Activity 1.1: Think-Pair-Share: Pollution vs Waste

Summary	Together, students propose draft definitions of pollution and waste and infer the definition of a pollutant.
What to do	1. Think-Pair-Share – write the words "**POLLUTION**" on the board and ask students to contribute to the general definition (or part of a definition) on post-it notes (or online brainstorming platform such as Google Jamboard). The nature of student answers may vary, encompassing definitions (or part of definitions), examples, effects or sources of each. 2. Ask students to share their thoughts with their neighbour to come up with a draft definition to share with the class. 3. Whole-class feedback: Create a common *draft* definition of "Pollution". 4. Add the word "**WASTE**" to the board and ask the students to discuss with their neighbour how the terms "Pollution" and "Waste" differ. 5. Whole-class feedback: discussion of the difference between "Pollution" and "Waste". Hint: water is a waste product of combustion; oxygen is a waste product of photosynthesis. 6. Synthesis – stay as true to the students' words as possible to provide co-constructed definitions of the words "pollution" and "waste". In summary, **pollution** is the introduction of substances that are regarded as harmful to human and/or environmental health. Substances produced as a by-product of a process and are no longer useful or required for that process are classified as **waste**. Pollution always carries negative consequences whereas the consequences of waste depend on the perspective. For example, oxygen, the waste product of photosynthesis, is necessary for human life, water is a waste product of combustion, and CO_2 is a waste product of burning fossil fuels. In these examples, O_2, H_20 and CO_2 are all waste products but only CO_2 contributes to pollution. Indeed, some refer to "waste pollution." Furthermore, a country or a city can produce more waste than others, but their waste management system may mitigate their effects (% recovery; treatment) and thus avoid waste becoming pollution. Can students come up with their own examples of pollution and waste? 7. Finally, add the word "**POLLUTANT**" to the board. The students should be able to infer that it is a substance that has the potential to cause pollution (if not managed properly). **EXTENSION ACTIVITIES** Provide students with a mixed list of pollution and waste examples and ask students to classify each one with justifications. Ask students to find a pollutant that was discovered to have human and/or environmental health impacts after we started using it. Examples include DDT, lead in fuel, CFCs, etc.
Materials	• Blackboard/Whiteboard/Interactive whiteboard • Post-it notes • Markers • Optional: Pollutants in Your Environment - Introduction PPT for Classes– slide 3

Activity 1.2: What types of facilities report to the NPRI?

Summary	Students will use NPRI's Student Dashboard to get a sense of the different types of facilities that report to the NPRI. They might be surprised that not all are considered industrial.
What to do	1. Predict: *What types of facilities do/should report to the NPRI?* 2. Record student answers on the board. Anticipated answers might include general categories such as factory or more specific like a pulp and paper mill. To help prompt more specificity, ask students to provide examples of facilities that might manufacture pollutants or produce them as by-products. 3. Introduce students to the NPRI Dashboard (see the first tab for general features of the dashboard which will help students manipulate the data). There is also a visual explanation in the accompanying PowerPoint presentation (see "How does the NPRI Student Dashboard work?"). 4. Students use the NPRI Dashboard to visualize the different types of facilities (industry vs. non-industry – e.g., Canadian Forces Base, University). They can toggle different sectors to get a sense of what types of facilities are listed in the NPRI database. They should pay particular attention to the "Other Manufacturing" and "Other (Except Manufacturing)." They are able to toggle them to see their distribution and to answer the following questions: a) Are all of the facilities industrial? b) Are all the facilities private companies? c) How many facilities reported releasing pollutants in the most recent year? *5. In the NPRI database, the title says "Releases by sector." Who would like to contribute to a definition of the word "sector"? What would be the interest in classifying by sector?* 6. Introduce the concept of a "sector." Businesses are grouped together in sectors, based on the types of activities they carry out to produce goods or services. Classifying by sector enables researchers, governments, businesses, organizations and individuals to look at its data to determine trends. Using the NPRI as a data source, an environmental protection agency could ask "which sector releases the most pollutants to air across Canada?" to determine where to concentrate its efforts. The North American Industry Classification System (NAICS) was developed by the statistical agencies of Canada, Mexico and the United States to provide common industrial definitions that will facilitate production-related analyses of the three economies.
What you need	• Computers with access to the Internet to access the NPRI Student Dashboard Activity 1.2 • Pollutants in Your Environment - Introduction PPT for Classes– slides 4-9

Teacher Backgrounder

NAICS Codes and definitions: North American Industry Classification System: https://www.statcan.gc.ca/en/concepts/industry

Activity 1.3: Introduction to the NPRI

Summary	Teacher presents the NPRI to students using the Intro to NPRI for Schools PowerPoint presentation
Topics	• What is the National Pollutant Release Inventory (NPRI)? • What information is reported to the NPRI? • What information is NOT reported to the NPRI? • How might NPRI data be used? • Examples of university student research projects (using NPRI data) • The NPRI has changed over time • How are substances selected for the NPRI?
What you need	Pollutants in Your Environment - Introduction PPT for Classes – slides 10-17)
What to do	1. Ask students to brainstorm ways in which the following organizations might use NPRI data (see PowerPoint slides): **Environmental protection agencies:** • which facilities in a region have cut back their releases in recent years; • which facilities take pollution prevention measures; • work with facilities to initiate prevention or restoration projects **Public health agencies:** • whether facilities in an area are releasing carcinogenic or toxic substances; • inform the medical community. **Emergency preparedness agency:** • find out which facilities in the area of interest harbour explosive, flammable, poisonous or otherwise hazardous substances; • develop an emergency plan based on which pollutants are present. **Citizen** • Pressure facilities in my neighborhood to adopt more pollution prevention measures; **EXTENSION ACTIVITY** Find organizations that use NPRI data. How do they use the data? Examples could include the Canadian Environmental Law Association (CELA), The Forest Products Association of Canada (FPAC) and National Council for Air and Stream Improvement, Inc. (NCASI), universities (see examples in the PowerPoint presentation), federal/provincial/municipal governments, NGOs, consultants etc. a. Which keywords did you use in your search? b. What is the name of the organization? c. How did the organization use the NPRI data? d. Did the report/article/website use the NPRI data to report positive, negative, or neutral trends? See *NPRI Use in Environmental Research* for further information.

