McKiggan Hebert
LAWYERS

March 9, 2018 File No. 8463-019

The Honourable Margaret Miller
Minister of Environment
Barrington Tower
1894 Barrington Street, Suite 1800
P.O. Box 442
Halifax, NS
B3J 2P8

Dear Ms. Miller,

Re: Consultation with Pictou Landing First Nation on an Application by Northern Pulp Nova Scotia Corporation for Approval of a Replacement Effluent Treatment Facility at Abercrombie Point and Pipeline to Caribou Harbour pursuant to the Environment Act.

Introduction

We understand that your department is currently the lead department on the formal consultation between the Crown and Pictou Landing First Nation with respect to the proposed replacement effluent treatment facility and pipeline for Northern Pulp's mill at Abercrombie Point, Nova Scotia (the "Project").

Pictou Landing First Nation was advised by letter dated February 6, 2019 from Lynn Bowen of your department that the Project would be registered pursuant to the ***Environment Act*** the following day (February 7, 2019) and that Pictou Landing First Nation would have until March 9, 2019 to provide written comments on the Project. In a subsequent exchange of correspondence with Ms. Bowen, she confirmed that the Crown intended to rely on the environmental assessment process to fulfil, in part, its s. 35 duty to consult.

Pending Decision

The decision currently before you is whether to approve the Project, reject the Project or require further steps be taken or other information provided before a final decision on the Project is made: ***Environment Act*** (the "***Act***"), s. 34(1).

In ***Pictou Landing First Nation v. Nova Scotia***, 2018 NSSC 306, Justice Timothy Gabriel ruled that the Province has a duty to consult with Pictou Landing First Nation in respect of the pending decision as to whether or not to fund the Project. While the Province has appealed that decision, the decision stands as good law until such time as the Court of Appeal rules otherwise. In light of this, we must make it clear that the comments which follow are restricted

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to the decision whether to approve the Project under the ***Environment Act*** and are not intended to constitute the comments of the Pictou Landing First Nation on the impending decision whether to fund the Project.

Summary of PLFN Position

Pictou Landing First Nation urges you to exercise your discretion to require an environmental-assessment report pursuant to s. 34(1)(c) of the ***Act***. The environmental assessment registration document ("EARD") filed by Northern Pulp establishes that there are a number of studies that are missing, not complete or require additional data collection before a full assessment of the impacts of the Project on the environment can be undertaken. In short, baseline information is lacking. There is no doubt that the Project will lead to the discharge of known contaminants into the waters of the Northumberland Strait and that the adverse impacts of those substances are not fully understood at this time. The same is true of the impacts of burning sludge in the power boiler – this will certainly lead to the emission of contaminants into the air, but these too are not fully understood at this time. For the reasons that follow, the only approach that respects the significance of the risks to Pictou Landing First Nation Aboriginal and Treaty tights is a full environmental assessment report.

Factors to Consider

The ***Environmental Assessment Regulations***, N.S. Reg. 26/1995 as amended, set out the factors to be taken into account in making a determination under s.34(1) of the ***Act***.

> 12 All of the following information shall be considered by the Minister in formulating a decision under subsection 34(1) of the Act:
>
> > (a) the location of the proposed undertaking and the nature and sensitivity of the surrounding area;
> >
> > (b) the size, scope and complexity of the proposed undertaking;
> >
> > (c) concerns expressed by the public and aboriginal people about the adverse effects or the environmental effects of the proposed undertaking;
> >
> > (d) steps taken by the proponent to address environmental concerns expressed by the public and aboriginal people;
> >
> > (da) whether environmental baseline information submitted under subclause 9(1A)(b)(x) for the undertaking is sufficient for predicting adverse effects or environmental effects related to the undertaking;

(e) potential and known adverse effects or environmental effects of the proposed undertaking, including identifying any effects on species at risk, species of conservation concern and their habitats;

(f) project schedules where applicable;

(g) planned or existing land use in the area of the undertaking;

(h) other undertakings in the area;

(ha) whether compliance with licences, certificates, permits, approvals or other documents of authorization required by law will mitigate the environmental effects;

(i) such other information as the Minister may require.

These submissions will address the factors relevant to this assessment in order.

Location of Project

Effluent

The proposed effluent treatment facility would be located next to the mill at Abercrombie Point. The proposed pipeline would be buried along an overland route from Abercrombie Point to Caribou, Nova Scotia where it would continue as a subsea pipeline buried under the bottom of the Northumberland Strait for 4 kilometers where it would rise out of the seabed and terminate at a diffuser. Effluent will flow through the pipeline from effluent treatment facility to the diffuser where it will be discharged into the waters of the Northumberland Strait.

The Northumberland Strait, and in particular, the area surrounding the proposed discharge point, is part of the traditional fishing territory of the Mi'kmaq, and Pictou Landing First Nation commercial, food and ceremonial fishers in particular. The diffuser is located in DFO Lobster Fishing Area 26A where many PLFN fishers participate in the lobster fishery pursuant to private and communal commercial lobster licenses. The Pictou Landing First Nation commercial fishery is the single biggest industry within the community employing 100 people each year out of a population of 280 working age members: EARD, p. 450. Species that are fished within the vicinity of the proposed diffuser are rock crab, lobster, scallops, herring, mackerel and tuna.

The unique characteristics of the Northumberland Strait are described in other submissions and will not be repeated here.

Air

The mill at Abercrombie Point is located approximately 6 kilometers Southwest of IR 24 where the Pictou Landing First Nation makes its home. The prevailing winds blow from the mill in the direction of the Pictou Landing First Nation: EARD, Appendix K, pp. 9-12.

Size, Scope and Complexity of the Project

Effluent

The effluent treatment facility is designed to discharge up to 85 million litres of effluent each day into the Northumberland Strait, although the anticipated daily average is predicted to be 63.6 million litres. The operations are projected to continue 24 hours per day, seven days per week non-stop for several decades.

Adding to the complexity of the Project is the fact that Northern Pulp is unable to identify what chemicals and other substances may be in the treated effluent: EARD, pp. 489, 493, 506.

Further adding to the complexity of the Project is that the interaction of the chemicals in the proposed effluent, even if they are known, with living organisms is species dependent and cannot be extrapolated from one species to another: EARD, Appendix R, p. 1.

The complexity of the Northumberland Strait makes it difficult to model and predict water movement: EARD, Appendix R, p. 11. In addition the effects of climate change and acidification further complicate the predictive value of any modelling: *ibid*. The Stantec Receiving Water Study was not supported by actual sampling and could be wrong: *ibid*, pp. 1-2.

Air

Sludge collected from the effluent treatment process is proposed to be burned as fuel in the power boiler of the mill: EARD, p. 45. The EARD does not indicate the volume of sludge to be burned but does indicate that it will be burned with the existing hog fuel in a ratio of 7 parts hog fuel to 1 part sludge: EARD, Appendix K, p. 7. In terms of rate of total particulate matter (TSP) emitted into the air during operations, Stantec predicts this to be 8.38 grams/second: Appendix K, p. 7. This equates to 257,755 kilograms per year. Not all of the anticipated emitted TSP will be attributable to the burning of sludge, but this gives an idea of the volumes emitted by the mill. They are not insignificant.

Adding to the complexity of the Project is the fact that the composition of the sludge is unknown at present: EARD, Appendix K, p. 6.

Predictive Value of Environmental Baseline Information

Effluent

As noted above, the effluent will contain chemicals and substances that are harmful to living organisms in the Northumberland Strait. In the EARD, Northern Pulp acknowledges that there are gaps in the information needed for an environmental assessment.

Pictou Landing First Nation retained the services of Exp Services Inc. to review the EARD and provide a summary of the information gaps, both those acknowledged by Northern Pulp in the

EARD itself, and those identified by Exp. In a letter dated March 8, 2019 to Chief Andrea Paul (enclosed), Exp listed the following deficiencies in the environmental information and studies:

1. Marine Benthic Habitat Studies

No study of the marine benthic habitat has been undertaken along the proposed pipeline route although it is suggested that one will be conducted as part of the design and to facilitate a request for review by DFO: EARD, p. 21. It does not appear that a benthic habitat study within the mixing area (100 metres from the diffuser) is being considered. There is no mention that any baseline studies have been undertaken to date either along the proposed pipeline route or in the mixing area. Once the seabed has been disturbed by trenching for the pipeline, no pre-Project baseline will be available. The same can be said of the mixing area – once it begins to be impacted there is no possibility of obtaining baseline information. Marine benthic habitat studies are carried out over a yearlong cycle.

2. Geotechnical Studies along Proposed Pipeline Route

No geotechnical studies have been carried out on the seabed along the proposed pipeline route: EARD, p. 21. Information from the geotechnical study would allow a determination as to whether the proposed route will support the pipeline without risk to the integrity of the pipeline from future geological events.

3. Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat Assessment

The Project has not been assessed from the point of view of impacts on fish and fish habitats. It is said that these studies will be developed later to support a Request for Review from DFO: EARD, p. 21. Given the potential for serious harm to the Pictou Landing First Nation commercial, food and ceremonial fisheries from the chemicals contained in the effluent, this is a glaring omission from the EARD.

4. Lethal and Sub-lethal Effect of Effluent on Lobsters (and Other Species)

The EARD contains a summary of existing research on the effects of bleached Kraft mill effluent on lobster prepared by Fraser Clark: EARD, Appendix R. While the conclusions of the research summary are based on the Receiving Water Study modelled by Stantec, the existing literature seems sparse and the author himself recommends further study on lethal and sub-lethal effects of bleached Kraft mill effluent on adult lobster and lobster larvae using current effluent. Exp makes a similar recommendation. In addition, Exp notes that the same testing should be carried out on other species of fish in the affected area. While Exp notes that testing ideally would be carried out with the actual effluent being produced, the studies could, and should, have been done using the current treated effluent in the meantime.

5. Mi'kmaq Ecological Knowledge (MEK)

No MEK has been obtained regarding the current proposed pipeline route: EARD, p. 451. No assessment has been made of the Pictou Landing First Nation's interactions with the marine environment: EARD, p. 490.

6. Human Health Risk Assessment

No human health risk assessment has been completed: EARD, p. 490. This is said to be due to in part from the lack of information concerning the chemical composition of the effluent after treatment. However, Exp points out that while it is impossible to know now what the final composition of the *treated* effluent will be, the current *untreated* effluent will not change with the proposed effluent treatment facility. Therefore it is, and has been, possible to analyze the current *untreated* effluent for the presence of various chemicals of interest. This would serve to identify any potential chemicals of concern that may find their way into the treated effluent. If this has been done, it has not been reported in the EARD and the results of the analysis have not been considered.

Exp notes that there are official sources which identify a number of contaminants of potential concern that are relevant and could be tested for in the current untreated effluent: *Nova Scotia Environment Contaminated Sites Regulation, Tier 1 Environmental Quality Standards Surface Water Parameters for Fresh Water and Marine Environments* and the *Halifax Regional Municipality Construction Dewatering Assessment Parameters*: Exp., pp. 5-7. Exp has set out the chemicals in two tables. There is considerable overlap in these tables. The current untreated effluent can be tested to determine which of these chemicals of concern are present in the untreated effluent and could therefor find their way into the treated effluent. This has apparently not been done.

This is particularly appropriate because some of the claims being made about the anticipated *treated* effluent in the EARD are based on the characteristics of the untreated effluent. For example, the presence of dioxins and furans was ruled out because these are not expected in the elemental chlorine free bleaching process: EARD, p. 509. Yet the analysis of water following the recent escape of untreated effluent from the existing pipeline did show elevated levels of dioxins and furans, according to your department's own records. Accordingly, rather than relying on assumptions about the characterization of the effluent, the actual untreated effluent should be analyzed before any decision is made.

Another flaw in the EARD analysis is that it focuses only on the regulated chemicals of interest, primarily those regulated under the federal *Pulp and Paper Effluent Regulations*. Presumably this would carry through to a future human health risk assessment. Exp recommends characterizing the effluent by testing for the chemicals of concern noted above rather nthan restricting the analysis to regulated chemicals.

Current effluent could be analyzed for those parameters recommended by Exp at two accredited laboratories in Nova Scotia - Maxxam Analytics Inc. and Agat Laboratories - both of which are accredited by both the Canadian Association for Laboratory Accreditation (CALA) and Standards Council of Canada (SCC).

The human health risk assessment should be completed before any decision is made and should follow the guidelines contained in *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)*, Version 2.0, 2010, Revised 2012.

Air

As noted above, burning of sludge could have an adverse impact on the air quality as it will be burned in the power boiler and existing prevailing winds will carry emissions towards Pictou Landing First Nation.

Exp notes that the 2019 Stantec air modelling report limited itself to an analysis of those few contaminants currently regulated in Nova Scotia either under the *Air Quality Regulations* or under the existing industrial approval applicable to Northern Pulp's operations: EARD, Appendix K, pp. i and ii. However, there is no reason to limit the analysis to those contaminants. For one thing, the present operation does not burn effluent sludge, whereas the proposed Project contemplates that 1/7 of the fuel burned in the power boiler will be sludge. As a result one cannot rely on the existing Industrial Approval to address contaminants that may be emitted from the burning of sludge.

In fact, Exp notes that it is well recognized that pulp and paper mills and their effluent treatment processes emit more air contaminants than those identified in the Stantec report. These include: volatile organic compounds (VOCs) and total reduced Sulphur (TRS) compounds consisting of H_2S, methyl mercaptan, dimethyl sulphide, dimethyl disulphide as well as chlorinated compounds.

There are existing guidelines on the contaminants released by the burning of effluent sludge. These are found in *AP-42 Chapter 1.6 Wood Residue Combustion in Boilers*, *AP-42 Chapter 2.2 Sewage Sludge Incineration* and *AP-42 Chapter 10.2 Chemical Wood Pulping*. Stantec was obviously aware of those guidelines: EARD, Appendix K, p. 6. These guidelines identify contaminants of concern. These contaminants were not addressed by Stantec.

Exp notes that the *Air Dispersion Modelling Guideline for Ontario, 2017* (ADMGO) lays out a procedure for modelling the dispersion of air contaminants. ADMGO is also cited by Stantec in its report: EARD, Appendix K, p. iii.

ADMGO requires, as a first step in the air modelling process, a source summary table for all contaminants emitted including a full rationale for any contaminants deemed insignificant. This was not done in the Stantec analysis and is a serious omission. As noted above, Stantec focused only on regulated contaminants. As such the analysis did not conform to ADMGO standards.

As part of a comprehensive environmental assessment report, Northern Pulp should provide a source summary table of all contaminants of interest.

ADMGO lays out an emission summary and dispersion modelling (ESDM) procedure to be followed. This requires that sample calculations be provided detailing emission rates determined, significance of each possible contaminant and emission factor ratings assigned to all possible contaminants. Again this is not contained in the Stantec report and is a major omission. It should be part of a required environmental assessment report.

The analysis should take into account future changes. For example in Ontario, sulphur dioxide will be reduced from 275 µg/m3 (1- hour) and 690 µg/m3 (24-hour) to 100 µg/m3 (1 -hour) and 10 µg/m3 (annual) in the year 2023. This not discussed in the EARD.

Finally, Exp notes that emissions of odorous contaminants should be assessed based on the criteria in the *Ontario Air Contaminants Benchmark* (ACB) list.

Given these gaps, it is difficult to see how the Project can be approved at this time. More information is required. The predicative value of the environmental baseline provided in the EARD is severely restricted due to the absence of baselines in key areas.

Potential and Known Adverse Effects

Effluent and Air

There are clearly contaminants of concern in the effluent: EARD, p. 503-504. Likewise, as noted above, there are contaminants of concern that will be released by burning sludge. The EARD is silent on the potential effects of each of these contaminants as they were not fully listed in the EARD.

The lack of information on the environmental and health impacts of these chemicals of concern is a major deficiency in the EARD.

Mitigation Effects of Permits, etc.

While the operations of the mill and the effluent treatment facility will require an Industrial Approval under the Nova Scotia ***Environment Act***, the terms of the industrial approval are unknown at this time as the existing Industrial Approval will expire on January 31, 2020 before the new treatment facility begins operation.

Without knowing the terms of a new Industrial Approval, it is impossible to know what mitigating impacts the Industrial Approval may have on the potential adverse impacts from contaminants in the effluent and air emissions.

Since your department is involved in both this environmental assessment and the presumed application for a new Industrial Approval, it makes sense that a full environmental assessment report be required at this time so that the two processes can work together based on a full understanding of the environmental impacts of the Project. It makes little sense to approve a project only to have it come to a halt by the terms of an Industrial Approval. Conversely, if adverse impacts are not addressed at this stage, we should not rely on the Industrial Approval process to correct fill in the blanks.

The effluent must also met the standards set out in the federal ***Pulp and Paper Effluent Regulations.*** As Exp notes, the ***PPER*** are under review and will likely change given that they have been in place since 1992. Further, the ***PPER*** only address a handful of parameters: EARD, Appendix E, p. 16. As noted above, there are many more chemicals of concern that are in the effluent.

The EARD notes that DFO will be asked to provide comments. Because of the ***PPER***, DFO's role in reviewing the Project will be limited to considering the impacts of the construction phase only. DFO will not be independently assessing the effects of effluent on the marine fish habitat or fish themselves. A pulp mill is allowed to discharge effluent into the marine environment as long as it complies with the PPER, whether or not the effluent is a deleterious substance. Thus Pictou Landing First Nation's concerns about the adverse impacts of effluent on its fishery will not be addressed by DFO above and DFO's inquiry will be limited to the impacts of the pipeline construction. Pictou Landing First Nation's concerns will only be addressed in this environmental approval process.

Air quality standards are governed by the Nova Scotia ***Air Quality Regulations***: EARD, p. 135. However, as noted above, the contaminants regulated under those regulations are limited in scope compared to the potential contaminants known to be generated in the pulp and paper industry and from burning sludge. Compliance with the ***Air Quality Regulations*** will not mitigate the adverse impacts of other contaminants.

Other Information

History of Government Failing to act Honourable

In making a determination under s. 34(1), it is important to consider the Honour of Crown vis-à-vis Indigenous peoples potentially impacted by the pending Project. In this case, the Project will be a component of the pulp mill. Since 1967, effluent from the mill has been discharged into Boat Harbour and this has had a significant and life altering adverse impact on the Pictou Landing First Nation.

The members of Pictou Landing First Nation are asking for a full environmental assessment report of the new treatment facility. There is good reason for this. In addition to the deficiencies in the EARD noted above, it must be remembered that the members of the Pictou Landing First Nation were lied to by representatives of the Provincial Water Authority about the potential impacts of treating effluent at Boat Harbour. They were advised there would be no odor problems associated with the facility. To further this deception, the Chief and one Council member were taken to Saint John, New Brunswick and shown a residential wastewater treatment facility that had not yet begun to receive any wastewater. The Chief and Councillor were told that the Boat Harbour waters would be just as clean. The sad part is that when deciding to accept the mill, the Chief and Council of the day were acting in the best interests of all of Pictou County with the Chief writing that "it would be good for the whole area".

Pictou Landing First Nation knew that they had been deceived immediately after the dark brown effluent began to flow into Boat Harbour. Fish were killed en masse as community members watched them trying to escape from the water onto the shores of Boat Harbour. This was soon followed by the putrid stench of Sulphur. The community protested to the Province and despite the Province's commitment to the federal government, as owner of the Reserve, the Province took several years to acknowledge the problem. It added infrastructure to aid in the treatment of the effluent. However, the odours remained and the fish did not come back. The effluent flowed out of Boat Harbour and affected Lighthouse Beach, with piles of brown foam constantly visible. Chemicals in the air, which could not be seen, reacted to the paint on people's houses, turning them black.

It was not until a lawsuit against the federal government was started in 1986, that the Province took Pictou Landing First Nation's demands to close Boat Harbour seriously. By 1992 the Province promised to close Boat Harbour at the end of 1995 when its agreement to treat the effluent would expire. However, that didn't happen. Instead the treatment facility was leased to the owners of the mill for a 10 year period to the end of 2005. Then in 2002 the Province extended the lease to 2030 based on a promise by the mill owner to build a by-pass pipeline within Boat Harbour which it represented would allow the Province to remediate most of Boat Harbour after 2005. The by-pass pipeline was not built and at the end of 2005 the Province asked Pictou Landing First Nation for a three-year extension which the community granted. When the extension was about to expire Pictou Landing First Nation announced that it would not grant a further extension.

In light of this the Province agreed in writing that it would close the treatment facility as soon as a new facility was built. However, within 6 months a new provincial government changed its mind and decided to study the problem. Over a year later the Province decided to renege on its commitment to close the Boat Harbour treatment facility.

It was not until the existing pipeline broke and the Pictou Landing First Nation refused to allow representatives of Northern Pulp onto its burial grounds at Indian Cross Point to fix the pipeline that the Province once again agreed to close the Boat Harbour treatment facility. This of course led to the ***Boat Harbour Act***.

The past 5 decades of deceit and indifference coupled with the Province's financial interest in the Project, have left the people of Pictou Landing First Nation very skeptical of the provincial government when it comes to environmental impacts associated with the Northern Pulp mill. This was recognized by Justice Gabriel in ***Pictou Landing First Nation v. Nova Scotia***, *supra*, at paragraph 74:

> This will do nothing to assuage whatever cynicism has been engendered in the past by the already significant environmental impact which has been visited upon Treaty lands and environs by the mill and its facilities to date.

While the Province has appealed Justice Gabriel's decision that the Province has a duty to consult with Pictou Landing First Nation regarding the funding of the Project, his words should be weighed carefully in the disposition of this application for environmental approval of the Project.

Justice must not only be done, but must be seen to be done. Having rejected a Class II environmental assessment, Pictou Landing First Nation now asks for a full environmental assessment report. The Honour of Crown requires it in light of the cruel treatment of Pictou Landing First Nation by successive provincial governments. Now is the time to do the right thing. Pictou Landing First Nation deserves a high level of assurance that their Aboriginal and Treaty rights to fish in the Northumberland Strait and to reside on Reserve lands free of airborne contaminants are not impacted by the Project.

PLFN Limited Time to Respond
PLFN has had an inadequate amount of time in which to respond to the 2,000 page EARD.

It appears even from the EARD itself, that further studies and investigations are required. These will take time in any event. Pictou Landing First Nation urges you to require the completion of these studies as part of a full environmental assessment report pursuant to section 34(1)(c) of the ***Act***. This will allow fuller participation by Pictou Landing Frist Nation.

Exp Comments
Exp has provided comments on other aspects of the EARD which are relevant if the Project is approved. We include portions of a Review Document that Exp prepared for Pictou Landing First Nation for your review. If the Project is approved Pictou Landing First Nation respectfully requests that these issues be considered and addressed in the conditions to the approval where appropriate. Further, Pictou Landing First Nation expects that consultation would continue on the terms of any environmental effects monitoring program that is established.

Tertiary Treatment
In 2011 Pictou Landing First Nation requisitioned a report from Exp. Exp was asked to review a 2010 report from Amec (now Wood) setting out options for the treatment of effluent from the Northern Pulp mill and in particular one option that was very similar to the Project under consideration. That option involved an AST system located adjacent to the mill much like the present Project. Exp was asked to report on feasible enhancements to the proposed treatment system that would allow the effluent to meet the same standards as the Town of Pictou would need to meet under the anticipated federal municipal waste water regulations. The resulting report is enclosed. Essentially Exp identified three options for a tertiary level of treatment to allow the pulp effluent to meet the federal municipal wastewater standards. The costs of these additional treatment modalities at the time ranged from $7 million to $12 million. While the

EARD suggests that tertiary treatment was considered, no detailed analysis is provided as to why these tertiary treatment options were ruled out.

Pictou Landing First Nation urges you to require a tertiary treatment system for the Project if it is approved.

Summary

Pictou Landing First Nation is concerned primarily about the impacts of the proposed Project on its fisheries and on its air quality on Reserve. There are significant gaps in the baseline information provided in the EARD and it would be difficult for Pictou Landing First Nation to understand how, in light of the decades-long history of environmental harm caused by the existing effluent treatment system, the Project could be allowed to proceed without a full environmental assessment report. The Honour of Crown requires it. If the Project is allowed to proceed, then conditions will be required to address the gaps identified herein as well as the additional comments of Exp in the documents enclosed. A tertiary treatment system should be mandated.

Yours very truly,

March 8, 2019 HFX-00247484-A0/60.2

C/O McKiggan Hebert Lawyers
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Halifax, Nova Scotia, B3J 3N2

Re: Northern Pulp Nova Scotia Replacement Effluent Treatment Facility Environmental Assessment Registration Document
Follow Up Studies and Further Assessment Required

EXP Services Inc. (EXP) is providing the following list of follow up studies and areas of further assessment based upon our review of the "Northern Pulp Nova Scotia Replacement Effluent Treatment Facility Environmental Assessment Registration Document (EARD), January 31, 2019".

