ONTARIO POWER GENERATION

Report

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Pickering Nuclear Generating Stations 2022 Impingement Monitoring Report

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Revision Summary

Revision Number	Date	Comments
R000	2023-03-17	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 2022 calendar year. 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. Primary and secondary skirts are attached to the main net and are designed to deploy if the float line of the main net sinks or is pulled beneath the surface. The FDS was in place and functioning from April 28 to November 3, 2022.

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 aspect was within the target 30 cm of the water surface 76.78% , 55.39% and 89.5%,50.98% of the time, but within 50 cm of the surface >95% of the time on all aspects.

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 2022, 302 bins were assessed.

A total of 35 taxa, identifiable to the species level were impinged. The combined biomass of all species and ages impinged in 2022 was 2,478.96 kg, a rate equivalent to 0.5 kg per million cubic metres of station intake volume. The combined biomass of all species and ages impinged in 2021 and 2022 were below the two consecutive year threshold of 3619 kg in each of the two years. The species with the largest all ages biomass impinged were Gizzard Shad (902.49 kg; 36.4% of total biomass) and Common Carp (315.27 kg, 12.7% of total biomass).

There were no Species at Risk Act (SARA) Schedule 1 fish species observed impinged in 2022. Thirty American Eel, with a combined biomass of 41.9 kg, were documented during impingement monitoring. The extrapolated number is 160 individuals with an estimated combined biomass of 225.89 kg. Fifteen Northern Pike were documented. The annualized estimate was 74 individuals with a combined biomass of 129.74 kg. There were no episodic fish kill events in 2022.

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 2022.

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 net by June 1 of each year. OPG completed installation of the FDS main net by April 28, 2022; and the primary and secondary skirts were installed by May 18, 2022.

In 2022, PNGS executed a vacuum building outage, a maintenance exercise which only occurs approximately every ten years. During the vacuum building outage, all six units were powered down, and several CCW pumps were taken offline, substantially reducing intake cooling water volumes. In 2022, during the VBO, portions of the intake forebay were also dredged after obtaining regulatory approvals. To provide dredge work boat access to the forebay, OPG proposed and received DFO agreement (DFO 2022b) to temporarily open one panel of the FDS. The temporary panel opening occurred from October 22 to October 23, 2022. Beyond this exception, the FDS was in place and functioning from the date of

installation to the start of removal on November 3, 2022. The FDS was removed from the Lake by mid November. The 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; and,
- 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 twenty-one depth loggers were installed on the FDS in 2022 to monitor the depth of the main net, primary skirt, and secondary skirt float lines relative to the water surface. There are four loggers attached to each aspect of the secondary skirt, two loggers to each aspect of the primary skirt and one logger on each aspect of the main net. All 21 loggers were retrieved however the South-Main logger malfunctioned early in the season and the data collected from this logger was therefore excluded from analyses.

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 2022, were:

- On June 18, a portion of the west panel was degraded. OPG dive operations advised that high northwest winds along with current and some algae loadings were contributing factors.

- On September 9, a routine check revealed an intermittent submersion of one or more float lines along the south aspect of the FDS. The net was assessed, and the cause was attributed to a strong west wind, current, and elevated algal load at the base of the net.

- As discussed previously, a panel of the FDS was temporarily opened on October 23 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 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 18 to November 3, 2022.

