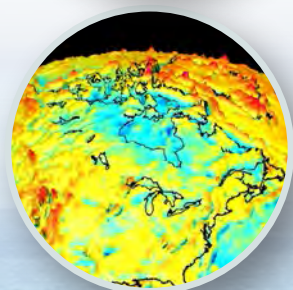




Natural Resources  
Canada

Ressources naturelles  
Canada



# Surveyor General Branch: *Beyond Boundaries*

Annual Review  
2013–2014

Themes: Canadian Geodetic Survey and National Parks

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**Themes: Canadian Geodetic Survey and National Parks**

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## 1. Highlights

- The Canadian Geodetic Survey was strategically aligned within the Surveyor General Branch.
- Thirteen staff presented visions for Blueprint 2020.
- Publishing increased by 145 percent.

## 2. Purpose

**This is the fourth annual review of the Surveyor General Branch (SGB) of the earth sciences sector of Natural Resources Canada.**

This review has two themes: prospective and retrospective. It focuses both on the aligning within SGB of the Canadian Geodetic Survey (CGS) in July 2013 and on SGB's ongoing role in working with Parks Canada. The enlarged SGB thus delivers Canada's legal boundaries (to support Aboriginal economic participation, unlock offshore potential and enhance northern property rights) and spatially enables Canada (by providing the geodetic foundation for boundaries and parcels). As per usual, the review lists the publications that disseminated SGB's initiatives to an external audience; and sets out the metrics demonstrating the volume of work between April 1, 2013, and March 31, 2014.

## 3. SGB's role within NRCan strategic outcomes

A key NRCan strategic outcome in the 2013–2014 Program Activity Architecture is safety, security and stewardship; an outcome predicated on natural resource knowledge and management systems that strengthen the safety and security of Canadians and the stewardship of Canada's natural resources and lands. Such knowledge systems are supported by essential geographic information, including Canada's legal boundaries and Canada's spatial reference framework.

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

### i) Canada's survey registry

SGB issues instructions for surveys, reviews plans of survey and registers these surveys to allow parcels to be created on Canada Lands and on fee simple parcels of land in Yukon, Northwest Territories and Nunavut. In 2013–2014, over 964 survey instructions were issued and 1,265 plans were registered in the Canada Lands Survey Records (CLSR). This public repository – created pursuant to legislation – contains over 105,000 records dating to the early 1800s.

### ii) Canada's survey program

SGB manages boundary surveys on Aboriginal 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 (e.g. Aboriginal Affairs and Northern Development Canada [AANDC]).

### iii) Canada's spatial reference framework

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.

### iv) Canada-United States International Boundary Commission

Embedded within SGB is the Canadian section of the International Boundary Commission (IBC). The Surveyor General is appointed by Order in Council as the Canadian Commissioner to the IBC with the mandate of maintaining the boundary between Canada and the United States for certainty in jurisdictional extent.

### v) Alberta-British Columbia Boundary Commission

The Commission meets on a semi-annual basis to set policy for boundary maintenance, to issue contracts for re-surveying and inspecting monuments and to engage in ad hoc repairs of damaged monuments.

## 5. Blueprint 2020: Visions from staff

In the summer of 2013, the Clerk of the Privy Council invited public servants to share their visions on the future of Canada's public service, so as to create a "world-class public service equipped to serve Canada and Canadians now and into the future."

Four principles guided the Blueprint 2020 exercise:

- a networked environment to engage citizens and partners for the public good
- a whole-of-government approach to enhance service delivery and value-for-money
- a modern workplace that makes smart use of new technologies
- a confident, diverse and high-performing workforce that embraces new ways of working

SGB participated in Blueprint 2020 by asking staff to present their own visions of the future for SGB. No restrictions were placed on the visions – any idea, large or small, was fair game. Thirteen brave volunteers presented their visions in two sessions – Edmonton in December 2013 and Ottawa in January 2014, either in person or through videoconferencing.

