



**Australian Government**

**Geoscience Australia**

South Pacific Sea Level and Climate Monitoring  
Project (SPSLCMP)

**Survey Report**

EDM Height Traversing  
Levelling Survey

**Honiara, Solomon Islands**

**May 2009**

This project is sponsored by the Australian Agency for International Development (AusAID), managed by the Bureau of Meteorology (BOM) and supported by the National Geospatial Reference Systems Project, Geospatial Earth Monitoring Division, GEOSCIENCE AUSTRALIA.

Geocat # 69405



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## Introduction

This report outlines the level survey completed during the visit to Honiara, Solomon Islands during 12-19 May 2009.

Personnel: Manoj Deo – Surveyor - **GEOSCIENCE AUSTRALIA**  
Andrick Lal – Surveyor - **SOPAC**

This is the second EDM Height Traversing levelling survey of the deep driven bench mark array in Honiara, Solomon Islands. The previous levelling survey was performed in August 2007 by Geoscience Australia and SOPAC.

Precise Differential Levelling surveys were performed on four previous occasions, from August 1994 to March 1999 by NTC.

## The Survey

The EDM Height Traversing level survey was carried out between the 4 deep driven driven bench marks:

**FBM3**

**FBM4**

**FBM8**

**FBM9**

All the deep driven bench marks were located and found in good order and undisturbed. Included in the survey were the tide gauge SEAFRAME Bench Mark **SOL103**, SEAFRAME Sensor Mark **SOL18** and the local Department of Lands and Survey bench mark **FBM1**.

Levelling connections were also made to the newly established CGPS bench mark **SOLOBM**, the CGPS mark **SOLO** and the three deep driven CGPS reference marks **RM1**, **RM2** and **RM3**.

A connection to **FBM2** at the Police Headquarters was not possible due to time constraints caused by failure of the total station equipment during the survey.

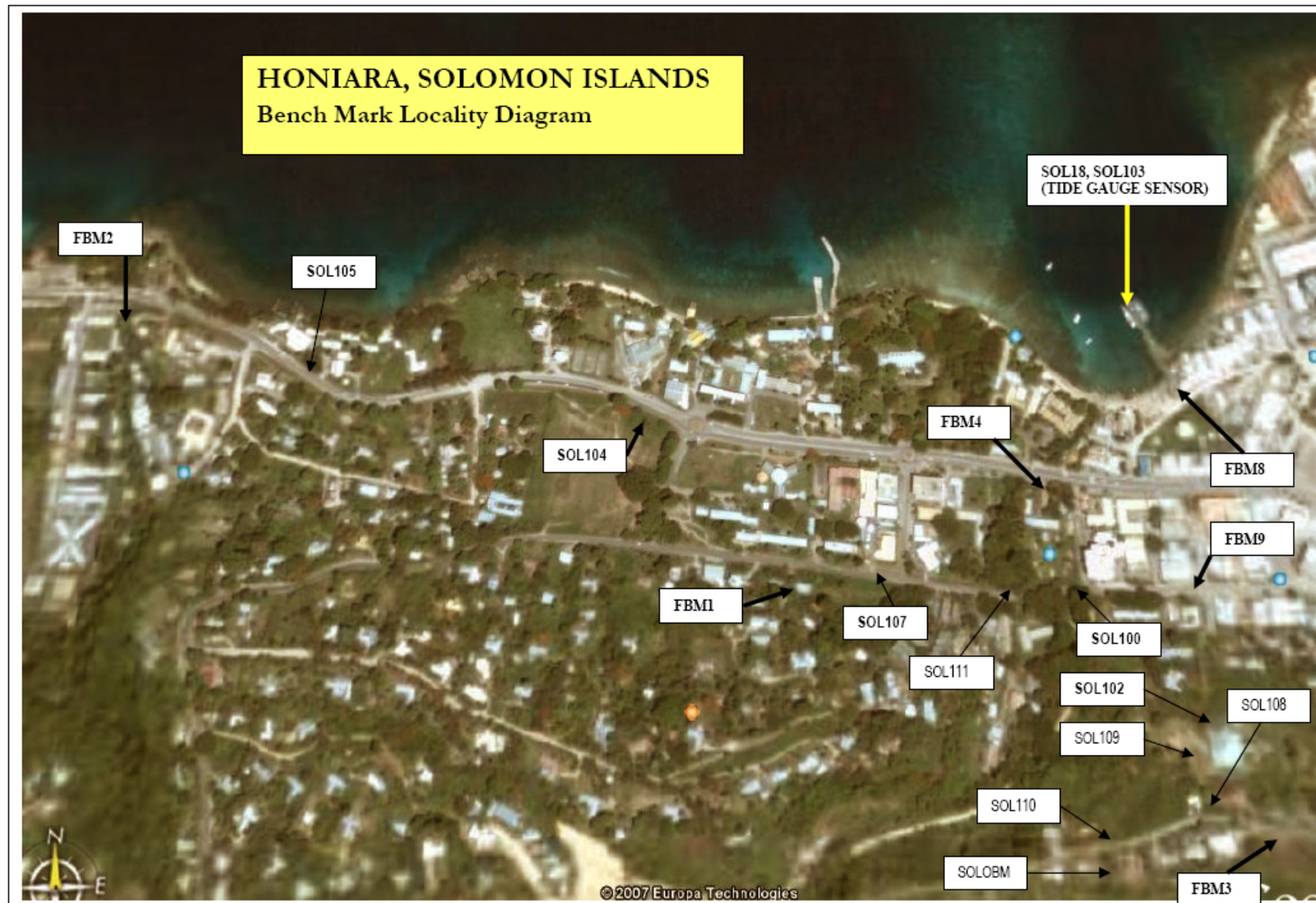


Temporary holding marks **SOL106-111** were placed during this survey and consist of stainless steel bolts drilled in concrete and then glued in place with quality epoxy resin.

The EDM Height Traversing levelling technique was performed to the Class L2A, as per the Inter-Government Committee on Surveying and Mapping (ICSM), Standards and Practices for Control Surveys, SP1, Ver. 1.5, May 2002.

After reduction an internal precision of **1mm  $\sqrt{K}$**  or better was achieved, where K is the levelled distance in kilometres. This is within the Project Specification of **2mm  $\sqrt{K}$**





## The Solomon Islands Datum

The Datum for the survey is Mean Sea Level (MSL).

Reduction of the data has been calculated holding **FBM4** fixed at 3.61966 metres. This value was determined by the NTC in 1994.

## Equipment

LEICA Total Station Model TCA2003 and TCA1800

LEICA Precision Prisms GPH1P (2).

LEICA Rigid Tripod.

Stainless Steel Target Poles supported by LEICA telescopic Bi-Poles (2).

LEICA Cast Iron Change Plates (2).

KESTRAL 4000 Pocket Weather Tracker

## Method

**“Leap-Frog” EDM-Height-Traversing:** "Leap-Frog" EDM-Height-Traversing involves the one target remaining at a particular change point for both sightings. To avoid the possibility of the target being placed on a different point the target is not moved between the back-sight and foresight. Two target/reflectors are employed (on reflector rods with struts). As in spirit levelling, it is imperative that the electronic tacheometer (total station) is set up in the middle between the two reflectors. Recorded are the height differences (between the instrument's trunnion axis and the reflector) that are computed by the electronic tacheometers. In consequence, the ambient temperature and pressure must be input into the instrument since the slope distances must be corrected for temperature and pressure (first velocity correction) on-line. See Rüeger & Brunner (1982) and *The Canadian Surveyor*, 36(1): 69-87.

***All observations were recorded digitally.***

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. Results can also be gained with the EDM Height Traversing method by using a single set-up / single rod configuration. To achieve height differences when using this single



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rod configuration, a simple comment line is added, indicating this is the case before running the program.

This “single set-up / single rod” configuration is particularly useful when levelling between bench marks which are close together e.g. between the Project Plaque BM and the SEAFRAME Sensor BM.

All levelling bays 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.

Atmospheric readings were obtained using a KESTRAL 4000 Pocket Weather Tracker. These atmospheric readings were recorded manually onto the Solomon Islands Levelling Booking Sheets and entered into the Total Station prior to each level run and approximately every hour thereafter or when ever an obvious change in weather conditions was observed.

## Survey Support

The survey team very much appreciated the assistance from Solomon Islands Meteorological Service, especially the assistance of Mr. Chanel Iroi in arranging for customs clearance for the replacement survey total station. Chanel is the Deputy Secretary for the Solomon Islands Ministry of Environment, Meteorology and Climate Change.

Staff from the Solomon Islands Meteorological Service have developed a keen interest in the SPSLCMP project and were eager to provide assistance when required.

## Issues

The Deep driven Driven Bench Mark FBM2 is inside the Solomon Islands Police headquarters which is a high security area. Special approval is required from the Commissioner of Police, which can be arranged by the Solomon Islands Meteorological Service.

The TCA2003 total station started malfunctioning from Thursday 14 May and





completely stopped working on Saturday. A replacement TC1800 total station was freighted from Geoscience Australia in order to complete the survey, which arrived on Sunday 17 May. All aspects of the survey were completed except a levelling connection to bench mark **FBM2** located at the police headquarters.

