Annex 14:

Required Power Capacity & Output of Solar Power System and Shop Drawings for Zonal Meters

REQUIRED POWER CAPACITY FOR SOLAR SYSTEM & OUTPUT OF SOLAR SYSTEM

1) Required Power Capacity for Solar System

Power generation capacity of solar system was designed in accordance with the load condition of equipment and cables. Prospective load is summarized as follows:

a. Ultrasonic Flow-meter

There are various kinds of power consumption of ultrasonic flow-meter; 19VA or less by Yokogawa Electric Company, 20W (25VA) by Pana Flow Company, 27VA (case by 200V) by Tokyo Keiki Inc. So that it shall be endured to the largest power consumption, therefore it shall be selected 30VA.

b. Telemetry System

There are various kinds of telemetry systems; 10VA or less by Yokogawa Electric Company, 20VA by Tokyo Keiki Inc. and less than about 30VA by Anritsu Corporation. Therefore, the loading of telemetry system was presumed at 30VA considering the middle class loading of 30VA.

c. Data Logger

Data logger is used aiming at steady and continual storage of the water flow rate measured by the ultrasonic flow-meter. Maximum electrical power consumption is estimated as 50VA.

d. Voltage Drop of Power Supply Cable

Cable length between solar panel and equipment storage panel is estimated as about 30m. In case that a nominal cross-sectional area of 35 and 50mm^2 is selected for the size of power supply cable, cable loss is calculated to approximately 30VA.

e. Factor of Margin

The factor of margin applies general value taking into consideration the safety factor.

The following table shows calculating process of power capacity of each site.

Table: Power Capacity of Each Site

Items	Basis	One Ultrasonic Flow-meter	Two Ultrasonic Flow-meter	One Ultrasonic Flow-meter + One Telemetry System
(1) Ultrasonic Flow-meter	[A]	30VA	30VA x 2sets = 60VA	30VA
(2) Telemetry System	[B]	zero	zero	30VA
(3) Data Logger	[C]	50VA	50VA	50VA
(4) Cable Loss	[D]	30VA	30VA	30VA
(5) Factor of Margin	[E]	1.2	1.2	1.2
Capacity of Solar Power System	[F] = ([A]+[B]+[C]+[D])x[E]	(30VA + 30 VA + 50VA) x 1.2 = 132VA ≈ 140VA	(60VA + 30VA +50VA) x 1.2 = 168VA ≈ 170VA	(30VA + 30 VA + 30VA + 50VA) x 1.2 = 168VA ≈ 170VA

Source: Project Team

2) Output of Solar System

Output of solar power was determined in consideration of period of time that battery can support power supply. Decision process is summarized as follows:

a. General Battery which is popular in Nigeria (12V150Ah)

The battery performance is specified by the 10 hour rating as minimum requirement. The battery of “12V150Ah” has performance which can feed 180VA (12V x 15A) in 10 hours, 140VA in 12.8 hours, 170VA in 10.6 hours continuously. Capacity of battery is designed in different cases of power supply such as main use of commercial power supply and solar power supply.

b. Duration of Commercial Power Supply

In FCT (Abuja), power is generally supplied for eight hours intermittently in a day. However, it is not recommended to use the commercial power supply as main power source because electrical power condition as mentioned above may interfere with stable data logging. Solar power system is therefore required as main power source.

c. Duration of Battery Support

According to the climatic condition by ‘National Report of Agricultural Performance Survey of 2013 Wet Season in Nigeria’, maximum number of rainy days in a year records 18 days. However, it is unlikely that rain falls continuously for a long period. It is realistic to assume three rainy days in a row. Therefore, battery shall support power supply three days in a row.

d. Solar Power Supply

According to ‘Renewable Energy for Rural Industrialization and Development in Nigeria, UNIDO and ECN, Dec.2003’, generation of solar power is 5.337kWh/m^2/day in annual mean in FCT (Abuja). So that it could get 5kw per 1m^2 solar panel.

Solar panel of 1m^2 enables to generate power of about 1kW. Therefore, unit generation capacity of solar power is about 5kWh per m^2 per day. The following table shows capacity of solar power generation by the capacity of solar power output.

Table: Solar Power Generation

Type	Condition	Required No. of Battery	Required Rating of Solar Power
1	140VA in Commercial Power Area	4 units	1.1kW
2	140VA not in Commercial Power Area	6 units	1.6kW
3	170VA in Commercial Power Area	5 units	1.3kW

Source: Project Team

The followings are the calculation basis for the output of solar power.

- **Required Number of Battery**

  <u>Type-1 (140VA in Commercial Power Area)</u>

If it would be three rainy days and 16 hour power cut hour (8 hour power support), it shall be necessary 6,336VA and it is four batteries.

- 132VA x 16h x 3d = 6,336VA
- 6,336VA / 1,800VA (12V150Ah) = 3.5 (≒four batteries)

Type-2 (140VA not in Commercial Power Area)

If it would be three rainy days and 24 hour without power, it shall be necessary 9,504VA and it is six batteries.

- 132VA x 24h x 3d = 9,504VA
- 9,504VA / 1,800VA (12V150Ah) = 5.3 (≒six batteries)

Type-3 (170VA in Commercial Power Area)

If it would be three rainy days and 16 hour power cut hour (8 hour power support), it shall be necessary 8,064VA and it is five batteries.

168VA x 16h x 3d = 8,064VA

8,064VA / 1,800VA (12V150Ah) = 4.5 (≒five batteries)

- **Required Rating of Solar Power**

Type-1 (140VA in Commercial Power Area)

It would be needed for 6,336VA due to rainy day. It would be need for 1.1kW solar power.

- The ability of generate power: five times of rating solar
- Power factor: 0.8
- 6,336VVA / 5 x 0.8 = 1,013.8W ≈ 1,100W (1.1kW)

Type-2 (140VA not in Commercial Power Area)

It would be needed for 9,504VA due to rainy day. It would be need for 1.6kW solar power.

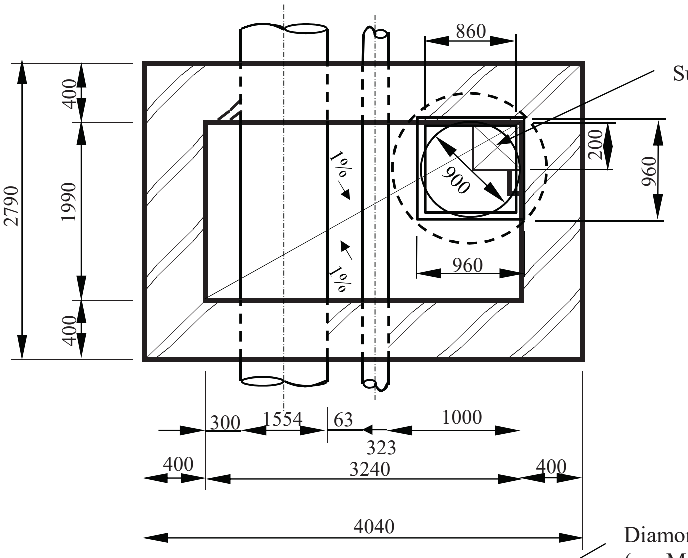
- The ability of generate power: five times of rating solar
- Power factor: 0.8
- 9,504VA / 5 x 0.8 = 1520.6W ≒ 1,600W (1.6kW)

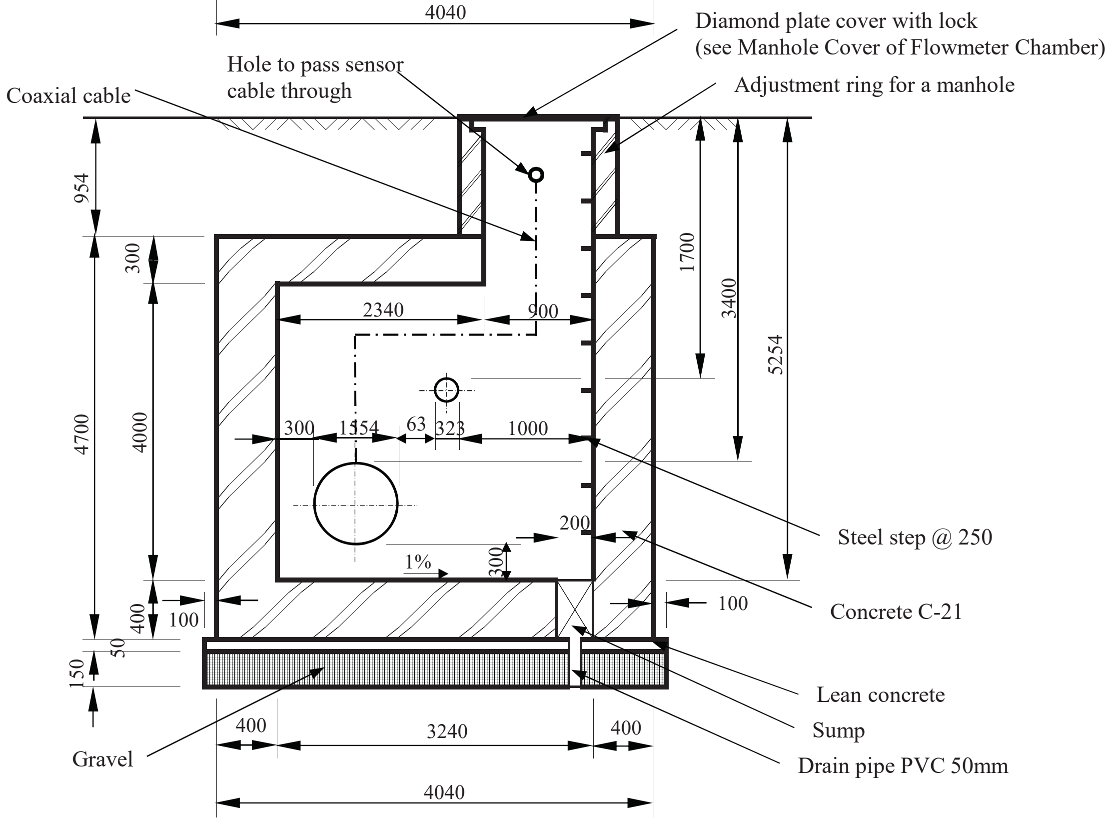
Type-3 (170VA in Commercial Power Area)

It would be needed for 8,064VA due to rainy day. It would be need for 1.3kW solar power.

