Coordinating Committee on Great Lakes
Basic Hydraulic and Hydrologic Data

Updating the International Great Lakes Datum

Vertical Control – Water Level Subcommittee
on behalf of the
Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

September 2017
Revised January 2018

Contents

List of Abbreviations

CACS	Canadian Active Control System
CC	Coordinating Committee on Great Lakes Basic Hydraulic & Hydrologic Data
CGS	Canadian Geodetic Survey
CGVD2013	Canadian Geodetic Vertical Datum of 2013
CHS	Canadian Hydrographic Service
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operation Reference Stations
ECCC	Environment and Climate Change Canada
GIA	Glacial isostatic adjustment
GNSS	Global navigation satellite system
IERS	International Earth Rotation and Reference Frames Service
IGLD	International Great Lakes Datum
IHRS	International Height Reference System
LWD	Low water datum
MSL	Mean sea level
NA	North America
NGS	National Geodetic Survey
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

What is IGLD

- IGLD = International Great Lakes Datum
- A common height reference system (vertical datum) within which water levels can be measured and meaningfully related to each other
- The official vertical datum for water levels throughout the Great Lakes, their connecting channels and the upper St. Lawrence River
- Required for the collection, compilation, use and dissemination of data related to hydraulics, hydrology & water levels

COORDINATING COMMITTEE

Importance of the IGLD

- Joint use of the Great Lakes & St. Lawrence River resources by U.S. & Canada requires an IGLD & water level gauge network for knowledge & measurement of water levels, depths, volumes and flows
- IGLD & water level gauge infrastructure are key components for
  - Transportation networks for a reliable port & inland waterway system that facilitates trade and recreational boating, and benefits the economies of both countries
  - Power generation, both hydroelectric and nuclear
  - Domestic and industrial water use
  - Monitoring of the largest freshwater ecosystem in the world
- Harmonious use of these waters requires international coordination of their management
  - Coordinating Committee on Great Lakes Basic Hydraulic & Hydrologic Data(CC) – ad hoc committee of experts from Federal agencies of the U.S. & Canada
  - International Joint Commission oversees binational water resources issues

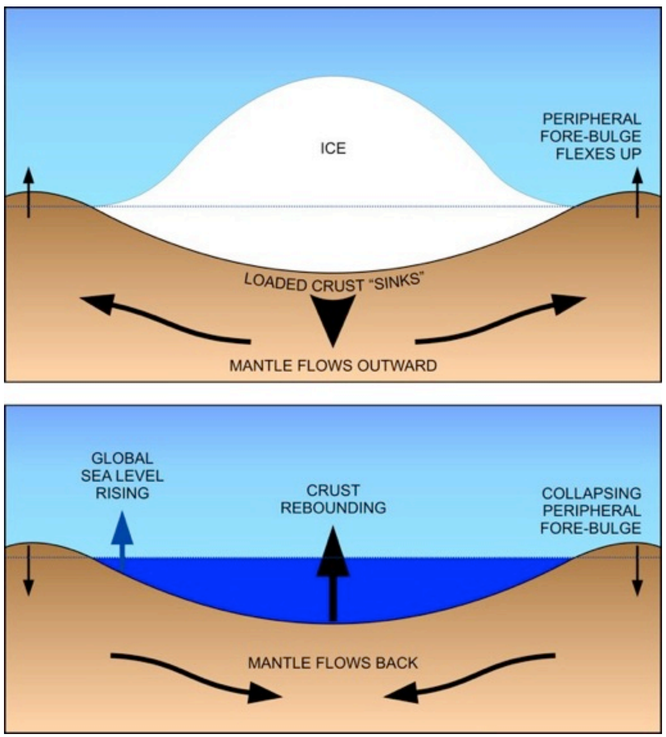
Why a New IGLD

- Two previous realizations of IGLD
  - Leveling-based datums
  - IGLD (1955)
  - IGLD (1985) − current − based on NAVD88
- Need to periodically update IGLD due to vertical crustal motion (glacial isostatic adjustment)
- IGLD (1985) also contaminated by systematic error in leveling

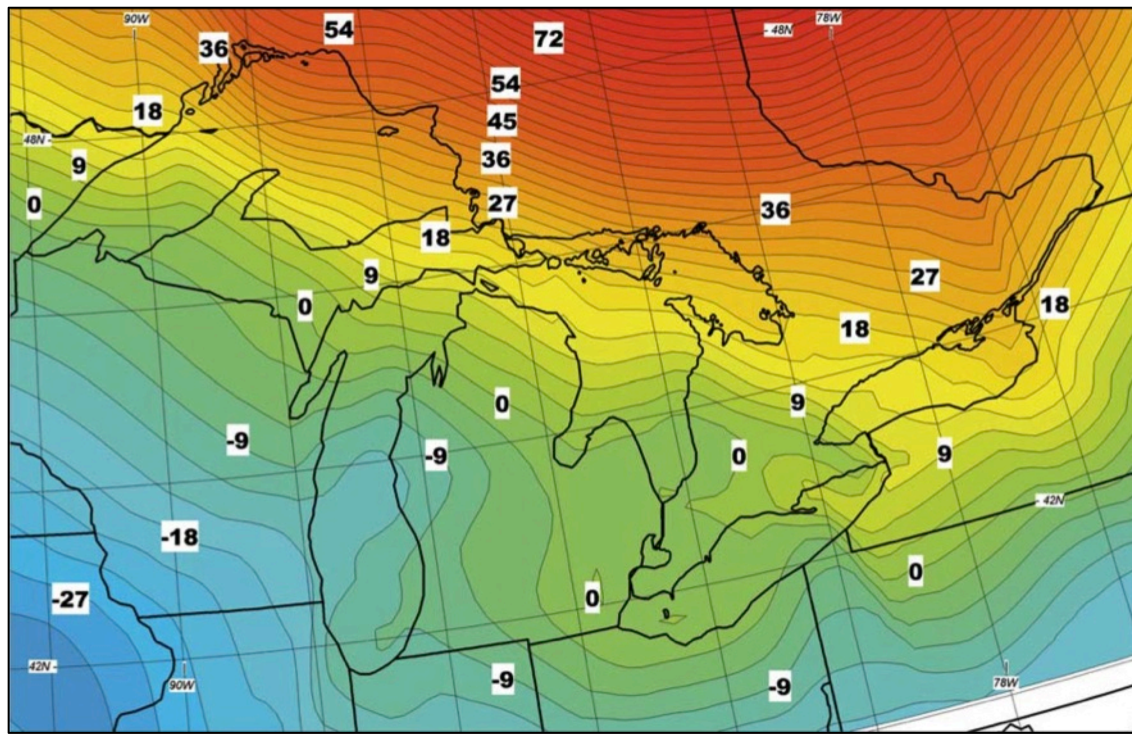
COORDINATING COMMITTEE

Glacial Isostatic Adjustment (GIA)

- Uplifting in north, subsiding in south
- Overall tilting ~7 cm/yr (21 cm over 30 yr)
- Need to update IGLD every 25-30 yr – overdue!



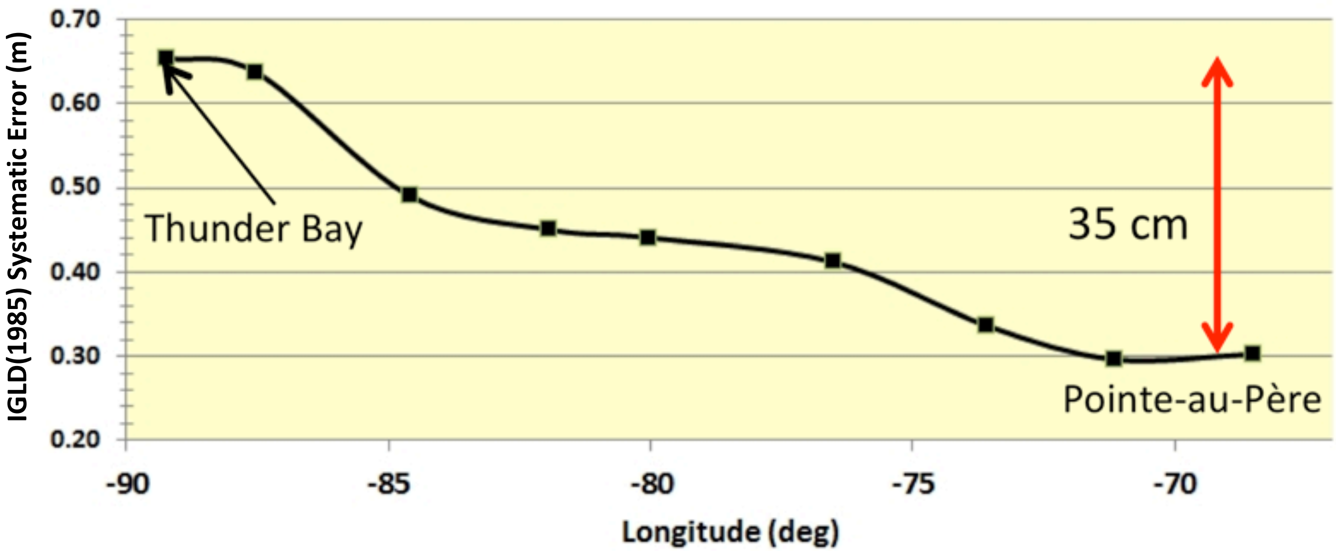
Process of glacial isostatic adjustment



Contour map of vertical velocities in cm/century from Mainville and Craymer (2005). Contour interval: 3 cm/century (0.3 mm/year)

