

SCIENCE 30
UNIT B:
Chemistry and the
Environment

AIR QUALITY RESEARCH DESIGN

A UNIT ON AIR QUALITY

Dear Teacher,

Thank you for your interest in the TELUS World of Science – Edmonton Professional Development Program on Air Quality for Science Teachers. We've worked hard to create a high-quality set of resources to help you bring the science of air quality into your classroom through hands-on activities, inquiry-based lessons, and real science tools. This unit guide has been designed to seamlessly integrate with the Alberta science curriculum and expose your students to this important subject matter through experimentation and exploration. Using the PocketLab Air sensor your students will explore air pollution in their own communities and connections to their daily lives.

We all have a stake in the quality of the air we breathe. Your participation in this project facilitates our goal of educating over 400,000 people on the gases and factors that impact air quality, the way in which air quality affects health and the environment, and where to find reliable sources of air quality information.

This guide includes all of the information, instructions, materials list, and resources necessary for you to confidently lead air quality lessons with your students. The unit is broken up into several lessons designed to be completed over a series of days or weeks. Follow the guide exactly, or adjust to suit your style and student needs.

All materials found within this booklet can also be accessed online at www.twose.ca. Here you will be able to access student worksheets, background information and full lesson plans.

We've partnered with The King's University Centre for Visualization in Science to provide you with additional resources, available at <http://sensors.kcvs.ca/>. Here you will find information on operating the PocketLab Air sensor, analyzing its data, and navigating Alberta's Air Quality Health Index online mapping tool.

We hope you enjoy these resources and will share your experience with us. To offer feedback, share your story, or if you require further information or clarification please contact us using the information below.

TELUS World of Science – Edmonton, Science in Motion

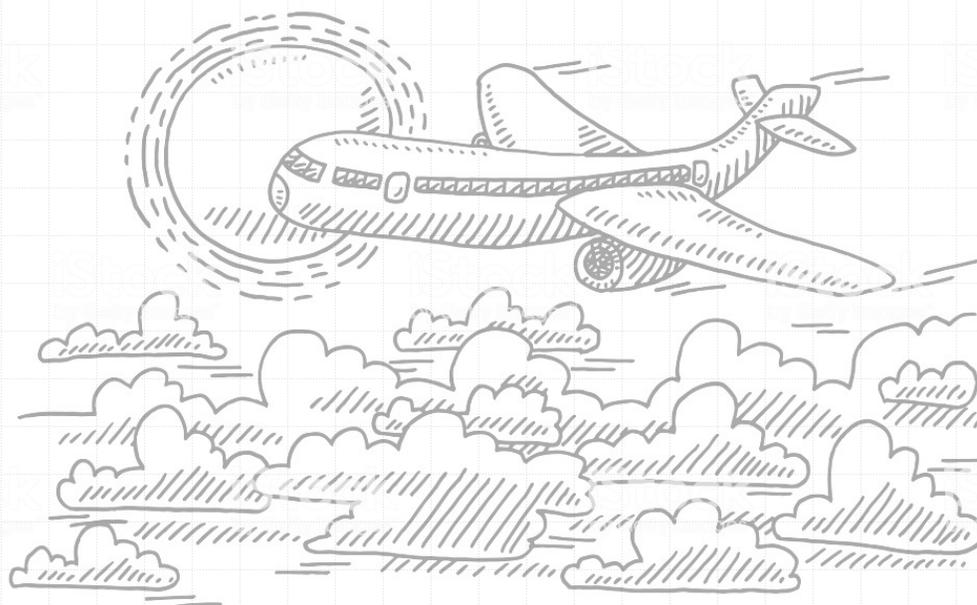
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This project was funded through a creative sentencing order of the Provincial Court of Alberta with the goal of bringing awareness about air quality issues to Albertans.

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INTRODUCTION

Air Quality Research Design

This unit is designed to be completed as a wrap-up project for Science 30 Unit B: Chemistry and Environment. Using what they have learned about air pollution, acid-base chemistry, and environmental impacts throughout the unit, students will be asked to design their own research project related to air quality in their community. Using existing data sources and a PocketLab air sensor, students will be collecting and analyzing data, and presenting their findings in a scientific poster. This unit was inspired by the Teach Engineering activity *Study Design for Air Quality Research* available from: https://www.teachengineering.org/activities/view/cub_airquality_lesson01_activity4.

Curriculum Connections

Science 30, Unit B: Chemistry and the Environment

- 30–B1.8k outline the chemical reactions (e.g., combustion reactions) that produce air pollutants (i.e., sulfur dioxide and nitrous oxides) that, when combined with water, ultimately result in acid deposition.
- 30–B1.9k describe impacts on the biotic and abiotic components of the environment caused by acid deposition; e.g., lowered pH in water systems, accelerated corrosion, metal leaching from bedrock, the impact of leached metals on plants and the food chain.
- 30–B1.2sts explain how science and technology have both intended and unintended consequences for humans and the environment.
- Identify and explain how human activities and natural events contribute to acid deposition in the environment.
- 30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results
- 30–B2.5k identify and explain how human activities and natural events contribute to the production of photochemical smog, the depletion of the ozone layer and increased concentrations of organic compounds in the environment; e.g., driving a car, use of CFCs, agricultural practice
- 30–B3.1k describe the risks and benefits of using chemical processes that may produce products and/or by-products that have the potential to harm the environment

Enduring Understandings

Pollutants in the atmosphere are harmful to environmental and human health specifically in regard to acid deposition and respiratory illness and disease.

Air quality data for Alberta is publicly available and can be accessed through simple online tools.

Research design begins with asking a question. Research is about developing methods and procedures to answer these questions.

Prior Knowledge

This lesson is meant to be completed after students have a good understanding of the content in Unit B. Specifically, students should have covered the products of combustion reactions, acid-base chemistry, and acid deposition. The first activity serves as a brief review of this content. The following activities ask the students to use their understanding to conduct their own air quality research experiment.

LESSON 1:

A BRIEF REVIEW

LESSON 1: A BRIEF REVIEW

This lesson introduces students to air quality monitoring in Alberta and explores Alberta's Air Quality Health Index (AQHI) Online Mapping Tool. The students are asked to reflect on what they learned throughout the Chemistry and the Environment Unit and apply that knowledge in the context of air quality. Students practice accessing data in the online tool in preparation for the next lesson, in which they will be designing their own research experiment.

Learning Goals:

- Students will identify the reactants and products of common combustion reactions.
- Students will determine the products that result from reactions involving mixing oxides with water.
- Students will list the pollutants that are monitored to inform Alberta's AQHI.
- Students will access online air quality data to complete the associated worksheet in preparation for a study design assignment.

Resources and Materials

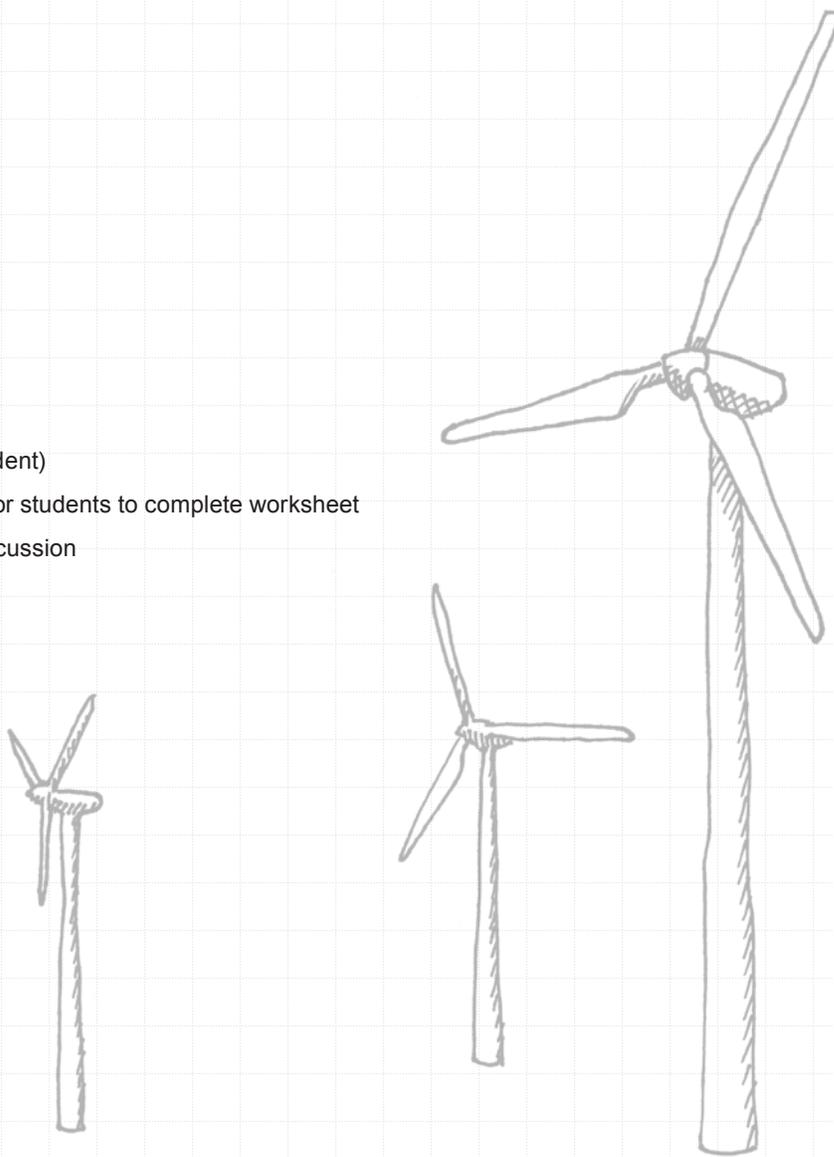
- Existing Data Worksheet
- Access to class laptops or computer lab

Time Required

80 minutes

Preparation

- Print Existing Data Worksheets (one per student)
- Arrange access to laptops or computer lab for students to complete worksheet
- Open AQHI mapping tool and display for discussion



Outline

Introduction

- Review products of combustion reactions.
- What gases are produced during the combustion of natural gas containing sulfur?
- Make connection to air quality concerns.

Body

- Introduce air quality, air monitoring in Alberta, Alberta Ambient Air Objectives, and the AQHI.
- Discuss carbon monoxide, ozone, particulate matter, sulfur dioxide, nitrogen dioxide (sources, health impacts, environmental impacts).
- Review reactions that result in acid precipitation.
- Introduce AQHI Online Mapping tool.
- Distribute Existing Data Worksheet for students to complete for the rest of class.

Conclusion

- Assign worksheet for homework or complete next class.

Assessment

Pre-Assessment

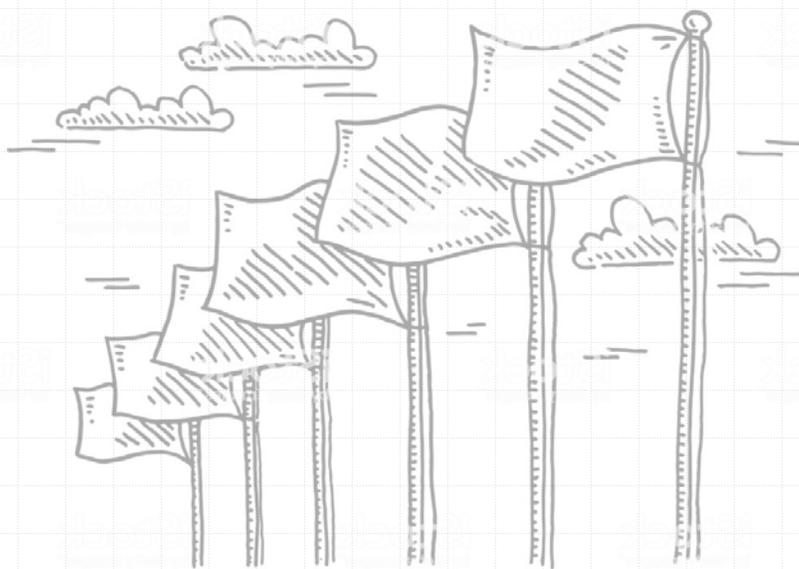
- Determine students' current understanding of combustion reactions and acid deposition. What are the products of combustion? What processes produce acid precipitation?

Formative Assessment

- Students are actively participating in the class discussion to review content previously presented in the unit.
- Students work individually or in pairs to access data using the online air quality tool to complete the Existing Data worksheet.

Summative Assessment

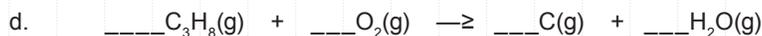
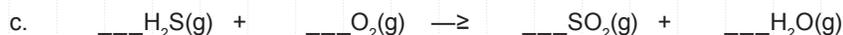
- Students complete the Existing Data worksheet to assess their understanding of key unit concepts and ability to utilize the online data air quality tool.