## Description of Marks – Honiara, Solomon Islands

**FBM4** is the bench mark held fixed with **RL = 3.61966 metres**

The height of **FBM4** was derived by NTC by:

**1994** Adopting the **MSL** height of **FBM4** for the 1994 survey. RL = 3.61966m MSL

**1996** Adopting the MSL height of **FBM4** as derived from the 1994 survey. RL = 3.61966m MSL.

Bench Marks **FBM3**, **FBM4**, **FBM8**, **FBM9** are all Deep driven Driven BM's.

Bench Mark **FBM1** is a Fundamental Bench Mark of the Department of Lands and Survey.

**SOL18** is the SEAFRAME Sensor Mark

**SOL103** is a bench mark located below the SEAFRAME Sensor Mark.

**SOLOBM** is the CGPS bench mark, **SOLO** is the CGPS mark and **RM1**, **RM2** and **RM3** are the three CGPS reference marks.

Points used with the prefix of **SOL** are temporary holding marks. These include marks placed in the previous survey (**SOL101-103**) as well as new marks placed during this survey (**SOL106-111**).

Locality Diagrams for all Marks used in the 2009 survey can be found on Pages 19 – 29.





## Table of Results and Comparisons between the 2007 and 2009 EDM Height Traversing Surveys

Solomon Islands 2007 EDM Height Traversing Levelling Comparison 2007- 2009 and Table of Results								
FBM4 - Adopted fixed height (MSL) = 3.6196600m								
Backsight	Foresight	Levelled Height Difference	Reduced Level 2009	Misclose (mm)	Distance (km)	1mm√K	Reduced Level 2007	Difference (mm) 2007-2009
FBM4			3.6197				3.6197	0.0000
SOL106	SOL106	-0.4128	3.2068	0.177	0.097	0.311		
FBM8	FBM8	-1.2443	1.9626	0.095	0.143	0.378	1.9626	0.0000
SOL103	SOL103	0.3459	2.3085	-0.166	0.124	0.352	2.3093	0.0008
	SOL18	1.2633	3.5718	-0.026	0.012	0.110	3.5720	0.0001
FBM4			3.6197				3.6197	0.0000
SOL107	SOL107	1.3793	4.9990	-0.009	0.115	0.340		
FBM9	FBM9	-0.2487	4.7502	-0.206	0.143	0.378	4.7500	-0.0003
SOL102	SOL102	26.4883	31.2386	-0.054	0.137	0.369	31.2348	-0.0038
SOL109	SOL109	9.1931	40.4317	-0.050	0.069	0.263		
SOL108	SOL108	9.8778	50.3095	0.138	0.096	0.310		
	FBM3	3.7389	54.0485	0.286	0.070	0.264	54.0467	-0.0018



SOL108			50.3095					
SOL110	SOL110	3.7805	54.0900	0.388	0.203	0.451		
SOLOBM	SOLOBM	0.2233	54.3134	-0.013	0.034	0.185	<b>**54.3111</b>	-0.0022
	SOLO	1.4667	55.7801	-0.075	0.027	0.163	<b>**55.7756</b>	-0.0045
SOLOBM			54.3134					
	RM1	-0.0687	54.2446	-0.010	0.027	0.164	<b>**54.2426</b>	-0.0021
SOLOBM			54.3134					
	RM2	-1.2953	53.0180	0.013	0.011	0.106	<b>**53.0157</b>	-0.0023
SOLOBM			54.3134					
	RM3	-0.5574	53.7560	0.033	0.028	0.166	<b>**53.7536</b>	-0.0024
SOL107			4.9990					
SOL111	SOL111	0.4890	5.4880	0.050	0.066	0.256		
SOL101	SOL101	-1.3604	4.1276	-0.215	0.201	0.449	4.1279	0.0003
	FBM1	2.2587	6.3863	0.263	0.148	0.384	6.3866	0.0003
Misclose for all bays levelled =				0.618	1.751	1.323	Allowable Misclose is $2\sqrt{K}=2.646\text{mm}$	
An internal precision of $1\text{mm}\sqrt{K}$ was achieved for all bays levelled. This is well within the project specification of $2\text{mm}\sqrt{K}$								
<b><i>**Reduced levels for SOLOBM, SOLO and RM1-3 were determined from an EDM height traversing survey performed during the installation of the Solomon Islands CGPS station in June 2008.</i></b>								



## Combined Comparisons 1994 to 2009

SOLOMON ISLANDS - Comparison of the Reduced Levels between the Precise Differential Levelling method (1994 to 1999) and the EDM Height Traversing Technique (2007-2009)													
YEAR	MARK												
	FBM1	FBM2	FBM3	FBM4	SOL18	SOL103	FBM8	FBM9	SOLOBM	SOLO	RM1	RM2	RM3
1994.7	6.3860	3.3171	54.0460	3.6197	3.5755								
1996.2	6.3848	3.3175	54.0457	3.6197	3.5758								
1997.7	6.3857	3.3182	54.0449	3.6197	3.5741								
1999.3	6.3856	3.3161	54.0444	3.6197	3.5742								
2007.7 EDM	6.3866	3.3177	54.0467	3.6197	3.5720	2.3093	1.9626	4.7500	<b>**54.3111</b>	<b>**55.7756</b>	<b>**54.2426</b>	<b>**53.0157</b>	<b>**53.7536</b>
2009.4 EDM	6.3863	-	54.0485	3.6197	3.5718	2.3085	1.9626	4.7502	54.3134	55.7801	54.2446	53.0180	53.7560

***\*\*Reduced levels for SOLOBM, SOLO and RM1-3 were determined from an EDM height traversing survey performed during the installation of the Solomon Islands CGPS station in June 2008.***



## Honiara – Solomon Islands 2009 Reduced Levels

**Date:** 12-19 May 2009

**Datum:** Mean Sea Level

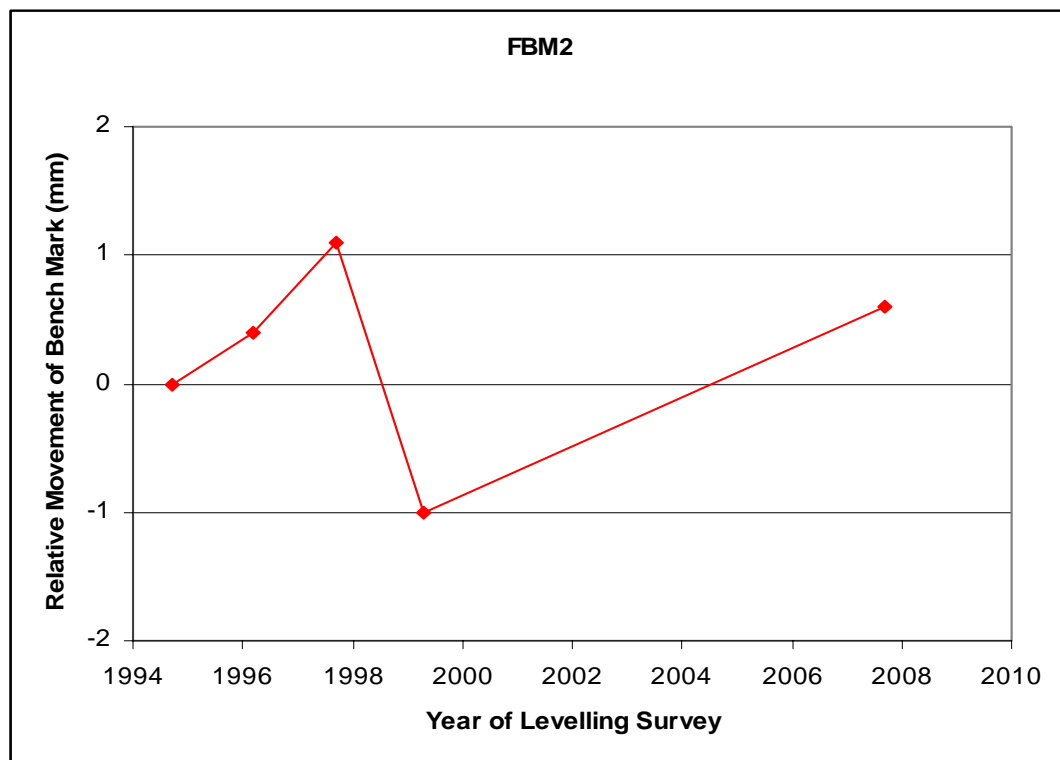
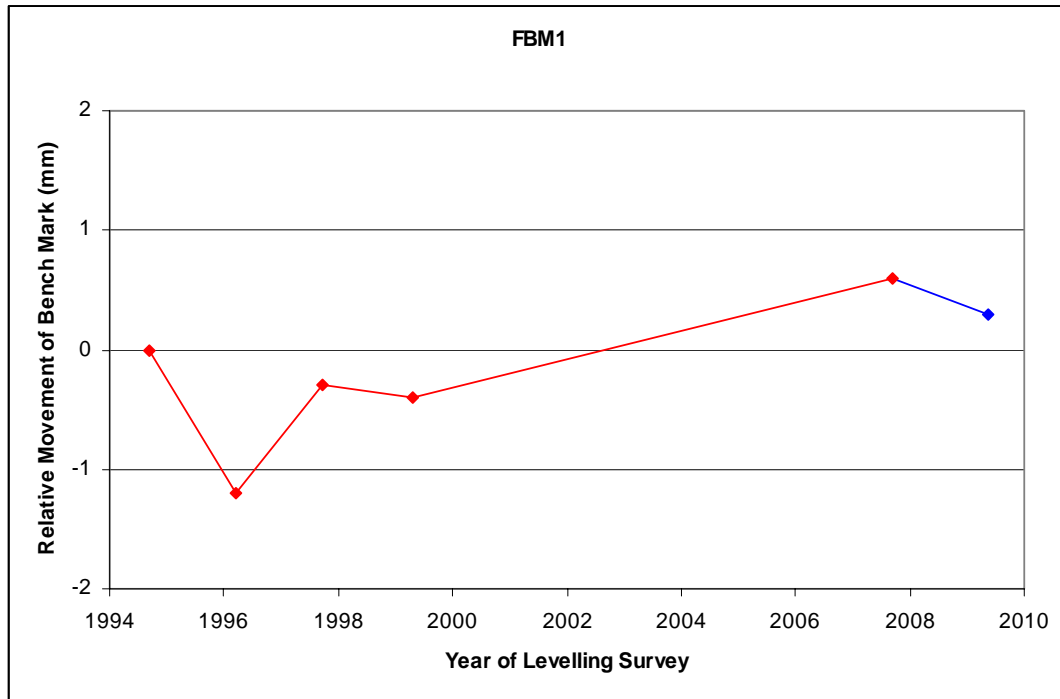
POINT#	2009 levelled diff. ht.	2009 RL
FBM4	0.0000	3.6197 (fixed)
SOL106	-0.4128	3.2068
FBM8	-1.6571	1.9626
SOL103	-1.3112	2.3085
SOL18	-0.0478	3.5718
SOL107	1.3793	4.9990
FBM9	1.1306	4.7502
SOL102	27.6189	31.2386
SOL109	36.8120	40.4317
SOL108	46.6899	50.3095
FBM3	50.4288	54.0485
SOL110	50.4704	54.0900
SOLOBM	50.6937	54.3134
SOLO	52.1604	55.7801
RM1	50.6250	54.2446
RM2	49.3984	53.0180
RM3	50.1363	53.7560
SOL111	1.8684	5.4880
SOL101	0.5080	4.1276
FBM1	2.7666	6.3863

