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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE
INFORMATION PRODUCT

CANADIAN GEOSPATIAL DATA INFRASTRUCTURE COOKBOOK

Hatfield Consutants

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Canada

CANADIAN GEOSPATIAL DATA INFRASTRUCTURE COOKBOOK

RECIPES AND CASE STUDIES

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1.0 INTRODUCTION

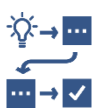
The Canadian Geospatial Data Infrastructure (CGDI) comprises technologies (hardware and software), data, policies, standards, partnerships, and human resources that allow us to create, access, use, and share geospatial data. The CGDI does not refer to a database or system, but rather, a collection of publicly available data and resources such as specific policies and standards to help ensure compatibility and interoperability. Available to all Canadians, and advanced by a range of users and producers, this infrastructure allows anyone to find, use, and share geospatial information. This allows geospatial data to be accessed and used when and as needed to benefit people, the environment, and the economy.

This CGDI Cookbook is intended to help new and current users of geospatial data increase their understanding of spatial data infrastructures (SDI) and to recognize the benefits and advantages of participation in the CGDI. The information in this Cookbook may be useful to a variety of roles and functions within organizations, including new or in-training geomatics practitioners, environment and lands managers, data managers, planners, policy analysts, researchers, and social and environmental service providers.

This Cookbook describes the components of the CGDI and provides step-by-step "recipes" related to data, technology, policies, standards, partnerships, and human resources. The recipes are designed to be standalone "how-to" documents to help integrate different components of CGDI into users' activities.

A Glossary of Cookbook Terms provides a reference to help new and novice users understand the technical terms that are used. Three Case studies are provided to describe use of the CGDI.

Recipe Themes



Planning – Recipes that help organizations ask the right questions and allocate time and resources appropriately when planning for the implementation of SDI concepts.

Data – Recipes that provide guidance on finding, accessing, sharing, and managing key framework and thematic geospatial datasets.

Standards – Recipes that introduce users to geospatial standards endorsed by CGDI that help organize data and make it accessible both internally and externally.

Technology – Recipes that help organizations choose and implement appropriate technologies and applications to collect, analyze, share, and manage geospatial data effectively.

Policies – Recipes that provide guidance on developing important internal policies that help manage geospatial data, such as how to protect or share data.

Collaboration – Recipes that demonstrate the benefits of the collaborative data management and sharing arrangements that help make the CGDI work.

Skill and Experience Levels

Recipes are intended for use by novice to intermediate CGDI users. Some recipes have equipment or skills prerequisites, while others will require Organizations' support to implement. The following symbols help users to quickly understand the target audience for a recipe and if there are prerequisites:

Basic GIS skills

Organizational commitment is required (icon)

Intermediate GIS skills

Equipment is required (icon)

Expert GIS skills

Other skills are required (icon)

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2.0 PLANNING RECIPES

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2.1 PLANNING: EXPAND YOUR GIS TOWARDS SPATIAL DATA INFRASTRUCTURE – UNDERSTANDING YOUR NEEDS AND REQUIREMENTS

What you will accomplish

This recipe will help you to assess existing infrastructure capacities, understand organizational GIS needs and plan for the enhancement of your GIS from being entirely based on local desktop computers towards an environment where you can access and share data more easily within your organization and with external partners.

What you will need

Commitment icon

- Time and resources to consider key strategic questions.
- A method for engaging the right personnel in your organization. This could be members, staff, or specialists to hold a workshop or complete a survey.
- Buy-in from managers or leaders.

Background

Many organizations across Canada have basic geomatics capability but are currently using a desktop approach to manage their geospatial data. These organizations store data on local or internally networked drives and view and analyze data only through desktop GIS applications. Organizations are increasingly looking to share data with internal or external users and to better integrate their geospatial data with key framework datasets from external sources available across Canada.

Recipe

1. Conduct an internal User Needs Assessment (UNA) to determine how your organization currently interacts with geospatial data. This should include compiling detailed answers to the following questions, at a minimum:
   a. What are the activities that you need to perform? (download existing data, create or update maps, collect field data, conduct spatial analysis, visualize or digitize information, create spatial databases)
   b. What activities are priorities, or are most important for your organization currently?
   c. What new activities would you like to perform, or will be priorities, in the future?
   d. Do you currently, or do you intend to, share or publish some of your data?
   e. With whom will you share data and how will they access it? (internally only, externally to specific organizations, available freely to the public)
   f. What are your specific concerns regarding data security and confidentiality? (risks associated with security breaches or hacking, proprietary data and intellectual property)
   g. What data formats do you use currently? (Raster, Vector, Tabular)
   h. What data formats would you like to use in the future?

i. Do you have the appropriate hardware? (server, disk storage space, bandwidth)

j. Do you have the appropriate software? (a GIS software package, a geospatial database, geonode)

k. How many people in your organization interact with geospatial data?

l. What functions do they perform? (create maps, analyze and manage data, collect field data, develop applications)

2. Validate your findings with other members of your organization. Consider whether you have captured the diverse needs in your organization.

3. Based on the results of the UNA, determine what type of user you currently are, and what type of user you would like to be in the future. Your organization probably belongs to more than one of these categories.

End User	Enabler	Publisher
Download and consume data from public sources	Manage web-based applications or portals to help user access geospatial information	Collect, process, and disseminate geospatial data
Use internal and external data to create maps or geodatabases	Develop guidelines on geospatial data standardization	Own or have rights to the geospatial data that they produce and share
Share some data with the public or external organizations	Provide support or funding for other organizations to use geospatial data and tools	Share some or all data publicly as part of their mandate
Recipes relevant to End Users	**Recipes relevant to Enablers**	**Recipes relevant to Publishers**
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4. Complete an internal gap analysis to determine what resources your organization may need. This may include, but is not limited to: purchase of a commercial GIS software package or adoption of a free, open source GIS software package, geomatics training for personnel, and/or additional disk storage space.

5. Prepare an implementation plan. Implementation plans typically establish priorities for action, describe what activities will be undertaken to achieve priorities, set timelines for achieving priorities, and describe performance measures used to track the progress of implementation. An example of a geospatial data infrastructure implementation plan is detailed below.

Example

The Valley First Nation (Valley) currently has a small geomatics department that conducts basic geospatial processing and analyses, including tracking field data collected by members and producing maps that are used in publications and by Chief and Council to support decision making. Geospatial data, maps, and products are primarily stored on the workstations of two geomatics staff members. Two key geospatial projects that Valley is working on are tracking the observations that community members make regarding wildlife abundance, movement, and health; and revitalizing language by improving public awareness of traditional place names. The Valley First Nation Lands Manager would like to make spatial datasets and maps related to these two projects easier to share with neighbouring Nations, the provincial government, forestry developers, and potential business partners. In addition, the Lands Manager would like to make Valley First Nation's data more compatible with existing framework data that staff members download from the provincial government. This "data infrastructure" would make it easier to overlay and analyze natural resources of interest to Valley members in relation to other land uses; and to share data with other organizations.

With support from Chief and Council, the Lands Manager decides to undertake a UNA to determine what Valley's needs and requirements are when it comes to geospatial data infrastructure.

What are the activities that you need to perform?

Valley needs to download existing framework datasets from the provincial geoportal; create maps for band managers and councilors; and collect, digitize, and store field data from members.

What activities are priorities, or are most important, for your organization currently?

Major priorities for Valley First Nation are: (1) reducing the amount of time spent on data discovery through standardization; (2) creating custom spatial layers for internal analysis; and (3) creating custom maps to be shared externally.

What new activities would you like to perform, or will be priorities, in the future?

In the future, Valley would like to: make data processing easier by standardizing existing internal datasets; easily share certain data layers with neighbouring Nations, potential business partners, and the public; and create custom spatial layers for lands managers to use to monitor wildlife management activities.

Do you currently, or do you intend to, share or publish some of your data?

Yes. Valley intends to share findings from wildlife monitoring with select users and place names with the general public.

With whom will you share data and how will they access it?

- External to specific organizations: certain findings from wildlife monitoring will be shared with a neighbouring Nation. Potential business partners, such as forestry companies, will also have access to abridged versions of these datasets.
- Available freely to the public: The general public will be able to access place name data through a Web Mapping Service, or by directly requesting access through Valley's Lands Department.

What are your specific concerns regarding data security and confidentiality?

Valley is concerned about losing important data that is stored on the hard drives of staff members, so the organization decided to transfer all data to a Geodatabase.

Valley is also concerned about potential business partners or external agencies misusing their data. They consider developing a Data Sharing Agreement with all potential users.

What data formats do you use currently?

Valley currently uses mainly vector and tabular data formats.

What data formats would you like to use in the future?

While vector and tabular data are Valley's primary data formats, the Lands Manager sees value in collecting and utilizing more Raster data such as: data collected from drone surveys and high-resolution remote sensing data. However, this may be limited by Valley's internet access and speed. The Lands Manager considers proposing that Valley invest in satellite internet in the future.

Do you have the appropriate hardware?

Valley has two PC workstations each running Windows 7 or later and equipped with 500 gigabytes (GB) and 1 Terabyte (TB) of disk storage space. Their office is located in a rural area and has access to internet speeds of 5 megabit per second download and 1 megabit per second upload.

Do you have the appropriate software?

Valley licenses a commercial geomatics software package that allows them to create and edit maps, conduct spatial analyses, and create and manage geospatial databases.

How many people in your organization interact with geospatial data? What functions do they perform?

Valley employs two GIS analysts who create maps and images, download and acquire external datasets, manage internal geospatial data, and perform analyses. Community members also interact with geospatial data by collecting data in the field using their mobile phones, tablets, or by sharing observations from specific areas directly to the Lands Department. In turn, other Valley members and employees interact with geospatial data by viewing and using maps.

After completing the UNA, the Lands Manager holds a half-day workshop with key staff and members to ensure that the findings are reflective of Valley's priorities and needs.

Valley considers itself to be both a CGDI End User and a Publisher. The organization has prioritized the following activities:

- Reduce time spent on data discovery by aligning Valley's datasets with CGDI endorsed data standards;
- Share data internally to support decision-making; and
- Share some data externally with specific partners.

Resources

Explore the CGDI Starter Kits (see Recipe 5.1) for access to free regional, curated framework and thematic datasets.

2.2 EQUIPPING YOUR ORGANIZATION TO ADOPT SPATIAL DATA INFRASTRUCTURE

What you will accomplish

This recipe will help you to design and create a strategic plan for implementing policies, standards, technologies, and data management practices that support a spatial data infrastructure in your organization.

What you will need

 Commitment icon	▪ A good understanding of your organization's current and future needs for geospatial data. ▪ Buy-in or agreement from leadership. ▪ A commitment to ongoing monitoring of the implementation plan.
 Skills icon	▪ Staff with basic GIS skills.

Background

Effective management of geospatial data and the ability to share it within your organization and with other organizations is one of the key drivers for creating a spatial data infrastructure. This means adopting technologies, policies, and standards that maximize interoperability of geospatial data and systems. Taking these steps can seem daunting, but with an implementation plan that is incremental, systematic, timebound, and monitored using key performance indicators (KPI), SDI objectives can be achieved one step at a time.

Recipe

1. Establish overall objectives based on the findings of a user need assessment (UNA) or through a good understanding of your organization's needs and capacity (technical and non-technical). Objectives should be concrete, specific, and indicative of specific outcomes.
2. Put objectives in chronological order based on which are the most immediately pressing.
3. For each objective, develop concrete outcomes, specific activities, or actions that your organization will undertake.
4. For each objective and activity, establish KPIs by which you will track progress.
5. Establish a timeline when KPI will be reviewed or reported on, including a target date for achieving each objective.
6. Estimate the financial and human resources required in your organization to take ownership of the strategic planning process and track the progress of implementation.

Template

An implementation plan requires objectives, actions, KPIs, targets, and personnel who are responsible for meeting targets. Use the template below to help clarify your organization's specific objectives, actions and timelines. A sample of an SDI implementation objective for Valley First Nation (Valley), a fictional organization, is provided from the case study in Recipe 1 – Understanding your needs. The first priority identified by Valley during an internal UNA process was to reduce the amount of time spent on data discovery for staff members by aligning their existing datasets with a CGDI endorsed metadata standard: *International Organization for Standardization (ISO) 19115-1:2014 Geographic Information – Metadata* (ISO 2013).

Objective 1: Reduce time spent on data discovery by aligning existing datasets with ***ISO 19115-1:2014 Geographic Information – Metadata***			
KPIs: (1) All existing datasets are aligned with CGDI endorsed standards by target date; (2) Data discovery time is substantially reduced as reported by staff members; (3) Organization has a clear policy for data standardization			
#	**Action**	**Target Date**	**Responsible**
1.1	Identify and select appropriate data standards	January 2020	GIS manager
1.2	Conduct a gap assessment of existing geospatial datasets (including file formats, metadata standards, etc.)	February 2020	Staff member
1.3	Bring datasets into compliance with desired standards	May 2020	Staff member
1.4	Create an internal policy for data management and standardization	July 2020	GIS manager
1.5	Review and implement policy	September 2020	GIS manager/ Staff member
Objective 2:			
KPIs:			
#	**Action**	**Target Date**	**Responsible**
2.1			
2.2			
2.3			
2.4			
2.5			
Objective 3:			
KPIs:			
#	**Action**	**Target Date**	**Responsible**
3.1			
3.2			
3.3			
3.4			
3.5			

Resources

- The Arctic SDI provides a good example of a regional-level implementation plan for an SDI: https://arctic-sdi.org/wp-content/uploads/2014/08/201511-Arctic-SDI-Implementation-Plan_FINAL.pdf
- Access ISO 19115-1:2014 standards for geographic information (metadata) and amendments: https://www.iso.org/standard/53798.html

3.0 DATA RECIPES

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3.1 DATA: HOW TO DECIDE IF YOUR DATA IS FIT FOR PURPOSE

What you will accomplish

This recipe will assist you in systematically evaluating if a dataset meets your data or information needs. The recipe provides guidance in choosing between different potential dataset options and suggests practical ways of evaluating dataset fitness for purpose.

What you will need

Commitment icon

- A good understanding of what you want to know or how you want to use a dataset.
- Time to search for and evaluate potential datasets to address your needs.

Skills icon

- Staff with basic GIS skills.

Background

A wealth of data is available to users from both public (open source) and commercial sources. Finding data that meets your needs is only the first step – to be truly useful, the data must be appropriate or “fit for purpose” for your intended uses. This can be challenging if you obtain data from a third party. If your organization or its partners are the producers of the data (e.g., from field work), assuring fitness for purpose will also be associated with costs including time, effort, and money.

Recipe

1. Determine the purpose you wish to address with the data. The purpose could be very general, for example:

    a. An image to provide background context such as a backdrop satellite image;

    b. General political/topographic features to locate an area of interest; or

    c. Specific regulatory, technical or communications requirements; for example to meet mapping standards of government agencies, to meet analytical requirements, or based on desired visual impact of a mapping product.

2. Evaluate which data quality components should be tested to assess if the data may meet your objectives. According to the International Organization for Standardization (ISO) geographic information standards for metadata (ISO 19115, 2014) and data quality (ISO 19157, 2013), which set standards for geospatial data quality, typical components for geospatial data quality are: Completeness, Logical Consistency, Positional Accuracy, Thematic Accuracy and Temporal Quality.

   a. Completeness: evaluation includes errors of commission and omission. An error of commission is a false positive, such as incorrectly including an object (e.g., a building) in a GIS dataset that does not exist in the real world, or classifying an object as a specific type (e.g., deciduous woodland) when they should have been classified as something else (e.g., coniferous). Errors of omission are false negatives, such as omitting a building that exists in the real world from a dataset, or failing to classify a deciduous woodland and classifying it as another type of land cover.

   b. Logical Consistency: includes conceptual, domain, format and topological consistency of the collection. Was the data collected by one scientific sensor, by visual interpretation, manual digitizing, or amalgamation of data sources? Was there data aggregation (raw units of measurement versus spatial or temporal averages, and at what scales)? Does the data collection reflect the property that was to be measured?

   c. Positional Accuracy: includes absolute, relative and gridded accuracy, reflecting how closely the measurements are estimated to match the "true" values. Measurement precision is also important, indicating how finely properties are measured, e.g., in centimetres, metres, kilometres.

   d. Thematic Accuracy: includes classification, and attribute correctness. As with positional accuracy, how closely the measurements are estimated to match the "true" values.

   e. Temporal Quality: includes accuracy, consistency and validity. The Vintage of the data (how recent or up-to-date it is) and whether it was all collected at once or amalgamated over several periods will affect its potential uses.

3. In a simple case, the authority of the issuing agency may be the main evaluation factor (i.e., you are using data from a trusted source). If the data will be generated in-house, these criteria should guide the sampling/collection design.

4. Search for (discover) candidate datasets, either from public or commercial sources. Discovery could be through a data portal (e.g., open.canada.ca or a provincial portal), online web search, or commercial listings (aerial survey, satellite imagery, postal or logistics information providers, etc.). Most portals allow searching by thematic subject and keyword. A spatial extent, data preview, and attribute field listing is also common. See also the CGDI Starter Kit.

5. Pre-evaluate the data properties against your requirements. Checking metadata that is provided can save time later so that you don't start to use a dataset and then find out one of its components of data quality was not suitable. At a minimum:

   a. Confirm that the data will cover your area of interest or that its proximity will make it relevant to your purposes.

   b. Unless a known, specific data product is desired, build a list of candidate datasets that are available and seem to meet your needs. This step can be overwhelming, especially if there are too many options, or finding options is very difficult. The CGDI Starter Kit (see Recipe 5.1) is a good reference. Completing steps 4 and 5 of the recipe may be an iterative process.

   c. Select the most likely candidates from your list and evaluate their stated properties against your requirements. It is useful to download or view a subset of the data to confirm that attribute ranges/categories match your expectations.

6. Evaluation may involve tradeoffs between cost, availability, and the ability of data to meet your requirements. This would include:
   a. Level of effort to prepare the data, including any required data conversion steps. Data transformation, resampling, reprojection, aggregating, etc., can be time consuming and can degrade the original data or make it unrepresentative of its original purpose;
   b. Cost (including licensing and ability to share the data with others);
   c. Use of alternative or older datasets; and
   d. Re-evaluation of your requirements. Can you get by with less?

Continue to evaluate datasets from your list until a suitable solution is found. Tradeoffs are often necessary. Not all solutions will involve free data, and sometimes adequate data is not available. This may require rethinking your purpose and evaluating alternative solutions.

Example

A local council has tasked their geomatics support team to evaluate flood sensitivity for structures and land use along a river bank. Historic information regarding river level fluctuation and upstream drainage is available, but there is no in-house elevation model for assessing overflow. The council wants a map of general hazard categories along a section of the bank.

The analyst discovers and downloads some public data including federal contour lines and Canadian Digital Elevation Data raster tiles. Agriculture and Agri-Food Canada's 1 metre elevation data is not yet available locally. Various levels of river height are mapped by removing the river polygon from the shape of the basin for given water heights. The geomatics provider presents the maps. Council finds that there is both too much variability (strange patterns in the polygon outlines) and not enough detail (polygon height steps are too large). The provider is asked to examine alternatives.

The analyst discovers that there may be older archived Light Detection and Ranging (LiDAR) elevation data from a local provider, who can also schedule new collection at additional cost. There is also the possibility of elevation stereo-extraction products derived from very high-resolution optical satellite images. Quotes are requested and the geomatics provider presents a report to council. The cost-benefit of the higher quality data options are to be discussed and a decision made based on a re-examination of the local requirements.

Resources

- Explore the CGDI Starter Kits for access to free regional, curated framework and thematic datasets.
- Learn more with the GIS Lounge discussion of data quality: https://www.gislounge.com/spatial-data-quality-an-introduction/
- Learn more about ISO 19157:2013 standards for geographic information (data quality): https://www.iso.org/obp/ui/#iso:std:iso:19157:ed-1:v1:en

3.2 DATA: FULFILL YOUR DATA REQUIREMENTS

What you will accomplish

This recipe will help you collect the data you require and to discover and access publicly available geospatial data. This includes accessing data by downloading it and accessing data from Open Geospatial Consortium (OGC) compliant web services. Definitions of key terms used in this recipe can be found in the Glossary section.

What you will need


Commitment icon

- A clear understanding of all the types of datasets you require and the questions or challenges you are trying to address through geospatial data analysis and visualization.
- An inventory of the required datasets that are accessible from your own internal sources.
- An inventory of the datasets that are required to fill gaps in the internally accessible data.


Equipment icon

- High speed internet connectivity.
- A desktop computer and GIS software (open source or commercial).


Knowledge icon

- Knowledge of external geoportals that support discovery of and access to geospatial datasets.

Skills icon

- A user with basic GIS skills.

Background

As a geospatial data user, you may spend a lot of time searching for geospatial datasets. If appropriate datasets are not accessible from internal sources, you can resort to the collection of new data, which can be expensive and result in project delays. Or you can try to find external sources to fill the data gaps. CGDI seeks to make the discovery and use of external data as easy as possible by enabling online search and discovery of key framework and thematic datasets. Many datasets are available online through federal, provincial and territorial government, and private sector portals, which are updated regularly.

Once you discover datasets that meet your requirements, there are often two options for access. Geoportals often allow you to download entire datasets in different data formats to your desktop computer or internal data server, enabling incorporation into your organization's geospatial data system. Alternatively, CGDI-compliant geoportals often allow you to access the dataset via web services. Web services present several advantages, notably that data does not need to be downloaded and stored locally. Such services also provide the latest version of data, eliminating the need to manage multiple versions of downloaded data in your system.

Recipe

1. Describe the purpose for which geospatial data is required (e.g., land use study, infrastructure development, conservation area management, etc.). Your description should provide enough detail to ensure that the complete data requirements are clearly evident.

2. Document your existing datasets related to your requirements. You can use the handy template provided in the Resources section below to document your requirements. Confirm which datasets you already have within your geospatial data management system that meet your requirements (e.g., recent aerial photos or postal code data).

3. Define the datasets you require and their spatial extent (e.g., Canada-wide, Western Canada, Alberta, City of Edmonton). With hundreds of framework and thematic datasets available on geoportals compliant with CGDI, it is possible that the data you are looking for already exist.

4. Select a data repository(ies) appropriate for your region. Most provinces and territories and many municipalities and other organizations have online geoportals where you can download Canadian datasets or access required data through web services. Examples of geoportals are provided in the Resources section below.

5. Explore the selected repository(ies) to ascertain whether the accessible datasets will meet your needs. Consider data content and format, coverage extent, data quality, accessibility options, etc. You can find these details about the available datasets by examining the data online within the geoportal application and by reviewing metadata records. Examples of available datasets can also be found in the *CGDI Starter Kit* referenced in the Resources section below.

6. Consider the most appropriate way for you to obtain your data, weighing the pros and cons of each option. As discussed under the Background section above, the two key options are: (1) downloading the entire dataset(s) for incorporation into your organization's geospatial data system; and (2) accessing the dataset(s) over the Internet from an external server. A useful resource for discovery of operational web services is the CGDI Geospatial Web Services webpage, which is updated weekly.

