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EDM Height Traversing Levelling Survey Report

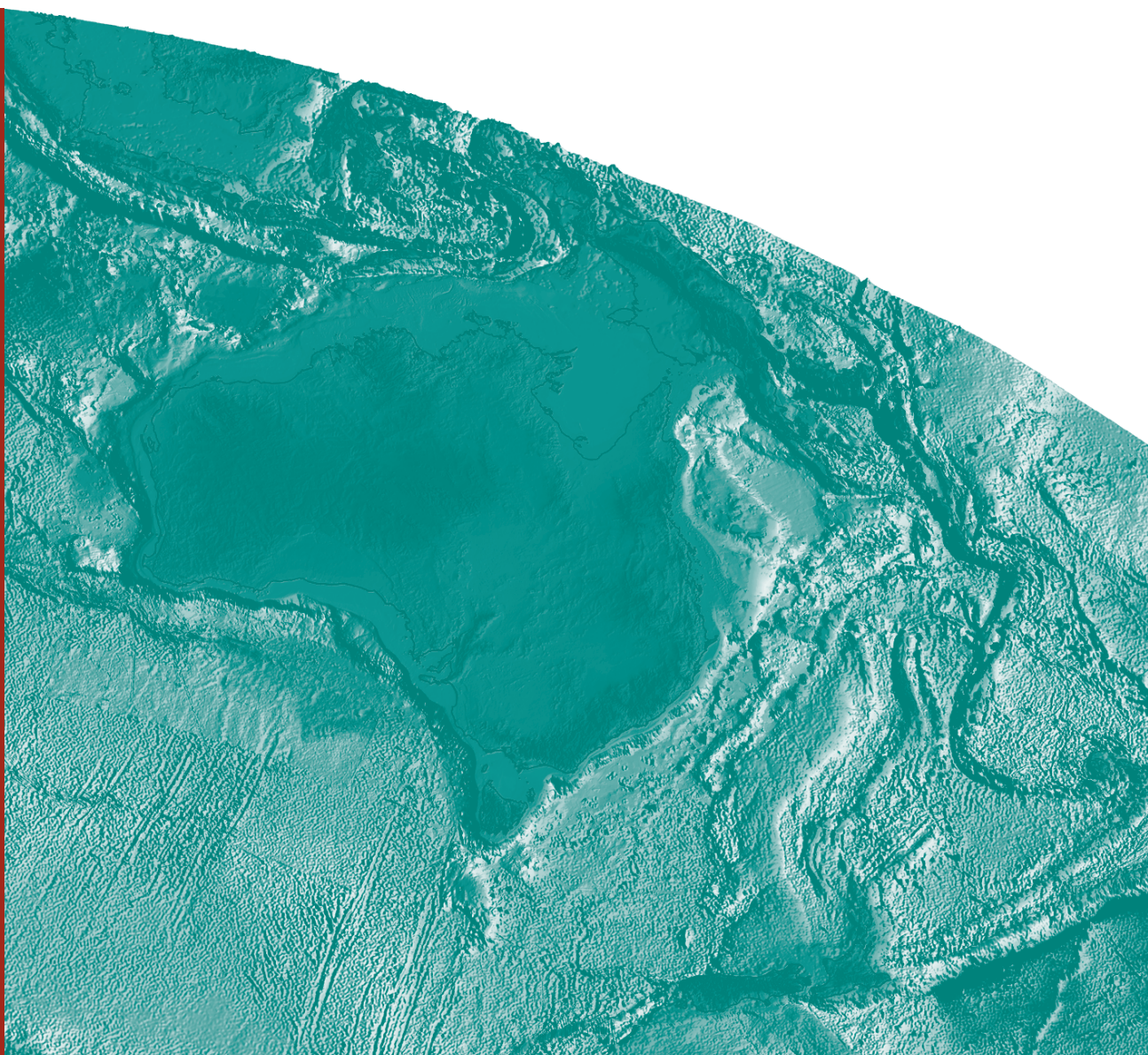
Honiara, Solomon Islands, November 2010

N. J. Brown, G. Hu, A. Lal

Record

2012/27

GeoCat #
71814



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Honiara, Solomon Islands, November 2010

GEOSCIENCE AUSTRALIA
RECORD 2012/27

N. J. Brown¹, G. Hu¹ A. Lal²,



Australian Government
Geoscience Australia

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 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



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ISSN 1448-2177

ISBN 978-1-922103-03-1

GeoCat # 71814

Bibliographic reference: Brown, N. J., Hu, G., & Lal, A., 2012, EDM Height Traversing Levelling Survey Report: Honiara, Solomon Islands, November 2010. Geoscience Australia, Record 2012/27. 24pp.

Contents

Introduction.....	1
The Survey.....	1
Bench Mark Locations.....	2
The Solomon Islands Datum.....	2
Equipment.....	2
Method.....	3
Survey Support	3
Issues.....	3
Comparisons between 2010 and 2009 EDM Surveys.....	5
Combined Comparisons 1994 to 2010.....	6
Time Series of Bench Mark Movement.....	7
Deep Bench Mark Locality Diagrams	13
Temporary Holding Marks Locality Diagrams.....	18
References.....	23

Introduction

This report outlines the high precision level survey completed between the SEAFRAME tide gauge and continuous GPS station in Honiara, Solomon Islands from 25 – 28 November 2010.

Personnel involved in the survey were Guorong Hu, Project Officer, Geoscience Australia and Andrick Lal, Surveyor, Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC). The processing of results and the report writing was completed by Nicholas Brown from Geoscience Australia.

The EDM height traversing levelling technique was employed to observe differences in height between the deep bench mark arrays in Honiara, which runs approximately 2 km from the tide gauge sensor to the continuous GPS antenna. Previous levelling surveys using this technique have been conducted along the route using this technique in 2007 and 2009.

In addition, precise differential levelling surveys were performed along the deep bench mark (BM) array from 1994 to 1999 by the National Tidal Centre (NTC). This report contains a comparison between the 2010 and 2009 EDM height traversing results as well as a combined comparison since the first levelling survey in 1994.

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 marks:

SOLOBM – GPS Benchmark

SOL103 – SEAFRAME Project Bench Mark

SOL18 - SEAFRAME Project Sensor Bench Mark

FBM1 – Local Department of Lands Survey Mark

FBM3 – Deep Driven BM

FBM4 – Deep Driven BM

FBM8 – Deep Driven BM

FBM9 – Deep Driven BM

All the deep bench marks were located and found in good order and undisturbed apart from **FBM2** which was unable to be located. Also included in the survey were temporary holding marks **SOL103**, **SOL106**, **SOL107**, **SOL108**, **SOL110**, **SOL111** and the newly placed **SOL112**, **SOL113**, **SOL114** which replace the temporary marks **SOL102** and **SOL109**.

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 (zero order); 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 Locations



The Solomon Islands Datum

The adopted reference point for this survey is **FBM4**. Reduction of the data was calculated holding **FBM4** fixed at 3.61966 metres. The height of **FBM4** was derived NTC in 1994.

Equipment

- Leica total station model TCA1800/TCA2003
- 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 Honiara tide gauge levelling survey. The “Leap-Frog” EDM-height-traversing technique involves setting up a total station (TCA1800) 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). 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, i.e. 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

The survey team very much appreciated the assistance from Solomon Islands Meteorological Service, Mr. Chanel Iroi in arranging for customs clearance for the Undersecretary/technical, Ministry of Environment, Climate Change, Disaster Management and Meteorology, Mr. David Hiriasia, Director of Meteorology and Mr. Luke Tema, Meteorological Officer. Staff from the Solomon Islands Meteorological Service have developed a keen interest in the SPSLCMP project and were always eager to provide assistance when required.

During the field survey, assistance from Mr Ronald Wale, Assistant Surveyor and Mr John Baleka, Planner of Lands & Survey Department was initiated with the support from then Acting Surveyor General, Mr Jimmy Ikina, which had been great.

Issues

Please see “Time Series of Bench Mark Movement” on page 8 for a description of issues related to the past few surveys and ideas to resolve the problems.

