
Framework for Pesticide Water Monitoring Programs in Canada



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Executive summary

Health Canada's Pest Management Regulatory Agency (PMRA) makes timely, science-based decisions to support the safe and sustainable use of effective pesticide products in Canada.

This involves:

- putting in place strong human and environmental health and safety
- ensuring strong oversight of currently registered pesticide products
- improving the availability of real-world data to support pesticide review decisions
- ensuring that the decisions we make are transparent

A key element to making timely, science-based decisions is generating and disclosing real-world data across the country.

This document outlines a framework for pesticide water monitoring programs in Canada that reflects information gathered from numerous consultations with partners and stakeholders. It contains guidance and recommendations that organizations can voluntarily use to design an effective pesticide monitoring program.

It is expected that data generated by following this framework could be effectively shared and used by relevant organizations including the PMRA to make regulatory decisions on pesticides.

By following the guidance outlined in this framework, the PMRA is developing a long-term water monitoring program for pesticides. A Canadian water monitoring program for pesticides managed by the PMRA is not intended to replace existing water monitoring programs in Canada. It is intended to supplement and strengthen existing programs through collaboration and partnerships.

This framework describes steps for:

- Designing a water monitoring program:

- identifying areas of interest
 - selecting a site
 - coordinating with partners
 - deciding on frequency and timing of sampling and sampling methods
- Collecting secondary information:
 - metadata
 - water quality parameters
- Deciding on which pesticides and transformation products to look for:
 - reference values
 - laboratory analyses
- Managing and reporting data:
 - reporting
 - interpreting
 - listing in a database
 - publishing

- Collaborating with Indigenous partners

This framework outlines the key elements for effective water monitoring programs for pesticides while recognizing that evolving science and program needs may warrant changes over time.

This framework is not a description of the PMRA's long-term program, the Canadian Water Monitoring Program for Pesticides (CWMPP).

Purpose of a water monitoring framework

The PMRA makes timely, science-based decisions to support the safe and sustainable use of effective pesticide products in Canada. In 2021, the federal government committed, through additional funding to PMRA, Environment and Climate Change Canada (ECCC) and Agriculture and Agri-Food Canada (AAFC), to strengthen human and environmental

health and safety by increasing oversight and protection related to pesticide registration. This included increasing the availability of independent, real-world data to support pesticide review decisions.

- The PMRA used the dedicated funding to develop this framework and undertake a short-term, small-scale water monitoring pilot program for pesticides. This framework, along with lessons learned from the pilot program, are being used to develop a Canadian water monitoring program for pesticides (CWMPP) managed by the PMRA.

The goal of this document is to provide guidance to coordinators of water monitoring programs in Canada on the collection of high-quality real-world data on concentrations of pesticides (and their transformation products) in water. Through following this framework, it is expected that data will:

- inform regulatory decisions for the protection of human health and the environment
- inform prioritization of pesticide re-evaluations
- guide implementation strategies for best management practices
- improve collaboration
- increase public confidence in the pesticide regulatory system
- inform other initiatives such as the Kunming-Montreal Global Biodiversity Framework

It is expected that this guidance will lead to greater consistency in water monitoring programs for pesticides across the country. Building upon the expertise, experience and contributions of different organizations can enhance our collective pesticide monitoring programs. To avoid duplication and provide the information required across the various mandates and agencies, close cooperation and collaboration is needed among federal and provincial governments and interested stakeholders in Canada.

Learn more:

- [Kunming-Montreal Global Biodiversity Framework](#)

How the framework was developed

The PMRA developed this framework in collaboration with national partners (other federal departments, provincial and territorial governments) and stakeholders (non-governmental organizations, industry, growers' associations, Indigenous communities and academia) that have an interest in protecting freshwater resources.

The PMRA consulted partners and stakeholders in various ways, including a Federal-Provincial-Territorial (FPT) survey and technical working group (TWG) sessions. Input on the framework development was also sought from PMRA staff and the PMRA's Science Advisory Committee on Pest Control Products.

The survey of federal, provincial and territorial governments received responses from:

- 3 Government of Canada representatives
- 17 provincial and territorial government representatives

The Technical Working Group sessions (TWG) consisted of:

- 51 federal, provincial and territorial participants
- 12 Growers Association
- 10 industry participants
- 9 academia participants
- 3 non-government organization participants

Learn more:

- [Science Advisory Committee on Pest Control Products](#)
- *Towards a national-scale water monitoring program for pesticides* — [What we heard](#)

This framework was also informed by a 2-year pilot program that enabled the PMRA to explore how to effectively design a long-term collaborative national-scale monitoring program. Running a pilot program on a smaller scale was also intended to enable the

Government of Canada to identify and address area for improvement and determine how to operate an effective program before expanding to a broader, national scope.

Samples were collected in all provinces in collaboration with federal governments:

- Agriculture and Agri-Food Canada
- Environment and Climate Change Canada

As well as with the following groups:

- Watershed alliances
- Provincial governments
- Indigenous communities
- Conservation Authorities

The pilot program laboratory analysis partners included:

- Health Canada
- Agriculture and Agri-Food Canada
- University of Guelph
- University of Manitoba

Results from the pilot program are available on the Open Government Portal, with additional details found on the PMRA website.

To access the raw data, consult the [Open Data](#) portal.

To visualize the results, consult the [water monitoring for pesticides dashboard](#).

For more details, visit [Water monitoring for pesticides](#).

Pesticide management in Canada

Laws and regulations

In Canada, the regulation of pesticide products is achieved using pre- and post-market scientific regulatory assessment, enforcement, education and communication with the public. The federal government registers pesticides when they are determined to present no unacceptable risks to human health and the environment. At the federal level, Health Canada's PMRA is responsible for the regulation of pest control products under the authority of the *Pest Control Products Act* (PCPA).

Learn more:

- [*Pest Control Products Act*](#)

The provinces and territories are responsible for the sale, use, management, storage and disposal of pesticides. These responsibilities are achieved using a combination of acts, regulations, guidelines, directives and bylaws. Provinces and territories can enact regulations to further restrict or prohibit the use of pesticides registered under the PCPA in their jurisdictions. All provincial and territorial governments in Canada have laws designed to minimize the risk to human health and the environment from pest control products.

Municipalities play a complementary role in protecting human health and the environment through the treatment and delivery of drinking water, sewage treatment, solid waste, land use and local transportation. In recent years, numerous municipalities in Canada have enacted by-laws restricting the use of pesticide products within municipal limits.

All levels of government require up-to-date information on the presence of pesticides in the Canadian environment to inform regulatory, policy and management decisions.

