EDM Height Traversing Levelling Survey Report

Apia, Western Samoa, May 2010

N. J. Brown, A. Lal
EDM Height Traversing Levelling Survey Report

Apia, Western Samoa, May 2010

GEOSCIENCE AUSTRALIA
RECORD 2012/20

N. J. Brown¹, A. Lal²

1. National Geospatial Reference System, Minerals and Natural Hazards Division, Geoscience Australia GPO Box 378 Canberra ACT 2601
2. Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC)
Department of Resources, Energy and Tourism
Minister for Resources and Energy: The Hon. Martin Ferguson, AM MP
Secretary: Mr Drew Clarke

Geoscience Australia
Chief Executive Officer: Dr Chris Pigram

© Commonwealth of Australia (Geoscience Australia) 2012

With the exception of the Commonwealth Coat of Arms and where otherwise noted, all material in this publication is provided under a Creative Commons Attribution 3.0 Australia Licence (http://creativecommons.org/licenses/by/3.0/au/)

Geoscience Australia has tried to make the information in this product as accurate as possible. However, it does not guarantee that the information is totally accurate or complete. Therefore, you should not solely rely on this information when making a commercial decision.

ISSN 1448-2177

GeoCat # 73811

Contents

Introduction ........................................................................................................................................... 1
The Survey ........................................................................................................................................ 1
Bench Mark Locality Diagrams ........................................................................................................... 2
The Western Samoa Datum .................................................................................................................. 2
Equipment ......................................................................................................................................... 3
Method .............................................................................................................................................. 3
Survey Support ................................................................................................................................. 3
Issues ............................................................................................................................................... 4
Comparisons between 2010 and 2008 EDM Surveys ........................................................................ 5
Combined Comparisons 1993 to 2010 ............................................................................................. 6
Time Series of Bench Mark movement relative to Fixed Deep Bench Mark BM201 ...................... 7
Deep Bench Mark Locality Diagrams ................................................................................................. 13
Western Samoa Reference Mark Locality Diagram ......................................................................... 19
Temporary Holding Mark Locality Diagrams .................................................................................. 20
References ...................................................................................................................................... 29
Introduction

This report outlines the high precision level survey completed between the SEAFRAME tide gauge and continuous GPS station in Apia, Western Samoa from 18 – 30 May 2010.

Personnel involved in the survey were Nicholas Brown, Project Officer, Geoscience Australia and Andrick Lal, Surveyor, Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC).

The EDM height traversing levelling technique was employed to observe differences in height between the deep bench mark array in Apia, which runs approximately 5.5 km from the tide gauge sensor to the continuous GPS antenna. Previous levelling surveys have been conducted along the route using this technique in 2006 and 2008.

In addition, precise differential levelling surveys were performed along the deep bench mark array from 1992 to 2004 by the National Tidal Centre (NTC). This report contains a comparison between the 2010 and 2008 EDM height traversing results as well as a combined comparison since the first levelling survey.

The Survey

The EDM height traversing levelling survey was carried out between the SEAFRAME tide gauge sensor, continuous GPS station and the deep driven bench mark array:

- **SAM16** - Project plaque at tide gauge
- **SAM17** - SEAFRAME sensor benchmark
- **BM201** - Deep driven BM, held fixed and located at the rear of the old Ministry of Resources, Energy and Environment Building along the Apia Port Road.
- **BM210** - Deep driven BM along Matafagatele Street inside Church grounds.
- **BM212** - Deep driven BM located at the end of Matafagatele Street and the start of the Main East Coast Road.
- **BM213** - Deep driven BM outside a shop at the corner of the Main East Coast Road and Vaivase Road.
- **BM214** - Deep Driven BM located corner of Vaivase and Fuaiupolu Roads.
- **BM215** - Deep Driven BM located inside church grounds, Plantation Road.
- **BM220** - Deep Driven BM located in front of Apia Park entrance gate

All the deep bench marks were located and found in good order and undisturbed. Also included in the survey were the holding marks **SAM 139, SAM 166, SAM 168, SAM 170, SAM 186, SAM 187**, permanent holding marks **SAM300, SAM301, SAM302, SAM 303, SAM 304, SAM 305 and SAM 306**. SAM 300-305 consist of domed stainless steel bolts drilled in concrete and glued in place with quality epoxy resin whereas SAM 306 is a steel rod driven approximately 1.5m into ground. Three new holding marks, **SAM307, SAM308 and SAM309** were also established for this survey. These are steel pins driven into concrete.

