

# **Great Slave Lake Monitoring Program Design Plan Review**

Prepared for:

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Environment and Natural Resources**

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### Table 1-1: Acronym Definitions

AE	Associated Environmental Consultants Inc.
AEMP	aquatic effects monitoring program
COY	City of Yellowknife
ECCC	Environment and Climate Change Canada
FLTS	Fiddler Lake Treatment System
GSLMP	Great Slave Lake Monitoring Program
GNWT ENR	Government of the Northwest Territories Environment and Natural Resources
GSL	Great Slave Lake
IDZ	initial dilution zone
MVLWB	Mackenzie Valley Land and Water Board
SNP	surveillance network program

# 1 Introduction

Zajdlik & Associates Inc. was retained by the Government of the Northwest Territories, Environment and Natural Resources (GNWT ENR) to review the Great Slave Lake Monitoring Program (GSLMP) Design Plan:

AE (Associated Environmental) 2023. City of Yellowknife Great Slave Lake Monitoring Program Design Plan.

The monitoring plan is required to meet the conditions of the City's type A water licence MV2021L3-0003. The intent of the plan is: "to better understand the treatment capacity of the Fiddler's Lake Treatment System and the potential effects on Great Slave Lake as the receiving waterbody" (AE 2023 §1). The monitoring plan presented does not provide information regarding treatment capacity and is inconsistent with the objectives presented in AE (2023 §1). A recommendation on this topic is presented in §1.1 below.

The plan uses Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life to assess contaminants other than phosphorous. GNWT should be aware that this implies that the City of Yellowknife (COY) has adopted a use-impairment approach to assess the effects of the Fiddler's Lake Treatment System discharge on Great Slave Lake (GSL). That approach is consistent with approaches used by other municipalities and may be acceptable, given that lake-wide contaminant / nutrient loads will be relatively small, and, that the local receiving environment is not unique with the assumption that no species in the potentially affected area fall within the Species at Risk Act (Government of Canada 2003). A recommendation on this topic is presented in §1.1 below.

## ***1.1 Recommendation***

- COY should modify the stated intent of the plan to reflect the monitoring plan’s content.
- COY should ensure that no species in the potentially affected area fall within the Species at Risk Act (Government of Canada 2003) if this has not already been done. If Species at Risk are present, the appropriateness of Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life should be reviewed.

## ***1.2 Caveats***

This project has a history, with public hearings and technical reviews. As stated within AE (2023 §2.1) “The Fiddler’s Lake Treatment System comprises the City’s sewage treatment lagoon, built in the 1980s, and approximately 13.5 km of wetland that carry and further treat effluent on its way to Great Slave Lake”. Given the past history, no comment regarding the use of natural wetlands and lakes to treat and “polish” sewage plant outflows is made.

Recommendations made herein assume that SNP location SNP 0032-F1 is the *de facto* outfall from the Fiddler’s Lake Treatment System complex.

Please also note that the absence of comment on any specific item should not be construed as endorsement.

## **2 Concordance with Water Licence Requirements**

Mackenzie Valley Land and Water Board (MVLWB) (2022a, Schedule 3, Part 3) presents minimum requirements for the GSLMP Design Plan. These are re-presented in AE (2023 Table 1-1) along with a location within the same document where the water licence requirement is addressed. The responses provided are reviewed in subsequent sections.

## ***2.1 GSLMP Objectives and Purpose***

MVLWB (2022a, Schedule 3, Part 3a) requires that: “Objectives and purpose of the Great Slave Lake Monitoring Program” be provided. AE (2023 Table 1-1) points to §1.2 as addressing this water licence requirement. In that section, the GSLMP objectives are clearly stated and appear to follow discussions and commitments made during the technical session (MVLWB 2021a) and in the water licence reasons for decision (MVLWB 2022b). The purpose of the design plan is stated to be attainment of the GSLMP objectives; a list of water quality requirements presented in the licence. There is some circularity here that is not addressed at the moment.

