ONTARIO POWER GENERATION

Report

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Pickering Nuclear Generating Stations 2023 Impingement Monitoring Report

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Revision Summary

Revision Number	Date	Comments
R000	2024-05-31	Initial issue.

Pickering Lands Acknowledgement

The lands and waters on which the Pickering Nuclear Generating Stations (PNGS) are situated are within the traditional and treaty territory of the Williams Treaties First Nations, which includes Curve Lake First Nation, Hiawatha First Nation, Alderville First Nation, Chippewas of Beausoleil First Nation, Chippewas of Georgina Island First Nation, Chippewas of Rama First Nation, and the Mississaugas of Scugog Island First Nation.

The PNGS is within the territory of the Gunshot Treaty and the Williams Treaties of 1923. The Gunshot Treaty Rights were reaffirmed in 2018 in a settlement with Canada and the Province of Ontario.

To acknowledge the treaty and traditional territory, is to recognize the rights of the First Nations. It is to recognize the history of the land, predating the establishment of the earliest European colonies. It is also to acknowledge the significance for the Indigenous peoples who lived and continue to live upon it, to acknowledge the people whose practices and spiritualties are tied to the land and water and continue to develop in relation to the territory and its other inhabitants today.

Executive Summary

This report documents outcomes of impingement mitigation measures and impingement monitoring for the 2023 calendar year at the Pickering Nuclear Generating Station (PNGS). The report satisfies both condition 3.1 and condition 3.2.1 of the *Fisheries Act* Authorization for Pickering Nuclear Generating Station (PNGS), which was issued in January 2018, and amended on August 25, 2022.

The primary measure to avoid or mitigate fish impingement at PNGS is the Fish Diversion System (FDS). The FDS is a net comprised of 20 mesh panels that extend from the lake bottom to the water surface and encompass the intake. Connected, the FDS panels have a combined length of 610 m. There are primary and secondary skirts attached to the main net, which are designed to deploy if the float line of the main net sinks or is pulled beneath the surface. The FDS was installed and functioning from April 27th to November 1st, 2023. A portion of one panel of the FDS was temporarily opened on August 16th to accommodate the entry of a dredging barge into the forebay. An additional day of routine impingement monitoring was conducted during the FDS panel lowering, to assess impingement rates during this period. Results indicated that rates were normal.

Consistent with prior years, depth loggers, recording instantaneous depth at 15-minute intervals, were installed on the FDS to monitor the float line depth relative to the water surface. The loggers were attached to the main net, the primary skirt, and the secondary skirt. According to logger data, the secondary skirt on the East, West and South aspects were within the performance target of 0-30 cm of the water surface for 99.6%, 88.2% and 96.6% of the time respectively. The South secondary skirt was pulled to depths of 200-300 cm 4.5% of the time the FDS was installed.

Impingement monitoring occurred throughout the calendar year. Fish collected in bar screen and travelling screen bins during the sampling periods were identified, counted, and weighed to calculate impingement numbers, biomass and rates of biomass impinged per unit volume of intake water. In 2023, 304 bins were assessed. A total of 44 taxa, identifiable to the species level were impinged. The combined biomass of all species and ages impinged in 2023 was 2,511 kg, a rate equivalent to 0.51 kg per million cubic metres of station intake volume. The combined biomass of all species and ages impinged in 2022 and 2023 was similar, and below the two consecutive year all ages biomass threshold of 3,619 kg in each of the two years. The species with the largest all ages biomass impinged were Alewife (1,415.63 kg; 56.4% of total biomass) and Round Goby (262.70 kg, 10.5% of total biomass). Gizzard Shad was third accounting for 216.57 kg, 8.6% of total biomass.

There were no Species at Risk Act (SARA) Schedule 1 fish species observed impinged in 2023. Eleven American Eel, with a combined biomass of 14.6 kg, were documented during routine impingement monitoring. The extrapolated number of American Eel was 37 individuals with an estimated combined biomass of 49.53 kg. Fifteen Northern Pike were documented as impinged. The annualized estimate was 41 individuals with a combined biomass of 39 kg. There were no episodic fish impingement events in 2023.

1.0 INTRODUCTION

Ontario Power Generation Inc. (OPG) is the owner and operator of the Pickering Nuclear Generating Station (PNGS). PNGS, located on the north shore of Lake Ontario, has eight CANDU pressurized heavy water reactors (Units) on the site. Six Units are operating with two Units in Safe Storage state. PNGS has been operating safely and generating electric power since 1971. Large volumes of lake water are drawn through a surface water intake, for cooling purposes. An incidental effect of the taking of lake water for cooling is impingement of aquatic organisms.

A *Fisheries Act* Authorization for PNGS (Authorization) was issued to OPG on January 17, 2018 (DFO, 2018) with administrative amendments approved on August 25, 2022 (DFO, 2022a). The Authorization period extends from January 17, 2018, to December 31, 2028.

This report is being submitted to satisfy both condition 3.1 and condition 3.2.1 of the Authorization.

2.0 IMPINGEMENT AVOIDANCE AND MITIGATION MEASURES

2.1 Fish Diversion System

2.1.1 Design and Design Modifications

The Fish Diversion System (FDS) is the primary measure to avoid and mitigate fish impingement. The FDS design consists of a main net, which covers the entire depth of the water column, and a primary skirt and secondary skirt that normally float on the surface but self-deploy when water depths increase, or when portions of the main net are pulled further down into the water column.

There were no modifications made to the FDS design in 2023.

2.1.2 Installation and Removal

A complete check of the FDS system components was completed by OPG prior to installation.

Condition 2.1.1.1 of the Authorization requires installation of the main net by May 1 of each year and installation of the secondary skirt nets by June 1 of each year. OPG completed installation of the FDS main net by April 28, 2023; and the primary and secondary skirts were installed by May 18, 2023.

