



**SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING
(SPSLCM) PROJECT III SURVEY VISITS TO
NAURU & KIRIBATI**

31st May to 13th June 2002

Andrick Lal

Assistant Surveyor

South Pacific Sea Level & Climate Monitoring Project Phase III

SOPAC Trip Report 314

July 2002

ACKNOWLEDGEMENT

The survey team of Mr Steven Turner, Mr John Ovenden and Mr Andrick Lal is really thankful to the Environment Department of Nauru; the Meteorological Department and the Lands Department of Kiribati for their kind support and help during the survey visits throughout the lifetime of the South Pacific Sea Level and Climate Project.

AusAID is gratefully acknowledged for the funding and technical support to this important Project.

PROJECT BACKGROUND

The 20-year SPSLCMP [South Pacific Sea Level and Climate Monitoring Project] is funded by AusAID and technically supported by the [Australia's] National Tidal Facility (out of Flinders University) has entered its third, 5-year phase. This Project began in October 1992.

SOPAC was approached by the Australia Marine Science & Technology Limited (AMSAT), the agency set up to coordinate the SPSLCM Project in the region, to support the Project by way of sharing the costs of a suitably qualified and experienced “**Assistant Surveyor**” to directly support the routine surveying and monitoring in the South Pacific Sea Level and Climate Monitoring Project [Phase III]. SOPAC would also act as a regional data archive for sea level, CGPS with the related data; and assist in the maintenance of the sophisticated suite of equipment that are part and parcel of the Project.

This Project was set up to provide quality meteorological and sea level data through an array of latest climate monitoring stations, backed by the precise geodetic survey data; and a series of high-resolution sea level stations has been established in eleven countries of the South Pacific Forum with data transmission via satellites to the National Tidal Facility in Adelaide. Research and results drawn from analysis of this data is to assist Forum island countries with their sustainable development agendas.

A series of high-resolution sea level recording stations has been established in twelve countries of the South Pacific Forum with data transmission via satellites to the National Tidal Facility in Adelaide.



South Pacific Sea Level and Climate Monitoring Project Sites.

OBJECTIVES

The South Pacific Sea Level and Climate Monitoring Project aims to help Pacific Island countries understand the implications and scale of sea level and climate changes. The AusAID-funded Project has the following objectives:

- a. Set up high-resolution monitoring stations in the South Pacific region to compute relative motions of land and sea at each station based in each of the twelve countries.
- b. Carry out a geodetic survey program to measure movements of the crust at other strategic sites in each country with respect to the reference station.
- c. Help identify changes to sea levels with reference to a similar network of stations in Australia and elsewhere in the world, whether these changes are due to thermal expansion of the ocean, contributions from land ice or changing properties of water from different ocean zones.
- d. Provide a measure of regional vertical controls and exchange information and data with national, regional and international climate change centres in relation to the ongoing international geodetic programmes, which incorporate satellite altimetry and radio astronomy.

The Assistant Surveyor was involved, during this survey, in Precise Differential Levelling activities in Nauru and Kiribati according to the following objectives:

- To provide assistance in the collection and reduction of precise leveling data between the Sea Level recorders, benchmark arrays and CGPS receivers in the field as part of the South Pacific Sea Level and Climate Phase III Project being funded by AusAID.
- To monitor and identify changes to sea levels in the South Pacific that is due to thermal expansion of the ocean, glaciations from the land ice or changing properties in the continental plates between zones.
- To accomplish the above tasks by providing survey assistance to Mr Steven Turner, Geodetic Surveyor of National Tidal Facility [NTF], Australia to carry out Differential Precise Leveling Survey at Project sites.

“**Precise Differential Leveling**” is being defined as the operation required to determine the heights of points on the surface of the earth in relation to a known point [benchmark] upon a vertical datum, whereby all possible sources of errors are identified and field procedures are adopted to eliminate or minimize their effect as possible. This survey satisfies the requirements of a **CLASS A** survey, the error accounted for should be less than $2\sqrt{k}$ where k is the distance to any station in kilometers. The survey team is constantly trying to eliminate errors and get misclosure to within $1\sqrt{k}$, which is even more accurate.