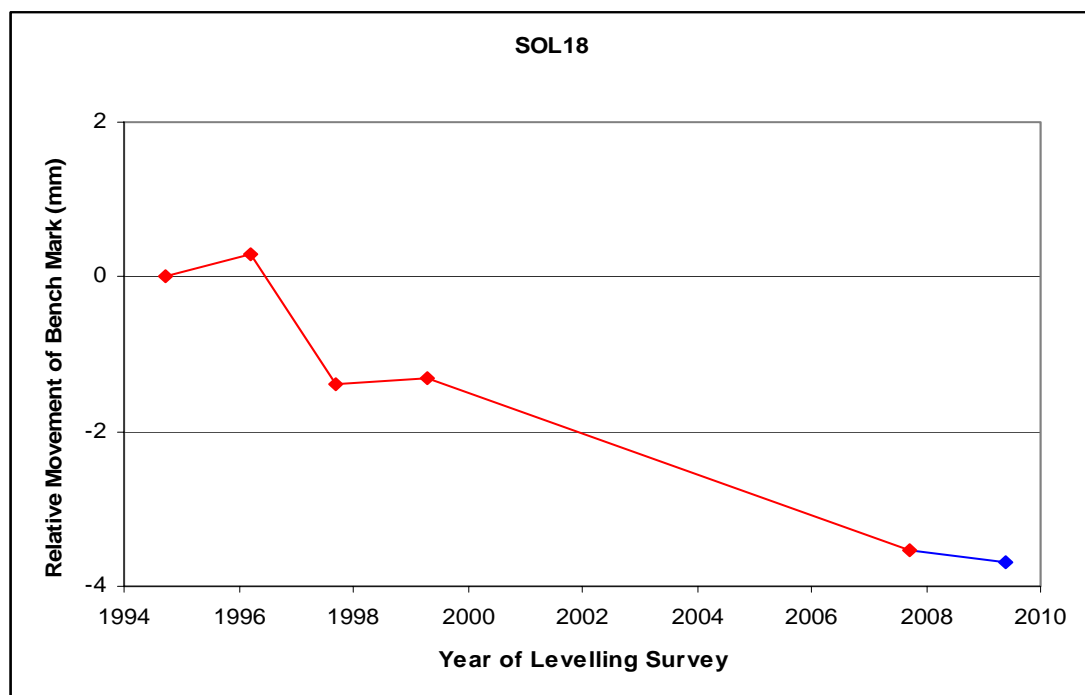
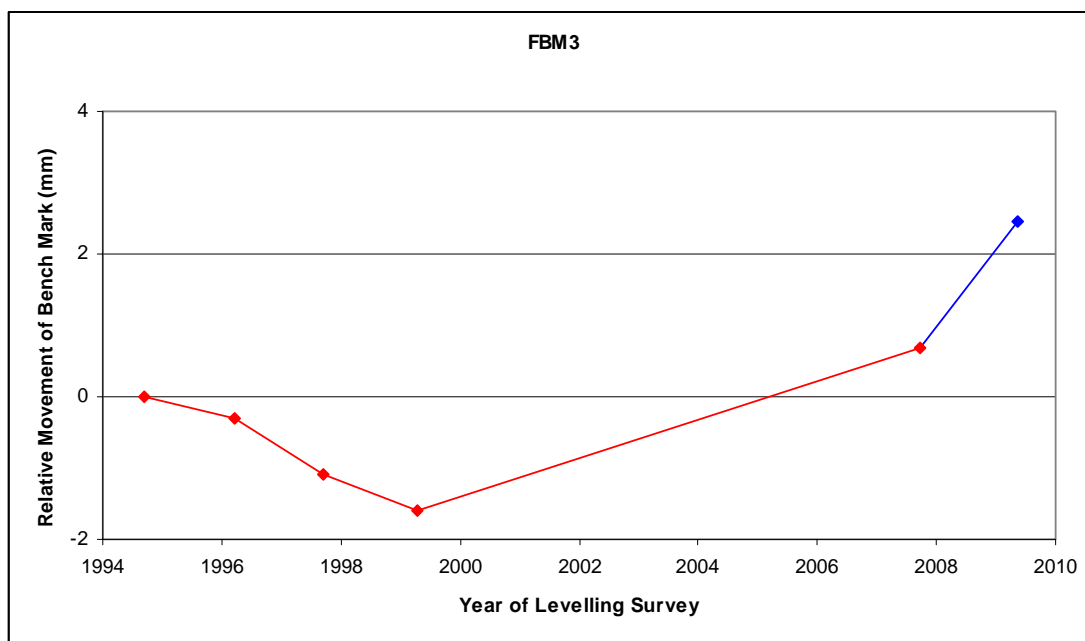


