S4.8-1 STRATEGIC IMPLEMENTATION PLAN

Solomon Islands Water Authority

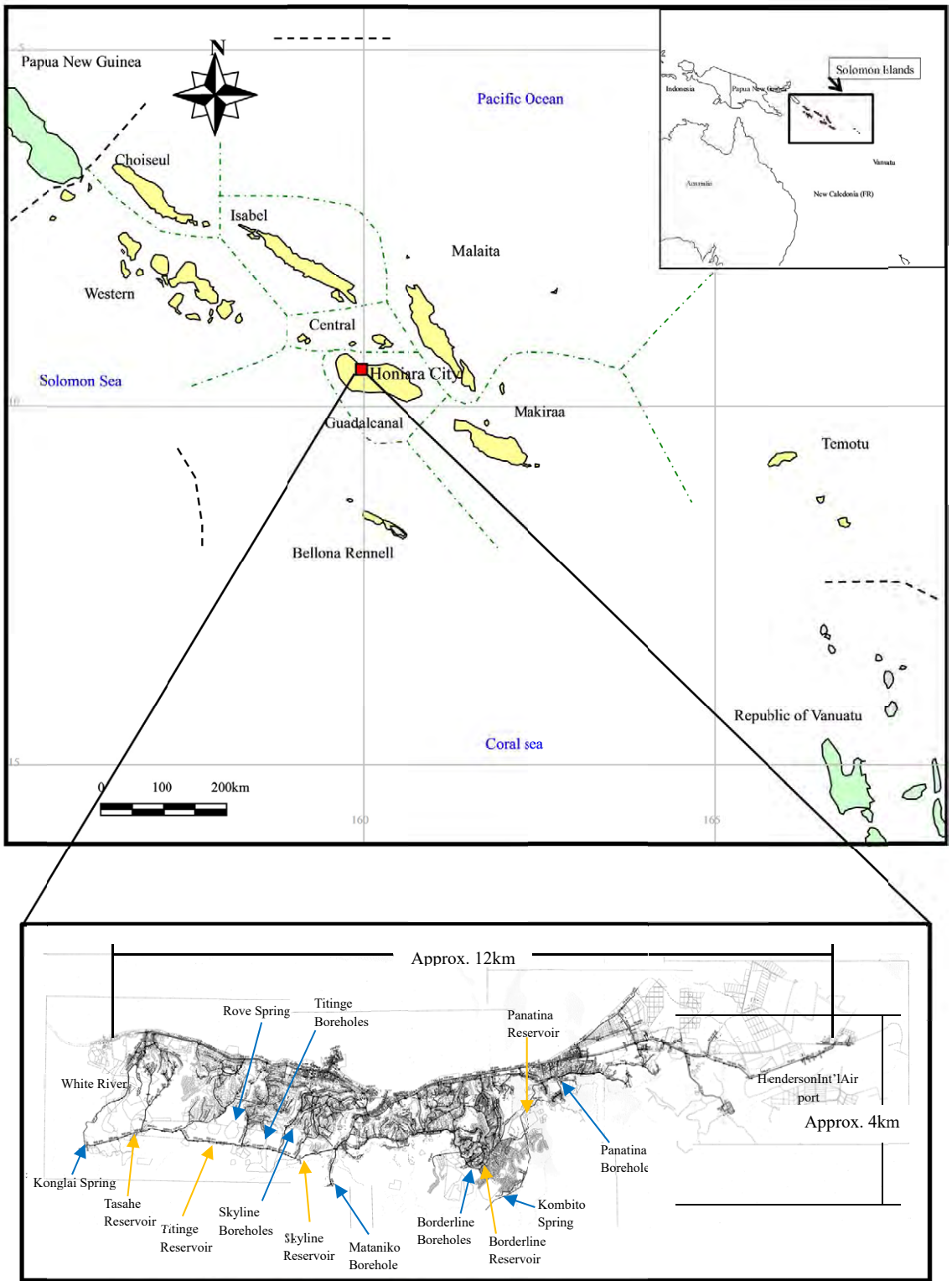
Japan International Cooperation Agency

The Project
for
Improvement of Non-Revenue Water Reduction Capacity
for
Solomon Islands Water Authority
in Solomon Islands

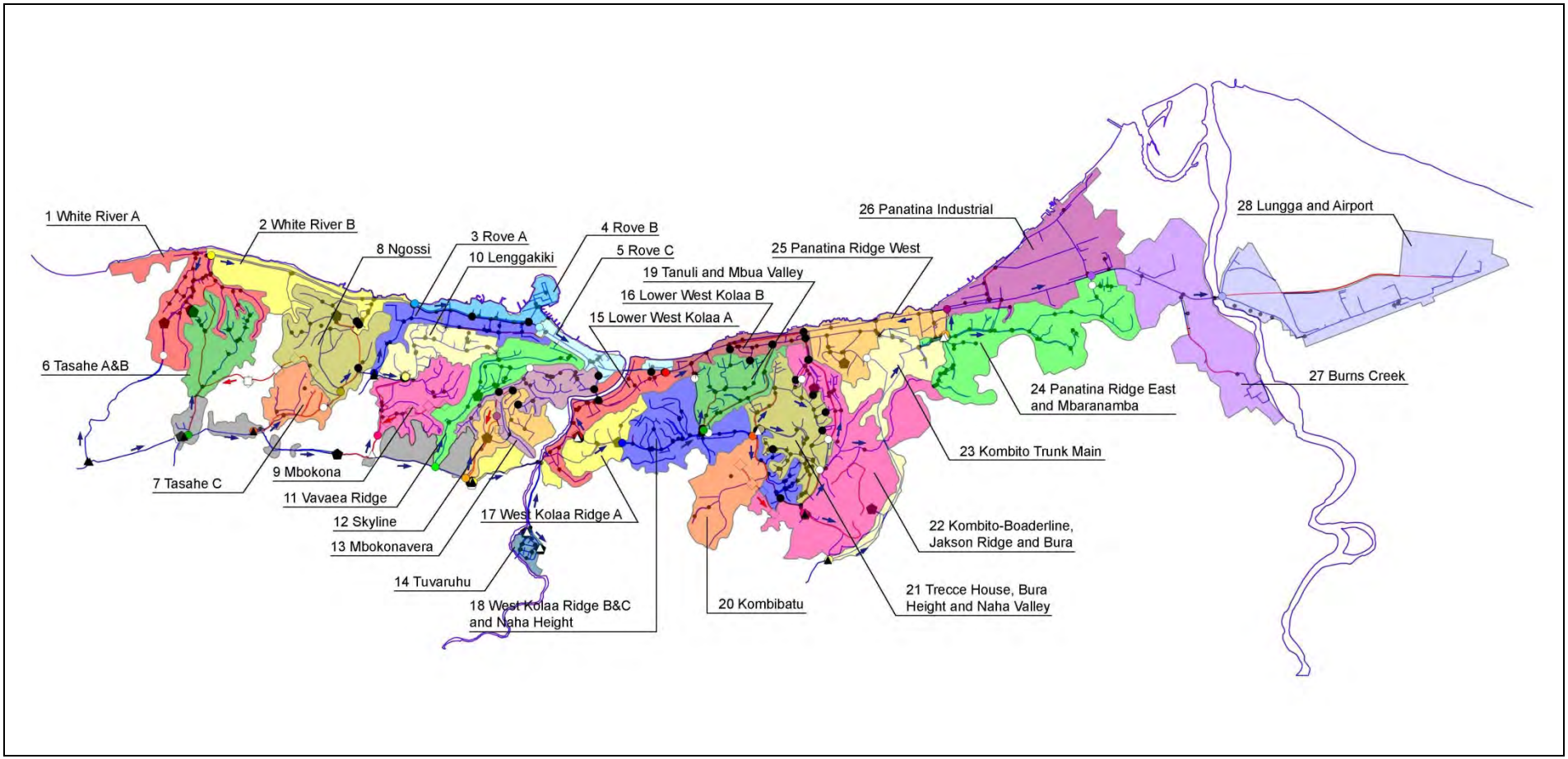
Strategic Implementation (Rolling-out) Plan

June 2016

Prepared by Project Team



Location Map of Honiara City and Main Water Supply Facilities



Location Map of the DMAs

ABBREVIATION

CPI	Consumer Price Index
DFAT	Department of Foreign Affairs and Trade of Australian Government
DI	Ductile Cast Iron
DMA	District Metered Area
GIS	Geographic Information System
GP	Galvanized Pipe
IWA	International Water Association
JICA	Japan International Cooperation Agency
LCZ	Leakage Control Zone
LCD	Liter per Capita per Day
MMERE	Ministry of Mines, Energy and Rural Electrification, Solomon Islands
MNF	Minimum Night Flow
NRW	Non-Revenue Water
NZ	New Zealand
OJT	On-the-Job Training
PCZ	Pressure Control Zone
PDCA	Plan-Do-Check-Action
PRV	Pressure Reducing Valve
PVC	Polyvinyl Chloride
SIV	System Input Volume
SBD	Solomon Islands Dollar
SW	Solomon Water (Solomon Islands Water Authority: SW)

Table of Contents

Location Map of Honiara City and Main Water Supply Facilities
Location Map of the DMAs
Abbreviation

Foreword **1**

CHAPTER 1 Objective of NRW Reduction **2**
1.1 Background and Objective of NRW Reduction 2
1.2 Mid-Term Goal of NRW Reduction 2

CHAPTER 2 Definitions of Terms **4**
2.1 Non-Revenue Water (NRW) 4
2.2 District Metered Area (DMA) 4
2.3 Leakage Control Zone (LCZ) 4
2.4 Pressure Control Zone (PCZ) 4

CHAPTER 3 Result of the Pilot Projects and Lessons Learnt **6**
3.1 Outline of the Pilot Project 6
3.2 Result of the Pilot Project 6
3.3 Current Issues 7
3.4 A Tendency for the Causes of NRW and Feature of Pilot Area 8
3.5 Lessons Learnt 9

CHAPTER 4 Implementing Structure **11**
4.1 Organization Chart 11
4.2 Role of Team Member 13

CHAPTER 5 Target Areas of NRW Reduction Activities **16**
5.1 Target Water Supply Facilities 16
5.2 Creation of DMAs 16
5.3 Feature of DMAs 16

CHAPTER 6 Implementation Process **19**
6.1 Priority of Implementation 19
6.2 Implementation Process 20

CHAPTER 7 Contents of Overall Activities **22**
7.1 Formulation of Action Plan 22
7.2 Procurement of Equipment 22

7.3 Preparation Work 23
7.4 Primary NRW Reduction Activities 23
7.4.1 Measuring NRW before Countermeasure 23
7.4.2 Countermeasure of NRW Reduction 24
7.4.3 Measuring NRW after countermeasure of NRW Reduction 25
7.5 Monitoring & Maintenance Work 25
7.5.1 Monitoring 25
7.5.2 Evaluating 25
7.5.3 Maintaining 25
7.5.4 Evaluating 27

CHAPTER 8 Cost-Effectiveness Analysis 28
8.1 Cost Estimate for NRW Reduction Activities 28
8.2 Allocation of Budget for NRW Reduction Activities 29
8.3 Estimation of Benefits by NRW Reduction Activities 29

CHAPTER 9 Implementation Schedule 31

CHAPTER 10 Project Management 32
10.1 PDCA 32
10.2 Weekly Meeting 33
10.3 Periodical Workshop 33
10.4 Annual Report 33

Foreword

One of major challenges which water utilities are faced with is reduction of water losses such as leakage and illegal use of supplied water, commonly known as “Non-Revenue Water (hereinafter “NRW”)”.

Solomon Water (hereinafter “SW”) has struggled with high NRW ratio and achieved a certain reduction of NRW through pilot projects under “the Project for Improvement of Non-Revenue Water Reduction Capacity for Solomon Islands Water Authority in Solomon Islands” (hereinafter “the Project”) assisted by Japan International Cooperation Agency (hereinafter “JICA”), This is carried out in collaboration with the Solomon Water Development Plan, 2013-2015 also known as “the Two-Year Plan” sponsored by the Department of Foreign Affairs and Trade of Australian Government (hereinafter “DFAT”). Furthermore, SW’s capacity in NRW reduction has been developed through a variety of lectures, workshop and on-the-job trainings throughout the process of the Project implementation.

As an output of the Project, the Strategic Implementation (Rolling-out) Plan (hereinafter “the Plan”) was prepared in order to expand NRW reduction activities into the whole of Honiara City and for the continuous implementation for the years to come and is subjected to be revised periodically as necessary.

It is with the hope that the Plan contributes to decision making by SW’s management, and also to see that SW’s staff can perform the activities reliably and efficiently, on the condition that SW’s management provides the necessary support and sufficient budget allocation for sustainability.

CHPTER 1 Objective of NRW Reduction

1.1 Background and Objective of NRW Reduction

1) Background

In 2010, Solomon Water was faced with an account deficit of SBD5,046,000 and the operational revenue-to-expenditure ratio was 84.7%, due to reasons such as high Non-Revenue Water (hereinafter "NRW") ratio reaching 56% in 2011, high electricity bills and an unsuitable water tariff. Although NRW reduction was a key to financial improvement, SW had no systematic plan but engaged only on repairing surface leaking pipes only when reported. SW also lacked in the capacity of NRW reduction including planning, leakage control and illegal connection regulation, etc.

Consequently, "The Project for Improvement of Non-Revenue Water Reduction Capacity for Solomon Islands Water Authority in Solomon Islands" (hereinafter "the Project") by JICA Expert Team and Counterparts was commenced in October 2012 for a period of 3 years and to be concluded in June 2016.

At the end of March 2015, NRW reduction activities at 15 Pilot Projects areas have been completed. The Project then proceeded to two District Metered Areas (hereinafter "DMAs"), utilizing the experiences and the lessons learnt through the Pilot Project.

2) Objective of NRW Reduction

Large quantity of NRW has resulted in deficit account and interruptions to the water supply service. In other words, SW could not provide appropriate water supply service to its users due to lack of adequate supplied water quantity and low water pressure, etc.

Therefore, in order to improve water supply service and to achieve a sound financial management NRW must be reduced significantly.

1.2 Mid-Term Goal of NRW Reduction

It was verified that NRW ratio had been reduced to about 18% as an average for the 15 pilot areas and the two DMAs (Tasahe A&B and West Kola Ridge A). However, even though countermeasures or NRW reduction activities are implemented in these particular areas, NRW recurs. Therefore, SW must continue monitoring and maintenance activities to maintain low NRW or to reduce even further as much as possible. Table 1.1 shows various options for the overall goal on NRW ratio by the year of 2025 as the mid-term (the next 10 years from now on). As shown in Annex 4, five teams from the Task Force will perform the primary NRW reduction activities in all the DMAs and will complete by the end of 2017. Out of 28DMAs, six groups were provisionally setup in the NRW Action Team and have started conducting NRW reduction activities to strengthen the capacity of staff members and other key counterparts.

It is likely that leakage and or other water loss may recur in some parts of the pipelines, therefore monitoring and maintenance activities are necessary in 2016 and 2017. Afterward, five Teams of the

Task Force of NRW reduction activities will efficiently take on monitoring and maintenance work to continue maintaining the areas where the primary NRW reduction activities have been previously being implemented.

Accordingly, Option 2 is preferable for the overall goal of NRW ratio for the mid-term.

Table 1.1 Mid-Term Goal of NRW Ratio

Option	NRW Ratio (%)												Trend
	Current	Future											
	2014	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	***2025***	
Option 1	62.8	53.4	43.9	36.8	25.0	25.0	25.0	25.0	25.0	25.0	25.0	**25.0**	NRW reduction activities will be carried out with enough manpower and budget until the year of 2018 and monitoring and maintenance work will indeed be carried on in future. Calculation Basis: Same rate between 2018 and 2025.
Option 2	62.8	59.6	56.4	53.2	50.0	46.4	42.9	39.3	35.7	32.1	28.6	**25.0**	NRW ratio will be reduced to 50% through the primary NRW reduction activities until the year of 2018. NRW ratio will gradually be reduced 25% with sufficient Monitoring & Maintenance by 2025. Calculation Basis: Proportional rate between 2018 and 2025.
Option 3	62.8	59.6	56.4	53.2	50.0	45.0	40.0	45.0	40.0	35.0	30.0	**35.0**	NRW ratio will be reduced to 50% through the primary NRW reduction activities until the year of 2018. Since recurrence of NRW is relatively high, NRW ratio will gradually be reduced 35% by 2025. Calculation Basis: Increasing and decreasing by 5 points between 2018 and 2025.
Option 4	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	**62.8**	NRW reduction activities will be suspended, so NRW ratio will not be reduced. Calculation Basis: Same ratio for all years
Option 5	62.8	59.6	56.4	53.2	50.0	55.0	50.0	55.0	50.0	55.0	50.0	**50.0**	NRW ratio will properly be reduced by the year of 2018 but NRW reduction activities will not systematically be carried out even after 2019. Calculation Basis: Increasing and decreasing by 5 points between 2018 and 2025.

Source: Project Team

CHPTER 2 Definition of Terms

2.1 Non-Revenue Water (NRW)

Table 2.1 shows the IWA standard international water balance and terminology. NRW is composed of unbilled authorized consumption, apparent and real losses.

Table 2.1 IWA Water Balance

<table>
<tr><td rowspan="10">Water Production</td><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered consumption</td><td rowspan="7">Non Revenue Water (NRW)</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized consumption (incl. illegal connections)</td></tr>
<tr><td>Metering inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on transmission and/or distribution networks</td></tr>
<tr><td>Leakage and overflow at utility’s storage tanks</td></tr>
<tr><td>Leakage on service connections to customer meters</td></tr>
<tr><td colspan="5">Treatment Losses (Backwash, etc.) and Evaporation</td></tr>
</table>

Source: IWA

2.2 District Metered Area (DMA)

“District Metered Area (DMA)” is defined as a discrete area of a distribution system permanently created by isolation or the complete disconnection of pipe work in which the quantities of water inflow and outflow are metered (see Figure 2.1). The water flow is analyzed to quantify NRW. In this way, it is possible to determine more precisely where and when it is most beneficial to undertake NRW reduction activities.

2.3 Leakage Control Zone (LCZ)

“Leakage Control Zone (LCZ)” introduced specially in Solomon Water is defined as a discrete zone of a distribution system tentatively created for implementation of countermeasures such as active leakage control against leakage (rather NRW) (see Figure 2.1). The discrete zones can be created by isolation or the complete disconnection of pipe work in which the rate of water inflow and outflow are metered temporarily.

The Project assumes each DMA consists of a number of LCZs, but that may be not always the case because of DMA size or configuration of network.

2.4 Pressure Control Zone (PCZ)

One of important factors in lowering and subsequently maintaining a low level of NRW ratio in a water network is “Pressure Control”. The division of network into DMAs facilitates the creation of a permanent pressure control system, thus enabling pressure reduction in DMAs which reduces the level

of background leakage, the flow rate of individual bursts and the annual burst frequency.

SW has already set up seven zones in six DMAs as "Pressure Control Zones (PCZs)" in which Pressure Reducing Valves (PRVs) will be installed and other remaining zones as "Non Pressure Control Zones (Non-PCZs)" in 22 DMAs in Honiara City. Their locations are shown in Table 2.2. Figure 2.1 shows a conceptual location drawing of a bulk flow meter, DMA flow meter, PRV in DMAs and or LCZs.

Table 2.2 Pressure Control Zones or Non Pressure Control Zones in Honiara City

No	DMA	PCZ / Non PCZ	Number of Zones where PRV is installed	No	DMA	PCZ / Non PCZ	Number of Zones where PRV is installed
1	White River A	Non-PCZ		15	Lower West Kolaa A	Non-PCZ	
2	White River B	Non-PCZ		16	Lower West Kolaa B	Non-PCZ	
3	Rove A	Non-PCZ		17	West Kolaa Ridge A	Non-PCZ	
4	Rove B	Non-PCZ		18	West Kolaa Ridge B & C and Naha Height	Non-PCZ	
5	Rove C	Non-PCZ		19	Tanuli & Mbua Valley	PCZ	1
6	Tasahe A and B	PCZ	2	20	Kombibatu	Non-PCZ	
7	Tasahe C	Non-PCZ		21	Trecce House, Bura Height and Naha Valley	Non-PCZ	
8	Ngossi	PCZ	1	22	Kombito-Borderline, Jakson Ridge and Bura Valley	Non-PCZ	
9	Mbokona	PCZ	1	23	Kombito Trunk Main	Non-PCZ	
10	Lenggakiki	Non-PCZ		24	Panatina Ridge East	Non-PCZ	
11	Vavaea Rigde	PCZ	1	25	Panatina Ridge West	Non-PCZ	
12	Skyline	Non-PCZ		26	Panatina Industrial	Non-PCZ	
13	Bokonavera	PCZ	1	27	Burns Creek	Non-PCZ	
14	Tuvaruhu	Non-PCZ		28	Lungga and Airport	Non-PCZ	
Total		**Number of DMAs with PCZs**				**6**	
		Number of DMAs with Non-PCZs				**22**	
		Number of Zones where PRV is installed				**7**	

Source: Project Team

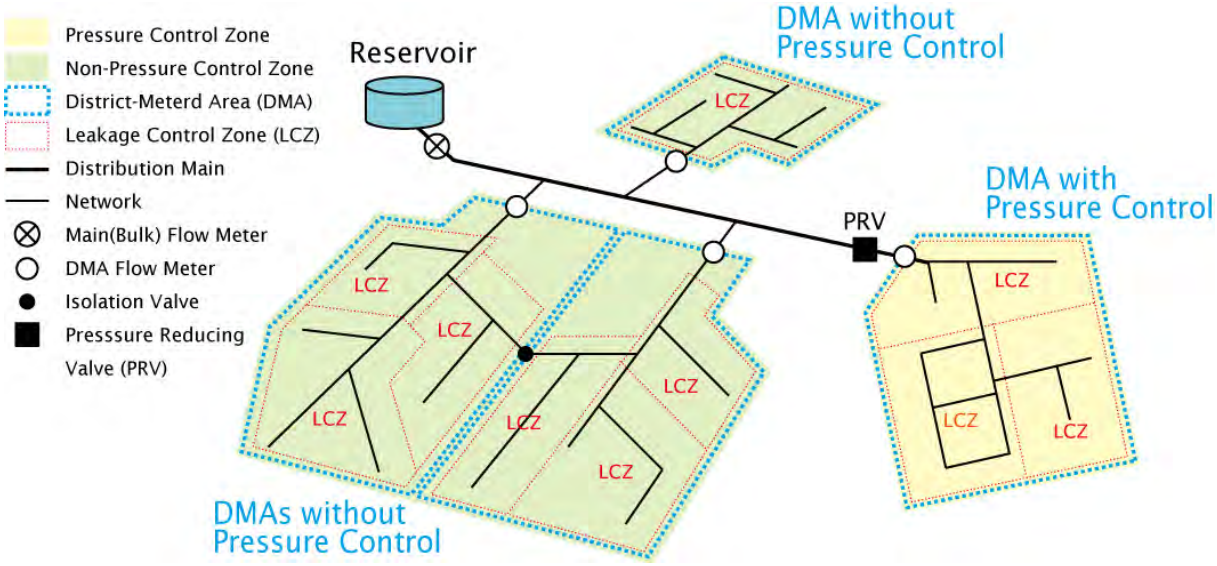


Figure 2.1 Conceptual Drawing of DMA, LCZ and Pressure Control Zone (PCZ) /Non-PCZ

CHPTER 3 Result of the Pilot Projects and Lessons Learnt

3.1 Outline of the Pilot Project

The 15 Pilot Projects target mainly residential areas where 40 to 70 households were served through distribution network, which is approximate 25mm to 150mm in pipe diameters and 1.0km to 1.5km in length. Also these are areas where Minimum Night Flow survey could be conducted efficiently.

The Project Team selected the areas suitable for the implementation of Pilot Project based on the following selection criteria

1) Easy isolation from surrounding area with existing valves.
2) Drawings or GIS maps are available to show location of the valves.
3) Distribution flow is enough and stable.
4) Size of the areas is suitable for easy monitoring.
5) Residential areas where 100 households as optimum size are located are preferable for the OJT.
6) Dendritically-expanded distribution networks are preferable.
7) Distribution pipelines are 150 mm or less in diameter and 1.0 to 1.5km in length.

Basic data such as pipe material, diameter, location, base map on water distribution networks, and number of households, etc. were collected at the beginning of the selection of Pilot Project areas.

3.2 Result of the Pilot Project

All of the Pilot Projects succeeded in reducing NRW according to the Project purpose. Result of the 15 Pilot Projects is reported as follows:

Table 3.1 Change in NRW Ratio between Before and After Countermeasures

No	Site No.	Site Name	Pipe Distance (m)	Households	1st Trial			2nd Trial (Follow-up)	
					Before	After	Reduction Point	After	Reduction Point
1	No.9	White River-NamoRuka	1,063.23	83	86.5%	32.2%	54.3	-	-
2	No.10	Independence Valley	2,184.45	91	57.7%	9.9%	47.9	-	-
3	No.3	Lenggakiki	2,481.38	161	62.0%	33.2%	28.8	14.7%	47.3
4	No.5	Mbokonavera-1	1,104.12	76	53.1%	14.7%	38.5	-	-
5	No.14	Tuvaruhu-1	1,205.88	47	65.4%	41.4%	24.0	11.0%	54.4
6	No.15	Tuvaruhu-2	1,371.31	62	67.2%	20.5%	46.7	-	-
7	No.6	Vavaya Ridge	1,298.15	163	63.1%	27.2%	35.8	-	-
8	No.4	Mbokona	1,418.66	110	50.2%	19.2%	31.0	-	-
9	No.8	Mbaranamba	1,512.29	100	23.2%	3.5%	19.7	-	-
10	No.2	Mbua Valley	1,989.95	122	50.9%	6.8%	44.1	-	-
11	No.11	BahaiKukum	1,691.80	182	58.6%	16.2%	42.4	-	-
12	No.7	Panatina Valley	885.12	60	37.9%	6.7%	31.2	-	-
13	No.12	Naha 2	785.93	57	51.7%	15.6%	36.1	-	-
14	No.13	Naha 3	959.63	67	60.9%	25.8%	35.1	-	-
15	No.1	FFA Kola Road	2,275.52	82	47.1%	14.9%	32.2	-	-

No	Site No.	Site Name	Pipe Distance (m)	Households	1st Trial			2nd Trial (Follow-up)	
					Before	After	Reduction Point	After	Reduction Point
Total			**22,227.42**	**1,463**					

Source: Project Team

3.3 Current Issues

1) Legalization of Illegal Connections

The number of illegal connections that have been converted to legal accounts through proper SW procedure was 27.1% of the total illegal connections in the 15 pilot project areas. Reasons behind the illegal connection include but not limited to the fact that water users are not satisfied with the high water tariff and its frequent increase, which resulted in cases of non-payment of bills and even illegal connections. It is essential that SW develops an appropriate water tariff structure and a continuous commitment to improve the water supply facilities and services. In addition, it is important to raise awareness of users bring about a better understanding on the importance of water conservation and other important aspects involving supplying of good quality water so as to eliminate illegal connection.

2) Increase in Customers

While there are newly-authorised or disconnected service users as part of NRW reduction activity, there are a certain number of customers disconnected by SW due to unpaid bills which is apart from the NRW reduction activities. Consequently, the NRW reduction activities could not always achieve the net increase in the number of customers in pilot areas as it has hoped for. One of the common reasons behind the arrears is customer's complaint against water tariff.

NRW reduction activities can contribute to reducing the quantity of NRW as well as potentially increase the number of customers and thus revenue. However, from experience in the pilot areas, it was a challenge to maintain or increase the number of customers mainly due to reason stated above. To avoid losing customers, it is essential that SW carries on awareness activities to obtain water user's understanding on the water tariff and beneficiary-pay in principle. Moreover, it is crucial to develop an appropriate water tariff structure and to commit to improve the water supply facilities and services.

3) NRW Reduction in DMAs and DMA-based Monitoring and Maintenance

SW has implemented NRW reduction in some of the 28 DMAs, and two DMAs have already been worked on by the Project team. However, SW currently does not have a concrete framework for DMA-based monitoring and maintenance of NRW, which is necessary to maintain the NRW ratio at a reduced level or even further reduction after the initial NRW reduction activities. The reason is that the present organizational structure of SW is still not robust in terms of the following points:

- Overconcentration of leadership to particular staff
- Non-existence of a dedicated section for periodical monitoring in DMAs after NRW reduction

- Inadequacy of manpower to monitor illegal connections on a regular basis
- Inadequacy of skilled manpower for hydraulic analysis

For this case, SW's G.M. has pledged his commitment to see that SW organisational structure would be reformed by the end of November 2015 in order to improve water supply service, to operate & maintain water supply facilities and conduct NRW reduction activities efficiently.

4) Appointment of the Proper Management

According to the Terminal Evaluation, the Project experienced frequent changes of the Counterpart members, especially at the management level, which causes delay in decision-making and implementation of some activities. It is desirable that SW should take immediate actions to cover the vacant positions to ensure that the task continues.

3.4 A Tendency for the Causes of NRW and Feature of Pilot Area

Correlation between causes of NRW and feature of the Pilot Areas is summarized in this section.

1) Definition of Correlation

Causes of NRW and feature of area for the 15 pilot project areas were plotted in graphs. If coordinates such as '(1, 1)', '(2, 2)' and '(3, 3)' on diagonal line is defined as correlation, percentage indicated in the graph stands for a tendency of correlation between causes of NRW and feature of area.

2) Feature of Area

Feature of areas is composed of the followings:

a. Percentage of low income group[1]
b. Frequency of monitoring due to distance from Solomon Water
c. Percentage of existence of non-public road
d. Number of Non-community[2]
e. Water pressure
f. Percentage of deteriorated pipes

3) Causes of NRW

It is found that causes of NRW are in the following order; first one is leakage, second one is water meter inaccuracy including unbilled authorized and third one is illegal connection. In the 15 pilot projects and the two DMAs, leakage, meter inaccuracy and illegal connections makes up about 87%, 9% and 4% respectively of the total NRW on an average.

4) Correlation between Causes of NRW and Feature of Area

Based on the pilot activities in the 15 pilot areas and two DMAs, it was observed that there exist relatively correlations between causes of NRW and feature of areas. They are as follow.

a. Leakage with 'e', 'f' and 'c' of the above feature.

[1] Daily expense of SBD6 per capita
[2] Any public group which is established for sports, church, etc.

b. Water meter inaccuracy with ‘b’ and ‘d’ of the above feature.

c. Illegal connection with ‘a’, ‘b’ and ‘c’ of the above feature.

Correlation between Causes of NRW & Feature of Area and its breakdown is shown in Table 3.2 and in Annex 6 respectively. The highest correlation rate (47.1%) was observed in three patterns between causes of NRW & feature as shown in Table 3.3. It is recommended that the NRW Team takes action in accordance with the correlation between causes of NRW and feature of areas in order to reduce NRW effectively and efficiently.

Table 3.2 Correlation between Causes of NRW & Feature of Area and its Composition

Causes of NRW / Feature of Area	Illegal	Meter Inaccuracy	Leakage
Percentage of Low Income Group	35.3%		
Frequency of monitoring due to distance from Solomon Water	47.1%	35.3%	
Percentage of existence of non-public road	35.3%		47.1%
Number of Non-Community		41.2%	
Water Pressure			35.3%
Percentage of deteriorated pipes			47.1%

: High Correlation Rate

: Moderate Correlation Rate

: Relatively Low Correlation Rate

Source: Project Team

Table 3.3 Top Percentage in High Correlation between Causes of NRW and Feature of Area

Causes of NRW	Feature of Area	Correlation Rate	Description
Leakage	Percentage of existence of non-public road	47.1%	Leakage is higher on non-public road than public road.
Leakage	Percentage of deteriorated pipes	47.1%	As the existing pipe is deteriorated, leakage is high.
Illegal Connection	Frequency of monitoring due to distance from Solomon Water	47.1%	As location of the existing pipe is far from Solomon Water, illegal connection is high, because of low frequency of patrol.

Source: Project Team

3.5 Lessons learnt

In addition to the correlation above between causes of NRW and features of area, the NRW Action Team has also learnt the importance of the following viewpoints through the Pilot Projects. In order to effectively implement the NRW reduction activities in DMAs, the lessons learnt should be put into practical use.

- Results of activities are recorded clearly and shared with staff members enabling them to proceed to the process efficiently.

- Proper data collection is important to analyze IWA water balance.
- Team members must be committed and corporate together to work properly and within time schedule.
- It is important to have communication between Sub-Teams* continuously.
- Supervisors are instrumental in identifying areas that lack capacity within their team and in requesting for capacity development.
- Workshop and OJT is seen as very important in capacity development of staff that would lead to long term sustainability of the Project.
- More than one staff must be able to do certain jobs to ensure that work continues even if one staff is absent.
- Field teams are more confident in performing NRW reduction activities as well as become familiar with important system features and their functions such as bulk meters, air valves, sluice valves etc.
- Team leaders should have daily meetings with field staff to motivate them to continue to maintain high perform amongst staff members.

*NRW Action Team was composed of Technical Sub-Team, Customer Service Sub-Team, GIS Sub-Team and Leakage Detection Sub-Team in the pilot projects of NRW reduction.

CHPTER 4 Implementing Structure

4.1 Organization Chart

Current organization chart of SW is shown in Annex 1. At present, there is no dedicated section and or teams in charge of NRW reduction. For example, all the SW's technical staffs belong to Planning & Operation Division and are working on general technical matters on water supply service. Since SW has been facing high NRW ratio, NRW reduction activities must be prioritized and a dedicated team should be established to focus only in reducing NRW.

SW has reformed the organization so as to carry on NRW reduction activities to reduce NRW ratio as much as possible. The structure of the reformed organization which the Project Team suggested is shown in Annex 2. As shown in Figure 4.1, A task Force for NRW reduction activities will be setup in the reformed SW's organization.

It is anticipated that Planning Team, Monitoring Team, Maintenance Team, Finance Team and Customer Care & Communication Team will be part of the Task Force members. They will be deployed in the Planning & Operation Division (Figure 4.2), and Finance & Administration Division (Figure 4.3) and Customer Care & Communication Division (Figure 4.4) respectively in the organization. Planning Team, Monitoring Team and Maintenance Team will be dedicated to implement the NRW reduction activities, while Finance Team and Customer Care & Communication Team will be engaged with not only NRW reduction activities but also other regular works.

Six candidates of a Task Force leader who are current key persons in the NRW reduction pilot project will be appointed. The Task Force leader will be rotated yearly or every two years among six members. Members of the Task Force in the Planning Team, Monitoring Team and Maintenance Team work on NRW reduction exclusively, but other Task Force members in the Finance Team and Customer Care & Communication Team also take up general routine work on NRW. The Monitoring Team compiles the result of the analysis, the data and records of DMA-based monitoring and maintenance while receiving the support from the Task Force Leader.

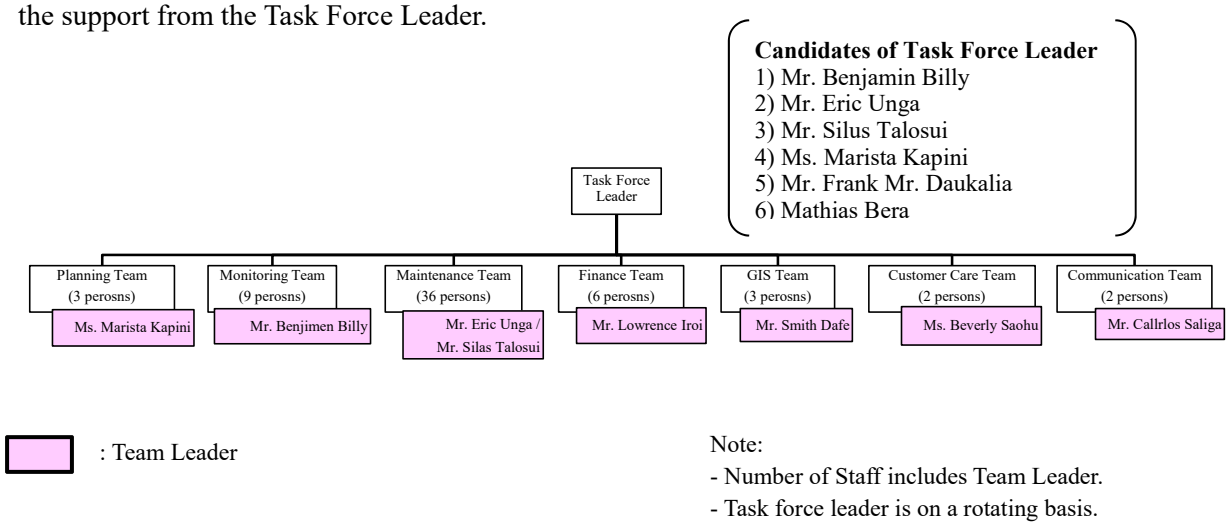
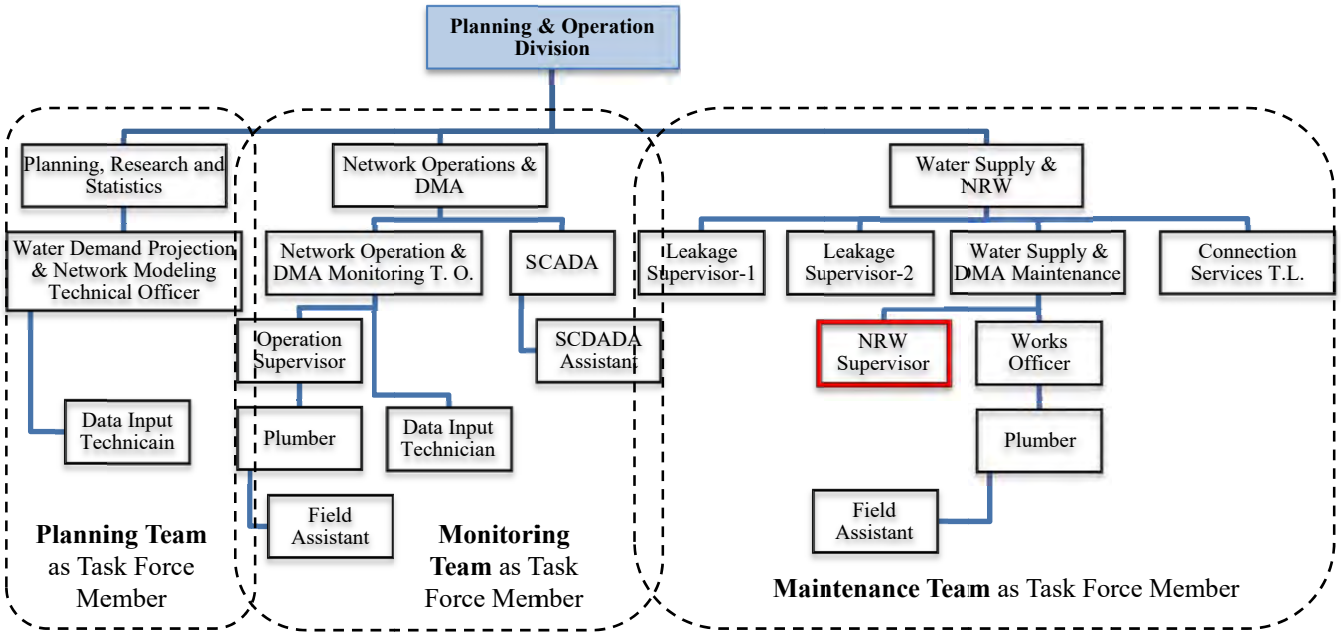


Figure 4.1 Composition of Task Force (Proposed)



: NRW Supervisors consist of six staff who take up a Task Force Leader.

Figure 4.2 Task Force Members of the NRW Reduction in Planning & Operation Division (Proposed)

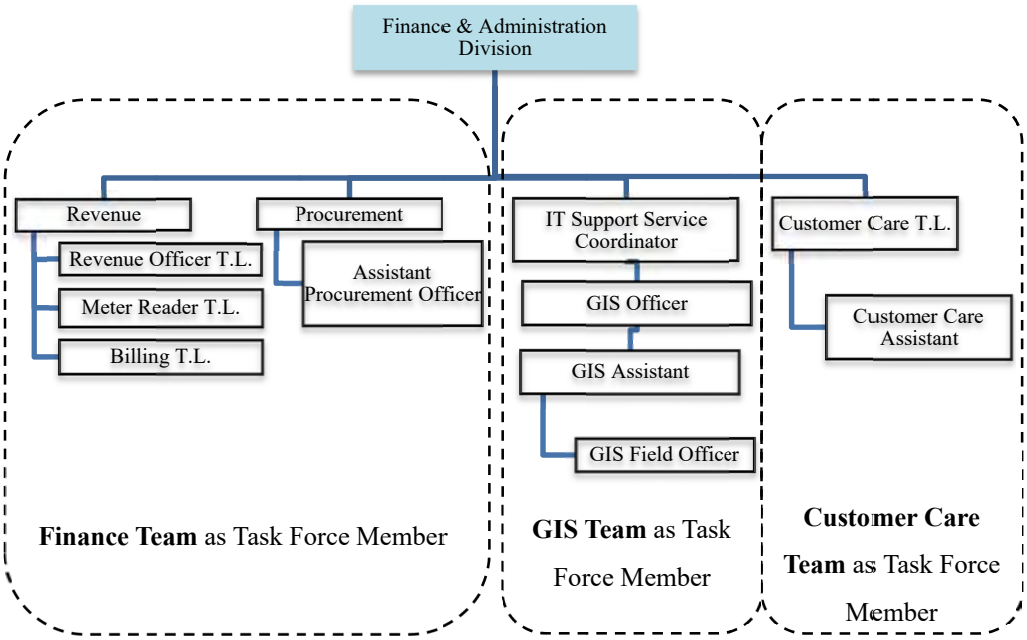


Figure 4.3 Task Force Members of the NRW Reduction in Finance & Administration Division (Proposed)

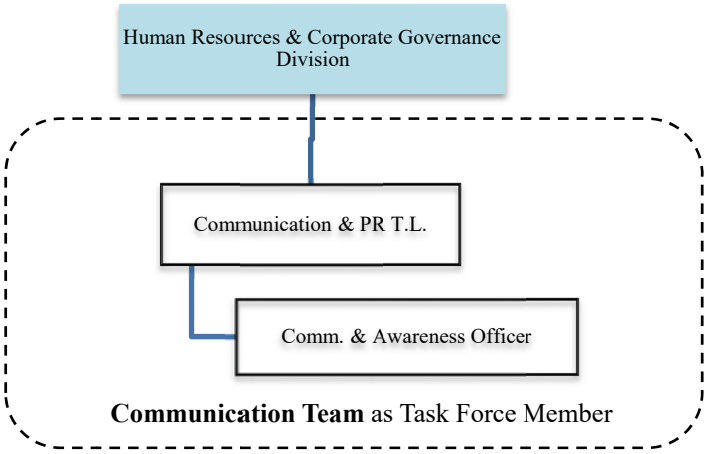


Figure 4.4 Task Force Members of the NRW Reduction in Human Resources & Corporate Governance Division (Proposed)

4.2 Role of Team Member

Roles of the departments are composed of the following five tasks:

- Formulation of Annual Action Plan
- Procurement of Equipment
- Preparation Work
- Primary NRW Reduction Activities
- Monitoring & Maintenance Work

Table 4.1 shows roles by five Team members of the Task Force. Each Team should be responsible for the concerned roles and keeps activities of NRW reduction routinely. Substitute members of the Team are responsible for the tasks, while Team Leader is not present.

Table 4.1 Each Role of the Team Members of the Task Force

No.	Roles	Planning Team	Monitoring Team	Maintenance Team	Finance Team	Customer Care & Communication Team*
1.	**Formulation of Annual Action Plan**					
1.1	Formulate Annual Action Plan	XX	X			
2.	**Procurement of Equipment**					
2.1	Procure Equipment		XX	X	XX	
3.	**Preparation Work**					
3.1	Compile Customer List		XX		X	X
3.2	Update Database	XX	X	X	X	X
3.3	Analyze the Existing Network hydraulically	XX		X		
4.	**Primary NRW Reduction Activities**					
4.1	**Measuring NRW Before**					

No.	Roles	Planning Team	Monitoring Team	Maintenance Team	Finance Team	Customer Care & Communication Team*
	Countermeasure					
4.1.1	Measure System Input Volume and Minimum Night Flow			XX		
4.1.2	Measure Individual Water Consumption			XX		
4.1.3	Measure Meter Inaccuracy			XX		
4.1.4	Observe Illegal Connections			XX	X	
4.1.5	Control Water Pressure		XX	X		
4.1.6	Detect Leakage and its Identification	X		XX		
4.1.7	Analyze IWA Water Balance		XX			
4.1.8	Select LCZs		XX			
4.2	**Countermeasure of NRW Reduction**					
4.2.1	Replace Water Meter and Newly Installation			XX	X	
4.2.2	Disconnect Illegal Connection			XX	X	X
4.2.3	Legalize Service Connection			X	XX	X
4.2.4	Repair or Replace Pipes			XX		
4.3	**Measuring NRW after Countermeasure**					
4.3.1	Measure System Input Volume and Minimum Night Flow			XX		
4.3.2	Analyze IWA Water Balance		XX			
4.3.3	Estimate Actual Cost of Activities		XX			
4.3.4	Report	X	XX	X	X	
5.	**Monitoring & Maintenance Work**					
5.1	**Monitoring**					
5.1.1	Monitor Flow Rate, Water Pressure, the Billed Water Consumption and analyze IWA Water Balance in DMAs		XX			
5.2	**Evaluating**					
5.2.1	Evaluate NRW ratio		XX			
5.2.2	Select DMAs		XX			
5.3	**Maintaining**					
5.3.1	Close LCZ Valves			XX		
5.3.2	Analyze NRW in LCZ		X	XX		
5.3.3	[Activities for Customer Meters]					
5.3.3 -1	Check Condition of Customer Meters/ Receive Report from Customers			XX	X	XX
5.3.3 -2	Advise the Finance Team of Status of Customer Meters		XX		X	
5.3.3 -3	Test Customer Meters with a Test Meter and analyze Water Meter Inaccuracy			XX		

No.	Roles	Planning Team	Monitoring Team	Maintenance Team	Finance Team	Customer Care & Communication Team*
5.3.4	[Activities for Illegal Connections]					
5.3.4 -1	Monitor Illegal Connections			XX	X	
5.3.5	[Activities for Leakage Detection]					
5.3.5 -1	Conduct Step-Test			XX		
5.3.5 -2	Detect Leak			XX		
5.3.6	Countermeasure					
5.3.6-1	Fix Customer Meters or Replace them with New Ones			XX	X	
5.3.6-2	Disconnect or Legalize Water Users			XX	XX	X
5.3.6-3	Fix Pipelines			XX		
5.3.7	Report from the Maintenance Team to the Monitoring Team and the Customer Care & Communication Team		XX	XX	X	XX
5.3.8	Report from the Customer Care & Communication Team to Customers					XX
5.4	**Evaluating**					
5.4.1	Evaluate NRW ratio in DMA		XX			

Note:

XX: Main responsibility, X: Assist other staff members in their role

* Customer Care & Communication Team conducts an awareness meeting and school program periodically.

CHAPTER 5 Target Areas of NRW Reduction Activities

5.1 Target Water Supply Facilities

As stated in above, leakage is the main cause of NRW. Therefore, leakage reduction needs more attention and commitment. Especially, much of the leakage occurs at service pipelines and distribution network and more frequently than at transmission pipelines. In addition, the other main causes of NRW are meter inaccuracies and illegal connections. Reduction of leakage targeting only the distribution network and service pipelines, elimination of water meter inaccuracies and removal of illegal connections is stated in this Strategic Implementation Plan. Reduction of leakage in the transmission pipelines and service reservoirs is not included in this plan.

5.2 Creation of DMAs

The Project Team created 28 DMAs in Honiara city. In order to establish DMA efficiently and economically, criteria to create DMAs are set as follows:

- One-point inlet to DMA
- Availability of valves to isolate areas (Economically isolation)
- Ease of area isolation (Not complicated network)
- DMA with pressure control distinguished from that without pressure control*
- Maximum 500 households of each DMA

* Pressure control zone was proposed by the Technical Coordinator for the Two Year Plan of SW.

5.3 Feature of DMAs

Scale and feature of each DMA is shown in Table 5.1. The features mentioned in 3.4 are analyzed and summarized in the "Feature" column. Issues stated in the feature which were observed through the pilot projects are related to the causes of NRW such as illegal connections, meter inaccuracy and leakage. This will be useful for SW to determine which countermeasures will be taken at each DMA.