## ***2.2 Previous Information and How it Informed the Design Plan***

MVLWB (2022a, Schedule 3, Part 3b) requires: “A summary of previous monitoring and how it informed the revised design plan”. AE (2023 Table 1-1) points to §2.3 as addressing this water licence requirement. The primary focus of previous monitoring is on “SNP 0032-F1, which provides an important indication of long-term trends in water quality in the Fiddler’s Lake Treatment System before effluent is discharged into the lake through the unnamed channel” (AE 2023 §2.3.1). While data collected at SNP 0032-F1 are discussed, the discussion has substantive limitations, consequently recommendations are presented in 2.2.1 below.

Water chemistry collected during the winter of 2019 is also described, citing Balch (et al. 2019). There is no indication as to where this report is published; two recommendations on this topic are presented in §2.2.1 below. Note that GNWT ENR did provide this report. Balch (et al. 2020) Figure 1 shows location YK1 which seems to extend further from the outflow<sup>1</sup> than the most distant exposure location (Site 5) proposed by AE (2023). Balch (et al. 2020) Figures 5 and 6 show substantively elevated ortho-phosphate (in 2019) and total P (in 2000), respectively, at location YK1 relative to more distant sites. Balch (et al. 2020) Figure 8 shows relatively elevated levels of total P at location YK11 in 2019 which again seems to extend further<sup>1</sup> from the

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<sup>1</sup> UTM coordinates from the various sampling campaigns were not plotted to absolutely confirm this statement at this time.

outflow than the most distant exposure location (Site 5) proposed by AE (2023). It appears that some nitrogen species may also be elevated at YK1 relative to more distant sites; this has not been reviewed in detail. A comment made by Balch et al. (2020) who reviewed antecedent data is worth re-stating here: “Associated Environmental (2017) has suggested that the IDZ (*initial dilution zone*) extends approximately 300 meters from the outflow channel of the FLTS. The data from Dillon & Environment Canada (2000), plus the CAWT 2019 study, suggest that during under ice time conditions, the size of the IDZ is larger and extends closer to 2000 - 2500 m from the outfall.” Note that results presented in AE (2017) for the summer of 2017 do suggest that during that time period at least, for the parameters presented, the concentration gradient falls to the background or reference concentration by the most distant proposed location, Site 5. A recommendation regarding this topic is made below.

### **2.2.1 Recommendation**

The following recommendations are provided in no particular order.

- AE (2023 Figure 2-1) presents an area labelled as “overflow”. This is likely the area described in AE §2.4 where effluent may travel south from Lake F2 under high-water conditions. COY should discuss the frequency with which this area may be subject to effluent and discuss the implications with respect to the adequacy of the monitoring plan in meeting the GSLMP objective.
- The textual description of water quality analytes collected in winter should be accompanied by graphics that present spatial trends in key analytes. That list of analytes should include at a minimum, those analytes for which effluent quality criteria and/or action levels will be finalized.
- COY should ensure that all authorities cited are done so in a manner consistent with accepted practice. This should include sufficient information that the cited documents may be found by reviewers.

- The collection of data near the outflow of the Fiddler’s Lake Treatment System to GSL during the summer of 2017 is discussed but no results are graphically presented. The COY should present graphical results so that reviewers can understand how water chemistry in this area varies over the season, and by location.
  
- It is critical to note that there appears to be a very limited amount of data within GSL. It is not clear how the winter sampling locations match the sampling locations that were sampled in the summer of 2017. COY should:
  - discuss whether the same or a similar location was sampled in both winter and summer; and,
  - present the data in such a manner that a within-year assessment is possible.
  
