Lakeland Industry and Community Association
8237, 5107W - 50 Street, Bonnyville, AB T9N 2J5
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Acid Deposition Monitoring Program Expansion Committee

Meeting Minutes

Monday, April 11, 2022
9:00 a.m. – 12:00 p.m.
LICA Boardroom and via Microsoft Teams

Present:	Heather Harms Desiree Parenteau Brent McGarry (left at 9:35 am) Clarence Makowecki Wally Qiu Leo Paquin Fin MacDermid Sean Mercer Salim Abboud Amanda Avery-Bibo Nikole Andres
Observers and Guests:	
Staff and Contractors:	Kristina Morris, LICA Executive Director Michael Bisaga, Manager, Environmental Monitoring Programs Lily Lin, LICA Data & Reporting Specialist Eveline Hartog, LICA Administrative Professional
Regrets:	Bob Myrick Jennifer O'Brien Andrea Woods

1.0 CALL TO ORDER

Heather Harms Committee Chairperson, called the meeting to order at 9:00 a.m.

1.1 Territorial Acknowledgement

1.2 Introductions

1.3 Vision, Mission, and Values

1.4 **Roll Call**

1.5 **Approval of Agenda**

1.5.1 **April 11, 2022**

#1 Moved by Heather Harms AND CARRIED that the April 11, 2022, Agenda be approved as presented.:

1.6 **Approval of the Minutes**

1.6.1 **January 17, 2022, ADMPEC Meeting**

#2 Moved by Desiree Parenteau AND CARRIED that the January 17, 2022, minutes be approved as presented.

2.0. ONGOING BUSINESS

2.1 Strategy Information

2.1.1 Acid Deposition Monitoring Strategy for the Cold Lake Region

The Manager of Environmental Monitoring Programs presented the acid deposition strategy for information. It was noted that although Alberta's new Acid Deposition Management Framework is not ratified, LICA's strategy recognizes this and is adaptable enough to change when the new requirements become available.

A Committee member inquired if monitoring of vegetation would be a part of the strategy, as well as monitoring fens and wetlands. The Manager of Environmental Monitoring Programs informed the Committee that approaches to monitoring vegetation would be conducted in Phase 3 of the ADMPEC's work; a approach for this type of monitoring has already been establish by the Wood Buffalo Environmental Association's forest health monitoring program. In relation to fens and lakes, LICA has passive monitoring stations near these areas and monitor for acid input and that the collected data would show us if critical loads are being exceeded. This is not direct monitoring of fens and lakes, but the passive stations will help inform triggering-in additional monitoring or management actions.

2.1.2 AER Authorization Letter

The Manager of Environmental Monitoring Programs presented the AER Authorization letter for information.

3.0 OTHER BUSINESS

3.1 Acid Deposition Monitoring Strategy Implementation Plan Development

3.1.1 Define Goals

The Manager of Environmental Monitoring Programs presented the outline for the goals of implementing the acid deposition monitoring strategy noting the 5 major components involved in the strategy:

- Wet deposition: with enhanced precipitation collection.
- Dry deposition: with enhanced passive monitoring using existing stations and adding new sites.
- Wet/dry deposition, Ion Exchange Resins (IER): deploy IER in monitoring sites.
- Soil acidification: expand long term soil monitoring using existing and new sites.
- Surface water: initiate water (lake) sampling.

3.1.2 Identify Information and Research Needs

Using the 5 implementation goals as the basis, the Manager of Environmental Monitoring Programs presented to the Committee the outline for identifying information and research needs noting:

- The need to get the updated GEM-MACH modelling for all deposition monitoring activities, noting that this should be available in Q1 2022-23.
- LICA can act on some acid deposition monitoring sites right away while we await the selection of other monitoring sites.
- That AEP evaluation of wet deposition sites information will be helpful for LICA in selecting our sites north of Cold Lake; and WBEA lab protocols will help us determine sites for our wet/dry deposition (IER) monitoring.
- An update on LICA's soil acidification mapping will need to be completed using updated soil acidification modelling map. He indicated that he would update the map and add supplemental information once the GEM-MACH modelling is implemented.
- That our approach to surface water monitoring should be aligned with other water monitoring and the OSM program.

A Committee member inquired if shallow bodied lakes in the Cold Lake region are being monitored for pH, namely Marguerite Lake and Barbara Lake. The Manager of Environmental Monitoring Programs was not certain of this and indicated that he would look into whether there is data available.

3.1.3 Map Out Risks

Once again using the 5 implementation goals as the basis, the Manager of Environmental Monitoring Programs presented to the Committee his outline for mapping out risks noting:

- Wet and Dry Deposition have very few barriers to implementation since sites are already established. Additional passive monitoring will be added to areas of higher deposition and regarding dry deposition the only barrier currently is selecting sites.
- Implementation of Wet/Dry Deposition (IER) will require more time upfront in site selection and implementation. These types of sites are not powered but they are clustered in order to do monitoring so there is a larger footprint. As well, bears are attracted to the sampling media used for monitoring so solar powered shock fences are used to keep them out.

- The establishment of soil acidification monitoring sites will also require a significant amount of time initially, but these sites will be good for the long term.
- Surface water monitoring sites are all located in the Cold Lake Air Weapons Range (CLAWR) and therefore more difficult to obtain samples since access will need to be obtained from the Department of National Defense. The Manager of Environmental Monitoring Programs indicated that land access to proposed sites is good, however he may rely on some committee members for assistance should there be any obstacles.
- LICA has not yet received approval for the 2022-23 OSM Deposition workplan and budget. This creates some uncertainty in how LICA may proceed in carrying-out the strategy implementation, as outlined within the current OSM workplan.

3.1.4 Schedule Milestones

Using the 5 implementation goals as the basis, the Manager of Environmental Monitoring Programs presented his outline for scheduling milestones noting:

- The map shown in the attached presentation includes known monitoring sites and where future sites would be implemented.
- Purchasing of additional equipment for dry deposition monitoring to enhance existing monitoring sites will need to be done. This forms the backbone of acid deposition monitoring in the region.
- New areas to monitor will hopefully be selected by the third quarter along with their implementation data collection since the new modelling protocols will be in place. Current identified sites (in the pink outlined area on the map) will have monitoring start immediately whereas everywhere else will take some time to establish.
- Wet/Dry Deposition (IER) monitoring is set out semi-annually with a summer season (May – October) and a winter season (November – April).
- Soil acidification monitoring is done in a staggered rotation, 1 site every 4 years at one of LICA’s four current plots and additional sites will be established in 2023 after screening and selection.
- Surface water monitoring is associated with risks in accessing the 4 lakes in the Cold Lake air weapons range but if these could be sampled this year LICA can establish their acid sensitivity rating.
- Wetlands are also needed in the acid deposition monitoring scope and is currently a gap which will need to be incorporated into the strategy.

A Committee member inquired if any agricultural lands would be monitored in the identified in the outlined area in the attached map. The Manager of Environmental Monitoring Programs indicated that this area of acid deposition monitoring would be part of Phase 3 of the strategy.

3.1.5 Assign Tasks

Regarding assigning tasks, the Manager of Environmental Monitoring Programs noted:

- Wet deposition will have a weekly sampling interval.
- Dry deposition samples will be collected by LICA monthly.

Initials

- Wet/Dry deposition (IER) will have a semi-annual (winter and summer) sampling interval and samples will be collected by LICA.
- Soil acidification sites will be sampled annually, and the Manager of Environmental Monitoring Programs will work with Salim Abboud in establishing additional sites to monitor.
- Surface water sampling will be done annually, and the Manager of Environmental Monitoring Programs indicated that he would work on this aspect of sampling immediately in order to accommodate any red tape from the Department of National Defense. Various Committee members offered to help him with this, and they will be called upon to give their assistance along with appealing to industry and Cold Lake First Nations for support as well.

3.1.6 Allocate and/or Identify Resources

Once again, using the 5 implementation goals as the basis, the Manager of Environmental Monitoring Programs noted that:

- He is still building actual budgets for all 5 implementation goals, and he would have most of these available for the May 2022 acid deposition monitoring program expansion committee meeting.
- He is waiting on OSM funding decisions. Some of the work may be staggered pending this funding and if possible, he would like to get as much done this year as possible.
- Upfront costs, since different from the ongoing costs, will determine how much work we can accomplish this year.
- It was noted that supply chain issues do exist, and this will be a factor to consider in acquiring resources from across the border.

3.1.7 Recognize Gaps

The Manager of Environmental Monitoring Programs informed the Committee of identified gaps noting:

- There was an urgent need to get the updated GEM-MACH modelling since this will help us in the deployment of our strategies for monitoring.

He added that the presentation at this meeting was an overview of the needs of the strategy and that moving forward, he will work on developing a master table to track progress in the implementation of the strategy along with tracking project work budgets.

4.0 ACTION LIST

4.1 Follow-up on Action List

4.1.1 Action List for January 17, 2022, ADMPEC Meeting

The Committee reviewed the action list from the January 17, 2022, meeting, noting all items have been completed, with the exception of 3.1.4.

5.0 UPCOMING MEETING DATES

5.1 Board Meeting – April 28, 2022

5.2 Next ADMPEC Meeting

The next ADMPEC meeting will be determined for some time in early May 2022 and a doodle poll will be forwarded to the Committee.

6.0 ADJOURNMENT

Meeting adjourned at 10:28 a.m.

#3 Moved by Sean Mercer AND CARRIED that the meeting be adjourned.

Approved on: ______________________________
Date

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Signature

____
Initials

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Observers and Guests:	
Staff and Contractors:	Michael Bisaga, Manager, Environmental Monitoring Programs Lily Lin, LICA Data & Reporting Specialist Eveline Hartog, LICA Administrative Professional
Regrets:	Larry Turchenek Colin Cooke Amanda Avery-Bibo Lindsay Hollands Bob Myrick

1.0 CALL TO ORDER

Heather Harms Committee Chairperson, called the meeting to order at 9:02 a.m.

1.1 Territorial Acknowledgement

1.2 Introductions

1.3 Vision, Mission and Values

1.4 Roll Call

1.5 Approval of Agenda

1.5.1 January 17, 2022

#1 Moved by Desiree Parenteau AND CARRIED that the January 17, 2022, Agenda be approved.

1.6 Approval of the Minutes

1.6.1 December 15, 2021, ADMPEC Meeting

#2 Moved by Heather Harms AND CARRIED that the December 15, 2021, minutes be approved as presented.

2.0. ONGOING BUSINESS

2.1

2.1.1 Synthesis Discussion on ADMPEC Presentation Session

The Manager of Environmental Monitoring Programs recapped with the Committee the January 13 webinar presented by Dane Blanchard on monitoring acid sensitive lakes in the Athabasca oilsands region. The monitoring information suggests that lakes in that area were not showing a trend towards acidification and his research is looking at factors which contribute to this. Part of his research suggests that some of the lakes are in fact showing trends towards becoming more alkaline however the cause is not entirely understood. Also noted was that the lakes monitored in the Athabasca area were experiencing a much higher deposition rate than Cold Lake will be. The Committee was informed that the lake monitoring section of the strategy (what to monitor, how lakes are chosen) is still being developed; learnings from the Athabasca region's acid sensitive lakes monitoring program will be incorporated into the strategy for the Cold Lake region as much as practicably possible.

The Committee wondered if fens, muskegs, and lakes would be included in our approach of wet monitoring especially in the area south of the main plant. The Manager of Environmental Monitoring Programs indicated that the proposed strategy does not say anything about wetlands and if that is something that the committee would like addressed, he will do some research and reach out to some Committee members that have expertise in this area to enhance the strategy. The Committee suggested that this section of the strategy be divided into lakes and wetlands.

2.1.2 Feedback on Draft Phase 1 Acid Deposition Program Expansion Strategy

The Manager of Environmental Monitoring Programs briefly went over the strategy and edits which were made after the Committee's input. The maps in the strategy were enhanced to clearly show where and what the program will be monitoring and to have consistency throughout the document. In addition, he included formulas to show how monitoring data will be used to determine potential acid input (PAI) which in turn will be used to support modelling efforts; this information was included in the Mitigation Response section of the strategy. In response to the Committee's suggestions, he will reach out to various Committee members with expertise to help him clarify some items in the strategy.

The Manager of Environmental Monitoring Programs indicated that there have been no major content changes to the strategy since it was first presented in December however there have been incremental improvements based on discussions at committee meetings and emailed feedback; overall, there have been no objections to the strategy or its content. After consultation with some members of the Committee regarding specific sections, the document will be available to the Committee on January 19 for final review (any changes to the document since the January 17th, 2022 meeting will be highlighted). He would like all suggestions by January 25 since the strategy will be presented at the Board of Directors meeting January 27.

3.0 OTHER BUSINESS

3.1 Next Steps in the Process

3.1.1 LICA Board Approval

The Committee chair reminded the Committee that the strategy will be presented to the Board of Directors at the January 27 meeting for review and approval.
The Manager of Environmental Monitoring Programs will have a power point presentation for the LICA Board of Directors highlighting the strategy; the January 17, 2022 version of the strategy will be made available to the Board in the agenda package. Any changes that may occur between Wednesday January 25, 2022 and the Board meeting date will be addressed at the Board meeting.

3.1.2 Alberta Energy Regulator (AER) Approval

The Committee was informed that it was up to the approver holder to submit the strategy for authorization as part of their approval requirements. The format followed is that these plans are usually submitted by email.

3.1.3 Oil Sands Monitoring (OSM) Approval

The Committee was reminded that the strategy was developed to both satisfy Cenovus monitoring requirements and also address acid deposition throughout the region and anticipated regulatory monitoring requirements at other facilities. The strategy is intended to provide a regional approach to monitoring acid deposition and potential acidification effects.

The Manager of Environmental Monitoring Programs informed the Committee that placeholders were also put in place in budget lines with OSM for future monitoring requirements in their next planning cycle.

3.1.4 Implementation Planning

The Manager of Environmental Monitoring Programs indicated that the next stage in the planning process is to turn the monitoring strategy into a monitoring plan. He will begin to compile information about locations, methods, laboratories, costs, etc. that will be used to inform the implementation phase.

4.0 ACTION LIST

4.1 Follow-up On Action List

4.1.1 Action List for December 15, 2021, ADMPEC Meeting

The Committee reviewed the action list from the December 15, 2021, meeting, noting that all items have been completed.

5.0 UPCOMING MEETING DATES

5.1 Board Meeting – January 27, 2022

5.2 Next ADMPEC Meeting

The next ADMPEC meeting will be determined later.

6.0 ADJOURNMENT

Meeting adjourned at 10:14 a.m.

#3 Moved by Jennifer O'Brien AND CARRIED that the meeting be adjourned.

Approved on: ______________________
Date

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Signature

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Initials

Lakeland Industry and Community Association

Acid Deposition Monitoring Strategy for the Cold Lake Region

Acid Deposition Monitoring Program Expansion Committee

LICA
ENVIRONMENTAL STEWARDS

Michael Bisaga, Monitoring Programs Manager
Version 1: January 31, 2022

Contents

Acknowledgements

Committee Members

LICA thanks the Acid Deposition Monitoring Program Expansion Committee (ADMPEC) members, their organizations and sectors which provided them with the support needed to be dedicated and committed to this project.

Salim Abboud – Soil Scientist, Abboud Research Consulting
Amanda Avery-Bibo – LICA, Board Chairperson
Michael Bisaga – LICA, Monitoring Programs Manager
Heather Harms – Strathcona Resources
Lindsay Hollands – Imperial Oil
Nikita Lattery – Cold Lake First Nations
Lily Lin – LICA, Data and Reporting Specialist
Findlay MacDermid – Cold Lake First Nations
Clarence Makowecki – Agriculture Sector
Brent McGarry - Alberta Energy Regulator
Sean Mercer – Imperial Oil
Jennifer O'Brien – Cenovus Energy
Leo Paquin – Canadian Natural Resources Limited
Desiree Parenteau – Community Member
Wally Qiu – Alberta Energy Regulator
Larry Turchenek – Soil Scientist
Greg Wentworth – Alberta Environment
Andrea Woods – Community Member

Territorial Acknowledgement

LICA operates within the traditional lands of the Dene, Cree, and Métis. This recognition represents respect and gratitude to share in the land and honors our responsibility to truth and reconciliation as members of Treaty 6, 8, and 10 territory and the Métis Homeland.

1. Lakeland Industry and Community Association

In response to the expansion of oil and gas production in the region, the Lakeland Industry and Community Association (LICA) was formed in October 2000 as a not-for-profit association, registered under the Alberta Societies Act.

Today, LICA is (1) a Synergy Group that facilitates all stakeholders' voices when addressing issues concerning the environment in the Cold Lake region, (2) the Watershed Planning and Advisory Council for the Beaver River Watershed, and (3) an Airshed Zone monitoring air quality and deposition throughout the LICA region.

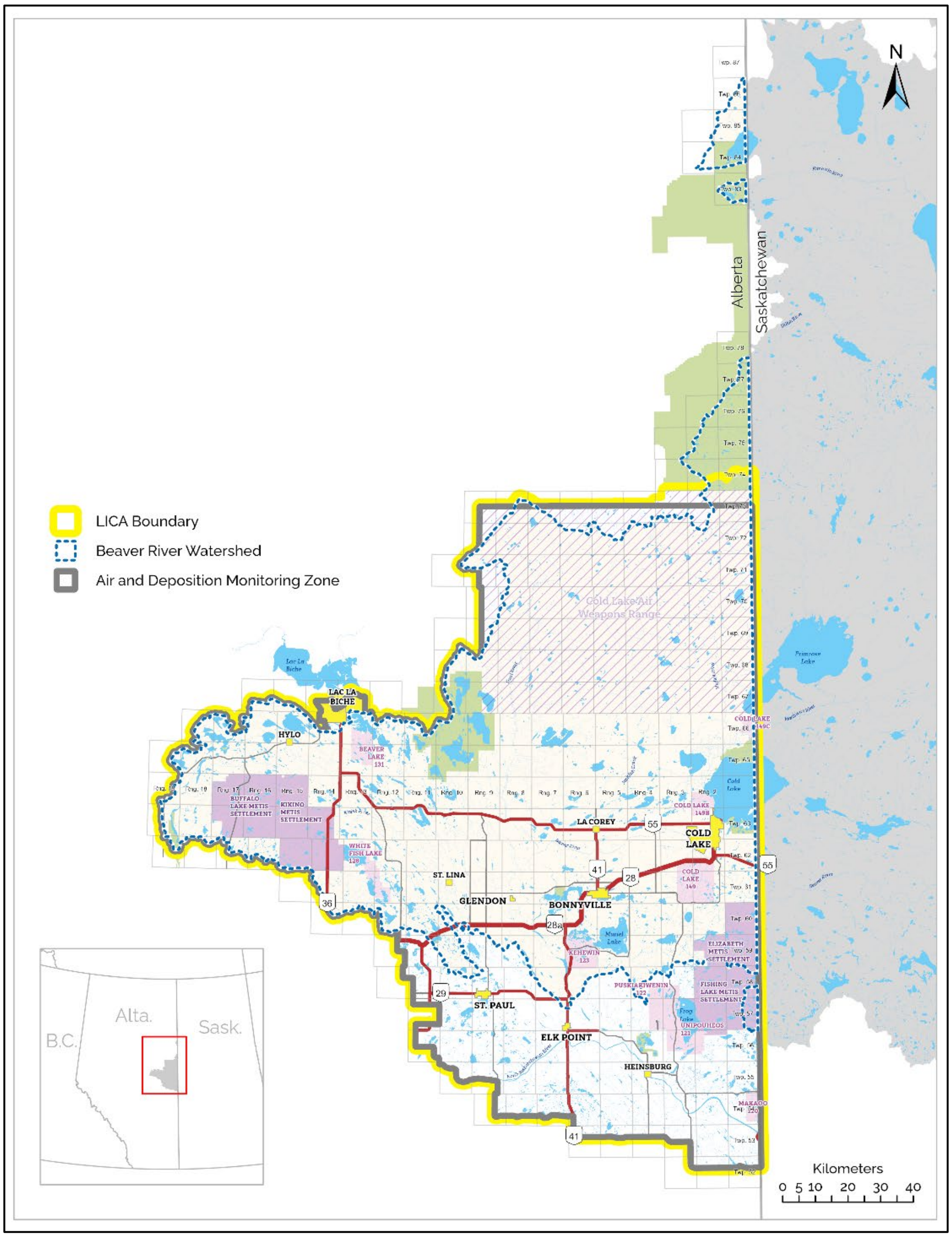

Figure 1: The LICA area

2. Acid Deposition Monitoring Program Expansion Committee

LICA's Acid Deposition Monitoring Program Expansion Committee (ADMPEC) was formed to assist in the development and oversight of the expansion of LICA's Acid Deposition Monitoring Program. The expansion of the Program will be completed in phases:

- Phase One of the expansion will address development of an acid deposition monitoring strategy to meet the needs of new regional regulatory compliance acid deposition monitoring and reporting requirements.
- Phase Two will address implementation of the Phase One.
- Phase Three will have a broader scope than Phase One and Two and address further enhancement of the program to implement a complete regional approach to acid deposition monitoring and reporting.

