MINISTRY OF LANDS & NATURAL RESOURCES

Water Quality Test Results

Post TC Gita Water Quality Assessment – ‘EUA

Water Resources Section

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Introduction

The purpose of this report is to present the results of water quality testing of water sources of 'Eua following the Tropical Cyclone Gita. This is a joint assessment with NEMO and WASH cluster. This report also aims to provide awareness of the existing conditions of the water quality of water sources across Tongatapu during and after Tropical Cyclone Gita.

It provides information on the background of the water sources, procedures, results and discussions of the water quality tests that had been carried out. Water Quality testing of water samples are undertaken at the Natural Resources Division and most information is extracted from Hydrogeological monitoring data from the Water Resources Section (WRS) of the Natural Resources Division of the Ministry of Lands, Survey and Natural Resources.

The interpretation of the data is theoretical and backed by examples both within the Kingdom and abroad. The Ministry, WRS or the author of this document shall not be held liable to any impacts for the use of the content of this document.

Table of Contents

Background

Tropical Cyclone Gita struck the mainland Tongatapu and neighboring island of 'Eua and the most South Eastern islands of the Ha'apai Group evening of 12th of February to the early morning of the 13th of February. Cyclone Gita classified as a category 4 Tropical Cyclone and one of the worst to have struck the islands in past ten years.

This joint assessment into the status of water, health and sanitation of the people on the mainland required water quality testing which was carried out by the Water Resources Section. There had been an assessment of water quality in the mainland Tongatapu had been carried out on from the 15th -18th of February with results reported out. The assessment of water quality of water sources in 'Eua had been carried out from the 24th of February to the 3rd of March. This water quality assessment was carried out by a team of 4 Water Resources Section staff and a New Zealand volunteer from the University of Canterbury. A total of 200 water samples 100 water sources consisting of 91 rainwater catchment tanks, 6 springs and 1 bore well and 2 TWB reservoir (refer to Figure 1). Of 91 rainwater catchment tanks, 63 sources were from individual households tanks that a large number of the community access to; 5 church hall tanks, 7 community hall tanks, 15 school tanks and 1 tank for the prison population. These sources are spread over 13 villages of 'Eua Motu'a and 'Eua Fo'ou.

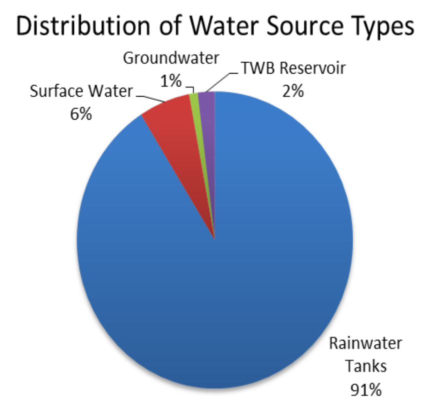


Figure 1 Distribution of water sources by type.

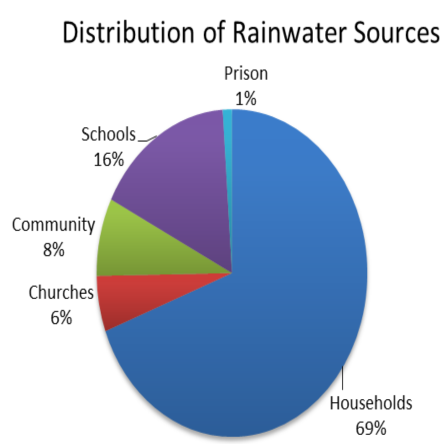


Figure 2 Distributions of Rainwater Sources

Not all water sources were tested. Instead, priority was taken for testing were evacuation centers, church and community rainwater tanks that were used for drinking by a large number of each individual community population. This includes household rainwater tanks that were used by a large number of each community.

It should be noted here that while the Sainai Prison has both rainwater catchment and spring water from their own spring. The spring water pipeline had broken as a result of the cyclone. Thus their rainwater tank is their sole water source. However, this tank is being filled with water from the main Tonga Water Board Spring water Reservoir.

It is also important to understand that the village of Houma has its own spring water sources. There are two spring feeding the taps at Houma. These spring feed one reservoir where the waters from both springs are blended together prior to distribution to the village. The team was only able to sample this spring water at a household tap in the village as the road and paths to the spring were inaccessible.

Figure 3 TWB reservoir field. Assistant geologist 'Amelia Sili is standing in front of the individual pipeline from different springs.

Furthermore, the 4 springs Pekepeka, Matavai, Fern Gully and Saoa were sampled at each of the main pipeline that brings water from the springs into the TWB reservoir field in Petani. Again this was due to inaccessible roads.

The springs at Hango Agriculture School was also tested in the same manner.

There are currently 3 bore wells in ‘Eua but only two have pumps installed and are operating. The two bore wells operating belong to the Tonga Water Board (TWB). These two bore wells are located in ‘Ohonua and is pumped into its own reservoir whereby the groundwater is blended with spring water from the reservoirs in Petani. Only one of these bore well was accessible for measurements and testing.

Fecal coliform is a specific subgroup of a collection of relatively harmless microorganisms that live in large number in the intestines of the warm and cold blooded animals. The most common member being *Escherichia coli*. These organisms may be repeated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm blooded animals.

The presence of fecal coliform bacteria in water sources indicate that the water has been contaminated with the fecal material of man or other animals. When this occurs, the source water may have been contaminated by pathogens or disease-producing bacteria or viruses which can also exist in fecal material. Some water-borne pathogenic diseases include typhoid fever, viral, and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water.

Although there are a few indicators of various forms of pollution readily available to be tested for in water. The WRS perform tests for levels of Nitrate, Phosphate and Ammonia as an indicator of possible pollutions in water sources. These three nutrients are normally occurring in water sources and only when water sources are comprised that they occur in high levels (WHO, 2008).

High levels of nitrate detected in drinking water could be due to excessive use of agriculture fertilizers, domestic effluent, and sewage disposal industrial discharges contaminating water sources. It is recommended that Nitrate not exceed **10mg** per litre in water sources (WHO, 2008).

High levels of Phosphate may result from the breakdown of organic pesticides which contain phosphates. High levels of phosphate in water sources is a major concern in terms of eutrophication in waterways and algae growth in storage tanks, but not a major concern in terms of health risks. It is recommended that phosphate remain at relatively low levels to ensure no eutrophication is occurring in and at water sources and storage (WHO, 2008).