- The discussion of analytes measured at location SNP 0032-F1 does not present sample sizes by year, among-years or, the number of years over which data are available. The discussion includes qualitative statements such as “Total and dissolved phosphorus concentrations were very high” and “Chloride concentrations were higher in the channel and Great Slave Lake near-field sites compared to reference lake sites” but the reviewer is left wondering, “How high were the phosphorous concentrations?”, “How do concentrations of a specific analyte change over time?”. These and other questions could be answered through the use of graphics. COY should:
  - present graphics that describe temporal trends at location SNP 0032-F1;
  - tabulate available data on an overall basis (i.e., what is the sample size?), by year and by season;
  - discuss seasonal effects and temporal trends;
  - provide all data in a usable electronic format such as the commonly used spreadsheet Microsoft Excel, if such data are not currently available; and,
  - explicitly state how the data collected to date, and, interpretations thereof have “informed the revised design plan” as required to do so by the MVLWB.
  
- A limited examination of the Balch et al. (2019) report provided by GNWT ENR suggests that the proposed spatial sampling design does not extend out sufficiently from



SNP 0032-F1 to delineate the spatial extent of the effluent plume<sup>2</sup>. A plume delineation study (see recommendation in §2.4.1 below) and a visual assessment of data (see recommendation above) at least appear to be necessary to confirm spatial adequacy of the proposed design. COY should reassess the proposed locations in light of data provided within Balch et al. (2020), and in consideration of a plume delineation study. As effluent can behave differently under ice, the plume delineation study should be conducted in both the open-water and under-ice seasons. The transects presented in Balch et al. (2020) may represent a useful starting point for the plume delineation studies.

### ***2.3 Maps Showing Proposed Sampling Locations***

MVLWB (2022a, Schedule 3, Part 3c i) requires: “Maps showing all proposed sampling locations”. AE (2023 Table 1-1) points to Figure 3-1 as addressing this water licence requirement. AE (2023 Figure 3-1) addresses this requirement.

### ***2.4 Rationale for Reference Location Selection***

MVLWB (2022a, Schedule 3, Part 3c ii a) requires: “Rationale for locations, including: how reference locations were selected”. AE (2023 Table 1-1) points to Table 3-1 as addressing this water licence requirement. AE (2023 Table 3-1) categorizes each site as a location type and provides a description. The site description states that the reference site is “outside the influence of the wastewater discharge”. While that statement may be correct, without supporting evidence the statement is merely an assertion.

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<sup>2</sup> Please see comment regarding defining the effluent plume as presented in §1.2.

### 2.4.1 Recommendation

- COY should refer to either known plume dispersion results or, qualify this statement by requiring confirmation from the plume delineation study mentioned in AE (2023 §3.1.2). Note that in 2021, Environment and Climate Change Canada (ECCC) made a recommendation that delineation commence immediately (MVLWB 2021b, ECCC Comment #10).

### 2.5 Rationale for Exposure Location Selection

MVLWB (2022a, Schedule 3, Parts 3c ii b and c) requires: “Rationale for locations, including: Information from the Wetland Delineation Study such as outflow location(s) to Great Slave Lake; and Spatial extent compared to zone of influence from FLTS [Fiddler’s Lake Treatment System] effluent.”. AE (2023 Table 1-1) points to Figure 3-1 and §3.1.1 and 3.1.2 as addressing this water licence requirement. AE (2023 Table 3-1) categorizes each site as a location type and provides a description. The rationale provided for exposure locations is limited to distance from SNP station 0032-F1. Guidance for metal mining is referred to and terms such as near-field and far-field are used. Those terms are incorrectly used as they refer to distance from a controlled discharge point and not “outflow from the wetland complex” (AE 2023 Table 3-1). Due to the Project history, no recommendations are made on this point<sup>3</sup>. AE (2023) states that exposure locations were selected following results of a wetland delineation study (not reviewed at this time) and a nutrient risk assessment (also not reviewed at this time). There is a comment that the modification to the effluent flow path identified during the wetland delineation study was made due to “the possibility that effluent could reach Great Slave Lake through another channel” (AE 2023 §3.1.1). We note with approval that a plume delineation study has been proposed. Given the uncertainty in the currently selected locations a recommendation is provided below.

