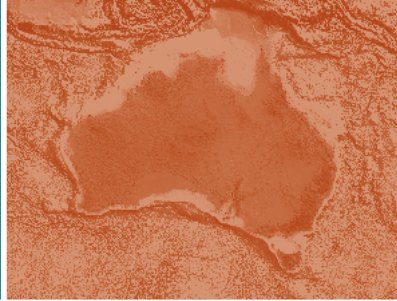




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EDM Height Traversing Levelling Survey Report

Apia, Western Samoa, November 2011

S. J. K. Yates, A. Lal

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Apia, Western Samoa, November 2011

GEOSCIENCE AUSTRALIA
RECORD 2014/24

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Australian Government
Geoscience Australia

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1 Introduction

This report outlines the high precision level survey completed between the Sea Level Fine Resolution Acoustic Measuring Equipment (SEAFRAME) tide gauge Bench Mark and the Continuous Global Navigation Satellite System (CGNSS) station in Apia, Western Samoa from 1 – 13 November 2011.

Personnel involved in the survey were Steve Yates, Project Officer, Geoscience Australia and Andrick Lal, Surveyor, Secretariat of the Pacific Community (SPC).

The Electronic Distance Measuring (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 SEAFRAME tide gauge sensor to the CGNSS antenna. Previous levelling surveys have been conducted along the route using this technique in 2006, 2008 and 2010.

In addition, precise differential levelling surveys were performed along the deep bench mark array from 1992 to 2004 by the National Tidal Centre Australia (NTCA). This report contains a comparison between the 2011 and 2010 EDM height traversing results as well as a combined comparison since the first levelling survey.

2 The Survey

The EDM height traversing levelling survey was carried out between the SEAFRAME tide gauge sensor, CGNSS 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 permanent holding marks SAM 104, SAM 139, SAM 166, SAM 168, SAM 170, SAM 180, SAM 186, SAM 187, SAM 300, SAM301, SAM 303, SAM 304, SAM 305, SAM 307, SAM 308, SAM 309, SAM 310, SAM 311, SAM 312, SAM 313, SAM 314, SAM 315, SAM 316. SAM 310 – 316 are new holding marks established in 2011 and consist of domed stainless steel bolts drilled in concrete and glued in place with quality epoxy resin.

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 $1\text{mm}\sqrt{K}$ 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 2011 reduced levels are detailed later in this report.

2.1 Bench Mark Locality Diagram



2.2 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.

2.3 Equipment

- Leica total station model TCA1800
- 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

2.4 Method

The “Leap-Frog” EDM height traversing technique was employed for the Apia tide gauge levelling survey. This 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 ($\pm 1\text{mm}$) 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). Four rounds of observations are taken to the back-sight and fore-sight targets from each instrument setup. All levelling runs started and finished with the same reflector and reflector rod, i.e. an even number of setups when the two reflector rod configuration was used. This eliminates any reflector rod zero error. This technique can also be performed using a single set-up / single rod configuration which is particularly useful when levelling between bench marks which are close together e.g. between the CGNSS 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.

2.5 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 be becoming more time consuming throughout most countries in the Pacific. Her assistance is greatly appreciated.

Senior Surveyor, Mr. Ueligitone Seiuli gave us valuable assistance and organised for a survey assistant to assist us for the levelling.

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.

2.6 Issues

Avoid levelling between SAM166 and 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 Weather Office or the 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 should be carried out during quiet traffic periods. It is recommended to avoid areas with drainage systems underneath the footpath in that area as the heavy trucks which drive past cause significant ground shake.

3 Comparisons

3.1 Comparisons between 2011 and 2010 Surveys

Table 3.1 Apia, Western Samoa 2010 EDM Height Traversing Levelling Comparison 2011 - 2010. BM201 - adopted fixed height of 1.3292 m

From	To	Levelled Ht. Diff.	RL 2012	Misclose (mm)	Dist. (km)	1mm/k	RL 2011	Difference (mm) 2012 - 2011
BM201			1.3292				1.3292	0.0000
SAM186	SAM186	0.99194	2.3211	0.10	0.094	0.307	2.3215	-0.0004
SAM166	SAM166	-0.10283	2.2183	0.38	0.190	0.436	2.2189	-0.0006
SAM309	SAM309	-0.27260	1.9457	0.10	0.186	0.431		
SAM16	SAM16	0.42758	2.3733	0.12	0.052	0.228	2.3742	-0.0009
	SAM17	1.78467	4.1580	0.03	0.011	0.105	4.1610	-0.0030
SAM186			2.3211				2.3215	-0.0004
SAM180	SAM180	-0.12721	2.1939	0.23	0.103	0.321		
SAM104	SAM104	-0.05781	2.1361	0.23	0.103	0.321		
SAM168	SAM168	-0.35291	1.7832	0.35	0.141	0.375	1.7854	-0.0022
SAM307	SAM307	-0.05641	1.7268	0.41	0.213	0.462		
	BM210	-0.47484	1.2519	0.00	0.017	0.130	1.2537	-0.0018
SAM307			1.7268					
SAM311	SAM311	0.36212	2.0889	0.41	0.203	0.451	New Mark	New Mark
SAM170	SAM170	-0.14476	1.9442	-0.04	0.154	0.392	1.9481	-0.0039
SAM300	SAM300	-0.48723	1.4569	0.43	0.199	0.446	1.4661	-0.0092
BM220	BM220	0.06113	1.5181	0.19	0.184	0.429	1.5221	-0.0040
SAM301	SAM301	0.09700	1.6151	0.03	0.206	0.454	1.6198	-0.0047
SAM187	SAM187	-0.23940	1.3757	-0.28	0.192	0.438	1.3816	-0.0059
SAM312	SAM312	0.03410	1.4098	0.39	0.201	0.448	New Mark	New Mark
SAM308	SAM308	0.08494	1.4947	0.30	0.101	0.318		
BM212	BM212	-0.11359	1.3811	-0.01	0.145	0.381	1.3884	-0.0073
SAM303	SAM303	0.70545	2.0866	-0.22	0.212	0.460	2.0938	-0.0072
SAM313	SAM313	-0.32558	1.7610	0.43	0.205	0.453	New Mark	New Mark
BM213	BM213	-0.58191	1.1791	0.28	0.204	0.452	1.1865	-0.0074
SAM304	SAM304	0.51478	1.6938	0.07	0.076	0.276	1.7018	-0.0080

From	To	Levelled Ht. Diff.	RL 2012	Misclose (mm)	Dist. (km)	1mm/k	RL 2011	Difference (mm) 2012 - 2011
SAM314	SAM314	1.95802	3.6519	0.11	0.200	0.447	New Mark	New Mark
BM214	BM214	4.46246	8.1143	0.25	0.172	0.415	8.1217	-0.0074
SAM305	SAM305	1.88784	10.0022	-0.04	0.145	0.381	10.0099	-0.0077
SAM315	SAM315	-0.13704	9.8651	0.25	0.184	0.429	New Mark	New Mark
SAM139	SAM139	7.79541	17.6605	0.30	0.156	0.395	17.6682	-0.0077
BM215	BM215	3.94376	21.6043	-0.28	0.092	0.303	21.6122	-0.0079
SAM310	SAM310	8.15688	29.7612	0.14	0.166	0.407	29.7693	-0.0081
SAM316	SAM316	0.53941	30.3006	-0.35	0.224	0.473	New Mark	New Mark
	SAMOBM	7.88299	38.1836	0.05	0.213	0.462	38.1914	-0.0078
			Misclose for all bays levelled =	3.63	4.411	4.190		
SAMOBM			38.1836				38.1914	
	RM1	-1.7312	36.4524	0.06	0.017	0.130	36.4602	-0.0078
SAMOBM								
	RM4	-0.7821	37.4015	0.02	0.025	0.158	37.4090	-0.0075
SAMOBM								
	RM3	-1.2222	36.9614	-0.02	0.028	0.167	36.9690	-0.0076

3.2 Combined Comparisons 1993 to 2011

Table 3.2 Apia, Western Samoa - Comparison of the RL's for Precise Differential Levelling (1993 - 2006) and EDM Height Traversing (2006 - 2011). Units are in metres.

Year	BM201	SAM16	SAM17	BM210	BM220	BM211	BM212	BM213	BM214	BM215	SAMOBM
1993.1	1.3292	2.3843	4.1769								
1994.8	1.3292	2.3812	4.1719								
1996.4	1.3292	2.3796	4.1696								
1998.4	1.3292	2.3783	4.1685								
1999.8	1.3292	2.3777	4.1675								
2001.4	1.3292	2.3768	4.1665								
2002.9	1.3292	2.3751	4.1634	1.2535		1.4287	1.3846	1.1826	8.1172	21.6076	38.1869
2004.7	1.3292	2.3757	4.1627	1.2538		1.4297	1.3864	1.1842	8.1189	21.6103	38.1889
2006.8	1.3292	2.3739	4.162	1.2546		1.4310	1.3884	1.1874	8.1223	21.6130	38.1926
2006.8	1.3292	2.3751	4.1629	1.2557		1.4321	1.3898	1.1876	8.1218	21.6128	38.1921
2008.3	1.3292	2.3744	4.1613	1.2542	1.5237	destroyed	1.3880	1.1861	8.1215	21.6131	38.1919
2010.5	1.3292	2.3742	4.1610	1.2537	1.5221	destroyed	1.3884	1.1865	8.1217	21.6122	38.1914
2011.9	1.3292	2.3733	4.1580	1.2519	1.5181	destroyed	1.3811	1.1791	8.1143	21.6043	38.1836

*The RL of the Reference Point SAMO (ARP) is derived from adding the static height difference of 0.7282 m (SAMOBM to SAMO) to the levelled RL of SAMOBM.