SGB is incorporating these visions in the SGB Integrated Business Plan, Strategic Business Plan and in collaborative work with AANDC.



## 6. Canadian Geodetic Survey

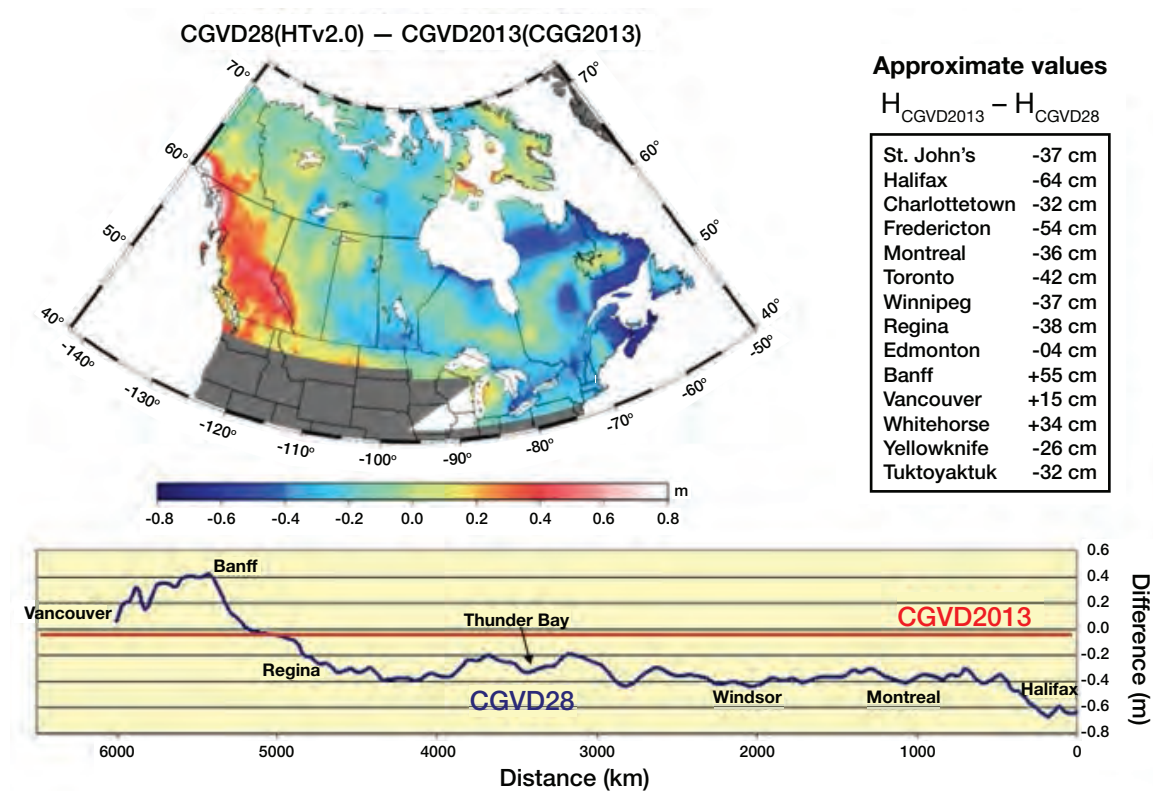
After becoming part of the SGB family, the Canadian Geodetic Survey (CGS) kept its name to emphasize the national scope of our geodetic initiatives to international collaborators. This transition happened at a time when CGS was marking its 10th year anniversary as an ISO 9001 certified organization.

### i) CGVD2013 release

The Canadian Geodetic Vertical Datum of 2013 (CGVD2013) was released in November 2013 and is now the reference standard for heights across Canada. This new height reference system replaces the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

CGVD2013 provides a direct connection to mean sea level for heights measured with Global Navigation Satellite Systems (GNSS) technologies such as GPS. Mean sea level is defined by the equipotential surface that best represents coastal mean sea level around North America, in accordance with an agreement reached with the United States National Geodetic Survey. This new vertical datum is realized by the CGG2013 geoid model that gives the separation between the GRS80 ellipsoid and the adopted equipotential surface in the NAD83 (Canadian Spatial Reference System [CSRS]) reference frame.

