Survey Report

Precise Differential Levelling

Tuvalu

May 2003

This project is sponsored by the Australian Agency for International Development (AusAID), managed by Australian Marine Science and Technology Ltd (AMSAT), and supported by NTF Australia at the Flinders University of South Australia.

PACIFIC MULTI-COUNTRY SEA LEVEL AND CLIMATE MONITORING PROJECT

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I authorise the issue of this document in accordance with the National Tidal Facility Australia Quality Assurance procedures.

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December 2003

FONGAFALE, FUNAFUTI, TUVALU

Bench Mark Locality Map

CONTENTS

South Pacific Sea Level and Climate Monitoring Project

Precise Differential Levelling Survey

TUVALU

May 2003

The eighth precise differential levelling survey of the three deep benchmarks installed during 1992 in Tuvalu has been successfully completed. The survey was carried out by Mr. Steven Turner, Geodetic Surveyor from the National Tidal Facility (NTF) Australia and Mr. Andrick Lal, Assistant Surveyor, from the South Pacific Applied Geoscience Commission (SOPAC).

For the first time a levelling connection was made to the Continuous Global Positioning System (CGPS) pillar and associated reference marks in the Tuvalu Weather Service Office compound. A closing connection was also made between the CGPS pillar and deep benchmark, BM 24, at the end of the airstrip.

An additional three new deep benchmarks were established as part of this survey.

Survey of Deep Bench Mark Array and SEAFRAME Station

Precise Differential Levelling was undertaken between six deep benchmarks, BM 22 - BM 27, the SEAFRAME station and the CGPS Pillar. Additional levelling was done to connect to the University of Hawaii tide gauge at the old wharf.

Precise level connections were made to the following marks:

- Six deep benchmarks BM 22 – BM27.
- SEAFRAME Sensor BenchMark, TUV 20.
- TUVABM, a mark on the Project's CGPS Pillar, and the associated reference marks, RM1, RM2 & RM3.
- University of Hawaii BenchMarks, UH 1 & UH 2.

- SW 1, SW 2 and Top of Tide Board on the University of Hawaii Tide Gauge.
- Local bench mark, TUVA4

The 2001 Survey Report noted that many of the electric light poles were to be upgraded with the possibility that the concrete bases of these poles in which the holding marks are placed were likely to be disturbed. Since then this upgrading has occurred and many, though not all, holding marks have been destroyed. Replacement holding marks were established during this survey.

Twenty new and replacement holding marks were placed during this survey. Location Diagram Pages (LDP's) have been prepared for these new marks. These, together with BenchMark Records for the new deep benchmarks, have been sent to the Ministry of Natural Resources, Lands & Survey Division for inclusion in Departmental records.

Results of the Bench Mark Array Survey

All the data have now been reduced and copies of the results and adjustment are included in this report. BM 22 has been held fixed at a Reduced Level (RL) of 3.2254 metres in the adjustment. This is the RL determined for the mark in the 1993 adjustment. The datum for this RL is the University of Hawaii Tide Staff Zero.

Installation of deep benchmark, BM 27

There is good agreement between the results of all the surveys. Since the start of the levelling program BM 24 has been moving with relation to the TGBM. Initially this relative movement was downwards to the extent that the movement was outside of Project

Specifications. It is pleasing to note that this relative movement has reversed over the past two surveys and the benchmark is now back within Project Specifications.

Adopting BM 22 as the TGBM produces the following RL comparisons:

Mark No.	2003 RL	2001 RL	2000 RL	1998 RL	1996 RL	1995 RL	1994 RL	1993 RL
BM 22	3.2254	3.2254	3.2254	3.2254	3.2254	3.2254	3.2254	3.2254
BM 23	3.1391	3.1390	3.1386	3.1383	3.1387	3.1392	3.1394	3.1385
BM 24	3.7960	3.7952	3.7951	3.7953	3.7958	3.7972	3.7968	3.7982
TUV 20	4.4593	4.4599	4.4600	4.4615	4.4608	4.4609	4.4603	4.4599
UH 2	3.0134	3.0128	3.0132	3.0152	3.0142	3.0177	3.0185	3.0259

Mark No.	03RL – 01RL (mm)	03RL – 93RL (mm)
BM 22	FIXED	FIXED
BM 23	+0.15	+0.61
BM 24	+0.83	-2.20
TUV 20	-0.59	-0.60
UH 2	+0.54	-12.55

This survey further confirms the substantial movement of several of the University of Hawaii marks that was measured in the 1998 survey. The structure on which the tide gauge is mounted continues to move down relative to all survey marks. This movement is now in excess of 19mm. There are no obvious signs of this movement nor are there any indications to a possible cause.

The movement of the SEAFRAME Sensor Bench Mark, TUV 20, relative to the Tide Gauge Bench Mark, BM 22, is –0.59mm since the last survey in 2001 and –0.60mm since the first survey in 1992. This relative movement is well within Project Specifications. With the relative movement of the other deep benchmarks also being within Project specifications indications are that the benchmark array and SEAFRAME gauge are stable.

Levelling deep benchmark BM24 at the end of the airstrip

The latest listing of RL's for all marks using the University of Hawaii Tide Staff Zero (TSZ) as datum is to be found on pages 13 and 14 of this report. A similar listing using Chart Datum as defined by the Royal New Zealand Navy follows on pages 15 and 16.

A summary of the 2003 levelling accompanies this report.

Survey Support

The Director of the Tuvalu Meteorological Service, Ms. Hilia Vavae, provided invaluable support for this survey by assisting in the clearance of the survey equipment prior to the arrival of the survey team in country. Furthermore Ms. Vavae helped by arranging for a hire vehicle for the survey team. The assistance and hospitality given by the Tuvalu Meteorological Service was appreciated by the survey team.

Levelling along main road

Staff from the Lands and Survey Division provided valuable help to the survey team by obtaining permission for the placement of the three additional deep benchmarks. Their involvement in the installation of the marks was greatly appreciated by the survey team. Similarly the survey team also appreciated their hospitality.

TUVALU

- **BM 22** is the adopted reference point for the coastal array.
  RL = 3.2254 metres TSZ (University of Hawaii Tide Staff Zero)

- The height of **BM 22** was derived by:

  1993 Adopting the height of **UH 1**
  RL = 3.0072 metres TSZ

  1994 Adopting the height of BM 22 as derived in the 1993 survey

- Points **BM 22**, **BM 23** & **BM 24** are the Deep BenchMarks.