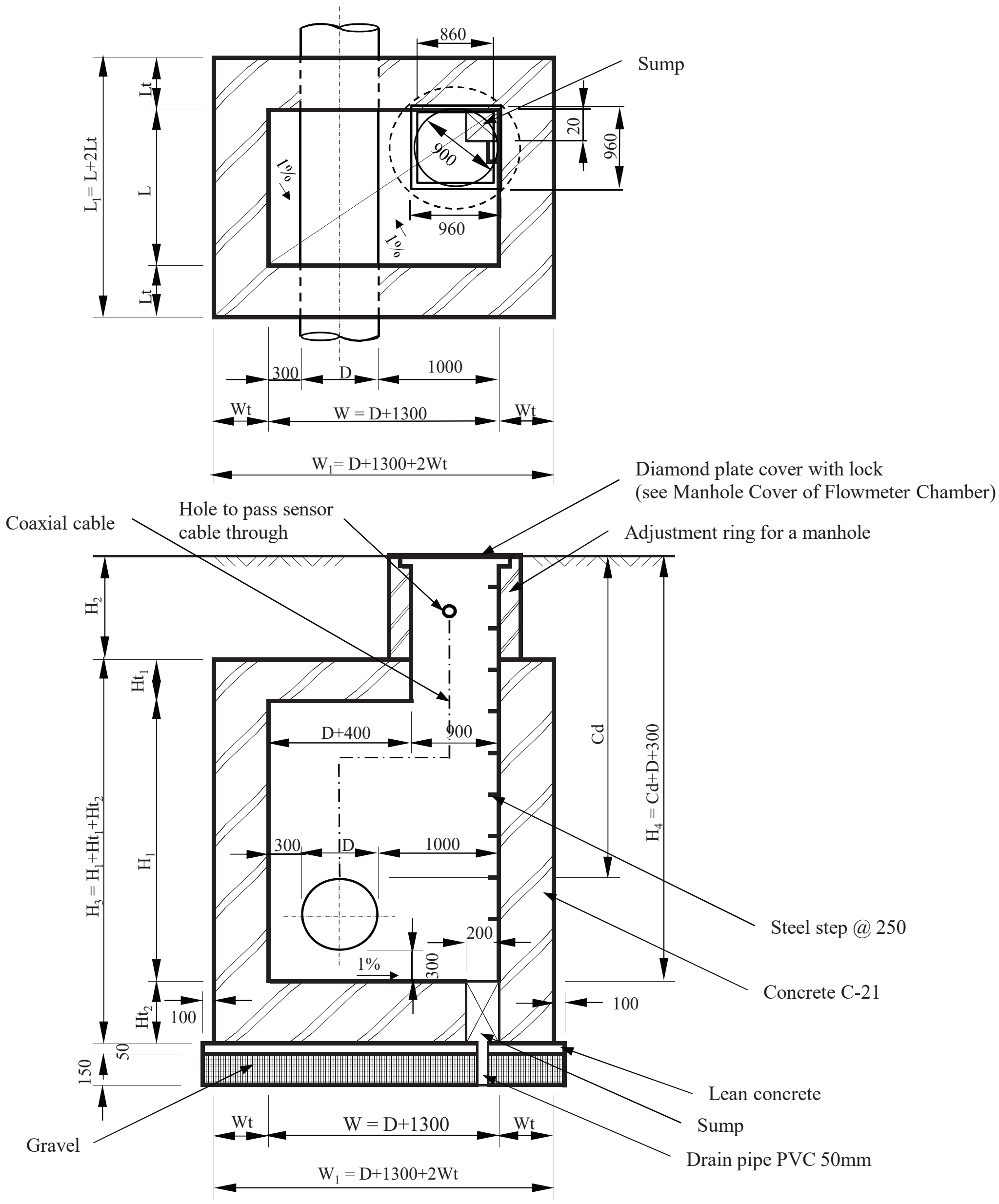
- The ability of generate power: five times of rating solar
- Power factor: 0.8
- 8,064VA / 5 x 0.8 = 1,290.2W ≈ 1,300W (1.3kW)

Type-A at Tank 2 (Not to Scale)



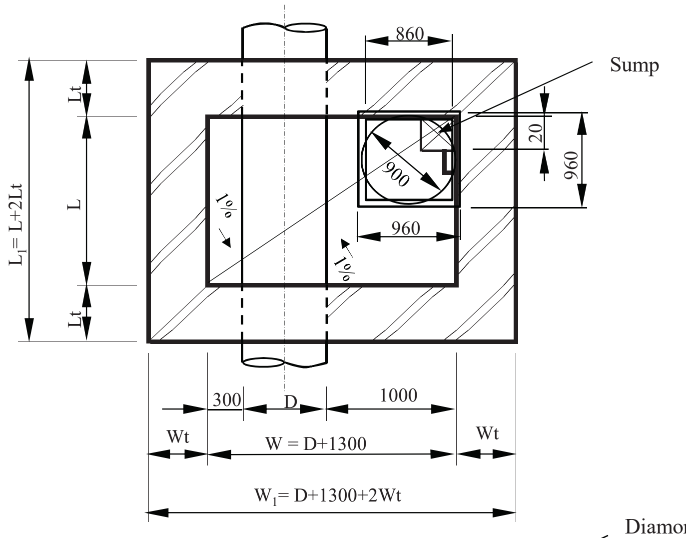


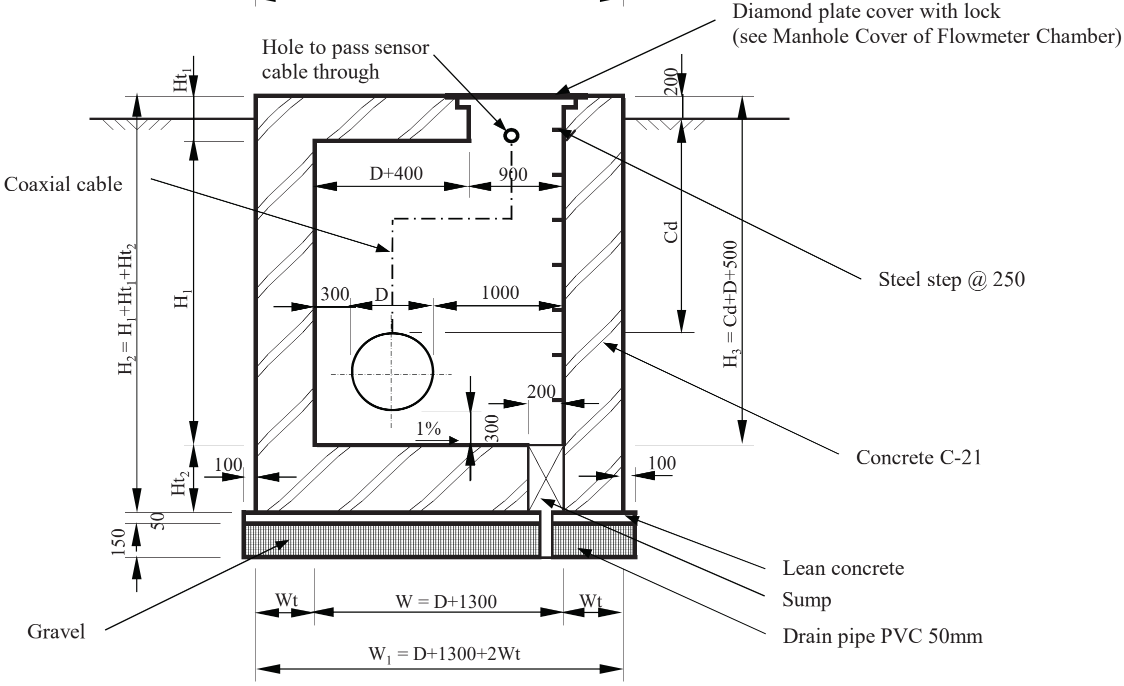
Type-B, C and D at Tank 3.1, 4.2, 5 and Gwako (Not to Scale)



S.R. No.	Type	Dia. (mm)	D	Cd	Wt	W	W_1	Lt	L	L_1	Ht_1	Ht_2	H_1	H_2	H_3	H_4
3.1	B	500	631	1500	250	1931	2431	250	1200	1700	250	250	2000	181	2500	2431
4.2	C	500	528	3300	400	1828	2628	400	1110	1910	300	400	2000	1828	2700	4128
5	D	1500	1554	3500	400	2854	3654	400	1990	2790	300	400	2600	2454	3300	5354
Gwako	B	600	631	1500	250	1931	2431	250	1200	1700	250	250	2000	181	2500	2431