**The 2011 RL of SAMO is 38.9118 m

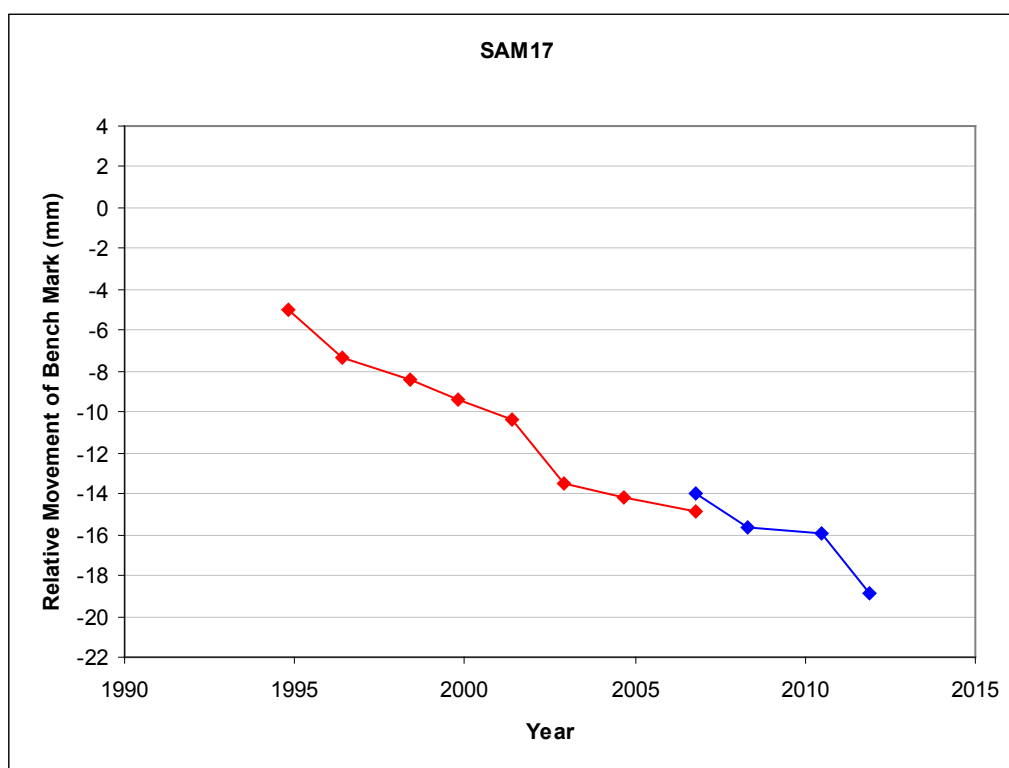
3.3 Time Series of Bench Mark movement relative to Fixed Deep Bench Mark BM201

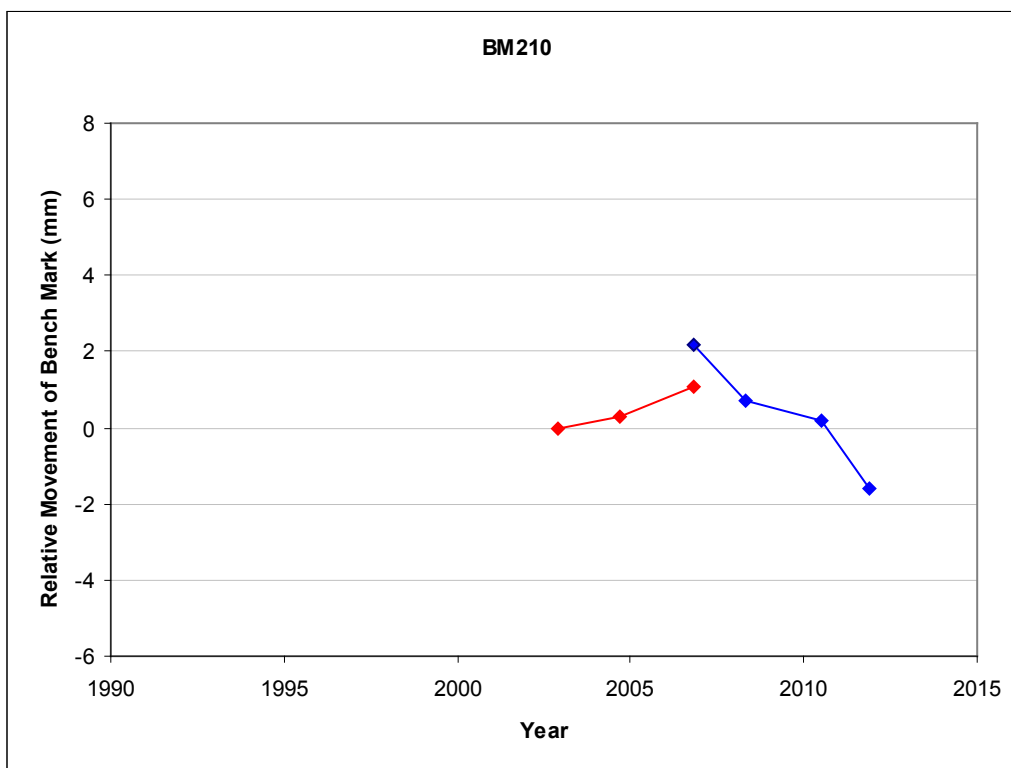
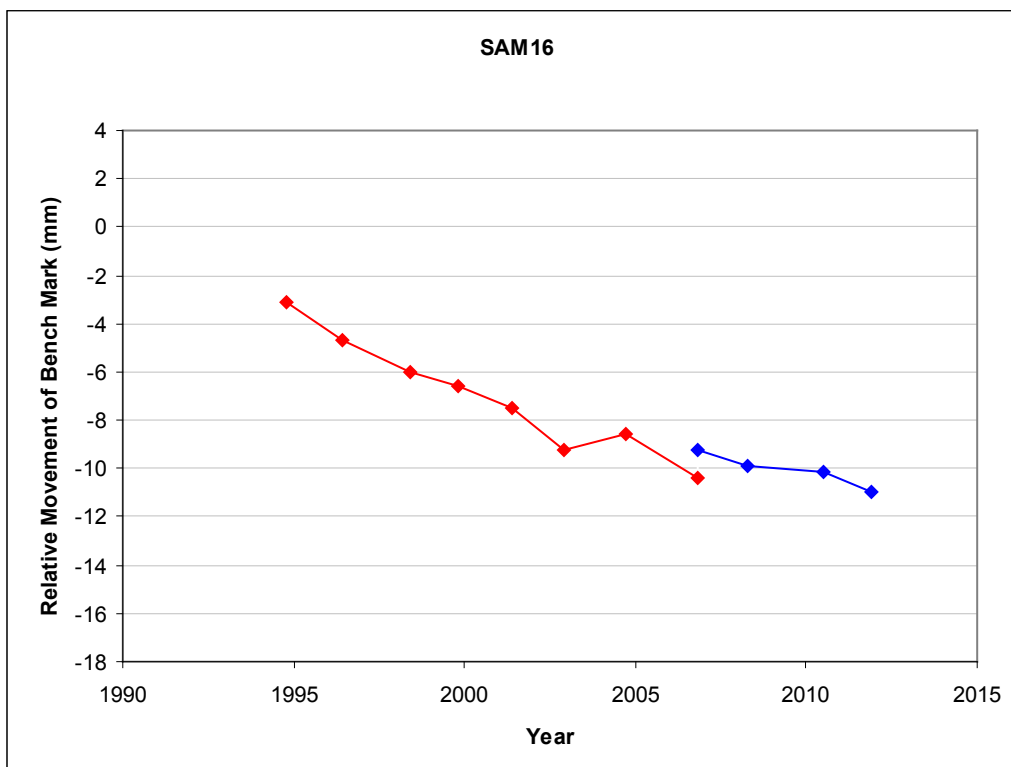
There is a 3mm drop in SAM17 and if you note the graph below there has been a gradual drop in SAM17 since 1995. This could be caused by the ports area being reclaimed land; but this theory has yet to be confirmed. The holding mark SAM300 has dropped a further 9mm since the 2010 survey and indicates that it is an unstable mark and should be used as a temporary mark only.

