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Report Reviewing Potential Effects to Surface Water and Aquatic Biota of Ontario Power Generation’s Proposal to Refurbish the Pickering Nuclear Generating Station

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Contents

OVERVIEW

This review report has been prepared for the Nuclear Transparency Project's intervention relating to Ontario Power Generations (OPG's) proposal to refurbish the B units of the Pickering Nuclear Generating Station (PNGS). This report addresses two primary areas of environmental concern associated with the PNGS: the historical and current environmental conditions around the PNGS site, and the potential environmental impacts of amending the cooling water system design from a lake surface intake to a deeper lakebed intake (Deep Water Intake, or DWI).

To provide context for this review, the current operational status of PNGS is briefly described here. Pickering Units 1-4 (Pickering A) is in transition to decommissioning. Units 2 and 3 have been in the Storage with Surveillance (SWS) state since 2010, while Units 1 and 4, shut down in late 2024, are currently in a Stabilization Phase and are projected to enter the SWS phase by 2028. This phase is expected to span 50 to 70 years to allow for the natural decay of radioactivity. Pickering Units 5-8 (Pickering B) are subject to OPG's current application for refurbishment. If approved, OPG hopes work on the first unit would begin in 2027 and the final unit expected to return to service by 2034 for approximately 30 additional years of operation, with an anticipated end of service transition to SWS around 2070.

The first area of the report stems from the use of the 2009 Environmental Assessment (EA) as the proposed baseline for the Pickering Refurbishment Project, which encompasses the refurbishment of Units 5-8. A historical scan was undertaken to evaluate whether the environmental conditions reported in the 2009 EA remain representative of current site conditions. This review is informed by publicly available Environmental Risk Assessments (ERAs) of PN (Pickering Nuclear) produced from 2013 onward. This area of review is structured around the following considerations:

- The fish species present at the site, their habitat use patterns including foraging, spawning, and migration, and whether continued changes in fish community structure and site use are evident over time.
- The temporal changes in phytoplankton and zooplankton community composition at the site from 2013 to the present.
- The structure of benthic invertebrate communities on site and how these communities have changed over the same period.
- The observed changes in terrestrial wildlife species at risk with respect to sightings, site use, and reporting from 2013 to the present.
- The evolution of screening and assessment approaches for Contaminants of Potential Concern (COPCs) over time, and whether changes in these approaches may compromise the reliability of a long-term environmental baseline.

- The evolution of tritium screening and assessment in groundwater over time, and the implications of any such changes for establishing a dependable long-term reference condition.
- The changes in the presence, screening, assessment, and reporting of tritium in surface water over the same period.

The second area of review concerns the proposal to construct and install a DWI at PNGS, modelled after the system already in operation at the Darlington Nuclear Generating Station (DNGS), with the assumption that the new DWI would be equally effective in reducing fish impingement and entrainment at the Pickering site. This review critically examines that assumption in light of the fact that the proposed installation would result in the permanent loss of 17.5 hectares of fish spawning, foraging, and migration habitat, the temporary alteration of 4.8 hectares of habitat, and the disruption of an additional 2.5 hectares of fish habitat. This area of review is structured around the following considerations:

- The anticipated effects of a new Lakebed Intake at Pickering on fish impingement and entrainment, the significant environmental impacts associated with its construction, and the broader implications for the protection of aquatic biota.
- The comparability of impingement data between the Darlington and Pickering sites as it pertains to the DWI proposal.
- The comparability of entrainment data between the two sites in the same context.
- The potential for PNGS refurbishment activities to result in changes to thermal discharges relative to historical conditions or predictive assessments.

As both the decommissioning of Units 1-4 and the refurbishment of Units 5-8 are within the scope of this predictive environmental review, references to both unit groups appear throughout this report especially in the second section below. This review is primarily informed by the ERAs produced for PNGS in 2013, 2017, and 2022, as well as the 2025 Predictive Environmental Risk Assessment (PERA). Where cross-comparison of information across multiple sources was warranted, tabular summaries have been included to provide clarity and context for the in-text discussion.

ISSUE 1: Historical and current environmental conditions of surface water around the PNGS site

This portion of the review is organized as responses to a series of questions relating to current and historical ecological conditions around the PNGS site. Questions generally relate to specific ecological components and responses include discussions of any constraints relating to available materials or methods.

Question 1:

What fish species use the site and how do they use it (e.g. foraging, spawning or migration)? Are there continued changes in fish community structure, and site use over time?

1.1 Constrains

There were several constrains to understanding local fish biodiversity and fish species' use of PNGS site, namely:

Stagnant Qualitative Descriptions: Much of the text regarding habitat use (e.g., Hydro Marsh, Frenchman's Bay) is verbatim across a nine-year span (ERA 2103, 2017 and 2022; section 2.2.6 of ERA 2013 and sections 2.3.6.3 of ERAs 2017, 2022). From a scientific perspective, there is a lack of updated field validation to confirm if these habitats still support the same densities or species compositions.

Large sections of text regarding fish spawning suitability and migration remain unchanged across the three ERAs (p. 2.56-2.57 ERA 2013; p. 2.76, ERA 2017; and p.2.79 ERA 2022). For example, the description of "high wave energy habitat" and its unsuitability for spawning (except for Emerald Shiner) is repeated word for word from 2013 to 2022.

Descriptions of Frenchman's Bay, the Rouge River mouth, and Duffins Creek as foraging or spawning habitats remain static. This fails to account for nearly 10 years of cumulative urban development and climate driven fluctuations in Lake Ontario water levels.

Climate Change and Thermal Trends: While "wind driven upwellings" are mentioned, there is no discussion on how changing baseline lake temperatures over the decade might be shifting the seasonal window for cold water species' nearshore foraging. How changing water levels could have affected spawning habitats of cold-water species like round whitefish? How changing water temperatures may affect migratory species?

Quantitative Gaps: None of the ERAs or PERA 2025 provide quantitative metrics for overall habitat quality, such as substrate composition with water quality parameters, or prey availability. The analysis therefore cannot assess whether habitat suitability has changed, only whether the description of species presence has been updated. This is a fundamental constraint because presence may not equal habitat function.

Lack of Fish biodiversity monitoring: The apparent lack of Fish Biodiversity Monitoring at the Pickering site is the main contributor of exposure to inherent limitations of impingement data. The PNGS used impingement data to reflect on fish biodiversity and site use. Impingement data could be taken as a reactive death census rather than a proactive ecological assessment. Because impingement only captures individuals that enter the forebay but are unable to escape the intake velocity, it fails to account for the healthy, living populations that successfully navigate and utilize the site's key features, such as the shoreline and thermal plumes. Furthermore, the size selective nature of intake screens creates a significant data bias, often underrepresenting smaller juveniles or stronger swimmers like adult Salmonids and Bass, both of which could be significant users of the habitat. Most importantly, impingement data cannot validate behavioral site use, such as spawning or social interactions; without biodiversity monitoring tools like netting, underwater observation, or eDNA, the claims regarding active spawning in discharge channels remain limited to outdated 2013 observations rather than scientifically up to date methods.

1.2. Site Use

The PNGS site fish community data available from ERAs (2013, 2017 and 2022) gives an impression that ecology is frozen in time, which is too hard to be true for dynamic ecosystems like Lake Ontario (p.2.54-2.56 ERA 2013; p.2.73-2.76 ERA 2017; p.2.75-2.79 ERA 2017). The ERAs rely on historical narrative. The ERAs continue to use the same verbatim qualitative descriptions for foraging and spawning habitats from 2013 through 2022. This suggests a lack of reevaluation of habitat suitability.

The 2017 and 2022 ERAs both exclude six species from Table 2.17 (p. 2.76 and 2.78 respectively), because they are "not typically considered to be resident or migratory fish species of Lake Ontario". In the 2011–2015 period, these "non-residents" included species like the Spotted Gar (Threatened) and Silver Shiner (Threatened). In the 2016-2020 period, these shifted to include Silver Redhorse, Northern Sucker, and unidentified salmonids. By labeling rare or at risk species as "non-resident" after single detections, the ERAs maintain a narrative of "stability" by effectively filtering out data that might suggest a changing or expanding ecological footprint.

The 2018 and 2022 ERAs use a 2014 study to argue that Round Whitefish are a single large population across the lake (p.2.76, ERA 2017; p.2.79-.80, ERA 2022).

This scientific update is used to justify a "stable" risk profile, potentially masking a possible localized habitat degradation at the Pickering site.

The PERA 2025 technical assessment demonstrates that site use is defined by season and specific depth related habitat roles, with a significant emphasis on the return and persistence of at risk species. Spawning activity in the nearshore zone (0–3 m) is heavily dominated by Alewife, though the area also supports seasonal spawning migrations for various salmonids (Rainbow Trout, Brown Trout, Atlantic Salmon). The nearshore also functions as a permanent nursery and foraging ground for invasive benthic species (Round Goby) and remains a critical migratory corridor for endangered species (American Eel) (p.6.32, PERA 2025). Foraging habitats on site involve a major seasonal shift in biomass; spring and summer are characterized by high numbers of small bodied forage fish (Alewife, Emerald Shiner, Threespine Stickleback), whereas the fall brings an influx of large bodied predators (Lake Trout, Lake Whitefish, Walleye) (p.6.31, PERA 2025). Deepwater grid sampling (12–18 m) in the fall of 2024 confirmed the site's role as a vital migratory and foraging path for rare or threatened species, most notably evidenced by the capture of a Lake Sturgeon; the first recorded observation of this species at the site in nearly two decades. While depth did not significantly impact species richness, the seasonal arrival of cold water species (Lake Trout, Lake Whitefish, Round Whitefish) in the fall drove an increase in total biomass, highlighting the site's transition from a major foraging and spawning ground use in the spring, to presumably a vital refuge for high priority conservation species in the autumn (p.4.37, PERA 2025).

1.3. Fish Community Change in periods covered in ERAs of 2013, 2017, 2022

Despite all the aforementioned hurdles and obstacles, the following could be noted on fish community structure.

1.3.1 Change between 2013-2022

There is evidence of ecological change rather than stability that could be detected from list of fish species of previous three ERAs (Tables 2.13, 2.17 and 2.17 of ERA 2013, 2017 and 2022 respectively). There are certain fish species that were reported present in 2017 ERA but are absent /replaced by other species in 2022 ERA. More simply, the 2022 data shows a loss of diversity compared to the 2017 ERA, with the following species no longer appearing in the primary impingement records. These include Lake Chub, Spottail Shiner, Common Shiner, Longnose Sucker, Lake Herring (Cisco), Johnny Darter, White Crappie. It should be noted that Spottail Shiner, once a key baitfish, appears to have been ecologically "displaced" in recent ERA (2022). On other hand, the 2022 list of impinged species introduced few species that were not highlighted in the previous 2017 impingement summary. These include Gold Shiner, Trout perch, and Brook Silverside.

The fish community structure at the Pickering site has undergone a clear shift in composition and diversity across the three assessment periods. In 2013, the baseline was characterized by high volumes of a few core species, specifically Emerald Shiner, Alewife, Smelt, Round Goby, and juvenile Gizzard Shad. By the 2017 ERA (covering 2011-2015), the identified diversity peaked at 52 species, confirming the invasive Round Goby's presence in all studies and documenting the detection of Species at Risk (SARA) such as the Silver Shiner and Spotted Gar; though these were ultimately dismissed as non-residents. However, the 2022 ERA (covering 2016-2020) indicated a decline in overall richness to 48 species, with the dominant community evolving to prioritize a mix of invasive and opportunistic species, including Alewife, Round Goby, Three-Spine Stickleback, Gizzard Shad, Emerald Shiner, and Rainbow Smelt.

In the 2024 studies for PERA 2025, the nearshore fish community comprised a total of 20 different species, while the Deepwater community consisted of 13 different species. Diversity and species richness exhibited distinct seasonal peaks across both habitats. In the nearshore, species richness peaked during the fall sampling event, which identified 15 unique taxa (dominated by Round Goby, Walleye, Brown Bullhead) compared to only 7 in the spring (dominated by Alewife and Round Goby) and 5 in the summer (dominated by Alewife and Round Goby). Similarly, the Deepwater community reached its highest species richness in the fall, identifying 9 species, whereas the spring and summer events recorded 3 and 7 species respectively.

Nonetheless, the most significant finding in the PERA 2025 is the capture of a Lake Sturgeon in the fall of 2024, the first recorded observation at the site in nearly two decades. This finding, alongside the continued presence of Atlantic Salmon, Brown Trout, and Chinook Salmon, confirms that the site remains a foraging and migratory corridor for both common and threatened species. The data suggests that while species richness varies by area, seasonal thermal shifts are the primary drivers of fish community structure and site utility.

1.4 Conclusion/comments

The transition from 2013 to 2024 reveals a community increasingly dominated by invasive and generalist species, accompanied by a recent reduction in overall species richness and the administrative filtering of sensitive at risk species. The rise of the Round Goby and Three-Spine Stickleback as dominant impinged species suggests a shift in the benthic community that is not fully addressed in the narrative "foraging habitat" sections, which still rely on 2013 descriptions of invertebrate prey. It should be noted that PERA 2025 presents both near shore and Deepwater fish community richness from a field study conducted in 2024. Nonetheless, it is not possible to cross reference or compare with the ERAs (2013, 2017 and 2022) because all of these refer to a common old study Golder 2007.

