

Wood Buffalo Environmental Association
Program Description

Ion Exchange Resins (IER)

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Program Overview

The Ion Exchange Resin (IER) sampling program is a part of a collection of integrated monitoring programs operated by the WBEA Deposition (DEP) monitoring group (formerly the Terrestrial Environmental Effects Monitoring [TEEM] group). IERs provides passive measurements of wet (ionic) atmospheric deposition in remote areas across the Regional Municipality of Wood Buffalo. The objective of the program is to characterize spatial gradients and seasonal trends of atmospheric deposition of ionic nitrogen (N), sulfur (S), and base cations (BC) to regional forests. Data collected by IER sampling is used along with denuders, passives, and meteorological data to model deposition across the region.

The IER program aims to address the following monitoring questions:

- What is the spatial extent of atmospheric deposition of ionic N, S, and BC?
- What are the temporal trends of atmospheric deposition of ionic N, S, and BC?
- How do the levels of acidifying N and S deposition compare to acid-neutralizing BC deposition?

Sampling Environment

IER sampling is conducted in two general ecological environments: in clearings with no tree canopy (freefall [FF], or bulk deposition sampling) and under jack pine forest canopies (throughfall [TF] deposition sampling).

IER-FF sampling in canopy-free environments provides a measurement of “bulk” deposition - the collectors are continuously open to the atmosphere resulting in the accumulation of dry- and wet-deposited materials. IER-FF monitoring sites are typically situated in natural clearings, either a peatland, fire-cleared, or upland area (Figure 1). Ideally IER-FF sites are adjacent to an IER-TF (Figure 2) and FHM monitoring site.





Figure 1. Site 3550, IER-FF sampling location. Winter configuration

IER-TF sampling is conducted under jack pine forest canopies, which provides a measurement of throughfall deposition: a combined measurement of wet deposition, ions released by plant tissues in the canopy, and dry deposition intercepted by the canopy and washed through by precipitation. The forest canopy may also uptake deposited ions (e.g., N uptake is common), which reduces the presence of some ions in the throughfall solution. WBEA IER-TF monitoring sites are typically situated under jack pine forest canopies within an FHM site.





Figure 2. Site 2050, IER-TF sampling location. Winter configuration

History

Below is a timeline of major network developments.

- 2008 - TF and FF sampling locations established at/near AMS and FHM sites. TF collectors were positioned on a wooden cross-arm mounted to tree trunks.
- 2010 - network redistribution - monitoring discontinued at some AMS stations, new sampling locations added at/near additional FHM sites.
- 2010 - 2013 - TF collectors moved to metal posts at ground level.
- 2014 - relocation of many FF sites from small clearings within jack pine stands to nearby canopy-free peatlands, additional collectors added to some stations for BC analysis.
- 2015 - upgrade of wildlife exclusion fencing at all TF sites - larger power systems and more robust fencing
- 2016 - Horse River Wildfire destroyed a subset of sites and samples from winter 2015
- 2015 - 2017 - established new TF sampling locations as replacements for fire-destroyed locations



- 2015 - 2021 - established new FF sampling locations to replace flooded or overgrown locations.
- 2018 - established additional TF monitoring sites in black spruce bogs
- 2019 - new collector design implemented across the network
- 2020 - addition of southern IERs
- 2021-2022
 - Laboratory transition from USDA FS to WBEA ASG
 - USDA prepared the Fall 2021 (October – April) samples and ASG performed analysis for these samples. ASG prepared and analyzed the Summer 2022 (May-September) samples.
- 2022
 - September 26, 2022 – Network Assessment / Review
 - October 11, 2022 – October 20, 2022 – Field Campaign / Implementation of *"WBEA Proposal_IER Program Optimization"*
 - Removal of sites: 1001, 2010, 2054, 2554, 3098, 3111, 3210, ANZC
 - Introduction of new sites: 3016-TF, 3016-FF, 3017-TF, 4017-FF, 3018-TF, 4018-FF, 1023-FF
 - Each site will be revised to have 10 collectors at Throughfall (TF) locations and 6 collectors at the Freefall (FF) locations. Bog sites will remain the same (6 collectors total). Each collector can be analyzed for either Base Cations (BC) or for Sulphur (S) and Nitrogen (N). Previously, analyses were heavily weighted towards S&N, with only some sites being analyzed for BC. By adding BC and reducing S&N the network harmonization will result in an equal number of IER columns analyzed for both BC and S&N. This change is due to the WBEA's 2019 review of Forest Health Data (see TEEM Publication Project manuscripts) which found that BC deposition is much higher and playing a much greater role than previously believed.
 - Reduced field blanks to 10 sites distributed across the network so as to include sites that are proximal, intermediate and distal with respect to central mining operations.
 - December 8, 2022 – WBEA TEEM Committee meeting.
 - *"WBEA Proposal_IER Program Optimization"* passed.
- 2023
 - Execution of the IER Program Optimization Proposal during Spring changeout
- 2024 - 2025
 - Expansion of Deposition Monitoring North



