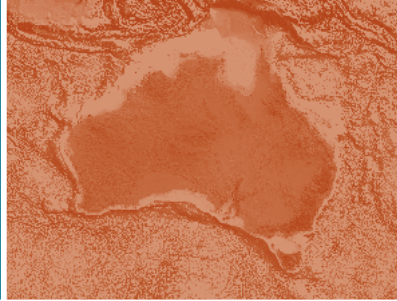




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EDM Height Traversing Levelling Survey Report

Nauru, September 2013

S. J. K. Yates, A. Lal

EDM Height Traversing Levelling Survey Report

Nauru, September 2013

GEOSCIENCE AUSTRALIA
RECORD 2014/23

S. J. K. Yates¹, A. Lal²



Australian Government
Geoscience Australia

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1. National Geospatial Reference Systems, Minerals and Natural Hazards Division, Geoscience Australia GPO Box 378
Canberra ACT 2601
 2. Secretariat of the Pacific Community (SPC)

Department of Industry

Minister for Industry: The Hon Ian Macfarlane MP

Parliamentary Secretary: The Hon Bob Baldwin MP

Secretary: Ms Glenys Beauchamp PSM

Geoscience Australia

Chief Executive Officer: Dr Chris Pigram

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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 and the Continuous Global Navigation Satellite System (CGNSS) Station in Nauru from 5th – 12th September 2013.

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 Measurement (EDM) Height Traversing levelling technique was employed to observe differences in height between the deep bench mark arrays in Nauru, which runs approximately 3.7km from the tide gauge sensor to the CGNSS Station. Previous levelling surveys have been conducted along the route using this technique in 2005, 2007, 2009, 2010 and 2012.

In addition, precise differential levelling surveys were performed along the deep bench mark array from 1993 to 2006 by the National Tidal Centre Australia (NTCA) and the survey in 2005 included a comparison between the precise differential levelling and EDM height traversing technique. This report contains a comparison between the 2013 and 2012 EDM height traversing results as well as a combined comparison since the first levelling survey in 1993.

2 The Survey

The EDM height traversing levelling survey was carried out between the SEAFRAME tide gauge sensor, continuous GNSS station and the deep driven bench mark array:

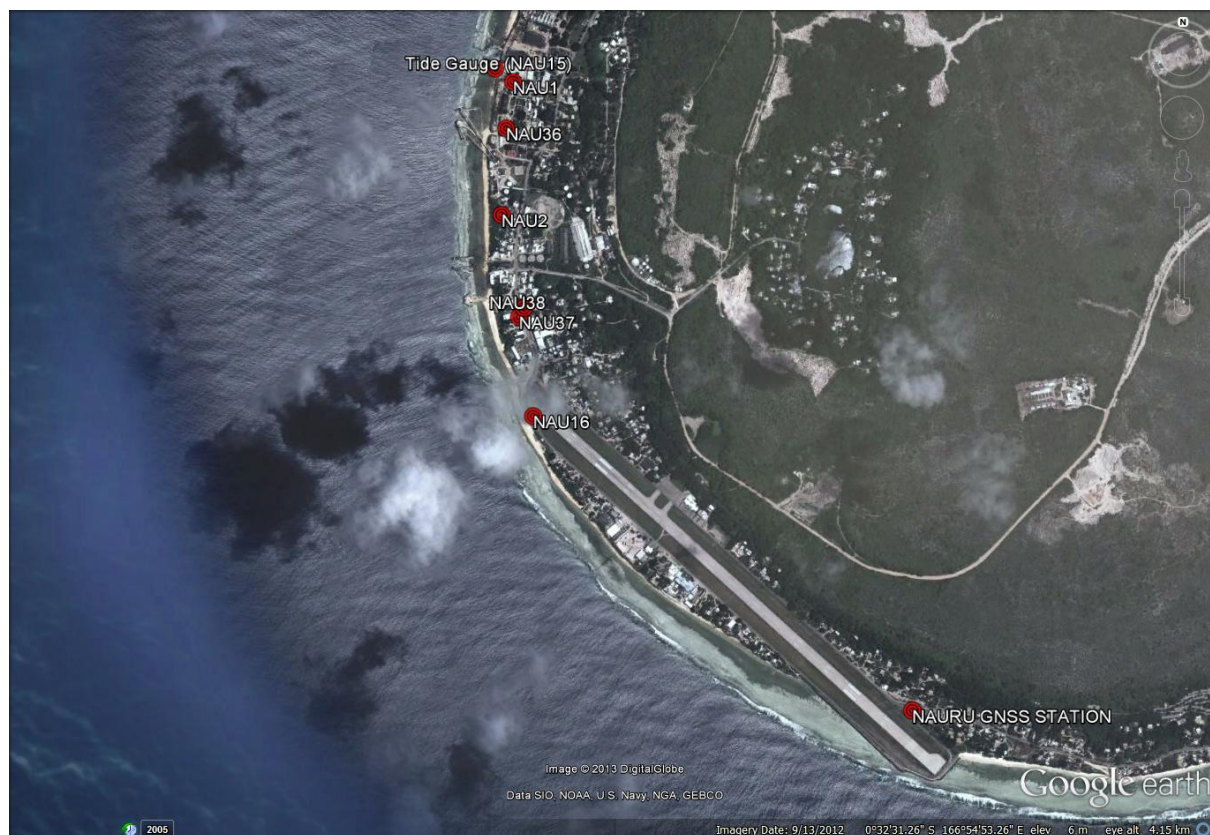
NAU1	– reference deep driven bench mark
NAU2	– deep driven bench mark
NAU36	– deep driven bench mark
NAU37	– deep driven bench mark
NAU38	– deep driven bench mark
NAU16	– deep driven bench mark
NAU14	– SEAFRAME sensor bench mark
NAU15	– SEAFRAME Project plaque bench mark
NAURBM	– reference bench mark for the GNSS pillar

Also included in the survey were temporary holding marks – NAU28, NAU100, NAU101, NAU102, NAU103, NAU104, NAU105, NAU106, NAU107, NAU108 NAU109, NAU33, NAU43, NAU44, NAU47, NAU53

The Continuous GNSS (CGNSS) Reference Point - NAUR and the three CGNSS Reference Marks – RM1, RM2 and RM3 were also levelled. All the deep bench marks were located and found in good order and undisturbed.

The EDM Height Traversing levelling technique was performed to the Class L2A specifications. After reduction an internal precision of $1\text{mm } \sqrt{K}$ or better was achieved, where K is distance in kilometres. This is well within the project specification of $2\text{mm } \sqrt{K}$. A table of results and comparisons and the 2013 reduced levels are detailed later in this report.

2.1 Bench Mark Locations – Nauru



2.2 The Nauru Datum

The Datum for the survey is the Nauru Island Datum (NID). Reduction of the data has been calculated holding NAU1 fixed at 7.2930 metres, this value was determined by the NTC in 1993 by:

1993 Adopting the height of UH 1 as 4.130m NID

1994 Adopting the 1993 height of U2B as 3.8894m NID

2.3 Equipment

- LEICA total station model TCA2003 (Serial No: 440883)
- 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 Nauru 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 Nauru 2013 Reduced Levels

Table 2.1 Nauru – Reduced levels 2013 survey

Date: 5 – 12 September 2013

Datum: Nauru Island Datum

Point ID	Reduced Level 2013	Type
NAU1	7.2930	Stainless Steel Rod in Ground
NAU14	3.8477	Stainless Steel Pin in Concrete
NAU15	6.0033	Stainless Steel Pin
NAU36	7.2189	Stainless Steel Rod in Ground
NAU28	7.7998	Stainless Steel Pin in Concrete
NAU2	7.7851	Stainless Steel Rod in Ground
NAU105	7.7828	Stainless Steel Pin in Concrete
NAU100	8.2108	Stainless Steel Pin in Concrete
NAU106	8.0465	Stainless Steel Pin in Concrete
NAU37	7.6995	Stainless Steel Rod in Ground
NAU38	7.5726	Stainless Steel Rod in Ground
NAU107	7.7801	Stainless Steel Pin in Concrete
NAU33	7.4100	Stainless Steel Pin in Concrete
NAU16	6.6939	Stainless Steel Rod in Ground
NAU108	6.8652	Stainless Steel Pin in Concrete
NAU43	5.9204	Stainless Steel Pin in Concrete
NAU44	6.4905	Stainless Steel Pin in Concrete
NAU109	5.7124	Stainless Steel Pin in Concrete
NAU47	5.8440	Stainless Steel Pin in Concrete
NAU101	6.3153	Stainless Steel Pin in Concrete
NAU102	6.3042	Stainless Steel Pin in Concrete
NAU103	5.6239	Stainless Steel Pin in Concrete
NAU104	5.1953	Stainless Steel Pin in Concrete
NAU53	5.4837	Stainless Steel Pin in Concrete
*NAUR	6.2065	Pillar Plate (ARP)
NAURBM	5.2593	Stainless Steel Pillar Pin
RM1	4.5476	Stainless Steel Rod in Ground
RM2	4.3842	Stainless Steel Rod in Ground
RM3	4.4824	Stainless Steel Rod in Ground

**The RL of the Reference Point NAUR (ARP) is derived from adding the static height difference of 0.9472m (NAURBM to NAUR) to the 2013 levelled RL of NAURBM.*

2.6 Survey Support

The survey team very much appreciated the assistance from staff of the Lands Department Nauru Office.

Personnel consulted during the visit were:

- Mr. Peniasi Nakautoga (peniasi.nakautoga@gmail.com) – Chief Surveyor, Lands Department
- Mr. Wess Tsitsi – Senior Surveyor, Lands Department

The Nauru Lands and Survey Department provided a trainee surveyor, Sebastian Gobune and chainman, Martin Aukbar to assist with the field survey. Wess Tsitsi has always taken a keen interest in the PSLMP and is always supportive with any associated project matters.

2.7 Issues

It is recommended to establish an additional deep driven bench mark approximately midway along the airport road between NAU16 and the CGNSS bench mark NAURBM.

Also, the valve boxes for the CGNSS reference marks, RM2 and RM3 require replacement.

2.8 Description of Marks – Nauru

NAU1	– reference deep driven bench mark (within wharf compound)
NAU2	– deep driven bench mark (within private residential compound)
NAU36	– deep driven bench mark (within Nauru Phosphate Head Quarters compound)
NAU37	– deep driven bench mark (on the corner of Catholic Church Hall)
NAU38	– deep driven bench mark (on the corner of Catholic Church)
NAU16	– deep driven bench mark (within airport runway compound)
NAU14	– SEAFRAME sensor bench mark (within the Boat Harbour)
NAU15	– SEAFRAME Project plaque bench mark (within the Boat Harbour)
NAURBM	– reference bench mark for the GNSS pillar

Holding pins along survey route from tide gauge to CGNSS (as listed previously) are all stainless steel bolts, drilled in concrete and glued in place.