7. Access the required external datasets. You can follow the instructions in the metadata file for the dataset(s) of interest to download or access them.

Example

A Rural Municipality in Alberta is developing a geospatial dataset on wetlands within their jurisdiction to assist in ensuring compliance with the Alberta Wetland Policy. The goal of the Alberta Wetland Policy is to conserve, restore, protect and manage Alberta's wetlands to sustain the benefits they provide to the environment, society and economy. Under the Policy, the onus is on the applicant (e.g., developers) to avoid wetland impacts, from planning the activity to submitting a regulatory application to the Municipality, and to justify wetland impacts where avoidance is not practicable. The Municipality wants to ensure that it has the best possible wetlands geospatial dataset so that any development activity is undertaken in conformance with the Policy.

The process to fulfill their data requirements follows these steps:

- The responsible team within the Municipality describes the regulatory application requiring geospatial data. The application will support the preparation of Alberta Wetland Assessment and Impact Reports for proposed activities impacting wetlands.
- The team completes a document fully describing their existing datasets. These include: named waterbodies (e.g., watercourses, wetlands and lakes), catchment areas, drainage patterns and connectivity between water bodies, contour maps depicting landscape position of wetlands; and surrounding land uses.
- The team identifies that data still required includes wetland types, classes, boundaries and sizes.
- The team discovers that a wetland dataset (i.e., the Alberta Merged Wetland Inventory) is produced by Alberta Environment and Parks and is accessible via the GeoDiscover Alberta portal.
- They examine the wetland datasets and determine that they meet most of their application requirements. They recognize that possible limitations for local work purposes include the data currency (year 2015) and accuracy (30 m), missing vegetated form data and some data incompatibilities resulting from compilation of the inventory from multiple sources However, their research indicates that this is the best available source.
- They explore access options for acquiring the data from GeoDiscover Alberta. They learn from an examination of the metadata file for the Alberta Merged Wetland Inventory that the only option is to download the file from a File Transfer Protocol (FTP) site.
- The team downloads all required datasets from GeoDiscover Alberta and integrates the data into their geospatial data system.

Resources

Select Examples of Geoportals	
Federal Government	Government of Canada Open Maps Portal (https://open.canada.ca/en/open-maps)
Provincial & Territorial Government	British Columbia Spatial Data Infrastructure/British Columbia Geographic Warehouse (https://www2.gov.bc.ca/gov/content/data/geographic-data-services/bc-spatial-data-infrastructure)
	Alberta – GeoDiscover Alberta (https://geodiscover.alberta.ca/geoportal/catalog/main/home.page)
	Alberta – AltaLIS (https://beta.altalis.com/map)
	Saskatchewan GIS Data (https://www.isc.ca/MapsandPhotos/GISData/Pages/default.aspx)
	Manitoba Land Initiative (http://mli2.gov.mb.ca/)
	Land Information Ontario (https://www.javacoeapp.lrc.gov.on.ca/geonetwork/srv/en/main.home)
	Géoboutique Québec (http://geoboutique.mern.gouv.qc.ca/edel/pages/recherche/critereRechercheEdel.faces)
	New Brunswick – GeoNB (http://www.snb.ca/geonb1/e/index-E.asp)
	Nova Scotia – GeoNOVA GeoData (https://geonova.novascotia.ca/geodata)

Select Examples of Geoportals	
Provincial & Territorial Government (cont'd.)	Prince Edward Island GIS Data Layers (http://www.gov.pe.ca/gis/)
	Newfoundland Geospatial Datasets (https://opendata.gov.nl.ca/public/opendata/page/?page-id=datasets-spatial)
	Geomatics Yukon Imagery & Data (http://www.geomaticsyukon.ca/data/datasets)
Local Government	City of Vancouver (https://vancouver.ca/your-government/open-data-catalogue.aspx)
	City of Montreal (http://donnees.ville.montreal.qc.ca/)
International	National Aeronautics and Space Administration (https://data.nasa.gov/)
	Polar Thematic Exploitation Platform https://portal.polartep.io/ssoportal/pages/login.jsf
Commercial	ESRI ArcGIS Hub (http://hub.arcgis.com/pages/open-data)
	DigitalGlobe Product Samples (http://www.digitalglobe.com/samples)
Other	World Wildlife Fund, Marine Ecoregions of the World https://www.worldwildlife.org/publications/marine-ecoregions-of-the-world-a-bioregionalization-of-coastal-and-shelf-areas
	OpenStreetMap (https://www.openstreetmap.org)

Reference Materials

Explore the CGDI Starter Kits for access to free regional, curated framework and thematic datasets.

Geospatial Information Requirements Template

The purpose of this template is to provide a structure for documenting your requirements for geospatial data that are publicly available from external sources.

1. Application Requiring/Purpose for Geospatial Data

Briefly describe the purpose for which you require geospatial data (i.e., the domain(s) the application serves, the questions being addressed, the decisions or operational processes the application supports, the timeframe over which the application will be used, etc.).

2. Inventory of Available Data

Complete the following table to record the datasets that are currently available from internal sources.

Dataset Name	Dataset Repository	Description of Dataset Content
1.		
2.		
3.		
Etc.		

Dataset Format	Coverage Extent	Accuracy	Currency
1.			
2.			
3.			
Etc.			

3. Inventory of Required Data

Complete the following table to record the datasets that have been discovered to fill existing data gaps.

Dataset Name	Dataset Repository	Description of Dataset Content
4.		
5.		
6.		
Etc.		

Dataset Format	Coverage Extent	Accuracy	Currency
4.			
5.			
6.			
Etc.			

Accessibility (Download or Web Services)
4.
5.
6.
Etc.

3.3 DATA: SEARCH FOR AND USE REMOTE SENSING DATA

What you will accomplish

This recipe describes issues in evaluating and selecting remote sensing satellite imagery to meet your needs, including commercial and free and open data options, complimenting recipes: 3 – How to decide if you data is fit for purpose; and 9 – How to choose a GIS software solution. Some common commercial and open data systems are listed, including associated data discovery and download data portals.

What you will need

 **Commitment icon**	▪ An understanding of your information requirements and why you need remote sensing data. ▪ Time to search for, download and/or process imagery.
 **Equipment icon**	▪ Budget for material costs (if any). ▪ Software tools and knowledge as applicable.
 **Skills icon**	▪ A user with basic GIS skills.

Background

Remote sensing refers to sensors making measurements of an object, area, or other phenomenon at a distance (without physical contact), but in most cases users are interested in remote sensing images. Satellite images have an advantage over airborne collection because they cover large areas and are cost effective (often free). Images are often collected and added to data archives without the end user needing to place an order ahead of time. Satellite remote sensing technology has developed rapidly in the past five years, with numerous advances in spatial resolution, spectral information, frequency of observation, and cost-effectiveness (open data). The number of satellite sensors is changing how spatial data users work and many choices are available – the options can be overwhelming. This recipe explores how to evaluate satellite image options and discusses some common choices. It also explains the difference between obtaining satellite images for your spatial data infrastructure via downloading, web map services, and applications such as Google Earth and Esri base image service.

Recipe

1. Evaluate your purpose in using imagery. The most common goal is to provide a contemporary visual base overview of the landscape for your area of interest. Other common goals include observing and extracting certain features or landscape changes using images collected at different points in time. Key considerations include:

- Spatial resolution – Spatial resolution refers to the level of detail that can be resolved in a geographic digital image. It is usually expressed as the size of one pixel on the ground. Very high resolution images (1 metre pixel size or better) can act as a surrogate for aerial image collection, allowing fine delineation or digital capture of ground features and precise spatial measurements.
- Spectral properties – Images may also be used for analytical purposes, such as forest change, ice mapping, or water quality. Application must consider spectral resolution (light wavelength ranges) and precision (how finely measured) across multiple parts of the electromagnetic spectrum, or on radar signal pulse interactions with the surface of the earth. Different sensors have different strengths, which should be matched to your goals, for example multi-spectral sensors commonly meet most land cover mapping needs, but hyper-spectral sensors also exist with 100s of spectral channels that may support specialized applications.

2. Determine what requirements are essential to meet your purposes. For example:
   - Do images have to be from the past month or acquired in the near future, or are older images adequate?
   - Are very high resolution images needed?
   - What is the size of your area of interest?
   - Do you want to simply view the image with other data, or do you want to analyze the data?
   - Do you require frequent images at regular intervals regardless of atmospheric conditions or daylight (e.g., from radar)?
   - Do you need specific wavelengths, such as thermal infrared band images?
   - Do you have a budget or resources to buy images?

   The answers to these questions will quickly cut down the list of candidate sensors. There are **always tradeoffs** between spatial resolution, size of study area, frequency of coverage, archive availability, budget, and other factors. If you need very high-resolution commercial images, determine the budget available.

3. The number of options and range of sensor capabilities in the commercial sector is vast, although there are also some very capable open data options. Some common systems are shown in Table 1. The table is arranged by optical then radar systems, and roughly in order from finer to coarser spatial resolution, by vendor, and by capability. Open data sensors providing free-for-use images are highlighted. Note that even for open data images, there are costs associated with processing, handling and storing the images even if you do this internally. Storage costs should also be considered for very high-resolution commercial data, and computer hardware will need to be sufficiently powerful to handle the large data volume. Web services that “stream” images are an alternative option to locally handling images, although usually with less flexibility. Example include:
   - Landsat streaming data from the United States Geological Survey (USGS)
   - Esri
   - Commercial web services such as DigitalGlobe EarthWatch.

4. Search for the images you want. If you are using commercial data, you can search the archives with in-house resources or contact an image reseller or consultant and have them do the archive search or new collection feasibility study for you. There are some high-quality web portals that can help with identifying candidate images, such as the USGS LandsatLook and SentinelHub Playground sites. Such sites are useful for determining which image dates may work for you.

5. If downloading open data imagery, connect to the provider portal and find the image dates you have identified. For Landsat, the most common download location is the USGS EarthExplorer, and for the Sentinel missions, the Copernicus Open Access Hub. Both Landsat and Sentinel optical data is available from other services as well, such as Google Cloud and Amazon Web Services, but these operations are more advanced and are mostly suitable for bulk downloading large collections of imagery.

   - Note that for both Landsat and Sentinel-2 optical data, level-1 and level-2 data are possible. Level-1 data have basic instrument calibrations applied, whereas level-2 data results from extra processing to convert the image values to surface reflectance (discriminating between the surface and the atmospheric contributions to the total observations made on-board the satellite). You may not need this level of processing, but new collections for both platforms are available pre-processed to level-2 if this is a requirement.

6. For medium to small scale mapping (approximately > 1:50,000 scale), Landsat imagery may be adequate. Landsat images have lower spatial resolution compared to Sentinel-2, which requires less storage, and their native image format (GeoTiff) is easily used with desktop GIS software. Sentinel-2 images ship in the Standard Archive Format for Europe (SAFE) format, which is more complicated to work with and may not be supported with software you are familiar with; however, at 10 m resolution with an approximate 5-day revisit cycle (from two separate satellites, 2A and 2B), it may be worth the effort depending on your organizational needs. SNAP desktop software (Sentinel Application Platform, European Space Agency) can be downloaded for free and can convert images to more commonly used formats.

7. Small to medium-sized organizations should not be afraid to use open data images or streaming services, such as those available from Google Earth, for simple display purposes. Acquisition, purchase, storage and use of remote sensing satellite imagery is a process of weighing benefits tradeoffs and involves a degree of art as well as science. If your needs become complex and in-house capacity is not available, there are many qualified companies that can take on specialist responsibilities on your behalf.

Table 1 Common commercial and open data satellite systems and providers.

Type	Satellites	Provider	Access
Optical – submeter to <10 m 4 band plus panchromatic	WorldView Constellation (GeoEye, WorldView series, Quickbird, Ikonos)	DigitalGlobe	Commercial
Optical – submeter to 30 m or better 4 band plus panchromatic	Pleiades, SPOT series	Airbus Defense and Space	Commercial

Table 1 (Cont'd.)

Type	Satellites	Provider	Access
Optical – submeter to <30 m 3 to 4 band	PanGEO, Deimos-1	Urthecast	Commercial
Optical – 5 m or better 4 to 5 band	PlanetScope, RapidEye Constellation	Planet Labs Inc. (Planet)	Commercial
Optical – 10 m multispectral	Sentinel-2 constellation	European Space Agency	Open Data
Optical – 30 m or better multispectral	Landsat series	United States Geological Survey	Open Data
Radar – 1 to < 20 m X band 4 polarizations	TerraSAR-X	Airbus Defense and Space	Commercial
Radar – 3+ m C band multiple polarizations	RADARSAT-1 and -2	MDA Geospatial Services Inc.	Commercial
Radar – 5+ m C band 4 possible polarizations	Sentinel-1 constellation	European Space Agency	Open Data

Example

A small community wants to monitor vegetation change patterns to track impacts and activities such as wildfire, resource exploration and forestry operations. The community envisions capturing yearly image information for the last five years, then supplementing this with monthly updates to assess changes.

The local engineering and planning department is the largest user of remote sensing images, almost exclusively from aerial orthophotography and photogrammetric products. A local consultant specializing in forestry and vegetation is also familiar with these products, but the historical aerial archive is inadequate. Very high resolution optical satellite imagery is considered as an alternative, and a reseller is contacted to provide a quote. The satellite archive is also incomplete, and new acquisitions are too expensive to meet local budgets.

The vegetation consultant suggests that open data imagery may be adequate for the community's needs, questioning if very high resolution products are actually necessary for wide area monitoring. A quick search of open portals reveals that free Landsat-8 imagery covers the area for the entire five year period at 30 m resolution, with 15 m panchromatically sharpened imagery also possible. Another search further reveals that free Sentinel-2 imagery is available at 10 m resolution going back to late 2015. Sample imagery is downloaded and found to be very suitable for the intended purpose.

Resources

1. Esri Landsat Image Service: https://www.esri.com/en-us/arcgis/landsat-imagery/services
2. USGS LandsatLook and Sentinel2Look viewers: https://landsatlook.usgs.gov/
3. SentinelHub Playground: https://www.sentinel-hub.com/explore/sentinel-playground
4. Landsat EarthExplorer: https://earthexplorer.usgs.gov/
5. Sentinel-1 and -2 Copernicus Open Access Hub: https://scihub.copernicus.eu/dhus/#/home

3.4 DATA: GEOSPATIAL DATABASES

What you will accomplish

This recipe explores the similarities and differences in common approaches to storing geospatial data and how to advance from using file-based methods (e.g., shapefiles and GeoTIFFs) towards common spatial relational databases, or enterprise-level spatial relational databases. You will understand why a spatial database is useful and what it can and cannot do, including when it is appropriate to implement enterprise-level solutions.

What you will need

 Equipment icon	▪ ArcGIS, QGIS or other GIS system capable of using GIS files (e.g., Shapefile), File Geodatabase, or GeoPackage formats. ▪ Sample data, either in-house or from the web.
 Skills icon	▪ Expert GIS User.

Background

Data are a fundamental component of a GIS and there are several approaches to data management. We often work with spatial data that combines simple geometries (spatial information) with simple attributes (measurements or records). For simple needs we use simple solutions – for example, the shapefile is a common and appropriate format to store vector data and a GeoTiff is appropriate for raster data. Part of the power of GIS is the ability to handle complex information and/or complex spatial relationships between features, including the discovery and description of these relationships. For example, topology defines rules for how features may share a geographic space (e.g., area features can share boundaries; line feature can share endpoints). As complexity increases, the information system must become more sophisticated. This is why spatial relational databases (also known as geospatial databases or simply geodatabases) exist. We will explore the levels of representation, information management, and data sharing implications for the choice of information system used.

Recipe

Part A – Database Creation and Population

1. Create a sample spatial database. If you are using Esri tools, right-click on a file path from ArcCatalog or from the ArcMap catalog view and select New/File Geodatabase (FGDB). If you are using QGIS (version 3 is described here), you can create a GeoPackage with a new layer by clicking the New GeoPackage Layer button. For an empty GeoPackage, download the template provided in the Resources section below.

2. Get some sample data to work with, either locally, from a public repository, or from the CGDI Starter Kit.

3. To import data into your FGDB:
   a. Right click on the database you created
   b. Select “Import/Feature Class (multiple)”
   c. Select the files you would like to import.

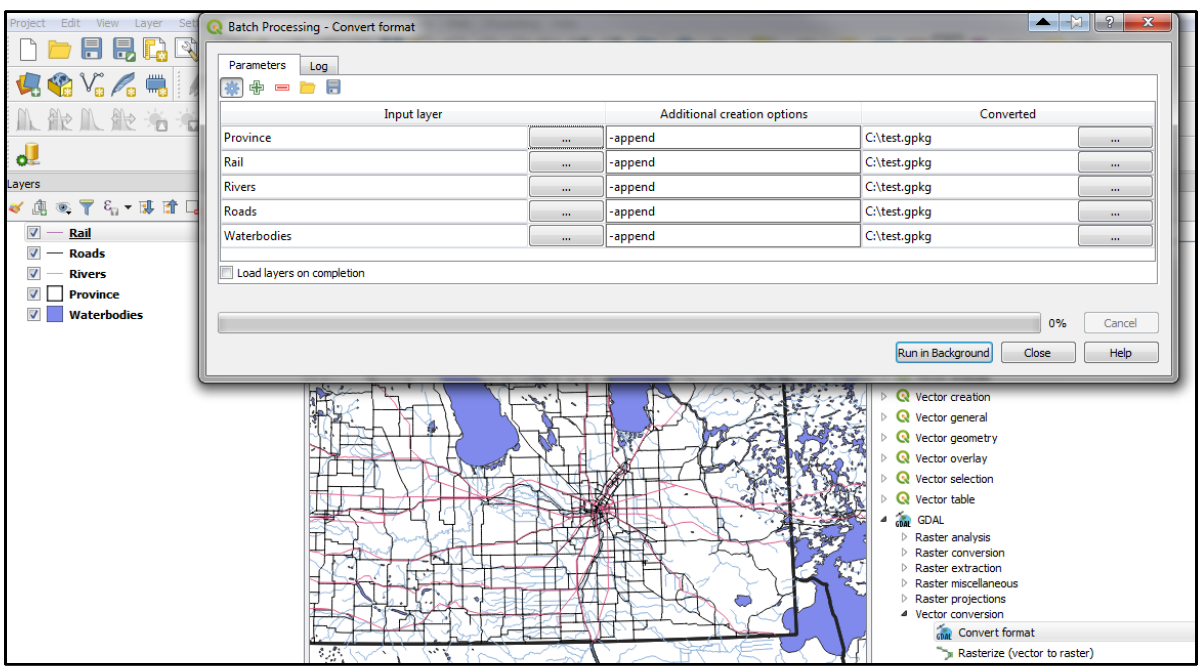
   For GeoPackage, this is not quite as easy:
   a. Add the files to QGIS
   b. From the Processing/Toolbox search for GDAL/Vector conversion/Convert format
   c. Right-click and select “Execute as Batch Process”. You can select multiple input files.
   d. Click the gear icon to select advanced mode,
   e. Type "-append" (without the quotes) into the Additional creation options dialog.
   f. Double click this field to populate the parameter to each row. Unfortunately, this trick won't work for the Converted (output) field.
   g. Copy and paste the output GeoPackage full path into this field and run the tool (Figure 1).

4. Note that entire databases or individual layers can be easily migrated between formats with Simple Features Library (OGR) tools. For example:

```
ogr2ogr -f GPKG test.gpkg test.gdb
```

   will copy an entire File Geodatabase into a new GeoPackage representation[1].

Figure 1 Batch export to GeoPackage example.



[1] E.g., executed from the command shell in Linux with the gdal-bin package installed, or from the OSGeo4W program shell in Windows.

Part B – Database Comparison

1. Consider these basic differences between Esri File Geodatabase and GeoPackage format.

   a. File Geodatabase is a proprietary format. It is Esri's suggested desktop-level format for working within their system. It provides many of the features we expect from a relational database in a standalone, file-based format. Esri has published an Application Programming Interface, and free tools have been created for accessing the format. A completely open source driver has been developed (OpenFileGDB) with read-only support. It can also read ZIP compressed file geodatabases directly.

   b. GeoPackage is a system-independent open source project designed and implemented by the Open Geospatial Consortium (OGC). Its goals include maximum portability and standardization, and it has been widely adopted by geospatial software projects and vendors. It is built on top of the widely deployed SQLite file-based database system, which implements most of the SQL-92 ISO structured query language specification.

2. Note some of the features and limitations of spatial data formats as shown in Table 2. SpatiaLite is a separate project from GeoPackage, also built on the SQLite database. SpatiaLite and SQLite were initially reference implementations for the design of GeoPackage. SpatiaLite implements a subset of the OGC/ISO Simple Feature Access specification standard to encode geometry, and it contains a rich set of spatial SQL functions. The table below is generally arranged in order of complexity from left to right, with Shapefile being the simplest format and enterprise spatial database solutions the most complex. The three middle options, File Geodatabase, GeoPackage and SpatiaLite each have similarities and differences with relative strengths and weaknesses.

Table 2 Comparison of spatial data storage formats.

	Shapefile	File Geodatabase	GeoPackage	SpatiaLite	Enterprise Database (DB)
Database Name	8.3 format (8 character name + 3 character extension)	OS dependent (e.g., 255 or more text characters)	OS dependent (e.g., 255 or more characters)	OS dependent (e.g., 255 or more characters)	DB dependent (typically 63 or more characters)
Database Size	2 GB for DBF attributes	Unlimited except through OS file/directory size limitations	~140 TB	~140 TB	Usually unlimited
Layer Name	8.3 format (name + extension) with DOS filename character restrictions	160 characters, cannot start with numeric, cannot contain special characters or spaces	Only limited by SQL statement length (default is 10 M characters total)	Only limited by SQL statement length (default is 10 M characters total)	DB dependent (typically 63 or more characters)
Layer Size	2 GB for DBF attributes	1 TB, upward configurable	Based on DB size limit	Based on DB size limit	Large (typically multiple TB)

Table 2 (Cont'd.)

