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Staff Report

Applicant: Northwest Territories Power Corporation	
Location: Jackfish Facility	**File Number:** MV2019L1-0001
Date Prepared: September 14, 2020	**Date of Board Meeting:** October 8, 2020
Subject: Thermal Plume Delineation Study Design	

1. Purpose

The purpose of this Report is to present to the Mackenzie Valley Land and Water Board (MVLWB/the Board) the Thermal Plume Delineation Study Design (Design) submitted by Northwest Territories Power Corporation (NTPC) to satisfy Part E, condition 4 (Schedule 2, condition 1)of Water Licence (Licence) MV2019L1-0001.

2. Background

- October 18, 2019 – Issuance of Licence MV2019L1-0001;
- July 16, 2020 – Thermal Plume Delineation Study Design received;
- July 17, 2020 – Thermal Plume Delineation Study Design deemed complete and review commenced;
- August 31, 2020 – Reviewer comments and recommendations due and received;
- August 14, 2020 – Proponent responses due and received;
- **October 8, 2020 – Thermal Plume Delineation Study Design presented to the Board for decision; and**
- October 17, 2044 – Expiration of Licence MV2019L1-0001.

3. Discussion

During the initial review of the Application, Environment and Climate Change Canada (ECCC) recommended that NTPC provide information relating to the details of facility discharge management (e.g., discharge method(s), rates, volumes, frequency, duration, locations), identification of mitigations currently in place to minimize the effects of thermal discharges on the aquatic receiving environment, as well as identify potential mitigation options to further minimize the effects of thermal discharges on the aquatic receiving environment

During the May 2, 2019 Technical Session, ECCC requested additional information relating to the aquatic habitat types in the vicinity of the discharges and potential thermal-related effects on fish. NTPC indicated that the information was not available at the time of the Application, that baseline work had begun, and that they would be open to completing a further study to gather the additional information.

An assessment of aquatic habitat within the thermal plume zone was included as a requirement under Schedule 2, condition 1.

Part E: Conditions Applying to Waste and Water Management – condition 4 states:

A minimum of 90 days following the effective date of this Licence, a Thermal Plume Delineation Study Design Plan. The Plan shall be in accordance with the requirements of Schedule 2, condition 1 and shall be submitted to the Board for approval.

Schedule 2, condition 1 states:
The Thermal Plume Delineation Study Design Plan referred to in Part E, condition 4 of this Licence shall include, but not be limited to, the following:

a) Seasonal delineation (spring freshet, late summer, late fall, and late under ice) of the thermal plume., include a calculation of maximum extent of plume as a percentage of lake area;
b) Temperature, dissolved oxygen profiles and any other parameters deemed relevant to the understanding of the thermal plume and the lake stratification.
c) As assessment of aquatic habitat within the thermal plume zone(s); and
d) Seasonal chemical characterization at a minimum of one station location outside of the potential plume but situated such that potential influence of inflow(s) can be characterized and one station located at or near the outflow of Jackfish Lake. Station locations and rational to be included.

The information that is to be gathered through the Thermal Plume Delineation Study will inform the Aquatic Effects Monitoring Design Plan.

On June 16, 2020 the Board approved a request submitted by NTPC to change the submission dates of various plans including the Thermal Plume Delineation Study Design, Thermal Plume Delineation Study Report, and the AEMP Design Plan. The dates were changed to allow for additional work to be completed on the Thermal Plume Delineation Study Design because the noted plans are interconnected.

On July 16, 2020, NTPC submitted the Thermal Plume Delineation Study Design in accordance with Licence MV2019L1-0001. The Thermal Plume Delineation Study Design was sent for review and comment on July 17, 2020.

4. Comments

Not applicable.

5. Public Review

By July 31, 2020, comments and recommendations on the Design were received from four reviewers:

- Environment and Climate Change Canada;
- Government of the Northwest Territories – Environment and Natural Resources (Environmental Assessment and Monitoring);
- Mackenzie Valley Land and Water Board Staff; and
- Tłı̨chǫ Government.

NTPC responded by August 14, 2020. The Review Summary and Attachments (attached) presents the concerns identified through this review.

Table 1: Design Completeness

	Components of the Design as required in Part E, condition 4 of the Licence	Where component of Design addressed	Board staff analysis of the adequacy of the Design in addressing the component
a)	Seasonal delineation (spring freshet, late summer, late fall, and late under ice) of the thermal plume., include a calculation of maximum extent of plume as a percentage of lake area	Sections 3.0, 4.1, 5.1, 6.1	Adequate
b)	Temperature, dissolved oxygen profiles and any other parameters deemed relevant to the understanding of the thermal plume and the lake stratification	Sections 3.0, 4.2, 5.2, 6.2	Adequate
c)	As assessment of aquatic habitat within the thermal plume zone(s);	Sections 3.0, 4.3, 5.3, 6.3	Adequate
d)	Seasonal chemical characterization a minimum of one station location outside of the potential plume but situated such that potential influence of inflow(s) can be characterized as one station located at or near the outflow of Jackfish Lake. Station locations and rational to be included.	Sections 3.0, 4.2, 5.2, 6.2	Adequate

6. Security

On May 4, 1988, NTPC was witnessed as a crown corporation when the Northern Canada Power Commission was acquired from Her Majesty the Queen in Right of Canada by the Government of the Northwest Territories. As a Crown Corporation, NTPC is exempt from paying security depositions or fees in relation to the Jackfish Lake hydroelectric power generation facility.

