Rio Tinto

Canada

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Environmental Report BC Works 2018

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1. About this report

This Annual Environmental Report is provided to share yearly environmental performance with our stakeholders and meet the reporting requirements under the multi-media permit from the provincial government of British Columbia. It is submitted to the provincial government and made available to the public through our BC Works web site and at our Kitimat Public Advisory Committee (KPAC).

In 2016, the multi-media Waste Discharge Permit underwent its most extensive makeover since it was issued by the provincial government of British Colombia in 1999, following the modernization of the Kitimat smelter.

In 1999, Rio Tinto's BC Works became the first industrial facility in British Columbia to obtain a multi-media environmental permit from the provincial government. The P2-00001 Multi-Media Waste Discharge Permit comprehensively addresses multiple emissions, effluents and solid waste, sets limits and establishes monitoring and reporting requirements. This permit is the key environmental regulatory compliance benchmark for smelter operations.

The permit provides guidelines for a results-oriented environmental management approach.

BC Works uses the permit guidelines with other proactive strategies to facilitate vigilant compliance monitoring and regular communications with public and private stakeholders.

The multi-media permit requires annual reporting to measure performance against established permit standards. More specifically, the annual reporting program includes air emissions monitoring, ambient air quality monitoring, effluents monitoring, groundwater monitoring, vegetation monitoring, and waste management monitoring. The yearly performance of the smelter are shared with the public in an Annual Environmental Report produced on a yearly basis by BC Works. A summary of the yearly accumulated non-compliances and spills is also included in the Annual Environmental Report.

In addition to the permit reporting for Kitimat Operation, a summary report for compliance of the Kemano Operations environmental permits is provided. This annual environmental report presents a summary of the permit required monitoring and reporting.

The 2018 Annual Environmental Report is available online at www.riotinto.com\bcworks.

The website also provides information on key environmental performance indicators. Questions or comments are welcome and may be made through the contact page on the website.

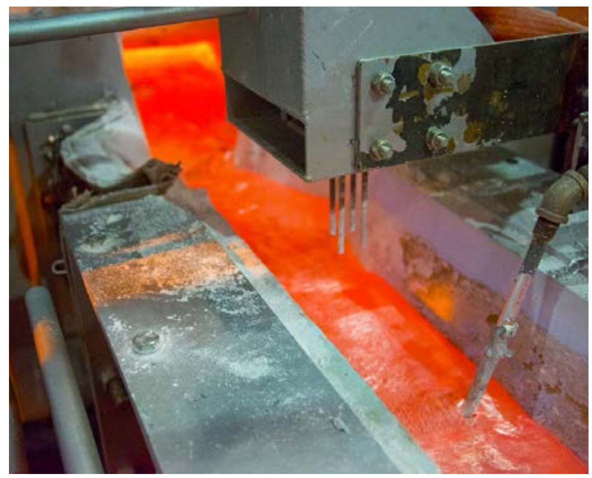
2. Operational overview

Rio Tinto operates a multi-faceted industrial complex in northern British Columbia, which is one of the largest industrial sites in the province. The operational footprint includes the Kitimat smelter, the power house at Kemano and the Nechako reservoir.

The main raw material used at the smelter is alumina ore; large volumes of which are imported from international suppliers and delivered by ship. Alumina is composed of bonded atoms of aluminium and oxygen. An electrolytic reduction process is used to break the bond and produce aluminium. The electrolytic reduction process takes place in the potroom buildings. These buildings house specially designed steel structures called pots. The pots function as electrolytic cells. They contain a molten bath or electrolyte made up mainly of highly conductive cryolite bath in which alumina ore is dissolved. Electricity flows through the electrolyte from an anode to a cathode. The electricity breaks the aluminium-oxygen bond. The heavier aluminium molecules sink to the bottom of the pot in the form of molten aluminium. Oxygen is combined with carbon from the anode to form carbon dioxide.

The molten aluminium that is extracted from the pots is transported to the two casting centers (B & C) located within the smelter, where it is temporarily stored in holding furnaces. Various alloying materials (such as magnesium, copper, silicon and iron) are added to produce specific characteristics such as improved strength or corrosion resistance. The new “C” Casthouse has a state-of-the-art water cooling and recycling system.

The aluminium is then poured into moulds and chilled, forming solid ingots of specified shapes and sizes. BC Works produces three types of aluminium ingots: value added sheets which uses a combination of pure aluminium mixed with alloying materials to enhance the properties of the product, pure aluminium remelt ingots, and pure aluminium sows which are sold to customers in North America, Asia and now also Europe, resulting in a variety of end-use applications.



The smelter site also includes facilities that produce materials required for aluminium production including the on-site Anode Paste Plant, Anode Rodding Shop, Coke Calciner, Carbon Recycling and Anode Baking Furnace, which produce materials used in the manufacturing and recycling of anodes. The new process also includes a Bath Treatment and Storage Facility for the recycling of electrolytic bath materials.

The electrolyte reduction process requires the use of large amounts of electricity. Electricity for BC Works is generated at the Kemano Operations’ powerhouse, a 1,000 megawatt hydroelectric generating station located 75 kilometers southeast of Kitimat. This generating station uses water impounded in the 91,000 ha Nechako Reservoir in north-central British Columbia.

In addition to the process related facilities, there are a number of environmental facilities for waste management, storm water management and managed sites. These environmental facilities are shown in Figure 2.1.

Pot replacement facility

2018 saw the initiation of a new construction project at BC Works related to the pot replacement facility (also known as the delining and relining facility). This facility represents investments of close to US $50 million and will be responsible for refurbishing the already aging AP40 pots. These pots can operate for 4-5 years before they need to be replaced and the first KMP pots that were commissioned in 2015 are already reaching the end of their service life. Replacing the pots for a next cycle of aluminium smelting is a crucial aspect for the sustainability of operations at BC Works. The facility is expected to be delivered in spring 2019.

The replacement operation involves stopping and cooling aging pots, disconnecting and transporting them to the refurbishing facility, removing and replacing the cathode and restarting the pot for another 4-5 years of service. It will take about 3 years to complete the replacement of the current 384 AP40 pots operating at BC Works.

The old smelter also operated a pot replacement facility and was generating large amounts of unquantified fugitive emissions. However, this new state of the art facility will include modern dust controlling equipment that will contribute in reducing emissions compared to the old pot replacement facility. Spent potlining (SPL) will be the most significant hazardous waste generated by this operation. SPL will be decontaminated and repurposed in the SPL treatment facility located in Saguenay, Quebec. This facility is the last step to fully modernize the smelter and ensure sustained operation for the next 60 years.

Kemano Second Tunnel Project (T2 project)

The Kemano Second Tunnel Project (T2 Project) received approval from Rio Tinto's board of directors in December 2017. The T2 Project is the second and final phase of a project that envisions the completion of a second 16km tunnel. The project includes the excavation of 7.6km of new tunnel, and the refurbishment of a 8.4km portion of the second tunnel that remained from the mid 1990s.

The T2 Project will ensure the long-term, sustainable operation of Rio Tinto's aluminium business in B.C. The completed second tunnel will allow Rio Tinto to conduct repairs and maintenance on the existing tunnel. BC Works depends on the guaranteed availability of a stable supply of electricity that Kemano and the Nechako Reservoir provide, and is key to Rio Tinto's ability to produce aluminium with one of the lowest carbon footprints in the world.

Construction is expected to be complete in 2020, and commissioning and close out in 2021.

Terminal A extension project

With a positive final investment decision (FID) by LNG Canada in October 2018, Rio Tinto's Terminal A Extension Project was initiated. There are two main components of the Project: the first involves the extension of Rio Tinto existing Terminal A and the second is the replacement of the barge ramp, tug dock and laydown area for staging and storage during construction. Dredging is also required to prepare the area for construction and to ensure the seabed is deep enough to safely accommodate vessels. A dredgate disposal site (DDS) has been constructed in 2018 on BC Works property to manage materials with shared responsibilities between Rio Tinto and LNG Canada.

The Project will accommodate bulk carriers for Rio Tinto BC Works' operations and will act as a replacement of existing facilities, which are to be used by LNG Canada. The Terminal A Extension Project enables other industries to operate in Kitimat and we are proud to be part of supporting the diversification of the regional economy.

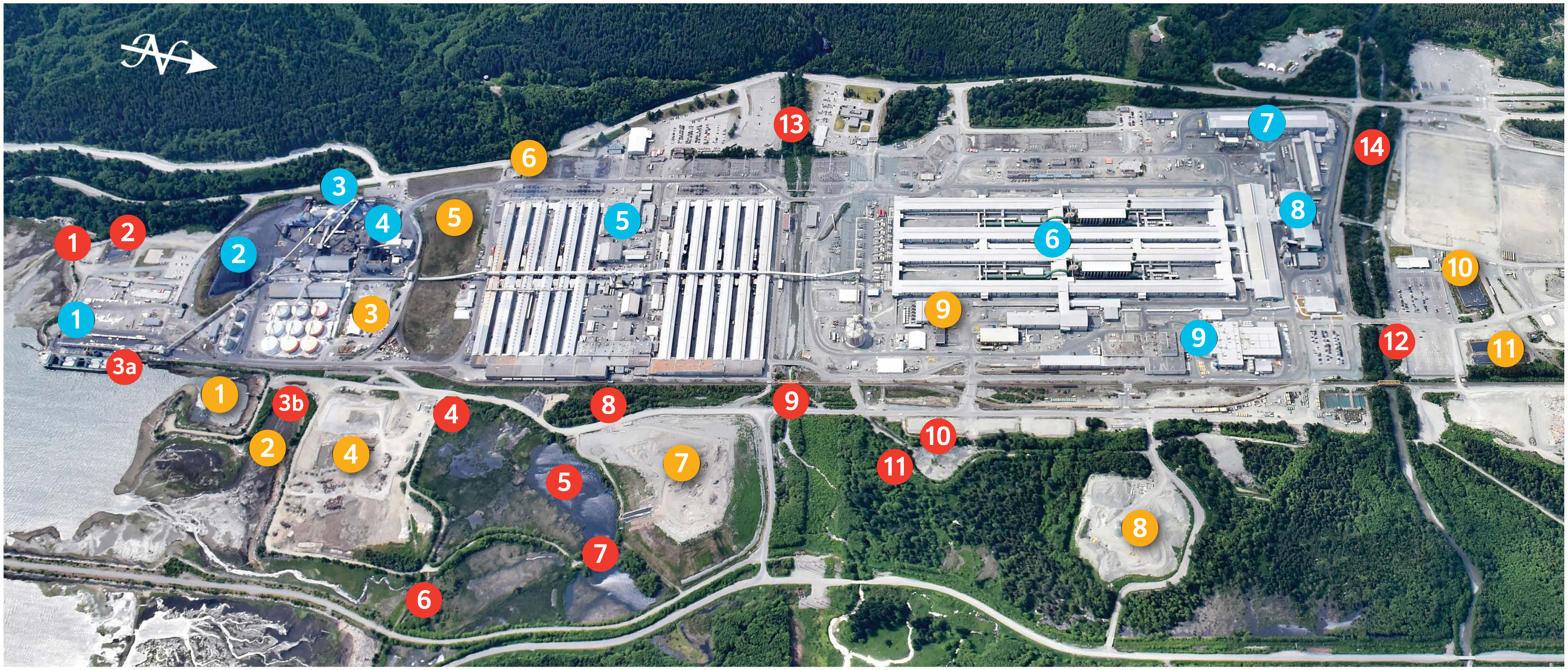


Figure 2.1 Kitimat Environmental operations.

Effluent Collection and Treatment

1. D-Lagoon emergency outfall
2. D-Lagoon
3a, 3b. Stormwater discharges
4. J-Stream discharge
5. B-Lagoon
6. B-Lagoon outfall discharge
7. Saltwater addition
8. A-Lagoon
9. Inverted siphon
10. F-Lagoon
11. F-Lagoon emergency overflow and sampling station
12. Anderson Creek parking lot stormwater discharges
13. Moore Creek
14. Anderson Creek

Waste Storage, Disposal and Managed Sites

1. Yacht basin
2. Scow grid
3. Scrap and salvage recycling
4. Dredgeate disposal site
5. SPL landfill
6. Waste oil storage (building 104)
7. South landfill
8. North landfill
9. Hazardous waste storage
10. SPL overburden soil cell
11. Wharf dredgeate cell

Plant Components

1. Terminal A wharf
2. Green coke storage
3. Coke calciner
4. Anode paste plant and green anode forming shop
5. VSS potline 1 - 5
6. AP4X potline
7. Anode bake furnace
8. Anode rodding shop
9. Casting centres (B & C)
10. Delining and relining facility

3. Environmental management and certification

The foundation for environmental management throughout Rio Tinto's global operations is the Health, Safety and Environment (HSE) Policy. HSE directives establish corporate- wide standards on major environmental, health and safety topics.

The HSE Policy and the more specific requirements of the Rio Tinto Health, Safety, Environment and Quality (HSEQ) standards are put into practice at BC Works through a comprehensive, operation specific Risk Management System. The system is maintained through adherence to the HSEQ Management System's 17 elements encompassing the continuous improvement cycle of Plan, Do, Check and Review (PDCR).

Independent certification

Since 2001, BC Works has been successfully certified under the requirements of ISO 14001 (2005) environmental program. The ISO 14001 certification requirements were revised in 2015 by the International Organization for Standardization and BC Works had until September 2018 to transition to the updated standard. BC Works successfully completed its transition and is now ISO 14001 (2015) certified. ISO 14001 (2015) provides independent conformance verification that BC Works evaluates its environmental impacts, has procedures in place to address practice, and works continually to lighten or eliminate its environmental footprint. In keeping with a corporate-wide commitment to a sustainable management approach, BC Works attains certification of ISO 14001 standards (Environment) and the ISO 9001 standards for Product Quality. For Environment, this covers all Rio Tinto BC Works activities and locations where risks of our business are managed. For Quality, the scope is for the processes of manufacturing of aluminium ingot and shipping.

In 2018, BC Works also achieved the Aluminum Stewardship Initiative (ASI) performance standard certification. This prestigious certification demonstrates our compliance with the highest environmental, social and governance standards.

The ASI certification is directly related to Rio Tinto values in applying the precepts of sustainable development. It validates our efforts to invest in high energy efficiency processes and to embed sustainability and human rights

Audit program

Independent ISO compliance and conformance audits are conducted as a condition of certification. The internal and external Environment and Quality Management System recertification audits took place in 2018 as planned. BC Works' integrated certification was successfully maintained and transitioned to the updated ISO 14001(2015). The ASI certification audit also took place in 2018 and this certification was proudly obtained by BC Works. Compliance with all environmental laws and regulations is the foundation of our environmental performance standards. Internal compliance audits of Rio Tinto Corporate standards, which are intimately linked with Rio Tinto's core operating values, was also successfully completed in 2018.

Health, Safety, Environment and Communities

Our commitment to health, safety, environment and communities is fundamental to how we do business at Rio Tinto. It applies wherever and whenever we operate, from exploration, to closure.

Safety
Caring for human life and wellbeing above everything else

Teamwork
Collaborating for success

Respect
Fostering inclusion and embracing diversity

Integrity
Having the courage and commitment to do the right thing

Excellence
Being the best we can be for superior performance

Delivering world class health, safety, environment and communities performance is essential to our business success. Meeting our commitments in these areas contributes to sustainable development and underpins our continued access to resources, capital and engaged people. Our focus on continuous improvement ensures regular renewal and relevance of our policies, procedures and activities.

We make the safety and wellbeing of our employees, contractors and communities our number one goal. Always. Where everyone goes home safe and healthy every day.

Equally critical, is maintaining stakeholder confidence through accountable and effective management of our risks and our impacts. Safely looking after the environment is an essential part of our care for future generations.

We approach each social, environmental or economic challenge as an opportunity to create safer, more valuable and more responsible ways to run our business. Wherever possible we prevent, or otherwise minimise, mitigate and remediate the effects of our business' operations. We assess the impact of our activities and products in advance, and we work with local communities and agencies to manage and monitor these impacts.

Our approach starts with compliance with relevant laws and regulations. We have the courage and commitment to doing what is right, not what is easiest. We maintain our focus on ethics, transparency and building mutual trust. We support and encourage further action by helping to identify, develop and implement world class practices through the application of our Group wide standards.

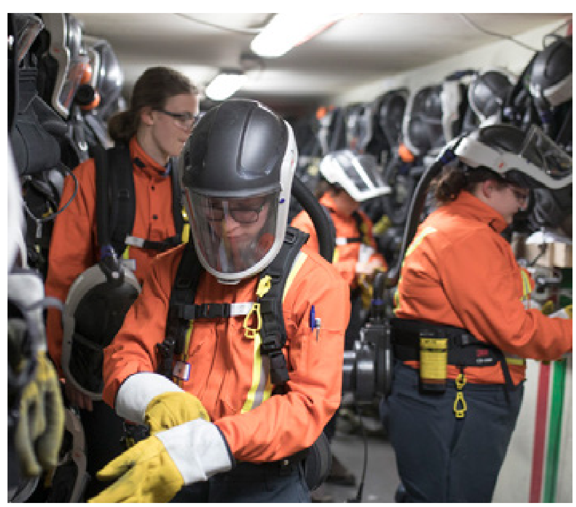
> We make the safety and wellbeing of our employees, contractors and communities our number one goal.

We actively monitor and ensure the security and resilience of our operations and collaborate when confronted with unwanted events or interruptions to minimise the impact on our people, communities, stakeholders and operations.

We work together with colleagues, partners and communities globally to deliver the products our customers need. We learn from each other to improve our performance and achieve success. We promote active partnerships at international, national, regional, and local levels, based on mutual commitment and trust. We engage with our joint venture partners to share our practices and insights. We recognise and respect diverse cultures, communities and points of view.

We acknowledge and respect Indigenous and local communities' connections to lands, waters and the environment and seek to develop mutually beneficial agreements with land connected peoples. We prioritise local economic participation through employment and business development. We respect human rights and work with communities to create mutual value throughout and beyond the life of our operations.

Importantly, it is a shared responsibility, requiring the active commitment and participation of all our leaders, employees and contractors. Our business standards, systems and processes, support responsible operations, as well as contributions and innovations that make a positive and sustainable difference in every region we are part of.



4. Effluents

Surface runoff from the smelter site, originating as snowmelt and rain, accounts for most of the water discharge. Seasonal precipitation varies significantly and total discharges can be over 100,000 m^3 per day during fall and winter storms.

Sources and infrastructure

Whether water is in use at the smelter or accumulating through surface runoff, it collects contaminants from various sources. It is directed through underground drains and surface channels to one of six inflows into B-Lagoon that discharges into the Douglas Channel.

B-Lagoon consists of a primary and a secondary pond: Upper and Lower B-Lagoons. It is designed to remove contaminants by sedimentation, phytoremediation, along with salt water addition to smooth fluctuations of inflows and contaminant levels. B-Lagoon discharges effluent continuously into the Douglas Channel. In 2018, the average discharge rate was 16,731 m^3 per day.

The retention time for water in the lagoon is usually more than ten hours (confirmed by measurements conducted in 2005), but is reduced to about five hours during runoff events and heavy rainfall.

In addition to the B-Lagoon outfall, there is an emergency outfall that can accommodate significant inflow surges. F-Lagoon and D-Lagoon are also designed with emergency overflows in case of significant surge. In 2018, all flows were retained in the lagoon system with the assistance of the bypass pumps.

Discharge measurements related to permit requirements and additional monitoring are described below in the following 2018 performance section.

2018 performance

Effluent water quality monitoring

Effluent water quality is monitored annually for the following parameters: flow variability, dissolved fluoride, dissolved aluminium, TSS, cyanide, temperature, conductivity, hardness, toxicity, acidity and Total PAH. Of these parameters, dissolved fluoride, dissolved aluminium, and TSS are monitored for long term trends.

Flow variability

Variability in the flow from B-Lagoon into the Douglas Channel is mainly a function of precipitation. As shown in Figure 4.1, peak rain events and flows occurred in January to March and in September through December. The total amount of rainfall in 2018 (2240mm) was very similar comparing to 2017 (2375mm).

Long-term trends

Dissolved fluoride, dissolved aluminium, and total suspended solids are the most meaningful performance indicators of plant effluent water quality. Average annual performance for these have been consistently maintained below permit levels (10 mg/L, 3 mg/L and 50 mg/L respectively) in recent years. Figure 4.2 illustrates the long-term trend performance.

In 2018 dissolved fluoride, and total suspended solids loads slightly decreased over a 10 year trend. The most significant change has been the reduction of dissolved aluminium in the lagoon system over the 10 years that can be attributed to the shutdown of the old smelter.

Dissolved fluoride

Dissolved fluoride originates mainly from the leaching of a landfill formerly used to dispose of spent pot lining. Information on the spent pot lining landfill is reported in Chapter 9, Groundwater monitoring. Other sources of fluoride are raw material losses around the smelter.

Dissolved fluoride is monitored continuously through daily composite sampling and monthly grab sampling. Daily composite and grab samples are sent to an outside laboratory for analysis (refer to Chapter 12, Glossary for sample method definitions).

The permit specifies a maximum concentration of 10 mg/L of dissolved fluoride in effluent; this level was not exceeded in 2018. Average dissolved fluoride concentration for the year derived from composite sampling was 3.02 mg/L. The long-term trend is illustrated in Figure 4.2. The 2018 composite and grab sampling results (Figure 4.3) profile the higher concentrations that occurred during the higher precipitation and surface run-off events during the year.

BC Works aimed to reduce fluoride loading to receiving environment from the South Landfill by 30% by the end of 2018 compared to 2013 baseline. BC Works achieved 79% reduction.

Dissolved aluminium

Aluminium metal at BC Works, such as finished products stored outside at the wharf, have a very low solubility and contribute little to the discharge of dissolved aluminium.

In addition to its use as a raw material, alumina is also used in the scrubbing process to remove fluoride from smelter emissions. Some scrubbed alumina is released through the potroom gases collection centers. In this form, scrubbed alumina has a higher solubility and is a contributor to both dissolved aluminium and dissolved fluoride.

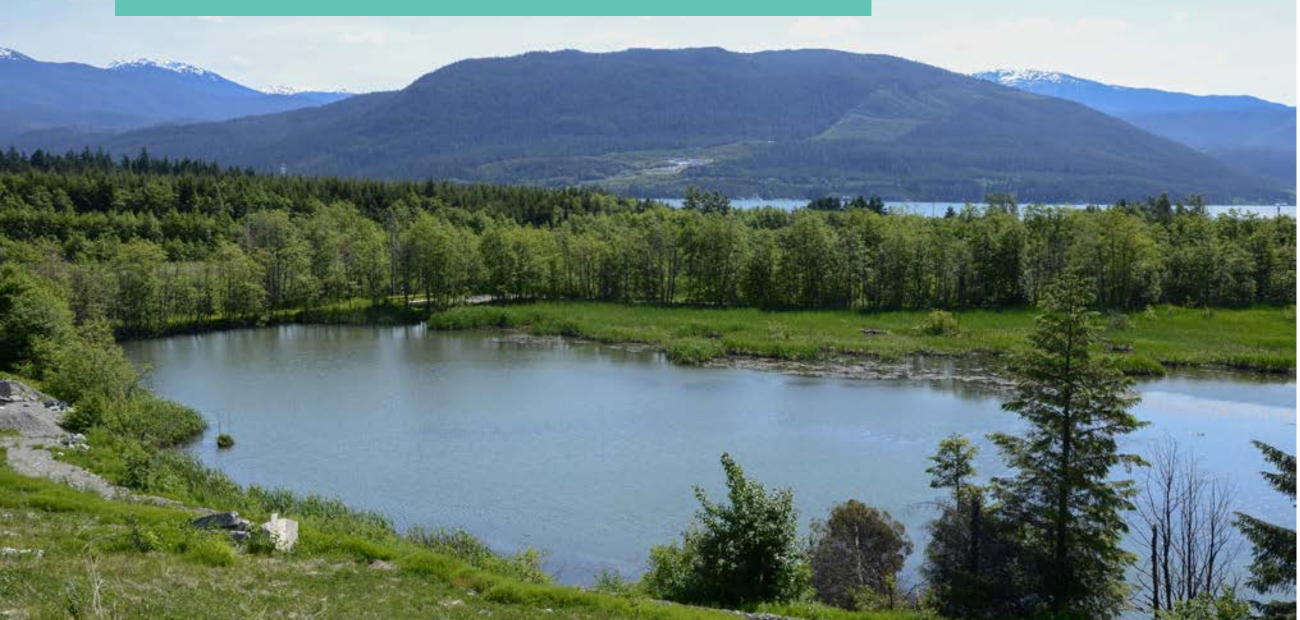
In 2018, concentrations of dissolved aluminium did not exceed the maximum permit limit of 3.0 mg/L. The annual average of dissolved aluminium concentration was 0.132 mg/L (Figure 4.4).

