Australian Government

Geoscience Australia

Survey Report

South Pacific Sea Level and Climate Monitoring Project
(SPSLCMP)

EDM Height Traversing (Leap Frog Method)
& Precise Differential Levelling Surveys.

KIRIBATI

March 2006

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1. Bench Mark Locality Map

2. Introduction

This report outlines the surveys completed during the visit to Kiribati, March 2006.
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As part of the South Pacific Sea Level and Climate Monitoring Project (SPSCLMP), Geoscience Australia has been requested to undertake the Levelling Survey of the Deep Bench Mark Array and SEAFRAME Station using both the Electronic Distance Measuring (EDM), Height Traversing, leap frog method and the Precise Differential Levelling techniques. This request was from the Australian Agency for International Development (AusAID).

The Levelling Comparison, Table of Results and Reduced Levels are listed on Pages 7, 8 and 9.

This survey was the first to be completed in Kiribati using the EDM Height Traversing and the Precise Differential Levelling techniques. From the results of the two techniques a comparison will be determined and on subsequent scheduled Kiribati visits, Geoscience Australia will perform the EDM Height Traversing Levelling method only.

3. Equipment

EDM Equipment

LEICA Total Station Model TCA1800 (S/N 424936).
LEICA Precision Prisms GPH1P (2).
LEICA Rigid Tripod.
Stainless Steel Target Poles supported by LEICA 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

Digital Levelling Equipment

LEICA Digital Level Model NA3003 (S/N 283676)
LEICA Invar Staves, supported by telescopic Bi-Poles (2)
LEICA Rigid Tripod.
LEICA Cast Iron Change Plates (2).

4. Method

The EDM Height Traversing and the Precise Differential Levelling methods were both 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.

All observations for both techniques were recorded digitally.

For the EDM Height Traversing method, atmospheric readings were obtained using a KESTRAL 4000 Pocket Weather Tracker. These atmospheric readings were recorded manually onto the Kiribati Levelling Booking Sheets and entered into the Total Station prior to each level run and approximately every hour thereafter.

For the Precise Differential Levelling method all observations were recorded manually, in the field, onto Field Levelling sheets.

5. Route (refer to Bench Mark Locality Map Page 4)

All the KIRI Reference Marks, KIRIBM and the Coastal Array Bench Marks were found undisturbed and in good order.*

Levelling connections were made to:

KIR1 - Deep driven BM (held fixed) located in the Department of Transport grounds.
KIR2 - Deep driven BM located at the U.S. WWII War Memorial Monument
KIR3 - Deep driven BM located at the Kiribati Weather Office
KIR46 - Deep driven BM located near the roundabout en-route to the Weather Office
KIR47 - Deep driven BM located within Church grounds en-route to the Weather Office.
KIR49 - Deep driven BM located outside the Police Marine Unit at the wharf area.
KIR40 - Stainless Steel Holding Mark, located on the left hand side of the wharf road.
KIR39 - Stainless Steel Holding Mark, located along the wharf road outside the Petrol Depot.
KIR53 - Masonry Nail Holding Mark, located on the left hand side of the wharf road.
KIR12 - Tide Gauge Project Plaque.
KIR13 - SEAFRAME Sensor BM.
KIRIBM and the 3 Reference Marks.

The Kiribati Level Route (EDM Height Traversing Technique) started at **KIR1,** which is held fixed and located within the Department of Transport grounds. From **KIR1** the level route proceeded via **KIR40, KIR39, KIR53, KIR49** and **KIR12**, the SPSLCMP Project Plaque at the Tide Gauge, and then the short connection to the SEAFRAME Sensor BM, **KIR13** was completed using the Primary Stainless Steel Levelling Pole.

The level route then recommenced at **KIR1** and followed the main road west to **KIR46** and then southwest along the main road towards the Weather Service Office and the CGPS Station via the following:
KIR2
KIR47
KIR3
KIRIBM and the 3 Reference Marks

A total distance of approximately 2.12 Kilometres.

The Precise Differential Levelling technique followed the same route and also included all the existing holding marks previously placed by NTC.

An internal precision of 1.0mm $\sqrt{K}$ or better was achieved for both methods and for all sections levelled.

*See the KIRI Reference Mark and KIRIBM locality diagrams on Pages 10 to 13 and the Deep Driven BM locality diagrams on Pages 14 to 19.