Week		Aspect		
Start	End	East	South	West
18-May-22	21-May-22	100.00%	100.00%	100.00%
22-May-22	28-May-22	99.96%	98.33%	92.56%
29-May-22	04-Jun-22	100.00%	94.12%	78.13%
05-Jun-22	11-Jun-22	93.12%	44.64%	39.10%
12-Jun-22	18-Jun-22	94.01%	70.80%	46.17%
19-Jun-22	25-Jun-22	98.40%	76.86%	40.63%
26-Jun-22	02-Jul-22	98.62%	73.70%	68.82%
03-Jul-22	09-Jul-22	100.00%	100.00%	100.00%
10-Jul-22	16-Jul-22	77.42%	41.63%	51.56%
17-Jul-22	23-Jul-22	88.95%	48.66%	56.73%
24-Jul-22	30-Jul-22	85.68%	51.12%	47.92%
31-Jul-22	06-Aug-22	77.38%	26.04%	45.72%
07-Aug-22	13-Aug-22	84.52%	37.05%	58.85%
14-Aug-22	20-Aug-22	85.94%	63.02%	75.41%
21-Aug-22	27-Aug-22	71.65%	53.94%	61.12%
28-Aug-22	03-Sep-22	78.24%	36.76%	42.37%
04-Sep-22	10-Sep-22	79.65%	35.42%	51.60%
11-Sep-22	17-Sep-22	68.49%	29.72%	70.35%
18-Sep-22	24-Sep-22	56.25%	41.96%	56.96%
25-Sep-22	01-Oct-22	76.38%	44.20%	56.81%

Week		Aspect		
Start	End	East	South	West
02-Oct-22	08-Oct-22	74.22%	43.15%	53.72%
09-Oct-22	15-Oct-22	33.48%	27.68%	22.14%
16-Oct-22	22-Oct-22	24.81%	17.34%	28.61%
23-Oct-22	29-Oct-22	22.58%	3.16%	19.01%
30-Oct-22	03-Nov-22	46.88%	25.39%	27.73%

Figure 1 to 3 provide the time series of average daily depth of the East, South and West aspects of the FDS, respectively. Table 2 provides a summary of the depth data as a frequency distribution during the monitoring period. On the East aspect, the secondary skirt was located within 30 cm of the water surface 76.78% of the time and was within 50 cm of the surface approximately 99.65% of the time. The secondary skirt on the West aspect was within 30 cm of the surface 55.39% of the time and within 50 cm of the surface 96.21% of the time. For the South aspect, the secondary skirt was within 30 cm of the water surface 50.98% of the time and within 50 cm of the surface 96.21% of the time. The primary skirt was located within 30 cm of the water surface, 89.7% and 67.45% of the time for the East and West aspects, respectively. The South primary skirt deployed most often and to the greatest depth relative to the East and West primary skirt.

Although the East and West extended skirts both dipped below the 30 cm threshold on several occasions during the season, they remained within 50 cm of the surface more than 90% of the deployment period. The secondary skirt on the south aspect was pulled to depths of 50-100 cm below surface about 15% of the time. The low fish impingement numbers during the period the FDS was installed (discussed in Section 4.0 Fish Impingement) indicate that it was effective in mitigating fish impingement.