EXISTING DATA WORKSHEET

Instructions: Complete the following questions, drawing on what you have learned throughout this unit and utilizing the Alberta Air Quality Health Index Map tool available at <http://airquality.alberta.ca/map/>.

1. Balance the following combustion reactions and list the name of the fuel and its products.



2. Nitrogen oxides are often referred to as NO_x . Explain.

3. Complete the following equations for reactions of certain oxides with water. Explain the significance of these reactions in terms of environmental impacts.



4. What is the AQHI forecast for our area tomorrow? What does this mean?

5. What was the AQHI for our area exactly one month ago?

Teaching Notes

**Words in italics generally represent teacher's script.*

Introduction – 5 minutes

This series of lessons is designed to be completed at the end of the Chemistry & the Environment Unit. Students should feel comfortable with the content of this unit.

We have already learned in this unit that the combustion of hydrocarbon fuels results in the release of oxides and water vapour into the atmosphere.

For example, the combustion of methane produces one molecule of CO₂ and two molecules of water. What gases are produced during the combustion of natural gas containing sulfur?

Prompt students to recall their previous learning. Show formulas for these combustion reactions on the board.

Today we are going to refresh our memories and further explore the substances that impact our air quality here in Alberta. We are also going to discover how Alberta monitors these pollutants and where we can find this information.

Body – 70 minutes

Air quality is a measure of how clean our air is, determined by the rate at which pollutants are emitted into the atmosphere and how effectively the atmosphere can disperse those contaminants. It is affected by wind, temperature, turbulence and local topography.

There are numerous pollutants that impact our air quality. Alberta uses three monitoring methods to track these pollutants: continuous, intermittent and passive. Continuous monitoring provides nearly instantaneous measurements of pollutant concentrations. Air is drawn into a commercial analyzer that has been calibrated to measure each pollutant being monitored. Data is stored in one-hour time blocks.

Intermittent monitoring involves collecting 24-hour average pollutant concentration once every 6 days. This method involves collecting pollutants using reactive tubes, absorbents or filters. The samples need to be analyzed in a lab to determine air pollutant levels, meaning data may not be available for several months. Intermittent monitoring methods is a more detailed approach to understanding air quality and typically looks at levels of particulate matter and hydrocarbons.

Finally, passive monitoring involves passive samplers collecting air pollutants without the need for electricity, data loggers, or pumps, unlike continuous and intermittent monitoring. Pollutants transfer from the air to a reactive surface and lab analysis is needed to determine concentration. This method is used for long-term trends and can be used in a network over large spaces to understand the spatial variance in pollution levels.

Air quality in Alberta is collectively monitored by the provincial government, airshed organizations, the federal government, and industry. The data is collected at a network of stations across the province, most of which is sent to airshed organizations or Alberta Environment and Parks. The stations use all three methods (continuous, intermittent and passive) to continually monitor average concentrations of pollutants as well as meteorological factors. The data is then checked and cleaned of errors before it is archived online in the Alberta Environment and Park air data warehouse, which is publicly available.

Albertans can also refer to the Alberta Air Quality Health Index (AQHI) to protect themselves from the harmful effects of air pollution. The AQHI relates air quality to health, using a scale from 1 to 10.

Briefly explain the AQHI levels and graphics (see Teacher's Background Information).

The pollutants measured to calculate the Alberta AQHI are carbon monoxide, nitrogen dioxide, ozone, fine particulate matter and sulfur dioxide.

Alberta's AQHI is determined by comparing hourly pollutant concentrations against Alberta's Ambient Air Quality Objectives (AAQOs). The AAQOs are like limits; each pollutant is given an acceptable one-hour, 24-hour and annual average concentration range. Exceedances, or levels above these limits, means the AQHI value triggered as High or Very High risk. The AAQOs, or limits, are set based on scientific factors including health risks, environmental concerns and previous research. The one-hour thresholds that trigger High or Very High AQHI values include:

- 80 micrograms per cubic metre for fine particulate matter
- 172 parts per billion for sulfur dioxide
- 159 parts per billion for nitrogen dioxide
- 82 parts per billion for ozone
- 13 parts per million for carbon monoxide
- 1 part per million for hydrogen sulfide and total reduced sulfur

Hydrogen sulfide is included on this list because of its serious health effects, even though it is not used to calculate the AQHI.

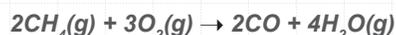
As an additional awareness measure, Alberta also releases special messages for odour and visibility events (events that are easily detectable) when the AQHI is rated as Low or Moderate risk, but the following thresholds are exceeded:

- 25 micrograms per cubic metre for fine particulate matter (based on visibility)
- 100 parts per billion for sulfur dioxide (based on odour)
- 10 parts per billion for hydrogen sulfide or total reduced sulfur (based on odour)

In this case, we may continue to enjoy our time outdoors even though we detect an odour or visibility change, unless we experience symptoms.

We have already studied some of these pollutants, but some are new to us.

Carbon monoxide (CO) is a product of incomplete combustion of a carbon compound. Remember, an incomplete combustion occurs when the quantity of oxygen is limited during the reaction process.



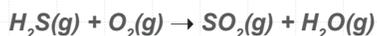
CO is toxic to all humans and animals because it easily binds to hemoglobin in our blood, which means the hemoglobin carries less oxygen throughout our body. Patients who suffer from CO poisoning show a range of clinical presentations including: headache, dizziness, coma, and even death. CO is one product of the combustion reactions that occur in motor vehicles. Its toxicity is the reason we cannot run our cars in closed spaces, like a garage.

Tropospheric O_3 is a secondary pollutant that is created through chemical reactions involving nitrogen oxides and volatile organic compounds (VOCs). It contributes to photochemical smog; a visible brown haze commonly noticed in highly populated areas. Vehicle exhaust and chemical solvents produce the nitrogen oxides and VOCs that contribute to the production of O_3 . Stratospheric ozone is formed naturally through reactions involving the oxygen and light from the sun. The ozone in the stratosphere is important as it protects the earth from too much UV radiation from the sun. Ground-level ozone, on the other hand, comes from human activity and leads to the production of smog. When O_3 enters our lungs it can cause coughing, irritation to the airways, and increased vulnerability to respiratory infections.

Particulate matter consists of a mixture of particles ranging from 10 micrometers (μm) in diameter (PM_{10}) that can be inhaled, to less than 2.5 μm in diameter ($\text{PM}_{2.5}$) that can become trapped in the airways and lungs and may also reduce visibility. PM_{10} particles include windblown soil, dust, particles from industrial activities. Also known as fine particulate matter, $\text{PM}_{2.5}$ particles come from gases

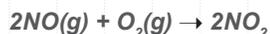
released into the atmosphere by combustion processes, such as forest fires.

Sulfur Dioxide (SO₂) is an oxide of sulfur. Do you remember how it is formed?



Sulfur Dioxide (SO₂) is a colourless gas with a strong odour (similar to matches) that comes from both natural and human-made sources, primarily the processing and combustion of fossil fuels containing sulfur.

Nitrogen dioxide (NO₂) is one of the oxides of nitrogen we have learned about. Do you remember how it is produced?



NO₂ is a reddish-brown gas with a sharp sweet-smelling odour that has been linked to respiratory disease.

Can you recall any environmental impacts that stem from increased levels of NO₂ and SO₂ in the atmosphere?

Prompt students to recall what they have learned about acid deposition.

NO₂, SO₂, and CO₂ can dissolve in water droplets in the atmosphere, creating an acidic solution and resulting in acid deposition.

Briefly discuss the formation of acid precipitation and its environmental impacts.

Of course, there are many other pollutants that enter the atmosphere both naturally and as a result of human activity. The five pollutants we've discussed are used to calculate the Alberta AQHI because of their potential health impacts. The pollutants are continuously monitored and inform the AQHI daily.

We can access information about AQHI values and pollutant levels online using the Alberta AQHI Mapping Tool. This tool is easy to use, and data is uploaded from monitoring stations across the province on an hourly basis. It is important to note that the data available through this tool is raw data, meaning it has not been checked for errors.

Open website and share with students. Walk them through how to find data for each example below (see teaching notes):

1. AQHI value for your area today.
2. The current level of fine particulate matter for Edmonton Central.
3. The current level of nitrogen dioxide in Fort Chipewyan.

To access the AQHI value for your area today launch the mapping tool at <http://airquality.alberta.ca/map/>. Navigate to your location by dragging the map and scrolling to zoom. Locate the nearest AQHI location pin (the map should already be set to the Communities tab in on the control panel on the left-hand side); this is the location of your nearest monitoring station. Click on the location pin to see more about the AQHI for the day. You can also scroll through the list of communities on the control panel to see the AQHI values across the province.

To access the current level of fine particulate matter in Edmonton click on the Stations tab in the control panel. Select Fine Particulate Matter – PM_{2.5} in the Current Parameters drop-down menu. Scroll to Edmonton Central in the list of communities below to see the level of PM_{2.5}.

To access the current level of nitrogen dioxide in Fort Chipewyan, remain on the Stations tab and choose Nitrogen Dioxide NO₂ from the Current Parameters drop down menu. Scroll through the list of communities to find Fort Chipewyan. The map will jump to the location of the community by clicking on the name. A box will also pop up at this location from which you can scroll through the full list of parameters to get a better idea of the air quality in the community.

We can also use this tool to produce queries and search for specific data of interest to us.

Walk students through the scenario below, explaining each function of the Query and Download tab as you go.

1. The AQHI values for the past week in your community (or nearest available community) in graph form and tabular form.
2. The level of fine particulate matter for the Fort McMurray Athabasca Valley over the past week in graph and tabular form.
3. The levels of fine particulate matter, nitrogen dioxide, ozone, and sulfur dioxide for the station nearest to your community.

To access the AQHI values for the past week in your community (or nearest community) select the Query & Download tab. Select the appropriate date range. Choose the By Community (AQHI) option from the list below. Select the name of your community, or closest community, then press the Graph Data button. A line graph will pop up from which you can observe trends in AQHI data. This data can also be viewed numerically by pressing the Tabular Data button. Keep in mind the data is recorded hourly. Both the graph and tabular data can be downloaded for future use.

To access the levels of fine particulate matter, nitrogen dioxide, ozone, and sulfur dioxide for the station nearest to your community remain on the Query & Download tab. Select the appropriate date range. Choose the By Station option from the list below. Select your nearest station from the Station drop-down menu. Select all four pollutants from the Parameter drop-down menu. Press the Tabular Data button to view data for all pollutants. This data can be exported to an excel data sheet for further analysis.