Prior approvals needs to be taken to access the following deep benchmarks; -

- Tide Gauge Station and Deep Driven Bench Mark, FBM8 – Police Patrol Base
- Deep Driven Bench Mark, FBM1 – Ministry of Agriculture
- CGPS Station – Meteorological Department

When in any instances, like wise on this survey visit, the survey equipment was hand carried; prior arrangement should be made with the Customs Department for the use in the country.

Prior approval should be made for access to survey array from deep driven bench mark FBM9 to FBM3. This survey array runs across the parliament complex building compounds

As for the CGPS Station and its hut, service or even replacement of the air condition unit upon diagnosis is required as it is malfunctioning. The CGPS Station PC rack is in place and is always locked.

Comparisons between 2010 and 2009 EDM Surveys

Table 1: Honiara, Solomon Islands 2010 EDM Height Traversing Levelling & Comparison 2010 - 2009.

FBM4 - ADOPTED FIXED HEIGHT OF 3.6197 m								
FROM	TO	Levelled Height Difference	Reduced Level 2010	Misclose (mm)	Distance (km)	1mm√k	Reduced Level 2009	Difference (mm) 2010 - 2009
FBM4			3.6197				3.6197	
SOL106	SOL106	-0.4133	3.2064	0.25	0.097	0.312	3.2068	-0.40
FBM8	FBM8	-1.2444	1.9620	0.20	0.141	0.376	1.9626	-0.59
SOL103	SOL103	0.3457	2.3078	-0.32	0.124	0.352	2.3085	-0.75
	SOL18	1.2629	3.5707	-0.16	0.015	0.123	3.5718	-1.12
FBM4			3.6197				3.6197	
SOL107	SOL107	1.3790	4.9987	0.27	0.115	0.340	4.9990	-0.33
FBM9	FBM9	-0.2486	4.7500	-0.18	0.150	0.387	4.7502	-0.17
SOL112	SOL112	1.4719	6.2219	0.09	0.040	0.199	*	*
SOL113	SOL113	25.0820	31.3039	-0.23	0.099	0.315	*	*
SOL114	SOL114	14.3846	45.6886	-0.16	0.086	0.293	*	*
SOL108	SOL108	4.6167	50.3052	0.17	0.059	0.243	50.3095	-4.27
	FBM3	3.7415	54.0467	0.09	0.069	0.263	54.0485	-1.76
SOL114			45.6886					
SOL110	SOL110	8.3908	54.0794	-0.38	0.156	0.395	54.0900	-10.63
SOLOBM	SOLOBM	0.2239	54.3032	-0.05	0.035	0.186	54.3134	-10.18
	SOLO	1.4646	55.7678	-0.08	0.016	0.127	55.7801	-12.32
SOL107			4.9987					
SOL111	SOL111	0.4881	5.4868	0.16	0.066	0.257	5.4880	-1.20
SOL101	SOL101	-1.3588	4.1280	-0.41	0.202	0.449	4.1276	0.38
	FBM1	2.2588	6.3868	0.00	0.144	0.379	6.3863	0.53
Misclose for all bays levelled =				-0.72	1.614	1.271		
All levelling was performed within the project specifications of 2√k								
SOLOBM			54.30322					
	SOLO	1.46456	55.76778	-0.08	0.016	0.127	55.78010	-12.32
SOLOBM								
	RM1	-0.0686	54.23465				54.24460	-9.95
SOLOBM								
	RM2	-1.2953	53.00793				53.01800	-10.07
SOLOBM								
	RM3	-0.5574	53.74583				53.75600	-10.17

Combined Comparisons 1994 to 2010

Table 2: Honiara, Solomon Islands - Comparison of the RL's for Precise Differential Levelling (1994-1999) and EDM Height Traversing (2007 - 2010). Units are in metres.

	Year						
	1994.7	1996.2	1997.7	1999.3	2007.7	2009.4	2010.9
FBM1	6.3860	6.3848	6.3857	6.3856	6.3866	6.3863	6.3868
FBM2	3.3171	3.3175	3.3182	3.3161	3.3177	-	-
FBM3	54.0460	54.0457	54.0449	54.0444	54.0467	54.0485	54.0467
FBM4	3.6197	3.6197	3.6197	3.6197	3.6197	3.6197	3.6197
FBM8	-	-	-	-	1.9626	1.9626	1.9620
FBM9	-	-	-	-	4.7500	4.7502	4.7500
SOL18	3.5755	3.5758	3.5741	3.5742	3.5720	3.5718	3.5707
SOL101	-	-	-	-	4.1279	4.1276	4.1280
SOL103	-	-	-	-	2.3093	2.3085	2.3078
SOL106	-	-	-	-	-	3.2068	3.2064
SOL107	-	-	-	-	-	4.9990	4.9987
SOL108	-	-	-	-	-	50.3095	50.3052
SOL110	-	-	-	-	-	54.0900	54.0794
SOL111	-	-	-	-	-	5.4880	5.4868
SOL112	-	-	-	-	-	-	6.2219
SOL113	-	-	-	-	-	-	31.3039
SOL114	-	-	-	-	-	-	45.6886
SOLOBM	-	-	-	-	54.3111	54.3134	54.3032
SOLO	-	-	-	-	55.7756	55.7801	55.7678

Time Series of Bench Mark Movement

The purpose of this survey is in 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 changes due to localised deformation.

After reviewing the previous three surveys, there appears to be either substantial movement throughout the survey area, or errors in the dataset. I have broken down each segment of the survey below and identified the trouble areas. In short, the problems can not be resolved because SOL114 was used as the beginning of RUN 3 instead of SOL108 which was used in previous surveys. My advice is to use SOL108 in the future, but also perform a survey between SOL114 to SOL110 in the next survey so the true cause of the problems in the 2010 survey can be identified and possibly readjusted.

RUN 1	FBM4	SOL106	stable
	SOL106	FBM8	stable
	FBM8	SOL103	-2mm over 3 years
	SOL103	SOL18	-5mm over 15 years
RUN2	FBM4	SOL107	stable
	SOL107	FBM9	stable
	FBM9	SOL112	-
	SOL112	SOL113	-
	SOL113	SOL114	-
	SOL114	SOL108	-4mm in 1.5 years
	SOL108	FBM3	stable
RUN 3	SOL114	SOL110	-10mm in 3 years
	SOL110	SOLOBM	-8mm in 3 years
	SOLOBM	SOLO	-8mm in 3 years
RUN 4	SOL107	SOL111	stable
	SOL111	SOL101	stable
	SOL101	FBM1	stable
	RM1		-8mm in 3 years
	RM2		-8mm in 3 years
	RM3		-8mm in 3 years

REFERENCE MARK TO TIDE GAUGE

Evidence Suggests

- Subsidence of the port area of ~5 mm over 15 years.