The EDM height traversing levelling technique was performed to the Class L2A specifications (ICSM, Standards and Practices for Control Surveys). After reduction an internal precision of 1\(\sqrt{K}\) or better was achieved; well within the specifications of the project which is 2\(\sqrt{K}\) where K is the distance in kilometres. A table of results and comparisons and the 2010 reduced levels are detailed later in this report.
Bench Mark Locality Diagrams

The Western Samoa Datum

The Datum for the survey is Mean Sea Level (1993) as established by the National Tidal Centre Australia. Reduction of the data has been calculated holding BM201 fixed at 1.3292 m.
Equipment

- Leica total station model TCA1800L
- Leica precision prisms GPH1P (2).
- Leica rigid tripod.
- Stainless steel target poles supported by Leica telescopic bi-poles (2).
- Shortened stainless steel target pole for the SEAFRAME sensor BM connection.
- Leica cast iron change plates (2).
- Kestral 4000 pocket weather tracker

Method

The “Leap-Frog” EDM-height-traversing technique was employed for the Apia tide gauge levelling survey. The "Leap-Frog" EDM-height-traversing technique involves setting up a total station (TCA1800L) midway between two target/reflectors (on reflector rods with struts). The targets remain at a particular change point for the back-sight and fore-sight observations. The instrument measures slope distances (±1mm) and vertical angle (1") to derive height differences (between the instrument’s trunnion axis and the reflectors). In support of the slope distance observations, the ambient temperature, pressure and humidity are recorded (Kestral 4000 pocket weather tracker) and input into the instrument to apply the first velocity correction to the observed distances (Rüeger & Brunner 1982). Several rounds (four) of observations are taken to the back-sight and fore-sight targets from each instrument setup. All levelling bays started and finished with the same reflector and reflector rod, ie an even number of setups when the two reflector rod configuration was used – this eliminates any reflector rod zero error. Results can also be gained with the EDM Height Traversing method by using a single set-up / single rod configuration. This “single set-up / single rod” configuration is particularly useful when levelling between bench marks which are close together e.g. between the CGPS RMs.

Reduction of the digital data was computed by the Geoscience Australia levelling program “leveling1.exe”. This program computes the height difference between the two reflectors at any one set-up.

Survey Support

Ms. Siosina Lui from the Ministry of Natural Resources & Environment provided valuable assistance in obtaining customs clearances for the surveying equipment. This is a lengthy process and seems to becoming more time consuming throughout most countries in the Pacific. Her assistance is greatly appreciated.

The Deputy CEO for the Survey Division of the Ministry of Environment and Natural Resources, Mr. Safuta Toelau and the Senior Surveyor, Mr. Ueligitone Seiuli came out to observe our procedures in the field and sent out a couple of their staff for training including Philip Olivia (Survey Assistant, mobile phone # 7739579).
Other personnel consulted during the visit were Mr. Austelaia Titimaea (Assistant CEO) and Me Sale from the Meteorology Division of the Ministry of Natural Resources & Environment. Me (work phone # 20855, mobile phone # 7231423) provided labour assistance throughout the survey.

A meeting was also held with the Australian High Commissioner, Matt Henderson to discuss the purpose of the survey and provide him with an overview of the findings to date. A major topic of conversation was the tsunami in Western and American Samoa following the magnitude 8.0 earthquake on the 29th September 2009. A copy of the results from the GPS analysis undertaken by Geoscience Australia was provided to the High Commissioner.

**Issues**

Avoid levelling between SAM166 to the tide gauge bench mark during offloading of ships or increased port activity. Access inside the Ports Authority area is strictly prohibited and arrange security pass through the Met Office or Lands and Surveys staff well in advance. The Ports Authority area is closed on Saturdays, however, security is still on the gate. This is a good day to arrange to perform the survey.