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<sup>3</sup> This topic is discussed in §1.2.

### **2.5.1 Recommendation**

- The current exposure monitoring location selection has been informed by some past work. Before finalizing these locations, COY should conduct the plume delineation study as soon as possible to confirm that sites have indeed been selected appropriately. The effects of fetch and water level on the effluent plume should be considered when finalizing the sampling plan. Rather than restricting sampling to a gradient design, COY could use a radial gradient design which may be more appropriate in what is primarily a lentic receiving environment. A radial gradient design should be used until such time as a defensible reduction in sampling effort is demonstrated.
- It is not clear why data from SNP 032-F11, which is further downstream than location SNP station 0032-F1 (AE 2023 Figure 3-1), was not used when supporting the choice of sampling locations and analytical parameters. COY should discuss why data from SNP 032-F11 was not used for these purposes.

### ***2.6 Does Proposed Study Address Recommendations from Past Monitoring Programs?***

MVLWB (2022a, Schedule 3, Part 3d) requires: “A summary of how the proposed study addresses the recommendations from past monitoring program(s).” AE (2023 Table 1-1) points to §2.3 as addressing this water licence requirement. AE (2023 §2.3.1) notes that results from location SNP 0032-F1 “provides an important indication of long-term trends in water quality in the Fiddler’s Lake Treatment System before effluent is discharged into the lake” which makes sense. Consequently, results from that location are discussed in AE (2023 §2.3.3). Observed changes are discussed in bullet form. While the discussion is useful, it could be greatly augmented by graphics. A recommendation on this topic is presented in §2.2.1 above. The limited data collected during the winter are discussed in AE (2023 §2.3.2) who state that “the outflow of the Fiddler’s Lake Treatment System into Great Slave Lake appears to be changing the water chemistry of the nearshore mixing zone”. While that statement confirms that change is

occurring, the mixing zone mentioned is not defined and, the link between that mixing zone and the currently selected locations is not provided. Aside from confirming that sampling should occur beyond SNP 0032-F1 and that monitoring should include ammonia and phosphorus (which it does), it is not clear how the winter sampling program informs the location of currently proposed monitoring locations. Two recommendations regarding AE (2023 §2.3.2) are presented in § 2.2.1 above. A recommendation regarding confirmation of sample locations is presented in §2.5.1 above; a further recommendation is presented below.

### **2.6.1 Recommendation**

- In order to make the GLSMP design plan a reasonably comprehensive stand-alone document, COY should provide information supporting the design rather than referring to other documents. This information includes a tabulation of all supporting data collected by sampling year, season and location. A map should be provided that presents all sampling locations. This would enable reviewers to understand the spatial and temporal scopes of what data are available.

## ***2.7 Description of the Sampling and Analysis to be conducted - Field Measurements***

MVLWB (2022a, Schedule 3, Part 3e i.) requires: “A description of the sampling and analysis to be conducted for field measurements.” AE (2023 Table 1-1) points to Table 3-3 as addressing this water licence requirement. While AE (2023 Table 3-3) does list the field measurements, there is no discussion of analysis that will be conducted and, there does not appear to be any mention of the analysis of field measurements elsewhere. Field measurements are typically used as supporting information when interpreting an AEMP and a discussion of analysis that will be conducted is typically not provided. Moreover, another water licence condition (Schedule 3, Part f), requires “a description of procedures to analyze and interpret data collected”. It is likely that this portion water licence requirement (Part 3ei “analysis”) is not necessary and so no

recommendation is provided for this portion of water licence condition. A clarification and recommendation regarding the AE response are presented below.

