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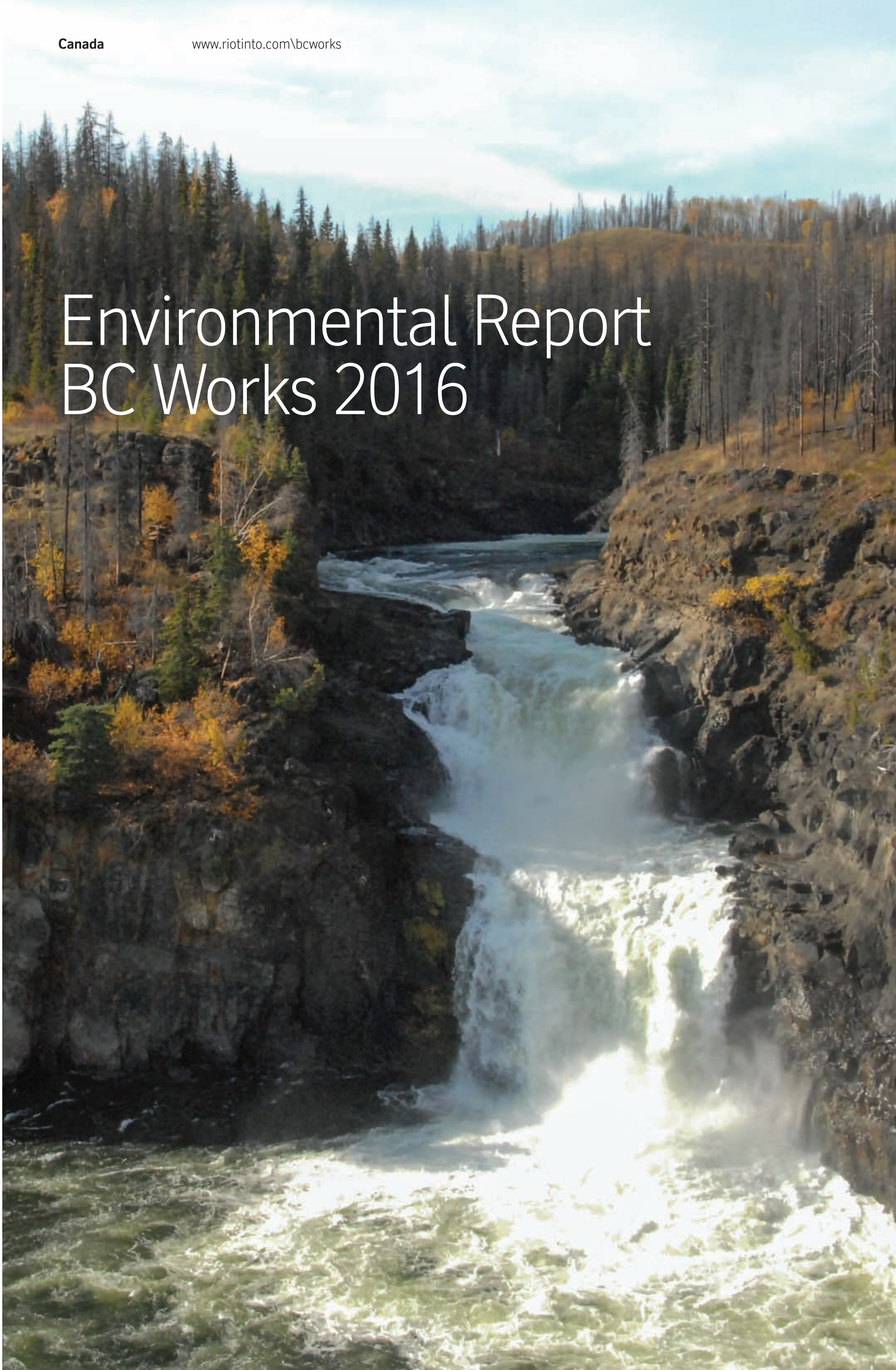
Environmental Report BC Works 2016



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1. About this report

This Annual Environmental Report is provided to 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.

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

The multi-media permit mandates annual reporting to measure performance against established permit standards. In addition to the permit reporting for BC Works, 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.

Stabilizing the new smelter

2016 was the first year of operation for the modernised smelter with the last of the 384 AP-4X pots being commissioned by the end of March. With all pots commissioned, smelter operations were focused on process stabilization and optimizing the new technology. Process stabilization will continue in 2017 to bring the new smelter up to full, stable and steady state production.

In 2016, BC Works reported 8 non-compliances. A discussion of the non-compliances, their impacts and Rio Tinto responses are highlighted in Chapter 11 of this report. A key challenge for 2016 was 4 non-compliant overflow events at F-Lagoon. A project is being developed to address these permit non-compliances.

The 2016 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 in the province. The operational footprint includes the Kitimat smelter, the power house at Kemano and the Nechako reservoir.

On December 1, 2011, Rio Tinto authorized the modernisation of the BC Operations with a total investment of US $4.8 billion. In 2015, it was fully built and substantively commissioned. By the end of the second quarter of 2016, all of the new pots were fully operational and in process stabilization mode. The operation of the new AP-4X technology has resulted in a remarkable step change in environmental performance compared to the old VSS aluminium smelting technology that was in operation for over 60 years.

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.

Our modernised smelter

The old VSS technology used a carbon anode that is baked in-situ. Electrical current was passed through the anode and into the molten bath to produce metallic aluminium. Fluoridised alumina ore was placed along the outer edge of the pot that would form a crust. This “sealed” the pot against a gas skirt where process gases were collected and taken to a dry scrubber to remove particulates and fluoride.

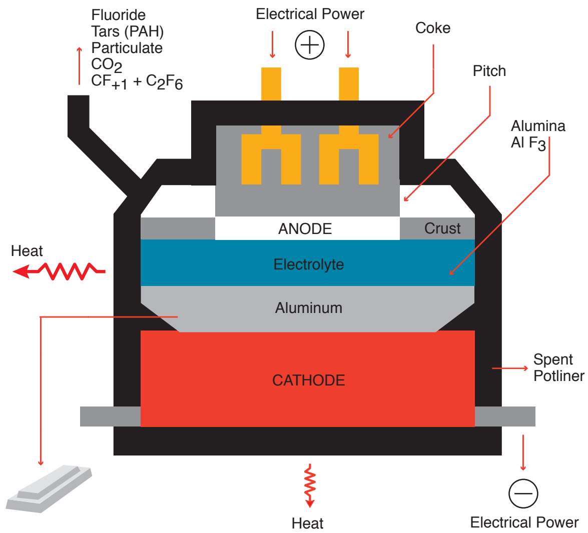
The new leading-edge AP40 technology in the modernised smelter.

The Söderberg technology from the old Kitimat smelter, which opened in 1954.

The old process had significant fugitive emissions through inefficiencies of gas collection and also the emissions of the baking anode. On a scheduled routine basis, the crust would be broken to "feed" the pot alumina or tap the pot to remove the aluminium. Whenever the crust would be broken, fugitive emissions would be generated.

The new AP-4X technology is a modern clean technology that is considered to be the best available technology for emission control (Figure 2.1).

Figure 2.1 Aluminium manufacturing process of the APX technology.



The AP-4X technology uses anodes that are pre-baked in an Anode Baking Furnace before they are used in the reduction process. This is how the modernised smelter is able to reduce polycyclic aromatic hydrocarbon emissions by 98%. The new AP-4X pots are under strong suction by the Gas Treatment Centres (GTCs) that continuously draw process gas from each pot and filters the gas to remove particulates and fluorides. Each AP-4X pot is enclosed by a series of hood cover plates that minimize the generation of fugitive emissions. Pot tending, feeding fresh aluminium and tapping metal from the pots are all done under strong gas collection from the GTCs. Gaseous fluorides and particulate emissions will be reduced by 72 and 80%, respectively, because of the gas collection and treatment system. The modernised smelter will reduce total air emissions discharge by nearly 50%. This overall reduction in air emissions is the difference between the contaminant loadings (PAH, fluoride, particulates, GHG & SO_2) produced by the old smelter annually and the forecasted loadings that will be generated by the new smelter over the years.

The molten aluminium that is extracted from the pots is transported to the two casting centres (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, remelt ingots, and sows which are sold to customers in North America and Asia 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 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 kilometres 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, stormwater management and managed sites. These environmental facilities are shown in Figure 2.2.

50%

The original smelter was challenged with environmental performance because of it's age and outdated technology. The modernised smelter is reducing total air emissions discharge by nearly 50%.

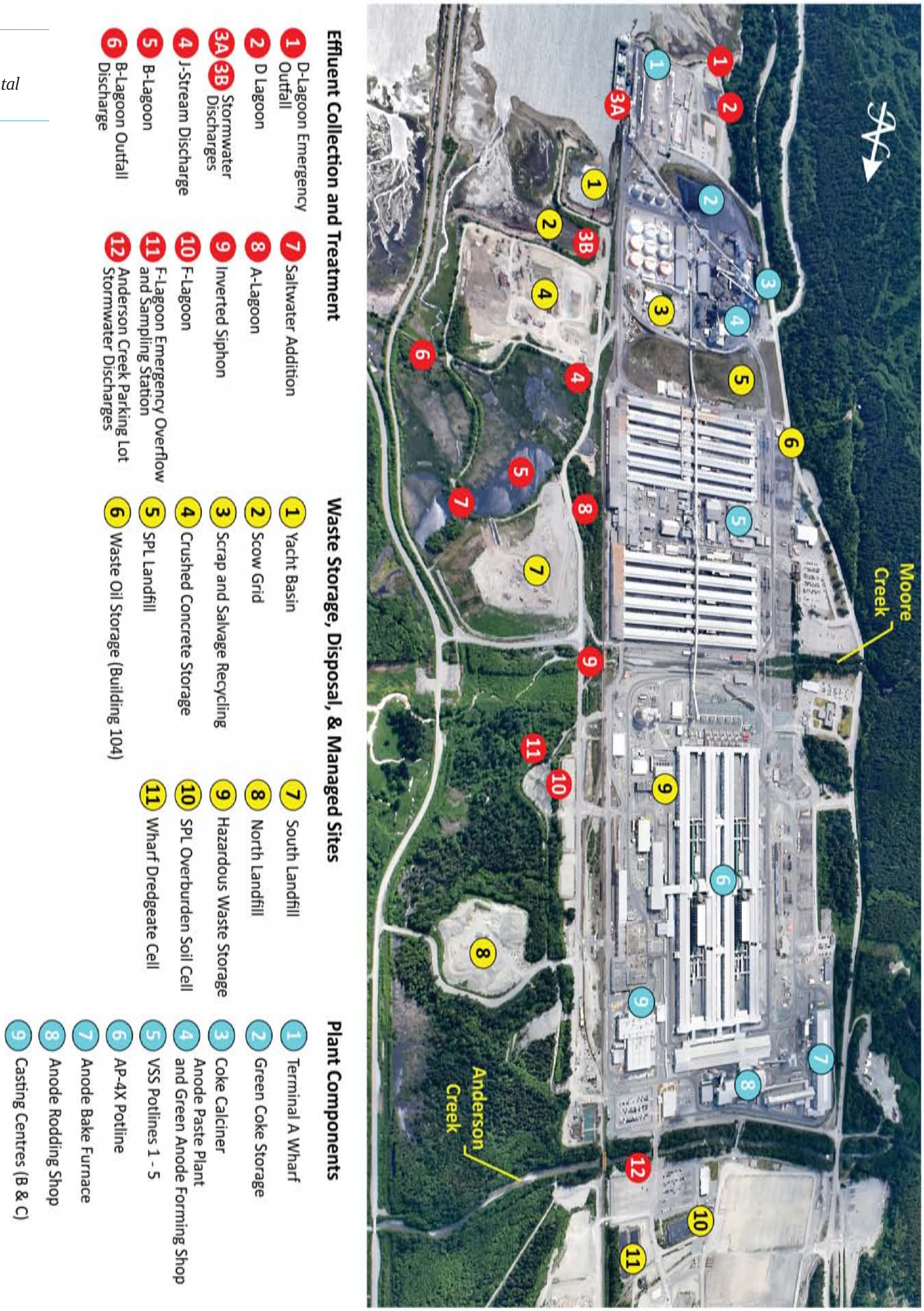


Figure 2.2 Kitimat Environmental operations.

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 the ISO 14001 environmental program. ISO 14001 provides independent conformance verification that ensures 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 ingots and shipping.

Audit program

Independent ISO compliance and conformance audits are conducted as a condition of certification. The internal and external Environment and Quality Management System surveillance audits took place in 2016 as planned. BC Works' integrated certification was successfully maintained.

Compliance with all environmental laws and regulations is the foundation of our environmental performance standards.

Health, Safety and Environment Policy – Aluminium

We care about people and the world we live in. We understand that effectively managing our HSE responsibilities is key to our long term success. That's why we are committed to Zero Harm by Choice. This entails preventing fatalities, injuries and illnesses while working proactively to protect the environment.




Our Health, Safety and Environment Policy

We strive to protect the environment and safeguard the health, safety and wellbeing not only of the people who work at our sites but of the communities in which we operate. We achieve this by continuously improving our HSE performance across the organisation, while complying with Rio Tinto HSE requirements and local HSE legislation.

AWARENESS: All our employees, contractors and other key stakeholders are aware of and understand the health, safety and environmental hazards and risks that affect our business and neighbouring communities.

- We openly communicate with our key stakeholders and ensure that our employees are actively involved in matters affecting our HSE performance.
- For all positions and functions, HSE roles and responsibilities are clearly defined within job descriptions and procedures, and our leaders ensure that appropriate resources are provided to improve performance and hold people accountable.

COMPETENCE: All our employees and contractors have the competencies to undertake their work safely while taking care of their health and minimising environmental impacts.

- We ensure that employees and contractors are knowledgeable about the HSE risks that affect their work, the safe practices to be followed and the controls to be applied. We expect them to stop their work whenever a risk cannot be adequately controlled.
- We have an effective HSE Management System in place that takes Human Performance into account, and we ensure that people are empowered to raise HSE concerns with management.
- Our leaders make sure that HSE issues are identified, assessed and managed. This includes assessing the risks associated with HSE workplace hazards and taking action to implement the required controls to avoid incidents.

COMPLIANCE: Our work activities comply with all legal and other HSE related requirements, and our employees are empowered to take action to minimise HSE risks.

- We adhere to Rio Tinto standards including "The way we work", HSEQ Management Systems and HSE performance standards.
- We report and investigate incidents and take corrective action to prevent their recurrence.
- We actively review and openly report on our HSE performance against published objectives and targets.
- We develop and communicate strategic action plans in line with Rio Tinto's HSE strategy to help us achieve these objectives and targets.
- We support and hold our contractors to the same HSE expectations and performance standards as our own employees.

EXCELLENCE: We are recognised for excellence in the way we manage HSE. We involve every employee in improving what we do in HSE.

- We learn from any mistakes and experiences related to major incidents so that we can prevent their recurrence.
- We encourage, develop, review and share HSE good practices both internally and externally
- Compliant with Rio Tinto HSE requirements, we continuously seek to minimise our environmental footprint by improving our energy efficiency and natural resource consumption as well as reducing, reusing and recycling materials to minimise waste and emissions.
- We also endeavour to protect biodiversity as well as identify and implement specific programmes to lower our greenhouse gas emissions.

Delivering our Health, Safety and Environment Policy by:

- Fostering a culture that does not tolerate threats to health, safety and the environment.
- Ensuring the real and active involvement of all employees and contractors.
- Holding our leaders accountable for improving HSE performance and providing the resources to do so.
- Supporting our teams with the right systems.

Alfredo Barrios, Chief executive, Aluminium
December 2014

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

B-Lagoon consists of a primary and a secondary pond: Upper and Lower B-Lagoons. It is designed to remove contaminants by sedimentation, phytoremediation, and with salt water addition to smooth fluctuations of inflows and contaminant levels. B-Lagoon discharges effluent continuously into the Douglas Channel. In 2016, the average discharge rate was 20,488 m^3 per day. This is a little lower than 2015 due to the completion of the Kitimat Modernisation Project (KMP) that originally forecasted to reduce process water consumption by 50%.

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 2016, there were four overflow events at F-Lagoon and two overflow events at B-Lagoon. Overflows at F-Lagoon were outside permit limits and will be discussed in Chapter 11.

Discharge measurements related to permit requirements and additional monitoring are described below in the following 2016 performance section.

2016 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 2016 (2328 mm) was lower when comparing to 2015 levels (2,813 mm). Most of the rain in 2016 fell from September through December.

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 in recent years. Figure 4.2 illustrates the long-term trend performance.

In 2016 dissolved fluoride, dissolved aluminium and total suspended solids loads increased in comparison to 2015 and 2014 levels. Although there is an increase when compared to the previous few years the overall ten year trend is downward.

The slight increase over the past several years can be attributed to the commissioning of the new 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 can be attributed to 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 2016. Average dissolved fluoride concentration for the year derived from composite sampling was 3.64 mg/L. This value is slightly lower than in 2015. The long-term trend is illustrated in Figure 4.2. The 2016 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.

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 used at the Fume Treatment Centre and the Gas Treatment Centres to remove fluoride from smelter emissions. Some scrubbed alumina can be accidentally released through the scrubbing process. In this form, scrubbed alumina has a higher solubility and is a contributor to both dissolved aluminium and dissolved fluoride. The cryolite bath used in the pots and recycled at the Bath Treatment and Storage Facility also represents a source of dissolved aluminium and dissolved fluoride.

In 2016, concentrations of dissolved aluminium did not exceed the maximum permit limit of 3.0 mg/L. The annual average of dissolved aluminium concentration was 0.18 mg/L (Figure 4.4).

B-Lagoon is a large and well-vegetated area that is highly efficient in absorbing and processing effluent compounds.

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.

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 2016 were much lower than the permit level. The annual average concentration for the composite samples was 3.0 mg/L (Figure 4.5), which is consistent with previous years.