	Shapefile	File Geodatabase	GeoPackage	SpatiaLite	Enterprise Database (DB)
Field Name Length	10 characters	64 characters	Limited by SQL statement length (default is 10 M characters total)	Limited by SQL statement length (default is 10 M characters total)	DB dependent (typically 63 or more characters)
Layer Bundling	None	Multiple layer support	Multiple layer support	Multiple layer support	Multiple layer support
Spatial Representation	No collections for lines or polygons. Only one geometry column	Multiple including collections and true curves, only one geometry type per layer	Multiple including collections and true curves, only one geometry type per layer	Multiple including collections, multiple geometry types per layer possible	Multiple (implementation dependent), multiple geometry types per layer possible
Multiuser Support	None	Concurrent read, write to tables not being read	Concurrent read, concurrent read/write on some file systems with write-ahead logging (WAL) journaling	Concurrent read, concurrent read/write on some filesystems with WAL journaling	Concurrent access, concurrent update, long transactions and versioning, disconnected editing (Esri)
Transfer Mechanism	Few individual files	Many individual files	One file	One file	Through export to dump file or replication options
Index Support	Spatial Index, limited attribute indexes	Spatial Index, single-field attribute indexes	Spatial Index, single and composite field indexes	Spatial Index, single and composite field indexes	Spatial Index, single and composite field indexes
Other Relational Database Management System (RDMS) Features	None	Esri-specific features (DB annotations, representations, topology check etc.), geometry compression, inner and left joins and spatial views through query tables Spatial SQL not supported natively*	Inner or left joins, views, transactions, triggers Complicated spatial view support, Spatial SQL not supported on native geometry**	Inner or left joins, views, spatial views, transactions, triggers, geometry compression, spatial SQL Drop columns not supported	Inner, left, right, outer joins, views, spatial views, transactions, triggers, prepared statements, geometry compression, spatial SQL, many more including client-server model

M = Million, GB = Gigabyte, TB = Terrabyte

* Can be done with OGR tools (e.g., ogrinfo -dialect sqlite -sql "<sql statements and layername>" <dbname.gdb>)1

** Possible by querying virtual GeoPackage layer representation through spatiaLite or through OGR tools

3. Some points of note about desktop formats from Table 2 and related comments:
    a. GeoPackage and SpatiaLite are the most easily transported formats;
    b. File Geodatabase, GeoPackage and SpatiaLite can each store very large datasets. The shapefile size limit could be an issue for some geoprocessing outputs, vectorized raster classifications, high-resolution contour lines, etc. File Geodatabase may have additional optimizations and seems much faster for certain geoprocessing tasks within the Esri processing environment;
    c. Shapefiles are very restricted in name lengths for the feature itself and its attribute names. This can be a significant problem with attribute-rich datasets. SpatiaLite has essentially no restrictions on table names or field names, which could be useful if nonstandard text encoding or long, descriptive names are needed;
    d. Shapefile geometry types are very simple, which can be an issue depending on the purpose. File Geodatabase and GeoPackage can store true parametric curves while SpatiaLite and Shapefiles cannot. SpatiaLite can have multiple geometry columns.
    e. None of the desktop formats listed in Table 2 is well-suited for concurrent use. Shapefile access will fail if another user is viewing the same file. The non-desktop formats allow concurrent reads but have restrictions or peculiarities when reading and writing occurs simultaneously. None of them support concurrent writes to the same layer (i.e., row level locking).

Part C – Guidance on Choosing a Geospatial Database Solution

As you learn more about geospatial data management and develop a more sophisticated SDI, you will likely need to advance the geospatial database solution that you use. For many organizations, maintaining an organized file-based data management solution works well, even if the files are saved on shared network storage. But as the number of users grows or you start to develop additional applications (e.g., mobile data collection, WebGIS) the database solution will need to become more sophisticated. Here are some simple tips on choosing a solution:

- If you are exchanging simple data with legacy systems, use Shapefile;
- If you are working entirely within the Esri ecosystem, use File Geodatabase;
- If maximum portability is important or the database needs to work with a range of computer architectures or portable devices, use GeoPackage;
- If spatial SQL functions are important or multiple geometry fields are needed in a desktop environment, use SpatiaLite;
- If many concurrent, multi-user reads or multi-user editing is required, or if you need advanced database management features, consider an Enterprise DBMS solution. This could implement Esri geometries through Spatial Database Engine (SDE), or or OGC geometries (e.g., through PostgreSQL or PostGIS) depending on your needs; and
- Cost limitations may necessitate the selection of a free option.

Resources

- See "empty GeoPackage template" under Creating a GeoPackage: http://www.geopackage.org/guidance/getting-started.html
- OGR Simple Features Library: https://trac.osgeo.org/gdal/wiki/FAQ

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4.0 STANDARDS RECIPES

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4.1 STANDARDS: MAKE YOUR DATA DISCOVERABLE

What you will accomplish

This recipe will help you to allow people with whom you wish to share datasets to discover the data that you want to make accessible. Definitions of key terms used in this recipe can be found in the Glossary section.

What you will need

Commitment icon

- An organizational decision to make specific internal datasets accessible for external users.
- An inventory of the datasets to be made accessible.

Equipment icon

- A desktop computer suitable for running GIS software and metadata creation tools.
- A webserver capable of running cataloging tools including providing web endpoints for updating and searching to make the metadata available over the Internet.
- High speed Internet connection and bandwidth for uploading metadata to a catalog.

Knowledge icon

- A staff member who is knowledgeable in the development of metadata records or capable of gaining such knowledge (i.e., with intermediate GIS skills).

Background

To allow diverse geospatial data sources, services, applications and systems to operate with each other on the Internet, experts have developed technical and data standards. Standards for geospatial interoperability provide consistent and interoperable patterns for creating, reproducing, updating and maintaining geospatial information and services. To make your data discoverable, you will use a metadata standard such as the North American Profile (NAP) of the ISO 19115: Geographic Information – Metadata standard. A metadata record is an information file that captures the basic characteristics of a geospatial data or information resource. Benefits of using a metadata standard include the ability to use tools that can ease creation and maintenance of metadata conforming to the standard and the ability to automatically check a metadata instance for conformance with the standard. Another benefit is clarity about metadata requirements and content within your organization, or between organizations that share geospatial data.

In order for external users to discover datasets that you make accessible and assess their fitness for use in their applications, they need access to your metadata. This is accomplished through a catalogue service. Catalogue service standards support the ability to publish and search collections of metadata for data, services and related information objects. Metadata will be discovered by your users with a web service such as Catalog Services for the Web (CSW), which will identify your organization as the agency that is responsible for each dataset and contain information on how to access your data. Several metadata software tools exist, such as GeoNetworks and CKAN.

Common elements of metadata records include:

- *Identification information*: information that allows the geospatial dataset to be uniquely identified and distinguished from other datasets (e.g., name of the dataset, keywords, basic description and geographic extents) and assists in cataloging the geospatial dataset.
- *Data quality information*: information that could include completeness of the data set, processes used to create and maintain it, and the amount of validation or verification performed on the dataset.
- *Spatial data representation information*: information that could include precision and accuracy of vector geometry or the resolution of raster data.
- *Non-spatial (attribute or tabular) data information*: information about the attribute data associated with features in geospatial data in vector format, or attribute data associated with cells of geospatial data in raster format. This could include the meaning of attribute names, valid values, domain or range for attribute values, and method used to collect and update attribute values.
- *Distribution information*: information that can be used to govern the distribution of the geospatial dataset, including the identity of the organization creating and maintaining the dataset, and date the dataset was published or made available to the public.

Although there is an initial cost associated with generating and documenting information about data (i.e., creating metadata), it is less than the potential costs of duplicated or redundant data generation. The costs of not creating metadata include potential loss of information about the data through staff changes, data redundancy, data conflicts, liability, misapplications, and most importantly, decisions based on poorly documented data. When essential information is missing or is not documented adequately, the value of the data to others is severely reduced. Lack of confidence in information can tarnish the results of any subsequent analysis of the data. Properly written metadata can help avoid confusion and uncertainty.

Recipe

1. Identify the person(s) best qualified to take responsibility for metadata development and maintenance. Common prerequisites for this task include knowledge and understanding of:
   - What a GIS is and what it can do;
   - How GIS data is collected and created;
   - How GIS data is organized into geospatial datasets; and
   - The differences between the two basic types of GIS data – raster and vector.
2. Research available tools for creation of metadata and choose the metadata tool that best matches the needs of your organization. Under Resources below are several sources of information about metadata creation tools.
3. Download and install the chosen metadata tool and learn the implementation process.

4. Create metadata records for your organization's geospatial datasets. Tools will typically provide instructions on how to create and manage metadata (see for example the instructions for creating North American Profile metadata within Esri's ArcGIS Pro software referenced in Resources below).

5. Research available tools for cataloging your metadata so that it will be discoverable and choose the catalog tool that best matches the needs of your organization. Under Resources below is a reference to the popular catalog creation tool PYCSW.

6. Download and install the chosen catalog tool and learn the implementation process. Some tools incorporate both metadata and cataloging functions (see for example instructions for use of the GeoNetwork open source tool in the User Guide referenced in Resources below).

7. Publish your metadata into the catalog. As an example of detailed instruction on how to publish metadata in a catalog service, see the PYCSW Workshop referenced in Resources below.

Example

The Treasury Board of Canada Secretariat (TBS) published the *Open Government Guidebook* for those wishing to learn more about GoC Open Government processes (TBS 2018). The *Guidebook* provides guidance on consistent approaches to implementation of open data and information practices across government. The process described in the *Guidebook* for making GoC data accessible includes the following steps:

1. *Identify what data should be released* – All data resources of business value held by GoC departments are to be open by default and released as open data.
2. *Prioritize data for release* – A prioritization toolkit is provided to help users evaluate priorities according to the criteria of:
   a. Value and importance to the public, considering service to public, reuse potential, government transparency and international priorities, etc.;
   b. Readiness for release, considering data quality, currency and ease of release;
   c. Cost of release, considering data formats, update frequency, operations and maintenance, etc.; and
   d. Risk of release, considering legislative requirements and privacy and security considerations.
3. *Identify what data should not be released* – Identify restrictions on data release due to concerns about:
   a. Privacy, considering disclosure of personal information about an individual that cannot be de-identified ("de-identification" is a process that removes features in data that would allow it to be connected with an individual);
   b. Security, considering data that provides details about vulnerable of targeted individuals or organizations;
   c. Legal and contractual limitations, considering data sharing agreements, commercial data licences, etc.; and

   d. Confidentiality, considering data that might compromise the government's ability to make decisions (e.g., court rulings, budget and policy decisions, etc.).

4. *Develop a data release scheme* – Develop clear descriptions of the data released under each listed category of data. Ensure that new data covered by each release scheme is available and that anything outdated is replaced or archived.

5. *Assess the data* – Asses data to ensure that it can be released, with the involvement of major players (e.g., Chief Information Officers, Business Owners, Department Open Government Coordinator, Information Technology Services, Legal Services, etc.).

6. *Prepare the data* – To successfully register open data via the Open Government Registry, the following requirements are mandatory:

   a. Metadata designed based on the Open Government Metadata Application Profile;

   b. Online access to one or more data file(s) in an open and accessible format(s);

   c. A direct link to the data on the web;

   d. A data dictionary or product specification file that contains definitions for data elements in the dataset; and

   e. Data availability on the web under an open licence, as structured data in an open, non-proprietary format.

7. *Obtain approval to release the data* – Chief Information Officers responsible for maximizing the release of Government of Canada open data can use a 'Release Checklist' that consolidates common release exceptions.

8. *Release the data* – To add a dataset to the Open Government Registry, GoC data providers need to create an account by completing and submitting a 'Request an Account' form, after which they can add open data records to the registry.

9. *Manage the data* – To manage the data that is released on open.canada.ca, data providers are encouraged to bundle similar datasets together and create one metadata record in the Open Government Registry, rather than creating a record for each individual resource. It is also recommended to provide information in the description on the metadata record or as an additional file to explain to users when data have been updated or changed.

10. *Develop an outreach and engagement strategy* – Data providers are encouraged to develop such a strategy so that: (1) users are more likely to be aware of new resources, changes to collection approaches, and the context of datasets and information assets; and (2) curators have an opportunity to learn from the community, gain new understandings of their resources and more effectively prioritize data release in response to users' preferences.

The Guidebook includes several appendices that provide valuable additional information to assist GoC data providers in their efforts to make their data assets discoverable and accessible (e.g., Security and Privacy Guidelines, guidance on Accessibility and Interoperability and on Governance, and Statistics Canada's Confidentiality Classification Tool and User Guide).

In 2017, the TBS published the *Open Government Metadata Application Profile* to ensure a consistent approach to describing open government resources in metadata. It includes a comprehensive set of metadata elements that enable the consistent description of all resources within the Open Government Portal, regardless of their content. Domain specific element sets, or extensions, were developed to support a refined search based on a particular collection (i.e., non-spatial data, geospatial data and publications).

A Government of Canada Metadata Schema was created that contains a foundational set of the metadata elements that are common to all resources, as well as catalogue and domain extensions that further assist in describing the structure and domain of the information. The schema aims to provide a single and scalable approach to metadata management to enable greater search and discovery, interoperability, and public understanding of information and data.

The Government of Canada Standard on Geospatial Data requires managers and functional specialists responsible for creating or using geospatial data or for systems that use geospatial data to apply the ISO 19115 Geographic information – Metadata standard (ISO 2014). In addition to foundational and catalogue extension metadata elements, departments that produce, use or consume geospatial data must use the additional minimum mandatory metadata elements.

Resources

- Tools for the creation and editing of metadata files ISO-19115-NAP and Catalogue Files ISO 19110 and ISO 19110-VCNP: https://www.nrcan.gc.ca/earth-sciences/geography/topographic-information/tools-applications/10997
- ISO Geospatial Metadata Editors Registry: https://www.fgdc.gov/iso-metadata-editors-registry/editors
- OSGeo Metadata Software Tools: https://wiki.osgeo.org/wiki/Metadata_software
- Create NAP metadata: https://pro.arcgis.com/en/pro-app/help/metadata/create-nap-metadata.htm
- GeoNetwork User Guide: https://geonetwork-opensource.org/manuals/3.6.x/en/user-guide/index.html
- PYCSW: https://pycsw.org/
- PYCSW Workshop: https://geopython.github.io/pycsw-workshop/
- The Federal Geospatial Platform (FGP) (https://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/geospatial-communities/federal)

4.2 STANDARDS: PROVIDE ACCESS TO DATA VIA WEB SERVICES

What you will accomplish

This recipe focuses on preparing and publishing geospatial data online to provide users with remote access to data by using spatial web services. It touches on related issues of data sensitivity/access policies. The recipe will provide a basis to plan the publication of geospatial data online including issues of data presentation and performance.

What you will need

 **Equipment icon**	▪ Desktop GIS software and web GIS server software capability (e.g., GeoServer, ArcGIS Online, etc.).
 **Commitment icon**	▪ Commitment from your organization to sharing certain datasets and choosing appropriate levels of access and security. ▪ Time to produce quality web symbology and to test map usability.

Background

Spatial web services are standards-based requiring a web server and server-side software that implements the appropriate standards for remote data access. The Open Geospatial Consortium (OGC) defines several publicly available, open spatial data service standards that have widespread adoption in both commercial software and open source software packages. Two commonly used OGC web services are Web Map Service (WMS) and Web Feature Service (WFS) – these services provide spatial data as pre-rendered (coloured, themed, labelled, etc.) raster information or as raw vector data, respectively. Proprietary web service protocols can also be used within the same software. For example, you can view an ArcGIS map service using ArcMap or an Esri Web Service compatible viewer (e.g., Leaflet or Dojo based).

Web service data can be viewed directly in desktop mapping applications such as ArcMap or QGIS. Additionally, a Web GIS application can be made available so that users can view and interact with the web service data in their web browser. Potential interactions can include:

- Toggling layers on and off;
- Reordering layers and zooming to layer extents;
- Querying attribute data contained in layers or viewing/exporting the underlying tables;
- Geoprocessing operations such as data clip and ship (using a polygon digitized by the user, the data are clipped to the polygon extent and packaged for download by the user); and
- Editing of vector data using a Web Feature Service (including concurrent, multiuser editing capabilities).

Recipe

1. Decide which geospatial data you want to share from your organization. This will require discussion and authorization within your organization, including managerial and potentially with legal services.

2. Review the implications of publishing the data and any relevant data sharing policies or data sensitivities. Confirm any security requirements and lists of authorized end users. If applicable, confirm that commercial data use or sharing licenses are respected, including concurrent use limits and correct source attribution (e.g., for commercial satellite image data). For Web Feature Services, confirm if end users should have write access to the data.

3. If data is to be edited with multiple users, the data must be migrated to an appropriate back-end data store (e.g., an enterprise-level spatial relational database).

4. For WMS:

   a. Create a desktop map incorporating the datasets of interest.

   b. Symbolize vector and raster data as appropriate. Consider that a static map for printing is different from a dynamic, online map. If publishing multiple layers for a Web GIS viewer, care must be taken with layer drawing order, scale dependent rendering, and labelling at multiple scales. The user experience should be consistent across viewing scales and locations. It can be time-consuming to achieve these balance of outcomes.

   c. Publish the map or raster layers as web services. For large raster source data, appropriate tiling must be used for service performance to be acceptable. Raster tilesets can grow very large, which should be considered if publishing to a cloud service with associated hosting costs (e.g., ArcGIS Online).

5. Test usability, possibly by consumption in desktop GIS software. Adjust symbology, scale dependencies, etc., and republish if needed.

6. Consider end user dependencies if Web GIS viewer software is being deployed. For example, does the viewer depend on any proprietary or binary installs, or does it only need commonly available web components such as Javascript? Is the viewer limited to a particular web browser software?

7. If applicable, host a Web GIS viewer with appropriate web services added. Adjust initial extent, available tools, and other components of the user interface such as legend and layer list.

8. If applicable, populate metadata and publish a metadata discovery service (e.g., OGC Catalog Service for the Web – CSW) along with the underlying layers. This will facilitate data discovery, especially if very large collections are being published.

9. Consider forming an end user testing group to evaluate the utility and usability of web services and/or the Web GIS viewer. Make adjustments where needed.

Example

GeoDiscover Alberta is a cross-ministry, provincial government run spatial data warehouse. It provides Alberta citizens and businesses with curated, authoritative spatial data to support decision making and understanding of provincial issues. It follows open data initiatives by design, implementing SDI concepts and contributing to the federal CGDI. Much of the data warehouse content is also browsable through the GeoDiscover online viewer, available for download, or as spatial web services.

Alberta has made significant efforts to manage its wetland ecosystems through mapping and characterization efforts. Historically, multiple wetland classification schemes have been employed in different parts of the province. The Alberta Merged Wetlands Inventory is a consolidation of multiple provincial wetlands datasets, following the categories of the Canadian Wetland Classification System (CWCS). Alberta also has a strategy for data collection according to the newer provincial Alberta Wetland Classification System, which should result in a product that will eventually replace the merged inventory.

The merged inventory provides information on the five wetland classes of the CWCS from 1998 to 2015. Comprehensive metadata describes the varied classifications in the merged product, image sources used to produce the classifications, and data gaps in coverage. GeoDiscover Alberta has made the data available as both an Esri Map Service and as WMS, and additionally through their online web geoportal. The inventory class layer has a scale dependency to not draw beyond approximately 1:50,000 scale. It is pre-symbolized and can be queried with an identify tool. Government web services are often delivered in this fashion.

Resources

- Catalog Services for the Web (CSW) for CGDI: https://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/standards-policies/8910
- Alberta Merged Wetland metadata: https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BA73F5AE1-4677-4731-B3F6-700743A96C97%7D
- See viewer links at GeoDiscover Alberta portal: https://geodiscover.alberta.ca/geoportal/catalog/main/home.page

5.0 TECHNOLOGY RECIPES

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5.1 TECHNOLOGY: CGDI STARTER KITS

What you will accomplish

This recipe provides an introduction to CGDI Starter Kits, which are designed to help new and novice CGDI users to quickly get started and begin to obtain value out of geospatial datasets available through the CGDI via open source and commercial GIS software (QGIS or ArcGIS).

What you will need

 Equipment icon	▪ A computer suitable for running GIS software or an organizational decision to acquire one. (E) Glossary ▪ High speed Internet connection and bandwidth for downloading large datasets. (E) Glossary
 Skills icon	▪ A staff member with basic GIS skills or a decision to hire someone who has those skills.

Background

Natural Resources Canada commissioned a UNA study for the CGDI to build upon previous work and understand the current requirements of Canadian CGDI users, including data users and suppliers, with special attention paid to the requirements of Indigenous organizations (Hatfield Consultants 2019). In response to the findings of the Assessment, the CGDI Starter Kits concept was established to help CGDI users to quickly get started and begin to obtain value out of geospatial datasets available through the CGDI. The Starter Kits include:

- A curated set of existing, open framework and thematic geospatial data.
- Data packages formatted to be easily opened in desktop GIS applications (ArcGIS and QGIS).
- Technical guidance on using the Starter Kit, including how to access linked datasets via spatial web services and downloading to a local computer/server.

The curation of content and datasets addresses the common challenge faced by new users regarding which datasets to access and use to get started with GIS and the CGDI. As seen in Figure 1, the Open Government Portal has over 71,000 datasets under the “Nature and Environment” theme. This vast number of datasets provides a barrier to novice users when deciding which datasets they should use.

Within the context of the CGDI, the data for the Starter Kits comes primarily from Federal and Provincial suppliers, e.g., Open Government of Canada and Provincial/Territorial agencies that are part of the Canadian Council on Geomatics. To embrace the benefits of the CGDI, where possible datasets are integrated into the Starter Kits using spatial web services (e.g., WMS or WFS), to limit the size of the data package and ensure that users always have access to the latest data being provided by the supplier. For both the ArcGIS and QGIS Starter Kits, for several layers scale dependency is used so that detailed datasets only appear when the user zooms into the map to a certain scale in some cases.

To pilot the CGDI Starter Kit concept, four kits were developed organized into four areas or categories: British Columbia, Northwest Territories, Climate Change, and Water Resources.

