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KIRIBATI INTERNATIONAL WATERS RIDGE TO REEF PROJECT WATER QUALITY TRAINING WORKSHOP REPORT

May 2020

Prepared by

Samasoni Sauni | Iliana Marama | Teema Biko

Jointly supported and funded by

Pacific R2R Ridge to Reef | Nei Akoako Ngkoa, Ngkai, ao n Taai Nako Environment and Conservation Division | Te Mauri Te Raoi ao Te Tabomoa

Kiribati International Waters Ridge to Reef Project
Water Quality Training Workshop Report

Prepared by
Samasoni Sauni[1]
Iliana Marama
Teema Biko

Jointly supported and funded by the SPC RPCU[2] and the
Ministry of Environment, Lands, Agriculture Development (MELAD),
Kiribati Government, Tarawa

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[1] SPC RPCU Science & National Project Team Leader, Samasons@spc.int; Iliana Marama, IAS-USP, Senior Lab Technician, iliana.koroi83@gmail.com; Kiribati IW R2R Project, Project Manager, teemab@environment.gov.ki

[2] Pacific Community Regional R2R Program Coordination Unit

ABBREVIATIONS

CCA	Climate Change Adaptation
DFAT	Department of Foreign Affairs and Trade (Australia)
DGV	Default Guideline Values
DLT	Dry Litter Technology
ECD	Environment and Conservation Division
FSM	Federated States of Micronesia
IANZ	International Accreditation New Zealand
IAS	Institute of Applied Sciences
ICM	Integrated Coastal Management
IW	International Waters
IWRM	Integrated Water Resources Management
MELAD	Ministry of Environment, Lands and Agricultural Development
MFAT	Ministry of Foreign Affairs and Trade (New Zealand)
PMU	Project Management Unit
QAQC	Quality Assurance and Quality Control
R2R	Pacific Ridge-to-Reef
RMI	Republic of the Marshall Islands
RPCU	Regional Program Coordination Unit
SPC	Pacific Community
STAR	System for Transparent Allocation of Resources
USP	University of the South Pacific

EXECUTIVE SUMMARY

The Kiribati International Waters Ridge to Reef (IW R2R) Project water quality training workshop convened from 2nd to 12th March 2020, in Tarawa, Kiribati. The training was jointly supported and funded by the Pacific Community Regional Program Coordination Committee (SPC RPCU) and Ministry of Environment, Lands and Agricultural Development of the Kiribati Government. Eighteen (18) participants from the Kiribati Government ministries and agencies responsible for the environment, fisheries, agriculture, infrastructure, public and environmental health in Tarawa last week. The USP campus in Kiribati also participated and offered their laboratory for the training. Over 50% of the participants were females.

The SPC RPCU in partnership with the Institute of Applied Sciences of the University of the South Pacific (IAS-USP) facilitated the week-long training.

The training was opened by the Officer in Charge of MELAD and Director of the Environment and Conservation Division of the Ministry of Environment, Lands and Agricultural Development, Ms Nenteiti Teariki Ruatu. She stressed the importance of the training in building capacity and enhance technical knowledge in water quality testing and the use of water quality test kits.

Mrs Ruatu underlined the importance of managing limited resources like water and ensuring quality is within the acceptable standards and thresholds safe for drinking and use by local population. She reiterated that with increasing population and the effects of climate change, water contamination continues to be a priority environment threat in Kiribati. The Government welcomed assistance from Ridge to Reef in addressing water contamination, and this training provides the opportunity to work towards fixing the problem.

The training successfully achieved its objectives and delivered on the following tasks:

I. Water quality monitoring and assessment training for the IW R2R project team at the Environment and Conservation Division.
II. Conducting baseline water quality assessment and the use of water quality test kits; and
III. Facilitating discussion towards development of a Monitoring Plan for the pilot site.

The highlights of the training were the:

- Practical demonstration on the use and application of water quality test kits;
- Sampling of water from selected boreholes and wells following sampling design;
- Analyses of results of water quality parameters and reporting.

The participants were also able to discuss the preliminary assessment results of water quality at the demonstration sites, and offered the following observations: -

I. There was little to no difference in most of the physical-chemical-biological parameters, suggesting that future samples can be taken at any depth for comparison;
II. There are relatively high levels of faecal coliforms and Escheria coli recorded in several boreholes and wells, suggesting water reserve contamination from human and animal waste, and possibly a graveyard in the vicinity;
III. The problem of abandoned scrap metals, including old vehicles, in the reserve may be the reasons the Director of Environment requesting further investigation into other contaminants like metals, radioactivity and related ones;

IV. Ongoing monitoring of the selected sites is expected to provide further validation and clear trends in the quality of water in the Bonriki reserve and enable an informed understanding of possible candidate sources of pollution, thereby informing strategic actions for management of the reserve;

V. Given the importance of selecting control sites as part of the sampling strategy, the R2R Technical Working Group, will, at their next sitting, consider focusing R2R interventions only in the Bonriki Water Reserve, while treating the Buota Water Reserve as a control site.

In summary, the training workshop was successful and delivered on the expected outcomes. There was great enthusiasm in the training particularly interests in the practical work of collecting water samples and learning how to use water quality test kits and related equipment in the field, then analysing samples in the lab. The training benefited not only the participants in career development, but also the skills and experiences would add value in future projects related to water management in the country. Such capacity building exercises strengthen efforts to sustainably manage water and ensure quality of water is safe to drink and not contaminated.

BACKGROUND

The Kiribati IW R2R project is focusing on Bonriki/ Buota Water Reserves as its demonstration sites. The water quality training is one of the activities implemented by this project. Generally, the Kiribati IW R2R logframe provides the relevant details supporting training on water quality to upscale skills and understanding, as well ensure support for ongoing future monitoring of water quality at the Bonriki/ Buota reserves. The IW R2R project is testing innovative technologies, in particular, cost-effective ways using dry litter technology (DLT) (piggeries) to improve quality of water to safe standards.

There are several contaminants impacting the quality of water in the Reserve, which includes nutrient and pathogen loads from human and animal wastes, dumping of metal and chemical wastes, and other municipal/ household wastes. The IW R2R project focuses only on testing municipal waste pollution reduction through dry litter piggeries technology. Unfortunately, there is no time to extend testing to sanitation system upgrades, which is potentially a better representation of municipal waste pollution.

The training on water quality is a priority activity in the Kiribati IW R2R project, specifically delivering on the following outcomes outlined in the logframe (2019): -

(i) Outcome 2.2 – Environment and public health safeguarded via targeted reductions in nutrient and pathogen contamination of coastal areas. The indicator would be the volume reduction in untreated pig pen effluent discharged into receiving waters. The target is a 5% reduction in total nitrogen from nutrient and pathogen loads from pig pen effluent discharging directly into the receiving environment. This is equivalent to 955 kg/ year, and to be achieved through construction of 30 DLT in demonstration sites.

(ii) Outcome 2.3 - supporting increase in national capacity for environmental assessment and water quality analysis. The indicator would be the number of training workshops and continuity of people trained in water quality data collection techniques. Another indicator would be the status of water quality collection programs at priority sites. The target is to ensure water quality at demonstration sites supported and characterized through participatory environmental data collection and monitoring programs. Another target is that more than 10 people in MELAD are trained and competent to carry out water quality monitoring, data analyses and reporting.

INTRODUCTION

Water is an essential resource used everyday and is a key priority sector in low-lying atoll countries like Kiribati. In atoll environments, water sources are limited to rain (precipitation) and groundwater in lenses and aquifers (infiltration & recharge). Invariably, atoll countries do not have the luxury of water sourced from rivers stretching from the high mountain ridges to low lying coastal plains and marine areas.

It is fundamentally important that lessons learned, and best practices are captured for continuous improvement in the replication and upscaling processes, considering changing circumstances and environmental dynamics. And that the results inform policy discussions and decision-making, supporting the principles of evidence-based, and participatory approaches.

