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# Technical Memorandum

**Date:** August 19, 2019  
**To:** Michel Groleau and Jamie Quesnel  
**From:** Gary Mann, Alena Fikart and Eric Franz  
**Our File:** AEM-19-03/WTP Permitting  
**RE:** Whale Tail Permitting Support – Revised Predictions of Fish Mercury Concentrations in Whale Tail Lake (South Basin) FINAL

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This report was prepared by Azimuth Consulting Group Partnership (Azimuth) on behalf of Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle). This memorandum presents revised predictions of fish mercury concentrations in the impounded Whale Tail Lake (South Basin) to support the permitting process for the Whale Tail Pit Expansion Project.

## Report Version

Version	Dates	Distribution
Draft for Client Review	Report issued: August 16, 2019	Jamie Quesnel (Agnico Eagle) Michel Groleau (Agnico Eagle)
Final version	Report issued: August 19, 2019	Jamie Quesnel (Agnico Eagle) Michel Groleau (Agnico Eagle)

## TABLE OF CONTENTS

1. INTRODUCTION .....	4
2. BACKGROUND .....	4
3. METHYLMERCURY PREDICTIONS .....	5
3.1. Review of 2017 Model Approach (Approved Project) .....	5
3.2. Revised 2019 Predictions for Expansion Project.....	7
4. IMPLICATIONS FOR FEIS .....	8
5. RECOMMENDATIONS FOR RISK MANAGEMENT .....	8
6. REFERENCES .....	9

## LIST OF FIGURES

<b>Figure 1</b>	2017 predicted changes in lake trout (550 mm) mercury concentrations for the Approved Project for Whale Tail Lake (South Basin) relative to baseline conditions and fish consumptions (servings per month) guidance based on Health Canada .....	11
<b>Figure 2.</b>	2019 Predicted changes in lake trout (550 mm) mercury concentrations for the proposed Expansion Project for Whale Tail Lake (South Basin) relative to baseline conditions and fish consumptions (servings per month) guidance based on Health Canada .....	12

## 1. INTRODUCTION

Azimuth Consulting Group Partnership (Azimuth) is pleased to provide Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) with revised predictions for fish (lake trout) methylmercury<sup>1</sup> concentrations in the flooded area of South Basin of Whale Tail Lake (hereafter referred to as the “Whale Tail Lake (South Basin)”). The revised predictions reflect changes to the proposed flooding duration of Whale Tail Lake (South Basin) as part of the proposed expansion activities for the Whale Tail Pit Project. In addition to revised predictions, this Technical Memorandum includes a risk communication and management strategy, should monitored fish mercury concentrations resulting from project activities substantially exceed those currently predicted.

The revised predictions presented in this Technical Memorandum are an update to a 2017 comprehensive study (Azimuth 2017<sup>2</sup>) conducted to predict the magnitude of change in fish mercury concentrations associated with the Approved Project. While important context for methylmercury predictions are provided in this memorandum, the Azimuth 2017 report should be referred to for details of mercury in the environment, site-specific factors relevant for predicting changes in fish mercury concentrations, baseline terrestrial and aquatic media, and overall approach and methodology to fish mercury modeling.

This technical memorandum is structured as follows:

1. Background;
2. Revised Predictions for the Expansion Project;
3. Implications for the Final Environmental Impact Statement (FEIS); and
4. Recommendations for Risk Management (RM).
5. References

A revised flooding scheduling provided by Golder Associates is presented in **Attachment 1**.

## 2. BACKGROUND

Agnico Eagle is currently developing the Whale Tail Pit Project (Approved Project) located on the Amaruq Exploration Property site as an extension to the operational Meadowbank Mine (approximately

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<sup>1</sup> Methylmercury is the most bioavailable and toxic form of mercury. It is the predominant form of mercury found in fish and is generally assumed to be the only form present in fish. For the purposes of this technical memorandum, the term “mercury” will be inferred to mean methylmercury unless specified otherwise.

<sup>2</sup> Azimuth 2017. Whale Tail Pit Project: Predicted Changes in Fish Mercury Concentrations in the flooded area of Whale Tail Lake (South Basin)

50 km northwest of the Meadowbank Mine). At this time, Agnico Eagle is seeking to extend operations by three to four more years by expanding the Whale Tail open pit, developing another open pit called the IVR Pit and including underground mining operations. These new mining operations are referred to as the “Expansion Project”. As a result of Expansion Project, the planned temporary flooding of the Whale Tail Lake (South Basin) will be increased by 4 years.