Systematic Error in IGLD (1985)

- IGLD (1955) & (1985) used geodetic leveling to indirectly define the reference surface
- IGLD (1985) affected by accumulation of systematic error in leveling



COORDINATING COMMITTEE

Attributes Defining an IGLD

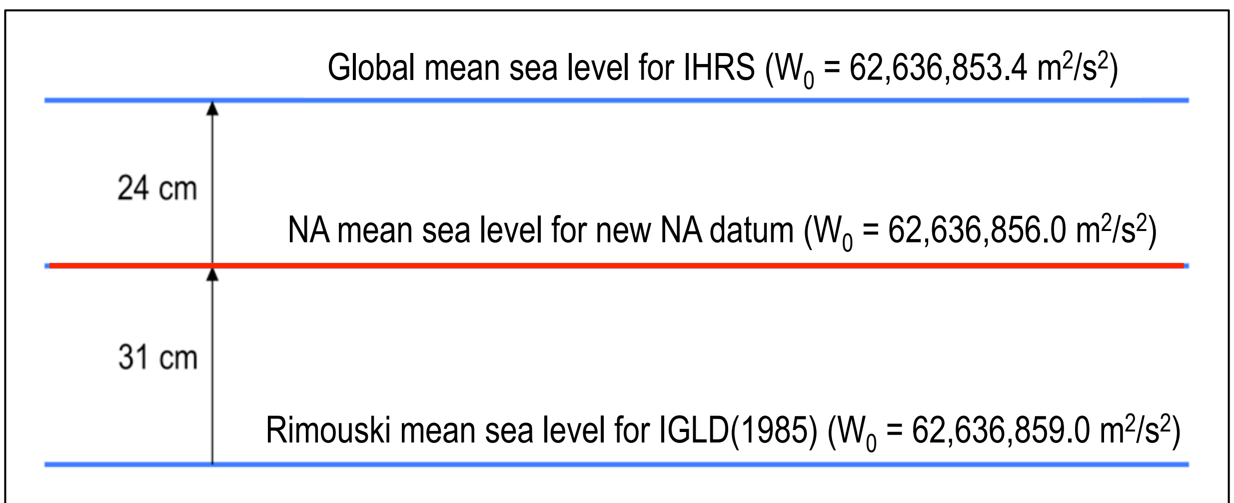
- Reference Zero
- Reference Surface (Equipotential Surface)
- Dynamic Heights
- Reference Epoch

Reference Zero

- Reference to which heights are referred
- Usually mean sea level (MSL) over decades
- Represented by a geopotential value (W_0)
- Different realizations of MSL
  - International Height Reference System (IHRS) and International Earth Rotation and Reference Frames Service (IERS) use global MSL
    - Average of mean sea level at a set of global stations
  - IGLD (1955) used MSL at Pointe-au-Père, QC
    - Outlet of Great Lakes basin
  - IGLD (1985) used MSL at both Pointe-au-Père & Rimouski (5 km upstream)
    - Pointe-au-Père gauge discontinued in 1984

New Reference Zero

- Reference zero for IGLD Update
  - Coordinating Committee adopted same reference zero (W_0) as the value adopted by convention for the new North American vertical datum in 2022 – see next slide
  - Same as value adopted by the IERS
  - Represents MSL of tide gauges around coasts of North America
  - Also adopted by Canadian Vertical Datum of 2013 (CGVD2013)



COORDINATING COMMITTEE

Canada-US Agreement

Agreement: The U.S. National Geodetic Survey and The Canadian Geodetic Survey

March 14, 2012

The U.S. National Geodetic Survey and Natural Resources Canada's Geodetic Survey Division, via conference call held 2012/02/17, **agree**:

- To ***define*** the common (a unique) vertical datum for the United States of America (USA) and Canada (CA) through use of an equipotential surface, realized through one commonly (jointly) computed geoid model, corresponding to the mean coastal sea level for North America by 2022. Adoption is subject to National decisions;
- To ***compute*** the potential W_0 of this equipotential surface using Global Positioning System (GPS) data on tidal benchmarks, by April 1, 2012 and to ***use*** this value, for the realization of geoid models in the USA and CA until 2022;
- To ***maintain*** this equipotential surface as one option to adopt as the vertical datum even if this surface diverges (departs) from the true mean coastal sea level for (around) North America over time;
- To ***monitor*** differences between the above-mentioned equipotential surface and the mean sea level via Global Navigation Satellite Systems (GNSS) on tidal benchmarks, altimetry or other means as required;
- To ***provide*** to the public, deformational velocities (*N-dot*) of the equipotential surface W_0;
- To ***collaborate*** in the realization of geoid models, through the sharing of data and related information:
- To ***compute*** updated geoid models and geoid deformation models with improved realizations as needed;
- To ***inform*** each other when large discrepancies (outside 95% confidence region) are found in overlapping regions; and
- To ***choose*** a threshold value (in alignment with both stakeholder needs and scientific integrity) in 2022, between predicted (modeled) geoid change and true geoid change (including deformation and sea level change) which will warrant new realization of the vertical datum.

Denis Hains
Director
Geodetic Survey Division
Canada Centre for Remote Sensing
Natural Resources Canada / Ressources naturelles Canada
Canada

Juliana P. Blackwell
Director
National Geodetic Survey

The geopotential for the North American height reference system **16 April 2012**

Canada and the United States are both working towards modernizing their national height reference systems to replace CGVD 28 and NAVD 88, respectively with the objective to create a seamless height reference system across North America. As the new vertical datum will be realized by a geoid model, it is essential that Canada and USA select a common equipotential surface. Both parties have agreed that this surface should be the best fit, in a least squares sense, of the coastal mean sea level around North America.

In order to compute the mean geopotential, GPS heights and water levels at coastal tide gauges were combined with various geoid models. Given the variability of the mean sea level due to Sea Surface Topography (SST), the analysis was affected by tide gauge location and distribution, and geoid model precision and resolution. Based on comparisons at tide gauges around Canada and the United States where SST models were available, the best fit is 62,636,856.0 m^2s^{-2}. By averaging the Arctic gauges that were outside the coverage of the SST models, the geopotential would have been higher, approaching 62,636,858.0 m^2s^{-2}. Although very little data were available around Mexico and in the Caribbean region, including more tropical data would have likely lowered the geopotential to 62,636,854.0 m^2s^{-2}. Thus, the lack of tide gauges in Arctic and tropical regions somewhat compensates itself. Estimates of the North American mean obtained with different datasets, station combinations and weighting scenarios remained within 1 m^2s^{-2} of each other depending on the particular tide gauge distribution and geoid models selected.

Understanding the importance of selecting a conventional value without delay for CGVD2013 realisation, the decision was made to select:

$$W_0 = 62{,}636{,}856.0 \ m^2s^{-2}$$

as the geopotential value for all geoid models in North-America until 2022. This agreed upon value of W_0 was found to be within the uncertainty of the mean estimate that best fits with mean sea level around North America. Although sea level is known to be changing, this W_0 value will be adopted as a fixed reference value until at least 2022 in order to enable consistent height determinations over the coming decade. This value could also be suitable for Mexico, the Caribbean region and Greenland. It also corresponds to the current convention adopted by the International Astronomical Union (IAU) and International Earth Rotation and Reference Systems Service (IERS).

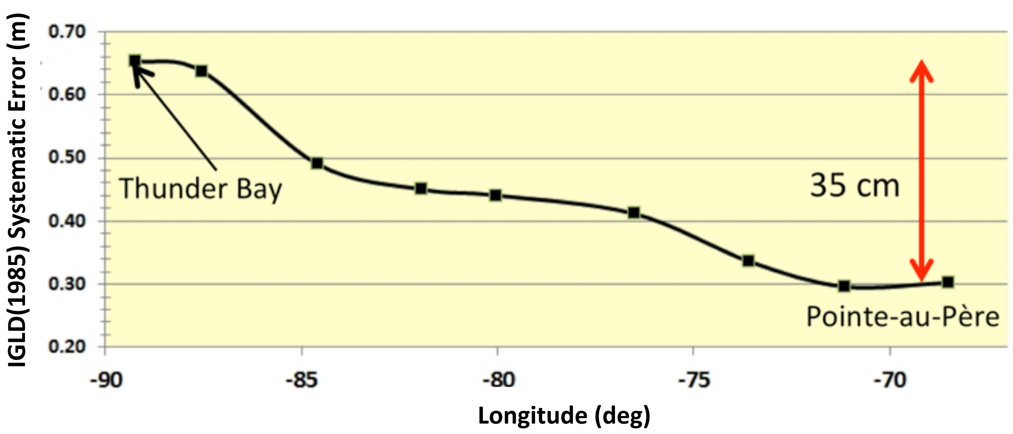
Denis Hains
Director
Geodetic Survey Division
Natural Resources Canada / Ressources naturelles Canada
Canada

Juliana P. Blackwell
Director
National Geodetic Survey

COORDINATING COMMITTEE

Reference Surface

- Reference surface is an equipotential surface to which orthometric or MSL heights are referenced
- Extends the reference zero inland
- IGLD (1955) & (1985) used geodetic leveling to indirectly define the reference surface
  - Too time consuming & cost prohibitive
  - Susceptible to accumulation of systematic errors (see fig.)
  - Datum accessible only where leveling exists (bench marks)



