Appendix D: Compliance Monitoring Reports

APPENDIX D.6: HOPE BAY PROJECT: 2023 AQUATIC EFFECTS MONITORING PROGRAM – AQUATIC RESPONSE PLAN FOR PHYTOPLANKTON BIOMASS

Hope Bay Project

2023 Aquatic Effects Monitoring Program – Aquatic Response Plan for Phytoplankton Biomass

PREPARED FOR

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Hope Bay Project

2023 Aquatic Effects Monitoring Program – Aquatic Response Plan for Phytoplankton Biomass

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ACRONYMS AND ABBREVIATIONS

Term	Definition
AEMP	Aquatic Effects Monitoring Program
Agnico Eagle	Agnico Eagle Mines Ltd.
CCME	Canadian Council of Ministers of the Environment
Chl *a*	Chlorophyll *a*
the Plan	Hope Bay Aquatic Effects Monitoring Plan
the Project	Hope Bay Project

GLOSSARY

Term	Definition
Action level	The Response Framework includes three tiers of action levels: low, medium, and high. The low action level for each monitored component is based on baseline data, and/or water or sediment quality guidelines, and/or recommended critical effects sizes for that component.
Benthic invertebrates	Benthic invertebrate communities are a group of organisms that live associated with the bottom of lakes or streams. These communities contain a diverse assortment of organisms that have different mechanisms of feeding. Benthic invertebrates are an important food source for fish.
Biomass	The amount of living matter as measured on a weight or concentration basis. Biomass is an indication of the amount of food available for higher trophic levels. In the AEMP, phytoplankton biomass is estimated as chlorophyll *a.*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a 'proxy' estimate for plant biomass in aquatic studies.
Contact water	As defined in the *Hope Bay Project Doris and Madrid Water Management Plan* (Agnico Eagle 2022): "runoff in contact with waste rock, ore stockpiles, tailings and process water".
Mine water	As defined in the *Hope Bay Project Doris and Madrid Water Management Plan* (Agnico Eagle 2022): "water which enters the underground workings".
Non-Contact Water	As defined in the *Hope Bay Project Doris and Madrid Water Management Plan* (Agnico Eagle 2022): "undisturbed runoff, runoff from access roads, overburden piles, quarries, fuel facilities, and landfills".
Phytoplankton	Phytoplankton are microscopic primary producers that live free-floating in water. These organisms are single-celled algae that photosynthesize.
Seasons	When not specified, refers to winter (under-ice) and spring/summer/autumn (open water) conditions.
Secchi depth	Secchi depth is the depth at which a Secchi disk (standardized white and back disc) can no longer be seen when it is lowered into a lake. Secchi depth is be used to calculate the depth of the euphotic zone.
Treated Sewage water	As defined in the *Hope Bay Project Doris and Madrid Water Management Plan* (Agnico Eagle 2022)*:* "domestic sewage".

1. INTRODUCTION

The *Hope Bay Aquatic Effects Monitoring Plan* (the Plan) outlines the Response Framework (Section 4) which identifies low action level conditions, that when exceeded trigger a low action level response through the development of a Response Plan (TMAC 2018). The annual Aquatic Effects Monitoring Program (AEMP) results for the Hope Bay Project (the Project) provide the necessary data to identify potential exceedances and the need for a Response Plan.

As identified for the 2022 AEMP results, phytoplankton biomass (as measured by chlorophyll *a* [chl *a*]) in Doris Lake exceeded the low action level conditions which triggers a low action level response (ERM 2023). This *Aquatic Response Plan for Phytoplankton Biomass* has been developed in accordance with the Response Framework outlined in the Plan (TMAC 2018).

The primary objectives of this Response Plan, as derived from Section 4.5 of the Plan (TMAC 2018), are to:

1. provide general description about phytoplankton biomass (the monitoring variable),
2. determine or confirm the action level exceedance,
3. describe the most likely cause(s) of the exceedance (observed increase in phytoplankton biomass in Doris Lake),
4. describe the ecological consequences of the exceedance (with the current level of phytoplankton biomass in Doris Lake), and
5. propose response actions and a schedule to address the observed increase if applicable, including the setting of medium action levels (and high action levels if appropriate).