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 for recycling or disposal in a secure landfill. 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 2016. 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 2016 (Figure 4.7). The missing temperature data in September in Figure 4.7 is from a faulty probe that was replaced (see Chapter 11).

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.

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.

In Figure 4.8 the missing conductivity data in July and August was due to faulty equipment. The probe was ordered and exchanged, bringing the readings back into their normal range in September.

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% for trout tested. All effluent discharge bioassay tests at B-Lagoon passed during 2016.

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 2016 annual pH composite sample average was 7.5. All sample measurements were within the permit limits during 2016 (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. Some operations at the smelter generate PAH. Other sources include process materials such as pitch, anode paste, and green anode. PAHs are monitored with 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 (refer to Figure 4.10). In 2016, the overall trend PAHs appear to be less than previous years which may highlight some of the benefits of the new smelter technology.

Figure 4.1 Flow variability, B-Lagoon 2016

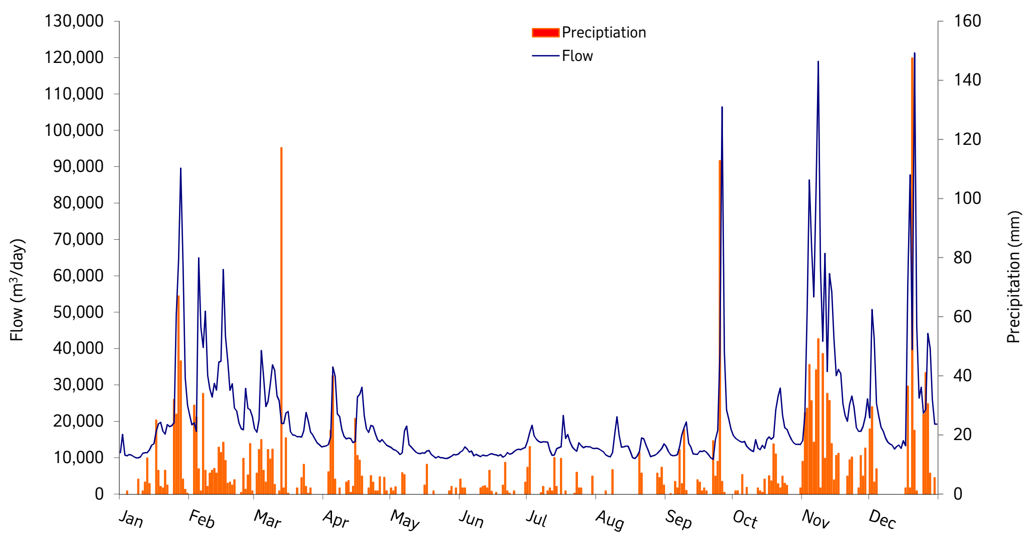


Figure 4.2 Dissolved Fluoride, Dissolved Aluminium and Total Suspended Solids, B-lagoon 2016

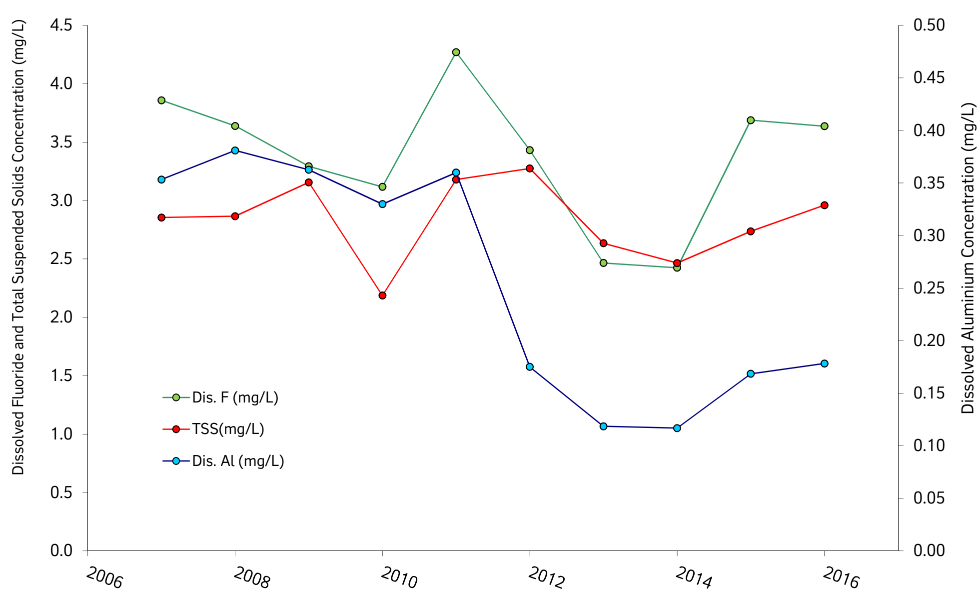


Figure 4.3
Dissolved fluoride, B-lagoon 2016

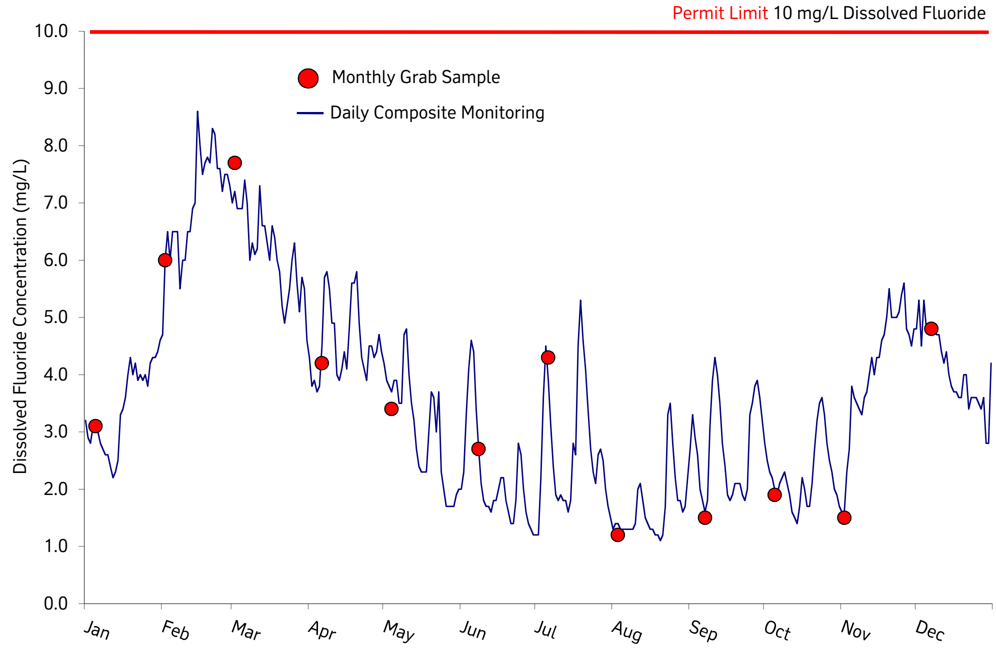


Figure 4.4
Dissolved Aluminium, B-lagoon 2016

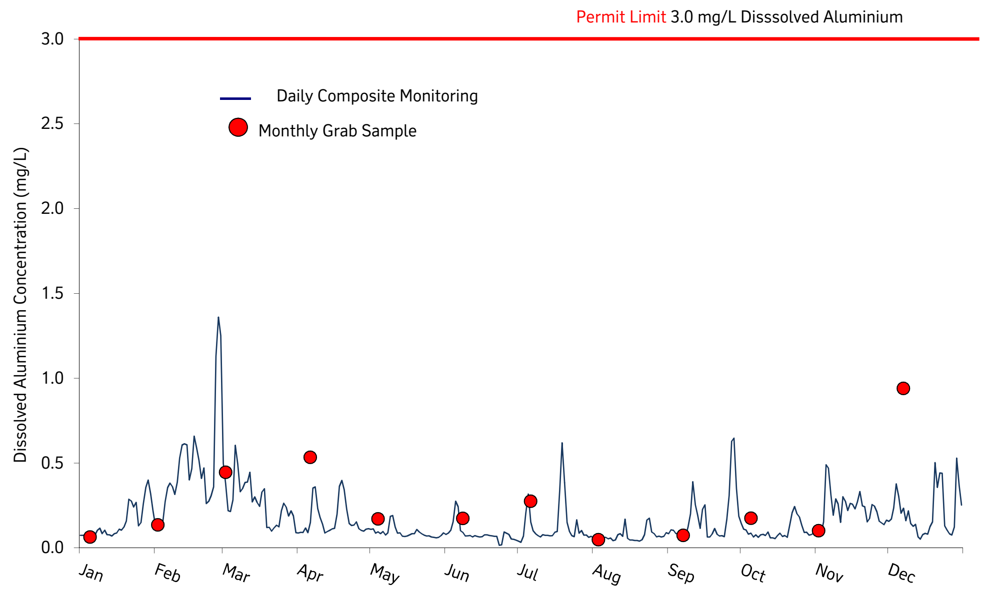


Figure 4.5
Total Suspended Solids, B-lagoon 2016

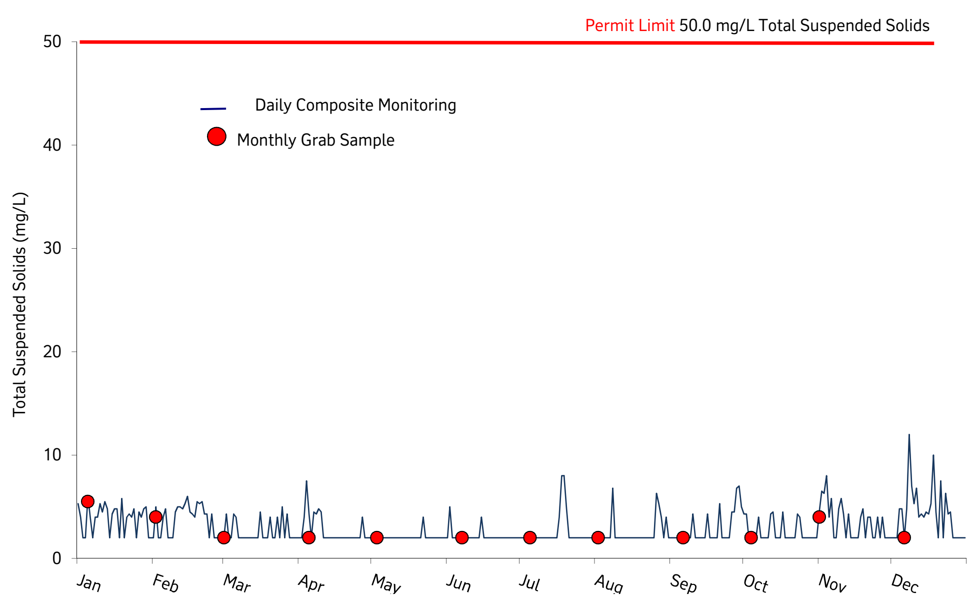


Figure 4.6 Cyanide, B-lagoon 2016

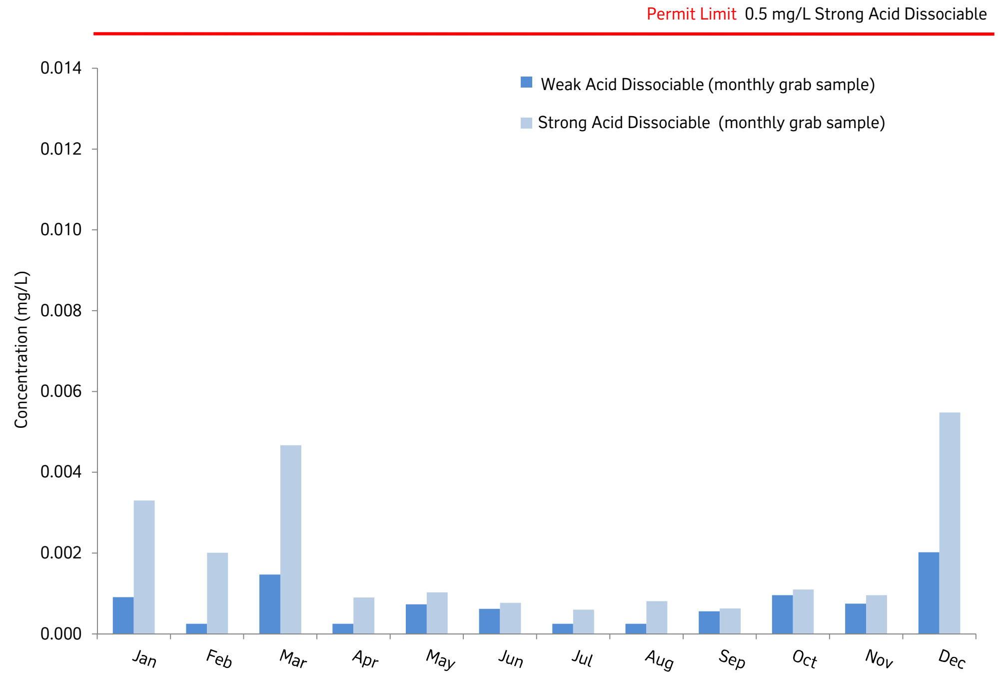


Figure 4.7 Temperature B-lagoon 2016

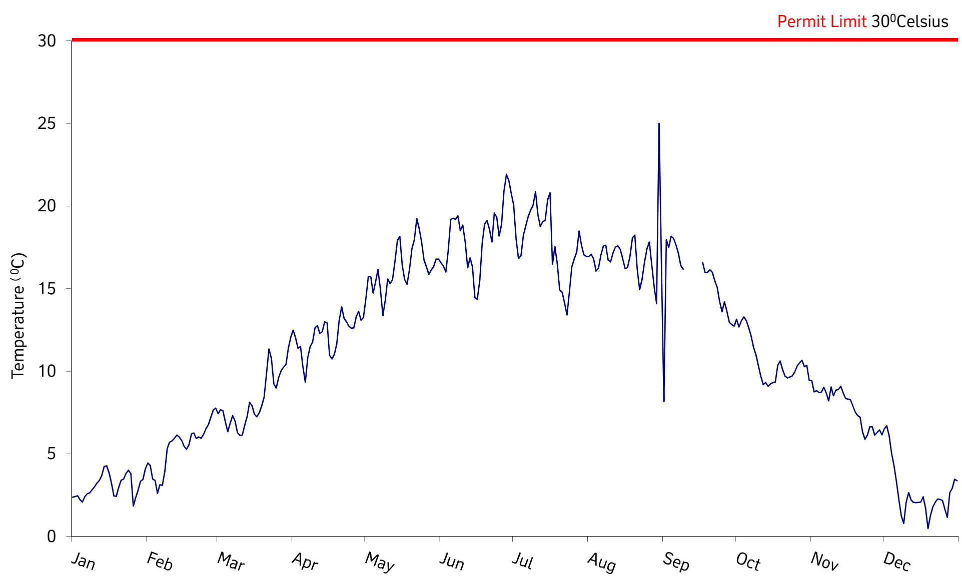


Figure 4.8 Conductivity and hardness, B-lagoon 2016

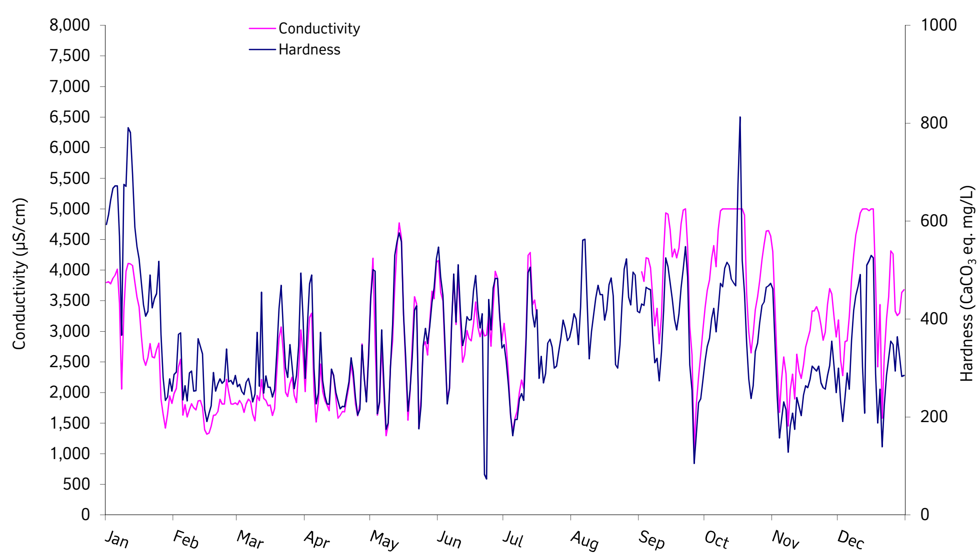


Figure 4.9
Acidity, B-lagoon 2016

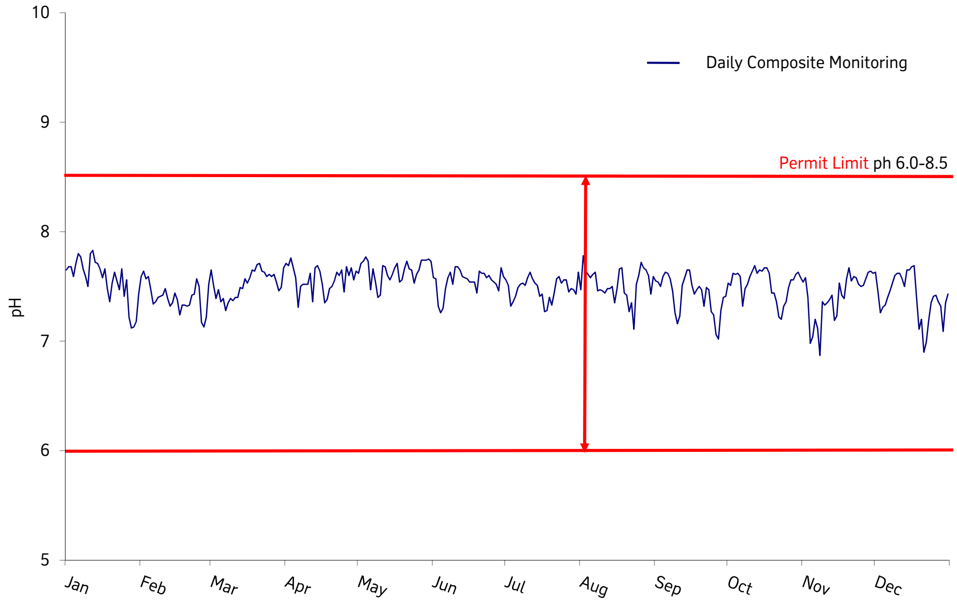
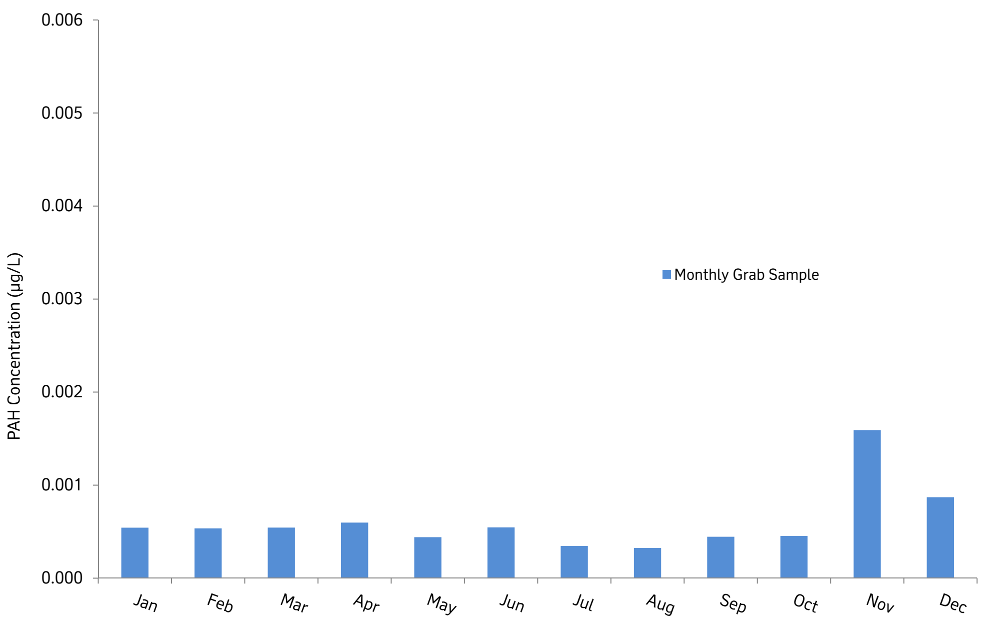