Table 5.1 Scale and Feature of Each DMA in Honiara

No.	DMAs		Population in DMAs as of Nov. 2014	Actual Average Customer Consumption as of Oct. 2013 to Nov. 2014 (m^3/month)	Daily per-Capita Water Consumption Rate (LCD)	Ratio of Illegal Connection (%)	Assumed Water Consumption of the Total existing Households (m^3/month)	Predicted Water Consumption after Five Years	Target Grade*	Feature**
			-	a)	-	b)	c) = a) / ((100-b)/100)	d) = c) x $(1+0.031)^5$		
1	DMAs with Pressure Control	No.6 Tasahe A&B	773	3,991	172	20	4,989	5,812	H	Low Income
									M	Water Pressure
									L	Frequency
2		No.8 Ngossi	2,265	13,118	193	10	14,576	16,980	H	Frequency
									M	Community
									L	Water Pressure
3		No. 9 Mbokona	2,190	12,548	191	5	13,208	15,386	H	Bush
									M	Community
									L	
4		No.11 Vavaea Ridge	2,258	12,981	192	10	14,423	16,802	H	
									M	Community

No.	DMAs		Population in DMAs as of Nov. 2014	Actual Average Customer Consumption as of Oct. 2013 to Nov. 2014 (m^3/month)	Daily per-Capita Water Consumption Rate (LCD)	Ratio of Illegal Connection (%)	Assumed Water Consumption of the Total existing Households (m^3/month)	Predicted Water Consumption after Five Years	Target Grade*	Feature**
			-	a)	-	b)	c) = a) / ((100-b)/100)	d) = c) x $(1+0.031)^5$		
									L	
5		No.13 Mbokonavera	2,430	12,971	178	10	14,412	16,789	H	Deterioration
									M	Water Pressure
									L	Bush
6		No.19 Tanuli & Mbua Valley	2,528	11,468	151	10	12,742	14,843	H	Deterioration
7		No. 22 Kombito Boaderline, Jakson Ridge & Bura	3,293	13,001	132	20	16,251	18,931	H	Low Income
									M	Bush
									L	Frequency
8	DMAs without Pressure Control related to DMAs with Pressure Control (Cascaded)	No.7 Tasahe C	1,020	4,584	150	10	5,093	5,933	H	Frequency
									M	Community
									L	
9		No.10 Lenggakiki	1,560	11,140	238	10	12,378	14,419	H	Deterioration
									M	Community
									L	
10		No. 12 Skyline	1,298	5,689	146	20	7,111	8,284	H	Low Income
									M	Deterioration
									L	
11		No.17 West Kolaa Ridge A	1,148	3,862	112	20	4,828	5,624	H	Deterioration
									M	Low Income
									L	
12		No.18 West Kolaa Ridge B & C and Naha Height	3,855	14,595	126	20	18,244	21,253	H	Deterioration
									M	Low Income
									L	
13		No. 20 Kombitatu	1,628	5,125	105	20	6,406	7,462	H	Frequency
									M	Low Income
									L	
14		No. 21 Trecce House, Bura Height and Naha Valley	3,360	12,190	121	10	13,544	15,778	H	Deterioration
									M	Bush
									L	Low Income
15	DMAs without Pressure Control	No. 1 White River A	2,213	8,527	128	20	10,659	12,417	H	Deterioration
									M	Frequency
									L	Low Income
16		No. 2 White River B	2,168	11,851	182	20	14,814	17,257	H	Deterioration
									M	Frequency
									L	
17		No. 3 Rove A	1,095	25,420	774	5	26,758	31,171	H	Deterioration
									M	Frequency
									L	
18		No. 4 Rove B	533	10,776	675	5	11,343	13,214	H	Deterioration
									M	
									L	
19		No. 5 Rove C	540	12,307	760	5	12,955	15,091	H	Deterioration
									M	
									L	
20		No. 14 Tuvaruhu	270	1,192	147	20	1,490	1,736	H	Deterioration
									M	Bush
									L	
21		No. 15 Lower West Kola A	2,213	11,488	173	20	14,360	16,728	H	Deterioration
									M	Bush
									L	Non-Community
22		No. 16 Lower West Kola B	1,898	11,524	202	5	12,131	14,132	H	Deterioration
									M	Bush
									L	Non-Community

No.	DMAs	Population in DMAs as of Nov. 2014	Actual Average Customer Consumption as of Oct. 2013 to Nov. 2014 (m^3/month)	Daily per-Capita Water Consumption Rate (LCD)	Ratio of Illegal Connection (%)	Assumed Water Consumption of the Total existing Households (m^3/month)	Predicted Water Consumption after Five Years	Target Grade*	Feature**
		-	a)	-	b)	c) = a) / ((100-b)/100)	d) = c) x $(1+0.031)^5$		
23	No. 23 Kobito Trunk Main	1,170	6,536	186	20	8,170	9,517	H	Bush
								M	Low Income
								L	Frequency
24	No. 24 Panatina Ridge East and Mbaranamba	2,355	14,996	212	10	16,662	19,410	H	Deterioration
								M	Frequency
								L	Bush
25	No. 25 Panatina Ridge West	1,193	6,536	183	5	6,880	8,015	H	Deterioration
								M	Frequency
								L	Bush
26	No. 26 Panatina Industrial	1,868	18,301	327	20	22,876	26,649	H	Deterioration
								M	Bush
								L	Frequency
27	No. 27 Burns Creek	930	1,159	42	20	1,449	1,688	H	Low Income
								M	Frequency
								L	Deterioration
28	No. 28. Lunga and Airport	593	141	8	20	176	205	H	Frequency
								M	Deterioration
								L	Bush
Total		**48,645**	**278,017**	**-**	**390**	**318,928**	**371,526**		

Source: Project Team
Note: Annual Increasing Rate of Water Consumption = 3.1% a year
* H: High, M: Moderate, L: Low
** **Low Income**: Comprise of more low income groups, **Water Pressure**: High water pressure, **Frequency**: Frequency of monitoring due to distance from Solomon Water, **Community**: Number of community, **Bush**: Pipes buried in unpaved road, **Deterioration**: Pipe deterioration,

CHAPTER 6 Implementation Process

6.1 Priority of Implementation

Since an annual budget of SW is limited, SW cannot conduct NRW reduction in a lot of DMAs at the same time. Therefore, SW must set priority in DMAs based on the criteria and contents shown in Table 6.1.

Table 6.1 Criteria to prioritize DMAs

No.	Criteria	Contents
1)	Seriousness of NRW	● Number of Illegals ● Number of Leakages ● Number of Direct Connections ● Frequent Bursts
2)	Water Supply System Condition	● Number of Bulk Flow Meter installed ● Number of the Pilot projects including the past projects which were done. ● Number of Cascading
3)	Effect on SW's Finance	● Amounts of Revenue in Sep. '14 (SBD/mon.)
4)	Number of Beneficiaries	● Number of Domestic ● Number of Commercial & Institutes
5)	Easiness of Isolation	● Number of the places to be Isolated
6)	Hydraulic Design of Network	● Number of More Simple Network ● Number of Dendritic Network ● Number of Raising Capacity

DMAs are prioritized based on a score system by the above items. Table 6.2 shows the results of prioritization of NRW Reduction Activities in the DMAs and Annex 3 shows scores of each DMA. Two DMAs were selected as Pilot Area in the Project and NRW reduction activities have been carried out through the Project. The highest and the lowest score is 8.30 as Tasahe A & B and 4.25 as Rove C.

Table 6.2 Prioritization of NRW Reduction Activities in the DMAs

DMAs without Pressure Control			DMAs with Pressure Control		
Priority No.	ID No.	DMA	Priority No.	ID No.	DMA
1	22	Kombito-Boaderline, Jakson Ridge and Bura	1	6	Tasahe A&B
2	17	West Kolaa Ridge A	2	13	Mbokonavera
3	18	West Kolaa Ridge B&C and Naha Height	3	8	Ngossi
4	23	Kombito Trunk Main	4	11	Vavaea Ridge
5	2	White River B	5	19	Tanuli and Mbua Valley
6	20	Kombibatu	6	9	Mbokona
7	26	Panatina Industrial			
8	15	Lower West Kolaa A			
9	1	White River A			
10	27	Burns Creek			
11	28	Lungga and Airport			
12	12	Skyline			
13	14	Tuvaruhu			
14	10	Lenggakiki			
15	24	Panatina Ridge East and Mbaranamba			
16	16	Lower West Kolaa B			
17	21	Trecce House, Bura Height and Naha Valley			
18	7	Tasahe C			

DMAs without Pressure Control			DMAs with Pressure Control		
Priority No.	ID No.	DMA	Priority No.	ID No.	DMA
19	3	Rove A			
20	25	Panatina Ridge West			
21	4	Rove B			
22	5	Rove C			

Note:
Two DMAs were selected for the Pilot Project as highlighted in white blue. Installation of PRV was planned in the ID No.22 Kombito- Boaderline, Jakson Ridge and Bura according to Water Supply Network Management and Information (Final Report) of SW. However, after prioritization of DMAs, the Project Team suggested its cancellation through a review of network analysis. Therefore, the second high scored ID No.17 was selected for the Project as DMA without pressure control.

The results of prioritizing the DMA based on the above criteria are shown in Annex 3. Namely, No.6 Tasahe A&B and No.10 West Kola Ridge A were selected as the most prioritized DMAs, and the Project has already performed the NRW reduction activities in those DMAs. However before implementing on Tasahe A& B and West Kola Ridge A, it was realized that No.10 Lengakiki DMA was also equipped with adequate isolation valves, step valves and a bulk flow meter, therefore NRW reduction activities were carried out in Lenggakiki earlier than other DMAs immediately after the 15 Pilot Projects were completed.

In addition, SW has the intention to train junior staff in the relatively simple and easy areas. Thus, the following areas are selected as the second prioritized DMAs:

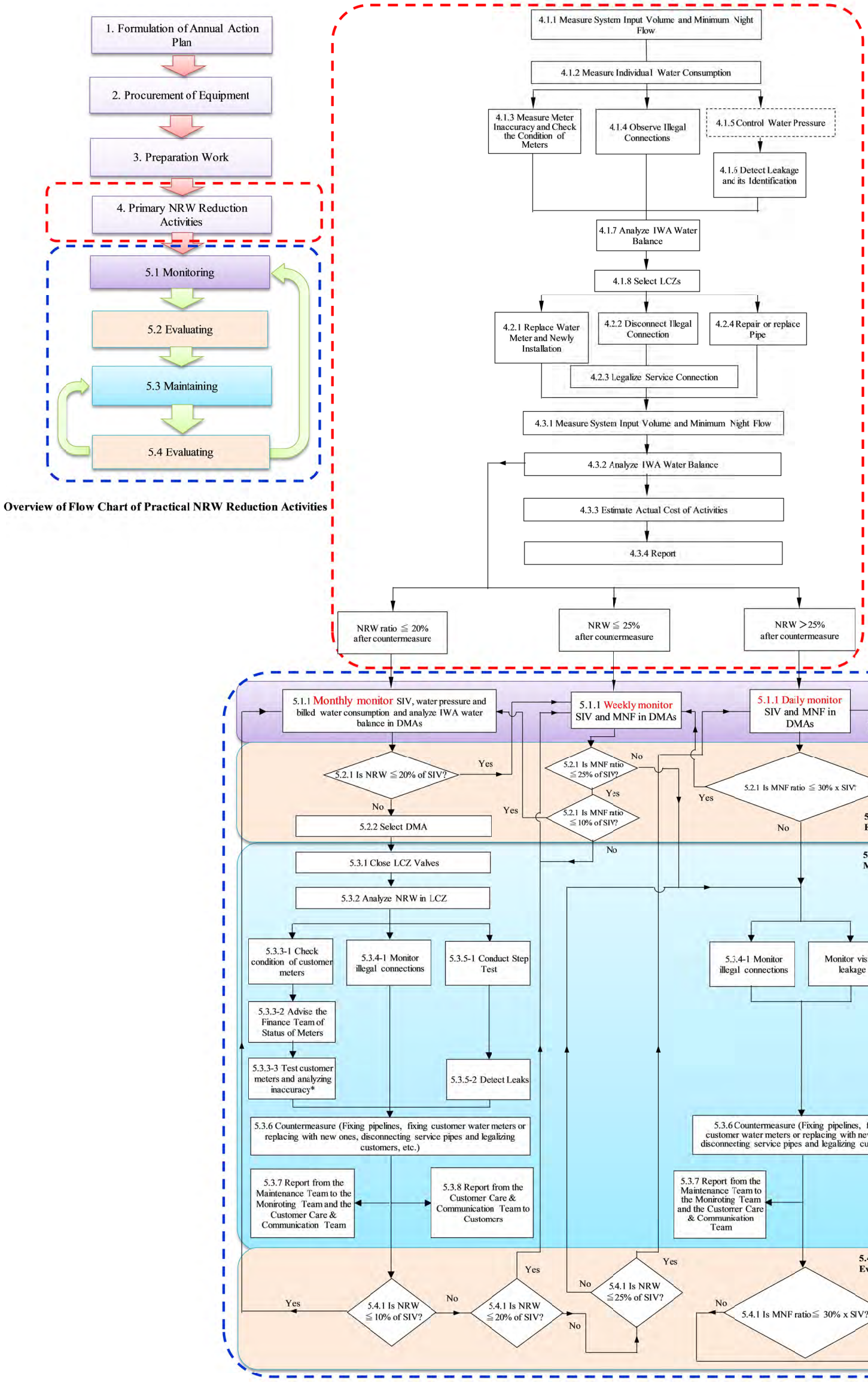
- No.7 Tasahe C
- No.22 Kombito- Boaderline, Jackson Ridge and Vura
- No.21 Trecce House, Bura Height and Naha Valley
- No.13 Mbokonavera
- No.12 Skyline
- No.11 Vavaea Ridge
- No.9 Mbokona

Note: No is for ID.

6.2 Implementation Process

Identification and the demarcation of the 28 DMAs were carried out for Honiara system during the Project. Primary NRW reduction activities are very important to setup a baseline of NRW ratio and to learn characteristics of NRW in each DMA. Out of the 28 DMAs, primary NRW reduction activities in 10 DMAs, which are mentioned in '6.1', should almost be completed by the beginning of 2016. NRW reduction in the remaining 18 DMAs will be carried out from the beginning of 2016. Work flow of NRW reduction activities with the primary NRW reduction activities is shown in the 'Overall Process of NRW Reduction Activities' of Figure 6.1.

In addition, monitoring and maintenance should continue keeping the effect of NRW reduction activities. Detailed work of monitoring and maintenance is indicated in 'Process of Monitoring & Maintenance on NRW Reduction Activities' of Figure 6.1.



Overview of Flow Chart of Practical NRW Reduction Activities

Detail Flow Charts of Practical NRW Reduction Activities

Note:

Activity number of each item refers to the role shown in Table 4.1 and each title in CHAPTER 4.

Figure 6.1 Flow Charts for Practical NRW Reduction Activities

CHAPTER 7 Contents of Overall Activities

7.1 Formulation of Annual Action Plan (Activity 1)

The Planning Team of the NRW reduction Task Force will formulate an annual action plan which specifies the following items by every December:

- Target Areas and Topographical Drawing
- Flow of Actions in Implementation of NRW Reduction
- Cost Estimation of NRW Reduction Activities in DMAs
- Detailed Implementation Schedule
- Individual Action Plan

7.2 Procurement of Equipment (Activity 2)

Delay in procurement processes would normally result in delays in the implementation of NRW reduction activities. In the pilot projects, it was observed that the length of time for the procurement process sometimes reaches to more than three months when equipment was purchased from abroad. Therefore, the procurement section of the Finance Team must commit to ensure that there are stocks of fittings and equipment available at all times so that the Maintenance Team can utilize them efficiently. Equipment required for NRW reduction activities is shown in Table 7.1. Procurement work should be systemized by types of material items. It is recommended that SW orders equipment from suppliers as shown in Table 7.2 considering the reliability of the suppliers themselves and the fact that these materials can be easily sorted and transported by the supplier.

Procurement section of the Finance Team must furnish Monitoring Team with information on the annual equipment cost incurred for NRW reduction activities in order for the Monitoring Team to prepare the report of the NRW reduction activities.

Equipment and concrete work for chambers with total cost of more than SBD80,000 per lot should be procured through bidding tender in principle. However, the Finance Team can exempt the bidding tender in the following cases.

- Delivery of equipment within two weeks
- Special fittings

Table 7.1 Standardization of Material

Items	Material	Purpose
■ Bulk Flow Meters	FCD	Measuring flow rate at inlet of DMAs
■ Pressure Reducing Valves including strainer and air relief valves	FCD	Reducing pressure
■ Sluice Valves	FCD	Isolating and maintaining
■ Air Relief Valves	FCD	Relieving air at downstream of PRV
■ Flange Adapters	GP, PVC or DI	Maintaining pipelines at the pipelines inside of chamber
■ Tees	GP, PVC or DI	Common use
■ Reducers	GP, PVC or DI	Common use
■ Bends	GP, PVC or DI	Common use

Items	Material	Purpose
■ Flexible Joints	DI	Avoiding irregular subsidence at the pipelines outside of chamber
■ Paddle Flange Spigot	GP or DI	Preventing groundwater to inflow to chamber
■ Water Pressure Gauges		Measuring water pressure at service areas
■ Customer Water Meters	Gun-metal	Measuring water consumption in corrosion resistance
■ Chamber of Valves, Flow Meters, etc.	Concreate in situ or pre-cast concrete bricks	Chamber for bulk flow meters and PRVs

Source: Project Team

Note:

FCD: Ferrum Casting Ductile, DI: Ductile Iron, GP: Galvanized Pipe, PVC: Polyvinyl Chloride Pipe

Table 7.2 Major Suppliers' List of Equipment

Supplier or Manufacturer	Email & Web site Address	Tel No.	Nationality
Pentair Water and Environmental Systems (Formerly Tyco Water Pty Ltd)	Bruce.Shannon@pentair.com www.pentair.com/water	+64-21-280-5264 +64-9-921-7264	New Zealand
South Austral Pty Ltd	sapl@southaustral.com.au	+61-2-9280-1100	Australia
Aquaduct Trading Pty Ltd	aquaduct@bigpond.com.au www.aquaduct.com.au	+61 3-5433-3271	Australia
Humes Pipeline Systems	gary.aitchison@humes.co.nz http://www.humes.co.nz/	+64-6-870-6011	New Zealand
Xylem Water Solutions New Zealand Limited	James.jacobsen@xyleminc.com		New Zealand
Mason Engineers (NZ) Ltd	process@masons.co.nz	+649-274-3143	New Zealand
Oceania Water Group Ltd	sales@oceaniawatergroup.com abdul@oceaniawatergroup.com neil@oceaniawatertreatment.com www.oceaniawatertreatment.com	+679-774-3126 +679-702-7161	Fiji
Global Imports & Exports Ltd	peter@globalimportexport.co.nz sales@globalimportexport.co.nz www.globalimportexport.co.nz	+64-9-278-0188	New Zealand
Tropex Exports Ltd	www.tropex.co.nz	+64-9-6254389	New Zealand

Source: Procurement of SW

7.3 Preparation Work (Activity 3)

1) Compile Customer List

The Monitoring Team mainly compiles customer ID Nos, number of customers, monthly water consumption, etc. into a database to calculate the NRW volume in the DMA.

2) Update Database

The Planning Team updates database with data and information which are provided by other Teams whenever pipelines are expanded, replaced, and the customers are newly registered or disconnected.

3) Analyze the Existing Network Hydraulically

The Planning Team examines distribution network through a hydraulic analysis in order to identify undersized pipelines to be replaced with larger size pipes in collaboration with the maintenance Team.

7.4 Primary NRW Reduction Activities (Activity 4)

7.4.1 Measuring NRW before Countermeasure (Activity 4.1)

1) Measure System Input Volume and Minimum Night Flow (Activity 4.1.1)

The Maintenance Team measures monthly system input volume and Minimum Night Flow (MNF) in each DMA in this survey. Water leakage volume can be estimated by the data of MNF.

2) Measure Individual Water Consumption (Activity 4.1.2)

Actual 24 hour water consumption for some customers is measured by the Maintenance Team as billed water. The customers are selected randomly.

3) Measure Meter Inaccuracy and Check the Condition of Meters (Activity 4.1.3)

The Maintenance Team measures the accuracy of water meters using a test-meter to identify which water meters needs replacement due to deterioration.

4) Observe Illegal Connections (Activity 4.1.4)

The Maintenance Team observes illegal connections by means of a daily monitoring by water meter readers of the Finance Team. Observation results are recorded and reported to the section in charge of disconnections.

5) Control Water Pressure (Activity 4.1.5)

In seven DMAs where minimum effective pressure is high, water pressure is controlled by Pressure Reducing Valves (PRVs) under supervision of the Monitoring Team.

6) Detect Leakage and Its Identification (Activity 4.1.6)

The Maintenance Team detects leakage with their locations identified in the selected LCZs using an acoustic bar, water leak detector and correlator with the drawing provided by the Planning Team.

7) Analyze IWA Water Balance (Activity 4.1.7)

The Monitoring Team estimates leakage volume by subtracting the billed water, water consumed by illegal users and water loss in water meters from system input volume.

8) Select LCZs (Activity 4.1.8)

The Monitoring Team selects LCZs in the prioritized DMAs in order to concentrate on leakage detection. Selection complies with the highest data of MNF among LCZs.

7.4.2 Countermeasure of NRW Reduction (Activity 4.2)

1) Replace Water Meters and Newly Installation (Activity 4.2.1)

In case that water meters are malfunctioning and does not exit, water meters are properly installed or replaced to measure actual water consumption by the Maintenance Team. Water meter readers must read water meters accurately.

2) Disconnect Illegal Connection (Activity 4.2.2)

SW encourages illegal users to register service connections. However, if illegal users do not register their connections within the given grace period of two weeks, service connections are disconnected by the Maintenance Team. Records of disconnections must be shared with the Finance Team.

3) Legalize Service Connections (Activity 4.2.3)

The Customer Care & Communication Team explains water tariff system and water supply service to communal water users through organizing awareness meeting and delivery of pamphlet in order for users to register their service connections. The finance Team mainly deals with legalization of service

connections.

4) Repair or Replace Pipes (Activity 4.2.4)

The Maintenance Team is also responsible for replacement and repairs of pipelines. Pipes to be repaired are composed of distribution and service pipes. Fittings such as mechanical & flange joints, saddle diverge, sluice & gate valves, air valves, etc. are repaired in case of defective condition.

In order to keep suitable water pressure in distribution network, undersized pipes are replaced with new pipes in optimum diameter according to the result of hydraulic analysis.

7.4.3 Measuring NRW after countermeasure of NRW Reduction (Activity 4.3)

1) Measure System Input Volume and Minimum Night Flow (Activity 4.3.1)

1) and 2) in '7.4.1' which are repeatedly measured after countermeasure provide NRW reduction points between before and after-countermeasure.

2) Analyze IWA Water Balance (Activity 4.3.2)

'7)' in '7.4.1' which are repeatedly measured after countermeasure provide NRW reduction points before and after-countermeasure.

3) Estimate Actual Cost of Activities (Activity 4.3.3)

In order to examine cost effectiveness and budget arrangement for next fiscal year, the Monitoring Team would estimate the actual cost from the track record of activities which took place in the current year.

4) Report (Activity 4.3.4)

The Monitoring Team compiles the result of the activities in cooperation with the Planning Team, Maintenance Team and the Finance Team and reports the summary to the Management Team of SW.

7.5 Monitoring & Maintenance Work (Activity 5)

7.5.1 Monitoring (Activity 5.1)

1) Monthly Monitor Flow Rate, Water Pressure, the Billed Water Consumption and Analyze IWA Water Balance in DMAs (Activity 5.1.1)

The Monitoring Team monitors flow rate and water pressure in each DMA by a telemetry system. If abnormal flow rate and or water pressure is confirmed at night, increase in NRW is suspected. In such a DMA, of the resultant IWA water balance analysis reveals increased NRW ratio. SW should commit to take NRW reduction activities immediately.

7.5.2 Evaluating (Activity 5.2)

1) Evaluate NRW Ratio (Activity 5.2.1)

The Monitoring Team figures out NRW ratio based on IWA water balance.

2) Select DMAs (Activity 5.2.2)

The Monitoring Team selects some DMAs NRW ratio of which is high through the monitoring work. NRW reduction activities will be carried out by LCZ in the selected DMAs.

7.5.3 Maintaining (Activity 5.3)

1) Close LCZ Valves (Activity 5.3.1)

The Maintenance Team closes each valve located at an inlet of LCZ so as to identify LCZs where NRW ratio is relatively high.

2) Analyze NRW in LCZ (Activity 5.3.2)

After identifying some LCZs, the Maintenance Team measures actual NRW ratio based on system input volume and the billed water consumption and reports to the Monitoring Team. The Monitoring Team identifies the LCZs in which NRW reduction activities are required to be carried out.

3) Activities for Customer Meters (Activity 5.3.3)

a) Check Condition of Customer Meters/ Report from Customers **(Activity 5.3.3-1)**

In the identified LCZs, the Maintenance Team checks customer meters to check their functionality and accuracy. Issues such as leakage, defective customer meters, etc. are reported to SW's Customer Care & Communication Team.

Condition of customer meters should be checked by water meter readers as proactive work through monthly meter reading. At the same time, customer meters must be sorted out for their durability by the Finance Team to ensure that they are managed properly and replaced on a timely basis.

b) Advise the Finance Team of Status of Customer Meters **(Activity 5.3.3-2)**

The Monitoring Team reports condition of the customer meters to the Finance Team to decide its replacement.

c) Test Customer Meters with a Test Meter and Analyze Water Meter Inaccuracy **(Activity 5.3.3-3)**

In case of the customer meters functionality, the Maintenance Team measures the accuracy of the water meters using a test-meter to identify which water meters are to be replaced due to deterioration. Meter inaccuracy is a gap between actual flow which measured by the test meter and reading flow of the customer meters.

4) Activities for Illegal Connections (Activity 5.3.4)

a) Monitor Illegal Connections **(Activity 5.3.4-1)**

The Maintenance Team checks customer status for each DMA on monthly basis. The Maintenance Team monitors illegal connections in the identified LCZs and identifies illegal households referring to the report from water meter readers. Specifically, the Team compares billing status of disconnections, suspensions and new connections with their respective status in the field to confirm whether the connections are illegal or not.

5) Activities for Leakage Detection (Activity 5.3.5)

a) Conduct Step-Test **(Activity 5.3.5-1)**

Meanwhile, observing leakage volume, step-test is carried out by the Maintenance Team in the worst LCZ in NRW ratio to identify the pipelines which are damaged.

b) Detect Leaks **(Activity 5.3.5-2)**

After identifying pipeline route which is suspected, the Maintenance Team identifies leak points by using leak detectors and or acoustic bar**.**

c) Monitor visible leaks **(Activity 5.3.5-3)**

Without leak detectors, the Maintenance Team quickly identifies the location of visible leaks such as surface leaks. Interview with neighboring dwellers is also one of the efficient manners to identify leak location.

6) Countermeasure (Activity 5.3.6)

a) Fix Customer Meters or Replace them with New Ones

After reported to customers, the Maintenance Team fixes or replaces current customer meters.

b) Disconnect or Legalize Water users

The Customer Care & Communication Team encourages illegal users to register service connections. However, if illegal users do not register their connections in grace period of two weeks, service connections are disconnected by the Maintenance Team.

c) Fix Pipelines

The Maintenance Team repairs leak-identified points as soon as it is identified.

7) Report from the Maintenance Team to the Monitoring Team and Customer Care & Communication Team (Activity 5.3.7)

The Maintenance Team reports output of the NRW reduction activities to the Monitoring Team and the Customer Care & Communication Team immediately.

8) Report from the Customer Care & Communication Team to Customers (Activity 5.3.8)

The Customer Care & Communication Team reports the results of measures such as disconnections, legalization, replacement of customer meters, etc. to customers.

7.5.4 Evaluating (Activity 5.4)

1) Evaluate NRW in DMA (Activity 5.4.1)

The Monitoring Team calculates the NRW ratio of the DMAs shown in '1)' in '7.5.2' based on the IWA water balance. If NRW ratio is more than 25%, the Monitoring Team directs other Team to carry on countermeasure.

CHPTER 8 Cost-Effectiveness Analysis

8.1 Cost Estimate for NRW Reduction Activities

The total initial cost for the 15 Pilot Projects was SBD 2,100,112. It means SBD140,008 per Pilot Project, and SBD1,435 per household. The cost required for the NRW reduction activities in DMAs is composed of the cost for the primary NRW reduction activities and that for regular monitoring & maintenance work. 33.3%[3] of the cost per household incurred in 15 pilot projects was added to SBD1,435 for monitoring and maintenance work, thus the unit cost for NRW reduction activities was estimated at SBD1,913 per household.

The cost for NRW reduction activities in Tasahe A&B, Tasahe C, Mbokona, Lenggakiki, Vavaea Ridge, Skyline, Mbokonavera, West Kola Ridge A, and Trecce House, Bura Height and Naha Valley, Kombito-Boaderline, Jakson Ridge and Bura have been disbursed between 2014 and the beginning of 2016. The estimated cost for those DMAs is about SBD 5.7 million. Total cost required for the NRW reduction activities in the 28 DMAs is estimated by applying unit cost per household, and it is around SBD14.5million (see Table 8.1).

Table 8.1 Cost Estimation for NRW Reduction Activities in 28 DMAs

No.	DMAs	Number of Registered Households	Ratio of Illegal Connection* (%)	Number of assumed households	Unit cost per household** (SBD)	Estimated Cost (SBD)
1	White River A	295	20	369	1,913	705,897
2	White River B	289	20	361	1,913	690,593
3	Rove A	146	5	154	1,913	294,602
4	Rove B	71	5	75	1,913	143,475
5	Rove C	72	5	76	1,913	145,388
6	Tasahe A&B	103	20	-	-	246,777
7	Tasahe C	136	10	151	1,913	288,863
8	Ngossi	302	10	336	1,913	642,768
9	Mbokona	292	5	307	1,913	587,291
10	Lenggakiki	208	10	-	-	441,903
11	Vavaea Ridge	301	10	334	1,913	638,942
12	Skyline	173	20	216	1,913	413,208
13	Mbokonavera	324	10	360	1,913	688,680
14	Tuvaruhu	36	20	45	1,913	86,085
15	Lower West Kolaa A	295	20	369	1,913	705,897
16	Lower West Kolaa B	253	5	266	1,913	508,858
17	West Kolaa Ridge A	153	20	-	-	365,383
18	West Kolaa Ridge B&C and Naha Height	514	20	643	1,913	1,230,059
19	Tanuli and Mbua Valley	337	10	374	1,913	715,462
20	Kombibatu	217	20	271	1,913	518,423
21	Trecce House, Bura Height and Naha Valley	448	10	498	1,913	952,674
22	Kombito-Boaderline, Jakson Ridge and Bura	439	20	549	1,913	1,050,237
23	Kombito Trunk Main	156	20	195	1,913	373,035
24	Panatina Ridge East and	314	10	349	1,913	667,637

[3] Not commencing the monitoring and maintenance work, the Project preliminary assumed to be 33.3% of the cost per household incurred in 15 pilot projects to determine their cost considering that countermeasure of NRW reduction is carried out once a three year. However, the cost will be reviewed based on the track record through the monitoring and maintenance work.

No.	DMAs	Number of Registered Households	Ratio of Illegal Connection* (%)	Number of assumed households	Unit cost per household** (SBD)	Estimated Cost (SBD)
	Mbaranamba					
25	Panatina Ridge West	159	5	167	1,913	319,471
26	Panatina Industrial	249	20	311	1,913	594,943
27	Burns Creek	124	20	155	1,913	296,515
28	Lungga and Airport	79	20	99	1,913	189,387
Cost to be disbursed by the beginning of 2016						**5,673,958**
Total cost in the year of 2016						**5,947,517**
Total cost in the year of 2017						**2,880,978**
Total		**6,485**		**7,030**		**14,502,453**

Note:

* Ratio of illegal connections was assumed in 5%, 10% and 20% by NRW Action Team experimentally.

** Cost of SBD1,435 per household incurred in 15 pilot projects multiplied by 133.3% was unit cost of SBD1,913 to be incurred for NRW reduction in DMAs. 33.3% of the cost per household incurred in 15 pilot projects was added to SBD1,435 for monitoring and maintenance work.

: On-going
: To be carried out in 2016
: To be carried out in 2017

8.2 Allocation of Budget for NRW Reduction Activities

Since NRW reduction is one of the most significant issues, SW must reduce NRW proactively following the Project. Therefore, it is desirable that a budget will be allocated for the first prioritized 10 DMAs during the year of 2016. SW examines a budget for the next fiscal year from August to September and applies it to the Ministry of Treasury in October. The proposed budget allocation is as follows:

- The 1st year (of 2016): SBD**5,947,517** (≒ SBD5.9million)
- The 2nd year (of 2017): SBD**2,880,978** (≒ SBD2.9million)

SW already applied the budget (SBD5.9Million) of the fiscal year of 2016 to the Ministry of Treasury in October 2015. Budget allocation of SBD5.8million at the maximum is feasible, because it makes up about 15% of annual Operation & Maintenance budget (SBD37.9million) for the year of 2015.

8.3 Estimation of Benefits by NRW Reduction Activities

NRW ratio is transited until 2025 as shown in Option 2 of Table 1.1, Cost benefit of each year is as shown in Table 8.2. It is likely that cost of NRW reduction activities is higher than the additional revenue recovered as the result from the NRW reduction activities. However, the additional revenue in the long run after two years will be more than the cost to implement the NRW reduction activities. In 2025, additional revenue annually is about SBD58million higher than the cost of NRW reduction activities.

Table 8.2 Cost Benefits of NRW Reduction Activities

Items	Calculation	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Water Production (m^3/day)*	[1]	30,203	30,203	30,203	30,203	30,203	30,203	30,203	30,203	30,203	30,203	30,203	30,203
Non-Revenue Water Ratio (%)**	[2]	62.8	59.6	56.4	53.2	50.0	46.4	42.9	39.3	35.7	32.1	28.6	25.0
Billed Water (m^3/day)	[3]=[1] x (100 -[2])/100	11,234	12,202	13,169	14,135	15,102	16,189	17,246	18,333	19,421	20,508	21,565	22,652
Increase Billed Water Volume (m^3/day)	[4]=[3] in each year -[3] in 2014	-	968	1,935	2,901	3,868	4,955	6,012	7,099	8,187	9,274	10,331	11,418
Increased Billed Water Volume for a year (m^3/year)	[5]=[4] x 365days	-	353,324	706,095	1,058,866	1,411,638	1,808,505	2,194,348	2,591,216	2,988,083	3,384,951	3,770,794	4,167,661
Anticipated Additional Revenue for a year (SBD/year)***, @SBD14.2/m^3	[6]=[5] x SBD14.2	-	5,017,206	10,026,555	15,035,904	20,045,253	25,680,770	31,159,745	36,795,262	42,430,780	48,066,297	53,545,272	59,180,790
Initial Cost incurred for three years (SBD)****	[7]		5,673,958	5,947,517	2,880,978	-	-	-	-	-	-	-	-
Recurring Cost for a year (SBD)*****	[8]=[7]/133.3% x 33.3%		-	-	-	1,417,425	1,485,764	719,704	1,417,425	1,485,764	719,704	1,417,425	1,485,764
Total Cost (SBD)	[9]=[7] +[8]		5,673,958	5,947,517	2,880,978	1,417,425	1,485,764	719,704	1,417,425	1,485,764	719,704	1,417,425	1,485,764
Cost Benefits (SBD/year)	**[10]=[6] -[9]**		**-656,752**	**4,079,038**	**12,154,926**	**18,627,827**	**24,195,006**	**30,440,041**	**35,377,837**	**40,945,016**	**47,346,593**	**52,127,847**	**57,695,026**

* It was assumed that water production was as same as present production.

** Source: Table 1.1

*** Water has not been supplied for 24 hours in Honiara. Therefore, anticipated additional revenue was estimated considering only increased billed water volume due to reduction NRW as precondition. In addition, revenue per m^3 is assumed to be constant in SBD14.2/m^3.

**** It was estimated based on the track record of the 15 pilot projects.

***** Assumed that leakage recurs once Three years, recurring cost a year was estimated.

CHPTER 9 Implementation Schedule

28 DMAs were prioritized based on criteria as shown in ‘6.1’. A priority of implementation of NRW reduction activities is shown in Annex 4.

Two or three DMAs are carried out at the same time. A period of the activities in each DMA was planned to be 3.5months based on the actual time schedule which was experienced through 15 pilot projects and the two DMAs (Tasahe A&B and West Kola Ridge A). However, the implementation schedule is subject to change due to procurement process of some pieces of equipment such as the existing isolation valves, step-test valves and water meters, etc. as necessary.

CHPTER 10 Project Management

10.1 PDCA

The frame of NRW reduction activities is composed of four main activities such as PDCA cycle. PDCA is defined as 'Plan', 'Do', 'Check' and 'Action' (see Figure 10.1). PDCA cycle is significant concept for any tasks. Activities of PDCA are as follows:

1) [Plan]: Formulate a Plan

The plan for NRW reduction activities for SW can be formulated based on the experience and the training conducted in the Pilot Project. The existing organization structure will be reformed to establish the dedicated NRW reduction team in order to monitor NRW and maintain low NRW ratio. Each team prepares the annual action plan for NRW reduction activities.

2) [Do]: Survey, Countermeasure, Record and Analysis

'Do' consists of the following activities:

a) Water meter survey, leakage detection, illegal connection survey, and their record, IWA water balance analysis and development of data base before countermeasure.

b) Countermeasures such as replacement of water meters and pipelines, pipe repair, disconnection of service pipes, legalization of users, and their record and development of data base.

c) IWA water balance analysis.

3) [Check]: Report and Evaluation

The results of survey, countermeasure, record and analysis are reported to SW's Managers to evaluate NRW reduction activities. The result of evaluation is reflected to improve the future activities.

4) [Action]: Improve the Plan

The original plan is improved through the result of evaluation for survey, countermeasure, record and analysis. The improved plan will be composed of further detailed information and additional strategy.

Figure 10.1 Concepts for PDCA Cycle

In order to overcome weak points of staff's skill, Human Resources Division of SW should conduct the in-house trainings for the staff at least every three months. Members shown in Table 10.1 are appointed as trainers. The lecture or trainings are mainly conducted by using the Manual on NRW Reduction, the Handbook for Operation and Maintenance of Equipment on Leak Detection for Solomon Water, GIS & Database Operation Manual and lecture materials which were used through the Project.

Table 10.1 Trainers by Subject

Subjects	Trainers	Team in Task-Force
Overall NRW Reduction	Mr. Benjamin BILLY*	Planning Team &Monitoring Team
	Mr. Frank DAUKALIA	Monitoring Team
GIS and Database	Mr. Gavin BARE*	Planning Team
Leakage Detection Technique	Mr. Eric UNGA*	Maintenance Team
	Mr. Matthew MAFE	Maintenance Team
PR, Water Meter Reading and Billing	Mr. Calros SALIGA*	Customer Care & Communication Team
	Ms. Daisy MENAGA	Finance Team
	Ms. Mary Tafoa	Finance Team
Hydraulic Analysis	Mr. Mathias BERA*	Planning Team

Note: * Leader of a trainer.

10.2 Weekly Meeting

A weekly meeting has taken place every Thursday since the Pilot Projects commenced in April 2013. SW confirms the weekly progress and issues on the activities, and discusses the measure for improvement. The progress of the activities is monitored with the monitoring sheet of NRW reduction activities as attached in Annex 5.

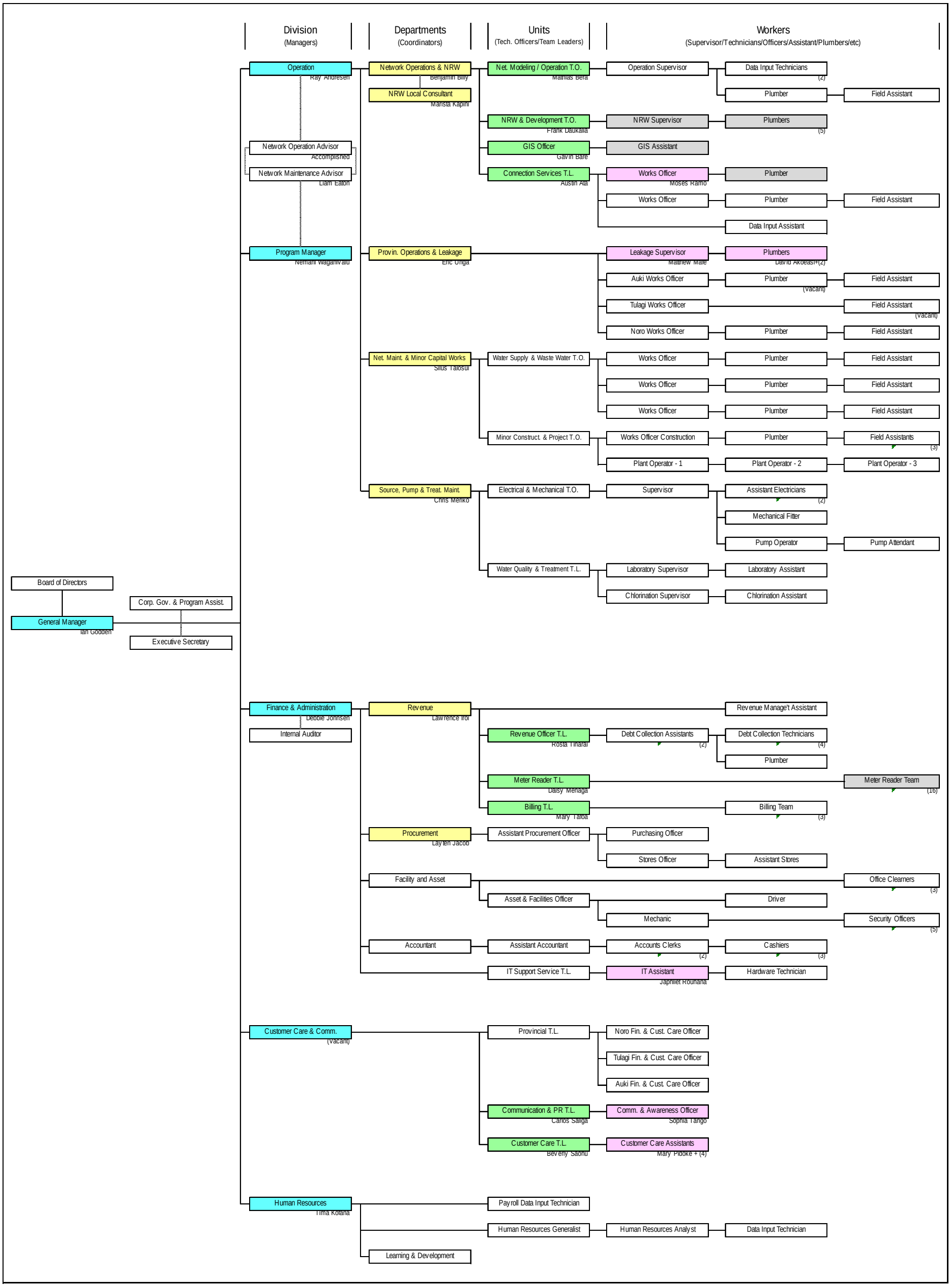
10.3 Periodical Workshop

Task-Force periodically reports the results of NRW reduction activities in some DMAs to the board members and Ministry of Mines, Energy and Rural Electrification (MMERE).

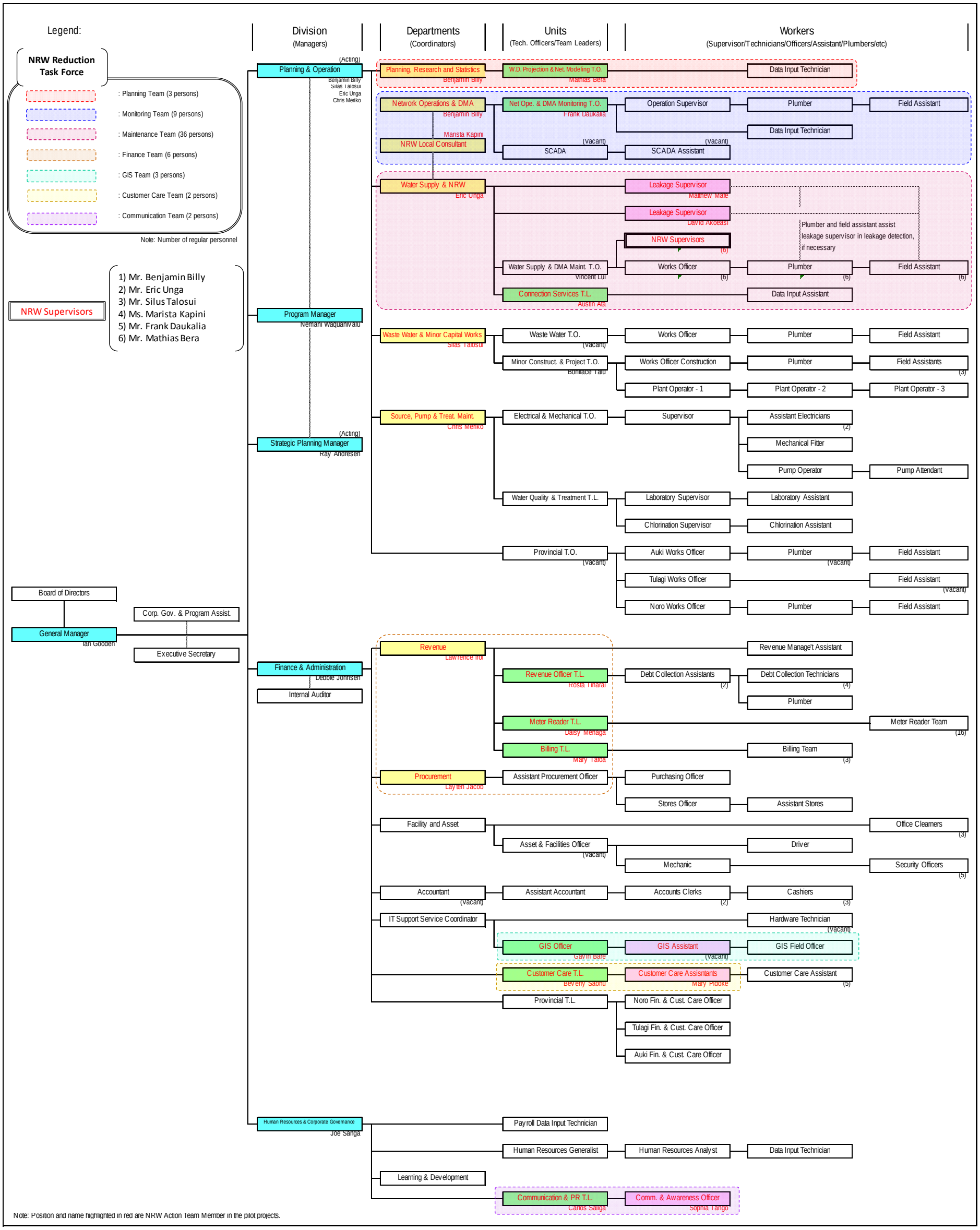
10.4 Annual Report

Fiscal year of SW is from January to December in Solomon Islands. SW prepares an annual report which includes the result of NRW reduction activities by the end of January of the following year. The annual report is composed of the result of NRW reduction activities in each DMA, an actual schedule, the total cost incurred, issues and their countermeasure.