Question 2:

What are the changes over time (from 2013 to the present) in Phyto- and Zooplankton communities on site?

2.1 Static descriptions from decades ago

The 2013, 2017, and 2022 ERAs rely on descriptions of Lake Ontario that are largely derived from studies conducted in the 1970s through the early 2000s. In the context of modern ecology, a 15-year reporting cycle that does not update its primary data is a historical retrospective (p.2.53, ERA 2013; p.2.72, ERA 2017; p.2.74, ERA 2022). If the ERA uses a 1998-2001 baseline to assess a 2022 project environment, it ignores 25 years of cumulative stressors, including climate warming, nutrient shifts, and new invasive species (p.2.74, ERA 2022). This renders the "Risk" component of the assessment speculative.

2.1 Why are plankton important?

Plankton (Phytoplankton and Zooplankton) are organisms form base of food chain for the lake. Phytoplankton convert sunlight into energy, phytoplankton are then consumed by zooplankton. These, in turn, are the primary food source for prey fish (like Alewife and Rainbow Smelt) that support the entire Great Lakes sport fishery. Any shift in plankton timing or species composition can cause a bottleneck, leading to starvation in higher food chain levels.

2.3 Observations from ERAs and PERA 2025

While the PERA 2025 provides a current baseline for zooplankton, the overall baseline for the plankton community may be considered missing. The 2024 macrozooplankton study specifically addressed depth strata between 12 and 18 meters, concluding that depth does not significantly influence macrozooplankton metrics unless algal mats are present. This study also successfully captured seasonal shifts, noting that Cladocera dominate in spring and summer while Calanoida dominate in the fall (p.4.62, PERA 2025). However, there appears to be a lack of recent primary field data for phytoplankton and periphyton. The text admits that historical information prior to the mid1970s is of limited use due to ecosystem changes like zebra mussel colonization. Despite this, the current description still relies on studies that are 13 to 27 years old, such as those from 1998, 2001, and 2012 (a consistent observation from ERAs 2013, 2017 and 2022). This creates an assumption of stability that may not account for more recent shifts in lake chemistry or climate. Because phytoplankton are the primary producers, an outdated baseline makes it difficult to reliably assess current conditions of Lake Ontario food web.

2.4 Conclusion/Comments

There is a potential knowledge gap regarding phytoplankton; if the environment has changed since 2012 due to further invasive species spread, or climate impacts, the baseline used for 2025 may be inaccurate. Furthermore, while the zooplankton data is site specific to the Deepwater intake (DWI) area, the phytoplankton data is largely generalized from broader areas, or older Lake Ontario studies. The 2024 study is used to justify that the placement of the Deepwater intake does not need to take depth into consideration regarding macro zooplankton, but no such recent data driven justification is offered for phytoplankton. Finally, the 2024 study noted that algal mats significantly influenced zooplankton biomass and diversity. This highlights that periphyton dynamics remain a key driver of the system, yet the text does not mention any new study performed to capture recent changes in these foundational communities.

To conclude, a full baseline for the PN refurbishment should include both near shore and Deepwater zooplankton community surveys. It is notable that a recent study, Figary et al. (2023) indicates that the nearshore and offshore summer zooplankton community compositions in Lake Ontario have become quite distinct overtime. The study highlights the importance of seasonal and long-term monitoring of both nearshore and Deepwater zooplankton community, because they respond differently to anthropogenic stress and Climate Change. Near shore monitoring is important because it reflects food availability for the larval fish, and is an early indicator of offshore changes.

Question 3:
What is the structure of benthic invertebrate communities on site and how has it changed over time (from 2013 to the present)?

3.1 Why are benthic invertebrates important?

Benthic invertebrates serve as the primary link between organic matter in the sediment (detritus) and higher trophic levels, such as the fish communities studied in the deep-water area. These are used as indicators of environmental health.

3.2 Observations from ERAs and PERA 2025

The documents (2013, 2017, 2022 and PERA 2025) regarding benthic macroinvertebrates near the PN site suggest a complex ecological picture. While some taxonomic groups appear to be consistent with reports from 2007 (note: this is an assumption, NTP does not have access to Golder 2007, the survey area and sampling locations of Golder 2007 are also not known, so comparison is not possible); a closer analysis of the 2024 data reveals a community significantly influenced by invasive species (Tables 4.10, 4.11 PERA 2025). The 2024 data highlights low evenness values, such as 0.12 at deep water station S9 and 0.17 at nearshore station 1, indicating that a few dominant taxa are dominating the rest of the community (p.4.58,4.59, PERA 2025).

The 2024 deep water study (17-19 m depth) identified a community dominated by Harpacticoid copepods, Phylum Nemata, Oligochaeta, and Chironomidae (p.4.59 PERA 2025). Although PERA 2025 claims this composition is consistent with findings from 2007 (Golder 2007); the interpretation is complicated by the presence of invasive Quagga mussels (*Dreissena bugensis*), which were found in three of the four deep water samples. The density of these mussels reached up to 969.55 organisms/m² at station S8 (p.4.59 PERA 2025). Because Quagga mussels have been shown in published literature to cause the collapse of native species like the amphipod *Diporeia spp.* (Burlakova et al., 2024), the claim of consistency of community structure between 2007 and 2024 appears to have overlooked a fundamental shift of the food web.

The nearshore areas (1 m to 10 m depth) show even more pronounced influence from invasive species and historical environmental stressors. Modern samples from 2024 found that Dreissenid mussels (Zebra and Quagga) make up a much higher proportion of the community in nearshore infill stations compared to deep water areas, with composition ranging from 0.56% to 50% (Table 4.11 PERA 2025). In some locations, such as station 3 and station 10, mussels are the dominant group. It is plausible that nearshore diversity had already been influenced by thermal plumes from PNGS Units 1-4 prior to the current assessment period, which may help explain the observed reduction in species diversity at depths of 610 m relative to reference sites.

The ecological implications of these possibilities and discussion above could be significant because benthic invertebrates occupy a key position in the Lake Ontario food chain. They act as a bridge, converting organic matter and algae into biomass that supports fish species. The reliance on out dated information for certain habitats is a notable gap; for instance, the assessment of local wetlands (Hydro, Frenchman's Bay, and Duffins Creek marshes) relies on data from 2002-2007, which rated them from "poor" to "good" based on Indices of Biological Integrity (p. 4.56 PERA 2025). Without current data for these wetlands, it is difficult to reliably see a true current baseline, as these communities could be highly sensitive to seasonal changes, lake currents, and the ongoing spread of invasive species.

3.3. Conclusion/comments

The technical analysis reveals a critical disconnect between the project's claim of community stability and the well documented ecological regime shifts in Lake Ontario. By relying on nearly two decade-old data for nearshore and wetland zones, the assessment does not account for "benthification" and loss of native indicator species like Diporeia caused by invasive dreissenid mussels (Burlakova et al., 2022). Therefore, it is unclear if the 2024 baseline correctly presents the true and the current ecological state of the site which is needed to predict and understand long-term impacts predictions.

Question 4:

How has the presence of terrestrial wildlife species at risk changed on site in terms of sightings, site use, and reporting (from 2013 to the present)?

4.1 Presence and absence

The recorded presence of species has changed over time. Early reports (2013-2017) listed a wide variety of species, including the Northern Map Turtle and Snapping Turtle, based on sightings (p. 2.48, ERA 2013; p.2.69, ERA 2017). However, by the 2022 ERA, species such as the Common Nighthawk, Bobolink, and Bank Swallow were recorded as absent from long-term monitoring for over a decade; suggesting they were no longer expected on site (p.2.52, ERA 2022). In contrast, the 2025 PERA re-reported several species following new sightings in 2023, including the Midland Painted Turtle, Eastern Whip-poor-will, and Red-headed Woodpecker (p.4.88-4.89, PERA 2025).

The Table 1 tracks all terrestrial animal species at risk reported across the four assessment periods (2013, 2017, 2022, and 2025). It is important to note that systematic **biodiversity monitoring only started from 2016**, whereas prior data relied on intermittent inventories and historical observations.

Table 1: Terrestrial wild life species at risk reported across the four assessment periods (2013, 2017, 2022, and 2025). This table is created to visualize the change over time. (Sources: sections 2.2.5.6 of ERA 2013, 2.3.5.6.2 of ERA 2017 and ERA 2022, and 4.5.2 of PERA 2025).

Common Name	Reported Years	Presence / Absence	Provincial Status Change 2013-2024	Site Use Notes
Snapping Turtle	2013, 2017	Absent since 2009	Current status: Special Concern	Historical observation (2009)
Blanding's Turtle	2013, 2017, 2022, 2025	Present (Historical)	Federal status was elevated from Special Concern to Endangered by 2017	Last observed in 2006
Northern Map Turtle	2013, 2017	Absent since 2006	Current status: Special Concern	Historical observation (2006)
Midland Painted Turtle	2025	Present	Assessed as Special Concern by COSEWIC in 2018.	Found in screenhouse collection bin in 2023.
Chimney Swift	2013, 2017, 2022, 2025	Present	Status has remained consistently Threatened across both levels	Forages widely; 2020 observation considered "possible breeding".
Black Tern	2013, 2017	Absent since 2008	Current status: Special Concern	Last observed in 2008
Common Nighthawk	2013, 2017, 2022, 2025	Absent / Historical	Federal status was downgraded from Threatened to Special Concern in the 2025 report.	Not observed in long-term monitoring; not expected to be present.
Bobolink	2013, 2017, 2022, 2025	Absent / Historical	Status has remained consistently Threatened	Not observed in long-term monitoring; not expected to be present.
Peregrine Falcon	2013, 2017, 2025	Present	Provincial status was downgraded from Threatened to Special Concern by 2017	Confirmed breeding pair inside the Protected Area in 2023.
Bald Eagle	2013, 2017	Absent since 2007	Current status: Special Concern	Last observed in 2007
Barn Swallow	2013, 2017, 2022, 2025	Present	Provincial status was downgraded from Threatened to Special Concern by 2022	Confirmed breeding pair inside the Protected Area in 2023.
Bank Swallow	2017, 2022, 2025	Present	Status remained consistent as Threatened since 2017	Successfully colonized artificial embankment (FFEE) in 2023/2024.
Eastern Wood-Pewee	2017, 2025	Present	Status remained consistent as Special Concern since 2017	Observed in 2015 and 2022.
Least Bittern	2017, 2022, 2025	Present	Status remained consistent as Threatened since 2017	Observed as recently as 2023.

Horned Grebe	2017	Present (Historical)	Special Concern	Observed in 2015.
Eastern Whip-poor-will	2025	Present	Federal status moved to Special Concern (COSEWIC 2022).	Found in Screenhouse in 2023; likely a migrant from nearby.
Red-headed Woodpecker	2025	Present	New addition in 2025, listed as Endangered at both federal and provincial levels.	New observation recorded in 2023.
Monarch butterfly (Insect)	2013, 2017, 2025	Present	Federal status was elevated from Special Concern to Endangered in the 2025 report.	Observed as recently as 2023.

4.2 Site Use

The understanding of how SAR (species at risk) utilize the PN site has become clearer in recent reports i.e., ERA 2022 and PERA 2025. For instance, while the Chimney Swift is still recorded, it is now considered as a "possible" breeder because of its ability to use a large foraging habitat and lacks of definitive evidence of on-site breeding (p.4.88, PERA 2025). Nonetheless, the 2025 PERA confirms active breeding pairs of Peregrine Falcons and Barn Swallows within the Protected Area (p.4.88, PERA 2025).

4.3 Changes in species status

There was an increasingly stringent shift in the at risk status of several species, reflecting broader environmental pressures. The most notable regulatory changes between 2013 and 2025 involve federal status upgrades for the Blanding’s Turtle and the Monarch butterfly, both rated up to Endangered status which requires stricter protection. On the other hand, the down rating of the Barn Swallow and Peregrine Falcon to provincial Special Concern status may suggest a recovery or stabilization of populations within Ontario, showing that management could shift focus from strict prohibition to long-term stewardship (p.2.48, ERA 2013; p.4.89, PERA 2025).

4.4 Shifts in Site Use and Residency

Site use changed to reflect active colonization and adaptation. The most prominent example of change is the Bank Swallow. After being declared absent from long-term monitoring for a decade (p.2.69, ERA 2017), the species was successfully re introduced through the creation of artificial habitat: the Fixed Face Earthen

Embankment (FFEE) (p.4.88, PERA 2025). Furthermore, the 2025 PERA confirms that the Peregrine Falcon and Barn Swallow are now active breeders within the Protected Area, which is a change from incidental migrants to most current residents (p.4.88, PERA 2025).

4.5 Conclusion/Comments

Site use may have changed over time to reflect active colonization and adaptation to climate change. The observations of new species at the site in 2023, such as the Red-headed Woodpecker (Endangered) and Eastern Whip-poor-will (Threatened), may suggest a change in local ecology possibly influenced by Climate Change. As temperature and habitat ranges shift northwards, the PN site could become a refuge for species that were not recorded earlier (2013-2017). The presence of these species could be an early indication of a possibility that the site could serve as an important migratory stopover or expanding breeding territory in a warming climate.