The ADMPEC is an ad-hoc committee of LICA and is supported by representation from industry, government, indigenous communities, and the public. A multi-stakeholder committee composition allows for diverse insight, expertise, and support for the development of recommendations for acid deposition monitoring. This document presents a strategy for building on the existing LICA monitoring program and expanding the acid deposition monitoring program in the Cold Lake region (Phase One).

The image below (USEPA, 2021) illustrates the pathway for acid deposition in our environment: (1) Emissions of sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) are released into the air, where (2) the pollutants are transformed into acidic particles. (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.) and (4) may cause impacts to soil, forests, streams, and lakes. LICA's acid deposition monitoring plan will be multi-media and will address direct deposition monitoring as well as potential acidification effects on soils and surface water.

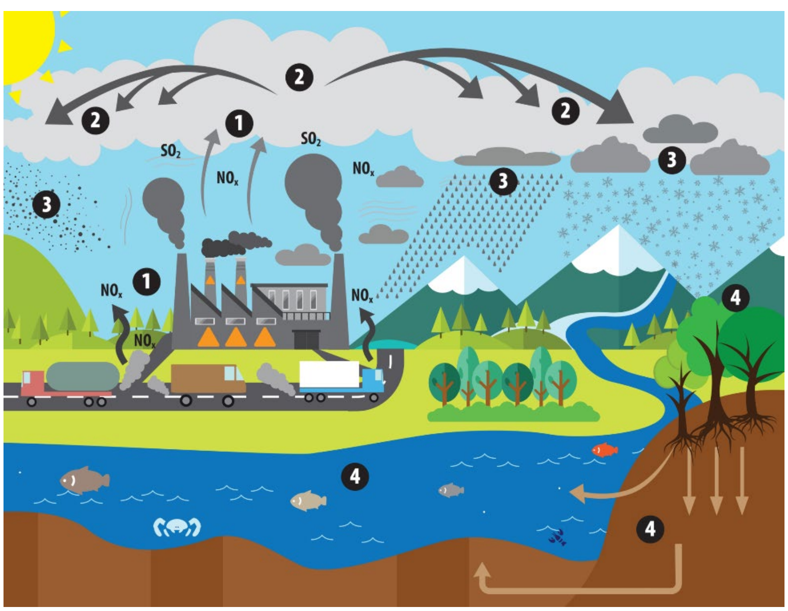

Figure 2: Pathway for acid deposition in our environment

3. Regulatory Context

In 2019, the Alberta Energy Regulator (AER) issued an operating approval to an oil sands facility in the Cold Lake region; the approval has requirements to develop an acid deposition monitoring program (referred to in the previous section as the *'new regional regulatory compliance acid deposition monitoring and reporting requirements'*). The acid deposition monitoring program must include the following at a minimum:

i) for air:
   (1) a plan to monitor dry and wet deposition;
ii) for soil:
   (1) identification of soils that are sensitive to acid deposition and will likely receive aerial deposition inputs;
   (2) a plan to monitor soil quality at locations representative of the soils identified in (b) (i);
   (3) 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;
iii) for water:
   (1) a summary of existing water quality data collected to date and analysis of the results;
   (2) a plan to monitor water quality for water bodies which will likely receive aerial deposition inputs;
   (3) identification of local water bodies that are sensitive to acidification;
   (4) a description of how water quality data collected under this program will be used to determine potential acidification effects under periods of increased sulphur dioxide emissions;
   (5) a plan to develop triggers for further enhanced surface water quality monitoring to determine impacts of aerial deposition inputs;
iv) reporting schedule for monitoring activities conducted for (i) through (iii)

In terms of the regional, temporal, and regulatory scope, there is a short-term need to develop and implement an acid deposition monitoring strategy to address new AER compliance requirements for *one* facility. There is, however, a medium to long-term need to do the same for similar requirements that are expected in *several* future operating approval conditions for oil sands facilities in the Cold Lake Region.

Regulatory drivers for developing a deposition monitoring program for the Cold Lake region include changes to sulphur limits at individual facilities, more stringent provincial deposition monitoring requirements, evolving acid deposition management frameworks, and determining the regional cumulative effect of acidifying emissions on the local environment. Acid deposition monitoring is sparse in the Cold Lake region, however there is some evidence that indicates potential soil acidification effects are occurring (LICA 2021). The location and nature of emissions from in situ oil sands facilities in the Cold Lake region likely result in a more 'diffuse' deposition pattern (i.e., less steep deposition gradient) compared to the Athabasca region.

LICA has elements of an acid deposition monitoring program in place, however these elements do not form a holistic and regional approach. The LICA deposition monitoring program is limited to soil acidification effects and potential acid input estimates using passive monitoring. Currently there is limited wet and dry deposition monitoring in place with most estimates being informed by passive monitoring data.

4. Oil Sands Monitoring Program

Since February 2012, the governments of Canada and Alberta have worked as partners to implement and jointly manage the Oil Sands Environmental Monitoring (OSM) Program. The program strives to improve characterization and the condition of the environment, while enhancing the understanding of the cumulative effects related to oil sands development in the oil sands area of Alberta. Building on existing monitoring, where possible, the approach to program implementation is adaptive to ensure the program is responsive to existing knowledge, emerging priorities, and input from Indigenous peoples and key stakeholders. LICA's existing regional air and deposition monitoring efforts form part of the OSM Program and it is expected that the enhanced deposition monitoring effort recommended by this strategy will also become part of the OSM Program.

5. Acid Deposition Management Framework

Alberta Environment and Sustainable Resource Development (ESRD) uses the Regional Lagrangian Acid Deposition (RELAD) model to simulate annual Potential Acid Input (PAI); RELAD simulations are run at a provincial scale and was last completed for Alberta in 2011 using 2006 and 2020 (projected) acidifying emissions (ESRD 2014). The comparison of RELAD predicted deposition values with inferred deposition using monitoring data indicates that RELAD modelling provides a representative estimate of regional deposition patterns of acid forming pollutants. RELAD is identified as *the* acid deposition assessment model for the implementation of the Alberta Acid Deposition Management Framework (Alberta Environment, 2008). Relatedly, ESRD's Acid Deposition Assessment Group (ADAG) provides input into the ongoing evaluation of current and projected acidifying emissions and resulting acid deposition levels and effects in Alberta, (this includes assessment of the RELAD outputs). This evaluation is required every five years under the 2004 Alberta Acid Deposition Management Framework. The 2014 report of RELAD results forms part of the 2011 acid deposition assessment; its purpose was to compile the current state of knowledge on provincial acidifying emissions, resulting acid deposition levels and effects in the province of Alberta.

At the time of creating this monitoring strategy, a new Alberta Acid Deposition Management Framework, a novel acid deposition modelling approach, and an updated acidifying emissions inventory were nearly complete; collectively, these components form the latest iteration of the outputs from the ADAG. These components were not ready for public release at the time that this strategy was created. LICA will however remain engaged in relevant policy developments and adaptively manage its approach to regional acid deposition monitoring as appropriate.

The tiered monitoring, target, and critical load acid deposition management approach that was used in the 2008 Alberta Acid Deposition Monitoring Framework (ADMF) is described in the sections below. 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 on how to manage and reduce, where necessary, acidifying emissions adversely affecting the identified areas. While LICA's strategy for monitoring acid deposition in the Cold Lake region is based on the guidance and triggers in the 2008 ADMF, the surveillance that the proposed monitoring methods provide can be adaptively managed to address the new requirements once the new ADMF is released.

LICA's monitoring strategy also examines contemporary modeling, monitoring, and emissions data to help inform the design of the proposed monitoring approach.

6. Potential Acid Input and Critical Loads

The deposition of acidifying species is determined from the modelled potential acid input (PAI), which represents the sum of the deposited acidifying and neutralizing species. RELAD was calculated using 1980 meteorology in conjunction with emissions from 2006 and projected emissions for 2020 to determine the deposition of acidifying species[1] and PAI in each modelled grid cell (approximately 111 km by 60 km). Modelling results are presented in Figure 3 and Figure 4.

[1] Acidifying species modelled include HNO_3 H_2SO_4, SO_4^{2-}, NO_3^-, SO_2 and NO_x

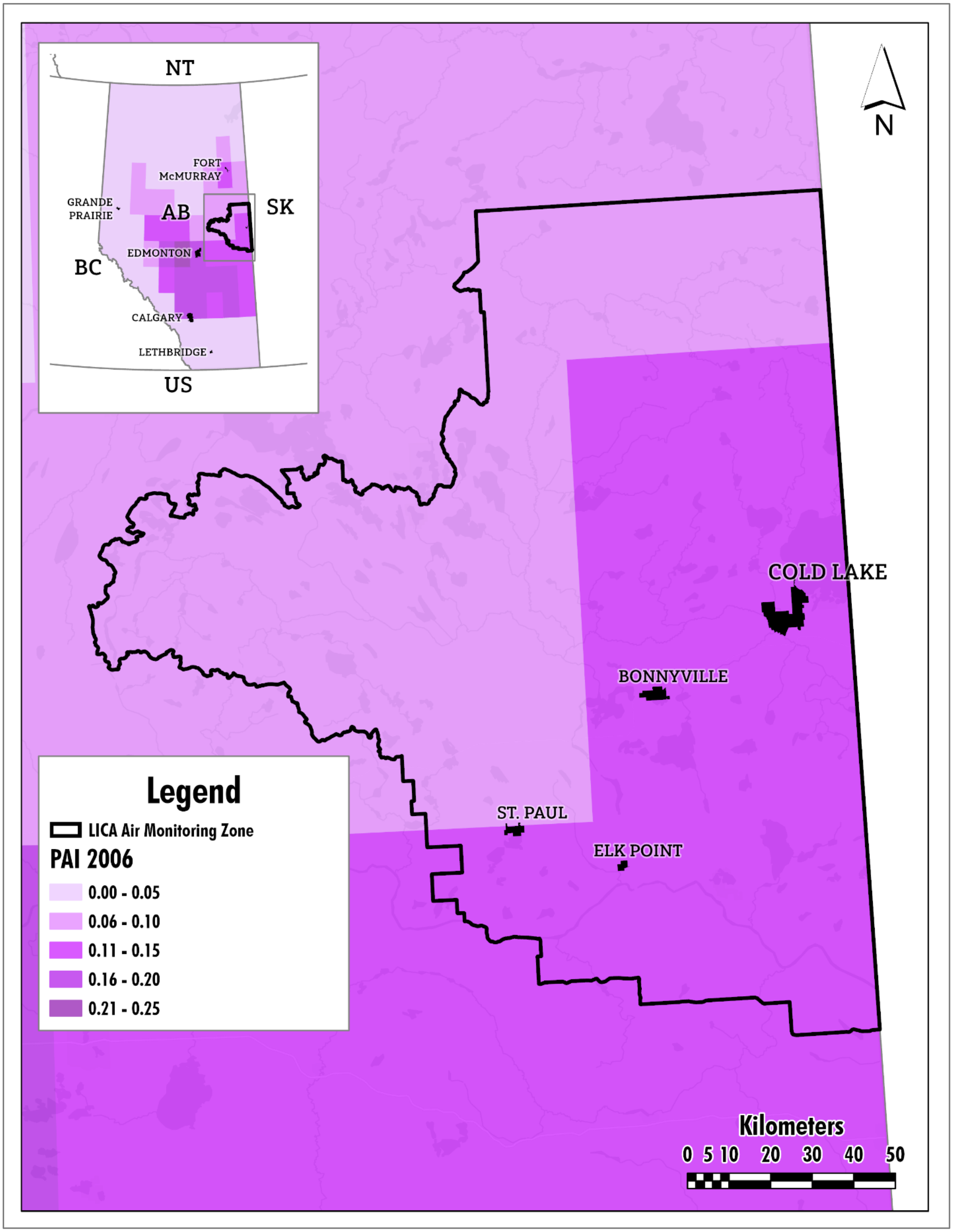

Figure 3: RELAD results for annual PAI for the years 2006 (keq H+ ha-1 yr-1) for Alberta

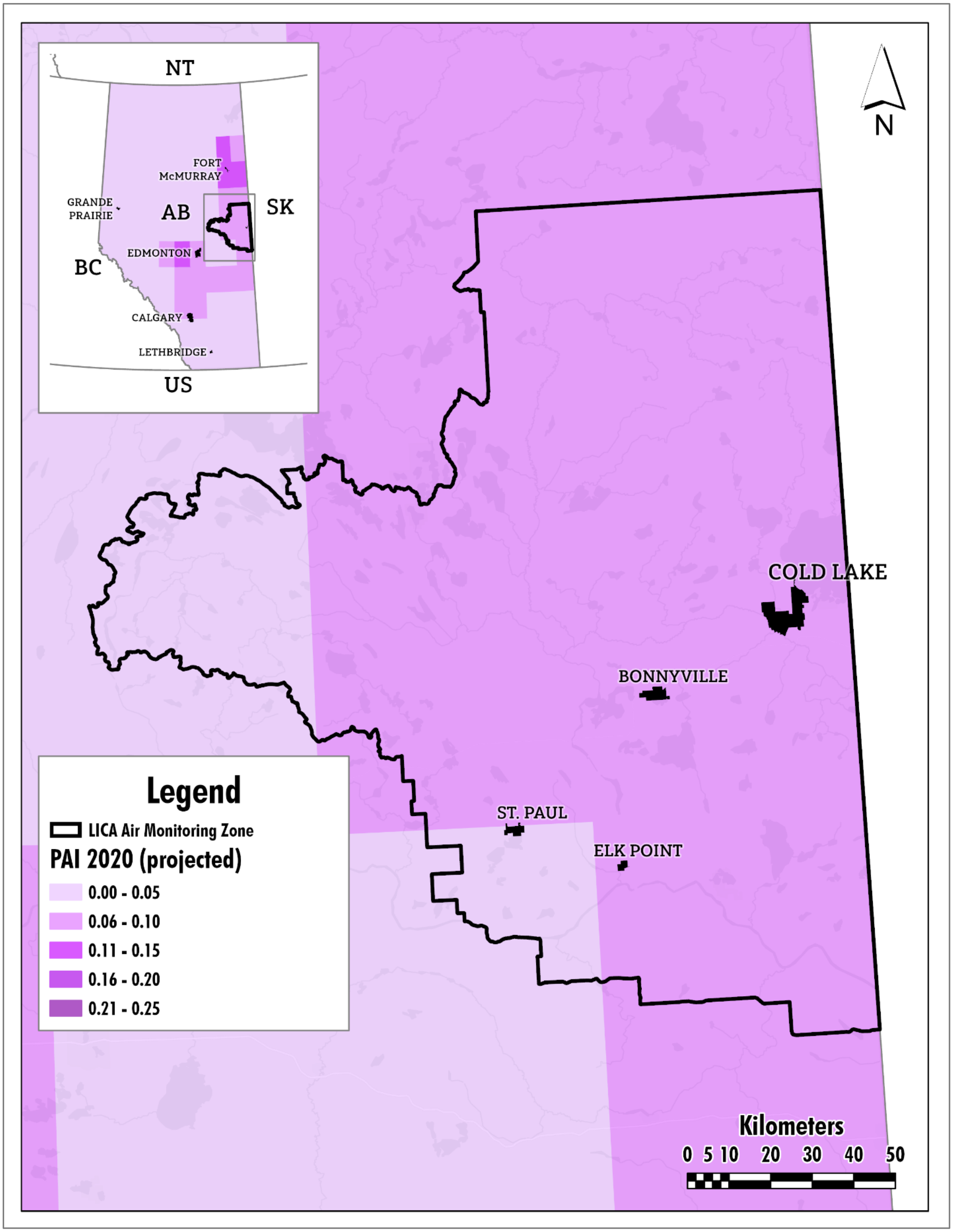

Figure 4: RELAD results for annual PAI projected 2020 (keq H+ ha-1 yr-1) for Alberta

The ADMF is based on three levels of PAI: Monitoring Load, Target Load, and Critical Load. Each level of deposition has an associated management action: increased monitoring (Monitoring Load), emissions management (Target Load), or emissions reduction (Critical Load). The RELAD model estimates acid deposition and assesses acid sensitivity of ecosystems to acidification in Alberta; in the ADMF, the ecosystem indicator is soil.

Comparison of RELAD modelled PAI to receptor sensitivity for each model grid cell is accomplished by estimation of the amount of acid deposition as a percentage of Critical, Target and Monitoring Loads.

Critical Loads for Alberta are set at 0.25, 0.50, and 1.0 keq H+ $ha^{-1}yr^{-1}$ for sensitive, moderately sensitive, and low sensitivity soils, respectively (Alberta Environment, 1999).

Target Loads for Alberta are set at 0.22, 0.45, and 0.9 keq H+ $ha^{-1}yr^{-1}$ for sensitive, medium sensitivity and low sensitivity soils, respectively (Alberta Environment, 1999). These Target Loads are established at approximately 90% of Critical Loads.

Monitoring Loads for Alberta are set at 0.17, 0.35, and 0.7 keq H+ ha^{-1} yr^{-1} for sensitive, medium sensitive and low sensitivity soils, respectively (Alberta Environment, 2008). The intent of the Monitoring Load is to allow time for collection of data on emissions, deposition and the sensitivity of receptor prior to the need to take emission management actions.

