Acid Deposition Monitoring Program Expansion Committee (ADMPEC)

Meeting Support Slides

September 16, 2021

LICA
ENVIRONMENTAL STEWARDS

Project Overview

- 3.1.1 AER Approval Conditions
- 3.1.2 Timeline and deliverables for monitoring plan

3.1.1 AER Approval Conditions

The Acid Deposition Monitoring Program proposal shall include, at a minimum, all of the following:

- **for air:**
  - a plan to monitor dry and wet deposition from project activities;
- **for soil:**
  - identification of soils that are sensitive to acid deposition and will likely receive aerial deposition inputs from project activities;
  - a plan to monitor soil quality at locations representative of the soils identified in above;
  - a description of how soil quality data collected under this program will be used to determine potential acidification effects under periods of increased sulphur dioxide emissions;
- **for water:**
  - a summary of existing water quality data collected to date and analysis of the results;
  - a plan to monitor water quality for water bodies which will likely receive aerial deposition inputs from project activities;
  - identification of local water bodies that are sensitive to acidification;
  - a description of how water quality data collected under this program will be used to determine potential acidification effects under periods of increased SO2 emissions;
  - a plan to develop triggers for further enhanced surface water quality monitoring to determine impacts of aerial deposition inputs;
- **reporting schedule for monitoring activities conducted above**

3.1.2 Timeline and deliverables for monitoring plan

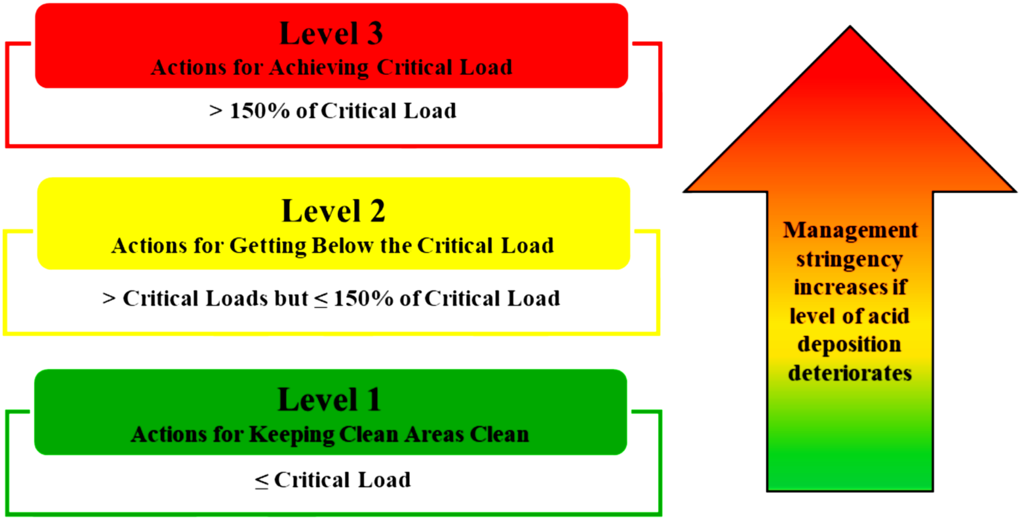
- Phase 1: December 31, 2021

Review Information, Data, and Other Input Sources for Monitoring Plan Development

- 3.2.1 Alberta Acid Deposition Management Framework
- 3.2.2 Oil Sands Monitoring (OSM) Environmental Effects Monitoring (EEM)
- 3.2.3 Past studies on acidification in the Cold Lake oil sands region
- 3.2.4 Regional acid deposition modelling studies
- 3.2.5 Acid deposition monitoring in the Athabasca oil sands region
- 3.2.6 Regional soil acidification monitoring results overview
- 3.2.7 Approaches to surface water acidification monitoring site selection

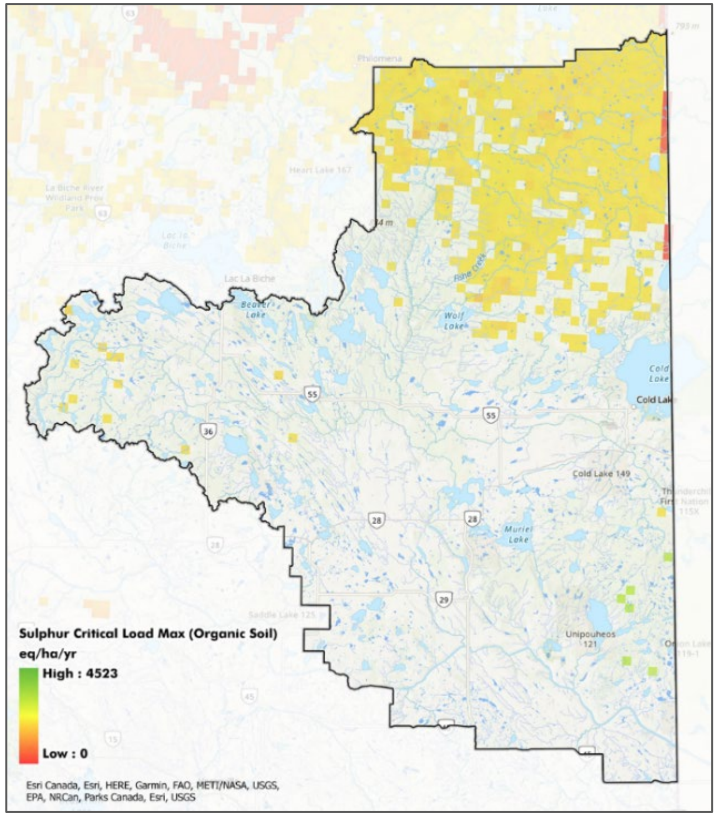
3.2.1 Alberta Acid Deposition Management Framework (ADMF) - 2021 Draft