7. Conclusion

The Thermal Plume Delineation Study Design as submitted is adequate, however, with the model that has been chosen it will take a year to fully calibrate and to confirm that the model is working and valid. Part E, condition 5 requires NTPC to submit a Thermal Plume Delineation Study Report, which will provide confirmation on the applicability of the model and additional information as outlined in schedule 2, condition 2. The Thermal Plume Delineation Study Report is to be submitted to the Board on December 31, 2021 for Board approval. Board staff are of the opinion that if the Thermal Plume Delineation Study Report identifies deficiencies, then these deficiencies can be addressed through a Board directive for additional thermal plume assessment or through on-going monitoring as part of the Aquatic Effects Monitoring Program (AEMP). Any continuation of thermal plume monitoring would be for Board approval.

8. Recommendation

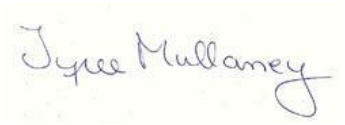
Board staff recommend the Board **make a motion to approve the Thermal Plume Delineation Study Design as required by Water Licence MV2019L1-0001.**

A draft decision letter is attached.

9. Attachments

- Water Licence MV2019L1-0001
- Thermal Plume Delineation Study Design
- Comment Summary Table and Attachments
- Review Summary and Attachments
- Draft Decision Letter from the Board

Respectfully submitted,



Tyree Mullaney
Regulatory Specialist

Katherine Harris
Senior Technical Advisor

Review Comment Table

Board:	MVLWB
Review Item:	Jackfish Generating Facility - Thermal Plume Delineation Study Design - MV2019L1-0001
File(s):	MV2019L1-0001
Proponent:	Northwest Territories Power Corporation
Document(s):	Thermal Plume Delineation Study Design (1 MB)
Item For Review Distributed On:	July 17 at 16:02 Distribution List
Reviewer Comments Due By:	July 31, 2020
Proponent Responses Due By:	Aug 7, 2020
Item Description:	Northwest Territories Power Corporation (NTPC) submitted their Thermal Plume Delineation Study Design on July 16, 2020. This Study Design is required by Water Licence MV2019L1-0001, Part E, condition 4. Using the Online Review System (ORS), reviewers are invited to submit comments and recommendations on the documents linked below by the review comment deadline specified. If reviewers seek clarification on the submission, they are encouraged to correspond directly with the Applicant prior to submitting comments and recommendations. All documents that have been uploaded to this review are also available on our public Registry. If you have any questions or comments about the ORS or this review, please contact Board staff identified below.
Contact Information:	Katherine Harris Tyree Mullaney 867-766-7464

Comment Summary

Environment and Climate Change Canada: Eva Walker				
ID	**Topic**	**Reviewer Comment/Recommendation**	**Proponent Response**	**Board Analysis**
1	General File	**Comment** (doc) ECCC Cover Letter **Recommendation**		Noted.
2	Development of a hydrodynamic/thermodynamic model	**Comment** The study design is well thought out and addresses key considerations in characterizing the thermal plume from the Jackfish power plant at Jackfish Lake. ECCC acknowledges that the development of a hydrodynamic/thermodynamic model of the plume will be helpful in understanding the		Noted.

		three dimensional behavior of the thermal plume in Jackfish Lake and increase the ability to assess potential impacts to the lake ecosystem as a result of the operation of the power plant. **Recommendation** No recommendation		
3	End-of-pipe monitoring	**Comment** It is not clear in the study design, what the distinction is between "Discharge Point" and "Discharge - In Lake" monitoring stations. However, the proponent clarified this in their responses made to ECCC during the regulatory process, that the discharge point thermistors were placed within the discharge pipes while the In Lake discharge thermistors were placed a short distance away from the end of pipe. It is important to monitor the temperature at the "end of pipe" to ensure that the cooling water discharge is not acutely lethal (either due to physical parameters such as temperature or due to contaminant parameters) before mixing with lake water. It is also useful to measure water temperature at locations where mixing is occurring as well to delineate the thermal plume. **Recommendation** ECCC recommends that for clarity in the final thermal plume study report that the monitoring stations are clearly described with adequate detail.	**Aug 14:** ECCC is correct in the distinction between the two the Discharge point stations and Discharge-in Lake; stations. This distinction will be clearly described and distinguished from one another in the final Thermal Plume Study Report.	Adequate response.
4	Magnification of thermal discharge	**Comment** Figure 3-2 shows that the intake and the discharges may be in close proximity, which may result in recirculation of discharged water back into the plant.	**Aug 14:** The model configuration will be set up in a manner that allows recirculation effects to be accounted for in the modelling results. In brief,	Adequate response.