Table 1: Acid Deposition Management Framework Soil Sensitivity Ratings

RELAD Sensitivity	Monitoring Load keq H^+/ha/yr	Target Load keq H^+/ha/yr	Critical Load keq H^+/ha/yr
High Sensitivity	0.17	0.22	0.25
Medium Sensitivity	0.35	0.45	0.50
Low Sensitivity	0.70	0.90	1.00

The areas of the LICA air and deposition monitoring zone (ADMZ) nearest facilities with potentially acidifying emissions are classified as <u>medium sensitivity</u> (south of 55° N) and <u>high sensitivity</u> (north of 55° N); the critical loads are 0.50 keq and 0.25 H^+/ha/yr, respectively. The northern most facility in the LICA region (Cenovus Foster Creek) is on the transition between these two sensitivity classes while all other facilities are in the medium sensitivity area.

Predicted 2020 emissions using RELAD show PAI in the LICA ADMZ both north and south of 55° N is 0.10 keq H+/ha/year. However, due to the difference in sensitivities as defined in the ADMF for these two adjacent areas, their predicted loading thresholds represent different percentages of critical loads:

- North of 55°N: 40% of Critical Load and below monitoring load
- South of 55°N: 20% of Critical Load and below monitoring load

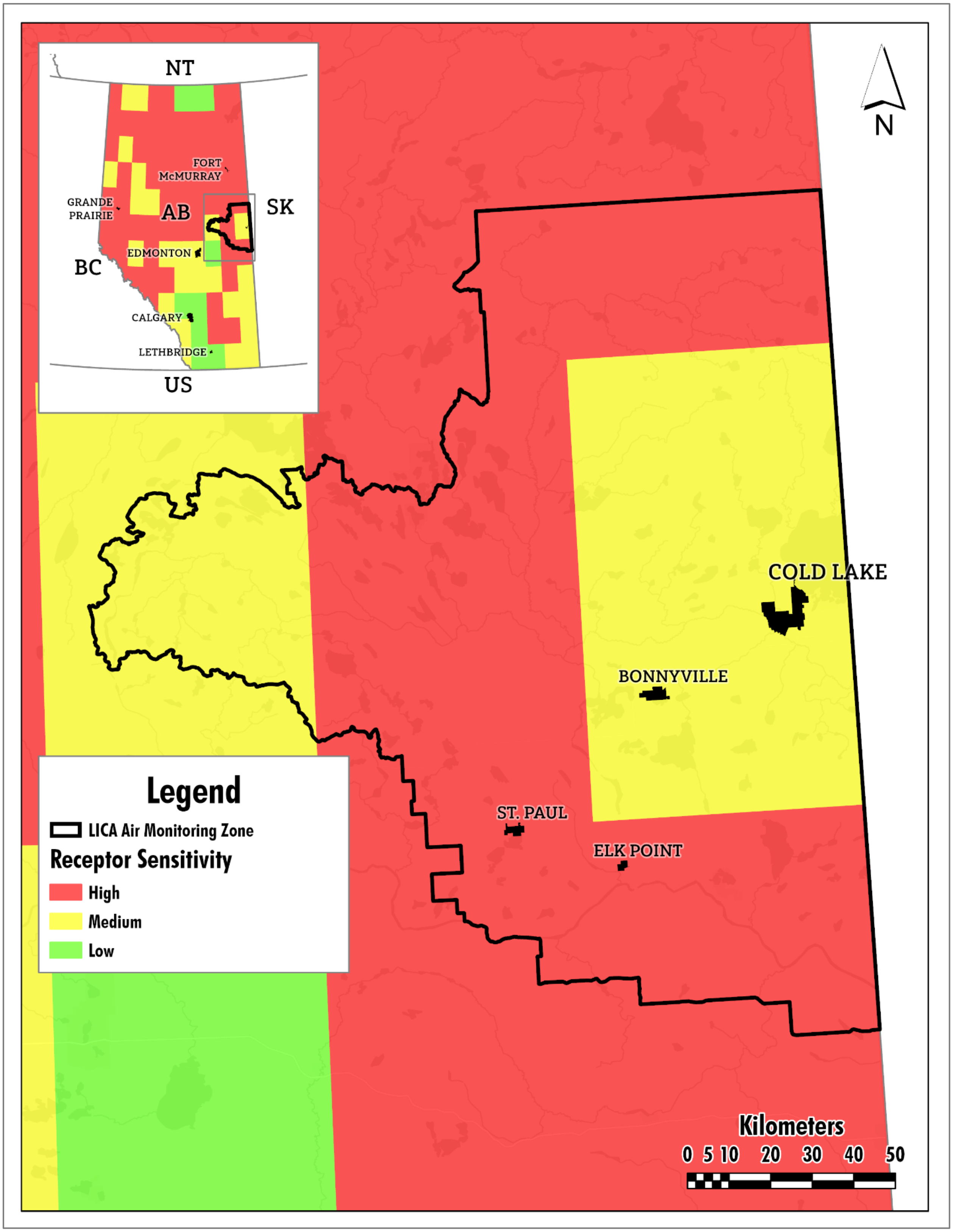

Figure 5: Alberta's soil sensitivity as defined under the Acid Deposition Management Framework (2008).

Based on RELAD modeling results, soils in the area are acid sensitive, however PAI is not predicted to increase above monitoring load levels for the two sensitivity areas within the LICA ADMZ. Relative to predicted PAI for 2006, the 2011 Acid Deposition Assessment for Alberta (ESRD 2014) showed an overall decrease in predicted PAI when using the projected 2020 emissions. This in large part is due to the predicted lowering of acidifying emissions over time, particularly sulphur dioxide. Projected emissions for 2020 did not identify acid deposition patterns over the long term that exceeded deposition criteria. However, in their assessment, ESRD notes that at the airshed level, acid deposition assessment, monitoring, and management may identify other reasons to conduct surveillance of acid deposition.

7. Contemporary Monitoring, Emissions and Modelling Context

In 2021, when LICA's ADMPEC began compiling information to develop an acid deposition monitoring strategy for the Cold Lake region, the 2008 ADMF was the most current comprehensive policy document available to guide its work. One of the objectives of LICA's acid deposition monitoring strategy is to address regional regulatory compliance, therefore the existing ADMF provides a basis and regulatory backstop to support and inform monitoring decisions and management actions. The ADMPEC recognized that while the 2008 ADMF serves these purposes, it is based on dated monitoring and modelling data. More sophisticated atmospheric modelling, current emissions data, advanced soil acidification modelling, and LICA's ambient air and soil acidification monitoring data are also available; these collectively provide valuable contemporary information to guide the ADMPEC in the development of a monitoring.

As described in later sections of this strategy, LICA's existing passive air monitoring network and soil acidification monitoring sites are the foundation upon which to deliver an enhanced acid deposition monitoring program for the Cold Lake region.

In operation since the early 2000s, LICA's 26-station passive monitoring network generally follows a 3 x 3 township grid, with a more densely deployed arrangement closer to oil sands facilities. The network monitors for sulphur dioxide, nitrogen dioxide, hydrogen sulphide, and ozone on a monthly basis; sulphur dioxide and nitrogen dioxide measurements help to inform where deposition of acidifying substances is likely occurring.

In 2010, LICA began soil acidification monitoring. Three long-term soil sampling plots were established: one in Moose Lake Provincial Park in 2010, another in Whitney Lakes Provincial Park in 2011, and a third on Crown Land near Tucker Lake in 2012. Soil sampling is carried out at these plots every four years in a staggered manner (one site per year). A fourth site established in the early 1980s is located near the west shore of Cold Lake; this location was commissioned by Alberta Environment but is now operated by LICA and is complementary to the more recently established sites established. The location of the three sites established by LICA as informed by a study commissioned by LICA in 2007. This preliminary or screening study of potential soil and water acidification within the LICA Area assembled information about locations and extents of sensitive soils as well as current levels of exposure to acidic deposition.

The passive station network and soil sites both appear in several maps in this document (unlabeled), as they provide a point of reference for monitoring recommendations found later in the strategy. Figure 6 presents the current deployment of LICA's passive monitoring network and soil acidification monitoring sites.

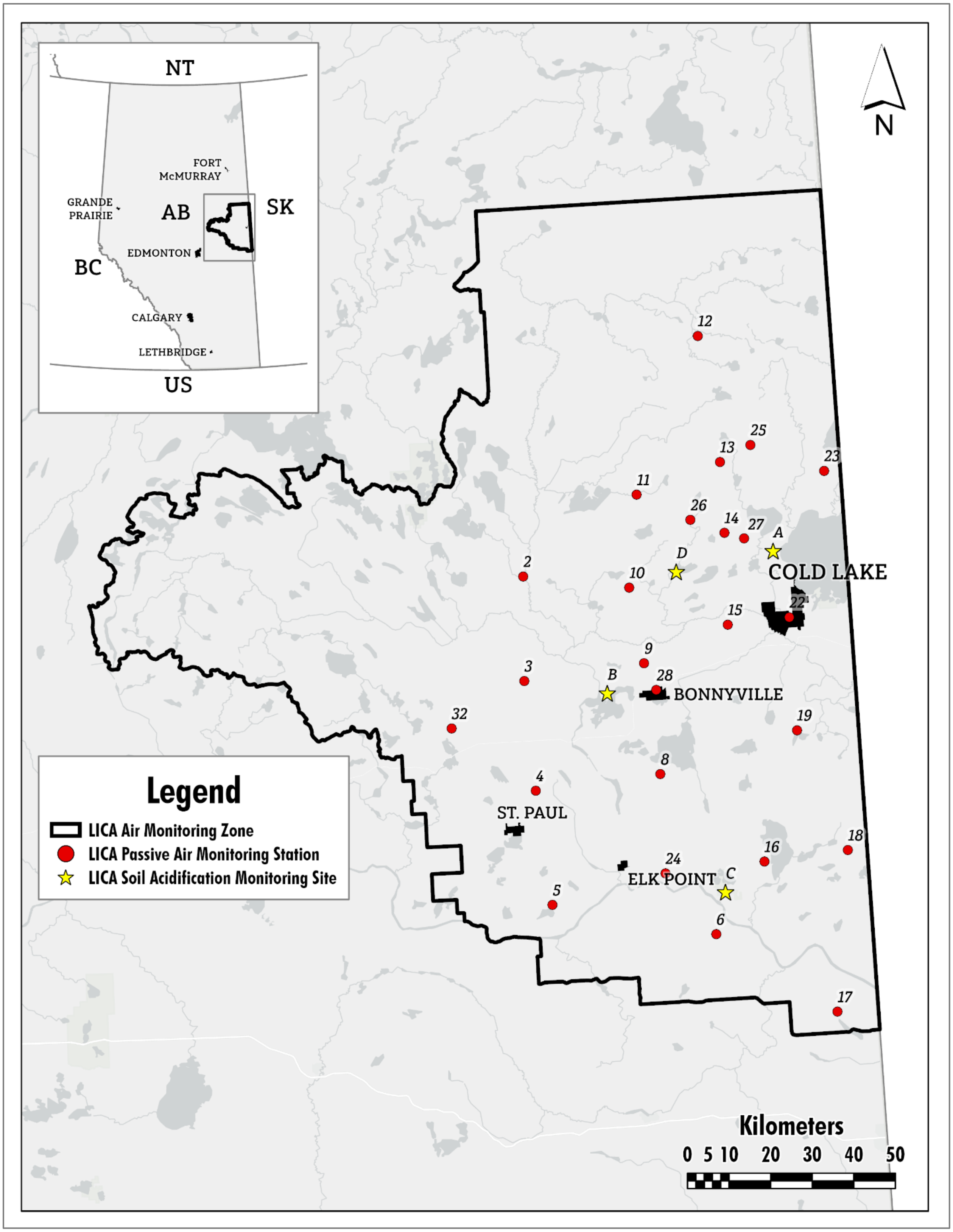

Figure 6: LICA passive air monitoring network and soil acidification monitoring sites

7.1. Sulphur Dioxide and Sulphur

7.1.1. Passive Monitoring Results

In the LICA region, the highest concentrations of sulphur dioxide were measured near the oil sands facilities northwest of Cold Lake. These facilities are the major point source of sulphur dioxide in the region. Monitoring data suggest that sulphur dioxide has a steep concentration gradient in relation to distance from the nearest emission source (stack); this indicates that deposition of sulphur compounds is likely higher close to emission sources. The interpolated isopleths for sulphur dioxide in the following map are generated by averaging data collected by the passive network over a 10-year period; this provides a general indication of the spatial pattern of sulphur dioxide in the Cold Lake region over a long term.

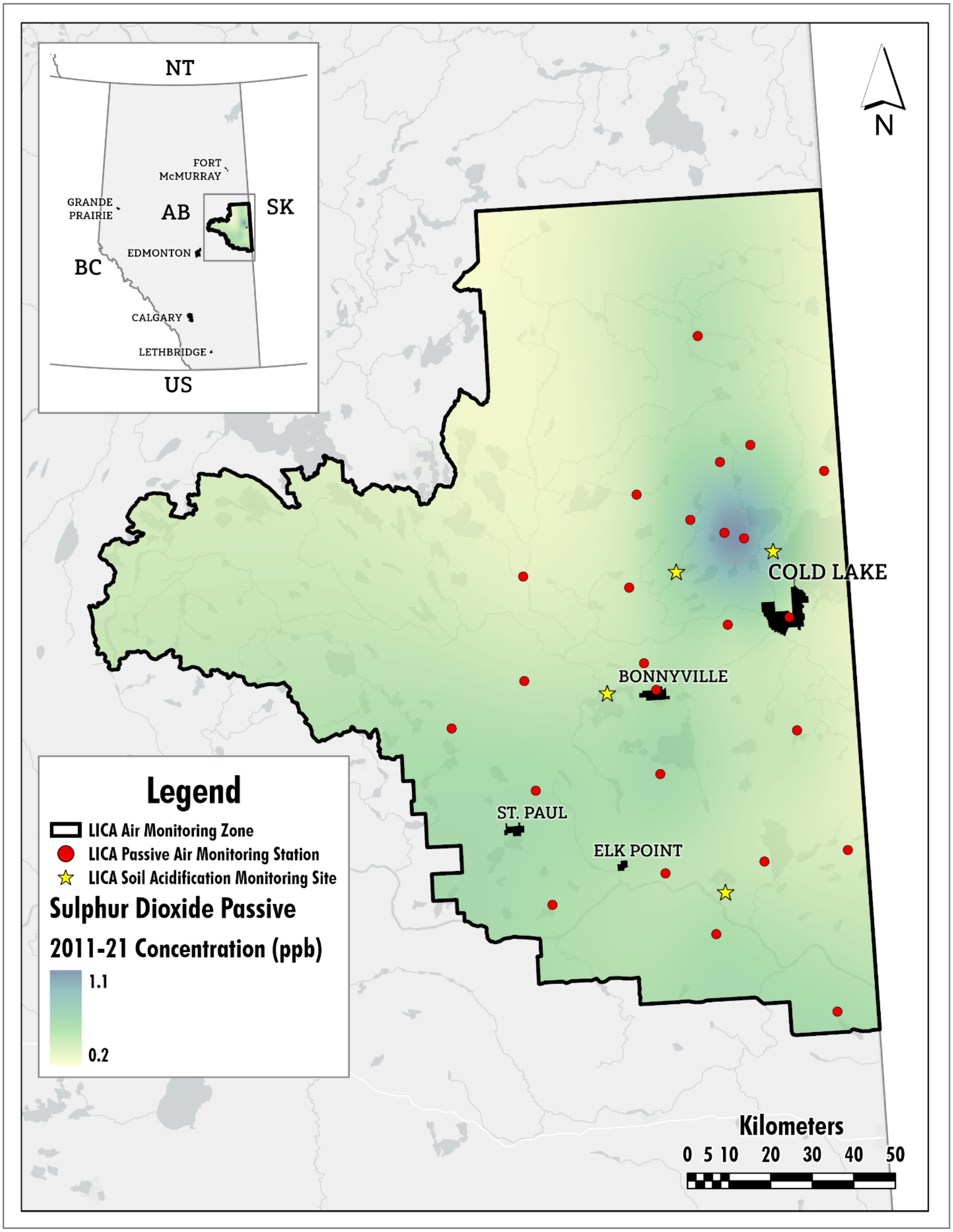

Figure 7: Sulphur dioxide passive results 2011-21 (ppb)

Sulphur dioxide has a seasonal pattern (higher concentrations in the winter during cold stagnant conditions) and as noted in the above map, the concentrations are higher at monitoring locations closer to large oil sands point sources. Below, passive monitoring data are presented as the monthly average of concentrations measured at stations greater than and less than 20km from oil sands operations. Sulphur dioxide at stations within 20km of oil sands sources show a pattern of slightly increasing concentrations over the last 10 years; this is generally in agreement with increasing emissions from oil sands facilities over the same time period. Sulphur dioxide at stations beyond 20km from oil sands operations show little to no change in concentration over time.

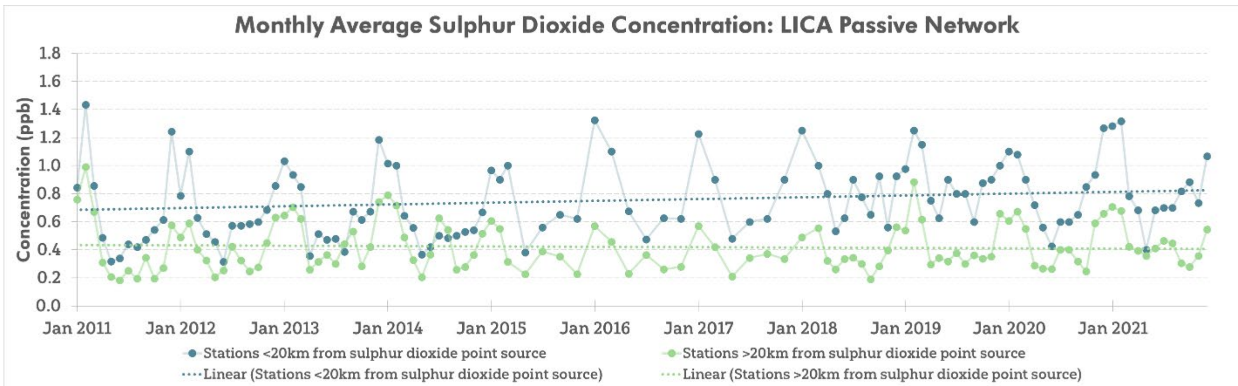

Figure 8: Passive network monthly average sulphur dioxide concentration 2011-2021 (ppb)

7.1.2. Emissions

One of the principle regulatory drivers for the development of this monitoring strategy is increasing sulphur dioxide emissions from oil sands facilities in the Cold Lake region. National Pollutant Release Inventory (NPRI) data indicate that sulphur dioxide emissions from area oil sands operations have increased from 3,500 tonnes per year (t/y) in 2011 to 8,400 t/y in 2020. In the 2011 to 2020 timeframe, new facilities and expansions have been commissioned and some existing facilities have had emission limits increased in response to economic conditions. The map below is a visual representation of the changes in sulphur dioxide emissions in the region since 2011.

