Australian Government

Geoscience Australia

South Pacific Sea Level and Climate Monitoring Project (SPSLCMP)

Survey Report

EDM Height Traversing
Levelling Survey

Fiji
September / October 2008

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 # 69397

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Introduction

This report outlines the level survey completed during the visit to Lautoka, Fiji Islands, from 24 September to 4 October 2008.

Personnel: Steve Yates – Surveyor - **GEOSCIENCE AUSTRALIA**
Andrick Lal – Surveyor - **SOPAC**

This is the third EDM Height Traversing levelling survey of the deep driven bench mark array in Lautoka, Viti Levu, Fiji Islands. These surveys follow the eight previous surveys from October 1992 to May 2003, undertaken by the National Tidal Centre (NTC) using the Precise Differential Levelling technique.

The Survey

The EDM Height Traversing level survey was carried out between the 6 deep driven bench marks:

BM3243
BM3244
BM3245
BM3246
BM3247
BM3248

Included in the survey was the CGPS Station bench mark **LAUTBM**, the Project Plaque point **FIJ12** and the SEAFRAME Sensor Bench Mark on the Tide Gauge **FIJ13**.

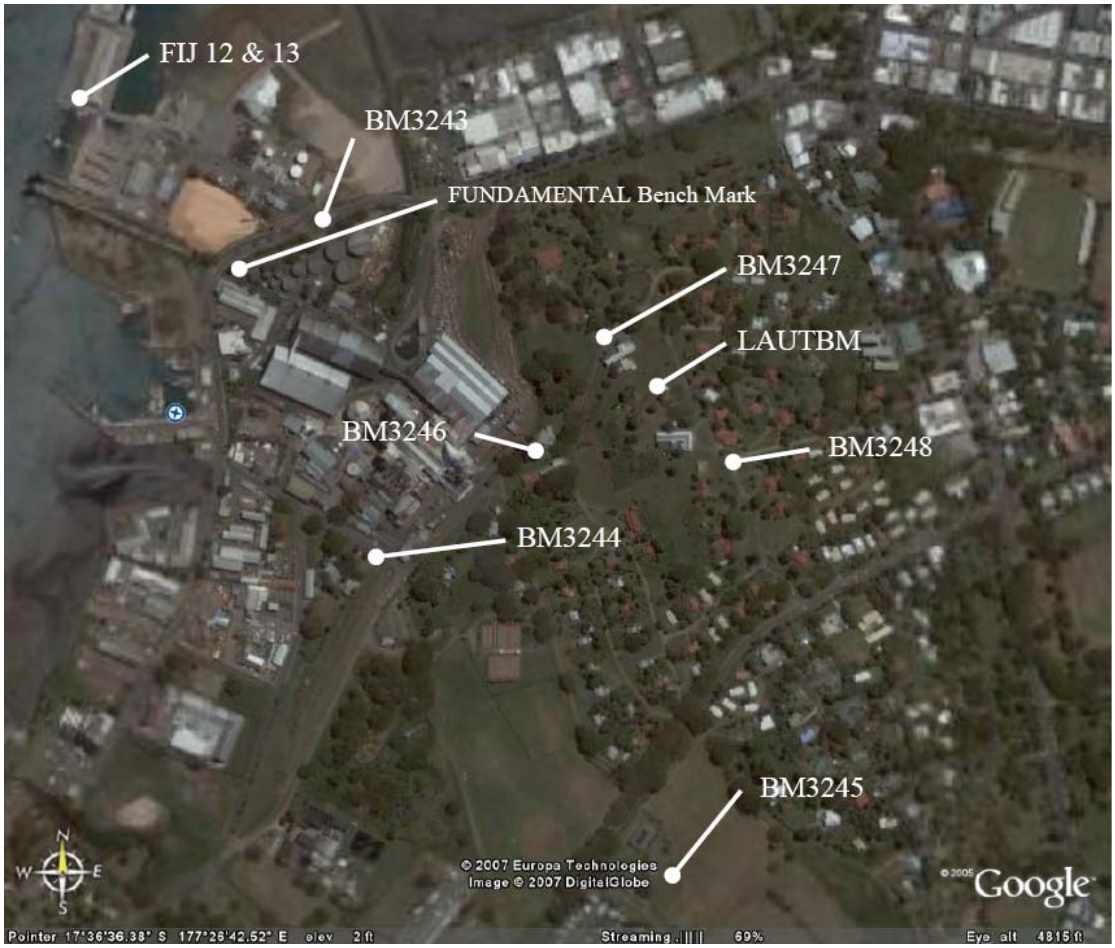
All the deep driven bench marks were located and found in good order and undisturbed. An additional six new permanent and stable holding marks were established during the 2008 visit – **FIJ205 – FIJ210**.
These new marks are domed stainless steel bolts drilled in concrete and then glued in place with quality epoxy resin.
A level connection from **FIJ205** to the **Fundamental Bench Mark or Wharf Pillar** was completed during this visit. The Pillar is located within the FSC grounds next to the sugar conveyor belt along the Waterfront Road.

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 √K** or better was achieved, where K is levelled distance in kilometres, this is well within the Project Specification precision of **2mm √K.**

Bench Mark Locality Map



The Fiji Datum

The Datum for the survey is Tide Staff Zero (TSZ).

Reduction of the data has been calculated holding BM3243 fixed at 3.1285175 metres, this value was determined by the NTC in October 1992.

Equipment

LEICA Total Station Model TCA2003 (S/N 440883).
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 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, ie an even number of setups when the two reflector rod configuration was used – this eliminates any reflector rod zero offset.

Atmospheric readings were obtained using a KESTRAL 4000 Pocket Weather Tracker. These atmospheric readings were recorded manually onto the 2008 Fiji 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 appreciated the support of Baseva Leba Gonewai from the Lands and Survey Drafting Office.
Leba assisted us greatly, out of hours and during the weekend to gain access to the Survey Office and to acquire the GGPS Hut keys – her efforts saved us a significant amount of time.
We would also like to mention the efforts from Kesho Sharma from the Lands and Survey Department, Kesho assisted us for a couple of days but due to his work and study commitments he was unable to assist us as much as he would have liked.

Other personnel consulted during the visit were:
Mr. Tevita Nalawa, Divisional Surveyor, Western Region
Mr. Walmik, Acting Senior Surveyor

The Lautoka Lands and Survey Department have always had a keen interest in the SPSLCMP and are always supportive with any associated project matters.

Issues

No issues or concerns of any significance were encountered during the 2008 visit but a few suggestions are worth mentioning.

1. Arrange access and security passes to the wharf area prior to arrival in Fiji. This can be done through the Lands and Survey Department.
2. Access to the GRIMIT Centre and BM3245 can be difficult at times, especially

during the weekend – the best contact is the maintenance man / gardener to organise access.

3. If the level run along the Waterfront Road from BM3243 to BM3244 (or the holding mark FIJ206, adjacent to BM3244) can be done during the weekend to avoid the heavy vehicle traffic it will save a considerable amount of time and reduce the occurrence of re-levels.

