg) de Toni	1794	5.71	81.0	10.0	3180.90
TPE - G	1	7-Aug-21	5702	Achnanthes minutissima Kutzing	3589	0.29	19.1	4.0	80.00
TPE - G	1	7-Aug-21	5854	Pinnularia borealis Ehrenberg	1794	26.38	116.0	22.0	14698.50
TPE - G	1	7-Aug-21	5882	Anomoenies vitrea Ross	1794	0.15	36.0	3.0	84.80
TPE - G	1	7-Aug-21	5916	Fragilaria capucina Grunow	1794	0.61	81.0	4.0	339.30
TPE - G	2	7-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	11215	1.31	103.0	1.2	116.50
TPE - G	2	7-Aug-21	1084	Gloeocapsa punctata	35889	1.20	4.0	4.0	33.50
TPE - G	2	7-Aug-21	1086	Calothrix sp.	60562	174.53	86.0	8.0	2881.90
TPE - G	2	7-Aug-21	1102	Gloeothece sp.	69534	0.33	2.1	2.1	4.80
TPE - G	2	7-Aug-21	1131	Heteroleibeinia profunda Komarek	251220	20.52	26.0	2.0	81.70
TPE - G	2	7-Aug-21	1223	Chamaesiphon incrustans Smith	22430	0.79	7.0	3.1	35.20
TPE - G	2	7-Aug-21	5306	Navicula minima Grunow	2243	0.09	10.0	4.0	41.90
TPE - G	2	7-Aug-21	5509	Cyclotella ocellata Pant.	4486	0.94	8.1	8.1	208.70
TPE - G	2	7-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	17944	23.94	26.0	14.0	1334.10
TPE - G	2	7-Aug-21	5702	Achnanthes minutissima Kutzing	31403	2.58	19.6	4.0	82.10
TPE - G	2	7-Aug-21	5825	Fragilaria pinata Ehrenberg	2243	0.11	12.0	4.0	50.30
TPE - G	2	7-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	6729	7.93	30.0	10.0	1178.10
TPE - G	2	7-Aug-21	5860	Diatoma vulgare Bory	4486	1.10	26.0	6.0	245.00
TPE - G	2	7-Aug-21	5873	Gomphonema minutum	6729	3.27	29.0	8.0	485.90
TPE - G	2	7-Aug-21	5875	Cocconies disculus Schum.	2243	4.10	31.0	15.0	1826.10
TPE - G	2	7-Aug-21	5882	Anomoenies vitrea Ross	2243	0.74	35.0	6.0	329.90
TPE - G	2	7-Aug-21	5910	Navicula exigua (Greg.) Muller	2243	0.82	39.0	6.0	367.60
TPE - G	3	7-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	114844	13.77	106.0	1.2	119.90
TPE - G	3	7-Aug-21	1086	Calothrix sp.	10767	28.86	80.0	8.0	2680.80
TPE - G	3	7-Aug-21	1102	Gloeothece sp.	139966	0.59	2.0	2.0	4.20
TPE - G	3	7-Aug-21	1131	Heteroleibeinia profunda Komarek	452196	55.39	39.0	2.0	122.50
TPE - G	3	7-Aug-21	2205	Mougeotia sp.	28711	60.61	42.0	8.0	2111.20
TPE - G	3	7-Aug-21	2216	Zygnema sp.	78955	178.59	20.0	12.0	2261.90
TPE - G	3	7-Aug-21	2231	Bulbochaete sp.	21533	8.52	14.0	6.0	395.80
TPE - G	3	7-Aug-21	5306	Navicula minima Grunow	10767	0.54	12.0	4.0	50.30
TPE - G	3	7-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	3589	17.15	23.0	23.0	4778.00
TPE - G	3	7-Aug-21	5509	Cyclotella ocellata Pant.	3589	0.75	8.1	8.1	208.70
TPE - G	3	7-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	136377	181.94	26.0	14.0	1334.10
TPE - G	3	7-Aug-21	5518	Synedra acus Kutzing	3589	0.45	120.0	2.0	125.70
TPE - G	3	7-Aug-21	5523	Synedra ulna (Nitzsch) Ehrenberg	7178	14.88	220.0	6.0	2073.50
TPE - G	3	7-Aug-21	5702	Achnanthes minutissima Kutzing	39477	3.24	19.6	4.0	82.10
TPE - G	3	7-Aug-21	5826	Cymbella gracilis (Rabhorst) Cleve	3589	12.15	44.0	14.0	3386.60
TPE - G	3	7-Aug-21	5875	Cocconies disculus Schum.	3589	5.52	30.0	14.0	1539.40
TPE - G	3	7-Aug-21	5882	Anomoenies vitrea Ross	7178	2.44	36.0	6.0	339.30
TPE - G	3	7-Aug-21	5910	Navicula exigua (Greg.) Muller	3589	3.38	36.0	10.0	942.50
TPE - G	3	7-Aug-21	5916	Fragilaria capucina Grunow	14355	4.09	68.0	4.0	284.80
TPE - G	4	7-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	31403	3.41	96.0	1.2	108.60
TPE - G	4	7-Aug-21	1070	Anabaenopsis sp.	62805	0.58	2.6	2.6	9.20
TPE - G	4	7-Aug-21	1086	Calothrix sp.	53833	137.10	76.0	8.0	2546.80
TPE - G	4	7-Aug-21	1131	Heteroleibeinia profunda Komarek	251220	23.66	30.0	2.0	94.20
TPE - G	4	7-Aug-21	1223	Chamaesiphon incrustans Smith	22430	0.74	7.0	3.0	33.00
TPE - G	4	7-Aug-21	1239	Homoeothrix varians Komarek & Kalina	6729	3.30	61.0	3.2	490.60
TPE - G	4	7-Aug-21	2205	Mougeotia sp.	8972	23.25	33.0	10.0	2591.80
TPE - G	4	7-Aug-21	2216	Zygnema sp.	8972	14.09	20.0	10.0	1570.80
TPE - G	4	7-Aug-21	5306	Navicula minima Grunow	2243	0.11	12.0	4.0	50.30
TPE - G	4	7-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	2243	11.58	23.6	23.6	5161.70
TPE - G	4	7-Aug-21	5509	Cyclotella ocellata Pant.	2243	0.56	8.6	8.6	249.80
TPE - G	4	7-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	35889	47.88	26.0	14.0	1334.10
TPE - G	4	7-Aug-21	5702	Achnanthes minutissima Kutzing	53833	4.51	20.0	4.0	83.80
TPE - G	4	7-Aug-21	5768	Nitzschia linearis W. Smith	2243	1.10	52.0	6.0	490.10
TPE - G	4	7-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	6729	7.93	30.0	10.0	1178.10
TPE - G	4	7-Aug-21	5870	Navicula radiosa Kutzing	4486	8.34	71.0	10.0	1858.80
TPE - G	4	7-Aug-21	5873	Gomphonema minutum	2243	1.09	29.0	8.0	485.90
TPE - G	4	7-Aug-21	5875	Cocconies disculus Schum.	2243	3.68	32.0	14.0	1642.00
TPE - G	4	7-Aug-21	5882	Anomoenies vitrea Ross	13458	4.57	36.0	6.0	339.30
TPE - G	4	7-Aug-21	5890	Diatoma mesodon Grun.	2243	4.70	20.0	20.0	2094.40
TPE - G	5	7-Aug-21	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	58960	6.27	94.0	1.2	106.30
TPE - G	5	7-Aug-21	1086	Calothrix sp.	33325	81.52	73.0	8.0	2446.30
TPE - G	5	7-Aug-21	1102	Gloeothece sp.	41016	0.17	2.0	2.0	4.20
TPE - G	5	7-Aug-21	1131	Heteroleibeinia profunda Komarek	289672	29.11	32.0	2.0	100.50
TPE - G	5	7-Aug-21	1239	Homoeothrix varians Komarek & Kalina	10254	5.36	65.0	3.2	522.80
TPE - G	5	7-Aug-21	2205	Mougeotia sp.	15381	48.32	40.0	10.0	3141.60

Area	Replicate	Date	Species Code	Species name	Density	Biomass	Length	Width	Cell Volume
					cells/cm²	µg/cm²	µ	µ	µ³
TPE - G	5	7-Aug-21	2216	Zygnema sp.	15381	24.16	20.0	10.0	1570.80
TPE - G	5	7-Aug-21	5311	Cymbella minuta Kutzing	5127	1.61	15.0	7.3	313.90
TPE - G	5	7-Aug-21	5507	Cyclotella stelligera Cleve and Grunow	2563	7.93	19.9	19.9	3094.70
TPE - G	5	7-Aug-21	5514	Tabellaria flocculosa (Roth) Kutzing	15381	20.52	26.0	14.0	1334.10
TPE - G	5	7-Aug-21	5702	Achnanthes minutissima Kutzing	2563	0.21	20.0	4.0	83.80
TPE - G	5	7-Aug-21	5726	Eucocconeis sp.	2563	11.27	42.0	20.0	4398.20
TPE - G	5	7-Aug-21	5781	Eunotia sp.	2563	0.43	21.0	5.5	166.30
TPE - G	5	7-Aug-21	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2563	3.02	30.0	10.0	1178.10
TPE - G	5	7-Aug-21	5870	Navicula radiosa Kutzing	2563	2.96	69.0	8.0	1156.10
TPE - G	5	7-Aug-21	5882	Anomoenies vitrea Ross	5127	1.74	36.0	6.0	339.30
TPE - G	5	7-Aug-21	5901	Denticula sp	15381	12.76	22.0	12.0	829.40
TPE - G	5	7-Aug-21	5916	Fragilaria capucina Grunow	2563	0.88	82.0	4.0	343.50

APPENDIX D
PRESENCE/ABSENCE MATRIX OF PERIPHYTON SPECIES

Table D-1. Presence (+) /absence (-) matrix of periphyton species, 2021.

