Comments on the Focus Report

By Dr. Lynn Cameron, BSc, MSc, PhD

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I am writing in relation to the Focus Report on Northern Pulp's Proposed Replacement Effluent Treatment Facility Project. My name is Lynn Cameron and I live in Three Brooks. My house is on the shore of the south gut, a tidal tributary of Caribou Harbour. Spring through fall, my dogs and I are in and on the water every day. I have a PhD in organic chemistry from the University of Victoria, an MSc in natural products synthetic chemistry from McMaster University and a BSc (Hon. Chemistry) from Saint Mary's University. Prior to my retirement in 2015, I worked at ThermoFisher Scientific (formerly known as Applied Biosystems) in the field of pharmacogenetics specializing in single nucleotide polymorphism detection and reverse transcription real time PCR (polymerase chain reaction) for gene expression analysis. Post retirement I was lucky to fish as a deck hand in the back of a boat full time during lobster season 2016 and 2017 and part time for the season of 2019.

Since I live close to the harbour and spend much of my time on or in the water I feel quite passionately against the pumping of pulp effluent into the Northumberland Strait and I urge you once again to reject the proposal.

I am writing this letter with emphasis on 3 of the terms of reference.

Term of Reference *"2.3 Submit data regarding the* ***complete physical and chemical characterization*** *of NPNS' raw wastewater (ie., influent at Point A for the Project),* ***to support the assessment of the appropriateness of the proposed treatment technology****. The influent characterization results must be compared against the proposed treatment technology specifications."*

The proposed treatment facility falls short of acceptable with respect to AOX removal (concentration measurements and lack of AOX degradation) and dangerous nitrogen and phosphorous loads that could lead to eutrophication and possible harmful algal blooms (HABs).
The proposed treatment facility is **not appropriate** because it will not sufficiently remove AOX which is composed of toxic organic chlorides including PCBs and chlorinated dioxins and furans. Nor does the facility remove excess nitrogen and phosphorous which can lead to eutrophication and ultimately harmful algal blooms (HABs).

1. **AOX Removal**

AOX is a term for a general group of organic compounds that contain 1 or more halogen atoms (in the case of bleached pulp effluent the halogen is predominately chlorine). In general, the compounds in this category are hydrophobic meaning they will adhere to fatty tissue, sediment or plant life.

Retention Time Comparison:
One of the factors affecting the amount of AOX in the water is the length of time the effluent is allowed to settle, often referred to as retention time. The authors use Point A for untreated effluent and use Point C (Boat Harbour influent) to represent the treated effluent (page 24 of the Focus Report, Figure 2.3-1).
Point C has a much longer retention time (8.5 days) which allows for the settling out of the heavier molecular weight AOX compounds compared to the proposed new ETF (less than 13 hours - Focus Report page 45). Given this fact, one can conclude that the AOX concentrations entering the marine environment from the proposed ETF will be higher than KSH predicts, and that the risk presented by such substances is greater than predicted. It is important to note that the higher the flow, the less retention time is available, which is counter to cleaning up the effluent.

Lack of AOX Degradation:
In Appendix 2.3 page 6 the authors claim the AOX is degraded into Cl- ions and carbon dioxide by photochemical and biological processes

This claim is not tenable. By the authors' own admission there can be up to 663 kg/day released into the Northumberland Strait (Focus Report, Table 2.4-3). Any AOX that can be degraded is done so during the retention time. This time is longer, as discussed above, in the current system than it will be in the proposed process. In fact, the authors show (Appendix 2.4, page 13, Table 1-5) that the concentration of AOX is lower in the current system (87 kg/day) than what was produced by Veolia (less than or equal to 225 kg/day). The RWS study shows 663 kg/day so the AOX released at the outfall could be more than half a metric tonne per day.

They claim that proof of the degradation is that the values for chloride ion are much greater at Point A than in the raw water (Appendix 2.3, page 6). The values for chloride are higher at Point A because chloride is produced during the bleaching process using ClO_2 as the bleaching agent which is what is used at Northern Pulp. The high chloride results are what we would expect based on the bleaching chemistry. Not because the AOX is degraded.