- **TUV 20** is the Sensor Bench mark

- **TUV 19** is the Project's plaque

- **BM SW**
  RL= 1.217m TSZ Dec 90

  UH 2
  RL= 3.0227m TSZ Dec 90

  Tide Staff Zero
  RL= 0.000m TSZ Dec 90

- New points

BM 25 – BM 27	**Deep BenchMarks**
TUV 55	replaces **TUV 31**
TUV 56	replaces **TUV 43**
TUV 57	replaces **TUV 45**
TUV 58	
TUV 59	replaces **TUV 46**
TUV 60	replaces **TUV 33**
TUV 61	replaces **TUV 47**
TUV 62	replaces **TUV 50**
TUV 63	
TUV 64	replaces **TUV 36**
TUV 65	replaces **TUV17**
TUV 66 – TUV 74	

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2003 REDUCED LEVELS

INSTRUMENT: Wild NA 3003 S/N 92897 **DATUM:** Tide Staff Zero

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POINT #	2003 DIFF	2003 RL	
BM 22		**3.2254000**	**Adopted Height**
TUV 55	+0.4193400	3.6447400	
TUV 56	+0.2728850	3.9176250	
TUV 42	-0.1528400	3.7647850	
TUV 41	-0.0781000	3.6866850	
TUV 40	+0.0446925	3.7313775	
TUV 19	-0.2462950	3.4850825	
TUV 20	**+0.9742150**	**4.4592975**	
BM 22		**3.2254000**	**Adopted Height**
TUV 44	+0.1008425	3.3262425	
TUV 57	-0.5961675	2.7300750	
BM 23	**+0.4090475**	**3.1391225**	
TUV 6	+0.2339325	3.3730550	
TUV 58	+0.0036350	3.3766900	
TUV 46	-0.1868650	3.1861900	
TUV 59	+0.2370300	3.4232200	
TUV 60	-0.5015150	2.9217050	
TUV 61	-0.0436375	2.8780675	
TUV 48	+0.1835650	3.0616325	
TUV 49	+0.1862825	3.2479150	
TUV 74	-0.6639874	2.5839711	
BM 24	**+1.2120325**	**3.7960036**	
TUVA4	+0.1758500	3.9718536	

POINT # (cont.)	2003 DIFF (cont.)	2003 RL (cont.)
TUV 48		3.0616325
TUV 62	-0.1537574	2.9078751
TUV 51	+1.2713086	4.1791837
TUV 52	-0.2471353	3.9320484
TUV 35	-0.1775075	3.7545409
TUV 52		3.9320484
BM 25	**-0.3951250**	**3.5369234**
TUV 52		3.9320484
TUV 14	-0.0961167	3.8359317
TUV 63	-0.0009925	3.8349392
TUV 14		3.8359317
TUV 53	-0.2215657	3.6143660
TUV 24	-0.0038375	3.6105285
TUV 53		3.6143660
TUV 54	+0.1833525	3.7978750
TUV 16	-0.0020850	3.7956018
TUV 54		3.7978750
TUV 64	+0.0250856	3.8227724
TUV 65	-0.2158560	3.6069164
BM 26	**-0.4969959**	**3.1099205**
TUV 66	+0.1600507	3.2699712
TUV 38	+0.3245850	3.5945562
TUV 67	+0.0010775	3.5956337
TUV 38		3.5945562
TUV 39	-0.1791775	3.4153787
TUV 68	-0.0032125	3.4121662
TUV 39		3.4153787
UH 2	**-0.4020150**	**3.0133637**
UH 1	-0.0194675	2.9938962
UH 2		3.0133637
SW 2	-1.8650042	1.1483595
SW 1	+0.0845417	1.2329012
BM@	+0.6310275	1.8639287

POINT # (cont.)	2003 DIFF (cont.)	2003 RL (cont.)

TUV 66		3.2699712
BM 27	**-1.0534502**	**2.2165210**
RM 3	-0.2849550	1.9315660
TUVABM	**+0.8097975**	**2.7413635**
RM 1	-0.6544050	2.0869585
TUVABM		**2.7413635**
RM 2	-0.5827550	2.1586085
BM 27		**2.2165210**
TUV 69	+0.0005881	2.2171091
TUV 70	+0.2835202	2.5006293
TUV 71	-0.2582689	2.2423604
TUV 72	-0.1105609	2.1317995
TUV 73	+0.1681907	2.2999902
TUV 74	+0.2839809	2.5839711

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TABLE OF REDUCED LEVELS:

INSTRUMENT: Wild NA 3003 S/N 92897 **DATUM:** Tide Staff Zero

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POINT #	2003 RL	2001 RL	1993 RL (see note below)
BM 22	**3.2254000**	**3.2254000**	**3.2254000**
TUV 55	3.6447400	**New Point (2003)**	
TUV 56	3.9176250	**New Point (2003)**	
TUV 42	3.7647850	3.7677175	**New Point (2001)**
TUV 41	3.6866850	3.6875775	**New Point (2001)**
TUV 40	3.7313775	3.7313750	**New Point (2001)**
TUV 19	3.4850825	3.4848200	3.4812950
TUV 20	**4.4592975**	**4.45988375**	**4.4598950**
TUV 44	3.3262425	3.3266800	**New Point (2001)**
TUV 57	2.7300750	**New Point (2003)**	
BM 23	**3.1391225**	**3.1389700**	**3.1385175**
TUV 6	3.3730550	3.3731900	3.3740600
TUV 58	3.3766900	**New Point (2003)**	
TUV 46	3.1861900	3.1873525	**New Point (2001)**
TUV 59	3.4232200	**New Point (2003)**	
TUV 60	2.9217050	**New Point (2003)**	
TUV 61	2.8780675	**New Point (2003)**	
TUV 48	3.0616325	3.0625725	New Point (2001)
TUV 49	3.2479585	3.2478775	**New Point (2001)**
BM 24	**3.7960036**	**3.7951750**	**3.7982000**
TUVA4	3.9718536	3.9708625	**New Point (2001)**

