July 29, 2024

Cory Barker
Manager, Project Monitoring
Nunavut Impact Review Board

Re: Agnico Eagle's response to Meadowbank (03MN107) and Whale Tail (16MN056) 2023 Annual Report comments

Dear M. Barker,

The following information are intended to address regulator's comments regarding the Meadowbank (03MN107) and Whale Tail (16MN056) 2023 Annual Report:

- Government of Nunavut – June 28, 2024: Comment Request for Agnico Eagle's Meadowbank Complex Project 2023 Annual Report
- Fisheries and Oceans Canada – June 27, 2024: 03MN107 & 16MN056 – Agnico Eagle – Meadowbank Gold Mine and Whale Tail Pit Projects (Meadowbank Complex) – 2023 Annual Monitoring Report.
- Crown-Indigenous Relations and Northern Affairs Canada – June 27, 2024: Comment Request for Agnico Eagle Mines Limited's Meadowbank Complex Project 2023 Annual Report
- Kivalliq Inuit Association – June 26, 2024: Review of Agnico Eagle Mines Limited's Meadowbank Complex 2023 Annual Report; NIRB File No.: 03MN107 & 16MN056
- Environment and Climate Change Canada – June 26, 2024: 2AM-WTP1830, 2AM-MEA1530 – Agnico Eagle Mines – Meadowbank Mine – 2023 Annual Report
- Transport Canada – June 10, 2024: Transport Canada's comments for NIRB 2023 Annual Report - Meadowbank Complex
- Health Canada – June 26, 2024: Health Canada's response to the Comment Request for Agnico Eagle Mines Limited's Meadowbank Complex Project 2023 Annual Monitoring Report

Should you have any questions or require further information, please do not hesitate to contact us at the below.

Regards,

Agnico Eagle Mines Limited – Meadowbank Complex

Eric Haley

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Environment & Critical Infrastructures Superintendent

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LIST OF APPENDICES

1 Government of Nunavut (GN)

1.1 Pit and Mine Ground Surveys for Wildlife

Term and Condition: 28 (Project Certificate No. 008, Amendment No. 1)

References: Agnico Eagle Mines Limited – Meadowbank Division. Meadowbank Division Terrestrial Ecosystem Management Plan, Version 7 (June 2019). Agnico Eagle Mines Limited. Appendix 39, Parts 1–5, Agnico Eagle Mines Limited – Meadowbank Complex 2023 Wildlife Monitoring Summary Report Annual Report (March 2024).

Identification of issue: The frequency of pit and mine ground surveys conducted in 2023, as reported in the Meadowbank Complex 2023 Wildlife Monitoring Summary Report – Appendix 39 (Appendix 39) (AEM, 2024) by Agnico Eagle Mines Limited (AEM or the Proponent), appears to be inconsistent with requirements of the Project's Terrestrial Ecosystem Management Plan (TEMP; AEM, 2019).

The Government of Nunavut (GN) is concerned that the triggering of mitigation actions (e.g., suspension of non-essential vehicle circulation and operation of heavy equipment) would be impaired by the failure to engage increased pit and mine ground surveys during sensitive seasons. Mitigation actions are intended to reduce the disturbance of caribou within the vicinity of the Project.

Importance to review and supporting rationale: Pit and mine ground surveys around the Whale Tail mine site are an important tool for detecting wildlife, such as caribou, near the Project and triggering mitigation actions such as stoppages of heavy equipment and circulation of non-essential vehicles. In the Project's TEMP (AEM, 2019) Figure 6: Thresholds for Monitoring and Mitigation of Caribou in Proximity to Mine Operations, lays out a decision tree for management of Whale Tail mine operations in response to the presence of caribou (see Appendix A). This decision tree indicates that when at least 1 caribou (based on collar data) is within 50 km of the site the frequency of ground surveys is increased from once weekly (see Table 14: Monitoring Approach for Ungulates for the Project) to every two days (during sensitive seasons –Spring: April 1 to May 25 and Fall: September 22 to December 15) for at least 5 days; Frequency of ground surveys further increases to daily or twice daily if caribou, in groups above the Group Size Threshold (GST), are seen within 4 and 1.5 km of the mine site, respectively (Page 42).

Table 4-1: Number of Formal Pit and Mine Site Ground Surveys by Month, 2023, in Appendix 39 indicates that there were between 4 to 5 pit and ground surveys conducted each month in April, May, September, October, November and December for the Whale Tail site. This frequency of surveying indicates that caribou monitoring around the Whale Tail site remained at its lowest level prescribed by the TEMP during these months (i.e., 1 survey per week) and it appears that a higher frequency of pit and mine site surveys was not triggered in response to the presence of caribou.

The GN notes that the TEMP's threshold for increasing the frequency (i.e., from weekly to every second day) for pit and mine site ground surveys would have been triggered multiple times during the 2023 Spring Sensitive Season as a result of collar caribou data (see Figures 1–3) that the GN provides to AEM on a daily basis (Page 6-1; AEM, 2024). Figures 1–3 illustrate that collared caribou were within 50 km of the mine site, as such, these additional ground surveys in April and May should have been conducted. As a result, it appears that AEM did not follow this requirement of the TEMP at this time.

Table 4-2: Wildlife Observations from Formal Pit and Mine Site Surveys by Month 2023 of Appendix 39, indicates that 69 caribou were observed in April during the pit and mine ground surveys that were conducted in 2023 at the Whale Tail site. However, this number is presented as total number of caribou for the month. As such, the number does not provide clarity as to whether these caribou were in groups above the GST (i.e., 33 for the 2023 Spring Sensitive Season) or at what distance from the Project they were seen. Consequently, the GN cannot determine whether any monitoring or mitigation action was required under the TEMP's decision tree (Figure 6; AEM, 2019).

Recommendation 1: The GN recommends the following regarding the above concerns:

1. AEM provide a detailed explanation as to why the frequency of pit and mine site ground surveys conducted at the Whale Tail Site in 2023 were not increased in April and May, as required by the TEMP (AEM, 2019).

   Agnico Eagle's Response: *Blast monitoring is completed prior to any blasts and often in conjunction with Mine and Pit surveys. All aspects of the Mine and Pit survey are covered in the Blast Monitoring survey and mitigation measures will be applied according to the TEMP.*

2. AEM provide additional information with respect to the 69 caribou reported in April in Table 4-2 of Appendix 39. This should include the number of groups and their sizes and whether any of the groups were observed within 4 or 1.5 km of the Whale Tail site.

   Agnico Eagle's Response: *The information requested was provided in Appendix A, Table A-4, of the 2023 Wildlife Monitoring Summary Report. The 69 caribou observed during April 2023 were from two separate observations recorded on April 29. One observation of 15 caribou did not exceed GST. The second observation of 54 caribou exceeded GST, which resulted in a road closure and postponement of blasting, as noted in Table A-4 of Appendix A.*

3. To demonstrate that the decision tree in Figure 6 of the TEMP (AEM, 2019) is being implemented, AEM should provide a table in all future reports that integrates the frequency of pit and mine site ground surveys at the Whale Tail Site, all observations of collared caribou within 50 km, and

observations of caribou within 4 and 1.5 km. Additionally, this table should indicate any mitigation action taken in response to the caribou observations.

<u>Agnico Eagle's Response:</u> *The information requested is already provided in Appendix A, Table A-4 of the 2023 Wildlife Monitoring Summary Report. These tables do not include collared caribou within 50 km, but the collar monitoring only triggers additional monitoring and not mitigation. Observation presented in this table are linked to whether or not mitigation was triggered.*

1.2 Collection of Caribou Collar Data

Term and Condition: 29 (Project Certificate No. 008, Amendment No. 1)

References: Agnico Eagle Mines Limited – Meadowbank Division. Meadowbank Division Terrestrial Ecosystem Management Plan, Version 7 (June 2019). Agnico Eagle Mines Limited. Appendix 39, Parts 1–5, Agnico Eagle Mines Limited – Meadowbank Complex 2023 Wildlife Monitoring Summary Report Annual Report (March 2024). Nunavut Impact Review Board. Project Certificate No. 008. (March 2018). Nunavut Impact Review Board. Project Certificate No. 008, Amendment No. 001 (February 2020).

Identification of issue: Since 2018, the Proponent has been required to collect additional caribou collar data to assess Project effects on the movements of caribou under Project Certificate No. 008 (NIRB 2018, 2020). However, as noted in section 6.4 of Appendix 39, AEM last contributed to the collection of collar data in April 2018 through the deployment of 34 caribou collars (Page 6-2; AEM, 2024). Additionally, while the Proponent expresses a general intention to continue collaborating with the GN on this matter (Page 6-1; AEM, 2024), Appendix 39 lacks specific information about future collaboration, financial contributions, or in-kind support to the GN.

Importance to review and supporting rationale: Term and Condition 29 of Project Certificate No. 008 states that:

> *<u>The Proponent shall</u>, in collaboration with the Government of Nunavut, <u>collect additional caribou collar data</u> and conduct analyses of this data to quantify the zone of influence and associated effects of project components on caribou movement for a study area that includes the Whale Tail mine site, the haul road, the Meadowbank Gold Mine and its All-Weather Access Road.*

And that the objective of this term and condition is to:

To reduce uncertainty associated with the potential impacts of the Project, including the haul road, as well as of the Meadowbank Gold Mine and its All-Weather Access Road on caribou and thereby improve caribou protection measures. (NIRB 2018, 2020)

Pursuant to this term and condition, section 6.4 of Appendix 39 provides a summary of successfully deployed caribou collars since 2008 (Page 6-2; AEM, 2024). However, as indicated in this section, AEM has not deployed collars since April 2018; Instead, the GN has deployed collars in subsequent years (Page 6-2; AEM, 2024). Additionally, this section lacks any specific information regarding in-kind or financial contributions made by AEM in these subsequent years towards the collection of collar data.

Furthermore, section 6.1 of Appendix 39 states, "Agnico Eagle intends to continue collaboration with the GN DoE caribou satellite-collaring program that includes data collected within the Meadowbank Complex RSA" (Page 6-1; AEM, 2024). However, Appendix 39 does not elaborate on intended future collaboration or financial contributions to the GN pursuant to term and condition 29.

Recommendation 2: The GN recommends the following regarding the above concerns:

1. In this and future reports, AEM should provide a table summarizing, by year since 2018, the in-kind versus financial contributions made by AEM towards the collection of collar data from the caribou herds that regularly interact with the Project (i.e., Wager Bay, Lorillard, and Ahiak).

   Agnico Eagle's Response: *Agnico Eagle has contributed to regional monitoring programs through payments made as per the previous Memorandum of Understanding (MOU) between Agnico Eagle and the GN. A yearly contribution of $150,000 was made between 2017 and 2019, for the term of the MOU which was in effect for 3 years as per condition 1.1.*

2. In this and future reports, AEM should provide further details of plans to collaborate with the GN in the collection of collar data, including any planned investment of funds and in-kind resources, as well as a schedule of contributions.

   Agnico Eagle's Response: *Between 2019 and 2023, discussions took place between the GN and Agnico Eagle to reach a new agreement that would replace the previous MOU. In early 2023, Agnico Eagle and the GN signed the Data and/or Sample Sharing Agreement (DSSA) acceptable to both parties. Agnico Eagle remains available to further discuss the details of the DSSA with the GN in a meeting.*

1.3 Comparison of Road and Viewshed Surveys for Caribou

Term and Condition: 29 (Project Certificate No. 008, Amendment No. 1)

References: Agnico Eagle Mines Limited – Meadowbank Division. Meadowbank Division Terrestrial Ecosystem Management Plan, Version 7. (June 2019). Agnico Eagle Mines Limited. Appendix 39, Parts 1–5, Agnico Eagle Mines Limited – Meadowbank Complex 2023 Wildlife Monitoring Summary Report Annual Report (March 2024).

Identification of issue: Section 17.3 of Appendix 39 presents a comparison of road and viewshed surveys for caribou concluding that the former were more likely to detect caribou and result in road closure mitigation. However, in comparing the effectiveness of these two methods for detecting caribou near the Project, the analysis does not account for differences in effort (i.e., time spent looking for caribou and number of observers).

Importance to review and supporting rationale: Section 17.3 Road and Viewshed Survey Comparison of Appendix 39 presents a comparison of road and viewshed surveys for caribou. AEM's conclusions of this comparison are:

> *Overall, road surveys were conducted more frequently, were more likely to detect caribou, and were more likely to result in road closure mitigation, despite the lower average detection distance compared to viewshed surveys. It's possible that even if viewshed surveys have a further average detection distance that this does not necessarily mean that viewshed surveys have a higher probability of detection compared to road surveys. Road surveys have greater spatial coverage and had a higher percentage of surveys with caribou detections compared to viewshed surveys. (Page 17-18; AEM, 2024)*

However, the analysis presented in the report does not account for differences in survey length between the two methods (i.e., the amount of time spent looking for caribou or the number of observers). The methodology for viewshed surveys involves observers spending 10 minutes looking for wildlife at each viewpoint (Page 7-11, AEM, 2024). The length of road surveys is not specifically detailed in the report. However, Appendix 39 states that the survey vehicles move at a maximum speed of 30 km per hour (Page 3-1; AEM, 2024) and that the Whale Tail Haul Road (WTHR) is 64 km long (Page 1-3; AEM, 2024). Furthermore, the number of observers is for either survey type (i.e., road or viewshed) does not appear to be incorporated in the analysis presented in section 17.3 of Appendix 39.

Recommendation 3: The GN recommends the following regarding the above concerns:

1. In this and future reports, AEM should provide an analysis of the road and viewshed survey comparison that adjusts for length of survey and number of observers, with an explicit consideration of survey effort.

Agnico Eagle's Response: *The purpose of the comparison is to determine whether viewshed surveys are detecting caribou further as an early warning of the approach of caribou and more importantly, are useful in triggering mitigation. Viewshed surveys are designed to occur at locations of maximum viewable area. Observers spend 10 minutes searching for caribou but also record caribou incidentally while traveling between viewshed sites. Road surveys include monitoring while driving so any unique location along Mine roads is monitored for a few minutes given vehicle speed. Agnico Eagle believes that the differences in spatial coverage and observer effort are negligeable given the differences in objectives between the two survey types. The biggest difference between the monitoring methods is that they are not designed to overlap in time (i.e., occur continuously throughout year), which is an artifact of their objectives (detecting caribou before they are near the Mine roads versus monitoring caribou near the Mine roads to trigger mitigation).*

Triggering of mitigation from viewshed surveys is rare and Agnico Eagle does not believe viewshed surveys are effective or add value relative to collar information and road surveys. Agnico Eagle will continue to evaluate the usefulness of viewshed surveys with the TAG and adaptively manage this monitoring.

1.4 Helicopter Traffic Monitoring and Reporting

Term and Condition: 61 and 62(f) (Project Certificate No. 004, Amendment No. 002). 28 (Project Certificate No. 008, Amendment No. 001).

References: Agnico Eagle Mines Limited. Appendix 2, Whale Tail Update on Implementation of Commitments (March 2024). Agnico Eagle Mines Limited. Appendix 39, Parts 1-5, Agnico Eagle Mines Limited - Meadowbank Complex 2023 Wildlife Monitoring Summary Report Annual Report (March 2024). Government of Nunavut. Government of Nunavut Comments on Agnico Eagle Mines Limited's Meadowbank Gold Mine Project and Whale Tail Pit Project 2019 Annual Report (June 2020). Government of Nunavut. Government of Nunavut Comments on Agnico Eagle Mine's Meadowbank and Whale Tail Project 2020 Annual Report (June 2021). Government of Nunavut. Government of Nunavut Comments on Agnico Eagle Mine's Meadowbank and Whale Tail Project 2021 Annual Report (June 2022). Government of Nunavut. Government of Nunavut Comments on Agnico Eagle's Meadowbank Complex 2022 Annual Report (June 2023). Nunavut Impact Review Board. Project Certificate No. 004, Amendment No. 002 (August 2016). Nunavut Impact Review Board. Project Certificate No. 008 (March 2018). Nunavut Impact Review Board. Project Certificate No. 008, Amendment No. 001 (February 2020). Nunavut Impact Review Board. 2019-2020 Annual Monitoring Report Meadowbank Gold Mine and Whale Tail Pit Projects. Agnico Eagle Mines Limited NIRB File Nos. 03MN107 & 16MN056 (December 2020). Nunavut Impact Review Board. Exhibit No: 21 Agnico Eagle Terrestrial Environment Commitments. Public Hearing for Whale Tail Pit and Haul Road - Meadowbank Gold Project (September 2017).

Identification of issue: Aircraft activity, including helicopter flights, are recognized as a potential source of disturbance for a variety of wildlife. Appendix 39 illustrates improvements in the Proponent's helicopter reporting, which address many of the comments made by the GN in previous years (GN, 2020-2023).

Despite these efforts, the GN maintains concerns regarding the potential impacts of flights operating below prescribed minimum altitudes (e.g., as detailed in Section 4.5.9 of Appendix 39). The GN requests that the Proponent provides additional justification for definitions concerning short-range and long-range flights, justification (as required by relevant laws and regulations where applicable) for the use of low-level flights for certain project activities (e.g., slinging) and ensure pilots provide an explanation for each low-level flight.

Importance to review and supporting rationale: During the NIRB's review of the Whale Tail Pit and Haul Road Project, the Proponent made the following commitments to the GN concerning helicopter traffic and monitoring:

> *26. Helicopter – Distance buffers for caribou*
> *The Proponent shall apply mandatory, minimum distance buffers of 300m vertically and 1000m horizontally for the operational of all helicopters and fixed winged aircraft in proximity to caribou, subject to exception for safety considerations or the fulfillment of regulatory compliance activities only.*
>
> *27. Helicopter – Distance buffers for landing and take offs*
> *The Proponent shall apply the mandatory, minimum distance buffers to landings and take-offs of helicopters, such that engine starts and takeoffs are suspended when caribou are observed within the buffer distance.*
>
> *28. Helicopter – Monitor traffic*
> *The Proponent shall revise the Project's TEMP to include a program to monitor and report helicopter traffic associated with the Whale Tail project (including existing Meadowbank infrastructure) and all associated exploration activities so that the spatial scale and intensity of this activity can be documented. This should include the collection and analysis of GPS track logs for all helicopter flights contracted by the Proponent. (NIRB, 2017)*

Concerning the above, Term and Condition 28 of Project Certificate No. 008 of the Whale Tail Pit Project states:

> *The Proponent shall maintain a Terrestrial Ecosystem Management Plan (TEMP) throughout all phases of the Project. The Plan shall include detailed monitoring mitigation, and adaptive*

management measures for wildlife, with consideration for each Project activity predicted to affect wildlife, and with inclusion of specific triggers for mitigation and adaptive management intervention. The TEMP shall demonstrate consideration for all relevant commitments made by the Proponent throughout the Nunavut Impact Review Board's review of the Project… (NIRB, 2018)

In its review of the Project's annual report for 2019, the GN expressed concerns that the TEMP, despite the production of various drafts, had not been revised to include a helicopter monitoring program and that helicopter traffic was not being recorded in annual reports by the Proponent (GN, 2020). In December 2020, the NIRB directed the Proponent to work with the GN and the Terrestrial Advisory Group (TAG) as per Term and Condition 27 and 28 of the Project Certificate No. 008 to revise its TEMP (NIRB, 2020). The GN notes that in annual reports from 2020-2023, the Proponent has provided some of the information requested in the above commitments and the GN's past annual report comments concerning helicopter traffic (GN, 2020-2023). However, as indicated Appendix 2 – Whale Tail Update on Implementation of Commitments, the TEMP update is ongoing, and the Proponent has plans to submit this document in 2024 (Page 5).

Despite the absence of an updated TEMP which clearly outlines helicopter monitoring and reporting, the Proponent summarizes the specific flight restrictions pertaining to helicopters used in Project operations and activities in Section 4.5.9 of Appendix 39:

- *Long-range flights are a minimum of 650 m above ground level, except for take-off and landings.*
- *Short-range flights are a minimum of 300 m above ground level, except for take-off and landings.*
- *Notification of caribou, muskox or other wildlife sightings within 1 km of the helicopter pad.*
- *Caribou groups of 50 or more animals, and muskoxen of 10 or more animals must be avoided by a minimum of 1,000 m vertically and 1,500 m horizontally. Flocks of migratory birds must be avoided by 1,100 m vertically and 1,500 m horizontally. Flying over known raptor nests will be avoided.*
- *Harassing wildlife (flying below 300 m) is expressly forbidden unless animals pose an immediate danger to humans. (Page 82)*

Definition for Long-range and Short-range Flights

In the GN's previous annual report comment for the Project (GN, 2023), the GN noted that definitions for long-range or short-range flights were absent in the Project's 2022 reporting materials. As a result, the GN recommended that the Project's TAG should be engaged to develop the definition for long-range and short-range flights. Additionally, the GN recommended that short-range flights be defined as flights of 5 km or less (GN, 2023).

In Appendix 39, the Proponent has provided a definition for long-range and short-range flights, stating that:

> *…flights were classified as short- or long-range by calculating the maximum distance spanned during an individual flight leg…If this distance was <25 km, the flight was classified as short-range. Flights with longer flight spans were classified as long range...* (Page 83)

As demonstrated above, the Proponent's implemented definition for short-range flights is significantly different from the GN's recommended definition. As such, the GN requests justification for the Proponent's use of <25 km as a threshold to define short-range flights. Additionally, the GN requests clarity on when the TAG was engaged to determine these definitions.

Justification for Flights below Mandatory Minimum Altitudes

Appendix 39 provides limited justification for flights occurring below the mandatory minimum altitudes:

> *…certain activities are required to be completed at lower altitudes than specified in the air traffic management plan. External load operations (equipment/material slinging), site inspections, reconnaissance and environmental surveys often require lower flight. Flights with these purposes have been considered permissible for low flight. Similarly, flights lower than 300 m have been considered permissible when flying low due to low visibility (poor weather conditions) or for emergency medevac services...* (Page 82)

Generally, more justification for flying below mandatory minimum altitudes is required. In reporting helicopter traffic, AEM should distinguish between flights where low-level flying is required by law, regulations, safety, or the performance of environmental monitoring required under the Project Certificate versus flights where low level flying was the preferred means of flying (but not required by statute, regulation, or Project Certificate). For example, the Proponent characterizes external load operations (equipment/material slinging) as permissible for low-altitude flights. However, the Proponent does not reference specific law or regulations that illustrate the requirement for low-altitude flights with external loads.

Furthermore, the GN notes that some justification included in the annual flight records fails to provide sufficient context or clarity to the reader. For example, one flight leg (Flight Report Number 600303) states "Road Survey" as the justification for a flight with a mean height above ground of 157.4 m. No further context is provided in the annual flight record tables or in section 4.5.9. Additionally, "Environmental Survey" is used as the comment justification for 15 flight legs that occurred below the minimum height requirement. While it is likely that these environmental surveys correspond to the helicopter surveys conducted under the Arctic Raptor program (this program involved two helicopter surveys; 23–28 May and 09-12 August 2023; Appendix 39, Part 6), reference to the specific environmental program(s) these environmental surveys correspond to is not detailed within these above-mentioned tables or in section 4.5.9. Including this information in future reports would improve transparency for reviewers.

In addition to the limited justification for flights occurring below mandatory minimums, the GN is concerned with the occurrence of low flights that do not provide any justification for the purpose of low flights (recorded at the time of the flight). The GN acknowledges that pilots were instructed to begin adding comments to record the reason for low flights beginning on July 28, 2023 (Appendix 39, Part 2; Page 6). However, of the 294 short-range flight legs occurring after this period, 57.1% operated below the minimum height requirement (300 m above ground), without documentation of the purpose of low flight. The mean height above ground for short-range flight legs during this period ranged from 34.1–299.6 m. Additionally, of the 81 long-range flight legs occurring after this period, 58% operated below the minimum height requirement (650 m above ground), without documentation of the purpose of low flight. The mean height above ground for long-range flight legs during this period ranged from 109–454.1m.

Missing or Unclear Data

The GN identified approximately 29 short-range flight legs (23 for slinging and 6 for Passenger), in the data provided where the Proponent did not provide a value for mean height above ground. Instead, the text "full flight too low to distinguish from takeoff/landing," was provided.

Additionally, the GN notes that one flight leg (Flight Report Number 321928) that occurred on April 10, 2023, lists "Wildlife" as both a Flight Code and Flight Type. This flight leg, while not occurring below the minimum height requirement, lists "Environmental Survey" as the justification for a low flight. Based on the materials reviewed, the wildlife survey associated with this flight leg was unclear.

Recommendation 4: The GN recommends the following regarding the above concerns:

1. Provide justification for the Proponent's implemented definition for short-range flights as it significantly differs from the GN's recommended definition.

   Agnico Eagle's Response: *When flight leg data were examined by distance flown, there were very few flights with a distance under 5 km (37 of 656 flight legs; average flight time of 6 mins). This is mostly by design of the site/area and general helicopter use requirements. Meadowbank and Vault are 6.2 km apart, whereas Meadowbank and Whale Tail are 47.8 km apart. When looking at the distribution of flights for analysis, it was clear that 5 km was an unrealistic starting point to distinguish flights within a smaller vicinity versus those that were travelling large distances, largely because these flights averaged 6 minutes including takeoff and landing. Because locations across the site are much further apart than 5 km and less than 5% of flights were under 5 km, a 5 km breakpoint would set unrealistic long-range flight minimums on shorter duration flights.*

Additionally, many of the flights taking place in a smaller area were slinging flights, which included many trips back and forth between the same two locations. Marking these flights as long distance (because their total distance flown was high) would look counterintuitive on a map and would likely be confusing to a reader. A break point was chosen based on the distribution of flight lengths in a way that was most likely to make logical sense to a reader and provide a starting point for a conversation to define short-range flights later at a TAG meeting. Short-range flights as currently defined allowed the flights to be distinguished between flights that were staying in and around one area of work (e.g. within 25 km of Meadowbank Mine or within 25 km of Whale Tail Mine) but not moving long distances between areas (e.g. from Meadowbank to Whale Tail, from Meadowbank to Meliadine, or completing surveys over large areas).

2. Provide clarity on how the TAG was engaged to determine the definitions of long-range and short-range flights.

   Agnico Eagle's Response: *The priority of TAG discussions over the last year has been on effective caribou mitigation measures, notably, the application of lead caribou monitoring and triggers for migration. Agnico Eagle intends to include discussion of long-range and short-range flights at future TAG meetings.*

3. Ensure that pilots provide justification for all low-level flights at their occurrence so that this information is included in annual report tables (e.g., information in "Comment Justification for Low Flight") to minimize data gaps.

   Agnico Eagle's Response: *Agnico Eagle will continue to work with helicopter contractors and pilots to improve the recording of flight information.*

4. Cite any relevant laws, regulations or project monitoring requirements for flight legs occurring below minimum flight altitude, with specific attention to external load operations (equipment/material slinging).

   Agnico Eagle's Response: *Aviation regulations are mostly governed by the Canadian Aviation Regulations (CAR), as well as each individual operator's Air Operator Certificate (AOC). The contractor Agnico Eagle retained to operate helicopters around its project require the type of helicopter used to be operated under Visual Flight Rules (VFR) only. The flight requirements for VFR can be found in the Canadian Aviation Regulations under section 602.114 & 602.115. Additionally, practical operational considerations suggest maintaining a lower altitude for several reasons:*

Complexities of External Load Operations*: The dynamics of the load, such as its flight characteristics and the potential for shifting, necessitate the ability to conduct a preemptive emergency landing. Being closer to the ground allows the pilot to land quickly if the load becomes unstable, minimizing the risk of total load loss.*

Situational Awareness in Low Visibility*: Staying closer to the ground helps maintain situational awareness, especially in flat light or whiteout conditions. This proximity to the ground provides better vertical reference, which is crucial if the pilot encounters Inadvertent Instrument Meteorological Conditions (IIMC). In such cases, executing a coordinated 180-degree turn to exit the conditions and regain visual contact with the ground is more feasible when flying at lower altitudes. Performing such maneuvers with an external load is challenging with the instrumentation available in VFR helicopters.*

As per Nunavut Water Licenses 2AM-MEA-1530 & 2AM-WTP-1830, the Meadowbank Freshet Action Plan and the Whale Tail Freshet Action Plan, Agnico Eagle is responsible for sediment and erosion monitoring and implementation measures. Aerial surveys are used to effectively monitor the entire project (roads and mine sites). During these surveys, periods of low flight altitude are required to monitor water crossings, shoreline erosion, and sediment transportation. These surveys are complementary to other monitoring measures in place.

During the Whale Tail NIRB process, the GN disputed claims made by Agnico Eagle regarding Project impact on raptors. The GN stated the current study design did not allow for adequate detection of project related impacts. To resolve this issue, an updated monitoring raptor monitoring program was initiated. Starting in 2021, Agnico Eagle has been conducting broad-scale helicopter surveys, (up to 25km away from the mine-site) to meet the TEMP objective of estimating the Project-related impacts to raptors. The nature of these broad-scale survey requires low-altitude flights.

5. Ensure that numerical data, detailing the mean height above ground, is provided for each flight leg.

Agnico Eagle's Response: *Agnico Eagle continues to work with helicopter contractors and pilots to improve the recording of flight information. Additionally, mean height above ground was provided for each flight in Appendix E of the 2023 Wildlife Monitoring Summary Report.*

6. Ensure that any flights that occur for the purpose of environmental surveys are clearly linked to their specific research program.

Agnico Eagle's Response: *Agnico Eagle will continue to work with helicopter contractors and pilots to improve recording of flight information. For flights completed during 2023 related to* *environmental monitoring, links to specific research programs were included in Appendix E of the 2023 Wildlife Monitoring Summary Report. Refer to 1.4.4 for more information.*

1.5 Spills Reporting – Coolants

Term and Condition: 26 (Project Certificate No. 004, Amendment No. 001).

References: Agnico Eagle Mines Limited: Meadowbank Complex. Meadowbank Complex 2023 Annual Report 61-000-100-REP-006. (March 2024). Government of Nunavut, Department of Environment, Environmental Protection Division. Environmental Guideline: General Management of Special and Hazardous Waste. (March 2023) https://www.gov.nu.ca/sites/default/files/publications/2024-05/Hazardous%20Waste%202023-03.pdf

Identification of issue: The GN appreciates the Proponent's efforts to include detailed information on all spills in Section 7. Spill Management, of the Meadowbank Complex 2023 Annual Report (Annual Report) (AEM, 2024). However, tables 7-3–7-5 indicated several spills involved an unspecified "coolant" by the Proponent. In the absence of information about the specific type of coolant(s) involved, the GN wishes to note that some coolants, particularly ethylene glycol, can be highly toxic and attractive to wildlife. As such, spills of ethylene glycol can pose a risk to wildlife that come into contact with contaminated soil or water.

Importance to review and supporting rationale: Section 7. Spill Management of the Annual Report (AEM, 2024) provides information regarding all reportable spills and non-reportable spills that occurred at the Meadowbank Site and Whale Tail Site in 2023. This section of the Annual Report indicates that 37 reportable spills occurred in 2023 and that these spills were reported to the GN; additionally, this section indicates that 151 non-reportable spills occurred in 2023. Summary details for both spill types (i.e., reportable and non-reportable) are provided in tables 7-2–7-5 of the Annual Report.

While the GN appreciates the Proponent's efforts to include detailed information on all spills in annual reports, the GN notes that tables 7-3–7-5 indicated several spills involved and unspecified coolant by the Proponent. In the absence of information about the specific type of coolant(s) involved, the GN wishes to note that some coolants, particularly ethylene glycol, can be highly toxic and attractive to wildlife (GN, 2023).

Recommendation 5: The GN recommends the following regarding the above concerns:

1. In this and future annual reports, the Proponent specify the type of coolant(s) involved in Project activities and spills.

<u>Agnico Eagle's Response:</u> *Agnico Eagle acknowledges the GN's comments and will provide more details regarding the specific type of coolant used on site for any reportable spill and/or reportable spill follow up.*

2. If and where applicable to this Project, the GN recommends using less toxic propylene glycol instead of ethylene glycol.

   <u>Agnico Eagle's Response:</u> *Agnico Eagle acknowledges the GN's comment and will continue to look for alternatives to ethylene glycol. Due to the harsh environmental conditions during winter, the use of ethylene glycol on equipment is a manufacturing requirement to maintain and ensure optimal operating performance and prevent equipment breakdown.*

1.6 Gender analysis of Meadowbank and Whale Tail 2023 Annual Report

References: Appendix 47, Kivalliq Projects 2023 Socio-Economic Monitoring Program Report. Aglu Consulting Ltd. (2023), Barrier to Employment of Inuit Women, Interim Report. Inuit Workforce Barriers Strategy (IWBS) Study.

Summary of Compliance: Appendix 47, Kivalliq Project 2023 Socio-Economic Monitoring Program Report, contains a gender analysis of the mine's employees. In response to this study's findings, the Proponent indicated that it has developed and implemented strategies and programs intended to increase the percentage of female employees at the mine.

Comments and supporting rationale: Several gender specific barriers identified in the report, such as sexual behaviour, sexual harassment, pregnancy, are linked to family-community-workplace interaction (organizational). In 2018, an Inuit Workforce Barriers Strategy (IWBS) Study identified many of these barriers.

While many of the barriers identified in the study "*Barrier to Employment of Inuit Women*" were examined in the context of whole group of young workers, the report states that largely young workers with young families face significant challenges adhering to rotational work schedules when combined with a severe shortage of daycare options. Inference can be made that a large percentage of the young-worker group facing this type of challenges are likely females.

According to the latest StatsCan census (2021), the growth rate for females in Nunavut is faster than that of males, and different studies have demonstrated that women's participation in Canada's economy is also increasing. So, implementing effectives strategies to fight the barriers women face at work will positively impacts the Inuit employment rate and their contribution to the local economy.

Unfortunately, Appendix 47, 2023 Annual Report, page 23, showed that female employees working directly for Agnico Eagle, and contractors decreased at Meadowbank/Whale Tail. At the same time, the report notes that AEM has designed and implemented different programs, intended to increase the female employment rate at the mine.

Recommendation 6: The GN recommends the following regarding the above concerns:

1. Given that those programs seem to have had less than consistent impact on increasing the female employment rate at the mine thus far, can AEM comment on any modifications it is contemplating for the programs and/or follow-up initiatives it intends to implement in both the short-term and long-term to increase the employment rate of females at the mine?

   Agnico Eagle's Response: *It's important to note the time lapse between the initial 2019 IWBS and the most recent one from 2023. As noted in the 2019 study, the employment situation in the region was greatly impacted between 2020 and 2022. The primary focus was on safely bringing back the workforce to the various sites for the benefit of both the workers themselves and the surrounding communities.*

   Following the return to work of all Nunavummiut, the Employment and Culture Committee (ECC), which comprises representatives from both Agnico Eagle and the Kivalliq Inuit Association, decided to update the 2019 version. The final 2023 version was completed and distributed in December 2023, which limited the opportunities to address the context and situation observed in the 2023 Annual Report.

   The most recent update of the 2023 IWBS allows Agnico Eagle to address the industry-specific barriers most commonly observed at our mine sites. To ensure attention is paid to gender-specific barriers, all barriers to Inuit women are clearly identified in the study. At the time of writing this response, barriers specific to Inuit women are being assessed within the objective of developing action plans. For example, some of these identified barriers include gender-based bias and differences in the workplace, and challenges with mining specific working conditions and expectations.

1.7 Employment and Turnover analysis of Meadowbank and Whale Tail 2023 Annual Report

References: Appendix 47, Kivalliq Projects 2023 Socio-Economic Monitoring Program Report. Vanclay F. (2003). International Principles for Social Impact Assessment. Inuit Workforce Barriers Strategy (IWBS) Study.

Summary of Compliance: Appendix 47 data related to employment shows an overall fluctuation in Inuit employment, and high turnover rate among the Inuit employees at the mine.

Comments and supporting rationale: EDT has concerns about the trends observed for the following employment-related indicators: Inuit employment rate, Full-Time Equivalent (FTE) and Resignation/Voluntary termination at both sites.

Appendix 47 (page 9), "Kivalliq Projects 2023 Socio-Economic Monitoring Program Report," mention a 13% decline in Inuit employment rate at Meadowbank and Whale Tale compared to the previous year.

Page 14, Appendix 47, Meadowbank / Whale Tail, shows that Inuit full-time Equivalent (FTE) comprised 16% of the total employee base in 2023, down from 18% in 2022. For contractors, Inuit FTEs were at 3% of total FTEs in 2022 and 2023, respectively.

Resignation / Voluntary termination rate for Inuit employees over the years has always been higher than that of non-Inuit employees. In 2019 Resignation / Voluntary Termination were 77 out of 145 and in 2023 the number of Resignation / Voluntary Termination was 53 out of a total of 77. Note that the percentage of Resignation / Voluntary Termination represents a higher percentage now than in 2019.

The above-mentioned trends for the indicators above are consistent for the years as illustrated on Chart 8, Appendix 47 (page 20), despite different training or programs AEM developed to support Inuit employment.

Recommendation 7: The GN recommends the following regarding the above concerns:

1. Given the current strategy implemented to support Inuit employment, can AEM provide an assessment of whether the strategy is working as intended?

   Agnico Eagle's Response: *Agnico Eagle will seek to provide an assessment on employment strategy. It is important to note that Inuit workforce returned to work in 2022, and that 2023 is the new baseline year (12 full months) of Inuit and Nunavummiut at work – post pandemic. Multiple year's reference will support a more in-depth analysis of our strategies.*

2. When graphs for Meadowbank, Whale Tail, and Meliadine are superimposed, 2020 showed a decline in Inuit employee turnover rate on these mines. Can AEM explain the reasons behind this simultaneous change at all its Kivalliq sites?