Question 5:
How has screening and assessment of COPCs evolved over time? Can this change complicate the depiction of a reliable point of reference for long-term continuing effects?

Changes that have occurred during the reporting period 2013-2022 are summarized below and detail is provided in Tables 2 and 3.

Table 2: Changes in non- RN COPCs over time (2013, 2017, 2022, and 2025). (Sources: sections 4.1.3. of ERAs 2013, 2017 and 2022, and 4.1 of PERA 2025).

Environmental Component	2013 ERA COPCs Data collection	2017 ERA COPCs Data collection	2022 ERA COPCs Data collection	2025 PERA COPCs Data collection	Impact of Regulatory & Standard Changes
Air	None carried forward. (NOx and SOx screened below AAQC).	None carried forward. (Max predicted concentration below benchmarks for hydrazine/morpholine).	None carried forward. (NOx, SOx, hydrazine, and morpholine remained below benchmarks).	TSP, PM10, PM2.5, NO2, and BaP (Benzo(a)pyrene) identified as potential stressors during refurbishment	MOECC requested a shift in hydrazine screening to annual averages 9duirng 2017 ERA). 2025 assessment focus shifted to construction-related particulates.
	Used REMP data from 2007–2011; relied on dispersion modeling rather than new field ambient air sampling.	Refined screening using 2014-2015 emission data; transitioned to annual average calculations for hydrazine.	Utilized existing 2017-2020 emission inventories; no new off-site ambient air stations established.	New Data: 2024-2025 ambient air monitoring program initiated to establish a	

				construction-phase baseline.	
Groundwater	Not a primary ecological focus; depth (>2m) limited exposure.	Evaluated as a pathway to surface water (e.g., East Landfill).	BTEX, PHCs, and Dissolved Iron monitored but not carried forward.	BTEX, PHCs, and Dissolved Iron; deemed bounded by previous assessments.	Adoption of CSA N288.6 led to formal assessment of the groundwater to surface water (started in 2017) pathway using a 10x dilution factor (2022).
	Screened out as a primary pathway; relied on 1999 site characterization reports.	Focused on the East Landfill pathway using existing PCP well data (2012-2015).	Used 2020 Conceptual Site Model (CSM) reports which were based on 2015/2016 well data.	Old Data: Bounded by 2022 results; no new sitewide groundwater characterization conducted specifically for 2025.	
Soil	Arsenic, cadmium, copper, lead, strontium, thallium, and zinc.	Arsenic, copper, lead, and zinc (Cadmium/thallium dropped).	Arsenic, copper, lead, and zinc.	Arsenic, copper, lead, zinc, and PHC F4 (linked to historic spills/runoff).	Updates to O.Reg 153/04 and MOE (2011) soil standards replaced 1997 guidelines, tightening metal criteria. Regulatory shift toward screening against "no-effect" levels rather than just acute toxicity thresholds (starting from 2017 onwards).
	Relied on a single historical dataset from a 1999 site-wide soil sampling event.	Conducted a new 2015 supplemental soil program to update the 1999 findings.	Old Data: Directly reused the 2015 dataset; no new soil samples were collected between 2016 and 2022.	New Data: New 2024-2025 sampling program launched to identify soil contaminants in future construction zones.	
Stormwater	None carried forward. (Catchments screened below PWQO/CCME).	None carried forward. (Discharges remained below screening levels).	Metals[1] screened; none exceeded updated benchmarks.	Metals[2] assessed as a pathway for demolition/construction runoff.	Regulatory shift toward screening against "no-effect" levels rather than just acute toxicity thresholds (starting from 2017 onwards).
	Utilized historical effluent monitoring results from the site's various catchments (typically 2007–2011). Analysis was restricted to routine operational compliance data rather than a	Relied on established storm sewer monitoring programs; no new site-wide stormwater characterization campaign was initiated.	No new field data. The assessment recycled existing data (largely from the 2015–2020 period) and compared it against updated regulatory standards.	new environmental monitoring in 2024 and 2025 to establish a current baseline for stormwater quality, to capture pre-construction conditions.	

	dedicated ERA baseline study.				
Surface Water (Lake Ontario)	Hydrazine, morpholine, TRC, copper, and cadmium.	Morpholine and copper. (Hydrazine dropped).	Hydrazine, morpholine, and copper.	Aluminum, Iron, Ammonia, and Phosphorus (notably in near-field/nearshore).	Hydrazine was removed in 2017 based on the new federal FEQG (2.6 µg/L) but re-added (2022) as data/guidelines evolved. Regulatory shift toward screening against "no-effect" levels rather than just acute toxicity thresholds (starting from 2017 onwards).
	Based on historical 2006 lake water dataset and effluent monitoring records.	Analyzed using a 2014-2015 baseline monitoring program specifically for the ERA.	Relied on a 2015-2020 monitoring dataset; no new station-specific lake sampling performed for this cycle.	New Data: Quarterly 2024 sampling at Nearshore and Intake locations to refresh the aquatic baseline.	
Sediments (Lake Ontario)	CCW/Bay Focus	Metals/RNs[3]	Cu, Zn	Metals/RNs[4]	Adoption of Lowest Effect Levels (LELs) for substances where federal guidelines were unavailable.
	Data sourced from various localized studies (2000-2010); lacked a unified sampling design.	New 2015 sediment sampling program established a consistent baseline for the Near-field.	Old Data: Screening based on the 2015-2016 sampling program results.	New Data: Specific 2024-2025 field studies conducted for the Deep Water Intake (DWI) and dredging areas.	
East Landfill Surface Water	Not specifically described as a standalone set in 2013 summary.	Focused on parameters exceeding PWQO (e.g., metals and nutrients).	Ammonia, Boron, Chloride, Iron, and Phosphorus.	Ammonia, Boron, Chloride, Iron, and Phosphorus.	Mercury was voluntarily added to monitoring in 2000 but deleted in 2012 due to consistent non-detects.
	Data pulled from the established Perpetual Care Program (PCP) monitoring wells.	Continuation of PCP monitoring; utilized annual compliance reports for 2012-2015.	Analyzed using 2016-2020 PCP data; assessment was limited to existing monitoring parameters.	New Data: Integrated updated 2024-2025 sampling results to evaluate potential leaching changes during site work.	
Frenchman's Bay Sediments	Not Separate	Al, Bi, B, Cd, Ca, Cr, Cu, Pb, Mn, Ni, P, Tl, Sn, Zn, and TOC.	Al, Bi, B, Cd, Ca, Cr, Cu, Pb, Mn, Ni, P, Tl, Sn, Zn, and TOC.	Aluminum and Iron noted; TKN (Total Kjeldahl Nitrogen) exceedances recorded.	2017-2022: Analyzed as a new component using baseline programs. 2025: Fresh 2024 data used to evaluate impacts from heavy urban runoff vs. site activity.
	No specific data; assumed similarity to	First dedicated sampling program (2015)	Old Data: Relied on the 2015 program data;	New Data: 2024 sediment cores analyzed to	

	open lake sediment values.	to characterize the Bay as a unique component.	no new cores taken for the 2022 update.	differentiate urban runoff accumulation from station-related impacts.	

1-Metals: Aluminum, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Uranium, and Zinc.
2- Metals: Aluminum, Arsenic, Boron, Cadmium, Chromium, Copper, Iron, Lead, Molybdenum, Nickel, Thallium, and Zinc.
3-Metals and radionuclides: Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Mercury, Nickel, and Zinc. Tritium (H-3), Carbon-14 (C-14), Cobalt-60 (Co-60), Cesium-134 (Cs-134), and Cesium-137 (Cs-137).
4-Metals and radionuclides: Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, and Zinc, Tritium (H-3), Carbon-14 (C-14), Cobalt-60 (Co-60), Cesium-134 (Cs-134), and Cesium-137 (Cs-137).

AAQC (ambient air quality criteria); MOE Ministry of Environment, MOECC Ministry of Environment and Climate Change, CCME Canadian Council of Ministers of the Environment; PWQO (provincial water quality objective); TRC (total residual chlorine); REMP (radiological environmental monitoring program)

Table 3: Changes in RN COPCs over time (2013, 2017, 2022, and 2025). (Sources: sections 4.1.3. of ERAs 2013, 2017 and 2022, and 4.1 of PERA 2025).

Environmental Component	2013 ERA COPCs Data collection	2017 ERA COPCs Data collection	2022 ERA COPCs Data collection	2025 PERA COPCs Data collection	Timeline of Regulatory Change
Air	HTO, C-14, Noble Gases	HTO, C-14	HTO, C-14, Noble Gases.	HTO, C-14.	2020: CSA N288.1:20 update required more granular modeling for ecological receptor exposure pathways.
	Analyzed 2007–2011 emissions.	Evaluated trends since 2008.	Old data (historical performance).	2024/25 data collected for existing conditions.	
Groundwater	H-3, Gross Beta-Gamma.	H-3	H-3.	H-3.	2017-2022: Under CSA N288.6, COPCs can be deleted from EcoRA if consistently below screening with no pathway.
	Monitored foundation drains and wells.	Ongoing monitoring (results below screening).	Data (relied on 2017–2021 reports).	Confirmed no offsite terrestrial exposure pathway.	
Soil	H-3, C-14, Cs-137, Cs-134, Co-60.	H-3, C-14, Cs-137, Cs-134, Co-60.	Same as 2017.	Adds K-40, I-131, Th-series, U-series	2023: Regulatory emphasis on "Data Currency" ensures baseline data is not older than 10 years.
	Compared 1999–2014 data to O. Reg. 153/04.	Data from October 2015 program.	Old data (referenced 2015 campaign).	2024 data (noted ~2x increase in H-3/C-14).	
Surface Water (Lake Ontario)	HTO, C-14, Gross Beta-Gamma	HTO, C-14, Co-60, Cs-134, Cs-137.	Same as 2017.	K-40, I-131, Th-series, U-series were added. .	2021: CNSC REGDOC-2.11.2 for decommissioning mandated broader baseline screening for refurbishment
	Analyzed 2007–2011 emissions.	2015 data from field sampling.	Old data (re-evaluated 2015 results).	2024/25 data collected.	
Sediment (Lake Ontario)	H-3, C-14, Gross Beta-Gamma.	H-3, C-14, Co-60, Cs-134, Cs-137	Same as 2017.	K-40, I-131, Th-series, U-series were added. .	2024: Shift toward Adaptive Management under CNSC requirements for refurbishment/decommissioning phases.
	Frenchman's Bay historical monitoring.	2015 data showing urban runoff impacts.	Old data (re-used 2015 results).	2024 data collection initiated.	
Frenchman's Bay Sediment	H-3,C-14, Gross Beta-Gamma.	H-3, C-14, Co-60, Cs-134, Cs-137.	Same as 2017 list.	K-40, I-131, Th-series, U-series were added.	2015-2017: Regulatory recognition of Frenchman's Bay as a Provincially Significant Wetland led to its addition as a standalone component in the 2017 ERA.
	Historically inferred from general site-wide data; limited local sampling.	2015 data collected specifically for the Bay as a distinct component.	Old data (re-evaluated findings from the 2015 field campaign).	2024 data collected to establish a decommissioning baseline.	
East Landfill Surface Water	H-3, Gross Beta-Gamma	Same as 2013 list.	Same as 2017 list.	K-40, I-131, Th-series, U-series were added.	2021-2024: CNSC REGDOC-2.11.2 requires high-resolution baselines for landfill areas to monitor potential legacy migration during decommissioning.
	Based on routine operational monitoring of the East Landfill area	2015 field data integrated to refine the landfill baseline	Old data (re-evaluated the 2015 dataset; results remained below benchmarks).	2024/25 data collected to support decommissioning planning.	

Following discussion is general for both RN and non-RN COPCs.

5.1 New environmental components

Regulatory oversight has evolved from monitoring broad site emissions to a highly specific, receptor-based model. In the 2013 assessment, the focus was primarily on site-specific soil, and direct discharge channels (p.3.22, ERA 2013). Since 2013, assessments have added entirely new components like storm water, East Landfill surface water, and Frenchman's Bay (water and sediment) as standalone components (p.3.24, 4.8, p.4.17-4.18, 4.41 ERA 2013). By 2022, and into the 2025 PERA, assessments further expanded to include complex groundwater to surface water pathways, assessing if or how on site plumes (like PHCs and BTEX) may interact with the aquatic environment (p.4.35, ERA 2022; p.130-132 PERA 2025). Furthermore, the inclusion of culturally significant biological receptors such as the Harvester, and Honey Bees means the current baseline includes ecological pathways that were never quantified in earlier decades (p.C.2, C.5, PERA 2025)

5.2 Shift in regulatory standards

A shift in regulatory framework sensitivity occurred with the adoption of CSA N288.6-12, which involved transitioning from acute toxicity thresholds to more stringent "no-effect levels" (NEL) for screening of COPCs on site (p.4.7, ERA 2013). This change in criteria directly altered the list of chemical stressors; for example, hydrazine and morpholine screening was refined from acute exposure limits to chronic annual averages as recommended by MOECC (Ministry of Environment and Climate Change). Because these newer benchmarks are designed to be more protective, chemicals that were previously dismissed as safe in 2013 from screening (p.4.6-4.7, ERA 2013), could now be considered for quantitative review. However, this regulatory shift makes it difficult to distinguish between an actual increase in environmental contamination and a simple change in the sensitivity of the guidelines used to measure it.