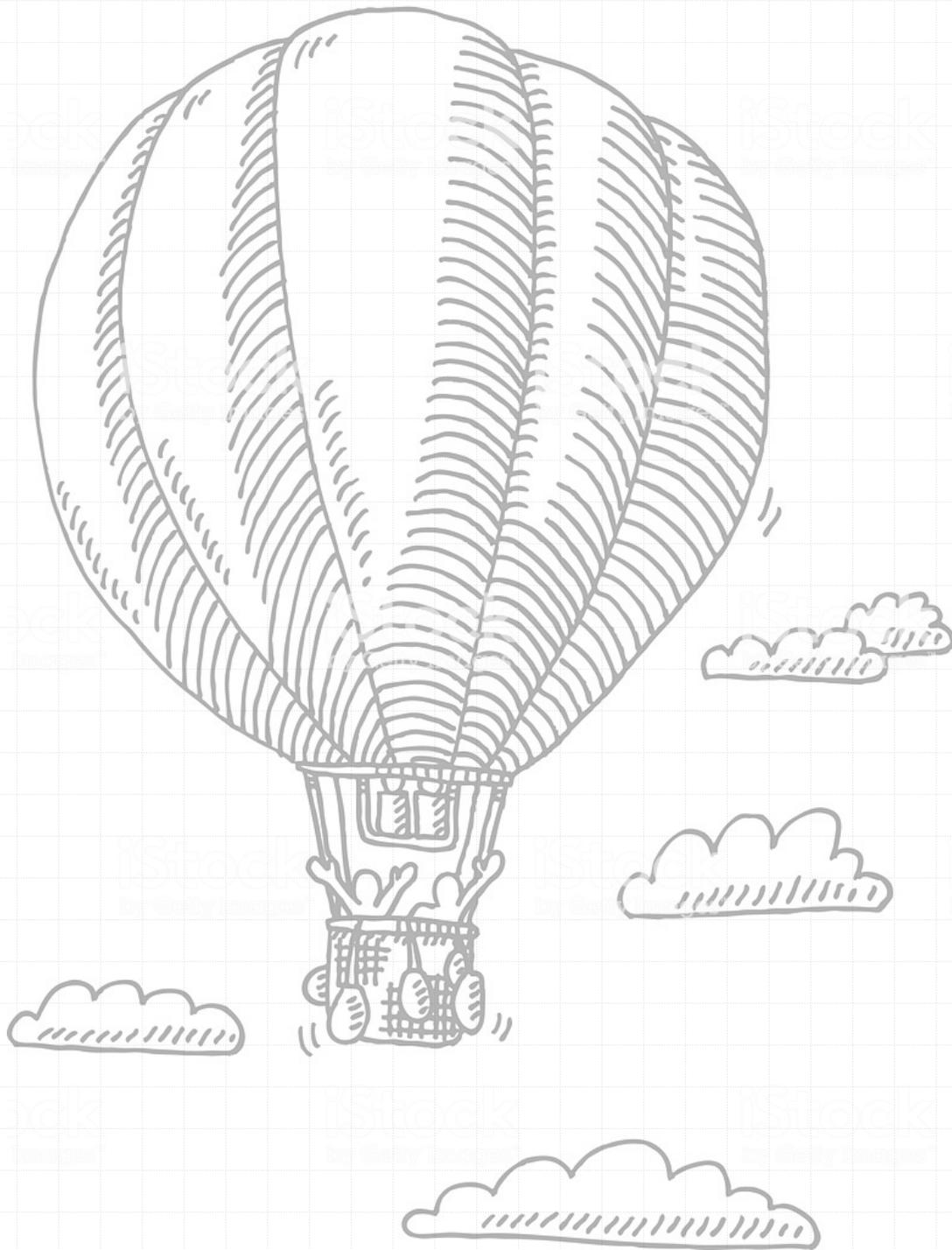
You may wish to further explore the online tool before this lesson as the students will be working with it extensively during this activity and subsequent lessons. For more details on how to use the AQHI mapping tool, go to <http://sensors.kcvs.ca/>.

For the rest of the day, you will be practicing using this tool as it will be an important source of data for you in our upcoming research project.

Direct the students to work on completing the Existing Data Worksheet either individually or in pairs. They will have the remainder of the class to complete the worksheet. You may choose to assign it for homework.

Conclusion – 5 minutes

Now that you know how to find information about air quality across Alberta, and how common pollutants are produced, we are going to begin planning and conducting our own research projects. Next class, you will be learning how you can collect your own air quality data using a PocketLab Air sensor. Be sure to keep your worksheet as it may be useful for you when you begin planning your research.



LESSON 2:

DATA COLLECTION
WITH
POCKETLAB AIR

LESSON 2:

DATA COLLECTION WITH POCKETLAB AIR

During this lesson, students will have the opportunity to familiarize themselves with the PocketLab Air sensors that they will be using to conduct their air quality research. Students will explore the sensor's data collection capabilities and outputs and begin brainstorming potential topics for their self-designed research projects.

Learning Goals:

- Students use the PocketLab Air sensor to collect air quality data as practice for their upcoming research process.
- Students identify a list of potential research topics or areas of interest.

Resources and Materials

- Project Overview Sheet
- PocketLab Air User Manual
- Brainstorming Guide
- PocketLab Air sensor

Time Required

80 minutes

Preparation

- Print Brainstorming Guide (one per group)
- Print Project Overview Sheet (one per student)
- Prepare to use PocketLab Air sensor and associated app

Outline

Introduction

- Distribute Project Overview Sheet and go through the activity with students.
- Divide students into groups of 3-4 or have them choose research teams.
- Prompt students to begin thinking of potential research topics or areas of interest during the lesson.

Body

- Distribute the Brainstorming Guide.
- Briefly explain the PocketLab Air sensors, its functions and capabilities, and how it is operated.
- Take students outside, if possible, to practice using the device.
- Work with one group at a time to practice using the PocketLab Air to take air quality readings.
- The rest of the class should be using the Brainstorming Guide and Project Overview Sheet within their research groups to generate a list of potential research topics.

Conclusion

- Regroup with the whole class and briefly discuss the research topics they identified and explain what will happen next class.

Assessment

Pre-Assessment

- Determine student's current level of engagement with air quality research. What questions would they like to answer? What pollutants are they most interested in? How would they go about answering these questions?

Formative Assessment

- Students work collectively to determine how the PocketLab Air sensor works, and how it can be used.
- Students observe the PocketLab Air data outputs and infer the meaning of the data.

Summative Assessment

- Students complete the Brainstorming Guide to complete a preliminary list of potential topics or areas of interest that they will further explore in subsequent lessons.

PROJECT OVERVIEW

As we have seen in the Chemistry and the Environment Unit, air pollutants have major impacts on the environment. For this project, your research group will be choosing a topic and generating a research question and hypothesis related to air quality in Alberta. You are responsible for planning the project, organizing tasks and keeping the project on schedule.

Project Outline

Phase 1

- Review air pollutants and environmental chemistry in class.
- Discuss data collection (PocketLab and Alberta AQHI website).
- Brainstorm ideas, select your topic, refine your research question or hypothesis.

Phase 2

- Plan the project including timeline, procedures, and responsibilities.
- Use your research template to help you with the planning phase.

Phase 3

- Collect data.
- Complete background research.

Phase 4

- Check, organize, and analyze data.

Phase 5

- Create a poster to display your results.
- Present your research poster.

PocketLabs

- The PocketLab Air can measure carbon dioxide, ozone, particulate matter (PM_1 , $PM_{2.5}$, PM_{10}), temperature, humidity, barometric pressure, and light.
- For more information on using the PocketLab Air, see the Quick Guide on page 43.

Existing Data

- Air quality data for stations across the province of Alberta can be found online at <http://airquality.alberta.ca/map>.
 - This tool allows you to gather information on air quality health index, individual pollutants (parameters), and station trends.
 - Data from the previous 365 days is stored on the tool.
 - Important: the tool uses raw data, meaning it has not been checked and may include errors. For this reason, data from the AQHI website is only suitable for educational purposes, such as this project.
- You may wish to identify additional existing data resources. For example, your project may wish to compare the air quality in Alberta to other jurisdictions within Canada or abroad. You may research additional data sources, but ensure you choose credible sources.
 - Think about where the data is coming from. Who collected it? Who is sharing it? Do you trust the organization? If you are unsure if a source is credible, be sure to ask your teacher!

Example Project Ideas

The examples below are meant to get you thinking about what an air quality research project might look like. You may use one of the ideas below, modify an idea to create something new, or come up with your own project idea entirely.

- Compare air quality data from different locations around/in the school.
- Compare air quality data from different locations in the community.
- Compare air quality in the parking lot or bus lane across time.
- Compare air quality inside the school to air quality outside of the school.
- Compare emissions for different vehicles.

Final Advice

- Many groups will be using the PocketLab; a class schedule will be posted to coordinate data collection.
- Remember, research changes all the time and often the data we collect leads to new ideas. It is okay for your research question or hypothesis to evolve during the data collection phase.



What are the sources of air pollution in your community?

What are the main environmental concerns resulting from air pollution in your community?

Air Quality

Brainstorming Guide

What are the main health concerns resulting from air pollution in your community?

Which air pollutants do you think are of most concern in your community?

Teaching Notes

**Words in italics generally represent teacher's script*

Introduction – 10 minutes

Today we are going to begin planning our air quality research projects. In your research teams, you will be coming up with a research question, creating a plan, collecting and analyzing data, and presenting your data in a scientific poster.

Give each student a Project Overview Sheet and go through the document together as a class. Divide the students into teams of 2 to 3 or have them choose research groups.

For this research project, you have three options for data collection. You may choose to use existing data available from the Alberta AQHI website, collect data using the PocketLab Air, or a combination of both. Today we are going to learn how to use the PocketLab Air, and each group will get a chance to practice using it.

As we go through the lesson and practice using the sensor your group should start brainstorming ideas for your own research projects. What questions do you have about air quality? What do you want to know about the air quality in our community? What has caught your interest during the unit so far?

This lesson is very exploratory in nature. The students are challenged to navigate the PocketLab Air on their own and learn its functions and capabilities without much guidance. If you are limited to a single sensor, you may wish to schedule this activity differently. For example, have the students explore the sensor over a series of days or class blocks.

Body – 60 minutes

The PocketLab Air allows us to study air pollution in our local environment. It can measure carbon dioxide, ozone, particulate matter (PM_{10} , $PM_{2.5}$, $PM_{1.0}$), temperature, humidity, barometric pressure, and light. PocketLab Air can also compute an Air Quality Index (AQI) score by measuring particles sizes of $1\ \mu m$, $2.5\ \mu m$, and $10\ \mu m$. Keep in mind that the AQI generated by the sensor is not the same as Alberta's AQHI.

Briefly explain the basic functions of the PocketLab, show the students how it is connected to a device (suggested to use one dedicated tablet or phone for all groups) and how data is displayed. It is useful to project the screen of the device for all students to see as you give the explanation. Keep the explanation brief as this activity is meant to be exploratory with the students working to determine how the device functions on their own.

Following the explanation, take the class outside so each group can practice using the sensor. When they are not using the PocketLab, students should be brainstorming research questions using the Project Overview Sheet and Brainstorming Guide. By the end of the class, they should have a list of potential topics or questions they will consider exploring. They do not need to make a final decision at this point.

The students should draw on their current understanding of air pollution and environmental chemistry to begin generating a series of questions or areas of interest that they wish to explore. Be sure each student has a Project Overview Sheet and Brainstorming Guide to assist in the self-guided nature of the activity.

Guide each group individually as they practice using the sensor. Allow them to explore and make mistakes and answer questions when necessary. Students should feel comfortable independently operating the sensor, be clear on how data is presented, and understand how to save and export their data by the end of class.

Conclusion – 10 minutes

After every group has had a chance to practice using the sensor, gather the class together to answer any final questions and hear some of the brainstorming work they have done.

Next class, we are going to examine what features make a strong research project. You will also have a chance to make your final topic selection, refine your research question or make a hypothesis.

LESSON 3:

WHAT MAKES A
GOOD RESEARCH
PROJECT?

LESSON 3:

WHAT MAKES A GOOD RESEARCH PROJECT?

In this lesson, students are introduced to the key components of a good research project and begin designing their study. Using the Project Overview sheet, Research Template, and Brainstorming Guide, the students will define a research question or hypothesis, develop a procedure and collect data, interpret the data and analyze results.

Learning Goals:

- Students list the components of a good research project (research question or hypothesis, background information, methods, procedure, analysis).
- Students formulate a research question or hypothesis based on what they know about air quality and the tools that are available.
- Students design and complete an air quality study.

Resources and Materials

- Research Template
- Project Overview Sheet
- KWL Chart
- PocketLab Air sensor
- PocketLab Air User Manual

Time Required

80 minutes, plus time to complete research project.

Preparation

- Print Research Template (one per group)

Outline

Introduction

- Distribute the Research Template and explain the project.
- Review the previous class and the students' brainstorming guides.

Body

- Explain the scientific process of research and the difference between a research question and a hypothesis.
- Guide the students through the research template.
- Discuss methods of data analysis.

Conclusion

- Students work on the research project for the remainder of class, and over the next several days/weeks.