Learn more:

- [Fact sheet on The regulation of pesticides in Canada](#)
- [Presence and levels of priority pesticides in selected Canadian aquatic ecosystems](#)

Pesticide registration

Before a pesticide can be registered for sale in Canada, it must undergo substantial testing. Pesticide manufacturers are required to provide the PMRA with extensive scientific

data. The data must demonstrate that risks following the use of the product are acceptable and there is reasonable certainty that no harm to human health, future generations or the environment will occur. They must also show that the pest control products have value. These data are reviewed by PMRA regulatory scientists to determine whether a product is acceptable for registration in Canada. The PMRA holds public consultations on their assessments prior to publishing final decisions.

Once registered, pesticides on the market become subject to a system of post-market risk management controls under the PCPA. This includes re-evaluation and special reviews of registered pesticides, sales reporting, compliance and enforcement activities, and reporting of health and environmental incidents.

Learn more:

- [Pesticide registration process](#)
- [Framework for risk assessment and risk management of pest control products](#)
- [Pesticides and pest management consultations](#)
- [Decisions and updates](#)
- [Re-evaluation program](#)
- [Mandatory pesticide sales reporting](#)
- [Pesticides compliance and enforcement: overview](#)
- [Report a pesticide incident](#)

Water monitoring data in pesticide risk assessments

The PMRA uses monitoring data in multiple ways, including risk assessment and continuous oversight.

Risk Assessment

Water monitoring data are routinely considered in both the human health and environmental risk assessments within PMRA's regulatory decision process. For the data to be used in regulatory decisions, it must be reliable, relevant and robust. Historically, available water monitoring data were largely insufficient for pesticide regulatory decision-making.

Reliable — Reliability of the data can be equated to data quality or soundness of the monitoring data. Additional information related to the collection and analysis of water samples improves the reliability of the results. This information includes raw data points, limits of detection (LOD), limits of quantification (LOQ), number of samples, sample date, sample location and associated quality assurance and quality control records.

Relevant — Water monitoring data should be relevant to the intended use of the data. Monitoring programs should consider the sources of water and the types of waterbodies where data are needed. The data must be collected from sites that are relevant for environmental or human health risk assessments. For example, to assess exposure to human health from dietary consumption, surface waters and groundwater used as drinking water sources would be considered relevant. Sampling programs should include periods of pesticide use and types of pesticides applicable to the geographical location. This includes considering the persistence and mobility of the chemical applied as well as the hydrologic response of the receiving water system. Site selection is critical to ensure the data are collected in areas where the pesticides may have been used.

Robust — Robustness describes the data's ability to represent the conditions found in specific water systems over the short- and long-term. The sample frequency should be sufficient to characterize and evaluate the potential exposure and duration. This relates to the intended use of the data and ultimately to the effects that are being assessed. High frequency sampling (2 to 3 times per week during pesticides use periods) permits an assessment of any potential acute impacts to aquatic life. Sampling throughout all relevant times of the year ensures the data can be robustly used to calculate chronic exposure values when these are required for risk assessment.

Additional (ancillary) data — Ancillary data can assist in determining the reliability, relevancy and robustness of the data. It is important in contextualizing data in risk assessments.

More information about PMRA's environmental risk assessments can be found in the [PMRA Guidance Document, Health Canada's Approach to Environmental Risk Assessment for Pest Control Products - Canada.ca](#)

Continuous Oversight

The PMRA will consider the water monitoring data for a pesticide as it implements its Continuous Oversight Policy, which will provide ongoing surveillance of new scientific information to ensure that the risks from pesticides to the environment and human health continue to be acceptable throughout their lifecycle. Water monitoring data is one component of continuous oversight that can be used to identify potential risk to human health and aquatic organisms. The PMRA screens the detected concentrations of pesticides in water against Aquatic Life Reference Values (ALRVs) and Human Health Reference Values (HHRVs). Where levels of a pesticide found in the Canadian environment exceed the reference values, all available lines of evidence will be considered to determine the appropriate regulatory action required.

Coordination across organizations

Pesticide monitoring is resource intensive and working collaboratively can make more efficient use of available resources to collectively achieve respective program goals. Strong communication and collaboration among the different levels of government, non-government organizations, grower groups, academia, industry and Indigenous organizations can enhance the generation of data related to pesticide levels in Canada. All have valuable experience and can help provide additional science-based and Indigenous knowledge for site selection and other areas of the program development. Establishing clear agreements and fostering transparency with other programs and partners will enhance knowledge, improve efficiency of resource use, facilitate data sharing, and create synergies across initiatives. As the collective knowledge about pesticides in the environment increases, there may be changes in partnerships and ways of collaborating to meet shared program goals.

Water monitoring programs in Canada

The protection of water sources and the environment are typically areas of interest for all levels of government. In Canada, the responsibility for water management and protection is shared by the federal, provincial, territorial and Indigenous governments.

Provinces and territories are primarily responsible for managing and protecting water resources within their borders, including:

- water allocation and use
- drinking water and wastewater services
- source water protection
- managing inland fisheries
- aquatic species at risk
- invasive species

The Government of Canada is responsible for management of freshwater on federal lands, such as Indigenous communities and properties belonging to federal departments or agencies (for example, Department of National Defense, Canadian Heritage and Public Services and Procurement Canada). In addition, the federal government is involved in freshwater-related areas, such as:

- fisheries
- pollution prevention
- shipping and navigation
- international relations
- domestic transboundary waters

As outlined in the *Canada Water Act* annual report for 20221 to 2023, under many historic and modern treaties and self-government agreements, Indigenous Peoples have freshwater-related rights. Indigenous Peoples are also involved in transboundary freshwater management.

To learn more consult [Canada Water Act Annual report to Parliament 2022–2023](#)

Differences in responsibilities and mandates of different levels of government, combined with the high cost of pesticide sampling and analysis, have resulted in limited water monitoring data on pesticides across Canada.

An examination of the existing programs and networks within Canada confirms variations exist across the country, with different objectives and varying levels of sampling intensity. Due to the high importance of protecting human health and shared aquatic resources, collaboration among federal, provincial and territorial programs would be beneficial. In addition, improving the ease of access to pesticide water monitoring data across Canada to facilitate its use in pesticide regulatory decision-making would increase process efficiency.

Learn more about other Canadian water monitoring programs:

- Environment and Climate Change Canada: [Overview of freshwater quality monitoring and surveillance](#)
- Agriculture and Agri-Food Canada: [Living laboratories initiative](#)
- Alberta: [Environmental monitoring \(in English only\)](#)
- British Columbia: [Water quality monitoring \(in English only\)](#)
- Manitoba: [Long term water quality monitoring program](#)
- New Brunswick: [River water quality data](#)
- Newfoundland and Labrador: [Long-term water quality monitoring data](#)
- Northwest Territories: [Water quality monitoring networks](#)
- Nova Scotia: [Monitoring and reporting \(in English only\)](#)
- Nunavut: [Welcome to Nunavut Water Board](#)
- Ontario: [Provincial \(stream\) water quality monitoring network](#)
- Prince Edward Island: [Open Data \(in English only\)](#)
- Quebec: [Atlas de l'eau](#) (in French only)
- Saskatchewan: [About The Water Security Agency \(in English only\)](#)
- Yukon: [Water Resources Branch data networks \(in English only\)](#)

Citizen science (participatory science)

Individual program managers are best suited to decide on the role of citizen science within their programs. The use of citizen science offers an opportunity to expand into areas of the country that might not be easily accessible by others.

