PFAS Treatment Trials with Granulated Activated Carbon – CFB Comox

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Introduction

- Source and surface water treatment for per- and poly-fluoroalky substances (PFAS - as reported by analysis or subsequently detected through a total oxidizable precursors assay (TOPs)), total and dissolved metals, polycyclic aromatic hydrocarbons (PAHs), and hydrocarbons is part of ongoing surface water management at CFB Comox
- Trialing of granulated activated carbon (GAC) was completed to assess treatment performance of PFAS impacted surface water collected in a retention pond at CFB Comox's Fire Fighting Training Area (FFTA)
- PFAS containing liquids directly from a cross contaminated firetruck tank were also treated with GAC to assess its performance as a treatment media. These liquids were considered to be sourced from a more recent formulation of aqueous film-forming foam (AFFF).

Fire Fighting Training Area

Site Conditions

- The site is a low flat area that drains to a network of surrounding swales and ditches
- Surface water flow extremes from the FFTA range from periods of no runoff through most of the summer to periods of significant runoff during periods of high precipitation in the fall and winter. 2,000 m^3/day and more of precipitation can fall in the FFTA and associated catchment during an extreme rain event
- Due to flatness and low permeability soils, water ponds in the mostly grassed FFTA during wetter periods. A constructed pond and graveled area also increases retention of surface water at the site immediately downgradient of the FFTA.

Treatment Scope

- Evaluate the treatment performance of GAC for the range of PFAS concentrations associated with the FFTA retention pond
- Trial the treatment of PFAS with other readily available PFAS treatment processes or media (advanced oxidation and resins)
- Trial the treatment of PFAS containing liquids from the cross contaminated firetruck tank with GAC