1.1 BACKGROUND

Through the regulatory review process for the 2022 AEMP Annual Report (ERM 2023), the result for phytoplankton biomass (as chl *a*) in Doris Lake was retroactively determined to exceed the low action level conditions as defined in the Plan (TMAC 2018). The 2022 AEMP Annual Report did not identify a trigger for a low action level response because it was concluded by professional judgement that the phytoplankton biomass in 2022 appeared within the range of natural variation for Doris Lake and there was no clear Project-related mechanism to cause an increase (ERM 2023). Through the regulatory review process for the Nunavut Impact Review Board 2022 Annual Report, a comment (KIA-NIRB-14) indicated that it was unclear if a Response Plan was required if the conditions of a low action level were met or whether the defined conditions are merely "*necessary conditions, and the determination as to whether a low action level exceedance has occurred is subject to additional considerations and professional judgement"* (KIA 2023). The text of the action level condition definitions, as outlined in the Plan (TMAC 2018), does not clearly identify how additional considerations, such as best professional judgment or evidence of a causal Project-related mechanism, could influence the trigger of a low action level. An outcome of the 2022 Annual AEMP Report review, was the completion of an *Aquatic Response Plan for Phytoplankton Biomass* as part of the 2023 AEMP annual reporting (Agnico Eagle 2023).

This Response Plan is inclusive to the 2022 low action level response trigger, the 2023 AEMP results were available at the time of writing and are therefore provided as supplemental information.

2. DESCRIPTION OF MONITORING VARIABLE

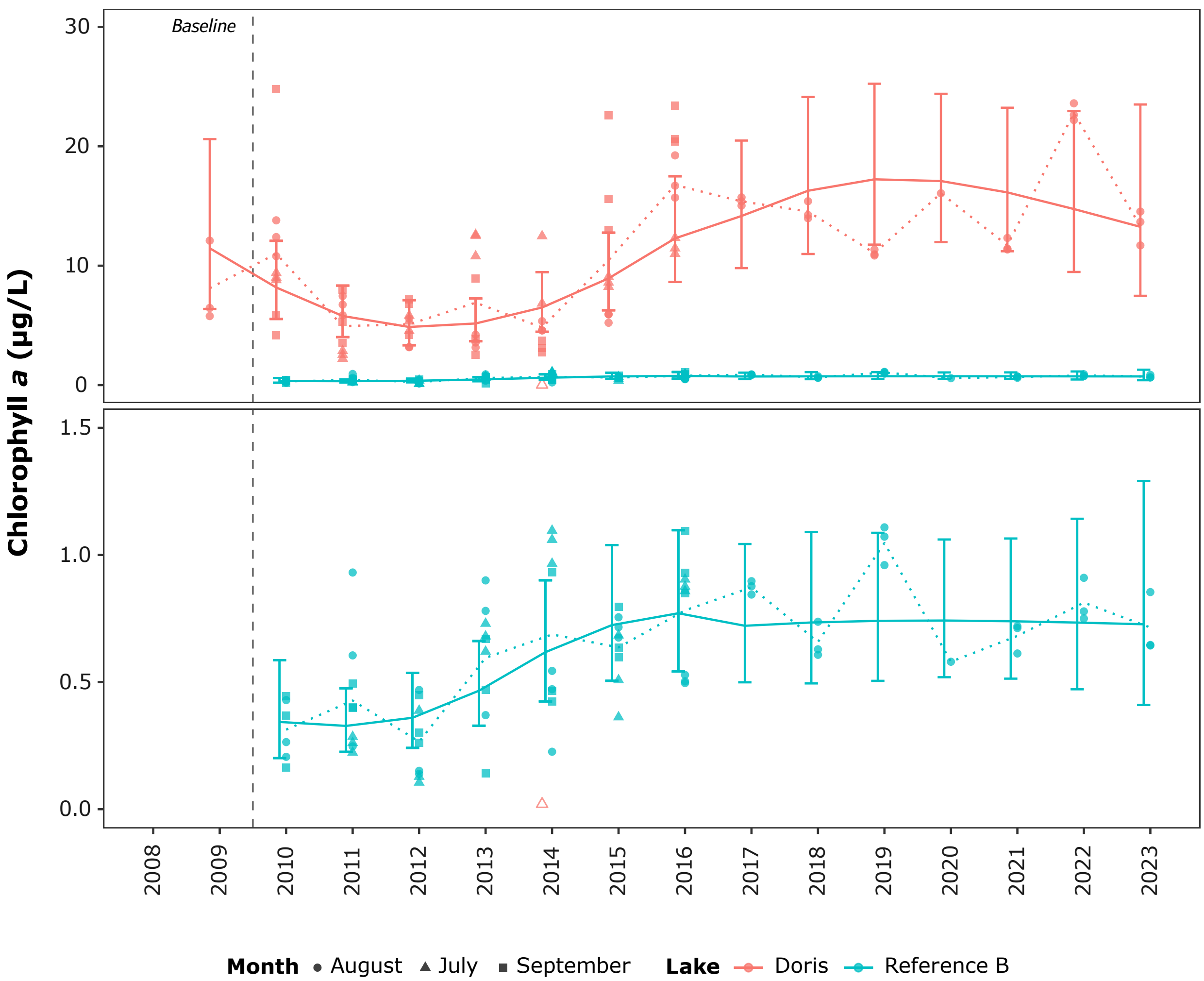
Phytoplankton are microscopic organisms residing in the water column of any aquatic environment (e.g., lakes, rivers, oceans); phytoplankton are single and small-cell colonies that rely on nutrients from the water column and light for growth (Carpenter et al. 1985; Wetzel 2001). Phytoplankton are primary producers and through the process of photosynthesis, which uses energy from sunlight to convert carbon dioxide into simple sugars and oxygen. Phytoplankton are often the dominant primary producers in lakes and contribute to the base of the aquatic food web as food for other aquatic communities (e.g., zooplankton, benthos, and planktivorous fish). Phytoplankton are primarily regulated by 1) the availability of light, 2) elemental nutrients (primarily phosphorus and nitrogen) and 3) temperature (Sterner and Elser 2002; Wetzel 2001). Throughout the open-water season, phytoplankton may also be regulated by biotic factors such as grazing by zooplankton and small fish (Carpenter et al. 1985; Adams et al. 2022).