Description of Survey Marks – LAUTOKA, FIJI

BM 3243 is the bench mark held fixed with an **RL = 1.1285175 metres**

The height of **BM3243** was derived by NTC by:

1992 Adopting **Tide Staff Zero**

1994 Adopting the height of **BM3243** from the 1992 survey

Bench Marks:
BM3243, BM3244, BM3245, BM3246, BM3247 and BM3248 are all Deep Driven BM's

Points:
FIJ13 is the SEAFRAME Sensor Bench Mark

FIJ12 is the Project Plaque point

LAUTBM is the Reference Bench Mark for the CGPS Pillar.

All other points used with the prefix of **FIJ** are holding marks.

Fundamental Bench Mark is a square concrete block approximately 1.2 metres high with a square metal plate attached to the top. The reference point is a punch mark in the centre of the plate.

Table of Results for 2008 and Comparisons between 2007 and 2008

FIJI 2008 - EDM Height Traversing Levelling Comparison 2007 - 2008 and Table of Results

BM3243 - Adopted fixed height (TGZ) 3.12852

FROM	TO	Levelled Height Difference	Reduced Level 2008	Misclose (mm)	Distance (Km)	1mm√K	Reduced Level 2007	Difference (mtrs) 2007 - 2008
BM3243	FIJ12	0.93867	4.06719	0.13	0.48	0.69	4.06635	-0.00084
FIJ12	FIJ13	0.37441	4.44160	-0.22	0.01	0.09	4.44125	-0.00035
BM3243	BM3244	1.04052	4.16904	-0.25	0.76	0.87	4.16793	-0.00111
BM3244	BM3246	3.65432	7.82336	-0.40	0.35	0.59	7.82196	-0.00140
BM3246	BM3247	13.13523	20.95859	0.43	0.22	0.46	20.95719	-0.00140
BM3247	LAUTBM	10.38131	31.33990	0.23	0.16	0.40	31.33841	-0.00149
LAUTBM	BM3248	3.89608	35.23598	0.32	0.17	0.41	35.23326	-0.00272
BM3248	BM3245	-18.59807	16.63791	0.06	0.95	0.97	16.63649	-0.00142
FIJ13	BM3245	12.19631	16.63791	0.30	3.089	1.76	*Allowable Misclose is 2√K*	

An internal precision of 1mm√K was achieved for all bays levelled - this is well within the Project Specification of 2mm√K

Combined Comparisons 1992 to 2008

FIJI - Comparison of the RL's for Precise Differential Levelling (1992 to 2005) and EDM Height Traversing (2005 to 2008)

YEAR	MARK								
	BM 3243	BM 3244	BM 3245	BM 3246	BM 3247	BM 3248	LAUTBM	FIJ 13	FIJ 12
1992	3.1285	4.1601	16.6280					4.4326	4.0591
1994	3.1285	4.1597	16.6270					4.4336	4.0597
1995	3.1285	4.1606	16.6293					4.4345	4.0606
1997	3.1285	4.1607	16.6293					4.4341	4.0608
1998	3.1285	4.1612	16.6243					4.4342	4.0606
2000	3.1285	4.1630	16.6314					4.4352	4.0611
2002	3.1285	4.1632	16.6313	7.8170	20.9526	35.2283	31.3337	4.4348	4.0603
2003	3.1285	4.1635	16.6327	7.8179	20.9533	35.2294	31.3338	4.4368	4.0624
2005	3.1285	4.1679	16.6362	7.8219	20.9571	35.2332	31.3375	4.4396	4.0657
2005 EDM	3.1285	4.1674	16.6366	7.8217	20.9569	35.2334	31.3379	4.4395	4.0655
2007 EDM	3.1285	4.1679	16.6365	7.8220	20.9572	35.2333	31.3384	4.4413	4.0664
2008 EDM	3.1285	4.1690	13.6379	7.8234	20.9586	35.2360	31.3399	4.4416	4.0672

FIJI – 2008 REDUCED LEVELS

VITI LEVU - LAUTOKA

Date: 26 September – 4 October 2008

Datum: Tide Staff Zero

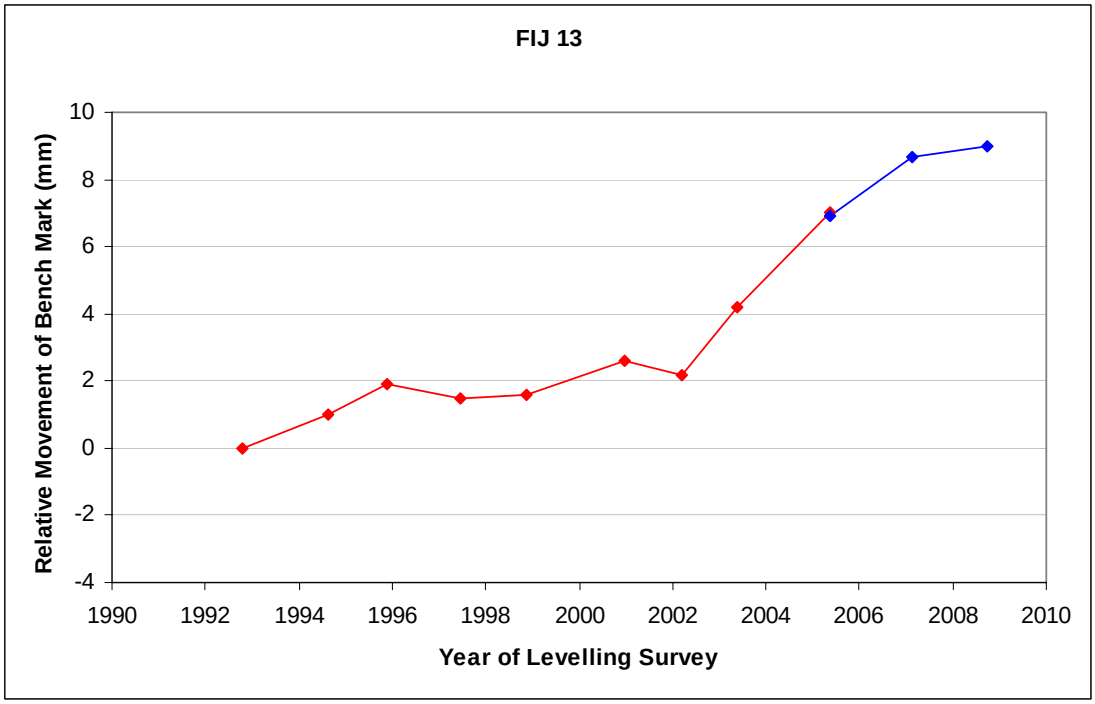
POINT#	2008 levelled diff. ht.	2008 RL
BM3243 (fixed)	***0.000000***	***3.1285175 (fixed)***
FIJ12	**+0.93867**	**4.06719**
FIJ13	**+0.37441**	**4.44160**
BM3243	***0.000000***	***3.1285175 (fixed)***
BM3244	**+1.04052**	**4.16904**
BM3246	**+3.65432**	**7.82336**
BM3247	**+13.13523**	**20.95859**
LAUTBM	**+10.38131**	**31.33990**
BM3248	**+3.89608**	**35.23598**
BM3245	**-18.59807**	**16.63791**

