

**Datum Issues
in the
Red River of the North Basin**

Scoping Document

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EXECUTIVE SUMMARY

Two datum issues have been addressed in this report. The first concerns whether the U.S. and Canada use the same reference elevation in the Red River of the North Basin. In the U.S. all topographic maps, flood insurance maps, and the USGS gaging stations on the main stem of the Red River are referenced to NGVD 29. Mapping products in Canada are referenced to CGVD 28; however some question remains concerning whether the datum at the Canadian main stem stations is CGVD 28 or NGVD 29.

The difference between CGVD 28 and NGVD 29 for the river crossing at the International Boundary is about 0.15 foot. Relative to the accuracy of the geodetic data this difference is insignificant. However, because the channel slope in the border area is 0.1 to 0.2 foot per mile the influence of this difference on a hydraulic model may possibly be significant unless the data are adjusted. Application of an adjustment, if indeed significant, appears to be simple.

The second issue of concern is whether the IJC Red River Flood Task Force should recommend conversion to NAVD 88 to achieve a common datum throughout the Red River Basin in both the U.S. and Canada. From a technical point of view, it would be much more convenient to use NAVD 88 for all geodetic and hydraulic modeling throughout the basin. However, there are no plans to revise existing map products using NAVD 88.

In order to facilitate conversion of datum the NGS has made their computer software, VERTCON, available at no cost. Use of such programs combined with the sophistication of hydraulic models currently used has mitigated the need for a common datum throughout the area modeled. Considering the large cost involved to convert from the existing datum, NGVD 29 in the U.S. and CGVD 28 in Canada, to a common datum, NAVD 88, the change does not appear to be practical and may not be politically acceptable at this time.

A periodic review should be conducted to determine when a transition to NAVD 88 should be made. The NGS has indicated a willingness to help form a team of interested partners to develop a long-term transition plan.

DATUM ISSUES IN THE RED RIVER OF THE NORTH BASIN

INTRODUCTION

The Task Force is supporting efforts to produce digital elevation models (DEMs) in an effort to get complete coverage along the Red River main stem for support of the hydraulic models. At an early meeting of the Task Force questions were raised concerning whether the datum in common use in Canada and in the United States were the same and whether the datum of current usage was the most recent available datum. These questions have been transformed into two issues addressed by this report:

1. Determine whether a difference exists between the datum used by United States in the upper Red River Basin compared to the datum used by Canada in the lower Red River Basin.
2. Identify the reasons for or against and the impacts of a potential recommendation by the Task Force for conversion to the most recent common datum throughout the entire Red River Basin.

DATUM DIFFERENCES AT THE BORDER

There is indeed a difference in datum used in the U.S. and Canada. Canada uses the Canadian Geodetic Vertical Datum of 1928 (CGVD 28), which is slightly lower than the National Geodetic Vertical Datum of 1929 (NGVD 29) used in the U.S.. The difference is rather small. For example, at Emerson, Manitoba, where the Red River flows into Canada, NGVD 29 is about 0.15 foot higher than CGVD 28. The correction is not constant. For example, about 250 miles west of Emerson at Portal, ND, the correction is about 0.25 foot.

Recent Global Positioning System (GPS) surveys in the vicinity of the International Boundary were conducted independently in the U.S. and Canada. However, no common reference marks were used in the two surveys. A subsequent GPS survey planned by the North Dakota State Water Commission will include reference marks from both of the recent surveys.

Canadian maps furnished by both the Federal and Provincial Governments use CGVD 28 for vertical datum although the maps are labeled as "Elevation in Feet above Mean Sea Level". USGS topographic maps also used a similar statement, "Datum is Mean Sea Level" on earlier maps and later changed the statement to "National Geodetic Vertical Datum of 1929".

CGVD 28 and NGVD 29 are both vertical datum obtained from a number of points around the perimeter of the continent where sea level was recorded over a long period of time resulting in usage of the terminology "mean sea level". It was later determined that sea level was a local phenomenon and that mean sea level on the Pacific Coast was different

than on the Atlantic Coast, perhaps being up to one meter higher; hence, the change in the U.S. to identification of NGVD 29 on topographic maps.

The datum issue is confusing, especially when dealing with maps, because there only are subtle differences between reference to horizontal datum and vertical datum. North American Datum of 1927 (NAD 27), a horizontal datum in wide usage in both the U.S. and Canada, is often confused with CGVD 28 and NGVD 29, which are both vertical datum. The key for differentiation between horizontal and vertical datum identification is the term "vertical" in the datum designation.

