Metropolis Pacific

Telios Corporate and Consultancy Services

Mamara New Capital City Development Phase 1 Environment Impact Statement (EIS)

Chapter 6: Water Quality and Sediments

Winston Lapo
Paddy Vaghi

August 2020

Table of Content

Figures

Tables

Acronyms

WHO	World Health Organisation
ANZECC	Australian and New Zealand Environment and Conservation Council
SW	Surface Water
GW	Ground Water

1.0 INTRODUCTION

This section discusses surface water, ground water, coastal water and sediment qualities and hydrological baseline of the Poha and Mamara Rivers and coastline between these two rivers. The baseline information are based on literature review and on site field work in June 2020.

The project area is located approximately seven kilometres (7 KM) Northwest of Honiara city, on the island of Guadalcanal. It covers an area of 1,166 hectares of Land. The project area is occupied by dispersed village settlements. Mamara spring source is the only drinking water source that the surrounding villagers do get water from. Also it has been a long time livelihood for the people who live there, especially for the watercress farmers who have been farming watercress along the watercourse. The rest of the land is predominantly covered in grasses, trees and in some parts planted with coconut and betel nut trees.

2.0 STUDY APPROACH

The objectives of the baseline are to assess the present state of the environment conditions in the area, and to provide a basis for evaluating environmental impacts and mitigation related to preconstruction, construction and operation of the Mamara Tasivarongo Mavo development.

The study includes the following activities:

- Identify and prepare sites for water quality samplings. This includes recording GPS points of specific sites of interest;
- Conduct hydrometric flow measurement on Poha river and Mamara artesian spring source;
- Install boreholes for collecting Groundwater samples and to identify water table height;
- Collect water samples from each of the boreholes;
- Collect water samples from coastal surface waters;
- Collect surface water samples from respective sites at Poha River and Mamara spring source;
- Collect sediment samples from marine coasts and river beds for quality check; and
- Samples taken to National Labs for tests.

2.1 Surface Water baseline field survey on hydrology

The surface water quality of Poha and Mamara Rivers were tested with respect to the following parameters:

- E coli and coliform bacteria
- Nutrients: Sulphate, potassium(K), phosphorus(P), Nitrate (NO3-N) and Ammonium Nitrate (NH4-P)
- Physical parameters: Temperature, Atmospheric pressure, PH, Oxygen Reduction potential, Dissolved oxygen, conductivity, Turbidity, Total Dissolved solids and Salinity

2.2 Groundwater Hydrogeology baseline field

Four boreholes were installed at selected locations in the project area to study the level of ground water and its link to climate scenarios. Groundwater boreholes were labeled as: GW1, GW2, GW3, GW4, and GW5.

The water quality parameters tested for ground water include the following:

- E coli and coliform bacteria
- Nutrients: Sulphate, potassium(K), phosphorus(P), Nitrate (NO3-N) and Ammonium Nitrate (NH4-P)
- Physical parameters: Temperature, Atmospheric pressure, PH, Oxygen Reduction potential, Dissolved oxygen, conductivity, Turbidity, Total Dissolved solids and Salinity

2.3 Coastal surface water quality

There were two sampling points for surface water quality along the coast, SW 5 and SW6.

In situ parameters were tested and samples were collected at site SW5. The location was positioned near the Mamara spring mouth.

The water quality parameters include the following:

- E coli and coliform bacteria
- Nutrients: Sulphate, potassium(K), phosphorus(P), Nitrate (NO3-N) and Ammonium Nitrate (NH4-P)
- Physical parameters: Temperature, Atmospheric pressure, PH, Oxygen Reduction potential, Dissolved oxygen, conductivity, Turbidity, Total Dissolved solids and Salinity

2.4 Baseline field survey of coastal and marine water sediments

Sediment deposition along the coastline enables the team to understand the trend in climatic actions overtime.

Coastal Sediments were collected at the same location as the surface water quality. Sediments were collected from the depositional zones on the coastal sea bed. Samples were picked directly from the sea bed and stored in zip-lock plastic bags. Samples then were transported directly to the laboratory for analysis.

The purpose of doing the baseline study was to understand the type of heavy metals that are present in the coastal marine bed.

3.0 EXISTING ENVIRONMENTAL VALUES IN THE AREA

3.1 Rainfall

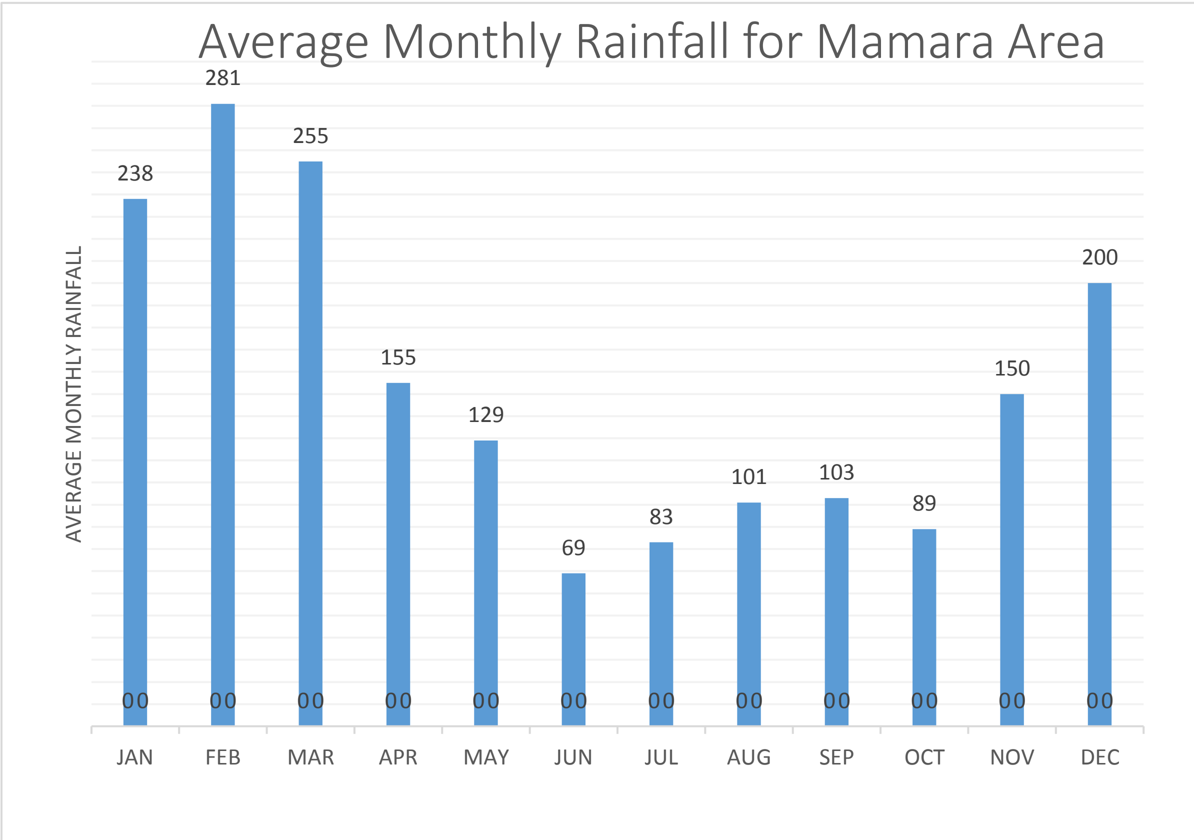


Figure 1: Average Monthly Rainfall for Mamara Area

The general rainfall pattern of this area is the same every year around, except when rainfall usually go up a little higher or lower at some occasions. In general, most parts of Solomon Islands experience the wettest period during Northwest monsoon period. Also, heavy rainfall is usually expected between June and September when the equatorial trough go furthest south of Solomon Islands. According to the data received, on average, March is the wettest month and August is the driest month. The average annual precipitation for the area is about 1,853 mm.

3.2 Hydrology and Hydrogeological connections within the area

The main water bodies that exist within the Mamara Tasivarongo Mavo vicinity are Mamara Spring and Poha River. Pockets of surface water bodies do exist in some parts of the area and were brought there through varied sizes of drainage systems that extends inland from the coast.

Poha River is connected to a large drainage system that extends inland through the mountainous region reaching the altitude of about 600m to the direction where it connects to the Lungga River catchment. It provides a body from which other surrounding rivers are fed from and the widespread catchment supports the sustainability of the of Poha River flow.

Mamara spring is characterized as groundwater based on its nature of source. The volume of water that it gives out is determined by its supply. It is being fed by the natural confined underground storage of water that depends on rainfall through surface water infiltration, from which replenishment of water is determined based on the rainfall distribution over the area.

Stream flow rate for Poha River is considered moderate and appeared to be declining in flow as less rainfall persists over time. Poha River appears to having more flow upstream than at downstream. This could be caused as a result of water sinking through the surface of the Poha River basin due to the geological formation of the region.

Poha River could be one of the main sources of groundwater recharge that links to Mamara spring network of aquifers.

3.3 Current context of water and sediment quality

Guadalcanal is known to have large rivers that drains from the high hills and mountains that run through the interior of the island. These north flowing rivers include Lungga, Mataniko, Poha, Mbonege rivers to name a few.