Taxon Code	Taxon Name	Cell Measurements			Second Portage Lake												Third Portage Lake – East Basin															
					Drilltrail Arm (Reference Area)						East Dike						Bay-Goose Dike – North Section						Reference Area					Bay-Goose Dike – South Section				
					SP-DT						SP-ED						TPE-BGN						TPE-G					TPE-BGS				
		length (µ)	width (µ)	volume ($µ^3$)	1	2	2R	3	4	5	1	2	2R	3	4	5	1	2	3	4	4R	5	1	2	3	4	5	1	2	3	4	5
Cyanobacteria																																
1028	*Merismopedia glauca (Ehrenberg) Kutzing*	3.5	3.5	22.4	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1057	*Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek*	105.5	1.2	119.4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	-	-	+	+	+	+	+	+
1070	*Anabaenopsis sp.*	2.4	2.4	7.4	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
1077	*Pseudanabaena sp.*	35.0	2.0	112.8	-	-	-	-	-	-	+	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1084	*Gloeocapsa punctata*	4.0	4.0	33.5	+	+	+	-	-	-	+	-	-	-	-	-	-	-	+	-	-	+	-	+	+	+	+	-	+	-	-	-
1086	*Calothrix sp.*	80.4	8.1	2779.5	+	+	+	+	+	+	-	-	-	+	-	-	-	+	+	-	-	-	+	+	-	-	+	+	+	+	+	+
1102	*Gloeothece sp.*	2.1	2.1	4.6	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	+
1122	*Phormidium autumnale Agardh*	310.0	6.0	8765.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
1124	*Petalonema alatum Berk*	89.0	6.0	2516.4	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-	+	+	-	+	-	-	-	-	-
1131	*Heteroleibeinia profunda Komarek*	24.3	2.0	76.4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1223	*Chamaesiphon incrustans Smith*	6.6	3.1	32.4	-	-	-	-	-	-	+	+	+	-	-	+	+	+	-	+	+	+	-	+	+	+	+	-	+	-	+	-
1239	*Homoeothrix varians Komarek & Kalina*	67.4	3.2	542.1	+	-	-	+	-	-	+	+	+	+	+	+	-	-	+	-	+	-	-	-	-	+	+	+	-	-	+	+
Chlorophyte																																
2205	*Mougeotia sp.*	35.7	9.3	2501.2	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+
2216	*Zygnema sp.*	19.0	11.0	1803.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+
2226	*Ulothrix sp.*	18.0	6.0	508.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
2228	*Oedogonium sp.*	18.0	5.2	385.2	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2231	*Bulbochaete sp.*	16.5	7.0	675.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-
Chrysophyte																																
4388	*Dinobryon sertularia Ehrenberg*	12.0	6.0	226.2	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-
Diatom																																
5306	*Navicula minima Grunow*	11.4	4.0	48.7	-	-	+	-	+	-	-	-	-	+	-	+	-	+	+	+	+	+	-	-	-	-	-	-	+	+	+	-
5311	*Cymbella minuta Kutzing*	15.5	7.8	370.0	+	+	+	-	-	+	-	-	-	-	-	-	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	+
5507	*Cyclotella stelligera Cleve and Grunow*	21.6	21.6	4013.8	-	+	-	-	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	+	+
5509	*Cyclotella ocellata Pant.*	8.5	8.5	243.8	-	+	-	+	-	-	+	-	-	-	+	+	-	-	+	+	-	+	+	-	-	+	-	+	+	+	+	-
5513	*Tabellaria fenestrata (Lyngbye) Kutzing*	84.6	6.0	797.3	+	-	-	-	+	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
5514	*Tabellaria flocculosa (Roth) Kutzing*	26.1	14.0	1340.0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5515	*Fragilaria crotonensis Kitton*	79.0	4.0	330.9	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5518	*Synedra acus Kutzing*	109.6	2.0	114.8	+	+	+	-	+	-	-	-	-	+	+	+	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-
5523	*Synedra ulna (Nitzsch) Ehrenberg*	228.3	6.0	2152.0	-	+	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-

Taxon Code	*Taxon Name*	Cell Measurements			Second Portage Lake												Third Portage Lake – East Basin															
					Drilltrail Arm (Reference Area)						East Dike						Bay-Goose Dike – North Section						Reference Area					Bay-Goose Dike – South Section				
					SP-DT						SP-ED						TPE-BGN						TPE-G					TPE-BGS				
		length (μ)	width (μ)	volume (μ^3)	1	2	2R	3	4	5	1	2	2R	3	4	5	1	2	3	4	4R	5	1	2	3	4	5	1	2	3	4	5
5546	*Gyrosigma sp*	66.5	5.5	795.3	-	-	-	+	+	-	-	+	-	-	-	+	-	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-
5547	*Frustulia rhomboides (Ehrenberg) de Toni*	79.3	10.0	3115.4	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
5702	*Achnanthes minutissima Kutzing*	19.7	3.9	80.1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5720	*Cyclotella bodanica Eulenst.*	34.0	34.0	15434.6	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5726	*Eucocconeis sp.*	41.3	20.0	4324.9	+	+	+	-	+	-	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
5728	*Epithemia argus Kutzing*	47.8	10.5	1353.8	+	-	-	-	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5753	*Navicula sp.*	58.0	8.0	971.8	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5767	*Nitzschia fonticola Grunow*	19.0	3.7	66.0	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
5768	*Nitzschia linearis W. Smith*	67.4	6.0	635.2	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-	-	-	+	-
5781	*Eunotia sp.*	21.0	5.5	166.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
5825	*Fragilaria pinata Ehrenberg*	12.0	4.0	50.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
5826	*Cymbella gracilis (Rabhorst) Cleve*	44.0	14.0	3386.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
5836	*Encyonema silesiacum (Bleisch) D.G. Mann*	30.0	10.0	1178.1	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
5854	*Pinnularia borealis Ehrenberg*	116.0	22.0	14698.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
5860	*Diatoma vulgare Bory*	25.2	6.0	237.7	-	+	+	-	-	-	-	+	+	-	-	+	-	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-
5865	*Cymbella prostrata (Berkeley) Cleve*	119.3	20.8	20444.7	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5870	*Navicula radiosa Kutzing*	71.0	8.8	1457.3	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+
5873	*Gomphonema minutum*	24.9	8.0	417.2	+	+	+	-	+	+	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	+	-
5875	*Cocconies disculus Schum.*	30.0	14.2	1578.6	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+	+	+	-
5881	*Diatoma elongatum Agardh*	44.0	4.0	184.3	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5882	*Anomoenies vitrea Ross*	35.9	5.9	326.9	+	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	-	+	+	+	+	+	-	+	+	+	+	+
5884	*Gomphonema angustum Agardh*	43.0	10.0	1125.7	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5890	*Diatoma mesodon Grun.*	20.0	20.0	2094.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
5901	*Denticula sp*	21.5	11.0	689.6	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
5910	*Navicula exigua (Greg.) Muller*	37.5	8.0	655.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
5916	*Fragilaria capucina Grunow*	66.0	4.6	368.3	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	+	+	+	-	-	+	+	+	+	-	+	-	+
				Total Richness	**15**	**19**	**18**	**16**	**17**	**15**	**16**	**14**	**14**	**13**	**15**	**15**	**10**	**10**	**11**	**12**	**14**	**12**	**11**	**13**	**11**	**14**	**15**	**15**	**17**	**19**	**20**	**18**

APPENDIX C

2021 AWAR Fisheries Data

Table C-1: Fish captured through hoopnets at location R02 in 2021. US = upstream; DS = downstream; ARGR = Arctic Grayling; RNWH = Round Whitefish; LKTR=Lake Trout.

Date	Water Temp (°C)	Staff Gauge (mm)	Species	Direction (US or DS)	Net ID	Fish #	Tag #	Fork Length (mm)	Weight (g)	Sex/Maturity
6/22/21	4	670	ARGR	US	R02A	1	985	342	480	F2
6/22/21	4	670	ARGR	US	R02A	2	986	318	420	M7
6/22/21	4	670	ARGR	US	R02A	3	988	310	380	F4
6/22/21	4	670	ARGR	US	R02A	4	989	324	480	F4
6/22/21	4	670	ARGR	US	R02A	5	990	367	650	F2
6/22/21	4	670	ARGR	US	R02A	6	991	308	350	M6
6/22/21	4	670	ARGR	US	R02A	7	992	318	390	M7
6/22/21	4	670	ARGR	US	R02A	8	993	330	450	F4
6/22/21	4	670	ARGR	US	R02A	9	994	350	540	M7
6/22/21	4	670	ARGR	US	R02A	10	996	299	310	M7
6/22/21	4	670	ARGR	US	R02A	11	997	310	350	M7
6/22/21	4	670	ARGR	US	R02A	12	998	287	290	M7
6/22/21	4	670	ARGR	US	R02A	13	700	310	360	M7
6/22/21	4	670	ARGR	US	R02A	14	696	311	350	M7
6/22/21	4	670	ARGR	US	R02A	15	695	276	280	Unknown immature
6/22/21	4	670	ARGR	US	R02A	16	694	287	280	M7
6/22/21	4	670	ARGR	US	R02A	17	691	286	280	M10
6/22/21	4	670	ARGR	US	R02A	18	432	290	260	M7
6/22/21	4	670	ARGR	DS	R02B	19	N/A	216	150	Unknown immature
6/23/21	3	640	ARGR	US	R02A	20	994 switch to 433	348	520	M7
6/23/21	3	640	RNWH	US	R02A	21	N/A	314	310	Unkown
6/24/21	2.2	650	ARGR	US	R02A	22	434	370	510	M9
6/24/21	2.2	650	ARGR	US	R02A	23	436	330	400	M7
6/24/21	2.2	650	ARGR	US	R02A	24	437	318	330	M7
6/24/21	2.2	650	ARGR	US	R02A	25	438	335	380	F4
6/24/21	2.2	650	ARGR	US	R02A	26	439	300	305	M7
6/24/21	2.2	650	ARGR	US	R02A	27	440	315	360	M7
6/24/21	2.2	650	ARGR	US	R02A	28	347	300	290	F5
6/24/21	2.2	650	ARGR	US	R02A	29	348	272	260	F5
6/24/21	2.2	650	ARGR	US	R02A	30	N/A	295	295	M7
6/25/21	2.8	650	ARGR	US	R02A	31	N/A	337	390	F4
6/25/21	2.8	650	ARGR	US	R02A	32	N/A	300	280	M9
6/25/21	2.8	650	ARGR	US	R02A	33	N/A	280	270	F4
6/25/21	2.8	650	ARGR	US	R02A	34	N/A	258	225	M7
6/25/21	2.8	650	ARGR	US	R02A	35	N/A	295	250	F2
6/25/21	2.8	650	ARGR	US	R02A	36	N/A	295	280	M7
6/25/21	2.8	650	ARGR	US	R02A	37	N/A	300	290	F4
6/25/21	2.8	650	ARGR	US	R02A	38	N/A	305	300	M7
6/25/21	2.8	650	ARGR	US	R02A	39	N/A	244	160	M6
6/25/21	2.8	650	ARGR	US	R02A	40	996	396	300	M7
6/26/21	6.7	635	No fish							
6/27/21	5.5	620	ARGR	US	R02A	41	N/A	299	330	F3
6/27/21	5.5	620	ARGR	US	R02A	42	N/A	287	290	F3
6/27/21	5.5	620	ARGR	US	R02A	43	N/A	311	340	M7
6/27/21	5.5	620	ARGR	US	R02A	44	N/A	300	300	F3
6/27/21	5.5	620	ARGR	US	R02A	45	N/A	338	400	M8
6/27/21	5.5	620	ARGR	US	R02A	46	N/A	319	350	F3
6/27/21	5.5	620	ARGR	US	R02A	47	N/A	310	340	F3
6/27/21	5.5	620	ARGR	US	R02A	48	N/A	296	300	M8
6/27/21	5.5	620	ARGR	US	R02A	49	N/A	309	340	F2
6/27/21	5.5	620	ARGR	US	R02A	50	N/A	317	370	M7
6/27/21	5.5	620	ARGR	US	R02A	51	N/A	324	390	M8
6/27/21	5.5	620	ARGR	US	R02A	52	N/A	297	270	M7
6/27/21	5.5	620	ARGR	US	R02A	53	N/A	271	240	F3
6/27/21	5.5	620	ARGR	US	R02A	54	N/A	263	230	M6

Table C-1: Fish captured through hoopnets at location R02 in 2021. US = upstream; DS = downstream; ARGR = Arctic Grayling; RNWH = Round Whitefish; LKTR=Lake Trout.