		Recommendation ECCC recommends that the final thermal plume study report address the possibility if recirculation of discharge to the plant and the potential for magnifying the thermal discharge.	the configuration adopted in the modelling will allow operational temperature increases between the intake and discharge to be applied rather than simply applying recorded discharge temperatures.	
5	Intake and Discharge temperature logger placement	**Comment** Table 4-1 shows that In-take and Discharge temperatures loggers will be multi-depth. ECCC understands that prior to placement the exact depths for the loggers may not be known, but the description of "multi-depth" is too vague. ECCC notes that at a minimum loggers should be placed to capture the vertical as well as the horizontal extent of the plume therefore it would be expected that surface and bottom temperatures would be monitored at each station. ECCC acknowledges that temperature loggers at mid-water column would also be useful in deeper waters. **Recommendation** ECCC recommends that the study design ensure that the temperature loggers are located such that at a minimum the study captures the bottom and surface temperatures.	**Aug 14:** Temperature loggers are installed near the surface and at the lake bottom as described in Section 4.1 (first paragraph under Temperature Loggers subsection). Additional seasonal profiles of temperatures will be collected at 1-m intervals at nine locations within Jackfish Lake, including three locations in the deeper areas of the lake (i.e., near the middle of the lake) See response to MVLWB IR#5 for additional information regarding how data from the temperature loggers and profiles will be used to calibrate the thermal plume model, which will be used to delineate the thermal plume.	Adequate response.
6	Fish Habitat Mapping	**Comment** (doc) ECCC is pleased that fish habitat mapping will be conducted during this study. It is important to correlate the various utilization of the lake by fish, especially those periods of sensitive life stages of certain species such as Lake Whitefish. Lake Whitefish use cobble and boulder type substrate for spawning at depths as shallow as 2m in	**Aug 14:** The assessment (Section 5.3 of Thermal Plume Delineation Study Design Plan Version 2.0) will consider the egg incubation period (under ice), as recommended by ECCC. Further, as part of the fish habitat mapping, an assessment of aquatic habitat within the thermal plume zone(s) will be undertaken, and potential	Adequate response.

		northern climates in late fall and incubate over the winter. The most thermally sensitive life stage of Lake Whitefish is the embryo development especially the early embryo developmental stages. In determining the significance of the effect of the thermal plume on fish, ECCC has used the metric of an exceedance of an effects threshold (e.g. Maximum Weekly Air Temperature based on egg mortality) of 10% over greater than 20% of the potential viable habitat. A technical justification for the 10% effects threshold exceedance is provided as an appendix to this comment. **Recommendation** ECCC recommends that the study clearly identify the potential spawning habitat for Lake Whitefish and evaluate the potential effects of the thermal plume during the egg stage of this species.	Lake Whitefish spawning habitat in Jackfish Lake will be identified and mapped; Modelled (see response to MVLWB ID#5 for details on how modelling will occur) and available monitored temperatures at potential Lake Whitefish spawning habitat(s) will be compared to published acute and chronic thermal benchmark limits (e.g., maximum weekly average temperature, upper incipient lethal temperature, critical thermal maximum), as described in ECCC (2019). Reference: ECCC (Environment and Climate Change Canada). 2019. Guidance Document: Environmental Effects Assessment of Freshwater Thermal Discharge. Environmental Protection Operations Divion - Ontario, Environmental Stewardship Branch, Environment Canada. February 2019.	

GNWT - ENR - EAM (Environmental Assessment and Monitoring): Central Email GNWT				
ID	**Topic**	**Reviewer Comment/Recommendation**	**Proponent Response**	**Board Analysis**
5	General File	**Comment** (doc) ENR Letter with Comments and Recommendations **Recommendation**		Noted.
1	Topic: Thermal Plume Delineation Report Due Date	**Comment** Section 1.0 of the Thermal Plume Delineation Study Design notes that instrumentation could not be installed until September 2020, causing a delay in the sampling program to occur, and a delay in submission of the Thermal Plume Study Report. The revised date for submission of the Report is 31	**Aug 14:** Section 3.5 of the Jackfish Lake Thermal Plume Study Design version 2.0 states that the Aquatic Effects Monitoring Program (AEMP) Design Plan will be submitted for approval to MVLWB by 31 March 2022; upon approval of the AEMP Design Plan by the	Adequate response.

		December 2021. ENR notes that the due date noted in Part E Condition 5 is August 1, 2021. The Aquatic Effects Monitoring Program (AEMP) Design Plan is due 90 days after the submission of the Thermal Plume Delineation Study Report, noted as November 1, 2021 in Part F, condition 2 of the Water Licence. ENR notes that with a delay in the submission of the Thermal Plume Study Report, and AEMP Design Plan, there will also be a delay in the approval and implementation of the AEMP. **Recommendation** 1) ENR recommends that Northwest Territories Power Corporation provide an updated estimate on when the AEMP will be implemented based on the revised submission date for the Thermal Plume Study Report.	MVLWB, the AEMP will be implemented.	
2	Topic: Modeling	**Comment** In their review comments on NTPC's Type A Water Licence Renewal Application, Environment and Climate Change Canada (ECCC) referenced their guidelines for thermal effluents (EC, 2014). The guidelines state that more than one model should be used to delineate the behavior and configuration of thermal plumes. Section 5.1.1 in the Thermal Plume Study Design states that an abridged hydrodynamic and thermodynamic lake model will be used, using the MIKE 3 Flexible Mesh (MIKE3 FM) platform. It isn't clear how, or if, NTPC considered ECCC's guidance document when selecting a single model to use in the Thermal Plume Study.	**Aug 14:** ECCC (2014) states that more than one model should be used to delineate the behavior and configuration of thermal plumes & differentiating model applicability as follows: Modelling approaches include: a mixing model for the near field (jet and momentum driven), an equilibrium thermal balance model for the far field where the mechanisms are dilution and heat loss to the atmosphere, and three-dimensional (3-D) hydrodynamic models for the far field. It is noted that the computational platform, MIKE3 FM, proposed for this thermal plume study is capable of	Adequate response.