3 Comparisons

3.1 Comparisons between 2013 and 2012 EDM Surveys

Table 3.1 Results of Nauru 2013 EDM Height Traversing Comparison 2013 – 2012. NAU1 - adopted fixed height of 7.2930m

From	To	Levelled Diff. Ht.	RL 2013	Misclose (mm)	Dist. (km)	1mm√k	RL 2012	Difference (mm) 2013 - 2012
NAU1			7.2930				7.2930	
NAU14	NAU14	-3.4453	3.8477	-0.160	0.104	0.322	3.8481	-0.36
	NAU15	2.1555	6.0033	0.000	0.009	0.095	6.0052	-1.95
NAU1			7.2930				7.2930	
NAU36	NAU36	-0.0741	7.2189	0.404	0.186	0.431	7.2190	-0.09
NAU28	NAU28	0.5809	7.7998	-0.340	0.197	0.444	7.7987	1.10
NAU2	NAU2	-0.0147	7.7851	-0.210	0.167	0.409	7.7846	0.51
NAU105	NAU105	-0.0023	7.7828	-0.067	0.072	0.268	7.7824	0.39
NAU100	NAU100	0.4280	8.2108	0.000	0.097	0.311	8.2100	0.80
NAU106	NAU106	-0.1643	8.0465	0.210	0.200	0.447	8.0458	0.69
NAU37	NAU37	-0.3470	7.6995	0.113	0.118	0.344	7.6988	0.67
NAU38	NAU38	-0.1269	7.5726	-0.133	0.054	0.232	7.5722	0.37
NAU107	NAU107	0.2075	7.7801	0.100	0.202	0.449	7.7797	0.38
NAU33	NAU33	-0.3700	7.4100	-0.040	0.130	0.361	7.4094	0.64
	NAU16	-0.7161	6.6939	0.319	0.123	0.350	6.6935	0.39
NAU33			7.4100					
NAU108	NAU108	-0.5448	6.8652	0.340	0.178	0.422	6.8638	1.43
NAU43	NAU43	-0.9448	5.9204	0.040	0.177	0.420	5.9197	0.70
NAU44	NAU44	0.5701	6.4905	-0.310	0.204	0.451	6.4896	0.90
NAU109	NAU109	-0.7781	5.7124	0.030	0.198	0.445	5.7107	1.74
NAU47	NAU47	0.1316	5.8440	0.375	0.199	0.446	5.8421	1.89
NAU101	NAU101	0.4713	6.3153	0.010	0.201	0.448	6.3134	1.87
NAU102	NAU102	-0.0111	6.3042	0.230	0.199	0.446	6.3031	1.07
NAU103	NAU103	-0.6802	5.6239	-0.320	0.200	0.447	5.6225	1.44
NAU104	NAU104	-0.4287	5.1953	0.160	0.199	0.446	5.1937	1.58
NAU53	NAU53	0.2884	5.4837	-0.050	0.193	0.439	5.4825	1.18
	NAURBM	-0.2244	5.2593	0.063	0.074	0.272	5.2580	1.31
			Misclose for all bays levelled =	0.763	3.678	1.918		

From	To	Levelled Diff. Ht.	RL 2013	Misclose (mm)	Dist. (km)	1mm√k	RL 2012	Difference (mm) 2013 - 2012
NAURBM			5.2593					
	RM1	-0.7117	4.5476	0.031	0.035	0.186	4.5456	2.01
NAURBM			5.2593					
	RM2	-0.8751	4.3842	0.01875	0.023	0.151	4.3831	1.14
NAURBM			5.2593					
	RM3	-0.7769	4.4824	-0.0125	0.026	0.161	4.481	1.38

All levelling was performed within the project specifications of 2√k

3.2 Combined Comparisons

Examination of the level survey results do not show any significant changes in reduced levels from the 2013 survey. All indications are that no immediate or significant displacement of any of the deep driven bench marks has occurred.

Table 3.2 Nauru – Deep Bench Mark final RL's for Precise Differential Levelling (1993 - 2005) and EDM Height Traversing (2005 - 2013).

Year	NAU1	NAU2	NAU36	NAU37	NAU38	NAU16	NAURBM	NAU14	NAU15
1993.52	7.2930	7.7837						3.8459	6.0044
1994.17	7.2930	7.7849				6.6915		3.8462	6.0041
1995.23	7.2930	7.7849				6.6923		3.8459	6.0038
1996.72	7.2930	7.7836				6.6923		3.8469	6.0048
1997.92	7.2930	7.7849				6.6920		3.8462	6.0027
1999.45	7.2930	7.7835				6.6916		3.8462	6.0032
2000.64	7.2930	7.7841				6.6920		3.8465	6.0050
2002.42	7.2930	7.7838	7.2191	7.6977	7.5711	6.6920		3.8464	6.0046
2003.86	7.2930	7.7842	7.2191	7.6979	7.5714	6.6915	5.2570	3.8472	6.0046
2005.79	7.2930	7.7846	7.2193	7.6987	7.5722	6.6934		3.8478	6.0064

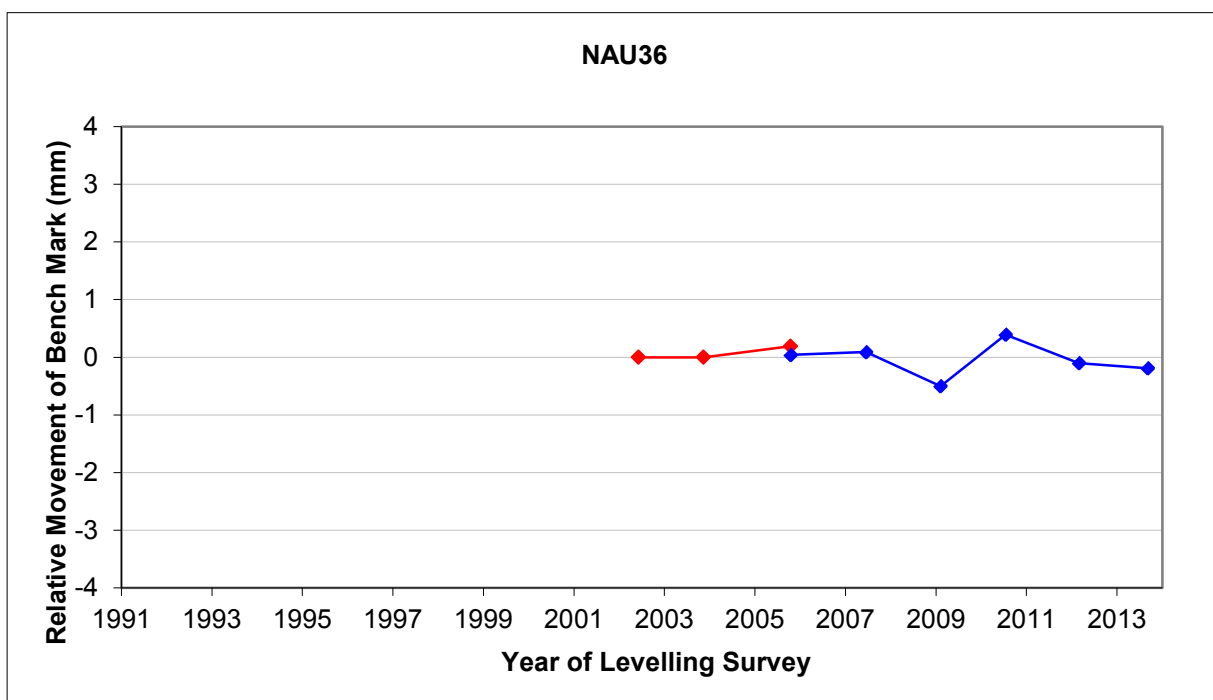
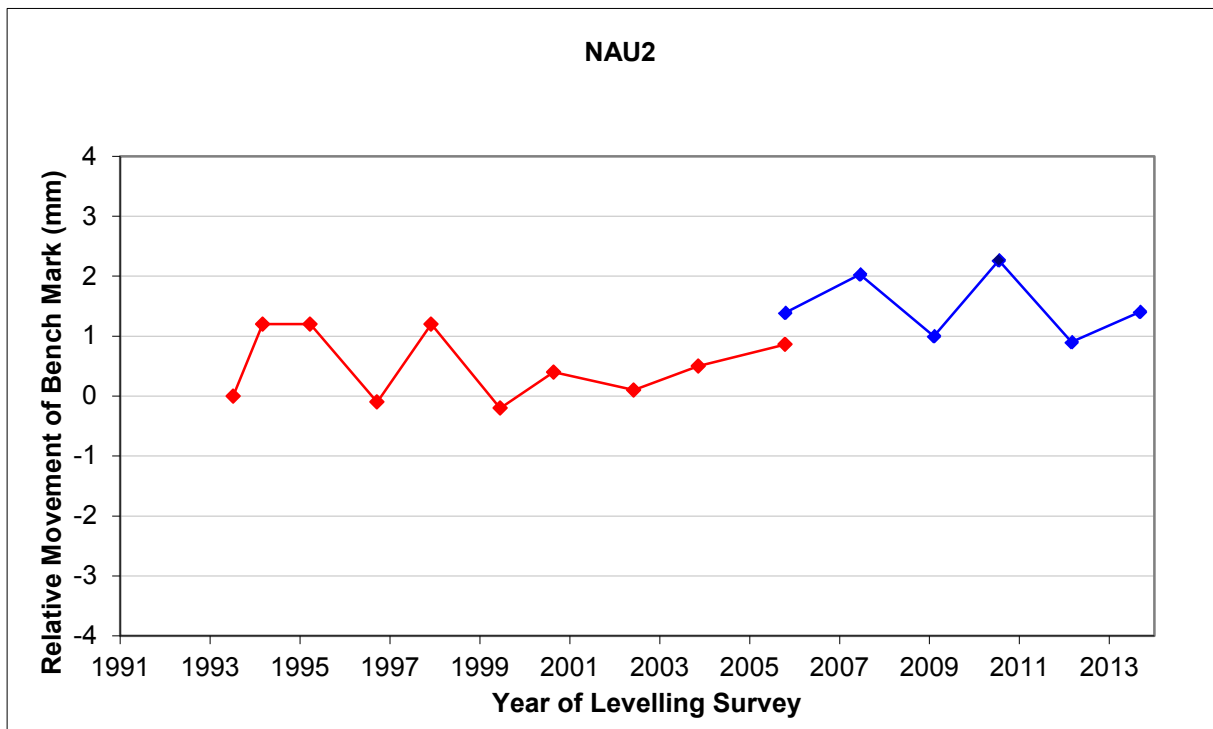
Year	NAU1	NAU2	NAU36	NAU37	NAU38	NAU16	NAURBM	NAU14	NAU15
2005.79	7.2930	7.7851	7.2191	7.6994	7.5729	6.6939	5.2613	3.8476	6.0070
2007.45	7.2930	7.7857	7.2192	7.6998	7.5731	6.6944	5.2625	3.8479	6.0070
2009.10	7.2930	7.7847	7.2186	7.6992	7.5725	6.6935	5.2604	3.8479	6.0073
2010.54	7.2930	7.7860	7.2195	7.7013	7.5744	6.6961	5.2647	3.8472	6.0061
2012.17	7.2930	7.7846	7.2190	7.6988	7.5722	6.6935	5.2580	3.8481	6.0052
2013.68	7.2930	7.7851	7.2189	7.6995	7.5726	6.6939	5.2593	3.8477	6.0033

