

Practice Advisory Department and Office of the Surveyor General
(with technical input from GeoBC)

Practice Advisory – 2022-01
Best practices for working with Vertical datums

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Introduction

Legal survey plans in British Columbia which show elevations (plans pursuant to *The Oil and Gas Activities Act* (Survey and Plan Rule 10-2(1)) and the *Land Title Act* (Part 9 - Air Space Titles - Section 138)) must be referenced to the official vertical datum for legal surveys in BC which continues to be Canadian Geodetic Vertical Datum of 1928 (CGVD28).

This requirement is found in [Circular Letter 465B](#).

For work where no plan is submitted to a registry (e.g. topographic plans, layout for engineering projects) Land Surveyors may need to reference their heights to some other vertical datum such as the Canadian Geodetic Vertical Datum of 2013 (CGVD2013) or an assumed local datum, depending on the needs of the client.

Planning for the official adoption of CGVD2013 in BC is underway, however, it will still be several years before CGVD2013 becomes the official vertical datum for legal surveys in BC. The delay in adoption is related to difficulties that the Province has experienced in arriving at an alignment (within acceptable accuracy) of all geodetic infrastructure throughout BC with the new datum. A Stakeholders Working Group has been established to review the circumstances and the Group has agreed that further investments need to be made into the Province's geodetic infrastructure before adoption of the new datum will be acceptable. Regardless of the status of CGVD2013 adoption, Land Surveyors need to begin learning how to work with the two datums as it will eventually be a daily occurrence. Even after the official Provincial adoption of CGVD2013, Land Surveyors will find themselves in scenarios where some projects and clients continue to operate in the legacy datum or in local vertical datums. Many data products in circulation may also remain in the legacy (or local datums) in the future.

The co-existence of two vertical datums in BC has the potential to create confusion. Depending on the location, there may be differences in heights exceeding 1 metre for a surveyed elevation referenced to CGVD28 versus CGVD2013. Throughout most of BC, differences are less than 50cm. The difference between datums varies and, for much of the province, the magnitude of the difference is only approximately known at this point in time.

The purpose of this Practice Advisory is to raise awareness about the existence of the two vertical datums, identify their characteristics, and to suggest some tips to help minimize errors due to the inadvertent mixing of vertical datums.

Characteristics of CGVD28 and CGVD2013

Canadian Geodetic Vertical Datum of 1928

- CGVD28 is the current approved vertical datum in BC for legal surveys as specified by the Surveyor General in Circular Letter 465B.
- The datum is realized through a nation-wide network of physical benchmarks where heights were established by levelling. The most accurate means of accessing the vertical datum is achieved by connecting project control directly to geodetic control monuments (GCMs) that have been accurately integrated into the datum. The monuments themselves therefore govern the datum. GCMs that show “Spirit Levelling” as the method of observation, and “Integrated” as the vertical integration status on MASCOT long forms have been accurately integrated into the federal network of elevation benchmarks.
- Elevations for MASCOT monuments continue to be referenced to CGVD28 as of the date of this publication. The Province does not provide CGVD2013 heights to the public at this point in time.
- In areas without MASCOT (or federal passive) monuments in close proximity, the use of the HTv2.0 hybrid geoid model in conjunction with GNSS observations may be the only practical means of arriving at a CGVD28 height. The use of GNSS without reference to passive geodetic infrastructure is considered acceptable in this circumstance. There are different versions of the HTv2.0 model and therefore Land Surveyors must know which version is appropriate for their geographic location. Please see the [“Use of HTv2.0 Models for Height Derivation in British Columbia”](#) page on GeoBC’s website for further information on selecting the correct epoch of HTv2.0 for survey projects in BC.
- In areas where passive geodetic infrastructure is abundant, use of GNSS to “parachute” in an approximate realization of CGVD28 without any connection to the established geodetic infrastructure is problematic and can lead to substantial misalignments between neighbouring projects. Ignoring passive geodetic infrastructure in the immediate vicinity of a project contravenes the governing principles of CGVD28, as the datum was conceived in an era long before GNSS technology. Keep in mind though, that the geodetic infrastructure is subject to natural and non-natural motions over time. Inspection and evaluation of the monument condition is advisable prior to acceptance and use of published values as a basis for your survey.

Canadian Geodetic Vertical Datum of 2013

- CGVD2013 is the federal reference standard for heights across Canada. It is defined as a static vertical datum.
- See the document [“Height Reference System Modernization”](#) on the NRCan website for a detailed paper and useful background on this topic.
- CGVD2013 elevations are realized by direct GNSS observations and the application of the CGG2013a geoid model to observed ellipsoid heights.
- The best means of accessing the vertical datum is by direct long/precise GNSS observation (e.g. using the Precise Point Positioning service, or Static baseline ties to Canadian Active Control Stations).
- If benchmarks with published CGVD2013 elevations are used as the reference, any error in the published CGVD2013 height of the benchmark will carry forward into your work. CGVD2013 elevations published for federal benchmarks on the NRCan website, where GNSS

observations were not collected, are approximate because they are calculated from an adjustment of historical levelling data constrained to GNSS observations and CGVD2013 at a number of selected benchmarks.