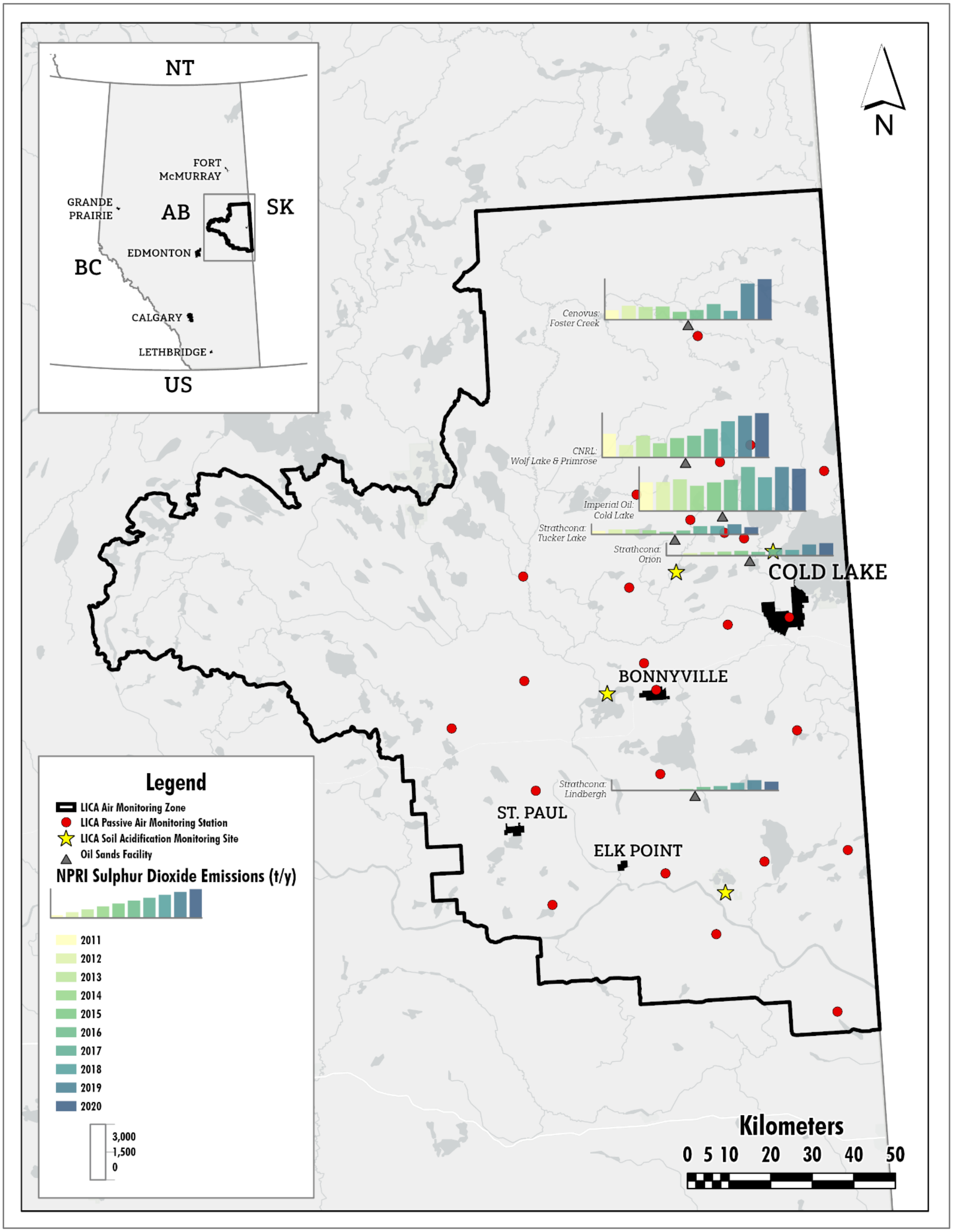

Figure 9: NPRI sulphur dioxide emissions 2011-20 (t/y)

7.1.3. Modelling

Environment and Climate Change Canada's (ECCC) Global Environmental Multiscale-Modelling Air-quality and Chemistry (GEM-MACH) model is increasingly becoming the preferred tool to simulate high-resolution outputs of atmospheric pollutant distribution and acidifying deposition in the oil sands region. Modelling results published in 2018 used 2013 emissions data to simulate total sulphur deposition in Alberta. Although the emissions profile has changed, the model suggests that the deployment of LICA's passive monitoring stations is reasonably well-suited to detect the gradient of predicted sulphur deposition in the Cold Lake Region. GEM-MACH sulphur deposition simulation results are presented on the map below (adapted from Makar et. al. 2018).

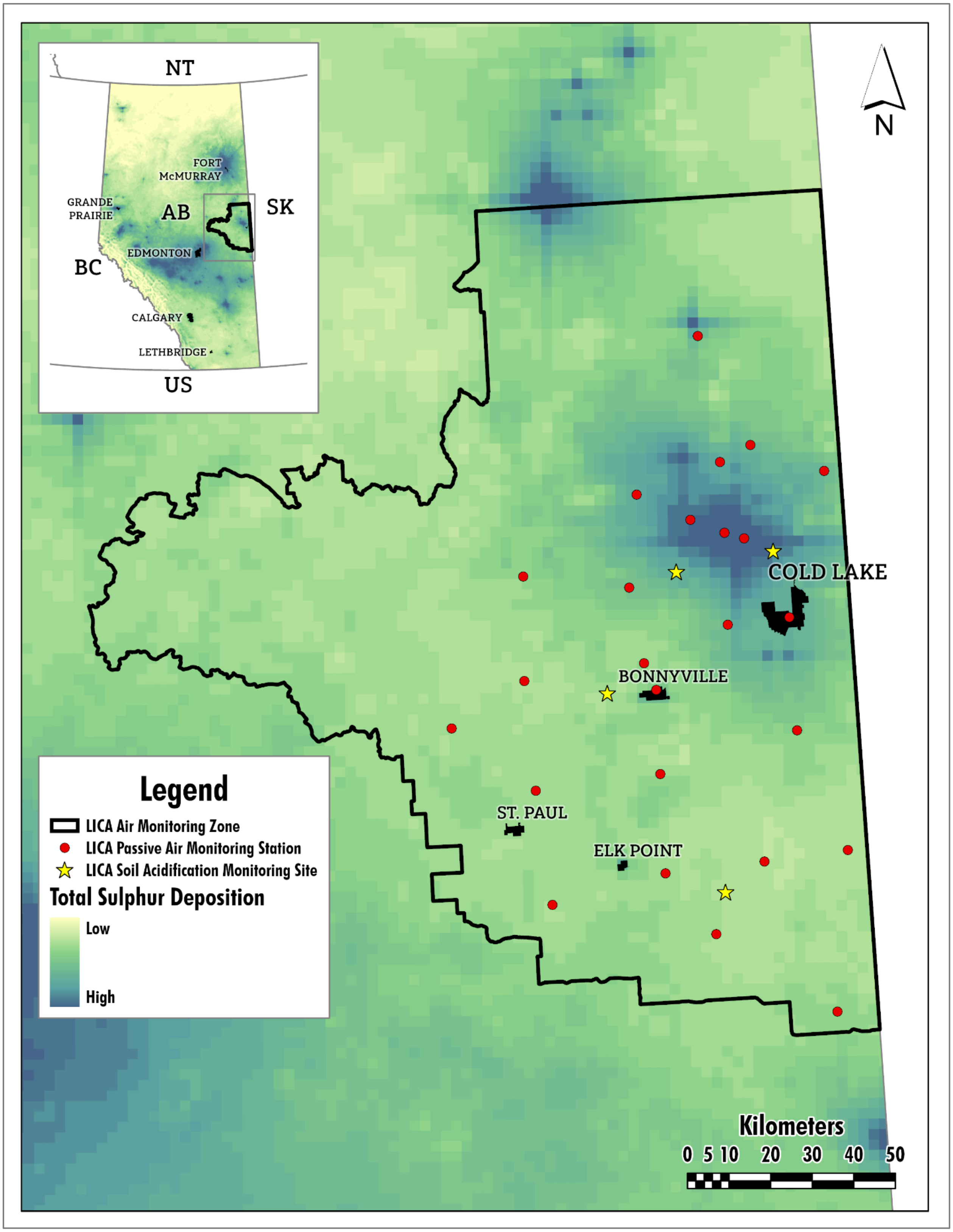

Figure 10: GEM-MACH predicted total sulphur deposition (2013 emissions profile)

7.2. Nitrogen Dioxide and Nitrogen

7.2.1. Passive Monitoring Results

In the LICA region, the highest concentrations of nitrogen dioxide were measured near major highways and in urban or built-up centers. In populated centers such as Bonnyville, the high density of combustion sources near the station (automobiles, home and office heating, trucking) are the likely cause for these elevated concentrations. A cluster of higher readings was also identified southeast of Elk Point because of prolific upstream heavy oil and gas development and associated hauling found throughout this part of the LICA region. Another hotspot is the busy Highway 55 and Highway 41 intersection near La Corey. The ambient concentration of nitrogen dioxide appears to be less influenced by the presence of large point sources such as stacks at oil sand operations; nitrogen dioxide concentrations are driven by diffuse ground-level releases including vehicle exhaust and home heating. The interpolated isopleths for nitrogen dioxide in the following map are generated by averaging data collected by the passive network over a 10-year period; this provides a general indication of the spatial pattern of nitrogen dioxide in the Cold Lake region over a long term.

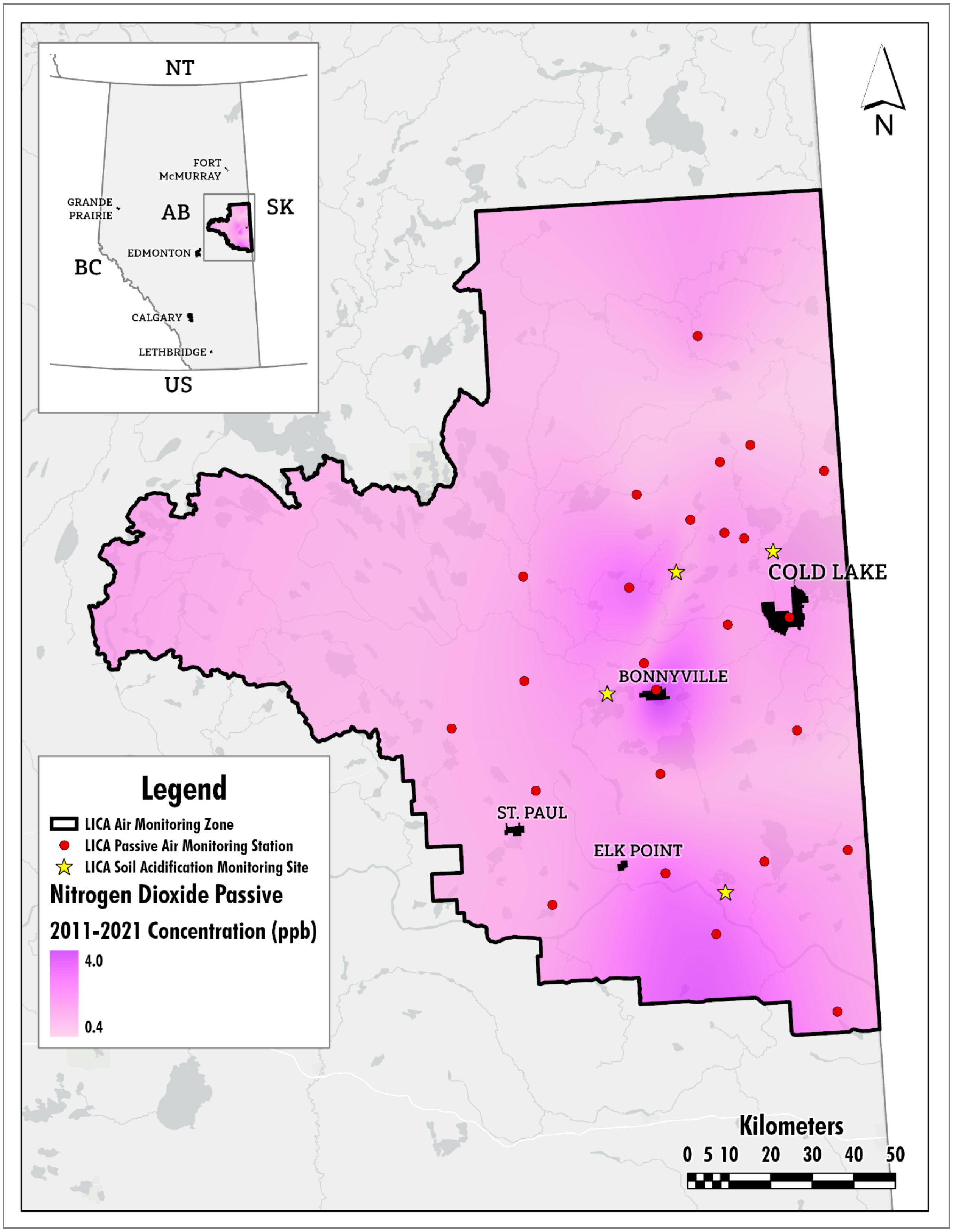

Figure 11: Nitrogen dioxide passive results 2011-21 (ppb)

Nitrogen dioxide has a seasonal pattern (higher concentrations in the winter during cold stagnant conditions) and as noted in the above map, the concentrations are higher at monitoring locations closer to diffuse ground-level emission sources. Below, monitoring data are presented as the monthly average of concentrations measured at stations greater than and less than 20km from oil sands operations. Regardless of distance from oil sands operations, nitrogen dioxide shows a pattern of slightly decreasing concentrations over the last 10 years; this observation is generally in agreement with nationally decreasing nitrogen dioxide emissions.

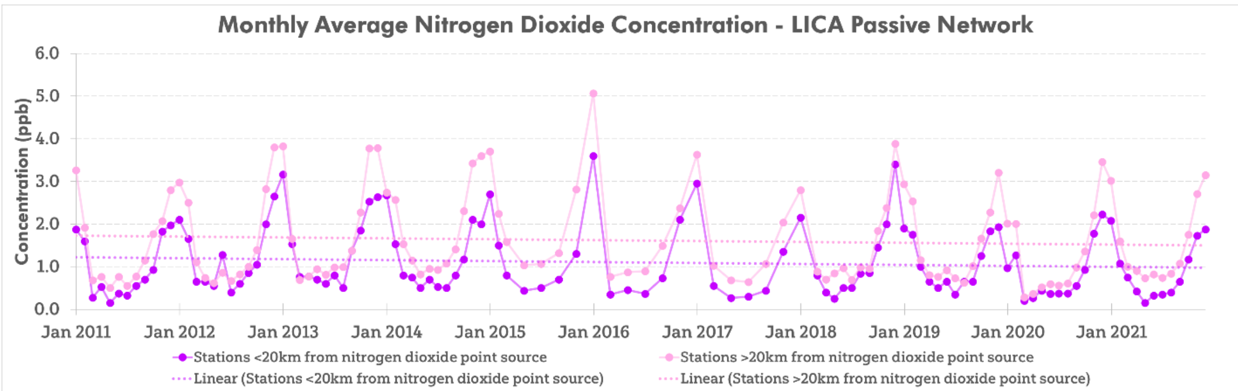

Figure 12: Passive network monthly average nitrogen dioxide concentration 2011-2021 (ppb)

7.2.2. Emissions

Relative to sulphur dioxide, changes in nitrogen dioxide emissions from point sources in the Cold Lake region have been comparatively small since 2011. There have been increases as new facilities and expansions have been commissioned. NPRI data indicate that nitrogen dioxide emissions from area oil sands operations have increased from 9,600 t/y in 2011 to 12,100 t/y in 2020. The map below is a visual representation of the changes in nitrogen dioxide emissions in the region since 2011.

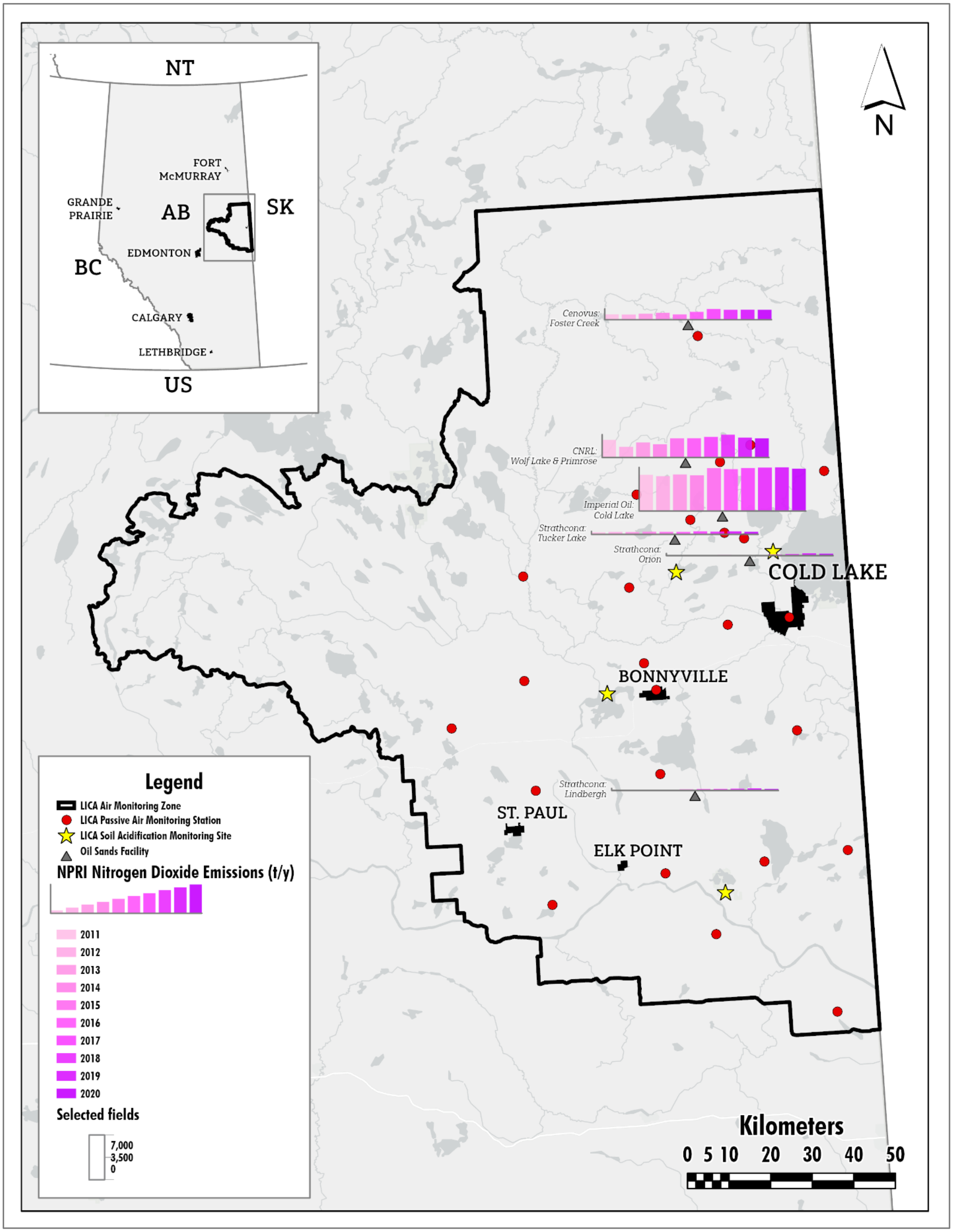

Figure 13: Figure 9: NPRI nitrogen dioxide emissions 2011-20 (t/y)

7.2.3. Modelling

ECCC used the GEM-MACH model to simulate total nitrogen deposition in 2018 (based on 2013 emissions data). Although the emissions profile has changed, the model suggests that nitrogen emissions are likely a relatively minor contributor to regional acid deposition in the Cold Lake area. GEM-MACH nitrogen deposition simulation results are presented on the map below (adapted from Makar et. al. 2018). The small-scale provincial inset in the figure below indicates that the urban corridor between Calgary and Edmonton is area of higher deposition, likely because of the dense transportation networks and urban populations. Another area of higher nitrogen deposition appears in the Fort McMurray area; deposition in this part of the province is likely influenced by the much larger point sources in the mining area and the significant contribution of ground-level emissions by the exhaust from the diesel-powered mine fleet.