Annex 1 Solomon Water Organizational Chart (Present)



Annex 2 Solomon Water Organizational Chart (Proposed)



Annex 3 Results of apriority of implementation of NRW Reduction in 28 DMAs

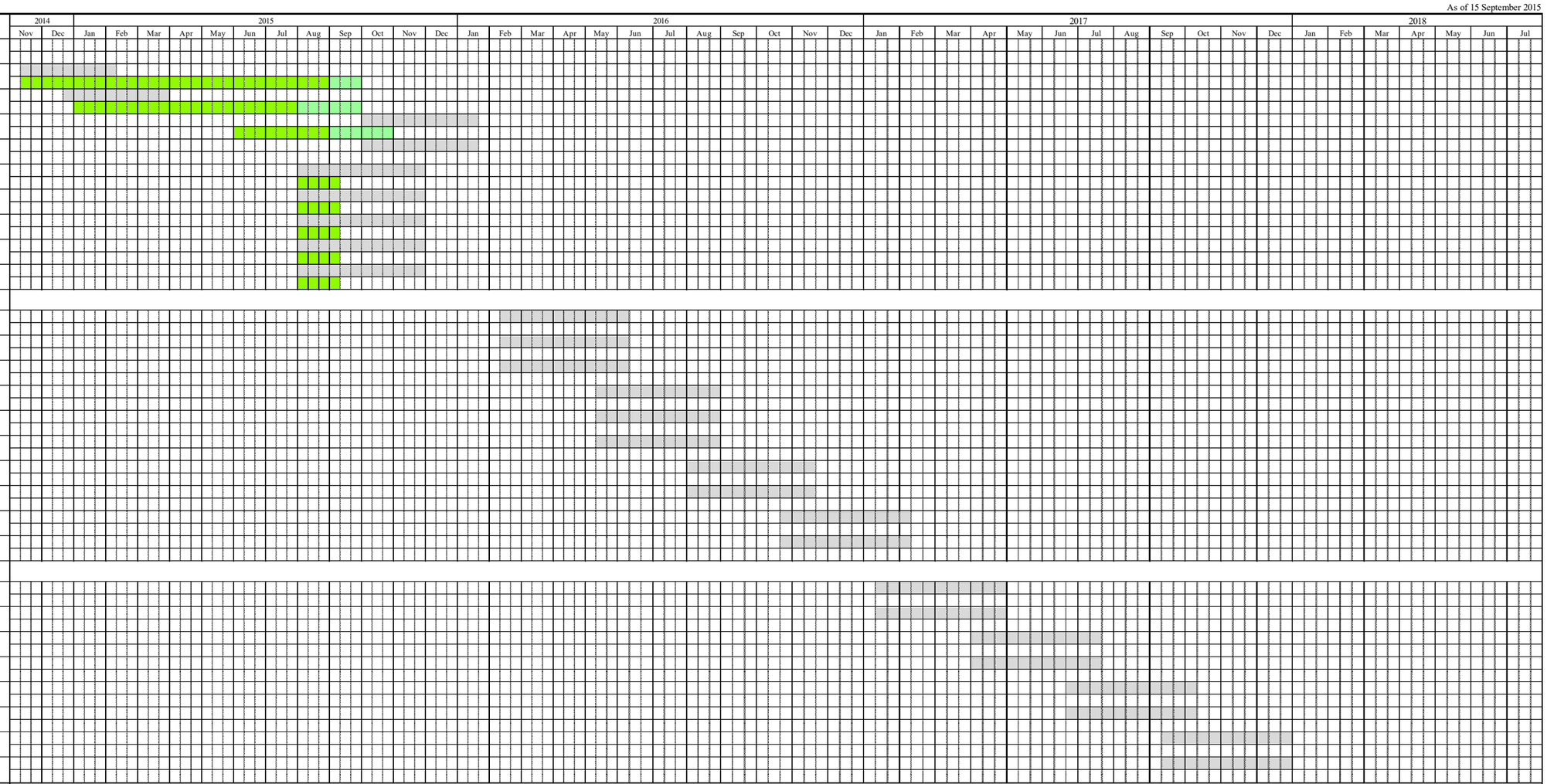
No.	DMAs	NRW serious situation							System Condition					SW's Finance			Number of Beneficiaries					Easy Isolation			Hydraulic design of network					**Total Score**	Pressure Control
		-	A	B	C	D	-		E	F	G	-		-	H		-	-	-	I			J		K	L	M				
		Illegals (%)	Score	Leakages	Direct Connections	Frequent Bursts	Total Score	Weighting Factor (x 45%)	Bulk Flow Meter installed	Pilot projects including the past projects have been done.	Number of Cascading	Total Score	Weighting Factor (x 25%)	Amounts of Revenue in Sep. '14 (SBD/mon.)	Score	Weighting Factor (x 10%)	Domestic	Commercial & Institutes	Total Number of Users	Total Score	Weighting Factor (x 10%)	Numbers of the places to be Isolated	Total Score	Weighting Factor (x 5%)	More Simple Network	Dendritic Network	Raising Capacity	Total Score	Weighting Factor (x 5%)		
1	White River A	20	3	3	2	2	10	4.50	1	2	3	6	1.50	96,874	1	0.10	294	1	295	3	0.30	2	2	0.10	1	3	2	6	0.30	**6.80**	
2	White River B	20	3	3	3	2	11	4.95	1	3	2	6	1.50	331,577	2	0.20	277	12	289	3	0.30	4	2	0.10	2	2	1	5	0.25	**7.30**	
3	Rove A	5	1	2	1	2	6	2.70	1	3	1	5	1.25	605,584	3	0.30	72	74	146	1	0.10	2	2	0.10	3	1	2	6	0.30	**4.75**	
4	Rove B	5	1	1	1	2	5	2.25	1	3	1	5	1.25	450,379	3	0.30	12	59	71	1	0.10	2	2	0.10	2	2	2	6	0.30	**4.30**	
5	Rove C	5	1	2	1	1	5	2.25	1	3	1	5	1.25	489,043	3	0.30	12	60	72	1	0.10	3	2	0.10	3	1	1	5	0.25	**4.25**	
6	Tasahe A&B	20	3	3	3	3	12	5.40	3	3	3	9	2.25	37,366	1	0.10	103	0	103	1	0.10	1	3	0.15	3	1	2	6	0.30	**8.30**	✔
7	Tasahe C	10	2	2	1	1	6	2.70	1	3	2	6	1.50	31,635	1	0.10	135	1	136	1	0.10	3	2	0.10	2	2	2	6	0.30	**4.80**	
8	Ngossi	10	2	2	2	2	8	3.60	2	3	1	6	1.50	178,693	2	0.20	297	5	302	3	0.30	1	3	0.15	2	3	2	7	0.35	**6.10**	✔
9	Mbokona	5	1	2	2	2	7	3.15	2	1	1	4	1.00	150,963	2	0.20	285	7	292	3	0.30	4	2	0.10	1	2	3	6	0.30	**5.05**	✔
10	Lenggakiki	10	2	2	2	1	7	3.15	3	1	3	7	1.75	115,907	1	0.10	192	16	208	2	0.20	0	3	0.15	3	1	2	6	0.30	**5.65**	
11	Vavaea Ridge	10	2	2	2	2	8	3.60	1	1	3	5	1.25	224,109	2	0.20	276	25	301	3	0.30	2	2	0.10	2	2	2	6	0.30	**5.75**	✔
12	Skyline	20	3	2	2	1	8	3.60	2	3	2	7	1.75	54,023	1	0.10	172	1	173	2	0.20	0	3	0.15	2	2	1	5	0.25	**6.05**	
13	Mbokonavera	10	2	3	2	3	10	4.50	2	1	2	5	1.25	144,818	1	0.10	311	13	324	3	0.30	2	2	0.10	2	2	3	7	0.35	**6.60**	✔
14	Tuvaruhu	20	3	3	1	2	9	4.05	1	1	3	5	1.25	16,821	1	0.10	35	1	36	1	0.10	0	3	0.15	2	2	3	7	0.35	**6.00**	
15	Lower West Kolaa A	20	3	3	3	2	11	4.95	1	2	2	5	1.25	269,932	2	0.20	191	104	295	3	0.30	2	2	0.10	2	2	2	6	0.30	**7.10**	
16	Lower West Kolaa B	5	1	2	1	2	6	2.70	1	3	2	6	1.50	276,919	2	0.20	186	67	253	3	0.30	7	1	0.05	3	1	2	6	0.30	**5.05**	
17	West Kolaa Ridge A	20	3	3	3	3	12	5.40	1	3	2	6	1.50	42,624	1	0.10	149	**4**	153	2	0.20	1	3	0.15	2	1	2	5	0.25	**7.60**	
18	West Kolaa Ridge B&C and Naha Height	20	3	3	3	3	12	5.40	1	3	1	5	1.25	200,066	2	0.20	509	5	514	3	0.30	5	2	0.10	1	3	2	6	0.30	**7.55**	
19	Tanuli and Mbua Valley	10	2	2	2	2	8	3.60	1	1	2	4	1.00	175,672	2	0.20	321	16	337	3	0.30	4	2	0.10	2	2	2	6	0.30	**5.50**	✔
20	Kombibatu	20	3	3	3	2	11	4.95	1	3	2	6	1.50	63,282	1	0.10	216	1	217	2	0.20	1	3	0.15	3	1	2	6	0.30	**7.20**	
21	Trecce House, Bura Height and Naha Valley	10	2	2	2	1	7	3.15	1	1	2	4	1.00	183,242	2	0.20	439	9	448	3	0.30	8	1	0.05	2	3	2	7	0.35	**5.05**	
22	Kombito-Boaderline, Jakson Ridge and Bura	20	3	3	3	3	12	5.40	1	3	3	7	1.75	242,448	2	0.20	437	2	439	3	0.30	4	2	0.10	1	3	2	6	0.30	**8.05**	
23	Kombito Trunk Main	20	3	3	3	3	12	5.40	1	3	2	6	1.50	107,913	1	0.10	154	2	156	2	0.20	2	2	0.10	3	1	1	5	0.25	**7.55**	
24	Panatina Ridge East and Mbaranamba	10	2	2	2	1	7	3.15	1	1	2	4	1.00	378,593	3	0.30	296	18	314	3	0.30	2	2	0.10	2	2	2	6	0.30	**5.15**	
25	Panatina Ridge West	5	1	2	1	1	5	2.25	1	3	2	6	1.50	322,114	2	0.20	157	2	159	2	0.20	6	1	0.05	2	3	2	7	0.35	**4.55**	
26	Panatina Industrial	20	3	3	2	2	10	4.50	1	3	3	7	1.75	563,848	3	0.30	80	169	249	2	0.20	1	3	0.15	1	2	2	5	0.25	**7.15**	
27	Burns Creek	20	3	3	3	1	10	4.50	1	3	1	5	1.25	16,036	1	0.10	103	21	124	1	0.10	0	3	0.15	3	1	1	5	0.25	**6.35**	
28	Lungga and Airport	20	3	3	3	1	10	4.50	1	3	1	5	1.25	2,513	1	0.10	76	3	79	1	0.10	0	3	0.15	2	1	2	5	0.25	**6.35**	
-	Other than DMA (Small areas supplied by trank main between Konglai Spring and Skyline Res.)	20	3	3	3	3	12	5.40	1	-	-	1	0.25	-	-	-	141		141	1	0.10	0	3	0.15	1	1	1	3	0.15	-	

Note:
A: 20%: 3, 10%: 2, 5%: 1
B to D, L, M: High: 3, Midium:2 , Low:1
E: Bulk flow meter was installed in the isolated DMA: 3, Bulk flow meter was installed at the upstream but there is no bulk flow meter in cascaded DMA at the down stream: 2, There is no bulk flow meter.: 1
F: Pilot projects have not been done so far: 3, Pilot projects other than this Technical Cooperation Project have been done in the past five years.: 2, Pilot Projects have been done in this technical assistance project.: 1
G: No cascading: 3, One cascading: 2, More than one cascading: 1
H: >SBD350,000/month: 3, SBD150,000 to 350,000/month: 2, <SBD150,000/month: 1
K: Simple: 3, Medium: 2, Dificult:1
I: Number of At least 250: 3, 150 to 250: 2, Less than 150:1
J: 0 to 1: 3, 2 to 5: 2, at least 6: 1

Annex 4 Implementation Schedule of NRW Reduction in DMAs and Cost to be incurred

As of 15 September 2015

DMAs	Estimated Cost (SBD)
1 No.10 Lenggakiki (Completed)	(441,903)
2 No. 6 Tasahe A & B	(246,777)
3 No.10 West Kola Ridge A	(365,383)
4 No.7 Tasahe C	(288,863)
5 No.22 Kombito-Boaderline, Jakson Ridge and Bura	(1,050,237)
6 No.21 Trecce House, Bura Height and Naha Valley	(952,674)
7 No.13 Mbokonavera	(688,680)
8 No.12 Skyline	(413,208)
9 No.11 Vavaea Ridge	(638,942)
10 No.9 Mbokona	(587,291)
Sub total cost from 2014 to 2015	**(5,673,958)**
11 No.18 West Kolaa Ridge B&C and Naha Height	1,230,059
12 No.23 Kombito Trunk Main	373,035
13 No.2 White River B	690,593
14 No.20 Kombibatu	518,423
15 No.26 Panatina Industrial	594,943
16 No.15 Lower West Kolaa A	705,897
17 No.1 White River A	705,897
18 No.27 Burns Creek	296,515
19 No.28 Lungga and Airport	189,387
20 No.8 Ngossi	642,768
Sub total cost for 2016	**5,947,517**
21 No.14 Tuvaruhu	86,085
22 No.19 Tanuli and Mbua Valley	715,462
23 No.24 Panatina Ridge East and Mbaranamba	667,637
24 No.16 Lower West Kolaa B	508,858
25 No.3 Rove A	294,602
26 No. 25 Panatina Ridge West	319,471
27 No.4 Rove B	143,475
28 N o.5 Rove C	145,388
Sub total cost for 2017	**2,880,978**
Disbursed Cost from 2014 to 2015	**(5,673,958)**
Total Cost from 2016 to 2018	**8,828,495**
Total Cost for all Activities in 28 DMAs	**14,502,453**



: Originally-planned Schedule : Actual Schedule : Revised Schedule

Note: Cost of replacement of downsized pipes is NOT included in the above. CPI (5%) was considered for the estimated cost.

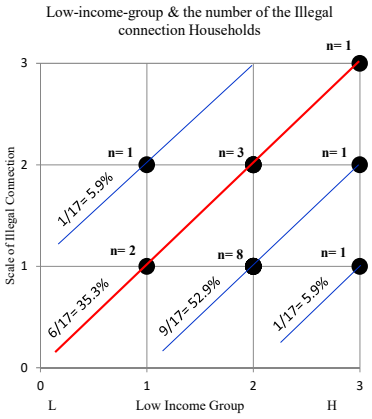
Annex 5 Monitoring Sheet of NRW Reduction Activities

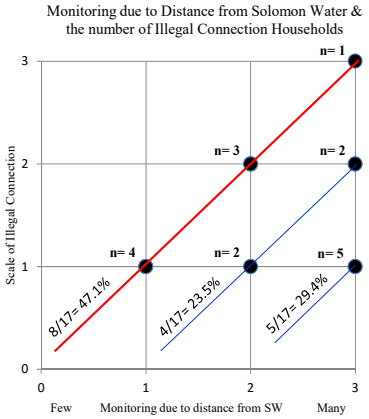
	Activities	Teams of Task Force					1	2	3	4	5	….	28
		Planning	Monitoring	Maintenance	Finance	Customer Care & Comm.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.
OJT through Actual NRW Activities	**1. Planning**												
	Formulating an annual action plan	✓					□	□	□	□	□	□	□
	2. Procurement												
	Procuring equipment		✓	✓	✓		□	□	□	□	□	□	□
	3. Preparation Work												
	Compiling customer lists	✓	✓		✓		□	□	□	□	□	□	□
	Updating database	✓					□	□	□	□	□	□	□
	Analyze the Existing Network hydraulically	✓					□	□	□	□	□	□	□
	4. Primary Survey												
	Measure System Input Volume and Minimum Night Flow (Before)			✓			□	□	□	□	□	□	□
	Observe Illegal Connections			✓			□	□	□	□	□	□	□
	Detect Leakage and its Identification			✓			□	□	□	□	□	□	□
	Measure Meter Inaccuracy			✓			□	□	□	□	□	□	□
	Analyze IWA Water Balance (Before)		✓				□	□	□	□	□	□	□
	Replace Water Meter and Newly Installation			✓			□	□	□	□	□	□	□
	Repair Pipe			✓			□	□	□	□	□	□	□
	Replace Pipe			✓			□	□	□	□	□	□	□
	Control Water Pressure			✓			□	□	□	□	□	□	□
	Disconnect Illegal Connection			✓	✓	✓	□	□	□	□	□	□	□
	Legalize Service Connection			✓	✓	✓	□	□	□	□	□	□	□
	Measure System Input Volume and Minimum Night Flow (After)			✓			□	□	□	□	□	□	□
	Analyze IWA Water Balance (After)		✓				□	□	□	□	□	□	□
	Estimate Actual Cost of Activities		✓				□	□	□	□	□	□	□

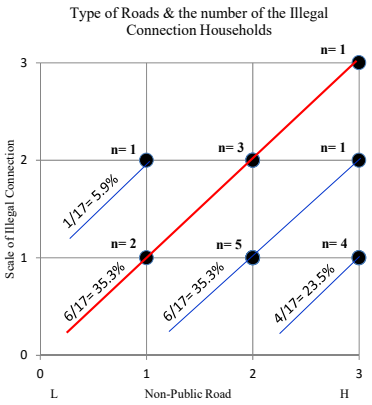
Activities	Teams of Task Force					1	2	3	4	5	….	28
	Planning	Monitoring	Maintenance	Finance	Customer Care & Comm.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.	DMA ID.
Report		✓				□	□	□	□	□	□	□
5. Monitoring & Maintenance Work												
Monitoring flow rate and water pressure in DMA		✓				□	□	□	□	□	□	□
Closing LCZ Valve			✓			□	□	□	□	□	□	□
Analyzing NRW in LCZ		✓				□	□	□	□	□	□	□
Checking customer meters			✓			□	□	□	□	□	□	□
Advising Finance division of status of customer meters		✓				□	□	□	□	□	□	□
Disconnection or legalization			✓			□	□	□	□	□	□	□
Checking duration of customer meters and reporting from water meter readers			✓			□	□	□	□	□	□	□
Receiving report from customers			✓			□	□	□	□	□	□	□
Reporting to monitoring team		✓				□	□	□	□	□	□	□
Testing customer meters			✓			□	□	□	□	□	□	□
Analyzing meter inaccuracy			✓			□	□	□	□	□	□	□
Reporting to monitoring team			✓			□	□	□	□	□	□	□
Reporting to customers		✓				□	□	□	□	□	□	□
Fixing customer meters or replacing with new one			✓			□	□	□	□	□	□	□
Conducting Step-Test			✓			□	□	□	□	□	□	□
Leak detection			✓			□	□	□	□	□	□	□
Fixing pipelines			✓			□	□	□	□	□	□	□

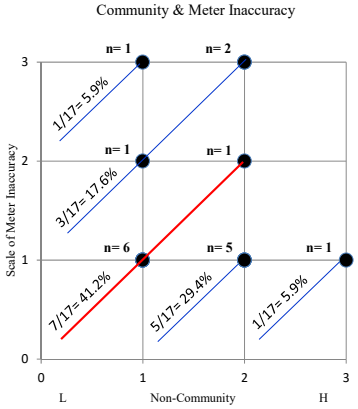
□: Not yet ☑: Next week's activities ☒: Ongoing ■: Completed -: Unexecuted

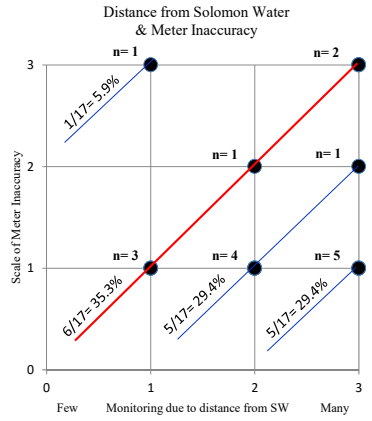
Annex 6 Correlation between the NRW Causes and Feature

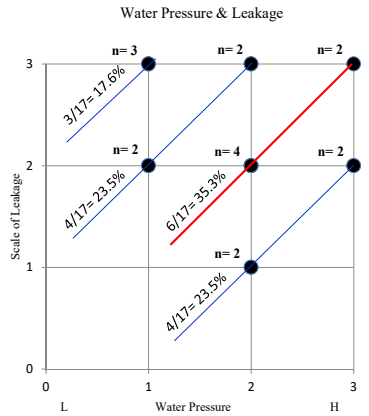


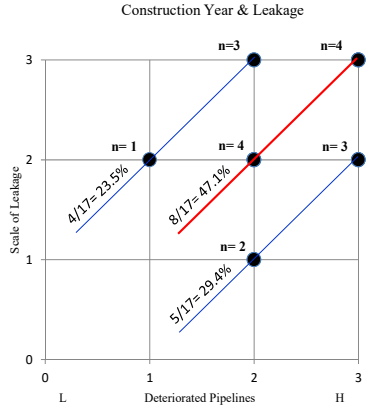


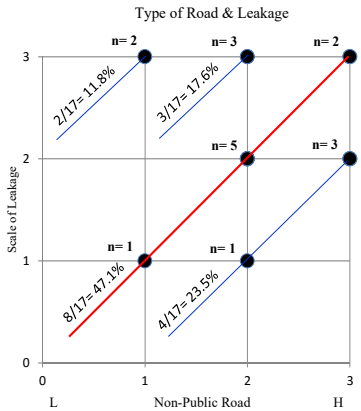












Note:

It is likely that correlation between NRW causes and feature shown in the graph which a red line is shown is high.

CHAPTER 5 ACTIVITIES FOR OUTPUT-2

S5.5-1 HANDBOOK FOR OPERATION AND MAINTENANCE OF EQUIPMENT ON LEAK DETECTION

Solomon Islands
Water Authority

Japan International
Cooperation Agency

The Handbook for Operation & Maintenance of Equipment on Leak Detection

June, 2015

JICA Expert Team & Counterpart Team

Preface:

This manual was prepared for the key counterparts of the NRW reduction team in SW for the purpose of effective implementation of leak detection activities on pipelines in Honiara. This manual contains the procedures for the operations of the leak detection equipment's and how they can best utilize at different pipes conditions and material types. This manual also includes processes for maintaining the devices to ensure their sustainability.

This manual is intentionally designed to be simple and easily followed by means of using simple instructions with the aid of flow charts and pictures. This is meant to be extensively read and understood by those responsible for carrying out leakage detection using the different equipment. In doing so, this should maintain the high and correct ways of detecting leaks and maintaining the equipment. This manual must be referred to when conducting in-house trainings for other staff on leakage detection.

Contents

1. Flow & Water Pressure Survey ····· 1
1-1. Ultrasonic Flow Meter (Porta Flow-C /Fuji Electric /Japan) ····· 1
1-2. Water Pressure Logger (Textlog /Ashridge Engineering /UK) ····· 7
2. Leakage Detection Survey ····· 11
2-1. Listening Stick (LSP-1.5 /Fuji Tecom /Japan) ····· 11
2-2. Electronic Listening Stick (FSB-8D /Fuji Tecom /Japan) ····· 13
2-3. Water Leak Detector (HG-10AⅡ/Fuji Tecom /Japan) ····· 15
2-4. Leak Noise Correlator (LC-2500 /Fuji Tecom /Japan) ····· 17
3. Pipe Location & Valve Survey ····· 23
3-1. Metal Pipe Locator (PL-960 /Fiji Tecom /Japan) ····· 23
3-2. Non-metal Pipe Locator (Tokio Rhythm Sankei /Japan) ····· 29
3-3. Metal Locator (F-90M /Fuji Tecom /Japan) ····· 31
4. Maintenance ····· 33
5. Maintenance Record ····· 33
6. Equipment of SW ····· 34
7. Contact for Repair ····· 35
8. Keys of Maintenance ····· 35
8-1. Common Items of Maintenance ····· 35
8-2. Cases of Repair in SW ····· 36

1. Flow & Water Pressure Survey

1-1. Ultrasonic Flow Meter

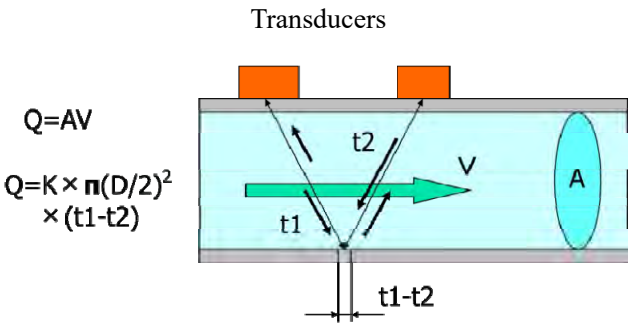
(Model: Portal Flow-C / Fuji Electric / Japan)

(1) Principle

The ultrasonic flow meter measures the travel time of two sound waves between two transducers which are mounted onto outside of a pipe. One wave travels the same direction as a flow and the other one travels against the flow direction as shown in Figure 1-1 below.

The measured difference in received time taken to travel upstream (t1) and downstream (t2) are processed as a velocity and the flow direction by the inside processor.

The flow rate is calculated by multiplying velocity (V) by cross-sectional area of the pipe (A).



Q: Quantity of Flow
A: Cross-sectional Area of Pipe
V: Velocity
D: Diameter of Pipe
K: Factor of Liquid
t: Time to Travel

Figure 1-1 Principle of the Ultrasonic Flow Meter

(2) Components

Components of the ultrasonic flow meter are as shown in Figure 1-2 below.

- Main Unit with a Printer Unit
- Standard Type Sensor with Two Transducers (Detector).
  (Applicable to 50mm to 400mm)
- Signal Cables (Red and Blue)
- DC Adopter
  (For 24 hours Measurement)
- 256KB SD Memory Card

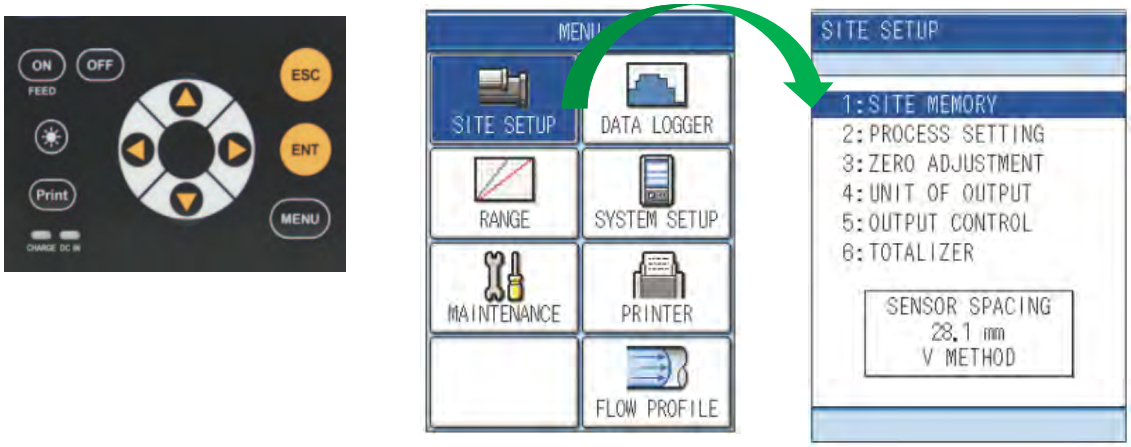
Figure 1-2 Components of Ultrasonic Flow Meter

(3)Intended Purpose

The ultrasonic flow meter can measure flow rate for both the total system input and the minimum night flow in the pilot areas by temporarily mounting the sensors onto a pipe without hindering the flow of water. It is very important for the NRW reduction activity to know the flow rate into a pilot/study area.

(4)Procedure of Operation

The main unit has a simple key panel, so it is easy to operate according to the instructions from the menu as shown in Figure 1-3 below.



Descriptions of each key are as follows;

Key indication or lamp	Description
ENT	The keyed-in data, selected item, etc. will be set by pressing this key.
ESC	Cancels any setting.
▲	Moves the cursor upward, increments set value, etc. (repeats if held down)
▼	Moves the cursor downward, decrements set value, etc. (repeats if held down)
◀	Moves the cursor leftward, change scale, etc. (repeats if held down)
▶	Moves the cursor rightward, change scale, etc. (repeats if held down)
ON/OFF	Turns on/off power supply.
PRINT	Print of the display screen or save the data to SD memory card. (outputs a hard copy).
☼ (LIGHT)	Turns on/off the backlight of display screen.
FAST CHARGE	Turns ON in charge. Turns OFF in fully charged condition.
DC IN	Turns ON with power cable connected.
MENU	Displays MENU screen.

Figure 1-3 Menu Screen of Ultrasonic Flow Meter

The operation itself is very simple. Select the necessary item from the tag page on the main menu. Thickness and diameter of the pipe should be input by numeral.

The sensor spacing will be indicated on the display after data inputting is completed.

Indicated sensor spacing is fixed using the scale on the devise.

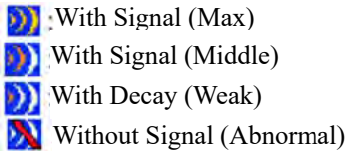
In order to receive signal well, surface of the pipe needs polishing until it becomes smooth.

The sensor unit is mounted onto the outside pipe and held tightly with a belt or a rubber tube.

Receiving signals must be checked on the screen after being mounted.

In case "Signal Decay" appears, the operator should try changing the "RANS-VOLTAGE" from 80Vpp or 160Vpp.

In cases where "Without Signal" is indicated on the display, the operator has to check the input data and the sensor spacing as well as the pipe surface condition. Signal sign will appear on the top as bellow;



The operator should select the **"Zero Clear" mode** before every measurement. If previous zero point remains in the memory, it has a possibility of making an error at the next measurement.

Procedure of the operation is instructed as shown in Figure 1-4.

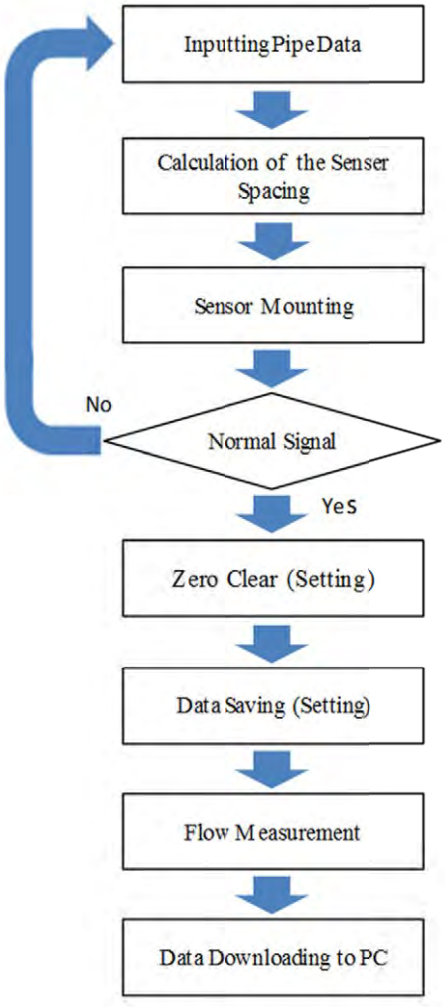


Figure 1-4 Flow Chart of the Operation

(5) How to Mount the Sensors onto a Pipe

The sensors must be placed parallel onto a side of the pipe as shown in Figure 1-5, otherwise reflection of sound wave is obstructed by bubbles which are sometimes flowing upper part of the pipe.

The sensors should be firmly retained with a fixation belt using grease to avoid air-gap between the tied surfaces of the pipe.

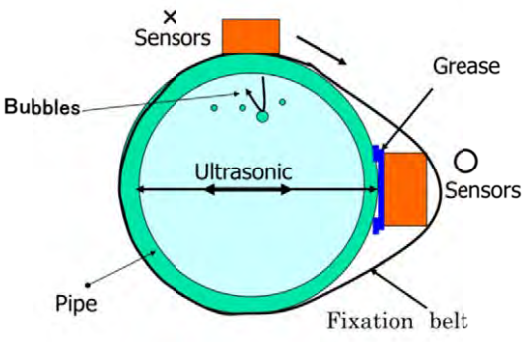


Figure 1-5 Position of Sensor Installation

(6) Saving Data to a SD Memory Card

The operator should confirm the SD memory card is firmly inserted for data saving to proper position at the bottom side of main unit on Figure1-6.

It is ready to record if you find file lists on the data logger page, and the signs below will be also appeared on the top as shown in Figure 1-7.

Figure 1-6 Position to insert SD Memory Card

: When the memory card is not set.
: When the memory card is set.

(7) How to Store Flow Data

The operator checks received signal after placing sensors, the data is calculated based on the pipe information.

If the received signal displays “Normal” on the display, “Log name”, “Flow Unit” as well as necessary information for operations should be inputted for the data saving.

Flow measurement starts after setting recording time and recording-interval at least 24 hours or longer.

Sign of data logging will appear on the top as below;

: Logger Stopped
: Waiting Logger Started

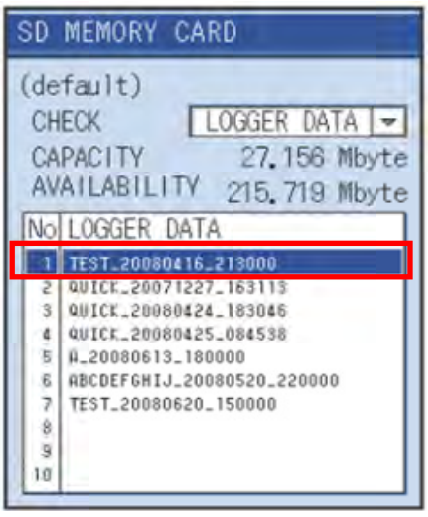


Figure 1-7 Sample of Data Name

The flow data is stored into the SD memory card as a CVS file named in order like "**Log name, Date, Time**".

The saved data in the SD memory card is downloaded to the PC, and a flow graph is created on an excel sheet.

(8) Points to be noted

1) Sensor Location

Measurement location sometimes has a great influence to the measurement accuracy as shown in Figure 1-8 below.

- Measurement location requires to keep a distance for **straight line of 10D** (10 times of the pipe diameter) or longer at the downstream from a 90° bend side and that of **5D or longer at the upstream** from a one.
- Measurement location at the downstream from a valve requires to keep a distance for straight line of **30D or longer and that of 10D** or longer at the upstream.
- Measurement location at the downstream from a pump with a check valve and a stop valve requires to keep a distance for straight line of ***50D*** or longer.

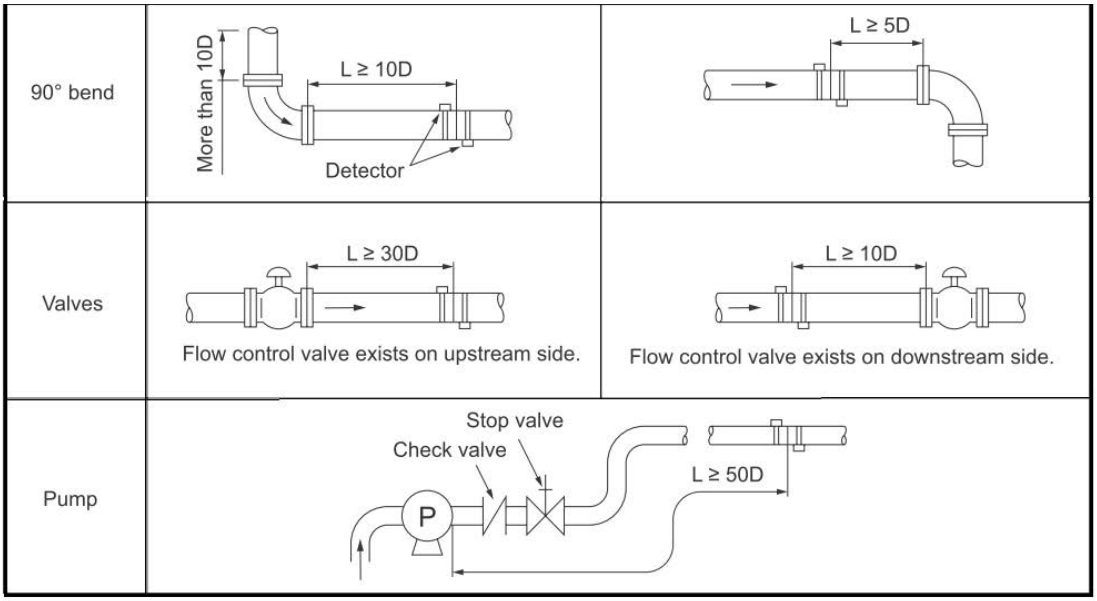


Figure 1-8 Recommended Sensor Distance from Objects

2) Sensor Type

The ultrasonic flow meter has 2 types of sensor; standard type and small type, applied depending on pipe size.

- **The standard type sensor is applied for 50mm to 400mm in diameter.**
- **The small type sensor is applied for 13mm to 50mm in diameter.**

3) Mounting Type

Standard mounting is **"V Method" which places the sensors horizontally** as shown in Figure 1-9 below.

If the pipe is bigger than the limit of "V Method" or the signals received are week, "Z Method" is adopted.

"Z Method" is able to receive signal at shorter distance between the sensors.

The sensors are mounted facing each other by the "Z Method" as shown in Figure 1-9 below.

Signal receiving situation probably improves by means of "Z Method".

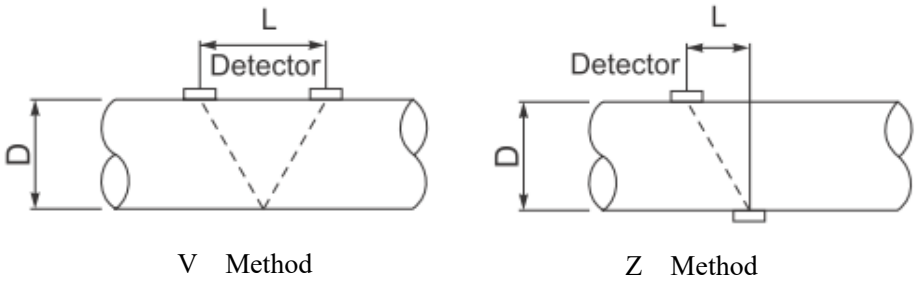


Figure 1-9 Image of V & Z Method

4) Flow Direction

In case of **negative sign (-), the operator should change the cable positions at the upstream and the downstream** because the flow direction may be wrong. If the situation does not change, check the cause on the operation manual.

5) Errors

Some errors might appear on the display such as key operation, measured value, analog output and so on. Find out the solutions from page 147 to page 151 of the operation manual.

6) Protection at Site

The ultrasonic flow meter should be stored in a box from rain and dust during flow measurement because it is not waterproof as shown in Figure 1-10 below.

Figure 1-10 Flow Measurement

1-2. Water Pressure Logger

(Model: Textlog / Ashridge Engineering ltd,/UK)

(1) Specification

The water pressure logger can measure water pressure data for any set period by the built-in pressure sensor and store it into the memory as shown in Figure 2-1 below.

- Range of Use: 1ch Water pressure 0-10 V, 0-20 Bar,
  2 ch 4-20 mA
- Battery Life: 5 years
- Memory: 4 MB 80,000 readings in cycle

Figure 2-1 Water Pressure Logger

(2) Intended Purpose

There is a strong correlation between water pressure and the flow rate in a network system.

Water pressure data should be collected together with the flow data for the monitoring because the flow rate always changes by consumption volume.

(3)Procedure of Operation

Setting of data saving should be operated through the software because the water pressure logger itself has no keys. The main menu and functions are as shown in Figure 2-2 and Table 2-1 below by numbers.

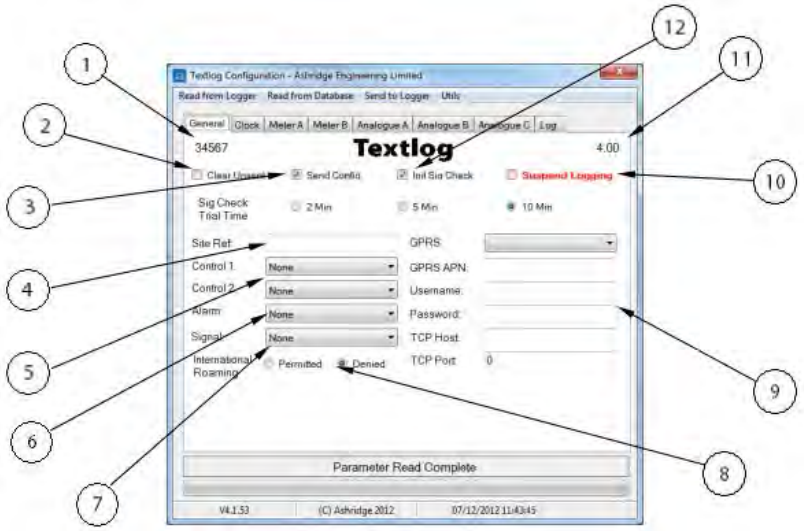


Figure 2-2 Setting Screen

Table2-1 Function of Numbers

1	Textlog serial number
2	Clear any messages currently waiting in the SMS queue. This can be used to remove messages if the Textlog has been logging with no SIM card or credit.
3	Triggers the unit to send configuration information to the server. This allows the server to keep up to date information on the Textlog for remote configuration at a later stage.
4	Site reference of where Textlog is to be installed. Note: Standard windows filename characters are not permitted.
5	Phone number for SMS reading message to be sent.
6	Phone number to which human readable alarm messages are sent. This could be the Engineer responsible for that area or Site Engineers.
7	Phone number the signal check message will be sent to, this is advised to be the Commissioning Engineer.
8	Permit or Deny international roaming. This needs to be set to permit if the SIM card used is not from the country the Textlog is situated in.
9	GPRS Settings, see section 7. It is advised to select GPRS settings from the drop-down box instead of entering manually to avoid errors.
10	**Warning:** This option when selected will put the Textlog into Dormant Mode, ready for transport or storage. No logging will happen in this mode.
11	Current Firmware Version
12	Initiates a signal check for the number of minutes selected in the "Sig Check Trial Time" below. This will also bring the Textlog out of Dormant Mode.

(4) How to Set Up

The port cable of infrared ray type is connected to a USB port of PC for data setting.

Serial Number of the pressure logger will display at the left upper side on the menu when "Read from Logger" is clicked. Port number should be checked when an error sign is displayed.

Click the tag of "Clock" and set the data logging interval, then click "Send to logger".

Current time will be synchronized at the time by your PC.

Setting of data saving for water pressure is prepared on the tag of "Analog A".

Check the data unit (mb) and tick "Normal-Enabled" box. Zero internal pressure transducer for atmospheric conditions key is to be clicked for the "Zero Adjustment" before measurement.

The setting will be completed when the "Send to logger" is clicked.

Measurement will start automatically when a hose is connected to the attachment of a pipe or a water tap. Procedure of operation is as shown in Figure 2-3 below.

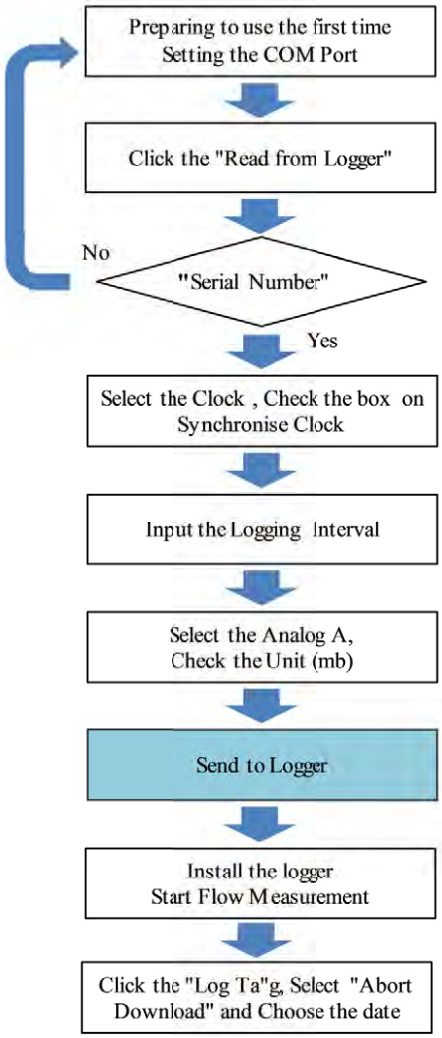


Figure 2-3 Flow Chart of Operation

(5) Data Downloading

Download saved data from “Log” tag. Input the 24 hours data, you like to down load.

The saved data is automatically downloaded into “Data Folder” under “***Ashridge***” by a text file.

A graph of water pressure is seen with the flow data on an excel sheet.

Figure 2-4 Setting on PC

(6) Combine the Flow and the Water Pressure Data

The flow data and the water pressure data are seen on an excel sheet as a line graph of MNF.

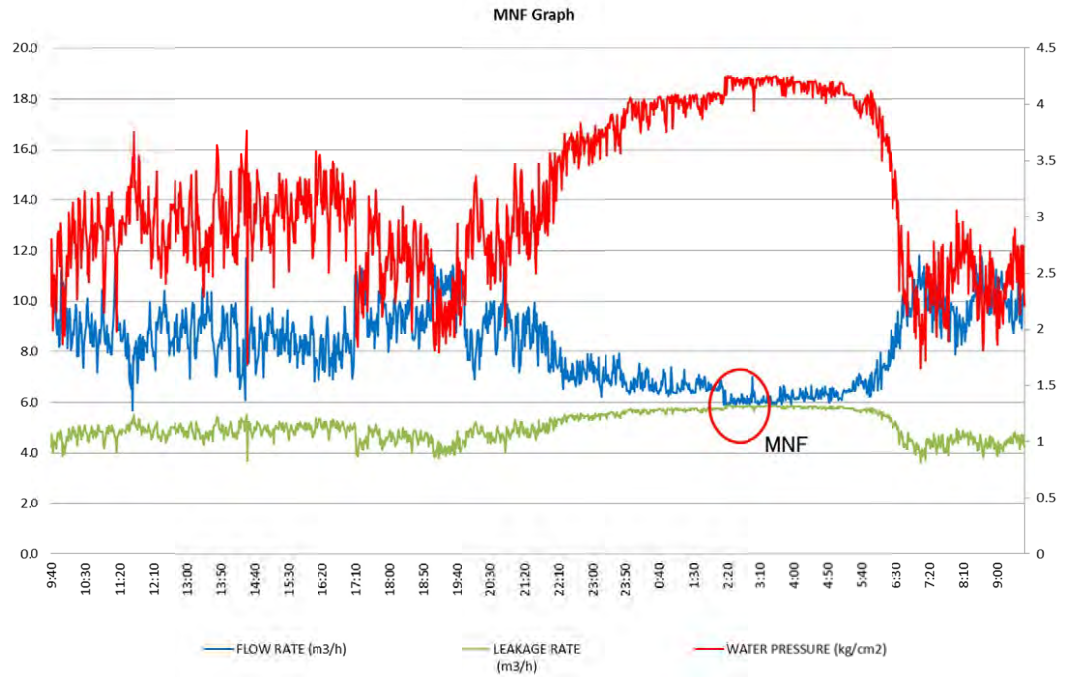


Fig2-5 Sample of Combined Graph

(7) Points to be noted

1) Location

Installation location of the water pressure logger needs to locate close to a flow meter on a main pipe.

2) Time Adjustment

Setting of time should be done before the water pressure measurement, otherwise time difference might happen on a combined graph.

2. Leakage Detection Survey

2-1. Listening Stick

(Model: LSP-1.5 / Fuji Tecom / Japan)

The listening stick is the most simplest device in the leakage detection equipment, and it has many uses in leak detection survey.

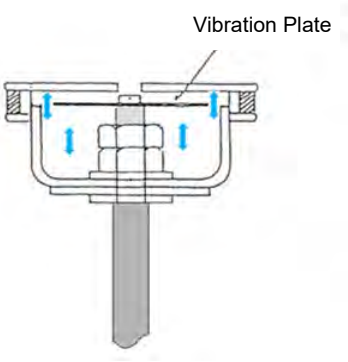


Figure 2-1 Principle

(1)Principle

Vibration of leak sound from the leakage point propagates to the head part of the listening stick through a water meter or a valve, and it would be amplified with a vibration plate inside as shown in Figure 2-1.

(2) Intended Purpose

There are two ways to use this device on a leak detection survey.

- Check the leakage sound from the leak point at customer meters or valves on an acoustic survey.
- The device is used to identify the exact leaking point on a confirmation survey by inserting it into a drilled hole.

(3) How to Operate

Contact the tip of the listening stick to the glass surface of a metallic part of water meter, valves and other fittings. Touch an ear to the head part of the listening stick to listen leak noise carefully.

Cover the other side of the ear with your fingers when the surrounding environment is noisy as shown in Figure 2-2 below.

Close a stop cock if the water meter is moving, and check it again.

Contacting points with a good sample and a bad sample are indicated below.

The stick connects to a metallic part. Good Sample Bad Sample

Figure 2-2 Acoustic Survey

(4) Points to be noted

1) Warning

- **Do not swing around** the listening stick to avoid personal injury.

2) Wrong Use

- **Do not bend** the stick part strongly.
- **Do not apply force to the head part** when pull it up from a drilled hole.
- **Do not hold the stick part** with a hand when listen to leak sound otherwise the sound will be attenuated.

2-2. Electronic Listening Stick

(Model: FSB-8D / Fuji Tecom / Japan)

The electronic listening stick can be used at a non-metallic service pipes such as PVC and polyethylene instead of the normal listening stick.

It is effective to detect a minor tone trough the headphones because it has an amplifier unit, in addition a sound level is on the LCD as shown in Figure 2-3.

Figure 2-3 Electric Listening Stick

(1) Intended Purpose

The electronic listening stick can check sound by contacting to customer meters or valves.

(2) How to Operate

Touch the tip of the contact rod to a meter, a water tap or other water fittings, and then press the switch button.

Adjust the sound level with the volume control if the sound is too loud.

The magnitude of the vibration is displayed on the LCD.

The vibration sound can be heard through the headphones at the same time as shown in Figure 2-4 and Figure 2-5 below.

The operator should mark the location on the survey map when he/she listens to a suspicious sound. The suspicious sound is confirmed by the water leak detector or other equipment.

Figure 2-4 Operation

Figure 2-5 Survey

(3) Points to be noted

- This equipment is not shock-resistant.
- Do not apply strong impact to it, otherwise troubles may arise.
- Do not swing around this listening stick to avoid personal injury.

2-3.Water Leak Detector

(Model: HG-10A Ⅱ / Fuji Tecom / Japan)

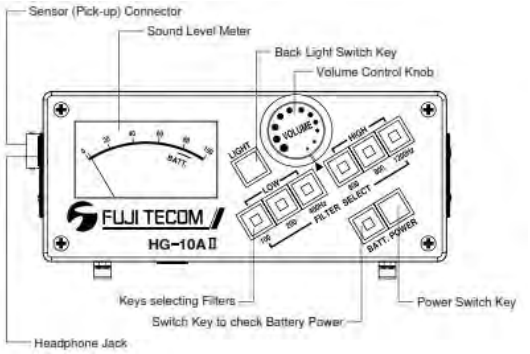


Figure 2-6 Function

(1) Specification

- Amplification: 62dB
- Frequency Range: 100Hz to 1200Hz
- Sensor Sensitivity: 0.7V/g at 400Hz

(2) Intended Purpose

Water leak detector can identify exact leaking points by listening peak sound from surface of a road on a pinpoint survey.

(3) How to Operate

1) Preparation for Survey

Turn on the switch, and check the residual amount of battery before using it at the site.

Keep holding the hand switch, and try making sound by your feet near the sensor to check the listening condition.

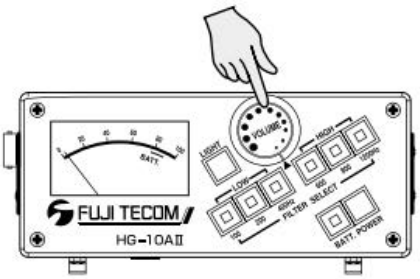


Figure 2-7 Sound Adjustment

Then, adjust the volume at the suitable level with the control knob. Filter frequency is to be adjusted according to the pipe material as shown in Figure 2-7.

2) Use

Water pressure will increase at midnight because the consumption becomes low.

Leak sound will also increase the friction noise of leak point by pushing water out from the inside pipe with strong energy.

Operators should walk with keeping at least 2 meters away from each other for avoiding foot noises of each other.

The operator who walks above the main pipes, and the other one walks on the opposite side of the road to detect leaks on the service pipes.

The operator should gently place the sensor at approximately every 30cm to 50cm.

The sensor should be placed forward, backward, rightward and leftward to detect the loudest point at the suspicious point as shown in Figure 2-8 below.

It should be marked on the survey map and the surface of the road when suspicious sound is heard.

Figure 2-8 Pinpointing Survey

(4) Environment for the Survey

Leak sound is generated by water coming out from a hole or a crack of a pipe.

Water pressure will increase when the water consumption goes down at midnight and the leakage sound becomes large.

Pinpointing survey is recommended to be implemented at a quiet environment and high water pressure at midnight.

(5) Points to be noted

Remove the plug of the headphone from the main unit while it is not in use, otherwise batteries will die.

Do not drop the sensor to the ground from the high position, otherwise element plate in the sensor will break.

Do not soak the sensor into water because the sensor is not waterproof.

2-4. Leak Noise Correlator

(Model: LC-2500 / Fuji Tecom / Japan)

(1) Components

The leak noise correlator is consists of one main unit and two pre-amplifiers with sensor and see functions as shown in Figure 2-9 below.

1) Main Unit

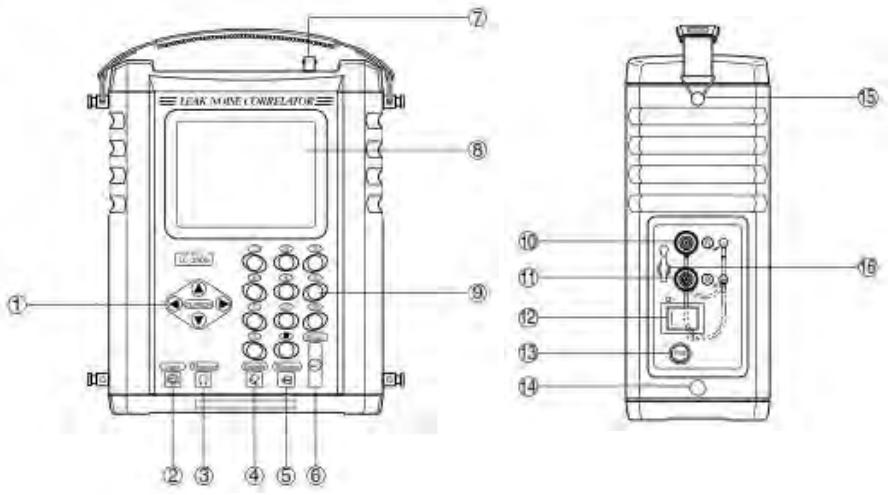


Figure 2-9 Main unit of Leak Noise Correlator

①Cursol Key：Move the cursor up, down, right, or left.

②Light Key：Turns on /off the backlight for membrane switch and LCD.

③Monitor Key: Change the outputstyle to the headphones or the speaker.

④Delete Key: Delete data input.

⑤Escape Key: Returns to previous screen.

⑥Entry Key: Confirms the menu and setting.

⑦Antenna: Connector: The receiving antenna is mounted here.

⑧LCD: Operate through this display.

⑨Numeric Key: Enter numerical data and selects items.

⑩Cable Connection(red):To use the unit in the cable mode, plug in the red here.

⑪Cable Connection(blue):To use the unit in the cable mode, plug in the blue here.

⑫Power Switch: Turns on the unit

⑬Fuse: Protects the unit from over current, In case of blowout, replace it with new one.

⑭Waist Strap Hook: Keeps a position of main unit on the waist.

⑮Shoulder Strap Hook: Hooks the strap on your neck at work or conveying unit on your shoulder.

⑯Headphone Jack: To listen leak noise with headphone set, plug in it here.

2) Pre-Amprifier

Functon of Pre-Amprifier and Pick up sensor are as shown in Figure 2-10 below.

①Antenna: Transmits radio wave

②Hook: Hooks the pick-up sensor

③LCD: Control the pre-amplifier condition on this screen.

④Select/Adjust Key: Select the setting and adjusts the sensitivity.

⑤Light Key: Turns on/off the backlight for membrane switches and LCD

While this key is active, a light symbol is observed on the upper right corner of the LCD.

⑥Speaker Key: Turns on/off the speaker.

⑦Enter Key: Changes the menu and confirms the setting.

⑧Power Key: Turn on/off the pre-amplifier

⑨Headphone Jack: To listen the leak noise with a headphone set, plug in it here.

⑩Cable Connector: To use the pre-amplifier in the cable mode, plug in the cable here.

⑪Pick-up Input Connector: The pick-up is connected here.

3) Pick-up Sensor

①Pick-up Sensor: Detects a leak noise at the measurement point.

②Magnet: Allows the pick-up to attract a pipe or other target.

③Pick-up Cord: Sends the signals acquired with the pick-up to the pre-amplifier.

④Pick-up Connector: Connects the pick-up and pre-amplifier.