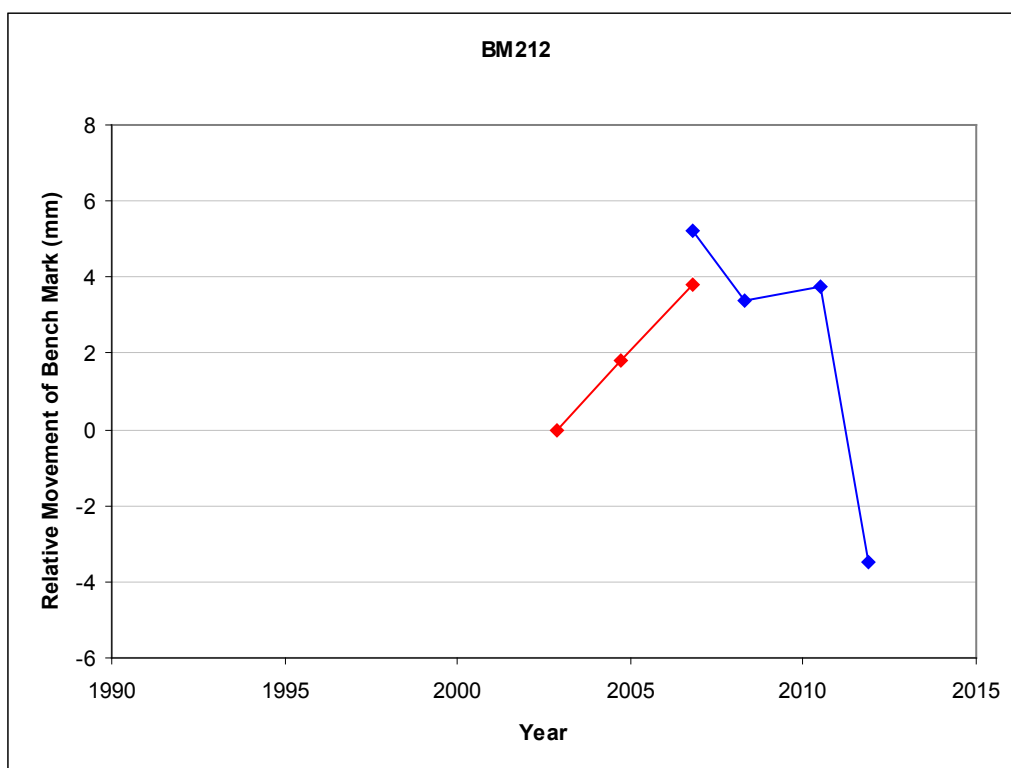
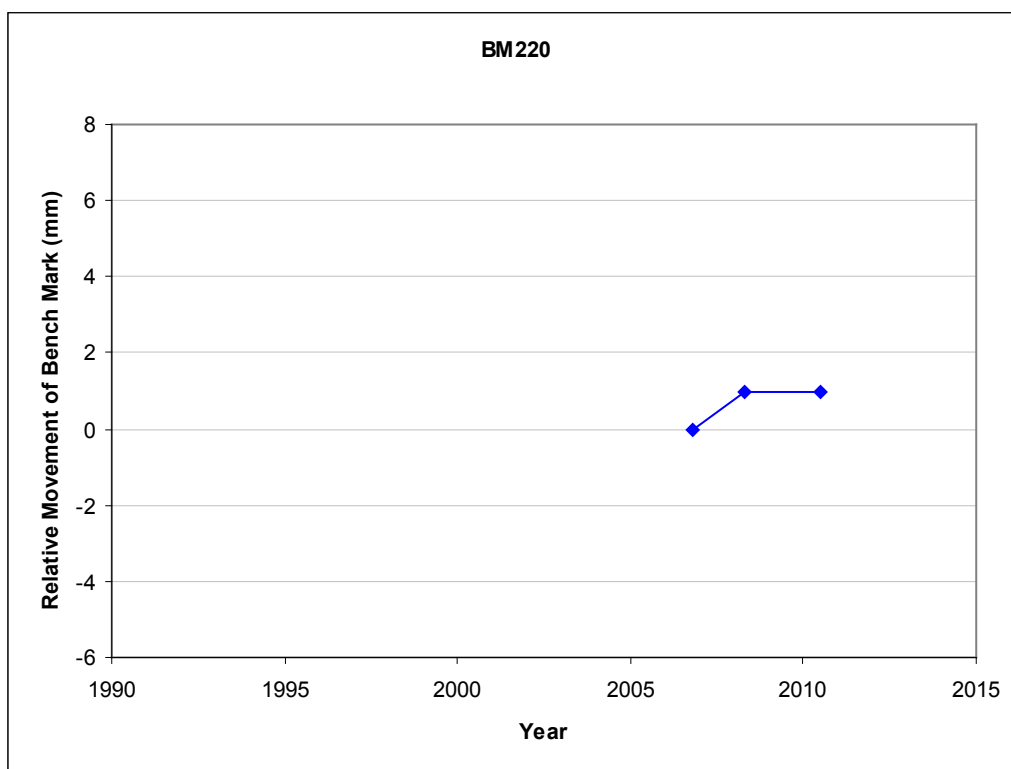
****Although the internal accuracy of the 2011 levelling survey was well within the project specifications it is NOT advised to use the 2011 RL's form holding mark SAM312 to the SAMOBM. From SAM312 an error has been detected in the survey of 7 to 8mm, and indicates an unexplained movement of the newly established mark SAM312 after closure of the levelling bay SAM187 to SAM312, this has resulted in the error being carried through to the subsequent levelling bays.**

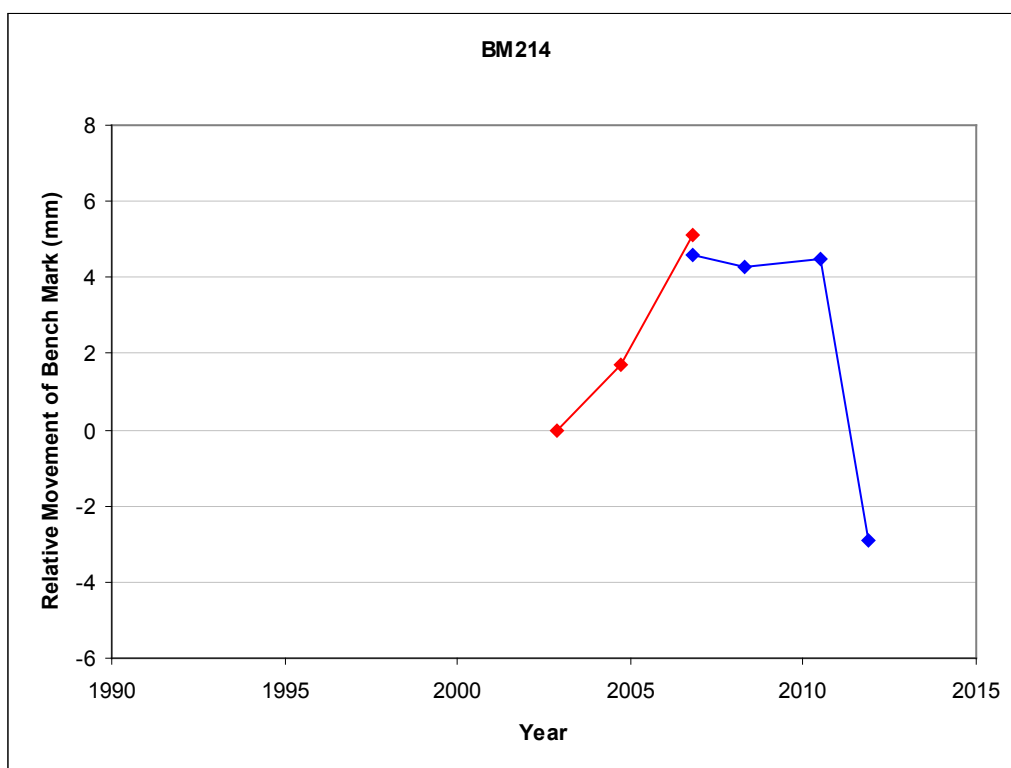
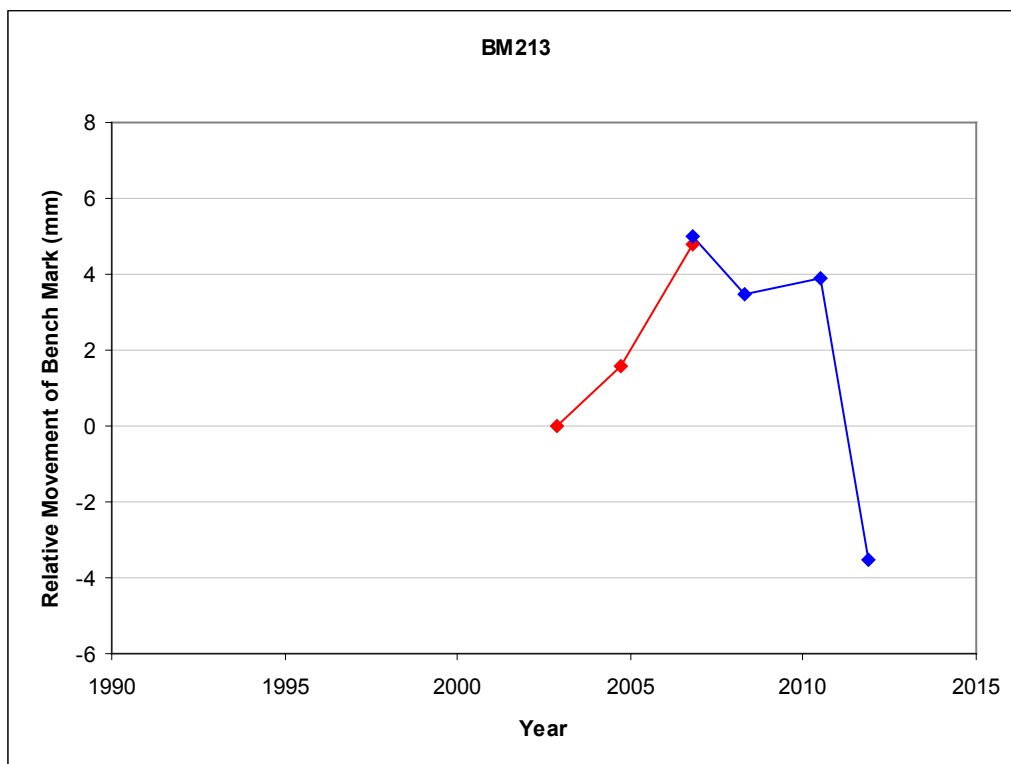
The purpose of these surveys is twofold: firstly, to provide accurate changes in land height to be used in computations of absolute sea level rise and secondly to provide accurate assessments of relative sea level rise. This is an excellent example to highlight the importance of measuring land height 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.