Regardless of who is collecting samples (internal staff, citizen scientists, federal or provincial departments, contractors, etc.), following established standard operating procedures (SOPs) and implementing quality assurance (QA) and quality control (QC) measures is crucial to maintaining sample and data integrity as well as consistency across programs. These components may include, but are not limited to, QC procedures both in the field (sample collection and submission) and in the laboratory.

The PMRA encourages all types of partnerships as long as the samples are collected by individuals who have received training to follow program SOPs.

Collaborating with Indigenous partners

The Government of Canada is working in consultation and cooperation with Indigenous Peoples to implement the *United Nations Declaration on the Rights of Indigenous Peoples Act*. This includes taking measures to achieve the objectives of the Declaration. Water monitoring for pesticides relates to human and environmental health and, therefore, co-developing distinctions-based approaches is key to ensuring Indigenous perspectives and knowledge are included. As described by the Department of Justice Canada, this principle is needed to ensure that the unique rights, interests and circumstances of the First Nations, the Métis Nation and Inuit are acknowledged, affirmed and implemented.

Bridging Indigenous science and knowledge with Western science during program development benefits everyone. It results in enhanced program design responding to Indigenous aspirations and improved information sharing with communities. Water monitoring programs can be strengthened through collaboration, co-learning and co-production of new knowledge with Indigenous communities and organizations. Building meaningful and trustworthy relationships deeply rooted in respect, reciprocity, relevance

and reconciliation is key. It is also important to consider the perspectives and priorities of Indigenous communities when developing water monitoring programs. It is essential to engage early, as dialogue and exchange of ideas require time and flexibility.

It is important to recognize that water monitoring for pesticides is only one of many initiatives of interest to Indigenous partners. By establishing collaborations with other programs, water monitoring programs can reduce the administrative burden on Indigenous partners through reducing the number of points of contact and processes required. Consideration must be given to how Indigenous communities' existing information and data and new data produced through the program will be collected, protected, used or shared principles (more details can be found in the "Managing and reporting" section).

Learn more:

- [Principles respecting the Government of Canada's relationship with Indigenous peoples](#)
- [Seeding reconciliation on uneven ground: the 4Rx approach to cross-cultural dialogue](#) (only in English)

Water monitoring program for pesticides design

To establish a monitoring program that will meet pesticide regulatory requirements, there are five key aspects to consider.

1. **Increase and strengthen the data available for risk assessment and risk management decisions.** Robust water monitoring data provide more realistic exposure scenarios, allowing for:
 - refinement of pesticide risk assessments beyond the use of water modelling exposure estimates
 - continuous oversight of registered products
 - identification of potential risks to human health and aquatic life

- effective regulatory decisions

2. Ensure transparency through open access to real-world water monitoring data. Through online publication in an accessible format, programs can provide data in various forms:

- raw results from the laboratories (the PMRA uses the Government of Canada Open Data portal)
- contextualized data with more information related to the samples (site location, ancillary data, etc.)
- interpreted data that encompasses all data generated and provides a full story

With access to the data, the public will be able to better understand the science behind pesticide regulation and individuals can conduct independent analysis of the data.

3. Provide a better understanding of spatial, temporal and regional differences.

Differences in pesticide and land use patterns, as well as physical factors such as climate, soil type and hydrology, may result in regional differences in pesticide concentrations observed across the country. Understanding these regional differences can assist in outreach to growers and allow for targeted innovation to improve sustainability of pest management practices to prevent potential human and environmental risks.

Detecting temporal changes in pesticide concentrations at specific sites can be influenced by the frequency and methods of sampling selected. Enhancing comparability of data among regions (for example, parameters assessed, frequency of monitoring, analytical methods) and improving the availability of ancillary information (for example, streamflow, weather, soil type) will improve our collective understanding of the factors contributing to regional differences. Close, ongoing collaboration between the various organizations would make acquiring this type of information possible.

4. Assess effectiveness of mitigation measures required to protect human health and the environment. Collecting data post-regulatory decision from the same sites where data was collected pre-regulatory decision can allow an

assessment of the effectiveness of the mitigation measures. This information may indicate that adjustments may be required based on real-world results. Regional programs can also use data generated following this framework to assess mitigation measures implemented at the provincial and territorial level.

- 5. Strengthen collaboration among sampling partners and stakeholders.** Water monitoring programs and collaboration across Canada can be strengthened through the use of a nationally consistent monitoring framework, as well as data sharing. Data generated using this framework can be used to support multiple mandates across Canada, including regulatory decision-making, understanding the state of the environment and further study on impacts related to pesticides.

Site Selection process

Identifying areas of interest

The identification of areas of interest is a key step to designing a pesticide water monitoring program that will generate useful data. The use of geospatial data (in other words, data that has a reference to a geographical location) is valuable as it can inform scientists on spatial relationships and patterns. Specialized software can be used to map and overlay geospatial data of interest to inform the identification of areas of greatest risk that best fit the goals of a program.

Learn more:

- [Federal Geospatial Platform](#)

Once prioritized, those areas could, through coordination with partners, inform establishment of sampling sites. Priorities for areas of interest would include those where elevated risks for pesticide movement to water from the application site are identified. However, areas of interest may also include reference areas, where risks are low or absent. Programs may also be interested in understanding differences in pesticide concentrations upstream and downstream of the point of interest (for example, an urban area, an area of high intensity agriculture with specific crops of interest, a specific lake or water body, or drinking water source).

Geospatial analysis

Geospatial analysis can be used by water monitoring experts to analyze and present the geospatial data to assist with selecting sites that align with program objectives. The analysis can be completed using the desired reporting units for the program, such as watersheds, across the country.

Geospatial data may be analyzed in many ways according to the scale and goals of the monitoring program. The geospatial data is typically collected by following these steps:

Step 1: Define the metrics of interest (for example, area of crop land per drainage area, average daily precipitation or water flow per drainage area) considering program objectives and geospatial data quality.

Step 2: Generate metrics data.

Step 3: Evaluate all data (overlay findings, where appropriate) and identify areas of interest.

Step 4: Consult with experts, partners and stakeholders for additional information on selected areas.

A systematic approach for identifying areas of interest is important to support overall network design, reproducibility and transparency. The established approach may be adjusted and validated through the evaluation of existing pesticide concentration data. Similarly, it should be updated as new knowledge becomes available.