Figure 1. Comparing the 1928 and 2013 vertical datums



The heights of more than 80,000 existing benchmarks are also available in CGVD2013 following the re-adjustment of the entire federal first-order levelling network. CGVD2013 heights were obtained by combining GNSS ellipsoidal heights and CGG2013 geoid undulations and are expected to be more reliable than benchmark elevations. Most provinces are planning to adopt CGVD2013.

## ii) Geodetic services

Statistics on the quality, coverage, timeliness and usage of the geodetic information CGS provides indicate a significant increase in user base and online service usage. The number of active and passive GNSS and gravity control stations maintained by CGS remains almost constant. Yet these appear adequate to support GNSS orbit estimation and Canada-wide end-user positioning with centimetre precision. Two-thirds of the 6,736 users who actively access online services submit GNSS data for precise point positioning (PPP) processing. The daily volume of almost 1,000 datasets continues to increase 20 to 30 percent annually.

## iii) National leadership

CGS co-authored a user guide of best practices for GNSS real-time kinematic (RTK) surveys in Canada (*Guidelines for RTK/RTN GNSS Surveying in Canada*). CGS also provided leadership to a task group developing a compliance agreement with GNSS RTK service providers to facilitate validation and publication of NAD83(CSRS) coordinates for all RTK reference stations. Public access to geodetic coordinates is critical to maintaining consistent geospatial fabric across Canada.

High-precision real-time GPS corrections (HP-GPS-C) continued to be made available for testing and evaluation by commercial distributors. High-precision navigation in the Canadian Arctic was evaluated in collaboration with the Canadian Hydrographic Service and supported by the Canadian Coast Guard and NovAtel Inc. The ability to determine the height of bathymetric survey launches with decimetre precision was demonstrated while practical aspects of using satellite Internet and cellular telephone communication were investigated. The HP-GPS-C service can support bathymetric survey operations north of 70 degrees latitude, a region that is not well covered by commercial services relying on geostationary satcoms.

## iv) International collaboration

CGS joined York University in organizing an international workshop on GNSS PPP in collaboration with the International GNSS Service (IGS) and the International Association of Geodesy. CGS played a key role supporting the workshop held in Ottawa in June 2013 by contributing to the program committee, assisting with local logistical support and encouraging its senior scientific staff to lead sessions and present papers. Several CGS staff benefited from the rare opportunity to attend such a specialized event that included more than 100 of the foremost international experts in the field of high-precision GNSS positioning.