Date	Water Temp (°C)	Staff Gauge (mm)	Species	Direction (US or DS)	Net ID	Fish #	Tag #	Fork Length (mm)	Weight (g)	Sex/Maturity
6/27/21	5.5	620	ARGR	US	R02A	55	N/A	295	350	M7
6/27/21	5.5	620	ARGR	US	R02A	56	N/A	287	270	M7
6/27/21	5.5	620	ARGR	US	R02A	57	N/A	290	300	F2
6/27/21	5.5	620	ARGR	US	R02A	58	N/A	295	290	F2
6/27/21	5.5	620	ARGR	US	R02A	59	N/A	265	200	M6
6/27/21	5.5	620	ARGR	US	R02A	60	N/A	288	230	F3
6/27/21	5.5	620	ARGR	US	R02A	61	N/A	315	300	M7
6/27/21	5.5	620	ARGR	US	R02A	62	N/A	300	310	F3
6/27/21	5.5	620	ARGR	US	R02A	63	N/A	276	230	M7
6/27/21	5.5	620	ARGR	US	R02A	64	N/A	270	250	F3
6/27/21	5.5	620	ARGR	US	R02A	65	N/A	261	190	M7
6/27/21	5.5	620	ARGR	US	R02A	66	N/A	304	320	M7
6/27/21	5.5	620	ARGR	US	R02A	67	N/A	292	280	M8
6/27/21	5.5	620	ARGR	US	R02A	68	N/A	291	320	F3
6/27/21	5.5	620	ARGR	US	R02A	69	N/A	293	300	M8
6/27/21	5.5	620	ARGR	US	R02A	70	N/A	281	250	M7
6/27/21	5.5	620	ARGR	US	R02A	71	N/A	244	160	F1
6/27/21	5.5	620	ARGR	US	R02A	72	N/A	296	290	M7
6/27/21	5.5	620	ARGR	US	R02A	73	N/A	340	310	M7
6/29/21	10	600	ARGR	US	R02A	74	N/A	230	160	F1
6/29/21	10	600	ARGR	US	R02A	75	N/A	286	240	M8
6/29/21	10	600	ARGR	US	R02A	76	N/A	242	170	F3
6/29/21	10	600	ARGR	US	R02A	77	N/A	291	300	M7
6/29/21	10	600	ARGR	US	R02A	78	N/A	275	270	F2
6/29/21	10	600	ARGR	US	R02A	79	N/A	335	400	M7
6/29/21	10	600	ARGR	US	R02A	80	N/A	286	300	M7
6/29/21	10	600	ARGR	US	R02A	81	N/A	295	280	F3
6/29/21	10	600	ARGR	US	R02A	82	N/A	320	365	F3
6/29/21	10	600	ARGR	US	R02A	83	N/A	308	300	M8
6/29/21	10	600	ARGR	US	R02A	84	N/A	296	275	M7
6/29/21	10	600	ARGR	US	R02A	85	N/A	278	280	F3
6/29/21	10	600	ARGR	US	R02A	86	N/A	304	330	M7
6/29/21	10	600	ARGR	US	R02A	87	N/A	328	380	M7
6/29/21	10	600	ARGR	US	R02A	88	N/A	296	260	M8
6/29/21	10	600	ARGR	US	R02A	89	N/A	290	260	F2
6/29/21	10	600	ARGR	US	R02A	90	N/A	308	300	M8
6/29/21	10	600	ARGR	US	R02A	91	N/A	312	390	M7
6/29/21	10	600	ARGR	US	R02A	92	N/A	299	305	M7
6/29/21	10	600	ARGR	US	R02A	93	N/A	293	290	F3
6/29/21	10	600	ARGR	US	R02A	94	N/A	287	280	M8
6/29/21	10	600	ARGR	US	R02A	95	N/A	344	420	M8
6/29/21	10	600	ARGR	US	R02A	96	N/A	335	415	M7
6/29/21	10	600	ARGR	US	R02A	97	N/A	304	320	F3
6/29/21	10	600	ARGR	US	R02A	98	N/A	347	480	F2
6/29/21	10	600	ARGR	US	R02A	99	N/A	241	180	M6
6/29/21	10	600	ARGR	US	R02A	100	700	310	340	M7
6/29/21	10	600	ARGR	US	R02A	101	N/A	279	240	F3
6/29/21	10	600	ARGR	US	R02A	102	N/A	302	290	M7
6/29/21	10	600	ARGR	US	R02A	103	N/A	306	300	M7
6/29/21	10	600	ARGR	US	R02A	104	N/A	278	230	M6
6/29/21	10	600	ARGR	US	R02A	105	N/A	290	290	F2
6/29/21	10	600	ARGR	US	R02A	106	N/A	265	210	F3
6/29/21	10	600	ARGR	US	R02A	107	N/A	300	320	M7
6/29/21	10	600	ARGR	US	R02A	108	N/A	334	400	M7
6/29/21	10	600	ARGR	US	R02A	109	N/A	295	310	M7

Table C-1: Fish captured through hoopnets at location R02 in 2021. US = upstream; DS = downstream; ARGR = Arctic Grayling; RNWH = Round Whitefish; LKTR=Lake Trout.

Date	Water Temp (°C)	Staff Gauge (mm)	Species	Direction (US or DS)	Net ID	Fish #	Tag #	Fork Length (mm)	Weight (g)	Sex/Maturity
6/29/21	10	600	ARGR	US	R02A	110	N/A	301	330	F2
6/29/21	10	600	ARGR	US	R02A	111	N/A	335	450	M7
6/29/21	10	600	ARGR	US	R02A	112	N/A	309	350	M7
6/29/21	10	600	ARGR	US	R02A	113	N/A	315	360	M7
6/29/21	10	600	ARGR	DS	R02A	114	N/A	343	440	M8
6/29/21	10	600	ARGR	DS	R02A	115	N/A	283	285	M6
6/29/21	10	600	ARGR	DS	R02B	116	N/A	255	170	M6
7/01/21	10.3	580	ARGR	US	R02B	117	N/A	212	130	F/M 1 0r 6
7/01/21	10.3	580	ARGR	US	R02B	118	N/A	274	260	F3
7/01/21	10.3	580	ARGR	US	R02A	119	N/A	216	130	M6
7/02/21	11.6	573	ARGR	US	R02A	120	N/A	330	410	M7
7/02/21	11.6	573	ARGR	US	R02A	121	N/A	334	460	M8
7/02/21	11.6	573	ARGR	US	R02A	122	N/A	307	360	M8
7/02/21	11.6	573	ARGR	US	R02A	123	N/A	274	250	F3
7/02/21	11.6	573	ARGR	US	R02A	124	N/A	296	270	M6
7/02/21	11.6	573	ARGR	US	R02B	125	N/A	285	250	F3
7/02/21	11.6	573	ARGR	US	R02B	126	N/A	290	290	M7
7/02/21	11.6	573	ARGR	US	R02B	127	N/A	344	490	M7
7/02/21	11.6	573	ARGR	US	R02B	128	N/A	293	290	M8
7/02/21	11.6	573	ARGR	US	R02B	129	N/A	298	290	M7
7/02/21	11.6	573	ARGR	US	R02B	130	N/A	268	240	F2
7/02/21	11.6	573	ARGR	US	R02B	131	N/A	309	340	M7
7/02/21	11.6	573	ARGR	US	R02B	132	N/A	270	249	F3
7/02/21	11.6	573	ARGR	US	R02B	133	N/A	280	250	F3
7/02/21	11.6	573	ARGR	US	R02B	134	N/A	285	260	M8
7/02/21	11.6	573	ARGR	US	R02B	135	N/A	270	250	F3
7/02/21	11.6	573	ARGR	US	R02B	136	N/A	275	240	F2
7/02/21	11.6	573	ARGR	US	R02B	137	N/A	275	230	M7
7/02/21	11.6	573	ARGR	US	R02B	138	N/A	309	340	F2
7/02/21	11.6	573	ARGR	US	R02B	139	N/A	295	290	M7
7/02/21	11.6	573	ARGR	US	R02B	140	N/A	225	110	F1
7/02/21	11.6	573	ARGR	US	R02B	141	N/A	245	210	M6
7/02/21	11.6	573	ARGR	US	R02B	142	N/A	264	220	F3
7/02/21	11.6	573	ARGR	US	R02B	143	N/A	240	150	M6
7/02/21	11.6	573	ARGR	US	R02B	144	700	300	350	M7
7/02/21	11.6	573	ARGR	US	R02B	145	348	270	240	F2
7/02/21	11.6	573	ARGR	US	R02B	146	N/A	246	180	M6
7/02/21	11.6	573	ARGR	US	R02B	147	N/A	300	280	M8
7/02/21	11.6	573	ARGR	US	R02B	148	N/A	299	260	F3
7/02/21	11.6	573	ARGR	US	R02B	149	N/A	280	260	F3
7/02/21	11.6	573	ARGR	US	R02B	150	N/A	286	300	M8
7/02/21	11.6	573	ARGR	US	R02B	151	N/A	319	340	M7
7/02/21	11.6	573	ARGR	US	R02B	152	N/A	299	280	M7
7/02/21	11.6	573	ARGR	US	R02B	153	N/A	240	180	M6
7/02/21	11.6	573	ARGR	DS	R02B	154	N/A	286	300	M8
7/02/21	11.6	573	ARGR	DS	R02B	155	N/A	319	340	M7
7/02/21	11.6	573	ARGR	DS	R02B	156	N/A	299	280	M7
7/02/21	11.6	573	ARGR	DS	R02B	157	N/A	240	180	M6
7/02/21	11.6	573	ARGR	US	R02C	158	N/A	326	390	M8
7/02/21	11.6	573	ARGR	US	R02C	159	N/A	291	260	F2
7/02/21	11.6	573	ARGR	US	R02C	160	N/A	284	300	M7
7/02/21	11.6	573	ARGR	US	R02C	161	N/A	220	130	M6
7/02/21	11.6	573	ARGR	US	R02C	162	N/A	270	260	M8
7/02/21	11.6	573	ARGR	US	R02C	163	N/A	323	340	F8
7/02/21	11.6	573	ARGR	US	R02C	164	N/A	335	350	M7

Table C-1: Fish captured through hoopnets at location R02 in 2021. US = upstream; DS = downstream; ARGR = Arctic Grayling; RNWH = Round Whitefish; LKTR=Lake Trout.