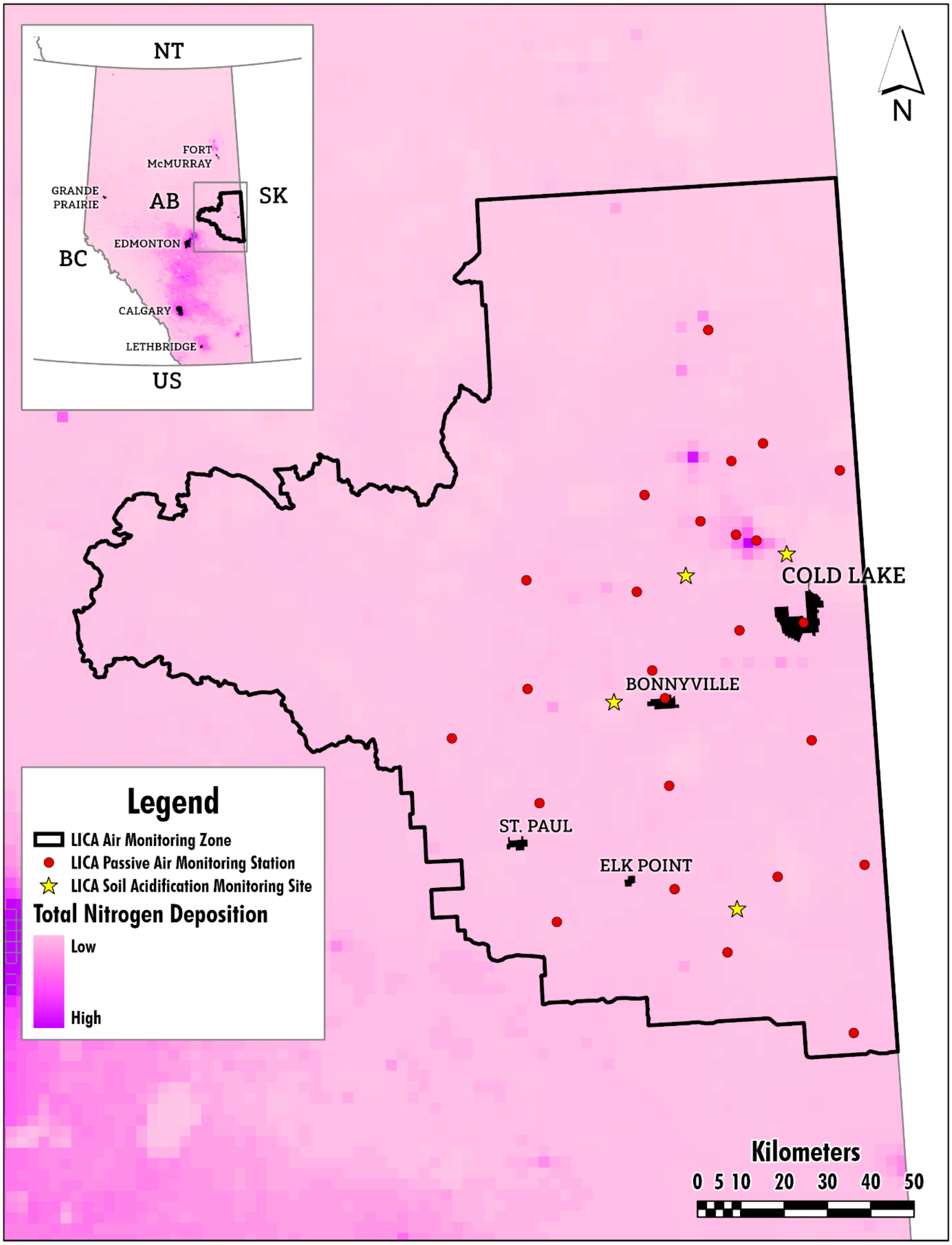

Figure 14: GEM-MACH predicted total nitrogen deposition (2013 emissions profile)

8. Acid Deposition Monitoring Strategy

Components of the existing LICA monitoring program can detect the presence and potential deposition of acidifying substances however, the Cold Lake region lacks a holistic approach to acid deposition monitoring. Typically, an acid deposition monitoring program involves monitoring direct deposition as well as ecosystem response as measured by effects on sensitive receptors. In terms of direct deposition measurements, data from LICA's passive monitoring program has been used to determine PAI and PAI gradients with mapping products (LICA 2007). Despite LICA's use of passive data to infer PAI, LICA's program does not involve some of the direct deposition measurement techniques employed by its sister monitoring organization, the Wood Buffalo Environmental Organization (WBEA). LICA engaged WBEA staff to learn about their direct deposition monitoring methods in the Athabasca region for consideration in the development of LICA's acid deposition monitoring strategy. LICA stakeholders believe it is prudent to collect samples and generate data in the same way as WBEA so datasets are comparable, as much as practicably possible.

8.1. Wet Deposition

Wet deposition monitoring involves collecting rain and snow samples using precipitation samplers. LICA's field staff operate rain and snow samplers at different locations in the LICA network; while LICA has expertise and experience operating these samplers, they are not configured for acid deposition measurements (sample media, laboratory analysis, etc.). Currently, LICA operates a snow precipitation sampler at the Tamarack monitoring station for which samples are sent to a laboratory for isotope analysis.

In the LICA region, Alberta Environment and Parks (AEP) operates a wet deposition monitoring station in Cold Lake Provincial Park; this site collects weekly samples and can provide an important link for regional historical deposition of key ions.

To supplement the AEP site, LICA proposes to collect weekly precipitation chemistry samples (for ion analysis) at an additional monitoring location in the Cold Lake region. This density of monitoring will mirror the wet deposition monitoring efforts in the southern WBEA network area which is characterized by in-situ oilsands operations, similar to the Cold Lake region. The site may be co-located with LICA's Tamarack monitoring station alongside other precipitation monitoring equipment or in the corridor between Imperial Oil's Cold Lake Operations and Cenovus' Foster Creek Facility. LICA's passive monitoring shows that this area has the potential to have higher rates of wet deposition due to the presence of acidifying substances available for scavenging by different forms of precipitation. LICA proposes to conduct wet deposition sampling using methods and standard operating procedures established by WBEA.

8.2. Dry Deposition

In the Cold Lake region, dry deposition modelling and PAI estimation can be conducted (partially) using LICA's regional passive air monitoring network. A similar approach is used by the WBEA program however additional parameters and sampling methods supplement monitoring in the Athabasca region.

Passive air sampling uses a permeative or diffusive membrane, allowing for the physical uptake of gas or vapour sample over the course of a month. Chemical species monitored by passive methods in the LICA network include nitrogen dioxide (NO_2), ozone (O_3), hydrogen sulphide (H_2S) and sulphur dioxide (SO_2). WBEA additionally monitors ammonia (NH_3), nitric acid (HNO_3) due to their roles in deposition processes at all passive monitoring locations. Passive monitoring does not require power and is easily deployed to remote locations.

LICA proposes to supplement the existing passive network with NH_3 and HNO_3 monitoring (monthly). The addition of these parameters to the LICA network is a logistical and cost-effective way to enhance LICA's ability to estimate and model dry deposition throughout the region and provide an appropriate level of surveillance. LICA also proposes to enhance the passive monitoring network with up to 5 additional stations in the corridor between Imperial Oil Cold Lake Operations and the Cenovus Foster Creek facility; this will improve LICA's ability to determine the gradient of acidifying substances in the area primarily characterized by in-situ oil sands development. The network has remained unchanged in this part of LICA's ADMZ since its inception in 2003 despite the increased number of facilities and potentially acidifying emissions. LICA also proposes to co-locate passive air samplers at LICA's existing soil acidification monitoring plots.

LICA's sulphur dioxide passive monitoring data provides a general indication of where sulphur deposition is occurring (Figure 10); recent modelling by Environment Canada (2013 emissions) suggests that predicted areas of higher deposition align well ground-based measurements of LICA's passive sulphur dioxide network.

Ion exchange resins (IER) are also used for passive deposition sampling. Deposition sampling using IERs is measured in forest clearings (bulk deposition) and under jack pine canopies (throughfall). Bulk deposition consists primarily of wet deposition, with a minor dry deposition component that collects onto the funnel collectors during dry periods. Throughfall deposition refers to the hydrologic flux of ions and other compounds washed from the tree canopies by precipitation or snowmelt and deposited in solution to the forest floor (Parker, 1983). Measurement of nutrient deposition in throughfall is a widely used method for estimating atmospheric deposition inputs to forest ecosystems (Bleeker et al., 2003; Thimonier, 1998). The IER technology uses a column of resin beads affixed to precipitation collectors to capture charged chemical species (ions) in precipitation water. IERs can be used to determine the deposition of ammonium (NH_4^+), nitrate (NO_3^-), sulphate (SO_4^{2-}), and calcium (Ca^+) and base cations. The major advantage of the IER method is that sample collection continues in the field without the need for repeated field trips to collect liquid samples or the need for repeated sample analyses from each collector. Deposition samples are collected seasonally. The IER columns for the summer exposures are installed in May and changed out in October. Winter exposures are from October to May. WBEA currently uses IERs at 45 sites; most are co-located with passive air samplers and form a key component of the forest health monitoring program. In the southern WBEA area, there are 6 existing + 2 proposed bulk IERs, and 6 existing + 2 proposed throughfall IERs.

While LICA employs a different soil sampling regime for its soil acidification monitoring plots than WBEA, the chosen soil type (sandy) and forest ecosystem (jack pine) by LICA and WBEA is similar. LICA proposes to deploy throughfall and bulk deposition IERs at LICA's 4 existing soil acidification monitoring sites. This approach will help fulfill the objective of determining potential cause-effect relationships between air pollutants, soils, and forest ecosystem health in the region. LICA also proposes to deploy 4 bulk deposition IERs (co-deployed with passives air samplers) in the corridor between Imperial Oil Cold Lake Operations and the Cenovus Foster Creek Project where deposition rates are expected to be higher than surrounding areas. Additionally, LICA proposes to deploy one 'upwind' and one 'downwind' bulk IER, ideally co-located with passive air monitoring stations; collectively, these sites are intended to provide an indication of the gradient of acidifying substances further afield from oil sands sources.

8.3. Soil Monitoring

As described earlier, LICA began soil acidification monitoring in the Cold Lake region in 2010 while Albert Environment commenced its program in the early 1980s. Major considerations and criteria for selecting sites included the following:

- Soils should be sensitive to acidic deposition, as indicated by low acid buffering capacity;
- Sites should be on similar soils and under similar native vegetation, these being generally sandy soils under jack pine stands as used in other monitoring programs;
- Landscape should be well drained and have gentle slopes; and,
- Since soil chemistry changes are slow, monitoring needs to be long-term; therefore, sites should be strategically selected so that there is a high likelihood of protection from development over a long-term.

LICA is proposing to add 1 *or more* additional long-term soil acidification monitoring plots in the area of highest simulated and monitored (potential) deposition. The 4 existing sites provide adequate surveillance of regionally acid sensitive soils from a long-term perspective, while the new site(s) will help improve LICA's understanding of potential acidification impacts in the area of highest regional acid deposition. When the existing soil monitoring sites were selected in 2010 and in the 1980s, modelling suggested at least one of the locations would be in an area of maximum deposition; GEM-MACH modelling (Figure 10) and LICA passive monitoring (Figure 8) indicate that existing soil acidification monitoring sites are on the periphery of areas of high deposition.

As described in the previous section, existing soil monitoring plots will be enhanced with passive deposition sampling and passive air monitoring to help establish potential cause-effect relationships between air pollutants, soils, and forest ecosystem health in the region; this new site(s) will also be established with co-located passive deposition sampling.

For LICA's existing long-term soil monitoring plots, the jack pine ecosystem was identified as the most sensitive receptor. The jack pine ecosystem is characteristically dry with nutrient poor soils and has limited buffering capacity. In these ecosystems, the effects of acid deposition are expected to be observed in a cascading manner from soils to vegetation, first impacting individual organisms, then the stand, and onward to landscape level impacts. This concept is depicted in the figure below (WBEA 2020).

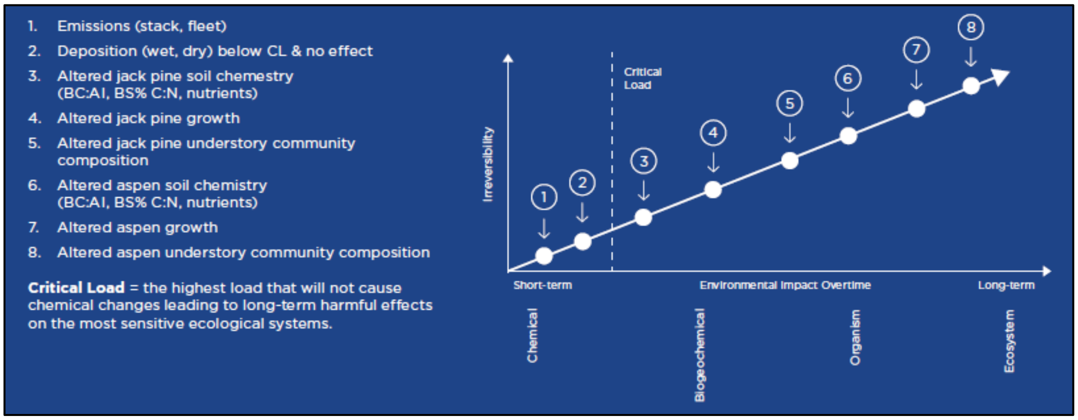

Figure 15: Cascading effect of acid deposition concept diagram (WBEA 2020)

If, through updated modelling, supported by the proposed IER and passive monitoring activities, the total PAI (sum of wet and dry deposition PAI) exceeds 0.17 or 0.35 keq H+/ha/yr, which are the triggers for monitoring of sensitive and medium sensitivity soils respectively, LICA will consider establishment of additional long-term soil monitoring sites in the region.

8.4. Surface Water Monitoring

Acid deposition has the potential to alter the chemistry of surface water. The primary pollutants associated with aerial depositions include nitrogen oxides and sulphur dioxide, the precursors to nitric and sulphuric acid, which are the main constituents contributing to the acidification of waterbodies and watercourses. Like soil acidification monitoring, the effect of acidifying emissions on surface water is primarily determined by routinely measuring key water chemistry indicators. Similar to the "cascading effects" of soil acidification and its effect on forest health, it is relatively simple to monitor water quality indicators which show responses to acid inputs well before aquatic organisms.

8.4.1. Lakes

Unlike the Athabasca oil sands region, the Cold Lake area lacks a robust and coordinated lake monitoring program. With a few exceptions, such as Alberta Lake Management Society (ALMS) and industrial in-field lake sampling programs, lake monitoring data sets in the Cold Lake area are often discontinuous and collected to support Environmental Impact Assessment applications. However, some of these data sets can been used to establish a starting point for a 'screening level' surface water monitoring program.

Work conducted by LICA (2007) and in several environmental impact assessments (EIAs) for projects in the LICA area (OSUM 2009; Cenovus 2013, IOR 2016) determined the acid sensitivity rating of lakes using the system established by Saffran and Trew (1996). The rating of acid sensitivity considers the measured alkalinity, expressed as calcium carbonate ($CaCO_3$), calcium cation concentration, and pH. Based on the values for these three parameters, lake sensitivity to acidification was determined. Waterbodies are determined to be more susceptible to acidification (or have a high sensitivity) when measured values for alkalinity, calcium, and pH are low. In general, lakes in the LICA region were determined to have low sensitivity to acid deposition.

Table 2: Acid sensitivity ratings for lakes in the LICA area (LICA 2007)

Lake Identifier	Lake Name	Zone	Easting	Northing	Lake Surface Area (ha)	Alkalinity (mg/L)	pH	Calcium (mg/L)	Specific Conductivity (µS/cm)	Total Dissolved Solids (mg/L)	Hardness (mg/L)
LICA Study Area											
43	Ipitiak Lake	12	496692	6127900	-	67	7.5	17	136	67	-
60	Burnt Lake	12	536930	6072588	-	108	8.1	28	200	142	-
61	Unnamed Lake	12	540333	6069577	-	117	8.2	30	207	153	-
62	Unnamed Lake	12	539546	6071719	-	53	7.8	13	105	110	-
63	Unnamed Lake	12	539930	6072774	-	61	7.9	16	124	113	-
64	Unnamed Lake	12	540067	6073823	-	65	7.9	18	127	120	-
65	Unnamed Lake	12	543092	6075676	-	52	7.8	14	105	100	-
66	Unnamed Lake	12	544835	6076985	-	98	8.1	26	182	140	-
67	Unnamed Lake	12	538930	6078203	-	98	8.1	26	180	137	-
68	Unnamed Lake	12	541457	6082627	-	49	7.8	13	96	125	-
516	Sinclair Lake	12	522000	6064200	-	243	8.0	36	430	248	-
518	Marguerite Lake	12	516000	6052000	-	538	9.0	22	538	516	-
520	Leming Lake	12	532000	6050000	-	121	9.0	18	168	35	-
521	Tucker Lake	12	525300	6042700	-	212	8.1	28	400	234	-
546	Cold Lake	12	560000	6045000	-	140	8.3	31	240	155	-
547	Moore Lake	12	543043	6017650	-	340	8.7	15	686	408	-
594	McDougall Lake	12	546792	6023259	-	144	-	22	-	-	-
595	Unnamed Lake	12	541860	6020776	-	316	8.1	33	549	597	-
596	Manatokan Lake	12	503000	6035000	-	203	8.7	35	211	16	-
597	Unnamed Lake	12	522600	6078500	-	162	7.9	29	270	146	-
599	Unnamed Lake	12	529300	6074800	-	41	6.8	8	86	46	-
600	Dolly Lake	12	549700	6048200	-	244	8.5	14	-	239	-
L1	Angling Lake	12	542500	6005000	585	320	8.8	25	584	-	-
L2	Bluet Lake	12	528500	5979500	120	360	9.0	21	-	511	-
L3	Bourque Lake	12	528900	6058400	Unknown	197	8.2	37	371	221	182
L4	Ethel Lake	12	541800	6042450	490	158	8.2	33	289	179	148
L5	Fishing Lake	12	550000	5971000	Unknown	226	8.8	26	455	243	-
L6	Frog Lake	12	543000	597500	5800	386	8.8	18	877	500	-
L7	Garnier Lake	12	527500	5985000	520	364	9.0	18	-	475	-
L8	Hilda Lake	12	536600	6040900	362	428	8.8	19	893	563	280
L9	Kehewin Lake	12	506500	5990000	620	214	8.6	26	-	-	-
L10	Laurier Lake	12	532000	5967000	642	564	8.9	14	-	655	-
L11	Marie Lake	12	547000	6064900	3600	150	8.3	35	282	161	146
L12	May Lake	12	539150	6063900	Unknown	133	8.1	35	251	161	135
L13	Moose Lake	12	505000	6010000	4000	332	8.9	25	919	581	-
L14	Muriel Lake	12	520000	6000000	6410	961	9.3	5	1908	-	-
L15	Wolf Lake	12	503222	6061410	3150	159	8.5	27	-	156	-
Lakes Bordering the LICA Study Area											
45	Unnamed Lake	12	497711	6132160	-	39	7.4	10	83	41	-
46	Unnamed Lake	12	498367	6133579	-	90	8.1	21	180	119	-
47	Unnamed Lake	12	493933	6132222	-	52	7.6	13	108	76	-
48	Unnamed Lake	12	491151	6134421	-	44	7.3	11	97	45	-
49	Unnamed Lake	12	493107	6134651	-	46	7.4	11	96	45	-
132	Grist Lake	12	533788	6137575	-	117	8.5	30	222	119	-
239	Unnamed Lake	12	525364	6133813	-	108	8.3	30	208	-	-
250	Unnamed Lake	12	475613	6118973	-	67	8.7	17	135	-	-
259	Logan Lake	12	476591	6104122	-	147	9.2	33	267	-	-
536	Touchwood Lake	12	474032	6075393	-	142	8.0	31	263	148	-

Legend for Acid Sensitivity Ratings (Saffran and Trew, 1996)

Parameter	High	Moderate	Low	Least
Alkalinity	0 - 10	11 - 20	21 - 40	> 40
pH	0 - 6.5	6 .6 - 7.0	7.1 - 7.5	> 7.5
Calcium	0 - 4	5 - 8	9 - 25	> 25

There are a few exceptions to the low sensitivity ratings among the studies reviewed for the development of this strategy. Unnamed Lake UN-5 and Underwood Lake (Cenovus 2013), Caribou Lake (IOR 2016), and Unnamed Lake 599 (LICA 2007) were identified as having moderate sensitivities or were a risk of potentially exceeding a critical load. LICA recommends sampling these lakes to establish a contemporary acid sensitivity rating and revisiting the lakes as part of an ongoing lake chemistry monitoring program.