Managing water resources and ensuring quality standards that are safe to drink, secure and sustainable, was the focus of a GEF funded Integrated Water Resources Management (IWRM) project, which ended in 2014[3]. The GEF funded International Waters Ridge to Reef project (IW R2R) is integrating lessons and best practices from the IWRM project with coastal management (ICM) and climate change adaptation (CCA).

This integration is coined the ridge to reef concept. In the context of Kiribati and other atoll countries, it is a whole-of-island approach towards integration, mainstreaming and sustainably or holistically managing ecosystem goods and services.

Component 1 of the Regional IW R2R project provides national demonstrations support R2R ICM/ IWRM approaches for island resilience and sustainability. Specifically, Activity 1.1.2.2 provides for the procurement of technical and managerial services to ensure the timely and efficient delivery of pilot activities at 14 sites. The procurement of water quality monitoring equipment and, national training for water quality in-country are part of this specific activity.

There have been water quality related activities already implemented in the past. Currently, the RPCU plans to carry out water quality training for IW R2R projects in Kiribati, Federated States of Micronesia (FSM) and the Republic of Marshall Islands (RMI). It is expected that all the training is completed at the end of this first quarter, and that national Project Management Units (PMUs) can continue with monitoring work. These are important undertaking that would assist in delivering milestone targets particularly regarding reduction of pollution and levels of water contamination in aquifers and surface waters. The new water quality test kit would also provide timely collection of tempo-spatial data on targeted parameters from selected sampling sites in the monitoring plan.

The RPCU procured the water quality monitoring equipment on behalf of the national IW R2R Project. The training workshop demonstrated the use and application of this equipment to assess quality of water from various sources like reserve bore-holes, wells, and coastal areas.

The purpose of the water quality training is primarily aimed at improving and upscaling skills of the National IW R2R project staffs and other stakeholders in the use of water quality test kits. The training also provided an opportunity to refresh and enhance understanding on aspects of water management including the importance of evidence and science-based technologies and innovations that support policy and decision making.

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3 See details in http://www.pacific-iwrm.org/

KIRIBATI IW R2R DEMONSTRATION SITES

The Kiribati IW R2R demonstration sites are Bonriki and Buota Water Reserves, and the former is the largest and the main source of freshwater for an ever- increasing population currently at around 50,182 people living in South Tarawa. Bonriki water reserve is a small, 0.7 km, but important aquifer for the country with most of the population residing in South Tarawa. Figure 1 & 2 below depict the two water reserves showing the boundaries, and features of galleries, monitoring bores, PUB[4] treatment plant and wetlands.

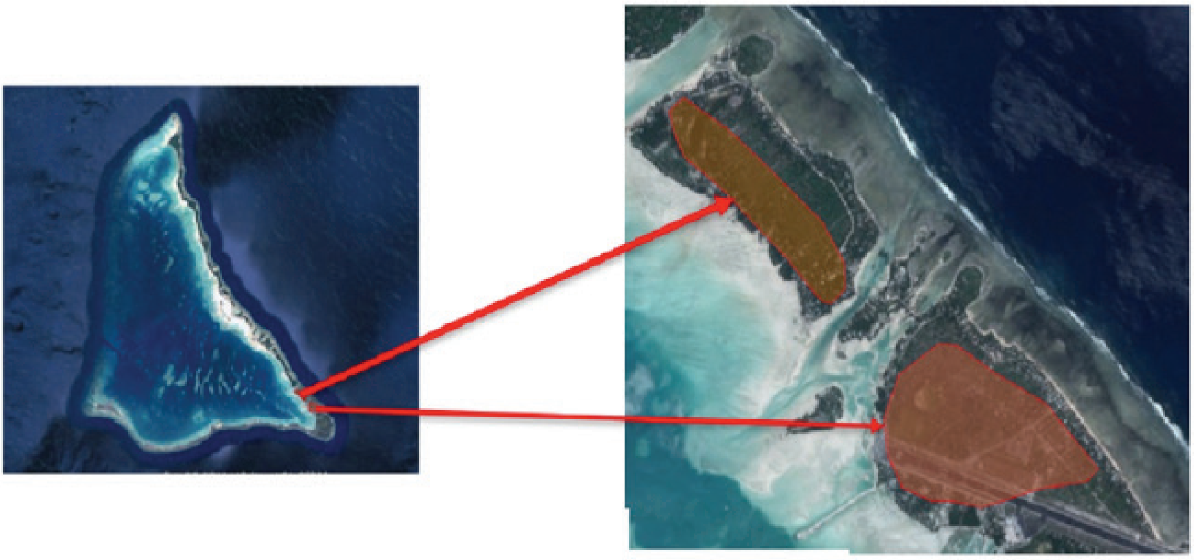

Figure 1. Kiribati IW R2R Demonstration Sites in South Tarawa – the shaded areas are roughly the boundaries of Bonriki & Buota Water Reserves

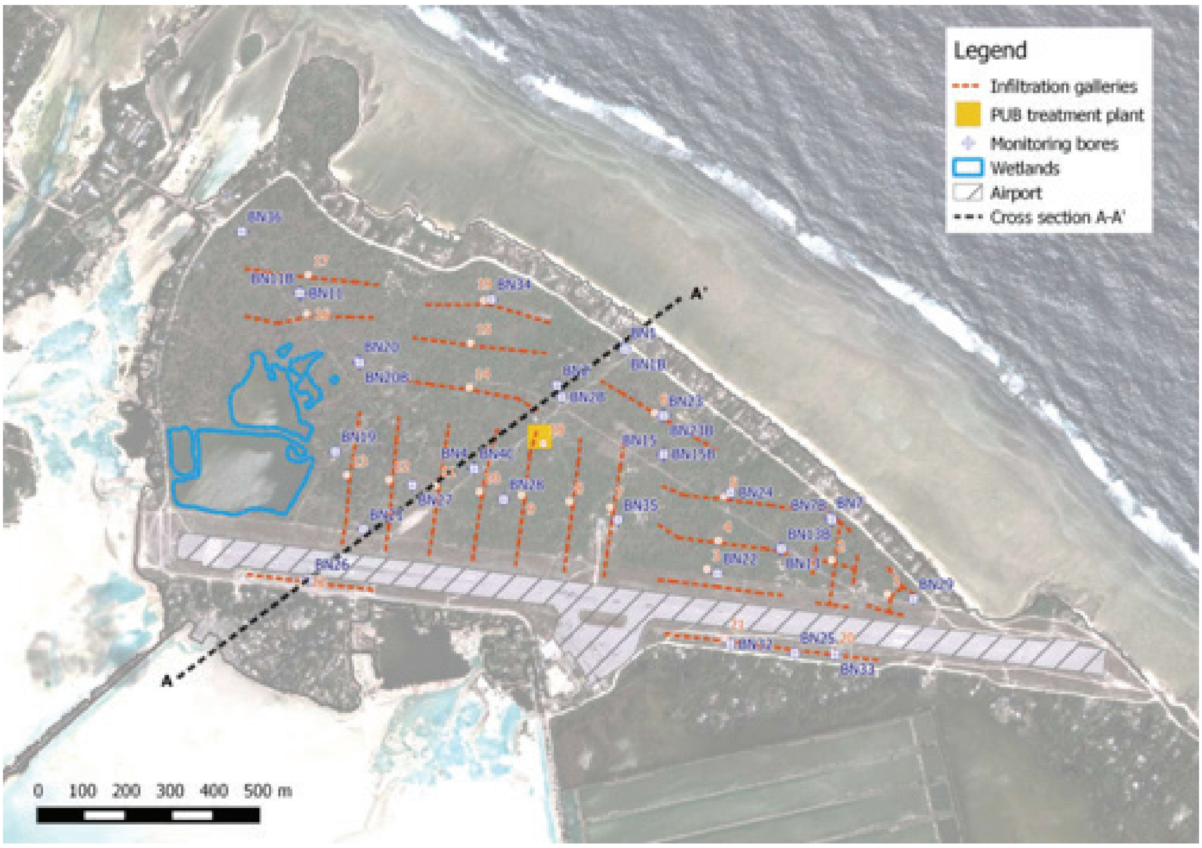

Figure 2. Depicting the Bonriki water reserve infiltration galleries, monitoring bores, wetlands, etc. (adapted from Galvis-Rodriguez, S et al. 2017)

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[4] Public Utility Board

Galvis-Rodriguez et al. (2017) estimated a long-term sustainable yield estimated at 1.6 million litres of freshwater per day, or less than 25L/p/d with system losses taken into account, the demands placed upon the Bonriki Water Reserve makes this aquifer one of the most "worked" aquifer systems in the Pacific, where demand outstrips supply. Figure 3 below shows the set up of the only water treatment and storage facility for the whole country. Water is extracted from all the boreholes of the Bonriki and Buota water reserves, which is then treated and stored in these facilities before distributed to paid customers and local population in South Tarawa.