   Agnico Eagle's Response: *The main explanations and assumptions that Agnico Eagle can draw from the formulated recommendations are linked with the impacts and effects of Covid-19 in early 2020.*

The decision was made to send all Nunavummiut employees (from all Kivalliq mine sites) home in order to limit any health risks for the surrounding communities. During the years when all Nunavummiut employees were at home and being paid 75% of their salary, there was limited turnover.

2 Fisheries and Oceans Canada (DFO)

2.1 Effects Monitoring

2.1.1 Fish passage at road crossings

References: Appendix 7: Meadowbank and Whale Tail 2023 Annual Geotechnical Inspection; Appendix 10 - Meadowbank and Whale Tail 2023 Annual Geotechnical Recommendation Implementation Plan; Appendix 31: Whale Tail 2023 Report on the Implementation of Measures to Avoid and Mitigate Serious Harm.

Comment: Culverts crossing fish bearing waters along the AWAR and WTHR requiring repair maintenance. The annual report does not identify issues with culverts affecting fish passage. The annual report does not provide a plan for repair/replacement. This was a commitment made by the proponent in response to comments on the 2022 Annual Report.

Appendix 10 - Meadowbank and Whale Tail 2023 Annual Geotechnical Recommendation Implementation Plan; states that along the AWAR "Close monitoring of the culverts will be performed by AEM at freshet…" which has "not started."

Recommendation 1: Proponent to provide a list of culverts along the WTHR and AWAR which cross fish bearing waters and if these require repair or replacement. Proponent to provide a plan for repair or replacement of damaged and obstructed culverts prioritizing repairs to culverts with potential to affect fish passage and those affecting fish and fish habitat.

Agnico Eagle's Response: *Agnico Eagle provided to DFO in 2023, a detailed list of all culverts along both roads for that are considered fish bearing.*

Agnico Eagle hired a subject matter expert to perform culvert stream assessment along the WTHR and AWAR. Field work took place at freshet 2024 and the conclusion of the assessment will be available later in 2024. Agnico Eagle will ensure to contact and collaborate with DFO once the conclusions of the assessment are available and will discuss any further actions, as needed.

Obstructed and damaged culverts are listed in the Annual Geotechnical Inspection Report. It will be specified into the 2024 Annual Geotechnical Inspection report if the culvert is fish bearing. As per *this report, if insufficient capacity to handle the flow is observed at locations where culverts are obstructed or damaged, Agnico Eagle will implement a plan to clear the obstruction, repair or replace the culvert. No issues with the capacity to handle the flow has been observed where the culverts are damaged or obstructed during freshet 2023.*

2.1.2 Location Data of Shipping Vessels

References: Appendix 32: Meadowbank and Whale Tail 2023 Marine Mammal and Seabird Report, 2023

Comment: Project Certificates 004, 006, and 008 require vessels supplying the Meadowbank Complex and Meliadine mines to avoid sensitive marine mammal and seabird habitats such as haul-outs and breeding colonies.

Ongoing outages for location data of ships continue to have ongoing Automatic Identification System issues lasting 12 hours or more between fixes.

The 2023 Annual Report did not contain the vessel tracking data, so it is uncertain if this issue persists.

Recommendation 2:

1- Proponent to provide additional details on any additional effort being implemented to ensure accurate vessel tracks, and compliance with setbacks from sensitive habitats.
2- Proponent to provide a summary of satellite outages and missing location data for 2023 shipping.

Agnico Eagle's Response: *As per Agnico Eagle's response to the 2022 Annual Report Comments and as reported in the 2023 Marine Mammal and Seabird Annual Report, Agnico Eagle acquires archived AIS data from Vesseltracker, a commercial AIS supplier that aggregates AIS data from satellite and shore-based stations. These data vary in frequency based on distance from shore, location of shore-based stations, and position of satellites. In some cases, AIS position data is available on an hourly or sub-hourly basis, but in other cases, position data can be 12 hours or more between fixes, due to the scarcity of satellites over remote areas such as the Arctic. As the position data is one fixed point in time using satellite AIS data, it is not possible to summarize "outages", but can provide a summary on the frequency of location fixes. Agnico Eagle has reviewed the location data for the 11 vessels (23 inbound trips) from 2023 to provide a summary of these gaps in location data, provided below:*

- *In total, the 2023 data contained 1,961 location fixes over the 23 trips.*
- *There was an average of 85 location fixes per journey, with a range of 26 to 255.*
- *Excluding location fixes when the vessels were anchored, and only considering the vessel tracks while underway, there was an average of 22 fixes per journey, ranging from 5 to 82.*

- *The total time vessels spent in the study area averaged 21 days (often times anchored for long periods of time), ranging from 8 to 80 days, with the average number of locations fixes per day ranging among vessels from 1.8 to 5.9 (minimum of 1 and maximum of 13).*

The frequency of fixes is beyond the control of Agnico Eagle, as it is often due to a "gap" in satellite availability over the location of the vessel in the Arctic at the time. As reported in the 2023 Marine Mammal and Seabird Annual Report, where AIS data was recorded frequently (every hour), vessel tracks avoided the setback areas. However, in some cases, the AIS data was recorded less frequently (every 6 to 12 hours). For example, during a vessel trip by the Marlin Hestia in September, no positions were recorded over two days between September 16 and September 18; therefore, the vessel track appears as a straight line going directly across Coats Island, while in fact the vessel traveled south of Coats Island, after confirming this information with the vessel captain. In October, the Kivalliq W. appears to cross over Southampton Island, as no positions were recorded over 24 hours, and the vessel made a stop in the community of Coral Harbour. Due to the poor resolution of these data, information (e.g., route, setbacks) regarding these trips cannot be extrapolated with confidence.

In all cases where it appears that vessels may have intersected setbacks, Agnico Eagle investigates the point locations further, as per Section 3.1.1 of the Marine Mammal and Seabird Annual Report. In 2023, it was noted that the same vessel entered the 2 km Marble Island buffer on two occasions (once in August, and once in October). Prior to the 2024 shipping season, vessel captains were reminded of the importance of maintaining a 2 km buffer around Marble Island.

Agnico Eagle continues to investigate alternative commercial AIS suppliers regularly; however, Vesseltracker remains the most reliable in the Arctic at this time. Agnico Eagle continues to train contracted shipping companies regularly and to remind them of the importance of maintaining sensitive habitat buffers. Meetings take place prior to the start of the shipping season and throughout the season each year, during which the mitigation measures and shipping requirements are discussed. A post-mortem meeting is also conducted after the shipping season is completed.

2.1.3 Marine Mammal Monitoring Program

References: Appendix 32: Meadowbank and Whale Tail 2023 Marine Mammal and Seabird Report, 2023

Comment: Current Marine Mammal Monitoring survey efforts (1 survey per day, lasting 1.5-2 hours) are not sufficient for effective marine mammal monitoring

Recommendation 3: DFO to work with the proponent to update their marine mammal monitoring protocol and include increased monitoring efforts.

Agnico Eagle's Response: *Agnico Eagle thanks DFO for their comment and wishes to reiterate that Agnico Eagle is operating as per its approved Shipping Management Plan and Marine Mammal Monitoring Protocol.*

As per Agnico Eagle's responses to the 2022 Annual Report Comments and as mentioned in the 2023 Annual Report, the protocol is for a dedicated MMSO to complete a minimum of one survey per day, however two or three surveys daily is preferred when timing allows, with each marine mammal survey lasting for a minimum of 1.5 hours to not more than two hours to mitigate observer fatigue and eyestrain. The marine mammal monitoring program is well implemented, with more than one dedicated marine mammal survey per day being frequently conducted during shipping.

In addition, crew members are always scanning for marine mammals. If a marine mammal is observed during the voyage outside of the dedicated marine mammal observation period (i.e., off-effort), this is recorded as an incidental sighting, and any mitigation required to avoid marine mammals during shipping is recorded and reported in the annual report.

Further and as reported in previous Marine Mammal and Seabird Annual Report reports, no interactions (e.g., strikes) between vessels and marine mammals or seabirds were recorded by the shipping compagnies in 2023 or in previous years, demonstrating the current monitoring program is adequate to prevent interactions with wildlife.

Agnico Eagle is available to discuss with DFO at their convenience.

2.1.4 Aquatic Invasive Species

References: Shipping Management Plan (Version 4)

Comment: Current monitoring plans do not include a monitoring program for aquatic invasive species. There is a risk of introducing aquatic invasive species through haul contamination from ships coming from Quebec. The Shipping Management Plan requires the shipping companies contracted to supply the mine though the annual sea-lift operations to comply with the Ballast Water Regulations, which reduces the risk of invasive species being introduced as a result of shipping activities but does not eliminate this risk so that monitoring for the occurrence of aquatic invasive species is required to confirm this.

Recommendation 4:

1- Proponent to consider a non-Indigenous Species/Aquatic Invasive Species Monitoring Program around zones of higher risk.

2- Proponent to provide specific monitoring and mitigation measure that are being conducted, including but not limited to any ballast water treatment, monitoring for aquatic invasive species, any haul clean-up and maintenance protocols, etc.

Agnico Eagle's Response: *As per Agnico Eagle's response to DFO's comment on the 2022 Annual Report, Agnico Eagle contracts shipping compagnies that comply with all applicable regulations, including the Ballast Water Regulations, which reduces the risk of invasive species being introduced as a result of mine related shipping activities.*

Under the Ballast Water Regulations, all vessels are required to have a Ballast Water Management Plan. The Ballast Water Management Plan is written in accordance with the requirements of Regulation B-1 of the International Convention for the Control and Management of Vessels' Ballast Water and Sediments and aims to prevent, minimize, and ultimately eliminate the risk of introducing harmful aquatic organisms and pathogens from vessels' ballast water and associated sediments, while protecting vessel's safety.

Agnico Eagle contracts Transport Canada certified shipping companies that are using standard and acceptable practices common for all vessels in the Canadian Arctic, complying with the requirements and shipping regulations related to the concerns DFO has expressed, including Project Certificate Terms and Conditions, the Shipping Act, the and the Ballast Water Regulations. Agnico Eagle feels this issue is resolved.

2.1.5 Underwater Noise

References: Shipping Management Plan (Version 4)

Comment: Underwater noise from shipping vessels has the potential to elicit disturbance effects on marine mammals by reducing their ability to travel, communicate, and find food.

During the 2023 shipping season, 23 vessel trips served the project. We currently do not know what noise level and characteristic is produced by those shipping vessels and the potential impact on marine mammals.

The FEIS predicted the residual environmental effect of a change in marine mammal behaviour as a result of Project vessel noise was considered to be low in magnitude, however the likelihood of behavioural disturbance from Project related vessel noise was considered likely. However, there is no monitoring of noise levels to help understand and mitigate these effects.

Recommendation 5: DFO to work with the Proponent to monitor and model their noise footprint using expert support. This model should aim at evaluating the impact of shipping noise on marine mammals present on the shipping route. A Shipping Management Plan should be updated according to the model.

> ***Agnico Eagle's Response:*** *Agnico Eagle would like to note that discussion was already initiated between Agnico Eagle and DFO on the topic of underwater noise monitoring.*
>
> *As previously communicated to DFO, Agnico Eagle is willing to participate in a committee led by DFO and including all relevant stakeholders involved with shipping activities in Nunavut.*

2.2 Compliance Monitoring

Provide a summary of any compliance monitoring and/or site inspections undertaken in association with the Project, including specifically

i. Identify the Terms and Conditions from the Project Certificate which have been incorporated into any permits, certificates, licenses or other approvals issued for the Project, where applicable;

   For Project Certificate No. 004 Amendment 3, Terms and Conditions 30, 31, 46, 47, 49, 50, 53, 85 were incorporated into Fisheries Act Authorizations

   For Project Certificate No. 008 Amendment 1, Terms and Conditions 19, 20, 21, 22, 23, 24, 46, 47, 50, 51 and 52 were incorporated into Fisheries Act Authorizations.

ii. A summary of any inspections conducted during the 2023 reporting period, and the results of these inspections:

   No compliance monitoring or site visits/inspections were conducted by DFO in 2023.

iii. A summary of Agnico Eagle's compliance status with regard to authorizations that have been issued for the Project.

   The proponent is largely compliant with the terms and conditions that pertain to DFO's mandate. DFO will continue to work with the proponent to ensure compliance.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges DFO's assessment of the 2023 compliance.*

3 Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)

3.1 Closure Planning

References: 2023 Annual Report: Section 9. NIRB Project Certificate No. 004, Amendment No. 003: Term & Condition 78, 79, and 80. NIRB Project Certificate No. 008, Amendment No. 001: Term & Condition 7 and 13

Background/Rationale: Section 9 of the 2023 Annual Report provides high-level discussion related to the closure planning and implementation processes. For example, the section describes the state of the closure planning process, ongoing studies, information gaps, and progressive reclamation. While CIRNAC appreciates receiving this information, the Department has a wide range of questions and comments regarding the closure planning process for the Meadowbank and Whale Tail sites, including issues related to:

- Freeze-back and capping thickness;
- Progressive reclamation;
- Results of thermistor measurements for tailings and waste rock storage facilities (WRSF);
- Meadowbank water treatment requirements;
- Meadowbank WRSF seepage quality;
- Meadowbank post-closure in-pit water quality;
- Meadowbank in-pit tailings covers;
- Thermal performance of Meadowbank WRSF covers; and
- Whale Tail Project post-closure water quality.

These questions and comments have been submitted in prior annual report reviews conducted by CIRNAC and are pending resolution, as summarized in Table A. While these questions and comments could be deferred until the submission of formal closure planning documents (e.g., periodic, updated Interim Closure and Reclamation Plans (ICRPs) and security estimates), CIRNAC is of the view that a more active dialogue on closure planning is required. This is particularly important for the Meadowbank and Whale Tail Projects, considering that active closure is currently scheduled to begin by 2026. Taking into consideration that relatively limited time remains before the implementation of closure, additional and regular dialogue between AEM, regulators, and interested parties would be beneficial. This would also help facilitate reaching technically sound closure and reclamation decisions in a timely manner.

Recommendation 1: CIRNAC recommends that AEM convene an annual workshop with regulators and interested parties to discuss the status of closure planning for the Meadowbank and Whale Tail Mines. The overall goal of the workshop is to ensure that all organizations, including AEM, are fully informed of closure requirements and to proactively identify key issues that need to be resolved on a priority basis.

This process will also facilitate the timely design, approval, and implementation of an appropriate closure strategy for the sites.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges that active dialogue on closure planning is justified between the involved organizations and regulators. Agnico Eagle intends to continue providing updates on progressive closure work, closure planning and closure engineering concepts, for both Meadowbank and Whale Tail sites, through the Annual Report and the next version of the Closure and Reclamation Plans.*
>
> *In the next version of the Closure and Reclamation Plan, a preliminary schedule of workshops with regulators and interested parties will be presented, for the remaining part of operation until the submission of the Final Closure and Reclamation Plan. As per the Water Licenses (2AM-MEA1530 and 2AM-WTP1830), the Licensee shall submit the Final Closure and Reclamation Plan to the Board for approval at least twelve (12) months prior to the expected end of planned mining.*
>
> *Agnico Eagle believes that the responses and actions provided in regard to the previous comments from CIRNAC related to closure (Table A) were adequate as per the progress of the closure work and will be further answered as additional information related to closure becomes available from various studies and monitoring data and will be presented as part of the next Closure and Reclamation Plan.*

3.2 Water Quality Prediction Methods

References: 2023 Annual Report Appendix 13: Meadowbank Water Management Plan (Version 12). 2023 Annual Report Appendix 14: Whale Tail Water Management Plan (Version 12). CIRNAC Technical Review Comments on the 2022 Annual Report to NIRB. AEM Responses to 2022 Annual Report Review Comments. CIRNAC Technical Review Comments on the Whale Tail Pit Project Expansion Environmental Assessment (Technical Review Comment #3).

Background/Rationale: CIRNAC provided a number of recommendations related to the water quality predictions for the Meadowbank and Whale Tail Projects in its review of the 2022 Annual Report. The specific request was as follows:

"…CIRNAC recommends that AEM, on a priority basis, revisit the water quality modelling assumptions and approaches used for both Meadowbank and Whale Tail to ensure all future project decisions (particularly closure) are informed by sufficiently accurate predictions. At minimum, factors to consider when revisiting the assumptions and approaches should include:

1. *using monthly (or smaller) time steps for all model inputs instead of the current one-year time step;*

2. performing hydrodynamic modelling of receivers instead of assuming fully mixed conditions;

3. performing sensitivity analyses to accurately capture the range of uncertainty associated with water quality predictions; and

4. expanding efforts to characterize loadings from pit walls."

CIRNAC reviewed AEM's response to the above-noted recommendations and the updated water quality predictions for the Meadowbank and Whale Tail sites, as presented in Appendices 13 and 14 of the 2023 Annual Report. Based on that review, CIRNAC concludes that the status of the recommendations are as follows:

1. Unresolved – It is CIRNAC's understanding that this recommendation has not been acted on, based on the Department's review of the updated water quality predictions.

2. Unresolved – The updated water quality predictions do not include hydrodynamic modelling of water quality concentrations. Notably, the updated water quality prediction reports include statements such as: "*The present mass balance model cannot simulate the treated effluent plume discharged in Kangislulik Lake or Whale Tail South Lake. A hydrodynamic model is required to simulate the discharge of treated effluent in these lakes, which is beyond the scope of this study*."

3. Partially resolved – The updated water quality predictions include sensitivity analyses to address the implications of dry years. The predictions do not, however, address the uncertainty within a broad range of other model inputs (e.g., contaminant source terms).

4. Partially resolved – The updated water quality predictions have incorporated the most recent monitoring data from pit sumps. However, uncertainty remains with respect to loadings from pit wall seeps.

For clarity, CIRNAC is of the opinion that these unresolved concerns represent substantive deficiencies in AEM's water quality prediction methods. Collectively, there are multiple simplifying assumptions and approaches being used by AEM to predict water quality that warrant reconsideration. While CIRNAC supported using simplifying assumptions and approaches during Project approval and the initial years of operation, the Project is now at a stage that justifies the development of more refined and accurate water quality predictions. In the absence of more refined and accurate predictions, CIRNAC lacks confidence in the conclusions reached by AEM that the project will not result in significant adverse impacts in the future.

To address the unresolved and partially resolved items noted above, the following recommendation reiterates prior requests from CIRNAC. Please refer to CIRNAC #8 in the 2022 Annual Report for additional details on the rationale for the request.

Recommendation 2: CIRNAC recommends that AEM revisit the water quality modelling assumptions and approaches used for both Meadowbank and Whale Tail to ensure that all future Project decisions, particularly those related to closure, are informed by sufficiently accurate predictions. At a minimum, factors to consider when revisiting the assumptions and approaches include the following:

a) Using monthly (or smaller) time steps for all model inputs instead of the current one-year time step;
b) Performing hydrodynamic modelling of receivers instead of assuming fully mixed conditions;
c) Performing sensitivity analyses to accurately capture the range of uncertainty associated with water quality predictions; and
d) Expanding efforts to characterize loadings from pit walls.

Agnico Eagle's Response: *Agnico Eagle appreciates CIRNAC's recommendations regarding the water quality modelling approach and assumptions for Meadowbank and Whale Tail. As closure approaches, new mandates to further refine our water quality forecasting have been initiated. These new models integrate recommendations a), c), and d) (monthly time steps for all model inputs, sensitivity analyses, and characterizing pit wall loadings), and will be gradually included in the 2024 and 2025 Annual Report. Agnico Eagle would like to note the current water quality model does account for pit wall loadings within the source terms and work is ongoing since 2022 to collect additional in-situ water quality data from the walls at Whale Tail Pit and IVR Pit to integrate in the water quality modelling.*

As for recommendation b) (hydrodynamic modelling of receivers), based on the CREMP program results at the Whale Tail Mine, samples taken near the discharge points match the FEIS concentrations predictions and in some cases are lower. At this point there is no evidence to suggest a need for this level of modelling. This will be reviewed annually and evaluated if deemed necessary.

3.3 Local Area Marine Mammal Monitors

References: NIRB Project Certificate No. 004, Amendment No. 003: Term & Condition 36. NIRB Project Certificate No. 004, Amendment No. 003: Appendix A, Commitment 37. 2023 Annual Report: Sections 11.8.1 and 11.8.2. 2023 Annual Report Appendix 32: Meadowbank and Whale Tail 2023 Marine Mammal and Seabird Report.

Background/Rationale: NIRB Project Certificate No. 004, Amendment No. 003, Term & Condition 36 states:

"*Cumberland shall ensure the placement of local area marine mammal monitors onboard all vessels transporting fuel or materials for the Project through Chesterfield Inlet*."

Term & Condition 36 is consistent with Commitment No. 37 in Appendix A of the amended Meadowbank Gold Mine Project Certificate.

The 2023 Annual Report does not make reference to the placement of local area marine mammal monitors onboard such vessels throughout the 2023 barge season. Sections 11.8.1 and 11.8.2 of the Annual Report communicates that there was a Marine Mammal and Seabird Observer Program in place. According to Section 11.8.2 and the 2023 Marine Mammal and Seabird Annual Report (Appendix 32), it is understood that AEM is experiencing challenges in recruiting and retaining local area marine mammal monitors. With the involvement of only one local monitor sourced from Baker Lake, AEM must rely on the crew of contracted shipping companies to perform the full scope of the observation work in the Chesterfield Inlet area, necessitated by Term & Condition 36.

If there were no local area marine mammal marine monitors onboard all vessels transporting fuel or materials through Chesterfield Inlet during the Project's 2023 barge season, AEM is in non-compliance with Term & Condition 36 of the amended Meadowbank Gold Mine Project Certificate.

Recommendation 3: CIRNAC recommends that AEM confirm whether or not it employed local area marine mammal monitors onboard all vessels transporting fuel or materials through Chesterfield Inlet in 2023, pursuant to Term & Condition 36. If it was not successful in doing so, a description of efforts that will be performed in 2024 to address this issue should be provided.

> ***Agnico Eagle's Response:*** *In 2023, Agnico Eagle had local wildlife observers for a total of 27 days surveyed in July, August and October. The intent is to always have one local monitor on transiting vessel, and they overlap on schedule between 10 to 14 days. Due to delays encountered in the arrival of the vessels deserving the Meadowbank Complex, outside of Agnico Eagle's control, the first monitor from Chesterfield Inlet was on stand-by at the mine site and was finally not able to board the vessel, nor was he able to perform any observations. The second local monitor from Chesterfield Inlet had to cancel his duty for personal reason the day before heading to Baker Lake to board the shipping vessel. In order to comply with Condition 36, Agnico Eagle was able to hire a local monitor from the Baker Lake community that boarded the vessel for a first observation period of 13 days (July-August) and then return on the vessel for an additional 2 days (August) with early departure due to personal medical conditions. The same local monitor then boarded again the transiting vessel in October for a total of 13 days of observations. If there is delay in the vessel arrival in Baker Lake or if the local monitor decides to not do the work anymore, the flexibility to hire someone else on a short notice is largely reduced, especially if flight and accommodation in Baker Lake are needed. For 2024, it is Agnico Eagle's intent to continue to hire local monitors in compliance with Term and Condition 36.*

Agnico Eagle confirms it hired three (3) local area mammal monitors in 2023 with two (2) being able to board vessels and two (2) to date have been hired in 2024. Agnico Eagle also would like to highlight that one of the persons hired in 2023 was re-hired in 2024 ensuring knowledge and skills development for this individual and further consistencies within the program. Furthermore, should no local monitor be able to board the vessel for any reason, all shipping companies contracted by Agnico Eagle have received the training to perform the marine mammal monitoring requirements, and would be able to perform the monitoring.

3.4 Community Information Meetings in Chesterfield Inlet

References: NIRB Project Certificate No. 004, Amendment No. 003: Term & Condition 39 and 40. NIRB Project Certificate No. 004, Amendment No. 003: Appendix A, Commitment 42 and 105. 2023 Annual Report: Section 11.9.1.

Background/Rationale: NIRB Project Certificate No. 004, Amendment No. 003, Term & Condition 39 states:

"*…Cumberland shall annually advertise and hold a community information meeting in Chesterfield Inlet to report on the Project and to hear from Chesterfield Inlet residents and respond to concerns. A consultation report shall be submitted to NIRB's Monitoring Officer within one month of the meeting*." This Term & Condition is consistent with Commitment No. 42 in Appendix A of the Project Certificate.

Furthermore, pursuant to Term & Condition 40 of the Project Certificate:

"*Cumberland shall gather Traditional Knowledge from the local HTOs and conduct a minimum of a one-day workshop with residents of Chesterfield Inlet to more fully gather Traditional Knowledge about the marine mammals, cabins, hunting, and other local activities in the Inlet. Cumberland shall report to the Kivalliq Inuit Association and NIRB's Monitoring Officer annually on the Traditional Knowledge gathered including any operational changes that resulted from concerns shared at the workshop.*"

This Term & Condition is consistent with Commitment 105 in Appendix A of the Project Certificate.

Section 11.9.1 of the 2023 Annual Report notes that the company was unable to visit Chesterfield Inlet and meet with community members in 2023 to satisfy the requirements of Project Certificate Term & Condition 39 and 40. Attempts to visit the community were unsuccessful due to unfavorable weather and limited availability of accommodations within the community due to competing demands from the construction industry. The company committed to proactively holding a community visit in Chesterfield Inlet in early 2024 before the recommencement of local construction projects.

Recommendation 4: CIRNAC recommends that AEM:

a) Consider alternate means of interacting with Chesterfield Inlet community representatives when it is unable to hold in-person information meetings and Traditional Knowledge workshops (e.g., video or telephone conference meetings can facilitate communication when in-person attendance is not possible or to supplement such interactions); and

> ***Agnico Eagle's Response:*** *Agnico Eagle has taken action on alternative means of interacting with the Chesterfield Inlet community representatives. For example, Agnico Eagle have held teleconference calls, phone sessions, and mandated the local Community Liaison Officer to hold engagement and/or information sessions. The Public Affairs department also planned visits earlier in the year to avoid the community's busy construction season.*

b) Provide an update on the completion status of in-person information meetings and Traditional Knowledge workshops in 2024.

> ***Agnico Eagle's Response:*** *Engagement activities, including information sessions and workshop, for 2024 will be available in the 2024 annual report.*

3.5 Consideration of Local Community Aesthetic Values in Reclamation Efforts

References: NIRB Project Certificate No. 008, Amendment No. 001: Term & Condition 12. 2023 Annual Report: Section 9.1.2.1.

Background/Rationale: NIRB Project Certificate No. 008, Amendment No. 001, Term & Condition 12 states:

"*As part of the Closure and Reclamation Plan, the Proponent shall develop and implement a program to:*

> *a) Progressively reclaim disturbed areas within the project footprint, with an emphasis on restoring the natural aesthetics of the area through re-contouring to the extent practicable; and*
>
> *b) In a manner that demonstrates that the Proponent has considered the aesthetic values of local communities (e.g., information regarding the acceptability of the topography and landscape of the project areas following progressive reclamation efforts)."*

Furthermore, the reporting requirements for Term & Condition 12 state:

"*The Proponent shall provide a summary of its progressive reclamation efforts and associated feedback received from communities with respect to aesthetic values solicited by the Proponent as part of its public engagement processes in its annual reporting to the Nunavut Impact Review Board*."

Section 9.1.2.1 of the 2023 Annual Report provides an update on AEM's compliance with Term & Condition 12. The Annual Report references the submission of an updated version of the Whale Tail Interim Closure and Reclamation Plan as part of the 2020 Annual Report. Reference is also made to the progressive placement on non-potentially acid generating aggregate material on the side slopes of the Whale Tail and IVR Waste Rock Storage Facilities. No mention is made to the collection of feedback from local communities with respect to their aesthetic values for closure planning in 2023 and how this feedback was applied to progressive reclamation efforts.

Recommendation 5: CIRNAC recommends that AEM:

a) Inform the NIRB on its efforts to collect and consider feedback from local communities with respect to their aesthetic values for progressive reclamation efforts in 2023; and

b) Provide descriptions of the collection and consideration of feedback from local communities with respect to their aesthetic values for progressive reclamation efforts in future Annual Report submissions.

> ***Agnico Eagle's Response:*** *Throughout the years, Agnico Eagle has met with the community and with local stakeholders within the Kivalliq Region regularly to discuss the Project activities, including closure, and will continue to do so. In response to recommendations from the Conceptual Socio-Economic Closure Plan, Agnico Eagle is planning site visits to the Meadowbank Complex site in Fall 2024, with various identified groups from the communities (youth, Elders, hamlet members, etc.). This site visit will cover the recommendation of consulting with communities and government to identify current risks, and link mitigation to the implementation plans and strategies developed through detail closure planning activities. It will cover specific closure elements related to tailings management, water management, and various other environmental-related topics to closure.*
>
> *The Closure and Reclamation Plan has been updated and will continue to be through operation phases as additional information and monitoring results became available and as additional community feedback is collected through ongoing public consultations. The progressive reclamation activities provided in the Closure and Reclamation plan will be updated in future versions of the plan to include new opportunities for progressive reclamation identified during operations. Completed and planned progressive reclamation activities will also be presented during upcoming public consultations to collect and integrate community feedback and comments.*

3.6 Consideration for Inuit Qaujimajatuqangit Contributed by Knowledge Holders in Terrestrial Ecosystem Management Plan Monitoring Results

References: NIRB Project Certificate No. 008, Amendment No. 00; Term & Condition 28: 2023 Annual Report: Section 8.18 and 8.18.2.

Background/Rationale: The reporting requirements for Term & Condition 28 state:

"*The Proponent shall submit a revised [Terrestrial Ecosystem Management Plan] TEMP to the Nunavut Impact Review Board (NIRB) within one (1) year of issuance of the Project Certificate, with subsequent versions provided as appropriate. Results of the TEMP shall be reported to the NIRB annually, including details of how Inuit Qaujimajatuqangit contributed by knowledge holders has been considered and utilized in associated activities and updates.*"

Section 8.18 and 8.18.2 of the 2023 Annual Report provide updates on the status of the TEMP and the Terrestrial Advisory Group (TAG) activities. While information is provided on the management plan's revision status and TAG meeting outcomes, no details were provided on how Inuit Qaujimajatuqangit, contributed by local knowledge holders, has been considered and utilized within TEMP activities and plan updates**.**

Recommendation 6: CIRNAC recommends that AEM provide details as to how Inuit Qaujimajatuqangit, contributed by local knowledge holders, has been considered and utilized in TEMP activities and plan updates. This would ensure compliance with the reporting requirements of Term & Condition 28 of the amended Whale Tail Project Certificate.

> ***Agnico Eagle's Response:*** *A draft update to the TEMP is under review with the TAG and includes two recent examples of how Agnico Eagle incorporates Inuit Qaujimajatuqangit (IQ). One example includes consensus decision making with IQ holders and elders (in addition to KivIA, BLHTO and GN) about the application of mitigation levels. Another includes the use of a lead caribou approach to trigger road mitigation during spring migration. The lead caribou approach is based on IQ and the traditional Inuit practice of letting lead caribou pass, was shared during TAG meetings and the IQ coordinator. Agnico Eagle completed the first iteration of a pilot program on lead caribou protection during the spring migration in 2024.*

3.7 Marine Shipping – Public Engagement

References: NIRB Project Certificate No. 008, Amendment No. 001: Term & Condition 41; 2023 Annual Report: Section 11.8.3.

Background/Rationale: NIRB Project Certificate No. 008, Amendment No. 001, Term & Condition 41 states:

"*The Proponent shall provide notification to communities regarding scheduled ship transits throughout the regional study area, including Hudson Bay and Chesterfield Inlet.*"

The reporting requirement for this Term & Condition states:

"*The Proponent shall provide a summary of public consultation activities undertaken to address this term and condition in its annual report to the Nunavut Impact Review Board.*"

According to Section 11.8.3 of the 2023 Annual Report, AEM intended to visit the communities of Chesterfield Inlet, Coral Harbour, Naujaat, Rankin Inlet, and Baker Lake in May 2023, before the barge season. Although multiple attempts were made to reach the communities, the tour was cancelled due to unfavorable weather conditions that prevented aircraft landings. Whale Cove was the sole community where an in-person presentation was delivered.

Recommendation 7: CIRNAC recommends that AEM provide details as to whether or not any other efforts were made to communicate with community representatives regarding scheduled ship transits through the regional study area, including Hudson Bay and Chesterfield Inlet in 2023.

Agnico Eagle's Response: *In 2023, although attempts from Agnico Eagle to ensure community representatives were informed of shipping activities in-person were not successful, the company still made efforts in informing local representatives and community groups. For examples, calls, meetings, communications and information sessions took place on shipping updates allowing questions and comments in a two-way communication with:*

- *Rankin Inlet Cabin Owners*
- *Baker Lake Cabin Owners*
- *Baker Lake Hamlet*
- *Baker Lake HTO*
- *KEAC (Kivalliq Elders Advisory Committee) with representatives from all Kivalliq communities*

General slides on the shipping process were also included in the cyanide information session with Chesterfield Inlet participants in December 2023. Agnico Eagle also attempted to reach out to the Regional Keewatin Mayor Meeting to provide an update, but the meeting was cancelled by local representatives.

3.8 Socio-economic Closure Planning

References: NIRB Project Certificate No. 008, Amendment No. 001: Term & Condition 51; 2023 Annual Report: Section 9.5; 2020 Annual Report: Appendix 51

Background/Rationale: AEM is required to develop a conceptual Socio-economic Closure Plan and advance the recommendations contained within this plan through the development of a Final Socio-economic Closure Plan that will be part of the Whale Tail Pit Project Final Closure and Reclamation Plan, pursuant to Term & Condition 51 of the amended Whale Tail Project Certificate.

Furthermore, the reporting requirement for Term & Condition 51 states:

"*The Conceptual Socio-economic Closure Plan will not be a stand-alone plan but will be included as part of the Whale Tail Pit Project Interim Closure and Reclamation Plan. The Whale Tail Pit Project Interim Closure and Reclamation Plan will be updated to include the Conceptual Socio-economic Closure Plan one year after the issuance of the amended water license and be provided to the Nunavut Water Board and Nunavut Impact Review Board*."

Section 9.5 of the 2023 Annual Report summarizes AEM's efforts to advance the recommendations presented within its Conceptual Socio-economic Closure Plan; including the development of a workforce transition plan between the Whale Tail Project and any other mines owned and operated in the Kivalliq region. No reference is made as to where the Conceptual Socio-economic Closure Plan is located on the NIRB Public Registry or confirmation that it has been integrated into the Whale Tail Pit Project Interim Closure and Reclamation Plan. Upon review of the Interim Closure and Reclamation Plan included in AEM's 2020 Annual Report (Appendix 51), it appears that it has not yet been revised to include the Conceptual Socio-economic Closure Plan.

Recommendation 8: CIRNAC recommends that AEM:

a) Provide the submission status of its Conceptual Socio-economic Closure Plan, including where it can be found on the NIRB public registry; and

> ***Agnico Eagle's Response:*** *Agnico Eagle already provided the Conceptual Socio-economic Closure Plan to NIRB. It can be found on the NIRB public registry under: 190409-03MN107 16MN056-App 52-Whale Tail Socio-Economic Closure Plan-IA1E.*

b) Provide an update as to when the Whale Tail Pit Project Interim Closure and Reclamation Plan will be updated to include the Conceptual Socio-economic Closure Plan.

> ***Agnico Eagle's Response:*** *The next update of the Closure and Reclamation Plan for Meadowbank and Whale Tail will be completed during the remainder of the operation phase and will include a summary of the Updated Conceptual Socio-economic Closure Plan for the Project. The submission of the Final Closure and Reclamation Plan will be submitted for approval at least twelve (12) months prior to the expected end of planned mining (as per the Water Licenses 2AM-MEA1530 and 2AM-WTP1830).*

3.9 Cross-cultural Awareness

References: NIRB Project Certificate No. 008, Amendment No. 001: Term & Condition 59; 2023 Annual Report: Section 11.10.3.2.3.2; AEM's response to the NIRB's 2022-2023 Annual Monitoring Report for the Meadowbank Gold Project and Whale Tail Pit Project with Board Recommendations.

Background/Rationale: NIRB Project Certificate No. 008, Amendment No. 001, Term & Condition 59 states:

"*The Proponent is encouraged to work with the Kivalliq Inuit Association to establish cross-cultural training initiatives, which promote respect and consideration for the importance of Inuit Qaujimajatuqangit to the Inuit identity and to make this training available to Project employees and on-site sub-contractors.*"

CIRNAC appreciates that section 11.10.3.2.3.2 of the 2023 Annual Report notes that, in 2022, the company decided to put this form of training on hold while it was being redeveloped to better achieve its intent. This was deemed necessary to ensure its continued relevance and effectiveness for enhancing cultural awareness. It was noted that no workshops were delivered at the Meadowbank Complex in 2023, but plans were made to deliver a new cross-cultural training program in 2024. Updates on the delivery of cross-cultural training initiatives in future annual reports will be required in order to determine AEM's compliance with this Term & Condition.

Recommendation 9: CIRNAC requests that in 2024, AEM provide an update on its plans to deliver cross-cultural training initiatives. This update can assist CIRNAC and other interested parties in determining whether necessary actions are being taken to implement the requirements of Term & Condition 59.