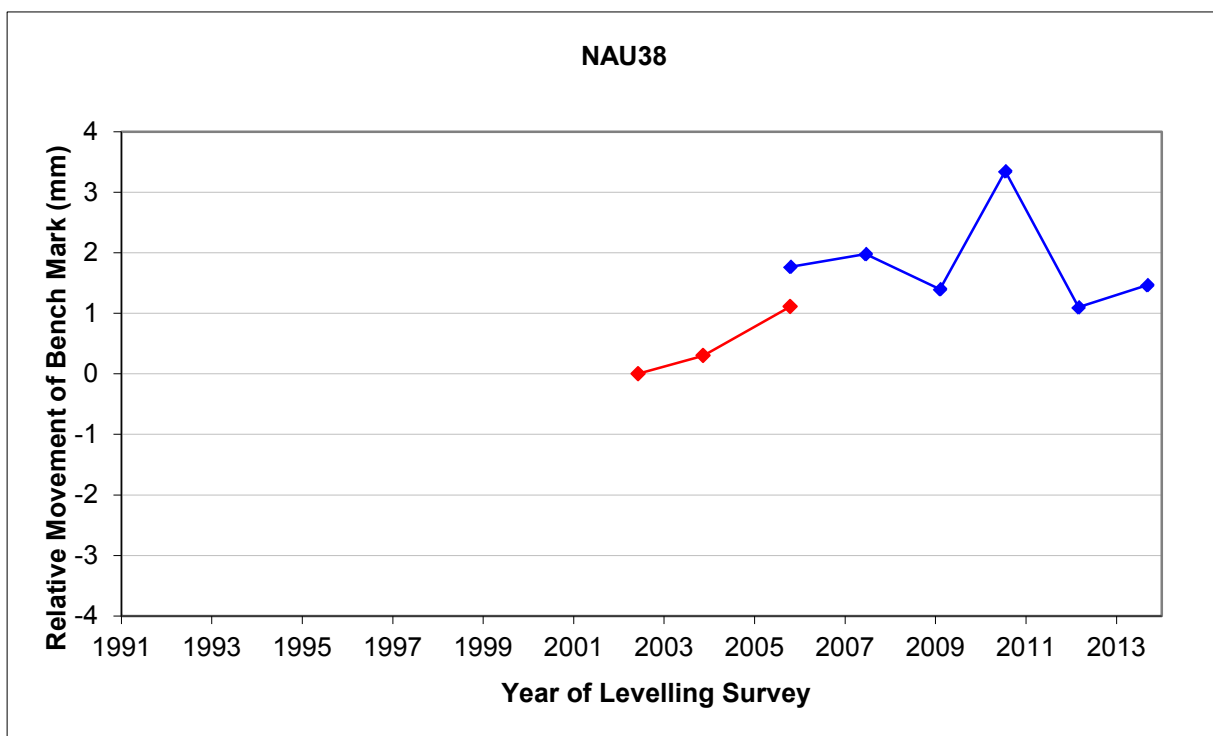
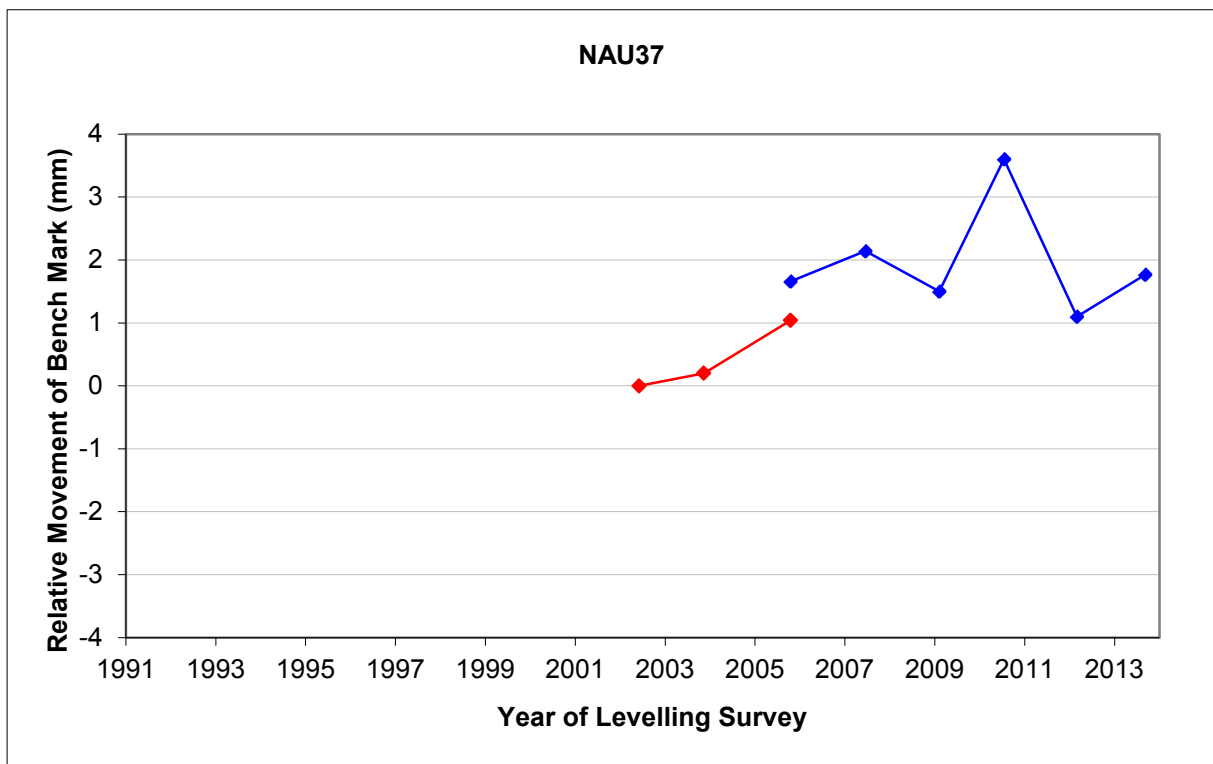
The 2013 RL of NAUR is 6.2065m

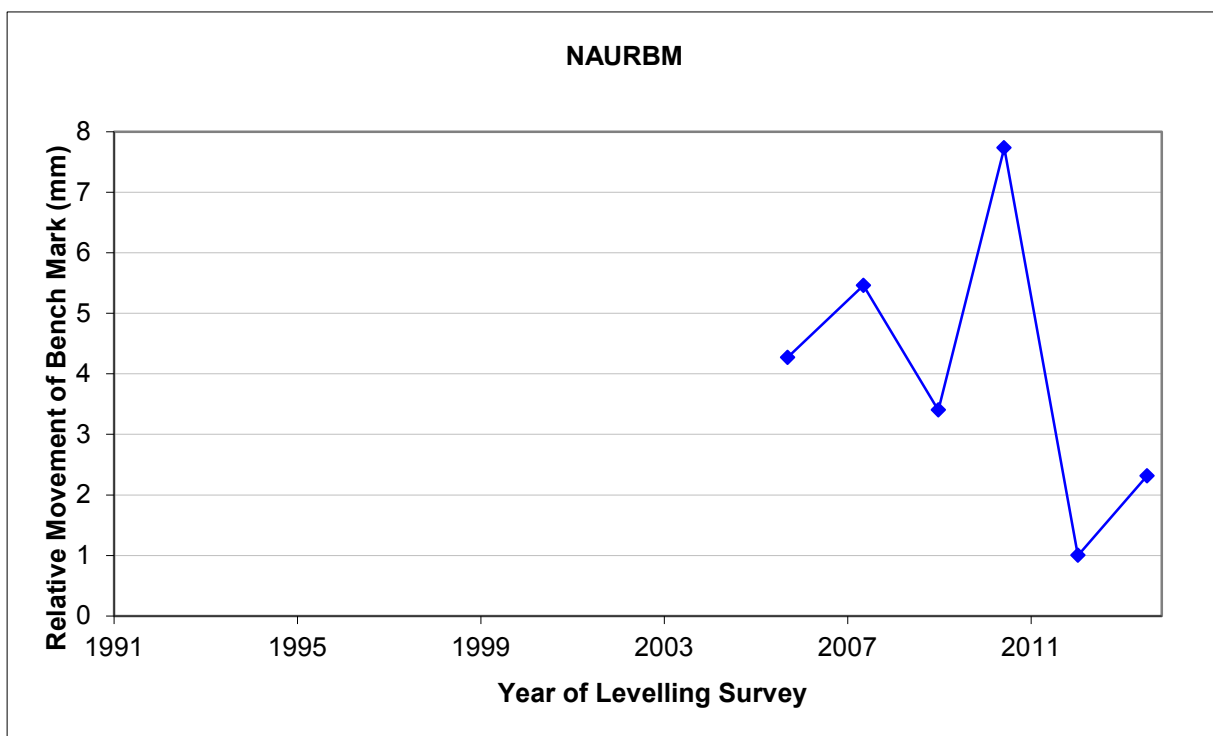
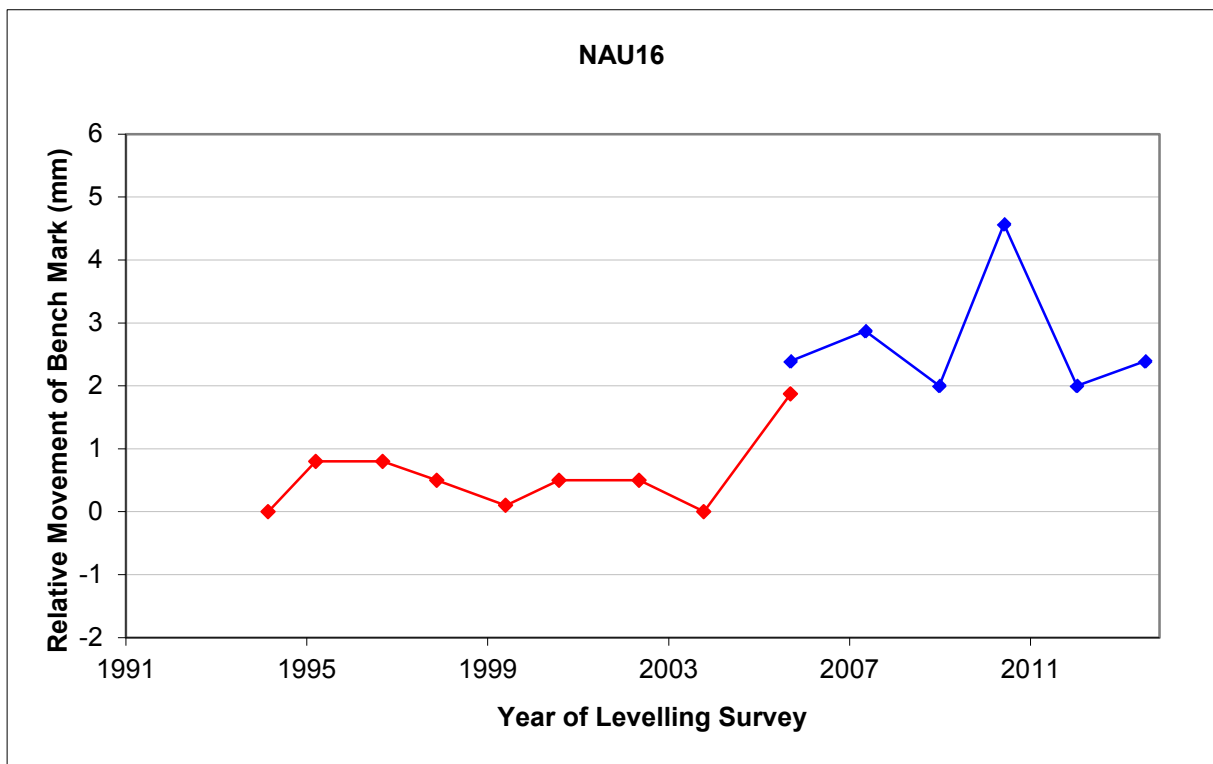
*The RL of the Reference Point NAUR (ARP) is derived from adding the static height difference of 0.9472m (NAURBM to NAURI) to the 2013 levelled RL of NAURBM.