SURVEY TEAM

The head of the Surveys and Geodesy Department of the National Tidal Facility, Mr Steven Turner, was Team Leader with Mr John Ovenden, Senior Technical officer from the South Australian Lands Department and Mr Andrick Lal, Assistant Surveyor (SOPAC) the other team members. The team is responsible for carrying out the Precise Differential Leveling survey in the Project sites on Nauru and Kiribati as part of the South Pacific Sea Level & Climate Monitoring Project Phase III.

ACTIVITIES UNDERTAKEN

The precise differential leveling surveys were carried out in Yaren, Nauru and in Betio, Kiribati where the Tide Gauges are situated. This survey was carried out from the Sea Level Fine Resolution Acoustic Measuring Equipment [SEAFRAME] station to the Tide Gauge benchmark

and to the inland primary benchmarks, which are driven deep into the soil and along the temporary benchmarks.

The benchmarks have the property of exceptional stability and are also established in very stable rock formations or in structures established on stable formations. These benchmarks are in terms of Mean Sea Level datum/Tide Gauge Zero or in terms of a country's datum where each benchmark has their known heights in relation to the datum.

This precise differential leveling survey is an on-going cycle of survey at every 18 months at all sites of the twelve SEAFRAME stations where all deep benchmarks were found disturbed/undisturbed and as per survey some movement of marks was detected.

Some of the holding marks (temporary benchmarks) were replaced and additional holding marks were placed in the survey network. As usual the in-county lead agencies and survey offices were consulted and visited. There were no unexpected happenings during the survey, except one, where one luggage parcel (dropper knocker) never reached Nauru with the rest of the items. Otherwise we were able to complete the survey. The survey report, which will detail all the results for this survey; is being processed by the survey team leader, Mr Steven Turner of National Tidal Facility in Australia.

Nauru Survey, 31 May – 5 June

I arrived in Nauru via Tarawa on the 31st May 2002 at 1330 hours from the Nadi airport and was picked up from the airport by Mr Steven Turner and Mr John Ovenden. We checked into the Menen Hotel. As circumstances permitted the survey team shared the presidential suite at the hotel. Before my arrival in Nauru, Steve and John had placed new and replaced some of the temporary benchmarks (holding marks); therefore after checking into the hotel I accompanied my fellow team members to the field.

We started off with the precise differential survey at the wharf completing about two bays of survey from the tide gauge to the wharf benchmark and then to the first deep benchmark, finishing of the fieldwork at 1715 hours. After carrying out the fieldwork we went back to the hotel. The next morning we left the hotel at 0800 hours and after a 15-minute drive to the survey site we began the precise differential leveling from the wharf.

We finished off one-kilometer of survey from the main wharf to the OD-NAIWO hotel at 1700 hours also going along the Nauru phosphate warehouse. As usual the weather was fine and hot but we set ourselves up during field work so that John was doing the observations from the digital level on the way forward from one benchmark to the next and I was setting up the starves on the backsight and foresight. When leveling backwards to the benchmark, I was doing the observations and John was setting up the starves on the foresight and backsight. Steve was recording all the data onto the field pages and making sure that the differences in heights obtained from the two sets of readings were within the allowable limit of 0.15 mm, if not, then the observations were repeated.

Even though all the data was recorded digitally, field observation data was also recorded in the field book, so that we always had a back-up copy for the all data collected on the field.

Steve also took his turn doing the observations, while John and myself manned the backsight and foresight stations, to avoid any disturbances on the set up by curious pedestrians. This procedure was used throughout the Nauru survey.

After finishing off the fieldwork we went to Capelle Store to do our groceries shopping and then back to the hotel. It took us twenty minutes to reach our hotel from the other side of the island. At the hotel we freshened up, and afterwards John and myself did the reductions while Steve checked that all the field observations were within the limits according to the standard $2\sqrt{k}$. At the end of the day it was concluded that one bay needed to be re-surveyed.

Therefore, next day on Sunday, (2nd June) we started off at 0800 hours with the precise differential leveling by completing the re-survey portion in front of the OD-NAIWO hotel and working out towards the airstrip and completing the six hundred meters of survey at the end of the

air strip where the last deep benchmark is located at 1600 hours. At the end of the day John and myself did the reductions while Steve checked that all the fieldwork data were within the limits of $2\sqrt{k}$.