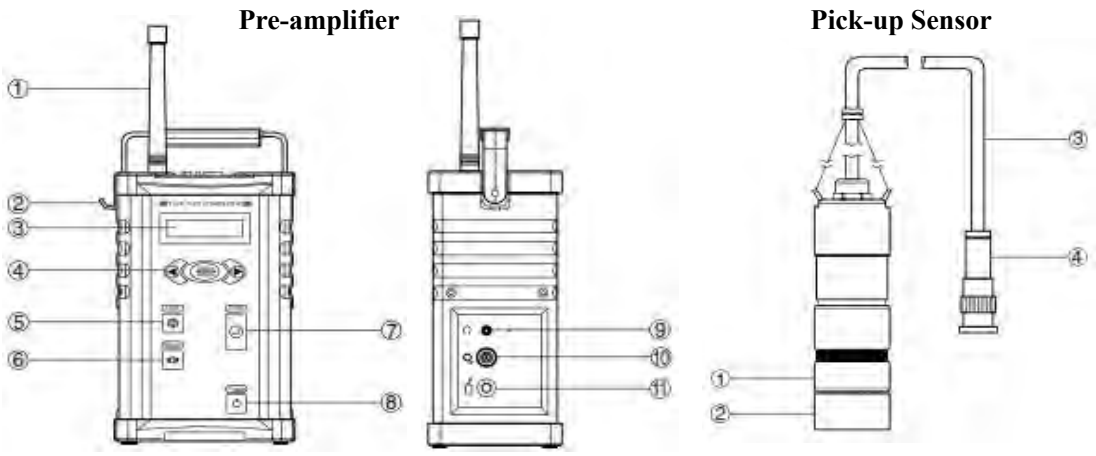
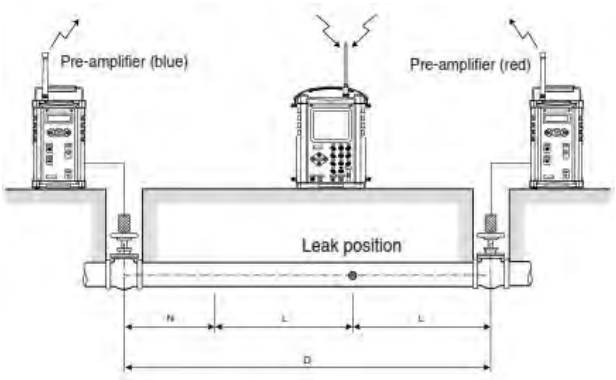


Figure 2-10 Pre-Amplifier & Pick-up Sensor

(2) Principle

In case leak position is close to the red pre-amplifier (on the right side in the Figure 2-11), the leak noise is detected with the pick-up (sensor) of the red pre-amplifier first.

The leak noise propagates to both the blue and the red pick-ups. The propagation speeds are identical under the same pipe conditions. When the leak noise is generated at a given timing and reaches the red pick-up, it also has traveled toward the blue pick-up sensor by distance, L, which is equal to the distance from leak position on the red pick-up sensor.



$$L = \frac{D-N}{2} = \frac{D-(V \times T_d)}{2}$$

Td: Delay time (time difference)

Figure 2-11 Principle

The leak noise furthermore travels the remaining distance, N, and reaches the blue pick-up. Therefore, an additional time equal to N divided by sound velocity is needed for the leak noise to reach the blue pick-up (This additional time is called ”Time difference”).

Since, the time difference is determined by calculating the correlation coefficient, N is a product of time difference and sound velocity. When N is known, the distance from the leak position to the red pick-up is calculated from (D-N)/2 since D is given as one of the preconditions.

(3) Intended Purpose

The leak noise correlator is used on confirmation, and can exactly identify the leak position if the pipe material, the pipe diameter and the distance between the pre-amplifiers are correctly inputted.

Especially, it is more effective to identify leaks at deep locations or a noisy area where leaks are difficult to detect by the water leak detector.

(4) Absolute Inputting Conditions

- Leak noise reaches two measurement points.
- Material of the target pipe is identified.
- Diameter of the target pipe is identified.
- Distance between the two pick-ups is identified.

  If any of these conditions is missing, the leak position cannot be detected.

(5) How to Operate

1) Preparation

Connect the pick-up cables to pre-amplifiers, and check the signal condition after turning on the switch of the main unit.

Install the pick-ups to the target valves and listen to the sound through the headphones or a speaker.

2) Pre-correlation Check

Select “correlation check” and press the enter key to check the correlation peak.

It will appear on the monitor as long as the leak sound propagates to both sides. It is a good way to move the pick-up sensors to closer points, if it is not able to make a graph with a correlation peak.

3) Correlation

A correlation peak appears on the screen when the pipe material, the diameter and the distance between the pick-up sensors scaled by a measuring device on the menu screen are inputted.

Start the program of correlation, and the distance of the leak will appear on the screen within a few seconds. Procedure of operation is as shown in Figure 2-12 and Figure 2-13 below.

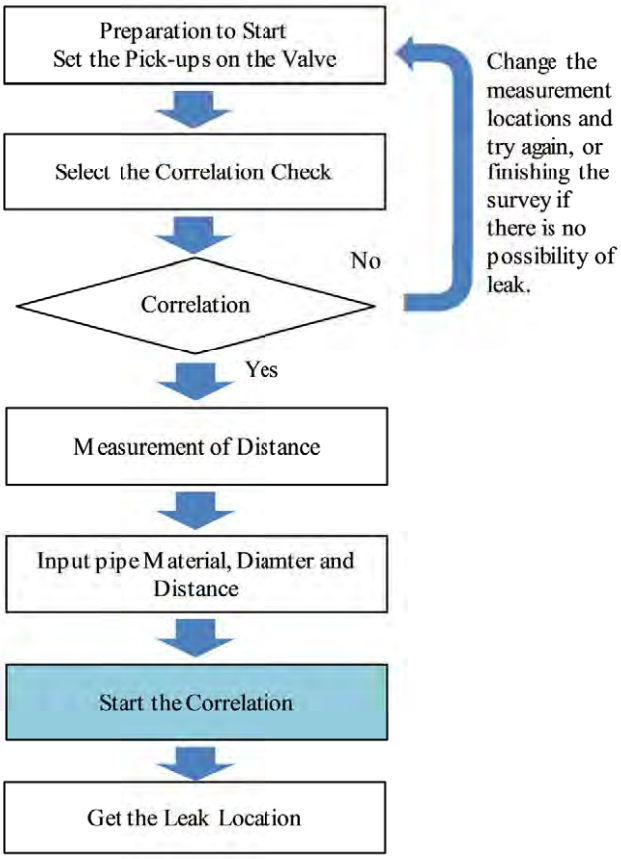


Figure 2-12 Flow Chart of Operation

Figure 2-14 Correlation Survey

(6) Points to be noted

1) Preparation

The tip of the pick-up sensors touch with contacted part of the valve should be kept clean.

2) Position of Pick-up Sensors

There are two possibilities when the distance from a leak is indicated 0 m at one side of the pick-up sensors. One the point is very close to the leak or just above it.

The other one, the point is out of coverage of the pick-up sensors.

In case 0 m is indicated, the pick-up must be moved closer to the suspicious point because leak always has to be between the two pick-up sensors as shown in Figure in 2-13 below.

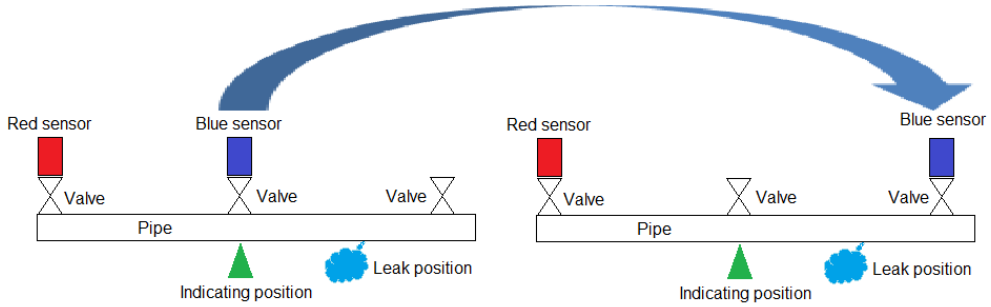


Figure 2-15 Sensor position

(7) Confirmation

Confirmation survey determines the leakage point by drilling a small hole and pushing in a boring bar in it, even if the correlator has identified the point already.

An error sometimes happens if wrong pipe information is given.

Equipment of confirmation is as follows;

- Generator
- Hammer Drill
- Boring bar (1.0m)
- Listening Stick (1.5m)

3. Pipe Location & Valve Survey

3-1. Metal Pipe Locator

(Model: PL960 / Fiji Tecom / Japan)

(1) Specification

Frequency: 27 kHz (Single line, Long distance, Deeper point),
83 kHz (Standard frequency, Town area, Middle distance, Plural lines)
334 kHz (Short distance, Shallow point)

Output Power: Induction mode 0.5W, Direction mode 3.0W

Detectable Depth: 5 meters or more

(2) Principle

The transmitter can generate an electric current to a metallic pipe from a ground.

Induction field will be generated around the metallic pipe or a cable when the transmitter gives the electric current to the pipe.

The receiver can detect a location of the metallic pipe by catching a peak point of the induction field from the surface of the road as shown in Figure in 3-1.

The depth of buried metallic pipe or the cable can be also detected by the inside antenna of the receiver.

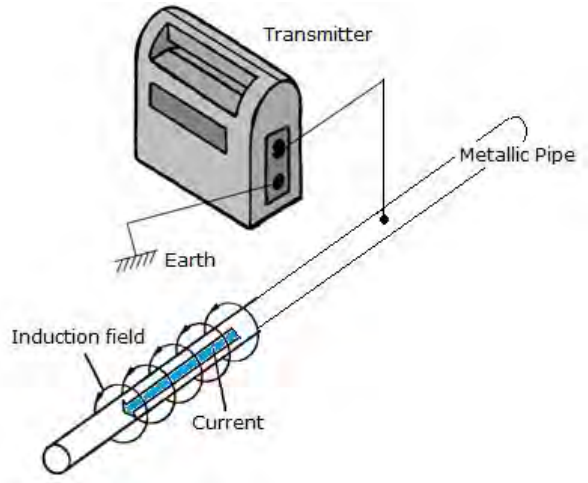


Figure 3-1 Principle

(3) Component

Function of the transmitter is as shown in Figure 3-2 below.

1) Transmitter (main unit)

①Battery Case Cover
②Direct Mode Connector
③Operation Panel
④Handle for Carry
⑤Warning Flag Holder
⑥Serial Number Plate

Operation Panel
①Power Switch Key
②LCD
③Mode Selection Key
④Frequency Selection Key
⑤Output Power Control Key

Figure 3-2 Transmitter

2) Receiver (Main Unit)

Function of the receiver is as shown in Figure 3-3 below.

①LCD
②Operation Panel
③Handle for Operation
④Antenna
⑤Battery Case Cover
⑥Foot Plate

Control Panel
①Power Switch Key
②LCD
③Volume Control Key
④Frequency Selection Key
⑤Mode Selection Key
⑥Sensitivity Adjustment Key
⑦Depth Measurement Key
⑧Back Light Key

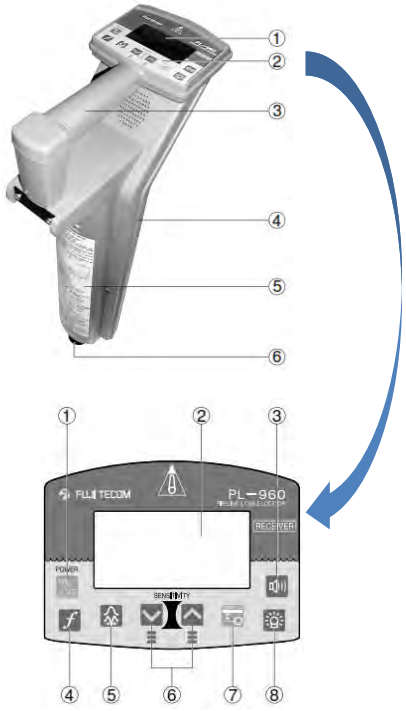


Figure 3-3 Receiver

(4) Intended Purpose

The metal pipe locater is not only used for detecting buried pipe but also useful to damages to other facilities such as electric cables or Telekom lines by knowing the locations of the buried pipes before

excavating around them.

Knowing the location of the buried pipes is important to detect the location of the leak exactly for leak detection survey from the surface of the road. The pipe location and its depth should be detected before the survey, if is the location of the pipe is not known.

(5) Indirect Mode

Indirect mode is one of the ways to detect the location of buried metallic pipes without connecting the cable to pipe or fittings.

Indirect mode is effective to detect for single line without any influence from other metallic objects.

(6) Direct Mode

Direct mode is to make an electric circuit between the pipe and the transmitter by connecting the cable. Direct mode is effective to detect only the location of the target pipe among other pipes cases where a number of pipes are buried or closely together.

(7) Operation

1) Indirect Mode

In cases where the location of the pipe is not known, two operators stand facing each other and move toward each other while holding the transmitter and the receiver respectively.

Two operators simultaneously move parallel until the end of the survey area to the same direction keeping a fixed distance so as to across the buried pipe at same time.

The buzzer sounds with maximum value when the receiver approach to an induction current of the buried pipe.

The transmitter is placed on the sounded point as the base point; the detection line is extended further to check for other parts of the pipe as shown in Figure 3-4 below.

Figure 3-4 Locating by Indirect Mode

The operator with the receiver checks the location of the remaining pipe at every 15 or 20 meters. The checked points on the road are marked by a colour spray.

Keep a distance at least 5 times of the pipe depth between the transmitter and the receiver.

The operators should check again the detected points by drawing the center line above the metallic pipe using a measuring tape or a string.

They should check the depth of the pipe on the display at the detected points whether it is a proper value as the depth of the water pipe.

Procedure of operation is as shown in Figure 3-4 below.

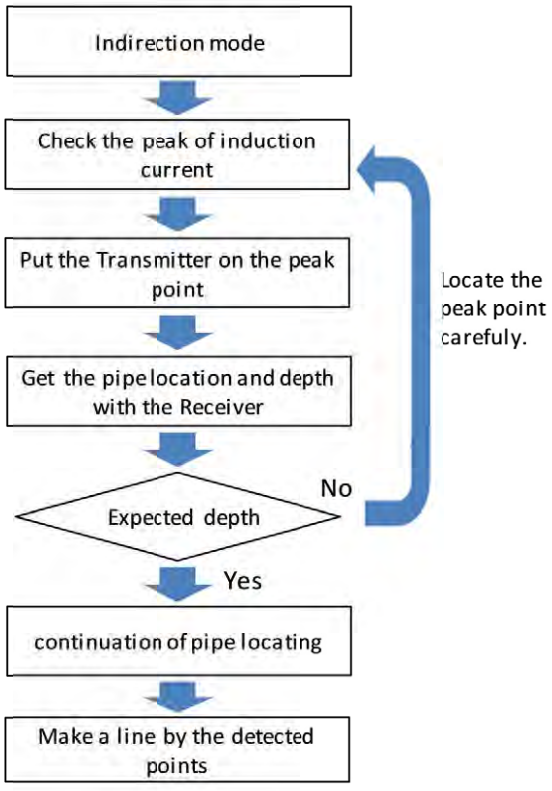


Figure 3-4 Procedure of Operation

2) Direct Mode

In case pipes are placed closely or buried together at a site, the target pipe should be detected by the direct mode.

Change the detecting method to the “Direct Mode”. One side of the connecting cable connects to the connector of “Direct Mode”, and the other side of the cable is clipped to an exposed fitting from the target pipe as shown in Figure 3-5 below.

Figure 3-5 Direct Mode

The earth condition should be checked with the signal.

If the ground is dry, pour some water to make the earth wet when the signal is weak.

The procedure of operation of direct mode is as shown in Figure 3-6 below.

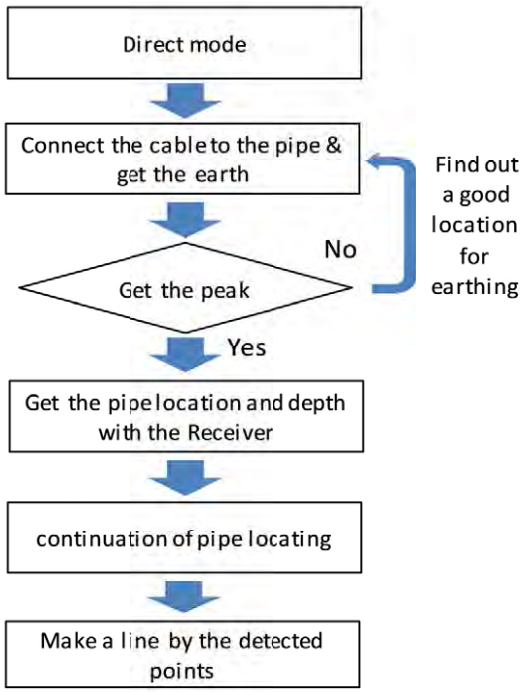


Figure 3-6 Procedure of Operation

(8) Points to be noted

1) Distance of the transmitter and the receiver

The receiver should keep away more than 10 meters or at least 5 times of pipe depth from the transmitter otherwise it will be affected by the induction current.

2) Induction mode

In case the locating point is close to a metal fence, the induction current might move there.

The transmitter should be kept away from it as shown in Figure 3-7 below.

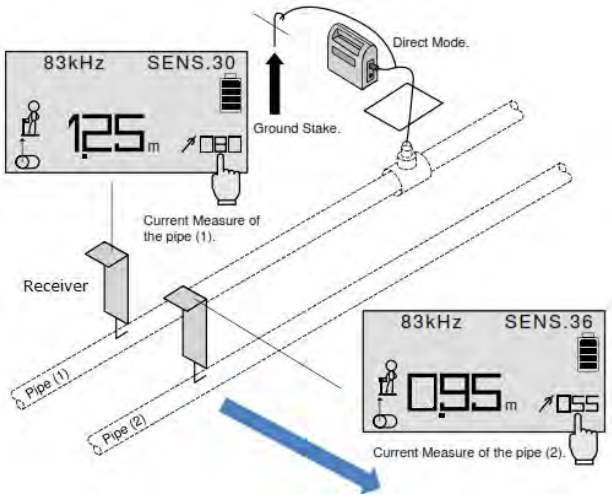


Figure 3-7 Position of Transmitter

3) Direct Mode

In case of location where more than one pipe is buried, the transmitter should be placed with keeping enough distance from the target pipe and other pipes as the figure 7-8.

4) Bending point

When the induction signal is weak at a location, the point could be a bend fitting of the pipe or end of pipe.

Induction signal is checked at all-direction around the last peak point which direction the pipe goes.

3-2. Non-metal Pipe Locator

(Model: Tokio Rhythm Sankei / Japan)

(1) Component

The non-metal pipe locator is consists of only a plunger pump and a rubber hammer.

(2) Principle

The plunger pump has a cylinder inside that moves up and down hitting the top of the plunger pump with the rubber hammer in a constant rhythm.

The moved cylinder makes an impact sound wave and pushes water into the pressured pipe.

Impact sound wave travels to the main pipe through the service pipe.

The hitting sound is detected by the water leak detector from the surface of the road as shown in Figure 3-8 below.

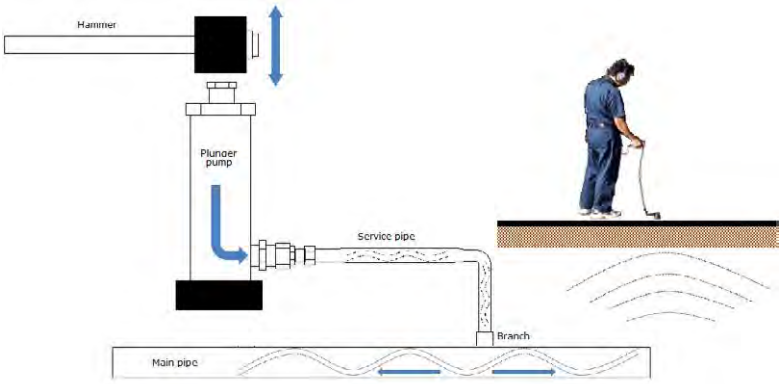


Figure 3-8 Non-metallic Pipe Locator

(3) Intended purpose

The non-metal pipe locator is useful to detect the non-metal pipe location.

(4) Operation

The location of non-metallic pipe subjected to leakage detection can be exactly known using this technology. This is done by removing the water meter or water tap and connect the hose to the non-metal pipe locator. Fill up the hose and the plunger pump with water. Air in the hose should be removed by opening the valve of the plunger pump.

Check the peak of the sound wave at the brunch or the main pipe with a water leak detector from the surface of the ground as shown in Figure in 3-9 below.

Figure 3-9 Operation

Procedure of operation of the non-metallic pipe locator is as shown in Figure 3-10 below.

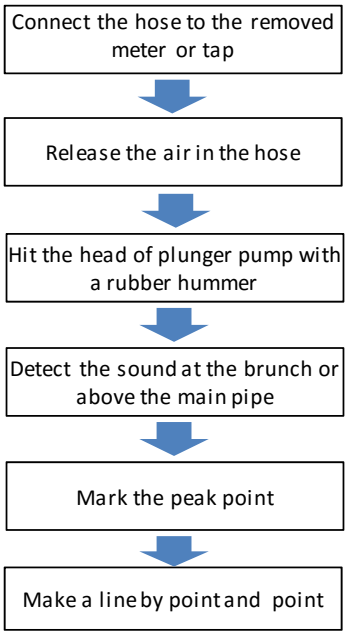


Figure 3-10 Procedure of Operation

(5) Points to be noted

- Do not hit the plunger pump strongly.
- Do not use a metallic hammer for hitting, otherwise the hitting sound and the propagated sound in the pipe may overlap.

3-3. Metal Locator

(Model: F-90M / Fuji Tecom / Japan)

(1) Specification

Detectable Depth: 42cm in case of the iron plate of 100mm diameter×20mm thickness.
65cm in case of the control valve cover of 180mm diameter

Oscillation Frequency: 9.75±15kHz

Oscillation Output: 8.2V/p-p

(2) Components

Function of the metal locator is as shown in Figure 3-11.

①Speaker
②Re-set Switch
③Headphone Jack
④Amplifier Housing
⑤Power and Sensitivity Control Switch
⑥Indicator Meter
⑦Battery Cover
⑧Length Adjustment
⑨Stopper
⑩Antenna Housing

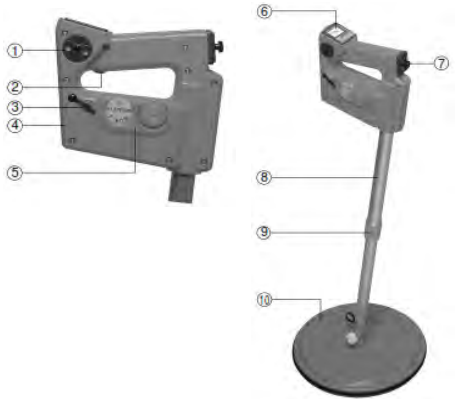


Figure 3-11 Metal Locator

(3) Principle

The simplest metal detector is consists of an oscillator producing an alternating current that passes through the coil producing an alternating magnetic field as shown in Figure 3-12 below.

When the antenna passes a metallic object, the alternating magnetic field will be high and the buzzer will sound.

Figure 3-12 Principle

(4) Intended Purpose

The metal box locator is useful to detect a buried boundary valves of DMA.

(5) How to Operate

Switch on the metal locator to start.

Check the reaction of the metal locator by the sound informing function when the antenna is close to a metallic object.

Switch the detection key to “(ON/Medium)” position at first.

Press the re-set switch once when the antenna is away from the metallic object.

When the buzzer sounds, move the antenna to all-direction there in order to estimate the size of the object.

(6) Points to be noted

1) Sensitivity Adjustment

The maximum sensitivity can be obtained from the following case.

In case the size of the object is 100mm in diameter, the metal box locator can detect a metal object located at the depth;

“ON” position is 30cm or so in depth.

“HI” position is 40cm or so in depth.

“LO” position is 15cm or so in depth.

2) Re-set Switch

The re-set switch is used when the point to locate has changed to another or when it takes long time to locate at one point on the ground as shown in Figure 3-13 below.

Figure 3-13 Adjustment

4. Maintenance

Most of equipment consists of electric parts. Electric devices need checking periodically to be sustained for a longer period of time.

There are two ways of maintenance for the equipment. One is a daily check test whether the equipment can work smoothly and properly when the power is turned on before using them at field.

The other one is a thorough check test as a periodical check for the accuracy of performance.

Thorough checking of the equipment for leak detection should be done at least every six months.

Daily check test and the maintenance of equipment have been explained and described at each part of this equipment manual and thorough check test is be explained as below.

(1) Way of Thorough Check Test

1) Metal Pipe Locator should be checked for the accuracy of the depth and the position of a target pipe at a test point where the depth and the position of the pipe are known.

2) Ultrasonic Flow Meter should be checked for the accuracy of flow at low, middle and high rate using a test pipe which has a water meter.

3) Water Leak Detector should be checked for the sensitivity and the filter conditions at a real leak point.

4) Leak Noise Correlator should be checked when Td condition is zero or around zero (m/s) when both sensors are connected and twisted.

5) Metal Locator should be checked for accuracy by detecting the distance from a valve box to the antenna at middle position (ON).

5. Maintenance Record

Recording maintenance is very important for understanding condition of the equipment.

(1) Management of Equipment

- Use of the equipment should be managed by a list of all components and a records of thorough check test must be kept every time.
- List of all components should be recorded to avoid loss of any component. The inventory record must include information "who" and "when" use them.
- It is to be clarified who has the responsibility of the equipment because the number of the equipment is limited and everyone cannot use them for a long time.
- All leak detection equipment should be maintained by the thorough check test every three months and all components are to be checked.

6. Equipment of SW

(1)Equipment List

SW has equipment for NRW reduction as shown in Table 6-1 below.

Table 6-1 Equipment List

1	Ultrasonic Flow Meter	Fuji Electric	1
2	Water Pressure Logger	Ashridge	1
3	Water Leak Detector	Fuji Tecom	2
4	Leak Noise Correlator	Fuji Tecom	1
5	Electric Listening Stick	Fuji Tecom	1
6	Metal Pipe Locator	Fuji Tecom	1
7	Metel Box Locator	Fuji Tecom	1
8	Non-metallic Pipe Locator	Tokio Rhythm	1
9	Generator	Yamaha	1
10	Hammer Drill	Hitachi Kohki	1
11	Boring Bar	Fuji Tecom	1
12	Listening Stick	Fuji Tecom	2
13	Residual chlorine Meter	DKK-TOA	1
14	Distance Meter	Tokyo Rasonic	1
15	Electronic Test Water Meter	Aichi Tokei Denki	1

As of the end of February, 2015

(2)Fitting List

SW has fittings for NRW reduction activities as shown in Table 6-2 below.

Table 6-2 Fitting List

Size (mm)	Valve		Meter		Repair Parts		
	Gate Valve (Brass)	Sluice Valve (D.I)	Water Meter (Brass)	Flanged Water Meter (D.I)	Compression Coupling (UPVC)	Gilbaults Coupling	Repair Clamp (SUS)
			302				
20			442		40		
25	100		32		45		
32	15		23		14		
40	52		7		67		
50	22	6		14	39		32
75	9	7		3	49	53	32
100	2	8		4		49	38
150		25		2		47	0
200		6		0		53	13
225		3		0		0	0
250		16		4		9	15

As of the end of February, 2015

7. Contact for Repair

If you have any problems of the equipment procured by JICA project, contact the address below.

(1) Japan: Fuji Tecom Inc.,

2-20 Kanda Sakuma-cho, Chiyoda-ku, Tokyo, Japan

TEL: +81-3-3862-3196

Email:kaigai@fujitecom.co.jp

Web site: http//www.fujitecom.com

(2) Australia: Detection Solutions Ltd. (Representative of Fuji Tecom in Australia)

Wakefield Centre, 15/276 New Line Rd, Dural, NSW, 2158, Australia

TEL: +61 1300 885 383

Email: Steve@detectionsolutions.com.au

URL:http//www.detectionsolutions com.au

Please tell them the equipment has been procured in Japan by JICA when you contact them for repairing.

If you send equipment to JAPAN for repair, it will take time depending on the condition of damage. Normally, it will take more than 2 months.

8. Keys of Maintenance

8-1. Common items of maintenance

(1) Operation

- Please read the respective operation manuals if you encounter a problem on operation. Most of troubles will be solved.

2)Storage

- Most of the Japanese equipment use dry batteries. Please detach the batteries when the equipment is not used for a long time. Batteries may leak and cause damage to the equipment after being stored inside.
- The equipment and its accessories should be always stored to a fixed place in the own case to cover from dust and soon.
- The equipment should be regularly checked to keep it in good condition even if it is not used for long time.

8-2. Cases of Repair in SW

The cases of repair in Japan were introduced as follows;

(1) Pipe Locator

1) Condition

The switch of the transmitter is on, but the indicator does not change.

2) Cause

Since the batteries have been kept for a long time without using it, the battery liquid has flown out from the battery to the electric circuit board.

3) Contents of the Repair

Replace the mother board of the transmitter and the battery case was replaced. It took about 2 months for repair.

4) Countermeasure

- Remove the batteries from the main unit when the equipment is not in use for more than one month.
- Removing batteries from the units was announced to all staff by noted seal on the main unit.
- An administrator regularly checks situation of use a sticker.

(2) Ultrasonic Flow Meter

1) Condition

The switch of the main unit cannot be turned on.

2) Cause

The connector of the AC adaptor has been shorted.

3) Contents of the Repair

The AC adaptor was replaced. It took about 1 month to get it back to SW.

4) Countermeasure

Notify all staff that the AC adaptor cable should not be pulled out strongly from the connector.

(3)Others

1) Water Leak Detector

Since the sensor of the Water Leak Detector has piezoelectric element which is made of fragile ceramic, do not drop it from more than 50 centimeter in height.

2) Other Electric Equipment

Since most of equipment has electric circuit inside, do not use them in rain.

S5.5-2 MANUAL OF NRW REDUCTION MEASURES

Solomon Islands
Water Authority

Japan International
Cooperation Agency

The Manual of NRW Reduction Measures

For

Solomon Water

August, 2016

JICA Expert Team & Counterpart Team

Preface

This manual was prepared purposely so that SW's key counterparts can continue to refer to when implementing Non-Revenue Water (NRW) reduction activities, NRW monitoring and maintenance, and also to be used when training new staff on NRW reduction measures. This manual is intended to maintain high level of individual capacity in the field of NRW reduction should it is read and referred to regularly.

To achieve comprehensibility and familiarity the manual was deliberately designed to contain raw data and photos on various steps of NRW reduction and leakage detection in the pilot project area. This manual must be referred to constantly to assist SW staff to detect leaks in areas that are difficult to locate location of pipes and leaks on it.

Contents

1. Definition in Revenue Water and Non-Revenue Water ····· 1
2. Effective NRW Reduction Method ····· 4
2-1. Plan of DMA ····· 4
2-2. DMA Creation and Installation of Boundary Valves ····· 4
2-3. Procedure of DMA Creation ····· 4
2-4. Type of Flow Measurement ····· 5
2-5. Concept of NRW Reduction ····· 6
2-6. Procedure of NRW Reduction ····· 7
3. DMA-based NRW Monitoring and Maintenance ····· 11
3-1. Overall Workflow of DMA-based Monitoring and Maintenance ····· 11
3-2. Monitoring Data ····· 11
3-3. Handling and Processing the collected Data ····· 11
3-4. Graphing Time-series Variation of Monitoring Data ····· 11
3-5. Unifying Monitoring Data ····· 11
4. Leak Detection Measures ····· 14
4-1. Method of Leak Detection ····· 15
5. Importance of Recording Leakage Information ····· 28

Reference
Estimating Leakage Volume ····· 26

1. Definition in Revenue Water and Non-Revenue Water

The first step in reducing NRW is to develop an understanding of the present situation of water system based on water balance sheet. This process helps utility managers to understand the magnitude, sources, and loss of NRW.

International Water Association (IWA) has developed a standard international water balance structure and terminology that have been adopted by national associations in many countries shown in the Table 1-1 below.

Mainly the leakage detection team tries to reduce the physical losses such as leakage on transmission and distribution main pipes, and leakage on service connection pipes in the cells highlighted in blue on the table below.

Table 1-1 Water Balance Sheet of IWA

<table>
<tr><td rowspan="9">(1)System Input Volume</td><td rowspan="4">(2)Authorized Consumption</td><td rowspan="2">(3)Billed Authorized Consumption</td><td>(3-1)Billed Metered Consumption</td><td rowspan="2">(8)Revenue Water(RW)</td></tr>
<tr><td>(3-2)Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">(4)Unbilled Authorized Consumption</td><td>(4-1)Unbilled Metered Consumption</td></tr>
<tr><td>(4-2)Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">(5)Water Losses</td><td rowspan="2">(6)Appearent Losses (Commercial Losses)</td><td>(6-1)Unauthorized Consumption</td><td rowspan="8">(9)Non-revenue Water (NRW)</td></tr>
<tr><td>(6-2)Customer Metering Inaccuracies</td></tr>
<tr><td rowspan="3">(7)Real Losses (Physical Losses)</td><td>(7-1)Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>(7-2)Leakage on Service Connections up to Point of Customer Metering</td></tr>
<tr><td>(7-3)Leakage and Overflow at Utility's Storage Tanks</td></tr>
</table>

Definition of water balance components are as follows;

(1) System Input Volume

This is the total input volume to a DMA (District Metered Area) which is measured by a DMA meter. System Input Volume is divided into; Authorized Consumption and Water Losses.

(2)Authorized Consumption

Authorized Consumption is divided into (3) Billed Authorized Consumption and (4) Unbilled Authorized Consumption.

(3) Billed Authorized Consumption

The Billed Authorized Consumption (3) is the volume of water usage that's being billed and is categorized into Billed Metered Consumption (3-1) and/or Billed Unmetered Consumption (3-2). Billed unmetered consumption are used by customers who use water but pay only standard flat rate charge regardless of the amount of water being used. SW has set a standard charge fee for unmetered customers and has authorized customers who fall under such circumstances to pay only the standard flat rate charge. These usages also include leaks and overflows after the point of customer metering.

Billed Metered Consumption (3) is authorized as following data and procedure;

- Billing records are used to quantify measured outputs from the DMA.
- Conduct customer verification to all households in the DMA.
- Convert monthly/quarterly billing data to average daily flow in m^3/day.

1) The Billed Unmetered Consumption (3-2) is as follows;

- This step identifies unmetered households and other authorized unmetered consumption.
- Estimate consumption of unmetered households. Monitor a sample household by installing a meter, or estimate water consumption per capita consumption and number of people live there.

(4) Unbilled Authorized Consumption

Unbilled Authorized Consumption (4) includes water usages such as fire-fighting, flushing of mains, cleaning of SW storage tanks, street cleaning, watering of parks, public fountains etc.

This item is divided into Unbilled Metered Consumption (4-1) and Unbilled Unmetered Consumption. (4-2)

(5) Water Losses

This is the difference of volume between the System Input Volume (1) and Authorized Consumption (2). The Water Losses is divided into Apparent Losses (6) and Real Losses (7).

(6) Apparent Losses

Apparent Losses (6) includes Unauthorized Consumption (6-1) which is illegal water use and Customer Meter Inaccuracies (6-2). Unauthorized Consumption is as follows;

1) Type of Illegal Use

Type of illegal use are as follows;

- Some people use water illegally without registered.
- Some previously registered customers still consume water even after disconnection.
- Some reconnect disconnected service pipes without permission or get a branch line before the

water meter illegally.

2) Type of Meter Inaccuracies

Customer Meter Inaccuracies (6-2) includes error of customer meters and meter handling errors.

Meter inaccuracies are as follows;

- Meter readers might misread meters and fabricate water bills without visit.
- Excess volume by flat rate customers who use water more than $32m^3$/month.
- Meter Inaccuracy can happen to aging meters after been in use for a long time.

Water Losses is calculated as below.

Water Losses = System Input Volume – Authorized Consumption

(7) Real Losses

Real Losses (7), are referred to volume lost through all types of leaks; Leakage on Transmission and/or Distribution Main Pipes (7-1), Leakage on Service Pipes (7-2) and Leakage and Overflow from Storage Tanks (7-3).

Leakage volume can be estimated from the MNF (Minimum Night Flow) which is assumed as the leakage volume in the system if nobody uses water at the time. Or the real loss can be regarded as the volume which authorized consumption and commercial losses are subtracted from the total input.

If there is a 24-hour water supply in the DMA, the measurement for inflow can be conducted, otherwise 24 hours water supply should be temporarily rearranged.

(8) Revenue Water (RW)

This is the total water consumption that can collect revenue from. Revenue water is from Billed Metered Consumption and Billed Unmetered Consumption.

(9) Non-Revenue Water (NRW)

This is the difference between the System Input Volume and Billed Authorized Consumption.

NRW is calculated as below.

NRW = System Input Volume － Billed Authorized Consumption

2. Effective NRW Reduction Method

Flow volume and water pressure in a distribution system should be monitored for NRW reduction.
The technique of leakage monitoring requires installation of flow meters at strategic points throughout the isolated areas, each meter records flow into a discrete area with a defined boundary. Such a discrete area is called a District Metered Area (DMA).

2-1. Plan of DMA

The design of a NRW monitoring system has two aims as follows:

- To divide the distribution network into a number of zones or DMAs, each has a defined boundary, so that night flows into each district can be regularly monitored. It enables to identify the location of unreported bursts and leakages on the distribution lines.
- To manage the pressure in each district or a group of districts, so that the network can operate at the optimum level of pressure.

2-2. DMA Creation and Installation of Boundary Valves

DMA planning is the process of dividing the distribution system into suitable sized DMAs.
Outline planning is the first step; it uses a small-scale distribution map to plan provisional boundaries.
Site survey is necessary to check the location of the valves for isolation of the DMA.

2-3. Procedure of DMA Creation

Procedure of DMA Creation is shown in Figure 2-1 below.
1) Site Survey location of installed valves, DMA meter and customer meters should be checked through site survey. If the boundary valve is missing, the missing valves should be detected with a metal box locator to be found.
2) Checking for Valve Function
Boundary valves are also to be checked whether they are operational or not.
3) Replacement
Functioning valves can be used and malfunctioning valves should be replaced with new valves.
If the boundary valve does not operate well, it should be replaced with new one.
4) Isolation Check
The DMA area should be confirmed in the field to isolate from the neighboring areas completely. If the isolation check failed, all boundary valves should be checked at pipeline which is connect to the neighbor area.
5) Identification of Boundaries
Confirmation of the isolation of the area can be done by closing the boundary valves and then check

if no water flows into the DMA.

6) Installation of DMA Meter and Water Pressure Logger

DMA Meter & Water Pressure Logger are installed at inlet point of DMA.

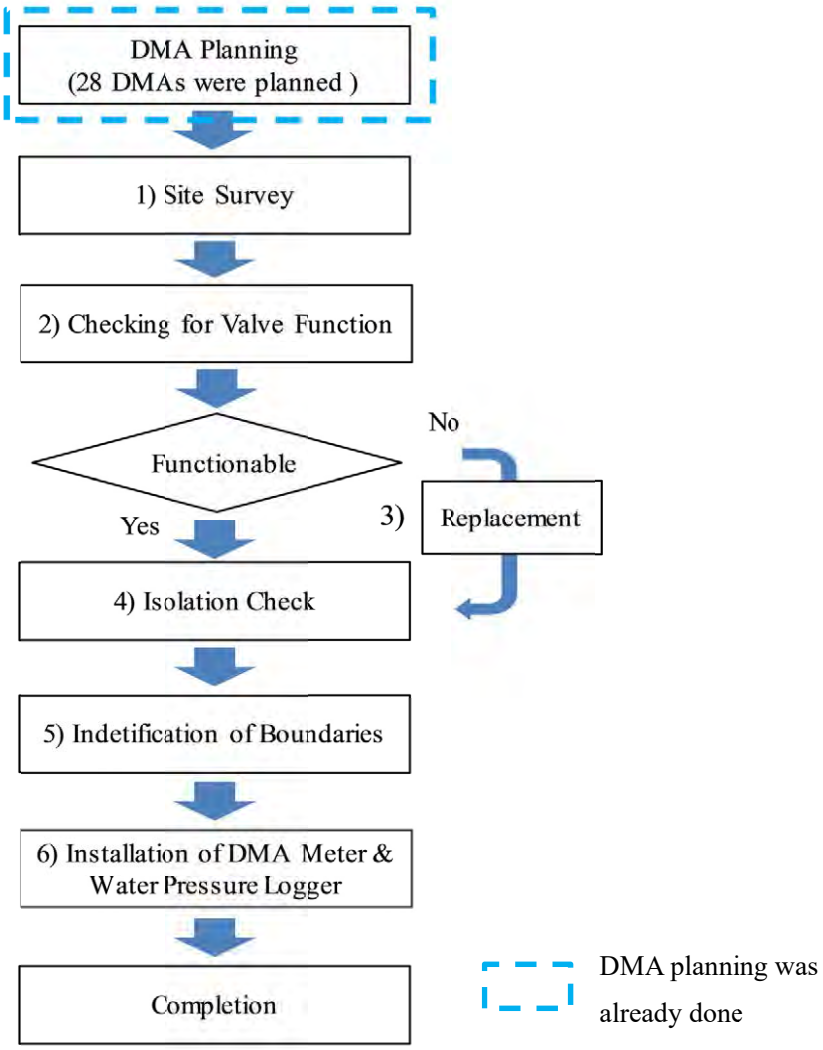


Figure 2-1 Procedure of DMA Creation

2-4. Type of Flow Measurement

There are two types of meter installation; one is inlet of DMA and the other one is cascade type of which inflow volume in DMA is calculated by subtraction between upstream volume and downstream volume.

Normally, only one meter is installed at inlet of DMA. In situations where the DMAs are cascading, two meters are necessary to be installed, one at the inflow of the DMA and the other at the end of the DMA which is the inflow of the next DMA as best illustrated in Figure 2-2.

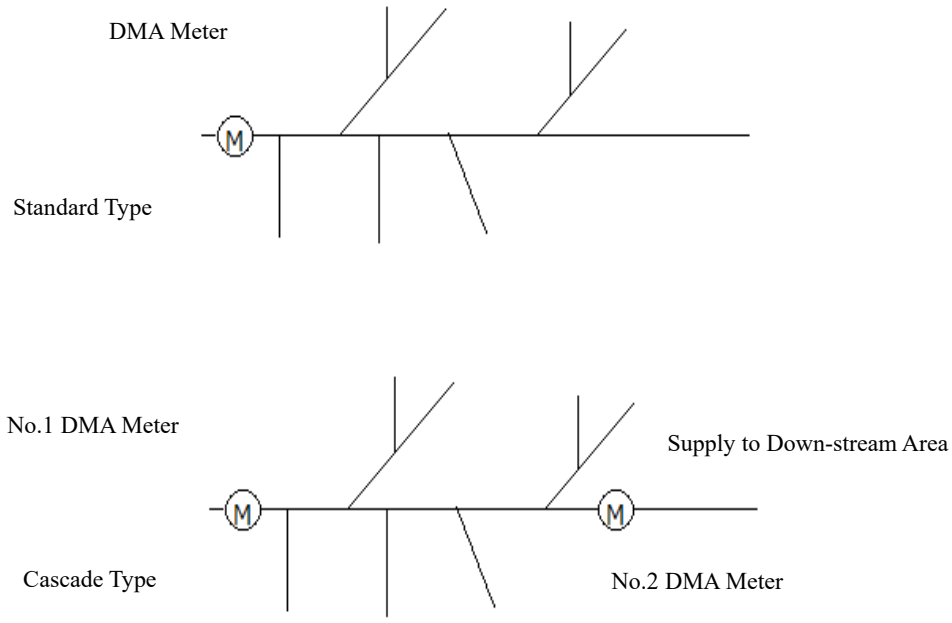


Figure 2-2 Type of Flow Measurement

2-5. Concept of NRW Reduction Procedure

Concept of overall procedure of NRW reduction activities is shown in Figure 2-3 below. There are two stages for prioritization of NRW reduction activities in DMAs; the first stage and the second stage is to conduct the primary activities and the monitoring & maintenance activities respectively.

2-5-1. Stage to conduct Primary Activities

A. Estimation of NRW Ratio for the four DMAs

The 28 DMAs were created in Honiara City and NRW ratio in the four DMAs[1] out of the 28 DMAs was estimated by the JICA Project.

B. Estimation of NRW Ratio for the 24 DMAs

NRW ratio for the 24 out of 28 DMAs will be estimated as scheduled by SW.

C. Prioritization of NRW Reduction Activities

The 24 DMAs are prioritized based on high NRW ratio by SW.

The above mentioned four DMAs out of 28 DMAs were selected by tallying the scores of selection criteria for DMAs such as NRW serious situation, system condition, SW's finance, number of beneficiaries, easy isolation and hydraulic design of the network as the first activities in the DMAs.

NRW reduction activities include (1) Check of Water Meter, (2) Illegal Connection Check and (3)

[1] Two DMAs such as Tasahe A&B and West Kola Ridge A were selected under SW-JICA commitment and NRW reduction activities were completed by the Project. Other two DMAs were selected by SW and their based activities were conducted by SW.

Leak Detection will be conducted based on prioritized DMA as stage to conduct primary activities is shown on the left side in Figure 2-3 below.

2-5-2. Stage to conduct Monitoring & Maintenance Activities

D. Monitoring NRW ratio of the 28 DMAs

NRW ratio of the 28 DMAs is monitored with monthly, weekly and daily inflow volume to be collected by DMA meter and monthly consumption volume and MNF.

E. Prioritization of NRW Reduction Activities in the 28 DMAs.

NRW reduction activities in the 28 DMAs are prioritized by high NRW ratio. NRW reduction activities on the next stage as monitoring & maintenance activities including (1) Check of Water Meter, (2) Illegal Connection Check and (3) Leak Detection will be conducted on stage for regular activities as the same way of the first stage to setup baseline shown on right side in Figure 2-3 below.

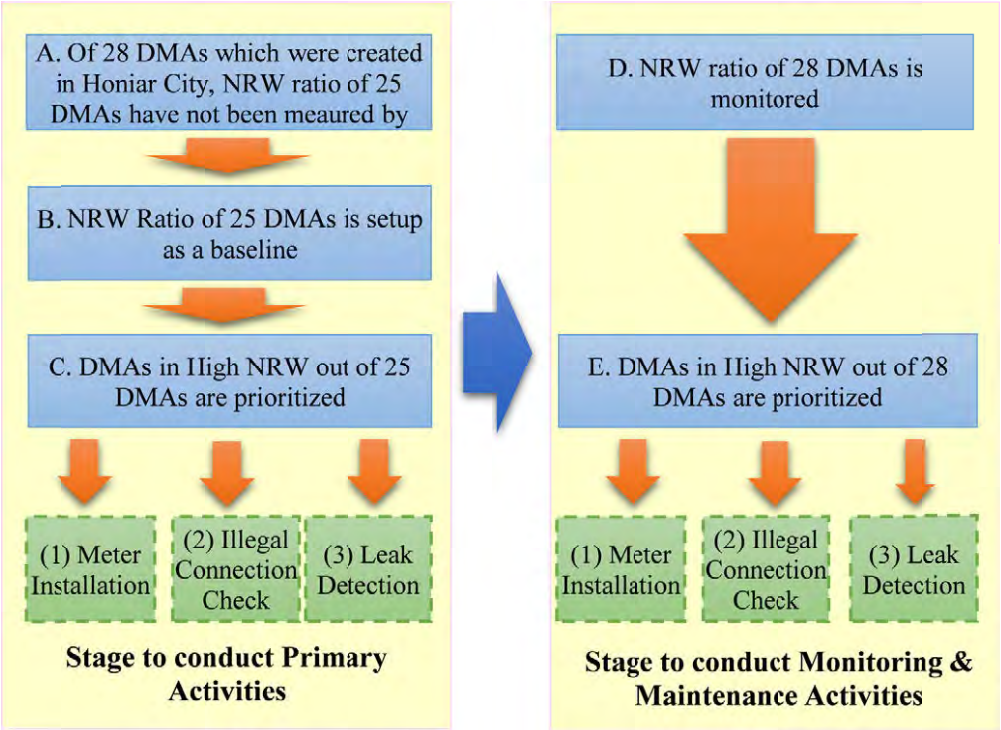
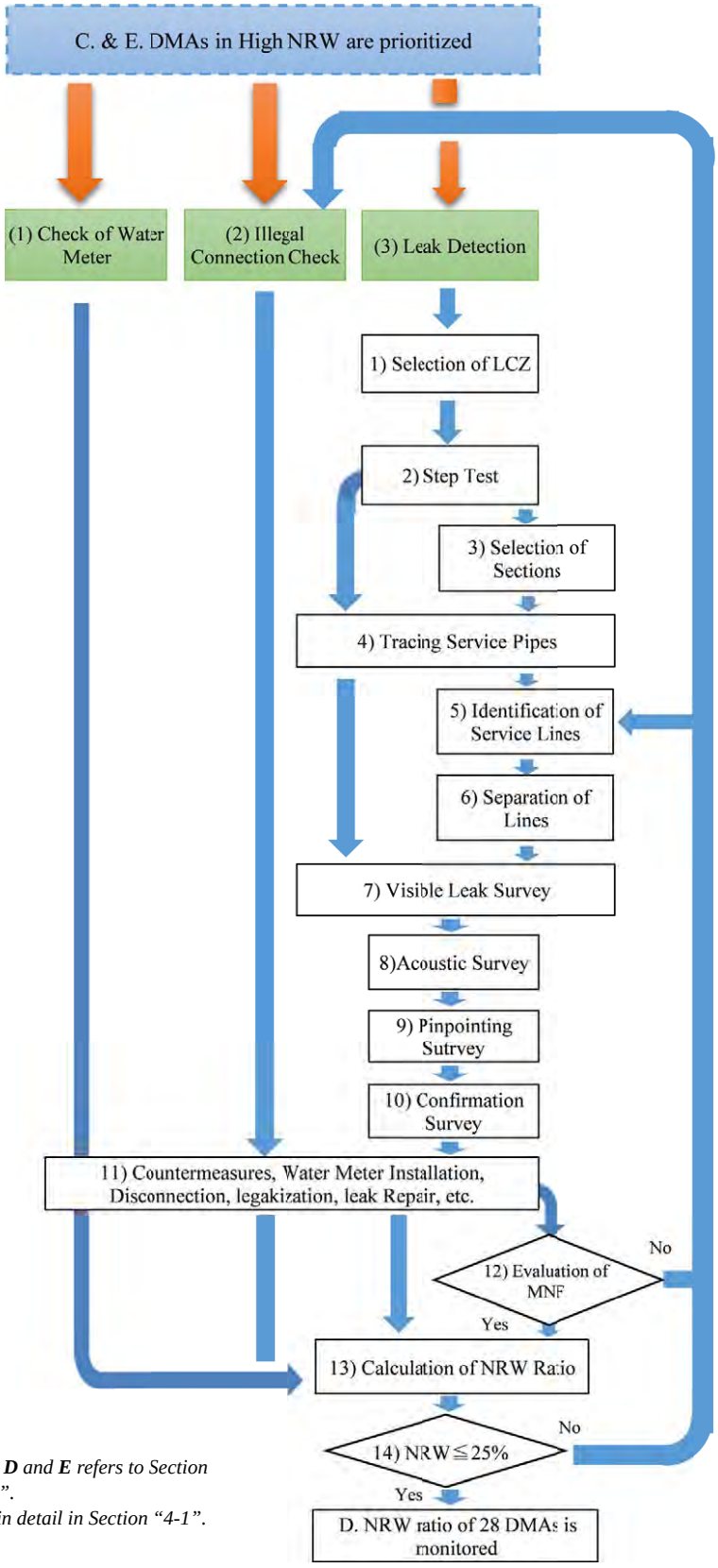


Figure 2-3 Concept of NRW Reduction in DMA

2-6. Procedure of NRW Reduction

Procedure in DMAs is shown in Figure 2-4 below.