Geospatial data

In terms of pesticide monitoring, geospatial data of interest should include:

- data informing pesticide use (for example, use information from growers) or locations where pesticides are likely to be used (for example, agricultural land)
- environmental factors influencing the movement of pesticides to water (for example, precipitation and land use characteristics that influence pesticide runoff to water)

Given that pesticide risk assessments are completed for both human health and the environment, monitoring programs should consider both types of exposure.

For drinking water, source waters include:

- natural or constructed reservoirs
- lakes
- rivers
- groundwater aquifers
- any other water sources that ultimately are used for drinking water

Some provinces may have local source protection plans that can assist in the identification of vulnerable areas where the application of pesticides may pose a risk to the quality of drinking water sources (for example, Ontario Source Water Protection).

Water body types relevant to environmental risk assessment are those expected to support aquatic life, such as:

- creeks
- lakes
- ponds
- rivers
- streams
- wetlands

While gathering geospatial information, data quality should be reviewed specifically in terms of:

- accessibility
- accuracy
- consistency
- coverage
- interpretability

- precision
- relevance
- reliability
- spatial resolution

Table 2 provides a broad list of geospatial data that can be used for the design of monitoring programs for pesticides in Canada. The example datasets listed in the table are all Open Data web links and will be updated as new data are generated.

Learn more:

- [Open Government](#)

Table 1: List of geospatial data, information provided and examples of datasets

Data	Potential Information provided	Links to Example datasets
Hydrography	This can include the location of watercourses and waterbodies, stream order, direction of water flow and drainage areas, watersheds and non-contributing areas.	National Hydro Network
Agricultural land	The location and crop type can indicate the use of pesticides.	Annual crop inventory
Census of agriculture	This can include agricultural industry information, crop type, land management practices, and pesticide use by area.	Census of Agriculture: Data linked to geographic boundaries
Runoff	This can indicate pesticide movement.	Average annual runoff in Canada, 1971 to 2013
Forestry	This can indicate other types of pesticides uses.	National forestry database
Digital elevation models	These provide topography, which influences pesticide movement in water.	Canadian digital elevation model 1945-2011 High resolution digital elevation model — CanElevation series
Soil	This can impact runoff and pesticide movement to surface and groundwater. Pesticides that are strongly adsorbed to soil are less likely to infiltrate the soil profile but easily eroded soil can carry pesticides to water bodies.	Gridded soil landscapes of Canada

Precipitation	This can impact runoff and pesticide movement to surface and groundwater. High precipitation rates can result in surface runoff, causing entrainment of water-soluble and adsorbed pesticides to water bodies.	NASA — Daymet Agroclimate maps 30-year average mean temperature
Temperature	This is a key factor that influences pesticide degradation.	NASA — Daymet Agroclimate maps 30-year average mean temperature
Urban characteristics*	These can indicate locations of urban pesticide use and movement.	Wastewater Systems Effluent Regulations reported data
Ecozones	These are standard ecological units characterized by distinctive abiotic or biotic factors.	National ecological framework for Canada
Critical habitats	These can indicate the proximity of vulnerable ecosystems and species.	Critical habitat for species at risk national dataset

* Golf courses, municipal parks, wastewater or stormwater infrastructure

Reporting units

Several reporting units can be used when examining the areas for potential sampling sites. These units refer to the extents of geographic areas that can be used to separate regions for mapping purposes. Three examples that may be relevant for the design of a water monitoring program for pesticides at a national scale are the National Hydro Network, ecozones and Canadian Hydrologic Network (under development).

National Hydro Network (NHN)

The National Hydro Network (NHN) Work Units are geospatial delineations of drainage areas across Canada. They are based on drainage area delineations from the Water Survey of Canada, Natural Resources Canada, and other federal, provincial and territorial partners.

The NHN Work Units provide a consistent and standardized way of dividing the country based on how surface water flows across the landscape. The data extend beyond the Canadian borders, and portions located within the United States are based on the National Hydrography Dataset by the United States Geological Survey (USGS). Consideration of

the transboundary portions may be relevant as some waterbodies flow towards Canada from the United States.

There are approximately 1340 NHN Work Units across the country (including transboundary regions). This level of detail is useful for assessing factors on a national scale, but specific regions or habitats may require smaller-scale reporting units.

The NHN units include geospatial features describing Canada's inland surface waters, such as lakes, reservoirs, rivers, streams, canals, islands and obstacles, as well as places and geographical names. The NHN features are meant to enable spatial analysis to support inland water resource management decision-making.

Learn more:

- [National Hydro Network — NHN — GeoBase Series](#)

Canadian Hydrologic Network (CHN)

The new CHN currently under development by Natural Resources Canada is an improvement from the National Hydrographic Network (NHN). This initiative will provide new high-resolution and analysis-ready hydrographic data in Canada. For water monitoring programs, it provides a better understanding of how water flows and how the environment may be impacted by pesticides. Compared to NHN, CHN units integrate new features:

- delineating smaller scale work units more accurately
- integrating data from ECCC's hydrometric stations
- incorporating elements for finer scale analysis (for example, nested hierarchical structure of drainage basins)

CHN units are not currently available across Canada, the first dataset released was of five work units that completed the Miramichi watershed in New Brunswick.

Learn more:

- [Hydrographic networks](#)

Ecozones

Regions of Canada can be represented by ecozones as defined in the National Ecological Framework for Canada. Ecological units from the National Ecological Framework for Canada capture all major components of ecosystems (air, water, land and biota) and the linkages between them. It is based on a 4-level hierarchical system that decrease in size of land coverage:

1. Ecozones
2. Ecoprovinces
3. Ecoregions
4. Ecodistricts

The Ecozones represent the top (largest) level and are suitable to support national-scale environmental management considerations. Whereas the lower levels may support smaller scale spatial analysis.

Learn more:

- [National ecological framework for Canada — Open government portal](#)
- [Terrestrial ecozones and ecoprovinces of Canada](#)
- [Ecozone and Ecoregion Maps and Descriptions](#)
- [Commission for Environmental Cooperation 1997 annual report](#)
- [A perspective on Canada's ecosystems: An overview of the terrestrial and marine ecozones — Canadian Council on Ecological Areas](#)

Other considerations

Other considerations that may be important when monitoring programs are selecting areas for sampling include:

- **Specific national, regional or local features that can affect the movement of pesticides from the site of application.** For example, the presence of tile drainage systems or mitigation measures. These unique features could provide

additional context for understanding differences in pesticide concentrations detected among regions.

