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Canada's Boundaries and Geodetic Foundation:

Surveyor General Branch Biennial Review 2014–2016

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1. Highlights of 2014–2016

- SGB-CLSS partnered with Wikwemikong First Nation and Indigenous and Northern Affairs Canada (INAC) on a pilot project to renew parcel fabric, resolve boundary and estate issues, and build surveying capacity within the community.
- Some 992 km of the Northwest Territories/Nunavut administrative boundary (47% of the boundary) was demarcated north to the Amundsen Gulf and across Victoria Island to Viscount Melville Sound.
- Tla'amin First Nation signed their Final Agreement, which required resurveying six reserves to allow for the transfer of survey jurisdiction from the Canada Lands Surveys Registry to the British Columbia Land Title system.
- Drone projects took flight in Alberta, Saskatchewan, Manitoba and Ontario to assess efficiencies in surveying parcels on First Nation reserves; efficiencies that facilitate socio-cultural and economic development within Indigenous communities.
- Surveyor General Branch–Canada Lands Surveys System (CLSS) was a founding member of the Expert Group on Land Administration and Management, pursuant to the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), and helped revise the action plan and set the agenda for the second meeting in August 2016.
- Surveyor General Branch–Geodetic (Canadian Geodetic Survey [CGS]) helped prepare a draft resolution for the Working Group on the Global Geodetic Reference Frame as part of the UN Committee of Experts (UN-GGIM).

2. Purpose

This is the fifth review of the Surveyor General Branch (SGB) of the earth sciences sector (ESS) of Natural Resources Canada (NRCan).[1] The review describes projects that SGB has been engaged in within the last two years; lists publications that disseminated SGB's initiatives to an external audience; and sets out the metrics demonstrating the volume of work between April 1, 2014, and March 31, 2016.

[1] This is the first biennial review; the previous four were annual reviews beginning with the 2010-2011 fiscal year.

3. SGB's role within NRCan strategic outcomes

Under the Program Alignment Architecture that the Government of Canada uses to link programs to strategic outcomes, SGB contributes to NRCan's Strategic Outcome 3:

> **"Canadians have information to manage their lands and natural resources and are protected from related risks"**

Sub-Program 3.2.1: Essential Geographic Information (Geodesy/Mapping/Earth Observation)

Many socio-economic and environmental decisions made by the public, academia and the private sector (e.g. emergency preparedness and response, land use, elections planning, transportation, real estate) rely on up-to-date, comprehensive and accessible land mass information. NRCan ensures open access to Canada's fundamental geomatics framework and information system, including accurate three-dimensional positioning, high-resolution satellite imagery and other remote sensing products, mapping and other analysis applications that are accurate, authoritative and assured. This essential geographic information enables sound socio-economic and environmental decisions, which support the effective management of Canada's natural resources and lands.

Sub-Program 3.2.2: Canada's Legal Boundaries (Property and jurisdictional boundaries)

Boundary certainty supports public confidence in the property rights system for all Canadians, enables the exercise of sovereign rights, and enhances socio-cultural and economic development. NRCan ensures such boundary certainty by maintaining the Canada-US international boundary (for purposes of law enforcement, land administration, customs/immigration, and transboundary resource management); by regulating boundary surveys of Indigenous lands to meet Canada's obligations under land claim settlement legislation and treaties; and by registering legal surveys on Canada Lands (Indigenous lands such as First Nation reserves, Crown land in the three northern territories, Canada's offshore area, and national parks). The boundary certainty provided by NRCan enables effective management of Canada lands and collaboration across jurisdictions, which advances the interests of Canada's natural resource sectors, both domestically and internationally.

4. SGB delivers Canada's legal boundaries and spatially enables Canada

Canada's survey registry

SGB-CLSS regulates legal surveys by providing instructions, setting standards, ensuring quality control and registering plans and field notes. This regulatory function allows legal definition of parcels and jurisdictional boundaries to be administered on Canada Lands and on private (fee simple) lands in Yukon, the Northwest Territories and Nunavut. The Canada Lands Survey Registry (CLSR) is a public repository pursuant to the *Canada Lands Surveys Act* that contains over 105, 000 records dating to the early 1800s.