POINT #	2003 RL	2001 RL	1993 RL (see note below)
TUV 62	2.9078950	**New Point (2003)**	
TUV 51	4.1791837	4.1836025	**New Point (2001)**
TUV 52	3.9320484	3.9320175	**New Point (2001)**
TUV 35	3.7545409	3.7533400	3.7540825
BM 25	**3.5369234**	**New Point (2003)**	
TUV 14	3.8359317	3.8356600	3.8406775
TUV 63	3.8349392	**New Point (2003)**	
TUV 53	3.6143660	3.6154800	**New Point (2001)**
TUV 24	3.6105285	3.6124825	3.6184300
TUV 54	3.7976868	3.7981125	**New Point (2001)**
TUV 16	3.7956018	3.7960150	3.8030825
TUV 64	3.8229950	**New Point (2003)**	
TUV 65	3.6071775	**New Point (2003)**	
BM 26	**3.1102150**	**New Point (2003)**	
TUV 66	3.2699715	**New Point (2003)**	
TUV 38	3.5945562	3.5939175	3.5938825
TUV 39	3.4153787	3.4146975	3.4144350
TUV 68	3.4121662	**New Point (2003)**	
UH 2	**3.0133637**	**3.0128250**	**3.0259150**
UH 1	2.9938962	2.9942175	3.0071625
SW1	1.2329012	1.2345825	1.2523625
SW2	1.1483595	1.1502350	1.1678225
BM@	1.8639287	1.8664425	1.8840675
BM 27	**2.2165210**	**New Point (2003)**	
RM 3	1.9315660	**New Point (2003)**	
TUVABM	**2.7416925**	**New Point (2003)**	
RM 1	2.0869585	**New Point (2003)**	
RM 2	2.1586085	**New Point (2003)**	
TUV 69	2.2171091	**New Point (2003)**	
TUV 70	2.5006293	**New Point (2003)**	
TUV 71	2.2423604	**New Point (2003)**	
TUV 72	2.1317995	**New Point (2003)**	
TUV 73	2.2999902	**New Point (2003)**	
TUV 74	2.5839711	**New Point (2003)**	

NOTE: The RL listed under 1993RL is the first RL determined for that point. The RL may not have first been determined in 1993 but is listed in that column for simplicity.

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COMPARISON OF RL DIFFERENCES:

INSTRUMENT: Wild NA 3003 S/N 92897 **DATUM:** Tide Staff Zero

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POINT #	03RL – 01RL (mm)	03RL – 93RL (mm)
BM 22	**Adopted Height**	
TUV 42	-2.93	**New Point (2001)**
TUV 41	-0.89	**New Point (2001)**
TUV 40	0.00	**New Point (2001)**
TUV 19	+0.26	+3.79
TUV 20	**-0.59**	**-0.60**
TUV 44	-0.44	**New Point (2001)**
BM 23	**+0.15**	**+0.61**
TUV 6	-0.14	-1.01
TUV 46	-1.16	**New Point (2001)**
TUV 48	-0.94	**New Point (2001)**
TUV 49	+0.08	**New Point (2001)**
BM 24	**+0.83**	**-2.20**
TUVA4	+0.99	**New Point (2001)**
TUV 51	-4.42	**New Point (2001)**
TUV 52	+0.03	**New Point (2001)**
TUV 35	+1.20	+0.46
TUV 14	+0.27	-4.75
TUV 53	-1.11	**New Point (2001)**
TUV 24	-1.95	-7.90
TUV 54	-0.43	**New Point (2001)**
TUV 16	-0.41	-7.48
TUV 38	+0.64	+0.67
TUV 39	+0.68	+0.94
UH 2	**+0.54**	**-12.55**
UH 1	-0.32	-13.27
SW1	-1.68	-19.46
SW2	-1.88	-19.46
BM@	-2.51	-20.14

SOUTH PACIFIC SEA LEVEL

AND CLIMATE MONITORING PROJECT

REDUCED LEVELS - FONGAFALE, FUNAFUTI, TUVALU

INSTRUMENT: Wild NA 3003 S/N 92897 **DATUM:** Tide Staff Zero

DATE: 13th – 20th May 2003 **PAGES:** 3051 - 3112

Table of University of Hawaii Benchmarks

POINT NUMBER	2003 RL	2001 RL	1993 RL	
T S ZERO	0.0000000	0.0000000	0.0000000	
BM @	1.8897600	1.8897600	1.8897600	**Scale**
UH 2	3.0391950	3.0361425	3.0242075	
SW 1	1.2587325	1.2579000	1.2580550	
SW 2	1.1741908	1.1735525	1.1735150	
UH 1	3.0197275	3.0175350	3.0054550	

Comparison of RL's

POINT #	03RL - 01RL (mm)	03RL - 93RL (mm)
UH 2	+3.05	+14.99
SW 1	+0.83	+0.68
SW 2	+0.64	+0.68
UH 1	+2.19	+14.27

SOUTH PACIFIC SEA LEVEL

AND CLIMATE MONITORING PROJECT

REDUCED LEVELS - FONGAFALE, FUNAFUTI, TUVALU

INSTRUMENT: Wild NA 3003 S/N 92897

DATE OF LEVELLING: 13th – 20th May 2003 **SURVEY TYPE:** First Order

DATUM FOR LEVELLING: Tide Staff Zero

BENCH MARK ADOPTED: BM 22 (3.2254 metres)

SURVEY MARK	2003 RL	TYPE OF MARK
BM 22	**3.2254**	**Deep Bench Mark**
TUV 55	3.6447	Stainless Steel Bolt in Concrete
TUV 56	3.9176	Stainless Steel Bolt in Concrete
TUV 42	3.7648	Stainless Steel Bolt in Concrete
TUV 41	3.6869	Stainless Steel Bolt in Concrete
TUV 40	3.7314	Stainless Steel Bolt in Concrete
TUV 19	3.4851	Project Plaque
TUV 20	**4.4593**	**SEAFRAME Sensor Bench Mark**
TUV 44	3.3262	Stainless Steel Bolt in Concrete
TUV 57	2.7301	Stainless Steel Bolt in Concrete
BM 23	**3.1391**	**Deep Bench Mark**
TUV 6	3.3731	Masonry Nail in Concrete
TUV 58	3.3767	Stainless Steel Bolt in Concrete
TUV 46	3.1862	Stainless Steel Bolt in Concrete
TUV 59	3.4232	Stainless Steel Bolt in Concrete
TUV 60	2.9217	Stainless Steel Bolt in Concrete
TUV 61	2.8781	Stainless Steel Bolt in Concrete
TUV 48	3.0616	Stainless Steel Bolt in Concrete
TUV 49	3.2479	Stainless Steel Bolt in Concrete
TUV 74	2.5840	Stainless Steel Bolt in Concrete
BM 24	**3.7960**	**Deep Bench Mark**
TUVA4	3.9719	Bench Mark