This list is being provided in two sections; follow up studies as identified by the proponent (Northern Pulp Nova Scotia) and recommended follow up studies as identified by EXP.

1 Proponent Identified Follow Up Studies

The following reports and studies have been identified in the EARD by the proponent as either requiring further work or have yet to be completed.

1. Marine Benthic Habitat Study Along the Proposed Pipe Line Route
    a. EXP notes that the study should also include the 100 metre radius at the discharge point.
    b. EXP notes that the Metal Mining Technical Guidance for Environmental Effects Monitoring, Chapter 4, Effects on Fish Habitat: Benthic Invertebrate Community Survey offers a solid framework for establishing the scope of the Benthic Habitat Study.
    c. EXP notes that the study should be completed at a minimum of four sites along the proposed pipeline route, before construction.

   d. EXP anticipates that this study would require 2 days in the field to complete the sampling followed by a six week period for development of the report.

2. Geotechnical Assessment along the land and underwater pipeline route.
   a. EXP notes that the sediments along the underwater pipe route should also be assessed for chemicals of concern which could include, at a minimum, metals, Polycyclic Aromatic Hydrocarbons (PAH) and Petroleum hydrocarbons (PHC).
   b. DFO may supply additional parameters to be analyzed once they review the application to dredge along the proposed route.
   c. The program should include assessment for the presence of unique habitats associated with submarine groundwater discharge sites.
   d. The Geotechnical assessment would be estimated to be completed within a two month window.
3. Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat Assessment for the Pipe Line and Water Crossings
   a. Preliminary assessment of fish habitat along the pipeline route was done in December 2018 and is to be supplemented with habitat assessment at a more appropriate time (early summer). It is incumbent on the project to avoid, mitigate or offset the harmful alteration, disruption or destruction of fish habitat. This work needs to be addressed in consultation with Fisheries and Oceans. It is EXPs experience that between the field work, submittal and approval there is a two to three month turnaround time.
4. Further assessment on Species At Risk (SAR) due to the Wetland Survey being completed in December 2018.
   a. EXP notes that wetland surveys for SAR should be completed at least twice during the plant growing season. Once in June (late spring) and secondly in September (early fall).
5. The construction phase environmental management plan
6. The construction phase environmental protection plan
7. Final reporting on the Mi'kmaq Ecological Knowledge (MEK)
   a. Has the MEK been resubmitted with the new pipeline route included?
8. Archaeological Assessments along the New Route
   a. This ties in with the MEK.
9. Human Health Risk Assessment (HHRA)

   a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0, 2010, Revised 2012.

10. Follow Up work on the Pipeline Preliminary Assessment completed in Fall 2018.
    a. Nova Scotia Transportation and Infrastructure Renewal (NSTIR) right of way access permission for placement of the effluent pipeline.
    b. Discussions should be held with the Town of Pictou to assess potential impacts of pipeline routing as it passes through their well head protection areas. Formal discussions with the Town of Pictou should be undertaken to ensure proper mitigative methods are employed for this section of pipeline that is acceptable to the Town of Pictou.
    c. In field inspections for nearby potable water wells
    d. Preparation of design and request for permitting associated with wetlands and other water crossings
11. The EARD indicated that a detailed response plan will be developed to manage malfunctions and accidents.
12. The EARD indicates aggregate will be required for the construction of the pipeline. It will be necessary to identify the source aggregate pits to ensure they are permitted and any quality issues pertaining to acid drainage or natural mineralization are accounted for.

2 EXP Identified Areas of Further Study

1. Studies to date have been deficient when examining the lethal and sub lethal effects of the proposed treated effluent on the various life stages of Lobster. It is recommended that both the larval and adult stages be assessed with the proposed treated effluent. The timeline for completion of this type of test is contingent on the availability of the new treated effluent. This is the difficulty with this study, in that it cannot be completed until after a new treatment system is in place. In terms of timing, it can be completed at anytime as it is a laboratory study, once the proposed effluent is available. This type of assessment could also be completed on any larval or adult species that is commercially fished in the Northumberland Strait.
2. Development of the Sediment and Erosion Control Plan for the Construction Phase.
3. Development of a monitoring plan for the Construction Phase to meet regulatory stipulations.
4. Details of the design storm (i.e. 1 in 100 year storm with a 24 hour duration) for the spill collection system basin should be provided.

5. What project bonding will be required for the proponent.
6. Nova Scotia Environment should be requested to identify how they will manage the project – with First Nations – to ensure design plans are followed in the field and monitoring meets stipulations.
7. Based on EXPs review of the Stantec 2019 Ari Modeling Study the following areas for consideration were identified:
   a) It is well recognized that pulp and paper facility and ETF process operations emit more air contaminants than the priority pollutants assessed. Volatile organic compounds (VOCs) and total reduced Sulphur (TRS) compounds consisting of H_2S, methyl mercaptan (CH3SH), dimethyl sulphide $(CH_3)2_S$), dimethyl disulphide $(CH_3)_2S_2$), and chlorinated compounds are potentially emitted by the kraft (bleached) pulping process. Established emission factors for additional contaminants than assessed from the pulp and paper making processes, co-combustion of hog fuel, and wastewater sludge incineration are available in the reference chosen (AP-42 Chapter 1.6 Wood Residue Combustion in Boilers, Sewage Sludge Incineration AP-42 Chapter 2.2) as well as within AP-42 Chapter 10.2 Chemical Wood Pulping.
      i. Provide a source summary table for all contaminants emitted from the ETF and the Kraft Pulp Mill facility in accordance with the ADMGO, including a full rationale for justification of any contaminants deemed insignificant.
      ii. Identify emission factors representative of the processes to assess potential contaminants of interest not included in priority contaminants assessed. (e.g. AP-42 Chapter 10.2 Chemical Wood Pulping, Table 10.2-1 lists Methyl mercaptan, Dimethyl sulfide and Dimethyl disulfide emissions (Emission Factor Rating: A); AP-42 Chapter 1.6 Wood Residue Combustion in Boilers; and AP-42 Sewage Sludge Incineration Chapter 2.2, Table 2.2-3.)
      iii. Assess emissions of odourous contaminants at 10- minute time interval based on criteria in Ontario Air Contaminants Benchmark (ACB) list.
      iv. Consideration should be given to the potential of changes in regulatory criteria, in particular sulphur dioxide, in the assessment of future operations scenario.
   b) The assessment of future operations should also consider the potential of changes in regulatory criteria. In particular, sulphur dioxide which in Ontario will be reduced from 275 µg/m3 (1- hour) and 690 µg/m3 (24-hour) to 100 µg/m3 (1 -hour) and 10 µg/m3 (annual) in 2023.

exp.

c) Emission factors used, for burning of sludge, by Stantec were US EPA AP-42 Chapter 2.2 Sewage Sludge Incineration for CO, SO2, NOx, TSP, and PM2.5. Both this reference and AP-42 Chapter 1.6 Wood Residue Combustion in Boilers lists other contaminants of interest that were not included in the assessment. Regardless of emission factor reference consideration should be given to assess all contaminants of interest within the reference chosen. EXP recommends:

   i. Provide a source summary table for all contaminants emitted from the ETF and the Kraft Pulp Mill facility in accordance with the ADMGO.

   ii. Provide sample calculations detailing emission rates determined, significance of contaminant, and emission factor rating in accordance with the ESDM Procedure.

   iii. Include assessment of emissions of potential contaminants from co-combustion of sludge and hog fuel in addition to priority contaminants.

8. Human Health Risk Assessment (HHRA) – The proponent has noted that the HHRA will look to exclude many parameters from the assessment based on prior studies and based on what is required under the PPER.

The Pulp and Paper Effluent Regulations, Current to February 14, 2019 list only the following minimum parameters for effluent monitoring:

a) Acute Lethality and Effect on *Daphnia magna*;

b) Biological Oxygen Demand;

c) Total Suspended Solids;

d) Volume;

e) pH; and

f) Electrical Conductivity.

Since the PPER are presently under evaluation, with an update pending, and likely additional parameters being added. EXP is proposing that chemical analysis on the untreated effluent be conducted for the following parameters listed in Table 1 and Table 2 below. These parameters have been selected based on present existing guideline information pertaining to protection of drinking water, marine aquatic life and fresh water aquatic life.

Table 1 shows the parameters that are regulated in Nova Scotia under the Contaminated Sites Regulations.

Table 1: Nova Scotia Environment Surface Water Parameters for Fresh Water and Marine Environments

Nova Scotia Environment Surface Water Parameters for Fresh Water and Marine Environments				
Aluminum	Zinc	Bromoform	Vinyl Chloride	Lindane
Antimony	Benzene	Bromomethane	Aldicarb	Linuron
Arsenic	Toluene	Carbon Tetrachloride (Tetrachloromethane)	Aldrin	Malathion
Barium	Ethylbenzene	Chlorobenzene	Atrazine	MCPA
Beryllium	Xylene	Chloroethane	Azinphos-methyl	Methoxychlor
Boron	Modified TPH	Chloroform	Bendiocarb	Metolachlor
Cadmium	MTBE	Chloromethane	Bromoxynil	Metribuzin
Chromium (hexavalent)	Naphthalene	Dibromochloromethane	Carbaryl	Paraquat
Chromium (total)	1 - Methylnaphthalene	1,2-Dichlorobenzene	Carbofuran	Parathion
Cobalt	2 - Methylnaphthalene	1,3-Dichlorobenzene	Chlorothalonil	Phorate
Copper	Acenapthene	1,4-Dichlorobenzene	Chlorpyrifos	Picloram
Cyanide	Acenapthylene	1,1-Dichloroethane	Cyanazine	Simazine
Iron	Anthracene	1,2-Dichloroethane	2,4-D	Tebuthiuron
Lead	Fluoranthene	1,1-Dichloroethylene	DDT	Terbufos
Manganese	Fluorene	cis-1,2-Dichloroethylene	Diazinon	Toxaphene
Mercury (total)	Phenanthrene	trans-1,2-Dichloroethylene	Dicamba	Triallate
Methylmercury	Pyrene	1,2-Dichloropropane	Dichlorfop-methyl	Trifluralin
Molybdenum	BaP Total Potency Equivalents	1,3-Dichloropropene	Dieldrin	Polychlorinated Biphenyl (Total PCB)
Nickel	Benz[a]anthracene	Ethylene Dibromide	Dimethoate	Dioxins and Furans (TEQ)
Selenium	Benzo[a]pyrene	Methylene Chloride (Dichloromethane)	Dinoseb	Pentachlorophenol (PCP)
Silver	Benzo[b,j,k]fluoranthene isomers	Styrene	Diquat	Organotins - Tributyltin
Strontium	Benzo[g,h,i]perylene	1,1,2,2-Tetrachloroethane	Diuron	Ethylene Glycol
Thallium	Chrysene	Tetrachloroethylene	Endosulfan	Propylene Glycol
Tin	Dibenz[a.h]anthracene	1,1,1-Trichloroethane	Endrin	Phenol
Uranium	Indeno[1,2,3-c,d]pyrene	1,1,2-Trichloroethane	Glyphosate	
Vanadium	Bromodichloromethane	Trichloroethylene	Heptachlor	

As an example of what would be required for discharge to a storm sewer from a routine construction project, EXP has presented the HRM's list of minimum parameters to be assessed in Table 2.

Table 2: HRM Construction Dewatering Assessment Parameters

HRM Construction Dewatering Assessment Parameters				
Arsenic, Total	Copper, Total	Nickel, Total	Toluene	trans -1,3 -Dichloropropylene
Benzene	Cyanide, Total	Phenols	1,1,2 -Trichloroethylene	Methylene chloride
Biochemical Oxygen Demand	Ethylbenzene	Phosphorus, Total	Xylene, Total	1,1,2,2 - Tetrachloroethane
Cadmium, Total	Fluoride	Selenium, Total	Zinc, Total	1,1,2,2 - Tetrachloroethylene

HRM Construction Dewatering Assessment Parameters				
Carbon tetrachloride	Lead, Total	Silver, Total	1,2 - Dichlorobenzene	Di-n-butyl phthalate
Chloroform	Mercury, Total	Suspended Solids, Total	1,4 - Dichlorobenzene	Bis (2-ethylhexyl) phthalate
Chromium, Total	Nickel, Total	Total Thallium	cis -1,2 - Dichloroethylene	PAHs

The parameters listed in Tables 1 and 2 are both available for analysis from two Canadian Association for Laboratory Accreditation (CALA) and Standards Council of Canada (SCC) accredited laboratories in HRM; Maxxam Analytics Inc. and Agat Laboratories.

While it is obviously not possible to test what the effluent would be from the new treatment system, it is possible to have the untreated effluent tested for the parameters listed in Table 1 and Table 2 to assess what chemicals of concern could be added to the list for assessment under the HHRA.

3 Standard Limitations

The information presented in this report is based on information provided by others and observations designed to provide a peer review of the reports provided.

Achieving the objectives of this report has required us to arrive at conclusions based upon the best information presently known to us. No investigative method can completely eliminate the possibility of obtaining partially imprecise or incomplete information; it can only reduce the possibility to an acceptable level. Professional judgment was exercised in gathering and analyzing the information obtained and in the formulation of the conclusions. Like all professional persons rendering advice, we do not act as absolute insurers of the conclusions we reach, but we commit ourselves to care and competence in reaching those conclusions.

Our undertaking at EXP, therefore, has been to perform our work within the limits prescribed by our clients.

4 Closure

We trust this summary report is satisfactory for your purposes. If you have any questions regarding our review, please do not hesitate to contact this office.

Sincerely,

Project Manager
EXP Services Inc.

Pictou Landing First Nation

Document Review

Northern Pulp Nova Scotia Corporation – Existing and Proposed Effluent Treatment Plant

Revision 3

Project Number: HFX-00247484-A0

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List of Acronyms

ABL	ABL Environmental Consultants Limited
ARD	Acid Rock Drainage
ASB	aerated stabilization basin
AST	activated sludge treatment
AOX	absorbed organic halogens
BCTMP	Bleached Chemi-Thermo-Mechanical Pulp
BMA	Brian McClay & Associates Inc.
BOD	biochemical oxygen demand
CEAA	Canadian Environmental Assessment Agency
C:N	Carbon-Nitrogen Ratios
DFO	Department of Fisheries and Oceans
Dillon	Dillon Consultants Limited
DNR	Department of Natural Resources
EA	Environmental Assessment
EARD	Environmental Assessment Registration Document
ECCC	Environment and Climate Change Canada
EEM	Ecological Effects Monitoring
EMP	Environmental Management Plan
EPP	Environmental Protection Plan
ESA	Environmental Site Assessment
ERINS	Ecosystem Research Initiative for the Northumberland Strait
ETF	Effluent Treatment Facility
ETP	Effluent Treatment Plant
EXP	EXP Services Inc.
FOTNS	Friends of the Northumberland Strait
HADD	Harmful Alteration, Disruption or Destruction
HHE	Human Health Evaluation

HHRA	Human Health Risk Assessment
km	kilometre
KSH	KSH Consulting
m	metres
m^2	square metres
m^3	cubic metres
m^3/d	cubic metres per day
m^3/sec	cubic metres per second
McKiggan Hebert	McKiggan Hebert Lawyers
MEKS	Mi'kmaq Ecological Knowledge Study
NAPS	National Air Pollution Surveillance Sites
NCASI	National Council for Air Stream Improvements Inc.
NBSK	Northern Bleached Softwood Kraft
NPNS	Northern Pulp Nova Scotia Corporation
NS	Nova Scotia
NSE	Nova Scotia Environment
NSTIR	Nova Scotia Transportation and Infrastructure Renewal
OME	Ontario Ministry of the Environment
PLFN	Pictou Landing First Nation
PPER	Pulp and Paper Effluent Regulations
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
RWS	Receiving Water Study
SGD	Submarine Groundwater Discharge
Stantec	Stantec Consulting Ltd.
TC	Transport Canada
TRS	total reduced sulfur
TSS	total suspended solids

UKP	Unbleached Kraft Pulp
VECs	Valued Environmental Components
VOCs	volatile organic compounds

Introduction

EXP Services Inc. (EXP) has been retained through McKiggan Hebert Lawyers (McKiggan Hebert) on behalf of the Pictou Landing First Nation (PLFN) to provide document review and advisory services as it pertains to the Northern Pulp Nova Scotia Corporation's (NPNS) bid to replace their existing effluent treatment facility (ETF).

The document review is based on information provided through McKiggan Hebert as it pertains to the existing effluent treatment system at the NPNS facility; the mechanical design of the proposed new ETF; the environmental studies and approvals associated with both the existing and approved ETF.

The document review will be provided in Chapters in this "living" document. As documents for review are added to EXP's mandate, they will be registered in this Introduction Section under the Document Register and a new Chapter will be added and referenced in the Document Register.

1.0 Reviewer Scope

EXP's mandate is to provide technical advice on the engineering, environmental and other technical aspects of the proposed ETF replacement project. EXP's reviewers are to examine each document provided by McKiggan Hebert and provide a brief, plain language synopsis of the report and outline any key deficiencies; errors and omissions; bias; applicable science; key findings; and any other points of interest. Some document reviews may be focused on a specific request or assignment from PLFN or McKiggan Hebert.

2.0 Reviewers

Redacted as per Section 20(1) of the FOIPOP Act

Redacted as per Section 20(1) of the FOIPOP Act

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Redacted as per Section 20(1) of the FOIPOP Act

Chapter 6 - Context for 2016 EEM Report

The "Context for 2016 EEM Report" is a one page cover letter that accompanied the 2016 EEM Cycle 7 report prepared by Dillon for NPNS. The purpose of the cover letter is to ensure that reviewers of the EEM Cycle 7 report understand that the monitoring report applies to the existing ETF System and not the proposed replacement.

The cover letter notes that while the EEM presented in the Cycle 7 report would be similar, it will not be the same. The new EEM will require to take into account any findings or actions from the EA report; will need to have new benthic and fish surveys completed; a new plume delineation study will be required; and will require new sampling locations to be defined. Overall, Dillon is noting that there will be significant due diligence required to properly update the EEM program should the proposed treatment facility move forward.

Chapter 7 - EEM Cycle 7 Interpretive Report for the Northern Pulp Nova Scotia Corp. Facility Near Pictou, Nova Scotia

The "EEM Cycle 7 Interpretive Report for the Northern Pulp Nova Scotia Corp. Facility Near Pictou, Nova Scotia" prepared by EcoMetrix Incorporated for NPNS in March 2016. This is a comprehensive review/summary of the Ecological Effects Monitoring (EEM) of the existing ETF at Boat Harbour from EEM Cycles 1 to 7. It gives a summary of work done and findings from EEM's 1 to 6 (1996 onward) and then the methods and results from the EEM Cycle 7 (2014 to 2015).

Work done is essentially limited to the PPER regulatory requirements and then, sometimes, modified from the results of prior years.

There is an Executive Summary that describes a bit of the history of the Plant and how the effluent is handled – noting that the 1% effluent concentration is highly variable in the receiving environment from many variables such as wind and tides. The summary then focuses on the EEM Cycle 7 dealing with:

- Sub-lethal toxicity of the effluent – concludes that even though effects (sea urchins and algae) are measured, what causes them is not clear.
- Benthic (Bottom) Macroinvertebrates (worms, snails, clams) – the Invertebrate Community Survey (ICS) showed variation, but not readily explainable – some exposure areas showed greater diversity and density, likely due to habitat variation as opposed to effluent discharge. They note that effluent is buoyant and so does not impact the bottom community easily.
- Fish – tries to answer two things noted in earlier EEM cycles:
  - Why the fish in Boat Harbour appear to be older than in reference areas – sampling gear? oxygen levels?
  - Why the fish in Boat Harbour have larger livers and higher lipid content – not diet?
- Supporting Environmental variables measured as other studies were carried out – chemical and physical aspects of the waters. Water chemistry from the mill (Boat Harbour) is measurable.
- Sediment Chemistry – as seen in other EEM studies, decreases in sulphide and higher C:N ratios were positive.

There is a lot of detail on each of these areas. All data from EEM 1 to 6 are summarized. The science looks as good as can be expected.

EXP concludes that, although there are measurable differences between exposed and reference sites, sometimes the differences are not what you would expect, and the reasons are usually unexplainable. Boat Harbour is essentially a treatment lagoon, but after the effluent is discharged, the differences are not clear nor dramatic. They conclude that it is not clear that the effluent is having any discrete effect, it is just suggestive and needs more monitoring.

1.0 Applicability to the Proposed Treatment System

Dillon goes out of its way with the "Context" page, before the main report, to make sure the reader does not confuse what they looked at for Cycles 1 to 7 as opposed to what type of EEM studies will be required with the new effluent discharge facility.

As Dillon noted, and EXP agrees, the discharge will happen in a much different place (at the bottom of the Northumberland Strait versus at the surface outlet from Boat Harbour) and will likely have a different chemical nature as it meets the receiving waters.

However, the EEM for the new system will have similarities to this methodology.

Discharge from plants such as NPNS will require a monitoring program with many of the same elements as in these studies (e.g., sub-lethal toxicity tests, benthic invertebrate community studies and water chemistry sampling).

The sampling program that will be laid out by ECCC will want to answer the question "Is the discharge having any effects on the receiving environment?" and, getting to your question...what they have been doing, in terms of approach, is what "they typically do".

This will involve a measure of how toxic the discharge is using standard toxicity testing of different concentrations on specific species, both animal and plant. This is also known as the "acute lethality of the discharge".

The impact zone is set at "where the effluent concentration has been diluted to 1%" and so they should measure where that zone is and sample for organisms and water chemistry inside and outside that zone.

Without getting into a detailed EEM plan, it should look at the chemical nature of the effluent, the benthic (bottom) communities around the discharge area, the potential effects on finfish moving through the area, and the impact on crab, lobster and scallop distribution.

There will likely be an amended version of the PPER created by ECCC and DFO for the new effluent facility with regulations for maximum levels of certain parameters in the effluent itself (e.g., total suspended solids (TSS), biochemical oxygen demand (BOD), acute lethality, sub-lethal effects, as well as the other potential impacts already mentioned).

Any proposed EEM program for the new system should also be available for review before it is implemented and will likely be included in the Provincial EA.

Chapter 9 - Preliminary Engineering for ETP Replacement Technology Selection Summary

The *"Preliminary Engineering for ETP Replacement Technology Selection Summary"* document was prepared by KSH for NPNS in July 2017.

General comments taken from the report are as follows.

1. Overall the report appears to have been developed as a PowerPoint presentation as opposed to a traditional Engineering report. A report of this significance (i.e. the main treatment technology review and selection) would benefit from a better overall structure with more defined sections including recommendations and conclusions. The report should also include some references where appropriate for some of the industry specific statistics that are provided.
2. Parameters such as flow, BOD, TSS and absorbed organic halogens (AOX) in the effluent per tonne of final product in the existing ETF system has improved from 2012 to 2016; in some cases, dramatically.
3. Current mill effluent flow ranges from 70,000 to 75,000 cubic metres per day (m^3/d). The report goes on to recommend a design flow for the plant of 85,000 m^3/d. It is not indicated whether this is an average daily flow, peak daily flow, or peak instantaneous flow – typically it would be recommend values for all of these flow capacities be defined. It also provides no description as to how this capacity was selected (i.e. was any future growth taken into account, how were ongoing water reduction efforts factored in, etc). Additional calculations should be provided to support the selection of this capacity.
4. Options for ETF included: aerated stabilization basin (ASB), activated sludge treatment (AST), and AST-like "high rate" systems, anaerobic treatment and tertiary treatment.
5. The use of moving bed bioreactor followed by activated sludge treatment seems to be a reasonable concept.
6. Selection of treatment technologies consisted of comparison between ASB and AST advantages and disadvantages. This selection was not guided by assessment of receiving water or environmental impact.
7. There is only one treatment process train so that if/when a treatment component is down for servicing, the process is either shut down or bypassed. This configuration seems to add a bit of risk for extended untreated by pass discharges. There should be multiple treatment trains.
8. Very little data is presented from the existing plant operations. Some average flows and contaminant loadings are provided in charts per metric tonne of final product. EXP would recommend that a summary table be provided to clearly define the effluent flow rate and the relevant contaminant concentrations in mg/L or similar applicable units.
9. The discharge limits or treatment objectives for the effluent treatment system are not given in the report. A summary of these limits should be provided.

