Appendix J2

What is Environmental Effects Monitoring

Environmental effects monitoring

The implementation of Pulp and Paper Effluent Regulations (PPER) under the Fisheries Act occurred in 1992, and directs pulp and paper mills to conduct environmental effects monitoring (EEM) as a condition governing the authority to deposit effluent into receiving waters. EEM is a science-based performance measurement tool used to evaluate the adequacy of effluent regulation in protecting fish, fish habitats and the usability of fisheries resources in receiving waters.

EEM studies can include:

- water quality monitoring
- effluent chemical characterization
- effluent sublethal toxicity testing
- biological monitoring in the receiving environment

Water Quality Monitoring - Water samples are collected at representative sample areas to get a detailed understanding of the variability and determination of the concentrations of the contaminants within the sampling area. Data is collected over a representative period of time. Written protocols and standard operating procedures (including quality assurance / quality control [QA/QC] requirements) are required for all data collection and testing.

Effluent Chemical Characterization - Chemical characterization is the use of analytical techniques and methods to identify, isolate and/or quantify chemicals or other contaminants in the water, soil or effluent and to characterize their physical properties.

Sublethal Toxicity Testing - Sublethal toxicity testing is conducted on effluent from the outfall structure that has potentially the most adverse environmental impact. This testing monitors effluent quality by measuring survival, growth and/or reproduction endpoints in marine or freshwater plant and invertebrate organisms in a controlled laboratory environment.

Biological Monitoring Studies - Biological monitoring studies are conducted in three or six-year cycles. The requirements for each study are dependent on the results of the previous cycle's results. Biological monitoring studies to assess effects are described in section 1.3.2.2 and 1.3.2.3. of the PPER and include a study respecting the fish population to assess effects on fish health, a study respecting the benthic invertebrate community to assess fish habitat or fish food; and a study respecting fish tissue dioxins and furans to assess the human usability of the fisheries resources. To investigate effects, biological monitoring studies are conducted for the purpose of describing the magnitude and geographic extent of effects, determining the causes of effects and identifying possible solutions to eliminate effects.

Environmental Effects Monitoring (EEM) studies are conducted to identify potential effects caused by effluents on fish, fish habitat and use by humans of fish.

The recommended methodologies used are based on generally accepted standards of good scientific practice and incorporate improvements based on program experience, input from multi-stakeholder working groups, consultations and external research initiatives responding to EEM needs.

It should be emphasized that the methodologies are considered the most applicable generic designs available. EEM studies are designed to detect and measure changes in aquatic ecosystems (i.e., receiving environments). The pulp and paper EEM program is an iterative system of monitoring and interpretation phases that is used to help assess the effectiveness of environmental management measures, by evaluating the effects of effluent~~s~~ on fish, fish habitat and the use of fisheries resources by humans. EEM goes beyond end-of-pipe measurement of chemicals in effluent to examine the effectiveness of environmental protection measures directly in aquatic ecosystems. Long-term effects are assessed using regular cyclical monitoring and interpretation phases designed to assess and investigate the impacts on the same parameters and locations. In this way, both a spatial characterization of potential effects and a record through time to assess changes in receiving environments are obtained. EEM studies consist of: sublethal toxicity testing of effluent to monitor effluent quality (PPER section [s.] 29); and biological monitoring studies in the aquatic receiving environment to determine if mill effluent is having an effect on fish, fish habitat or the use of fisheries resources.

The first pulp and paper EEM cycle, completed in April 1996, was intended to establish a baseline against which data from future cycles could be compared, and to provide a preliminary assessment of whether effects, if any, are evident in the receiving environment. EEM cycles occur every 3-4 years, with NPNS presently conducting Cycle 8.

Defining and Confirming Effects

The studies for the fish population and benthic invertebrate community components are conducted in both exposure and reference areas. The exposure area means all fish habitat and waters frequented by fish that are exposed to effluent, and the reference area means water frequented by fish that are not exposed to effluent and that has fish habitat that, as far as is practical, is the most similar to that of the exposure area. Generally, an effect on the fish population or benthic invertebrate community means that there is a statistical difference between data collected in an exposure area and in a reference area for a study on the fish population or benthic invertebrate community; or that there is a statistical difference between data collected from sampling areas within an exposure area where there are gradually decreasing effluent concentrations. In order to confirm that observed effects are not artifacts and are mill-related, biological monitoring studies to assess effects are repeated in subsequent three-year cycles. If the same effect on the fish population, benthic invertebrate community or fish tissue occurs in studies from consecutive cycles, the effect is considered confirmed.

Steps in Conducting and Reporting Environmental Effects Monitoring Studies

Conducting EEM studies, involves the following key steps: 1. Submit sublethal toxicity testing results to Environment Canada 2. Submit study design to Environment Canada 3. Conduct biological monitoring study to Environment Canada 4. Conduct data assessment to Environment Canada 5. Submit interpretive report to Environment Canada.

Review and acceptance of the Interpretive Report

Environment Canada uses a panel approach. A panel is made up of academics from government, university and private sector subject matter experts who conduct a peer review of the reports and its contents. Following the review the panel comments and/or makes recommendations, including requests addition information and requests for addition information. The report is not accepted by EC until the Panel is satisfied that the report meets the requirements of the EEM. New requirements maybe recommended for next cycles.