According to Tenaru road study of the Tenaru Rivers, north flowing river carry reasonably high bed loads of fine to medium sized (5-10 cm) gravels and sand that are derived from upland volcanic sources and consist of 70% andesitic rocks and 30% limestone. The majority of this is derived from natural geological erosion as the upper catchments of both rivers still retain most of their original forest cover, though areas around Mt. Austen in the upper catchment are being harvested. In the alluvial plain sections, bank erosion occurs from the channels natural meandering requirements and this will be a major source of finer material in the lower section. Bars build up at the mouth of both rivers during the drier season but during the wet season these are breached and the rivers discharge directly to Iron Bottom Sound. During dry season, these rivers are slightly turbid, even the discharge is small, in the case for Poha but during the wet season, these Rivers are prone to rapid changes in discharge and become highly turbid.

Large flows not easily contained by a river channel normally erode and break banks and create other secondary flow routes as can be seen with Poha over the years. Large flow also means the river has a greater capacity to carry sediments down the river. As is visible with Poha, it has wide sand and gravel bars and braids and very coarse sediment load within a few kilometers of the river mouth. Sediment loads are brought into the river channel by floodwaters and they go through the process been fragmented due to abrasion against river bed and banks. This process continues down the river channel and at the end of it, very fine and rounded particles are produced which are nicely sorted into varies sizes clearly identified as, sand, gravel and pebbles. The deposition of the various sizes and types of the sediments along the river banks is related to the flow energy of the actual river at any given time. That is why towards the river mouth, mud, silt and sand deposits are common while further upstream, gravels and pebbles are found in the river bed and banks.

Catchments in the project site has river courses that traverse the limestone area, are dry or intermittent; sink-holes and springs frequently mark the boundaries with adjacent formations. The tributary systems feature small, blind, dry valleys. The catchment have distinct waterways including the Kongulai spring, Kohove, Matanggunggulu, Musona, Ora and several other springs. There are markedly sink-holes present in the area due to the karstic limestone formation.

Water and sediment quality baseline information from Poha and Mamara Rivers are limited at this stage. Studies conducted along the Mataniko River and Honiara Coast line by the SIG through the Mataniko Rehabilitation Program and Cefas CMEP South Pacific are the only information available. The studies however, mainly focus on Honiara discharge and coastline. These locations are susceptible to high impacts compared to the Mamara Poha Area which is deemed low. According to the Cefas CMEP South Pacific and SIG Mataniko studies, the Honiara coastline and its discharge are highly contaminated with T.Coli and E.Coli indicating high levels of untreated sewage discharge.

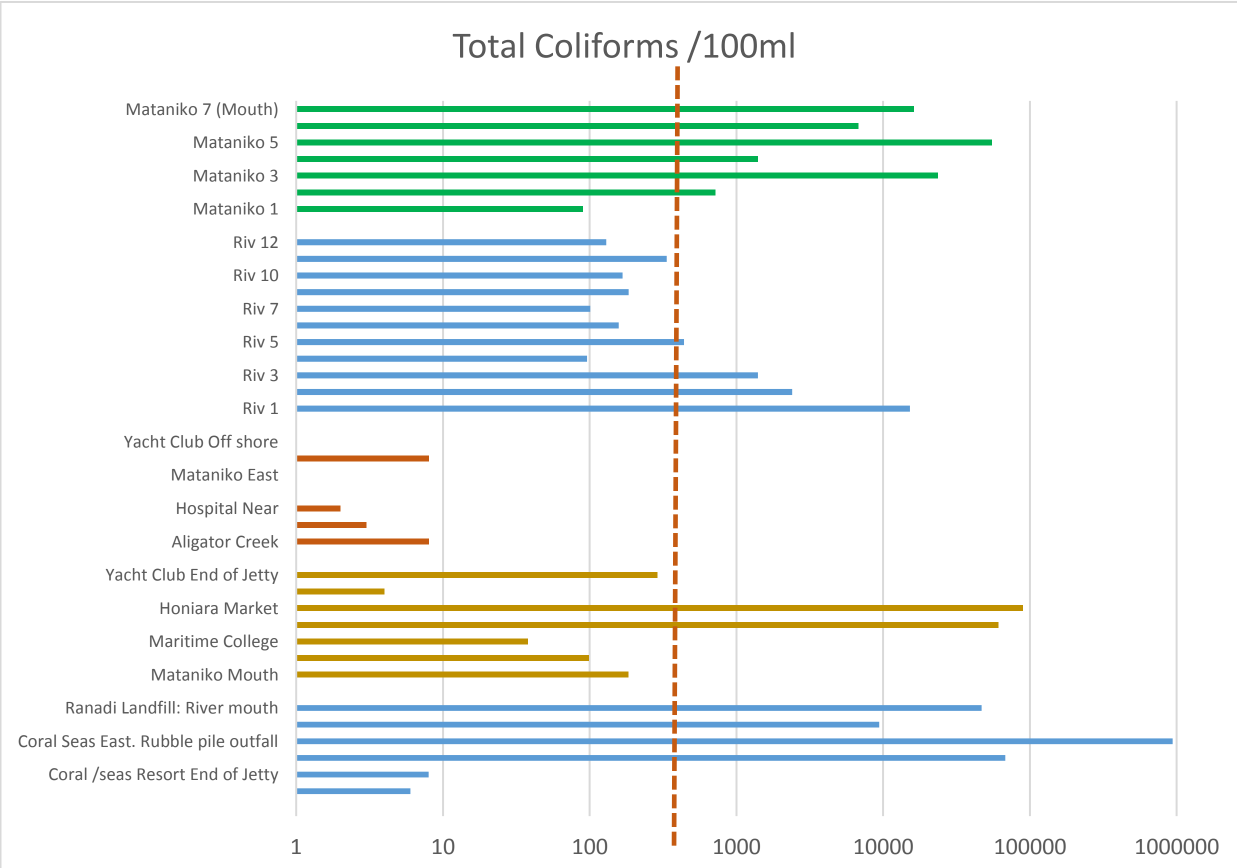


Figure 2: Cefas CMEP South Pacific

3.4 Legislative Framework

The legislations and standards that were used are Solomon Islands legislations. They are as listed below:

- **Environmental Health Act 1980**, this act plays a role when it comes to regulating and management of rural water and sanitation nationwide.
- **River Waters Act 1964,** ensuring the protection of selected rivers within Solomon Islands, in which defined parts of Mamara spring water are part of.
- **Environment Act 1998**, it provides a platform that establishes prevention and regulations of pollution to reduce human health issues caused; from which environmental impact assessment comes under.

3.5 Water quality Standards used

Water quality standards used as the guideline for this study are as listed below:

- Australian Drinking water guidelines 6 2014
- WHO - Guidelines for Drinking Water Quality
- ANZECC and ARMCANZ water quality guidelines 2000

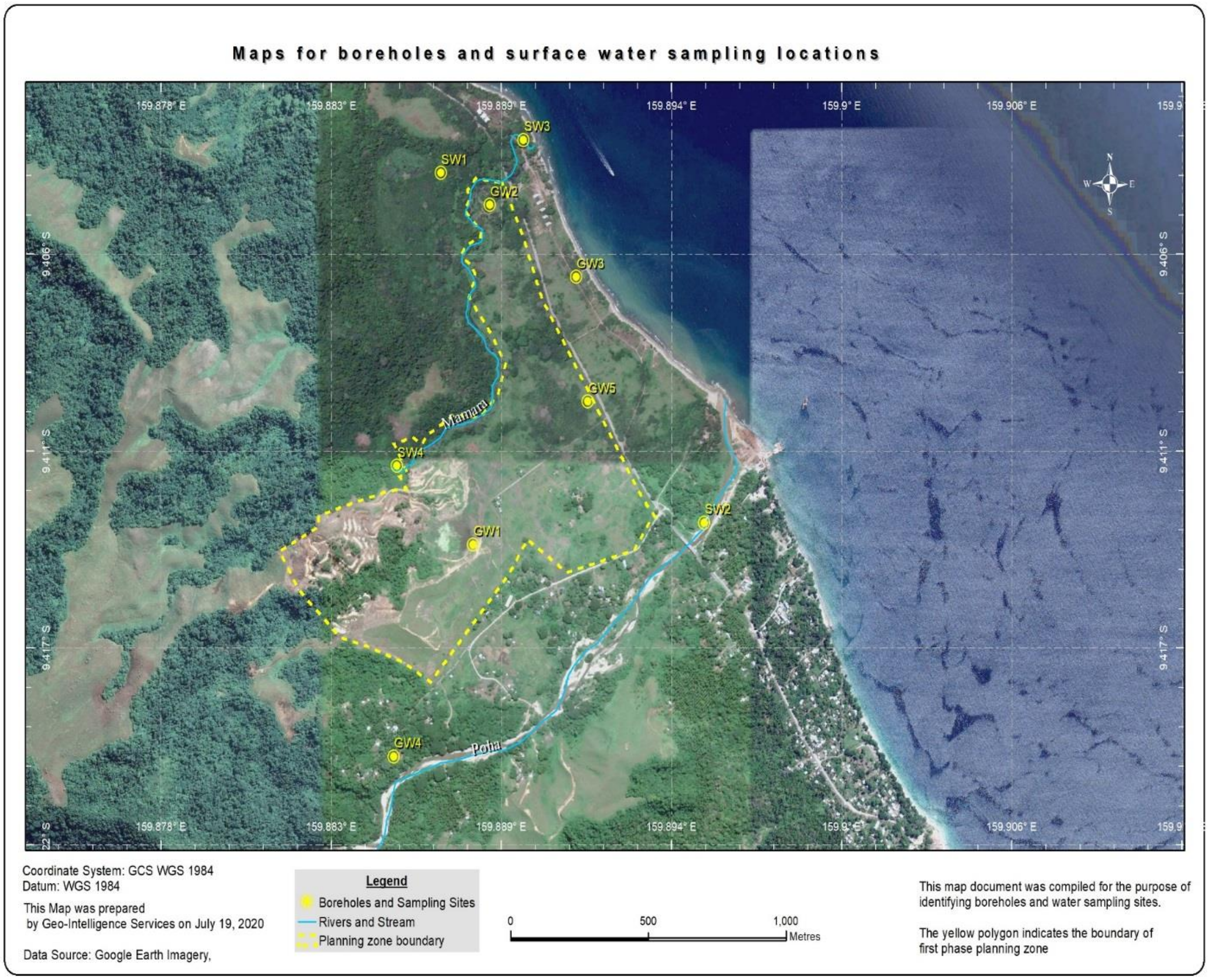


Figure 3: Map of Surface Water and Groundwater sampling locations

4.0 PROCESS AND METHODOLOGY

4.1 In situ water quality methodology

In situ measurements for surface water and groundwater parameters were done using a calibrated meter (HANNA INSTRUMENTS) equipped with probes that measure multiple parameters. Results were recorded directly from the display screen of the instrument by submerging the probe under the surface of the water. Usually the readings from the screen are recorded on a notebook. The same process is repeated again for each sampling.