### **2.7.1 Recommendations**

- Although AE (2023 §3.1.1) states that that field measurements will be collected at all locations, and, that additionally, a depth profile will be collected at Site 7 this is not clear in AE (2023 Table 3-3), as written. COY should clarify the wording in the AE (2023 Table 3-3).
- Depth information is not provided for the proposed sampling locations in AE (2023 Table 3-3) where information satisfying this water licence requirement is provided (AE 2023 Table 1-1). COY should amend AE (2023 Table 1-1) to include AE (2023 Table 3-1) where this information is embedded in the description of Site 7.

## ***2.8 Description of the Sampling and Analysis to be conducted - Analytical Parameters***

MVLWB (2022a, Schedule 3, Part 3e ii.) requires: “A description of the sampling and analysis to be conducted for analytical parameters.” AE (2023 Table 1-1) points to Table 3-4 as addressing this water licence requirement. AE (2023 Table 3-4) presents what appears to be<sup>4</sup> a reasonable list of analytical parameters for effluent from a wastewater treatment plant.

## ***2.9 Description of the Sampling and Analysis to be conducted – Sample Media***

MVLWB (2022a, Schedule 3, Part 3e iii.) requires: “A description of the sampling and analysis to be conducted for sample media.” AE (2023 Table 1-1) points to §3.3.3 as addressing this

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<sup>4</sup> Note that antecedent documents have not been reviewed at this time.

water licence requirement. AE (2023 §3.3.3) mentions accepted sampling methods which contain details of sample media as appropriate. No recommendations on this topic are necessary.

## ***2.10 Description of the Sampling and Analysis to be conducted – Sampling Methods***

MVLWB (2022a, Schedule 3, Part 3e iv.) requires: “A description of the sampling and analysis to be conducted for sampling methods.” AE (2023 Table 1-1) points to §3.3.4 and 4 as addressing this water licence requirement. As sampling methods are presented in AE (2023 §3.3.3) and not in the sections mentioned in AE (2023 Table 1-1), a recommendation is provided below. No other recommendations on this topic are necessary for the reasons mentioned in §2.9 above.

### **2.10.1 Recommendation**

- AE should correct Table 1-1 to point to the correct location for sampling methods.

## ***2.11 Description of the Sampling and Analysis to be conducted – Quality Assurance and Quality Control Procedures***

MVLWB (2022a, Schedule 3, Part 3e v.) requires: “A description of the sampling and analysis to be conducted for quality assurance and quality control procedures.” AE (2023 Table 1-1) points to §3.3.4 and 4 as addressing this water licence requirement. AE (2023 §3.3.4) refers to a quality assurance / quality control plan. This plan has not been reviewed at this time.

## ***2.12 Description of the Procedures to Analyze and Interpret Data***

MVLWB (2022a, Schedule 3, Part 3f) requires: “A description of procedures to analyze and interpret data collected.” AE (2023 Table 1-1) points to §4 as addressing this water licence requirement.

An ability to create of time-series plots and comparison to guidelines by the COY is mentioned in AE (2023 §4.1) should an online repository be created. It is not clear whether all Interested Parties will have access to the repository. The requirements to make online data accessible to Interested Parties has not been reviewed at this time; consequently, no recommendation is provided. It is worth noting that an opportunity for Interested Parties to assess data, while laudable, does not address the water licence requirement.

Data interpretations that will be provided by COY include:

- comparison with Canadian Council of Ministers of the Environment guidelines for the protection of aquatic life (see recommendation in §1.1 above regarding appropriateness of these guidelines);
- comparison of phosphorous concentrations with a yet-to-be estimated trigger range which follows accepted practice in Canada;
- comparison of chlorophyll *a* concentrations with an Organisation for Economic Co-operation and Development trophic status range which although somewhat simplistic is acceptable; and,
- comparison with the reference site.

In addition, “an evaluation of spatial effects in Great Slave Lake from the Fiddler’s Lake Treatment System” will be conducted “after completing four years of sampling” (AE 2023 §4.3). Data will also be used to asses action levels but not until four years from now.