Appendix K

Air Quality Modeling Report

Appendix K1 – Stantec Air Dispersion Modeling Study of Replacement Effluent Treatment Facility
Appendix K2 – Stantec Memo re Hoffman Report

Appendix K1

Stantec Air Dispersion Study of Replacement Effluent Treatment Facility

Air Dispersion Modelling Study – Replacement Effluent Treatment Facility

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January 21, 2019

Executive Summary

Northern Pulp Nova Scotia Corporation (Northern Pulp) currently operates a kraft pulp mill (the Facility) located at Abercrombie Point, Pictou County, Nova Scotia (approximately 3 kilometers from the town of Pictou and 9 km from New Glasgow). The mill has been in operation since September 1967 and currently produces 280,000 to 300,000 air dried metric tonnes (ADMT) of bleached kraft pulp per year. The effluent waste from the Facility is treated in an existing effluent treatment facility (ETF) located approximately 4 km east of the mill site and consists of a series of sedimentation, aeration, and stabilization basins. The existing ETF is owned by the Government of Nova Scotia and operated by Northern Pulp. This treatment system, however, must be closed by 2020 in accordance with the *Boat Harbour Act*. The design of a replacement effluent treatment facility (ETF) is currently underway and will consist of an activated sludge treatment system, including a primary clarifier, an aeration basin and two secondary clarifiers. The replacement ETF will be located within the site boundaries of the mill. The locations of the existing and replacement ETFs are displayed in Figure 1.1.

Stantec Consulting Ltd. (Stantec) was retained by Northern Pulp to conduct an Air Dispersion Modelling Study to support the Environmental Assessment currently being conducted for the replacement ETF. The objective of the study is to assess the potential effects of the existing and future operation of the Facility on air quality in the region around the pulp mill.

The air contaminants considered in this air dispersion modelling study include those regulated by the Government of Nova Scotia under the *Air Quality Regulations*, as amended on October 12, 2017, as well as fine particulate matter ($PM_{2.5}$), as it is regulated under Northern Pulp's Industrial Approval (2011-076657-A01). The air contaminants in the assessment therefore include:

- Carbon monoxide (CO)
- Hydrogen sulphide (H_2S)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Total suspended particulate matter (TSP)
- Fine particulate matter ($PM_{2.5}$)

Air quality in Nova Scotia is regulated under the Environment Act. The Regulations specify concentrations for the criteria air contaminants including nitrogen dioxide (NO_2), total suspended particulate matter (TSP), carbon monoxide (CO), sulphur dioxide (SO_2), ozone (O_3) and hydrogen sulphide (H_2S). The regulations also address other issues such as the provincial cap on the emission of SO_2. The Nova Scotia *Air Quality Regulations* under Schedule A are presented in Table 3.1.

Currently, there are no provincial ambient air quality standards for fine particulate matter (i.e. particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)). However, ambient air quality standards for $PM_{2.5}$ are included in Northern Pulp's Industrial Approval (2011-076657-A01, Table 1 Section 9 c). These criteria are consistent with the Canadian Ambient Air Quality Standard for $PM_{2.5}$. For the 24-hour time averaging period the criterion is 28 μg/m^3 (changing to 27 μg/m^3 in 2020) and for the annual time averaging period it is 10 μg/m^3 (changing to 8.8 μg/m^3 in 2020). The 24-hour standard is based on a 3-year average of the 98th percentile of the daily 24-hour average concentrations and the annual standard is based on a 3-year average of the annual average concentrations.

Table E.1 Nova Scotia Air Quality Regulations, Schedule "A"

Air Contaminant	Averaging Period	Nova Scotia Maximum Permissible Ground Level Concentration Limits μg/m^3	pphm
Carbon monoxide (CO)	1-hour	34 600	3000
	8-hours	12 700	1100
Hydrogen sulphide (H_2S)	1-hour	42	3
	24-hours	8	0.6
Nitrogen dioxide (NO_2)	1-hour	400	21
	Annual	100	5
Sulphur dioxide (SO_2)	1-hour	900	34
	24-hours	300	11
	Annual	60	2
Total suspended particulate (TSP)	24-hours	120	-
	Annual	70[1]	-

[1] geometric mean
μg/m^3 - micrograms per cubic metre
pphm - parts per hundred million

In order to determine if the existing (i.e. existing mill and effluent treatment facility (ETF)) and future operation (existing mill and replacement effluent treatment facility (ETF)) of the kraft pulp mill will be in compliance with provincial and federal air quality criteria, an air dispersion modelling study was conducted.

An air dispersion modelling study is one which relies on regulatory approved atmospheric dispersion models to predict off-property receptor concentrations of those air contaminants released from the operation of a facility and compare such concentrations to regulatory criteria to determine if the facility is operating in compliance with regulatory criteria. Atmospheric dispersion modelling is a mathematical simulation of how air contaminants disperse once released to the atmosphere using computer programs. The computer programs are equipped with dispersion algorithms and use site-specific data including terrain elevation data, meteorology data, facility air contaminant and emissions data, and building information inputted by the user to make predictions at pre-determined locations (i.e. receptors). Typically, the data inputted into the model is such that will present the worst-case operating scenario of the facility being modelled, so that the model predictions represent the overall maximum predicted concentrations possible from the facility. Such methodology tends to be overly conservative but allows for the worse-case scenario to be identified.

The air dispersion modelling program used in this study (i.e. the AERMOD Modelling System) was previously approved by Nova Scotia Environment (NSE) for use in the province of Nova Scotia and is considered a preferred and recommended air quality dispersion model by the United States Environmental Protection Agency (US EPA).

The main releases of air contaminants (including CO, NO_x, SO_2, TSP, $PM_{2.5}$, and H_2S) at the Facility are from the five major stacks from the Mill and the existing ETF, which will be replaced by the new ETF. The major differences between the existing and future operating scenarios are the change in the design of the ETF and the co-combustion of sludge (from the replacement EFT) with hog fuel in the power boiler.