Figure 3. PUB Water Treatment and Storage Facility located in the Bonriki Water Reserve.

There are nine (9) bore holes in Buota and twenty-five (25) in Bonriki water reserves, and not all are functional or operational in terms of ability to extract water samples through the monitoring tubes or pipes in those bore-holes. For instance, at the time of fieldwork, there were only four (4) bore-holes functional in Buota Water Reserve, and eighteen (18) in Bonriki Water Reserve. The current state of bore-holes will change with regular and routine maintenance. The details of all boreholes and their GPS locations in both Reserves are provided in **Attachment 3a**. The details for other boreholes in North and South Tarawa are also provided for consideration as reference or control points – details in **Attachment 3b**.

Like other areas in the Pacific, the Bonriki water reserve is subject to impacts from reduced recharge from drought and overtopping from storm surges, causing water quality impacts, which in some cases can make the water unusable for its intended purpose. Figure 4 shows several land-use activities contributing to water quality contamination.

Figure 4. Land-use activities in the Water Reserves contributing to water contamination and degraded coastal ecosystems (cemetery, fishponds, stray pigs, squatters)

Notably, SPC past numerical modelling work provided increased information and knowledge needed for informed management decisions on the dynamic groundwater systems of Bonriki aquifer, which includes (Galvis-Rodriguez, S et al. 2017): -

(i) By projecting possible rainfall and storm surge scenarios, it has been possible to model the behaviour of the freshwater lens and the impact from severe droughts and wave overtopping on the underlying freshwater lens, including timing of impacts and importantly recovery of the lens under different climate conditions.

(ii) Complementary donor efforts informed by SPCs work has seen bilateral funding by MFAT & DFAT, supported the installation of variable speed pumps on the horizontal water supply wells, galleries, used to abstract the groundwater from the Bonriki Water Reserve.

(iii) The science employed in this project has been successful in demonstrating a new approach to groundwater management in atolls resulting in an improved and more robust drought management response plan, the learnings of which can, and have, been applied successfully elsewhere.

APPROACH

The RPCU staff and Consultant conducted water quality training for the IW R2R project staff and stakeholders from the STAR R2R project staffs, ECD, Fisheries, Agriculture, Public Health, USP Campus, and others (see details in **Attachment 1**). The training workshop adopted the consultative and participatory process and approach during classroom and fieldwork sessions.

The training follows the schedule of activities set out in **Attachment 2**, which also corresponds to training objectives workshop sessions on 'Water Quality Assessment' as outlined below: -

Session 1: Discuss the steps in monitoring cycle of coastal zone; values and objectives

Session 2: Understand and apply concepts of water quality

Session 3: Identify early warning signs of environmental problems

Session 4: Understand and demonstrate the newly purchased water quality test kits use and maintenance

- 4.1 Physical parameters - Multiparameter Photometer e.g. YSO ProDSS, YSI ProPlus
- 4.2 Pathogens & nutrients – Colorimeter, Photometer, Chemical Tests e.g. nitrate, nitrite, phosphate, ammonia, BOD
- 4.3 Coliforms & E. coli – EC MPN and TC

Session 5: Demonstrate in-situ sampling procedures

The following are the specific tasks of the training:

(i) Training on sampling protocol (including sampling plan, selection of sampling equipment, selection of test kit and field gear, preparation of data sheets, storage, preservation, and transport of samples).

(ii) Preparation, laboratory analysis and reporting (including sample registration, pre-treatment of samples, selection of test method and in-house laboratory and data analysis, report sheets).

(iii) Teaching the basic quality assurance and quality control (QAQC) requirements for water quality assessment based on ISO17025;2017 and requirements of the International Accreditation New Zealand (IANZ), including QC Charts and reference materials.

(iv) Hands-on operation of the field test kits for water quality assessments (including Lovi Bond Kit, Aqua read and the Salinity Refractor meter).

(v) Facilitate discussion on the development of a water quality monitoring program/ plan for Bonriki and Buota Water Reserves.

MATERIALS & METHODS

The Regional IW R2R project purchased several water quality test kits for the Kiribati IW R2R project. The equipment is user friendly, compact, and easy to carry around during fieldwork and outdoor research. The equipment/ material list for the training is appended as **Attachment 5.**

Sampling Design or Strategy

Participants discussed and prepared a sampling/ experimental design or strategy that would establish baselines for the quality of water in the Bonriki Reserve. The key underlining objective in the design is to establish if the water reserve is contaminated. The levels of pathogens and nutrients, including coliforms and E. coli will be measured and recorded. The results of this training will be used as baselines, and the parameters will be monitored and recorded into the future.

Further discussion on the sampling design and long-term monitoring plan continued after the training. A final sampling strategy and design would need to be robust and rigorous in order to respond to the underlined objective and provide evidence-based data corresponding to the quality of the Bonriki water reserve. The baseline pollution levels will be compared against future readings of water quality parameters in order to achieve target 5% reduction of pollution through pathogen and nutrient offloads to receiving environment.

Sampling water was performed only in the Bonriki Water Reserve and not the Buota Water Reserve. There was little time to cover both Water Reserves let along sampling the full thirty-four (34) bore-holes and household wells in Bonriki & Buota Water Reserves.

Participants collected water samples from ten (10) bore-holes (depths 5-30m) and four (4) ground-water wells (depths 0.5-1.5m) in the Bonriki water reserve. There were water hoses installed at different depths in the boreholes to pump up water samples for testing. To investigate water quality at different depths, samples were collected from pre-selected 6m and 12m depths. The water hoses set at 6m and 12m worked well for most of the boreholes but collecting from greater depths was unsuccessful.

Sample collection at each borehole was undertaken by sampling two (2) replicates, each at two depths of 6m and 12m, respectively. Water samples were also collected in four (4) household wells. The boreholes and wells are randomly distributed around the Bonriki water reserve and, the aim was to sample as many boreholes and wells as possible within one day. The process of sampling boreholes and wells was repeated across the Reserve to provide a snapshot of water nutrient concentration (nitrate, nitrite, ammonia, phosphate) and presence or levels of coliforms and E. coli.

At each borehole water sampled at each depth was stored in a 2-litre plastic bottle. The same process was repeated for sampling household wells. The sample bottles were carefully labelled and stored away in the cooler box for transportation back to the laboratory.

Prior to Fieldwork/ Classroom Sessions

Preparatory tasks include training Participants to understand the basics and science of water, interactions, and reactions with range of unnatural or man-made contaminants, extent of contamination or pollution thereby impacting on the receiving environment and users (animals and humans).

The Participants discussed and developed a sampling design for purpose of sampling water and demonstrating the use of water quality test kits in the field. Participants revisited discussing the sampling design post fieldwork in later sections for purposes for agreeing on future sampling protocols and design for the R2R Water Quality Monitoring Plan for Bonriki/ Buota Water Reserves.

During Fieldwork

The aim of the sampling design was to sample as many boreholes and household wells as possible for better representation and scientific rigor in the results. This approach was also adopted given not all the boreholes are functional and unable to extract water samples through the 'water-depth tubes.' Accessibility to several boreholes proved difficult due to poor unpaved roads restricting mobility of the trucks with equipment.