Teacher Backgrounder

National Pollutant Release Inventory: tools and resources The National Pollutant Release Inventory (NPRI) Academic Challenge

The National Pollutant Release Inventory (NPRI) Academic Challenge is a mentoring opportunity offered by Environment and Climate Changes Canada (ECCC) for college, cégep (Collège d'enseignement général et professionnel) and university students. The NPRI is Canada's public inventory of pollutant releases to air, water and land, including pollutant disposals and transfers, from more than 7,000 facilities across various industrial sectors.

The goal of the Challenge is to encourage students to collaborate on current environmental topics and issues of concern and to advance science using actual pollution data from Canadian industries. The Challenge provides real work experience by encouraging students to conduct their own analysis, while also facilitating networking with environmental professionals.

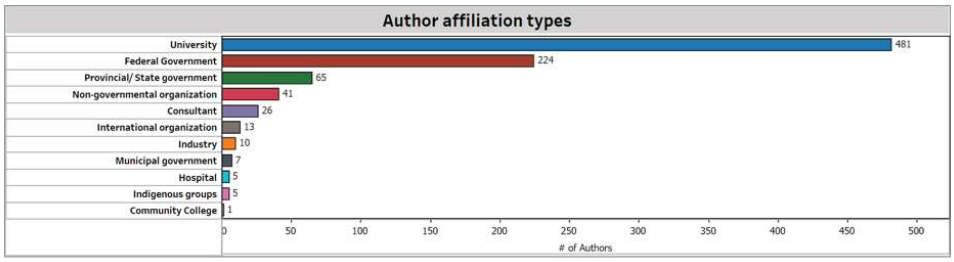
Please consult academic challenge document for more information.

OTHER EXAMPLES OF NPRI DATA USE

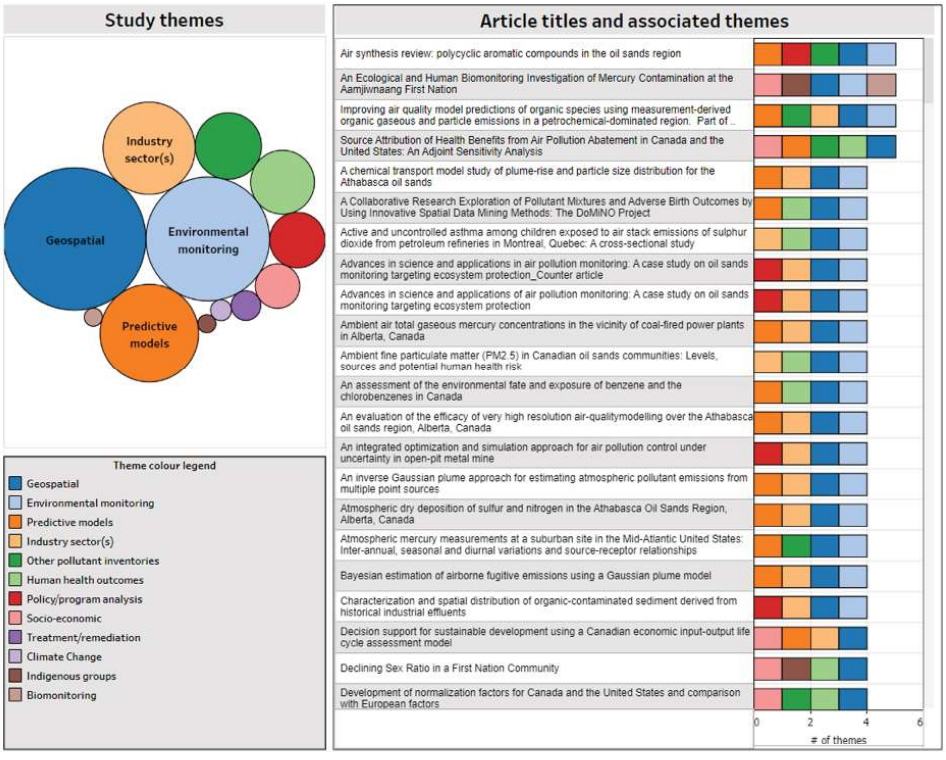
Toronto Star: Poorest areas also most polluted, report shows

Environmental Racism and First Nations: A Call for Socially Just public Policy Development laws and Climate Change and Vulnerable Communities

Use of the National Pollutant Release Inventory in environmental research: a scoping review (Click for full review)



Berthiaume, A. (2020) Scoping review of NPRI-relevant literature_Figure 3 in Tableau Public



Berthiaume, A. (2020) Scoping review of NPRI-relevant literature_Figure 4 in Tableau Public

Activity 1.4: Pollutant Destiny Intro

Summary	Together, students brainstorm different "destinies" for pollutants once they are released. They propose a classification system to group these destinies, drawing a parallel with the brainstorming process involved in developing the International Waste Identification Code (IWIC).
What to do	1. *What happens to pollutants once they are produced by a facility? Where is "away"?* 2. *Whole-class brainstorming session: write all ideas on the board.* 3. *Can some of these destinies be grouped together? If so, which ones?* 4. Distribute the **Pollutant Destiny Infographic** to the students. Do our ideas correspond to the infographic? Are there some categories we hadn't thought of? Are there parallels between the destinies provided by the students and the destinies provided on the infographic? 5. Why would the ministry of Environment and Climate Change Canada want to create a pollutant tracking system? 6. **Synthesis**: Draw a parallel between the brainstorming/classification process you did a moment ago with the work of teams of scientists: it is through many rounds of brainstorming, dialogue and drafts that scientists have been able to reach a consensus to classify pollutant destinies according to this infographic. Scientists from around the world have come together through the OECD to create the International Waste Identification Code (IWIC) to categorize hazardous waste and hazardous recyclable material using common criteria and language. The IWIC is refined regularly with the suggestions and justifications of the OECD members. The National Pollutant Registry Inventory (NPRI) is the branch of the Environment and Climate Change Canada (ECCC) that keeps track of pollutant releases from facilities across Canada. **Teacher Note**: The word "destiny" is chosen somewhat metaphorically to describe the many journeys taken by a pollutant depending on who is releasing it and how it is released.
What you need	• Pollutants in Your Environment - Introduction PPT for Classes – slides 18-19 • Pollutant Destiny Infographic (Student handout) • Pollutant Destiny Glossary (Student handout) – double-side photocopy along with the Infographic as it will be used for Activity 1.5