Levelling along the reclaimed area around the wharf and along Matafagatele Street, especially around Apia Park Stadium to be carried out during quiet traffic periods. It is recommended they you avoid areas with drainage systems underneath the footpath in that area as the heavy trucks which drive past cause significant ground shake.

BM212 is missing a lid. A makeshift lid was placed over the mark (half a plastic chopping board), however, a more permanent solution needs to be arranged during the next visit.
Comparisons between 2010 and 2008 EDM Surveys

Table 1: Apia, Western Samoa 2010 EDM Height Traversing Levelling Comparison 2010 - 2008.

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>Levelled Height Difference</th>
<th>Reduced Level 2010</th>
<th>Misclose (mm)</th>
<th>Distance (km)</th>
<th>1mm/√k</th>
<th>Reduced Level 2008</th>
<th>Difference (mm) 2010 - 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM201</td>
<td>BM201</td>
<td>1.3292</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAM186</td>
<td>SAM186</td>
<td>0.99233</td>
<td>2.3215</td>
<td>-0.15</td>
<td>0.091</td>
<td>0.301</td>
<td>2.3232</td>
<td>-1.71</td>
</tr>
<tr>
<td>SAM166</td>
<td>SAM166</td>
<td>-0.10260</td>
<td>2.2189</td>
<td>0.12</td>
<td>0.186</td>
<td>0.432</td>
<td>2.2211</td>
<td>-2.13</td>
</tr>
<tr>
<td>SAM16</td>
<td>SAM16</td>
<td>0.15524</td>
<td>2.3742</td>
<td>0.16</td>
<td>0.248</td>
<td>0.498</td>
<td>2.3744</td>
<td>-0.21</td>
</tr>
<tr>
<td>SAM17</td>
<td>SAM17</td>
<td>0.78693</td>
<td>4.1610</td>
<td>0.05</td>
<td>0.016</td>
<td>0.125</td>
<td>4.1613</td>
<td>-0.34</td>
</tr>
<tr>
<td>SAM186</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAM166</td>
<td>SAM166</td>
<td>-0.53111</td>
<td>1.7654</td>
<td>0.14</td>
<td>0.347</td>
<td>0.589</td>
<td>1.7874</td>
<td>-1.99</td>
</tr>
<tr>
<td>BM210</td>
<td>BM210</td>
<td>-0.53173</td>
<td>1.2537</td>
<td>-0.40</td>
<td>0.570</td>
<td>0.755</td>
<td>1.2542</td>
<td>-0.48</td>
</tr>
<tr>
<td>SAM170</td>
<td>SAM170</td>
<td>0.69437</td>
<td>1.9481</td>
<td>0.01</td>
<td>0.357</td>
<td>0.597</td>
<td>1.9489</td>
<td>-0.84</td>
</tr>
<tr>
<td>SAM300</td>
<td>SAM300</td>
<td>-0.48198</td>
<td>1.4661</td>
<td>-0.44</td>
<td>0.199</td>
<td>0.446</td>
<td>1.4760</td>
<td>-9.96</td>
</tr>