Canada's survey program

SGB-CLSS manages boundary surveys on Indigenous settlement lands to meet Canada's obligations in land claim settlement agreements and legislation and administers boundary surveys required by other departments across the Government of Canada.

Canada's spatial reference framework

SGB-CGS establishes and provides the fundamental reference values used as standards for measuring latitude, longitude, elevation and gravity within Canada; and monitors the motions of the continental land mass to support geomatics and geoscience. CGS operates geodetic infrastructure that enables numerous applications while making critical contributions to international reference systems, such as the International Terrestrial Reference Frame (ITRF). The official NAD83 (CSRS) geodetic datum used for surveying and other applications is referenced to the ITRF. The ITRF provides latitude, longitude, and ellipsoidal height on the Earth determined by geodetic techniques. SGB-CGS also contributes scientific support to the global Very Long Baseline Interferometry (VLBI) community.

Canada-United States International Boundary Commission

Embedded within the SGB is the Canadian section of the International Boundary Commission (IBC). The Surveyor General is appointed pursuant to the International *Boundary Commission Act*[2] as Canadian Commissioner to the IBC with the mandate of maintaining the boundary between Canada and the United States.

Alberta-British Columbia Boundary Commission

The Surveyor General is appointed to the Alberta-British Columbia Boundary Commission. The Commission meets twice per year to set policy for boundary maintenance, to issue contracts for re-surveying and inspecting monuments, and to repair damaged monuments. Annual reports are maintained by Alberta and British Columbia as well as in the CLSR.

[2] *International Boundary Commission Act*. See **www.internationalboundarycommission.org**.

5. SGB – Geodetic: Canadian Geodetic Survey

SGB-CGS provides essential geographic information to Canadians through geospatial positioning products, services and leadership within Canada and to the international geo-community.

i) Federal leadership in global navigation satellite systems (GNSS)

Virtually all of the departments of the Government of Canada use GNSS to serve Canadians, and the Federal GNSS Coordination Board (FGCB) coordinates GNSS-related issues within the Government of Canada. NRCan, the Canadian Space Agency, Fisheries and Oceans, Industry, Public Safety, and Transport are active members of the FGCB. In addition, several other departments participate in various capacities. The Surveyor General chairs the FGCB, and SGB-CGS leads the board's Infrastructure Task Group.

In the spring of 2014 the FGCB hosted the second one-day workshop on national GNSS infrastructure. This meeting involved 15 participants from three federal departments (NRCan, Fisheries and Oceans, and Industry), one national agency (NAV CANADA) and one academic institution (University of New Brunswick). The goal of the workshop was to provide a forum for participants to exchange information and consider opportunities to coordinate and collaborate when deploying and operating their respective GNSS infrastructure.

ii) Geodetic services

Statistics on the quality, coverage, timeliness and use of the geodetic information that SGB-CGS provides demonstrate an increase to on-line service usage. A daily volume approaching 1,100 datasets is now being achieved with the Precise Point Positioning (PPP) tool. An upgrade to the PPP software suite that optimizes the management of user requests has also translated into shorter and more predictable end-user response times.

iii) International collaboration

On February 26, 2015, the General Assembly of the United Nations passed a resolution, co-sponsored by 52 member states including Canada, entitled "A global geodetic reference frame for sustainable development." Emphasizing that "no one country can do this alone," the General Assembly called for greater multilateral cooperation on geodesy, including open sharing of geospatial data, further capacity-building in developing countries and the creation of international standards and conventions.

SGB-CGS was part of the Working Group on the Global Geodetic Reference Frame responsible for preparing the draft resolution. The effort was delivered under the auspices of the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM).