New Reference Surface

- New NA vertical datum in 2022 will use a NA geoid for the reference surface*
  - Geoid is a continuous equipotential surface aligned to the reference zero (MSL)
  - Available everywhere in Canada & U.S.
  - Consistent & accurate at cm-level
  - Orthometric or MSL heights (*H*) determined via geoid heights (*N*) and ellipsoidal heights (*h*) – see next slide

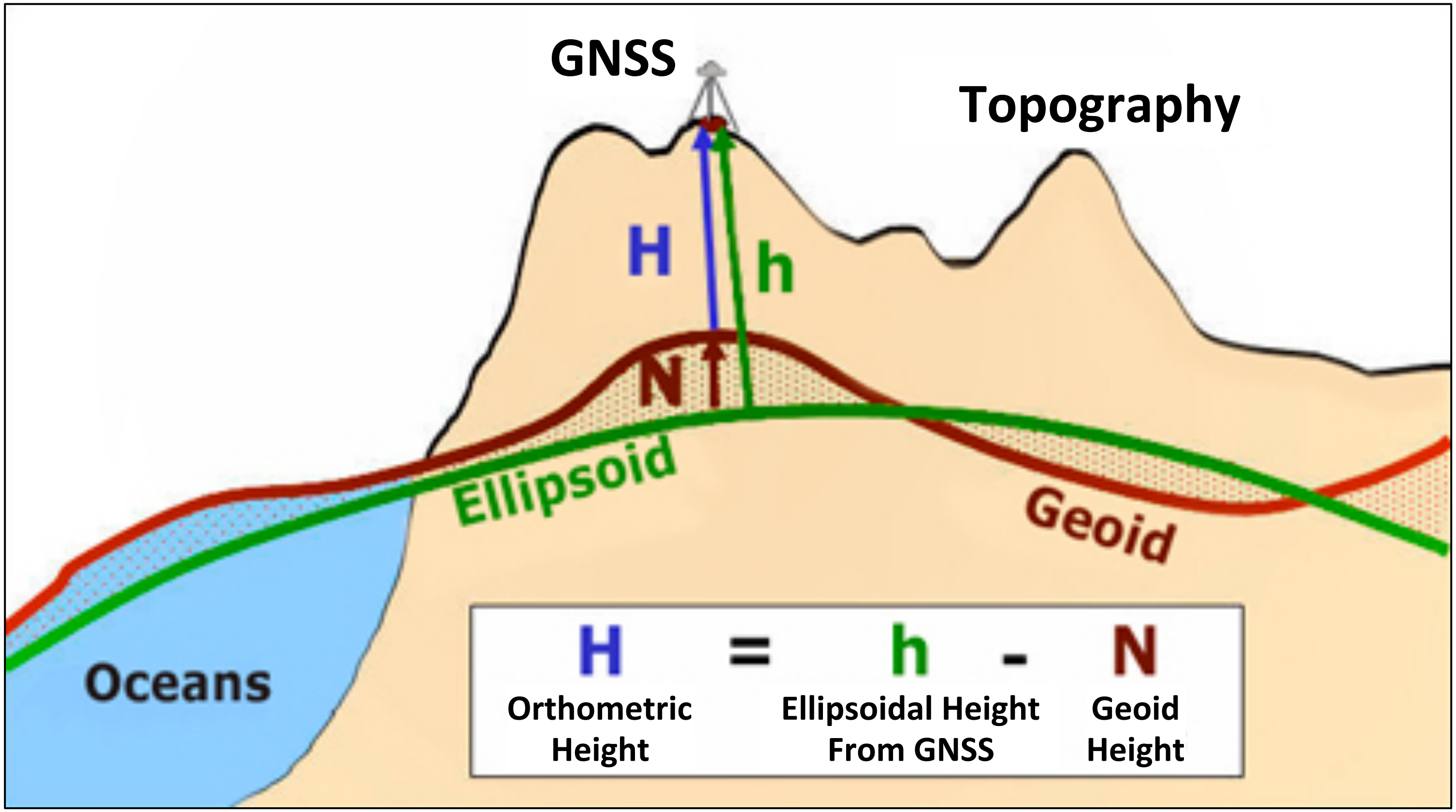
$$H = h - N$$

- The IGLD update, referred to here as IGLD (2020), will use same reference surface

---

* See http://www.ngs.noaa.gov/datums/newdatums/

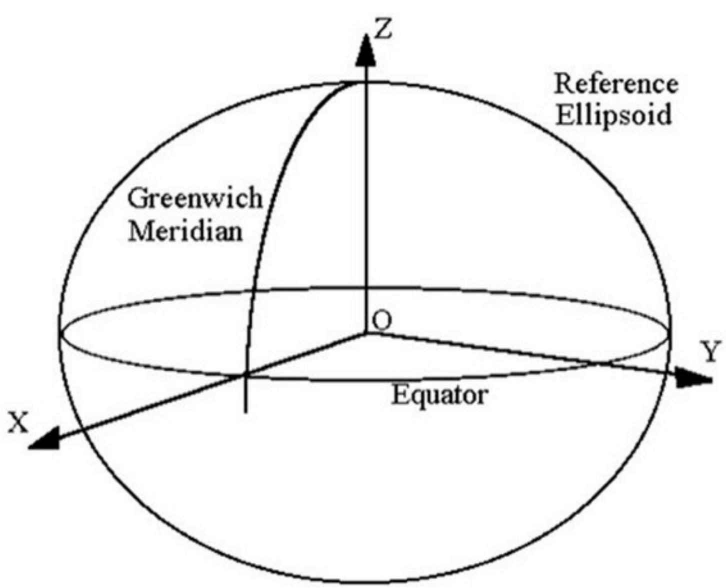
Heights and the Geoid

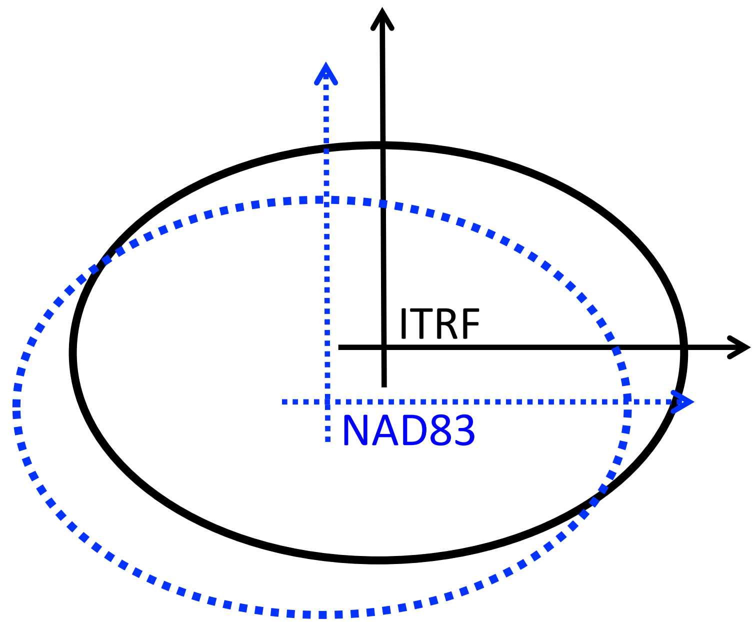


Relation between ellipsoidal height (*h*), orthometric height (*H*), and geoid height (*N*). Orthometric height (or mean sea level height) can be obtained by subtracting the geoid height from the GNSS-determined ellipsoidal height. Both *h* and *N* must be referenced to the same reference ellipsoid (see next slides).

Reference Ellipsoid

- Ellipsoid of revolution that best fits the Earth
- Centered on a 3D Cartesian XYZ coordinate system (reference frame)
- Different reference frames can have the same ellipsoid but centered in different locations (e.g., NAD83 & ITRF)

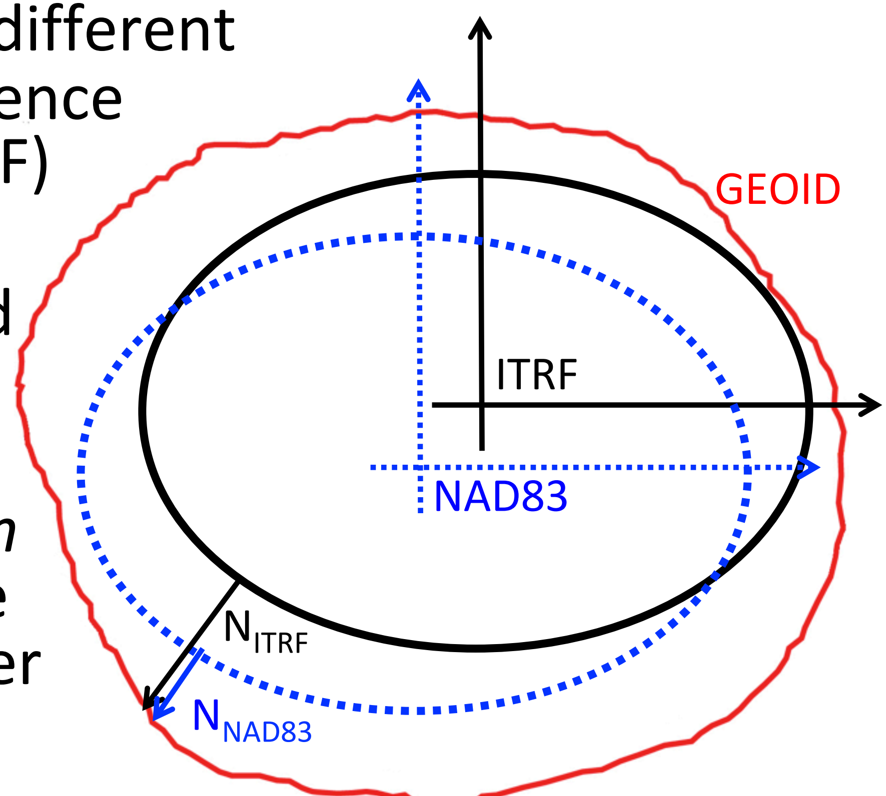




COORDINATING COMMITTEE

The Geoid & Reference Ellipsoid

- The geoid can be referenced to different reference frames (ellipsoids)
  - Geoid height (*N*) is height above ellipsoid
  - The same geoid will have different *N* values in different reference frames (e.g., NAD83 & ITRF)
  - Both geoid & ellipsoidal height must be referenced to same reference frame (ellipsoid)
  - Can easily transform *N* & *h* values from one reference frame (ellipsoid) to another