<tr>
<td>BM220</td>
<td>BM220</td>
<td>0.05608</td>
<td>1.5221</td>
<td>0.25</td>
<td>0.186</td>
<td>0.432</td>
<td>1.5237</td>
<td>-1.55</td>
</tr>
<tr>
<td>SAM301</td>
<td>SAM301</td>
<td>0.09763</td>
<td>1.6198</td>
<td>-0.24</td>
<td>0.207</td>
<td>0.455</td>
<td>1.6216</td>
<td>-1.83</td>
</tr>
<tr>
<td>SAM187</td>
<td>SAM187</td>
<td>-0.23821</td>
<td>1.3816</td>
<td>-0.17</td>
<td>0.192</td>
<td>0.439</td>
<td>1.3834</td>
<td>-1.87</td>
</tr>
<tr>
<td>SAM302</td>
<td>SAM302</td>
<td>-0.00097</td>
<td>1.3806</td>
<td>-0.29</td>
<td>0.201</td>
<td>0.448</td>
<td>1.3853</td>
<td>-4.68</td>
</tr>
<tr>
<td>BM212</td>
<td>BM212</td>
<td>0.00777</td>
<td>1.3884</td>
<td>0.13</td>
<td>0.247</td>
<td>0.497</td>
<td>1.3880</td>
<td>0.36</td>
</tr>
<tr>
<td>SAM303</td>
<td>SAM303</td>
<td>0.70547</td>
<td>2.0938</td>
<td>0.44</td>
<td>0.209</td>
<td>0.457</td>
<td>2.0940</td>
<td>-0.18</td>
</tr>
<tr>
<td>BM213</td>
<td>BM213</td>
<td>-0.90734</td>
<td>1.1865</td>
<td>-0.43</td>
<td>0.407</td>
<td>0.638</td>
<td>1.1861</td>
<td>0.45</td>
</tr>
<tr>
<td>SAM304</td>
<td>SAM304</td>
<td>0.51529</td>
<td>1.7018</td>
<td>-0.13</td>
<td>0.083</td>
<td>0.287</td>
<td>1.7016</td>
<td>0.18</td>
</tr>
<tr>
<td>BM214</td>
<td>BM214</td>
<td>6.41991</td>
<td>8.1217</td>
<td>0.24</td>
<td>0.375</td>
<td>0.612</td>
<td>8.1215</td>
<td>0.21</td>
</tr>
<tr>
<td>SAM305</td>
<td>SAM305</td>
<td>1.88821</td>
<td>10.0999</td>
<td>0.35</td>
<td>0.146</td>
<td>0.382</td>
<td>10.0101</td>
<td>-0.20</td>
</tr>
<tr>
<td>SAM139</td>
<td>SAM139</td>
<td>7.65827</td>
<td>17.6682</td>
<td>-0.51</td>
<td>0.341</td>
<td>0.584</td>
<td>17.6692</td>
<td>-1.01</td>
</tr>
<tr>
<td>BM215</td>
<td>BM215</td>
<td>3.94400</td>
<td>21.6122</td>
<td>0.03</td>
<td>0.099</td>
<td>0.315</td>
<td>21.6131</td>
<td>-0.93</td>
</tr>
<tr>
<td>SAM310</td>
<td>SAM310</td>
<td>8.15712</td>
<td>29.7693</td>
<td>0.41</td>
<td>0.166</td>
<td>0.408</td>
<td>new mark</td>
<td></td>
</tr>
<tr>
<td>SAMOBM</td>
<td>SAMOBM</td>
<td>8.42204</td>
<td>38.1914</td>
<td>0.24</td>
<td>0.437</td>
<td>0.661</td>
<td>38.1919</td>
<td>-0.54</td>
</tr>
<tr>
<td>SAMO</td>
<td>0.73381</td>
<td>38.9196</td>
<td>-0.04</td>
<td>0.028</td>
<td>0.168</td>
<td>38.9202</td>
<td>-0.60</td>
<td></td>
</tr>
</tbody>
</table>