10. The report summarizes two options for treating the D0 and E1 filtrate streams separately but neither are recommended.
11. The report discusses two options for modifications to the pulp making process that could reduce the downstream loading to the treatment system: extended delignification and oxygen delignification. The report rejects extended delignification outright but does not appear to reject oxygen delignification, however, nor does it specifically recommend it. If oxygen delignification is recommended, this needs to be clearly stated in the report as well as the impacts/benefits it might have on reduced loading to the downstream treatment system.
12. The report clearly identifies aerated stabilization basins (ASB), also known as an aerated lagoon) and the conventional activated sludge process as the two most prevalent treatment processes in the industry. The report does a good job of summarizing the key points of each treatment technology including the benefits and drawbacks. In general EXP is in agreement on the comments although detailed verification on the statistics given for the pulp industry was not completed and no references were provided. There are several reasons given for why ASB was ruled out and these seem reasonable. It is assumed that some investigation was done to determine that land availability would be an issue as no background was provided such as a site plan or property map.
13. The report goes on to briefly identify other technologies including several variations on the activated sludge process as well as anaerobic treatment. There is very little discussion other than a couple of bullets for each of these technologies with a bullet to state that conventional activated sludge process is the preferred technology. While EXP would not disagree that the final technology selection is potentially valid, this section would benefit from some significant discussion as to why these other technologies were rejected.
14. There is a final summary of potential tertiary treatment objectives and the recommendation is not to include tertiary treatment unless there is a very specific reason to do so. EXP would agree with this as a rule of thumb but the report does not provide enough information to independently draw conclusions as to whether tertiary treatment may be required in this case. Reasons could include specific contaminants that are untreatable by the activated sludge process or overly stringent discharge limits. With no summary of the contaminant concentrations or the effluent treatment objectives, it is difficult to comment on whether tertiary treatment might be required.
15. Some preliminary capital cost estimates may have helped justify any technology selections made.
16. The report would benefit from some basic process flow block diagrams to better illustrate the processes.

Chapter 17 - Draft and Final EEM Program

The "Environmental Effects Monitoring Program Investigations Associated with The New Proposed Treated Effluent Discharge Configuration at The Northern Pulp Nova Scotia Corporation Mill" was prepared by EcoMetrix Incorporated. The draft version was completed in August 2018 while the final version was issued in January 2019.

This review was based on the draft versions of the documents and amended where applicable based on EXPs review of the final document issued in January 2019.

This document was reviewed by Jim Foulds, Ph.D., EP and Steven Schaller, B.Tech., EP. Generally speaking this document contains the monitoring regimes that are being proposed for after the completion of the replacement ETF. One of the underlying comments that EXP noted is that it is suggested that any of the monitoring programs do not have to be completed for up to 24 months after commencement of discharge from the ETF. It would be expected that any discharge from the Plant would need to be tested prior to discharge into the environment. If this is going to be conducted, it was not discussed in this document.

It would be expected that a second version of this document would be created following the completion of the EA and will take into account any new regulatory requirements that are in place at that time.

1. The draft report describes the work that will be part of an EEM program if the EA is approved and the proposed outfall (12 km out) goes ahead as proposed. The final report was based on the revised outfall location that requires 11 km overland and 4km under water.
2. The report summarizes the many years of previous EEM studies to date – not sure of the relevance of that history since the effluent is being treated differently and discharged in a different manner. It I noted that both the draft and final documents nit that empirical confirmation of the predicted spatial extent of the effluent plume (as documented by Stantec in the RWS 2017 and RWS Addendum 2018) will be needed to support the EEM program design.
3. The work described has been derived from the PPER requirements as well as the EEM's technical guidance document from Environment Canada, i.e., it is designed to meet the requirements for effluent discharge for Pulp and Paper Mills in Canada.
4. This work will comprise a "first" program or cycle for the new effluent treatment and discharge location.
5. Elements of the work to include:
    a. Treated Effluent Plume Delineation – to verify the theoretical studies predicting certain dilution rates at 100 m from the diffuser – the "mixing zone".
    b. Biological monitoring of:
        i. benthic community "condition";
        ii. fish population health; and

iii. dioxins and furans levels in fish.

6. Page 14 - Plume delineation defines the "exposure area" to be where the concentration of effluent to seawater is periodically 1% or greater. They also define long-term conditions for this zone, but the definition is incoherent. Viz. …. "the zone within which effluent concentrations of 1% or greater, and 0.1% or greater would be regularly detectable."
7. Page 16 noted that the PPER state that monitoring of Benthic Communities is not required if the dilution from the diffuser is down to 1% within 100 m and Fish Population studies are not required if the dilution is down to 1% within 250 m of the diffuser.
8. The dioxins and furans sampling in fish tissues are also not required if the levels of dioxins and furans are below a defined amount in the raw effluent. Since these two groups have been below the defined PPER level for a number of years, the authors concluded that testing for dioxins and furans in fish tissue is not likely to be required. The final version of the document updated this section to note that annual testing for dioxins and furans would continue to be performed on the treated effluent.
9. The report describes, generally, the approach to be taken to monitoring if these studies are required. They give general approaches and state that detailed study plans will be developed as needed.
10. Fish population health is proposed to be measured by the effect on mussels. This has been done earlier and seems a reasonable alternative to assessing fish populations themselves, in Control and Exposed areas….. they move around too much!
11. In terms of a Work Schedule, they recommend doing a survey for the Benthic Community and the Fish Population health before any effluent is discharged as a baseline. The EEM from PPER does not require that any of this start before discharge of effluent begins. It will allow for more statistical analyses along a time axis, as well as a spatial one.

Chapter 18 - Draft and Final Follow-Up Studies

The "Follow-Up Studies Associated with The Environmental Assessment Process for The New Treated Effluent Discharge Configuration at The Northern Pulp Nova Scotia Corporation Mill" prepared by EcoMetrix Incorporated. The draft version was completed in August 2018 while the final was completed in January 2019.

The main difference between the draft and the final document is the reference to the change in the discharge point from the ETF from the initial option of a 12 km offshore pipeline to a 11km over land pipeline with 4 km in the water.

This document was reviewed by Jim Foulds, Ph.D., EP and Steven Schaller, B.Tech., EP. Generally speaking this document contains the proposed monitoring regimes that are being contemplated for after the completion of the replacement ETF. One of the underlying comments that EXP noted is that it is suggested that any of the monitoring programs do not have to be completed for up to 24 months after commencement of discharge from the ETF. It would be expected that any discharge from the Plant would need to be tested prior to discharge into the environment. If this is going to be conducted, it was not discussed in this document.

It would be expected that a second version of this document would be created following the completion of the EA and will take into account any new regulatory requirements that are in place at that time.

The document describes the proposed follow-up monitoring program to be completed following the Environmental Assessment process and commencement of the ETF Plant. The proposed monitoring plans include options for both baseline (preconstruction) monitoring and performance monitoring. The objective of the monitoring programs is to be able to evaluate the effectiveness of the new ETF by measuring its effect on the receiving environment.

1. The document notes that the proposed monitoring programs are considered provisional and may be revised based on feedback during the EA process.
2. Toxicity testing of treated effluent on lobster larvae and herring eggs looks good. Something similar will also be part of any required monitoring in the EEM program mandated by the PPER.
3. Baseline phytoplankton and zooplankton sampling not spelled out in terms of time should be done for 1 year before construction. There is so much patchiness and seasonal changes in these planktonic communities that any effect of the ETF will be undetectable. Seems to be work that we know will not yield useful data.
4. Why would vertical tows for zooplankton be restricted to the photic zone?
5. A focus on zooplanktonic lobster sampling seems like it is trying to assure fishers that they are looking after lobsters, but it really will not show anything better than the toxicity testing of the effluent.
6. Benthic community to be sampled every 500 m along outfall pipe corridor with a small bottom grab. This approach seems acceptable, but other aspects of benthic community structure will also be covered by the EEM program. The number of sample stations in the draft report was noted at 24 based on the length of

marine pipe, however the final document notes that there will be only 8 sample stations. The reduction in sample stations is only because of the reduction in the length of pipe required to traverse under water.

7. On Page 2.5, Section 2.5 there is a reference to a footnote "[4]" next to sediment sample analysis for acid-volatile sulphide and low level mercury however there is no foot note corresponding in the document.
8. Supporting Environmental Data: Long list of other parameters to be measured, but no rationale provided. Suspect these parameters will be refined through the EA process.
9. Water Quality Samples: There was no details on where these samples are to be taken in the water column. A rationale for these parameters would make a stronger case for the time and expense. It would be expected that water quality samples would accompany any toxicity testing samples, but this was not defined.
10. Fish Community and Fisheries Resource Characterization: The document notes that this type of study will not be completed and concludes that there is sufficient data from existing information.
11. Tissue Chemistry Testing: Done on a wide range of species found in the area, mostly those that are associated with the fishing industry. Need to sharpen that list of species and give a rationale for the items being measured.
12. The Proposed Schedule is overly simplistic and does not contain significant information.

Chapter 19 – Addendum Receiving Water Study

The "Addendum Receiving Water Study for Northern Pulp Effluent Treatment Facility Replacement Project – Additional Outfall Location CH-B, Caribou Point, Nova Scotia" prepared by Stantec in 19 December 2018 was reviewed by EXP.

This document was reviewed by Jim Foulds, Ph.D., EP and Fred Baechler, M.Sc., P.Geo.

Stated Rationale: Earlier study for effluent outfall indicated that a site, Alt-D, in the Northumberland Strait, was the preferred outfall location. Subsequent field investigations of the Alt-D location indicated that ice scour at that depth (11 m) would preclude that site and so alternate sites were required – at greater depths. This report attempts to do this and is an Addendum to the Stantec (2017) document[1].

Stantec identified (but don't explain how or why) a new alternative outfall location - offshore of Caribou Harbour, off Caribou Point. They picked 2 locations, CH-A and CH-B at 25 and 20 m depths respectively.

They applied the same modelling (MIKE 21 and CORMIX) as was done for the earlier study (Stantec, 2017). These models are industry standards for this type of assessment. The approach Stantec has taken – with conservative assumptions for dilution and dispersion (Table 2.1) – is well-founded.

Stantec conclude that dilution, dispersion and meeting compliance levels of discharge elements (parameters of concern) would be achieved by a 3-port diffuser at CH-B. Modelling results also suggest this design would be better than the 6-port diffuser at Alt-D and a 3-port diffuser would take up less space on the bottom of the ocean.

Far-Field Modelling:

Modeling of far-field dispersion characteristics indicated that CH-B was better at dispersing the discharge. Results under various tidal conditions in Figures 2.5 to 2.13 seem to indicate concentrations in surface waters but they only demonstrate the concentrations from the CH-B model. For comparison, CH-A should also be shown. Further, the locations of CH-A and CH-B should be shown on each of these Figures for relative notation of the predicted concentrations shown. There is no figure to show dispersion throughout the water column, ie a cross section.

Near-Field Modelling:

Used the same approach (CORMIX model) as in the 2017 study. They compare a one port and three port diffuser design and conclude that a 3-port diffuser at CH-B would be better than at the Alt-D location and without the issue of ice scour.

Ultimate Recommendation from this report:

Change the design and location of the diffuser – i.e. a 3-port diffuser at CH-B.

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[1] Stantec Consulting Ltd. (Stantec). 2017. Preliminary Receiving Water Study for Northern Pulp Effluent Treatment Plant Replacement, Pictou Harbour, Nova Scotia. August 2017.

EXP commentary:

1. The Alt-D site has received an enormous negative public response – especially from the fishing community. This new site for the diffuser/outfall takes it away from "highly valued" fishing grounds and puts it beside the ferry routing between Caribou, NS and Wood Islands, PEI. It also reduces the length of the underwater transmission footprint.
2. The report does briefly discuss the role of ice conditions by saying more dilution/dispersion is expected under winter ice regimes. However, Table 2.1, which summarizes conditions and assumptions used in hydrodynamic modelling, doesn't outline how ice is modelled e.g. extent, thickness, type.
3. There is no mention of sea level rise in this or the main report of the engineered life time of the facility. This becomes important in addressing the impact/adaptation strategies required for handling changing climate; in particular sea level rise for this assignment. There is no indication in either report of how the modelling results would differ with rising sea level.
4. The modelling exercise appears to focus on dilution/dispersion of the effluent as dissolved load within the water column. EXP hasn't noted anything in either report on the impact of natural suspended sediment loads in the Northumberland straits after large storm events. This suspended sediment may act on the positive side to ad/absorb contaminants. However, the key for impacts is then to determine where this sediment would settle out, which maybe much farther away than 100 m discussed in the report. Assessing this transport method would also require:
    a. sedimentological transport modelling;
    b. an assessment of natural concentrations for the COCs in existing fine grained sediment deposition areas; and
    c. biological assessment of what is present in those deposition areas.
5. Sub-marine Groundwater Discharge (SGDs) are becoming more important worldwide in understanding the interaction between fresh terrestrial and saline marine waters. Freshwater sub-marine springs can be critical in supporting local, diverse biological communities on the sea floor. There is no discussion on whether such ecosystems are present at the diffuser site locations.

3.3 Section 3.0 Regulatory Environment

The Federal Agencies and Departments have been waiting for the submission of the EARD to make their decision as to whether a Federal CEAA will be required. The EARD references that several consultations have been made with Federal regulators. Copies of these correspondence should be made available to PLFN.

This Section also identifies the following studies, which EXP would consider significant to the EA, that need to be completed:

1. Marine benthic habitat study along the proposed pipe line route.
2. Geotechnical Assessment.
3. Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat Assessment for the Pipeline and the water crossings.
4. Archeological Assessments along the new route, to be started in 2019.

Risk that a “listed species” was not seen because of the wetland survey was done in December.

Section 3.4 Other Relevant Guidance notes the guidelines being looked at as it pertains to the project. Omitted from the list is the Federal Wastewater System Effluent Regulations.

3.4 Section 4.0 Project Justification and Alternatives Considered

This section presents the project alternatives, but EXP is of the opinion that the section has a slight bias towards the chosen project option.

The original outfall location was abandoned ostensibly because of the potential for ice scour and yet the design of the new outfall location will be engineered to resist ice scour damage.

The section does present some information on the performance of the chosen system in an existing application in the United States where the effluent discharge is to a fresh water stream. EXP recommends that the Environmental Effects Monitoring that has been completed on similar facilities be reviewed as a comparison of similar installations from around the world.

3.5 Section 5.0: Project Description:

Section 5.2.2: It is noteworthy that the regulatory compliance point is positioned before the effluent enters the transmission pipeline and so the regulators are not including natural attenuation in the Strait as part of the treatment chain.

Section 5.2.2.3: Discussion on the Spill Effluent Basin that will be used to add retention time of 10 to 13 hours of effluent diversion if needed. The EARD notes that the basin should never be full but there is no mention of what controls will be in place to monitor the ponds level and prevent overfilling. This basin will be located between 80 to 100 metres from the Harbour with only an elevation change of 5 to 6 metres.

Section 5.2.3: While the report identifies that the spill collection system basin will be lined. However, since the basin is apparently open to precipitation what is the design storm for the basin so that it doesn't overflow? What happens if the effluent still doesn't meet specs prior to overflow?

Section 5.2.2.8: Appropriate to see that the sludge management system allows for burning to create energy.

Section 5.3.1.10: Pipe Installation – Marine Portion. This section notes that the trench will be 3 metres deep and will affect a 13 m wide swath. Further details on the pipe installation we presented in Appendix F.

Appendix F contains the Pipeline Conceptual Design and Construction Methodology Report prepared by Makai Ocean Engineering Inc. EXP's review of this report revealed the following:

1. Pages 14-15. The proposed trench cross section is approximately 3 m deep and 13 m wide and almost 4 km long. Per kilometer, the estimation is approximately 13,500 m^3 of material that needs to be removed for the trench. 156,000 m^2 of sea bed will be disturbed without considering additional area from over-excavation. If the side-casting method for dredged material is used, that could affect twice that area of sea bed.

   The report should mention considerations from an environmental/resource perspective looking to either minimize habitat destruction or establish a zone of ground fish/shellfish over fishing in an effort to harvest existing resources there instead of simply mulching it up and burying it. Perhaps this will follow with some of the further assessment work to be completed in 2019.

   Page 21. In three instances, utilizing a grading beam to regrade the trench backfill, after pipe installation is complete, was mentioned. Pulling a submerged bar blindly through possibly turbid water while trying to follow the previously dug trench, that is not visible from the surface, seems quite difficult to ensure quality and effectiveness of the backfilling procedures without doubling or tripling the impact on the adjacent ecosystem. What considerations are in place to ensure the grading beam stays within the trenches foot print and what tolerances are expected under normal operation conditions with the grading beam method?

2. Understanding the sea floor soil conditions will guide the proponent on how to handle the dredged materials. This is an unknown variable at this point but in a theoretical situation where a large quantity of the dredged material is classified as contaminated, what method of trench development would be most cost effective? There was a brief mention in the document about NSE Guidelines for Disposal of Contaminated Solids in Landfills. There is a large cost associated with transporting contaminated materials to a landfill facility capable of accepting the materials. Would a method such as the ploughing method, where sea soil material is displaced then reinstated almost immediately while burying the pipe at the same time, provide economic and environmental incentives? If so, it would be a good idea to include something in the literature to identify whether it as a viable option.

Will there been any chemical testing along the trench to assess the types and concentrations of contaminants that may be disturbed as a result of the dredge?

Section 5.3.2 Operation and Maintenance Phase: notes that through the NPNS O&M manuals there are already existing EMP provisions. If they have an existing EMP manual for their current ETF then it would be appropriate to request a copy of this document for review to assess what potential care for the environment will be employed with any future EMP or EPPs developed.

Ongoing maintenance issue: What materials are used to clean the effluent pipe along its length? Would there be caustic chemicals that are discharged into the Northumberland Strait?

Section 5.6.5: How will heavy equipment be fueled up - on-site at specially designed locations?

Section 5.6.6 Surface Run-off and Sedimentation. Noted in this section and elsewhere in the EARD the proposed pipe line will follow along the existing roadways and make use of the shoulder for the installation of the pipe. There are several drawings and schematics that show the route. On these schematics it shows that the shoulder will be expanded in most cases to accommodate the pipe installation. The EARD seems to rely heavily on the fact that this is an existing roadway as the mitigation factor for potential risk (surface run ff and sedimentation). As a result EXP has identified the following points to consider:

1. Has NSTIR approved the use of their road system?
2. There will still be a requirement for water crossings with the most significant being across the causeway through the harbour.

Section 5.7.2.3: provides just general comments on sediment erosion control plans. EXP trusts that regulatory stipulations applied to permits will required detailed plans for review, including monitoring and compliance points/parameters/concentrations.

Section 5.7.2.4: How and where will grubbings be disposed of?

Section 5.7.2.6: provides general comments on water crossings. EXP trusts that the detailed plans required as a results of regulatory stipulations applied to water crossing permit application, will be provided for review.

Section 5.7 general: What quarries will provide aggregate and fill materials? Do they have permits? Has the quality of the aggregate been tested for sulfide bearing capacity and/or acid rock drainage (ARD) potential.

3.6 Section 7.0: Environmental Scope and Methods

Acceptable approach to defining Valued Environmental Components (VEC's) and their boundary conditions.

To better define temporal boundaries they should identify what is the expected life time of the facility.

Table 7.4-1 doesn't include:

1. No mention of odour from the new ETF;
2. Continued impact to PLFN, Town of Pictou or tourism industry as a result of odours.
3. Springs, Pictou well field and domestic wells not included under groundwater
4. Submarine groundwater discharge zones not included under Harbour physical Environment

3.7 Section 8.0: Environmental Effects Assessment

Section 8.3.2 Discussion of surficial geology doesn't include:

1. sand/gravel outwash plain which forms one of the aquifers from which town Pictou draws water from
2. natural geochemistry of overburden materials.
3. Discussion of erosion potential doesn't identify natural inherent erodibility factor of soils and glacial materials

Section 8.3.2 Discussion of bedrock geology doesn't include a discussion of any natural mineralization.

Section 8.3.3.3 Discussion of characterization of residual effects during construction phase doesn't discuss where grubbing materials will be disposed of and how.

Section 8.4.1.2 It was indicated that no watercourses were identified as potable water sources- but did they check in the field and talk with residents? How did they define watercourses – from existing mapping or in the field?

Section 8.4.2.2: Did water quality monitoring between 2012 and 2017 include discharge and stream sediment geochemistry? Where the analyses on filtered and/or non-filtered samples? Based upon the program what statistics were applied to determine "background" conditions and identify anomalous situations? Any monitoring of where grubbed materials placed?

Section 8.5.1: Groundwater VEC – scope doesn't include the well head protection area for the Town of Pictou's Caribou well field; although it is mentioned later.

Section 8.5.2: Did they augment the well log data base search with field inspections?

Section 8.5.3.2: Appropriate to see that where the pipeline route crosses the Town of Pictou's source water protection area that additional mitigative measures will include lining the trench with an impermeable material to contain any leak and a leak detection system. However, a review of the details of that design should be undertaken by at least Town of Pictou personnel prior to construction.

Section 8.7.2.3: Text notes that as an alternate pipeline route was selected in fall 2018 only preliminary recon visits of the new pipeline footprint area undertaken in late fall. The text Indicates follow up work to be undertaken in spring summer 2019. The resultant report should be reviewed.

Section 8.11.2: Submarine groundwater springs are not included in Harbour physical environment.

Section 8.18: The impact of sea level rise is not included in the effects of the environment on the project

Section 8.18.4.1: Why use wind data from Halifax Airport – nothing closer?

Section 8.18.4.2 Discussion of seismicity doesn't include discussion of related tsunami events from submarine landslides

Section 8.18.6: Appropriate that the project should be designed to 1:100 - 24 hr duration flood event during construction period. Will require review of that design prior to construction

3.8 Section 9: Human Health Evaluation

The Human Health Evaluation (HHE) section is presented primarily as a scoping exercise to define what NPNS will assess should they be regulated to complete a Human Health Risk Assessment (HHRA).

The HHE notes that PLFN will be a key receptor but they note that it would not be feasible to have health surveys completed in the FN community. It is noted that data will be based on existing studies and literature, if they are not able to complete the Surveys.

The HHE notes that "many" if the chemicals in treated effluent and air emissions will be treated as COPC. They note the limitations associated with not having the actual effluent available to analyze as well as not having the completed ETF design to fully develop the COPCs. The HHE also notes that there will be an effort to utilize screening approaches to reduce the lists for COPC down to a reasonable and representative list. It would be suggested by EXP that if the engineering design is not able to clearly define what will be in the effluent, than caution should be employed as it pertains to how many elements are screened out of the list of COPCs.

The Air emission COPCs are being restricted to only those that are regulated or stimulated in the existing environmental approval.

The HHE section reviews the Air Dispersion Modeling study (also reviewed in this Document, Chapter 12) and basically refutes the claim that VOCs are associated with NPNS and further note that VOCs will not be considered any further at this time.

The HHE notes that AOX will likely be omitted from any future HHRA as AOX is type of analysis that covers a multitude of compounds. This does not mean it should not be assessed or included in any monitoring.

They will be looking to use some of the data and concentrations from the Toxikos HHRA to serve as an indication of what the NPNS plant might produce.

- The HHE notes that there were at least four (4) previous HHRA associated with the Boat Harbour Site. It noted that there were not reviewed in detail but that they contained conclusion that there were no risk to human health under reasonable or realistic exposure scenarios for the COPCs.
- There was a sample collected in 2018 of the raw effluent that was found to contain: "hydrocarbons, toluene, cyanide, metals and metalloids, phenol, o-cresol, a phthalate ester compound (likely from pipe materials rather than due to mill processes), chloroform, total trihalomethanes, and trace PAHs (phenanthrene and pyrene only)". There was no note how these parameters and concentration compared to any guidelines, jus that they were detected in the sample.

A review of the sediments from the existing Boat Harbour settling pond may provide useful insight into some of the expected chemicals of concern. This information should be publicly available as part of the Boat Harbour Remediation Project.

3.9 Section 10.0: Accidents, Malfunctions and Unplanned Events

Risk of pipeline break/leak. Dealt with in Chapter 10. E.g., What would be the effect of a break in the well field for Pictou or Caribou?

Risk of diffuser caught in a bottom trawl.

Risk of the diffuser being fouled by an anchor.

Risk of ice scour.

Risk of the berm forming the walls of the spill basin having a failure resulting in a spill or release of contained effluent. Not mentioned was an overfill of the spill basin resulting in an overflow.

Domestic wells may be impacted by a pipeline spill. Is there a contingency plan for a compromised water supply?

Surface water might be threatened by a spill during the operational phase but is not addressed in Section 8. Not mentioned for the Groundwater section either.

Risk of pipeline spill from road accidents on bridge.