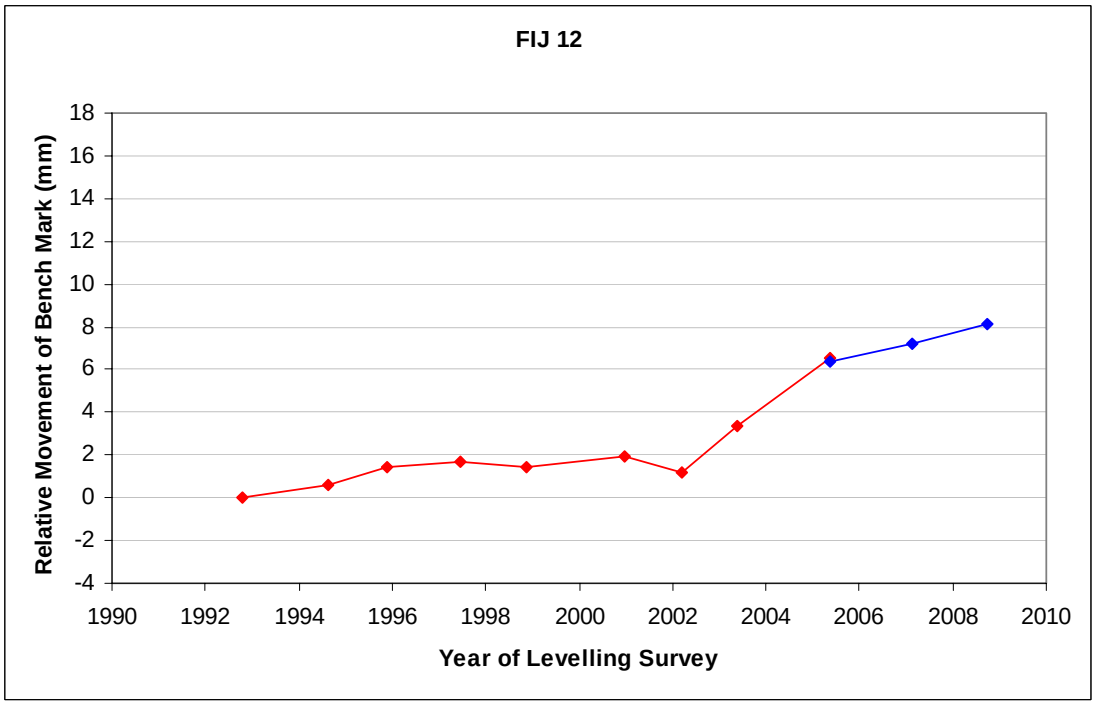
Fundamental Bench Mark 2008 Reduced Level **4.79652**

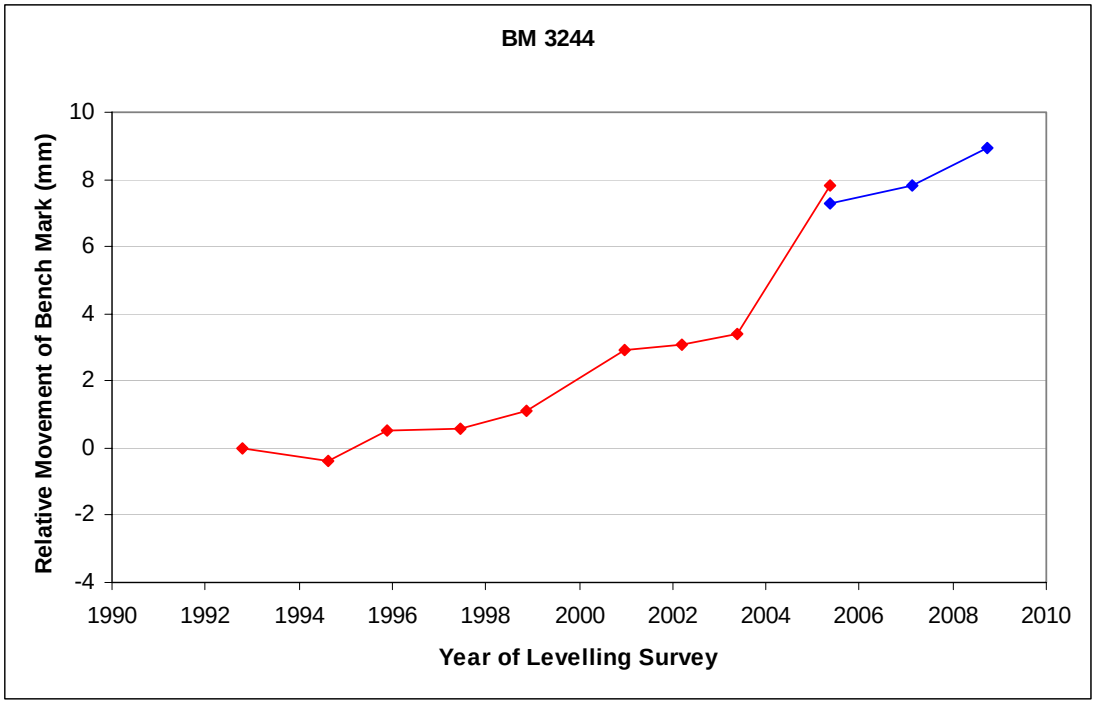
Time Series of Bench Mark movement relative to the Fixed Deep Driven Bench Mark - BM 3243

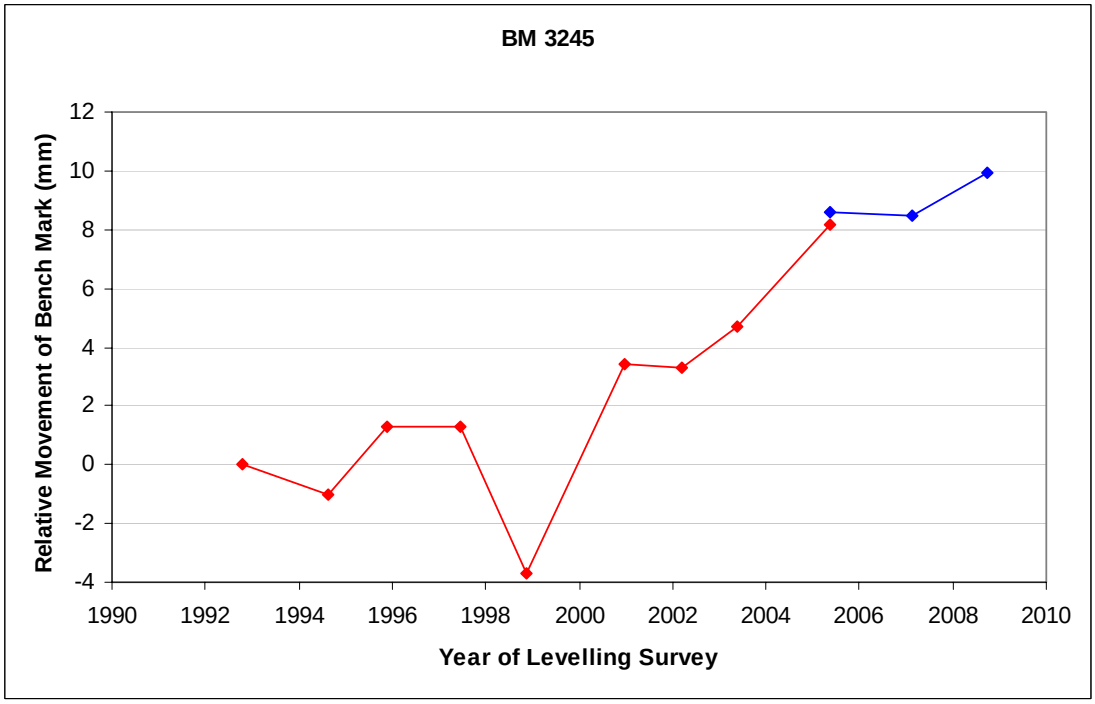
Precise Differential Levelling - 1992 to 2004 (2006)