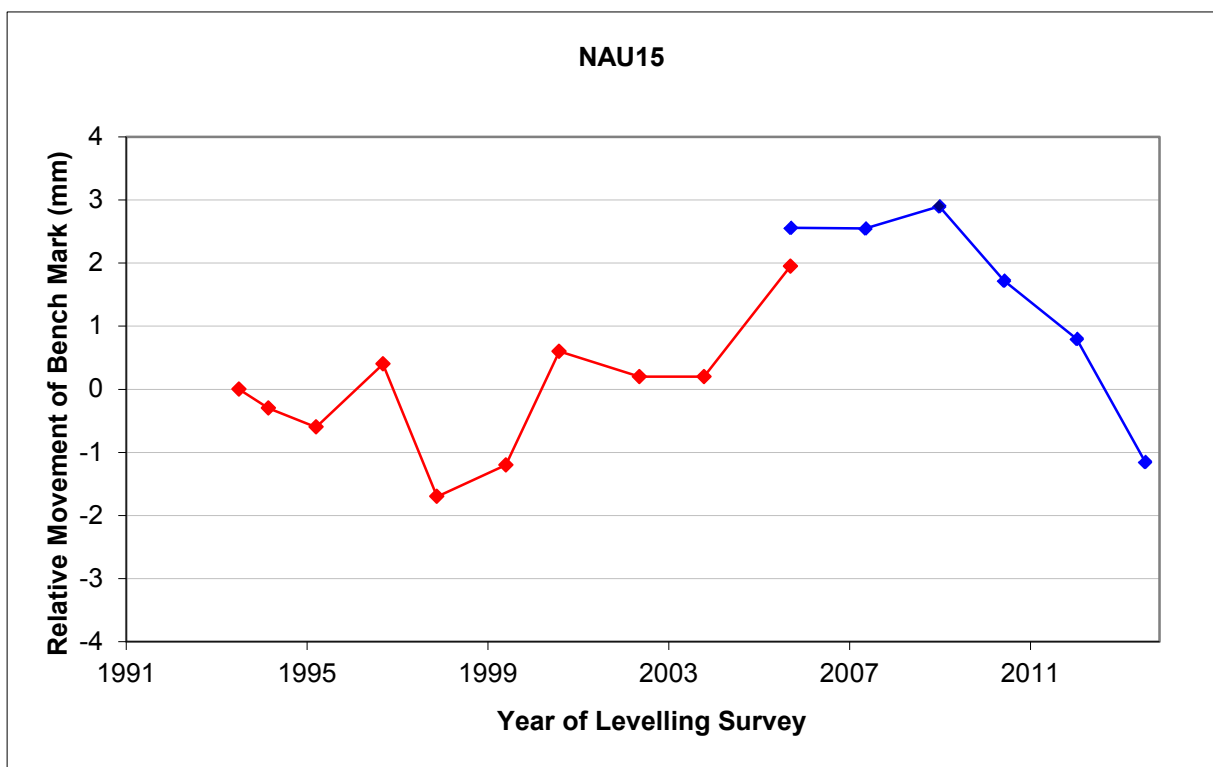
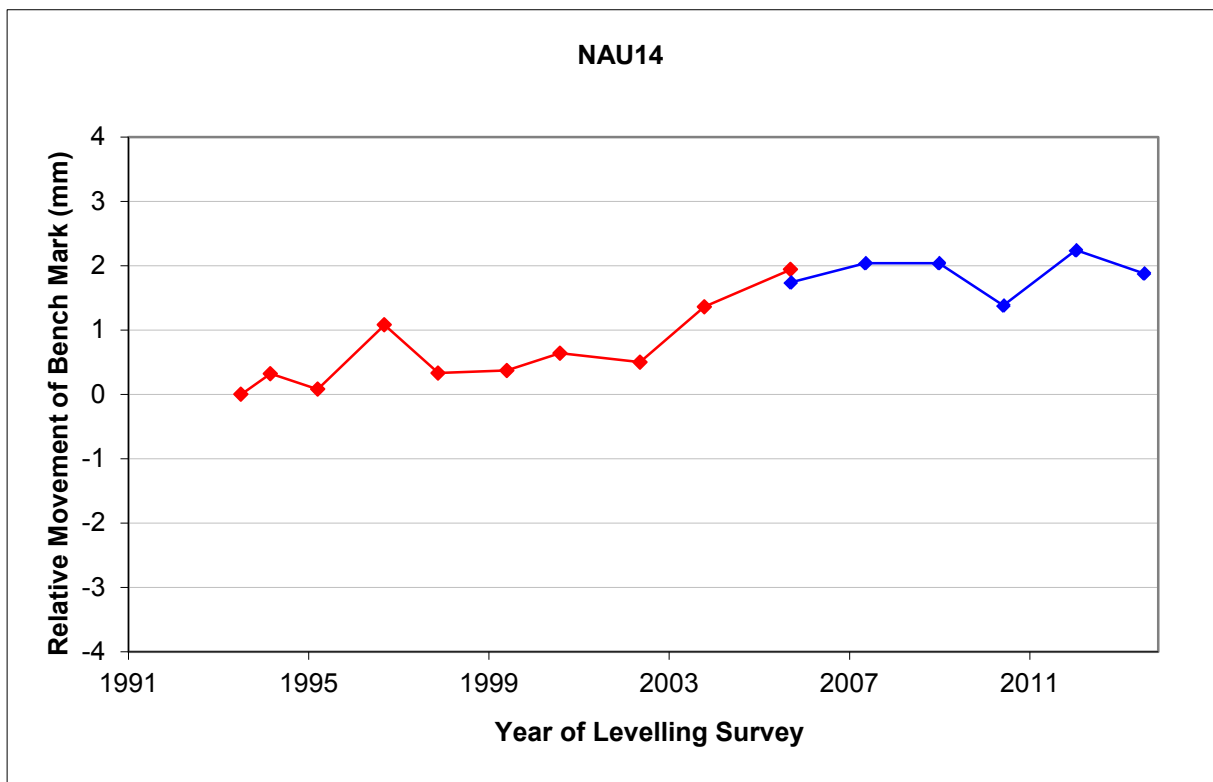
3.3 Time Series of Bench Mark movement relative to Fixed Deep Bench Mark NAU1

Precise Differential Levelling: 1993 - 2005 ◆ — ◆
EDM Height Traversing: 2005 onwards ◆ — ◆









4 Deep Driven Bench Mark Locality Diagrams



SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT



Survey Bench Mark Record

Bench Mark Number: NAU1

Original Bench Mark Established by: National Tidal Centre Australia, Oceanographic Services, Bureau of Meteorology, 25 College Rd, Kent Town, SA.	Date: 11-02-92
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Existing Bench Mark Established by:	Date:
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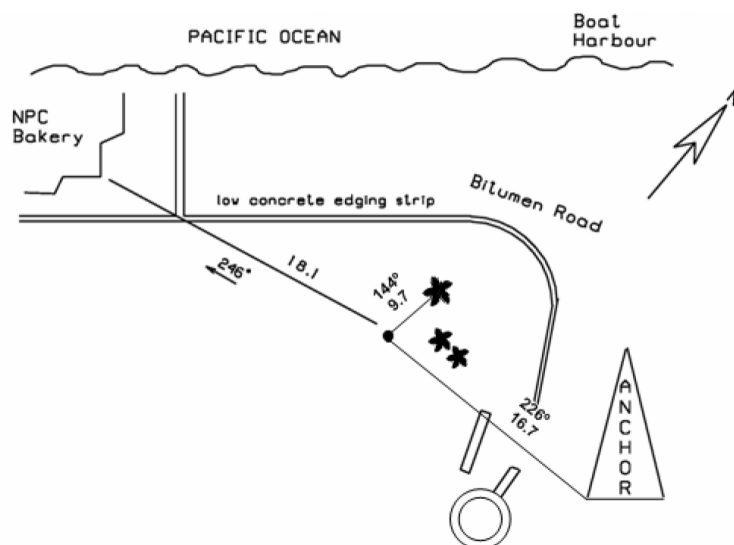
Notes / References: Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.

Country: Nauru Island: Nauru	Atoll: Nauru
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Marking and locality sketch

Bench Mark: 4.3m of 19mm diameter stainless steel capped rod driven to refusal.
Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.5m. Top of mark 0.2m below ground level.