In response to commitment no. 19 from the Whale Tail Expansion Technical Meeting, Agnico Eagle committed to provide updated fish mercury predictions (i.e., updated from Azimuth 2017) to the Kivalliq Inuit Association (KivIA) regarding additional flood duration under the Whale Tail Expansion Project as compared to flood duration of the Approved Project.

Flood duration is not typically a factor that gets considered when predicting peak fish mercury concentrations in newly created reservoirs. The reason for this is that reservoirs are rarely built on a temporary basis. The temporal pattern in fish mercury concentrations seen at most reservoirs includes an initial increase to a peak (e.g., by 4 to 12 years), followed by a gradual decrease to baseline or near-baseline concentrations (e.g., by 15 to 30 years after impoundment). Thus, the 2017 assessment for the Approved Project took the influence of short flood duration (i.e., 4 years) into account when predicting peak fish mercury concentrations for Whale Tail Lake (South Basin), resulting in lower fish mercury concentrations than would be predicted for a similar impoundment without a short life span. However, the longer impoundment period for the proposed Expansion Project will negate the positive influence of reservoir life span, thus warranting the revision of the original 2017 predictions. Revised predictions based on increased flood duration are presented in **Section 3** below.

### 3. METHYLMERCURY PREDICTIONS

The sections below include a brief review of the 2017 approach for context as well as the revised 2019 predictions.

#### 3.1. Review of 2017 Model Approach (Approved Project)

The 2017 fish mercury predictions for the Approved Project are presented in **Figure 1**. These predictions were calculated following best management practices (HESL 2016), with some project-specific modifications for target fish species and short impoundment time as described below (see Azimuth 2017 for details):

1. Baseline fish mercury concentrations were established based on size-standardized (for a 550-mm lake trout) tissue mercury concentrations (0.58 mg/kg wet muscle).

2. The mean of empirical model predictions (Johnston et al. 1991 and Bodaly et al. 2007) were used as a starting point for predicting peak post-impoundment mercury concentrations for lake trout in Whale Tail Lake (South Basin)<sup>3</sup>. Key factors include the following:
  - a. These models assume a full life span reservoir.
  - b. Both empirical models are based on northern pike or walleye, neither of which occur in the Meadowbank region. Lake trout is the top predatory fish in Whale Tail but has a similar fish-based diet as pike and walleye. As none of the models directly predicts changes in mercury concentrations for lake trout, the peak-increase-factor (PIF) empirical models for both northern pike and walleye were used to estimate post-impoundment concentrations in lake trout. Post-impoundment lake trout mercury concentrations were estimated by multiplying the PIF results by the baseline mercury concentrations for lake trout.
  - c. The 95% confidence interval of baseline mercury concentrations in lake trout was applied to the mean of the empirical models (extrapolated as a percent of the mean, so the range gets wider with higher mercury concentrations).
3. The 2017 predictions were made under the assumption the peak mercury concentrations in fish tissue would not occur given the short flooding duration time. Modifying factors were developed to adjust (reduce) the empirical model peak fish mercury predictions to account for the shortened life span, as follows:
  - a. Modifying factors (monitoring-based and RESMERC mechanistic model-based; see Azimuth 2017 for details) for short life span of impoundment were applied to the mean empirical model (see number 2 above) estimates to account for the expected lower peak mercury concentrations due to the short life span of the proposed Whale Tail Lake (South Basin) relative to long-term hydroelectric reservoirs upon which the empirical models are based.
4. The mean of all the modifying factor (MF)-adjusted predictions was used as the weight-of-evidence based prediction of peak mercury concentrations in lake trout in the Whale Tail Lake (South Basin). Uncertainty around that prediction was conservatively based on the maximum extent of all the MF-adjusted 95% confidence intervals (**Figure 1**).
5. While there were a number of uncertainties associated with these predictions (i.e., arctic environment, tundra soils, ice rafting, ice cover, interrupted discharge, cold water, slow fish growth and shorter impoundment time), they were relatively balanced in how they might affect

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<sup>3</sup> Two other empirical models (Harris-Beals and Axor) were considered in Azimuth 2017; however, results indicated that they were not intended to apply in no flow, or low flow conditions as per Whale Tail Lake (South Basin). Consequently, neither model was considered suitable.

the predicted magnitude of change in lake trout mercury concentrations (see Azimuth 2017 for details).