As members of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data of the Canada-US International Joint Commission, SGB-CGS and the United States National Geodetic Survey (NGS) provide the expertise to maintain the geodetic reference that supports the International Great Lakes Datum (IGLD). In 2015, SGB-CGS and NGS performed GPS surveys on some 100 benchmarks near IGLD water level gauges. The survey assessed the stability of the reference benchmarks, measured crustal motion, validated geoid models and integrated hydrometric data across the basin.

Figure 1. UN General Assembly, February 2015

Along with a campaign to be carried out in 2020, this effort will provide a consistent set of heights and crustal velocities defining a more stable frame. Once completed, IGLD 2020 will enable water level monitoring with centimetre precision across the Great Lakes and along the St. Lawrence River. This represents a tenfold improvement in precision compared to IGLD85 and will provide a reliable reference for the integration of data from high-resolution sensors used in LIDAR[3] and bathymetric surveys.

[3] light detection and ranging

6. SGB – Canada Lands Surveys System (CLSS)

i) Demarcating the NWT-NU administrative boundary

The boundary between Nunavut and the Northwest Territories was established in 1999. It was defined in legislation but not demarcated on the ground, making it the longest un-surveyed boundary in Canada. This led to some uncertainty as to its location, particularly in regard to mining rights issued by each territory. Beginning in 2010, SGB-CLSS has administered and regulated the survey of the boundary.[4] The surveyed boundary promises to be an essential tool for land governance because it will specify the exact NWT-NU boundary on both map and ground, ultimately preventing any conflicts that pertain to land.

As boundary experts, SGB resolved three issues:

Point of commencement. Map coordinates of the south corner did not correspond to a survey monument (at the Manitoba–Saskatchewan corner). The monument (No. 157) was accepted.

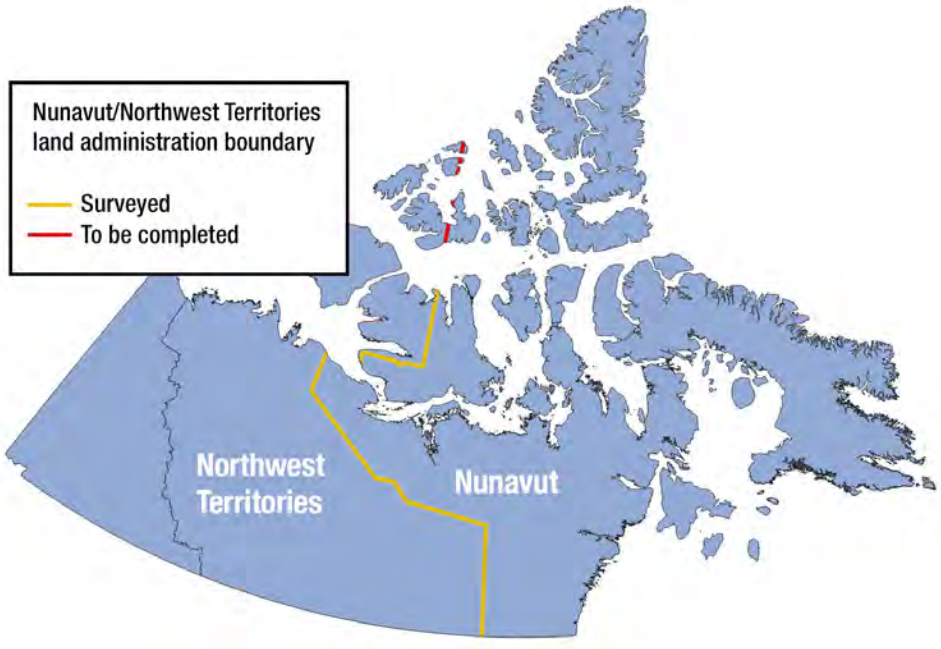
Mismatch of mapped straight lines to actual ground. Because of map distortion, the long, straight lines on the map were improperly aligned to their associated ground bearings. In general, the boundary was refined as geodesic lines via a survey revisit, where new data was obtained from short courses of 20-km intervals.