Total suspended solids (TSS)

Solids that remain suspended in discharge from B-Lagoon include small amounts of materials used in industrial processes at the smelter and other naturally occurring substances like dust, pollen and silt. There is a proportional relationship between TSS levels and concentrations of both dissolved aluminium and polycyclic aromatic hydrocarbons (PAHs) because these contaminants are usually bound to suspended solids in water when entering the B-Lagoon system.

B-Lagoon is a large and well-vegetated area that is highly efficient in absorbing and processing effluent compounds. The permit specifies a concentration maximum of 50 mg/L of TSS in effluent.

Concentrations in 2018 were much lower than the permit level. The annual average concentration for the composite samples was 2.5 mg/L (Figure 4.5) which is consistent with previous years.



When looking at the chart, the July 16 sample is missing, as a result of a leaking sample bottle. By the time the sample arrived at the lab there was not enough water to run the sample. Samples were collected the day before and the day after and the results were below detection limits for TSS, it can be inferred that the results on the 16th would be very similar.

Cyanide

Cyanide is formed during the electrolytic reduction process and retained in the cathode lining material known as spent pot lining (SPL). In the past, material in the cathode was deposited on-site at the SPL landfill. Today, all generated SPL is shipped off-site to a a Rio Tinto SPL treatment facility where the material is decontaminated and repurposed for various use. Groundwater and the bottom of the SPL landfill lining interact, generating a leachate containing cyanide. The source of the cyanide in B-Lagoon is from the J-Stream outlet.

The permit specifies a maximum concentration of 0.5 mg/L of strong acid dissociable cyanide (the more abundant, although less toxic form) in B-Lagoon. Concentrations are determined from the monthly grab samples. The permit level was not exceeded in 2018. Weak acid dissociable cyanide is also monitored, although there is no permit requirement (Figure 4.6).

Temperature

Water used for cooling is the major source of effluent at BC Works. B-Lagoon is designed to retain effluent long enough to ensure water temperatures are not elevated when discharged. The permit requires that the temperature of the lagoon discharge does not exceed 30°C. Temperatures were within permit requirements during 2018 (Figure 4.7).

During the month of October there were some challenges with the continuous monitoring probe. Some of the data was not able to be processed as a result of a failed conductivity and temperature probe. Temperatures in the lagoons both before and after the repair indicate a stable temperature reading.

Conductivity, hardness, salt water addition and toxicity

Since 1997, salt water has been pumped into B-Lagoon at the connection between the primary and secondary ponds. As per permit requirements, the addition of salt water is monitored and managed to maintain non-toxic discharges.

In 2008, an independent consulting firm conducted a review to examine the correlation between seawater addition rates, conductivity, hardness, and toxicity. The review was in fulfillment of section 8.2.5 of the multi-media permit requirement. Results confirmed that the addition of sea water was successful at reducing the toxicity of the B-Lagoon effluent.

The data also confirmed the best way to predict toxicity is via aluminium concentration, conductivity and pH. Conductivity and hardness are monitored on a continuous and daily composite basis respectively, even though there are no permit limits for either parameter (Figure 4.8). These measures provide information that ensures the salt water addition system is contributing to the reduction of toxicity at the at the B Lagoon outfall.

Water toxicity is determined through the application of a bioassay test. The toxicity of water discharged from B-Lagoon is tested by exposing juvenile rainbow trout to the effluent in a certified laboratory under controlled conditions (96LC50 bioassay test). The permit requires quarterly monitoring with a survival rate of at least 50 per cent for trout tested. All effluent discharge bioassay tests at B-Lagoon passed during 2018.

A similar comment can be made for the missing conductivity data during the month of October, there were some challenges with the continuous monitoring probe. Some of the data was not able to be processed as a result of a failed conductivity temperature probe. The composite hardness readings were very stable during this period confirming that there was stability in the readings during this period.

Acidity

A variety of contaminants can influence the acidity of effluent, by either increasing or decreasing the pH levels. A pH level of 7.0 is neutral, and water sources found adjacent to BC Works (Anderson Creek and the Kitimat River) usually have a pH level slightly below neutral (i.e. acidic, rather than alkaline).

Acidity is monitored using a variety of methods (continuous, daily composite and monthly grab samples). Daily composite samples are provided to an external laboratory for analysis. The permit requires that the pH of the effluent is maintained between 6.0 and 8.5. The 2018 annual pH composite sample average was 7.5. All sample measurements were within the permit limits during 2018 (Figure 4.9).

Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are a large family of chemical compounds (more than 4,000 have been identified) generated by the incomplete combustion of organic material.

Various operations at the smelter generate PAH in both particulate and gaseous forms.

Other sources include raw materials (green coke and pitch) handling. PAHs are monitored using two methods: weekly analysis of composite and monthly grab samples. PAHs are also analyzed from grab samples taken during special events. B-Lagoon discharges are monitored and analyzed for 15 of the most common PAH compounds (Figure 4.10). In 2018 the overall trend PAHs appear to be less than previous years which may highlight some of the benefits of the new smelter technology.

All PAH results from 2018 were within permit limits set at 0.01 mg/L. The average reading for 2018 was 0.004 mg/L a little lower than 2017.

Figure 4.1
Flow variability, B-Lagoon 2018

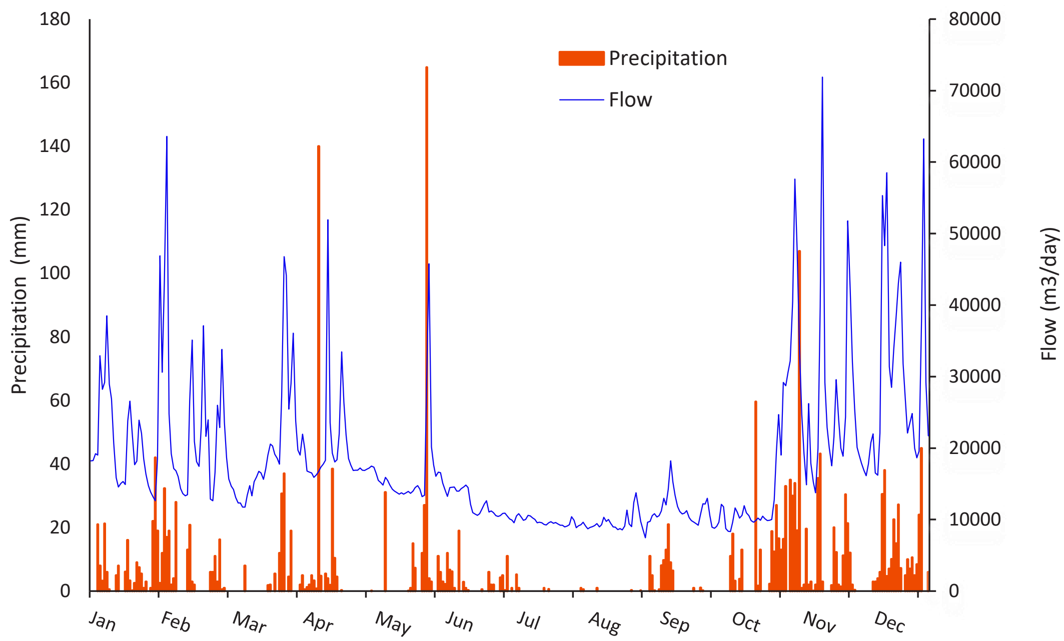


Figure 4.2
Dissolved Fluoride, Dissolved Aluminium and Total Suspended Solids, B-lagoon 2018

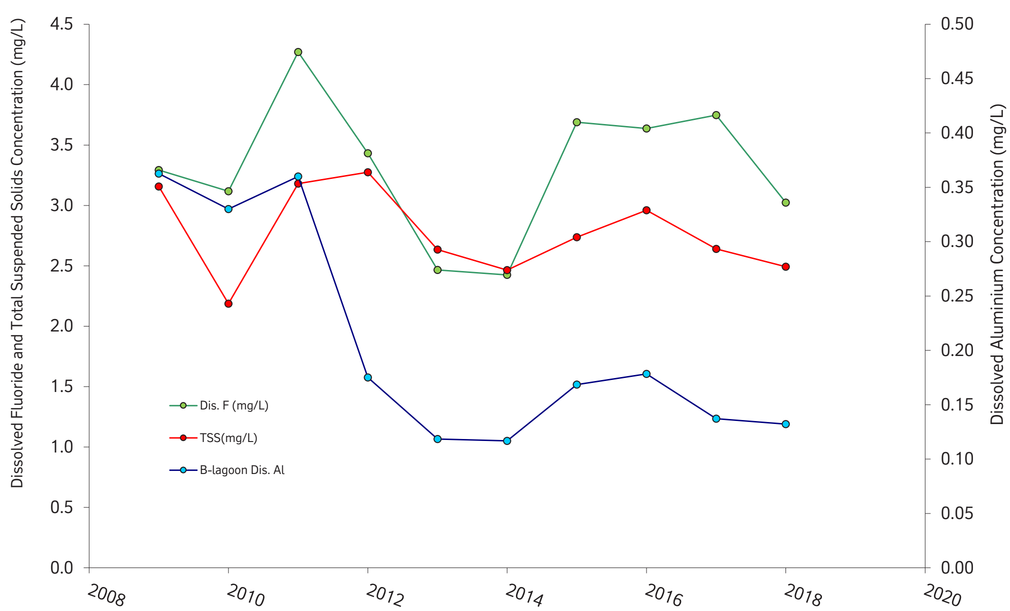


Figure 4.3 Dissolved fluoride, B-lagoon 2018

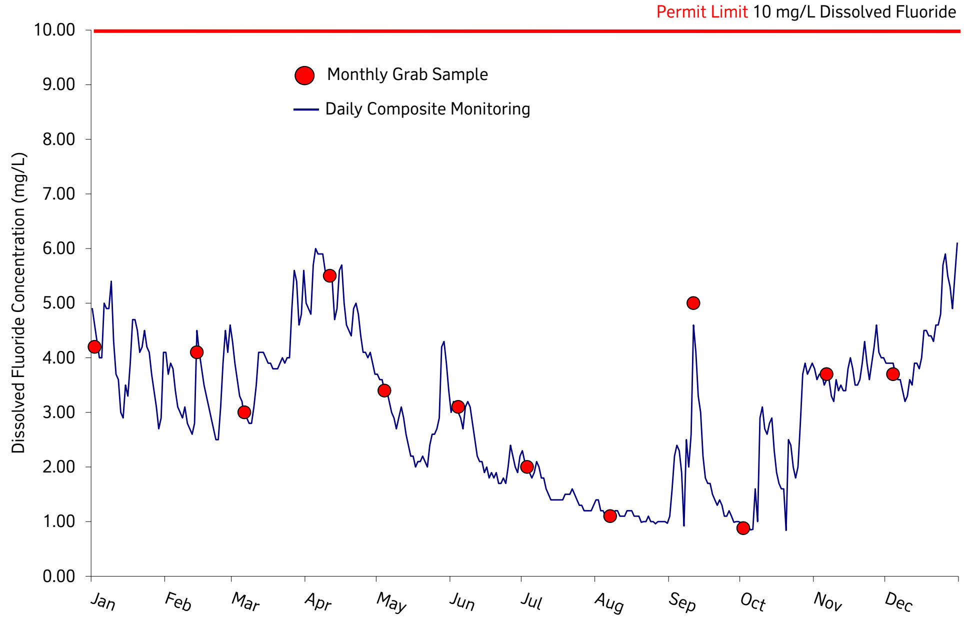


Figure 4.4 Dissolved Aluminium, B-lagoon 2018

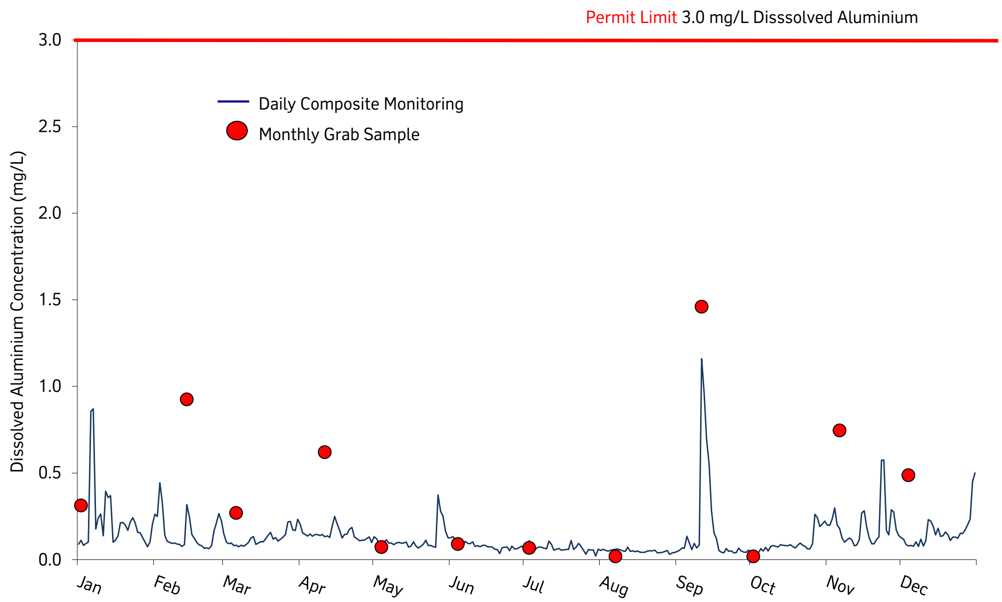


Figure 4.5 Total Suspended Solids, B-lagoon 2018

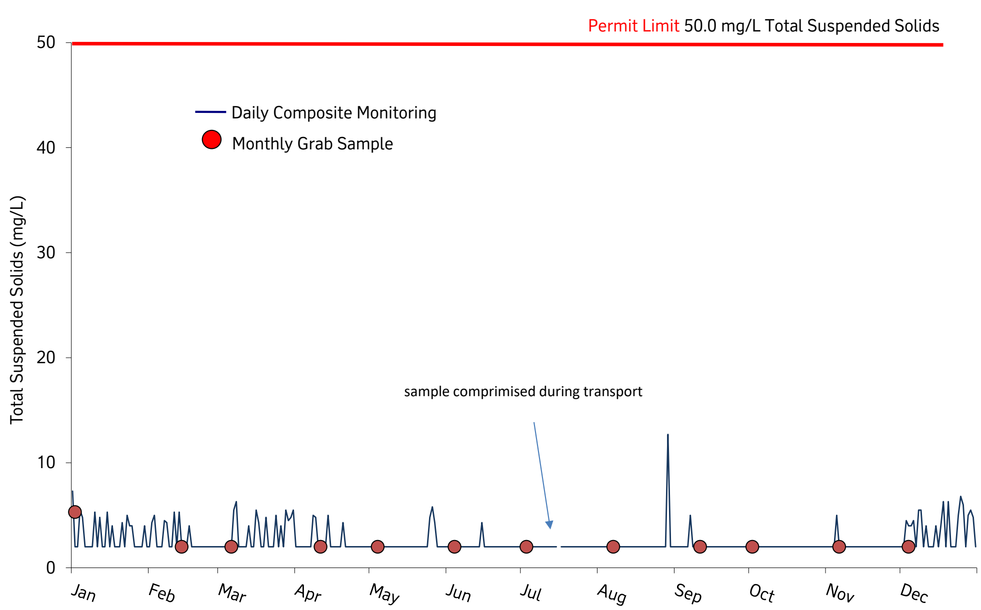


Figure 4.6
Cyanide, B-lagoon 2018

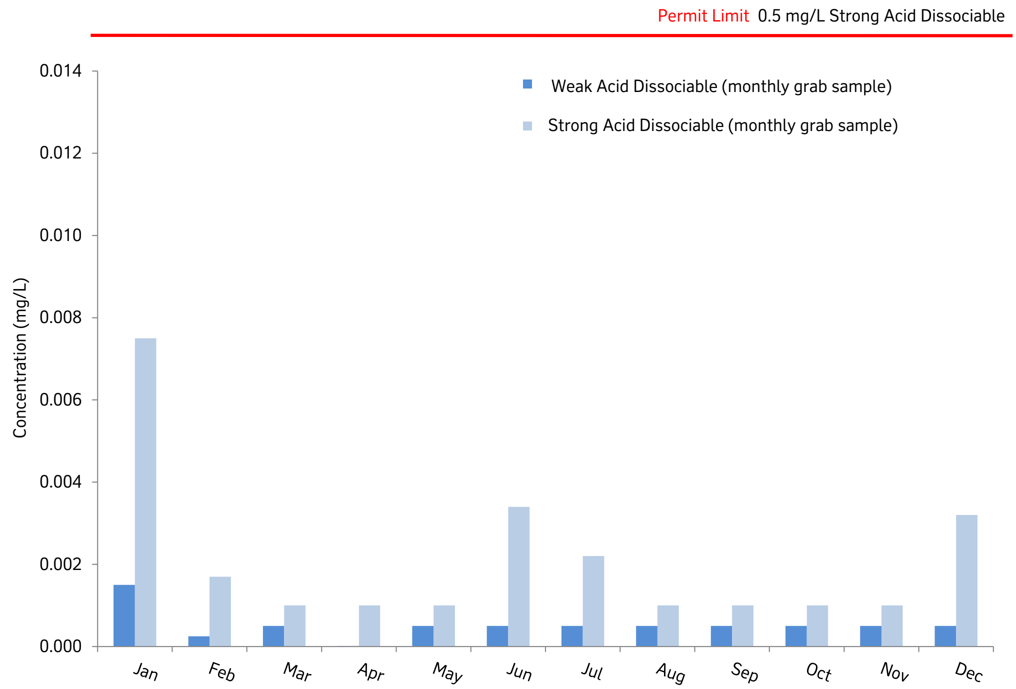


Figure 4.7
Temperature B-lagoon 2018

Figure 4.8
Conductivity and hardness, B-lagoon 2018

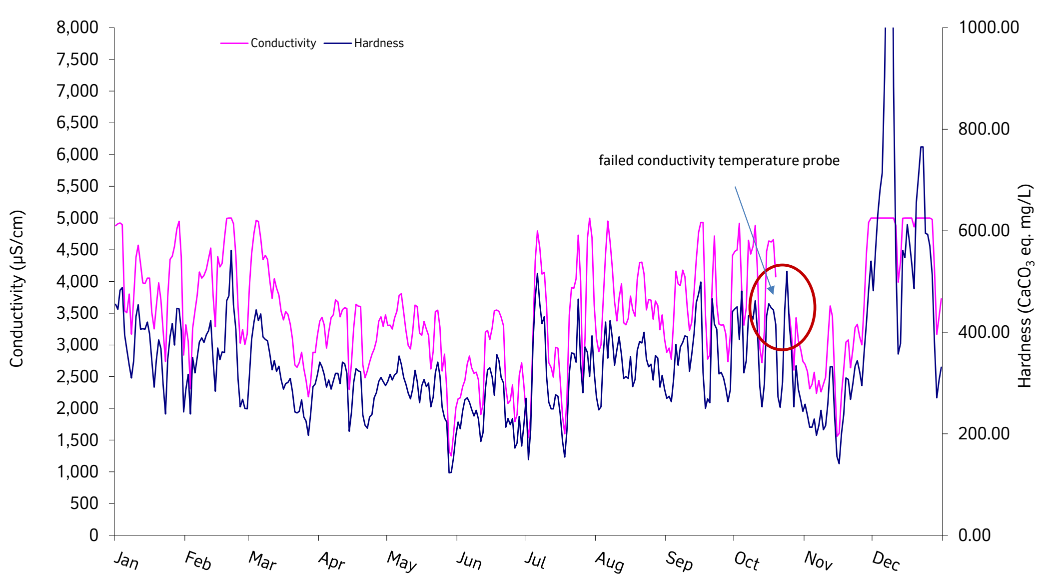


Figure 4.9
Acidity, B-lagoon 2018

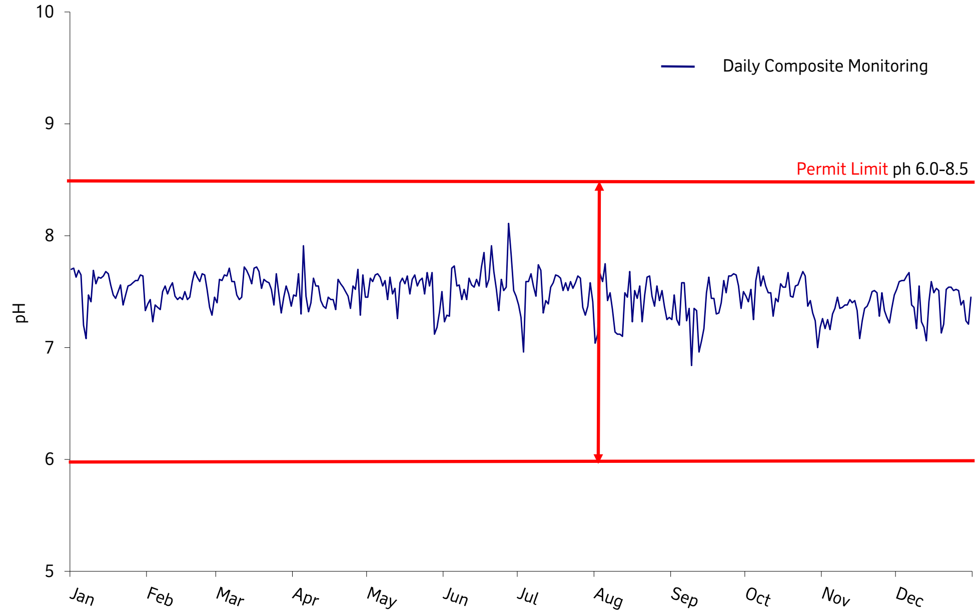
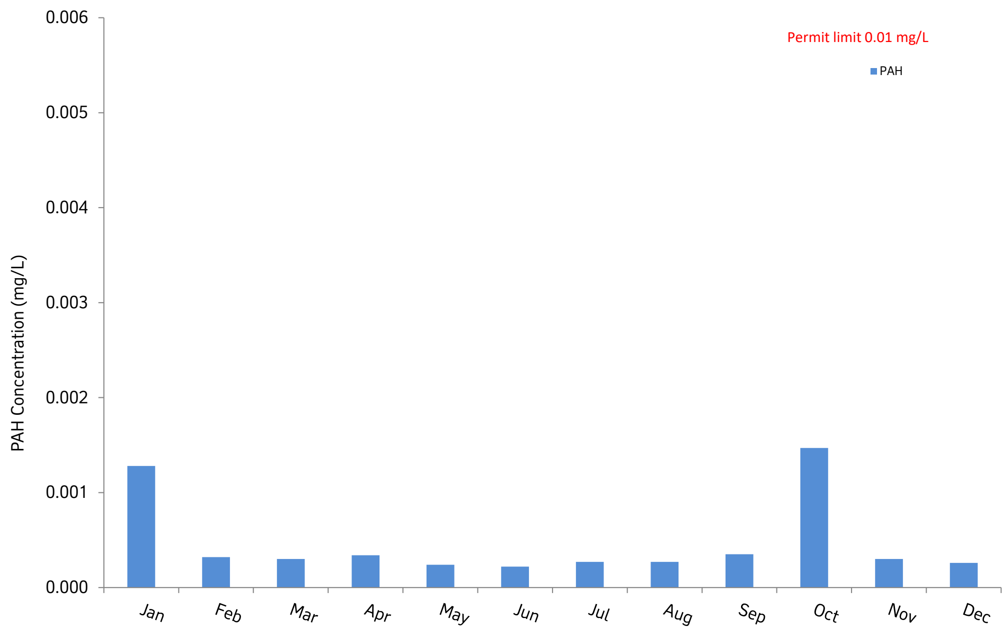


Figure 4.10
Polycyclic Aromatic Hydrocarbons, B-lagoon 2018



5. Emissions

This chapter describes the results of ongoing monitoring of various gaseous and particulate-matter in air emissions from BC Works. Performance results relate to type and source of emissions.