Date	Water Temp (°C)	Staff Gauge (mm)	Species	Direction (US or DS)	Net ID	Fish #	Tag #	Fork Length (mm)	Weight (g)	Sex/Maturity
7/02/21	11.6	573	ARGR	US	R02C	165	N/A	316	330	M8
7/02/21	11.6	573	ARGR	US	R02C	166	N/A	187	120	F1
7/02/21	11.6	573	ARGR	US	R02C	167	N/A	346	380	M8
7/02/21	11.6	573	ARGR	US	R02C	168	N/A	250	200	F3
7/04/21	10.4	542	LKTR	US	R02C	169	N/A	388	510	M8
7/04/21	10.4	542	ARGR	US	R02C	170	N/A	127	60	M6
7/04/21	10.4	542	STICKLEBACK	US	R02C	171	N/A	40	2	N/A
7/04/21	10.4	542	ARGR	US	R02B	172	N/A	246	200	M6
7/04/21	10.4	542	ARGR	US	R02B	173	N/A	250	190	M6
7/04/21	10.4	542	ARGR	US	R02B	174	N/A	240	190	F1
7/04/21	10.4	542	ARGR	US	R02B	175	N/A	226	160	M6
7/04/21	10.4	542	ARGR	US	R02B	176	N/A	277	210	F2
7/04/21	10.4	542	ARGR	US	R02B	177	N/A	294	330	M8
7/04/21	10.4	542	ARGR	US	R02B	178	N/A	284	280	M8
7/04/21	10.4	542	ARGR	US	R02B	179	N/A	301	340	M8
7/04/21	10.4	542	ARGR	US	R02B	180	N/A	275	250	M6
7/04/21	10.4	542	ARGR	US	R02B	181	N/A	248	180	F1
7/04/21	10.4	542	ARGR	US	R02B	182	N/A	279	260	F1
7/04/21	10.4	542	ARGR	US	R02B	183	N/A	295	300	M6
7/04/21	10.4	542	LKTR	US	R02B	184	N/A	525	2000	F3
7/04/21	10.4	542	ARGR	US	R02A	185	747	291	310	M7
7/04/21	10.4	542	ARGR	US	R02A	186	N/A	314	350	M7
7/04/21	10.4	542	RNWH	US	R02A	187	N/A	333	380	F3
7/04/21	10.4	542	ARGR	US	R02A	188	N/A	330	425	M7
7/04/21	10.4	542	RNWH	US	R02A	189	N/A	293	240	F1
7/04/21	10.4	542	RNWH	US	R02A	190	N/A	298	240	F3
7/04/21	10.4	542	RNWH	US	R02A	191	N/A	275	200	F2
7/04/21	10.4	542	ARGR	US	R02A	192	N/A	302	250	F2
7/04/21	10.4	542	ARGR	US	R02A	193	N/A	295	300	M8
7/04/21	10.4	542	RNWH	US	R02A	194	N/A	298	250	F3
7/04/21	10.4	542	ARGR	US	R02A	195	N/A	296	290	F1
7/04/21	10.4	542	RNWH	US	R02A	196	N/A	280	210	M6
7/04/21	10.4	542	ARGR	US	R02A	197	N/A	291	290	M8
7/04/21	10.4	542	ARGR	US	R02A	198	N/A	300	300	M7
7/04/21	10.4	542	ARGR	US	R02A	199	N/A	259	290	M6
7/04/21	10.4	542	LKTR	US	R02A	200	N/A	520	1500	F8
7/06/21	8.7	51.5	ARGR	US	R02A	201	N/A	236	150	M6
7/06/21	8.7	51.5	ARGR	US	R02A	202	N/A	252	150	M6
7/06/21	8.7	51.5	ARGR	US	R02A	203	N/A	210	140	F1
7/06/21	8.7	51.5	ARGR	US	R02A	204	N/A	275	260	F4
7/06/21	8.7	51.5	ARGR	US	R02A	205	N/A	330	390	M9
7/06/21	8.7	51.5	ARGR	US	R02A	206	N/A	295	280	M9
7/06/21	8.7	51.5	ARGR	US	R02A	207	N/A	290	300	M9
7/06/21	8.7	51.5	ARGR	US	R02A	208	N/A	276	250	F4
7/06/21	8.7	51.5	RNWH	US	R02A	209	N/A	288	250	F4
7/06/21	8.7	51.5	ARGR	US	R02A	210	N/A	230	140	F1
7/06/21	8.7	51.5	ARGR	US	R02A	211	N/A	294	260	M9
7/06/21	8.7	51.5	ARGR	US	R02A	212	N/A	286	250	M9
7/06/21	8.7	51.5	ARGR	US	R02A	213	N/A	285	240	F4
7/06/21	8.7	51.5	ARGR	US	R02A	214	N/A	243	130	M6
7/06/21	8.7	51.5	ARGR	US	R02A	215	N/A	270	240	M9
7/06/21	8.7	51.5	ARGR	US	R02A	216	N/A	286	340	M9
7/06/21	8.7	51.5	ARGR	US	R02A	217	N/A	224	150	M6
7/06/21	8.7	51.5	ARGR	US	R02A	218	N/A	278	300	M9
7/06/21	8.7	51.5	ARGR	US	R02A	219	N/A	277	180	M6

Table C-1: Fish captured through hoopnets at location R02 in 2021. US = upstream; DS = downstream; ARGR = Arctic Grayling; RNWH = Round Whitefish; LKTR=Lake Trout.

Date	Water Temp (°C)	Staff Gauge (mm)	Species	Direction (US or DS)	Net ID	Fish #	Tag #	Fork Length (mm)	Weight (g)	Sex/Maturity
7/06/21	8.7	51.5	ARGR	US	R02A	220	N/A	241	160	M6
7/06/21	8.7	51.5	ARGR	US	R02A	221	N/A	260	240	F4
7/06/21	8.7	51.5	ARGR	US	R02A	222	N/A	225	140	M6
7/06/21	8.7	51.5	ARGR	US	R02A	223	N/A	250	250	F1
7/06/21	8.7	51.5	ARGR	US	R02A	224	N/A	246	200	F1
7/06/21	8.7	51.5	ARGR	US	R02A	225	N/A	272	250	F1
7/06/21	8.7	51.5	RNWH	US	R02A	226	N/A	289	210	M9
7/06/21	8.7	51.5	RNWH	US	R02A	227	N/A	305	310	M9
7/06/21	8.7	51.5	RNWH	US	R02A	228	N/A	308	280	F4
7/06/21	8.7	51.5	RNWH	US	R02A	229	N/A	300	290	M9
7/06/21	8.7	51.5	RNWH	US	R02A	230	N/A	300	300	F4
7/06/21	8.7	51.5	RNWH	US	R02A	231	N/A	254	160	M6
7/06/21	8.7	51.5	RNWH	US	R02A	232	N/A	320	340	F4
7/06/21	8.7	51.5	ARGR	US	R02A	233	N/A	316	330	M9
7/06/21	8.7	51.5	RNWH	US	R02A	234	N/A	280	240	M9
7/06/21	8.7	51.5	ARGR	US	R02A	235	N/A	210	150	F1
7/06/21	8.7	51.5	ARGR	US	R02A	236	N/A	274	250	M9
7/06/21	8.7	51.5	ARGR	US	R02A	237	N/A	280	240	M9
7/06/21	8.7	51.5	RNWH	US	R02A	238	N/A	300	280	F4
7/06/21	8.7	51.5	ARGR	US	R02A	239	N/A	309	340	F4
7/06/21	8.7	51.5	ARGR	US	R02A	240	N/A	240	160	M6
7/06/21	8.7	51.5	ARGR	DS	R02B	241	N/A	220	100	F4
7/06/21	8.7	51.5	ARGR	US	R02C	242	N/A	310	280	F4
7/06/21	8.7	51.5	ARGR	DS	R02C	243	N/A	168	40	F1

APPENDIX D

2021 Interstitial Water Quality Data

Table D-1: Interstitial water quality results for HCMP dewatering dike and reference stations.

Parameter	CCME - Aquatic Life[d]	27/09/2021	27/09/2021	27/09/2021	26/09/2021	26/09/2021	26/09/2021	27/09/2021
		BG-PW-2	BG-PW-4	BG-PW-6	ED-PW-2	ED-PW-4	SP-REF	TPL-REF
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Conventional Parameters								
Hardness, as CaCO3		10.5 10.3	10.4 10.5	10.0 10.4	13.5 13.6	12.3 12.7	13.4 13.9	10.2 10.3
TSS	5[a]	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
Nutrients								
Total phosphorus	<0.004	< 0.050 < 0.0020	< 0.0020 < 0.050	< 0.050 0.0029	0.0021 < 0.050	0.0025 < 0.050	0.0034 < 0.050	< 0.050 < 0.0020
Total Metals								
Aluminum	0.1[b]	0.0088	0.0087	0.0122	0.0085	0.0096	0.0074	0.0083
Antimony		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Arsenic	0.005	0.00053	0.00048	0.00047	0.00031	0.00036	0.0003	0.00046
Barium		0.00273	0.00279	0.00269	0.00251	0.0025	0.00244	0.00272
Beryllium		< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100
Bismuth		< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Boron	1.50	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cadmium	0.00004[b]	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
Calcium		2.58	2.58	2.54	3.52	3.25	3.61	2.56
Cesium		0.00002	0.000017	0.000014	< 0.000010	< 0.000010	< 0.000010	0.000014
Chromium	0.001[c]	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Cobalt		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Copper	0.002[b]	< 0.00050	< 0.00050	< 0.00050	0.00075	0.00069	0.00077	< 0.00050
Iron	0.30	0.013	0.012	0.017	0.015	0.017	0.016	0.013
Lead	0.001[b]	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Lithium		< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Magnesium		0.982	0.959	0.98	1.16	1.11	1.18	0.958
Manganese		0.00117	0.00121	0.0013	0.00124	0.00134	0.00134	0.00122
Mercury	0.000026	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
Molybdenum	0.07	0.000117	0.000127	0.000112	0.000133	0.000124	0.000144	0.000114
Nickel	0.025[b]	0.00056	0.00054	0.00058	< 0.00050	< 0.00050	< 0.00050	0.00051
Potassium		0.543	0.518	0.551	0.538	0.535	0.542	0.537
Rubidium		0.00088	0.00086	0.00082	0.00076	0.00081	0.00075	0.00076
Selenium	0.001	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Silicon		0.14	0.12	0.11	0.25	0.21	0.25	0.12
Silver	0.00025	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Sodium		1.03	1.01	1.04	0.847	0.896	0.837	1.02
Strontium		0.0115	0.0115	0.0114	0.0167	0.0145	0.0168	0.0111
Tellurium		< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
Thallium	0.0008	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Thorium		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Tin		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Titanium		< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030
Tungsten		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Uranium	0.015	0.000049	0.000049	0.000047	0.000061	0.000056	0.000062	0.000049
Vanadium		< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Zinc		< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zirconium		< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020

Table D-1: Interstitial water quality results for HCMP dewatering dike and reference stations.