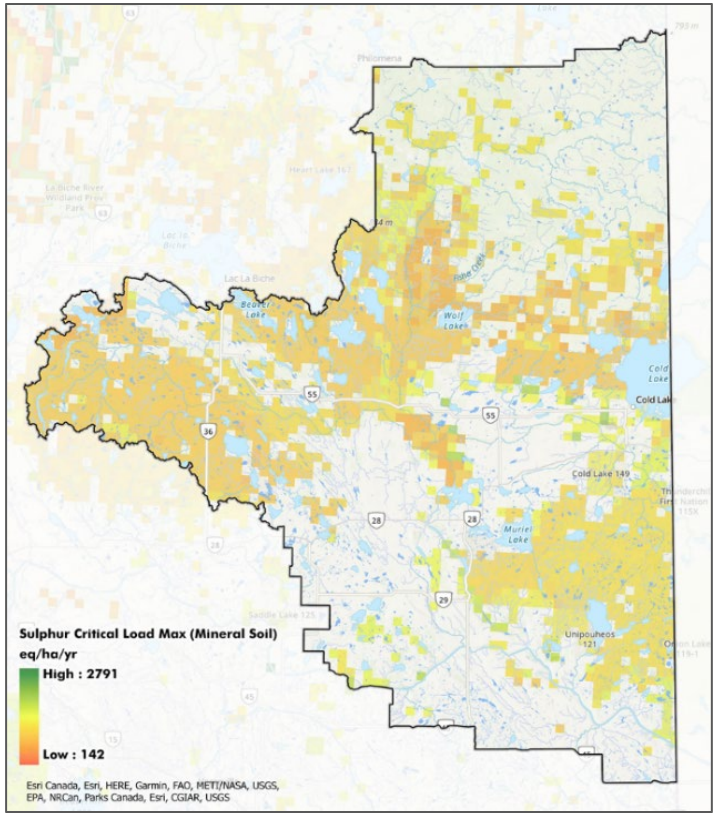
- **Critical Load**
  - A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge (Nilsson & Grennfelt, 1988).
- **Acid Deposition Management Levels**
  - A tiered monitoring, target and critical load acid deposition management approach was used in the 2008 ADMF.
  - It is being replaced with a new management approach that will provide an early warning of potential areas “at risk” to long-term acidification.
  - The new approach also provides guidance to manage and reduce, where necessary, acidifying emissions adversely affecting the identified areas.



3.2.1 Alberta Acid Deposition Management Framework (ADMF) - 2021 Draft

- **Critical Load Maps**
  - The critical load is based on the soil properties of the ecosystems within each grid cell on the maps. Sensitivity in each grid cell is indicated by the magnitude of the critical loads – the lower the critical load, the greater the sensitivity of the grid cell.





3.2.2 Oil Sands Monitoring (OSM) Environmental Effects Monitoring (EEM)

Phase	Name	Description
Tier 0	Project Planning and Engineering Design	Design monitoring program and establish triggers.
Tier 1	Baseline	Baseline monitoring period
Tier 2	Surveillance/minimal	Core monitoring (regular/reduced cycle)
Tier 3	Confirmation	Model validation. Deposition as expected?
Tier 4	Investigation of cause	Is change emissions/deposition related?
Tier 5	Focused study	Investigate magnitude and extent.
Tier 6	Investigation of solutions	Potential solution known?

An Adaptive Environmental Effects Monitoring Framework for Assessing the Influences of Liquid Effluents on Benthos, Water, and Sediments in Aquatic Receiving Environments

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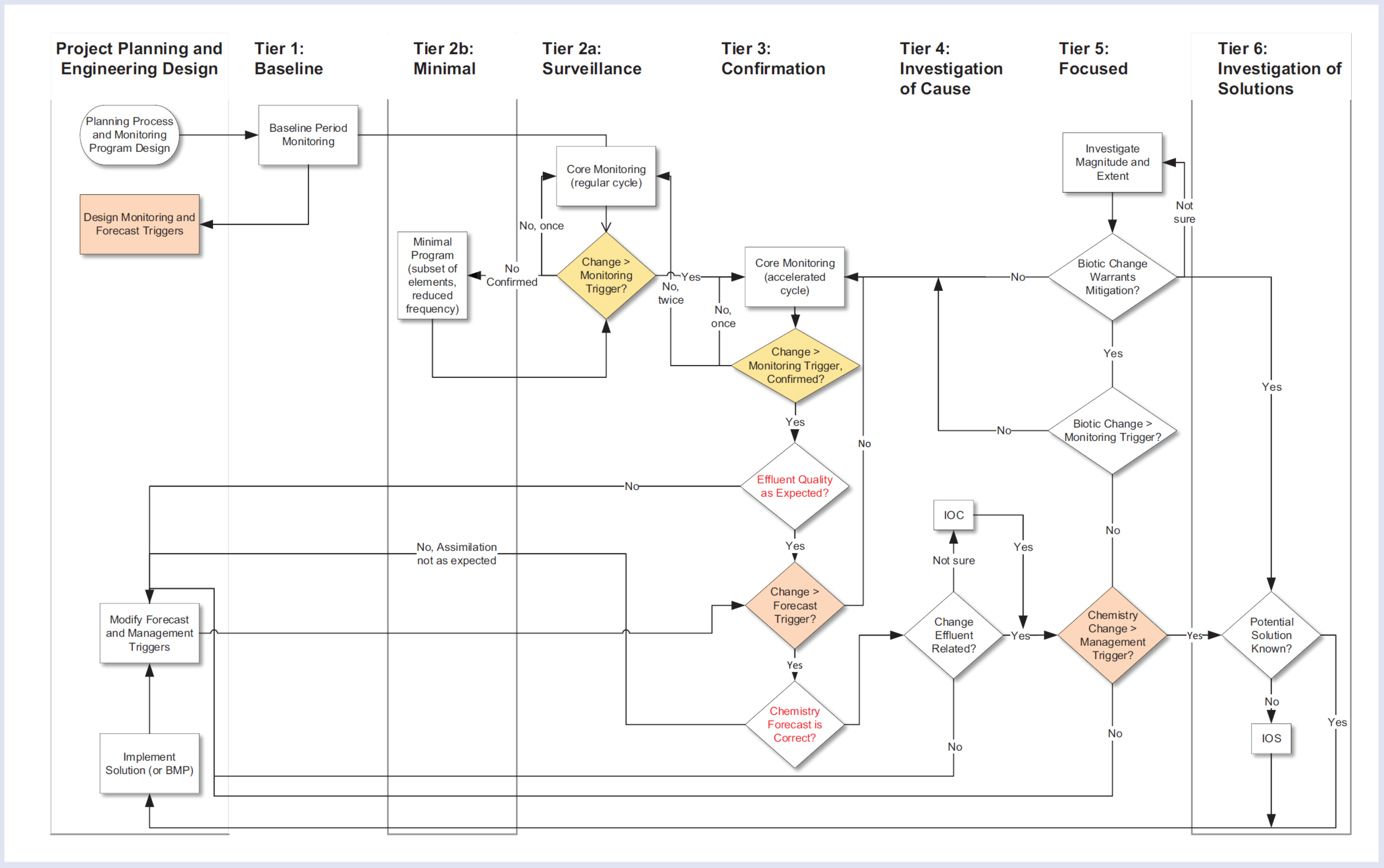
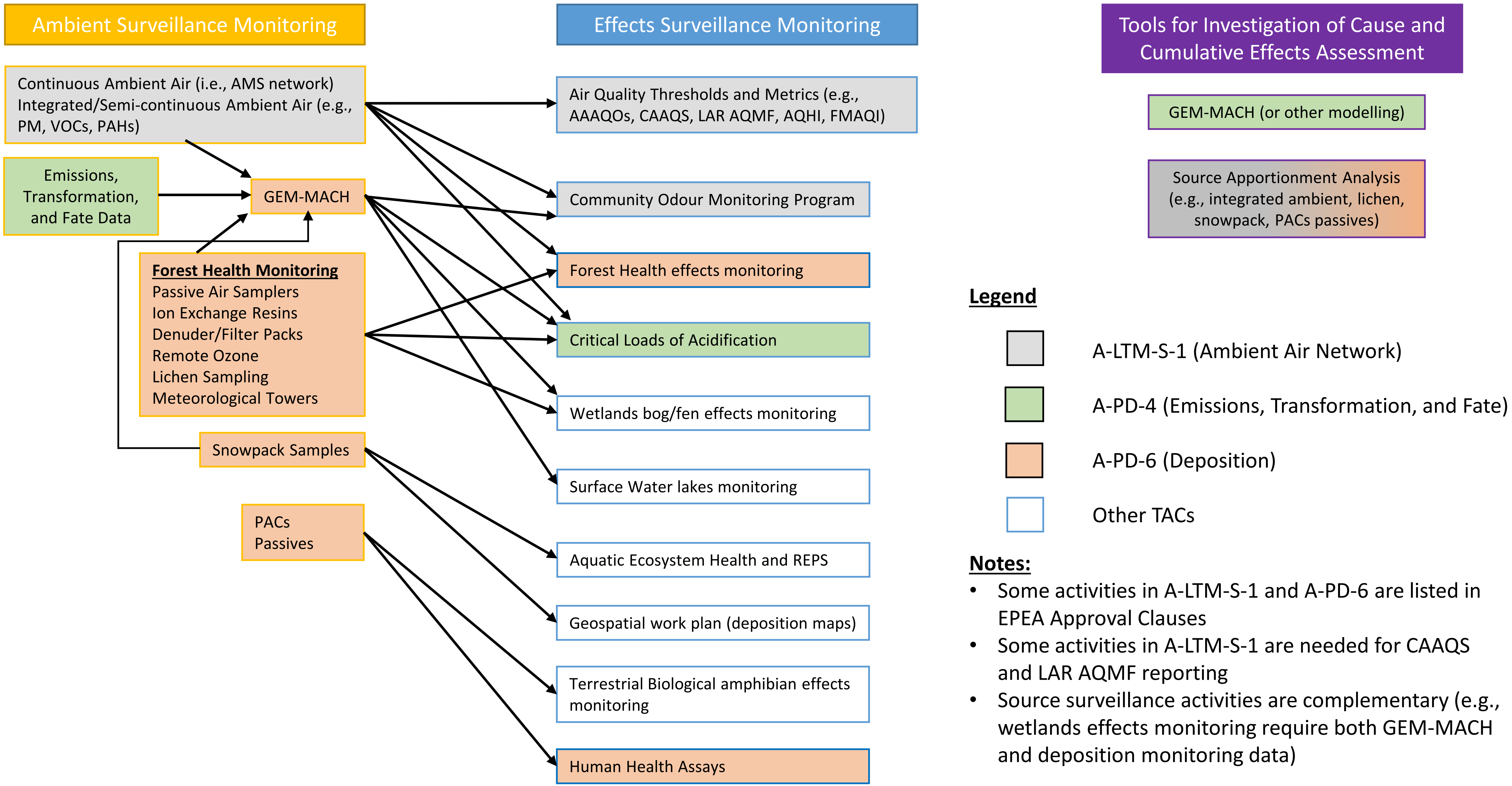