Information pertaining to the above noted sources of emissions, quantity of emissions and other site-specific data such as terrain elevations, meteorological data, building data, were gathered and inputted into the AERMOD Modelling System to predict the maximum concentrations of the air contaminants of interest to this study for two operating scenarios (i.e. existing and future operations). Details pertaining to the air dispersion modelling methodology and input data are presented in the main body of this report (refer to Sections 4 and 5).

The results of the air dispersion modelling study are presented in Sections 6 of the report, and an analysis and discussion of those results are presented in Section 7. The analysis of the modelling results is based on methodologies laid out by the Ontario Ministry of Environment, Conservation and Parks in the "Air Dispersion Modelling Guideline for Ontario" (2017), as the Province of Nova Scotia has not developed a provincial air dispersion modelling guideline.

Based on the modelling results, the predicted concentrations of air contaminants for the operation of the existing mill (with current ETF) and the operation of the existing mill in future (with the ETF replaced) are expected to be in compliance with the provincial and federal ambient air quality criteria at the representative off-property discrete receptors.

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January 21, 2019

1.0 INTRODUCTION

Northern Pulp Nova Scotia Corporation (Northern Pulp) currently operates a kraft pulp mill (the Facility) located at Abercrombie Point, Pictou County, Nova Scotia (approximately 3 kilometers from the town of Pictou and 9 km from New Glasgow). The mill has been in operation since September 1967 and currently produces 280,000 to 300,000 air dried metric tonnes (ADMT) of bleached kraft pulp per year. The effluent waste from the Facility is treated in an existing effluent treatment facility (ETF) located approximately 4 km east of the mill site and consists of a series of sedimentation, aeration, and stabilization basins. The existing ETF is owned by the Government of Nova Scotia and operated by Northern Pulp. This system, however, must be closed by 2020 in accordance with the *Boat Harbour Act*. The design of a replacement effluent treatment facility (ETF) is currently underway and will consist of an activated sludge treatment system, including a primary clarifier, an aeration basin and two secondary clarifiers. The replacement ETF will be located within the site boundaries of the mill. The locations of the existing and replacement ETFs are displayed in Figure 1.1.

Stantec Consulting Ltd. (Stantec) was retained by Northern Pulp to conduct an Air Dispersion Modelling Study to support the Environmental Assessment currently being conducted for the replacement ETF.

The objective of the study 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.

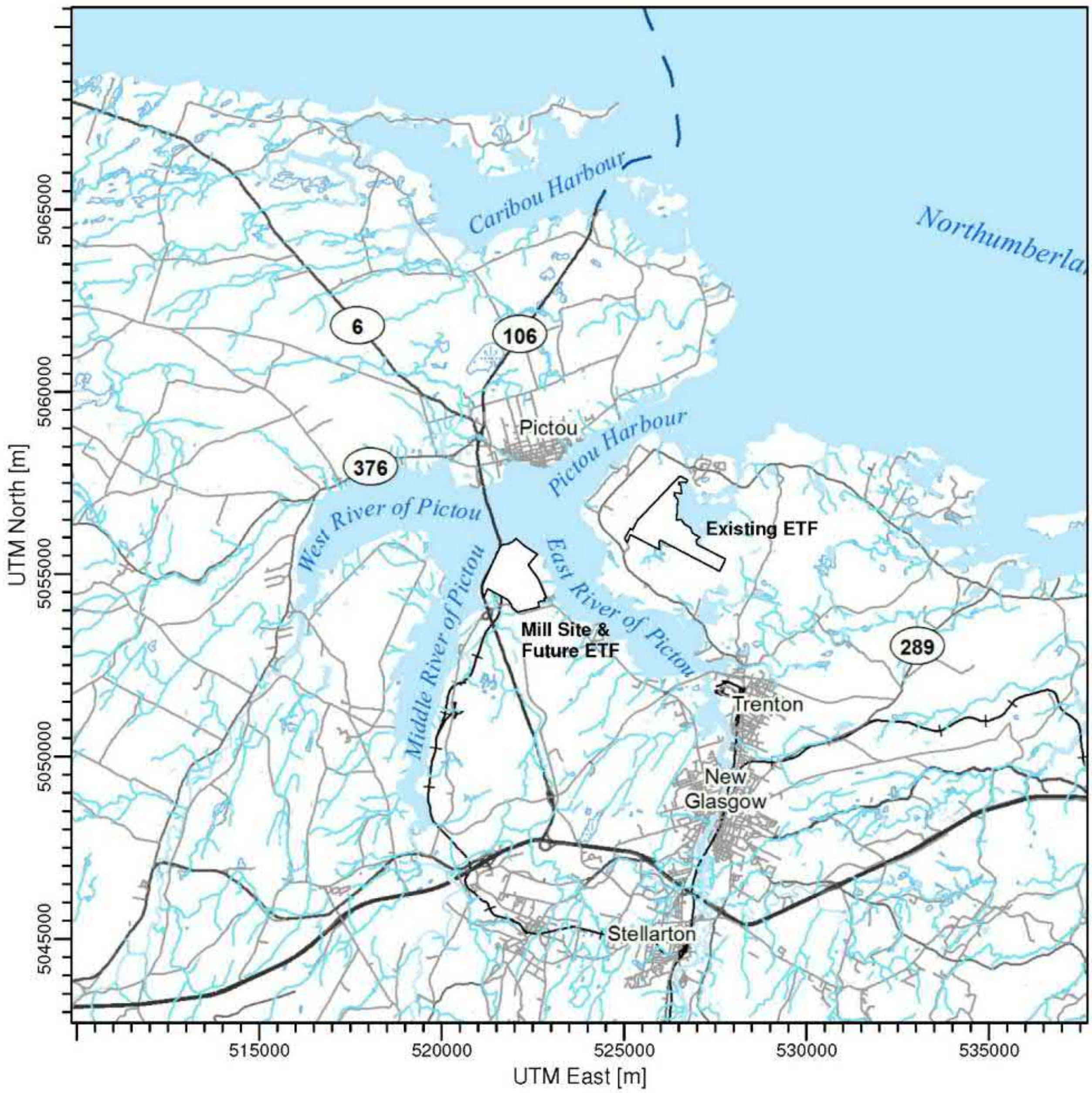
The dispersion modeling includes scenarios that are representative of both current and future operating conditions, to characterize the existing and future emissions, i.e., with the existing effluent treatment facility in operation and with the new treatment facility in operation (and the existing treatment facility not operating), all other activities remaining the same.