Table 3: Lakes recommended for sampling to establish contemporary acid sensitivity rating.

Water Body	Map ID	Zone	Easting	Northing
Unnamed Lake 599	A	12U	529300	6074800
Caribou Lake	B	12U	508026	6104880
Underwood Lake	C	12U	537061	6127376
Unnamed Lake UN-5	D	12U	526901	6081167

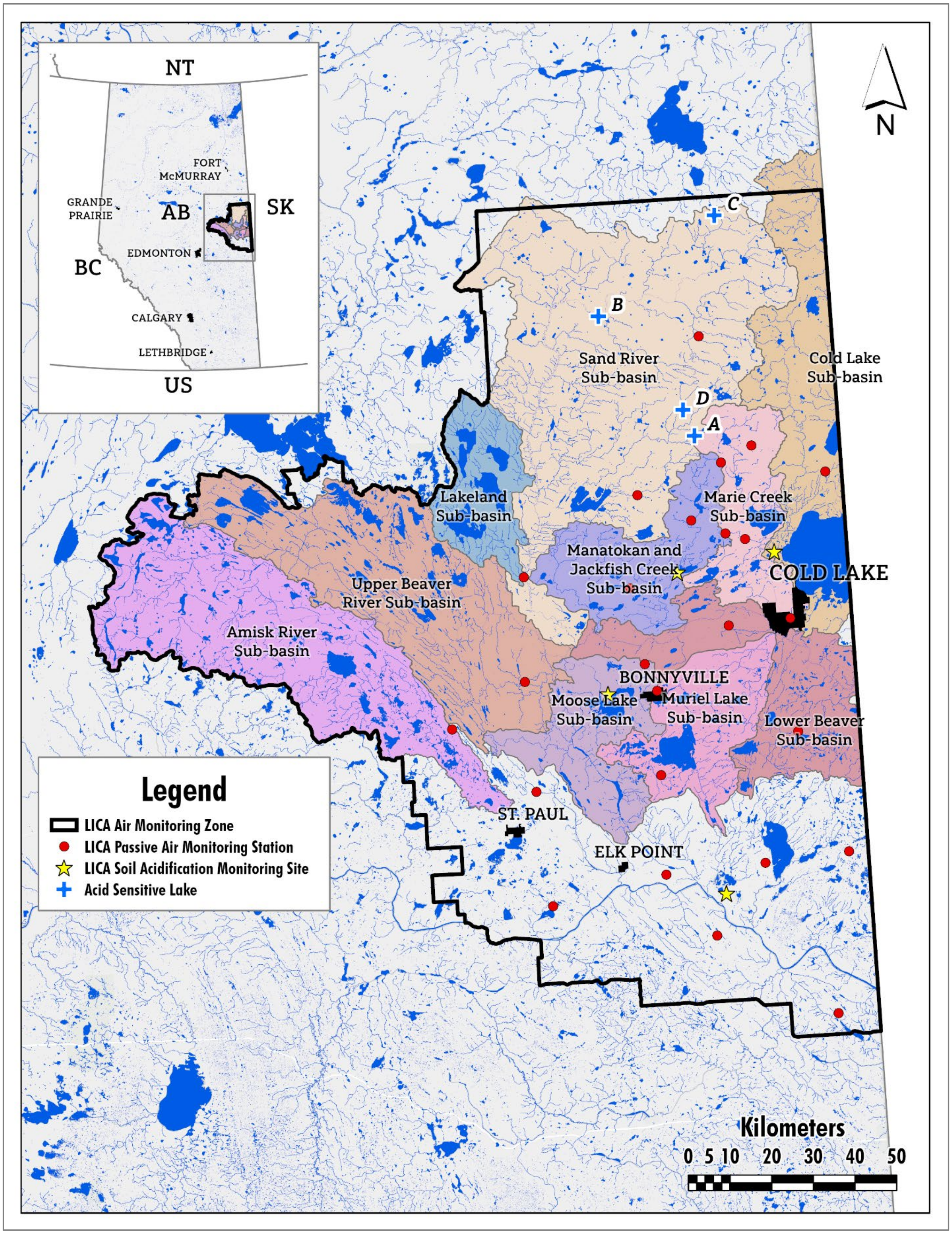

Figure 16: Location of Lakes recommended for sampling to establish contemporary acid sensitivity rating

LICA will also leverage existing regional monitoring programs such as ALMS to support the ongoing and routine assessment of lake acid sensitivity in the Cold Lake region. As input to the Integrated Watershed Management Plan, in early 2022 LICA is collecting survey information from stakeholders about how different water bodies in the region are used. This information may reveal observations and other *intrinsic* considerations for establishment of surface water monitoring from an acid deposition perspective.

Annual analysis of wet and dry deposition will be evaluated to identify potential increases in acidifying substances. Deposition rates above 0.17 keq H+/ha/yr (the monitoring load for sensitive soil) would trigger a monitoring response of nearby waterbodies to identify potential increases in surface water acidification. LICA will review a monitoring response with this approach because most acidic components ultimately deposited in lakes originate from land runoff and drainage from the soil surface (vs. deposition of acidifying substance onto surface water bodies). LICA will also remain engaged in the Acid Sensitive Lakes component of the OSM program to ensure methods for identifying and monitoring acid sensitive lakes in the Cold Lake region are complementary to similar work in the Athabasca and Peace oil sands regions.

8.4.2. Wetlands

The Alberta Biodiversity Monitoring Institute's (ABMI) province-wide wetland inventory and spatial database were adopted to generate the map in Figure 17. Wetlands in Alberta are broadly divided into three ecoregions of Alberta, within which, there are distinct types of wetlands; the Cold Lake region is in the boreal and foothills region, which is characterized by large peatland complexes. Most wetlands found in the LICA region are classified as fens. Fens are minerogenous peatlands, meaning they receive water from a variety of sources that accumulates dissolved minerals and increases the alkalinity of the environment. Fens are permanently saturated wetlands that are typically dominated by sedges and dense mats of bryophyte species (ESRD 2015). Fens are often well buffered to acid inputs and recent modelling for organic soils in Alberta (ESRD 2020) indicate fens in the LICA region have high critical loads as shown in Figure 18; no wetland monitoring for acidification effects is recommended at this time. Wet and dry deposition monitoring described in earlier sections of this strategy can be used to calculate area- and receptor- specific PAI, including fens; PAI can be compared against modelled critical loads to adaptively manage the monitoring program.

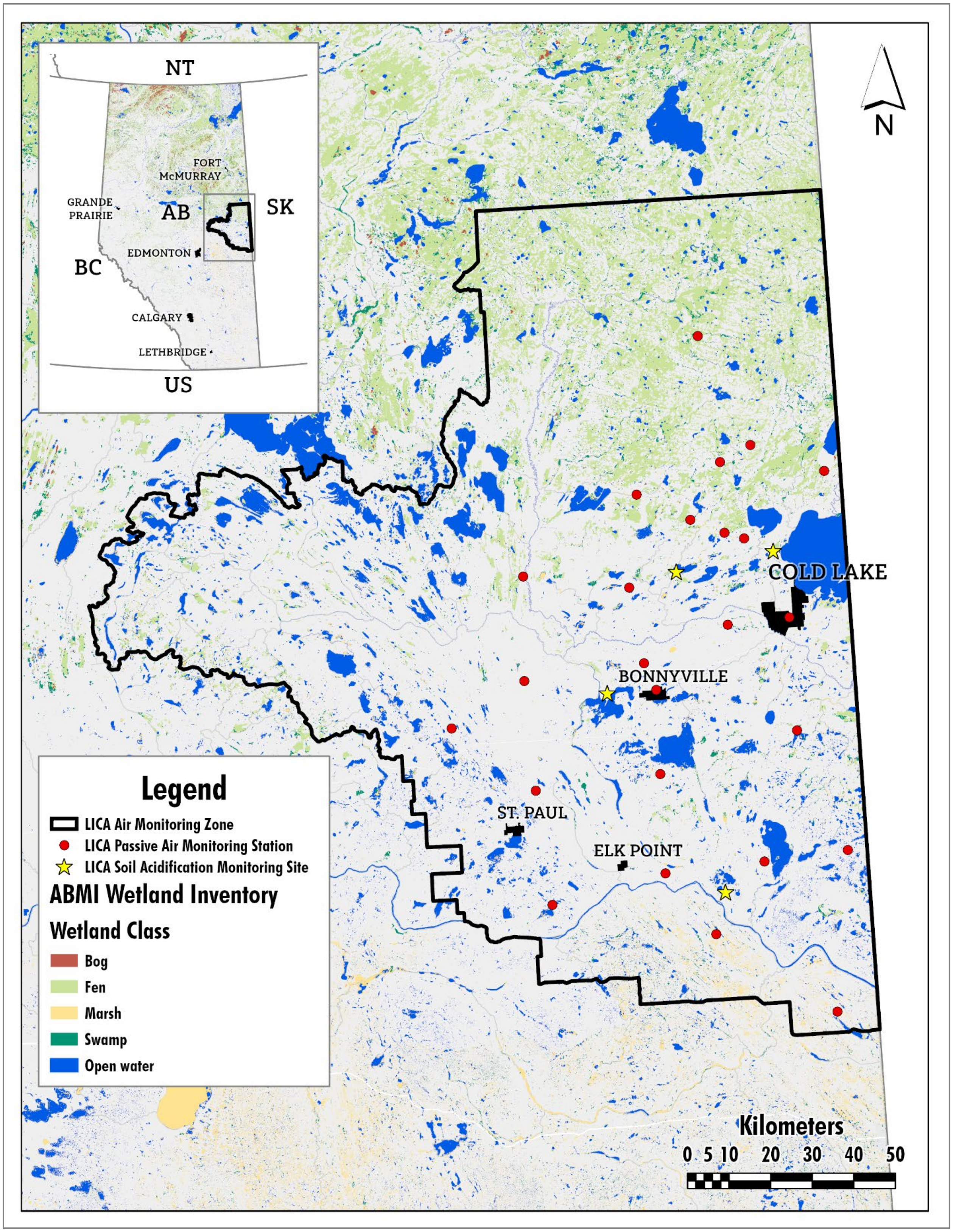

Figure 17: Alberta Biodiversity Monitoring Institute (ABMI) wetland classification

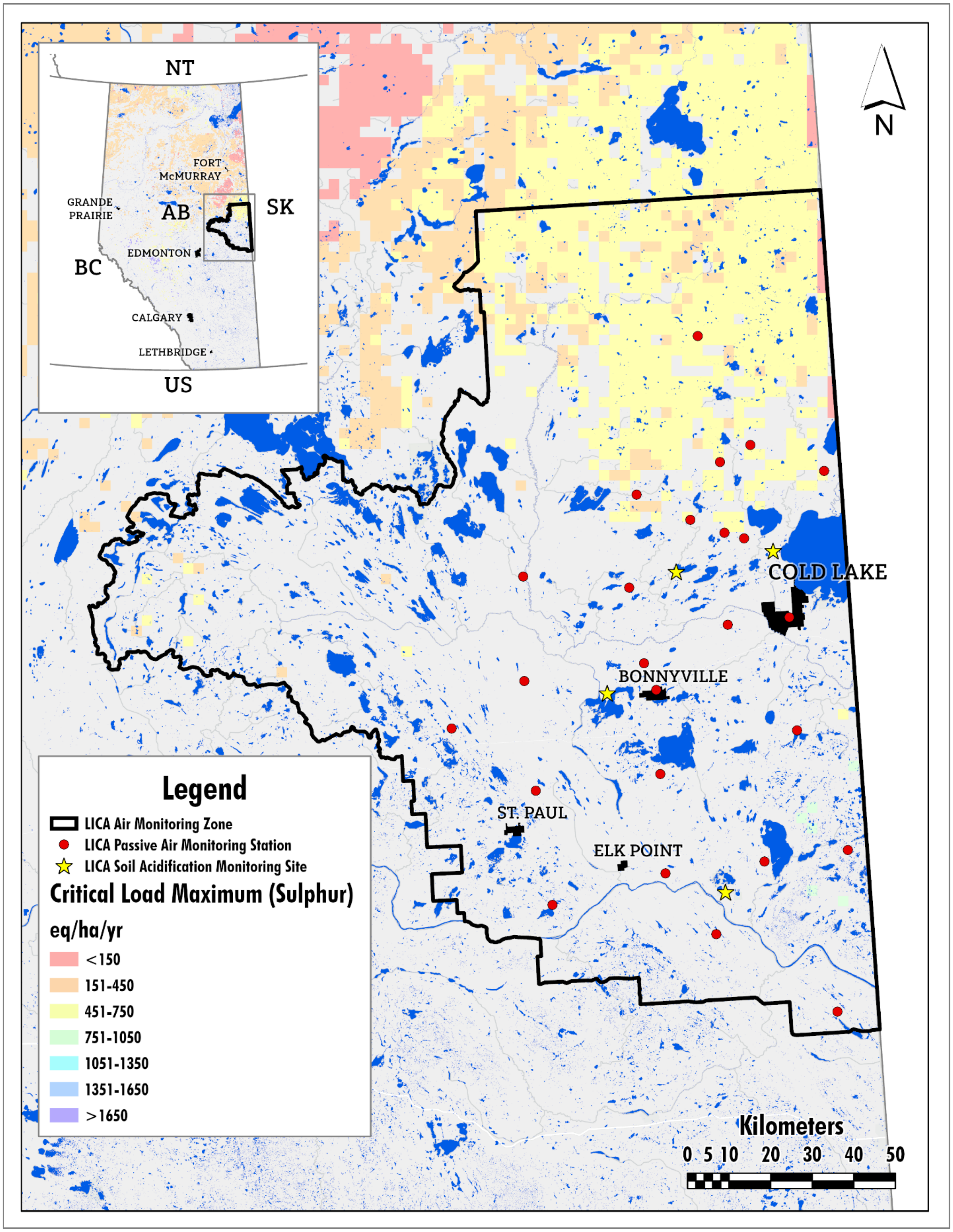

Figure 18: Critical loads (sulphur max) of acidity for organic soils.

9. Mitigation Response

As defined in the ADMF, the triggers for monitoring in the LICA region are PAI values of 0.17 and 0.35 keq H+/ha/yr (sensitive and medium sensitivity respectively). The ADMF also defines target loads for the LICA region as 0.22 and 0.45 keq H+/ha/yr (sensitive and medium sensitivity respectively). If the PAI is above the target load, mitigation will be implemented in the year following the detection of the target load exceedance and area operators will work with LICA and the AER to review monitoring data and evaluate potential mitigation options.

$$PAI = S_{dep} + N_{dep} - BC_{dep}$$
$$= (S_{wet} + N_{wet} - BC_{wet}) + (S_{dry} + N_{dry} - BC_{dry})$$

Where:

- BC = base cations (Ca^{2+}, K^{+}, Mg^{2+}, Na^{+}), and units are kequiv/ha.
- Ca^{2+} is the dominant base cation
- N_{dry} is estimated from ambient concentrations of NO_2, HNO_3, NH_3, velocity (V_d)

If annual monitoring data exceeds the target load, area operators will evaluate mitigation measures in consultation with LICA and the AER in the region. Preliminary corrective actions may include:

- Evaluation of emissions and control mechanisms
- Initiation of additional soil monitoring sites
- Initiation of additional surface water sampling
- Review of potential outlier events (upset conditions, forest fires)

10. Other Considerations

10.1. Baseline

The ADMPEC discussed establishment of a regional baseline indicator for acid deposition and understands the importance and priority of baseline establishment within the Oil Sand Monitoring (OSM) program. The committee didn't identify a key indicator or method for establishing baseline conditions, however LICA will remain engaged in the OSM discussions on this topic and adapt its approaches to monitoring as needed.

10.2. Adaptive Monitoring

Adaptive monitoring involves the removal, relocation or addition of monitoring parameters and stations over time. The Oil Sands Monitoring (OSM) Program has identified that an adaptive monitoring approach is a key consideration in the design of environmental monitoring programs. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. The most effective form of adaptive management employs management programs that are designed to experimentally compare selected policies or practices and evaluate alternative hypotheses about the system being managed.

LICA's acid deposition monitoring program will seek to understand results that the network provides, and the anticipated benefits or losses imposed by potential changes to the program. By setting evaluation criteria in advance and employing a scientific methodology, LICA can minimize bias in network modification discussions.

As an example, if LICA were contemplating the elimination of a parameter from the acid deposition monitoring program, it would be important to understand the risks associated with not detecting important deposition velocities or ecosystem responses to the deposition of acidifying substances. Important questions to ask include:

- Have there been short-term deposition-related changes or is a meaningful fraction of a critical load being measured (e.g., 50% of critical load for jack pine ecosystem)?
- Are long-term deposition-related changes observed in excess of any other meaningful metrics, such as critical loads?
- If so, are these changes attributable to an industrial source in the Cold Lake area, or are these isolated incidences attributable to other sources inside or outside the region?
- If not, what potential development or circumstance in the Cold Lake area may warrant the continued monitoring of this parameter?

The same discussions can occur when LICA considers adding a new parameter or site, or if there has been an increase in acidifying emissions in the region.

Implementation of a consistent and properly resourced OSM-wide adaptive monitoring approach is still being discussed however, LICA proposes using the new ADMF as a preliminary guidance tool. The early warning system embedded in the new ADMF (which identifies areas or receptors "at risk" to long-term acidification), provides the basis for adaptively managing the monitoring program by informing decisions about removal, relocation or addition of parameters.