Teacher Backgrounder

Countries from the OECD (Organisation for Economic Co-Operation and Development) have come together to negotiate international obligations regarding the transboundary movement of hazardous waste and hazardous recyclable materials across international borders.

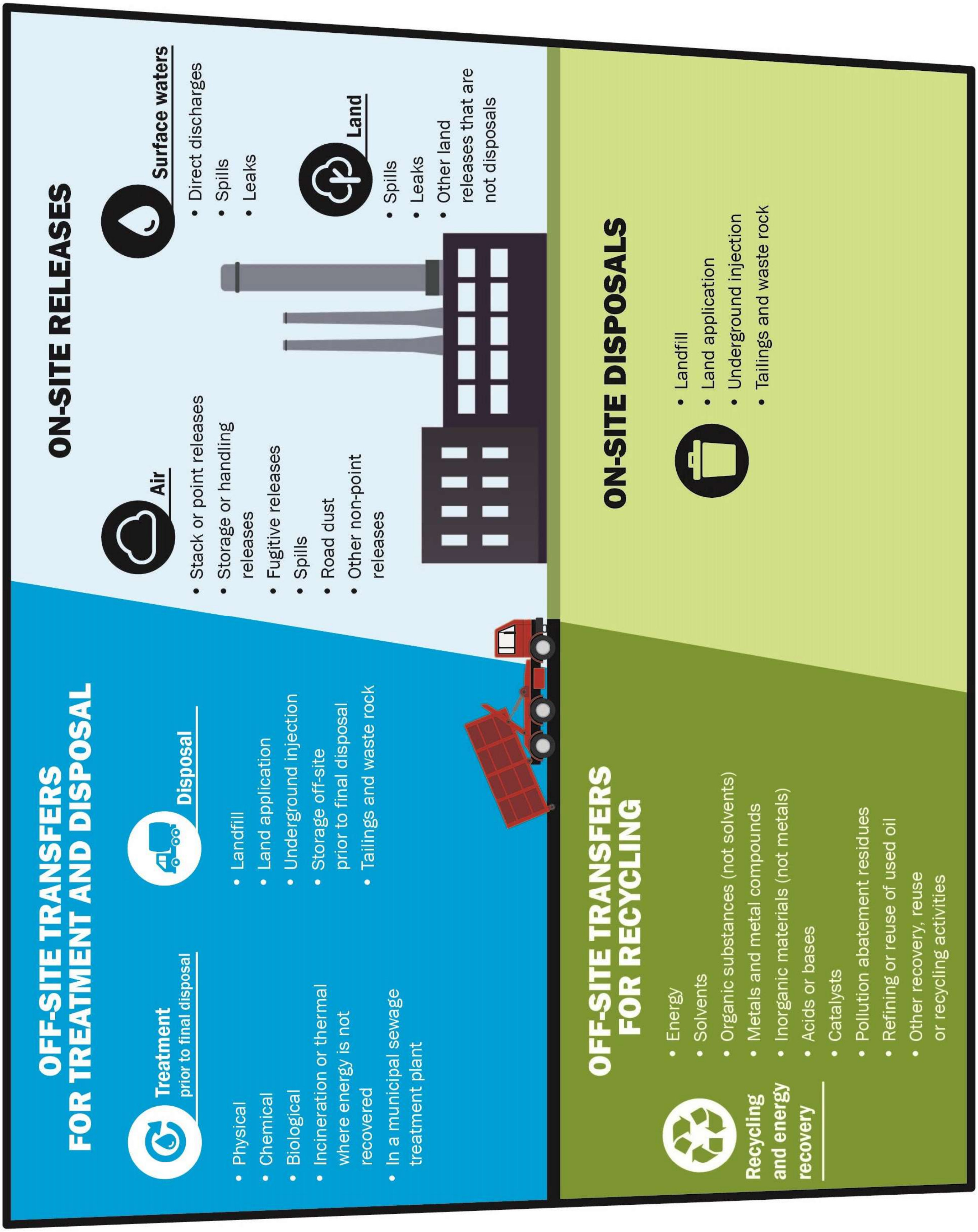
A combination of domestic and internationally recognized codes allows everyone to understand what is being shipped by categorizing waste and recyclables by their:

- Composition or constituents
- Physical or chemical properties
- How they are regulated

The NPRI is part of the OECD's Pollutant Release and Transfer Registers working group. The NPRI classifies substances using the standard chemical abstract service (CAS) registry numbers from the American Chemical Society, and organizes listed substances in five parts, each having different reporting requirements.

See Waste Management in Canada > Hazardous waste and recyclable materials at https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/permit-hazardous-wastes-recyclables/classify.html.

Pollutant Destiny Infographic: Activity 1.4 and 1.5



Activity 1.5: Pollutant Destiny Glossary

Transfers: Movement of a substance to a location off the facility site for treatment prior to final disposal or for recycling and energy recovery.

Off-site Transfers for Recycling and Energy Recovery: activities that prevent a substance from becoming a waste destined for final disposal. A transfer occurs when a substance is moved to a location away from the facility site.