SURVEY MARK (cont.)	2003 RL (cont.)	TYPE OF MARK (cont.)
TUV 62	3.0616	Stainless Steel Bolt in Concrete
TUV 51	4.1792	Stainless Steel Bolt in Concrete
TUV 52	3.9320	Stainless Steel Bolt in Concrete
TUV14	3.8359	Masonry Nail in Concrete
TUV 53	3.6144	Stainless Steel Bolt in Concrete
TUV 54	3.7977	Stainless Steel Bolt in Concrete
TUV 16	3.7956	Masonry Nail in Concrete
TUV 64	3.8228	Stainless Steel Bolt in Concrete
TUV 65	3.6069	Stainless Steel Bolt in Concrete
BM 26	**3.1099**	**Deep Bench Mark**
TUV 66	3.2700	Stainless Steel Bolt in Concrete
TUV 38	3.5946	Masonry Nail in Concrete
TUV 67	3.5956	Stainless Steel Bolt in Concrete
TUV 39	3.4154	Masonry Nail in Concrete
TUV 68	3.4122	Stainless Steel Bolt in Concrete
UH 2	**3.0134**	**Bench Mark**
UH 1	2.9939	Bench Mark
SW 2	1.1484	Tide Gauge Switch
SW 1	1.2329	Tide Gauge Switch
BM @	1.8639	Top of Tide Board
BM 27	**2.2165**	**Deep Bench Mark**
RM 3	1.9316	Reference Mark
TUVABM	**2.7414**	**CGPS Bench Mark**
RM 1	2.0870	Reference Mark
RM 2	2.1586	Reference Mark
TUV 69	2.2175	Stainless Steel Bolt in Concrete
TUV 70	2.5010	Stainless Steel Bolt in Concrete
TUV 71	2.2428	Stainless Steel Bolt in Concrete
TUV 72	2.1323	Stainless Steel Bolt in Concrete
TUV 73	2.3005	Stainless Steel Bolt in Concrete

SOUTH PACIFIC SEA LEVEL

AND CLIMATE MONITORING PROJECT

REDUCED LEVELS - FONGAFALE, FUNAFUTI, TUVALU

INSTRUMENT: Wild NA 3003 S/N 92897

DATE OF LEVELLING: 13th – 20th May 2003 **SURVEY TYPE:** First Order

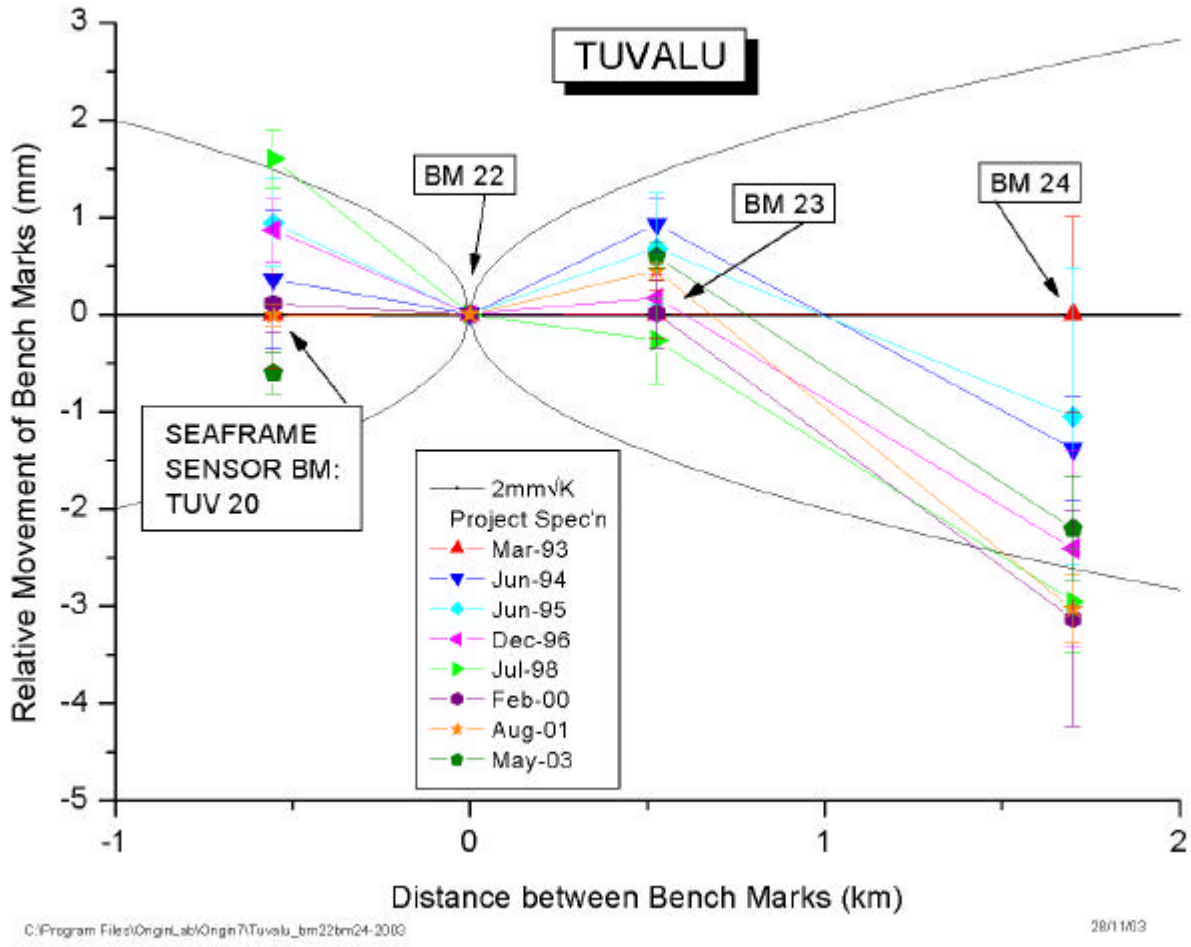
DATUM FOR LEVELLING: Chart Datum (Royal New Zealand Navy)