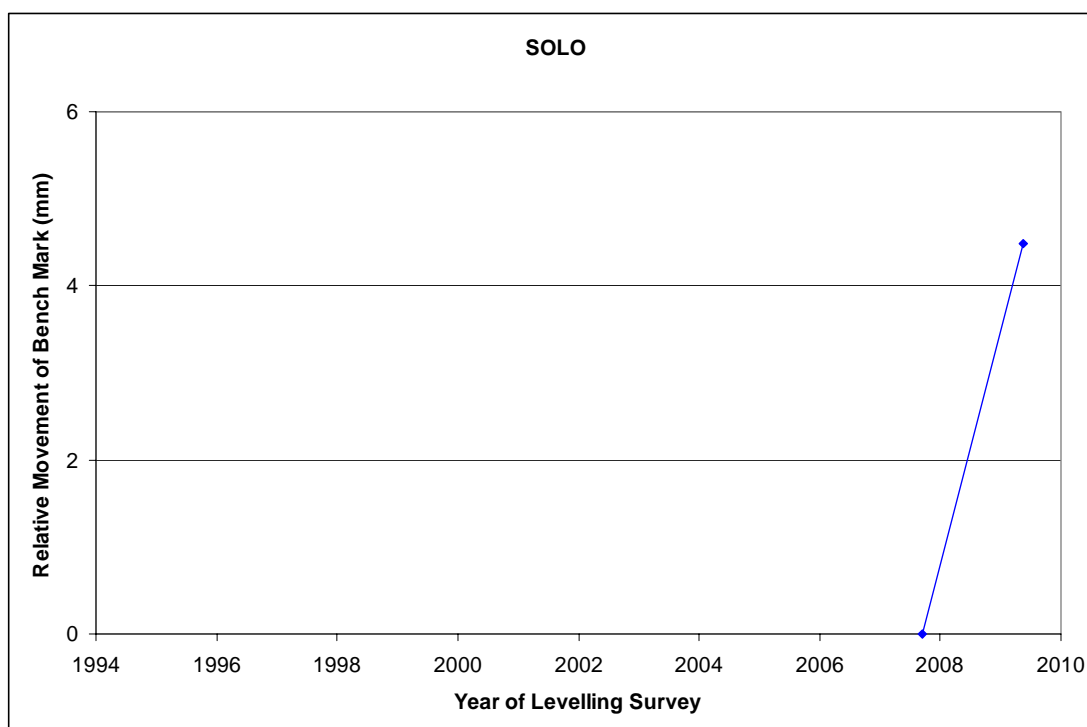
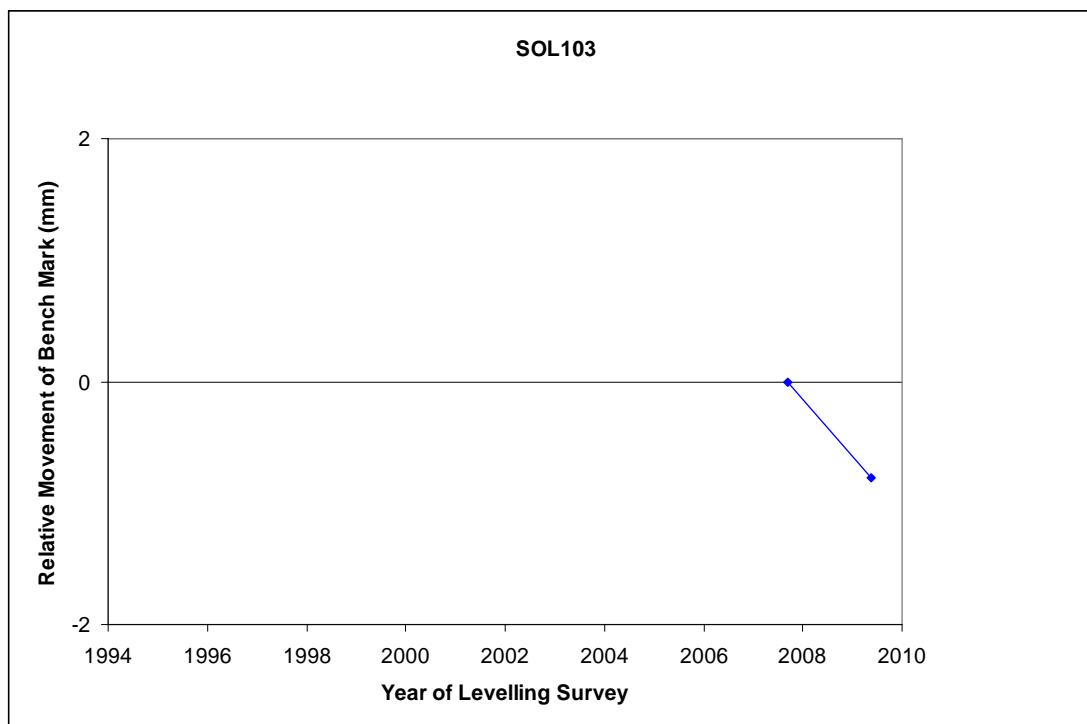
## Time Series of Bench Mark Movement relative to the Fixed Deep driven Bench Mark – FBM4

Precise Differential Levelling - 1994 to 1999

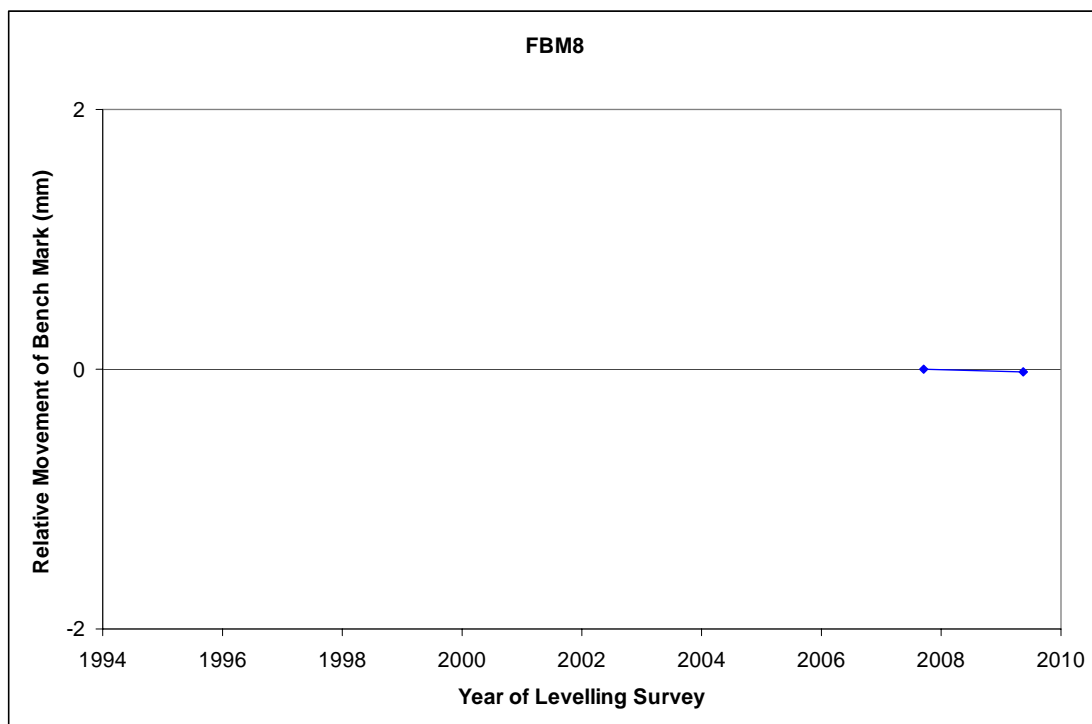
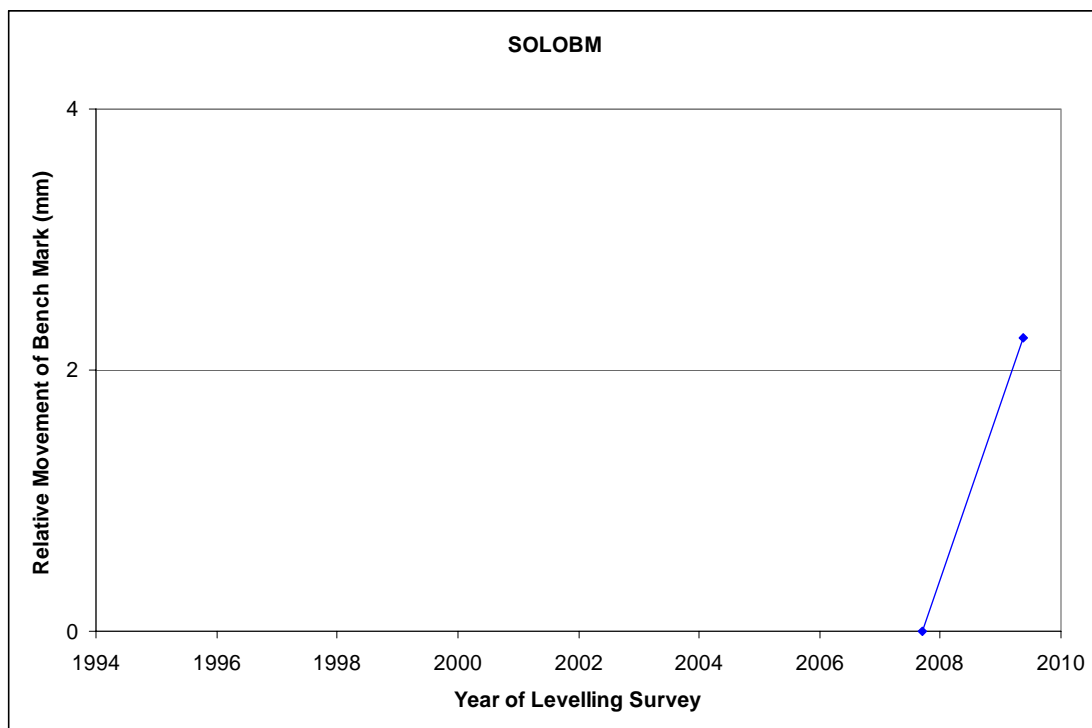
EDM Height Traversing - commenced 2007