Recyclable materials may:

- be cleaned, regenerated or reprocessed to their original specifications and reused for their original purpose.
- be used for an entirely different purpose without any pre-treatment or modification.
- have parts recovered or reclaimed from the recyclable material.
- be used in the manufacture of another product.
- be sent back to a manufacturer, supplier or recycler for reprocessing, repackaging, resale or for credit or payment.

DESTINY	DEFINITION
Energy Recovery	Substance transferred to a location off the facility site to be used as fuel. Example: wood chips from a mill are sent to a company that packages them and sells them for fuel.
Solvents	The recovery or renewal of substances that have been used as solvents. A solvent is a substance that is used to dissolve other substances. For example, the solvent methanol is distilled to recover pure solvent methanol.
Metals and metal compounds	Metals and metal compounds on NPRI list: aluminum, antimony, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thorium, titanium, vanadium and zinc.
Organic substances (not solvents)	Organic substances (other than solvent) extracted from waste to be reused or sold.
Inorganic materials (not metals)	Inorganic materials (except metals) on NPRI list: ammonia, arsenic, asbestos, boron trifluoride, bromine, carbon disulphide, chlorine, chlorine dioxide, fluorine, hydrazine, hydrogen sulphide, ionic cyanides, nitrate ion, phosphorus and sulphur hexafluoride.
Acids or bases	Acids on the NPRI list: hydrochloric, nitric and sulphuric.
Catalysts	Substances that are recovered, reactivated, regenerated or otherwise renewed for reuse as a catalyst. A catalyst is a substance that speeds up chemical reactions.
Pollution abatement residues	Pollution abatement residues are materials left over from pollution control and/or from removing polluted/contaminated soil, water and air. Abatement means reducing the severity of something.
Refining or reuse of used oil	Lubricating oils are not on the NPRI list of substances (not hazardous). However, used oils are sometimes contaminated with NPRI substances, such as zinc additives. Contaminated oil can be treated to be reused.

Activity 1.5: Pollutant Destiny Glossary cont.

Off-site Transfer for Treatment

Treatment of pollutant before its final disposal to reduce its harmful effects or to make it easier to extract.

DESTINY	DEFINITION
Physical	Process that separate components of a waste stream or change the physical form of the waste without altering the chemical structure of the constituent materials. For example, liquid containing oils or light suspended solids will float to the top and can be removed. It is often a first step to separate the materials so that they can eventually be reused, burned or detoxified by chemical or biological treatment or destroyed by high-temperature incineration. Physical treatments include drying, evaporation, gravity separation, filtration and distillation.
Chemical	Process alters the chemical structure of the pollutant to produce either a non-toxic or a less hazardous material. For example, ultraviolet (UV) ray treatment breaks the bonds of dioxins contained in liquid waste, destroying it. Chemical treatments include neutralization, stabilization, precipitation, oxidation, hydrolysis, redox, UV/Photolysis, vitrification.
Biological	Uses living organisms (e.g., bacteria, plants, yeast or fungi) to treat waste. Some the organisms might digest organic matter around the pollutant making it easy to extract. Others might break down the pollutant to use it as a source of energy, transforming it into a safe form of the pollutant or changed into other substances like carbon dioxide or water. Others might simply absorb the pollutant, making it easier to extract (e.g., lead and copper in the ground can be absorbed by either the roots, shoots and leaves of the sunflower to be collected and destroyed).
Incineration or thermal	Pollutant-contaminated material is destroyed by high heat but is not used as a heat source.
Municipal sewage treatment plant	Contaminated material is sent to a municipal sewage treatment plant where it may be subjected to further treatment and/or disposal.

On-site Disposals or Transfer for Off-Site Disposal

A disposal is the act of placing a substance in an intentional space to reduce its environmental impact, either temporarily (e.g., storage) or as a final destination. The disposal of a substance is different from a direct release to air, water or land.

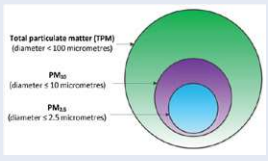
DESTINY	DEFINITION
Landfill	Substances sent to a designated land area (such as a dump or a designated storage facility).
Land application	Substances applied to or incorporated into soil.
Underground injection	Liquid waste stored in an injection well underground.

Activity 1.5: Pollutant Destiny Glossary cont.

Storage or handling releases	Releases from storage or handling of materials, such as storage piles or tanks. For example, releases associated with the transfer, loading and unloading of liquids to and from storage tanks.
Tailings and waste rock	*Tailings* are finely ground waste material, which may or may not be mixed with water, that remain after processing ore (rock containing the valuable mineral, metal, or bitumen). Waste rock is rock that is removed in the mining process to get access to the ore (rock containing the valuable mineral or metal) but that does not contain any mineral or metal of interest. Tailings and waste rock are discarded or stored in a designated area and further managed to reduce or prevent releases to air, water and land.

On-site releases

Direct discharge of a substance to the environment within the physical boundaries of the facility. Includes releases to air, surface waters (oceans, lakes, wetlands, rivers, streams) and land (surface and underground).

DESTINY	DEFINITION
Direct discharges (water)	Releases that are directly discharged to surface waters, including on-site wastewater treatment systems and discharges to sewers. Discharges to municipal or other off-site wastewater treatment facilities are reported as off-site transfers for treatment prior to final disposal.
Fugitive releases (air)	Any leaks, or other non-routine releases of gases, that are unintentional and can't be captured. Includes any other fugitive or non-point air emissions from land treatment, tailings, waste rock, storage piles, etc.
Leaks (water, land)	Leaks differ from spills in that they are chronic events, occurring over a comparatively long time (days, months, etc.).
Other non-point releases (air)	Any other non-point releases to air that are not captured in the other categories
Other releases to land that are not disposals (land)	Substances releases to land that are not spills or leaks and are not for the purposes of disposal, including NPRI substances that are injected underground for purposes other than disposal. For example, using certain solvents to make bitumen extraction easier – a pollutant is released to the land but not for the purpose of disposing it.
Road dust (air)	Total particulate matter, PM_{10} and $PM_{2.5}$ released from road dust must be reported if vehicles travelled more than 10 000 kilometres on unpaved roads at the facility. The subscript refers to their size in micrometres (1 µm= 0.000 001m). 
Spills (air, land or surface waters)	Spills include any accidental releases to air, land or surface waters, normally occurring over a short period of time (hours or days).
Stack or point releases (air)	Releases from stack or other constricted process streams, such as stacks, flares, vents and ducts.