High levels of Ammonia also, indicate pollution of water sources. The acceptable limit of Ammonia in water is **0.5mg per litre** in water sources (WHO, 2008).

Apart from directly affecting the taste of water, these nutrients are more than often readily available in many water sources.

EC is the ability of an electric current to pass through water. This is proportional to the amount of dissolved salts in the water. Otherwise known as the amount of charged (ionic) particles (Kumar& Puri, 2012). Hence, EC is a measure of the concentration of dissolved ions in water, and is reported as MicroSiemens per centimeter (µS/cm). The usefulness of water according to EC ranges are depicted in Table 1.2. (Anderson&Cummings, 2015)

EC range (µS/cm)	Usefulness of water
0 - 800	Good drinking water for humans (provided there is no organic pollution and not too much suspended clay material)
800 - 2,500	Can be consumed by humans although most would prefer water in the lower half of this range if available.
2,500 - 10,000	Not recommended for human consumption, although water up to 3000 µS/cm could be drunk if nothing else was available.
Over 10,000	Not suitable for human consumption or irrigation

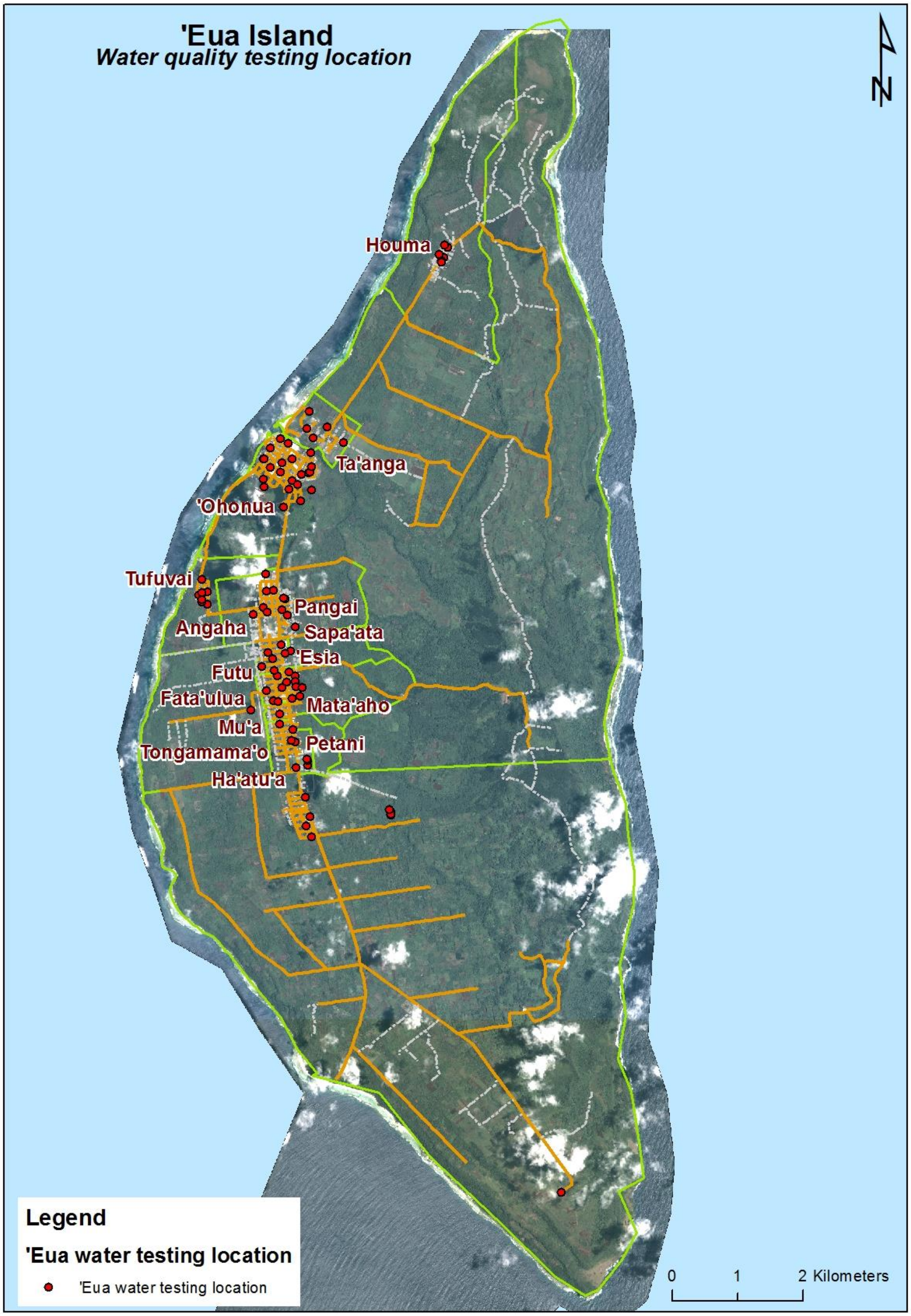
Table 1 EC range in water and its uses

pH is a numeric scale which identifies the amount of acid and/or base present in water. The acid is defined as the number of hydrogen ions (H^+) present in the water and base is defined as the number of hydroxide ions (OH^-) present in water. It is with the balance of these two ions that water is formed as depicted in Eq.1.1 (Covington, A., Bates, R. & Durst, R, 2009)

$$\mathbf{H3O} + (\mathbf{aq}) \; + \; \mathbf{OH} - (\mathbf{aq}) \; \rightleftharpoons \; \mathbf{H2O}(\mathrm{l}) \; + \; \mathbf{H2O}(\mathrm{l})$$

Equation 1

In this instance the pH would be defined on a scale from 1 to 14 as having a pH of 7. This means that it is an equal amount of hydrogen ions (H^+) and hydroxide ions (OH^-) present to form water. Water with a pH of 7 is considered neutral and thus pure. The acceptable pH range as prescribed by the WHO is 6.5-9.5. This is to facilitate fluctuations in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system. (Covington, A., Bates, R. & Durst, R, 2009)


'Eua Island
Water quality testing location
Houma
Ta'anga
'Ohonua
Tufuvai
Pangai
Angaha
Sapa'ata
'Esia
Futu
Fata'ulua
Mata'aho
Mu'a
Petani
Tongamama'o
Ha'atu'a
Legend
'Eua water testing location
'Eua water testing location
0
1
2 Kilometers

Procedures

Water samples were collected from evacuation centers and individuals water sources of rainwater catchment tanks and springs that were used to drinking during and after the Tropical Cyclone Gita.