Locality sketch: Mark approximately 100m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC

Date: November 2006

c:\users\andrick\sps\cmp\localitydiagrams\nauru



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



Survey Bench Mark Record

Bench Mark Number: NAU2

<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> 11-02-92
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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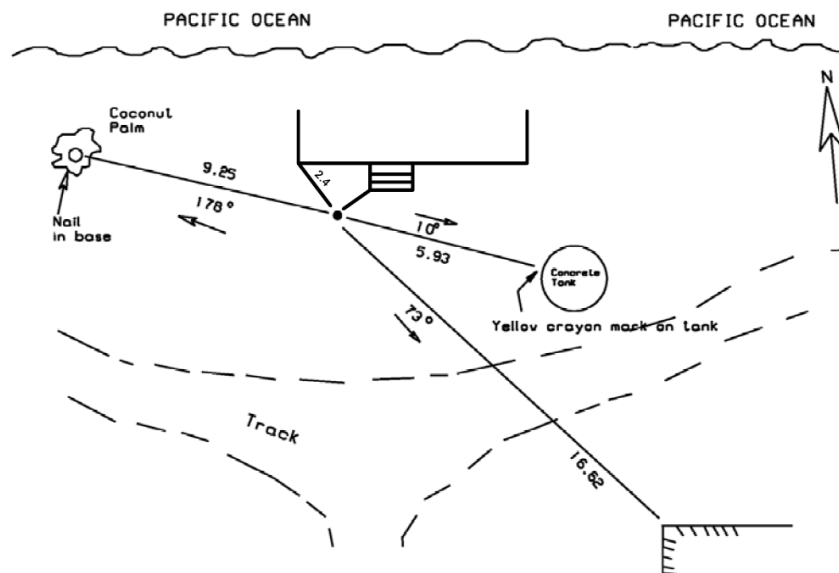
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is in a good locality for GPS occupation.
--

<i>Country:</i> Nauru <i>Island:</i> Nauru	<i>Atoll:</i> Nauru
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Marking and locality sketch

Bench Mark: 4.8m of 19mm diameter stainless steel capped rod driven to refusal.
 Rod sheathed with 50mm diameter PVC pipe, filled with bentonite, for 1.8m. Top of mark 0.1m below ground level.

Locality sketch: Mark approximately 600m from the tide gauge station.



Not to scale Distances in Metres Magnetic bearings

Approved by: Geoscience Australia / SOPAC	Date: November 2006 c:\users\andrick\spslcmp\localitydiagrams\nauru
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: NAU16

<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> 25-08-93
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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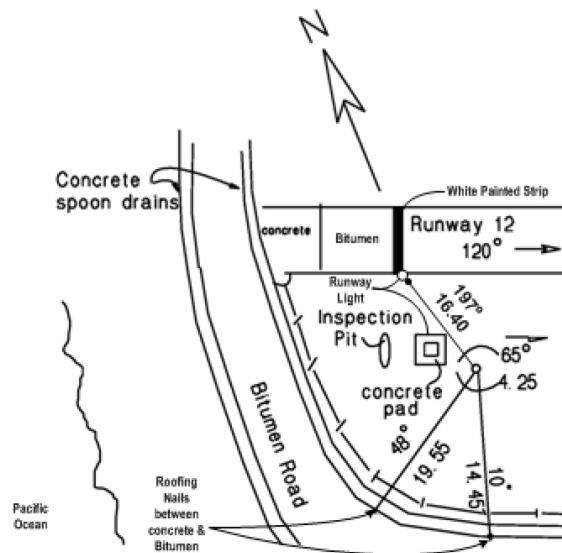
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
--

<i>Country:</i> Nauru <i>Island:</i> Nauru	<i>Atoll:</i> Nauru
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Marking and locality sketch

Bench Mark: 4.3m 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 1500m from the tide gauge station.



Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC	Date: November 2006 c:\users\andrick\spslcmp\localitydiagrams\nauru
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**SOUTH PACIFIC SEA LEVEL
&
CLIMATE MONITORING PROJECT**



Survey Bench Mark Record

Bench Mark Number: NAU36

<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> 03-06-02
<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> Nauru <i>Island:</i> Nauru	<i>Atoll:</i> Nauru
<u>Marking and locality sketch</u> 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 600m from the tide gauge station. The diagram is a schematic locality sketch. It shows a horizontal line representing a 'Road'. Above the road, on the left, is a building labeled 'MIS & AUDIT No. 22'. To the right of the road, there is a 'low concrete wall'. Further right, a 'Walkway' is indicated. A point on the walkway is marked with a dot and labeled '1.0'. To the right of the walkway are two small squares labeled 'Conc. Posts'. Below the road, towards the right, is another building labeled 'NPC HQ'. The sketch is not to scale and uses magnetic bearings.	
Not to scale	Distances in Metres
Magnetic bearings	
Approved by: Geoscience Australia / SOPAC	
Date: November 2006 c:\users\andrick\spslcmp\localitydiagrams\nauru	



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



Survey Bench Mark Record

Bench Mark Number: NAU37

<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> 03-06-02
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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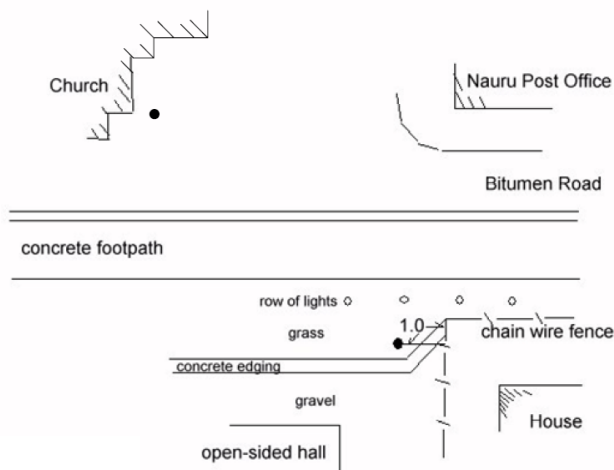
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
--

<i>Country:</i> Nauru <i>Island:</i> Nauru	<i>Atoll:</i> Nauru
---	---------------------

Marking and locality sketch

Bench Mark: 3.3m 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 1200m from the tide gauge station.



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



Survey Bench Mark Record

Bench Mark Number: NAU38

<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> 03-06-02
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<i>Existing Bench Mark Established by:</i>	<i>Date:</i>
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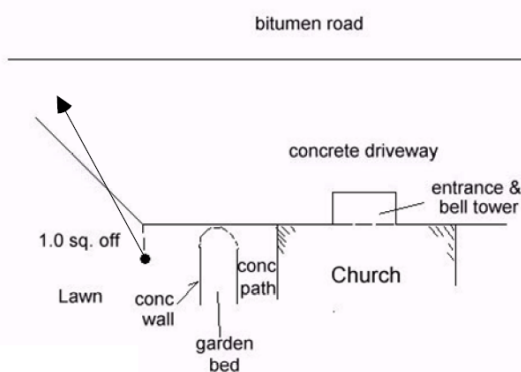
<i>Notes / References:</i> Deep Survey Benchmark This survey mark is not in a good locality for GPS occupation.
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<i>Country:</i> Nauru <i>Island:</i> Nauru	<i>Atoll:</i> Nauru
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Marking and locality sketch

Bench Mark: 3.3m 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 1200m from the tide gauge station.



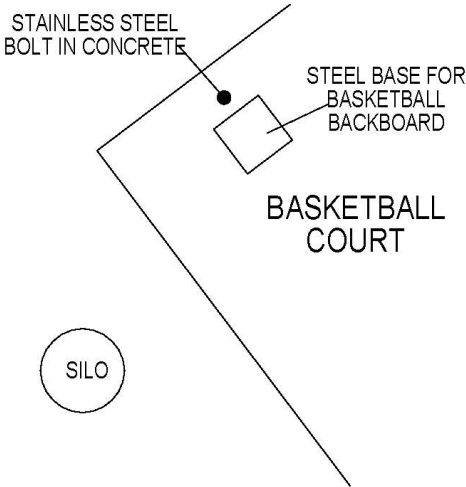
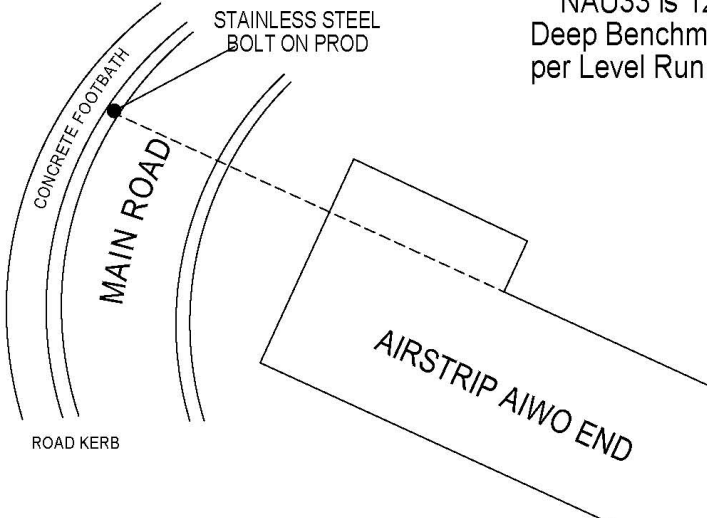
Not to scale	Distances in Metres	Magnetic bearings
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Approved by: Geoscience Australia / SOPAC

Date: November 2006

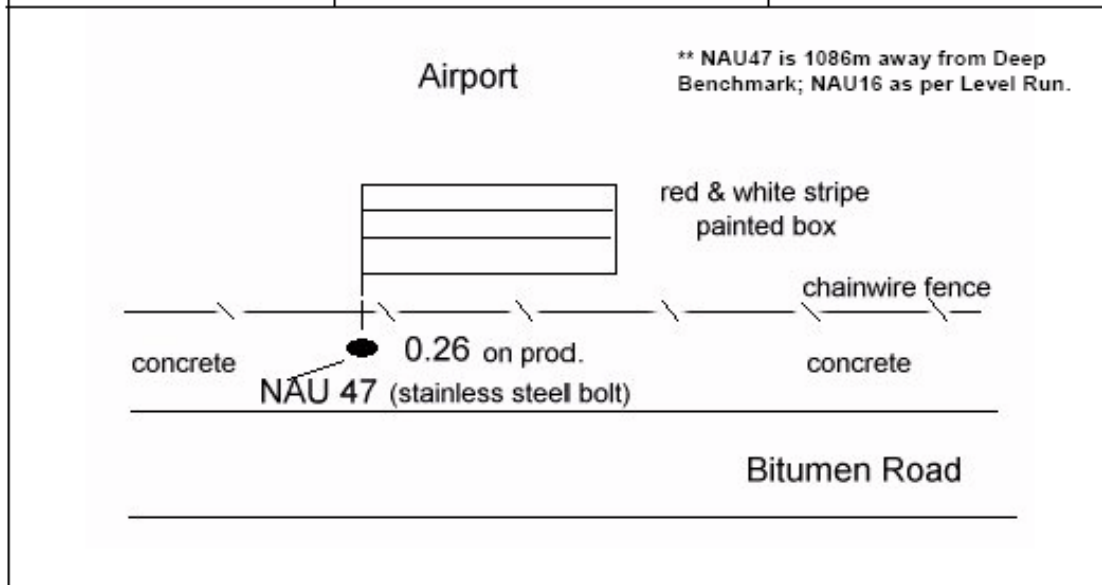
c:\users\andrick\spslcmpl\localitydiagrams\nauru