REFERENCE MARK TO CGPS

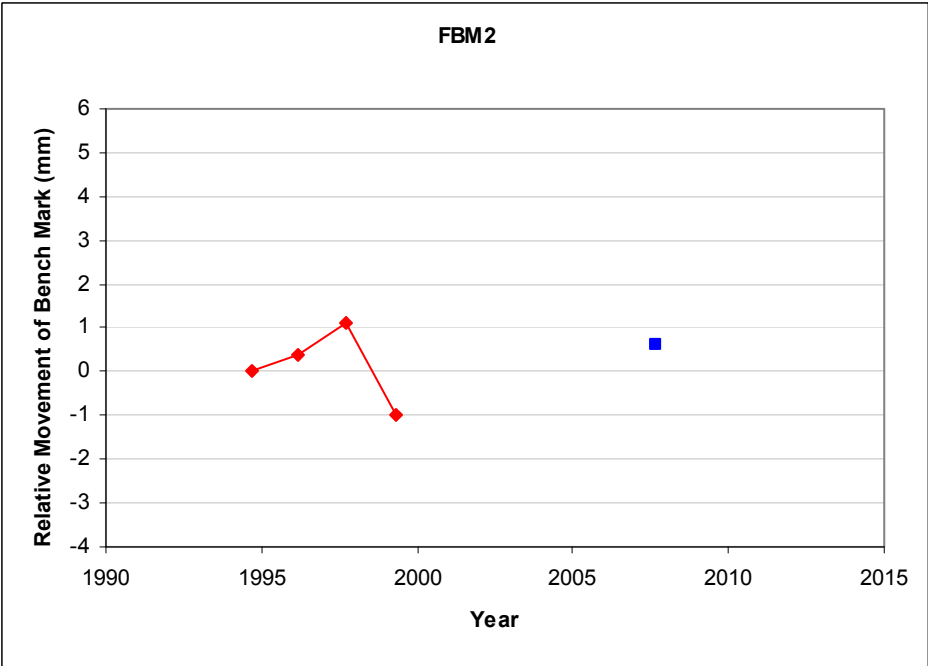
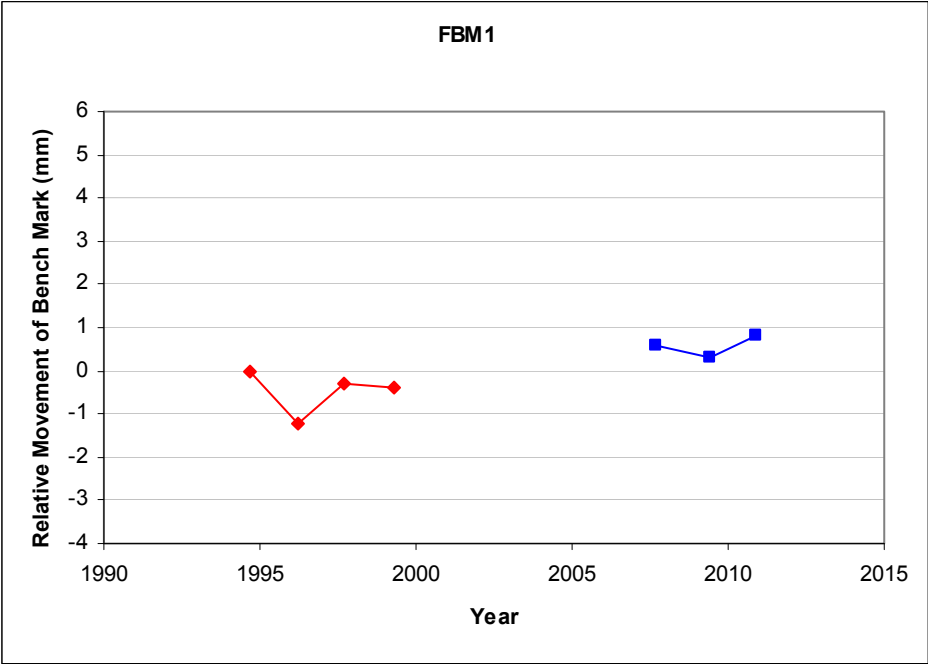
Evidence Suggests

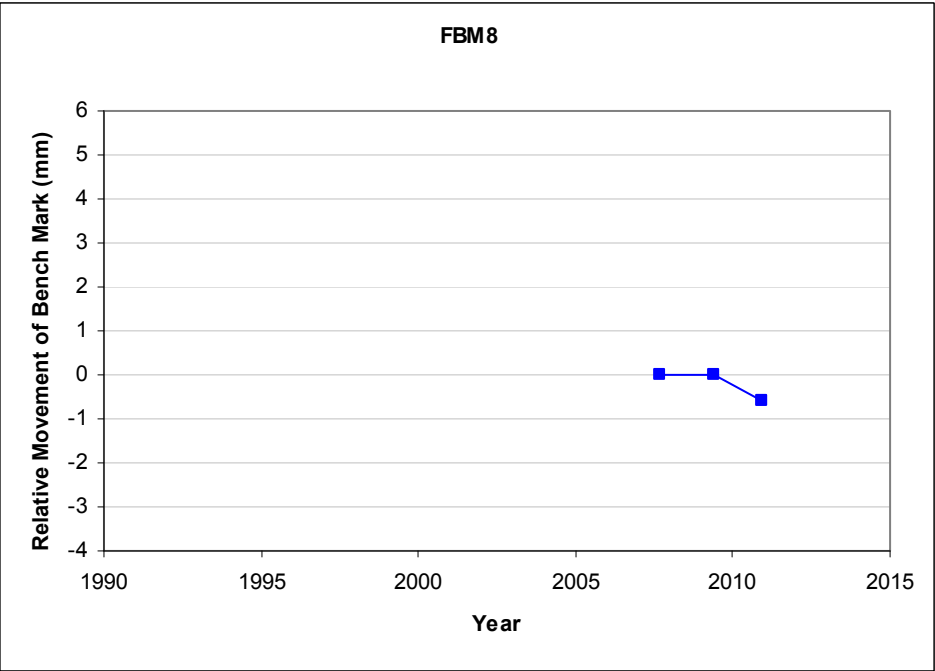
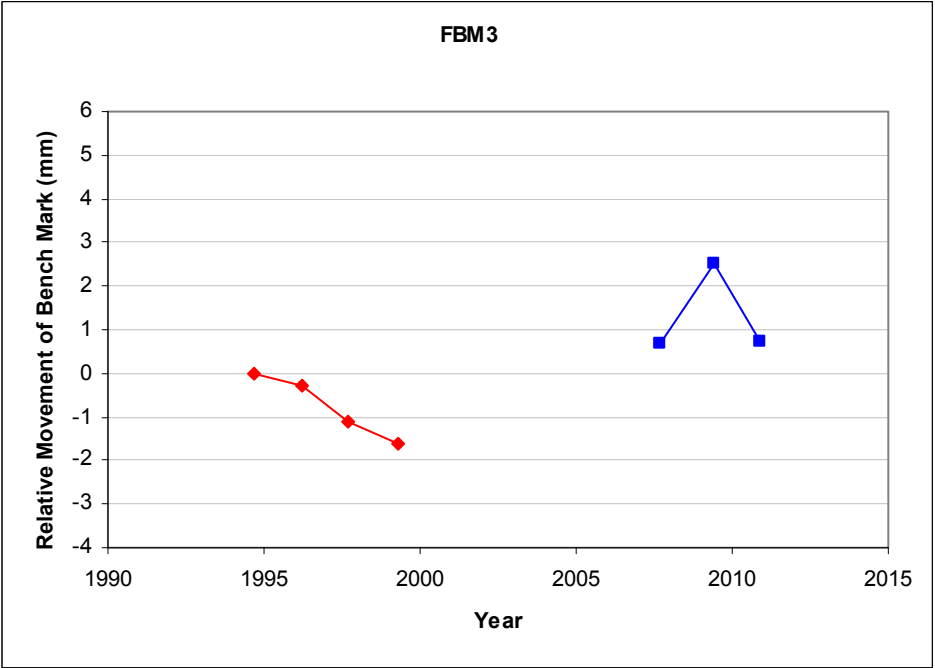
- SOL108 is 4 mm lower than 18 months ago.
- There was a 3mm increase in height diff between SOL108 and FM3 which supports the claim of a drop in SOL108.
- OR,
- Could be related to the problem discussed below.