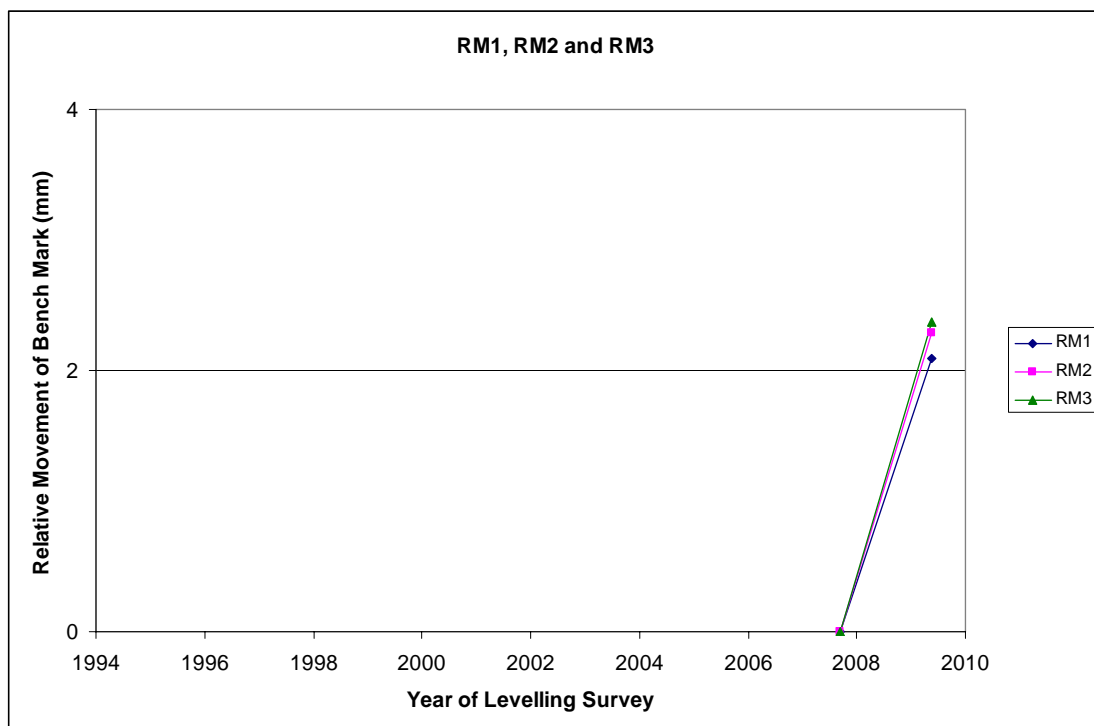
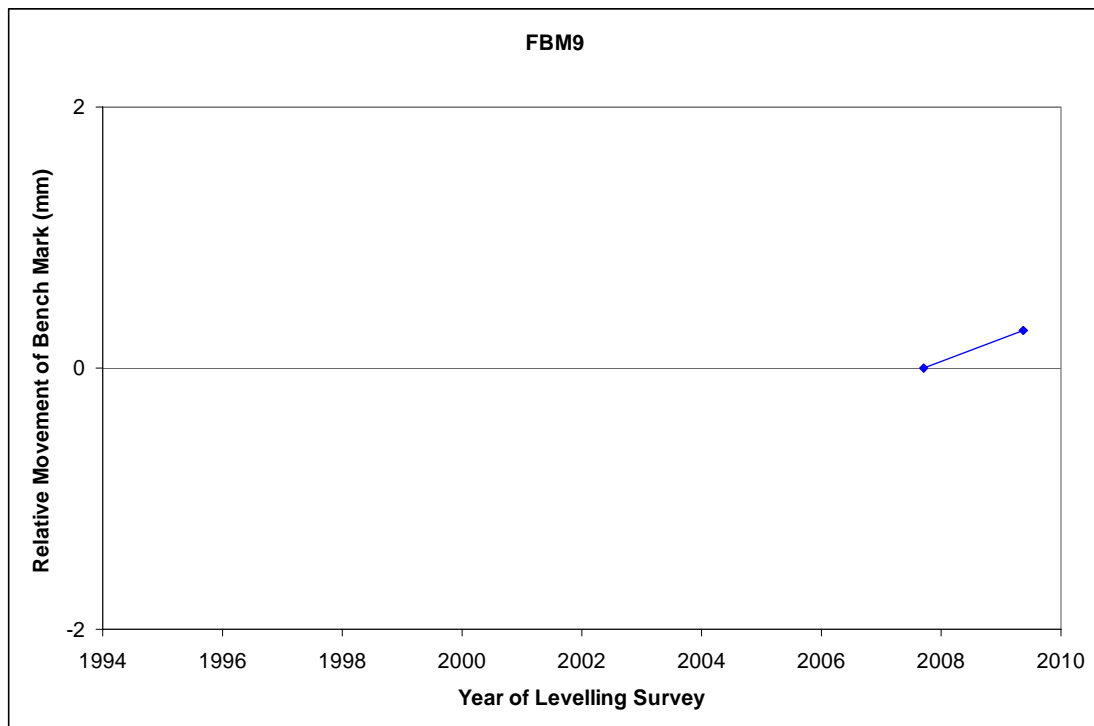












# Deep driven Bench Mark Locality Diagrams



## SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



### Survey Bench Mark Record

**Bench Mark Number: FBM1**

Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.		Date: Unknown
Existing Bench Mark Established by:		Date:
Notes / References: Department of Lands & Surveys BM register - FBM (Honiara) This survey mark is not in a good locality for GPS occupation.		
Country: Solomon Islands Island: Guadalcanal		City: Honiara
<p align="center"><u>Marking and locality sketch</u></p> <p>Bench Mark: Brass bolt in the centre of a concrete pillar 35cm diameter and approx. 70cm above ground level</p> <p>Locality sketch: Mark approximately 750m from the tide gauge station.</p> <p>Not to scale                      Distances in Metres                      Magnetic bearings</p>		
Approved by: Geoscience Australia / SOPAC		Date: Dec 2007





SOUTH PACIFIC SEA LEVEL  
&  
CLIMATE MONITORING PROJECT



Survey Bench Mark Record

**Bench Mark Number: FBM3**

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. Date: 28-10-91

Existing Bench Mark Established by: Date:

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

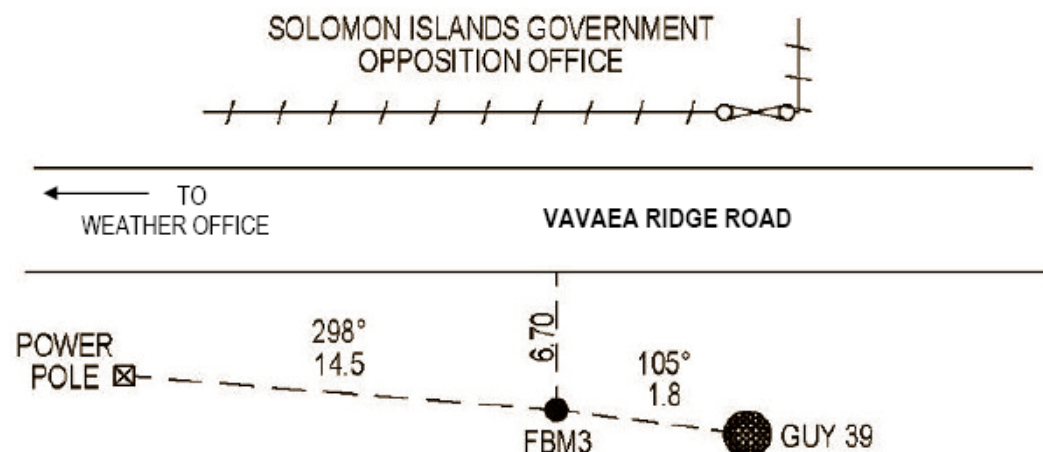
Country: Solomon Islands  
Island: Guadalcanal

City: Honiara

Marking and locality sketch

Bench Mark: 6.0m of 19mm diameter stainless steel capped rod driven to refusal.  
Rod sheathed with 50mm diameter PVC tube for top 2.0m. Top of mark  
0.25m below ground level

Locality sketch: Mark approximately 2200m from the tide gauge station.



Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: Dec 2007





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



**Survey Bench Mark Record**

**Bench Mark Number: FBM4**

<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> 30-07-94
<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
<i>Notes / References:</i> Deep Benchmark This survey mark is not in a good locality for GPS occupation.	
<i>Country:</i> Solomon Islands <i>Island:</i> Guadalcanal	<i>City:</i> Honiara
<p style="text-align: center;"><u>Marking and locality sketch</u></p> <p>Bench Mark: 1.8m of 19mm diameter stainless steel capped rod driven to refusal.          Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark          0.3m below ground level</p> <p>Locality sketch: Mark approximately 370m from the tide gauge station.</p> <div style="text-align: center; margin-top: 20px;"> </div>	
<div style="display: flex; justify-content: space-between;"> <span>Not to scale</span> <span>Distances in Metres</span> <span>Magnetic bearings</span> </div>	
<div style="display: flex; justify-content: space-between;"> <span>Approved by: Geoscience Australia / SOPAC</span> <span>Date: Dec 2007</span> </div>	