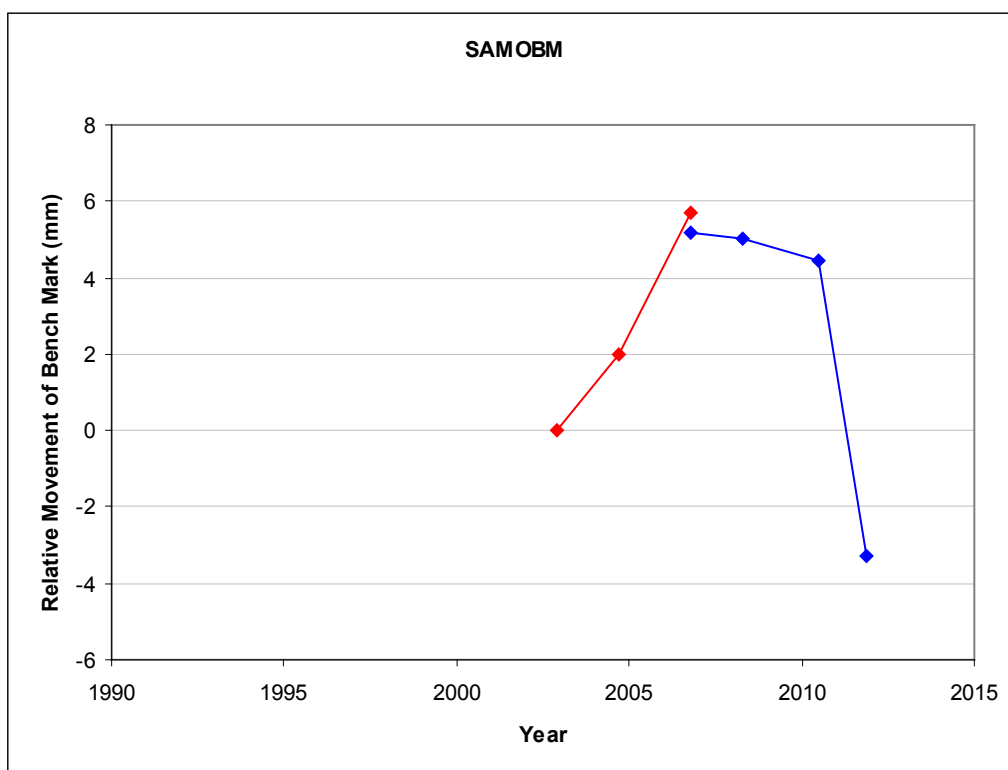
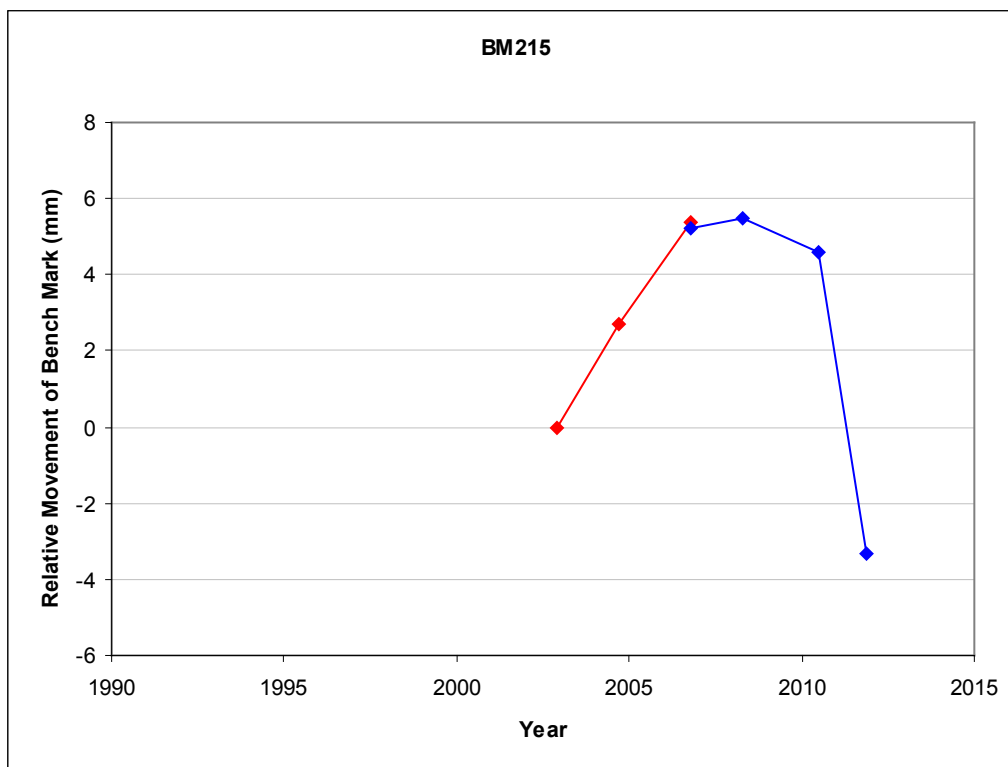
Precise Differential Levelling: 1995 - 2006 ◆ ◆
EDM Height Traversing: 2006 onwards ◆ ◆











4 Deep Bench Mark Locality Diagrams



SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: BM201

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	Date: 27-11-91
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Existing Bench Mark Established by:	Date:
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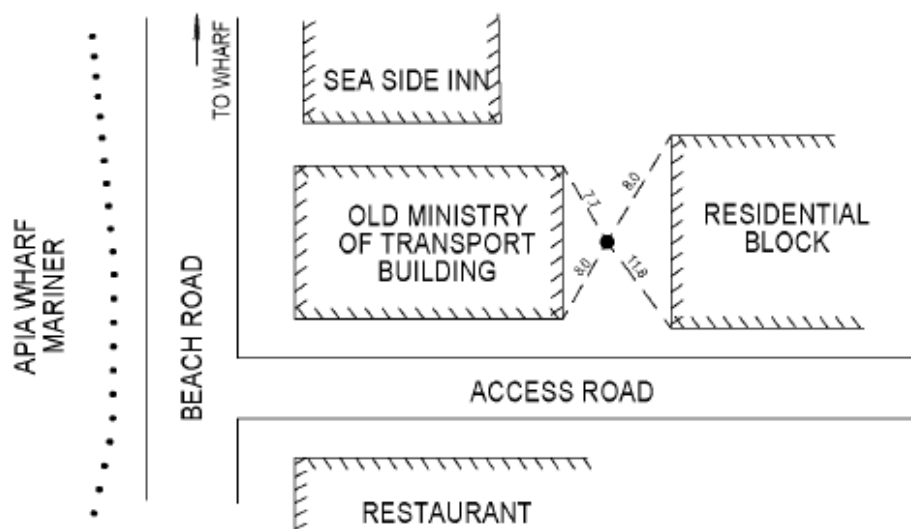
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.