Parameter	CCME - Aquatic Life[d]	27/09/2021	27/09/2021	27/09/2021	26/09/2021	26/09/2021	26/09/2021	27/09/2021
		BG-PW-2	BG-PW-4	BG-PW-6	ED-PW-2	ED-PW-4	SP-REF	TPL-REF
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Dissolved Metals								
Aluminum		0.0033	0.003	0.0033	0.0034	0.0034	0.0028	0.0032
Antimony		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Arsenic		0.00046	0.00045	0.00044	0.00029	0.00033	0.00029	0.00044
Barium		0.00281	0.00284	0.0027	0.00251	0.00252	0.00245	0.00274
Beryllium		< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100	< 0.000100
Bismuth		< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Boron		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cadmium		< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
Cesium		0.000019	0.000016	0.000014	< 0.000010	0.00001	< 0.000010	0.000014
Chromium		< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Cobalt		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Copper		0.00045	0.00056	0.00042	0.00078	0.00073	0.00071	0.00044
Iron		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Lead		< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Lithium		< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese		0.00028	0.00029	0.0003	0.0003	0.00032	0.00027	0.00027
Mercury		< 0.0000050	< 0.0000050	< 0.0000050	0.000009	< 0.0000050	< 0.0000050	< 0.0000050
Molybdenum		0.000131	0.000186	0.000122	0.000175	0.000166	0.000144	0.000123
Nickel		0.00053	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Rubidium		0.00082	0.00082	0.00074	0.00081	0.00069	0.00075	0.00081
Selenium		< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
Silicon		0.081	0.087	0.089	0.199	0.174	0.208	0.089
Silver		< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Strontium		0.0115	0.0119	0.0112	0.017	0.0155	0.0172	0.0116
Tellurium		< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
Thallium		< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Thorium		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Tin		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Titanium		< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030	< 0.00030
Tungsten		< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Uranium		0.000046	0.000044	0.000042	0.000053	0.000053	0.000056	0.000041
Vanadium		< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Zinc	0.001[b]	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Zirconium		< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020

a - CCME maximum long-term (>24 h) increase over background

b - calculated as per CREMP threshold methods (2019 Core Receiving Environment Monitoring Program - Meadowbank Mine and Whale Tail Project, Prepared by Azimuth Consulting Group, March 2020)

c - value for hexavalent chromium

d - CCME Water Quality Guidelines for the Protection of Aquatic Life - Freshwater, Long-Term. Current to February 2022. Available at: https://ccme.ca/en/summary-table

Table D-2: Interstitial water quality duplicate results for HCMP dewatering dike stations.

Parameter	27/09/2021	27/09/2021	RPD	RPD Limit
	BG-PW-6	BG-PW-DUP		
	mg/L	mg/L	Diff or %	Diff or %
Conventional Parameters				
Hardness, as CaCO3	10	10.5	5%	NA
Hardness, as CaCO3	10.4	10.2	2%	NA
TSS	< 3.0	< 3.0		
Nutrients				
Total phosphorus	< 0.050	< 0.050		
Total phosphorus	0.0029	<0.0020		
Total Metals				
Aluminum	0.0122	0.009	0.0032	0.009
Antimony	< 0.00010	< 0.00010		
Arsenic	0.00047	0.00048	0.00001	0.0003
Barium	0.00269	0.00276	0.0001	0.0003
Beryllium	< 0.000100	< 0.000100		
Bismuth	< 0.000050	< 0.000050		
Boron	< 0.010	< 0.010		
Cadmium	< 0.0000050	< 0.0000050		
Calcium	2.54	2.63	3%	30%
Cesium	0.000014	0.000014	0.000000	0.00003
Chromium	< 0.00050	< 0.00050		
Cobalt	< 0.00010	< 0.00010		
Copper	< 0.00050	< 0.00050		
Iron	0.017	0.013	0.004	0.03
Lead	< 0.000050	< 0.000050		
Lithium	< 0.0010	< 0.0010		
Magnesium	0.98	0.962	2%	30%
Manganese	0.0013	0.00119	9%	30%
Mercury	< 0.0000050	< 0.0000050		
Molybdenum	0.000112	0.000124	0.00001	0.00015
Nickel	0.00058	0.00054	0.00004	0.0015
Potassium	0.551	0.54	2%	30%
Rubidium	0.00082	0.0008	0.000	0.001
Selenium	< 0.000050	< 0.000050		
Silicon	0.11	0.11	0.0	0.3
Silver	< 0.000010	< 0.000010		
Sodium	1.04	1.03	1%	30%
Strontium	0.0114	0.0114	0%	30%
Tellurium	< 0.00020	< 0.00020		
Thallium	< 0.000010	< 0.000010		
Thorium	< 0.00010	< 0.00010		
Tin	< 0.00010	< 0.00010		
Titanium	< 0.00030	< 0.00030		
Tungsten	< 0.00010	< 0.00010		
Uranium	0.000047	0.000047	0.000000	0.00003
Vanadium	< 0.00050	< 0.00050		
Zinc	< 0.0030	< 0.0030		
Zirconium	< 0.00020	< 0.00020		

Table D-2: Interstitial water quality duplicate results for HCMP dewatering dike stations.

Parameter	27/09/2021	27/09/2021	RPD	RPD Limit
	BG-PW-6	BG-PW-DUP		
	mg/L	mg/L	Diff or %	Diff or %
Dissolved Metals				
Aluminum	0.0033	0.0033	0.000	0.003
Antimony	< 0.00010	< 0.00010		
Arsenic	0.00044	0.00044	0.0000	0.0003
Barium	0.0027	0.00279	0.0001	0.0003
Beryllium	< 0.000100	< 0.000100		
Bismuth	< 0.000050	< 0.000050		
Boron	< 0.010	< 0.010		
Cadmium	< 0.0000050	< 0.0000050		
Cesium	0.000014	0.000015	0.00000	0.00003
Chromium	< 0.00050	< 0.00050		
Cobalt	< 0.00010	< 0.00010		
Copper	0.00042	0.00045	0.0000	0.0006
Iron	< 0.010	< 0.010		
Lead	< 0.000050	< 0.000050		
Lithium	< 0.0010	< 0.0010		
Manganese	0.0003	0.00029	0.0000	0.0003
Mercury	< 0.0000050	< 0.0000050		
Molybdenum	0.000122	0.000138	0.00	0.00015
Nickel	< 0.00050	< 0.00050		
Rubidium	0.00074	0.00084	0.00	0.0006
Selenium	< 0.000050	< 0.000050		
Silicon	0.089	0.082	0.01	0.15
Silver	< 0.000010	< 0.000010		
Strontium	0.0112	0.0115	0.0003	0.0006
Tellurium	< 0.00020	< 0.00020		
Thallium	< 0.000010	< 0.000010		
Thorium	< 0.00010	< 0.00010		
Tin	< 0.00010	< 0.00010		
Titanium	< 0.00030	< 0.00030		
Tungsten	< 0.00010	< 0.00010		
Uranium	0.000042	0.000042	0.00000	0.00003
Vanadium	< 0.00050	< 0.00050		
Zinc	< 0.0010	< 0.0010		
Zirconium	< 0.00020	< 0.00020		

APPENDIX E

Technical Memorandum: Evaluation of Arctic Grayling Production at the R02 Spawning Pads (Drift) – February 28, 2020

TECHNICAL MEMORANDUM

DATE 3 April 2020 **Reference No.** 19122020-474-TM-RevA

TO Manon Turmel, Permitting Lead
Agnico Eagle Mines Limited

CC Nancy Duquet Harvey, Jen Range, Cam Mackenzie, Leilan Baxter

FROM Cam Stevens **EMAIL Cameron_Stevens@golder.com**

EVALUATION OF ARCTIC GRAYLING PRODUCTION AT THE R02 SPAWNING PADS

Introduction

On 1 April 2019, staff from Agnico Eagle Mines Limited (Agnico Eagle) and Fisheries and Oceans Canada (DFO) met to discuss the technical memorandum provided by Agnico Eagle on updates to the no-net loss plan (NNLP) for the Meadowbank Site (Agnico Eagle 2019). The technical memo included an analysis of fishery productivity gains (benefits) to be achieved through the implementation of the contingency measures described in the 2012 NNLP. Most of the gains were to be achieved through the construction of spawning pads for enhancing the productivity of Arctic Grayling populations. The predicted gains were quantified using fish production units, specifically biomass generated from spawning habitat enhancements, and calculations were based, in part, on long-term monitoring data collected upstream of the R02 crossing on the All Weather Access Road (AWAR) where four spawning pads were constructed for Arctic Grayling in winter 2008/2009 (Agnico Eagle 2019).

Data on fish presence and spawning activities have been collected by Agnico Eagle upstream of the R02 crossing starting in 2006, and are summarized in annual reports, provided as a component of the Meadowbank Annual Reports submitted each year to the Nunavut Impact Review Board (NIRB). In Agnico Eagle's technical memorandum on the updated NNLP, the collected monitoring data were used to demonstrate the benefits of spawning pad construction for Arctic Grayling production using larvae counts. That analysis suggested that the spawning pads increased larvae (young-of-year) densities by 4.3-times post-construction. Agnico Eagle assumed that this observed increase in larvae catch was directly related to the availability of new spawning habitat, and was consistently proportional to changes in the adult population post-construction. It was proposed that the adult Arctic Grayling biomass in the system increased an average of 70 fish per year or 21 kg per year after 8 years in use.

Upon discussion of the technical memo results with DFO, an outcome of the 1 April 2019 meeting was a request from DFO to provide additional information to confirm the predicted gains in the productivity of the fishery from the construction of four gravel spawning pads above the R02 crossing (Figure 1). In a follow-up email from DFO received on 16 May 2019, the scope of the additional analyses was clarified as more information on assumptions to better understand how changes in larval fish captures relate to changes in fish production, the use of standard criteria or methods for selecting suitable monitoring data for analysis to account for variations in the study design across monitoring years, and a modelling approach that is aligned with other offsetting plans that focus on stream habitat enhancements in the North, such as the Back River Offsetting Plan (Golder 2019).

In response to the information request from DFO, Agnico Eagle then contracted Golder Associates Ltd. (Golder) to provide an evaluation of gains in fish production from the construction of the four spawning pads above the R02 crossing (i.e., the R02 spawning pads). The objectives of this memo are to i) examine changes in the Arctic Grayling population over time using data collected on the Arctic Grayling population upstream of the R02 crossing (from 2007 to 2019) and ii) develop a conceptual fish production model to quantify changes in Arctic Grayling biomass following the construction of spawning pads.

Figure 1: Arctic Grayling Spawning Pads Upstream of the All Weather Access Road (AWAR) Crossing R02 (Agnico Eagle 2019)

R02 Monitoring Results (2006-2019)

Larval Drift Traps

Larval drift traps were set in the R02 study reach since 2006 for varying lengths of time between June 10 and August 7 (see Figure 2; also summarized in Agnico Eagle 2019). No sampling occurred in 2012, 2014, 2016, and 2018 (Figure 2). Because of data issues that could not be resolved in time for this technical memo, larval trap data from 2006 monitoring was excluded from analyses.

The larval drift traps typically consisted of a square-sided cone with a ridged frame that funnelled into a 0.5 mm Nitex mesh bag (Agnico Eagle 2018). Attached at the back of the Nitex mesh bag was a Nalgene®-type container where the drift was collected. Frames were either 60 x 30 cm or 47 x 30 cm. The frame was submerged at least halfway under water and secured to the streambed by poles on each side. Drift traps were checked at least every three days, but most commonly every day. Across the study years, drift traps were set in various locations in the immediate vicinity of the spawning pads, including locations just upstream and downstream of the spawning pads.