Emission types

The primary types of emissions monitored are total fluoride (Ft), sulphur dioxide (SO_2), polycyclic aromatic hydrocarbons (PAHs), nitrogen oxides (NO_X), total particulates, and greenhouse gases (GHGs).

Sources

Major sources of air emissions at BC Works include the reduction roof vents, Gas Treatment Centres (GTCs), Calcined Coke Plant, Anode Paste Plant, Anode Baking Furnace (ABF) and the exhaust stacks. Wind-blown or fugitive dust (picked up from raw material storage piles, process ventilation systems and during raw material transportation) is another contributor to air emissions.

Pollution control equipment, situated at various locations in and around BC Works, includes the reduction GTC's, the coke calciner pyroscrubber, the Fume Treatment Centre (FTC) at the ABF, and the dust collectors. Air emissions are collected and processed via these pieces of equipment to remove airborne pollutants.

Air quality monitoring

In addition to monitoring emissions, regular and extensive air quality and vegetation monitoring is conducted in the Kitimat valley. Information on these monitoring programs is detailed in Chapters 6 and 7.

2018 performance

Emission Parameters

Total fluoride (F_t)

Four major sources contribute to fluoride emissions: the reduction roof vents, the Gas Treatment Centers, the Fume Treatment Center and the Pallet Storage Building where anode butts are cooled before recycled. In reduction, the molten bath dissolves the alumina ore by an electrolytic reduction process through which aluminium is produced. The bath is composed primarily of sodium fluoride and aluminium fluoride and is the main source of fluoride emissions at BC Works. The modern AP4X technology has strong gas suction and hoods on the pots, so the collection and recycling of emissions has improved in comparison to the old Söderberg technology. Gas collection efficiency for the new smelter is greater than 98 per cent.

The first pot of the modern AP4X prebake smelter began producing metal in June 2015 and all 384 pots were started sequentially with the last pot started at the end of March 2016. Compliance monitoring and reporting of the reduction roof emissions (fluoride and particulate) started in September 2016 when the process stabilized (refer to the yellow dots on the potroom roof sampling locations on Figure 5.1). Fluoride emissions are monitored at roof top locations inside the reduction buildings A, B, C and D (Figure 5.2).

In preparation for the idling of the VSS potlines, in 2008 the gaseous fluoride permit limit (including both reduction and dry scrubber emissions) was set by the Ministry at 50 tonnes of gaseous fluoride loading per month and replaced the rate measurement of gaseous fluoride per tonne of aluminium. The fluoride permit limit has transitioned to 33.3 tonnes per month of total fluoride for the new AP4X smelter for 2016 and 2017 (Figure 5.3). This permit limit has further transitioned to 0.9 kg/t Al in January of 2018.

The total fluoride limit includes emissions from the reduction roof vents, GTCs, FTC and the Pallet Storage Building. Total fluoride includes the gaseous fluoride plus the fluoride particulate. During 2018, there were no loading monthly exceedances of the total fluoride emissions permit limit (Figure 5.3)

In 2018 the overall contribution of PFC's (Green house gas) from anode effects decreased from 13% in 2017 to 3% in 2018.

Sulphur dioxide (SO_2)

Sources of sulphur dioxide at BC Works include petroleum coke (green and imported calcined) and coal tar pitch. Both are raw materials used to manufacture anodes. Coke calcination is a process used to change green coke into a usable form. Sulphur dioxide emissions occur during calcination, baking of the anodes at the Anode Baking Furnace and the electrolytic reduction process through which aluminium is produced.

From 1993 to 1999, the permitted sulphur dioxide emission was set at 20.7 tonnes per day on an annual average. In 2000 the permitted sulphur dioxide emission was set at 27 tonne per day on annual average to reflect the quality challenges observed in the global coke market. In April 2013 the operation permit was updated to reflect the new SO_2 emission permit limit of 42.0 tonnes per day on annual average in preparation to the modernised smelter production increase. The average SO_2 emissions have increased since 2015 which can be attributed to the smelter reaching full metal production in 2016 and continuing to produce approximately 50% more tonnes of aluminium . In 2018 the monthly average SO_2 emission levels remained below the permit limit (Figure 5.4). Throughout 2018 each month was consistently below the permit limit (Figure 5.5).

In addition to monitoring emissions, BC Works carries out every year extensive monitoring activities under the SO_2 Environmental Effects Monitoring program (SO_2 EEM) where four different lines of evidence are studied; water, human heath, soil and vegetation. Results and information about the SO_2 EEM can be found online at www.riotinto.com\bcworks.

Polycyclic aromatic hydrocarbons (PAHs)

PAHs are produced by both industrial processes and various forms of combustion such as wood-burning stoves and forest fires. Since the anodes for the AP4X technology are baked before being placed in the pot, the PAH emissions are greatly reduced as compared to the Söderberg technology. PAHs are measured by annual stack tests at the Fume Treatment Centre (Table 5.7), Pitch Fume Treatment Centre, Liquid Pitch Incinerator and at the FC-3 day tank (Table 5.6)

A measurement campaign will be completed in the potrooms and at the Gas Treatment Centers once the pots are stable to confirm the low levels of PAH emissions.

Nitrogen oxides (NO_x)

Nitrogen oxides are a minor emission from the Smelter. NO_x emissions are generated plant wide from three main sources: natural gas consumption, coke calcination and open burning of wood. Nitrogen oxides are relevant to smog and other potential air quality concerns.

NO_x emissions are estimated using a combination of actual measurements and US-EPA emission factors. In 2013 the method of calculation of NO_x emissions for the annual environmental report changed to reflect the same calculation used for the National Pollutant Release Inventory (NPRI). Smelter-wide NOx emissions for 2018 was estimated at 313 tonnes per year (Figure 5.6).

Operational Areas

Reduction Gas Treatment Centres (GTCs)

The reduction potrooms are a major source of emissions at BC Works, and the reduction GTC's are therefore very important components of the plant's pollution control system. Continuous monitoring for gaseous fluoride is conducted on both the East and West GTC to ensure elevated emissions levels are promptly addressed.

The permit requires annual compliance stack tests on the two GTCs. These results are included in the plant wide limit and reported in Table 5.1. Table 5.2 contains a summary of upset operating conditions for the GTCs. Upset conditions are when the GTCs are not operating under normal conditions.

Reduction particulate emissions

The annual average for reduction particulate samples including both GTCs was 0.51 kg/tonne of Aluminium which is under the permit limit of 1.3 kg/tonne of Al (Figure 5.7).

The decrease in measured particulate emissions after 2015 is a result of the modernised smelter coming on-line and the full shutdown of the old VSS operation (Figure 5.8).

Particulate emissions from the reduction roof vents accounted for 74 per cent of total particulate emissions for BC Works in 2016 (Figure 5.9).

Calcined Coke Plant

The two emission sources at the Calcined Coke Plant (the pyroscrubber and the cooler) are monitored relative to permit limits for particulate content. In 2018, the pyroscrubber and the cooler were tested and all results were compliant (Table 5.3).

Anode Paste Plant

Various emission sources at the Anode Paste Plant are controlled using dust collectors and two pitch incinerators. The dust collector discharge stacks are monitored relative to permit levels for total particulate content (Table 5.4) PAHs are tested there as well and are monitored relative to a permit limit. The pitch incinerator discharges are monitored relative to permit levels for total particulate and PAH content (Table 5.6). There were no exceedances for PAHs or total particulate at the Anode Paste Plant in 2018.

Carbon South is composed of both the calcined coke plant and the anode paste plant, both areas contain emission control devices that at time require to be bypassed for maintenance purposes. Table 5.5 outlines the bypasses that took place in 2018 in Carbon South.

Anode Baking Furnace – Fume Treatment Centre (FTC)

The emission source at the Anode Baking Furnace is monitored relative to permit limits for total particulate and PAH. In 2018 there were no exceedances of the permit limit (Table 5.7). The SO_2, Fluoride and NO_x emissions at the anode baking furnace are included in the plant wide limits. The FTC is designed to allow the bypass of emissions from the ABF direct to the FTC stack without treatment under emergency conditions or exceptional major maintenance restarts and operations. FTC bypass Table 5.8 lists the bypass mode occurrences for 2018. The FTC was available 99.5 % of the year in 2018, a slight decrease from 2017 in which the FTC was available 99.6 % of the year.

Bath Treatment and Storage Facility

The two major dust collectors at the bath treatment and storage facility are monitored relative to permit levels for total particulate. There were no exceedances of the permit limits in 2018 (Table 5.9).

Casting

Gaseous chlorine was not used during the process of casting aluminium ingots in 2018. The permit limit for chlorine consumption is 300 kg per day. This limit has not been exceeded since 1999. Over the past years, the use of chlorine was reduced and finally eliminated in April 2014.

There was no SF6 consumption in 2018 during the process of casting aluminium ingots. In 2013, the casting centres that used the SF6 gas were shut down.

Other stack tests were completed in 2018 for casting operations (Table 5.11).

Plant-Wide – Natural gas consumption

Natural gas is widely used at BC Works in various applications where heat is required. Variables affecting usage levels include production levels and the availability of energy generated by the hydroelectric facility at Kemano Operations.

BC Works consumption rates and associated emissions are calculated using standards developed by the US Environmental Protection Agency (US- EPA). Plant-wide natural gas consumption can be seen in Table 5.10.

Plant-Wide – Greenhouse gas emissions

There are a number of sources of greenhouse gas (GHG) emissions at BC Works (Figure 5.10). Most emissions occur during the smelting process (81%) and most smelting-related emissions are attributable to anode consumption (Figure 5.11). The frequency and duration of anode effects in aluminium smelting can either increase or decrease the amount of CO_2 equivalent produced in aluminium smelting (Figure 5.12). Two process stability disruptions occurred in February and June which led to an increase in anode effects. In 2018 the overall contribution of PFC's (Green house gas) from anode effects decreased from 13% in 2017 to 3% (Figure 5.11) of the overall aluminium smelting greenhouse gas production. This is largely attributed to reduction's improvement in responding to anode effects.

BC Works GHG 2018 emissions have been steadily decreasing since 2015 (Figure 5.13) emitting on average 1.91 tonnes of CO_2 equivalent per tonne of aluminium.

Table 5.1 GTC Annual Stack Tests 2018

Performance Measure	GTC East	GTC West
Dates	**Oct-18**	**Oct-18**
Flow (m^3/min) Permit limit: None	48223	48408
Total Particulates (mg/m^3) Permit Limit: Included in Plant Wide limit	0.35	0.168
Particulate Fluoride (mg/m^3) Permit Limit: Included in Plant Wide limit	0.03	0.0097
Gaseous Fluoride (mg/m^3) Permit Limit: Included in Plant Wide limit	0.13	0.247
Sulphur Dioxide (mg/m^3) Permit Limit: Plant Wide limit	227.1	192.8

Table 5.2
GTC Upset Conditions 2018

Date	GTC	Upset Condition	Bypass Type	Duration	Cause
14-Jan-18	West	No Feed	Emergency	13h	Compounding equipment failure
30-Jan-18	East	No Feed	Emergency	16h	Emergency repair
9-Feb-18	West	Zero Exhaust	Emergency	20m	Power Outage
9-Feb-18	East	Zero Exhaust	Emergency	20m	Power Outage
9-Feb-18	West	No Feed	Emergency	3h 20m	Power Outage
9-Feb-18	East	No Feed	Emergency	3h 20m	Power Outage
4-Apr-18	West	No Feed	Approved	5h 30m	Air Lift Cleaning
5-Apr-18	East	No Feed	Approved	5h 15m	Air Lift Cleaning
25-May-18	East	No Feed Zero Exhaust No air Fluidization	Emergency	20m	Power Outage
25-May-18	West	No Feed Zero Exhaust No air Fluidization	Emergency	20m	Power Outage
4-Jun-18	West	No Feed Zero Exhaust No air Fluidization	Emergency	30m	Power Outage
4-Jun-18	East	No Feed Zero Exhaust No air Fluidization	Emergency	30m	Power Outage
18-Jun-18	East	No Feed	Emergency	7h	Hole in the air slide canvas
20-Jun-18	West	No Feed No air fluidization	Emergency	3h 3m	Power Outage
20-Jun-18	East	No Feed No air fluidization	Emergency	4h 25m	Power Outage
20-Jun-18	West	Zero Exhaust	Emergency	1h 9m	Power Outage
20-Jun-18	East	Zero Exhaust	Emergency	1h 7m	Power Outage
18-Jul-18	East	No Feed	Approved	5h 50m	Air Lift Cleaning
19-Jul-18	West	No Feed	Approved	5h 30m	Air Lift Cleaning
31-Jul-18	West	Zero exhaust	Emergency	1h 36m	Power Outage
31-Jul-18	East	Zero exhaust	Emergency	60m	Power Outage
31-Jul-18	West	No Feed No air fluidization	Emergency	3h 40m	Power Outage
31-Jul-18	East	No Feed No air fluidization	Emergency	2h 45m	Power Outage
31-Jul-18	West	Zero exhaust	Emergency	35m	Power Outage
31-Jul-18	East	Zero exhaust	Emergency	38m	Power Outage
31-Jul-18	West	No Feed No air fluidization	Emergency	1h 20m	Power Outage
31-Jul-18	East	No Feed No air fluidization	Emergency	58m	Power Outage
20-Sep-18	East	No Feed	Approved	4h 50m	Replace airslide that had a hole in the canvas
7-Nov-18	West	No Feed	Approved	5h 30m	Air Lift Cleaning
8-Nov-18	East	No Feed	Approved	6h 5m	Air Lift Cleaning
9-Nov-18	East	Zero Exhaust	Emergency	9m	Loss of duct temp reading
31-Dec-18	West	No Fluidization	Emergency	3h 55m	Loss of communication with the fluidization fans

Table 5.3
Calcined Coke Plant Biannual Stack Tests 2018

Pyroscrubber		
Parameters	**Jul-18**	**Sep-18**
Particulates (Kg/hr) Permit Limit: 21.1 (Kg/Hr)	4.0	3.3
SO_2 (Kg/hr)	218.1	237.6
NO_X (Kg/hr)	19.9	13.1

Cooler		
Parameters	**Jul-18**	**Sep-18**
Particulates (Kg/hr) Permit Limit: 3.9 (Kg/Hr)	0.96	0.94
SO_2 (Kg/hr)	1.07	0.27

Table 5.4
Anode Paste Plant Annual Stack Tests 2018

Source	Particulate Permit Limit (mg/m³)	Particulate Emissions (mg/m³)
Dust Collector DC10	120	11.1
Dust Collector DC11	120	10.5
Dust Collector DC12	120	9.1
Dust Collector DC13	120	16.2
Dust Collector DC14	120	6.2
FC3 (Day Tank)	120	27.8
Liquid Pitch Incinerator	500	53.8
Dust Collector PFTC	30	2.8

Table 5.5
Carbon South Emission Control Bypass 2018

Date	Equipment	Bypass Type	Duration	Cause
16-Feb-18	PFI	Approved	1h 51m	Maintenance
11-Apr-18	PVT	Approved	11h 30m	Maintenance
14-Jun-18	PFI	Approved	2h 8m	Maintenance
1-Aug-18	PFI	Approved	60m	Maintenance
1-Aug-18	FC-3	Approved	1h 55m	Maintenance
9-Aug-18	PFI	Approved	10 m	Maintenance
4-Dec-18	PFI	Approved	8h 30m	Maintenance
12-Dec-18	FC-3	Approved	9h 30m	Maintenance

Table 5.6
Anode Paste Plant Annual PAH Stack Tests 2018

Source	PAH Emissions
Liquid Pitch Incinerator (mg/m³)	0.2152
FC3 Day Tank (mg/m³)	0.0048
Dust Collector PFTC (Kg/Mg Paste) Permit Limit: 0.3 (Kg/Mg Paste)	0.0014

Table 5.7
FTC Annual Tests 2018

Flume Treatment Centre	
Parameter	**Oct-18**
Particulate (Kg/Mg of baked anode) Permit Limit: 0.3 Kg/ Mg of baked An.	0.038
PAH (Kg/Mg of baked anode) Permit Limit: 0.05 Kg/ Mg of baked An.	0.000079

Table 5.8
FTC Bypass Modes 2018

Date	Bypass Mode	Bypass Type	Duration	Cause
8-Jan-18	Mode 4	Emergency	23m	Operator Error
6-Feb-18	Mode 2	Approved	25m	ABF Shutdown
1-Mar-18	Mode 2, 3, 4	Approved	6h 27m	Maintenance
2-Mar-18	Mode 2	Emergency	31 m	Plant Air Down
2-Mar-18	Mode 2	Emergency	17m	Plant Air Down
22-Mar-18	Mode 2	Emergency	8m	Air lance in cooling tower corroded
22-Mar-18	Mode 3	Emergency	4m	High temperature in cooling tower
22-Mar-18	Mode 4	Emergency	34m	Diesel fan faulted
22-Mar-18	Mode 2	Emergency	11m	Manually controlling temperature
22-Mar-18	Mode 4	Emergency	4m	Set point for temperature to high
22-Mar-18	Mode 2	Emergency	2h 23m	High temp in cooling tower
28-Mar-18	Mode 2	Emergency	19m	Temperature deviation
7-Apr-18	Mode 2	Emergency	14m	Water pump did not start
16-Apr-18	Mode 2	Emergency	11m	Low draft during ID fan PM
23-Apr-18	Mode 2	Emergency	13m	Unintentionally triggered by maintenance
16-May-18	Mode 2	Emergency	28m	High temperature
25-May-18	Mode 2	Emergency	39m	Plant Air Down
4-Jun-18	Mode 3	Emergency	50m	Power outage
14-Jun-18	Mode 2	Approved	1h 45m	Maintenance
20-Jun-18	Mode 3	Emergency	1h 39m	Power outage
20-Jun-18	Mode 4	Emergency	10m	Power outage
9-Jul-18	Mode 2	Emergency	33m	Human Error
31-Jul-18	Mode 2	Emergency	20m	Power outage
7-Aug-18	Mode 2	Approved	6.4hrs	Maintenance
12-Sep-18	Mode 4	Emergency	31m	Emergency stop button activated
25-Oct-18	Mode 2	Approved	3h 11m	Cleaning the cooling tower
11-Nov-18	Mode 3	Emergency	1h 30m	Outlet Temperature spiked
13-Nov-18	Mode 2	Emergency	7m	Operator Error
20-Nov-18	Mode 2	Emergency	21 m	Loss of plant air
21-Nov-18	Mode 2	Approved	9h 28m	Maintenance
22-Nov-18	Mode 4	Emergency	1h 18m	Loose wire in PLC cabinet tripped the breaker
23-Nov-18	Mode 2	Approved	2h 9m	Maintenance

Table 5.9
Bath Treatment and Storage Annual Stack 2018

Source	DCB-001	DCB-003
Particulate Emissions (mg/m^3) Permit Limit: 30 (mg/m^3)	11.5	12.5

Table 5.10
Natural Gas Consumption and Associated Emissions 2018

Year	Natural Gas Consumption m^3/yr	Associated Emissions (tonnes/year)			
		Nitrogen Oxides	Total Particulates	Sulphur Dioxide	Carbon Monoxide
2008	25,931,400	41.49	3.15	0.25	34.85
2009	24,013,100	38.42	2.92	0.23	32.27
2010	23,564,629	37.70	2.87	0.23	31.67
2011	20,864,400	33.38	2.54	0.20	28.04
2012	19,695,700	31.51	2.39	0.19	26.47
2013	19,492,700	31.19	2.37	0.19	26.20
2014	18,048,900	28.88	2.19	0.17	24.26
2015	22,801,400	36.48	2.77	0.22	30.65
2016	32,066,200	51.31	3.90	0.31	43.10
2017	31,360,000	50.18	3.81	0.30	42.15
2018	31,240,900	49.99	3.80	0.30	41.99

Table 5.11
Bi-Annual Stack Test Casting 2018

	B Casting		C Casting			
	DC 4		Furnace 61		Furnace 62-63	
Parameters	Jul-18	Sep-18	Jul-18	Sep-18	Jul-18	Sep-18
NO_x (Kg/hr)	0.01	0.04	0.05	0.21	0.04	0.19
Chloride (Kg/hr)	0.9	1.01				
Chlorine (Kg/hr)	0.018	0.0098				
Particulate (Kg/hr)	0.54	0.46	0.86	1.02	1.22	1.57