The bore well was monitored using a multifunction dipmeter that measure the temperature and electrical conductivity at different water levels inside the bore well. A sample of water for nutrient and bacteria testing is collected via bailing water up from inside the bore well using a bailer. The pH of bore well samples is taken using a handheld pH meter.

A total of 100 water sources were sampled and tested over a period of 6 days. There were two water samples per water sources collected. One sample for nutrient testing and another for bacterial testing. Thus in total 200 water samples were received into the makeshift water testing room of Vaiola Hospital.

The rainwater catachment and spring samples were first tested for electrical conductivity and pH at the source using a handheld pH meter and EC meter . Global positioning system (GPS) coordinates of each testing site was recorded for mapping.

Figure 4 L-R, Assistant Hydrogeologist Sesimani Lokotui sampling spring water at Tonga Water Board supply pipeline from springs. New Zealand Student volunteer Georgia Crisp is Microbiological sampling at the Tonga Water Board Reservoir, Georgia Crisp and Assistant Hydrogeologist ‘Asena Foliaki monitoring ‘Ohonua borewell 2, Senior Geological Assistant 'Apai Moala taking GPS coordinates at sites

The two batches of water samples were tested accordingly.

The nutrient samples were tested for levels of Ammonia, Phosphate and Nitrates using a Palintest photometer and specific reagents. The photometer gives a reading that is recorded against an acceptable limit defined by the guidelines prescribed by the World Health Organisation (WHO, 2008).

The bacterial testing had been carried out using E.Coli Compact Dry Kits and the Aquagenx compartment test bags. The E.Coli Compact Dry method requires the inoculation of the water samples onto prepared petri dishes and incubated of water samples for 24 hours at 35 ± 2 °C. After the incubation period, the petri dishes are removed from the incubator and the number of colony forming units produced on each plate counted and noted (Nissiu Pharmaceutical Co., LTD, 2009).

The Aquagenx compartment test bag requires 100ml of sample water. 100ml of sampled water was collected using specified sampling bags that readily comes with a pill form reagent and a nutrient bud that is added at testing site. The sampling bag will gradually change color leaving the immersed bud colorless. The colored sample water is then tipped into a testing bag that is readily compartmentalized into various milliliters. The color change of sample water in each compartment is noted after 24 hours of forming units (cfu) was then counted and noted.

Results & Discussions

Salinity & pH Testing Results

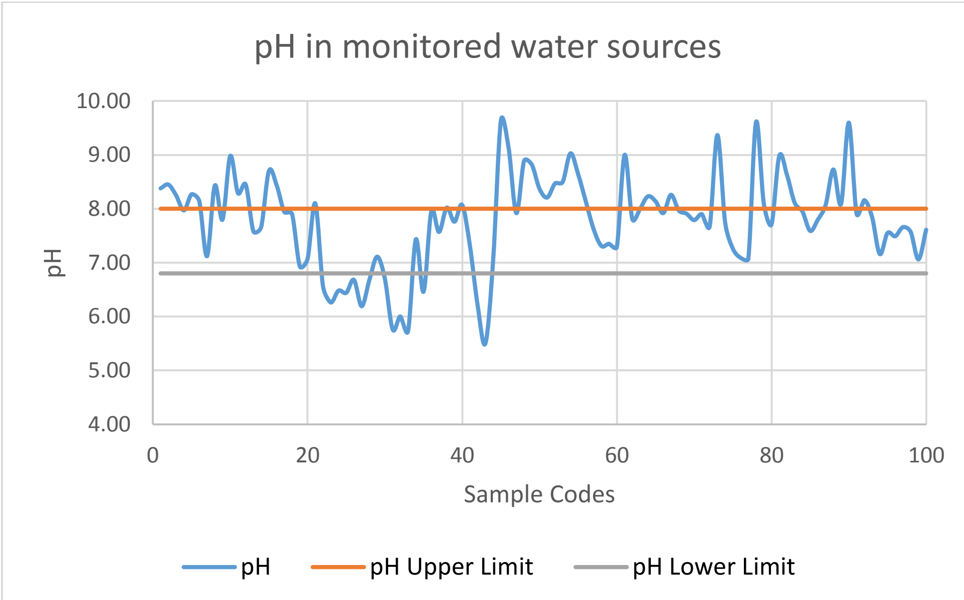


Figure 5 pH for monitored sites.

The pH levels resulted both above the upper portable limit and below the lower portable limit in water sources. Sites resulting outside the portable range require further investigation to determine the source of acidity and alkalinity disturbances.

The electrical conductivity for rainwater catchment tanks were disregarded in this assessment mainly because it the electrical conductivity of rainwater in these tanks remained consistently below 300µS/cm.

The electrical conductivity of the springs were measured in accessible springs and compared to past data. This is depicted in the *figure 6*. The changes in the electrical conductivity are minor and still within potable range.

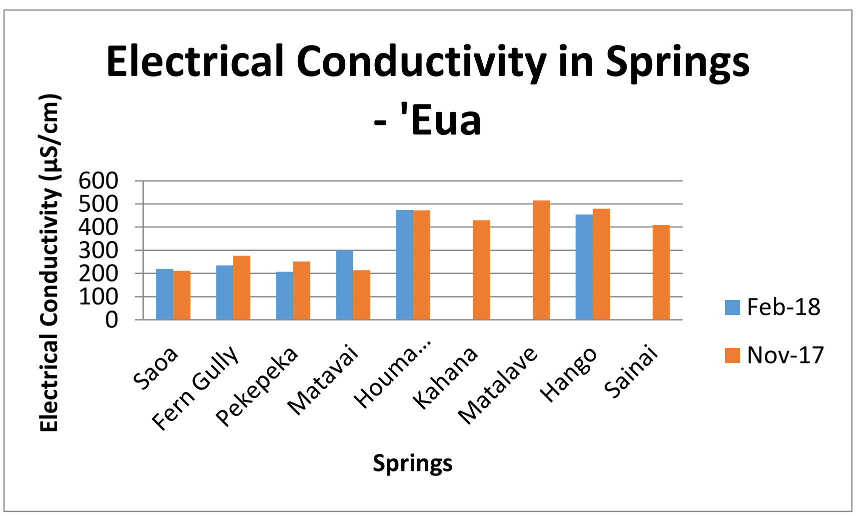


Figure 6 Electrical Conductivity changes in spring water 2017-2018

The bore well that was accessible for measurements and testing was 'Ohonua bore well number 2.