5.3 Changes in COPC lists

The list of COPCs has been changing constantly due to the introduction of new Federal Environmental Quality Guidelines (FEQGs) and provincial Lowest Effect Levels (LELs). For example, hydrazine was removed as a surface water COPC for HHRA (Human Health Risk Assessment) and EcoRA (Ecological Risk Assessment) in 2017 when its levels fell below the FEQG applicable at that time (p. ix, xv ERA 2017); and then reconsidered in 2022 (p. 3.59, 4.48 ERA 2022), and 2025 (p.4.2, 4.24 PERA 2025) as data and guidelines evolved. Similarly, sediment assessments shifted to the use of LELs for metals like aluminum and iron when federal standards were absent. These frequent additions and deletions mean that the COPCs profile of the site kept changing, which complicates long-term trend analysis.

Early ERAs focused almost exclusively on operation-related isotopes like Tritium (HTO) and Carbon-14. Under updated regulation CNSC REGDOC-2.11.2 requirements for decommissioning, the 2025 PERA has expanded to include naturally occurring radionuclides such as Potassium-40, Iodine-131, and the Thorium/Uranium decay series (p.4.27, PERA 2025). Because these were not included in 2013 or before, there is no true pre-refurbishment baseline to determine if future fluctuations are site related or natural.

5.4 Conclusion/Comments

The data trends indicate that the 2022 ERA may have functioned primarily as a desktop exercise, reusing figures, big data tables in appendices and the main document from 2015, that create a seven-year data gap. This reliance on outdated information, combined with evolving regulatory criteria could make the establishment of a credible baseline impossible This problem can easily be observed if one compares the big data tables in appendices of ERAs 2013, 2017 and 2022.

The 2025 PERA seems to address this issue by introducing a fresh baseline program including new ambient air stations, sediment sampling, and quarterly water quality monitoring to capture a reliable 2024-2025 snapshot before major refurbishment begins. But again, this does not reflect historical data and the historical data still stays fragmented, which could make cumulative effect assessment of the project unreliable.

This transition of site from power generation to industrial (safe storage of Units 1-4 and refurbishment of Units 5-8) is critical because the project’s hazard profile is basically changing. The 2025 PERA introduces COPCs specific to industrial dismantling and rebuilding such as TSP, PM10, and Benzo(a)pyrene, which were absent from the operational focused ERAs of 2013 and 2017.

Ultimately, the recycling of data between consecutive ERAs, shifting toxicity benchmarks, and entirely new activity based COPCs means that a reliable over time cumulative impact assessment may not feasible, using existing frameworks.

Question 6:
How has the screening and assessment of Tritium in ground water evolved over time? Can this change complicate the depiction of a reliable point of reference for long-term continuing effects?

The screening and assessment of tritium in groundwater and soil at the PNGS site across various ERAs (2013-2022) leading into the 2025 PERA is summarized in Table 4 and discussed below.

Table 4: Data of Tritium in ground water and soil extracted from ERA 2013, 2017, 2022 and PERA 2025. (Source: p 4.17, 4.40 pf ERA 2013; p 4.29, 4.31, 4.67 of ERA 2017; p 3.18, 4.75 ERA 2022; p 4.82, A.20 (PERA 2025).

Environmental Component	2013 ERA	2017 ERA	2022 ERA	2025 PERA
Groundwater	Benchmark; 3E+06 Bq/L Locations of exceedances: Based on data from 2008 to 2012 the exceedances were found around Unit 1 in PNGS A and one well in PNGS B. Conc at PN site (Bq/L): 1.14E+05 (max) 4.09E+05 (mean) Based on groundwater monitoring (1999-2000)	Benchmark; 3E+06 Bq/L Locations of exceedances: the locations where tritium in groundwater exceeded were around Unit 1, the PN U1-4 and PN U5-8 Irradiated Fuel Bay ground tubes, one ground tube at PN U5, and the Vacuum Building ramp sump Highest reported conc: 8510 Bq/L	Mentions that there are no published standards for tritium in groundwater Benchmark for humans developed by Ecometrix: 6.19×10^9 Bq/L f Benchmark for ecological receptors developed by Ecometrix: 1×10^8 Bq/L f No data provided, as no COPCs were selected for Eco RA or HHRA	Benchmark for humans developed by Ecometrix: 6.19×10^9 Bq/L f Benchmark for ecological receptors developed by Ecometrix: 1×10^8 Bq/L f Retained as a COPC for GWMP
Soil	Benchmark; DRL Conc at PN site (Bq/Kg): 1.14E+05 (max) 4.09E+05 (mean) Based on groundwater monitoring (1999-2000)	Benchmark; DRL Conc at PN site (Bq/kg): 9.24E+01 (max) 5.25E+01 (UCLM)	Benchmark; DRL Conc at PN site (Bq/kg): 4.86E+02 (max) 3.48E+02 (mean)	Benchmark; DRL 9.97-154 Bq/Kg

6.1 Evolution of groundwater screening criteria

As obvious from the documents listed above, the benchmark for screening of tritium in groundwater assessments has undergone significant change. In the 2013 and 2017 ERAs, a screening benchmark of $3x10^6$ Bq/L was applied (p. 4.19, ERA 2013; p. 4.30 ERA 2017). This value was characterized as highly conservative, based on earthworms residing directly in groundwater; nonetheless it was expected to be protective of all aquatic biota (p.4.30 ERA 2017). Then, by the 2022 ERA and 2025 PERA, the evaluation criterion was substantially increased to $1x10^8$ Bq/L for ecological receptors (p. 4.40 ERA 2022; p.4.26 PERA 2025). During this time, measured groundwater concentrations have consistently shown high activity zones, particularly around Unit 1, where 2022 monitoring recorded average concentrations as high as $1.96x10^7$ Bq/L (at MW-270-20) and$1.92x10^7$ Bq/L (at U1-RBFD-2). While these measured values exceeded the original 2013/2017 benchmark, they remain below the revised 2022/2025 criteria. The justification for the 33 fold increase in the ecological benchmark between 2017 and 2022 is not explained or discussed in the text. This could be taken as a potential area of uncertainty in the long-term consistency of the risk profile.

6.2 Tritium Levels for Safe Storage (Units 1-4) and Refurbishment (Units 5-8)

The following tables present summaries of long data tables provided in Appendix A, Tables A1-A3 of ERA 2022.

Table 5: Summary of Tritium Groundwater Concentrations (Unit 1-4) extracted from ERA 2022. (Sources: Tables A1, A2 and A3 of ERA 2022).

Sampling Location	Hydrostratigraphic Unit (HU)	Sampling Frequency	Min (Bq/L)	Max (Bq/L)	Average (Bq/L)
Units 1 to 4 & Vacuum Building					
IAD-SU-1	HU 7	Quarterly	7.40E+03	**2.70E+04**	1.85E+04
IAD-SU-3	HU 7	Quarterly	1.70E+04	**2.97E+05**	1.95E+05
MW-230-30	HU 6	Quarterly	6.66E+05	**7.10E+05**	6.91E+05
MW-234-30	HU 6	Quarterly	2.60E+06	**3.27E+06**	2.81E+06
MW-239-30	HU 6	Quarterly	8.95E+06	**1.01E+07**	9.48E+06
MW-270-20	HU 1-3	Quarterly	1.39E+07	**2.19E+07**	1.96E+07
MW-273-20	HU 1-3	Quarterly	1.60E+06	**1.55E+07**	6.27E+06
MW-315-15	HU 1-3	Quarterly	1.38E+05	**2.11E+06**	1.44E+06
MW-321-15	HU 1-3	Quarterly	4.77E+04	**1.89E+05**	1.17E+05
U1-RBFD-1	HU 1-3	Quarterly	1.27E+07	**2.65E+07**	1.84E+07
U1-RBFD-2	HU 1-3	Quarterly	1.22E+07	**2.62E+07**	1.93E+07
VB Ramp Sump	HU 1-3	Quarterly	7.07E+05	**1.10E+06**	9.42E+05

Table 6: Summary of Tritium Groundwater Concentrations (Unit 5-8) extracted from 2022. (Sources: Tables A1, A2 and A3 of ERA 2022).

Monitoring Location	Hydrostratigraphic Unit (HU)	Frequency	Min (Bq/L)	Max (Bq/L)	Average (Bq/L)
IAD-SU-5	HU 7	Quarterly	3.33E+04	8.40E+04	5.48E+04
IAD-SU-6	HU 7	Quarterly	2.52E+04	4.74E+04	3.69E+04
IAD-SU-7	HU 7	Quarterly	2.52E+05	4.37E+05	3.29E+05
IAD-SU-8	HU 7	Quarterly	1.52E+04	2.52E+04	1.96E+04
MW-264-10	HU 1-3	Annual	2.78E+03	2.78E+03	2.78E+03
MW-265-12	HU 1-3	Quarterly	1.33E+04	2.07E+04	1.64E+04
MW-266-19	HU 1-3	Quarterly	4.03E+04	5.07E+04	4.57E+04
MW-267-17	HU 1-3	Quarterly	8.29E+03	1.33E+04	1.06E+04
RBU5-GT-1	HU 1-3	Quarterly	5.18E+04	1.15E+05	8.51E+04
RBU5-GT-2	HU 1-3	Quarterly	1.33E+04	2.41E+04	1.84E+04
RBU5-GT-3	HU 1-3	Quarterly	5.55E+03	1.33E+04	9.99E+03
RBU5-GT-4	HU 1-3	Quarterly	2.04E+03	3.70E+03	2.87E+03
RBU6-GT-2	HU 1-3	Quarterly	7.77E+03	1.22E+04	1.02E+04
RBU6-GT-3	HU 1-3	Quarterly	4.81E+03	7.77E+03	6.33E+03
RBU6-GT-4	HU 1-3	Quarterly	3.33E+03	5.18E+03	4.22E+03
RBU7-GT-1	HU 1-3	Quarterly	2.22E+04	6.29E+04	4.59E+04
RBU7-GT-3	HU 1-3	Quarterly	2.04E+04	2.59E+04	2.32E+04
RBU8-GT-1	HU 1-3	Quarterly	7.03E+03	1.44E+04	1.12E+04
RBU8-GT-2	HU 1-3	Quarterly	1.81E+03	4.07E+03	2.89E+03
RBU8-GT-3	HU 1-3	Quarterly	2.96E+03	4.81E+03	4.00E+03

U5 MK 26	HU 1-3	Quarterly	1.78E+04	3.33E+04	2.41E+04
U6 MK 30	HU 1-3	Quarterly	1.67E+04	3.26E+04	2.46E+04
U7 MK 36	HU 1-3	Quarterly	2.52E+04	4.37E+05	2.73E+05
U8 MK 42	HU 1-3	Quarterly	3.22E+05	5.18E+05	3.84E+05

Table 7: Summary of Tritium Groundwater Concentrations (fuel bay areas) extracted from ERA 2022. (Sources: Tables A1, A2 and A3 of ERA 2022).

Monitoring Location	Hydrostratigraphic Unit (HU)	Frequency	Min (Bq/L)	Max (Bq/L)	Average (Bq/L)
IFBA-GT-1A	HU 1-3	Quarterly	8.88E+02	1.81E+03	1.41E+03
IFBA-GT-2A	HU 1-3	Quarterly	6.29E+03	1.26E+04	1.00E+04
IFBA-GT-3A	HU 1-3	Quarterly	1.07E+04	1.44E+04	1.27E+04
IFBA-GT-4A	HU 1-3	Quarterly	2.70E+03	3.92E+03	3.13E+03
IFBA-GT-5A	HU 1-3	Quarterly	2.15E+04	4.44E+04	3.33E+04
IFBA-GT-1B	HU 6	Quarterly	2.59E+04	5.92E+04	4.25E+04
IFBA-GT-2B	HU 6	Quarterly	3.33E+04	8.14E+04	5.00E+04
IFBA-GT-3B	HU 6	Quarterly	2.96E+04	5.92E+04	4.07E+04
IFBA-GT-4B	HU 6	Quarterly	2.85E+03	4.22E+03	3.37E+03
IFBA-GT-5B	HU 6	Quarterly	1.52E+04	2.04E+04	1.81E+04
IFBA-GT-6B	HU 6	Quarterly	1.74E+03	2.78E+03	2.42E+03
MW-171-15	HU 1-3	Quarterly	2.33E+03	5.55E+03	3.90E+03
MW-172-25	HU 6	Quarterly	1.92E+03	3.33E+03	2.68E+03
MW-244-18	HU 1-3	Quarterly	2.59E+03	3.70E+03	3.10E+03

The data presented in Tables 5, 6, and 7 establish the current radiological baseline for the Nuclear Safe Storage of Units 1-4 and the refurbishment of Units 5-8. Several monitoring locations adjacent to Units 1 to 4 show tritium concentrations that exceed the early $3x10^6$ Bq/L benchmark. Specifically, MW-239-30 (Average $9.48x10^6$ Bq/L), MW-270-20 (Average $1.96x10^7$ Bq/L), and U1-RBFD-2 (Average $1.93x10^7$ Bq/L) represent high-concentration zones. Despite these high levels, they remain below the revised $1x10^8$ Bq/L ecological criterion. In contrast, the baseline levels for Units 5-8 and the fuel bay areas are notably lower, with most averages ranging from10^3 to 10^5 Bq/L. The highest average recorded in the Unit 5-8 area was $3.84x10^5$ Bq/L at U8 MK 42, which is below the screening levels. (Appendix A, Tables A1-A3, PERA 2025)

6.3 Exposure pathway assessment and hydraulic mitigation

A recurring conclusion across the 2013, 2017, and 2022 assessments is that identified COPCs in groundwater do not require inclusion in the EcoRA Tier-2 for quantitative assessment, due to a lack of complete exposure pathways (p.4.13, ERA 2013; p.4.30 ERA 2017; p.4.39 ERA 2022). The technical justification relies on the fact that groundwater flows toward Lake Ontario, and the highest tritium concentrations are found in areas where station structures act as hydraulic sinks. For example, groundwater near Unit 1 and the Irradiated Fuel Bays is captured by the Turbine

Auxiliary Bay (TAB) foundation drains or the Vacuum Building Ramp Sump (VBRS). Because this captured water is monitored and not discharged directly to the lake, the assessment concludes that on-site ecological receptors (located at depths less than the 2 meter water table) and off-site terrestrial biota are not exposed.