		Recommendation 1) ENR recommends NTPC provide rationale for selecting an abridged hydrodynamic and thermodynamic lake model rather than selecting more than one model as recommended by ECCCs guidance.	simulating all three of the processes described above. Accordingly, only MIKE3 FM has been suggested for this study. An abridged version of the MIKE3 FM platform, referring to the fact that that calibration and validation will be based on thermal data only, has been recommended because the small size of the lake means that hydrodynamics will be relatively simplistic (i.e., limited fetch distance, no significant upwelling and or downwelling processes; Reference: ECCC (Environment and Climate Change Canada). 2014. Guidance Document: Environmental Effects Assessment of Freshwater Thermal Discharge. Environmental Protection Operations Divion - Ontario, Environmental Stewardship Branch, Environment Canada. April 2014. ISBN 978-1-100-22615-6	
3	Topic: Ice Coverage	**Comment** Section 5.1.3 of the Thermal Plume Delineation Study Design states that no explicit formulation of ice thickness will be developed to simulate ice cover and that ice coverage will be represented in a binary manner to express its lake-wide presence or absence. ENR notes that it isn't clear how this model parameter is applied without designating an ice thickness. **Recommendation** 1) ENR recommends NTPC provide additional detail on the use of ice coverage in a binary	**Aug 14:** The presence and thickness of ice affects hydrodynamic and thermodynamic behavior within the lake in two primary ways: 1. The presence of a uniform covering of ice across the lake prevents wind sheer, resulting in substantially reduced current speeds or calms, limits heat exchange and reinforces stratification (however, typically in deeper waterbodies than Jackfish Lake). 2. In freshwater applications such as	Adequate response. The Board notes that if inadequacy is identified in the model assumption(s), including those related to ice-covered conditions, during the review of the Thermal Plume Delineation Study Report, then further work to refine the model could be requested by the Board at that time.

		manner, rather than assigning a thickness to the ice cover.	Jackfish Lake, the formation of ice depresses the water level by approximately 92% of ice thickness and may result in temporary increased discharge via the lake outlet although shore-bound ice can minimize this offset in small waterbodies. The small size and shallow nature of Jackfish Lake suggest that ice-formation over the lake will generally occur rapidly in response to decreasing air temperatures at the onset of winter. The study objectives for NTPC are to characterize thermal plume configurations during representative seasonal conditions which implicitly exclude the short periods where transition in weather conditions could lead to partial ice cover of the lake. As such, a binary on-off approach to representing ice-cover and ice-free conditions is considered appropriate to address the stated study objectives. Similarly, water level data collected via the monitoring program will be used to establish dynamic water level boundary conditions for the model throughout the full simulation year, thus circumnavigating the need to simulate variable water level displacement related to variable ice thicknesses on the lake.	
4	Topic: References	**Comment** The following reference is submitted in support of ENR's submission: Environment Canada, 2014.	N/A	Noted.

		Environmental Effects Assessment of Freshwater Thermal Discharge. Environmental Protection Operations Division - Ontario. April 2014. **Recommendation** 1) ENR recommends the Board note the above reference in support of ENR comments.		
MVLWB: Katherine Harris				
ID	**Topic**	**Reviewer Comment/Recommendation**	**Proponent Response**	**Board Analysis**
1	Section 2.1 Site Conditions	**Comment** The spelling of Ndilo is incorrect in the text (i.e., it is written as N'Dilo). **Recommendation** Please verify community names are correct in future documents.		The Board notices that no response was provided to comment MVLWB-1. Board assumes NTPC has made note of this and will correct the spelling of community names in future documents.
2	Figure 3-1	**Comment** The white hatched area is not correctly representing the location of the Yellowknife Airport. While this area does include various air-related business (e.g., helicopter bases, expeditors, air cargo) the actual airport is located further west than the area shown on the figure. **Recommendation** The location of the Yellowknife Airport should be verified and adjusted in future documents.		The Board notices that no response was provided to comment MVLWB-2. The Board assumes NTPC has made note of this and will correct the spelling of community names in future documents.
3	Table 3-1	**Comment** It would help to avoid confusion if the discharge and in-lake stations were not named the same. Without the area designation it is not possible to discern which is the actual discharge vs. the associated in-lake station. Replacing "discharge" with "in-lake" in the station name (e.g., K in-lake, EMD in-lake, CAT in-lake) would retain the link to the respective discharges, but eliminate confusion of in-lake locations.	**Aug 14:** ECCC is correct in the distinction between the two the Discharge point stations Discharge-in Lake stations. This distinction will be clearly described and distinguished from one another in the final Thermal Plume Study Report.	Adequate response. The Board notes that the response references ECCC, who had the same comment (see ECCC-3) rather than MVLWB.