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



**Survey Bench Mark Record**

**Bench Mark Number: FBM8**

Original Bench Mark Established by: National Geospatial Reference Systems, Geospatial & Earth Monitoring Division (GEMD), Geoscience Australia.	Date: 20-08-07
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Existing Bench Mark Established by:	Date:
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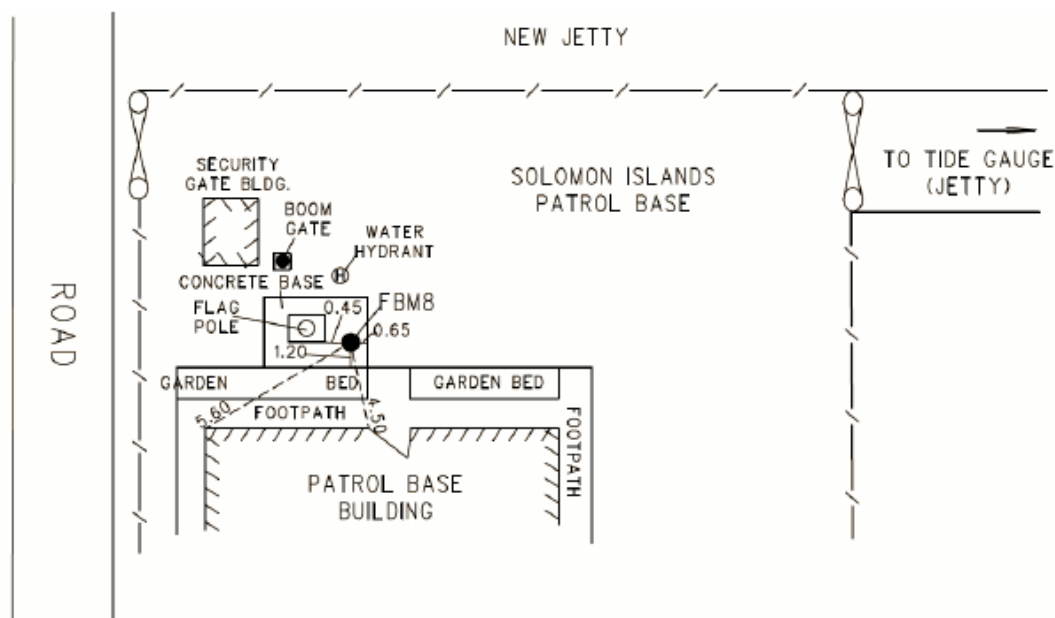
Notes / References: Deep Benchmark This survey mark is in a good locality for GPS occupation.
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Country: Solomon Islands Island: Guadalcanal	City: Honiara
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**Marking and locality sketch**

Bench Mark: 3.0m of 19mm diameter stainless steel capped rod driven to refusal.  
Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark 0.2m below ground level

Locality sketch: Mark approximately 125m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
Approved by: Geoscience Australia / SOPAC		Date: Dec 2007





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



**Survey Bench Mark Record**

**Bench Mark Number: FBM9**

<i>Original Bench Mark Established by:</i> National Geospatial Reference Systems, Geospatial & Earth Monitoring Division (GEMD), Geoscience Australia.	<i>Date:</i> 20-08-07
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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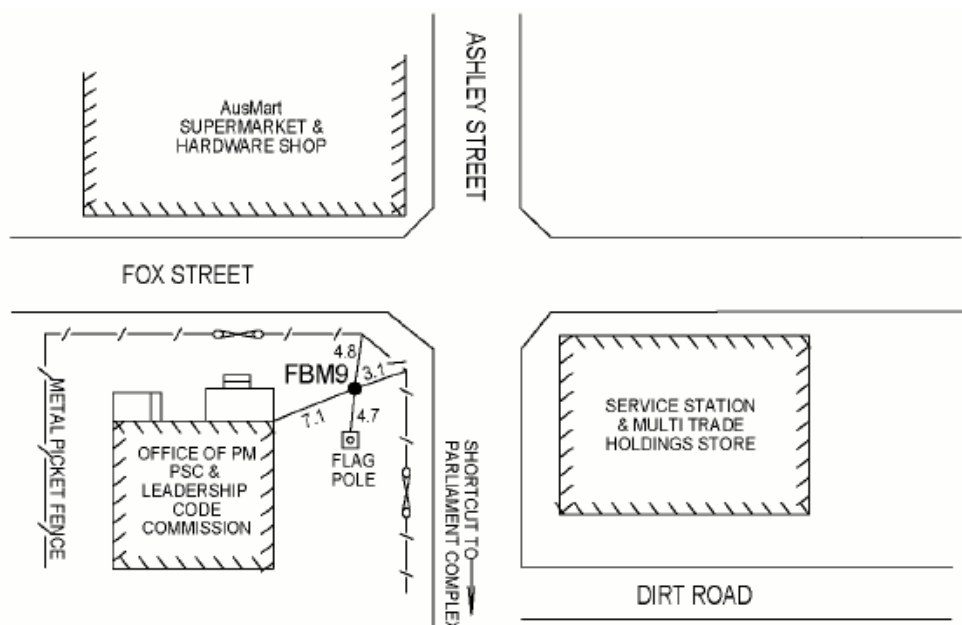
*Notes / References:* Deep Benchmark  
 This survey mark is in a good locality for GPS occupation.

<i>Country:</i> Solomon Islands <i>Island:</i> Guadalcanal	<i>City:</i> Honiara
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**Marking and locality sketch**

Bench Mark: 2.0m of 19mm diameter stainless steel capped rod driven to refusal.  
 Rod sheathed with 50mm diameter PVC tube for top 0.3m. Top of mark 0.2m below ground level

Locality sketch: Mark approximately 125m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: Dec 2007
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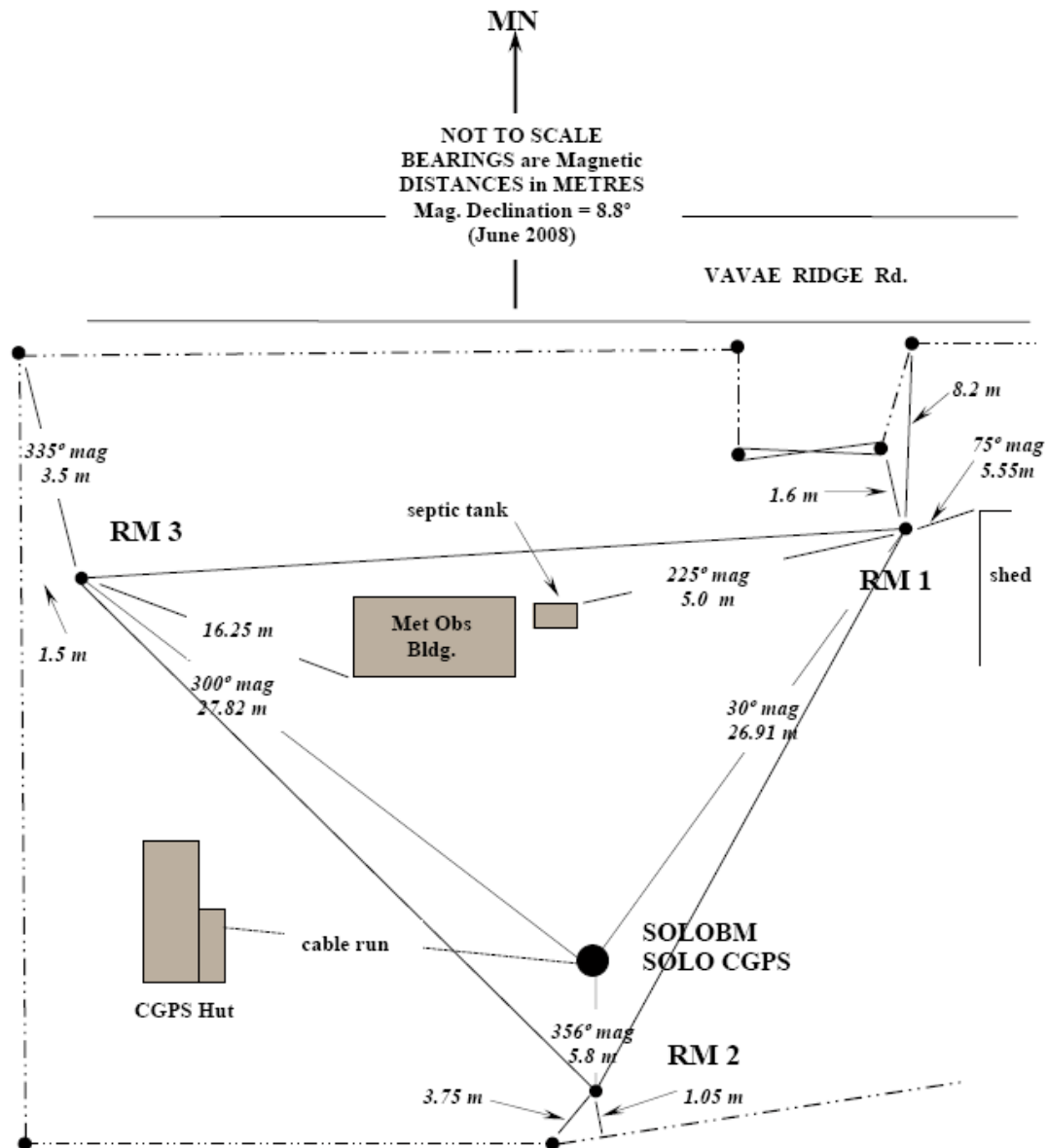