6.4 Predicted adverse effects and 2025 PERA uncertainties

For the 2025 PERA (p.5.70-5.72), a shift in planning indicates that TAB foundation drains and VBRS water will be discharged into the forebay during the Storage with Surveillance Phase of Units 1-4. This could introduce new uncertainties regarding cumulative effects. Historically, the risk was deemed low because tritium heavy groundwater was captured by hydraulic sinks and not discharged to Lake Ontario. However, the 2025 PERA predicts a change in this pathway, where groundwater from the Units 1-4 foundation drains and the Vacuum Building Ramp Sump (VBRS) will be discharged into the forebay. Although modeling predicts these doses will stay below aquatic benchmark (9.6 mGy/d), these predictions rely on hydrological flow data from 2002. This reliance on 20 year old data to predict future concentrations at the point of exposure complicates the ability to understand a reliable baseline and accurately understand the cumulative impact of tritium as the site would transition into its next lifecycle phase.

6.5 Assessment of Tritium in soil

The assessment of tritium in soil is treated as a minor focus, with concentrations consistently remaining below the Derived Release Limits (DRL). Data from the 2017 and 2022 ERAs show maximum concentrations of 92.4 Bq/kg and 486 Bq/kg, respectively (p.4.42, ERA 2013; p.4.67 ERA 2017; p.4.75 ERA 2022). The 2025 PERA predicts that refurbishment activities will have a negligible impact on soil and groundwater quality, citing construction best practices and the prevalence of paved, hardened surfaces that would limit the infiltration of contaminants into the underlying soil. Consequently, soil has not been retained as a primary driver for adverse ecological effects in the current predictive assessment (p.5.66 PERA 2025).

6.6 Comments

There is a huge difference in tritium levels of groundwater monitoring wells near Units 1-4 and Units 5-8. Units 1-4 concentrations are predicted to be roughly 50 times higher than those in the Units 5-8 zone. This shows the problem in establishing a consistent site wide baseline. Because the 2025 PERA relies on 20-year-old flow data from 2002 to model how these high concentrations will behave when discharged into the forebay, the reliable baseline for the Safe Storage phase of the project is based on apparently outdated hydrological assumptions. This lack of new data use could limit the reliability and validity of cumulative effect assessments.

- Without an updated study to confirm if current groundwater flow matches 2002 patterns, the cumulative release of tritium into Lake Ontario might be underestimated if underground plumes may have shifted or expanded over the last two decades.
- The shift from $3x10^6$ Bq/L benchmark in 2017 to $1x10^8$ Bq/L in 2022 effectively disregards high-concentration wells (like MW-270-20) that could have previously triggered exceedance protocols. This upward shift in criteria could mask the cumulative increase of radionuclides by changing the definition of what constitutes a trigger level or adverse effect.
- The decision to discharge groundwater into the forebay during Safe Storage (Units 1-4); a change not bounded by previous assessments can also introduce new cumulative stressor to aquatic receptors, being not part of the original environmental baseline.

Question 7:
How has the presence, screening, assessment, and reporting of tritium in surface water evolved over time?

The following tables summarize the presence of tritium in ground water

Table 8: Tritium in various surface water bodies. (Sources: p.4.17, 4.40 of ERA 2013; p.4.30, 4.31, 4.65 of ERA 2017; p.3.18, 4.75 of ERA 2022; p 5.47 and Appendix A of PERA 2025).

Environmental Component	2013 ERA	2017 ERA	2022 ERA	2025 PERA
Surface Water (Lake Ontario)	Benchmark; 7000 Bq/L No baseline data in this ERA Measured Conc. at Outfall (Bq/L): 2.61E+02 (max) 8.48E+01 (mean)	Benchmark; 7000 Bq/L Baseline: <4.2-69.1 Bq/L which is Based on data collected in 2015 Measured Conc. at Outfall (Bq/L): 1.70E+02 (max) 7.38E+01 (mean) based on monthly effluent and CCW flow rates from PN U1-4 and PN U5-8 from 2011 to 2015.	Benchmark; 7000 Bq/L Baseline: No new baseline data <4.2-69.1 Bq/L collected in 2015 Measured Conc. at Outfall (Bq/L): 2.09E+02 (max) 9.51E+01 (UCLM) based on monthly effluent and CCW flow rates from PN U1-4 and PN U5-8 from 2016 to 2020.	Benchmark; 7000 Bq/L New baseline data Lake Ontario (Bq/L): Spring 2024: 0-31.7 Summer 2024:0-47.8 Fall 2024: -10.5-31.7 Predicted Conc. (Bq/L): Unit1-4 discharge channels: 2.49E+00 Unit 5-8: discharge channels: 4.76E+02
Sediments (Lake Ontario)	Benchmark; DRL Measured Conc. at Outfall (Bq/Kg): 1.14E+03 (max) 3.67E+02 (mean) Based on REMP reports from 2007-2009	Benchmark; DRL Measured Conc. at Outfall (Bq/Kg): 1.14E+00 (max) 3.67E-01 (mean) Max and mean of PN U5-8 Discharge 2006- 2009 EMP reports.	Benchmark; DRL Measured Conc. at Outfall (Bq/Kg): 2.09E+02 (max) 9.51E+01 (UCLM) based on monthly effluent and CCW flow rates from PN U1-4 and PN U5-8 from 2016 to 2020.	No data
Surface Water (Frenchman's Bay)	Benchmark; 7000 Bq/L Measured Conc. at Frenchman's Bay (Bq/L): 4.99E+01 (max)	Benchmark; 7000 Bq/L Measured Conc. at Frenchman's Bay (Bq/L): 1.62E+01 (max)	Benchmark; 7000 Bq/L Measured Conc. at Frenchman's Bay (Bq/L):	Benchmark; 7000 Bq/L New baseline data Frenchman's Bay water (Bq/L): Spring 2024: 31.7-37.1 Summer 2024:15.9-26.4 Fall 2024: 21-31.2

	3.38E+01 (mean) Based on REMP reports from 2007-2011	1.34E+01 (UCLM) 2015 Frenchman's Bay Sampling	5.01E+01 (max) 3.33E+01 (UCLM) based on measured concentrations during the 2016-2020 EMP monitoring period	Predicted Conc. at Frenchman's bay inlet (Bq/L): 2.21E+00
Sediments (Frenchman's Bay)	No data	No data	No data	19.6-227 Bg/Kg

7.1 Lake Ontario: Surface Water

Throughout the decade of monitoring (2013-2025), surface water benchmarks for Lake Ontario have remained consistent at 7,000 Bq/L. In the 2013 ERA, the maximum measured Tritium concentration at the outfall was reported at $2.61x10^{2}$ Bq/L (p.4.40, ERA 2013). By the 2017 ERA, the reporting indicated a lower maximum concentration of $1.70x10^{2}$ Bq/L (p.4.65, ERA 2017). Despite the 2025 PERA later reporting that tritium emissions were actually elevated between 2018 and 2020 due to increased processing of active liquid waste (p.4.25, PERA 2025), the 2022 ERA reported a maximum measured H-3 concentration of $2.09x10^{2}$ Bq/L (p.4.75, ERA 2022) at the outfall. This suggests a disconnect between the timing of environmental reporting and the actual emission peaks occurring on site. The 2025 PERA provides more recent measured H-3 concentrations for Lake Ontario from 2024, showing a maximum of 47.8 Bq/L in the summer (Appendix A, PERA 2025), while simultaneously predicting that refurbishment activities will result in concentrations as high as $4.76x10^{2}$ Bq/L at the Units 5-8 discharge channels (p.5.47, PERA 2025).

7.2 Lake Ontario: Sediments

The assessment of Lake Ontario sediments reveals significant data gaps and a concerning trend of removing high risk areas from active monitoring. In 2013, the outfall sediment concentration was recorded at a maximum of $1.14x10^{3}$ Bq/kg (p.4.40, ERA 2013). Interestingly, the 2017 ERA reported a significantly lower maximum of 1.14 Bq/kg by citing older data from 2006–2009, which indicates a selective use of historical data rather than up to date sampling (p.4.65, ERA 2017).

7.3 Frenchman's Bay: Surface Water

In Frenchman's Bay, the 2013 ERA reported a maximum measured concentration of $4.99x10^{1}$ Bq/L. By the 2017 ERA, this figure decreased to a reported maximum of $1.62x10^{1}$ Bq/L. However, the 2022 ERA noted a return to higher levels, recording a maximum measured concentration of 5.01×10^1 Bq/L. Nonetheless, the concentrations were consistently deemed minor because they remained well below the established 7,000 Bq/L benchmark. More recent data from 2024, as cited in the 2025 PERA, shows measured spring concentrations ranging from 31.7 to 37.1 Bq/L.

7.4 Frenchman's Bay: Sediments

Historical data of sediments in Frenchman's Bay is characterized by significant gaps, with no data reporting in the 2013, 2017, and 2022. It is not until the 2025 PERA that a measured range of 19.6 to 227 Bq/kg is provided. This lack of continuous monitoring makes it difficult to assess the long-term accumulation of tritium in the Bay or to evaluate how past operational spikes in liquid waste processing might have influenced sediment quality over the last decade.

7.5 Issues from PERA 2025

A comparison of exposure assessment of tritium between the 2022 ERA and 2025 PERA reflects a methodology that utilizes changes in discharge volumes to possibly get lower estimated dose values of tritium, and lacks quantification of risk by skipping calculation of risk or hazard quotients as explained below.

Table 9: Predicted Lake Water Concentrations for Tritium (p.5.47, PERA 2025).

Receptor Location	Tritium (Bq/L)
Reactor Building Service Water	7.00E+03
PNGS Units 1-4 Discharge Channel	2.49E+00
PNGS Units 5-8 Discharge Channel	4.76E+02
Frenchman's Bay Inlet	7.80E-01

Table 10: Summary of Tritium Dose Estimates for Biota at the Pickering Site (p.4.76 of ERA 2022 and PERA 2025). Note: PERA 2025 provides HTO and OBT separately, the numbers provided here are calculated by adding HTO and OBT.

		Dose Estimates	
Location	**VCs**	**ERA 2022**	**PERA 2025**
		HTO+OBT (max) Bq/kg(fw)	HTO+OBT (max) Bq/kg(fw)
Outfall	Benthic Fish	2.40E+00	2.74E-05
	pelagic fish	1.86E+02	2.57E-05
	benthic invertebrates	1.86E+02	2.58E-05
	ring billed gull	3.74E+03	5.17E-04
Frenchman's Bay	White sucker	4.45E+01	6.16E-06

	Lake trout	4.45E+01	6.16E-06
	Frog	4.45E+01	6.16E-06
	aquatic plant	4.30E+01	5.95E-06
	benthic invertebrates	4.45E+01	6.18E-06
	bufflehead	1.21E+01	1.11E-05
	common tern	5.74E+01	7.94E-06
	trumpeter swan	5.62E+01	7.78E-06
	ring billed gull	1.12E+02	1.55E-06
	Muskrat	5.31E+01	7.33E-06

If dose estimates are used as proxy for assessment of species-specific exposure to Tritium; a spatial gradient between the Lake Ontario outfalls and Frenchman's Bay can be noted. It shows a reduction in estimated exposure levels in the 2025 projections compared to 2022 data. In the 2022 dataset, Tritium exposure (HTO+OBT) at the outfall locations was comparatively high for pelagic fish and benthic invertebrates, reaching $1.86x10^2$ Bq/kg(fw), while the highest recorded dose estimate was for the Ring-Billed Gull at $3.74x10^3$ Bq/kg(fw). On the other hand, while Frenchman's Bay shows lower peak values, the 2022 data indicates same exposure across various taxa, such as the White Sucker, Lake Trout, and Frog, all estimated at $4.45x10^1$ Bq/kg(fw). In 2025 PERA, these estimates across all species and locations drop by several orders of magnitude, with Frenchman's Bay aquatic biota falling to approximately $6.16x10^{-6}$ Bq/kg(fw), reflecting changes in operation and discharge management.