Persistent Organic Pollutants, Bioaccumulation and Biomagnification
Most AOX are toxic to marine and human health and some are considered Persistent Organic Pollutants (POPs). Persistent organic pollutants are organic compounds that do not degrade by chemical, biological, or photolytic processes.
Under the United Nations environmental program the Stockholm Convention lists 12 original, plus 16 newly classified compounds as Persistent Organic Pollutants (POPs). (1)
Included in the initial 12 are hexachlorobenzene; polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans and PCBs which are also found in the pulp effluent.
Because of their persistence and lipid solubility they tend to bioaccumulate. POPs have been found in the deep ocean so they do not just disappear no matter how dilute the concentration.(2)
The chlorinated dibenzo-p-dioxins (CDDs) that are eaten by marine organisms biomagnify in the food chain. The half-life in the human body for the family of

compounds known as CDD is anywhere from 5 to 15 years. (3) The ETF project entails continuous release of these harmful compounds into the Northumberland Strait. They will bioaccumulate over time and create an escalating risk as the flow continues year over year. This fact alone dictates that dilution is not the solution for pollution when it comes to chemicals that bioaccumulate.

Incorrect Sampling Technique:
The sampling reported in the Focus Report (Appendix 2.3 Pg 104 of 541 Job#B9C9662 , Pg 368 of 541 Job#B9E4451, Pg 413 of 541 Job#B9E4487, Pg 497 of 541 Job#B9E4476 , pg 541 of 541 Job# B9E4405) was done using HDPE containers. Sampling for halogenated organic compounds is typically carried out using amber glass bottles (4, 5) because the AOX molecules of interest are known to adhere to surfaces that are less hydrophilic. They stick to plastic, organic tissue (like plankton, fish and plants), sediment and HDPE. We would expect the AOX numbers to be higher if they used the proper glass bottles for sampling.

Nitrogen and Phosphorous
In Appendix 2.4 at page 10 the authors admit there is a large variation in the phosphorous content of the untreated effluent (0.12 to 5.8 mg/l) and they will not be able to attain the decreased level. Rather, they used the value from Point C (1.5 mg/L where the effluent has already settled for 8.5 days). Point C is once again not representative of actual effluent content and it is clear the phosphorous content will be variable and high.

Excessive amounts of nitrogen and phosphorous lead to algal blooms which deplete the area of oxygen and create "dead zones" in the ocean where many species can no longer live or thrive. The algal blooms can produce toxins which lead to health issues for marine life and ultimately to humans who ingest them. Algal blooms containing toxins are referred to as harmful algal blooms (HABs). Different ratios of nitrogen to phosphorous will encourage different species of algae growth. This phenomenon is not completely understood and is a current area of research. Not all algae contain toxins at all times but it is unpredictable and can change at any time. Alexandrium spp. and Pseudonitzschia spp. are both known to be present in the Northumberland Strait. (6) They have been known for producing paralytic shellfish poisoning and the neurotoxin domoic acid respectively. When conditions are not favourable for algae growth they remain in the environment as cysts. When favourable conditions arise they grow. Nitrogen and phosphorous in the effluent will surely lead to an increase in the number of blooms. With an increase in the number of blooms there is a chance that the HABs will also increase.

2. Baseline studies for fish and shellfish

"9.1 ***Complete baseline studies for fish and shellfish tissue*** *(via chemical analysis) of representative key marine species important for commercial, recreational and Aboriginal fisheries in the vicinity of the proposed effluent pipeline and diffuser location."*

It is important to note not all of the chemicals present in the effluent are tested nor are the chemical components of the effluent fully understood. The following statement is from a *Canadian Environmental Protection Act* Priority Substances List assessment report(7):
"Although approximately 250 individual compounds have been characterized in bleachery effluents, they have been estimated to represent only 10 to 40% of the total low molecular weight materials present."
I am not confident that we truly know the effect of the chemical mixture on biological systems and therefore cannot confidently predict the risks associated with effluent exposure.

It should be noted that "not detected" does not mean the substance is not present. They are known to be generated during the pulping process and the amounts of each individual substance changes based on the type of wood that is used. Some toxins are capable of accumulating in fish up to 25 000 times the concentration in water.(7) Given that the proposed treatment facility only removes about half of the organic chemicals that will be released into the Northumberland Strait, we need further investigation into the long-term health effects before the risks can be predicted accurately.