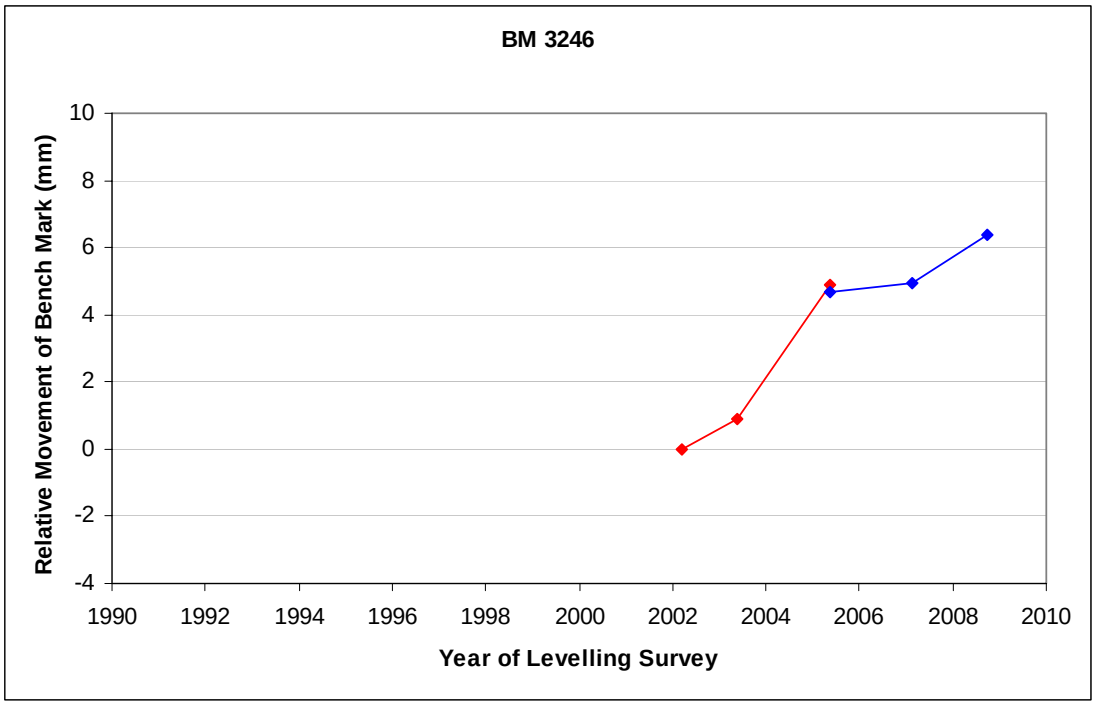
EDM Height Traversing - commenced 2006

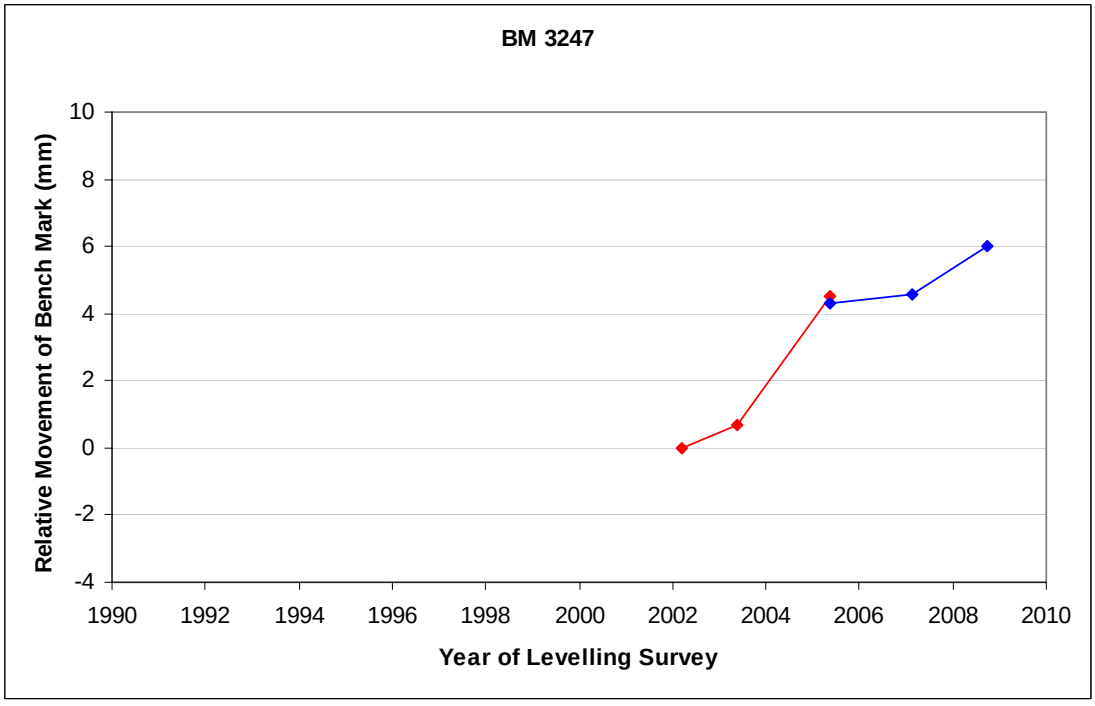


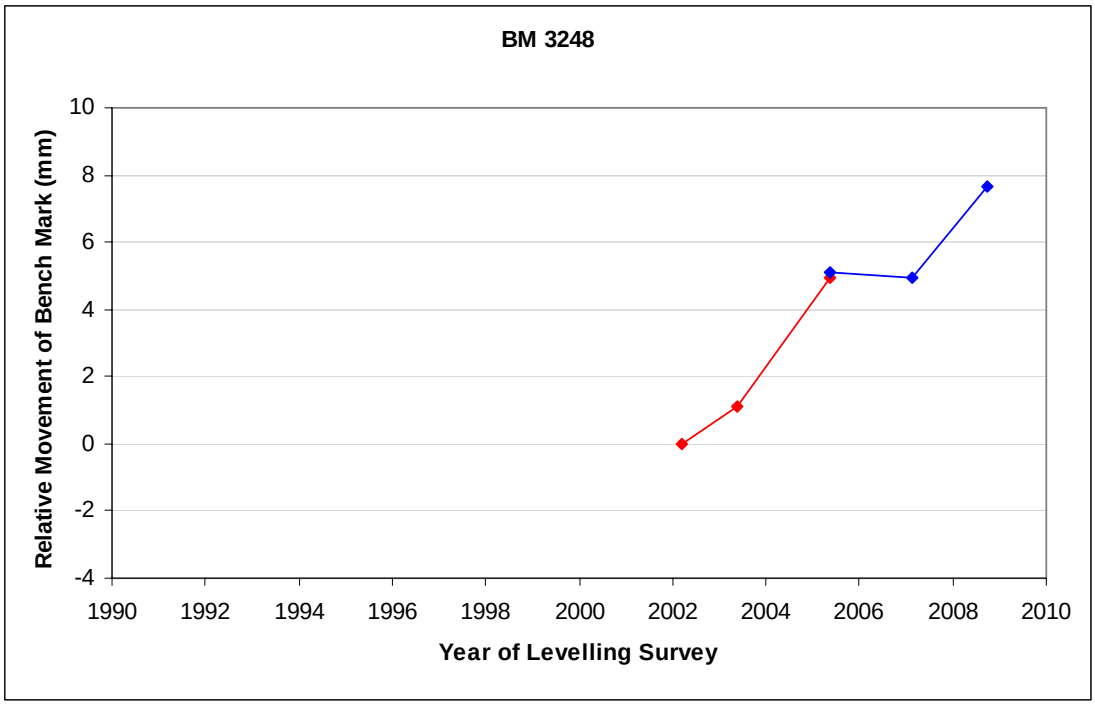


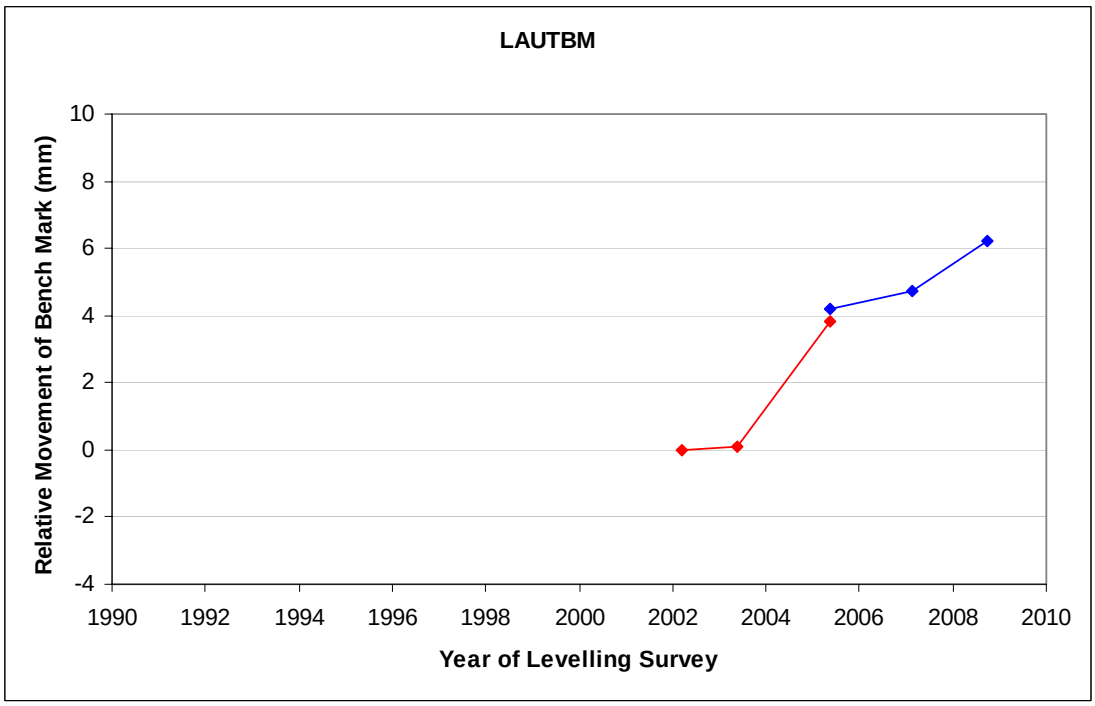












Deep Driven Bench Mark Locality Diagrams

SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

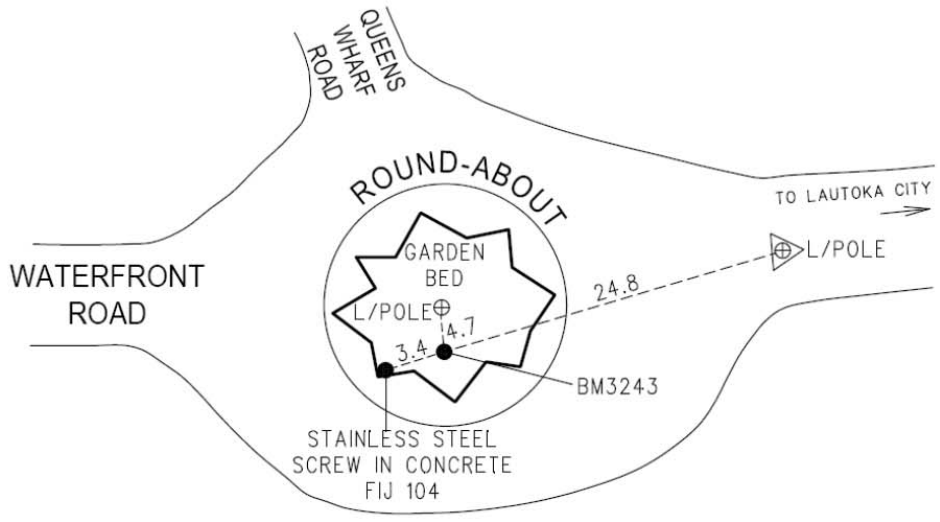
Bench Mark Number: BM3243

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 16-01-92
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.	
Country: Fiji Islands *Island*: Viti Levu	*City:* Lautoka

Marking and locality sketch

Bench Mark: 8.6m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 0.75m. Top of mark 0.5m 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: April 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