5 Temporary Holding Mark Location Diagrams

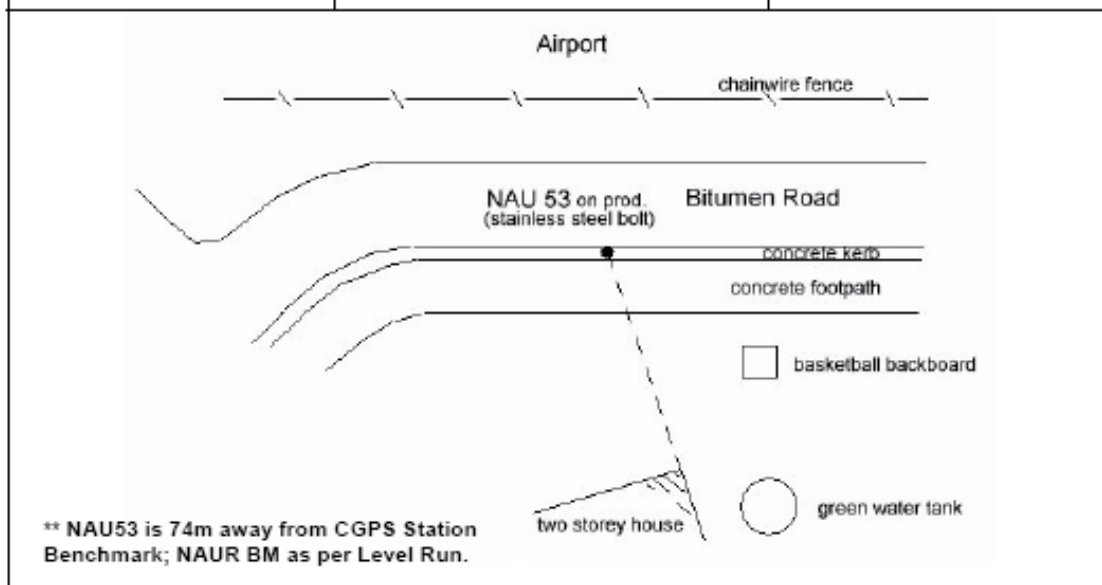
COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 565 POINT NO. NAU 28
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 31-05-02
** NAU28 is 197m away from Deep Benchmark; NAU36 as per Level Run  STAINLESS STEEL BOLT IN CONCRETE STEEL BASE FOR BASKETBALL BACKBOARD BASKETBALL COURT SILO		
COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 570 POINT NO. NAU 33
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 31-05-02
** NAU33 is 129m away from Deep Benchmark; NAU16 as per Level Run  CONCRETE FOOTPATH STAINLESS STEEL BOLT ON PROD MAIN ROAD ROAD KERB AIRSTRIp AIWO END		

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/ Boe	L. D. P. 752 POINT NO. NAU 43
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 06-11-03
Airport ** NAU43 is 486m away from Deep Benchmark; NAU16 as per Level Run.		
COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/ Boe	L. D. P. 753 POINT NO. NAU 44
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 06-11-03
Airport ** NAU44 is 690m away from Deep Benchmark; NAU16 as per Level Run.		

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/ Boe	L. D. P. 756 POINT NO. NAU 47
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 06-11-03

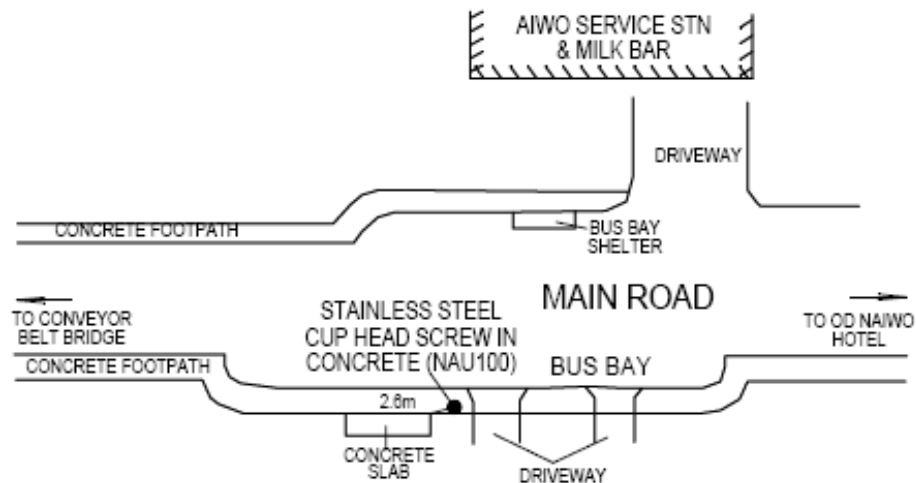


COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/ Boe	L. D. P. 762 POINT NO. NAU 53
PROJECT: SPSLCMP	SURVEYOR: S. Turner	DATE: 06-11-03

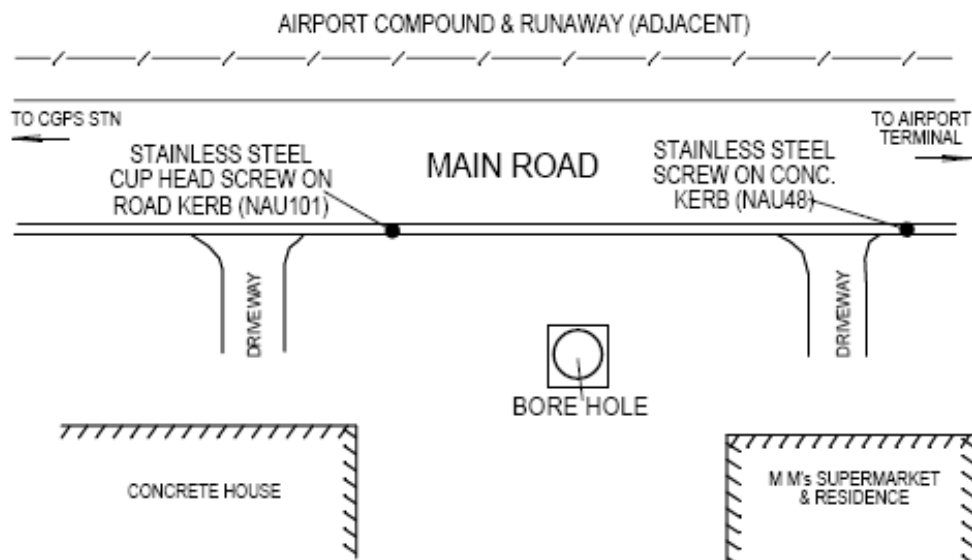


COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 786 POINT NO. NAU 100
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 04-06-07

** NAU100 is 166m away from Deep Benchmark; NAU2 as per Level Run

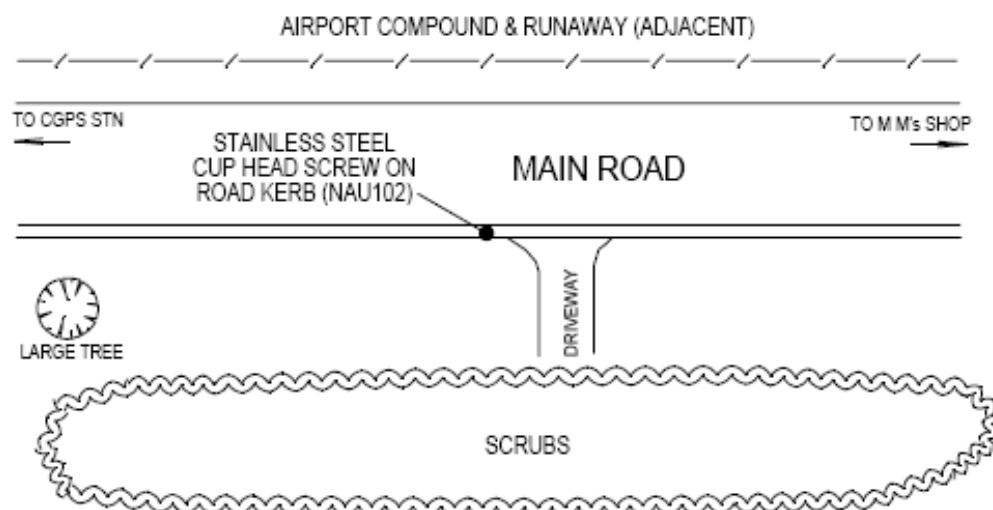


COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 787 POINT NO. NAU 101
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 04-06-07



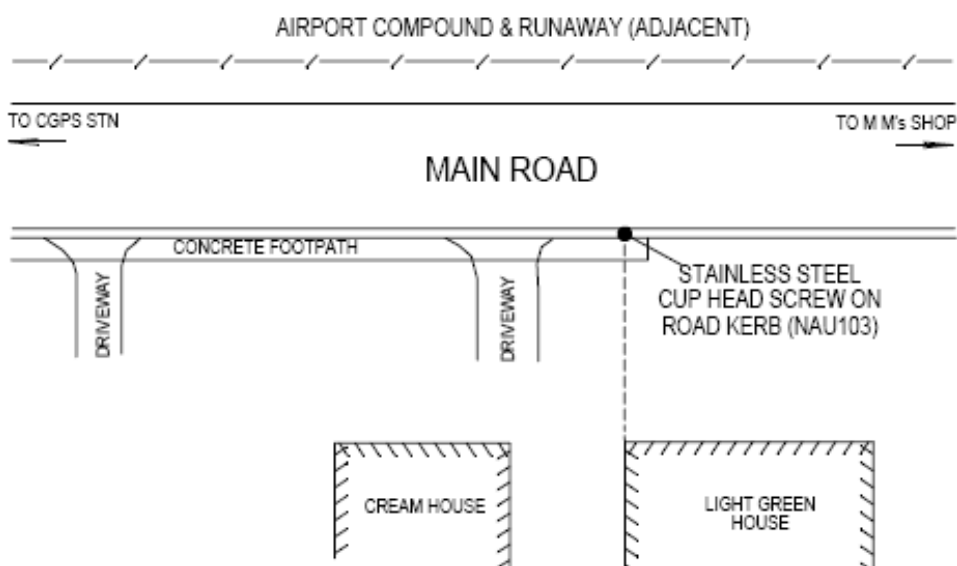
** NAU101 is 1287m away from Deep Benchmark; NAU16 as per Level Run