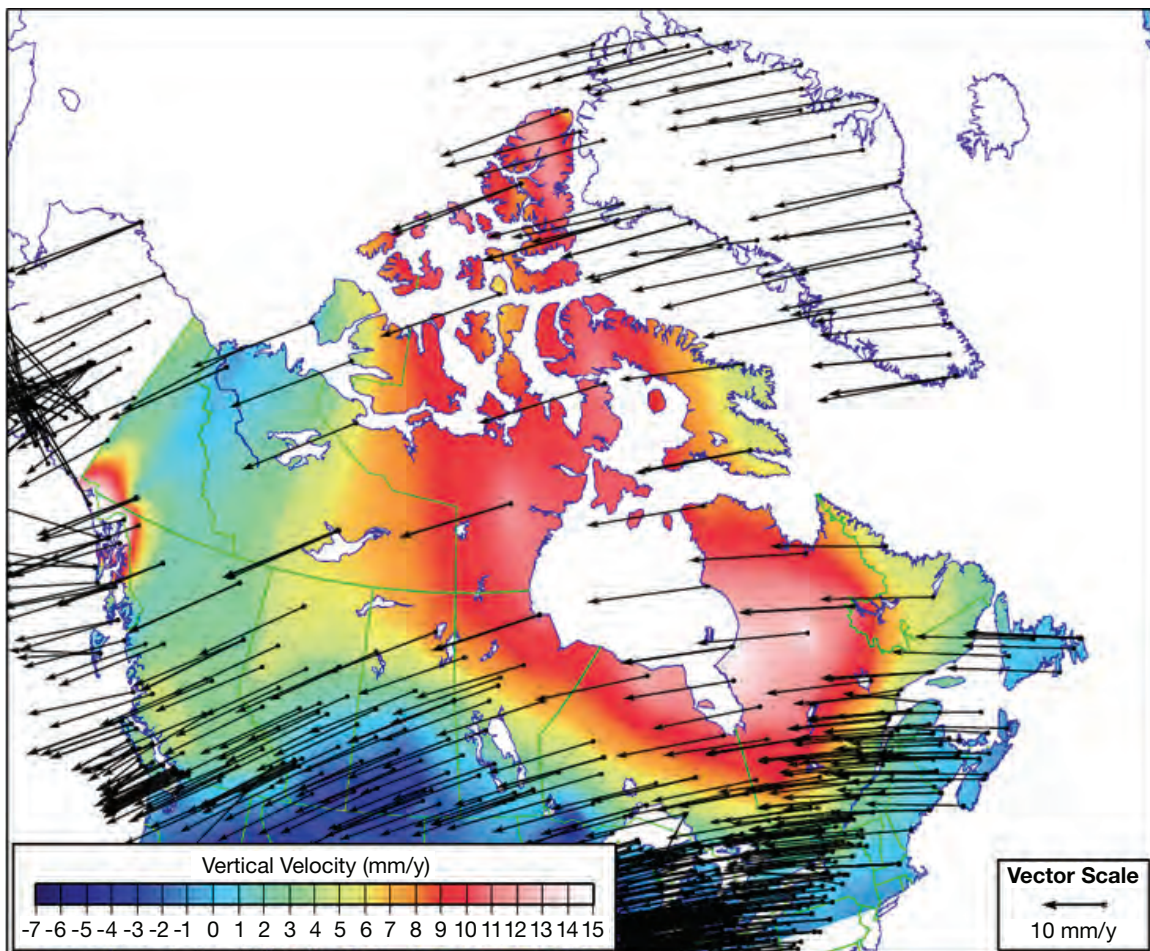
The IGS launched a GNSS orbit and clock correction service called Real-Time Service in April 2013. Streams of precise GNSS data and orbit products now enable uniform real-time positioning with decimetre precision globally. Free and open public access to this source of real-time GNSS data fosters the development of value-added applications to be used in both the public and private sectors for many years to come. CGS made a significant contribution to this effort by driving consensus on the adoption of common data and product standards and getting significant contributions from international partners by promoting the use of open software tools.

## v) Innovation

A national geodynamic velocity grid (rate of geodetic coordinate change over time) is now available to maintain the precision of GPS surveys affected by the complex motion of the Earth's surface. Evidence shows that geodetic control points firmly anchored to the ground can move decimetres over a decade in relation to a stable global reference. Considering that GPS surveys routinely deliver centimetre-level relative precision over large areas, this variance is not tolerable.

A national velocity grid was derived in 2010 to meet provincial requirements; a more consistent grid was officially unveiled in May 2012. This solution has been integrated into NRCan's tools (principal among these is CSRS-PPP). The success of CSRS-PPP is in no small part due to the facility with which this tool enables surveying clients to work within the different standards of the provinces.

**Figure 2. Horizontal and vertical velocity model showing the direction of shift**



The need for an accurate velocity model is increasing because GPS-controlled, high-resolution sensors are used in integrated data acquisition platforms (e.g. LIDAR [L<sub>I</sub>ght D<sub>E</sub>tectio<sub>N</sub> A<sub>N</sub>d R<sub>A</sub>nging], InSar). Studies of earthquakes, tsunamis, coastal erosion and global sea level also drive quality improvements because they depend on a reliable and stable geodetic reference.