Section 10.2.7: Vehicle accident – no discussion of spill during fueling heavy equipment

Section 10.5: The text notes that an EPP for management and prevention of such accidents will be developed. It will also develop effective response mechanisms for accident, malfunctions or unplanned events. This will require review.

3.10 Section 12.0: Cumulative Environmental Effects Assessment

Table 12.1-2 identifies activities with environmental effects that might overlap those of the proposed project. There is no discussion of tourism, increased traffic on road to Ferry terminal, road wash runoff.

Section 12.3.10.3: The EIA quite rightly focuses on significant negative impacts. Perhaps it should also provide a discussion of significant positive impacts of the proposed work.

3.11 Section 13.0: Follow-up and Monitoring Summary

Follow up and monitoring is critical to ensure that the non-significant impacts stay non-significant. The Environmental Effects Monitoring (EEM) program is entirely compliance driven – as per the PPER and EEM program obligations. The programs should also give consideration to assessment of any collected data to background and baseline conditions, not just stipulated compliance values.

The significance of impacts is compliance driven and, for the marine component, are at 100 m from the diffuser. This means that the baseline assessment area would be a circle of 100 m diameter which would be roughly 31,416 m^2 or 5 football fields to give some perspective.

The text notes that monitoring programs identified are conceptual and presented at a relatively high level. As project advances through detailed design, permitting, construction and into operation and as follow-up or monitoring programs are carried out the methodology for each program will be documented and adjusted as necessary to meet the environmental protection requirements or commitments. These changes will need to be reviewed not only in their design – but how the data will be utilized – by whom – how often - who will analyze – what are the action levels etc.

3.12 Appendix K

3.12.1 Background

The Stantec report was conducted to support the Environmental Assessment for the replacement of the Effluent Treatment Facility (ETF) owned by the Government of Nova Scotia and operated by the Northern Pulp Nova Scotia Corporation, located at Abercrombi Point, Pictou County, Nova Scotia. The stated objective of the Stantec report is "to assess the potential effects of the existing operation of the Facility with the existing wastewater treatment system in place and the future operation with the new wastewater treatment system in place, on air quality in the region around the pulp mill."

EXP's scope of work is to conduct a peer review of the Stantec report and provide a professional opinion on its suitability as an assessment of the potential effects on air quality in the region around the pulp mill.

The following report reviews the approach, findings, and recommendations of the Stantec report and provides recommendations in regard to an assessment of the potential effects on air quality in the region.

3.12.2 Assessment

3.12.2.1 Documents Reviewed

The following documents were provided for review:

- Dillon Consulting, January 2019. Appendix J2 Environmental Assessment Registration Document Replacement Effluent Treatment Facility.
- Stantec Consulting Inc., Appendix K1, Air Dispersion Modelling Study – Replacement Effluent Treatment Facility. January 21, 2019.
- Stantec Consulting Inc. Comments on Paper – Pilot study investigating ambient emissions near a Canadian kraft pulp and paper facility in Pictou County, Nova Scotia by Hoffman et al (2017 a b). June 15, 2018.
- Northern Pulp's Industrial Approval 076657-A01.

3.12.2.2 Assessment of Method

Stantec conducted air dispersion modelling of contaminants regulated by the Government of Nova Scotia under the Air Quality Regulations, as amended on October 12, 2017 as well as fine particulate matter (PM2.5). The air dispersion modelling program used was AERMOD Modelling System promulgated by the US EPA and approved for use by Ontario and Nova Scotia regulatory authorities. The analysis of the modelling results is based on Air Dispersion Modelling Guideline for Ontario [Guideline A-11] (ADMGO) due to the absence of a suitable air dispersion modelling guideline adopted by the Province of Nova Scotia.

3.12.2.3 Choice of Model

The choice of models for a scenario depends on the scale of the sources and complexity of atmospheric and topographical conditions. The U.S EPA AERMOD modelling system is a Gaussian-plume model which accounts for the majority of dispersion modelling scenarios. Gaussian-plume models assume spatial uniformity in meteorology. In situations of complex terrain or near coastal boundaries significant changes in meteorological conditions can occur over short distances. The proposed ETF is located 0.2 km from the coast line with other on-site sources with elevated stacks located within 0.35 km of the shoreline, therefore, special consideration for shoreline fumigation is required (i.e. the use of fumigation option within AERMOD or advanced models e.g. CALPUFF.)

AERMOD requires specific model input data representative of site and source conditions and accurate emissions inventory. It is important to note that the model input and output data files were not provided and therefore cannot be verified.

EXP Review Findings

- Details on calculation of emission rate estimates were not provided.
- Assessment of quality of emission rate factors were not provided.
- The model input and output data files, typically attached as a CD or flash drive, were not provided, therefore, the input and output parameters cannot be verified.
- Modeling results for 10-min averaging time were not assessed.
- Use of fumigation option is not stated.

EXP Review Recommendations

- Provide model input and output electronic files to verify model parameters and model processing.
- Provide details on calculation of emission rates as recommended in the Ontario Procedure for Preparing an Emission Summary and Dispersion Modelling Report version 3.0 PIBs # 3614e03 (ESDM Procedure)
- Provide an assessment of quality of emission rate factors as recommended in the ESDM Procedure.
- Assess for 10-minute time averaging in accordance with ADMGO

3.12.2.4 Air Contaminants of Interest and Assessment Criteria

The following air contaminants of interest were assessed based on those regulated by the Government of Nova Scotia under the Air Quality Regulation, as amended on October 12, 2017, as well as fine particulate matter (PM2.5) as regulated under the Norther Pulp's Industrial Approval # 076657-A01:

- carbon monoxide (CO)
- hydrogen sulphide (H_2S)
- nitrogen dioxide (NO_2)

- sulphur dioxide (SO_2)
- total suspended particulate matter (TSP)
- fine particulate matter ($PM_{2.5}$)

It is well recognized that pulp and paper facility and ETF process operations emit more air contaminants than the priority pollutants assessed. Volatile organic compounds (VOCs) and total reduced Sulphur (TRS) compounds consisting of H_2S, methyl mercaptan (CH_3SH), dimethyl sulphide ($(CH_3)_2S$), dimethyl disulphide ($(CH_3)_2S_2$), and chlorinated compounds are potentially emitted by the kraft (bleached) pulping process. Established emission factors for additional contaminants than assessed from the pulp and paper making processes, co-combustion of hog fuel, and wastewater sludge incineration are available in the reference chosen (AP-42 Chapter 1.6 Wood Residue Combustion in Boilers, Sewage Sludge Incineration AP-42 Chapter 2.2) as well as within AP-42 Chapter 10.2 Chemical Wood Pulping.

The assessment of future operations should also consider the potential of changes in regulatory criteria in the future. In particular, sulphur dioxide which in Ontario will be reduced from 275 µg/m^3 (1- hour) and 690 µg/m^3 (24-hour) to 100 µg/m^3 (1 -hour) and 10 µg/m^3 (annual) in 2023.

EXP Review Recommendations

- Provide a source summary table for all contaminants emitted from the ETF and the Kraft Pulp Mill facility in accordance with the ADMGO, including a full rationale for justification of any contaminants deemed insignificant.
- Identify emission factors representative of the processes to assess potential contaminants of interest not included in priority contaminants assessed. (e.g. AP-42 Chapter 10.2 Chemical Wood Pulping, Table 10.2-1 lists Methyl mercaptan, Dimethyl sulfide and Dimethyl disulfide emissions (Emission Factor Rating: A); AP-42 Chapter 1.6 Wood Residue Combustion in Boilers; and AP-42 Sewage Sludge Incineration Chapter 2.2, Table 2.2-3.)
- Assess emissions of odourous contaminants at 10- minute time interval based on criteria in Ontario Air Contaminants Benchmark (ACB) list.
- Consideration should be given to the potential of changes in regulatory criteria, in particular sulphur dioxide, in the assessment of future operations scenario.

3.12.2.5 Emission Inventory and Emission Factors

The Facility rates of emissions for CO, NOx, SO_2, TPM were based on Facility stack emission testing reports and H_2S based on Site specific data for TRS. The ETF emission rate was based on site testing at the Boat Harbour ETF in 2012. While the use of source testing data typically has a high emission factor rating (A – high quality) it should be noted that no speciation or details on Total Reduces Sulphur (TRS) monitoring and emission factor rating are provided. It is recognized that the majority of the TRS Compounds emissions (facilities that are part of the class identified by NAICS code 3221 (Pulp, Paper and Paperboard Mills) are Facility emissions, with H2S emissions from the ETF are less than 1.2% of total H_2S emission, however, the total H_2S emissions for the future operations has increased by more than 3 times.

Emission factors used, for burning of sludge, by Stantec were US EPA AP-42 Chapter 2.2 Sewage Sludge Incineration for CO, SO_2, NOx, TSP, and $PM_{2.5}$. Both this reference and AP-42 Chapter 1.6 Wood Residue Combustion in Boilers lists other contaminants of interest that were not included in the assessment. Regardless of emission factor reference consideration should be given to assess all contaminants of interest within the reference chosen.

EXP Review Recommendations

- Provide a source summary table for all contaminants emitted from the ETF and the Kraft Pulp Mill facility in accordance with the ADMGO.
- Provide sample calculations detailing emission rates determined, significance of contaminant, and emission factor rating in accordance with the ESDM Procedure.
- Include assessment of emissions of potential contaminants from co-combustion of sludge and hog fuel in addition to priority contaminants.

3.12.3 Model Results

Stantec states that based on the modelling results, with the exclusion of meteorological abnormalities, the existing and future operations meet the criteria for carbon monoxide (CO), hydrogen sulphide (H_2S), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), total suspended particulate matter (TSP), and fine particulate matter (PM2.5). Modelling was not conducted for TRS species or assessment at 10 min criteria, and wood-sludge co-combustion emissions.

EXP Review Recommendations

- Provide model input and output electronic files to verify model parameters and model processing.

3.12.4 Conclusion

EXP cannot verify Stantec's findings without provision of the model input and output files and supporting calculations for emission rates as identified above. Further the assessment is restricted to priority pollutants regulated (CO, H_2S, NO_2, SO_2, TSP, and $PM_{2.5}$) without consideration of other potential pollutants associated with the pulp and paper process or wood residue combustion in boilers.

3.13 Appendix R

Appendix R is a literature review summarizing what is known about the effects of BKME (Bleached Kraft Mill Effluent) on lobsters. It concludes that any studies done before have used the former effluent - not the new effluent and so there should be studies to look for effects of the new effluent on lobster.

Appendix R also generally concludes that most studies to date all indicate little to no effect on the benthic animal community - including lobsters.

This being stated, EXP identifies the need for an additional study to better delineat the lethal and sub-lethal effects of treated effluent on larval and adult lobsters.

Northern Pulp

Tertiary Treatment Study

Pictou Landing First Nation

DRAFT

ADI Limited

Report: (34) 6716-001.1
Date: March 2011

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ADI Quality System Checks	
Project No.: (34) 6716-001.1	Date: *2011 March 31*
Issue Status: DRAFT	Revision No.: 0
Prepared By: *, M.Sc.E., P.Eng.*	
Reviewed By: *, P.Eng.*	

Executive Summary

Boat Harbour, a small body of water located just to the south of Pictou Landing First Nation that flows into Pictou Road, was incorporated into a wastewater treatment facility in 1967 when the facility was constructed by the Province of Nova Scotia as part of an agreement for the construction of a kraft pulp mill at Abercrombie, NS. Currently, the source of wastewater being treated in the facility is the pulp mill owned and operated by Northern Pulp Nova Scotia (NPNS).

It has been recognized that the use of Boat Harbour as a component of the wastewater treatment facility needs to be re-evaluated. A commitment has been made by the Provincial Government to address the issue of returning Boat Harbour to a natural state and to provide solutions to the decades-long problem. The objectives of this study are:

1. Consider additional effluent tertiary cleaning processes that would be applicable to kraft pulp secondary wastewater treatment systems which could result in improved effluent quality;
2. Evaluate the required level of tertiary treatment required for direct discharge into Pictou Harbour;
3. Summarize the Provincial and Federal permits and water-quality testing and quality requirements for discharging secondary and tertiary treated wastewater;
4. Identify any scheduled or anticipated changes in kraft pulp discharges (both Provincial and Federal);
5. Summarize all Municipal, Provincial and Federal discharge regulations for effluent discharges in Pictou Harbour;
6. Identify potential business opportunities to use the waste heat from the tertiary treated effluent (potential of 15,950 m^3/d at 43ºC); and,
7. Provide probable costs (±30%) for additional treatment, outfall options and associated equipment.

Maintaining just a secondary level of wastewater treatment and bypassing Boat Harbour will require that the effluent discharge point be relocated out into the Northumberland Strait. Conversely, if tertiary treatment is added, it may be possible to discharge the effluent into Pictou Harbour resulting in a shorter (and more economical) outfall. Several tertiary treatment systems were investigated for their appropriateness in treating pulp mill wastewater after secondary treatment. They are:

1. clarification
2. ozone addition;
3. engineered wetlands;
4. enhanced filtration; and,
5. membrane filtration.

Of these, the first three are of the most interest from a technical and financial perspective. The last two, while technically feasible, would be significantly more expensive and likely cost prohibitive.

There is also the potential for capturing a quantity of heat that is being released with the wastewater. The secondary treatment system would benefit in its operation if the pulp mill effluent temperature was reduced to less than 30^{o}C. A wastewater temperature any higher than 30^{o}C increases the difficulty of treating the wastewater as well as the operational costs. However, reducing the mill effluent temperature also reduces the amount of thermal energy available for recovery by potential external users as well as the potential uses for such low-grade thermal energy.

The operation of the wastewater treatment system for the pulp mill falls under federal jurisdiction (Pulp and Paper Effluent Regulations (PPER) under the Fisheries Act). While some provinces regulate the wastewater effluent quality generated by pulp and paper mills, Nova Scotia does not. As such, the current quality of the wastewater treatment plant effluent meets the requirements of the PPER.

There are no anticipated changes to the PPER, or any other regulations, that would impact on the current wastewater treatment plant operation. As well, there are no technical or regulatory reasons to prevent discharging the current treatment plant effluent to Pictou Harbour. However, aesthetically, the conditions within the harbour would, in all likelihood, deteriorate due to the size of the harbour and the volume of the effluent. Discharging effluent directly to the harbour would benefit from the addition of a tertiary treatment process following the secondary wastewater treatment system.

Various opportunities have been presented that would benefit from the waste heat being discharged in the treatment plant effluent. All of the opportunities have focussed on the non-contact use of the effluent; the use of the treated effluent in a direct-contact manner is deemed not feasible. In most cases, the quality of the water is not of a major concern; the water should be “clean” enough to be utilized in a heat exchanger with minimal fouling.

The opportunities examined included:

- District heating;
- Lumber drying;
- Power generation;
- Aquaculture; and,
- Agriculture.

As well, the mill could investigate the feasibility of reclaiming the heat to pre-heat the raw water for the appropriate processes requiring “hot” water. Regardless of the end use, the wastewater treatment process would benefit if the heat was removed prior to the wastewater being introduced into the secondary treatment system.

The district heating option, in and of itself, would not be considered feasible since the existing building density/building types in the vicinity of the mill are not conducive to that type of an operation. There may be possibilities within an industrial park complex adjacent to the mill configured to attract a cross-section of businesses that could make use of the waste heat year round.

Using the waste heat for lumber drying, only, particularly with the current state of the lumber industry, may be a difficult opportunity to promote.

Both the aquaculture and agriculture industries are well established in Nova Scotia. Using the waste heat in the agricultural industry, however, may require a different business model than currently practiced. Most greenhouse operations that would benefit from this heat source are seasonal whereas a year-round operation would be better suited to take advantage of this heat source. Conversely, a land-based aquacultural operation would require the heat on a continuous basis throughout the year.

"Green" power generation, on the other hand, could be located at the mill site. The infrastructure is, for the most part, already in place to accept the extra power allowing it to be used at the mill or to be introduced onto the grid.

Various costs have been presented for the three tertiary treatment options deemed most appropriate for treating the pulp mill wastewater prior to discharging to Pictou Harbour, though the costs are, for the most part, for illustration purposes. The costs vary from $ 7.8 M to $ 17.4 M. If effluent from a tertiary treatment plant being discharged to Pictou Harbour appears economically feasible, the process(es) need to be pilot tested to determine design criteria as well as the quality of effluent that could be produced.

Similarly, costs for the two discharge options have been determined. More accurate cost information would be made available once the actual discharge point is chosen, an environmental assessment of the project is undertaken, and preliminary design work is completed. For comparison purposes, the cost of the Pictou Harbour outfall is in the order of $ 7.13 M whereas the Northumberland Strait (MacKenzie Head) outfall is $ 23.76 M. In the event that the discharge point has to be moved further out into the harbour or ocean from the point(s) shown, the additional underwater piping cost will be in the order of $300,000/100m.

1.0 Introduction

1.1 Background

Boat Harbour is a small body of water, located just to the south of Pictou Landing First Nation, that flows into Pictou Road, a bay that connects Pictou Harbour to the Northumberland Strait. Boat Harbour was incorporated into a wastewater treatment facility in 1967 when the facility was constructed by the Province of Nova Scotia as part of an agreement for the construction of a kraft pulp mill at Abercrombie, NS. Currently, the source of wastewater being treated in the facility is the pulp mill now owned and operated by Northern Pulp Nova Scotia (NPNS).

It has been recognized that the use of Boat Harbour as a component of the wastewater treatment facility needs to be re-evaluated; previous studies have examined options for alternative treatment processes and effluent discharge points so Boat Harbour can be returned to a natural state[1,2].

1.2 Objectives of Study

A commitment has been made by the Provincial Government to address this issue and to provide solutions to this decades-long problem. The objectives of this study, as presented to ADI Limited in an RFP dated May 24, 2010, are:

1. Consider additional effluent tertiary cleaning processes that would work on kraft pulp secondary wastewater treatment systems which could result in improved effluent quality;
2. Evaluate the required level of tertiary treatment required for direct discharge into Pictou Harbour;
3. Summarize the Provincial and Federal permits and water-quality testing and quality requirements for discharging secondary and tertiary treated wastewater;
4. Identify any scheduled or anticipated changes in kraft pulp discharges (both Provincial and Federal);
5. Summarize all Municipal, Provincial and Federal discharge regulations for effluent discharges in Pictou Harbour;
6. Identify potential business opportunities to re-use tertiary treated effluent (potential of 15,950 m^3/d at 43°C); and,
7. Provide probable costs (±30%) for additional treatment, outfall options and associated equipment.

It must be noted that any reference to wastewater treatment made in this report focuses on **tertiary** treatment, a treatment process that would follow secondary wastewater treatment. Previous reports[1,2] have addressed the possible secondary wastewater treatment process and their associated costs.

[1] "Evaluation of Effluent Treatment Alternatives", AGRA Simons, Project J632A, Feb 2000
[2] "Boat Harbour: Return to Tidal Re-Evaluation", AMEC, April 2010

2.0 Pulp Mill Wastewater Effluent Treatment

2.1 Secondary Treatment vs. Tertiary Treatment

2.1.1 Secondary Wastewater Treatment

There are varying levels of wastewater treatment available to municipalities and industry to remove pollutants from their wastewaters. Primary or chemically-enhanced primary treatment is used in many municipalities to remove solids, floatables and, to some degree, BOD (organics). A recent strategy proposed by the Canadian Council of Ministers of the Environment (CCME)[3] and currently under review by the Federal Government[4] would require municipal wastewater treatment systems to meet a National Performance Standard. To achieve this, secondary wastewater treatment technology is required; secondary treatment utilizes biological systems to consume the organics followed by solids removal devices (clarifiers, dissolved air flotation units, filters, membranes, etc.) to remove the pollutants allowing the discharged effluent to approach the quality of the receiving stream. The CCME strategy, currently under review by the Federal government, does not include industrial wastewaters directly discharged to the receiving environment.

However, under the Federal Fisheries Act (Chapter F-14), several industries are regulated as to the quality of the effluent they can discharge to the environment, one of which is the pulp and paper industry[5]. In order to meet these regulations, pulp and paper mills generally use a form of secondary wastewater treatment.

2.1.2 Existing Wastewater Treatment

The existing wastewater treatment system for the Northern Pulp mill consists of sedimentation basins followed by a four-cell aerated stabilization basin (ASB) with the effluent being discharged to Boat Harbour then flowing to Pictou Road. If required, nutrients can be added to the wastewater prior to its introduction into the ASB; the nutrients are provided to promote the appropriate biomass growth to consume the organics in the wastewater. There is no active wastewater treatment in Boat Harbour other than providing a degree of suspended solids removal (polishing step).

One aspect of this study is to evaluate options of final effluent discharge and treatment required for eliminating the use of Boat Harbour as part of the wastewater treatment process for the operation of the Northern Pulp mill in Ambercrombie, Nova Scotia. Past study reports (AMEC, 2010; AGRA Simons, 2000) have investigated this issue and two re-occurring options for proceeding toward the final corrective action have been:

[3] "Canada-wide Strategy for the Management of Municipal Wastewater Effluent", CCME, February 2009
[4] "Wastewater Systems Effluent Regulations" Canada Gazette, Volume 144, No. 12, March 20, 2010
[5] "Pulp and Paper Effluent Regulations, SOR/92-269", Minister of Justice, February 26, 2011

1. Construct a treatment plant using an activated sludge process (ASP) on the mill site, construct a storage basin and pumping system for 6hr capacity, discharge the effluent in 6hr (tidal) cycles to a new outfall located at Lighthouse Beach (or other location).
2. Construct a treatment plant using an activated sludge process (ASP) on the mill site, along with a tertiary treatment system and pumping system for a new continuous outfall into Pictou Harbour.

The commonality of these two different plans is the inclusion of an ASP plant located on the current mill site. The new ASP plant will be able to deliver effluent to the same standard, if not better, than the current lagoon system. It is also assumed that an overall plant-wide reduction of wastewater flows will occur and will have the overall flow volume reduced to at least 45,000 m^3/d. It is likely possible to improve on this wastewater reduction, which can result in better effluent quality from the ASP. However, for the evaluation of options for this outfall, the following has been assumed:

1. Effluent quality is equivalent to current discharge at Point “C” and typically includes the characteristics as presented in Table 1 (based on 2010 data).
2. Effluent flow is 45,000 m^3/d and is a combination of process/alkali sewer collection, acid sewer collection and sanitary with expected effluent characteristics as presented in Table 2.

Table 1: Currently Reported Effluent Levels

	UNITS (SI)		**Units (kg/ADT)**	**Units (kg/day)**	**Effluent Regulation**	
					kg/day	**mg/L****
Sulfate	308	mg/L	37.0	28,890		
Nitrate-Nitrite	0.05	mg/L	0.0	5		
Ammonia (N)	2.56	mg/L	0.3	240		
Suspended solids	35	mg/L	4.2	3,313	14,268	152
Color	1,450	TCU	174.0	135,914		
Conductivity	1,996	mmho/cm				
pH units	7.8					
Carbonaceous BOD	28	mg/L	3.3	2,606	9,512	101
COD	729	mg/L	87.5	68,348		
Total Phosphorus	1.43	mg/L	0.2	134		
Kjeldhal Njitrogen	7.47	mg/L	0.9	701		
Volitile Suspended Solids	32	mg/L	3.8	2,977		
Hydrogen Sulphide	0.70	mg/L	0.1	66		
Dissolved Organic Carbon	166	mg/L	20.0	15,586		
Ortho Phosphorus	0.48	mg/L	0.1	45		

**Based On: 781 Adt/d 93,761 m3/d

Table 2: Future Estimated Effluent Levels (ASP Achieving BOD/TSS of 25/25)

	UNITS (SI)		Units (kg/ADT)	Units (kg/day)	Effluent Regulation	
					kg/day	mg/L**
Sulfate	642	mg/L	37.0	28,890		
Nitrate-Nitrite	0.11	mg/L	0.0	5		
Ammonia (N)	5.33	mg/L	0.3	240		
Suspended solids	35	mg/L	2.0	1,575	14,268	317
Color	3,061	TCU	174.0	135,914		
Conductivity	1,998	mmho/cm				
pH units	7.8					
Carbonaceous BOD	28	mg/L	1.6	1,260	9,512	211
COD	729	mg/L	42.0	32,805		
Total Phosphorus	2.98	mg/L	0.2	134		
Kjeldhal Njitrogen	15.57	mg/L	0.9	701		
Volitile Suspended Solids	32	mg/L	1.8	1,440		
Hydrogen Sulphide	1.46	mg/L	0.1	66		
Dissolved Organic Carbon	200	mg/L	11.5	9,000		
Ortho Phosphorus	1.01	mg/L	0.1	45		

**Based On: 781 Adt/d 45,000 m3/d

It should be noted that the existing effluent meets the current federal pulp and paper regulations.