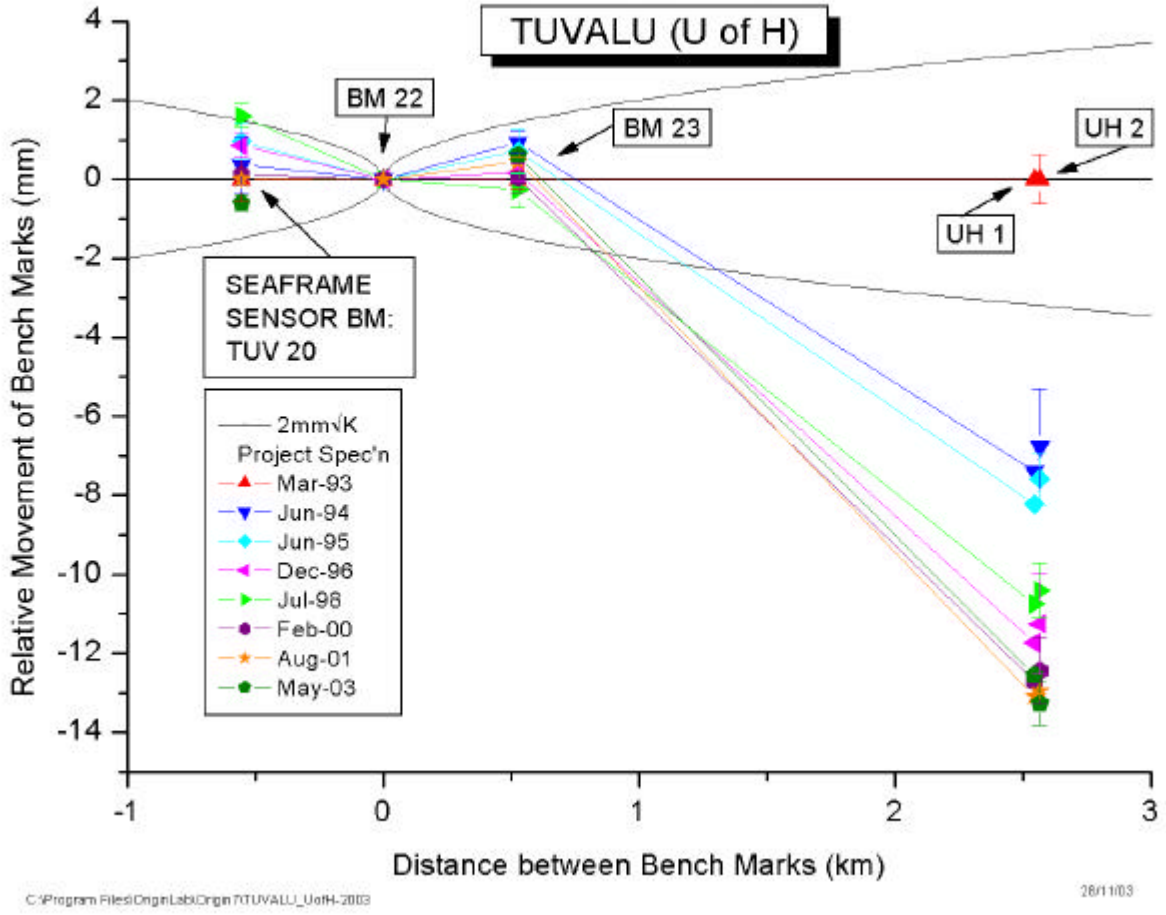
BENCH MARK ADOPTED: 1993 RNZN BM 2 (RL = 4.3190 m MSL)
1994 BM 22 (RL = 4.0123 m MSL)

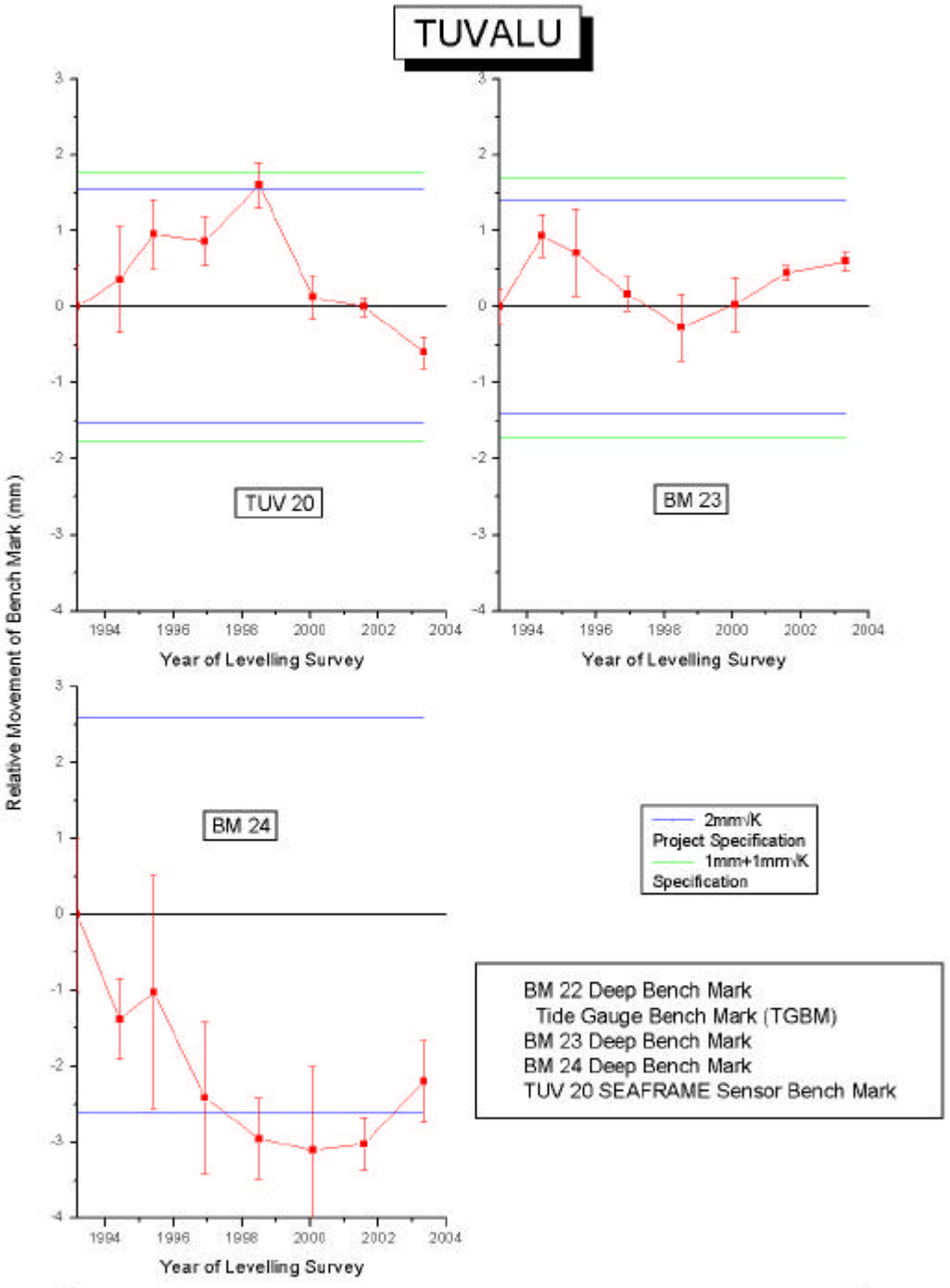
SURVEY MARK	2003 RL	TYPE OF MARK
BM 22	**4.0123**	**Deep Bench Mark**
TUV 55	4.4316	Stainless Steel Bolt in Concrete
TUV 56	4.7045	Stainless Steel Bolt in Concrete
TUV 42	4.5517	Stainless Steel Bolt in Concrete
TUV 41	4.4738	Stainless Steel Bolt in Concrete
TUV 40	4.5183	Stainless Steel Bolt in Concrete
TUV 19	4.2720	Project Plaque
TUV 20	**5.2462**	**SEAFRAME Sensor Bench Mark**
TUV 44	4.1131	Stainless Steel Bolt in Concrete
TUV 57	3.5170	Stainless Steel Bolt in Concrete
BM 23	**3.9260**	**Deep Bench Mark**
TUV 6	4.1600	Masonry Nail in Concrete
TUV 58	4.1636	Stainless Steel Bolt in Concrete
TUV 46	3.9731	Stainless Steel Bolt in Concrete
TUV 59	4.2101	Stainless Steel Bolt in Concrete
TUV 60	3.7086	Stainless Steel Bolt in Concrete
TUV 61	3.6650	Stainless Steel Bolt in Concrete
TUV 48	3.8485	Stainless Steel Bolt in Concrete
TUV 49	4.0348	Stainless Steel Bolt in Concrete
TUV 74	3.3709	Stainless Steel Bolt in Concrete
BM 24	**4.5829**	**Deep Bench Mark**
TUVA4	4.7588	Bench Mark