The experiments used to determine the effect of stress (toxins, temperature, salinity, pH, turbidity, etc.) on an organism have come a long way since the early 1990s. Consequently, the Acute Lethality test (LC50) should no longer be considered sufficient. Sublethal exposure may still affect the physiology and gene expression of the fish and/or shellfish and more work is required to understand this. We know many of the halogenated organic compounds affect the reproductive and immune systems, and can lead to developmental disorders or cause cancer. Gene expression experiments help gain a better understanding of the exposure effects on protein and enzyme production which gives us an idea of how the effluent will influence the function of biological processes. Popesku et al (8) look at the effects of pulp effluent (3 Kraft and 2 Thermomechanical) on gene expression of the neuroendocrine brain of fathead minnows. They conclude that pulp effluent does inhibit spawning by females by decreasing the levels of key enzymes in the hypothalamus. They conclude that effluents contain neuroactive substances that have yet to be characterized which is made more difficult because of the complex mixture that composes pulp mill effluent. The paper by Brockmeier et al (9) use gene expression to investigate exposure of mosquitofish to kraft pulp mill effluent on the Fenholloway river and demonstrates endocrine disrupting properties of the pulp mill effluent. They found 121 genes upregulated (over-expressed) and 91 genes downregulated by effluent exposure. Sixty-two of the genes are involved in metabolic pathways and are consistent with experimental results of the fish exposed to androgens. They conclude the effluent is responsible for masculinizing the female mosquitofish.
In order to understand and assess the risk presented by the effects of effluent components, further gene expression profiling experiments must be performed on fish and shellfish that are exposed to the effluent at concentrations consistent with what will exit at the diffuser as final effluent, and not once it is diluted. The results should then be compared to those from unexposed samples from the same species.
While the toxicity of each individual compound can be taken into account, as I mentioned in my comments on the EARD, the cumulative **effect of the mixture of toxins** in the

effluent on sea life and ultimately human health is unknown and the risk cannot be assessed with the information as summarized in the Focus Report and EARD. (10)

3. Assessment of impacts on Human Health

9.2 Commence a Human Health Risk Assessment (HHRA) to ***assess potential project-related impacts on human health****. The risk assessment must consider human consumption of fish and other seafood, consumption of potentially contaminated drinking water, exposure to recreational water and sediment, outdoor air inhalation, and any other potential exposure pathways. The analysis must inform the identification of contaminants of concern and updating of the receiving water study.*

In Appendix 9.2, Table A.6a the dioxin 2,3,7,8-TCDD is flagged as a contaminant of potential concern in the seafood ingestion pathway and is present in the effluent sought to be discharged at the outfall for the proposed ETF. This compound, 2,3,7,8-tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD), is the most toxic of the dioxins known. It is believed to cause liver damage, increased risk of diabetes and abnormal glucose tolerance along with possible reproductive or developmental effects as demonstrated in animal studies and may increase the risk of cancer in people. (3) As a CDD it is included in the POP as designated by the Stockholm convention mentioned above.

In Appendix 9.2, Table A-4 the authors maintain that total phosphorous is not a parameter considered to be of potential human health concern.
"Phosphorus is a required dietary mineral. Phosphorus exists in the environment as phosphate anion, where it acts as a nutrient, and has not been associated with adverse effects in humans. Human health concerns are primarily related to increased productivity (eutrophication) in aquatic systems, which is outside the scope of this human health risk assessment (CCME, 2004)."

The conclusion is not accurate: Eutrophication is an issue. Various levels of nitrogen and phosphorous will lead to algal blooms and potentially **harmful** algal blooms (HABs). (11, 12, 13, 14, 15)

Comments on Table: Understanding Water Measurement Units

As a final point, I have attached a revision to the Table found at page xix of the Focus Report as Appendix 1 to these comments. In my view, the time analogy presented in that table is misleading and fails to properly depict the presence and significance of various compounds in the effluent. The Dillon table suggests that the presence of certain compounds is miniscule and they are therefore harmless. This is dangerous and misleading as the risks from many of these substances is very high even at extremely low concentrations. My revised table provides a better summary based on molecules per litre and molecules per day of these substances. I provide further explanatory comments following my revised table.

Conclusion

Thank you for taking the time to read this letter and please consider that we could potentially be destroying the sensitive aquatic ecosystem of the Northumberland Strait and rendering it uninviting for aquatic species and human recreation if the current proposal is granted. We could also be poisoning and/or killing the fish and thereby poisoning ourselves. I beg you to ensure the proper and current experiments are performed before pulp effluent is pumped into the strait. It is my opinion that the limits of allowable toxins and effects of said toxins are not well established and some risks remain unidentified, while others are much more significant than predicted in the Focus Report and EARD.