2.1.3 *Tertiary Wastewater Treatment*

By definition, tertiary treatment is applied after a traditional mechanical process. The term tertiary treatment typically applies to reducing the BOD and TSS in the effluent to levels lower than 20 ppm (known as the 20-20 level). This is usually the case when specific issues are present with the receiving water such that lower BOD and TSS concentrations are necessary. Tertiary treatment is also considered as advanced wastewater treatment for specific issues with the effluent. Typically this is not related to BOD and TSS (i.e., an effluent with a BOD and TSS concentration of 20/20 is generally suitable and acceptable for the receiving stream); however, it is related to other detrimental attributes of the effluent. Some examples of this include nutrient removal (nitrogen and phosphorous), hardness removal, reduction of endocrine disrupters or removal of colour from the effluent.

Additional or tertiary treatment for this effluent source is currently not required by the governing regulations of the Pulp and Paper industry. The regulations specify the levels of BOD and TSS only, based on the mill production level, average daily tonnage produced, and on the potential detrimental impact and toxicity to the local environment. However, it has been indicated that the local users of Pictou Harbour and Boat Harbour feel that the current level of treatment is not adequate due to the presence of colour and odour within the treated effluent. This would indicate that an aesthetic improvement in the effluent is desired.

An aesthetic improvement is mainly reflected in improving the appearance and the odour of the effluent, but is not dependant on any improvement of toxicity or contamination of the local environment. The reduction of colour from a pulp mill effluent would be a considerable improvement to the aesthetic qualities of the effluent. One means of colour removal is using a chemical precipitation /oxidation process followed by clarification. That is, the colour causing particles (long organic chains from lignins and tannins in the wood fibre) must be gathered together chemically (coagulation/flocculation) and then removed from the effluent via clarification (settling or flotation). This can be a costly and chemically intensive process when treating large volumes of water with limited amounts of colour after a secondary treatment. An alternative to this would be the isolation of the raw high colour source stream prior to it being blended with all other sewer streams and treating the high colour waste localized, prior to the full treatment system. **This option could potentially be a more cost effective treatment than the full colour removal system for all effluent. Current upgrades being made in the mill (with funding from the federal Green transformation Program) are expected to reduce the wastewater generated within the mill. There may also be a positive impact on the colour of the wastewater generated.**

Additional forms of tertiary treatment can in be in the form of filtration. Filtration covers a wide variety of methods of removing contaminants in effluent. A multi-media sand filter for removal of particulate can be a good “polishing” method for many secondary treatment plants to bring the effluent quality to below 10 ppm TSS and BOD. A more elaborate filtration method would be a membrane filter unit that would concentrate most contaminants and permit virtually zero TSS and reduced colour. This is a very costly option for large volumes, such as is the case for Northern Pulp. Ozonation (the injection of ozone into the wastewater) can also provide colour reduction in the effluent through the oxidation of the colour-causing compounds.

A less complicated approach to tertiary treatment is the use of an engineered wetland. An engineered wetland replicates the filtration, aeration and organic/nutrient consumption of a naturally occurring wetland, with the safeguards of a lining to prevent any unplanned effluent entering the environment. An engineered wetland is a very low maintenance operation with a variety of “bed” designs depending on the treatment that is required. For the flow requirements at Northern Pulp, a wetland area of 15 to 20 acres would be required.

2.2 Appropriate Tertiary Effluent Treatment Systems for Kraft Pulp Mills

With the proposed upgrades at Northern Pulp, it is understood that a significant improvement in the quality of effluent that will require tertiary treatment may occur and significant reduction of the flow of effluent may be realized. Based on the AMEC report (April 2010) primary clarification followed by a secondary aerobic activated sludge process is assumed to be incorporated as the initial wastewater treatment. Based on available information, the TSS and BOD will be reduced to 30mg/L each, but the colour will not be significantly reduced so is assumed to remain at the current 1500 PtCU (mg/L) level.

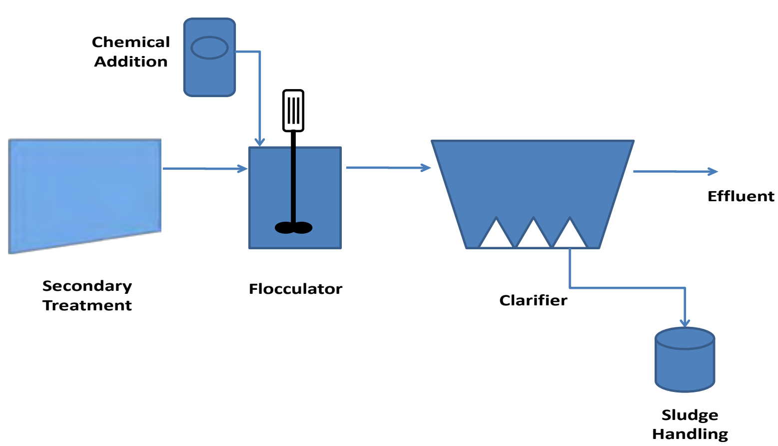
The tertiary treatment designs that are proposed follows up the primary/secondary treatment upgrades that have been undertaken by others. The scope of our investigation will be for the additional treatment required for further reduction of BOD and TSS as well as the reduction of colour in the effluent.

2.2.1 *Clarification*

The clarification process (Figure 2-1) is primarily a chemical treatment stage that forces dissolved colour particles to combine and form a bulky floc (an agglomeration of smaller particles) that can be settled or floated for removal. This chemical treatment will lower colour and COD (Chemical Oxygen Demand) as well as potentially reduce TSS and BOD further. This equipment would be installed inline at the end of the secondary treatment process. The configuration of equipment would include a flocculation tank (gentle mixing) and clarification units. Multiple clarifier units should be installed so that regular maintenance can be performed without completely stopping the flow or bypassing the process.

The clarification technology would likely include a clarifier with lamella plates for enhanced clarification and the reduction of the required footprint. With this technology, the overflow rate can be increased and the final size of the clarifying units can be reduced. The clarification stage will require the addition of chemical for the creation of a settable floc. The chemical design must be done with jar testing that will trial a variety of coagulants and dosages. This chemical addition can then be further controlled in the full-scale system with the use of online analyzers for Turbidity / TOC (Total Organic Carbon) levels and coagulant dosages using streaming current (zeta potential). With a highly automated system, the chemical consumption can be minimized as much as possible. There is potential for a very high level of process control and quality control of the effluent because of the relatively low possibility of upset from the upstream activated sludge process. For cost calculation purposes, a dosage of 150 ppm of an alum-based chemical has been selected but this has not been confirmed by specific analysis or pilot work.

Figure 2-1: Clarification Process

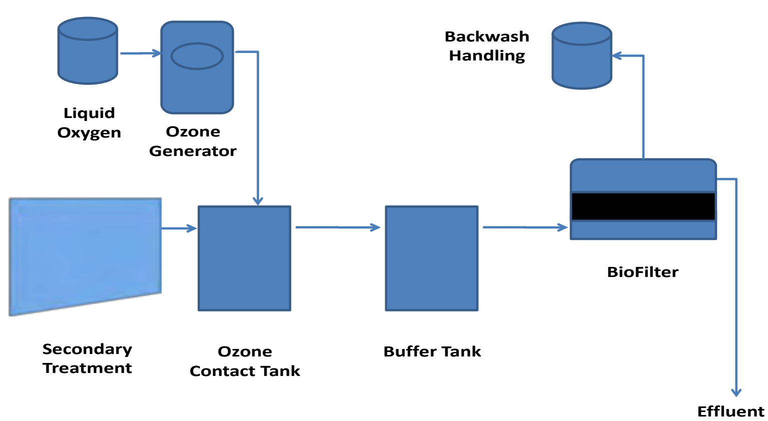


2.2.2 *Ozone Addition*

Tertiary treatment using ozone for the additional removal of colour from the secondary treated effluent would be undertaken using an onsite ozone generation system, an injection system and a reaction tank (Figure 2-2). The ozone would react with the long tannins and lignin organic chains and break them apart. However, it is impossible to predict the effluent characteristics of this reaction with respect to creation of biodegradable matter or any level of harmful bi-product. With this technology, it will require further investigation through a pilot test to determine the bi-product formation and the dosage of ozone required.

The generation of ozone is done onsite with electric-powered ozone generators that are supplied air or oxygen in order to create ozone. For a large application such as this, an onsite oxygen generation system would be required to feed multiple ozone generation units. The dispersion disks used to entrain the ozone in the water should be submerged in at least 5 meters of water to ensure a transfer of at least 75% of the ozone. A recycle system may be employed to "super saturate" the ozone into the water as required. The use of standardized equipment with the feed stream of purified oxygen from an onsite oxygen generation skid would likely be the best application for the supply of oxygen. A biofilter would be used to remove the BOD that would have formed from the conversion of some COD to BOD. It is anticipated that up to 40% of the COD may be converted to BOD and would require further treatment; however, this can only be confirmed with a pilot analysis.

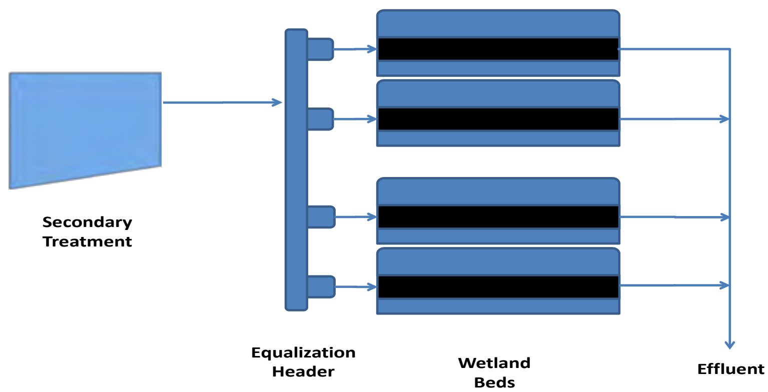
Figure 2-2: Ozone Process



2.2.3 *Engineered Wetland*

Engineered wetlands take advantage of the natural processes that occur for the breakdown of colour-forming constituents (Figure 2-3). They also filter the suspended solids (TSS) and further remove (BOD). A typical engineered wetland would be constructed with a geo-membrane liner that would prevent the effluent from coming in contact with the natural environment. In the lined bed, a configuration of various media types and a piping distribution network would distribute the effluent and treatment will occur with a variety of plant species and micro-organisms that naturally occur in the root structure. This technology would typically require at least 15 acres of usable area for the potential flows that are predicted from the mill. Given that the design will largely be dominated by the hydraulic requirements of such a large flow (and not the biodegradation capabilities), the use of an engineered wetland could potentially reduce the treatment requirements of secondary treatment or at a minimum, provide additional protection in the event of a process upset in the secondary treatment operation.

Figure 2-3: Engineered Wetland

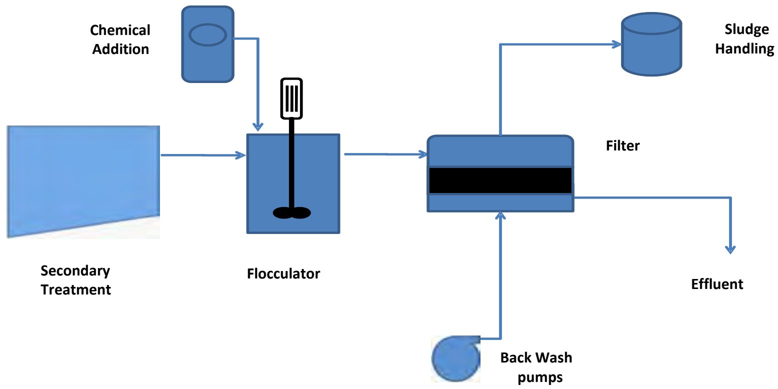


2.2.4 *Enhanced Filtration*

An enhanced filtration technology would utilize the addition of chemicals to aid with conventional filters (Figure 2-4). The use of chemical addition would be very similar to the chemical addition required for clarification, only the resulting floc would not be removed with a settling or floating operation, rather the filters would cause the removal. The additional filters would have to be conservatively designed to accommodate for the higher solids loading that would be provided by the flocculation process. The filters would have to be designed with a minimum of 150% treatment ability and a filter backwash handling system.

With this technology the main drawback would be the requirement for backwashing the filters. The backwash requirements would be considerable from the perspective of the pumping power required as well as the storage of backwash water. Additionally, the handing and treatment of the backwash water is considered problematic because removing the contaminants is more desirable than reintroducing them to the beginning of the treatment system.

Figure 2-4: Enhanced Filtration

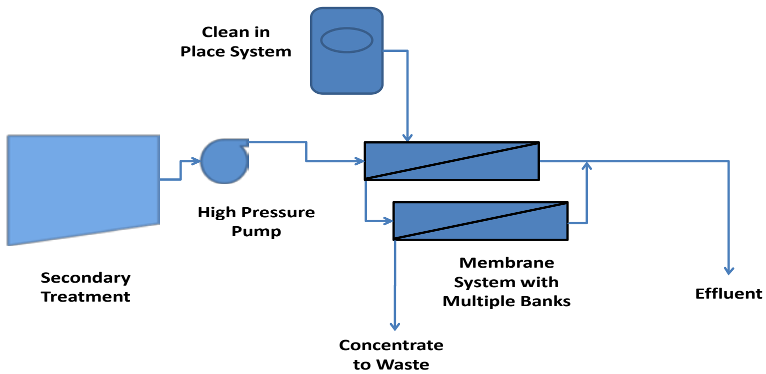


2.2.5 *Membrane Filtration*

The use of membranes for the removal of colour and polishing of suspended solids is an energy intensive operation. The effluent (after secondary treatment) would be pressurized against a microfiltration membrane (Figure 2-5). The clean water would pass through the membrane and the dirty water would be concentrated and have to be further treated. The use of micro filtration is recommended instead of reverse osmosis, as the colour particle is typically 0.45microns in size, so filtration with RO (openings 0.001 microns) would be considered to be in excess.

The use of membrane technology is typically quite costly from the perspective of the pumping power requirements. Additionally, the use of membranes for the removal of colour (although effective) is typically very detrimental to the membranes due to very high organic fouling. This results in an increase in operational cost that would continue to climb as the system aged. Further to this, the handling of the concentrated waste could prove to be problematic. The use of membrane technologies is good for concentrating the particles in the water that are undesirable, however dealing with these after they have been separated is not a straight forward task. Much like the filter backwash, recycling this to the front end of the waste treatment system is undesirable.

Figure 2-5: Membrane Process



2.2.6 *Process Selection*

Moving forward, the most promising opportunities for additional treatment would appear to be in the form of:

- Engineered Wetland
- Clarification
- Ozone Treatment

There are other options for this tertiary treatment; however, these three have the potential to be the most cost effective in terms of improving the effluent from the BOD, TSS and colour perspective.

For any large process application, a significant amount of design must be undertaken prior to implementation and pilot testing of the process should be considered. A pilot plant is essentially a small-scale version of a full-scale treatment plant. Piloting will allow the process to be exposed to the actual wastewater allowing the designers to determine the appropriate criteria for design purposes. Any major process changes are easily implemented so that operational parameters can be well established prior to the design of a new plant. The use of pilot scale testing for wastewater processes is particularly useful because water-quality related issues are location and industry specific.

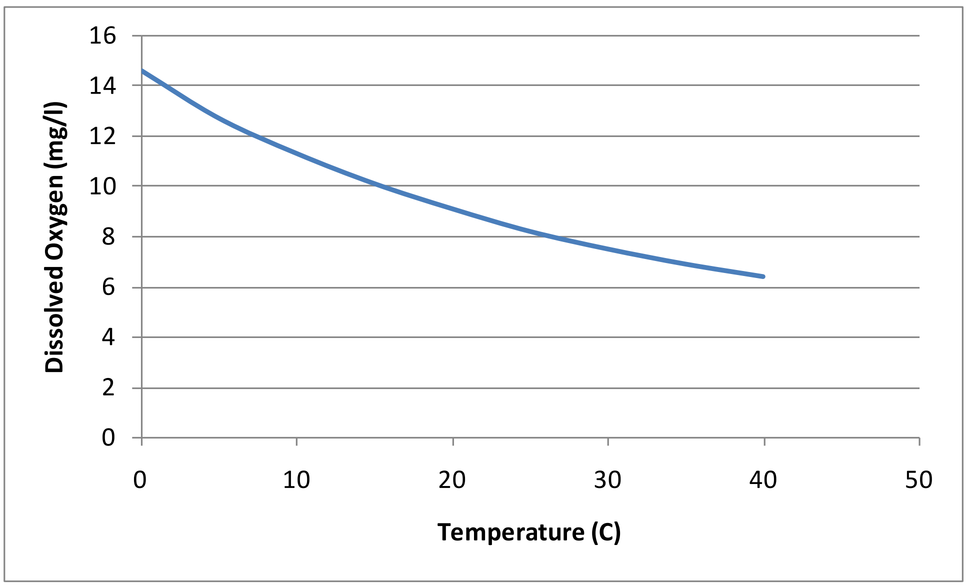
The scale of a pilot may be in the range of 10-200 Litres per hour (and, on occasion, larger). With the pilot testing, the primary, secondary as well as tertiary treatment processes can all be studied. This additional testing will aid in the final process selection which can be completed with sound economic understanding of reagent chemical cost, vessel sizing and sludge volumes that all greatly effect operational requirements and costs.

2.3 Heat Re-use and the Impacts of Effluent Treatment

As noted elsewhere in this document, the impacts of temperature of the effluent greatly affect the magnitude of the treatment equipment that will be required. A cooler effluent results in typically lower sizes of many treatment methods. Specifically aeration, ozone and membrane filtration all benefit from having cooler temperatures. The enhanced filtration and the clarification will not be as greatly affected and having a warmer effluent will assist with the flocculation needed for these treatment types. Additionally (outside the scope of this investigation) there would be significant improvement to the secondary treatment (proposed activated sludge) for two reasons: oxygen transfer rate and biomass. Should there be a decrease in the temperature of the wastewater entering the aeration stage, then the oxygen transfer will greatly increase and thus a reduced energy input for aeration. With a decrease in the temperature, the aerobic micro-organisms associated with the activated sludge wastewater treatment process perform better; ideally, activated sludge systems work best with wastewater temperatures < 30^{o}C.

In the following diagram, it can be observed that more oxygen can be saturated and held in water at a cooler temperature. The difference in temperature from 40^{o} to 10^{o} can be from 6.5 to 11 mg/L of dissolved oxygen. This, in turn, offers a substantial reduction in aeration equipment requirements.

Figure 2-6: Dissolved Oxygen Saturation Curve



Energy recovery scenarios (use of waste heat) can have either the current water as the carrier of the thermal energy or transfer the energy to another media. From the treatment perspective the transfer of energy should occur prior to treatment and transfer the energy to another media. A selection of energy recovery technologies should be considered that would result in the energy removal process (i.e., heat recovery) being applied prior to the secondary and tertiary treatment.

That being said, the use of heat exchangers or any sort of heat pump to compound the energy in the wastewater would likely be subject to fouling when passing a wastewater stream through it. The prevention of fouling in any heat exchanger would be by using the highest quality of effluent possible. This is a balancing act of “treatability” of warm water and “heat potential” for energy recovery. Therefore, likely the best location for heat recovery would be after primary clarification and before the aeration stages. The primary clarifier(s) would remove a great deal of the suspended solids; however, there may still be some potential "fouling agents" in the effluent. The proposed modifications in the mill should significantly reduce the quantity of fouling agents. The recycled activated sludge from the proposed new secondary treatment stage should be returned to the system downstream of the heat exchanger so that the biomass does not contribute to the fouling in the heat exchanger. With heat being recovered prior to the aeration stage, better oxygen transfer will be achieved in the aeration basin and the secondary clarifier will be sized more conservatively based on the increased density of the micro-organisms in the sludge blanket.

The concept of water re-use from a large effluent stream can be implemented either one of two ways: either a non-contact or a direct-contact application. With a non-contact application for this waste stream, heat is transferred from the effluent to a new media, usually a clean and pristine supply of water that can be used for a variety of uses including aquaculture, agriculture or highly sensitive heating equipment (heat pump or radiant heating). The use of the mill effluent in a direct-contact application is more limited due to the sensitivity to trace pollutants for any sort of food or health-related water use. The use of tertiary treated water for any sort of food-related use is not a standard practice and not generally accepted in industry due to the inherent risks associated with potentially adverse health effects. In many jurisdictions, any form of contact water is strictly used for non-consumable crop irrigation and for some sanitary applications (i.e., grey water uses). There are a variety of applications that use non-contact heated water, and these would appear to be more desirable from the perspective of treatability and public scrutiny.

The other potential use of the non-contact heating system would be for mill reuse potential. The benefit to preheating much of the water for the mill would be seen mainly in the inlet water treatment and chemistry demands. With an elevated temperature, the coagulation and flocculation chemicals used in the raw water treatment would be more effective and likely reduce dosage requirements as well as reduce the mixing energies required. With warmer water, coagulation chemicals are more effectively used and carryover of these chemicals into the final treated product water is minimized. Additionally, this water stream would be preheated for use in boiler applications and other warm water applications. There would still be the need for raw cooling water at a lower temperature particularly in the steam turbine/generator surface condenser; however the treated, warm water could still be used at various processes throughout out the mill.

2.4 Outfall Relocation

2.4.1 *Background*

In order for Boat Harbour to be returned to its natural state, a new effluent discharge location is required for the mill wastewater treatment plant. Two candidate locations (Pictou Harbour, MacKenzie Head*)* have been selected as potential discharge points. Routing plans and budgetary opinions of the probable costs associated with these endeavours (Figure 2-7) have been prepared. Various factors (social, political, technical, financial, etc.) may force a change in the actual location but these locations provide an appropriate level of detail to provide preliminary costs.

To calculate costs, the pipe material, shipping and installation costing were calculated separately. A crew and production quantity was estimated and applied. Costs are based on pricing for high-density polyethylene (HDPE) DR-17, 900mm pipe, which was sized to accommodate a flow of 45,000 m^3/d.

2.4.2 *Site Selections*

The Pictou Harbour effluent main would begin at the new treatment facility location, located southeast of the current Northern Pulp facility. The effluent pipe will run terrestrially underground for 600m from this location to Abercrombie Point, where it would enter the Pictou Harbour. After entering the Harbour, the pipe would then travel underwater for approximately 1100m to the offshore diffuser.

The Mackenzie Head route will begin by travelling the length of the existing effluent main to 150m northeast of Pictou Landing Road, where the installation of the new pipeline will begin. The pipe then would travel along the existing gravel roadway 1150m north-northeast to the west edge of Boat Harbour. At this point, the pipe would cross the most westerly projection of Boat Harbour then head approximately 4575m East through the wooded area, around the Fishers Grant Indian Reserve to Pictou Landing Road. The exact route through the wooded area would be subject to possible land acquisitions. The option has been designed to avoid crossing the Fishers Grant Indian Reserve. The pipe route would then carry 1100m along the Pictou Landing roadway to Macleannans Memorial Camp Road. It would then travel 100m up Macleannans Memorial Camp Road to Cameron Lane, which it would follow until its termination (approximately 950m). A 325m route through the wooded area from the termination of Cameron Lane to the Northumberland Strait would be chosen based on possible land availability. The pipe would finally travel underwater 900m to the offshore diffuser located in the Northumberland Strait.

The two potential locations of the diffusers have been selected solely based on achieving the required depth as identified in the ARGA Simons (2000) Report. Other factors have not been taken into account at this time and will likely impact the final location of the pipe. In the case of the Pictou Harbour option, there could be exclusion zones for fisheries or shipping channels as well as any environmental and social impacts. The Mackenzie Head (Northumberland Strait) location may possibly encounter ice scouring depending on ice flows, fishery and shipping channel exclusions as well as other local environmental (sensitive land impacts) and social impacts. In the event the diffuser has to be placed further offshore in the Strait, a cost-per-100m value has been provided.