In the reserve, the installation and use of variable pumps are used to optimise water abstraction while maintaining water quality. However, for purposes of monitoring water quality, concrete platforms are set at the top of each borehole with plastic water tubes coming through concrete surface, which are used to extract water from different depths. Each tube represents one depth. Using different connectors, a rubber water pipe is connected to the a 'depth pipe' one end and the end connects to a battery-powered water pump which then connects to another water piping to fill sample bottles. The details are clearly shown in Figure 5 below.

Figure 5. Showing concrete platforms of boreholes with plastic water tubes coming through concrete surface, which are used to extract water from different depths.

Water was sampled from ten (10) boreholes and four (4) households. On return from the field, all samples were immediately stored and refrigerated for two days before lab work.

Post Fieldwork/ Laboratory Sessions

Samples were removed from the refrigerator and prepared for testing. Participants worked in two groups or teams and quantitatively assessed the quality of water samples using the new test kits. Participants took turns in using the equipment following clear steps and procedures. The groups measured and recorded pre-selected parameters that would be used to establish the current levels of contamination in the water reserve.

These estimates would be also used as baselines for monitoring target of 5% reduction of pollution in the water reserve by end of the project.

On the first day of laboratory work, several water samples were prepared for coliform and E. coli counts, which first need incubation overnight and count resumes the next day. Figure 6 below shows participants at work during laboratory sessions.

Figure 6. Showing participants busy with laboratory work assessing and testing water sampled from boreholes and wells at the Bonriki Water Reserve.

The estimates of the parameters measured from the two groups were tabulated for analyses and discussion. The results are provided in sections further below.

Monitoring Plan

The last session of the training was on scoping out a practical plan to monitor the quality of water in the Reserves. Reflecting on training and use of equipment, coupled with resources and commitments, it was accepted to prepare a simple monitoring plan that recognises other monitoring efforts by other agencies limited time remaining of the project. It was also considered paramount that despite the constraints, monitoring exerts efforts and provides the science-based advice to policy makers for informed decisions. Participants developed a skeletal draft monitoring plan and map out areas of collaboration with partners in implementing the plan. The draft monitoring plan is appended as **Attachment 6**.

RESULTS

Comparing Selected Parameters Between 6m and 12m Depth

It is uncertain if there were potential differences between the quality of water at different depths of the boreholes. The water quality at depth is an important indicator of the characteristics in the water column and its interactions with possible contaminants. The results generally show no potential differences between 6m and 12m in levels of nitrite, ammonia, pH and DO. However, there are marked differences in actual readings between several boreholes. For instance: -

(i) At 6m depth, there are higher levels of nitrite in BN2 and BN28; higher levels of ammonium in BN27; higher levels of pH in BN13, BN2; higher levels of DO in BN13

(ii) At 12m depth, there are higher levels of nitrite in BN23, ammonium in BN1, BN13, BN19and BN2, and pH in BN21.

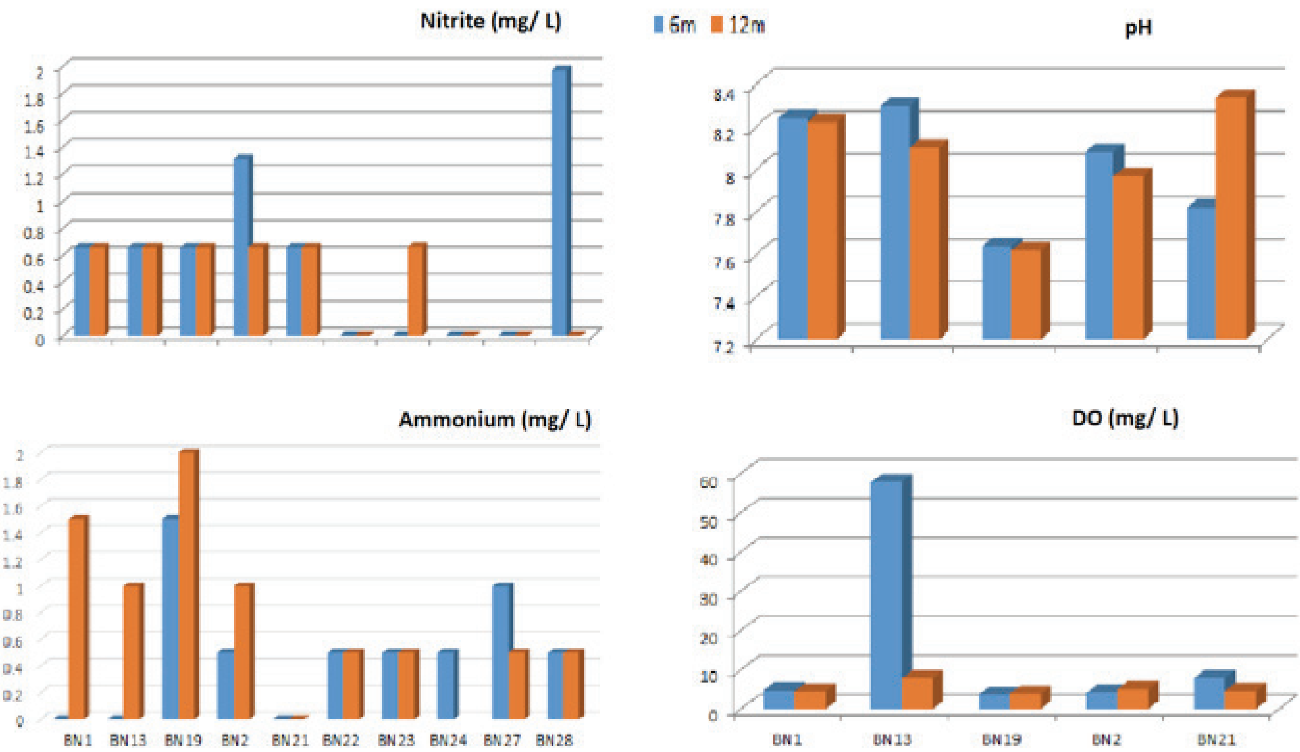

Figure 7. Comparing several water quality parameters between 6m and 12m depth.

The results suggest that it is safe to assume uniform spread of pollution or contamination throughout the water column of the monitoring boreholes. This also means water samples can be taken at any depths of each boreholes for testing as long as the water tubes are functional.

The Participants sampled only 10 out 25 bore holes were sampled. The sample size is relatively high so there is high probability that the preliminary results are relatively sound that there is no potential difference in pollution levels between 6m and 12m depth.

Assessing Physical Parameters Against Guidelines & Standards

The results show concentration of DO in measured monitoring bores well within thresholds and maximum concentration of dissolved oxygen (DO) in water under ambient conditions (about 6–10 mg/L) – details in Figure 7 above. This is dependent on the atmospheric pressure and the water temperature and salinity. The results suggest decreased in turbid water and temperature, acceptable input levels of nutrients and algal production.

However, pH level across all measured monitoring bores exceed neutral reading of 7 (pH > 8 in BN1, BN13, BN12 and BN21, suggesting basic or alkaline conditions of water (noting pH < 7 is acidic). Levels of pH changes with increased DO, runoff, and pollution, and may also indicate land-based pollutants and point source pollution.

Default trigger value for electrical conductivity of water that increases/ decreases with salinity (EC, salinity) varies between places. Conductivity serves to identify unacceptable levels of salinity, and changes may indicate agricultural runoff or a sewage leak or rising groundwater/ saltwater intrusion.