Note:

- *Alphabet such as **C, D** and **E** refers to Section "2-5-1" and "2-5-2".*
- *1) to 14) are stated in detail in Section "4-1".*

Figure 2-4 Procedure of NRW Reduction Activities

2-6-1. Prioritization of the DMA

The 28 Areas in Honiara city were selected and planned for DMA by NRW Action Team and JICA Expert Team, and two out of 28, Tasehe A&B and West Kolaa Ridge A were selected based on the criteria of selection of DMA prior to NRW reduction activity on JICA Project. Other two DMAs were selected by SW to conduct to train the staff to implement NRW reduction activities.

The remaining 25 DMAs will be created based on planning of SW and will be prioritized by high NRW ratio which is calculated temporarily from inflow data and consumption volume. Other conditions can be a factor for the selection of NRW reduction activities such as frequency of leakage, water system condition, SW's financial situation, population, difficulty of isolation and hydraulic design of network.

DMA creation is to install a meter at inlet point or preparing the place for the temporary measurement. Boundary valves and pressure reduce valve in the concrete pit need installation at the necessary locations.

After the DMA creation is completed, the NRW ratio is estimated from total of monthly inflow which is measured by the installed DMA meter and monthly billing consumption in the present situation

2-6-2. Activities in the DMAs

(1) Check of Water Meter

Meter installation should be carried out on all unmetered customers, newly-registered customers, and also all malfunction meters must be replaced with new ones based on Check of Water Meter survey.

(2) Illegal Connection Check

The illegal connection check should be done to all water users in DMAs whether they use water legally or not. Procedure of illegal connection check is as shown in the Figure 2-5 below.

1) At first, find out customers who consume water less than average volume based on the billing data,

2) Create a list of customers who use water less than average consumption, they might be illegal water users.

3) Open all of the taps in the property and check the customer meter condition.

If water runs from any of the taps without moving the meter counter, either the service is illegal or the meter is malfunctioned.

4) The malfunctioned meters should be replaced and the meter number and volume of the present reading should be reported to the customer care section.

5) Close a stop cock which is located before the customer meter

Open one of the taps and check flow one by one. The customer has an illegal connection if water comes out from the tap even though the stop cock is closed.

6) Illegal connection point should be checked on an exposed service line. Especially, disconnected

users and customers who have tanks for drinking water should be checked strictly. NRW Project Team should take a countermeasure to disconnect the illegal connections.

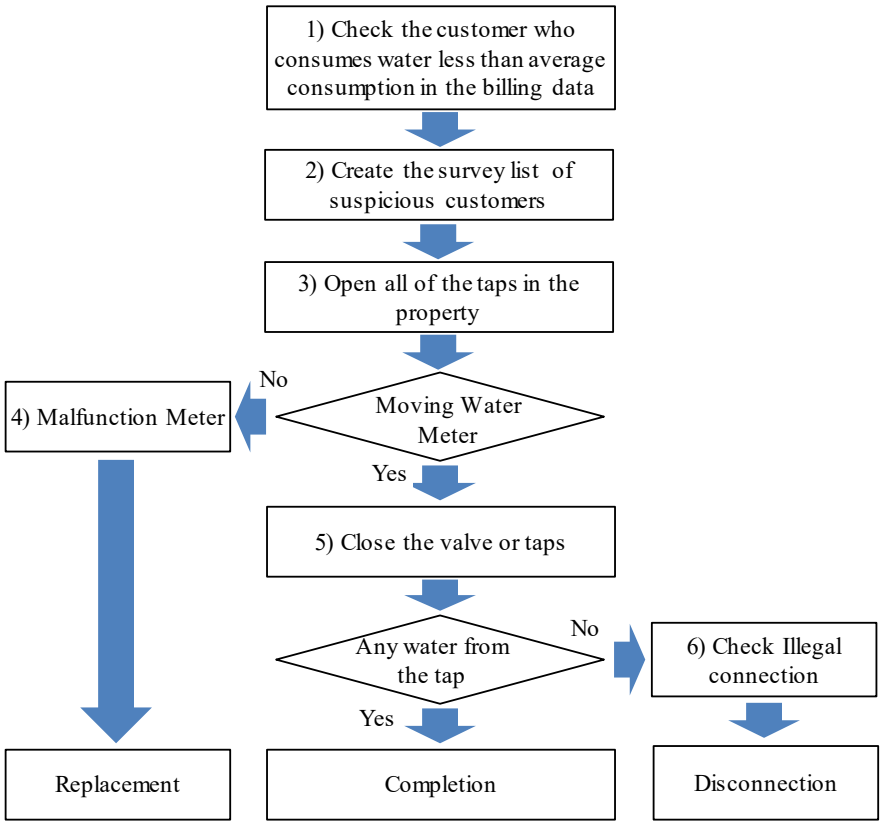


Figure 2-5 Procedure of Illegal Connection Check

(3) Leak Detection

Detailed leak detection is described on “3.Leak Detection Measures”.

3. DMA-based NRW Monitoring and Maintenance

3-1. Overall Workflow of DMA-based Monitoring and Maintenance

The Project prepared overall workflow of DMA-based monitoring and maintenance as shown in Figure 3-1, which should be modified and updated by SW to make DMA-based monitoring and maintenance more practical and efficient.

3-2. Monitoring Data

DMA-based NRW monitoring and maintenance targets simply water inflow at DMA flowmeters as system input volume to each DMA and outflow, particularly billed water consumption at customers as revenue water in each DMA, and then NRW as balance between both them.

Water inflow data is recorded and monitored monthly in principle, and weekly or daily if necessary according to degree of NRW ratio to evaluate water supply situation.

3-3. Handling and Processing the collected Data

Water inflow data at DMA flowmeters, collected by telemetry system or manual reading, are accumulated in Microsoft® Excel® sheet. Difference between current reading and previous reading becomes water inflow in specific period such as month, week or day.

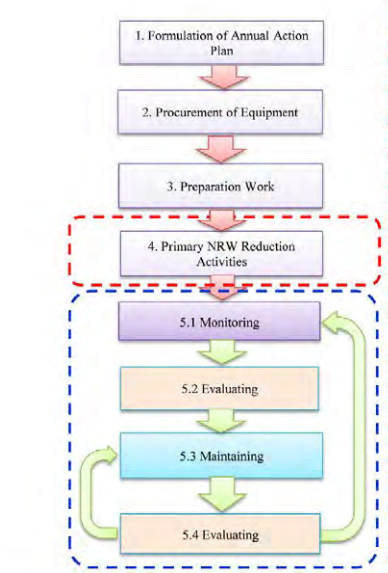
On the other hand, water consumption data is calculated by tallying all billed consumption in NCS (billing system of SW) and also geospatial referencing by MapInfo®, GIS software to make consumption allocated into each DMA.

3-4. Graphing Time-series Variation of Monitoring Data

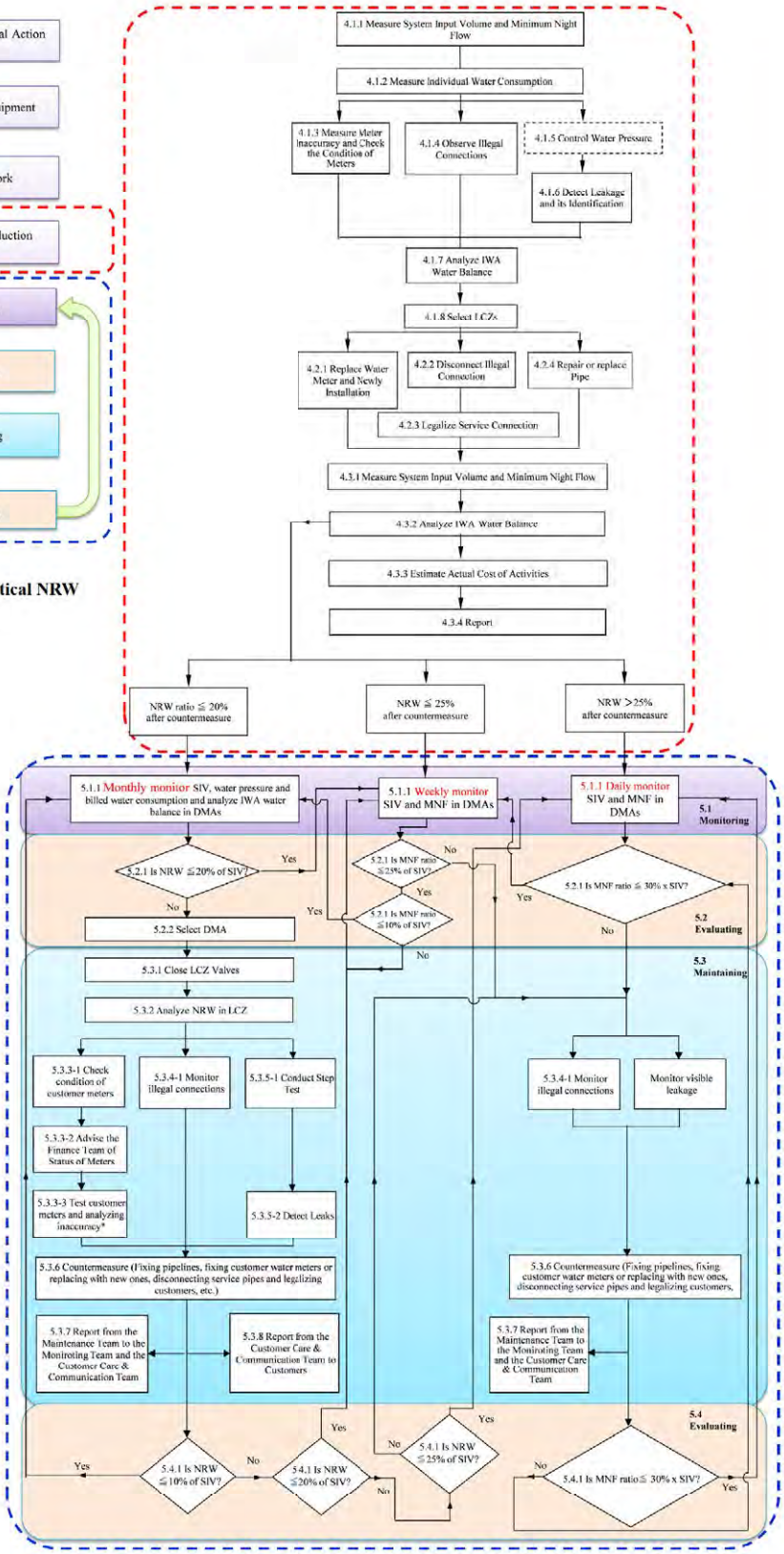
The Project prepared a template for monthly monitoring of system input volume, revenue water, NRW and it ratio as shown in Tale 3-1 as well as a graph for time-series variation of monitoring data as shown in Figure 3-2.

3-5. Unifying Monitoring Data

SW just continues to add monthly data, but apart from working files, all monitoring data of DMAs should be unified in a file to monitor NRW and trend effectively and also to compare them among DMAs for prioritizing maintenance activities and reporting to SW Management. Figure 3-3 shows comparison of monitoring data among DMAs.



Overview of Flow Chart of Practical NRW Reduction Activities



Detail Flow Charts of Practical NRW Reduction Activities

SIV = System Input Volume (or Distribution Volume)
: Activities only for DMAs with pressure control
: Primary NRW Reduction Activities
: Monitoring & Maintenance Work
*: Every six months for meter inaccuracy

Figure 3-1 Flow Charts for Practical NRW Reduction Activities

Table 3-1 Template for Monthly Monitoring (Excel: DMA Monitoring Summary)

Indicator	Reduction	Month-1	Month-2	Month-3	Month-4	Month-5	Month-6
SIV	24,399	13,855	14,270	15,135	11,761	12,272	11,291
SIV per day	813	462	476	505	392	409	376
RW (m3/month)	18,886	9,761	10,300	8,975	8,935	8,725	9,521
NRW (m3/month)	5,513	4,094	3,970	6,160	2,826	3,547	1,770
NRW %	**22.6%**	**29.5%**	**27.8%**	**40.7%**	**24.0%**	**28.9%**	**15.7%**
Pipeline Length (km)	4.035	4.035	4.035	4.035	4.035	4.035	4.035
NRW per km (m3/day/km)	**45.5**	**33.8**	**32.8**	**50.9**	**23.3**	**29.3**	**14.6**
No of Connection	210	210	210	210	210	210	210
NRW per connection (m3/day/connection)	**0.9**	**0.6**	**0.6**	**1.0**	**0.4**	**0.6**	**0.3**

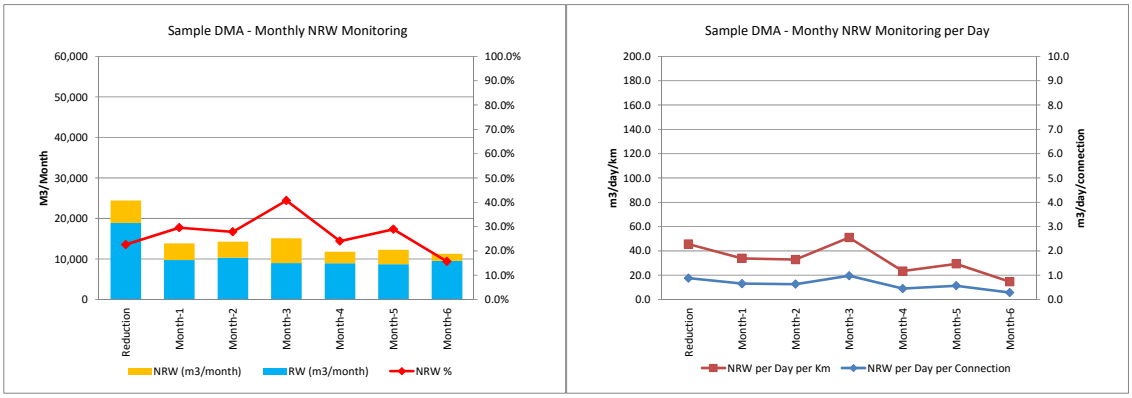


Figure 3-2 Time-series Variation of Monitoring Data (Excel: DMA Monitoring Summary)

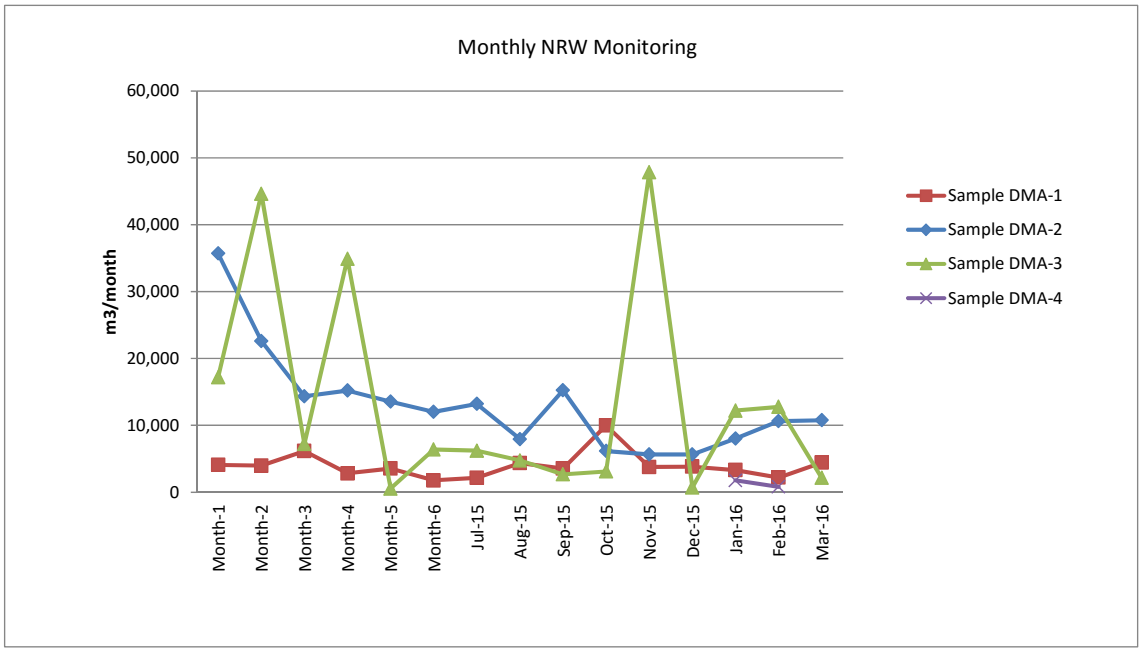


Figure 3-3 Comparison of Monitoring Data among DMAs (Excel: DMA Monitoring Summary)

4. Leak Detection Measures

There are three methods in the leak detection survey: Area Method, Line Method and Point Method. Leak point is identified by narrowing down the point from larger area. Procedure of leak detection is shown in Figure 4-1 below.

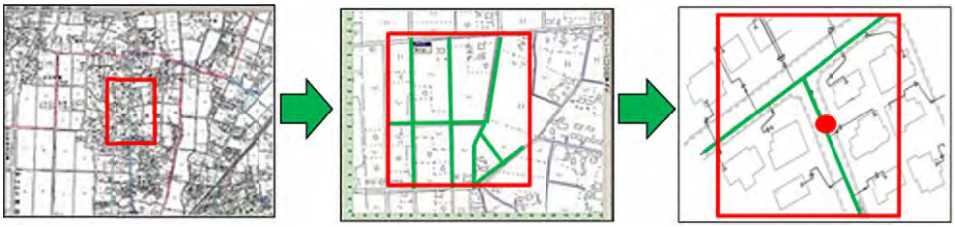


Figure 4-1 Procedure of Leak Detection

1) Area Method

Area method is to narrow down a suspicious leakage area from large area. Leakage area is identified by flow measurement.

Monthly inflow volume in a DMA is measured at the inlet point by a DMA meter.

If the DMA meter is not installed, average inflow in a week can be used instead of monthly inflow data which is collected by the ultrasonic flow meter.

The ultrasonic flow meter and the water pressure logger are installed at the inlet point in the Figure 4-2 below.

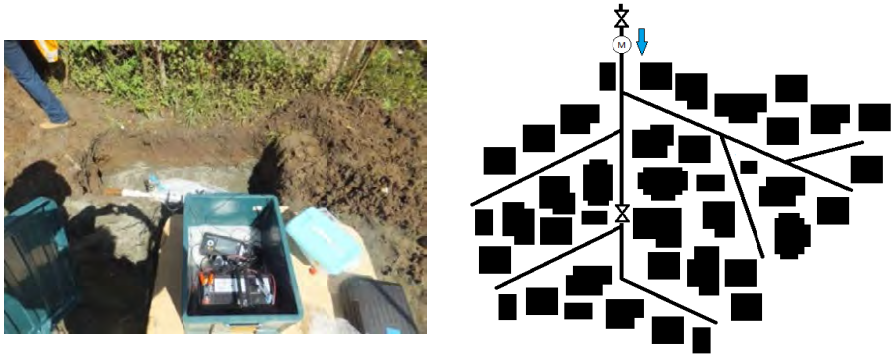


Figure 4-2 Flow Measurement

2) Line Method

Suspicious leakage lines are identified by change of flow volume by closing several valves (Step Test) or detecting the leakage sound which propagates to the lines from the leakage point (Acoustic Survey).

3) Point Method

Leak point is identified exactly on the suspicious lines. Leakage point is confirmed by the leak sound and wet from underground.

4-1. Method of Leak Detection

Methods of leak detection are described as follows;

1) Selection of LCZ

a. Preparation of the Measurement

Size of measurement pit needs approximately 1m in width, 1.5 meter in length and at least 20 centimeter in depth from the exposed pipe.

Inflow of water into the excavated hole should be covered to prevent with a plastic sheet or canopy from the unexpected rain.

b. Store in a box

Ultrasonic flow meter should be kept in a plastic box to be covered from dust or water because it is not waterproof type.

c. Data Compilation

MNF in the DMA is the minimum flow around midnight or the early hours of the morning. It is normally recorded between 0 am to 5 am while water pressure becomes high (as shown in the figure below) when customers use water least. However, MNF is not equivalent to leakage volume here because it includes basic water usage such as toilet flushes, shower and other usages.

Flow data and water pressure data are combined on an excel sheet as Figure 4-3 below after downloading both data.

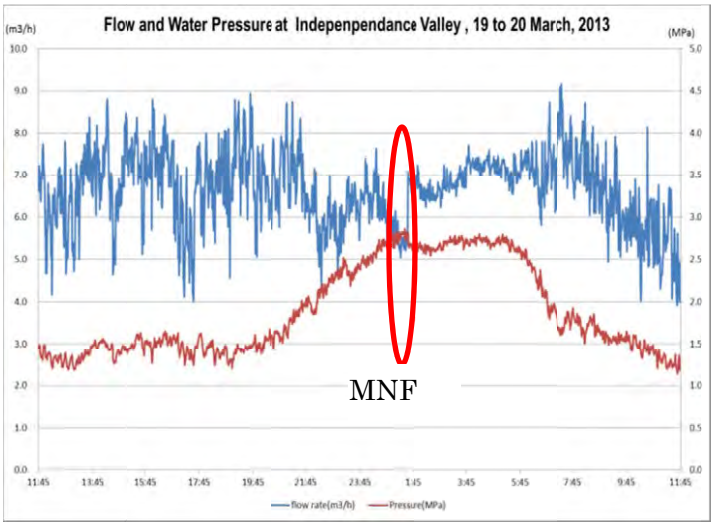


Figure 4-3 Minimum Night Flow (MNF)

d. Selection of LCZ (Leak Control Zone)

Leak control zones are established in a DMA which divides some areas into small zones for effective management of leak detection by installing valves at necessary points.

Selection of LCZ 1) in the DMA is the first step of leak detection as shown in Figure 4-4.

It is conducted by closing LCZ control valves to measure the change of flow. Large amount of flow in LCZ can be clarified.

MNF volume in of the LCZ-1 and the LCZ-2 are estimated by closing valves either of the V-2 or the V-1. It can be estimated that LCZ-2 zone has $30m^3/h$ and LCZ-1 has $5m^3/h$ out of the total $35m^3/h$ of MNF in the DMA. The priority of leak detection is determined from the result of change of the volume. Leak detection will be skipped, if the volume of MNF in the LCZ is acceptable.

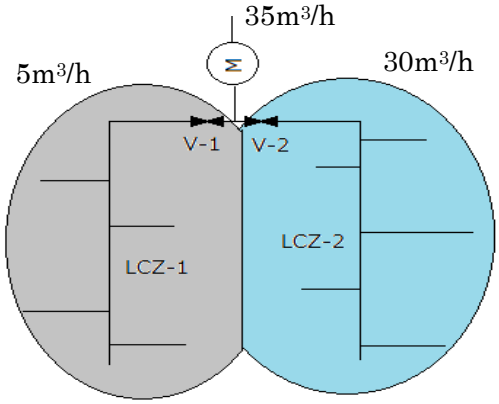


Figure 4-4 Selection of LCZ

2) Step Test

a. Identification of Suspicious Lines

Step Test is the next step of Selection of LCZ as shown in Figure 2-4. The step test is one of line method and sections or lines are identified by a change of flow of DMA meter or ultrasonic flow meter by closing existing valves in the area and measuring flow volume.

The step test is the most effective method to identify a leakage section and a pipeline by means of manipulating valves, and reading changing volume.

The step test is conducted to identify the leak section in the line by manipulating existing valves as shown in Figure 4-5 below. If valves do not exist on the main line where step test is to be conducted within the DMA, it will be skipped or new valves are installed at necessary points.

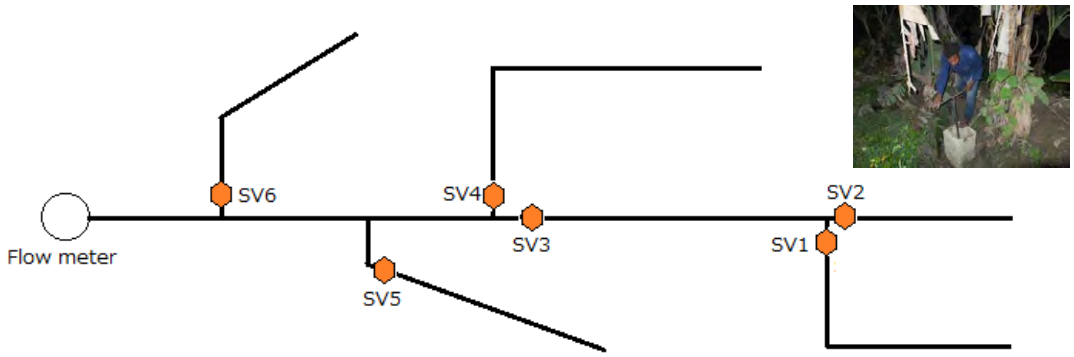


Figure 4-5 Step Test

b. Procedure of Step Test

Time of MNF in a DMA is recorded together with a momentary flow data on DMA meter or ultrasonic flow meter. The step test is carried out during this time.

c. Record of Valve Operation

The leak detection team has to make a plan for the order of valve operation and the closing time etc., and record on a valve operation sheet.

The valve operation sheet of the step test is shows in Table 4-1 below.

Table 4-1 Valve Operation Sheet

No,	Status	Valve No,	Operating Time	Flow rate (m^3/h)	MNF (m^3/h)	Remarks
1			2:10	12.8		Strat-Recording
2	MNF		2:15	12.1		
3	Close	SV1	2:20	9.2	2.9	SV1-Pipe end
4	Close	SV2	2:25	5.3	3.9	SV2-Pipe end
5	Close	SV3	2:30	5.0	0.3	SV3-SV2
6	Close	SV4	2:35	2.1	2.9	SV4-Pipe end
7	Close	SV5	2:40	1.8	0.3	SV5-Pipe end
8	Close	SV6	2:45	0.5	1.3	SV6-Pipe end
9		Meter			0.5	Meter-SV3
10	Open	SV1	2:50			
11	Open	SV2	2:51			
12	OPen	SV3	2:53			
13	OPen	SV4	2:55			
14	Open	SV5	2:58			
15	Open	SV6	3:00			

d. MNF Measurement

MNF is measured with an ultrasonic flow meter or DMA meter which is installed at the inlet point by means of closing valves around midnight.

The Table 3-1 shows the order of valve operation and closing time with change of flow as a result of the step test measured by a flow meter, and in Figure 3-6 shows how to calculate the volume of each

section.

MNF of the DMA is 12.1m^3/h between 2:10 to 2:15 am based on the Table 3-1 and Figure 3-6.

e. Order of Valve Operation

Start to manipulate the valves from the farthest point to the inlet point and from a small size of pipe to a large size.

As shown in the valve operation sheet of the Table 3-1, SV1 which is located at the furthest point from the flow meter should be closed first, and the change of flow is 2.9 m^3/h calculated as the flow within SV1 – pipe end. The Interval of manipulating each valve should be at least 5 minutes in order to allow time for the flow rate to be stable each time.

The SV2 is closed for section of SV2-pipe end, and the flow rate is 3.9 m^3/h by calculating change of flow from Figure 3-6.

Other sections: section of the SV3-pipe end, the SV4-SV3, the SV5-pipe end, the SV6-pipe end and meter-SV3 are calculated from the change in flow rate.

The result of the step test is shown in Figure 3-6 with arrows pointing at the time of closing valves and also shows the different volume between previous flow and present flow with horizontally lines.

The section of meter-SV3 is the volume that must be equal to the remaining volume of MNF after all valves are closed.

f. Point of Valve Operation

The valves should be manipulated slowly and gently otherwise the pipe might be broken by strong water pressure.

The tap at the end of line or fire-hydrant on the main should be opened to lease air in the pipe and closed valves should be opened gently otherwise the pipes might get damage by the air pressure.

3) Selection of Sections

Selection of Sections is the next step of Step Test as shown in Figure 2-4.

Minimum flow in respective lines is calculated by the changing volume of the step test in Figure 4-6 below. Leak detection will be conducted with a priority in the section of high flow rate.

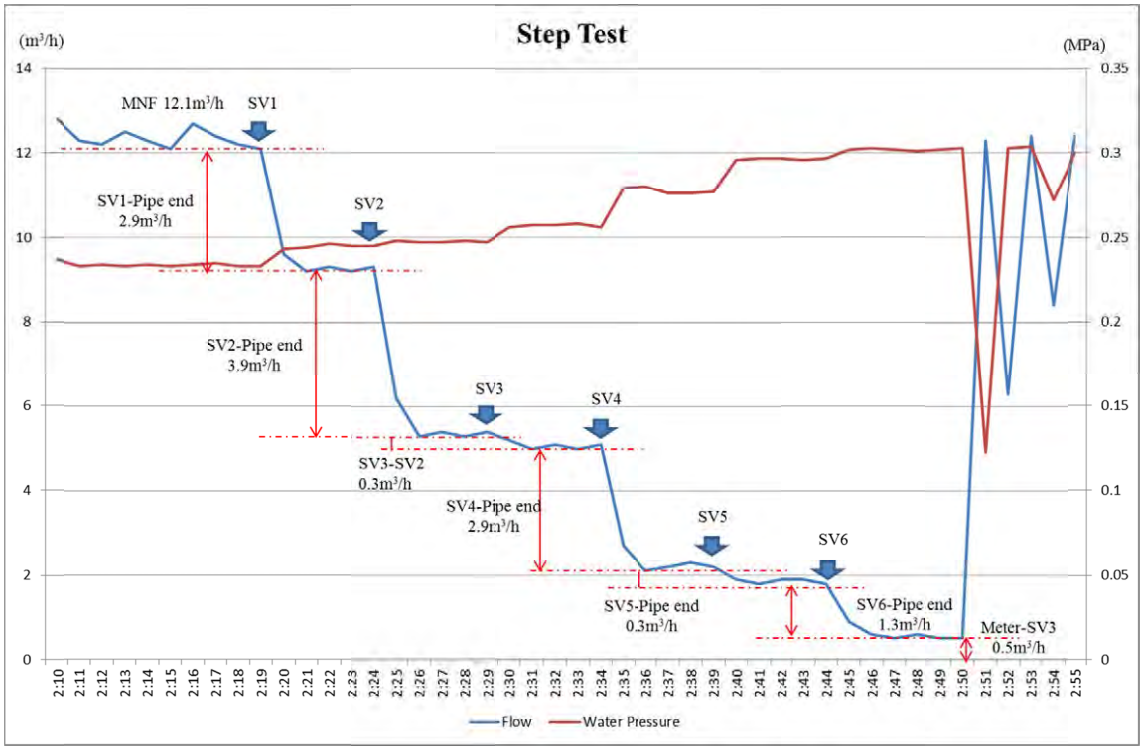


Figure 4-6 Graph of Step Test

4) Tracing Service Lines

Tracing Service Lines is conducted as the next step of Selection of Sections in Figure 2-4.

It is conducted on selected sections of pipeline with high flow volume by tracing route with the eyes carefully.

Most of the leaks were found on service pipes by leak detection on the pilot areas.

Some parts of service pipe lines at mountain sides could not be found because they are long and have many branches in addition they go inside another people's properties and covered with vegetation.

Tracing service pipe lines with the eyes in the LCZ is very effective not only for the leak detection but also detecting illegal connection lines.

The location data of detected long service lines are to be inputted into a GPS unit and it should be updated on the GIS system for the pipelines management and further planning of NRW reduction.

5) Identification of Service Lines

Identification of Service Lines is the point method and the next step is Tracing Service Lines as shown in Figure 2-4. Identification of service pipes is conducted after the tracing service lines in the selected sections. The most seriously leakage line will be identified there and it will be a high priority. Procedure of the identification of service lines is as follows;

- Check the Sound

Sound of each service line is checked at a valve of branch point or on the point of service lines whether the sound exists due to high flow in the service line.

- Creation of Midnight Condition

  All of the stopcocks are closed to create the same situation as a midnight for identification of leakage volume on the line in the daytime.

- Flow Measurement of Service Pipe

  Flow measurement unit with water meter are installed at the branched point of the service pipe temporarily to make a same condition as no consumption. The measuring unit is installed around the branched point temporarily or at a coupling point where cut pipes are jointed, if a valve does not exist at the branched point as the Figure 4-7 below. Flow rate on the service line is measured every minute and is continued to record at least for 5 minutes.

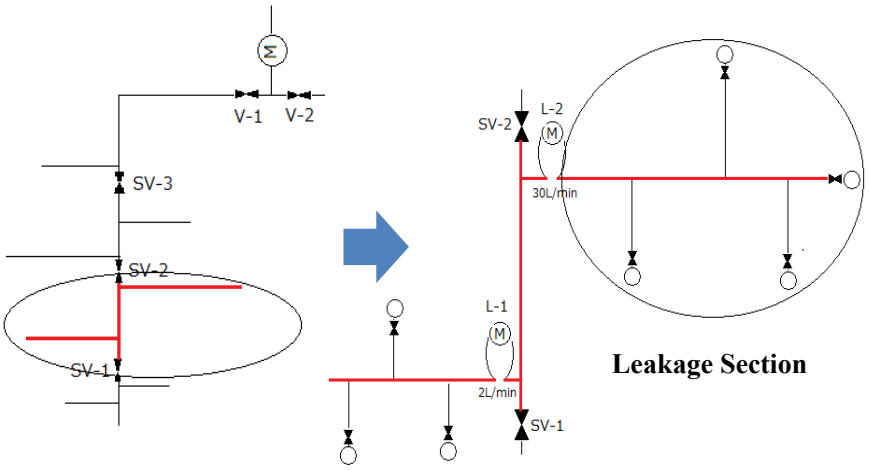


Figure 4-7 Selection of Service Lines

6) Separation of Lines

Separation of Lines is conducted as the next step of Identification of Service Pipes as shown in Figure 2-4.

In cases where a suspicious service line is encountered with a high possibility that it is long, the line will be separated into several sections and the customer meter unit is installed at each section as Figure 4-8 and 4-9 below. It is an effective way to detect the leaks on the long service line especially in the mountain area.

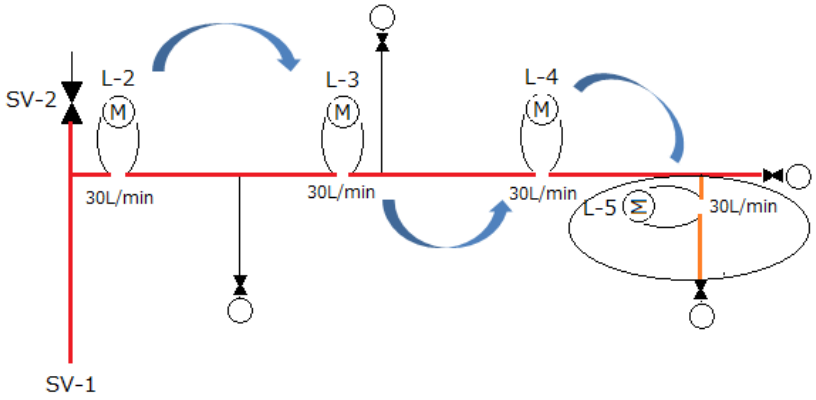


Figure 4-8 Separation of Service Lines

Figure 4-9 Measurement for Separation of Service Lines

7) Visible Survey

Visible Survey is conducted as the next step of Separation of Lines as shown in Figure 2-4. The visible survey is to find out leakage on pipelines by patrolling without special equipment. The points to be checked for this survey are as follows;

- Wet point on the ground even on a sunny day is to be checked and excavated for confirmation.
- Area with continuous water sounds or spouting sounds are checked and vegetation cover should be cut to see the actual ground condition if it is necessary.

8) Acoustic Survey

a. Listening Stick

Sound check at customer meter for the service line and at valve for the main pipes are conducted by using a listing stick called the acoustic survey. This Acoustic Survey is shown as the first step of leak detection in Figure 2-4. Listening Stick is the common device to check a sound when carrying out acoustic survey and procedure of the acoustic survey is as follows;

- Acoustic survey is a survey to check leakage sounds at customer meters and valves.
- It is a basic method to check leakage sounds. Leakage sounds can be heard on pipes if leak

occurs around them. Leakage sounds propagate to the fittings, such as water meters, valves and other fittings. The higher water pressure it is, the clearer the leak sound is we listen.

- Leakage sound should be checked at water meters, as well as exposed points with a listening stick shown in Figure 4-10 below.
- If you hear any suspicious sound at water meters, it might be also the sound of water being actually used as well as sound of water leaking.
- Water usage can be confirmed by checking the water meters whether they are working or not. All taps should be closed at the time when checking of the meter.

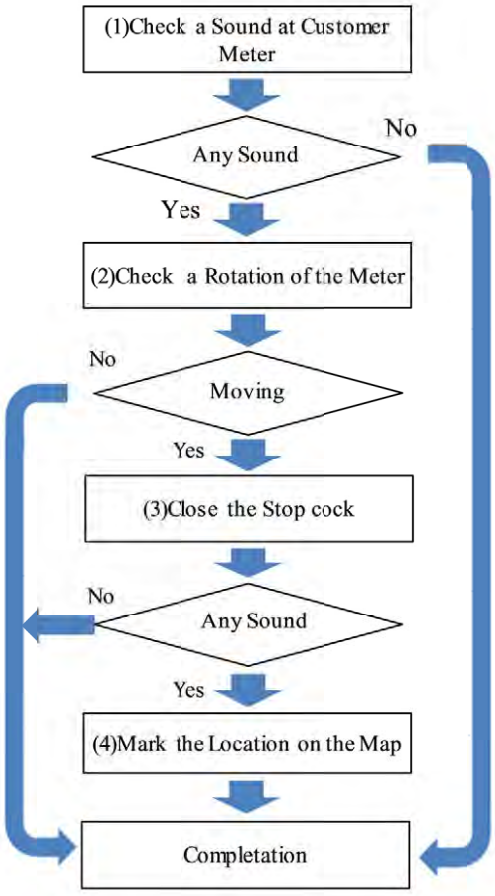


Figure 4-10 Procedure of Acoustic Survey

b. Electric Listening Stick

Electric listening stick is a very effective device to identify leakage sound on non-metallic pipes because sound is amplified by the electric circuit. Procedure of sound check at meters and valves is the same as in Figure 3-10 above.

c. Sound Check

Valves and fire-hydrants connected to the distribution pipes should be checked with the listening

stick or the electric listening stick whether leakage occurs there as shown in Figure 4-11 below. Suspected points should be marked on the survey list and the survey map with the detailed site situation for pinpointing survey for the next step.

Figure 4-11 Acoustic Survey

9) Pinpointing Survey

Pinpointing Survey as point method is shown as a next step of acoustic survey in Figure 2-4. Suspicious sound or places where water is obvious on the ground, found through visible survey must be checked by the use of listening stick and must be pinpointed by water leak detecting equipment.

a. Water Leak Detector

Water leak detector is typical equipment used for the point method to detect the exact leakage point.

- Survey Team

The pinpoint survey is conducted with two operators. One operator walks above the main pipe with a water leak detector and the other operator walks on the other side with a listening stick or another water leak detector with keeping distance from each other.

- Keep a Distance to each other

One might hear foot noises of the other if they walk too closely because the sensor of the water leak detector is quite sensitive. Operators keep a distance at least 7 to 10 meter from each other not to miss a leak sound by footstep noise.

- Placing Sensor

Operator should gently put the sensor on the surface of the road above a buried pipe at every 30 centimeter or less to check a sound by the sensor.

The sensor should be moved to all directions when the operator detects any suspicious point on the ground. There is a high possibility of leakage point where you hear the loudest beep shown in Figure 4-12 below.

- Mark a Suspicious Point

The loudest point should be marked on the surface of road and the survey map. The marked point will be confirmed on the confirmation survey.

This device is suitable for leaks under paved road otherwise it cannot catch leak sound clearly.
If the operator detects a suspicious sound on grass or unpaved ground surface, place a hard material such as brick or board there and check the sound, it may echo leak sound better.

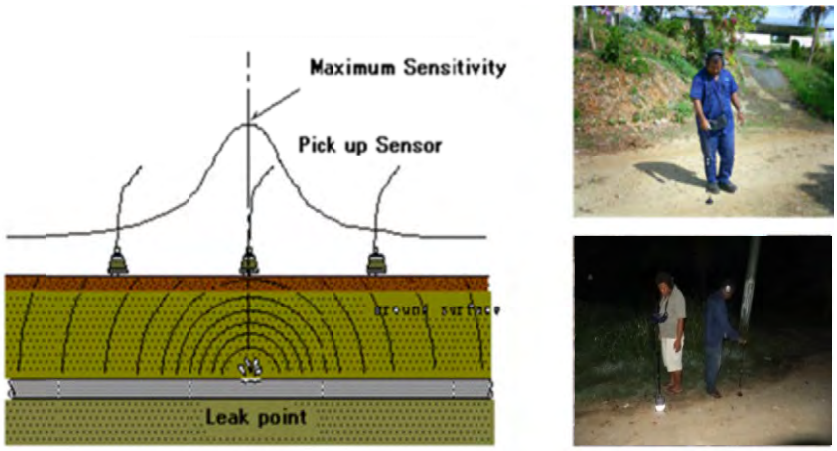


Figure 4-12 Water Leak Detector

- Safeguard

The Pinpointing survey is conducted at nighttime. Operators should wear brightly colored vest and should have torch lights for the prevention of car accidents during the time.

10) Confirmation Survey

Confirmation Survey is shown as the final step of leak detection survey in Figure 2-4.

a. Residual Chlorine Meter

Residual chlorine meter is mainly used to measure the concentration of residual chlorine at the end points of the distribution pipe lines. This can also be used for leak detection.

Wet points on the ground or clean water flown into drains should be checked whether it is tap water or ground water by the residual chlorine meter as Figure 4-13 below.

When a high concentration of residual chlorine is indicated on the display, the water point may close to a leak point.

Figure 4-13 Residual Chlorine Meter

b. Leak Noise Correlator

The leak noise correlator is one of the equipment which can identify location of leakage points. In cases where leak pipe is buried outside paved roads or leakage sound does not reach the surface of the road, leak noise cannot be detected by the water leak detector, because the surface of the ground becomes an obstacle to detect the echo sound. Instead of water leak detector, the leak noise correlator can be used to detect leaks on pipelines which are buried outside of paved road. If we can estimate a rough location of suspicious leak, excavation of surveying point can be narrowed to smaller area.

It is indicated in the correlation peak on the display when leakage sound is propagating to two sensors like a Figure 4-14 below.

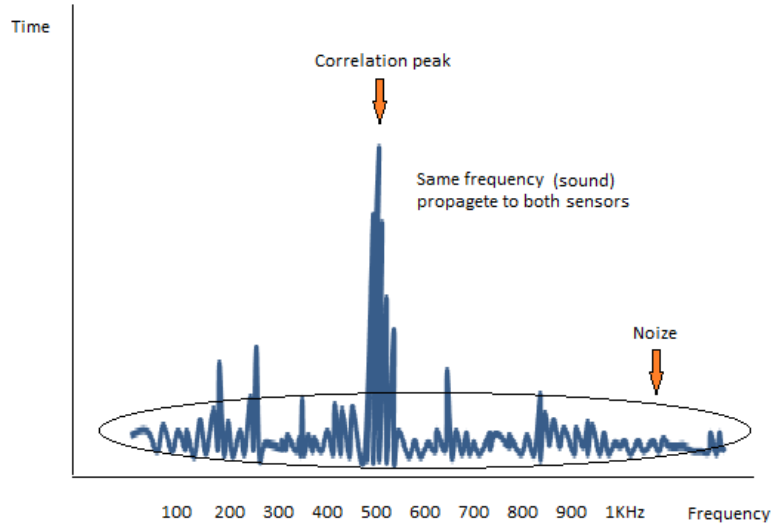


Figure 4-14 Correlation Peak

ⅰ) Necessary conditions

The necessary conditions to be inputted for the operation of the leak noise correlator are as follows;

- Leak sound must be propagated to two sensors.
- The pipe material is known.
- The pipe diameter is known.
- Distance between two sensors is known.

ⅱ) Double-checking

The indicated point by the correlator should be checked by the leak detector and the use of boring bar as double-checking tool because the pipe information on the map and the actual condition of the pipes is often different.

c. Identifying Leakage Point

Excavation area should be as small as possible for saving cost and time of road restoration.

ⅰ) Drilling

Procedure of drilling is as follows;

- A leakage point should be identified by boring a hole on the ground whether it is a leakage or not.
- Operator makes a hole of a depth of 40cm or deeper with a drill at the marked point to.
- Other staff listens to the drilling sound at the closest meter or valve by a listening stick.
- He informs the staffs who operates the drill that the drill bid is approaching to the pipe. When the sound becomes bigger, the drilling has to be stopped to avoid damage to the pipes.

ⅱ) Boring

Procedure of boring is as follows;

- The second step is to insert a boring bar into the drilled hole, and push it in deeper while holding the handle carefully.
- In case a leak may occur on the main pipe, the depth of valve near the pipe should be measured to guess the depth of pipe in order not to break the pipe. You should pay attention not to damage any pipes by listening carefully.

ⅲ) Inserting a Listing Stick

Procedure of inserting a listening stick as follows;

- Insert the listening stick into the hole slowly.
- Listen to the sound in the ground.
- The operator has to check whether the listening stick is wet or not after pulling it up from the hole.
- You will distinguish the sound by the listening stick clearly when the drilling point becomes close to the leakage point.

Procedure of confirmation survey is shown in Figure 4-15 below.

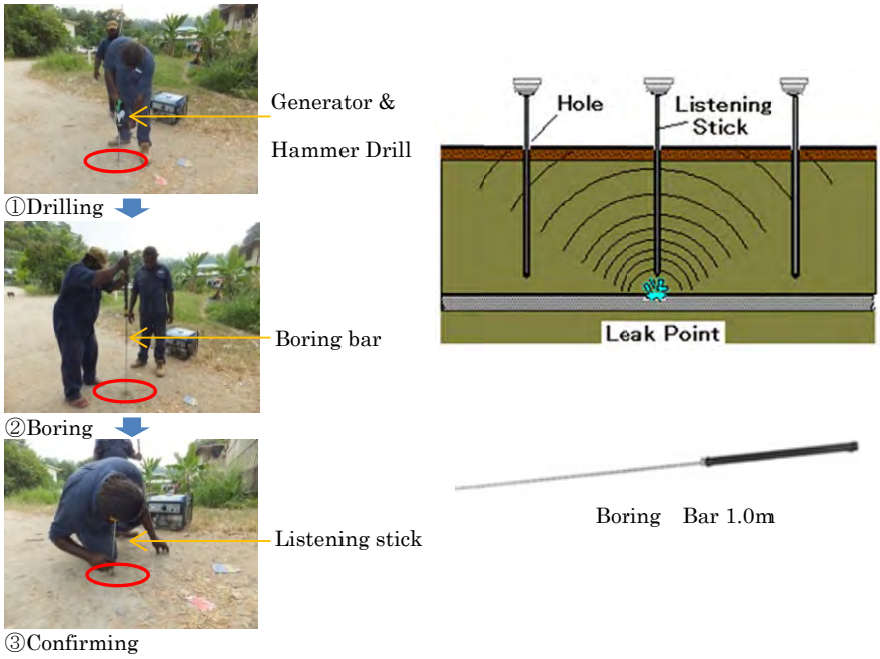


Figure 4-15 Confirmation Survey

11) Countermeasures

Countermeasures of NRW reduction activities in Figure 2-4 should be done by water meter installation through (1) Check of Meter, disconnection for illegal connection and/or legalization of illegal user on (2) Illegal Connection Check and leak repair, (3) Leak Repair and water pressure control.

12) Evaluation of MNF Reduction

Measurement of MNF in Figure 2-4 should be done after countermeasures. Identification of leak point should be conducted again by Identification of Service Lines, if MNF volume is still over 3.0m^3/h/km after countermeasures.

13) Calculation of NRW Ratio

Calculation of NRW Ratio in Figure 2-4 should be calculated after countermeasures from inflow volume and consumption of the DMA.

14) Evaluation of NRW Ratio

As the result of NRW ratio, evaluate how much NRW ratio was reduced after countermeasures. Leak detection should be done again from Identification of Service Lines and illegal Connection Check (2) as Figure 2-4 until the NRW ratio has achieved the target below 30%.

5. Importance of Recording Leakage Information

Actual pipe information sometimes differs from one of distribution map. Pipe information cannot be obtained if leaks are repaired. New brunch lines are installed, or any pipelines are excavated and are not updated on the database.

The obtained information always should be updated on GIS mapping system. Leakage information also should be collected to be utilized when making a pipe replacement plan and the leakage action plan.

Information of items to be updated on the GIS database is as follows;

(1) Pipe information

1) Main pipe
- Material
- Diameter
- Depth

2) Service pipe
- Material
- Diameter
- Depth

3) Pipe Location

(2) Leakage Information
- Customer's Address
- Registered Number

(3) Leakage information
- Location
- Condition
- Couse
- Leakage size or Volume
- Detection method

(4) Others
- Attached Location Map and Photo
- Repair information (Used Parts, Working Time, Number of worker, etc.)

Above information should be collected and recorded on a leakage record sheet when a leak is repaired at a site shown in Figure 5-1 below.

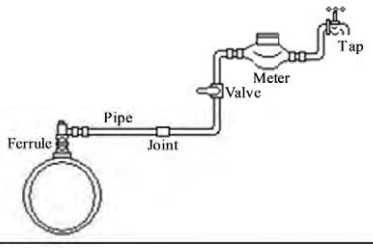
Leakage Record Sheet

Leak. No: 3-8

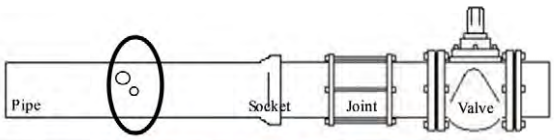
Date of Survey:	25, November 2013	Street	Lengakiki
Date of Repair:	7, December 2013	House No.	201
Name of DMA	Lergakiki	Customer	In front of Mr David Akoea's house

Main Pipe	1. CIP, 2. uPVC, (3.) GP, 4. PE, 5. Others	**Location**	(1.) Pipe, 2. Connection, 3. Ferrule, 4. Valve, 5. Meter, 6. Tap, 7. Reservor Tank, 8. Others,
Diameter	40 mm	**Condition**	(1.) Hole, 2. Crack, 3. Breakage, 4. Packing, 5. Loose Connection, 6. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PE, 2. uPVC, 3. GP, 4. Dux 5. Others( )	**Cause**	1. Corrosion, (2.) Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Vandalism, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth/Distance	(90)cm / (2.5m) from egg of road	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, (4.Grass), 5.Soil, 6.Others
Leakage Size	(1.) Large, 2. Midium, 3. Small, 4. Drops, Measured or Estimatated(90)L/min	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, (4.) Pinpoint,

Leak Location



(Hole) / Crack Size:(7mm/5mm)



Location Map

Photo

Remarks:
Leak Flows into a Ditch

Information of Leak Repair

Excavation Size: 1.5 m X 1.0 m X 1.2 m = (1.8 m^3)

	Unit price	Hour	Volume	Sub Total
Worker		2.0	3.0	
Plumber		2.0	2.0	
Supervisor		2.0	1.0	
Engineer		1.0	1.0	
Backhoe		2.0	1.0	
Generator		1.0	1.0	
Drainage Pump		1.0	1.0	
Lighting Equipment				
Sand			0.3	
Gravel			0.2	
Asphalt			1.5	
Total				

Used Materials

	Size/Type	Unit Price	Volume	Sub Total
Pipe-1	150 PVC		2.0	
Pipe-2				
Pipe-3				
Joint-1	150 Coupling		2.0	
Joint-2				
Joint-3				
Joint-4				
Joint-5				
Meter				
Packing				
Saddle				
Total				

Figure 5-1 Leakage Repair Sheet

Reference

It is important to know how much volume of leakage is prevented through the evaluation of activities and as a basic knowledge of NRW reduction.