Phytoplankton are useful indicators of change because they have rapid generation times and are sensitive to environmental change (i.e., physical, chemical, and biological stressors). Phytoplankton biomass levels are monitored using the concentration of the main photosynthetic pigment, chl *a,* as an indicator.

Phytoplankton biomass, as measured by chl *a* concentration, is monitored concurrently with water and sediment quality in the AEMP lakes to evaluate changes in the trophic status of the exposure lakes which could be affected by potential Project-related nutrient inputs either from a point-source (e.g., effluent discharge) or non-point-source (e.g., runoff). Chlorophyll *a* concentrations are measured in August at the monitored Project lakes when primary production is expected to be at, or near, maximum levels because light availability and water temperatures during the open-water season promote higher rates of primary productivity than during the under-ice season.

As indicated in the 2023 AEMP Annual Report (ERM 2024), phytoplankton biomass has changed over time in Doris Lake. Relative to the mean baseline (2009) and initial (2010) monitoring chl *a* concentrations (8.11 and 11.01 µg/L, respectively), phytoplankton biomass initially decreased from 2011 to 2014 (range of 4.94 to 6.91 µg/L; Figure 2-1). The mean chl *a* concentration then increased between 2014 and 2016 (from 5.43 to 16.76 µg/L) and has been generally greater than baseline and early monitoring mean concentrations (2009 to 2014) since 2016, ranging from 11.05 to 22.81 µg/L. The mean chl *a* concentration in 2022 (22.81 µg/L) was elevated relative to the mean observations throughout the monitoring period (4.94 to 16.76 µg/L) however the observed concentrations in 2022 did not continue. The mean chl *a* concentration measured in 2023 (13.30 µg/L) decreased relative to the 2022 observation.

FIGURE 2-1 PHYTOPLANKTON BIOMASS IN DORIS LAKE AND REFERENCE LAKE B, HOPE BAY AEMP, 2009 TO 2023



Notes: Symbols represent observed data values.
Observations less than the detection limit are shown by hollow symbols and plotted at half the detection limit.
Dotted lines connect the annual observed means.
Solid lines represent the the annual fitted mean and the error bars are the 95% confidence intervals of the fitted means as per the 2023 AEMP results (ERM 2024).

3. CONFIRMATION OF THE ACTION LEVEL EXCEEDANCE

As described in Section 4.4.3 of the Plan (TMAC 2018), a low action level is exceeded for phytoplankton biomass (as measured by chl *a*) when all the following conditions are met:

1. identification of a statistically significant change from baseline conditions when assessing the results of the AEMP for chl *a*;
2. the concentration of chl *a* is outside of the normal range based on baseline concentrations; and
3. the absence of a similar change at the reference location.

The AEMP evaluation of effects used a trend analysis to detect a change in phytoplankton biomass over time and compared to the reference lake, in Doris Lake (TMAC 2018). Comparison to baseline concentrations for phytoplankton biomass included the mean concentration from the current year compared to the range of observations from the baseline period. For the second (2) condition which compares to the normal range based on baseline data, it is noted that there is only one year of baseline data for Doris Lake and consequently the normal range of chl *a* concentration available for Doris Lake is based on triplicate samples collected from a single sampling event in 2009. Therefore, conclusions from comparisons with only this baseline data must be interpreted with caution.