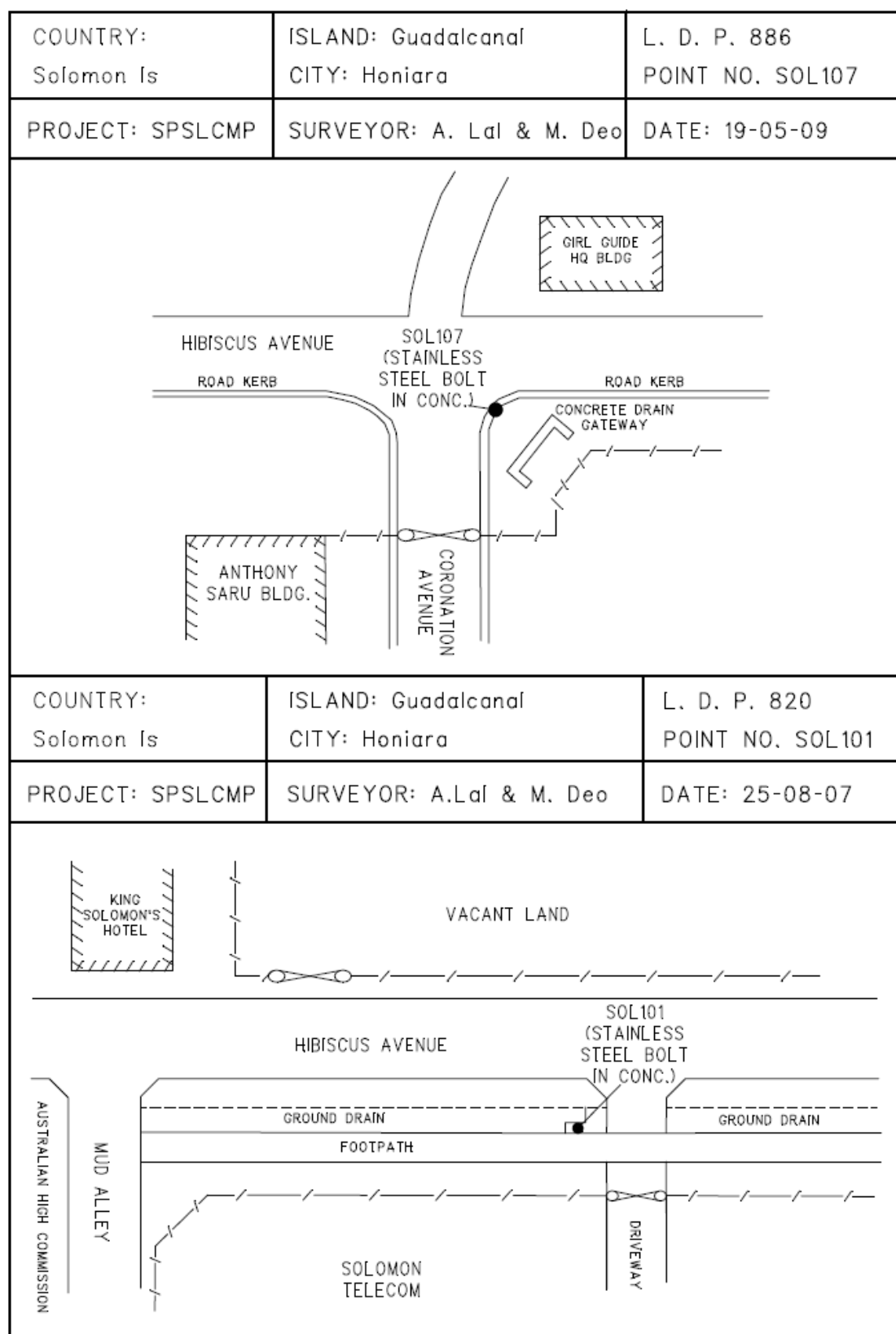
## SOLOMON IS. CGPS Station – Reference Marks

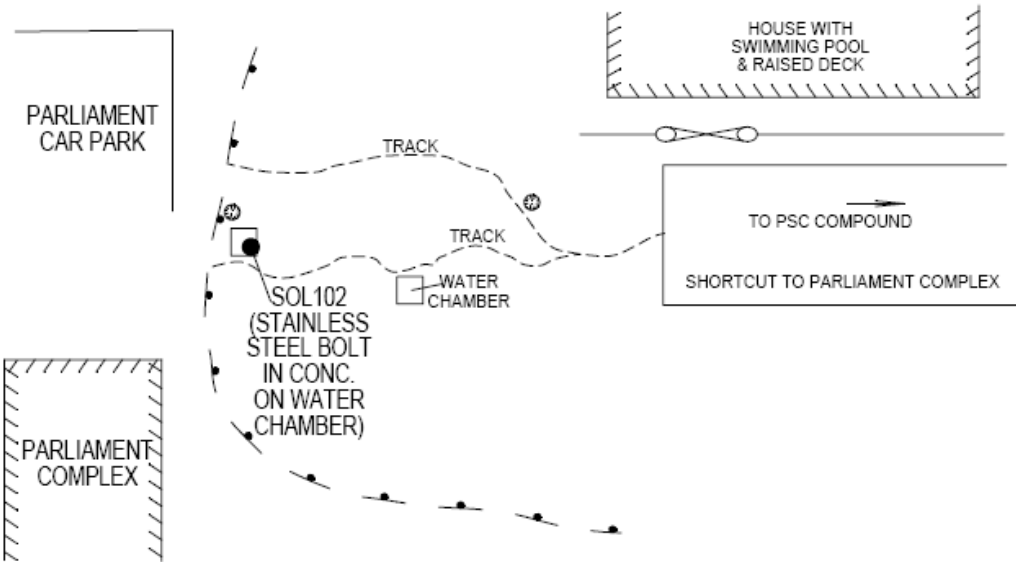
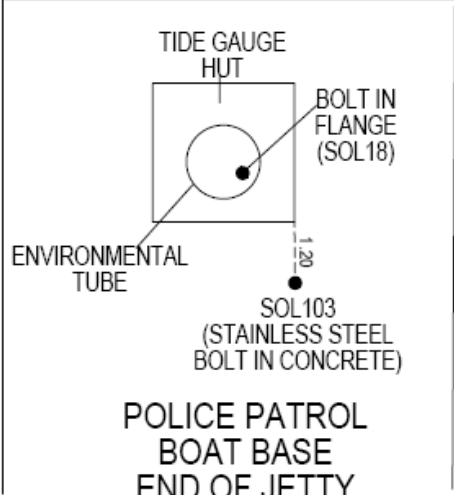
### REFERENCE MARKS