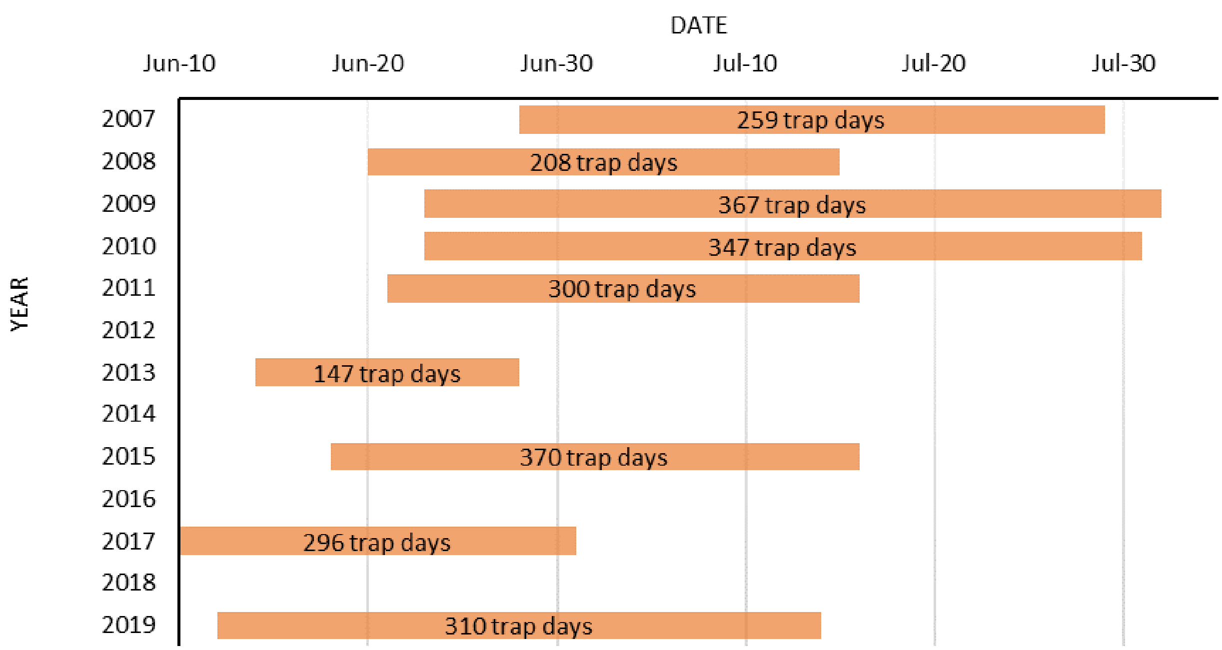


Figure 2: Larval Drift Trap Sampling Schedule and Total Trapping Effort (# Trap Days) During R02 Monitoring Period

The larval drift-trap data provided by Agnico Eagle was summarized as mean daily catch per unit effort (CPUE), calculated as the mean trap CPUE across all traps, for each day. Two summaries were completed, one using the full dataset and then an analysis of a subset of the full dataset to better understand the response of Arctic Grayling to the construction of the R02 spawning pads. The full dataset included all data collected over the monitoring period at both upstream and downstream locations of the four spawning pads. The full dataset was subset to include only data collected downstream of the four spawning pads and data collected after a calculated emergence date for Arctic Grayling. The emergence date was based on water temperature data collected during the trapping program, combined with Arctic Grayling life cycle guidance provided in a review by Stewart et al. (2007). The range of emergence dates was determined with the following conditions:

- Minimum spawning temperatures of 4°C
- Incubation times of 13 to 18 days under normal stream conditions that fluctuate about a mean daily temperature of 8.8°C
- Larval Arctic Grayling emerge from the gravel 3 to 5 days after they hatch

Using water temperature data provided by Agnico Eagle, a polynomial scatterplot smoothing function (i.e., locally weighted scatter-plot smoother) was fit to calculate mean daily temperatures for the duration of the trapping period. As illustrated in Figure 3, expected emergence of larvae was 7 to 14 July, depending on the trapping year, and the analysis of trap data presented further below uses a general guideline of 10 July as the earliest date of emergence of Arctic Grayling. The result of the emergence date analysis indicated that any small fish captured and identified as Arctic Grayling prior to 7 July were likely incorrectly identified as larval Arctic Grayling. Fish samples collected prior to 7 July that were preserved should be re-examined for identification in a laboratory. These samples could be either age-1 year Arctic Grayling or recently emerged young-of-year from an adfluvial coregonid species that spawn either upstream of the trap locations or possibly in the spawning pad area.

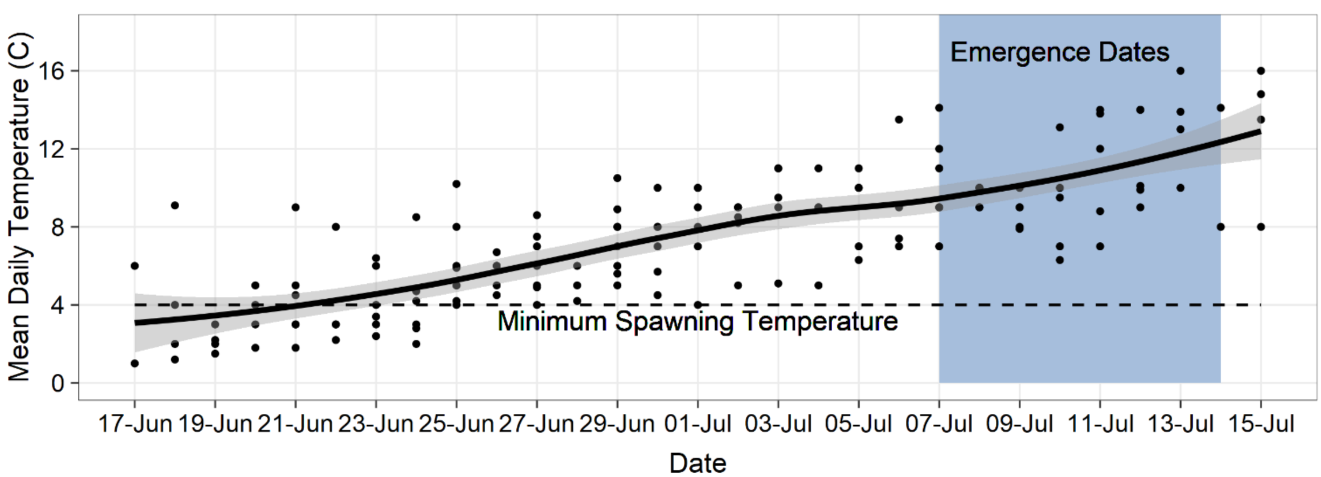


Figure 3: Range of Predicted Arctic Grayling Emergence Dates Based on Observed Water Temperature at R02 Crossing, 2007 – 2019

Note: Line Created Using Polynomial Scatterplot Smoothing Function; Shading = Standard Error

Larval drift-trap data are summarized per year in Figure 4 and Figure 5. Based on visual assessment of the plots in the figures below, notable trends in CPUE include the observations that i) peak catch rates occur prior to 1 July for all trapping years (Figure 4), and ii) catch rates are increasing over time, with measurably higher catches after the construction of the spawning pads in winter 2008/2009 (Figure 4; Figure 5). Using the full dataset from monitoring above the R02 crossing, the mean pre-construction CPUE was 1.1 larvae per trap day (standard deviation [SD] ± 2.7), whereas the mean post-construction CPUE was 5.2 larvae per trap day (SD ± 11.0). Larval densities increased, on average, 4.7-times following the construction of the R02 spawning pads. Similar trends were observed for the subset of data collected on or after the 10 July emergence date for Arctic Grayling in the traps immediately downstream of the R02 spawning pads. Using the reduced dataset, the mean pre-construction CPUE was 0.2 larvae per trap day (SD ± 0.6), whereas the mean post-construction CPUE was 0.8 larvae per trap day (SD ± 3.2). Larval densities collected downstream of the spawning pads after 9 July increased, on average, 4.0-times post-construction per monitoring year.

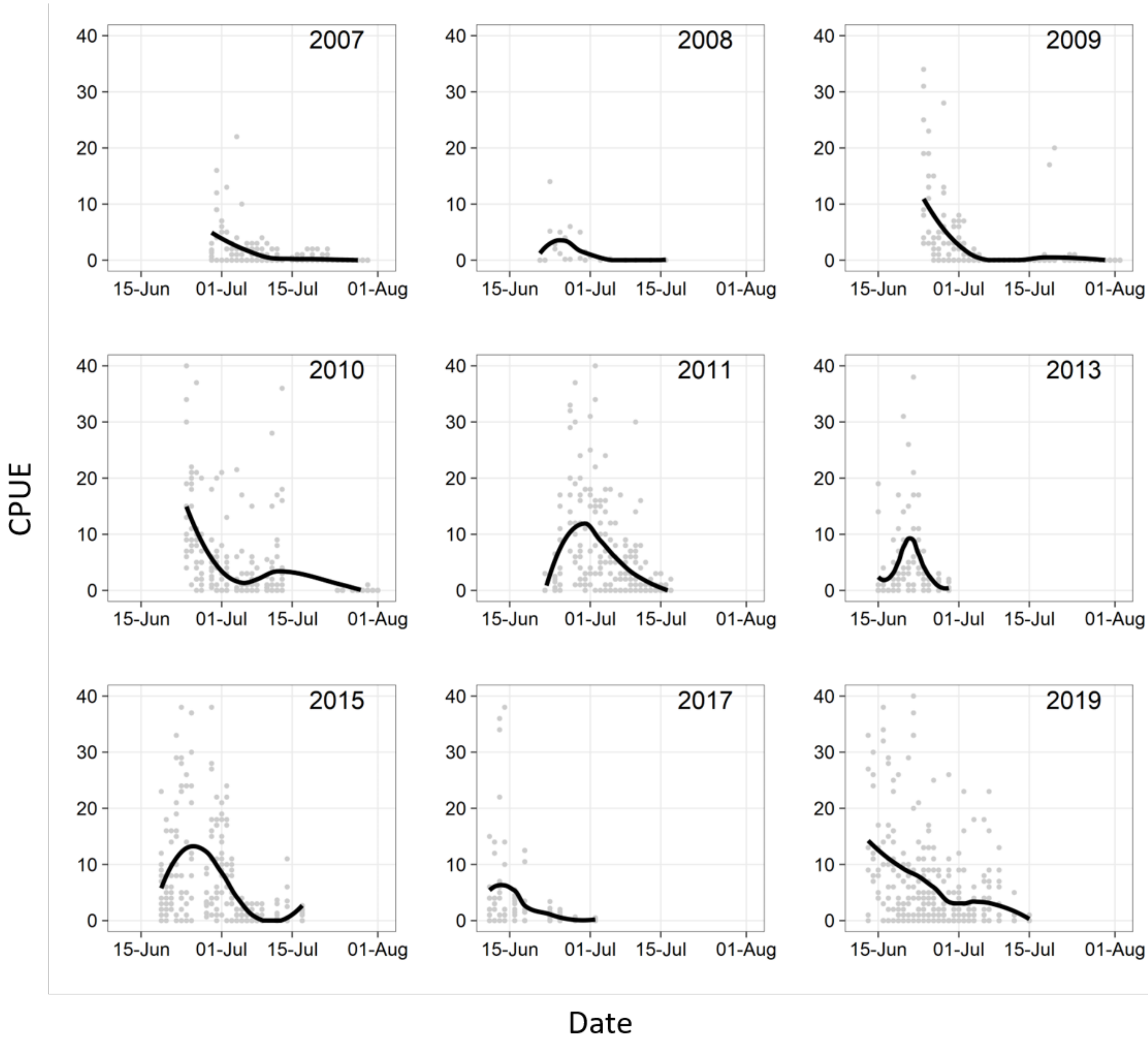


Figure 4: Summary of Larval CPUE using all Larval Data Collected Above the R02 Crossing, 10 June to 7 August