Figure 4.10
Polycyclic Aromatic Hydrocarbons, B-lagoon 2016



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). As per the permit requirements for the AP-4X smelter, the compliance monitoring for the pre-bake emission points gradually started in 2016.

Sources

Major sources of air emissions at BC Works include the potroom roofs and Gas Treatment Centres (GTCs), the Calcined Coke Plant, the Anode Paste Plant, the Anode Baking Furnace (ABF) and exhaust stacks. Wind-blown or nuisance 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 potroom GTCs, 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.

2016 performance

Total fluoride (F_t)

Four major sources contribute to fluoride emissions: the potroom roofs, the Gas Treatment Centres, the Fume Treatment Centre and the Pallet Storage Building where anode butts are cooling before recycling. In the potrooms, 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 AP-4X technology has strong gas suction and hoods on the pots, so the collection of emissions and recycling of emissions back into the process is much improved from the Söderberg technology. Gas collection efficiency for the new smelter is greater than 98%.

The first pots of the modern AP-4X prebake smelter began producing metal in June 2015 and all 384 pots were started sequentially by the end of March 2016. Compliance monitoring and reporting of the roof emissions (fluoride and particulate) started in September 2016 when the process stabilized. Fluoride emissions were monitored at roof top locations on potroom buildings A, B, C and D (refer to the yellow dots on the potroom roof sampling locations in Figure 5.1).

In preparation for the idling of the VSS potlines, in 2008 the gaseous fluoride permit limit (including both potroom 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 AP-4X smelter. This limit will further transition to 0.9 kg/t Al at the start of 2018. The total fluoride emissions rate is tracked internally (Figure 5.2).

The total fluoride limit includes emissions from the potroom roofs, GTCs, FTC and the Pallet Storage Building. Total fluoride includes the gaseous fluoride plus the fluoride particulate. During 2016, there were no loading monthly exceedances of the total fluoride emissions limit (Figure 5.3).

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 tonnes 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 (42.0 tonnes per day on annual average) in preparation to the modernised smelter production increase. The average SO_2 emissions increased from 8.3 tonnes per day in 2015 to 27.8 tonnes per day in 2016. This increase can be attributed to the smelter reaching full metal production in 2016, and reduced downtime at the coke calciner in 2016 when comparing to 2015. In 2016, the SO_2 emission levels remained well below the permit limit (Figure 5.4). Monthly average performance was also consistently below the permit limit (Figure 5.5).

In addition to monitoring emissions, BC Works carries out extensive annual monitoring activities under the SO_2 Environmental Effects Monitoring program (SO_2 EEM) where four different lines of evidence are studied: water, human health, 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 AP-4X technology are baked before being placed in the pot, the PAH emissions are greatly reduced as compared to the Söderberg technology.

A measurement campaign will be done in the potrooms once the pots are stable to confirm the low levels of PAH emissions. A 98% reduction in PAH emissions from anode baking and consumption is forecasted for the modernised smelter.

98%

PAH emissions from the AP-4X potrooms are expected to be reduced by over 98% due to the anode pre-bake process.

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 NO_x emissions for 2016 were estimated at 284 tonnes per year compared to 188 tonnes per year in 2015 (Figure 5.6). The coke calciner operated 325 days in 2016; 56% more than the 181 days in 2015.

Potroom Gas Treatment Centres (GTCs)

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

The permit requires annual stack testing on the two GTCs (Table 5.1). The test results are used to calculate total fluoride plant-wide emissions and potroom particulate emissions (refer to Figures 5.3 and 5.7). Upset conditions are when the GTCs are not operating under normal conditions.

Potroom particulate emissions

Particulate emissions for the potrooms are monitored at the roofs and at the GTCs. The permit limit for the combined emissions is 1.3 kg/tonne of Al. The annual average for the potroom roof particulate samples was 0.50 kg/tonne of Al. The annual average including the GTCs particulate emissions was 0.53 kg/tonne of Al which is under the permit limit of 1.3 kg/tonne of Al (Figure 5.7).

The reduction in measured particulate emissions in 2016 is a result of the modernised smelter coming on-line and the full shutdown of the old VSS operation (Figure 5.8). In 2015, particulate emissions were higher due to sampling biases caused by the progressive shutdown of the old potlines.

Particulate emissions from the potroom roofs accounted for 75% of total particulate emissions for BC Works in 2016 (Figure 5.9).

Total particulate emissions

The plant-wide total particulate emissions for 2016 were 310.3 tonnes compared to 2015 at 1,345.1 tonnes. This total includes all sources including the potroom roofs (Figure 5.9). The decrease is primarily due to the decrease in potroom roof particulate emissions from the AP-4X technology.

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 2016, 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). As part of the modernisation, a new dust collector was added to the Pitch Fume Treatment Centre (PFTC). PAH is tested there as well and monitored relative to a permit limit. The pitch incinerator discharges are monitored relative to permit levels for total particulate and PAH content. There were no exceedances for PAH at the Anode Paste Plant in 2016 (Table 5.5). In 2016, some PAH samples we missed at the Anode Paste Plant due to planning issues. Details are provided in Chapter 11.

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 2016 there were no exceedances of the permit limit (Table 5.6). The SO_2, Fluoride and $N0_x$ emissions at the Anode Baking Furnace are included in the plant-wide limit. The FTC is designed to allow the bypass of emissions from the ABF directly to the FTC stack without treatment under emergency conditions or exceptional major maintenance restarts and operations. Table 5.7 lists the bypass mode occurrences for 2016. The FTC was in good working order for 99.8% of the year. Out of the 525,600 minutes in a year, the FTC was down for a combined 1,301 minutes (21.7 hours).

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 2016 (Table 5.8).

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 in 2016, consumption increased by 28.9% (Table 5.9) due to the AP-4X technology reaching full production at the end of March 2016.

Chlorine and sulphur hexafluoride (SF_6) consumption

Chlorine was used during the process of casting aluminium ingots. 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 SF_6 consumption in 2016 during the process of casting aluminium ingots. In 2013 the Casting Centers that used the SF_6 gas were shut down.

Other stack tests were completed in 2016 for casting operations (Table 5.10).

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, and most smelting-related emissions are attributable to anode consumption (Figure 5.11).

BC Works 2016 GHG emissions decreased to 2.32 tonnes of CO_2 equivalent per tonne of aluminium produced from 4.89 in 2015 (Figures 5.12 and 5.13). The decrease was caused by the stabilization of the AP-4X line.

Table 5.1
GTC, annual stack tests, 2016

Performance Measure	GTC East	GTC West
Date	**26 Dec**	**21 Dec**
Flow (m^3/min) Permit limit: None	45,542	40,829
Total Particulates (mg/m^3) Permit Limit: Included with potroom particulate limit	0.10	0.07
Particulate Fluoride (mg/m^3) Permit Limit: Included with plant-wide limit	0.02	0.03
Gaseous Fluoride (mg/m^3) Permit Limit: Included with plant-wide limit	1.1	0.4
Sulphur Dioxide (mg/m^3) Permit Limit: Included with plant-wide limit	179.1	147.6

Table 5.2
GTC upset conditions, 2016

Date	GTC	Upset condition	Duration	Cause
5 July	East	Fresh alumina stopped for more than 2 hours	240 minutes	Maintenance and cleaning activities
8 July	East	Fresh alumina stopped for more than 2 hours	120 minutes	Maintenance and cleaning activities
5 August	East	Fresh alumina stopped for more than 2 hours	40 minutes	Power outage
27 September	East	Fresh alumina stopped for more than 2 hours	516 minutes	Mandatory air lift cleaning (de-scaling)
29 September	East	Fresh alumina stopped for more than 2 hours	260 minutes	Mandatory air lift cleaning (de-scaling)
29 October	East	Loss of fluidization air	14 minutes	PLC fault
16 December	East and West	GTC shutdown	301 minutes	Power fluctuation
21 December	East	GTC shutdown	14 minutes	Power outage

Table 5.3
Calcined Coke Plant biannual stack tests, 2016

	Pyroscrubber			Cooler		
Parameter	**Limit**	**Nov.**	**Dec.**	**Limit**	**Nov.**	**Dec.**
Particulates (kg/hr)	21.1	4.8	4.1	3.9	1.17	1.13
SO_2 (kg/hr)	n/a	114.0	111.6	n/a	0.79	1.14
NO_X (kg/hr)	n/a	2.1	2.1	n/a	n/a	n/a

Table 5.4
Anode Paste Plant, annual stack test, 2016

Source	Particulate Permit Limit (mg/m^3)	Particulate Emissions (mg/m^3)
Dust Collector DC10	120	12.8
Dust Collector DC11	120	8.1
Dust Collector DC12	120	7.6
Dust Collector DC13	120	17.7
Dust Collector DC14	120	8.0
FC 3 (Day tank)	120	30.5
Pitch Incinerator (liquid pitch storage tanks)	500	88.8*
Dust Collector PFTC	30	2.4

*Sampled in January 2017, see Chapter 11

Table 5.5
Anode Paste Plant PAH stack tests, 2016

Source	PAH Permit Limit (mg/m^3)	PAH Emissions (mg/m^3)
Pitch Incinerator (liquid pitch storage tanks)	None	1.79*
FC 3 (Day tank)	None	Not tested**
Source	**PAH Permit Limit (kg/tonne of paste)**	**PAH Emissions (kg/tonne of paste)**
Dust Collector PFTC	0.03	0.002

*Sampled on January 2017, see Chapter 11

** Not tested in 2016, see Chapter 11

Table 5.6
Annual stack test, 2016

Source	Particulate Permit Limit (kg/tonne of baked anode)	Particulate Emissions (kg/tonne of baked anode)
FTC 8 April 2016	0.3	0.007
Source	**PAH Permit Limit (kg/tonne of baked anode)**	**PAH Emissions (kg/tonne of baked anode)**
FTC 16 May 2016	0.05	0.00002

Table 5.7
FTC bypass modes, 2016

Date	Bypass Mode	Duration	Cause
8 September	Normal bypass (Mode 2)	13 minutes	Low draft caused burner to turn off
12 September	Normal bypass (Mode 2)	35 minutes	Crane breakdown
19 September	Normal bypass (Mode 2)	30 minutes	Damper sensor failure.
23 September	Full bypass (Mode 4)	23 minutes	Primary controller failed and secondary controller did not function.
30 September	Full bypass (Mode 4)	32 minutes	Reduced alumina feed
13 October	Normal bypass (Mode 2)	21 minutes	High deferential pressure
19 October	Diesel bypass (Mode 3)	19 minutes	Diesel bypass mode 3 troubleshooting
20 October	Normal bypass (Mode 2)	290 minutes	Planned inspection and cleaning of the FTC inlet
26 October	Full bypass (Mode 4)	23 minutes	Further diesel bypass mode 3 troubleshooting
7 November	Normal bypass (Mode 2)	42 minutes	Faulty sensor
13 November	Full bypass (Mode 4)	32 minutes	Fan high pressure
18 November	Normal bypass (Mode 2)	110 minutes	Planned cleaning of the bottom of the cooling tower
24 November	Normal bypass (Mode 2)	35 minutes	Unplanned shutdown of an alumina airslide
25 November	Diesel bypass (Mode 3)	22 minutes	Test of the diesel fan
5 December	Normal bypass (Mode 2)	54 minutes	High temperature at the cooling tower outlet
6 December	Normal bypass (Mode 2)	18 minutes	Loss of fluidization air due to fans tripping.
7 December	Normal bypass (Mode 2)	19 minutes	Loss of FTC filters 3 and 5
7 December	Normal bypass (Mode 2)	20 minutes	Loss of fluidization air due to fan 2 tripping due to cold temperatures.
7 December	Normal bypass (Mode 2)	39 minutes	Loss of fluidization air due to fan 2 tripping due to cold temperatures.
15 December	Normal bypass (Mode 2)	98 minutes	Planned shutdown of plant compressed air supply
21 December	Normal bypass (Mode 2)	326 minutes	Planned maintenance of the FTC inlet damper and cooling tower.

Table 5.8
Bath Treatment and Storage, annual stack test, 2016

Source	Particulate Permit Limit (mg/m^3)	Particulate Emissions (mg/m^3)
DCB-001	30	2.4
DCB-003	30	2.6

Table 5.9
Natural gas consumption and associated emissions

Year	Natural Gas Consumption m^3/yr	Associated Emissions for Natural Gas Use (tonnes/year)			
		Nitrogen Oxides	Total Particulates	Sulphur Dioxide	Carbon Monoxide
2001	24,719,317	39.55	3.01	0.24	33.22
2002	26,718,911	42.75	3.25	0.26	35.91
2003	26,412,184	42.26	3.21	0.25	35.50
2004	27,610,071	44.18	3.36	0.27	37.11
2005	24,423,744	39.08	2.97	0.23	32.83
2006	25,403,363	40.65	3.09	0.24	34.14
2007	25,837,200	41.34	3.14	0.25	34.73
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	35.89	2.73	0.22	30.14
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

Table 5.10
Casting bi-annual stack test, 2016

Emissions Perfomance Measure	B Casting		C Casting			
	DC 4 Casting		Furnace 61		Furnace 62 63	
	11 June 2016	2 Dec 2016	26 June 2016	30 Nov 2016	26 June 2016	30 Nov 2016
NO_x mg/m^3	207	19.8	Not tested*	Not tested*	Not tested*	Not tested*
Chloride mg/m^3	45.6	0.1	Not applicable	Not applicable	Not applicable	Not applicable
Chlorine mg/m^3	0.8	0.1	Not applicable	Not applicable	Not applicable	Not applicable
Total Particulate mg/m^3	43.8	39.9	29.9	20.1	13.6	27.2