> ***Agnico Eagle's Response:*** *Agnico Eagle wishes to highlight the significant progress made in 2023 on the Cross-Cultural training program revamp, with support of Aqqiumavvik – a recognized local organization based in Arviat. Building upon the insights gained from the previous year's evaluation, the training program underwent a comprehensive overhaul to better align with Agnico Eagle's core values and to foster a deeper understanding of local culture.*
>
> *One notable enhancement to the program was the inclusion of Inuit perspectives and voices. Recognizing the importance of authentic representation and cultural sensitivity, efforts were made to have Inuit facilitators lead the workshops.*
>
> *The training has been rebranded as Cultural Awareness. For the first half of 2024, Meadowbank Complex delivered over 125 hours of the new Cultural Awareness training to its employees. In total, more than 40 people at Meadowbank Complex received this specific training.*

3.10 Pre-employment Orientation for Potential Hires

References: NIRB Project Certificate No. 004, Amendment No. 003: Appendix A, Commitment 102; 2023 Annual Report: Appendix 1.

Background/Rationale: Pursuant to Commitment 102 in Appendix A of the amended Meadowbank Project Certificate, AEM is:

"*…to include pre-employment orientation for potential hires by Cumberland in the Labour Force Development Plan that will be developed under the terms of the IIBA. This commitment is in recognition that it is in the interest of both potential hires and Cumberland to ensure to the extent practicable that potential hires are well informed of the implications (nature of work, workforce management, personal and family challenges etc.) of accepting employment with Cumberland.*"

According to the commitment update in Appendix 1 of the 2023 Annual Report, this commitment has been completed and is included in Term & Condition 63 of the Amended Meadowbank Gold Mine Project Certificate. This Term and Condition concerns the formation of the Meadowbank Gold Mine Socio-Economic Monitoring Committee, which has since transformed into the Kivalliq Regional Socio-Economic Monitoring Committee and is supported by AEM's Kivalliq Socio-Economic Working Group. Upon further review of the 2023 Annual Report and the Kivalliq Projects 2023 Socio-Economic Monitoring Program Report (Appendix 47), no information can be found that provides an update on Commitment 102. It is important for potential hires to receive adequate pre-employment orientation to maximize their likelihood of succeeding in their careers with AEM.

Recommendation 10: CIRNAC requests that AEM provide an update on its implementation of Commitment 102 from Appendix A of the amended Meadowbank Project Certificate. This commitment concerns the provision of pre-employment orientation for potential hires as part of its Labour Force Development Plan, required under the terms of its IIBA.

> ***Agnico Eagle's Response:*** *In 2023, five (5) Pre-employment Training programs were delivered with a total of 45 participants completing the training programs. Training programs are fully facilitated by Ilitaqsiniq. Programs were delivered in the following communities: Arviat (2 sessions), Rankin Inlet (2 sessions) and Baker Lake (1 session). One (1) additional session was scheduled for Chesterfield Inlet, but it was cancelled due to a lack of accommodation in the community.*

4 Kivalliq Inuit Association (KivIA)

4.1 Defining mitigation effectiveness

References: Appendix 39 Part 2, S. 8.0

Gap/Issue: The minimal progress toward measuring mitigation effectiveness is a significant gap.

Disagreement with the Annual Report conclusion: The 2023 monitoring report does not summarize the monitoring data to measure mitigation effectiveness.

Reasons for disagreement with the Annual Report conclusion: T&C 29 requires the Terrestrial Ecosystem Management Plan to include "specific triggers for mitigation and adaptive management intervention." Specific triggers for adaptive management would include measuring if mitigation was effective or ineffective and whether mitigation has to be increased or decreased. T&C 30's objective is to verify the effectiveness of the caribou protection measures within the Terrestrial Ecosystem Management Plan. While the currently TEMP vs.7 has monitoring thresholds to trigger mitigation, it has almost no detail on how to measure if mitigation is effective or needs to be changed.

Auditing the effectiveness of mitigation is annually required (Appendix 39, Part 1, S.1.8). Testing the efficacy of mitigation is an objective for the Caribou Management Decision Tree (Appendix 39, Part 1, S.2.2).

Previously, the KivIA had requested additional data with respect to a definition and study designs for mitigation effectiveness in their review of the 2022 Annual Report. Agnico Eagle's response was to defer the topics to the TAG, but this has not yet happened except for the 'letting the leaders pass" pilot project. To support progress toward measuring mitigation effectiveness while being sensitive to demands on the TAG's time, the KivIA has re-examined its previous requests to be more specific (see KivIA comments 1, 2 and 3).

The TAG is currently reviewing draft TEMP 8 (Appendix 39, Part 1, S.1.8). An expanded understanding of how to measure mitigation effectiveness will be useful to TAG for the TEMP review. Mitigation effectiveness should be defined with thresholds and include how much the level of disturbance during mitigation that has to be decreased (such as traffic frequency) and how the caribou responses themselves will be decreased (such as a daily cap of how foraging time is lost to disturbance). Consideration is needed for how the effectiveness will be sensitive to the caribou spring and fall life- cycles.

Recommendation 1: The KivIA requests that Agnico Eagle provide a table defining mitigation effectiveness and proposing thresholds for each type of caribou mitigation to measure whether mitigation is effective. The table and any supporting rationale would be provided to the TAG for review in 2024.

Agnico Eagle's Response: *The TEMP and annual reports already provide action thresholds and adaptive management actions for compliance with T&C 29. For example, tables in the 2023 annual Wildlife Monitoring Summary Report include thresholds associated with residual effects for habitat loss (Table 5-3), sensory disturbance, Project-related mortalities (Table 3-21) along with whether Agnico Eagle adaptively managed. Agnico Eagle considers the thresholds as indices of effectiveness as they reflect the intent of mitigation hierarchy (BPOP 2024), which is minimization of residual effects of the Project. It is important to note that the action levels in the TEMP that Agnico Eagle implements are conservative relative to the small predicted residual effects that were approved for the Project to proceed. For example, residual effect on ungulate mortality was predicted to be low (Cumberland 2005). The TEMP includes a threshold for mortality of ungulates at two, which if met is highly unlikely to have a measurable influence on ungulate populations. The removal of two ungulates is well below allowable annual harvest amounts that the GN and co-managers deem as acceptable levels of removal without putting ungulate populations at risk.*

References

BPOP (Business and Biodiversity Program). 2024. The mitigation hierarchy. Available at: https://www.forest-trends.org/bbop/bbop-key-concepts/mitigation-hierarchy/. Accessed July 15, 2024,

Cumberland (Cumberland Resources Ltd.). 2005. Meadowbank Gold Project: Terrestrial Ecosystem Impact Assessment. October 2005.

4.2 How have the road closures changed traffic frequency?

References: Appendix 39 Part 3, Section 8.0

Gap/Issue: The issue is the incomplete information for traffic frequency during road closures and partial closures.

Disagreement with the Annual Report conclusion: Agnico Eagles responded to KivIA's 2023 request for daily traffic frequency for days when the roads are open, partially closed and closed, by saying that it was difficult but would be attempted for the 2023 Annual Report.

Reasons for disagreement with the Annual Report conclusion: The 2023 Annual Report did not have daily traffic frequencies during the closures or partial closures except for daily convoy frequency: convoy frequency is mostly daily with 118 convoys between 3 April and 7 December involving 644 vehicles (App. 39, Part 1, Table 3.16).

Agnico Eagle reported monthly traffic (Appendix 39, Part 1, Figure 3.5) and a daily average traffic for WTHR which does suggest that Agnico Eagle has daily traffic at least for the WTHR (181 vehicles/day; Annual Report Table 11-5). Traffic frequencies in April and November (peak migration) were reduced by between 50 and 75% compared to the preceding month (based on Appendix 39, Part 1, Tables 3-14 and 3-15). Although the traffic is reduced in April and November, it still averages between 16 and 165 mine vehicles/day and the latter higher rate exceeds the 5 vehicles/h. The rate of 5 vehicles/h was measured as a threshold for caribou responses for the Central Arctic herd[1]. Additional to the mine traffic, the AWAR's gatehouse reports monthly non-mine use; annual non-mine use has doubled since 2003 to total 3143 passages in 2023 (Annual Report Table 11.12).

The KivIA's concern about traffic frequency is to understand whether caribou are more likely to cross when there are gaps in traffic and how long the gaps have to be for the caribou to cross. In other words, how effective are partial road and 24h closures for caribou to cross? The first step is to measure how the road closures reduce daily traffic and create hourly and daily gaps in traffic frequency.

[1]*Severson, J.P., T.C. Vosburgh, & H.E. Johnson (2023). Effects of vehicle traffic on space use and road crossings of caribou in the Arctic. Ecological applications (2023): e2923.*

Recommendation 2: The KivIA requests descriptive statistics and a tabulation of daily traffic during closure, partial closure and open road periods.

> ***Agnico Eagle's Response:*** *Agnico Eagle would like to explore the feasibility to improve the camera study to addressed KivIA's concern and would require further discussion in an upcoming TAG meeting.*

4.3 Uncertainty about caribou responses to road closures and convoys

References: Annual Report S. 8.18.1.8; p. 346. Appendix 39 Part 6, Appendix K

Gap/Issue: Effectiveness of convoying in relation to caribou disturbance is not proven from the analysis of caribou behavioural monitoring.

Disagreement with the Annual Report conclusion: The statement in the Executive Summary (Appendix 39, Part 6, Appendix K) that "Findings from these analyses suggest that the use of convoys to consolidate multiple essential vehicles into a single disturbance event is an effective mitigation measure for reducing disturbance to caribou." Is not explicitly supported by the analyses.

Reasons for disagreement with the Annual Report conclusion: The KivIA appreciates that Agnico Eagle undertakes extensive road closures in 2023 (80 days AWAR and 33 WTHR 24 h closures (App. 39, Part 1, S.

3.6.6.), but the KivIA remains concerned about what we know about caribou behavior during the road closures.

We know that, overall, when most caribou encountered a road, the road was closed but this depended on caribou numbers (Appendix 39, Part 1, Table 3.13). When caribou numbers were lower, from only half to three-quarters of the caribou encountered a closed road (AWAR 90.5% +/-5.6 and WTHR 74 %+/- 10.4 SE from Table 3.13). During the behavior monitoring, about half the bouts included a disturbance and whether the road was closed or not did not statistically affect caribou behavior. Even when the road is closed, there are convoys and other traffic.

The KivIA's concern is that Agnico Eagle did not analyse responses to convoying relative to being effective mitigation. Two issues are that firstly, there are no criteria to establish what constitutes and defines 'effective' mitigation and, secondly, there is no description of the duration of the caribou's exposure to the length of the convoy (number of vehicles and their spacing distance) and the caribou's response.

In raising this issue, the KivIA is at pains to point out that the behavioral monitoring and analyses are informative about how caribou groups respond to disturbances along the roads. The statistical analyses are clearly explained and could be a basis for follow-up analyses for adaptive mitigation and measuring mitigation effectiveness. The analyses acknowledge caution in interpreting the analyses as the high number of variables and individual variability in behavior (Appendix 39, Part 6, Appendix K, p.36). The KivIA recognizes that sample size may be a limitation to further analysis and thus to increase statistical power, grouping bedding and foraging into undisturbed and alert, walking and trotting into disturbed categories may help. Foraging and bedding are related to each other as caribou both ruminate and nap when bedded and ruminating is essential before caribou can start foraging.

Elsewhere in the Annual Report, the daily convoys for 2023 are tabled by date with number of vehicles: based on App. 39, Table 3.16, we can see that the convoys were between 2 and 11 vehicles, up to three times a day and irregular being 118 convoys (644 vehicles) over 127-day period of road closure. It is not reported whether there was other traffic on the days without convoys or how long a convoy took to pass a group of caribou. The duration of a convoy is important because the duration of behavior responses increased with the frequency of disturbances and it is uncertain whether the caribou would perceive a convoy as a single or multiple disturbance (App. 39; Part 6, App. K, p. 35; Part 7, App. B).

The behavior monitoring methods mentions 'multiple' convoys and 90min bouts of monitoring behavior before, during and after convoys (p.10) but the responses to the convoys were not separate from other disturbances in the analyses. However, Agnico did note that although road closure status did not significantly predict response behaviour, the frequency of walking increased during road closures possibly as a result of the convoys (App. K, Table 6.4-1).

Recommendation 3: The KivIA requests an analysis of 2023 caribou behavioral responses to convoys including convoy duration and number of daily disturbances.

Agnico Eagle's Response: *Agnico Eagle appreciates this comment and associated recommendation relating to the caribou behaviour monitoring program. As a new analysis for the 2023 reporting year, Agnico Eagle included statistical investigation of the time to return to baseline (pre-disturbance) behaviours for surveys where one, two or three, and greater than three survey intervals recorded a disturbance event. Across all surveys (including those conducted during convoys) the mean number of three-minute intervals where a disturbance was recorded was 2.1, with the median being one interval, and the maximum being nine intervals. The results show that when fewer survey intervals include a disturbance event, caribou return to baseline behaviours more quickly. As such, convoys serving to concentrate multiple vehicles within the shortest possible period are likely to reduce the time for caribou to return to baseline, and thus effectively reduce overall disturbance to caribou. Agnico Eagle does agree that information on the duration of exposure to each convoy is a useful metric, alongside the number of vehicles in each convoy.*

Moving forward, Agnico Eagle will endeavour to collect this information for convoys wherever possible and conduct an analysis including convoy duration and number of vehicles within convoys. Specifically, this would mean adding new data recording for: a) the number of vehicles in the convoy, b) the time required for a convoy to pass a particular location/caribou, and c) the time when the last vehicle passed. For the 2024 annual reporting period, this information is likely to only be available starting in the fall of 2024.

4.4 Adaptive management and the remote camera program

References: S. 8.0 Appendix 39 Part 3, S.8.

Gap/Issue: Absence of information on the use of remote cameras to assess how the traffic on the Whale Tail Haul Road interacts with the caribou.

Disagreement with the Annual Report conclusion: The KivIA finds that the 2023 remote camera monitoring program is not meeting its objectives.

Reasons for disagreement with the Annual Report conclusion: 2023 is the 4th year of the remote camera's updated program. The monitoring objectives include describing caribou road crossings relative to traffic frequencies on the Whale Tail Haul Road. However, this did not happen in 2023: the number of caribou crossings was relatively low and mostly pairs or single caribou in summer. Traffic is not reported.

The Annual Report does not shed light on why the number of detections for the 10 pairs of cameras was so low. Caribou were detected between 15 February 2023 and 28 October 2023 when the traffic was approximately 54,000 vehicles and the total caribou counted was 35,863 (App. 39, Part 1 Tables 3.5 and 3.15) but only 66 crossing events were detected by the cameras. Agnico Eagle does not discuss whether the criteria of caribou on both sides of the road as a crossing event is too stringent.

The remote camera program was briefly discussed at the November 2022 TAG meeting although without recommendations (TAG meeting no. 11 minutes).

T&C 29 requires the Terrestrial Ecosystem Management Plan to include "specific triggers for mitigation and adaptive management intervention." The KivIA disagrees with Agnico Eagle's conclusion that that "The remote camera program is unlikely to contribute to adaptive management . . . ". But the KivIA does agree that the remote camera monitoring "could potentially provide insight into time between vehicle traffic and caribou crossing events" and we suggest that information would be a useful contribution to adaptive management to determine the duration of gaps between vehicles to increase the likelihood of caribou crossing.

At the November/December 2022 TAG meeting, there was an acknowledgement that using the remote cameras to collect traffic use would be useful, but it did not happen in 2023 which in turn, meant that time between caribou crossing events, and previous vehicle time is not presented. The daily convoys and caribou crossings from road surveys and incidental sightings (App. 39, Table 3.16, Table 3.17) are not cross-referenced to the camera data.

Recommendation 4: The KivIA requests further progress toward T&C 29 through use of the remote cameras. This includes that Agnico Eagle assesses why the caribou detection rate was low, provide options on how to detect daily traffic frequencies and describe the timing of caribou presence and road crossings relative to traffic as potential triggers for adaptive mitigation.

> ***Agnico Eagle's Response:*** *As stated in the 2023 Wildlife Monitoring Summary Report (Section 8.2), the objective of the remote camera program is to monitor caribou interactions with the Whale Tail Haul Road (WTHR) and whether crossing locations are associated with the physical parameters of the WTHR such as backfill height, slope and grain size and traffic rates. Agnico Eagle suggested that alternative methods may be more appropriate to achieve what the KivIA is recommending in the Management Recommendations section (Section 8.6) of the 2023 Wildlife Monitoring Summary Report. Agnico Eagle would like to note that T&C 29 does not require the use of remote camera monitoring and that specific triggers for mitigation and adaptive management are already present in the TEMP (see Table 14; Agnico Eagle 2019).*

References

Agnico Eagle (Agnico Eagle Mines Limited). 2019. Meadowbank Division: Terrestrial Ecosystem Management Plan. Version 7. June 2019.

4.5 Annual herd distribution and seasonal exposure to Meadowbank and Whale Tail

References: S. 8.0 Appendix 39, Parts 2 and 3, S. 6; Part 5, Technical Memo

Gap/Issue: It is uncertain whether different herds will respond the same way to the Meadowbank and Whale tail projects as potential impacts had been projected for the Lorillard and Wager Bay herds.

Disagreement with the Annual Report conclusion: The updated collar analysis does not describe possible differences in potential impacts for the different herds annually encountering the project.

Reasons for disagreement with the Annual Report conclusion: The updated collar information is consistent with T&C 29 and 30 and is provided as the Satellite Collar Program (Appendix 39; Parts 2 and 3, Section 6) and a Technical Memo (Appendix 39, Part 5) for updating the caribou collar information. Both reports have identical objectives and analyse the same data but at different levels of detail. One report maps caribou movement pathways for 2020-2023 while the technical memo maps pathways for 2005 - 2023. Both reports reach similar management recommendations which are for further study into underlying mechanisms such as snow conditions and that annual variability in the timing of spring and fall seasons may influence the movements of the different herds.

The standout feature of the Technical Memo is Table 1 which lists by herd, the year and the herd designation for the collars encountering Meadowbank and Whale Tail projects. Table 1 clarifies that, in most years, individual collared cows from four caribou herds (Ahiak, Beverly, Lorillard, Qamanirjuaq, Wager Bay and North East Mainland) encounter the Meadowbank and Whale Tail projects and not just the Lorillard and Wager Bay herds. For example, at least one Ahiak collared cow encountered the mine site in 13 years between 2002 and 2023. The collared caribou encountering the mine in fall 2022 and spring 2023 (fall 2023 is not included) were only from the Ahiak (and Beverly) and the North East mainland (Appendix 39, Part 5, Table 1).

Agnico Eagle does not discuss implications on the annual variability in which herds encounter the mine site. Annual changes in herd distribution may correlate with annual changes in caribou sighting rates. For example, does the road survey caribou sighting rate (App. 39, Part 1, Tables 3.3 and 3.6) relate to whether it is unusual for the collar distribution of the Ahiak and North East mainland wintering west of AWAR. Unfortunately, the collar maps are a composite 2003-2023 and annual trends in distribution are not presented.

The updated collar information has implications for cumulative impacts as, for example, any delays or deflections from the roads will likely have greater costs for the Ahiak as it calves almost three times the distance from Meadowbank compared to, for example the Lorillard herd. The annual differences in which herds are exposed to the mines activities also raises questions about whether combining data among years such as for the behavior monitoring analyses.

Recommendation 5: The KivIA requests Agnico Eagle describe the overlap of the collar pathways with the AWAR and WTHR for the different herds at an annual scale; update the TEMP to include the exposure of the different herds and summarize evidence on whether and how potential incremental and cumulative impacts may be herd specific.

Agnico Eagle's Response: *The potential residual impacts to different caribou herds will depend on the impact strength, geographic extent, duration, frequency and likelihood as assessed in the FEIS for Meadowbank and Whale Tail projects (Cumberland 2005; Golder 2018). The incremental and cumulative impacts for the Ahiak, Beverly, Lorillard and Wager Bay herds was completed as part of Commitments 9 and 10 of the Whale Tail Project (Golder 2017). This report shows that incremental and cumulative impacts experienced by herds are different and depends on the frequency of interactions and residency time in nearby areas. This report shows that Lorillard caribou have the most frequent and regular annual interactions and the longest residency times among these herds. Other herds had fewer interactions, do not interact every year and spend less time near the Meadowbank Mine and the Whale Tail Mine.*

Table 1 of Appendix F of the 2023 Wildlife Monitoring Summary Report summarizes the annual spring and fall interactions of the Ahiak, Beverly, Lorillard, Northeast Mainland, Qamanirjuaq and Wager Bay collared caribou with north-south reference lines that represent the most westerly and easterly points of the Meadowbank and Whale Tail development, including roads. Note that these reference lines extend well north beyond the Meadowbank and Whale Tail development, but their use provides a broad index of movement through the general area where the Mine is located. Agnico Eagle's understanding is that Northeast Mainland designation is not a herd per se but includes individuals that have not been assigned to other herds. Table 1 shows that the herd with greatest numbers of collared individuals and most frequent annual interactions with reference lines are from the Lorillard caribou herd. Based on these results, herds that have lower proportions of collared individuals interacting or are absent in some years will experience residual impacts to a lesser degree, or no impacts at all, compared to Lorillard caribou. The higher degree of relative exposure by Lorillard means that focussed monitoring of residual effects on Lorillard caribou is conservative. Mitigation applied by Agnico Eagle is not herd specific and it would be impossible to identify which herd caribou belong to when observed in the field during Mine monitoring used to trigger mitigation.

Agnico Eagle demonstrated in its analysis of Lorillard collared caribou interactions with the Mine and roads (Golder 2020), that apparent spring migration delays attributed to the Mine and road do not influence the ability of caribou cows to reach calving areas on time or decrease calving success or increase neonate mortality relative to caribou that do not interact with the Mine and roads. This means that a cost associated with apparent delays during spring migration is not measurable demographically.

References

Cumberland (Cumberland Resources Ltd.). 2005. Meadowbank Gold Project: Terrestrial Ecosystem Impact Assessment. October 2005.

Golder (Golder Associates Ltd.). 2017. Whale Tail Commitments 9 and 10; Cumulative Encounter and Residency Assessment for Caribou. P Prepared for Agnico Eagle Mines Limited by Golder Associates Ltd. July 2017.

Golder. 2020. Lorillard Collared Caribou Movements: Implications from Interacting with the Whale Tail Haul Road and All-Weather Access Road. Report prepared for Agnico Eagle Mines Ltd.

2018. Final Environmental Impact Statement Addendum, Whale Tail Pit – Expansion Project. Prepared for Agnico Eagle Mines Limited by Golder Associates Ltd. December 2018.

4.6 Wolf and Wolverine Mortality

References: S. 8.0 Appendix 39; Part 2, Table 4.6 and Section 4.7, Part 4, Appendix C

Gap/Issue: The number of wolverine and wolves killed when deterrence failed exceeds the threshold for predatory mammal deaths.

Disagreement with the Annual Report conclusion: The 2023 Annual Report does not offer explanation for the record number of deterrence activities and carnivore deaths and does not describe additional mitigation actions.

Reasons for disagreement with the Annual Report conclusion: In 2022, Agnico Eagle responded to KivIA's comment on two wolverine deaths which equaled but did not exceed the threshold and that the TEMP 7.0 identifies that additional mitigations are only applied when the threshold is exceeded. (Table 4-8: Summary of Project-Related Wildlife Mortality Records for Caribou and Predatory Mammals (2007 to 2023) only shows 1 not 2 wolverine deaths).

In 2023, three wolverine and three wolves were killed when they were not deterred from the incinerator, landfill, and other facilities and the number of deterrence actions was at an all time high since 2015 (Appendix 39, Part 4, Table 4.6). Contrary to TEMP 7.0, the 2023 Annual Report did not describe additional mitigations. Section 4.7 refers to 'continuing' on-going mitigation rather than enhanced or changed mitigation.

The Wildlife Incident reports are repetitive (Appendix 39, Part 4, Appendix C) with no case specific details on why high levels of deterrent activities were needed leading to several deaths while the only adaptive management taken appeared to be general reminders. Although six carnivores were shot, there was no mention of mitigating circumstances such as the carnivores being in poor health or existing injuries.

Recommendation 6: The KivIA requests that Agnico Eagle describe additional mitigation to reduce carnivore deaths and to collaborate with GN and the HTO to train staff to collect detailed information on why mitigation failed and whether there were under-lying causes for nuisance wildlife.

> ***Agnico Eagle's Response:*** *Agnico Eagle continues to deliver wildlife awareness to on site personnel with a focus on waste management. As part of Agnico Eagle's monitoring and inspection program, the Meadowbank and Whale Tail sites are inspected on routine basis. When wildlife incidents occur on site, inspections in specific areas are increased to ensure there is no food waste or shelter for wildlife. Agnico Eagle works with the GN Conservation officers and requests guidance on actions prior to initiating any deterring efforts. Agnico Eagle will continue improving on the reporting process to ensure more details on under-lying causes are included in the mortality report should an incident occur again in the future. Agnico Eagle will also engage with the GN and the HTO to perform a site tour so mitigation can be reviewed, and recommendation provided.*

4.7 Annual Report -Appendix 39 organization

References: Appendix 39

Gap/Issue: The issue is the difficulty of navigating through the Annual Report Appendix 39 (Meadowbank and Whale Tail 2023 Wildlife Monitoring Summary Report).

Disagreement with the Annual Report conclusion: The layout (structure) of Appendix 39 is the apparently random splitting into seven separate pdfs (parts) which hinders any reviews.

Reasons for disagreement with the Annual Report conclusion: The split into the seven parts are in the middle of sections, or part way through a table – that's one hinderance to reviewing, page numbers are not consecutive between sections and the List of Contents does not cross-reference how Appendix 39 was divided into seven separate files to mitigate individual file size.

Recommendation 7: KivIA requests Agnico Eagle improve flow and readability for the 2023 Annual Wildlife Report, and other split reports for future review. Lists of Contents (in Part 1) should have cross-references to the individual parts, and tables (such as Table A.1 – 113 pages) should be grouped together rather than interrupting the flow of the monitoring results.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges KivIA's comment and will work to improve flow and readability in future split documents. Agnico Eagle would like to remind that the full version and the split documents are both available and shared with all the regulators via OneDrive. More access can be provided on request.*

4.8 Meadowbank Implementation of Commitments

References: Appendix 1 – Meadowbank Update on Implementation of Commitments # 38, 41, 42, 72 and 101 to 112 all use the company name of "Cumberland."

Recommendation 8: The KivIA would like an explanation on why the company name has not been changed to Agnico Eagle Mines Limited.

> ***Agnico Eagle's Response:*** *Under the Meadowbank Project certificate, Section 4.0 Project Specific Terms and Conditions notes that the terms and conditions reference Cumberland as the Proponent:*
>
> > *'However, in light of AEM's acquisition of the Meadowbank Gold Mine Project through it's purchase of Cumberland Resources Ltd in 2007 and the change in Proponent name on Project Certificate No. 004 on November 20, 2009, the references to Cumberland Resources in the following terms and conditions apply to AEM.'*

4.9 Portage Pit B and B Dump

References: Appendix 8 – Meadowbank 2023 Annual Open Pit Geomechanical Inspection; Table 2 – 2023 Annual Open Pit Geomechanical Inspection, Summary of Recommendations.

Comment: The 2023 recommendation stated "The possibility of the settlement of the B Dump progressing back to the Amaruq Road was discussed in 2022 and concluded to be unlikely as the settlement and tension cracks appear to be limited to within the footprint of the pit. SNC Lavalin was retained by AEM to complete a detailed assessment in order to confirm this conclusion.

Recommendation 9: The KivIA would like to request to have the opportunity to review the results of the SNC Lavalin assessment when they become available. In particular, prior to the 2024 Annual report review.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges KivIAs' comment and is currently working with an external consultant (WSP) with a final deliverable expected to be submitted to Agnico Eagle by the end of 2024. As a result of the timing, the main conclusion of the report will be provided as part of the 2024 Annual Report. Agnico Eagle would like to mention there's been an error in the mentioned referenced document, we should have read WSP instead of SNC-Lavalin as the selected consultant.*

4.10 Dust Mitigation on North Tailing Cell

References: Appendix 17 – Meadowbank Waste Rock and Tailings Management Plan Version 14; Section 6.5 Monitoring of Tailings Dust, page 22.

Comment: Section 6.5 states that "Mitigation measures were implemented by AEM in 2021 and 2022 to prevent further dust generation from wind erosion of the surface of the south and north tailing cells, especially the North cell where less water is retained. In 2023, fresh tailings were deposited in the South Cell for an increased mitigation of dust generation."

Recommendation 10: The KivIA would like to request what mitigation was completed for the North Cell in 2023, given that this cell retains less water and is more susceptible to dust generation.

> ***Agnico Eagle's Response:*** *Agnico Eagle managed the North Cell using a combined approach that included water level management, tailings surface capping in strategic areas and building temporary infrastructures to allow fresh tailings deposition.*

5 Environment and Climate Change Canada (ECCC)

5.1 Contaminant loading – Meadowbank site

References: Meadowbank Complex – 2023 Annual Report

Comment: Table 4-13 summarizes the key differences between the predicted and the measured water quality data at the Third Portage Open Pit Sump (i.e. Portage Pit E), Goose Island Open Pit Sump (i.e. Goose Pit), North Portage Pit Sumps, Vault Pit Sumps and Phaser Pit Sumps, and is followed by comparison figures which illustrate these differences. Page 82 of the annual report indicates that, based on this analysis, many of the predicted values for water quality and quantity for the Probable and Probable Poor End scenarios and Annual Average and 25% Percentile Water Quality Forecast have differences greater than +/- 20%

when compared to the measured values. This section identifies several potential causes that could contribute to these differences, including the following potential causes of higher contaminant loading:

- Higher contaminant loads observed in Portage Pit could be the result from additional transfer of reclaim water from the Central Dike Downstream Pond.
- Higher contaminant loads of arsenic and nickel could also be the results of processing ore from Whale Tail Pit. This ore was shown to leach out higher concentration for certain metals, such as arsenic.
- Since 2019, in-pit deposition activities in Goose and Portage Pit contribute the main contaminant loading to the pit water.
- For North Portage Pit, the higher load could originate from water transfer from South Cell TSF, Downstream Pond and Goose Pit and transfer from Third Portage Pit.
- Higher observed load in the seepages flowing into the pits also contribute in part to the contaminant loads observed in Goose and Portage Pits.
- The contaminant loads measured in Vault and Phaser Pits water were generally higher than the prediction. However, there has been a continued improvement in pit water quality year after year since the end of mining at Vault and natural re-flooding was allowed to take place in the pits.

Clarification should be provided whether this information is used to inform water quality modelling for the project.

Recommendation 1: Describe how the potential causes of higher contaminant loading identified on page 82 of the 2023 annual report are incorporated into the ongoing updates to the Meadowbank water quality predictions.

Agnico Eagle's Response: *It is important to note that the water quality forecasted in the FEIS was based on a set of hypotheses used to develop the Life of Mine at that time. The WQF model is adapted annually to consider actual site conditions, site constraints, water volume transfers and characteristics of the tailings to manage in order to produce a reliable forecast.*

More specifically, the water quality forecast model is updated annually based on the following information from the site:

- *All the different volumes of water transferred between different ponds on the site, including the transfer of reclaim water.*
- *Water quality data sampled each year for the different source terms reporting to the site.*

Using this information, the water quality forecast (WQF) model is updated to consider the different water transfers that occurred on the site. The water quality for each source term is also updated based on the field measurements.

A preliminary water quality forecast for each contaminant of concern is then generated and compared to the measured values. If the forecasted trend does not follow or match the trend observed based on the field measurement, it indicates that the load considered in the model is either too low or too high. To rectify this, the main source term load reporting to the different ponds and pit lakes (i.e surface runoff, seepages and mill effluent) on the site is adjusted so that the forecasted trend follows the measured concentration. Thus, any higher loads that are observed in the ponds or pit lakes are captured in the annual update of the WQF model. For the remaining years of the Life of Mine, the source term load for each contaminant is maintained at the same concentration as the value selected for 2023. However, the source term load for each contaminant of concern considered in the model will be re-evaluated and adapted annually based on the field measurements.

5.2 Detection limits

References: Meadowbank Complex – 2023 Annual Report

Comment: Page 82 of the annual report identifies several potential causes that could contribute to differences between the predicted and the measured water quality data at the Third Portage Open Pit Sump (i.e. Portage Pit E), Goose Island Open Pit Sump (i.e. Goose Pit), North Portage Pit Sumps, Vault Pit Sumps and Phaser Pit Sumps, including the following:

- Some accredited laboratory water quality measurements have detection limits that are higher than the predicted values. This is particularly true for dissolved metal analysis, such as cadmium, iron, lead, nickel, molybdenum, selenium, thallium, and zinc.

It is important to verify that detection limits are sufficiently low, particularly for the parameters noted in the excerpt from page 82. Clarification should be provided.

Recommendation 2: ECCC recommends that the Proponent verify that laboratory detection limits are sufficiently low to meet the water quality detection limits specified in the Metal and Diamond Mining Effluent Regulations (MDMER) and also advised in the EEM technical guidance documents, including but not limited to cadmium, iron, lead, nickel, molybdenum, selenium, thallium, and zinc.

Agnico Eagle's Response: *Agnico Eagle acknowledges ECCC's comments and is providing below the comparison of the method detection limits specified in the Metal and Diamond Mining Effluent Regulations (MDMER) and in the EEM technical guidance documents. In 2023, except for some of* *the mercury results, all method detection limits from the accredited laboratory were below the requirements noted in the above reference documents, including CCME Canadian environmental quality guideline. As noted in the Meadowbank Complex Annual Report, it is understood that the Water License, and MDMER criteria apply to mining effluents discharged to the environment and are as such not applicable to the pit water since it is managed within the site and undergoes a treatment step if required prior to discharge to the environment. These criteria are used as a guide to identify potential parameters of concern.*

Parameters**	Units	Method Detection Limits (MDL)		
		Requirement		Archived
		MDMER	EEM	Accredited Laboratory
Arsenic	mg/L	0.0025	-	0.00002
Copper	mg/L	0.001	-	0.00005/0.0001*
Cyanide	mg/L	0.005	-	0.0005
Lead	mg/L	0.0005	-	0.000005/0.00002*
Nickel	mg/L	0.0125	-	0.00002/0.0001*
Zinc	mg/L	0.010	-	0.0001/0.001*
TSS	mg/L	2	-	1
Radium 226	Bq/L	0.01	-	0.005
Total ammonia	mg/L expressed as nitrogen (N)	0.05	0.05	0.05
Aluminum	mg/L	-	0.005	0.0005/0.003*
Cadmium	mg/L	-	0.000045	0.000005*
Chloride	mg/L	-	60	1
Chromium	mg/L	-	0.00445	0.0001
Cobalt	mg/L	-	0.00125	0.000005/0.00001*
Iron	mg/L	-	0.15	0.001/0.005*
Manganese	mg/L	-	0.005	0.00005/0.0001*
Mercury	mg/L	-	0.00001	0.00001/0.0001*
Molybdenum	mg/L	-	0.0365	0.00005
Nitrate	mg/L expressed as nitrogen (N)	-	1.46835	0.1
Phosphorus	mg/L	-	0.05	0.001/0.005*
Selenium	mg/L	-	0.0005	0.00004
Sulphate	mg/L	-	0.6	0.5
Thallium	mg/L	-	0.0004	0.000002

Parameters**	Units	Method Detection Limits (MDL)		
		Requirement		Archived
		MDMER	EEM	Accredited Laboratory
Uranium	mg/L	-	0.0075	0.000002/0.000005*
Hardness	mg/L	-	1	0.5
Alkalinity	mg/L	-	2	1

**Different method detection limits used in 2023*

***Parameters not part of the comparison provided in Section 4.4.3.1 of the annual report. MDL provided as a reference of limits that could or were archived.*

5.3 pH of Portage and Goose pit water

References: Meadowbank Complex – 2023 Annual Report

Comment: Page 82 of the annual report identifies several potential causes that could contribute to differences between the predicted and the measured water quality data at the Third Portage Open Pit Sump (i.e. Portage Pit E), Goose Island Open Pit Sump (i.e. Goose Pit), North Portage Pit Sumps, Vault Pit Sumps and Phaser Pit Sumps, including the following:

- The pH measured in Portage and Goose Pits is generally higher than the predicted values. A possible cause for this phenomenon is that the groundwater infiltrating into the pits have a higher alkalinity concentration and pH when compared against the background water quality of the surrounding Third Portage Lake.

- Un-ionized ammonia concentration in water is greatly influenced by the pH. The higher the pH, the higher the fraction of un-ionized ammonia in the water. The predicted pH of the Portage and Goose pit water is between 6.1 and 6.3, while the measured values are generally between 7.7 and 8.4.

Additional information should be provided to support a better understanding of how the higher-than-expected pH affects the project, including both current and future water quality. pH is a known toxicity modifying factor and may influence the availability of other constituents.

Recommendation 3: With respect to the measured pH of Portage and Goose pit water exceeding the predicted pH, ECCC recommends that the following information be provided:

(i) Discuss the implications over the life-of-mine if pH continues to exceed predictions;

(ii) Describe potential effects the higher-than-expected pH has on water quality (site and receiving environment) and the aquatic environment; and

(iii) Discuss adaptive management options and whether updates to the site water quality model are required.