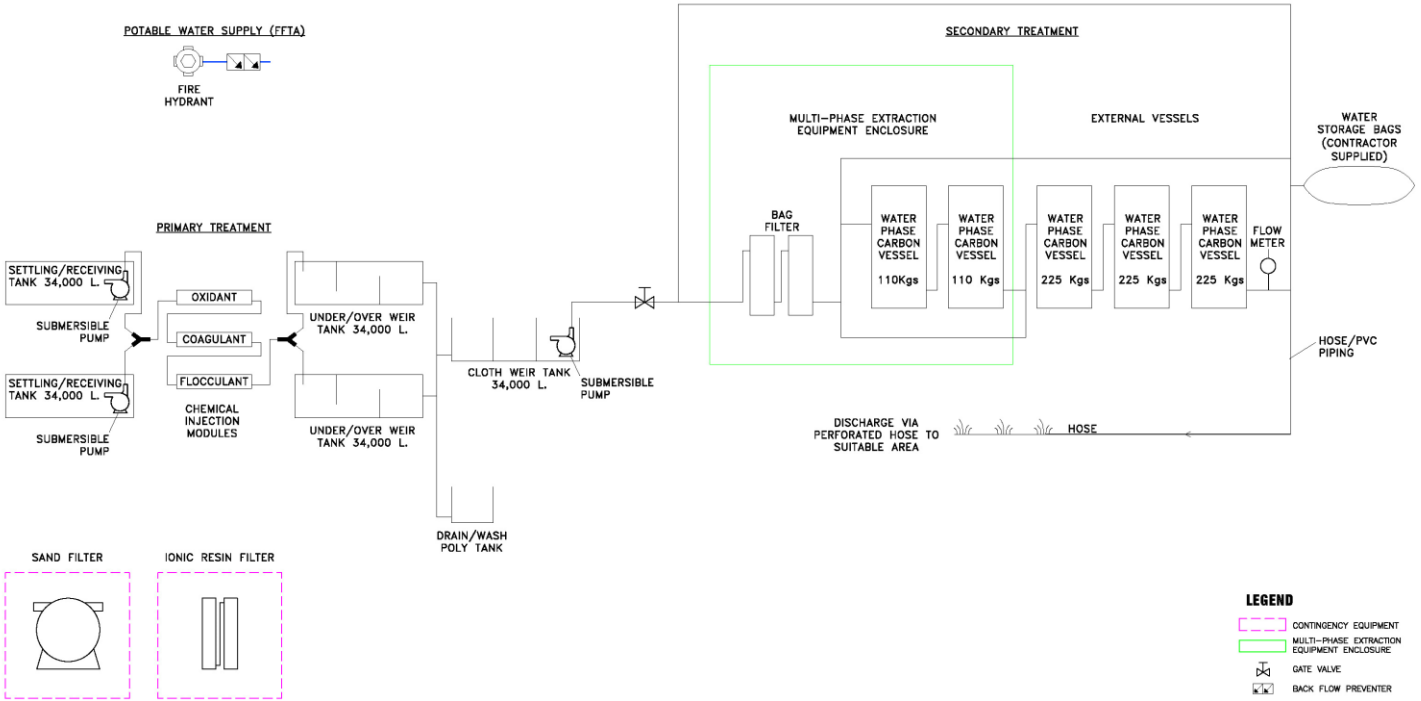
Treatment Objectives

- Surface water treatment objectives are to British Columbia Water Quality Guidelines (BCWQG) and Canadian Environmental Quality Guidelines (CEQG).
- Additional federal and provincial standards or guidelines were considered for potential contaminants of concern not considered in the BCWQG or CEQG
- Following treatment and characterization, results were compared to guidelines and standards and if acceptable authorization to discharge to ground surface on site was requested from the Department of National Defense
- Where liquids failed to meet objectives, the volume was retreated until acceptable concentrations were achieved

Water Quality

- Total PFAS concentrations in surface water collected in the retention pond are around ~150 µg/L. TOPs was completed on retention pond liquids which produced a lower total PFAS result of 125 µg/L
- Total PFAS concentrations in liquids generated from the cross contaminated firetruck tank ranged from 60 to 600 µg/L. TOPs on these liquids identified that there was also a significant concentration of initially unreported oxidizable PFAS compounds giving a total PFAS concentration of 6,000 µg/L
- F1 and F2 in the liquids from the cross contaminated firetruck tank were also at concentrations requiring treatment
- Total and dissolved metals also exceed guidelines in the retention pond and the liquids from the cross contaminated firetruck tank

Treatment Process



Retention Pond Liquid Recovery Considerations

- The retention pond has become habitat for insects and amphibians (frogs). Biological surveys of the area have identified the surrounding habitat is suitable for the red legged frog which is a species of concern in the Species at Risk Act (SARA)
- To minimize the potential for harm to biota the pond was inspected for egg masses and tadpoles prior to recovering collected liquids. A trial planned for mid May was not started due to the presence of tadpoles and a limited pond volume
- Retention pond liquid recovery was timed for early spring when pond liquid levels were higher and egg masses would remain submerged through the course of the trial
- A recovery sump was designed and employed to minimize the potential for generating sediments and entraining biota

Retention Pond Liquid Recovery

GAC Trials Summary

Trial	Total Empty Bed Volume (L)	Mass of Carbon Used (kg)	Process Flow Rate (L/min)	EBCT* (minutes)	Total PFAS/Total PFAS (from TOPs) Loading (g)
Trial 1 (Pond Water)	~1,600	~720	36-42	38-44	3.437/2.972
Trial 2 (Firetruck Liquids)	~1,600	~720	29.5-31.5	51-54	10.9/112.5
Trial 3 (Firetruck Liquids/Second Treatment)	~1,600	~720	45-64	25-36	2.96/20.7
Trial 4 (Firetruck Liquids/ 3rd Treatment)	~1,900	~840	57-61	31-33	0.279/3.146

* The greater Empty Bed Contact Time (EBCT) value is associated with the lower process flow rate value. The same carbon was used for Trials 1 and 2. Otherwise virgin carbon was used.