		Recommendation NTPC should consider adjusting the station names for the in-lake locations.		
4	Figure 3-1 and Table 3-1	**Comment** Schedule 2, Item 1(a) requires the Thermal Plume Study to seasonally delineate the edge of the thermal plume. It is not clear how the cluster of three mid-lake stations will be used to delineate the full extent of the thermal plume. **Recommendation** NTPC to provide additional information to support the use of the mid-lake stations to delineate the extent of the thermal plume.	**Aug 14:** The two additional mid-lake stations (i.e., beyond the single mid-lake station monitored during the 2018 field programs [Golder 2019]) were proposed to collect additional information regarding dissolved oxygen (DO) and temperature at deep locations in Jackfish Lake (as per rationale provided in Table 6.2 of the Thermal Plume Delineation Study Design), not specifically to delineate the thermal plume. The largest vertical gradients in temperature and DO concentrations (i.e., largest decrease in temperature and DO with increasing depth) were observed at the single deep location monitored in 2018 (Golder 2019). The deepest parts of Jackfish Lake are expected to be near the middle of the lake, and therefore, two additional stations near the middle of the lake are proposed to be; monitored for field profiles only to provide additional information regarding temperature and DO gradients at deeper locations in the lake; See response to MVLWB IR#5 for additional information regarding how data from the temperature loggers and profiles will be used to calibrate and validate the thermal plume model, which will be used to	Adequate response.

			delineate the thermal plume. Reference: Golder (Golder Associates Ltd.). 2019. 2018 Environmental Monitoring Report. Submitted to Northwest Territories Power Corporation. 25 February 2019.	
5	Figure 3-1 and Table 3-1	**Comment** It is not clear how the cluster of mid-lake stations will be adapted to monitor for seasonal variability of the edge of the thermal plume. Is the intent to develop the thermal plume model and then validate it through ongoing SNP and AEMP monitoring? **Recommendation** NTPC to provide additional information to explain how station locations will be adapted to accommodate anticipated seasonal variability, as well as clarify how model validation will be completed.	**Aug 14:** Based on the proposed methods of delineating the plume in the Thermal Plume Study Design, adapting station locations to accommodate anticipated seasonal variability is not necessary because the monitoring data will not be used directly to delineate the edge of plume Instead, the monitoring data will be used to perform model calibration and validation. Thermal monitoring data will be collected within and outside of the extents of the thermal plume. By calibrating model performance against a subset of these thermal data (both within and outside of the extents of the plume), model performance will be enhanced to recreate observed temperature conditions throughout the lake. Model validation will subsequently be completed using a different subset of thermal data from those used to calibrate the model in order to assess the calibrated model's performance. The model will be calibrated based on approximately 10 months of continuous data at 6 stations, at two depths	Adequate response. The Board notes there is still some uncertainty as to how the edge of the thermal plume will be verified, but accept the Thermal Plume Study to enable proceed and if any deficiencies arise, these can be addressed through the review of the Thermal Plume Study Report as well as potentially through on-going monitoring in the AEMP.

			each, and seasonal profile measurements at 9 stations in Jackfish Lake. It is important to use the longest available time period of data to calibrate the model so that the greatest amount of variation in conditions (e.g., due to daily and seasonal fluctuations in temperatures, and operational changes) can be captured in the model calibration. Reasonable model performance at different locations and at different depths, within and outside the extent of the thermal plume, indicates that areas between these two areas (such as at the edge of the thermal plume) are also well define by the model. Validation of model results will compare modelled and monitored results for approximately one month of continuous data and from one set of seasonal profile measurements at the same locations used in calibration. Visual graphical comparisons of modelled versus monitored temperatures and comparison metrics, such as Root Mean Squared Error and R squared values, will be used to evaluate model performance. The results of the validation will be used to define the accuracy of the plume delineation (e.g., model error as well as positive or negative bias to assess the accuracy of the model and whether the model results have a tendency to be	

			conservative or be under-representative of temperatures). The calibrated thermal model is expected to simulate the observed temperatures within and outside of the thermal plume (collected over approximately a 1 year period) with sufficient accuracy so that the results can be used to identify the edge of the thermal plume at any point in time (such as for a specific event) or over a period of time (such as for spring freshet, late summer, late fall, and late under ice conditions). Two separate simulations will be carried out to determine the extent of operational effects (to delineate the thermal plume). The first of these will be carried out to simulate operational conditions over the full period of interest (circa one year) by assimilating the meteorological and operational (i.e., from the Jackfish Lake generating station) inputs that result in variable heating in time and space to derive a cumulative thermal characterization within the lake. The second of these simulations will be carried out over the same time period as the first simulation but exclude all operational inputs to the lake to develop a corresponding non-operational (base case) characterization of temperatures throughout the lake. By subtracting the water temperature	

			results for the non-operational simulation from water temperature results for the operational condition simulation it is possible to develop a representation of operational water temperatures effects (in the absence of atmospheric heating and cooling) at each model node throughout the lake for each timestep for the entire simulation. Model nodes are anticipated to be several metres to tens of metres apart; modelling nodes will be closer in areas of interest such as the discharge area, where bathymetry indicates greater changes in depth over a short distance, and areas of interest for fish habitat (e.g., locations of potential spawning habitat for Lake Whitefish). Subsequent data processing of these operational effects data will then be completed to map the thermal plume delineations for each seasonal condition. These plume delineations will identify the extent and size of the operational thermal plume (i.e.,. identified as a temperature increase of 1°C or more above the base case) for each of these seasonal conditions. The Thermal Plume Study report will provide figures that show the operational thermal plume and the calculated area for these thermal plumes for each seasonal condition.	