This Report is divided into the following sections:

- Section 1 provides a general introduction to the Project;
- Section 2 provides a description of the Facility and operations;
- Section 3 describes the air contaminants of interest to this study and provincial Air Quality Regulations;
- Section 4 provides an overview of the emissions;
- Section 5 provides the methods and inputs used to conduct the air dispersion modelling;
- Section 6 provides the results of the modelling study; and
- Section 7 provides a discussion of the results.

The references that are cited in the report are provided in Section 8, closing remarks are provided in Section 9, and additional supporting documentation is provided in **Appendix A**.

Figure 1.1 Location of the Northern Pulp Mill - Existing and Future Effluent Treatment Facilities (ETFs)



2.0 FACILITY DESCRIPTION AND PROCESS OVERVIEW

The pulping process at the Facility consists of digesting wood chips in white liquor, at elevated temperature and pressure, in a continuous digester to separate lignin from cellulose fibers. Once the cooking of the wood chips is complete, the stock is transferred to a blow tank and then to brown stock washers, where the pulp is separated from the cooking liquor by continuous washing of progressively cleaner water. The separated pulp is further washed, bleached, pressed and dried into the finished product, with ventilation in place during the washing and the bleaching stages to remove water vapour and airborne contaminants. The remainder of the process is designed to recover cooking liquor (for reuse) and heat.

The spent cooking liquor and the pulp wash liquid are combined to form weak black liquor, which is sent through a series of evaporators to become concentrated (55% solids). This liquor is then further concentrated within a direct-contact evaporator to form strong black liquor (approximately 70% solids). The strong black liquor is burned in the recovery boiler to provide heat and power for the mill's processes. Gases from storage tanks at each stage of the concentration process are vented into either the high-level roof vent (HLRV) or into the recovery boiler for direct incineration. The inorganic material that is collected following the burning of strong black liquor is called smelt. Smelt is combined with weak wash to form green liquor in the smelt dissolving tank. The green liquor is clarified then converted back to white liquor, to be re-used in the chip digestion process, in the slaker and causticizer system by adding calcium oxide (quicklime). The mud precipitate from the green liquor is sent to a lime kiln to re-generate the calcium oxide (quicklime).

The mill also operates a power boiler which, for the most part, burns hog fuel (coarse wood chips, bark); however, natural gas is used as needed.

The mill's liquid effluent is piped under the East River to the existing ETF located at Boat Harbour. Here, the effluent is treated by a series of sedimentation, aeration and stabilization basins, prior to being released to the Northumberland Strait. As mentioned in Section 1 however. this existing ETF must be closed by 2020 in accordance with the *Boat Harbour Act*. The design of a replacement effluent treatment facility (ETF) is currently underway and will consist of a Biological Activated Sludge (BAS) process, including a primary clarifier, an aeration basin and two secondary clarifiers. The replacement ETF will be located within the site boundaries of the mill (refer to Figure 1.1).

The major sources of air contaminants, of interest to this study, released to the atmosphere therefore include:

- Power boiler;
- Existing effluent treatment facility (ETF) located at Boat Harbour, which will be replaced with an Biological Activated Sludge (BAS) process to be located on the mill site.

There are a number of other smaller emission sources associated with the pulping process. However, the air contaminants of interest to this study (refer to Section 3) are not typically emitted from these sources and therefore they have not been included in the dispersion modelling.

3.0 AIR CONTAMINANTS OF INTEREST

The air contaminants considered in this air dispersion modelling study include those regulated by the Government of Nova Scotia under the *Air Quality Regulations*, as amended on October 12, 2017, as well as fine particulate matter ($PM_{2.5}$), as it is regulated under Northern Pulp's Industrial Approval (2011-076657-A01). These air contaminants include:

- Carbon monoxide (CO)
- Hydrogen sulphide (H_2S)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Total suspended particulate matter (TSP)
- Fine particulate matter ($PM_{2.5}$)

3.1 AIR QUALITY REGULATIONS

Air quality in Nova Scotia is regulated under the Environment Act. The Regulations specify concentrations for the criteria air contaminants including nitrogen dioxide (NO_2), total suspended particulate matter (TSP), carbon monoxide (CO), sulphur dioxide (SO_2), ozone (O_3) and hydrogen sulphide (H_2S). The regulations also address other issues such as the provincial cap on the emission of SO_2. The Nova Scotia *Air Quality Regulations* under Schedule A are presented in Table 3.1.