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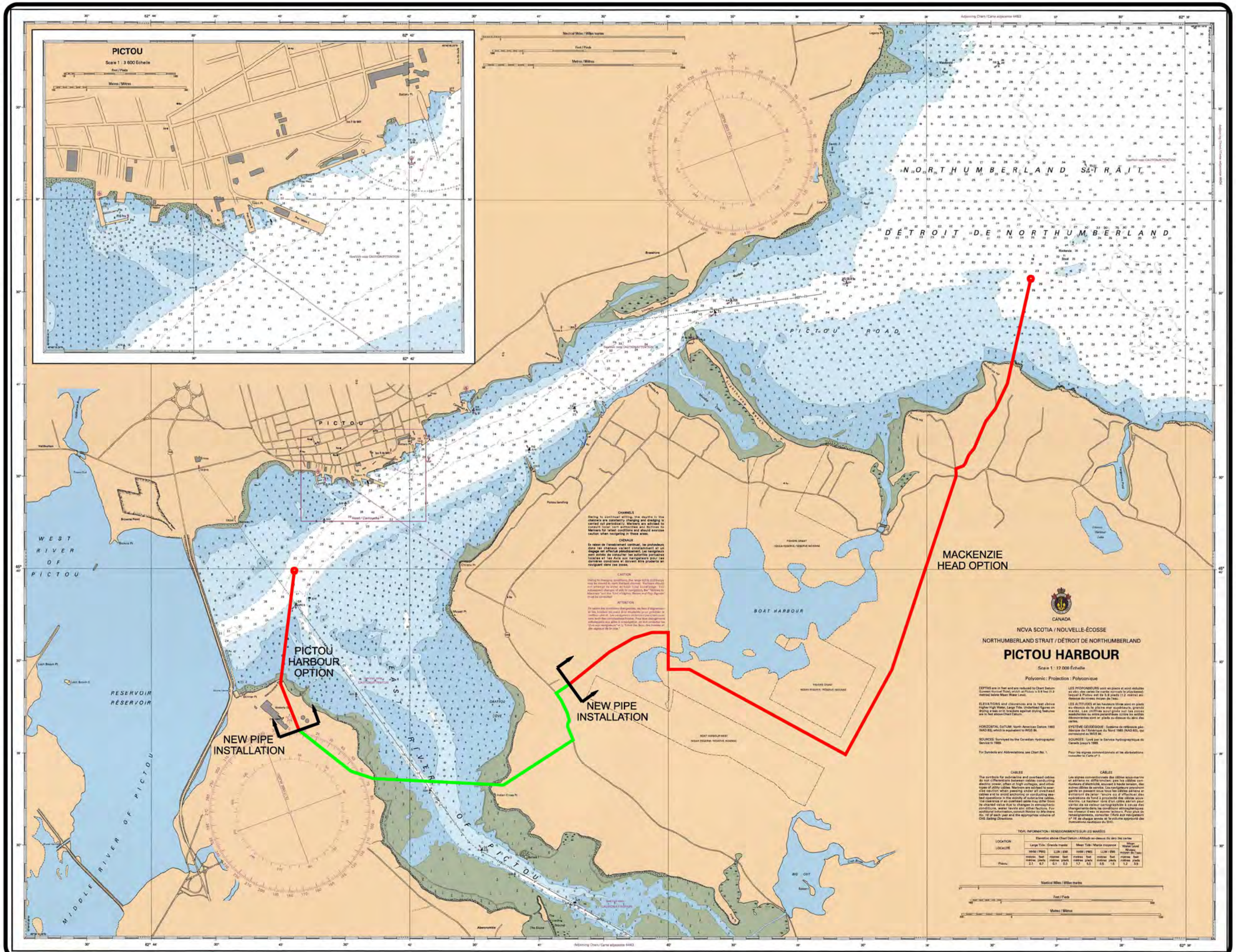

EXISTING EFFLUENT FORCEMAIN

PROPOSED PIPING OPTIONS

PROPOSED DIFFUSER LOCATION

No.	Revision	Ckd. By	Date

FOR INFORMATION ONLY

Const. North

Drawn By: STWD

Dwg. Standards Ckd. By:

Designed By: JCB

Date Printed

Dwg. Design Ckd. By:

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Project Title

NORTHERN PULP TERTIARY STUDY

Dwg. Title

PROPOSED OPTIONS FOR PIPE ROUTING

Project No. L6716-001.1

Dwg. No. 2-7

Rev. No. 0

Scale NOT TO SCALE

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3.0 Kraft Pulp Mill Effluent Requirements

3.1 Federal and Provincial Pulp Mill Treatment Requirements

In Canada, both the federal and provincial governments have the power to enact legislation relating to the environment. Federal legislation includes:

- Canadian Environmental Protection Act (CEPA);
- Canadian Environmental Assessment Act (CEAA);
- Pest Control Products Act;
- Canadian Shipping Act;
- Arctic Waters Pollution Prevention Act;
- Fisheries Act; and,
- Transportation of Dangerous Goods Act.

One of the primary federal laws relating to water pollution is the Fisheries Act. This act gives the federal government certain regulatory powers to pass regulations to establish standards for certain industries, one of which is the pulp and paper industry. The Pulp and Paper Effluent Regulations (SOR/92-269) lists the following classes of substances from a mill or an off-site wastewater treatment facility as "deleterious substances" (as defined in the Fisheries Act, subsection 34(1)):

a) acutely lethal effluent;
b) BOD matter; and,
c) suspended solids.

In and of itself, colour is not deemed as a "deleterious substance" and is not listed.

The Pulp and Paper Effluent Regulations (PPER) also includes an Environmental Effects Monitoring (EEM) program which provides Environment Canada with information to help assess the adequacy of the PPER in protecting fish, fish habitat and the use of fisheries resources. The results of the EEM are combined with information from other factors (ecological, economic, social and technical) to determine the adequacy of the regulations.

From a provincial regulatory standpoint, while other provinces (particularly British Columbia and Ontario) have specific regulations for pulp and paper mill effluents, the Province of Nova Scotia does not. The Nova Scotia government has enacted the Environmental Act (1994-1995, c. 1, s. 1) and through it various regulations (e.g., *Activities Designation Regulations* (N.S. Reg. 352/2007), *Environmental Assessment Regulations* (N.S. Reg. 277/2009) and *Air Quality Regulations* (N.S. Reg. 187/2010)) that can be applied to pulp and paper mill operations. However, the Province essentially relies on the PPER to regulate the mill wastewater discharges.

3.2 Potential Changes to Federal and Provincial Discharge Regulations

On March 20, 2010, Environment Canada proposed *Wastewater Systems Effluent Regulations* under the *Fisheries Act* in the *Canada Gazette*, Part I, as the federal government's principal instrument to implement the "Canada-wide Strategy for the Management of Municipal Wastewater Effluents" proposed by the Canadian Council of Ministers of the Environment (CCME) in February 2009. The proposed regulations include baseline effluent quality standards, compliance timelines, and rules for monitoring and reporting. They would apply to municipal, community and federal wastewater systems (treating primarily municipal wastewater that could include an industrial contribution), including those on Aboriginal lands across Canada, except, initially, those in far northern regions. These are still in the proposal stage as what the federal government is proposing differs substantially from what was originally endorsed by the CCME and supported by the provinces.

The objective of the proposed Regulations is to reduce the risks to ecosystem health, fisheries resources and human health by decreasing the level of harmful substances deposited to Canadian surface water from wastewater effluent. To achieve the objective, the proposed Regulations would set national effluent quality standards that would require secondary wastewater treatment, or equivalent, in wastewater systems across Canada[6].

3.3 Treatment Requirements for Direct Discharge to Pictou Harbour

To determine the level of treatment required to discharge a wastewater treatment plant effluent to a receiving stream, several factors must be considered:

1. Location of the receiving stream;
2. Current status of the receiving stream;
3. Physical characteristics of the receiving stream (primarily to determine the configuration of the outfall and diffusers);
4. Flow variations within the stream (this is primarily for freshwater streams/rivers that experience seasonal flows);
5. Downstream uses of the receiving stream (water supply, fishing grounds, recreational purposes, etc.);
6. The assimilative capacity of the receiving stream; and,
7. Other site specific factors.

As mentioned above, CCME has developed the "*Canada-wide Strategy for the Management of Municipal Wastewater Effluent*" (February 2009) that is in the process of being adopted by the Federal Government (Environment Canada) with the Department of Fisheries and Oceans having the statutory authority. It specifically excludes industrial wastewater treatment plants. The strategy outlines two main objectives:

[6] Canada Gazette, Part 1: Notices and Proposed Regulations, March 20, 2010

1. Improved human health and environmental protection.
2. Improved clarity about the way municipal effluent is managed and regulated.

The strategy also specifies effluent discharge criteria identified as the minimum National Performance Standards (NPS). All facilities must meet these standards as a minimum with more stringent requirements being applied on a case-by-case basis by the jurisdiction having authority. The minimum standards from the strategy are:

- Carbonaceous Biochemical Oxygen Demand ($cBOD_5$) ≤ 25 mg/L;
- Total Suspended Solids (TSS) ≤ 25 mg/L; and,
- Total Residual Chlorine ≤ 0.02 mg/L

In addition to the minimum performance standards, plant-specific Effluent Discharge Objectives (EDOs) need to be developed based on a one-year characterization of the plant effluent quality and also taking into consideration the characteristics of the receiving environment (environmental effects monitoring) and mixing that occurs in a defined mixing zone associated with the point of discharge. For any discharged substance that is in excess of safe levels for human health or the environment, a discharge objective will be implemented. This could mean lower values for the minimum performance standards or an additional discharge limit for an entirely different substance.

Keeping in mind that the above only applies to municipal wastewater treatment plants, the process could be followed to determine the level of treatment required to have the mill wastewater treatment plant effluent discharged directly to Pictou Harbour. The current treatment system produces an effluent that is close to meeting the minimum NPS. Proposed changes within the mill that are planned to be completed in 2011 should positively affect the quantity and quality of the raw wastewater leaving the mill allowing a secondary treatment system to produce a better-quality effluent than is currently being produced; unfortunately, the extent of the changes are unknown at this time. It is believed, however, that the volume of raw wastewater flow will be reduced considerably which would have a positive impact on secondary treatment.

Replacing the existing treatment system (settling basins followed by aerated and non-aerated stabilization ponds) with a new secondary treatment system that is designed to provide better control of the effluent total suspended solids may produce an effluent that meets the minimum NPS. Again, with the in-plant changes that are being considered, the colour of the effluent may be improved (it should be noted that colour is not a parameter that is regulated though the reason for the colour may be regulated).

3.4 Federal, Provincial and Municipal Discharge Regulations to Discharge to Pictou Harbour

As stated above, the mill effluent is regulated under the Pulp and Paper Effluent Regulations. However, to change the point of discharge, whether it is to Pictou Harbour or the Northumberland Strait, would require an Environmental Assessment under the *Canadian Environmental Assessment Act* pertaining to the *Fisheries Act* with reference particularly to the depositing of a deleterious substance. This EA process would preempt any provincial or municipal requirements but would allow any and all stakeholders (provincial, municipal, special interest groups, etc.) to have a part in the process.

Transport Canada would also become involved in the approval process for discharging to either point under the Navigable Waters Protection Program through the administration of the *Navigable Waters Protection Act*[7] (NWPA). This is to ensure that the public can navigate the waters without any obstructions. There is a detailed application process that is required of the proponent that can be viewed at the following transport Canada website: http://www.tc.gc.ca/eng/marinesafety/oep-nwpp-guide-2053.htm.

[7] "Navigable Waters Protection Act, Chapter N-22", Minister of Justice, February 28, 2011

4.0 Market Opportunities – Re-use of Treated Effluent

As described in Section 2.3, the treated effluent can be used either in a direct-contact or a non-contact basis. Given the source of the wastewater, a direct-contact application is not recommended. All the potential opportunities presented below are of a non-contact nature.

4.1 Waste Heat Utilization

Recovering heat or thermal energy from a wastewater stream that is otherwise of no further use and is going to be discharged or discarded and utilizing the recovered energy for a useful purpose is known as waste heat recovery. The higher the temperature of the waste stream from which it is desired to recover heat and the greater the quantity of thermal energy available to recover, the more uses that the recovered heat can be utilized for. This is largely due to the natural laws that govern heat transfer and thermodynamics, the branch of science that deals with the relationship between heat and work.

Waste heat is typically classified as being high, medium or low grade. The classification is based on the temperature of the waste stream. While the boundaries or temperature range for these classifications are not absolute or fixed, it is fairly common practice to regard waste streams at 650^{o}C (1200^{o}F) or hotter to be high-grade waste heat sources. Medium-grade heat includes the temperature range from 121^{o}C (250^{o}F) to 650^{o}C (1200^{o}F) and low-grade waste heat would encompass the range from 20^{o}C (68^{o}F) to 121^{o}C (250^{o}F). Not only is there more energy contained in the higher temperature waste streams per each kilogram (pound) of effluent, but as will be discussed further below, the greater the temperature difference between the waste stream or media from which the thermal energy is to be extracted and the stream or media receiving the thermal energy, the easier the transfer and the greater the amount of energy that can be transferred.

It is apparent from the above paragraph that the tertiary treatment effluent, which is expected to vary in temperature from approximately 43^{o}C (110^{o}F) to 63^{o}C (145^{o}F) during the course of a year, is at the low end of the low-grade heat classification. Existing as a low grade of heat or thermal energy puts limitations on the potential uses for the energy contained in the tertiary treatment effluent as well as the types of equipment that can be used for the energy transfer. Subsequent sections will describe one of the most common types of heat transfer equipment, namely, heat exchangers and the more complex heat pump as well as discuss potential uses for the thermal energy contained in the tertiary treatment effluent.

4.1.1 *Heat Exchangers*

Heat transfer, or more correctly thermal energy transfer, is the exchange of energy from one fluid or media to another. In conventional heat transfer, the direction of the energy transfer must be from the object at the higher temperature or thermal energy level to the object at the lower temperature. Additionally, the lower temperature object cannot be heated to a temperature above that of the higher temperature object. The device or piece of equipment that accomplishes the heat transfer is known as a "heat exchanger". One of the most commonly used heat exchangers is the automobile radiator where the engine's cooling fluid is cooled i.e., transfers thermal energy to the air blown across the finned tubes carrying the engine fluid. The air is simultaneously heated by accepting the thermal energy from the engine cooling fluid. The cooling fluid can never be cooled below the temperature of the air blown through the radiator and the air can never be heated to a temperature above that of the cooling fluid. Similarly to voltage or electrical potential difference being the driving force for current flow in electrical circuits, temperature difference is the driving force for heat or energy transfer in heat exchangers. The greater the temperature difference between the two media, the greater the amount of thermal energy that can be transferred. Expressed in a different manner, for a given size exchanger (amount of transfer surface), the greater the temperature difference, the more thermal energy it can transfer between the two media.

One of the major classification criteria for heat exchangers is whether they are contact or non-contact pieces of equipment. In the contact type of heat exchanger, the two fluids or media which enter the exchanger actually mix with each other and leave as a single stream. In the non-contact heat exchanger, there is a solid physical boundary between the two fluids such as a tube wall or plate. When one of the fluids is a waste stream, particularly if it is toxic or otherwise hazardous, the heat exchanger would normally be of the non-contact type.

While there are some heat exchangers that utilize rotating parts to rotate or move heat from one process fluid or stream to another, the majority of heat exchangers are static, i.e., they contain no moving components. Three common forms of static heat exchangers are the double pipe, the shell and tube and the plate type. In the double pipe exchanger a smaller pipe is located inside a larger pipe. One fluid flows through the inner pipe while the other fluid flows in the annular space created between the two pipes. In the shell and tube exchanger, a series of tubes commonly secured at each end to a plate known as a "tubesheet" are enclosed inside a shell. One fluid flows inside the tubes while the other fluid flows over the outside of the tube bundle and is contained by the outer shell. In the plate type heat exchanger, a series of thin, separated plates are sandwiched together. The plates have large surface areas and narrow fluid flow passages. One of the two fluids flows on each side of the plates.

4.1.2 *Heat Pumps*

A heat pump allows for the normal restrictions of heat transfer to be overcome and for heat energy to be transferred from a source at lower temperature to a source at higher temperature. The most common example of a heat pump is a home refrigerator where heat is removed from the interior of the refrigerator and transferred to the ambient environment of the room containing the refrigerator, even though the refrigerator interior is at a lower temperature than the room in which it is located.

As a device that can transfer and recover energy from a waste stream that would otherwise be considered unusable and non-recoverable, to a higher temperature process where the energy does become usable, the heat pump may seem magical. However, the heat pump cannot achieve this transfer of heat energy without the input of energy from an external source, which typically takes the form of mechanical energy or thermal energy, which may come from a source that would otherwise be considered unusable or waste. In the case of the home refrigerator, mechanical energy is supplied to the compressor by an electric motor. The goal of a properly selected heat pump application is to achieve the state where the amount of energy recovered from what would otherwise be a waste energy stream exceeds the energy input required by the heat pump.

Although there are several different types of heat pumps, all heat pumps accomplish the following three basic functions[8]:

- Absorb heat from the waste heat source;
- Increase the heat temperature within the delivery fluid; and,
- Delivery of the useful heat at the required elevated temperature.

A key parameter in determining the performance of a heat pump and therefore the energy savings that can be achieved is the temperature lift that the heat pump must produce. The temperature lift is the difference in temperatures between the waste heat source temperature at which the heat pump absorbs thermal energy and the temperature at which the heat pump delivers thermal energy. The lower the temperature lift, the better the performance of the heat pump, i.e., the greater the amount of heat energy transferred for each unit amount of external energy supplied to the heat pump.

The performance of a heat pump is usually expressed as the heat pump Co-efficient of Performance (COP_{HP}). COP_{HP} is defined as:

$$COP_{HP} = Q_{out} / W_{in}$$

where Q_{out} is the heat (thermal energy) delivered by the heat pump and W_{in} is the energy or "work" supplied to the pump driver. As an example, a COP_{HP} of 4 means that the heat pump is delivering four times as much thermal energy to the process it is supplying than the amount of work supplied to the pump driver.

Two major categories of heat pumps are mechanical and closed-cycle absorption. Mechanical heat pumps, which can be either open cycle or closed cycle, use mechanical compression of a fluid to achieve their temperature lift. In the closed-cycle mechanical heat pump (e.g. the household refrigerator) a working fluid is circulated through a closed loop in which it is alternately compressed and condensed. In the open-cycle mechanical heat pump a waste vapour is compressed (pressure increased). These mechanical vapour compression heat pumps are considered to be open cycle because the working fluid is a process stream. Typically, mechanical heat pumps are used in situations with temperature lifts less than 55^{o}C (100 ^{o}F).

[8] U.S. Department of Energy, Industrial Technologies Program, "Industrial Heat Pumps for Steam and Fuel Savings", DOE/GO-102003-1735, June, 2003.

Closed-cycle absorption heat pumps use a dual component working fluid and the fluid properties of boiling point elevation and heat of absorption to accomplish their temperature lift. Advantages of absorption pumps are that they can deliver a higher temperature lift than other types, their energy performance does not degrade rapidly at higher temperature lifts and they can be configured to provide combined heating and cooling. In order to obtain these advantages, however, they are more complicated and require more equipment than the other types of pumps. Typically, four separate heat exchangers are found in an absorption heat pump, designated as the evaporator, condenser, generator, and absorber. In some cases high lift or extended range absorption heat pumps can achieve a temperature lift exceeding 111°C (200 °F).

4.2 District Heating

One possible use of the recovered energy from the warm tertiary treatment effluent is a district heating scheme. Such schemes have been receiving increasing attention in recent years as fuel cost have risen dramatically and concern for the global warming effects produced by the generation of greenhouse gases has similarly increased. District heating schemes have the potential to produce energy savings and reduce greenhouse emissions, particularly if they include recovery of thermal energy that would otherwise be wasted. Many communities have adopted “sustainability” as a key component in their planning. District heating or energy systems are increasingly being considered a part of the sustainability portion of municipal/community plans, particularly if they can contribute to the reduction of greenhouse gases through the recovery of waste energy or energy production from biomass. However, as will be discussed in more detail below, there can be a large difference between technical feasibility and financial feasibility; thus, even though something may be easy to accomplish from a technical perspective it may not prove to be financially viable.

One of the parameters, normally considered to be critical to achieving a successful district heating project is the population density for the district to be serviced. The population densities of most districts in Europe are larger than those in Canada, particularly rural Canadian villages and towns. The FVB report[9] indicates the following densities for a number of district heating schemes in southern Ontario as tabulated below:

Location	Net Hectares	Units/Net Hectare
Central Pickering – Low Density		25 – 40
Central Pickering – Med. Density		40 – 80
Central Pickering – High Density		140 – 250
Markham Centre	13.5	250
Regent Park	13.4	380
West Don Lands	12.27	470
East Bayfront	21.1	300

[9] FVB Energy Inc., “City of Pickering, District Energy Pre-Feasibility Assessment”, January, 2007

Converting the density information provided by Nijjar *et al*[10] for some selected rural Nova Scotian towns to put it on the same land area basis as that utilized above for the southern Ontario district energy projects, produces the following tabulation:

Location	Hectares	Houses/Hectare
Trenton	600	1.85
Middleton	540	1.50
Berwick	680	1.33
Shelburne	900	0.97

It is obvious from a quick inspection of the two tables above that the densities in the rural Nova Scotian communities are more than two orders of magnitude less than for the projects in the greater Toronto area (GTA) (Markham Center, Regent Park, West Don Lands, and East Bayfront). An important reason for the difference in residential unit densities is that as Nijjar *et al* indicates, 96.8% of residential units in rural Nova Scotia are single, detached houses. However, FVB notes that approximately 90% of the residential units in the GTA projects will be apartments or Multiple Unit Residential Buildings (MURBs). It is further noted by FVB that 85% of the residential units in the new neighbourhoods of Central Pickering are expected to be single detached homes. Thus, it can be seen that the unit density in the lower density neighbourhoods of central Pickering are much closer to those for rural Nova Scotia than the projects in the GTA. FVB indicates that it is unlikely that with such densities (25 – 40 units/net hectare), that district energy could be justified on an economic basis. This would suggest that the rural Nova Scotia densities of 0.97- 1.85 houses/hectare would be very economically challenging to operating a district energy project.

FVB Energy indicate in their report that they consider building type to be even more important than housing/building density to a commercially viable district heating scheme. This is due to the ratio between connection cost and thermal energy revenue for the different building types. According to FVB this ratio should be as low as possible, i.e., the connection cost should be low compared to the estimated future revenue from the sale of thermal energy to increase the chance of commercial success due to the shorter payback period that will be realized by the purchaser of the thermal energy. However, this ratio is highest for detached, single family residences. As noted above, almost all housing units in rural Nova Scotia communities are single family, detached residences. FVB state that the preferred type of customers for a district energy project are apartments (MURBs), and commercial and institutional buildings such as shopping centers, office buildings, civic centers, churches and schools. It is expected that such buildings both in terms of number and percentage of total system energy demand would be a minority in rural Nova Scotia.

[10] Jaspreet S. Nijjar et al, "District Heating System Design for Rural Nova Scotian Communities Using Building simulation and Energy Usage Databases", Transactions of Canadian Society of Mechanical engineering, Vol. 33, No. I, pg 51-63.

There are also a number of technical and physical issues with the quality (grade) of waste heat available and its annual variation in quality compared with the requirements of a typical district energy system. Firstly, the waste heat is of a lower grade than is typically utilized for the supply of heat in a district energy system. Church[11] indicates that the hot water supply temperature for conventional district heating schemes is 90^{o}C (194^{o}F) and that many European systems operate with a temperature drop or "DELTA-TEE" of 30^{o}C in the energy transfer station at the customer buildings. The use of higher supply temperatures (and therefore higher grade thermal energy) and higher temperature drops reduces the volume of water that has to be circulated and therefore the size of the piping required. However, the higher temperature drop requires additional heat transfer surfaces in the buildings supplied.

The waste energy available from the mill is expected to range from 43^{o}C (110^{o}F) in the winter to 60^{o}C (140^{o}F) in the summer. To transfer heat from this lower temperature waste water to the higher temperature district heating circulating water would require the use of a heat pump. The use of a water-to-water heat pump in such a situation is certainly technically feasible and it should be expected to achieve a fairly good COP.

The annual variation in waste water quality is the reverse of the annual heating load for a district heating system, i.e., the waste water is hottest in the summer when the load on the district heating system would be the lowest and is at the lowest temperature (grade) when the demand on the district heating system is the largest. Adding a geothermal energy storage component to a district heating scheme where during the summer the hot waste water could be used to store energy in the ground, which would be extracted during the winter heating period is a potential method of bridging the difference in the energy availability and energy demand annual profiles. It would, however, add to the capital cost of the project and requires suitable geology to implement. It is unknown at this time whether the Pictou area would offer suitable geology for geothermal energy storage.

There appears to be more than enough thermal energy in the tertiary treatment effluent to supply a district heating scheme. Based on the town of Berwick, which represents the average Nova Scotia rural town, Nijjar *et al* assumed a hypothetical community with 800 houses. For this hypothetical community they calculated an annual community heat load including losses of 24,880 MWh and a peak heating load of 8,670 kW. These loads included piping losses, which accounted for 6.4% of the total heat load. To meet the peak load would require a temperature drop of approximately 11^{o}C in the tertiary effluent (e.g. enter at 43^{o}C and leave at 32^{o}C) if the transfer of energy from the effluent to the district heating circulating water was completed without loss.