6. Levelling Comparison and Table of Results

KIRIBATI - Levelling Comparison and Table of Results (March 2006)

BENCH MARK NUMBER		EDM Height Traversing Technique			Distance (Km)	1mm√K	Precise Differential Levelling			Comparison between Levelled Height Differences EDM - Precise (Metres)
From	To	Levelled Diff. Ht. (Metres)	Reduced Level (Metres)	Misclose (mm)			Misclose (mm)	Levelled Diff. Ht. (Metres)	Reduced Level (Metres)	
KIR1 (fixed)			*3.53340*						*3.53340*	
KIR1 (Fixed)	KIR40	0.07736	3.61076	0.335	0.117	0.342	0.090	0.07683	3.61023	0.00053
KIR40	KIR39	0.46787	4.07863	0.060	0.175	0.418	-0.250	0.46762	4.07785	0.00025
KIR39	KIR53	-0.22838	3.85025	0.243	0.202	0.449	0.115	-0.22791	3.84994	-0.00047
KIR53	KIR49	0.17278	4.02303	0.288	0.143	0.378	-0.125	0.17269	4.02263	0.00009
KIR49	KIR12	0.19626	4.21929	-0.223	0.174	0.417	0.240	0.19685	4.21948	-0.00059
KIR12	KIR13	0.41327	4.63256	0.038	0.007	0.084	0.000	0.41332	4.63280	-0.00004
KIR1	KIR46	-0.15391	3.37949	0.004	0.207	0.455	-0.060	-0.15457	3.37884	0.00066
KIR46	KIR2	-0.19506	3.18443	0.313	0.378	0.615	-0.115	-0.19496	3.18388	-0.00010
KIR2	KIR47	0.11092	3.29535	-0.238	0.354	0.595	-0.175	0.11172	3.29560	-0.00080
KIR47	KIR3	0.26929	3.56464	0.220	0.360	0.600	-0.530	0.27059	3.56619	-0.00130
KIR3	KIRIBM	0.84771	4.41235	0.025	0.017	0.130	-0.095	0.84770	4.41389	0.00001
						Allowable Misclose is 2mm√K				
KIR13	KIRIBM	0.22021	4.41235	1.065	2.134	1.461	-0.905	0.21891	4.41389	0.00130

7. Comparison of Reduced Levels

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

YEAR						MARK			
	KIR1	KIR2	KIR3	KIR12	KIR13	KIR46	KIR47	KIR49	KIRIBM
1992	3.5334	3.1835	3.5657	4.2176	4.6302				
1994	3.5334	3.1838	3.5655	4.2187	4.6319				
1995	3.5334	3.1845	3.5654	4.2195	4.6331	New Points establised in 2002			
1996	3.5334	3.1843	3.5654	4.2191	4.6321				
1997	3.5334	3.1843	3.5657	4.2196	4.6325				
1999	3.5334	3.1844	3.5644	4.2195	4.6324				
2000	3.5334	3.1847	3.5658	4.2195	4.6321				
2002	3.5334	3.1843	3.5648	4.2191	4.6321	3.3782	3.2948	4.0232	4.4124
2004	3.5334	3.1843	3.5653	4.2190	4.6324	3.3788	3.2952	4.0225	4.4130
2006	3.5334	3.1839	3.5662	4.2195	4.6328	3.3788	3.2956	4.0226	4.4139
2006 EDM	3.5334	3.1844	3.5646	4.2193	4.6326	3.3794	3.2953	4.0230	4.4124

8. Summary

All the data have been reduced holding KIR 1 fixed at 3.53340, Tide Staff Zero (TGZ) - the value NTC derived by adopting the TGZ height of bench mark UT 8 for the 1992 survey.

The 2006 comparison between the Precise Differential Levelling method and the EDM Height Traversing method has indicated no significant differences between accuracies of the two techniques, refer to **Table 7. Comparisons of Reduced Levels.**
Both methods produced results and accuracies better than **1mm$\sqrt{K}$,** well within the Project specifications of **2mm$\sqrt{K}$**.

While the EDM Height Traversing technique is by no means new, the advancement of equipment technologies now makes the use of Total Stations a practicable replacement for the normal spirit levelling.

The Total Station Levelling technique has a number of benefits over normal spirit levelling. The elimination of collimation errors and Staff calibration errors and the minimisation of refraction errors make the technique attractive to those undertaking Class A ("First Order") levelling. The use of significantly longer sight lengths makes it attractive to everybody else. The technique does require slightly longer observation periods per standpoint, however this is offset by fewer instrument standpoints for the same length of run.

The other significant advantage is that the Total Station already exists on the surveyor's equipment list. There is no need for extra equipment to complete highly accurate level runs.

Taking all the benefits into account i.e. accuracy, simplicity of operation, the time taken for observing and the reduction of observations plus the dual use of the Total Station equipment for the Levelling Surveys as well as for the CGPS Station Local Stability Monitoring Surveys, significant gains are achieved with the adoption of the EDM Height Traversing technique.

9. 2006 Reduced Levels.