Misclose for all bays levelled = -0.21 5.340 2.311

All levelling was performed within the project specifications of 2√k

<table>
<thead>
<tr>
<th>SAMOBM</th>
<th>38.19135</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMO</td>
<td>-0.73381</td>
</tr>
<tr>
<td>RM1</td>
<td>-1.7312</td>
</tr>
<tr>
<td>RM4</td>
<td>-0.7823</td>
</tr>
<tr>
<td>RM3</td>
<td>-1.2224</td>
</tr>
</tbody>
</table>
Combined Comparisons 1993 to 2010

Table 2: Apia, Western Samoa - Comparison of the RL's for Precise Differential Levelling (1993 - 2006) and EDM Height Traversing (2006 - 2010). Units are in metres.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BM201</th>
<th>SAM16</th>
<th>SAM17</th>
<th>BM210</th>
<th>BM220</th>
<th>BM211</th>
<th>BM212</th>
<th>BM213</th>
<th>BM214</th>
<th>BM215</th>
<th>SAMOBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993.1</td>
<td>1.3292</td>
<td>2.3843</td>
<td>4.1769</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994.8</td>
<td>1.3292</td>
<td>2.3812</td>
<td>4.1719</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996.4</td>
<td>1.3292</td>
<td>2.3796</td>
<td>4.1696</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998.4</td>
<td>1.3292</td>
<td>2.3783</td>
<td>4.1685</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999.8</td>
<td>1.3292</td>
<td>2.3777</td>
<td>4.1675</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001.4</td>
<td>1.3292</td>
<td>2.3768</td>
<td>4.1665</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002.9</td>
<td>1.3292</td>
<td>2.3751</td>
<td>4.1634</td>
<td>1.2535</td>
<td>1.4287</td>
<td>1.3846</td>
<td>1.1826</td>
<td>8.1172</td>
<td>21.6076</td>
<td>38.1869</td>
<td></td>
</tr>
<tr>
<td>2006.8</td>
<td>1.3292</td>
<td>2.3739</td>
<td>4.162</td>
<td>1.2546</td>
<td>1.4310</td>
<td>1.3884</td>
<td>1.1874</td>
<td>8.1223</td>
<td>21.6130</td>
<td>38.1926</td>
<td></td>
</tr>
<tr>
<td>2006.8</td>
<td>1.3292</td>
<td>2.3751</td>
<td>4.1629</td>
<td>1.2557</td>
<td>1.4321</td>
<td>1.3898</td>
<td>1.1876</td>
<td>8.1218</td>
<td>21.6128</td>
<td>38.1921</td>
<td></td>
</tr>
<tr>
<td>2008.3</td>
<td>1.3292</td>
<td>2.3744</td>
<td>4.1613</td>
<td>1.2542</td>
<td>1.5237</td>
<td>destroyed</td>
<td>1.3880</td>
<td>1.1861</td>
<td>8.1215</td>
<td>21.6131</td>
<td>38.1919</td>
</tr>
<tr>
<td>2010.5</td>
<td>1.3292</td>
<td>2.3742</td>
<td>4.1610</td>
<td>1.2537</td>
<td>1.5221</td>
<td>destroyed</td>
<td>1.3884</td>
<td>1.1865</td>
<td>8.1217</td>
<td>21.6122</td>
<td>38.1914</td>
</tr>
</tbody>
</table>
Time Series of Bench Mark movement relative to Fixed Deep Bench Mark BM201

There is an obvious drop in SAM16 and SAM17. This could be caused by the ports area being reclaimed land; however confirmation of this theory will be sought from the Ministry of Lands in Samoa. If this is the cause and the area of reclaimed land extends to BM201 (the fixed deep driven benchmark of the survey), this would explain of the apparent rise of BM210 – BM215, BM220 and SAMOBM which on average have risen by ~5 mm since 2002; the same amount SAM16 and SAM17 have dropped.

The purpose of these surveys is two fold: firstly, to provide accurate changes in land height to be used in computations of absolute sea level rise and secondly to provide accurate assessments of relative sea level rise. This is an excellent example to highlight the importance of measuring land height variations and the impact they can have on absolute sea level rise measurements. Furthermore, it provides useful information regarding localised deformation and the potential relative sea level height impacts.

Precise Differential Levelling: 1993 - 2006
EDM Height Traversing: 2006 onwards
EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010

SAM16

Year

Relative Movement of Bench Mark (mm)


SAM17

Year

Relative Movement of Bench Mark (mm)

EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010
BM220

Year
Relative Movement of Bench Mark (mm)

SAMO8M

Year
Relative Movement of Bench Mark (mm)
Deep Bench Mark Locality Diagrams

Bench Mark Number: BM201

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.

Existing Bench Mark Established by: Date:

Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Western Samoa
Island: Upolu
City: Apia

Marking and locality sketch

Bench Mark: 7.4m of 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.2m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 400m from the tide gauge station.

Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: December 2006

[Diagram showing the locality with marked spots such as Sea Side Inn, Old Ministry of Transport Building, Residential Block, Beach Road, Access Road, and Restaurant.]