Activity 1.5: Pollutant Destiny Cards

Summary	Students discover where pollutants go once they leave a facility. This activity can either be done together as a whole-class discussion or as an exit card activity. **NOTE**: All companies mentioned in the destiny cards are fictitious.
What to do	1. *Classify the pollutant release scenarios provided on the card into one of the 4 Pollutant Destinies from the infographic. Discuss with your team and provide justifications for your answer, using the Pollutant Destiny Infographic and Glossary.* 2. Whole-class feedback (15 min) • *Were some more difficult than others to place?* • *What happens when one's transfer becomes another's disposal? What information would the NPRI have to collect to avoid double-counting? A facility would have to report the information of the company it transferred it to. That way data users can track the correct amount of the pollutant being released and avoid double-counting it.* • *What is the difference between an on-site disposal vs. a land release? A land release is the release of a substance from the facility site to land, either as a spill, a leak, or as part of a process (e.g., injecting a pollutant to facilitate bitumen extraction). A disposal is the act of putting the pollutant in a place for the purpose of discarding it.* • *Are facilities always able to predict how pollutants are going to be released? Students will notice "fugitive releases and spills".* • *Are facilities obligated to report their pollutant releases? Yes, if they meet the reporting threshold for the substance being released or if certain activities take place at the facility (such as incineration).* • *What is meant by a "circular economy"? Do some of the cards provide an example of a circular economy? Waste from one can be used to run/fuel another or other uses, for example: ashes and sludges can be used as fertilizers for agricultural lands;* **TEACHER TIP** **The cards increase in complexity from 1–9. Expanded explanations for answers are included in the "Notes" section of the PowerPoint slides.**
What you need	• Set of Pollutant Destiny Cards (9 cards). The pollutant destiny card includes the name of a fictitious facility, its sector and what it does with a specific pollutant (release, disposal, transfer). • Pollutant Destiny Infographic and glossary (Student Handout) • Pollutants in Your Environment - Introduction PPT for Classest – slides 20-30

Teacher Backgrounder

Article: Beefed-up Bacteria Get The Lead Out Of Water

Article: Lead absorption mechanisms in bacteria as strategies for lead bioremediation

Hardrock mining waste

Mercury and the environment

What scrap metals are in computers?

Copper Recycling and Sustainability

Activities that might lead to pollutant production

TYPE	ACTIVITIES	EXAMPLES
MANUFACTURE Manufacture means to produce, prepare or compound an NPRI substance. It also includes the incidental production of an NPRI substance as a by-product.	• For on-site use/processing • For sale/distribution • Incidentally as a by-product* • As an impurity	The production of chlorine dioxide by a chemical plant is an example of manufacturing. The production of hydrochloric acid during the manufacture of chlorofluorocarbons is an example of the incidental manufacture of hydrochloric acid.
PROCESS Process means the preparation of an NPRI substance, after its manufacture, for distribution in commerce	• As a reactant • As a formulation component • As an article component • During repackaging • As a by-product*	The use of chlorine to manufacture hypochloric acid (not an NPRI substance) is an example of processing of chlorine. The use of toluene and xylene to blend paint solvent mixtures is an example of processing without changes in chemical form.
OTHERWISE USED Otherwise used (or other use) means any use, disposal or release of an NPRI substance that does not fall under the definitions of manufacture or process.	• as a physical or chemical processing aid • As a manufacturing aid • For ancillary/other use • As a by-product* • Any other releases or disposals of the substance	For example, the use of trichloroethylene in the maintenance of manufacturing and process equipment is an example of an “other use” of that substance.

* The term “by-product” refers to the quantity of an NPRI Part 1 substance that is incidentally manufactured, processed or otherwise used at the facility at any concentration, and released to the environment or disposed of. Some examples of by-products include:

Hydrogen fluoride is incidentally manufactured and released during aluminum smelting. Therefore, the hydrogen fluoride is a by-product and must be included in the calculation of the reporting threshold, regardless of concentration.

Manganese and nickel are incidentally present in coal and are therefore by-products of the coal combustion process. During combustion, a portion of these metals is concentrated in the ash, which is disposed of, and a portion of the metals is released in stack emissions. The weight of the metals released from the stack and in the ash sent for disposal, as well as any other releases or disposals of the metals from the coal combustion, must be included in the calculation of the reporting threshold, regardless of concentration.

What is the circular economy?

The circular economy is a different way of doing business.

The way our economies extract, use, then dispose of resources is putting pressure on our natural systems, communities, and public health. This is a linear economy—it moves in a straight line from resource extraction to waste disposal.

In a circular economy, nothing is waste. The circular economy retains and recovers as much value as possible from resources by reusing, repairing, refurbishing, remanufacturing, repurposing, or recycling products and materials.

Circular economy (Government of Canada)

Explore circular economy initiatives (Government of Canada)

Get involved in the circular economy: Funding opportunities for individuals or businesses (Government of Canada)

World Circular Economy Forum 2021 (Government of Canada)

Pollutant Destiny Cards

CARD 1

Ethylene glycol is an industrial chemical that is used as a component of ice-removing and anti-freeze fluid.

The Airports and Services to Air Transportation sector is by far the largest contributor in terms of quantities, with nearly all of the reported ethylene glycol from de-icing operations. Overall, total releases of ethylene glycol have increased between 2010 and 2019. The annual variability can be explained by variations in winter temperatures, as colder winters would call for more de-icing operations. How would an **airport** report its ethylene glycol release to the NPRI?