Agnico Eagle's Response: *The higher pH observed in the pit lakes result from the loading from the mill effluent which is alkaline in nature. The mill effluent pH is raised as part of the cyanide destruction process prior to discharge to the pit lakes.*

*Under the current plan, during the Life of Mine, it is important to note that **no contact water** is discharged to the environment from the Portage and Goose Pit. At closure, the contact water stored in the pit lakes will be treated, if necessary, prior to discharge. The selected water treatment process will be designed to include a final pH adjustment step. This step will ensure that the pH in the final effluent is close to neutral so that any residual ammonia will be in the form of ammonium ($NH4+$) instead of un-ionized ammonia ($NH3$). The potential effects of un-ionized ammonia in the treated effluent to the receiving environment and the aquatic environment will thus be limited and controlled. Note that a new water management strategy may be proposed in the near future as water treatment studies progress.*

The main adaptive management options that will be used to control the pH of the final effluent is with an active water treatment where the pH can be adjusted. During the operation of the water treatment plant at closure, the pH will be monitored continuously using a pH sensor. If a non-compliance situation is detected, the treated water shall be discharged back to the pit lake instead of the receiving environment.

As described in Section 5.1, the source terms considered in the WQF model are updated annually so that the forecasted trends follow the observed field measurements.

5.4 Sewage treatment

References: Meadowbank Complex – 2023 Annual Report

Comment: In 2023, sewage treatment plant effluent concentrations for nitrate-nitrogen and total phosphorus were above the operational targets. Section 8.5.4 (Sewage Treatment Plant) of the 2023 annual report describes challenges in meeting the sewage treatment plant (STP) operating targets for nitrate-nitrogen and total phosphorus, but the report does not discuss how exceeding these targets could affect other aspects of the Project. A discussion should be provided to understand how higher STP nutrient levels could affect future nutrient management in other aspects of the project, including the water and sediment quality of the IVR Attenuation Pond. The elevated levels of nutrients may accumulate in the sediments of the attenuation ponds over time and could potentially become a future source of nutrients following reconnection to surface waters.

Recommendation 4: ECCC recommends that the Proponent provide a discussion on the potential implications of the higher levels of nitrate and phosphorus in sewage treatment plant discharge on other aspects of the project. This should include consideration of parameter concentrations in attenuation pond water and sediments, potential for attenuation pond sediments to act as a nutrient sink, potential for attenuation pond sediments to act a nutrient source following any reconnection to surface waters and managing nutrient levels to prevent changes in the receiving environment.

Agnico Eagle's Response: *In 2023, effluent from the Sewage Treatment Plan was discharged to the IVR Attenuation Pond on a daily basis. As mentioned in the Annual Report, a monthly sample is taken at the STP effluent to assess the efficiency of the STP. Agnico Eagle intends to follow the operational parameters outlined in Table 8-64 of section 8.5.4.2, however operational realities have made meeting some of those operating targets challenging. It should be noted that operational parameters are guidelines only and that there are no applicable license limits for the STP effluent. Treated sewage effluent is discharged to the IVR Attenuation Pond along with other site contact water, and from there to the As-WTP for treatment before discharge to the receiving environment. Nevertheless, it is important to highlight that no issues in the receiving environment and no noncompliance have occurred as a result of the deviation to the operational parameters for the STP.*

The current Whale Tail Pit Project Interim Closure and Reclamation Plan (ICRP, version 4, July 2020) assumes that IVR Attenuation Pond (former lake A53, dewatered) will be emptied and backfilled with NPAG rock at closure. Other alternatives will be evaluated prior to closure for the IVR Attenuation Pond. It should be noted the IVR Attenuation Pond is located outside of the area of the North Whale Tail basin to be reflooded in closure, and therefore will not be connected to the Whale Tail Lake.

5.5 Toxicity test results

References: Meadowbank Complex – 2023 Annual Report

Comment: Section 8.5.7 (QAQC Sampling) indicates that toxicity testing was conducted during 2023 and states that toxicity reports for Meadowbank and Whale Tail can be provided on request. It would be preferable to include these reports as part of the annual report.

Recommendation 5: ECCC recommends that, in future, toxicity reports are included in the annual report submission.

Agnico Eagle's Response: *Agnico Eagle report all toxicity results on the ECCC SWIM platform as required by the Metal and Diamond Mining Effluent Regulation (MDMER). To minimize the size of the annual report document, Agnico Eagle will not include the toxicity reports in the annual report and will continue to provide them on request.*

5.6 High PM2.5 to PM10 ratios

References: Agnico Eagle Meadowbank Complex 2023 Annual report, Section 8.14.2.1 Onsite Dust Mitigation and Air Quality Monitoring

Comment: In Section 8.14.2.1, Figure 23 shows 24-hour average concentrations of PM2.5 at the Whale Tail Mine monitoring station DF-6B reaching about 31-32 µg/m^3 in July 2023. Figure 22 is the corresponding plot for PM10 with maximum 24-hour averages less than 40 µg/m^3 in July 2023. This yields an unusually high PM2.5/PM10 ratio of more than 0.8 whereas typical ratios are 0.65 or less.

Recommendation 6: ECCC recommends that the Proponent check the PM2.5 and PM10 data for this period for any artifacts that may cause readings too high for PM2.5 and/or too low for PM10.

Agnico Eagle's Response: Agnico Eagle has reviewed the 2023 suspended particulate results for the Whale Tail Mine and confirms the values in question are correct as presented. Agnico Eagle has calculated PM2.5/PM10 ratios for the 2023 dataset (Table 1), and notes that the distribution of measured values is within the range of those reported historically in the literature for similar dichotomous filter-based instruments at a suite of NAPS sites (e.g. Health Canada, 1999 – see Section 5.4). While typical or average ratios for both the Whale Tail Mine and national dataset are less than 0.65, as suggested by ECCC, the upper end of distributions (95th centiles) for most individual NAPS sites (both urban and rural; Figure 1) exceeded 0.8, with many exceeding 0.9 (Health Canada, 1999 – see Figure 5.18). Thus, a small proportion of measurements in this range may be expected, as occurred at the Whale Tail Mine in 2023.

Table 1. Summary statistics for PM2.5/PM10 ratios measured by dichotomous sampler at the Whale Tail Mine in 2023 and from combined data from 14 NAPS sites in operation between 1986 and 1994 (Health Canada, 1999; Table 5.20).

Statistic	PM2.5/PM10 Ratio	
	Whale Tail Mine (2023) n = 56	Health Canada, 1999 (Table 5.20) n = 2831
Mean	0.46	0.51
Max.	0.96	1.00
10th centile	0.12	0.29
50th centile	0.43	0.50
70th centile	0.66	0.60
90th centile	0.83	0.74

95th centile	0.90	0.80

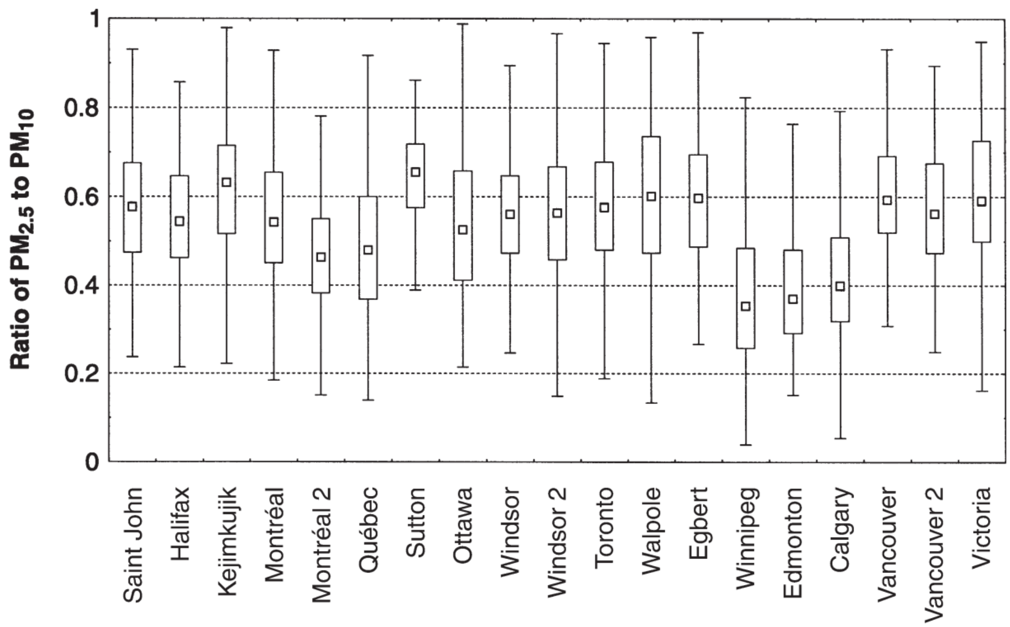

Figure 1. Figure 5.18 from Health Canada (1999). Distributions of the ratio of PM2.5 to PM10 at NAPS dichotomous sampler sites. Box plots indicate median, 5th and 95th and 25th and 75th percentiles.

Reference

Health Canada (1999). National ambient air quality objectives for particulate matter. Part 1, Science assessment document: a report / by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. Ottawa, Ontario. Catalogue number: H46-2/98-220-1E-PDF. Accessed at: https://publications.gc.ca/site/eng/9.695398/publication.html

5.7 Environmental Emergencies regulated commodities

References: 240330-03MN107-2023 Annual Report-IA1E; Section 7.1 Spill Summary, p.119, 231003-03MN107 16MN056-Site Visit Report-OT6E; Photo 48, p.42, 240330-03MN107-Appendix 22-IA2E, Table 6 - Materials stored at site during operations, p.34-36 and appendix P - Environmental Emergency Regulation Plan Cross Reference Table, p.214

Comment: The Proponent acknowledges that certain commodities stored on-site are subject to the Environmental Emergencies (E2) Regulations or may be. However, given the various containment methods used throughout the project and potential eligibility for exclusions outlined in the E2 Regulations, it remains unclear which commodities are currently captured under these regulations.

The Nunavut Impact Review Board Site Visit Report, dated October 2023, states that a new fuel tank was constructed in 2023 in the title of Photo 48. ECCC would like to bring to the attention of the Proponent that a notice of change may be required as stipulated in subsection 3(5) of the Environmental Emergency (E2) Regulations, 2019:

“(5) A responsible person must, within 60 days after the day on which any of the following situations occurs, submit an updated notice to the Minister that contains the information referred to in Schedule 2:

(a) the information that was reported under section 1 or 2 of Schedule 2 has changed;

(b) the maximum expected quantity that was most recently reported under paragraph 3(d) of Schedule 2 in respect of a substance has increased by 10% or more; or

(c) the maximum capacity that was most recently reported under paragraph 3(f) of Schedule 2 in respect of a container system, in which a quantity of a substance is contained, has increased by 10% or more.”

Recommendation 7: ECCC recommends adding a table in the Spill Contingency Plan (SPC) summarizing the commodities subject to the E2 Regulations. This will ensure that the Proponent is fully aware of its responsibilities under the E2 Regulations.

Additionally, an updated notice should be submitted if a situation covered under subsection 3(5) of the E2 Regulations occurs.

> ***Agnico Eagle’s Response:*** *Agnico Eagle thanks ECCC for their comments. Updated notices under the E2 SWIM platform have been submitted to account for the new tank at Meadowbank. Agnico Eagle will continue to submit notice under the E2 SWIM platform as situation detailed in subsection 3(5) of the Environmental Emergency (E2) Regulations happen. Agnico Eagle will provide a table summarizing the E2 commodities subject to the E2 regulation in the next update of the Spill Contingency Plan.*

5.8 Hazardous materials storage practices and forklift related incidents.

References: 240330-03MN107-2023 Annual Report-IA1E; Table 7-2 - Table 7-2 Meadowbank 2023 spills reported to the GN 24Hr spill HotLine and table 7-4 - Whale Tail 2023 spills reported to the GN 24Hr spill HotLine, p.121 to 127, 240330-03MN107-Appendix 23-IA2E; 2023-06-03 MBK_1500L_Waste Oil incident, p.34-38, 240330-03MN107-Appendix 24-IA2E: 2023-01-14_WTM_900L_Windshield Washer Fluid, p.2-4.

Comment: The 2023 annual report indicates that there were seven (7) instances of punctured totes at the White Tail site in 2023. Additionally, some totes expanded and failed within their storage area at the Meadowbank site. The utilization of secondary containment in the storage area could have greatly minimized the impact of these accidents and malfunctions. Cumulatively, these incidents resulted in the excavation/removal of over 6.5 m^3 of contaminated soil, 28 m^3 of contaminated snow, 23 m^3 of contaminated material, and 58 m^3 of contaminated water due to the omission of secondary containment.

ECCC commends the Proponent on implementing a new procedure to minimize accidents related to forklift operations, as noted in event 2023-10-11-WTM_1000L_Diesel Exhaust Fluid of appendix 24: "A procedure has been implemented on site since August 2023 for handling totes and barrels with forked equipment." ECCC is unclear as to whether this is an operational and staff training issue or a storage infrastructure issue (storage containers too narrow for safe handling).

The Proponent states, "Agnico Eagle operates Meadowbank and Whale Tail under extreme cold conditions during winter, which creates extra pressure on equipment that can lead to more frequent equipment failure even with good inspections and maintenance." Given that certain means of containment (MOC) may become fragile and prone to failure when exposed to cold temperatures, freezing of liquid hazardous materials can lead to expansion/contraction, resulting in a pressure differential within the MOC that could cause failure. Consequently, hazardous substances could leak from the doors of the sea cans into the environment. This exact event occurred on June 3, 2023, at the Meadowbank site, when 1500 L of waste oil was released because "two totes had frozen and expanded causing oil to leak onto the sea-can floor as well as onto the ground within the laydown area." ECCC would like to highlight that the utilization of appropriate secondary containment in this scenario would have contained the MOC failures and greatly aided recovery operations, minimizing the impact on the environment. Furthermore, assessing if the MOC's build and materials are appropriate for the extreme conditions of the Project site could minimize future MOC failures.

Recommendation 8: ECCC recommends that the Proponent commit to installing a lined and bermed area or appropriate secondary containment method for the storage of hazardous chemicals/waste at the Meadowbank and White Tail locations and any other locations where appropriate secondary containment is not currently used. This measure would minimize the potential release of hazardous chemicals from storage areas into the environment. Secondary containment would provide an easier means to clean up a spill while minimizing the impact on the environment. Moreover, assessing if there are means of containments that would be better suited for the extreme conditions of the Project site may reduce their failure rate.

> ***Agnico Eagle's Response:*** *It is industry practice not to use secondary containment in the case of seacans received from a sealift operation. Since the inventory seacans are not in use, the probability of a spill is minimized as the containers inside the seacans are protected from the elements and from collision. These would be the primary causes of a spill from a container.*

As per the approved Hazardous Materials Management Plan hazardous material is stored within their container within seacans. No other contingency measures, such as secondary containment (i.e spill trays), are required under the plan for inventory seacans, unless needed.

It as part of our current practices at site to limit the time where chemicals/hazmat are outside of their respective containments to only during transit periods. As such, all areas of the mines site are regularly inspected by the Environmental department to identify areas of concerns, if any.

Additional lined areas are not considered at this time.

ECCC recommends that the proponent seek out other MOC's that might be more suitable to the harsh conditions experienced at the mine site.

Agnico Eagle's Response: *As stated above, since it is industry practice not to use secondary containment in the case of seacans received from a sealift operation it would not be required to seek out alternative MOC at this time. Focus will rather be placed in ensuring that totes/drums are not filled to maximum capacity and always considering expansion ratios.*

Additionally, ECCC requests clarifications on the new procedure that was put in place to minimize accident events related to the operat*ion of forklifts in the storage area.*

Agnico Eagle's Response: *The use of a spotter has been standardized and is now mandatory for the movement of all totes, drums, chemical bulk bags, or any product transported by forked equipment, which has the potential to be spilled, when the transport is occurring outside of a building or secondary containment area. More details were also included in ensure load are properly secured. Finally, fork adjustment needs to be assessed prior to moving any loads to ensure they are properly adapted to the containers being moved.*

5.9 Toxic gas release event

References: 240330-03MN107 16MN056-Appendix 46-IA1E, Section 7.9 Toxic gas releases, p.40-41

Comment: The Proponent fails to specify the types of toxic gases that could be released in such an event. Given the presence of numerous hazardous substances on-site, it would be beneficial to identify credible and realistic scenarios under which toxic gas substances might be released in large quantities. Does the Proponent possess any means to monitor air quality that could result from a toxic gas release? Are there any alternate muster points if the wind blows a toxic gas in the direction of the assigned muster point? Clarity on these matters is essential for ensuring effective risk management and emergency response protocols.

Recommendation 9: ECCC suggests that the Proponent indicates which toxic gas(es) is(are) at risk of being release for the presented scenario and a description of preparedness measures to address such releases. Further, ECCC encourages the Proponent to specify its air quality monitoring practices within the context of that emergency scenario. ECCC suggests that the Proponent identify what type of air monitoring is accessible [e.g., 4-gas detectors, fixed/portable detectors, LEL detectors or PIDs (Photoionization Detectors)].

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges ECCC recommendations and will include the above-mentioned components in the next version of the Emergency Response Plan.*

5.10 Emergency response guidebook

References: 240330-03MN107 16MN056-Appendix 46-IA1E, Section 13.4 Cyanide involved in Fires, p.119

Comment: The Proponent mentions the use of the Emergency Response Guidebook 2016 by the incident commander as a reference for addressing fires of sodium cyanide.

ECCC would like to inform the Proponent that the latest version of the Emergency Response Guidebook is the 2024 edition. Additionally, a free training package on the book is available upon request.

Recommendation 10: ECCC recommends utilizing the latest version of the Emergency Response Guidebook 2024 as it provides the most up-to-date information. Additionally, Emergency Response Team training should incorporate best practices demonstrated in the free training package to ensure effective utilization.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges ECCC recommendations and has already implemented the 2024 Emergency Response Guidebook within the Meadowbank Complex and will update the information in the next version of the Emergency Response Plan.*

5.11 Response procedure guides

References: 240330-03MN107-Appendix 22-IA2E: 240330-03MN107-Appendix 22-IA2E, Table 6 - Materials stored at site during operations, p.34-36, Appendix F - General Response Procedures for Spilled Chemical Substances Oxidizing Substances, p.103, Appendix H - General Response Procedures for Spilled Chemical Substances Corrosive Substances, p.111.

Comment: Various hazardous materials are necessary to carry out the Meadowbank Complex Project. The Spill Contingency Plan (SCP) explains with general response procedures how it would deal with various type of hazardous materials in Appendices C to I. While some substances have dedicated plans (e.g., ANFO, ammonium nitrate, sodium cyanide), others are subject to general response procedures based on their physical properties. It's important to cross-reference Table 6 of the SCP with the appropriate response plan in Appendices C to I to ensure clarity on how to handle each commodity. For example, certain hazardous materials may fit into multiple response procedures. Establishing clear and concise guidelines for hazardous material spill responses minimizes confusion and facilitates timely interventions.

Recommendation 11: ECCC suggests that the Proponent assigns each hazardous material listed in Table 3-1 of the SCP to a specific guide rather than relying solely on physical properties to direct users to a response procedure.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges ECCC's comment regarding Hazardous Materials and the response procedures. The spill contingency plan specifies a general spill response procedure and clearly instructs a responder to consult the SDS for the specific spilled compound to determine whether deviations from the general guidance are required.*
>
> *Agnico Eagle will evaluate ECCC's suggestion and determine how and if it needs to be integrated in the next version of the Spill Contingency Plan.*

5.12 Aircraft – Low Flights

References: Meadowbank Complex – 2023 Annual Report, Appendix 39: Meadowbank and Whale Tail 2023 Wildlife Monitoring Summary Report, 61-000-100-REP-006, 28 March 2024.

Comment: Page 4-29 of the Meadowbank and Whale Tail 2023 Wildlife Monitoring Summary Report states:

> *"Eleven percent of all short-range flights in 2023 (27.8 hours) were identified below the minimum requirement (300 m), without documentation of the purpose of low flight…*
>
> *32.0% of long-range flights in 2023 (28.9 hours) were identified below the minimum height requirement, without documentation of the purpose of low flight…*
>
> *Overall, 16% of all flight hours in 2023 (56.7 hours) were identified as operating below the project specific flight restrictions, without documentation for the purpose of low flight."*

The majority of low flights occur during the summer, which overlaps with migratory bird breeding season in this area (N9 and N10 ranges from mid-May to mid-August).

The area also includes a number of caribou freshwater crossings included in the 2021 Draft Nunavut Land Use Plan which could be impacted by low flights.

Agnico Eagle plans to improve compliance rates for low flights in 2024 by:

- Reviewing methods with the Terrestrial Advisory Group (TAG) and helicopter contractor to discuss decisions made for take-off/landing and short versus long-range flights;

- Improving comments for reasons for low flights, even if flying low for only a portion of the flight; and

- Considering error for flight altitude measurements as well as error for Latitude and Longitude provided from aircraft monitoring.

Recommendation 12: ECCC recommends that the proponent improve low flight compliance in 2024 by:

a. Reminding pilots that the migratory bird breeding season in this area ranges from mid-May to mid-August;

Agnico Eagle's Response: *Agnico Eagle will continue to work with helicopter contractors and pilots to inform them on the items noted by ECCC.*

b. Considering the proposed designations of caribou crossings and Thelon River Areas of significance under the Draft Nunavut Land Use Plan in discussions with the Terrestrial Advisory Group (TAG); and

Agnico Eagle's Response: *Agnico Eagle will consider the proposed designations of caribou crossings and Thelon Areas of significance under the Draft Nunavut Land Use Plan in discussions with the TAG.*

c. Including all planned mitigation and adaptive measures into the updated Terrestrial Environment Monitoring Plan (TEMP version 9), which is planned for submission to the NIRB later in 2024.

Agnico Eagle's Response: *The TEMP includes all planned mitigation, action thresholds and management actions and these are not anticipated to change in the updated TEMP that is under review with the TAG.*

ECCC recommends that the updated TEMP (version 9) planned for submission in 2024 be made available for review.

Agnico Eagle's Response: *Agnico Eagle acknowledges ECCC's recommendation and will make effort to have the updated TEMP available for ECCC review.*

5.13 Waterfowl Nest Monitoring Results

References: Meadowbank Complex – 2023 Annual Report, Appendix 39: Meadowbank and Whale Tail 2023 Wildlife Monitoring Summary Report, 61-000-100-REP-006, 28 March 2024, "Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds" (Holmes 2022).

Comment: 2023 Wildlife Monitoring Summary Report, page 14-1:

> "*The Whale Tail expansion required the construction of two dykes within Whale Tail Lake to divert water from the proposed pit to surrounding lakes and tributaries, resulting in flooding that with potential impacts to migratory birds and their nests…*
>
> *The complete analysis and report on behavioural responses will be included in a second Trent University MSc Thesis manuscript, expected to be submitted prior to September 2024.*
>
> *References for any publications produced in 2024 will be provided in the 2024 Annual Report*."

ECCC could not find the report "Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds" (Holmes 2022).

Recommendation 13: Please provide link or copy or reference to previous submission regarding the report "*Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds*" (Holmes 2022).

Agnico Eagle's Response: *Agnico Eagle added in Appendix A of this document a copy of the report 'Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds' (Holmes 2022).*

Reference

Holmes, G. I. (2022) Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds. Trent University MSc Thesis. Available at: *http://digitalcollections.trentu.ca/objects/etd-976*

Note: The above online digital collection for Trent University was not functioning at the most recent time of access in July 2024. However, the document link is accessed at: https://ocul-tu.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma991009159669805159&context=L&vid=01OCUL_TU:TU_DEFAULT&lang=en&search_scope=OCULDiscoveryNetworkNew&adaptor=Local%20Search%20Engine&tab=OCULDiscoveryNetwork&query=any,contains,Assessing%20and%20Mitigating%20the%20Impacts%20of%20Mining-Induced%20Flooding%20on%20Arctic-Nesting%20Birds&mode=basic

Please provide new publications in an appendix for 2024 Annual Report.

> ***<u>Agnico Eagle's Response:</u>*** *Agnico Eagle will provide any new publications as appendices in the 2024 Annual Report.*

5.14 Sensory Disturbance on Birds - Lighting

References: Meadowbank Complex – 2023 Annual Report, 61-000-100-REP-006, April 2024.

Comment: Term & Condition 58 of NIRB Project Certificate 004 requires the proponent to design the lighting and use of lights at the mine site to minimize the disturbance of lights on sensitive wildlife and birds.

Lighting at the mine site was not mentioned in the Meadowbank Complex – 2023 Annual Report.

Recommendation 14: ECCC recommends that the proponent clarify how light disturbance on sensitive wildlife and birds was monitored and/or mitigated at the mine site(s) in 2023.

Light disturbance monitoring should be included in the updated TEMP (version 9) planned for submission in 2024 and be made available for review.

> ***<u>Agnico Eagle's Response:</u>*** *Lighting and use of lights are required for human safety. Light mitigation includes directing lighting downward where it does not affect human safety. Agnico Eagle also uses motion activated light controls at the Mine site so that light is not emitted when rooms are empty of people. It should be noted that most bird species are present during spring and summer when nighttime is minimized and the need for lighting is less. Monitoring of lighting and light use is not a requirement of T&C 58.*

5.15 Species at Risk, Effects and Missing Measures

References: Meadowbank Complex – 2023 Annual Report, 61-000-100-REP-006, April 2024, Species at Risk Public Registry.

Comment: Term and Condition No. 35 of Project Certificate No. 008 requires the proponent to ensure that the mitigation and monitoring strategies developed for Species at Risk are updated as necessary. As a matter of best practice, Committee on the Status of Endangered Wildlife in Canada (COSEWIC)-assessed species should be assessed similarly to those listed under the Species at Risk Act (SARA).

The Proponent has not identified all species at risk that are likely to be present in the Project area and the associated adverse effects of the Project. Harris's Sparrow (*Zonotrichia querula*) has been listed as a species of Special Concern by COSEWIC since April 2017 and has been listed as a species of Special Concern on Schedule 1 of SARA since February 2023.

The Project may have adverse effects on Harris's Sparrow including the following: direct habitat loss; impacts due to noise; dust or other sensory disturbances; wildlife injury or mortality; exposure to toxic or hazardous substances; and wildlife attraction.

Recommendation 15: ECCC recommends the Proponent:

a) Identify adverse effects of the Project on the Species at Risk likely to be affected and their critical habitat.

b) Ensure that measures are taken to avoid or lessen those adverse effects and monitor them to inform adaptive management; and

c) Update the next version of the TEMP to include all Species at Risk that are likely to be present in the Project area, and update associated mitigation of project effects.

As species are assessed and listed on a regular basis, ECCC recommends the Proponent consult the Species at Risk registry to obtain the most current information for their operations.

> ***Agnico Eagle's Response:*** *ECCC's recommendations are already present in the TEMP. Species at risk registries are reviewed annually for updated information on new species at risk and recovery plans are included when applicable. Consistent with ECCC, the TEMP identifies direct and indirect effects to habitat and injuries and mortalities as potential effects and associated monitoring for species at risk.*
>
> *According to the Cornell Lab All About Birds (Cornell 2024) the Meadowbank Mine does not occur within the annual and breeding distribution of Harris's sparrow. According to the resource e-bird data base of 2019 to 2024 species observations (Cornell 2024). According to COSEWIC assessment status report (COSEWIC 2017), Harris's sparrow's northern most occurrence is near Rankin Inlet, which is approximately 250 km south of Baker Lake, NU (COSEWIC 2017); the closest community to the Mine. Agnico Eagle does not agree that the Meadowbank Mine TEMP needs to be updated to include Harris's sparrow as a Mine-associated species at risk.*
>
> ***References***
>
> *Cornell (Cornell Lab). 2024. All about birds. University of Cornell website: https://www.allaboutbirds.org/news/. Accessed July 15, 2024.*

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2017. COSEWIC assessment and status report on the Harris's Sparrow Zonotrichia querula in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 36 pp.

6 Transport Canada (TC)

6.1 Marine Safety and Security

6.1.1 Inspections - Marine Transportation; Oil Handling Facility

References: 2023 Annual Report, Section 11.8: Shipping Management. 2023 Annual Report, Appendix 25 Parts 1 and 2: Oil Pollution Emergency Plan.

Comment: The oil handling facility is in compliance with regulatory requirements as per part 8 of the *Canada Shipping Act*, 2001. No inspection was carried out in 2023.

The facility is in compliance with the Marine Transportation Security Regulations.

Tanker *Marlin Hestia*, associated with project shipping, was inspected by Transport Canada in 2023 and no deficiencies were noted.

No enforcement activity was undertaken or required last year by Transport Canada's Marine Safety and Security group.

Recommendation 1: None

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges Transport Canada's comment on the Oil Handling Facility 2023 Compliance.*

6.1.2 Marine Transportation Spill at Oil Handling Facility

References: 2023 Annual Report, Section 11.8: Shipping Management Section 11.8.4: Ingress/Egress of Ship Cargo NIRB Project Certificate No.008 Condition 43.

Comment: At p. 417 of the 2023 Annual Report, AEM provided details of a diesel spill during a ship to shore transfer of fuel on August 27, 2023.

Regarding the spill incident, the spill was reported to Transport Canada and our inspector followed up with the Operator. The Oil Handling Facility crews implemented their Oil Pollution Emergency Plan (OPEP), deploying absorbent booms and pads in the affected area. Agnico Eagle subsequently initiated mitigation measures to prevent future punctures to hose lines. At this time, no further follow-up from Transport Canada is required.

Recommendation 2: None

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges Transport Canada's comment.*

6.1.3 Small vessel inspections

References: 2023 Annual Report, Section 11.5 Inspections and Compliance Reports

Comment: At pp. 401-402 of the 2023 Annual Report, AEM reported that Transport Canada conducted an inspection of small boats/vessels used at the Meadowbank Complex.

Transport Canada notes that all deficiencies identified during the inspection were followed up and completed by AEM.

Recommendation 3: None

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges Transport Canada's assessment of the 2023 Compliance*.

6.1.4 Marine Transportation – 2024 Annual Notice to Mariners

References: 2023 Annual Report, Section 11.8: Shipping Management

Comment: Transport Canada recommends the Proponent make vessel operators serving the Project aware of the 2024 Annual Notice to Mariners, and in particular section A2 Marine Mammal Guidelines and Marine Protected Areas and section 7A Voyage Planning for Vessels Intending to Navigate in Canada's Northern Waters (see: Annual Notice to Mariners at:

https://publications.gc.ca/collections/collection_2024/mpodfo/Fs151-4-2024-eng.pdf)

Recommendation: 4 Transport Canada requests that the above information be brought to AEM's attention.

> ***Agnico Eagle's Response:*** *Agnico Eagle thanks Transport Canada for bringing this information to Agnico Eagle's attention. The vessel operators are made aware of the notice and related requirements and reminders are sent by the shipping companies at the start of the season.*

6.1.5 Shipping Management Plan – Ballast Water

References: 2021 Annual Report, Appendix 56: Shipping Management Plan Version 4 (April 2022), Section 7

Comment: An updated Shipping Management Plan was not provided with the 2023 Annual Report. Version 4 of the Shipping Management Plan does not reflect the current requirements of the Ballast Water Regulations (SOR/2021-120).

Transport Canada's ballast water exchange and treatment requirements were updated in the Ballast Water Regulations, SOR/2021-120, that came into force on June 3, 2021, and which implement the Ballast Water Management Convention in Canada. Treatment and water quality standards applicable to ballast water discharged within Canada will be coming into effect in 2024 using a phase-in approach until 2024. From the date of entry into force of the Ballast Water Management Convention (September 8, 2017), all vessels must conform to at least the D-1 standard (exchange); and all new vessels, to the D-2 standard (treatment) (refer to the infographic attached). Note that Canadian vessels that don't voyage internationally, other than to U.S. Great Lakes waters, or on the high seas need to meet Convention standards and the Ballast Water Regulations no later than September 2024 or September 2030, depending on when they were built.

- Ballast Water Regulations Ballast Water Regulations (justice.gc.ca)
- https://tc.canada.ca/en/marinetransportation/marine-safety/list-canada-sdesignated-alternate-ballast-water-exchangearea-fresh-waters-tp-13617e-2021#item2

Recommendation 5: Transport Canada requests that:

1- AEM update Section 7 – Shipping Management Plan be updated to reflect the requirements of the Ballast Water Regulations.

2- A new version of the Shipping Management Plan be included with the 2024 Annual Report.

Agnico Eagle's Response: *Agnico Eagle will update relevant sections of the Shipping Management Plan to reflect the current Ballast Water Regulations (SOR/2021-120) in the next update of the Plan.*

Agnico Eagle would like to note the contracted shipping companies comply with all applicable regulations, including the Ballast Water Regulations, and that the Shipping Management Plan update is not required annually, but as needed when changes occur.

6.1.6 Shipping Management - Biofouling

References: 2021 Annual Report, Appendix 56: Shipping Management Plan Version 4 (April 2022), Section 7

Comment: The following is for the information of AEM, NIRB, and reviewers of the 2023 Annual Report on the subject of biofouling:

In Fall 2022, Transport Canada published its Voluntary Guidance for Relevant Authorities on In-Water Cleaning of Vessels (canada.ca), which includes a biofouling management plan and biofouling record book templates that have been well regarded internationally. The guidance provides clarity to stakeholders (competent authorities, vessel owners and operators, and in-water clean-up service providers) on recommended best practices that can be used to manage the biosecurity and water quality risks associated with cleaning vessels underwater.

The International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) adopted the revised "Guidelines for the Control and Management of Ship's Biofouling to Minimize the Transfer of Invasive Aquatic Species" (Marine Environment Protection Committee (MEPC 80), 3-7 July 2023 –preview (imo.org)). These guidelines provide recommendations on in-water inspections with a focus on the quantitative assessment of biofouling using a biofouling rating number, as well as on observations of the anti-fouling system condition, which will assist vessel owners and operators in minimizing the transfer of potentially harmful aquatic species, following globally agreed guidance.

Recommendation 6: Transport Canada requests that the above information be brought to AEM's attention.

> ***Agnico Eagle's Response:*** *Agnico Eagle thanks Transport Canada for bringing this information to Agnico Eagle's attention, and confirms it was shared with the currently contracted shipping companies.*

6.2 Transportation of Dangerous Goods

6.2.1 Transportation of Dangerous Goods /Hazardous Materials

References: 2023 Annual Report, 6.1.13 – Hazardous and non-hazardous waste, 2023 Annual Report, Appendix 21 -Meadowbank 2023 Hazardous and Non-Hazardous Waste Transport Manifest

Comment: At p. 109 of the 2023 Annual Report (Table 6-2), AEM reported that 5,200 kg of lead batteries were recycled, which presumably would have required shipment to the south. Table 6-2 identifies the batteries as a dangerous good. However, when reviewing the Transport Manifest (Appendix 21), Transport Canada could not find a record of the shipment of the lead batteries.

Transport Canada's TDG Group will follow up directly with AEM about this matter.

Recommendation 7: Transport Canada recommends NIRB request that AEM also explain this discrepancy in its response to comments on the 2023 Annual Report.

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges recommendation and will engage with TC to determine the best way to address this matter.*

6.2.2 Transportation of Dangerous Goods /Hazardous Materials

References: 2023 Annual Report, Section 6.1.13 – Hazardous and non-hazardous waste

Comment: No TDG monitoring was carried out at the Meadowbank Complex by Transport Canada in 2023. No complaints/concerns regarding TDG were received by Transport Canada and the Department did not undertake any TDG related enforcement actions.

Other than the shipping waste manifest, Transport Canada's TDG Group had no other concerns with the 2023 Annual Report.

Recommendation 8: None

> ***Agnico Eagle's Response:*** *Agnico Eagle acknowledges Transport Canada's assessment of the 2023 Compliance*.

7 Health Canada (HC)

7.1 HHRA problem formulation – exposure pathways

References: 2023 Annual Monitoring Report, Section 8.19 – Country Foods (Monitoring), PDF pg. 387; 2023 Annual Monitoring Report, Appendix 40: 2023 Wildlife and HHRA Country Foods Screening Level Risk Assessment Plan Version 9, Section 3.1.1: Exposure Pathways, PDF pg. 29; 2023 Annual Monitoring Report, Appendix 39: 2023 Wildlife Monitoring Summary Report. Appendix G: Hunter Harvest Study (HHS), Section 7.3 & Figure 7.1, pg. 29-30; Health Canada. 2023. Guidance for Evaluating Human Health Effects in Impact Assessment: Human Health Risk Assessment. Section 7.1.1., Identification of Study Boundaries PDF pg. 14.

Comment: The rationale for exclusion of fish from the *Country Foods Screening Level Risk Assessment Plan* is insufficient and may not be protective of human health in future use scenarios.

Specific country foods evaluated in the *Country Foods Screening Level Risk Assessment Plan* are listed in Section 3.1.1 of Appendix 40 and include caribou and Canada goose. Fish consumption remains excluded because of the "no fishing policy" at the project site targeting mine employees and the non-migratory nature of the fish.

The current rationale for excluding fish does not appear to consider a non-employee/local harvester exposure pathway. Information on recent and current fishing in lakes near the mine sites (e.g., Wally Lake, 2nd & 3rd Peninsula Lake, Whale Tail Lake, Kangislulik Lake, etc.) would help characterize use and describe the operability of this potential exposure pathway.

Relevant information could be obtained from:

- Creel Surveys (HHS);
- Engagement with harvesters; and/or,
- Dietary surveys.