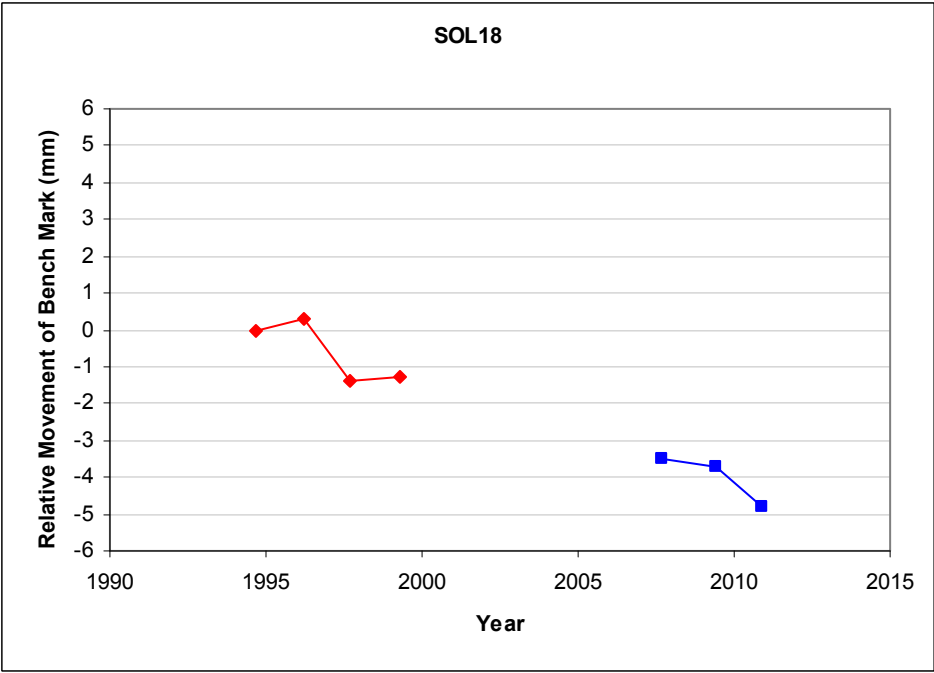
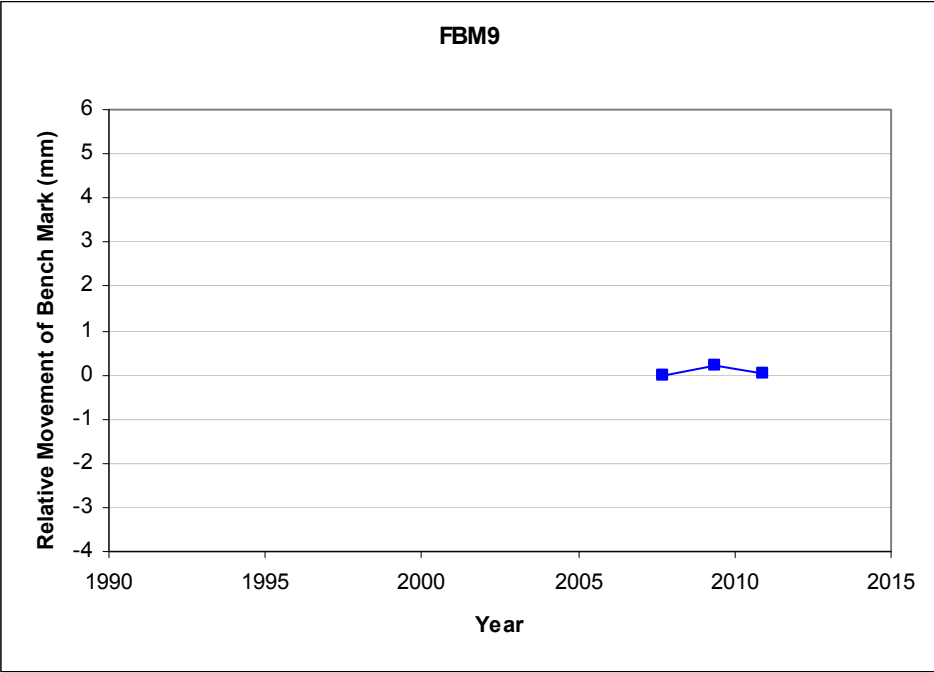
Evidence Suggests

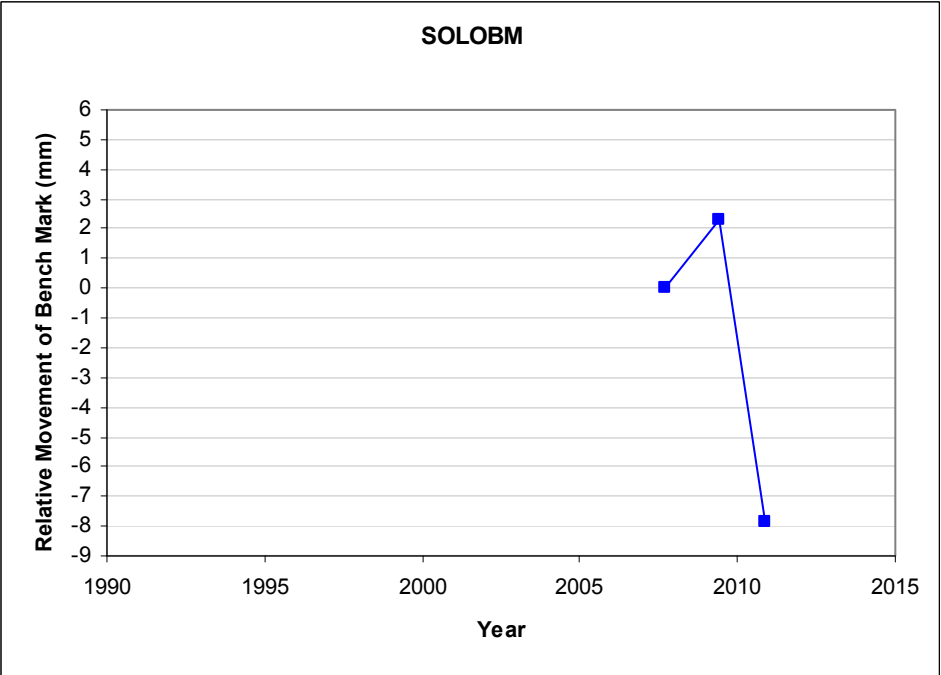
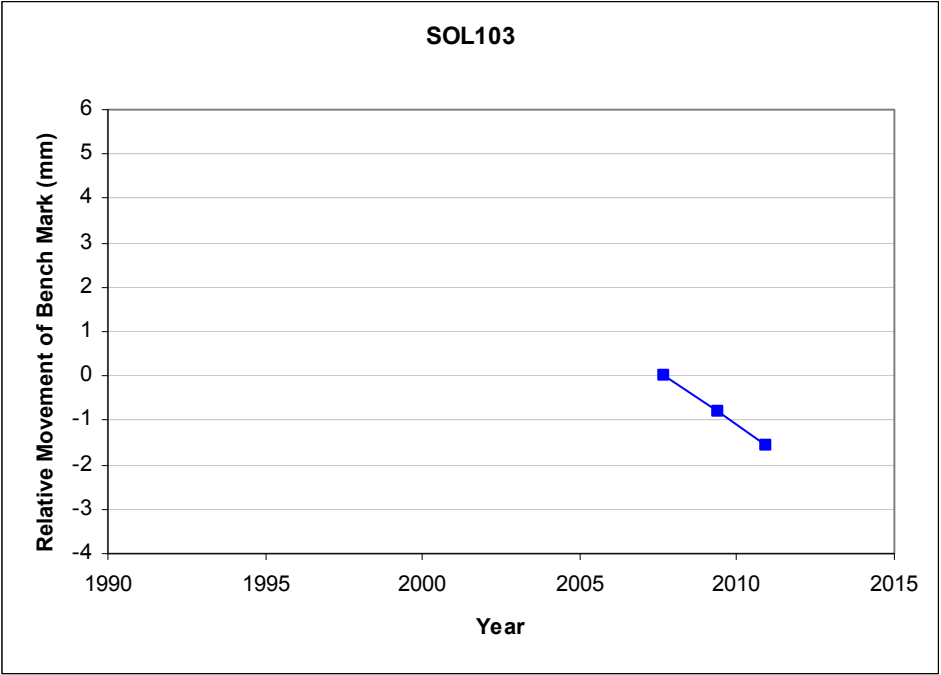
- The relative height differences from SOL110, SOLO, SOLOBM and all the RM's have not changed significantly.
- Therefore, they have either all moved equally (unlikely) or SOL114 is incorrect.
- Potential Causes
- The RL of SOL114 is 8-10 mm lower than it should be
 - Error in FBM9-112/112-113/113-114.
 - OR,
 - Error in measurement of 114-110. e.g. The pole on 114 was set on the wrong point and was ~10mm too high.