13
EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010

SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

Survey Bench Mark Record

Bench Mark Number: BM210

<table>
<thead>
<tr>
<th>Original Bench Mark Established by</th>
<th>Date: Nov 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Existing Bench Mark Established by</th>
<th>Date:</th>
</tr>
</thead>
</table>

| Notes / References: Deep Survey Benchmark |
|------------------------------------------|-------|
| This survey mark is in a good locality for GPS occupation. |

| Country: Western Samoa |
|------------------------|-------|
| Island: Upolu |
| City: Apia |

Marking and locality sketch

Bench Mark: 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.2m. Top of mark 0.15m below ground level.

Locality sketch: Mark approximately 1200m from the tide gauge station.

---

Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: December 2006

cuserland/ndrk/spsdbm/localty/gram/samoa
EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010

SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT
Survey Bench Mark Record

Bench Mark Number: BM220

Original Bench Mark Established by: National Geospatial Reference Systems
Geospatial & Earth Monitoring Division (GEMD)
Geoscience Australia

Existing Bench Mark Established by: Date: May 2008

Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Western Samoa
Island: Upolu
City: Apia

Marking and locality sketch
Bench Mark: 5.3m of 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.5m. Top of mark 0.1m below ground level.
Locality sketch: Mark approximately 2000m from the tide gauge station.

Not to scale
Distances in Metres
Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: May 2008

15
Bench Mark Number: BM212

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.

Existing Bench Mark Established by: Date: Nov 2002

Notes / References: Deep Survey Benchmark
This survey mark is not in a good locality for GPS occupation.

Country: Western Samoa
Island: Upolu
City: Apia

Marking and locality sketch

Bench Mark: 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.2m. Top of mark 0.1m below ground level.

Locality sketch: Mark approximately 2800m from the tide gauge station.

MOUNTAIN CONGREGATIONAL CHRISTIAN CHURCH

not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: December 2006

c/users/androk/spstmp/localysagrams/samoa
**Survey Bench Mark Record**

**Bench Mark Number:** BM213

<table>
<thead>
<tr>
<th>Original Bench Mark Established by:</th>
<th>Date: Nov 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Existing Bench Mark Established by:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes / References:** Deep Survey Benchmark
This survey mark is not in a good locality for GPS occupation.

**Country:** Western Samoa  
**Island:** Upolu  
**City:** Apia

**Marking and locality sketch**

- **Bench Mark:** 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.2m. Top of mark 0.5m below ground level.
- **Locality sketch:** Mark approximately 3450m from the tide gauge station.

![Diagram of locality sketch]

**Not to scale**  
**Distances in Metres**  
**Magnetic bearings**

**Approved by:** Geoscience Australia / SOPAC  
**Date:** December 2006
Bench Mark Number: BM214

Original Bench Mark Established by:
National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.

Existing Bench Mark Established by:

Date: Nov 2002

Notes / References: Deep Survey Benchmark
This survey mark is in a good locality for GPS occupation.

Country: Western Samoa
Island: Upolu
City: Apia

Marking and locality sketch

Bench Mark: 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.2m. Top of mark on ground level.

Locality sketch: Mark approximately 3900m from the tide gauge station.

VAI/VASE ROAD

POST & WIRE FENCE

Flaupolu Road

To East Coast Road

Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC
Date: December 2006
Western Samoa Reference Mark Locality Diagram

SAMO Pillar and RM Diagram
FAGALII AIRPORT - SAMOA

NOT TO SCALE
Distances are Metres

SAMO CGPS Pillar is within the Fagali'i Airport compound approximately 4 kilometres SE from Apia City. The
Pillar is approximately 250 metres East of the Airport Terminal past the Fuel Depot, and stands 1.5m high and is
0.4m in diameter. A one metre square concrete pad is at the base of the pillar.
A stainless steel plate, 250mm in diameter, with a standard threaded 5/8 inch spigot is set in the top of the pillar.
All height references are to the stainless steel plate (not to the spigot).