- **Information on the stream hierarchy** (for example, the Strahler order). Pesticides are generally more likely to be detected in smaller-order streams (for example, Strahler order 1, 2 or 3) than in higher-order streams. First-order streams receive water from the surrounding catchment area (for example, runoff from a rain event) and are not fed by other streams. Higher-order streams are fed by multiple smaller-order streams and contain more water. Pesticides become more diluted after application or rain events in higher-order streams. Smaller-order streams are expected to have higher concentrations of a small number of pesticides. Larger rivers (for example, Strahler order 5, 6 or 7) are fed by multiple smaller streams and are therefore expected to contain a greater number of pesticides but at lower concentrations.
- **Information on wetland type** will support the selection of sites over a range of wetland types and classes. For example, identification of the wetland as bog, fen, marsh, swamp, seasonal or artificially constructed as well as wetland class (class I-ephemeral versus Class VII-permanent) using the Stewart and Kantrud wetland classification system. For pesticide risk assessment wetlands that are ephemeral (temporary) and likely to dry up in a few days would be less relevant.
- **Information on the depth of the water table and soil properties** are examples of additional factors worth considering for groundwater sampling. Pesticides are more likely to be detected in groundwater sources where the water table is shallower and where the soil has higher permeability.

Learn more:

- [Stewart & Kantrud classification system](#)
- [The quality of our nation's waters — Water quality in principal aquifers of the United States, 1991-2010](#)
- [How Stream Order works—ArcGIS Pro | Documentation](#)

Identifying specific sampling locations

Once areas of interest are identified using geospatial analysis (described in previous sections), reviewing existing water quality monitoring networks can assist in identifying specific sampling locations. This helps find opportunities for collaboration and avoid repeating work already done by other groups. The aim would be to ensure a coordinated, complementary and strategic approach to ensure representative sites are sampled. High risk areas identified by the geospatial analysis can be overlaid with proposed or existing water quality monitoring locations for a prioritization exercise. Local expertise of existing and potential sampling partners is critical in this exercise. Engaging with hydrogeologists can be beneficial in determining the best location for groundwater sampling.

From a pesticide regulatory perspective, site selection would ideally be based on vulnerable areas, which could be defined as areas with elevated risks for pesticide movement to water.

In addition, the presence of historical monitoring data at specific sites may be informative when selecting the best sites for a pesticide monitoring program. This information can provide insight into areas with known exceedances of reference values or high concentrations over several years.

In the absence of an existing monitoring program or local knowledge, a site characterization survey could help to gather knowledge to support identifying sampling site locations that best align with program objectives. Passive samplers can be used as a screening tool to identify where pesticides are detected. With this knowledge, areas of potential concern can be identified for targeted sampling.

Access to private lands

Where sampling requires access to privately owned lands (for example, wetlands, smaller streams or drains), samplers must communicate with landowners to ensure that permission is granted before sample collection starts. Samplers should stay in contact throughout the sampling season to keep landowners informed of sampling activity on their land.

Additionally, all programs that work directly on farms or ranches to collect samples should ensure the appropriate biosecurity measures are followed.

Several aspects should be addressed during the process of forming and sustaining partnerships with private lands owners. These include:

- communicating the objectives of the program
- setting up engagement methods
- defining roles of all parties involved
- determining the partnership duration
- identifying compensation structures
- crafting clear agreements to access sites
- ensuring data confidentiality
- involving landowners in agreement development to address potential participation barriers

It is also important to promote transparency by stating what data will be collected and how they will be used (for example, potential use for regulatory decisions). This is crucial for maintaining mutual trust and building and maintaining relationships with landowners and local communities. This process can take time so appropriate planning must be done to complete proper agreements before field activities take place.

Sampling

Different types of water bodies may require different sampling methods and frequencies. Monitoring programs should be developed to obtain the highest quality data for the intended use. Risk assessments for pesticide regulations require knowledge of both acute and chronic exposure. Depending on the water body type, acute concentrations can be transitory. To ensure data can be useful in pesticide risk assessment, collection of samples must include sufficient spatial and temporal coverage.

Methods

Various sampling methods can be used to achieve objectives and goals of a particular program with the knowledge and understanding that sampling methods carry different levels of uncertainty. Local partners or experts may be best positioned to advise on the best sampling methods based on local knowledge of the waterbodies.

Regardless of the sampling methods used, following established standard operating procedures (SOPs) and quality assurance and quality control measures (QA and QC) will help maintain sample and data integrity.

Components covered in SOPs may include, but are not limited to:

- health and safety documentation and protocols
- quality control field procedures (sample collection and submission)
- quality control laboratory procedures (holding-time, storage temperature and preservatives required)

Sharing of standard operating procedures and protocols can improve transparency, foster collaboration and enhance consistency among sampling programs.

A document such as the USGS *Design, analysis, and interpretation of field quality-control data for water-sampling projects* could be used as a reference when developing local SOPs. This report provides extensive information about statistical methods used to analyze quality-control data in order to estimate potential bias and variability in environmental data.

To learn more, consult the USGS [Design, analysis, and interpretation of field quality-control data for water-sampling projects](#)

Grab samples

Grab sampling, also known as discrete sampling, is the most widely used method for collecting water samples. Identification of the desired frequency and timing for sample collection is critical as grab samples represents a single point in time and provide a

snapshot of pesticide concentrations. Examples of grab sampling methods include hand-dips, pole-sampling, sampling by drones and weighted bridge samplers.

Autosamplers

Where autosamplers can be installed, automated or high-frequency sampling at specific time intervals can provide valuable data. These instruments can be triggered automatically, to collect samples, by hydrological changes (for example, streamflow) and/or water chemistry fluctuations (for example, turbidity, pH, conductivity).

Some autosamplers enable collecting and storing samples at appropriate temperature for a longer timeframe, but this also requires consideration of the stability of pesticides of interest. Autosamplers may be initially costly to purchase and install, but over the longer-term usually require fewer resources as less frequent site visits are needed. In this way, autosamplers may also permit higher frequency of sample collection.

Passive samplers

Passive samplers produce time-weighted average concentrations as well as provide a measure of the bioavailability of pesticides at a site. Time-weighted averages can be considered by the PMRA in long-term exposure scenarios; however, there is uncertainty as to how useful these data are for acute or short-term assessments.

Benefits of passive samplers include:

- identification of potential sites where more intensive, more frequent sampling may be warranted
- detection of pesticides that are known to be highly variable over time
- detection of a broader spectrum of pesticides that might be expected at lower concentrations given that chemicals accumulate in the sampling medium over time
- sample collection in locations where high sampling frequency is difficult to achieve
- supplementing lower frequency sampling

Frequency and timing

To ensure the data collected can be used in pesticide risk assessments, it is important to ensure the frequency and timing of sampling is appropriate for the type of risk to be assessed.

Pesticide risk assessments consider both acute and chronic exposure. Frequent sampling during pesticide use periods is more likely to capture peak concentrations and provide information on changes over time required. Statistical tools can be used to determine both frequency and duration of sampling to increase the likelihood of capturing peak concentrations of pesticides, if desired. The need for a given sampling frequency to achieve the monitoring goal may influence the sampling method employed.