Figure 1. A flowchart illustrating the relationships in a tiered and triggered monitoring system applicable to assessment of effluent release into an aquatic environment. Baseline, forecast, and management triggers are defined as part of the project-planning process. IOS = investigation of solutions; IOC = investigation of cause.

Monitoring Activities in an EEM Framework (with existing linkages)



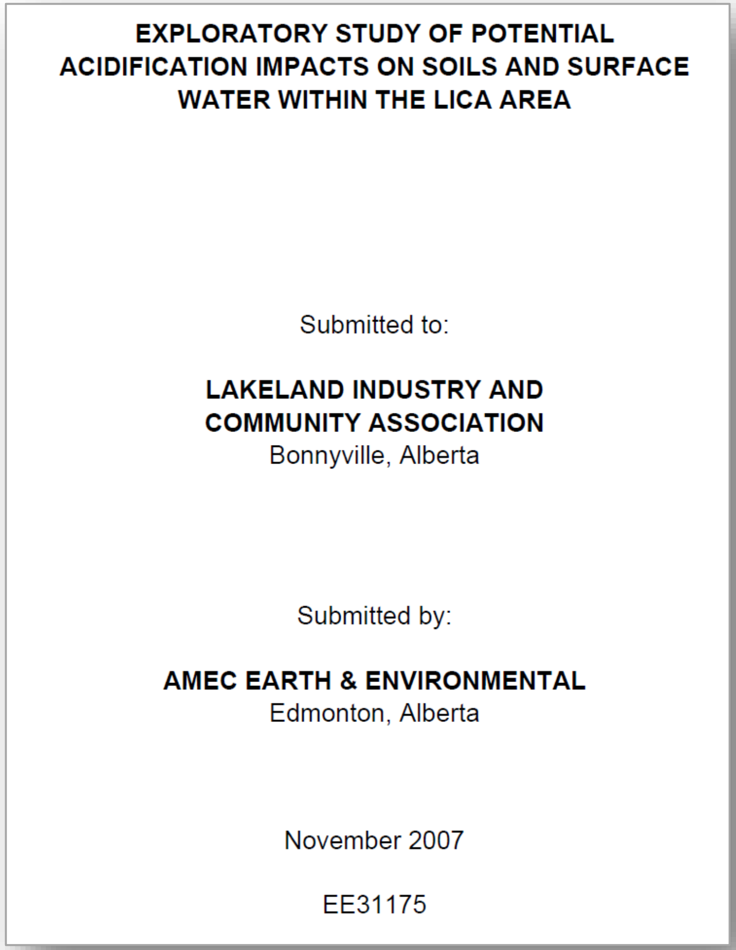
Notes:

- Some activities in A-LTM-S-1 and A-PD-6 are listed in EPEA Approval Clauses
- Some activities in A-LTM-S-1 are needed for CAAQS and LAR AQMF reporting
- Source surveillance activities are complementary (e.g., wetlands effects monitoring require both GEM-MACH and deposition monitoring data)

3.2.3 Past studies on acidification in the Cold Lake oil sands region

Exploratory Study Of Potential Acidification Impacts on Soils and Surface Water Within the LICA Area (2007)

- This study had three main components:
  - The potential effects of emissions of oxides of nitrogen (NOX) and sulphur dioxide (SO_2) on acid deposition in the LICA region. This included an estimation of potential acid input (PAI)
  - The assessment of surface water sensitivity to acidification and analysis in relation to potential acid input levels.
  - A soils component assesses soil sensitivity in relation to PAI estimates


EXPLORATORY STUDY OF POTENTIAL ACIDIFICATION IMPACTS ON SOILS AND SURFACE WATER WITHIN THE LICA AREA

Submitted to:

LAKELAND INDUSTRY AND COMMUNITY ASSOCIATION
Bonnyville, Alberta

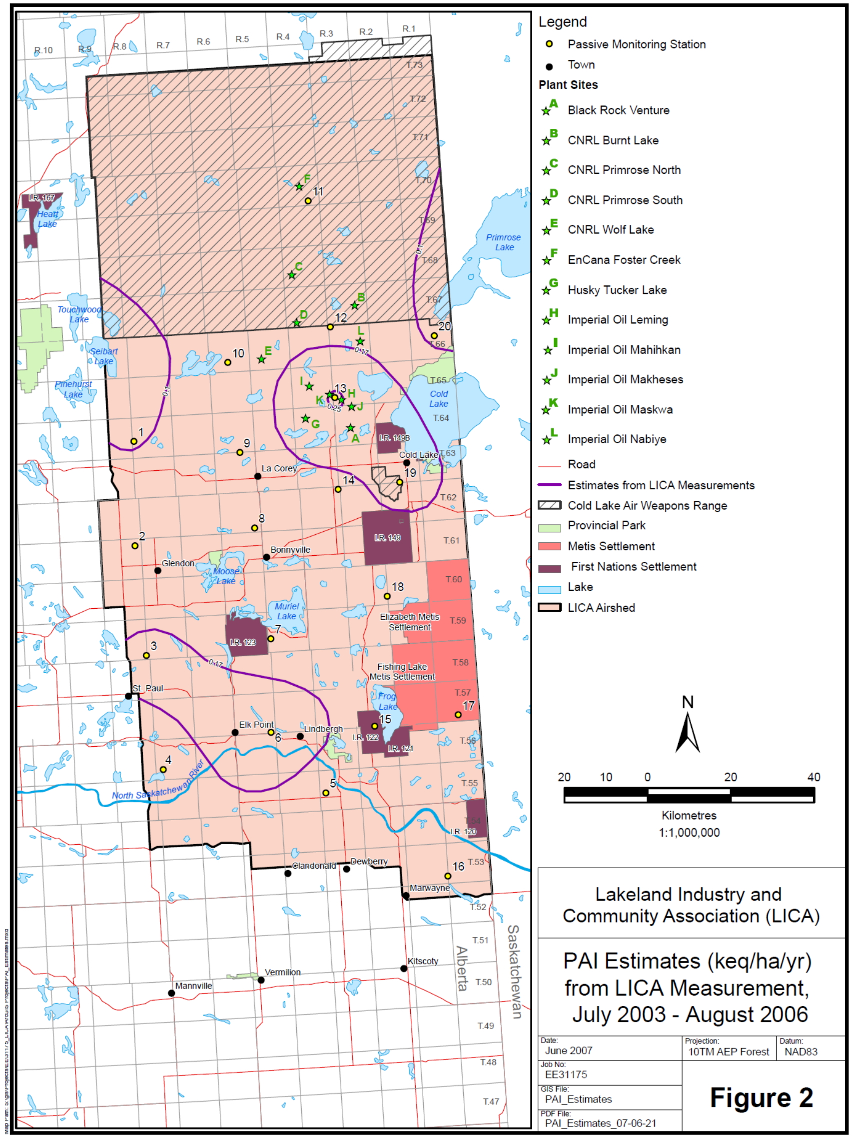
Submitted by:

AMEC EARTH & ENVIRONMENTAL
Edmonton, Alberta

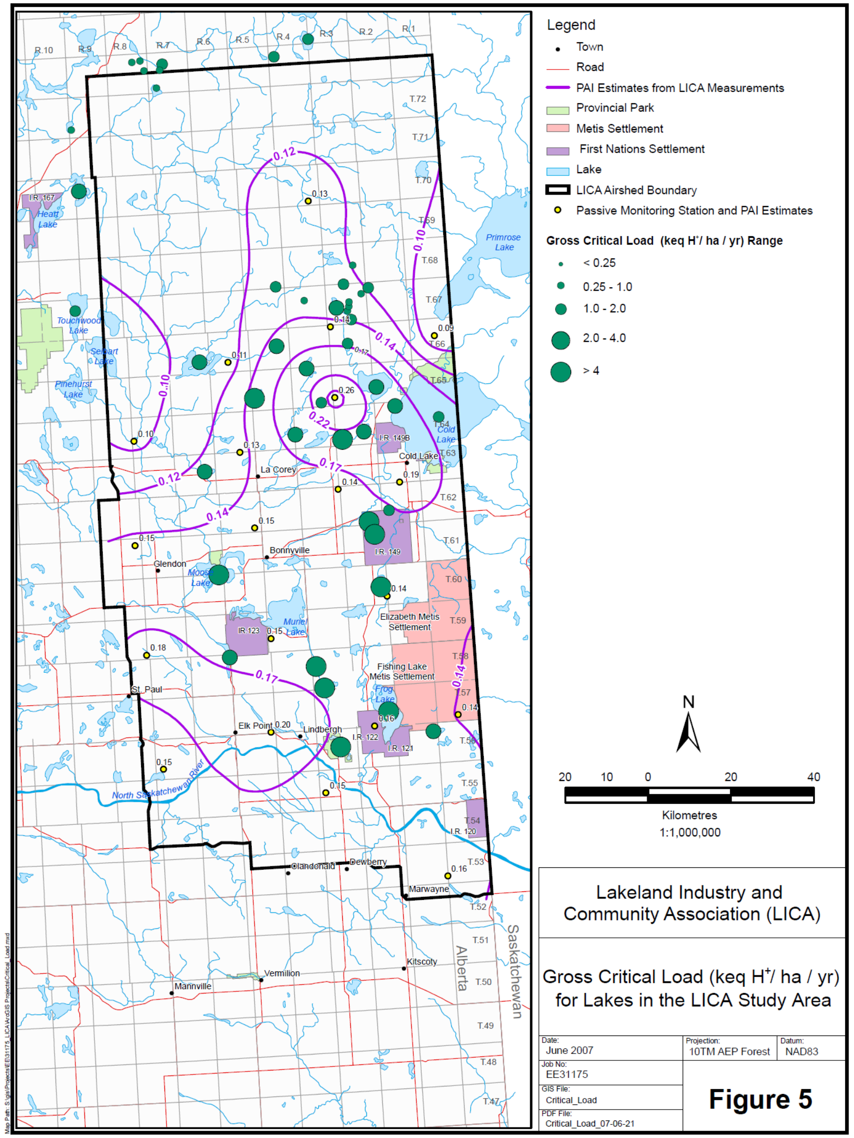
November 2007

EE31175

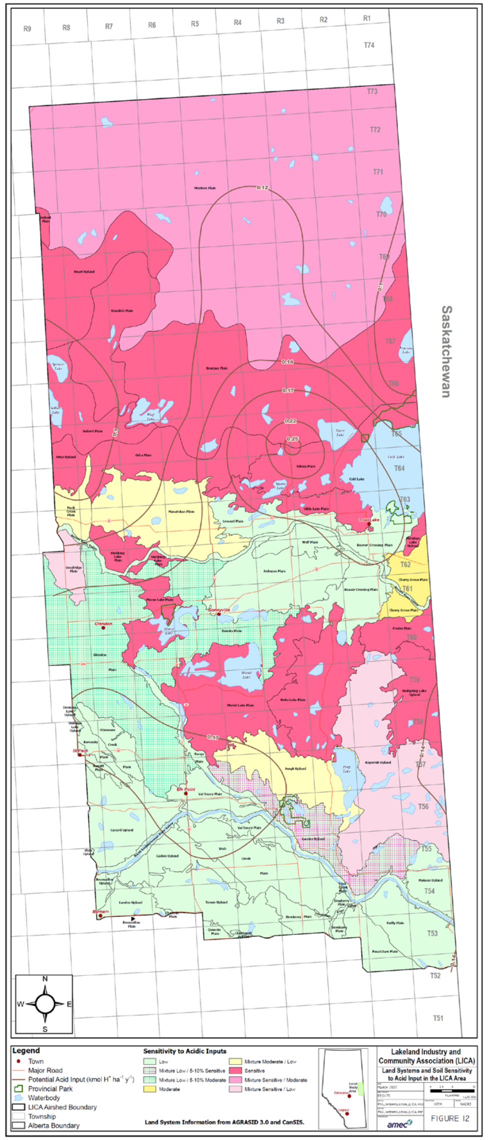
Exploratory Study Of Potential Acidification Impacts on Soils and Surface Water Within the LICA Area (2007)



Potential Acid Input Estimate



Surface Water Sensitivity



Soil Sensitivity

3.2.4 Regional acid deposition modelling studies

"Estimates of exceedances of critical loads for acidifying deposition in Alberta and Saskatchewan"

- In 2018, a Environment and Climate Change Canada (ECCC) - led paper was published regarding modelling acid deposition in the Oil Sands Region using GEM-MACH model
- The data used in the model runs are for the 2013 emissions year which was the most complete data set available at the time
- As part of this year's OSM workplans, ECCC is repeating the simulations, with an upgraded version of the model and a more recent dataset

Atmos. Chem. Phys., 18, 9897–9927, 2018
https://doi.org/10.5194/acp-18-9897-2018

Atmospheric Chemistry and Physics
Open Access
EGU

Estimates of exceedances of critical loads for acidifying deposition in Alberta and Saskatchewan

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Received: 23 November 2017 – Discussion started: 26 February 2018
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Abstract. Estimates of potential harmful effects on ecosystems in the Canadian provinces of Alberta and Saskatchewan due to acidifying deposition were calculated, using a 1-year simulation of a high-resolution implementation of the Global Environmental Multiscale-Modelling Air-quality and Chemistry (GEM-MACH) model, and estimates of aquatic and terrestrial ecosystem critical loads. The model simulation was evaluated against two different sources of deposition data: total deposition in precipitation and total deposition to snowpack in the vicinity of the Athabasca oil sands. The model captured much of the variability of observed ions in wet deposition in precipitation (observed versus model sulfur, nitrogen and base cation R^2 values of 0.90, 0.76 and 0.72, respectively), while being biased high for sulfur deposition, and low for nitrogen and base cations (slopes 2.2, 0.89 and 0.40, respectively). Aircraft-based estimates of fugitive dust emissions, shown to be a factor of 10 higher than reported to national emissions inventories (Zhang et al., 2018), were used to estimate the impact of increased levels of fugitive dust on model results. Model comparisons to open snowpack observations were shown to be biased high, but in reasonable agreement for sulfur deposition when observations were corrected to account for throughfall in needleleaf forests. The model–observation relationships for precipitation deposition data, along with the expected effects of increased (unreported) base cation emissions, were used to provide a simple observation-based correction to model deposition fields. Base cation deposition was estimated using published observations of base cation fractions in surface-collected particles (Wang et al., 2015).

Both original and observation-corrected model estimates of sulfur, nitrogen, and base cation deposition were used in conjunction with critical load data created using the NEG-ECP (2001) and CLRTAP (2017) methods for calculating critical loads, using variations on the Simple Mass Balance model for terrestrial ecosystems, and the Steady State Water Chemistry and First-order Acidity Balance models for aquatic ecosystems. Potential ecosystem damage was predicted within each of the regions represented by the ecosystem critical load datasets used here, using a combination of 2011 and 2013 emissions inventories. The spatial extent of the regions in exceedance of critical loads varied between 1×10^4 and 3.3×10^5 km^2, for the more conservative observation-corrected estimates of deposition, with the variation dependent on the ecosystem and critical load calculation methodology. The larger estimates (for aquatic ecosystems) represent a substantial fraction of the area of the provinces examined.

Published by Copernicus Publications on behalf of the European Geosciences Union.