In 2022 a low action level response was triggered for phytoplankton biomass in Doris Lake because:

1. based on the results of the AEMP evaluation of effects there was a statistically significant change over time;
2. the observed chl *a* concentration in 2022 (mean = 22.81 µg/L) was greater than the observed range during the baseline year (i.e., 2009; 5.78 to 12.10 µg/L; Figure 2-1); and
3. the change was greater than the trend in Reference Lake B (ERM 2023).

4. RESPONSE ACTIONS

This Response Plan has been developed following a phytoplankton biomass exceedance of a low action level observed during the 2022 AEMP monitoring for Doris Lake. As outlined in the Plan (TMAC 2018), monitoring and management response actions for a low action level Response Plan may include:

- an investigation to verify the source(s) of observed change;
- a comparison to predictions made in the 2017 Final Environmental Impact Statement (TMAC 2017);
- the evaluation or confirmation of ecological relevance;
- increased monitoring frequency;
- the planning or initiation of an issue-specific information collection program or study to define the magnitude, spatial extent, and reversibility of the effect; or
- the identification of possible mitigation options.

If a likely cause can be identified, management responses for a low action level may include updates to best management practices or standard operating procedures to improve the mitigation or avoidance of the Project-related effect.

Comparison to the 2017 Final Environment Impact Statement predictions for phytoplankton biomass is not applicable as chl *a* concentrations or Doris Lake, were not directly assessed (TMAC 2017).

4.1 REVIEW OF POTENTIAL CAUSE(S) OF ACTION LEVEL EXCEEDANCE

The following sub-sections outline the evidence of potential Project-related and natural factors that may have resulted in the action level exceedance for phytoplankton biomass in Doris Lake.

4.1.1 PROJECT-RELATED FACTORS

Phytoplankton biomass is primarily controlled by environmental factors such as light/solar radiation, nutrient availability, water temperature, and hydrological conditions (Lewis 2011). Project-related effects to phytoplankton biomass would be manifested through changes to the nutrient availability, water temperature, or hydrological regime as the Project would not have influence on light/solar radiation availability.

Doris Lake does not receive Project-related point-source influences such as discharge of effluent (i.e., mine water [water from underground], treated sewage water, or contact water [runoff in contact with waste rock, ore stockpiles, tailings and process water]) from Project activities. However, Doris Lake is adjacent to the Doris Camp development and constructed roads, and is monitored in the AEMP to assess for potential non-point-source aquatic effects related to the Project (TMAC 2018). The potential pathways for Project-related non-point-source influence to Doris Lake, include groundwater mine inflows, non-contact water runoff (undisturbed runoff, runoff from access roads, overburden piles, quarries, fuel facilities, and landfills), fugitive dust, and water level drawdown.

However, the 2022 and 2023 AEMP results did not detect changes over time through statistical analyses and/or compared to baseline and did not indicate evidence of a Project-related effect for nutrient concentrations (i.e., nitrite, nitrate, and total phosphorus), water temperature, or water level in Doris Lake (ERM 2023, 2024).

4.1.2 NATURAL FACTORS

The scope of the AEMP does not monitor every potential factor affecting phytoplankton growth and annual sampling is limited to one sampling event during the under-ice and open-water season. However, phytoplankton biomass can vary greatly within a lake, within a season, and across years based on the many environmental factors that regulate with their growth (Lewis 2011).

Although there were no detected Project-related effects for nutrients (i.e., nitrite, nitrate, and total phosphorus) in 2022 and 2023 (ERM 2023, 2024), natural variation in nutrients may partially account for changes in phytoplankton biomass. Open-water total phosphorus observations in 2022 (0.0301 to 0.0367 mg/L) were within the observed baseline range (2004 to 2009; 0.018 to 0.051 mg/L). However, relative to the baseline year that aligns with chl *a* (2009; mean total phosphorus = 0.0191 mg/L), the mean total phosphorus was slightly higher in 2022 (1.76-times; 0.0336 mg/L). In 2023, the chl *a* concentrations and the total phosphorus concentrations decreased relative to the 2022 (chl *a* = 13.30 μg/L and total phosphorus = 0.0295 mg/L). Thus, natural variation in the total phosphorus concentrations may partially influence the observed phytoplankton biomass trends.