Figure 5.1
Potroom roof sampling locations

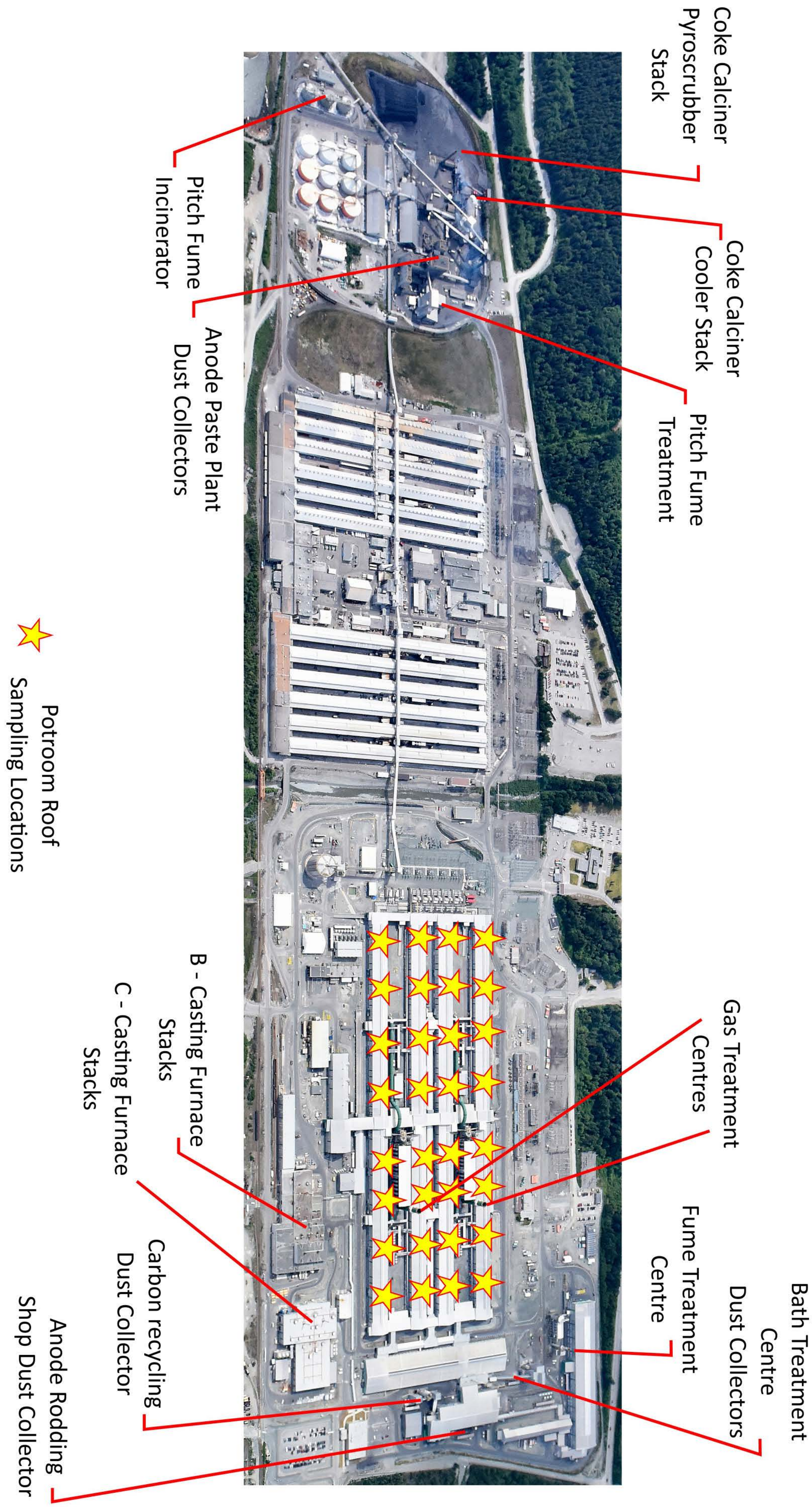


Figure 5.2
Potroom total fluoride emissions rate, 2018

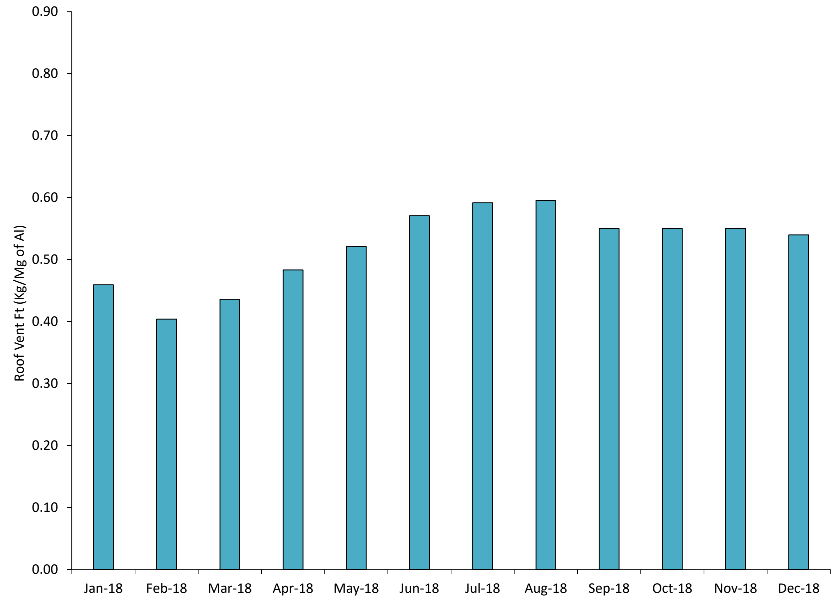


Figure 5.3
Plant-wide fluoride total, 2018

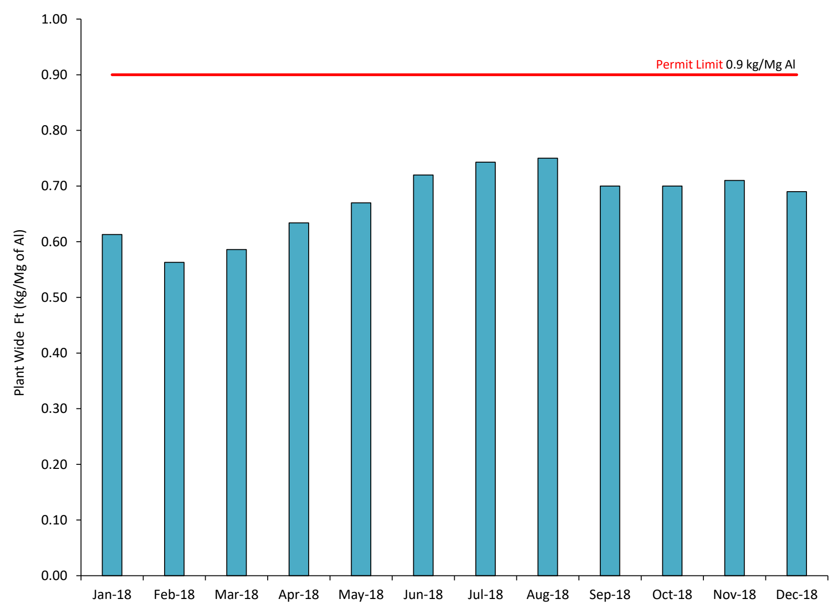


Figure 5.4
Annual average SO_2 emissions, BC Works 2007-2018

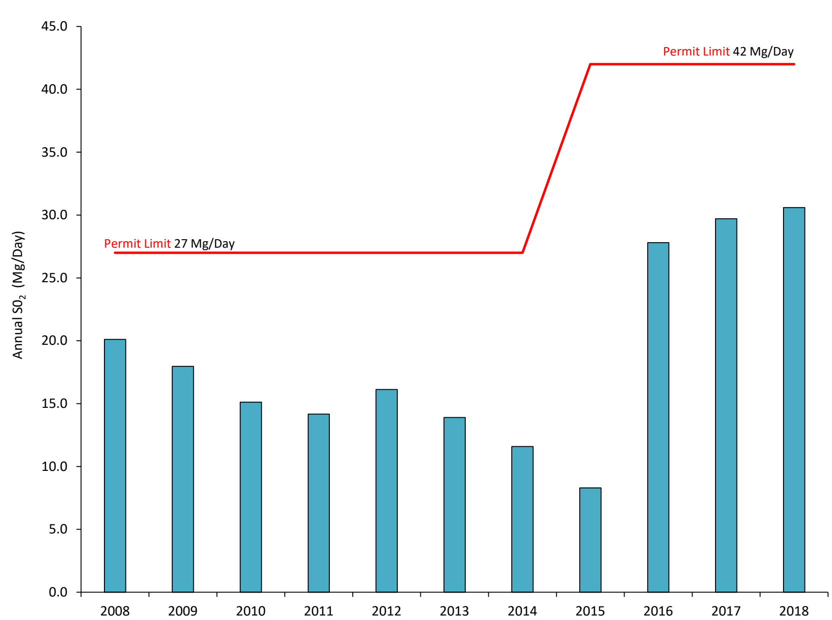


Figure 5.5 Monthly SO_2 emissions, BC Works 2018

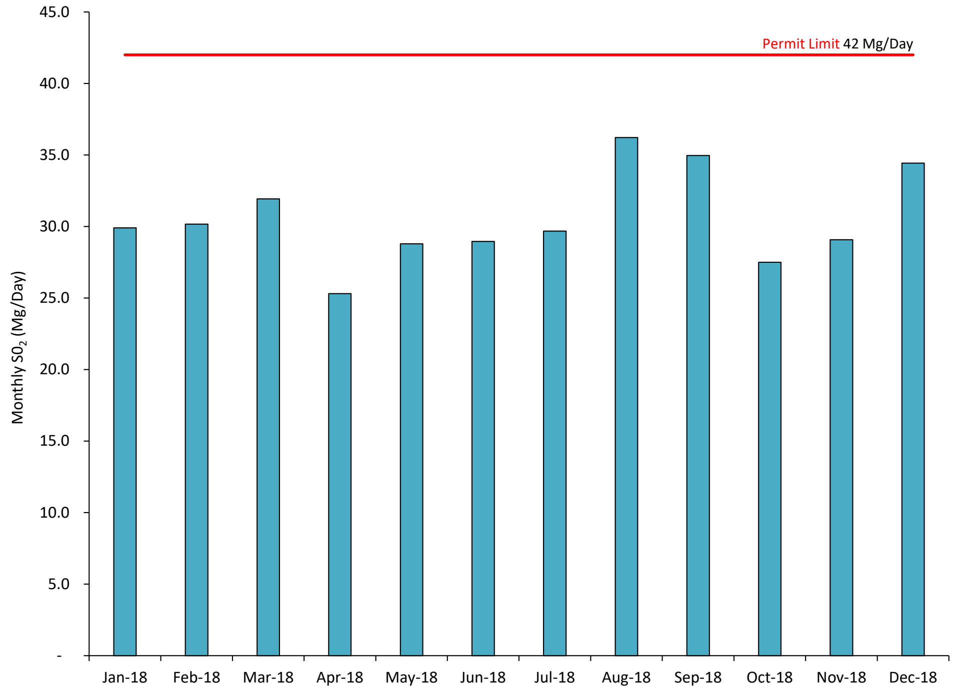


Figure 5.6 Nitrogen oxide emissions, BC Works 2007-2018

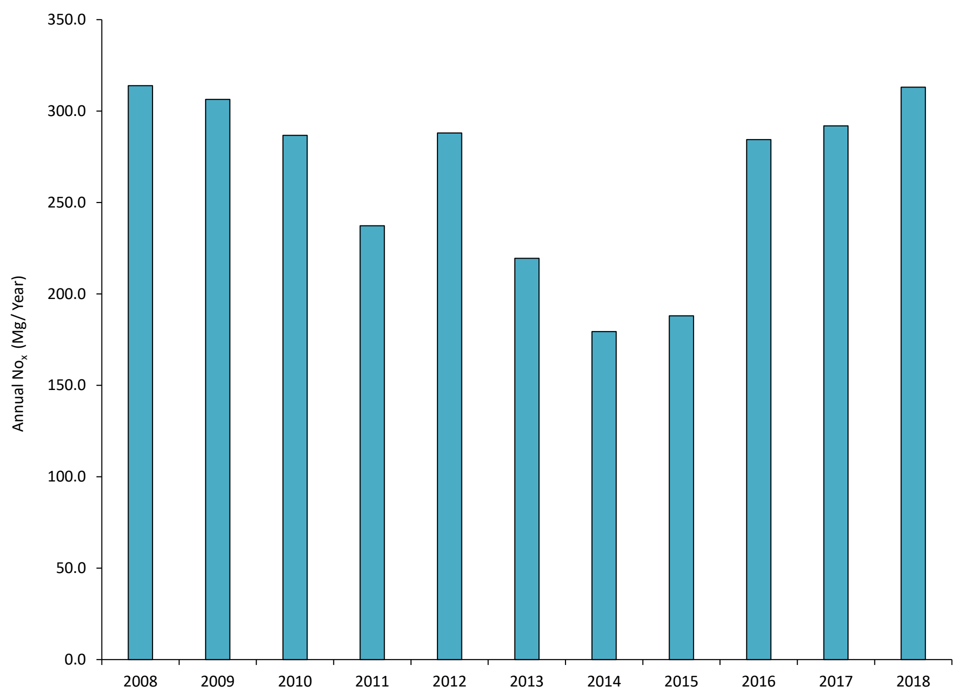


Figure 5.7
Potroom particulate emissions monthly rate, 2018

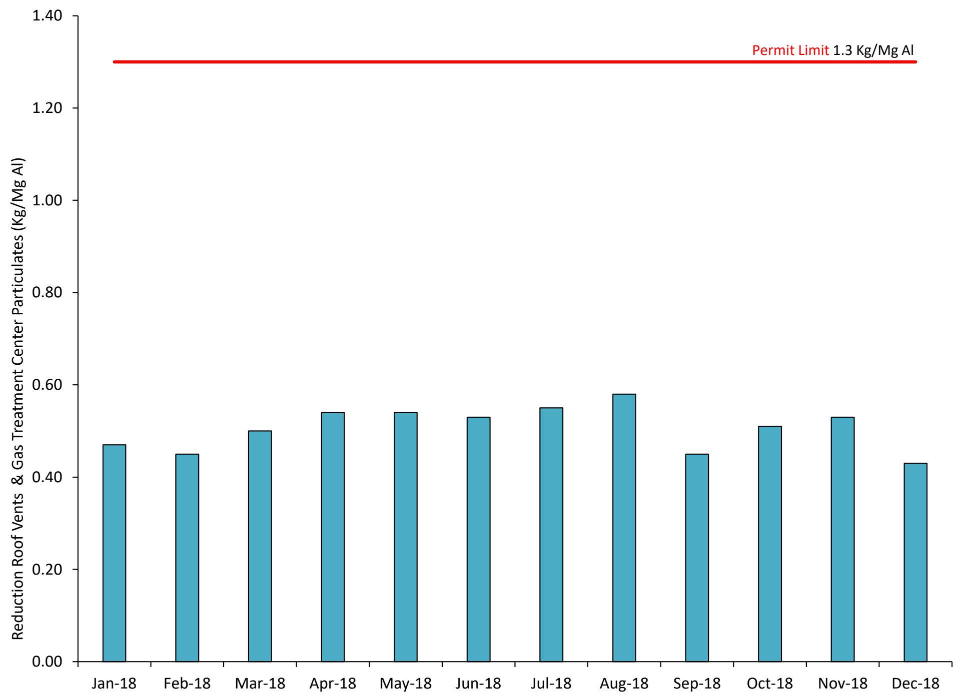


Figure 5.8
Potroom particulate emissions, 2008-2018

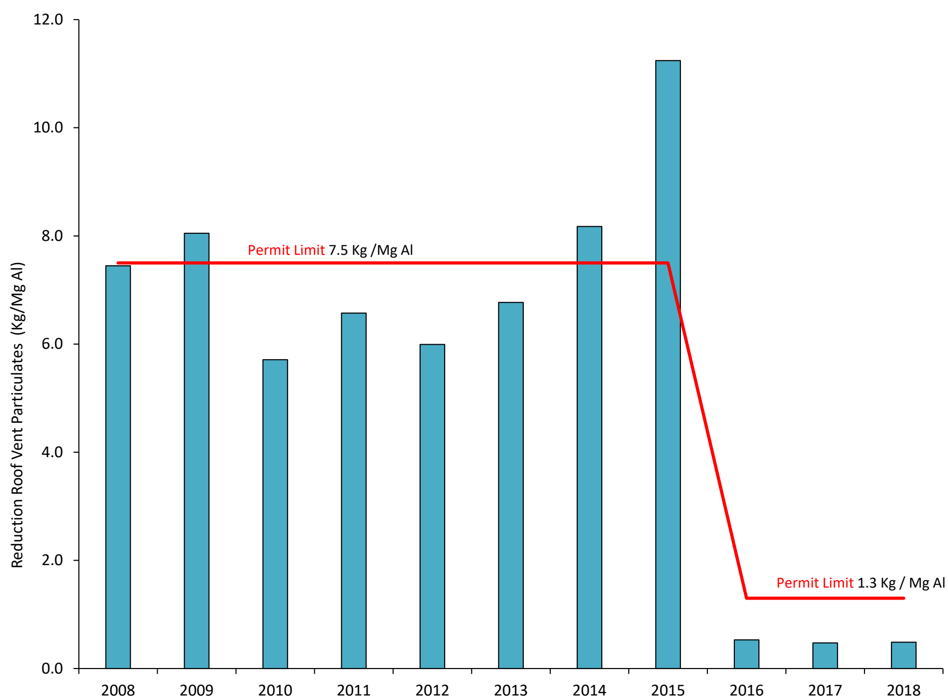


Figure 5.9
Particulate emissions distribution in 2018, BC Works

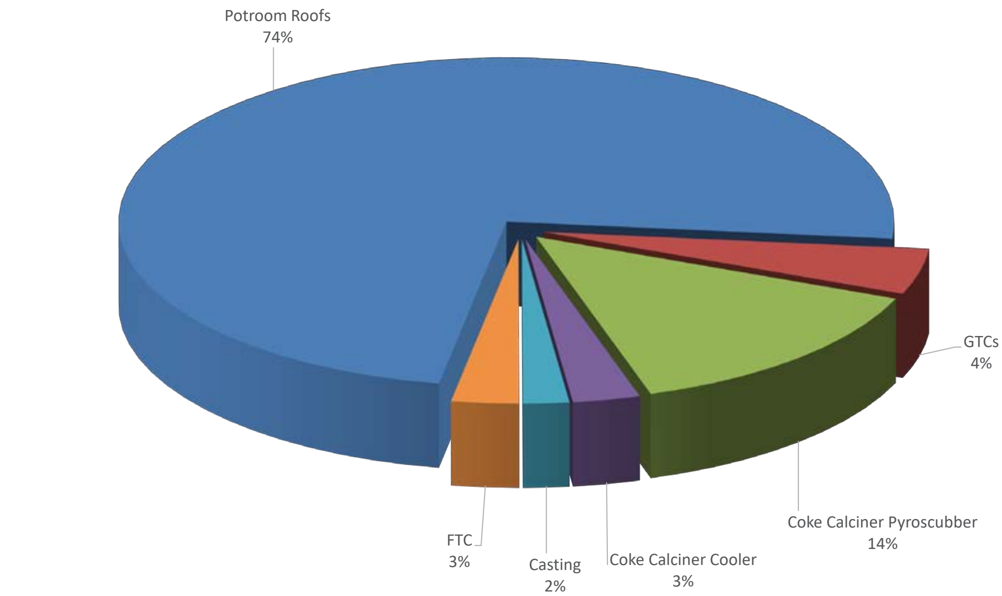


Figure 5.10
Total GHG emissions by Source, 2018

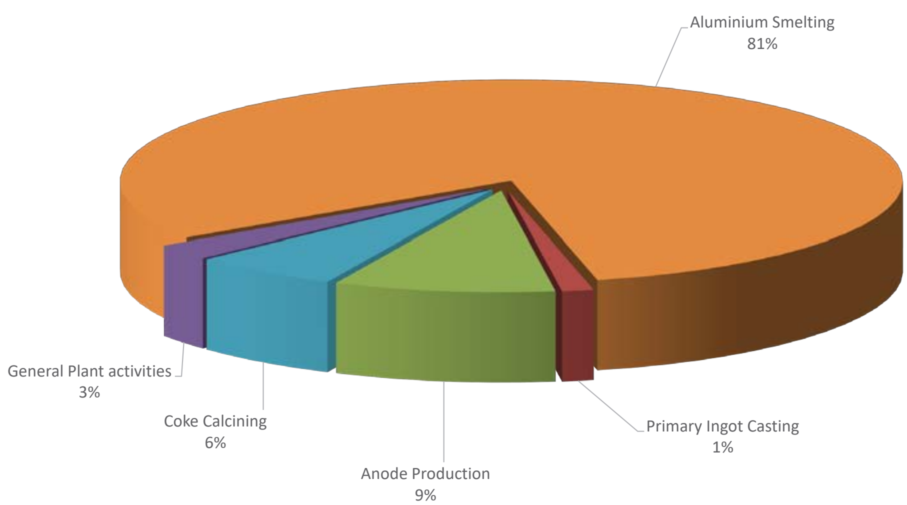


Figure 5.11
Breakdown of aluminium smelting GHG by Source, 2018

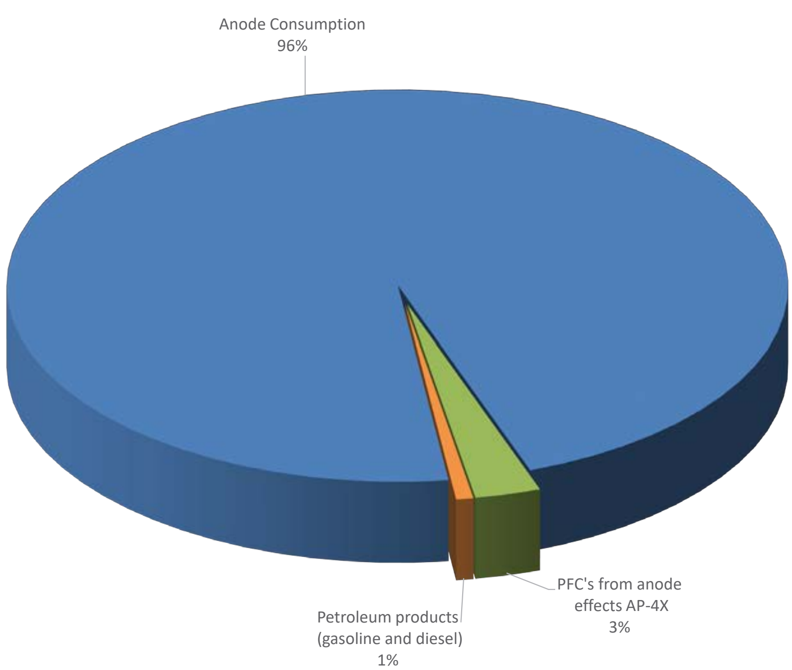


Figure 5.12
GHG Emissions,
BC Works 2018

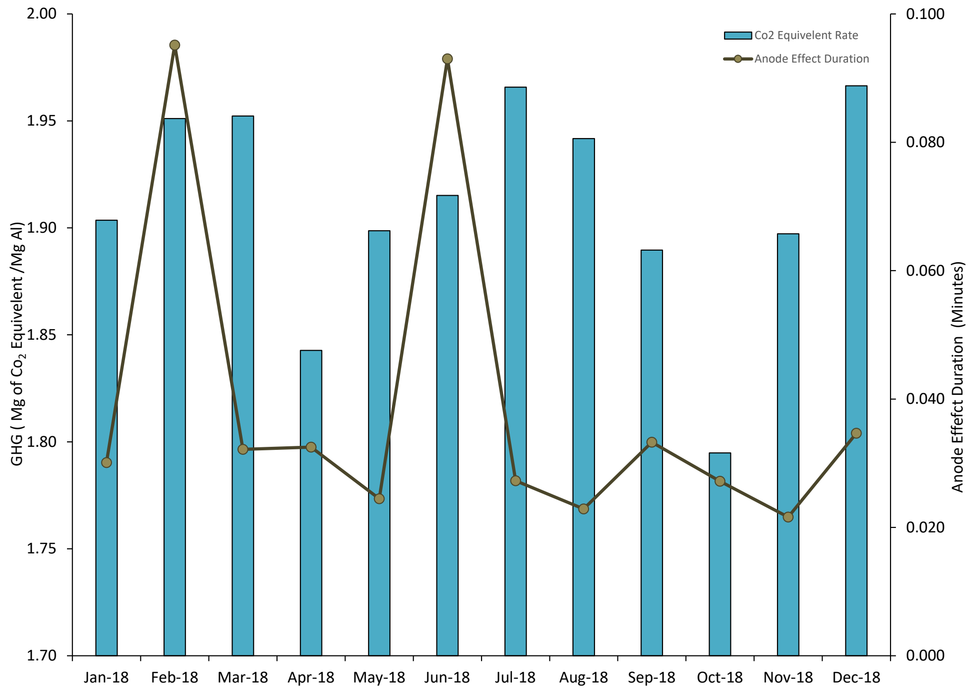
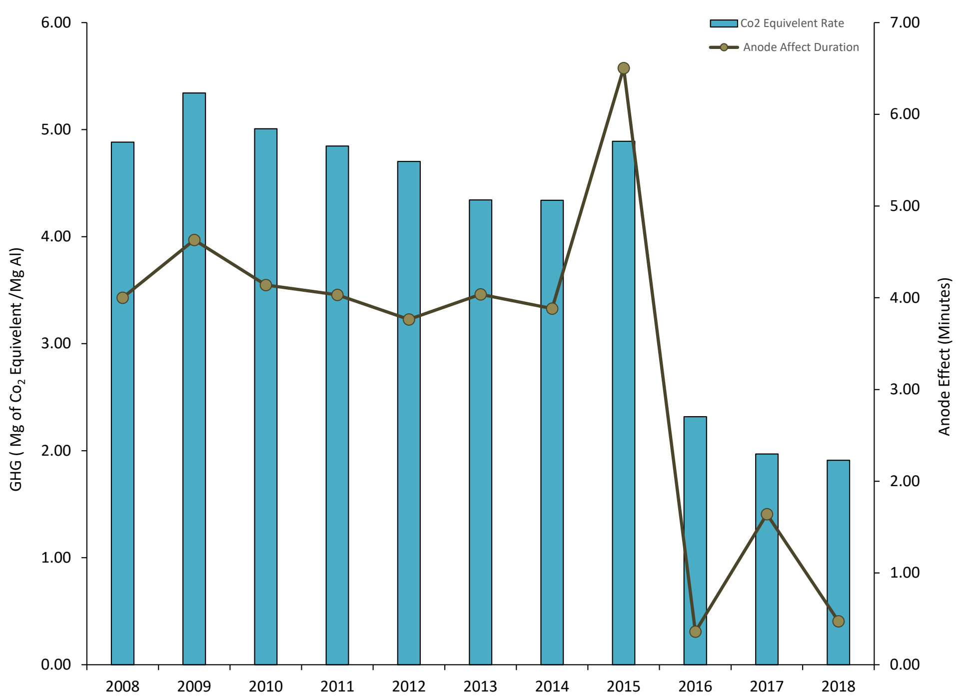


Figure 5.13
GHG emissions
BC Works 2008-2018



6. Air quality monitoring

BC Works conducts continuous ambient air quality monitoring at four stations in the lower Kitimat valley and one specialized station at Lakelse Lake. The monitoring parameters are illustrated in Table 6.1.