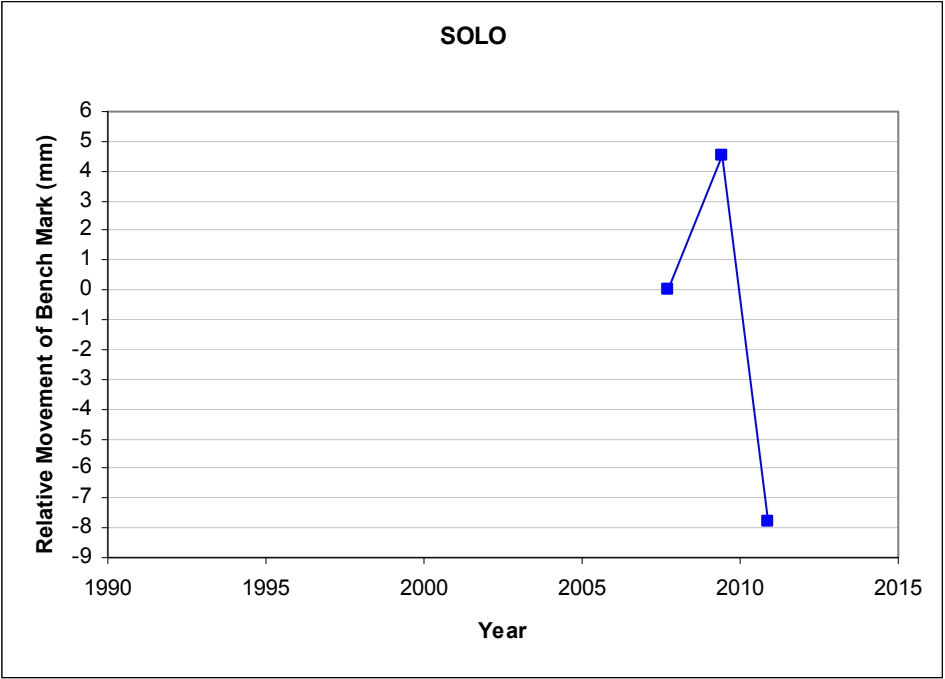
This perpetuates the ~10mm error throughout the rest of the survey. This theory can not be confirmed because we have no other estimate of the height differences between to and from SOL114.











Deep 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.

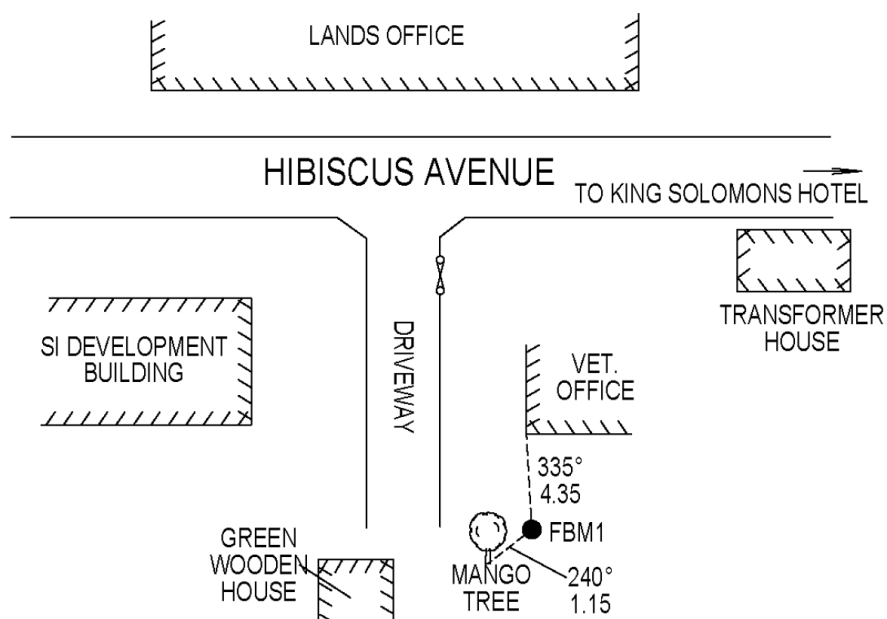
Country: Solomon Islands
Island: Guadalcanal

City: Honiara

Marking and locality sketch

Bench Mark: Brass bolt in the centre of a concrete pillar 35cm diameter and approx. 70cm above ground level

Locality sketch: Mark approximately 750m from the tide gauge station.



Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: Dec 2007

c:\users\landrick\spslcmp\localitydiagrams\solomons



**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
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Existing Bench Mark Established by:	Date:
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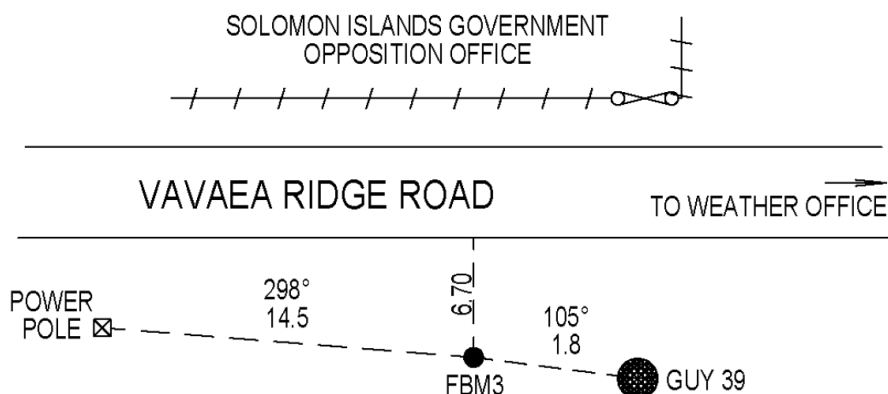
Notes / References: Deep Benchmark This survey mark is in a good locality for GPS occupation.
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Country: Solomon Islands Island: Guadalcanal	City: Honiara
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Marking and locality sketch

Bench Mark: 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
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Approved by: Geoscience Australia / SOPAC

Date: Dec 2007

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**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
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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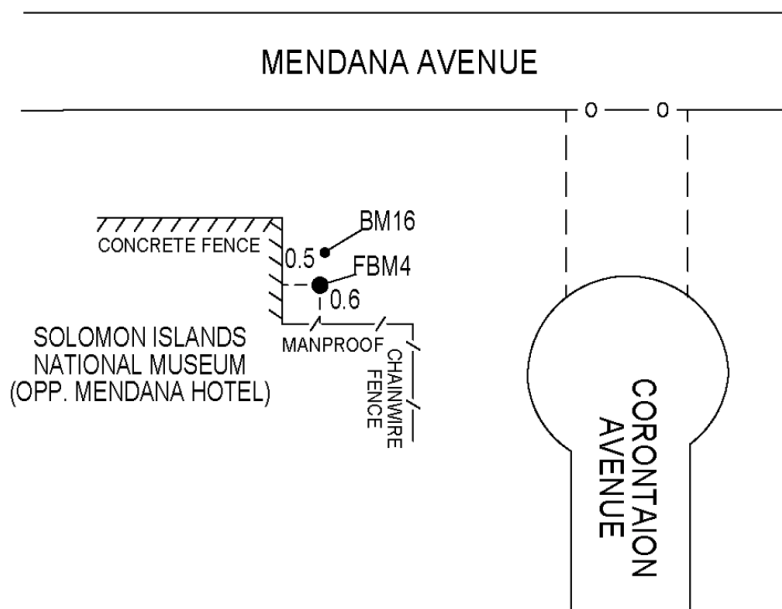
<i>Notes / References:</i> Deep Benchmark This survey mark is not in a good locality for GPS occupation.

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

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

Locality sketch: Mark approximately 370m from the tide gauge station.