The datum used for the USGS streamflow stations on the main stem of the Red River, the North Dakota tributaries, and most of the Minnesota tributaries is NGVD 29; although datum as published in the USGS annual Water Resources Data series is not explicit, only being referred to as "above sea level". However, several of the Minnesota sites are referenced to the "adjustment of 1912". It also should be noted that, although most tributary stations are referenced to NGVD 29, the gage reference datum was not necessarily set by running standard levels. For some sites datum was obtained from USGS topographic maps with a contour interval of 10 feet and the accuracy of the datum at individual sites must be judged appropriately. However, all USGS main stem gages have been referenced to NGVD 29 datum using standard leveling techniques.

The datum for the Water Survey of Canada stations on the Red River main stem is given as NGVD 29. However, it seems unlikely that stations other than those in the vicinity of the International Boundary would be tied to the U.S. datum. It is possible that use of "mean sea level" to describe CGVD 28 in Canada as well as NGVD 29 in the U.S. has led to the generalization that CGVD 28 and NGVD 29 are equivalent and may be used interchangeably. Further investigation of the Canadian datum may be necessary, if the difference between CGVD 28 and NGVD 29 is deemed significant for the hydraulic models.

A difference of 0.15 foot in datum at the International Boundary may seem to be significant relative to water levels used in the models because the channel slope in that area is 0.1 to 0.2 foot per mile. However, adjusting the Canadian water-level data or the U.S. water-level data in the models apparently is not a difficult task. Thus, the issue of different datum used in the U.S. and Canada does not appear to be a problem; however, whether to use an adjustment or ignore the difference, relative to water-level data, should be evaluated.

From a modeling stand-point, accuracy of 0.5 foot for the geodetic data generally is considered acceptable. Therefore, relative to use of geodetic data in the model, the difference between CGVD 28 and NGVD 29 would appear to be insignificant.

CONVERSION TO BASIN-WIDE COMMON DATUM

Establishment of the North American Vertical Datum of 1988 (NAVD 88) was a cooperative effort between the U.S. and Canadian governments. Rather than using a number

of widely separated points for the reference elevation, as was done for NGVD 29, NAVD 88 was referenced to a single benchmark located at Father's Point/Rimouski at the mouth of the St. Lawrence River. The same benchmark had been used as a reference for the International Great Lakes Datum of 1985.

In 1994 the U.S. affirmed NAVD 88 "as the official civilian vertical datum for surveying and mapping activities in the United States performed or financed by the Federal Government, and to the extent practicable, legally allowable, and feasible, require that all Federal agencies using or producing vertical height information undertake an orderly transition to NAVD 88." (Federal Register, Vol.58, No. 120) Although the Geodetic Survey Division of Canada has computed NAVD 88 elevations for most of its network, the adoption of NAVD 88 has been postponed until validation is possible using a sufficiently accurate geoid model and until significant benefits of its adoption are demonstrated.

Failure to convert to general usage of NAVD 88 appears to be a monetary issue rather than a technical issue. All of the topographic maps in both countries are referenced to the earlier datum and it would be very expensive, if indeed practical, to revise all of the maps. In fact, the USGS National Mapping Division (NMD) policy states that "NMD will provide information on shifts from NGVD 29 to NAVD 88 with new or revised maps and digital products and on minor revision reprints and standard reprints; however, elevation data will be retained on NGVD 29." (NMD Policy Number 98-NMD-4, Aug. 7, 1998)

NAVD 88 is superior to NGVD 29 at least in part because actual gravity measurements were obtained at the reference marks. The improved techniques used removed several distortions present in NGVD 29 and provided corrections of from +5.0 feet (1.5 meters) in the Rocky Mountain area to -1.3 feet (-0.4 meters) in the east. Corrections required in the Red River Basin are shown in the table below:

Location	Latitude deg min sec	Longitude deg min sec	Corrections meters/feet
Headwaters	45 36 00	96 52 00	+0.233/0.76
Wahpeton	46 15 55	96 35 40	0.242/0.79
Fargo	46 51 40	96 47 00	0.287/0.94
Grand Forks	47 55 38	97 01 34	0.326/1.07
Emerson	49 00 30	97 12 40	0.387/1.27
Winnipeg	49 55 00	97 07 30	0.414/1.36
Portal	49 00 00	102 32 30	0.408/1.34