The implications of the predicted changes in fish mercury concentrations were explored on the basis of the number of servings<sup>4</sup>/month of lake trout (for a 550-mm fish) following Health Canada (2007) guidance. This information is intended to provide some context for interpreting the predicted magnitude of change in fish mercury concentrations with respect to ‘servings per week or month’ that are permissible to stay within guidelines; it is not intended to be a comprehensive human health risk assessment (see Azimuth 2017 for details).

As shown in **Figure 1**, the advised number of servings/month of a 550-mm lake trout based on baseline fish mercury concentrations (0.58 mg/kg wet weight [wwt]) would be 11 for adults in general and four (4) for women of child-bearing age (WoCBA). Based on the 2017 mean weight-of evidence predictions for fish mercury concentrations (1.34 mg/kg wwt, see **Figure 1**), the number of servings/month of lake trout (based on a 550-mm fish) would drop to 5 and 2 servings for adults in general and women of child-bearing age, respectively, but could be as low as 3 and 1 at the upper bound of the prediction range (1.76 mg/kg wwt, see “Health Canada Servings/mth” in **Figure 1**).

### 3.2. Revised 2019 Predictions for Expansion Project

The 2019 revised predictions are presented in **Figure 2**. These were calculated following the 2017 Model Approach, but assumed no reduction in peak fish mercury concentrations due to short life span (i.e., to account for the longer flood duration time proposed under the Expansion Project). Specifically, the Johnston et al. 1991 and Bodaly et al. 2007 empirical models (see **Section 3.1** above) were used to make predictions but modifying factors for shorter impoundment time were not applied (see **Section 3.1**, numbered list, No. 3 and 4). Importantly, with the exception of flood duration, all other factors relevant to fish mercury predictions were assumed to be the same or similar between the Approved Project and Expansion Project<sup>5</sup>.

The 2019 revised prediction for the mean methylmercury concentrations in standard-sized (550 mm) lake trout is estimated to be approximately 1.55 mg/kg wwt (**Figure 2**). The 95% confidence interval of baseline mercury concentrations in lake trout was applied to the mean of the empirical models (extrapolated as a percent of the mean, so the range gets wider with higher mercury concentrations). Key comparisons of the 2019 revised predictions to baseline and 2017 predictions are as follows:

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<sup>4</sup> Servings per month calculations used default Health Canada assumptions (see Azimuth 2017 for details).

<sup>5</sup> While there are small differences in total terrestrial area flooded between the Approved and the Expansion Project (i.e., the total terrestrial area flooded is calculated to be bit smaller under the Expansion Project), the differences were not considered large enough to rerun the 2017 empirical models.

1. The 2019 revised mean prediction for peak methylmercury concentrations in lake trout is approximately 3 times the baseline concentration.
2. The revised 2019 mean prediction for peak fish mercury concentrations is slightly higher than the 2017 mean weight-of-evidence prediction provided in **Figure 1** (1.34 mg/kg ww; adjusted using modifying factors for short-impoundment time) but remains within the bounds of the uncertainty estimate of the 2017 weight-of evidence prediction (based on the maximum extent of all the MF-adjusted 95% confidence intervals).
3. Based on the 2019 mean empirical model prediction for peak fish mercury concentrations (see **Figure 2**), the number of servings/month of lake trout (550 mm) would be approximately 4 for adults in general and one (1) for women of child-bearing age (based on Health Canada 2007). The upper bound of the prediction estimate (1.76 mg/kg ww) has not changed from the 2017 prediction (i.e., 3 and 1 servings/month at the upper bound of the prediction range, see “Health Canada Servings/mth” in **Figure 2**).

## 4. IMPLICATIONS FOR FEIS

The 2017 fish mercury concentration predictions were estimated taking a shorter flood duration time into consideration, which effectively reduced the predicted peak fish mercury concentrations relative to a full life span reservoir. The longer flood duration time proposed under the Expansion Project will negate the reductions in the predictions for the Approved Project relative to a full life span reservoir. As a result, the revised predictions for the mean methylmercury concentrations in lake trout are slightly higher (1.55 mg/kg ww compared to 1.34 mg/kg ww) under the Expansion Project. However, the revised 2019 mean prediction remains within the bounds of the uncertainty estimate around the 2017 weight-of evidence prediction (see **Figure 2**) and conclusions presented in the FEIS Addendum (Golder 2018) are still applicable.