This shift in exposure dynamics is mainly linked to the changes in operational status of the PNGS and the associated hydrologic modeling. During the transition of PNGS Units 1 and 4 into stabilization and the refurbishment shutdown of Units 5-8, discharge patterns will be rerouted, potentially leading to periods of no flow from condenser cooling water pumps for Units 5-8. To maintain environmental safety, inactive drainage will be directed to intake ducts rather than the Radioactive Liquid Waste Management System, and expected minimum flow rates are projected to increase fivefold from 50,000 m^3/day to 2,050,000 m^3/day (p.5.52, PERA 2025). It is notable that this increase in water flow is a critical factor in improving the dilution of contaminants at the outfall, directly contributing to the drastic reduction in predicted dose estimates for 2025.

The approach above reflects a potential disagreement between predicted Lake water concentrations and the resulting dose estimates. Referring to Table 9, Predicted Lake water concentrations are high in the Reactor Building Service Water ($7.0x10^3$ Bq/L), which is considerably higher than the PNGS Units 1-4 discharge channel at (2.49 Bq/L). However, the 2025 dose estimates for all biota are negligible, suggesting that the model relies heavily on the projected 2,050,000 m^3/day flow rate to achieve extreme dilution. This methodology utilizes dilution factors derived from 2011-2012 Lake data. The dilution factors were developed based on Lake data from 2011-2012. Although a recent 2022 review of conditions from 2016-2020 (including water levels and current speeds) concluded that these factors remain applicable, the model's accuracy depends on the assumption that these "bounding conditions" capture the full range of environmental variability. If the actual flow rate during the refurbishment period does not reach to the projected 2,050,000 m^3/day, it may potentially lead to higher than predicted exposures for sensitive species. Hence, this approach does not satisfy the principles of conservatism.

Furthermore, the 2025 PERA lacks new empirical sediment data for Lake Ontario, and is instead relying on a bounding strategy which asserts that most activities are covered by previous assessments. For Frenchman's Bay, the PERA provides 2024 baseline data but offers no predictive modeling for how refurbishment related waterborne increases may affect these sediments over time. By deferring detailed dismantling and demolition assessments until 2050, the PERA avoids addressing the long-term cumulative impact of sediment bound tritium during the most intrusive phases of the project

7.6 Issues in the adverse effect assessment of aquatic biota

The ERAs do not calculate hazard quotients of radionuclide contaminants despite the presence of following data:

- Estimated dose of exposure
- Body Weight and Intake Rates
- Receptor Occupancy Factors
- Bioaccumulation Factors
- Transfer Factors for Riparian Birds and Mammals
- Dose Coefficients
- Stable Carbon Content for Food Types of surrogates

The omission of Hazard Quotient (HQ) calculations in the presence of comprehensive exposure parameters including intake rates, bioaccumulation factors, and specific activity data such as stable carbon content may indicate a technical gap in the risk characterization. While the report successfully compiles the foundational metrics required to model the Estimated Dose for both animal and plant VCs (which are reported for specific VCs in ERA 2022, and PERA 2025); the omission to progress to a quantitative HQ is a huge hurdle to get a quantitative meaningful estimate of risk. This lack of integration suggests a fragmented methodology where physiological modeling is decoupled from toxicological endpoints. Without the final HQ, the "Estimated Dose" remains just a number lacking biological context, obscuring the actual level of protection afforded to sensitive aquatic receptors. Furthermore, the availability of transfer factors and receptor occupancy data implies that a refined, site-specific exposure model was intended. However, omission of calculation of a risk ratio may suggest either an over-reliance on qualitative screening or a strategic avoidance of highlighting potential exceedances.

7.7 Conclusions

The 2025 PERA serves as a baseline for future refurbishment activities but introduces a predictive model that relies heavily on dilution to justify continued emissions. While current modeling suggests these operational changes will effectively mitigate exposure from source concentrations as high as 7.0×10^3 Bq/L in service water, the reliance on decade old dilution factors introduces a layer of uncertainty regarding the realistic release levels into Lake Ontario and Frenchman's Bay biota during the refurbishment phase of Units 5-8. Moreover, the lack of quantitative characterization of Hazard Quotients (HQs) obscures the actual level of protection for Valued Components and undermines the transparency of the exposure assessment. In addition, the lack of continuous sediment data and the deferral of detailed dismantling assessments until 2050 could limit the understanding of long-term cumulative effects in the Lake Ontario and Frenchman's Bay ecosystems.

Issue 2: Potential Impacts of Amending the Cooling Water System Design from Lake Surface Intake to Lakebed Intake

Question 1:

What might a new Lakebed intake at Pickering mean for the impingement and entrainment of fish? What could be some plausible environmental impacts of its construction/operation, and how could that relate to overall protection of aquatic biota?

This is a complex question bounded by many variables based off of localized hydrography, biological productivity, habitat and ecological mapping.

The lakebed intake would be more similar to the intake structure at the Darlington Nuclear Generating Station (DNGS). The impression of equalness between DNGS or DNNP and PNGS deep water intake's impact is also obvious from text in section 5.3.2.1.2 of PERA 2025. But, two sites cannot be exactly identical in terms of site-specific hydrography, ecology and preferred use of local habitats (Taft, 2000; INL, 2010). Understanding the adverse effects (impingement and entrainment) of a water intake structure design for PNGS would require a site-specific evaluation that should extends far beyond replicating an existing design of DNGS or DNNP. While PNGS and DNGS may share the location of water withdrawal for once through cooling system in broad terms i.e., Lake Ontario; the localized biological, and physical environments may not be 100% identical. Scientific literature and regulatory reports emphasize that Best Technology Available must be determined on a case-by-case basis (Taft, 2000) for each site.

The discussion in section 5.3.2.1.2 of PERA 2025 (p. 203) is vague, lacks definitive designs details of the DWI structure of PNGS; a comprehensive comparison of design features with DNGS; and performance predictions of PNGS with uncertainty estimates of predictions. PERA mentions two studies/reports: "*a recent Best Available Techniques and Technology Economically Achievable (BATEA) assessment of different intake technologies and techniques*" and that "*the proposed DWI is strategically located at a depth where the presence of eggs and early life stages of key species, such as Round Whitefish and Lake Trout*", with no references for such statements. It is obvious that detailed design features have not been finalized yet from the text: "*The specific approach velocity and screen size of the DWI structure, along with the methods to achieve them, are currently being determined*". Hence, the discussion of the DWI as presented seems incomplete and insufficient.

The following discussion outlines why a design considered suitably protective of impingement and entrainment for DNGS/DNNP may not fully qualify for reduced impingement and entrainment effects at PNGS (note: impingement and entrainment are discussed separately in this report).

1.1 Differences in site-specific localized ecology

While comparing the Darlington and Pickering intakes designs may be useful in understanding how a new Lakebed intake for the Pickering site could operate; this approach may have some real limitations. The most important factor is that fish distribution in Lake Ontario is not uniform. The effectiveness of any intake technology is intrinsically linked to the localized "Source Water Baseline" (INL, 2010). Source water baseline could differ in terms of localized spawning and nursery grounds and species-specific behavioral responses.

- The DWI site of PNGS may have a higher concentration of ichthyoplankton (fish eggs and larvae) or species that could be more susceptible to entrainment due to poor/limited swimming ability (Taft, 2000). The effectiveness of a technology like a wedge wire screen or a velocity cap depends entirely on the specific life stages (eggs, larvae, juveniles) present at the intake site. For example, if the PNGS DWI is located near a spawning site for Lake Whitefish, Round Whitefish or Lake Trout, a design that was sufficient for DNGS DWI may not be successful to protect these specific life stages (INL, 2010). PERA 2025 does not specify if absence of sensitive fish species spawning habitat was confirmed through habitat mapping and how habitat use may change over the course of remaining life of PNGS.
- Fish movements are influenced by local bathymetry and shoreline features. Different species exhibit unique avoidance behaviors and swimming speeds. A velocity cap designed to trigger horizontal avoidance in one fish community may be less effective if the second site has a higher concentration of bottom dwelling species or different migratory patterns. Hence, an intake design that successfully avoids fish entrainment or impingement at one site might be positioned in a migratory corridor or a preferred nursery habitat at another site, and may lead to higher-than-expected impingement rates (Taft, 2000).

1.2. Differences in physical and limnological conditions

The physical interaction between the DWI structure and the lake environment may vary across the Lake Ontario coastline in terms of local hydrodynamics, bathymetry and depth.

- The success of velocity caps relies on creating a horizontal flow field that fish can detect and avoid (Taft, 2000). However, local currents, wave energy, and ambient lake velocity at a PNGS DWI may interfere with this flow field, rendering a previously successful design less effective (INL, 2010).

- The depth required to reach the hypolimnion (colder, less biologically active water) varies depending on the Lakebed slope (INL, 2010). A design that reaches deep water at one site (DNGS) may remain in the more productive zone at a second site (PNGS DWI) if the offshore slope is shallower, which can possibly lead to increase in entrainment risk (Taft, 2000).

1.3. Differences in operational hazards

Environmental factors that do not directly involve fish can still impair the technology's ability to protect them. Two such examples could be biofouling, debris and ice loading.

- Invasive species like Quagga and Zebra mussels are prevalent in Lake Ontario, but their colonization rates vary by location, depth, and nutrient availability (INL, 2010). A narrow slot wedge wire screen that remains clear at DNGS may suffer from rapid biofouling at another, necessitating mechanical changes or chemical treatments that could impact the local environment (Taft, 2000).
- The presence of frazil ice or heavy organic debris (e.g., Cladophora algae) is highly localized (INL, 2010). If the PNGS is prone to higher debris loading (algae and aquatic weeds), the intake screens may require more frequent backwashing or different mesh sizes, which could change the impingement profile of the structure (Taft, 2000).

1.4 Conclusions

The technical literature and regulatory guidance generally suggest that the designation of Best Technology Available for cooling water intake structures may be inherently site specific and not readily transferable between facilities. The effectiveness of any intake design appears to be contingent on the localized intersection of biological, hydrological, and physical conditions, including site specific fish communities and life stages, ambient hydrodynamics, thermal plume geometry, and localized seasonal considerations such as frazil ice and biofouling. On this basis, what performs reliably at one Lake Ontario facility may not necessarily provide equivalent protection at another. It is also worth noting that regulatory standards for intake design continue to evolve, and historical compliance may not therefore be sufficient to ensure compliance under current or future environmental frameworks.

Question 2:
Considering impingement data from Darlington and Pickering sites to understand OPG's proposal to construct a DWI at Pickering

According to INL 2010: "*Impingement mortality results when fish and other aquatic life are trapped on equipment at the entrance to the cooling water intake structure*".

For this report, annual impingement data was extracted from various monitoring reports of PNGS site (2019-2024) and of DNGS site (DNGS ERA) and compiled in the Table (Table 11) below.

Table 11: Summary of impingement data extracted from various reports of PNGS (OPG 2019-2024) and DNGS site (OPG 2004). Note: impingement data for DNGS was not publicly available, and data shown here was extracted from DNGS ERA 2020.

Year Station	**Total number Total biomass No. of fish species impinged**	**Species Included in Age-1 Equivalency Estimates**[3]	**Regulated and Other Aquatic Invasive Species**	**SARA Schedule 1 Fish Species**	**Endangered Species**	**Northern Pike**	**Comparison with FAA Predictions**	**Trends**
2024 PNGS	Total species = 33 Total no. =315151 Total biomass=3159 4 kg Total species = 33 Highest no: Alewife Round Goby Three-spine Stickleback Rainbow smelt Largemouth bass	Total species = 21 Total biomass= 2748.7 kg Highest biomass: Alewife, Round Goby, Gizzard Shad, American Eel, Northern Pike, Emerald Shiner, Rainbow Smelt, Three-spine stickleback	Invasive-Round Goby -total biomass = 291.0 kg). No specific mentions of regulated invasive mussel species.	None	14 individuals of American Eel extrapolated to 37 with a total biomass of 49.53 kg.	20 individuals extrapolated to 73 with a total biomass of 73.4 kg.	Combined biomass for 2023 and 2024 was below the two-consecutive-year all-ages threshold of 3,619 kg.	Total biomass was 3,159.4 kg (0.65 kg per million m^3); there were no episodic fish impingement events in 2024
2022 PNGS	Total species = 35 Total no. =43945 Total biomass=2478.9 kg Highest no: Round Goby, Alewife, Rainbow smelt, Three-spine Stickleback, Bluegill	Total species = 22 Total biomass= 1964 Kg Highest biomass: Gizzard Shad, Common Carp, Northern Pike, Rainbow Smelt, Walleye and white sucker	Invasive-Round Goby -total biomass = 100.9 kg). No specific mentions of regulated invasive mussel species.	None	30 individuals American Eel extrapolated to 160 with a total biomass of 225.9 kg.	15 individuals extrapolated to 74 with a total biomass of 129.74 kg.	2021 and 2022 biomass were both below the two-consecutive-year threshold of 3,619 kg	Total biomass (2,478.96 kg) was higher than 2021 (1,585.07 kg) but remained below regulatory thresholds
2019 PNGS	Total species = 35 Total no, = 2234198 Total biomass: 15114.5 kg Highest no: Three-spine Stickleback, Round Goby, Gizzard shad, Rainbow smelt, Alewife, Emerald Shiner	Total species = 22 Total biomass= 14600 Kg Highest biomass: Alewife, Gizzard Shad, Common Carp, Northern Pike, Chinook Salmon, Three-spine stickleback	Invasive-Round Goby -total biomass = 450.9 kg). No specific mentions of regulated invasive mussel species.	None	12 individuals of American Eel extrapolated to 42 with a total biomass of 58.8 kg.	21 individuals extrapolated to 92 with a total biomass of 143 kg. Max biomass (188 kg) was impinged in 2013	2019 biomass (15,114.5 kg) exceeded the Fisheries Act Authorization (FAA) projected annual average of 3,620 kg This exceedance was also noted in 2018	Impingement was higher than the prior five years. High rates in Jan, June, Nov, and Dec were attributed to cold weather/environmental events, not station operations.
2020 ERA DNGS (p.332-333) (data collected	Total number = 274931 Biomass= 2362 Kg Total species = 13 Highest numbers:	Total species = 14 Examples: Round goby, Spoonhead Sculpin, Alewife,	Invasive-Round Goby -total biomass = 1308 kg). No specific mentions of regulated	None	American Eel impinged Between April 2016 - March 2017=13 April 2017-March 2018=24	No mention	Not discussed	Both numbers and biomass of fish impinged in 2010-2011 were higher than the estimates made in 2006-2007 (26,024 fish, 893 kg).