Currently, there are no provincial ambient air quality standards for fine particulate matter (i.e. particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)). However, ambient air quality standards for $PM_{2.5}$ are included in Northern Pulp's Industrial Approval (2011-076657-A01, Table 1 Section 9 c). These criteria are consistent with the Canadian Ambient Air Quality Standard for $PM_{2.5}$. For the 24-hour time averaging period the criterion is 28 $\mu g/m^3$ (changing to 27 $\mu g/m^3$ in 2020) and for the annual time averaging period it is 10 $\mu g/m^3$ (changing to 8.8 $\mu g/m^3$ in 2020). The 24-hour standard is based on a 3-year average of the 98th percentile of the daily 24-hour average concentrations and the annual standard is based on a 3-year average of the annual average concentrations.

Table 3.1 Nova Scotia Air Quality Regulations, Schedule "A"

Air Contaminant	Averaging	Nova Scotia Maximum Permissible Ground Level Concentration Limits	
	Period	**$\mu g/m^3$**	**pphm**
Carbon monoxide (CO)	1 hour	34 600	3000
	8 hours	12 700	1100
Hydrogen sulphide (H_2S)	1 hour	42	3
	24 hours	8	0.6
Nitrogen dioxide (NO_2)	1 hour	400	21
	Annual	100	5

Table 3.1 Nova Scotia Air Quality Regulations, Schedule "A"

Air Contaminant	Averaging	Nova Scotia Maximum Permissible Ground Level Concentration Limits	
	Period	μg/m³	pphm
Sulphur dioxide (SO_2)	1 hour	900	34
	24 hours	300	11
	Annual	60	2
Total suspended particulate (TSP)	24 hours	120	-
	Annual	70[1]	-

[1] geometric mean
μg/m³ - micrograms per cubic metre
pphm - parts per hundred million

4.0 EMISSIONS INVENTORY

As noted in Section 2, the main releases of CO, NO_x, SO_2, TSP, $PM_{2.5}$, and H_2S at the Facility are from the five major stacks at the Mill and the existing ETF. Once the replacement ETF is operational, the main releases of CO, SO_2, NO_x, TSP, $PM_{2.5}$ and H_2S will also be from the five major stacks and the replacement ETF. The major differences are the change in the design of the ETF and the co-combustion of sludge (from the replacement EFT) with hog fuel in the power boiler.

The Facility's emissions, for the air contaminants of interest to this study (refer to Section 3), for existing operations is provided in Table 4.1.

The rates of emissions of CO, NO_x, SO_2, TPM, and $PM_{2.5}$ from the existing operation were obtained from the Facility stack emissions testing reports for 2015, 2016 and 2017.

The rates of emission of H_2S for each of the five point sources (i.e. five major stacks) were calculated based on a combination of site-specific data on total reduced Sulphur (TRS). This data was speciated for H_2S based on information published by the National Council for Air and Steam Improvement (NCASI) (NCASI 2007).

The emissions data used to calculate the rate of emission of H_2S from the existing ETF was acquired from testing conducted by AirZone at the Boat Harbour ETF in 2012.

Table 4.1 Emissions – Existing Operations

Source	Air Contaminant Rate of Emission (g/s)					
	Carbon Monoxide (CO)	Nitrogen Oxide (NO_X)	Sulphur Dioxide (SO_2)	Total Suspended Particulate Matter (TSP)	Fine Particulate Matter ($PM_{2.5}$)	Hydrogen Sulphide (H_2S)
Power Boiler	11.4	3.40	-	3.87	1.14	-
Other Mill Point Sources[1]	76.9	8.72	1.73	5.61	0.79	1.60
ETF – Settling Pond	-	-	-	-	-	0.0202
ETF – Cell 1	-	-	-	-	-	0.00008
ETF – Cell 2	-	-	-	-	-	0.00006
ETF – Cell 3	-	-	-	-	-	0.0001
ETF – Cell 4	-	-	-	-	-	0.0001

"-" air contaminant is not released in a substantial amount from this source

[1] Each "Other Mill Point Source" was modelled individually and the total emission rate is shown in Table 4.1

The Facility's emissions inventory for future operations is provided in Table 4.2.

Once the replacement ETF is operational, the major differences between the existing operation of the Facility and the future operation will be:

- The change in the design of the ETF (i.e. activated sludge treatment (AST) vs. a series of sedimentation, aeration and stabilization basins), and
- The co-combustion of sludge and hog fuel in the Facility's power boiler (vs. hog fuel and natural gas).

There are no planned changes to the operation of other sources of emissions at the Mill. Therefore, the rates of emission of CO, SO_2, NO_x, TSP, $PM_{2.5}$ and H_2S from these sources, are the same for both scenarios.

The emission rates of CO, SO_2, NO_x, TSP, and $PM_{2.5}$ from the future operation (i.e. co-combustion of sludge and hog fuel) of the power boiler were estimated using the following information:

- Anticipated fuel usage for both fuel types;
- the 2017 stack emissions testing data and operational data (i.e., hog fuel feed rate and heat input); and
- guidance published by the United States Environmental Protection Agency (US EPA) AP-42: Compilation of Air Emissions Factors, Chapter 2.2 Sewage Sludge Incineration (US EPA 1995).

As there is limited information publicly available pertaining to the combustion of pulp and paper sludge, Stantec used guidance published by the US EPA for Sewage Sludge Incineration to estimate emission rates of CO, SO_2, NO_x, TSP, and $PM_{2.5}$ from this proposed activity. It is emphasized that sludge is considered, by Environment and Climate Change Canada (ECCC), a non-hazardous fuel, and the combustion of sludge in an industrial boiler (such as the power boiler) is not considered a form of incineration. This is consistent with guidance published by Environmental and Climate Change Canada (ECCC) (2016), “incineration does not include industrial processes where fuel derived from waste is fired as an energy source, such as industrial boilers”. Furthermore, during the future operation of the Facility it is anticipated that hog fuel will remain the primary fuel for the power boiler, and sludge would be combusted at a 7:1 ratio (7 parts hog fuel, 1 part sludge). The emissions profile for the power boiler would not change substantively and is likely to be similar to existing operations.

