Amended Green Lake Flow Analysis

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Introduction:

A flow analysis was conducted by the Green Lake Water Power Company (GLWP) (dated 03-May-2024) to show that Reeds Brook is, at best, an intermittent stream. Land it drains should therefore not have been designated as critical habitat for Atlantic Salmon[1].

The 03-May-2024 flow analysis has subsequently been improved to increase its accuracy. It was then extended to provide guidance on different Green Lake management approaches to answer some of the Federal Energy Regulatory Commission's (FERC) questions in their Additional Information Request of 15-Jul-2024. This document describes the results of the improved and extended flow analysis. Appendix A of this document describes the complete flow analysis methodology.

Flow Analysis Improvements:

A flow analysis was performed as part of a US National Marine Fisheries Service study dispute. This analysis showed that summer flows at the Project are very low[2]. However, that flow analysis did not take evaporation into account. The basis of the flow values at the Project was flow data from USGS Gauge No. 01021480 on Old Stream near Wesley, Maine, scaled by the ratio of the drainage areas.

All significant Project flows come through Green Lake, so evaporation will affect available Project flows significantly during the summer months. The Old Stream watershed, above the USGS gauge, does not contain any lakes, so it would not be influenced by lake surface evaporation. However, the Old Stream flow would be affected by forest evaporation.

The 03-May-2024 flow analysis estimated the evaporation from Green Lake and removed it from the project flow estimates. The improved flow analysis described in Appendix A below takes the differences between forest evaporation and lake evaporation into account to improve the flow analysis accuracy. The details of this analysis are contained on a page of the overall flow analysis spreadsheet that is being filed with this document. Table 1 contains the estimated evaporation equivalent flows from evaporation at Green Lake during the summer months.

Green Lake Evaporation Equivalent Flows by Summer Month						
Month	May	June	July	August	September	October
Flow - cfs	18.43	19.46	20.79	18.01	12.83	7.05

Table 1: Estimated Green Lake evaporation equivalent flows.

A detailed flow analysis for the Project, that includes both lake and forest evaporation, is described in Appendix A. This flow analysis looked at daily flow values for 1998 through 2023 for the months May through October. Over 46% of the July, August, and September days are predicted to have no available flow. When Hatchery flows are included, the numbers get worse. When fish passage flows are considered, 83% of the days in July, 88% of days in August, and 84% of the days

[1] Accession # 20240506-5036 – GLWP Comments on USFWS EOS-IPaC Updated List
[2] Accession # 20200320-5152(34027600) – GLWP NMFS Dispute Letter – Appendix B

in September do not have the necessary flow. Table 2 contains a summary of results from the daily flow analysis.

	May	June	July	August	September	October
Count of Daily Values	775	750	775	806	780	806
Percent <0 cfs	0.4%	13.1%	46.1%	54.5%	46.5%	11.7%
Percent < 1 cfs	0.6%	14.9%	47.9%	56.2%	48.6%	13.5%
Percent <(Hatchery+1) cfs	2.6%	30.0%	58.5%	69.9%	68.3%	37.1%
Percent <(Hatchery+25) cfs	18.8%	52.7%	74.6%	83.3%	78.5%	55.2%
Percent <(Hatchery+50) cfs	37.8%	68.3%	83.6%	88.1%	84.7%	65.0%

Table 2: Percentage of days within each month target flows would not be met.

The flow analysis also determined what percentage of years would have periods of zero flow during each summer month. The flow analysis shows that 52% of the Junes and 30% of the Octobers had one or more days with zero available flow. For July through September, 76%, 88%, and 88% had one or more (often many) days with no available flow for any use. No minimum flow nor Hatchery flow amounts were subtracted from the available flows when testing for zero flow. Only 2 of the 26 years examined have no days of zero flow. Clearly, Reeds Brook would historically go dry during some period most summers. Reeds Brook is intermittent during normal summers, not just during summers with abnormally low precipitation. Table 3 below shows the results of this analysis.

Month		May	June	July	August	September	October
Month dry days by year:	1998	0	0	0	27	23	0
	1999	0	10	25	26	13	0
	2000	0	0	12	22	22	4
	2001	0	4	24	27	25	21
	2002	0	2	17	27	22	15
	2003	0	2	24	24	22	0
	2004	0	6	12	5	3	3
	2005	0	0	11	18	8	0
	2006	0	0	0	7	4	0
	2007	0	6	20	23	25	8
	2008	0	8	20	8	13	0
	2009	0	0	0	9	14	0
	2010	3	6	26	24	16	0
	2011	0	3	24	4	7	0
	2012	0	0	17	20	12	0
	2013	0	0	0	0	0	0
	2014	0	0	0	2	11	0
	2015	0	0	8	9	10	0
	2016	0	9	23	27	24	16
	2017	0	0	24	28	28	21
	2018	0	9	20	25	23	0
	2019	0	0	1	14	0	0
	2020	0	13	21	22	26	6
	2021	0	14	8	17	1	0
	2022	0	6	20	24	11	0
	2023	0	0	0	0	0	0
Count years with <=0 flow		1	14	20	24	23	8
Years		25	25	25	26	26	26
Percent with <=0 flow		4.0%	56.0%	80.0%	92.3%	88.5%	30.8%

Table 3: Yearly zero flow day counts and percentages.