Not to scale

Distances in Metres

Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: Dec 2007

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**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

Existing Bench Mark Established by: *Date:*

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

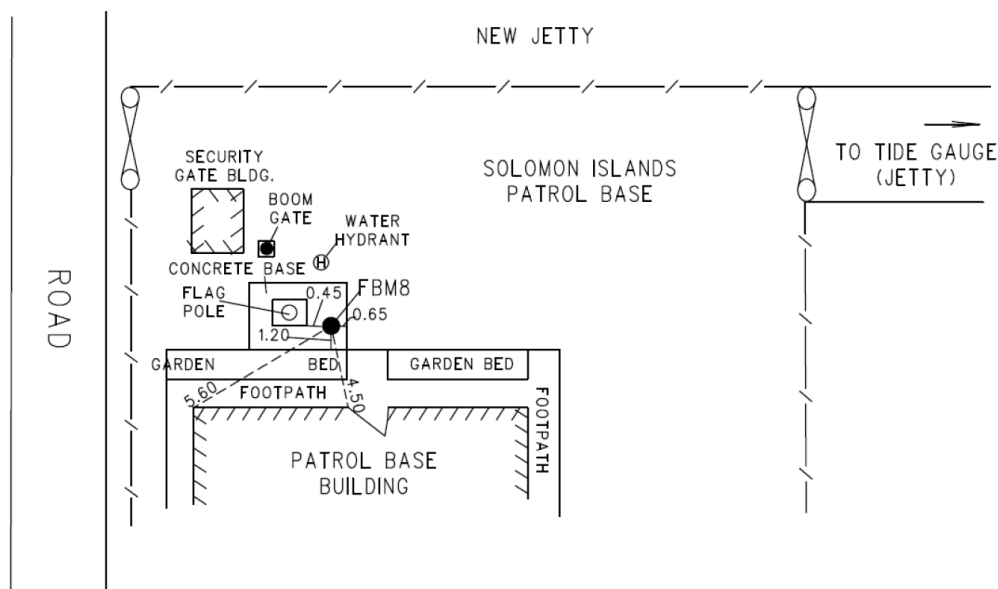
Country: Solomon Islands
Island: Guadalcanal

City: Honiara

Marking and locality sketch

Bench Mark: 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

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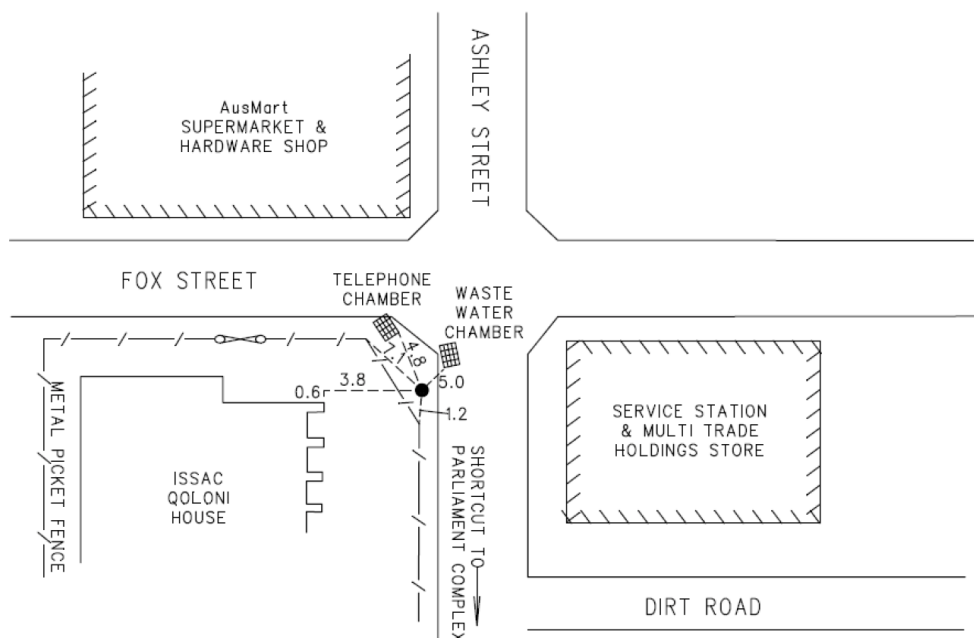
<i>Notes / References:</i> Deep Benchmark This survey mark is in a good locality for GPS occupation.

