New Zealand Vertical Datum 2009

A geoid based height system for the unification of disparate local vertical datums

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Overview

- Existing New Zealand height systems
- Limitations of current practise
- New datum options
- New Zealand Vertical Datum 2009
- Implementation of new datum
Heights in New Zealand

- 13 main regional vertical datums
- Based on local MSL at tide-gauge origins
- Extended by precise levelling along major roads
- Normal-orthometric heights (GRS67)
- Each datum independently adjusted
Problems with Local Datums

- Origins do not represent current MSL
  - Gauges located in harbours
  - Short-duration observations (1 – 37 years)
  - Not updated since definition (1923 – 1970)
- Datums are independent
  - Few levelling connections
  - Unknown offsets
  - No national adjustment
- Benchmarks only on roads
  - NZ has sparse road network
- Not compatible with GNSS

Desirable Vertical Datum Attributes

- Single reference system across NZ and its offshore islands
- Consistent with NZ Geodetic Datum 2000
- Compatible with GNSS heighting
- Consistent with gravity field and sea level (intuitive to use)
- Easily adopted by users
Vertical Datum by Precise Levelling

- Existing levelling combined in single adjustment
  - Fix one or many tide-gauges
  - Previous or updated MSL estimates
  - Little redundancy in adjustment
- Not practical approach for NZ today:
  - Age of levelling observations
  - Networks poorly connected and configured
  - Coverage limited to levelling routes
  - Not compatible with GNSS or NZGD2000
  - Not economic to re-level benchmarks

Vertical Datum by Gravimetric Geoid

- Geoid is datum reference surface
  - Rather than tide-gauge MSL
  - Geoid broadly coincident with level of sea at global scale
  - May be offset from local mean sea level
  - Heights generally reflect Earth’s gravity field
- Heights determined by:
  - Direct levelling from bench marks
  - GNSS heighting with transformation
- Datum connection anywhere within geoid coverage
  - Consistent heights across NZ and offshore islands
New Zealand Vertical Datum 2009

- Normal-orthometric height system (GRS80)
- Zero-tide Earth-tide model
- NZGeoid2009 reference surface
- Offsets to local datums
- Transformations between local and geodetic datums

New Zealand Vertical Datum 2009

- NZ one of the first countries to adopt a national geoid based datum
- First proposed in 2001, 8 years to publish
- Provides a consistent national vertical datum anywhere within the NZ continental shelf
- Easier to maintain in areas where precise levelling is not possible or practical
NZVD2009: Reference Surface

- NZ Quasigeoid 2009 (NZGeoid2009)
  - Actually quasigeoid
  - Geoid terminology used to avoid user confusion
  - Based on EGM2008
  - Not fitted to levelling or tide-gauges
- Characteristics:
  - 25°S–60°S, 160°E–170°W
  - 1° x 1° grid
  - 0m in south, 45m in north

NZVD2009: Offsets

- GPS-levelling observations used to:
  - Determine datum offsets
  - Estimate quality of the geoid
- 1422 GPS-levelling points spread among the datums
- National fit to GPS-levelling: 0.062m
## NZVD2009: Offsets

<table>
<thead>
<tr>
<th>Local Vertical Datum</th>
<th>Offset (m)</th>
<th>Std (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Tree Point 1964</td>
<td>-0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Auckland 1946</td>
<td>-0.34</td>
<td>0.05</td>
</tr>
<tr>
<td>Moturiki 1953</td>
<td>-0.24</td>
<td>0.06</td>
</tr>
<tr>
<td>Gisborne 1926</td>
<td>-0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>Taranaki 1970</td>
<td>-0.32</td>
<td>0.05</td>
</tr>
<tr>
<td>Napier 1962</td>
<td>-0.20</td>
<td>0.05</td>
</tr>
<tr>
<td>Wellington 1953</td>
<td>-0.44</td>
<td>0.04</td>
</tr>
<tr>
<td>Nelson 1955</td>
<td>-0.29</td>
<td>0.07</td>
</tr>
<tr>
<td>Lyttelton 1937</td>
<td>-0.47</td>
<td>0.09</td>
</tr>
<tr>
<td>Dunedin 1958</td>
<td>-0.49</td>
<td>0.07</td>
</tr>
<tr>
<td>Dunedin – Bluff 1960</td>
<td>-0.38</td>
<td>0.04</td>
</tr>
<tr>
<td>Bluff 1955</td>
<td>-0.36</td>
<td>0.05</td>
</tr>
<tr>
<td>Stewart Island 1977</td>
<td>-0.39</td>
<td>0.15</td>
</tr>
</tbody>
</table>

## NZVD2009: Transformations

- Enables simple transformation of heights between:
  - NZVD2009
  - NZGD2000
  - 13 Local datums

\[
H_{NZVD2009} = h - N \\
H_B = H_A - o_A + o_B \\
H_{NZVD2009} = H_A - o_A \\
h = H_A + N - o_A
\]

(N is bi-linearly interpolated at NZGD2000 position)
NZVD2009: Implementation

- Publish NZVD2009 heights for marks with existing heights
- Provide online tools for users to convert heights
- Seminar series to inform users about new datum
- Education to encourage users to migrate data
- Existing datums not updated but not removed either

Summary

- NZ is first country to implement a national geoid based vertical datum
- NZVD2009 provides NZ with a nationally consistent height reference system
- NZVD2009 can be easily accessed by users throughout NZ using GNSS
- Geoid-based vertical datums are easier to maintain in areas with few roads or sparse population
Thank you