The Electrical Conductivity of the bore well number 2 was very similar to the bore well number 1 located 50m away. This means that the results from one bore well can be said to define the conditions surrounding the neighbouring bore well.

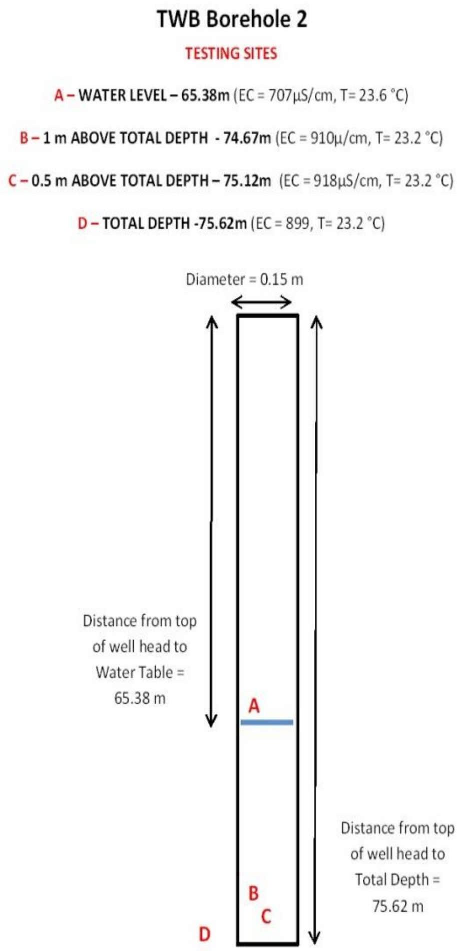


Figure 7 schematic diagram of measuring sites within 'Ohonua bore well 2

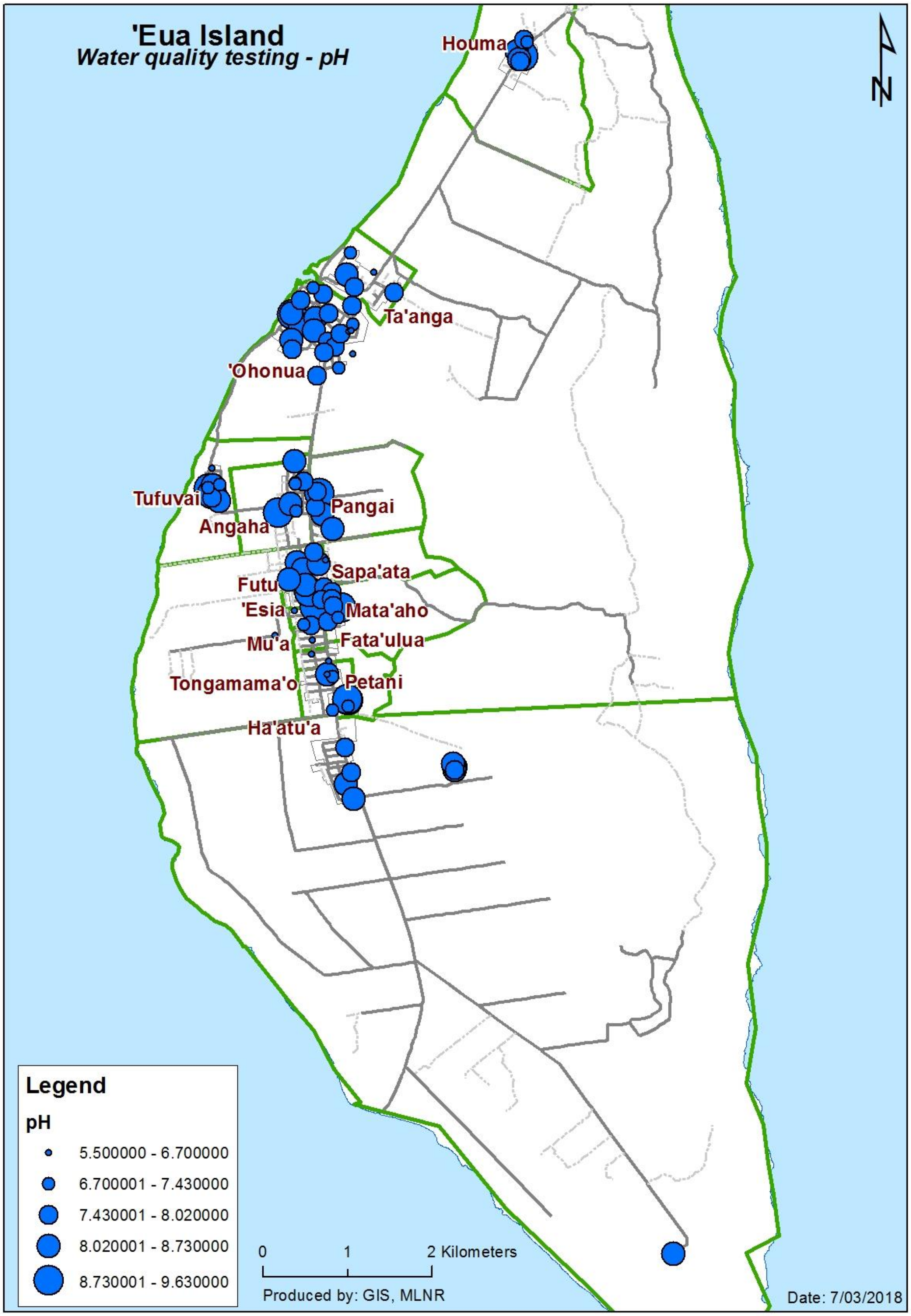
The schematic diagram of these measurements in the bore well seen on the left further describes the testing sites for electrical conductivity within the bore well.

The electrical conductivity was compared to previous monitoring data (refer to *figure 7*) shows that the electrical conductivity of Bore well 2 is only slightly different which we refer to as no change. The water table is also similar to last monitoring data.

It can be said that there are no changes that can found in this bore well that might have been the result of the Tropical Cyclone Gita.