In 2023, PNGS executed dredging to remove sediment built up in the forebay. To provide dredge workboat access to the forebay for dredging, OPG proposed and received DFO agreement (DFO 2023b) to temporarily lower one panel of the FDS. The temporary panel lowering occurred over 4.75 hours on August 16th commencing at 11:45, with the lowered FDS panel closed by 16:30. Additional impingement monitoring was conducted that day to document potential changes in the rate of fish impingement during the panel opening. Beyond this exception, the FDS was in place and functioning from the date of installation to the start of

removal on November 1st, 2023. The FDS was fully removed from Lake Ontario by November 16th, 2023The start of removal date complies with condition 2.1.1.2 of the Authorization which requires the FDS, in its entirety, to remain in place and functioning until November 1st of each year.

2.1.3 Operations and Maintenance

While installed, the FDS was inspected and maintained on an ongoing basis. Inspection and maintenance consisted of:

- Visual checks of net floats by nuclear security officers to assess if main, primary, or secondary floats were below the surface.
- If visual checks indicated some of the floats were submerged, follow up checks were completed to determine whether additional maintenance was necessary.
- Multi-day per week subsurface inspection, hydraulic cleaning, and net maintenance were performed by the dive operations team of OPG's Advance Inspection Maintenance (AIM) Department.

2.1.4 Functionality and Performance

The Authorization requires OPG to demonstrate the FDS is functioning as intended. During operations, functionality and performance are measured through visual checks, inspections and maintenance as described above. If the FDS is not functioning as intended, the cause is investigated and addressed.

The performance of the net was assessed using loggers which record atmospheric pressure and convert pressure to depth based on the difference between the FDS logger and an onshore reference logger. The loggers are attached to the FDS while the main net and both skirts are installed. The loggers are removed, and data is downloaded, after the FDS is removed in November. A total of 21 depth loggers were installed on the FDS in 2023 to monitor the float line depth of the main net, primary skirt, and secondary skirt positions relative to the water surface. Loggers are installed on each of the three panel sections (south facing, west facing, and east facing). The main net has three loggers (one on each panel), the primary skirt has six loggers (two on each panel), and the secondary skirt has 12 loggers (4 on each skirt). All 21 loggers were retrieved.

For monitoring purposes, FDS performance is deemed acceptable when the loggers on the secondary skirt are at the surface or submerged to depths not exceeding 30 cm. Logger data, in conjunction with visual or field observations, are used to assess relative performance.

If the FDS fails in any capacity, repairs are expedited, and visual inspections are conducted to verify functionality has been restored.

Based on the combined visual checks, inspections, maintenance, and logger data evaluation, the FDS performance was acceptable. Factors that may have affected the FDS during 2023, were:

- On August 8th, a routine check reported the middle section of the west aspect of the FDS was not visible. The net was assessed, and the cause was attributed to high winds and algae loading causing a float line to detach. The OPG dive team completed cleaning of the FDS to remove excess algae, the team confirmed they reattached the float line, and verified the FDS was returned to proper functioning condition.

- Between August 19th and August 21st, routine checks reported the west side panel was submerged/degraded. The FDS was assessed, and the cause was attributed to wind conditions, current direction and heavy algae loading. The OPG dive team advised the FDS was still stopping fish during this time. As a precaution, extra maintenance, and algae removal was conducted. This brief period of degradation is reflected in Table 1 as the west side aspect time within 30 cm of the surface declines to 80.02% in the week of August 13th and 87.83% in the week of August 20th.

- On September 19th, a portion of the west panel was reported by security as submerged/degraded. The OPG dive team investigated and advised that no degradation was present.

- On September 29th, a routine check reported the FDS appeared to be detached from the east intake groyne. Upon assessment, the cause was determined to be excessive algae loading. The OPG dive team completed cleaning on the FDS, advised that no degradation was present, and verified the FDS was still functioning properly and stopping fish.

- As discussed previously, a panel of the FDS was temporarily opened on August 16th to allow vessel entry into the forebay.

Table 1 provides a weekly summary of the percentage of time that floats on the secondary skirt were between the surface and 30 cm depth, for each aspect of the FDS, for the period the FDS was in service, and loggers were attached to main, primary, or secondary skirts. As a benchmark, a 3% reduction equates to five hours of submergence below 30 cm. Table 2 indicates the South secondary skirt was pulled to depths of 200-300 cm 4.5% of the time the FDS was installed. This is reflected in Table 1 also, where the percentage of time the South aspect secondary skirt is above 30 cm depth declines during mid July to early September.

Table 1 Fraction of Week That Each Aspect of the FDS Secondary Skirt Was at The Surface or Not Greater Than 30 cm Below the Surface from May 10 to November 1, 2023

Week		Aspect		
Start	End	East	South	West
10-May-23	13-May-23	100.00%	100.00%	100.00%
14-May-23	20-May-23	90.44%	86.31%	78.87%
21-May-23	27-May-23	100.00%	100.00%	100.00%
28-May-23	03-Jun-23	100.00%	100.00%	100.00%
04-Jun-23	10-Jun-23	100.00%	100.00%	100.00%

Week		Aspect		
Start	End	East	South	West
11-Jun-23	17-Jun-23	100.00%	88.91%	100.00%
18-Jun-23	24-Jun-23	100.00%	96.32%	100.00%
25-Jun-23	01-Jul-23	100.00%	99.78%	100.00%
02-Jul-23	08-Jul-23	100.00%	100.00%	100.00%
09-Jul-23	15-Jul-23	100.00%	91.56%	100.00%
16-Jul-23	22-Jul-23	100.00%	79.06%	99.89%
23-Jul-23	29-Jul-23	100.00%	76.86%	99.67%
30-Jul-23	05-Aug-23	100.00%	76.60%	100.00%
06-Aug-23	12-Aug-23	99.96%	78.09%	92.75%
13-Aug-23	19-Aug-23	100.00%	69.61%	80.02%
20-Aug-23	26-Aug-23	100.00%	66.44%	87.83%
27-Aug-23	02-Sep-23	100.00%	67.04%	91.33%
03-Sep-23	09-Sep-23	100.00%	75.26%	96.35%
10-Sep-23	16-Sep-23	100.00%	83.85%	95.42%
17-Sep-23	23-Sep-23	100.00%	79.84%	95.83%
24-Sep-23	30-Sep-23	100.00%	89.62%	99.96%
01-Oct-23	07-Oct-23	100.00%	100.00%	100.00%
08-Oct-23	14-Oct-23	100.00%	100.00%	98.66%
15-Oct-23	21-Oct-23	100.00%	100.00%	99.78%
22-Oct-23	28-Oct-23	100.00%	100.00%	98.96%
29-Oct-23	01-Nov-23	100.00%	99.83%	100.00%