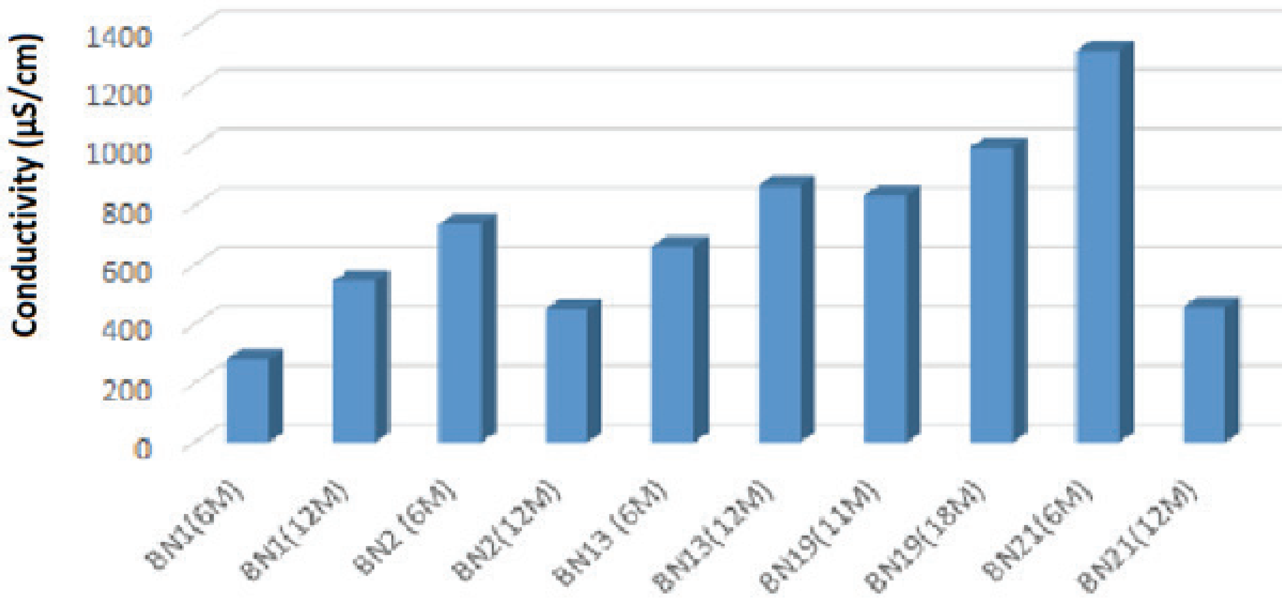

Figure 8. Comparing electricity conductivity readings between water samples taken in 5-monitoring bores.

The results on electrical conductivity (EC, salinity) of water samples in five monitoring bores range from 200 to 917 µS/cm – see details in Fig. 8 above. This range falls below the Kiribati DC-adopted salinity threshold of 1,500 µS/cm as the acceptable upper limit for potable use of water. The typical value of EC in potable waters 50-500 µS/cm, and freshwater < 1,500 µS/cm; the latter varies widely between locations and aquifers and catchments. Higher values than the threshold is considered unacceptable for potable use of water pumped from the Bonriki Water Reserve Treatment/ Storage facility.

Assessing Nutrients (Nitrites & Ammonia) Against Guidelines & Standards

Nutrients influence aquatic primary production – growth of benthic microalgae, photosynthetic bacteria, phytoplankton, macroalgae, and aquatic vascular plants. Algae growth in boreholes and wells suggest high and excess levels of nutrient loads into underwater aquifers which could be attributed to human and animal waste from piggeries.

Figure 9 shows relatively high concentration of nutrients in both wells and boreholes, with a highest reading close to 2 mg N/ L in BN19 and BN28 sites. All the monitoring bores or sites measured higher than the ANZECC & ARMCANZ (2000) DGV's and the IMCRA (2018)[5] DGV's for nitrite (0.2 mg/ L) and ammonium (0.1 mg/ L). Participants also recorded nitrate levels as 44.3 mg/ L in BN24 (6m), 10 mg/ L in BN24 (17.6m) and BN28 (well, 1.3m), and < 10 mg/ L in BN1 (well). There were no readings on phosphate levels.

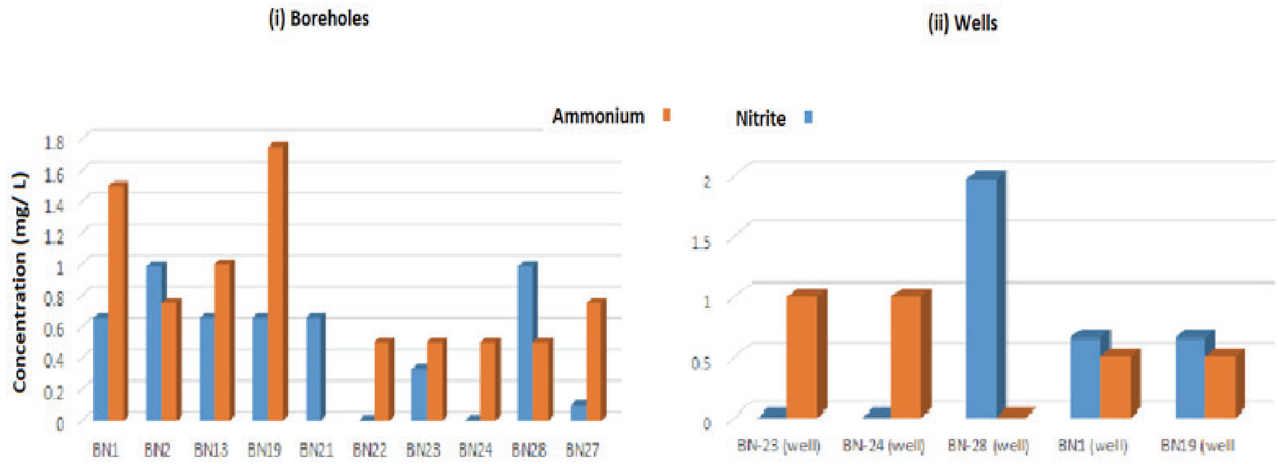

Figure 9. Average measured of nutrient concentrations (ammonium & nitrite) in (i) boreholes and (ii) wells

Assessing Coliforms & E. coli Against Guidelines & Standards

The results are variable in the coliform and E. coli counts. Several sites have very high counts, and this was predominantly recorded for samples taken in wells and at depths of 12m. Boreholes and wells showing positive counts of coliforms and E. coli are located closed to houses and piggeries. There was no clear trend to suggest plausible reasons for the results.

According to the WHO Health risk category, the samples extracted from the following sites were very high and therefore unsafe to drink – BN23 (well), BN23 (12m), BN24 (well), BN22 (12m), BN28 (well) and BN1(6m) with >100 counts/100ML; possibly unsafe for BN21 (12m). The maximum acceptable value (MAV) is < 1 per 100mL for similar ecosystem in Australia & New Zealand (ANZECC & ARMCANZ., 2018). Figure 10 shows counts from several boreholes and wells.

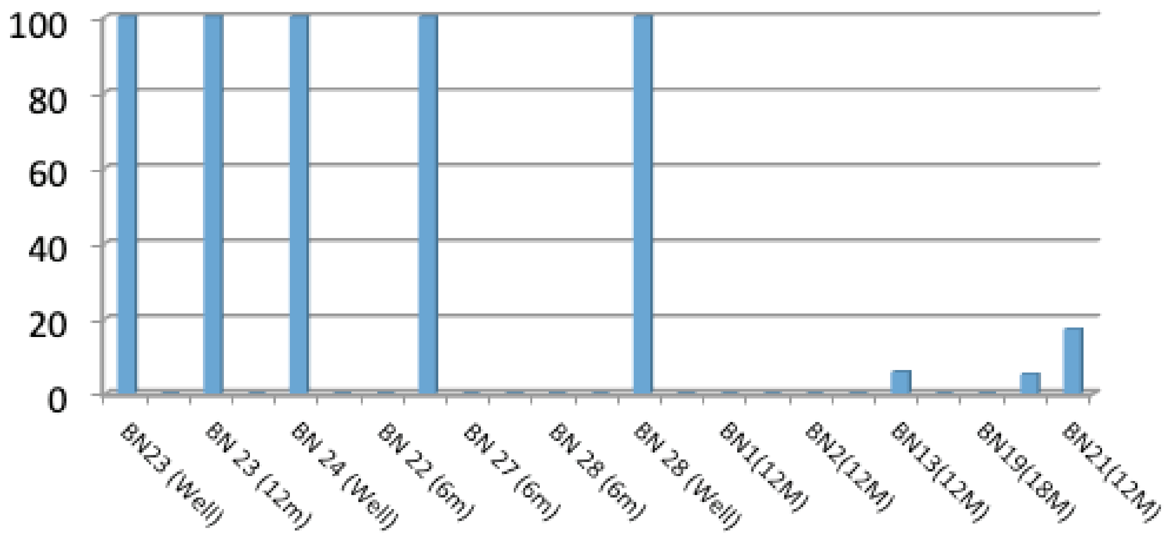

Figure 10. Coliform and E. coli counts (MPN/100mL) by Boreholes and Wells in the Bonriki Water Reserve

[5] Default guideline values

DISCUSSION

Water Quality Training

The water quality training set out to upskill and refresh understanding and demonstrate the use of new test kits in-situ both in the field and laboratory. This exercise requires extraction of water samples from the demonstration sites following an agreed sampling design. The samples were tested, and readings recorded for pre-selected water quality parameters. The estimated levels of nutrients, chemical and physical parameters selected for monitoring under R2R are assessed against guidelines and standards or comparing data from different sources. A matrix of published guidance values and related details are appended as **Attachment 6**.