*Not sampled in 2016, see Chapter 11

Figure 5.1
Potroom roof sampling locations

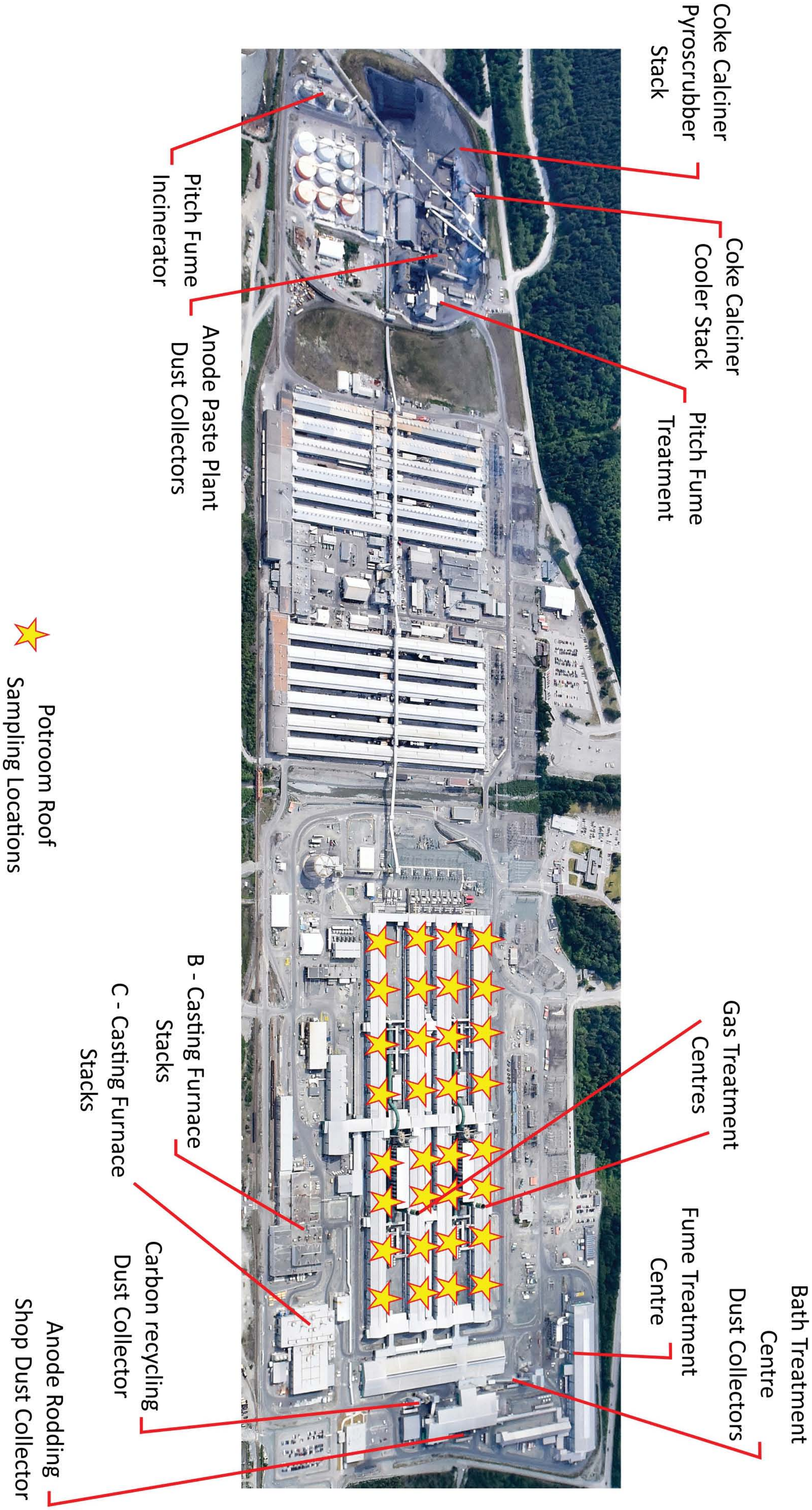


Figure 5.2
Potroom total fluoride emissions rate, 2016

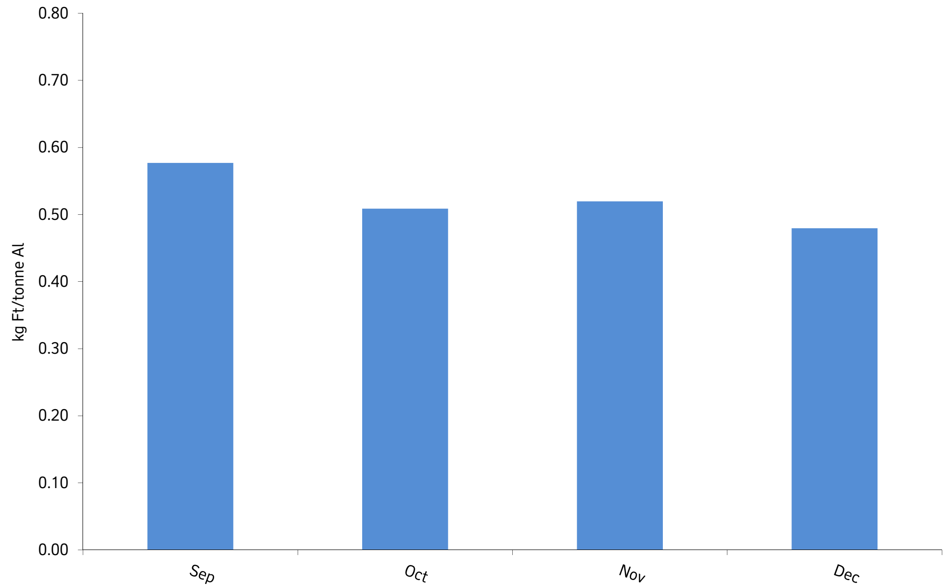


Figure 5.3
Potroom total fluoride emission monthly loadings, 2016

Note: Compliance monitoring started in September 2016

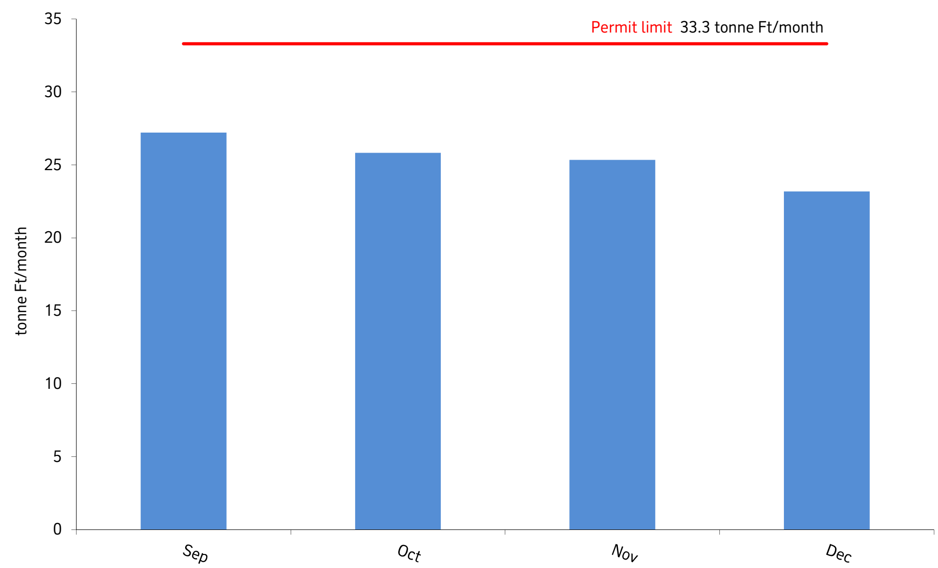


Figure 5.4
Annual average SO_2 emissions, BC Works 2006-2016

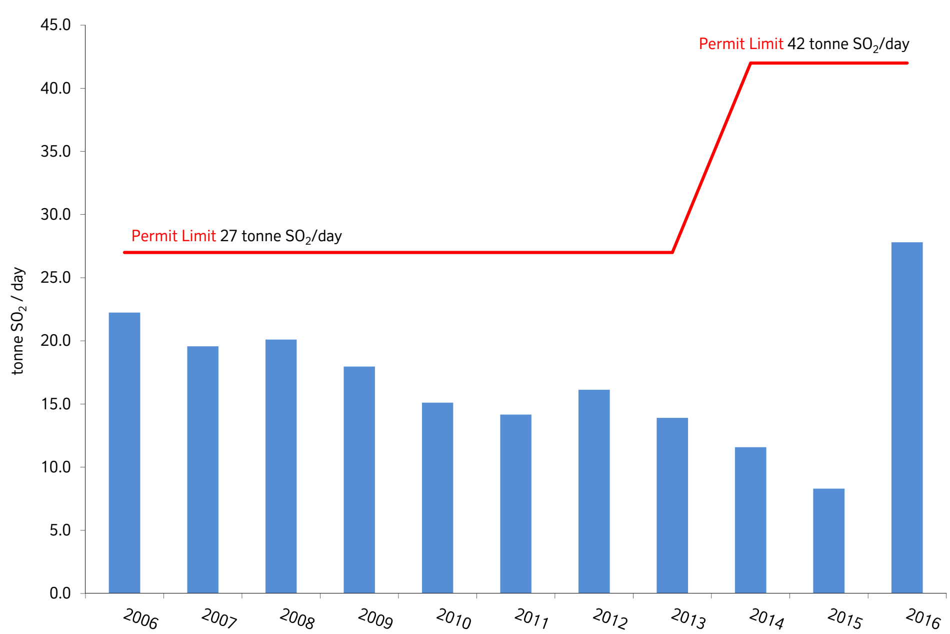


Figure 5.5
Monthly SO_2 emissions, BC Works 2016

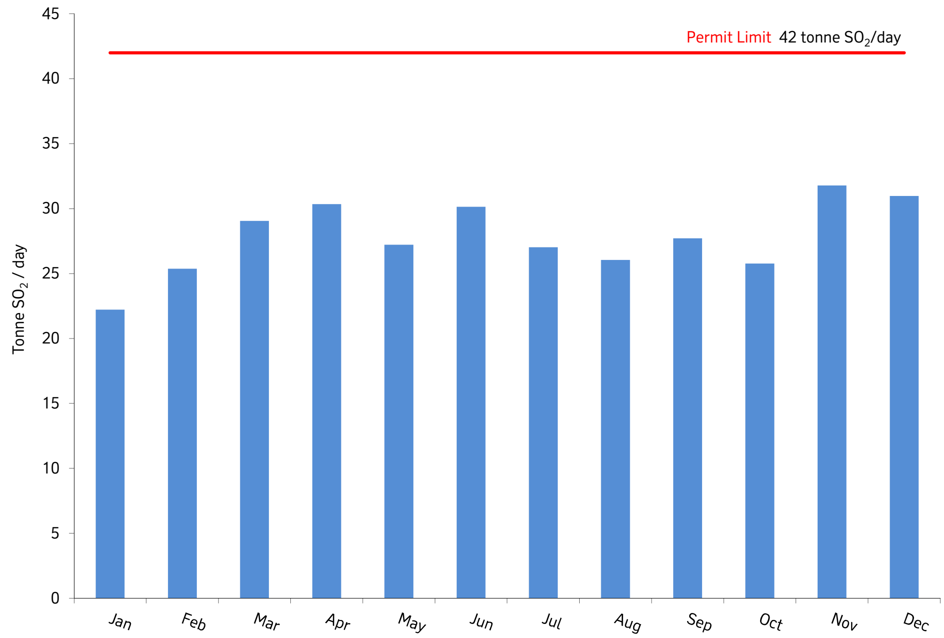


Figure 5.6
Nitrogen oxide emissions, BC Works 2007-2016

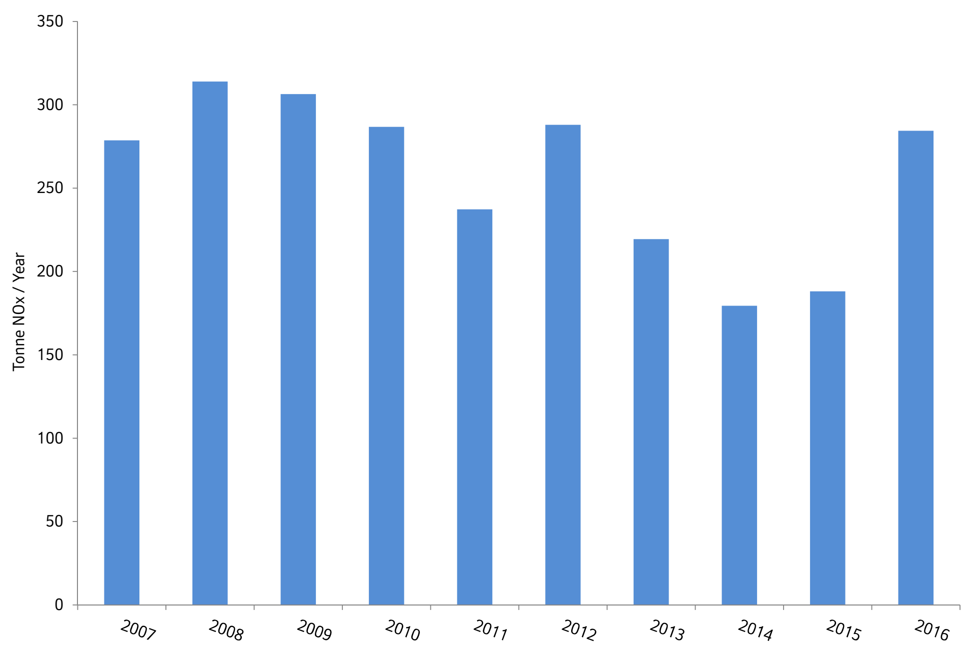


Figure 5.7
Potroom particulate emissions monthly rate, 2016

Note: Compliance monitoring started in September 2016

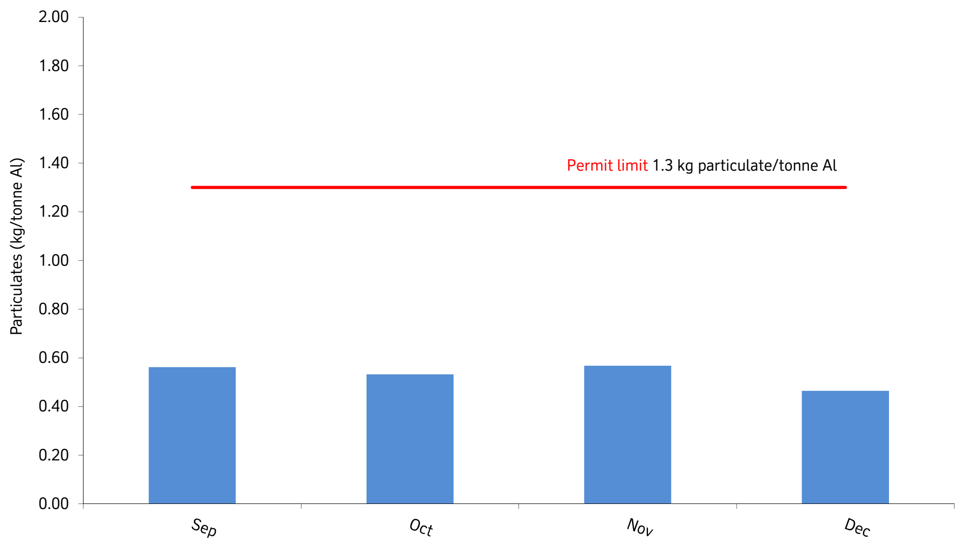


Figure 5.8
Potroom particulate emissions, 2007-2016

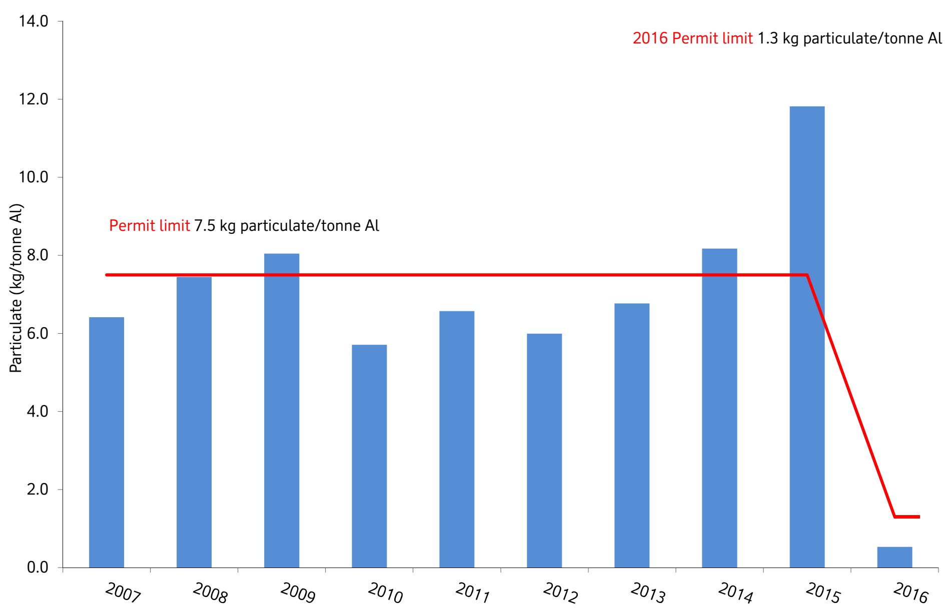


Figure 5.9
Particulate emissions distribution in 2016, BC Works

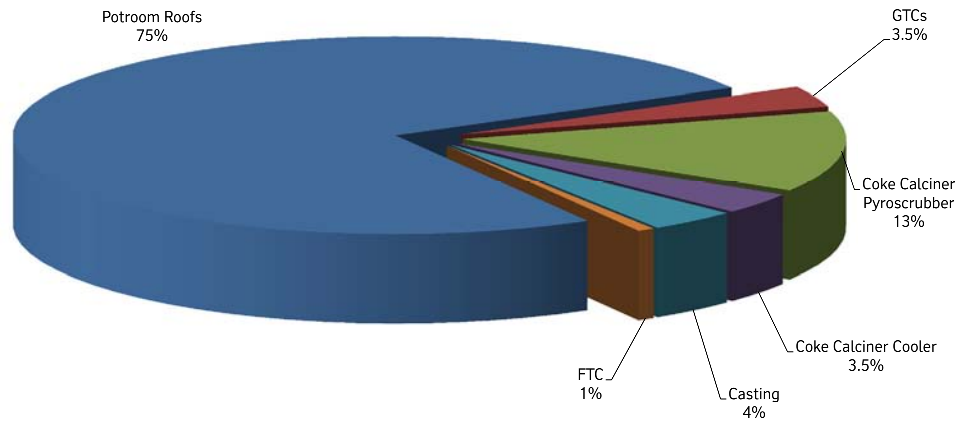


Figure 5.10
Total GHG emissions by Source, 2016

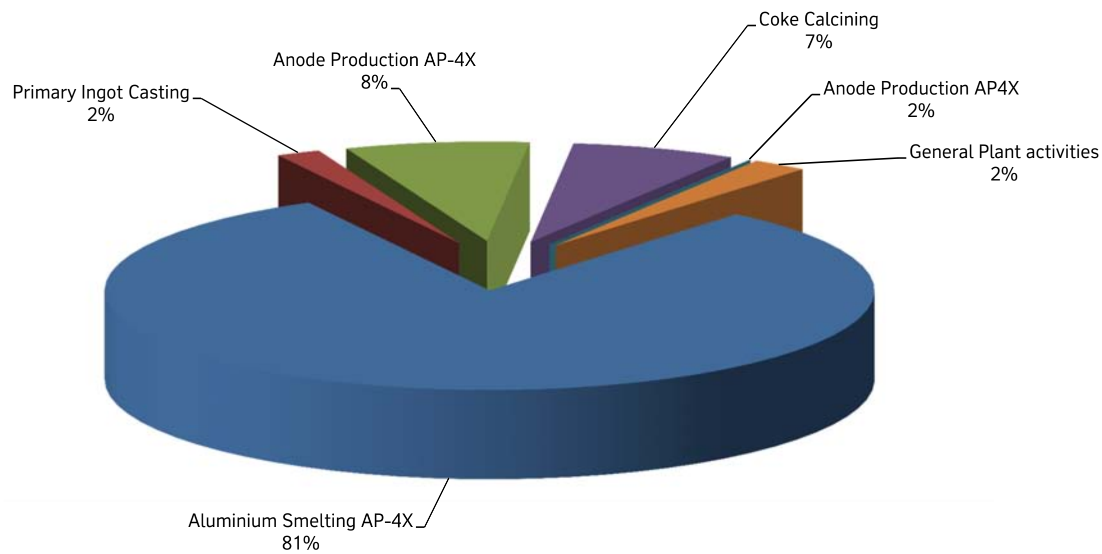


Figure 5.11
Breakdown of aluminium smelting GHG by Source, 2016

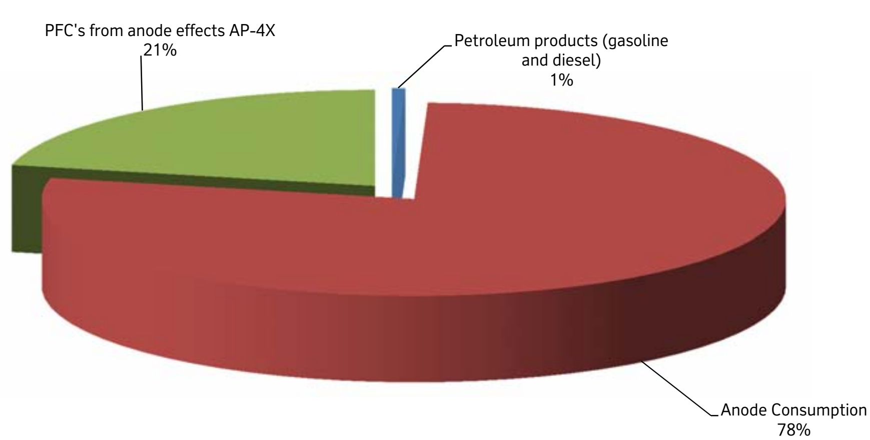


Figure 5.12
GHG Emissions, BC Works 2016

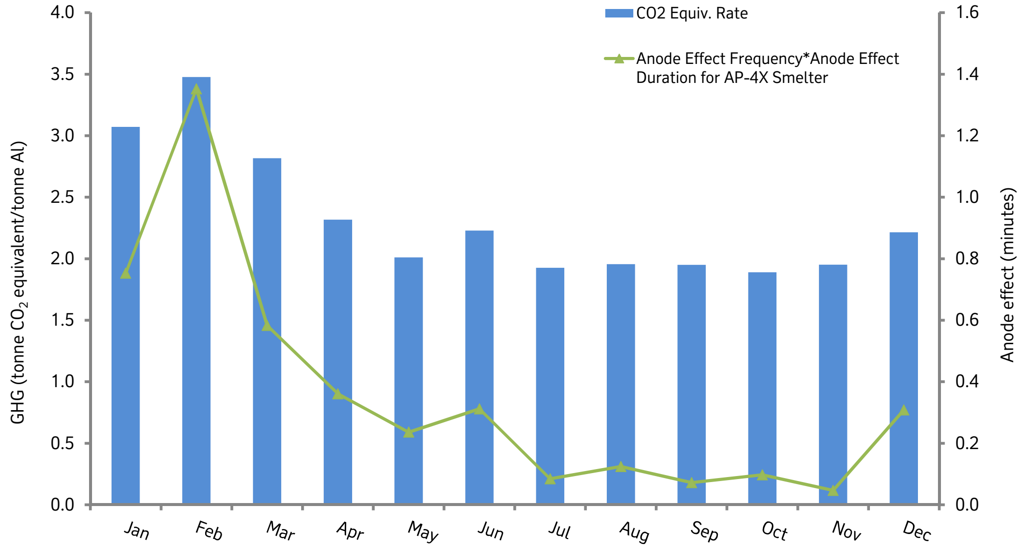
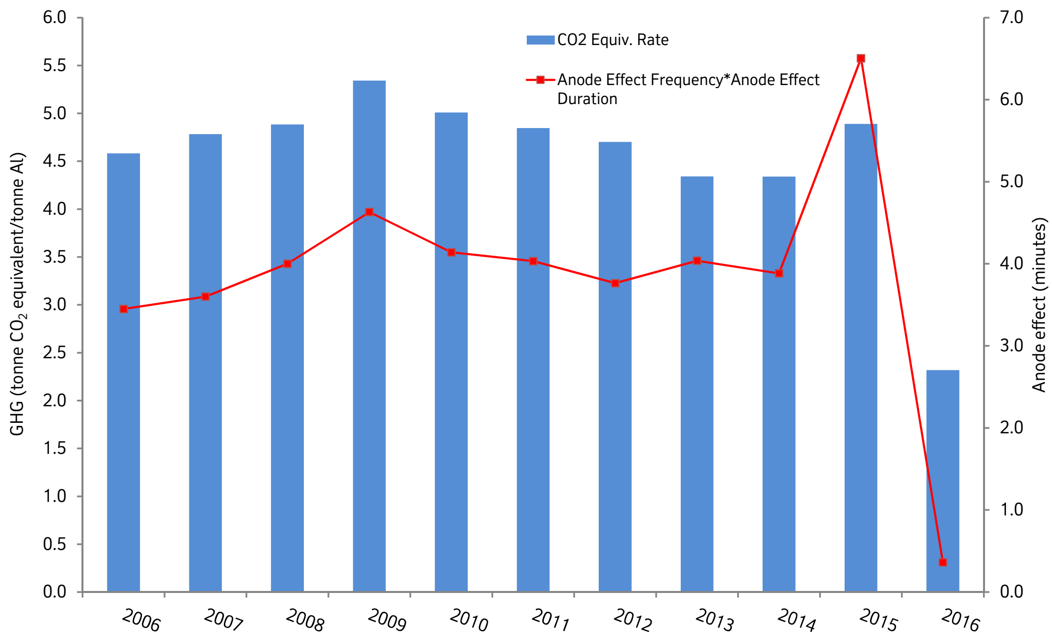


Figure 5.13
GHG emissions BC Works 2006-2016



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.

Meteorological (weather) monitoring data are collected at all five 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 precipitation sampler was upgraded in 2013. 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})		✔				
Polycyclic aromatic hydrocarbons (PAH)	✔		✔	✔		
Hydrogen Fluoride (HF)	✔	✔		✔		
Rain chemistry	✔					✔
Meteorological monitoring	✔	✔	✔	✔	✔	

The collected air quality data are reported out according to the P2-0000 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.

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).

2016 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)

There are currently three Picarro analyzers (cavity ring down spectroscopy) operating in the network: Riverlodge, Kitamaat Village and Haul Road. HF monitoring results are presented in Table 6.2. The annual average measurement at Riverlodge was 0.1 parts per billion (ppb) and Kitamaat Village Stations was < 0.1 parts per billion (ppb). The maximum daily average concentrations were significantly lower than the 1 ppm HF objective for Kitimat (lower by 1,250 times Riverlodge and more than 10,000 times for Kitamaat Village). The HF analyzer for the Haul Road Station fell out of calibration in the spring and was not recalibrated by the manufacturer until September. As a result, HF data for the Haul Road is not presented in this report. Monthly HF averages for the residential stations are presented in Figure 6.1. Riverlodge (maximum 30 day average of 0.18 ppb) was 222 times below the 40 ppb chronic exposure objective. Monthly HF averages are presented in Figure 6.2.

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 2016 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 2016 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 recently adopted Provincial SO_2 Interim ambient Ambient Air Quality Objective. The maximum residential annual average SO_2 concentration was 0.5 ppb. In comparison to the new interim SO_2 air quality objective of 75 ppb (that comes into effect for 2017), Riverlodge's three year 97th percentile average is 9.9 ppb and Kitamaat Village's three year 97th percentile average is 5.3 ppb. These values are 13% and 7%, respectively, of the Air Quality Objective. The SO_2 Environmental Effects Monitoring program Health KPI, has been updated with the new SO_2 Air Quality Objective.

The residential maximum hourly average SO_2 concentrations shown in Table 6.2 ranged from 31.8 ppb to 37.0 ppb. There were no days in 2016 where the residential SO_2 hourly concentrations were above 75 ppb. Figure 6.4 shows the plots of hourly average SO_2 concentrations. Annual SO_2 monitoring values are provided in table 6.2. The annual average for the stations slightly increased in 2016 due to the ramp up of the new modernised smelter. The two previous years were periods of lower SO_2 emissions from the Smelter due to the wind down of the old VSS Potlines (2014-2015) and the start-up of the new AP-4X potline (2015-2016).

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), beehive burners, 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 limit for PM_{10} as 50 micrograms per cubic metre (µg/m^3) and the 98th percentile of the daily hourly maximum limit for $PM_{2.5}$ is 25 ug/m^3.

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 Figure 6.5. Average $PM_{2.5}$ levels for Kitimat are low, ranging between 4.7 ug/m^3 to 7 ug/m^3. All stations (industrial and residential) had days above the BC air quality objective of 25 ug/m^3 for $PM_{2.5}$. These exceedances were due to third party slash or wood burning. Chart of the daily average of PM_{10} for Riverlodge station is provided in Figure 6.6.

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 reported total PAHs from the ambient monitoring program include 19 PAH congeners.

2016 was an important year for PAH ambient air quality monitoring. Due to the complete shutdown of VSS potlines in 2015 and the full ramp up of the AP-4X technology, ambient PAH concentrations have significantly decreased in response to an estimated 98% reduction in PAH emissions from the smelter due to the Kitimat Modernisation Project. The 2016 ambient PAH monitoring results are summarized in Table 6.3. The geometric mean PAH concentration observed at Haul Road station was lower in 2016 (12 ng/m^3) than in 2015 (39 ng/m^3). At the Whitesail station, the PAH concentration was lower in 2016 (5 ng/m^3) compared to 2015 (9 ng/m^3). At the Kitamaat Village station PAH concentrations were lower this year (6 ng/m^3) compared to 2015 (9 ng/m^3).