Once the replacement ETF is operational, Northern Pulp, pending approval by the province, will conduct a study of the co-combustion of hog fuel and sludge in the power boiler. During the study, the power boiler exhaust gas will be tested and upon receipt of the results, the air dispersion modelling will be updated using the data collected during the study to determine if the predicted ground level concentrations are below corresponding ambient air quality standards.

The emissions of H_2S from the operation of the replacement ETF were estimated based on known quantities of sulphur present in the Facility’s raw effluent. Stantec used the guidance published by the Ontario Ministry of the Environment, Conservation and Parks (MECP) “Procedure for Preparing an Emission Summary and Dispersion Modelling” (2018) to estimate emissions from the primary and secondary clarifiers and a combination of mass balance and engineering judgement approach for the aeration basin. A 90% H_2S removal efficiency was assumed for the primary clarifier (pers.comm Guy Martin, KSH, May 4th, 2018) and a 90% H_2S removal efficiency was assumed for the aeration basin (Crawford et al. 2009)). No further reduction of H_2S is expected by the secondary clarifiers (pers.comm Guy Martin, KSH, May 4th, 2018).

Table 4.2 Emissions – Future Operations

Source	Air Contaminant Rates of Emission (g/s)					
	Carbon Monoxide (CO)	Nitrogen Oxide (NO_X)	Sulphur Dioxide (SO_2)	Total Particulate Matter (TSP)	Fine Particulate Matter ($PM_{2.5}$)	Hydrogen Sulphide (H_2S)
Power Boiler	**3.26**	**7.42**	**0.358**	**2.77**	**0.595**	-
Other Mill Point Sources[1]	76.9	8.72	1.73	5.61	0.79	1.604
Primary Clarifier	-	-	-	-	-	**0.059**
Aeration Basin	-	-	-	-	-	**0.002**
Secondary Clarifier No.1	-	-	-	-	-	**0.001**
Secondary Clarifier No.1	-	-	-	-	-	**0.001**

“-“ air contaminant is not released in a substantial amount from this source
“bold” indicates sources/emissions rates that have changed from existing operations
[1] Each “Other Mill Point Source” was modelled individually and the total emission rate is shown in Table 4.2

5.0 AIR DISPERSION MODELLING METHODOLOGY

5.1 MODEL SELECTION

In the fall of 2012 and winter of 2013, a Facility Air Dispersion Modelling Study was conducted by Stantec (Stantec 2013) on behalf of Northern Pulp to satisfy various conditions in the Facility's Industrial Approval that were in effect at that time. The AERMOD dispersion modelling system was used in the 2013 study and was approved by NSE and is therefore used in this current study.

AERMOD is a steady-state Gaussian plume dispersion model developed by the United States Environmental Protection Agency (U.S. EPA, 2014). The model is designed to incorporate planetary boundary layer concepts to predict downwind concentrations from one or more industrial sources within a defined modelling domain. The AERMOD model system consists of three components: the plume dispersion model (AERMOD), a meteorological pre-processor (AERMET), and a terrain pre-processor (AERMAP). Details pertaining to the AERMOD modelling system are provided in the following paragraphs.

AERMOD makes use of two continuous stability parameters, friction velocity, and Monin-Obukhov length to characterize the atmosphere turbulence. The friction velocity is a measure of mechanical effects alone, such as wind shear at ground-level. The Monin-Obukhov length indicates the relative strengths of mechanical and buoyancy effects on atmospheric turbulence. Thus, AERMOD can account for turbulence both from wind shear and from buoyancy effects due to solar heating during the day and radiational cooling at night. To properly account for these effects, AERMOD requires three land use parameters: albedo, Bowen ratio, and surface roughness. Albedo is defined as the fraction of total incident solar radiation reflected by a particular surface without absorption. Bowen ratio is an indicator of surface moisture conditions and can be defined as the ratio of the sensible heat flux to the latent heat flux and is an indicator of surface moisture conditions. Bowen ratio can vary significantly over the course of the day; however, it usually remains fairly constant during mid-day. Surface roughness is a length scale that characterizes the mechanical mixing of air due to roughness of the earth's surface.

Modern planetary boundary layer theory is used to scale turbulence and other parameters to the height of the plume. AERMET derives hourly mixing heights based on the morning upper air temperature profiles and the surface meteorology, including available solar radiation. AERMAP is a terrain pre-processor that is designed to handle the input of receptor terrain elevation data for the AERMOD dispersion model. With the assumption that the effect of terrain on an individual receptor is directly proportional to the difference between the elevation of the receptor and the height of the local terrain features and inversely proportional to the distance between the receptor and terrain features, AERMAP searches for the terrain height and location that has the greatest influence on dispersion for an individual receptor. This height is referred to as the height scale. The height scale, which is uniquely defined for each receptor location, is used to calculate the dividing streamline height along which a plume is assumed to travel under stable atmospheric conditions. Output from AERMAP therefore includes the location and height scale for each receptor, which are used for the computation of air flow around and over elevated terrain features.

AERMOD version 16216r was used to complete this air dispersion modelling study.