Betio Island – KIRIBATI

2006 REDUCED LEVELS:

Date:	**March 2006**
DATUM:	**Tide Gauge Zero**
INSTRUMENT:	**LEICA Total Station TCA1800 S/N 424936**

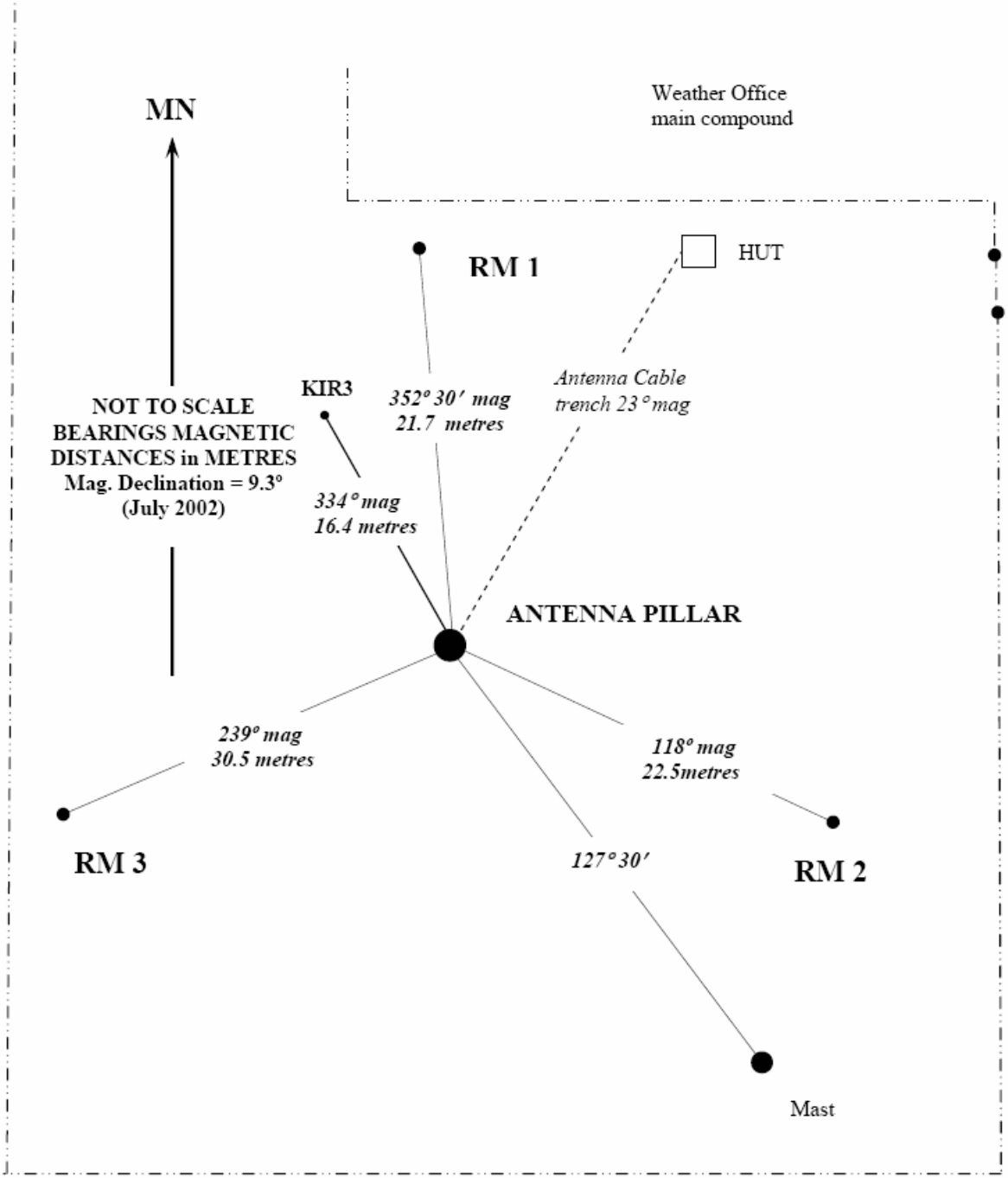
POINT #	**2006 RL**
KIR1	**3.53340 (Adopted fixed height)**
KIR40	3.61076
KIR39	4.07863
KIR53	3.85025
KIR49	**4.02303**
KIR12	**4.21929**
KIR13	**4.63256**
KIR46	**3.37949**
KIR2	**3.18443**
KIR47	**3.29535**
KIR3	**3.56464**
KIRIBM	**4.41235**