In 2016, total PAHs showed a reduced degree of variability (Figure 6.7) when compared to previous years. This is due to the significant reductions in PAH emissions by the modernised smelter. The maximum total PAH measurements between 2016 and 2015 have also been reduced significantly: by 91% at Haul Road, 92% at Whitesail and 74% at Kitamaat Village.

The decrease in PAH concentrations is very significant when compared to the baseline of the old VSS smelter operations. Using a baseline of 2005 to 2009, total ambient PAHs have decreased 90% at Haul Road, 79% at Whitesail, and 72% at Kitamaat Village. The total PAH decreases at the residential stations are smaller compared to the Industrial Haul Road site due to other PAH contributing sources.

A change made to the PAH reporting for 2016 has been made with the figure showing the distribution of the individual PAH congeners. This figure has been changed from a simple pie chart to a PAH finger print bar chart. The PAH congeners have also been rearranged from simple alphabetical order to ordering by molecular weight (light to heavy). This new chart better depicts the distribution of PAHs between the stations and shows the change in ratios of specific PAH congeners between the three stations. The change 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 (Figure 6.8).

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. A relative colour scale has been added to the table to enhance the visualization of trends in the data. There are no permit levels or objectives for this procedure. Key observations in the rain chemistry are that the dissolved fluoride, aluminium, and base cations have reduced between 2013 and 2016, which are likely due to shut down of the VSS smelter and full ramp-up of the new AP-4X smelter. Sulphate levels have slightly increased, as expected with the increased hot metal production with the modernised smelter.

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
*2016 Ambient Air Quality Monitoring Results**

Statistic	Industrial	Residential		
	Haul Road	Riverlodge	Whitesail	Kitamaat Village
	SO_2			
2016 Average (ppb)	4.2	0.5	0.5	0.4
97th percentile		12.9	11	8.4
Days above 75 ppb (Hourly)		0	0	0
Minimum (hourly, ppb)	0	0	0	0
Maximum (hourly, ppb)	94.1	31.8	37	36.6
Percent Data Capture (%)	93	95	95	95
Standard Deviation (ppb)	8.9	1.2	1.1	1
	PM2.5			
2016 Average (ug/m^3)	5	4.7	5.7	7
98th percentile		9.7	16.4	18.5
Days above 25 ug/m^3		0	2	4
Minimum (hourly, ug/m^3)	0	0	0	0
Maximum (hourly, ug/m^3)	189	71	67	90
Maximum daily average (ug/m^3)	36.5	24.1	26.8	27.3
Percent Data Capture (%)	98	98	94	90
Standard Deviation (ug/m^3)	6.2	3.9	4.6	5.9
	PM10			
2016 Average (ug/m^3)		9.7		
Minimum (hourly, ug/m^3)		0		
Maximum (hourly, ug/m^3)		162		
Maximum daily average (ug/m^3)		31.4		
Days above 50 ug/m^3		0		
Percent Data Capture (%)		97		
Standard Deviation (ug/m^3)		6.7		
	HF			
2016 Average (ppb)		0.1		0
Minimum (hourly, ppb)		0		0
Maximum (hourly, ppb)		0.8		0.1
Days above 1ppm (hourly)		0		0
Percent Data Capture (%)		100		99.5
Standard Deviation (ppb)		0.1		0.05

*Air quality data extracted from BCMOE's Envista database on 31 January 2017

Table 6.3 Geometric mean Total PAH Concentrations, 2015 & 2016

Station	Average (ng/m^3)		2016 Statistics (ng/m^3)			
	2016	2015	Min	Max	Standard Deviation	Percent data Capture
Haul Road	12.0	39.3	1.8	59.0	9.5	100%
Whitesail	4.8	8.5	1.7	12.9	2.8	97%
Kitimat Village	6.2	9.1	1.7	44.2	7.8	97%

Table 6.4
Rain chemistry monitoring (2013 to 2016)

			Haul Road				Lakelse Lake			
Year			**2013**	**2014**	**2015**	**2016**	**2013**	**2014**	**2015**	**2016**
Important Milestone			**Start of NADP rain chemistry analysis**	**VSS Wind down**	**VSS stopped AP-4X Ramp-up**	**AP-4X Last Pot Started**	**Start of NADP rain Chemistry Analysis**	**VSS Wind Down**	**VSS stopped AP-4X Ramp-up**	**AP-4X Last Pot Started**
	Parameter									
Precipitation	Annual Precipitation Depth (mm)	Total	2201	2619	2802	2467		1566	1526	1661
Acidity	Rain (pH)	average	4.4	4.7	4.6	4.6	5.1	5.2	5.2	5.0
		geomean	4.3	4.6	4.6	4.5	5.1	5.2	5.2	5.0
	Acidity (to pH 8.3) $CaCO_3$ (mg/L)	average	4.4	3.5	2.2	4.0	1	1.8	0.7	1.0
		geomean	3.2	2.7	1.9	3.4	0.9	1.2	0.7	1.0
	Acidity - Free (μeq/L)	average	24.5	15.3	9	21.0	5.3	9.9	3.6	5.4
		geomean	16.7	7.6	5.1	10.5	4.5	3.3	2.7	3.1
	Alkalinity - Total $CaCO_3$ (mg/L)	average	0.3	0.7	3.7	1.1	0.8	0.9	1.8	0.8
		geomean	0.3	0.7	1	1.0	0.8	0.8	1.1	0.8
Concentration of Specific Substances (mg/L)	Chloride (Cl)	average	0.3	0.4	0.3	0.3	0.09	0.15	0.13	0.11
		geomean	0.2	0.2	0.2	0.2	0.05	0.1	0.08	0.08
	Fluoride (F)	average	1.9	0.6	0.4	0.6	0.03	0.2	0.02	0.02
		geomean	1.4	0.4	0.3	0.4	0.03	0.03	0.01	0.02
	Sulphate (SO_4)	average	1.4	1.2	1.5	1.8	0.46	0.39	0.28	0.56
		geomean	1.1	0.7	0.8	1.4	0.35	0.22	0.19	0.37
	Ammonia Nitrogen (NH_4)	average	0.05	0.06	0.06	0.06	0.06	0.13	0.03	0.02
		geomean	0.04	0.04	0.03	0.03	0.02	0.02	0.00	0.01
	Nitrate Nitrogen ($N0_3$)	average	0.16	0.16	0.22	0.17	0.16	0.16	0.22	0.17
		geomean	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Total Dissolved Phosphate ($P0_4$)	average	0.01	0.01	0.01	0.03	0.02	0.08	0.00	0.01
		geomean	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Aluminium (D-Al)	average	0.46	0.15	0.08	0.17	0.004	0.026	0.01	0.02
		geomean	0.24	0.1	0.06	0.11	0.004	0.007	0.008	0.012
	Calcium (D-Ca)	average	0.22	0.08	0.09	0.14	0.04	0.04	0.06	0.04
		geomean	0.11	0.06	0.05	0.06	0.03	0.03	0.03	0.03
	Magnesium (D-Mg)	average	0.06	0.03	0.03	0.03	0.01	0.02	0.01	0.01
		geomean	0.04	0.02	0.02	0.03	0.01	0.01	0.01	0.01
	Potassium (D-K)	average	0.16	0.02	0.02	0.08	0.05	0.05	0.02	0.02
		geomean	0.06	0.01	0.01	0.02	0.02	0.01	0.01	0.01
	Sodium (D-Na)	average	0.54	0.31	0.28	0.27	0.05	0.09	0.07	0.06
		geomean	0.36	0.22	0.18	0.20	0.03	0.06	0.04	0.04