COORDINATING COMMITTEE

Dynamic Heights

- Heights are fundamentally based on the geopotential difference between a point and the reference surface (geoid)
- Geopotential difference (*C*) from the reference surface is constant along an equipotential surface (e.g., undisturbed lake)
- Orthometric heights (*H*)
  - Physical distance from reference surface to point
  - $H = C$ / mean value of gravity along the plumb line ($\bar{g}$)
  - Gravity of equipotential surface not constant over large areas
    => *H* is NOT constant along an equipotential surface (lake)
- Dynamic heights (H^d)
  - Scaled version of geopotential difference
  - $H^d = C$ / normal gravity at 45 degrees latitude ($\gamma_{45°} = 9.806199$ m/s^2)
  - H^d is constant along an equipotential surface (lake)
  - H^d provides a direct determination of hydraulic head
  - Required for water management & power generation

Dynamic vs Orthometric Heights

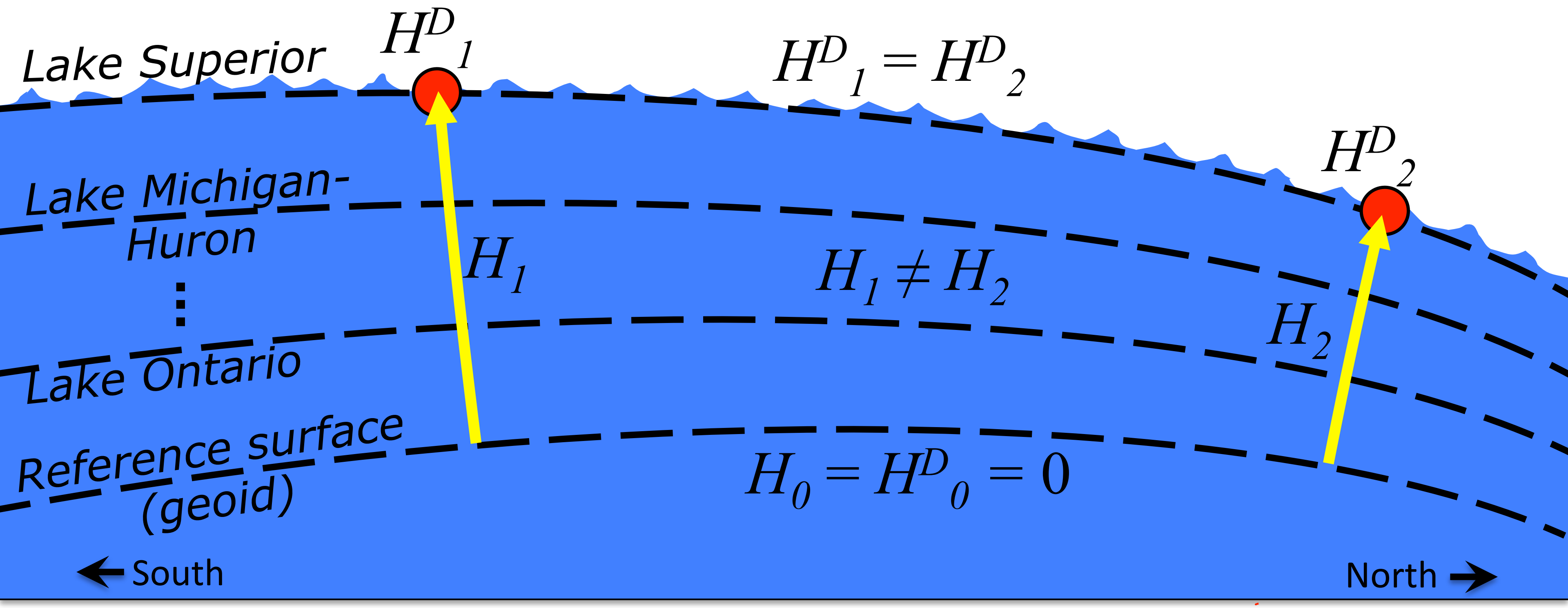
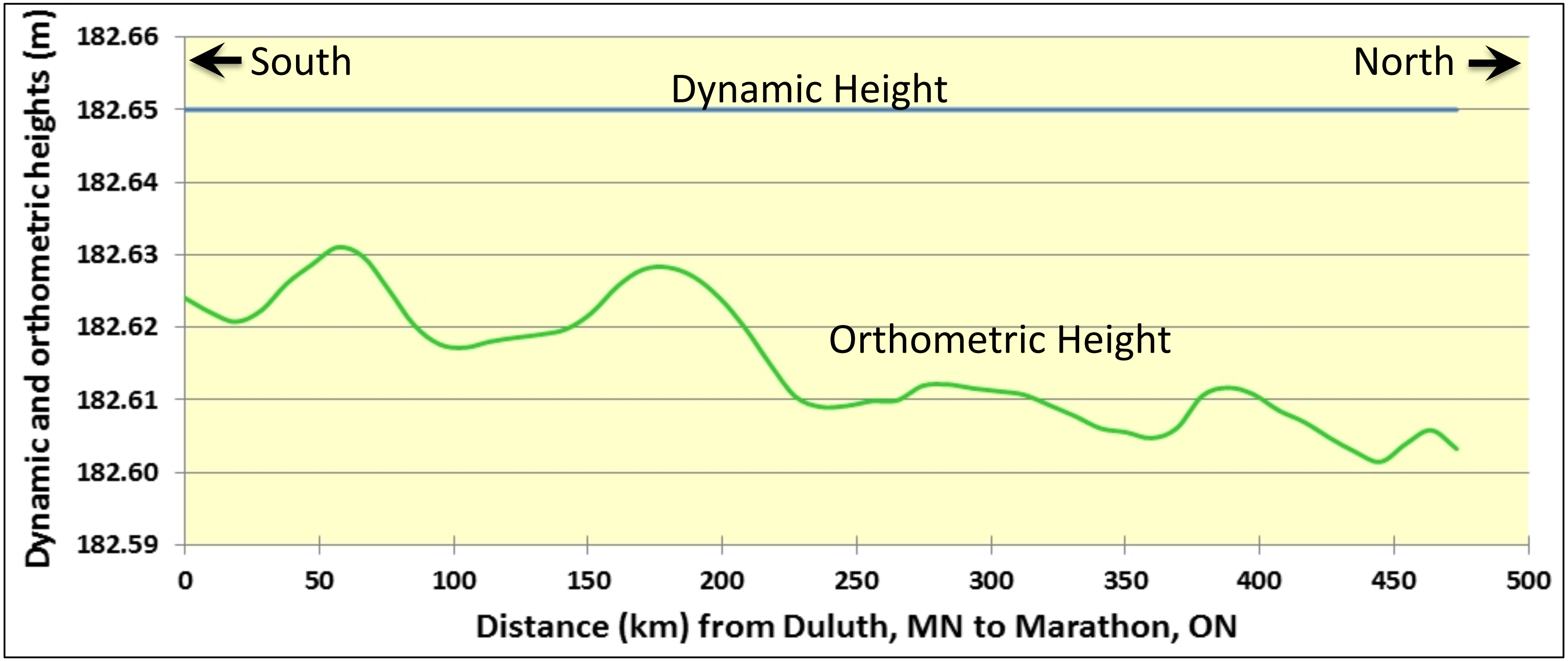


Illustration of dynamic versus orthometric heights on equipotential (level) surfaces such as the undisturbed surfaces of three of the Great Lakes. Dynamic heights ($H^D{}_1$ & $H^D{}_2$) are constant. Orthometric heights (H_1 & H_2) represent the physical distance from the level reference surface (geoid) which changes mainly because of convergence of equipotential surfaces (and increasing value of gravity) as one proceeds north and is closer to the center of mass of the Earth due to the flattening of the shape of the Earth at the poles.