Sampling Details

The IER sampling method is well suited for measuring deposition in remote areas because it requires no electrical power (passive sampling method), and sampling occurs continuously over long periods (typically months) without the need for repeated field visits to collect sample solutions.

Field blanks are deployed at 20% of sites within the IER program. Each of the sites will receive 2 field blanks. These columns stay capped and are attached to IER Post #1 with a hose clamp. The field blanks stay out with the other sampling media for the duration of the season and are collected during the next media changeout.

Sampler Description

The IER method uses widely available, low-cost materials for sample collection. Sample collectors are constructed from a polyethylene funnel and PVC fittings that channel precipitation (or canopy throughfall solution) through the sample media where ions are retained. During the winter sampling periods, the funnel volume is increased by adding a snow tube constructed from a polyethylene drainage tube. The snow tube allows snow to build up in the tube and then, during the spring thaw, the sample media will capture the contents. See Figure 4 below for both summer and winter configurations. Each collector is mounted to the top of a six-foot-long metal post installed in the ground vertically.

Each site will have 10 collectors at Throughfall locations and 6 collectors at the Freefall locations. Each collector can be analyzed for either Base Cations (BC) or for Sulphur (S) and Nitrogen (N). Field blanks will be distributed across the network to include sites that are proximal, intermediate, and distal with respect to central mining operations. The location of field blanks stay the same year-to-year, assuming no major changes in IER network.





Figure 4. IER-FF collector in summer configuration (left; without sampling media) and winter configuration (right; with snow tube and sampling media column attached).

Sampling Media

The IER sampling media consists of a PVC tube (6 inches in length, 0.5 inches inside diameter) filled with Amberlite IRN150 mixed-bed analytical grade ion exchange resin beads to create a sampling column. During the sampling period, the column is connected to the bottom of the precipitation collector in a vertical orientation, directing the solution from the collector to pass through the column and out to the bottom (the bottom cap has a drain hole). Columns are capped on both ends for transport (before and after sampling).

Sampling media is prepared and packaged by the WBEA ASG laboratory, deployed, and retrieved by WBEA staff, and returned to the laboratory for analysis. For base cation (BC) determination, columns are extracted with ammonium acetate, and the extracts are analyzed for calcium (Ca), potassium (K), magnesium (Mg), and sodium (Na) by inductively coupled plasma mass spectroscopy (ICP-MS). For N and S determination, columns are extracted with potassium iodide, and the extracts are analyzed for nitrate (NO_3^-), sulfate (SO_4^{2-}), and ammonium (NH_4^+) by ion chromatography (IC).

Quality control measures include analysis of laboratory blanks, analysis of field blanks, and the determination of phosphate (PO_4^{3-}) / phosphorus (P) concentrations in extracts (via IC) for detection of bird dropping contamination.



Sampling Schedule

Sampling media is deployed for two consecutive periods each year with media changeouts occurring in early May and early October. This timing generally delineates the summer (growing) and winter seasons. However, it is not uncommon to encounter snowfall events during spring changeout (2019) or fall changeout (2017, 2018) activities.