Major commercial decisions that revolve around a proposed district heating project include what entity will own and operate the project and how the project will be funded. FVB Energy state that the most successful district energy projects are those that are municipally owned, which has been for most such

[11] Ken Church, "Is District energy Right for Your community? Part 2: Sizing the system", Municipal World, December, 2007.

projects in Ontario including those in Cornwall, Sudbury, Windsor, Markham and Hamilton. Church[12] indicates that: "The singularly independent nature of district energy development in Canada has led to the creation of a variety of business models, with ownership ranging from 100 percent private to 100 percent public." Church further notes that due to the moderate rate of return produced by most district energy projects the interest shown in such projects by the venture capital sector is limited.

District energy in Canada has been stagnant for some time. A number of proponents feel this is due to the "project" approach that has been utilized in the past where only the most attractive loads have been selected for inclusion in the project and the system has been designed and built to service only these loads. Potential customers (loads) who might want to connect to the system after its original construction are discouraged because of the cost to connect to the system (typically driven by the need to expand the system) and the smaller energy cost savings available when a relatively cheap alternative energy source such as natural gas is available in many jurisdictions. Some suggest that in order for district energy to really expand it needs to change from the project type approach to a "utility" approach where the system would be considered as a continuous and ever expanding entity in which the cost of system expansion should be aggregated and assessed against the levelized cost of heating to the customer base. The province of British Columbia is the first province in Canada to regulate district energy, which requires these systems to behave like a utility.

A district heating/energy scheme would not necessarily be limited to supplying energy to existing communities in the vicinity of the Northern Pulp mill. If other business could be attracted to the industrial park in which the mill is located, there might be a better fit in terms of annual load (energy) requirement than supplying heating to predominantly residential customers during the heating season. The lumber drying, aquaculture and agriculture applications discussed in subsequent sections might be among the possibilities of the types of businesses that could locate to the industrial park.

4.3 Lumber Drying

In order to be used for either construction lumber or wood products, the wood produced by sawmills has to be dried or thermally treated before it can be utilized. Even after a tree has been cut, the wood that is derived from the tree will continue to exchange moisture with the ambient air surrounding the wood until the moisture level in the wood and the moisture level in the air reach an equilibrium. If this equalization of moisture or drying of the wood is allowed to proceed in an uncontrolled manner a number of undesirable consequences such as splitting, checking, and warpage can occur which damage the wood and can render it unsuitable for its desired purpose. Further, natural air drying will take significantly longer than controlled drying in a kiln, and will not typically reach moisture levels low enough for uses such as furniture that will spend its life in climate controlled buildings.

Due to the above reasons, lumber and wood producers typically use kilns to maximize the amount of usable wood produced from the green (wet) wood sawn from trees and to minimize the time required

[12] Ken Church, "Is District energy Right for Your community? Part 3: Supporting Resources", Municipal World, January, 2008.

to dry the wood to the point where it can be utilized. The kilns typically form part of the sawmill plant. The kilns use heated, dry air to perform the wood drying and are also equipped with fans so that the flow of the heated air through the kiln can be controlled, which ensures a more positive and even distribution through the wood stacks located in the Kiln. Achieving a uniform distribution of air through the wood stacked in the kiln is important to ensure a more uniform quality in the dried wood.

The air in conventional kilns is typically heated by finned-tube heat exchangers (coils) through which steam, hot water, or hot oil are circulated. The steam, water or oil are heated in a boiler or heater that was most commonly fired by a fossil fuel but in recent years many sawmills have converted to boilers that burn biomass waste resulting from the sawmill's operation. After passing over the coils, the air flows through the lumber stacks in the kiln. The warm, moisture laden air leaving the lumber stacks is exhausted to atmosphere from the kiln.

A more recent development in wood drying kilns is the dehumidification kiln. The advantage that the dehumidification kiln has over a conventional kiln is that in the dehumidification kiln heat is continuously recycled rather than vented to atmosphere as occurs in the conventional kiln. The device that allows this savings in energy to be accomplished is a closed-cycle mechanical heat pump. The warm, moisture laden air leaving the lumber stacks is passed over a cooling coil, which serves as the closed-cycle heat pump's evaporator. As the air cools it gives up heat to the heat pump working fluid and moisture contained in the air is condensed. The condensed moisture is drained away and the air is then passed over heating coils, which serve as the heat pump's condenser.

In the heating coils, which serve as the heat pump's condenser, the energy which the air previously gave up in the cooling coils is returned to the air through the use of the closed-cycle heat pump. The heated, dehumidified air is then recirculated through the lumber stacks. Each time the air is recirculated through the coils its temperature is increased. The U. S. Department of Energy[13] indicates that the most common industrial application of heat pumping is the dehumidification drying of lumber.

Kilns used to dry softwood, which is the predominant type of wood used for structural or framing purposes, typically operate below 115°C (240°F). Kilns used to dry hardwoods, which are typically used for furniture, flooring, or other wood products, operate at lower temperatures commonly keeping the air temperature below 82°C (180°F). These operating temperature ranges are certainly at a workable level for recovery of waste energy from the tertiary effluent. However, a short search of kiln manufacturers did not find any who supplied kilns that utilized waste heat recovery from a waste liquid stream. Recovery of waste energy could take a number of different forms including using a conventional heat exchanger to preheat the circulating water in a conventional kiln and a boiler or other type of heater to raise the temperature the rest of the way, or utilizing a heat pump to transfer heat from the tertiary treatment effluent to the fluid being circulated through the heating coils. It would

[13] U.S. Department of Energy, Industrial Technologies Program, "Industrial Heat Pumps for Steam and Fuel Savings", DOE/GO-102003-1735, June, 2003.

appear, however, that a customized design would be required to utilize waste heat recovery from the tertiary effluent.

Discussions with a current large operator of lumber drying kilns indicate that the largest single cost of production for lumber is the energy required to dry it. However, to utilize the tertiary treatment effluent as a source of thermal energy for a lumber drying kiln would require that a new kiln be located within a reasonable distance from the source of the effluent since the energy spent pumping the effluent long distances would likely negate the value of the energy recovered. A major financial question for such a new venture would be whether the energy savings available by recovery of waste heat would offer a sufficient return on a fairly significant capital investment required to build a new lumber drying kiln, which typically would form part of a sawmill complex. It is a possibility to locate the kiln on a separate property from the sawmill which produces the wood to be dried; however, this would open the possibility that the energy saving achieved by recovering waste heat from the tertiary effluent was negated by the fuel (energy) cost to transport the lumber from the sawmill to the kiln.

Locating a sawmill complex including drying kiln adjacent to the Northern Pulp Mill could produce a potential business synergy between the two businesses. The sawmill would have an existing and nearby customer for some of its residue. The close proximity of the two mills would reduce transportation cost and would allow the sawmill to sell its residue at a lower cost to the pulp mill compared to more distant sources of wood fibre, which would benefit both parties. This would of course be in addition to the benefit of lower lumber drying costs for the sawmill produced by the energy recovery from the tertiary effluent.

Unfortunately, in recent years the business outlook for sawmills has been quite dark. The softwood lumber dispute with the United States, the significant increase in the value of the Canadian dollar, which hurts all exports including lumber, and most recently the housing crisis in the United States have had quite devastating effects on the commercial viability of sawmills. Indeed, the majority of sawmills in Atlantic Canada that were operating prior to the beginning of the current recession in mid-2008, have since closed. During a visit to the Northern Pulp mill in January, 2011, mill personnel indicated that a local sawmill that had been a source of wood chips for Northern had closed. Any further consideration of this potential usage of waste heat would therefore require a thorough investigation/market analysis of the lumber industry.

4.4 Organic Rankine Cycle Power Generation

A thermodynamic cycle is a sequence of thermodynamic processes that continuously repeat in the same order. A thermodynamic cycle uses a working fluid that changes state as it flows from one process step to another in the cycle returning to its original state at the end of the last process step to begin its flow around the process path again. The repeating nature of the process steps or process path permits continuous operation, which makes the cycle an important concept in thermodynamics.

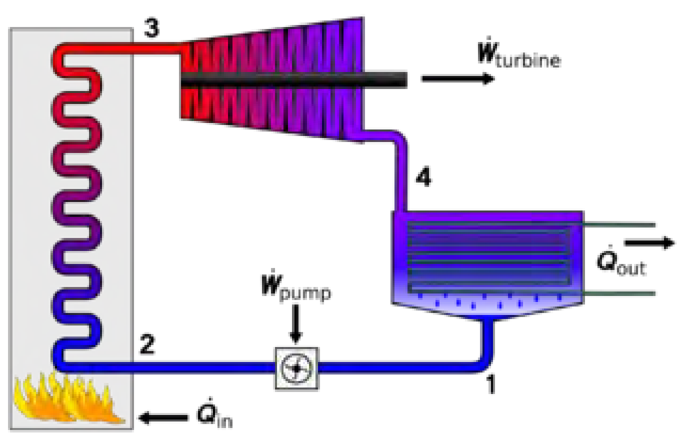
There are two major classifications of thermodynamic cycles, namely power cycles and heat pump cycles. In a power cycle a portion of the heat input to the cycle is converted to mechanical work output from the cycle. In a heat pump cycle, as previously discussed, heat is transferred in the opposite direction from which it would naturally occur, i.e., from low to high temperature media or fluids using mechanical work input.

Power cycles are the basis for the operation of the heat engines that power our cars and generate most of the world's electricity. The ubiquitous gasoline fuelled, spark ignited engine that powers most of the automobiles on the road is known as the "Otto" cycle, named after its German inventor. The heat engine that generates a majority of the world's electrical energy is the steam turbine. Its operation and performance is defined by the power cycle known as the "Rankine" cycle, also commonly known as the steam cycle.

The working fluid in the Rankine cycle is water which is vaporized into steam in the boiler by the addition of heat (the thermodynamic process of heat addition under constant pressure), and transfers thermal energy to the steam turbine in the vapour state. The steam turbine converts the thermal energy into mechanical shaft power or work (through the thermodynamic process of isentropic expansion), which is the input to the generator. The generator in turn converts the shaft work input into electrical energy. After exhausting from the steam turbine, the steam is condensed back into water in the condenser (the thermodynamic process of heat rejection at constant pressure) and starts the cycle over again.

The major components of the conventional Rankine cycle, namely, the boiler, the steam turbine, the condenser and the boiler feedpump are illustrated graphically below:

Rankine Cycle Schematic[14]



[14] http;//www.answers.com/topic/rankine-cycle?&print=true

The Rankine cycle uses heat at much higher temperatures than what is available from the tertiary treatment effluent. In many fossil fuel fired thermal generating stations, steam enters the turbine at 538^{o}C (1000^{o}F). In recent years generating stations known as supercritical Rankine cycle plants have been constructed that operate with steam temperatures in the order of 649^{o}C (1200^{o}C). The higher the steam temperature entering the turbine, the better the thermodynamic efficiency of the plant, i.e., the more electrical energy that is produced from a given amount of fuel (heat) input. The temperature at which most Rankine cycle plants reject heat, typically in the 38^{o}C (100^{o}F) to 43^{o}C (110^{o}C) range, is very close to the expected tertiary effluent temperature range of 43^{o}C (110^{o}C) to 63^{o}C (145^{o}C).

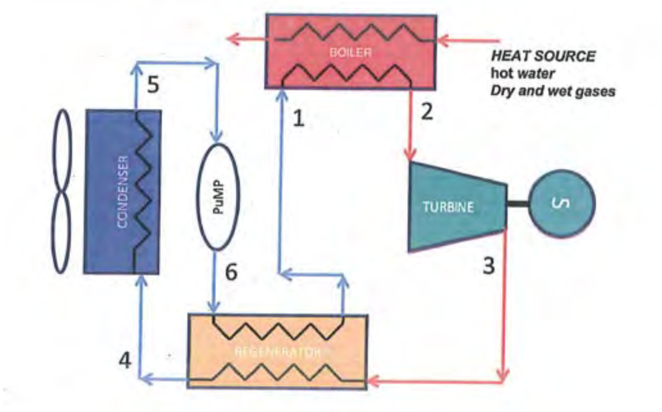
In an “organic” Rankine cycle, water is replaced as a working fluid by another fluid, with a lower boiling temperature than water. Organic refers to the fact that the alternate fluid contains carbon as one of the elements making up the fluid. The benefit of the lower boiling point of the organic Rankine cycle that is relevant to the area of focus for this study is that a lower grade of heat can be used as heat input to the cycle, including low grade industrial waste heat. The organic Rankine cycle is composed of the same four thermodynamic process steps as the conventional Rankine cycle, but operates at lower temperatures and pressures than the conventional cycle.

The selection of fluid is important to the organic Rankine cycle because its physical and thermodynamic properties, particularly its phase change or boiling point, determines what types of heat input to the cycle are viable. While fluids with lower boiling points will allow for lower grades of waste heat to be utilized, this also lowers the achievable thermodynamic efficiency of the cycle. However, if the waste heat would otherwise have to be discarded, the lower efficiency is secondary to the ability to achieve some energy recovery. Common fluids utilized in the organic Rankine cycle are refrigerants and hydrocarbons such as pentane.

A schematic of an organic Rankine Cycle is illustrated below. Instead of a boiler burning a fossil fuel, the boiler in this case is in fact a heat exchanger in which the thermal energy from the waste fluid is transferred to the organic cycle fluid, changing its state (vaporizing it). There is an additional heat exchanger called a “regenerator” utilized to cool the organic fluid being exhausted from the turbine.

Producing power from an organic Rankine cycle plant utilizing a waste industrial heat source as the heat input to the cycle has a number of advantages. Firstly, it eliminates the greenhouse gas generation which would result from producing the power in a conventional Rankine cycle plant where the heat input typically comes from burning a fossil fuel such as coal, oil or natural gas in a boiler. Secondly, it converts the waste heat energy recovered into an energy form, namely, electricity that can be transmitted substantial distances to prospective customers and thirdly, electricity is an energy form that is in constant demand. In a district heating scheme, heat demand is not constant and pumping hot water significant distances can reduce the overall energy savings associated with recovering the waste heat.

Organic Rankine Cycle Schematic[15]



Preliminary inquiries were made to a potential supplier of organic Rankine cycle technology and equipment, namely, Trans-Pacific Energy Inc., to determine if it was feasible to utilize the low grade waste heat contained in the tertiary treatment effluent and, if so, obtain an estimate of the potential electrical energy production. Trans-Pacific have developed a working fluid which is composed of four different refrigerants, which they claim allow it to use lower grade waste heat than most other suppliers of organic Rankine cycle equipment, e.g., down to 27^{o}C (80^{o}F).

With the estimated16,000 m^{3}per day of 43^{o}C tertiary treatment effluent, Trans-Pacific estimates that a gross electrical power output of 949 kW could be obtained if a water cooled condenser was utilized and a gross electrical power output of 686 kW could be obtained if an air cooled condenser was utilized. It is apparent from the information obtained that water cooling provides a significant improvement in energy recovery. There is a readily available source of cooling water in the form of the treated portion (clarified) of the raw water intake to the mill. Therefore, it would seem most beneficial that if an organic Rankine cycle plant was utilized for energy recovery to locate it on the mill property and utilize the clarified water as the cooling fluid in the condenser before the water continued on to the intended process uses in the mill. Further, locating the equipment on the mill property would minimize piping (and therefore costs) required for the cooling water and the tertiary treatment effluent. Additionally, the mill has an existing connection to the NS Power transmission grid and internal power distribution buses that may have sufficient spare capacity to allow connection of the organic Rankine cycle generator to them. This could potentially eliminate the need for a new transformer and some or all of the switchgear and protective devices that would be required for a generator installation.

A subsequent, more detailed study of this option would be required to determine estimated costs, payback period and return on investment. At a first high level overview, however, this option does look technically feasible and potentially quite attractive. As well, the full wastewater flow could be utilized as a source of heat potentially making this a much larger project; the above is based on a flow approximately ⅓ of the total wastewater flow.

[15] TransPacific Energy Inc., Technical Bulletin

4.5 Aquacultural Applications

Land based aquaculture operations in Canada generally require energy to maintain water temperatures that ensure the health and efficient growth of the various finfish and other aquaculture products. To this end, there may be the potential to utilize waste heat from the Northern Pulp wastewaters to maintain the appropriate water temperatures.

Canada is a major player in the aquaculture industry due to its access to: suitable sources of fresh and sea water, feed, and land. Canada is also well positioned in terms of good access to major markets; particularly the US.

4.5.1 *Canadian Aquaculture Species*

Canadian aquaculture production is dominated by four main categories by volume: salmon 66.7%; mussels 15.8%; oysters 8.7%; trout 3.4%. Other commercial species include: Manila clams, Soft shell clams, Arctic char, Tilapia, Atlantic cod, Sablefish, Geoducks, Atlantic halibut, Quahogs, White Sturgeon and Scallops. Emerging aquaculture species include: Spotted wolffish, American eels, Abalone, Sea cucumbers, Sea urchins, Cockles and Marine plants.

More than 85% of Canadian aquaculture production is exported – the largest export market is the United States.

- **Salmon**

Farmed salmon is by far the most important finfish species grown by Canadian aquaculturists. With a production volume of 118,058 tonnes and a value of $748 million, farmed salmon accounted for ~85% of both the volume and value of finfish produced by Canada's aquaculture industry in 2006.

Canada accounts for 8.2% of global farmed salmon production – and ranks 4th behind Norway, the UK and Chile as a producer of farmed salmon.

British Columbia and New Brunswick are the predominant producers of Canadian farmed salmon. In 2005, British Columbia accounted for 59% of Canada's total farmed salmon production – while New Brunswick accounted for 36%. Farmed salmon is British Columbia's largest agricultural export product - and the largest crop in the New Brunswick agri-food sector.

The United States is Canada's major export market for farmed salmon - accounting for 93% of Canada's farmed salmon exports in 2006. In 2006, the US imported 78,733 tonnes of Canadian farmed salmon worth $505 million.

- **Shellfish**

Canada's total shellfish production in 2006 was 38,676 tonnes with a value of $71 million. By volume, mussels and oysters are the primary shellfish species cultured in Canada: in 2006, mussels accounted for 62% of the total national shellfish production while oysters accounted for an additional 32%. Canada ranks 12th globally in the production of both mussels and oysters.

The United States is Canada's major export market for farmed shellfish. In fact, Canada is the largest supplier of shellfish to the United States.

- **Mussels**

In 2006, Canadian farmed mussel production was 23,822 tonnes valued at over $33 million. Eastern Canada produced 99% of Canada's total production in 2006. Prince Edward Island is the major mussel producing province – followed by Newfoundland, Nova Scotia, Quebec and New Brunswick.

Eastern Canadian mussels are primarily marketed in the northeastern US and the Canadian fresh, live market – these markets consume 97% of the Canadian mussel harvest. In 2006, the value of the Canadian mussel exports to the United States was $23 million.

- **Oysters**

In 2006, Canadian farmed oyster production was 12,488 tonnes valued at $18.5 million. Oyster production is distinctly divided between two Canadian regions: in 2006, 60% of the volume of Canada's oysters were produced in British Columbia; the remainder were produced in Atlantic Canada.

- **Clams**

British Columbia is Canada's largest producer of farmed clams – in 2006, it produced 1,600 tonnes of farmed clams valued at $8.3 million.

- **Scallops**

Canadian production of farmed scallops occurs in British Columbia, Nova Scotia, New Brunswick and Quebec. In 2006, Canada produced 58 tonnes of scallops with a value of $0.5 million. British Columbia accounted for 76% of this volume.

Table 4.1 summarizes the major aquaculture species produced in Atlantic Canada.

Table 4.1

Major Aquaculture Species – Atlantic Canada

	AQUACULTURE SPECIES		
	Finfish	**Shellfish**	Output $ (2009)
New Brunswick	Atlantic Salmon Rainbow Trout Steelhead Trout Cod Halibut	Eastern Oysters Blue Mussels	$164 million
Nova Scotia	Atlantic Salmon Arctic Char Halibut Steelhead Trout Rainbow Trout Tilapia	Eastern Oysters Blue Mussels Clams Quahogs Abalone	$57 million
Newfoundland and Labrador	Atlantic Salmon Steelhead Trout Cod	Mussels Clams	$92 million
Prince Edward Island	Salmon Processing Rainbow Trout Arctic Char	Blue Mussels Eastern Oysters	$31 million

Like most of Canada, NS aquaculture is dominated by salmon production, which is primarily undertaken using ocean cages. However, there are also numerous land-based aquaculture operations raising such species as arctic char, halibut, rainbow trout and tilapia. The land based operations usually require some heating of the water to ensure the survival and growth of the fish. While the heating requirements vary by species and operation, energy for heating the water is considered a significant production cost, particularly for warm water species such as tilapia.

4.5.2 *Aquaculture Feasibility Considerations*

Any potential aquaculture operation looking at using the waste heat available from Northern Pulp will need to examine a number of key considerations.

- **Waste Heat Availability and Cost**

Potential users of the waste heat will need to know the quantity, quality, availability and cost of the waste heat. On the plus side, 16,000 m^3 of 40^o to 50^o C water would clearly meet the heating requirements of several land-based aquaculture operations. Any potential user of the waste heat will need to know the availability, reliability and cost of the waste heat. An aquaculture operation would also require some form of backup heating system to protect their valuable products. This would be an additional cost.

- **Water Supply**

Water Supply is likely the most critical factor in determining the technical feasibility of an aquaculture operation. Water supply includes quality, quantity, and temperature. Some species require fresh water and others salt water. Fresh water supplies could be groundwater or surface water. Most aquaculture species are very sensitive to water quality and thus water quality has played a significant role in either the success or failure of many operations.

- **Land**

Aquaculture operations, either land-based or marine-based require suitable locations where they can be operated safely, securely and efficiently. In the case of a potential Northern Pulp waste heat operation it would need to be located adjacent to the mill to take advantage of the low-cost waste heat. The available land in the vicinity of the mill will need to be examined to determine its suitability.

- **Technology**

Aquaculture technology continues to evolve to address production challenges. The design of the production facilities and selection of the appropriate technology must match the unique circumstances of each operation.

- **Production and Management Expertise**

Aquaculture operations require a great amount of expertise and experience to address the ongoing production and management challenges. Successful track records in terms of operations and management will be a critical success factor for any operation.

- **Financing, Marketing, Human Resources Etc.**

Like any business operations, the execution of a sound business plan will be critical. Ignoring one factor, such as human resource requirements, can lead to serious problems and business failure.

4.5.3 Existing and Proposed Waste Heat Aquaculture Projects

There are a number of existing and planned aquaculture operations utilizing waste heat from industrial operations or from geothermal resources. The following examples illustrate the potential for a similar operation using the available waste heat from Northern Pulp wastewater.

- **Nofima Recycle Waste Heat Aquaculture Centre (Norway)**

This project entails the use of waste heat for a aquaculture research centre in Sunndalsøra, Norway. The waste heat comes from an aluminum plant. The research centre is focused on re-circulating aquaculture systems for Norwegian land-based aquaculture. Power company Sunndal Energi has laid a 750 m pipeline to connect the waste heat to the centre. The waste heat is used to heat the water in the tanks, the air used in the recirculation process and to heat the buildings. The water has a temperature of 90^{o}C when it reaches the centre, and it goes through two stages of heat exchange so that an optimal temperature of 12 ^{o}C is obtained before it reaches the fish.

- **MinAqua Fisheries – Minnesota (US)**

MinAqua Fisheries has an indoor aquaculture facility that annually produces approximately $1.5 million worth of tilapia. The water and building are heated by waste heat from a nearby sugar beet processing operation.

- **Shrimp Aquaculture with Waste Heat (Rotterdam, Holland)**

This project is located next to the Eon power plant in an industrial park at Rotterdam's port, known as the Maasvlakte. A 2.5-kilometre pipeline was constructed to the power plant to recover waste heat. The operation is located in a hangar, where sunlight filters through a white roof covering. The operation includes 24 tanks filled with sea water for the Pacific white shrimp, a popular species choice for shrimp farming that has had success elsewhere, notably Ecuador.

The sea water, warmed by a waste heat from the energy plant, is kept at 29 ^{o}C, the ideal temperature for this species of shrimp.

- **ADM Hydroponics and Aquaculture - Decateur, Illinois (US)**

The following section on greenhouse opportunities describe an integrated operation in Illinois, involving the use of waste heat for both greenhouse and aquaculture operations.