## 5. RECOMMENDATIONS FOR RISK MANAGEMENT

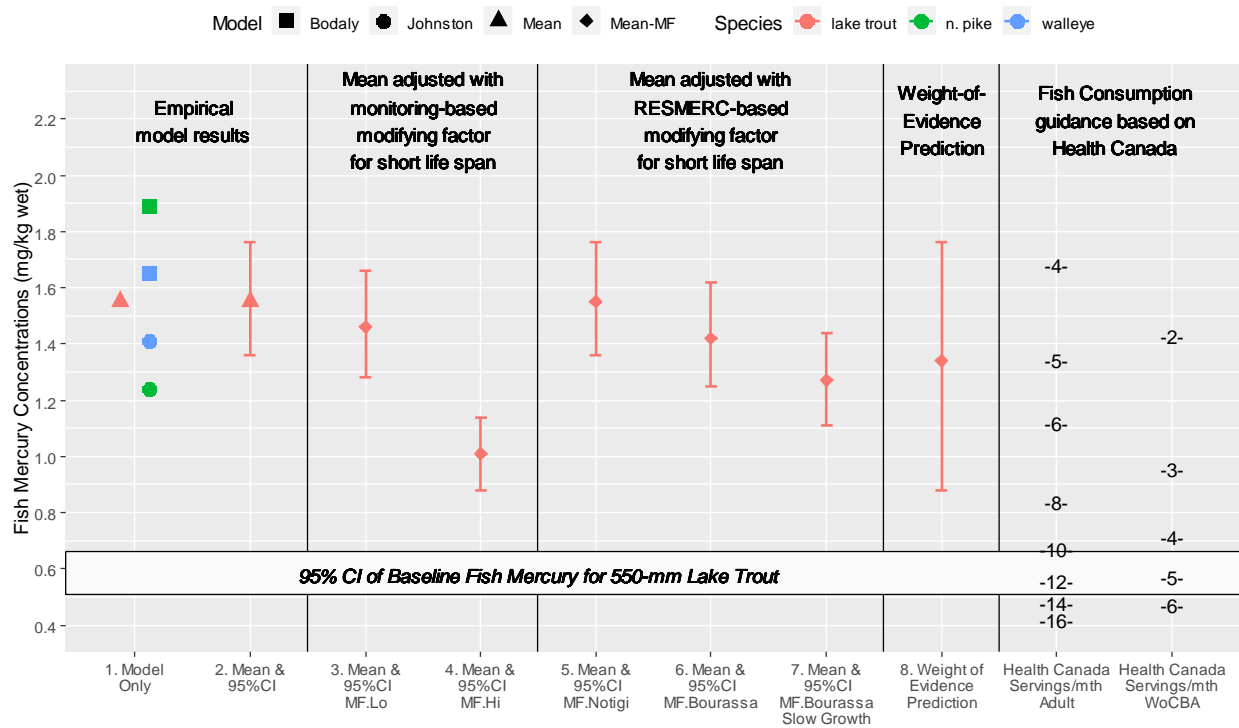
Agnico Eagle has committed to long-term monitoring of fish mercury concentrations (Agnico Eagle 2018, Mercury Monitoring Plan [MMP]) to be synchronized with the Environmental Effects Monitoring (EEM) Biological Monitoring Program. The MMP commits to further risk-based analyses if measured fish tissue concentrations exceed model predictions (i.e., approximately three times baseline fish mercury concentrations for a 550 mm lake trout). This approach is reasonable considering the low rates of fishing by local residents in the Project area and a non-fishing policy for workers while onsite (Agnico Eagle 2018).

## 6. REFERENCES

- Agnico Eagle Mines Ltd. 2018. Whale Tail Pit. CREMP Addendum – Appendix A: Mercury Monitoring Plan for Whale Tail South Area. Prepared by Agnico Eagle in July 2018.
- Azimuth Consulting Group Partnership (Azimuth). 2017. Whale Tail Pit Project: Predicted Changes in Fish Mercury Concentrations in the flooded area of Whale Tail Lake (South Basin). Prepared for Agnico-Eagle Mines in February 2017.
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- Golder Associates. 2018. Final Environmental Impact Statement Addendum - Whale Tail Pit Expansion Project. Submitted to Nunavut Impact Review Board by Agnico Eagle Mines Limited – Meadowbank Division.
- Hutchinson Environmental Sciences Ltd (HESL). 2016. Best Management Practice – Small Hydropower and Methyl Mercury. Prepared for Ontario Waterpower Association, February 2016.