COORDINATING COMMITTEE

Dynamic vs Orthometric Heights



Simulation of orthometric heights (lower green line) and dynamic heights (upper blue line) of Lake Superior water surface along a straight line profile from Duluth, MN to Marathon, ON, illustrating orthometric heights are not constant along a level water surface, while dynamic heights are. The downward trend is due to the increasing gravity as one proceeds north and is closer to the center of mass of the Earth (flattening)

Accuracy of Dynamic Heights

- Dynamic height (H^d) for IGLD (2020) will be derived from ellipsoidal height (h) – see slides 14 & 18

$$H^d = (h - N)\ (\bar{g} / \gamma_{45^\circ})$$

- Accuracy of H^d a function of
  - Accuracy of h from GNSS: cm-level
  - Accuracy of N from geoid model: cm-level
  - Accuracy of $\bar{g}$: depends if measured or interpolated
  - γ_{45° is a constant (errorless)
- Accuracy of $\bar{g}$ needs to be determined
  - $\bar{g}$ can be measured with equivalent of mm-level accuracy
  - Need to investigate how accurately $\bar{g}$ can be interpolated from existing gravity measurements

Reference Epoch

- Epoch is a point in time to which data are referenced to
- Mean water level defined over a 7-year observation period
  - IGLD (1955) used 1952-1958
  - IGLD (1985) used 1982-1988
  - IGLD (2020) will use 2017-2023 (central reference epoch = 2020)
  - Mean levels used for evaluating lake topography (see Hydraulic Correctors slide)
- Heights will be referenced to the same epoch to account for crustal motion & ensure compatibility of heights
  - Need to use a velocity (GIA) model to propagate height from observation epoch to reference epoch

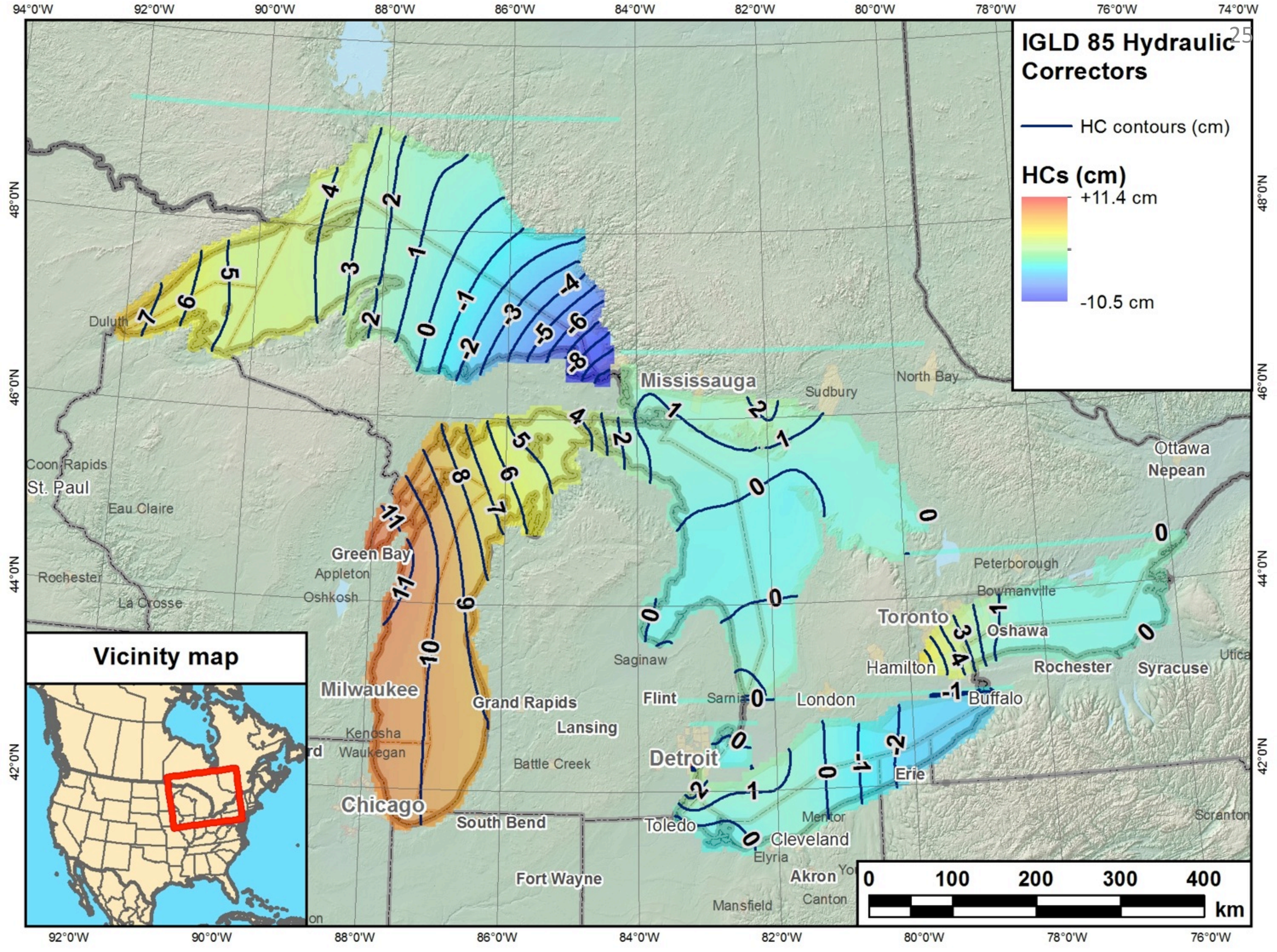
Additional Issues

- Hydraulic correctors
- Determining heights in a geoid-based datum
- Transforming between datums
- Impacts of a new IGLD
- Low Water Datum
- Outreach
- Resource requirements

COORDINATING COMMITTEE

Hydraulic Correctors

- Water surface of each of Great Lakes considered to be an equipotential surface (level surface)
- Dynamic heights of mean water level at gauges should be the same within each lake
- This is not the case in reality because of lake topography
  - Currents, river discharge, temperature/density variations, water pile up due to prevailing winds, etc.
- Hydraulic correctors used in IGLD (1985) to account (correct) for these variations and any errors in the datum
  - Dynamic heights at gauges adjusted to agree with a single “master” gauge on each lake – interpolated elsewhere


IGLD 85 Hydraulic Correctors
HC contours (cm)
HCs (cm)
+11.4 cm
-10.5 cm
Vicinity map
0 100 200 300 400 km
Duluth
Mississauga
Sudbury
North Bay
Ottawa
Nepean
Coon Rapids
St. Paul
Eau Claire
Green Bay
Appleton
Oshkosh
Rochester
La Crosse
Peterborough
Bowmanville
Toronto
Oshawa
Hamilton
Rochester
Syracuse
Utica
Saginaw
Milwaukee
Grand Rapids
Flint
Sarnia
London
Buffalo
Kenosha
Waukegan
Lansing
Detroit
Battle Creek
Erie
Chicago
South Bend
Toledo
Mentor
Cleveland
Elyria
Akron
Canton
Mansfield
Fort Wayne
Scranton
94°0'W
92°0'W
90°0'W
88°0'W
86°0'W
84°0'W
82°0'W
80°0'W
78°0'W
76°0'W
74°0'W
48°0'N
46°0'N
44°0'N
42°0'N

COORDINATING COMMITTEE

Hydraulic Correctors (cont'd)

- In IGLD (1985), hydraulic correctors mainly represent the errors in datum/leveling (±0.11 m) − see
- In IGLD (2020), hydraulic correctors should represent mainly actual lake topography
  - Errors in the new geoid-based IGLD (2020) are expected to be at least an order of magnitude smaller
  - Need to determine if hydraulic correctors are still required
- Seasonal gauging needed for analysis of hydraulic correctors
  - To densify network of gauges (increased spatial sampling)
  - Need to determine how much seasonal gauging needed
  - Need to ensure binational consistency & linking of observations
  - Need to account for fluctuating water levels between seasonal gauging observations
  - Use of "entity" gauges will help

Determining Heights in a Geoid-Based Datum

- Traditionally, heights determined by spirit leveling from known bench marks in a leveling network
- In a geoid-based datum, heights are most easily determined via GNSS positioning
- Leveling provides orthometric heights (H)
- GNSS provides ellipsoidal heights (h)
- H obtained from h by subtracting the geoid height (N) – see slides 14 & 15
  - h & N must be in the same reference frame (w.r.t. same reference ellipsoid) − e.g., NAD83 or NATRF2022
- Dynamic heights (H^D) computed from H – see slides 18 & 21

Determining Heights in a Geoid-Based Datum

- Traditionally, heights determined by spirit leveling from known bench marks in a leveling network
- In a geoid-based datum, heights are most easily determined via GNSS positioning
- Leveling provides orthometric heights (H)
- GNSS provides ellipsoidal heights (h)
- H obtained from h through the geoid height (N) – see slides 14 & 15
  - h & N must be in the same reference frame (w.r.t. same reference ellipsoid) − e.g., NAD83 or NATRF2022
- Dynamic heights (H^D) computed from H – see slide 18 & 21