Figures 1, 2, and 3 illustrate the time series of average daily depth of the main net and the primary and secondary skirts of the East, South and West aspects of the FDS, respectively. Table 2 summarizes the portion of time, over the entire period the FDS was installed, that the loggers on each aspect were within different depth ranges. On the East aspect, the secondary skirt was located within 30 cm of the water surface 99.6% of the time and was within 50 cm of the surface 100% of the time. The secondary skirt on the West aspect was within 30 cm of the surface 96.6% of the time and within 50 cm of the surface 99.4% of the time. For the South aspect, the secondary skirt was within 30 cm of the water surface 88.2% of the time and within 50 cm of the surface 90.1% of the time.

The low fish impingement numbers during the period the FDS was installed (discussed in Section 4.0 Fish Impingement) indicate that the FDS was effective in mitigating fish impingement.

Figure 1 Daily average depth of FDS float lines on the East facing aspect.

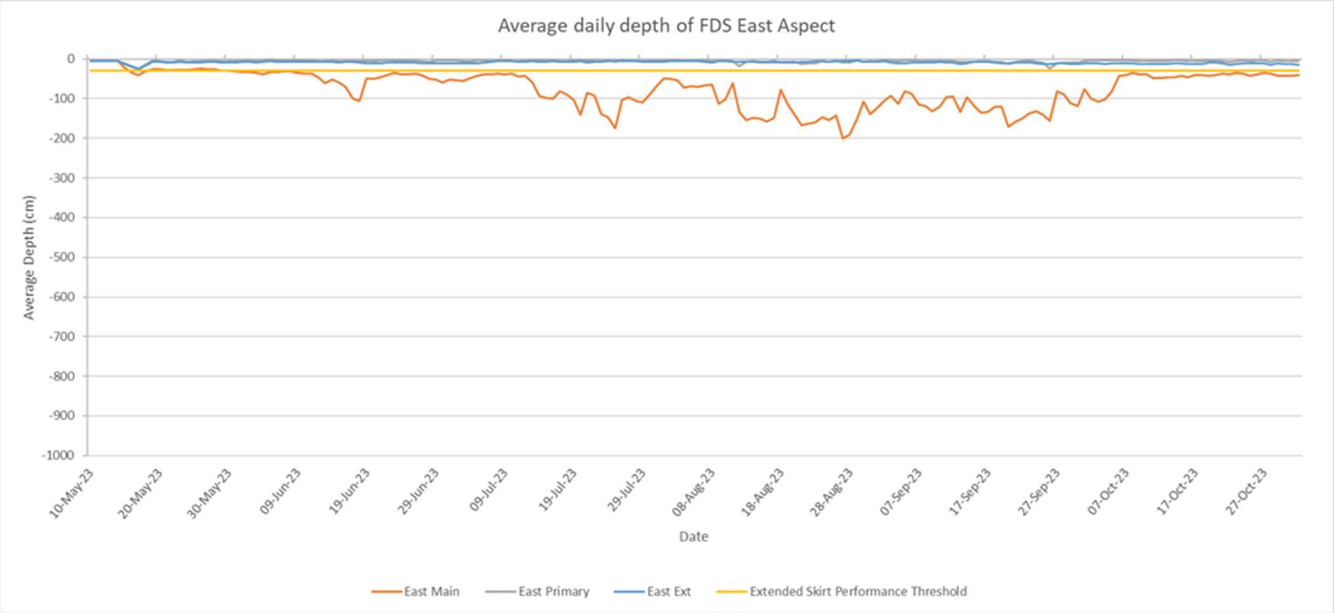

Figure 2 Daily average depth of FDS float lines on the South facing aspect.

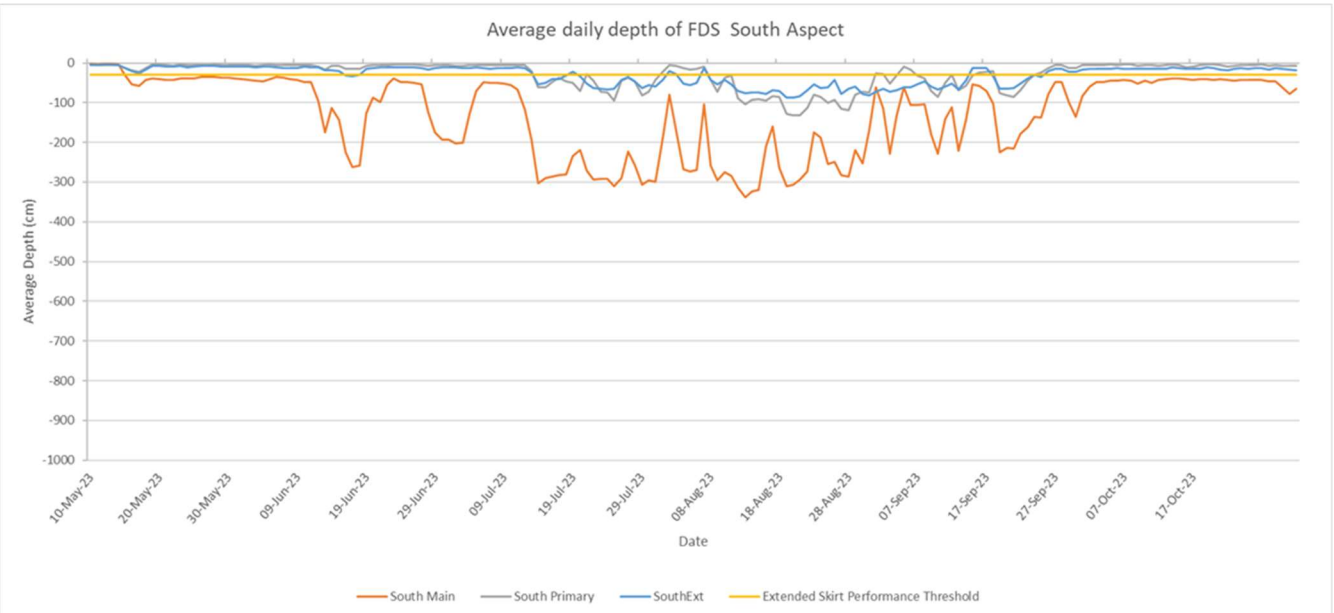

Figure 3 Daily average depth of FDS float lines on the West facing aspect.