Country: Western Samoa Island: Upolu	City: Apia
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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
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Approved by: Geoscience Australia / SOPAC	Date: December 2006
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c:\users\andrick\spslcmp\localitydiagrams\samoa



**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM210

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> Nov 2002
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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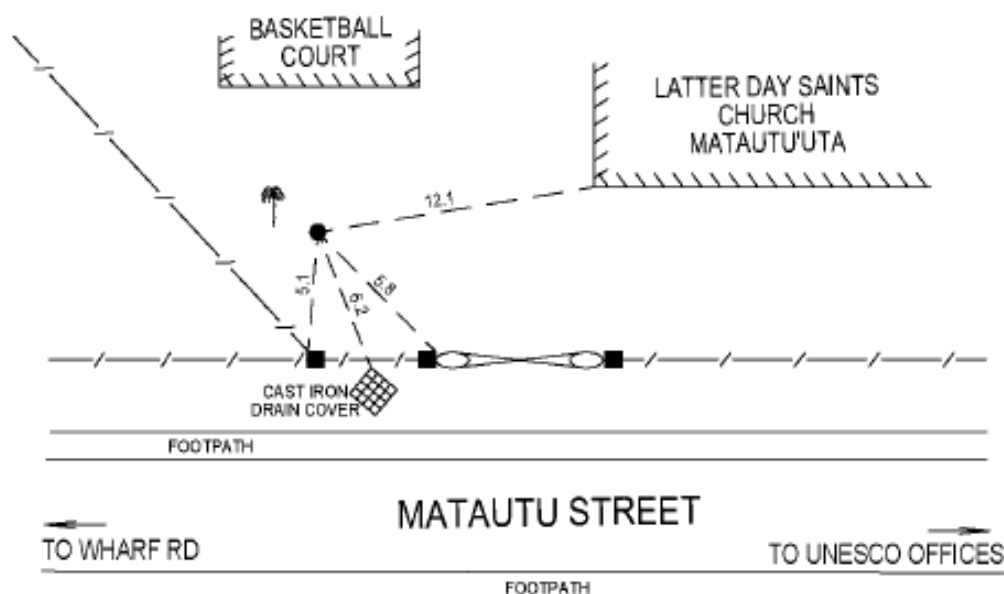
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
--

<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> 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
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Approved by: Geoscience Australia / SOPAC	Date: December 2006 c:\users\landrick\spslcmpl\localitydiagrams\samoa
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM220

<i>Original Bench Mark Established by:</i> National Geospatial Reference Systems Geospatial & Earth Monitoring Division (GEMD) Geoscience Australia	<i>Date:</i> May 2008
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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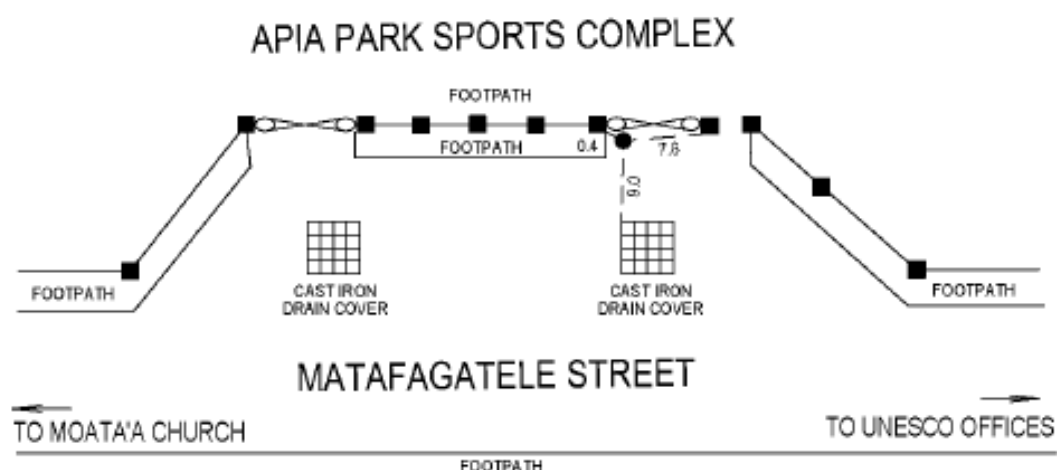
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
--

<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> Apia
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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
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Approved by: Geoscience Australia / SOPAC	Date: May 2008
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM212

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> Nov 2002
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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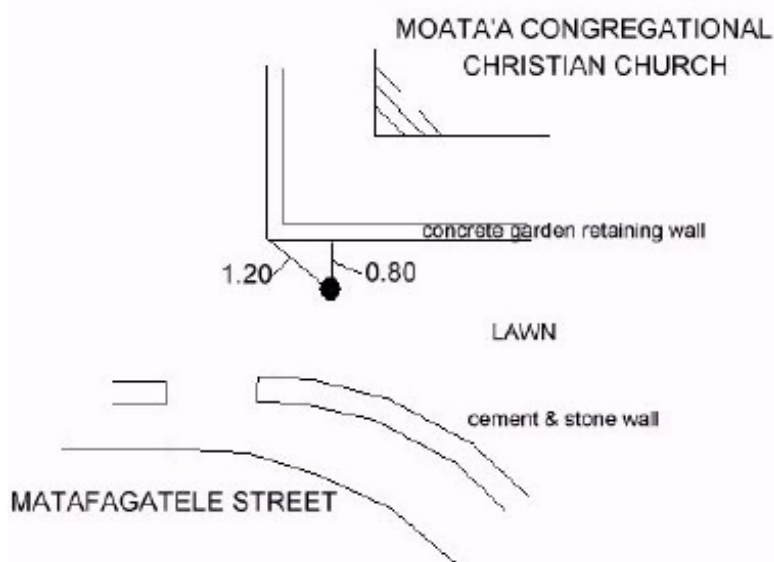
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
--

<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> 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.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: December 2006 c:\users\landrick\spslcomp\localitydiagrams\samoa
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM213

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> Nov 2002
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> Apia
<u>Marking and locality sketch</u> 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. The diagram is a locality sketch showing the location of the bench mark (BM213). It features a network of roads: Vaivase Road running horizontally, and East Coast Road running vertically. A bus stop is located on Vaivase Road. A 'TAEI' shop with a yellow painted verandah is situated south of Vaivase Road. The bench mark is indicated by a point on the verandah, with a distance of 0.5m from the ground level and 1.2m from the top of the rod. The SEA BREEZE RESTAURANT is located further east, near East Coast Road.	
Not to scale Distances in Metres Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: December 2006 c:\users\andrick\spslcomp\localitydiagrams\samoa	



**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM214

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> Nov 2002
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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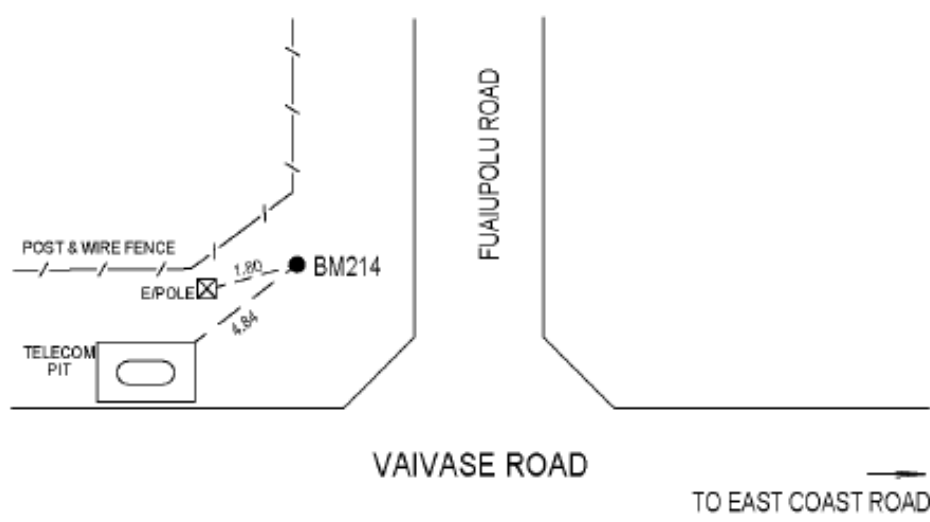
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
--

<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> Apia
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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.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: December 2006
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: BM215

<i>Original Bench Mark Established by:</i> National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	<i>Date:</i> Nov 2002
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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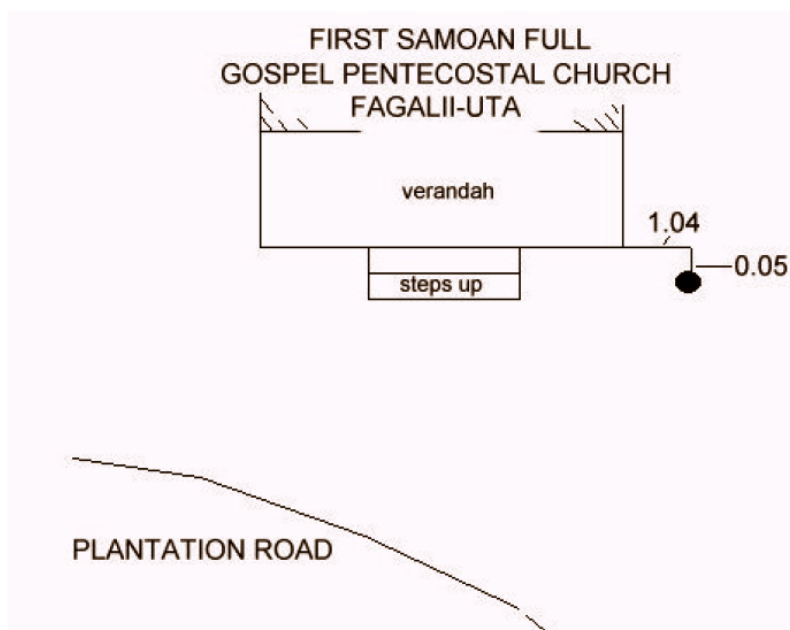
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
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<i>Country:</i> Western Samoa <i>Island:</i> Upolu	<i>City:</i> Apia
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Marking and locality 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 0.2m below ground level.