4.2 Process and Methodology for Hydrometric flow measurement

Streamflow measurements were taken using Hydrometric flow measurement equipment. The Method used was rod-mounted current meter gauging, where a propeller is being driven by opposite force of the water. Results were calculated using the number of revolutions the propeller completes in a given time, the cross-sectional area of the stream and the velocity at which the stream flows.

4.3 Process and Methodology for microbiological and water sampling

Process used in collecting water samples for microbiological assessment is called grab sampling method. It is called grab sampling because the area of sampling is chosen based on where you think is best.

The following apparatus and steps below are used in micro sampling.

1. Select the sampling locations;
2. Carefully open the sampling bottle, make sure not to touch the interior of the lid, and gently fill the sampling bottle;
3. Carefully close the lid and store in esky with ice packs;
4. Repeat the same process for every sample;
5. Ensure the holding time is not more than 24 hours; and
6. Bring the samples to laboratory for analysis.

4.4 Methods of Test and analysis

Table 1: Public Health Lab Method of analysis (surface and ground water)

Parameter	Method
T.Coli and E.Coli	Colilert-18:IDXX

Table 2: SPE Analytical Method of analysis (surface and ground water)

Parameter	Method
Sulphate (SO4)	Using Hach Reagent & Method 8051 (US EPA Compliant) And UV Spectrophometry (Hach DR3900, with RFID technology)
Potassium (K+)	Using Hach Reagent & Method 8049 (US EPA Compliant) And UV Spectrophometry (Hach DR3900, with RFID technology)
Total Reactive Phosphorus (PO4)	Using Hach Reagent & Method 8030 (US EPA Compliant) And UV Spectrophometry (Hach DR3900, with RFID technology)

Nitrogen (N)	Using Hach Reagent & Method 8171 (US EPA Compliant) And UV Spectrophometry (Hach DR3900, with RFID technology)
Total Suspended Solids (TSS)	Using US EPA Gravimetric / Filtration Method
T.Coli and E.Coli	Colilert-18:IDXX

4.5 Sediment Sampling

The following steps were used in sediment sampling:

a) Locate the four sampling site using a GPS. Ensure coordinates in the GPS is consistent with the given coordinates.

b) Label all bottles using a weather proof pen with sampling site name, date and time.

c) Whenever possible scoop sediments at the middle of the river using grab sampler equipment or similar equipment.

d) When retrieving sediments, fill sample bottle to the top. Repeat with another bottle if necessary.

e) Place the sample in double zip-lock plastic bag or cooler to minimize the risk of contamination.

f) Cooler for soil samples will be different from water samples.

5.0 DISCUSSIONS AND ANALYSIS

5.1 Bacteriological quality for surface and ground water

Bacteriological quality standards are set to prevent diseases and infections when human use the rivers and coastline for swimming and bathing. A key indicator of bacteriological quality of water is detecting traces of Escherichia Coli (E.Coli) levels. Escherichia coli (E.Coli) and Total Coliforms levels for six surface water and five boreholes are presented in the table below. All sites are contaminated and are above the WHO water quality guideline of zero (0) MPN/100ml for E.Coli levels in water. E. Coli is the dominant bacterial organism in human faeces but is also found in faeces of birds and mammals (Steblin, 2007). E.Coli is usually used as an indicator organism for pathogens. Total coliforms are also indicator of pathogens, but total coliforms can also be derived from sources other than sewage. These pathogens can cause acute and also chronic health effects. The greatest microbial risks are associated with ingestion of water that is contaminated with human and animal (including bird) faeces. Surrounding communities do collect water from the source for drinking and cooking.

5.1.1 Micro test results and WHO guideline

According to the World Health Organization (WHO) Guidelines for Drinking-Water Quality (4th Edition), the acceptable E.coli levels in drinking water is 0 MPN/100 ml and 200 MPN/100ml for water used for recreational purposes. The results are above the WHO drinking water level and water for recreational purposes indicating faecal contaminations in the river system, coastline and ground water. It is possible that harmful germs like viruses, bacteria, and parasites might also be found in the river, ground water and coastline. These microbes typically do not make people sick; but exposure to such high concentration overtime could result in sickness or diseases. Escherichia coli (E. coli) bacteria normally live in the intestines of healthy people and animals. Most species of E. coli are harmless or cause relatively brief diarrhea and gastro illness.

5.1.2 Potential source of micro organisms

The contamination are caused by surface runoff from settlements in the area and lack of sanitary facilities. Natural occurrence of fecal colifroms from wildlife faeces could be considered as the prime sources of faecal coliforms in SW04, Mamara water source and groundwaters. The other factor could be related to increased thermotolerant bacteria that are commonly found in groundwater aquifer or from warm-blooded animals. Evidence from the social survey indicated, ninty percent of the household in the area do not have sanitation facilities. People use the bush, river and coastline for comfort.

Table 3: Surface water results for Micro Surface water

Sample ID	Total Coli	E.Coli
SW 1	>2420	248
SW 2	>2420	727
SW 3	>2420	167
SW 4	173	1
SW 5	<1	<1
SW 6	<1	<1

Table 4: Ground Water Micro Results

Sample ID	Total Coli	E.Coli
GW 1	>2420	1986
GW 2	$>2.4x10^4$	3448
GW 3	$>2.4x10^4$	$1.6x10^4$
GW 4	<10	<10
GW 5	$>2.4x10^4$	$2.0x10^4$

5.2 Nutrients in surface and ground water.

Nutrients reaches surface water and ground water as an end product of industrial activities, agricultural activity (including use of fertilizer and manures), waste water disposal, untreated sewage, waste products such as human wastes, wild life, storm water and natural decompositions. These nutrients are essential to the environment and human beings but excessive concentration can have negative impacts on the environment. Nutrient levels would be low in less impacted areas (Upstream Rivers) where there is less microbial reduction activity. In densely populated area such as downstream of Rivers, there would be elevated levels of nutrients as a result of waste water disposal and seepages from septic tanks from the urban areas. Excessive nutrient can also lead to eutrophication.

Mamara and Poha areas are once occupied by cattle and coconut plantations and scattered settlements. In 2018, the Poha catchment was logged by foreign companies. The Poha and Mamara beaches and rivers receive visitors' every day. Again sanitation has been an ongoing issue in the area. These activities contribute to occurrence of nutrients in the rivers and ground water. At the operation stages, it is projected that these nutrients will slowly increase and if runoffs are not managed properly may result in eutrophication.

5.2.1Test results and WHO guidelines

Potassium does not have a standard or guideline value. WHO indicated, it is not considered necessary to establish a health-based guideline value for potassium in drinking-water. WHO sulfate concentration should not exceed 500ppm. The test results in this study range from 5-120ppm, all fall below the guideline concentration level. The guideline value for nitrate is 50 mg/L, (as nitrate ion), to be protective of the health of the most sensitive subpopulation, bottle-fed infants. The result indicate GW3 and GW5 exceed the acceptable WHO concetration levels. The threshold odour concentration of ammonia at alkaline pH is approximately 1.5 mg/l, and a taste threshold of 35 mg/l has been proposed for the ammonium cation. Ammonia is not of direct relevance to health at these levels, and no health-based guideline value has been proposed. Naturallly, surface and ground concentration for ammonia would be below 0.2ppm. In anaerobic conditions ammonia levels are always high as indicated in GW3. Phosphate are found in fertilizers and used to suppress corrosivity. The WHO does not mention any guideline level for ammonia.

5.2.2 Potential source of nutrients

The high concentration of nutrients in ground water are due to both anthropogenic and natural sources. The anthropogenic sources are mainly from activities mention above including cattle grazing, plantation and farming including the use of fertilizer. Excess nutrients from these activities leach into the soil profile subsequently affect ground water quality overtime. SW05 and SW06 are surface water samples from salt water environment so the nutrient composition are extremely higher compared to other samples.