For BC and NWT, base datasets are grouped thematically as follows:

- Administrative Boundaries;
- Hydrology;
- Protected Areas;
- Land Cover/Land Use;
- Mining;
- Elevation;
- Base imagery;
- Settlements;
- First Nations/Inuit;
- Forestry;
- Wildlife;
- Oil and Gas;
- Infrastructure;

For Climate Change and Water Resources, base datasets are grouped thematically as follows:

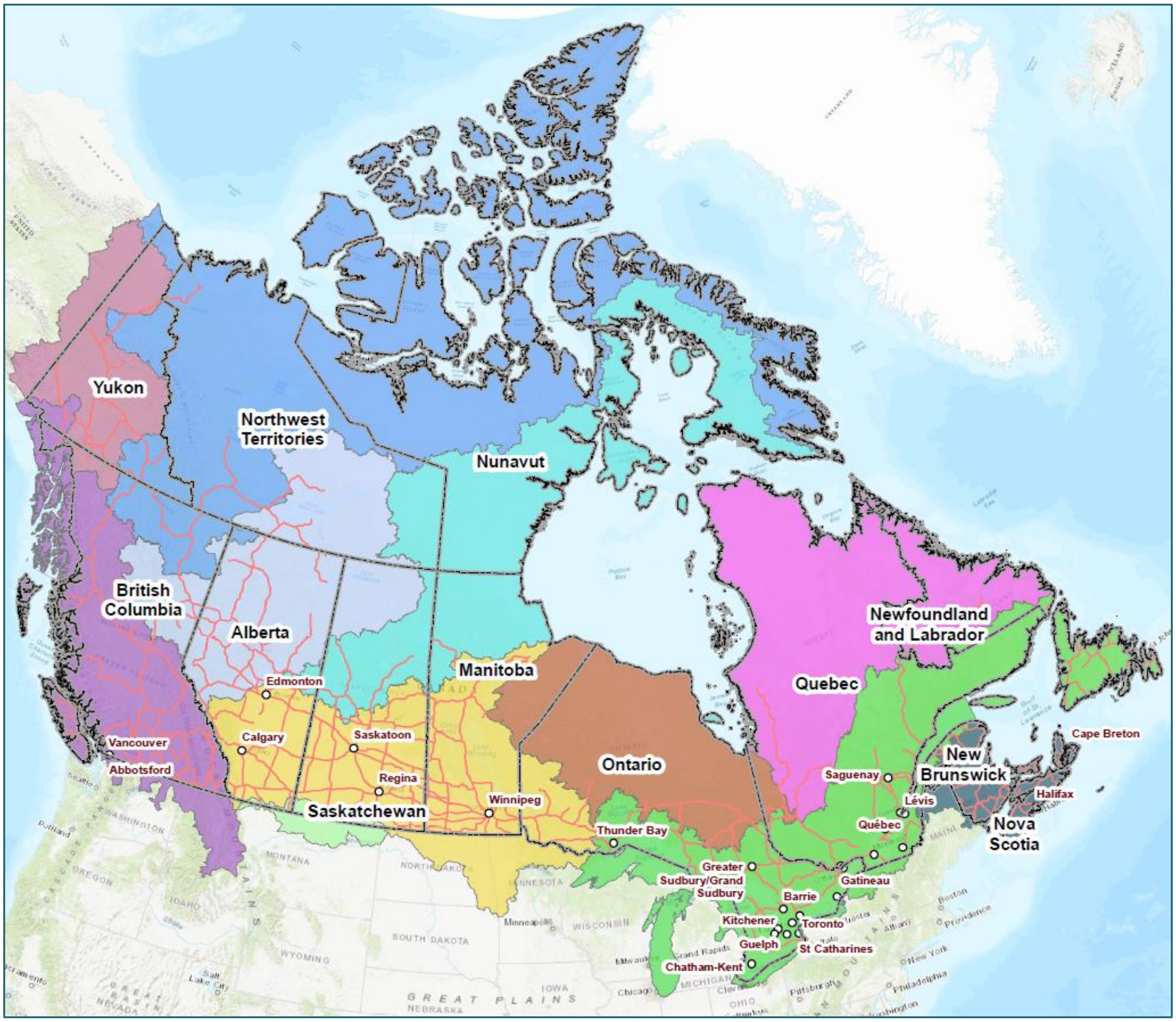
- Administrative Boundary;
- Settlements;
- Infrastructure;
- Critical Habitat
- Natural Events;
- Elevation and Hillshade;
- Base imagery;
- Base hydrology

Additional select data sets focused on the themes of water resources and climate change are also compiled and included. Example example datasets include:

- Groundwater (e.g., aquifer vulnerability):
- Marine (e.g., shoreline classification);
- Snow and Ice (e.g., permafrost)
- Adjusted and Homogenized Canadian Climate Data (AHCCD)
- PRISM Data for BC (e.g., Precipitation, Max and Minimum Temperation);
- Climate Atlas of Canada
- Arctic Ocean currents
- Spatial distribution of hillslope thermokarst
- Surface Water (e.g., National Hydro Network);
- Water Quality (e.g., Canadian Aquatic Biomonitoring Network -CABIN)
- Agri-Environmental Indicator – AEI (e.g., Air Quality, GHG budge,etc.)
- Meteorological Service of Canada (e.g., Geospatial Web Services 2.8.0)
- Climate Normals 1981-2010
- AdaptWest Climate Adaptation Data.

Each Starter Kit is "a start" and should not be considered a comprehensive compilation of geospatial data. Its purpose is to stimulate users to search for and obtain additional datasets as needed (supported using other recipes in this CGDI Cookbook). A screenshot of the Water Resources Starter Kit is provided in Figure 2.

Figure 2 Screenshot of the Water Resources Starter Kit showing major river basins of Canada.



Recipe

For users with access to ESRI ArcGIS:

Map packages (.mpk) allow the sharing of map documents and the data layers referenced in those documents, by packaging this information into one convenient, portable file. The map package Starter Kits were created using ESRI ArcGIS 10.5. To open please follow these steps:

1. Launch ArcMap
2. Drag and drop the map package (.mpk) file into the table of contents.

   OR

3. Launch ArcMap.
4. Press CTRL + F to search.

5. Search for and open the “Extract Package (Data Management)” tool.
6. Use the map package (.mpk) as input for the tool.
7. Navigate to the folder where the map package was extracted and open the ArcMap Document (.mxd) file within the “v105” folder.

For users with access to QGIS:

Quantum GIS (QGIS) is a cross-platform free and open source desktop GIS application that provides data viewing, editing, and analysis capabilities. Sharing map documents via this popular open soure package uses the Quantum GIS Compressed Project (.qgz) format and the unified GeoPackage container format (.gpkg). GeoPackagess are open, non-proprietary, platform-independent and standards-based data format to store spatial datasets. The QGIS compatible Starter Kits were created using QGIS version 3.4.1-Madeira. To open please follow these steps:

1. Extract the contents of the compressed file (.zip) to a folder on our local computer.
2. Double click the QGIS Project (.qgz) file to open the data package.

   OR

3. Drag and drop the QGIS Project (.qgz) file into the table of contents of your QGIS application.
4. If any data sources are not linked (e.g., “Handle Bad Layers”), click Browse and navigate to the geopackage (.gpkg) file that was included in the zipped folder for each broken source. Save the QGIS Project file so that the source paths stay linked.

Note: Given the map document relies on links to the GeoPackage, do not rename any files provided in the Starter Kits.

5.2 TECHNOLOGY: HOW TO CHOOSE A GIS SOFTWARE SOLUTION

What you will accomplish

This recipe will help you understand the considerations and process for choosing GIS software that can support your organization's SDI development.

What you will need

Commitment icon

- A User Needs Assessment that documents how your organization currently interacts with geospatial data and needs that can be served better through enhancing internal GIS capacity. (O)_1_PLANNING:_EXPANSION_Glossary
- Identified long term funding to support the staff position and any training required to upgrade the staff member's skills. (O)
- An organizational decision to acquire GIS software. (O)

Equipment icon

- A computer suitable for running GIS software or an organizational decision to acquire one. (E)_Glossary
- High speed Internet connection and bandwidth for downloading large datasets. (E)_Glossary

Skills icon

- A staff member with basic or intermediate GIS skills or a decision to hire someone who has those skills._Glossary

Background

Organizations looking to develop SDI have many GIS software options. In general, the software may be classed as open source, which is available at no cost, or commercial software (proprietary), which is available for a range of costs.

In the past, it was generally true that commercial software supported more advanced functions and capabilities that were not available from open source software. Open source software has matured and developed, and many GIS functions can now be completed. While functionality supporting very large and complex organizations sharing data in multiple locations is still more robust using commercial software, processing and analytical functions are most often comparable. Similarly, in earlier times open source software did not always support multiple data formats and standards, sometimes making sharing of data between organizations using open source and proprietary software difficult. This is no longer the case and open source software are often the most advanced in supporting data formats.

Using any GIS software, it can be expected that problems can be encountered using some of the more complex functions, either as a result of software peculiarities or misunderstanding of how to use the functions. In such a situation, users of commercial software may be able to rely on dedicated technical support departments to resolve the difficulties (sometimes at a dollar cost). Those using open source software are often reliant on a volunteer community of fellow users, existing discussions and solutions documented in an online forum, or those reliant on open GIS solutions may need to find and pay an expert in open source software to solve a problem. However, paid technical support does not guarantee that you will be able to solve an unusual software problem.

Where commercial software has a functional edge over open source software is in providing pre-packaged sets of functions specific to organizational needs. For instance, a municipality can buy a package of pre-built functions to support planning and traffic analysis, either from the software maker or from a third party specialist that has built the functions. Commercial software vendors also have dedicated resources to more seamlessly integrating mobile devices using Global Positioning System (GPS) or drone data collection.

The decision on what GIS software to select should be based on a broad set of criteria, not just a narrow assessment of what the software can do and what it will cost. Considerations include:

- the experience and training the people who will use the software have, or if you intend to hire staff, the number of people in the job market who will have this experience;
- the software used in your peer community. Other organizations that you work with may be able to provide assistance and guidance on their own experience and knowledge;
- the software used by external geomatics service providers who complete work for your organization;
- whether it is attractive to support your organization's needs through pre-built custom functions available from a commercial vendor; and
- the long term intended or possible uses for the software, and whether the software will accommodate your organization's growth.

Recipe

1. Review your user needs assessment to produce a list of tasks and software functions necessary to complete them. Considerations include:
   - Your user needs assessment should document the functions your organization undertakes and point to tasks that GIS software can support. These should be compiled and reviewed to establish lists of software functions that must be used. A staff member with GIS skills or an outside expert should be involved in this task.
   - Do not forget to consider factors that may affect the number of software licences you will require. For instance, if your list of tasks includes using the software away from your office, or collecting data using mobile devices, your list should capture this need.
   - Include, as part of your list, possible functions that could be supported by the software in the longer term if your organization chooses to add these later. While these are not critical deciding factors, it is good to consider them and whether undertaking them could be accommodated by your chosen software. Identify these in your list as future considerations.

2. Contact your peer community of organizations and ask them what software they use, their level of satisfaction with it, and any difficulties they have encountered:

   - Your peer community of organizations can be an invaluable resource in providing feedback on practical experiences with software and considerations that may not be captured in your user needs assessment, no matter how carefully it is done.
   - For instance, two pieces of software may list functions you require, but a peer with experience can tell you that one needs careful use to make it work with large datasets, or one requires several complex steps to complete a task while with another it is straightforward.
   - Your peers can form a community of practice that can provide informal support to staff using GIS. Knowing what software your peers use can be invaluable for your decision making.
   - If they are willing and it does not disclose information you should not share, provide your list of tasks and functions to your peers and invite their comments.

3. Contact geomatics service providers your organization has used and ask them what software they use, what data formats have been used to store your organization's data, and whether they can provide assistance and training. Considerations include:

   - If your organization has relied on outside geomatics service providers, buying software compatible with theirs can help maintain compatibility with data and information they have produced for you and may produce for you in the future. As with your peer community, knowing what software they use should be considered when making your decision.
   - If they are willing and it does not disclose information you should not share, provide your list of tasks and functions to your geomatics service providers and invite their comments.

4. Discuss with your staff with GIS skills or background their experience with GIS software, and training needs they anticipate having to support the tasks you listed from the user needs assessment. Even if your organization plans to hire new staff to run the GIS software, knowing that others in the organization have some background in particular software is a consideration, as it can help them understand the capabilities of and challenges using the software.

5. For commercial software, request a quote for software with the functions you have identified in the earlier steps. Considerations include:

   - Take care to specify how many individuals will be using the software. Software licences business models are changing and shifting towards named users and subscription models where you need to pay an annual fee. Sometimes licences are per computer or installed on a server and allow software to be use by anyone but restricted to one user at a time. Software licences for mobile data collection software may be priced separately.
   - GIS software may also be sold for an initial licence fee, but an annual maintenance fee is subsequently charged for technical support and software updates. Make certain that you take this into account when making your decision. Several popular commercial software packages are summarized in the CGDI Primer. _Glossary

6. Identify open source software with the functions you have listed in earlier steps. Considerations include:
   - Your communication with your peer organizations and geomatics service providers may have brought software to your attention that possibly can serve your needs. Because open source software does not have an organization with dedicated sales and technical support, you will need to research the capabilities of the software through such avenues as reviewing online documentation, looking at dialogues and posting questions to online discussion forums, and asking questions to your peer community and geomatics service providers if they use or are familiar with the software.
   - If your staff have some familiarity with or background using the software, you can also have them install it to test its capabilities. Several popular open source software packages are summarized in the **CGDI Primer**.
7. Review your staff experience using the software options you have identified. While gaps in experience can be filled through training courses or online resources, existing staff experience using particular software will help them become productive more quickly than if they have experience with other software. This needs to be weighed along with all other factors when making your decision.
8. Prepare a decision matrix that details all of the information you have compiled regarding software functions, staff experience and training, and cost. Rate the software functions on a simple schema such as: must-have, useful to have, and nice to have functions. If certain functions are available but at additional cost, include this information.
9. Review your findings and make a decision.

Example

An administrator working for a First Nation community is tasked with choosing a GIS software. The Nation's traditional territory is subject to a large amount of oil and gas extraction activity – drilling, extraction, and installation of pipelines. Because of the legal duty to consult and accommodate Indigenous peoples when their Treaty rights are affected, her administration receives a large number of Crown Referrals, documents describing proposed projects. If her Band wishes to raise any concerns, it has a prescribed time in which to respond, and if it does not respond this is construed as an indication that it has no concerns. If her administration responds with concerns, the Crown must undertake a consultation process where identified issues are considered and means of mitigating them are defined.

Political leadership and her administration are concerned about impacts the activities can have on the land, but find that they do not have enough time to assess all the Referrals they receive. Through conferences and discussions with other First Nations in their area, the Band has become aware that development of an SDI can support rapid appraisals of project proposals. In particular, GIS software, data, and trained staff can help identifying possible impacts such as roads crossing streams where fish spawning occurs, pipeline corridors crossing wildlife corridors, or drilling occurring close to hunting cabin locations.

As part of SDI development, Chief and Council have requested an individual named Leanne to explore the feasibility and cost of acquiring GIS software to support Referral processing. Administration has conducted a user needs assessment aimed at documenting how GIS can be used to support the Band in processing and responding to Referrals. It has also had some less formal discussions about how GIS could be used to manage community infrastructure and for other purposes.

The Band administrator begins by reviewing the user needs assessment and the tasks it describes. After listing these, she shares the list with the staff member responsible for managing Referrals to confirm that nothing has been missed. She also goes over the list with a staff member who has experience using GIS software, and has him list as best he can the process steps necessary to complete the tasks, and the software functions needed. She asks him to rank, as best he can, how important each of the steps are to completing the work. She also asks this staff member about his background using GIS software, including what software he has used, his ability to do the process steps he is describing, how much training he thinks he would require, and how taking on this work would impact his other job responsibilities.

The Band administrator contacts the administrations of some of the other First Nations in her area to ask if they use GIS for Referral processing, and if so, what software they use and their experiences. She also posts to an Internet forum which focuses on First Nations administration issues asking if others who use GIS software to support Referrals processing can contact her to share information on the software and approach they use.

Her Band administration has previously completed a study of community use of the land that included producing maps using GIS and delivered geospatial data to the community. She contacts the company that did the work and asks what software they use and whether they have any comments or feedback regarding the Band's plans to use GIS.

The Band administrator summarizes the feedback she has received from the peer community and geomatics consultant. As part of this process she updates her list of process steps and software functions required.

She contacts two commercial software vendors, Esri and Manifold, that were identified by her peer community to ask for detailed information on their software. She asks if their applications support the software functions in her list, if they can provide references to other clients with similar needs, and for costing of versions that support all the software functions described in her list. She also contacts a service provider identified by one of her peer communities that provides a web-based service that supports processing Referrals and includes a mapping component. She asks for information on how the service can support her Band's needs and what the costs would be related to the service.

The Band administrator asks a staff member who has GIS experience to investigate the capabilities of an open source software package, QGIS. She had read about QGIS in the CGDI Cookbook and wants to determine if a free option could satisfy all the potential GIS functions performed by her office.

Finally, she summarizes the costing and other information received, the capabilities of each software option with regard to the list of required functions, and comments received in a document to be presented to Chief and Council with her recommendations.

Resources

Good Practices Guide: Success in Building and Keeping an Aboriginal Mapping Program:
http://publications.gc.ca/collections/collection_2011/rncan-nrcan/M114-24-2010-eng.pdf

Thinking About GIS: Geographic Information System Planning for Managers:
https://esripress.esri.com/display/index.cfm?fuseaction=display&websiteID=241&moduleID=0

5.3 TECHNOLOGY: CHOOSE A MOBILE DATA SOLUTION

What you will accomplish

This recipe will help you make informed decisions regarding the use of mobile geospatial data tools and technologies, such as tablets and accompanying software that are used to collect data in the field.

What you will need

 Knowledge icon	▪ Full knowledge of data that is currently collected or will be collected in your organization's field operations. ▪ Trained staff to operate hardware and software in the field and office.
 Commitment icon	▪ Understanding of the alternative options to collect and digitize data to include in your organization's geospatial data system. ▪ Buy-in from managers or organizational leaders to adopt a mobile data solution.
 Equipment icon	▪ Funds to purchase hardware and software as necessary.

Background

Mobile geospatial data tools include devices, software, and apps that allow geospatial data to be collected in the field. These tools and technologies have become important components of data collection and analytics systems for many organizations, from municipalities, to Indigenous governments, to public health organizations.

Mobile geospatial data tools consist of:

- Hardware – like GPS, tablets, and smartphones;
- Software that supports the collection, storage, and management of data.

Many mobile geospatial data collection software tools run as apps on smartphones or tablets and can be operated with a real-time network connection, or in an offline mode. When offline, the operator can still collect data, photos, and GPS points that are stored in the device. These data are then synchronized with a central system once the operator has access to an internet connection.

For organizations that collect location-based data in the field, mobile data collection technology systems provide several benefits such as:

- eliminating the need for data entry or digitizing of data collected on paper forms, which increases efficiency and eliminates transcription errors;
- eliminating time lag between data collection and updating data in your geospatial data system;
- helping secure data by digitizing it and storing location information;

- allowing for more efficient communication between the field and office;
- improving situational awareness in the field and allowing field staff to verify information at specific sites; and
- improving accuracy and reducing data entry errors using data validation (e.g., temperature or pH data points must be within a certain numerical range).

Mobile data solutions can be simple – for example a mobile smartphone app that collects georeferenced photos where the user adds a description of the photo content, which could later be plotted in a map. More complex mobile data solutions are essentially mobile GIS software that enables the capture and editing of spatial and attribute data in the field, and subsequent storage on the device. Mobile data solutions can integrate with other operations such as business planning, accounting, or customer relationship management. Since there are many options, it is important for organizations to carefully consider what features are essential, important, nice-to-have, or not important in helping them meet their objectives.

Recipe

1. Determine what operations might be improved by using mobile geospatial data collection. Ask the following questions:
   a. What tasks might be more efficient if they were digitized?
   b. What other benefits might be obtained, such as reduced errors or improved situational awareness in the field?
   c. What data might be more meaningful if it is geolocated and can be mapped?
   d. Do you currently use software or applications for reporting, analyzing, or visualizing data (e.g., Google Earth, QGIS, or ArcGIS,) that could integrate the mobile geospatial data?
2. Using the answers to the questions above, consider your key objectives for implementing mobile geospatial data technologies and tools.
3. Consider what geospatial data you will be collecting using mobile technologies. This might include the following (and often a combination of these data types):
   a. Survey forms with pre-determined fields – e.g., household survey;
   b. Georeferenced photos – e.g., photo of revegetation;
   c. Points – e.g., location of bear sightings;
   d. Lines – e.g., trapline; or
   e. Polygons – e.g., perimeter of a wetland.

   The type of data to be collected will influence the type of app that will meet your needs.
4. Decide what hardware features you need. Many mobile geospatial data software systems can be run on a variety of different devices (for example, smartphones or tablets). Depending on how and where members of your organization will use the device, you may want to consider features such as: cost; cellular network connection; battery life; performance in different temperatures; weight; waterproofing; shockproofing. If possible, rank these features by importance.

5. Decide what software features you need. This depends largely on what objectives your organization wishes to accomplish. Some factors to consider include:
   a. cost of purchase and/or licensing;
   b. type of interface (table/form or map);
   c. types of data formats that may need to be imported into the software tool (Excel, CSV, XML, Esri shapefile; KML, SQL, PDF, SPSS, etc.);
   d. types of data supported that the tool will collect (tabular/forms; points; polygons);
   e. ability to receive forms/survey responses from other users via SMS or text message;
   f. whether organizational policies allow for data storage on external servers (i.e., in the cloud);
   g. ability to take photos;
   h. data back-up or syncing and ability to operate online and offline;
   i. level of skill in data management required for use; and
   j. talk-to-text functionality.

   Several solutions may have the functionality that your organization wants; but it is helpful to determine what features are essential, important, and 'nice-to-have'. If you are still unsure of what features your organization might need, there are some resources that may help you determine what technical specifications are necessary to meet your organization's needs.
6. Choose a few hardware and software options to compare systematically, using the criteria you have identified in #4 and #5. It is a good idea to purchase one device or use software trials to make the most informed decision before you purchase multiple devices and a software package or subscription.

Example

Emergency Health Responders (EHR) is a Canadian NGO that provides environmental and public health services during emergencies and natural disasters in Canada and abroad. EHR receives funding from donors and the Government of Canada to deploy staff and volunteers to various locations to monitor and manage disease outbreaks during emergency situations. Field staff and volunteers typically collect data about victims and their needs, document outbreaks of communicable diseases, and monitor environmental health factors such as drinking water contamination and the presence of pests. This data is then used to acquire and distribute the appropriate supplies and services, including: bottled water; face masks; and medical equipment and personnel.

One of EHR's key projects is assessing and monitoring public health needs in rural communities in northern Manitoba after major flooding damaged drinking water infrastructure and caused several rural communities to be evacuated.

The EHR Field Manager for Northern Canada decides to explore options for mobile geospatial data technology. The Field Manager believes that using mobile geospatial data collection technology will:

1. Improve the efficiency of data collection
2. Increase spatial accuracy to allow for better spatial analysis of data

3. Reduce the lag time between data collection and analysis, and speed up the delivery of needed supplies
4. Secure data by making sure that all field observations are automatically backed up

After consulting with staff, the Field Manager determines that the most important location-based data that EHR collects includes: points that identify potential public health hazards; lines that identify safe transit routes into and around temporary settlements; and qualitative survey data collected from evacuees. Currently, EHR manages this data using spreadsheets. Basic spatial analysis of this data is done after it is collected manually, processed, and mapped using custom base maps of the areas where EHR is working.

In terms of hardware, EHR's needs are relatively simple: the organization needs devices that are cost-effective, have at least 32 gigabytes of internal disk storage capacity to accommodate large datasets, are lightweight enough for staff to carry on foot for a full day of use, and are waterproof and shockproof. The Field Manager determines that a specific brand of waterproof, shockproof tablets are the best solution. An additional benefit is that the tablets can be used for other functions within EHR's operations.