<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

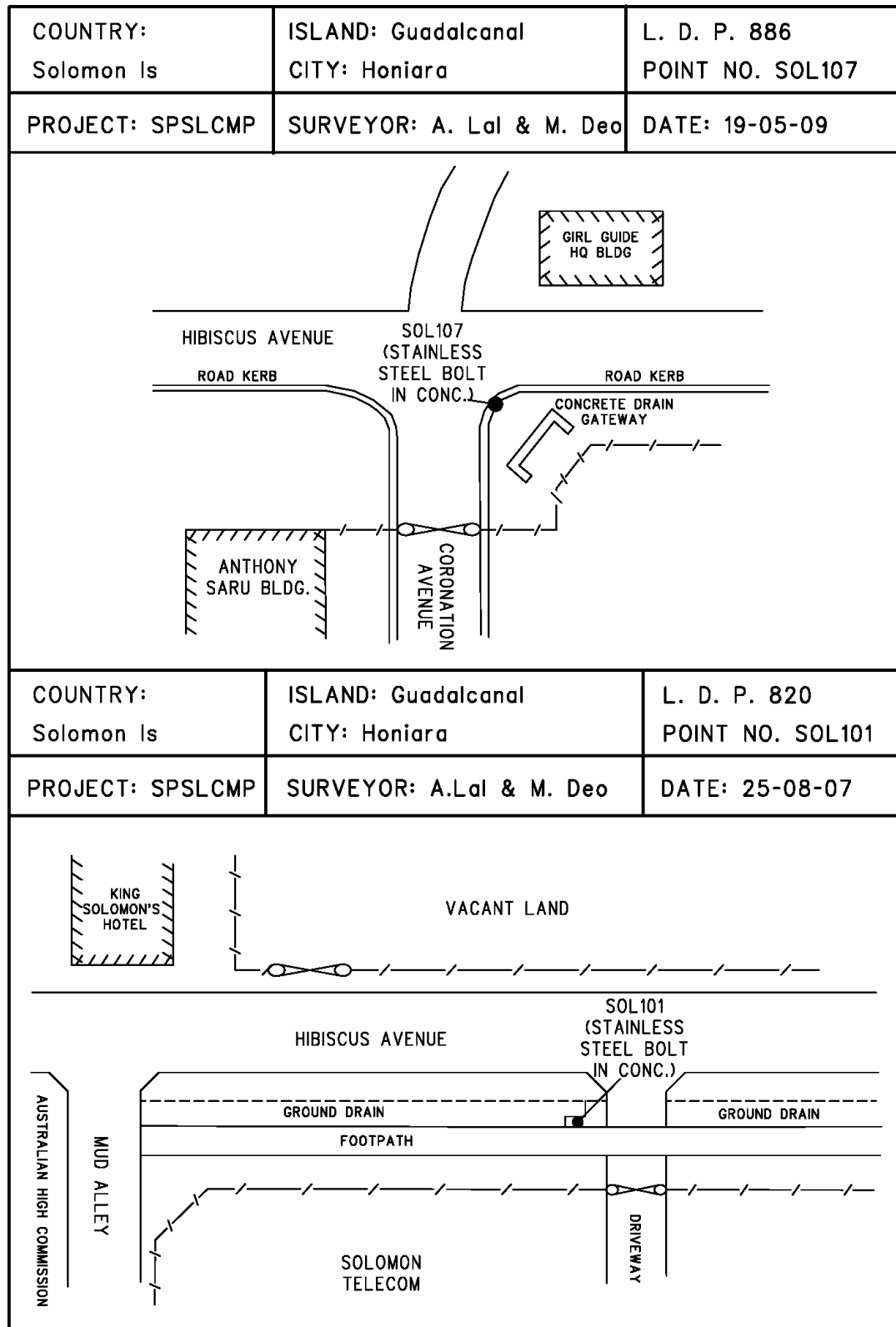
Magnetic bearings

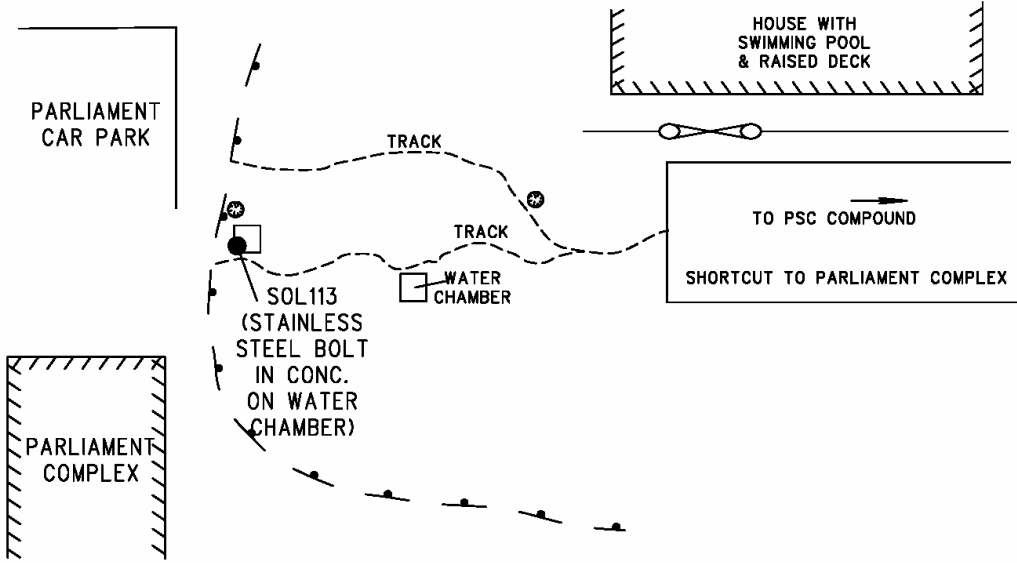
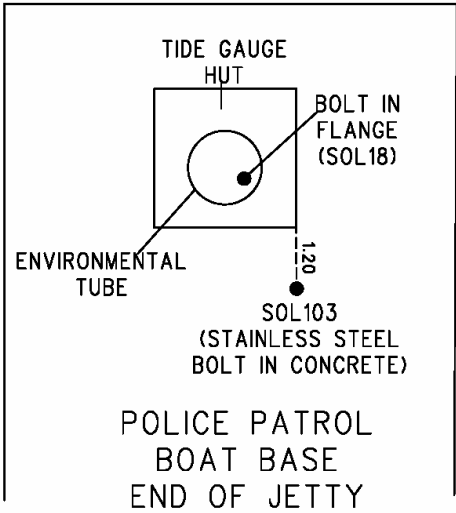
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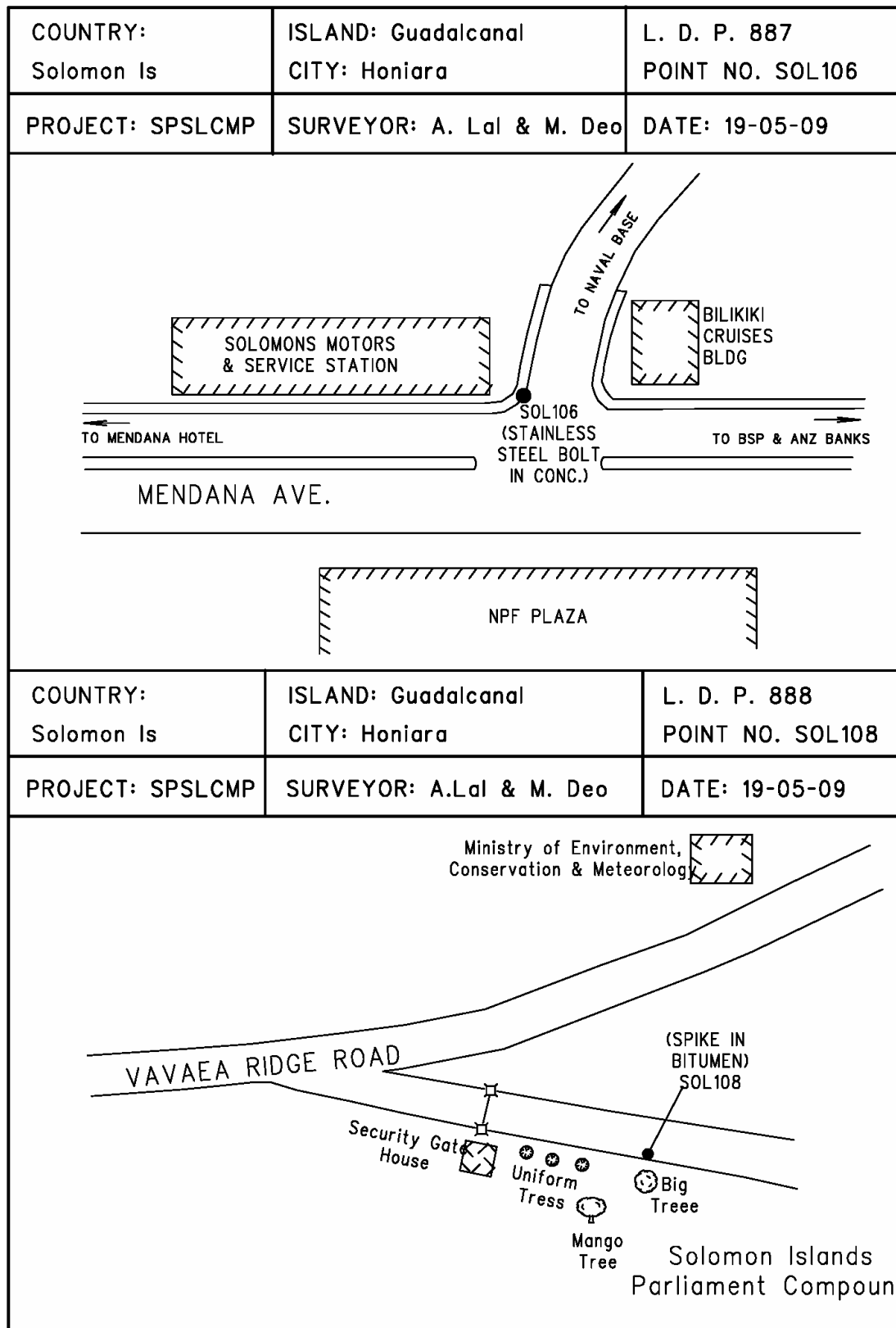
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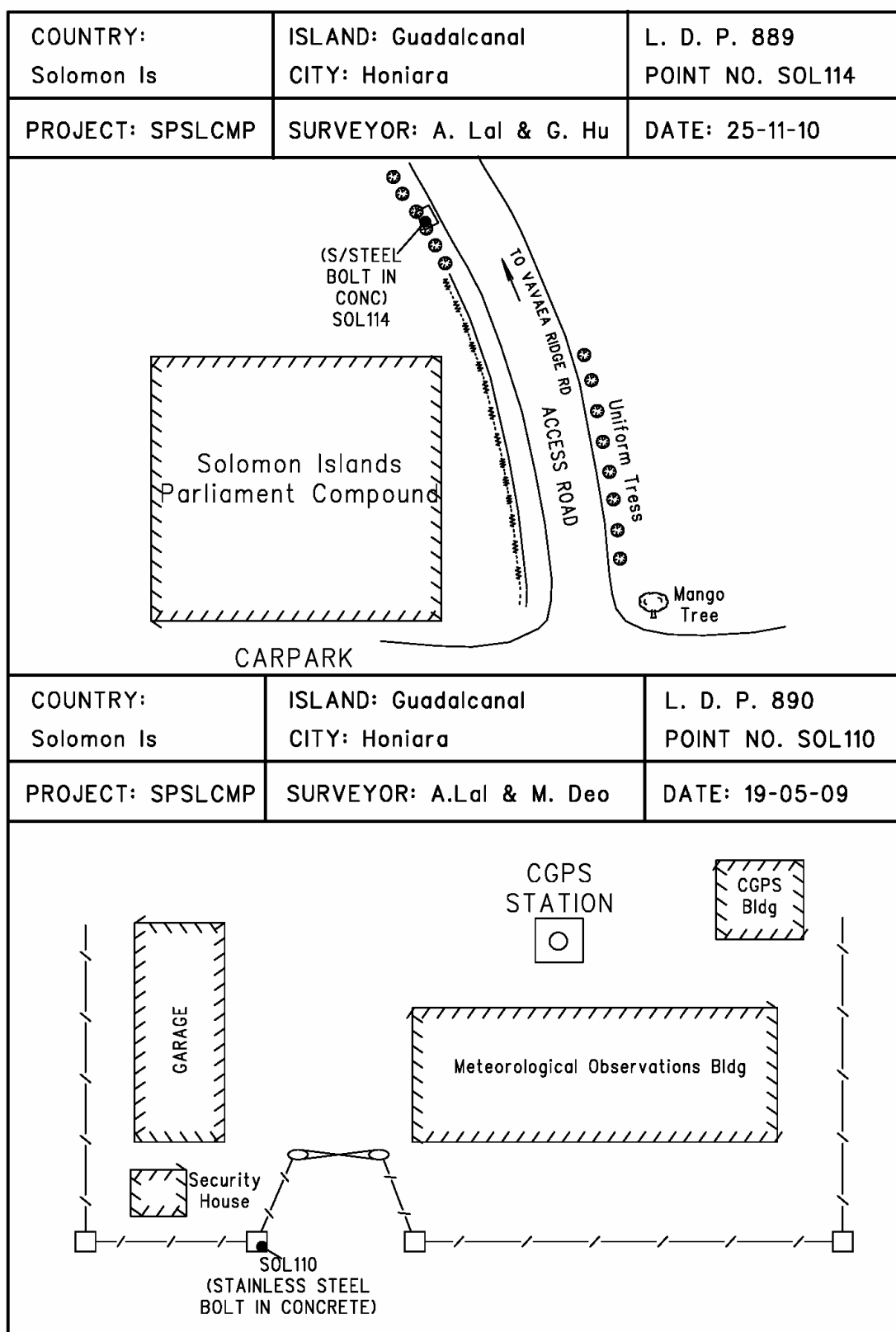
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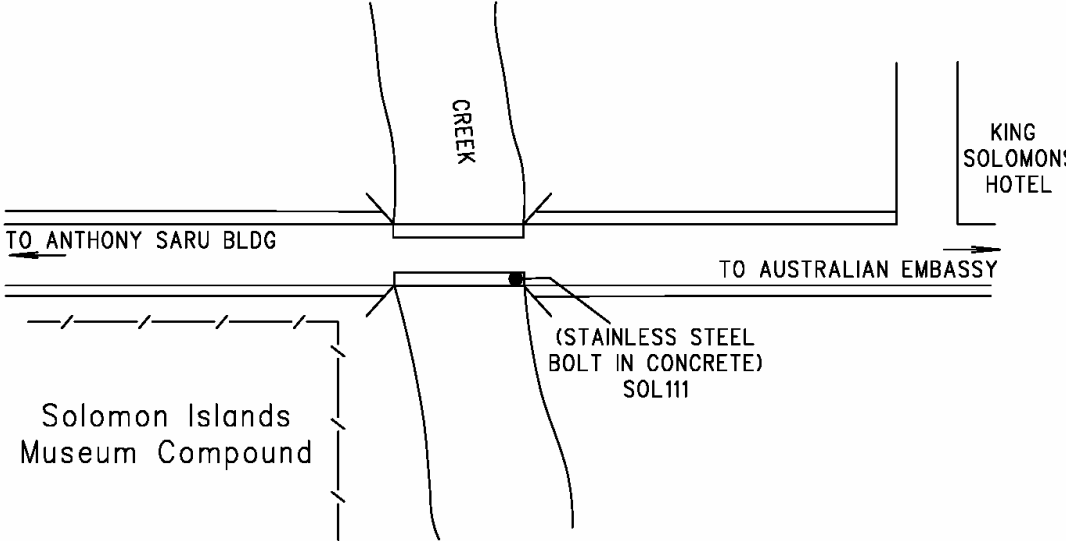
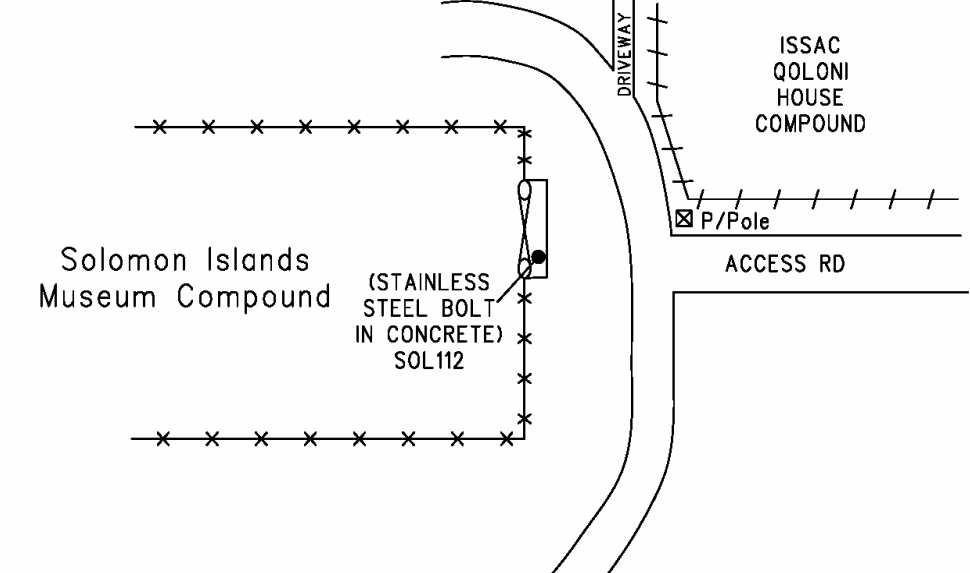
Temporary Holding Marks Locality Diagrams



COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 821 POINT NO. SOL113
PROJECT: SPSLCMP	SURVEYOR: A. Lal & G. Hu	DATE: 25-11-10
 <p>PARLIAMENT CAR PARK</p> <p>PARLIAMENT COMPLEX</p> <p>TRACK</p> <p>WATER CHAMBER</p> <p>SOL113 (STAINLESS STEEL BOLT IN CONC. ON WATER CHAMBER)</p> <p>HOUSE WITH SWIMMING POOL & RAISED DECK</p> <p>TO PSC COMPOUND</p> <p>SHORTCUT TO PARLIAMENT COMPLEX</p>		
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>MBOKONA BAY</p> <p>TIDE GAUGE HUT</p> <p>BOLT IN FLANGE (SOL18)</p> <p>ENVIRONMENTAL TUBE</p> <p>SOL103 (STAINLESS STEEL BOLT IN CONCRETE)</p> <p>POLICE PATROL BOAT BASE END OF JETTY</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>CREEK</p> <p>KING SOLOMONS HOTEL</p> <p>TO ANTHONY SARU BLDG</p> <p>TO AUSTRALIAN EMBASSY</p> <p>(STAINLESS STEEL BOLT IN CONCRETE) SOL111</p> <p>Solomon Islands Museum Compound</p>		
COUNTRY: Solomon Is	ISLAND: Guadalcanal CITY: Honiara	L. D. P. 892 POINT NO. SOL112
PROJECT: SPSLCMP	SURVEYOR: A. Lal & G. Hu	DATE: 25-11-10
 <p>DRIVEWAY</p> <p>ISSAC QOLONI HOUSE COMPOUND</p> <p>ACCESS RD</p> <p>⊗ P/Pole</p> <p>Solomon Islands Museum Compound</p> <p>(STAINLESS STEEL BOLT IN CONCRETE) SOL112</p>		

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.