There are two methods to estimate leakage volume.

(1) Estimating Leakage Volume

1) Measuring Cup

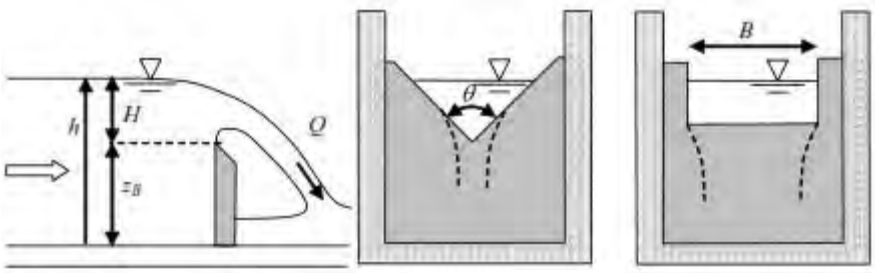
One is to measure leakage volume by means of a measuring cup directly, or calculating leakage volume by a drain pump or a triangular weir, or a rectangular weir as Figure R-1 below.

Figure R-1 Measurement of Leakage Volume

2) Measuring Wire

A triangle weir and a rectangular weir are sometime used when a measuring cup cannot measure the leakage volume directly at a leakage point.

Leakage volume is calculated by measuring the height of the flow volume from the weir bottom of the triangular weir. In the rectangular weir, the width and the height are measured and calculated as Figure R-2 below.



Triangular Weir (θ=90°)

$Q(m^3/min)=0.00084\times H^{2.5}$

Rectangular Weir

$Q(m^3/min)=1.84\times(B-0.2\times H)\times H^{1.5}\times 60$

Figure R-2 Estimation of Leakage Volume

(2) Calculation from Leakage Size

The other one is to calculate leakage volume by the size of the leakage and the strength of the water

pressure. There are two indicators for estimation of leakage volume by the size of a hole or a crack. Leakage volume varies by the size and shape of a leak and the water pressure as the Table R-1 and Table R-2 below.

Table R-1 Leakage Volume by the Size of a Hole

Shape: Hole		Water Pressure (MPa)							
Leakage Size (mm)	Area (mm^2)	0.10		0.20		0.30		0.40	
		L/min	m^3/h	L/min	m^3/h	L/min	m^3/h	L/min	m^3/h
1.0	0.785	0.330	0.020	0.466	0.028	0.571	0.034	0.659	0.040
1.5	1.767	0.742	0.045	1.049	0.063	1.285	0.077	1.484	0.089
2.0	3.141	1.319	0.079	1.865	0.112	2.284	0.137	2.638	0.158
2.5	4.908	2.061	0.124	2.914	0.175	3.569	0.214	4.121	0.247
3.0	7.068	2.967	0.178	4.196	0.252	5.140	0.308	5.935	0.356
3.5	9.621	4.039	0.242	5.712	0.343	6.995	0.420	8.078	0.485
4.0	12.566	5.275	0.317	7.460	0.448	9.137	0.548	10.550	0.633
4.5	15.903	6.676	0.401	9.442	0.567	11.564	0.694	13.353	0.801
5.0	19.634	8.243	0.495	11.657	0.699	14.276	0.857	16.485	0.989
5.5	23.757	9.973	0.598	14.105	0.846	17.274	1.036	19.947	1.197
6.0	28.273	11.869	0.712	16.786	1.007	20.558	1.233	23.738	1.424
6.5	33.181	13.930	0.836	19.700	1.182	24.127	1.448	27.860	1.672
7.0	38.482	16.155	0.969	22.847	1.371	27.982	1.679	32.311	1.939
7.5	44.176	18.546	1.113	26.227	1.574	32.122	1.927	37.091	2.225
8.0	50.262	21.101	1.266	29.841	1.790	36.548	2.193	42.202	2.532
8.5	56.742	23.821	1.429	33.688	2.021	41.259	2.476	47.642	2.858
9.0	63.613	26.706	1.602	37.768	2.266	46.256	2.775	53.411	3.205
9.5	70.878	29.755	1.785	42.081	2.525	51.538	3.092	59.511	3.571
10.0	78.535	32.970	1.978	46.627	2.798	57.106	3.426	65.940	3.956

Table R-2 Leakage Volume by the Size of a Crack

Shape of Leak: Crack			Water Pressure (MPa)							
Length (mm)	Width (mm)	Area (mm^2)	0.10		0.20		0.30		0.40	
			L/min	m^3/h	L/min	m^3/h	L/min	m^3/h	L/min	m^3/h
10	0.25	2.5	2.331	0.140	3.297	0.198	4.037	0.242	4.662	0.280
15		3.8	3.497	0.210	4.945	0.297	6.056	0.363	6.993	0.420
20		5.0	4.662	0.280	6.593	0.396	8.075	0.484	9.324	0.559
25		6.3	5.828	0.350	8.241	0.494	10.094	0.606	11.655	0.699
30		7.5	6.993	0.420	9.890	0.593	12.112	0.727	13.986	0.839
50		12.5	11.655	0.699	16.483	0.989	20.187	1.211	23.310	1.399
75		18.8	17.483	1.049	24.724	1.483	30.281	1.817	34.965	2.098
100		25.0	23.310	1.399	32.965	1.978	40.374	2.422	46.620	2.797
10	0.5	5.0	4.662	0.280	6.593	0.396	8.075	0.484	9.324	0.559
15		7.5	6.993	0.420	9.890	0.593	12.112	0.727	13.986	0.839
20		10.0	9.324	0.559	13.186	0.791	16.150	0.969	18.648	1.119
25		12.5	11.655	0.699	16.483	0.989	20.187	1.211	23.310	1.399
30		15.0	13.986	0.839	19.779	1.187	24.224	1.453	27.972	1.678
50		25.0	23.310	1.399	32.965	1.978	40.374	2.422	46.620	2.797
75		37.5	34.965	2.098	49.448	2.967	60.561	3.634	69.930	4.196
100		50.0	46.620	2.797	65.931	3.956	80.748	4.845	93.240	5.594
10	1.0	10.0	9.324	0.559	13.186	0.791	16.150	0.969	18.648	1.119
15		15.0	13.986	0.839	19.779	1.187	24.224	1.453	27.972	1.678
20		20.0	18.648	1.119	26.372	1.582	32.299	1.938	37.296	2.238
25		25.0	23.310	1.399	32.965	1.978	40.374	2.422	46.620	2.797
30		30.0	27.972	1.678	39.558	2.374	48.449	2.907	55.944	3.357
50		50.0	46.620	2.797	65.931	3.956	80.748	4.845	93.240	5.594
75		75.0	69.930	4.196	98.896	5.934	121.122	7.267	139.860	8.392
100		100.0	93.240	5.594	131.861	7.912	161.496	9.690	186.480	11.189

2) Estimation from Photos

Leakage volume is estimated as shown in Figure R-3 below.

Pipe Diameter 100mm

Discharge Distance: 80cm	Discharge Distance: 40cm	Discharge Distance: 20cm
P: 0.2MPa Q: 75m^3/h	P: 0.2MPa Q: 40m^3/h	P: 0.2MPa Q: 25m^3/h
P1:0.3MPa Q1: 92m^3/h	P1:0.3MPa Q1: 49m^3/h	P1:0.3MPa Q1: 30m^3/h
P2:0.3MPa Q2:106m^3/h	P2:0.3MPa Q2: 56m^3/h	P2:0.3MPa Q2: 25m^3/h

Pipe Diameter 75mm

Discharge Distance: 130cm	Discharge Distance: 40cm	Discharge Distance: 20cm
P: 0.2MPa Q: 75m^3/h	P: 0.2MPa Q: 40m^3/h	P: 0.2MPa Q: 8m^3/h
P1:0.3MPa Q1: 92m^3/h	P1:0.3MPa Q1: 49m^3/h	P1:0.3MPa Q1: 10m^3/h
P2:0.3MPa Q2:106m^3/h	P2:0.3MPa Q2: 56m^3/h	P2:0.3MPa Q2: 12m^3/h

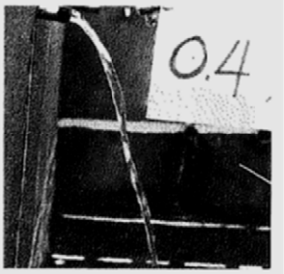
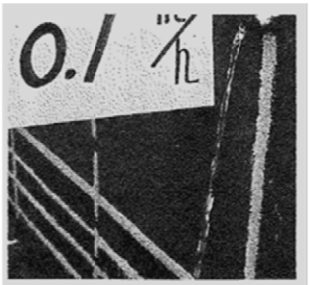
Pipe Diameter 50mm

Discharge Distance: 150cm	Discharge Distance: 80cm	Discharge Distance: 40cm
P: 0.2MPa Q: 40m^3/h	P: 0.2MPa Q: 20m^3/h	P: 0.2MPa Q: 10m^3/h
P1:0.3MPa Q1: 49m^3/h	P1:0.3MPa Q1: 24m^3/h	P1:0.3MPa Q1: 12m^3/h
P2:0.3MPa Q2: 56m^3/h	P2:0.3MPa Q2: 28m^3/h	P2:0.3MPa Q2: 40m^3/h

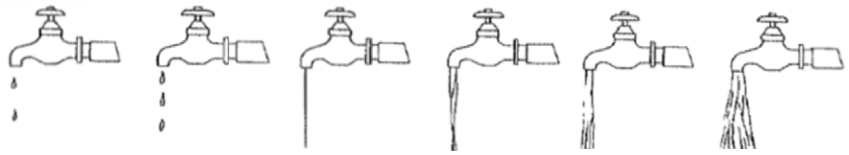
Loose Joint

Pipe Diameter 50mm	Pipe Diameter 100mm	Pipe Diameter 150mm
		
P: 0.2MPa Q: 40m^3/h P1:0.3MPa Q1: 49m^3/h P2:0.3MPa Q2: 56m^3/h	P: 0.2MPa Q: 40m^3/h P1:0.3MPa Q1: 49m^3/h P2:0.3MPa Q2: 56m^3/h	P: 0.2MPa Q: 40m^3/h P1:0.3MPa Q1: 49m^3/h P2:0.3MPa Q2: 56m^3/h

Service pipe 13mm

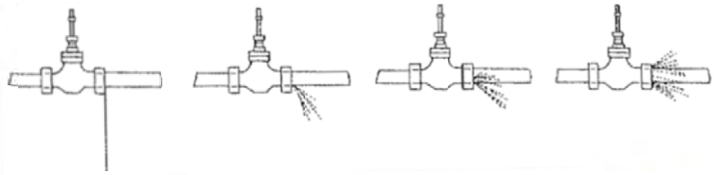
		
P: 0.2MPa Q: 1.00m^3/h P1:0.3MPa Q1: 1.22m^3/h P2:0.3MPa Q2: 1.41m^3/h	P: 0.2MPa Q: 0.40m^3/h P1:0.3MPa Q1: 0.49m^3/h P2:0.3MPa Q2: 0.57m^3/h	P: 0.2MPa Q: 0.1m^3/h P1:0.3MPa Q1: 0.12m^3/h P2:0.3MPa Q2: 0.14m^3/h

Tap



Water Drop 0.001L/min	Water Drop 0.03L/min	String like Water 0.07L/min	90 Degrees Open 2L/min	180 Degrees Open 15L/min	Full Open 30L/min

Stopcock



Stringlike Water 0.03L/min	Spraying (in Part) 1.5L/min	Spraying (Half) 2.0L/min	Spatter 4.0L/min

PE Pipe

Pin Hole	Crack (1cm)	Crack (2cm)	Crack (3cm)
0.02L/min	4L/min	10L/min	20L/min

Fig R-3 Estimation of Leakage Volume by Photos and Figures

S5.5-3 RULE BOOK OF DATABASE [HOW TO UPDATE TO DEVELOP DATABASE]

Solomon Islands
Water Authority

Japan International
Cooperation Agency

Solomon Water GIS Database

Rulebook

June 2016

JICA Expert Team & Counterpart Team

Table of Contents

1. Introduction 1
2. GIS Database Operational Structure 2
2.1. Database Operational Structure 2
2.2. Member of the GIS Database Committee 3
3. GIS Database Management Policy 4
3.1. Database Composition 4
3.2. Database Update 5
3.2.1. Database Update Units in Charge 5
3.2.2. Preparation for Update Operation 5
3.2.3. Update Frequency 6
3.3. Data Backup Policy 6
3.3.1. Necessity of Backup and Restoration 6
3.3.2. Daily Backup 7
3.3.3. Monthly, Quarterly Backup 7
3.4. Operation Workflow 8
4. GIS Database Update Method 10
4.1. Type of Exisiting Data 10
4.2. Update Procedure and Updating Existing GIS Database 10
4.2.1. Updating data in daily operations 10
4.2.2. Relating with External Data 11
4.2.3. Relating with investigation data 12
4.2.4. Replacing Background Data 12
5. Database Update Details 13
5.1. Target Items to be Updated 13
5.2. Update Procedures and Matters to be noted 13
5.3. Management of Update History 16
6. Recommendation 17

ABBREVIATIONS

CAD: Computer-Aided Design
CD: Compact Disc
DVD: Digital Versatile Disc
GIS: Geographical Information System
HDD: Hard Disc Drive
ID: Identification Data
JICA: Japan International Cooperation Agency
NRW: Non-Revenue Water
RAID: Redundant Array of Inexpensive Discs
SW: Solomon Water
TAB file: Table And Binary file
WG: Working Group

1. Introduction

Centralized management of waterworks facilities information is of great importance in the effort to pass on the technical knowledge and experience of SW staff and to further improve water supply services for the future. Work has begun on the construction of a GIS database to be used as a tool with which to study operation and maintenance methods based on this information, the technical support provided to staff, etc. During 2014 practical trials of information management targeting mainly information on water distribution pipes and water supply facilities will begin, and following the completion of "the Project for Improvement of Non-Revenue Water Reduction Capacity for Solomon Islands Water Authority in Solomon Islands" (hereinafter "The Project") by JICA Expert Team and Counterparts in November 2015 things will be ready for a switchover to operation by the Solomon Water (SW) staff themselves.

However, the construction of this kind of database is not the end of the matter; it is important that it continue to be used to support the above-mentioned passing-on of staff skills and the improvement of the water supply services; in order for the database to continue to be used into the future it is important that it parallel accurately the needs relating to its use in daily operation. For this reason operation management of the database, including data updates and the improvement of business practices, is important.

On the subject of data updates, if a database does not reflect data that is as up-to-date and as accurate as possible, it loses its reliability and will cease to be put to use. With respect to the improvement of business practices, without a review of the original purpose of the work and the consideration of a truly rational operation flow (methods and necessary functions) not only will it be impossible to improve efficiency, it will simply increase the burden of operation. In other words, it is necessary to establish a system to organize and put into practice the knowhow needed to ensure that the data is properly updated, and to establish a system to gather the needs of the staff and look into the improvement of business practices.

Further, once this kind of system is established and the use of the database becomes indispensable to the performance of SW's business, the normal operation of the database will be recognized as the norm, and there will no longer be any toleration of a situation whereby business cannot be conducted due to a system failure.

It follows that management of the database includes, in addition to the maintenance of the hardware, software, etc., so that it functions properly, the ability to respond quickly when a problem does occur. For example, it is important that information such as the number of computers and peripherals, where to contact in the event of a problem, what remedial measures to take, etc., is properly managed.

On the basis of the above, this paper has been compiled as an Operational Manual to provide operation management guidelines regarding the basic information, structure, know-how and points to note for

the continuous use of the GIS database in SW.

2. GIS Database Operational Structure

As the GIS database will be provided with data/information from each department in SW, it is important that there be coordination throughout the SW organization. For the sake of the continued development/improvement of the water supply services, it is also essential that the database be seen as the property of SW as a whole, and that the operation management structure be clearly defined.

2.1. Database Operational Structure

A structure is needed by which this information can be gathered into a database and an examination made of how it can be used efficiently for the management of the SW organization while the data is updated as necessary.

In order for the information to be managed centrally in the database, the cooperation of the various departments, centering on the GIS Team in charge of the operation and maintenance of the GIS, is essential; who handles what information/data must be made clear. Figure 2-1 illustrates how the data is channelled into the database.

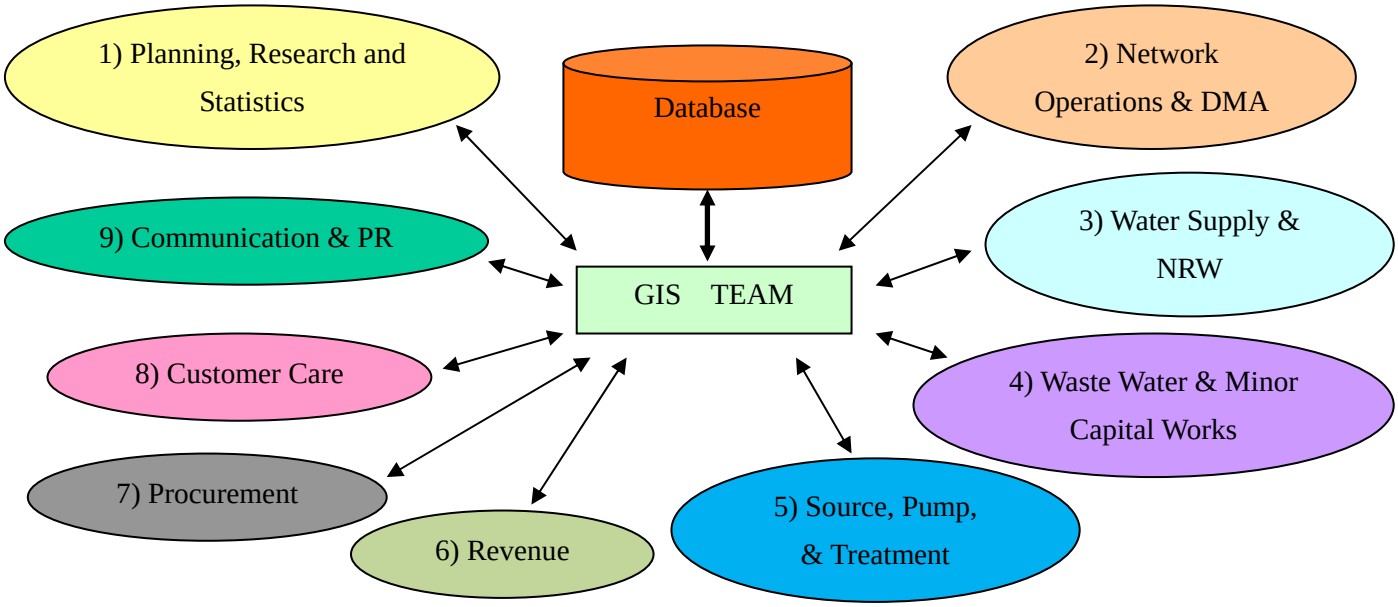


Fig. 2-1 Database Operation Structure

Each department should appoint one or two members of staff to be in charge of GIS database-related matters, those staff serve concurrently as work of each department and GIS activity. And it is important that a system for the discussion of ideas and requests be established in order to eliminate obstacles to the operation of the database. The specific duties of the appointed staff members are listed below.

A) The provision of information for data updates, transfer of data to and from the GIS Team
B) The gathering of ideas and requests within the department regarding use of the database

C) The proposal of improvements in the use of the database

2.2. Member of the GIS Database Committee

The following members of staff were appointed from the various departments of SW to be in charge of the construction and operation of the GIS database, and they organized the operation flow and the various kinds of information/data associated with it. It is hoped that even after the database begins operation, these will continue to be improved, based on the use of the database in the field.

GIS Database Committee	
GIS Team:	Mr. Yaxley Solomon
1) Planning, Research and Statistics:	Mr. Benjamin Billy , Mr. Mathias Bera
2) Network Operations & DMA:	Mr. Frank Daukalia
3) Water Supply & NRW:	Mr. Eric Unga , Mr. Vincent Lui,
4) Waste Water & Minor Capital Works:	Mr. Silus Talosui
5) Source, Pump,& Treatment (including Water Quality & Treatment):	Mr. Chris Meriko Mr. Jeremy Maneipuri
6) Revenue:	Ms. Daisy Menaga, Ms. Rosta Tinarai, Mrs. Mary Tafoa
7) Procurement:	Mr. Patrick Moli
8) Customer Care:	Mrs. Beverly Sahu
9) Communication & PR:	Mr. Carlos Saliga, Ms. Sophia Tango

Fig.2-2 Member of the GIS Database Committee

3. GIS Database Management Policy

Management of data accuracy is aimed at “provision of the latest and accurate data” and the target of management consists of the freshness and the accuracy of the attribute and position information of facilities. In order to develop, update and maintain the data in the right way, it is necessary to keep the following points in mind.

3.1. Database Composition

The GIS database, which is developed through The Project, mainly deals with information of facilities, such as pipelines, valves and hydrants, key facilities and water distribution blocks. On the other hand, water meter information and customer ID (Account number), which belongs to customer information, should be used by creating a relation with the customer information exported from the billing system (NCS). To make a wide variety of data up-to-date and accurate, it is necessary to understand the configuration (attribute items) of each data as a prerequisite for appropriate update management. Fig 3-1 shows the outline drawing of the GIS database.

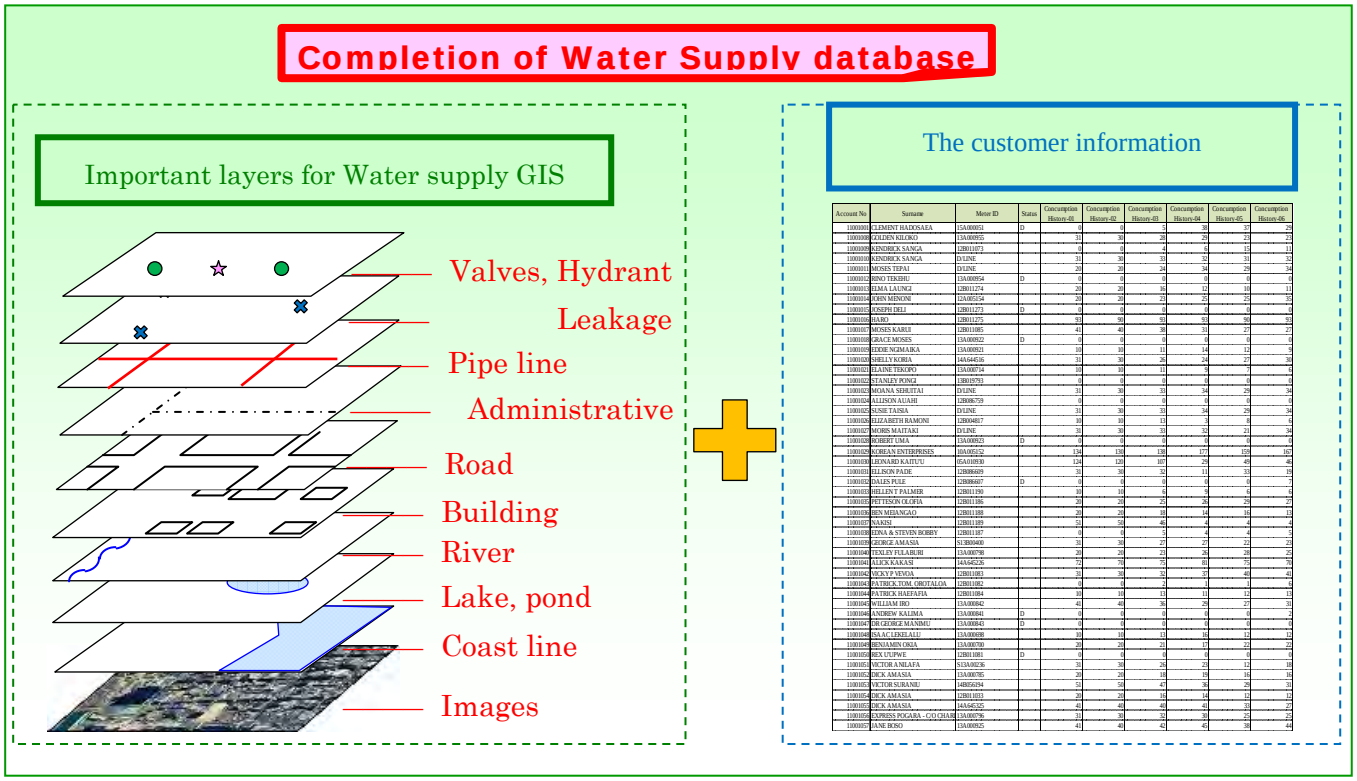


Fig 3-1 Outline Drawing of the GIS Database

3.2. Database Update

2.1.1.

2.1.2.

2.1.3.

3.1.

3.2.

3.2.1. Database Update Units in Charge

From the viewpoint of preventing input errors, it is most desirable that those who are most familiar with the data to be input update the data. In other words, updating data by each team will make the registered data accurate and up-to-date. However, since the number of licenses for the GIS software is limited, currently, only the member of the GIS Team should be allowed to update data. To avoid overloading the GIS Team, data update scheduling by the WG should always be shared and an adjustment should be made whenever necessary.

However, if it can be expected that the staff enhance the understanding of the GIS as they use the database in the future and the database may be operated in a more efficient and advanced manner, measures to make an improvement should be studied as necessary.

Access Control

The GIS database must be updated by the authorized person only. The staff who be allowed to edit (Input newly, modify, delete) are belong to “Administrator Group” appointed by the GIS team leader.

Table 3-1 Administrator Group Member

Administrator Group Member (1st, May, 2016)
Administrator: Mr. Yaxley Solomon ,
Operating personnel: (Vacant)

An administrator group update for the GIS database using by “Mapinfo”, and the TAB file (Mapinfo’s native file format) has to be kept appropriately as “Master data”.

The SW staff can request a data offer to administrator group, and view and print out the offered data. In addition, if you have any GIS software (e.g. QGIS etc.), SW staff can process offered data and make the user map for own field / office work. However, the master data (Mapinfo) doesn't reflect processed data by each of staff. If it is necessary to reflect on the master data, SW staff has to offer the information material which wrote the edit contents and the edit location clearly according as the workflow to administrator group, and request to edit it. Fig 3-1 shows the workflow of the GIS database.

3.2.2. Preparation for Update Operation

In order to realize appropriate update operations, the SW staff needs to clarify the update target. For this purpose, the following preparatory operations should be carried out.

• Secure delivery of information

Most data to update are generated by new construction and rehabilitaion. The as-built drawing is a source of information for updating data. As such, it should not merely report the completion of construction, but should include all the information necessary for maintenance after the completion of the new construction and rehabilitaion. At the same time, the form should be so designed that it can be easily used for updating data. Also, to prevent miscommunication, it is necessary to fill in the form with carefully-written letters. By ensuring these, the flow of materials in updating data should be unified.

• Organizing update content and giving instructions

If the as-built drawings and the information entry sheets (forms) are input appropriately, the update content is naturally organized by GIS team. However, if it is considered that the description in the drawing may be misleading, it is necessary to check with the person in charge in each team as appropriate.

3.2.3. Update Frequency

In order to keep the data up-to-date, it is necessary to carry out data update immediately after the need for updating or modifying the data arises. However, since SW is in a stage of initial data development at this moment, it is considered difficult to ask for immediate response. Accordingly, the update frequency should be once a week at first and it should be gradually increased to improve the freshness of the information. With respect to water meter information, the latest information can be viewed by periodically combining with the data output from the billing system (NCS).

It is necessary to grasp at what point in time the latest information was collected based on the update cycle. Annex-1 shows the Update Frequency of each GIS databse items.

3.3. Data Backup Policy

In data management, it is necessary to backup data (duplicate and migrate data to another media) as a daily practice to provide for restoration in case the data is damaged. Although the rigidity of the server is maintained by incorporating RAID technology into the hard disk and online backup to an external hard disk, the following management should be implemented to further ensure safety.

3.3.

3.3.1. Necessity of Backup and Restoration

A computer system consists of hardware, software and data.

The hardware and the software can be easily replaced or reinstalled even if they are damaged. With respect to the users, training and handover can be carried out to prepare for personnel transfer so that stagnation may be avoided in operation.

However, if the data is damaged, the data needs to be restored (redeveloped) at a cost of time and expenses equivalent to that of the development of the data, which will make a significant impact on the execution of operations and the financial management. Data backup (duplication and migration of

data to another media) is needed to perform the restoration work promptly and at the lowest possible cost.

If backup is created, the restoration work only involves restoration of the backup data and redevelopment of the data updated after the point in time that the backup data was created. Therefore, the key to prompt and secure restoration is how recent the available backup data is as compared to the point in time that the data was damaged.

3.3.2. Daily Backup

Broadly speaking, there are two kinds of data in the computer. The one is “System data” that is called basic OS (Operation System) (Windows7, 8, 10 or server2012 etc), and another are “general data” that were made by application (Excel, Word, Access or the GIS software).

Since daily data update is carried out by the staff in SW, basically, a backup should be created every day. The data subject to backup is “general data” that is limited to those in the following files.

- •GIS database files (a set of *.TAB files for each layer)
  *at least four files. : *.TAB, *.DAT, *.ID, *.MAP
- •Information form files (spreadsheet : *.xls, *.xlsx, *.ods, etc)
- •Files into a predetermined folder in the server

Also, to make the restoration work as simple as possible, data duplication and migration to other media should be recommended.

"Task scheduler" of the Windows standard function is convenient for the daily backup method. It's possible to start by the following procedure.

[Start] >> [Control panel] >> [Manabement Tool] >> "Task scheduler" (The icon is as: )

In addition, it is desirable to store backup data of two generations or more for a certain period of time and manage the same data at two locations by preparing several pieces of backup media (recording media, such as CD, DVD and HDD) and using them in rotation. This should be done to provide for a case in which data cannot be restored due to an abnormality of the media.

3.3.3. Monthly, Quarterly Backup

System data as well as application data should also be backed up by a monthly, quarterly backup. When a computer has not started by a hard disk obstacle, an advantage of a system backup can do a downtime of a computer short, and can be restored earlier. In addition, it's possible to return it at the time when a computer was backed up.

An important thing is "Generation management" on a system backup. It'll be taken a load for a system (I take time and effort.) to save the generation too much. The backup method and the frequency should be discussed and decided about it with an IT section member.

"Task scheduler" of the Windows standard function is convenient for monthly or quarterly backup method of the general data. It's possible to start by the following procedure.

[Start] >> [Control panel] >> [Manabement Tool] >> "Task scheduler" (The icon is as: )

3.4. Operation Workflow

The GIS database is expected to be used by many teams of SW in their work. Accordingly, while efforts should be made to maintain the freshness and accurateness of the data, it is also necessary to continually study how to make an effective use of the data to improve the water supply services.

For this purpose, it is necessary to encourage all the staff working in SW to consider the utilization of the database including the improvement of the operation flow as they execute the operations, and collect their opinions.

The collected opinions should be examined through discussion with other teams and the priorities should be studied for improvement.

The person in charge at each team is required to routinely collect requests from the staff, regularly make proposals to the GIS Team and the IT Team, and lead this project in cooperation with other teams, taking a bird’s eye view of SW. Fig 3-2 shows the workflow of the GIS database.

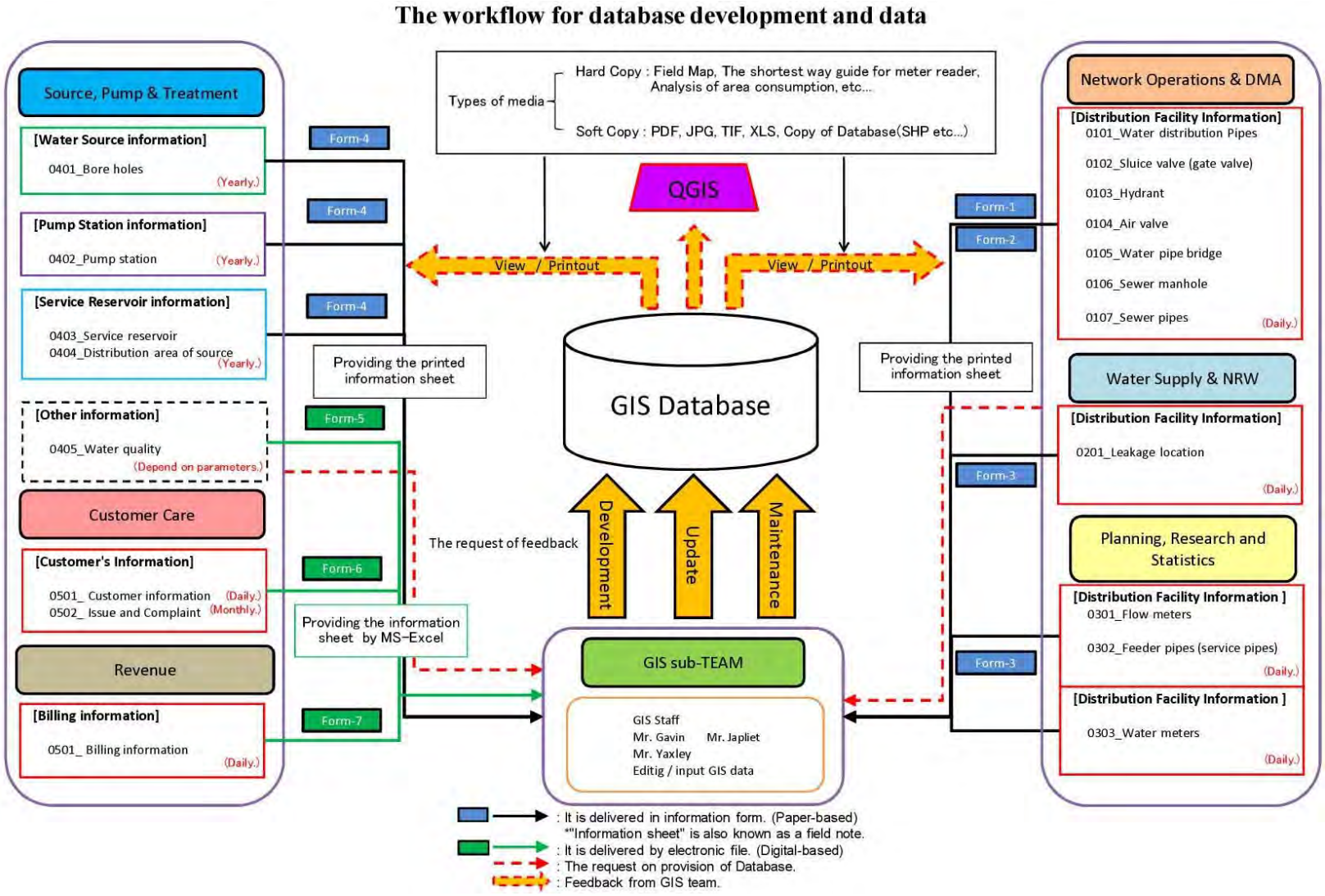


Fig. 3.2 Workflow of GIS Database

4. GIS Database Update Method

In the past, in SW, information of water distribution pipe reinstallation and other facility construction works had not been accumulated as paper or electronic data (CAD data) in accordance with a common format nor had it been shared among the staff. As such, when renewing a facility, inquiries often had to be made of retired staff to check the information. However, once the GIS database is constructed and used in daily operations, it will be possible to establish a structure in which work completion information is prepared in a common format of electronic data that can be directly used for updating data in future. As improvement of the IT environment by data standardization, etc., is required to realize this and such improvement can hardly be achieved by 201, when the database is operated on a trial basis, data should be updated mainly by referring to paper drawings, such as as-built drawings, or sketches and forms created in the field by the time an adequate environment is developed.

4.1. Type of Existing Data

With respect to updating data, the following operations need to be carried out, depending on the type and content of the data.

- Updating data in daily operations
- Relating with External Data
- Relating with investigation data
- Replacing background data *Not scheduled at this point in time

This section broadly outlines the method of data update operations. Details of each operation will be described in Chapter 5.

4.2. Update Procedure and Updating Existing GIS Database

Data to be updated in daily operations and the update procedure are described below.

2.1.4.

4.1.

4.2.

4.2.1. Updating data in daily operations

- Water Facility Information

Based on the materials submitted by the Maintenance and Leakage Teams, figures of each water facility are edited and corresponding attributes are input from the form (information input sheet) to create a database.

With respect to the facility information, only the attribute information of the target facility should be stored.

With respect to the meter attribute information, as the latest information can be viewed when the information is related with the billing system (NCS) data, link key attributes (Customer ID or Account No.) should be developed for linkage with the position information.

Likewise, as water quality investigation data can be related with the water quality investigate record data, link key attributes (investigation point ID) should be developed for linkage with the position information.

4.2.2. Relating with External Data

The data described below should be periodically related with the data output from the billing system (NCS).

The data to be related and the relating procedures are as follows.

A) Water meter & Customer Account Number

The data output from the billing system and periodically related with the GIS database and the capturing frequency are shown below.

Customer information (once a week)

Customer information can be output from the billing system by the Billing Team staff in spreadsheet (e.g. excel file format). The output data can be related with the GIS database by being stored in a prescribed shared folder on the network.

The following points should be noted when outputting data in spreadsheet from the billing system.

i) The data should include link key attributes (Customer ID or Account No.) for linkage with the position information (GIS data). Also, the link key attributes should be located on the left end.

ii) Configuration, such as attribute items and sequence, should not be changed.

iii) Updating Customer Information

As the billing system cannot be linked to the GIS database, viewing of the latest information is enabled by relating data periodically output from the billing system with the GIS database. The billing data is updated day by day and SW requires access to the latest possible information. Accordingly, a mechanism enabling periodical capturing should be made available.

B) Water Rate Data

Hydrant information, such as water meter owner information and user information, and water consumption data should be periodically related with each other (Figures 4.1 and 4.2).

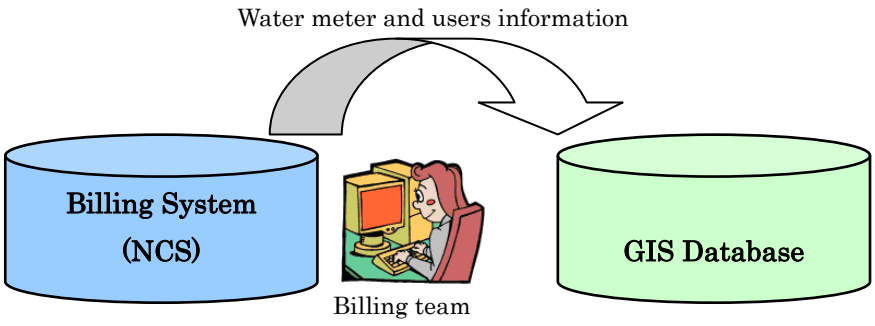
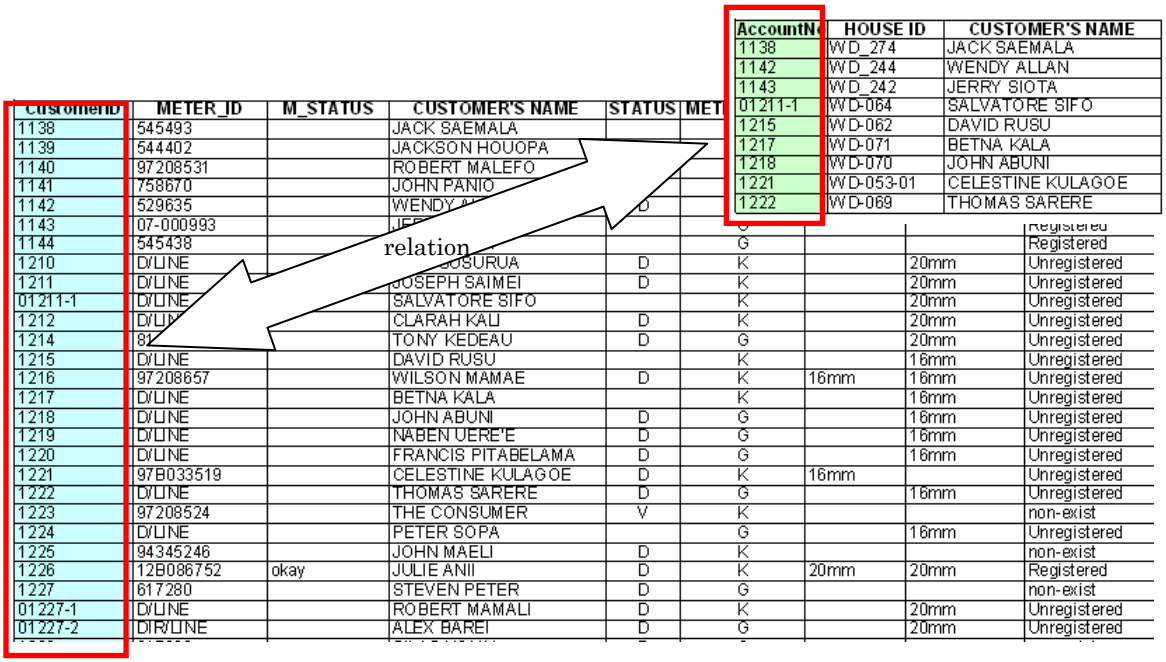


Fig. 4.1 Data passing



AccountNo	HOUSE ID	CUSTOMER'S NAME
1138	WD_274	JACK SAEMALA
1142	WD_244	WENDY ALLAN
1143	WD_242	JERRY SIOTA
01211-1	WD-064	SALVATORE SIFO
1215	WD-062	DAVID RUSU
1217	WD-071	BETNA KALA
1218	WD-070	JOHN ABUNI
1221	WD-053-01	CELESTINE KULAGOE
1222	WD-069	THOMAS SARERE

CustomerID	METER_ID	M_STATUS	CUSTOMER'S NAME	STATUS	MET			
1138	545493		JACK SAEMALA					
1139	544402		JACKSON HOUOPA					
1140	97208531		ROBERT MALEFO					
1141	758670		JOHN PANIO					
1142	529635		WENDY A	D				
1143	07-000993		JE					
1144	545438				G			Registered
1210	D/LINE		SOSURUA	D	K		20mm	Unregistered
1211	D/LINE		JOSEPH SAIMEI	D	K		20mm	Unregistered
01211-1	D/LINE		SALVATORE SIFO		K		20mm	Unregistered
1212	D/LIN		CLARAH KALI	D	K		20mm	Unregistered
1214	81		TONY KEDEAU	D	G		20mm	Unregistered
1215	D/LINE		DAVID RUSU		K		16mm	Unregistered
1216	97208657		WILSON MAMAE	D	K	16mm	16mm	Unregistered
1217	D/LINE		BETNA KALA		K		16mm	Unregistered
1218	D/LINE		JOHN ABUNI	D	G		16mm	Unregistered
1219	D/LINE		NABEN UERE'E	D	G		16mm	Unregistered
1220	D/LINE		FRANCIS PITABELAMA	D	G		16mm	Unregistered
1221	97B033519		CELESTINE KULAGOE	D	K	16mm		Unregistered
1222	D/LINE		THOMAS SARERE	D	G		16mm	Unregistered
1223	97208524		THE CONSUMER	V	K			non-exist
1224	D/LINE		PETER SOPA		G		16mm	Unregistered
1225	94345246		JOHN MAELI	D	K			non-exist
1226	12B086752	okay	JULIE ANII	D	K	20mm	20mm	Registered
1227	617280		STEVEN PETER	D	G			non-exist
01227-1	D/LINE		ROBERT MAMALI	D	K		20mm	Unregistered
01227-2	DIR/LINE		ALEX BAREI	D	G		20mm	Unregistered

Fig.4.2 Data relation

4.2.3. Relating with investigation data

The GIS data has not been created at this point, but by relating the following investigation data with the position information in the process of data development within SW, new methods for utilizing the data may be discovered.

Water quality investigation

Position information of each investigation point (captured by GPS) should be developed on the GIS database in daily operations, and relating the information with the data of water quality investigation results makes it possible to view the latest investigation data at each investigation point.

4.2.4. Replacing Background Data

The GIS data collected in the past included the following data.

i) Aerial photograph

ii) Sewage information

iii) Road shape

iv) House shape

v) Contour data

All of these data can be used as background data, although they were obtained around 2000 and some of them do not conform to the current situation. However, since it is difficult for SW to create these data on its own, these data should be replaced with the updated data as soon as the government or related organizations update the data.

5. Database Update Details

The GIS database needs to be updated to the latest data on a continual basis, as it is expected to be used in the daily operations of SW. More specifically, it is necessary to update the figure and attribute information of water facilities, etc. The items to be updated and the matters to be noted are described below.

5.1. Target Items to be Updated

The information in the GIS database should be updated when water facilities are newly built or changed by construction work, etc.

Update Details

Annex-2 shows the objects to be updated in the GIS database and the attribute items. Reference materials used in the update operation are also shown in the Table.

Annex-3 shows the Contraction Information Forms.

5.2. Update Procedures and Matters to be noted

All the figures and attributes of the objects shown in Table 5.1 should be updated. The update operation should be carried out by referring to the materials, such as as-built drawings, forms filled in and sketches created in the field. The following matters should generally be noted in updating data in the GIS database.

i) Reference materials specified in Table 5.1 and other related materials should be used in updating the data.

ii) Essential items of figures and attributes should be input by all means.
See “Object Definition Document” (GIS Database Specifications)

iii) To input a date, such as [Date of Replacement/Rehabilitation] and [Last maintenance Date], the year, month and day should be entered as eight-digit numbers (YYYYMMDD).

iv) Materials and drawings used in updating the data should be scanned to create electronic data and the originals in paper should be filed and retained.

(1) Water Distribution Pipes

The position and types of existing pipelines, which are main data of the GIS database, cannot be verified unless the site is actually excavated. Accordingly, the data should be updated not only in accordance with reinstallation or other construction works but also by interview surveys of veteran staff.

Both figure shapes and attributes should be input by referring to as-built drawings and Form-1(*).

(i) Updating figures
(ii) Updating attributes

(2) Sluice Valve (Gate Valve)

The position information should be captured by GPS device and the attributes should be input by referring to as-built drawings and Form-1(*).

It is anticipated that point symbols may not be placed on the line of the pipeline, depending on the accuracy of the GPS or the existing data, but the position should not be edited on the GIS software, since the purpose of creating the database is to grasp the number and approximate position of the facilities.

(3) Hydrant

The position information should be captured by GPS device and the attributes should be input by referring to as-built drawings and Form-1 (*).

(4) Air Valve

The position information should be captured by GPS device and the attributes should be input by referring to as-built drawings and Form-1 (*).

(5) Water Pipe Bridge

Damage to pipelines installed within a bridge due to a natural disaster or an accident will make a great impact on the water supply service. Therefore, data is created in order to identify pipelines built within a bridge. Both figure shapes and attributes should be entered by referring to the as-built drawings and Form-1 (*).

(6) Sewer Manhole

The position information should be captured by GPS device and the attributes should be input by referring to Form-2(*).

(7) Sewer Pipes

The position information should be captured by GPS device and the attributes should be input by referring to Form-2 (*).

(8) Leakage Location

The position information should be captured by GPS device and the attributes should be input by referring to Form-3 (*).

(9) Flow Meters

The position information should be captured by GPS device and the attributes should be input by referring to Form-2 (*).

(10) Feeder Pipes (Service Pipes)

Both figure shapes and attributes should be entered by referring to Form-2 (*). Feeder pipes should be input as pipes from water distribution pipes to water meters.

(11) Water Meters

・The position information should be captured by GPS device and the attributes should be input by referring to Form-2 (*).

・Due to the accuracy of the GPS, it is anticipated that the position captured by the GPS device may be five or six meters away from the actual position, but the position should not be edited on the GIS software, since the purpose of creating the database organize to grasp the number and approximate position of the facilities.

・With respect to the attributes of the meter, [Account No.], which makes the link key to relate with the data of the billing system, should always be entered.

(12) Boreholes

The position information should be captured by GPS device and the attributes should be input by referring to Form-4 (*).

(13) Pump Station

The position information should be captured by GPS device and the attributes should be input by referring to the as-built drawings and Form-2 (*).

(14) Service Reservoir

The figure shape should be input by referring to the contours and the attributes should be input by referring to Form-4 (*).

(15) Distribution Area of Source

The figure shape should be input by referring to the status of the pipeline network and the attributes should be input by referring to Form-4 (*).

(16) Water Quality

The position information should be captured by GPS device and the figure attributes should be input by referring to Form-5(*). The data should be related with the Spreadsheet file.

Annex-4 shows the Water Quality Information Forms.

With respect to updating the attributes, the following points should be noted.

i) [Point No.], Which allows the link key to relate with the data of water quality investigation results, should always be input?

ii) The link key should be located on the left end.

iii) Configuration, such as attribute items and sequence, should not be changed.

(17) Customer's Information

i) Should be exported in spreadsheet from the billing system (NCS).

ii) The data content should be thoroughly checked before providing the data, because the GIS Team does not process (modify or delete) the Spread sheet data, in principle.

iii) [Account No.], which makes the link key to relate with the water meters data, should always be

entered.

iv) The link key should be located on the left end.

v) Configuration, such as attribute items and sequence, should not be changed.

vi) Annex-5 shows a sample of the billing system (NCS) format.

(18) Issue and Complaint

The figure shape and the attributes should be input by Customer Enquiry and Complaint Form. Annex-6 shows the Issue and Complaint Forms.

5.3. Management of Update History

Forms provided by each team should be scanned to create electronic data (PDF files), and the files should be stored in the shared folder on the network. This makes it possible to capture the update details and timing. The following points should be noted in scanning.

(i) Scanning

Forms received as updated information are scanned to create PDF files.

i) One file should be created for each piece of update information.

ii) Basically, monochrome 200dpi may be chosen, but if a handover message or similar is highlighted, color should be chosen.

iii) The files should be stored in the shared folder on the network after determining the filenames according to the rule.

(ii) Filename rule

Table 5.2 shows the filename rule to classify different types of construction.

"Code" & "Receiving Date of the Form" & "Form Number".pdf

Table 5.1 Numbering of filename

No	Classification	Code	Example
1	Water distribution Pipes	WDP	WDP-(Date[YYYYMMDD])-001.pdf
2	Sluice valve (gate valve)	SV	SV-(Date[YYYYMMDD])-001.pdf
3	Hydrant	HD	HD-(Date[YYYYMMDD])-001.pdf
4	Air valve	AV	AV-(Date[YYYYMMDD])-001.pdf
5	Water pipe bridge	WPB	WPB-(Date[YYYYMMDD])-001.pdf
6	Sewer manhole	SM	SM-(Date[YYYYMMDD])-001.pdf
7	Sewer pipes	SP	SP-(Date[YYYYMMDD])-001.pdf
8	Leakage location	LL	LL-(Date[YYYYMMDD])-001.pdf
9	Flow meters	FM	FM-(Date[YYYYMMDD])-001.pdf
10	Feeder pipes (service pipes)	FP	FP-(Date[YYYYMMDD])-001.pdf
11	Water meters	WM	WM-(Date[YYYYMMDD])-001.pdf
12	Bore holes	BH	BH-(Date[YYYYMMDD])-001.pdf

13	Pump station	PS	PS-(Date[YYYYMMDD])-001.pdf
14	Service reservoir	SR	SR-(Date[YYYYMMDD])-001.pdf
15	Distribution area of source	DAS	DAS-(Date[YYYYMMDD])-001.pdf
16	Water quality	WQ	WQ-(Date[YYYYMMDD])-001.pdf
17	Customer's Information	CI	CI-(Date[YYYYMMDD])-001.pdf
18	Issue and Complaint	IC	IC-(Date[YYYYMMDD])-001.pdf

6. Recommendation

The Operational Manual was drawn up in preparation for the start of full-scale operation of the database. The purpose of constructing the GIS database is to help improve water supply services through the continued and evolving use of the database, and with this in mind, in the Operational Manual emphasis was placed on organizing management of the usage environment and data updating, and the structure needed for these activities.