References:

1. The 12 initial POPs under the Stockholm Convention
http://chm.pops.int/TheConvention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx

2. Depth Profiles of Persistent Organic Pollutants in the North and Tropical Atlantic Ocean Environmental Science and technology, Caoxin Sun, Thomas Soltwedel, Eduard Bauerfeind, Dave A. Adelman, and Rainer Lohmann
https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b05891

3. TOXICOLOGICAL PROFILE FOR CHLORINATED DIBENZO-p-DIOXINS
https://www.atsdr.cdc.gov/toxprofiles/tp104.pdf

4. from Environment Canada THE INSPECTOR'S FIELD SAMPLING MANUAL
http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf

5. US EPA Sampling Guidance for Unknown Contaminants in Drinking Water
https://www.epa.gov/sites/production/files/2017-02/documents/sampling_guidance_for_unknown_contaminants_in_drinking_water_02152017_final.pdf

6. Paralytic Shellfish Poisoning (PSP) toxins in Miramichi Bay (New Brunswick, southern Gulf of St. Lawrence): Seeking the source, Claude E. Léger and Stephen S. Bates, 2012
https://waves-vagues.dfo-mpo.gc.ca/Library/346923.pdf

7. Canadian Environmental Protection Act Priority Substances List Assessment Report No. 2 Effluents from Pulp Mills Using Bleaching
https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/psl1-lsp1/pulp_mill_effluents_pate_blanchie/pulp_bleaching-pate_blanchie-eng.pdf

8. Gene expression profiling of the fathead minnow (Pimephales promelas)

neuroendocrine brain in response to pulp and paper mill effluents, Jason T. Popeskua, Elvin Y.Z. Tana, Pierre H. Martelb, Tibor G. Kovacsb, Andrea Rowan-Carrollc, Andrew Williamsc, Carole Yaukc, Vance L. Trudeaua, Aquatic Toxicology, 99 (2010) 379–388

9. Brockmeier EK, Jayasinghe BS, Pine WE, Wilkinson KA, Denslow ND (2014) Exposure to Paper Mill Effluent at a Site in North Central Florida Elicits Molecular-Level Changes in Gene Expression Indicative of Progesterone and Androgen Exposure. PLoS ONE 9(9): e106644. doi:10.1371/journal.pone.0106644

10. DETECTION OF REPRODUCTIVE IMPACTS OF EFFLUENTS FROM PULP AND PAPER MILLS: SHIFTS IN ISSUES AND POTENTIAL CAUSES KELLY R. MUNKITTRICK, MARK E. MCMASTER, AND MARK R. SERVOS Environmental Toxicology and Chemistry, Vol. 32, No. 4, pp. 729–731, 2013 https://s3.amazonaws.com/academia.edu.documents/41222345/Detection_of_reproductive_impacts_of_eff20160115-2201-1taioh7.pdf?response-content-disposition=inline%3B%20filename%3DDetection_of_reproductive_impacts_of_eff.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20191011%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20191011T005246Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=8f04e71dc392e64754628c99d028463ad8ac3bad4bb831177cab01c5b2d627e6

11. US EPA The Facts about Nutrient Pollution https://nepis.epa.gov/Exe/ZyNET.exe/P100UWV3.txt?ZyActionD=ZyDocument&Client=EPA&Index=2016%20Thru%202020%7C1991%20Thru%201994%7C2011%20Thru%202015%7C1986%20Thru%201990%7C2006%20Thru%202010%7C1981%20Thru%201985%7C2000%20Thru%202005%7C1976%20Thru%201980%7C1995%20Thru%201999%7CPrior%20to%201976%7CHardcopy%20Publications&Docs=&Query=marine%20nutrient%20levels&Time=&EndTime=&SearchMethod=2&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C11THRU15%5CTXT%5C00000031%5CP100UWV3.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=15&FuzzyDegree=0&ImageQuality=r85g16/r85g16/x150y150g16/i500&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x#

12. US EPA Preventing Eutrophication: Scientific Support for Dual Nutrient Criteria https://nepis.epa.gov/Exe/ZyNET.exe/P100V89H.txt?ZyActionD=ZyDocument&Client=EPA&Index=2016%20Thru%202020%7C2011%20Thru%202015&Docs=&Query=algae%20bloom&Time=&EndTime=&SearchMethod=2&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C11THRU15%5CTXT%5C00000031%5CP100V89H.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-