10. KIRIBATI RM's and BM locality diagrams.

KIRIBATI CGPS Station, Betio Is. – Reference Marks

REFERENCE MARKS

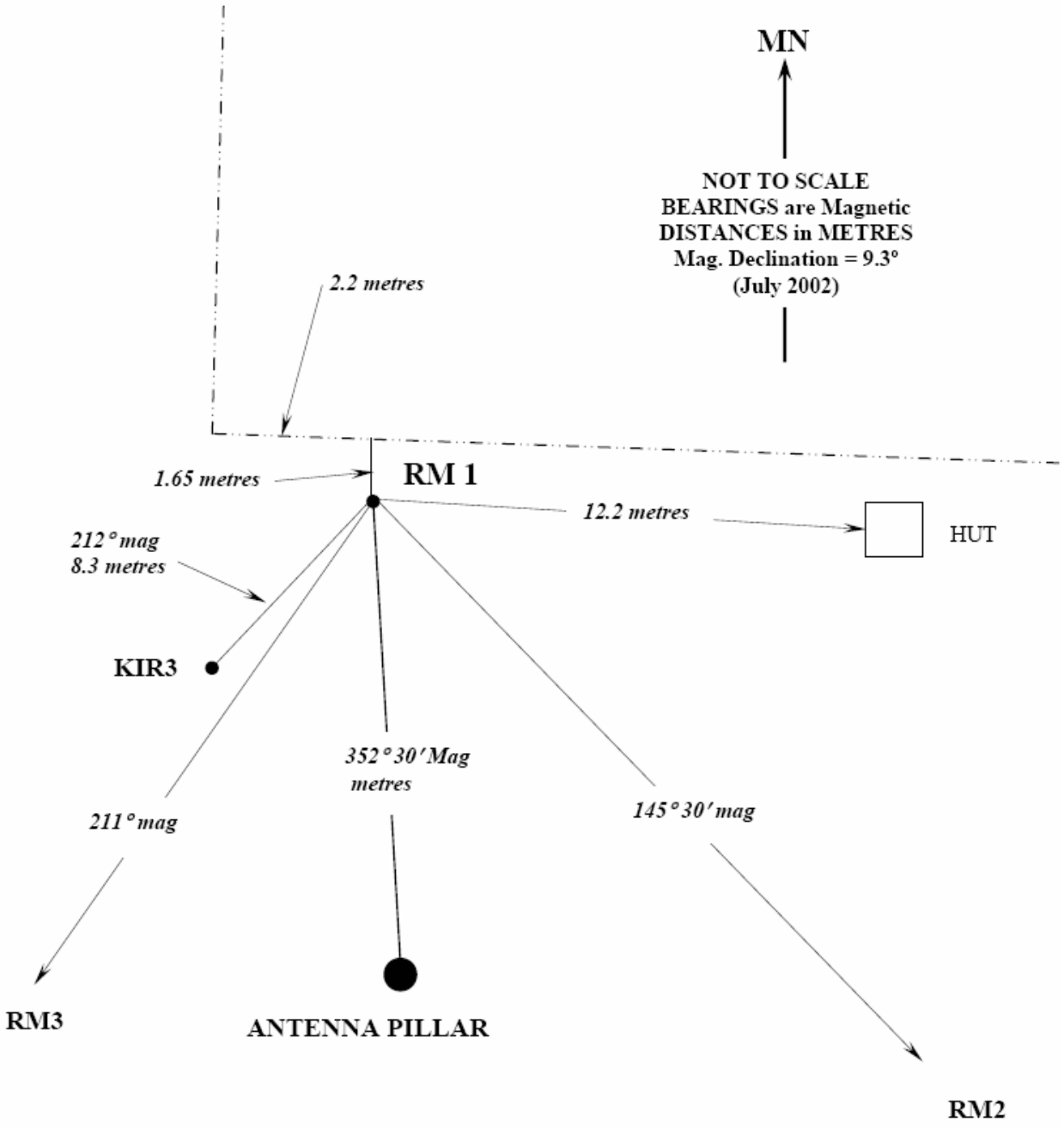
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 50mm below ground level.



KIRIBATI CGPS Station, Betio Is. – RM 1

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 50mm below ground level.