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

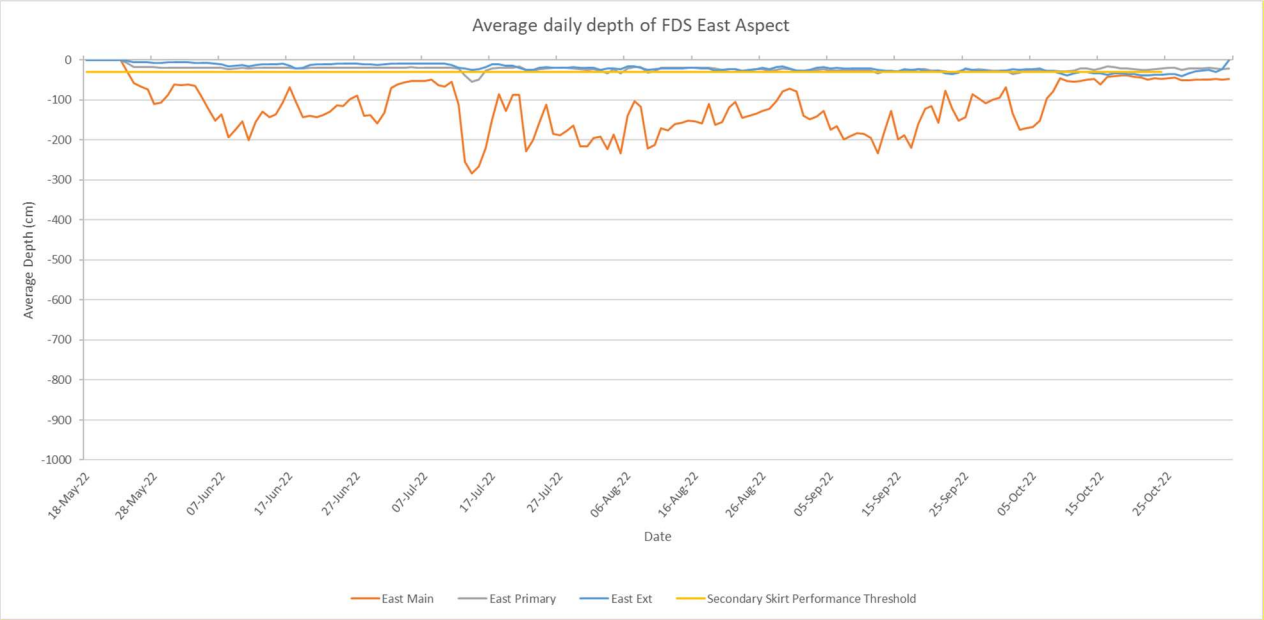
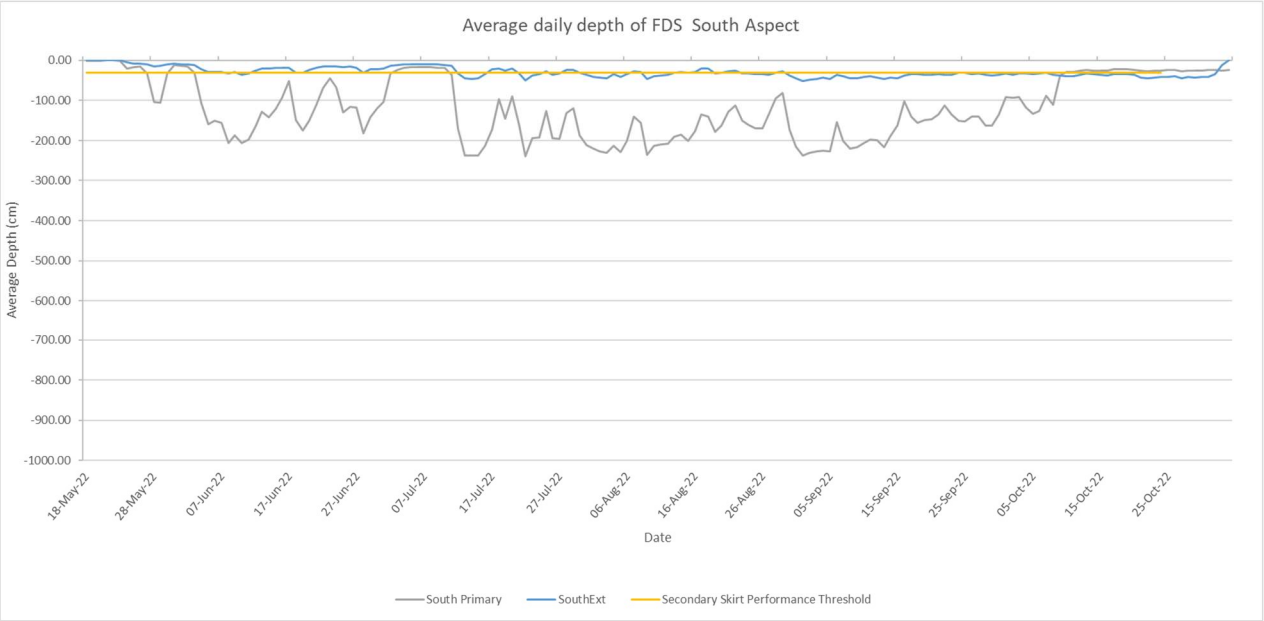


Figure 2 Daily average depth of FDS float lines on the South facing aspect.