Intersection of the boundary with the Inuvialuit Settlement Region (ISR). The northerly limit of the boundary was defined as a natural boundary that overlapped with the ISR (portions of the Inuvialuit 7.1.b lands) and with the Tuktut Nogait Park. The issues of including settlement land and interpreting the location over time of the water boundary were addressed.

In 2014-2015, 472 km of the boundary on the administrative boundary was demarcated south of the Amundsen Gulf; in 2015-2016, 520 km of the boundary was demarcated north to the Amundsen Gulf and then across Victoria Island to Viscount Melville Sound. Over the two-year period, 47% of the entire NWT-NU boundary was surveyed.

[4] To be clear, Nunavut, the Northwest Territories and Canada must constitutionally sanction the surveyed boundary to replace the boundary defined in statute; resolutions of the four legislative assemblies are probably required. Until such sanction, the surveyed boundary is administratively efficient for the Mining Recorders and for others.

Figure 2. NWT-NU boundary surveyed as of 2015-2016



The final product will be a demarcated boundary with precise locations of adjacent intercepts, such as land claims and mineral dispositions.

Figure 3. Boundary inspection

ii) Surveying partnership with Wikwemikong First Nation

Wikwemikong First Nation (WUIR) submitted a proposal to SGB and INAC in early 2015 to form a surveying partnership to sever undivided estate parcels on the Wikwemikong Unceded Indian Reserve No. 26, (Lot 569, Township of Kaboni). SGB-CLSS entered into the partnership to renew parcel fabric, to enhance land use planning, and to strengthen the community's knowledge and skill base on land surveying. WUIR is one of many First Nations interested in accredited training in land use planning, mapping and surveying so as to build capacity within the community; and to enable socio-cultural and economic development.

Figure 4. The combined Wikwemikong FN and SGB team: John Manitowabi, Todd Lewis, Quinton Recollet, Gavin Lawrence, and Norm Assiniwe (left to right)

Over 20 days across many months, principles and techniques were taught and fieldwork was done. In sum, the First Nation crew members were taught practical field surveying and drafting skills. Although the project is in its infancy, it is now gaining interest from First Nations and others, including the Assembly of First Nations.

iii) Tla'amin Final Agreement

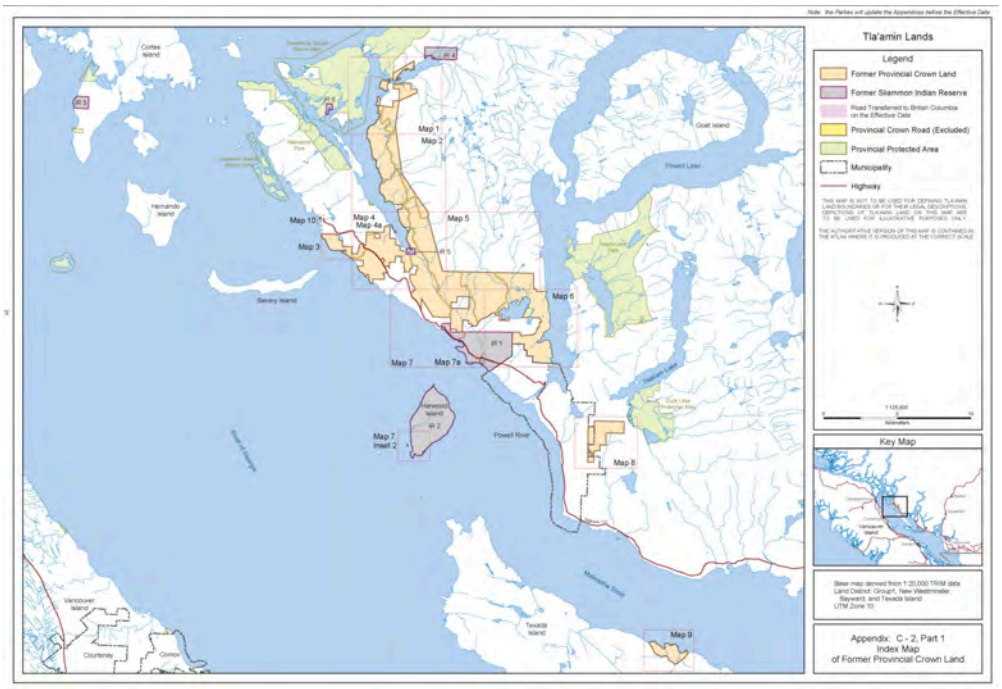
April 5, 2016, marked a monumental day for the Tla'amin peoples of the Sliammon First Nation in British Columbia. After 20 years negotiating for self-governance of their land, a treaty settlement entitled "Tla'amin Final Agreement" was put into full effect by the governments of British Columbia and Canada. Specifically, the Final Agreement states that Tla'amin lands are under full Tla'amin Nation entitlement, with the exception of surveying and recording interests.

