

NIUE

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Niue Island is situated in the South Pacific Ocean approximately 480 km east of Tonga, 550 km southeast of Samoa and 900 km west of Rarotonga. The name NIUE is composed of "NIU," a coconut tree, and "E," behold. The island is isolated and does not form part of any recognized island group. Niue has an area of just over 250 square kilometers. It is approximately 21 km long and 18 km wide, and the main road that roughly follows the coastline is about 64 km in length. The island is an elevated coral outcrop with a coral reef fringing a precipitous and broken coastline. The general formation takes the shape of two terraces, the lower coastal terrace being about 28 m above sea level; the upper terrace that forms the bulk of the island, is about 69 m above sea level. Apart from the rise from the lower to the upper terrace, there are no hills. The island has no running streams or surface water. There are no good harbors and the best anchorage is at Alofi, being an open roadstead. Niue is on the edge of the hurricane belt. Hurricanes and winds of high velocity are sometimes experienced between December and March. The climate is mild and equable; the mean annual temperature over the last 30 years has been 24.7°C, and the annual rainfall for the same period was 2,047 mm. Occasionally, droughts do occur but the rainfall is generally well distributed over the entire year.

It is believed that Niue has been inhabited for over a thousand years. Some authorities believe that there were two principal migrations to the island, one from Samoa and one

from Tonga and a smaller migration from Pukapuka. There were probably also contacts with Aitutaki and Rarotonga. In 1774, the English explorer, Captain James Cook, landed on Niue and received a less than friendly reception. Cook named it Savage Island. In 1830 the Reverend John Williams attempted to land Christian island teachers, but the party was repulsed. The next 15 years continued to have little success with attempts to bring Christianity to the island until 1846. Nukai Peniamina, who was a Niuean teacher of the London Missionary Society, landed and succeeded in converting the inhabitants, and the first European missionary landed in 1851. After requests of the Niueans, a British protectorate was declared over the island in 1900, and the island was formally annexed by New Zealand in 1901. In 1974 Niue gained independence in free association with New Zealand.

According to correspondence in 1998 from the Department of Justice, Lands & Survey Niue,

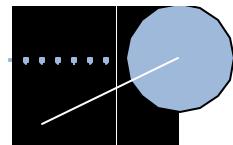
"The island is so flat that we do not have a triangulation system. What we have instead is a series of control traverses along the main roads around and across the island. They are primarily for cadastral survey. The very first survey of Niue was established in 1903 (or there about) by Harzard, a surveyor from New Zealand. He established the initial or origin station Tomb Point and also observed the Latitude and Longitude, however there is no record or information of the Grid System used."

(Note: Tomb Point Datum of 1903 coordinates are $\Phi_0 = -19^\circ 01' 42''$ South, $\Lambda_0 = -169^\circ 55' 15''$ West of Greenwich). "What we have in our records is just a single plan showing all the marks including bearings and distances with no Grid lines. In the late 1930's to the

early 1940's another visiting surveyor (A. A. Bailey) established the traverses along all the main roads as aforementioned. This surveyor managed to find only a few of the old marks placed by Harzard back in 1903. This survey is based on a plane Grid system with the coordinates in terms of Tomb Point and stellar observations made every 20 to 25 stations. The false origin of Tomb Point was 0.0 chain North and 0.00 chain East. In 1980 with the introduction of metrication, the false origin of 15000 mN and 5000 mE were adopted in order to keep all coordinates on the island positive. All cadastral surveys are now based and in terms of the above false origin. In the late 70's to the 80's general roads were re-traversed by modern equipment – EDM, Total Station theodolite, etc ... these traverses were also in terms of Tomb Point. The mapping Grid is now officially known as Niue Map Grid. In 1990, Niue took another step further by completing a GPS survey of the whole Island. Please note that the GPS survey stations selected include some of the existing marks established in the 60's, and from Plan 461 known as the Niue North Control. This latter control was established in the mid 80's incorporating some of Bailey's marks as part of the traverse regime. We are now in the process of re-adjusting some of the road traverses / controls in terms of the NGD 91. But we found that some of the controlled closure from GPS to GPS system is quite large considering the distances between marks. We need to investigate and analyze all available data to pin point the problem. There is the possibility that the GPS survey for some of the stations are unreliable or questionable."

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The astronomic origin coordinates observed by A. A. Bailey for the Tomb Point Datum of 1945 are $\Phi_0 = -19^\circ 03' 10''$ South, $\Lambda_0 = -169^\circ 55' 22''$ West of Greenwich, $H_0 = 18.86$ m above sea level, and the defining astronomic azimuth to Namou is $\alpha_0 = 356^\circ 10' 42''$. The ellipsoid of reference is the International 1924 where the semi-major axis, $a = 6,378,388$ m and the reciprocal of flattening, $1/f = 298$. The plane coordinate system used for this Datum is presumably based on the Transverse Mercator projection. Considering the size of Niue, the choice of projection is rather moot for this old Datum because the coordinates were only used for cadastral purposes and never intended for geodetic applications.

The traverse of 1965 was performed by Lee, and a few points were added to the list of cadastral control. The bulk of new North Control was observed in the middle 1980s by J. G. Kammanankada and was adjusted with an H-P 41 CV pocket computer! The GPS Survey performed in 1991 was by the Department of Survey and Land Information of New Zealand, and 11 existing points were colocated in that survey. The new definitions are as follows: The Niue

Geodetic Datum 1991 (NGD91) is based on origin point "SW Pacific Mark" where the geodetic coordinates are: $\Phi_0 = -19^\circ 04' 54.704''$ South, $\Lambda_0 = -169^\circ 55' 29.383''$ West of Greenwich, the ellipsoid height is $h_0 = 88.00$ m, and the Geodetic Reference System 1980 is the ellipsoid of reference where $a = 6,378,137$ m, and $1/f = 298.257222101$. The new Niue Map Grid is based on the Transverse Mercator projection with the origin at Tomb Point with NGD91 coordinates of the Grid Latitude of Origin $\Phi_0 = -19^\circ 03' 13.96''$ South, the Grid Central Meridian $\lambda_0 = -169^\circ 55' 15.15''$ West of Greenwich, the scale factor at origin is equal to unity, the False Easting = 5 km, and the False Northing = 15 km. No parameters were offered for performing transformations between the old cadastral coordinate system and the new Niue Map Grid. Although it is technically correct to consider the NGD91 as the very first geodetic datum, the local surveyors were left in a quandary as how to relate all the cadastral surveys of the 20th century to the new coordinate system.

Roy Ladner was in need of just one more Engineering course at the University of New Orleans to complete his requirements for a PhD back in the Fall of 1999. I suggested

that he re-adjust all the surveys of Niue with ties to the NGD91 as a special topic course in engineering, and he agreed. The software used to accomplish the adjustment was "ADJUST v4.41" available from the National Geodetic Survey. All original observations were tabulated by (now) Dr. Ladner, consisting of 808 stations for the 1940s traverse and an additional 180 stations for the 1980s traverse. The result was two constrained adjustments that provided the Niue Lands & Survey Department with a tool to allow correlation of the NGD91 with the historical records of the cadastral surveys of the 20th century. Dr. Ladner's report consisted of a final written report as well as all input data, ADJUST software, utility software written specifically for Niue, and more, on a CD disk that was transmitted to the Lands & Survey Department. Although Niue is moving towards Tonga at a rate of about 20 cm per year, a three-parameter Datum Shift from the Tomb Point Datum 1945 to NGD91 is $\Delta X = +138$ m, $\Delta Y = -178$ m, and $\Delta Z = +92$ m (data as of 1991). Hurry and transform before the parameters change!