KIRIBATI CGPS Station, Betio Is. – RM 2

REFERENCE MARKS

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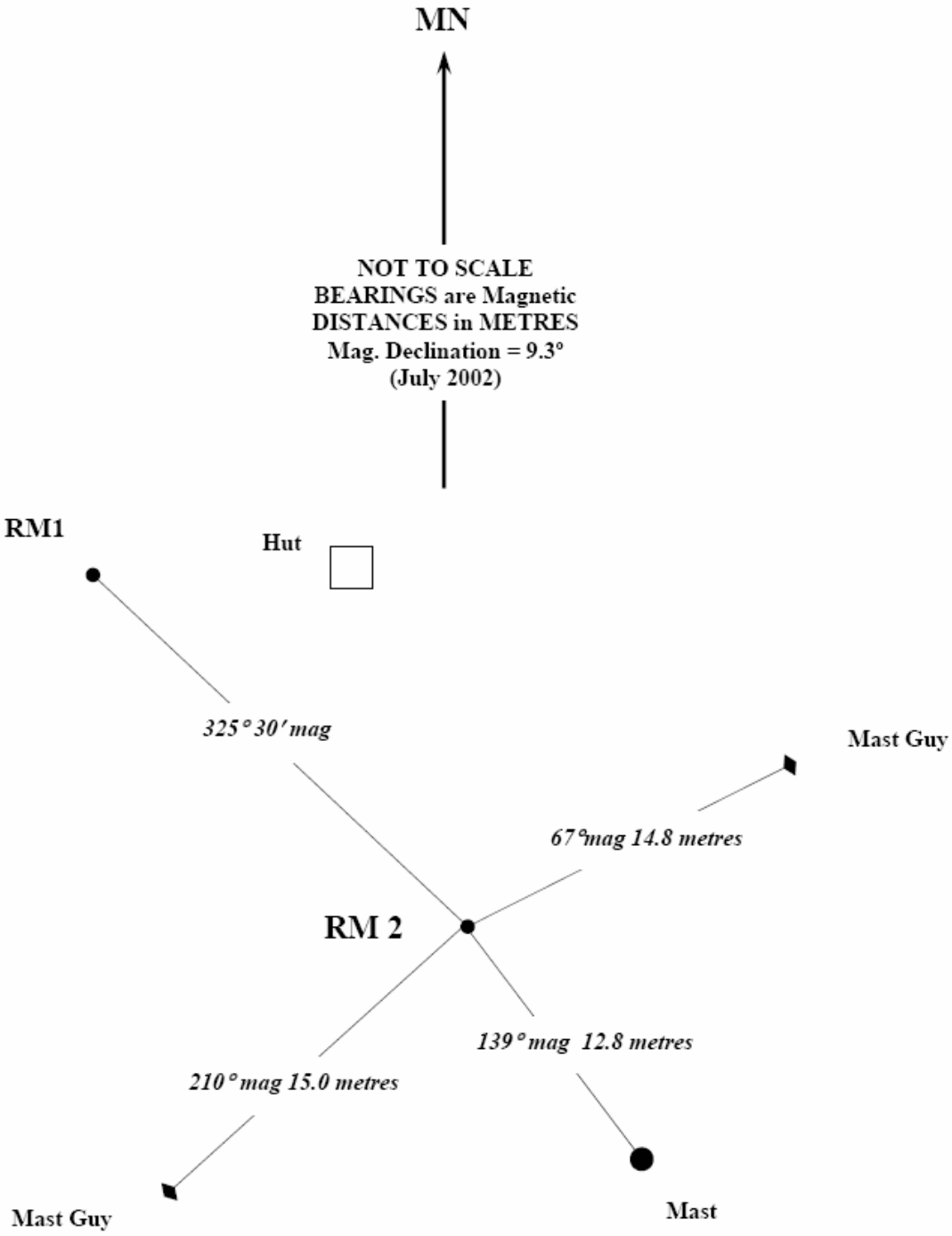
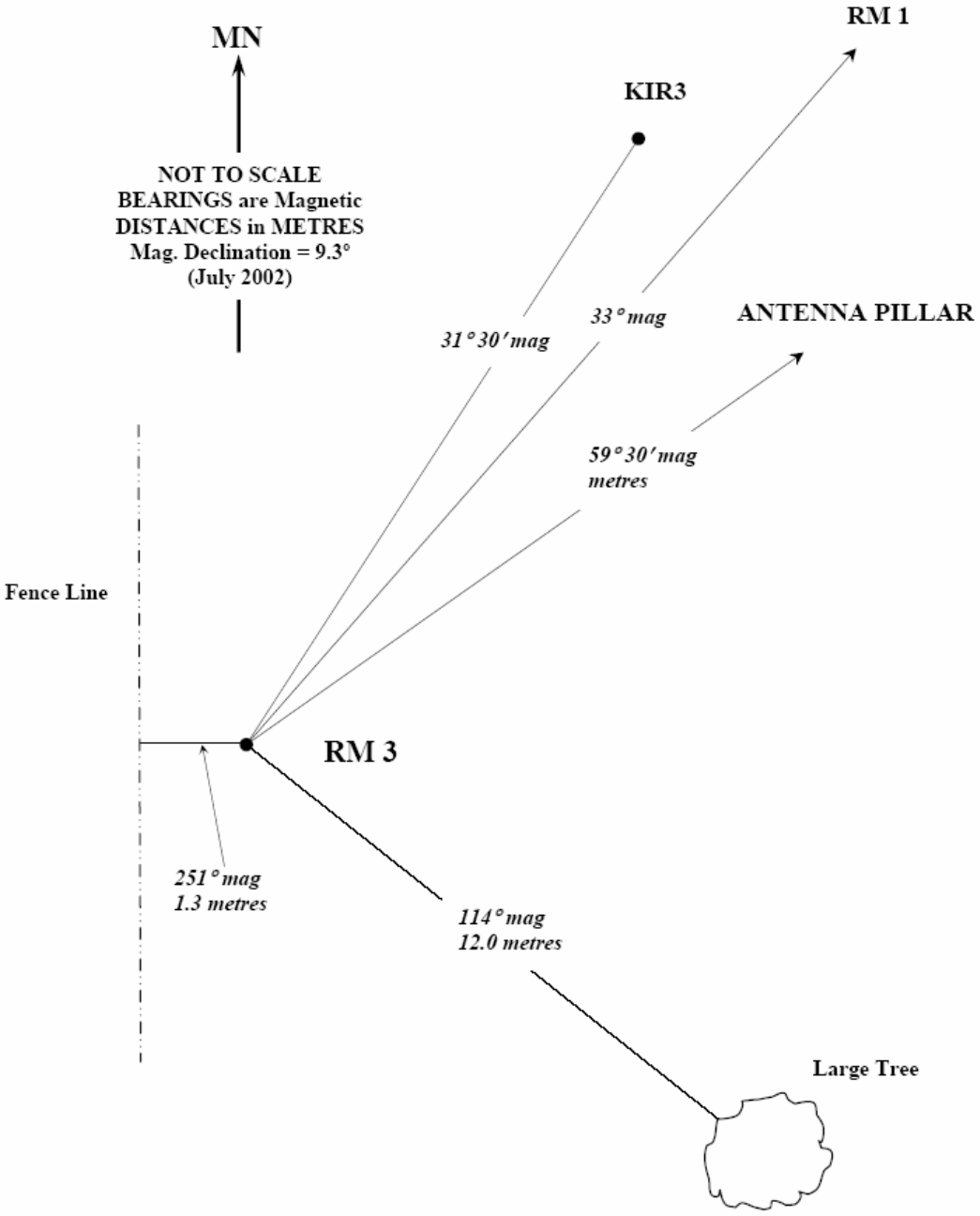