Arctic and sub-Arctic ecosystems are experiencing the effects of climate change at an accelerating rate, and for many Arctic lakes small changes in the physical, chemical, or biological environment can result in substantial changes to the aquatic ecosystem (Šmejkalová et al. 2016; Vincent et al. 2008). Various environmental factors which affect phytoplankton growth are experiencing climate-driven changes in the Canadian northern region, which may result in changes in phytoplankton biomass outside of Project-related effects. One example is changing ice phenology (i.e., timing of the seasonal freeze-up to ice-out cycle) in Arctic and sub-Arctic environments. Phytoplankton dynamics are connected to ice thickness and cover, which influences water temperature and nutrient availability, but most importantly light availability (Hodgson and Smol 2008). The 'ice-out' events (i.e., ice break-up to open-water conditions) for ice-covered Arctic lakes has been trending earlier in the spring season, compounded with delays in freeze up during fall season, which results in earlier exposure to warmer temperatures and increased light availability for phytoplankton productivity. In brief, phytoplankton in lakes in the Project area are experiencing a longer growing season and potentially increasing annual net primary productivity (Adams et al. 2022; Benson et al. 2012; Forsström et al. 2005; Šmejkalová et al. 2016). Furthermore, lakes of higher trophic status, for example eutrophic Doris Lake compared to ultra-oligotrophic Reference Lake B, are considered more sensitive to changes in surface solar radiation than lakes of lower trophic status during the spring growing period (Adams et al. 2022). The AEMP does not measure under-ice light penetration, the timing and duration of open-water, or potential spatial variation in the monitored lakes. Trends over time between lakes could also vary due to differences in lake morphology, hydrological regime, catchment size, as well as seasonal and annual variations in sources of nutrients, sediments, or organic matter related to runoff of the natural landscape, natural erosion and weathering patterns, as well as permafrost degradation. These changes may not necessarily affect all lakes in a region equally.

Furthermore, the annual mean chl *a* concentrations in Reference Lake B have also increased over time (Figure 2-1). Specifically, chl *a* concentrations in Reference Lake B increased from a mean of 0.31 to 0.60 µg/L from 2010 to 2013 and consistently exceeded 0.58 µg/L from 2014 to 2023. Although the absolute mean concentrations of chl *a* in Doris Lake (4.94 to 22.81 µg/L) have been greater than observed in Reference Lake B (0.27 to 1.05 µg/L) since monitoring began, similar increases in chl *a* were observed in both lakes as the mean chl *a* concentration increased by an approximate factor of three between 2012 and 2016. Chlorophyll *a* concentration increased in Reference Lake B by a factor of 2.94 compared to a factor of 3.29 for Doris Lake. Additionally, during the baseline period (2009 to 2018) for another exposure lake upstream in Doris Watershed (i.e., Patch Lake), chl *a* concentration increased by a factor of 2.13 (0.43 to 0.91 µg/L). Consistently higher chl *a* concentrations in both the exposure and reference lakes in recent years suggest regional factors may have influenced phytoplankton biomass throughout the monitoring period in the Project area.

As inter-annual chl *a* concentrations can vary substantially across years based on the regional and hydrological conditions (Lewis 2011), the one year of baseline data available for Doris Lake is limited in providing robust quantitative comparisons. For example, in Reference Lake B the mean chl *a* concentrations has varied by 394% over the monitoring period (0.27 to 1.05 µg/L; 2010 to 2023). In 2022, the mean chl *a* concentration (22.81 µg/L) in Doris Lake exceeded the maximum baseline observation (12.10 µg/L) by 89%; however the 2023 the mean concentration (13.30 µg/L) exceeded the maximum baseline concentration by only 10%. As climate change continues to increase temperatures and alter ice phenology (Rantanen et al. 2022; Šmejkalová et al. 2016), observed chl *a* concentrations over time in exposure and reference lakes may exceed normal ranges defined more than 10 years ago.

4.1.3 SUMMARY

The 2022 and 2023 AEMPs did not detect statistical changes over time or evidence of Project-related effects for nutrient concentrations, water temperature, or water level along with the observed increase in phytoplankton biomass in Doris Lake (ERM 2023, 2024). However, it is known that Arctic and sub-Arctic ecosystems are experiencing the effects of climate change at an accelerating rate and changes in temperature and ice-phenology may be influencing phytoplankton dynamics throughout the open-water season in lakes around the Project area, including Doris Lake (Šmejkalová et al. 2016; Vincent et al. 2008). The overall increases in phytoplankton biomass throughout the monitoring period (2009 to 2023) that have been observed in the reference lake and throughout the baseline period of another exposure lake suggest that regional factors may be influencing chl *a* concentrations in the Project area. Thus, the increase in phytoplankton biomass is considered to be due to natural variability and/or regional non-Project-related factors.