Note: Line Created Using Polynomial Scatterplot Smoothing Function

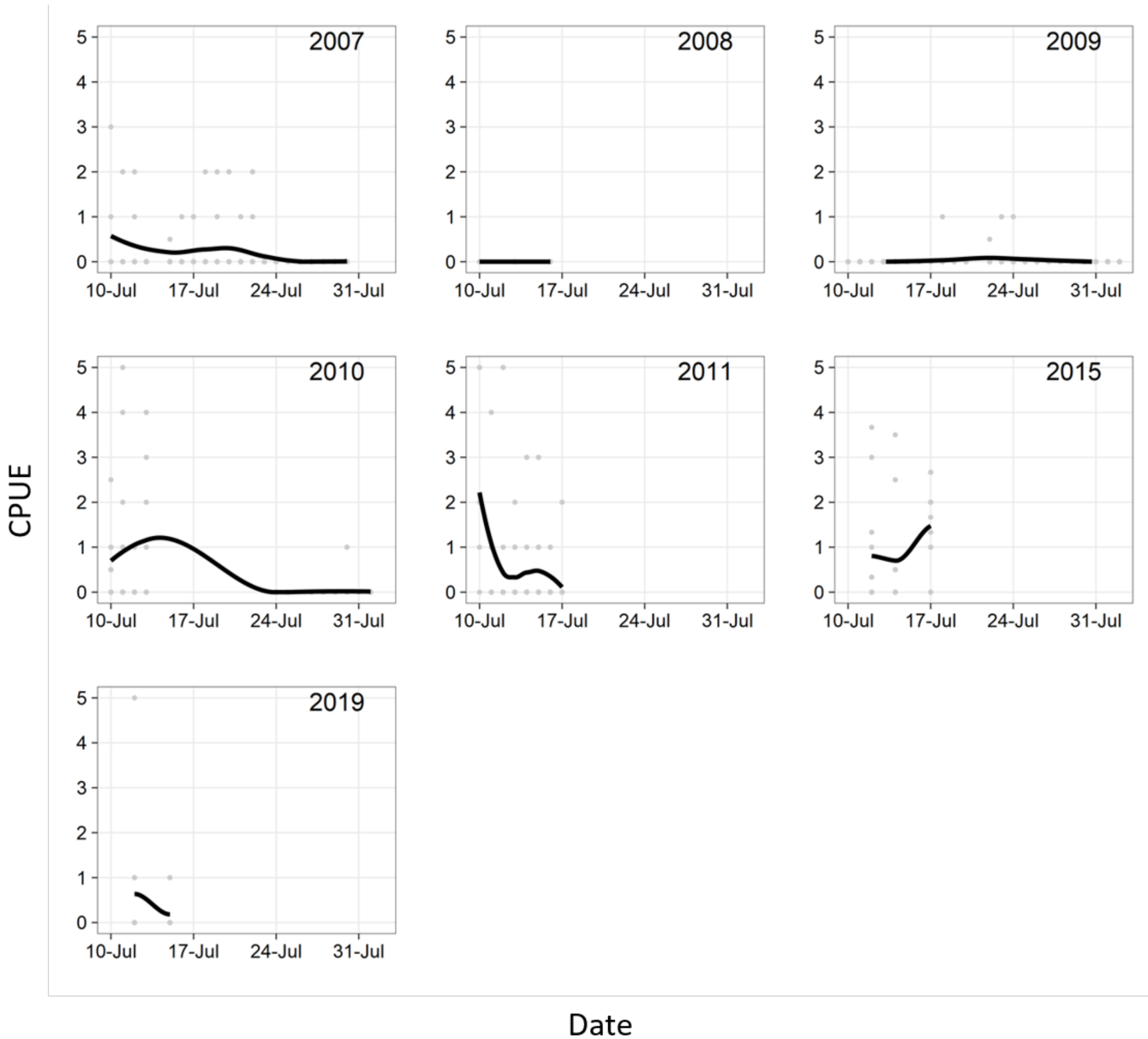


Figure 5: Summary of Larval CPUE using Data Collected Downstream of Spawning Pads after 9 July

Note: Line Created Using Polynomial Scatterplot Smoothing Function

Hoop-Net Traps

Hoop-net traps were set concurrently with the larval traps in the R02 study reach since 2006, however the timing of the larval trap and hoop-net sampling periods in each year did not completely overlap (Figure 6). Hoop-net traps have been set over various periods of time between June 11 and July 19. As with the larval trapping, no sampling occurred in 2012, 2014, 2016, and 2018 (Figure 6).

Hoop-net traps were installed upstream of the R02 crossing with the primary objective to monitor the passage of fish and evaluate population structure of Arctic Grayling (Agnico Eagle 2018). The hoop-net trap design was intended to confirm the continued presence of a self-sustaining population of Arctic Grayling following the construction of the R02 crossing (not necessarily for measuring the size of the spawning population following the construction of the spawning pads). The traps consisted of either a 4 ft (1.22 m) or 3 ft (0.9 m) diameter front hoop, with interior hoops and compartments to hold fish. The configuration of the traps and the number of traps deployed varied across years depending on flow conditions and monitoring objectives. After construction of the spawning pads, the typical configuration was two to three stations deployed upstream, adjacent, and downstream of the spawning pads. Each station was oriented to capture fish moving in both upstream and downstream directions as a two-way design with the front hoop of each trap attached to wings to direct fish into the net. To maximize detection of migrating fish, the hoop-net traps were typically installed in the thalweg of the river depending on ice-flow conditions and stream velocities. However, the wings of each trap station configuration could not effectively span the width of the river given the size of the river under spring flow conditions.

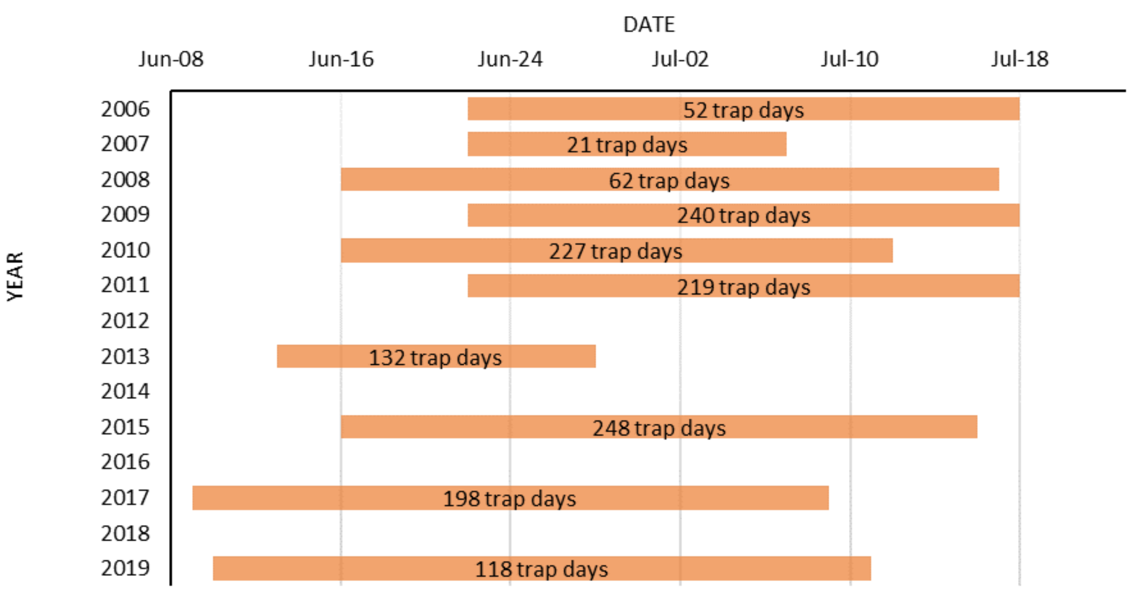


Figure 6: Hoop Net Sampling Schedule and Total Trapping Effort (# Trap Days) During R02 Monitoring Period

Hoop-net data was summarized as mean daily CPUE per year (# Arctic Grayling caught per trap), calculated as the mean of daily catch of Arctic Grayling divided by the reported number of traps for the season. Catch from all traps was considered regardless of direction of fish movement (net orientation), however traps set downstream of the bridge (in 2007 and 2008; outside of the standard survey area) were excluded from the analysis. All results are considered preliminary in that some assumptions were applied around details of the trapping effort and sampling design (e.g., where information was unclear, descriptions from previous sampling years were applied) that require additional follow up before confirmation of trends, or lack thereof. In brief, the hoop-net data summary indicated that Arctic Grayling abundance was variable across monitoring years with high and low CPUEs both before and after the construction of the spawning pads (Figure 7). Although the abundance of migrating fish was variable over time, the long-term dataset incudes evidence of a self-sustaining population of Arctic Grayling above the R02 crossing.

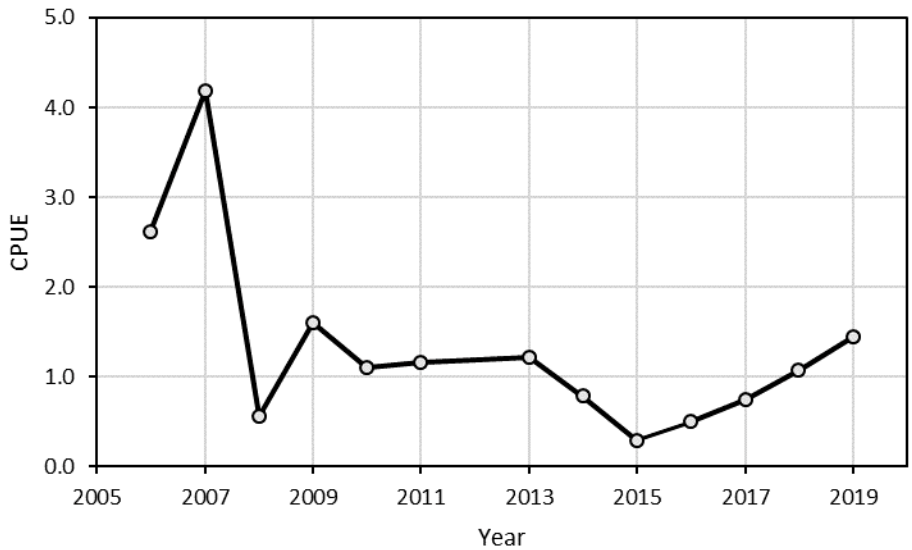


Figure 7: Annual Catch Per Unit Effort (CPUE) of Arctic Grayling in the Hoop-Net Traps, R02 Site, 2006-2019.

Conceptual Fish Production Model

Through discussion with DFO during the 1 April 2019 meeting, biomass production has been proposed as a currency for a spawning pad offsetting measure for the determination of equivalency for the Meadowbank Mine based on the premise that fisheries production (e.g., biomass) is an acceptable surrogate of fisheries productivity (Randall et al. 2013). Fish production would also provide a transferrable unit for both the calculation of losses from activities at the Meadowbank or All Weather Access Road (AWAR) projects and the calculation of gains at the spawning pad offsetting measure constructed upstream of R02 crossing (i.e., R02 spawning pads).

Life History-Based Biomass Predictions

A modified Leslie matrix model was constructed using life history inputs derived from the literature to estimate the potential increase in fish production from the R02 spawning pads. This analysis was intended to supplement that provided by Agnico Eagle (2019) using methods similar to that applied to other offsetting plans for new mining developments in the Northwest Territories and Nunavut.