Notwithstanding, the training successfully delivered on its objectives and improved the understanding and awareness of Participants. There was indeed interest and enthusiasm amongst the participants, driven primarily by the available opportunity for upskilling and capacity building as well as career development.

Despite a few logistical setbacks, the participants were trained in the basic knowledge and application of the water quality test kits particularly in its use, maintenance, and troubleshooting water quality equipment. Participants learned clear protocols and steps to take at various stages of preparing a sampling design and agreeing on a monitoring plan, preparations before and after field sampling. Participants also conducted in-field water quality monitoring, laboratory analysis and assessed water quality data and prepared simplified reports for stakeholder use.

Moreover, participants developed a draft monitoring plan which was guided by group discussions of the preliminary results on the quality of ground coastal waters in Bonriki. The draft plan includes specific details on objectives, parameters to monitor, responsible person(s) or agencies, areas of collaboration with partners, and tentative timelines.

Preliminary Results

Because it was a training exercise, there were mistakes associated with sampling protocols and undertaking analyses, which in turn led to contamination of samples. Therefore, there are ‘noises’ in the datasets and the results should be treated with care and as preliminary only. There was also limited time for sampling water in the field and analyses in the laboratory. As a result, participants were not able to provide readings for all the parameters and several readings discarded because samples were contaminated.

Nevertheless, the preliminary assessment results of water quality at the demonstration sites can be treated as baselines or possibly discarded because primary data was collected during a training workshop and therefore suffered from range of errors or “noises”. Alternatively, the project may treat the level of nutrients and other parameters as baselines and to be reconsidered and compared against future readings.

The first assessment compares the level of physical-chemical-biological parameters sampled at different depths (6m vs. 12m) of the monitoring bores. The results clearly show general and consistent similarity with marked differences occurring in few monitoring bores. Nonetheless, the relatively high sample size of close to 50% boreholes sampled is adequate to suggest that there is generally no difference. This also means sampling in monitoring bores can be done at any depths. If the results remain uncertain, there is the opportunity to repeat sampling of the same boreholes into the future.

In contrast, this assumption is not necessarily true comparing levels spatially across the boreholes. The reason is explained by the processes of infiltration and charging such that contamination does not flow freely in an underground stream from one borehole to the next, but through unsaturated zone of soil, rubbles, limestone, and rocks. A highly porous or permeable unsaturated zone, such as karst limestone, can result in the relatively quick transfer of contaminants from the surface to groundwater. However, 'reaction' of contaminants with the soil and rock of the unsaturated zone can slow or even stop contamination reaching groundwater.

On this basis, the second assessment focused on a spatial comparison between boreholes and wells. The results are generally consistent and measured levels of physical-chemical-biological parameters for DO, pH, conductivity, salinity falling within the guidelines. The results also suggest much reduced excessive impacts and proper management of the Bonriki water reserve.

For instance, the implication of droughts, seawater intrusion, aquifer salinization, and excessive pumping of fresh water increase salinity levels as freshwater lenses floating on top of salt water may be reduced. Rather, the preliminary results suggest the opposite is true for excessive precipitation that helps with recharging of underground freshwater lenses in recent times.

The importance of monitoring water quality cannot be over-emphasised to provide accurate science-based advice when underground water exceeding salinity thresholds and no longer safe to use. It has been highlighted that the key groundwater quality issue in Australia is salinity, followed by acidity, trace elements, and nutrients and pesticides. In this context, salinity refers to the salinisation of groundwater because of dryland salinity, irrigation salinity, aquifer salinisation and seawater intrusion (ANZECC & ARMCANZ, 2018).

Anthropogenically driven saline groundwater discharge occurs in coastal areas as well as inland areas and poses a high risk to wetlands, surrounding native vegetation and aquatic ecosystem health. Nutrients and pesticides have been detected in most intensively farmed irrigation agriculture areas, while contamination from industrial areas is largely in urbanised areas but can also occur in regional areas (e.g. mine sites, CSG operations) (ANZECC & ARMCANZ, 2018).

The third assessment is on microbiology and investigates the coliforms and Escherichia coli levels in the boreholes and wells. The results show relatively high levels of coliforms and E. coli recorded in several boreholes and wells, suggesting that the Bonriki water reserve is contaminated from human and animal waste, and possibly similar influence from a graveyard in the vicinity. Future sampling work can confirm these preliminary findings and most importantly, monitor future trends and advise the authorities appropriately.

Furthermore, the problem of abandoned scrap metals, including old vehicles in the reserve area raise concerns over possible contamination of the underground water lenses and aquifer. The Director of Environment requested further investigation into other contaminants like metals, solid wastes, sediments, radioactivity, and related ones. The Kiribati IW R2R project does not extend its assessment to cover these "other parameters"

The preliminary results suggest a need for ongoing monitoring of the selected sites. Monitoring provides further validation and clear trends in the quality of water in the Bonriki reserve and provide accurate science advice informing strategic management and policy actions. A monitoring plan will be finalised by the R2R Technical Working Group at their next sitting.

Broader Implications and Prospects

The Kiribati IW R2R project training on water quality is one important part of managing water resources in the country. The training builds on previous efforts to increase local capacity, encourage renewed interests and commitment, and collectively work towards addressing environmental threats to water resources. Scientific research and monitoring efforts continue to provide relevant technical inputs into policy and decision-making processes.

All these efforts demonstrate the gravity of the problem and priority given by the Kiribati Government to mitigate environmental threats associated with water and sanitation. The Acting CEO of MELAD reminded participants during her opening remarks not to downweigh the importance of water quality training because the government places great importance on the sustainable management of limited water resources and minimise or avoid contamination.

Conclusion & Recommendations

Capacity building and technology transfer are important for sustainable development. These are priorities for vulnerable economies like Kiribati. Ensuring safe drinking water can only be achieved if there are mechanisms in place, local capacity and resources available, and commitment for consistent ongoing monitoring and evaluation of water resources in the country. The water quality training that successfully ended recently is one example showcasing domestic efforts to refresh and upskills stakeholders in various sectors and communities on the basics of water and sanitation.

Participants are now ready to apply their skills and knowledge to use the test kits and monitor quality of water and provide regular scientific advice wherever it is needed, such as policy discussion. The participants improved their skills and understanding on the use of water quality test kits, collected and analysed water samples in the field, further analyses of samples in the laboratory, processing and analyses of data and prepare reporting of results. Participants also put together a draft monitoring plan for future monitoring and testing of water quality at the Reserves. There may be opportunities and options from the outcomes of the training for improving and enhancing project implementation as basis for results-oriented planning for achieving project results.

The following recommendations may be useful to consider for future training: -

(i) Finalise and approve the monitoring plan for implementation;

(ii) Consider water quality training at different levels that start off with training of trainers (national), then plan for sectors and/or community training (sub-national, island community, groups);

(iii) Consider expanding future training to cover testing quality of water for other parameters such as metals, hydrocarbons;

(iv) Recognise that water and sanitation is cross-cutting and therefore must be central in strategic planning and cross-sectorally and in various communities;

(v) Water quality test kits are essential part of training and therefore need to be well stored and maintained;

(vi) Encourage use of local expertise as much as possible, and if required, supported by external expertise;

(vii) Preparing and approving a monitoring plan for water quality is important and must be regularly reviewed due to changing circumstances and situations. The monitoring plan must be accompanied by an implementation schedule (who does what and when) and approved budget.