TWB Borewell 2	Depth to Water level (DWL) (m)	EC (µS/cm)	Temp (°C)	Total Depth (m)	EC (µS/cm)	Temp (°C)	0.5m from Total depth (m)	EC (µS/cm)	Temp (°C)	1m from total depth (m)	EC (µS/cm)	Temp (°C)
Feb-18	65.38	707	23.6	75.62	899	23.2	75.12	918	23.2	74.62	910	23.2
Nov-17	65.46	642	23.5	75.65	829	23.02						

Figure 8. Comparative data table for 'Ohonua bore well 2


'Eua Island
Water quality testing - pH
Houma
Ta'anga
'Ohonua
Tufuvai
Angaha
Pangai
Sapa'ata
Futu
'Esia
Mata'aho
Mu'a
Fata'ulua
Tongamama'o
Petani
Ha'atu'a
Legend
pH
5.500000 - 6.700000
6.700001 - 7.430000
7.430001 - 8.020000
8.020001 - 8.730000
8.730001 - 9.630000
0 1 2 Kilometers
Produced by: GIS, MLNR
Date: 7/03/2018

Nutrient Testing Results

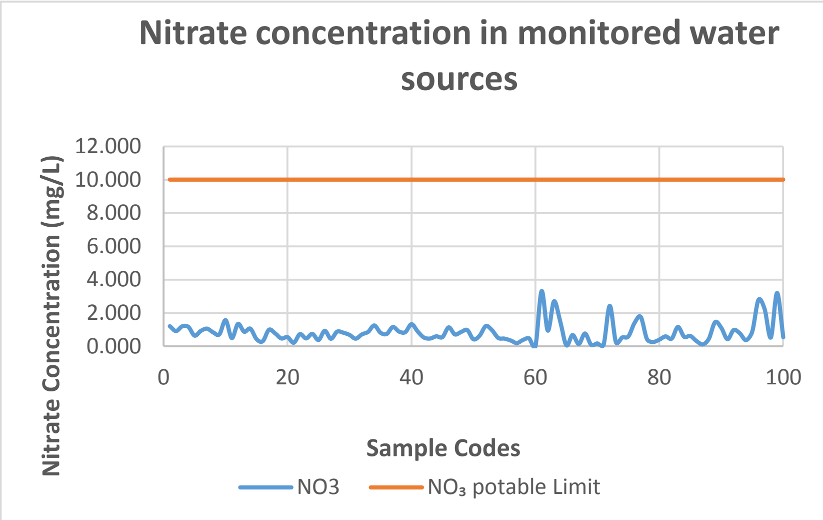


Figure 9 Nitrate Concentration in monitored sites

All monitored and tested sites resulted below the portable limit nitrate concentration in drinking water.

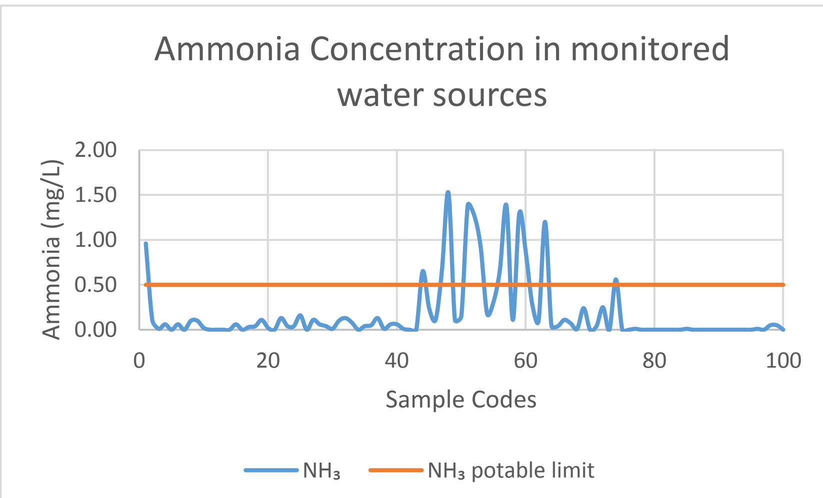


Figure 10 Ammonia Concentration in monitored water sources

All monitored and tested sites resulted below the portable limit for ammonia levels in water sources with the exception of some. 8 sites tested above the potable limit for Ammonia in drinking water sources. 6 of these 8 sites are household tanks, 1 government primary school and one spring source.