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

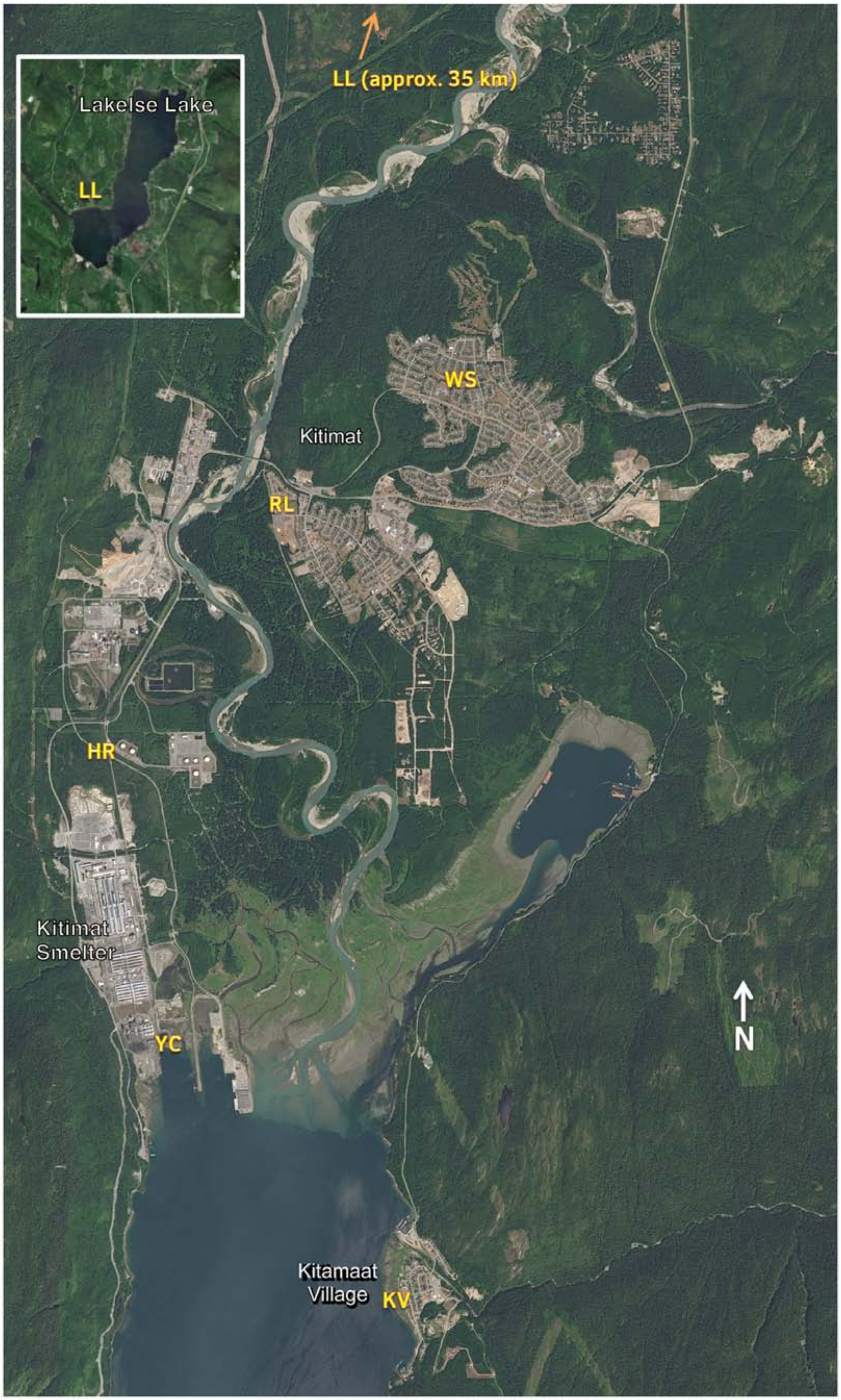


Figure 6.2
Hydrogen Fluoride Monthly Average Concentrations

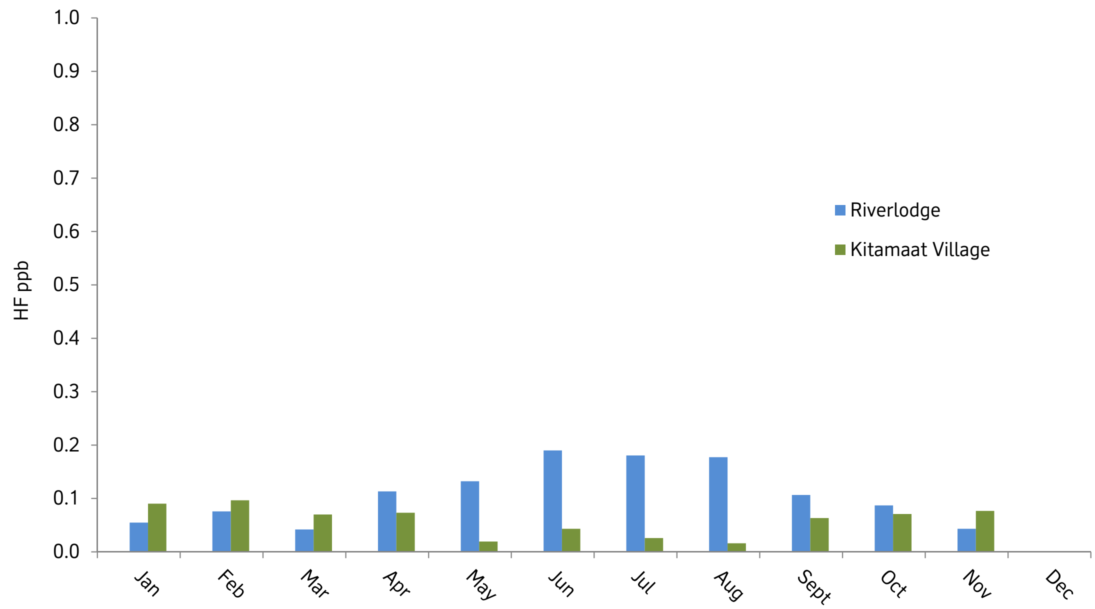


Figure 6.3a
SO_2 Residential Monthly Average Concentrations

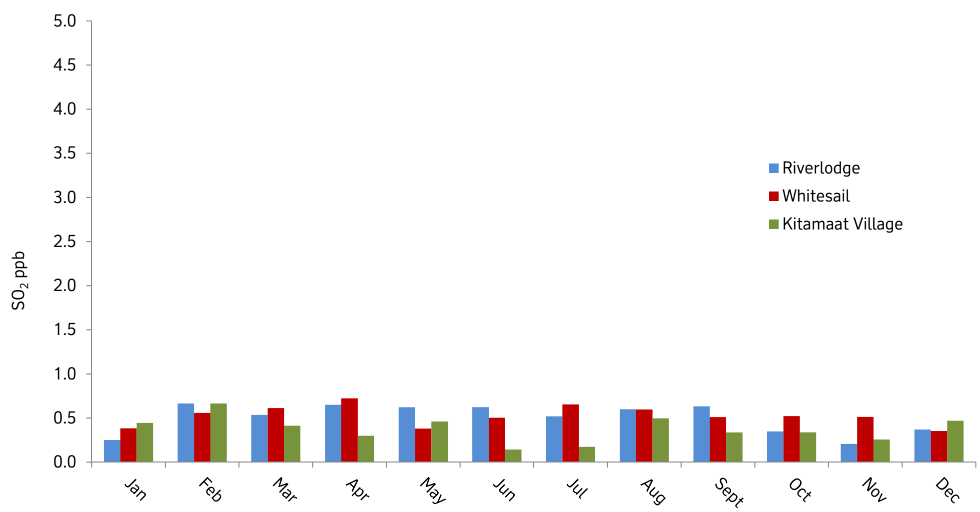


Figure 6.3b
SO_2 Haul Road Monthly Average Concentrations

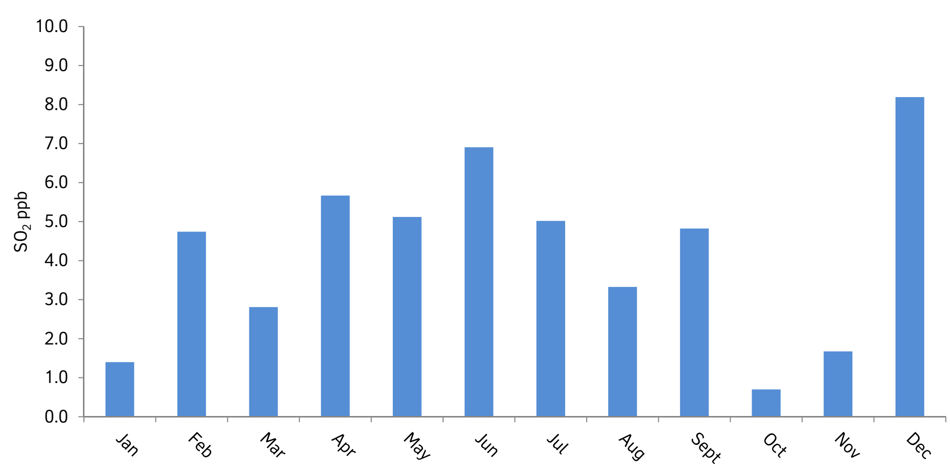


Figure 6.4a
SO_2 Haul Road Hourly Concentrations

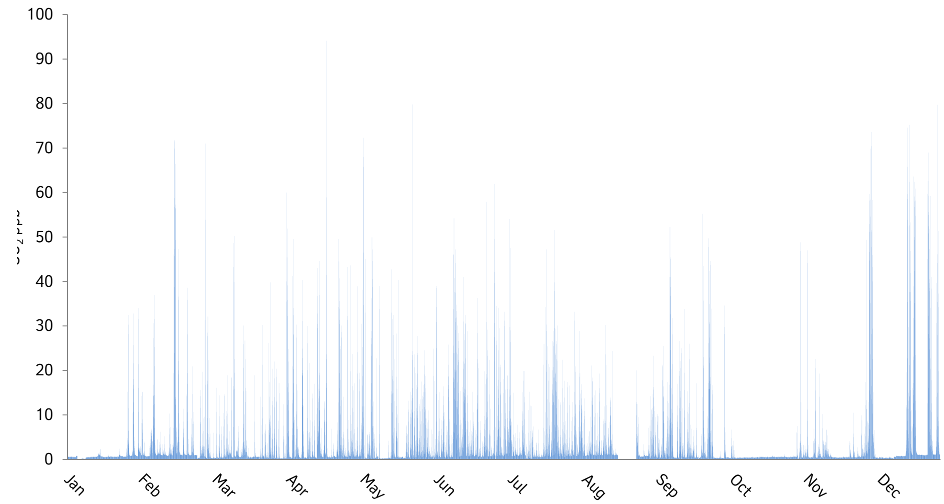


Figure 6.4b
Riverlodge 2016 Hourly SO_2 Concentrations

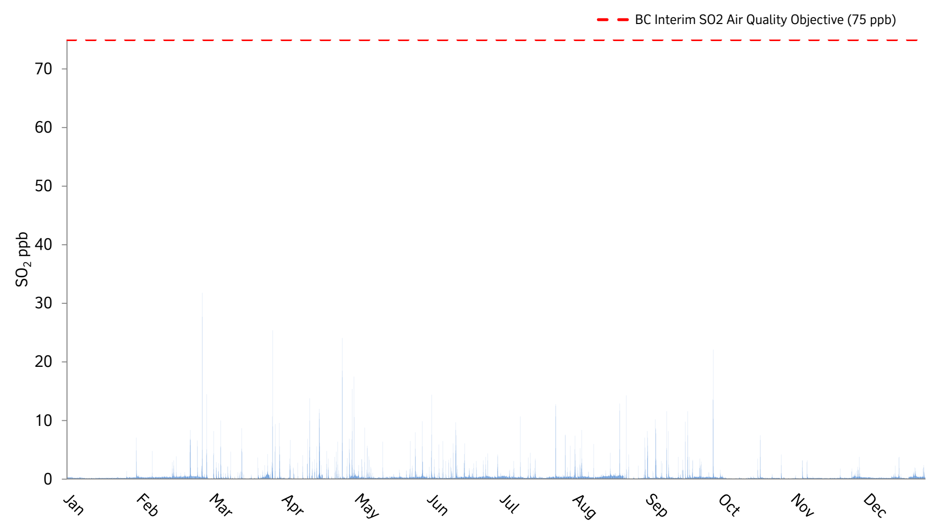


Figure 6.4c
Whitesail 2016 Hourly SO_2 Concentrations

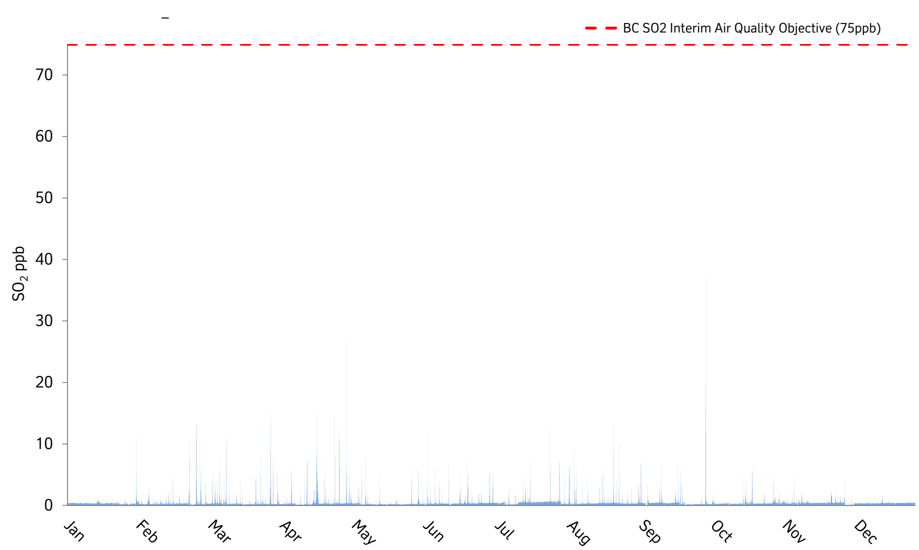


Figure 6.4d Kitamaat Village 2016 Hourly SO_2 Concentrations

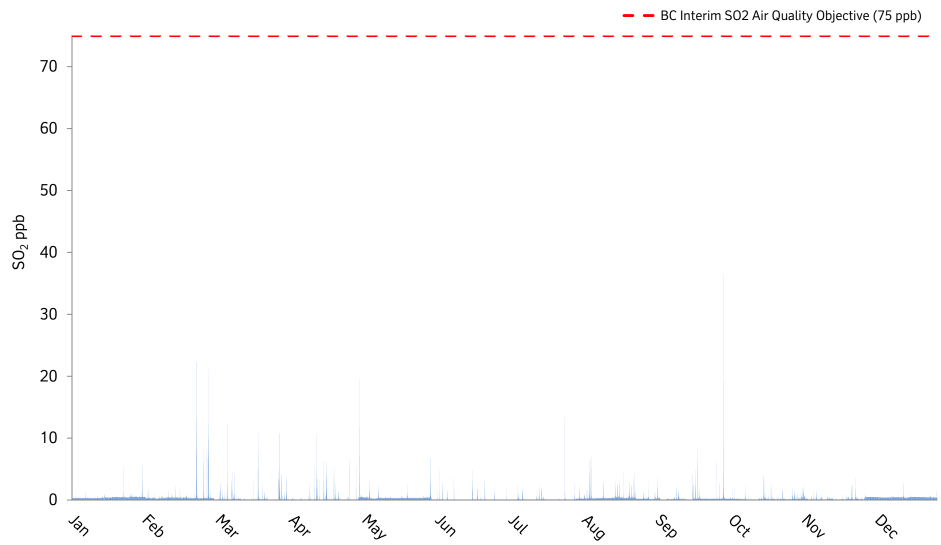


Figure 6.5a Haul Road $PM_{2.5}$ 2016 Daily Average

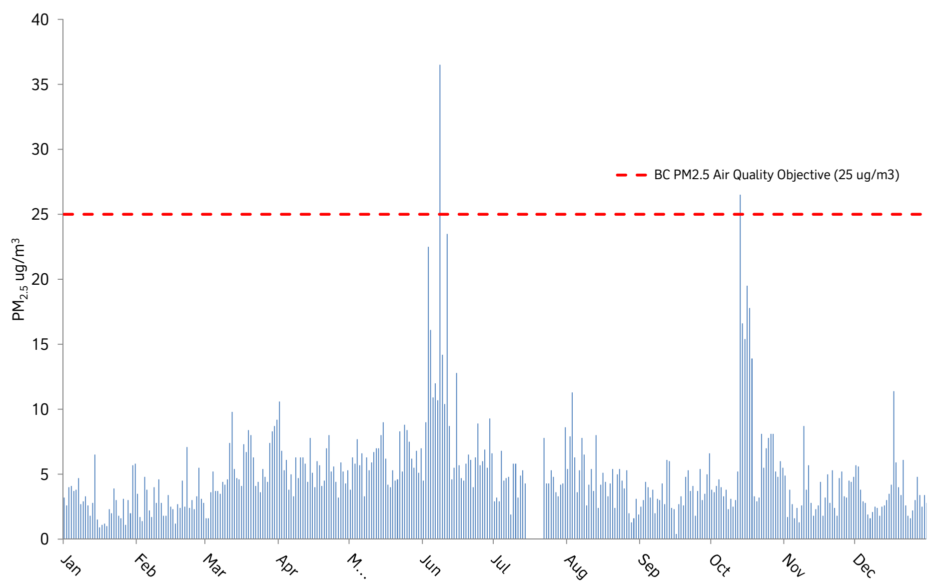


Figure 6.5b Riverlodge 2016 $PM_{2.5}$ Daily Average

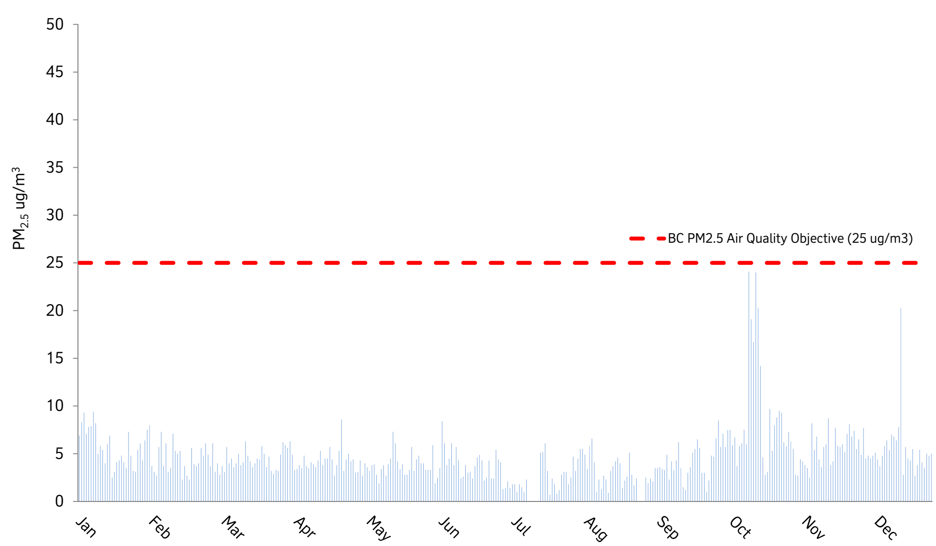


Figure 6.5c
Whitesail 2016 $PM_{2.5}$
Daily Average

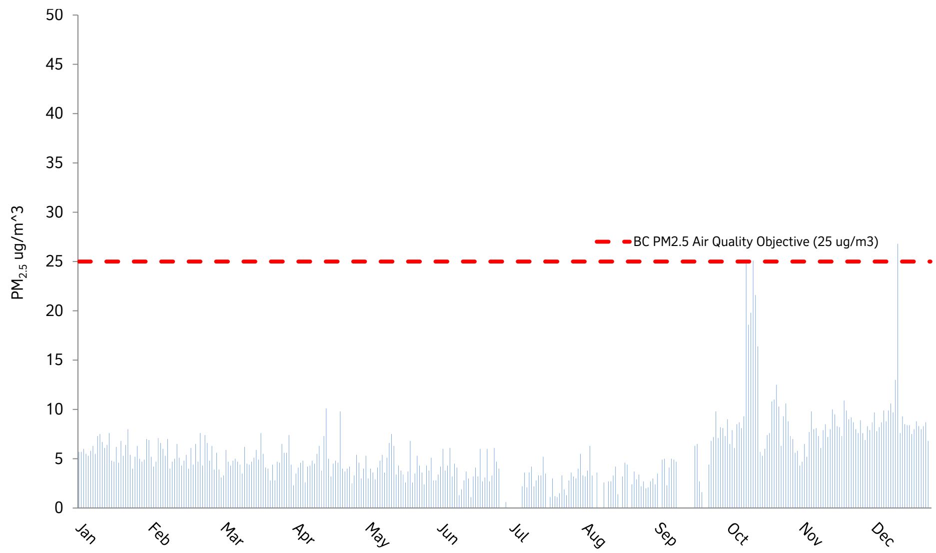


Figure 6.5d
Kitamaat Village
2016 $PM_{2.5}$
Daily Average

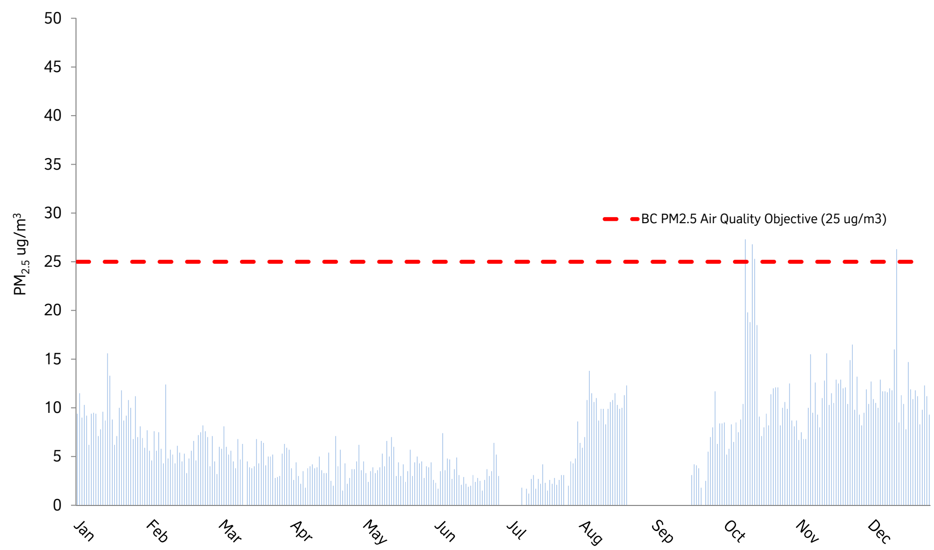


Figure 6.6
Riverlodge 2016 PM_{10} Daily Average

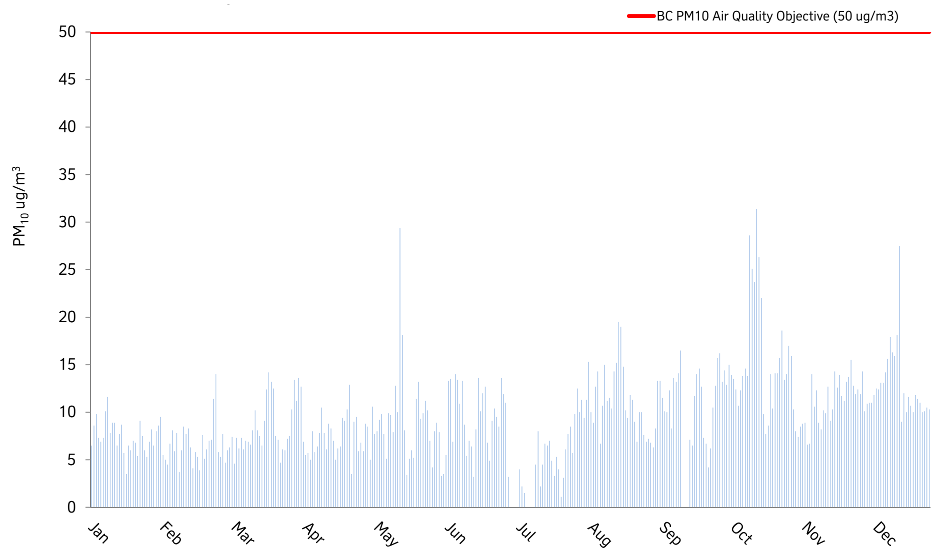


Figure 6.7a
Haul Road 2016
Total PAH

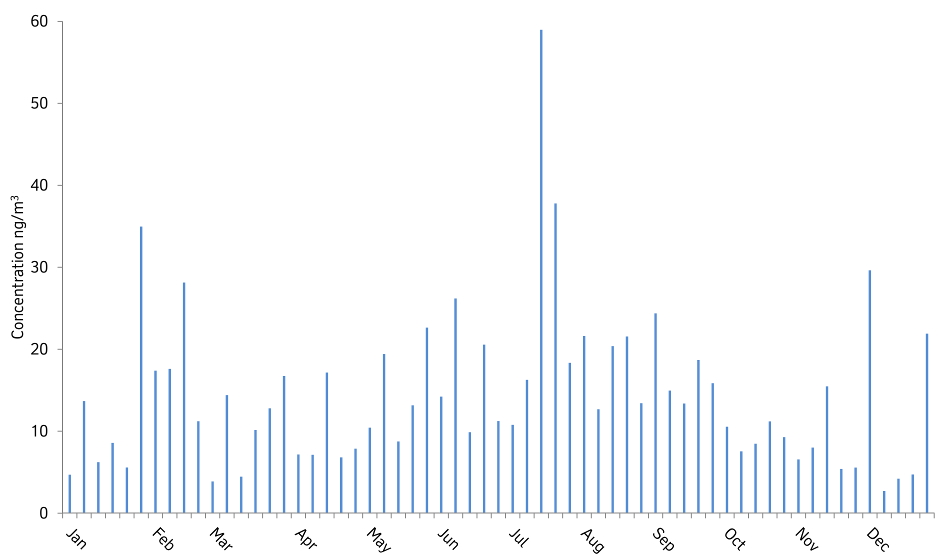


Figure 6.7b
Whitesail 2016
Total PAH

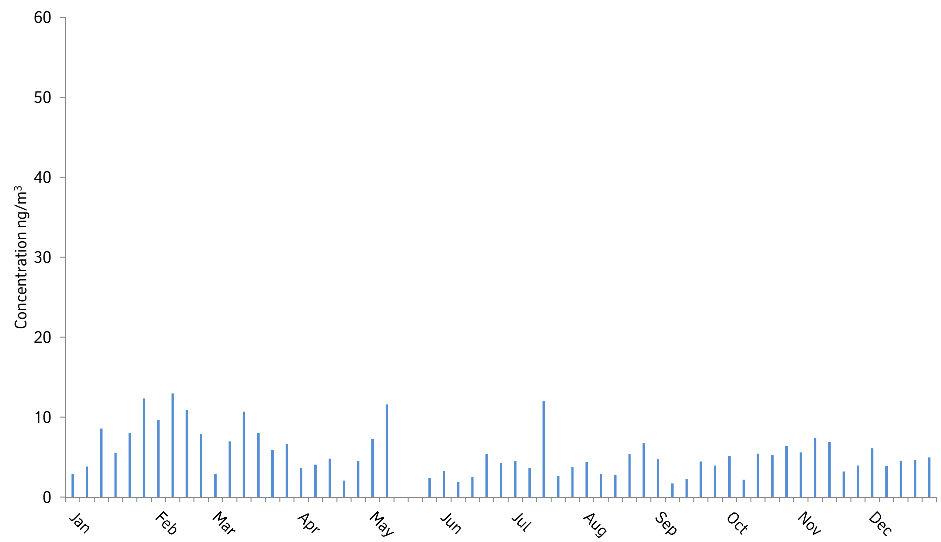


Figure 6.7c
Kitamaat Village
2016 Total PAH

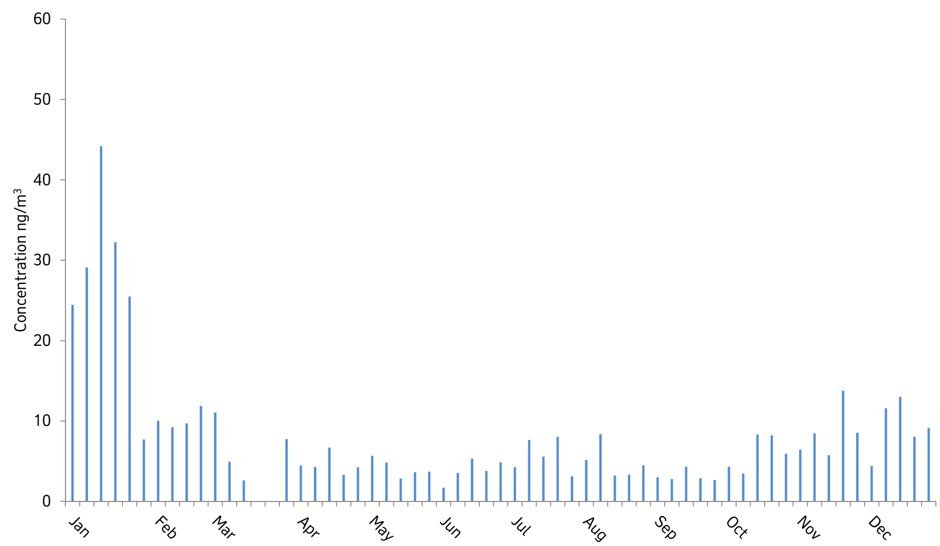
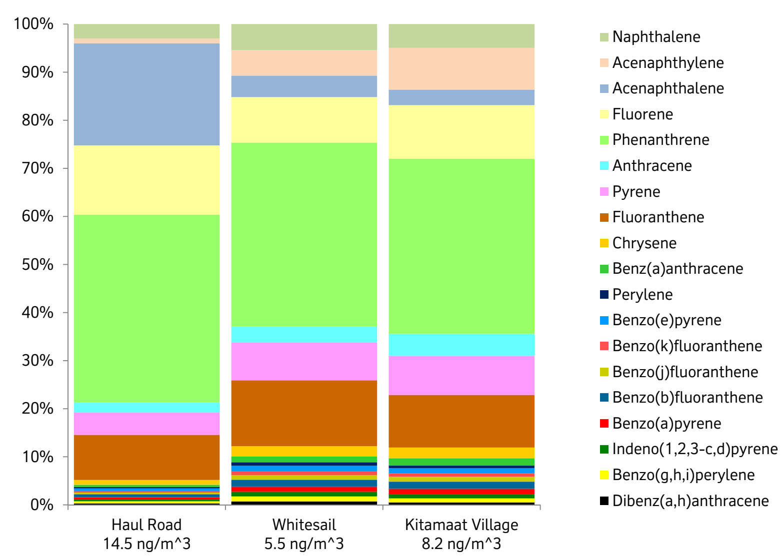


Figure 6.8
2016 PAH Congener
Distribution



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 our operations to document the health and condition of vegetation.

Introduction

The annual collection 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 (gaseous fluoride) 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 centred 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.

Sample collection is usually conducted at 38 sites at the end of the growing season by gathering the current year's growth. This is done because vegetation is more sensitive to fluoride and sulphur emissions in the spring, when new tissue is tender and growing rapidly.