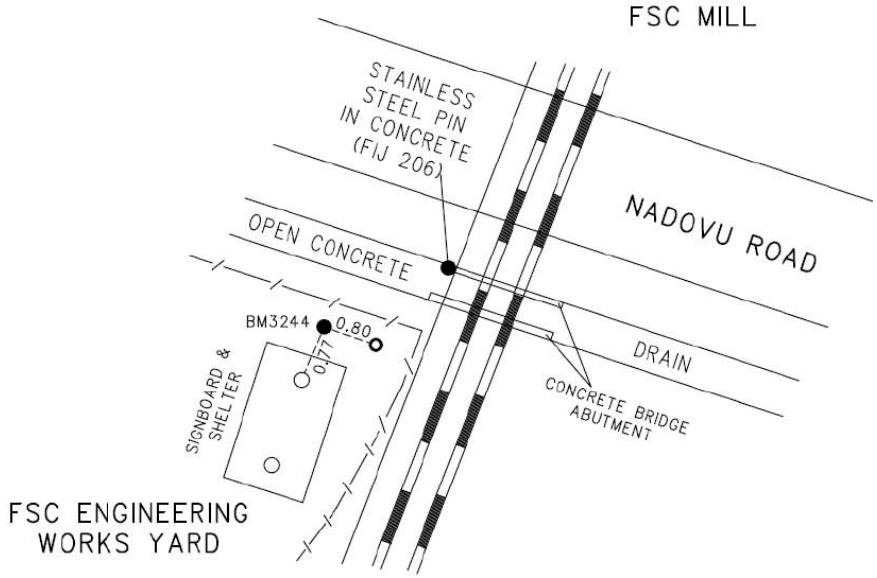
Bench Mark Number: BM3244

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 08-02-92
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
Country: Fiji Islands *Island*: Viti Levu	*City:* Lautoka

Marking and locality sketch

Bench Mark: 9.8m 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 0.2m below ground level.

Locality sketch: Mark approximately 1150m from the tide gauge station.



Not to scale | Distances in Metres | Magnetic bearings

Approved by: Geoscience Australia / SOPAC — Date: April 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

Bench Mark Number: BM3245

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

Date: 16-01-92

Existing Bench Mark Established by:

Date:

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

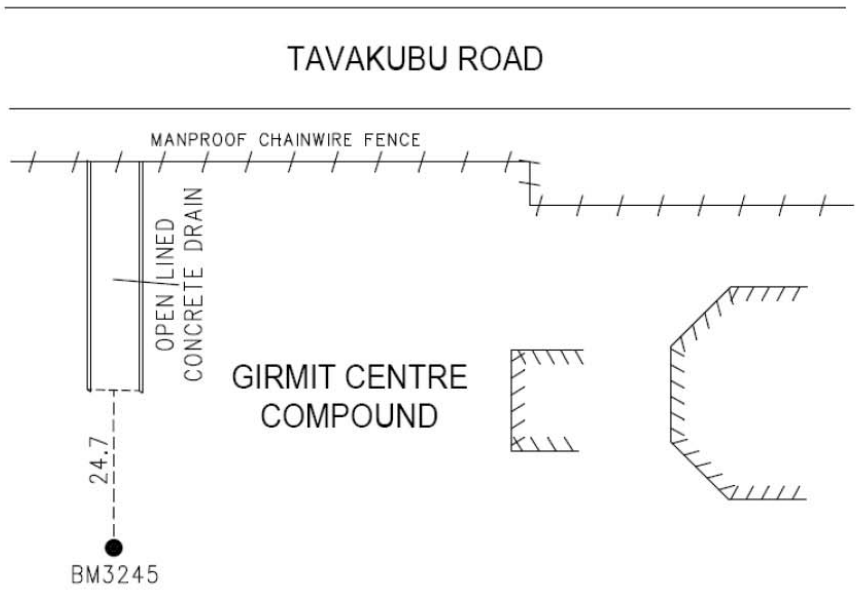
Country: Fiji Islands
Island: Viti Levu

City: Lautoka

Marking and locality sketch

Bench Mark: 8.6m 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 0.2m below ground level.

Locality sketch: Mark approximately 2300m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: April 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

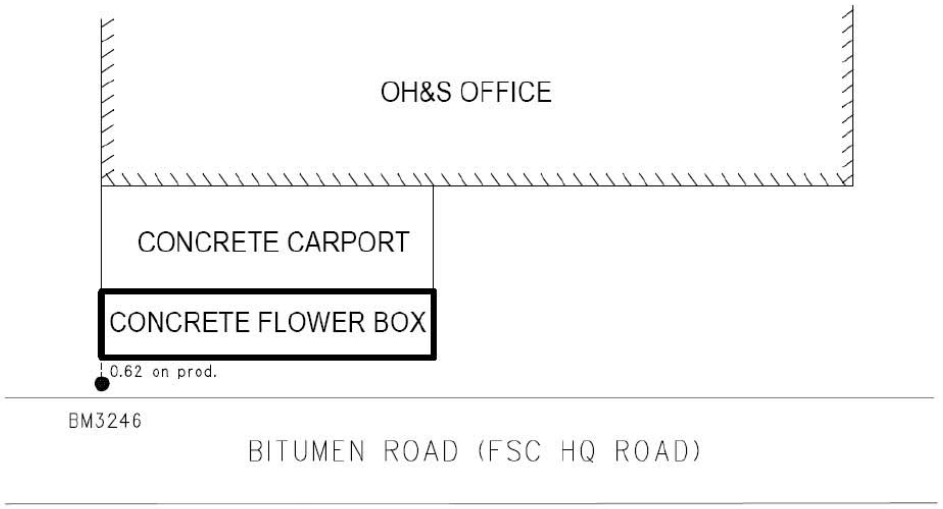
Bench Mark Number: BM3246

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 27-02-02
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
Country: Fiji Islands *Island*: Viti Levu	*City:* Lautoka

Marking and locality sketch

Bench Mark: 6.9m 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 1600m from the tide gauge station.



Not to scale | Distances in Metres | Magnetic bearings

Approved by: Geoscience Australia / SOPAC | Date: April 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

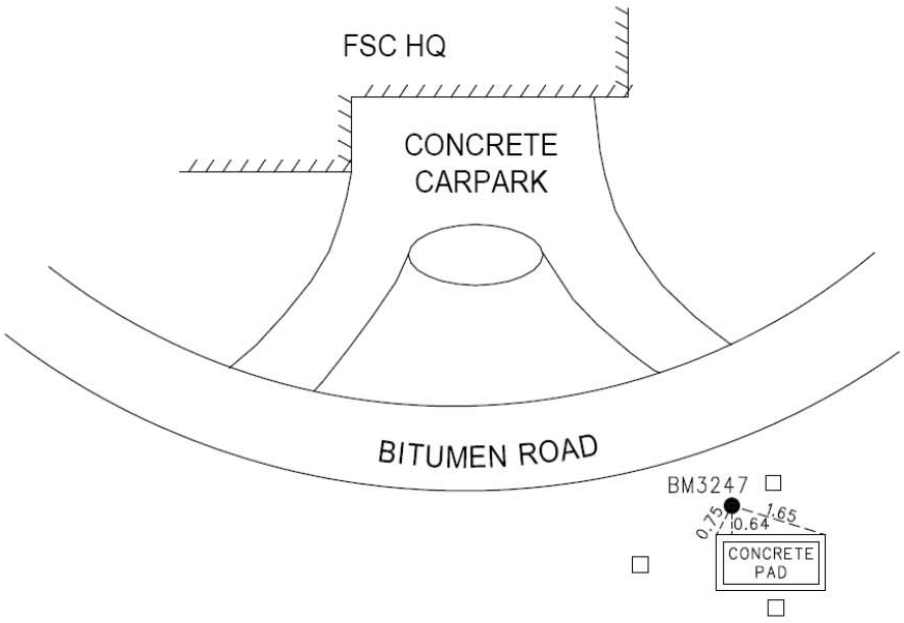
Bench Mark Number: BM3247

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 27-02-02
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.	
Country: Fiji Islands *Island*: Viti Levu	*City:* Lautoka

Marking and locality sketch

Bench Mark: 4.2m 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 1800m from the tide gauge station.