At spring and fall changeout, the existing columns are retrieved, and the collectors are disassembled and checked for damage or obvious contamination. Any damaged or excessively dirty components are replaced, and the collector is cleared of debris and rinsed with de-ionized water before a new set of media is deployed. During spring changeout, the snow tube is removed. During fall changeout, the snow tube is added to the sampler.

Regular site visits to check on sampling equipment are typically scheduled concurrently with other monitoring activities.

Wildlife Interference

Due to wildlife's curious nature towards novel things in their environment, and the strong odor of the sampling media, the IER sampling sites are frequently visited by wildlife. In recent years most sample losses have been attributed to wildlife through contamination or damaged samplers.

Contamination due to bird droppings is minimized by installing a ring around the collector opening that is wider than, and elevated above, the opening. These "bird rings" are typically constructed from tomato plant support cages. If appropriately sized and installed correctly, the ring positions a perching bird—and their droppings—outside of the collector opening. Samples contaminated by bird droppings are identified by elevated phosphate and nitrogen concentrations.

Solar-powered wildlife exclusion fencing is reasonably effective in keeping sampling locations free from interference by large wildlife (bears, moose, bison). Wildlife-related sample losses are incurred in nearly every sampling period but have been minimized in recent years due to the time, labor, and cost invested in wildlife exclusion fencing. Wildlife fences have been installed and maintained at nearly all TF monitoring sites and select FF monitoring sites that are frequently visited by wildlife. Each IER sampling location should be checked multiple times throughout the sampling period to confirm that the fence is operational and in good repair and to resolve any wildlife interference that may affect sample integrity or sampling efficacy. It is not uncommon for bears to damage or remove funnels and/or bend the mounting posts while leaving the sampling media column attached to the post. If caught early, the sample may be salvaged by replacing the damaged collector components and allowing the column to continue sampling until the scheduled changeout.



Equipment Parts

A list of collector parts is included in the WBEA IER SOP (2023). Detailed specifications are provided for most parts, however, details for the four-piece PVC fitting assembly that attaches the sample media column to the funnel are missing from the document so are included here (Table 2).

Table 2 - The four-piece PVC reducer assembly, from 1 ½ inch socket (non-threaded, for attachment to the funnel neck) to ½ inch threaded (attachment of sampling column). All non-threaded connections between components are held together with stainless-steel screws.

Part Description	Part Number (McMaster Carr)
Adapter, 1½ socket (internal) x 1½ NPT (internal)	4880K85
Adapter, 1½ socket (internal) x 1½ NPT (external)	4880K65
Reducer, 1½ socket (external) x ¾ socket (internal)	4880K333
Reducer, ¾ socket (external) x ½ NPT (internal)	4880K201

Timeline of Annual Activities

All year

- Periodic site visits to check on collectors - concurrent with other monitoring activities
 - Confirm wildlife exclusion is operational and in good repair
 - Confirm samplers are free from damage and oriented properly for sampling
 - Repair any damages
 - Make detailed field notes of repairs for submission and ensure sample-specific notes are entered for each affected sample on the COC form
- Construct, wash, and package collector components in preparation for spring and fall changeout activities
- Purchase supplies to replace used inventory

Spring Changeout

March

- Confirm sampling media delivery date for mid-April, to allow sufficient time to prepare sample media for deployment



April

- Prepare sampling supplies and field kits
- Print sample media labels
- Assign labels to media and package media by site
- Prepare wildlife exclusion fencing supplies for repairs or new installations

May

- Conduct media changeouts and maintenance on collectors
- Setup collectors in summer configuration (snow tube removed)
- Make detailed field notes of sample changeout for submission and ensure sample-specific notes are recorded

Fall Changeout

August

- Confirm sampling media delivery date for mid-September, to allow sufficient time to prepare sample media for deployment

September

- Prepare sampling supplies and field kits
- Print sample media labels
- Assign labels to media and package media by site
- Prepare wildlife exclusion fencing supplies for repairs or new installations

October

- Conduct media changeouts and maintenance on collectors
- Setup collectors in winter configuration (snow tube attached)
- Make detailed field notes of sample changeout for submission and ensure sample-specific notes are recorded