KIRIBATI CGPS Station, Betio Is. – RM 3

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 50mm below ground level.



11. Deep Driven Bench Mark Locality Diagrams

SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

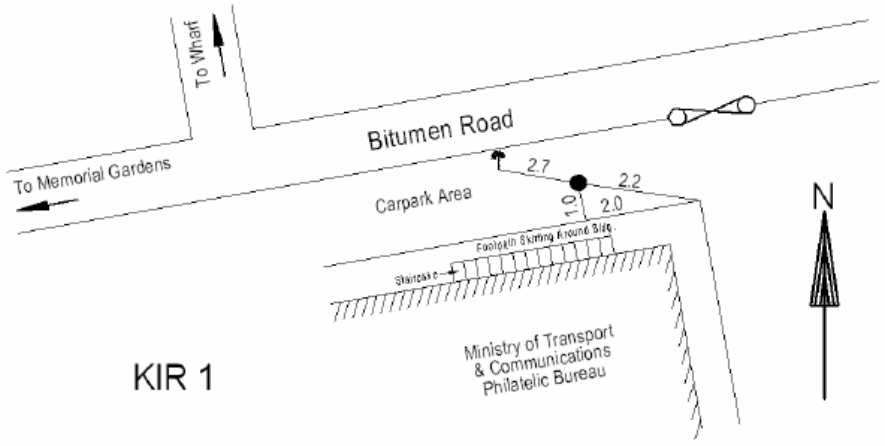
Bench Mark Number: KIR1

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 28-01-92
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
Country: Kiribati *Island*: Tarawa	*Atoll: Betio*

Marking and locality sketch

Bench Mark: 6.2m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.0m. Top of mark 0.2m below 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: April 2006