Network overview

Five air quality parameters are monitored: hydrogen fluoride (HF), sulphur dioxide (SO_2), polycyclic aromatic hydrocarbons (PAHs), and two levels of fine particulate matter. Particulate matter is referred to as PM_{10} and $PM_{2.5}$, and is measured against size thresholds of 10 and 2.5 microns, respectively. Rio Tinto voluntarily upgraded the Whitesail monitoring station in 2018 with new Nitrous Oxide (NO_X) and Ozone (O_3) monitors so that an Air Quality Health Index (AQHI) for Kitimat can be reported.

Meteorological (weather) monitoring data are collected at all four air quality monitoring stations plus the Yacht Club station. Precipitation monitoring and analysis is undertaken using samples collected at the Haul Road and Lakelse Lake stations. The weather and the precipitation data provide additional insight into air quality data interpretation.

Table 6.1 Ambient Air Monitoring Network

Ambient Air Network	Haul Road (HR)	Riverlodge (RL)	Whitesail (WS)	Kitamaat Village (KV)	Yacht Club (YC)	Lakelse Lake (LL)
Sulphur Dioxide (SO_2)	✔	✔	✔	✔		
Particulates ($PM_{2.5}$)	✔	✔	✔	✔		
Particulates (PM_{10})		✔				
Hydrogen Fluoride (HF)	✔	✔		✔		
Nitrous Oxides (NO_X)			✔			
Ozone (O_3)			✔			
AQHI Plus			✔			
Rain Chemistry	✔					✔
Meteoroidal Monitoring	✔	✔	✔	✔	✔	

The collected air quality data are reported out according to the P2-00001 Multimedia Waste Discharge permit. Specifically, Section 8.5 of the P2 permit requires the following reporting:

- SO_2 and HF: Mean monthly concentration and daily hourly maximums.
- $PM_{2.5}$ and PM_{10}: Daily average and daily hourly maximum concentrations
- PAH (15 congeners): all PAH data on a NAPS cycle.
- Rain chemistry for the Haul Road and Lakelse Lake stations (SO_2 EEM stations).

The scope of this chapter is to provide an interpretive summary of the above permit required monitoring and reporting. Additionally, hourly NO_X, O_3 and AQHI are presented.

Weather monitoring

Two new meteorological stations became operational in 2011, one at the Kitamaat Village station and the other at the Yacht Club located at the south end of the plant site. Each station measures temperature, wind direction and wind speed. Additionally, the Kitimat Smelter Road Station measures relative humidity.

The 2013 upgraded meteorological and weather monitoring data control program operated by BC Works is carried out to meet Ministry standards. In the event that air quality monitoring data indicate a problem on a particular date, weather data can provide insight into pollutant sources and other contributing factors. The upgraded meteorological installations at the ambient air quality monitoring stations go beyond the two weather station requirements in the P2 permit.

Quality assurance and control

The validation of air quality data is conducted using a quality control/quality assurance process. The quality control component is to ensure that all instrument maintenance and operational guidelines for the instruments are being followed correctly and documented. Moreover, when summarizing air quality data, a data completeness criteria of 75% is applied, as recommended in Ministry of Environment guidance documents.

Air quality monitoring stations in the Kitimat valley are operated by an independent consultant. A technician performs weekly inspections and routine maintenance on the equipment. Air quality data are reviewed monthly, validated and submitted to the Ministry. In the event where remedial actions are required to ensure the validity of the data, this information is reported to the Ministry.

The quality assurance procedure is conducted by Ministry staff. This involves visits twice per year to the sites. A review of station and instrument documentation, condition and a reference audit calibration check on each instrument being operated under permit is completed.

The results of the quality control/quality assurance process are then used to validate the data collected by the Provincial Air Quality Monitoring network (www.env.gov.bc.ca/epd/bcairquality).

2018 monitoring results

Ambient air quality monitoring for all results stations and parameters are presented in Table 6.2. This summary table has been changed from the previous Annual Environmental Reports, to include summary statistics for the reporting year in addition to comparisons against the BC Air Quality Monitoring Objectives.

Hydrogen fluoride (HF)

HF monitoring is done with Picarro analyzers (cavity ring down spectroscopy) and are presented in Table 6.2. The annual average measurement at Kitamaat Village was 0.0 parts per billion (ppb) and Riverlodge was 0.1 parts per billion (ppb). The maximum daily average concentrations were significantly lower than the 1 ppm HF objective for Kitimat by a factor of 10,000. Monthly HF averages for the residential stations are presented in Figure 6.2 and are below 0.1 ppb. The 30 day average is 400 times below the 40 ppb chronic exposure objective.

Sulphur dioxide (SO_2)

SO_2 is monitored at three residential stations (Riverlodge, Whitesail and Kitamaat Village) in addition to the Industrial Haul Road station. The P2 permit requires the reporting on hourly daily maximums and monthly averages. A summary of the 2018 monitoring results are provided in Table 6.2 and monthly means are shown in Figure 6.3. Beyond the required P2 permit reporting, the daily hourly averages for 2018 for all four stations are presented in Figure 6.4. Additionally the summary statistics in Table 6.2 include the percentile results for comparison to the 2017 adopted Provincial SO_2 Interim Air Quality Objective. In comparison to the new interim SO_2 air quality objective of 75 ppb (that came into effect in 2017), Riverlodge had the highest value but was only 23% of the BC air quality objective. SO_2 levels in the form of the BC AQO have increased over 2017's values due to the SO_2 interim AQO's escalating schedule of annual percentiles and having three years of full smelter production captured in the three year averaging period.

The residential maximum hourly average SO_2 concentrations shown in Table 6.2 ranged from 35.1 ppb to 8.4 ppb. There were no days in 2018 where the residential SO_2 hourly concentrations were above 75 ppb. Figure 6.4 shows the plots of hourly average SO_2 concentrations. Compiled annual SO_2 monitoring data are provided in Table 6.2. The maximum residential annual average SO_2 concentration was 0.5 ppb.

Particulate (PM_{10} and $PM_{2.5}$)

Fine particulates have a wide variety of sources, both natural and human-caused. In northern BC, forest fires (prescribed and wild), and emissions from fireplaces and wood burning stoves, are among the major contributors to fine particulate emissions.

In addition to these primary particulate emissions, further contribution occurs due to gas emissions undergoing physical and chemical reactions. Emissions from BC Works, including sulphur dioxide and nitrogen oxides, are among the precursors to these secondary particulates.

Provincial ambient air quality objectives define the 24 hour average for PM_{10} as 50 micrograms per cubic metre (µg/m³) and the 98th percentile of the daily average over 1 year for $PM_{2.5}$ is 25 ug/m³.

The P2 permit requires the reporting for particulate matter to include both daily average and daily hourly maximum concentrations for both $PM_{2.5}$ and PM_{10}. Beyond the required permit reporting, additional statistics for fine particulates are presented in Table 6.2. Charts of the daily average fine particulates for all the reporting stations are provided in Figures 6.5 and 6.6. Average $PM_{2.5}$ levels for Kitimat are low, ranging between 4.7 ug/m³ to 5.3 ug/m³. Residential stations had 3 days above the BC AQO due to forest fire smoke.

$PM^{2.5}$ data for the Whitesail and Kitimat Village stations were invalidate from August 2016 to June 16, 2018 and PM^{10} data for Riverlodge was invalidated from August 2016 to June 20, 2018 due to the Service Provider for the Monitoring stations missing the completion of annual tests to correct for background noise. The particulate measurements during these periods were reported higher than actual.

NO_X, O_3 and AQHI-Plus

Information on NO_X, O_3 and AQHI-Plus is provided in addition to P2 Permit requirements. The Whitesail station was upgraded in the spring of 2018 with two new monitors for measuring ambient NO_X (NO and NO_2) and O_3. The addition of these new monitors along with the existing $PM_{2.5}$ monitor allows for the reporting of the Air Quality Health Index (AQHI). The AQHI-Plus is an adjustment to AQHI for smoke. Information on the AQHI-Plus and health risk information can be found at https://www2.gov.bc.ca/gov/content/environment/air-land-water/air/air-quality/aqhi. Figures 6.7 and 6.8 present the NO_X and O_3 monitoring data from July to December. AQHI-Plus is shown in Figure 6.9 for the same period. For most of the hours between July to December, the AQHI-Plus values are low. There were two periods in July and August when the AQHI-Plus ranged from Moderate to Very High health risks due to wildfire smoke. November and December had two periods on Moderate health risks due to wood smoke that was likely associated with open burning.

Polycyclic aromatic hydrocarbons (PAHs)

PAHs are generated by the incomplete combustion of organic material. Various procedures at Kitimat Operations generate PAHs, in both dissolved and gaseous forms. They occur in emissions primarily as a by-product of the anode manufacturing process; other sources include vehicle exhaust and smoke from forest fires and wood-burning stoves.

Ambient air monitoring is conducted to test for the presence of some of the most common PAHs, although no permit limits exist. Sampling is done on a schedule that is coordinated with the National Air Pollution Surveillance (NAPS) to enable comparison of findings from different monitoring sites. The P2 permit requires the monitoring of 15 PAH congeners.

The 2018 ambient PAH monitoring results are summarized in Table 6.3. The geometric mean PAH concentration observed at Haul Road station was 7.9 ng/m^3, Whitesail station was 3.1 ng/m^3 and Kitimat Village was 4.0 ng/m^3. In 2018, total PAHs showed a reduced degree of variability (Figure 6.9) when compared to previous years. This is due to the significant reductions in PAH emissions by the modernised smelter.

Figure 6.10 shows the distribution of the 15 PAH congeners for the three stations. The PAH congeners are sorted according to molecular weight. As can be seen in figure 6.8, over 80% of the PAHs for all three stations are light molecular weight PAHs. Changes in distribution of PAH congeners between the stations is not only due to distance from the smelter source, but also photochemical degradation and seasonal contributions of different PAH sources such as vehicle exhaust, petroleum fumes and wood stoves.

Rain chemistry

Precipitation samples are collected on a weekly basis from the Haul Road and Lakelse Lake stations. Rain chemistry monitoring has been conducted since 2000 and was expanded to include Lakelse Lake in 2013. Rainfall quantity is recorded. Samples are assessed for rain acidity and concentrations of 11 specific substances. Annual averages of weekly samples and the geometric mean measures are presented in Table 6.4. High levels of acidity (i.e. a low pH) and concentrations of certain substances are characteristic of the condition referred to as 'acid rain'. Long-term vegetation monitoring (refer to Chapter 7 – Vegetation monitoring) in the Kitimat valley has confirmed an absence of this type of damage.

Table 6.2: 2018 Ambient Air Quality Monitoring Results

Statistic	Industrial	Residential		
	Haul Road	Riverlodge	Whitesail	Kitamaat Village
	SO_2			
2018 Annual average (ppb)	3.7	0.5	0.3	0.2
BC AQO for SO_2*		17.2	13.4	8.4
Days above 75 ppb (Hourly)		0	0	0
Minimum (Hourly, ppb)	0	0	0	0
Maximum (hourly, ppb)	101.9	35.1	23.7	30.7
Percent Data Capture (%)	94	95	95	95
Standard Deviation (ppb)	7.9	1.8	1.3	1.3
	$PM_{2.5}$			
2018 Average (ug/m^3)	4.7	5.3	4.7	5
BC AQO for PM2.5		10.9	14	16.8
Days above 25 ug/m^3		2	3	3
Minimum (Hourly, ug/m^3)	0	0	0	0
Maximum (hourly, ug/m^3)	177	122	121	165
Maximum daily average (ug/m^3)	64.3	57.9	61	67.1
Percent Data Capture (%)	97	99	52	54
Standard Deviation (ug/m^3)	4.5	3.9	5.6	6.1
	PM_{10}			
2018 Average (ug/m^3)		5.3		
Minimum (Hourly, ug/m^3)		0		
Maximum (hourly, ug/m^3)		133		
Maximum daily average (ug/m^3)		63.6		
Days above 50 ug/m^3		1		
Percent Data Capture (%)		53		
Standard Deviation (ug/m^3)		6		
	HF			
2018 Average (ppb)		0.1		0.0
Minimum (Hourly, ppb)		0.0		0.0
Maximum (hourly, ppb)		0.2		0.1
Days above 1ppm (hourly)		0.0		0
Percent Data Capture (%)		100		16
Standard Deviation (ppb)		0.1		0.0
	NO_X			
Average July – December (ppb)			2.8	
Minimum (Hourly, ppb)			0.0	
Maximum (hourly, ppb)			33.2	
Percent Data Capture (%)			94.2	
Standard Deviation (ppb)			3.1	
	O_3			
Average July – December (ppb)			15.2	
Minimum (Hourly, ppb)			0.0	
Maximum (hourly, ppb)			46.2	
Percent Data Capture (%)			94.7	
Standard Deviation (ppb)			9.1	

* 2018 BC Ambient Air Quality Objective (AAQO) for SO_2 is the 3 year average of the 97.5th percentile of the annual 1 hour daily maximum

** BC Air quality objective for $PM_{2.5}$ is the annual 98th percentile of the 24 hour average.

Table 6.3
Geometric mean Total 15 PAH Concentrations (2016, 2017 and 2018)

Station	15 PAH Average (ng/m^3)			2018 15 PAH Statistics (ng/m^3)		
	2016	2017	2018	Min	Max	Standard Deviation
Haul Road	8.9	9.5	7.9	1.0	72.0	10.9
Whitesail	4.1	3.3	3.1	0.7	12.8	12.8
Kitimat Village	5.3	5.2	4.0	0.8	19.6	2.9

Table 6.4
Rain chemistry monitoring (2015 to 2018)

			Haul Road				Lakelse Lake			
Year			2015	2016	2017	2018	2015	2016	2017	2018
Important Milestone / Parameter			"VSS stopped KMP Ramp-up"	APX Last	Smelter stabilization	Smelter stabilization	"VSS stopped KMP Ramp-up"	APX Last	Smelter stabilization	Smelter stabilization
Precipitation	Precipitation Depth (mm)	Total	2372	1700	2467	1700	1526	1661	1506	979
Acidity	Rain (pH)	average	4.5	4.4	4.6	4.4	5.2	5.0	4.9	4.9
		geomean	4.5	4.4	4.5	4.4	5.2	5.0	4.9	4.9
	Acidity (to pH 8.3) $CaCO_3$ (mg/L)	average	3.9	3.4	4.0	3.4	0.7	1.0	2.1	0.5
		geomean	3.5	2.5	3.4	2.5	0.7	1.0	1.2	0.5
	Acidity - Free (µeq/L)	average	20.4	27.7	21.0	27.8	3.6	5.4	7.6	1.2
		geomean	14.9	13.6	10.5	13.6	2.7	3.1	5.1	1.2
	Alkalinity - Total $CaCO_3$ (mg/L)	average	0.9	0.8	1.1	0.9	1.8	0.8	0.9	0.1
		geomean	0.9	0.8	1.0	0.8	1.1	0.8	0.9	0.0
Concentration of Specific Substances (mg/L)	Chloride (Cl)	average	0.3	0.4	0.3	0.5	0.1	0.1	0.1	0.2
		geomean	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	Fluoride (F)	average	0.6	0.8	0.6	0.8	0.02	0.02	0.11	0.01
		geomean	0.5	0.5	0.4	0.5	0.01	0.02	0.02	0.01
	Sulphate (SO_4)	average	1.8	1.9	1.8	1.9	0.28	0.56	0.55	0.74
		geomean	1.4	1.3	1.4	1.3	0.19	0.37	0.37	0.45
	Ammonia Nitrogen (NH_4)	average	0.06	0.07	0.06	0.07	0.03	0.02	0.03	0.05
		geomean	0.03	0.03	0.0	0.03	0.00	0.01	0.02	0.02
	Nitrate Nitrogen (NO_3)	average	0.18	0.27	0.17	0.27	0.22	0.17	0.17	0.31
		geomean	0.14	0.03	0.13	0.16	0.13	0.13	0.13	0.1
	Total Dissolved Phosphate (PO_4)	average	0.01	0.01	0.03	0.01	0.00	0.01	0.00	0.00
		geomean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Aluminium (D-Al)	average	0.23	0.11	0.17	0.11	0.01	0.02	0.03	0.00
		geomean	0.15	0.07	0.11	0.07	0.01	0.01	0.01	0.00
	Calcium (D-Ca)	average	0.06	0.09	0.14	0.09	0.06	0.04	0.03	0.07
		geomean	0.05	0.06	0.06	0.06	0.03	0.03	0.02	0.04
	Magnesium (D-Mg)	average	0.02	0.03	0.03	0.03	0.01	0.01	0.01	0.02
		geomean	0.01	0.02	0.03	0.02	0.01	0.01	0.01	0.01
	Potassium (D-K)	average	0.02	0.02	0.08	0.02	0.02	0.02	0.01	0.02
		geomean	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
	Sodium (D-Na)	average	0.26	0.35	0.27	0.35	0.07	0.06	0.06	0.10
		geomean	0.22	0.23	0.20	0.23	0.04	0.04	0.03	0.04

Figure 6.1 Location of Ambient Air Monitoring Stations in the Kitimat Valley.