The sampling program focuses on hemlock because it is evenly distributed throughout the valley and is a reliable indicator for vegetative absorption of emissions. This year's samples were collected by an independent consultant and analysed at Rio Tinto's Vaudreuil Analytical Laboratory in Quebec.

2016 monitoring results

Fluoride content

There is historically a strong correlation between fluoride concentrations in hemlock and fluoride emissions from the potroom roofs at BC Works. In 2016, fluoride concentration in hemlock samples averaged 25 ppm, which is slightly lower than the 31 ppm observed in 2015 (Figure 7.2).

On a monthly basis, total fluoride emissions from BC Works did not exceed the permit limit of 33.3 tonne per month (Figure 7.1). The permit limit came into effect in September 2016 when the process stabilized, and there were no reliable sample results before then.

There were no non-compliances relative to the total fluoride emissions in 2016.

Sulphur content

Vegetation can absorb higher concentrations of sulphur than fluoride before visual damage can be detected. Annual averages of sulphur concentrations in vegetation in the Kitimat-Terrace area have remained relatively uniform, with little variance across the sample area and have rarely been found above background levels.

The average sulphur concentration in hemlock for 2016 was 0.08% which was the same as in 2015 (Figure 7.3).

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. Even though the qualitative assessment was done in 2015, it was done again in 2016 due to the startup of the AP-4X technology.

Some of the observations reported are as follows.

- The condition of vegetation was similar to what was reported in 2015. No symptoms of injury to vegetation were observed except some minor injury at the Rio Tinto administration building.
- There were no remarkable insect outbreaks, disease epidemics or other stress factors affecting vegetation.

Figure 7.1
Western hemlock fluoride content and fluoride emissions, 2006- 2016

Note: Compliance monitoring started only in September.