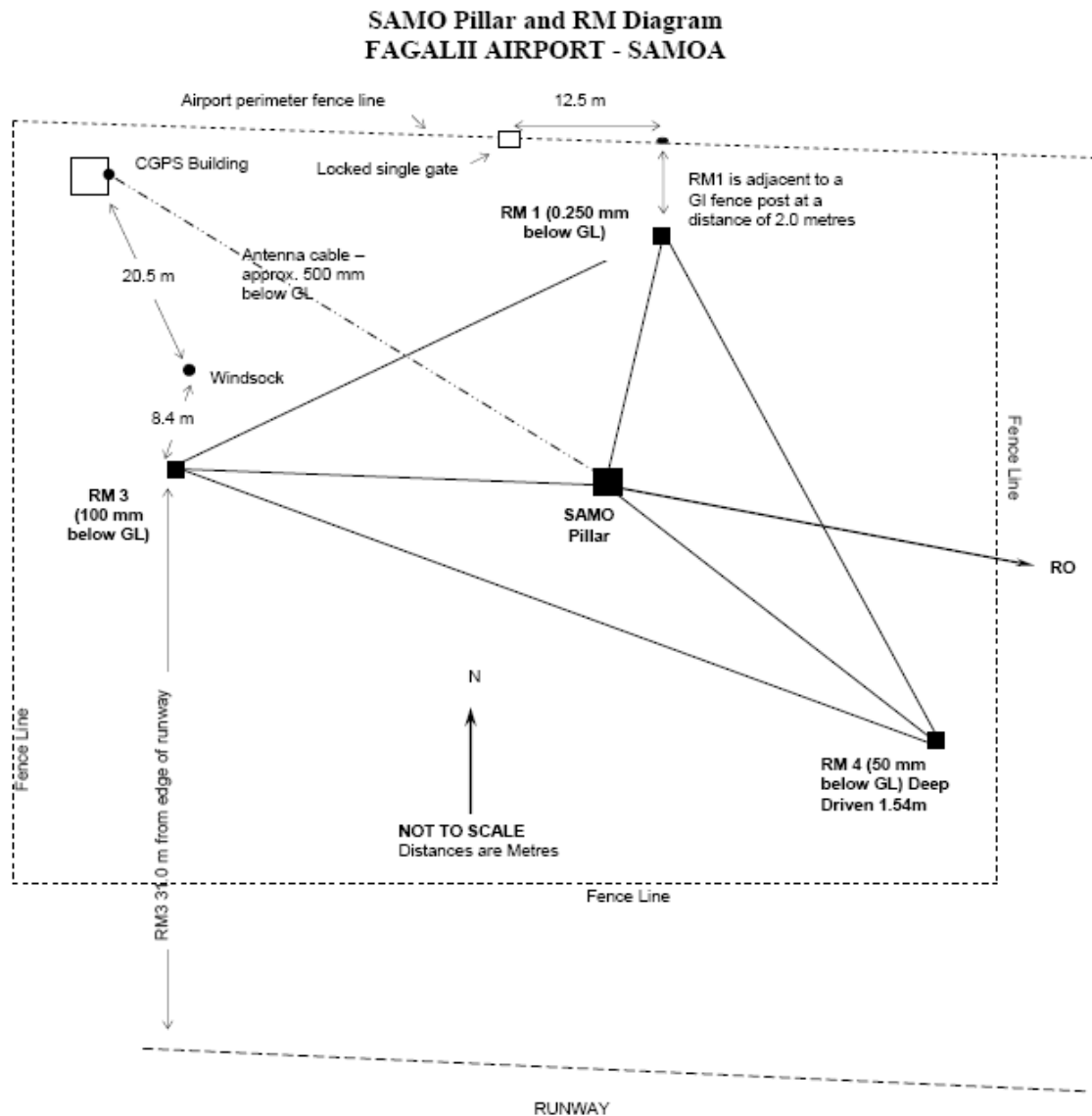
Locality sketch: Mark approximately 4500m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: December 2006
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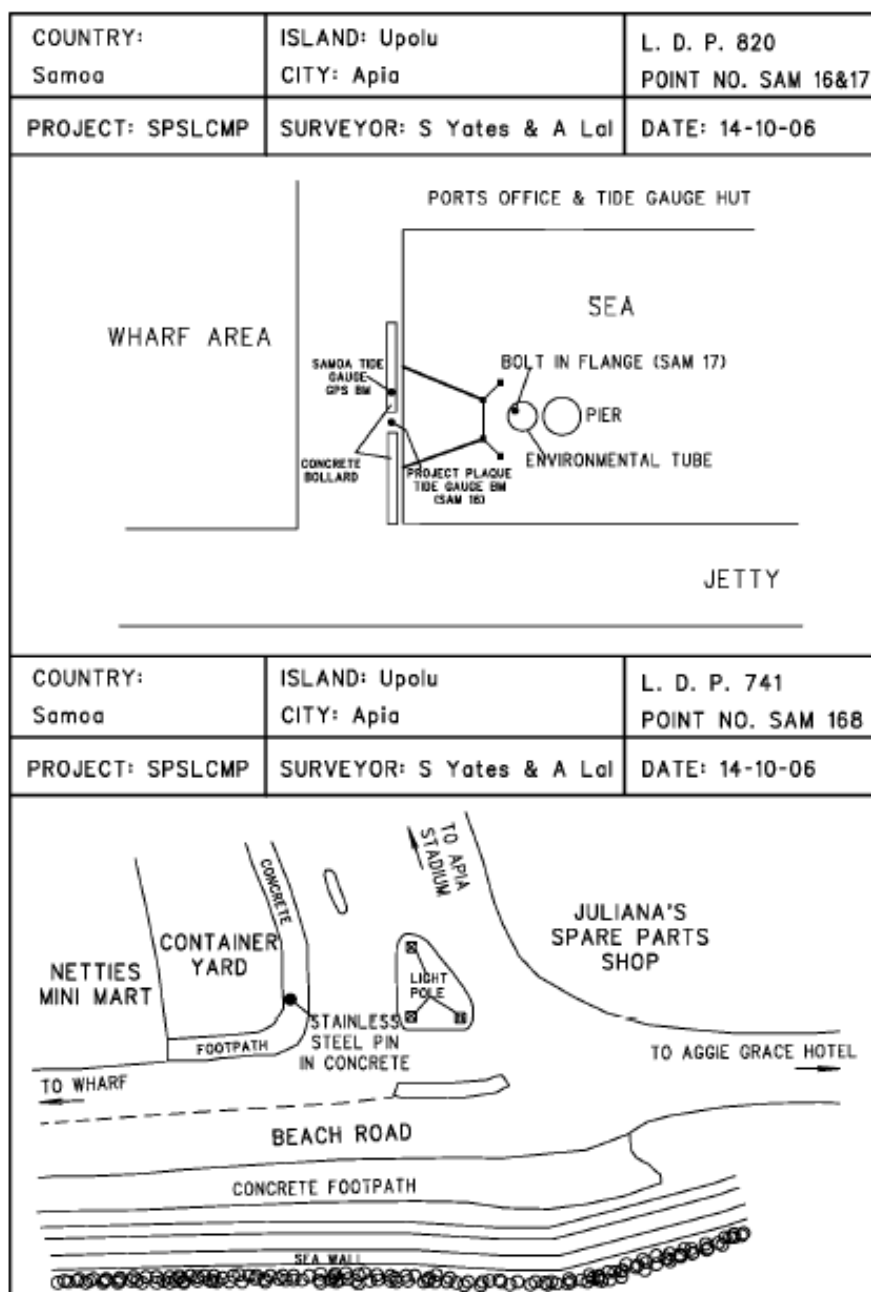
5 Western Samoa Reference Mark Locality Diagram