Like many organizations, EHR's software needs are specific. Mobile data collection technology will only be useful to them if it helps them collect the data they need more accurately and efficiently. Based on consulting with staff, the Field Manager comes up with the following criteria, characterized by importance:

Create custom forms	Importance
▪ Using GPS can collect points, lines, and polygons (no need for Internet connection)	Essential
▪ Add base data to a map that can be viewed when collecting data through the app (from KML and other common formats)	Essential
▪ Stores data on device and performs back-up and sync to cloud when Internet connection becomes available	Essential
▪ Take geolocated photo linked with field form data	Essential
▪ Map that can view the data collected	Essential
▪ Ability to review data collected and already submitted in the field	Important
▪ Ability to collapse and expand sections of the form during data entry	Nice-to-have
▪ Talk-to-text functionality	Nice-to-have

With these criteria in mind, the Field Manager compares several options for mobile geospatial data collection using the template below to make the final decision.

Software					
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Ability to create custom forms					
Offline GPS collects points, lines, and polygons					
Add base data to a map that can be viewed when collecting data through the app (from KML and other common formats)					
Stores data on device and performs back-up and synching to cloud when connection becomes available.					
Ability to take geolocated photo associated or linked with field forms					
Provides a back-end mapping interface to view data collected					
Ability to review data collected and already submitted in the field					
Ability to collapse form or condense form entry					
Talk-to-text functionality					
Hardware					
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Cost					
Battery life					
Reliability/familiarity with operating system					
Ability to use device for other functions (i.e., install other apps)					
Offline download of data and backup to other devices					
Portability and weight					
Waterproof and shockproof					

Resources

The "Finding the Right Mobile Data Solution" questionnaire developed by the NOMAD Project was designed to help humanitarian organizations choose from one of 50 different mobile data collection platforms: https://humanitarian-nomad.org/. Experts from iMMAP and CartONG took the lead in the NOMAD project. The mobile data solution database is no longer being updated.

5.4 TECHNOLOGY: REMOTELY PILOTED AERIAL SYSTEMS (DRONES)

What you will accomplish

This recipe provides information and guidance to make informed decisions regarding the use and potential investment in a Remotely Piloted Aerial System (RPAS), commonly known as a drone.

What you will need

 Knowledge icon	▪ Knowledge of Transport Canada laws and regulations – specifically Canadian Aviation Regulations (CARs): Part IX – Remotely Piloted Aircraft Systems. ▪ A qualified drone pilot, or budget for pilot training and certification.
 Commitment icon	▪ A good understanding of your organizations data requirements and needs and how they could be fulfilled with a drone. This should include consideration of the costs and benefits of alternative methods to fulfill data requirements. _1_PLANNING:_EXPANSION ▪ Support from managers or organizational leaders based on data requirements and availability of storage space for imagery once collected.
 Equipment icon	▪ Budget to purchase hardware and software.

Background

Drones are an area of rapid innovation and currently most appropriate for the collection of very high-resolution images (e.g., 3-10 cm) over small areas (a few square kilometres) . The companies, platforms and capabilities of systems, not to mention the rules and regulation around their use, are evolving rapidly. Highly automated and precise navigation coupled with automated image processing and mapping reduce the barriers to entry for acquisition and processing tasks that are typically performed by remote sensing specialists.

RPAS typically consist of both hardware (e.g., aircraft, flight control system, sensors) and software for flight mission planning and image post-processing. External equipment could include mobile phones or tablets, high-precision GPS, ground control targets, and laptops that make the collection and management of data possible.

Drones come in two common varieties: vertical take-off and landing (VTOL, e.g., quadcopters or hexacopters) and fixed-wing. The size of a drone can vary greatly and dictates several factors relating to its performance, capabilities, and the information that it can obtain (e.g., digital cameras vs. LiDAR sensors). Common factors to consider include cost, complexity, flight time, and ability for add-ons to increase capabilities. Fixed-wing drones tend to have greater endurance and can be used to cover larger areas, whereas VTOL multi-rotor drones are more maneuverable in small areas but cover smaller areas.

Commonly used commercial VTOL and fixed-wing systems, and their various capabilities are provided in Table 3. A few commercial software options and their capabilities are provided in Table 4.

Table 3 Example commercial drones on the market.

Type	Model	Cost	Complexity rating	Flight time	Add-ons	Image Of Drone
QC	DJI Inspire 2	$$	■■	✈	Yes (camera and additional payload)	
QC	DJI Matrice 200	$$$	■■	✈✈	Yes (camera, sensors, additional payload)	
QC	3DR Solo	$$	■	✈	Yes (changeable cameras – MAPIR)	
QC	DJI Mavic	$	■	✈	No	
HC	Tarot Hexacopter	$$$	■■■	✈✈	Yes (camera, sensors, additional payload)	
FW	eBee	$$$	■■	✈✈✈	Yes (camera, sensors, additional payload)	
FW	MyFlyDream MFD Fixed Wing Nimbus	$	■■	✈✈✈	Yes (camera, additional payload)	

Notes:

QC = quadcopter; HC = hexacopter; FW = fixed wing.

Cost rating: $$$ = > $10 000; $$ = ≤ $5 000; $ = ≤ $2 000.

Complexity rating: ■ = beginner user; ■■ = expert user, good documentation; ■■■ = expert user.

Flight time rating: ✈✈✈ > 1 hour; ✈✈ = ≤ 30 minutes; ✈ = ≤ 15 minutes.

Adapted from: (Aguilar-Manjarrez, Wickliffe, & Dean, 2018)

Table 4 Example software for RPAS mission planning, operations, and post-processing.

Name	Function			Type			Cost	Complexity rating
	Planning	Mission	Post process	App	Desktop	Cloud		
DJI GS PRO	+	+	-	+	-	-	$	■
Pix4D Capture	++	++	-	+	-	-	$	■■
Pix4D Mapper	-	-	++	-	++	++	$$	■■■
ArduPilot Mission Planner	++	++	-	++	-	-	$	■■■
Agisoft PhotoScan	-	-	++	-	++	-	$$$	■■
Drone2Map for ArcGIS	-	-	++	-	++	++	$$	■
DroneDeploy	+	+	+	+	-	++	$$	■
Open DroneMap	-	-	+		+	-	$	■■■
Maps Made Easy and Map Pilot for DJI	+	+	+	+	-	++	$	■

Notes:

Cost rating: $$$ > $5 000; $$ ≤ $5 000; $ = free.

Complexity rating: ■ = beginner; ■■ = expert, good documentation; ■■■ = expert.

Function: - = not applicable; + = suitable; ++ = high performance.

Adapted from: (Aguilar-Manjarrez, Wickliffe, & Dean, 2018)

Understanding the difference between **basic** and **advanced** drone operations is an important factor in determining the drone you will purchase and the training requirements.

According to Transport Canada rules (Transport Canada 2019) in effect from June 1, 2019, if you meet all three of these conditions, you are conducting basic operations:

- You fly it in uncontrolled airspace (defined as all airspace not covered by official Air Traffic Control systems);
- You fly it more than 30 metres (100 feet) horizontally from bystanders; and
- You never fly it over bystanders.

For basic operations, some of the rules you must follow include:

- Register your drone with Transport Canada before you fly it for the first time;
- Mark your drone with its registration number;
- Pass the Small Basic Exam; and
- Be able to show your Pilot Certificate – Basic Operations and proof of registration when you fly.

For advanced operations you will also need to:

- Pass the Small Advanced Exam offered by Transport Canada;
- Pass a flight review with a flight reviewer;
- Be able to show your Pilot Certificate – Advanced Operations and proof of registration when you fly your drone;
- Fly within the operational limits of your drone; and
- **Always refer to the latest Transport Canada rules and regulations for flying your drone safely and legally.**

Recipe

1. Conduct a requirements survey within your organization to determine what activities may benefit from using a drone. The survey should try to find answers to questions like:
   - Where would most drone flights occur (rural, controlled airspace, near or over people, or urban environments);
   - What type of missions are needed in the organization (visual reconnaissance or mapping);
   - How large of an area would a typical mission cover;
   - What are the typical weather conditions where missions will be completed;
   - What type of geospatial data is needed (e.g., RGB image/video, thermal images, multi-spectral, images, or precise elevation data); and Glossary
   - What are the other alternatives that could be used to obtain the required information (e.g., very high resolution satellite images, aerial survey).
2. After consulting with staff within the organization, develop criteria based on the requirements and Transport Canada rules. Characterize these criteria by importance.
3. With these criteria in mind, compare different options for RPAS, image processing software, and external hardware, to see what fits within the assigned budget and make a shortlist or a final selection.
4. Identify individuals who will become RPAS pilots within your organization and obtain all necessary training and certification for the type of operations required.
5. Throughout the whole process, you will need to develop a company/organization endorsed **RPAS Operations Manual**. This manual should cover standard operating procedures for drone usage, checklists, and health and safety policies and procedures. You must have a system in place to ensure you comply with Transport Canada rules – a helpful checklist is available.
6. Review liability insurance requirements. Although this is not mandatory under the new Transport Canada rules (effective June 1, 2019), it is recommended that you obtain public liability insurance for your drone operations.
7. With trained and certified personnel, hardware, and your compliance system in place, you are ready to fly. Respect the law, follow the rules and fly safe!

Resources

- For complete information on Transport Canada rules before June 1st, 2019 – please visit the following website: https://www.tc.gc.ca/en/services/aviation/drone-safety/flying-drone-safely-legally-current-rules.html
- For complete information on Transport Canada rules effective June 1st, 2019 – please visit the following website: https://www.tc.gc.ca/en/services/aviation/drone-safety/flying-drone-safely-legally.html

5.5 TECHNOLOGY: USE GEOSPATIAL TECHNOLOGY FOR PRODUCING PRECISE CONTOURS AND SLOPE MAPS

What you will accomplish

This recipe will help you produce contours and slope maps for any application that requires topographic information or analysis, such as calculating potential runoff and indicative areas of flooding.

What you will need

Skills icon

- A staff member with intermediate GIS skills. _Glossary


Equipment icon

- A computer suitable for running GIS software. _Glossary
- Installed GIS software capable of analyzing digital elevation data and creating elevation contours. _Glossary_Glossary
- High-speed Internet connection and bandwidth for downloading large datasets. _Glossary

Background

Topographic information for your community and surrounding area can be valuable for many reasons. For example, knowing how far land lies above shorelines can help planners assess potential for flooding. Knowing slope gradients is valuable for development planning and understanding potential construction challenges or the potential for soil erosion and runoff if trees or vegetation are removed. Slope aspect (the direction a slope faces) affects micro-climate and can be used by ecologists or ethno-ecologists along with land cover, temperature, and precipitation data to determine sites worthy of field investigation to find animal populations or point to locations where archaeological sites might be located.

While framework contour data has long been available from federal, provincial and territorial governments, these datasets were originally developed for making maps at relatively coarse scales (normally 1:250,000 and 1:50,000). They are of limited value for site-specific topographic analyses since they generally only include contours at relatively coarse elevation intervals.

Advances in remote sensing technologies such as airborne LiDAR and satellite image processing allow government and the private sector to generate precise digital elevation models (DEMs) that can be used to generate finer and more precise contour and slope data. Natural Resources Canada recognizes the importance of topographic framework data and is developing its High Resolution Digital Elevation Model (HRDEM) as part of the CanElevation Series, in support of the National Elevation Strategy. It includes a Digital Terrain Model (DTM), a Digital Surface Model (DSM) and other derived data such as slope, aspect, shaded relief, colour relief and colour shaded relief maps. In the southern part of the country (south of the productive forest line), DTM and DSM datasets are generated from airborne LiDAR data. In the northern part of the country (north of the productive forest line), DSM datasets are generated mostly using optical satellite imagery as their source data. For example, in 2018 Natural Resources Canada released the HRDEM product for the Canadian Arctic that covers nearly 3 million km² north of the 60th parallel. The data comes from the ArcticDEM project which aims to provide high-resolution digital surface models for all the Arctic regions of the planet.

Federal Flood Mapping Guidelines

In consultation with provincial and territorial partners, the Government of Canada has undertaken a program to develop Federal Flood Mapping Guidelines to identify the boundaries of potential flood events and support informed decisions and investments to reduce the impacts of flooding. Floods are the most commonly occurring natural hazard. Overland flooding costs the Canadian economy more than any other hazard. By anticipating possible flood impacts communities can take measures proactively to reduce the risk of death and injury, environmental damage, economic loss, and destruction of cultural assets. Community/municipal roles can include: water management; emergency management and continuity of service; land use planning/zoning regulation; critical infrastructure design and utility operation; public services; ownership/operation/insurance of public assets; and, climate change resilience and adaptation.

Flood mapping is an involved technical process that typically includes acquisition of airborne LiDAR to generate a very high accuracy DEM, research into past flood events, changing river levels, soil permeability, and consideration of complex scenarios including flow velocities and other parameters to define the 1:20 year floodplain (zones that are likely to flood on average once every 20 years) and the 1:100 year floodplain (zones likely to flood on average once a century). These provide a basis for land use planning and restrictions, informing emergency management, presenting information on flood hazards to stakeholders and the general public, and enabling community preparedness.

Recipe

The recipe uses flood mapping as an example of how to create and use contour and slope data. This is not equivalent to engineering-level floodplain hazard assessment. It is intended as an example of the processing steps and a way to identify areas of concern for further study.

1. Review or establish desired data uses. Goals for data use will help you to identify:
   - The data and data analysis needs. For example, if the intended use is for assessing slope values for potential walking trails, you will want to focus on small contour intervals derived form LiDAR data in a relatively small, local site.
   - Potential companion, or overlay, datasets needed to analyze your data layers against other land uses or features.
2. Define the land area for the analysis. Contour, slope, and aspect analysis are computer processing intensive operations, especially when fine-grained analysis products are required. While it might be tempting to run the analysis for a large area, define a test area, or start by using a relatively coarse contour dataset (even if a detailed dataset is available) to assess computational times.

3. Research levels reached by previous flood events. If flood hazard is the management concern, knowing water levels reached during previous flood events in your community can help you to anticipate the possible impact of future events.

4. Make a list of datasets you want to map in comparison to contours and slope values. Your list should consider the currency (vintage) of data and how accurate the results need to be from your analytical process. See Recipe 4 - Fulfilling your data requirements that includes a template for documenting data requirements.

5. Review datasets that you already have from the list you made in the previous step. Flag datasets that you do not have or that should be updated. Recipe 3 - How to decide if your data is fit for use details how to assess whether datasets are good for a particular use.

6. Locate sources for accurate framework data for your community and surrounding area. Considerations include:

   - Recipe 4 - Fulfilling your data requirements has directions on how to locate sources of data.
   - Highly-accurate data are often maintained in provincial/territorial data repositories.
   - Pay careful attention to metadata documenting data accuracy and reliability. While there can still be some value in using data accurate to less detailed scales, you must exercise caution and be aware of their data limitations. Glossary

7. Locate the DEM data for your community and surrounding area that meets your accuracy requirements. The Government of Canada's National Elevation Data Strategy (NRCan 2018) aims to offer a national one-metre resolution elevation grid for the south of Canada derived from LiDAR. As these data are being put in place, they are being made available on the Open Maps website on the Open Government Portal. In much of northern Canada, ArcticDEM data are available (Polar Geospatial Center 2019). These data are derived from processing overlapping pairs of high-resolution optical satellite images using a technique called stereo auto-correlation. ArcticDEM data are available at two-metre resolution.

8. Download the datasets you identified. To complete spatial analysis, DEM datasets will typically need to be stored on your computer for processing using GIS software.

9. If necessary, consolidate DEM tiles into a single dataset. DEM data are provided through rectangular tiles. If your area of analysis covers more than one tile, GIS software may require consolidating the tiles into a single dataset.

10. Conduct neighbourhood statistical analysis on raw DEM data as required for the intended use of data. Contour, slope, and aspect analysis often requires processing DEM data using neighbourhood statistical analysis to reduce variance between neighbouring grid cells. Such variance arises from data accuracy limitations and local variations in topography that can affect desired smoothness of output contours and generalization of slopes.

11. Generate the contour lines. The contour unit interval value will need to be chosen based on needs identified in earlier steps.

12. Generate the slope raster. The slope is calculated using the difference in elevation between adjacent DEM cells to calculate the slope, either in degrees or as a percentage grade value.
13. Make the required maps.

Example 1 – Topographic analysis for initial review of climate change risk

A GIS specialist works for the administration of a community on the Hudson Strait in northern Quebec. She uses the open source software QGIS. The community's leadership wants to explore the potential long-term effects of water level changes attributed to climate change on the community. She makes plans to hold discussions with the provincial government about having high-accuracy LiDAR floodplain mapping completed for the community and surrounding area. In the meantime, the community leaders would like a contour map produced from the best data available. This will be posted in the local Hunters and Trappers Committee office and used in Community Council discussions.

After reviewing the community's internal datasets, the specialist determines that the best way to present the information is to use a georeferenced aerial photograph of the community that she already has, and overlay accurate and current contours on it.

Using the Government of Canada Open Maps Data Viewer, the specialist finds that high-resolution LiDAR elevation data are not available for her community, so she will need to find another type of data that accurately depicts elevation for her area of interest. Her search brings her to an initiative called ArcticDEM Polar Geospatial Center 2019) that works to produce a high-resolution digital surface model of the Arctic by processing optical satellite data. She finds that ArcticDEM has a two-meter dataset available for the entire circumpolar Arctic.

The specialist downloads an index shapefile of ArcticDEM tiles from the ArcticDEM website and loads it into her QGIS software, identifies a DEM tile that covers the area of her community, and downloads the tile.

Since the ArcticDEM provides elevations referenced to the WGS84 ellipsoid (vertical datum) and not to tidal datums such as mean sea level, a geoid undulation model must be applied to the ArcticDEM dataset in order to approximate orthometric/sea-level values. To do this, she uses the following steps:

- From the US National Geospatial-Intelligence Agency website, she downloads a 2.5-minute Geoid Undulations raster file for the area of her community.
- She uses a tool to clip the section of the DEM in the area of her community into a new, smaller file.
- She adds the 2.5-minute Geoid Undulations as a raster layer in QGIS. Using the QGIS Raster Calculator, she subtracts the geoid undulation raster values from the clipped section of the DEM to create a new, corrected clipped DEM.
- Using the clipped, corrected DEM tile, the specialist generates contours with a two-metre interval using the QGIS Raster tool.

She creates a simple map using the aerial photograph with the contours overlaid on it, symbolized using red-to-green for values from zero to 20 metres (Figure 3).

Figure 3 Aerial image and ArcticDEM contours.

Example 2 – Topographic analysis for recreation planning

The Municipal Council for a rural community is considering developing municipal land for a park that includes recreational trails suitable for multiple activities. The land has varied terrain, and some locations that might be suitable for rest stops with views of a large river that runs through the area. Council members ask a geomatics specialist from the planning department to produce a series of maps to illustrate different options for how trails might be laid out. The maps will support staff planning possible route corridors, and others field-checking feasibility.

The geomatics specialist works with other planning staff to determine what maps will need to contain to help planners and councillors make their decision. These include: a map with a two-metre contour overlaid on existing roads, trails, streams and ponds, and land cover; a map symbolizing slopes in a range of values suitable for walking and self-motivated transportation, excluding ones beyond a steepness cutoff; and a map highlighting areas with steep slopes facing in the direction and abutting flatter areas that might be suitable for rest stops. Each map will include symbolized vegetation cover.

The specialist then does an inventory of what datasets will be needed to produce the above maps against the data that the community already has available or in storage. The community's internal database has acceptably current and accurate data for roads, water features, and land cover. However, the specialist finds that they will need to acquire the following data:

- Updated location and route information for existing trails – the specialist notices that the maps of existing trails are out of date and need to be updated by staff using GPS. The specialist arranges for a small team to walk the existing trails to update the dataset.
- High Resolution DEM data – the specialist knows that high-resolution DEM data is available for most parts of Canada through the federal government.

The specialist navigates to the Open Maps Canada geoportal and sees that there is one-meter resolution DEM data available for the community, and that a single tile covers the area proposed for the park. He selects the tile using the Open Maps Data Viewer and downloads it as a georeferenced TIFF using a link provided by the Viewer.

The specialist adds the DEM data to ArcGIS. Using an ArcGIS tool, he extracts a portion of the DEM tile that covers the proposed park and surrounding area. With this as an input, he generates a two-metre contour for the area.

The specialist notices that there are many squared off contours surrounding the DEM pixels. This is a common issue when using high-resolution DEM data and typically means that the contours being generated are reflecting variances in the raw DEM data. He undertakes the following steps to smooth the DEM pixel values:

1. Compute the mean values for neighbouring DEM cells using a "Focal Statistics" tool and regenerate the contours.
2. Test different smoothing filters (narrower and wider) and determine which produces the best contours for working on route corridors and field checking the proposed routes.
3. The specialist determines that smoothing across several adjacent DEM cells produces the most appropriate contours. Using another software function, the specialist generates a raster containing estimates of slope values.

Finally, the specialist produces two maps depicting the contours and slopes he has generated on top of an aerial photograph of the area and combined with vector data depicting local roads, trails, lakes, and streams (Figure 4).

Figure 4 Aerial image and HRDEM contours.

Background image from ArcGIS Online World Imagery service.

Resources

- Open Maps Canada: https://open.canada.ca/en/open-maps
- ArcticDEM: https://www.pgc.umn.edu/data/arcticdem/
- Government of Canada Federal Flood Mapping Guidelines Series: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/ndmp/fldpln-mppng-en.aspx
- Risk-based Land-use Guide: Safe use of land-based on hazard risk assessment: http://publications.gc.ca/collections/collection_2017/rncan-nrcan/M183-2/M183-2-7772-1-eng.pdf
- US National Geospatial-Intelligence Agency EGM2008 Geoid Undulations datasets: http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/egm08_gis.html
- Mean Sea Level, GPS, and the Geoid: https://www.esri.com/news/arcuser/0703/geoid1of3.html

6.0 POLICIES RECIPES

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6.1 POLICIES: PROTECT SENSITIVE DATA AND INTELLECTUAL PROPERTY

What you will accomplish

This recipe will help you identify geospatial datasets that may be candidates for accessibility to external users and develop appropriate mechanisms for sharing sensitive datasets. It will also help you protect the intellectual property (IP) and sensitive or confidential information in your organization's data. Definitions of key terms used in this recipe can be found in the Glossary.

What you will need

Commitment icon

- An organizational decision to share certain data to external users but requirement to protect sensitivities in the datasets and protect IP.
- An inventory of the datasets or components of datasets to be classified as sensitive.
- Written documentation of the conditions under which the sensitive data and IP will be shared.