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

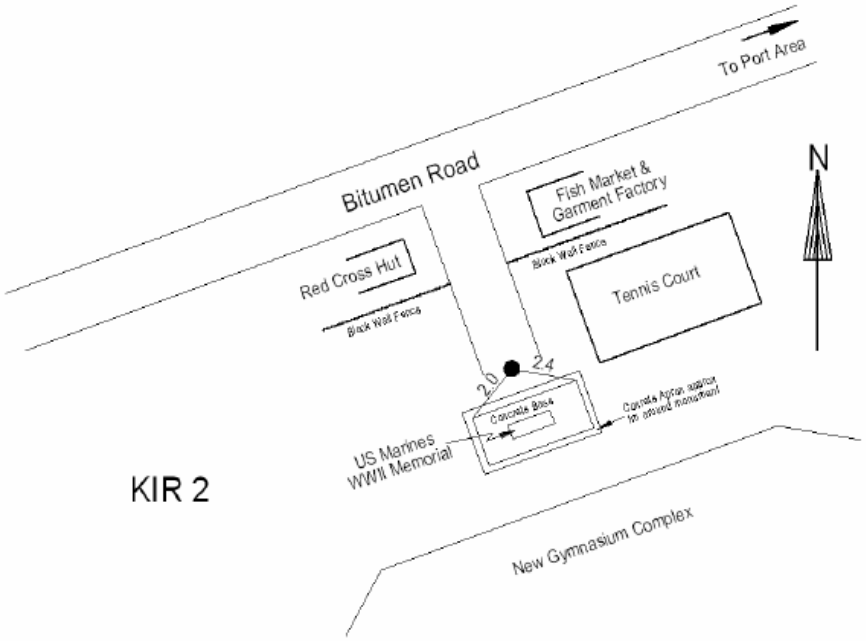
Bench Mark Number: KIR2

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 28-01-92
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.	
Country: Kiribati *Island*: Tarawa	*Atoll: Betio*

Marking and locality sketch

Bench Mark: 6.2m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.0m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 1250m from the tide gauge station.



Not to scale | Distances in Metres | Magnetic bearings

Approved by: Geoscience Australia / SOPAC — Date: April 2006

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

Bench Mark Number: KIR3

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

Date: 28-01-92

Existing Bench Mark Established by:

Date:

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

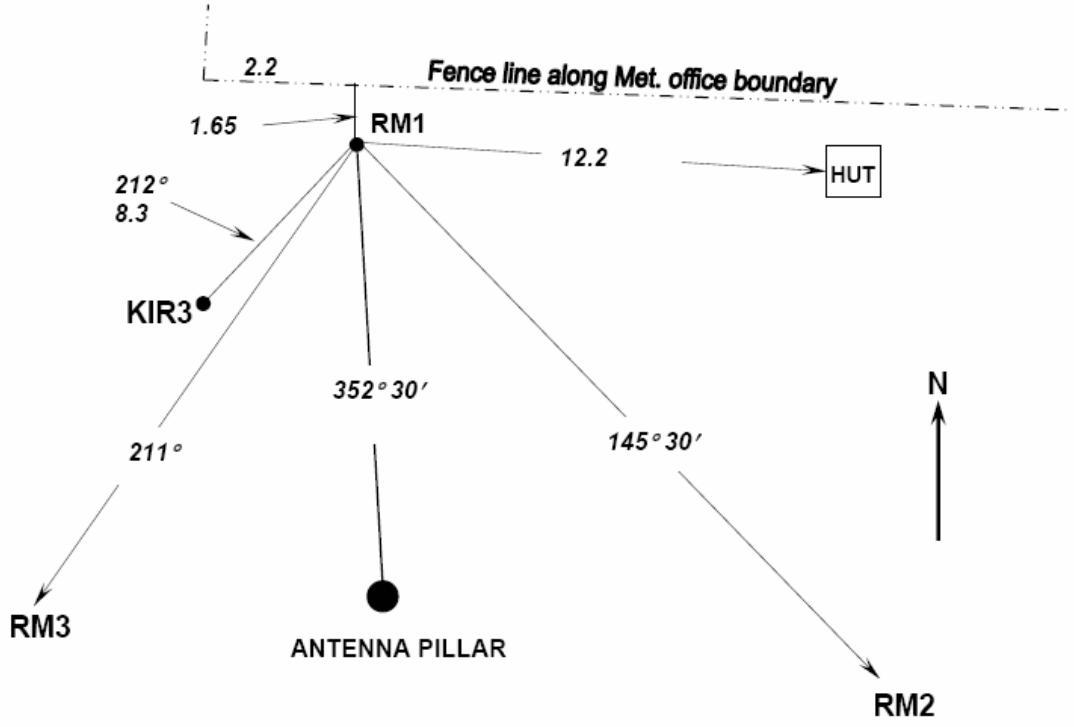
Country: Kiribati
Island: Tarawa

Atoll: Betio

Marking and locality sketch

Bench Mark: 6.2m of 19mm diameter stainless steel capped rod driven to refusal. Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.0m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 2000m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: April 2006