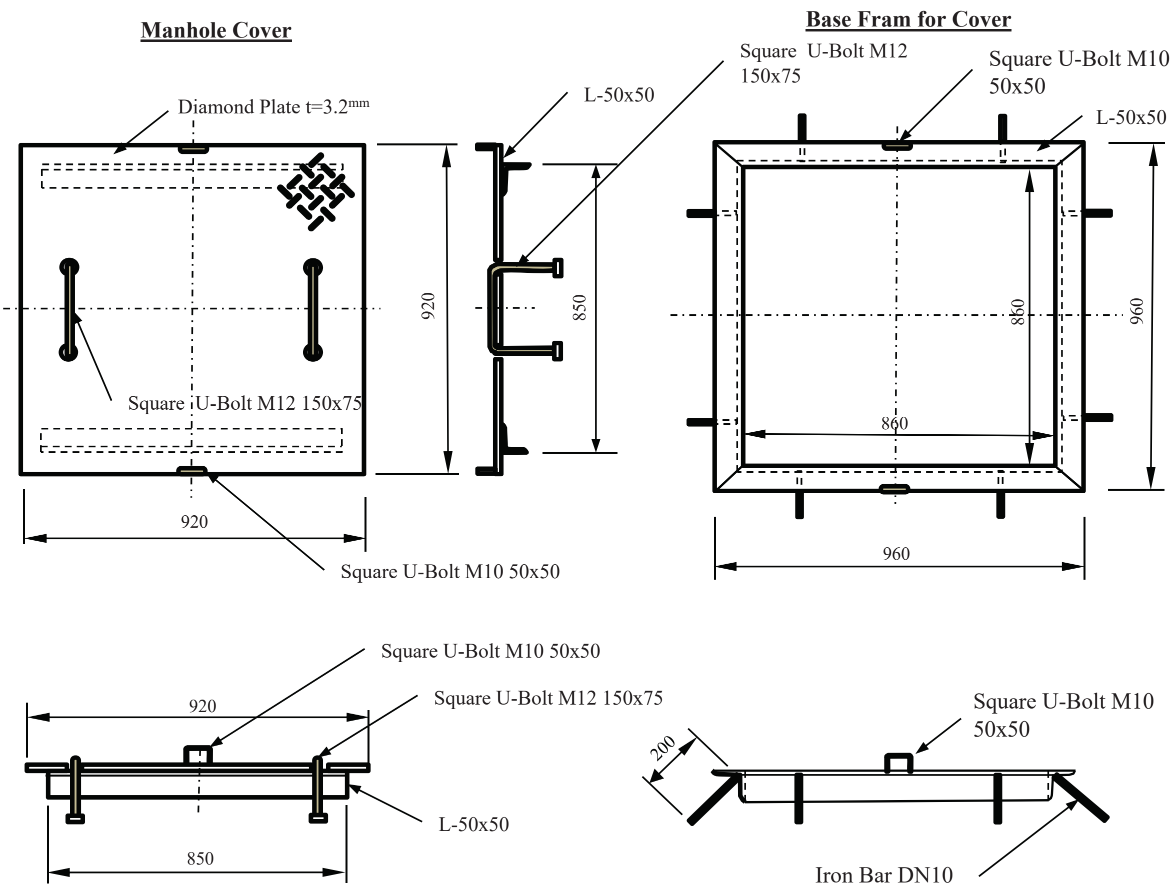
Type-E, F and G at Tank 3.2, 4.1.1 and Kubwa (Not to Scale)



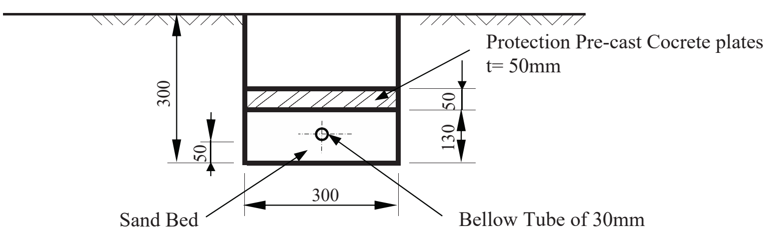


S.R. No.	Type	Dia. (mm)	D	Cd	Wt	W	W_1	Lt	L	L_1	Ht_1	Ht_2	H_1	H_2	H_3
3.2	E	300	323	900	250	1623	2123	250	940	1440	250	250	1473	1973	1723
4.1.1	F	250	323	500	250	1623	2123	250	940	1440	250	250	1073	1573	1323
Kubwa	G	600	631	1000	250	1931	2431	250	1200	1700	250	250	1881	2381	2131

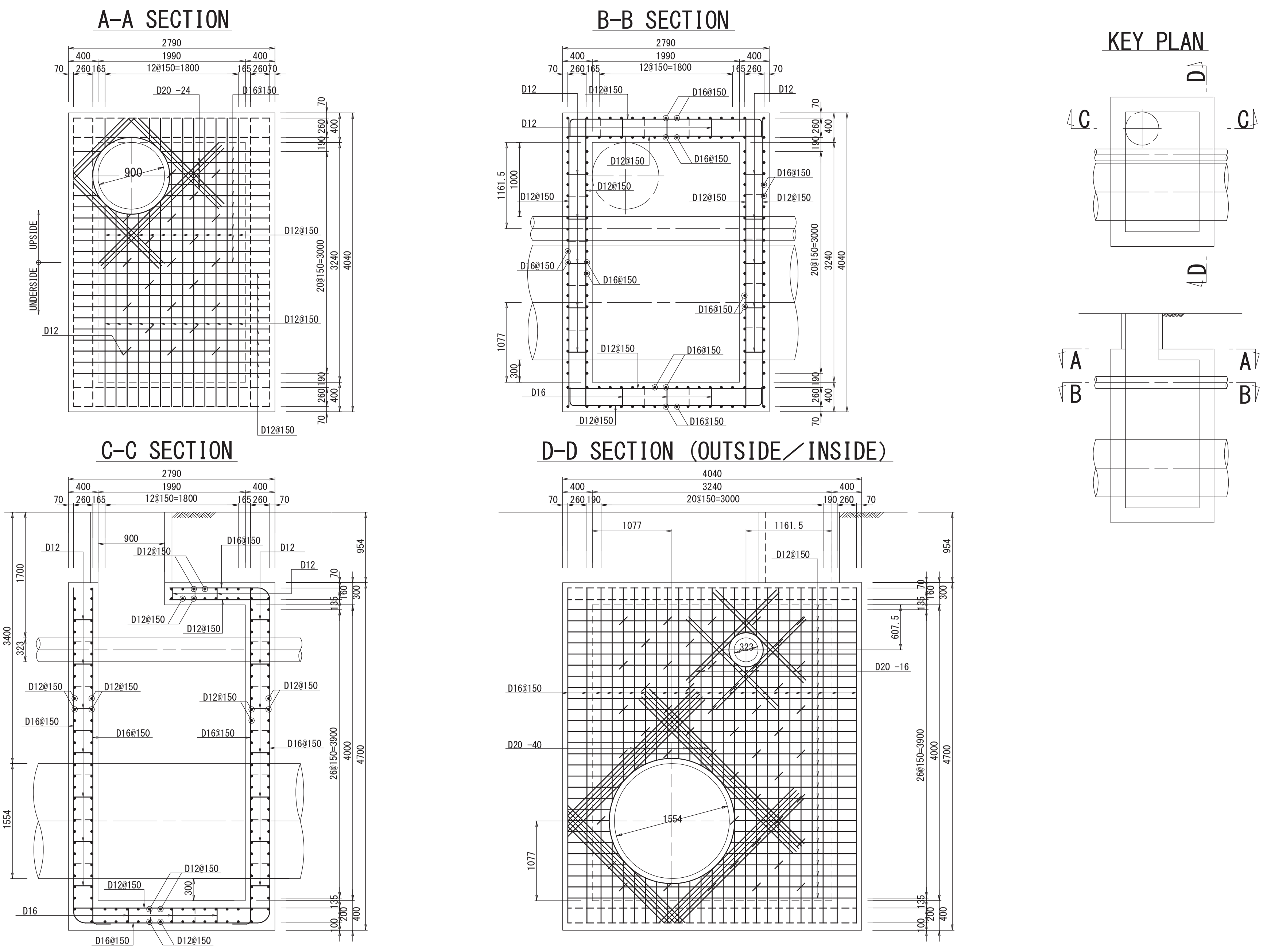
Manhole Cover of Flowmeter Chamber (Not to Scale)



Bellow tube laying for Sensor Cables (Not to Scale)



RE-BAR ARRANGEMENT OF CHAMBER OF TYPE-A FLOW METER S=1:50



RE-BAR ARRANGEMENT OF CHAMBER OF TYPE-B FLOW METER S=1:50

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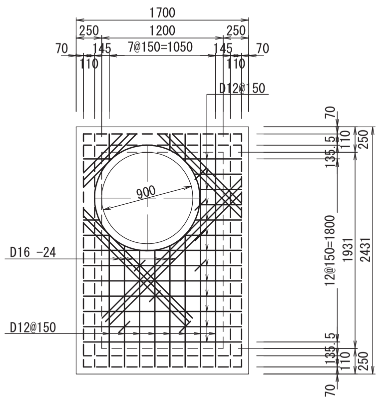

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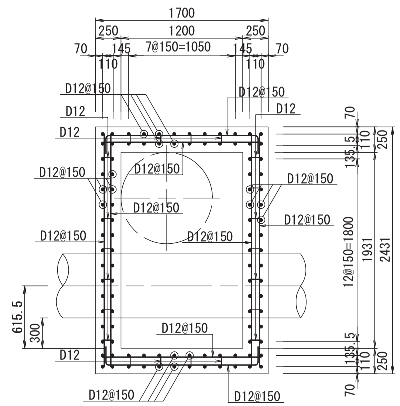