It is also acknowledged that important information can be gained from low frequency sampling at many sites in a region to understand the spatial picture of pesticide concentrations. However, the data generated under a low frequency sampling program at more sites may not be reliable for pesticide regulatory decisions that require the assessment of acute risk.

A variable sampling site-specific approach could be considered with higher frequency sampling at certain sites and lower frequency at other locations. Depending on a program's goals, this variable frequency approach could provide temporal and spatial information. High frequency at certain sites would inform temporal patterns, while sampling at lower frequency at other sites could provide greater spatial coverage. Overall, it is important to ensure data collected are sufficient for consideration for pesticide risk assessment.

After collecting data for a certain period of time, there may be evidence to suggest that sampling at high frequencies may not be required. Under certain conditions, it may not provide more meaningful information than samples collected at a lower frequency. For example, at sites with little variability, resources might be best spent evaluating the spatial extent of an issue. Evaluating the data collected and adjusting the sampling regime accordingly would continuously enhance programs.

When determining the timing of sample collection, the following considerations should be taken into account:

- meteorological events that contribute to runoff
- timing of pesticide application(s)
- interest in pesticide persistence, which may suggest collecting samples during post-harvest and pre-seeding periods
- potential impacts of climate change on the timing of pesticide applications and/or planning windows
- the desire to understand pesticide detections throughout the year

Streams and other flowing waterbodies

Sampling frequency in flowing waterbodies is a key consideration for producing data that can be used in pesticide risk assessments. Due to the costs associated with sample analysis, daily sampling is not feasible for most sampling programs.

The review of years of water monitoring data supports the practice of collecting grab samples 2 to 3 times per week in flowing surface water during high pesticide movement periods (for example, during pesticide application period and close to runoff events). Sampling at this frequency is most likely to generate data suitable for risk assessment while meeting other provincial, territorial and community program objectives.

Norman et al. (2020) investigated the impact on the detection of pesticides in various agricultural streams using both autosamplers and grab sampling. The results of this study indicated that

- daily composite samples, using autosamplers, result in a more comprehensive list (and higher concentrations) of pesticides than were detected in weekly autosampler composite and weekly grab samples
- autosamplers provided a reasonable approximation of the 90th percentile concentration.

Therefore, if programs have access to autosamplers, this could also be considered as a sampling strategy, recognizing that information may still be missed with weekly composite samples.

Another strategy to consider would be to prioritize high frequency grab sampling during high pesticide application periods, with reduced frequency during shoulder seasons. In this way, reliable and sufficient data are collected at the most appropriate time for monitoring, with less intensive effort at times when concentrations might be expected to be lower.

Lakes

Lakes have large catchment areas with many smaller tributaries feeding into these lakes. As such, pesticides detected in lakes are a result of inputs from many sources in the surrounding area. In addition, due to the larger volume of water, pesticide concentrations are diluted. Concentrations of pesticides will tend to be lower in lakes compared to concentrations detected in contributing tributaries. Individuals responsible for managing lakes may wish to know the concentrations of pesticides in lake water periodically to investigate the current status or to track changes over time.

Less frequent sampling is appropriate in some lakes, especially those with long residence times due to the period of time a single parcel of water remains in a given waterbody. For very large lakes, such as the Laurentian Great Lakes, annual or less frequent monitoring at offshore stations can be used to track long-term (for example, decadal scale) changes. Timing of lake monitoring will need to take into account the timing of pesticide use in the surrounding watersheds, the time needed for waters to reach the lake and the potential for dilution in the lake.

Other considerations for lake sampling include:

- high variability within lentic systems especially when they are stratified (not mixed well)
- the point in the lake and the depth of the water column can impact water quality and concentrations detected (dilution factor)

- sampling can be a high priority given important local resources such as drinking water, swimming, recreation and fishing

Finding a representative location to sample for pesticides can be challenging especially in larger waterbodies.

Wetlands

Wetlands are unique, biologically active, habitat rich, and productive ecosystems that are important to monitor for pesticides. Because of the complex nature of wetlands, the sampling approach may vary.

Many wetlands, including most in the prairie pothole region, are "closed basins", meaning they do not contribute flow downstream in a typical or average year. In arid regions such as the prairies, many wetlands can be stagnant with no inflow or outflow for significant periods of time. With limited outflow, wetlands can accumulate contaminants from their surrounding drainage area. These situations may allow for a reduced sampling frequency, as peaks are likely to be less transitory than in flowing waterbodies such as streams and rivers. However, it should be noted that wetlands are very biologically active, so the water chemistry can change drastically, even during stagnant periods.

Depending on the regional topography, wetlands can have defined inflow and outflow points or "streams" that enter and exit the wetland. These inflow and outflow points could be used for sampling to evaluate what is going in and out of the wetland. This is especially true in large wetlands, where selecting a single sampling location to be representative of the whole wetland can be particularly difficult. Selecting the inflow or outflow will be more representative of overall conditions within the wetland.

During periods of high flow (for example, large precipitation events or spring freshet periods), wetlands can contribute to downstream waterbodies as water levels rise and the wetlands are "flushed out."

To achieve data that would be reliable for pesticide risk assessment, sampling in wetlands once per week would be acceptable with an increased sampling frequency following

pesticide application or during runoff events. Increasing sampling frequency to 2 to 3 times per week during these time periods will aid in capturing peak concentrations. Sampling frequency may be reduced to weekly, or less frequent, during extended dry periods with no runoff to the wetland.

Groundwater

The optimal frequency for monitoring pesticides in groundwater will depend on several factors.

The probability of detecting pesticides in groundwater is increased with:

- shallow depth to water table
- high permeability of surrounding soils
- presence of potential pesticide sources
- pathway linking those sources with the groundwater aquifer

In situations where there is a higher potential risk of pesticides reaching groundwater, an increased sampling frequency should be considered to capture peak concentrations.

In most cases, programs use wells that were installed at strategic locations to monitor water quality (called monitoring wells). Domestic wells, on the other hand, were installed to have access to a source of drinking water. These wells are also being monitored at certain locations by water monitoring programs to obtain data on all types of groundwater sources.

Groundwater monitoring programs tend to collect samples for chemical analyses less frequently compared to surface water programs due to the less transient nature of these systems. For shallow monitoring wells that are installed to monitor a potential pollution source (monitoring wells), quarterly sampling may be sufficient, though twice monthly frequency may be preferred for reactive chemical constituents. As for domestic wells with less frequent pumping rates, they could be sampled once or twice per year.

Learn more:

- USEPA's [Sampling Frequency for Ground-Water Quality Monitoring](#) report

- Reference sheet from University of California [Groundwater Sampling and Monitoring](#)

Some consideration may be given to other indicators to guide groundwater sampling frequency. For example, water level fluctuations or high concentrations of nutrients or elevated turbidity may be used to indicate aquifer supplies that may be at higher risk of contamination by pesticides.