4.2 REVIEW OF ECOLOGICAL IMPLICATIONS OF ACTION LEVEL EXCEEDANCE

A significance threshold is "*a limit of environmental change which, if reached, would likely result in significant adverse impacts*" (MVLWB 2019). As defined in the Plan, the significance threshold for water quality, sediment quality, and/or phytoplankton biomass is: "*the water, sediments,* *and/or phytoplankton biomass of the monitored lakes have changed in such a way that a healthy aquatic ecosystem can no longer be supported*" (TMAC 2018).

For phytoplankton biomass, adverse ecological implications may arise from a decrease or increase in phytoplankton biomass. Phytoplankton growth inhibition, through natural phenomenon or in response to a toxic contaminate, may resulting in lower phytoplankton biomass and a reduction in the quantity of food available to higher aquatic organisms (i.e., zooplankton, benthos, planktivorous fish). Conversely, an increase in phytoplankton biomass may result in an increase in the quantity of food available to higher aquatic organisms (i.e., zooplankton, benthos, planktivorous fish). However, with increased phytoplankton biomass, there is potential for adverse effects if Doris Lake reaches a 'hyper-eutrophic' state.

Three parameters, chl *a*, total phosphorus, and Secchi depth (i.e., water transparency) are commonly assessed to determine the 'trophic state' of a lake as they are typically correlated with productivity of aquatics systems. Trophic state is a classification to systematically describe the productivity of lake based on observed conditions relative to empirically and/or modelled defined ranges of the particular parameter of interest. Chlorophyll *a* concentration is regarded as the most accurate predictor of trophic state (Carlson 1977). A scientifically accepted trophic classification was developed by Vollenweider and Kerekes (1982) and cited in the Canadian Guidance Framework for the Management of Phosphorus (Environment Canada 2004; Table 1.4-1). Based on the available 2009 baseline data for chl *a* concentrations, Doris Lake was classified at the boundary of meso-eutrophic to eutrophic (Table 1.4-2). The same meso-eutrophic to eutrophic classification based on the mean and maximum chl *a* concentration was observed in 2022, as well as in 2023. This suggests that the observed change in chl *a* concentration has not resulted in change in the overall trophic state of Doris Lake and the observed range on chl *a* may be within the natural range for Doris Lake.

TABLE 1.4-1 TROPHIC CLASSIFICATION OF LAKES, WITH CORRESPONDING TOTAL PHOSPHORUS AND CHL *A* CONCENTRATIONS

Variable:	**Total Phosphorus (mg/L)**		**Mean Chl *a* (µg/L)**	**Max Chl *a* (µg/L)**
Source:	**Wetzel (2001)**	**Vollenweider and Kerekes (1982)**	**Vollenweider and Kerekes (1982)**	
Trophic Level				
Ultra-oligotrophic	< 0.005	< 0.004	< 1	< 2.5
Oligo-mesotrophic	0.005 to 0.010	0.004 to 0.010	< 2.5	< 8
Meso-eutrophic	0.010 to 0.030	0.010 to 0.035	2.5 to 8.0	8.0 to 25
Eutrophic	0.030 to 0.100	0.035 to 0.100	8.0 to 25	25 to 75
Hypereutrophic	> 0.100	> 0.100	> 25	> 75

Source: Environment Canada (2004)

TABLE 1.4-2 CHL *A* CONCENTRATIONS AND TROPHIC CLASSIFICATION OF DORIS LAKE FOR BASELINE, 2022, AND 2023

Period/Year	Mean (µg/L)	Max (µg/L)	Trophic Classification based on Vollenweider and Kerekes (1982) in Table 1.4-1
Baseline (2009)	8.11	12.10	meso-eutrophic to eutrophic
2022	22.81	23.60	meso-eutrophic to eutrophic
2023	13.30	14.53	meso-eutrophic to eutrophic

As a lake becomes hyper-eutrophic, adverse effects are evident in parameters such as declines in dissolved oxygen levels (at depth and under-ice) as well as decreased water clarity, increases in total organic carbon deposits to sediment, and subsequent changes in the benthic community more suited to these conditions (Wetzel 2001).