6	Figure 3-1 and Table 3-1	**Comment** Schedule 2, Item 1(a) requires the Thermal Plume Study to seasonally delineate the edge of the thermal plume. It is not clear how the cluster of three mid-lake stations will be used to delineate the full extent of the thermal plume. It is also not clear how the cluster of mid-lake stations will be adapted to monitor for seasonal variability of the edge of the thermal plume. Is the intent to develop the thermal plume model and then validate it through ongoing SNP and AEMP monitoring? **Recommendation** NTPC to provide additional information to support the use of the mid-lake stations to delineate the extent of the thermal plume, including how station locations will be adapted to accommodate anticipated seasonal variability, as well as clarify how model validation will be completed.	**Aug 14:** Monitoring data are not used to delineate the edge of the thermal plume but used to develop and validate a reliable model that is instead used to identify plume extents at each point in time. Please see response to MVLWB IRS #4 and #5.	Adequate response. The Board notes that although responses to MVLWB #4 and #5 provide further information on model development, there remains some uncertainty associated with the model validation. The Board is of the opinion that this uncertainty can be addressed in the Thermal Plume Delineation Study Report, which is for review and Board approval. Should inadequacies be identified during the review, then further work to refine the model could be requested by the Board at that time
7	Section 4.2 Water Quality - Water Quality Field Measurements	**Comment** NTPC is proposing to profile water column temperature, dissolved oxygen, pH and specific conductivity at one metre intervals. Has consideration been given to using a smaller depth increment (e.g., 0.5 m) within observed zones of thermal stratification to more accurately assess the boundaries of this layer? **Recommendation** NTPC to comment on the potential of using a shorter depth interval within zones of thermal stratification.	**Aug 14:** Good quality information has previously been obtained using 1 m measurement intervals (Golder 2019); 1-m intervals allow the clear identification of the absence, presence and degree of seasonal gradients in water quality field parameters, as described in Golder (2019). The potential benefits of increasing the vertical resolution of measurements from 1 m to 0.5 m is therefore not considered to be beneficial to this program. The additional vertical discretization of monitored temperature	Adequate response.

			data is not considered necessary to fulfill the modelling scope. Reference: Golder (Golder Associates Ltd.). 2019. 2018 Environmental Monitoring Report. Submitted to Northwest Territories Power Corporation. 25 February 2019.	
8	Section 4.2 Water Quality - Water Quality Samples	**Comment** NTPC is proposing to collect water quality samples from mid-depth and 1 m from the bottom; however, this may not coincide with the depth of thermal stratification. Has consideration been given to determine the depth of the thermocline and adjusting the sample collection depth accordingly (i.e., to ensure the water quality sample is taken above and below the thermocline)? **Recommendation** NTPC to provide further rationale supporting the collection of water quality samples from pre-defined depth intervals rather than determining the appropriate sample depths based on the field water quality profile results.	**Aug 14:** The proposed sampling will result in sampling above and below the depth of the thermocline when thermal stratification occurs in Jackfish Lake. Temperature gradients and thermoclines were observed during the 2018 July and August field programs, respectively (Golder 2019). In both programs, the lowest temperatures and dissolved oxygen concentrations, which have the potential to influence concentrations of some water quality parameters (e.g., ammonia, iron), were observed at the bottom of the lake, and therefore, sampling 1 m from the bottom of the lake is appropriate to capture the depth below the thermocline and where these influences are likely to be greatest. The largest gradients in temperature in July and the thermocline in August were below mid-depth; therefore, mid-depth sampling will characterize water quality above the thermocline.; Reference: Golder (Golder Associates Ltd.). 2019.	Adequate response.

			2018 Environmental Monitoring Report. Submitted to Northwest Territories Power Corporation. 25 February 2019.	
9	Section 4.3 Fish and Fish Habitat	**Comment** On p.17, reference is made to fish and fish habitat data previously collected in 2019, but the baseline data program was completed in 2018. Is this a typographical error or is there additional fish and fish habitat that have not been previously reported? If so, where and when will that information be provided? **Recommendation** NTPC to confirm date reference and clarify when additional fish and fish habitat information will be made available, if applicable.	**Aug 14:** This is a typo and was meant to be 2018. There was no fish sampling or surveys completed in 2019.	Noted.
10	Section 5.1.2 Data Requirements	**Comment** The amount of data that the thermal plume model will be based on are limited (lake morphology and environment data are only available from the 2018 survey and whatever is collected in 2020/2021). How is the model calibration/validation potentially affected given the high water volumes recorded in the Yellowknife area in 2020? **Recommendation** NTPC to comment on how current extreme water levels may influence/impact the thermal plume model and associated uncertainty.	**Aug 14:** Lake bathymetry has been assumed to remain static between the time of the 2018 survey and the proposed simulation period (2020/2021) because no significant changes in morphology are anticipated. Meteorological data corresponding to the simulation period will be obtained from the nearest Environment and Climate Change Canada Climate Station, as required. Lake level and temperature data, as well as operational data (inflows, outflows, discharge configuration and temperatures) will be obtained from NTPC for the simulation period and used to evaluate operational effects over the period of that	Adequate response.