Table 5: Nutrient result-surface water

N.o.	Sample ID	Sulphate	Potassium	Nitrate	Ammonium	phosphate
				(N03-N)	Nitrate	(P04-P)
					($NH4^+$)	
		mg/L	mg/L	mg/L	mg/L	mg/L

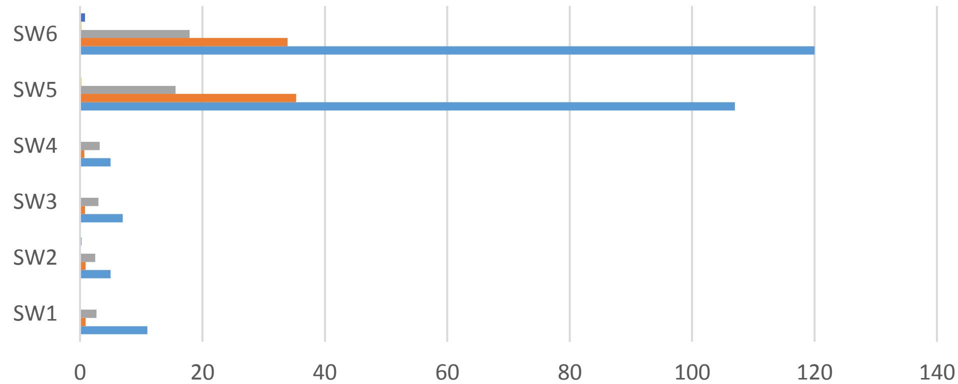
1	SW1	11	0.9	2.78	0.01	0.09
2	SW 2	5	0.9	2.49	0	0.09
3	SW 3	7	0.8	2.99	0	0.07
4	SW 4	5	0.7	3.2	0	0.08
5	SW 5	107	35.3	15.57	0.21	0.13
6	SW 6	120	33.9	17.9	0.21	0.8

Table 6: Nutrients result-Ground Water

N.o.	Sample ID	Sulphate	Potassium	Nitrate (N03-N)	Ammonium Nitrate ($NH4^+$)	phosphate (P04-P)
		mg/L	mg/L	mg/L	mg/L	mg/L
1	GW1	20	5.1	11.97	0.01	0.5
2	GW2	12	2.7	32.21	0.29	0.95
3	GW3	162	84	118.84	2.39	14.71
4	GW4	36	3.6	24.94	0.03	0.84
5	GW5	80	19	101.9	0.21	1.75

Figure 4: Graphical presentation of surface water nutrients

Nutrients content in surface waters



	SW1	SW2	SW3	SW4	SW5	SW6
phosphate	0.09	0.21	0.07	0.08	0.13	0.8
ammonium nitrate	0.01				0.21	0.21
nitrate	2.7	2.5	2.99	3.2	15.6	17.9
potassium	0.9	0.9	0.8	0.7	35.3	33.9
Sulphate	11	5	7	5	107	120

phosphate ammonium nitrate nitrate potassium Sulphate

5.3 Insitu Parameters –surface and ground waters

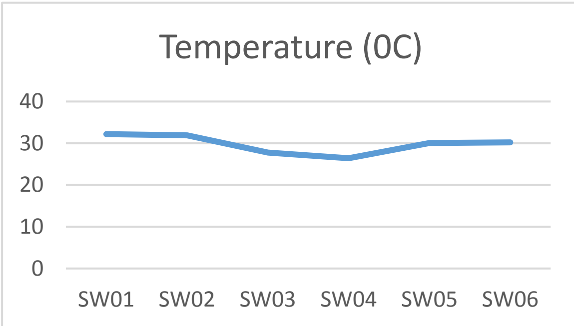
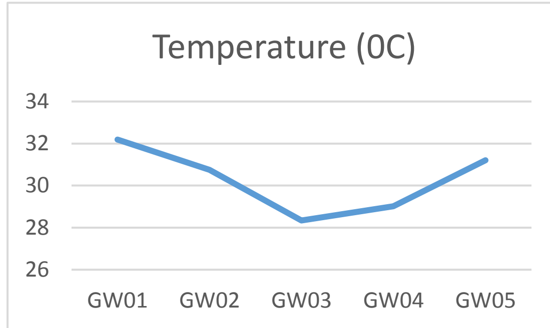
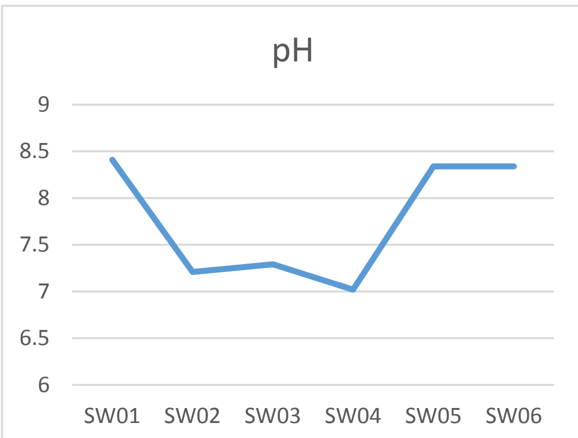
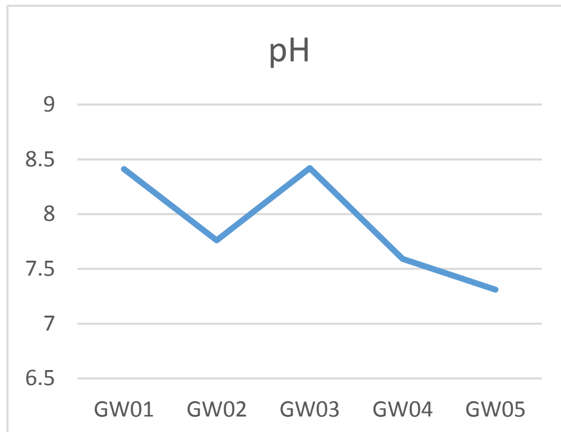
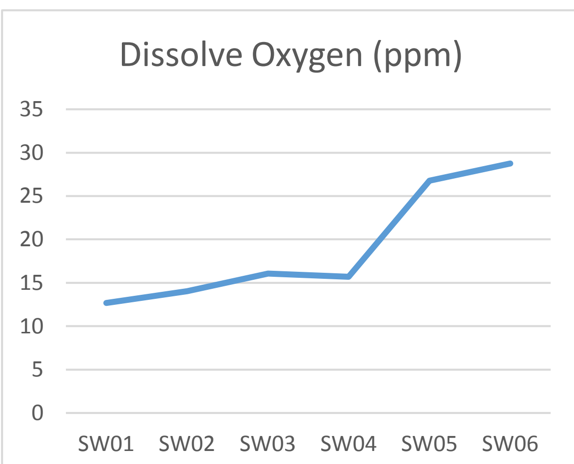
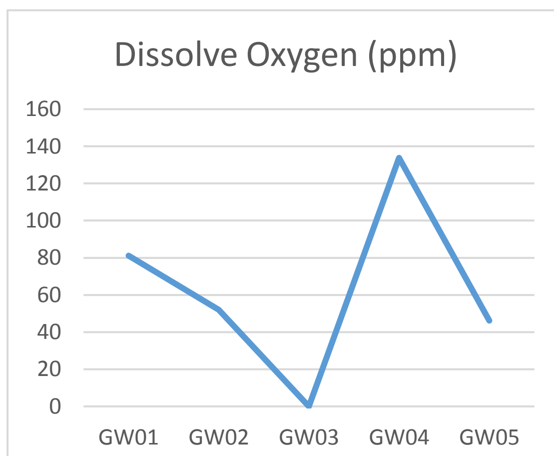
5.3.1 Surface water

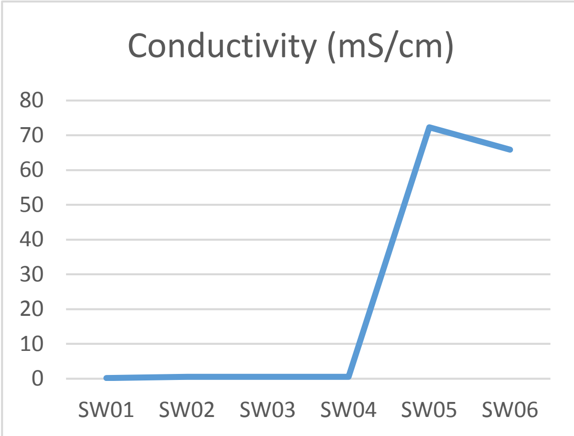
In open channels and along the coast, temperatures ranges from 28-33 degree celcius. Temperatures for sites in Poha are higher because the river is not flowing and channel exposed to sunlight. Poha do have a low DO, conductivity, TDS and Salinity which indicate, the river system has been affected to certain extend. Algal growths are common in Poha river at locations where there are very low flow. Though life forms including fish are evident in the lower reach, the aquatic fauna are not diverse due to low DO levels. The Mamara River in general is healthy with diverse life forms including aquatic species the EIS team believed are yet to be discovered. The Mamara source pH is almost neutral and is rich in minerals, salts, metals, cat ions or anions as indicated by its conductivity and TDS.