COORDINATING COMMITTEE

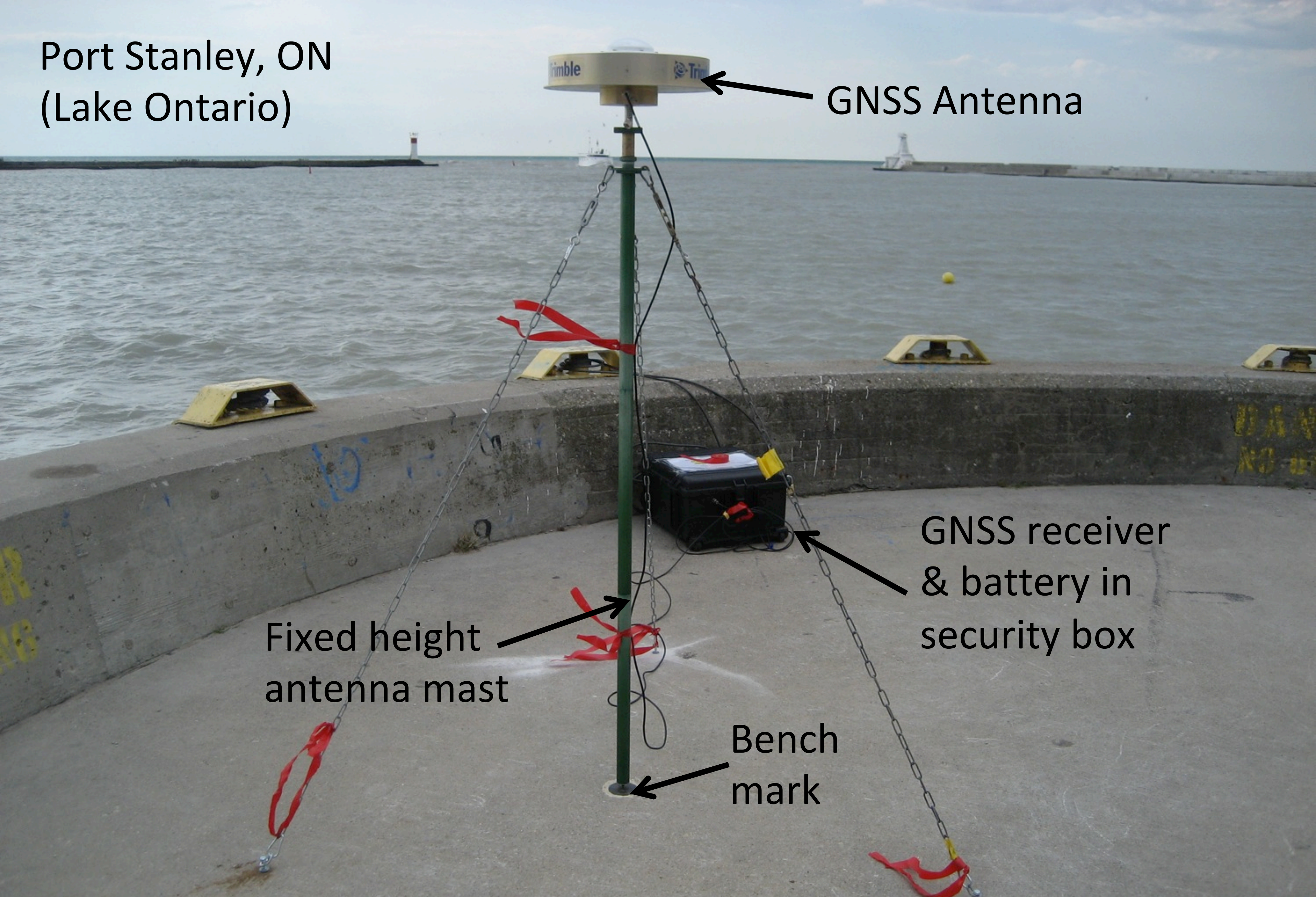
GNSS Leveling

- GNSS-based height determination (GNSS leveling) has been widely used in the surveying community for many years
- More efficient, cost effective & accurate over longer distances than spirit leveling
- Need a velocity (GIA) model to propagate heights to a common reference epoch
- Still need local leveling between reference bench marks and gauge at water level stations

COORDINATING COMMITTEE

GNSS Campaign Surveys

- GNSS survey campaigns will be required at all water level stations
- Needed to determine their heights in the new geoid-based IGLD
- Standardized binational guidelines for GNSS surveys being prepared to achieve required accuracies
- Survey campaigns at permanent gauges in 1997, 2005, 2010 & 2015
- New campaigns required in 2020 (reference epoch of IGLD (2020)) and 2025
- Will also contribute to improving velocity model



Typical GNSS Survey Setup

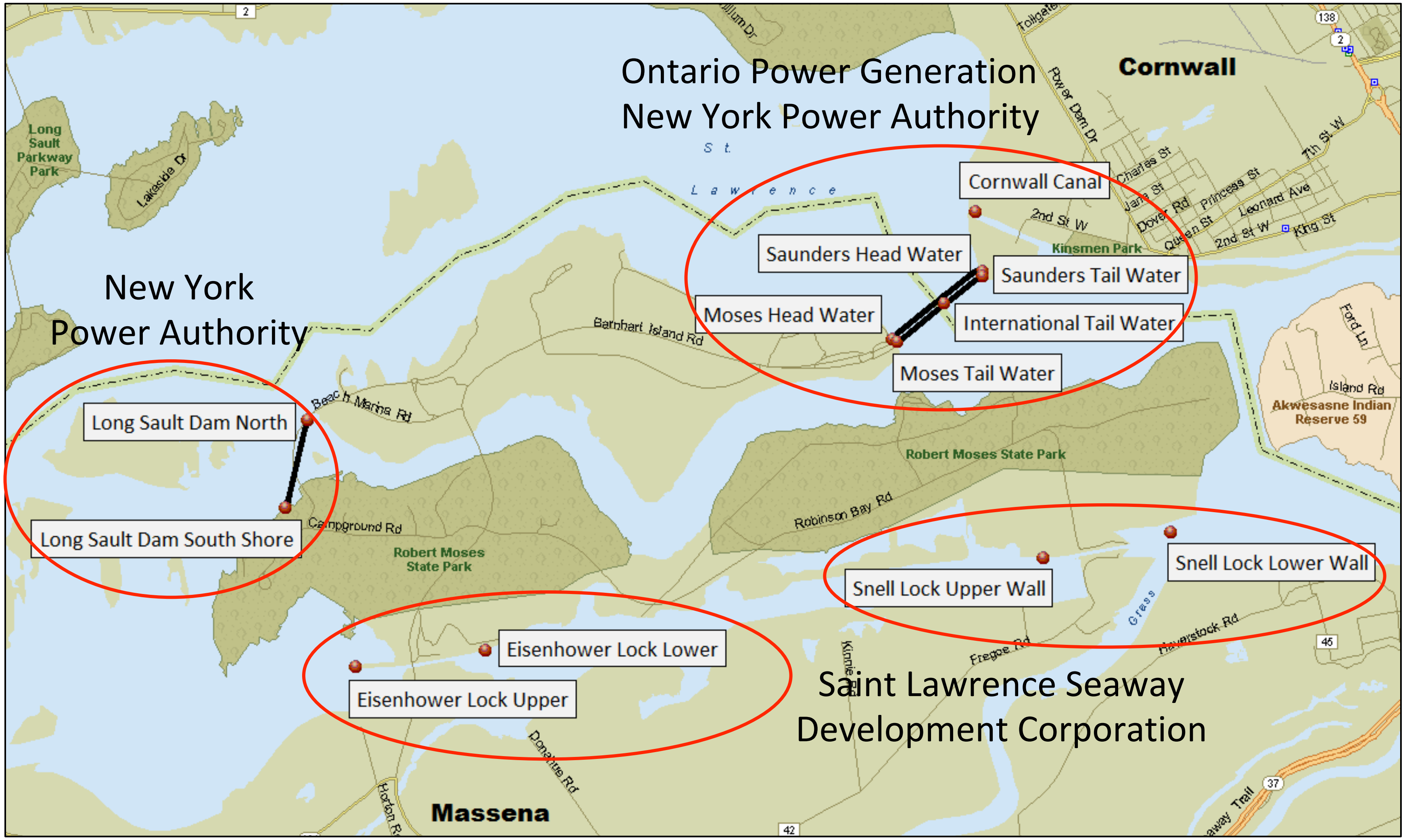
COORDINATING COMMITTEE

Updating Other Gauges

- Many other gauging stations used for water management operations, such as:
  - International Gauging Stations (IGS) & Binational Interest Gauging Stations (BIGS) for water outflow regulation
  - Seaway gauges for lock operations & navigation
  - Gauges used for dredging operations
  - Power entity gauges for power generation operations
  - Inland river & canal gauges
  - Municipal gauges
- Need to update heights of these gauges to IGLD (2020) – recommend to include them in 2020 GPS survey
- Will also help with determination of hydraulic correctors