Assessment

Pre-Assessment

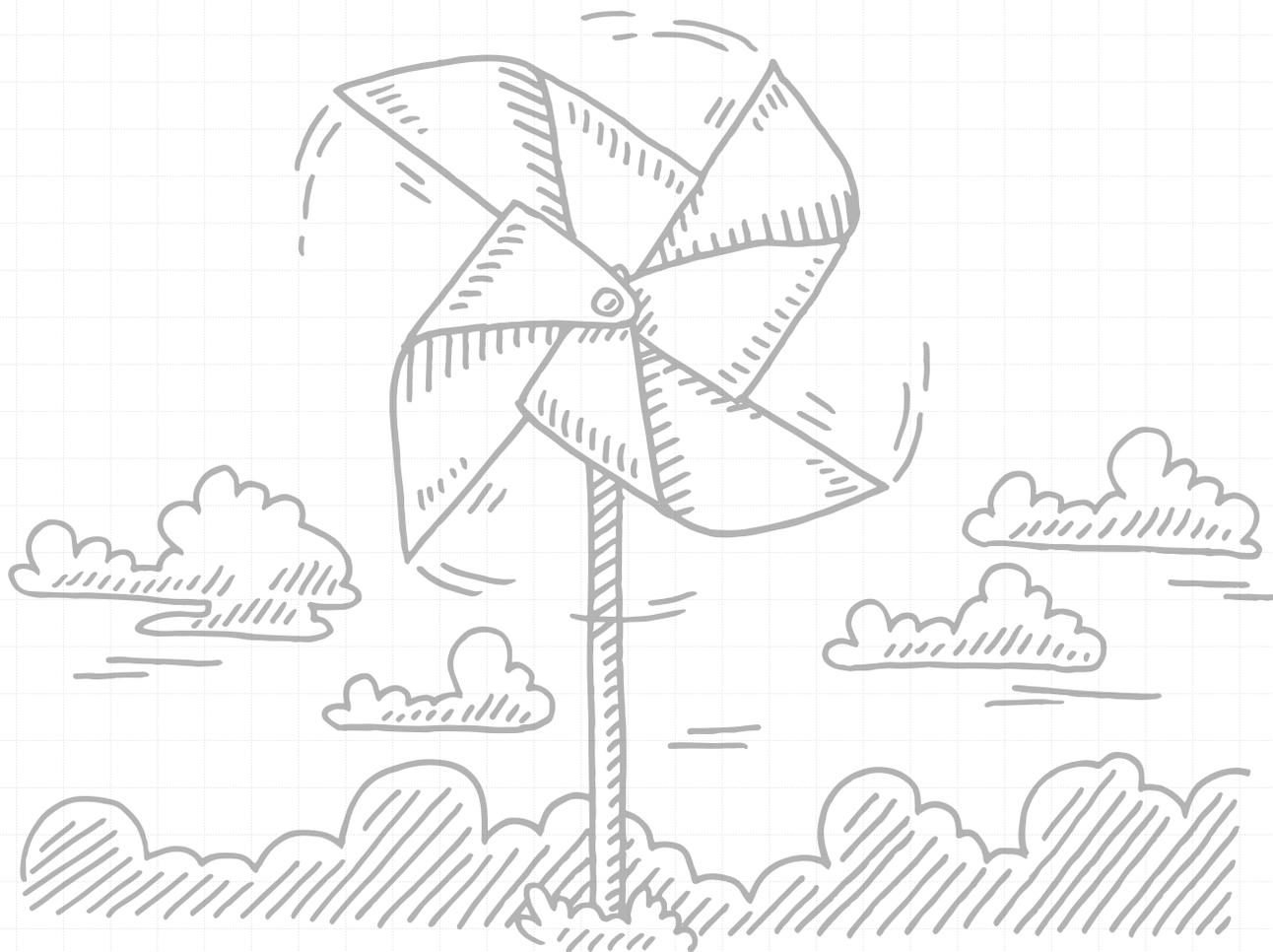
- Determine students' current interests regarding air quality. What were some of the questions or topics you brainstormed last class? Are there any others you would like to add to the list?

Formative Assessment

- Students work collectively to develop a research question or hypothesis, design a research project with all necessary components to answer their question or test the hypothesis.
- Students collect data using the PocketLab Air sensor, publicly available AQHI data, or a combination of both.
- Students design a plan to analyze the data.

Summative Assessment

- Students complete the research template to guide the project and in preparation for the next activity in which they will present their findings in a scientific poster.



RESEARCH TEMPLATE

Use this template as a guide to complete your research project. Be sure to complete the template fully as you will be required to hand it in.

Group Members

Include contact information for each group member.

Research Question or Hypothesis

What air quality topics are you interested in? Have you made observations in the past regarding air quality that you would like to research?

State the topic you have chosen in the form of a research question or hypothesis. Remember, choosing a hypothesis will require testing a prediction. A research question will require a broader exploration of your topic.

What larger themes relate to your research question or hypothesis? Consider climate change, health impacts, etc.

Who might be interested in your data? Why?

Background Information

Refer to your KWL Chart to complete this section. Include what you already know and what you want to know. Consider what we have learned in class as well as any additional background research you may have done.

Methods

How will you answer your research question? What pollutants are you studying? What are you comparing? What tools will you use to collect your data? What additional data might you need? Where will you find it?

Procedure

How will you collect your data, step by step? How will you organize your data? Create a template for your data collection sheet to submit for review before you begin collecting data.

Schedule

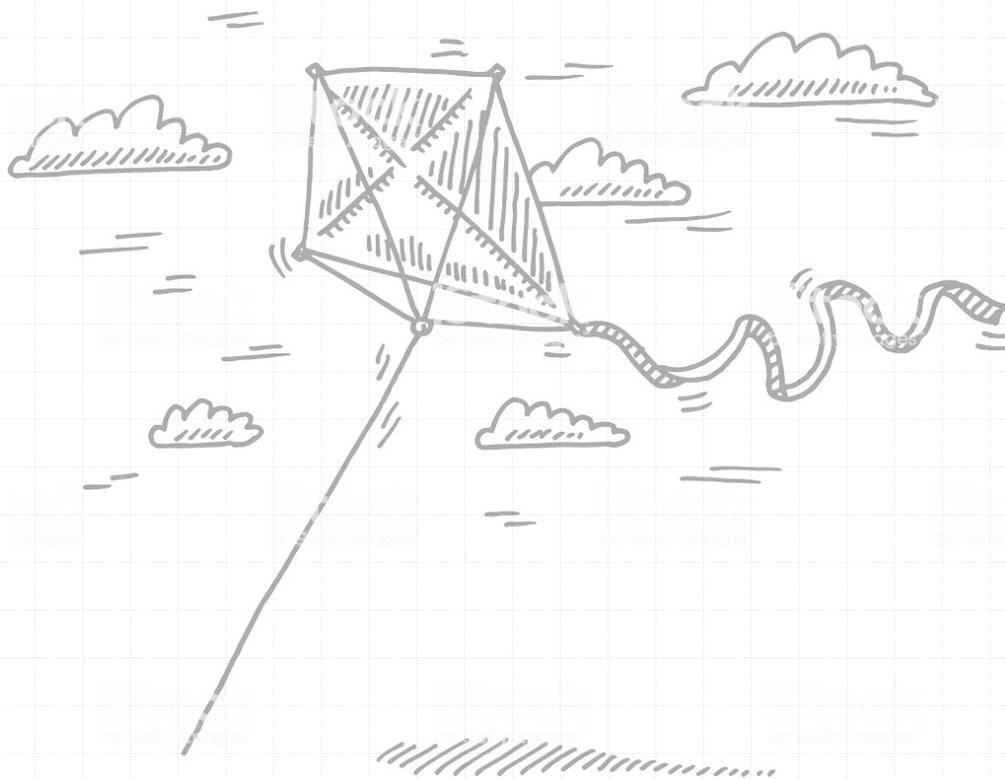
Divide your project into manageable phases. Assign responsibilities to each group member. Be sure to consider important deadlines such as due dates, and presentation dates. It may be helpful to create a template or use the one provided below.

Project Phase	Complete by (date)	Responsible	Equipment/Materials
Planning			
Data Collection			
Check Data			
Analyze Data			
Prepare Poster			
Presentation			

Analysis

What will you do with your data? What statistical analyses will you use (ex. average pollutant concentrations)?

How will you display your data (ex. bar graph)?



K

What I Know

What is your baseline understanding? What do you currently know about your chosen topic? What background information do you have?

W

What I Want to Know

What is your research question asking? What reasons do you have for choosing this topic? What are you hoping to learn?

L

What I Learned

What did you discover through your project? Can you answer your research question or verify your hypothesis? Why are your findings important? Did anything go wrong during your research? What did you learn because of it?

Teaching Notes

**Words in italics generally represent teacher's script.*

Introduction – 5 minutes

Today we are going to examine the aspects of a good research project and review the tools and data available to you as you plan and execute projects in your group.

To help guide you through the research process, your team may refer to the Research Template.

Hand out one template to each student. You will refer to the template throughout the lesson.

Body – 70 minutes

A good research project always starts with curiosity, or scientific inquiry. We start by asking questions about something we wish to understand and to generate ideas. You have already done a bit of this during our brainstorming session.

Research is about asking questions and testing ideas. To begin your project, your group brainstormed several ideas or topics of interest. Today we will review your Brainstorming Guide from last class and you will get a chance to discuss these ideas with your group and select one topic you wish to study. Then you will refine your research question or hypothesis.

Each group is responsible for coming up with a research question or hypothesis. It is okay for groups to have similar questions, but the students should work within their research groups for this project. If there are complementary research questions among the groups, you might encourage data sharing between groups.

It is important to remember that it is okay if you don't know what will happen. You can choose to test a prediction by stating your hypothesis, or you can investigate more broadly using a research question. It is also important to recognize that sometimes our data doesn't answer our initial question, and that, too, is okay. Often, new, exciting research will be generated from these situations.

Once you have defined your hypothesis or research question, it is time to begin your project. The research template will help guide you through this process.

Guide students through each section of the research template.

It is often helpful to define our "why." What larger themes or issues does your research relate to? Who would be interested in your data and why? Asking ourselves these questions can help us further define our question or hypothesis.

Next, it is useful to start with what you know; this is what we call background information. Of course, you aren't required to know absolutely everything about your topic. You should use what we have learned in class as a basis for your project. You may also choose to do some further research. For example, maybe you are researching the level of particulate matter in our school. You might want to take an in-depth look at the sources of PM and potential health impacts to inform your project.

During this phase, you will also want to define what you want to know about your topic. This goes along with generating your hypothesis or research question. You may wish to use the KWL chart that has been provided to help organize your thoughts.

Your group will need to think carefully about the methods you will use to answer your research question or test your hypothesis. Remember, there are a couple of options for you to consider; collecting data with the PocketLab or using existing data from Alberta's AQHI Online Mapping Tool. You may also choose to use a combination of both. Refer to the Overview Sheet to remind yourself of what can be measured using the PocketLab, and for a list of data sources.

The next aspect of your project to consider is the procedure. What steps will you take to collect your data? Map out who will complete each step, for PocketLab data as well as data from existing sources. It may be useful to create a schedule or timeline for your team to follow throughout the project.

Finally, your team will need to determine how your data will be analyzed. Think about statistics or graphs what will help you convey meaning. How will you present your data to evaluate your hypothesis or answer your research question?

You might consider offering your students an online tool to help visualize their data such as: <https://plot.ly/create/#/>, or working through data analysis together, perhaps as part of a math class.

For the remainder of the class your group will begin work on your project. Remember to use the template to guide you. Over the next few weeks, we will be working on these projects, but you may need to schedule time outside of class to collect data or conduct your analysis.

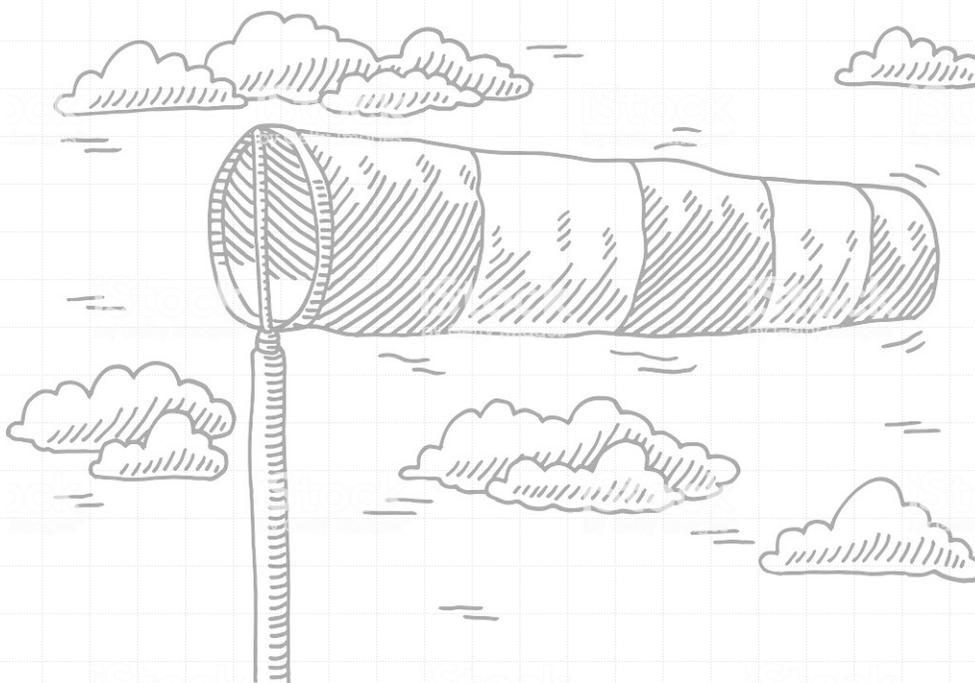
Make sure to document everything as you go. You may want to create a data sheet template to help your group collect and store data. Be sure to complete the template as you will be required to hand it in at the end of the project.