Land surveys on the six Tla'amin Indian Reserves were started in 2015 to transition surveys prepared under the Canada Lands Surveys System, to surveys registered in the BC Land Title survey system and used to issue fee simple title to the First Nation. To do this, SGB with the Tla'amin First Nation managed the resurvey of the exterior boundaries of all six reserves, under survey instructions approved by SGB and issued by the BC Surveyor General. Two reserves had very complex and challenging natural boundaries consisting of tidal estuaries, and several of the reserves had meandering navigable and non-navigable watercourses flowing through the reserves which had to be surveyed and analysed.

The main village reserve, IR 1, required the survey of provincial Highway No. 101 which had been previously defined by a rough and mathematically unreliable centreline survey. This presented challenges to reconcile the rough mathematical survey with the historical and existing road location and with abutting subdivision surveys within the reserve that had attempted to define the road limits independently. A secondary provincial road through IR 1 was found to be constructed in an entirely different location than the 1920s era survey that officially defined the road, resulting in interesting road exchange discussions not contemplated or documented in the Final Agreement. In all 19 separate surveys were prepared to deal with the exterior boundaries of the reserves, roads through the reserve, access easements, land exchanges, and provincial Treaty lands lying within the reserves. These were surveyed through a cost sharing arrangement with the Province of B.C.

Pursuant to the Final Agreement, the Tla'amin peoples acquired 6,405 hectares of Crown land, and their self-governed parcels now have an area of about 8,323 hectares. They also own two small parcels as private land on Savary Island and Powell River and have the option to purchase 1,212 hectares of Crown land. The Tla'amin government plans to use this new land to improve the quality of life for residents of the Tla'amin community, as the basis for infrastructure, services, housing, businesses, education, and new jobs.

Figure 5 –Crown land (pink) supplements former Reserve land (purple). Source: Powell River Community Foundation. A historic time for Tla'amin Nation 2015.



To commemorate and traditionally record their milestone day, the Tla'amin carved three totem poles that mirror their past, present, and future in front of their local government building.

Figure 6. A symbolic end to the *Indian Act* for the Tla'amin community. Image courtesy of Tla'amin First Nation.

iv) Unmanned aerial vehicles

SGB-CLSS investigated the technical viability and cost-effectiveness of unmanned aerial vehicles (UAV) for legal surveying and mapping on Canada Lands. Pilot projects in Alberta, Saskatchewan, Manitoba, and Ontario tested UAV capabilities and collected data in areas that are notoriously difficult to access using traditional survey methods.[5]

In Alberta, the project at Wabamun Lake Reserve 133A familiarized staff with UAV technology and tested accuracy. In Saskatchewan, pilot projects studied aggregate volume and farm drainage at Flying Dust First Nation, water boundary determination to correct title documents at Makwa Reserves 129 and 129B, and water boundary determination of a migratory bird sanctuary at Last Mountain Lake Wildlife Area.