## Figures

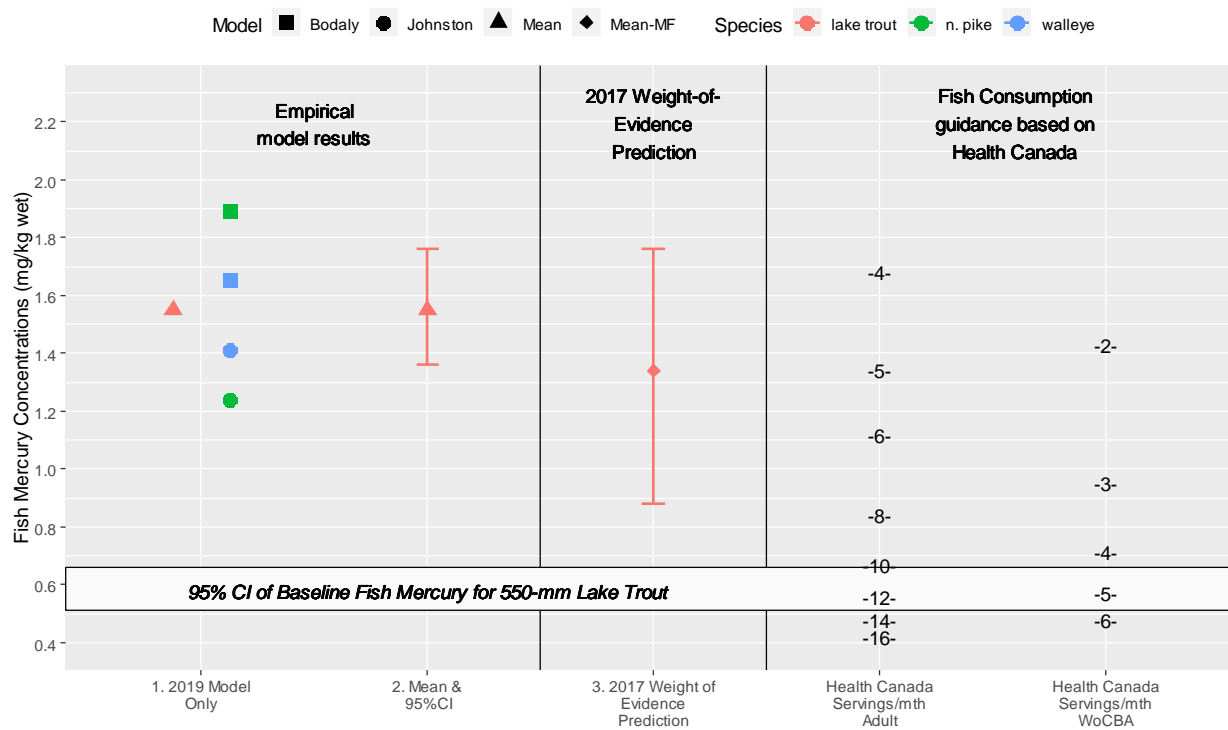
**Figure 1** 2017 predicted changes in lake trout (550 mm) mercury concentrations for the Approved Project for Whale Tail Lake (South Basin) relative to baseline conditions and fish consumptions (servings per month) guidance based on Health Canada



#### Characteristics of Proposed Whale Tail Impoundment

	Values	Units	Source
Flooded Terrestrial Area	1.58	km <sup>2</sup>	Golder (Appendix B)
Total Area	3.85	km <sup>2</sup>	Golder (Appendix B)
Percent Flooding	41	percent	calculated
Mean Annual Flow	0.00194	km <sup>3</sup> /yr	Golder (Appendix B)
Baseline Hg for 550-mm lake trout	0.58	mg/kg wet muscle	WTP Baseline
Weight for 550-mm lake trout	1800	g wet	WTP Baseline

**Figure 2.** 2019 Predicted changes in lake trout (550 mm) mercury concentrations for the proposed Expansion Project for Whale Tail Lake (South Basin) relative to baseline conditions and fish consumptions (servings per month) guidance based on Health Canada