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

CARD 2

RedMeat Co, a meat processing plant, sprays ammonium hydroxide to disinfect the fatty trimmings on meat, which have more chances of getting contaminated than other cuts of beef. It reported sending 17 tonnes of ammonia through the sewage system to the local municipal sewage treatment plant (**MSTP**). That **MSTP** reported direct releases of 304 tonnes of ammonia to a river.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

Pollutant Destiny Cards

CARD 3

Tailings are the by-products that remain following the extraction and recovery of valuable minerals from mines. In 2014, **MineLot** mine sent half of its tailings to backfill a nearby mine and the other half was contained in an on-site tailings pond. However, later that same year, the containment pond failed and a significant number of pollutants were released into the Singsong river.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

CARD 4

Nemo, a large underwater surveillance software development company, decides to replace 275 staff computers and laptops which are now 15 years old (a computer contains around 0.7kg of copper wires). They send the computers to **ACME Inc**, which collects electronic waste such as laptops that contain confidential data and environmentally harmful substances. In 2020, **ACME Inc** extracted 170 tonnes of copper from outdated electronics and sent it to **MetRec** for recycling. **MetRec** melts the copper to sell it to customers in sheet form.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

Pollutant Destiny Cards

CARD 5

Jonestrong pulp and paper mill produces waste that contains nitrogen and phosphorus. In 2017, they bought a machine to transform this waste into thick fertilizing mud, filling 4-8 trucks daily to deliver it to nearby farmers' fields. In 2021, 38% of the mud ended up in the landfill due to not being able to find enough farmers who trusted the quality of the mud. **Jonestrong** hopes to someday prevent all of their waste from reaching a landfill.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

CARD 6

PetrolCan, a petroleum refinery that produces lead as a by-product treats 2500kg of lead in its own on-site bacterial treatment plant. Here, the bacteria uses some of the lead's electrons to make energy, reducing the lead's reactivity. Then, **PetrolCan** hires the company **ToxEase** to transport the lead away to be injected into concrete to be further stabilized. Finally, **ToxEase** safely disposes the concrete into one of its storage facilities.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

Pollutant Destiny Cards

CARD 7

Deep in the Earth's crust, naturally occurring metals such as lead and mercury are stable. When a mining company digs up the Earth's surface to extract ore (rock that contains desired substance), these metals undergo chemical reactions when they interact with air and water, making them toxic for human health and the environment. **NorCo**, a copper mining company, sends its tailings containing lead to **Envirillium** where the tailings are treated with genetically-modified bacteria that have lead-binding sites on their cell membrane. The lead-carrying bacteria is heated to isolate the lead, then sent to **RecyMet** where the lead is further refined, packaged and sold on the market.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

CARD 8

Mercury is found naturally in rock deep underground. When it is disturbed through mining or burned in coal or fossil fuels, mercury can form toxic compounds. In 2019, coal-fired power plants released 102,799 kg of mercury. Due to governmental regulations stemming from a United Nations global treaty on mercury, **CoalGen**, a coal-fired power plant, injected bromine into the combustion gas to capture 90% of the mercury. The mercury was then sold to **DuraBat**, a battery manufacturer to produce batteries.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

Pollutant Destiny Cards

CARD 9

SanOil extracts oil sand containing a mixture of sand, clay, minerals, water and bitumen (heavy oil). On site, it separates the bitumen from the mix. Since bitumen is very dense and viscous, it must be processed or diluted. **SanOil** sends 45 tonnes of bitumen containing sulphur to nearby **Slick Inc** to be diluted. **Slick Inc** then sends the diluted bitumen to **TranX**, a refinery that chemically transforms bitumen into crude oil, removing sulphur dioxide in the process. Finally, **TranX** sends the SO_2 to **AgroPlus** in Saskatchewan, where it is transformed into ammonium sulphate that can be sold as a fertilizer.

Classify the pollutant release for each **company** into one of the 4 Pollutant Destinies (see infographic). Provide justifications for your answer. If a **company** doesn't need to report to the NPRI, explain why.

Pollution Destiny Cards (Key)

Card 1. Ethylene glycol is an industrial chemical that is used as a component of ice-removing and anti-freeze fluid**.**

The Airports and Services to Air Transportation sector is by far the largest contributor in terms of quantities, with nearly all of the reported ethylene glycol from de-icing operations. Overall, total releases of ethylene glycol have increased between 2010 and 2019. The annual variability can be explained by variations in winter temperatures, as colder winters would call for more de-icing operations. How would an **airport** report its ethylene glycol release to the NPRI?

- Land release since ethylene glycol is used on the tarmac

Card 2. RedMeat Co, a meat processing plant, sprays ammonium hydroxide to disinfect the fatty trimmings on meat, which have more chances of getting contaminated than other cuts of beef. It reported sending 17 tonnes of ammonia through the sewage system to the local **municipal sewage treatment plant** (MSTP). That MSTP reported direct releases of 304 tonnes of ammonia to a river.

- **RedMeat Co**: Off-site transfer – Municipal sewage treatment plant
- **MSTP**: On-site release to surface waters – direct discharge (MSTP normally discharge into the waterbody they're adjoined to)

Card 3. Tailings are the by-products that remain following the extraction and recovery of valuable minerals from mines. In 2014, **MineLot** mine sent half of its tailings to backfill a nearby mine and the other half was contained in an on-site tailings pond. However, later that same year, the containment pond failed and a significant number of pollutants were released into the Singsong River**.**

- Onsite Disposal: Tailings management
- Transfer for offsite disposal: Tailings management
- Release to water: spill (because it was a significant event over a short period of time)

Card 4. Nemo, a large underwater surveillance software development company, decides to replace 275 staff computers and laptops which are now 15 years old (a computer contains around 0.7kg of copper wires). They send the computers to **ACME Inc,** which collects electronic waste such as laptops that contain confidential data and environmentally harmful substances. In 2020, **ACME Inc** extracted 170 tonnes of copper from outdated electronics and sent it to **MetRec** for recycling. **MetRec** melts the copper to sell it to customers in sheet form.