Selected model outputs and predictions

- Predicted forest ecosystem critical load exceedances with respect to acidity
- Predicted aquatic ecosystem critical load exceedances with respect to sulfur and nitrogen deposition
- Predicted terrestrial ecosystem critical load exceedances with respect to sulfur and nitrogen

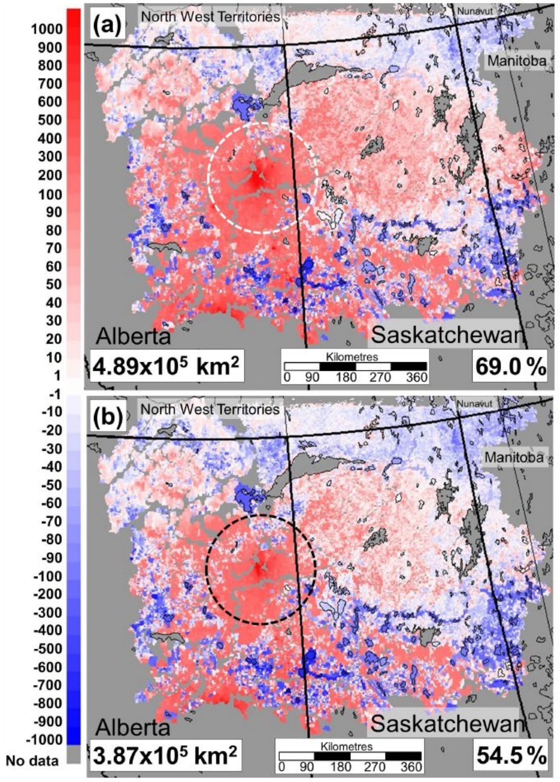
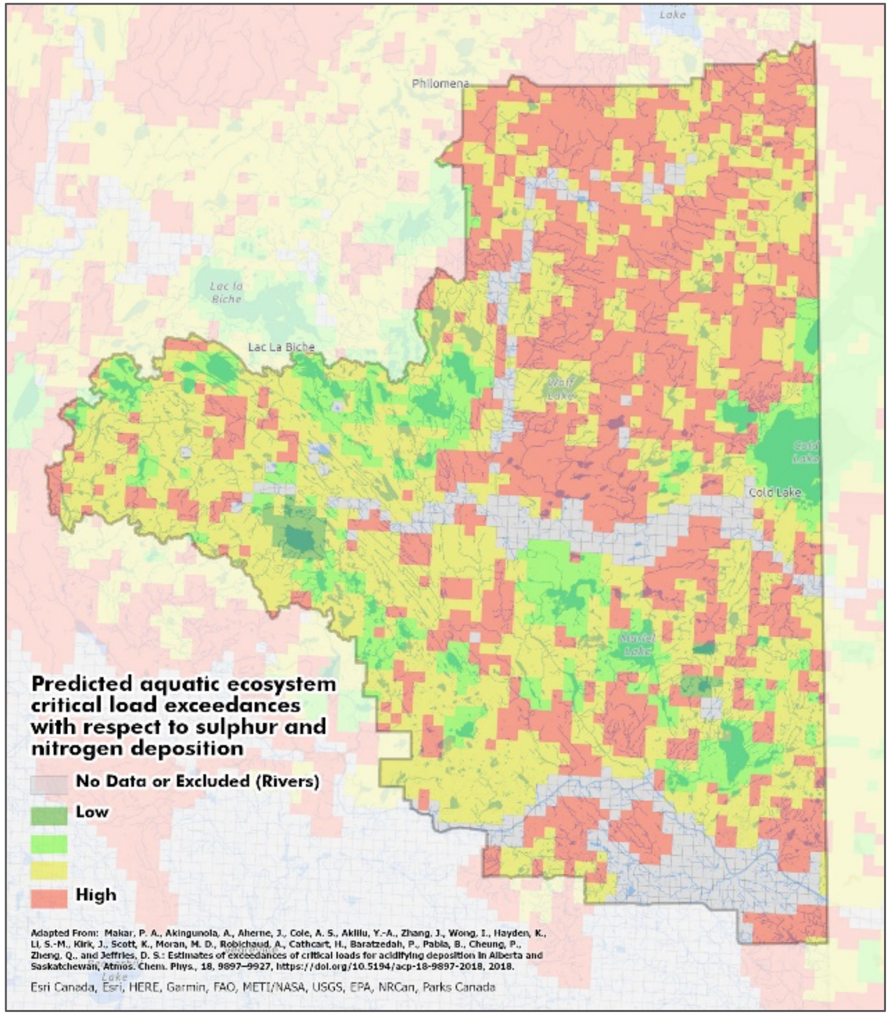


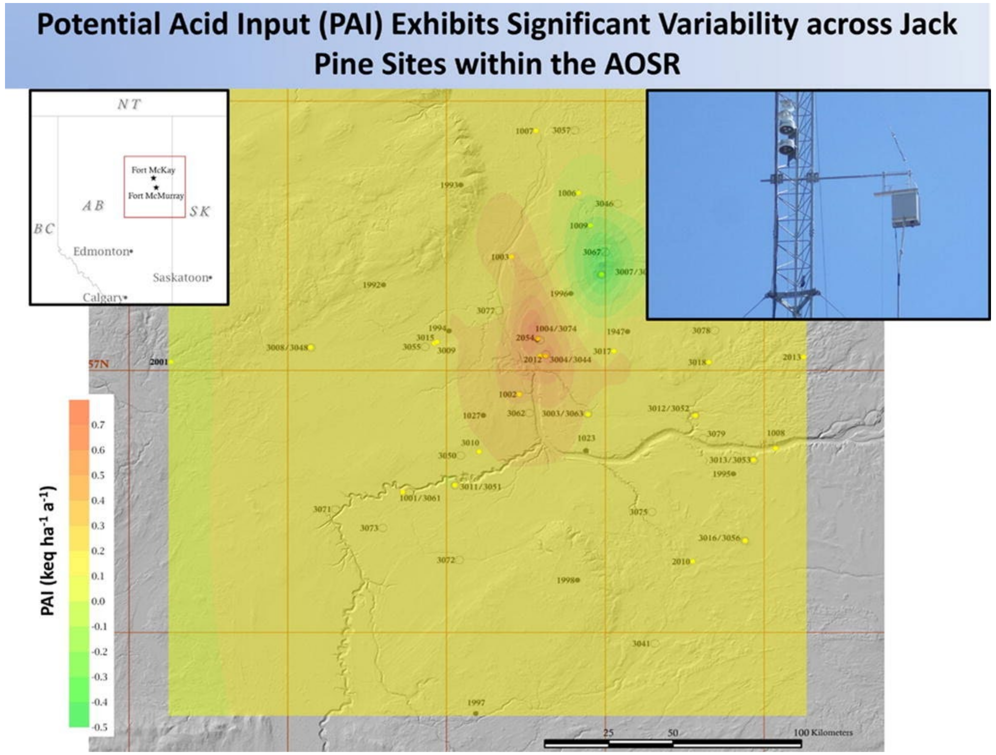
Figure 19. Predicted aquatic ecosystem critical load exceedances with respect to sulfur and nitrogen deposition, (eq ha^{-1} yr^{-1}). Boxed numbers are the area in exceedance and the percent of the total area for which critical loads are available which is in exceedance. **(a)** Calculated using original model sulfur and nitrogen deposition. **(b)** Calculated using model sulfur and nitrogen deposition corrected to match precipitation observations. Circled region: 140 km radius diameter circle around the Athabasca oil sands.