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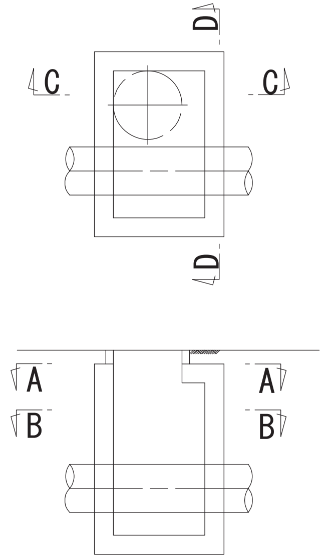

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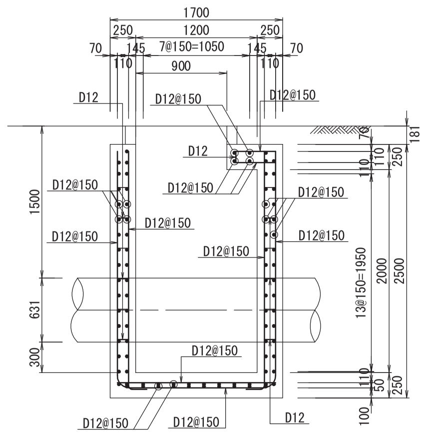

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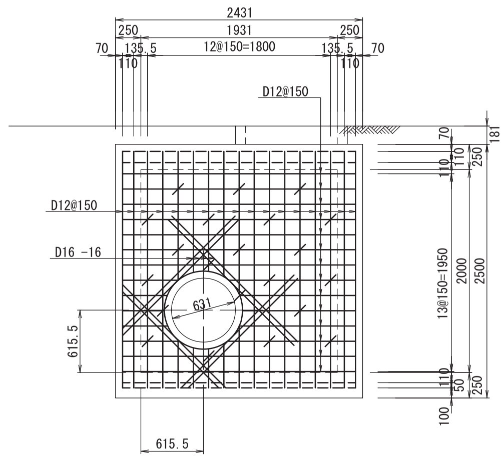

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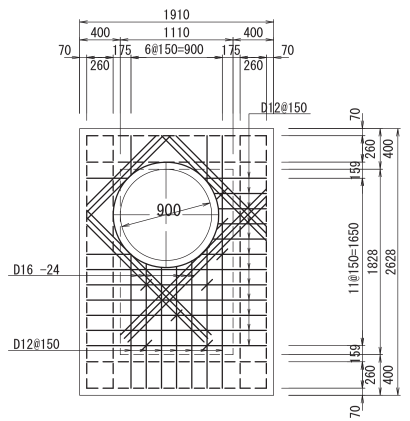

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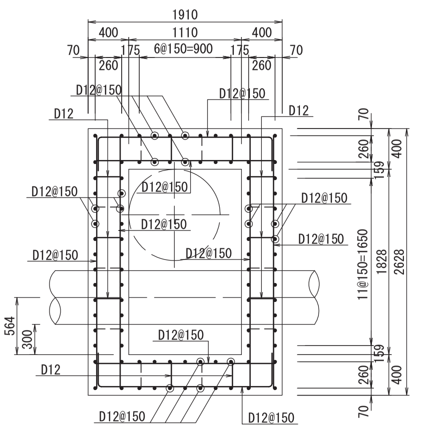

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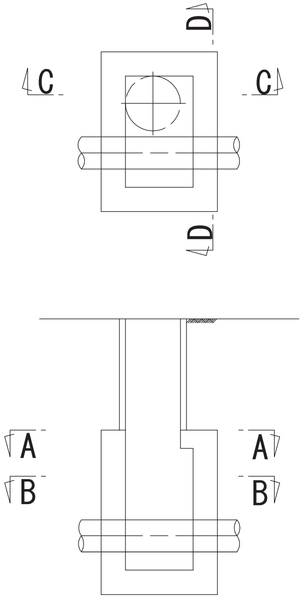

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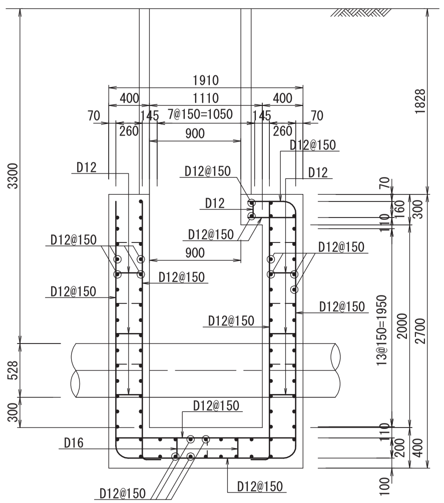

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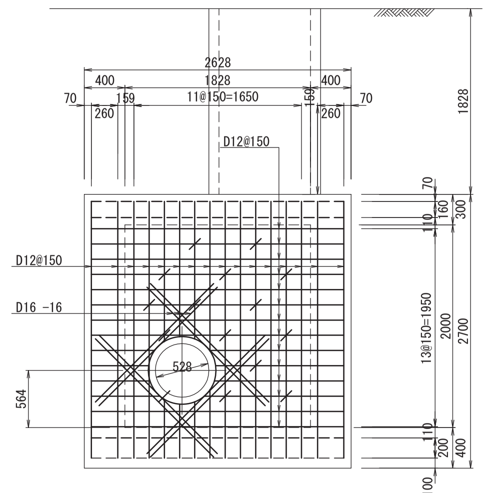

RE-BAR ARRANGEMENT OF CHAMBER OF TYPE-D FLOW METER S=1:50

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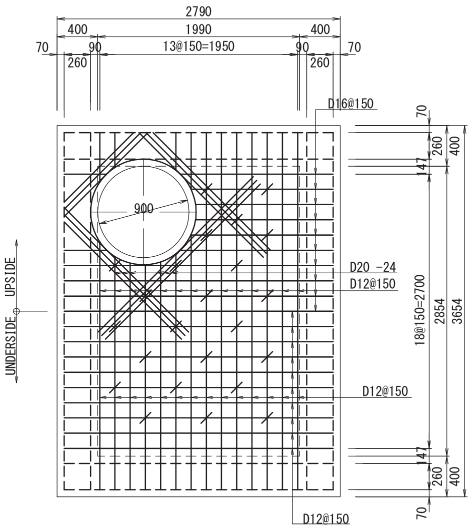

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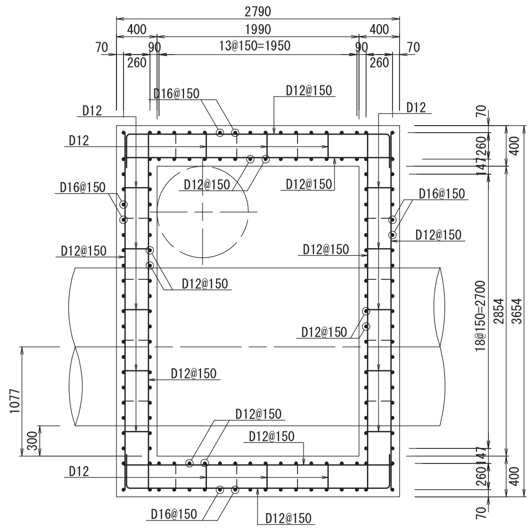

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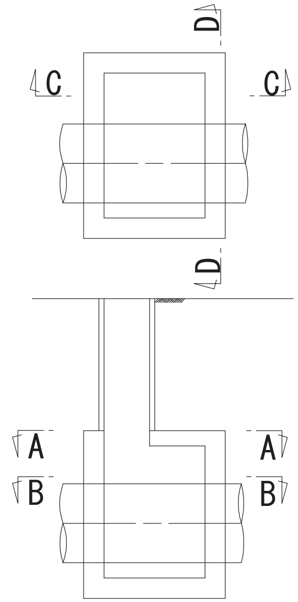

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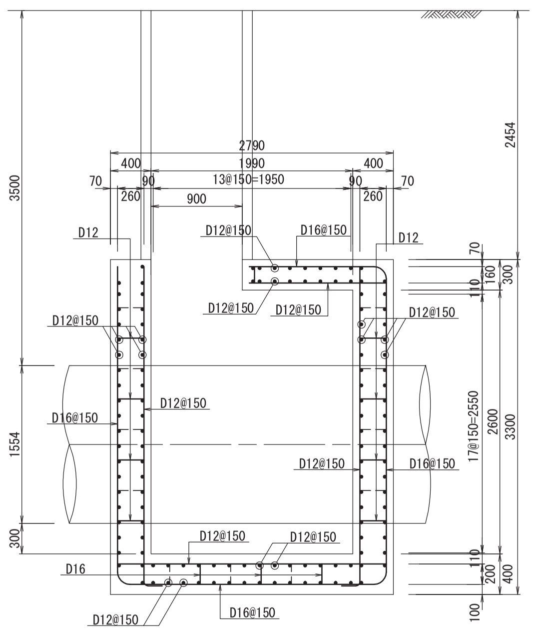