Consideration of potential future use scenarios during decommissioning, closure and post-closure phases of the project, where infrastructure will remain on-site (e.g., tailings impoundment), is also recommended as part of a complete rationale for including/excluding fish consumption from future risk assessments related to country foods[2].

[2]Health Canada. 2023. Guidance for Evaluating Human Health Effects in Impact Assessment: Human Health Risk Assessment

Recommendation 1: HC recommends including consumption of fish in the potential exposure pathways for the *Country Foods Screening Level Risk Assessment Plan* or providing data that demonstrates that fish from the lakes near the mine site are not being consumed now and in the future.

> ***Agnico Eagle's Response:*** *Current fishing locations: Beyond the FEIS stage, consumption of fish was not included in country foods assessments because no-fishing policies are in place for workers and consumption of fish from project lakes was expected to be negligible. Creel surveys are completed annually, and recent reports continue to indicate that fish are not caught by local harvesters in lakes near the Meadowbank Complex (e.g. Second and Third Portage Lakes, Wally Lake, Whale Tail Lake, Kangislulik Lake, etc.). Complete results are provided each year in the annual Wildlife Monitoring Summary Report (Hunter Harvest Survey), and locations of successful catch in 2023 are copied below (Figure 2). Regardless of success rate, creel survey results indicated that fishing does not generally occur beyond the immediate areas of Baker Lake, Whitehills Lake, and the southern portion of the AWAR. It was determined that study participants are less willing to travel long distances to catch*

fish, regardless of AWAR access, likely due to the abundance of fish near the Hamlet of Baker Lake and around Whitehills Lake. Therefore, in keeping with Health Canada's recommendation, Agnico Eagle concludes that consumption of fish from the project lakes remains an incomplete exposure pathway under the current operational scenario but will continue to review annual creel survey results in this context. It is also noted that monitoring of mercury concentrations in fish tissue are conducted under the Mercury Monitoring Plan for the Whale Tail Mine. Results are compared to FEIS predictions, including consumption guidelines, and will be summarized in the HHRA-country foods report.

Future fishing locations: Consumption of fish by members of the public will however be considered in the closure-phase HHERA as a complete pathway, since fishing is a possible activity in the lakes following the closure of the mine. This assessment will be included in the HHERA in support of the Closure and Reclamation Plan.

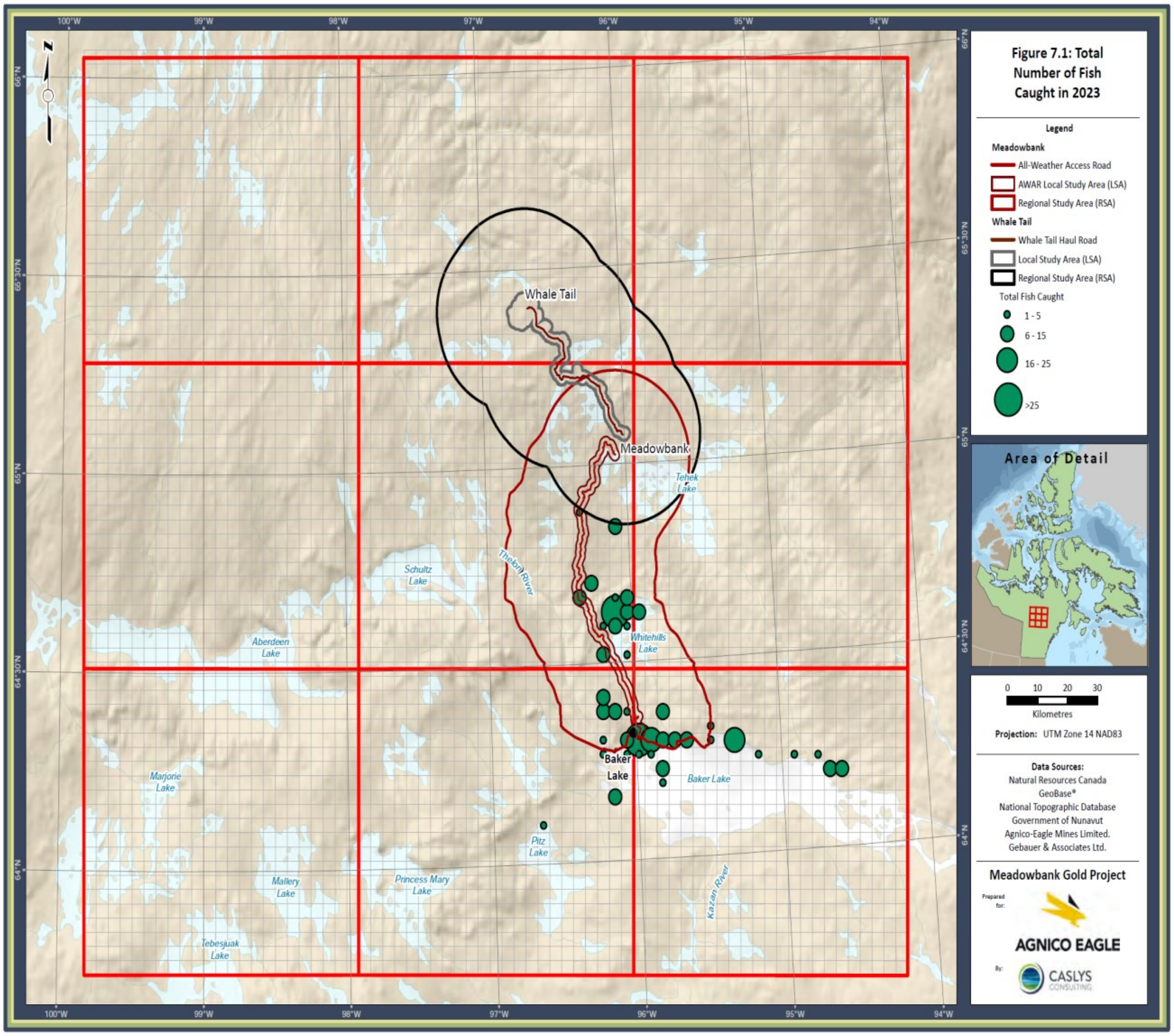

Figure 2. Figure 7.1 from the 2023 Hunter Harvest Study and Creel Survey Summary Report (an appendix of the 2023 Wildlife Monitoring Summary Report).

Appendix A

Assessing and Mitigating the Impacts of Mining-Induced Flooding on Arctic-Nesting Birds" (Holmes 2022).

ASSESSING AND MITIGATING THE IMPACTS OF MINING-INDUCED FLOODING ON ARCTIC-NESTING BIRDS

A Thesis submitted to the Committee on Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Master of Science in the Faculty of Arts and Science

TRENT UNIVERSITY
Peterborough, Ontario, Canada

Environmental and Life Sciences M.Sc. Graduate Program
January 2022

ACKNOWLEDGMENTS

I am grateful for the guidance and support of my two supervisors, Dr. Erica Nol and Dr. Paul A. Smith, who provided me with feedback and critique throughout my project. I would not have been able to finish this without their encouragement. Thank you for believing in my abilities when I did not believe in myself. You provided me with a rare opportunity to continue research in the Arctic; I am forever grateful for your ongoing mentorship and supervision.

I was fortunate to spend my field seasons trekking the tundra with a group of incredibly hard-working individuals who did their best and kept laughing even on the toughest of days. Thank you to Sarah Bonnett, Jessica Ballie, Sophie Roy, Joanne Hamilton, Amy Wilson and Nathalie Paquette. You helped find over three hundred nests within two field seasons and worked tirelessly to make sure data were collected accurately.

This project would not have been successful without logistic and financial support from Environment and Climate Change Canada’s Canadian Wildlife Service, and Agnico Eagle Mines Ltd. Special thanks to Environment Department staff and Leilan Baxter at Agnico Eagle Mines Ltd. for their support during the field season and to the student and Inuit workers who helped in the field.

I would also like to thank my additional funding sources; Queen Elizabeth II Graduate Scholarship in Science and Engineering (QEII-GSST), W. Garfield Weston Award in Northern Research (Master's), MITACS, and Fern A. Rahmel Graduate Bursary. Thanks to this financial support, I could focus solely on my research project during the unprecedented year of 2020. Thank you for believing in my skills and abilities and providing me with the opportunity to achieve my academic goals.

Abstract

Assessing and Mitigating the Impacts of
Mining-Induced Flooding on Arctic-Nesting Birds

Gillian I. Holmes

Mining and resource development are growing industries in the Arctic, resulting in increased conflict with wildlife. Best practices for mitigation require an understanding of the potential ecological effects. One such effect concerns the flooding of terrestrial bird habitat from dewatering of lakes during mining pit development. I first assessed the efficacy of bird deterrents to mitigate impacts of mining-induced flooding on arctic-nesting birds at a gold mine in Nunavut. I used a Before-After Control Impact (BACI) design to determine changes in male territory densities, between year and treatment types (Control, High and Low Deterrent Intensity). Additionally, I assessed whether deterrents impacted daily survival rates of two passerine species, and the incubation behaviour of female Lapland Longspur. Finally, I quantified nest losses during the breeding season due to direct flooding of the tundra nesting habitat caused by mining operations. Deterrents did not affect male territory densities and neither deterrent treatment nor year affected the daily survival rate of nesting passerines. Female Lapland Longspurs exposed to deterrents exhibited more incubation off-bouts than control females. I documented six flooded nests. Deterrents used in this study appear to be ineffective in mitigating nesting in potential zones of impact. Incidental take accounted for about 1.2% of all nests found in the 0.48 km^2 Whale Tail Lake study area.

Keywords: audio deterrents, visual deterrents, incidental take, nest incubation, mining and resource development, arctic-nesting bird, daily survival rate, territory density.

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CHAPTER 1 — GENERAL INTRODUCTION

Rationale for Study

Mining is an important economic driver in northern Canada as it provides scarce job opportunities for people living in northern communities (Cameron and Levitan 2014; Belayneh et al. 2018). In Nunavut, Canada, 18% of the gross domestic product in 2014 was associated with resource extraction (AMAP 2017). Mineral, oil and gas exploration is expected to expand across the Arctic landscape (A.T. Kearney Inc. 2015) during the rest of the 21st century, leading to land use changes and disturbance of critical habitat for wildlife (Wilson et al. 2013).

Mining and other forms of resource development frequently result in disturbance to wildlife that is difficult to avoid (Wickham et al. 2013; Cristescu et al. 2016). Resource extraction can have detrimental impacts on habitat quality through direct impacts such as the loss of habitat from mine development and flooding (Johnson et al. 2005), and indirect impacts such as increased pollutants, human traffic, and noise (Reijnen et al. 1997; Hassan 2016). An intensification in resource extraction across the Arctic landscape can potentially lead to a greater chance for species loss (Gajera et a l. 2013; Bernath-Plaisted and Koper 2016) as many arctic-nesting birds are already vulnerable to climate change (Wauchope 2016; Hof et al. 2017; Smith et al. 2020). Therefore, finding a balance between conservation and economic growth is crucial in the Arctic.

Intensive resource extraction activities and mining development in the North are carried out at the same time as nesting by birds, because both industrial activities and bird nesting are constrained by suitable weather in the Arctic. For example, ‘dewatering’ of lakes for mining pit development occurs during spring melt in the Arctic, adding to the amount of run-off on the tundra because the water is directed elsewhere. This additional run-off coincides with birds' arrival on the breeding grounds, leading to destruction of nesting habitat (Pirie et al. 2009; Gajera et al. 2013), and exacerbating the conflict between policies and regulations that protect wildlife and overall economic growth in the north (A.T. Kearney Inc. 2015). Thus, there is value in identifying ways to minimize violations of existing legislation that protects birds, such as the Migratory Birds Convention Act (MBCA 1994).

One way of limiting impacts of human infrastructure and development on wildlife is by discouraging wildlife from settling in at-risk areas. Discouragement can be achieved with the use of deterrents. Deterrents can be visual (e.g., mylar tape, flares, helium balloons) or auditory (e.g., cannons, predator and prey distress calls, bangers, and crackers), including objects or methods that mimic risk of predation (e.g., canids, falconry). Deterrents have been used for decades to discourage birds from congregating in human-made infrastructure (Kalmach 1940; Mott 1980; Hothem and Dehaven 1982). This infrastructure includes airports, where domestic canines and falcons are used to deter birds from congregating on airstrips and potentially colliding with aircrafts (Ball 2000).

On agricultural lands and in fisheries, deterrents are used to limit yield loss, as demonstrated in scientific literature as early as the 1960s with scarecrows, which have a long history of use against birds (Frings and Frings 1967; Achiron 1968). Over time, researchers have looked for other ways to use human and predator effigies to seem more life-like (Marsh et al. 1992). For example, an effigy of an animated crow-killing owl was used to deter crows from feeding on crops (Conover 1985). Past studies have used a combination of pyrotechnics, flashing lights and human effigies to compare the efficiency of these methods in deterring herons from harvesting fish from aquaculture farms (Andelt et al. 1997). Additionally, deterrents have been used in urbanized areas such as parks and subdivisions, which are major areas of congregation for blackbirds and other flocking passerines (Kalmbach 1940). Deterrents are a practical tool to prevent wildlife from destroying property and reducing harm to wildlife in at-risk areas (Cleary and Dolbeer 2005; Schlichting et al. 2017).

There are numerous studies related to the use of deterrents for discouraging birds from tailing ponds on mining sites that may be harmful to birds (Boag and Lewin 1980; Ronconi and St. Clair. 2006). For example, Ronconi et al. (2004) discovered that some migratory bird species avoid sites when multiple deterrent types, such as robotic peregrine falcon effigies, audio calls of predators, high-intensity strobe lights and propane cannons, are used to mitigate the impacts of toxic tailing ponds in the oil sands region of Alberta, Canada. Ronconi et al. (2004) exhibited success in using deterrents to mitigate impacts of pollution on birds during migration. Nevertheless, there is limited research on how to deter birds from nesting in at-risk areas (Marcus et al. 2007) and how to mitigate impacts on offspring reared in areas where they are vulnerable (Kruk et al. 1997). Consequently, there are gaps in the literature related to the use of deterrents for preventing nesting of migratory birds in any environment, and there is little research regarding deterrent use as mitigation options in Arctic regions (Umlah 1996; Racca 2005).

Study Area

My study area is located approximately 250 kilometres west of Hudson Bay and 130 kilometres north of Baker Lake, in the Kivalliq region of Nunavut (N65° 24' 14.0"

W96° 40' 48.4"), near Amaruq Mine, operated by Agnico Eagle Mine Limited (AEM). The region is situated in Wager Bay Plateau ecoregion of the Arctic ecozone (Campbell et al. 2012). The region exhibits a range of tundra habitats, with rolling hills, rocky terrain and scattered lakes and ponds. Habitats are primarily heath, lichen and rock in the uplands and wet graminoid-dominated lowlands, with tundra of varying moisture regimes in between (Campbell et al. 2012). Shrub species such as willow (*Salix* spp.), dwarf birch (*Betula glandulosa* Michx.) and blueberry shrub (*Vaccinium* spp.), primarily dominate the landscape and elevated hills, interspersed with *Dryas* spp. The mid- to low-lying areas are dominated by grasses (e.g. *Puccinellia* spp.) and sedges (e.g. *Carex* spp.), along with a mix of herbaceous plants such as Labrador tea (*Rhododendron tomentosum* Harmaja.) and *Saxifraga* spp. These low-lying sedge meadows provide habitat for numerous breeding and migrating arctic-nesting bird species (Young et al. 2015). Due to mining in the area since 2010, there is a 160-kilometre, elevated gravel road that runs from Baker Lake, Nunavut to Amaruq Mine. The larger Meadowbank Mine, also operated by Agnico Eagle Mine Ltd., is situated between Baker Lake and Amaruq Mine (Figure 1.1).

Focal Species

The study area provides breeding habitat for multiple species of arctic-nesting birds, many of which are likely to be impacted by mining-induced flooding. I identified four of the most abundant species at the study sites that were also the easiest species for both locating and monitoring nests, so that I could obtain sufficient sample sizes for analysis. Below, I briefly discuss the life history of the four focal species in the study, as life history traits could be important determinants for the effectiveness of deterrents (Ronconi and St. Clair 2006).

Lapland Longspur

Lapland Longspur (*Calcarius lapponicus* L.) is the most widely distributed and abundant species of arctic-nesting passerine as it breeds throughout most of the North American Arctic, including Greenland (Hussell and Montgomerie 2020). The Lapland Longspur breeding season starts at the beginning of June and can go as late as the second week of August (Fink et al. 2020). Typically, the Lapland Longspur nests in wet and hummocky tundra meadows, often on relatively flat ground but nests can also be found on drier well-vegetated slopes. The species avoids thickets and forested areas and is not usually found in rocky habitats (Hussell and Montgomerie 2020).

Nesting and Breeding Behaviour

Male Lapland Longspur establish territories before pairing with females, who arrive to the breeding grounds after males (Hussell and Montgomerie 2020). Pairs start to build nests in early to mid-June (Parmelee et al. 1967; Sutton 1932). Territory densities of Lapland Longspurs on lowland hummocky tundra are estimated at 10-15.4 pairs/km^2 pairs at Melville Peninsula, Nunavut (Montgomerie et al. 1983). The species averages only one brood/year with rare second broods, however when they occur, they are unlikely to succeed due to the short breeding seasons (Custer and Pitelka 1977; Hussell 1972). Clutch-initiation dates vary among years, with a median of 26 June (Hussell and Holroyd 1974).

Lapland Longspur females incubate 4-5 eggs for 10.5 – 13 days (Jehl and Hussell 1966), and incubation begins as early as the first egg (Watson 1957). Lapland Longspur have altricial offspring, meaning they hatch with their eyes closed and with no feathers. The nestling stage occurs for 8-11 days, and nestlings are fed by both parents (Drury

1961). Fledglings leave the nest a few days before they can fly and begin to fly at 13-15 days (Drury 1961; Parmalee et al. 1967). Once the nestlings fledge, the brood is divided and fed between parents (Sutton and Parmelee 1955). Parents will travel with the fledglings for up to distances of 600 m from the nest site (Mclaughlin and Montgomerie 1989).

Life Span and Survivorship

Based on subsequent return data of Lapland Longspurs captured in a two-year study, their annual adult annual return rate is 42.9 % for males and 45.4% for females (Custer and Pitelka 1977). The oldest recorded age of a Lapland Longspur was 6 years (Custer and Pitelka 1977). The population status of Lapland Longspur is listed as least concern with an increasing population trend (BirdLife International 2009). Lapland Longspur are recognized as the most common arctic-nesting terrestrial bird worldwide with an estimated global population as high as 150 million mature individuals (Hussell and Montgomerie 2020).

Horned Lark

Horned Lark (*Eremophila alpestris* L.), another passerine species, breeds throughout North America, from northern Baffin Island (Godfrey 1986) to the highlands of Mexico (Howell and Webb 1995). This species has a total of 21 subspecies in North America (AOU 1998), but also breeds throughout Europe. The subspecies identified in this study is presumed to be *E. alpestris hoyti* B., identified as a one of the three migratory subspecies of *E. alpestris* that nests in Eastern Canada (*E. a. alpestris* L. and *E. a. praticola* O.; Beason 2020). The *E. alpestris hoyti* B. subspecies breeds from north Baffin Island, Nunavut to northern Alberta and east to western Ontario (Behle 1942).

Horned Lark nest on open, barren ground with vegetation height less than 10 cm (Wiens et al. 1987), with an avoidance of forested areas (Behle 1942). *E. a. hoyti* arrives on the breeding ground in Nunavut as early as the last week of May and breeds into the first week of August (Beason 2020).

Nesting and Breeding Behaviour

Male Horned Lark establish breeding territories within the first 2 weeks of June (Drury 1961). Their territories are uniformly dispersed, and are defined as all-purpose, in that they are used for all aspects of mating, nesting and feeding (Drury 1961). Reported densities of Horned Lark territories range from 2.3 to 5.1 territories/ha in high latitudes (Cannings and Threlfall 1981). Horned Lark begin nest building and egg laying as early as the second week of June (G. Holmes, pers. obs.) and as late as mid-July in the Arctic (Parmelee et al. 1967), but due to a short nesting season in the Arctic, this species has only one brood per season (Verbeek 1967).

The clutch size of Horned Lark ranges from 2 – 5 eggs per nest (Maher 1980). Horned Lark incubation is uniparental, with female Horned Lark incubating for 11 – 12 days (Cannings and Threlfall 1981). Horned Lark offspring are altricial and are born with their eyes closed and covered in cream-buff down (Beason and Franks 1973). Horned Lark nestlings depart the nest at the age of 8 – 10 days (Cannings and Threlfall 1981) and begin to fly short distances at 16 days of age (Beason 1970). Both Horned Lark parents feed nestlings and continue to do so for over a week after fledging (Beason 1970). Nestlings become independent after 4 weeks post fledge (Cannings and Threlfall 1981).

Life Span and Survivorship

There are no available long-term studies that accurately measure the life span of Horned Lark; however, banding recoveries indicate that adult Horned Lark can live about 2 – 3 years (Beason 2020). The oldest Horned Lark was reported to be at least 8 years old (Klimkiewicz and Futcher 1989). The Horned Lark global populations are large with population estimates for Russia reaching one hundred thousand to one million pairs (Beason 2020). North America population estimates for this species are lacking, but it is known to be widespread and common (Beason 2020). Based on population trends from the North American Breeding Bird Survey (Sauer et al. 2017), Horned Lark populations have declined by 70% over the last 50 years (1966 – 2015), yet their status is considered of least concern (BirdLife International 2019). However, the subspecies, *E. alpestris strigata* H., with distribution along the western coast of Canada and United States, is considered endangered in Canada and is considered close to extirpation (COSEWIC 2004). The reason for the decline of *E. alpestris strigata* H. is loss or degradation of suitable breeding habitat due to industrial agriculture leading to range contraction (Camfield et al. 2011).

Semipalmated Sandpiper

Semipalmated Sandpiper (*Calidris pusilla* L.) is a small shorebird that breeds across Arctic and sub-arctic Canada, from the Alaskan coast east to northern Quebec, including the central Baffin Island and northern Labrador (Godfrey 1986; Johnson et al. 2007). Semipalmated Sandpiper nest in mixed habitats but are usually found in low-lying habitats near water (Hicklin and Gratto-Trevor 2020) although nests are sometimes found in drier, upland tundra with low vegetation near small ponds and streams (Godfrey 1986).

Semipalmated Sandpiper arrive at the breeding grounds in Nunavut in late May and early June (Parmelee et al. 1967; Jehl 2006).

Nesting and Breeding Behaviour

Semipalmated Sandpiper begin to establish territories when they arrive on the breeding grounds. The territories are established by males via flights displays, vocalizations and chases (Gratto-Trevor 1992). Semipalmated Sandpiper are known to reuse their territory from previous years (Gratto et al. 1985). Territory size varies between areas and years but is estimated to be 1 territory/ha in La Pérouse Bay, Manitoba (Gratto et al. 1985), while in Churchill, Manitoba densities ranged from 3.2 – 4.1 territories/ha when they were still a common breeding species there (Jehl 2006). Territories are not used for foraging, as this activity occurs off territory and up to 2-3 kilometres away (Jehl 2006).

The standard clutch size for Semipalmated Sandpiper, as with all arctic-breeding shorebirds, is 4 eggs, with 3 eggs being more prevalent in second broods (Sandercock 1997). Peak nest initiation for Semipalmated Sandpiper starts the third week of June, with peak hatch occurring during the second week of July (Gratto and Cooke 1987). In instances where clutch initiation occurs later than 1 July, there is a higher chance of desertion late into incubation (Holmes and Pitelka 1968). Offspring are precocial, leaving the nests with the guidance of parents 24 hr post hatch (Ashkenazie and Safriel 1979).

Life Span and Survivorship

The oldest known Semipalmated Sandpiper is recorded as 17 years old (Jehl 2007). The North American population is estimated at 3.5 million birds (Morrison et al. 2000). However, migratory stopover sites have shown a pronounced decline in populations of Semipalmated Sandpipers in the last 30 years (Gratto-Trevor et al. 2012; Morrison et al. 2012). Estimates of Semipalmated Sandpipers across their breeding range demonstrates population declines in the east, stable populations in the central Arctic and increasing populations in the west (Smith et al. 2012). Semipalmated Sandpiper are currently listed as near threatened with global population trends decreasing (BirdLife International 2016). Threats to Semipalmated Sandpiper populations are thought to include energy production and mining, hunting and trapping of individuals in South America (Andres 2011), habitat shifts on the breeding grounds and increased storms during migration due to climate change (Brown et al. 2017), although the actual causes of decline are not known.

Least Sandpiper

The Least Sandpiper (*Calidris minutilla* V.), another small shorebird, breeds across the Canadian Arctic and along the northern coast of British Columbia to northern Quebec and Newfoundland and Labrador (Nebel and Cooper 2020). Least Sandpiper prefer breeding in low and sub-arctic wet sedge habitat, near water or muddy areas (Godfrey 1986). Least Sandpiper arrive to the breeding grounds in the eastern Canadian Arctic at the end of May (Littlefield and Pakulak 1969) and breeding adults are known to return to previous nesting territories and are observed to the use the same nest between years (Miller 1983).

<u>Nesting and Breeding Behaviour</u>

The nesting phenology of Least Sandpiper is similar to that of Semipalmated Sandpiper (see above; Ashkenazie and Safriel 1979). Least Sandpipers are biparental, lay a four-egg clutch, have chicks that are precocial, and produce only one brood per season (Miller 1984; Nebel and Cooper 2020).

<u>Life Span and Survivorship</u>

The oldest recorded age for a Least Sandpiper was 16 years (Miller and McNeil 1988). The population numbers of Least Sandpiper vary between spring and fall migrations (Morrison et al. 2001), but the most recent available population estimates for North America suggest a population of about 700,000 individuals (Morrison et al. 2006; Andres et al. 2012). Least Sandpiper population trends show a decrease, and the IUCN status is least to moderate concern (BirdLife International 2016; Nebel and Cooper 2020). Declines in populations of Least Sandpiper are thought to be due to habitat shifting on the breeding grounds or an increase in severe weather during migration due to climate change, as well as habitat modification along migratory routes (Butler 2003), although the actual causes of decline are not known.

Thesis Objectives

My thesis examines options for deterring arctic-nesting birds from potential flood zones caused by mining activities. The research aims to expand knowledge of deterrents as a means for preventing birds from nesting in areas that are a risk to their reproductive success. I meet these objectives through two research chapters and one general concluding chapter.

The objectives for Chapter 2 are to explore options for mitigating nest losses from flooding by 1) determining the effectiveness of deterrents at reducing the densities of breeding birds, 2) establishing the individual behavioural responses of nesting female Lapland Longspurs, the most abundant species in the study area, to deterrents, 3) examining the impacts of deterrents on nesting success two passerine species, and 4) assessing the practicality of erecting and maintaining deterrents in arctic environments.

The objectives for Chapter 3 are to 1) estimate the magnitude of the effect of mining-induced flooding on nest losses by arctic-breeding birds by evaluating the change in nesting densities, before and after flooding, 2) estimate the potential for dispersal and re-nesting after nest loss due to mining-induced flooding, and 3) determine if the daily nest survival of nests located in areas predicted to flood is lower than those that nested outside the predicted flood area. My research results will assist in decisions regarding future deterrent use on arctic-nesting birds and will allow for strong inferences about the effectiveness of deterrents in tundra environments.

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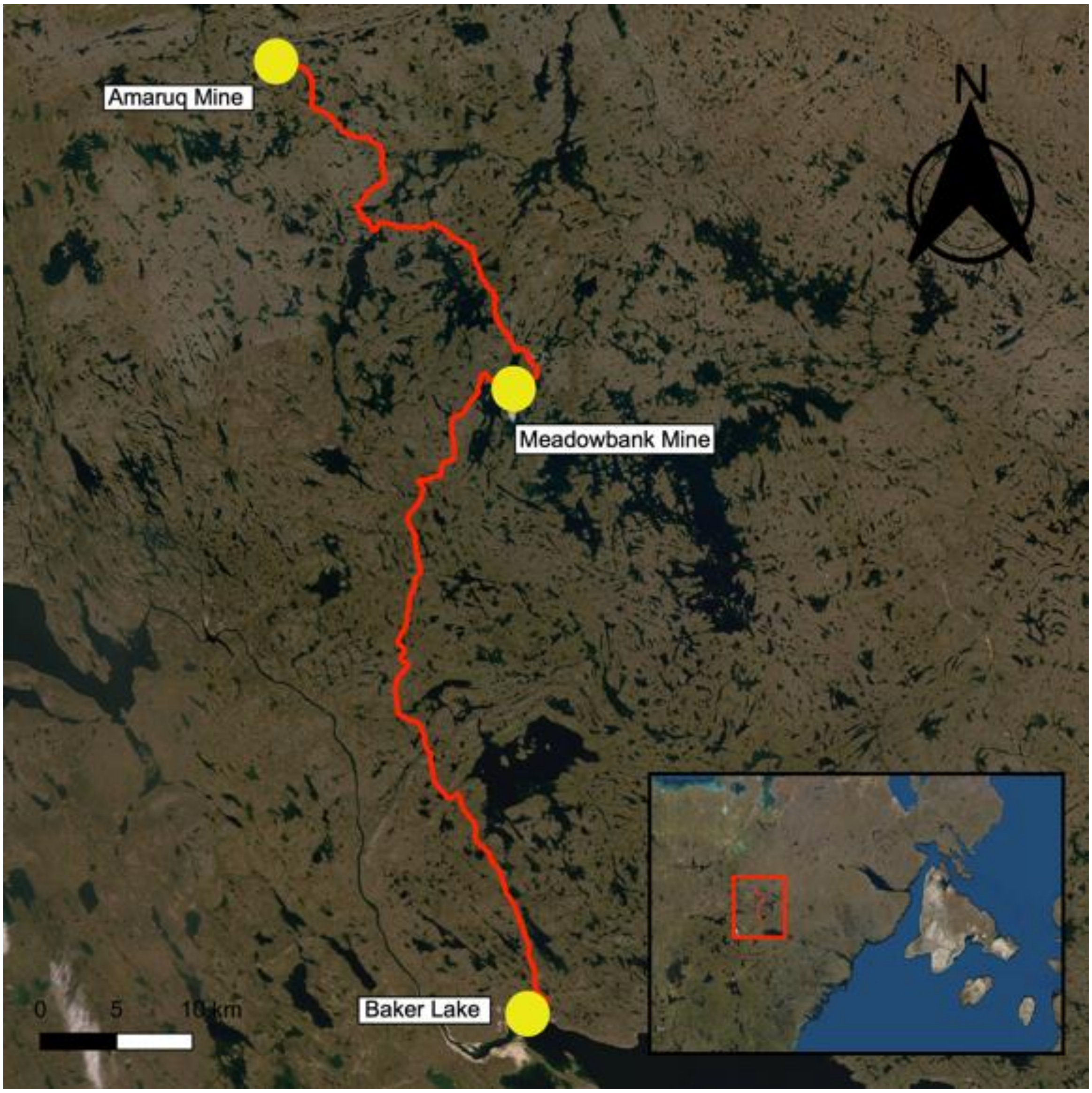

Figure 1.1: Map of Amaruq Road in red, which runs from Baker Lake community in the south, north toward Meadowbank Mine and further north-west toward Amaruq Mine (location of study sites), located in Nunavut, Canada.

CHAPTER 2 — ATTEMPTS TO MITIGATE MINING DEVELOPMENT: DETERRENTS FAIL TO CHANGE NESTING BEHAVIOUR OF ARCTIC-NESTING BIRDS

ABSTRACT

Mining and resource extraction is an important economic driver in the Arctic that leads to land-use changes resulting in habitat loss. Arctic environments are vulnerable to change, with species whose life history are explicitly adapted to its strong seasonality. This study aims to assess the efficacy of deterrents to mitigate harm to arctic-nesting birds during flooding caused by mining pit development. At our study site north of Baker Lake, Nunavut, we used audio and visual deterrents (flash tape and hawk effigies, predator and prey distress calls) to attempt to discourage nesting by birds. We used a BACI design to determine changes in male territory densities between year and treatment types (Control, High and Low Deterrent Intensity). We assessed whether deterrent intensity had an impact on daily nest survival of the two most common passerines (Lapland Longspur and Horned Lark) and the apparent survival of shorebird nests (Semipalmated Sandpiper and Least Sandpiper). We also determined whether deterrents influenced the behaviour of incubating Lapland Longspur females. Deterrents did not impact male territory densities, and neither treatment nor year predicted daily nest survival of nesting passerines or shorebirds. While the deterrents affected the frequency of nest off-bouts for incubating Lapland Longspur females, they did not impact nest survival. Overall, the deterrents used in this study were not effective in limiting male territory density. We do not suggest them for mitigating effects of mine flooding for arctic-nesting birds.

Introduction

Mining and other forms of resource development are critical economic drivers in Canada's North as they provide well-paying, stable jobs for people living in rural northern communities (Cameron and Levitan 2014; Belayneh et al. 2018). In 2014, 18% of the gross domestic product of Nunavut, Canada, was associated with resource extraction (AMAP 2017). Mineral, oil and gas exploration is predicted to grow across the Arctic landscape (A.T. Kearney Inc. 2015), leading to land-use changes and disturbance of wildlife and habitats (Wilson et al. 2013). Although resource extraction plays an important role in northern economies, it is crucial to balance economic growth with conservation, especially in vulnerable landscapes such as the Arctic (Arbo et al. 2012; Tolvanen et al. 2019).

The Canadian Arctic plays a key role in the life cycle of many long-distance migratory birds, as it provides habitat to meet their requirements for breeding (Gratto-Trevor 1996). Because of the limited human footprint, Arctic habitats are often considered secure from human-induced habitat change. However, the effects of resource development on habitat can be substantial at a local- or regional scale. For example, Pirie et al. (2009) predicted an 8 – 30% decrease in Whimbrel (*Numenius phaeopus*) habitat due to flooding of nesting grounds from pipeline development within the Kendall Island Bird Sanctuary (623 km^2) and Fish Island (7560 km^2) in the outer Mackenzie Delta, Northwest Territories. An increase in resource extraction in northern landscapes means a greater likelihood of loss of nesting habitat (Gajera et al. 2013; Bernath-Plaisted and Koper 2016). More subtle effects are also possible; previous studies have shown that mines have a relatively limited impact on species diversity (Smith et al. 2005; Bol et al.

2018, N. Grishaber in prep.), but there is still a possibility for mines and associated infrastructure to impact nest success or other aspects of habitat quality (Male and Nol 2005, Van Wilgenburg et al. 2013; Ludlow and Davis 2018).

The impacts of resource development might be mitigated by deterring birds from nesting in areas where development activities or infrastructure pose a risk. For decades, researchers have studied audio and visual deterrents as methods to limit the impacts of human infrastructure and development on wildlife (Kalmbach 1940; Conover 1985; Andelt et al. 1997; Ronconi et al. 2004). A deterrent is an object or action that scares birds or other wildlife, causing them to leave the area (Bishop et al. 2003). Some deterrents frighten birds using novel or erratic visuals and sounds, such as cannon blasts or flickering laser lights. Other deterrents mimic the sights or sounds of predators, increasing birds' perceived predation risk, and triggering them to flee. Deterrents are used to convey to birds, through perceived predation, that prospective nesting, feeding or roosting areas are not suitable, discouraging birds from settling in or remaining in areas where human activities might cause them harm (Ball 2000; Schlichting et al. 2017) or where humans identify birds as pests.

Visual deterrents are the oldest form of deterrent, with studies dating back to the 1940's (Kalmbach 1940). For example, human effigies or "scarecrows" have a long history of preventing birds from foraging in agricultural fields (Conover 1985). Visual deterrents can be effective in various settings, including for migratory or wintering birds foraging at airports (Blackwell and Fernadez-Juricic 2013) and agricultural fields (Mason et al. 1993). Visual deterrents are also used for limiting roosting of Turkey Vultures (*Carthartes aura*; Seamans 2004). Examples of effective visual deterrents include predator or human effigies, flash tape, scare balloons, and lasers or strobe lights (Mott

1980; Marsh et al. 1992; Ronconi et al. 2004; Blackwell and Fernadez-Juricic 2013). In recent years, flash tape has been used effectively to deter Ring-billed (*Larus delawarensis*) and Herring (*Larus argentatus*) Gulls from loafing in urban areas (Belant and Ickes 1997). Flash tape has also been a useful tool in deterring birds such as Least Terns (*Sterna antillarum*) and Piping Plovers (*Charadrius melodus*) from nesting in gravel pits, where their nests are at risk of being crushed by heavy machinery (Marcus et al. 2007). Although the simplicity of effigies and flash tape make them attractive options, they do require regular maintenance to work effectively (Ronconi and St. Clair 2006). For example, flash tape is easily damaged when close to the ground which is necessary for deterring ground-nesting birds, as it gets caught on small shrubs or rocks and frays, requiring frequent replacement and repair (Marcus et al. 2007).

Acoustic deterrents use distress calls from conspecifics to mimic stress (Andelt and Hopper 1996; Mariappan et al. 2015), or predator calls to mimic the threat of predation (Gunn 1973). Studies have demonstrated the efficacy and cost-effectiveness of bioacoustic deterrents (Li et al. 2019), but the literature has also suggested that this form of ‘trickery’ must be paired with visual deterrents to be most effective (Ronconi et al. 2004). Compared to conventional visual deterrents on their own, pairing alarm and distress calls with visual deterrents was effective at deterring foraging birds in vineyards (Berge et al. 2007), therefore limiting potential economic loss. Additionally, results from a study at a university campus located in South Africa showed a short-term behavioural change in roosting pigeons within a 30-minute period post-deployment at dawn as a result of a mix of visual and audio deterrents to represent raptor presence (Harris et al. 2020).