The three (3) Reference Marks and the RO consist of deep driven stainless steel rods, 20mm in diameter with a
domed cap.
All the reference marks and the RO are below ground level and are protected by irrigation valve boxes.
Temporary Holding Mark Locality Diagrams
EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010

COUNTRY: Samoa
ISLAND: Upolu
CITY: Apia
L. D. P.: 745
POINT NO.: SAM 170
PROJECT: SPSLCMP
SURVEYOR: S. Yates & A. Lal
DATE: 14-10-06

MATAUTU STREET
TO SERVING STATION

SUPERMARKET
STAINLESS STEEL
PIN IN CONCRETE

MICHIEL'S
HANDY SHOP

MATAFAGATELE STREET
TO APA PARK

SERVICE STATION

ANZ BANK & UNESCO OFFICE

COUNTRY: Samoa
ISLAND: Upolu
CITY: Apia
L. D. P.: 749
POINT NO.: VARIOUS
PROJECT: SPSLCMP
SURVEYOR: S. Yates & A. Lal
DATE: 14-10-06

VILEX INDUSTRIAL COMPLEX
(BURNOUT BUILDING)

MASONRY NAIL
IN CONCRETE
(SAM 127)

STAINLESS STEEL
PIN IN CONCRETE
(SAM 129)

MATAFAGATELE STREET
TO WESTERN SAMOA GYM
TO MOAATA VILLAGE
## EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010

<table>
<thead>
<tr>
<th>COUNTRY:</th>
<th>ISLAND:</th>
<th>L. D. P.</th>
<th>POINT NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samoa</td>
<td>Upolu</td>
<td>762</td>
<td>SAM 139</td>
</tr>
<tr>
<td></td>
<td>Apia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PROJECT:** SPSLCMP  
**SURVEYOR:** S. Yates & A. Lai  
**DATE:** 15-10-06

---

<table>
<thead>
<tr>
<th>COUNTRY:</th>
<th>ISLAND:</th>
<th>L. D. P.</th>
<th>POINT NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samoa</td>
<td>Upolu</td>
<td>820</td>
<td>SAM 300</td>
</tr>
<tr>
<td></td>
<td>Apia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PROJECT:** SPSLCMP  
**SURVEYOR:** M. Deo & A. Lai  
**DATE:** 27-05-08

---

---
<table>
<thead>
<tr>
<th>COUNTRY:</th>
<th>ISLAND:</th>
<th>CITY:</th>
<th>L. D. P.</th>
<th>POINT NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samoa</td>
<td>Upolu</td>
<td>Apia</td>
<td>925</td>
<td>SAM 305</td>
</tr>
<tr>
<td>PROJECT:</td>
<td>SURVEYOR:</td>
<td>DATE:</td>
<td></td>
<td>25-05-08</td>
</tr>
<tr>
<td>SPSLCMP</td>
<td>M Seo &amp; A Lei</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Diagram: EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010**

- ZAM 303 S/S PIN in concrete or kerb along footpath
- STORM WATER & SEWER PIT SAM 34
- TO FIAUPOLI ROAD
- BLS STEP
- VAIVASE ROAD

<table>
<thead>
<tr>
<th>COUNTRY:</th>
<th>ISLAND:</th>
<th>CITY:</th>
<th>L. D. P.</th>
<th>POINT NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samoa</td>
<td>Upolu</td>
<td>Apia</td>
<td>902</td>
<td>SAM 310</td>
</tr>
<tr>
<td>PROJECT:</td>
<td>SURVEYOR:</td>
<td>DATE:</td>
<td></td>
<td>25-05-10</td>
</tr>
<tr>
<td>SPSLCMP</td>
<td>N Brown &amp; A Lei</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Diagram: EDM Height Traversing Levelling Survey Report: Apia, Western Samoa, April 2010**

- DARY SHOP
- DARY SHOP
- DARY SHOP
- TO VAIVASE ROAD (SNW215)
- PLANTATION ROAD TO CGPS STATION
- STONEMULL STUMP SEAT AROUND BREADFRUIT TREE
- SAM 380 S/S PIN IN CONCRETE
- FAGA’ALLI AIRPORT BUILDING
References