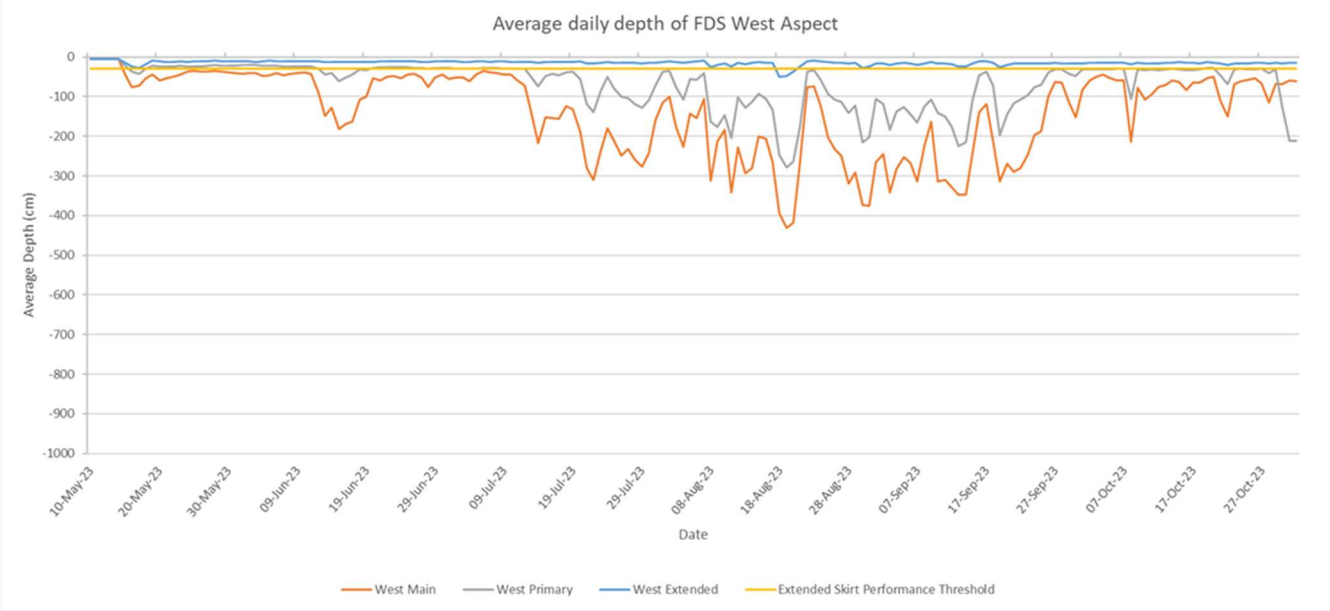

Table 2 Time frequency that primary and secondary float lines were in individual depth ranges based on depth logger data.

Depth below surface (cm)	Aspect and Net								
	East			South			West		
	Ext	Main	Primary	Ext	Main	Primary	Ext	Main	Primary
0-30	99.6%	12.5%	98.9%	88.2%	3.4%	81.6%	96.6%	3.5%	31.3%
30-50	0.4%	34.8%	0.8%	1.9%	33.9%	3.1%	2.8%	23.3%	40.6%
50-100	0.0%	24.8%	0.3%	1.4%	18.3%	4.4%	0.5%	29.6%	6.9%
100-200	0.0%	25.3%	0.1%	3.8%	13.2%	8.1%	0.1%	14.7%	10.7%
200-300	0.0%	2.5%	0.0%	4.6%	23.7%	2.7%	0.0%	15.7%	10.2%
300+	0.0%	0.0%	0.0%	0.0%	7.5%	0.0%	0.0%	13.3%	0.3%

3.0 IMPINGEMENT MONITORING

3.1 Monitoring Effort

Fish collected in bins during the sampling periods are identified, counted, and weighed to calculate impingement numbers, biomass and rate of biomass impinged per unit volume of intake water. Table 3 displays the sampling effort in 2023 and compares it with the previous

years. Results indicate that the fraction of time the bins were sampled in 2023 was 19% of the year compared to the 2013 to 2022 average of 16.8%.

Table 3 Comparison of yearly impingement monitoring effort during different monitoring periods.

Period	Year	# Bins Sampled	Total In-Service Bin Hours sampled	% of time sampled [2]
Pre-FDS	2003 - 2004	574	32,236	46%
	2006 [1]	234	25,420	36%
FDS Performance Evaluation	2010	1,505	37,904	54%
	2011	1,456	38,541	55%
	2012	1,181	29,415	42%
FDS Compliance Verification	2013	400	14,711	21%
	2014	353	12,178	17%
	2015	281	9,516	14%
	2016	338	12,012	17%
	2017	327	11,808	17%
Fisheries Act Authorization Monitoring	2018	354	11,495	16%
	2019	353	12,439	18%
	2020 [3]	334	10,374	15%
	2021 [3]	325	12,388	18%
	2022 [3]	302	10,574	15%
	2023 [3]	424	13,655	19%

Notes:

1. Monitoring in 2006 encompassed spring, summer and fall only.

2. Based on full year of service (52 weeks) for the 8 bin locations (70, 080 hours), which conservatively assumes all CCW screenhouses are always operating.