The mission of a water utility is set forth in the three principles (a *plentiful* supply of *pure* water, at *low cost*); in maintaining this while further improving functionality, the maintenance and management of the network of water supply pipes that stretches to all parts of the water-supply service area can be considered to be the most important and fundamental task in the administration of the water utility. It follows that the GIS database ranks as a piece of facilities information infrastructure in the administration of the water utility; it is one of the most important assets with applications in every aspect of the work of the water utility.

This is an indication that a GIS database is not a piece of software for use at the level of the individual, like Word or CAD; it is a business system that needs to be made use of in a state of coordination with plans for the future administration of the water utility. It follows that its use requires the consideration of an organizational response, so that it is important that the kind of guidelines given in this paper be clarified. They are summarized once more below.

Most important for the continued use of the database is the need for data updates to be carried out reliably. This requires the prior organization of the content of the data update, clarification of the rules for updating, and management of the entire updating process. Regular training also needs to be implemented so that workers can understand the database and acquire the skills needed to operate it.
This needs to be fully understood by each and every member of the SW staff, and needs to be fully incorporated into the work of each one; but if each person has a different understanding and a different response, systematic management could become difficult. This is why it is necessary to establish a structure through which the data updates and the operation of the database can be managed and implemented comprehensively.

In order for this to be fully and thoroughly implemented, it is hoped that from now on painstaking observation of the state of database operations will be maintained, and discussions held within SW

regarding future facility maintenance and management.

Annex-1

Update Frequency of GIS Database

Update Frequency of GIS Database (1/3)

No.		GIS subject	Update frequency of Original source			Update frequency of GIS database			Remarks
			Daily	Weekly	Monthly	Daily	Weekly	Monthly	
		1. Distribution Facility information							
0101	Graphic	Water distribution pipes	●				●		required
	0101-1	Pipe ID	●				●		required
	0101-2	Networks	●				●		required
	0101-3	Systems	●				●		required
	0101-4	Pipe material	●				●		required
	0101-5	Pipe diameters	●				●		required
	0101-6	Pipe length	●				●		required
	0101-7	Pipe Depth	●				●		required
	0101-8	Pipe Use	●				●		required
	0101-9	Completion year	●				●		required
	0101-10	Date of last maintenance	●				●		required
	0101-11	Date of Replacement / Rehabilitation	●				●		required
	0101-12	Date of Repairing	●				●		required
	0101-13	Date of Leakage detection	●				●		required
	0101-14	Pipe Notes	●				●		required
0102	Graphic	Sluice valve (gate valve)	●				●		required
	0102-1	Valve ID	●				●		required
	0102-2	Networks	●				●		required
	0102-3	Systems	●				●		required
	0102-4	Valve material	●				●		required
	0102-5	Valve size	●				●		required
	0102-6	Depth	●				●		required
	0102-7	Direction of turn	●				●		required
	0102-8	Valve status	●				●		required
	0102-9	Date of Installation	●				●		required
	0102-10	Date of last maintenance	●				●		required
	0102-11	Valve Notes	●				●		required
0103	Graphic	Hydrant	●				●		required
	0103-1	Hydrant ID	●				●		required
	0103-2	Networks	●				●		required
	0103-3	Systems	●				●		required
	0103-4	Hydrant type	●				●		required
	0103-5	Hydrant diameters	●				●		required
	0103-6	Date of Installation	●				●		required
	0103-7	Last maintenance Date	●				●		required
	0103-8	Hydrant Notes	●				●		required
0104	Graphic	Air valve	●				●		required
	0104-1	Air Valve ID	●				●		required
	0104-2	Networks	●				●		required
	0104-3	Systems	●				●		required
	0104-4	Air Valve size	●				●		required
	0104-5	Date of Installation	●				●		required
	0104-6	Last maintenance Date	●				●		required
	0104-7	Air Valve Notes	●				●		required
0105	Graphic	Water pipe bridge	●				●		required
	0105-1	ID	●				●		required
	0105-2	Length	●				●		required
	0105-3	Pipe material	●				●		required
	0105-4	Last maintenance Date	●				●		required
	0105-5	Bridge Name	–	–	–	–	–	–	–
	0105-6	Bridge material	–	–	–	–	–	–	–
0106	Graphic	Sewer Manholes	●				●		required
	0106-1	Sequential number	–	–	–	–	–	–	–
	0106-2	Distribution System number	●				●		required
	0106-3	Distribution System name	●				●		required
	0106-4	Distribution System location	●				●		required
	0106-5	Distribution System code	●				●		required
	0106-6	SSYSAC	●				●		required
	0106-7	SSYSLINENO	●				●		required
	0106-8	SMH_number	●				●		required
	0106-9	SMH_type	●				●		required
	0106-10	SMH_IL	●				●		required
	0106-11	SMH_RL	●				●		required
	0106-12	SMH_size	●				●		required
	0106-13	SMH_date	●				●		required

Update Frequency of GIS Database (2/3)

No.		GIS subject	Update frequency of Original source			Update frequency of GIS database			Remarks
			Daily	Weekly	Monthly	Daily	Weekly	Monthly	
0107	Graphic	Sewer Pipelines	●				●		required
	0107-1	Sequential number	●				●		–
	0107-2	Distribution System number	●				●		required
	0107-3	Distribution System name	●				●		required
	0107-4	Distribution System location	●				●		required
	0107-5	Distribution System code	●				●		required
	0107-6	SSYSAC	●				●		required
	0107-7	SSYSLINENO	●				●		required
	0107-8	SP_NO	●				●		required
	0107-9	Sewer Pipe Length	●				●		required
	0107-10	SP_SIL	●				●		required
	0107-11	SP_EIL	●				●		required
	0107-12	SP_ACV	●				●		required
	0107-13	Sewer Pipe diameters	●				●		required
	0107-14	SP_TYPE	●				●		required
	0107-15	SP_MAKE	●				●		required
	0107-16	SP_DATE	●				●		required
	0107-17	SP_SLOPE	●				●		required
	0107-18	SP_CONNO	●				●		required
	0107-19	SP_CONNEC	●				●		required
	0107-20	SP_LINK	●				●		required
0201	Graphic	Leakage location	●				●		
	0201-1	ID	●				●		
	0201-2	Leakage Type	●				●		
	0201-3	Status of Leak	●				●		
	0201-4	Location	●				●		
	0201-5	Condition	●				●		
	0201-6	Asset type	●				●		required
	0201-7	Asset Size	●				●		required
	0201-8	Asset Material	●				●		required
	0201-9	Date of survey	●				●		
0301	Graphic	Flow meters	●				●		required
	0301-1	ID	–	–	–	–	–	–	required
	0301-2	Networks	●				●		required
	0301-3	Systems	●				●		required
	0301-4	Location	●				●		required
	0301-5	Size	●				●		required
	0301-6	Date of Installation	●				●		required
	0301-7	Last maintenance Date	●				●		required
	0301-8	Logging	●				●		required
	0301-9	Flow meter Notes	●				●		required
0302	Graphic	Feeder pipes (service pipes)	●				●		required
	0302-1	PipeID	–	–	–	–	–	–	required
	0302-2	Pipe material	●				●		required
	0302-3	Pipe size	●				●		required
0303	Graphic	Water meter	●				●		
	0303-1	HouseID	–	–	–	–	–	–	required
	0303-2	Customer's Name	●				●		
	0303-3	MeterID	●				●		
	0303-4	Status of Meter (whether working, buried etc)	●				●		required
	0303-5	Manufacturer	●				●		required
	0303-6	Size of Meter	●				●		required
	0303-7	Date of Installation	●				●		required
	0303-8	Lot Number	●				●		required
	0303-9	Comments	●				●		required
		2. Water Source information							
0401	Graphic	Bore holes			●			●	required
	0401-1	Borehole ID			●			●	–
	0401-2	Borehole Type			●			●	–
	0401-3	Well depth(m)			●			●	required
	0401-4	Head			●			●	–
	0401-5	Head Max			●			●	–
	0401-6	Pump ID			●			●	–
	0401-7	Location			●			●	required
	0401-8	Manufacturerre			●			●	–
	0401-9	Serial No			●			●	–
	0401-10	Flow Rate			●			●	required
	0401-11	Static Water Level			●			●	required
	0401-12	Dynamic Water Level			●			●	required
	0401-13	Date of Pump Installed			●			●	required
	0401-14	Date of last maintenance			●			●	required
	0401-15	Age			●			●	required
	0401-16	Status			●			●	required

Update Frequency of GIS Database (3/3)

No.		GIS subject	Update frequency of Original source			Update frequency of GIS database			Remarks
			Daily	Weekly	Monthly	Daily	Weekly	Monthly	
		3. Pump Station information							
0402	Graphic	Pump station			●			●	required
	0402-1	Station ID			●			●	–
	0402-2	Unit name			●			●	required
	0402-3	Station type			●			●	required
	0402-4	Location			●			●	required
	0402-5	Age			●			●	required
	0402-6	Status			●			●	required
	0402-7	Power Usage (KWh)			●			●	required
	0402-8	Number of pump			●			●	required
		4. Service reservoir information							
0403	Graphic	Service reservoir			●			●	required
	0403-1	Service reservoir name			●			●	required
	0403-2	Structure of service reservoirs			●			●	required
	0403-3	Elevation of service reservoirs			●			●	required
	0403-4	Capacity of service reservoir			●			●	required
	0403-5	H.W.L, L.W.L			●			●	required
	0403-6	Date of last maintenance			●			●	required
0404	Graphic	Distribution area of source			●			●	
	0404-1	Area name			●			●	
		6. Other informations							
0405	Graphic	Water quality (Fixed-point observation)	●				●		
	0405-1	Water Quality Point No			●			●	
	0405-2	Location Name			●			●	
	0405-3	Data of Survey			●			●	
	0405-4	Source name			●			●	
	0405-5	Source Type			●			●	
	0405-6	Catchment condition			●			●	
	0405-7	Catchment area(Hectares)			●			●	
	0405-8	Flow Rate (L/s)			●			●	
	0405-9	Chlorine Demand (mg/10L)	●				●		
	0405-10	Hardness (mg/L)			●			●	
	0405-11	Turbidity (NTU)	●				●		
		5. Customer's information							
0501		Customer information	–	–	–	–	–	–	–
	0501-1	Customer ID	●				●		
	0501-2	Customer's name	●				●		
	0501-3	House ID	●				●		
	0501-4	Type Of Account	●				●		
	0501-5	Boundary of plot (land)	●				●		
	0501-6	Customer's status	●				●		
0502		Issue and Complaint	–	–	–	–	–	–	–
	0502-1	Customer ID	●					●	
	0502-2	Customer's name	●					●	
	0502-3	Account No	●					●	
	0502-4	Contact Details	●					●	
	0502-5	Cycle	●					●	
	0502-6	Type Of Cpmplaints	●					●	

Annex-2

GIS Database Items to be updated

See Annex-3 for Forms with (*).

Category	Layer No	Layer Name	Attributes	Figure type	Reference information	Feedback tools
Distribution Facility Information	101	Water distribution Pipes	P_ID Networks Systems P_Type P_Size P_Length P_Depth Pipe_Usedt_Install dt_Maintained dt_Replace dt_Repair dt_Leakage Pipe_Notes	Polyline	As-built drawing Form-1(*)	Field survey map PDF format
	102	Sluice valve (gate valve)	V_ID Networks Systems V_type V_size V_Depth T_Direction V_status dt_Install dt_Maintainance Vnotes	Point	As-built drawing Form1(*)	Field survey map PDF format
	103	Hydrant	FH_ID Networks Systems FH_type dt_Install FHsize dt_Maintenance Fhnotes	Point	As-built drawing Form1(*)	Field survey map PDF format
	104	Air valve	AV_ID Networks Systems AV_type dt_Install dt_Maintenance Fhnotes	Point	As-built drawing Form1(*)	Field survey map PDF format

See Annex-3 for Forms with (*).

Category	Layer No	Layer Name	Attributes	Figure type	Reference information	Feedback tools
Distribution Facility Information	105	Water pipe bridge	WPB_ID WPB_Length P_type dt_Maintenance Brg_Name Brg_type	Polyline	As-built drawing Form1(*)	Field survey map PDF format
	106	Sewer Manhole	ID SSYSNO SSYSNA SSYSLO SSYSCD SSYSAC SSYSLINENO SMH_number SMH_type SMH_IL SMH_RL SMH_size SMH_date	Point	Form2(*)	
	107	Sewer Pipes	ID SSYSNO SSYSNA SSYSLO SSYSCD SSYSAC SSYSLINENO SP_NO SP_LGTH SP_SIL SP_EIL SP_ACV SP_SIZE SP_TYPE SP_MAKE SP_DATE SP_SLOPE SP_CONNO SP_CONNEC SP_LINK	Polyline	Form2(*)	

See Annex-3 for Forms with (*).

Category	Layer No	Layer Name	Attributes	Figure type	Reference information	Feedback tools
Distribution Facility Information	201	Leakage position	LK_ID LK_type Leak_Status LK_Position LK_Condition Asset_type Asset_Size Asset_Material dt_survey	Point	Form3(*)	Field survey map PDF format
	301	Flow meters	FM_ID BF_Location Systems FM_Size Networks dt_Install dt_Maintenance Logging BFnotes	Point	Form3(*)	Field survey map PDF format
	302	Feeder pipes (service pipes)	FP_ID FP_type PF_size	Polyline	Form3(*)	Field survey map PDF format
	303	Water meters	AccountNo(*Link Key) Cstmr_Name MTR_ID MTR_Status Meter_Make Meter_Size dt_Install Lot_Number Meter_notes	Point	Excel file that exported from NCS.	1- Field survey map PDF format
Water Source information	401	Bore holes	BH_ID BH_type BH_depth Head Head_Max Pump_ID Location Manufacturerre Serial_No Flow_Rate Static_Wtr_Lv Dynamic_Wtr_Lv dt_Install dt_Maintenance Age Status	Point	Form4(*)	

See Annex-3 for Forms with (*).

Category	Layer No	Layer Name	Attributes	Figure type	Reference information	Feedback tools
Pump Station information	402	Pump station	Station_ID Station_name Station_type Location Age Status Power_Usage Number_of_pump	Point	Form4(*)	
Service Reservoir information	403	Service reservoir	SR_name, SR_Structure SR_Elevation H.W.L, L.W.L, SR_Capacity	Polygon	Form4(*)	
	404	Distribution area of source	D_Area name	Polygon	Form4(*)	
Other information	405	Water quality	WQ_ID Location dt_Survey pH COD DO Coli Source_name Source_Type Ctchmnt_condition Ctchmnt_area Flow_Rate cl_Demand Hardness Turbidity	Point	Excel file	

See Annex-3 for Forms with (*).

Category	Layer No	Layer Name	Attributes	Figure type	Reference information	Feedback tools
	501	Customer's Information	Cstmr_ID(*Link Key), Cstmr_name House_ID Account_Ty Consumption1 Consumption2 Consumption3 Consumption4 Consumption5 Consumption6 Consumption7 Consumption8 Consumption9 Consumption10 Consumption11 Consumption12 Boundary_of_plot_(land) Status	-	-	1- Field survey map PDF format 2- Consumption analysis PDF, JPG, Tiff and Spreadsheet
	502	Issue and Complaint	Distribution System name Reading Adjustments Complain of no water but bill high Outstanding bills left by previous occupant Faults No water Sewerage block Illegal users Leakage Burst pipe Faulty meter Meter replacement Diversion Follow up on Reconnection	Polygon	Excel file	Distribution map of complain PDF format

Annex-3

Construction Information Sheet

Solomon Water GIS INFORMATION SHEET

Form-1

No,		Address :			
Date of survey			Date of Receipt :		
Surveyed by			Received by		
Distribution system:			Management No,		

Information of attribution

0101. Water distribution Pipe					
P_ID		Networks		Systems	
P_Type		P_Size		P_Length	
P_Depth		Pipe_Use		dt_Install	
dt_Maintained		dt_Replace		dt_Repair	
dt_Leakage		Pipe_Notes			

0102. Sluice Valve					
V_ID		Networks		Systems	
V_type		V_size		V_Depth	
T_Direction		V_status		dt_Install	
dt_Maintainance		Vnotes			

0103. Hydrant					
FH_ID		Networks		Systems	
FH_type		FHsize		dt_Install	
dt_Maintenance		Fhnotes			

0104. Air Vale					
AV_ID		Networks		Systems	
AV_type		dt_Install		dt_Maintenance	
Fhnotes					

0105. Water pipe bridge					
WPB_ID		WPB_Length		P_type	
dt_Maintenance		Brg_Name		Brg_type	

Breakdown of construction	Construction Type	Survey / Repair / Pipe laying			Depth (cm)
		Installation / Replacement / Abandonment			
	Valve Box	Existence / Naught	Type		

Please specify Sketch

Comments:

Annex-4

Water Quality Information Sheet

Solomon Water GIS INFORMATION SHEET

Form-5

No,		Address :			
Date of survey			Date of Receipt :		
Surveyed by			Received by		
Distribution system			Management No,		

Information of attribution

0405. Water Quality

Water Quality Parameter	WHO Drinking Water Guidelines	Impact type	Value1	Value2
Chlorine Residue	≥0.5mg/L	Taste		
Chloride	5.0mg/L	Taste		
E.coli	0 MPN	Health		
Total Coliform	<10MPN	Health		
pH	6.5–8.5	Corrosion of pipes		
Turbidity	<5NTU	Aesthetic		
Dissolved Oxygen	5.0mg/L	Taste		
Conductivity	0.05S/m = 500uS/c	Taste		
TDS	500mg/L	Aesthetic		
Hardness	<120mg/L	Scales in pipes		
True and Apparent Colour	15 Colour units	Aesthetic		
Chloride Dioxide	250mg/L	Health		
Trihalomethane	<0.08mg/L	Health		
Nitrate (As NO3)	50mg/L	Health		
Nitrite (as NO2)	3.0mg/L	Health		
Ammonia, Nitrogen	NA	Health		
Sulphate	250mg/L	Health		
Arsenic	0.01mg/L	Health		
Cadmium	0.003mg/L	Health		
Chromium	0.05mg/L	Health		
Lead	0.01mg/L	Health		
Iron	0.3mg/L	Health		
Manganese	0.4mg/L	Health		
Selenium	0.01mg/L	Health		
Copper	2.0mg/L	Health		
Nickel	0.07mg/L	Health		
Zinc	5.0mg/L	Health		

Please specify Sketch

Comments:

Annex-5

Customer Information Sheet

User Alpha-01	Account No	Surname	Consumer Analysis Code	Meter ID-01	Status	Units History-12	X	Y
1000	11001001	CLEMENT HADOSAEA	1	15A000051	D	30	601839.5661	8957217.235
01001-1	11001008	GOLDEN KILOKO	1	13A000955		25	601913.7127	8957331.182
01001-2	11001009	KENDRICK SANGA	1	12B011073		60	601940.957	8957370.804
1002	11001010	KENDRICK SANGA	1	D/LINE		26		
01002-1	11001011	MOSES TEPAI	1	D/LINE		33		
01002-3	11001012	RINO TEKEHU	1	13A000954	D	15	601911.0988	8957244.49
1003	11001013	ELMA LAUNGI	1	12B011274		10	601979.4898	8957417.395
01003-1	11001014	JOHN MENONI	1	12A005154		29	601990.7537	8957442.899
1004	11001015	JOSEPH DELI	1	12B011273	D	30	601985.5918	8957469.464
1005	11001016	HARO	1	12B011275		83	601974.6743	8957494.899
1006	11001017	MOSES KARUI	1	12B011085		31	601968.7125	8957498.078
01006-1	11001018	GRACE MOSES	1	13A000922	D	34	601986.4658	8957511.386
01006-2	11001019	EDDIE NGIMAIKA	1	13A000921		14	602013.5534	8957479.172
01006-3	11001020	SHELLY KORIA	1	14A644516		14	602026.0788	8957493.019
01006-4	11001021	ELAINE TEKOPO	1	13A000714		8	601971.0708	8957539.76
01007-06	11001022	STANLEY PONGI	1	13B019793		4	602188.0685	8957760.705
01007-07	11001023	MOANA SEHUITAI	1	D/LINE		0		
01007-3	11001024	ALLISON AUAHI	1	12B086759		1	602175.3286	8957554.737
01007-5	11001025	SUSIE TAISIA	1	D/LINE		33		
01007-7	11001026	ELIZABETH RAMONI	1	12B004817		4	601574.6189	8957866.533
01007-8	11001027	MORIS MAITAKI	1	D/LINE		64	602031.4881	8957787.979
1008	11001028	ROBERT UMA	1	13A000923	D	115	601954.5544	8957519.004
01008-02	11001029	KOREAN ENTERPRISES	1	10A005152		198	601508.6026	8958030.01
01008-2	11001030	LEONARD KAITU'U	1	05A010930		24	601512.2885	8957904.246
01008-3	11001031	ELLISON PADE	1	12B086609		4	601531.8312	8957889.229
1009	11001032	DALES PULE	1	12B086607	D	32	601951.5199	8957540.83
01009-1	11001033	HELLEN T PALMER	1	12B011190		2	601930.3034	8957544.839
1010	11001035	PETTESON OLOFIA	1	12B011186		35	601927.2936	8957559.156
1011	11001036	BEN MEIANGAO	1	12B011188		6	601926.6917	8957559.166
1012	11001037	NAKISI	1	12B011189		87	601925.4713	8957564.495
01012-1	11001038	EDNA & STEVEN BOBBY	1	12B011187		6	601926.6917	8957559.586
01012-2	11001039	GEORGE AMASIA	1	S13B00400		27		
1013	11001040	TEXLEY FULABURI	1	13A000798		11	601908.8312	8957590.729
01013-1	11001041	ALICK KAKASI	1	14A645226		63	601843.3509	8957531.561
1015	11001042	VICKY P VEVOA	1	12B011083		71	601884.9925	8957617.524
1017	11001043	PATRICK.TOM. OROTALOA	1	12B011082		14	601900.6925	8957634.87
01017-1	11001044	PATRICK HAEFAFIA	1	12B011084		14	601899.835	8957626.662
1018	11001045	WILLIAM IRO	1	13A000842		39	601874.413	8957650.697
01018-1	11001046	ANDREW KALIMA	1	13A000841	D	15	601874.1904	8957648.428
01018-2	11001047	DR GEORGE MANIMU	1	13A000843	D	33	601874.0585	8957647.898
1019	11001048	ISAAC LEKELALU	1	13A000698		12	601868.7564	8957668.394
1020	11001049	BENJAMIN OKIA	1	13A000700		23	601860.9476	8957663.934
1021	11001050	REX U'UPWE	1	12B011081	D	28	601838.1973	8957667.524
1022	11001051	VICTOR ANILAFA	1	S13A00236		44		
01022-1	11001052	DICK AMASIA	1	13A000785		12	601883.0135	8957627.552
01022-1.1	11001053	VICTOR SURANIU	1	14B056194		0	601853.5263	8957636.88
01022-2	11001054	DICK AMASIA	1	12B011033		23	601883.9452	8957627.262
01022-3	11001055	DICK AMASIA	1	14A645325		67	601884.3245	8957628.392
1023	11001056	EXPRESS POGARA - C/O C	1	13A000796		40	601850.4836	8957642.279
1024	11001057	JANE BOSO	1	13A000925		47	601835.5091	8957651.547
1025	11001058	NELSON AMASIA	1	13A000830		72	601813.1134	8957663.705
01025-1	11001059	ISAAC TOSIKA	1	13A000924		84	601806.2941	8957665.664
1027	11001060	STELLA BENDLEY	1	13A000713		26	601774.6548	8957675.312
01027-1	11001061	ALEX MCDONALD	1	13A000711		87	601774.3662	8957680.091
1028	11001062	TOMMY ALUTA	1	13A000712		29	601774.5146	8957681.291
1029	11001063	TAPUALIKI SAMASONI	1	13A000902		26	601752.4488	8957695.478

Annex-6

Issue and Complaint Sheet

Solomon Water Customer Enquiry and Complaint Form

P.O.Box 1407, Honiara, Solomon Islands | Fax: 20723 | Phone: 23984/23985 | Email: service@solomonwater.com.sb
Provincial Offices | Auki: 40287 | Tulagi: 32029 | Noro: 61044

Part 1: Customer Details (To Be Filled By The Customer Care Staff)

Customer Name:		Contact Details: .....
Location:		.....
Account No:		.....
Cycle:		.....

Part 1.1: Nature of enquiries and complaints

Type of enquiries (Please tick the appropriate box)

- ☐ New Application Process
- ☐ Illegal Taping
- ☐ Services Offered
- ☐ House Deposit
- ☐ Change of Address
- ☐ Off - Set Payments
- ☐ Disconnection Prior to receiving bill
- ☐ Final Accounts
- ☐ Refund of payments
- ☐ Meter Replacement

Other relevant details .....

.....

Type of complaints (Please tick the appropriate box)

- ☐ No Water, Low Pressure, Service Line
- ☐ Fixed Charge Faulty Meter, Meter Stop
- ☐ Error Reading
- ☐ Billing, disconnection with V&D Status
- ☐ Inconsistent disconnection service
- ☐ Bill left by previous tenant
- ☐ Feedback follow up
- ☐ Illegal Connection
- ☐ No proper connection done
- ☐ Payment Plan

Other relevant details .....

.....

Customer Care Staff		Sign		Date	

Part 2: Feedback from relevant units (To be filled by the network and Operations, Meter Reading and Accounts Team

Part 2: 1 Operations and Maintenance Team (Refer to Tee Card System report attached ☐

Part 2: 2 Meter Reading enquiries and complaints (To be filled by the Meter Reading team)

Recheck Reading		Date		Meter Reader	
Verified by Team Leader		Date			

Part 2: 3 Verification by the Customer Care Team if neccessary

Correct Readings		Correct Readings but never read by assigned Meter Reader		Error Reading	
Customer Care Staff		Sign		Date	

Part 2: 4 Debt Recovery Input: Refer to adjustments / Transfer / Off-Set Forms

Adjustment Input		Transfer Input		Off-Set Input	

Part 3: Feedback to customers (To be filled by Customer Care Staff delivering outcome of investigation

Customer Care Staff		Sign		Date	

Comment if enquiries continues .....

.....

Part 3.1: Duration taken for resolving customer issue

No of Days		No of Weeks		No of Months	

Part 3.2: Scanning and Filing

Scanned & Filed by		Sign		Date	

S5.5-4 O&M MANUAL OF DATABASE

Japan International Cooperation Agency

Solomon Islands Water Authority

The Project
for
Improvement of Non-Revenue Water Reduction Capacity
for
Solomon Islands Water Authority
in Solomon Islands

Solomon Water GIS Database Operation & Maintenance Manual

June 2016

JICA Expert Team & Counterpart Team

Table of Contents

1. Introduction *1*

1.1 Outline of the Manual 1

1.2 GIS Database Structure 1

1.3 GIS Database Specifications 1

2. GPS Measurement *2*

2.1 Workflow for Observation of GPS signals 2

2.2 GPS measurement in the field 5

2.3 Convert and Import the GPS log files to desktop PC 7

2.4 Preparation 10

3. Location map for observation *12*

3.1 Field Work 12

3.1.1 How to set up equipment 12

3.1.2 How to measure GPS 12

3.1.3 How to use and describe field note 12

3.1.4 How to check the acquired data 14

3.2 Data Arrangement 15

3.2.1 How to input the observed data into Excel 15

3.2.2 How to back up the data 15

4. GIS Data Creation *16*

4.1 Workflow 16

4.2 Import GPS Data 17

4.3 Create GIS Data 17

4.4 Edit Attribute Data 17

4.4.1 Adding new field to existing table 17

4.5 Extracting Consumption Data from NCS 20

5. Troubleshooting *21*

5.1 GPS Device 21

5.1.1 Technical Support 21

5.1.2 Contact a Trimble Dealer 21

5.1.3 Known solution 22

5.1.4 Official User's Guide 22

5.2 GIS Database 23

5.2.1 The Tab files don't open. 23

5.2.2 New data are shown at a separate location from existing data. 23

5.2.3 Please append new knowledge to following, if needed. 23

Appendix 24

Appendix-1 Specifications of GIS Database

Appendix-2 Field note (Information form)

1. Introduction

1.1 Outline of the Manual

This manual covers the method of the water supply facility database maintenance and collecting GPS location data (hereinafter referred to as the field survey).

The user can understand a necessary procedure to the GPS data collection and the GIS data editing by reading this manual.

1.2 GIS Database Structure

The water supply facility database consists of total 18 kinds of layer. The water supply facility information of SW is classified as follows:

- Distribution facility information: 11 Layers

Water distribution Pipes / Sluice valve (gate valve) / Hydrant /
Air valve / Water pipe bridge / Sewer manhole / Sewer pipes /
Leakage location / Flow meters / Feeder pipes / Water meters

- Water source information: 1 Layer

Bore holes

- Pump station information: 1 Layer

Pump station

- Service reservoir information: 2 Layers

Service reservoir / Distribution area of source

- Customer's information: 2 Layers

Customer information and Billing information / Issue and Complaint

- Other information: 1 Layer

Water quality

The target water supply facilities of the project are all water supply facilities in Honiara city.
Each layer includes spatial information (the location) and text information (the attribute).

1.3 GIS Database Specifications

The JICA expert team and the GIS sub-team discussed and formulated a GIS database specification. The following item is defined by a GIS database specification.

- Layer Name ie) Water distribution Pipes, Sluice valve, Hydrant, Air valve, etc…
- Field Name ie) Pnumber, Systems, Ptype, Psize, Plength, Depth, etc…
- Field Type ie) Character, Integer, Double
- Field Length ie)30, 20, 5, (5,3), etc…
- Descriptions ie) Valve ID, Distribution System, Valve material, Valve diameters, Depth, etc…
- Feature type ie)Point, Polyline, Polygon

And so on…

Please refer to Appendix-1 for details.

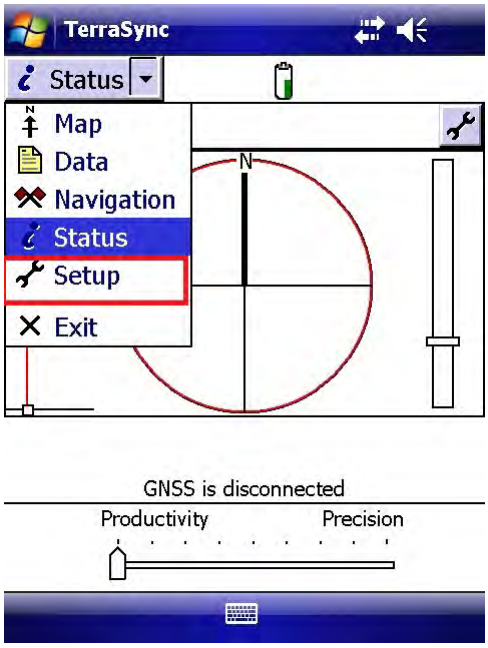
2. GPS Measurement

2.1 Workflow for Observation of GPS signals

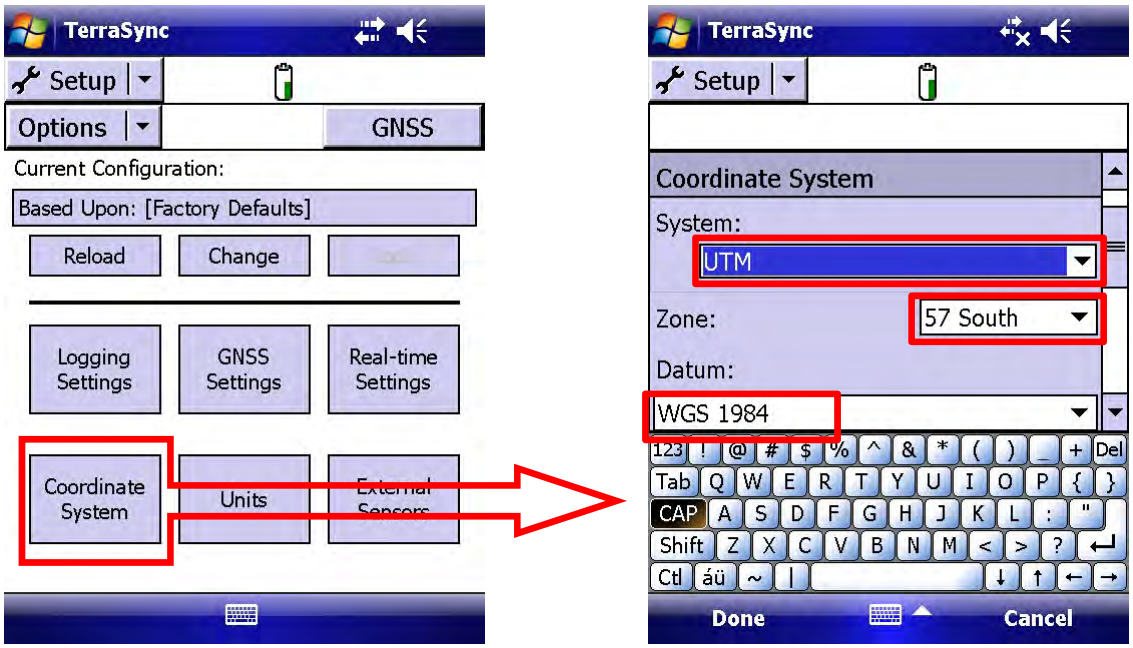
2.1.1 Turn on the GPS device before observation start at least 20 minutes.

2.1.2 Start TerraSync

2.1.3 Select "Setup" from pulldown menu beside Status



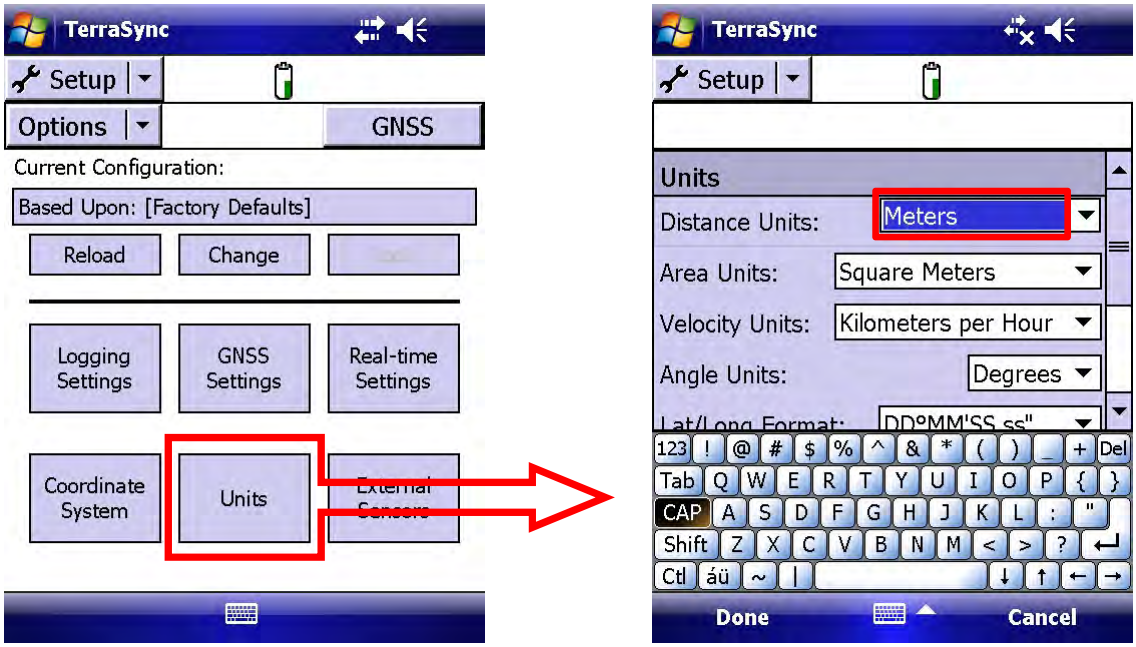
2.1.4 Make sure the “Coordinate System” is correct and the “Units” are according.



System: UTM

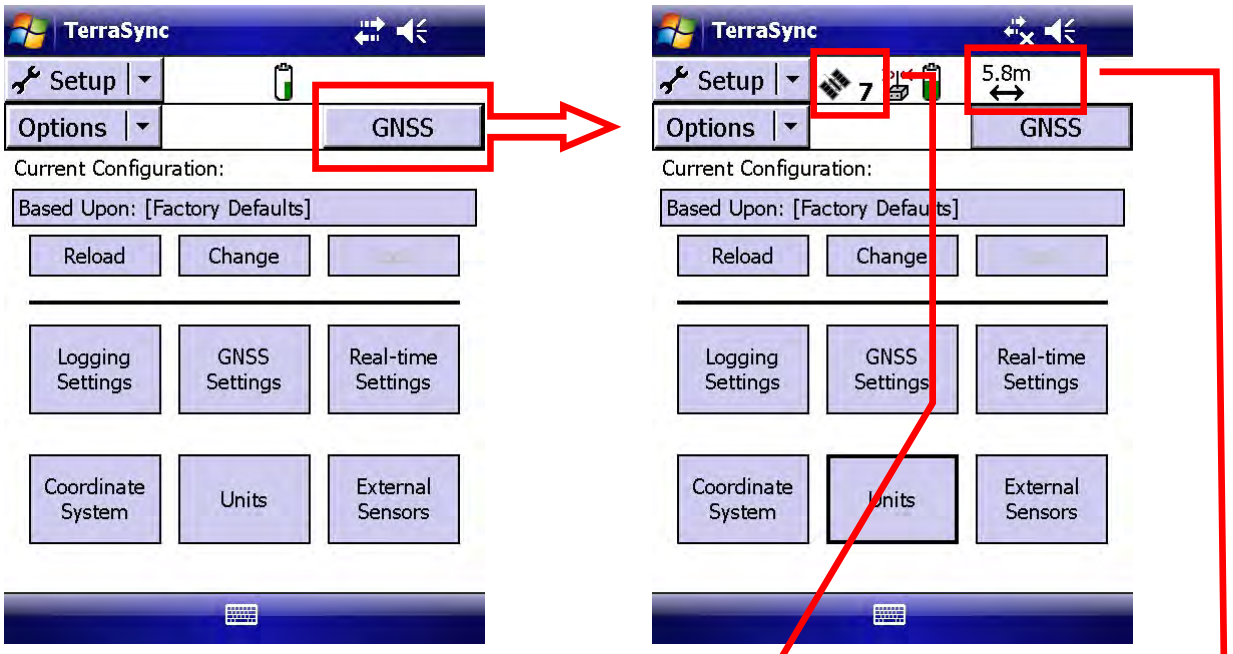
Zone: 57 South

Datum: WGS 1984



Distance Units: Meters

2.1.5 Tap “GNSS” to connect



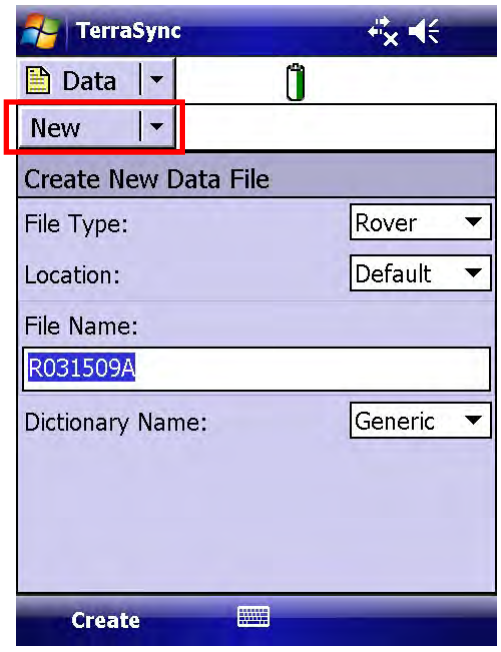
Observe the number next to the *Satellite icon* which indicates how many satellites are being used to compute the GNSS positions. (At least four satellites are needed to compute GNSS positions)

Estimated Accuracy icon shows the estimated accuracy of the current GNSS position.

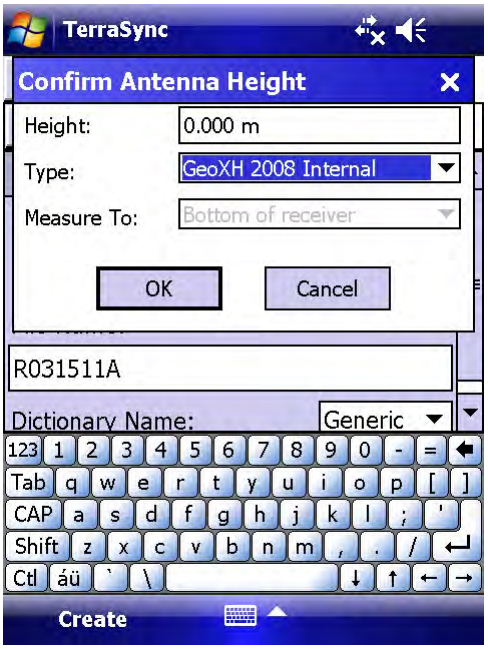
2.2 GPS measurement in the field

2.2.1 Start “Terrasync” application from START menu.

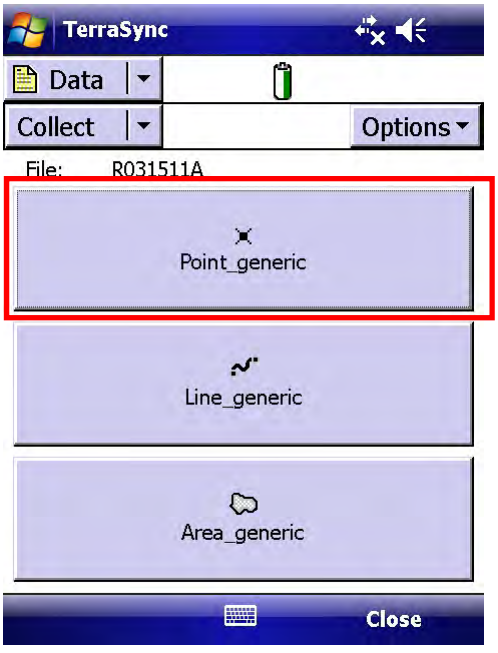
2.2.2 Create New file.



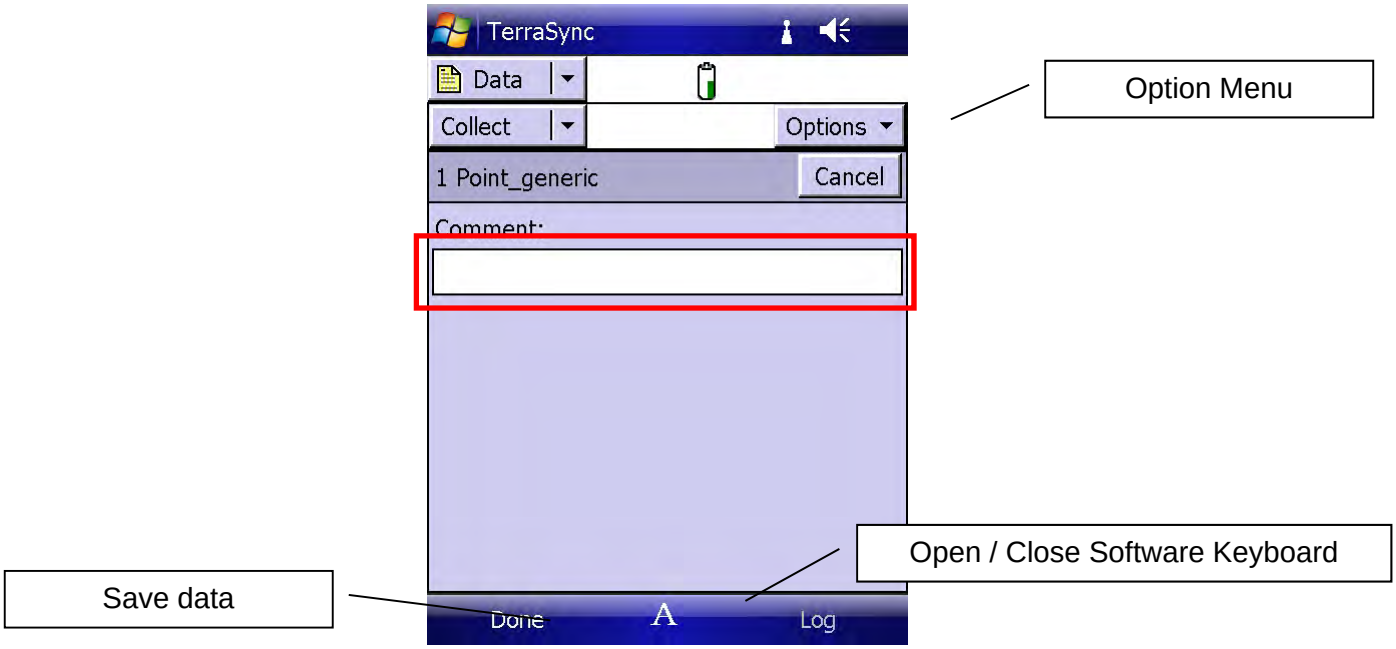
2.2.3 Confirm Antenna Height.



2.2.4 Tap “Point_generic”.



2.2.5 Input a comment using software keyboard.

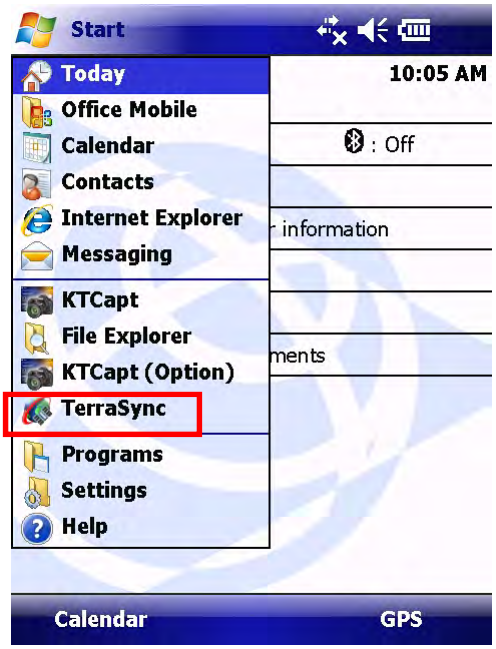


2.2.6 Click Done after 2 or 3 minute of recording to save data.

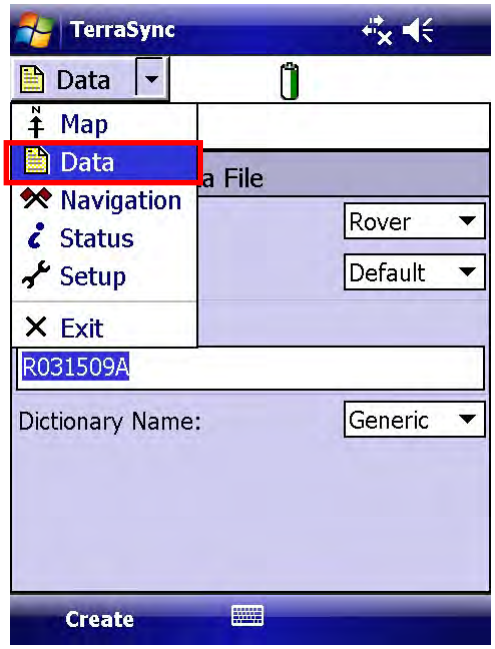
2.3 Convert and Import the GPS log files to desktop PC

Data arrangement after measuring.

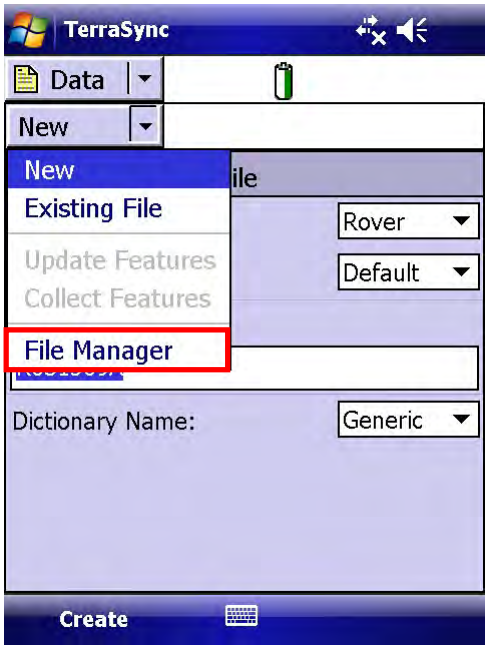
2.3.1 Start “Terrasync” application from START menu.



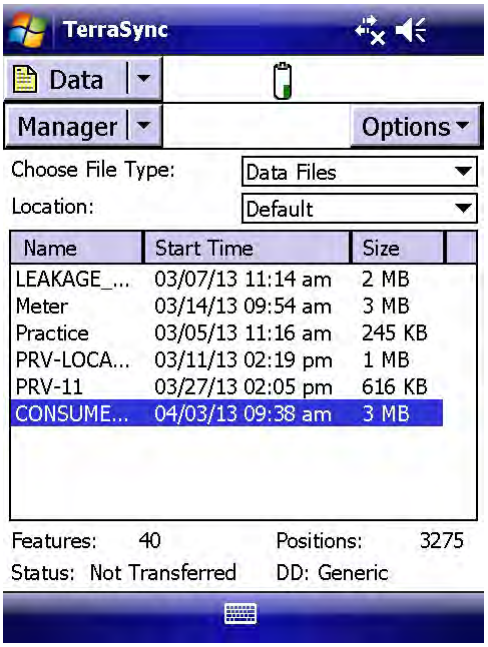
2.3.2 Select “Data” mode from pulldown menu



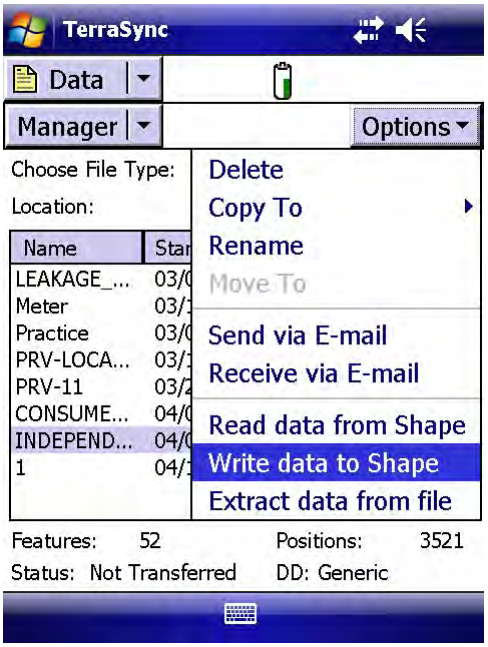
2.3.3 Select “File Manager” from pull-down menu.