One of the major objectives of this survey visit was to place the three deep benchmarks within the survey network.

Therefore the following day on the 3rd June 2002, we had the task of placing the three benchmarks. The three deep benchmarks were placed in the compounds of (1) the Accounts Building of the Nauru Phosphate Corporation; (2) the Nauru Catholic Church; and (3) the Nauru Young Men Gymnasium, opposite the church.

The deep benchmarks were driven into the ground with the use of dropper knocker. We borrowed the dropper knocker from the International Migration office workshop guys. The benchmarks are stainless steel rods in lengths of 1.40 meters.

Basically, the holes were dug for each benchmark and then the stainless steel rods were driven into the ground, length by length. We took turns piledriving it down into the ground with the dropper knocker the rods get to the hardest substratum below ground level. A stainless steel cap was screwed and glued on top of the stainless rod. After placing the deep benchmarks we finished off the day's work.

Next day we started the fieldwork at 0800 hours completing all the survey arrays from the temporary benchmarks to the new benchmarks placed and also connecting the survey array from the airstrip benchmark to the temporary benchmark on the side of the road.

At the end of the survey, we went back to the hotel to check on all the data collected for the day and of the whole survey visit. Upon checking and reduction of the field data collected was deemed to be sound.

The following day, we had no survey work to do; therefore we visited our local counterparts and notified them that all the survey work had been completed. We also packed the survey gear for travel to Kiribati, the next stop for this one survey visit.

Although there was a problem with cash flow on Nauru; we were able to cash some money at the hotel to pay our hotel bills. We also covered the deep benchmarks with soil to conceal them and took photographs of their localities for our records. We came back to the hotel at 1500 hours and took the rest of the afternoon off.

Next morning at 0630 hours on the 6th June 2002 we left the Menen Hotel and checked in at the airport. We departed for Kiribati at 0840 hours and arrived there at 1000 hours.

Kiribati Survey, 6-12 June

One of the staff from the Otintai Hotel, where we stayed during the survey visit, picked us up from the airport. Steve hired a vehicle for the survey work from the Toyota Rentals. We left the hotel at 1400 hours to pay visits to the AusAID personnel at the Australian High Commission and to the Meteorological and Survey Department of Kiribati based at Bairiki. After the visits we then went to Betio where the Tide Gauge is based and our whole survey would be concentrated.

At Betio we located some of the temporary benchmarks and all the three deep benchmarks, also placing some new temporary benchmarks. At 1730 hours we went to Bikenbieu where our hotel is located; it took us half an hour to drive back to the hotel. On our way back to the hotel we stored all our survey equipment in the CGPS hut, as the CGPS was not functional.

On 7th June 2002 we (Steve, John and Andrick) left the hotel at 0800 hours and got to Betio at 0830 hours. Upon arrival we arranged for a dropper knocker and got a new one made up with the help of AusAID project co-workers (Steve & Chris). Our dropper knocker was misplaced along the way to Nauru. The weather was fine and very hot.

We started the precise differential leveling at 1100 hours from the Ministry of Information & Communication inland deep benchmark and proceeded to the temporary benchmarks inland (in front of Betio Town Council). This was about 600 m of surveying.

We used the field setup used in Nauru, with John doing the observations from the digital level on the way forward from one benchmark to the next and me setting up the starves on the backsight and foresight. For backward leveling to the benchmark I was doing the observations and John was setting up the starves on the foresight and backsight. Steve was recording all the data onto the field pages and ensuring that the differences in heights obtained from the two sets of readings were within the limits 0.15 mm, if not, then the observations were repeated.

Steve also took his turn at doing observations while John and myself manned the backsight and foresight stations, to avoid disturbances to the set up by curious pedestrians. Sometimes small kids disturb the survey set-ups so we have to man the stations (backsight, foresight and instrument) to safeguard them. We completed the fieldwork at 1600 hours.

After this round of field surveys, we put our survey gear in the CGPS hut as a routine, as it was not being used.

Along the way to the hotel I was interested in the sight of the wreckage of the army tanks from World War II.