SURVEY MARK (cont.)	2003 RL (cont.)	TYPE OF MARK (cont.)
TUV 62	3.8485	Stainless Steel Bolt in Concrete
TUV 51	4.9661	Stainless Steel Bolt in Concrete
TUV 52	4.7189	Stainless Steel Bolt in Concrete

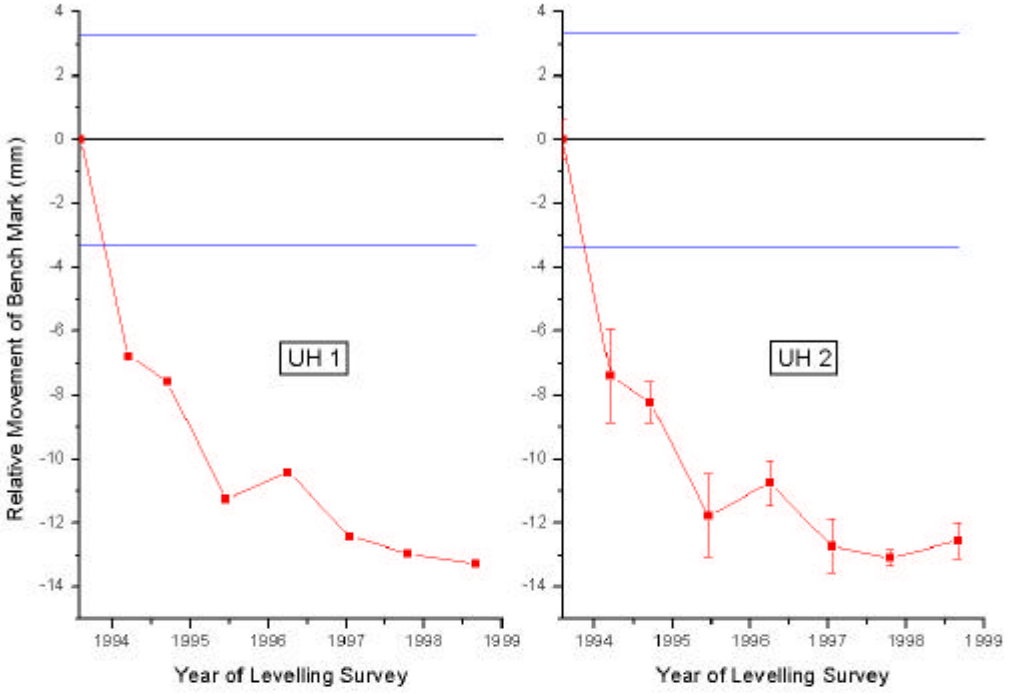
TUV14	4.6228	Masonry Nail in Concrete
TUV 53	4.4013	Stainless Steel Bolt in Concrete
TUV 54	4.5846	Stainless Steel Bolt in Concrete
TUV 16	4.5825	Masonry Nail in Concrete
TUV 64	4.6097	Stainless Steel Bolt in Concrete
TUV 65	4.3938	Stainless Steel Bolt in Concrete
BM 26	**3.8968**	**Deep Bench Mark**
TUV 66	4.0569	Stainless Steel Bolt in Concrete
TUV 38	4.3815	Masonry Nail in Concrete
TUV 67	4.3825	Stainless Steel Bolt in Concrete
TUV 39	4.2023	Masonry Nail in Concrete
TUV 68	4.1991	Stainless Steel Bolt in Concrete
UH 2	**3.8003**	**Bench Mark**
UH 1	3.7808	Bench Mark
SW 2	1.9353	Tide Gauge Switch
SW 1	2.0198	Tide Gauge Switch
BM @	2.6508	Top of Tide Board
BM 27	**3.0034**	**Deep Bench Mark**
RM 3	2.7185	Reference Mark
TUVABM	**3.5283**	**CGPS Bench Mark**
RM 1	2.8739	Reference Mark
RM 2	2.9455	Reference Mark
TUV 69	3.0044	Stainless Steel Bolt in Concrete
TUV 70	3.2879	Stainless Steel Bolt in Concrete
TUV 71	3.0297	Stainless Steel Bolt in Concrete
TUV 72	2.9192	Stainless Steel Bolt in Concrete
TUV 73	3.0874	Stainless Steel Bolt in Concrete


TUVALU
BM 22
BM 23
BM 24
SEAFRAME
SENSOR BM:
TUV 20
2mm√K
Project Spec'n
Mar-93
Jun-94
Jun-95
Dec-96
Jul-98
Feb-00
Aug-01
May-03
Relative Movement of Bench Marks (mm)
Distance between Bench Marks (km)
3
2
1
0
-1
-2
-3
-4
-5
-1
0
1
2
C:\Program Files\OriginLab\Origin7\Tuvalu_bm22bm24-2003
28/11/03