- **Nemo**: Does not report this transfer since it does not meet the reporting thresholds for copper release

- **ACME**: Off-Site transfer for recycling: recovery of metals and metal compounds
- **MetRec** does not report its activities since it does not release it into the environment

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Card 5. Jonestrong pulp and paper mill produces waste that contains nitrogen and phosphorus. In 2017, they bought a machine to transform this waste into thick fertilizing mud, filling 4-8 trucks daily to deliver it to nearby farmers' fields. In 2021, 38% of the mud ended up in the landfill due to not being able to find enough farmers who trusted the quality of the mud. **Jonestrong** hopes to someday prevent all of their waste from reaching a landfill.

- Onsite Disposal: Land application (considered "on-site" because it is not transferred to another facility for treatment – it is directly applied to the fields from their own trucks)
- Transfer for offsite disposal: Landfill

Card 6. PetrolCan, a petroleum refinery that produces lead as a by-product treats 2500kg of lead in its own on-site bacterial treatment plant. Here, the bacteria use some of the lead's electrons to make energy, reducing the lead's reactivity. Then, **PetrolCan** hires the company **ToxEase** to transport the lead away to be injected into concrete to be further stabilized. Finally, **ToxEase** safely disposes the concrete one of its storage facilities.

- At first glance, students may choose the "bacteria treatment" subcategory. However, since the treatment plant is at its own facility, it does not qualify as an "Off-site transfer - Biological Treatment."
- **PetrolCan** would report that 2500kg of lead was released as "Off-site transfer – Chemical Treatment" since the process involves stabilization of the element.
- **ToxEase** would report the release as "On-Site Disposal – Landfill."

Card 7. Deep in the Earth's crust, natural-occurring metals such as lead and mercury are stable. When a mining company digs up the Earth's surface to extract ore (rock that contains desired substance), these metals undergo chemical reactions when they interact with air and water, making them toxic for human health and the environment. **NorCo**, a copper mining company, sends its tailings containing lead to **Envirillium** where the tailings are treated with genetically-modified bacteria that have lead-binding sites on their cell membrane. The lead-carrying bacteria is heated to isolate the lead, then sent to **RecyMet** where the lead is further refined, packaged and sold on the market.

- **NorCo**: Off-site transfer – biological treatment
- **Envirillium**: off-site transfer for recycling – metals and metal compounds
- **RecyMet**: would not require to report lead to the NPRI since it is not being released in the

environment (although they might report other substances released in the lead-processing procedure)

Card 8. Mercury is found naturally in rock deep underground. When it is disturbed through mining or burned in coal or fossil fuels, mercury can form toxic compounds. In 2019, coal-fired power plants released 102,799 kg of mercury. Due to governmental regulations stemming from a United Nations global treaty on mercury, **CoalGen**, a coal-fired power plant, injected bromine into the combustion gas to capture 90% of the mercury. The mercury was then sold to **DuraBat**, a battery manufacturer to produce batteries.

- **CoalGen** would report an Off-site Transfer: metals and metal compounds
- **DuraBat** is not required to report to the NPRI for mercury since it is not releasing it to the environment

Card 9. **SanOil** extracts oil sand containing a mixture of sand, clay, minerals, water and bitumen (heavy oil). On site, it separates the bitumen from the mix. Since bitumen is very dense and viscous, it must be processed or diluted. **SanOil** sends 45 tonnes of bitumen containing sulphur to nearby **Slick Inc** to be diluted. Slick Inc then sends the diluted bitumen to **TranX**, a refinery that chemically transforms bitumen into crude oil, removing sulphur dioxide in the process. Finally, **TranX** sends the SO_2 to **AgroPlus** in Saskatchewan, where it is transformed into ammonium sulphate that can be sold as a fertilizer.

- **SanOil** does not report its bitumen separation activities since it is done on-site.
- **SanOil** reports the Off-site Transfer: Physical treatment since dilution is a physical process (a solvent is added to substance to dilute it, but the reverse can be done to concentrate it – it is therefore a physical transformation);
- **Slick Inc**: Off-site Transfer – chemical treatment. (Although it will be used to manufacture a new product, it must undergo chemical treatment first)
- **TransX**: Off-site transfer for recycling: Inorganic material – the SO_2 is used in the manufacture of another product
- **AgroPlus**: does not report it as a release since it is not directly releasing it into the environment (it is bagging it to be sold); however, large-scale farming activities would have to report the release as land application

Activity 1.6: Does a pollutant's destiny change based on which type of facility is releasing it?

Summary	Students manipulate the NPRI Dashboard to discover the variety of paths a pollutant can take depending on what type of facility is releasing it. Their task is to compare and contrast three sectors with regards to the release of a chosen pollutant and brainstorm questions from the perspectives of both a geographer and a scientist.
What to do	1. *Does a pollutant's destiny change based on which type of facility is releasing it?* 2. Model the use of the NPRI Dashboard to track the trajectory of one of 14 pollutants of interest*. 3. In teams, students choose one of the 14 pollutants of interest and plug it into the NPRI Student Dashboard. To help them choose, they can see a brief summary of the pollutant by hovering over it and can get a more detailed description by clicking its information button. 4. Task 1: *Compare and contrast the destiny of your pollutant between 3 sectors.* 5. Task 2: *Write down 3 questions that came up when comparing the sectors. For example, "why does X sector have such a high proportion that is recycled?"* 6. Task 3: Brainstorm 4 questions with regards to your data from both a geographer's perspective and a scientist's perspective. What might a geographer want to know (e.g., people, politics, human activities, impacts)? What might a scientist want to know (cause and effect; invention and innovation of technology, environmental and human health impacts)? 7. Whole-class feedback Did focusing on one source in particular change the story? What surprised you or caught your attention? Why does the Canadian Government choose to collect this information? **EXTENSION ACTIVITY:** Students present their work, including environmental/health risks and threshold information for the selected pollutant of interest; OR Enter into a mock NPRI consultative process to convince the class to increase or diminish the threshold of their substance by referring to their research as justification (see Consultation and Engagement: National Pollutant Release Inventory)