			monitoring program. Additional localized bathymetric data collection will be undertaken in known areas of fish habitat and at the intakes and outfalls and integrated with existing bathymetric data for the purposes of enhancing model definition ; however, more comprehensive surveys are not considered to add value. The small catchment area to the lake and small storage of the lake necessarily mean that high water levels in Jackfish Lake are unlikely to increase much beyond that of the water level control at the outlet and will be short in duration. As such, the focus of this modelling investigation will be on environmental, meteorological and operational conditions during the 2020/2021 monitoring period. See response to MVLWB #5 for additional information regarding model calibration and validation.	
11	Section 5.3 Fish and Fish Habitat	**Comment** Reference is made to characterizing the oxythermal habitat for Lake Whitefish. Why are the oxythermal habitats of the other identified fish species (i.e., Northern Pike and Trout-perch) not being considered? **Recommendation** NTPC to clarify if the oxythermal habitats of other fish species will be considered and if not, provide rationale as to why they are excluded.	**Aug 14:** Salmonids, like Lake Whitefish, are generally considered sensitive fish species, and more sensitive to changes in temperature and dissolved oxygen and Northern Pike and Trout Perch. Therefore, Lake Whitefish represents a suitable surrogate for the assessment because any conclusion or recommendations from the assessment, including mitigations, would be	Adequate response.

			conservatively applied to all fish species in the lake, as needed.	
12	Section 6.2 Water Quality	**Comment** NTPC is proposing to alternate between sampling programs the inclusion of a field or travel blanks. The purpose of these two QC samples is very different. It is unclear how alternating between these two types of QC samples may not lead to a potential gap in the QA/QC program results (i.e., if contamination is encountered, but the field blank shows no issues and a travel blank was not collected [or vice versa], how will this be resolved?). **Recommendation** NTPC to provide further rationale supporting the proposed alternating QC sample approach.	**Aug 14:** The proposed schedule for field and travel blank samples is consistent with the schedule followed during monitoring completed for the 2018 Environmental Monitoring Report (Golder 2019). During the 2018 field programs, ten blank samples (five equipment blanks, two travel blanks, and three field blanks) were collected and analyzed. The percentage of detectable concentrations in the blank samples was less than 2%. No reportable detections (i.e., greater than five times the detection limit) were found in the blank samples; therefore, no parameters were detected at a frequency or magnitude that were likely to influence the results of the water quality samples. Based on the 2018 results and the requirements for field crews to follow specific work instructions and technical procedures to standardize sample collection and handling methods (see Section 6.0 of Thermal Plume Delineation Study Design Plan Version 2.0), the proposed alternating schedule for field and travel blanks is considered reasonable. Reference: Golder (Golder Associates Ltd.). 2019. 2018 Environmental Monitoring Report. Submitted to	Adequate response.

			Northwest Territories Power Corporation. 25 February 2019.	
13	Section 6.2 Water Quality	**Comment** Text on p. 26, paragraph 3, 5th bullet refers to split samples; however, no split samples seem to be proposed for the water quality component. Is this a typographical error? **Recommendation** NTPC to confirm and clarify if split samples will be collected.	**Aug 14:** Split samples are not proposed in the Thermal Plume Delineation Study Design Plan Version 2.0.	Adequate response.
Tlicho Government: LONGINUS EKWE				
ID	**Topic**	**Reviewer Comment/Recommendation**	**Proponent Response**	**Board Response**
1	Climate change	**Comment** NTPC provided an excellent background information on the impacts of increased temperature on water bodies. Definitely, change in temperature affects the health of any water body, impacts aquatic life, depletes available oxygen, increases dissolved minerals and boosts the growth of algae and some vegetations that may impact water quality. There has been a consistent report on the continually increase of the average global temperature, both on land and at water surface which negatively impacts the overall water body temperature. **Recommendation** While modelling the Jackfish lake thermal plume condition, it will be more accurate to consider the projected impact of climate change based on available record of annual temperature variations at least for the past 10 years. Making decisions on the study in isolation of climate change impacts (increased temperature, precipitation, ice melting) may not provide a	**Aug 14:** The Thermal Plume Study Design objectives were designed to meet Schedule 2, condition 1 in the Water Licence, as outlined in Section 1.2 of the Thermal Plume Delineation Study Design Plan Version 2.0. The spatial and temporal delineation of thermal plumes in Jackfish Lake will be assessed through the development of a hydrothermal (hydrodynamic and thermodynamic) model of Jackfish Lake that will simulate the physical processes affecting heat accumulation, dissipation, and transfer resulting from atmospheric and operational influences. It is noted that temperature variations over a 10-year period should not be considered meaningful information with which to estimate the potential long-term lake temperature effects of climate change; rather, these may be of value in	Adequate response. The Board notes that the intent of developing the thermal plume delineation model was to document existing seasonal conditions in Jackfish Lake to help inform the AEMP Design Plan for on-going monitoring.

		comprehensive information on the entire lake water temperature variation.	evaluating the range of temperature effects during the current climate era.	
2	Additional technology	No comment **Recommendation** Additional technology to compliment the use of temperature loggers will assist in acquiring more accurate data. Such technology as a cloud based software that can be used to analyze a satellite imagery of the thermal plume can help in receiving a near real time data of the lake.	**Aug 14:** We have previously considered satellite and aerial imagery of lake surface temperature data for similar purposes and have found these to provide lower accuracy that in-situ logger data. Although it is acknowledged that aerial/satellite imagery provides more comprehensive spatial coverage, the compromised spatial resolution (relative to in-situ loggers) necessarily renders this approach less reliable. There is also a range of other issues associated with the suggested approach, not least, that aerial and satellite imagery do not confer any reliable understanding of sub-surface temperatures which are critical to addressing the objectives of this scope of work. Moreover, the current scope of work does not rely on real-time modelling but, rather, hindcast modelling that is particularly suited to using in-situ measurements collected by long-term deployed loggers.	Adequate response. The Board notes that consideration of alternate technology for remote monitoring could be considered for future monitoring, if it is determined to be appropriate.