- In the coming era of CGVD2013, the provincial geodetic control database will have a new field providing vertical uncertainty estimates. Not all monuments will have high vertical precision and therefore Land Surveyors must make note of the precision of the published heights they are using.
- Provincial and local government LiDAR projects are now being referenced to CGVD2013 in preparation for the eventual adoption of the datum.
- There are 2 parameters that Land Surveyors must define when referencing CGVD2013 heights in a plan/document:
 - a) The geoid model (currently CGG2013a).
 - b) The epoch for GNSS observations.

Changes to either of the 2 parameters will yield different orthometric heights. It will therefore be important for Land Surveyors to begin recording each of these parameters on all vertical datasets; stating “CGVD2013” alone is an incomplete record.

Geoid Model Notation

The official geoid model for CGVD2013 has been CGG2013a since 2015. New and improved geoid models may be released in the future. Changes between geoid models will result in changes to orthometric heights and therefore noting the geoid model will provide a means to convert datasets.

Epoch Notation

NRCan’s official reference epoch is 2010. However, when processing GNSS data operating in a single epoch for both the horizontal and vertical components would be the least problematic. Operating on different epochs would require separate data processing for the two components and add unnecessary complications. In BC there are three common epochs in use; 1997 on Vancouver Island, 2002 for the remainder of the Province, and also 2010 when working in the official federal datum of NAD83 CSRS v7.

The orthometric height(in the new vertical datum) at a given location changes over time due to constant motion of the earth’s crust. In order to provide a static and consistent reference system, a necessity for feasible georeferencing, official reference epochs have been defined in BC and all other provinces across Canada. By contrast, CGVD28, by definition has no such parameter. Orthometric heights in CGVD28 are treated as “locked” – any vertical movement of the earth’s crust is accounted for by defining reference epochs of the [HTv2.0 model](#) for GNSS users.

Land Surveyors can also expect a newer standard reference epoch in the future, e.g. Epoch 2020. It is therefore best practice to determine the appropriate epoch for the survey type and client’s needs on a case-by-case basis. Datasets that have the epoch recorded can later have an “epoch transformation” applied to them; mobility between epochs is possible through [NRCan’s TRX application](#). Recording the epoch therefore enables compatibility between present and future datasets that have different reference epochs.

The BC Active Control System and CGVD2013

The BC Active Control System, since inception, has been “moulded” to best fit with CGVD28 in conjunction with a standard height transformation model (currently either HTv2.0 Epoch 1997 or HTMVBC00_Abb). Published values at all BCACS stations have been derived by first determining the orthometric height and then applying the assumed geoid-ellipsoid separation from the appropriate height transformation model to derive a **hybrid ellipsoid height**. For this reason, the current published heights of all BCACS stations are therefore not appropriate for CGVD2013 height derivation. The current published values are meant to provide Land Surveyors with optimal compatibility with the CGVD28 heights of local passive GCMs in the vicinity of each BCACS station.

Meanwhile, the CGVD2013 reference system is defined in the opposite manner – the ellipsoid is at the root of the new datum. Therefore, Land Surveyors who wish to use BCACS to derive CGVD2013 heights, must first obtain **true ellipsoid heights** at the stations being used; these values are not currently published by GeoBC, however values can be provided by submitting a request to GeoBCInfo@gov.bc.ca .

Tips for working with Vertical Datums

- When working with new projects, Land Surveyors must ensure that any plans or reporting created includes explicit notes about which vertical datum (and datum parameters) is referenced. Land Surveyors should also ensure they are aware of the prescribed vertical datum for specific purposes. For example, a municipal bylaw¹ requiring certification of a minimum elevation for a building foundation or infrastructure/services may already require elevations in CGVD2013.
- When the work involves joining a project in progress, the land surveyor must pay close attention the vertical datum of the initial project by reviewing the project documentation and confirming with check observations that they are able to continue work in and reproduce results in the specified datum.
- Making assumptions about a project’s vertical datum without proper confirmation has the potential to result in substantial problems and can be very costly both financially and reputationally.
- In the absence of documentation identifying the vertical datum, the surveyor must carry out sufficient field work to determine which vertical datum the project is based upon.
- In all instances, field surveys involving heights must always include sufficient quality control processes and redundant and rigorous field and office procedures that will catch errors related to datum referencing.

Questions on this topic can be directed to the ABLCS Practice Advisory Department or the Surveyor General’s Office as deemed appropriate.

¹An Example bylaw from the Cowichan Valley Regional District which requires the use of CGVD2013 <https://www.cvrld.ca/DocumentCenter/View/103531> (see section 3. a.)