3. In 2020 to 2023, when a bin was out of service, but cooling water was still being drawn into the station, surrogate data was used to conservatively estimate impingement in these bins over the out-of-service period.

3.2 Unit Operating Status and Intake Volume

Table 4 provides the number of days that condenser cooling water (CCW) pumps were not operating at a specific Unit in 2023. Total CCW intake volume in 2023 was 4.88 billion cubic

metres. PNGS Unit 2 and Unit 3 are in a safe storage state and the CCW pumps are not used, as these Units are not generating power. When operating, each Unit normally has two CCW pumps running. CCW pumps are normally out of service only during planned unit outages, but on occasion are shut down during an unplanned outage or debris run as per procedure.

Table 4 CCW pump operating status in 2023.

Unit Operating Status	
Unit	**Days without operating CCW pumps at unit**
1	0
2	365
3	365
4	80
5	0
6	93
7	0
8	109

3.3 Unit Operating Status and Intake Volume

OPG undertakes data quality management of the fish impingement monitoring program at various steps during the program design, data collection, data entry, data analysis and results reporting process. Impingement monitoring followed OPG approved procedures, standards, guides, and manuals.

Fish were identified and enumerated by staff that are trained in identification of Ontario fish species. Photos of impinged fish that are measured and weighed were taken and archived to assist in subsequent species verification, if an identification was uncertain. If captured, identification of species listed in Schedule 1 of the Species at Risk Act (SARA) are verified by the Royal Ontario Museum (ROM) or other qualified third party; however, none were captured in 2023.In some cases, uncommon species or species that are particularly difficult to key to species level are also verified by ROM staff. There were two fish in 2023 that presented a challenge for identification. One fish, field identified in the Cisco genus (i.e. Cisco spp.), and one fish, field identified as an unidentified Redhorse (see Table 6 and Table 7), were frozen and will be transferred to the ROM for third-party verification of the species taxonomy.

Field results were entered into an impingement database and independently verified. The total number of routine monitoring samples and monitoring hours for each month at each bin monitoring location was reviewed. In 2023, 52 routine monitoring sample events were completed, and 1 additional non routine sampling event was completed on August 16th to capture the period when the FDS was opened for the dredging barge to enter the forebay (as mentioned in section 2.1.2). Since the CCW pumps were operational, or service water supply to the station was still being obtained, impingement for these sampling periods was estimated

using sample data obtained from the neighbouring unit, for the same screen type. For 012 and 034 trash screens, surrogate impingement values from 056TS were used, which is likely to yield conservative estimates since historic data indicates that higher impingement biomass is observed in 058 units than 014 units. When surrogate data was applied, bin sampling and fish data were assumed to be equal to the referenced unit while intake volumes referenced unit specific volumes (i.e., the original intake volumes for the out-of-service unit and screen type were still applied to the impingement calculations).

3.3.1 Atypical Impingement Volumes that were Potential Data Outliers

Once all entered data was validated, queries in the database that are designed to calculate impinged numbers and biomass for each bin sampled during routine monitoring were run. Except for bins using surrogate data, the total count and total biomass in each bin for each monitoring event was reviewed and compared against historic (2010-2018) rates, standardized to a 24-hour collection period, to flag potential outliers. Four outliers above the bin specific threshold were observed (Table 5) but all were retained in the analysis.

Table 5 Individual bins identified as having count or biomass estimates that were potential data outliers.

Date	Bin Location	Calculated 24 hr. Count (#)	2010-2018 Count Outlier Threshold (g)	Calculated 24 hr. Weight (g)	2010-2018 Weight Outlier Threshold (g)
16-Jan-23	12 BS	4	92	8,613	3,622
19-Jun-23	12 TS	1,280	421	7,568	5,214
19-Jun-23	34 TS	1,280	549	7,568	6,509
26-Jun-23	12 TS	1,280	421	7,568	5,214
26-Jun-23	34 TS	1,280	549	7,568	6,509
14-Aug-23	12 TS	956	421	8,816	5,214
14-Aug-23	34 TS	956	549	8,816	6,509
10-Oct-23	34 TS	14,911	549	29,321	6,509
6-Nov-23	12 TS	652	421	4,504	5,214
6-Nov-23	34 TS	652	549	4,504	6,509

3.4 Impingement Estimate

The formulas used to calculate monthly impingement and extrapolate it over the year are provided in Appendix A.

4.0 2023 FISH IMPINGEMENT

4.1 All Species and Life Stages

Figure 4 and Table 6 provide the biomass of fish impinged in 2023. The quantity of fish impinged is provided in Table 7 and the rate of biomass impinged per unit volume of intake water used by the CCW pumps is provided in Table 8. The Authorization value is presently based on Age-1 equivalent impingement and entrainment estimates for 23 modelled species only, not the all-species, all-age impingement biomass estimate provided in this report. The 23 species are identified with an asterisk (*) beside the species name in Table 6 and Table 7.

Impingement samples were collected on August 16th, 2023, and used to estimate relative impingement rates during the period of FDS temporarily lowering. As this time was less than 24-hrs in duration, the data was standardized to a 24-hr sampling period. The biomass impinged ranged from 0.04 to 1.22 kg / day. Bin estimates were all below their bin specific count and biomass outlier thresholds. Therefore, the temporary lowering of one FDS panel did not result in any abnormal impingement rates.

Figure 4 illustrates cumulative monthly biomass of impinged fish of all species and ages. The combined biomass of all species and ages impinged in 2023 was 2,511 kg, a rate equivalent to 0.51 kg per million cubic metres of station intake volume.

Figure 4 Annual cumulative biomass (kg) of fish of all species and ages impinged from 2018-2023.