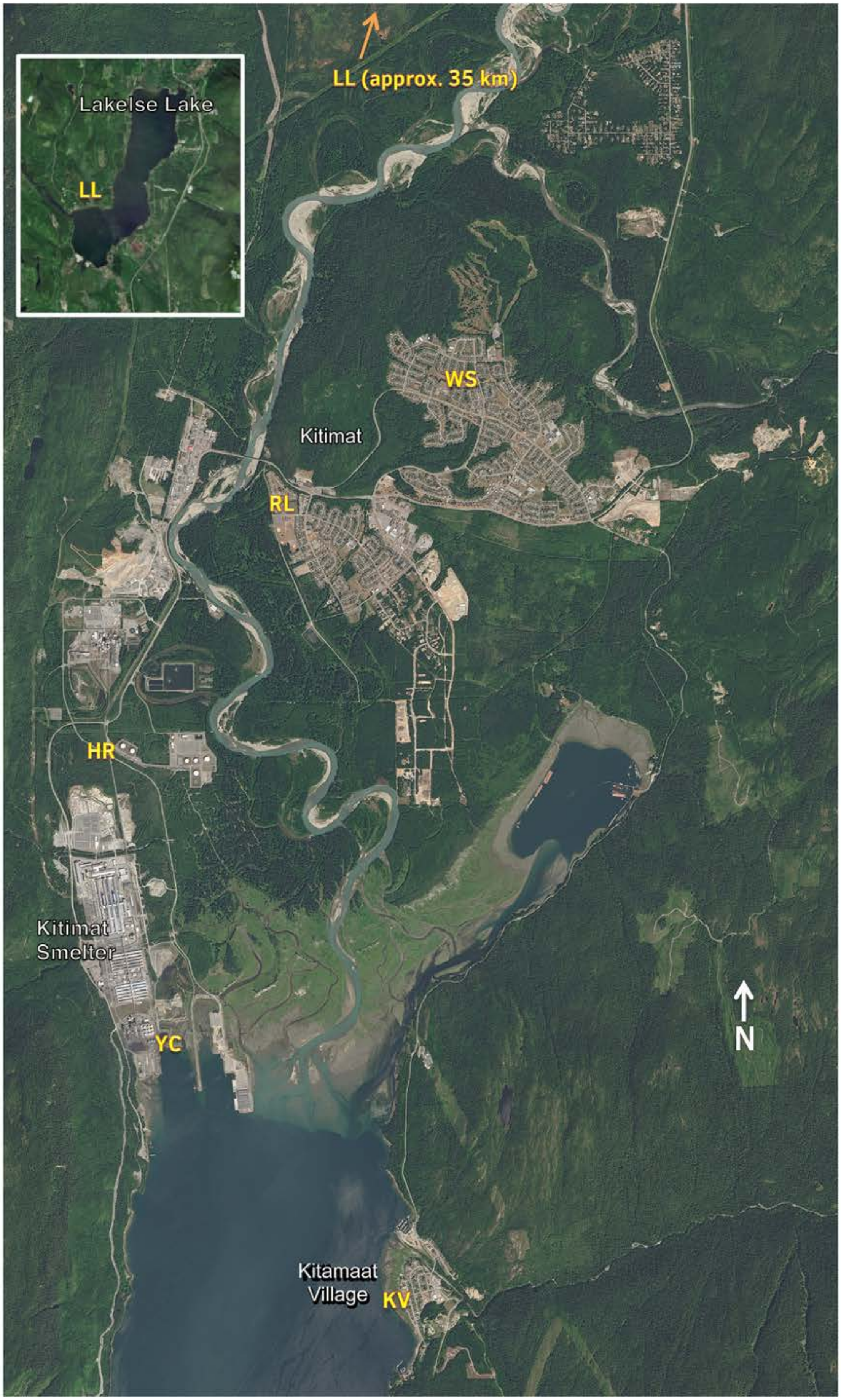


Figure 6.2
Hydrogen Fluoride Monthly Average Concentrations

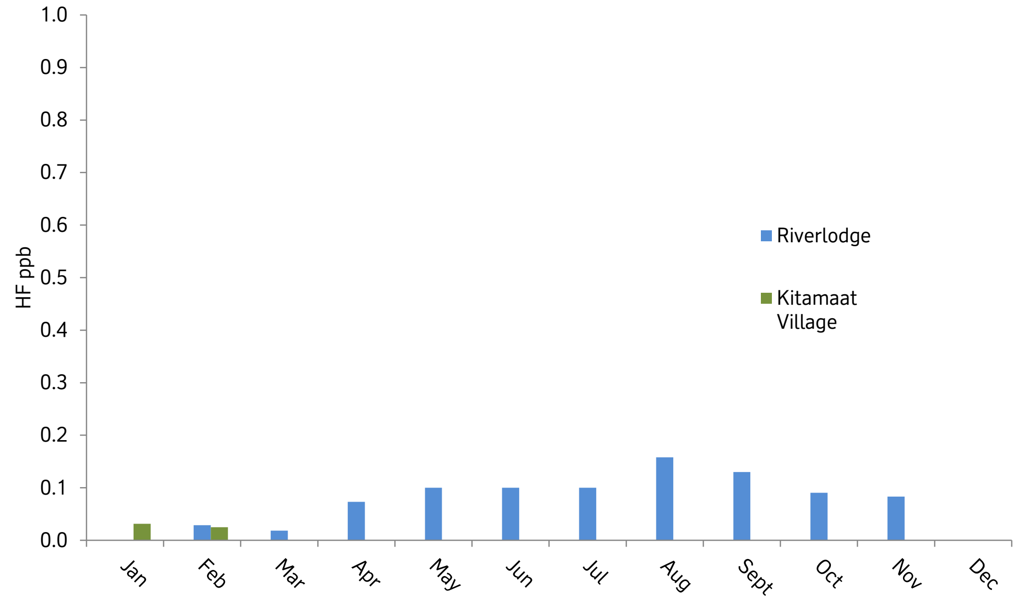


Figure 6.3a
SO_2 Residential Monthly Average Concentrations

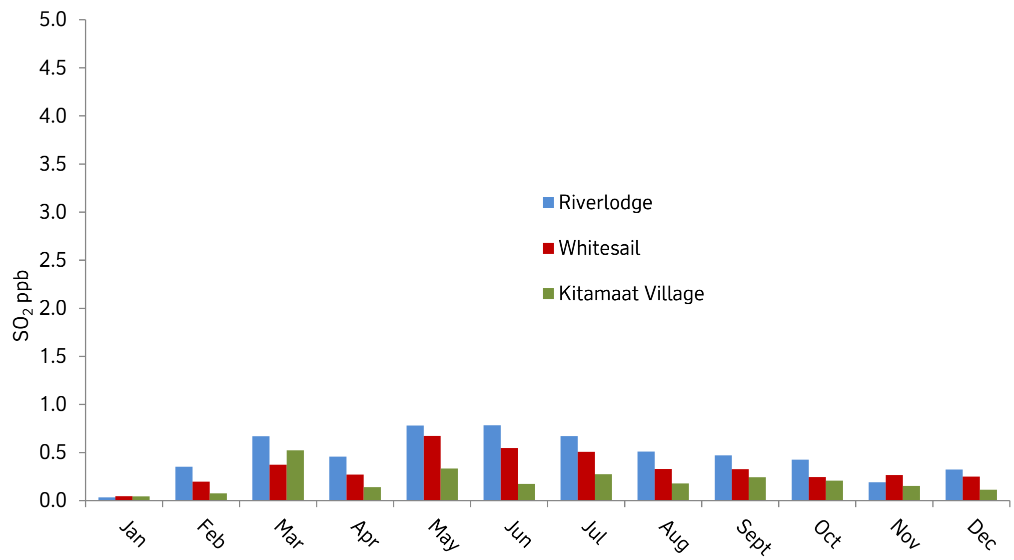


Figure 6.3b
SO_2 Haul Road Monthly Average Concentrations

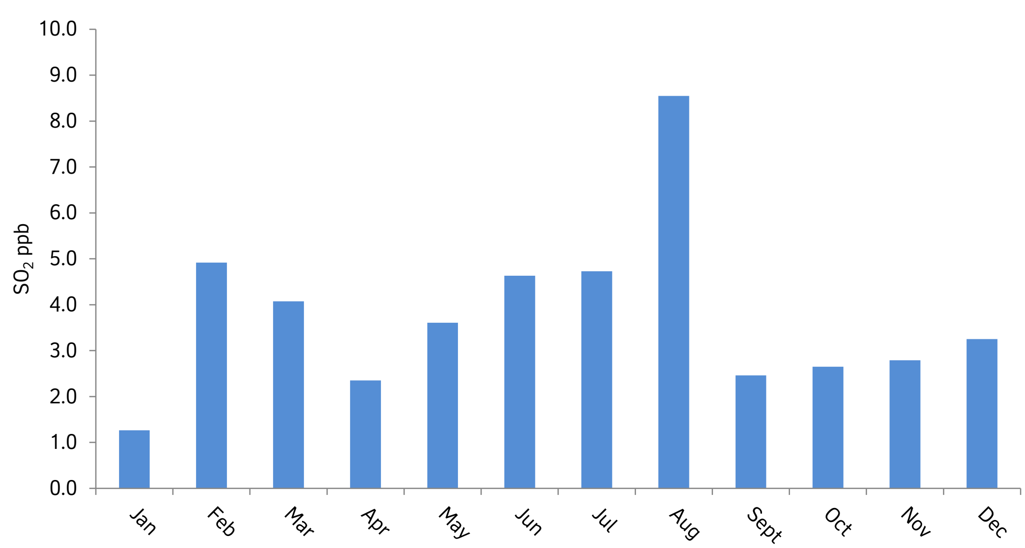


Figure 6.4a
SO_2 Haul Road 2018 Hourly Concentrations

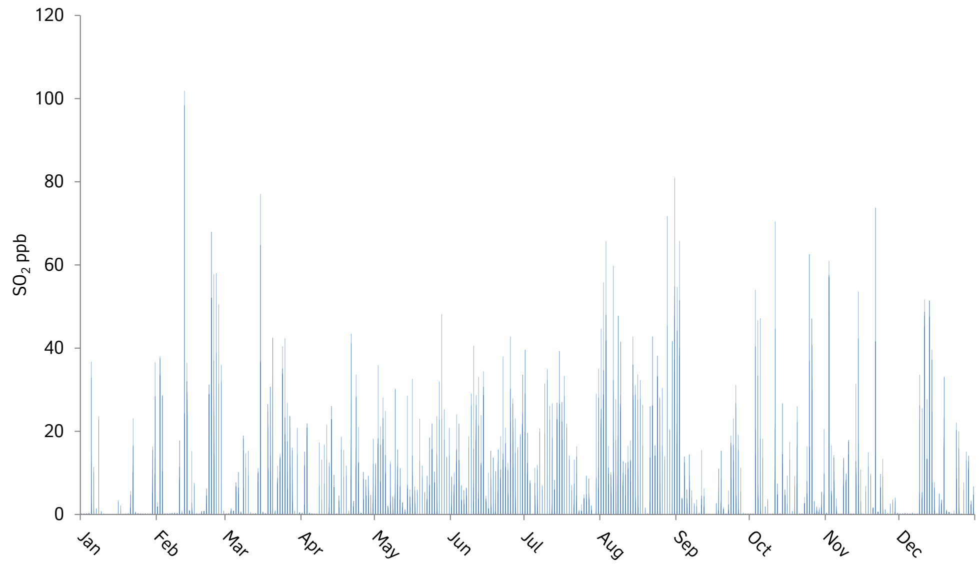


Figure 6.4b
Riverlodge 2018 Hourly SO_2 Concentrations

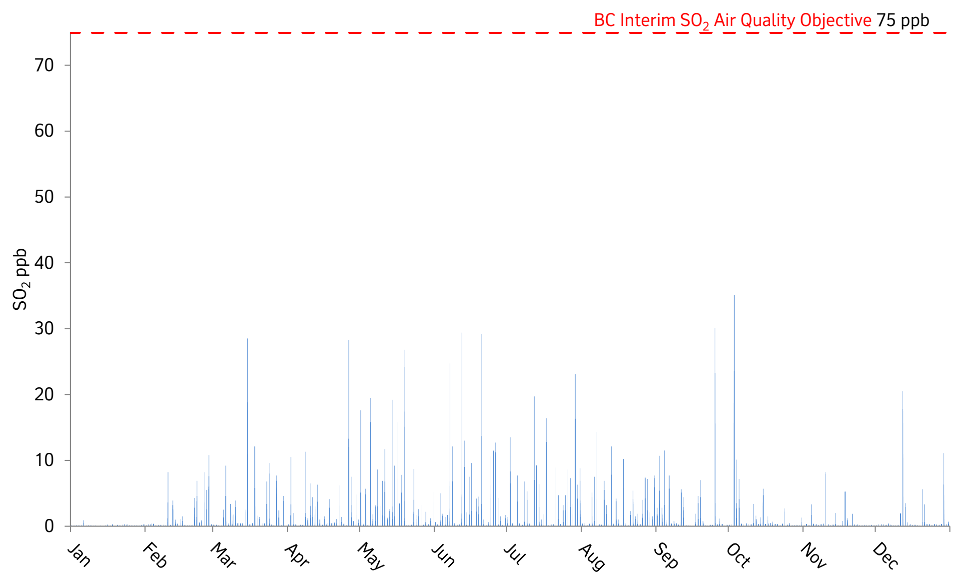


Figure 6.4c
Whitesail 2018 Hourly SO_2 Concentrations

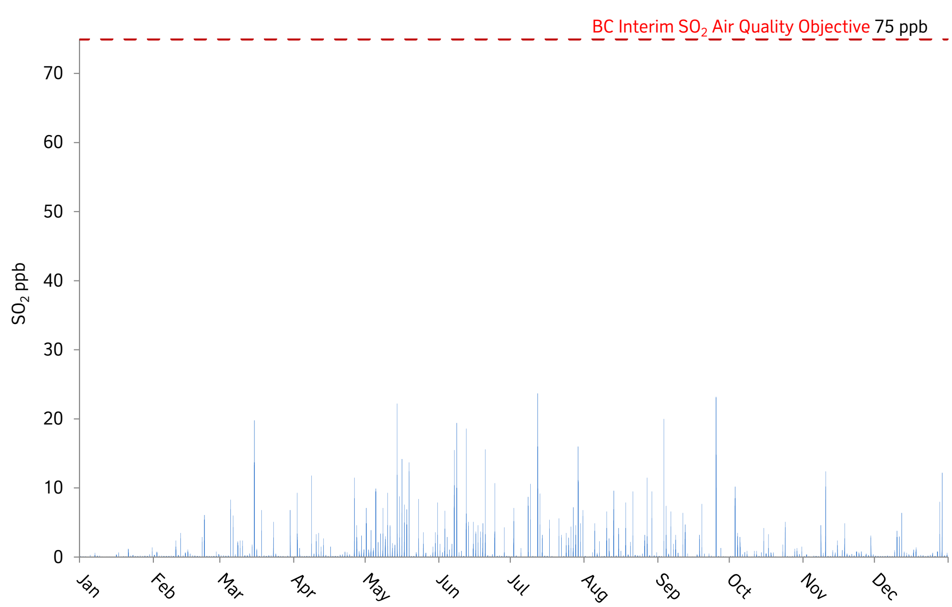


Figure 6.4d
Kitamaat Village
2018 Hourly SO_2
Concentrations

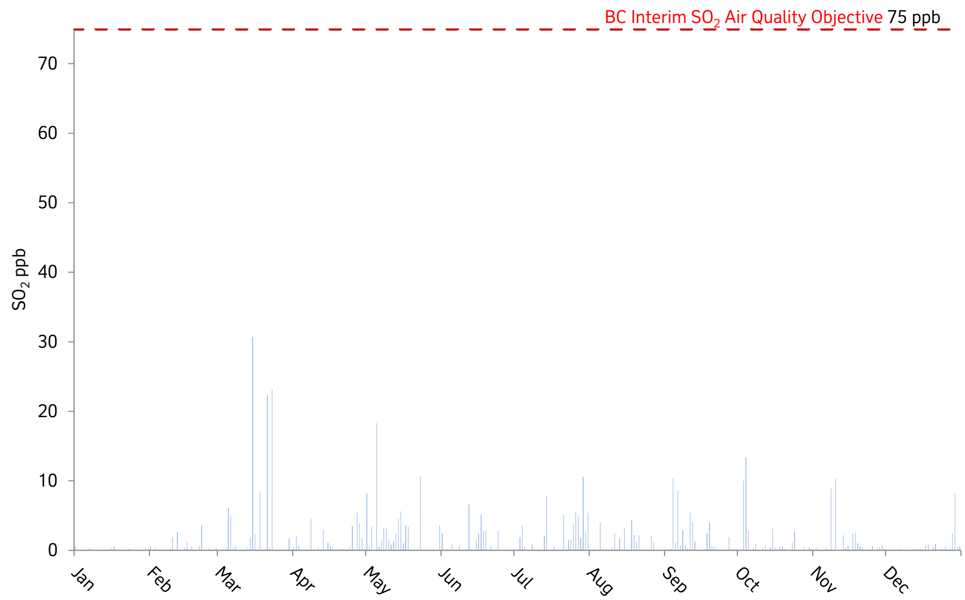


Figure 6.5a
Haul Road $PM_{2.5}$
2018 Daily Average

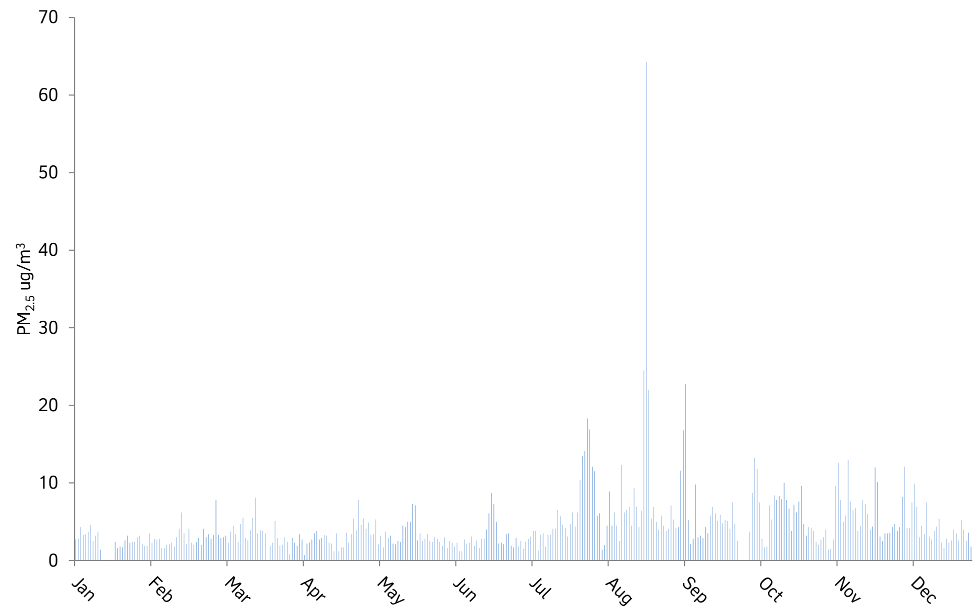


Figure 6.5b
Riverlodge
2018 $PM_{2.5}$
Daily Average

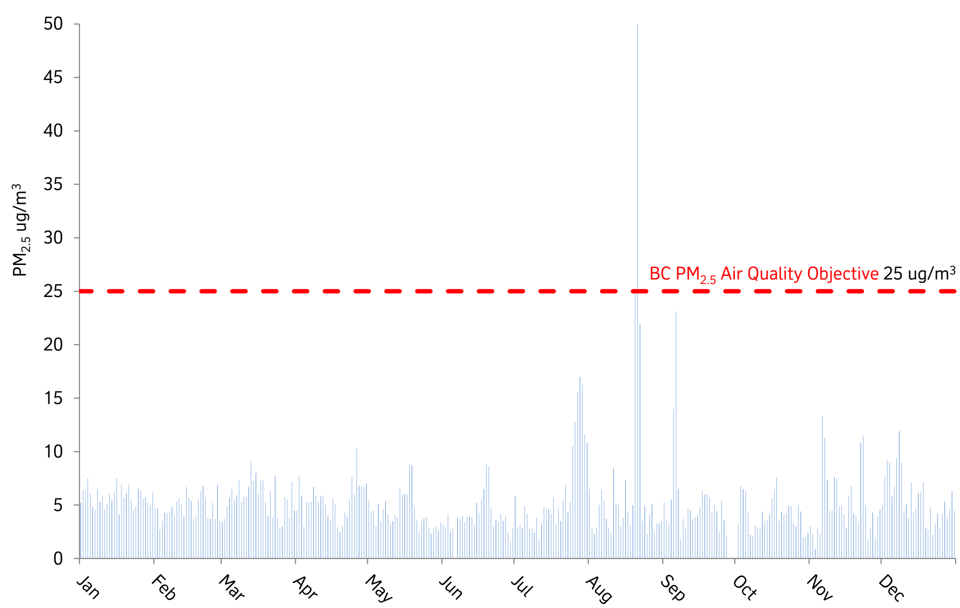


Figure 6.5c
Whitesail 2018
$PM_{2.5}$ Daily Average

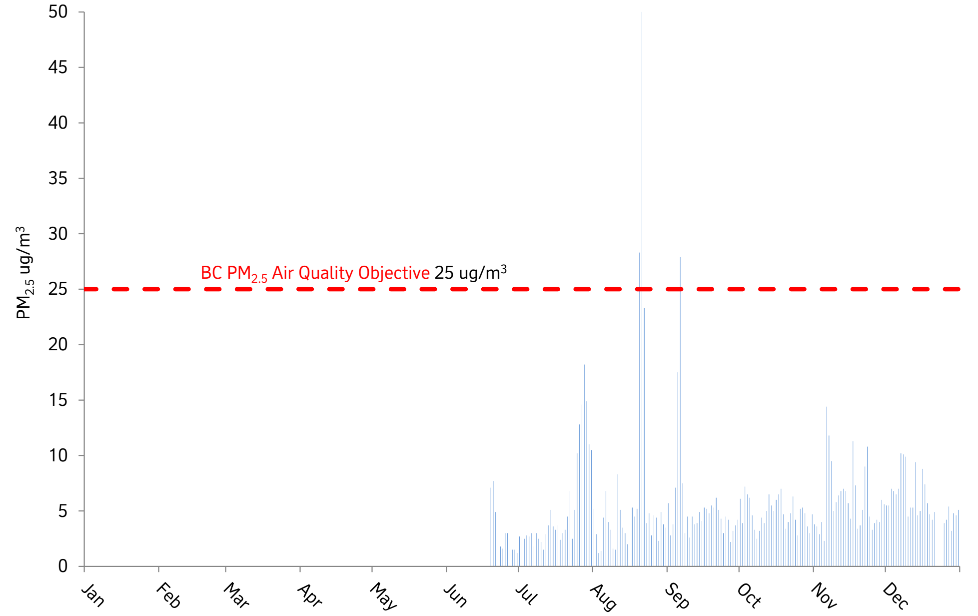


Figure 6.5d
Kitamaat Village
2018 $PM_{2.5}$
Daily Average

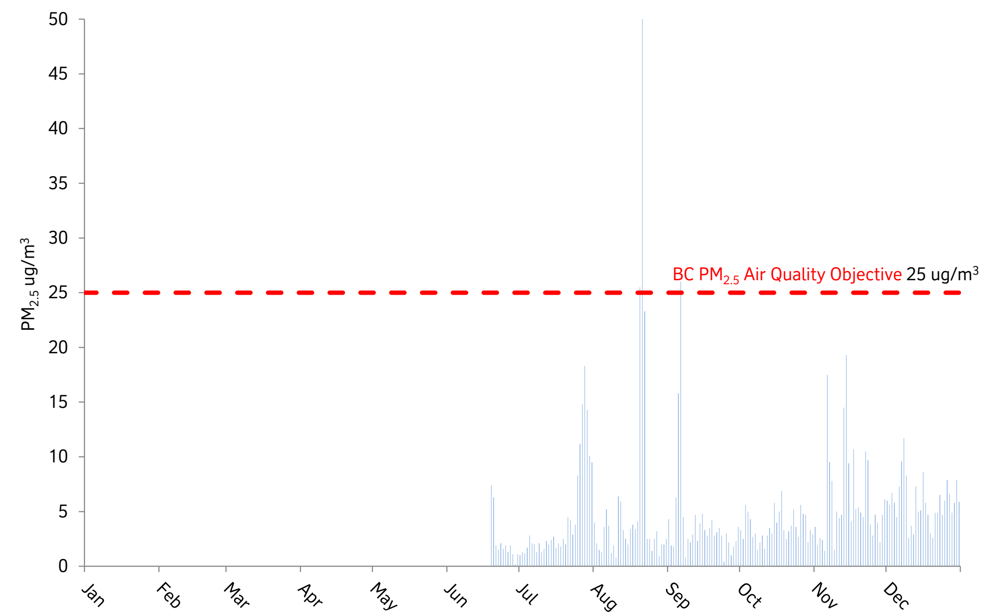


Figure 6.6
Riverlodge 2018
PM_{10} Daily Average

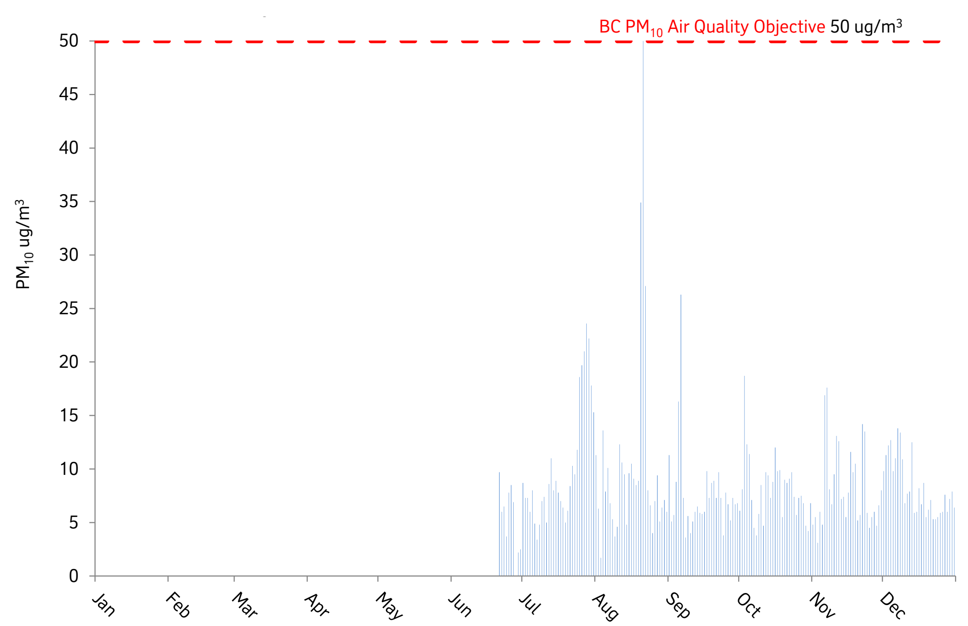


Figure 6.7
Whitesail 2018
NO_X Hourly
Concentrations

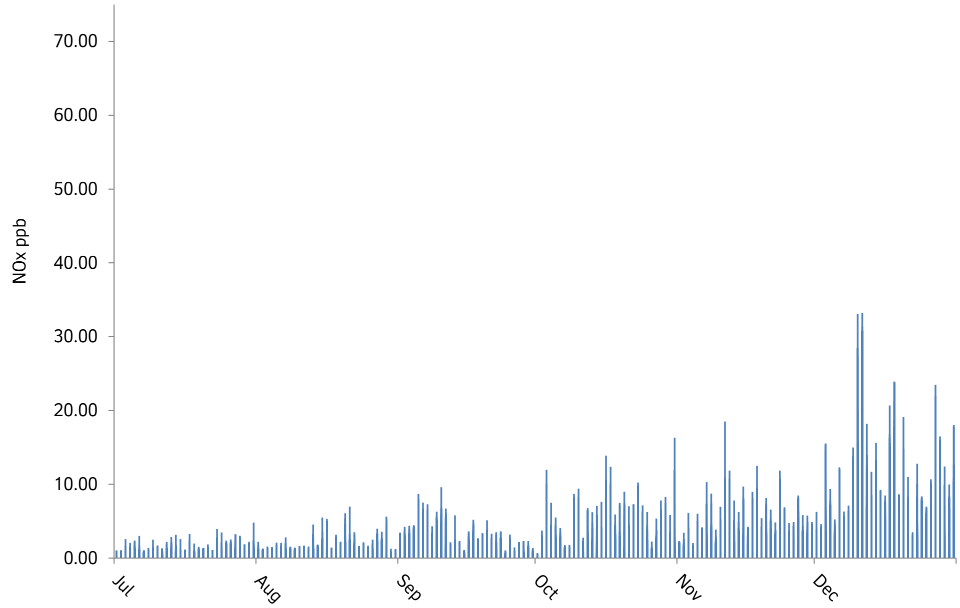


Figure 6.8
Whitesail 2018
O_3 Hourly
Concentrations

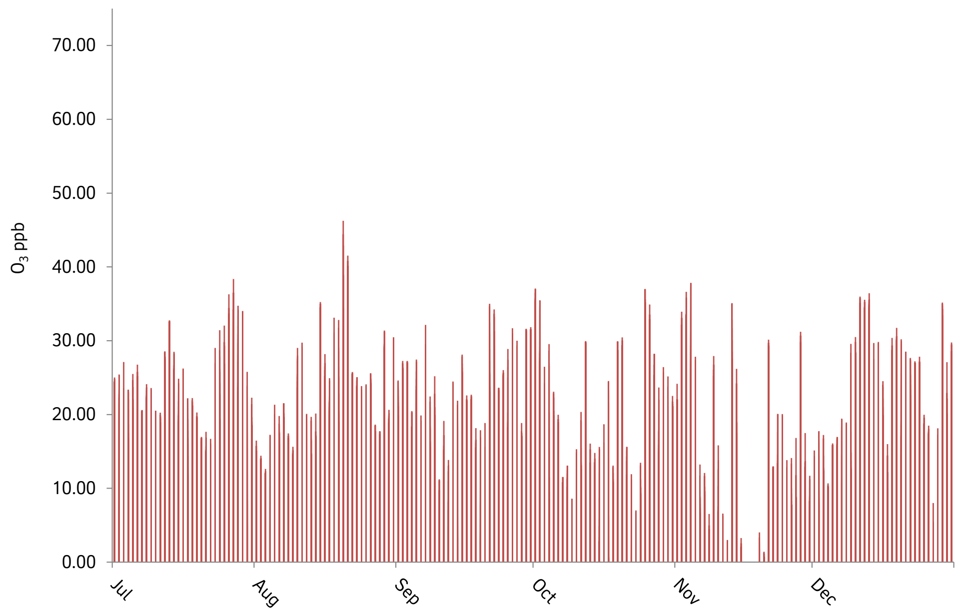


Figure 6.9
Hourly Air Quality
Health Index
(AQHI-Plus)

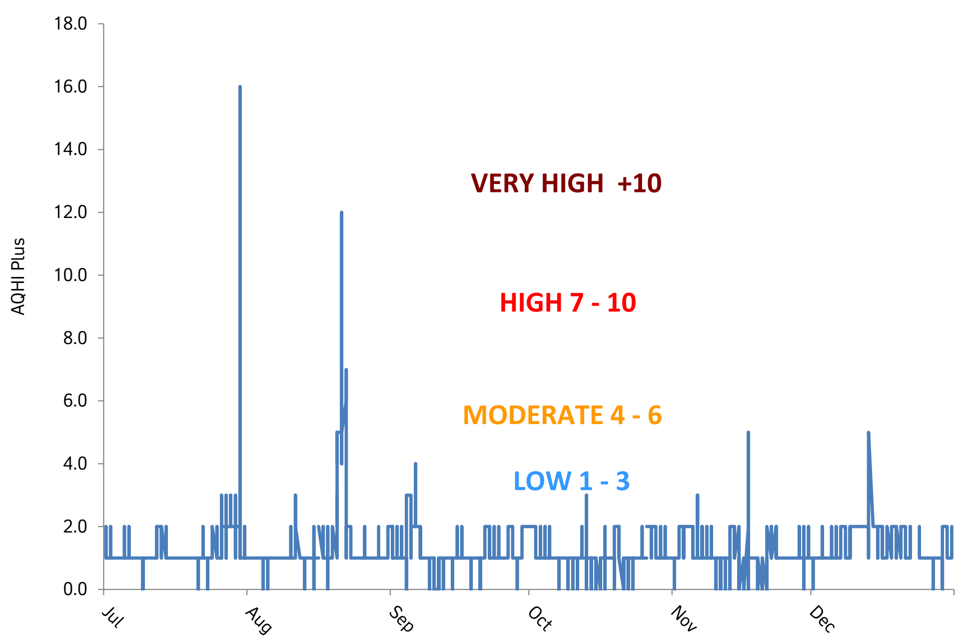


Figure 6.10a
15 PAH Haul Road 2018

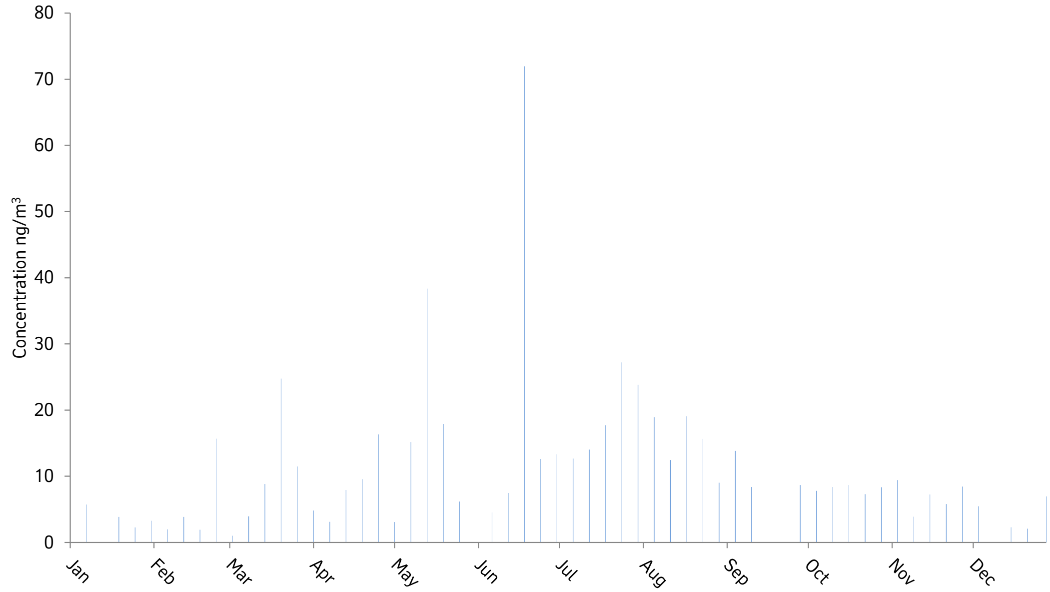


Figure 6.10b
15 PAH Whitesail 2018

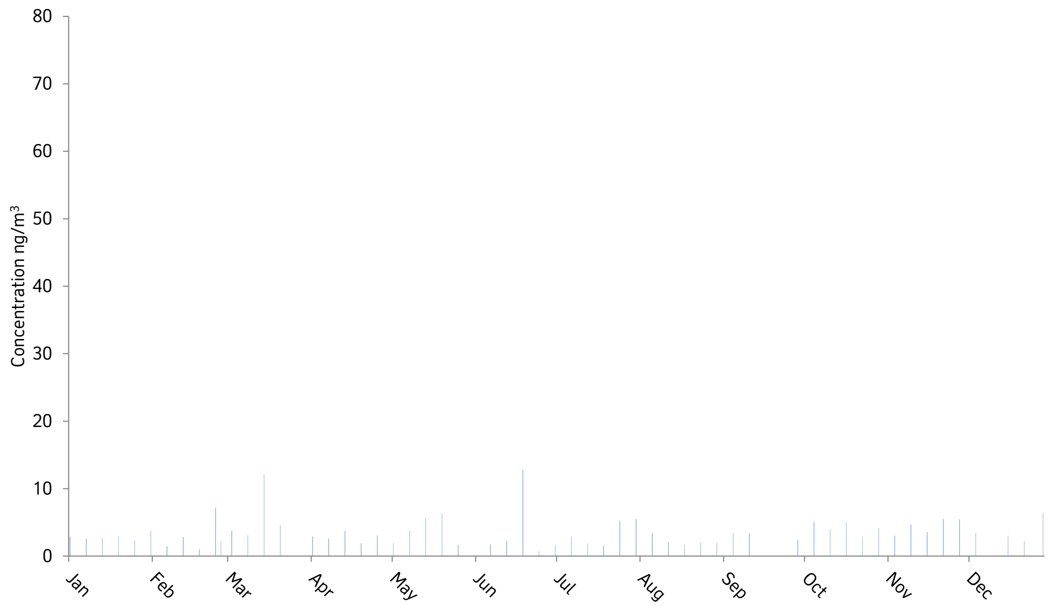


Figure 6.10c
15 PAH Kitamaat Village 2018

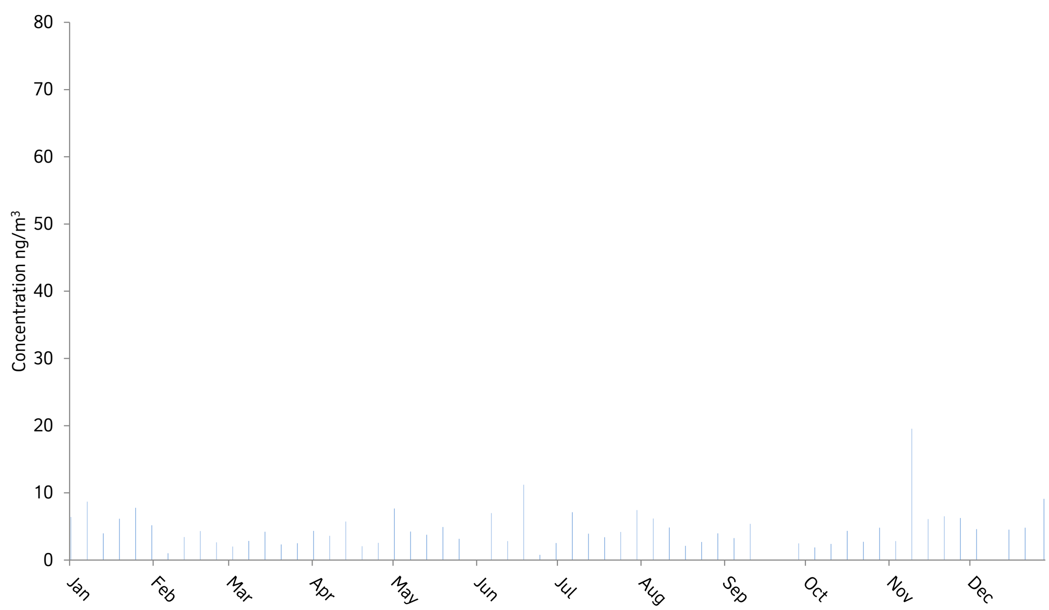


Figure 6.11
2018 PAH Congener Distribution

7. Vegetation monitoring

The vegetation monitoring and assessment program consists of two parts: first, an annual collection of current year foliage of western hemlock, followed by an analysis of the concentration of fluoride and sulphur content in needle tissue; and second, on a biennial basis, a survey of vegetation in the vicinity of Operations to document the health and condition of vegetation.

Introduction

The annual collection of vegetation has been conducted since 1970, giving BC Works one of the largest historical databases of this type in British Columbia. The data provides long-term and comparable measures of fluoride and sulphur absorption in vegetation, both of which are found in emissions from BC Works. The purpose of the monitoring and assessment program is to:

- Document the general growing conditions in the Kitimat area during the year of the inspection.
- Provide an assessment of the overall health of vegetation in the area, including documenting significant occurrences of insects and diseases.
- Document the concentration of fluoride and sulphur content in vegetation.
- Document the extent and severity of injury to vegetation associated with emissions from BC Works.
- Provide early warning of changes in conditions.

In 2010 changes were made to the vegetation monitoring and assessment program based on Dr. John Laurence's (plant pathologist consultant) recommendations. The results of that investigation centered on the effectiveness of the monitoring program. Changes to the program were made in three areas:

- Changes to sample site locations.
- Standardization of sampling protocols.
- Increased quantitative assessment and documentation of the vegetation condition during biennial visual inspections.

Collection of western hemlock for foliar analysis is now conducted along directional transects away from the center of BC Works. The directional transects allow an estimation of the maximum concentrations of fluoride and sulphur in foliage as well as the reduction in deposition with distance from the smelter. Sample harvesting is conducted at 40 sites at the end of the growing season by gathering the current year's growth. This sampling and visual inspection is typically completed in late August and early September in order to allow season-long uptake.

The sampling program focuses on hemlock because it grows throughout the study area, it is intermediate to tolerant to air pollutants including fluoride and sulphur and is generally not injured by aerial emissions. This year's samples were collected by an independent consultant and analyzed at Rio Tinto's Vaudreuil Analytical Laboratory in Quebec.

2018 monitoring results

The 2018 growing season was characterized by warmer than expected temperature ranges and drier than normal precipitation compared to historical conditions. July and August mean temperatures were several degrees higher than historical mean conditions and total precipitation during these months was 40% less than that of historical (1981 to 2010) mean summer total precipitation.

Fluoride content