Although not effective in every situation, deterrents can be effective at deterring foraging, roosting or loafing by birds (Boag and Lewin 1980; Ronconi et al. 2004; Berge et al. 2007; Conklin et al. 2009). Deterrents have also been successful in redirecting some nesting birds, such as terns and plovers, by modifying habitat best suited for nesting (Marcus et al. 2007; McGowan et al. 2019). The variation in the effectiveness of deterrents depends in part on species' behaviour and life history (Ronconi and St. Clair 2006). Studies demonstrate that larger bird species are more likely to respond to deterrents than smaller bird species (Schlichting et al 2017). Although rarely demonstrated, it is likely that the effectiveness of deterrents could also depend on the stage of breeding during which they are applied; birds become increasingly invested in their breeding attempt as they progress from territory establishment to the chick-rearing period (Klaassen et al. 2006; Souchay et al. 2014).

The use of deterrents can be labour intensive and, regardless of the methods used or the intensity of effort, birds can still become tolerant of them (Marsh et al. 1991; Bishop et al. 2003). Tolerance occurs when individual birds determine that the costs associated with relocating nests or feeding sites outweigh the benefits (Gill et al. 2001). These determinations are based on the quality of the site, the distance to or quality of alternative sites, and the relative predation risk or density of competitors (Gill et al. 2001; Frid and Dill 2002; Bejder et al. 2009). If birds do not find the risk to be worth the loss of a quality site, they will not be disturbed as easily by deterrents.

This chapter explores the degree to which visual and audio deterrents can alter birds' nesting behaviour so that they avoid nesting in high-risk areas in Arctic Canada. The goal of the deterrents was to direct birds away from areas subjected to mining-induced flooding. I used a before-after control-impact experiment to determine the efficacy of two combinations of deterrent intensities representing different levels of effort for deployment and maintenance: audio deterrents combined with predator effigies, and audio deterrents and predator effigies combined with flash tape. I examined the effects of deterrents on (1) territory densities, by examining the differences between male territory densities between years (before-after) and treatments, (2) nest survival, by examining whether treatment intensity impacted daily nest survival rates of passerines and the apparent survival of shorebirds, and (3) incubation behaviour, by examining whether deterrents influenced the incubation behaviour of the most abundant bird species at this site, the Lapland Longspur.

METHODS

Study Area

The study was conducted in the Kivalliq Region of Nunavut, 130 km north of Baker Lake (N65° 24' W96° 40'). Situated in the Northern Arctic ecozone of Arctic Cordillera, the region exhibits a range of tundra habitat with rolling hills and rocky terrain, with scattered lakes and ponds. Habitats are primarily heath, lichen and rock in the uplands and wet graminoid-dominated lowlands, with tundra of varying moisture regimes in between (Campbell et al. 2012).

In the Amaruq Road Experimental Area (Figure 2.1), I established fifteen 6 ha plots (300 x 200 m each) along Amaruq Road, between Meadowbank Mine and the Amaruq Mine for convenience of access. Plots were placed >200 m from Amaruq Road to avoid potential impacts of dust and sedimentation, which can cause early snowmelt and in turn, impact nest timing and success (Smith et al. 2010; Grabowski et al. 2013).

Deterrent Treatments

We deployed deterrents 6 – 17 June 2019. In the study area plots were grouped into clusters of three, with a control and two deterrent treatment plots, in each cluster (*n* =

5). In each cluster, plots were randomly assigned to control or treatments. While we attempted to place treatment and control plots at distances of 50 – 100 m within clusters, to allow for spatial independence of bird response variables, the actual distances ranged from 20 - 150 m due to limited suitable habitat within clusters (Figure 2.1). The distance between clusters of plots ranged from 1 to 9 kilometres. The two deterrent treatments were distinguished based on intensity (Table 2.1). The High Intensity Treatment included a hawk kite effigy, an audio deterrent system with four speakers, and ribbons of flash tape, distributed evenly throughout the 6-ha plot (see below). The Low Intensity Treatment contained only a hawk kite effigy and an audio deterrent system with four speakers (Table 2.1).

Audio deterrents ("Super BirdXpeller® PRO," Bird-X, Inc., Elmhurst, Illinois) consisted of a central unit with four speakers (sound pressure: 110-115 DB at 1 m). I placed the main unit in the middle of the 6-ha plot, with each speaker attached to a wooden stake, hammered into the tundra at a height of 1 m, at each cardinal direction, 25 m from the main unit. The Bird X unit played a mix of distress calls from American Crow (*Corvus corax*) and generalist predator calls (Ring-billed Gull, *Larus delawarensis*; Common Raven, *Corvus corax*; Blue Jay, *Cyanocitta cristata*; Black-billed Magpie, *Pica pica*; Peregrine Falcon, *Falco peregrinus*). The only plausible predators in the study area are Common Raven and Peregrine Falcon, as recorded calls of locally relevant predators (e.g., Arctic Fox, *Vulpes lagopus*, Arctic Ground Squirrel, *Urocitellus parryii*, Rough-legged Hawk, *Buteo lagopus*, Parasitic Jaeger, *Stercorarius parasiticus*) are not available on these units. Speakers either played all at once, broadcasting audio recordings in non-sequential order, continuously for 24 hours at 10 – 30-minute intervals (High Intensity) or one speaker at a time with audio recordings broadcasting in sequential order at 5 – 10-

minute intervals (Low Intensity), for the entire experiment (June 10 – July 16). To ensure consistent power for the audio deterrents, speakers were powered with a 40 aH 12v car battery, and a 25 W solar panel to maintain power during the experiment (Figure 2.2).

The flash tape grid was erected by stringing monofilament fishing line (100 lb test, Hercules PE Braided Fishing Line 4 Strands) between 1.5 m long aluminum angles that we hammered 0.5 m into the tundra every 60 m across the 300 m length of the study plot, and every 20 m along the 200 m length of the plot (Figure 2.3). Every 20 m along the monofilament lines, I affixed a piece of flash tape ("Birdscare Flash Tape," Sutton Agricultural Enterprises, Salinas, California): a metallic tape with red and silver on opposite sides, 30 mm wide and 0.025 mm thick. Each flash tape piece was 5 m long, with one end knotted to the fishing line and the other end free to sway with the wind.

We erected hawk kite effigies using 5.2 m tall fibreglass pole in the middle of each treatment plot, near to the central unit of the audio deterrent system. I used two different brands of hawk kites: "Peregrine Falcon Kite" (Margo Supplies, High Water, Alberta) placed in the High Intensity Treatment and "Birds of Prey Falcon Kite" (Sutton Agricultural Enterprises, Salinas, California), placed in the Low Intensity Treatment (Table 2.1).

Deterrents were maintained as needed every four days during nest monitoring, by tightening the fishing line, replacing flash tape, ensuring that the predator effigy was still intact and checking the electrical connections and power supply for audio deterrents. Because the effort required to use deterrents is an important practical consideration, I recorded the number of person-hours spent erecting and maintaining the deterrents and recorded the full cost to purchase the equipment and supplies used.

The breeding bird population in the study area consisted primarily of arctic-nesting passerines, with lower densities of shorebirds and ducks. The four main study species were Lapland Longspur (*Calcarius lapponicus*), Horned Lark (*Eremophila alpestris*), Semipalmated Sandpiper (*Calidris pusilla*) and Least Sandpiper (*Calidris minutilla*). I selected these species due to their abundance at the study site and their preference for nesting in low elevation sedge meadows, close to water bodies. These features made these species potentially the most at risk of impact by the mining-induced flooding.

Nest Searching, Monitoring of Daily Survival and Territorial Mapping

Nest searching and monitoring occurred 6 June – 15 July 2018 and 2019. Territorial mapping occurred primarily at the beginning of each breeding season, after male birds arrived and began to sing and display, and mapping continued throughout the breeding season where appropriate. Mapping was done by following displaying males and recording the displaying bird's location with a waypoint (± 3 m) using a Garmin GPS. I aimed to obtain a minimum of 5 waypoints per visit. While following males, I attempted to avoid disturbance to the birds by staying low to the ground and moving only after the bird moved to a new position to sing.

Nest searching was conducted by systematically walking plots and observing behavioural cues of breeding adults (e.g., flushing, mate courtship, alarm calls). Upon nest discovery, the nest was marked with a tongue depressor within 5 m of the nest, in a random direction. The observer recorded nest coordinates using the "average waypoint" function in the Garmin GPS unit, as well as the species, number of eggs present, and date found. For nests found outside of the laying period, I floated eggs to determine nest age to estimate the initiation date and hatch date (adapted from Liebezeit et al. 2007).

Nests were monitored on a 4-day schedule until fates were determined. Methods to assess nest fate depended on the life history of each target species. Nests occupied by species with precocial young (i.e., *Calidris sp*.) were considered successful if at least one egg hatched, while nests occupied by species with altricial young (i.e., Lapland Longspur and Horned Lark) were considered successful if at least one chick fledged. Signs of predation (loss of a whole clutch, nest disturbance, large eggshell fragments or yolk) or abandonment (no sign of adults or cold eggs; Mabee et al. 2006) indicated failed nesting attempts.

Defining Territory Densities

Territories with a minimum of 5 waypoint locations of singing males were defined using minimum convex polygons (MCPs) in the package adehabitatHR (Calenge 2006). Nests in plots that were not associated within a delineated territory were given an assumed territory size, by using the st_buffer function in sf package to assign a circular spatial buffer around the nest (Pebesma 2018). Buffers were delineated based on the average territory size that I documented for each species observed in this study based on the song-perch mapping (average territory size of Lapland Longspur, = 3988.0 ± 482.3 m^2; Horned Lark = 7258.2 ± 2185.7 m^2; Semipalmated Sandpiper and Least Sandpiper = 4294.6 ± 1488.7 m^2). I used the st_intersection function in the sf package (Pebesma 2018) to determine the proportion of each territory (MCP or buffer based) that occurred in the plots.

Temperature Probe Deployments

To compare the effects of deterrents on incubation behaviour of disturbed versus undisturbed birds, I deployed Tinytag© (Tiny Tag Plus 2 Logger, TGP-4020, Gemini Data Loggers) temperature probes in Lapland Longspur nests in 2019. Temperature probes were deployed at nests located in treatment plots regardless of intensity as long as they were 5 – 20 m from a deterrent audio speaker or flash tape, and in control plots. The temperature probe of the Tinytag© was in contact with the brood patch of the incubating female, recording a temperature near to 39°C when the incubating bird was present, and dropping to ambient temperature when the bird left the nest for an incubation recess. The data logger unit was secured under the peat near the nest as not to attract predators or rouse suspicion of incubating birds. Probes recorded a temperature every minute, providing a high-resolution dataset with which to evaluate incubation behaviour (Joyce et al. 2001; Schneider and McWilliams 2010).

Nest vegetation was recorded for all nests including vertical concealment, which estimates the percentage of vegetation that concealed the nest from above. Ambient temperature data were collected from the weather station located nearby at Baker Lake, Nunavut (64°19’ N, 96°00’W; Government of Canada 2020). All analyses were carried out using R Studio (version 1.2.1335; RStudio Team 2020), unless otherwise stated.

STATISTICAL ANALYSIS

Territory Densities

I used a before-after-control-impact (BACI) design, examining the effects of deterrents by examining the significance of the interaction effect between year (before/after) and treatment. I predicted that the density of territorial males would be reduced from pre-treatment (2018) levels in plots where I applied deterrents, whereas there should be no such reduction in control plots. I summed the count of male territories in a plot and converted them into a density (territories per km^2) in each 6-ha plot, separately for each year (2018, 2019). I used a generalized linear mixed-effects model using the lme4 and lmerTest packages (Bates et al. 2015; Kuznetsova et al. 2016) with the density of territorial males as the response variable and treatments (High Intensity Treatment, Low Intensity Treatment and Control, Table 2.1), year (2018 or 2019) and their interaction as the fixed effects. I included an offset of hours within the model to account for the number of hours spent in each plot. I included cluster as a random effect to account for the geographic association of the treatment and control plots within the study area. This statistical model was first applied to assess potential changes in densities of territorial males of target species in aggregate (Lapland Longspur, Horned Lark, Semipalmated Sandpiper, and Least Sandpiper), then separately for shorebirds in aggregate (Semipalmated Sandpiper, and Least Sandpiper), and individually for Lapland Longspur and Horned Lark. Additionally, I assessed if there was a difference in territory size of Lapland Longspur between Treatment and Control plots using a linear model (lm). I assessed the differences in territory size only for territories that had at least 50% of their area within a plot.

Daily Nest Survival

I calculated daily nest survival rates (Mayfield 1961, Dinsmore and Dinsmore 2007) using the RMark Package (Bollier and Laake 2013) in R Studio (Version 1.3.1093; R Core Team 2020) for the main taxonomic group, passerines (Lapland Longspur, Horned Lark). The nest survival package allowed me to calculate estimates of daily survival rate of nests while incorporating predictor variables using a logit-link function (Walker et al. 2013). I excluded nests that did not include a known fate (13/90). We translated ordinal dates into nest-specific dates (henceforth referred to as season-date) in which the first initiation date was 0 (passerines, 10 June, ordinal date 161) and the final nest check was 36 for passerines (16 July, ordinal date 197). We intended to calculate daily survival rate for shorebird species (Semipalmated Sandpiper and Least Sandpiper, n = 27) at our study site, but had too few nests to analyze the data with logistic exposure. Therefore, I computed apparent nest survival for shorebird species between years and treatment.

I assessed the effect of nest age (i.e., the age of a nest in days, where age 0 = day first egg laid) on daily survival rate of passerine nests (n = 74) of a sub-sample of all nests, as this predictor variable only slightly limited sample size (missing nest age data, n = 3). In the first stage of modelling, I ran six candidate models (including an intercept-only model) consisting of temporal variables: nest age, season-date, quadratic season-date ($date^2$), cubic season-date ($date^3$), and year. I found that nest age was not a good predictor of daily nest survival, as it was not in a top or competitive model (passerines, $\Delta AIC_C < 6$; Burnham et al. 2011). Therefore, we removed nest age from the model, which allowed us to add in the three additional nests to the passerine species group data set (n = 77; i.e., nests found during incubation but failed before hatch, without determination of day first egg laid or float age). Additionally, while the variable year was not in one of the top models (passerines, $\Delta AIC_C < 6$; Burnham et al. 2011), to account for interaction effects between years and treatment, as done in the BACI territory density model, I included year in analyses of nest survival.

The second stage of modeling included an intercept-only model and four additional candidate models consisting of temporal variables: season-date, quadratic season-date ($date^2$), cubic season-date ($date^3$), and year. Lastly, in the final stage of modeling, I carried the top temporal model (date + $date^2$) from the second stage of modeling as a foundation for testing the impacts of treatment on daily nest survival, including year, treatment and the interaction of year and treatment. I used Akaike's Information Criterion (Akaike 1973), adjusted for small sample size (AIC_C; Hurvich and Tsai 1973) to assess relative model support. Only variables with 95% confidence intervals not overlapping zero were considered important for explaining daily survival rate (Fromberger et al. 2020).

Incubation Behaviour

For analysis, I removed the first two hours of temperature recording post-deployment to account for any human-induced behaviour changes or effects of the birds becoming acquainted with the device. Furthermore, based on preliminary inspection, I removed data recorded on 1 – 2 July 2019 from the analysis due to two days of inclement weather that kept birds off their nests for up to 16 hours. I analysed data only from the incubation period of each nest. I removed incubation days 1, 2, 11 and 12, as on those days, there was only one nest per treatment in the treatment and control comparison. Therefore, I only used temperature date from incubation days 3 – 10.

I used the program RHYTHM (1.0; Cooper and Mills 2005) in combination with Raven Lite (2.0) to automate measurements of on- and off-bout length of incubation for female Lapland Longspurs. For my study, I considered a drop of $\geq$3 °C within 1 minute to be an off-bout. These are different than criteria used in similar studies on Horned Lark

(Camfield and Martin 2009; MacDonald et al. 2013), which considered a recess as a drop of $\geq$3 °C in the nest and a decline in temperature that lasted more than 3 minutes. I chose these criteria to account for swift off-bouts that may last for less than a minute in situations where birds are disturbed frequently by deterrents such as the flash tape. Results of the recesses estimated by Raven Lite (2.0) were manually examined for quality control. I added off-bouts in accordance with my parameters set in RHYTHM (1.0; drop in $\geq$3 °C within 1 minute) where they were missed by the automated measurements of RHYTHM (1.0) and adjusted off-bouts accordingly.

Upon inspection of the data, there were a greater number of recesses and for longer periods of time during the day than at night, despite the relatively continuous daylight (Steiger et al. 2013). Therefore, to account for the effect of time of day in incubation bouts (Camfield and Martin 2009), I distinguished between time of day as periods of night (18:00-6:00 CST) and day (6:00-18:00 CST). I calculated the number and proportion of off-bouts (proportion of time spent off the nest) during each 12-hour period of night and day for each incubation day of a nest. To evaluate if incubation rhythm was impacted by treatment type, I used linear mixed-effects models using a maximum likelihood method of parameter estimation in the statistical package lme4 (Bates et al. 2015) in R studio.

In my model, I included two response variables: the proportion of time off nest and the number of off-bouts within 12-hour periods and included treatment type and nest fate as fixed effects and nest ID as a random factor to account for repeated sampling of individual nests over time. Nest incubation patterns vary with ambient temperature, vertical nest concealment, time of day (day/night), clutch size, and stage in the incubation cycle (Wiebe and Martin 1998; Camfield and Martin 2009; Ricklefs and Brawn 2012), so

I included these variables as fixed effects. I used AIC_C for model selection, which assessed whether the inclusion of additional fixed effects strengthened the model (Camfield and Martin 2009). One of the 20 nests that were monitored was known to be a second nesting attempt (i.e., a "re-nest"). I did not include renesting as a factor in the analysis. The significance of all parameter estimates and tests were evaluated at $\alpha = 0.05$.

RESULTS

During the two years of the study, my assistants and I found and monitored a total of 182 nests (2018, *n* = 90; 2019, *n* = 92), of which 140 nests were found within the Experimental Area Plots (nests within plots, 2018 = 66; 2019 = 74). In 2019, my analyses of timing of breeding suggested that 79% of nests in the Low Intensity Treatment and 92% of nests in the High Intensity Treatment across the four study species initiated after the deterrents were erected in their associated plots in the Amaruq Road Experimental Area (6 – 17 June; *n* = 62). The average nest initiation date for the four study species in aggregate in 2018 was 18 June and in 2019 was 15 June, while the average date for deterrent deployment in 2019 was 12 June, with full deployment 6 – 14 June.

Territory Density

I mapped a total of 120 territories of 4 bird species within the Amaruq Road Experimental Plots in the two years of study. Of the 120 territories, 61 were not associated with a nest that we located, and 59 were associated with at least one nest. I found an additional 67 nests that did not meet my criteria for spot-mapping (5 waypoints per territory) and assigned the average territory size to these territories. Densities of territorial males for the four study species combined (Lapland Longspur, Horned Lark, Semipalmated Sandpiper, Least Sandpiper; Table 2.2) ranged from 56.1 – 104.5

territories/km^2. Deterrents did not reduce the density of territorial birds within the plots. There was a disproportionate rise in the treatments relative to the control, with a 35% increase in densities between years in the High Intensity Treatment, while the density in the Control only increased by 12%, although this difference was not significant. There was no significant interaction between year and treatment of all four study species in aggregate ($F_{2,20}$ = 0.54, p = 0.59). However, there was a significant difference in the densities of territorial males between years for all treatments ($F_{1,20}$ = 4.58, p = 0.04), with the late snow melt year of 2018 with its lower temperatures associated with lower densities than in 2019 (average air temperature, 1 – 10 June, in 2018: -1.35 °C; in 2019: 1.99 °C).

Densities of territorial males of the two shorebird species (Semipalmated Sandpiper and Least Sandpiper) averaged between 8.2 – 23.8 territories per km^2 (Table 2.3). While average shorebird species densities increased by 65% between years in the High Intensity Treatment, and decreased in the Controls by 8%, there was no significant interaction between year and treatment for densities of territorial males of shorebird species ($F_{2,20}$ = 0.27, p = 0.77). Lapland Longspur male territory densities ranged from 41.4 – 76.7 territories per km^2 (Table 2.4), also exhibiting an 42% increase in the High Intensity Treatment and a 13% increase in the Control but with no significant interaction between year and treatment ($F_{2,24}$ = 0.70, p = 0.51). Horned Lark ranged from 3.2 – 15.2 territories per km^2 (Table 2.5). For this species, there was a significant interaction between year and treatment for Horned Lark densities ($F_{2,20}$ = 5.17, p = 0.01) with a significant reduction in densities of territorial male Horned Larks in High Intensity Treatment plots in 2019, the year that deterrents were applied ($t(20)$ = -2.98, p = 0.007). Territory densities of Horned Lark males reduced by 74% in 2019 relative to the pre-treatment year 2018 (Table 2.5). There was no significant difference in the territory size of Lapland Longspur between Treatment and Control plots within the experimental year ($t(34) = 0.33$, $p = 0.74$; Mean territory size of Lapland Longspur; Control = 4533.50 m^2 ± 2123.13, Treatment = 5505.4 m^2 ± 1445.9).

Daily Survival Rate

There was a total of 77 passerine nests (Lapland Longspur, $n = 64$; Horned Lark, $n = 13$) included in the daily survival rate analysis. For passerines, 45 nests fledged (58% passerine apparent nest success), with 4 known abandonments (12% of failed passerine nests) and 16 known cases of predation (50% of failed passerine nests). For shorebirds, 20 out of 27 nests (Semipalmated Sandpiper, $n = 23$; and Least Sandpiper, $n = 4$) hatched (74% shorebird apparent nest success), with 0 known abandonments and 5 known cases of predation (71% of failed shorebird nests). Out of the 27 shorebird nests in the control plots, 1 of 3 shorebird nests in 2018 (75%) and 0 of 4 shorebird nests in 2019 failed due to predation. In comparison, in the treatment plots, 2 of 7 in 2018 (28%) and 4 of 13 in 2019 (15%) shorebird nests failed due to predation.

Neither treatment, year, nor their interaction predicted daily survival rates of passerines; however, season-date (date) and quadratic season-date ($date^2$) were included in the top models for explaining daily survival rates (Table 2.6). The predicted daily survival rate of passerine species in the High Intensity Treatment plots decreased from 0.99 (CI 95% = 0.97, 1.0, day 1) to a low of 0.94 (CI 95% = 0.88, 0.97, day 23) in 2018 and from 0.99 (CI 95% = 0.98, 1.0, day 1) to a low of 0.96 (CI 95% = 0.93, 0.98, day 23) in 2019. Passerine daily survival rate increased after day 23 of the breeding season, increasing to 0.99 (CI 95% = 0.92, 0.99, day 35) in 2018 (CI 95% = 0.95, 0.99, day 35) and in 2019 (Figure 2.4). The passerine daily survival rate in Control and Low Intensity Treatment plots had a similar pattern as that of the High Intensity Treatment, with nests experiencing the lowest daily survival rates across years and treatments on day 23 (Figure 2.4).

Incubation Behaviour

I placed temperature probes in 20 Lapland Longspur nests in 2019: 10 nests in control plots and 10 in treatment plots. Of these nests, 6 nests were deployed within the Whale Tail Flood Area (refer to Chapter 3 for study site description), with the additional 14 found within the Amaruq Road Experimental Area. Incubation data were obtained from 21 June to 30 June and 3 to 4 July. I deployed one temperature probe in a Lapland Longspur renesting attempt from 10 – 18 July.

I found no significant difference in the proportion of time off nest per 12-hour period between nests in treatment and control plots (Est ± SE = 0.03 ± 0.02, $t(12) = 1.26$, $p = 0.23$), but there was a significant difference in the number of off-bouts per 12-h period between treatment and control (Est ± SE = 2.68 ± 1.15, $t(10) = 2.32$, $p = 0.04$), with a greater number of recesses observed in the treatment plots. Additionally, there was a significant positive effect of ambient temperature on both proportion of time off nest per 12 hr period (Est ± SE = 0.01 ± 0.002 , $t(190) = 2.21$, $p = 0.02$) and number off-bouts per 12 hour (Est ± SE = 0.50 ± 0.16, $t(192) = 3.04$, $p = 0.002$), and a significant negative effect of time of day (day/night) on both metrics (proportion of time off nest per 12 hr period, Est ± SE = -0.16 ± 0.02 , $t(187) = -10.75$, $p = < 0.001$; number off-bouts per 12 hour, Est ± SE = -4.01 ± 0.97, $t(187) = - 4.13$, $p = < 0.001$). Furthermore, incubation day had a significant influence on both response variables (Figure 2.5; proportion of time off nest per 12 hr period, Est ± SE = -0.02 ± 0.003, $t(197)$ = -6.36, p = <0.001; number off-bout per 12 hour, Est ± SE = 0.61 ± 0.20, $t(197)$ = 2.99, p = 0.003).

Additional variables such as fate (proportion of time off nest per 12 hr period, Est ± SE = -0.02 ± 0.03 , $t(11)$= -0.89, p = 0.39; number off-bout per 12 hour period, Est ± SE = -0.02 ± 1.39, $t(10)$ = -0.01, p > 0.05) or vertical nest concealment (proportion of time off nest per 12 hr period, Est ± SE = 0.06 ± 0.05, $t(10)$ = 1.05, p = >0.05; number off-bout per 12 hour period, Est ± SE = -0.94 ± 2.88, $t(10)$ = -0.33, p = >0.05) did not significantly influence either response variable. However, clutch size did negatively influence number of off-bouts per 12 hours period (Est ± SE = -2.43 ± 0.20, $t(11)$ = -2.66, p = 0.02) with more off-bouts in smaller clutches, but no difference in the proportion of time off nest per 12 hr period in these smaller clutches (Est ± SE = 0.03 ± 0.02, $t(10)$ = 1.47, p = >0.05).

Costs of Deployment and Maintenance of Deterrents

Deterrents took a total of 200 person-hours to deploy, not including the extra 120 person hours to assemble and troubleshoot before deployment (Table 2.7). For example, a crew of 6 – 8 people spent 4 hours deploying the flash tape grid within a single High Intensity Treatment, 6-ha plot. Deterrent maintenance was done every 4 days, ranging from 30 mins to 4 hours per plot, depending on damage and needs. Examples of maintenance included ensuring that the hawk kite effigies poles were erect and that the kite was still intact, ensuring the fishing line holding together the flash tape grid was taut, and ensuring flash tape was not tangled around hummocks or brush. In some cases, deterrents were destroyed, taking hours to fix or were unable to be repaired. For example, the flash tape grid was dismantled likely due to disturbance by Barren-ground Caribou

(*Rangifer tarandus groenlandicus* B.) or Muskoxen (*Ovibos moschatus* Z.), causing the entire grid to collapse and requiring a full new deployment. This re-deployment took hours and also demonstrated a possible risk to mid-size to large arctic mammals who may have become entangled or injured in the flash tape grid.

Financial costs for audio and visual deterrents and accessories (Table 2.7), included each Bird-X Super Bird X-peller Pro audio unit of $509.99 CAD, with 14 purchased in 2019. This cost included audio chips for each audio unit ($60.00 CAD each). To keep the batteries charged so the audio deterrents would run 24 hours a day for 6 weeks, I purchased 14 solar panels, $89.99 CAD each. The 12V batteries used to run the audio deterrents and hold the solar panel charge, were donated by Environment and Climate Change Canada and cost $55.00 CAD per battery (14 batteries, $770.00 CAD). Visual deterrent costs came to a total of $5,131.25 CAD, with Hawk Kite Effigies costing $524.75 CAD for 12 Hawk Kites, with Fiber glass poles (10) totaling $517.50 CAD and replacement strings (7) $42.00 CAD. Flash tape rolls were $5.40 CAD per roll, amounting to $1,917.00 CAD for 355 rolls. Fishing line was used to string the flash tape grid together, costing $850.00 for 34 rolls of 100lb Hercules PE Braided Fishing Line 4 Strands. Lastly, the Aluminum Angle used to erect the flash tape grid, with 640 pieces of 1 m long angles, cost $1,280.00 CAD. The complete cost of purchasing deterrents and their accessories was $14,300.17 CAD.

DISCUSSION

Efficacy of Deterrents on Territory Density

Deterrents are designed to mimic the risk of predation, through visual and audio cues that 'trick' a bird into perceiving that predation risk is high (Frid and Dill 2002), and then preventing animals from occupying areas where human activities might harm them (Berge et al. 2007; Marcus et al. 2007) or where animals may cause damage to agricultural crop, aircraft or other human infrastructure (Conover 1985; Ball 2000). Animals frequently exhibit anti-predator behaviour, features or traits that reduce the probability of being detected, attacked or killed by a predator (Caro 2005), if the situation is perceived as a real risk. However, research has shown that many animals are less likely to respond to "artificial" predation risk or human disturbance, especially when the risk to their survival or breeding success is low (Nisbet 2000; Beale 2007).

My results suggest that deterrents did not significantly impact territory densities for all species combined, nor for the shorebird species as there were no significant interaction terms between year (before/after) and treatment for these two subsets of the data. In most cases, plots exposed to the High Intensity Treatment had disproportionately higher territory densities than that of the Control and Low Intensity Treatment in the same experimental year (2019, Table 2.2 – 2.5). Similarly, there was no significant impact of deterrents on the most abundant species, the Lapland Longspur. While the deterrent treatment plots had higher densities in the experimental year, the control plots also had higher densities (Table 2.2 – 2.5). These results do not support our prediction that deterrents would decrease territory densities. However, there is some suggestion that Horned Lark may be influenced by flash tape, as the territory density of High Intensity Treatment plots decreased by 74% post-deterrent use, while the territory density of Control plots increased by 48% post-deterrent use in the same year (Table 2.5). Horned Lark occupied our plots in low densities and tend to have larger territories compared to our most abundant passerine, Lapland Longspur. Thus, for plots with deterrents, the decrease in density reflected minimum loss of one breeding pair and while significant, this decline is unlikely to impact local populations.

Other studies have demonstrated measurable effects of deterrents (Marcus et al. 2007; McGowan et al. 2019). However, the study species in these experiments (Common Tern, *Sterna hirundo* and Least Tern, *Sternula antillarum*) rely on active nest defense (Coulson 2002). In contrast, our study species more often rely on concealment and cryptic behaviour to avoid predation, using their plumage as camouflage to avoid being detected (Caro 2005; Ruiz-Rodríguez et al. 2013). Species that are more aggressive and use active forms of nest defence such as terns and gulls, may be more noticeably responsive to predators, and therefore more likely to respond to the artificially elevated predation risk mimicked by deterrents. This life history strategy may explain why most of my study species did not show an obvious response to deterrents.

Arctic-nesting species often have high nesting site fidelity, returning to the same territories year after year (Gratto et al. 1985; Craig et al. 2015; Herzog et al. 2018), making it difficult to deter birds from occupying a territory that is habitually theirs. For example, within our two study sites over two years, there were seven individuals that returned to the same territory between years: five adult banded Semipalmated Sandpiper, one Least Sandpiper, and one male Lapland Longspur (G. Holmes, pers. obs.). In 5 of 6 of the cases for shorebird species, the birds nested in the same nest cup for two consecutive years, as already observed in Semipalmated Sandpipers (Herzog et al. 2018). Although high site fidelity does occur with Semipalmated Sandpipers and Least Sandpipers, there was still variation in nest densities in control plots between years, possibly limiting the power to find significant effects of deterrents. In the case of Lapland Longspur, individual females are likely to return to the same nesting site if they are successful the previous year; females seem to disperse only in cases where failed nesting attempts occur over 3 or more consecutive years (Custer and Pitelka 1977).

Daily Nest Survival

Deterrent treatments had no impact on the daily survival rate or apparent survival of either taxonomic bird group, indicating that despite the deterrents, birds that bred were still successful in their breeding attempts. However, date was a predictor of daily survival rate of nests for passerines (Figure 2.5), signifying that breeding season date had an impact on the likelihood of a nest surviving to the next day. Daily survival rate for passerines was at its highest in the early and late breeding season and at its lowest mid to late-breeding season. The low daily survival rate for passerines aligns with egg hatching and the beginning of feeding of nestlings, which often coincides with the highest rates of predation (Grant et al. 2005). Additionally, shorebird nest survivorship is often predicted by nest age and incubation behaviour (Liebezeit et al. 2011) and predator abundance (Smith et al. 2007; Liebezeit et al. 2009).

Nest failure in arctic-nesting birds is most often caused by predation rather than abandonment or inclement weather (Lecomte et al. 2008; Meyer et al. 2020). Out of the nests that failed, for passerines and shorebirds, a large proportion of them failed due to predation (54%). A possible reason why passerines experienced similar patterns of lowest daily survival rates during the mid-season (the mid-incubation period for shorebirds) could be a result of a greater number of predators in the area that were attracted by other prey items such as provisioning passerines (Smith and Wilson 2010). To combat nest loss they have developed anti-predator traits such as cryptic plumage, nest-site concealment and non-conspicuous behaviours that help them avoid detection from predators (Smith et al. 2005; Cunningham et al. 2016).

Timing of nesting is important, as arctic-nesting birds must contend with a short breeding season by synchronizing their arrival and nest initiation with the relevant ecological processes of the arctic if they are to breed successfully (Smith et al. 2010). Due to a short breeding season, there are few opportunities to re-nest and therefore birds must compensate by increasing investment in a single brood (Badyaev and Ghalambor 2001; Camfield 2008). Furthermore, insect emergence plays a vital role in the life history of arctic-nesting birds as the timing of emergence assists in the cost of migration, egg-laying, and raising of young (Liebezeit et al. 2014). Such constraints may explain the general lack of response from arctic-nesting species to deterrents.

Incubation Behaviour

The results from the temperature probe analysis indicated that there was a greater number of off-bouts in a 12-hour incubation period for Lapland Longspur nesting in treatment than in control plots. This was not the case for proportion of time off the nest in a 12-hour period, demonstrating shorter off-bouts in treatment plots over control plots, which could possibly be attributed to the periodicity of auditory disturbance from audio deterrents. These results reveal that even though birds may not be off for longer periods of time, they were likely to be disturbed and pushed off their nest more often in treatment plots than in control plots. It is common for incubating females to reduce the length of off-bouts but have more frequent off-bouts to minimize the risk of eggs cooling and minimize the cost of having to re-warm eggs (Camfield and Martin 2009). This response appears to be heightened when adding the additional variable of disturbances such as deterrents. Therefore, it is possible that deterrents had a slight behavioural effect on incubating female Lapland Longspurs in treatment plots.

The presence of deterrents, some 5 m or less from a nest, did not appear to impact nest success of passerines. In the field, I observed five separate Lapland Longspur nests where flash tape extended directly over top of the nest (Figure 2.6). Additionally, I found that the proportion of time off nest decreased with incubation day, while the number of off-bouts increased with incubation day for both nests in treatment and control plots. A decrease in the proportion of time off nest and increase of number of off-bouts as the incubation period advances is consistent with incubation behaviour of other ground-nesting birds such as Horned Lark (Camfield and Martin 2009) and White-tailed Ptarmigan (*Lagopus leucura*; Wiebe and Martin 1997). Despite some effects of deterrents on incubation behaviour, the results comparing daily nest survival between birds in treatment and control plots suggest that these effects on incubation behaviour did not significantly impact nest survival.

Deterrent Outcomes and Recommendations

We deployed deterrents as early in the season as was practical. While our deterrents were in place before nests were established, territories were likely already established in many cases, given that we observed territorial males singing during deployment. Deploying deterrents in arctic environments before territories are established may be more effective but is logistically challenging. This would require erecting deterrents during late winter and early spring, when the ground is still frozen and there is still snow present on the landscape, because most arctic-nesting birds start to breed in available snow-free places as they emerge (Liebezeit et al. 2014). These wintery conditions made it difficult to travel with equipment on foot and the frozen ground can make it difficult to hammer the aluminum angle in the ground, as well as making it difficult to ensure that the audio deterrent speakers stayed upright. The use of snowmobiles could provide an accessible alternative to deploying deterrents on foot as well as continued maintenance but would require additional costs and resources. While sturdier stakes could have been employed (e.g., rebar), use of this much heavier material would have greatly increased both costs of transport and physical effort.

During the experiment there were a few instances where deterrents were damaged or destroyed, likely due to mammals. In some plots where we found Arctic ground squirrels (*Spermophilus parryii*) or Arctic hare (*Lepus arcticus*), we anticipated that there might be some damage to the wires associated with the audio deterrent units. Damage by Arctic ground squirrels occurred on one occasion when a speaker cord was chewed, but we noticed this event and replaced the cord quickly. A more concerning issue arose as there was some noticeable impact on large ungulate species such as Ground-barren Caribou and Muskoxen, where deterrents may have caused harm or major disturbance to large mammals as they were grazing or loafing. There were multiple occasions where visual deterrents were destroyed by caribou or muskoxen walking through the treatment plots, causing aluminum poles to be ripped out of ground and carried away.