Results

Event	GAC Mass Used (kg)	Total Estimated PFAS Removed (g)	Total Estimated PFAS Percentage Removal (%)	Total Estimated Adsorption Rate for PFAS (mg/kg)	Total Estimated PFAS (from TOPs) Mass Removed (g)	Total Estimated PFAS (from TOPs) Percentage Removal	Total Estimated Adsorption Rate for PFAS (from TOPs) (mg/kg)
Trial 1 (Pond Water)	720	3.435	99.9	5	2.969	99.9	4
Trial 1 (Pond Water - At discharge of Secondary GAC Vessel)	440	3.435	99.9	8	-	-	-
Trial 2 (Firetruck Liquids)	720	13.074*	88	18	109.823*	95.1	150
Trial 3 (Firetruck Liquids)	720	2.675	90	4.3	17.5	84.7	24
Trial 4 (Firetruck Liquids)	840	0.277	99.3	0.3	3.143	99.9	4

* Also includes mass removal from Trial 1.

Discussion

- Total PFAS mass adsorption rates for the GAC ranged from 0.3 to 18 mg/kg
- Total estimated PFAS adsorption rates for the GAC, as determined from TOPs, ranged from 4 to 150 mg/kg
- Mass adsorption rates were greatest when total PFAS/total PFAS from TOPs loading was greatest from the cross contaminated firetruck tank liquids
- Removal percentage ranged from 88% to 99.9% for total PFAS and 84.7% to 99.9% for PFAS from TOPs

Discussion Cont'd

- An adsorption rate of 4 mg/kg or lower, as determined from TOPs, is expected to have a removal percentage of 99.9%. For total PFAS 99.9% removal was observed up to an adsorption rate of 8 mg/kg, however a removal percentage of 99.3% was observed at an adsorption rate as low as 0.3 mg/kg
- A percentage removal of 99% or greater was generally required to achieve water with concentrations of Total PFAS or Total PFAS, as determined through TOPs, below guidelines
- To remove >99.9% of PFAS from ~20,000 L of retention pond water requires ~440 kg of GAC
- To remove >99% of PFAS from ~40,000 L of liquids from the cross contamination of the firetruck tank requires ~2,300 kg of GAC

Discussion Cont'd

- Treatment with GAC is confirmed to be effective, but generation of a large amount of GAC waste makes full scale treatment with this method untenable without a suitable method for the treatment or disposal of spent PFAS impacted media
- Completion of the TOPs Assay on the liquids from the cross contamination of the fire truck tank increased the concentration of C8 and higher chain PFAS concentrations suggesting these liquids were not exclusively from a newer C6 AFFF formulation
- Total PFAS following the TOPs Assay on the retention pond liquids was lower suggesting that PFAS in the FFTA are already degraded into readily analyzable forms

Next Steps

- Given the anticipated significant amount of GAC generation, options for more effective adsorption with ionic exchange resins were incorporated into the treatment process
- Advanced oxidation was trialed as a method for reducing PFAS concentrations in retention pond water and was determined to have a limited effect. It is understood that PFAS chemistry is such that PFAS oxidation is exceptionally challenging as demonstrated by its propensity to prevent the spread of flame
- Management of existing spent media to ease future treatment or disposal options are currently underway
- Long-term media management – incineration?
- Use of total organo-fluorine (TOF) analysis to qualify treatment performance?

Questions?

Our values are the essence of our company's identity. They represent how we act, speak and behave together, and how we engage with our clients and stakeholders.

SAFETY

We put safety at the heart of everything we do, to safeguard people, assets and the environment.

INTEGRITY

We do the right thing, no matter what, and are accountable for our actions.

COLLABORATION

We work together and embrace each other's unique contribution to deliver amazing results for all.

INNOVATION

We redefine engineering by thinking boldly, proudly and differently.

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