in 2010-2011)	Round Goby Alewife Rainbow smelt Spoonhead Sculpin[1] Cottus species[2]	Unidentified sculpin, Slimy sculpin	invasive mussel species.		April 2018 - March 2019=5 April 2019 - March 2020=0			

1. Note taken from p. 332 DNGS ERA: Examination of photographs presented in the source document by experienced fish taxonomists suggested misidentification. It is probably Mottled Sculpin
or Slimy Sculpin, as the preopercular spine was not curved enough for a Spoonhead Sculpin

2. *Cottus* means a genus of sculpins

3. For entrainment, fish eggs and larvae are expressed as age-1 equivalents to my understanding (p.226 ERA 2022)

2.1 Impingement trends at PNGS

Based on the available data from 2019-2024, fish impingement at PNGS has shown significant variability, and is stated to be mainly driven by environmental factors rather than station operations. In 2019, the station experienced a major exceedance where the total biomass reached 15,114.5 kg, significantly surpassing the *Fisheries Act* Authorization (FAA) authorized annual average of 3,620 kg. This spike was attributed to high rates of impingement in winter and early summer caused by cold weather and environmental events. Following this, impingement levels stabilized. By 2022, the biomass dropped to 2,478.9 kg, and in 2024, it was recorded at 3,159.4 kg. In both recent years, the combined biomass remained safely below the two consecutive year regulatory threshold of 3,619 kg.

<u>Key species of concern</u>

Northern Pike: This species consistently contributes to the impingement biomass at PNGS. In 2019, 20 individuals were sampled (extrapolated to 92) with a biomass of 143 kg. While the numbers fluctuated slightly to 15 individuals in 2022 and 20 in 2024; the associated biomass remained a notable component of the highest biomass category for the station.

While Northern Pike was observed at DNGS site in 2010, 2011 and 2019 (p.2.70 DNGS ERA 2020), no discussion on impingement was present.

American Eel: As an endangered species, American Eel is monitored at PNGS. In 2019, 12 individuals were extrapolated to 42 (58.8 kg). There was a noticeable increase in 2022 with 30 individuals extrapolated to 160 (225.9 kg), before declining in 2024 to 14 individuals extrapolated to 37 (49.53 kg).

In addition to data in Table 11, the number of American Eels that were killed by impingement in 2020, 2021 and 2022 at DNGS were 1, 5 and 4 respectively (p.4.22, 2024 ERA Addendum for DNGS).

2.2 PNGS vs. DNGS Performance

The performance of the DWI design currently operational at the DNGS and proposal of similar performance at PNGS is evaluated here by comparing the impingement rates between the two sites.

2.2.1 Comparison including PNGS 2019

If 2019 data is included, DNGS appears to perform quite better than PNGS in terms of total biomass. The DNGS 2020 ERA report (using 2010-2011 data) shows a total impinged biomass of 2,362 kg, which is more than six times lower than the 15,114.5 kg recorded at PNGS in 2019. This suggests that the offshore DWI location at DNGS may provide an advantage in avoiding the high biomass episodic events triggered by shoreline environmental conditions. Nonetheless, if 2019 is considered a worst-case event or an anomaly, it would be more appropriate to cross compare worst case events or anomalies of the both stations (which was not done here).

2.2.2 Comparison excluding PNGS 2019

If the anomalous 2019 data is excluded and we focus on the more recent PNGS performance (2022 and 2024), the gap narrows considerably. The DNGS biomass of 2,362 kg is very similar to the PNGS 2022 biomass of 2,478.9 kg and slightly lower than the 2024 biomass of 3,159.4 kg. While DNGS still maintains a lower absolute biomass, the performance benefit is less pronounced during years where PNGS does not experience extreme weather-related impingement events.

2.2.3 Comparison of species of concern impingement

The divergence regarding this aspect between the two sites is significant. At PNGS, the number of American Eels impinged is significantly higher, with 2022 alone reporting 30 individuals (extrapolated to 160 individuals with a biomass of 225.9 kg). Even in a low reporting year like 2024, PNGS extrapolated 37 individuals. The DNGS offshore intake, by comparison, shows very small impact on this SARA Schedule 1 species, with annual counts remaining in the low single digits.

Comments: The incorporation of specific DNGS mortality counts of just 1 to 5 individuals annually may indicate a contrast to the PNGS shoreline intake, which impinged dozens to hundreds of American Eels (up to 160 extrapolated in 2022). Interestingly, this difference may imply that the proposed DWI could effectively shield nearshore dependent and endangered species. Nonetheless, the 2025 PERA's reliance on total biomass metric is technically weak. The dominating presence of invasive Round Goby at DNGS site impingement (over 55% of biomass) can statistically mask the impingement and hence protection of high priority native species. Hence, the projected 89% reduction in impingement is based off of DNGS estimates and the DWI may benefit a few species heavily rather than a uniform ecological benefit. Moreover, there would be a mitigation gap for sensitive native populations until the DWI becomes operational in 2030.

2.3 2025 PERA and the DWI

The 2025 PERA's projected 89% reduction in impingement relies on the assumption that deeper waters offer lower fish productivity and that a porous veneer intake design would effectively prevent the entrapment of large schools. This optimistic prediction is weakened by actual DNGS data, which showed higher than expected biomass and significant populations of invasive species like the Round Goby at offshore depths.

The data suggests that the high prevalence of Round Goby in impingement could mask the relative impact on native species. At the DNGS offshore site, the Round Goby alone accounted for 1,308 kg of the total 2,362 kg biomass meaning a single invasive species represented over 55% of the total impingement weight. While the 2025 PERA argues that deeper waters are predominantly inhabited by large bodied fish (p.5.60); the DNGS data shows a high abundance of smaller invasive and forage fish. Hence, this may underrepresent the true ecological risk to sensitive native species like the American Eel (SARA Schedule 1) or Northern Pike. This domination by a few abundant species can skew the perceived success of the DWI, as the reduction in total biomass might be driven by changes in Round Goby distribution rather than improved protection for ecologically significant or endangered native populations.

2.4 Conclusions

Overall, the projected environmental benefits of the proposed DWI appear to be based largely on extrapolations from the DNGS experience and theoretical assumptions that introduce a degree of uncertainty into the assessment. The cited 89% reduction in impingement is not convincingly substantiated by the available comparative data, as impingement biomass at DNGS has not consistently been lower than that recorded at PNGS, and earlier DNGS estimates were themselves subject to revision. The validity of the DNGS analogy also appears to be affected by documented uncertainties in offshore species identification, and the characterization of deep water zones as predominantly large fish habitat may not fully account for the documented biomass contributions of smaller invasive species such as Round Goby. On this basis, the projected protective outcomes of the DWI could more appropriately be regarded as plausible estimates.

Question 3:
Considering entrainment data from Darlington and Pickering sites to understand OPG's proposal to construct a DWI at Pickering

According to INL 2010: *"Entrainment results when aquatic organisms, eggs, and larvae are taken into the cooling system, passed through the condenser, and then discharged back into the source water body"*.

It appears that more detailed data has been collected for DNGS though not as regularly. The following table (Table 12) has annual entrainment data compiled from 2 reports: one is from 2004 and other from 2015-2016.

Table 12: Summary of two publicly available entrainment data of PNGS and DNGS (na= not available and nc= not calculated). PNGS data was sourced from ERAs which cites Golder 2007 (not accessible).

Year	**Species**	**Eggs (millions)**	**Larvae (millions)**	**Equivalent number of spawning females**
2007 PNGS	Not given	51.99	11.39	455373
Golder 2007 from all ERAs				
Data from DNGS				
2004	Alewife	5.96	0.64	4600
Source: DNGS entrainment sampling report 2004	Rainbow smelt	na	0.40	2500
	Unknown	5.38	na	400
	Total	11.34	1.04	7500
2015-2016	Alewife	87.43	0.10	nc
Source; Patrick et al., 2021	Round Goby	0.26	9.90	nc
	Slimy/mottled sculpin	0.27	na	nc
	Walleye	6.47	na	nc
	Burbot	na	0.03	nc
	Deepwater Sculpin	na	0.72	nc
	Rainbow Smelt/Alewife	na	0.06	nc
	Unidentified	0.05	0.10	nc
	Total	94.48	10.98	nc

3.1. Gaps in PNGS entrainment data

Despite the PNGS water intake being located nearshore; an area typically associated with higher biological productivity, there is a clear absence of routine entrainment monitoring. While annual impingement reports for 2019, 2022, and 2024 provide specific numbers for fish impinged, they fail to provide precise data for the entrainment of fish eggs and larvae.

The ERAs from 2013, 2017, and 2022 rely almost exclusively on a single study from 2007 (Golder 2007- reference provided in the list). This passive reliance on nearly two decades old data is problematic for several reasons:

- Biological communities in Lake Ontario are dynamic; relying on 2007 data ignores shifts in species composition or population density over the last 15 years.
- While some fish species like Common Carp and Alewife are noted, the annual totals for invertebrates are entirely absent from the 2017, 2019, and 2022 ERAs.
- OPG was ordered in 2008 to reduce entrainment by 60%, yet subsequent ERAs repeatedly state that "*no reasonable technological solution is available*" to meet this requirement; essentially acknowledging a persistent environmental impact that is not being actively measured.

3.2. PNGS vs. DNGS entrainment

A comparison between the two sites suggests that the offshore design of DNGS may offer advantages, though the data remains inconsistent.

While the DWI at DNGS is intended to reduce biological impact, the 2015-2016 sampling actually shows a significantly higher number of entrained eggs (94.48 million) compared to the PNGS 2007 baseline (51.99 million). However, DNGS appears to collect more robust data, identifying a wider variety of species such as Walleye and Deepwater Sculpin, which are missing from PNGS reports. The efficiency of the DNGS DWI is currently based on the theory that larval abundance decreases with depth, specifically that 44% of larvae are found at 5 m depth (p.5.59, PERA 2025).

Furthermore, the comparison between the two sites may be confounded by species specific behaviors; for instance, the DNGS data suggests potential misidentification of sculpin species (Spoonhead vs. Mottled or Slimy), which could affect the accuracy of the baseline risk assessments used to justify the DWI design.

3.3 DWI at PNGS and potential uncertainties

The proposal to install a DWI at PNGS by 2030 is modeled after the DNGS offshore structure. Initial estimates suggest this could reduce entrainment by 60% relative to the current shoreline intake. This prediction is based on the assumption that deeper waters contain lower densities of fish larvae.

However, there could be uncertainty in these predictions due to following reasons:

- Because PNGS has not routinely monitored entrainment, there is no current and historical nearshore baseline to compare against the projected offshore benefits.
- The assumption that the PNGS site will behave exactly like the DNGS site is an extrapolation. Differences in lake bottom topography, local currents, and thermal plumes could result in different larval distributions.
- The planned 2024-2025 monitoring program is intended to substantiate these values, but until then, the 60% reduction (p. 5.59, PERA 2025) remains a theoretical estimate derived from a similar assessment at a different location.

3.4 Conclusions

The available entrainment data for PNGS is limited, with biodiversity assessments seemingly relying predominantly on a single 2007 study despite nearly two decades of intervening ecological change. Annual monitoring reports provide impingement figures but does not consistently capture entrainment of eggs, larvae, or invertebrates, suggesting a potentially notable gap in the long-term evidence base. A comparison with DNGS entrainment data does not appear to clearly demonstrate that a DWI intake structure would necessarily result in substantially lower entrainment, as egg entrainment figures at DNGS were reportedly higher than those historically estimated for PNGS.