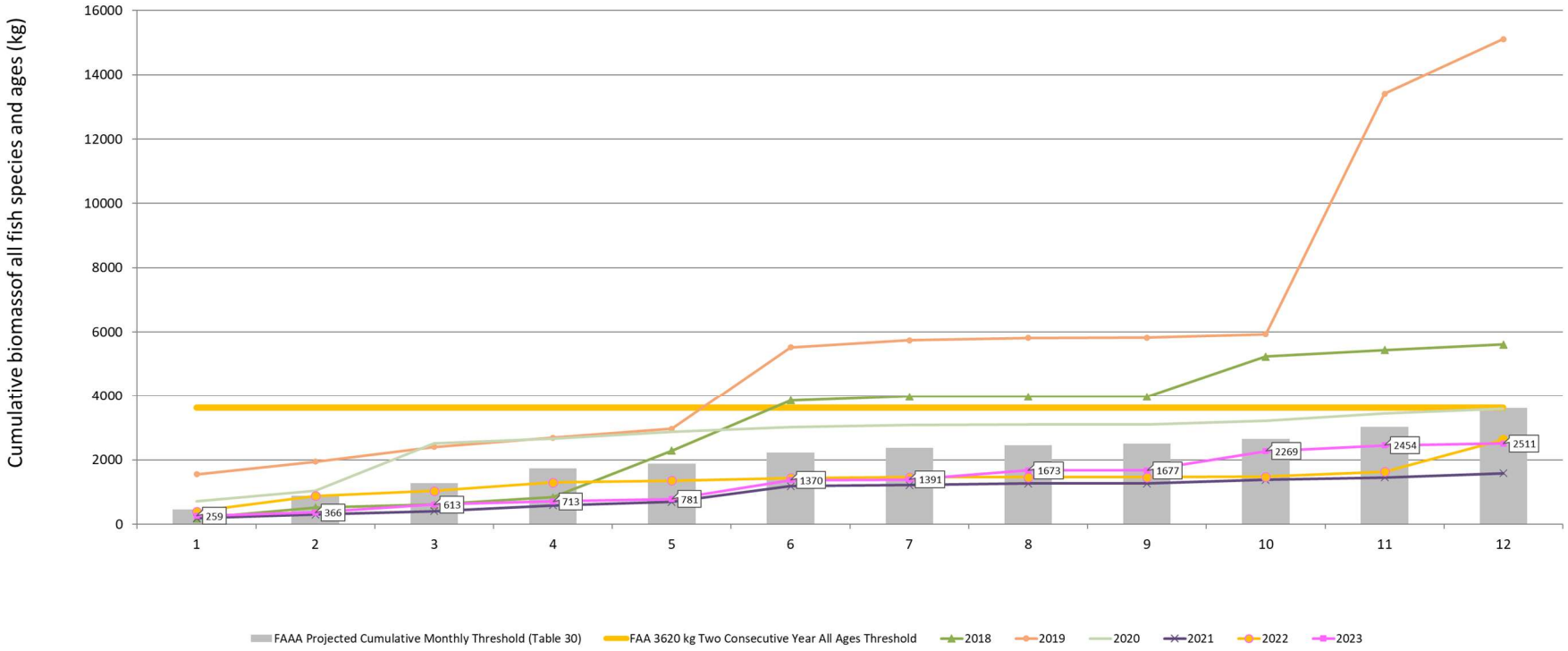

Table 6 Monthly biomass and annual fish impinged (kg) at Pickering Nuclear Generating Station in 2023.

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Alewife*	5.00			0.55	3.69	467.34	13.95	255.75	0.53	569.22	99.46	0.15	1415.63
American Brook Lamprey												0.02	0.02
American Eel	26.88	3.93									4.46	14.26	49.53
Atlantic Salmon*			0.85	0.02							0.58	0.27	1.72
Black Bullhead*	1.25	0.78						0.45					2.48
Black Crappie		0.20										0.24	0.44
Bluegill*	2.71	3.68	4.90	2.43	0.48	0.83	0.23		0.31	2.76	6.45	3.24	28.03
Bowfin			5.72										5.72
Brown Bullhead*	3.74	1.63	12.24	2.68	0.56	32.21			0.78	0.88	5.86	5.25	65.83
Brown Trout			1.13										1.13
Channel Catfish				0.51							1.21		1.72
Chinook Salmon*	1.31		0.63			1.13							3.07
Cisco spp.												2.25	2.25
Coho Salmon			0.08				0.10						0.17
Common Carp*	40.53	58.70	40.18										139.40
Emerald Shiner*	18.37	0.97	0.48	1.36	0.01	0.07		0.25	0.09	0.01	4.35	1.81	27.77
Gizzard Shad*	42.43	22.91	104.58	6.36							25.36	14.92	216.57
Lake Whitefish											2.95		2.95
Largemouth Bass*											3.94	0.30	4.24
Logperch				0.27		0.06							0.33
Longnose Dace			0.01										0.01

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Longnose Gar			1.32								0.92		2.24
Longnose Sucker		2.08											2.08
Mottled Sculpin				1.37									1.37
Northern Hog Sucker	5.05												5.05
Northern Pike*	15.70		18.08								2.66	2.94	39.37
Pumpkinseed	1.89	1.14	0.35		0.03			0.23	0.50		2.10	2.12	8.38
Rainbow Smelt*	3.23	1.59	25.99	29.37	1.95	4.40		0.01		0.66	1.53	0.70	69.42
Rainbow Trout*	15.28		23.06					3.77					42.11
Rock Bass		0.15											0.15
Round Goby	6.80	1.32	0.95	41.35	59.76	82.11	6.46	21.57	1.81	16.11	20.67	3.77	262.70
Round Whitefish*		1.84											1.84
Sea Lamprey	10.20	0.80	1.66	0.90									13.56
Short Jaw Cisco			0.99										0.99
Shorthead Redhorse				0.49									0.49
Silver Shiner	0.11	0.05										0.19	0.34
Slimy Sculpin											0.41		0.41
Smallmouth Bass*	17.29	2.25								0.96	0.51	1.07	22.08
Three-spine Stickleback*	11.97	1.44	3.04	3.42	1.04	1.19					0.04	0.64	22.79
Unid													0.00
Unid-Redhorse Species	0.23										0.62	0.04	0.89
Walleye*	13.52	0.19	0.21										13.92

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
White Bass*	0.02										0.19		0.21
White Perch*										0.15		2.59	2.74
White Sucker*	14.16	0.97	0.02	0.75						0.81	0.41		17.12
Yellow Perch*	1.40		0.91	8.41				0.03		0.35	0.45	0.14	11.68
Total (#)	259.05	106.61	247.36	100.24	67.53	589.34	20.74	282.05	4.03	591.92	185.15	56.90	2510.91

Table 7 Number of fish impinged at Pickering Nuclear Generating Station in 2023.