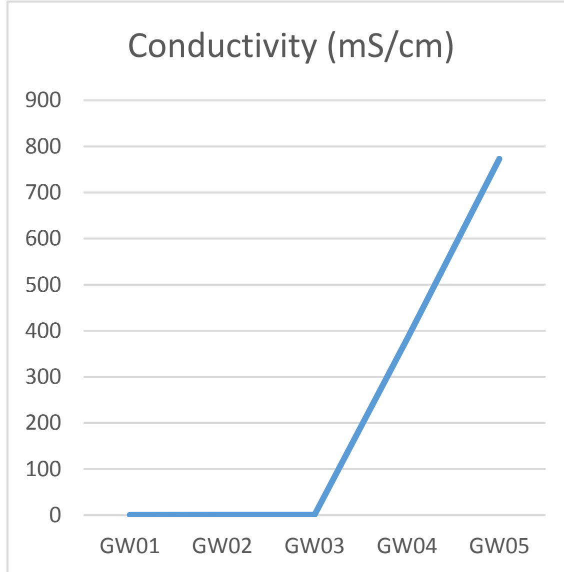
5.3.2 Ground water

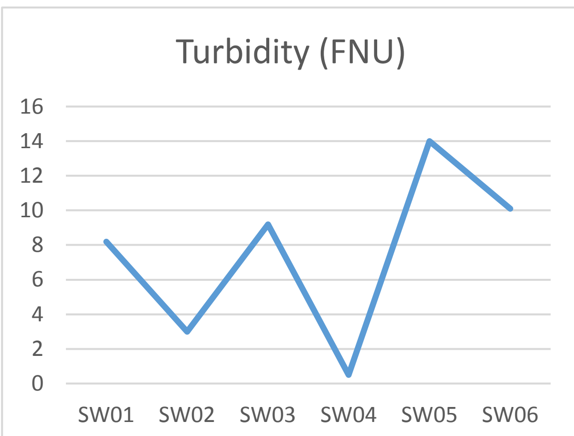
Four boreholes were installed to collect soil and water samples for Geo-tec and water quality studies. The control is an existing borehole near Poha used for washing by communities in the area. The insitu parameters by comparison are much higher than surface water results. The high DO, conductivity, TDS and Salinity are due to concentration of minerals, salts, metals, cations or anions leach from the soil profile. The nutrient test confirm the boreholes are high in P, S, N, K and NH4 concentrations. The turbidity of the boreholes that are extremely high is believed to be from disturbance when the sampler was lowered into the boreholes. High salinity in the result indicate the water is hard water and may have the presence of Mg and Na.

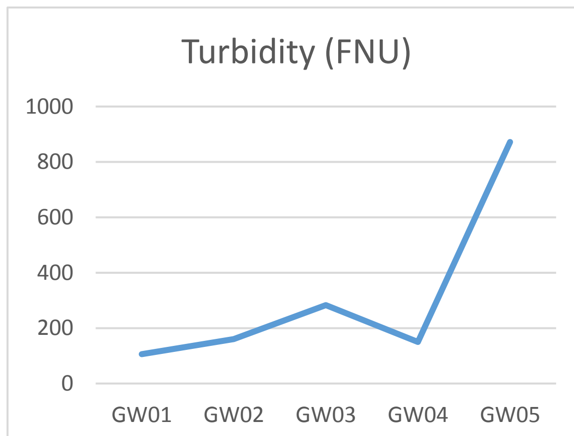
Figure 5: Insitu Parameters-surface water and ground water

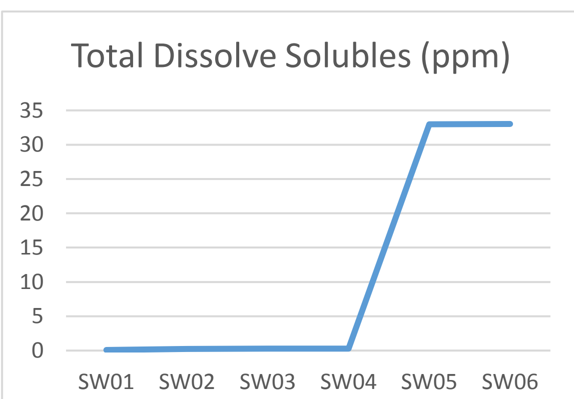
Surface Water (SW)	Ground Water (GW)
	
	
	

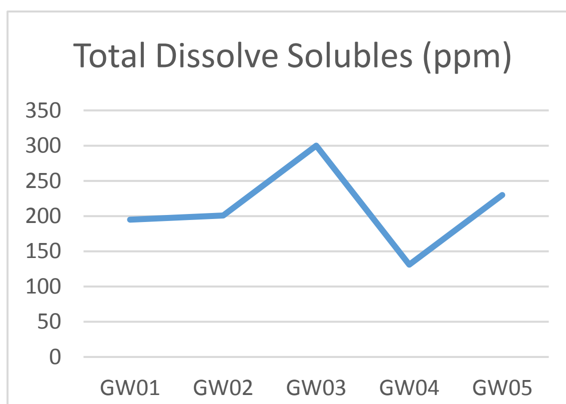

Conductivity (mS/cm)
80
70
60
50
40
30
20
10
0
SW01
SW02
SW03
SW04
SW05
SW06

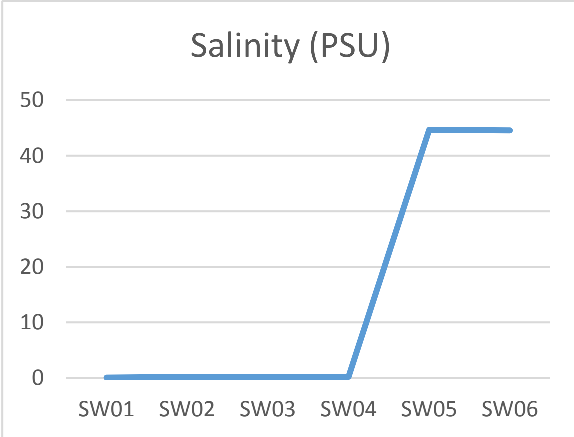

Conductivity (mS/cm)
900
800
700
600
500
400
300
200
100
0
GW01
GW02
GW03
GW04
GW05

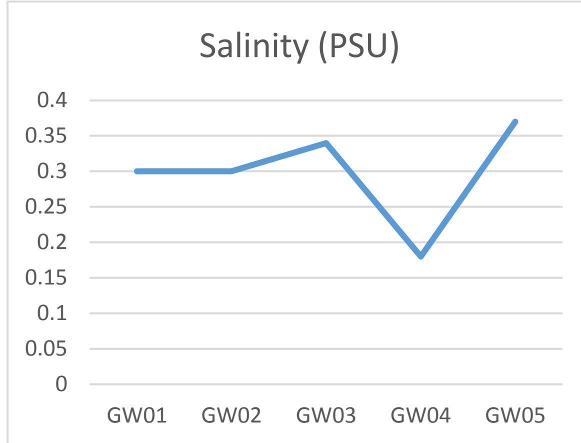

Turbidity (FNU)
16
14
12
10
8
6
4
2
0
SW01
SW02
SW03
SW04
SW05
SW06


Turbidity (FNU)
1000
800
600
400
200
0
GW01
GW02
GW03
GW04
GW05


Total Dissolve Solubles (ppm)
35
30
25
20
15
10
5
0
SW01
SW02
SW03
SW04
SW05
SW06


Total Dissolve Solubles (ppm)
350
300
250
200
150
100
50
0
GW01
GW02
GW03
GW04
GW05





5.4 Sediment quality

5.4.1 Trace Metals

The bottom substrate of the rivers and coastline composed of sediments, cobbles, and debris. The geochemistry of these substrates are by origin from volcanic activities and mineralization of the bed and sedimentary rocks upstream. Poha volcanic and sedimentary substrates are seemingly round due to its large catchment and hydrology. Unlike Mamara, the bottom substrate is a mixture of clay and slightly irregular substrates. According to the Lab results, the concentration of elements found in sediments from the two rivers and coastline varies significantly. The results indicate the following elements are detected in the project area: Potassium (K), Sulphur (S), Chlorine (Cl), Calcium (Ca), Titanium (TI), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), Arsenic (As), Rubidium (Rb), Strontium (Sr), Yttrium(Y), Gold (Au), Zirconium (Zr), Niobium(Nb), Barium (Ba), Lead (Pb), Thorium and Uranium (U). All these elements are detected at Poha and Mamara except Au and U that are only detected at Poha. These elements occur naturally and are important to the environment. Human induced activities have exacerbated the concentration of these elements in the environment and in many cases led to health impacts. Heavy metals are normally stored in the fatty tissues of animals and eating the same diet for example fish from an impacted river system overtime can be fatal.

The concentrations of K range from 6540-8792ppm, respectively. The distribution of concentration is almost the same for all measured samples. Relatively high levels of K in all samples in the river and along the coast can be attributed to the weathering of basic and ultrabasic igneous rock in the drainage area of the rivers. The range of minor elements were: Titanium 1564-2742ppm, Vanadium 42-67ppm, Chromium 104-173ppm, Manganese 433-845ppm, Iron 1.97%-3.44%, Copper 26-66ppm, Zinc 42.5-46.1ppm, Arsenic 2.3-5.7ppm, Rubidium 21.3-44.2ppm, Strontium 276-820ppm, Yttrium 7.5-9.6ppm, Gold (Poha) 5.8-58ppm, Zirconium 85-95ppm, Niobium 4.8-7ppm, Barium 358-434ppm, Lead 7-16.4, Thorium 5.4-15.4ppm and Uranium (Poha and coastline) 7-8.8ppm. The average concentrations of metals exceeded acceptable standards for sediment pollution with heavy metals. It is highly likely, that operation of the city will have significant impacts on the marine and aquatic environment. It was reported by many researchers that the effluents from the urban areas are the main cause for the elevated levels of trace metals in the aquatic systems. The wetland act as sink for runoffs and sediments, however will be reclaimed to secure platform for the development.