As an input to the life history modelling, the capacity of the spawning pad reach to support spawning pairs (i.e., the 150 m linear length section of the R02 spawning pads) was first estimated with the assumption that spawning habitat was a limiting habitat feature in the study reach prior to the construction of the R02 spawning pads, and that emigration (or mortality) processes are common when a local population exceeds the carrying capacity of the reach (Einum and Nislow 2005). Based on the calculation of area of affected river habitat using satellite imagery, it was determined that a minimum of 0.4 ha (4,000 m^2) was either moderately enhanced or greatly enhanced from the placement of gravel substrates and the diversity of velocities in the vicinity of four constructed spawning pads. To conservatively estimate the potential gains in fish production, the focal area for calculations was reduced to habitat immediately adjacent of the spawning pads (e.g., within 10 m) where the effects of enhancement may have been greatest, which was visually estimated to be approximately 200 m^2 per pad.

Based on enhanced spawning habitat per constructed pad in the study reach, and a maximum density of one spawning male or one spawning pair per 15 m^2 (Kratt and Smitt 1980), the carrying capacity of each spawning pad was calculated to be 13 spawning pairs of Arctic Grayling under typical flow conditions. Because of the potential for patches of spawning habitat (e.g., gravel) to be present prior to construction, the actual gain in the carrying capacity of habitat resulting from the construction of the R02 spawning pads was determined to be a 4.3 fold increase from three spawning pairs. This was considered a conservative assumption given that pre-construction surveys did not record gravel patches within the spawning pad area (Golder 2007). Therefore, the contribution of the spawning pads to the carry capacity of the study reach was estimated to be a gain of at least 10 spawning pairs per spawning pad (in other words, a total minimum gain of 40 spawning pairs of Arctic Grayling for the enhanced river section).

Fecundity estimates were based on an average fecundity of 9,670 eggs per kg of body weight for a female Arctic Grayling at maturity (Bishop 1971; Stewart et al. 2007). For example, if considering mature female Arctic Grayling with a mean weight of 0.571 kg (Table 1), the R02 spawning pads have the potential to add 220,749 eggs per year.

Key assumptions in the calculation of gains for the spawning pad offsetting measure include age-specific survival rates of Arctic Grayling, and age-specific weights of Arctic Grayling, both of which were included in the production calculations for the R02 spawning pads. Life history statistics were provided up to age 9 years, in part, to simplify the assumptions of the life history modelling even though Arctic Grayling can live much longer beyond age 9 years (Table 1; Stewart et al. 2007). Age-specific statistics for lengths and weights were obtained from the Gahcho Kué Diamond Mine fish-out summary report (Table 1; De Beers 2015). Because data on survival rates for Arctic Grayling were limited to a long-term survival study of adult Arctic Grayling in the Kuparuk River, Alaska (Buzby and Deegan 2004), survival rates for younger ages were supplemented with data from a diversity of salmonid species to provide the most reliable predictions as possible (Table 1).

Table 1: Arctic Grayling Life History Inputs Used in Fish Production Calculations

Age / Stage	Length[1] (mm)	Weight (kg)[1]	Annual Biomass Production (kg)	Survival Rate[2]
Egg	-	-	-	40%
0 (YOY)	-	-	-	10%
1	111	16.6	16.6	30%
2	189	83.2	66.6	35%
3	244	179.7	96.5	40%
4	282	279.8	100.1	45%
5	309	368.8	89.0	50%
6	328	441.4	72.6	60%
7	341	497.6	56.2	70%
8	350	539.7	42.2	70%
9	357	570.7	31.0	70%

YOY = young of year; "-" not applicable as biomass gains are not attributed to Year 0 in the model; [1]source includes De Beers (2015); [2]sources include Lee and Rieman (1997), Shuter et al (1998), Siter et al. (1999), Barlaup and Moen (2001), Aprahamian et al. (2003), Peterson et al. (2004), Buzby and Deegan (2004), and Honea et al. (2009)

Age-specific survival rates were obtained from the literature (Table 1) so that when linked to the abundance of a population and age-specific weights, annual fish production could be determined for a specific cohort of Arctic Grayling. Previous researchers noted an average survival of salmonid eggs of 67% to hatching (range of 6% to 98%; reviewed in Barlaup and Moen 2001), and others used values that ranged from 10% to 70% to model salmonid population sizes (Lee and Rieman 1997). Researchers found annual variability in egg to fry survival for Chinook Salmon, with mean survival rates of 49% to 69% annually, and reach-specific survival ranging between 9% to 91% (Roni et al. 2006). Researchers have also noted a 2% survival rate of fertilized egg to first summer for Atlantic Salmon (Shearer 1961), 4% survival rate of eyed-egg to first summer for Atlantic Salmon (Kennady and Strange 1981), and 1% to 3% survival rate of eyed-egg to first autumn parr for Brown Trout (Syrjänen et al. 2015). Lee and Rieman (1997) modelled populations of salmonids using an incubation success rate in the range of 10% to 70%, a fry survival rate in the range of 10% to 40%, and a juvenile survival rate in the range of 15% to 60%.

Annual survival rates are generally higher as individuals grow making them less susceptible to predation; for example, Honea et al. (2009) modelled populations of Chinook Salmon using the following rates per ocean stage: 5% for year 1 wild fish (or 3% for year 1 hatchery fish), 80% for year 2, and 90% for years 3 and 4. In the Aprahamian et al. (2003) review, average survival from summer age 1 to age 2 smolt for wild Atlantic Salmon was 19% to 45%, much higher than earlier life history stages. Similarly, age 1 survival for Lake Trout can be 40% (Sitar et al. 1999) and annual survival for age 3 and older Lake Trout can be 92% for unexploited populations (Shuter et al. 1998). High survival rates have also been recorded for first-time spawning adults for Brown Trout (90%; Berg et al. 1998). For unexploited to lightly exploited populations of Arctic Grayling, mean survival rates calculated for a long-term study of Arctic Grayling in Alaska was 71% (Buzby and Deegan 2004).

At each stage of development, a survival rate at the lower end of what has been reported in the literature was applied as a conservative assumption (Table 1). This approach aims to address any uncertainty related to the calculation of biomass of recruits (Table 2), which showed that Arctic Grayling production generated from one year of successful spawning on the spawning pads is equivalent to 403 kg when considering annual production from that cohort over a 10-year period. Repeated annual spawning over a 10-year period in the enhancement area may generate as much as 4,030 kg of cumulative biomass production when considering gains from all ten cohorts combined. Assumptions underlying this forecast are consistent conditions over time that reflect the selected vital rates in the life history model and a scenario where the R02 spawning pads are at capacity every year.

Finally, it is important to note that cumulative gains in fish production may be much greater than what was calculated using the model presented in this technical memo. For example, gains will be higher under the following conditions:

- the actual area or size of a male territory is smaller than what was selected for understanding carry capacity of the R02 spawning pads
- the area of enhanced habitat is greater than was visually estimated using satellite imagery
- the placement of spawning pads created spawning habitat in an area of the river where pre-construction substrates and velocities were not suitable for spawning
- the actual survival and fecundity rates are higher than the selected inputs used in the biomass production model
- the mean weights and growth rate of the local population are higher than what was selected for the biomass production model
- the spawning pads have the potential to provide recruits that are a source of mature adults for spawning in other locations in the study system

Table 2: Arctic Grayling Production Generated from One Year of Successful Spawning on Enhanced Habitat (Four Spawning Pads) in the R02 Study Reach

Stage (Age)	Survival Rate	Number of Fish	Mean Weight (kg)	Standing Stock Biomass (kg)	Annual Production (kg)
Egg	0.40	187,071	--	--	--
Age 0	0.10	74,828	--	--	--
Age 1	0.30	7,483	0.0166	124.22	124.22
Age 2	0.35	2,245	0.0832	186.78	149.52
Age 3	0.40	786	0.1797	141.24	75.85
Age 4	0.45	314	0.2798	87.86	31.43
Age 5	0.50	141	0.3688	52.00	12.55
Age 6	0.60	71	0.4414	31.34	5.15
Age 7	0.70	42	0.4976	20.90	2.36
Age 8	0.70	30	0.5397	16.19	1.26
Age 9	0.70	21	0.5707	11.98	0.65
				Total	***402.99***

Summary

The benefits of constructing spawning pads for river-spawning Arctic Grayling were demonstrated by i) examining monitoring data collected on the Arctic Grayling population upstream of the R02 crossing (from 2007 to 2019) and ii) developing a conceptual fish production model to quantify changes in Arctic Grayling biomass following the construction of spawning pads. The conclusions from this study were consistent with those made by Agnico Eagle in their NNPL update, and are supported by other research, including research by DFO Scientists (e.g., Loughlin and Clarke 2014). The use of physical in-stream structures, including the placement of gravel and cobble substrates to improve spawning habitat and provide cover and habitat for fish, is a common technique applied in fisheries conservation and management (reviewed in Roni et al. 2005; Fitzsimons 1996).

The extensive dataset from long-term monitoring of the Arctic Grayling population upstream of the R02 crossing clearly identifies a self-sustaining population of Arctic Grayling that can benefit from the constructed spawning pads (for more details see the Meadowbank Mine annual reports submitted to NIRB). Results from the larval drift traps combined with the life history modelling completed in this technical memo also provide the evidence to demonstrate gains in fish production were achieved from the construction of the four spawning pads above the R02 crossing in winter 2008/2009. The magnitude of the annual gain has the potential to be substantial, approximately a 4-fold increase in larval recruitment every year post-construction, which is consistent with the conclusions drawn by Agnico Eagle in the NNPL update.

The life history model developed for this study, which was a modified Leslie matrix model similar to that used for offsetting plans for other projects in the North (e.g., Golder 2019), demonstrated that Arctic Grayling production generated from only one year of successful spawning on the four spawning pads is expected to provide a minimum gain of 403 kg of biomass. This prediction considers the annual production resulting from one spawning event that would be generated from one cohort over a 10-year period. Over a ten year period with successful spawning events each year, the minimum cumulative gain would be 4,030 kg of biomass. It is important to note that predicted gains in fish production may be much greater than what was calculated using the conservative model inputs selected in this technical memo (e.g., if carrying capacity of the spawning pads are higher than what was assumed, or if fecundity rates are higher than the selected inputs).

To reduce any uncertainty around the identified trends and recognizing that the monitoring program was initially designed to monitoring Arctic Grayling movements in relation to the construction of the R02 crossing, it is recommended that future monitoring is adapted to focus on the distribution and abundance of incubating eggs on the spawning pads. Site-specific information on Arctic Grayling egg incubation would also help address any potential uncertainties related to the identification of larvae captured during spring sampling. That said, there remains sufficient evidence to support the use of the spawning pad concept as a contingency measure for the Meadowbank Site. Given the results presented in this memo as a reply to concerns raised by DFO, future offsetting plans can be scaled by adjusting the number of spawning pads to be installed as a cost-effective offsetting tool to counterbalance a range of residual effects on fish habitat (i.e., losses in fish production) from mining-related activities.

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https://golderassociates.sharepoint.com/sites/109587/project files/5 technical work/spawning pad review memo/19122020-474-tm-awar-argrspawningpad-rev0.docx

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