5.2 MODELLING APPROACH

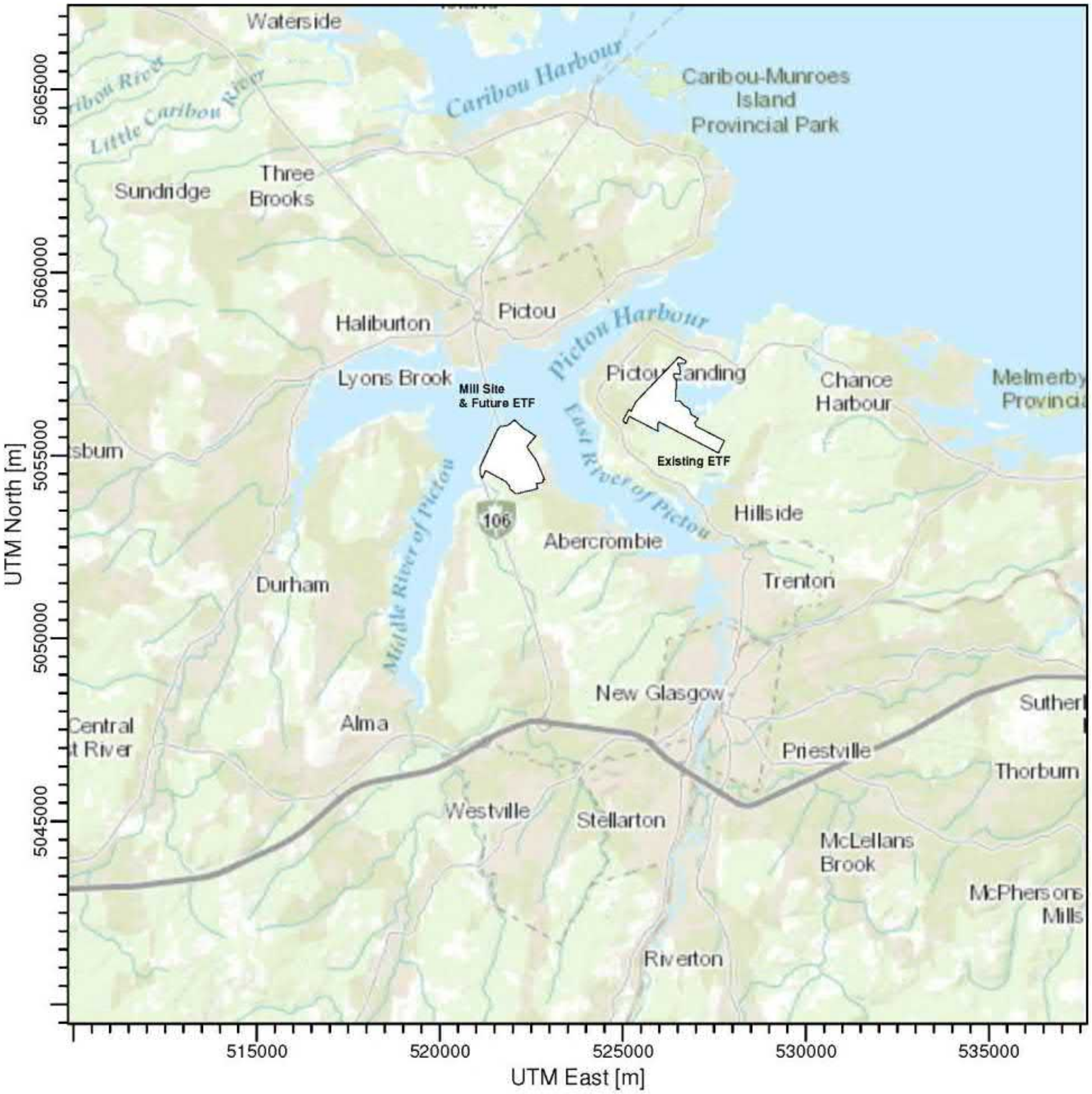
Ground level concentrations of the air contaminants of interest (refer to Section 3) were predicted for two modelling scenarios, characterized as follows:

- Existing Operations – existing Facility and existing ETF; and
- Future Operations – existing Facility and replacement ETF, with the power boiler co-combusting sludge and hog fuel.

5.3 MODEL DOMAIN

The modelling domain for the current modelling study consists of a 30 km by 30 km area centered at the mill site (Zone 20, UTM coordinate 522,065 m easting, 5,055,526 m northing). The modelling domain is illustrated in Figure 5.1.

Figure 5.1 Modelling Domain



5.4 TERRAIN DATA

The terrain surrounding the Facility to the south and south-east, is complex, meaning that the height of the surrounding terrain is higher than the release heights (stacks or vents) of the emission sources. Water (i.e. Pictou Harbour) surrounds the Facility to the west, north, and east. The town of Pictou lies to the north of the plant directly across the Pictou Harbour, and Pictou Landing lies north-east of the plant on the other side of the Pictou Harbour.