There is historically a strong correlation between fluoride concentrations in hemlock and fluoride emissions from the reduction roof vents at BC Works (Figure 7.1). The average Fluoride concentration in hemlock increased in 2018 in comparison to 2017, while annual emissions of fluoride gas also increased by 14.6% from 139 tonnes in 2017 to 164 tonnes in 2018. The analysis of fluoride in western hemlock in 2018 continues to show that fluoride content in western hemlock foliage is generally higher near the Rio Tinto aluminium smelter compared to distant sampling sites (i.e., more than 49 km away from the smelter).

On a monthly basis, total fluoride emissions from BC Works did not exceed the permit limit of 0.9 kilograms per tonne of aluminium (Figure 7.2). This permit limit came into effect in January 2018 when the process stabilized, from 2016 to 2017 the permit limit of 33.3 tonnes of total fluoride per month and prior to 2016 the permit limit was 50.0 tonnes of fluoride gas per month.

There were no permit exceedances of the total fluoride emissions in 2018.

Sulphur content

The sulphur content in western hemlock over the past 10 years has ranged from 0.06 to 0.12% (Figure 7.3). All sites measured in 2018 were below background concentrations of S measured in western hemlock foliage in British Columbia. The mean SO_2 loadings for 2018 were at a historical high—30.6 tonnes/day—1.6 times greater than the mean for 2009–2018 (18.5 tonnes/day).

There were no permit exceedances of sulphur dioxide emissions in 2018.

Qualitative assessment

In addition to annual vegetation sampling, the multi-media permit also requires that a qualitative assessment of vegetation condition in the Kitimat valley be conducted by an external expert every second year. The qualitative assessment took place in 2018 during the western hemlock sampling.

Some of the observations reported in 2018 are as follows.

- Trees at a number of sites show some level of chlorosis. Chlorosis is a general symptom that may be associated with natural processes such as senescence, as well as stress due to site conditions (soil, water, drought, etc.), pests and pathogens, or other stress factors including air pollution. The cause of the chlorosis was not determined.
- No symptoms of F injury were observed at any sampling and/or inspection sites.
- No symptoms of SO_2 injury were observed at any site and/or inspection site
- Pest and pathogen activity were generally at low incidence and severity.

Figure 7.1
Western hemlock fluoride content and fluoride emissions, 2008-2018

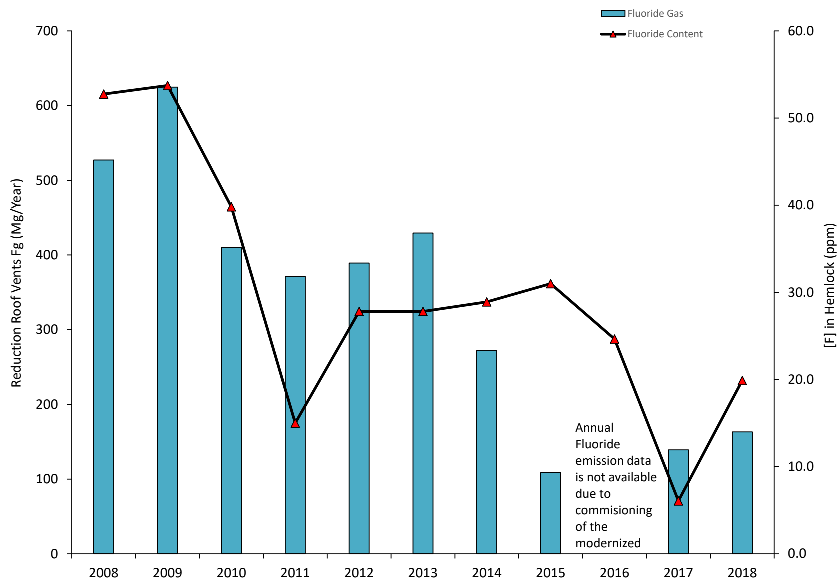


Figure 7.2
Potroom total fluoride emission monthly loadings, 2018

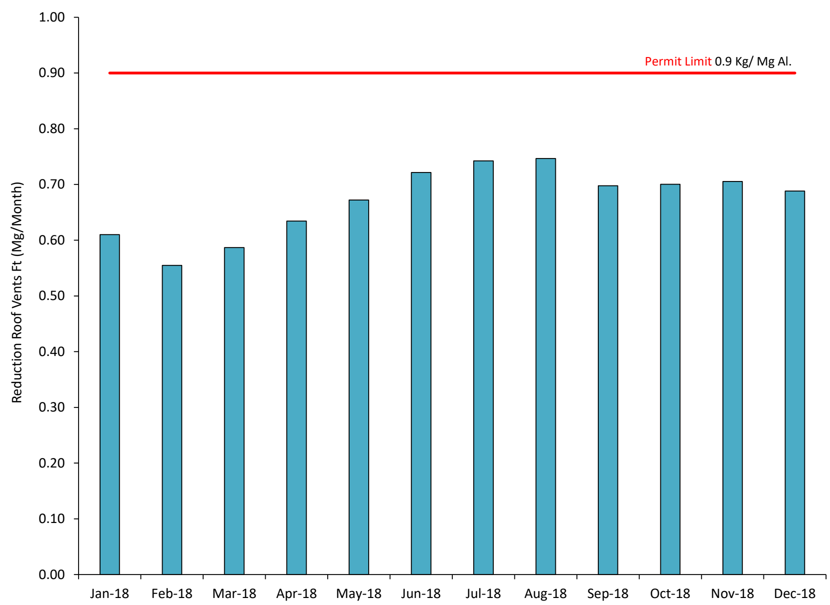
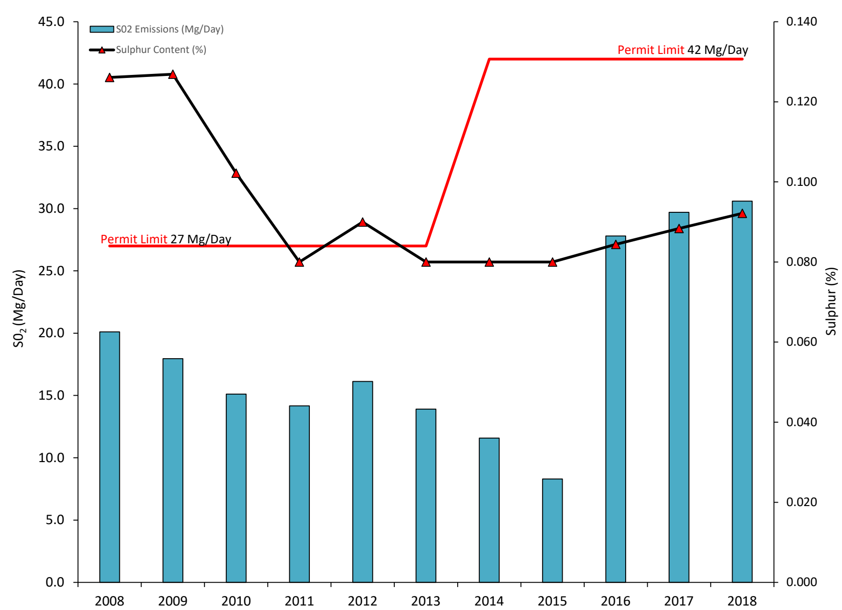


Figure 7.3
Western hemlock sulphur dioxide emissions, BC Works, 2008-2018



8. Waste management

The operation of the smelter results in the generation of various solid and liquid wastes. Appropriate management of these wastes is a central part of BC Work's operating strategy with the objective of limiting the smelter's environmental footprint.

Introduction

In August 2010, the multimedia permit was amended to allow for the disposal of KMP non-hazardous related wastes into the south landfill.

The amendment is inclusive of the design, operation and closure phases. The appropriate procedures for handling, storage and disposal of these wastes are in place and are reviewed as changes in operations occur.

Waste management procedures ensure full compliance with requirements related to regulated hazardous wastes and additional materials deemed to be hazardous by BC Works.

Opportunities for waste reduction and for improvements in waste handling are assessed and implemented on a continuous basis. In particular, opportunities to recover, reuse, and recycle waste materials are pursued whenever feasible. On-going practices include reducing raw material usage, thus reducing demand on the landfill and contributing to reducing the overall impact on the environment.

Waste management activities are tracked and reported. All waste types including those disposed at the South Landfill (i.e. inert industrial waste, asbestos materials, contaminated soil, and putrescibles), monthly wood waste and hazardous waste externally disposed or sent for recycling are reported in compliance with the permit requirements.

2018 performance

Spent potlining

Spent potlining (SPL) is one of the most significant hazardous waste materials produced at BC Works, and its disposal presents a challenge throughout the aluminium industry.

During 2018, 9,550.5 metric tonnes of SPL was generated and shipped off-site. 100 percent of that material was sent to the Spent Potlining Recycling Plant located in Saguenay, Quebec where the material was treated and recycled. Most of the SPL generated in 2018 originated from the last VSS pots during the dismantling activities taking place in the old Pot Lines 1-5.

Asbestos and refractory ceramic fibres (RCF)

Asbestos and refractory ceramic fibres (a less hazardous substitute to asbestos) are used for insulation. These materials are considered by BC Works to be sufficiently hazardous to require special disposal methods.

In 2018, no asbestos or ceramic fibers materials were sent to the North and South Landfill (refer to BC Works map Figure 2.1 for waste storage, disposal and managed sites).