The next morning we all met at the breakfast table at 0730 hours. After the breakfast we left Bikenibeu and reached the commercial center for Kiribati in Betio, at 0830 hours. On the way we picked up the survey gear. We started precise differential leveling from the Betio Town Council to the Roman Catholic Church when John felt sick from the drink he took and was suffering from stomach pains; so we took him back to the hotel and dropped him off to have some rest while we went back to Betio to carry out the leveling from the Roman Catholic Church to the Meteorological Office, where CGPS site is located. This time Steve was setting up the instrument and observing, I was setting up starves all the way to the CGPS benchmark.

The Meteorological Office is where our survey concluded from the Tide Gauge up at the wharf. We came back to the hotel at 1630 hours. At the hotel John and myself reduced the field data and checked the survey misclosure while Steve checked the survey misclosure in comparison with the fixed benchmark and checked that the survey is less than the $2\sqrt{k}$ of allowable limit. At the conclusion of field data checking he told us that one bay (one benchmark to the next) of re-leveling had to be redone.

On Sunday, 9th June 2002, we started off with up at the wharf and surveyed from the Tide Gauge benchmark to the temporary benchmark. There were strong winds but we were able to complete the survey at the wharf. John was fit enough to also come out to the field after some hours of rest. We carried out precise leveling from the Bulk Store opposite the Ministry of Information & Communication building to the University of Hawaii benchmark in front of the Fisheries Warehouse. After completing that portion of the survey, we re-leveled the bay in front of the fish market, which had the misclosure.

We usually took a 15-minute break after every bay of surveying. We went back to the hotel at 1630 hours and reduced all our collected data. Checking of the survey data by Steve found the observations within the limits of allowable error.

The following day we went to the survey site to place the deep benchmarks. Four survey marks were placed in (1) front of the Naval Police Warehouse; (2) half way along the causeway to the wharf; (3) in the Betio park; and in the compound of the Roman Catholic Church.

The same procedure used in Nauru for placing deep benchmarks was employed here. Two of the deep benchmarks driven were only 1.40 m inside the ground because it had hit the substratum below; while the other two were driven 7.0 m inside the ground. The benchmarks were placed within the survey network.

Prior to placing the benchmarks we sort prior approval from the Lands Department and showed them the locations where we wanted to place them.

On Tuesday, we took one of the survey assistants from the Lands Department out with us to the field and carried out the survey to connect survey arrays from the temporary benchmarks to the new benchmarks placed. This routine completed the whole of the survey work in Kiribati on schedule. We also took photographs of all the benchmarks for their localities and covered them up so that the general public would not disturb them.

Next morning we packed all the survey gear and freighted it to Fiji through DHL.

The survey equipment was provided to SOPAC as part of the Project for the purpose of conducting precise differential leveling in the region.

We visited the National Representative of SOPAC in Kiribati, the Meteorological Office and the Lands Department and thanked them for their support. We also checked that the Tide Gauge tools used were stored, returning to the hotel at 1430 hours.

On Thursday morning we left Kiribati bound for home as per the itinerary (Attachment).

FIELD EQUIPMENT

Below is the list of instruments used by the Survey Team, carrying out Precise Leveling in the South Pacific Sea Level & Climate Monitoring Project – Phase III:

1. Leica NA3003 Digital Level
2. Instrument Tripods
3. Leica Invar Leveling Staffs
4. Leveling Struts
5. Ground Plates
6. 50 m Measuring Tape
7. Electric Drill
8. Stainless Steel Rods
9. Aluminum Screws
10. Dropper Knecker
11. Spade
12. Crow Bar
13. Bench Mark PVC casing

REFERENCE

- Turner, S. M., 1996, *Precise Vertical Survey Control Course Manual*, National Tidal Facility, Adelaide, Australia.

ATTACHMENT

Travel Itinerary

1. Friday 31st May 2002: Depart Suva (0530)
Arrive Nadi (0555)

Friday 31st May 2002: Depart Nadi (0755)
Arrive Nauru via Tarawa (1305)
2. Thursday 6th June 2002: Depart Nauru (0830)
Arrive Tarawa, Kiribati (0945)
3. Thursday 13th June 2002: Depart Tarawa (1045)
Arrive Nadi (1345)

Thursday 13th June 2002: Depart Nadi (1530)
Arrive Nadi (1600)