2.3.4 Select the Data concerned.

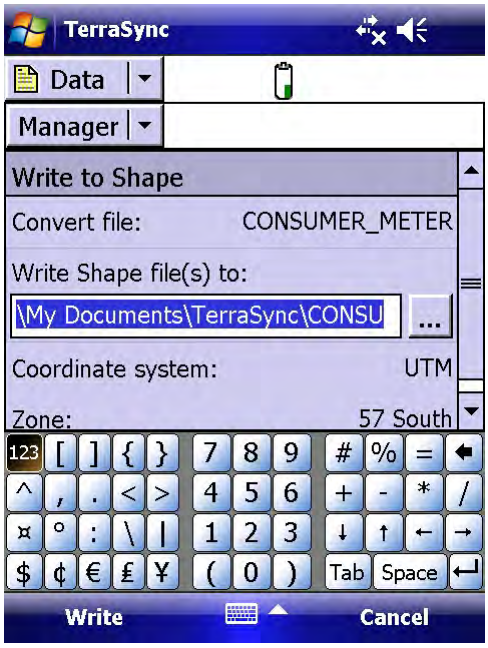


2.3.5 Select “Write to Shape file” from Option menu.



2.3.6 Write data to Shape

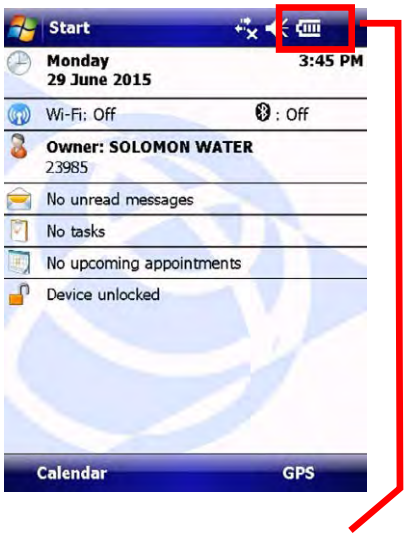
Specify folder location for the written shape file within the Windows Mobile file directory to avoid over writing existing logged data.



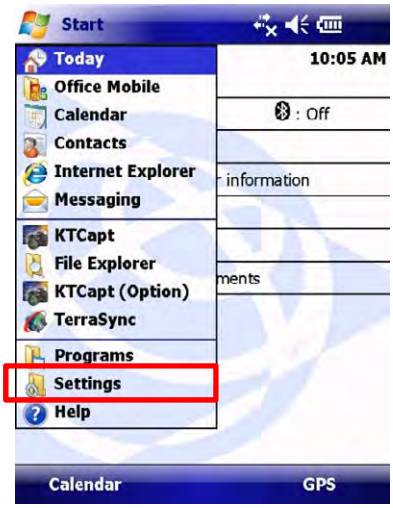
2.4 Preparation

2.4.1 Preparation for GPS measurement.

Operation checks for GPS (battery condition and remaining storage capacity)

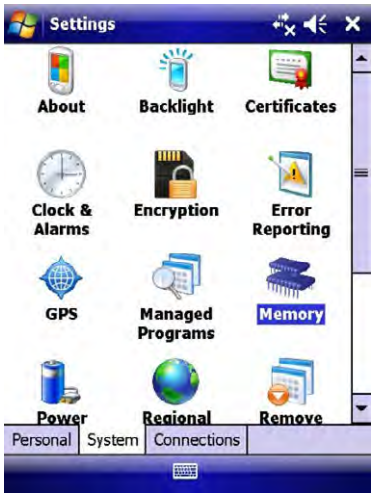


Battery condition can be checked and monitored as shown at the top right side of the screen.



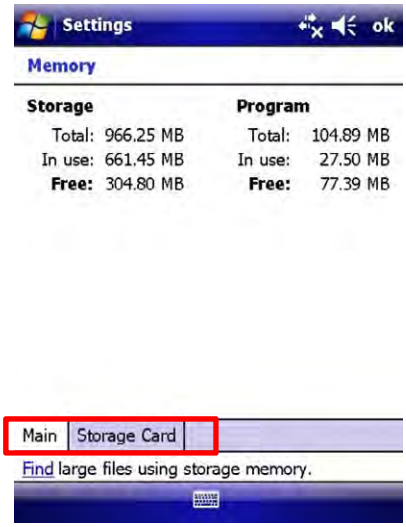
1

To check the status of the storage capacity go to *Start* and select *Settings.*



2

On the settings page that opens select the *System* tab below.



3

The memory page appears that shows Total Storage capacity, howmuch in use and howmuch is free. The same can be checked for any external storage card by tapping on the *Storage Card* tab below.

2.4.2 Field Note

TerraSync has a default form for recording 3 types of data in the field. The 3 types of data are *Point, Line* and *Area.* However a Dictionary is created using *GPS Pathfinder Office* that can cater for most features in Solomon Water so data can be recorded specifically to the kind of feature it is. The Data Dictionary can be specified upon creating a new data. Otherwise all other data created afterwards will be defaulted to the last selected data dictionary.

It's possible to check an input mistake of data by recording it by a handwritten analog data in addition to the digital data. The Project recommends that you put the surrounding sketch in handwriting data. Please refer to Appendix-2 for details.

3. Location map for observation

3.1 Field Work

The work procedures for GPS measurement at the field.

3.1.1 How to set up equipment

GPS Handheld device must be switched on and GNSS must be connected at least 20minutes before survey.

Refer to diagram 2.1.5

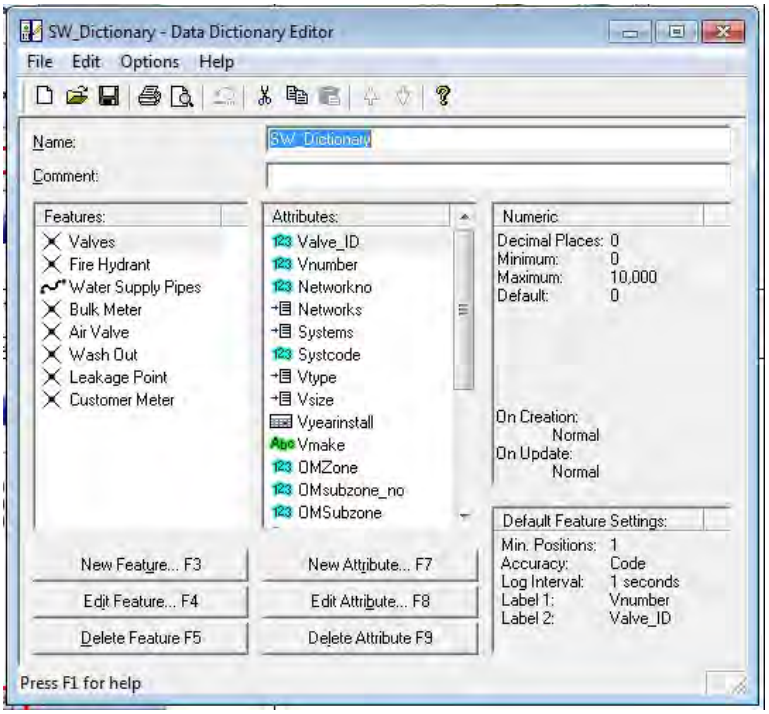
3.1.2 How to measure GPS

Measuring of GPS is done prior to actual survey. Measuring involves observation of connectivity of GNSS, sattelites signals available, accuracy of measurement available etc.

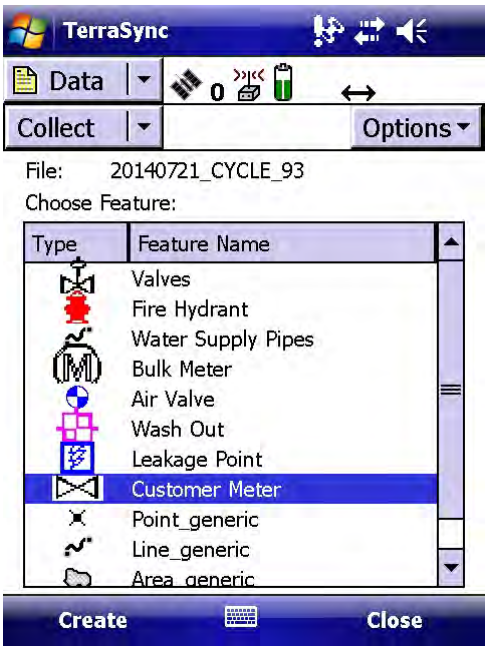
Refer to diagram 2.1.5 for steps.

3.1.3 How to use and describe field note

A data dictionary specific to Solomon Water features was created intitially using ***GPS Pathfinder Office*** and uploaded onto the handheld device. Instead of the default Point, Line and Area features these features will be used to record specific features accordingly with related attributes available.



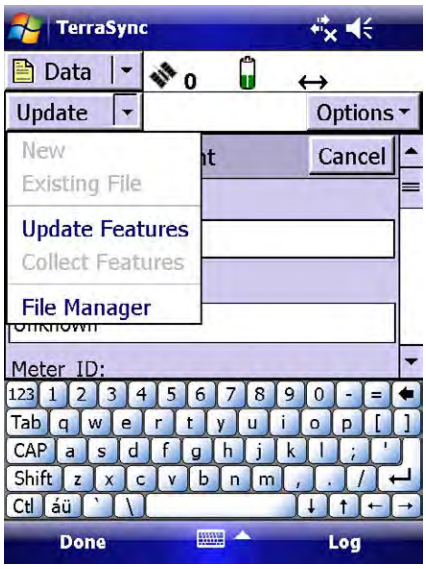
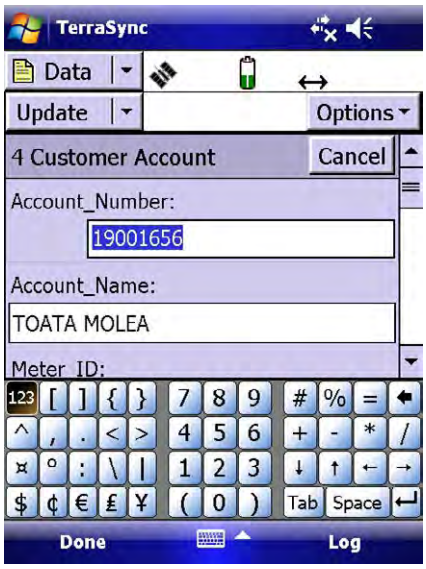
Data Dictionary as prepared using GPS Pathfinder Office.



List of Features available to record Solomon Water features.

3.1.4 How to check the acquired data

Acquired data can be checked, updated or edited on the handheld device by selecting *Update* option on the *Data* menu.

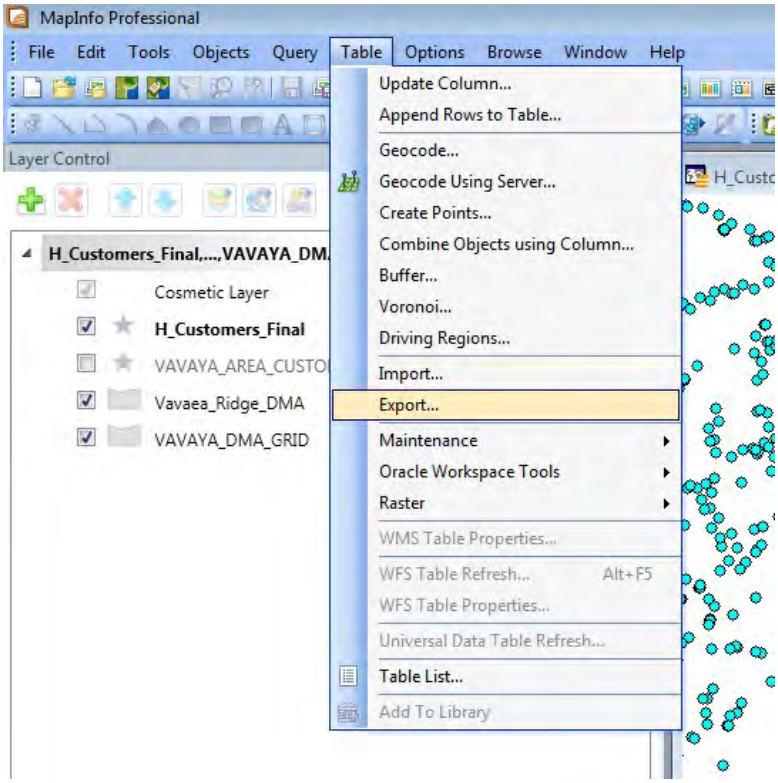
	
Tap on *Update Features* to make changes to data.	Inaccurate or missed data can be updated and completed by tapping on *Done*.

3.2 Data Arrangement

The work procedures for data arrangement after completing field work.

3.2.1 How to input the observed data into Excel

After completion of section 4.1 the observed data can be exported to excel by using the ***Export…*** function under the ***Table*** menu in the Toolbar.



In the ***Export Table:*** dialogue box that appears select the desired table amongst the list of opened layers (If there is more than one opened layer) and then click the ***Export*** button on the right. ***The Export Table to File*** that appears next allows you to specify the preferred directory and the file type for the table to be saved in, in this case .csv or .txt.

3.2.2 How to back up the data

The IT department runs a scheduled backup of the entire GIS network drive 10pm daily. Otherwise a shadow backup is performed on all files and folder on a 10 minute interval which goes back as far as 48 hours.

4. GIS Data Creation

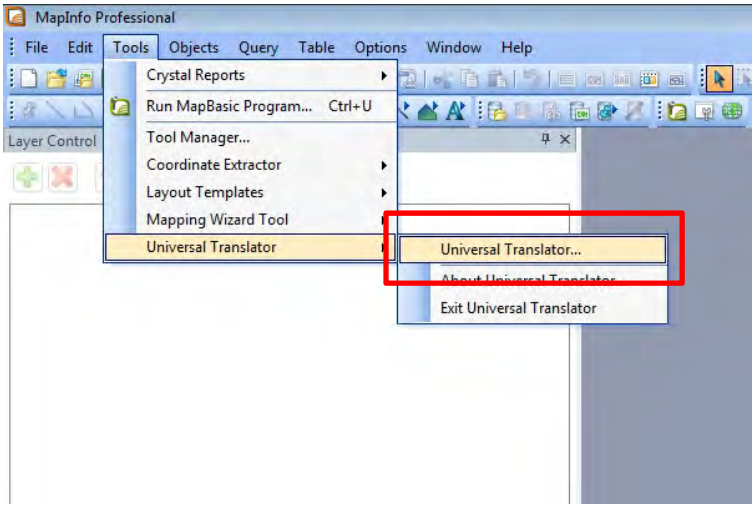
4.1 Workflow

The basic workflow for GIS data creation using the data measured at the field shall be defined here. For instance,

4.1.1 Import GPS data into GIS

GPS Handheld device is connected to the PC using the ***Windows Mobile Device Center*** application software with USB port.

4.1.2. Format conversion

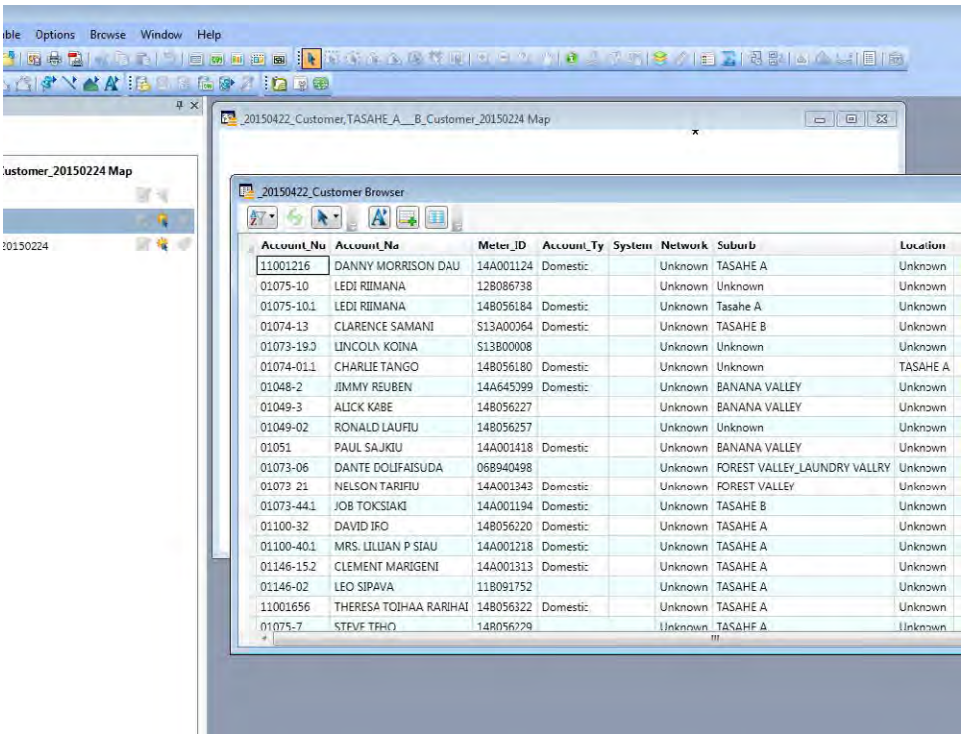


Files downloaded from handheld device are in shapefiles (.SHP).

MapInfo uses mapinfo table format (.TAB) to convert shapefiles to tab file we use Universal Translator.

4.1.3 GIS data creation (Point, Line or Polygon)

4.1.4 Edit attribute data



Account_Nu	Account_Na	Meter_ID	Account_Ty	System	Network	Suburb	Location
11001216	DANNY MORRISON DAU	14A001124	Domestic		Unknown	TASAHE A	Unknown
01075-10	LEDI RIIMANA	128086738			Unknown	Unknown	Unknown
01075-10.1	LEDI RIIMANA	148056184	Domestic		Unknown	Tasahe A	Unknown
01074-13	CLARENCE SAMANI	S13A00064	Domestic		Unknown	TASAHE B	Unknown
01073-19.0	LINCOLN KOINA	S13B00008			Unknown	Unknown	Unknown
01074-01.1	CHARLIE TANGO	148056180	Domestic		Unknown	Unknown	TASAHE A
01048-2	JIMMY REUBEN	14A645099	Domestic		Unknown	BANANA VALLEY	Unknown
01049-3	ALICK KABE	148056227			Unknown	BANANA VALLEY	Unknown
01049-02	RONALD LAUFIU	148056257			Unknown	Unknown	Unknown
01051	PAUL SAJKIU	14A001418	Domestic		Unknown	BANANA VALLEY	Unknown
01073-06	DANTE DOLIFAISUDA	068940498			Unknown	FOREST VALLEY_LAUNDRY VALLRY	Unknown
01073_21	NELSON TARIFIU	14A001343	Domestic		Unknown	FOREST VALLEY	Unknown
01073-44.1	JOB TOKSIAKI	14A001194	Domestic		Unknown	TASAHE B	Unknown
01100-32	DAVID IFO	148056220	Domestic		Unknown	TASAHE A	Unknown
01100-40.1	MRS. LILLIAN P SIAU	14A001218	Domestic		Unknown	TASAHE A	Unknown
01146-15.2	CLEMENT MARIGENI	14A001313	Domestic		Unknown	TASAHE A	Unknown
01146-02	LEO SIPAVA	118091752			Unknown	TASAHE A	Unknown
11001656	THERESA TOIHAA RARIHAI	148056322	Domestic		Unknown	TASAHE A	Unknown
01075-7	STEVE TEHO	148056229			Unknown	TASAHE A	Unknown

The attribute can be edited after opening up data in MapInfo by right clicking on the layer in the layer control and select '*Browse Table*' or "F2" key on the keyboard.

4.2 Import GPS Data

[Refer to section 4.1]

4.3 Create GIS Data

The work procedures for GIS data creation, such as point, line, or area shall be shown here. Also, the points to remember are covered adequately, for instance coordinate systems etc.

[Refer to section 2.2.4]

4.4 Edit Attribute Data

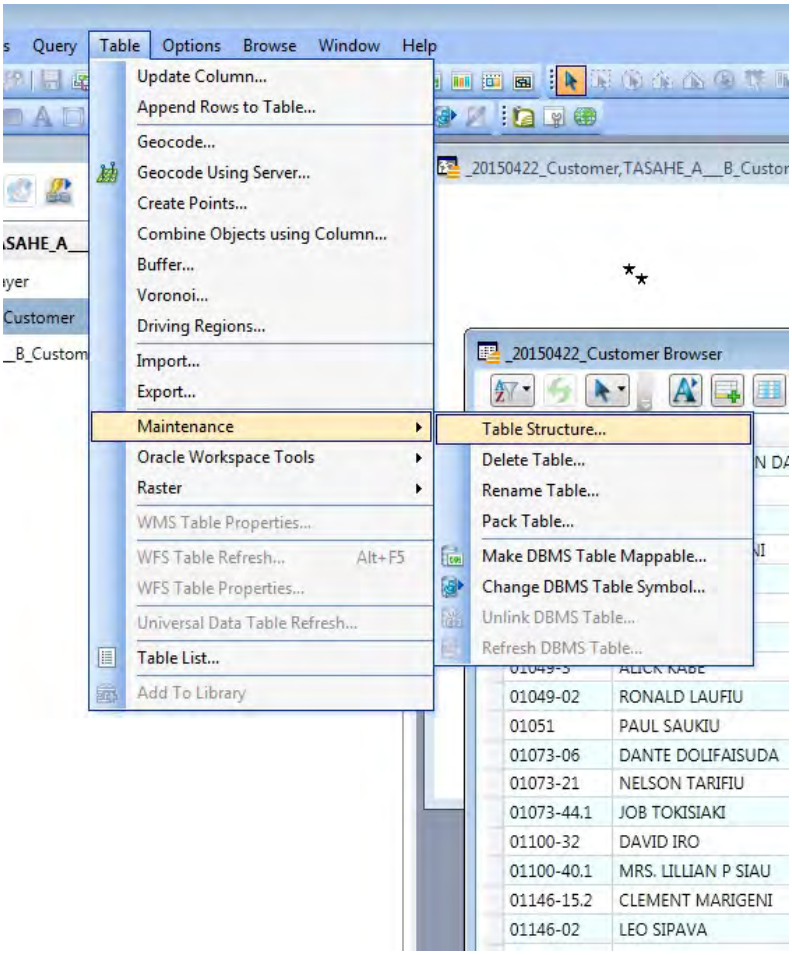
The work procedures for editing attribute tables shall be explained here. And at least following contents are contained.

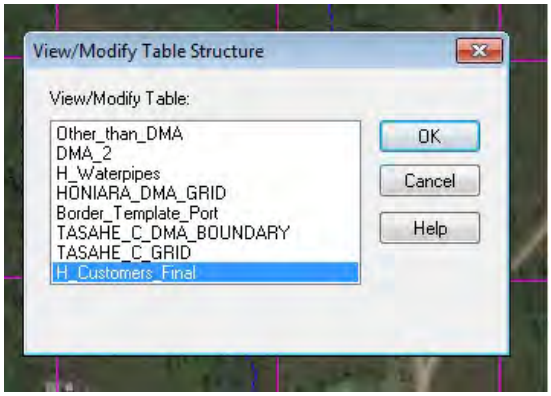
✓ How to add a new field

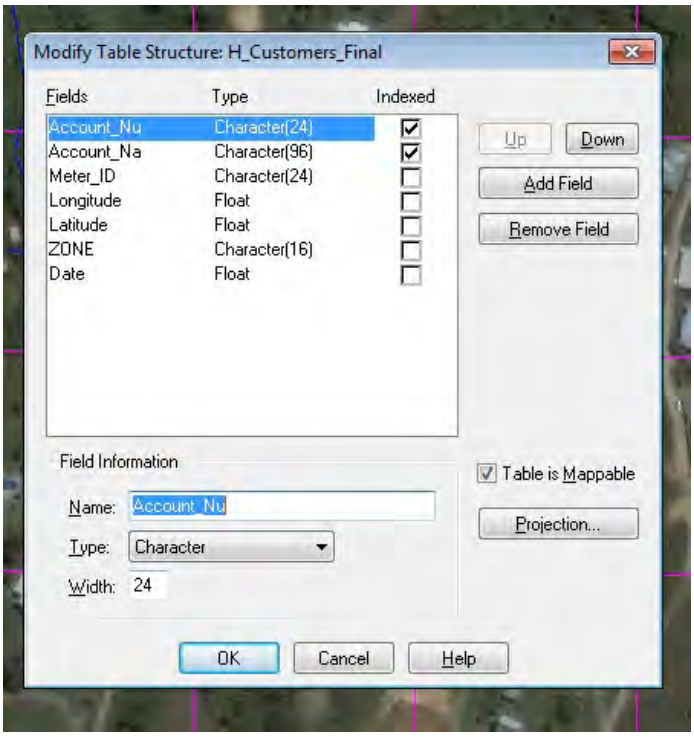
4.4.1 Adding new field to existing table

To add a new field to existing table go to ***Table*** menu select ***Maintenance*** and click ***Table Structure…***

On the dialogue box that pops up there should be a list of tables that is currently open. Double click on the preferred table or select and click ok to open the dialogue box to modify the table structure.


Query
Table
Options
Browse
Window
Help
Update Column...
Append Rows to Table...
Geocode...
Geocode Using Server...
Create Points...
Combine Objects using Column...
Buffer...
Voronoi...
Driving Regions...
Import...
Export...
Maintenance
Oracle Workspace Tools
Raster
WMS Table Properties...
WFS Table Refresh... Alt+F5
WFS Table Properties...
Universal Data Table Refresh...
Table List...
Add To Library
Table Structure...
Delete Table...
Rename Table...
Pack Table...
Make DBMS Table Mappable...
Change DBMS Table Symbol...
Unlink DBMS Table...
Refresh DBMS Table...
_20150422_Customer Browser
01049-02 RONALD LAUFIU
01051 PAUL SAUKIU
01073-06 DANTE DOLIFAISUDA
01073-21 NELSON TARIFIU
01073-44.1 JOB TOKISIAKI
01100-32 DAVID IRO
01100-40.1 MRS. LILLIAN P SIAU
01146-15.2 CLEMENT MARIGENI
01146-02 LEO SIPAVA

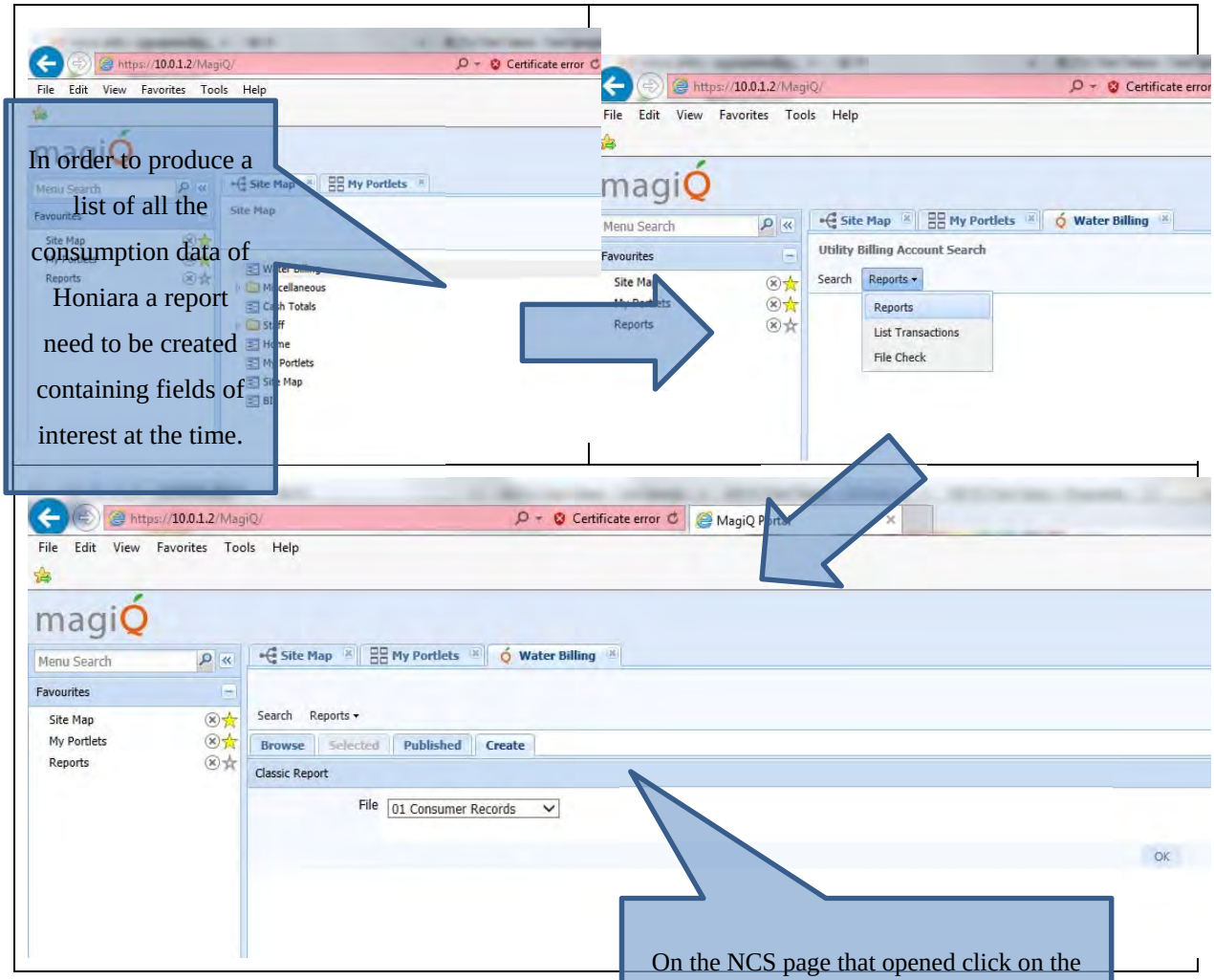

View/Modify Table Structure
View/Modify Table:
Other_than_DMA
DMA_2
H_Waterpipes
HONIARA_DMA_GRID
Border_Template_Port
TASAHE_C_DMA_BOUNDARY
TASAHE_C_GRID
H_Customers_Final
OK
Cancel
Help


Modify Table Structure: H_Customers_Final
Fields
Type
Indexed
Account_Nu
Character(24)
Account_Na
Character(96)
Meter_ID
Character(24)
Longitude
Float
Latitude
Float
ZONE
Character(16)
Date
Float
Up
Down
Add Field
Remove Field
Field Information
Name:
Account_Nu
Type:
Character
Width:
24
Table is Mappable
Projection...
OK
Cancel
Help

4.5 Extracting Consumption Data from NCS

There will be a regular request for consumption data for customers with interests of particular areas. The following will describe method of extracting the data.

Solomon Water's NCS billing system can be accessed over the browser with the address https://10.0.1.2. And of course login credentials may be obtained from the IT team.



On the NCS page that opened click on the ***Water Billing*** from the menu -> then click on the ***Water Billing*** tab, click on the ***Reports*** drop down menu and then click ***Reports.*** On the ***Classic Report*** page that opens, let the file be ***01 Consumer Records*** and then click ***OK.***

5. Troubleshooting

5.1 GPS Device

Troubleshooting on GPS device shall be covered here.

5.1.1 Technical Support

Go to www.trimble.com where we can find product information and FAQ's (Frequently Asked Questions) for our various products.

http://www.trimble.com/TrimbleProtected/Technical_Support.aspx

5.1.2 Contact a Trimble Dealer

If we can't find the information that we need on the Trimble website, or we require more help, please contact a local Trimble Distribution Partner.

Dealer information-1 (Australia)

Trimble Navigation Australia Pty. Ltd.

Web site: http://dealerlocator.trimble.com/locator.aspx

www.trimble.com

Phone: +61-732160044

FAX: +61-732160088

Email: Sales_Aus@trimble.com

Dealer information-2 (New Zealand)

Geosystems New Zealand Limited

Web site: http://dealerlocator.trimble.com/locator.aspx

www.geosystems.co.nz

Phone: +64-3-963-2858

FAX: +64-3-963-2857

Email: sales@geosystems.co.nz

Dealer information-3 (Japan)

Nikon-Trimble co.,ltd

Web site: http://www.nikon-trimble.co.jp/english/index.html

Phone: +81-3-5710-2598

(Person in charge)

Email: nakazawa hiroyuki <nakazawa.hiroyuki@nikon-trimble.net>

Phone: +81-3-5710-2593

5.1.3 Known solution

(Case-1) If the screen on the handheld is blank, do one of the following:

1. Soft reset

2. Hard reset

Please refer to the official User's documentation for the details.

Page.29,

(Case-2) Expire the license

Reinstall Terra Sync software.

	GPS Device-1	GPS Device-2
Product Name	GeoExplorer 3000 XT	GeoExplorer 3000 XT
Part No	70950-21	70950-21
Serial number	5110447434	5150486355
Software Name	TerraSync Professional	TerraSync Professional
Install Key	613496-00110-14056-9C8BB14F	613497-00110-14059-CDBA731E

5.1.4 Official User's Guide

Please refer to the official User's documentation for the details on the web site.

Trimble GeoExplorer 3000 Series User Guide

http://trl.trimble.com/docushare/dsweb/Get/Document-528617/GeoExpl3000_UserGde_RevB_ENG.pdf

MapInfo Professional® v11.5 USER GUIDE

http://reference.mapinfo.com/software/mapinfo_pro/english/11.5/MapInfoProfessionalUserGuide.pdf

5.2 GIS Database

Please describe that you learned and noticed in GIS work in the past for three years.

It is a lesson learned or a common mistake.

5.2.1 The Tab files don't open.

A MapInfo table consists of at most 5 files.

(1) TableName. TAB ・・・Attribute field definition (Field Name, Field Type etc…)

(2) TableName.DAT ・・・Attribute Information

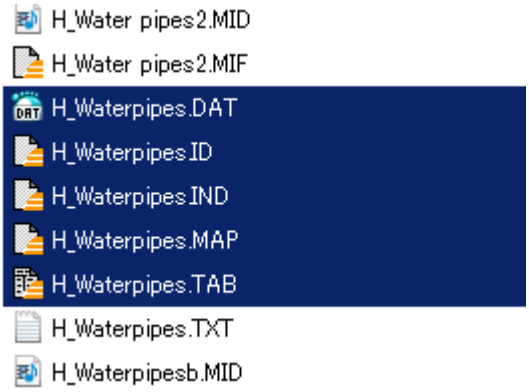
(3) TableName. IND ・・・Index for searches

(4) TableName. MAP ・・・Figure (map) Information

(5) TableName. ID ・・・Relating of attribute information and figure information

You should confirm that these files exist.

You should pay attention at the time of rename, file copy / movement.



5.2.2 New data are shown at a separate location from existing data.

You should confirm the projection definition.

We use "WGS_1984_UTM_Zone_57S" on Honiara.

5.2.3 Please append new knowledge to following, if needed.

Appendix

Appendix-1

Specifications of GIS Database

Classification	Layer No	Layer Name	File Name	Updated_Attributes_(Draft)			Descriptions	Feature type	from Where
				Field_name	Type	Length			(Inforomation Source
Distribution Facility Information	0101	Water distribution Pipes	0101_WaterPipes	P_ID	Character	10	Pipe Number	Polyline	NETWORK
				Networks	Character	30	Supply Source		OPERATION
				Systems	Character	30	Distribution System		
				P_Type	Character	10	Pipe material		
				P_Size	Integer	5	Pipe diameters		
				P_Length	Double	(7,2)	Pipe length		
				P_Depth	Double	(8,2)	Pipe Depth		
				Pipe_Use	Character	15	Whether Transmission or Distribution		
				dt_Install	Date	8	Completion year (Date of Pipe laid)		
				dt_Maintained	Date	8	Date of last maintenance		
				dt_Replace	Date	8	Date of Replacement / Rehabilitation		
				dt_Repair	Date	8	Date of Repairing		
				dt_Leakage	Date	8	Date of Leakage detection		
				Pipe_Notes	Character	51	Comments		
Distribution Facility Information	0102	Sluice valve	0102_Valves	V_ID	Character	10	Valve ID	Point	
		(gate valve)		Networks	Character	30	Supply Source		NETWORK
				Systems	Character	30	Distribution System		OPERATION
				V_type	Character	10	Valve material		
				V_size	Integer	5	Valve diameters		
				V_Depth	Double	(5,3)	Depth		
				T_Direction	Character	20	Direction of turn		
				V_status	Character	30	Valve status (operationg)		
				dt_Install	Date	8	Year of Installation		
				dt_Maintainance	Date	8	Time of last maitenance		
				Vnotes	Character	51	Comments		
Distribution Facility Information	0103	Hydrant	0103_Hydrant	FH_ID	Character	10	Hydrant ID	Point	NETWORK
				Networks	Character	30	Supply Source		OPERATION
				Systems	Character	30	Distribution System		
				FH_type	Character	10	Hydrant type		
				FHsize	Integer	8	Fire Hydrant diameters		
				dt_Install	Date	8	Year of Installation		
				dt_Maintenance	Date	8	Last maintenance Date		
				Fhnotes	Character	51	Comments		
Distribution Facility Information	0104	Air valve	0104_AirValve	AV_ID	Character	10	Air Valve ID	Point	NETWORK
				Networks	Character	30	Supply Source		OPERATION
				Systems	Character	30	Distribution System		
				AV_type	Character	10	Air Valve type		
				dt_Install	Date	8	Year of Insatallation		
				dt_Maintenance	Date	8	Last maintenance Date		
				AVnotes	Character	50	Comments		
Distribution Facility Information	0105	Water pipe bridge	0105_WPBridge	WPB_ID	Character	10	ID	Polyline	NETWORK
				WPB_Length	Double	(7,2)	Length		OPERATION
				P_type	Character	10	Pipe material		
				dt_Maintenance	Date	8	Last maintenance Date		
				Brg_Name	Character	30	Bridge Name		
				Brg_type	Character	10	Bridge material		
Distribution Facility Information	0106	Sewer Manhole	0106_SwrManhole	ID	Character	10	Sequential number	Point	NETWORK
				SSYSNO	Character	10	Distribution System number		OPERATION
				SSYSNA	Character	21	Distribution System name		
				SSYSLO	Character	21	Distribution System location		
				SSYSCD	Character	21	Distribution System code		
				SSYSAC	Character	2	T or F What does this mean? Please describe for details.		
				SSYSLINENO	Character	2			
				SMH_number	Character	12			
				SMH_type	Character	12			
				SMH_IL	Double	12			
				SMH_RL	Double	(8,2)			
				SMH_size	Integer	(8,2)			
				SMH_date	Date	8			

Classification	Layer No	Layer Name	File Name	Updated_Attributes_(Draft)			Descriptions	Feature type	from Where (Inforomation Source
				Field_name	Type	Lengt			
Distribution Facility Information	0107	Sewer_Pipes	0107_SwrPipes	ID	Character	10	Sequential number	Polyline	NETWORK
				SSYSNO	Character	10	Distribution System number		OPERATION
				SSYSNA	Character	21	Distribution System name		
				SSYSLO	Character	21	Distribution System location		
				SSYSCD	Character	2	Distribution System code		
				SSYSAC	Character	2	T or F What does this mean? Please describe for details.		
				SSYSLINENO	Character	12			
				SP_NO	Integer	5			
				SP_LGTH	Double	(8,2)	Sewer Pipe Length		
				SP_SIL	Double	(8,2)			
				SP_EIL	Double	(8,2)			
				SP_ACV	Double	(5,2)			
				SP_SIZE	Integer	5	Sewer Pipe diameters		
				SP_TYPE	Character	7			
				SP_MAKE	Character	11			
				SP_DATE	Date	8			
				SP_SLOPE	Character	7			
				SP_CONNO	Integer	8			
				SP_CONNEC	Character	21			
				SP_LINK	Character	21			
Distribution Facility Information	0201	Leakage position	0201_LeakagePT	LK_ID	Character	10	ID (Leakage Number)	Point	LEAKAGE & NRW
				LK_type	Character	10	Leakage Type		
				Leak_Status	Character	21	Status of Leak (eg. Reported, Repaired or Pending)		
				LK_Position	Character	20	Position (eg. Overground, Underground)		
				LK_Condition	Character	30	Condition (Scale of leakage, estimated size)		
				Asset_type	Character	10	Asset Type (eg. Pipe, Valve)		
				Asset_Size	Integer	5	Asset Size		
				Asset_Material	Character	10	Asset Material (eg. PVC, Cast Iron)		
				dt_survey	Date	8	Date of survey		
Distribution Facility Information	0301	Flow meters	0301_FlowMeters	FM_ID	Character	10	ID	Point	MAINTENANCE
				Networks	Character	30	Supply Source		
				Systems	Character	30	Distribution System		
				BF_Location	Character	30	Location		
				FM_Size	Integer	5	Size(mm)		
				dt_Install	Date	8	Year of Installation		
				dt_Maintenance	Date	8	Last maintenance Date		
				Logging	Character	10	Whether logged or not		
				BFnotes	Character	51	Comments		
Distribution Facility Information	0302	Feeder pipes (service pipes)	0302_FeederPipes (service pipes)	FP_ID	Character	10	PipeID	Polyline	MAINTENANCE
				FP_type	Character	10	Pipe material		
				PF_size	Integer	5	Pipe diameters		
Distribution Facility Information	0303	Water meters	0303_WaterMeters	AccountNo	Character	10	AccountNo (*Link Key)	Point	MAINTENANCE
				Cstmr_Name	Character	30	Customer's Name		
				MTR_ID	Character	10	MeterID		
				MTR_Status	Character	30	Status of Meter (whether working, buried etc)		
				Meter_Make	Character	30	Manufacturer		
				Meter_Size	Integer	5	Size of Meter		
				dt_Install	Date	8	Date meter is installed		
				Lot_Number	Date	8	Lot Number		
				Meter_notes	Character	51	Comments		

Classification	Layer No	Layer Name	File Name	Updated_Attributes_(Draft)			Descriptions	Feature type	from Where (Inforomation Source
				Field_name	Type	Lengt			
Water Source information	0401	Bore holes	0401_BoreHoles	BH_ID	Character	10	Borehole ID	Point	RESOURCE & TREATMENT
				BH_type	Character	30	Borehole Type		
				BH_depth	Integer	5	Well depth(m), Borehole depth		
				Head	Double	(8,2)			
				Head_Max	Double	(8,2)			
				Pump_ID	Character	10	Pump ID		
				Location	Character	30	Location		
				Manufacturerre	Character	30	Manufacturerre		
				Serial_No	Character	10			
				Flow_Rate	Double	(8,2)	Q(Flow_Rate)		
				Static_Wtr_Lv	Double	(8,2)	Static Water Level		
				Dynamic_Wtr_Lv	Double	(8,2)	Dynamic Water Level		
				dt_Install	Date	8	Date of Pump Installed		
				dt_Maintenance	Date	8	Last maintenance Date (Service_History)		
				Age	Integer	5			
				Status	Character	30			
Pump Station information	0402	Pump station	0402_PumpStation	Station_ID	Character	10	Station ID	Point	RESOURCE & TREATMENT
				Station_name	Character	20	Unit name, Station Name		
				Station_type	Character	30			
				Location	Character	30	Location		
				Age	Integer	5			
				Status	Character	30			
				Power_Usage	Integer	5	Power Usage (KWh)		
				Number_of_pump	Integer	4	Number of pump		
Service Reservoir information	0403	Service reservoir	0403_ServiceReservoir	SR_name	Character	20	Service reservoir name	Polygon	RESOURCE & TREATMENT
				SR_Structure	Character	20	Structure of service reservoirs		
				SR_Elevation	Double	(7,2)	Elevation of service reservoirs		
				SR_Capacity	Double	(7,2)	Capacity of service reservoir		
				H.W.L_L.W.L	Double	(7,2)	H.W.L L.W.L		
				dt_Maintenance	Date	8	Last maintenance Date		
	0404	Distribution area of source	0404_DistributionArea	D_AreaName	Character	20	Area name	Polygon	
Other information	0405	Water quality	0405_WaterQuality	WQ_ID	Character	10	Water Quality Point No	-	RESOURCE & TREATMENT
				Location	Character	30	Location_Name		
				dt_Survey	Date	8	Data of Survey		
				Source_name	Character	30	Source name		
				Source_Type	Character	30	Source Type (Either it be Boreholes or Surface water)		
				Ctchmnt_condition	Character	30	Catchment condition (Brief on catchment area. Protected or not.)		
				Ctchmnt_area	Character	30	Catchment area(Hectares)		
				Flow_Rate	Double	(5,2)	Flow Rate (L/s)		
				cl_Demand	Double	(5,2)	Chlorine Demand (mg/10L)		
				Hardness	Double	(5,2)	Hardness (mg/L)		
				Turbidity	Character	5	Turbidity (NTU)		
Customer's Information	0501	Customer's Information	Customer's Information (*CSV Format)	Cstmr_ID	Character	10	Customer ID(*Link Key)	-	CUSTOMER CARE
				Cstmr_name	Character	30	Customer's name		
				House_ID	Character	10	House ID		
				Account_Ty	Character	21	Type Of Account		
				Consumption1	Double	(6,2)	This month		
				Consumption2	Double	(6,2)	1 month ago		
				Consumption3	Double	(6,2)	2 month ago		
				Consumption4	Double	(6,2)	3 month ago		
				Consumption5	Double	(6,2)	4 month ago		
				Consumption6	Double	(6,2)	5 month ago		
				Consumption7	Double	(6,2)	6 month ago		
				Consumption8	Double	(6,2)	7 month ago		
				Consumption9	Double	(6,2)	8 month ago		
				Consumption10	Double	(6,2)	9 month ago		
				Consumption11	Double	(6,2)	10 month ago		
				Consumption12	Double	(6,2)	11 month ago		
				Boundary_of_plot_(land)	Character	20	Boundary of plot (land)		
				Status	Character	30	Customer's status V:vacant, D:disconnect		

Classification	Layer No	Layer Name	File Name	Updated_Attributes_(Draft)			Descriptions	Feature type	from Where (Inforomation Source
				Field_name	Type	Lengt			
Customer's Information	0502	Complaint	0502_Complaint (*CSV Format)	Cycle	Character	21	Distribution System name	Polygon	CUSTOMER CARE
				Reading	Integer		Reading		
				Adjustments	Integer		Adjustments		
				CNWBBH	Integer		Complain of no water but bill high		
				OBLBPO	Integer		Outstanding bills left by previous occupant		
				Faults	Integer		Faults		
				No water	Integer		No water		
				Sewerage block	Integer		Sewerage block		
				Illegal users	Integer		Illegal users		
				Leakage	Integer		Leakage		
				Burst pipe	Integer		Burst pipe		
				Faulty meter	Integer		Faulty meter		
				Meter replacement	Integer		Meter replacement		
				Diversion	Integer		Diversion		
				FUOR	Integer		Follow up on Reconnection		
Grid		1kmGrid	Honiara_1kmGrid	ID	Integer				
				GRID_Name	Character	10			
		4x3kmMesh	Honiara_4x3kmMesh	ID	Integer				
				GRID_Name	Character	10			
		10kmGrid	Honiara_10kmGrid	ID	Integer				
				GRID_Name	Character	10			

Appendix-2

Field note (Information form)

Solomon Water GIS INFORMATION SHEET

Form-1

No,		Address :			
Date of survey			Date of Receipt :		
Surveyed by			Received by		
Distribution system:			Management No,		
Information of attribution					
0101. Water distribution Pipe					
P_ID		Networks		Systems	
P_Type		P_Size		P_Length	
P_Depth		Pipe_Use		dt_Install	
dt_Maintained		dt_Replace		dt_Repair	
dt_Leakage		Pipe_Notes			
0102. Sluice Valve					
V_ID		Networks		Systems	
V_type		V_size		V_Depth	
T_Direction		V_status		dt_Install	
dt_Maintainance		Vnotes			
0103. Hydrant					
FH_ID		Networks		Systems	
FH_type		FHsize		dt_Install	
dt_Maintenance		Fhnotes			
0104. Air Vale					
AV_ID		Networks		Systems	
AV_type		dt_Install		dt_Maintenance	
Fhnotes					
0105. Water pipe bridge					
WPB_ID		WPB_Length		P_type	
dt_Maintenance		Brg_Name		Brg_type	

Breakdown of construction	**Construction Type**	**Survey / Repair / Pipe laying**			Depth (cm)
		Installation / Replacement / Abandonment			
	Valve Box	**Existence / Naught**	Type		

Please specify Sketch

Comments:

Solomon Water GIS INFORMATION SHEET

Form-2 **(Sewer information)**

No,		Address :			
Date of survey			Date of Receipt :		
Surveyed by			Received by		
Distribution system:			Management No,		

Information of attribution

0106. Sewer Manhole

SMH_ID		SSYSNO		SSYSNA	
SSYSLO		SSYSCD		SSYSAC	
SSYSLINENO		SMH_number		SMH_type	
SMH_IL		SMH_RL		SMH_size	
SMH_date					

0107. Sewer pipe

SP_ID		SSYSNO		SSYSNA	
SSYSLO		SSYSCD		SSYSAC	
SSYSLINENO		SP_NO		SP_LGTH	
SP_SIL		SP_EIL		SP_ACV	
SP_SIZE		SP_TYPE		SP_MAKE	
SP_DATE		SP_SLOPE		SP_CONNO	
SP_CONNEC		SP_LINK			

Breakdown of construction	**Construction Type**	**Survey / Repair / Pipe laying**			Depth (cm)
		Installation / Replacement / Abandonment			
	Valve Box	**Existence / Naught**	Type		

Please specify Sketch

Comments:

Solomon Water GIS INFORMATION SHEET

Form-3

No,		Address :				
Date of survey				Date of Receipt :		
Surveyed by				Received by		
Distribution system:				Management No,		
Information of attribution						
0201. Leakage position						
LK_ID		LK_type		Lk_Status		
LK_Position		LK_Condition		Asset_type		
Asset_Size		Asset_Material		dt_survey		
0301. Flow meter						
FM_ID		Networks		Systems		
BF_Location		FM_Size		dt_Install		
dt_Maintenance		Logging				
Bfnotes						
0302. Feeder pipe						
FP_ID		FP_type		PF_size		
Breakdown of construction	**Construction Type**	**Survey / Repair / Pipe laying**				Depth (cm)
		Installation / Replacement / Abandonment				
	Valve Box	**Existence / Naught**	Type			
Please specify Sketch						
Comments:						

Solomon Water GIS INFORMATION SHEET

Form-4

No,		Address :			
Date of survey			Date of Receipt :		
Surveyed by			Received by		
Distribution system:			Management No,		
Information of attribution					
0401. Bore holes					
BH_ID		BH_type		BH_depth	
Head		Head_Max		Pump_ID	
Location		Manufacturerre		Serial_No	
Flow_Rate		Static_Wtr_Lv		Dynamic_Wtr_Lv	
dt_Install		dt_Maintenance		Age	
Status					
0402. Pump Station					
Station_ID		Station_name		Station_type	
Location		Age		Status	
Power_Usage		Number_of_pump			
0403. Service reservoir					
SR_name		SR_Structure		SR_Elevation	
H.W.L_L.W.L	/	dt_Maintenance		SR_Capacity	
0404. Distribution area of source					
D_AreaName					
Breakdown of construction	Construction Type	Survey / Repair / Pipe laying			Depth (cm)
		Installation / Replacement / Abandonment			
	Valve Box	Existence / Naught	Type		
Please specify Sketch					
Comments:					