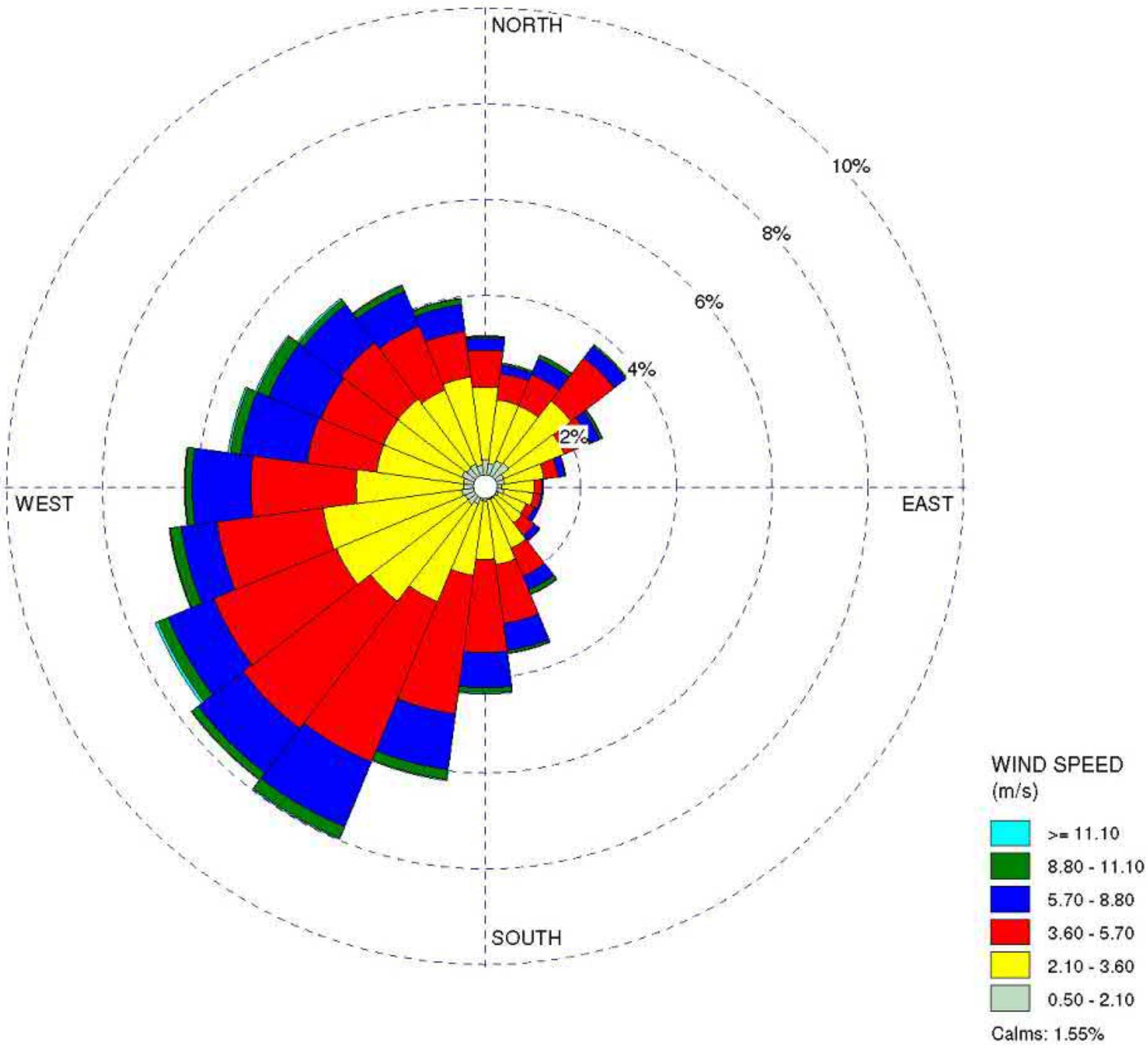
The terrain elevations used in this modelling study were acquired from the online version of Global 30 Arc-Second Elevation (GTOPO30), as available through the United States Geological Survey.

5.5 METEOROLOGICAL DATA

A meteorological data set for the 5-year period 2013-2017 was obtained from Lakes Environmental for both surface and upper air data, corresponding to the location of the Facility (Lakes Environmental Software 2018). This AERMET ready meteorological data file was then processed with AERMET, according to the US EPA Guideline on Air Quality Models, and incorporated into each model run.

A joint wind direction and speed frequency diagram, or "wind rose", of these data is presented in Figure 5.2. For wind direction, the convention used is "wind blowing from".

Figure 5.2 Annual Windrose (2013-2017)



5.6 BUILDINGS

The buildings at Northern Pulp are relatively large in dimension. Because of their size, they represent aerodynamic structures that can cause the formation of turbulent flow over and around the buildings, and where the flow may interact with the exhaust gases released from stacks and vents. For example, if not released at sufficient height, these exhaust gases may be entrained in the turbulent flow around the building and can be brought down to near ground level in the lee of the building by a process known as downwash. In order to calculate building downwash effects, the Building Profile Input Program (BPIP) was run prior to AERMOD and results were incorporated in the AERMOD runs. BPIP is a program that takes as input the building location, heights and widths and then uses this information to determine whether or not a particular source(s) is subject to wake effects from surrounding structures. If a source is found to be subject to wake effects, BPIP goes on to calculate building downwash parameters. These parameters are then used within AERMOD in the "PRIME" algorithm, to estimate the downwind concentrations at ground level.

For the existing Facility and ETF, building and tank geometries were obtained from the AutoCAD drawings provided by the Northern Pulp personnel. This information included the building/tank perimeter, elevations of all roof sections, and locations of stacks/vents. For the replacement ETF, information was provided by the design engineers.

5.7 RECEPTORS

Receptors represent specific locations where the air dispersion modelling program (i.e. AERMOD) will compute a ground level concentration value. A receptor grid is created for the dispersion modelling consisting of a 30 km by 30 km area as follows:

- 50 m spacing from the center of the operation out to 500 m;
- 100 m spacing from 500 m out to 5,000 m;
- 200 m spacing from 5,000 m out to 7,500 m;
- 500 m spacing beyond 7,500 m

The receptor grid for the existing operations included receptors around the mill site and existing ETF, and for the future operations it included receptors around the mill site and replacement ETF. The receptor grids for each modelling scenario are displayed in Figures 5.3 and 5.4. The difference in the two receptor grids is that for the future operations modelling scenario receptors are placed within the area currently representing the location of the existing ETF.

This receptor grid is used to create contaminant impact plots for the modelling domain (refer to **Appendix A**).

Figure 5.3 Receptor Grid, Modelling Scenario 1