Figure 7. UAV launch at Wabamun Reserve 133A, Aberta

In Manitoba, the UAV project took flight at Rolling River Reserve 67B, stemming from research completed by the First Nation's lands manager. The project focused on legal parcel and digital surface mapping and as an alternative to using conventional aircraft for scattered parcels. The project in Ontario took place at Rouge Urban National Park in swampy and heavily vegetated areas that are difficult to access using conventional survey methods, as well as under bridges that cannot be mapped using conventional aircraft.

[5] The pilot projects also expanded the use of UAV/drone technology to compile jurisdictional boundary opinions.

Figure 8. Imagery of Rolling River Reserve 67B, Manitoba

Each of the projects presented different challenges: choosing take-off and landing locations, establishing ground control and obtaining permits. The pilot projects allowed SGB to explore the use of UAV imagery to be incorporated into future survey plans and familiarized staff with the new technology.

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9. Metrics from SGB-CLSS

Output	2013–2014	2014–2015	2015–2016
Parcels created in cadastral datasets	6,687	4,843	4,445
Documents registered	1,896	1,612	1,885
Instructions issued	965	946	970
Plans deposited/registered	1,265	1,150	1,242
Saskatchewan treaty land entitlement			
Area of parcels described	3,812 ha	9,820 ha	6,222 ha
Progress[6]	53%	58%	59%
Manitoba treaty land entitlement			
Area surveyed	9,446 ha	0[8]	11,756 ha
Progress[7]	53%	53%	55%
FNLMA			
Land descriptions	53	37	45
Research reports	76	101	132
Interdepartmental letters of agreement			
Number	39	37	40
Value	$4.1 million	$4.3 million	$4.9 million
Survey contracts to the private sector			
Number	175	166	170
Value	$2.5 million	$2.9 million	$2.6 million[9]

[6] Progress refers to the proportion of the total shortfall of 859,000 ha that has been described by SGB.

[7] Progress refers to the proportion of the total obligation of 577,000 ha that has been described by SGB.

[8] Although lands were surveyed in 2014/2015 for MB TLE, none of the survey plans were requested by INAC to form legal descriptions creating reserves in 2014/2015. This was due to INAC's ongoing duty to consult. It is expected that the surveys completed in 2014/2015 will be utilized in future reserve creations once consultations are complete. The area will be counted in that yearly total.

[9] This includes survey-related charges, such as registration and search fees set by provinces/territories.

10. Metrics from SGB-CGS

Responsibility	Measured output			
Provide accessible, authoritative, reliable and accurate geodetic information				
	Target accuracy	2013–2014	2014–2015	2015–2016
Quality and extent of coverage				
Final GNSS orbits/clocks accuracy with respect to international standards				
Orbits	<4 cm	~1.6 cm	~1.6 cm	~1.1 cm
Clocks	<100 picoseconds	~19 ps	~15 ps	~15 ps
Canadian GNSS stations for which data were distributed	Positive trend	71 stations	82 stations	103 stations
Canadian GNSS stations for reference frame and velocity computations	Positive trend	120 CACS stations	141 CACS stations	177 CACS stations
		151 CBN stations	151 CBN stations	148 CBN stations[10]
Maintenance of the Canadian gravity standardization network (CGSN)	<10 microGals		3 microGals	3 microGals
Timelines				
Posting of Canadian Active Control System GNSS observation files				
Hourly files[11]	CACS posted within 15 min. hourly, 90% of the time	89.80%	92.20%	99.25%
Daily files[12]	CACS posted within 30 min. daily, 95% of the time	98.20%	99.10%	99.60%
Geodetic survey product usage				
On-line sessions/data requests	Positive trend	26 076 requests/month	16 524 requests/month	19 966 requests/month
GNSS data files retrieved	5% yearly increase	27 016 files/ month	33 471 files/ month	34 327 files/ month
Precise Point Positioning (PPP)				
Active PPP Users	Positive trend	4420 users	4482 users	4969 users
PPP files processed	Positive trend	26,489 files/ month	33,338 files/ month	27,891 files/ month

[10] The decline is because some CBN points were converted to CACS stations.

[11] This standard is for available files; communication issues or power outages might limit availability.

[12] Files will be at least 98% complete.