3.2.5 Acid deposition monitoring in the Athabasca oil sands region

“Ambient concentrations and total deposition of inorganic sulfur, inorganic nitrogen and base cations in the Athabasca Oil Sands Region”

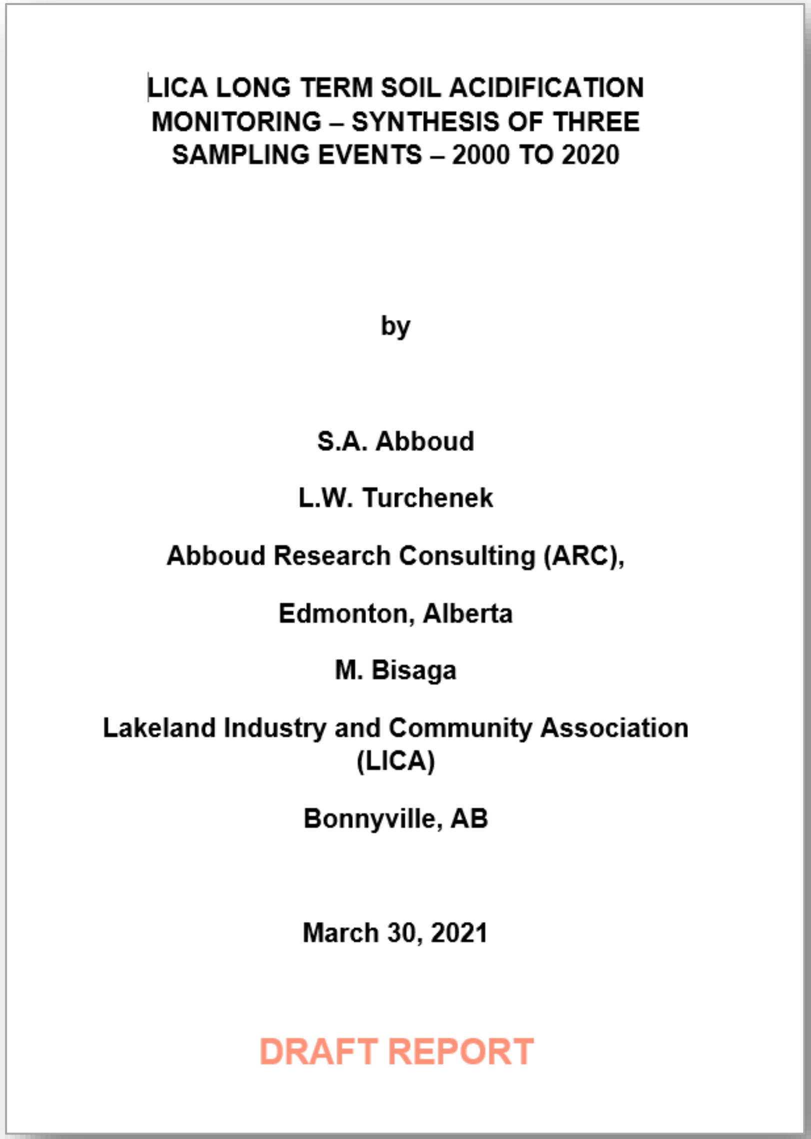
- A region-wide passive sampling network was established in 1998–99 to monitor above-canopy concentrations of SO_2, NO_2, O_3, HNO_3 and NH_3 at Forest Health Monitoring (FHM) sites.
- A second network was established in 2008 to measure bulk and throughfall deposition of inorganic acids and base cations at FHM sites
- A third network was established in 2013–17 to measure above canopy concentrations of gases and $PM_{2.5}$ composition at several solar-powered FHM sites.
- Together, these networks provide a dense array of measurements for examining patterns and trends of deposition and air quality.



3.2.6 Regional soil acidification monitoring results overview

"LICA Long Term Soil Acidification Monitoring – Synthesis Of Three Sampling Events – 2000 To 2020"

- LICA initiated soil acidification monitoring in 2010 by establishment of three long-term soil sampling plots within the LICA area
    - Moose Lake Provincial Park in 2010
    - Whitney Lakes Provincial Park in 2011
    - Crown Land near Tucker Lake in 2012
- Soil sampling is being carried out at these plots every four years in a staggered manner (one site per year).
- A fourth site, located near the west shore of Cold Lake and operated by Alberta Environment, was added to the LICA sites in the analysis of monitoring results to date.