## ii) Mingan Archipelago National Park Reserve, Quebec

In February 2012, Parks Canada contacted the Quebec Regional Office (QRO) of SGB for an aerial photography project for the Mingan Archipelago National Park Reserve. The scope of the project included creating mapping products (mosaics and large-scale shore data). Both organizations recognized the potential benefits of producing large-scale shore data because it could be used to create a cadastral dataset of the park. Parks Canada managed and paid for the aerial photography, and SGB managed and paid for the aero-triangulation and large-scale shore data.

The dataset capture was a challenging project because the archipelago extends for more than 150 km along the north shore of the Gulf of St. Lawrence and includes hundreds of isles and islets, most of which have not been surveyed. The extent of the territory is defined in Schedule 2 of the *Canada National Parks Act* and excludes the lands situated below the ordinary high water mark (OHWM). The intent was to use tide gauge information to identify the OHWM on the large-scale map data, but weaknesses in the aero-triangulation led to the use of photogrammetric interpretation techniques.

Different quality control processes were applied to validate the data capture. For instance, LIDAR data was used to validate the photogrammetric interpretation of the OHWM. Discussion among SGB, Parks Canada and the province of Quebec focused on identifying islands in the mouths of rivers and inlets and on improving the positional accuracy of the dataset in the future. The cadastral dataset was made public in December 2012.

**Figure 4. Differences between LIDAR (green) and photogrammetry (pink) interpretations of a water boundary**





### iii) Mealy Mountains National Park Reserve, Newfoundland and Labrador

The proposed national park reserve (PNPR) in the Mealy Mountains is in the Labrador region of Newfoundland and Labrador. This project will change the atlas of Canada. The PNPR will help protect a boreal forest that has an extensive cultural history and protect wildlife such as the threatened Mealy Mountains caribou herd.

The PNPR is approximately 10,700 km<sup>2</sup>. Defined by nearly 1,000 km of boundary, 760 km of natural features (such as watercourses and watersheds) and 240 km of artificial boundaries, the PNPR is traditionally accessed by snowmobile or boat and has no roads.

SGB made major contributions to the project. In 2010, a federal-provincial negotiating team created a boundary working group to refine the conceptual boundary and organize the research and land surveys needed for an unambiguous legal description. The working group included representatives of several federal and provincial departments. Representing Canada were the Parks Canada Agency, NRCan (SGB) and AANDC. Representing the Province of Newfoundland and Labrador were the Parks and Natural Areas Division, Crown Lands Division, Surveys and Mapping Division and the Intergovernmental and Aboriginal Affairs Secretariat. These partnerships were critical to the success of such a diverse project.

In addition to contributing to the working group, the SGB provided professional services and equipment for four field campaigns and wrote the specifications that governed the isolated boundary survey. Each field campaign gathered new information that was incorporated into the next campaign to improve efficiencies and meet schedules. The campaigns placed 125 survey monuments and recorded 636 hours of GNSS observations. Having this new data enabled SGB to prepare 17 survey plans, a 16-sheet descriptive map plan and the metes and bounds description of the parcel.

**Figure 5. Surveying the summit as part of the boundary between the park reserve and a Labrador Inuit parcel**



#### iv) Rouge National Urban Park, Ontario

On June 16, 2014, the Government of Canada tabled legislation to create the Rouge National Urban Park in the eastern sector of the Greater Toronto Area. It will become one of the largest metropolitan parks in the world, with an area of some 47 km<sup>2</sup>. The land is an assembly of natural, cultural, agricultural and recreational lands that overlap private properties and municipal and provincial infrastructure corridors within the cities of Toronto, Markham and Pickering. The legislation also contains a consequential amendment that will include the Rouge National Urban Park as Canada Lands under the *Canada Lands Surveys Act* (the Act).