Conclusion – 5 minutes

For the remainder of the class and over the course of several blocks the students will be working independently. The amount of time allowed to complete this aspect of the unit will vary from class to class.

This lesson can be completed in one 80-minute block, but the time required for the students to complete the research project will vary. After all groups have finalized a research question or hypothesis you may wish to develop a class schedule for the use of the PocketLab Air. Students may also need regular access to the AQHI Online Mapping Tool to collect existing data.

The research project is inquiry driven, with the students creating and guiding their own research. They may need assistance with data analysis and interpretation. For support in this area, please refer to our online web element at: <http://sensors.kcvs.ca/>.



LESSON 4:

SCIENTIFIC POSTERS

LESSON 4:

SCIENTIFIC POSTERS

Students will have the opportunity to present the results of their research study in a scientific poster. They will learn about the necessary components of a good scientific poster, design and create their own poster, and present the poster to the class to conclude this air quality unit.

Learning Goals:

- Students list the necessary components, or headings, of a good scientific poster (title, authors, summary, introduction, methods, results, discussion, and references).
- Students synthesize their findings and relate their research to larger themes or context to which it applies and present this in the discussion section of the poster.
- Students communicate their research design, process, and findings to the class.

Resources and Materials

- Scientific Poster Guide
- Data Analysis Questions
- Access to laptop or computer lab for research and poster development

Time Required

80 minutes, plus time to complete posters

Preparation

- Print Scientific Poster Guide (one per student)
- Print Data Analysis Questions (one per student)
- Arrange access to laptops or computer lab

Outline

Introduction

- Distribute the Scientific Poster Guide (one per student)
- Introduce the purpose of the lesson and review the scientific process

Body

- Discuss each section of a scientific poster
- Discuss data analysis and review Data Analysis Questions with the students
- Students begin working on their posters

Conclusion

- Discuss final presentation of the posters and establish expectations for the project.

Assessment

Pre-Assessment

- Determine students' progress on their research project. Have they collected all necessary data? Have they completed the research template?

Formative Assessment

- Students distill their research into a scientific poster format, including all necessary components mentioned above.
- Students work collectively to plan and design a scientific poster.

Summative Assessment

- Students complete a scientific poster to present their original research and present the poster and their findings to the class clearly and concisely.

SCIENTIFIC POSTER GUIDE

Criteria

Your poster must contain the following sections:

- Title: The title should be descriptive and grab the reader's attention.
- Authors: List all group members.
- Summary: Explain your project in a few sentences including what the research question is, when and where data was collected, and why the project matters.
- Introduction: This section helps the audience to understand your project. Include background information and history where necessary, including the pollutants you are measuring, where they come from and why they are important.
- Methods: Explain how and where data was collected, including tools and sources that were used.
- Results: What did you find? Include information on data analysis.
- Discussion: Explain why your research matters. What do your results mean? Did you answer your research question? What are the limitations of the data? How could you continue the research?
- References: Include all sources that were used.

Templates

There are many scientific poster templates available online. You may choose to download a template from the following:

https://www.makesigns.com/SciPosters_Templates.aspx

<https://www.genigraphics.com/templates>

<https://templates.office.com/en-us/Posters>

You may also choose to make your own poster template on Microsoft PowerPoint or Google Slides. We recommend enlarging the size of your slide to be 91 x 122 cm (36 x 48 inches) if you plan on printing it.

Tips

- Think about your audience. How will they read the poster? Create a logical flow of information.
- Use visuals. Charts or images will engage your audience more than blocks of text.
- Think about font sizes carefully. Body text should be no smaller than 35 pt.
- Use colours to enhance your poster. Use contrasting colours for backgrounds and fonts to ensure easy readability.
- Someone should be able to understand your poster and project even if you are not there to explain it.

Presentation

In your group prepare a 5-10 minute presentation to share with your class alongside your poster. It might be useful to imagine your project as a story. Use storytelling to convey meaning and engage your audience.

DATA ANALYSIS QUESTIONS

The questions below are meant to guide your data analysis work. It can also be helpful to discuss your research with another group. For example, share with another research group your purpose for collecting your data, why you were interested in this data, how the data was collected and your initial impressions of the data. By sharing this information with others, they will be able to help you make sense of your work and identify questions or missing information you may consider addressing.

- What are your variables for this study?
- What variable are you manipulating?
- What comparisons are you making?
- List all the graphical ways in which your variables might be shown.
- Why might one graph format be more useful than another for your data?
- What might be some powerful ways to present your data?
- Do you have any data that doesn't seem to fit? Any outliers?
- Based on your data, what are you learning about air quality?
- How would you summarize your work for someone who doesn't know about air quality?
- What is your data telling you about the area you researched?
- How can you visually represent your data (graphs, charts, etc.)?
- What are the implications of your findings for the community?
- What changes might you make in your study design based on your analyses of these data?
- What new questions do you have?

Teaching Notes

**Words in italics generally represent teacher's script.*

Introduction – 5 minutes

This lesson will follow the student's completion of their research projects.

Now that you have completed your research projects, the final step is to present your findings.

Today we are going to learn how to make a high quality scientific poster. Your research group will design your poster to present to the class at a future date. Remember, completing the research is the first step. Now we need to share what we learned.

Body – 70 minutes

A good scientific poster has certain criteria, but most importantly, tells the story of your research clearly and concisely. The poster should include the following information:

- *Project Title*
- *Authors*
- *Summary*
- *Introduction*
- *Methods*
- *Results*
- *Discussion*
- *References*

Hand out the Scientific Poster Guide. Students will refer to this sheet as they complete their poster.

An important aspect of your poster will be the discussion section. This is where you get a chance to explain what your findings mean. You will need to interpret your results and tell us how much confidence you have in the data you collected and some of your concerns. For example, perhaps you were not able to collect data over a long period of time. To help you work through this important step, consider the list of Data Analysis Questions you have been given.

It may also be helpful for you to examine examples of scientific posters. Observe what you like and dislike about each poster. Think about how these observations could be applied to your own poster.

There are many poster templates available online. You can choose to use one of these templates or create your own. You will have ____ days to complete your posters. Don't forget that they will be presented to the class so be prepared to discuss your work.

Conclusion – 5 minutes

For the remainder of the class and over the course of several blocks the students will be working independently. The amount of time allowed to complete this aspect of the unit will vary from class to class.

This lesson can be completed in one 80- minute block, but completion of the poster may take several blocks. You may choose to print student posters for display during the presentation or have them presented digitally. Alternatively, you could ask the students to prepare a slide show presentation rather than a poster depending on the skills you wish to assess.

TAKE THE NEXT STEP

We encourage you and your students to continue engaging with air quality issues in Alberta even after you complete these lessons. The following list offers suggestions for your class to get involved in improving air quality in your community and continuing engaging with this important conversation.

- Contact your local Airshed to learn how you can be a champion for clean air.
 - The Alberta Airsheds Council offers student friendly resources and information on how to get involved, as well as links to all of the Airshed organizations around the province:
 - <https://www.albertaairshedsCouncil.ca/>
- Host an air quality event at your school. This is a great opportunity for your students to share their final projects, and educate their peers on the importance of air quality.
- Submit your student's work to the TELUS World of Science – Edmonton Blog.
 - Share your class's final project, or tell us about the air quality event you hosted at your school. We'll share it with our readers through our science blog.
 - To submit a blog post please send the following information to sim@twose.ca
 - School Name and community
 - Grade
 - Teacher's Name
 - Photos of final projects, events, or lesson plan activities (please ensure student faces are not included in the photo)
 - Caption for each photo
 - Description of the project, activity or event.
 - Tell us about your experience with the lesson plan. Did you complete all, or some of the activities? Did you adapt or change the lesson plan in any way?
 - Did you or your students engage with air quality beyond the scope of the lesson plan? Tell us how so.
 - Optional: student reflections on the project, activity or event.
 - To see sample posts, check out the blog at <https://twose.ca/learn/>

AIR QUALITY IN ALBERTA - TEACHER'S BACKGROUND INFORMATION

AIR QUALITY: WHAT IS IT AND HOW IS IT MEASURED?

Our Atmosphere

Earth's atmosphere is unique in that it is the only one that we know of that supports life. Made up of 78% nitrogen gas, 21% oxygen gas, 1% argon and many other trace gases, this mixture of gases regulates the planet's temperature, protects us from UV radiation and facilitates natural cycles such as cellular respiration and photosynthesis (King's Centre for Visualization in Science, n.d.).

Our atmosphere is divided into four layers: the troposphere, the stratosphere, the mesosphere and the thermosphere. Most of the atmospheric gases are found in the troposphere which extends 15 km above the earth's surface. The atmosphere is very thin. If we think of the Earth as the size of a globe, our atmosphere would be as thin as the layer of paint surrounding the globe (King's Centre for Visualization in Science, n.d.).

Air Quality

Air quality is a measure of how clean our air is, determined by the rate at which pollutants are emitted into the atmosphere and how effectively the atmosphere can disperse those contaminants. It is affected by wind, temperature, turbulence and local topography (Alberta Capital Airshed, n.d.).

High winds disperse pollutants more rapidly, while slower wind speeds can cause pollutant dispersal rates to slow and contaminants to build up, especially where pollutant sources are concentrated. Normally, temperature in the lower atmosphere decreases with height. However, sometimes a temperature inversion occurs and temperature actually increases with height. During an inversion atmospheric mixing decreases causing pollution dispersion to also decrease. Temperature inversions are common in Alberta in the wintertime and can last up to several days. Turbulence is the random movement of air in the atmosphere; this movement allows contaminants to disperse more readily. Finally, topographical features such as mountains and valleys significantly impact wind speed and direction, impacting pollutant dispersion (Alberta Environment and Parks, n.d.).

Pollutants

There are numerous pollutants that impact our air quality and are monitored on a continuous or intermittent basis in Alberta.

Carbon monoxide (CO) is a colorless, odorless gas formed during incomplete fossil fuel combustion when there is not enough oxygen present to produce carbon dioxide (King's Centre for Visualization in Science, n.d.). Sources of CO include vehicle emissions, gas appliances, blocked fireplaces, charcoal grills and smoking (Alberta Capital Airshed, n.d.). CO is toxic to all humans and animals. Patients who suffer from CO poisoning show a range of clinical presentations including: headache, dizziness, coma, and even death (Shochat, 2017).

Nitrogen oxides (NOX) are most commonly found in the form nitrogen oxide (NO) and nitrogen dioxide (NO₂). They are produced during high temperature combustion of fossil fuels, such as in motor vehicles, power plants, furnaces, and space heaters. Typically these sources release NO, which is quickly changed to NO₂ when NO reacts with ozone (O₃) in the atmosphere. NO₂ is a reddish-brown gas with a sharp sweet-smelling odour that has been linked to respiratory disease and contributes to acid rain (Alberta Capital Airshed, n.d.).

Ozone (O₃) is found naturally in the atmosphere and is a component of smog. Stratospheric ozone is formed by reactions involving oxygen and light from the sun. It is an important component of our atmosphere as it protects us from too much UV radiation. Ground-level ozone, on the other hand, is produced by human activity and can be harmful to our health (King's Centre for Visualization in Science, n.d.). At normal concentrations, O₃ is an odorless colourless gas, but at concentrations over 1 part per million (ppm) it has a metallic or "clean" smelling odour. Tropospheric O₃ is a secondary pollutant created through chemical reactions between nitrogen oxides and volatile organic compounds (VOCs). These reactions contribute to the production of photochemical smog; a visible brown haze commonly noticed in highly populated areas (Energy Education, 2015). The largest sources of tropospheric O₃ are vehicle exhaust and chemical solvents (a substance that dissolves a solute to produce a solution) as they produce the nitrogen oxides and VOCs that lead to the production of O₃. Lightning and some vegetation species also emit ozone (Alberta Capital Airshed, n.d.).

Sulfur dioxide (SO₂) is a colourless gas with a strong odour (similar to matches) that comes from both natural and man-made sources, primarily the processing and combustion of fossil fuels containing sulfur. SO₂ reacts in the atmosphere to form sulfuric acid, contributing to acid precipitation. It can also combine with other atmospheric gases to produce fine particulate matter (Alberta Capital Airshed, n.d.). In Alberta over half of atmospheric SO₂ comes from natural gas processing plants. Oil

sands facilities and coal-fired power plants are also major sources (Alberta Environment and Parks, n.d.).