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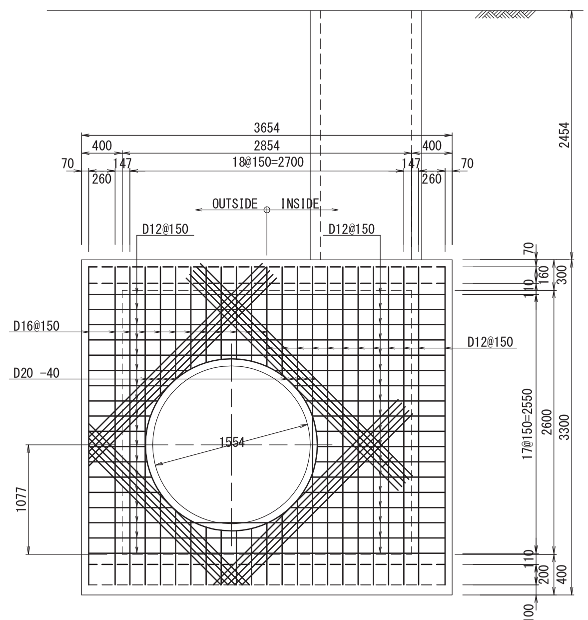

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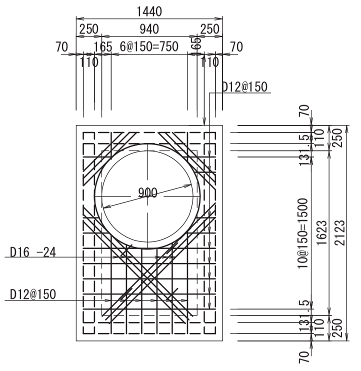

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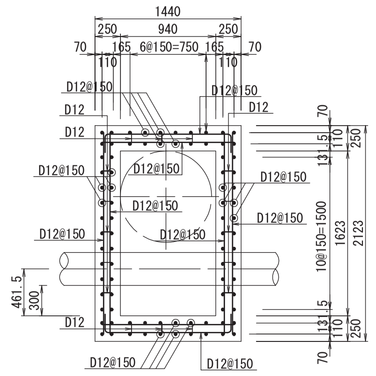

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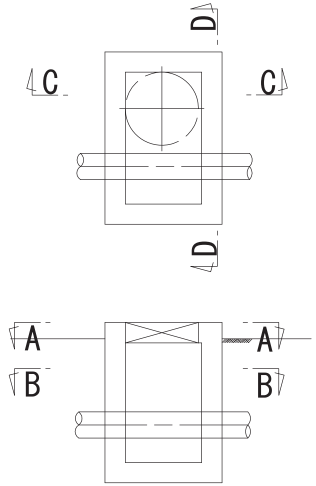

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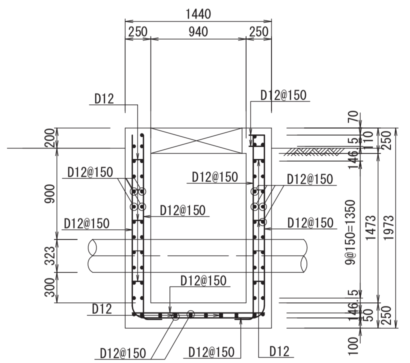

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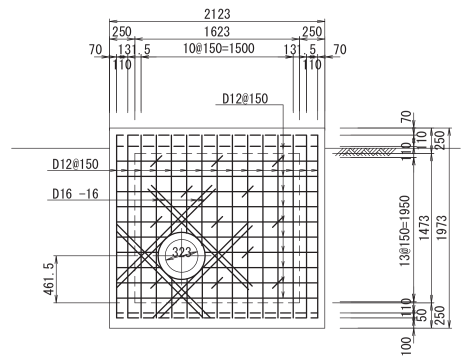

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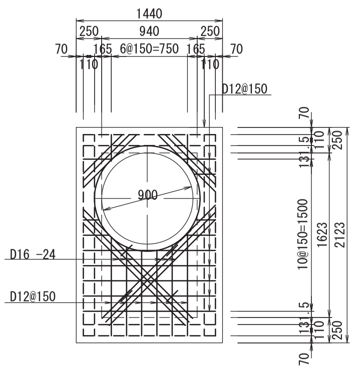

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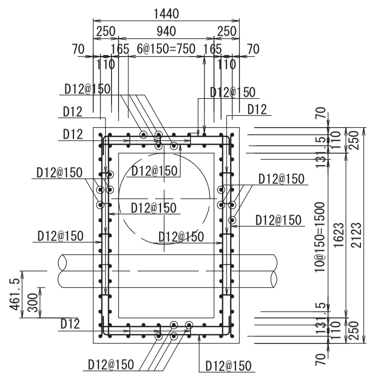

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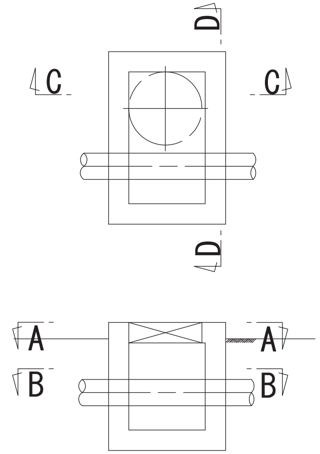

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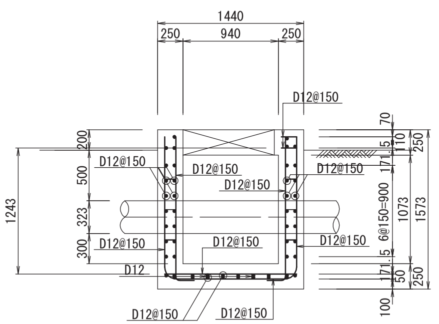

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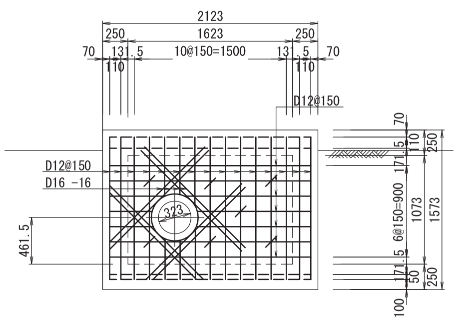

RE-BAR ARRANGEMENT OF CHAMBER OF TYPE-G FLOW METER S=1:50

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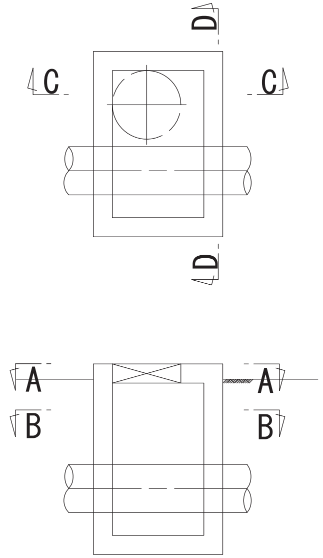

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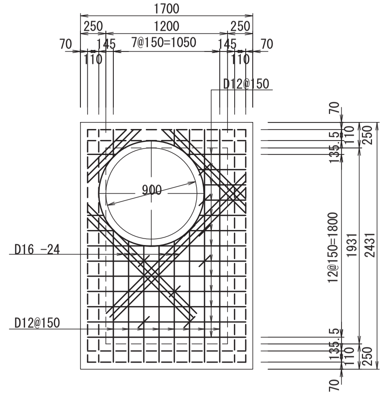

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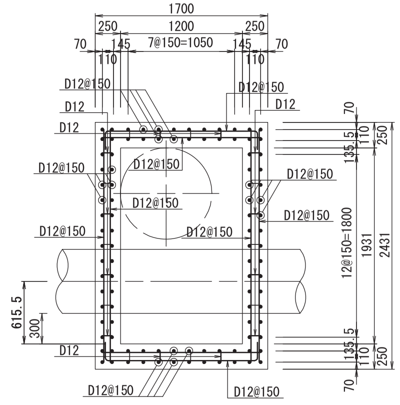

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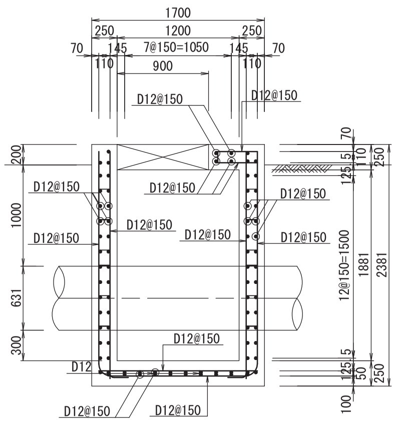

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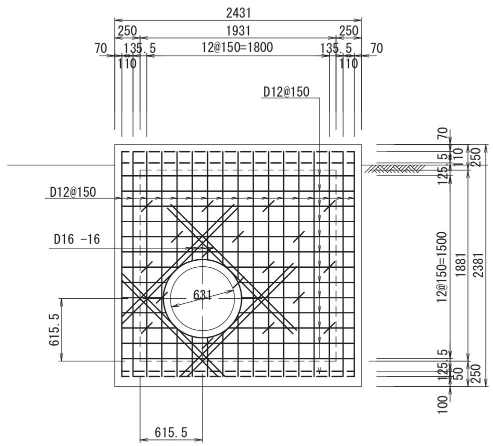


Annex 15:

Manual on NRW Reduction Operations
(including GIS and Hydraulic Analysis)

The Federal Capital Territory

Reduction of Non-Revenue Water Project

Manual
for
Non-Revenue Water (NRW)
Reduction Operations

Version 2

May 2018

Index

Annex (for Action Team)