COORDINATING COMMITTEE

Example of Other Gauges



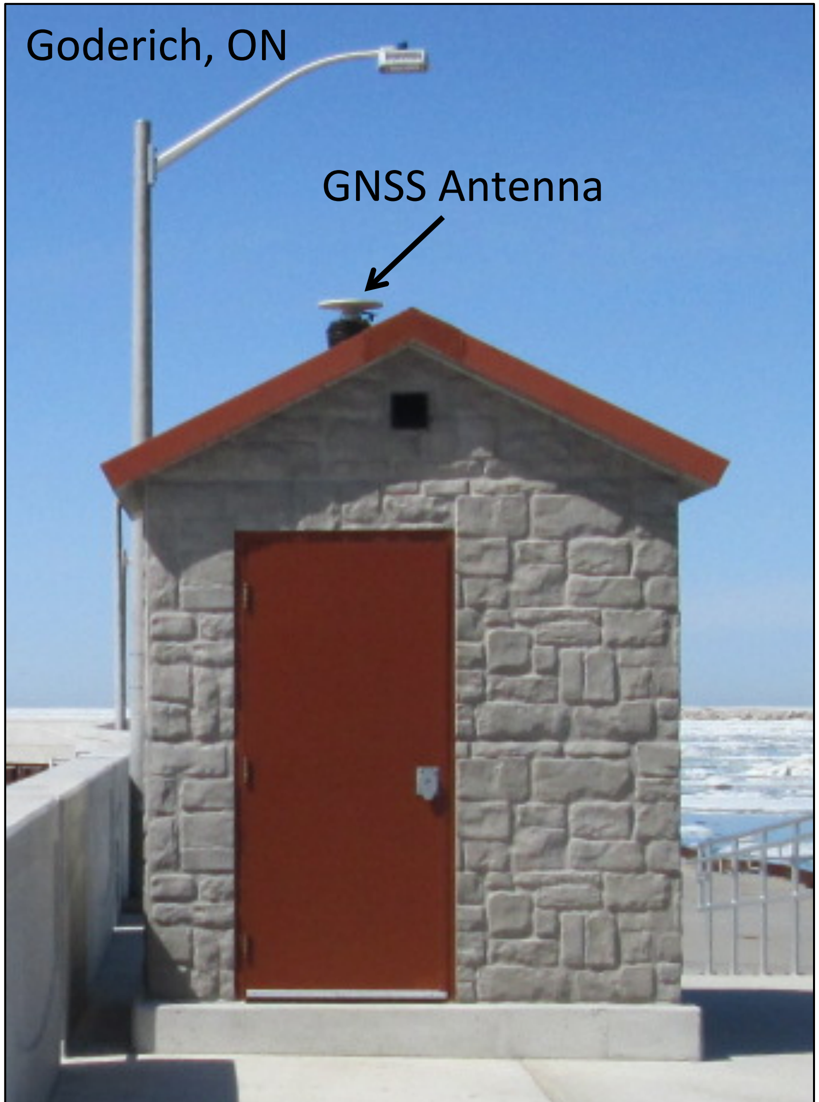
COORDINATING COMMITTEE

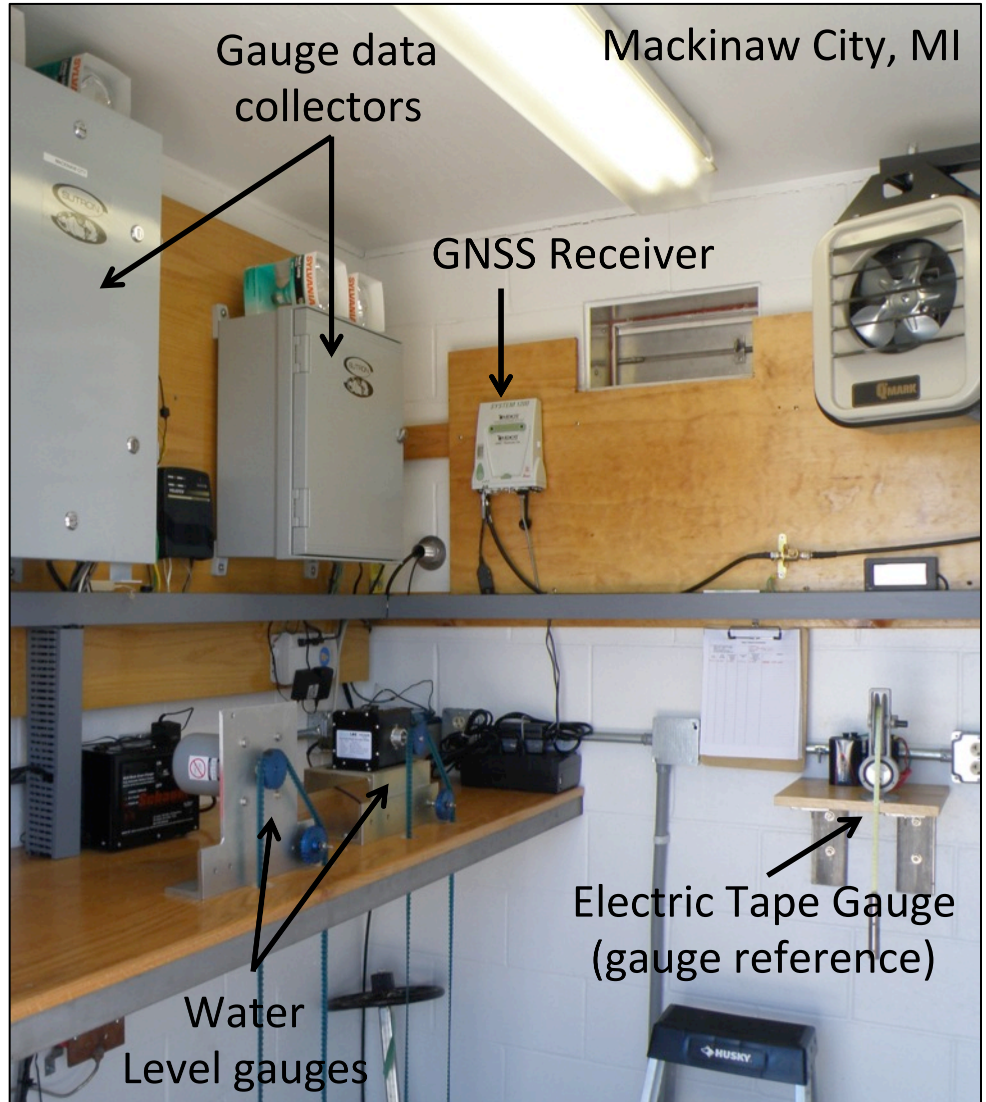
Permanent GNSS Stations

- Permanent GNSS stations (CORS & CACS) installed at many key water level stations
- Connected to same structure as the gauge reference
- Enables
  - Accurate determination of absolute height of gauge reference and water level
    - No bench mark network needed if GNSS antenna reference point accurately tied to gauge reference – cost saving
  - Determination of crustal motion at water level stations for velocity model
    - Accurate velocity model allows datum to be used for longer period of time by accounting for crustal motion
- CORS & CACS need to be maintained – further expansion is recommended

COORDINATING COMMITTEE

Typical CORS/CACS & Gauge





COORDINATING COMMITTEE

Transforming Between Datums

- Many products using IGLD will need to be updated to the new datum
- Will not be possible to regenerate some products in the new datum without collecting new data
- Transformation models & tools will be needed to update these products to IGLD (2020)
  - Need heights at common points in old and new datums
  - Will require digitizing heights in older datums
  - Tools must be capable of transforming thousands of data points

Impacts of a New IGLD

- Updating water levels to a new IGLD will have significant impacts on many operations, products and services in the Great Lakes region; e.g.,
  - Water level regulation and forecasting
  - Economic viability and safety of commercial and recreational navigation, including charts, ports/ harbors and dredging of navigation channels
  - Coastal zone management and planning, including flood & erosion prediction and response, and coastal structure design, construction & maintenance
  - Coastal habitat restoration under the Great Lakes Restoration Initiative (GLRI)

COORDINATING COMMITTEE

Specific Impacts of IGLD Update

Navigation	• LWD (or chart datum) will need to be changed on nautical charts from IGLD (1985) to a new IGLD. • LWD at the connecting channels and St. Lawrence River gauging stations, along with those at locations used for dredging, will need to be re-determined. • The shoreline depicted on nautical charts (high water mark) may change. • Chart depths may need to be changed. • Under-keel clearance may be affected.
Outflow Regulation	• Height references will require adjustment for regulating Lake Superior and Lake Ontario outflows, and the Chippawa – Grass Island Pool in the Niagara River. • Flooding/erosion control heights, trigger heights, and criteria thresholds will change. • Engineering project datums will be affected. • Restoration project datums will be affected. • Models and tools used in adaptive management to evaluate regulation plan performance will be affected.

Impacts (cont'd)

Water Management	• Update of historical water level records and lake level forecasting products to new datum will be required. • Update of stage-discharge rating equations and other supporting models/data/tools (e.g., bathymetry), used to calculate lake outflows, lake and connecting channel hydrodynamic and routing models, to new datum • Update of hydroelectric rating tables to new datum will be required. • Update of water supply information will be needed. • Effect on infrastructure such as municipal water intakes and nuclear power station water cooling systems must be determined. • Updating of heights of power entities' and Seaway authorities' water level gauges for flow determination and regulation planning are needed. • Updating of water level information in publications and other communications will be required.
Shoreline Use Planning	• Shoreline use permits in the U.S. and Canada will need to be referenced to IGLD (2020) because... • Lake level, IGLD station bench marks and high water mark will be based on the new datum. • Monthly water level bulletins and weekly water level forecasts published by USACE, ECCC and CHS will be on the new datum.