Ancillary information

Ancillary (supplemental or metadata) information is the term used to describe additional information that can be collected and helpful to contextualize water monitoring results. When this type of data is available for water monitoring datasets, it enhances their usefulness for pesticide risk assessments.

Surface water

For surface water sampling sites, this additional information should include as much of the following as possible:

- name of the waterbody
- description of the water body such as: type of water body, size, stream order or wetland class, degree or intactness of vegetative filter strip
- location of the sampling site within waterbody (GPS coordinates – consideration can be made for sites on private land although, in many cases, sites can be masked and still provide sufficient information)
- sample timing versus date of application
- soil properties and topography
- data and time of samples collection
- general site observations or specific conditions at the time of sampling
- site photographs

Runoff events are important indicators of pesticide movement to adjacent waterbodies. Therefore, meteorological information may help explain variability in pesticides concentration detected, such as:

- weather at time of sampling
- recent and historical precipitation events
- temperature
- snowmelt
- water level changes

For flowing waters, streamflow data (where available) or water level can relate directly to pesticide concentrations as mentioned in the previous section. The presence of nearby hydrometric stations could provide additional data on water flow and water level.

Information on watershed land use for the sampling sites, including the specific crops grown within the watershed, is important to contextualize pesticide results. Certain crop types may relate to the specific pesticides that are detected at a site. Although more challenging to obtain, detailed pesticide use data in the watersheds contributing to each site is extremely valuable to explain observed concentrations. For risk assessment, linking pesticide use with environmental results is important for informing pesticide risk management.

Groundwater

For groundwater sampling sites, ancillary information could include:

- depth of the water table
- direction of groundwater flow
- surrounding land uses
- name of the aquifer, if known
- information about whether the aquifer is confined or unconfined.

Specific data relating to well construction, geological or soil records, as well as the results of any previous hydrogeological investigations may be important to consult. Groundwater

flow paths can be difficult to interpret, especially in geologically complex areas, and original well records may be absent or incomplete.

Sampling depth, screen depths as well as static water levels are important to consider. Pesticide concentrations are likely to be higher in situations where there is a direct connection between the surface and groundwater resources. In these cases, determining the potential sources of contamination may require additional study to understand the vulnerabilities of the site.

Water quality parameters

In general, water and land use can be divided into 5 main categories, namely:

- water for aquatic life
- source of drinking water
- agriculture use (irrigation and livestock watering)
- recreational use and
- industrial use

Depending on the type of activity, a core set of variables could be identified in addition to supplementary parameters based on a case-by-case site evaluation.

The Canadian Council of Ministers of the Environment (CCME), through members of the Water Quality Task Group, proposed a list of suggested core variables for water quality purposes that could be considered ([link provided](#)). As for pesticide monitoring programs, these could be different depending on the goals and purposes.

For protection of aquatic life, the parameters suggested include:

- dissolved oxygen
- water temperature
- pH
- turbidity
- conductivity

- nutrients

In terms of drinking water, the following parameters were identified:

- *Escherichia coli* (*E. coli*)
- total coliforms
- nitrate
- nitrite
- colour
- odor
- taste
- chloride
- ammonia
- water temperature
- total dissolved solids
- dissolved organic carbon
- pH

As stated in the CCME's framework, it may be possible to achieve a consensus on a list of core variables so that water quality assessments can be done consistently across Canada. Many existing water quality monitoring programs maintain a list of core parameters that are analyzed for all samples collected. In many cases, however, these lists are site-specific or regional and can vary widely among programs. Including additional parameters for specific purposes, such as a water monitoring program for pesticides, could involve consulting partners and stakeholders on relevance and feasibility.

Learn more:

- [A Canada-wide framework for water quality monitoring](#)

Pesticides and transformation products

Pesticides

Determining which pesticides are of interest for a monitoring program can be influenced by the sampling locations and laboratory protocols. The establishment of a suggested suite of pesticides that may be used across the country to permit national consistency would allow for comparison of results among regions and across sites. However, there may be important considerations regionally that may influence selection of pesticides.

Several aspects related to the goals and objectives of the program will help determine which pesticides should be included. Given that the PMRA provides regulatory oversight of pesticides that are currently registered and used in Canada, monitoring current-use pesticides should be a key consideration to provide data needed for PMRA's risk assessments.

Pesticides that are not registered in Canada are less likely to be detected in water samples. Legacy substances, such as pesticides that may have been used historically but have since been banned or discontinued, may be of interest to identify contamination or to monitor recovery. However, these data are of limited regulatory value to the PMRA.

The following can be considered when selecting pesticides for a monitoring program:

- pesticides that are currently registered for use in Canada
- pesticides that are used in large volumes in Canada (publicly available sales data can be used as a surrogate for use)
- pesticides that have the potential to move to water sources
- pesticides that are used outdoors
- pesticides that have higher risk of causing adverse effects to either Canadians or the environment
- specific public concerns
- Indigenous interests
- regional differences such as type of crops
- long-range transport for certain compounds

Transformation products

Transformation products are molecules formed from a parent compound (for example, pesticide active ingredient) as a result of metabolism, chemical reactions or environmental processes. They are also called degradation products, breakdown products and metabolites.

Measuring the concentrations of transformation products in the environment can help confirm a pesticide was present at some point in the system but has since degraded.

Theoretically, if a pesticide is determined to be a priority, the transformation products for that active ingredient should be analyzed. However, few analytical methods exist for transformation products, and it can be cost-prohibitive to include all transformation products in a monitoring program. As such, it would be important to prioritize the addition of transformation products to ensure a balance between cost and risk assessment needs. A non-target analysis (NTA) approach could be considered to identify relevant compounds prior to the addition of these substances to the target analytical method and/or prioritization list.

Transformation products are often included in the residues of concern for drinking water due to potential toxicity. The lack of real-world information on transformation products results in risk assessors having to rely on modelling to estimate concentrations. It may be possible to use these modelling estimates to help prioritize transformation products for monitoring.

Reference values

Reference values (also referred to as guidelines or benchmarks in some jurisdictions) are used to identify the concentration of pesticides that may pose concern for aquatic life or human health. A variety of organizations (for example, provinces, Canadian Council of Ministers of the Environment (CCME), United States Environmental Protection Agency (US EPA)) publish reference values for pesticides for the protection of aquatic life, established using a variety of methods. In Canada, the frequency of updates varies by organization, and reference values are often only available for a small number of currently registered

pesticides. Establishing reference values for all currently registered pesticides is beneficial to multiple partners for data analysis and interpretation.

The PMRA has established Aquatic Life Reference Values (ALRVs) and Human Health Reference Values (HHRVs) based on effects metrics used in regulatory decision-making. They represent targets, below which pesticide concentrations are not expected to pose risks to freshwater aquatic life or human health. As such, ALRVs and HHRVs can be used as a regulatory trigger to suggest additional investigation if required when exceedances of these reference values are found in water. ALRVs and HHRVs can be updated following the review of new scientific information by the PMRA.