1 Flow of NRW Reduction Activities

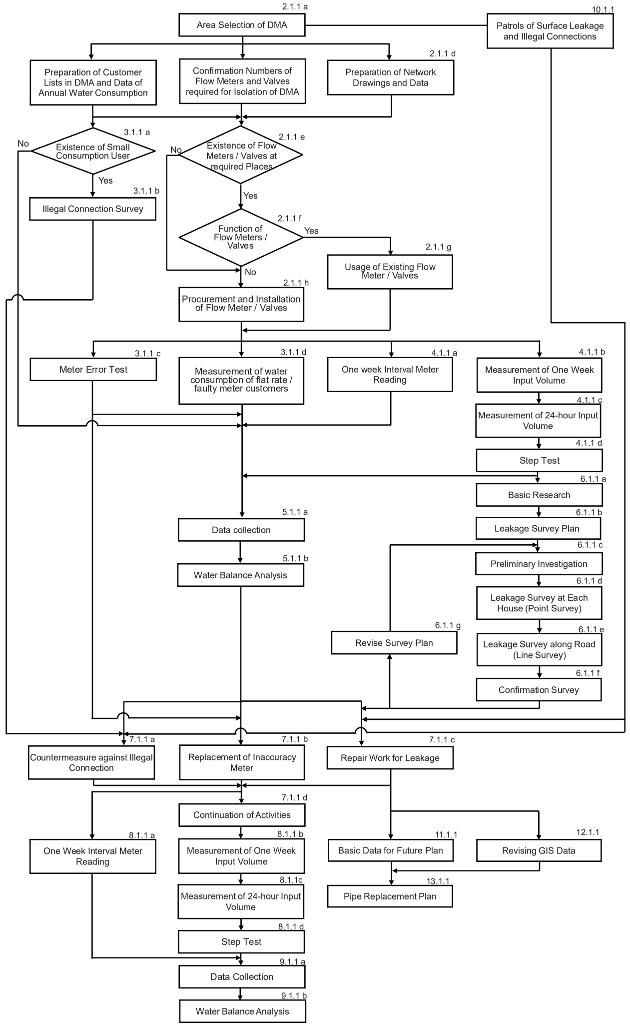


Fig. 1-1 Flow Chart of NRW Reduction Activities

2 DMA creation

Generally Non-Revenue Water (NRW) reduction activities in distribution network are undertaken when the leakage is appeared on the ground or overflow from tanks. When we consider more effective activities, it is more effective to measure NRW using zones. The pipe network system is divided into series of smaller sub-systems for which NRW can be calculated individually. These small sub-systems are known as District Metered Areas (DMAs). DMAs should be hydraulically isolated so that it can be calculated as water loss volume in the DMA.

There are three types of DMA shown as typical layout of DMAs.

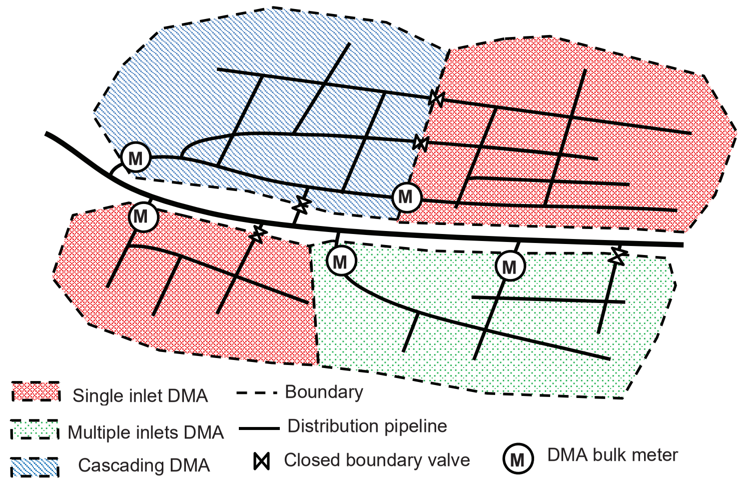


Fig.2-1 Typical Layout of DMAs

a Single inlet DMA: The inlet of DMA is only one and there is no outlet to other pipeline network system. One DMA bulk meter is installed at inlet point of DMA.

b Multiple inlet DMA: The inlets of DMA are more than two and there is no outlet to other pipeline network system. More than two DMA bulk meter are installed at inlet points of DMA.

c Cascading DMA: The inlet of DMA is single or multiple and there is outlet to another DMA. One or more than two DMA bulk meters are installed at these inlet points of DMA and DMA bulk meter for measuring outlet volume from DMA is installed at outlet of DMA. Closed boundary valves are installed at boundary between two DMAs for isolation.

2.1 DMA creation method

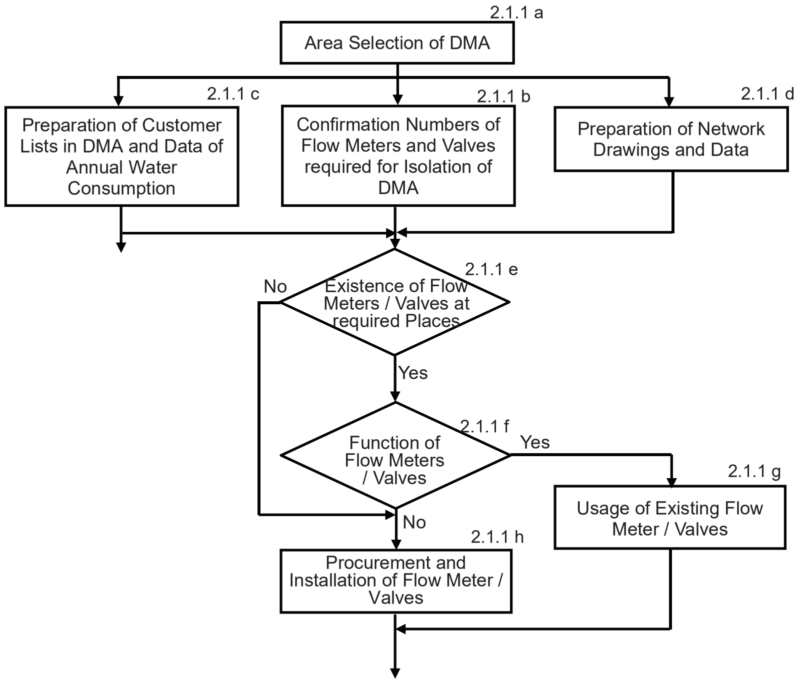


Fig. 2-2 Flow Chart of DMA Creation

2.1.1 Procedure

a. Area selection of DMA: Staff of distribution in HQ and Area Office

For area selection of DMA, it is necessary to consider the size, hydraulic isolation, cost, and so on as follows:

- Size of DMA is generally between 1,000 and 2,500 house connections.
- The area can be isolated hydraulically.
- Natural boundaries should be used.

- Number of valves that must be closed to isolate the DMA should be minimum numbers.
- Number of flow meters to measure inflow and out flow should be fewer. (For reducing costs and more accurate flow measurement)
- Ground level variations and thus pressures in DMA are flatter and more stable. (For easier pressure control)
- Easily visible topographic features that can serve as boundaries for DMA, such as rivers, drainage channels, highways, etc.

b. Confirmation numbers of flow meters and valves required for isolation of DMA: Distribution Staff at the HQ and Area Office

It is important to confirm the number of flow meters to measure inflow and outflow of DMA. Also, it is important to confirm the number of valves to isolate DMA and to separate DMA to small areas for step test. Necessary procedure is as follows:

- To confirm numbers of flow meters and valves required for isolation of DMA by network drawings. (GIS data)
- To survey numbers of flow meters and valves required for isolation of DMA at the site.
- Flow meter should be installed at inlet points and outlet points.
- Valves should be installed at boundary of DMA and next to flow meter for hydraulic isolation.
- Valves should be installed at branches of distribution pipe for step test.
- To confirm number of inlet points and which inlet point can be closed by boundary valve by hydraulic analysis.
- To confirm number of outlet points and which outlet point can be closed by boundary valve by hydraulic analysis. (Confirmation for cascaded DMA)

c. Preparation of customer lists in DMA and data of annual water consumption: Staff of commerce in HQ and Area Office

For NRW reduction, it is necessary to grasp water consumption totally in DMA and water consumption on each pipeline in DMA. <u>Refer to Annex "Manual for Commerce (Action Team) 1 Meter Reading" for details of meter reading.</u> Necessary procedure is as follows:

- To prepare customer lists in DMA and annual water consumption of customers

- To calculate hourly water consumption using annual water consumption data for each customer. The hourly water consumption data is used for hydraulic analysis and water balance analysis.
- To allocate customers to whom water supplied from which pipelines. The data is used for hydraulic analysis and water balance analysis.

c-1 Customer Map

It is necessary to make a "Customer Map" for confirmation of customer condition. Customer maps should be updated regularly. Necessary procedure is as follows:

- To prepare plotting map by GIS section.
- To take the plotting map to the site and write information such as: Plot Number (House Number), Customer's Name, Meter Number/Type on it.
- To keep the original drawing in the area office.
- To give GIS section the copy of it.
- To input the information this is got by field survey to GIS map by staff of GIS section.
- To update data when information of the customer map is changed (write changed information on the original map kept in the area office.
- To inform changes of data to GIS section.
- To update GIS data by GIS section regularly.
- Necessary Items and an example of Customer Map are follows: Fig. 2-3 and 2-4