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alewife*	82			147	567	100,269	1,404	25,636	24	280,247	14,833	24	423,233
American Brook Lamprey												4	4
American Eel	22	3									4	8	37
Atlantic Salmon*			3	9							4	12	27
Black Bullhead*	88	41						6					135
Black Crappie		3										4	7
Bluegill*	241	164	328	124	26	31	6		8	115	174	64	1,282
Bowfin			3										3
Brown Bullhead*	50	43	186	160	48	212			36	7	70	40	851
Brown Trout			3										3
Channel Catfish				18							37		55
Chinook Salmon*	134		44			24							202
Cisco spp.												4	4
Coho Salmon			14				6						20
Common Carp*	10	3	8										21
Emerald Shiner*	3,850	166	146	246	5	24		53	58	35	916	446	5,944

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gizzard Shad*	88	27	93	7							240	16	472
Lake Whitefish											8		8
Largemouth Bass*											37	4	41
Logperch				18		15							33
Longnose Dace			3										3
Longnose Gar			6								4		10
Longnose Sucker		3											3
Mottled Sculpin				53									53
Northern Hog Sucker	41												41
Northern Pike*	10		13								11	15	49
Pumpkinseed	53	41	5		5			6	8		52	51	221
Rainbow Smelt*	602	314	2,997	4,924	411	697		6		292	170	144	10,558
Rainbow Trout*	7		8					40					55
Rock Bass		3											3
Round Goby	760	112	134	5,694	8,021	7,910	1,518	3,992	429	3,924	2,770	331	35,594
Round Whitefish*		5											5
Sea Lamprey	34	4	7	4									49
Short Jaw Cisco			3										3
Shorthead Redhorse				4									4
Silver Shiner	9	3										43	55
Slimy Sculpin											4		4
Smallmouth Bass*	13	3								18	7	16	57
Three-spine Stickleback*	8,211	1,004	1,883	2,165	665	748					33	359	15,067
Unid		3											3
Unid-Redhorse Species	4										11	4	19
Walleye*	3	9	3										15
White Bass*	4										30		33

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
White Perch*										18		70	87
White Sucker*	188	19	7	11						42	4		271
Yellow Perch*	75		78	164				6		35	4	16	377
Total (#)	14,576	1,978	5,973	13,750	9,747	109,930	2,934	29,746	562	284,733	19,421	1,673	495,021

Notes:

1. The extrapolated number of fish per month is rounded to the nearest whole number.

Table 8 Impinged biomass, intake volume and impingement rate by volume.

Year	Annual Biomass (kg)	Annual Station Flow (10^9 m^3)	Annual Rate (kg/million m^3)
2003/2004	18,214	4.19	4.35
2010	4,617	4.88	0.95
2011	4,012	4.77	0.84
2012	1,706	4.94	0.35
2013	2,926	4.86	0.6
2014	3,953	4.82	0.82
2015	8,553	5.07	1.69
2016	1,035	4.7	0.22
2017	1,217	5.05	0.24
2018	5,616	4.88	1.15
2019	15,083	5.27	2.86
2020	3,525	4.91	0.72
2021	1,585	5.02	0.32
2022	2,479	4.99	0.50
2023	2,511	4.88	0.51

Note: [1] 6,000 kg of impingement in 2015 was attributable to a single event in May 2015 caused by an opening in the net seam. Excluding this event, the impingement rate in 2015 was 2,553 kg or 0.50 kg/million m^3 of station intake volume.

4.2 Species Impinged in 2023 to be Included in Age-1 Equivalency Estimates

The Authorization value is based on the modeled Age-1 equivalent biomass for 23 species which were used in the Fisheries Act Application for Authorization (FAAA) (OPG, 2017). In 2023, 21 of the 23 species were impinged. Freshwater Drum and Lake Trout were not observed in impingement monitoring in 2023. The combined biomass impinged for the 21 species was 2,148.02 kg, representing 85% of the total biomass impinged

4.3 Regulated and Other Aquatic Invasive Fish and Mussel Species

One regulated invasive species, Round Goby (204.98 kg extrapolated value) was impinged in 2023. Round Goby is an invasive species listed in Part 2 of SOR/2015-121 Aquatic Invasive Species Regulations and is a Species Subject to Prohibitions and Controls. In Ontario, the Aquatic Invasive Species Regulations also applies to Grass Carp, Bighead Carp, Silver Carp, Black Carp, Zebra Mussel, Quagga Mussel, any species of the Snakehead family, Ruffe, Rudd, and Tubenose Goby. Zebra Mussel and Quagga Mussel are impinged consistently, but like Round Goby these species are not included in estimates of serious harm to fish due to impingement.

Though Round Goby is included in impingement estimates for all species and age classes, DFO agreed in their review of the FAAA and the Authorization that they are not included in estimates of Age-1 equivalent losses.

4.4 Species at Risk Act Schedule 1 Fish Species

There were no SARA Schedule 1 fish species observed impinged in 2023.

4.5 Endangered Species Act Species at Risk in Ontario List fish species

American Eel is a species listed as Endangered in the Species at Risk in Ontario (SARO) List of the Endangered Species Act (ESA).). During 2023, 11 American Eel, with a combined biomass of 14.6 kg, were documented during impingement monitoring. All American Eel were impinged when the FDS was removed, with seven in January, one in February, one in November, and two in December. The extrapolated number of American Eel impinged in 2023 was 37 individuals with an estimated combined biomass of 49.53 kg.