&MaximumDocuments=15&FuzzyDegree=0&ImageQuality=r85g16/r85g16/x150y150g16/i500&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionE&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1

13. Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States Donald M. Anderson, Joann M. Burkholder, William P. Cochlan, Patricia M. Glibert, Christopher J. Gobler, Cynthia A. Heil, Raphael M. Kudela, Michael L. Parsons, J. E. Jack Rensel, David W. Townsend, Vera L. Trainer, Gabriel A. Vargo, Harmful Algae 8 (2008) 39–53

14. Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences DONALD M. ANDERSON1, PATRICIA M. GLIBERT, and JOANN M. BURKHOLDER, Estuaries Vol. 25, No. 4b, p. 704–726 August 2002

15. Lucy Ngatia, Johnny M. Grace III, Daniel Moriasi and Robert Taylor (January 14th 2019). Nitrogen and Phosphorus Eutrophication in Marine Ecosystems, Monitoring of Marine Pollution, Houma Bachari Fouzia, IntechOpen, DOI: 10.5772/intechopen.81869. Available from: https://www.intechopen.com/books/monitoring-of-marine-pollution/nitrogen-and-phosphorus-eutrophication-in-marine-ecosystems

Appendix 1

	Symbol	Multiplying Factor	Exponent Form	Parameter Measurements	Units	Part per	**molecules per L** (assume ave molecular weight of 300)	**molecules/day** (assume ave. molecular weight of 300 and 85 million litres per day)
Base Unit	*Base unit*	1	1.00E+00	gram/litre	g/L	1 part per thousand	2,047,000,000,000,000,000,000	174,000,000,000,000,000,000,000,000
deci	d	0.1	1.00E-01	decigram/litre	dg/L	1 part per ten thousand	204,700,000,000,000,000,000	17,400,000,000,000,000,000,000,000
centi	c	0.01	1.00E-02	centigram/litre	cg/L	1 part per hundred thousand	20,470,000,000,000,000,000	1,740,000,000,000,000,000,000,000
milli	m	0.001	1.00E-03	milligram/litre	mg/L	1 part per million (ppm)	2,047,000,000,000,000,000	174,000,000,000,000,000,000,000
micro	u	0.000001	1.00E-06	microgram/litre	ug/L	1part per billion (ppb)	2,047,000,000,000,000	174,000,000,000,000,000,000,000
nano	n	0.000000001	1.00E-09	nanogram/litre	ng/L	1 part per trillion (ppt)	2,047,000,000,000	174,000,000,000,000,000,000
pico	p	0.000000000001	1.00E-12	picogram/litre	pg/L	1 part per quadrillion (ppq)	2,047,000,000	174,000,000,000,000,000

For the purpose of this exercise I used an average molecular weight of 300. The calculation is shown below.

As you can see, in the mg/L range, the number of molecules per litre is in the billions of billions order of magnitude! My point is that a part per million is not as dilute a solution as the time analogy would imply. So, even if we assume the best case scenario after "cleanup" is correct, the amount of AOX is estimated to be approximately 1.02mg/L (which calculates to 87kg/day) from Table 2.3-3 we can expect somewhere around 2 billion billion halogenated molecules per litre (that is 174 trillion trillion halogenated molecules per day).

The number of molecules present in a given mass is dependent on the chemical structure (number and type of atoms that make up the molecule), therefore, an average molecular weight of 300 was used. Typically, in chemistry terms, we refer to that as 300 grams per mole (or 300g/mol).
If molecular weight is half of the assumed value, ie half of 300 is 150, the final number of molecules per litre would be doubled. Conversely, if the molecules were larger, say a MW 600, then molecules per litre would be halved.

Calculation:
Molecular weight: 300g/mole
Avogadro's number: 6.022×10^{23} molecules/mole (this is a constant)

molecules/gram: 6.022×10^{23} molecules/mole ÷ 300g/mole = 2.007×10^{21} molecules/g
molecules/mg: 2.007×10^{21} molecules/g x 0.001g/mg = 2.007×10^{18} molecules/mg
molecules/L in a 1 ppm (mg/L) solution:
2.007×10^{18} molecules/mg x 1.02 mg/L = 2.047×10^{18} molecules/L
molecules/day in a 1ppm (mg/L) solution at a flow rate of 85 million L/day (peak flow, page 38 Focus Report):
2.047×10^{18} molecules/L x 85,000,000L/day = 1.74×10^{26} molecules/day