(viii) Encourage opportunities to undertake similar training in schools or as part of the curriculum. For example, students may wish to take up major research projects that focuses on water and sanitation with emphasis of ensuring water quality remains acceptable thresholds and not contaminated.

The RPCU will continue to standby to respond to questions or inputs required during the continuation of sampling and testing of water quality. It is expected that testing for water quality will strictly follow the monitoring plan, and covering the boreholes and wells located in the demonstration sites and those in reference or control areas.

Moreover, RPCU and Consultants are expected to provide support consolidating and finalizing the workshop report and the summary of discussions. Assistance will also be provided with drafting of the monitoring plan. Support and advice will be provided where appropriate of the ongoing sampling and testing of water quality in the bore holes and wells located both in the demo sites and those in reference or control areas.

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ATTACHMENT 1: LIST OF PARTICIPANTS

R2R IW Project Water Quality Training Attendance (Alphabetical Order)					
#	Name	F	M	Ministry	Email Address/Contact
1	Alice Tekaieti	✓		Kiribati USP campus	alicetekaieti@gmail.com
2	Aobure Teatata		✓	ECD-MELAD	aobure@environment.gov.ki
3	Aritu Iotia		✓	MHMS	aritu2012@gmial.com
4	Beretekira Beero	✓		ECD-MELAD	beretekirab@gmail.com
5	Bungiia Kirata	✓		MHMS	bkirata87@gmail.com
6	David Yeeting Jr	✓		STAR IW R2R	david.yeeting@fao.org
7	Fay Tiata		✓	ECD	fayt@gamil.com
8	Gerdi Raimon	✓		ECD-MELAD	ggerdi.nam@gmail.com
9	Iliana Marama	✓		USP IAS	iliana.koroi83@gmail.com
10	Kaaroti Henry	✓		ECD-MELAD	kaarory123@gmail.com
11	Kamarawa Tamton		✓	MFMRD	kamarawat@fisheries.gov.ki
12	Kitareti Burangke		✓	MISE	k.burangke@mise.gov.ki
13	Longo Rimatu		✓	MISE	l.rimatu@mise.gov.ki
14	Ioteba Karuaki		✓	MHMS	jnineinei@gmail.com
15	Ngarennao Ateota	✓		ECD	baab.ateotaz97@gmail.com
16	Rakentai Kaiuea	✓		MELAD-ALD	soo2@melad@gov.ki
17	Rokonimaeu Eritaia	✓		MELAD-ECD	ms.eritaia@gmail.com
18	Samasoni Sauni		✓	SPC	samasonis@spc.int
19	Taina Temakei	✓		MISE	t.tamaroa@mise.gov
20	Taomarie Baraam	✓		ECD-MELAD	taomarieb@environment.gov.ki
21	Teema Biko		✓	R2R IW R2R	teemab@environment.gov.ki
22	Teniti Taam	✓		MELAD-ECD	tenitit@environment.gov.ki
23	Tiaon Tonganibeia		✓	MHMS	marisiaon@gmail.com
24	Uaekeia Tofinga	✓		MISE	ueakeiatofinga@gmail.com

14 Female Participants; **10** Male Participants

ATTACHMENT 2: SCHEDULE/ PROGRAMME OF ACTIVITIES

Day	Time	Activity	Responsible Person/s	Attendees
Day 1 (2th March)		Arrive Tarawa Check in at accommodation	**Sam, Iliana Marama**	
		Briefing with IW R2R on the objective and output of the country visit	**Sam**	Teema, Director, DD others
		Meeting with R2R team and USP-IAS to review the training modules and delivery	**Sam, Iliana Marama**	IAS-USP & RPCU/SPC, R2R, partners
Day 2 (3th March)	9 - 4	**Workshop 1:** Scoping for development of Environmental Monitoring Program (or similar) Introduction to USP-IAS and water quality assessment for R2R	**Sam** **Iliana Marama**	R2R Project staff, key project stakeholders
Day 3 (4th March)	9 – 12 1 – 4	**Workshop 2:** Introduction to WQ Monitoring and Assessment **Workshop 3:** WQ Equipment Use and Maintenance **Workshop 4:** Introduction to Field Exercise	**Sam, Iliana Marama**	R2R and ECD staff, USP-IAS
Day 4 (5th March)	9 – 4	**Field Work:** WQ data collection from Pilot site Equipment maintenance	**Sam**	R2R and ECD staff, USP-IAS
Day 5 (6th March)	9 – 12 1 – 4	**Workshop 5:** Introduction to WQ Data Analysis and Reporting **Review:** Environmental Monitoring Program	**Sam, Iliana Marama**	R2R and ECD staff, USP-IAS
Day 6 (9-11th Mar		Work with IW Project Manager on other project matters – e.g. progress implementation of activities by timelines Workshop reporting Visit to Bonriki/ Buota reserves Debriefing	**Sam, Teema** **Sam, Iliana, Teema**	
Day 6 (12th March)		Depart Tarawa	**Sam, Iliana**	

ATTACHMENT 3A: DETAILS OF BORE-HOLES AT THE BUOTA & BONRIKI WATER RESERVES

Area	No	Borehole No.	Status	GPS co-ordinates		Number of monitoring tubes (incl. pipe)
				North	East	
Buota	1	BU2	Operational	1° 23' 46.3”	173° 7' 41.1''	5
	2	BU3	Non-operational	1° 23' 41.0”	173° 7' 35.9''	----
	3	BU4	Operational	1° 23' 35.3”	173° 7' 45.1''	6
	4	BU5	Non-operational	1° 23' 41.6”	173° 7' 42.4''	----
	5	BU12	Non-operational	1° 23' 33.0”	173° 7' 53.7''	----
	6	BU13	Non-operational	1° 23' 42.9”	173° 7' 40.8''	----
	7	BU14	Operational	1° 23' 41.1”	173° 7' 36.0''	7
	8	BU15	Operational	1° 23' 36.4”	173° 7' 56.9''	7
	9	BU16	Non-operational	1° 23' 38.0”	173° 7' 45.2''	7
Bonriki	1	BN1	Operational	1° 23' 12.7”	173° 8' 48.2''	7
	2	BN2	Operational	1° 23' 9.0”	173° 8' 43.6''	7
	3	BN3	Vandalized			
	4	BN4	Non-operational	1° 23' 3.9”	173° 8' 37.0''	
	5	BN7	Non-operational	1° 23' 0.1”	173° 9' 3.3”	7
	6	BN11	Operational	1° 23' 16.8”	173° 8' 24.3”	7
	7	BN13	Operational	1° 22' 57.8”	173° 8' 59.6”	7
	8	BN15	Operational	1° 23' 4.7”	173° 8' 51.0”	7
	9	BN19	Operational			7
	10	BN20	Operational			7
	11	BN21	Operational	1° 22' 59.4”	173° 8' 28.9''	7
	12	NB22	Operational	1° 22' 56.0”	173° 8' 55.0''	7
	13	NB23	Operational			
	14	BN24	Operational	1° 23' 1.3”	173° 8' 56.1''	7
	15	BN25	Operational	1° 23' 1.3”	173° 8' 56.1''	7
	16	BN26	Operational	1° 22' 55.5”	173° 8' 24.9''	7
	17	BN27	Operational	1° 23' 2.8”	173° 8' 32.6''	7
	18	BN28	Operational	1° 23' 1.4”	173° 8' 39.2''	7
	19	BN29	Operational	1° 22' 54.1”	173° 9' 9.5''	7
	20	BN30	Vandalized			
	21	BN32	Operational	1° 22' 50.7”	173° 8' 55.9''	9
	22	BN33	Operational	1° 22' 49.9”	173° 9' 3.9''	9
	23	BN34	Non-operational	1° 23' 16.2”	173° 8' 38.4''	9
	24	BN35	Non-operational			
	25	BN36	Non-operational			

Note: Each monitoring tubes/ pipes at the bore-holes represents different level of water depths from surface. The aim is to monitor the quality of water at different depths which range from deepest of about 20m to 4m as the shallowest.