#### Characteristics of Whale Tail Impoundment Expansion Project

	Values	Units	Source
Flooded Terrestrial Area	1.48	km <sup>2</sup>	Golder (Attachment 1)
Total Area	4.07	km <sup>2</sup>	Golder (Attachment 1)
Percent Flooding	36	percent	calculated
Mean Annual Flow	0.00201	km <sup>3</sup> /yr	Golder 2018 (FEIS)
Baseline Hg for 550-mm lake trout	0.58	mg/kg wet muscle	WTP Baseline
Weight for 550-mm lake trout	1800	g wet	WTP Baseline

Attachment 1:  
Whale Tail Lake (South Basin) – Flooding Schedule –  
Golder Associates

Date	Total Inflow (Net from Losses)	Elevation (masl)	WTS Storage (m <sup>3</sup> )	Total Flooded Area (m <sup>2</sup> )	Flooded Terrestrial Area (m <sup>2</sup> )	Flooded Aquatic Habitat (m <sup>2</sup> )
Jan-18	0	152.50	4,597,768	0	0	0
Feb-18	0	152.50	4,597,768	0	0	0
Mar-18	0	152.50	4,597,768	0	0	0
Apr-18	0	152.50	4,597,768	0	0	0
May-18	0	152.50	4,597,768	0	0	0
Jun-18	0	152.50	4,597,768	0	0	0
Jul-18	29,839	152.53	4,627,607	898,624	11,300	887,324
Aug-18	125,342	152.67	4,752,949	915,346	22,379	892,967
Sep-18	657,009	153.36	5,409,958	994,054	101,086	892,967
Oct-18	0	153.36	5,409,958	994,054	101,086	892,967
Nov-18	0	153.36	5,409,958	994,054	101,086	892,967
Dec-18	0	153.36	5,409,958	994,054	101,086	892,967
Jan-19	0	153.36	5,409,958	994,054	101,086	892,967
Feb-19	0	153.36	5,409,958	994,054	101,086	892,967
Mar-19	1,138,399	154.34	6,548,357	1,422,375	371,432	1,050,943
Apr-19	1,138,817	154.83	7,687,173	2,944,510	503,135	2,441,375
May-19	788,766	155.08	8,475,939	3,204,742	732,695	2,472,047
Jun-19	1,825,642	155.61	10,301,581	3,711,875	1,127,826	2,584,048
Jul-19	0	155.58	10,206,673	3,685,908	1,108,249	2,577,659
Aug-19	0	155.58	10,189,708	3,681,082	1,104,974	2,576,107
Sep-19	460,632	155.70	10,650,340	3,796,728	1,212,680	2,584,048
Oct-19	0	155.69	10,624,298	3,790,392	1,206,344	2,584,048
Nov-19	0	155.68	10,599,125	3,784,268	1,200,219	2,584,048
Dec-19	0	155.68	10,573,083	3,777,931	1,193,883	2,584,048
Jan-20	0	155.67	10,552,551	3,772,936	1,188,887	2,584,048
Feb-20	0	155.67	10,533,700	3,768,350	1,184,301	2,584,048
Mar-20	0	155.66	10,513,574	3,763,453	1,179,404	2,584,048
Apr-20	0	155.66	10,494,086	3,758,711	1,174,663	2,584,048
May-20	0	155.65	10,473,901	3,753,800	1,169,752	2,584,048
Jun-20	1,359,059	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-20	0	155.97	11,719,553	4,043,612	1,459,563	2,584,048
Aug-20	0	155.96	11,683,836	4,035,615	1,451,567	2,584,048
Sep-20	149,124	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-20	0	155.99	11,812,793	4,064,487	1,480,438	2,584,048
Nov-20	0	155.99	11,793,295	4,060,121	1,476,073	2,584,048
Dec-20	0	155.98	11,773,189	4,055,620	1,471,571	2,584,048
Jan-21	0	155.98	11,752,840	4,051,064	1,467,016	2,584,048
Feb-21	0	155.98	11,734,495	4,046,957	1,462,908	2,584,048
Mar-21	0	155.97	11,714,207	4,042,415	1,458,366	2,584,048
Apr-21	0	155.97	11,694,526	4,038,009	1,453,960	2,584,048
May-21	0	155.96	11,674,238	4,033,466	1,449,418	2,584,048
Jun-21	158,722	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-21	0	155.99	11,805,808	4,062,923	1,478,874	2,584,048
Aug-21	27,152	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Sep-21	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-21	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Nov-21	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Dec-21	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jan-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Feb-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Mar-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Apr-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
May-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jun-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-22	0	156.00	11,826,643	4,067,587	1,483,539	2,584,048
Aug-22	6,317	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Sep-22	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-22	0	156.00	11,814,980	4,064,976	1,480,928	2,584,048
Nov-22	0	155.99	11,796,939	4,060,937	1,476,889	2,584,048
Dec-22	0	155.99	11,778,352	4,056,776	1,472,727	2,584,048
Jan-23	0	155.98	11,760,676	4,052,818	1,468,770	2,584,048