It is important that thoughtful analysis of the data be conducted to provide decision makers with an objective view of the risks and rewards. Such analyses should include exercises where null and alternate hypotheses are carefully developed and tested for statistical significance, and where two data sets are being compared (e.g., a reference and impacted site), tests of goodness of fit to determine if the data sets are similar or different.

Additionally, there are standard tests and analyses particular to the air quality community that can provide a valuable insight into the relationship between sources and receptors. Examples of this includes pollution rose analyses, and receptor and trajectory modelling.

11. Summary

The table and map below provide a summary of the proposed enhancements to the LICA acid deposition monitoring program. The table summarizes the parameters, methods, sampling and reporting frequency, and implementation schedule. The map provides a visualization of the monitoring network with (1) existing sites, (2) proposed sites where locations are known, and (3) proposed sites where locations are not ground-truthed and are to be determined (TBD).

Table 4: Monitoring strategy summary

Monitoring	Parameters	Method	Number of Locations	Reporting Schedule	Implementation
Wet Deposition	Ions as defined by National Atmospheric Chemistry protocols (Ca^{2}+, Mg^{2}+, K+, Na+, Br-, NH_4+, NO3-, Cl-, $SO_4$2-, $PO_4$3-), conductivity, and pH	Precipitation collection (Environment and Climate Change Canada)	1 existing 1 new	weekly/annually	2022
Dry Deposition	sulphur dioxide SO_2 nitrogen dioxide NO_2 ozone O_3 ammonia NH_3 nitric acid HNO_3	Enhanced Passive (AEP, WBEA)	35 total *26 existing sites* *26 enhanced* *9 new enhanced*	monthly/annually	2022-23
Wet/Dry Deposition	ammonium (NH_4+), nitrate (NO3-), sulphate (SO_4^{2-}), and calcium (Ca+)	Ion Exchange Resin (WBEA)	4 (at soil acidification sites) 4 (in Imperial Oil – Foster Creek corridor) 2 (up/down wind)	Biannually (winter and summer)	2022-23
Soil	Indicators of Soil Acidification (soil pH, base saturation, base cation to aluminum ratio, total sulphur)	Long-term AEP soil acidification monitoring protocol (AEP/LICA)	- 4 existing long-term - 1+ new long-term in high deposition zone	- 4-year staggered cycle	Existing: N/A New: 2022-24
Surface Water	Indicators of lake sensitivity expressed as alkalinity (calcium carbonate ($CaCO_3$)), calcium cation concentration, and pH.	Whole water sample (Regional Aquatics Monitoring Program) Assessment (Saffran and Trew)	Unnamed Lake 599, Caribou Lake, Underwood Lake, Unnamed Lake UN-5	Annually	2022-24

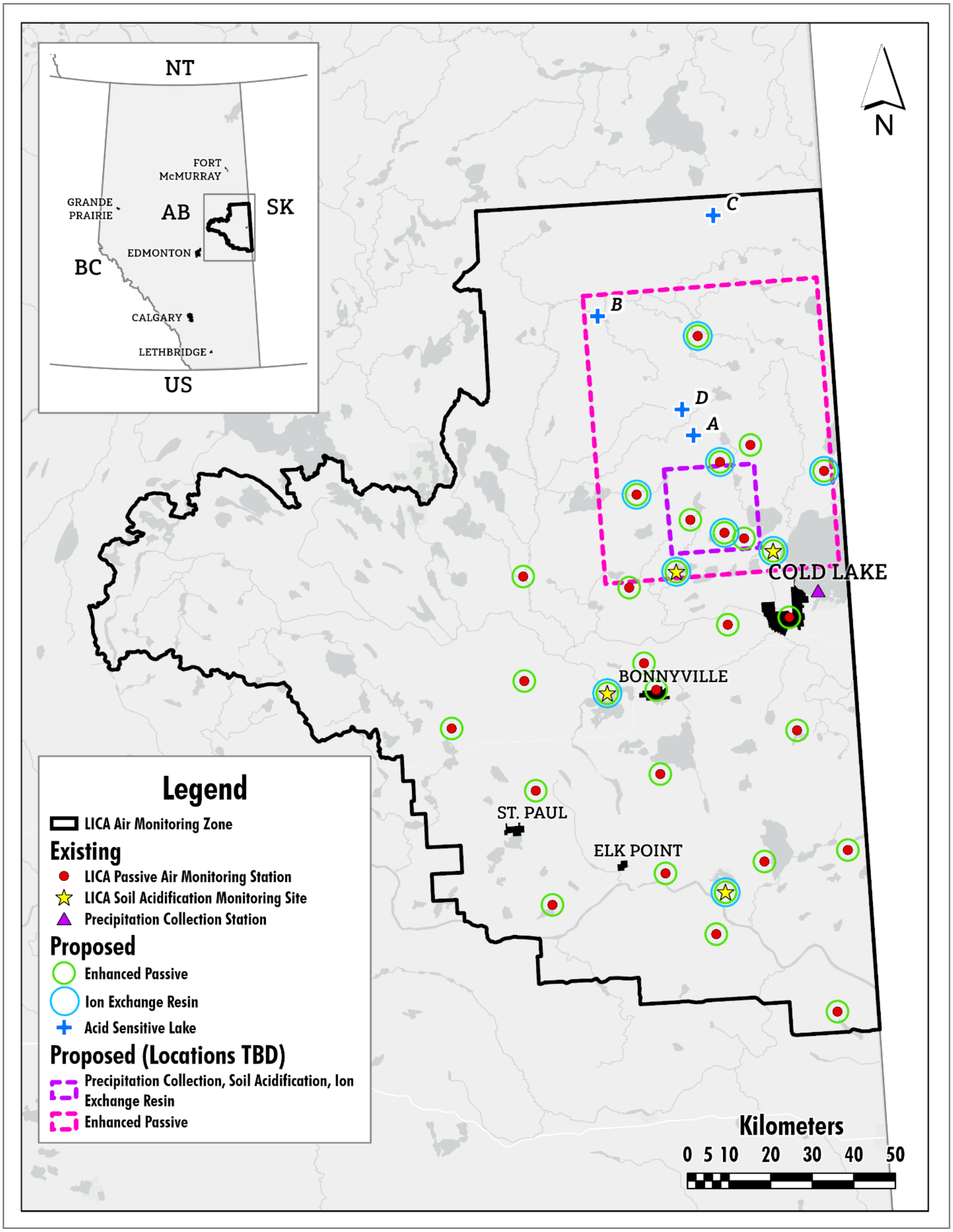

Figure 19: Monitoring strategy visualization

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File No. 4101-00068492-0501
February 15, 2022

By e-mail only

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Calgary, AB T2P 0M5

Email: Jennifer.Obrien@cenovus.com

RE: Foster Creek Thermal Project Acid Deposition Monitoring Program Proposal
***Environmental Protection and Enhancement Act* Approval No. 68492-01-00 (as amended)**

Dear Ms. O'Brien,

The Alberta Energy Regulator (AER) has reviewed Cenovus Energy Inc.'s (Cenovus's) Acid Deposition Monitoring Program proposal dated January 31, 2022. The proposal has been reviewed relative to the requirements of the *Environmental Protection and Enhancement Act* (*EPEA*), and the terms and conditions of *EPEA* Approval No. 68492-01-00, as amended.

This letter serves as written authorization for the Foster Creek Thermal Project Acid Deposition Monitoring Program, pursuant to Condition 3.23 of *EPEA* Approval No. 68492-01-00, as amended. Should you have any questions, please contact Ms. Aruna Bissonauth at (780) 642 9294 or Aruna.Bissonauth@aer.ca.

Sincerely,

Shay Dodds, P.Eng.
Manager, In Situ Applications Conformance
Regulatory Applications

SD/ab

cc: Brent Mitchell, Cenovus
Stanley Ngwa, AER
Wally Qiu, AER
Chris Teichreb, AER

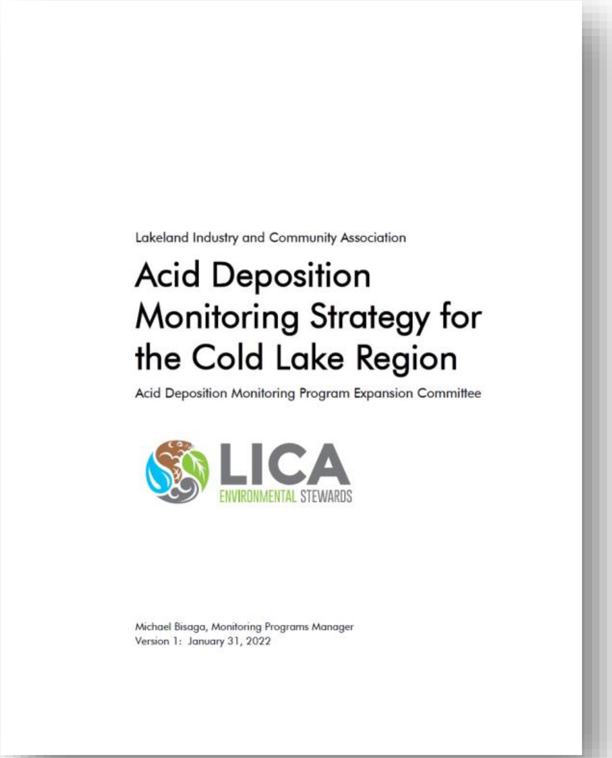
Acid Deposition Monitoring Program Expansion Committee Meeting

Monday April 11, 2022

LICA
ENVIRONMENTAL STEWARDS

2.0 Ongoing Business

- 2.1.1 Acid Deposition Monitoring Strategy for the Cold Lake Region



Lakeland Industry and Community Association

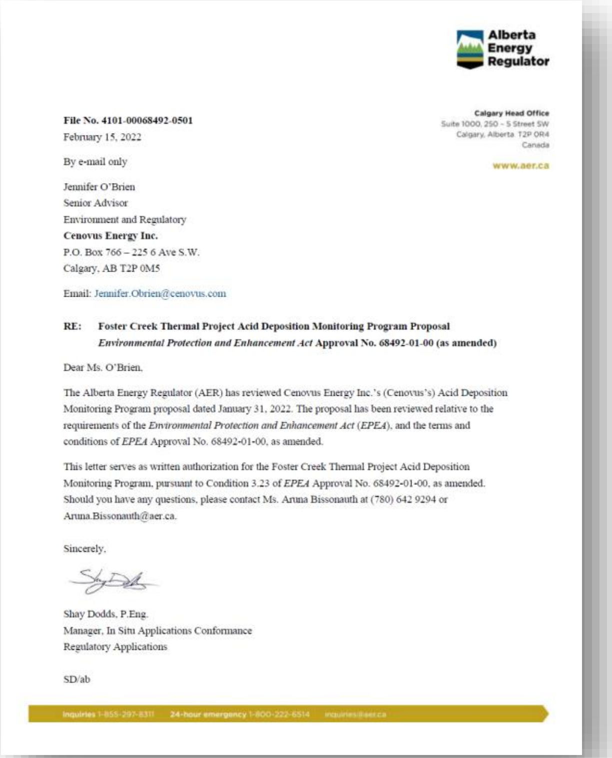
Acid Deposition Monitoring Strategy for the Cold Lake Region

Acid Deposition Monitoring Program Expansion Committee

LICA ENVIRONMENTAL STEWARDS

Michael Bisaga, Monitoring Programs Manager
Version 1: January 31, 2022

2.1.2 AER Authorization Letter



Alberta Energy Regulator

File No. 4101-00068492-0501
February 15, 2022

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Sincerely,

Shay Dodds, P.Eng.
Manager, In Situ Applications Conformance
Regulatory Applications

SD/ab

Inquiries 1-855-297-8311 24-hour emergency 1-800-222-6514 inquiries@aer.ca

3.0 New Business

3.1.1 Implementation Goals

- Wet Deposition
  - Enhance precipitation collection
- Dry Deposition
  - Enhance passive network
- Wet/Dry Deposition (IER)
  - Deploy ion exchange resins
- Soil Acidification
  - Expand long-term soil monitoring
- Surface Water
  - Initiate lake sampling
  - Determine alignment opportunities for wetlands monitoring

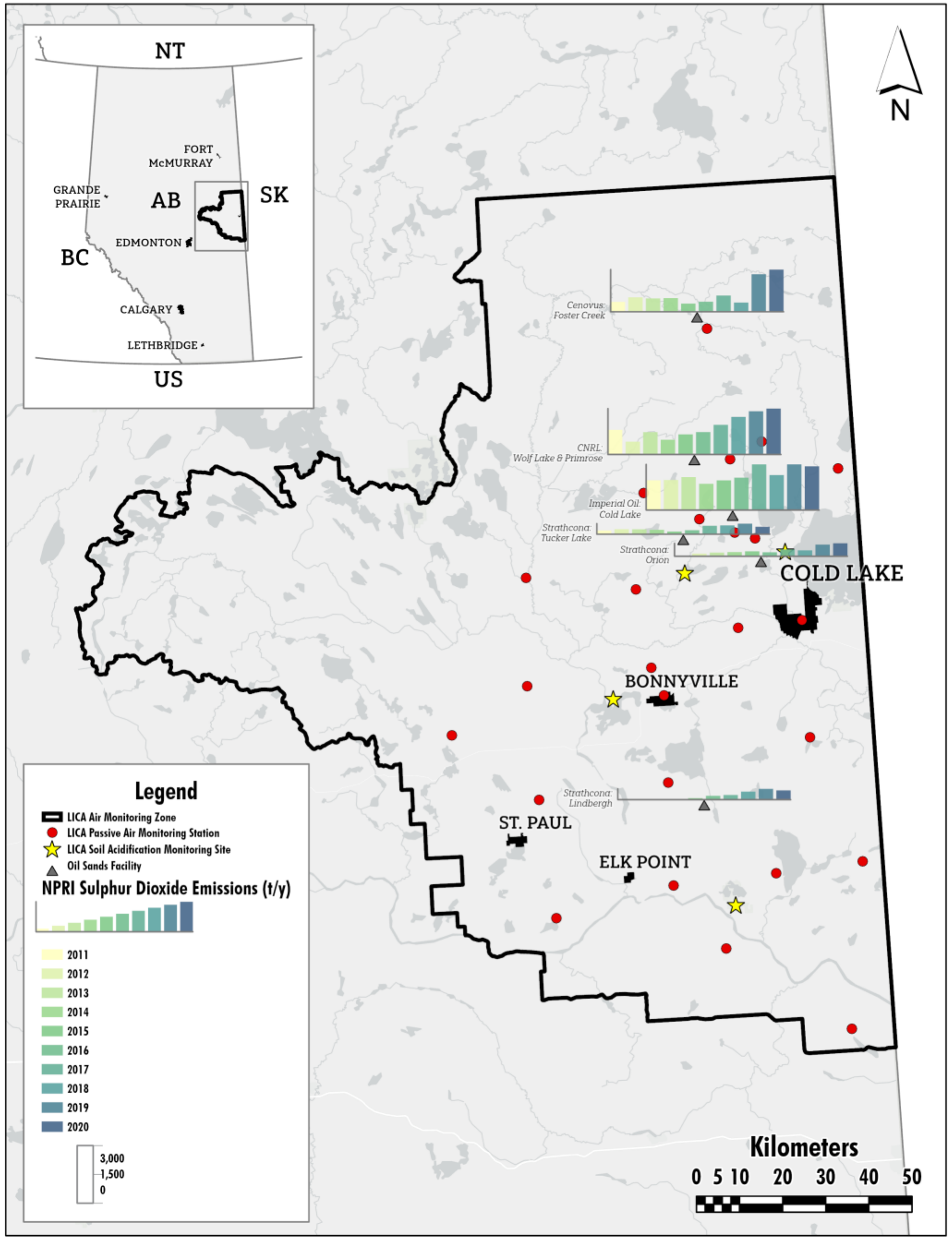

Figure 9: NPRI sulphur dioxide emissions 2011-20 (t/y)

3.1.2 Information and Research Needs

- Wet Deposition
  - Updated GEM-MACH modelling
  - OSM wet deposition sampling and site selection protocol
  - AEP data analysis (MER project)
- Dry Deposition
  - Updated GEM-MACH modelling
  - WBEA monitoring protocol and laboratory information
- Wet/Dry Deposition (IER)
  - Updated GEM-MACH modelling
  - WBEA IER monitoring protocol and laboratory information
- Soil Acidification
  - Updated GEM-MACH modelling
  - Soil mapping, new site selection screening
- Surface Water
  - Updated GEM-MACH modelling
  - OSM acid sensitive lake sampling protocol
  - Integration or alignment with OSM wetlands work

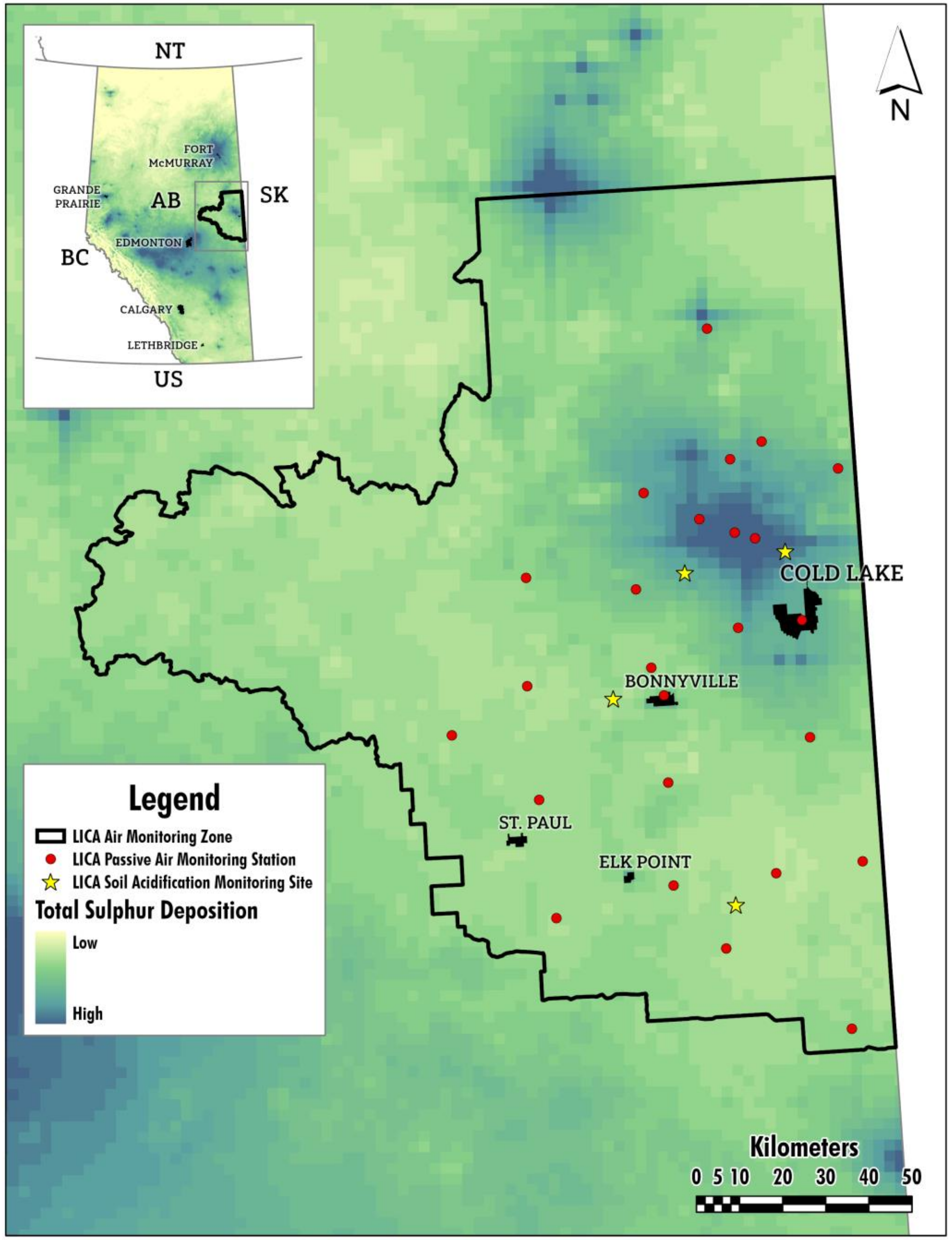

Figure 10: GEM-MACH predicted total sulphur deposition (2013 emissions profile)