- **Other Examples**

Worldwide, there are numerous aquaculture operations producing a wide range of aquaculture products using the steady waste heat from electrical power generation. Often these are warm water species being produced in cold climates. Tilapia is a common aquaculture species requiring warm water. Seabait Ltd, in England, is using waste heat to grow worms that are used for many things beyond fish bait. A salmon aquaculture operation used waste heat from the Lingan thermal electric generation facility in Cape Breton. A land based aquaculture based aquaculture and greenhouse operation was established in Minto, NB to use waste heat from a thermo electric generation facility.[16]

4.5.4 *Northern Pulp Waste Heat Aquaculture Opportunities*

The Northern Pulp waste heat would be potentially very attractive to the aquaculture industry, if it could be demonstrated that it would substantially reduce the heating costs compared to other heating options such as oil, natural gas or biomass. There appears to be available land adjacent to the Northern Pulp operations as well as access to both freshwater and sea water.

Among the potential aquacultural operations would be hatchery operations to supply salmon and other finfish operations. Numerous attempts have been made to establish land-based finfish production operations for salmon, halibut and other species. There have been a number of successes in Nova Scotia and elsewhere, including operations that tap into industrial waste heat and geothermal resources.

Tropical species such as tilapia would also be potential applications. There are numerous land-based tilapia aquaculture operations both in warm locations such as Asia and in colder regions in North America. Tilapia is a relatively easy species to raise, has an established market in North America, and requires significant energy input to maintain warm water conditions.

As mentioned previously, there are numerous factors beyond access to low cost heating source which will determine the economic feasibility of an aquaculture operation. In addition, aquaculture has proven to be a very challenging industry in Canada and elsewhere. The initial excitement of the early years has disappeared. Numerous aquaculture companies have been created and disappeared due to a long list of challenges (changing markets, production issues, emergence of new competitors, management). However, there are also numerous successes, demonstrating the potential for new operations and new species. While preliminary discussions have been held with aquaculture officials and industry experts, the next step should be to approach the Provincial government and existing aquaculture companies with a package of information on the availability of the waste heat, land, and water resources to determine the level of interest and development requirements.

4.6 Greenhouse and Other Agriculture Applications

Greenhouses are used for the production of various plants, flowers, seedlings and other agriculture products. Greenhouses allow production to take place year-round in locations such as Nova Scotia. Flowers, seedlings and bedding plants are likely the most common products produced by greenhouses in Canada; however, vegetables such as tomatoes and lettuce are becoming more common in Canada. Greenhouse operations in climates such as Nova Scotia's require significant heating to achieve adequate plant/crop growth. Heating cost are one of the most significant costs of production and is a major focus

[16] It should be noted that both the Lingan and Minto aquaculture operations are now closed due to production and financial reasons.

in terms of minimizing energy requirements and developing the most efficient heat sources. There are numerous examples of greenhouse operations (in other parts of Canada and elsewhere) taking advantage of heat sources such as waste heat from industrial and electrical power generation facilities. Whole greenhouse industries have grown up around industrial and geothermal heat sources.

The Northern Pulp waste heat represents a potential opportunity for existing and new greenhouse operations to reduce their very significant energy costs.

4.6.1 *The NS Greenhouse Industry*

The NS greenhouse industry consists of approximately 130 growers who together have in excess of 3 million ft^3 of production space under glass or plastic. The industry generates approximately $36 million in annual sales. The sector employs over 1250 people, contributing in excess of $9 million to the economy through annual payroll. [17]

Greenhouse operations are spread throughout Nova Scotia producing a variety of plant materials and food items. The list includes:

- Annuals and Perennials for gardens and landscaping
- Cut Flowers and potted plants
- Herbs and Vegetables - tomatoes, cucumbers, peppers etc.
- Trees - Christmas tree seedlings, fruit, ornamental

The Pictou-area greenhouse operations include Sunrise Gardens located just outside Pictou as well as Duykers Greenhouses in Antigonish.

4.6.2 *Greenhouse Operations Feasibility Considerations*

Any potential aquaculture operation looking at using the waste heat available from Northern Pulp will need to examine a number of key considerations.

- **Waste Heat Availability and Cost**

Potential users of the waste heat will need to know the quantity, quality, availability and cost of the waste heat. On the plus side, 16,000 m^3 of 40^o to 50^o C water would clearly meet the heating requirements of several major greenhouse operations. Any potential user of the waste heat will need to know the availability, reliability and cost of the waste heat. A greenhouse operation would also require some form of backup heating system to protect their valuable products. This would be an additional cost.

Depending on the product and market focus of the greenhouse operation, the heat requirements could be considerably different. As discussed elsewhere, most greenhouse operations in Nova Scotia are

[17] Source Greenhouse Nova Scotia www.greenhousenovascotia.com

seasonal operations, requiring heat during the late winter and spring period. These types of operations would not be as suitable as an operation that had a more consistent heat requirement throughout the year, or at least throughout the heating season (fall, winter, spring).

- **Water Supply**

Greenhouses require a reliable water supply. However the requirements would not be as large or as critical as the aquaculture industry. With the significant freshwater availability in the area, water supply is not anticipated to be a concern for greenhouse operations.

- **Land**

Greenhouse operations require significant space for the greenhouses, supporting operations and potentially for retail operations. In the case of the Northern Pulp waste heat operation, the greenhouses would need to be located adjacent to the mill to take advantage of the low cost waste heat. The available land and transportation access in the vicinity of the mill will need to be examined to determine its suitability.

- **Financing, Marketing, Human Resources Etc.**

Like any business operations, the execution of a sound business plan will be critical. Ignoring one factor, such as human resource requirements, can lead to serious problems and business failure.

4.6.3 Waste heat Use by Greenhouse Operations

There are numerous examples around the world of greenhouse operations using waste heat from industrial and electric power generation operations. Following are examples of a number of successful applications.

- **Greenhouse Operation Thermal Electric Facility Waste Heat (Italy)**

ENEL (the National Board of Electricity, in Italy) established a program to research the use of thermoelectric power plant cooling waters for aquaculture and agriculture. As a part of this program, in South Italy, some technological (greenhouse heating through buried pipes and water-to-air heat exchangers) and agronomical aspects (growing of different ornamental pot plants) related to the use of low enthalpy waters (20^{o} to 26^{o}C), were developed.

- **Burlington, Vermont Food Works Agricultural Eco-Park (US)**

The Agricultural Eco-Park in Burlington's Intervale project is using waste heat from a local wood-fired power plant to fuel a series of year-round greenhouses where byproducts from local food manufacturers and farms are converted to fish, shrimp, mushrooms, salad greens, and composts.

- **Quebec Agrothermal Projects (Canada)**

There has been considerable research and development work in Quebec related to the use of waste heat for greenhouses and aquaculture. There is a major proposal for a 10 hectare greenhouse operation to grow tomatoes, peppers, lettuce and other vegetables. This proposed project would be in Salaberry de Valleyfield. The original feasibility study was completed in 2004. While the study was quite positive, the Community has not been able to proceed to implementation. Other waste heat proposals have been developed for Saguenay Lac St-Jean, and Témiscamingue.

- **New Richmond Waste Heat Tomato Greenhouse Operation (Gaspe, Canada)**

A more modest waste heat/greenhouse project was developed in New Richmond (Gaspe Region). This 12,000 m^2 greenhouse produces tomatoes and other products for the local, Quebec and other Eastern Canada markets. The greenhouse was originally heated by waste heat from a Smurfit Stone Paper Mill. The Paper Mill has since closed and the heat is now provided by a biomass heating facility. The available waste heat was an impetus to develop the greenhouse. A solid business strategy and plan has allowed the greenhouse to remain in business despite the loss of the waste heat supply.

- **ADM Hydroponics and Aquaculture Decateur, Illinois (US)**

ADM is a large multinational agribusiness company headquartered in the US. It has a major production facility in Illinois, including a number of hydroponic greenhouse operations. It is using waste heat from one part of its operation to heat the hydroponic nutrient as well as the greenhouses. Waste heat is also used for an adjacent aquaculture operation that produces tilapia. Byproducts from processing operations also provide nutrients for the fish.

*4.6.4 **Northern Pulp Waste Heat Agriculture Opportunities***

The application of waste heat to greenhouse operations is well established in many jurisdictions. The potential of a large volume of low grade waste heat from the Northern Pulp operation would be extremely attractive to a new greenhouse operation, provided the other critical business requirements can be met. Other requirements would include land, water, markets, labour, financing and operational/management expertise.

While heating costs are a very significant cost factor for greenhouses in Nova Scotia, there are many other factors that will determine if an operation would take advantage of the Northern Pulp waste heat. First on the list will be the actual cost of the waste heat in relation to existing heat sources such as oil or biomass.

Many greenhouses operate seasonally, in that their major markets are to serve the local and regional gardening and landscaping markets. These seasonal greenhouses start up operations in the late winter to be able to meet the spring and summer market requirements. This reduces the annual heat requirements. A greenhouse operation based on the use of Northern Pulp waste heat would likely need to be a year round operation to justify the investment in a waste heat recovery system.

Canada is seeing an expansion of year-round greenhouse operations producing vegetables for the local markets. The New Richmond operation is a good example. There are also other examples in Atlantic Canada. These types of operations would benefit more from the available waste heat.

Nova Scotia has a relatively modest greenhouse industry with not a lot of new operations occurring each year. The modest growth combined with the cost for an existing operation to relocate to the Northern Pulp site would mean there would likely be very few businesses that would seriously consider this opportunity.

On the plus side, there would be support from all levels of government to investigate and potentially implement such an operation. For example the Nova Scotia Government has funding programs for agriculture energy conservation and renewable technologies. These programs are available for the identification, assessment and implementation of energy conservation and renewable technologies. Furthermore, the Nova Scotia Department of Agriculture has an Energy Specialist to advise on the options and programs (Julie Bailey (902) 896-4473). The federal government has similar programs that generally mesh with the Provincial programs.

The next steps should be to enter into discussions with agriculture officials and the greenhouse industry to review the waste heat opportunities and receive feedback on how best to take advantage of this potential energy resource.

4.7 Summary of Waste Heat Utilization Options

The review of options for use of the available waste heat has identified a number of options that warrant further research and analysis. The nearly 16,000 m^3/d of 43ºC wastewater represents a very significant energy source that could potentially be used by both Northern Pulp and other new operations. All of the opportunities have focussed on the non-contact use of the effluent; the use of the treated effluent in a direct-contact manner is deemed not feasible. In most cases, the quality of the water is not of a major concern; the water should be “clean” enough to be utilized in a heat exchanger with minimal fouling.

The opportunities examined included :

- District heating;
- Lumber drying;
- Power generation;
- Aquaculture; and,
- Agriculture.

As well, the mill could investigate the feasibility of reclaiming the heat to pre-heat the raw water for the appropriate processes requiring “hot” water. Regardless of the end use, the wastewater treatment process would benefit if the heat was removed prior to the wastewater being introduced into the secondary treatment system.

The district heating option, in and of itself at the high level of review conducted for this report, would not be considered feasible since the existing building density/building types in the vicinity of the mill are not conducive to that type of an operation. However, the concept of marketing the available waste heat as a regional asset to businesses and other forms of development could be considered.

Using the waste heat for lumber drying, only, particularly with the current state of the lumber industry, may be a difficult opportunity to promote.

Aquaculture and agriculture (greenhouse operations) are two examples of the types of industries that should be part of any attempt to develop markets for the waste heat. Lower cost heat sources are always of interest to these industries, particularly in a colder climate like Nova Scotia. The key to pursuing these opportunities will be to determine the delivered cost of the heat to these potential operations, along with the other required basic business inputs (land, water, transportation, markets etc.)

Electric Power Generation – There is limited demonstrated success of generating electricity from low grade heat sources such as is available. However, there is enough promising new developments to continue to investigate the potential. There is a well established and stable market for the electricity which will be key for any potential user of the waste heat. Locating a power generation system at the mill would provide access to their grid infrastructure. The generation of “green” power also conforms to the Nova Scotia provincial government’s policy to increase the percentage of power being generated from renewable resources.

5.0 Opinion of Probable Costs

5.1 Tertiary Effluent Treatment

The capital costs for the various process options of tertiary treatment have been calculated based on a variety of resources. All probable costs are preliminary and originate from vendors budgetary quotes, published R&D papers and ADI in-house experience. The capital costs, as well as operating costs, have all been calculated based on large equipment prices and considering industry standard construction rates. The installation of specialized equipment is anticipated to be challenging so it is included as a cost that is equal to that of the equipment costs. Any sludge handling equipment is not included in the probable costs as the secondary treatment will be required to do this operation and it is anticipated that it would be sized to accommodate the sludge handling requirements of the tertiary treatment system. It should be noted that this may impact the sizing of the secondary treatment sludge handling equipment and configuration. Additionally, all probable costs include a contingency for the purpose of covering currently unknown costs that will be realized when the piloting stage and detail design is undertaken.

The operational costs have been calculated based on estimated power costs, chemical consumption estimates and cross referenced to other installations. Not included is any additional labour costs as it is assumed that minimal operation time will be required and will be done by existing WWTP personnel.

The following tables provide the breakdown of the costs for the three tertiary treatment systems that are deemed the most appropriate for this project.

Table 5-1 Engineered Wetlands

ITEM NO	Definition	Units	Quantity	Unit Price	Total
1	Clearing & Grubbing	ha	6.1	$ 20,000	$ 122,000
2	Berms	m	1750	$ 200	$ 350,000
3	Excavation	m^3	75000	$ 15	$ 1,125,000
4	Liner	m^2	61000	$ 10	$ 610,000
5	Distribution Header	m	550	$ 500	$ 275,000
6	Collection System	m	500	$ 500	$ 250,000
7	Wetland Media	m^3	91500	$ 25	$ 2,287,500
8	Wetland Vegetation	m^2	61000	$ 5	$ 305,000
	Other				
9	Indirect Costs @ 15%				$ 780,375
10	Engineering @ 15%				$ 780,375
11	Contingency @ 20%				$ 1,040,500
	Total Opinion of Probable Cost				**$ 7,804,000**

Table 5-2 Chemical Precipitation/Clarifier

ITEM NO	Definition	Units	Quantity	Unit Price	Total
1	Capital Equipment				
	Clarifier	ls	1	$ 1,500,000	$ 1,500,000
	Floculator	ea	3	$ 100,000	$ 300,000
	Chemical Addtion	ea	3	$ 40,000	$ 120,000
	Process Piping	ls	3	$ 150,000	$ 450,000
2	Equipment Installation, % of Equip.	%	100%		$ 2,370,000
3	Building	m^2	500	$ 3,000	$ 1,500,000
	Other				
4	Indirect Costs @ 15%				$ 936,000
5	Engineering @ 17%				$ 1,060,800
6	Contingency @ 20%				$ 1,647,360
	Total Opinion of Probable Cost				**$ 8,236,800**

Table 5-3 Ozonation

ITEM NO	Definition	Units	Quantity	Unit Price	Total
1	Capital Equipment				
	Ozone Generator	ea	3	$ 1,660,000	$ 4,980,000
	Oxygen Skid	ea	1	$ 300,000	$ 300,000
	Contact Chamber	ea	3	$ 100,000	$ 300,000
	Biofilter	ea	3	$ 250,000	$ 750,000
2	Equipment Installation, % of Equipment	%	50%		$ 3,165,000
3	Building	m^2	500	$ 3,000	$ 1,500,000
	Other				
4	Indirect Costs @ 15%				$ 1,649,250
5	Engineering @ 17%				$ 1,869,150
6	Contingency @ 20%				$ 2,902,680
	Total Opinion of Probable Cost				**$ 17,416,080**

Annual operating costs for the various tertiary treatment options are presented in Table 5-4.

Table 5-4 Annual Probable Operations and Maintenance Costs

Tertiary Treatment Process	Estimated Annual Operating Cost **
Ozonation	$ 2,363,000
Clarification	$ 2,063,000
Engineered Wetland	$ 500,000

**based on 350 days/year, $0.1 per kWh electricity

5.2 Outfall Extension to Northumberland Strait or Pictou Harbour

Probable costs have been developed for the two outfall options: to the inner harbour of Pictou Harbour and to the MacKenzie Head area in the Northumberland Strait. These costs provide order-of-magnitude values which should be refined once a decision has been made to proceed with the project, an environmental assessment has been completed and preliminary design work has been done.

Some assumptions which were made during the formation of this opinion of probable cost are as follows:

1. Locations where gravel roads currently exist, it was assumed that the pipe can be installed within the road itself, without causing traffic disruptions;
2. Pipe being installed within wooded areas, a swath width of 15m was deemed sufficient and that this area will serve as the permanent access road once work has been completed. As such, it was assumed that the permanent access road will be completed with access points (manholes for inspection, vacuum and air relief, etc.);
3. The underwater routes were assumed to be buried in armour rock. The volume of rock could vary depending on amount of protection required;
4. Additional costs would include survey, contractor's overhead and profit, mobilization and demobilization;
5. The engineering costs would include design and field services; and,
6. There has been no accounting for the possible costs of land acquisition or easements.

The following tables provide the breakdown of the costs for the two discharge location options. In the event that the discharge point has to be moved further out into the harbour or ocean from the point(s) shown in Figure 2-7, the additional underwater piping cost will be in the order of $300,000/100m.

Table 5-5 Outfall into Pictou Harbour

ITEM NO	Definition	Units	Quantity	Unit Price	Total
	Pipe Work				
1	Clearing & Grubbing	ha	0.23	$ 20,000	$ 5,000
2	900 mm HDPE DR 17	kg	248754	$ 2.45	$ 610,000
3	Pipe Delivery	ea	28	$ 4,000	$ 112,000
4	Pipe Fusion	m	1700	$ 15.5	$ 27,000
5	Land Installation	m	600	$ 750	$ 450,000
6	Marine Installation	m	1100	$ 2,250	$ 2,475,000
7	Diffuser	ls	1	$ 500,000	$ 500,000
8	Armour Rock	m^3	1100	$ 250	$ 275,000
9	Rock to be Excavated	m^3	2550	$ 80	$ 204,000
10	Manhole (Inspection, Vacuum, Air Relief)	ea	1	$ 5,000	$ 5,000
	Road Work				
11	Access Road	m^3	563	$ 35	$ 20,000
	Restoration				
12	Topsoil and Hydroseed	m^2	1150	$ 6	$ 7,000
	Other				
13	Indirect Costs @ 15%				$ 703,500
14	Engineering @ 17%				$ 797,300
15	Contingency @ 20%				$ 938,000
	Total Opinion of Probable Cost				**$ 7,128,800**

Table 5-6 Outfall into Northumberland Strait (MacKenzie Head)

ITEM NO	Definition	Units	Quantity	Unit Price	Total
	Pipe Work				
1	Clearing & Grubbing	ha	8.36	$ 20,000	$ 168,000
2	900 mm HDPE DR 17	kg	1331566	$ 2.45	$ 3,263,000
3	Pipe Delivery (truckload, 4 pipe/truck)	ea	150	$ 4,000	$ 600,000
4	Pipe Fusion	m	9100	$ 16	$ 142,000
5	Land Installation	m	8200	$ 750	$ 6,150,000
6	Marine Installation	m	900	$ 2,250	$ 2,025,000
7	Diffuser	ea	1	$ 500,000	$ 500,000
8	Armour Rock	m^3	900	$ 250	$ 225,000
9	Rock to be Excavated	m^3	13650	$ 80	$ 1,092,000
10	Manhole (Inspection, Vacuum, Air Relief)	ea	5	$ 5,000	$ 25,000
	Road Work				
11	Access Road	m^3	23415	$ 35	$ 820,000
12	Asphalt (x0.13)	tonne	72	$ 110	$ 8,000
13	150 mm Granular Base	m^3	1969	$ 35	$ 69,000
14	450 mm Granular Sub-base	m^3	5906	$ 35	$ 207,000
	Restoration				
15	Topsoil and Hydroseed	m^2	55750	$ 6	$ 335,000
	Other				
16	Indirect Costs @ 15%				$ 2,344,350
17	Engineering @ 17%				$ 2,656,930
18	Contingency @ 20%				$ 3,125,800
	Total Opinion of Probable Cost				**$ 23,756,080**

6.0 Conclusions/Recommendations

6.1 Conclusions

The current use of Boat Harbour as a component of the wastewater treatment system for the Northern Pulp mill at Ambercrombie is being re-evaluated with a commitment being made by the Provincial Government to return Boat Harbour to its natural state. Previous studies have examined the changes required to the wastewater treatment system to remove the existing system form Boat Harbour as well as options for alternative outfall locations. This study further examined the additional treatment required to improve upon the quality of the final effluent to allow discharging into Pictou Harbour. This study also examined an alternative outfall location if tertiary treatment is not implemented.

From a regulatory perspective, there are no regulations preventing the effluent from being discharged into Pictou Harbour. In its current state, it is anticipated that the poor aesthetic quality could lead to a degradation of the visual quality of the Harbour and would require an improvement of the effluent qualities to have the discharge to the Harbour be acceptable from a public perspective. It is believed that, from a technical perspective, the addition of a tertiary treatment process would improve the effluent quality sufficiently to allow the effluent to be discharged into the Harbour.

Several tertiary treatment system options have been presented that could improve upon the secondary treatment (the option if tertiary treatment is not applied is to relocate the outfall to the Northumberland Strait a sufficient distance from Pictou Harbour such that tidal action does not pull the effluent into the Harbour on an incoming tide). The three tertiary treatment options that show promise are:

1. Engineered wetlands;
2. Chemical precipitation followed by clarification; and,
3. Ozonation.

Costs for the tertiary treatment ranged from $ 7.8M to $ 17.4M. Costs for the two outfall options (Pictou Harbour and Northumberland Strait (MacKenzie Head area)) range from $ 7.13M to $ 23.76M. However, it must be noted that the Pictou Harbour outfall cost ($ 7.13M) must be combined with a tertiary treatment cost (minimum of $ 7.8M) to realize the full cost of the discharge option to Pictou Harbour. Where there is no need for tertiary treatment to extend the outfall to the Northumberland Strait, this option will, in all likelihood, have the lowest operational and maintenance cost.

There are market opportunities that could benefit from the availability of heat that could be recovered from the wastewater effluent. The opportunities exist within the mill (pre-heat the incoming fresh water), in the aquacultural and agricultural industries, as well as potential “green” power generation. As well, it may be possible to combine opportunities (e.g., power generation plus raw water pre-heating for the mill).

6.2 Recommendations

The Northern Pulp mill has plans to implement in-mill process changes this year (2011) (using funding obtained from the federal Green Transformation Program) that may impact mill effluent quality. This impact is expected to be in both quantity (less wastewater produced) and quality (a reduction in the organic and solids loading requiring wastewater treatment as well as a possible colour reduction). It is, therefore, recommended that any decisions on effluent treatment options be delayed until after these changes are implemented. Further, it is recommended that at least three (3) months of effluent monitoring data be collected after the changes are implemented with this data being used in conjunction with the tertiary treatment option review.

If the decision is made to proceed with tertiary treatment to allow the outfall to be potentially relocated to Pictou Harbour, it will be necessary to pilot test the technologies so to gather additional data for design and costing purposes. Through the pilot-testing process, additional information will be collected regarding the improvement on the effluent quality as well as operational requirements. Pilot testing for the precipitation/clarification option would take six to eight weeks; the ozonation option may require four to six moths (due to the biological nature of the filter for the follow-up BOD removal); and the wetlands option should be pilot tested a minimum of one (1) year due to the biological nature of the process.

Additional preliminary design work will be required to determine the appropriate site for the new outfall. The best approach may be to continue to investigate both sites so that better pricing can be established. As well, the other factors that will determine the final location (social, political, regulatory, etc.) can be examined.

While several potential market opportunities for using the waste heat have identified, additional studies will be required to determine their feasibility. One promising opportunity is power generation; however, the quantity of heat available may change with the completion of the current modifications within the mill. While further preliminary studies can be undertaken to provide additional details, it is recommended that the results of the in-mill changes be reviewed so to provide better definition of the available waste heat. This study also only focussed on a portion of the effluent as a source of the heat available for such a project. In fact, the whole wastewater stream can be utilized for this type of non-contact application.

Identify an appropriate organization (e.g. Pictou Regional Development Agency) that would take the lead in identifying potential businesses that would locate in the proposed business/industrial park and take advantage of the available waste heat. Initial focus should include the aquaculture, agriculture and power generation sectors. However, there are many other businesses and institutions that would be attracted by access to a lower cost energy source. Then, develop a conceptual plan and preliminary cost estimate to develop serviced business/industrial lots in the park adjacent to Northern Pulp. These lots would include municipal services including access to the available waste heat from Northern Pulp.