Notes: *The South-Main logger malfunctioned and all South-Main data was excluded from analysis.

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

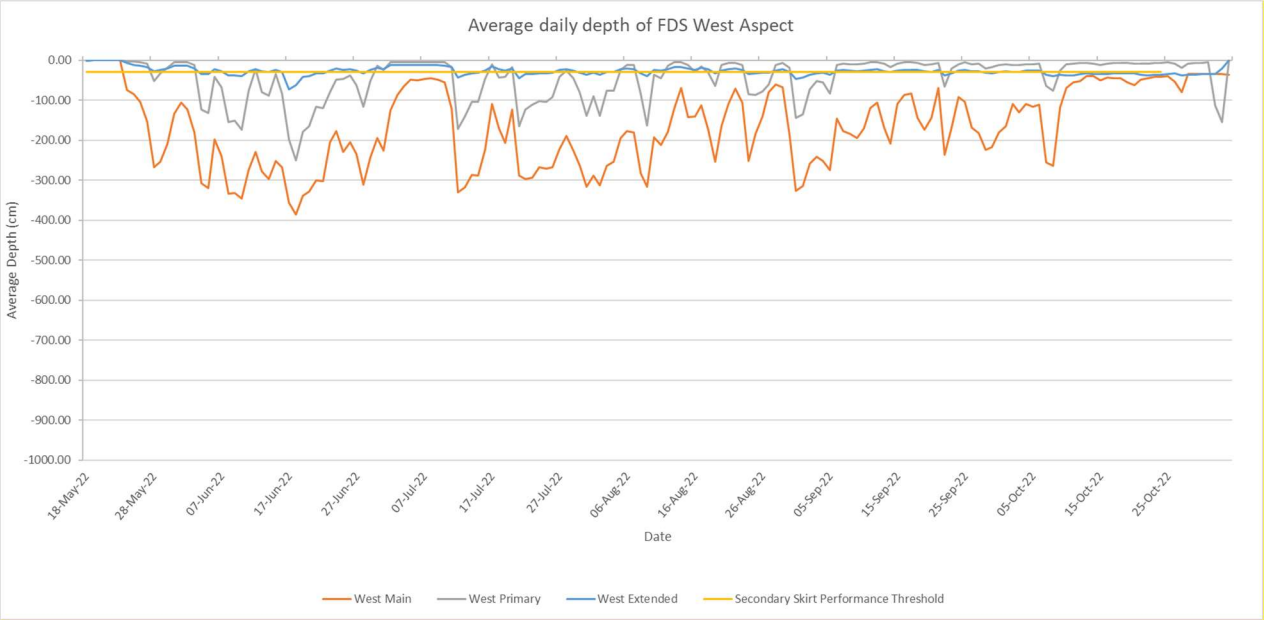


Table 2 Time frequency that primary and secondary float lines were in individual depth ranges based on depth logger data.

Depth below surface (cm)	Aspect and Net								
	East			South			West		
	Ext	Main	Primary	Ext	Main	Primary	Ext	Main	Primary
0-30	76.78%	3.96%	89.97%	50.98%	-	30.18%	55.39%	4.20%	67.45%
30-50	22.87%	13.48%	8.70%	33.64%	-	5.45%	40.82%	13.71%	4.13%
50-100	0.35%	32.38%	1.19%	15.37%	-	8.07%	3.59%	17.47%	9.66%
100-200	-	35.07%	0.12%	-	-	34.78%	0.17%	25.00%	15.25%
200-300	-	14.72%	0.01%	-	-	21.53%	0.03%	24.68%	3.35%
> 300	-	0.39%	-	-	-	-	-	14.93%	0.15%
	100.00%	100.00%	100.00%	100.00%	-	100.00%	100.00%	100.00%	100.00%

Notes:

1. The South-Main logger malfunctioned, and all South Main data was excluded from analysis.

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 2022 and compares it with the previous years. Results indicate that the fraction of time sampled in 2022 was 16% 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]
FDS Compliance Verification [1]	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 [1]	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	16%

Notes:
1. In addition to the weekly routine impingement sampling, OPG has committed to undertake event-based sampling if a fish run occurred between the regularly scheduled sampling events.
2. Based on full year of service for the 8 bin locations
3. In 2020 to 2022, 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 2022. Total CCW intake volume in 2022 was 4.99 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. As discussed in Section 2.1.2 there was a VBO in October of 2022 and during this period all units were temporarily shutdown and a reduced number of CCW pumps were operational.

Table 4 CCW pump operating status in 2022.

Unit Operating Status	
Unit	Days without operating CCW pumps at unit
1	94
2	365
3	365
4	0
5	116
6	25
7	13
8	17

3.3 Data Quality Management

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 2022. In some cases, uncommon species or species that are particularly difficult to key to species level are also verified by ROM staff.

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 2022, Unit 012 trash screens (012TS) were out-of-service during 50 sampling occasions, Unit 034 trash screens (034TS) were out-of-service during 46 sampling occasions, the Unit 012 bar screen (012BS) was out of service during three sampling occasions and the Unit 034 bar screen was out of service during four sampling occasions. 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 (#)	Calculated 24 hr weight (g)	2010-2018 Count Outlier Threshold (#)	2010-2018 Weight Outlier Threshold (g)
22-Feb-22	12 BS	8	18,566	92	3622
22-Feb-22	34 BS	20	28,148	120	10,663
28-Mar-22	12 BS	5	4,398	92	3,622
19-Dec-22	78 BS	6	15,207	357	10,845

3.4 Impingement Estimate

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

4.0 2022 FISH IMPINGEMENT

4.1 All Species and Life Stages

Figure 4 and Table 6 provide the biomass of fish impinged in 2022. 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. All estimates are for all species and life stages of fish impinged. Consistent with prior impingement reports for the Authorization period, Figure 4 and Table 6 and Table 7 exclude the 2017 impingement event. In 2017, an additional 24,000 kg of Alewife were impinged during a November event that OPG reported to CNSC and DFO. A report investigating the factors contributing to the event was subsequently submitted to CNSC and DFO. CNSC staff accepted OPG's conclusions that the impingement event was an unusual occurrence, that likely could not have been anticipated or mitigated, and warranted no corrective action. CNSC staff also accepted that it is likely that the environmental conditions at the time of event caused the impingement event as indicated by OPG (CNSC, 2018). As a result, Figure 4 and Table 8 have been adjusted to reflect the impingement biomass and rate precluding the event. 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.

Figure 4 illustrates cumulative monthly biomass of impinged fish of all species and ages. The combined biomass of all species and ages impinged in 2022 was 2,478.96g, a rate equivalent to 0.5 kg per million cubic metres of station intake volume. In 2021, the annual total biomass reported impinged was 1,585.07 kg. Collectively, the annual 2021 and 2022 biomass impinged were below the two consecutive year threshold of 3,619 kg each year.

Figure 4 Annual cumulative biomass (kg) of fish of all species and ages impinged from 2017-2022.