Wood waste

Wood waste is collected from around the smelter site on a regular basis and sent to a wood containment area. Wood is burned once sufficient volumes have accumulated at the containment area. In 2018, a total of 3830 m^3 of wood waste was burned during the year using open burning.

South Landfill management

The South Landfill is the main landfill for smelter operations. It has been operational since the plant opened and is expected to be open until full capacity. Incoming waste streams included: industrial waste, putrescible waste, contaminated soils, asphalt and asbestos contaminated materials which include soil and concrete.

A survey is carried out once a year for reconciliation of the forecasted disposed volumes. The total volume of materials disposed at the South Landfill in 2018 was 3,426 m^3, which corresponds to 4,514 metric tonnes.

As part of the requirement of the P2-00001 Multi-Media Permit related to the South Landfill, Rio Tinto completes and Environmental Effects Monitoring program (South Landfill EEM) annually. The overall objective of the ongoing South Landfill EEM program is to evaluate the health of the receiving environment which is potentially impacted by the landfill.

The overall conclusion of the 2018 South Landfill EEM program was that there was a low risk to ecological receptors due to impacts from the South Landfill. These results were based on consideration of chemistry, toxicity tests, and benthic community.

9. Groundwater monitoring

Long-term initiatives are underway with objectives to further reduce groundwater impact and identify disposal and treatment options for stored materials.

Introduction

A variety of monitoring programs are conducted relating to groundwater quality and flow in the vicinity of BC Work's Kitimat landfill sites that are, or have the potential to be, a source of contamination. In 2018, these efforts focused on the spent potlining landfill and the dredgeate short-term storage cells. Long-term initiatives are underway with objectives to further reduce groundwater contamination and identify disposal and treatment options for stored materials.

2018 monitoring results

Spent potlining landfill

The spent potlining landfill is comprised of three separate subsections formerly used to dispose of spent potlining (SPL). The landfill is located south of Potroom 1A and north of the Anode Paste Plant (refer to Kitimat Operations map Figure 2.1).

Prior to 1989, approximately 460,000 m^3 of SPL were disposed of at the landfill site as per permit limits. The landfill was decommissioned in the fall of 1989 and initially capped with a low permeability cover. Over the next decade the three subsections were capped with polyvinyl chloride (PVC) liners. The capping significantly reduced surface water infiltration, thus reducing contaminant loading into the environment.

Groundwater monitoring has been carried out in accordance with the requirements of the multi-media permit and the SPL management plan. The existing program consists of a quarterly monitoring program where selected wells are visited to monitor water level trends. In addition to monitoring water levels a geochemical sampling campaign that occurs in the fall of each year also occurs as part of the annual program. The information collected is used to assess groundwater quality for any significant changes in chemistry that may exceed previous year's results.

Estimates of annual contaminant mass loading to Kitimat Arm were prepared for fluoride, SAD-cyanide, dissolved aluminium, and dissolved aluminium. These estimates are based on estimated groundwater flux through a rectangular cross-section across the SPL plume immediately up gradient of the Yacht Basin, coupled with measured contaminant concentrations in groundwater within this cross-section.

Estimated groundwater flux for 2018 was 246,623 m^3/yr. This is a 10% reduction compared to 2017, reflecting reduced precipitation in 2018.

The 2018 mass loading estimate for fluoride was 16,597 kg/yr. This represents a 13% decrease compared to 2017. The decrease is due to the reduced groundwater flux. Fluoride concentrations tended to be higher than in 2017.

The 2018 mass loading estimate for SAD-cyanide was 113 kg/yr. This represents a 3% increase compared to 2017, reflecting increased concentrations of SAD-cyanide.

The 2018 mass loading estimate for dissolved aluminium was 569 kg/yr. This represents a 14% decrease compared to 2017. The decrease is due to the reduced groundwater flux. Aluminium concentrations were similar to 2017.

The 2018 mass loading estimate for dissolved aluminium was 222 kg/yr. This represents a 21% decrease compared to 2017. The decrease is due to the reduced groundwater flux and reduced iron concentrations.

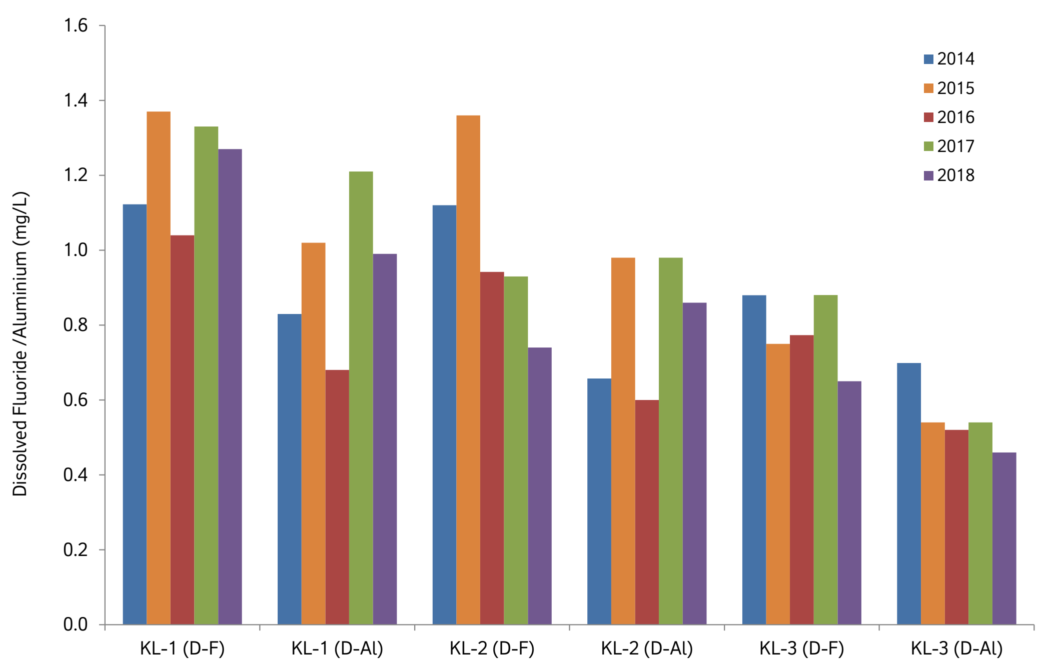
Dredgeate cells and SPL overburden cell

The wharf dredgeate cells consist of two lined cells located north of Anderson Creek. They contain approximately 2,000 m^3 of ocean sediment dredged from the wharf berthing area in 1995. This sediment was removed during a normal dredging operation and required special disposal because of the presence of PAHs in the form of solid pitch (pencil pitch). BC Works no longer receives pitch in this form. Three wells are used to monitor groundwater in the area surrounding the wharf dredgeate cells. They are referred to as KL-1, KL-2 and KL-3 and are located to the West, South and East of the cells respectively. Groundwater sampling was conducted on a quarterly basis in 2018. The samples were analyzed for dissolved fluoride and dissolved aluminium. The 2018 contaminant monitoring results are comparable to historical trends from previous years. (Figure 9.1).

The SPL overburden cell is located west of the wharf dredgeate cells. The SPL material is composed of approximately 10,500m^3 of overburden material that came from the eastern lobe of the SPL landfill in 1996. The overburden cell was originally lined with a Claymax liner that has since been replaced several times, with a synthetic liner most recently in 2010.

Both the wharf dredgeate cells and SPL overburden cell have a double membrane lining system that collects water between the primary and the secondary liners. This water is tested and pumped out on a regular basis. In 2018 7m^3 of water was pumped out from the six pumps.

Figure 9.1 - Dissolved fluoride & aluminium, wharf dredgeate monitoring cells



Dredgate Disposal Site (DDS) Landfill

In 2018 the Dredgate Disposal Site was commissioned and utilized by the project team leading the Terminal A expansion. Over the course of 2018 there was 13, 302m^3 of IL+ sediment that was dredged and placed in cell as of Dec 31, 2018. Groundwater for the cell was measured for a number of analytical different parameters. In August and September of 2018 two sampling events were completed to capture base line conditions prior to infilling of the IL+ cell. Commencement of infilling began in early November and two subsequent groundwater sampling events were also completed

The subsequent sampling events conducted in 2018 did detect some changes in groundwater chemistry related to pH and metals. The results are currently under investigation at the time of this report submission and the details regarding the conclusion of the investigation will be provided in the next year's submission of the Annual report.

10. Kemano permits

BC Works Kemano facility is the hydroelectric power station that supplies electricity to BC Works.

Introduction

Up until 2000, Kemano Operations included a town site with a resident population of 200 to 250 people. At that time the powerhouse was automated which reduced the operations and maintenance personnel to rotating crews of 20 to 30 people.

2018 performance

Kemano effluent discharge

The Kemano sewage treatment plant and several septic tanks in the area surrounding Kemano have effluent discharge permits. The discharges consist of treated sewage and are subject to permit requirements with respect to Biological Oxygen Demand (BOD) levels and concentrations of TSS. BOD is an indirect measure of the concentration of biodegradable matter, while TSS is a direct measure of suspended solids.

In 2018 all effluent discharge permit measurements were in compliance (Figure 10.1).

Kemano emission discharge

An incinerator is used to burn municipal-type waste generated by rotating crews while residing at Kemano Operations. The incinerator is a double-chambered, fuel-fired, forced air unit. The permit requires that the exhaust temperature of the incinerator remain above 980°C and in 2018 permit requirements were in compliance.

Kemano landfill

Non-combustible refuse and ash from the incinerator is buried in a landfill near Kemano. The landfill permit limits the amount of material to an annual maximum of 300 m^3. In 2018 26 m^3 of refuse was buried.

Treated sludge from the sewage treatment plant, septic tanks and biological containers are also deposited in the same landfill. Filtration ponds are used to de-water the sludge before disposal. The permit allows for disposal of up to 900 m^3 of treated sludge per year. In 2018, 183 m^3 of sludge was disposed of which is a slight increase from 2017.

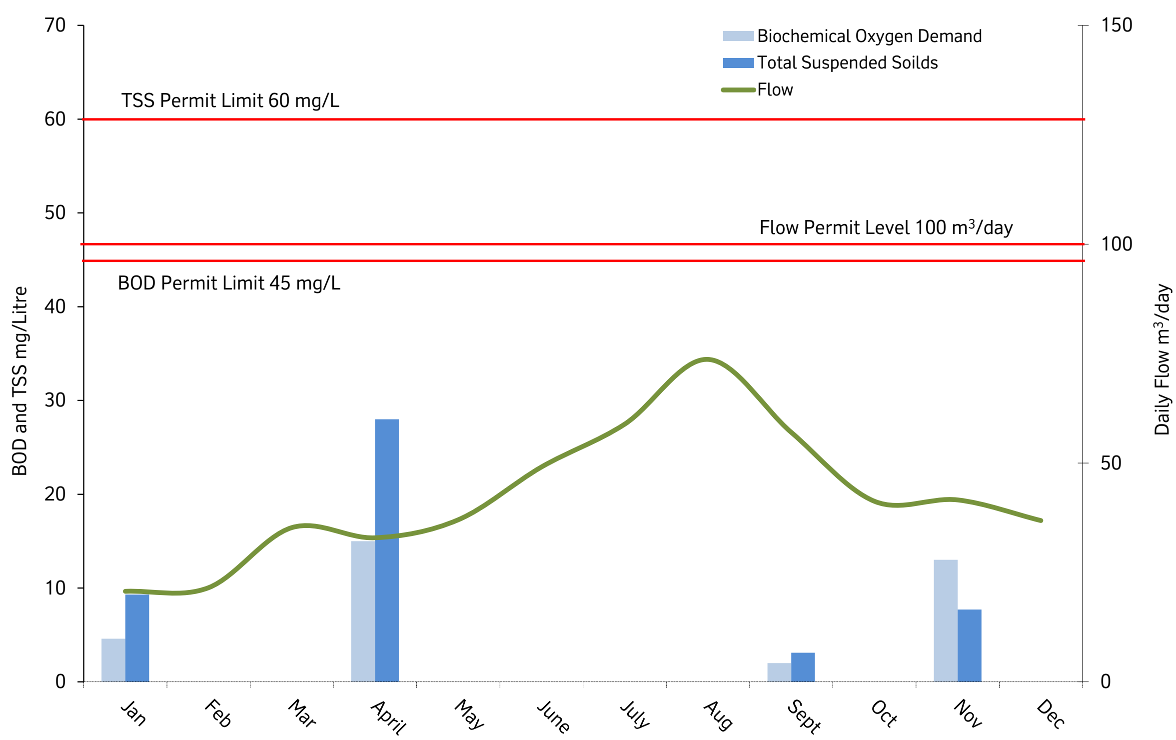
Seekwyakin camp effluent discharge

Seekwyakin construction camp, located three kilometers north of Kemano, was historically used by West Fraser Timber Co. Ltd. and BC Works. Effluent sewage discharges from the camp require a permit when the camp has more than 25 residents. In 2018, Seekwyakin camp sewage treatment plant was reestablished to manage the T2 project sewage in a transition period while they awaited their municipal waste water discharge authorization for the construction camp. The facility was used from August through December

As part of the operating permit a quarterly sample for BOD and TSS is to be collected. The first sample was missed. After it was recognized that the sample was missed a more comprehensive sampling program was established starting in October of 2018 to gain a better understanding of the performance of the sewage treatment plant. From review of the results all TSS values were in compliance, in 2018, and all BOD values with exception of 1 were above permitted thresholds. A number of actions were implemented to improve the performance of the system (e.g., clearing of the sludge and scum pit return line) with some improvements and reduction in BOD numbers.

The root cause of the high BOD is still under investigation. The drainage of the effluent is a tile field and the Kemano river is approximalty 250 meters away so it is not anticipated that there are adverse effects on aquatic life from the discharge.

Figure 10.1
Effluent discharge, Kemano 2018



11. Summary of non-compliance and spills

In 2018, BC Works received two notices of non-compliance from Ministry of Environment for Kitimat smelter.

2018 performance

Non-compliance summary

The stabilization of the modernized smelter now fully complete, the environmental compliance of the operation significantly improved in 2018 compared to 2017. The Ministry of Environment issued two notices of non-compliances to BC Works in 2018. Efforts to maintain compliance is part of BC Works operational culture.

These non-compliances are summarized with a brief description of their causes and the corrective actions that are either being assessed or implemented at the time this report was prepared (Table 11.1).

Spill summary

Spills at BC Works are first reported to the Plant Protection department and subsequently to the Environmental Services Department. Regulatory requirements are in place to report certain types of spills to the Ministry of Environment (referred to as "reportable" spills), depending on the nature and volume of the substance spilled. In 2018, 7 spills were reported to the Ministry (Table 11.2).

Spill-related awareness and prevention is a major focal point throughout BC Works. Immediate containment and minimization of potential environmental damage is the first priority. Specially equipped response teams are available when required. If appropriate, other agencies are informed and their cooperation enlisted.

Investigations and root cause analysis of reportable spills is conducted to prevent recurrence, and a system is maintained for recording and reviewing all spills and their frequency by type. This ensures that appropriate corrective actions are identified and tracked through to completion.

When spills occur in water, consultants are deployed to assess the impacts on the receiving environment. No known environmental damage was associated with any of the spills reported during 2018.

Table 11.1 Summary of non- compliances, 2018

Non-Compliance	Occurrence date	Impact	Permit Requirement	Cause	Implemented Corrective Actions
Waste was discharged to the environment without being processed through the relevant pollution control works.	**19 November** Effluent water high in Total Suspended Solids from DDS landfill was discharged to marine environment	Discharge to marine environment	Ensure that no waste is discharged without being processed through the relevant pollution control works unless prior approval is received from the director.	High rain events lead to increased water levels around the DDS landfill leading to the discharge of turbid water to the Scow Grid area.	Corrective action: • Construction of ditch and pump system • Installation of silt fencing in area of concern along with additional monitoring of critical areas in areas of concern
Waste was discharged to the environment without being processed through the relevant pollution control works.	**21 November** FTC bypass exceeded the approved duration	Discharge to atmosphere	Ensure that no waste is discharged without being processed through the relevant pollution control works unless prior approval is received from the director.	The maintenance activities required more work than anticipated which extended the bypass.	Corrective action: • Investigation completed to understand maintenance difficulties • Improved inspection procedures to better scope maintenance work on the FTC • Working at establishing a process for bypass extension approval during exceptional events where critical additional maintenance is required
Sampling on particulate monitors at the ambient air stations did not follow manufacturers recommendation.	**November 22**	Over-estimation of PM2.5 concentration in Ambient Air	All sampling locations, techniques and equipment shall be to the satisfaction of the Regional Director.	Service provider managing the ambient air station did not fully understand calibration requirements.	Corrective action: • Check list for instrument maintenance and calibration • Increased support for the onsite technician • Increased professional oversight for interpretation of results leading to potential maintenance/calibration needs

Table 11.2 Summary of reportable spills, 2018

Occurrence	Substance	Amount	Environmental Media	Causes	Corrective Actions
2 March	Hydraulic Oil	170 L	Gravel	Hydraulic fluid line on an anode transport vehicle ruptured	Clean up of gravel and hydraulic line was replaced.
16 May	Alumina	2000 kg	Air	Abrasive alumina eroded the feeding line which caused a leak in the pipe	Process was stopped and leak was sealed.
29 June	Liquid pitch	50 L	Concrete	Build-up of pressure ruptured a piece of the equipment	Spill was cleaned up and equipment was fixed.
21 July	Bath	100 kg	Air	Accumulation of material caused blockage in the feeder pipe escaped the equipment once unblocked	Improved inspection of equipment to capture accumulation of material.
14 Oct	Weathered Diesel	5 L	Fresh water	Originated from historical spill.	An investigation with a qualified professional was initiated to locate the source. After several days they were not able to locate it. Currently there is ongoing monitoring of the site.
29 Oct	Sewage	Unknown	Fresh water	After restarting the pumps after maintenance at the lift station the valve became plugged and was not seated properly causing a backup of fluid.	The valve was reseated and by operator and removing the blockage. Operations has improved procedures to prevent a re occurrence of the event again.

12. Glossary

Anode
One of two electrodes (the positive electrode) required to carry an electric current into the molten bath, a key component of the electrolytic reduction process that transforms alumina ore into aluminium.

Anode Baking Furnace
Green anodes (un-baked) are brought to the Anode Baking Furnace (ABF) to bake the anodes. This process hardens the anodes and drives off volatile hydrocarbons (such as PAHs) from the liquid pitch used to bind the calcined coke and recycled carbon.

Anode Rodding Shop
The shop where baked anodes are rodded with electrodes and where spent anodes from the potrooms are disassembled.

Anode effects
A chemical reaction that occurs when the level of alumina in a pot falls below a critical level, resulting in reduced aluminium production and the generation of perfluorocarbons (PFCs) – a variety of gases with a high carbon dioxide equivalency.

Anode paste
One of the materials used to manufacture green anodes, composed of calcined coke and coal tar pitch.

Attrition index
An index used to express alumina strength; the higher the value, the weaker the alumina.

Bath
An process material consisting primarily of sodium aluminium fluoride which is melted in the pots and used to dissolve the alumina for the electrolytic reduction process of making aluminium.

Bath Plant and Bath Tower
Bath generated from the pots is taken to the bath plant for processing and recycling. The bath tower is one component of the plant that conveys the reclaimed bath for processing.

Carbon dioxide equivalency (CO_2e)
This is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of $C0_2$ that would have the same global warming potential as the emission, when measured over a specified time period.

Cassette sampling
A sampling procedure for air emissions where contaminants are collected using filters placed at regular intervals along the length of the potroom.

Cathode
One of two electrodes (the negative electrode) required to carry an electric current into the molten bath; a key component of the electrolytic reduction process that transforms alumina ore into aluminium.

Coke calcination/calcined coke
A process involving the use of high temperatures to drive off volatile matter found in green coke, thus producing calcined coke for use in anode manufacturing.

Composite sample
A composite sample is treated as a single sample, despite being made up of multiple temporally discrete samples. For example, all effluent composite samples are taken over 24 hours during which a 50mL sample is collected every 10 minutes.

Dredgeate
Any material removed by dredging.

Dry scrubber
Pollution control equipment used to remove contaminants (in gaseous or particulate forms) from air emissions.

Effluent (B-lagoon)
Water discharge flowing out of the B-Lagoon outfall after treatment in the B-Lagoon system.

Electrolyte
A chemical compound that provides an electrically conductive medium when dissolved or molten.

Electrolytic reduction
This process uses electricity to remove oxygen molecules from aluminium oxide to form aluminium metal.

Fugitive dust
Solid airborne particulate matter that is emitted from any source other than a stack or a chimney.

Fume Treatment Centre
Is the primary pollution control system for the anode baking furnace. The Fume Treatment Centre (FTC) uses water to cool the hot fumes from the ABF. The FTC then filters the fumes to remove particulates, fluorides and PAHs.

Geometric mean
A geometric mean is a type of mean or average, which indicates the central tendency or typical value of a set of numbers by using the product of their values. The geometric mean is often used when comparing different items when each item has multiple properties that have different numeric ranges.

Green coke
The raw form of coke received at Kitimat Operations, which is calcined for use in the manufacture of anodes; a by-product of oil refining.

Grab sample
A grab sample is a discrete sample used to collect information for a specific or a short time. Variability of this data is much higher than a composite sample.

Gas Treatment Centre
Is the primary pollution control system for the potline. There are two Gas Treatment Centres (GTCs) for the modernized smelter, replacing the function of the 9 dry scrubbers used in the old VSS smelter. The GTCs filter the pot gases to remove particulates and fluorides.

Leachate
A liquid which results from water collecting contaminants as it passes through waste material.

Leftover metal
Metal which accumulates in a pot when the schedule to remove the metal is not followed.

Loading
Loading is the emitted amount of a contaminate in a given time period.

Maximum allowable level
This level provides adequate protection against pollution effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.

Maximum desirable level
This level is the long-term goal for air quality programs and provides a basis for the federal government's antidegradation policy for unpolluted parts of the country.

Maximum tolerable level
This level denotes time-based concentrations of air contaminants beyond which appropriate action is required to protect the health of the general population.

Ministry
The British Columbia Ministry of Environment (BCMOE) to which BC Operations reports on compliance with its permit requirements.

Piezometer
A small diameter water well used to measure the hydraulic head of groundwater in aquifers.

Pitch
One of the materials from which anodes are made, and a by-product of metallurgical coke production.

Polycyclic aromatic hydrocarbons (PAHs)
A group of aromatic hydrocarbons containing three or more closed hydrocarbon rings. Certain PAH are animal and/or human carcinogens.

Pots/potline
Pots are large, specially designed steel structures within which electrolytic reduction takes place. The 396 pots at Kitimat Works are housed within a single potline.

Process correction
Accessing the condition of exception or sick pots and bringing them back to normal operating conditions.

Putrescible waste
Waste that rots which can be easily broken down by bacteria, for example food and vegetable waste.

Pyroscrubber
A combustion-based system that controls dust emissions from the coke calciner.

Retention time
The average time a drop of water takes to move through a lagoon from inlet to outlet.

Scow grid
A dry dock for flat bottomed vessels (scows) formed from a series of piles and sills.

Sick pot
A pot that has an elevated bath temperature and cannot be sealed properly or is uncovered.

Spent pot lining (SPL)
Lining from the inside of pots, composed of refractory bricks and carbon that has deteriorated to the point where it needs to be replaced.

Stud
Studs constructed of steel are inserted vertically into the anode to conduct the flow of electricity through the anode and into the electrolyte.

Total suspended solids (TSS)
A water quality measurement that refers to the dry weight of particles trapped by a filter, typically of a specified pore size.

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