Other federal and provincial agencies may also develop thresholds or reference values, with different risk management goals, using varying methods. As a result, other jurisdictions' thresholds may differ from the PMRA's ALRVs or HHRVs.

Learn more:

- [Aquatic life reference values \(ALRVs\)](#)
- [Human health reference values \(HHRVs\)](#)
- [Framework for risk assessment and risk management](#)
- [Environmental risk assessment approach](#)

Laboratory analysis

Many analytical laboratories develop methods to reach the lowest possible limit of detection (LOD) for the compound of interest. To achieve the lowest possible LOD, the analytical cost for method development and analysis typically increases.

To make risk management decisions on pesticide registrations, the LOD should be lower than the reference value(s) but, does not need to be as low as possible. After establishing the pesticides for consideration in an analytical method, recommendations for analytical targets based on reference value(s) should be communicated to the laboratory.

If more than one (1) laboratory is analyzing samples in a pesticide monitoring program, it would be beneficial to complete inter-laboratory studies to compare the data between

laboratories. Having more than one laboratory that can produce interoperable and standardized data would avoid reliance on a single laboratory and enhance analytical capacity for monitoring programs.

A non-targeted analysis (NTA) method that can screen water could be considered as an alternative approach to setting a pre-determined list of pesticides. This approach is considered to be a non-biased and powerful tool to detect and identify unknown pesticides (and transformation products). Follow up with targeted analytical methods to obtain quantified results for use in pesticides risk assessment would likely be required.

Health Canada has developed a liquid chromatography – mass spectrometry (LC-MS) method designed to analyze nearly 200 pesticides and several transformation products using the guidance outlined above. This method is available upon request.

Managing and reporting data

Data management is a process that involves collecting, organizing, storing and retrieving data so that it can be used for its intended purpose while maintaining a high level of data quality.

To improve the availability of independent data to support pesticide review decisions, it is of interest to promote increased data sharing and to ensure efficient access to data and information.

Program operators are encouraged to make pesticide data in environmental samples available to the public in an accessible and usable format. This can be achieved by releasing data to Open Data sources, in a timely fashion and on a regular basis that is appropriate to the program's needs and requirements. Strong consideration should be made for FAIR (Findable, Accessible, Interoperable and Reusable) data principles.

FAIR data principles are a component of Health Canada's Open Science Action Plan for developing sound data management. Guidance regarding FAIR data principles can be

found within the Open Government Guidebook published by the Treasury Board of Canada Secretariat. Health Canada datasets are published according to the following FAIR data principles:

- **Findable:** unique identifiers and metadata are used to help locate data quickly and efficiently. metadata and data should be easy to find for both humans and machines
- **Accessible:** data are available with the appropriate permissions and that metadata are freely available and can be accessed in a standardized way
- **Interoperability:** data usually need to be integrated with other data, machine readable data yield outputs in readable and useful formats
- **Reuse:** metadata exist to describe data, enabling the meaningful reuse of data over time

When working with data collected in partnership with, or pertaining to, Indigenous communities, groups, land or resources, it is critical to follow other relevant data governance principles. These principles guide aspects related to ownership, control, access and possession of the data, commonly referred to as OCAP®. It is also recommended to complement FAIR data management practices that emphasize openness and sharing with CARE (Collective Benefit, Authority to Control, Responsibility and Ethics) principles for Indigenous data governance. These guiding principles pertain to collective benefit, authority to control, responsibility and ethics.

OCAP® and CARE not only create transparency and facilitate sharing, where appropriate, but also ensure that the data management approaches are agreed upon by, and beneficial to, all parties. Adherence to these principles, practices and approaches will help to proactively address and mitigate concerns related to sensitivity of data and any potential harm that could be caused by data publication or sharing. For example, masking the location of sampling sites on or near Indigenous lands prior to inclusion on public websites or in reports and other publications.

Together, these principles:

- increase the value of scientific data

- increase the capacity to manage, use and understand data
- enhance accessibility and shareability of the data with partners serve as a tool to leverage technology and infrastructure to turn data into action

Learn more:

- [FAIR data principles: What is FAIR?](#)
- [First Nations principles of ownership, control access and permission](#)
- [Care principles for Indigenous data governance](#)
- [Open science action plan](#)
- [The open government guidebook](#)
- [Government of Canada's standard on web accessibility](#)

Database

All data and sample information are best stored in standardized and easily extractable databases. Before data are entered in the database, they should be verified for quality assurance and quality control (for example, verify accuracy of sample date and time, site info, no duplications). This can be done using automated tools that can be run simultaneously with data ingestion steps.

As an example, ECCC uses a national database to manage their water quality data, including a consistent series of codes to describe:

- analytical methods (for example, standardized variable names, method codes, detection limits and units)
- sample sites (for example, location)
- field data
- analytical results (for example, value, qualifiers)

To facilitate FAIR principles, it is important to consider using complementary approaches across the country. Programs should aim to provide additional ancillary data, which is

called metadata (for example, site, date, time, chemical(s) analyzed, and methods). This will enable data use across different programs and for a variety of purposes.

Standardized laboratory submission and chain of custody forms should be considered. This enables samplers to submit a consistent set of information about the sample.

Use of consistent site and sample identification processes and the tracking of analytical parameters and associated method information would allow for results in a database to be more easily compared by regulators, other jurisdictions and interested parties. Use of systematic or automated processes for recording and entering field data would increase robustness and consistency of ancillary data collected in the field.

Reporting

There are various means to report results of monitoring data, including:

- factsheets
- reports
- webpages
- dashboards

All these methods have merit, and the ideal approach may be tailored to the program. Reporting activities can be done at various pre-determined frequencies. When reporting results and interpretation of data, it is important to provide context for any conclusions drawn.

Regular and well-timed communication by federal departments with provinces and territories on potential risks of pesticides in their province is important. As soon as risks are identified (for example, exceedances of federal reference values) it should be communicated to provinces and territories through a pre-established line of communication prior to releasing data to the public. This will allow the provincial or territorial government to take appropriate actions and address potential questions from the public.

Finding interactive ways of presenting results is of interest to many. As such, consideration for online dashboards that can be designed to meet the needs of a variety of end users is

recommended. These tools enable end users to independently contextualize, summarize and interpret data results.

Closing words

This document was written after gathering information from consultation events with provincial and territorial government and stakeholders. The PMRA is grateful to the many contributors who took the time to share their experience and expertise. Participants provided valuable information that was considered in the development of this framework for pesticide water monitoring programs in Canada.

This framework is intended to capture the key elements of effective water monitoring programs for pesticides while recognizing that evolving science and program needs may necessitate changes over time. The PMRA will continue to engage with provincial and territorial governments, Indigenous groups and stakeholders on the most current practices of generating water monitoring data and incorporating results into regulatory decision-making.

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