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 788 POINT NO. NAU 102
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 04-06-07



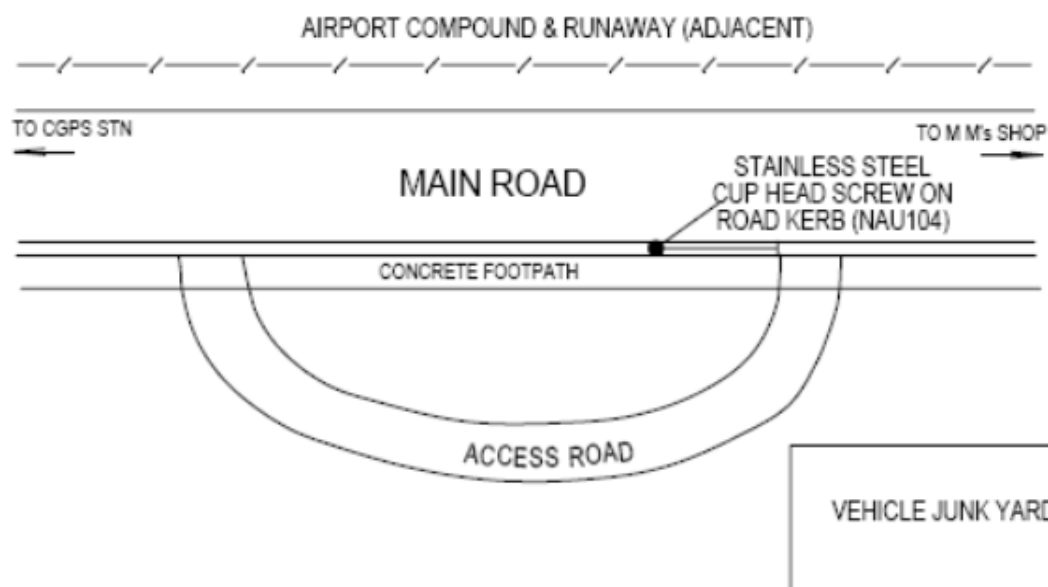
** NAU102 is 1486m away from Deep Benchmark; NAU16 as per Level Run

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 789 POINT NO. NAU 103
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 04-06-07



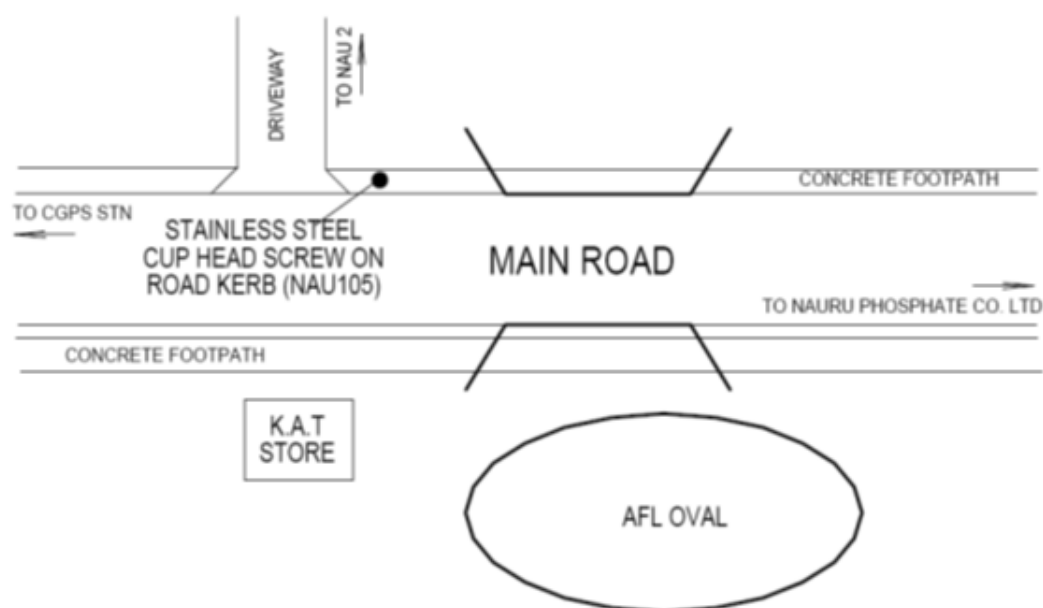
** NAU103 is 1686m away from Deep Benchmark; NAU16 as per Level Run

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 790 POINT NO. NAU 104
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 04-06-07

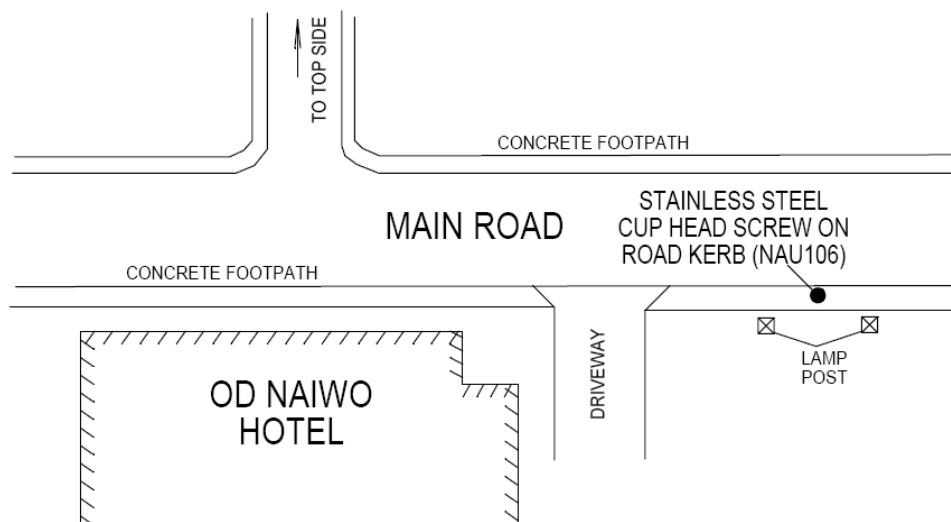


**** NAU104 is 265m away from CGPS Benchmark; NAURBM as per Level Run**

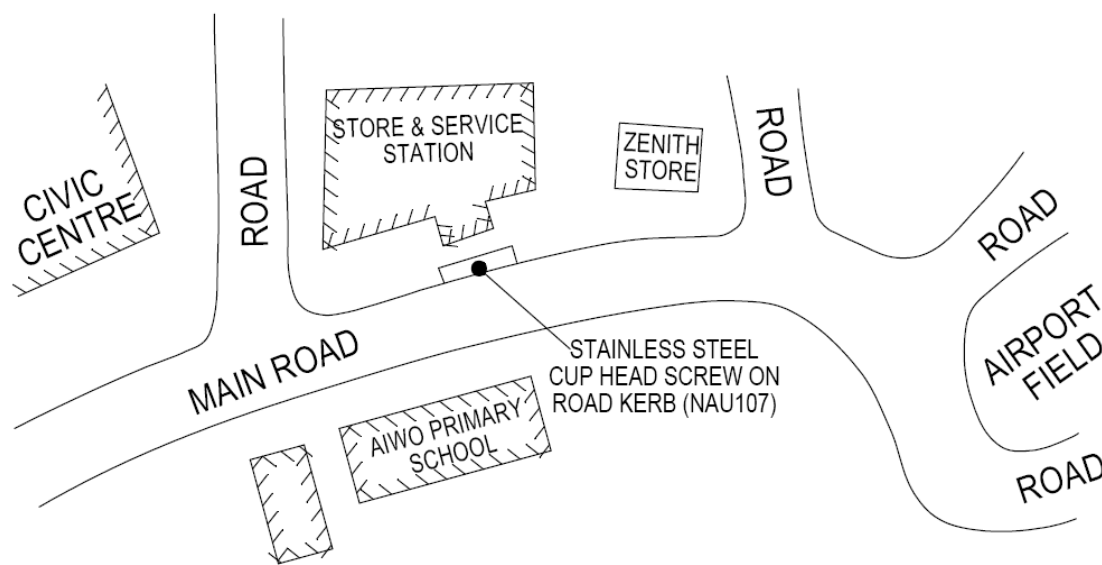
COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 892 POINT NO. NAU 105
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09



COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 893 POINT NO. NAU 106
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09



COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 894 POINT NO. NAU 107
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09



COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 895 POINT NO. NAU 108
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09

Diagram description: A plan view showing a 'MAIN ROAD' running horizontally. A 'ROAD' branches vertically upwards from the center of the main road. On the left side of the main road, there is a 'CONCRETE FOOTPATH' with a 'STAINLESS STEEL CUP HEAD SCREW ON FOOTPATH (NAU108)' marked by a black dot. To the left of the footpath, an arrow points 'TO CIVIC CENTRE'. To the right of the footpath, an arrow points 'TO AIRPORT TERMINAL'. Below the main road, there are 'RUNAWAY MARKINGS' consisting of several short vertical lines. Further down is the 'AIRPORT RUN-AWAY' area.

COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 896 POINT NO. NAU 109
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09

Diagram description: A plan view showing an 'AIRCRAFT PARKING BAY' at the top. Below it is the 'AIRPORT TERMINAL' building. A 'MAIN ROAD' runs horizontally below the terminal. An arrow on the left points 'TO CIVIC CENTRE' and an arrow on the right points 'TO CGPS STATION'. Below the main road is the 'AIRPORT RUN-AWAY' area. On the left side of the runway is 'ENTRY B' with a rectangular boundary. In the center of the runway is 'ENTRY A' with a rectangular boundary. A 'STAINLESS STEEL CUP HEAD SCREW ON BASE OF RUNAWAY LIGHTS (NAU109)' is marked with a black dot on the right side of the runway. To the right of the runway is a 'RED/WHITE BOX' with a small square and a circle next to it.