Phytoplankton biomass is connected to dissolved oxygen concentrations through the increased supply of organic carbon which increases microbial respiration, and results in a decrease in the concentration of dissolved oxygen. Lower dissolved oxygen concentrations could adversely affect other aquatic organisms (e.g., fish) health and/or survival if concentrations decreased below the Canadian Council of Ministers of the Environment (CCME) guideline for aquatic life (i.e., 6.5 mg/L; CCME 1999). However, dissolved oxygen in Doris Lake during both the under-ice and open-water seasons in 2022 and 2023 were similar to, or greater than, the baseline observations (ERM 2023, 2024). While under-ice dissolved oxygen was less than the CCME guideline of 6.5 mg/L near the lakebed in 2022 and 2023 (i.e., at depths >13 m and >14 m, respectively), low dissolved oxygen concentrations at depth were similarly observed during the baseline years in Doris Lake and is commonly observed in ice-covered lakes (Clilverd et al. 2009; Top et al. 1985), including in the Project area (Rescan 2010). During the open-water seasons, dissolved oxygen in Doris Lake was greater than the CCME guideline for all early life stages of 9.5 mg/L throughout the water column in 2022 and 2023, indicating that there is no co-occurring change indicating an adverse eutrophication impact in Doris Lake.

Secchi depth, a measure of water transparency, is monitored in the AEMP but not assessed in the evaluation of effects (TMAC 2018). Overall, Secchi depth measurements have not closely followed trends in chl *a* concentrations throughout the monitoring period. For example, from 2011 to 2014 when observed chl *a* concentrations were relatively low, Secchi depth was near the minimum of the observed range (i.e., 1 m; ERM 2017), and a similar Secchi depth was measured in 2022 (0.95 m; ERM 2023) when chl *a* concentrations were at the upper limit of the observed range.

Sediment total organic carbon increases with advancing eutrophication through the increased annual deposition of organic matter as a result of the increased water column productivity (i.e., phytoplankton biomass stock; Fiskal et al. 2019). Sediment quality is monitored and assessed every three years in the AEMP and sediment quality was last monitored in 2022 (TMAC 2018). Organic carbon in sediments is monitored but not assessed through the AEMP, a comparison of the observed total organic carbon in 2022 (3.2 %) indicated that total organic carbon was similar to the baseline (2009) observations (2.9 %; Rescan 2010; ERM 2023).

Benthic invertebrates are also assessed in the AEMP (TMAC 2018). An increase was observed in benthic invertebrate density in Doris Lake between baseline (i.e., 2009) and 2014 with mean values of 607 organisms/m^2 and 4,353 organisms/m^2, respectively (ERM 2023). The *Aquatic Response Plan for Benthos Density* (ERM 2018) indicated the increase in total density was not an adverse change and there was no evident Project-related mechanism for the observed increase (ERM 2018). Benthic invertebrate density was last assessed in the 2022 AEMP and while 2014 densities were elevated compared to the single year of baseline observations (2009), those densities have not increased further and had no consistent directional trend across years (ERM 2023). For lake benthos communities at depth, both biomass and community structure can change in response to eutrophication factors. Benthos biomass has been found to increase non-linearly with increasing chl *a* concentration or total phosphorus in lakes (Rasmussen and Kalff 1987). Decreases in benthos biomass at higher concentrations of chl *a* are likely related to higher deposition of organic matter and signals advancing eutrophication such as decreases in hypolimnetic oxygen (Pilotto et al. 2012; Rasmussen and Kalff 1987). Benthos community structures also respond, through shifts from taxa sensitive to low dissolved oxygen condition to hypoxia-tolerant taxa (Pilotto et al. 2012; Wolfram et al. 2002). The increase in benthic invertebrate density was not considered an adverse ecological change because it increased in food availability for the fish in Doris Lake (e.g., Lake Whitefish and young Lake Trout; Rescan 2011) and there was no discernable change in the community metrics assessed (i.e., family richness, evenness, and diversity; ERM 2018).

In summary, the observed phytoplankton biomass in 2022 in Doris Lake is not considered as an adverse change to the aquatic ecosystem and there is no indication that Doris Lake has approached the significance threshold and "*changed in such a way that a healthy aquatic ecosystem can no longer be supported"* (TMAC 2018). The observed change in phytoplankton biomass from baseline observations did not occur concurrently with other signals of eutrophication measured in the AEMP (i.e., increased nutrient concentrations, increased organic matter deposition in sediments, changes in benthic invertebrate community) or indicators of an adverse effects such as a decrease in dissolved oxygen concentrations in Doris Lake. Overall, the estimated ecological implication of the increase observed in phytoplankton biomass and benthos density over time may be beneficial through additional food sources for fish and other aquatic invertebrates.