5.4.2 Test result and ANZECC guidelines

The ANZECC sediment quality guideline provide guideline values for the following metals only: Chromium, copper and arsenic. Other metals in the guideline are not detected by the MMERE scan machine. On the same note, the elements detected by the MMERE scan machine are not discussed in the ANZECC guideline. See table below for the guideline value (SQGV)s. All copper test results are below SQGV except S1, upstream Poha River. All chromium test values are above the SQGV, however, below the Sediment Quality Guideline-High value. Test for Arsenic remain lower.

5.4.3 Potential source of elements

The main source of elements in the project area are from weathering and mineralization of bed and sediment rocks upstream Poha and Mamara. Human activities including farming and logging may have excerbated the occurance of these metals in the environment. Since, there are no major industrial activities in the area, the assessment team decided the pontential source is mainly natural at this stage.

Table 7: ANZECC sediment quality guideline values

CONTAMINANT	GUIDELINE VALUE	SQG-HIGH
METALS (mg/kg dry weight) [a]		
Antimony	2.0	25
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1.0
Nickel	21	52
Silver	1.0	4.0
Zinc	200	410
METALLOIDS (mg/kg dry weight) [a]		
Arsenic	20	70

Source: ANZECC sediment quality guideline.

5.5 Hydrolometric flow for Mamara

Mamara spring is flowing at an inclined angle of about 1.25 degrees from the source to the coast. Its flow was 1,245.5 L/s at the time of assessment. The length of its channel is about 1,540 m. Obviously mamara spring flow is affected by the channel slope and pressure from the ground water aquifer. Nevertheless, physical and Human factors can influence discharge or flow rate of rivers and streams over time.

Rainfall intensity and duration, size of drainage basin, geological factors and other weather conditions are examples of physical factors that affect flow of a river. Heavy rainfall over long period of time usually increases flow rate. The larger the drainage basin, possiblity of increased runoffs become higher. Increase in temperature gives rise to flow rate. According to study done by water resources division of ministry of Mine, Energy and Rural Electrification, during the year 2014 heavy rainfall, mamara source flow rate was 2,746L/s with the stage of 1.8m.

Human factors on the other hand can cause significant changes to the flow of mamara source. Development of structures due to urbanization is one of the primary factors that would affect its streamflow. For instance, pavements and road infrastructures are made of impermeable materials that increases runoffs and disallow groundwater infiltration. Thus far, much have been learnt from deforestation.

In addition,ecrected artificial barriers in the water ways or by the banks can alter the water level and flow relationship. Stability of a river banks is critical to the water level and its flow. Activities like riverbed gravel extraction and diversion of water ways are considered threat to the stability of stage and flow of a river.

Table 8:Mamara stream flow measurement

Site number	**Site name & location**	**Stage (m)**	**Area (m^2)**	**Mean velocity (m/s)**	**Maximum depth (m)**	**Wetted perimeter (m)**	**Flow**	
							(m^3/s)	**L/s**
1	Mamara downstream Approx. 20m from coast	0.77m	2.0045	0.622	0.680	4.690	**1.246**	**1,246**
2	Mamara upstream Approx. 25m downstream of spring source	0.75m	1.9120	0.651	0.570	6.107	**1.245**	**1245**

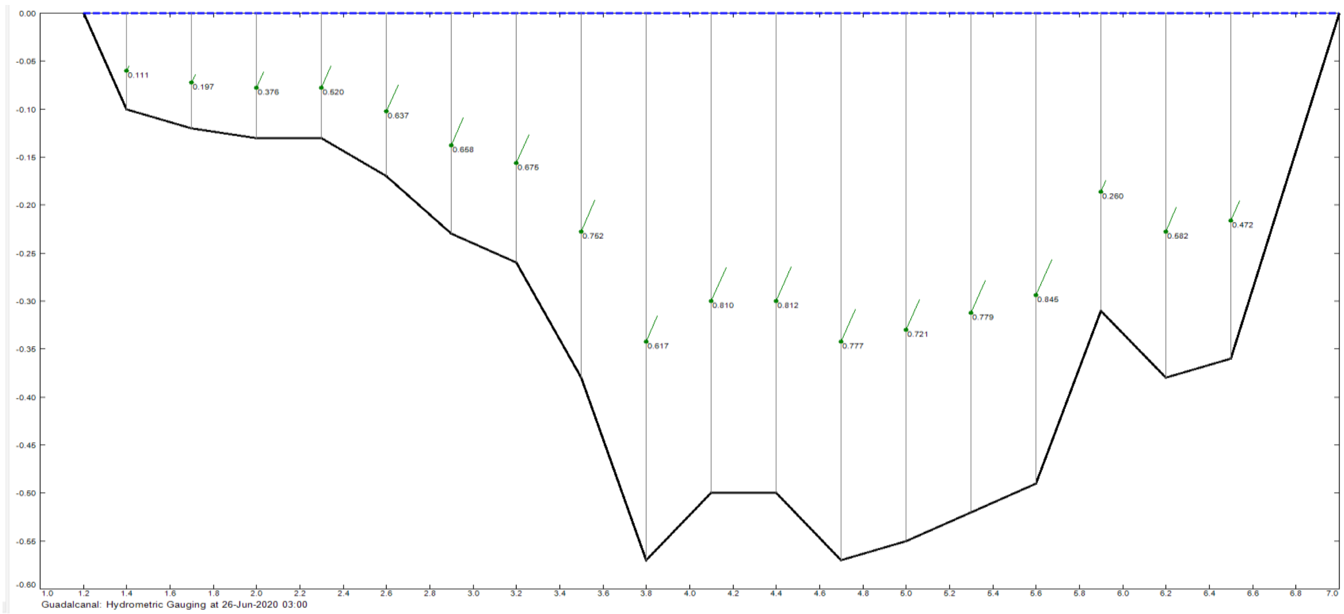


Figure 6: Mamara up stream gauging spot cross-sectional profile(wetted perimeter) (Right – Left bank)

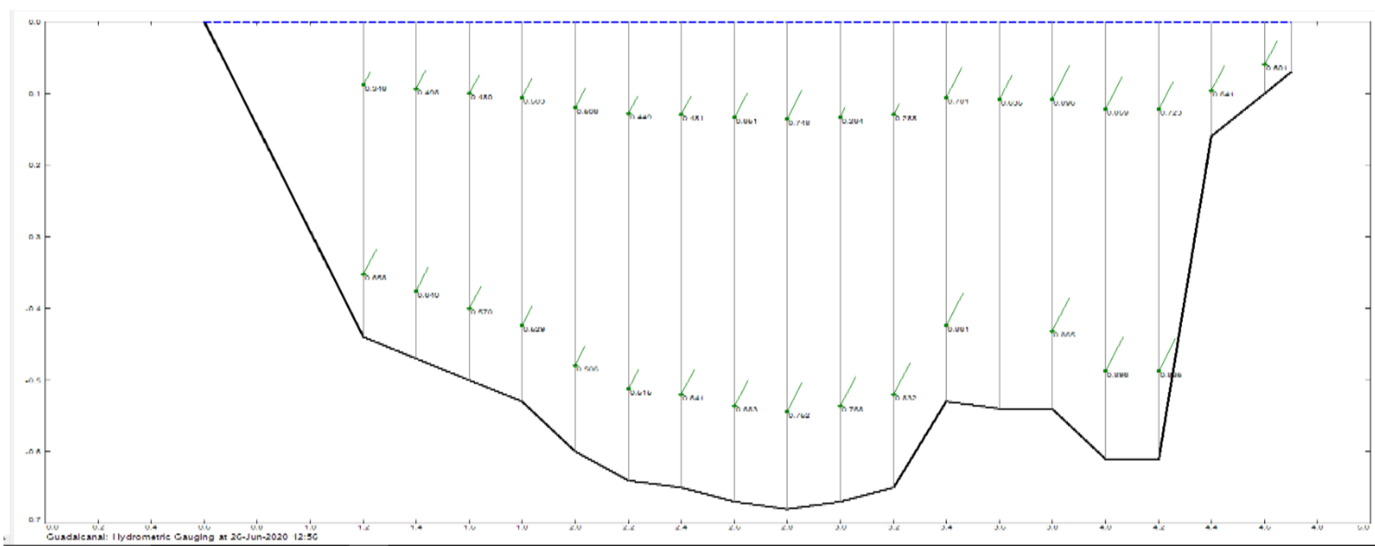


Figure 7: mamara down stream gauging spot cross-sectional profile (wetteted perimeter) (Right- Left bank)