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

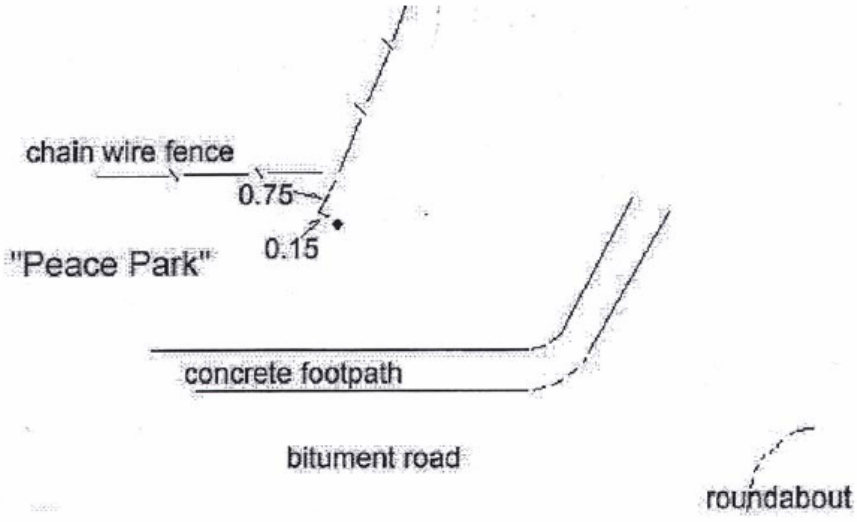
Bench Mark Number: KIR46

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	*Date*: 07-06-02
Existing Bench Mark Established by:	*Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.	
Country: Kiribati *Island*: Tarawa	*City: Betio*

Marking and locality sketch

Bench Mark: 7.0m 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 1000m from the tide gauge station.



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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

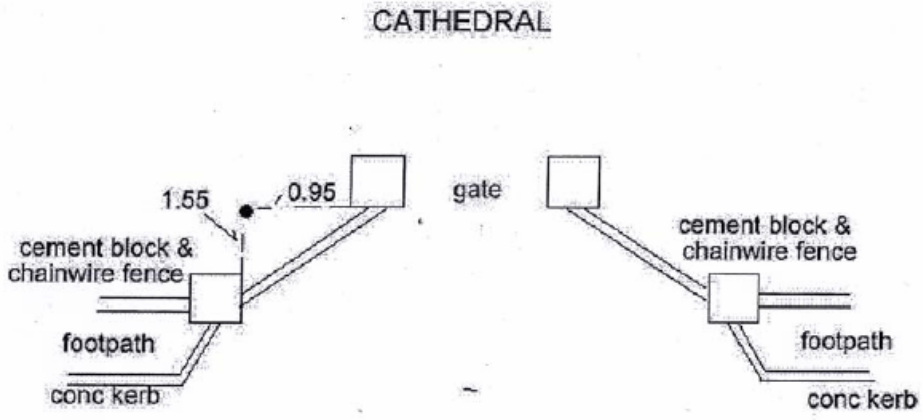
Bench Mark Number: KIR47

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. — *Date*: 07-06-02
Existing Bench Mark Established by: — *Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
Country: Kiribati *Island*: Tarawa — *Atoll: Betio*

Marking and locality sketch

Bench Mark: 7.9m 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 1700m from the tide gauge station.



Not to scale — Distances in Metres — Magnetic bearings

Approved by: Geoscience Australia / SOPAC — Date: April 2006

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SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT

Survey Bench Mark Record

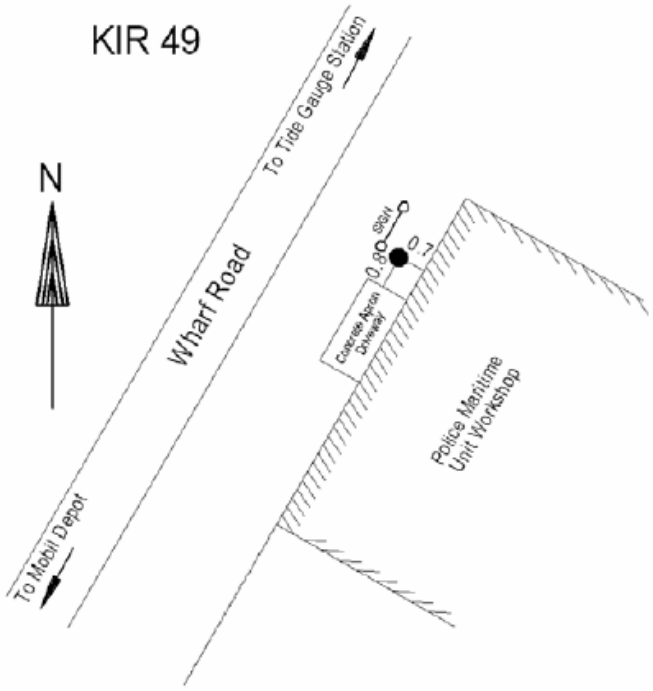
Bench Mark Number: KIR49

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA. *Date*: 07-06-02
Existing Bench Mark Established by: *Date*:
Notes / References: Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
Country: Kiribati *Island*: Tarawa *Atoll: Betio*

Marking and locality sketch

Bench Mark: 2.5m 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 200m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC Date: April 2006

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