The cost of deterrents was on the low end of the scale compared to deterrents in other studies; however, deployment and maintenance were time-consuming and required many person-hours. In comparison to other options that might have been more effective, such as trained domestic dogs (Ball 2000) or radar-activated on-demand deterrence systems (Ronconi et al. 2004), the financial cost of deterrents in this experiment was small. Ultimately, the cost and labour of the deterrents used here were not justifiable given the outcome of the experiment, as 3 of 4 of our main species of arctic-nesting birds apparently were not successfully deterred and the fourth only mildly and in a real-world scenario would have faced the risk of nest loss due to the industrial development.

In our study, birds appeared tolerant of deterrents, as there are no substantial signs of alteration in nest densities, nest survivorship, or individual behaviour at a level that would suggest significant impacts such as an impact to nest survival. It is likely that the birds tolerated the deterrents so to be successful in their breeding cycle, as the deterrents posed no imminent threats but rather may have been perceived as an annoyance or inconvenience. There was a great amount of effort put into designing and implementing the study experiment to understand if deterrents could minimize nest loss in the case of mining-induced flooding or future industrial development. Therefore, the results of this study, approached from a variety of potential responses of breeding birds (settlement, nest success and behaviour), strongly suggest that deterrent use as a tool to discourage arctic-nesting birds from nesting in high-risk areas is not effective. Thus, I do not recommend them for mitigating the potential effects of impending or ongoing industrial development.

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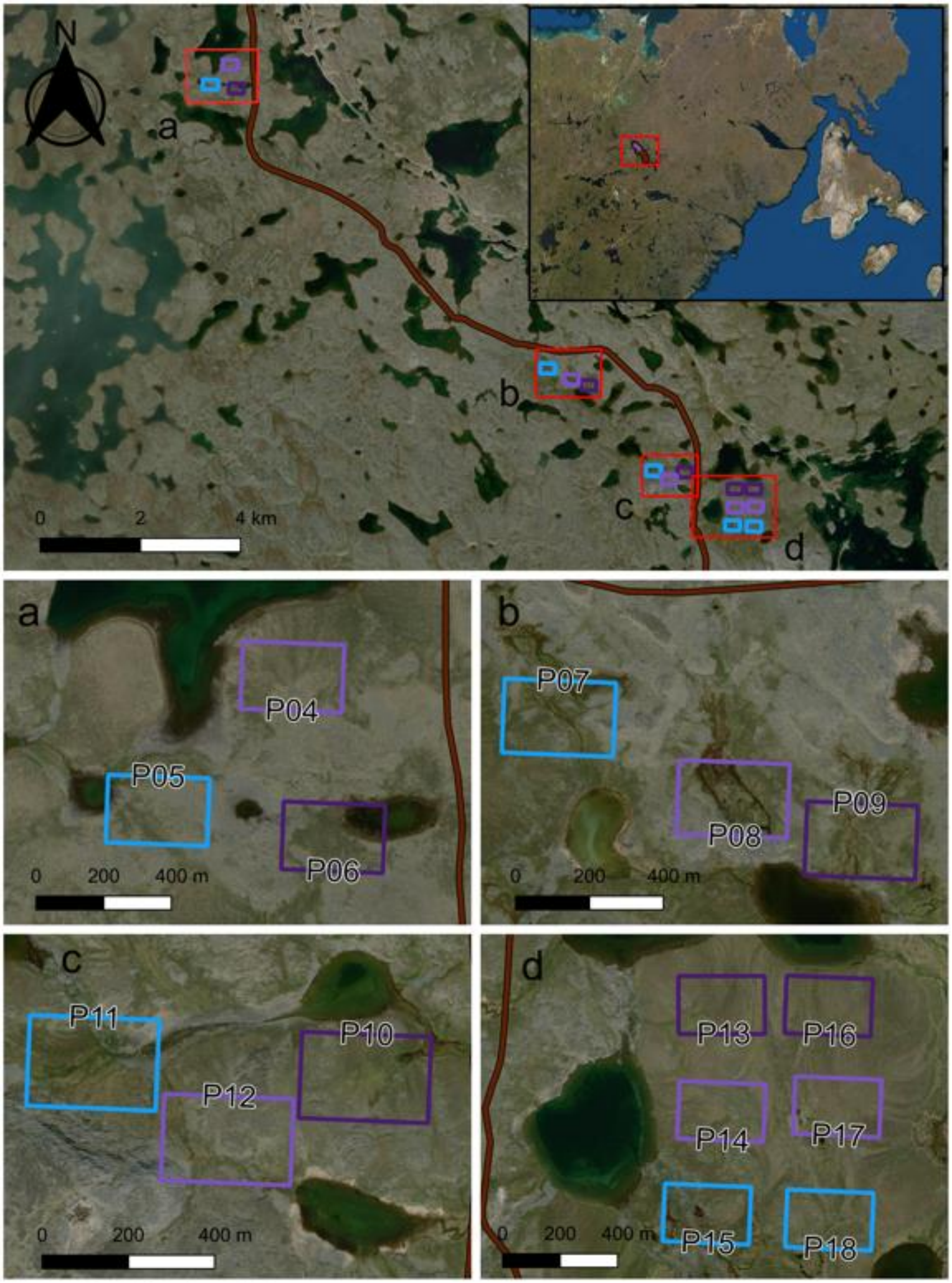

Figure 2.1: Map of Amaruq Road Experimental Area study site, located north of Baker Lake, Nunavut, along Amaruq Road between Amaruq Mine and Meadowbank Mine (refer to Figure 1.1), run by Agnico-Eagle Mines Ltd. The site was split into five separate clusters: (a) Cluster One included plots 4, 5 and 6, (b) Cluster Two included plots 7, 8, and 9, (c) Cluster Three included plots 10, 11, and 12, and (d) Cluster Four included plots 13, 14, 15, and Cluster Five includes plots 16, 17, and 18. Plots colours were associated with treatment type; dark purple is high intensity treatment, light purple is low intensity treatment, and light blue is control.

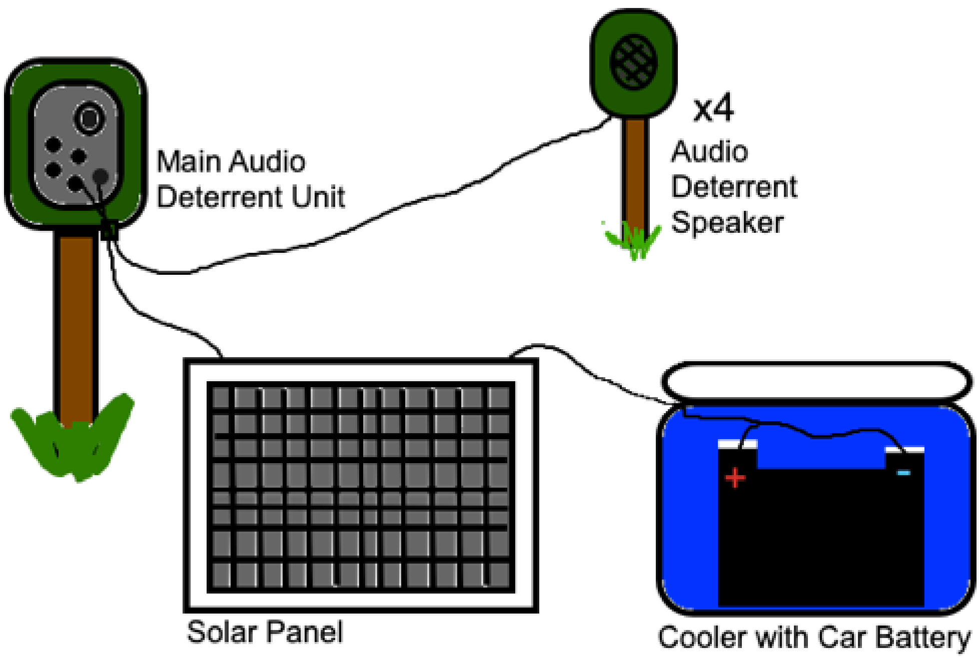

Figure 2.2: A diagram of the Audio Deterrent setup for both treatment plots, including the Bird-X Inx. "Super BirdXpeller PRO" main unit with four speakers, each attached to a wooden stake, a cooler with a 14V Car Battery, and solar panel. All the 12V batteries and the main speaker units are connected to the solar panel's controller. The solar panel sat south-facing against the cooler, close to the main speaker unit in the middle of the plot. The four speakers were spaced 25 m from the main unit in each cardinal direction.

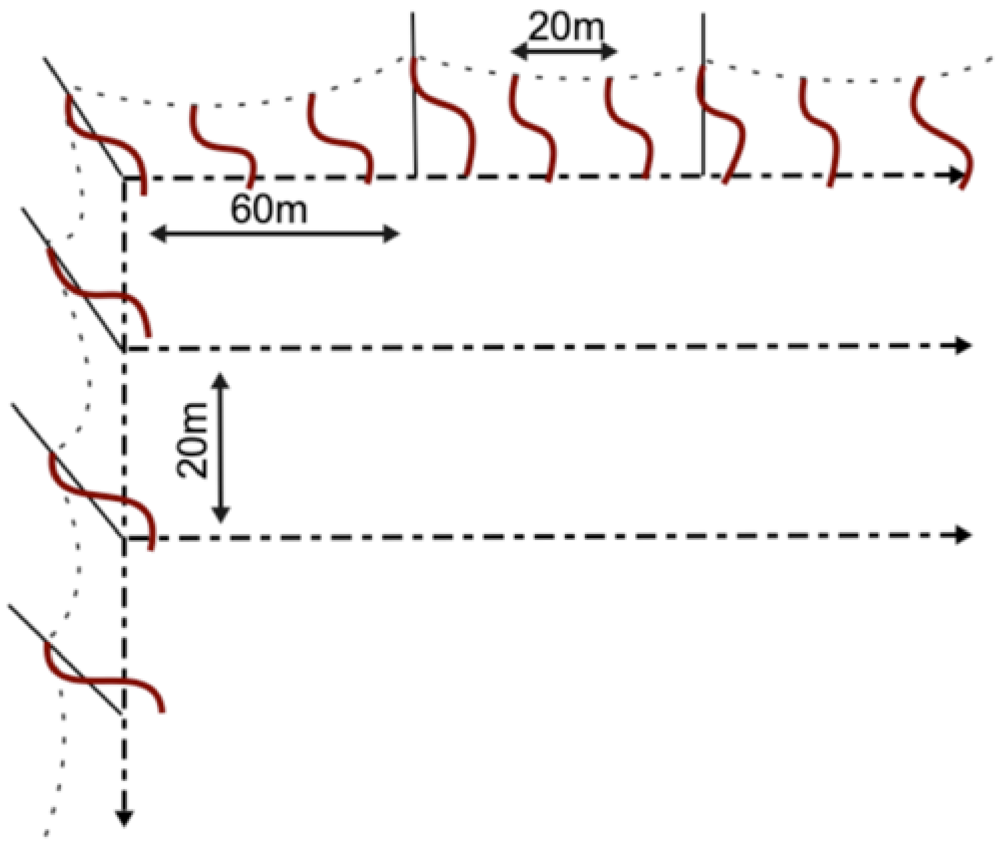

Figure 2.3: A diagram of the flash tape grid (20 x 20 m) setup within the High Intensity Treatment plots. Plots were 300 x 200 m (6 ha; indicated by broken line), with aluminum angle (indicated by a solid line) placed every 60 m across and every 20 m down with a total of 20 rows of aluminum angle. Monofilament fishing line (indicated by the dotted line between aluminum angle; 100- lb test Hercules PE Braided Fishing Line, 4 Strands) was strung between aluminum angles, with a 5-m piece of flash tape (red squiggle; "Birdscare Flash Tape," Sutton Agricultural Enterprises) attached to the fishing line or aluminum angle every 20 m.

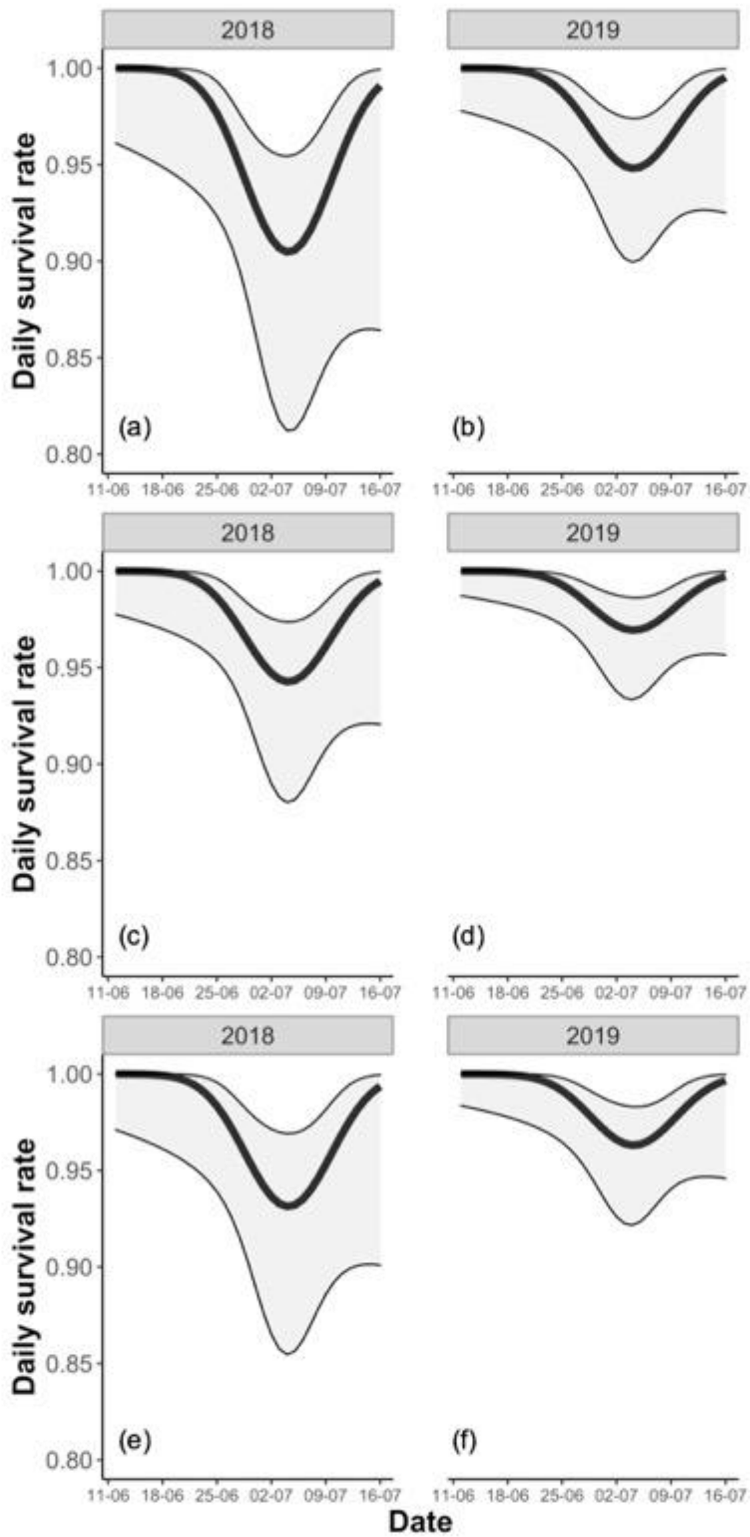

Figure 2.4: Estimated daily survival of passerine (total passerine, *n* = 77; Lapland Longspur, *n* = 64; Horned Lark, *n* = 13) nests located within Amaruq Road Experimental Area plots, analyzing the interaction of DSR between treatment types (a-b = control, c-d = high intensity treatment, e-f = low intensity treatment) and years (2018, 2019). Years are defined by before and after treatment (2018 = before, 2019 = after). Date indicates the day and month. Shaded areas indicate 95% CI.

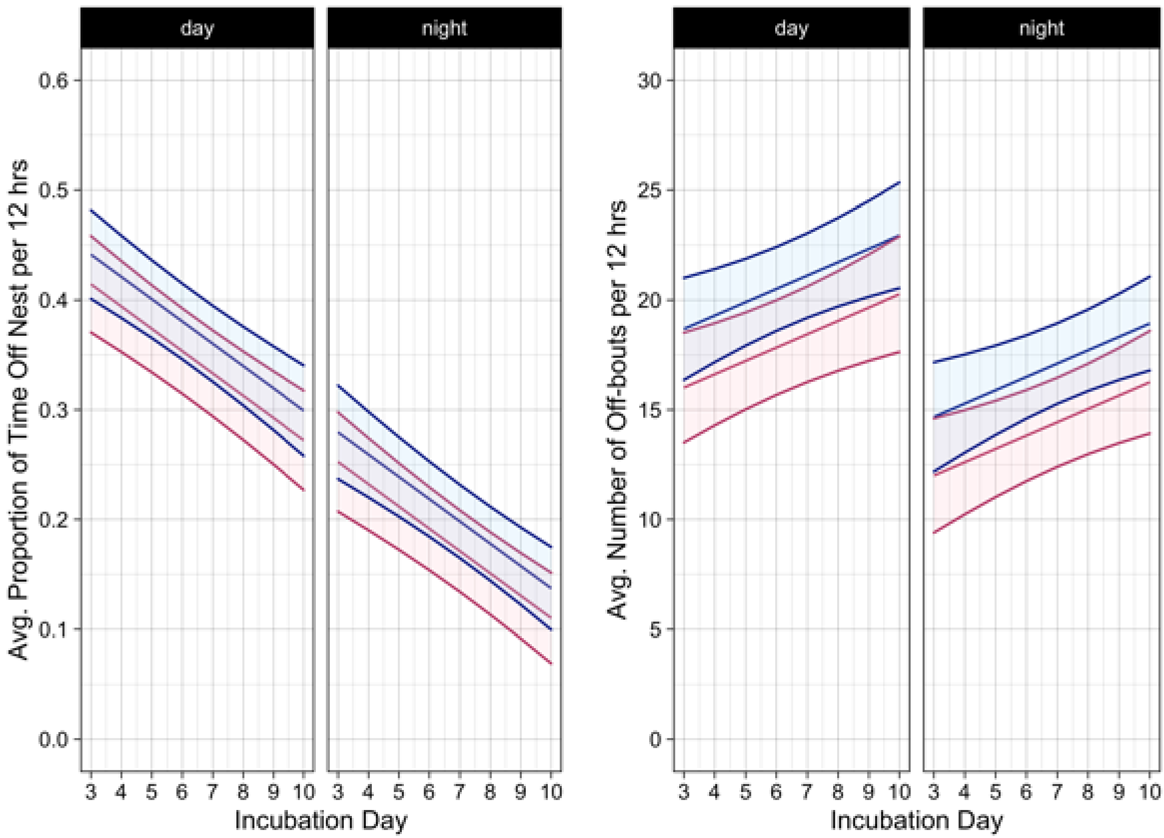

Figure 2.5: Predicted values form a mixed effects model of Lapland Longspur incubation behaviour, with 95% confidence intervals, for proportion of time off nest and count of off-bouts per 12 hour period, split between day and night, comparing nests within treatment (*n* = 10; blue line and fill) and control (*n* = 10; red line and fill) over the incubation period from day 3 to 10.

Figure 2.6: A concealed Lapland Longspur nest located within a High Intensity Treatment plot. The nest is shown with a single piece of flash tape draped over it, which is how it was found.

Table 2.1: Description of the three treatment types deployed within the plots located within two study sites: the Amaruq Road Experimental Area site and Whale Tail Flood Area site. Details include an outline of equipment, description of use, and frequency of use.

Treatment Name	Location	Deterrents Used
High Intensity Treatment	Amaruq Road Experimental Area	• Audio Deterrents: "Super BirdXpeller ® PRO" by Bird-X, Inc. Speakers broadcasting all at once with recordings played randomly in non-sequential order, continuously for 24 hours at 10 - 30-minute intervals. • Hawk Effigy: "Peregrine Falcon Kite" by Margo Supplies. • Flash tape Grid: 20x20m grid.
Low Intensity Treatment	Amaruq Road Experimental Area	• Audio Deterrents: "Super BirdXpeller ® PRO" by Bird-X, Inc. Each speaker broadcasting one at a time with recordings playing in sequential order continuously for 24 hours at 5 - 10-minute intervals. • Hawk Effigy: "Birds of Prey Falcon Kite" by Sutton Agricultural Enterprises. • Flash tape Grid: None
Treatment (additional deterrent plots used for incubation behaviour monitoring, Chapter 3)	Whale Tail Flood Area	• Audio Deterrents: "Super BirdXpeller ® PRO" by Bird-X, Inc. Speakers broadcasting all at once with recordings played randomly in non-sequential order, continuously for 24 hours at 10 - 30-minute intervals. • Hawk Effigy: None • Flash tape Grid: 20x20m grid.

Table 2.2: Mean density per plot of territorial males of the four main study species combined (Lapland Longspur, Horned Lark, Semipalmated Sandpiper and Least Sandpiper) in the control and treatment plots between years, pre-deterrents in 2018 and post-deterrents in 2019.

Treatment	2018 (territories/km^2 ± SE)	2019 (territories/km^2 ± SE)
Control	56.1 ± 14.9	64.0 ± 8.7
High Intensity Treatment	67.5 ± 13.7	104.5 ± 15.2
Low Intensity Treatment	70.8 ± 5.4	77.7 ± 10.1

Table 2.3: Mean density per plot of territorial males of two shorebird species combined (Least Sandpiper and Semipalmated Sandpiper) in the control and treatment plots between years, pre-deterrents in 2018 and post-deterrents in 2019.

Treatment	2018 (territories/km^2 ± SE)	2019 (territories/km^2 ± SE)
Control	11.4 ± 5.5	10.5 ± 4.7
High Intensity Treatment	8.2 ± 3.5	23.8 ± 8.2
Low Intensity Treatment	9.3 ± 4.1	14.3 ± 11.1

Table 2.4: Mean density per plot of territorial males of Lapland Longspur in the control and treatment plots between years, pre-deterrents in 2018 and post-deterrents in 2019.

Treatment	**2018** (territories/km^2 ± SE)	**2019** (territories/km^2 ± SE)
Control	41.4 ± 7.8	47.4 ± 9.6
High Intensity Treatment	44.1 ± 7.9	76.7 ± 10.3
Low Intensity Treatment	49.2 ± 4.9	52.1 ± 6.6

Table 2.5: Mean density per plot of territorial males of Horned Lark in the control and treatment plots between years, pre-deterrents in 2018 and post-deterrents in 2019.

Treatment	**2018** (territories/km^2 ± SE)	**2019** (territories/km^2 ± SE)
Control	3.2 ± 3.2	6.2 ± 3.1
High Intensity Treatment	15.2 ± 7.1	3.9 ± 2.5
Low Intensity Treatment	12.3 ± 3.7	11.1 ± 3.5

Table 2.6: Model parameter estimates (± SE) and 95% confidence interval (95% CI) of the logit-link model of daily survival between year and treatments from the final stage of modeling of daily survival rate of Passerine species group nests explained by temporal and special covariates.

Model Variable	**Estimate ± SE**	**CI 95%**
Intercept	10.85 ± 3.90	3.21, 18.49
High Intensity Treatment	0.55 ± 0.43	-0.30, 1.40
Low Intensity Treatment	0.36 ± 0.45	-0.52, 1.24
Year 2019	0.65 ± 0.37	-0.07, 1.38
Date	**-0.77 ± 0.37**	**-1.51, -0.04**
Date^2	**0.02 ± 0.01**	**0.00, 0.03**
Year 2019*High Intensity Treatment	0.16 ± 0.88	-1.55, 1.88
Year 2019*Low Intensity Treatment	-0.13 ± 0.90	-1.89, 1.63

Table 2.7: Break down of deployment (person hours), maintenance (person hours per 4 days) and total cost ($ CAD) per deterrent type and treatment.

Deterrent Type	Treatment	Deployment (Total Person Hours)	Maintenance (Person Hours per 4 days)	Total Cost ($ CAD)
Flash Tape Grid (20 x 20 m)	High Intensity Treatment; *n* = 5	140 – 160	2.5 – 20	4,047
Audio Deterrents	High and Low Intensity Treatment; *n* = 10	40	5	9,168.92
Hawk Kite Effigy	High and Low Intensity Treatment; *n* = 10	5	5	1,084.25

CHAPTER 3 – IMPACTS OF MINING-INDUCED FLOODING ON DENSITIES, BEHAVIOUR AND SURVIVAL OF ARCTIC-NESTING BIRDS.

ABSTRACT

Development activities caused by mining-pit development, such as dewatering, can result in loss of nests and eggs due to flooding of terrestrial habitats. Mining development and resource extraction are set to increase in northern environments, leaving arctic-nesting birds vulnerable as such development may lead to habitat and population declines. This study assessed the impact of mining-induced flooding during the development of a new gold mine pit at Amaruq Mine located north of Baker Lake, Nunavut, Canada. Based on intensive and rapid surveys of the predicted flood area (1.52 km^2) in 2018, we first estimated the number of nests of four passerine species, two shorebird species and other waterbirds to be lost due to flooding. We then assessed the impact of flooding in 2019 on nesting densities, daily survival rate and renesting rates after nest loss. Based on an observed loss of 6 nests within a total of 0.16 km^2 terrestrial area lost in the advancing water levels, we estimated an average loss of 37.5 nests/km^2 on flooded tundra. Out of the six nests lost, only one pair (Lapland Longspur) renested. Densities in plots increased by 5.5 territories/km^2 from pre-flood to mid-flood levels, yet not statistically significantly, to suggest territory packing in unflooded habitat post-flooding. Flooding did not impact average Lapland Longspur daily nest survival rates.

INTRODUCTION

The Canadian Arctic plays a crucial role in the life cycle of many long-distance migratory birds, by providing habitat to meet their breeding requirements (Gratto-Trevor 1996). While Arctic habitats face fewer pressures from human populations than more heavily populated temperate regions, these remote habitats are not without anthropogenic threats. Climate change is amplified at high latitudes (Badeck et al. 2004), and arctic-nesting birds are especially vulnerable to changing climate (Hof et al. 2017). A warming climate can reduce the breeding range of arctic-nesting birds through tree and shrub encroachment (Harsch et al. 2009; Myers-Smith et al. 2011) or alter phenology through shifting seasons (Howard et al. 2018) or disrupted environmental cues during the long sequence of decisions prior to the start of reproduction (Knudsen et al. 2011). Although less pervasive than the effects of climate change, mineral, oil and gas exploration are predicted to increase throughout the Arctic landscape (Krivovichev 2019), leading to land-use changes and disturbance of critical habitat for wildlife (Wilson et al. 2013). Alone or in combination with climate change, these resource extraction activities can lead to a significant loss of nesting habitat (Bernath-Plaisted and Koper 2016), for Arctic breeding birds (Gajera et al. 2013)

Arctic ecosystems are both sensitive to disturbance and slow to recover from disturbance (Rapport et al. 1997). The mining industry's impact on tundra landscapes is expected to affect wildlife that relies on these landscapes during part or all of their annual life cycle (Smith et al. 2005; Johnson et al. 2005). Examples of direct and indirect impacts on nesting birds caused by mining development and ongoing activities in the Arctic include increased predation risk from augmented predator populations (Liebezeit et al.

2009), habitat fragmentation (Smith et al. 2005; Scanes 2018), and an overall loss or alteration of breeding habitat due to infrastructure and flooding of natural landscapes (Pirie et al. 2009). These impacts have varying degrees of disturbance on birds that nest in or travel through development areas. Some mines have a relatively limited impact on species diversity (Smith et al. 2005; Bol et al. 2018, N. Grishaber in prep.), but there is still a possibility for mines and associated infrastructure to impact nest success or other aspects of habitat quality (Male and Nol 2005, Van Wilgenburg et al. 2013; Ludlow and Davis 2018). While studies rarely provide estimates of indirect losses due to development, we can estimate the potential losses with a pre-disturbance estimate of how many animals are using the habitat (McGowan and Ryan 2009; McGowan 2013).

The development of mine infrastructure can increase the risk of predation for nesting birds, as there is often an increase in the abundance of nest predators closer to areas of concentrated human development (Haskell et al. 2001). Liebezeit et al. (2009) explored this phenomenon by assessing the influence of nest predation on the population dynamics of arctic-nesting birds in the Arctic Coastal Plain of Alaska, with ongoing oil and natural gas development. The study demonstrated that infrastructure had a negative effect on nest survival of passerines, which was reduced within 5 km of an oil field infrastructure. This reduced nest survival was thought to be caused by increased predator abundance, due to the infrastructure of the oil refineries providing nesting, perching and denning sites for avian and mammalian predators (Liebezeit et al. 2009). A local increase in the abundance of predators could lead to local decreases in the survival of nests, as predation is the primary cause of nest failure for many arctic-nesting birds (Liebezeit et al. 2009; Meyer et al. 2020). Although birds have suites of behaviours to combat predation risk, an unnatural increase in predators in a short time period does not leave room for rapid adaptation (Lecomte et al. 2008).

One of the expected outcomes of mine site development is flooding of terrestrial areas due to dewatering that is typical used to gain access to minerals below lakes, both directly and indirectly impacting birds during their nesting period. For example, a study predicted an 8 – 30% decrease in Whimbrel (*Numenius phaeopus*) habitat due to subsidence-induced flooding of nesting grounds due to the construction of a pipeline within the Kendall Island Bird Sanctuary (623 km^2) and Fish Island (7560 km^2), located in the outer Mackenzie Delta, Northwest Territories (Pirie et al. 2009). An increase in resource extraction in northern landscapes means a greater likelihood of losing nesting habitat to mining or subsidence-induced flooding that arises with mining development (Gajera et al. 2013; Bernath-Plaisted and Koper 2016). Loss of crucial nesting habitat due to flooding has the potential to push birds into adjacent habitats, causing higher territory densities that might be unsustainable, and potentially leading to a concentration of nest predators (Schneider 2001). There is some evidence for this from forested environments, as nesting Ovenbirds (*Seiurus aurocapilla*) responded to habitat loss through clear cutting by crowding territories together into smaller, unsuitable breeding sites within the remaining fragmented patches of habitat (Burke and Nol 1998). Although the number of nests did not change, the density increased in less suitable habitats, which could lead to local population decline if these nests are less successful (Bayne and Hobson 2001).

Nest losses due to mining development are considered “incidental take” (Van Wilgenburg et al. 2013); disturbances that cause harm to nests and eggs are incidental, arising from otherwise legal activities. Incidental take is a concern in many activities related to resource development, including vegetation clearing, road or pipeline maintenance, and flooding from dams used to control water on the landscape (CMIAE 2017). These effects on birds are regulated through the Migratory Birds Convention Act (1994), and industry therefore has a legal requirement to understand and mitigate the impacts.

This chapter explores the degree to which mining-induced flooding impacts arctic-nesting birds through a case study of mining development in Nunavut during the 2018 and 2019 nesting seasons. We were asked by mine personnel at Agnico-Eagle Mines Ltd. to attempt to deter birds directly from the predicted flood area during dewatering, to minimize nest loss due to flooding. In Chapter 2, I demonstrated that deterrents were unsuccessful in reducing breeding bird densities in experimental plots at this site. In this chapter, I examined (1) the direct losses of nests due to flooding, (2) whether nest and territory densities were elevated in the remaining, unflooded habitats, (3) the daily nest survival in intact habitats compared to sites with flooding, (4) the return rate of nesting birds between years, and (5) the likelihood that individuals renested after losing their nest due to the flooding.

I predicted nest loss due to flooding, that nest and territory densities would increase in the areas adjacent to active flooding, and that the flooding event would impact the survival of nearby nests. I also predicted that birds were likely to attempt to return to their nest site in the previous year, as nest success at our site is high (see Chapter 2), and that birds that lost their nest during the early to mid-breeding season would initiate a second nesting attempt. I studied these potential impacts of flooding at an active gold mine in the Kivalliq Region of Nunavut, Canada.

METHODS

Study Area

The study was conducted in the landscape surrounding the Agnico-Eagle gold mine, within the Kivalliq Region of Nunavut, 130 km north of Baker Lake (N65° 24' W96° 40'), during the summers of 2018 and 2019. Situated in the Northern Arctic ecozone, the region exhibits a range of tundra habitats with rolling hills and rocky terrain, with scattered lakes and ponds. Habitats are primarily heath, lichen and rock in the uplands and wet graminoid-dominated lowlands, with tundra of varying moisture regimes in between (Campbell et al. 2012).

Agnico-Eagle Mines Ltd. proposed, and has now built, the Whale Tail Project, that included the construction of two dikes within the northern portion of Whale Tail Lake that diverted water from the Whale Tail mining pit into the surrounding lakes and tributaries (Figure 3.1). One dike resulted in flooding that elevated the water levels by 4 m (pre-flood: 152 masl) from May 2019 to August 2020, causing approximately 157 ha of flooded tundra, coinciding with the timing of birds' nest initiation over two breeding seasons (as described in Golder Associates and AEM 2016).

The breeding bird population in the study area consists primarily of arctic-nesting passerines, with lower densities of shorebirds and other waterbird species, many of which nest in low-elevation sedge meadow, close to water bodies. We selected several species for the study, based on their use of habitats that could be affected by flooding, and their presence in our plots: Lapland Longspur (*Calcarius lapponicus*), Horned Lark (*Eremophila alpestris*), Semipalmated Sandpiper (*Calidris pusilla*) and Least Sandpiper (*Calidris minutilla*), Savannah Sparrow (*Passerculus sandwichensis*), White-crowned

Sparrow (*Zonotrichia lucophrys*), Common Redpoll (*Acanthis flammea*), Long-tailed Duck (*Clangula hyemalis*), Red-throated Loon (*Gavia stellata*) and Herring Gull (*Larus argentatus*).

Location of Plots

I established sixteen, 6-ha plots of varying shapes along the riparian edge of Whale Tail Lake's southern basin and its surrounding lakes and tributaries (Figure 3.1). Plots were selected in clusters of four: 8 plots were selected to be within the predicted flood zone, accounting for 31% of the predicted flood area (1.52 km^2), with 8 additional plots situated adjacent to the flood zone plots (Figure 3.1). Whale Tail Lake is located adjacent to the Amaruq Mine site. Due to active draw-down of the Whale Tail pit and the flooding of the southern basin of Whale Tail Lake in 2019, plots situated in the predicted flood area decreased in size, as a function of their distance from the Whale Tail Lake dam (Figures 3.1).

Four of the eight plots situated in the predicted flood zone received deterrent treatments in 2019 (Figure 3.1). Deterrents used within treatment plots at the Whale Tail Lake consisted of a 20 x 20 grid of flash tape and audio deterrent speakers set at high intensity (see Chapter 2, Table 2.1). Because of the relatively small area flooded by the Whale Tail project, clusters of plots were close together, separated by 0.25 to 1.25 kilometres.

Rapid and Intensive Surveys, Nest Searching and Monitoring of Daily Survival

During the 2018 field season, before the development of dikes and the dewatering, we surveyed the predicted flood area in the Whale Tail Lake southern basin for breeding birds on a single day (25 June), with a total of 75 person-hours of effort within an area of

2.23 km^2. This surveyed area was greater than predicted flood area of 1.52 km^2, adding an additional 0.71 km^2 to the area around the predicted flood area (AEM and Golder Associates 2016). The rapid survey consisted of four surveyors walking a transect parallel to the lake's edge, across the width of the proposed flood zone, as described in Appendix 6-F - Flooding During Phases report (Golder Associates and AEM 2016). Surveyors were 20 – 40 m apart, depending on the flood zone's width, and watched the ground ahead of their trajectory to observe flushing birds or other breeding activity. When a bird was observed, all surveyors stopped, and one or more surveyors attempted to find the nest by waiting for the bird to return to its nest, or by searching the area where the bird was initially observed. A GPS was used to record the location of any nests that were found. In the case of no nest found, a location was recorded at the approximate centroid of the area where the bird was observed, and behavioural observations were recorded. Behavioural observations that were used to identify breeding birds as a (1) possible nest, when a female was flushed from the ground and was acting restless or exhibiting distraction display for species with such behaviours, (2) male territory, when we observed a male singing or displaying, (3) pair, when a female and male were observed foraging together. We did not consider birds to be breeding within the plots when observed in groups, such as when a group of both sexes were observed foraging together, or singles, such as when a bird was either flying overhead, flushed or foraging with no indication of a possible nest or territory.

After the initial survey on 25 June 2018, to reduce the search time, we divided and subsampled the Whale Tail predicted flood area into four flood zone areas (total 0.87 km^2 surveyed). This approach allowed us to concentrate on areas of the flood zone that were most likely to support breeding birds, including sedge meadow and low elevation sites.

The Whale Tail Lake southern basin was accessed via helicopter, and our ability to visit these sites was therefore constrained by access. We conducted intensive surveys for 96 hours over three days (29, 30 June and 1 July) within these four areas. Intensive survey data were combined with the rapid survey data to calculate the densities of nesting or territorial birds that were predicted to be exposed to the flooding event in 2019 in the predicted 1.52 km^2 flooded area.

In 2019, the second year of the study, I established 16 plots (Figure 3.1) in the subsampled areas surveyed in 2018. Within these 16 plots, I performed intensive nest searching and surveys for territorial birds every 4-5 days, 16 June - 14 July 2019. The presence of territories was documented primarily at the beginning of the breeding season, through territory mapping, but attempts to map territories continued throughout the breeding season where males continued to display. Mapping was done by following displaying males and recording the displaying bird's location with GPS (± 5 m). We aimed to obtain a minimum of 5 points per bird, each visit. While following males, I attempted to avoid disturbing the birds by staying low to the ground and moving only when the bird moved to a new position to sing. Every visit to predetermined territories was to establish if males were still present on their territory throughout the breeding season, to increase our certainty of the territory centroid for territories where nests were never found.