TEACHER TIP

Clicking on the (i) symbol next to the pollutant name will bring students to a detailed summary of the pollutant, should they require more detailed information on the the pollutant of interest

What You Need	• Computers with access to the Internet to access the NPRI Student Dashboard Activity 1.6 • Pollutants in Your Environment - Introduction PPT for Classes – slide 31 • Activity 1.6 Student Handout

Teacher Backgrounder

Consultation and engagement: National Pollutant Release Inventory

Example of a submission in the consultative process: NGO comments recent changes to NPRI reporting criteria in New requirements for reporting releases of criteria air contaminants and speciated volatile organic compounds to the National Pollutant Release Inventory

*THE NPRI HAS HIGHLIGHTED THESE POLLUTANTS OF INTEREST BECAUSE:

- they are well known by the public (such as arsenic, mercury)
- the substances are released by a sector of interest to the public and/or stakeholders (such as VOCs and oil sands);
- they link to other "high profile" issues such as climate change and wetland/water quality.

NPRI SUBSTANCES OF INTEREST (LINKS ARE ACCESSIBLE DIRECTLY FROM THE DASHBOARD)

In this activity, the substances are a subset of those found in the Canadian Environmental Protection Act, 1999 (CEPA) List of Toxic substances. These are considered toxic because it is entering or may enter the environment in a quantity or concentration or under conditions that:

a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;

b) constitute or may constitute a danger to the environment on which life depends.

c) constitute or may constitute a danger in Canada to human life or health.

CEPA, 1999 (Section 64)

CAS*	NAME	DETAILED INFORMATION (LINK)**
NA-16	Ammonia	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/ammonia.html
NA-02	Arsenic	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/arsenic.html

CAS*	NAME	DETAILED INFORMATION (LINK)**
NA-03	Cadmium	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/cadmium.html
630-08-0	Carbon Monoxide	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/carbon-monoxide.html
107-21-1	Ethylene Glycol	https://environmental-maps.canada.ca/RAMP-Storylines/index-ca-en.html#/en/ea24000c-7dc3-49a9-baac-c55d28dcaeb9
50-00-0	Formaldehyde	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/formaldehyde.html
NA-08	Lead	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/lead.html
NA-10	Mercury	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/mercury.html
11104-93-1	Nitrogen Dioxide	https://www.canada.ca/en/environment-climate-change/services/air-pollution/pollutants/common-contaminants/nitrogen-oxides.html
PM 2.5	Particulate Matter 2.5 ($PM_{2.5}$)	https://www.canada.ca/en/environment-climate-change/services/air-pollution/pollutants/common-contaminants/particulate-matter.html
NA-M14	Sulfur (Total Reduced)	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/total-reduced-sulphur.html
7446-09-05	Sulphur dioxide	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/sulphur-dioxide.html
7664-93-9	Sulphuric Acid	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/sulphuric-acid.html
NA-M16	Volatile Organic Compound (VOC)	https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/volatile-organic-compounds.html

* The Chemical Abstract Service (CAS) is a unique number given to each substance in the registry.

** NPRI factsheets for select substances are available on their website. If any of the links in the table above no longer work they can all be accessed there.

In determining whether a substance should be declared “toxic” under CEPA, the likelihood and size of releases into the environment and the harm it may cause to human health or ecosystems at levels occurring in the Canadian environment are taken into account. If a substance is found to be “toxic,” the Ministers recommend that the substance be added to the List of Toxic Substances (CEPA, Schedule 1). The federal government then works with the provinces, territories, industry, non-government organizations and other interested parties to develop a management plan to reduce or eliminate the harmful effects the substance has on the environment and the health of Canadians.

To see a complete list of the substances classified by CEPA, please visit CEPA 1999 Schedule 1 - List of Toxic Substances

Reference: Government of Canada – ECCC (2019) Toxic Substances: Definition.

Activity 1.6: Exploring the destiny of a pollutant of interest

Often, scientists and geographers will use NPRI data to investigate a question they have in mind. Sometimes, looking at the data directly will stimulate questions that they wish to pursue. In this activity, you will compare and contrast a pollutant across sectors to see how its destinies differ. The goal of this exercise is to look at the data from both a geographer's and scientist's perspective and imagine the type of questions they would be interested in pursuing.

WHAT TO DO:

1. Go to Activity 1.6 *Exploring the destiny of a pollutant of interest* on the NPRI Student Dashboard: https://public.tableau.com/app/profile/ingenium5439/viz/NPRIStudentDashboard/Instructions

2. Choose one of the 14 pollutants of interest to investigate (Hint: hovering over the pollutant will give you a quick summary about it. If you click one by accident, click it again to reset).

3. Pollutant to investigate: _____

4. Click the sectors one at a time to see how they differ.

5. Compare and contrast 3 destinies with regards to your pollutant. Summarize your observations below.

Activity 1.6: Exploring the destiny of a pollutant of interest

(SEE QUESTIONS ON THE REVERSE SIDE)

1. **Write down 3 questions that came up when comparing the sectors (for example, "Why does X sector have such a high proportion that is recycled?"**

_____

_____

_____

_____

_____

_____

2. **Brainstorm 4 questions with regards to your data from both a geographer's perspective and a scientist's perspective.**

   a. What might a geographer want to know (e.g., social, political, environmental, economic, or patterns and trends, interrelationships, spatial significance)?

   Question 1: _____

   _____

   Question 2: _____

   _____

   b. What might a scientist want to know (e.g., cause and effect; invention and innovation of technology, environmental and human health impacts)?

   Question 3: _____

   _____

   Question 4: _____

   _____