TUVALU (U of H)
BM 22
BM 23
UH 2
UH 1
SEAFRAME
SENSOR BM:
TUV 20
2mm√K
Project Spec'n
Mar-93
Jun-94
Jun-95
Dec-96
Jul-98
Feb-00
Aug-01
May-03
Relative Movement of Bench Marks (mm)
Distance between Bench Marks (km)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-1
0
1
2
3
C:\Program Files\OriginLab\Origin7\TUVALU_UofH-2003
26/11/03


TUVALU
TUV 20
BM 23
BM 24
Relative Movement of Bench Mark (mm)
Year of Levelling Survey
Year of Levelling Survey
Year of Levelling Survey
2mm√K
Project Specification
1mm+1mm√K
Specification
BM 22 Deep Bench Mark
Tide Gauge Bench Mark (TGBM)
BM 23 Deep Bench Mark
BM 24 Deep Bench Mark
TUV 20 SEAFRAME Sensor Bench Mark
Time series of Bench Mark movement relative to the
Tide Gauge Bench Mark, BM 22, sinceMarch 1993
C:\Program Files\OriginLab\Origin7\TUVALU INDIVIDUAL PLOTS_1 BM22-2003
28/11/03

TUVALU



2mm√K
Project Specification

BM 22, Deep Bench Mark
Tide Gauge Bench Mark (TGBM)
UH 1 University of Hawaii Bench Mark
UH 2 University of Hawaii Bench Mark

Time Series of Bench Mark movement relative to the Tide Gauge Bench Mark, BM 22, since March 1993

C:\Program Files\OriginLab\Origin7\TUVALU INDIVIDUAL PLOTS_2 BM 22-2003

1/12/03

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	25-03-93	27-06-94		28-06-95			11-12-96		
Point no.	1. Meas.	2. Measurement		3. Measurement			4. Measurement		
	Height TSZ	Height TSZ	D 2-1	Height TSZ	D 3-2	D 3-1	Height TSZ	D 4-3	D 4-1
	m	m	mm	m	mm	mm	m	mm	mm
SW1		1.25236		1.25189	-0.47	-0.47	1.24938	-2.51	-2.98
SW2		1.16782		1.16677	-1.05	-1.05	1.16431	-2.46	-3.51
TSZ		-0.00569		-0.00608	-0.39	-0.39	-0.00873	-2.65	-3.04
UH1	3.00716	3.00039	-6.77	2.99958	-0.81	-7.58	2.99591	-3.67	-11.25
UH2	3.02592	3.01852	-7.40	3.01770	-0.82	-8.22	3.01418	-3.52	-11.74
BM22	3.22540	3.22540	0.00	3.22540	0.00	0.00	3.22540	0.00	0.00
BM23	3.13852	3.13945	0.93	3.13923	-0.22	0.71	3.13869	-0.54	0.17
BM24	3.79820	3.79682	-1.38	3.79718	0.36	-1.02	3.79579	-1.39	-2.41
TUV6	3.37406	3.37448	0.42	3.37421	-0.27	0.15	3.37311	-1.10	-0.95
TUV14	3.84068	3.83898	-1.70	3.83918	0.20	-1.50	3.83608	-3.10	-4.60
TUV16	3.80308	3.79953	-3.55	3.79957	0.04	-3.51	3.79620	-3.37	-6.88
TUV19	3.48130	3.48259	1.29	3.48328	0.69	1.98	3.48335	0.07	2.05
TUV20	4.45990	4.46026	0.36	4.46086	0.60	0.96	4.46076	-0.10	0.86
TUV24		3.61843		3.61638	-2.05	-2.05	3.61332	-3.06	-5.11

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	31-07-98			03-03-00			29-08-01		
Point no.	5. Measurement			6. Measurement			7. Measurement		
	Height TSZ m	D 5-4 mm	D 5-1 mm	Height TSZ m	D 6-5 mm	D 6-1 mm	Height TSZ m	D 7-6 mm	D 7-1 mm
SW1	1.23789	-11.49	-14.47	1.23526	-2.63	-17.10	1.23460	-0.66	-17.76
SW2	1.15349	-10.82	-14.33	1.15048	-3.01	-17.34	1.15024	-0.24	-17.58
TSZ	-0.02035	-11.62	-14.66						
UH1	2.99675	0.84	-10.41	2.99474	-2.01	-12.42	2.99423	-0.51	-12.93
UH2	3.01517	0.99	-10.75	3.01321	-1.96	-12.71	3.01284	-0.37	-13.08
BM22	3.22540	0.00	0.00	3.22540	0.00	0.00	3.22540	0.00	0.00
BM23	3.13825	-0.44	-0.27	3.13855	0.30	0.03	3.13897	0.42	0.45
BM24	3.79525	-0.54	-2.95	3.79509	-0.16	-3.11	3.79518	0.09	-3.02
TUV6	3.37261	-0.50	-1.45	3.37288	0.27	-1.18	3.37320	0.32	-0.86
TUV14	3.83804	1.96	-2.64	3.83644	-1.60	-4.24	3.83569	-0.75	-4.99
TUV16	3.79806	1.86	-5.02	3.79655	-1.51	-6.53	3.79604	-0.51	-7.04
TUV19	3.48482	1.47	3.52	3.48423	-0.59	2.93	3.48482	0.59	3.52
TUV20	4.46150	0.74	1.60	4.46003	-1.47	0.13	4.45990	-0.13	0.00
TUV24	3.61566	2.34	-2.77	3.61311	-2.55	-5.32	3.61251	-0.60	-5.92

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	31-07-98			03-03-00			29-08-01		
Point no.	5. Measurement			6. Measurement			7. Measurement		
	Height TSZ m	D 5-4 mm	D 5-1 mm	Height TSZ m	D 6-5 mm	D 6-1 mm	Height TSZ m	D 7-6 mm	D 7-1 mm
TUV35	3.75408			3.75314	-0.94	-0.94	3.75335	0.21	-0.73
TUV38				3.59391			3.59394	0.03	0.03
TUV39				3.41446			3.41472	0.26	0.26
TUV40							3.73137		
TUV41							3.68756		
TUV42							3.76772		
TUV44							3.32668		
TUV46							3.18736		
TUV48							3.06258		
TUV49							3.24788		
TUV51							4.18361		
TUV52							3.93203		
TUV53							3.61551		
TUV54							3.79814		
TUVA4							3.97087		