Nest searching was conducted by systematically walking plots and observing behavioural cues of breeding adults (e.g., flushing, mate courtship, alarm calls). Upon discovery, nests were marked with a tongue depressor within 5m in a random direction. The observer recorded the nest's exact coordinates using the "average waypoint" function (± 3 m) within the Garmin GPS unit, as well as the species, number of eggs present, and date found. For nests found outside of the laying period, we floated eggs to determine the nest's age and to calculate the estimated initiation date and hatch date (adapted from Liebezeit et al. 2007).

Nests found in 2019 were monitored on a 4-day schedule until fates were determined. Methods to assess nest fate depended on the life history of each target species. Nests occupied by species with precocial young (i.e., *Calidris* spp.) were considered successful if at least one egg hatched, while nests occupied by species with altricial young (i.e., passerines) were considered successful if at least one chick fledged. Signs of predation (loss of a whole clutch, nest disturbance, large eggshell fragments or yolk) or abandonment (no sign of adults or cold eggs over 3 visits; Mabee et al. 2006) indicated failed nesting attempts.

Marking and Re-sighting

In both 2018 and 2019, adults of the four focal study species (Lapland Longspur, Horned Lark, Semipalmated Sandpiper and Least Sandpiper) found within the proposed flood zone were captured opportunistically on the nest with the use of a bow net. Capture was attempted only once clutches were complete (i.e., the number of eggs in the nest do not increase each day) or when a nest had fledglings younger than four days old. We captured the incubating bird (female) for species where only one adult incubates (i.e., Lapland Longspur and Horned Lark), and attempted to capture both members of the pair for species where both adult birds incubate (i.e., *Calidris* spp.). We measured head-bill length, tarsus length, and wing length (± 1 mm) and weight (± 1 g). We banded birds with a standard federal metal band with a unique 10-digit number. Shorebird species (Semipalmated Sandpiper and Least Sandpiper) were also given a white leg-flag with a 3-

letter code placed on the upper leg. Passerines (Lapland Longspur and Horned Lark) were given unique colour band combinations comprising one metal band and three plastic colour bands. We released birds immediately after processing, which took less than 15 minutes per bird.

We re-sighted banded birds throughout the breeding season to estimate return rates of birds marked in 2018 and to ensure that birds marked in 2019 were still present on the site throughout the breeding season and as nests were found and disturbed due to flooding, deterrents or predators. Band combinations were read from left to right as per standard protocol and recorded with location and date. Resighting occurred during every site visit.

Flood Level Monitoring

Agnico-Eagle Mines Ltd. began flooding in February 2019 and continued until October, after which the water receded. Hydrological modelling suggested that the flooding would reach a peak of 156 masl around July 2019. While we were present on site, from 17 June – 18 July, water levels varied from 154.68 – 155.54 masl, increasing through our field season. During the field season, there were some delays in dewatering due to the water turbidity in the middle of the breeding season (June 2019). The eight plots located in a portion of proposed flood areas had an area of 0.06 km^2 each in 2018, "pre-flood" (a total of 0.24 km^2; Figure 3.1). The extent of terrestrial area lost between 2018 and the beginning of the 2019 season was dependent on the amount of flooded terrestrial area present (a total decrease of 0.06 km^2 from 2018 to 2019 in all eight plots). We consider the breeding season "mid-flood", as it was during the middle of the flooding event. Throughout the 2019 field season, we monitored active flooding as it occurred during the breeding season. "Peak-flood" did not occur until October 2019, with the water receding after this date.

In 2019, I monitored the ongoing flood water levels and loss of terrestrial area throughout the breeding season, I recorded a track using a GPS by walking the waterline of the 8 plots experiencing flooding during every visit. I used these lines to determine the lowest to greatest extent of flooding observed by us during the 2019 breeding season (from our earliest dates of survey, 17 June, to the end of our field season, 10 – 14 July; Figure 3.1). Using the clip tool in QGIS (Version 3.10.12; QGIS Development Team 2021), I clipped the track lines against the plot polygon files to determine the change in area between pre-flood (2018) and mid-flood (early 2019), and changes within the 2019 season as flooding progressed.

STATISTICAL ANALYSIS

Flooding Impacts on Nest and Territory Density

We used data from 2018 to estimate the number of nests and territorial birds potentially impacted by the flooding in 2019. I assumed that every nest, possible nest, or territorial male encountered during the 2018 surveys was a single territory held by a male and female pair, with a nest (Bart and Earnst 2005). To avoid double counting territories, I manually assessed the location of each sighting within QGIS, to determine whether two sightings could be associated with a single territory. For example, if a nest coordinate was within 20 m of the location of a possible nest or territorial male of the same species, recorded on either the same or separate survey day, I considered the latter as a duplicate and omitted it from the data. For nests and territories monitored in 2019, I considered all nests to be associated with a single territory, and also recorded a territory for areas occupied by a male during the entire season, with the presumed territory centroid within the plot, but for which no nest was found.

To determine density of birds, I divided the number of territories observed within each plot by the plot area during the pre- and mid-flood. I first assessed whether deterrent treatments had an impact on nest and territory densities between years, with a paired t-test (2018: before deterrents; 2019: with deterrents) for plots that had deterrent treatments. Territory density was used rather than nest densities as territory is a more reliable comparison between the two years since nest numbers in 2018 were lower owing to a lower search effort. There was no evidence of a decrease in nest densities ($t(3) = -1.79$, $p = 0.17$; 2018: 84.8 ± 33.6 nests/km^2, 2019: 121.7 ± 26.9 nests/km^2) or territory densities ($t(3) = -2.93$, $p = 0.06$; 2018: 125.5 ± 34.5 territories/km^2, 2019: 158.3 ± 29.7 territories/km^2) between years for plots that received deterrents in 2019. Instead, there was a marginal increase in nest and territory densities in 2019, contrary to what was expected if deterrents were effective. I reported a similar result in Chapter 2 at a different study site. Therefore, we ignored the presence of deterrents for the remaining analyses in this chapter.

Nest Survival

We monitored nests after they were found by visiting them every 4 days to assess if they were still active (i.e., observing incubating bird, warm eggs and active nestlings) or whether they were lost due to predation, abandonment or flooding. A nest was considered lost to flooding once the nest was either entirely flooded, or when nests were found damp or eggs were cold with a lack of adult attendance.

I calculated daily survival rate (Mayfield 1961, Dinsmore and Dinsmore 2007) using the RMark Package (Bollier and Laake 2013) in R Studio (Version 1.3.1093; R Core Team 2020) for passerine nests; I grouped Horned Lark and Lapland Longspur (Horned Lark Incubation duration = 11 – 12 days; Cannings and Threlfall 1981; Lapland Longspur Incubation duration = 10.5 – 13 days; Jehl and Hussell 1966) located within the plots in 2019 due to small sample sizes of each. I excluded nests with unknown fates (3/44). Shorebird species were not included in the analysis due to the small sample size (n = 11), however, I report the raw data on apparent survival. The nest survival package allowed me to calculate estimates of daily survival rate of nests while incorporating predictor variables using a logit-link function (Walker et al. 2013). We translated ordinal dates into season-dates in which the first date a nest was found in the season was 1 (17 June, ordinal date 168) and the final nest check was 30 (16 July, ordinal date 197).

I first ran four candidate models (including an intercept-only model) to accommodate temporal variation in nest survival: season-date, quadratic season date ($date^2$), and cubic season date ($date^3$). In the next stage of modeling, to test whether the location of a nest relative to flooding predicted daily survival, I used the top temporal model ($date + date^2$) as a foundation for testing the effect of the spatial variable (i.e., flood vs. no flood).

Return Rates and Likelihood of Re-Nesting

In 2019, at every nest check we attempted to resight the parents to determine whether either parent had nested at the site in 2018 and had therefore returned to the study area in 2019. For birds marked in 2019 that lost nests due to flooding, we attempted to relocate marked individuals to determine whether and where they renested. When individuals with bands were discovered, we actively searched for their second nest attempt. The number of nests lost and the number of birds to renest was analyzed to calculate the minimum proportion of birds likely to renest after their nest was lost to flooding.

RESULTS

Impacts of Flooding on Territory Density

A total of 125 nests were found and monitored in Whale Tail Lake area and its surrounding tributaries in 2018 (n = 49) and 2019 (n = 76), in and outside the plots. A total of 19 nests (Table 3.1) were found within the predicted flood area outlined by Agnico-Eagle Mines in 2018 (1.52 km^2). When we arrived at the study site in 2019, we estimated that the water had advanced inland from the lakes edge on to the shoreline by approximately 40 m at three of four of the study plots (with an average loss of 0.01 km^2 per plot). The fourth cluster of plots (Figure 3.1a) situated adjacent to a lake south of Whale Tail Lake with a steep land bridge between the lake and Whale Tail Lake; consequently, flooding was not heavy enough at the beginning of the season to flood much of the plot area (refer to Figure 3.1 to observe connection between Whale Tail Lake and lower lake). As planned, flooding began in late winter and continued beyond the end of breeding season (February – October 2019; Golder Associates and AEM 2016). At peak-flood in October 2019, the area flooded was a total of 1.35 km^2, 11% less than expected by AEM and Golder Associates (2016; 1.52 km^2), accounting for 17% of area lost within the eight plots during the 2019 breeding season. The vegetation was visibly intact in the submerged portion of plots (Figure 3.2), with some debris such as lichen, peat and leaves from dwarf and willow shrubs on the surface of the water.

In 2019, the Whale Tail plots were surveyed for a total of 148 search hours within the predicted flood zone from 16 June to 14 July, with 63 nests found within the plots. We found no significant difference in the average densities of nests (nests/km^2: $t(14) = -0.20$, $p = 0.84$) and territories (territories/km^2: $t(14) = -1.21$, $p = 0.25$) between pre-flood (2018) and mid-flood (2019) plots. Across years, coincident with flooding, the occupancy of birds tended to increase in our experimental plots, but not significantly. Territory densities of the pre-flood (2018) plots had an average density of 121.3 ± 19.5 territories/km^2, while mid-flood (2019) plots had an average density 126.8 ± 19.2 territories/km^2. Additionally, nest densities of the pre-flood (2018) plots had an average density of 58.6 ± 18.3 nests/km^2, while mid-flood (2019) had an average density of 89.3 ± 17.8 nests/km^2, although there was more effort in nest searching in 2019 than in 2018.

Flooding was ongoing throughout the 2019 season, including freshet and days of heavy rain (30 June – July 03). Results from the waterline analysis from the beginning to the end of the season (17 June – 14 July) suggested an additional average loss of 0.16 km^2 of terrestrial area within the eight plots along the riparian edge. On top of the 0.06 km^2 lost from the beginning of flooding to the first day of the field season (February – 17 June), a total of 0.22 km^2 of terrestrial area was lost within plots subjected to flooding.

Nest Survival Analysis

We found 41 passerine nests within the Whale Tail plots (Lapland Longspur, n = 38; Horned Lark, n = 3). Of these, 22 successfully fledged (54% nest success), and 19 failed. Among failed nests, 2 failed due to known abandonments (10% of failed passerine nests), 4 were known cases of predation (21% of failed passerine nests), and 4 nests were inundated due to flooding (21% of failed passerine nests, Table 3.1). We found 12 shorebird nests (Semipalmated Sandpiper only) within the Whale Tail Flood area plots; 10 successfully hatched (83% shorebird success) and the only observed nest failure was due to flooding (Table 3.1). Observed hatch dates for passerines ranged from 29 June to 9 July, and for shorebirds, 9 July to 12 July.

Whether a nest was within a plot that experienced flooding or not did not predict estimated daily survival of passerine (nests in flood plot, n = 26; nests in no flood plots, n = 15; -0.04 ± 0.48, CI 95% = -0.98, 0.89), however quadratic season-date ($date^2$) did predict estimated daily survival (Table 3.2). The predicted daily survival rate of passerine nests appears largely unchanged during the first 12 – 15 days of the season, and subsequently decreased to a low around day 20, and then increased again toward the end of the season (Figure 3.3).

Nest Loss and, Return Rates, and Likelihood of Re-nesting

During the ongoing flooding event in 2019, we documented six nests of three species lost due to rising waters, within a search area of 0.16 km^2 (Table 3.1; Figure 3.4). Based on the density of the loss (6 / 0.16 km2 = 37.5 nests/km^2), we estimate a minimum of 57 nests lost across 1.52 km^2 of the predicted flood area. We assume that this is a minimum of nests lost as we most likely did not find all nests that may have experienced the flood event. Our nest lost estimate from 2019 is based on what we observed within the plots (31% of the entire predicted flood area), with searching that took place in uniformly similar and overall suitable habitats for arctic-nesting birds.

The true flooded area during the breeding season was roughly one tenth of what was expected by the mines own modeling (Golder Associates and AEM 2016), but the affected nests are roughly one-third of what we predicted based on our 2018 nest surveys

(Table 3.1). The species that lost nests due to flooding in 2019 were Lapland Longspur (4), Semipalmated Sandpiper (1) and Herring Gull (1). Furthermore, there were 5 nests (Lapland Longspur = 4, Savannah Sparrow = 1) observed within the active flood area of plots that failed before the full impact of flooding. Of these five nests, four failed due to predation and one failed due to abandonment. Whether the flooding had an impact on the failure of the abandoned nests is unknown.

A total of 13 female Lapland Longspur and 8 Semipalmated Sandpipers were banded within the projected flood area in 2018. Only one Semipalmated Sandpiper was resighted in 2019, nesting in the same location as 2018. No Lapland Longspurs banded in 2018 were resighted. In 2019, a total of 17 female and 3 male Lapland Longspur and 13 Semipalmated Sandpipers were banded. Only one female Lapland Longspur was resighted within the same year and was from one of 6 nests lost due to active flooding in 2019. We found the second nest attempt of this marked Lapland Longspur, who re-nested 127 m from the location of their first nesting attempt. The original nest was estimated to be lost during the nestling stage (1-2 days old) due to flooding between 30 June – 2 July. We estimated that the bird initiated a new nest on 3 July, with 3 eggs in the second nesting attempt compared to 5 eggs in the first nesting attempt. The placement of the first nesting attempt was on a tall hummock; when the nest was found, the water level was 19 cm from the nest (Figure 3.5), 4 days later the water level was 12 cm from the nest, with damp nest lining and damp chicks. On the second nest check 5 days later, the nest was completely flooded with the water level greater than 10 cm above the nest.

DISCUSSION

Our results suggest that some nests were lost, proportional to the typical densities in lowland wet-sedge meadow habitats and the extent of the flooding. However, we found no significant evidence of birds' territory packing into habitats at elevated densities, adjacent to flooded areas, nor did we find evidence of reduced nest survival for nests near flooded areas as there were also losses of nests in areas not flooded, due to other causes including predation or abandonment.

The daily survival rate for passerine species showed a steep decline in survival rate 12-15 days into the breeding season, reaching a low around day 20 (Figure 3.4). The reduction of daily survival aligns with the timing of the nestling stage for passerine species at our study site, when nests are the most susceptible to predation as adults begin to feed nestlings (Grant et al. 2005; Chapter 2). Furthermore, water levels continued to rise late into the season, with nests lost due to flooding as early as 29 June and as late as 4 July. Nevertheless, while some nests were lost to flooding, the survival of nests in flooded vs. non-flooded plots did not appear to differ significantly.

Our study demonstrated a low site fidelity for passerines at this study site over two years. Of 21 individuals banded in 2018, only one individual returned to the study area to breed, despite efforts of all observers to watch for banded birds. This Semipalmated Sandpiper nested in the same nest cup in both years. No Lapland Longspurs marked in 2018 were resighted in 2019. Furthermore, we resighted only one of 5 individual birds marked in 2019 that lost their nest to flooding. It is possible that birds that had previously nested in flooded habitat chose to disperse further than the study area, making it difficult to detect between years providing us with low statistical power. Studies reveal variation in site fidelity for Lapland Longspur. A study by Custer and Pitelka (1977) found that 7.8% of males and 18.1% of females returned to the same general breeding site between years in Barrow, Alaska, while another study detected 54.7% of breeding adults returned in a subsequent breeding year in Sarcpa Lake, Nunavut (Montgomerie et al. 1983). Previous studies have demonstrated high levels of site fidelity for shorebird species (54-74% for Dunlin *Calidris alpina pacifica*, van Leeuwan and Jamieson 2018), specifically Semipalmated Sandpiper (50-80%, Gratto et al. 1985), including some examples of individuals re-using the same nest cup for at least 3 consecutive years (Herzog et al. 2018).

Mining and resource extraction can significantly impact wildlife (Rapport et al. 1997; Van Wilgenburg et al. 2013) through habitat loss or degradation (Smith et al. 2005; Pirie et al. 2009). In the case of our study at Amaruq Mine in 2019, the direct impact of flooding on nesting birds was modest during the two-month breeding season. At least 6 nests were lost to flooding in 2019, and our predictions in 2018 for nest loss suggest that the number would not be more than 19 nests (Table 3.1). Additionally, the flooding occurred for 9 months and during one breeding season, of which 44% occurred prior to birds' arrival to the site (February – May 2019), 22% occurred during the breeding season (June – July 2019), and 33% occurred post-breeding. The flood waters in the study area have since receded as per Agnico-Eagle Mines Ltd. operation plans for Amaruq Mine's development (October 2019; Golder Associates and AEM 2016). Nesting activity has been assessed in the previously flooded area and did not occur (S.M. Bonnett, pers. comm. 2021). Lack of nesting birds in previously flooded area could be due to terrestrial vegetation, such as shrubs and grasses, dying during one year of high-water levels (Figure 3.6; S. M. Bonnett, pers. Comm. 2021).

In many cases, when habitat is altered due to mining and resource extraction, it can be remediated and eventually recolonized by species that use it (Brown and Naeth 2013). For example, even in Canada's oil sands region, where substrates are physically removed, government policymakers are working with mining companies to develop strategies to restore lands that are no longer in use by industry (Wellstead et al. 2016). Lakes at our site have defined shorelines that remain intact at least during the first season of flooding. However, throughout the flooding event, the water advanced over the shoreline, covering vegetation, which appeared to remain intact at least during the flooding. In Arctic environments, surface hydrology and soil moisture are important factors in controlling plant community composition and ecosystem function (Chapin et al. 2005; Campbell et al. 2021), therefore changes to surface hydrology and soil moisture could have drastic consequences on plant community composition (Walker et al 2006; Goswami et al. 2011). Development-induced changes to Arctic landscapes could have subtle effects to which vegetation may not be able to reacclimate, and while reclamation of degraded habitat is an important mitigation technique, it is a slow process and often fails to duplicate the previous habitat (Foote 2012). Therefore, habitat effects can impact a local wildlife population over the long-term.

Studies examining phenotypic plasticity in animals aim to better understand whether species can adjust to extreme climatic events (ECEs) such as droughts or floods caused by global climate change (Coumou and Rahmstorf 2012). ECEs have long-term impacts on wildlife populations and habitats (van de Pol et al. 2010). An organism's behaviour and life-history are adapted to accommodate the long-term rates of extreme events. However, with the increased rate of ECEs from climate change, organisms are in some cases struggling to deal with the changes. Extreme events arising from temporary flooding or other development-related changes represent an additional unnatural pressure that may prove difficult for individuals to respond to adequately (Charmantier et al. 2008; Pirie et al. 2009).

Bailey et al. (2017) examined nest-site selection of Eurasian Oystercatchers (*Haematopus ostralegus*) over two decades in an area with increasingly extreme flooding events driven by sea-level rise and wind and storm patterns. These progressively intense flooding events substantially impacted Eurasian Oystercatcher's nest success, washing away eggs or drowning young (van de Pol et al. 2010). The study demonstrated that over time, Eurasian Oystercatcher selected nests at successively higher elevations, especially for individuals that experienced the flooding events, regardless of nest fate (Bailey et al. 2017). However, the adaptation was observed within some individuals and not within the overall nesting population. The oystercatcher study suggests that individual birds may change their behaviour in response to ECEs, but there was no evidence that a long-term change would occur for the entire population. While short-lived individuals may not have the scope for modifying their behaviour, whether the population can adapt likely depends on whether the behaviour is in the species' repertoire. Therefore, it is likely that the species at our study site, with much shorter life spans and breeding seasons (one nest per season), would not have a chance of adjusting individual behaviour to the extent that adaptation could occur within a population over time.

Our study demonstrates that mining-induced flooding had some impact on nesting birds within the areas flooded, and we found little evidence that birds that lost nests produced a second nesting attempt elsewhere, resulting in a loss of offspring at least for that breeding season. The lack of a second nest attempt could be due to the short breeding season for arctic-nesting birds, however it also possible that we failed to find renests, as studies in arctic environments have demonstrated that renesting rates are high when nest failure is early in the season and is less likely when the nest is lost late into the breeding season (Gates et al. 2013; Pakanen et al. 2014). Additionally, deterrents were not effective at dissuading birds from nesting in areas where flooding was a risk, and an alternative solution is needed to prevent nest loss in the future. However, beyond direct loss of nests, we found little evidence of other behavioural effects from one year of mining-induced flooding during the Arctic breeding season.

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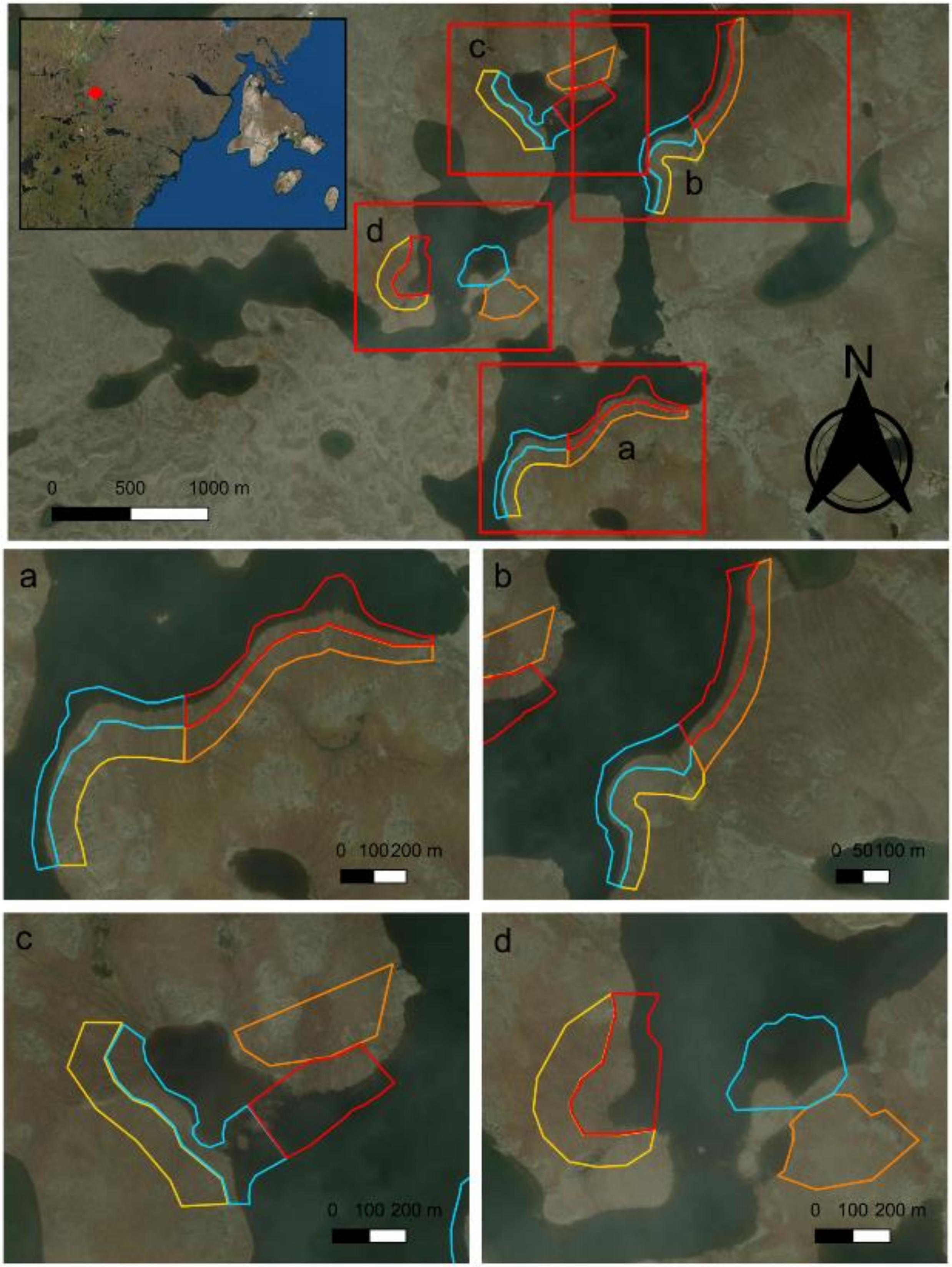

Figure 3.1: Map of the Whale Tail Lake study area, including Whale Tail Lake and surrounding lakes and tributaries, located at the Amaruq Mine site north of Baker Lake, Nunavut. Survey plots are grouped into clusters with four plots in each cluster. Red indicates plots within the flood area that had deterrents (ineffective; see text and Chapter 2), blue indicates plots in the flooded areas without deterrents, yellow and orange indicate plots outside of the flood zone (with no deterrents, control). The base map imagery is from 2019 and shows water levels that correspond to peak-flood in October 2019.

Figure 3.2: Photo taken of the active flooding where water is covering tundra / terrestrial area, occurring in the Whale Tail flood area (image is taken from within the plot shown in panel C, Figure 3.1), facing northeast toward Whale Tail Lake with Amaruq Mine site in the top left hand corner of the photo.

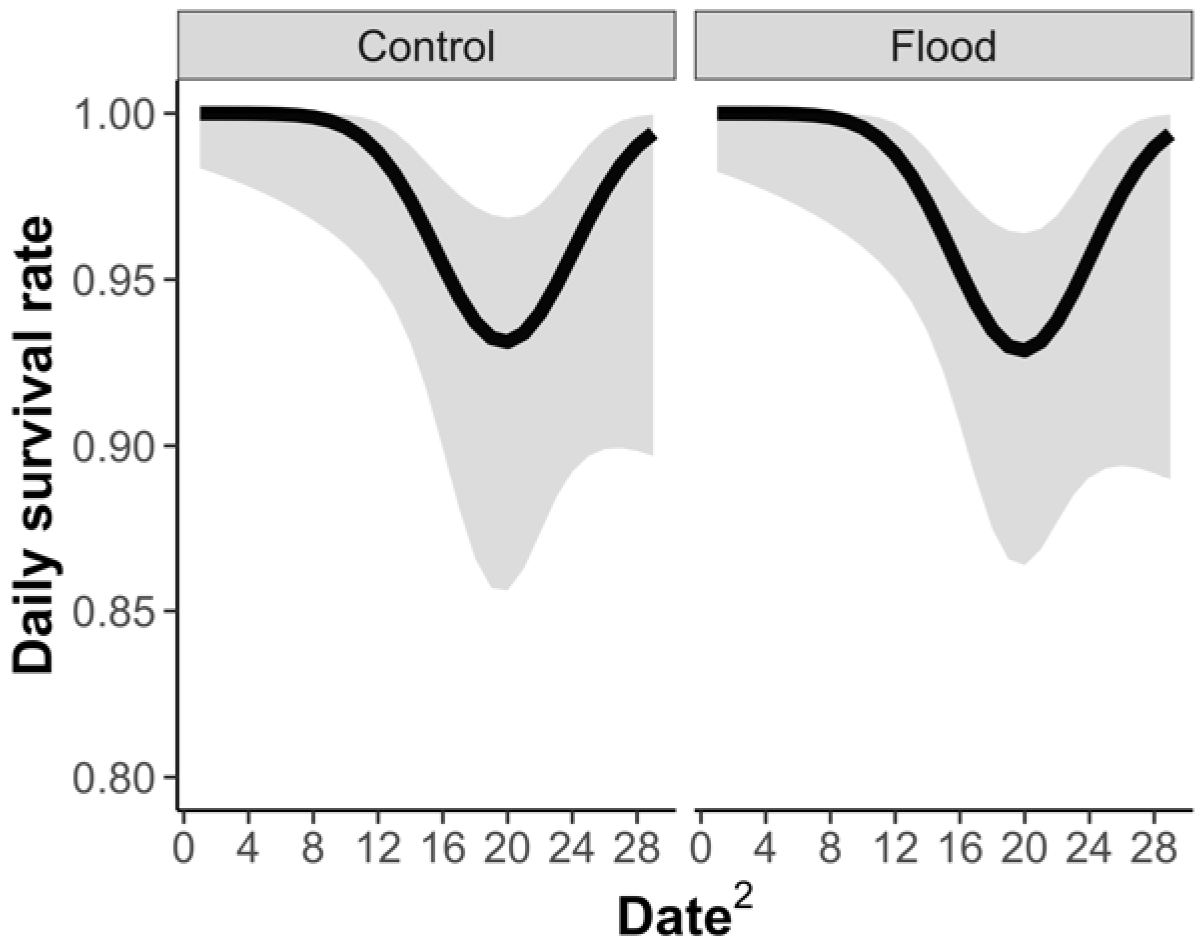

Figure 3.3: Estimate daily survival of passerines (*n* = 41; Lapland Longspur, *n* = 38; Horned Lark, *n* = 3) nests located within the Whale Tail Lake study area plots, depicting the difference in Daily Survival Rate between nests that experienced flooding and those that did not (control), during the 2019 breeding season. Date on the x-axis indicates the day and the month. Shaded areas indicate 95% CI.

Figure 3.4: Photo of a Lapland Longspur nest that failed due to flooding during the nesting season at Whale Tail Lake.

Figure 3.5: Photo of a Lapland Longspur incubating her nest as the water level rises (see red circle). This photo was taken during the second nest check (29 June), the water level is 12 cm from the nest. The nest is estimated to have failed due to active flooding between 1-3 July. This female Lapland Longspur was marked, and her second nesting attempt was found 127 m from this nesting location on 9 July.

Figure 3.6: Photo taken of WT2 site during the 2021 breeding season the second year after receding water levels caused by dewatering of Whale Tail Pit. Photo facing south toward the southern basin of Whale Tail Lake. The terrestrial area in the foreground (exposed green moss; *Spagnum* sp.) experienced flooding, while the area in the background (light coloured grasses) did not.

Table 3.1: Number of nests by species found within the predicted flood area of Whale Tail Lake in 2018 and the number of nests lost to active flooding (June – July) in 2019.

Species	**Number of nests found in 2018 in predicted flood zone (1.52 km^2)**	**Number of nests lost in 2019 in observed flood zone (0.16 km^2)**
Lapland Longspur	10	4
Semipalmated Sandpiper	4	1
Savannah Sparrow	3	0
Herring Gull	1	1
Northern Pintail	1	0
Total	19	6

Table 3.2: Model parameter estimates (± SE) and 95% confidence interval (95% CI) from the a logit-link model of daily survival rate of passerine nests (Lapland Longspur = 38; Horned Lark = 3) located in the Whale Tail study area, explained by temporal (date and date^2) and spatial (flood vs. control) covariates.

Model Variable	**Est ± SE**	**CI 95%**
Intercept	13.18 ± 4.64	4.09, 22.27
Flood	-0.04 ± 0.48	-0.98, 0.90
Date	**-1.12 ± 0.53**	**-2.16, -0.08**
Date^2	**0.03 ± 0.01**	**0.00, 0.06**

CHAPTER 4 — GENERAL CONCLUSION

Arctic-nesting birds exhibit unique life histories, migrating thousands of kilometres annually from their winter grounds in southern North America and South America to their summer breeding grounds in the Canadian Arctic, with many obstacles along the way (Hof et al. 2017). Despite this effort, their breeding season is short, providing them only two months to establish territories, build nests, incubate a clutch of eggs and raise their young. Due to the short breeding season, they commonly attempt only one brood per season and place their energy and time into its success. Therefore, arctic-nesting birds must be successful in their breeding season. Reproductive success is particularly pertinent as arctic-nesting birds, and specifically arctic-nesting shorebirds are declining (Andre et al. 2012).

My thesis examined the impact of mining, specifically flooding from the development of a pit mine, on arctic-nesting birds during the breeding season. Through my research, I aimed to provide insight into the use of deterrents as a method of preventing birds from nesting in high-risk areas. I also examined the behaviour of arctic-nesting birds when faced with flood-related nest loss during the breeding season.

In Chapter 2, I examined the efficacy of audio and visual deterrents that mimic predation risk as a means of preventing birds from nesting in areas of possible risk of nest loss through impending habitat loss. The study evaluated the effectiveness of deterrents by examining birds' nesting behaviour, changes in nest and territory densities, incubation behaviour and daily survival. Through my findings, we discovered that the deterrents, including audio predator and prey distress calls and visual deterrents such as flash tape and hawk effigies, were unsuccessful, despite previous studies claiming their success in other contexts (Ronconi et al. 2006; Marcus et al. 2007; McGowan et al. 2019). However, a study on deterrents of breeding birds has never been attempted in an Arctic environment, where birds experience shorter breeding seasons and exhibit different life-history strategies than those in previous studies (Klaassen et al. 2006).

It is conceivable that arctic-nesting birds are more tolerant of deterrents to continue their breeding season activities without interruption. Because deterrents only mimic predation, they pose no real threat to the parents' survival, and therefore with time, the birds may have learned to tolerate the flash tape and audio predator calls. There was some evidence showing that incubating Lapland Longspur nesting within plots with deterrents were somewhat disturbed by the deterrents. Birds that experienced deterrents were off the nest two times more often compared to birds nesting in control plots. However, this difference was only marginally statistically significant. Overall, deterrents were not sufficiently effective for birds to forgo a nesting attempt or abandon an already established nest. However, there was some evidence that Horned Lark were deterred by the flash tape, as densities of nesting Horned Lark decreased by 74% between years and treatments where flash tape deterrents were present (Table 2.5). Horned Larks occurred in very low densities on our study plots as they appear to have larger territories than Lapland Longspur. Thus, for plots with deterrents, the decrease in density reflected minimum loss of one breeding pair and while significant, this decline is unlikely to impact local populations. We were not able to determine whether Horned Lark densities were low because they were disturbed by the flash tape deterrents or whether their nests or territories happened, by chance, to be located outside the plots in the second year of my study.

Chapter 3 focused on the effects of mining-induced flooding on ground-nesting birds in the Arctic tundra. With the deterrents being unsuccessful, it was with great interest to determine the overall effect of mining-induced flooding on nesting birds. Before the flooding event, I observed nesting birds in the predicted flood zone to determine an average nest density. I predicted the number of nests lost due to active flooding in the next year. During flooding, I examined how active flooding impacted the change in nesting densities and how individuals behaved once they lost their nests due to flooding. As we predicted, nest densities increased as the flooding advanced along with the terrestrial areas of Whale Tail and its adjacent lakes and tributaries, albeit not substantially. There was also no significant difference in daily survival rate between nests located in plots within the predicted flood zone that experienced flooding compared to those in plots were outside the predicted flood zone and did not experience flooding. Return rates between years for banded birds were low, indicating that the Whale Tail Lake site sees individual turnover between breeding seasons. Additionally, renesting rates for birds that lost their nest due to flooding were also very low as only one of five birds renested after nest loss. Arctic-nesting birds are not likely to produce a second brood or attempt a second nest mid-season as it is not likely to be successful (Gates et al. 2013).

Significant cost and effort was put into designing and implementing the study and experiments to monitor nests faced with loss due to flooding and to understand if deterrents could minimize nest loss. The results of my research demonstrate that deterrents are an inadequate tool for mitigating nest loss of arctic-nesting birds. Also, the overall impact of mining-induced flooding on arctic-nesting birds was minimal during one season of flooding. Our results demonstrate that deterrents were likely not effective at deterring birds from nesting in possible at-risk areas and we do not recommend them for future use. However, future experimental studies regarding impacts of mining-induced flooding and the use of deterrent as mitigation would require multiple seasons of experimental testing to get a better idea of changes in densities and bird behaviours in the face of deterrent use and to account for variation in nesting bird densities between years. For example, between years in control plots during the experiment design on Amaruq Road, there was an increase of territory densities by 12% for all species in aggregate (Lapland Longspur, Horned Lark, Semipalmated Sandpiper, and Least Sandpiper, Table 2.2), demonstrating that even control plots could show variation in territory densities over many years that could impact the field experimental designs. However, if deterrents were still ineffective, mining companies' flooding schedules may need to be adapted to mitigate nest loss. For example, flooding could occur either before the breeding season (February - May) and post-breeding season (August to October) to avoid nest loss during the nesting period (June and July). Such accommodations may be challenging given natural variation in water levels related to spring melt, but there is value in attempting to protect arctic-nesting birds by preserving their nesting habitat and minimizing disturbance during the breeding season. Therefore, identifying mitigation approaches that simultaneously conserve vulnerable nesting habitat and allow for continued mining activities that produce jobs for northern communities are of great value.

We suggest assessing the overall impact of flooding on vegetation communities for future additional research, as we did not examine changes in tundra vegetation after flooding. Future research could assess whether the flood might have had an irreversible change to habitats used by arctic-nesting birds. This research could provide additional insight into the impacts of mining-induced flooding on arctic-nesting birds regarding habitat selection pre-and post-flooding impact as well as inform science about the resilience and potential recovery of arctic vegetation.

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