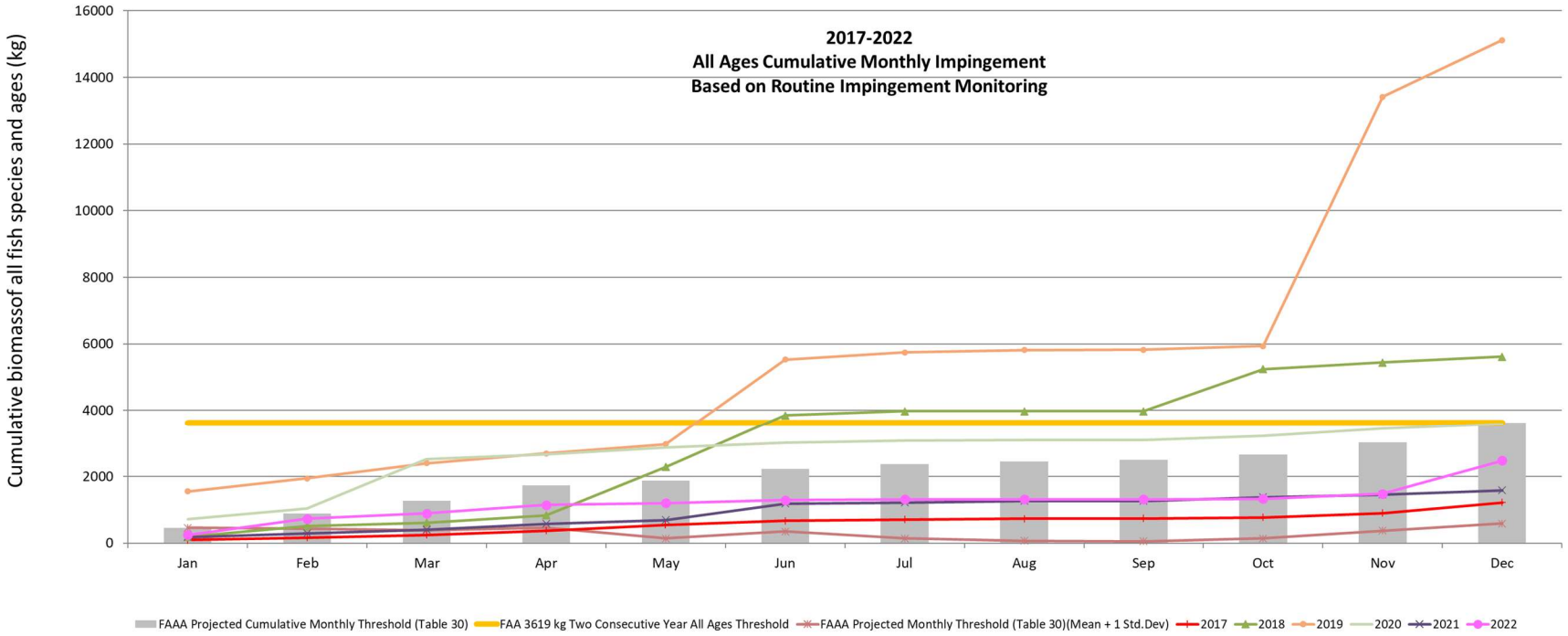


Table 6 Monthly biomass and annual fish impinged (kg) at Pickering Nuclear Generating Station in 2022.

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Alewife*	0.06	0.02	0.15		8.36	35.09	15.07	1.27		1.98	13.73	13.87	89.61
American Eel	7.04									8.96	113.98	95.91	225.89
Atlantic Salmon*			0.15		0.15						0.07	1.96	2.32
Black Bullhead*		0.80			0.12	2.25							3.17
Bluegill*		0.07	0.03	1.02	6.23	1.09	0.52				5.68	25.29	39.93
Bowfin				12.38									12.38
Brown Bullhead*	0.83	3.79	0.58		1.55		0.32				1.24	19.14	27.45
Brown Trout						0.61							0.61
Channel Catfish			0.05	3.83		2.50						15.32	21.70
Chinook Salmon*				6.91		0.73							7.63
Coho Salmon											2.58		2.58
Common Carp*		135.05	10.57									169.65	315.27
Common Shiner												0.56	0.56
Emerald Shiner*	0.83	0.05	0.09			0.45	0.03					2.03	3.48
Freshwater Drum*	10.18												10.18
Gizzard Shad*	206.23	282.99	72.65	44.41		6.72			0.75			288.73	902.49
Lake Trout*													0.00
Largemouth Bass*		2.80	0.03										2.83
Longnose Gar		0.17											0.17
Northern Pike*		48.56	23.78	22.31							0.34	34.75	129.74
Pumpkinseed	0.33					1.81				0.61	0.13		2.88
Rainbow Smelt*	0.89	1.14	9.89	17.07	0.50	1.81				0.04	2.72	19.56	53.61
Rainbow Trout*	15.90		12.02	47.44			1.31					24.88	101.55
Rock Bass						1.39							1.39
Round Goby	2.14	0.40	3.58	78.99	41.78	24.41	5.85	0.45		1.08	9.98	36.32	204.98