Not to scale | Distances in Metres | Magnetic bearings

Approved by: Geoscience Australia / SOPAC | Date: April 2007

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

Bench Mark Number: BM3248

Original Bench Mark Established by:
National Tidal Centre Australia, Oceanographic Services,
Bureau of Meteorology, 25 College Rd, Kent Town, SA.
Date: 27-02-02

Existing Bench Mark Established by:
Date:

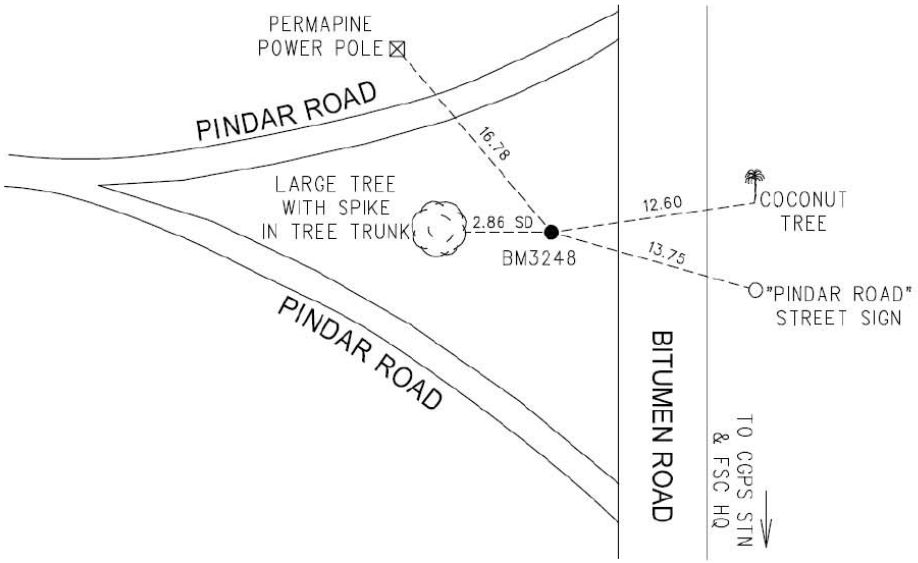
Notes / References: Deep Survey Benchmark
This survey mark is not in a good locality (tree) for GPS occupation.

Country: Fiji Islands
Island: Viti Levu
City: Lautoka

Marking and locality sketch

Bench Mark: 4.2m 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 2250m from the tide gauge station and approximately 200m from the CGPS Station.



Not to scale | Distances in Metres | Magnetic bearings

Approved by: Geoscience Australia / SOPAC
Date: April 2007
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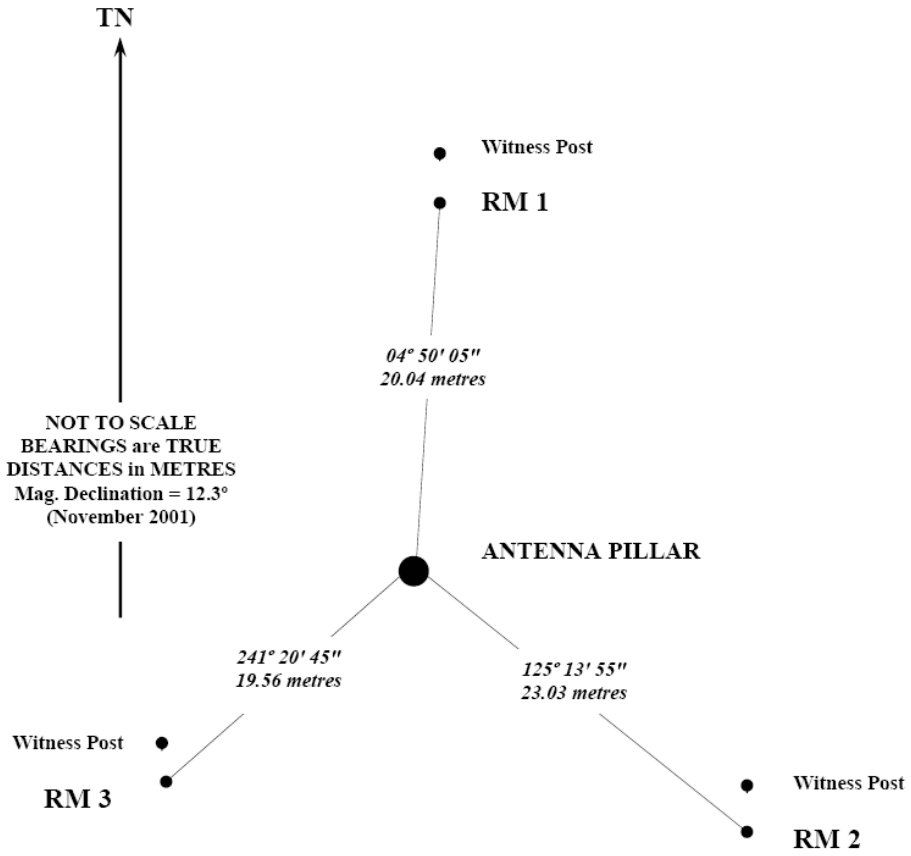
LAUTBM and LAUT Reference Mark Locality Diagrams