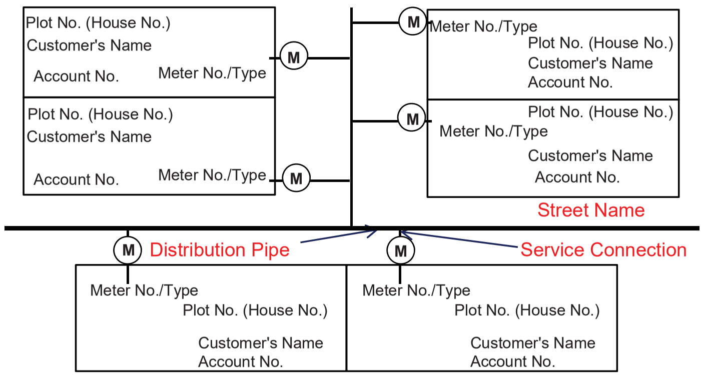


Fig. 2-3 Items which should be written on Customer Map

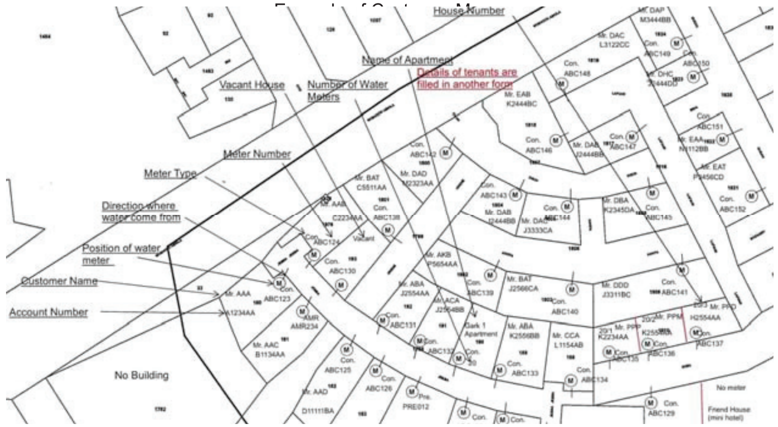


Fig. 2-4 Example of Customer Map

d. Preparation of network drawings and data: GIS Section staff, Distribution staff at the HQ and Area Office

Network drawings and data are necessary for confirmation of the position of valves and flow meters in DMAs. And, they are necessary for measuring input water volume to DMAs, step test and water balance analysis of DMA and SMAs. Necessary procedure is as follows:

- To prepare a GIS map including DMA area.
- To prepare a satellite map including DMA area, when a GIS map is not available.
- To confirm and draw pipelines, valves and flow meters in DMA on the map by distribution staff of the area office.
- To confirm which customer gets water from which distribution pipeline.
- To add the information which is got by procedure of confirmation of position of pipelines, valves and flow meters to a GIS map.

e. Existence of flow meters / valves at required places: Distribution staff at the HQ and Area Office

After confirmation of necessary number of flow meters and valves, it is necessary to confirm existence of them at site of DMA. Necessary procedure is as follows:

- To confirm existing flow meters and valves at inlet points and outlet points at the site.

- To confirm existing valves at boundary of DMA
- To confirm existing valves at branches of distribution pipe
- When there are existing flow meters and valves at required places, confirm their function.
- When there are not existing flow meters and valves at required places, make bill of quantities (BOQ) for procurement. (Diameter of flow meters / valves and their fittings, fittings for setting them on pipe lines)

f. Function of flow meters / valves: Distribution staff at the HQ and Area Office
It is necessary to confirm that existing flow meters and valves can be used or not. Necessary procedure is as follows:

- To confirm existing flow meters which are working or not.
- To confirm existing valves whether they can be closed or opened completely or not.
- When flow meters and valves are not working well, make BOQ for procurement. (Diameter of flow meters / valves and their fittings, fittings for setting them on pipe lines).
- When flow meters and valves are working well, use them for creation of DMA.

g. Usage of existing flow meters / valves: Distribution staff at the HQ and Area Office
If existing flow meters and valves can be used, they should be used for establishment of DMA.

- To use functional flow meters and valves.
- If malfunctioned flow meters and valves can be worked by small maintenance, they should be used after maintenance.

h. Procurement and Installation of flow meters / valves: Distribution staff at the HQ and Area Office
If flow meters and valves do not exist or work at required places, it is necessary to purchase them for creation of DMA. Necessary procedure is as follows:

- To ask for quotation from suppliers (at least three suppliers) by BOQ.
- To design and estimate cost to make chambers for flow meters and valves.

- To check and compare BOQ and quotations which are submitted by suppliers.
- To choose the supplier who submits the cheapest quotation for procurement.
- To submit the budget for procurement to the Director attaching the quotation of equipment and cost estimation for chambers.
- To purchase flow meters, valves and fittings by quotation.
- To inspect equipment which is delivered by the supplier using BOQ and the quotation
- To order the contractor to make chambers using designed drawings.
- To supervise construction work by comparing to the drawings.

3 Commercial loss surveys

NRW consists of commercial losses and physical losses. Commercial losses consist of unbilled authorized consumption, illegal connection, customer meter inaccuracy and unidentified consumption. It is also commercial loss to use water excess from water volume which calculated flat rate tariff equal to metered charge.

3.1 Commercial loss survey method

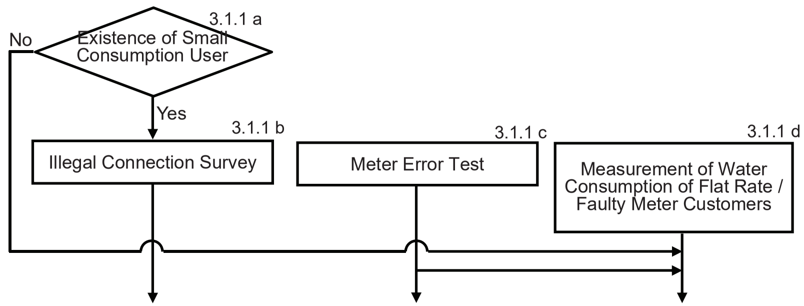


Fig. 3-1 Flow Chart of Commercial Loss Survey

3.1.1 Procedure

a. Existence of small consumption user: Staff of commerce in HQ and Area Office
The consumer who gets water illegally, such as bypass meter, illegal connection to distribution pipe, irregular use of meter and so on, use small quantity of metered water. Therefore, it is important to inspect customer's water consumption. Small consumption customer is suspected using water illegally. They should be targets for

illegal connection survey. Refer to Annex "Manual for Commerce (Action Team) 3 Illegal Connection" for details of Illegal Connection Necessary procedure is as follows:

- To calculate the water consumption average of all customers in DMA
- To find customers who use water less than a half of average consumption compare to others.
- If there are small consumption customers, illegal connection survey should be carried out on them (targets).
- To make a list of targeted customers for illegal connection survey.
- If there are many targets, prioritize them. Top priorities are customers who use water less than a quarter of average. Second priorities are rest of them.
- If there is no small consumption customer, illegal survey is not necessary.
- It is very important to check unusual condition of meter and small water consumption every month.

b. Illegal connection survey: Meter readers, Distribution staff at the HQ and Area Office
Illegal connections are usually under the ground therefore, it is difficult to find illegal connection/users. To make illegal survey easier, it is necessary to narrow down the targets to be inspected. There are two types of illegal connection survey such as: visual inspection and survey using equipment. Necessary procedure is as follows:

- By analysis of customer list and their consumption, the SMA which small consumption customer is many should be given top priority to survey.
- Other SMAs also should be surveyed after top priority's SMA.
- It' very difficult finds illegal connections. But it should not be allowed.
- It is very important to check unusual condition of meter and small consumption every month.
- To inspect surroundings of meter and service pipeline whether strange pipe line is existing or not and meter is in normal condition or not. (meter readers should inspect them)
- To get a list of targets from commerce (after this sentence distribution staff should manipulate or inspect them)
- To close stop valve on service pipeline.
- To confirm stop water flow by small indicator of meter.
- To hear flow noise by acoustic bar touching stop valve.

- When flow noise can be detected, close inlet valve of water tank or inlet valve of house (in case of no water tank).
- If water flow noise stops, there is a bypass.
- To dig service pipe before stop valve to confirm bypass
- If water flow noise continues, close outlet valve of water tank and inlet valve of house.
- If water flow noise stop, there is an illegal connection.
- To dig distribution pipe around service branch to confirm illegal connection.
- To report to area manager and ask decision for the disconnection.

c. Meter error test: Distribution staff at the HQ and Area Office, Staff of commerce in Area Office
Meter error test should be done for measuring meter inaccuracy Refer to Annex" Manual for Commerce (Action Team) 2 Meter Error" for details of meter error test Necessary procedure is as follows:

- To close stop valve on service pipe.
- To disconnect or remove pipe after meter.
- To connect inlet of test meter to outlet of customer's meter.
- To read and record meter value of customer's meter and test meter before starting to check meter inaccuracy.
- To open stop valve.
- To flash about 100 litter of water from outlet of test meter.
- To close stop valve.
- To read and record meter value of customer's meter and test meter.
- To calculate the value of difference between the meters value at the start and end of customer's meter and test meter.
- V1 = end meter value minus start meter value of customer's meter.
- V2 = end meter value minus start meter value of test meter.
- V3 = V1 – V2
- Meter inaccuracy = V3 divides V2 times 100 = A%

d. Measurement of water consumption of flat rate / faulty meter customers: Distribution staff and commerce at the HQ and Area Office
Excess use of flat rate is commercial loss. In case of faulty meter, excess use of estimated consumption is also commercial loss. It is necessary to measure actual

water quantity which customers use. Necessary procedure is as follows:

Setting temporally meters and Meter Reading for Flat rate customers and Faulty meter customers (one week)

- To make customer’s list of flat rate customer and faulty meter customer.
- To install temporally meters at customer’s house by the list.
- To read starting meter value and record it on the form.
- To read meter value after one-week interval and record it on the form.
- To calculate one-hour water consumption using the record.
- To make comparison between the one-hour consumption and flat rate volume. (equivalent to metered tariff)
- If the one-hour consumption exceeds flat rate volume, it is commercial loss volume.
- To make comparison between the one-hour consumption and estimate value.
- If the one-hour consumption exceeds estimated volume, it is commercial loss.