The experimental design is potentially, a gradient design (see recommendation in §2.5.1 above on this topic as to why the adverb “potentially” is used) with a single site identified as a reference site and another site that is “a representative deep-water site distant from all other sites (selected because all other sites were found to be less than 2 m in depth” (AE 2023 Table 3-1). The purpose of the deep water site is not clear. There is an implication that it is not directly comparable to other sites as a depth<sup>5</sup> limitation is mentioned. A recommendation on this topic is presented in §2.12.1). If the deep water site is not comparable to other sites, then the sampling design is a gradient design with 4 or possibly 5 exposure locations (2, 3A, 4 and 5) and 1 reference location. The utility of Site 1 is in question because the description places it upstream of a surveillance network program (SNP Station 0032-F11) location. Typically, SNP locations represent stations upstream of receiving environment locations. Past discussions regarding SNP sampling (see MVLWB 2022b §6.11) have not been reviewed at this time; such discussions may shed light on whether the proposed site 1 should be included as an exposure location within the expected concentration gradient.

### **2.12.1 Recommendations**

The data analysis plan is useful as a beginning but should be amended as follows:

1. COY should discuss the intended purpose of the deep water site #7. If the purpose is to use this location as a reference site, rationalization should be provided. The implication on the data analysis plan is formal statistical comparisons may be made between the exposure and reference locations which is highly desirable.
2. Formal statistical gradient analyses should be conducted every year once a concentration gradient has been demonstrated through a plume delineation study as recommended in §2.5.1.
3. Data collected from exposure sites should be formally compared to data collected from reference areas using a statistical test if a spatial gradient is not detected. In order to

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<sup>5</sup> Depth information for other locations is not provided.



defensibly estimate the reference condition, more than a single reference location is necessary.

4. Power analyses should be conducted for all statistical tests after the first year of data are available to ensure that there is sufficient information to detect changes of interest. The change of interest is the low action levels which have yet to be finalized (please see the following comment for a discussion on this topic). This will inform all Interested Parties as to the ability of the GSLMP to detect meaningful change and, whether changes to the proposed design are necessary.
  
5. It is not clear why action levels for nutrients at least, cannot be finalized now as current Federal guidance is that trophic status should not change. AE (2023) cites authorities that provide ranges for trophic levels that can and should be used to define action levels. Action levels for non-nutrient contaminants may be established as departures from baseline (which may be difficult at this point as there seems to be a dearth of baseline data – see recommendation in §2.6.1) or as fractions of water quality guidelines depending on whether a use-impairment approach is adopted (see recommendation in §1.1 above). As there is no impediment to finalizing action levels (as long as a use-impairment approach to mitigating environmental risks is not ruled out) COY should finalize action levels now. Note that GNWT ENR made this recommendation in 2021 (MVLWB 2021b, ENR Comment #14). The associated response from COY provides no reason to delay finalizing Action Levels.

### 3 References

AE (Associated Environmental) 2017. City of Yellowknife Great Slave Lake Nutrient Risk Assessment.

AE (Associated Environmental) 2023. City of Yellowknife Great Slave Lake Monitoring Program Design Plan.

Balch et al. 2020. Assessing water quality parameters under ice in Great Slave Lake at the outfall of the Fiddler's Lake treatment system. Report Prepared for the Government of Northwest Territories April 2019 - amended June 2020.

Government of Canada. 2003. Species at Risk Act.

MVLWB (Mackenzie Valley Land and Water Board). 2021a. City of YK – Technical Session Transcripts Day 2, June 2, 2021, pgs. 64, 167.

MVLWB (Mackenzie Valley Land and Water Board). 2021b. Water Licence MV2021L3-003 Application – Review Comment Table May 7, 2021.

MVLWB (Mackenzie Valley Land and Water Board). 2022a. City of Yellowknife Water Licence MV2021L3-003, April 6<sup>th</sup> 2022.

MVLWB (Mackenzie Valley Land and Water Board). 2022b. Water Licence MV2021L3-003 Application - Reasons for Decision. February 9, 2022.