SGB's involvement is in the initial stages of a multi-year \$5-million agreement with Parks Canada for survey services through its Ontario Regional Office (ORO).

The ORO prepared a legal description of three parcels used in the schedule of lands under the Act, comprising approximately 4 percent of the area under study for the park. The description was based on existing bilingual (English-French) administrative plans. As land is transferred to Parks Canada using provincial plans, subsequent bilingual administrative plans will be compiled from the provincial plans to describe parcels of land that may be added to the park by an order of the Governor in Council.

Figure 6. Comparing the park's area to three existing urban parks

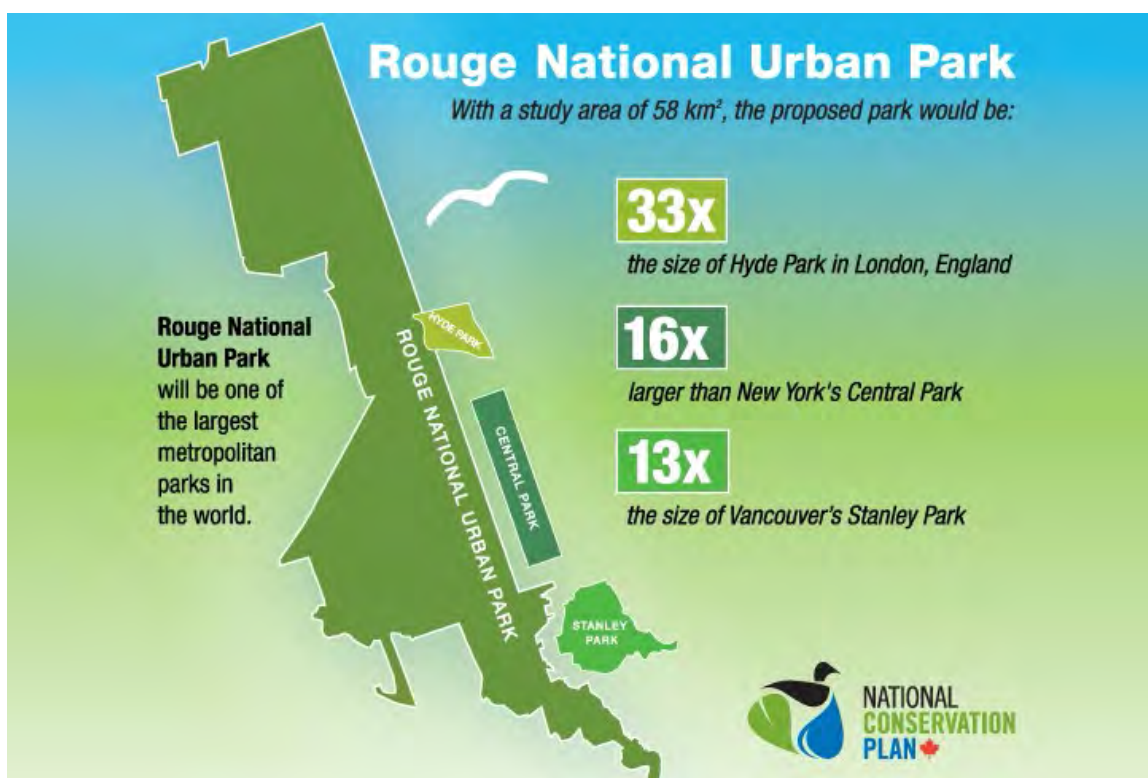


Image from Parks Canada

## 8. External publications

### Canada's legal boundaries

- Sullivan & Ballantyne. Parcel renewal & land management for infrastructure on Reserves. *Proceedings of the Assembly of First Nations Infrastructure Conference*. Toronto. February 2014.
- Shrivastava, Ballantyne & Rogers. Hybrid cadastre for Alberta: A mélange of coordinates & monuments. *GeoAlberta Proceedings*. Edmonton. September 2013.
- Rogers. Land tenure reform for First Nations in Canada – A buffet of options. *Proceedings of the Association of American Geographers Annual General Meeting*. Los Angeles, CA. April 2013.
- Rogers. Complex research, simple answers: Mineral ownership on the Rama Indian Reserve. *Ontario Professional Surveyor*. v 56-n3. pp16–20. Summer 2013.
- Rogers. The centennial of the Alberta-British Columbia Boundary Commission. *ALS News*. p38. December 2013.
- M'Bala & Gagnon. Towards a marine cadastre for the integrated management of Canada's oceans. *Geomatica*. v40-n2. pp12–18. Autumn 2013.
- Langen. Third-generation web mapping. *GeoAlberta Proceedings*. Edmonton. September 2013.
- Langen. A surveyor's bonanza. *Professional Surveyor*. pp32–34. February 2014.
- Fligg. Exploring human behavior using agent-based modelling, neural networks & land use/land cover. *Proceedings of the IGU Conference on applied GIS & spatial modelling*. Leeds, UK. May 2013.
- Ballantyne. Fish weirs, ktaronto & 13 other riparian boundary fallacies. *Ontario Professional Surveyor*. v56-n2. pp8–2. Spring 2013.