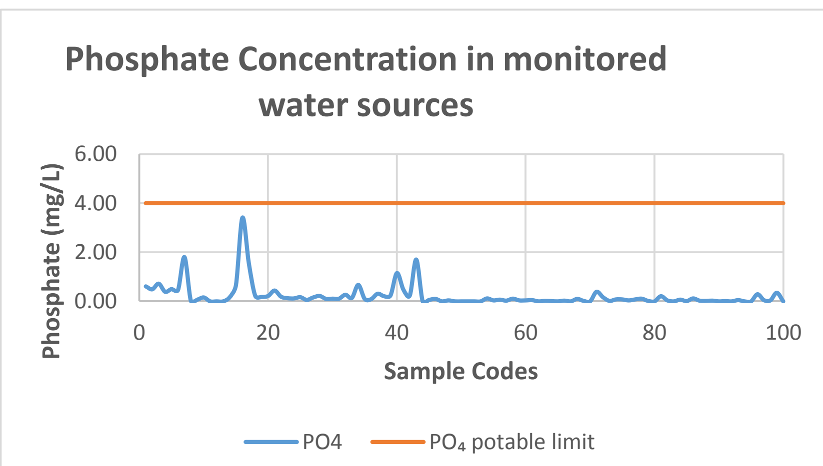
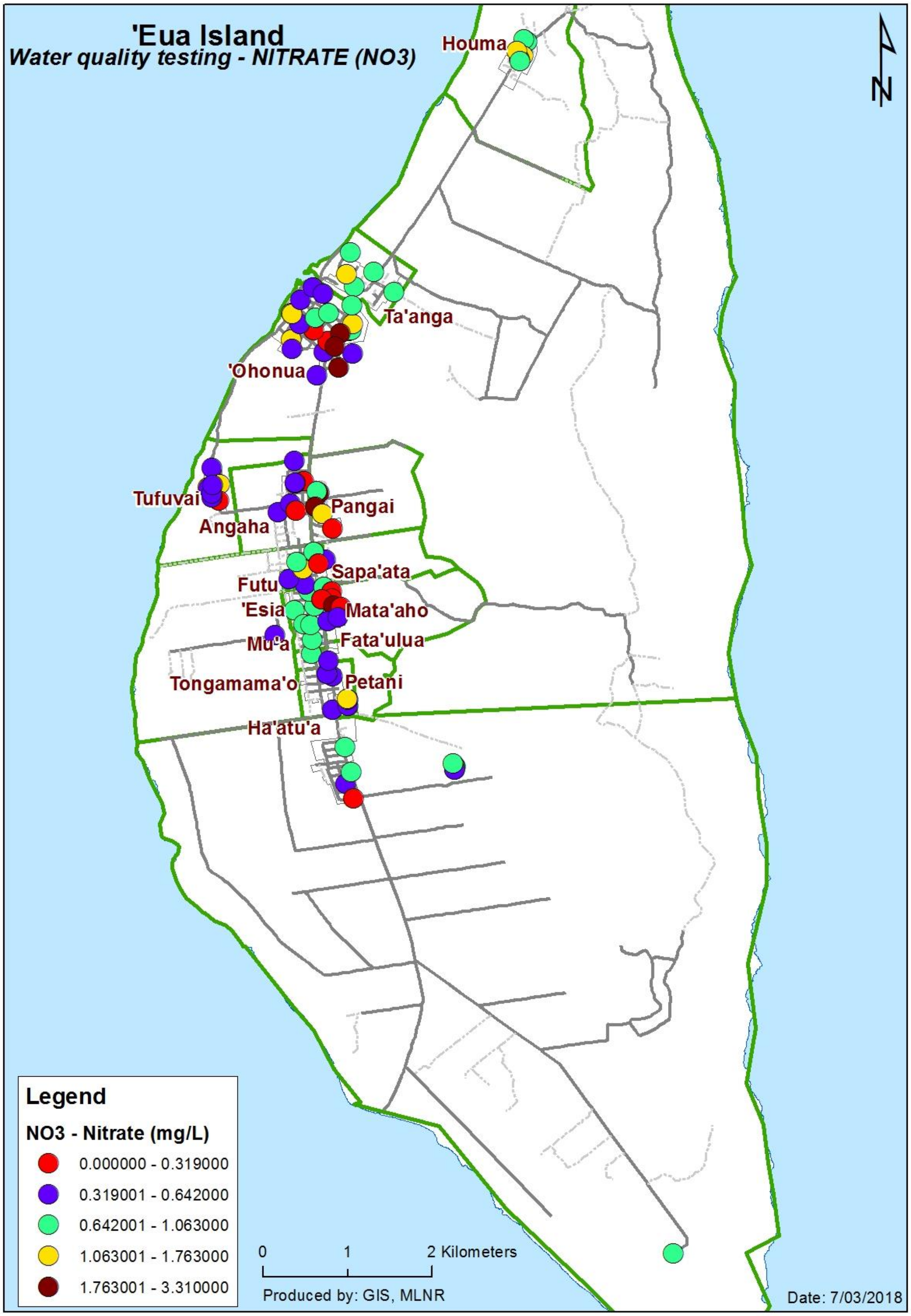
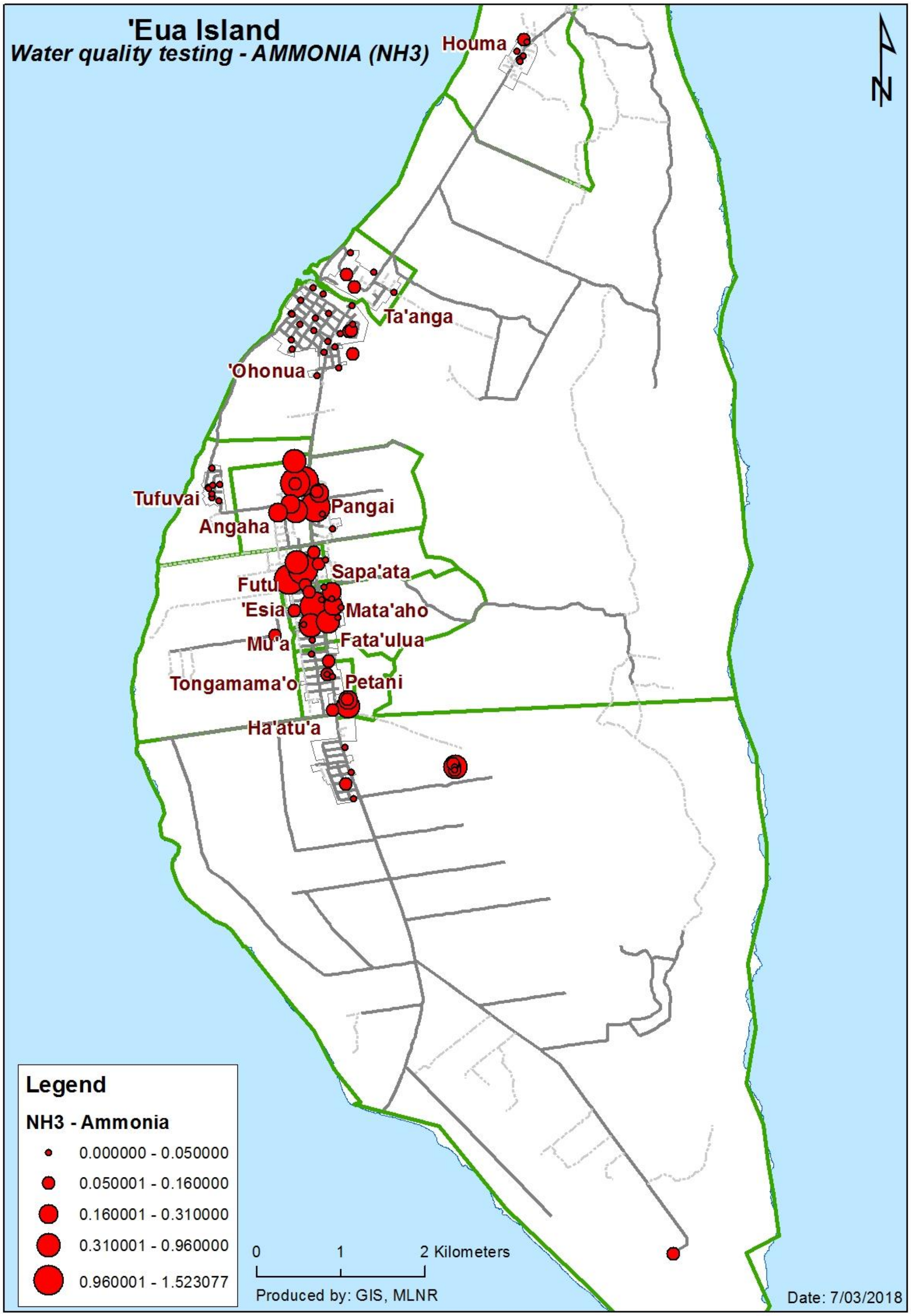
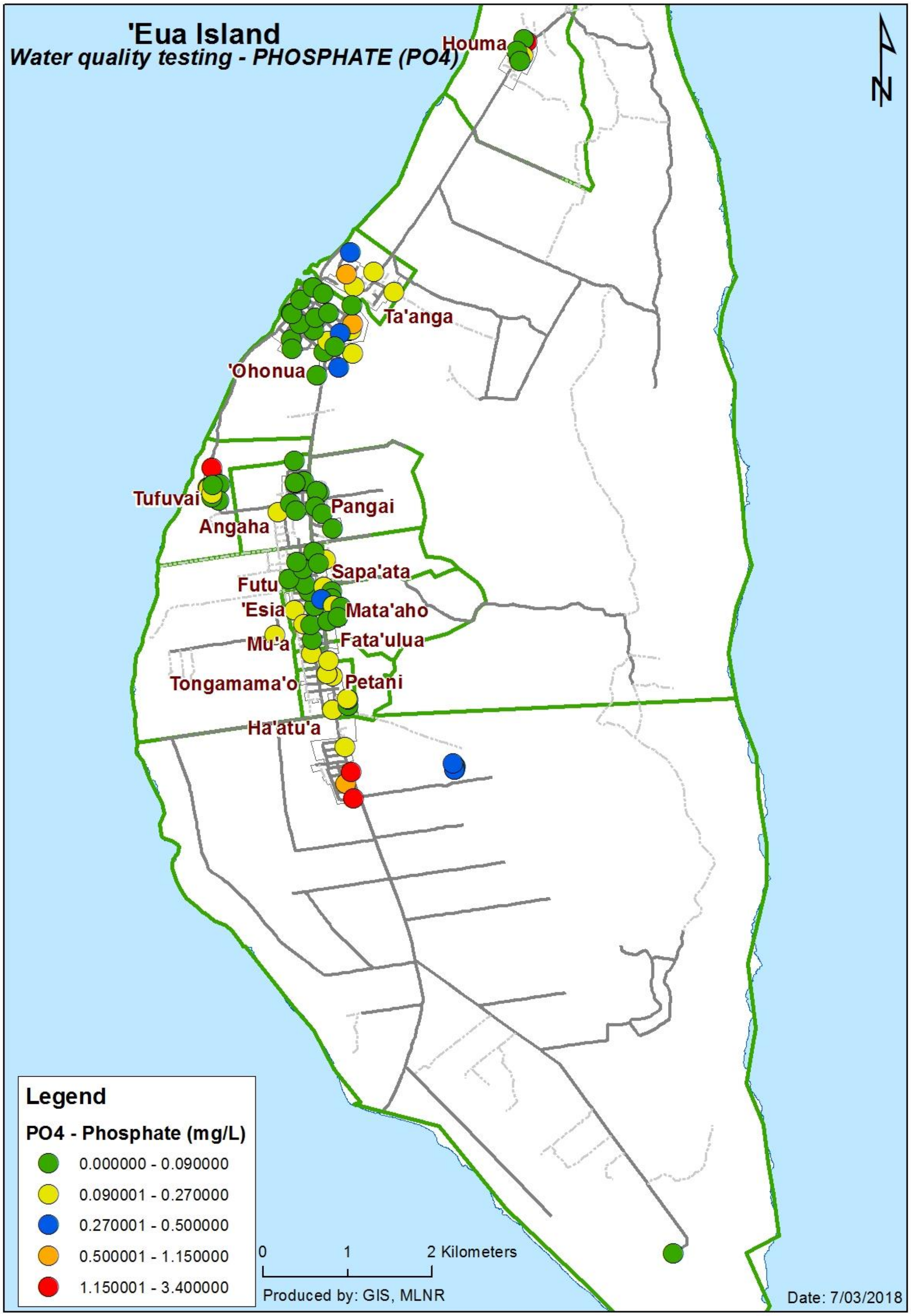