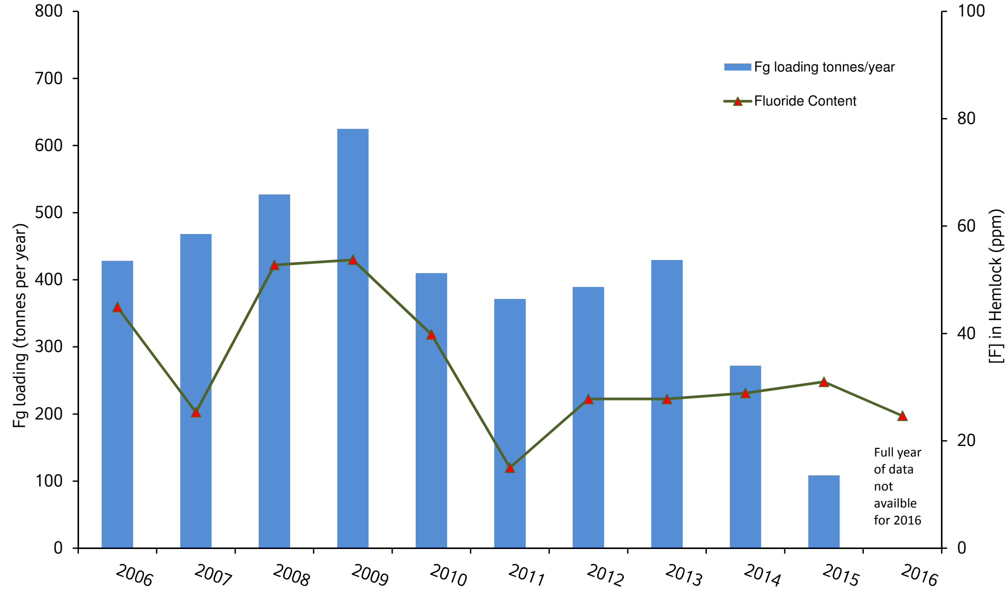


Figure 7.2
Potroom total fluoride emission monthly loadings, 2016

Note: Compliance monitoring started in September 2016

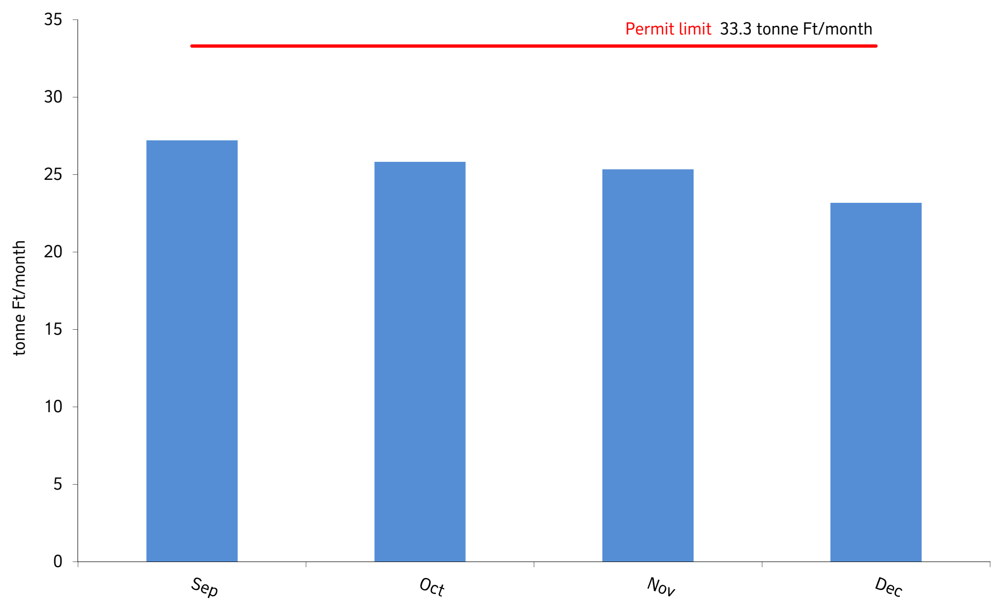
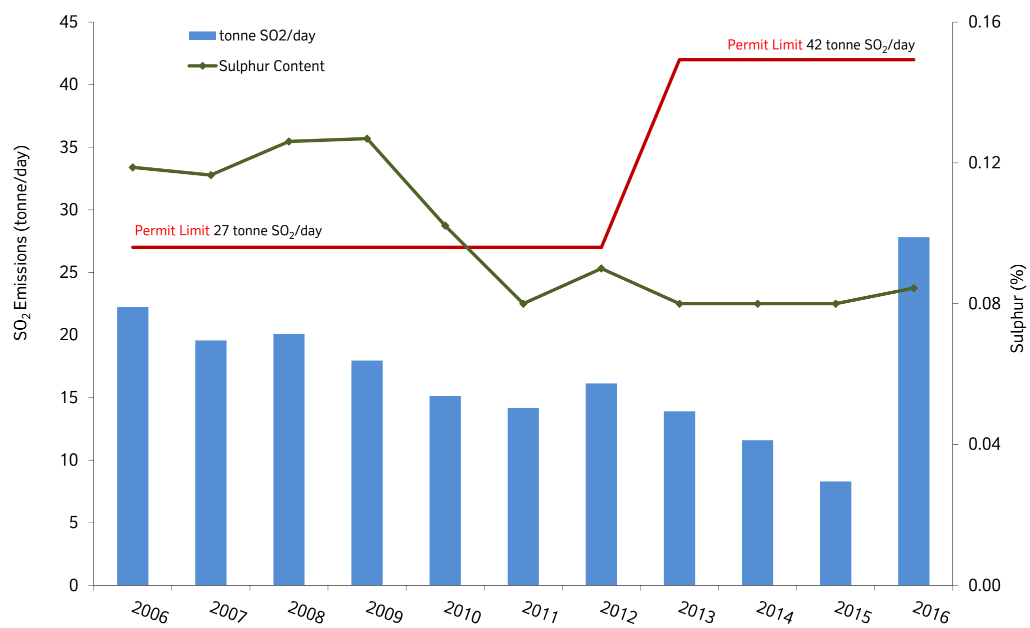


Figure 7.3
Western hemlock sulphur dioxide emissions, BC Works, 2006-2016



8. Waste management

The operation of the smelter results in the generation of various solid and liquid wastes.

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. Ongoing 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.

2016 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 2016, 710 metric tonnes of SPL was generated and shipped off-site. 94 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 2016 originated from the VSS pot 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 2016, 5 m^3 of asbestos and ceramic fibres materials associated with smelter maintenance activities were collected and disposed. The material was disposed of at the South Landfill. No asbestos or ceramic fibres materials were sent to the North Landfill in 2016 (refer to BC Works map Figure 2.2 for waste storage, disposal and managed sites).

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. Two non-compliances were reported for the South Landfill in 2016 (see Chapter 11).

A survey is carried out once a year for reconciliation of the forecasted disposal volumes. The total volume of materials disposed of at the South Landfill in 2016 was 6,187 m^3, which corresponds to 6,617 metric tonnes.

As part of the requirements of the permit related to the South Landfill, Rio Tinto completes an 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 scope of work for the 2016 South Landfill EEM program consisted of hydrology monitoring; surface water, groundwater, porewater, and ditch watch quality monitoring; benthic invertebrate community assessment; and, estimate annual fluoride mass fluxes from the landfill.

The overall conclusion of the 2015 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, benthic community and an adult fisheries assessment. The results of the 2016 South Landfill EEM program do not change the conclusion of low risk to aquatic organisms in Moore Creek main channel; however, two side channels with localized elevated concentrations were identified which may result in an elevated risk to aquatic organisms during low-flow periods in Moore Creek.

Annual loading estimate of Potential Contaminants of Concern (PCOC) to the receiving environment are calculated based on a mass balance approach. This approach was previously used for the 2012, 2013 and 2014 South Landfill EEM programs. The estimates of total fluoride mass flux from the landfill are as follows: 2,276 kg/yr (2012), 2,373 kg/yr (2013), 2,554 kg/yr (2014), 2,530 kg/yr (2015) and 2,233 kg/yr in 2016. The decrease in 2016 compared to 2015 is due to a decrease in precipitation.

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 2016, a total of 2,390 m^3 of wood waste was burned during the year using open burns. In 2016, the open burning pit was relocated to Terminal B.

9. Groundwater monitoring

Long-term initiatives are underway with objectives to further reduce groundwater contamination 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 Works' landfill sites that are, or have the potential to be, a source of contamination. In 2016, 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.

2016 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 2.2).

Prior to 1989, approximately 460,000 m^3 of SPL was 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 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 the previous year's results.

Estimated groundwater flux for 2016 (260,491m^3/yr) was lower than 2015 (354,026 m^3/yr). For 2016, fluoride, cyanide, aluminium and iron loading were estimated at 15,062 kg/yr, 114 kg/yr, 478 kg/yr and 339 kg/yr, respectively.

The 2016 loading estimates for fluoride, aluminium, and iron were lower than the 2015 loading estimates and within the range of estimates from previous years The lower values in 2016 can be attributed to less precipitation in 2016 along with a slight reduction in concentrations of chemistry in the near shore groundwater wells.

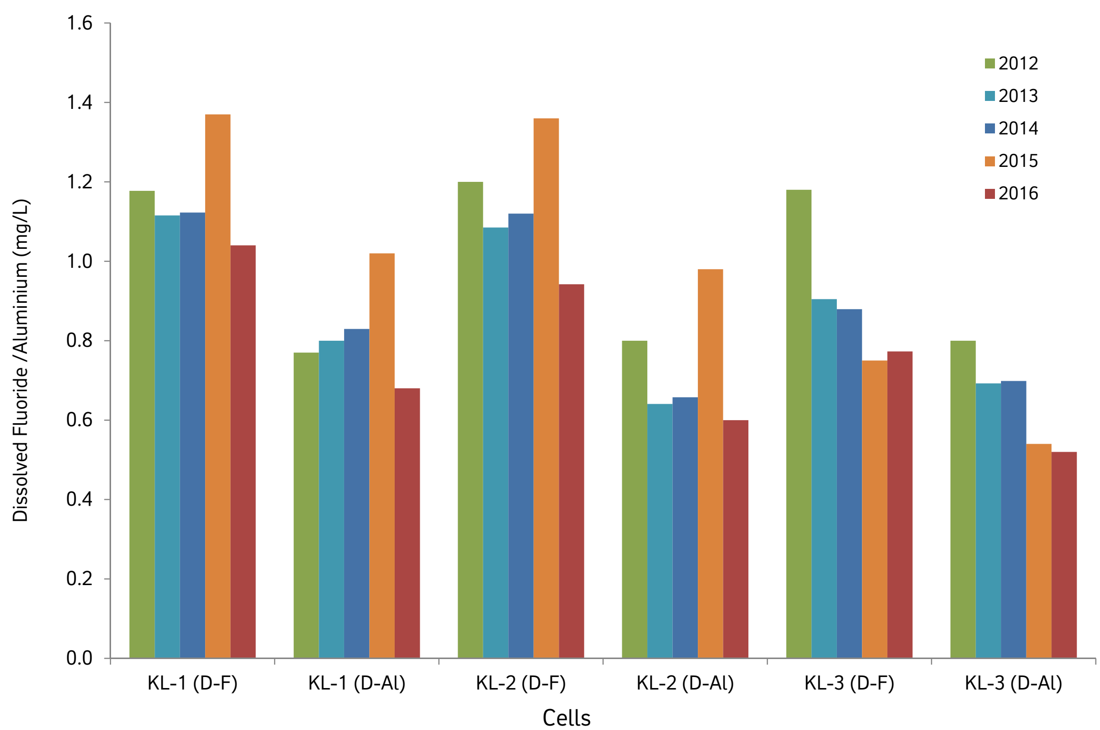
Dredgeate cells and SPL overburden cell

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 2016. The samples were analyzed for dissolved fluoride and dissolved aluminium. The 2016 contaminant monitoring results are slightly lower when compared 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 10,500 m^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 2016 approximately 90.0 m^3 was pumped out from the six sumps.

Figure 9.1 Dissolved fluoride & aluminium, wharf dredgeate monitoring cells



10. Kemano permits

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

Introduction

Up until 2000, Kemano Works 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.

2016 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. Prior to 2006, effluent results were generated monthly to establish a baseline. Since then, the permit requires only quarterly sampling. In 2016, 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. The incinerator is a double-chambered, fuel-fired, forced air unit. The permit requires that the exhaust temperature of the incinerator remain, and in 2016, permit requirements were in compliance.

Kemano landfill

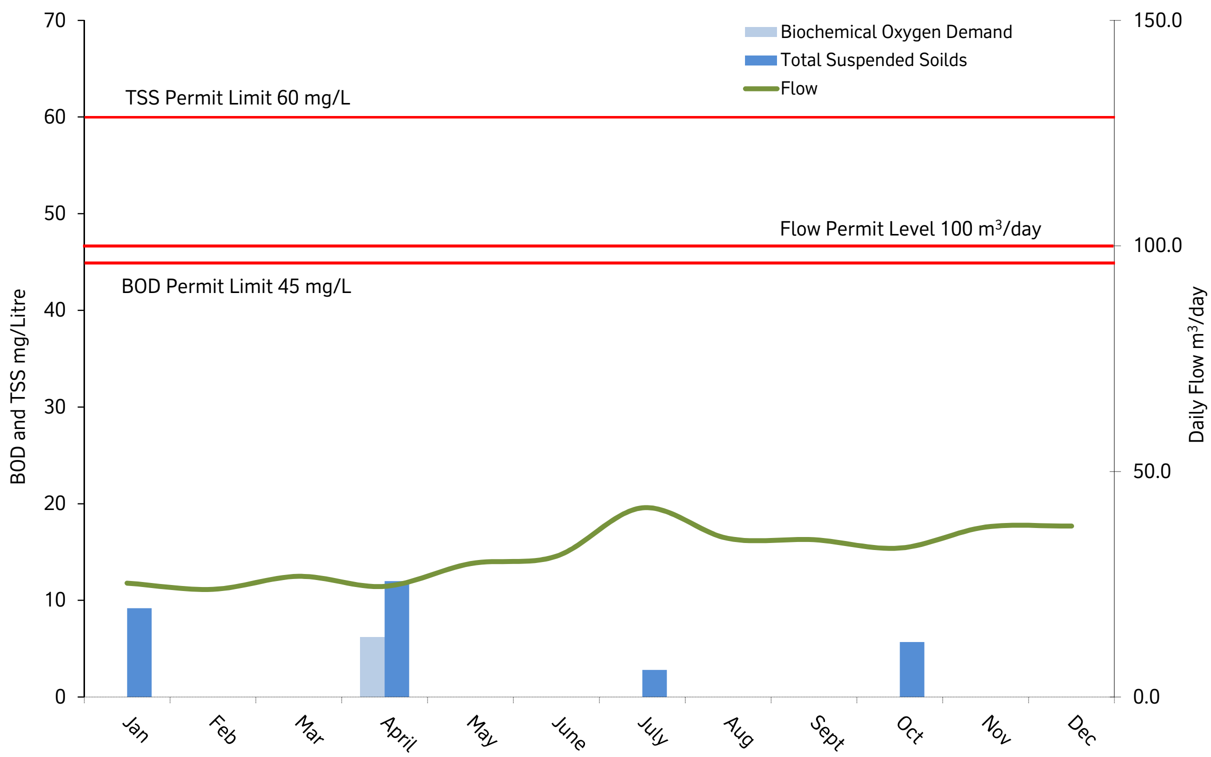
Non-combustible refuse and ash from the incinerator is buried in a landfill near Kemano. The landfill permit limits the amount of material to an annual maximum of 300 m^3. In 2016, 8.8 m^3 of refuse was buried.

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 2016, 122 m^3 of sludge was disposed, which is a slight decrease from the 170 m^3 in 2015. This decrease can be explained by the decrease in population through 2016.

Seekwyakin camp effluent discharge

Seekwyakin construction camp, located three kilometres 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 2016, Seekwyakin camp saw very little activity and usage remained well below 25 residents.

Figure 10.1
Effluent discharge, Kemano 2016



11. Summary of non-compliance and spills

In 2016, there were a total of eight non-compliances for Kitimat and zero non-compliance for Kemano.

2016 performance

Non-compliance summary

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 2016, four 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.

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.

No known environmental damage was associated with any of the spills reported during 2016.

Table 11.1 Summary of non-compliances, 2016

Non-Compliance	Occurrence date	Impact	Permit Requirement	Cause	Implemented Corrective Actions
B-Lagoon instrumentation failure	July and September	Invalid conductivity and temperature readings	B-Lagoon monitoring and sampling requirements	A lightning storm event affected instrumentation at the B-Lagoon outfall. Conductivity and temperature readings were affected	Short term: Validate that anomalous readings were caused by instrumentation issue. Repair faulty equipment – Completed Long term: Training and awareness to employees involved in sampling and calibration – Completed
Electric bear fence at South Landfill not meeting permit requirements	26 July	Risk of wildlife interaction	Electric fencing design and maintenance requirements	During and MOE onsite inspection broken insulators and improper wire repairs were observed.	Short term: Repair bear fence – Completed Long term: Training to contractor responsible to maintain bear fence – Completed
Unauthorized waste deposited at South Landfill	2 November	Hazardous waste deposited to South Landfill	South Landfill requirements	Human error and lack of awareness	Short term: Material covered and characterized – Completed Over excavate material and it to secured landfill – Completed Long term: Update and improve load acceptance procedure – Completed
Toxicity test (LC5096h) failure and dissolved Aluminium (dAl) exceeding permit limits during overflow events at F-Lagoon.	26 September dAl: 3.18 mg/L LC5096h: Fail 7 November dAl: 1.99 mg/L LC5096h: Fail 18 December dAl: 2.80 mg/L LC5096h: Fail 20 December dAl:2.44 mg/L LC5096h: Fail	Discharge to fresh water	F-Lagoon permit limits : Dissolved Aluminium: 1mg/L Toxicity test (LC5096h): pass with 50% survival	Process material losses (sources control) in different areas of the smelter and F-Lagoon capacity	Short term: Detailed investigation – Completed Corrective action: • Housekeeping in contributing areas – Ongoing • Deployed action plan to address material losses at Gas Treatment Centres and Bath Plant – Completed • Deploy Receiving environment assessments – Completed • Install temporary pumping system to reduce overflow occurrences and minimize volume spilled – Completed Long Term: Engineered solution at F-Lagoon to or eliminate non-compliant overflows to fresh water environment
Toxicity test failure during overflow events at B-Lagoon	21 December LC5096h: Fail	Discharge to marine environment	B-Lagoon permit limits : Toxicity test (LC5096h): pass with 50% survival	After review of the overflow results the toxicity test failure could not be explained by the chemistry results and scientific literature. This event has been identified as an anomaly.	Short term: Detailed investigation and review of chemistry results – Completed Long term: This event have been identified as an anomaly (cannot be explain by chemistry results) and further actions will be taken should it occur again.
Missed stack samples for C-Casting, FC3 and Pitch Incinerator (liquid pitch storage tanks)	December	Missed sample	Annual stack sampling requirements	Planning and safety issues	Corrective action: • Action plan developed with contractor to eliminate the risk of missed samples and to improve sampling execution for 2017 – Completed • Complete sampling of Pitch Incinerator (Liquid pitch storage tanks) in early January 2017 – Completed

Table 11.2 Summary of reportable spills, 2016

Occurrence	Substance	Amount	Environmental Media	Causes	Corrective Actions
9 March	Diesel Fuel	<5 litres	Asphalt and marine	Mobile equipment breakdown at Terminal A	Equipment repaired and area cleaned up
13 August	Hydraulic oil	6 litres	Kemano river	Equipment failure on Generator 8 in Kemano	Equipment repaired and area cleaned up
5 October	Hydaulic oil	157 litres	Concrete	Hydraulic oil leak from vehicle on wharf apron	Equipment repaired and area cleaned up
3 November	Hydaulic oil	250 litres	Asphalt	Hydraulic hose disconnected	Equipment repaired and area cleaned up by specialist

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 anodes, composed of calcined coke, recycled carbon and coal tar pitch.

AP-4X
Pre-bake aluminium smelting technology used in the Kitimat modernised smelter.

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 Treatment and Storage Facility
Bath generated from the pots is taken to the Bath Treatment and Storage Facility for processing and recycling.

Carbon dioxide equivalency (CO_2e)
This is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_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 a 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.

Exception pot
A pot that is not operating within the normal range and could result in openings in the alumina sealing. Exception pots are associated with increased fluoride emissions.

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.

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

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 BC Works, 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 modernised 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; to which BC Works 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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