Background

When assessing datasets to share with external users, your organization may identify types of geospatial data or components of data that are considered to be sensitive. Previous CGDI research has revealed that the concept of sensitivity changes with context (i.e., time and recent events), an organization's regulatory environment (e.g., legislation, policy, competition, etc.), jurisdictions and the personal views of Data Contributors/Owners/Custodians and that there is considerable intertwining of these elements (see the CGDI *Best Practices for Sharing Sensitive Environmental Geospatial Data* referenced in Resources below for further details). It is prudent for your organization to develop dataset sensitivity criteria independent of any specific dataset, establish them in advance of any dataset assessment, document the criteria, and have it vetted by an authorized organizational representative (e.g., legal or policy specialist). By doing so, your organization will not only be establishing the process but also providing a documented baseline for justifying the classification of a dataset as sensitive if challenged at a later date. Typical criteria for categorizing data as sensitive can include:

- *Legislation/Policies/Permits* – data that is identified by legislation as requiring safeguarding; for example, safeguarding data is required by the federal *Privacy Act* if an individual can be identified either directly by georeferenced information (such as the geo-coordinates of an address) or indirectly through the amalgamation of geospatial data and related attributes;
- *Confidentiality* – data that is considered confidential by an organization or its use can be economically detrimental to a commercial interest;
- *Natural Resource Protection* – information, the use of which can result in the degradation of an environmentally significant site or resource;
- *Cultural Protection* – information, the use of which can result in the degradation of a culturally significant site or resource; or

- *Safety and Security* – information that can be used to endanger public health and safety or national security.

Once a dataset or data component is defined as sensitive, your organization will need to choose an appropriate protection mechanism (see *Best Practices for Sharing Sensitive Environmental Geospatial Data* referenced in Resources below for details of possible mechanisms). Options include:

- Removal of sensitive components – this could include modifying geographic features (e.g., aggregate points showing locations of rare species into management zone polygons; generalizing the accuracy of spatial locations) or modifying attributes (e.g., removing or redacting certain attributes that identify rare species).

- Licences or agreements – these could restrict the purpose to which the data can be used, prevent storing the data beyond fulfilling the purpose, and prevent sharing of the data.

- Metadata to facilitate understanding of requirements for sensitive data access and use on a case-by-case basis.

Successful sharing of sensitive geospatial data is dependent upon the mechanisms used to: present the underlying knowledge yet remove the sensitivity; define the conditions of use and protection within the chosen instrument; and train participants to ensure that they are cognizant of their roles and responsibilities. Your organization may use a combination of mechanisms to ensure data is shared and used responsibly and that the credibility of the process is maintained.

The primary mechanism for the protection of IP in geospatial information and related information products is copyright (see CGDI *Intellectual Property Law Backgrounder* in Resources below for further details). Owners of copyrights may assign (i.e., sell or transfer) their rights in whole or in part or license their works. A licence is a contract that permits certain acts in relation to the work (e.g., use of the data in creation of value-added information products) that would otherwise be copyright infringement. The following table provides an overview of four typical licence types that can be used to protect IP rights (see the CGDI *How to Share Geospatial Data Primer* referenced in Resources below for further details). Given the recent trend to making geospatial data as open and freely available as possible, the prevalent licence type is the first one, which for example is used by the Government of Canada as the Open Government Licence – Canada (see the CGDI *The Open Government Licence – Canada User Guide* referenced in Resources below for further details).

Table 5 Typical licence types to protect IP rights.

Licence Type	Purpose	Conditions
No-cost Data Access with No Restrictions	For sharing of data under licensing terms, where there are no restrictions on the use of the data and no fees are to be paid to the licensor	No conditions attached to the use of the data
Fee-Based Data Access with No Restrictions	For sharing of data under licensing terms, where there are no restrictions on the use of the data and fees are to be paid to the licensor	No conditions attached to the use of the data

Table 5 (Cont'd.)

Licence Type	Purpose	Conditions
No-cost Data Access with Restrictions	For sharing of data under licensing terms, where some restrictions on the use of the data apply (e.g., for protection of sensitive data) and no fees are to be paid to the licensor	Typical conditions: ▪ Intended use(s) stated ▪ Disallowed use(s) stated
Fee-Based Data Access with Restrictions	For sharing of data under licensing terms, where some restrictions on the use of the data apply (e.g., for protection of sensitive data) and fees are to be paid to the licensor	Typical conditions: ▪ Intended use(s) stated ▪ Disallowed use(s) stated

Trademarks are marks used in commercial contexts as indicators of the source of wares or services and can be affixed to datasets to show that they come from a particular source. A third party can be licensed to use that mark or can be prevented from using the mark, if the trademark holder does not wish to be associated with any potentially inferior or problematic downstream products or services that rely on the data.

Recipe – Data Sensitivities

1. Develop and document criteria for your organization's use in determining datasets for which sensitivities may exist. This is an important first step, prior to the selection of any sensitive datasets, and will require the input of not only data custodians but also legal and policy experts.
2. Examine all organizational datasets to identify those that may be made available to external users but require protection of sensitivities and IP. Prepare an inventory of the data to be protected taking into consideration the sensitivity criteria discussed in Background provided above. Considerations include:
   - Your organization may want to make all of its data holdings accessible in principle, but restrict access to certain datasets or parts of datasets due, for example, to sensitivity or privacy considerations.
   - Principles for sensitivity assessment (see *Best Practices for Sharing Sensitive Environmental Geospatial Data* referenced in Resources below for more details) can include:
     - Data sharing – ensure that without an acceptable reason (e.g., privacy, security, competitiveness), a data custodian cannot arbitrarily decide not to share the data;
     - Data uniqueness – prevent data being considered sensitive if it is readily available through other sources or if it is not unique;
     - Standardized process – justify and support decisions to safeguard data by a process that is consistent and repeatable, while accommodating all relevant legislation, regulation, policies and standards governing the organization;
     - Data custodian role – give data custodians responsibility to determine data to be classified as sensitive under the legislative and policy framework governing their organization;
     - Data sharing conditions – define conditions under which sensitive data can be shared and/or define means to remove the sensitive elements from data;

- Original data – retain an unaltered, original version of the dataset that has the sensitivity removed;
- Document and publish – make information on the process, criteria, metadata and resulting decisions available to data contributors, custodians and consumers; and
- Respect restrictions – make it incumbent upon data consumers to respect the defined restrictions placed on sensitive data.

3. Gain management approval to proceed with protection of sensitive data. Once the inventory of data to be protected is prepared, the organization's management must decide how to effectively implement protection mechanisms (see ideas in the Decision Framework in the *Best Practices for Sharing Sensitive Environmental Geospatial Data* referenced in Resources below).
4. Identify and document the sensitivities that need to be dealt with in the case of each selected dataset. In order to determine the best mechanism to use in protecting the sensitive data, your organization needs to be specific about the kinds of sensitivities that exist in each case (e.g., privacy considerations, security concerns and liability issues).
5. Identify and document the type of protection mechanism to be used for each selected dataset. Possible mechanisms are discussed in Background above.
6. Create and implement the necessary protection mechanisms. Considerations include:
   - If licences are to be used, the two "with restrictions" types shown in the table in Background above are relevant (see also the CGDI *The Dissemination of Government Geographic Data in Canada: Guide to Best Practices*, the Information Sharing Agreement Template contained in the *Indigenous Guardians Toolkit* and *Framework for a Data Sharing Agreement, Prepared for The Alberta First Nations Information Governance Centre* referenced in Resources below for examples of licence formats).
   - Methods to remove the sensitive part of a dataset (from a copy of the affected dataset, not the original) can include:
     - Generalizing the spatial locality or georeference;
     - Aggregating or statistically summarizing data; and
     - Modifying or removing attribution.
   - Metadata can be used to inform prospective users of sensitive data that may be available under restricted conditions upon request.
   - Training mechanisms may be required for both data custodians (to reduce the risk of sensitive data inadvertently being shared) and users (to manage and safeguard any sensitive content that is imported into their organization).

Recipe – IP Protection

1. Examine all organizational datasets that require protection of IP, which have not already been identified for sensitivity protection, and prepare an inventory of the data. Considerations include:

- Aside from sensitivity considerations, your organization may want to protect IP rights in its data assets for a number of reasons (e.g., to ensure acknowledgement of your organizations as the source of the data incorporated in value-added information products, disclaiming any liability for any errors or omissions in the data, etc.).
- For this purpose, the two "no restrictions" types shown in the table in Background above are relevant.

2. Gain management approval to proceed with protection of IP. As with decision on data sensitivities, this will require the input of not only data custodians but also legal and policy experts.
3. Create and implement the necessary IP protection licence. See the CGDI *The Dissemination of Government Geographic Data in Canada: Guide to Best Practices* referenced in Resources below for examples of licence formats.

Example – Clyde River Knowledge Atlas

The Exchange for Local Observations and Knowledge of the Arctic (ELOKA) fosters collaboration between resident Arctic experts and visiting researchers for the collection, preservation, exchange and use of local observations and Indigenous knowledge. ELOKA provides data management and user support to Indigenous communities to ensure their data and knowledge are managed, visualized and shared in an ethical manner in order to work toward information and data sovereignty. ELOKA receives funding support from the U.S. National Science Foundation and other funding bodies.

ELOKA operates on the principles that all knowledge should be treated ethically, and IP rights should be respected. Without a network and data management system to support Indigenous Knowledge and community-based research, a number of problems can arise. These include: loss of extremely precious data, information and stories from Elders who pass away; repetition and duplication of research efforts and wasted resources due to a lack of awareness of previous studies; and a reluctance or inability to initiate or maintain community-based research without an available data management system. ELOKA addresses these challenges by partnering with Indigenous communities to guarantee their knowledge and data are stored in an ethical way, thus ensuring sovereignty over these valuable sources of information.

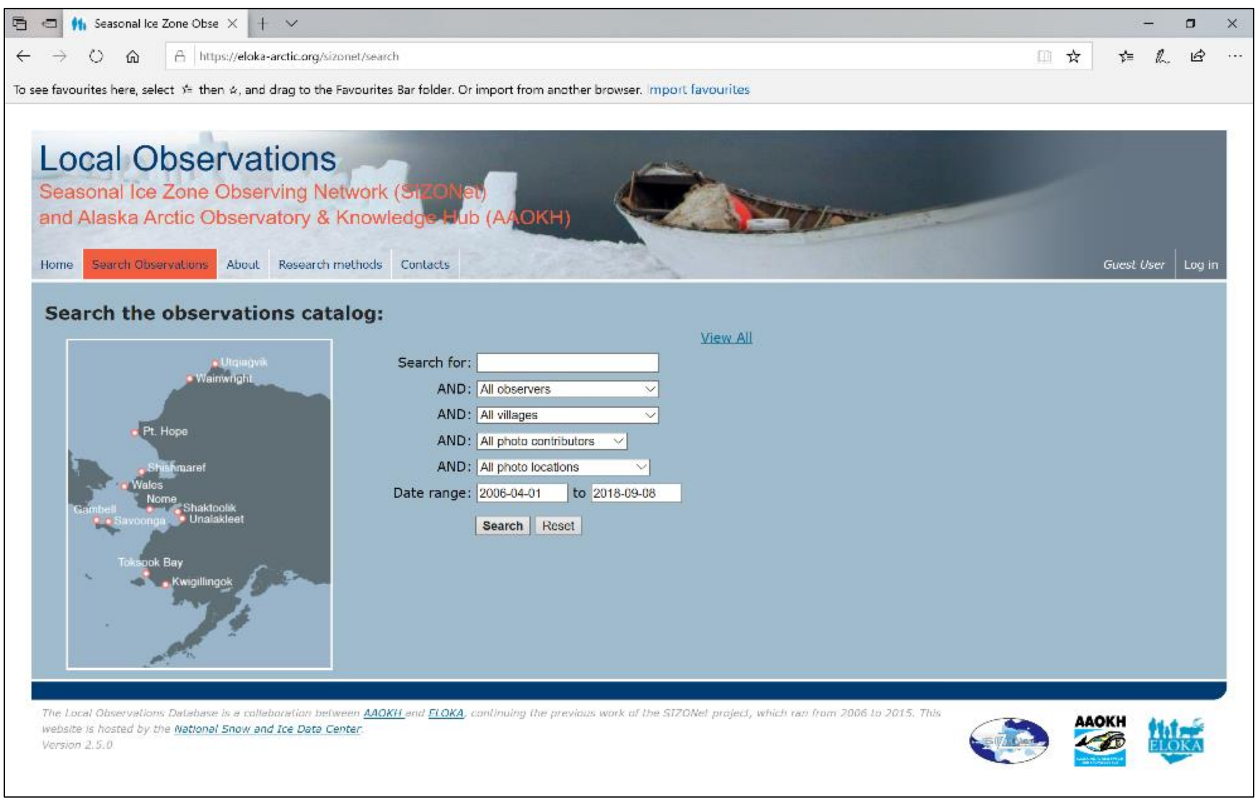
ELOKA provides services for research projects, communities, organizations, schools and individuals who need help to store, protect and share local and Indigenous knowledge. ELOKA works with many different types of data and information, including:

- Written interview transcripts;
- Audio and video tapes and files;
- Photographs, artwork, illustrations and maps;
- Digital geographic information such as GPS tracks, and data created using Geographic Information Systems;
- Quantitative data such as temperature, snow thickness, wind data, etc.; and
- Many other types of Indigenous knowledge and local observations, including place names.

When presented in the absence of the local and cultural context in which it was collected, local observations and knowledge can lose value at best, and be misleading at worst (Pulsifer & McNeave, 2014). Data management best practices place an emphasis on data documentation to help mitigate the risk of exchanging or using data without suitable contextual information. To promote more complete representation of data, and to ensure discoverability, access to and preservation of data, metadata must be collected (see also: *Make your Data Discoverable*).

ELOKA hosts several websites and online applications that provide access to various information about the Arctic. For example, the Local Observations portal (see Figure 5) from the Alaska Arctic Observatory and Knowledge Hub (AAOKH) (formerly the Seasonal Ice Zone Observing Network [SIZONet]) records, archives, and shares indigenous sea ice knowledge and expertise while protecting sensitive information and IP. AAOKH is led by the International Arctic Research Center at the University of Alaska Fairbanks and partners with many Alaskan communities. Information is shared with the public under a use agreement, which obligates users to respect several conditions for the use of and referencing of data accessed through the site. Certain data provided to AAOKH by Inupiaq and Yupik sea ice experts is sensitive or private in nature. This data is protected by making it accessible to only registered users who have met certain qualifications and who have a password.

Figure 5   SIZONet Local Observations search function.



ELOKA also protects sensitive information as part of the Community-Based Environmental and Species Observations from the Bering Sea Sub-Network initiative. The objective of the network is to enable residents in remote Arctic communities to systematically document physical and social changes occurring in their region. In 2008 and 2009, approximately 300 hunters and fishermen participated in a pilot survey. Harvest data collected as part of the survey included: species caught, species health and intended use; changing climate and environmental conditions; location and travel information; and a review of harvest conditions. A summary of the pilot project results is publicly accessible but the sensitive survey data, including traditional knowledge, is restricted. Access to this data is assessed on a case-by-case basis through submission of a Data Set User Registration Form. Use of this data must be approved by the community, a process that may take between 4 and 12 weeks.

Protection of sensitive data and IP is a significant consideration in a protocol developed for ELOKA. The protocol uses a decision tree approach to help communities plan their data collection and management activities. A selection of specific elements of the ELOKA Protocol (Tides Canada, 2018) include:

- *User needs assessment* – required functionality in relation to information and processing requirements (e.g., data collection and display, quality control, data processing and visualization).
- *Licensing of IP* – open source versus restrictions on access to sensitive data, access control.
- *Collaboration* – cost-sharing opportunities, leverage of relevant other existing or planned activities.
- *Data sharing* – interoperability with partners' systems.
- *Location of data management system* – local or cloud infrastructure, partner organization.
- *Ease of installation and maintenance* – capacity of existing facilities, expertise of team.
- *Archiving and preservation* – requirements beyond simple data backup.

The Protocol includes guides users through several questions, including:

- **What methods will be used to collect data?** It is important to ensure that methods are clear, defensible and deliver credible data. Methods also need to be realistic (e.g., considers relevance, accessibility, repeatability, and match with local capacity). In addition, established data collection methods have broader impact, save time and money and provide an opportunity to compare data over time.
- **What tools will be used to collect data?** Considerations include cost-effectiveness and user-friendliness of tools, capacity or skills needed to use the tools and availability of training.
- **How will data be stored and managed?** Data management system(s) may already exist in the community/organization that could be employed to make use of the data. If not, decisions on an alternative need to consider such things as: who should be responsible for managing the data; options for building and maintaining the data management system (e.g., internal or out-sourced); how will data be backed up; and who will have access to the data (e.g., free and open accessibility to the public, restricted access to sensitive data, etc.).

- **How will the results of the data collection project be shared and reported?** When shared and used, data is powerful and creates influence and impact. To be most effective, careful consideration must be given to: community support of the data collection project through sharing results; who will decide how data will be shared (i.e., the need for clear guidelines and protocols for data sharing); and how will published data be made more accessible (e.g., visual representation of the data – a picture is worth a thousand words).

Resources

- Best Practices for Sharing Sensitive Environmental Geospatial Data: http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/288/288863/cgdi_ip_15_e.pdf
- Intellectual Property Law Backgrounder: http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/291/291932/cgdi_ip_19e.pdf
- The Open Government Licence – Canada User Guide: http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/297/297541/cgdi_ip_0045_en.pdf
- The Dissemination of Government Geographic Data in Canada: Guide to Best Practices: http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/288/288853/cgdi_ip_08_e.pdf
- Indigenous Guardians Toolkit – Information Sharing Agreement Template: https://www.indigenousguardianstoolkit.ca/sites/default/files/Community%20Resource_Central%20Coast%20Indigenous%20Resource%20Alliance_Draft%20Information%20Sharing%20Agreement%20Template_0.pdf
- Framework for a Data Sharing Agreement, Prepared for The Alberta First Nations Information Governance Centre by Krista Yao: http://www.afnigc.ca/main/includes/media/pdf/community%20resources/Data_Sharing_Agreement.pdf

6.2 POLICIES: DEVELOP AN OPEN DATA POLICY

What you will accomplish

This recipe will help you create a policy to make your organization's geospatial data open and freely available to external users. Definitions of key terms used in this recipe can be found in the Glossary section of the *CGDI Cookbook*.

What you will need

Commitment icon

- An organizational decision to provide free and open access to selected datasets.
- An inventory of the datasets to which external users will have free and open access.
- Written documentation of the conditions under which the chosen datasets will be made accessible on a free and open basis.

Background

Over the past ten years there has been a significant shift in access to geospatial data, from a model typically based on the recovery of all or part of the costs of data development and maintenance through user fees, to one oriented towards free and open access to the data. This shift is aligned with the open data movement, which has promoted the idea that data is open if anyone is free to use, reuse, and redistribute it subject only, at most, to the requirement to acknowledge the source and share-alike. It has particularly been the case with public sector data in Canada, the majority of which is openly and freely accessible under open government policies.

Your organization may wish to follow this trend and make some or all of its geospatial datasets open to use by external parties. Typical considerations when making this decision include: quality of datasets and their potential fitness-for-purpose for external uses; computer and software infrastructure and staff resources required to make the data accessible and maintain its currency; and any data sensitivity or privacy issues that need to be addressed. Once these considerations have been taken into account and addressed, it is time to develop an organizational policy to cover your open data practices. The policy will address:

- The policy purpose and objectives;
- The types of datasets that will be made public;
- How the data will be made public; and
- How the policy will be implemented.

Recipe

The following provides a step-by-step recipe that you can follow to complete your open geospatial data policy development task, including guidelines for creating typical policy components drawn from the work of the Sunlight Foundation (see reference in Resources below for detailed guidelines). The accompanying Use Case illustrates how this might work in a typical application instance.

1. Examine all organizational datasets to identify those that may be made open and freely available to external users and prepare an inventory of the potential open data. Your organization may want to make all of its data holdings accessible or restrict access to certain datasets due, for example, to sensitivity or privacy considerations.

2. Gain management approval to proceed with opening data to external users. Once the inventory of potential open data is prepared, the organization's management must decide how to proceed, taking into consideration the points raised in Background given above.

3. Draft your organization's open data policy. Typical policy sections include the following:

   - Objectives – describe the key outcomes the policy is designed to achieve.
   - Open Data – identify the datasets to be made open and freely available.
   - Prioritization of Data Release – specify the order in which datasets will be made available and timetables for their release.
   - Removal of Access Restrictions – specify that access to data be as open as possible with no restrictions on reuse.
   - Safeguarding Sensitive Data – identify any data that must be subject to access restrictions for privacy, security or other reasons.
   - Data Citation – mandate the creation of model citations for datasets by their data managers, to help users identify the origin of data sources within value-added data products.
   - Data Quality – specify processes to keep open datasets up-to-date, accurate and accessible and to document any concerns with accuracy or quality concerns to avoid possible confusion or misinformation.
   - Data Formats – ensure that data is released in formats that maximize the ease and efficiency of reuse (i.e., using open standards/web services).
   - Metadata – mandate the publication of metadata, providing a common and fully described core metadata scheme based on open standards (see reference to metadata standard in Resources below).
   - Data Portal Creation – describe responsibilities for, and high level contents of, the internet site that will provide access to open and freely available data.
   - Unique Identifiers – mandate the use of reference numbers used to identify unique individuals, entities or locations within and across datasets, to help improve the quality and accuracy of data analysis by data users.
   - Data Maintenance – mandate the ongoing revision of publicly accessible datasets and their publication as close as possible to the date of collection.
   - Archival Material – mandate consideration of archiving previous versions of datasets and making them publicly available.
   - Oversight Authority – appoint a single authority empowered to resolve conflicts and ensure compliance with new open data measures.

- Guidance – direct the creation of guidance documentation to assist data managers to comply with the Open Data Policy.
- Partnerships – mandate exploration of potential collaborative arrangements with other organizations to increase the availability of open data.
- User Feedback – create opportunities for user feedback about data quality, quantity, selection, and format, as well as the user-friendliness of data portal.
- Implementation Timetable – set clear deadlines, giving relevant internal stakeholders enough time to prepare for the changes brought about by the new open data policy.
- Future Changes – mandate future review of the policy itself as well as of any guidance created by the policy or other implementation processes.

4. Develop an open data licence specifying the conditions under which your data will be made available. Such licences may be either:
    - Online web-wrap agreements (i.e., an agreement to abide by the terms of a license signified by downloading data, which generally does not provide for any means by which the user can acknowledge acceptance of the terms of the agreement, apart from the act of downloading itself); or
    - Formal signed agreements (i.e., an agreement to abide by the terms of a license signified by the parties' signatures, which may be necessary if there are any restrictions on the use of the data to be downloaded.

    See reference to the CGDI How to Share Geospatial Data Primer in Resources below.

Example

GeoBase is a geospatial framework dataset developed and maintained by the Canada Centre for Mapping and Earth Observation (CCMEO), Natural Resources Canada in collaboration with sister organizations in all the provinces and territories and a number of federal organizations. GeoBase facilitates universal access to key datasets such as: administrative boundaries; the Canadian Digital Elevation Model (Figure 6); geodetic data; National Road Network; National Railway Network; National Hydro Network; satellite orthoimagery; Canadian Land Cover; and Canadian Geographical Names.