Figure11 - Phosphate concentration in monitored water sources

All monitored water sources tested below the potable limit for phosphates in drinking water sources


'Eua Island
Water quality testing - NITRATE (NO3)
Houma
Ta'anga
'Ohonua
Tufuvai
Angaha
Pangai
Sapa'ata
Futu
'Esia
Mata'aho
Mu'a
Fata'ulua
Tongamama'o
Petani
Ha'atu'a
Legend
NO3 - Nitrate (mg/L)
0.000000 - 0.319000
0.319001 - 0.642000
0.642001 - 1.063000
1.063001 - 1.763000
1.763001 - 3.310000
0 1 2 Kilometers
Produced by: GIS, MLNR
Date: 7/03/2018
N


'Eua Island
Water quality testing - AMMONIA (NH3)
Houma
Ta'anga
'Ohonua
Tufuvai
Pangai
Angaha
Sapa'ata
Futu
'Esia
Mata'aho
Mu'a
Fata'ulua
Tongamama'o
Petani
Ha'atu'a
Legend
NH3 - Ammonia
0.000000 - 0.050000
0.050001 - 0.160000
0.160001 - 0.310000
0.310001 - 0.960000
0.960001 - 1.523077
0
1
2 Kilometers
Produced by: GIS, MLNR
Date: 7/03/2018
N


'Eua Island
Water quality testing - PHOSPHATE (PO4)
Houma
Ta'anga
'Ohonua
Tufuvai
Angaha
Pangai
Sapa'ata
Futu
'Esia
Mata'aho
Mu'a
Fata'ulua
Tongamama'o
Petani
Ha'atu'a
Legend
PO4 - Phosphate (mg/L)
0.000000 - 0.090000
0.090001 - 0.270000
0.270001 - 0.500000
0.500001 - 1.150000
1.150001 - 3.400000
0
1
2 Kilometers
Produced by: GIS, MLNR
Date: 7/03/2018

Microbiological Testing Results

The bacterial testing for sites varied across testing sites in ‘Eua. There were two methods used in this assessment.