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Sea Lamprey	1.16	1.18	1.03								1.41	186.22	190.99
Slimy Sculpin					0.06								0.06
Smallmouth Bass*		0.18	0.09		0.79							0.93	1.99
Spottail Shiner	0.02												0.02
Three-spine Stickleback*	0.17	0.19	2.40	4.03	0.74	0.97	0.01			0.01	0.02	0.17	8.70
Unid	0.02	4.42											4.44
Unid- Catfishes													0.00
Unid-Sucker Species		0.33											0.33
Walleye*			13.99	13.76								21.38	49.13
White Bass*						2.11							2.11
White Perch*	0.93	0.98											1.91
White Sucker*	0.28	0.82	0.09	1.43							0.87	40.63	44.12
Yellow Perch*	0.17	4.99	2.24	3.65		1.61	0.09						12.76
Total (#)	**247.19**	**488.93**	**153.40**	**257.24**	**60.28**	**83.54**	**23.19**	**1.72**	**0.75**	**12.68**	**152.75**	**997.29**	**2,478.96**

Table 7 Number of fish impinged at Pickering Nuclear Generating Station in 2022.

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (#)
Alewife*	3	3	8		1,090	4,299	1,136	63		237	2,266	2,202	11,305
American Eel	13									8	79	61	160
Atlantic Salmon*			4		6						3	5	18
Black Bullhead*		7			5	15							27
Bluegill*		7	4	19	468	78	18		24		127	1,097	1,843
Bowfin				7									7
Brown Bullhead*	9	37	4		6		6				7	240	310
Brown Trout						7							7
Channel Catfish			4	42		15						403	464
Chinook Salmon*				19		149							168
Coho Salmon											20		20
Common Carp*	3	17	4									22	45
Common Shiner												31	31
Emerald Shiner*	154	27	31			93	8					339	652
Freshwater Drum*	3												3
Gizzard Shad*	197	314	65	96	5	52			24		7	253	1,014
Lake Trout*		3											3
Largemouth Bass*		3	4										7
Longnose Gar		3											3
Northern Pike*		24	8	11							4	28	74
Pumpkinseed	36					82				47	12		177
Rainbow Smelt*	197	130	892	1,981	178	261				8	554	3,255	7,454
Rainbow Trout*	3		4	21			368					6	402
Rock Bass						15							15
Round Goby	140	34	214	2,277	2,466	2,697	1,630	119	21	88	784	2,792	13,261

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (#)
Sea Lamprey	6	3	4								7	416	436
Slimy Sculpin					5								5
Smallmouth Bass*		3	15		6							5	30
Spottail Shiner	3												3
Three-spine Stickleback*	102	113	1,604	2,198	367	506	8			8	34	154	5,094
Unid	3	3											7
Unid- Catfishes					15								15
Unid-Sucker Species		3		7									11
Walleye*			4	3								6	13
White Bass*						7							7
White Perch*	3	3											7
White Sucker*	3	17	4	145							14	403	586
Yellow Perch*	13	24	27	44		134	17						259
Total (#)	**891**	**781**	**2,901**	**6,871**	**4,617**	**8,411**	**3,191**	**181**	**70**	**395**	**3,917**	**11,719**	**43,945**

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 (Billion 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	0.60
2014	3,953	4.82	0.82
2015[1]	8,553	5.07	1.69
2016	1,035	4.70	0.22
2017	1,217	5.05	0.24
2018	5,616	4.88	1.15
2019	15,114	5.27	2.87
2020	3,525	4.91	0.72
2021	1,585	5.02	0.32
2022	2,479	4.99	0.50

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 2022 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 2022, 22 of the 23 species were impinged. Round Whitefish were not observed in impingement monitoring in 2022. The combined biomass impinged for the 22 species was 1964 kg, representing 75% 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 2022. 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 2022.