The National Geodetic Survey(NGS) has developed computer software, VERTCON, that computes the modeled difference in elevation between NGVD 29 and NAVD88 (Correction = NAVD 88 elev. - NGVD 29 elev.). Although the VERTCON model is considered accurate for determining the correction within 2 cm, the actual accuracy of the elevations provided is determined by the accuracy of the original elevations that are converted. The software converts from NGVD 29 to NAVD88 and vice versa. It may be

used for individual points or applied as a grid correction to a digital elevation data set. The VERTCON software is available at no cost from NGS at the following URL address:

http://www.ngs.noaa.gov/PC_PROD/pc_prod.html

Changing to NAVD 88 does not horizontally reposition the 100-year and 500-year flood lines on the Federal Emergency Management Administration (FEMA) flood insurance maps. For example if the datum at Fargo were converted to NAVD 88, the elevation of the 100-year flood as computed from the streamflow records would raise about 0.94 foot; however, the elevation of contours on the FEMA flood insurance maps would increase an identical amount so the position of the 100-year flood line on the map would not change horizontally. In fact, FEMA has adopted NAVD 88 and NAD 83 as the reference systems for all new flood plain mapping and insurance maps, but has no intention of revising any of the existing flood maps. Rather, they intend to provide a formula or correction for each community.

NAVD 88 is more compatible with current surveying techniques such as GPS. NAVD 88 more closely approximates the elevations derived using GPS and the geoid (zero reference datum) than NGVD 29 and requires less adjustment. If NGVD 29 datum is to be used for a GPS survey it is considered more accurate to use NAVD 88 for the survey and convert the final elevations than to use NGVD 29 for the GPS work.

Most USGS streamflow stations in the Red River Basin are referenced to an arbitrary datum that was originally selected to make the reported gage height roughly equivalent to river depth, but to assure that the zero gage reading physically was low enough to avoid publishing negative river levels. In the early 1980s with the increased use of computers and a conversion from analog recorders that required manual interpretation to automatic digital recorders (ADRs), the data processing became faster and more automated, but the ADRs were limited to maximum recorded values of 99.99. The advent of Satellite Data Collection Platforms (DCPs) and electronic dataloggers removed the constraint in the number of digits recorded making direct recording of river level as elevation possible.

Although the USGS has the instrumentation required and computation ability to convert to reporting elevation rather than gage height, it would be a costly change. All staff gages would have to be replaced. And, such a change likely would require resurveying the gage reference datum, probably with GPS methods, for at least all of the main stem Red River stations. If within monetary constraints, it would be preferable to establish accurate datum at all USGS streamflow stations. The question of whether to use NGVD 29 or NAVD 88 as the datum for reporting river stage data still remains.

Converting from NGVD 29 to NAVD 88 would effect regulatory levels for reservoir operations. Lake Ashtabula, Lake Traverse, Lake Orwell, and Homme Reservoir operated by the U.S. Army Corps of Engineers and perhaps other smaller works would be impacted. The cost of implementation of a conversion to NAVD 88 for regulatory facilities would be similar to those for USGS streamflow stations.

If the USGS converts to reporting river stage as elevation rather than gage height, the flood forecasting and reporting by the National Weather Service will become more difficult. The public are familiar with the gage height reference in their area of interest and reporting of elevation may be confusing to them. Dual reporting for a period of time, perhaps until the next large or significant flood event is warranted. Reporting of both gage height and elevation greatly increases the probability of reporting errors. Reporting of elevations also would require a significant public education campaign that could prove costly. However, in Canada the river stage data already is reported as elevations and forecasts also are provided in elevation.

There exists a large body of opinion that NGVD 29 serves most needs well and the cost to convert to exclusive use of NAVD 88 would be much greater than the benefits derived. From a practical point of view, when working in a limited-sized area, which datum is used makes little difference as long as the datum used is consistent throughout the study area. However, when working in very large areas, such as the entire Red River Basin, the value of a single datum reference is much greater.

There exists an equally large body of opinion that a transition to general use of NAVD 88 should be implemented as soon as possible. The improved accuracy of NAVD 88 over NGVD 29 has not been challenged. Expected improvements in GPS technology may result in sub-centimeter accuracy of elevation in realtime mode within 10 years. Therefore, some experts feel that the Task Force will be missing a great opportunity to further the science and to serve the people of the basin, if the Task Force does not support transition to NAVD 88 at this time.

NAVD 88 provides a consistent datum for the entire Red River Basin and from a technical point of view is better, if everyone uses it. However, most contour maps and other maps of general usage are not provided in NAVD 88 and there is no apparent intention to provide revised contour maps. Rather corrections to NAVD 88 using readily available computer software or published corrections for individual maps will be provided.

Use of NAVD 88 is highly recommended for GPS work requiring high accuracy of determined elevations. However, VERTCON has a modeled accuracy of 2 cm in areas where both NGVD 29 and NAVD 88 control was available and NAVD 88 elevations may be quickly and easily converted to NGVD 29, if desired.

Once most products, such as flood inundation maps, topographic maps, etc., are in digital form the transition to NAVD 88 will be much easier and indeed more practical. The NGS has expressed a willingness to convene a forum of datum experts (US and Canadian) to discuss the Red River Basin datum issues and develop a long-term transition plan.