Hydrogen sulfide (H_2S) is a colourless gas with a rotten egg odour and is commonly produced by natural gas processing plants, petroleum refineries, and animal feedlots. H_2S in natural gas makes the gas “sour,” making it hard to store and ship due to the damage it causes to equipment and piping (Alberta Capital Airshed, n.d.). H_2S occurs naturally in the body and the environment but in high concentrations becomes harmful, with a similar toxicity to CO (Wikipedia, 2018). Our body uses small amounts of H_2S as a signaling molecule, but a few breaths of air containing high concentrations of this substance can cause death (Prostak, 2013).

Particulate matter (PM_{10} , $\text{PM}_{2.5}$) consists of a mixture of particles ranging from 10 micrometers (μm) in diameter (PM_{10}) that can be inhaled, to less than 2.5 μm in diameter ($\text{PM}_{2.5}$) that can become trapped in the airways and lung tissue and may also reduce visibility. PM_{10} particles include wind blown soil, dust, particles from industrial activities. $\text{PM}_{2.5}$, also known as fine particulate matter, comes from gases released into the atmosphere by combustion processes, such as forest fires (Alberta Capital Airshed, n.d.).

Total hydrocarbons (THC, CH_4 , NMHC) are a family of chemicals that contain carbon and hydrogen. CH_4 , or methane, is a non-reactive hydrocarbon and the hydrocarbon that is most commonly found in our atmosphere. Other non-methane hydrocarbons can react with nitrogen oxides in sunlight to form ozone. Sources of hydrocarbons include vegetation, vehicle emissions, gasoline storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, and aircraft traffic (Alberta Capital Airshed, n.d.). Hydrocarbons can also be emitted by the evaporation of solvents, leaking valves, and pumps and compressors at industrial facilities. Vehicles are the major source of hydrocarbons in urban locations (Alberta Environment and Parks, n.d.).

Methane (CH_4) is a colourless, odourless gas. It is the main component of natural gas and is used as fuel (Alberta Capital Airshed, n.d.). The main impact of methane on a global scale is as a greenhouse gas. Methane is produced naturally by wetlands and oceans, but it is also produced during the production, transportation and use of fossil fuels. Livestock farming is also a source of methane (What's Your Impact, n.d.).

Lead (Pb) is a metal that can be found in our air as a constituent of particulate matter. Using lead as an additive in fuels for decades has resulted in its continued presence in our atmosphere. Leaded fuel products have been phased out of use, but lead continues to be present in the atmosphere (King's Centre for Visualization in Science, n.d.).

Ammonia (NH_3) is a colourless gas with a strong odor found in household cleaners. It is produced by both natural and human sources. In Alberta, the fertilizer industry is the main industrial source of NH_3 , followed by commercial feedlots as NH_3 is produced during the decay of plant and animal waste (Alberta Environment and Parks, n.d.).

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of chemicals that are formed during incomplete combustion of gasoline, diesel, oil, coal, wood, garbage, or other organic substances. Tobacco smoke and charbroiled meats are other sources of PAHs. These substances usually occur as mixtures rather than single compounds. People can be exposed to these chemicals through breathing, eating or drinking, or even touching substances that contain PAHs (Alberta Environment and Parks, n.d.).

Volatile Organic Compounds (VOCs) include a large group of chemicals containing carbon and hydrogen atoms that can react quickly to form other chemicals in the atmosphere. They can react with oxides of nitrogen in the presence of sunlight to form ozone and photochemical smog, and they can be toxic to humans, animals or vegetation. VOCs come from vegetation, vehicle emissions, gasoline dispensing and storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustion and aircraft emissions. Natural sources (forests, swamps, etc.) are estimated to contribute almost 6 times more VOCs than human sources. VOCs can be released indoors by furniture, paint, adhesives, draperies, carpeting, spray cans, cleaning compounds and other household products. Indoor concentrations are usually higher than outdoor concentrations (Alberta Environment and Parks, n.d.).

Sources

The pollutants listed above come from both human activity and natural sources. There are three main types of emission sources:

1. Point Sources – factories, industry, electrical power plants, etc.
2. Non-Point/Mobile Sources – cars, trucks, lawnmowers, airplanes, etc.
3. Natural Sources – trees, vegetation, gas seeps, wetlands, etc.

The Government of Alberta regulates emissions from point sources through approvals under the Environmental Protection and Enhancement Act. Approvals cover all phases of an industrial operation and may require operators to minimize pollution, install control measures, or a combination of both. A facility is allowed a maximum amount of pollution based on models and impact assessments.

Non-point source emissions (such as from vehicles) are not easily regulated. Typically these emissions are managed during the manufacturing phase (i.e. production of the vehicle) and through public awareness efforts, such as no idle education (Fort Air Partnership, n.d.).

It is important to know that certain pollutants can react with other substances in the environment to form different pollutants. Nitrogen oxides, for example, are involved in complex reactions that increase the level of atmospheric particulate matter. Primary pollutants are those that are emitted directly from a source. Secondary pollutants are those that result from reactions involving primary pollutants (King's Centre for Visualization in Science, n.d.).

Ambient Air Quality Objectives (Alberta)

Alberta's Ambient Air Quality Objectives are meant to provide protection of the environment and human health in a way that is technically and economically feasible, as well as socially and politically accepted. The objectives are used to:

- Assess compliance near major industrial air emission sources
- Establish approval conditions for regulated industrial facilities
- Evaluate proposals for constructing facilities
- Guide special ambient air quality surveys
- Inform Albertans on air quality through an air quality index
- Report on the state of Alberta's atmospheric environment

The objectives are based on scientific, social, technical and economic factors that consider: monitoring, natural levels and fluctuations, sensitive environmental receptors (i.e. an organism's sensitivity to the pollutant throughout its lifecycle), substance behaviour in the atmosphere, substance behaviour in the environment (i.e. bioaccumulation), and technological availability.

The Air Quality Objectives and Guidelines Summary can be found online here:

<http://aep.alberta.ca/air/legislation-and-policy/ambient-air-quality-objectives/documents/AAQO-Summary-Jun29-2017.pdf>

(Alberta Environment and Parks, 2018)

Environmental Impacts

Human activity can compromise the atmosphere and its protective properties through the release of pollutants. For example, the temperature on Earth is regulated predominantly due to the effects of greenhouse gases (GHGs) in our atmosphere such as carbon dioxide, methane and water vapour. These gases help to "trap" warm air in the atmosphere by absorbing the infrared radiation that the earth emits back into space. Without GHGs the average temperature on Earth would be -18°C . However, we have significantly increased the rate at which GHGs enter the atmosphere since the industrial revolution (King's Centre for Visualization in Science, n.d.). The burning of fossil fuels in motor vehicles, industrial activity, and power production release carbon dioxide into the atmosphere. In addition landfills, natural gas and oil use, agriculture, and coal mining produce methane. Both of these substances are GHGs, and the accumulation of these gases in the atmosphere contributes to climate change (Fort Air Partnership, n.d.), resulting in increased global temperatures, increased frequency of extreme weather events, and rising sea levels.

High levels of air contaminants can result in smog, which is primarily made up of ground-level ozone and particulate matter. Smog causes plants to grow more slowly and become vulnerable to disease, pests, drought and cold (Fort Air Partnership, n.d.). Ground-level ozone is effectively toxic to plants, interfering with photosynthesis (King's Centre for Visualization in Science, n.d.).

Air pollution can also result in acid deposition (the transfer of acidic substances in the air onto surfaces). Sulfur dioxide and nitrogen oxides are the primary components of acid precipitation (Fort Air Partnership, n.d.). Acid precipitation forms when these pollutants dissolve in water droplets, making them acidic, or when the oxidation products of SO_2 and NO_2 are found in particulate matter. Natural precipitation has a pH of approximately 5.6 due to the presence of dissolved CO_2 . Acid precipitation, on the other hand, results from the presence of other acids, such as sulfuric acid or nitric acid, or acid-forming substances such as sulfate and nitrate ions. These substances cause the pH of acid precipitation to be much lower. Because the pH scale is logarithmic, a drop in pH by one point represents a ten-fold increase in acidity (King's Centre for Visualization in Science, n.d.).

Monitoring Methods

There are three methods for monitoring air quality in Alberta: continuous, intermittent and passive. Continuous monitoring provides nearly instantaneous measurements of pollutant concentrations. Air is drawn into a commercial analyzer that has been calibrated to produce an output that is proportional to the ambient pollutant concentration. Data is stored in one-hour time blocks. Intermittent monitoring involves collecting 24-hour average pollutant concentration, once every 6th day. This

method involves collecting pollutants using reactive tubes, absorbents or filters. The samples provide a more detailed look at air quality but need to be analyzed in a lab to determine air pollutant levels, meaning data may not be available for several months. Finally, passive monitoring involves passive samplers collecting air pollutants without the need for electricity, data loggers, or pumps (unlike continuous and intermittent monitoring). Pollutants transfer from the air to a reactive surface and lab analysis is needed to determine concentration. This method is used for long-term trends and can be used in a network over large spaces to understand the spatial variance in pollution levels (Alberta Environment and Parks, n.d.).

Nitrogen oxides are measured continuously using the principle of chemiluminescence. The air sample is split into two pathways. The first pathway is to measure NO; it goes directly into the analysis chamber and is mixed with O₃ in a reaction that produces light. The amount of light that is detected is proportional to the NO concentration and is the measurement of NO in the sample air. In the second pathway, a catalytic converter is used to change all of the NO in the sample into NO₂. A catalytic converter is a device that catalyzes redox reactions, in this case a molecule of oxygen is added to NO to produce NO₂ in an oxidation reaction. The sample then goes into the analysis chamber. The amount of light detected is the sum of NO and NO₂. The difference in the readings between the two pathways is calculated and is the concentration of NO₂ (Alberta Environment and Parks, n.d.).

Carbon monoxide (CO) is continuously monitored by either non-dispersive infrared photometry or gas filter correlation. Non-dispersive infrared photometry is a process based on the absorption of infrared light by CO. Gas filter correlation is operated on the same principle, but is more specific to CO because it eliminates water vapour, CO₂ and other interferences allowing for more precise results (Alberta Environment and Parks, n.d.).

Ozone (O₃) is monitored continuously using ultra-violet (UV) light. The air sample is exposed to UV light which is absorbed by O₃. The amount of UV light that is absorbed is proportional to the amount of O₃ in the sample. The more UV light that is absorbed, the greater the amount of O₃ that is present (Alberta Environment and Parks, n.d.).

Sulfur dioxide (SO₂) is continuously monitored by pulsed fluorescence. Air is drawn through a sample chamber where it is irradiated with pulses of UV light. Any SO₂ in the sample is excited to a higher energy level. When it returns to its ground state, light or fluorescence is released. The amount of fluorescence measured is proportional to the concentration of the pollutant (Alberta Environment and Parks, n.d.). Hydrogen sulfide (H₂S) is monitored with the same method. Initially all of the SO₂ is scrubbed out of the sample so that it does not interfere with the measured H₂S concentration (Alberta Environment and Parks, n.d.).

Particulate matter is monitored using Beta attenuation or Tapered Element Oscillating Microbalance (TEOM). For both methods, particle sizes (PM₁₀, PM_{2.5}) are aerodynamically separated before analysis. Beta attenuation involves particle matter being deposited onto filter tape and emitted beta rays (high energy, high speed electrons emitted by radioactive substances) being attenuated, or slowed, as they pass through the sample. Readings from this process are then converted into mass concentrations. TEOM has the air sample pass through a filter that is attached to a tapered element in the mass transducer. The element naturally vibrates its frequency. As particles are deposited onto the filter the oscillating frequency changes in proportion to the amount of mass deposited. Particulate matter is also monitored on an intermittent basis using a dichotomous sampler. The sample aerodynamically separates the two size fractions (PM₁₀, PM_{2.5}). The particles are collected by drawing a known volume of air through two filters for a 24-hour period. The total particulate concentration in the two size ranges may then be calculated for the 24-hour period (Alberta Environment and Parks, n.d.).

Hydrocarbons are monitored continuously by a hydrogen flame ionizer detector. Hydro-carbon bonds are broken when burned creating ions that conduct electricity. An electrical current can then be measured by an electrometer (an instrument that measures electrical charge) to give a signal proportional to the number of ions (Alberta Environment and Parks, n.d.).

Polycyclic Aromatic Hydrocarbons (PAHs) are analyzed in total suspended particulate samples every 6th day. The samples undergo laboratory analysis using gas chromatography/mass spectrometry. Gas chromatography (GC) is a process that allows you to separate and identify gases based on the compounds boiling point and relative molecular weight. Mass spectrometry, which analyzes masses within a sample, is paired with GC for more precision. The specific PAHs that are monitored are benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, indeno(1,2,3-c,d)pyrene, benzo(k)fluoranthene and benzo(g,h,i)perylene (Alberta Environment and Parks, n.d.).