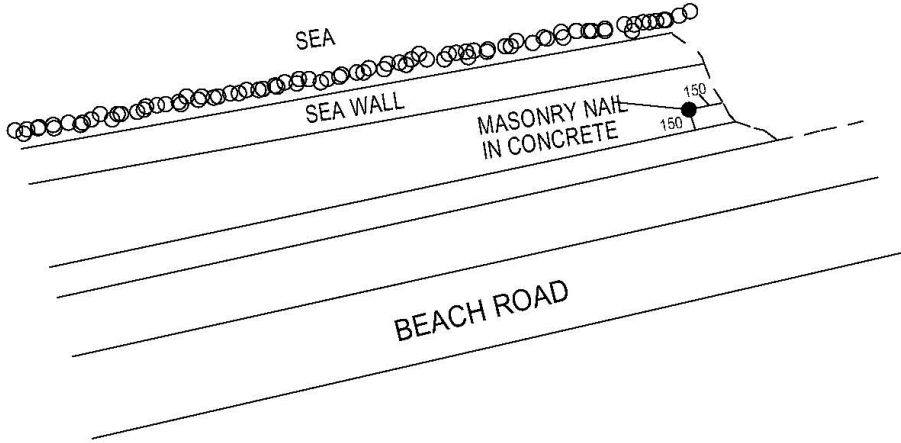
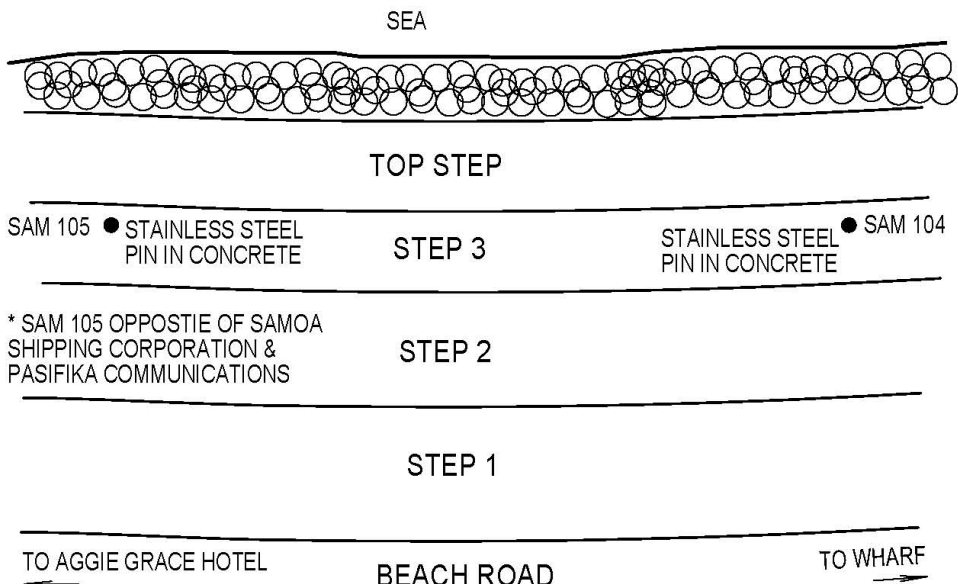
SAMO CGPS Pillar is within the Fagali Airport compound approximately 4 kilometres SE from Apia City. The Pillar is approximately 250 metres East of the Airport Terminal past the Fuel Depot, and stands 1.5m high and is 0.4m in diameter. A one metre square concrete pad is at the base of the pillar. A stainless 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).

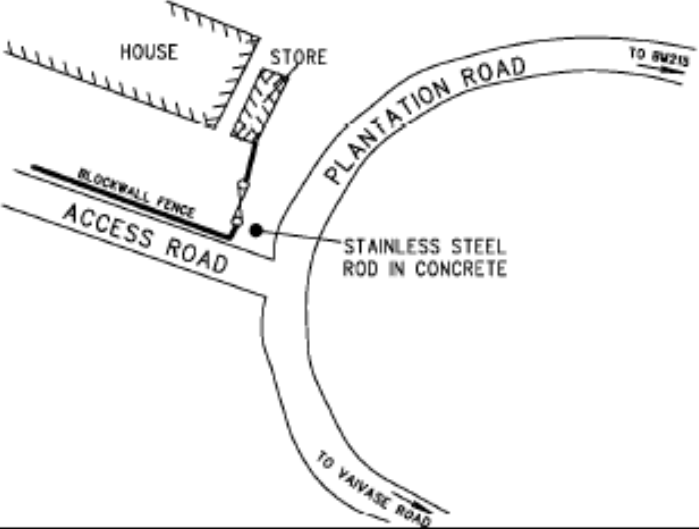
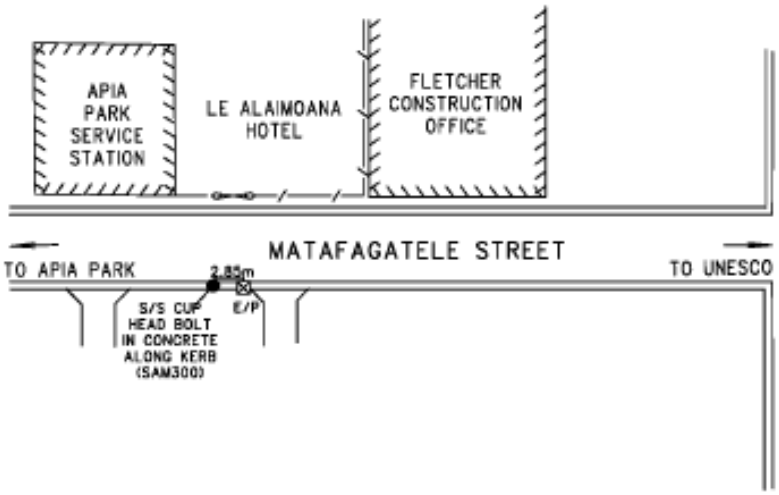
The three (3) Reference Marks and the RO consist of deep driven stainless steel rods, 20mm in diameter with a domed cap. All the reference marks and the RO are below ground level and are protected by irrigation valve boxes.

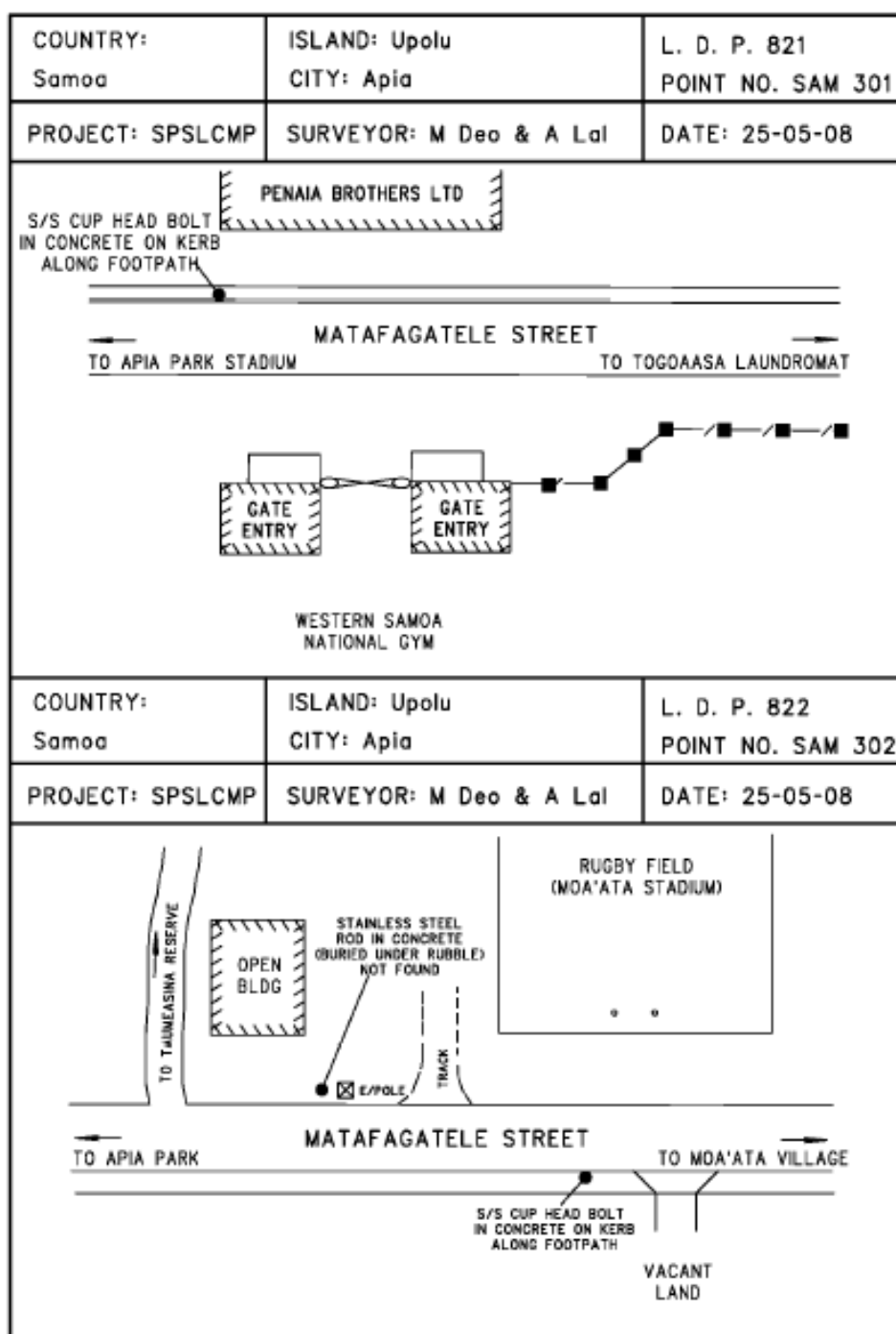
6 Temporary Holding Mark Locality Diagrams