The development of GeoBase was initially a response to the work of the CGDI Policy Advisory Node in the early 2000s to remove barriers to geospatial data access. Some of the barriers identified in several studies commissioned by Natural Resources Canada (Hickling Arthurs Low, 2001) included:

- *Data Accessibility* – Digital geospatial data that are collected or created by any level of government should be made as readily available electronically to the public as possible by improving access mechanisms and processes, unless there are privacy, security or competitive reasons not to do so.
- *Core Framework Data* – Core framework data, particularly the geo-reference and topographical framework maps used as the underlay for thematic data, should be provided free as a public good (or more properly, licensed at no cost) to encourage use, standardization and consistency amongst all client groups.

- *Copyright and Licensing* – Digital geospatial data should be licensed at no royalty cost to users with respect to use and redistribution. Use copyright and licensing within Canada to protect quality of geospatial data originating from all government agencies, particularly at the federal level, rather than to prevent use. Most digital geospatial data should be licensed at no cost to users. “Branding” of the original source data would facilitate re-use by retaining the “brand name” as long as the original data is not modified.
- *Inter- and intra-governmental data sharing* – Develop an inter- and intra-governmental data sharing policy model which would encourage and allow the free exchange and sharing of geospatial data by data agencies with other government departments and with other levels of government.
- *Degrading quality of national geospatial base data* – Growing concern in the user community pointed to degrading quality of national geospatial framework datasets, to the point where it a lack of action would render Canada’s existing framework datasets irrelevant.

These results were given serious consideration by the Canadian Council on Geomatics (CCOG), whose members agreed to collaborate in the development and management of GeoBase. The collaboration arrangements have been formalized in successive “Canadian Geomatics Accords”, signed by the parties in 2001, 2007 and 2014.

The most recent Accord states “*In order to provide the highest quality of geographical information we the signatories agree to work within these principles:*

- *To provide effective leadership and governance within the geomatics community in order to contribute to a vital Canadian geomatics sector;*
- *To promote and contribute to the development of best practices, pan-Canadian and international standards and policies to support geospatial information sharing and integration;*
- *To support the efficient use of resources by collaborating to reduce management and maintenance costs through the development of harmonized collection strategies [e.g., for GeoBase] and shared infrastructure for geomatics [e.g., the CGDI];*
- *To promote the benefits of integrating geographic information in business processes to enrich analysis and decision making;*
- *To enhance the availability and usability of geographic information in an open government context.”*

In addition to the Accord, the GeoBase parties signed agreements covering the sharing of different layers of GeoBase data. To facilitate this process, provincial/territorial and federal partners had access to funding under the GeoConnections program to offset the additional expenses of making their data available in standardized formats to Canada Centre for Mapping and Earth Observation (CCMEO) for incorporation into GeoBase.

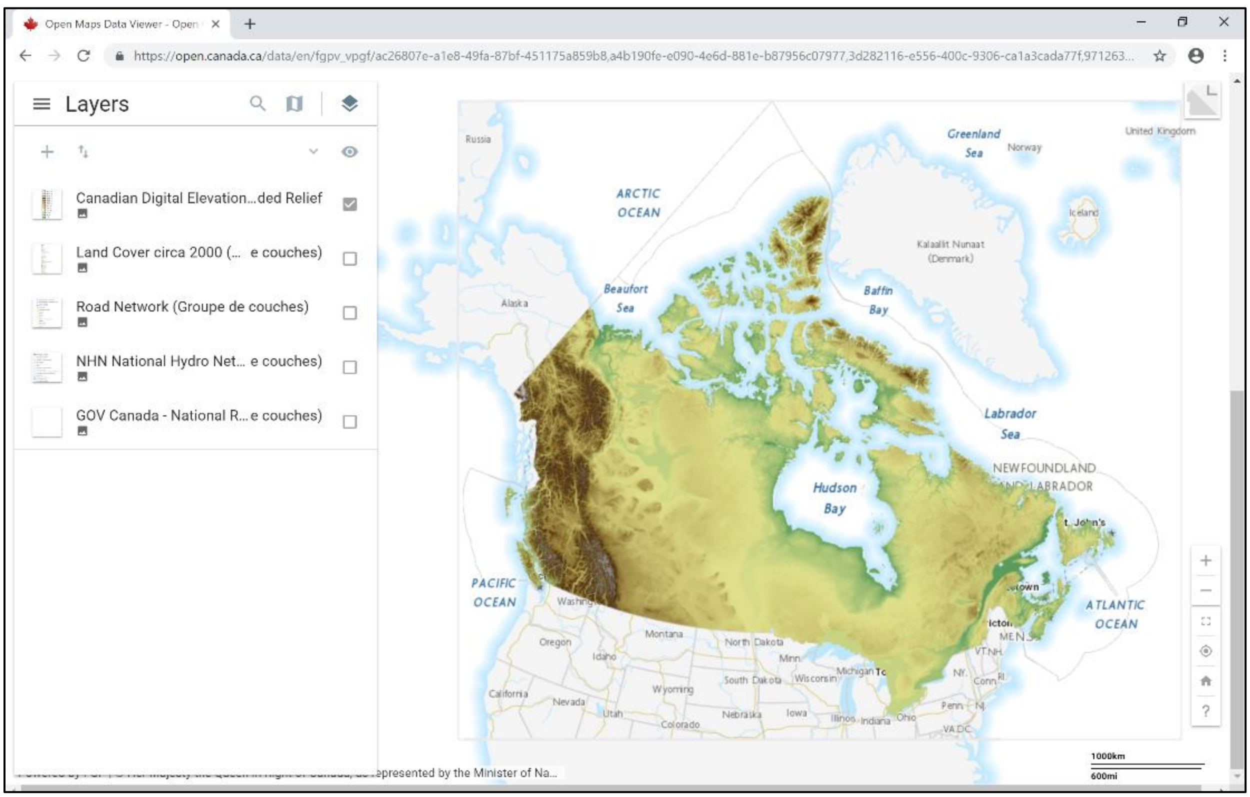
The principles of GeoBase as defined in *GeoBase Principles, Policies, and Procedures (PPP)* on which the creation of GeoBase was based are:

- Source, regional and, where practical, national data all share the same geometry.
- Source data is collected once and used by many.

- Source data is collected and maintained closest to source.
- GeoBase provides national data coverages.
- All GeoBase data is available at no charge.
- GeoBase data has no restrictions on its subsequent use.
- GeoBase data uses a common license.

The PPP provides details of the GeoBase data themes, describes processes for identifying and adding new data themes, criteria for accepting new themes and identifies GeoBase standards. A GeoBase Portal was created, providing one location to obtain the data, to view all the standards associated with the datasets and to understand the data and how it could be used. Access to GeoBase data is now provided through the Government of Canada's Open Government Portal, where it can be viewed on the Open Maps portal. The PPP contains operational policies that were developed for the Portal, including for data distribution clearance, portal maintenance and online availability and free and open data provision through Web services. Finally, the GeoBase partners agreed on the implementation of the policy to provide free and open data via the GeoBase Unrestricted Use Licence Agreement, which is in alignment with the GeoBase principles.

Figure 6 GeoBase theme Canadian Digital Elevation Model in Open Maps Data Viewer.



The licence grants *"a non-exclusive, fully paid, royalty-free right and licence to exercise all Intellectual Property Rights in the Data. This includes the right to use, incorporate, sublicense (with further right of sublicensing), modify, improve, further develop, and distribute the Data; and to manufacture and / or distribute Derivative Products derived from or for use with the Data."* With the transfer of GeoBase access to the Open Government Portal, the GeoBase licence has been replaced by the Open Government Licence – Canada.

Resources

- Open Data Policy Guidelines:
  https://opendatapolicyhub.sunlightfoundation.com/guidelines/
- North American Profile (NAP) of the ISO 19115: Geographic Information – Metadata:
  https://webstore.ansi.org/standards/incits/incits4532009
- How to Share Geospatial Data Primer:
  http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/292/292415/cgdi_ip_27e.pdf

7.0 COLLABORATION RECIPES

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7.1 COLLABORATION: DEVELOP COLLABORATIVE DATA MANAGEMENT AND SHARING AGREEMENTS

What you will accomplish

This recipe will help you develop acceptable arrangements with other organizations for the management and sharing or exchange of geospatial data. Definitions of key terms used in this recipe can be found in the Glossary section of the *CGDI Cookbook*.

What you will need

Commitment icon

- An organizational decision to collaborate with other organizations on the management and sharing of specific datasets.
- An inventory of the datasets to be collaboratively managed and shared.
- Written documentation of the conditions under which the chosen datasets will be collaboratively managed and shared.

Background

Your organization may find that it is advantageous to collaborate with one or more other organizations on the management and sharing or exchange of geospatial datasets of common interest. The rationale for this decision might include, for example, that you have programs or projects that are very similar to those of potential collaborators, requiring the development and use of similar datasets. Or budgetary constraints might be an incentive to seek partners to share the development and management of key datasets. In addition, complementary organizational strengths may factor into this decision (e.g., specific technical strengths or data management strengths). A key factor may also be the increased emphasis on horizontal initiatives within government (e.g., forest inventory management and reporting), requiring multi-party information integration and use. Regardless of the reasons for seeking collaborators, your organization will need to be prepared to negotiate arrangements that will meet both your and your collaborators' needs.

In preparing for these negotiations, it is important to be aware of any potential legal impediments to sharing your data, for example:

- Third-party data: Where an organization receives, integrates or redistributes data from a third-party data provider, it must ensure that it has the right to share that data.
- Data containing personal information: Federal and provincial privacy acts prohibit the government's use of personal information for purposes other than those for which the information was collected.
- Other government restrictions: Where data could prejudice safety or defence of Canada, federal and provincial legislation prohibits sharing of that information. Any data from a Canadian satellite remote sensing system also carries specific restrictions pursuant to the Remote Sensing Systems Space Act.

Your organization will also need to consider what type of written agreement will best suit your data sharing arrangements. Such agreements typically fall into two categories: (1) Non-Legally Binding (Non-contractual) Agreements, often referred to as “handshake agreements”, “Memoranda of Understanding (“MOU”) or “Memoranda of Agreement” (“MOA”); and (2) Legally-Binding (Contractual) Agreements or licence agreements, contracts that create legally-binding obligations enforceable before a court of law. The *How to Share Geospatial Data Primer* referenced in Resources below provides direction on the choice of agreement as well as other valuable advice on data sharing arrangements.

Finally, your organization will need to assess the risks and probability of success of the prospective collaborative arrangement. This assessment will take into consideration such factors as: the risks of sharing responsibility of data management with partners; the expertise and performance record of the prospective collaborator(s); the organization’s ability to recover if the co-venture fails; and the relative costs and benefits of the data sharing arrangement versus an internal solution.

Recipe

1. Identify a prospective data management and sharing collaborator(s). You will need to develop a complete understanding of the prospective partner(s) to ensure that there is enough common interest for a collaboration to be feasible.

1. Define the contents of datasets that you are interested in collaboratively managing and sharing. There must be enough similarity in the two (or more) organizations’ datasets needs and views on shared data management for a successful collaboration.

2. Identify and document any legal impediments to the collaborative management and sharing of the data. The focus will be primarily on your organization’s datasets but any knowledge you can gain on the prospective collaborator(s)’ datasets will also be to your advantage in subsequent negotiations.

3. Assess the risks and probability of success of the prospective collaborative arrangement. Typical questions that need to be answered in this assessment may include:
   - What are the risks of the collaborative arrangement (e.g., incompatibilities in practices and data formats, accuracies, etc.; loss of control of datasets; failure of partners to deliver; loss of one or more partners in a multi-collaborator arrangement)?
   - What has been the past performance record of the collaborator(s) in managing and delivering high quality geospatial data products and services?
   - What challenges will our organization face in working in a collaborative environment?
   - What are the costs and benefits of meeting our data requirements internally versus through a collaborative management and sharing arrangement?
   - What are the key factors that might interfere with the success of the collaborative arrangement?

4. Prepare a draft agreement to cover the collaborative management and sharing arrangements. Your organization will need to decide which type of agreement is most suitable in your circumstances. You can find a comparison of different agreement types in the *Share Geospatial Data Primer* referenced in Resources below.

5. Contact the prospective collaborator(s) and negotiate the arrangements. With your preparations completed, your organization will be in a strong position to begin negotiations with an organization(s) that you have determined may be a suitable collaboration candidate(s). If working relationships are already in place based on previous initiatives of common interest, typically the preparatory work will be less time consuming and the negotiations will have a higher probability of success.
6. Finalize and implement the arrangements. Following successful negotiations, agreements can be signed by the parties and the technical and interpersonal relations development work can proceed.

Example

The National Forest Inventory (NFI) is an ongoing forest measurement program undertaken by collaborators from 10 provinces, two territories and the Canadian Forest Service of the Federal Government. Repeated measurements are taken at a network of sampling points across Canada to provide accurate, timely and consistent information on the extent, composition and characteristics of Canada's forests and how they are changing over time. The NFI provides data to inform domestic forest policies and positions, and to support science initiatives and regional, national and international reporting commitments.

The Canadian Forest Service has been collaborating with provincial/territorial forest management agencies for decades. In 1981, a computer-based system, known as Canada's Forest Inventory was developed to summarize the data obtained from the management agencies. In 1996, the need for a new NFI with a statistically valid sampling approach was identified (Gillis, Omule and Brierley 2005). This would require a cooperative multi-agency approach with a consistent methodology and a network of plots to provide the framework for ongoing re-measurement and monitoring. The NFI's design-based statistical survey of permanent, geo-referenced plots that sample all of Canada's forests was established between 2000 and 2006, and the first ten-year re-measurement cycle was completed between 2008 and 2017.

The NFI is maintained by a team of forest inventory managers from federal, provincial and territorial governments. This group of professionals works collaboratively to:

- review and approve plans for the design, development and implementation of the NFI;
- observe, study and discuss the continued state, practice and research of forest inventory methods within jurisdictions, nationally and internationally towards a common standard for data collection, compilation, analysis, reporting and dissemination of information and knowledge;
- identify research and development priorities for improved data collection, compilation, analysis and reporting;
- promote standardization of measurement and terminology, to improve the quality and utility of forestry data;
- promote liaison and dialogue with organizations engaged in the collection of forestry data for the purpose of improving the accuracy and efficiency of reporting forestry statistics; and
- make information publicly available that provides a comprehensive and objective view of the issues and options faced by the forest sector.

Collaboration on the National Forest Inventory (NFI) has been formalized through bilateral MOU Concerning Cooperation in the Continuation of the National Forest Inventory between the federal and territorial Minister of Natural Resources and the Minister responsible for forest management in provincial jurisdictions across Canada. The terms of these agreements generally cover the following topic areas:

- Purpose of the MOU;
- Areas of Cooperation (e.g., standards administration, data management systems, data collection, etc.);
- Designation of Representatives to undertake activities;
- Implementing Arrangement (e.g., annual work plans and rights of each party);
- Cost (e.g., agreement in writing to share costs, availability of resources);
- Annual Reporting;
- Confidentiality (e.g., sharing of agreement with other parties, rights to data use);
- Term of MOU; and
- MOU Non-binding (to guide actions, but no legal obligations).

Canada's National Forest Inventory is managed by the NFI Project Office at the Canadian Forest Service, using the National Forest Information System (NFIS), the information infrastructure created to answer questions on matters relating to sustainable forest management in Canada. The NFIS portal provides open and free online access to a wealth of data about the NFI, with a few products that require a custom request process to protect privacy of land owners.

Resources

How to Share Geospatial Data Primer:
http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/292/292415/cgdi_ip_27e.pdf

8.0 CASE STUDIES

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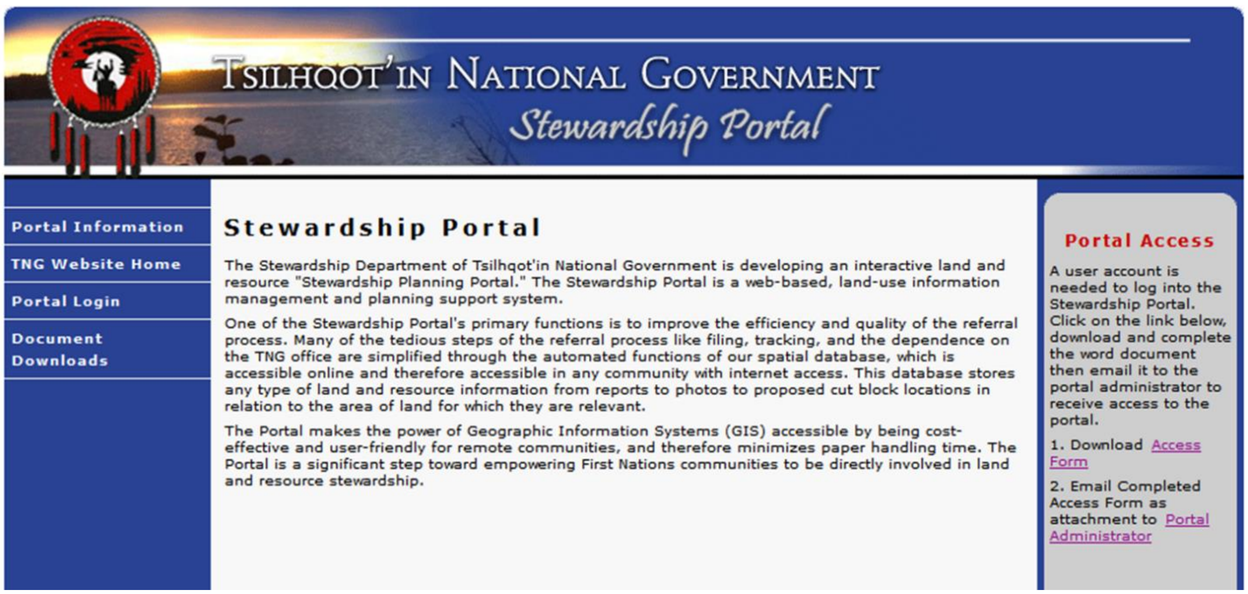
8.1 TSILHQOT'IN NATIONAL GOVERNMENT STEWARDSHIP PORTAL

The Tsilhqot'in National Government (TNG) Stewardship Portal (Figure 7) is an online land use management and planning support system designed by First Nations and for First Nations. The portal was launched in 2007 as a tool to help TNG manage the administration and data associated with land use planning, community information and the complex referral processes for natural resource projects. Processes include responding to requests for information and consultation that natural resources companies or governments make as part of environmental assessment and permitting procedures.

Figure 7 Tsilhqot'in National Government Stewardship Portal.



For TNG and many Indigenous organizations across Canada, managing referrals is a substantial burden on administrative and geomatics staff. At the time, TNG was tracking referrals data in a spreadsheet and storing geospatial data on several desktop personal computers. TNG received geospatial data from proponents or the provincial government, it was sent to them via email, File Transfer Protocol (FTP), or hard copy using a variety of formats and spatial data standards. Before long, managing geospatial and non-geospatial data became overwhelming and an obstacle to effectively responding to referral requests. The TNG Stewardship Department (with the support of the Tsilhqot'in leadership) decided to adopt a spatial data infrastructure approach as a strategy to improve geospatial data management, build capacity, and ensure ownership, control, and security and data sovereignty over important information.

With funding from GeoConnections and the British Columbia Capacity Initiative, TNG worked with community members and staff to understand their needs and hire a web based application developer to build a custom solution that combined data management and standardization, mechanisms to protect and control sensitive information (such as traditional use data) and ease the technical and administrative burdens of referrals processes. Today, the TNG Stewardship Portal provides an online tool for geospatial-enabled land use management and natural resource planning. The portal simplifies tracking and storing of complex referral data and provides a permanent record of all communication and information accessible from anywhere with an internet connection.

Adopting this approach lead to a number of benefits for TNG including:

- **Supporting data sovereignty** by giving the organization full control over all data on the portal, including internal confidential datasets, and datasets that are contributed by external users. Using the portal, TNG can restrict access to internal data while still allowing external users to contribute geospatial data to support analysis and decision making. Importantly, TNG leadership operates the portal on an internal server only, allowing data to be backed up regularly while giving members confidence that their information will not be compromised.
- **Standardizaton of geospatial data** using custom schemas and data entry forms filled out by proponents. This allows TNG to keep all internal and incoming data aligned with geospatial standards. Standards are determined by TNG's geomatics staff based on the organization's needs and current practices in data standardization.
- **Increased capacity for TNG staff** by using proponent-driven data entry and simple online mapping interfaces. Proponent-driven data entry transfers the administrative and technical burden of entering standards-compliant data from TNG staff to the proponents or government agencies that want to work with them. The portal's mapping interface makes it possible for referrals staff to use it to view and analyze data without geomatics expertise. In turn, this has helped staff build basic skills in working with geospatial data while allowing TNG's geomatics specialist to focus their efforts on more advanced spatial analysis and planning initiatives.
- **Facilitating collaboration and data sharing** between TNG and other parties. Using the portal makes it simple to understand what data needs to be shared, with whom, in what format and standard, and at what frequency. A good example of this is when the British Columbia Government uses the TNG portal to request and document engagement activities and share key spatial datasets according to the Tsilhqot'in Stewardship Agreement (2014-2017 and 2017-2020).

The TNG Stewardship Portal is based on open source technology, so it can be adopted and customized by any Indigenous organization with no licensing fees.

8.2 NATIONAL FOREST INVENTORY

The National Forest Inventory (NFI) is an ongoing forest measurement program undertaken by collaborators from 10 provinces, two territories and the Canadian Forest Service of the federal government. Repeated measurements are taken at a network of sampling points across Canada to provide accurate, timely and consistent information on the extent, composition and characteristics of Canada's forests and how they are changing over time. The NFI provides data to inform domestic forest policies and positions, and to support science initiatives and regional, national and international reporting commitments.