Environmental Protection Operations Directorate
Prairie & Northern Region
5019 52nd Street, 4th Floor
P.O. Box 2310
Yellowknife, NT X1A 2P7

ECCC File: 5420 000 001/013
MVLWB File: MV2019L1-0001

July 31, 2020

via online review system

Katherine Harris
Regulatory Specialist
Mackenzie Valley Land and Water Board
7th Floor, 4922 48th Street
P.O. Box 2130
Yellowknife, NT X1A 2P6

Dear Katherine Harris:

RE: MV2019L1-0001 – Northwest Territories Power Corporation - Thermal Plume Delineation Study Design

Environment and Climate Change Canada (ECCC) has reviewed the information submitted to the Mackenzie Valley Land and Water Board (MVLWB) by the Northwest Territories Power Corporation (the proponent) regarding the Thermal Plume Delineation Study Design. ECCC has uploaded our comments to the MVLWB On-line review system.

If you need more information, please contact Jody Small at 780-951-8961 or Jody.Small@Canada.ca.

Sincerely,

[original signed by]

Eva Walker
Senior Environmental Assessment Coordinator

Attachment(s): ECCC Comments Excel Sheet

cc: Jody Small, Head, Environmental Assessment North (NT and NU)

July 31, 2020

Tyree Mullaney
Regulatory Specialist
Mackenzie Valley Land and Water Board
7th Floor – 4910 50th Avenue
P.O. Box 2130
Yellowknife, NT
X1A 2P6

Dear Ms. Mullaney,

Re: Northwest Territories Power Corporation (NTPC)
Water Licence – MV2019L1-0001
Thermal Plume Delineation Study Design
Request for Comments

The Department of Environment and Natural Resources (ENR), Government of the Northwest Territories has reviewed the document at reference based on its mandated responsibilities under the *Environmental Protection Act,* the *Forest Management Act*, the *Forest Protection Act, the Species at Risk (NWT) Act, the Waters Act* and the *Wildlife Act* and provides the following comments and recommendations for the consideration of the Board.

Topic 1: Thermal Plume Delineation Report Due Date

Comment(s):

Section 1.0 of the Thermal Plume Delineation Study Design notes that instrumentation could not be installed until September 2020, causing a delay in the sampling program to occur, and a delay in submission of the Thermal Plume Study Report. The revised date for submission of the Report is 31 December 2021. ENR notes that the due date noted in Part E Condition 5 is August 1, 2021.

The Aquatic Effects Monitoring Program (AEMP) Design Plan is due 90 days after the submission of the Thermal Plume Delineation Study Report, noted as November 1, 2021 in Part F, condition 2 of the Water Licence. ENR notes that with a delay in the submission of the Thermal Plume Study Report, and AEMP Design Plan, there will also be a delay in the approval and implementation of the AEMP.

Recommendation(s):

1) ENR recommends that Northwest Territories Power Corporation provide an updated estimate on when the AEMP will be implemented based on the revised submission date for the Thermal Plume Study Report.

Topic 2: Modeling

Comment(s):

In their review comments on NTPC's Type A Water Licence Renewal Application, Environment and Climate Change Canada (ECCC) referenced their guidelines for thermal effluents (EC, 2014). The guidelines state that more than one model should be used to delineate the behavior and configuration of thermal plumes.

Section 5.1.1 in the Thermal Plume Study Design states that an abridged hydrodynamic and thermodynamic lake model will be used, using the MIKE 3 Flexible Mesh (MIKE3 FM) platform. It isn't clear how, or if, NTPC considered ECCC's guidance document when selecting a single model to use in the Thermal Plume Study.

Recommendation(s):

1) ENR recommends NTPC provide rationale for selecting an abridged hydrodynamic and thermodynamic lake model rather than selecting more than one model as recommended by ECCC's guidance.

Topic 3: Ice Coverage

Comment(s):

Section 5.1.3 of the Thermal Plume Delineation Study Design states that no explicit formulation of ice thickness will be developed to simulate ice cover and that ice coverage will be represented in a binary manner to express its lake-wide presence or absence. ENR notes that it isn't clear how this model parameter is applied without designating an ice thickness.

Recommendation(s):

1) ENR recommends NTPC provide additional detail on the use of ice coverage in a binary manner, rather than assigning a thickness to the ice cover.

Topic 4: References

Comment(s):

The following reference is submitted in support of ENR's submission:

Environment Canada, 2014. Environmental Effects Assessment of Freshwater Thermal Discharge. Environmental Protection Operations Division – Ontario. April 2014.

Recommendation(s):

1) ENR recommends the Board note the above reference in support of ENR comments.

Comments and recommendations were provided by ENR technical experts in the Water Management and Monitoring Division and the North Slave Region and were coordinated and collated by the Environmental Assessment and Monitoring Section (EAM), Environmental Stewardship and Climate Change Division.

Should you have any questions or concerns, please do not hesitate to contact Patrick Clancy, Environmental Regulatory Analyst at email: patrick_clancy@gov.nt.ca.

Sincerely,

Patrick Clancy
Environmental Regulatory Analyst
Environmental Assessment and Monitoring Section
Environmental Stewardship and Climate Change Division
Department of Environment and Natural Resources
Government of the Northwest Territories