- Ballantyne & LeDressay. From observations to hypotheses for First Nations property rights in Canada: The role of institutions, taxes & surveys. *Proceedings of the Annual Conference on Land & Poverty*. World Bank. Washington, DC. April 2013.
- Ballantyne. Rhapsody in pink: Jurisdictional boundaries of Henvey Inlet Indian Reserve. *Ontario Professional Surveyor*. v56-n3. pp6–10. Summer 2013.
- Ballantyne. Boundary disputes: the price of federalism. *Proceedings of the 125th Annual Conference of the New Zealand Institute of Surveyors*. Dunedin, NZ. August 2013.
- Ballantyne. Occam's razor at Gull River Indian Reserve: The south boundary. *Ontario Professional Surveyor*. v56-n4. pp10–15. Autumn 2013.
- Ballantyne. Intra fauces terrae and jurisdictional boundaries. *Geomatica*. v67-n4. pp272–275. 2013.
- Ballantyne. Nuanced & impartial: The bounds of expertise. *Geomatica*. v68-n1. pp276–281. 2014.



Ballantyne B, Rogers & Ballantyne C. Parcels as spatial data: Supporting Aboriginal title to huge tracts of land. *Proceedings of the Annual Conference on Land & Poverty*. World Bank. Washington, DC. March 2014.

## Spatially enabling Canada

Veronneau & Huang. Canadian gravimetric geoid model 2010. *Journal of Geodesy*. v87. pp771–790. August 2013.

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Veronneau & Huang. Contribution of the GRACE and GOCE models to a geopotential-based geodetic vertical datum in Canada. *EGU General Assembly*. Vienna. April 2013.

Simon, James, Forbes, Telka, Dyke & Henton. A relative sea-level history for Arviat, Nunavut, and implications for Laurentide Ice Sheet thickness west of Hudson Bay. *Quaternary Research (New York)*. v82-n1. January 2014.

Lambert, Henton, Mazzotti, Huang, James, Courtier & Van der Kamp. Postglacial rebound and total water storage variations in the Nelson River drainage basin: A gravity-GPS study. *Geological Survey of Canada*. 2013.

Hains, Veronneau & Huang. Modernization of Canada's Geodetic Vertical Datum. *International Association of Geodesy Scientific Assembly*. September 2013.

Ghoddousi-Fard, Lahaye & Prikyl. GPS Phase Difference Variations and Phase Scintillation Index: A Comparison. *International Reference Ionosphere (IRI) & American Geophysical Union*. pp1–20. June 2013.

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Donahue, Wentzel & Berg. Guidelines for RTK/RTN GNSS surveying in Canada. *General Information Product 100-E*. July 2013.