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	20-05-03										
Point no.	8. Measurement			9. Measurement			10. Measurement				
	Height TSZ m	D 8-7 mm	D 8-1 mm	Height TSZ m	D 9-8 mm	D 9-1 mm	Height TSZ m	D 10-9 mm	D 10-1 mm		
RM1	2.08692										
RM2	2.15857										
RM3	1.93153										
SW1	1.23286	-1.74	-19.50								
SW2	1.14834	-1.90	-19.48								
TSZ	-0.02583	-20.14	-5.48								
UH1	2.99386	-0.37	-13.30								
UH2	3.01333	0.49	-12.59								
BM22	3.22540	0.00	0.00								
BM23	3.13912	0.15	0.60								
BM24	3.79594	0.76	-2.26								
BM25	3.53692										
BM26	3.10989										
BM27	2.21648										
TUV6	3.37306	-0.14	-1.00								
TUV14	3.83593	0.24	-4.75								
TUV16	3.79558	-0.46	-7.50								
TUV19	3.48507	0.25	3.77								
TUV20	4.45929	-0.61	-0.61								
TUV24	3.61051	-2.00	-7.92								

	TUV35	3.75454	1.19	0.46										
	TUV38	3.59453	0.59	0.62										

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	20-05-03										
Point no.	8. Measurement			9. Measurement			10. Measurement				
	Height TSZ	D 8-7	D 8-1	Height TSZ	D 9-8	D 9-1	Height TSZ	D 10-9	D 10-1		
	m	mm	mm	m	mm	mm	m	mm	mm		
TUV39	3.41535	0.63	0.89								
TUV40	3.73137	0.00	0.00								
TUV41	3.68668	-0.88	-0.88								
TUV42	3.76478	-2.94	-2.94								
TUV44	3.32624	-0.44	-0.44								
TUV46	3.18619	-1.17	-1.17								
TUV48	3.06163	-0.95	-0.95								
TUV49	3.24792	0.04	0.04								
TUV51	4.17920	-4.41	-4.41								
TUV52	3.93205	0.02	0.02								
TUV53	3.61435	-1.16	-1.16								
TUV54	3.79767	-0.47	-0.47								
TUV55	3.64474										
TUV56	3.91763										
TUV57	2.73007										
TUV58	3.37670										

o	TUV59	o	3.42322	3	3	o	3	3	o	3	3	o
o	TUV60	o	2.92170	3	3	o	3	3	o	3	3	o
o	TUV61	o	2.87806	3	3	o	3	3	o	3	3	o
o	TUV62	o	2.90789	3	3	o	3	3	o	3	3	o
o	TUV63	o	3.83493	3	3	o	3	3	o	3	3	o
o	TUV64	o	3.82276	3	3	o	3	3	o	3	3	o

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT

Date:	20-05-03										
Point no.	8. Measurement			9. Measurement			10. Measurement				
	Height TSZ m	D 8-7 mm	D 8-1 mm	Height TSZ m	D 9-8 mm	D 9-1 mm	Height TSZ m	D 10-9 mm	D 10-1 mm		
TUV65	3.60689										
TUV66	3.26994										
TUV67	3.59561										
TUV68	3.41213										
TUV69	2.21707										
TUV70	2.50059										
TUV71	2.24231										
TUV72	2.13175										
TUV73	2.29993										
TUV74	2.58391										
TUVA4	3.97180	0.93	0.93								
TUVABM	2.74133										

Difference from 1st measurement always refers to 1st measurement of respective point (D=last-initial measurement),
Difference from measurement n-1 always refers to penultimate measurement (D=last-penultimate measurement)

TUVALU

PRECISION OF 2003 SURVEY:

INSTRUMENT: Wild NA 3003 S/N 92897 **DATUM:** Tide Staff Zero

DATE: 13th – 20th May 2003 **PAGES:** 3051 - 3112

POINT #	FORWARD LEVELLING	BACK LEVELLING	DIFF (mm)	DIST (km)	PRECISION (mm / K)
TUV 20 BM 22	-1.2338025	-1.2339925	0.190	0.610	0.24 / K
TUV 20 BM 24	-0.6628125	-0.6639075	1.095	2.327	0.72 / K
TUV 20 UH 2	-1.4451325	-1.4461175	0.985	3.435	0.53 / K
TUV 20 TUVABM	-1.7173125	-1.7181050	0.585	3.388	0.32 / K
TUVABM UH 2	+0.2718950	+0.2720650	0.170	0.543	0.23 / K
BM 22 TUVABM	-0.4835100	-0.4839050	0.395	2.778	0.24 / K
BM 22 BM 24	+0.5709900	+0.5700850	0.905	1.717	0.69 / K
BM 22 UH 2	-0.2113300	-0.2121250	0.795	2.825	0.47 / K
BM 24 TUVABM	-1.0549900	-1.0553600	0.370	1.211	0.34 / K

INDIVIDUALS CONSULTED DURING THE GEODETIC SURVEY VISIT

MINISTRY OF NATURAL RESOURCES
Lands & Survey Division

Mr. Fa'atasi Malologa, Surveyor
Mr. Vakafa Lupe, Survey Assistant
Mr. Manuella Falaile, Survey Assistant
Mr. Savaliga Malau, Survey Assistant

TUVALU METEOROLOGICAL SERVICE

Ms. Hilia Vavae, Director

GEODETIC SURVEY VISIT ITINERARY

Depart Adelaide	0820	QF740	Sunday 11 May 2003
Arrive Sydney	1040		Sunday 11 May 2003
Depart Sydney	1235	QF391	Sunday 11 May 2003
Arrive Nadi	1830		Sunday 11 May 2003
Depart Nadi	0645	PC502	Monday 12 May 2003
Arrive Suva	0715		Monday 12 May 2003
Depart Suva	0830	PC601	Monday 12 May 2003
Arrive Funafuti	1045		Monday 12 May 2003
Depart Funafuti	1130	PC602	Thursday 22 May 2003
Arrive Suva	1345		Thursday 22 May 2003
Depart Nadi	1015	FJ211	Saturday 31 May 2003
Arrive Tonga	1235		Saturday 31 May 2003
Depart Tonga	0820	PH749	Saturday 07 June 2003
Arrive Auckland	1000		Saturday 07 June 2003
Depart Auckland	1300	QF190	Saturday 07 June 2003
Arrive Sydney	1430		Saturday 07 June 2003
Depart Sydney	1650	QF765	Saturday 07 June 2003
Arrive Adelaide	1825		Saturday 07 June 2003