FIJI CGPS Station, FSC Lautoka – Reference Marks

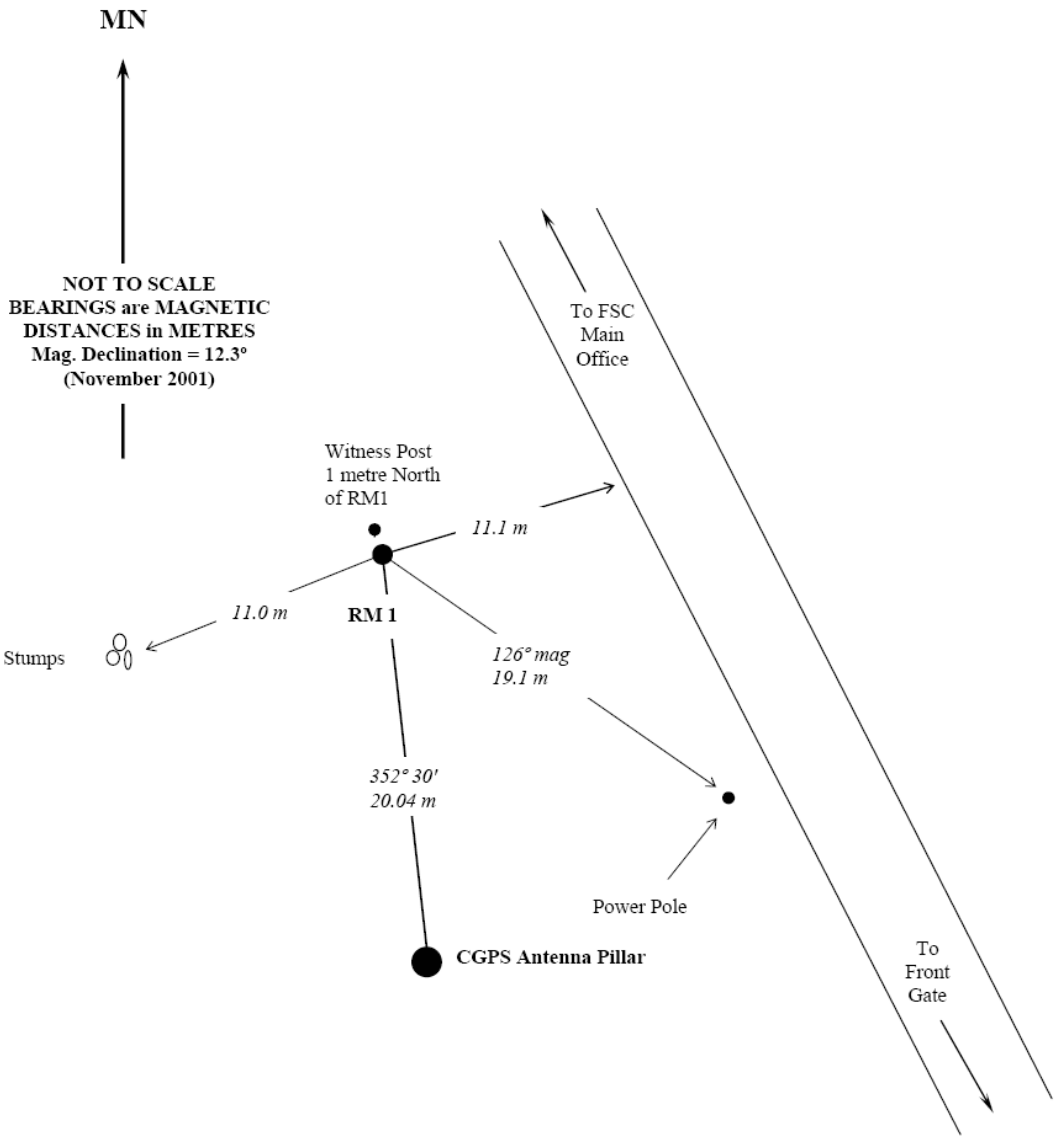
REFERENCE MARKS

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 150 mm below ground level.
Treated pine witness posts 150 mm in diameter and 1.4 m high are located 1 metre to the north of each RM.



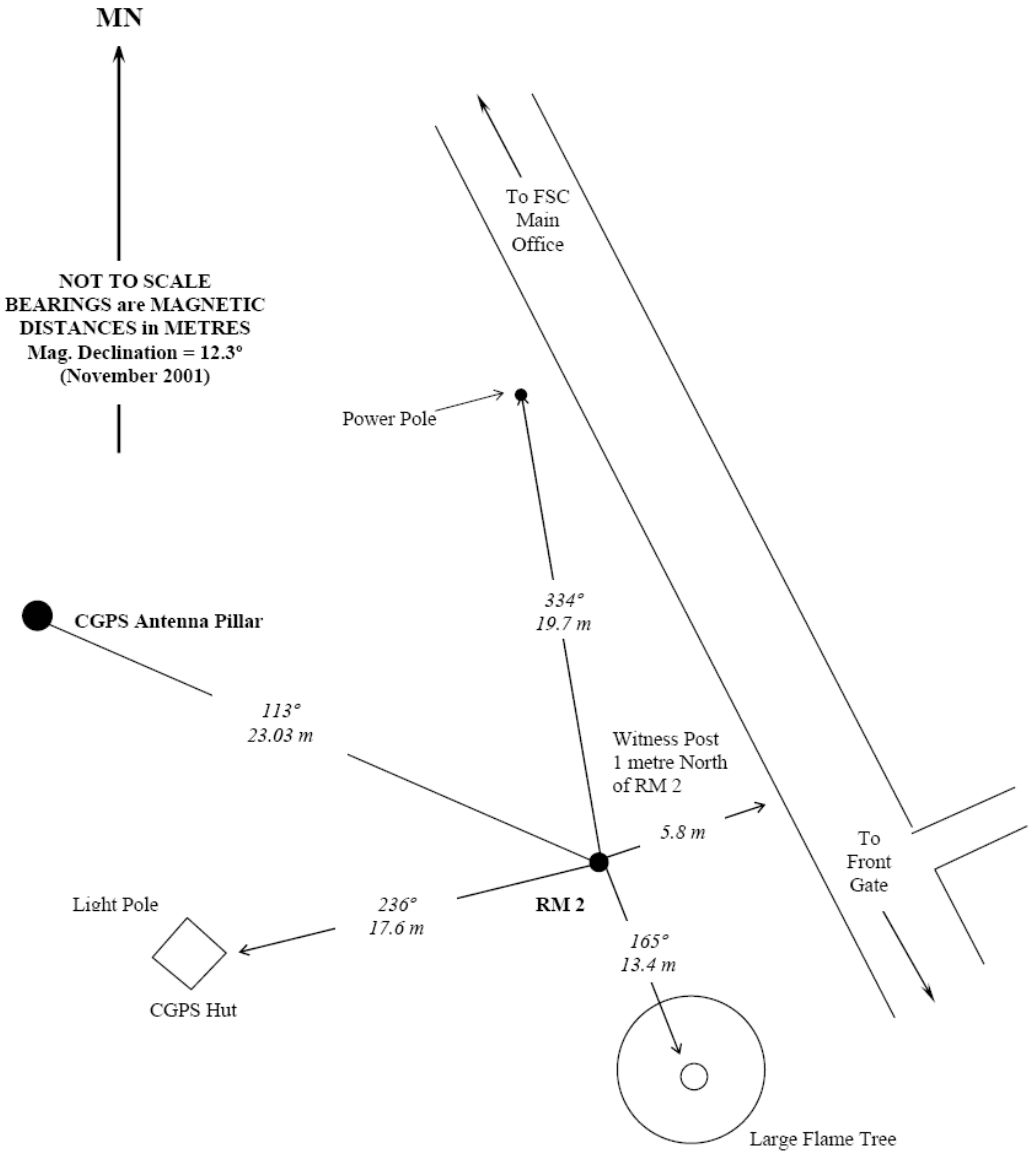
FIJI CGPS Station, FSC, Lautoka – RM 1 Location Diagram

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 150 mm below ground level.
Treated pine witness posts 150 mm in diameter and 1.4 m high are located 1 metre to the north of each RM.



FIJI CGPS Station, FSC, Lautoka – RM 2 Location Diagram

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 150 mm below ground level.
Treated pine witness posts 150 mm in diameter and 1.4 m high are located 1 metre to the north of each RM.



FIJI CGPS Station, FSC, Lautoka – RM 3 Location Diagram

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 150 mm below ground level.
Treated pine witness posts 150 mm in diameter and 1.4 m high are located 1 metre to the north of each RM.