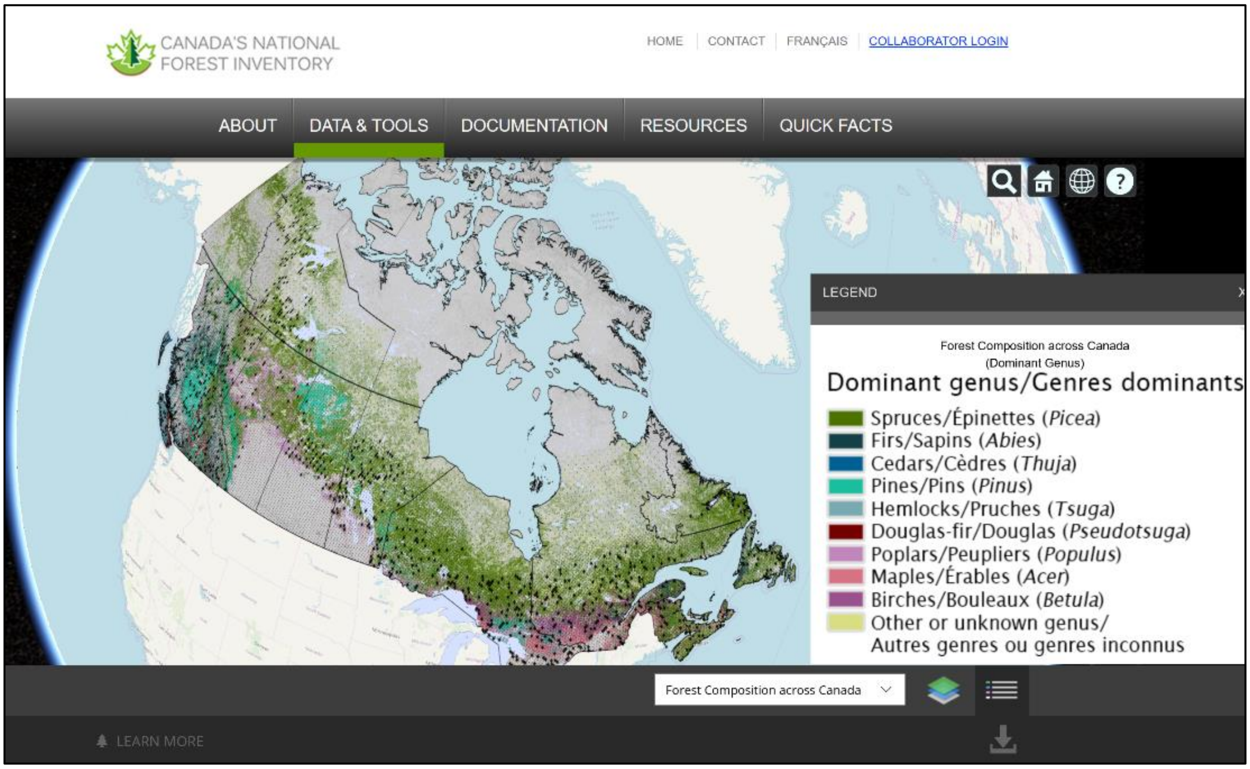
The NFI is maintained by a team of forest inventory managers from federal, provincial and territorial governments. This group of professionals works collaboratively to:

- review and approve plans for the design, development and implementation of the NFI;
- observe, study and discuss the continued state, practice and research of forest inventory methods within jurisdictions, nationally and internationally towards a common standard for data collection, compilation, analysis, reporting and dissemination of information and knowledge;
- identify research and development priorities for improved data collection, compilation, analysis and reporting;
- promote standardization of measurement and terminology, to improve the quality and utility of forestry data;
- promote liaison and dialogue with organizations engaged in the collection of forestry data for the purpose of improving the accuracy and efficiency of reporting forestry statistics; and
- make information publicly available that provides a comprehensive and objective view of the issues and options faced by the forest sector.

Canada's National Forest Inventory (CFI) is managed by the NFI Project Office at the Canadian Forest Service, using the National Forest Information System (NFIS) (Figure 8), the information infrastructure created to answer questions on matters relating to sustainable forest management in Canada. The NFIS portal provides open and free access to a wealth of data about the NFI. For example, NFI data have been used to produce a suite of continuous maps of 127 forest attributes at a 250 m resolution. Map data can be viewed in the portal and accessed with web services. Standard statistical reports provide estimates of basic forest attributes such as area, volume and biomass, summarized in various ways (e.g., by forest type, age class, ownership, and protection status) for three geographic stratifications: Canada, Terrestrial Ecozones and Boreal Zone. Users can create their own reports online by interactively querying the National Forest Inventory database. In addition, Biomass Calculators are provided to allow users to estimate biomass of four components (i.e., stem wood, stem bark, branches and foliage) for a forest stand or an individual tree.

NFI provides direct online access to most inventory data. The only exceptions are requests for custom estimates and map products, as well as raw data, which require the submission of an NFI Data Request Form. In those cases, firstly the exact locations of ground plots are not made available, to protect the representativeness of their survey and the privacy of land owners. Just as polling agencies cannot give out the phone numbers of the people they survey, the NFI cannot reveal the exact coordinates of plots without risk of introducing bias into their reports. They currently provide these data with approximate locations. Secondly, they consult provincial/territorial partners when users request data summarized at the provincial/territorial level. For example, if a user's study area is a single forest management unit, the province/territory will typically have more detailed data and the NFI Project Office may refer the data request to their partner.

Figure 8 Data on forest composition Displayed on the NFI Maps Viewer.



8.3 GEOBASE OPEN DATA POLICY

GeoBase is a geospatial framework dataset developed and maintained by the Canada Centre for Mapping and Earth Observation (CCMEO), Natural Resources Canada in collaboration with sister organizations in all the provinces and territories and a number of federal organizations. The available data themes are:

- Administrative Boundaries
- Canadian Digital Elevation Data
- Geodetic Data
- National Road Network
- National Railway Network
- National Hydro Network
- Satellite Orthoimagery
- Canadian Land Cover
- Canadian Geographical Names

The GeoBase Case Study is an excellent example of the development of an open data policy as well as a collaborative arrangement for the development and maintenance of shared data.

The development of GeoBase was initially a response to the work of the CGDI Policy Advisory Node in the early 2000s to remove barriers to geospatial data access. The Node commissioned KPMG to conduct the Canadian Geospatial Data Policy Study (Sears 2001) to provide empirical information on the impact of geospatial data policies at that time on all three levels of government (federal, provincial, municipal) and the users and distributors of the data in the business sector and in the geomatics community at large. Published in March 2001, the study report documented the current data policies of government geospatial agencies, which at the time were strongly oriented to some form of cost recovery through access fees, and the unintended consequences of those policies. Among others, the report included the following recommendations:

- *Data Accessibility* – Digital geospatial data that are collected or created by any level of government should be made as readily available electronically to the public as possible by improving access mechanisms and processes, unless there are privacy, security or competitive reasons not to do so.
- *Core Framework Data* – Core framework data, particularly the geo-reference and topographical framework maps used as the underlay for thematic data, should be provided free as a public good (or more properly, licensed at no cost) to encourage use, standardization and consistency amongst all client groups.
- *Copyright and Licensing* – Digital geospatial data should be licensed at no royalty cost to users with respect to use and redistribution. Use copyright and licensing within Canada to protect quality of geospatial data originating from all government agencies, particularly at the federal level, rather than to prevent use. Most digital geospatial data should be licensed at no cost to users. “Branding” of the original source data would facilitate re-use by retaining the “brand name” as long as the original data is not modified.
- *Inter- and intra-governmental data sharing* – Develop an inter- and intra-governmental data sharing policy model which would encourage and allow the free exchange and sharing of geospatial data by data agencies with other government departments and with other levels of government.

Another key motivation for the creation of this open and freely available geospatial data source was the release in June 2001 of the report *The Case to Upgrade the National Geospatial Information Base*, prepared for Natural Resources Canada by Hickling Arthurs Low. The report documented growing concern within the user community about the degrading quality of national geospatial base data and set out a vision for a new national geospatial information base, built and maintained through a coalition of federal and provincial/territorial governments, working in concert with public and private users, the geomatics industry and the academic sector. The report authors concluded, based on their research and consultations, that the existing information base would degrade to the point where it became irrelevant if the federal government did not make a new substantial commitment to the provision of base data.

The conclusions and recommendations of these two studies were given serious consideration by the federal-provincial/territorial geospatial information coordination body, the Canadian Council on Geomatics (CCOG). The CCOG provides a forum for the exchange of information on common operational issues and seeks to identify opportunities to collaborate on pan-Canadian initiatives and promote standards that are essential for geospatial data and systems interoperability. Consideration of the KPMG report recommendation concerning core framework data and the HAL report vision resulted in agreement by the CCOG members to collaborate in the development and management of GeoBase. The collaboration arrangements have been formalized in successive "Canadian Geomatics Accords", signed by the parties in 2001, 2007 and 2014. The most recent Accord states:

> "*In order to provide the highest quality of geographical information we the signatories agree to work within these principles:*
>
> - *To provide effective leadership and governance within the geomatics community in order to contribute to a vital Canadian geomatics sector;*
> - *To promote and contribute to the development of best practices, pan-Canadian and international standards and policies to support geospatial information sharing and integration;*
> - *To support the efficient use of resources by collaborating to reduce management and maintenance costs through the development of harmonized collection strategies [e.g., for GeoBase] and shared infrastructure for geomatics [e.g., the CGDI];*
> - *To promote the benefits of integrating geographic information in business processes to enrich analysis and decision making;*
> - *To enhance the availability and usability of geographic information in an open government context."*

In addition to the Accord, the GeoBase parties signed agreements covering the sharing of different layers of GeoBase data. To facilitate this process, provincial/territorial and federal partners had access to funding under the GeoConnections program to offset the additional expenses of making their data available in standardized formats to CCMEO for incorporation into GeoBase. To oversee the development of the dataset and the ongoing governance of the GeoBase initiative, in 2001 the CCOG formed the GeoBase Steering Committee (SC), which is currently composed of members representing the federal and provincial/territorial governments. The SC continues to function, with regular teleconference meetings and an in-person meeting at least once a year and is supported by a GeoBase Secretariat hosted by Natural Resources Canada.

Prepared by the GeoBase SC and Secretariat and adopted by the CCOG, *GeoBase Principles, Policies and Procedures* (PPP) sets out a vision and end state for the initiative and steps for their implementation. The vision encompasses: the provision of high-quality geospatial framework data for Canada; coordinated, effective and economical use of data, expertise and systems; and value add (beyond data) in support of common policy mandates and issues. The principles on which the creation of GeoBase was based are:

- Source, regional and, where practical, national data all share the same geometry.
- Source data is collected once and used by many.
- Source data is collected and maintained closest to source.
- GeoBase provides national data coverages.
- All GeoBase data is available at no charge.
- GeoBase data has no restrictions on its subsequent use.
- GeoBase data uses a common license.

The GeoBase PPP provides details of the GeoBase data themes, describes processes for identifying and adding new data themes, criteria for accepting new themes and identifies GeoBase standards. A GeoBase Portal was created, providing one location to obtain the data, to view all the standards associated with the datasets and to understand the data and how it could be used. Access to GeoBase data is now provided through the Government of Canada's Open Government Portal, where it can be viewed on the Open Maps portal (see Figure 6). The GeoBase PPP contains operational policies that were developed for the Portal, including for data distribution clearance, portal maintenance and online availability and free and open data provision through web services.

Finally, the GeoBase partners agreed on the implementation of the policy to provide free and open data via the GeoBase Unrestricted Use Licence Agreement, which is in alignment with the GeoBase principles. The licence grants *"a non-exclusive, fully paid, royalty-free right and licence to exercise all Intellectual Property Rights in the Data. This includes the right to use, incorporate, sublicense (with further right of sublicensing), modify, improve, further develop, and distribute the Data; and to manufacture and / or distribute Derivative Products derived from or for use with the Data."* With transfer of GeoBase access to the Open Government Portal, the GeoBase licence has been replaced by the Open Government Licence – Canada.

Resources

Sears, G. 2001. Canadian Geospatial Data Infrastructure Information Product 22e: Executive Summary Geospatial Data Policy Study. Natural Resources Canada.

9.0 EXTERNAL RESOURCES

More information on the CGDI administered by the GeoConnections initiative within Natural Resources Canada.

CGDI Resources website

Natural Resources Canada provides more information including funded projects, operational policies and standards, user needs assessments, and key publications

Canadian Council on Geomatics (CCOG)

A cooperative body made up of provincial, territorial, and federal government agencies that advances geomatics activities, geospatial data collection and interoperability of geospatial data infrastructure between jurisdictions. CCOG develops and endorses national data and data exchange standards that enable sharing of information and technical expertise between governments, and advocates for the use of geospatial data and information in enhancing policy and decision making.

Arctic SDI Manual

SDI Manual for the Americas

New Zealand SDI Cookbook

Global Spatial Data Infrastructure SDI Cookbook

10.0 LIST OF ACRONYMS

AAFC	Agriculture and Agri-Food Canada
AAOKH	Alaska Arctic Observatory and Knowledge Hub
CCMEO	Canada Centre for Mapping and Earth Observation
CCOG	Canadian Council on Geomatics
CGDI	Canadian Geospatial Data Infrastructure
CSW	Catalog Services for the Web
CGCRT	Canadian Geomatics Community Round Table
CRTC	Canadian Radio-Television and Telecommunications Commission
CWCS	Canadian Wetland Classification System
DB	Database
DEM	Digital elevation model
DSL	Direct service line
DSM	Digital Surface Model
DTM	Digital Terrain Model
EHR	Emergency Health Responders
ELOKA	Exchange for Local Observations and Knowledge of the Arctic
FGDB	File geodatabase
FGP	Federal Geospatial Platform
FTP	File Transfer Protocol
GB	Gigabyte
HRDEM	High-Resolution Digital Elevation Model
HTTP	HyperText Transfer Protocol
GIS	Geographic information system
GPKG	GeoPackage
GPS	Global Positioning System
IoT	Internet of Things
IP	Intellectual property
ISO	International Organization for Standardization
KPI	Key performance indicator
LiDAR	Light Detection and Ranging
MOU	Memoranda of Understanding
NFI	National Forest Inventory
NFIS	National Forest Information System
NGO	Non-government organizations
OGC	Open Geospatial Consortium
PPP	Principles, policies and procedures
RPAS	Remotely piloted aerial system
SAFE	Standard Archive Format for Europe
SDI	Spatial Data Infrastructure
SNAP	Sentinel Application Platform (European Space Agency)
TB	Terabyte
TBS	Treasury Board of Canada Secretariat
TNG	Tsilhqot'in National Government
UNA	User Needs Assessment
USGS	United States Geological Survey
VTOL	Vertical take-off and landing
WFS	Web Feature Service
WMS	Web Map Service

11.0 GLOSSARY

Application	A program or software that is designed and coded to perform a certain function for the user.
Application Programming Interface	A set of subroutine definitions, protocols, and tools used for building software and computer programs.
Attributes	Characteristics used to describe conditions at a location (e.g., temperature, population).
Bandwidth	The rate of data transfer in computing, measured in bits per second. Bandwidth is often used as a measure of Internet performance.
Basic GIS skills	Describes CGDI users who can comfortably view and use maps as part of their profession. Users may use GIS software to create maps and perform basic operations such as map overlay and identification of features occasionally (e.g., once per month).
Biomass	The total mass of organic matter in a given area or volume.
Buffer	A basic GIS operation that creates a zone or space around a feature on a map, typically measured in units of distance or time.
Catalogue	An application that is used to organize and manage metadata.
Catalog Services for Web	A standard for sharing a catalogue of geospatial data on the Internet.
Client-Server Model	In computer science, a client-server model is a type of software architecture that allows two parts, the client and the server, to communicate over a network or on the same computer. When you visit a geoportal to search for geospatial data, your web browser is the client and the machine on which the geospatial data is stored is the server. When you click on a dataset to view in your browser, the browser (client) is sending a request to the server to send it to you. Server-side software refers to software that is used to undertake operations performed by the server, such as rendering a contour dataset as a WMS so it can be viewed in your browser. Client-side software refers to software that is used to undertake operations performed by the client, such as symbolizing a drawing a pre-symbolized contour dataset provided by the server as a WFS WMS service.
Commercial software	Software that does not have source code that is publicly available. Commercial software is typically built by individual developers or companies and sold to users.
Computer suitable for running GIS software	Most GIS software applications have requirements for hardware and software. It is always a good idea to review these before downloading or purchasing software. In general, computers running GIS software should have the following specifications: ▪ at least 8GB of RAM; ▪ CPU speed of 2.2 GHz hyper-threading (HHT) or multi-core; ▪ at least 500GB of hard drive storage; ▪ a 64-bit operating system; ▪ a 3D graphics card if 3D imaging will be utilized
Data format (geographic)	A way of encoding geographic information into a digital file. Some geographic data formats include: Shapefile, GeoTIFF, and Keyhole Markup Language (KML).

Data portal/geoportal	A type of web portal used to find and access geospatial data and associated services and applications (e.g., to view or analyze data) via the Internet. Geoportals are a key element CGDI. The federal government has a national geoportal at open.canada.ca; and most provincial and territorial governments have geoportals where users can access regional data.
Data quality	Refers to completeness of the dataset, processes used to create and maintain it, and amount of validation or verification performed on the dataset. ISO 19157:2013 is an international standard that establishes principles for describing the quality of geographic data.
Data repository	A virtual or physical location that is designated for data storage. Geoportals are an example of a virtual data repository.
Datum	A a surface of zero elevation to which heights of various points are referenced.
Digital Elevation Model	A way of capturing elevation using a bare-earth raster grid referenced to a vertical datum.
Digital Terrain Model	A way of capturing elevation using a vector data set composed of regularly spaced points and natural features such as ridges and breaklines. A DTM complements a DEM by including linear features of the Earth's natural terrain.
Digital Surface Model	A way of capturing elevation which includes the height values of natural and built features on the Earth's surface.
Enterprise-level spatial relational database	A digital database for storing geospatial data based on a relational model of data. Enterprise-level spatial relational database are multiuser geodatabases that are often used within businesses or other organization, as they can be unlimited in size and number of users.
Expert GIS skills	Describes CGDI users who advanced skills in GIS analysis, visualization, and computing. Expert users typically have formal training or advanced degrees in geomatics, and work with complex geospatial datasets daily.
File Geodatabase	A collection of files, stored as folders in a digital file system, that helps to easily store, query, and manage both geospatial and non-geospatial data.
File Transfer Protocol – FTP	A web protocol that provides an easy way to transfer files over the internet. It helps users move information from the computer they are working on to an internal or external server, or vice-versa.
Framework data	Framework data are the essential datasets that provide context and reference for all of Canada, depicting consistent information that can be used across all sectors and organizations. For example, the boundaries that delineate provinces and territories and physical features such as lakes and rivers are framework data.
Geodatabase	A way to store geospatial information in one large file that may contain multiple point, polygon, or image layers, as opposed to storing related geospatial datasets as separate shapefiles.
Geoid	The geoid is a model of a sea-level surface that undulates over all over the earth, based on the influence of gravity; it extends through the oceans and landmasses. Surface elevations measurements that reference a geoid have a high degree of accuracy.
Geolocate	The identification of the location of a feature or data point on the Earth's surface using geomatics tools or software.

Geomatics	The discipline concerned with the collection, distribution, storage, analysis, processing, and presentation of geographic information.
GeoNode	A web-based application and platform for developing geospatial information systems (GIS) and for deploying spatial data infrastructures (SDI).
Geospatial data	The information that is used to describe a place, object, or event on the Earth's surface.
GIS software	A Geographic Information System (GIS) is a framework for gathering, managing, and analyzing location-based data. It organizes spatial information into layers and visualizes them using maps. GIS software includes computer programs and applications that allow people to use a GIS. Some examples include Esri ArcGIS and QGIS.
High-speed internet	Internet access that meets the minimum performance standard established by the Canadian Radio-Television and Telecommunications Commission (CRTC): 50 megabit per second download and 10 megabit per second upload.
Intellectual property	The legal right to ideas, inventions, and creations in the industrial, scientific, computing, and artistic fields. Intellectual property in the geospatial data field can include datasets themselves as well as applications or programs.
Intermediate GIS skills	Describes CGDI users who can comfortably work with geospatial data as part of their profession. Users may have formal training in GIS and use software to analyze and visualize geospatial data and perform advanced operations using statistical analyses regularly (e.g., more than once per week).
KPI	Key Performance Indicator - a measurable value that demonstrates how effectively an organization is achieving a key objective.
Licence	The permit or authority to own or use geospatial data or a geospatial product.
Metadata	Information that describes a geospatial dataset. Reading metadata can give a user information such as: the source of the data; the date and time that it was collected; and the type of map projection it uses.
Open Data	Structured data that is machine-readable, available at no cost, and encouraged to be used and built upon without restriction.
Open Geospatial Consortium (OGC)	An international volunteer organization that builds consensus on developing and implementing open standards for geospatial content and services. OGC has hundreds of member organizations across the globe from governments; multi-lateral institutes; universities and colleges; private companies; and NGOs; who collaboratively develop and promote geospatial standards.
Open-source software	Software that people can download, inspect, modify and enhance freely. Software is considered open source when its source code (the computer commands that make up the software) is publicly available.
Optical sensor	These sensors convert light, including visible, near-infrared and/or short-wave infrared, into electronic signals.
Overlay	In geomatics, an overlay is a basic operation in which two or more maps or layers covering the same geographic area are superimposed on top of each other, with the objective of showing the relationships between features that are in the same geographic space.
Policies	A broad range of practical instruments such as guidelines, best practices, directives, procedures and manuals related to how geospatial data is produced, accessed, maintained, and shared.

Printer suitable for printing maps	High quality geospatial imagery and maps are best printed on either specialized devices called “plotters” or on wide-format conventional printers. Typically, organizations use these devices because they are able to print high-quality maps in large sizes. Some organizations invest in this equipment for in-house use, while others use third-party printing companies to meet their needs.
Radar sensor	In satellite remote sensing an active system that emits microwave energy and measures the energy reflected (or backscattered) from objects. As the radar satellite platform orbits a two-dimensional image of the surface is developed.
Raster data	A type of data model that represents features on the Earth’s surface using a grid of individual cells, each containing information such as temperature or chemical composition.
Remote sensing	Hardware (sensors), software, and analytical capabilities used to acquire, process and deliver remotely sensed data from satellites, aircraft and drones to name a few.
Schema	A set of rules that govern a database.
Semantics	Branch of linguistics and logic concerned with meaning.
Server-side software	Software designed for use in operations that are performed by the server in a client-server computing relationship.
Shapefile	A simple, nontopological format for storing the geometric location and attribute information of geographic features.
Spatial accuracy	Describes how close the information about a feature on a map matches its real-world position or characteristics.
Spatial resolution	Refers to the level of detail in a geographic digital image. It is usually expressed as pixels per line, dots per inch, lines per millimetre, etc.
Spatial data infrastructure	The collection of data, technologies, policies, standards, and institutional arrangements that facilitate the production, use, and sharing of geospatial data at the organizational, national, or international level.
Spheroid	A geometric model of the earth’s surface as a flattened sphere, calculated based on a hypothetical equipotential gravitational surface.
Standards	Geospatial standards are technical documents that provide details about interfaces or encoding and allow systems to follow a common language.
Syntax	The arrangement of words and phrases.
Tabular data	Data that describes features on the Earth’s surface using information sorted into columns and rows.
Thematic data	Sector or theme-specific data such as forest cover or population density. Thematic datasets are typically layered with framework or basemap data.
Vector data	A type of data model that represents features on the Earth’s surface using points, lines, and polygons.
Web Services	A way of sharing a georeferenced map image over the internet. Two commonly used Web Services that are endorsed by CGDI include: ▪ Web Mapping Service (WMS) – includes a standard protocol or set of rules that computers follow to read and display raster information without the user needing to download it locally. ▪ Web Feature Service (WMS) – includes a standard protocol or set of rules that computers follow to read and display vector information without the user needing to download it locally.

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