3.1.3 Map out Risks

- Wet Deposition
  - OSM funding decision
  - Few barriers to implementation
- Dry Deposition
  - OSM funding decision
  - Few barriers to implementation
- Wet/Dry Deposition (IER)
  - OSM funding decision
  - Front-end time commitment
- Soil Acidification
  - OSM funding decision
  - Front-end time commitment
- Surface Water
  - OSM funding decision
  - All proposed sites are on the CLAWR

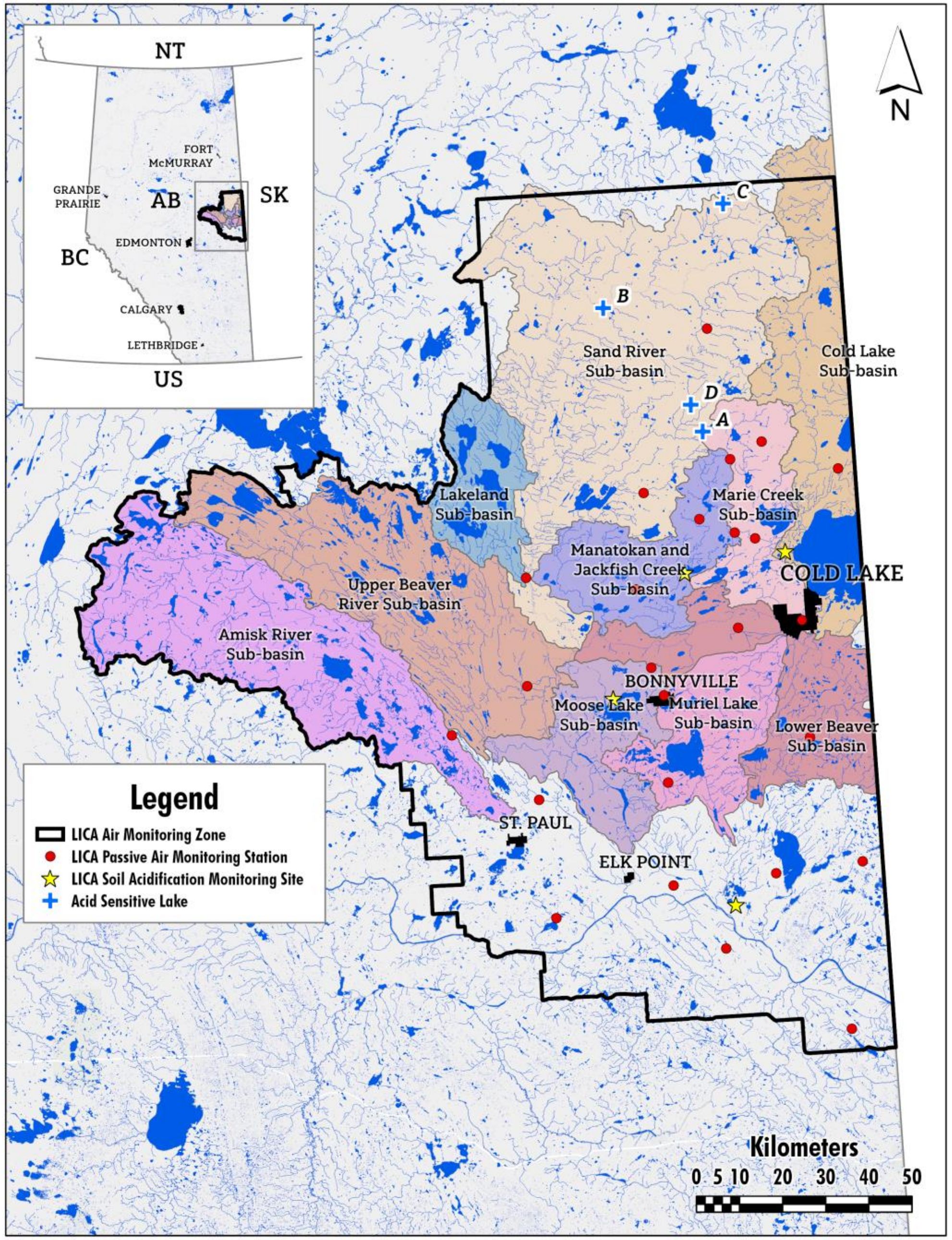

Figure 16: Location of Lakes recommended for sampling to establish contemporary acid sensitivity rating

3.1.4 Schedule Milestones

- Wet Deposition ***(Weekly Sampling Interval)***
  - Implementation: Q3 (Oct-Dec 2022)
- Dry Deposition ***(Monthly Sampling Interval)***
  - Implementation: Enhance Existing Q2 2022 (July-Sept 2022)
  - Implementation: New Q3 2022 (Oct-Dec 2022)
- Wet/Dry Deposition ***(Semi-annual Sampling Interval)***
  - Implementation: “Identified” Pink Area: Q3 2022 (Oct-Dec 2022)
  - Implementation: Everywhere Else + New: Q1 2023 (Apr-Jun 2023)
- Soil Acidification ***(Annual Sampling Interval)***
  - Screening: Q2 2022-Q2 2023 (July 2022-Sept 2023)
  - Implementation: Q3 2023 (Oct 2023-Dec 2023)
- Surface Water ***(Annual Sampling Interval)***
  - Implementation: Identified Lakes Q2-Q3 2022 (July-Dec 2022)
  - Implementation: Wetlands as-needed Q2-Q3 2023 (July-Dec 2023)

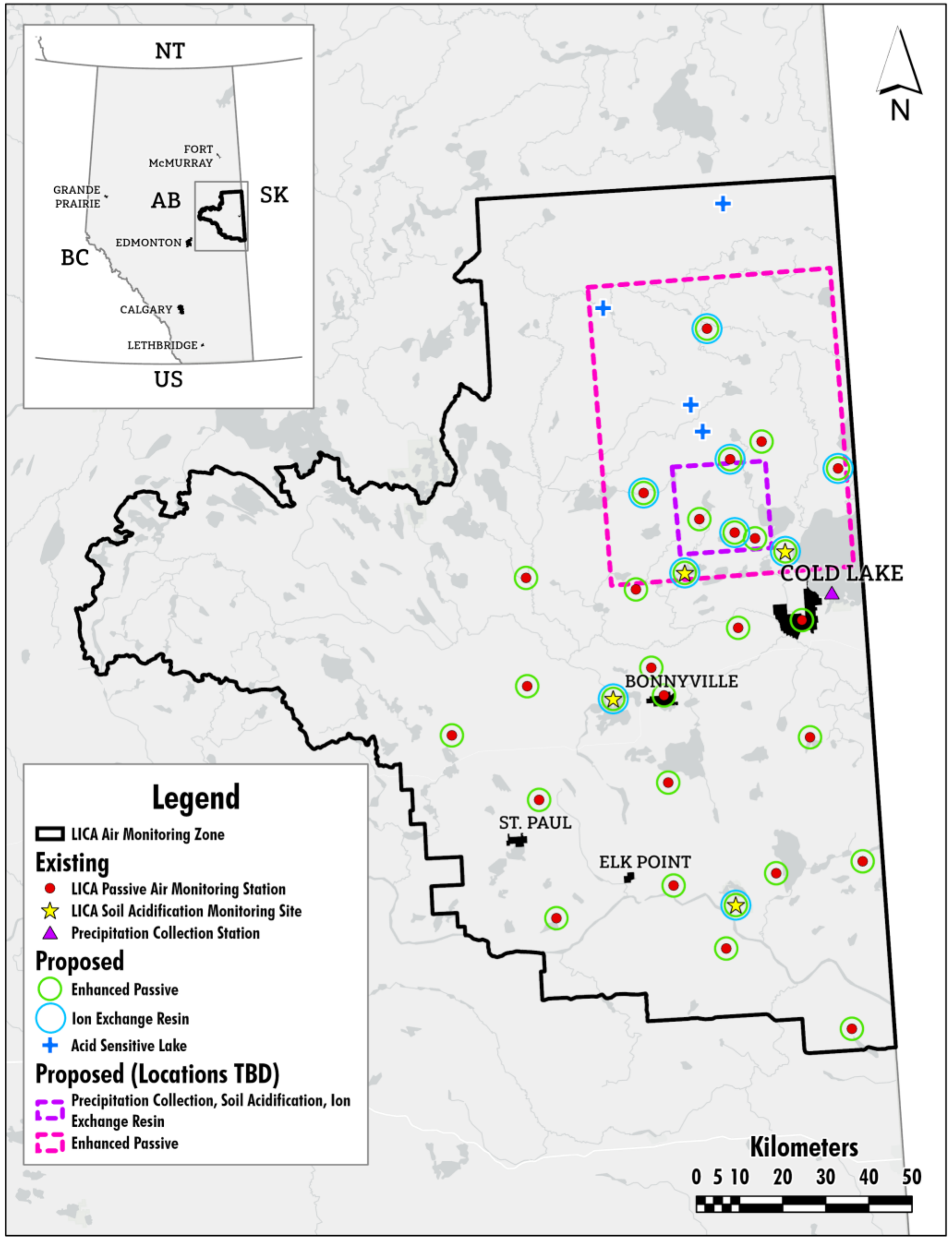

Figure 19: Monitoring strategy visualization

3.1.5 Assign Tasks

- Wet Deposition
  - Collector deployment: LICA
  - Long-term existing data analysis: AEP
- Dry Deposition
  - Passive deployment: LICA
- Wet/Dry Deposition (IER)
  - Ion-exchange resin deployment: LICA
- Soil Acidification
  - Screening: Soil science advisors
  - Plot establishment: LICA
- Surface Water
  - Identified lake sampling: LICA (with industry, CLFN support)
  - Wetlands: TBD

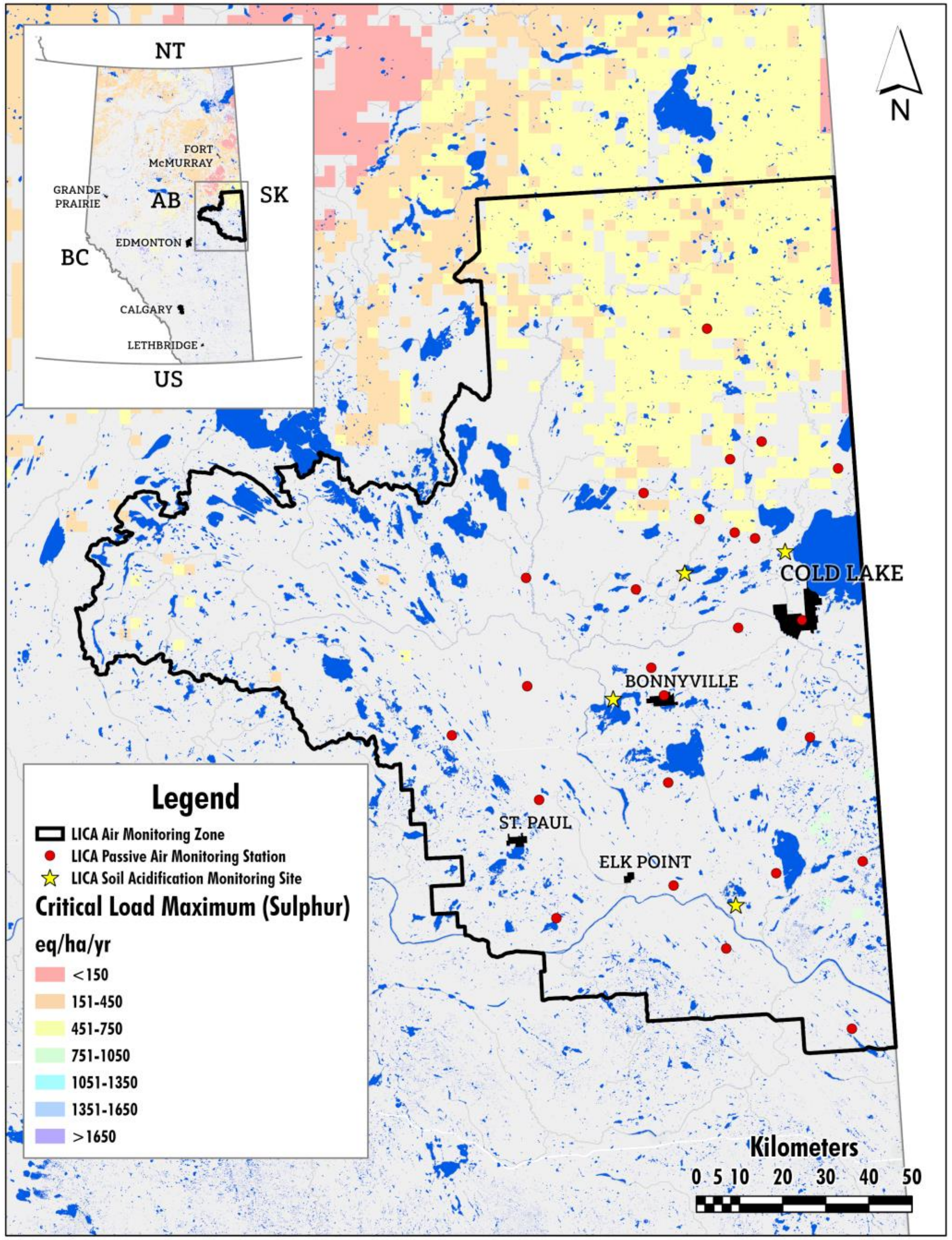

Figure 18: Critical loads (sulphur max) of acidity for organic soils.

3.1.6 Allocate and/or Identify Resources

- Wet Deposition
  - Pending OSM funding decisions
- Dry Deposition
  - Pending OSM funding decisions
- Wet/Dry Deposition (IER)
  - Pending OSM funding decisions
- Soil Acidification
  - Pending OSM funding decisions
- Surface Water
  - Pending OSM funding decisions

NOTE: Budgets are 'under construction'.
Implementation tasks may be staggered.

3.1.7 Recognize Gaps

- Wet Deposition
  - Updated GEM-MACH modelling
  - Acid Deposition Management Framework
- Dry Deposition
  - Updated GEM-MACH modelling
  - Acid Deposition Management Framework
- Wet/Dry Deposition (IER)
  - Updated GEM-MACH modelling
  - Acid Deposition Management Framework
- Soil Acidification
  - Updated GEM-MACH modelling
  - Acid Deposition Management Framework
- Surface Water
  - Updated GEM-MACH modelling
  - Acid Deposition Management Framework

NOTE: New ADMF may inform adaptive monitoring

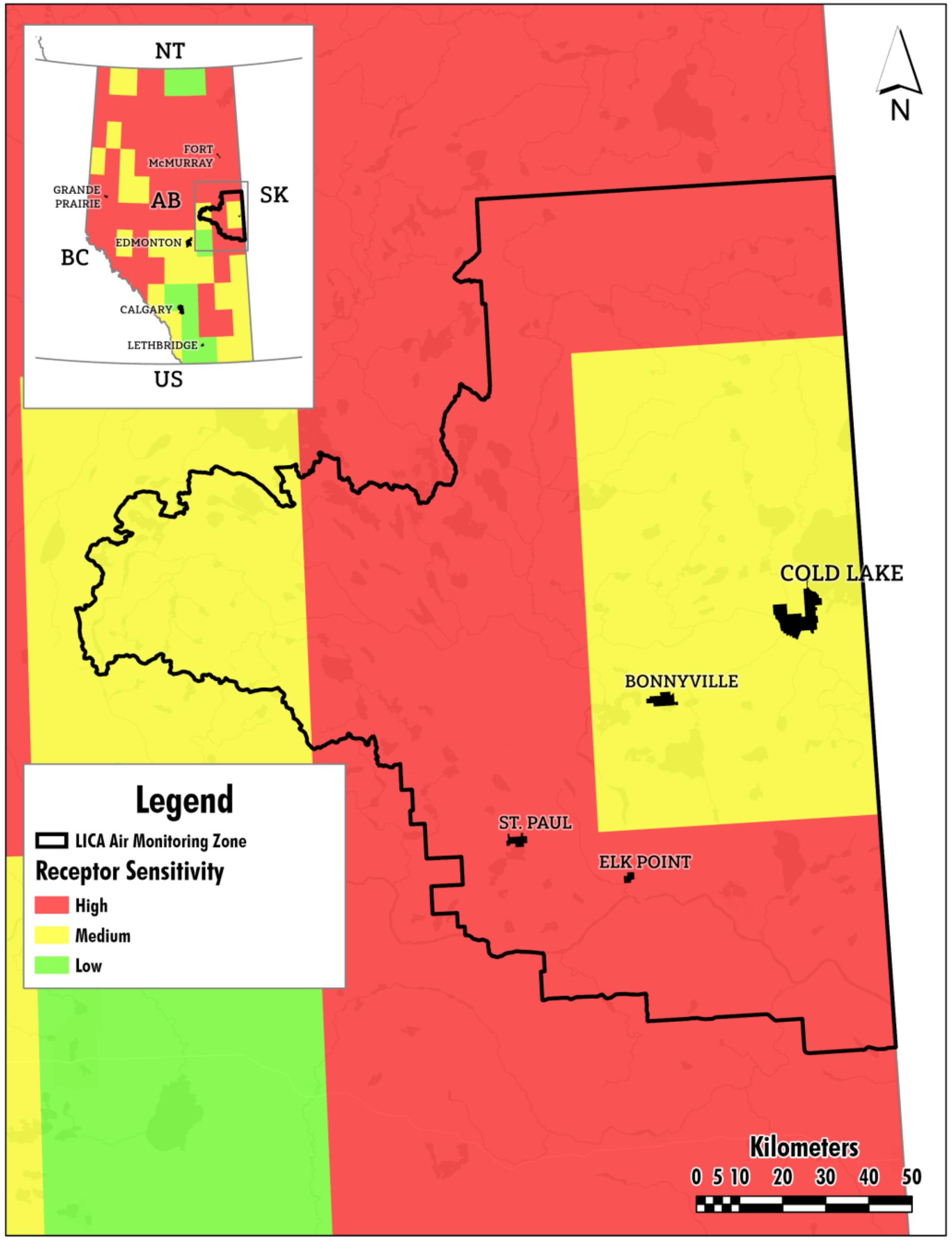

Figure 5: Alberta's soil sensitivity as defined under the Acid Deposition Management Framework (2008).