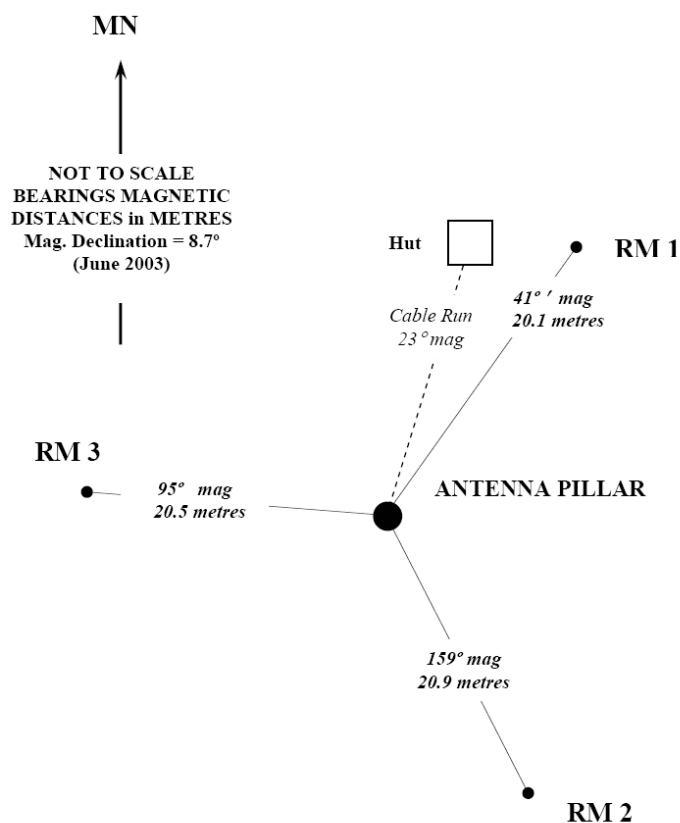
COUNTRY: Nauru	ISLAND: Nauru DISTRICT: Aiwo/Boe	L. D. P. 897 POINT NO. NAU 14 & 15
PROJECT: SPSLCMP	SURVEYOR: S. Yates & A Lal	DATE: 05-02-09

6 NAURBM and NAUR Reference Mark Locality Diagrams

NAURU CGPS Station, Yaren District. – Reference Marks

REFERENCE MARKS

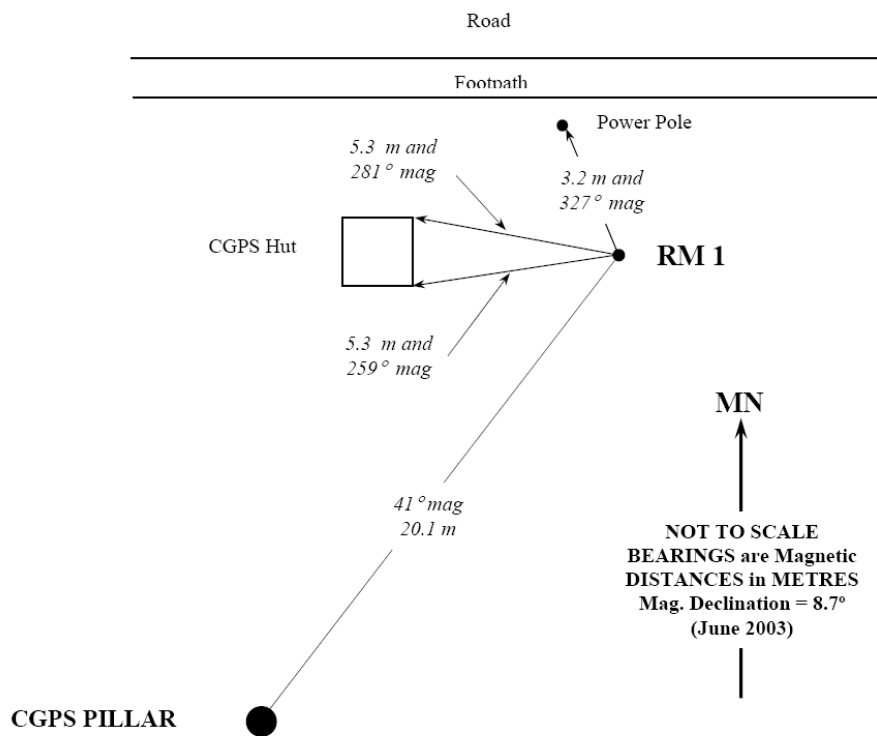
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 50mm below ground level.



NAURU CGPS Station, Yaren District. – RM 1

REFERENCE MARKS

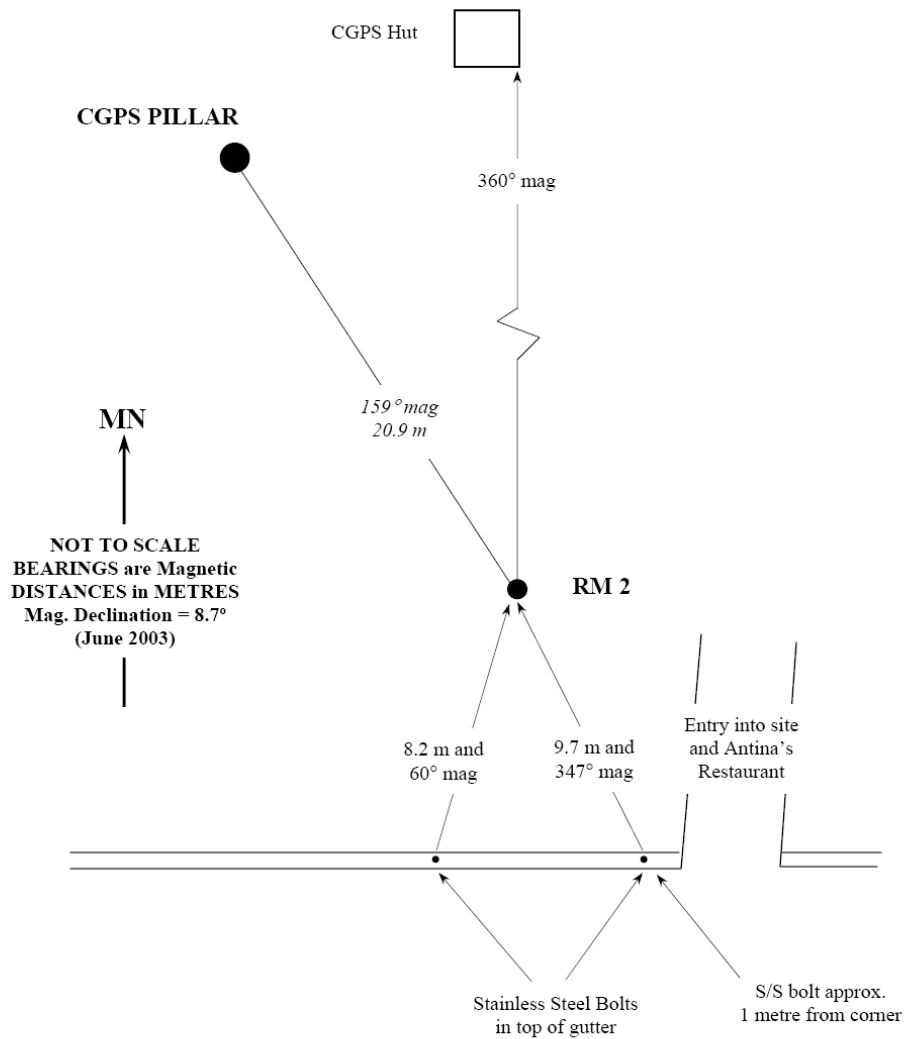
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 50mm below ground level.



NAURU CGPS Station, Yaren District. – RM 2

REFERENCE MARKS

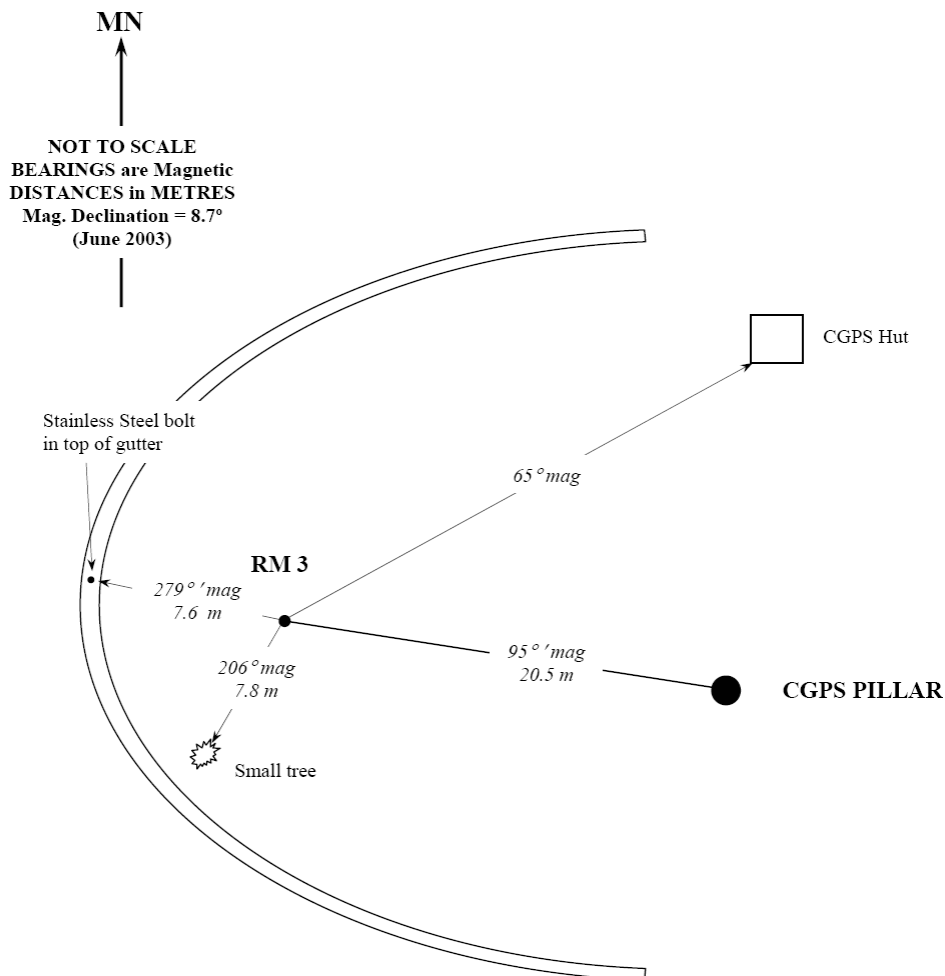
All RM's are capped 20 mm stainless steel rods driven to refusal and protected by 150 mm PVC pipe within circular poly carbonate valve boxes. The valve box lids are approximately 50mm below ground level.



NAURU CGPS Station, Yaren District. – 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.



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.