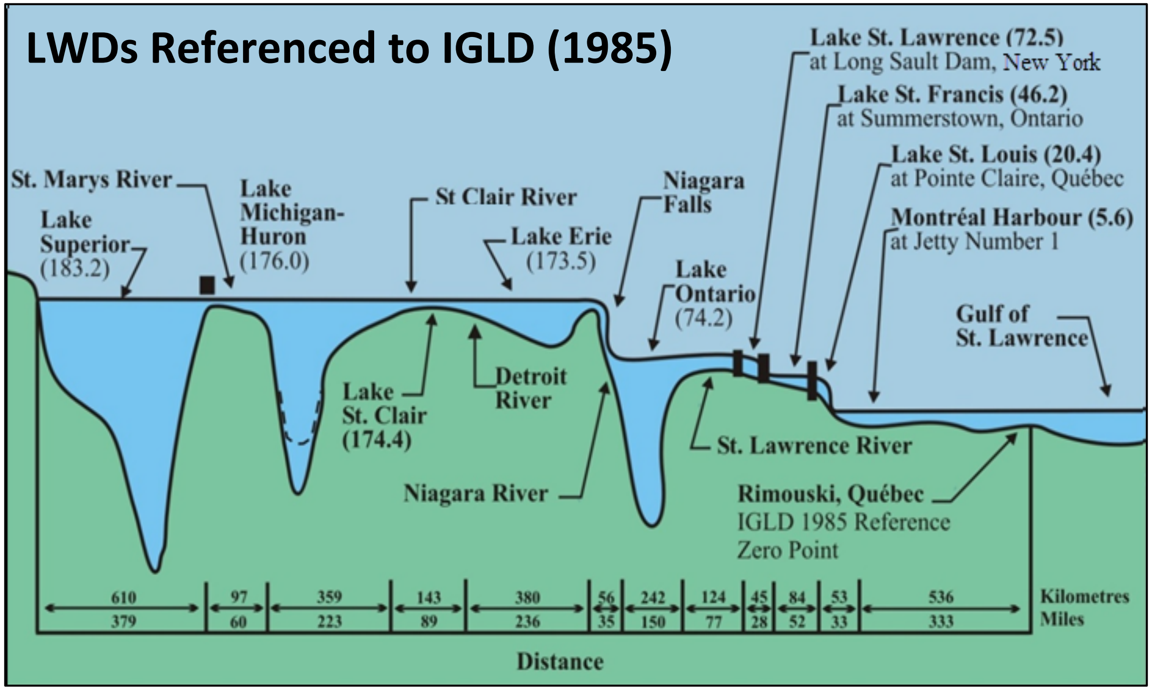
Impacts (cont'd)

Surveying and Mapping	• GNSS surveys and the adopted IGLD geoid (datum) will substitute for geodetic leveling between gauges. • Procedures and algorithms for using geoid-based datums to estimate accurate IGLD (2020) GNSS-derived dynamic heights will need to be developed and published. • Crustal movement models will be available. Procedures and tools using movement rates will need to be developed for applications that require high-accuracy coordinates.

COORDINATING COMMITTEE

Low Water Datum (LWD)

- LWD or chart datum identifies a surface so low that the water level will seldom fall below it
- Different LWD surfaces are used for different lakes & rivers
- Depths on navigation charts & for navigation improvements refer to LWD

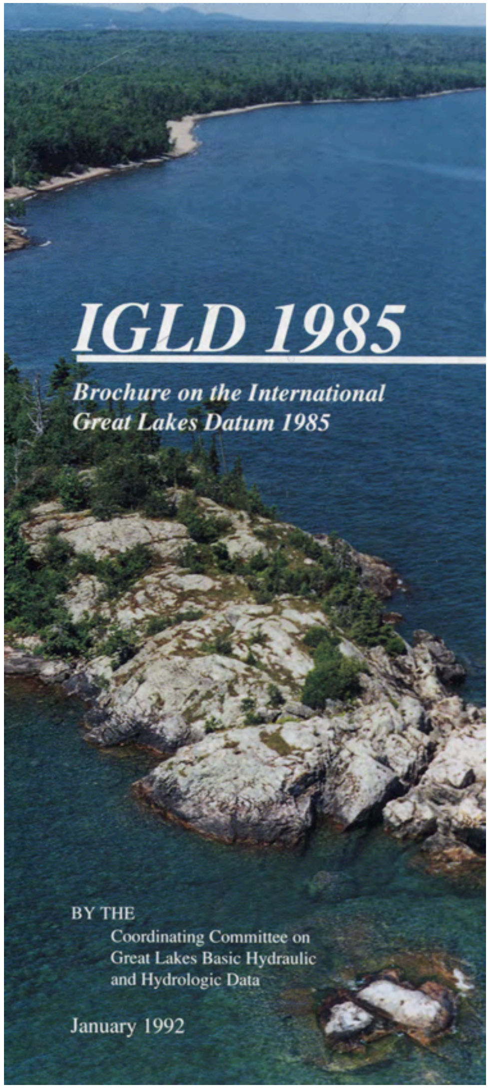


Low Water Datum (cont'd)

- LWD originally determined in 1933 and has not been reviewed since
- The same LWD surface has been referenced to the different IGLD datums through a translation of the old LWD surface
- Can reference the same LWD to IGLD (2020) but…
- Re-evaluation of LWD is recommended due to
  - Historically high and low water levels since 1933
  - Changes to hydraulic and hydrologic conditions

Outreach

Example of
Brochure for IGLD (1985)
(click on image to see brochure)



- Internationally coordinated outreach and communication strategy needed
- Identify stakeholders
- CC member agencies need to inform & educate stakeholders of update and its impact
  - Web site http://GreatLakesCC.org/
  - Publications & brochures
  - Conferences, meetings & Webinars
  - Annual status reports on update

Resource Requirements

- Need a wide range of personnel, knowledge, skills in geodesy, hydrography, hydrology, etc.
- Need international coordination of all activities
- Funding & personnel required for
  - Maintenance of permanent gauges
  - Installation & maintenance of CORS/CACS
  - 2020 GNSS survey campaign, including Seaway and power entity gauges
  - Seasonal gauge measurements
- See Table for agencies responsible for project activities

Activities & Milestones

Activity	Target Date/Period	Recommended Responsible Agencies
Complete binational plan for IGLD (2020) and present to the Coordinating Committee for approval	Completed	**VC-WL Subcommittee**
Choose and adopt a W_0 as the new IGLD reference zero (Section 2.1)	Completed	**Coordinating Committee (CC)**
Identify potential IGLD partners and users who can help develop and implement IGLD (2020)	2016-2023	**VC-WL Subcommittee**
Digitize and archive old leveling information, as required	2016-2023	**CO-OPS**, NGS **CHS**, CGS
Perform annual maintenance and leveling ties at permanent water level gauges	2016-2024	**CO-OPS**, USACE **CHS**, ECCC & others
Perform analysis of permanent gauging requirements and prioritize new proposed gauges	2017	**CO-OPS** **CHS**
Adjust and publish 2015 GPS campaign survey results	2017	**NGS** **CGS**
Complete preparation of internationally coordinated methodologies for determining heights using GNSS surveys and local leveling ties at gauges	2017-2018	**NGS**, CO-OPS, USGS, USACE **CGS**, CHS, ECCC
Complete preparation of international outreach and communication plan, and begin implementation	2017- 2018	**VC-WL Subcommittee**
Review historic water level data for re-evaluation of LWD	2017-2018	**CO-OPS**, USACE **CHS**, ECCC

Lead agencies for each task highlighted in bold font

Activities & Milestones (cont'd)

Activity	Target Date/Period	Recommended Responsible Agencies
Reanalyze and compare all GNSS campaign surveys from 1997, 2005, 2010, 2015 to estimate preliminary rates of movement	2017-2018	**NGS** **CGS**
Perform analysis of seasonal gauging requirements and prioritize locations	2017-2023	**CO-OPS** **CHS**
Begin annual installations of seasonal water level gauges with GPS and leveling ties	2017-2023	**CO-OPS** **CHS**
Perform 2020 GNSS campaign survey in Great Lakes – St. Lawrence River system, including entity gauges	Summer 2020	**NGS**, CO-OPS **CGS**, CHS and others
Adopt N.A. geoid model for IGLD (2020)	2022	**CC with NGS & CGS**
Create crustal movement models for the Great Lakes – St. Lawrence River system using all available GPS campaigns and CORS/CACS data	2023	**NGS** **CGS**
Complete seasonal water level gauging	2023	**CO-OPS** **CHS**
Determine hydraulic correctors	2024	**NGS**, CO-OPS **CGS**, CHS, ECCC
Determine new LWD on lakes and rivers with respect to IGLD (2020)	2024	**CO-OPS**, USACE **CHS**, ECCC
Determine and publish transformations between IGLD (2020) and other datums, including IGLD (1985)	2024	**NGS**, CO-OPS, USACE **CGS**, CHS
Publish new IGLD (2020) datum	2025	**CC**

Lead agencies for each task highlighted in bold font

For Further Information

- Publication: Updating the International Great Lakes Datum (IGLD), September 2017
- Coordinating Committee (CC) Web Site *http://GreatLakesCC.org/*
- Coordinating Committee agencies (see CC web site)

Extra Slides

COORDINATING COMMITTEE

Potential Use of CORS/CACS

- In future, it is expected that water level stations can use CORS/CACS to determine absolute height of gauge reference (and water level) to 1 cm accuracy in near real-time
- No need for a reference bench mark network
- Stable water gauge structures may not be necessary but still desirable and required for crustal motion estimation
- GNSS can monitor position of structure in near real-time
- Can reduce operational costs in the long term & provide more accurate water levels
- Can provide a more accurate velocity model (longer datum validity)
- Will require close cooperation between geodetic & water level gauging agencies