Couture, Craymer, Forbes, Fraser, Henton, James, Jenner, Manson, Simon, Siliker & Whalen. Coastal geoscience for sustainable development in Nunavut: 2013 activities. *Canada-Nunavut Geoscience Office*. pp139–148. January 2014.

Banville, Collins & Lahaye. Concepts for Undifferenced GLONASS Ambiguity Resolution. *ION GNSS 2013 Conference Proceedings*. Nashville, TN. September 2013.

Banville, Collins & Lahaye. GLONASS ambiguity resolution of mixed receiver types without external calibration. *GPS Solutions*. pp1–8. July 2014.

## 9. Results and performance measures

### Canada's legal boundaries

Output	2011–12	2012–13	2013–14
Parcels created in the cadastral dataset	6,339	9,469 <sup>1</sup>	6,687
Documents registered	2,480	2,036	1,896
Instructions issued	1,033	1,256	965
Plans deposited/registered	1,780	1,473	1,265
<b>Saskatchewan treaty land entitlement</b>			
Area of parcels described	10,657 ha	14,135 ha	3,812 ha
Progress <sup>2</sup>	55%	57%	57%
<b>Manitoba treaty land entitlement</b>			
Area surveyed	4,009 ha	22,057 ha	9,446 ha
Progress <sup>3</sup>	47%	51%	53%
<b>FNLMA</b>			
Land descriptions	10	12	53
Research reports <sup>4</sup>	–	56	76
<b>Interdepartmental letters of agreement</b>			
Number	40	36	39
Value	\$7.4M	\$5.3M	\$4.1M
<b>Survey contracts to the private sector</b>			
Number	249	140	175
Value	\$9.5M	\$3.9M	\$2.5M

ha = hectare  
 FNMLA = First Nations Management Land Act  
 M = million

<sup>1</sup> This is inflated by the 3,200 parcels created in the Mingan Archipelago National Park Reserve.

<sup>2</sup> Progress refers to the proportion of the total shortfall of 859,000 ha that has been described by SGB.

<sup>3</sup> Progress refers to the proportion of the total obligation of 577,000 ha that has been surveyed.

<sup>4</sup> The process changed in 2012–2013; research reports now supplement land descriptions.

## Spatially enabling Canada

Provide accessible, authoritative, reliable and accurate geodetic information.

<b>Responsibility</b>	<b>Measured output</b>
<b>Quality and extent of coverage</b>	
Final GNSS orbits/clocks accuracy with respect to international standards	Orbits accuracy ~1.6 cm (Target: <4 cm) Clock accuracy ~19 ps (Target: <100 ps)
Canadian GNSS stations for which data were distributed	71 (increase of 8 from 2010–11)
Canadian GNSS stations for reference frame and velocity computations	271 CACS+CBN (increase of 4 from 2010–11)
Primary gravity stations based on absolute gravity	Accuracy of 3 microGals for 64 gravity stations (Target: <10 microGals)
<b>Timeliness</b>	
Posting of Canadian Active Control System GNSS observation files:	
Hourly files <sup>1</sup>	89.8% within 10 min. after the end of the hour, (service standard ≥90% of the time)
Daily files <sup>2</sup>	98.2% within 30 min. after the end of the day, (service standard ≥95% of the time)
<b>Geodetic Survey product usage</b>	
Registered active users	6,736 users (increase of 30% from 2010–11)
Online sessions/data requests	26,076 requests/month (increase of 78% from 2010–11)
GNSS data files retrieved	26,805 files/month (increase of 35%/year from 2010–11) Target: 5% yearly increase
Precise point positioning	4,420 registered active users (increase of 89% from 2010–11) 26,489 files/month submitted by users for processing (increase of 128% from 2010–11)

<sup>1</sup> This standard is for available files. Problems such as communication issues or power outages could cause a file to be unavailable.

<sup>2</sup> Files will be at least 98 percent complete.