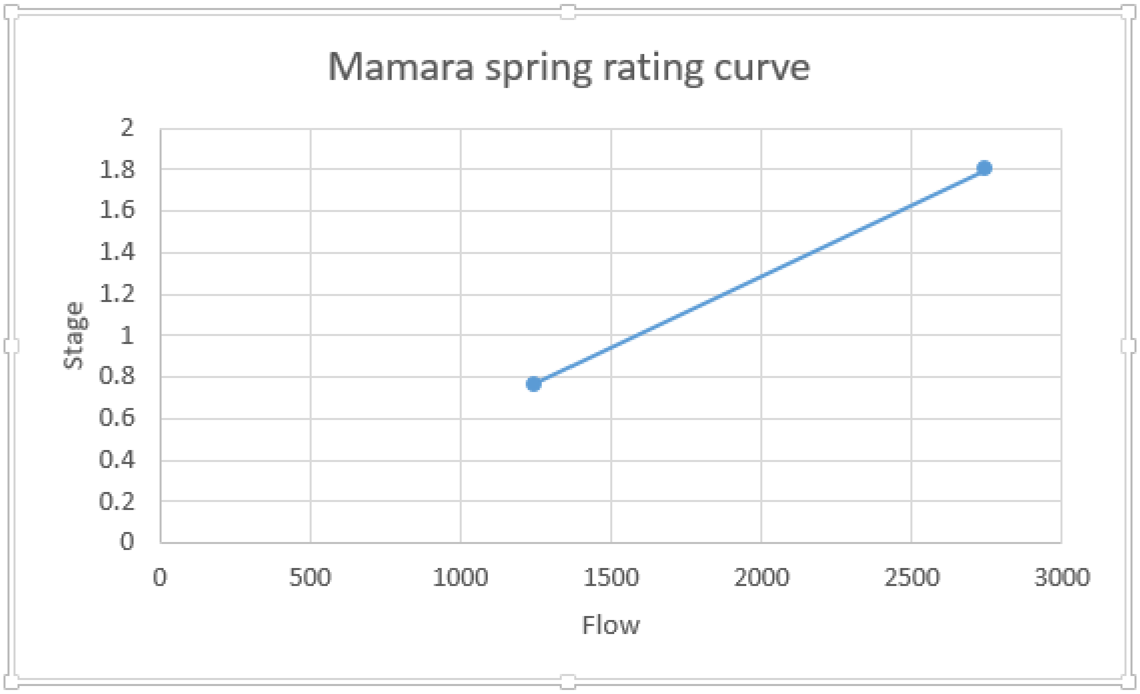


Figure 8: Mamara spring flow stage rating curve

6.0 POTENTIAL IMPACTS AND MITIGATION MEASURES

Phase 1 (reclamation and excavation works)	Impact	Mitigation Measures
	High turbidity in rivers and sea waters due to River crossing by machineries	Avoid machineries crossing rivers
	Impact due to Untreated dispersal of machinery parts into rivers or buried underground	Avoid disposal of machinery parts into rivers. Dispose at the designated site approved by the responsible agency
	Increased sedimentation into rivers during gravel extraction and reclamation	Use of silt traps, bund, coffer dams and sediments ponds
	Watershed, catchment and drainage loss during land levelling	Company to make sure that levelling does not develop flooding of adjacent lots.
	Alteration of groundwater recharge zone when covering the area with concrete cement	Minimize ground cover to design standard.

Phase 2 (Construction)	Accidental release of hydrocarbon from construction machines impacting soil and water and frequent machine exposure to sea or water releases hydrocarbons	Ensure all construction machines are well maintained; A prestart on construction machine carried out every morning; Oil/fuel remediation agents, oil pads, oil booms and geo-fabric clothes are ready for usage as ***per emergency response plan;*** (Hazardous material management manual).
	Reservoir construction for water supply could change stream flow	Metropolis Mamara Development Ltd to ensure consistent stream flow in the reservoir detail design.
	Spilling paint and other hazardous construction materials	***Detailed Emergency Response Plan*** (as part of detail EMP) prepared by Metropolis Mamara Development Ltd to cover hazardous materials/oil storage, spills and accidents; • Chemicals will be stored in secure containers 20m away from the coastline or rivers; • Chemicals stored in area or compound with concrete floor and weatherproof roof and fire extinguishers; • Spills will be cleaned up as per emergency response plan; • Accidents reported to relevant authority within 24 hours; (Hazardous material management manual)
Phase 3 (operation)	Oil and other hydrocarbon substances spill from power station	• Chemicals stored in area or compound with concrete floor and weatherproof roof and fire extinguishers; • Spills will be cleaned up as per emergency response plan;

		• Ensure all construction machines are well maintained; • Accidents reported to police and ECD within 24 hours;
	Untreated Effluent waste disposal into river and onto the ground that can affect surface and ground water quality	• Ensures wastes not discharged to rivers or coastal waters and that all wastes; disposed of at designated site
	Disposal of household wastes into rivers	Garbage receptacles set up at residential sites, which will be regularly cleared by the Metropolis Mamara Mamara Development Ltd.
	Nutrient enrichment through storm water runoff	Use of silt control devices and sediment traps/fences and sediment settling ponds

7.0 CONCLUSION

The study of water and sediment concentration levels is important in understanding water and sediment quality and its link to past and current developments. Water and sediment quality is a significant environmental determinant of health. The test results indicate both natural and anthropogenic activities influence water and sediment chemical properties in the project area including recent clearing of river banks by Metroplis Mamara Developemnt Ltd.

Surface and ground water results vary due to mineralization, leaching of salts, metals, ions, cat ions, this a naturally occuing phenomena and does not affect the water quality significantly. The nutrient and elemental concentration levels are high in comparison to World Health Organizations (WHO) standards which is expected due to ongoing activities by settlers and recent land clearing along the river bank for Mamara. The Micro test for all sites is relatively high for Poha river, some of the ground water sites especially the control site near Borosughu and the coastline which is liked to land-based activities and Honiara . The Mamara rivier source test result however, indicated that it is healthy and conducive for drinking and domestic use.

8.0 LIMITATIONS

It is important in addition to the in-situ, chemistry (Nitrite and Sulphate) and E.Coli results to test for heavy metals in water. Obtaining realistic results that are more site specific requires regular test over certain period of time, minimum of one (1) year and at different weather or climate conditions for at least twenty (20) sampling sites that spreads evenly over the entire catchment. At this stage, six sites for surface water, five sites for ground water and five sites for sediments were covered in this assessment. Additional sites likely to be considered relevant would have to be included at the implementation stage. The MMERE conduct elemental test for this study using a scan machine. It would be good to send samples to accredated labs for verification purposes.

Reference

Andy Smith, Powell, Scott Davis. 2018. CEFA CMEP South Pacific, s.l.: s.n.

ANZECC. 2014. Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. Retrieve on 9th of July at URL: https://www.researchgate.net/publication/269819076_Revision_of_the_ANZECCARMCANZ_Sediment_Quality_Guidelines

MECM. 2010, *Environment Impact Assessment Guideline*, MECM, Honiara.

SIG. 1999. *Solomon Islands Environment Act 1998*, Honiara: Solomon Islands.

Solomon Islands Environmental Act of 1998

Solomon Islands Environmental Health Act

Solomon Islands River Waters Act of 1969

Solomon Islands Tentative Water Resource Act, dract, 2008

Solomon Islands Water Authority Act of 1992

Sustainable Groundwater Management-Concepts

World Health Organization. 2000. *Rapid Assessment of Drinking Water Quality*, *A handbook for implementation*, WHO, Geneva.

World Health Organization. 2011a. *Guidelines for Drinking Water Quality* (4th Edition), WHO Geneva.(Page,315,327,334,341,340,383,397,398,412,416,419)

World Health Organization. 2011b. *Hardness in Drinking-Water,* WHO Geneva.

Appendix

Annex A: Nutrient test-Surface water

Analytical
Soils, Plants and Environmental Analytical and Scientific Supplies Services

SIBN 734/2013

Location: Best Buys Building, Ranadi Industrial Estate, Honiara; Postal address: P.O Box R40, Honiara, Solomon Islands, Tel: +677 38585; mobile ph: +677 7487599; email: spe.analytical@gmail.com

BASIC CHEMICAL WATER QUALITY ANALYSES

Client: Telious Corporation & Consulting Services

Job No:	*MID_01*
No of Samples:	*4*
Date Samples Received:	*25/06/2020*
Date of Issue:	*10/07/2020*

No	Sample ID	Sulphate	Potassium	Nitrate (NO3-N)	Ammonium Nitrate (NH_4^+)	Phosphate (PO4-P)
		mg/L	mg/L	mg/L	mg/l	mg/L
1	S1	11.0	0.9	2.78	0.01	0.09
2	S2	5.0	0.9	2.45	0.00	0.21
3	S3	7.0	0.8	2.99	0.00	0.07
4	S4	5.0	0.7	3.20	0.00	0.08
5	S5	107.0	35.3	15.57	0.21	0.13
6	S6	120.0	33.9	17.85	0.21	0.80

Analysed by: Annie Apusae (Lab Technologist, SPE)

Authorised & Approved By: Dr Shane Tutua

Date: 10/07/20

Signature

SPE ANALYTICAL

Annex B: Nutrient test-Ground water

Analytical SIBN 734/2013
Soils, Plants and Environmental Analytical and Scientific Supplies Services

Location: Best Buys Building, Ranadi Industrial Estate, Honiara; Postal address: P.O Box R40, Honiara, Solomon Islands, Tel: +677 38585; mobile ph: +677 7487599; email: spe.analytical@gmail.com

BASIC CHEMICAL WATER QUALITY ANALYSES

Client: Telious Corporation & Consulting Services

Job No:	*MID_62*
No of Samples:	*5*
Date Samples Received:	*10/07/2020*
Date of Issue:	*21/07/2020*

No	Sample ID	Sulphate	Potassium	Nitrate (NO3-N)	Ammonium Nitrate ($NH4^+$)	Phosphate (PO4-P)
		mg/L	mg/L	mg/L	mg/l	mg/L
1	S1	20	5.1	11.97	0.01	0.50
2	S2	12	2.7	32.21	0.29	0.95
3	S3	162	84	118.84	2.39	14.71
4	S4	36	3.6	24.94	0.03	0.84
5	S5	80	19	101.90	0.21	1.75

Analysed by: Annie Apusae (Lab Technologist, SPE)

Authorised & Approved By: Dr Shane Tutua

Date: 21/07/20

SPE ANALYTICAL
TEL: 36585

Signature

Annex C: Micro test-Ground water

National Public Health Laboratory (NPHL)
P.O. Box 349, Honiara, Solomon Islands.
Telephone: (+677) 38871

Test Report No. MTR 85/20 Date of Issue 13/07/2020 Page 1 of 1

MICROBIOLOGY TEST REPORT

Customer: Winston Lapo
Address: Geology,
Lengakiki,
Honiara

Sample Type: Raw Water

Date/time received: 09/07/2020, 4:55 pm

Sample No.	Date/time collected	Sample description	Analysis	Result	Units	Method
20-454	09/07/20 4:00 pm	GW 1	Total coliforms	>2420	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E. coli	1986	MPN/100 mL	
20-455	09/07/20 4:00 pm	GW 2	Total coliforms	$>2.4x10^4$	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E. coli	3448	MPN/100 mL	
20-456	09/07/20 4:00 pm	GW 3	Total coliforms	$>2.4x10^4$	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E. coli	$1.6x10^4$	MPN/100 mL	

Results apply to samples as received

P/A = Presence/Absence in 100 mL water
MPN/100 mL = Most Probable Number per 100 mL of water
CFU/mL = colony forming units per mL of water
< = less than, > = greater than

WHO guidelines (2011) for drinking water: Water intended for public consumption must not contain any *E. coli* in a 100 mL sample.