LICA LONG TERM SOIL ACIDIFICATION MONITORING – SYNTHESIS OF THREE SAMPLING EVENTS – 2000 TO 2020

by

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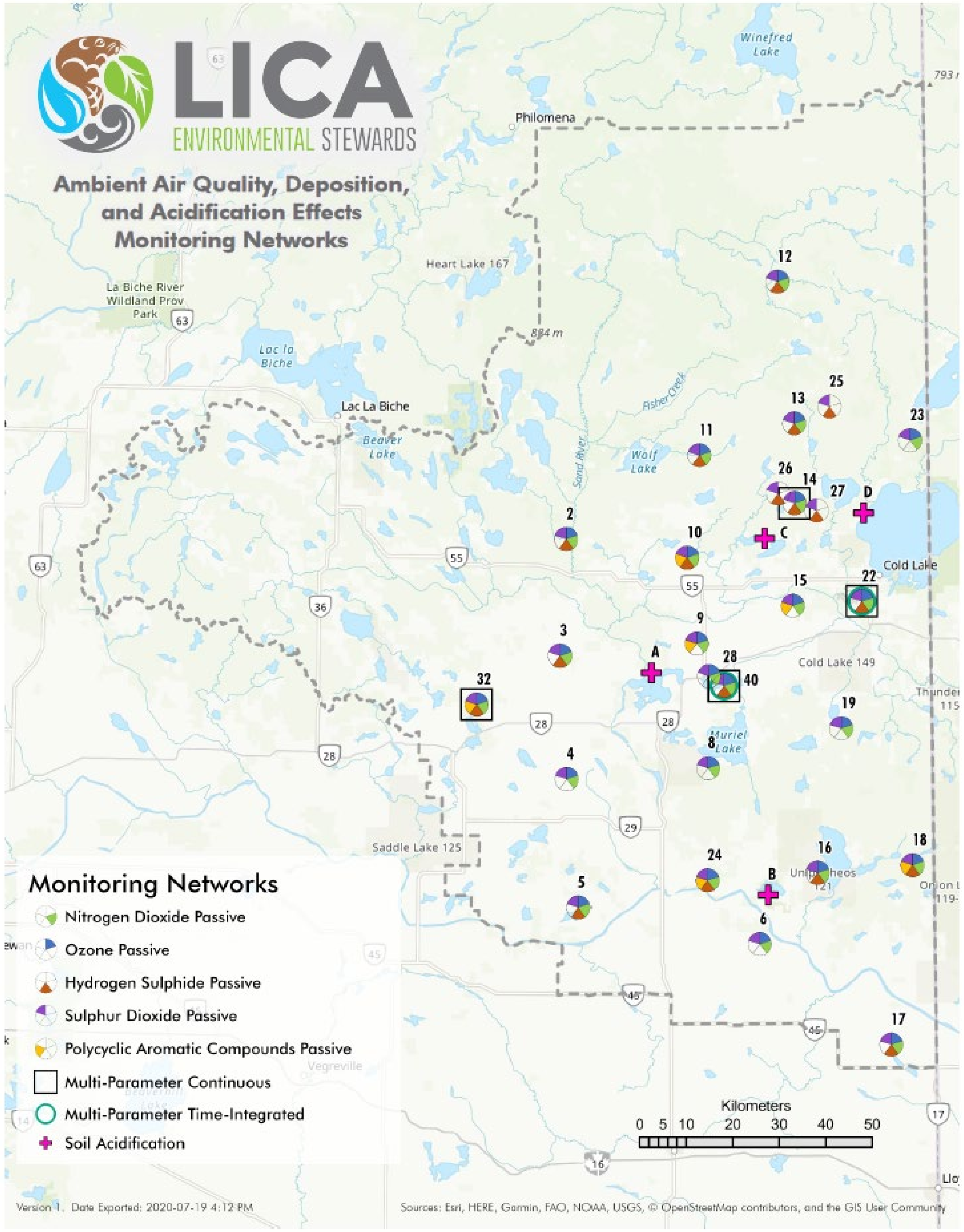
March 30, 2021

DRAFT REPORT

Summary of Results

- Some indications of acidification among the LICA sites were found mainly for Tucker Lake **(C)** and Moose Lake **(A)** sites. No indications were found for Whitney Lakes **(B)** site.
- Overall, interpretations are challenging with results from just three monitoring events at the LICA sites to date.
- After eight monitoring events, the LTSAM Cold Lake **(D)** site showed acidification trends since initiation of monitoring in 1982.
- Measurements of pHc provide the strongest evidence for acidification, supported to some extent by total sulphur measures.
- Currently, in discussion with ECCC on how these monitoring data can be used in GEM-MACH modeling

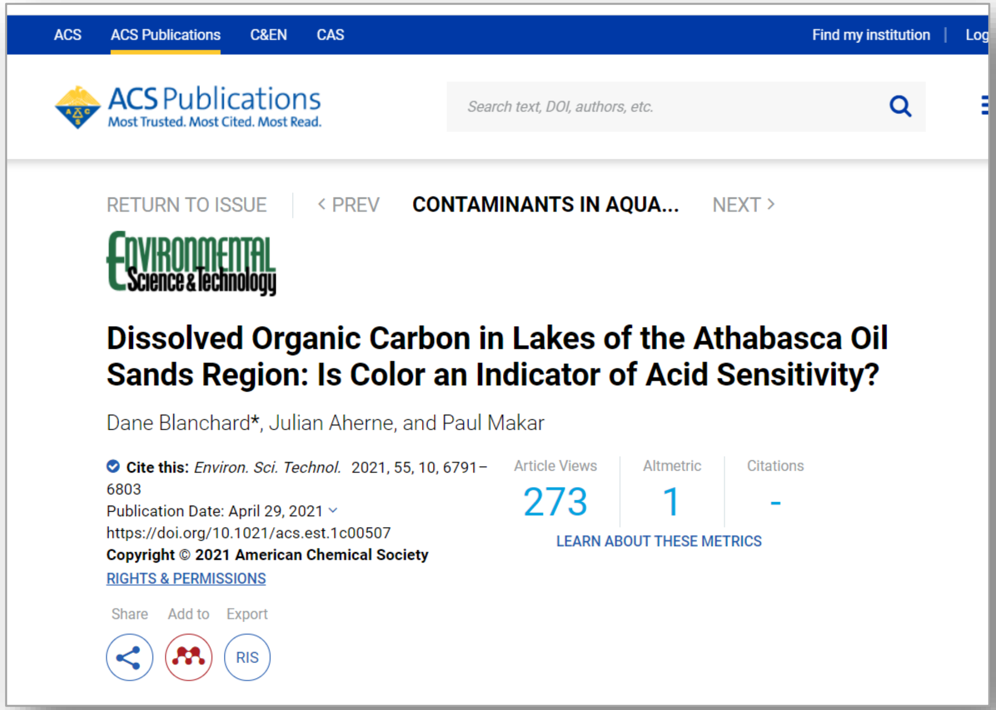
Monitoring Station Identification					
2	Sand River	13	Primrose	25	Burnt Lake
3	Therien	14	Maskwa	26	Mahihkan
4	Flat Lake	15	Ardmore	27	Mahkeses
5	Lake Eliza	16	Frog Lake	28	Bonnyville
6	Telegraph Creek	17	Clear Range	32	St. Lina
8	Muriel - Kehewin	18	Fishing Lake	40	Bonnyville East - Charlotte Lake
9	Dupre	19	Beaverdam	A	Moose Lake Soil Plot
10	La Corey	22	Cold Lake South	B	Whitney Lakes Soil Plot
11	Wolf Lake	23	Medley - Martineau	C	Tucker Lake Soil Plot
12	Foster Creek	24	Fort George	D	Cold Lake Fish Hatchery Soil Plot



3.2.7 Approaches to surface water acidification monitoring site selection (novel)

“Dissolved Organic Carbon in Lakes of the Athabasca Oil Sands Region: Is Color an Indicator of Acid Sensitivity?

- Surface-water data from 50 lakes were analyzed in Athabasca Oil Sands Region.
- Variables known to be associated with the light-absorptive properties were evaluated in the context of lake acidification and buffering capacity.



Identify Other Sources

- 3.3.1 Round table on other considerations, information, and data sources

Next Steps and Proposed Approach for Monitoring Plan Development

- 3.4.1 Identification of data and information gaps
- 3.4.2 Desktop overlay of input sources: site selection screening