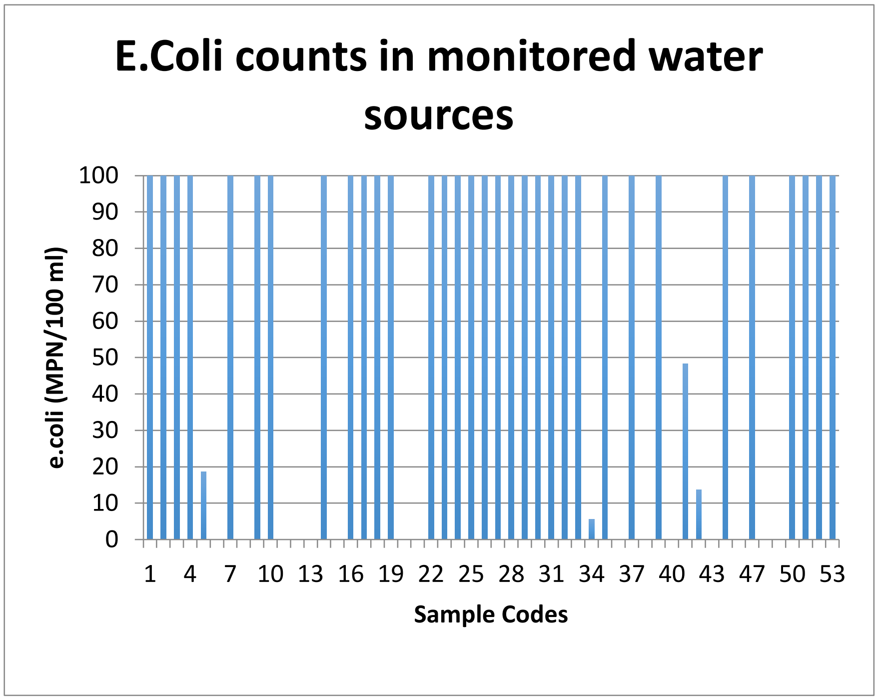


Figure 12. E.coli Counts (MPN/100mL) using compartment bag tests

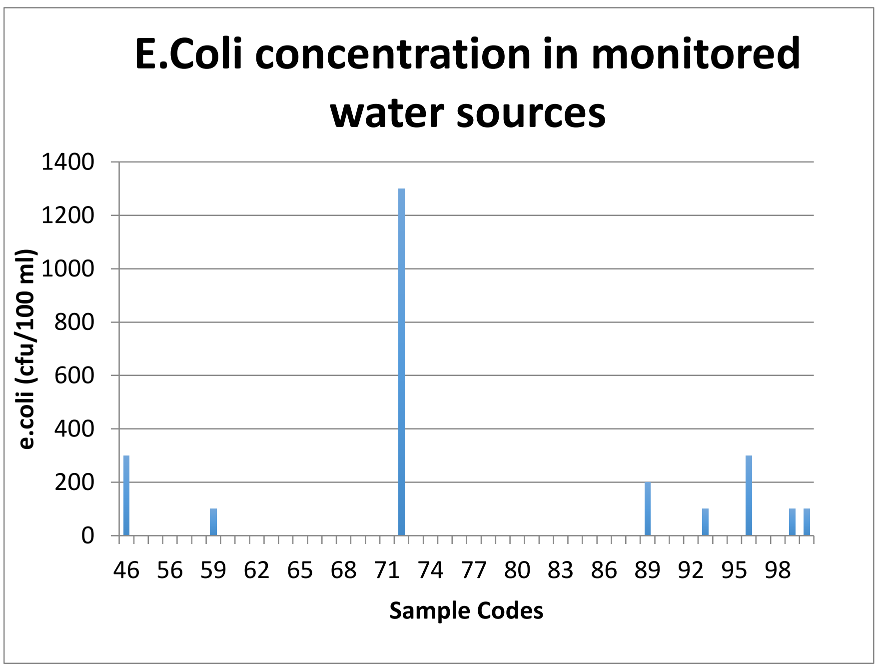


Figure 13. E.coli counts (cfu/100mL) using Compact Dry Test

The first method is called the compartment test bags and was used in 52 sites during the first two days of monitoring and testing. These resulted in E.coli found in 37 sites out of the 46 tested.

The second method used was the Compact Dry method which was used in 48 sites for the remainder of the monitoring and testing period. Only 8 sites had E.coli bacteria growth after 24 hours of incubation.

It is suggested that the filtration and treatment of water sources had resulted the testing data for the Compact Dry method as the Water Purification Team had been on ‘Eua.

E.coli that is found in any Tonga Water Board spring sources is not a cause for concern. It is common for surface water to be easily contaminated. The Board does treat the water prior to distribution which has been tested to be E.coli free.

Recommendations

It is conclusive from the results that the water quality across the island varies but there is no evidence to suggest that the water quality in ‘Eua was much affected by the Tropical Cyclone Gita

The Salinity indicated by the EC measurements coupled with the pH measurements places the water at a very good range with the exception of some sites.

The nutrient test results dispute any possible contaminations in could and would have occurred during the cyclone. However some sites should be investigated for point contamination for ammonia.

Although the E.coli counts are variable, it is from experience that the colony forming unit counts for rain catchment tanks vary between 100-300 cfu/mL in Tonga. This has been attributed to the guttering and catchment tanks conditions. There usually none found in groundwater unless contaminated.

References

Anderson, H., & Cummings, D. (2015, November 17). Measuring the Salinity of Water. Retrieved January 25, 2017, from http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/salinity/measuring-the-salinity-of-water

Covington, A., Bates, R. & Durst, R. (2009). Definition of pH scales, standard reference values, measurement of pH and related terminology (Recommendations 1984). *Pure and Applied Chemistry*, 57(3), pp. 531-542. Retrieved 25 Jan. 2017, from doi: 10.1351/pac198557030531

Kumar, M., & Puri, A. (2012). A review of permissible limits of drinking water. *Indian Journal of Occupational and Environmental Medicine*, *16*(1), 40–44. http://doi.org/10.4103/0019-5278.99696

Nissiu Pharmaceutical Co., LTD. (2009). *User Mannual for Compact Dry 'Nissiu' EC for Coliform and E.Coli.* Tokyo: Nissiu Pharmaceutical Co., td.

State Water Resources Control Board. (2016). *GROUNDWATER INFORMATION SHEET Salinity.* California: GAMA Program.

WHO. (2003). *Ammonia in Drinking-water.* Geneva: World Health Organisation.

WHO. (2003). *Total dissolved solids in Drinking-water.* Geneva: World Health Organisation.

WHO. (2008). *Guidelines for Drinking Water Quality.* Geneva: World Health Organisation.

WHO. (2011). *Nitrate and Nitrite in Drinking-water.* Geneva: World Health Organisation.