4.6 Northern Pike

Table 9 summarizes the extrapolated annual number and extrapolated annual biomass of Northern Pike impingement since 2010. In 2023, OPG documented 15 Northern Pike during impingement monitoring with a combined mass of 13.26 kg. All were captured outside of the period the FDS was installed. The annualized estimate of impingement in 2023 was 49 individuals with a combined biomass of 39.37 kg.

Table 9 Extrapolated number and biomass of Northern Pike impinged annually, 2010-2023.

Year	Annual Number	Annual Biomass(kg)
2010	50	51
2011	46	120
2012	46	133
2013	58	188
2014	36	112
2015	27	70
2016	12	31
2017	33	21
2018	67	106
2019	92	145
2020	49	99
2021	41	91
2022	74	130
2023	41	39

4.7 Episodic Fish Kill Events

There were no episodic fish kill events in 2023 or over the Authorization period to date..

5.0 IMPINGEMENT TRENDS

5.1 Comparison with Authorization and FAAA Impingement Predictions

OPG's FAAA estimates were used to define an annual all ages impingement threshold of 3,619 kg in each of two consecutive years of impingement monitoring during the Authorization period. Condition 3.2.1.1 of the Authorization states that if this threshold is exceeded, communications with DFO should be held to discuss the root causes, with the potential need

for subsequent adaptive management. This commitment was included as a condition of the Authorization.

The impingement estimates for both 2022 and 2023 were below 3,619 kg. Therefore, impingement is below the two-year threshold.

5.2 Trends

The 2023 impingement rate was 0.51 kg/million cubic metres of CCW intake volume, which is below the rolling (2018-2023) five-year mean of 1.01 kg/million cubic metres of CCW intake volume, and ten-year mean of 0.90 kg/million cubic metres of CCW intake volume.

The species with the largest all ages biomass impinged were Alewife (1,415.63 kg; 56.4% of total biomass) and Round Goby (262.70 kg, 10.5% of total biomass). Except for 2014 and 2022, Gizzard Shad and Alewife have been the top two species impinged since 2013. In 2023, Gizzard Shad impingement fell to 216.57 kg, ranking third, and accounted for 8.6% of the impinged biomass.

5.3 Uncertainty

The following are the primary factors that contribute to uncertainty in the impingement estimates:

- There is uncertainty associated with the performance of the FDS. Depth loggers are used to assess the performance of the FDS over the installation period.
- There is uncertainty associated with numbers and species of fish that may be present in the forebay prior to FDS installation, and the number of additional fish that may enter the forebay if performance is affected by natural causes, tears, or small holes.
- There is a lag effect between the period that fish enter the forebay and the time they may be impinged. Some large fish with strong swimming capabilities may never be impinged and could leave the forebay after the FDS is removed. The lag effect and how this affects monthly impingement numbers and biomass varies between species and life stages.
- There is uncertainty associated with the identification of fish sampled from the bins (physical counting, length/weight measurements, subsamples, and identification), largely due to the physical condition of the fish after being impinged. To mitigate misidentification, sampling practices have procedures and monitoring is undertaken by qualified individuals that have completed the ROM fish identification course. Photos are taken of collected fishes to aid in validation. If misidentification is not corrected during quality management review, this may result in small errors associated with the individual species data reported in Tables 6 and 7.There is uncertainty associated with missing or incomplete data from field forms. This has been minimized by self checks, peer checks and follow up communications. If necessary, missing values for certain parameters (e.g., fish length, weight) can be estimated using descriptive statistics calculated or interpreted from available data, as described in Section 3.4.

- There is uncertainty in extrapolating data for periods that bins are out-of-service and non-sampled time periods. Surrogate data was used to conservatively estimate impingement for out-of-service periods. There is also high natural variability from season to season. This uncertainty has been reduced by extrapolating data within each month, and appropriate flagging, verification, and treatment of outliers in the database and associated number and biomass calculations.

- There is high natural variability from day to day, which is largely influenced by environmental factors and movement of fishes through the zone affected by the PNGS intake. The variability associated with this is real and cannot be reduced through increased sampling effort. Typically, impingement rates are more stable when the FDS is installed as the FDS deters migration of many species and life stages into the intake forebay. However, Monte Carlo simulations on the 2011 data indicated that reducing the sampling frequency from five samples to one sample per week would have minimal impact on the 95% confidence intervals.

6.0 CONCLUSION

This report documents outcomes of impingement mitigation measures and impingement estimates for the 2023 calendar year and is submitted to satisfy both condition 3.1 and condition 3.2.1 of the amended Authorization.

OPG completed installation of the FDS main net prior to May 1, 2023, the primary and secondary skirts before June 1, and commenced removal after November 1, all in compliance with condition 2.1.1.2 of the Authorization.

All ages impingement in 2023 was 2,511 kg. 2022 and 2023 impingent remained below the two consecutive year threshold of 3619 kg.

8.0 REFERENCES

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Appendix A: Estimation of Annual Impingement

The following formulas were used calculate monthly impinged biomass for each species:

Monthly annualized biomass impinged for species x =

$$\sum_{Locn=1\ to\ 8} \left[\left(\sum_{Bin=1}^{j} \sum_{Fish=1}^{i} Measured\ Fish\ Weight \right) * \frac{Total\ Flow}{SampledFlow} \right]$$

Where:

- Fish = Record of individual fish in bin_j
- i = Total number of fish of species x in bin_j
- Bin = Record of bin sampled at a specific bin location
- j = Number of bins sampled at single bin location in one month
- Locn = one of 8 screenhouse bin locations
- Total Flow = Total monthly condenser cooling water and reactor building service water flow at the bin location
  = $\sum_{\text{Day}=1}^{\#\ \text{Days in Month}} \text{Hourly Flow}_{\text{day,locn}} * 24\ \text{hr}$
- Sampled Flow = Total flow at the bin location for the sampled time periods
  = $\sum_{\text{bin}=1\text{j}} \text{Hourly Flow}_{\text{day,locn}} * \#\ \text{Hours bin j was in Service}_{\text{day,locn}}$