4.3 PROPOSED RESPONSE ACTIONS

Based on the review of the potential causes, the low action level exceedances for phytoplankton biomass observed in Doris Lake were considered to be due to natural variability and/or regional non-Project-related factors as there was no evidence to indicate the change was due to Project-related effects (Section 1.3). In addition, the environmental implication of the low action level exceedances for phytoplankton biomass in Doris Lake in 2022 is not considered to be adverse and there is no evidence to suggest that Doris Lake is approaching the significance threshold where phytoplankton biomass has *"changed in such a way that a healthy aquatic ecosystem can no longer be supported"* (TMAC 2018) and the trophic status of Doris Lake has not changed compared to the baseline conditions (based on the observed chl *a* concentrations and a scientifically accepted trophic classification (Vollenweider and Kerekes 1982; Section 1.4).

Phytoplankton biomass will continue to be monitored annually through the AEMP to assess if the trophic status of Doris Lake remains consistent and confirm if the observed changes in phytoplankton biomass stabilize, are inconsistent, or continue to increase. The results of the AEMP indicate a statistical change over time and Doris Lake phytoplankton biomass has had a non-linear change throughout the monitoring period and mean chl *a* concentrations have fluctuated slightly above and below the upper limit of the defined 'normal' baseline range since 2018 (Figure 2-1). Therefore, for phytoplankton biomass when the current year's mean chl *a* concentration is outside of the normal range based on the baseline observations, a supplemental statistical test (two-tailed t-test) will be used in the AEMP to confirm the first (1) condition that the current years mean is statistically different from the baseline mean.

Total phosphorus will continue to be evaluated in the AEMP as a supplemental variable to interpret its potential influence on phytoplankton biomass.

Additionally, potential Project-related effects for variables that may influence phytoplankton biomass dynamic (i.e., nutrient concentrations, water temperature, and water level) will continue to be assessed through the annual AEMP, and any increase related to the Project would be managed through the Response Framework as outlined in the Plan (TMAC 2018).

4.4 DEFINITION OF MEDIUM AND HIGH ACTION LEVELS

The Response Framework outlines low action level conditions and indicates that medium and high action levels, if appropriate, would be determined through the development of a Response Plan (TMAC 2018). Medium and high action level conditions and proposed actions would correspond to increasing magnitude of potential risk for potential, adverse, Project-related effects to the aquatic environment.

4.4.1 MEDIUM ACTION LEVEL

The medium action level specifies the conditions relating to an increased risk of exceedance of significance thresholds, in the context of a potential Project-related effect, compared to the low action level.

Since the observed action level exceedance is applicable to an increase in Doris Lake, the medium action level conditions outlined are specific to increases in phytoplankton biomass for Doris Lake. For example, if a phytoplankton biomass low action level is exceeded in response to a change observed in Patch Lake, the appropriate medium action levels conditions specific to Patch Lake would be developed at that time. If a phytoplankton biomass low action level is exceeded in response to a decrease in biomass in an exposure lake, appropriate medium action levels specific to a decrease would be developed as required.

The conditions that would trigger a medium action level for phytoplankton biomass in Doris Lake are defined as follows:

1. The low action level has been triggered for three (3) consecutive years;
2. A low action level was exceeded due a Project-related, or suspected Project-related, increase in phytoplankton biomass; and

3. Based on the Vollenweider and Kerekes (1982) trophic classification from the baseline period for Doris Lake (eutrophic), the chl *a* concentrations do not exceed 75% of the concentration for the next higher trophic classification (hyper-eutrophic). That is:
    a. the mean chl *a* concentration exceeds 75% of the upper limit of the mean concentration range (18.75 µg/L) for two consecutive years; or
    b. the maximum chl *a* concentration from two or more samples exceeds 75% of the upper limit of the maximum concentration range for a eutrophic lake (56.25 µg/L).

4.4.2 HIGH ACTION LEVEL

High action level conditions have not been defined at this time as the observed low action level exceedances are considered to be due to natural variability and/or regional non-Project-related factors (Section 4.1) and not considered to of adverse ecological implication (Section 4.2). Definition of high action level conditions may be considered through the update of this Response Plan following a medium action level response.

5. SCHEDULE AND RECOMMENDED NEXT STEPS

Phytoplankton biomass in Doris Lake and the reference lake will continue to be monitored through annual AEMP sampling and reporting.

In the case of a similar low action level exceedance for phytoplankton biomass in Doris Lake, where the low action level conditions are met but there is no evidence of a Project-related effect, no concurrent effects detected for AEMP parameters that primarily influence chl *a* concentrations (i.e., nutrient water quality parameters or temperature profiles), and no effects detected for parameters that may indicate an adverse change due to eutrophication (i.e., dissolved oxygen); an update to this Response Plan is not required and the low action level exceedance will be documented in the AEMP Annual Report.

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