VOCs are monitored continuously by gas chromatography or intermittently using a stainless steel electropolished (SUMMA) canister. For the canister sampling method, air samples are drawn into the canister at a constant rate for a 24-hour time period. These air samples are then analyzed by gas chromatography systems using a cryogenic preconcentration technique, which improves GC results, to quantify concentrations of over 150 hydrocarbon species (Alberta Environment and Parks, n.d.).

Monitoring Air Quality in Alberta

Alberta is a signatory to the National Air Quality Management System which is a comprehensive collaborative approach to reduce air pollution in Canada. The System calls for consistency across Canada but also allows flexibility for provinces to achieve optimal air quality outcomes (Government of Alberta, 2017).

Ambient air monitoring in Alberta happens in two ways: community monitoring and perimeter (or fenceline) monitoring. Community monitoring uses permanent monitoring stations to measure the level of air pollution where people live and to track trends over time. Perimeter monitoring involves discrete sampling of substances at various locations along an industrial property boundary to measure the level of pollution leaving a facility. Ambient air monitoring allows the province to assess the impact of releases on the environment, ensure pollution control technologies are operating effectively, and provide data to track trends in environmental performance and effects (Government of Alberta, 2017).

Air quality for industrial facilities is primarily monitored through the environmental assessment, approval and enforcement process. Facility operators are mandated to report ambient air monitoring data and pollution emissions. The nature of these reports is determined through the project approval process (Government of Alberta, 2018).

Air quality in Alberta is collectively monitored by the provincial government, airsheds (see below), the federal government and industry. The data is collected at a network of stations across the country, most of which is sent to airsheds or Alberta Environment and Parks. It is archived online in the Alberta Environment and Park airdata Warehouse. The stations monitor average concentrations of pollutants as well as meteorological factors (Fort Air Partnership, n.d.).

The National Air Pollution Surveillance (NAPS) Network also plays a role in monitoring air quality. The NAPS Network is a joint federal and provincial program that monitors and assesses ambient air quality in urban centers across Canada. Airsheds provide data for this program which allows comparisons across 55 Canadian cities (Fort Air Partnership, n.d.).

Airsheds

Airsheds are not-for-profit, multi-stakeholder organizations that monitor, collect and share information on air quality to the public. There are nine airsheds in Alberta, each with its own geographical zone, that provide data to the airdata warehouse. Because air quality issues are local, these airsheds provide an opportunity for local stakeholders to design local solutions to their concerns when province-wide approaches may not be appropriate. Each airshed is responsible for monitoring and reporting on air quality in the region, and play an important role in developing management plans to deal with air quality concerns. The nine airsheds in Alberta are:

- Alberta Capital Airshed (ACA)
- Calgary Region Airshed Zone (CRAZ)
- Fort Air Partnership (FAP)
- Lakeland Industry and Community Association (LICA)
- Parkland Airshed Management Zone (PAMZ)
- Palliser Airshed Society (PAS)
- Peace Airshed Zone Association (PAZA)
- West Central Airshed Society (WCAS)
- Wood Buffalo Environmental Association (WBEA)

(Alberta Environment and Parks, n.d.)

Indoor Air Quality

The quality of the air in our homes, places of work and recreation facilities is also important to consider as Albertans, and Canadians in general, spend 90% of their time indoors. Indoor air quality is greatly affected by the ambient outdoor air quality, but is also impacted by climate, household products and furnishings, temperature, and building regulations. Climate and weather combined with building structures can result in the growth of mold in households. This mold can then be released into the air and make its way into our respiratory system. Household products and furnishings on the other hand, can release pollutants into the air in our homes, often as volatile organic compounds, and airborne particles and gases (Government of Alberta, 2009).

The factors that impact air quality in our homes include: the type of building, the weather, the quality of the outdoor air, nearby industry, products of combustion during cooking, furnishings, toiletries, cleaning products, and waste. In addition, because we keep our doors and windows closed for most of the year, the toxins and pollutants that are released remain in a relatively closed system (Government of Alberta, 2009).

In offices, shopping centres and schools furnishings again, are the major source of pollutants, but printers, computers, carpets, and painted walls can also generate VOCs. The air quality of commercial centres can also suffer from asbestos found in insulation and the contamination of heating, ventilation and air conditioning systems (Government of Alberta, 2009).

Finally, indoor industrial environments pose significant health effects as the result of poor air quality. Industrial facilities are of special concern because of the proximity of pollutants. These facilities often produce polycyclic aromatic hydrocarbons, pesticides, mercury, lead particles, and sulfur compounds (Government of Alberta, 2009).

Because indoor air quality is affected by numerous factors it is hard to manage and regulate. In Alberta industrial settings are regulated by occupational exposure limits but there is no mechanism in place to manage air quality in our homes. The Alberta Indoor Air Quality Toolkit offers recommendations for appropriate temperature, humidity level, and contaminant concentrations for commercial buildings, but exposure limits for households are only recommended and not enforceable (Government of Alberta, 2009).

AIR QUALITY AND HEALTH

Nitrogen dioxide, ground-level ozone and particulate matter are the pollutants of greatest importance when it comes to health as these contaminants have been found to contribute to cardiovascular and respiratory disease. Depending on a person's state of health and the concentration of pollutants, air pollution can irritate lungs and airways, make it harder to breathe, and worsen chronic illnesses. Children, people participating in outdoor sports or other strenuous activities, people with lung disease, and seniors are high-risk populations who may experience the effects of air pollution more severely (Government of Alberta, 2017).

Particulate matter contains particles that are as small as 2.5 micrometers (μm). For reference, a human hair is about 60 μm in diameter. These small particles are able to pass through our body's protective membranes and can become deeply embedded in our lung tissue, which can lead to respiratory diseases and lung cancer. Continual exposure to fine particulate matter (such as in large cities) can be linked to serious health effects and mortality (King's Centre for Visualization in Science, n.d.).

When inhaled, nitrogen dioxide inflames the lining of the respiratory tract, increasing the likelihood of respiratory disease. NO₂ can also aggravate existing conditions, such as asthma (King's Centre for Visualization in Science, n.d.).

Stratospheric ozone is formed naturally through reactions involving the oxygen and light from the sun. Ozone in the stratosphere is important as it protects the earth from too much UV radiation from the sun. Ground-level ozone, on the other hand, comes from human activity and leads to the production of smog. When O₃ enters our lungs, it can cause coughing, irritation to the airways and increased vulnerability to respiratory infections. Ozone can also aggravate existing conditions (King's Centre for Visualization in Science, n.d.).

Sulfur dioxide can also lead to serious health effects. At high levels, SO₂ is fatal, but at lower levels it can cause eye and respiratory irritation and increases the likelihood of cardiovascular and respiratory disease. Exposure to this substance has also been linked to increased vulnerability to respiratory infections and chronic bronchitis (King's Centre for Visualization in Science, n.d.).

Carbon monoxide is another gas that can cause harmful health effects. CO reduces the amount of oxygen that is able to circulate in our blood because it easily binds to hemoglobin (a protein that carries oxygen). This means there is less hemoglobin available to carry oxygen. Decreased oxygen in the blood can lead to headaches, fatigue, difficulty concentrating or nausea. Exposure to high levels of CO can cause more serious effects and even death (King's Centre for Visualization in Science, n.d.).

Lead found in particulate matter can make its way into the blood stream, and eventually build up in bones. Very young children and pregnant women are especially sensitive to the effects of lead. Exposure can result in learning deficits, behavioral problems, and delayed growth. The substance can cross the placental barrier and affect fetuses. Lead can also impact adults, causing hypertension, decreased kidney function and reproductive problems (King's Centre for Visualization in Science, n.d.).

Albertans can refer to the Air Quality Health Index (AQHI) to protect themselves from the harmful effects of air pollution. The AQHI relates air quality to health, using a scale from 1 to 10. The pollutants measured to calculate the AQHI are carbon monoxide, nitrogen dioxide, ozone, fine particulate matter and sulfur dioxide. (Fort Air Partnership, n.d.)



(Government of Alberta, 2018)

The AQHI also identifies health messages for the general population and at-risk groups.

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population	General Population
Low Risk	1 – 3	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities.
Moderate Risk	4 – 6	Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High Risk	7 – 10	Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High Risk	Above 10	Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

(Government of Alberta, 2018)

The Canadian national Air Quality Health Index (AQHI) represents a mixture of common air pollutants which are known to be harmful to human health. Three pollutants were chosen as indicators of the overall mixture of outdoor air including: ground-level ozone, fine particulate matter, and nitrogen dioxide.

In Alberta the national AQHI was modified to account for additional pollutants and rapidly changing air quality. Hourly pollutant concentrations are compared against Alberta's Ambient Air Quality Objectives and if the following thresholds are exceeded the AQHI value is adjusted to the High or Very High risk value:

- 80 micrograms per cubic metre for fine particulate matter
- 172 parts per billion for sulfur dioxide
- 159 parts per billion for nitrogen dioxide
- 82 parts per billion for ozone
- 13 parts per million for carbon monoxide
- 1 part per million for hydrogen sulfide and total reduced sulfur

Alberta also has a special messaging protocol for odour or visibility events when concentrations of specific pollutants are higher than specified odour or visibility thresholds. When these thresholds are triggered the AQHI value is rated as Low or Moderate risk:

- 25 micrograms per cubic metre for fine particulate matter (based on visibility)
- 100 parts per billion for sulfur dioxide (based on odour)
- 10 parts per billion for hydrogen sulfide or total reduced sulfur (based on odour) (Government of Alberta, 2018).

MANAGEMENT & REPORTING

Management

The air quality data that is collected across the province is used by stakeholders (airsheds, industry, governments, researchers) for numerous purposes including:

- Assessing whether additional industrial activity in an area should be approved
- Establishing operating conditions for approved industrial facilities
- Providing information that helps decision makers develop air quality management policies
- Ensuring pollutant concentrations remain below levels that are considered safe for human exposure
- Assessing how pollutant concentrations compare with government air quality standards
- Supporting policy monitoring programs
- Assessing impacts of local emissions sources on air quality
- Evaluating long-term trends
- Informing the public
- Supporting research efforts
- Validating the accuracy of predictive air modeling computer programs

Overall, the data is primarily used by Alberta Environment and Parks to ensure industrial activities are designed and operated in a way that meets the Alberta Ambient Air Quality Objectives, and to support policy decisions (Fort Air Partnership, n.d.).

Air quality management in Alberta includes a number of elements including the National Air Quality Management System which is a national collaborative approach for reducing air pollution in Canada. Alberta also takes a provincial approach to air quality management with industrial approvals, ambient air monitoring, management frameworks, and regional planning (Alberta Environment and Parks, 2018).

Reporting

Airsheds, industry, Alberta Environment and Parks and the NAPS Network analyze and report on air quality data. Airsheds are primarily responsible for reporting air quality data to the public, often producing annual reports and educational materials. Industry is required to submit monthly and annual compliance reports to the Province. Data collected by industry may also be used to inform public consultation processes. Alberta Environment and Parks uses air quality data to produce numerous reports including the State of the Environment report. Finally, the NAPS network publishes reports that compare air quality with the National Air Quality Objectives under the Canadian Environmental Protection Act and uses the data to evaluate pollution control strategies and identify trends (Fort Air Partnership, n.d.).