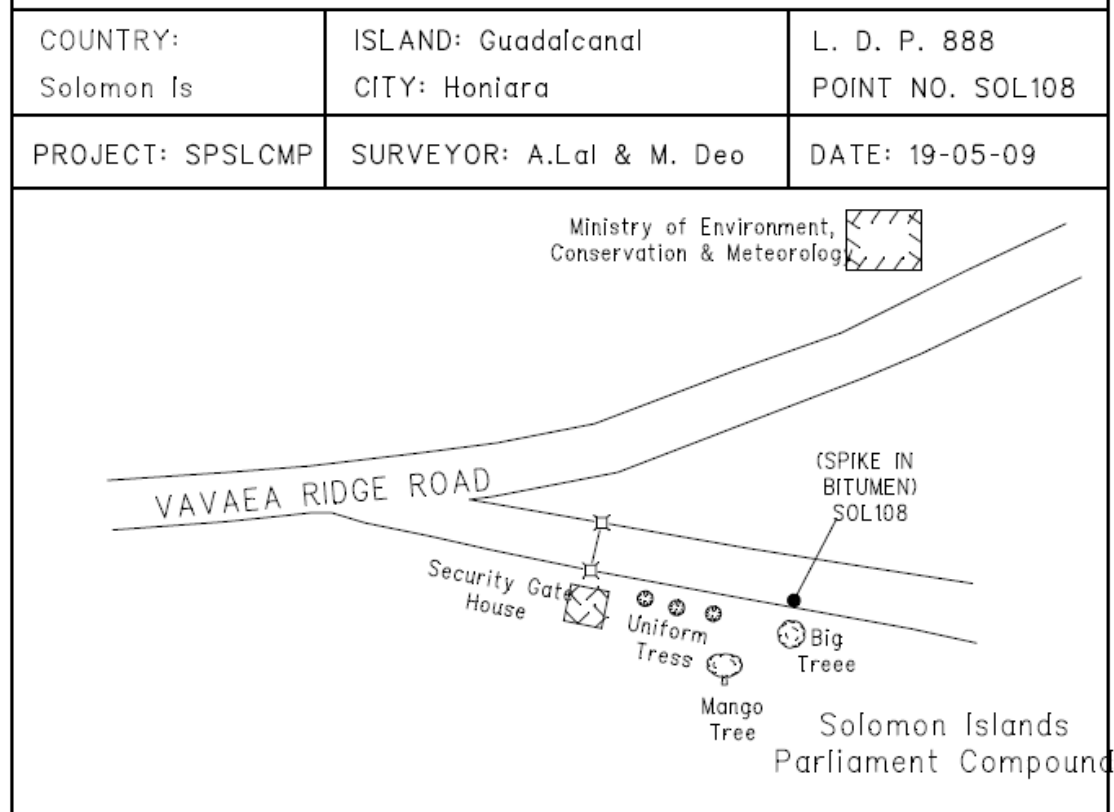
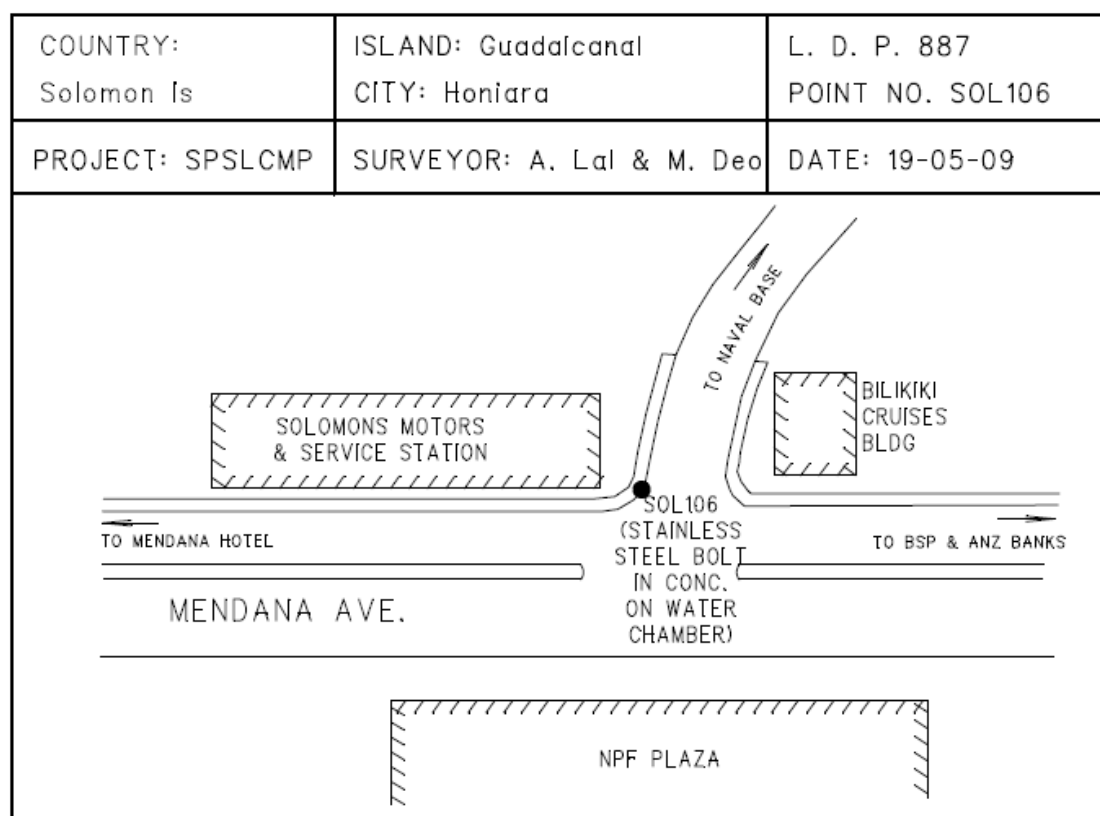
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 200mm below ground level.

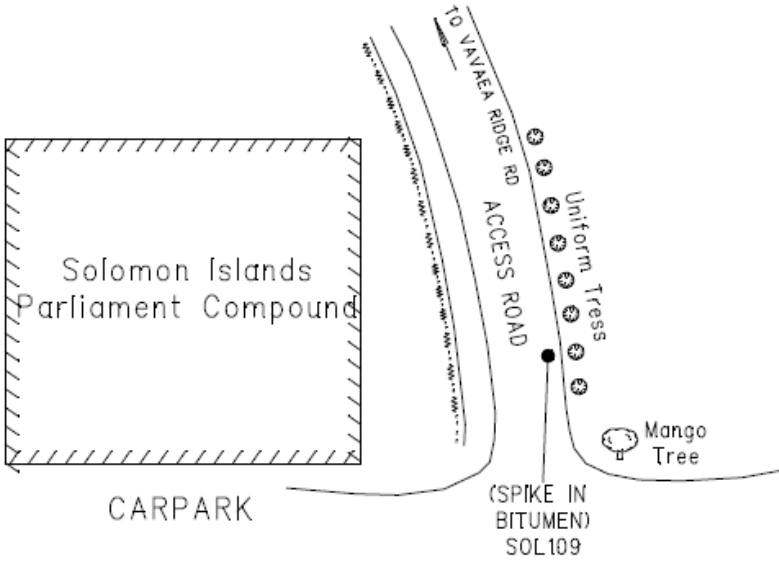
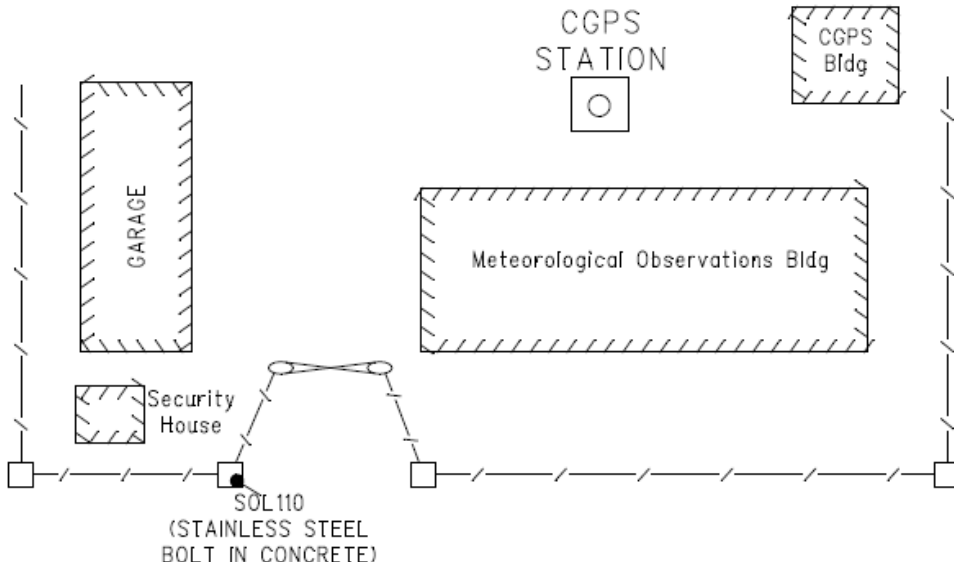


## Temporary Holding Marks Locality Diagrams



COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 821 POINT NO. SOL102
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 25-08-07
		
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 822 POINT NO. SOL103
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 25-08-07
<p style="text-align: center;"><b>MBOKONA BAY</b></p> 		



COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 889 POINT NO. SOL109
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 19-05-09
 <p>The diagram for Point SOL109 shows a rectangular area labeled 'Solomon Islands Parliament Compound' with a hatched border. To its right is a 'CARPARK'. Further right is an 'ACCESS ROAD' leading 'TO VAIKIA RIDGE RD'. Along this road are several 'Uniform Trees' and a 'Mango Tree'. A point labeled 'SOL109' is marked on the road with the note '(SPIKE IN BITUMEN)'.</p>		
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 890 POINT NO. SOL110
PROJECT: SPSLCMP	SURVEYOR: A.Lal & M. Deo	DATE: 19-05-09
 <p>The diagram for Point SOL110 shows a 'CGPS STATION' (a circle in a square) and a 'CGPS Bldg' (a hatched rectangle). Below these is a 'Meteorological Observations Bldg' (a large hatched rectangle). To the left of this building is a 'Security House' (a hatched rectangle) and further left is a 'GARAGE' (a hatched rectangle). A point labeled 'SOL110' is marked with the note '(STAINLESS STEEL BOLT IN CONCRETE)'. A line connects the 'Security House' to the 'SOL110' point, and another line connects the 'SOL110' point to the 'Meteorological Observations Bldg'.</p>		

COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 891 POINT NO. SOL111
PROJECT: SPSLCMP	SURVEYOR: A. Lal & M. Deo	DATE: 19-05-09
<p>The diagram is a hand-drawn site sketch. At the top, a vertical line represents a 'CREEK' flowing downwards into a horizontal road. The road has two arrows: one pointing left labeled 'TO ANTHONY SARU BLDG' and one pointing right labeled 'TO AUSTRALIAN EMBASSY'. To the right of the road, a building is labeled 'KING SOLOMONS HOTEL'. To the left of the road, a dashed line indicates the 'Solomon Islands Museum Compound'. A point on the road, just below the creek crossing, is marked with a black dot and labeled '(STAINLESS STEEL BOLT IN CONCRETE) SOL111'.</p>		