The proposed DWI at PNGS, modelled on the DNGS DWI structure, carries a projected 60% reduction in entrainment that remains theoretical at this stage. This estimate appears to be based on generalized assumptions about larval depth distribution in Lake Ontario rather than site specific longitudinal data for Pickering. Given that there could be localized ecological differences between the two sites, and the apparent absence of a robust PNGS baseline; the projected reduction may be more appropriately regarded as a plausible estimate pending further substantiation through the future monitoring after installation and operation of the DWI in 2030.

Question 4:
Can Pickering's refurbishment result in changes from historical or predicted thermal discharges?

There was no information available on the design of the cooling water outfall which leads to the assumption that it will remain as is. In terms of predicted changes to thermal discharge of the refurbishment and subsequent operation, there are the following predictions.

- *Acute cold shock risk:* Fish can experience physiological stress if operational units shutdowns trigger a rapid decline in plume temperatures, creating a high thermal gradient between discharge and ambient conditions that fish are unable to acclimate to in time.
- *Deep water intake thermal profiles:* While drawing water from the DWI is expected to be 3-5°C cooler than existing surface intake, empirical data from the DNGS suggest this may not result in a cooler plume. Because DNGS operates with a larger ΔT (temperature difference between the ambient and the plume), its discharge temperatures would remain equivalent to current PNGS levels despite the colder intake.
- *Depth and turnover variations:* Although the proposed average depth of DWI intake (11-11.5 m) at PNGS is slightly deeper than the 10 m intake at DNGS, 2024 thermal profiles indicate a negligible temperature difference (approximately 1°C) between these depths following spring and fall lake turnovers.
- *Operational projections:* While intake conditions will shift, discharge temperatures during continued operations are projected to remain similar to or only marginally lower than current operational baselines of PNGS.

The operation of PNGS represents a significant source of alteration of the Lake Ontario nearshore thermal environment. While historical assessments suggest manageable impacts, the transition to refurbishment and the implementation of a DWI could introduce complex thermal dynamics that would require rigorous monitoring.

4.1 Historical thermal impacts on Lake water and fish

Historically, PNGS has functioned as a point source of significant thermal enrichment. As stated by PA Henderson (2018), "*According to OPG's 2017 ERA, the thermal plume with water over 2^{o}C above ambient lake water temperature spans approximately 1.5-8 km^{2} from the PNGS at the water's surface year-round, and approximately 0.5-3 km^{2} at the bottom of the lake during colder weather conditions. Further, data from 2006/7 indicates that the PNGS thermal plume has been as large as 62.6 km from the Pickering site along the surface of the lake and 12.8 km along the lake bottom*".

While past assessments by OPG conclude that the discharge has not resulted in chronic or acute adverse effects on Round Whitefish embryo survival, the reality might be more complex. The thermal plume has consistently created localized environments where temperatures may exceed a 6°C threshold; the agreed upon trigger for adaptive management regarding Round Whitefish. (PERA 2025, p. 6.37, section 6.2.1)

For other species, the Hazard Quotient (HQ) approach reveals that thermal criteria for several fish were frequently exceeded within the plume. While proponents argue these exceedances align with high ambient lake temperatures, the station's contribution effectively removes any remaining thermal margin for these species. Notably, Walleye demonstrated a 5% exceedance above thermal criteria specifically within the plume that was not found in reference areas. Furthermore, the plume could have fundamentally altered local community composition, artificially attracting species like Smallmouth Bass, Common Carp, and Emerald Shiner to the discharge channels. (PERA 2025, p. 6.37, section 6.2.1)

Table 13: Historical and plausible future thermal risks and projections for fish species

Fish Species	**Sensitivity and Historical Impact**	**Plausible future Thermal Risks and Projections**
Round Whitefish	Past studies found no chronic/acute adverse effects on embryo survival. However, localized plume temperatures have exceeded the 6°C adaptive management threshold.	Climate-driven hypolimnion warming (+1.0°C) could increase threshold exceedances, lowering recruitment. Rising lake temperatures may prevent water from falling below the 4°C criteria of spawning water temperature.
Walleye	Historically demonstrated a marginal exceedance (5% above criteria) in the thermal plume that was not observed in reference areas.	Could be anticipated to experience one of the greatest shifts in thermal stress due to the combined inputs of climate change and station discharge. Could likely be forced to shift habitats to remain in optimal ranges.
Smallmouth Bass	Known to utilize PNGS discharge channels for spawning, exposing them to temperatures significantly higher than natural nearshore habitats.	Like Walleye, this species could be projected to experience heightened stress from synergistic climate and discharge warming. This species may be expected to reduce in number near Units 1-4 as discharge ceases.
Alewife and Gizzard Shad	Highly fragile to cold temperatures.	There may be high risk of mortality or morbidity due to operationally induced cold shock (e.g., rapid temperature drops during station shutdown), which may lead to increased impingement liability.
Emerald Shiner	Historically attracted to the warmer temperatures of the discharge channel.	Could be anticipated to decrease in population density in the immediate vicinity of the Units 1-4 discharge as those units would move into a permanent stabilization phase.
Lake Trout and White Sucker	Included in thermal criteria monitoring; historical modeled temperatures generally did not exceed critical spawning criteria.	Could generally be anticipated to face reduced thermal margins as lake warming progresses, though most are not expected to exceed upper lethal temperatures.

Common Carp	Attracted to and currently reside in the warmer thermal plume of the discharge channels.	Could be expected to migrate away from the Units 1-4 discharge area as temperatures return to natural Lake Ontario nearshore conditions.

4.2 Future thermal effects: Refurbishment and the DWI

The proposed refurbishment and the shift to a DWI system (targeted for 2030) may introduce two primary risks: acute cold shock during transitions (p.4.111, ERA 2022; section 6.2.1, p. 6.37, PERA 2025) and long-term thermal loading under a warming climate.

4.2.1 Cold shock vulnerabilities

Cold shock could be a critical liability, occurring when rapid temperature drops outpace the physiological acclimation of fish. Historically, cold shock is most probable during full station outages, which typically occur only every 10 years. The permanent shutdown of Units 1 and 4 in late 2024 was managed through phased intervals to mitigate this risk. Starting in fall 2026, Units 5-8 will be shut down for refurbishment. To prevent mass mortality, OPG must execute a staggered shutdown, as each unit requires 48 hours for a complete cessation of thermal discharge. Alewife and Gizzard Shad remain particularly fragile to these operationally induced shifts; their death or morbidity could create a direct regulatory liability for OPG regarding impingement losses. Nonetheless, PERA 2025 does not discuss the risk of cold shock in association with probability of impingement and entrainment (assuming that at that time, the old cooling water intake and FDS would be still operational).

4.2.2 DWI implementation and the warming climate

The DWI will draw water from 1.5 km offshore at depths of 10.5-12 m, where temperatures are 3-5°C cooler than the surface. While this might imply a cooling effect, evidence from the Darlington DWI suggests that lower intake temperatures often result in a larger ΔT (temperature difference between the ambient and the plume), leading to discharge temperatures that remain equivalent to current surface intake levels. (p.5.62, PERA 2025)

The critical concern lies in the intersection of PNGS operations and Climate Change. By 2070, Lake Ontario surface temperatures are projected to rise by 1.3-1.6°C or by 2.5°C by as early as 2041 (PERA 2025; PA Henderson, 2018)

- *Fish can experience synergistic stress.* For species like Smallmouth Bass and Walleye, the combined input of climate warming and PNGS discharge would likely force a habitat shift as they may struggle to remain within optimal temperature ranges.

- *Round whitefish recruitment and spawning success might be vulnerable.* Under high-warming scenarios (+1.0°C in the hypolimnion), increased frequency of threshold exceedances could lead to lower embryo survival and recruitment. There is a distinct possibility that as the lake would warm, winter temperatures may fail to drop below the 4°C required for successful Round Whitefish spawning, a phenomenon the PNGS plume could exacerbate.

4.3 Conclusions

The thermal impact assessments conducted to date suggest that temperature related stress at PNGS is largely localized and appears to remain within acceptable ecological thresholds for most species assessed. Hazard Quotient analysis indicates that thermal exceedances are predominantly confined to the immediate discharge channel, and peak thermal stress for warm water species tends to occur late in the developmental cycle, moderating overall reproductive risk. Regulatory thresholds for sensitive species such as Round Whitefish appear to be met with reasonable margin, with modelled relative survival losses remaining well below the established 10% regulatory benchmark.

Looking ahead, Climate Change introduces a layer of uncertainty that may need ongoing consideration. Cold shock risk associated with polar vortex events represents an area of residual uncertainty, as the intensity and frequency of such events under future climate scenarios is not fully predictable. While the frequency of thermal stress events appears relatively stable under current projections, the duration of individual events is anticipated to increase for certain species, and the cumulative interaction between ambient lake warming and station thermal discharge remains difficult to fully characterize at this stage. The proposed DWI is expected to draw from cooler, deeper water strata, potentially moderating intake temperatures by several degrees and partially offsetting climate driven warming trends, though this remains a modelled outcome subject to site specific validation. Ultimately, while OPG claims discharge temperatures will remain "similar to or lower than" current conditions, this assumes the station's thermal load will not increase as it fights to comply with thermal discharge limits against a backdrop of a warming Lake Ontario. Verification through future thermal monitoring and public data sharing remains essential to ensure that improved conditions are a physical reality rather than a modeled projection.

References

EcoMetrix, 2014. Environmental Risk Assessment Report for Pickering Nuclear. OPG Report No. P-REP-07010-10012. January 2014. (Cited as ERA 2013 in the text)

EcoMetrix, 2018. Environmental Risk Assessment Report for Pickering Nuclear. OPG Report No. P-REP-07701-00001 R001. February 2018. (Cited as ERA 2017 in the text)

EcoMetrix, 2023. Environmental Risk Assessment Report for Pickering Nuclear. OPG Report No. P-REP-07701-00007 R001. 2023-03-31. (Cited as ERA 2022 in the text)

EcoMetrix, 2022. Predictive Effects Assessment for Pickering Nuclear Safe Storage – 2022 Addendum Report. P-REP-07701-00006 R001 2023-03-31

EcoMetrix, 2025. Predictive Environmental Risk Assessment for Pickering Refurbishment, Decommissioning, and Continued Operations. P-REP-07701-00014 R000. 2025-04-07 (cited as PERA 2025 in the text)

EcoMetrix, 2024. Environmental Risk Assessment Addendum for The Darlington Nuclear Site. OPG REPORT: D-REP-07701-00002 R00

EcoMetrix, 2020. Environmental Risk Assessment for The Darlington Nuclear Site. D-REP-07701-00001-R001

OPG, 2019. Pickering Nuclear Generating Station 2019 Impingement Monitoring Report. P-REP-07263-00013-R000. 2020-04-29

0OPG, 2021. Pickering Nuclear Generating Station 2021 Impingement Monitoring Report. P-REP-07263-00015

OPG, 2022. Pickering Nuclear Generating Station 2022 Impingement Monitoring Report. P-REP-07263-00016-000. 2023-03-17

OPG, 2023. Pickering Nuclear Generating Station 2023 Impingement Monitoring Report. P-REP-07263-00017-R000.

OPG, 2024. Pickering Nuclear Generating Station 2024 Impingement Monitoring Report. P-REP-07263-00019-R000. 2024-05-31

OPG, 2004. Entrainment Sampling at Darlington Nuclear Generating Station 2004. NK38-REP-07264-10001-R00. 2006-08-24

Burlakova LE, Karatayev AY, Hrycik AR, Daniel SE, Mehler K, Rudstam LG, Watkins JM, Dermott R, Scharold J, Elgin AK, Nalepa T. Six decades of Lake Ontario ecological history according to benthos (2022). Journal of Great Lakes Research, 48(2):274-288. doi: 10.1016/j.jglr.2021.03.006.

Burlakova, L. E., et al. (2024). Lake Ontario Benthos Survey Cooperative Science and Monitoring Initiative 2023. Technical Report USEPA-GLRI. Great Lakes Center, SUNY Buffalo State University.

Figary, S.E., et al. (2023). Lake Ontario's nearshore zooplankton: Community composition changes and comparisons to the offshore. Journal of Great Lakes Research, 49(2), 482-494.

Golder, 2007. Aquatic Environment Technical Support Document Refurbishment and Continued Operation of Pickering B Nuclear Generating Station Environmental Assessment. Report No. NK30-REP-07701-00008. March.

Idaho National Laboratory (INL) (2010). Cooling Water Issues and Opportunities at U.S. Nuclear Power Plants. Rev. 1. Prepared for the U.S. Department of Energy. Report No. INL/EXT-10-20208.

Patrick, P.H., Di Giuseppe M., Manolopoulos, H., Mo-Ki Tai, J., Poulton, S., & Wright, J. (2021). Entrainment of fish eggs and larvae at an operating nuclear generating station using improved methodology, Lake and Reservoir Management, 37:2, 186-198, doi: 10.1080/10402381.2020.1843207

Swim, Drink, Fish (2018). Relicensing hearing before the Canadian Nuclear Safety Commission (CNSC) for the Pickering Nuclear Generating Station Notice of Public Hearing, Ref. 2018-H-03. May 18, 2018

Taft, E. P. (2000). Fish protection technologies: a status report. Environmental Science & Policy, 3, S349–S359.