Signature: PP [signature]
Authorised by: Kim Irofufuli
Section Head, Microbiology

Signature: [signature]
Released by: Dickson Manongi
Director

Date: 13/7/20

National Public Health Laboratory (NPHL)
P.O. Box 349, Honiara, Solomon Islands.
Telephone: (+677) 38871

Test Report No. MTR 86/20 Date of Issue 13/07/2020 Page 1 of 1

MICROBIOLOGY TEST REPORT

Customer: Winston Lapo
Address: Telios Consultation Service,
Honiara,
Solomon Islands

Sample Type: Raw Water
Date/time received: 10/07/2020, 3:00 pm

Sample No.	Date/time collected	Sample description	Analysis	Result	Units	Method
20-457	10/07/20 1:00 pm	GW 4	Total coliforms	<10	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E. coli	<10	MPN/100 mL	
20-458	10/07/20 1:00 pm	GW 5	Total coliforms	$>2.4x10^4$	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E. coli	$2.0x10^4$	MPN/100 mL	

Results apply to samples as received

P/A = Presence/Absence in 100 mL water
MPN/100 mL = Most Probable Number per 100 mL of water
CFU/mL = colony forming units per mL of water
< = less than, > = greater than

WHO guidelines (2011) for drinking water: Water intended for public consumption must not contain any *E. coli* in a 100 mL sample.

Signature:
Authorised by: Kim Irofafuli
Section Head, Microbiology

Signature:
Released by: Dickson Marongi
Director

Annex D: MMERE elemental test

Test Result

Test ID: 24/07/20 #6
88.0 sec
88.0 sec

El	PPM	+/-
K	8834	108
S	170	53
Cl	437	59
Ca	2.04%	0.02
Ti	1679	22
V	56	2
Cr	181	6
Mn	589	7
Fe	2.65%	0.01
Cu	66	3
Zn	46.1	1.8
As	2.3	0.7
Rb	31.3	0.8
Sr	322	4
Y	9.2	0.9
Au ✓	58	2 ✓
Zr	93	2
Nb	7.0	0.9
Ba	434	16
Pb	7.0	1.0
Th	11.5	1.9
U	7	2

Not Detected

P	ND	< 816
Co	ND	< 61
Ni	ND	< 11
Se	ND	< 2.2
Mo	ND	< 2.7
Rh	ND	< 0.50
Pd	ND	< 1.4
Ag	ND	< 3.7
Cd	ND	< 4.3
Sn	ND	< 9
Sb	ND	< 10
La	ND	< 63
Ce	ND	< 77
Pr	ND	< 148
Nd	ND	< 279
W	ND	< 15
Pt	ND	< 6.0
Hg	ND	< 3.6
Bi	ND	< 12

Test information

Analyzer Mode: Soil
Analyzer Serial #: 550248

Field	Info
sample id	SS1
sample type	rock

Signature: ____________ Date: 24/07/20

Test Result

Test ID: 24/07/20 #7
88.0 sec
88.0 sec

El	PPM	+/-
K	8513	106
S	217	55
Cl	214	55
Ca	2.25%	0.02
Ti	2046	24
V	57	2
Cr	119	5
Mn	845	9
Fe	2.85%	0.01
Cu	58	2
Zn	42.5	1.7
As	4.6	0.9
Rb	28.1	0.7
Sr	287	4
Y	9.5	0.8
Zr	95	2
Nb	6.9	0.8
Ba	422	16
Pb	15.3	1.2
Th	8.8	1.7

Not Detected

P	ND	< 830
Co	ND	< 63
Ni	ND	< 11
Se	ND	< 2.0
Au	ND	< 4.0
Mo	ND	< 2.6
Rh	ND	< 0.49
Pd	ND	< 1.4
Ag	ND	< 3.5
Cd	ND	< 4.2
Sn	ND	< 8
Sb	ND	< 10
La	ND	< 62
Ce	ND	< 76
Pr	ND	< 145
Nd	ND	< 275
W	ND	< 9
Pt	ND	< 5.3
Hg	ND	< 2.8
Bi	ND	< 12
U	ND	< 6

Test information

Analyzer Mode: Soil
Analyzer Serial #: 550248

Field	Info
sample id	SS2
sample type	rock

Signature:__________ Date: 24/07/20

Test Result

Test ID: 24/07/20 #9
88.8 sec
88.8 sec

El	PPM	+/-
K	7220	101
S	372	80
Cl	508	69
Ca	> 10%	
Ti	1564	22
V	42	2
Cr	104	5
Mn	487	7
Fe	2.88%	0.01
Cu	40	2
Zn	43.9	1.8
As	5.7	0.9
Rb	24.1	0.8
Sr	820	9
Y	8.4	0.9
Au	5.8	1.4
Zr	88	3
Nb	5.0	0.8
Ba	358	16
Pb	15.4	1.2
Th	14	2

Not Detected

P	ND	< 1519
Co	ND	< 87
Ni	ND	< 11
Se	ND	< 2.1
Mo	ND	< 3.0
Rh	ND	< 0.50
Pd	ND	< 1.5
Ag	ND	< 3.6
Cd	ND	< 4.3
Sn	ND	< 9
Sb	ND	< 10
La	ND	< 65
Ce	ND	< 80
Pr	ND	< 154
Nd	ND	< 291
W	ND	< 10
Pt	ND	< 5.7
Hg	ND	< 3.1
Bi	ND	< 13
U	ND	< 9

Test information

Analyzer Mode: Soil
Analyzer Serial #: 550248

Field	Info
sample id	SS3
sample type	rock

Signature: ____________ Date: 24/07/20

Test Result

Test ID: 24/07/20 #12
88.4 sec
88.4 sec

El	PPM	+/-
K	6450	96
S	365	69
Cl	431	67
Ca	4.42%	0.03
Ti	2742	31
V	67	3
Cr	173	6
Mn	533	7
Fe	3.44%	0.02
Cu	26	2
Zn	32.8	1.6
As	4.5	0.9
Rb	21.3	0.7
Sr	368	5
Y	9.6	0.8
Zr	97	2
Nb	8.1	0.9
Ba	365	16
La	65	22
Hg	3.1	1.0
Pb	16.4	1.2
Th	5.4	1.8

Not Detected

P	ND	< 1094
Co	ND	< 72
Ni	ND	< 11
Se	ND	< 2.1
Au	ND	< 4.0
Mo	ND	< 2.7
Rh	ND	< 0.50
Pd	ND	< 1.5
Ag	ND	< 3.6
Cd	ND	< 4.2
Sn	ND	< 8
Sb	ND	< 10
Ce	ND	< 79
Pr	ND	< 152
Nd	ND	< 289
W	ND	< 9
Pt	ND	< 5.8
Bi	ND	< 12
U	ND	< 6

Signature:__________ Date: 24/07/20

Test Information

Analyzer Mode: Soil
Analyzer Serial #: 550248

Field	Info
sample id	SS4
sample type	rock

Test Result

Test ID: 24/07/20 #13
88.4 sec
88.4 sec

El	PPM	+/-
K	8792	104
S	372	56
Cl	2975	93
Ca	2.44%	0.02
Ti	1815	22
V	46	2
Cr	130	5
Mn	433	6
Fe	1.97%	0.01
Cu	54	2
Zn	33.3	1.5
As	4.0	0.8
Rb	34.2	0.7
Sr	276	4
Y	7.5	0.8
Zr	85	2
Nb	4.8	0.8
Ba	385	15
Pb	12.0	1.1
Th	9.2	1.7
U	7	2

Not Detected

P	ND	< 801
Co	ND	< 51
Ni	ND	< 10
Se	ND	< 1.8
Au	ND	< 3.6
Mo	ND	< 2.6
Rh	ND	< 0.47
Pd	ND	< 1.4
Ag	ND	< 3.5
Cd	ND	< 4.1
Sn	ND	< 8
Sb	ND	< 9
La	ND	< 61
Ce	ND	< 74
Pr	ND	< 143
Nd	ND	< 270
W	ND	< 8
Pt	ND	< 5.0
Hg	ND	< 2.7
Bi	ND	< 11

Test Information

Analyzer Mode: Soil
Analyzer Serial #: 550248

Field	Info
sample id	SS5
sample type	rock

Signature:____________________ Date:____________________