DATA SOURCES

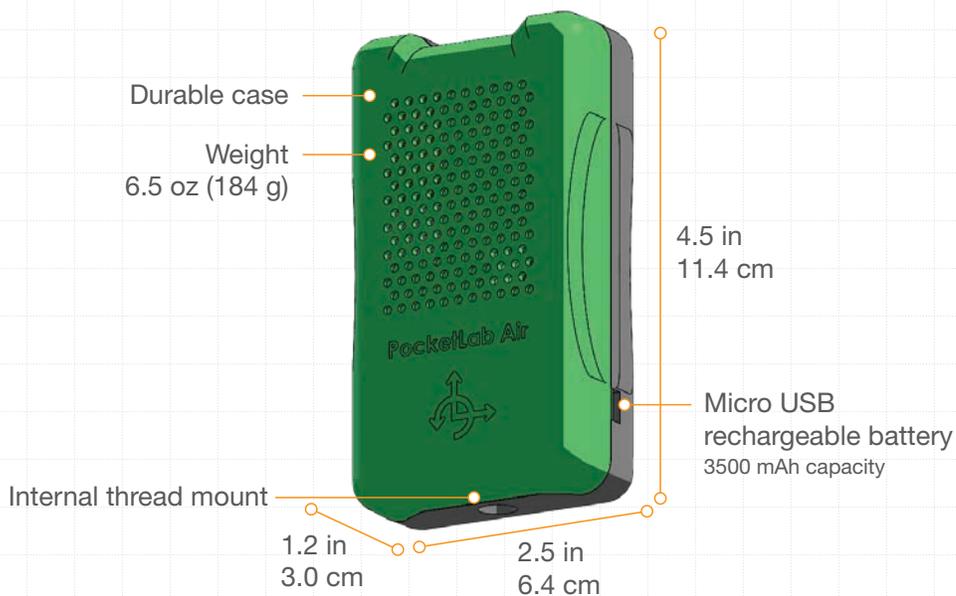
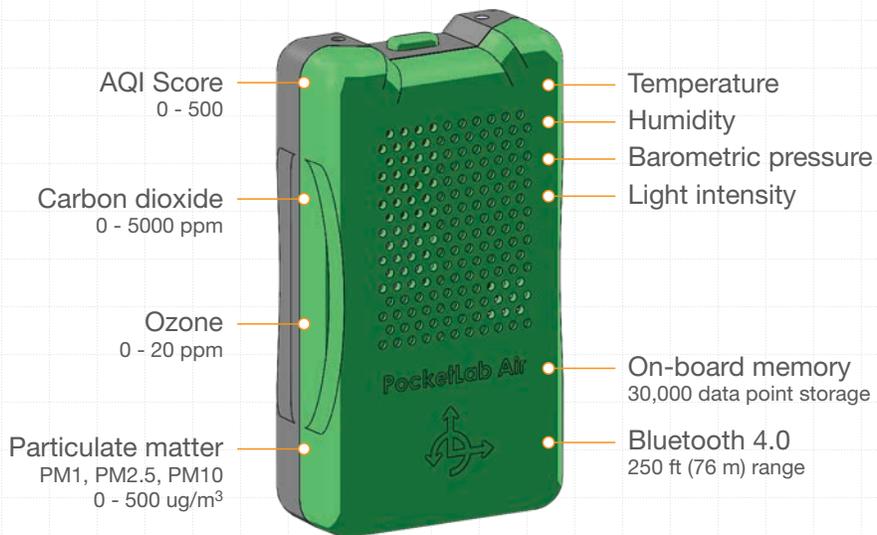
Alberta Environment and Parks Data Warehouse: airdata

Formerly known as the Clean Air Strategic Alliance (CASA) Data Warehouse, Alberta's ambient air quality data warehouse, airdata, was operational in September of 1997. airdata was created in responses to CASA's 1995 strategic plan that recommended a central repository for ambient air and ecological data. The data warehouse would also be responsible for the dissemination of information to a wide range of stakeholders. It is publicly available and contains both archived historical data extended back to 1986 and near real-time, current air quality data (Alberta Environment and Parks, n.d.). <http://www.airdata.alberta.ca/Default.aspx>

Air Quality Health Index (AQHI) Map

Real time air quality data can also be accessed by the public at any time using Alberta's AQHI online mapping tool. The map displays AQHI values for the province, and can be used to search for levels of specific pollutants. Data is stored for the previous 365 days. It is important to note that the data has been uploaded from monitoring stations in real time and therefore has not been checked or cleaned of errors. Data accessed through this site is purely for informational/education purposes (Government of Alberta, n.d.). <http://airquality.alberta.ca/map/>

POCKETLAB AIR GETTING STARTED GUIDE



PocketLab Button

Short button press	Fast red and green flash	Start Bluetooth advertising
Long button hold	Solid red	Power off PocketLab

LED Flashing Codes

Alternating fast red and green flash	PocketLab Air is advertising and ready to connect via Bluetooth
3 blue flashes	PocketLab Air initiated Bluetooth connection to the app
1 violet flash every 5 seconds	PocketLab Air is connected to the app
Alternating slow red and green flash	PocketLab has disconnected from the app is powered on
3 red flashes every 5 seconds	PocketLab battery is low
3 red flashes every 10 seconds	PocketLab battery is changed when connected to micro USB
Orange flashes	PocketLab is downloading stored memory data to the app

App Button Functionality

	Settings, help, and battery meter
	Select sensor graph views
	Memory Data Logging set up
	Select sensor data rate
	Select the graph units
	Select camera mode (iOS only)
	View more options

App Requirements

iOS	iPhone 4s, and newer iPads all except the iPad 1 and iPad 2 iPod Touch 5th gen and newer
Android	Android OS 5.0 and newer Most phones and tablets made since 2013
Windows 10	Native Bluetooth 4.0 support required. Most PCs made since 2013. Updated Chrome browser.
Mac OS	Macbook, Macbook Pro, Macbook Air with OSX 10.11 or later. Updated Chrome browser.
Chromebook	Bluetooth 4.0 support required. Most Chromebooks made since 2013.

App Installation and Setup

1. The PocketLab App is supported on the latest operating system and app versions. Please make sure your OS version and PocketLab App are up to date.
2. Before connecting, go to your device settings and turn Bluetooth ON.
3. For iPhones, iPads, and Android phones, download the PocketLab App from the Apple App Store or Google Play Store.
4. For MacOS, Chromebooks, and Windows 10 devices there is no need to download anything. Make sure you are using the latest version of a Google Chrome web browser and go to thepocketlab.com/app to connect to the PocketLab Web App.

Battery Charging

1. To charge the battery, connect a micro USB cable to the connector on the PocketLab. Plug the USB cable into a USB charger or computer port.
2. The LED will blink **red** every 10 seconds while charging and stop blinking when fully charged.

Connecting to PocketLab from an iPhone, iPad, or Android Phone

1. Launch the PocketLab app.
2. Press the top button on the PocketLab sensor. The LED will flash alternating **red** and **green**.
3. If the PocketLab sensor is in close range to your device, the sensor will connect automatically, and the LED will flash **blue**. If the sensor does not connect, tap on the serial number on the connection screen.
4. When connected to the app, the LED will flash **violet** every 5 seconds.

Connecting to PocketLab from a MacOS, Chromebook, and Windows 10 Device

1. Open a Chrome browser and go to thepocketlab.com/app.
2. Click "Connect to PocketLab."
3. A connection window will appear listing available PocketLabs to connect with.
3. Press the top button on the PocketLab sensor. The LED will flash alternating **red** and **green**.
4. The name of the PocketLab will appear in the connection window. Click on the name of the PocketLab and then click "Pair."
5. When connected to the app, the LED will flash **violet** every 5 seconds.

Display and Record Sensor Data

1. To record data, press the Record button on the graph screen. The current data will clear and the app will record new sensor data.
2. To stop the data recording, press the Stop button.
3. When the data recording has stopped, you can scroll through the graph, zoom in and out, and select graph points to view the data values.
4. Press the Share button to save or export the recorded sensor data.
5. When you are done reviewing or saving your data, press the Clear button to start streaming real-time sensor data gain.

Disconnect the Sensor

1. To disconnect, press and hold the top button on the PocketLab sensor for 5 seconds. The LED indicator will flash red then stop.
2. Exit the PocketLab App.

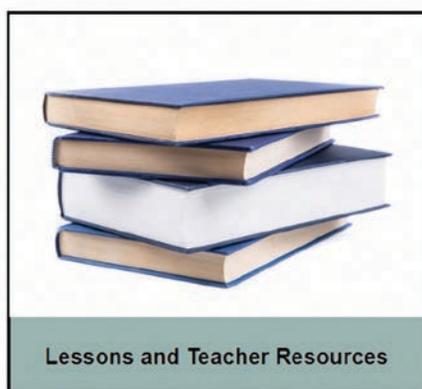
AQHI MAPPING TOOL USER MANUAL

AIR QUALITY MATTERS

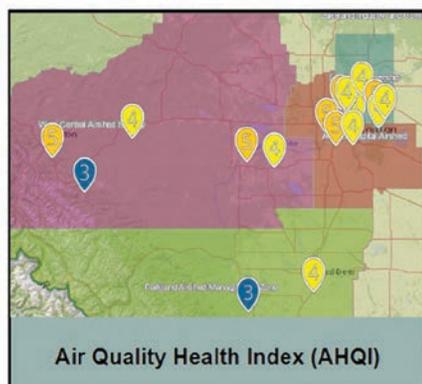
TELUS World of Science – Edmonton worked in partnership with The King's Centre for Visualization in Science from The King's University to develop resources you can access to supplement the workshop and tools presented in these lesson plans. The electronic resources shown below can be found at <http://sensors.kcvs.ca/>.



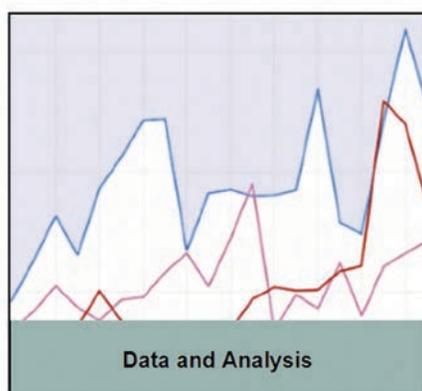
How to use your PocketLab Air, including detailed instructions, updates, possible extensions, and more.



Here you can find more resources on Air Quality including our lessons for Grade 4, 7, 9, and Science 30. As the Alberta curriculum is updated, keep an eye on <http://sensors.kcvs.ca/> and www.twose.ca for current content.



A detailed guide to using the Alberta Air Quality Health Index (AQHI) interactive map.



Many of our lessons involve processing data, a skill that takes time to learn. These tools can help you and your students understand air quality data and how to record and display the data collected with the PocketLab Air.

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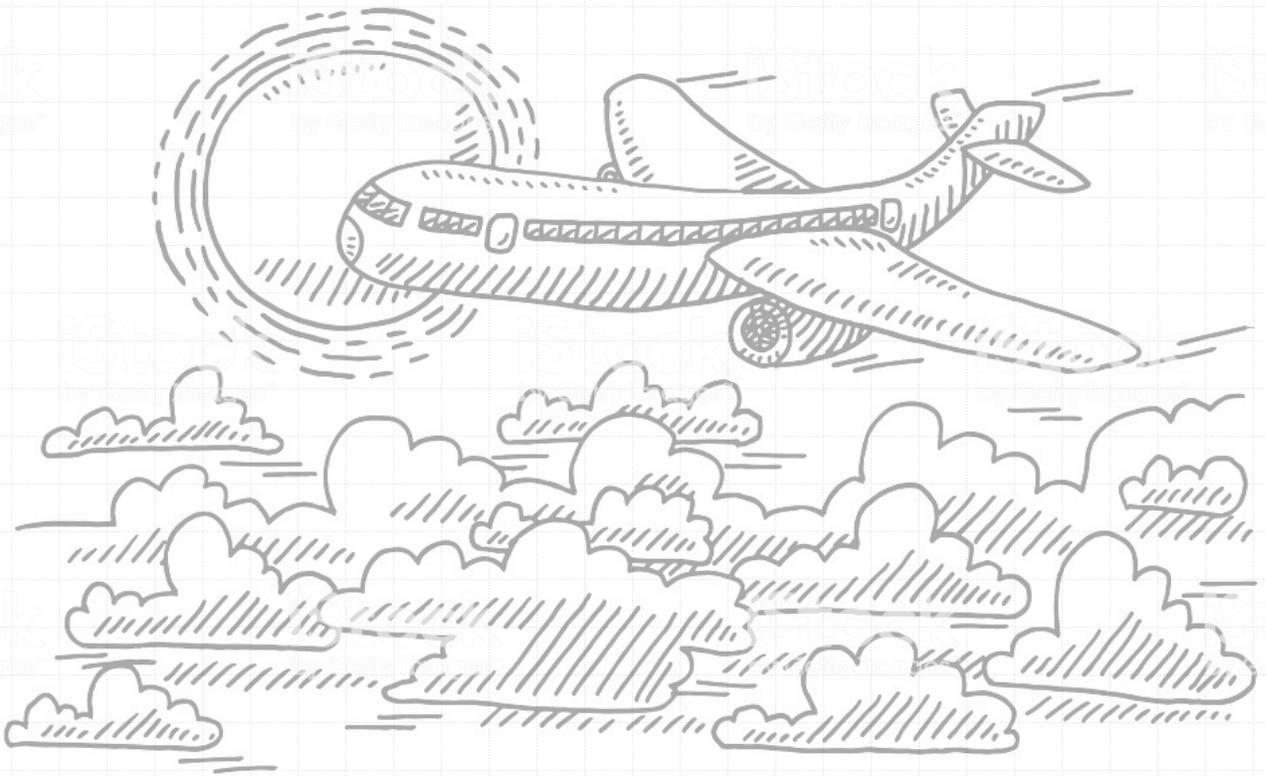
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