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 2022, 30 American Eel, with a combined biomass of 41.9 kg, were documented during impingement monitoring. Except for one American Eel captured in October, all other Eel were impinged when the FDS was removed, with four in January, 14 in November, and 11 in December. The extrapolated number of American Eel impinged in 2022 was 160 individuals with an estimated combined biomass of 225.89 kg.

4.6 Northern Pike

Table 9 summarizes the extrapolated annual number and extrapolated annual biomass of Northern Pike impingement since 2010. In 2022, OPG documented 15 Northern Pike with a combined mass of 25.03 kg during impingement monitoring. All were captured outside of the period the FDS was installed. The annualized estimate of impingement in 2022 was 74 individuals with a combined biomass of 129.74 kg.

Table 9 Extrapolated number and biomass of Northern Pike impinged annually, 2010-2022.

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	143
2020	49	99
2021	41	91
2022	74	130

4.7 Episodic Fish Kill Events

There were no episodic fish kill events in 2022.

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 2021 and 2022 were below 3,619 kg. Therefore, impingement is below the two-year threshold.

5.2 Trends

The 2022 impingement rate was 0.5 kg/million cubic metres of CCW intake volume, which is low compared to the rolling (2018-2022) five-year mean of 1.11 kg/million cubic metres of CCW intake volume, and ten-year mean of 0.91 kg/million cubic metres of CCW intake volume.

The species with the largest all ages biomass impinged were Gizzard Shad (1,051.26 kg; 39.9% of total biomass) and Common Carp (315.27 kg, 12% of total biomass). Except for 2014 and 2022, Gizzard Shad and Alewife have been the top two species impinged since 2013. In 2022, Alewife impingement of 89.61 kg ranked eighth, and accounted for 3.4% 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 the physical condition of the fish, bins are exchanged prior to weekly monitoring. To mitigate misidentification, sampling practices have been proceduralized and monitoring is undertaken by qualified individuals that have completed the Royal Ontario Museum (ROM) fish identification course. Photos are taken of collected fishes which aid in validation. Misidentification 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 2022 calendar year and is submitted to satisfy both condition 3.1 and condition 3.2.1 of the amended Authorization.

The primary measure to avoid or mitigate fish impingement at PNGS is the FDS. OPG completed installation of the FDS main net prior to May 1, 2022, and the primary and secondary skirts before June 1, 2022, which meets the installation timing conditions.

The FDS removal commenced after November 1, which complies with condition 2.1.1.2 of the Authorization.

Impingement monitoring was conducted throughout the calendar year. Fish collected in bins during the sampling periods were identified, counted, and weighed to calculate impingement

numbers, biomass, and rates. Over 2022, 302 bins were assessed during routine impingement monitoring in Units 1, 4, 5, 6, 7 and 8 combined.

All ages impingement in 2022 was 2,478.96 kg or 0.5 kg/million cubic meters of CCW intake volume. The combined biomass of all species and ages impinged in 2021 and 2022 were below the two consecutive year threshold of 3619 kg. A total of 35 taxa, identifiable to the species level and an estimated 43,945 fish were impinged in 2022.

7.0 REFERENCES

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Appendix A: Estimation of Annual Impingement

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

$$\text{Monthly annualized biomass impinged for species x} = \sum_{Locn=1\ to\ 8} \left[\left(\sum_{Bin=1}^{j} \sum_{Fish=1}^{i} Measured\ Fish\ Weight \right) * \frac{Total\ Flow}{SampledFlow} \right]$$

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

$= \sum_{\text{bin}=1\text{j}} \text{Hourly Flow}_{\text{day,locn}} * \#\ \text{Hours bin j was in Service}_{\text{day,locn}}$