ATTACHMENT 3B: DETAILS OF BORE-HOLES IN OTHER AREAS OF NORTH TARAWA (TABUKI, TABIANG & NABEINA) AND SOUTH TARAWA (BIKENIBEY, BAIRIKI & BETIO) - ADAPTED FROM GALVIS-RODRIGUEZ ET A.. 2017.

Borehole name	GPS location		Borehole depth (mbgl)	Depth of standpipes (midpoints of 1m screens, mbgl)	Dates of drilling
	Northing	Easting			
Nabeina BH 1	1°26'17.9"	173°04'50.1"	20.7	4.5; 11.9; 19.5	06-10/04/2010
Nabeina BH 1A	1°26'17.9"	173°04'50.1"	16.5	5.8; 8.6; 15.0	12-14/04/2010
Nabeina BH 2	1°26'16.6"	173°04'51.0"	19.3	4.5; 12.0; 18.0	15-20/04/2010
Nabeina BH 2A	1°26'16.6"	173°04'51.0"	16.5	6.0; 9.0; 15.0	20-22/04/2010
Tabuki BH 1	1°25'39.7"	173°05'49.5"	20.8	6.0; 12.0; 19.5;	24-28/04/2010
Tabuki BH 1A	1°25'39.7"	173°05'49.5"	16.5	3.0; 9.0; 15.0	28-29/04/2010
Tabuki BH 2	1°25'38.3"	173°05'47.4"	19.5	6.0; 12.0; 18.0	30/04/2010-01/05/2010
Tabuki BH 2A	1°25'38.3"	173°05'47.4"	16.5	3.0; 9.0; 15.0	03-04/05/2010
Tabiang BH 1	1°26'03.8"	173°05'29.9"	23.3	6.0; 12.0; 21.8	05-09/05/2010
Tabiang BH 1A	1°26'03.8"	173°05'29.9"	18.5	4.5; 9.0; 17.0	10-11/05/2010
Tabiang BH 2	1°26'00.7"	173°05'25.0"	25.5	6.0; 12.0; 24.0	12-13/05/2010
Tabiang BH 2A	1°26'00.7"	173°05'25.0"	19.5	4.5; 9.0; 18.0	14-15/05/2010
Bikenibeu	1°21'48.7"	173°06'38.0"	25.0	3.0; 6.0; 9.0; 12.0; 15.0; 18.0; 24.0	19-21/05/2010
Bairiki	1°19'46.4"	173°58'35.5"	19.0	3.0; 5.0; 7.0; 9.0; 12.0; 15.0; 18.0	26-28/05/2010
Betio	1°21'20.1"	173°55'41.0"	24.5	3.0; 6.0; 10.0; 14.0; 18.0; 21.0; 24.0	31/05/2010-01/06/2010

ATTACHMENT 4: CERTIFICATE OF ATTENDANCE (SAMPLE)

Certificate of Attendance

This is to certify that

has completed the Training Workshop:

GEF Pacific International Waters
Ridge to Reef Water Quality Training

Held in Tarawa, Kiribati from 6 – 11 March, 2020

Mr Peter Cusack
Regional Programme Coordinator – GEF
Pacific Ridge to Reef Project, GEM - SPC

Mrs Taare Uriam Aukitino
Secretary, MELAD

ATTACHMENT 5: PACKING LIST FOR THE KIRIBATI IW R2R WATER QUALITY TRAINING

Item	QTY	Pre-Depart	In country	Return
Black casing				
ProDSS-10 Meter 4 port Cable Assembly	1			
Black Backpack				
Stopwatch	2			
Ziplock bag	4			
Sample bottle	1			
Folding bucket	1			
Measuring tape	1			
Extech TISAB tablet	1			
EC standard solution – 400 mL	1			
Turbidity standard solution – 500 mL	2			
Blue Backpack				
pH buffer – 7.00 (1 litre)	1			
pH buffer – 4.00 (1 litre)	1			
pH buffer – 10.01 (1 litre)	1			
Conductivity standard solution (1 litre)	1			
Zobell's solution (250 mL)	2			
Secchi disk	1			
Hydrometer	1			
Fluoride meter	1			
Backpack lab manual	1			
Luggage Bag				
Carbon dioxide Test Kit	1			
Alkalinity Test Kit	1			
Salinity Test Kit	1			
DO Test Kit	1			
Acidity Test Kit	1			
Nitrate Reagent 2 Test Kit	1			
Nitrite Reagent 2 Test Kit	1			
Phosphate Reagent Test Kit	1			
Ammonia Reagent Test Kit	1			
YSI Pro Plus 4M	1			

YSI Pro Comm II Kit	1			
YSI polar graphic DO sensor	1			
Colorimetric	1			
Handheld colorimeter – phosphorus	1			
Waterproof tester	2			
Sodium sulphite for zero DO (50 g)	1			
Scissors	1			
Batteries:				
Idc battery	8			
CSi	4			
AA	6			
AAA	4			

ATTACHMENT 6: GUIDELINE VALUES FOR DETERMINANDS/ PHYSICAL OR CHEMICAL STRESSORS FOR ECOSYSTEMS LIKE UNDERGROUND WATER LENSES OR AQUIFERS.

Determinands	Guideline Value (GV)	Max. acceptable value (MAV)	Unit	Remarks	Source
Ammonia (NH_4)	0.1		mg/ L	aesthetic	ANZECC & ARMCANZ. (2000)
	10.0		µg/ L		ANZECC & ARMCANZ (2018)
pH	7.0 – 8.5			< 8 preferred; aesthetic	ANZECC & ARMCANZ. (2000)
	6.0 – 8.0			upper & lower limit	ANZECC & ARMCANZ (2018)
Turbidity	2.5		NTU		ANZECC & ARMCANZ (2010)
[6]Nitrate, short-term		50	mg/ L	Inorganic	ANZECC & ARMCANZ (2018)
Nitrite, short-term		0.2	mg/ L	Inorganic	ANZECC & ARMCANZ (2018)
Nitrite, long-term		3.0	mg/ L	Inorganic	ANZECC & ARMCANZ (2018)
Nitrite	10		µg/ L	Default trigger value	
Salinity[7]	90 - 900		mg/ L	Lakes, reservoirs wetlands; nutrient concentration	ANZECC & ARMCANZ (2018)
	1,500		µS/cm	Kiribati acceptable upper limit; conductivity	Galvis-Rodriguez *et al*. (2017)
Turbidity	2 - 200		NTO		
E. coli		< 1	Per 100mL	Micro-organisms	
Total Nitrogen (TN)	10		µg/ L	Default trigger value	

https://www.waterquality.gov.au/guidelines/anz-fresh-marine

[6] Results of nutrient analyses can be reported in two ways – as the whole compound or as the principal element in the compound. For example, nitrate may be reported as nitrate (NO3) or nitrate as nitrogen (NO3-N). When assessing results against guidelines and standards, or when comparing data from different sources, it is important to compare like with like and convert the results if needed.

[7] Default trigger value for electrical conductivity of water that increases/ decreases with salinity (EC, salinity) varies between places. The unit of measurement for conductivity is siemens (S) per unit of length of water that the current is passed through. The Kiribati DC adopted a salinity threshold of 1,500 micro siemens per centimetre (µS/cm) as the acceptable upper limit for portable use of water. Higher values than the threshold is considered unacceptable for potable use of water pumped from the Bonriki Water Reserve Treatment/ Storage facility.

ATTACHMENT 7
EVALUATION ASSESSMENT (AVAILABLE SEPARATELY)

ATTACHMENT 8
DRAFT IW R2R WATER QUALITY MONITORING PLAN FOR BUOTA & BONRIKI WATER RESERVES (AVAILABLE ON REQUEST)

ATTACHMENT 9
TRAINING MATERIALS (ONLY AVAILABLE ON REQUEST AND WITH CONSIDERATION OF THE RPCU-SPC & ECD-MELAD)