Details on the data and calculations behind the above tables are in the spreadsheet filed with this document[3]. The flow analysis methodology is described in Appendix A below.

[3] Flow Analysis spreadsheet – Green_Lake_Flow_Analysis_May-Dec.xlsx filed with this submission.

Flow Analysis Extensions:

The daily flow values were used to calculate average flows for each month from May through December. These flow values were used to simulate lake levels with various numbers of generation days each month during this period. The control points were identified in the lake levels and used to determine when the Project should plan to generate and when maintenance should be planned.

The major control point during the May through December period was determined to be the summer minimum value at the end of August. To investigate this further, the average flow for each week from 01-July through 01-September was calculated. Another simulation was done using the weekly flows. Using this simulation it was determined that, on the average, the summer period from early or mid-July through mid-August was the best period for performing Project maintenance that is facilitated by warm, dry weather.

The details of the flow analysis extensions are included in the spreadsheet filed with this document.

APPENDIX A

GREEN LAKE DETAILED FLOW ANALYSIS

This appendix discusses the methodology used for the analysis of the flow available at Green Lake during the different months of the year. The numeric details of the analysis are included in a spreadsheet that has been filed with this submission.[4]

Green Lake Evaporation:

The first stage of the analysis determined an estimate of the effects of evaporation during the summer at Green Lake. This was done by consulting a National Weather Service (NWS) document *Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States*.[5] Two Maine sites are recorded in the NWS document: New Gloucester, ME and Caribou, ME. The historic Class A Evaporation Pan average readings for the months of May through October at the two sites were gotten from Table 1 in the NWS document. Green Lake is between the two Maine sites, so the readings were averaged to get estimated pan evaporation readings by month for Green Lake.

Another NWS document, *Evaporation Atlas for the Contiguous 48 United States*[6], was referenced to convert from measured pan evaporation to an estimate of lake evaporation. Map 4 in the document, *Map of Coefficients to Convert Class A Pan Evaporation to Free Water Surface Evaporation*, shows that the coefficient to use in the Green Lake area is approximately 78.5%.

Using the coefficient and the average pan reading for the two Maine sites, an estimate of the monthly Green Lake evaporation drop was calculated. Using the summer lake area, this drop was used to calculate the cubic-ft of water evaporated from Green Lake each month. Dividing by the number of seconds in each month gave the flow in cubic-ft per seconds (cfs) equivalent to the estimated evaporation at Green Lake. The estimated evaporation values at Green Lake are given in Table 1 in the main section of this document above.

Daily Summer Green Lake Flows:

During the flow analysis for Exhibit E of the Green Lake Project FLA, USGS flow gauge site No. 01021480 on Old Stream near Wesley, Maine was used to estimate flows into Green Lake. It was determined that the drainage area above the Old Stream gauge had similar characteristics and weather to the drainage area upstream of Green Lake[7]. Daily values from the gauge for 1998 through 2023 are available on a USGS site[8]. These values were retrieved for the months of May through October each year and entered into a spreadsheet organized by month. To scale values to the Green Lake watershed they were multiplied by 1.437, which is the ratio of the Green Lake

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[4] Flow Analysis spreadsheet – Green_Lake_Flow_Analysis_May-Dec.xlsx filed with this submission.
[5] NOAA Technical Report NWS 34, Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States, 1982 – https://www.weather.gov/media/owp/oh/hdsc/docs/TR34.pdf
[6] NOAA Technical Report NWS 33, Evaporation Atlas for the Contiguous 48 United States, 1982 – https://repository.library.noaa.gov/view/noaa/55711
[7] Accession No. 20220912-5163 - Green Lake Project FLA, Exhibit E, Section 5.3, Aquatic Resources
[8] Historical data for: USGS Gauge No. 01021480, Old Stream near Wesley, Maine – https://waterdata.usgs.gov/monitoring-location/01021480/

drainage area (minus the area of the actual lake itself) to the Old Stream drainage area above the USGS gauge. The precipitation recorded for each day at Green Lake was used to calculate the acre-feet of water deposited in the lake from rain that day. This amount of water was then converted to equivalent flow throughout the day and added to the scaled Old Stream flow for that day. The equivalent monthly evaporation flows, as described above, were subtracted from the scaled daily flow values. This resulted in an estimate of the daily summer inflows to Green Lake for 1998 through 2023.

Flows for the months of November and December were also calculated. Evaporation from the lake (or from forest) during these months is minor and ice becomes an issue, so the NWS does not publish pan evaporation readings for the Green Lake area for November and December. Because of this, the flows from Old Stream were scaled using the ratio of the total Green Lake drainage area to the Old Stream drainage area.

Comparisons were performed of the estimated daily flows against various target flows to determine the percentages of days within each summer month each target flow was not met. These results are presented in detail in the spreadsheet and in Table 2 above.

Counts were also done by month and year to determine what percentage of the years studied had no available flow for some number of days within a given month. Table 3 above contains yearly zero flow day counts and year percentages by month.