Date	Total Inflow (Net from Losses)	Elevation (masl)	WTS Storage (m <sup>3</sup> )	Total Flooded Area (m <sup>2</sup> )	Flooded Terrestrial Area (m <sup>2</sup> )	Flooded Aquatic Habitat (m <sup>2</sup> )
Feb-23	0	155.98	11,744,700	4,049,242	1,465,193	2,584,048
Mar-23	0	155.97	11,727,024	4,045,284	1,461,236	2,584,048
Apr-23	0	155.97	11,709,955	4,041,463	1,457,414	2,584,048
May-23	0	155.96	11,692,279	4,037,505	1,453,457	2,584,048
Jun-23	140,681	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-23	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Aug-23	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Sep-23	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-23	0	156.00	11,815,830	4,065,167	1,481,118	2,584,048
Nov-23	0	155.99	11,798,762	4,061,345	1,477,297	2,584,048
Dec-23	0	155.99	11,781,085	4,057,388	1,473,339	2,584,048
Jan-24	0	155.98	11,763,409	4,053,430	1,469,382	2,584,048
Feb-24	0	155.98	11,746,887	4,049,731	1,465,683	2,584,048
Mar-24	0	155.97	11,729,211	4,045,774	1,461,725	2,584,048
Apr-24	0	155.97	11,712,142	4,041,952	1,457,904	2,584,048
May-24	0	155.97	11,694,466	4,037,995	1,453,946	2,584,048
Jun-24	138,494	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-24	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Aug-24	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Sep-24	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-24	0	156.00	11,815,830	4,065,167	1,481,118	2,584,048
Nov-24	0	155.99	11,798,762	4,061,345	1,477,297	2,584,048
Dec-24	0	155.99	11,781,085	4,057,388	1,473,339	2,584,048
Jan-25	0	155.98	11,763,409	4,053,430	1,469,382	2,584,048
Feb-25	0	155.98	11,747,434	4,049,854	1,465,805	2,584,048
Mar-25	0	155.97	11,729,818	4,045,910	1,461,861	2,584,048
Apr-25	0	155.97	11,712,689	4,042,075	1,458,026	2,584,048
May-25	0	155.97	11,695,012	4,038,117	1,454,069	2,584,048
Jun-25	137,948	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Jul-25	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Aug-25	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Sep-25	0	156.00	11,832,960	4,069,002	1,484,953	2,584,048
Oct-25	0	156.00	11,815,830	4,065,167	1,481,118	2,584,048
Nov-25	0	155.99	11,798,762	4,061,345	1,477,297	2,584,048
Dec-25	0	155.99	11,781,085	4,057,388	1,473,339	2,584,048
Jan-26	0	155.98	11,763,591	4,053,471	1,469,423	2,584,048
Feb-26	0	155.98	11,747,677	4,049,908	1,465,860	2,584,048
Mar-26	0	155.97	11,730,061	4,045,964	1,461,916	2,584,048
Apr-26	0	155.97	11,712,992	4,042,143	1,458,094	2,584,048
May-26	0	155.61	10,300,421	3,711,592	1,127,544	2,584,048
Jun-26	339,131	155.70	10,639,552	3,794,103	1,210,055	2,584,048
Jul-26	0	155.28	9,157,934	3,415,600	897,779	2,517,820
Aug-26	0	154.86	7,784,078	2,974,046	532,671	2,441,375
Sep-26	0	154.54	6,936,836	2,230,827	389,639	1,841,188
Oct-26	0	153.48	5,524,230	1,008,963	115,996	892,967
Nov-26	0	152.50	4,597,768	0	0	0