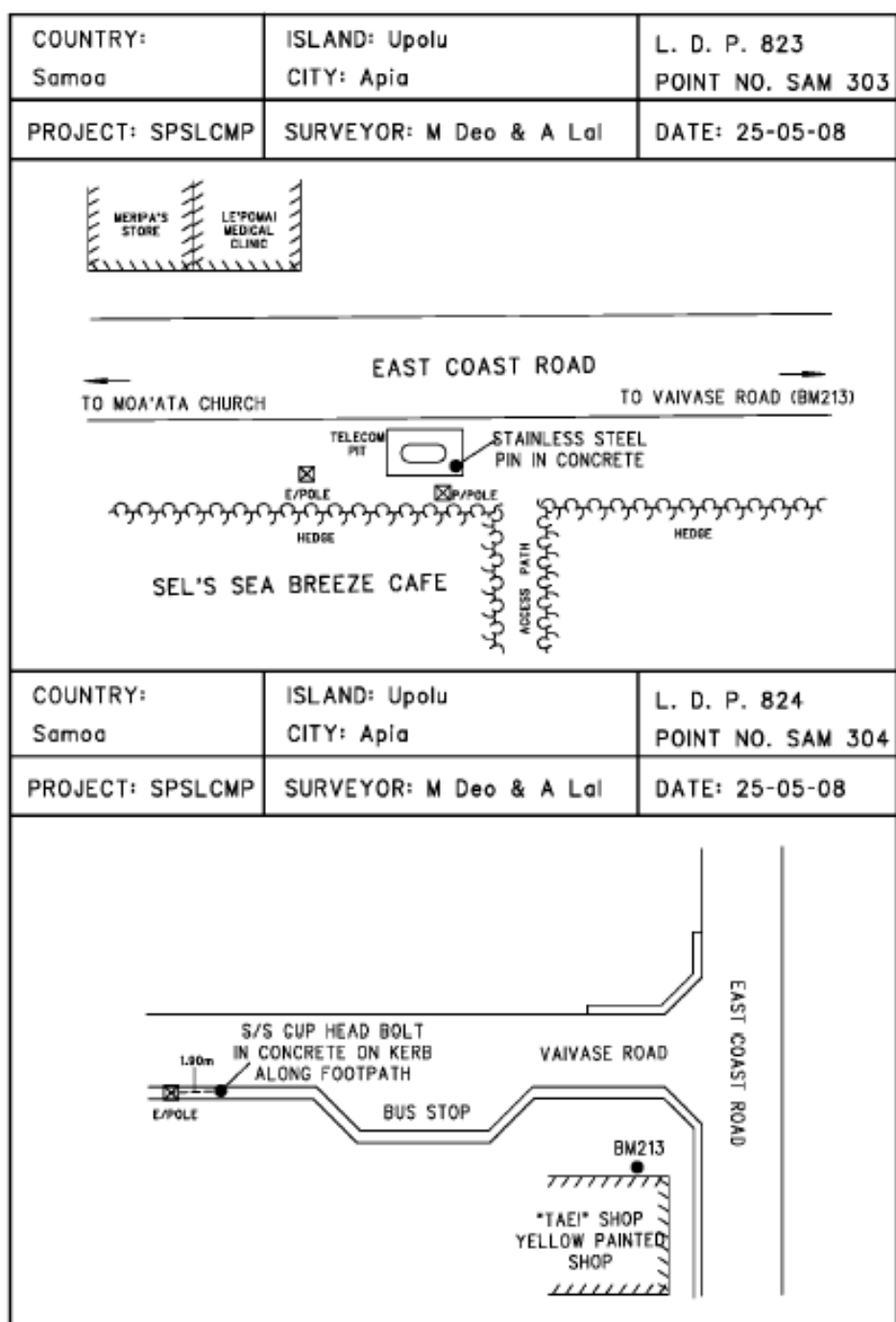


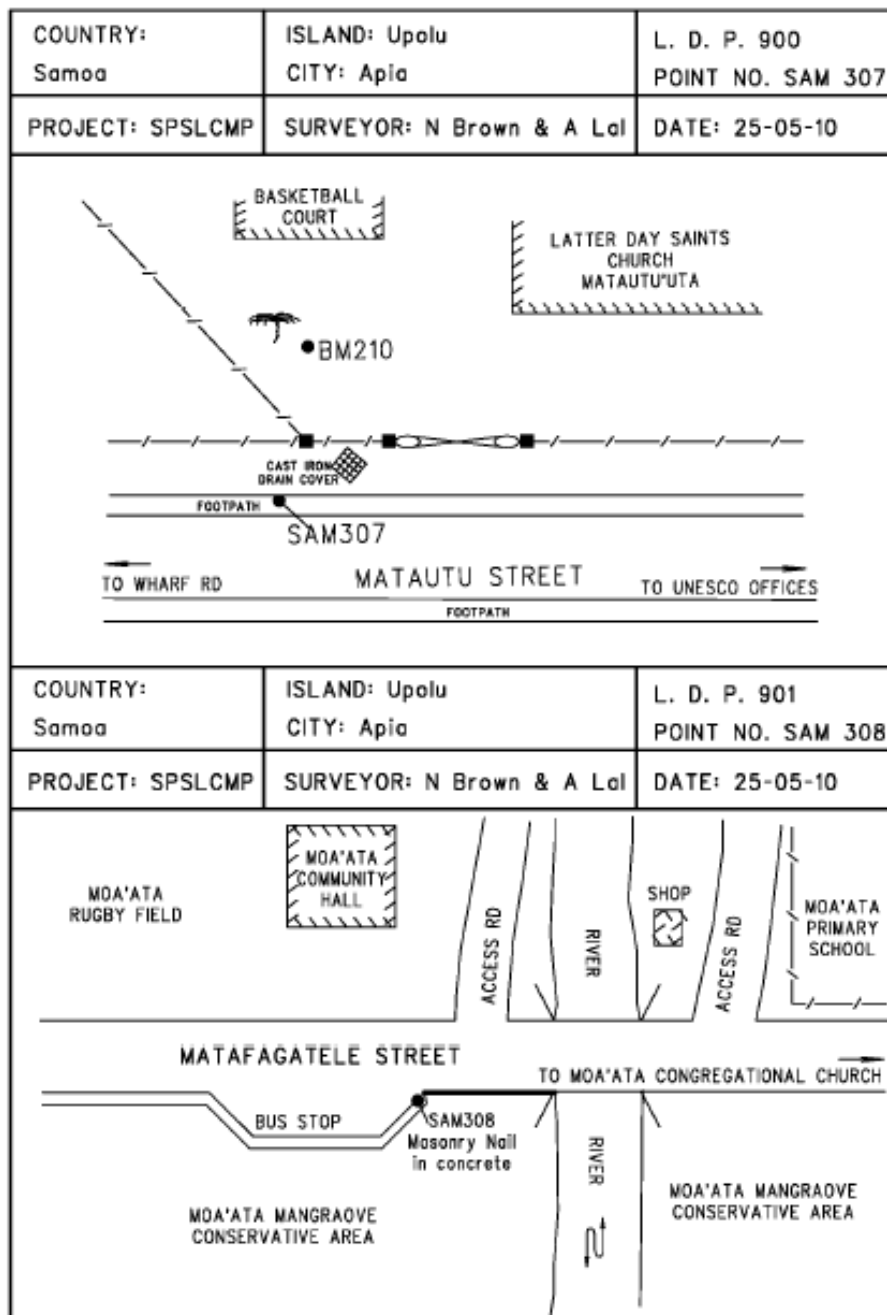
COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 745 POINT NO. SAM 170
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 14-10-06
COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 749 POINT NO. VARIOUS
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 14-10-06

COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 739 POINT NO. SAM 180
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 14-10-06
		
COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 740 POINT NO. VARIOUS
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 14-10-06
		

COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 762 POINT NO. SAM 139
PROJECT: SPSLCMP	SURVEYOR: S Yates & A Lal	DATE: 15-10-06
		
COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 820 POINT NO. SAM 300
PROJECT: SPSLCMP	SURVEYOR: M Deo & A Lal	DATE: 27-05-08
		







COUNTRY: Samoa	ISLAND: Upolu CITY: Apia	L. D. P. 903 POINT NO. SAM 309
PROJECT: SPSLCMP	SURVEYOR: N Brown & A Lal	DATE: 25-05-10

SAM309
STAINLESS STEEL
BOLT IN TAR

TIDE
GAUGE
HUT

SAMOA PORTS
AUTHORITY
WHARF OFFICE

7 References

- Rüeger, J.M. & Brunner, F.K. 1982, 'EDM Height Traversing versus Geodetic Levelling', The Canadian Surveyor, vol. 36, no. 1, pp. 69-87.
- Inter-Government Committee on Surveying and Mapping (ICSM) 2002, Standards and Practices for Control Surveys, SP1, Ver. 1.5, May 2002.