4 Water Consumption Measurements

It is necessary to measure water consumption

4.1 Methods of water consumption measurements:

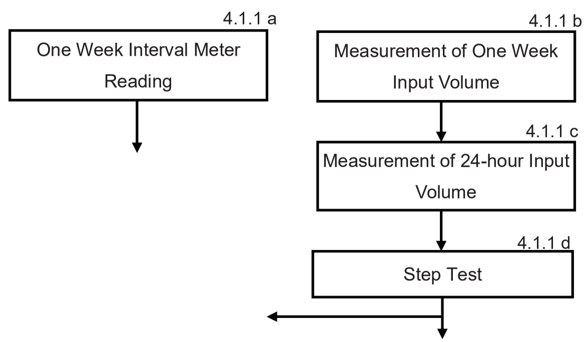


Fig. 4-1 Flow Chart of Commercial Loss Survey

4.1.1 Procedure

a. One-week interval meter reading: Staff of commerce in Area Office,

It is necessary to know the actual water consumption in DMA for calculation of NRW. Usually one-year consumption record is used for the calculation of water

consumption in DMA. Necessary procedure is as follows:

- To prepare customer list in DMA
- Each customer should be allocated to each distribution pipeline.
- To visit customer’s house and read customer’s meter value and record it on the form.
- To confirm meter condition, whether unusual pipeline (illegal connection) is existing or not, number of residents and water tank volume at same time.
- To visit customer’s house again one week after the first visit and read customer’s meter value and record it on the form.
- To calculate one-hour consumption of total customers for calculation of water balance analysis.

b. Measurement of one-week input volume: Distribution Staff at Area Office

It is necessary to measure input volume of DMA. Necessary procedure is as follows:

- To set ultrasonic flow meter at all inlet points and outlet points (Fig. 4-1 Setting Points of Ultrasonic Flow Meter: point A and D) and log the data.
- Water flow volume at A is inlet to DMA, and water flow volume at D is outlet water volume

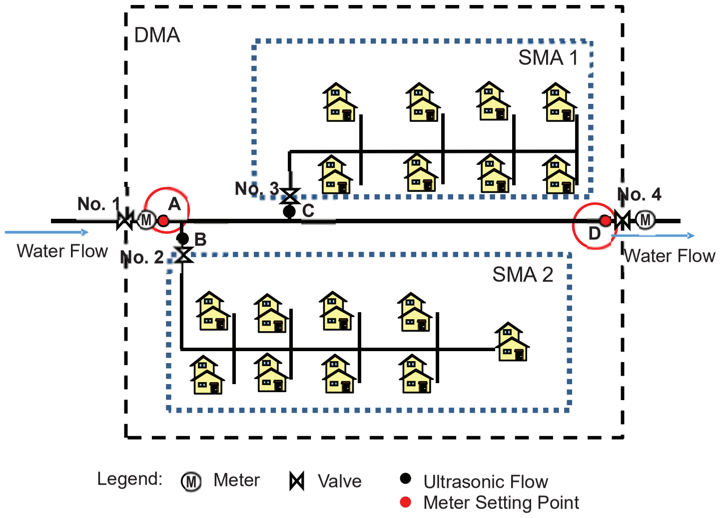


Fig.4-1 Setting Points of Ultrasonic Flow Meter

- Ultrasonic flow meter needs distance from fittings (valves, mechanical meters, pipe bends, reducer pipe, etc.)
- When setting after (water flow direction) fittings, it needs 10 times of pipe diameter. (ex.: pipe diameter 100 mm, distance 100 x 10 = 1,000 mm)
- When setting before (water flow direction) fittings, it needs 5 times of pipe diameter. (ex.: pipe diameter 100 mm, distance 100 x 5 = 500 mm)

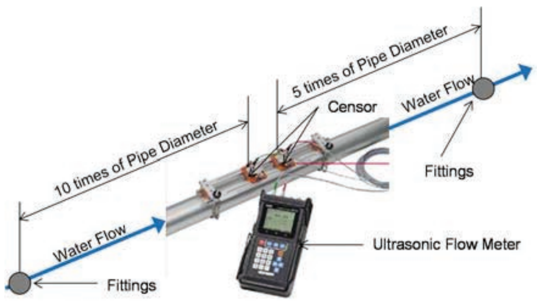


Fig. 4-2 Distance between Meter and Fittings

- The ultrasonic flow meter needs outer buttery to measure one-week water flow.

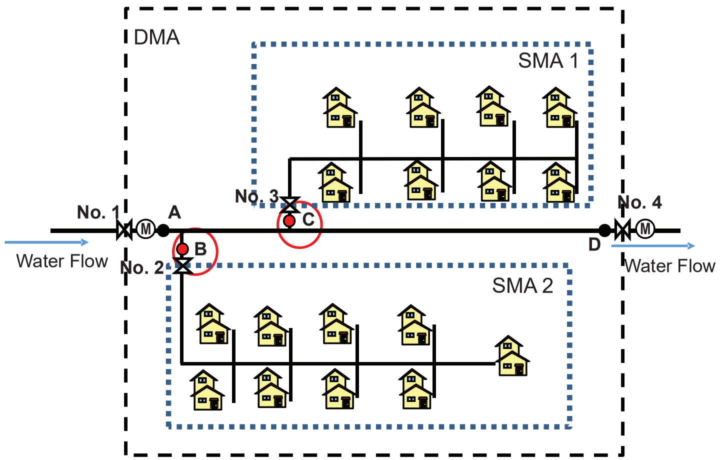
(a big buttery is needed)

- To record the start/end time and date.
- To connect ultrasonic flow meter to outer battery.
- Meter settings refer to handling manual.
- In case of single inlet DMA, measured value at inlet point is input volume of DMA
- In case of multiple inlets DMA, the total volume of multiple inlet points is input volume of DMA.
- In case of cascading DMA, the total inlet volume minus total outlet volume is input volume of DMA.
- After one week, stop and remove ultrasonic flow meter and get data by plugging in USB memory to the device.
- To plug in USB flash memory to PC and get data (excel file)
- To calculate average of one-hour input volume using one-week input volume for calculation of water balance analysis.

c. Measurement 24-hour input volume: Staff of distribution in Area Office

It is necessary to measure input volume of DMA (PMA) and SMA. Because, we should identify inlet volume to each SMA so that water balance of each SMA can be known. And, we can know minimum night flow of DMA and SMAs. The minimum night flow volume is expected to be leakage volume. Necessary procedure is as follows:

- To set ultrasonic flow meter at all inlet points and outlet points of DMA same as “b. Measurement of one-week input volume”. (Fig.4-1 Setting Points of Ultrasonic Flow Meter: point A and D)
- To set ultrasonic flow meter at inlet points of each SMAs (Fig.4-3 Setting Points of Ultrasonic Flow Meter: point B and C)



Legend: Ⓜ Meter ⋈ Valve ● Ultrasonic Flow ● Meter Setting Point

Fig.4-3 Setting Points of Ultrasonic Flow Meter

- The ultrasonic flow meter needs a big outer buttery to measure one-week water flow.
- To connect ultrasonic flow meter to outer battery.
- Meter setting refer to handling manual.
- To record the start/end time and date.
- After 24-hours, stop and remove ultrasonic flow meter and get data by plugging in USB memory to the device.
- To plug in USB memory to PC and get data (excel file)
- To calculate average of one-hour input volume using one-week input volume for calculation of water balance analysis.
- They are input volume of DMA and SMAs.
- To check the minimum value of DMA and SMAs. They are expected to be each leakage volume.

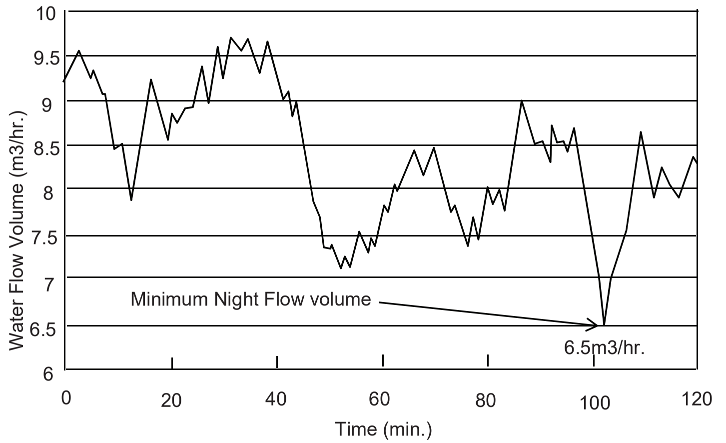


Fig. 4-4 Minimum Night Flow Measurement

d. Step Test: Staff of Area office and Head Quarter

Step test is used for grasp leakage volume in each SMA or pipeline instead of 24-hour input volume measuring. Step test is done at night time when water consumption is expected to be minimum use. Necessary procedure is as follows:

- To set ultrasonic flow meter at all inlet points and outlet points of DMA same as "b. Measurement of one-week input volume". (Fig.4-5 Setting Points of Ultrasonic Flow Meter: point A and D)
- Water flow volume at point A is inlet of DMA and passing volume to other areas.
- Water flow volume at point D is passing volume to other areas.
- The volume at point A minus at point D is input volume to DMA.

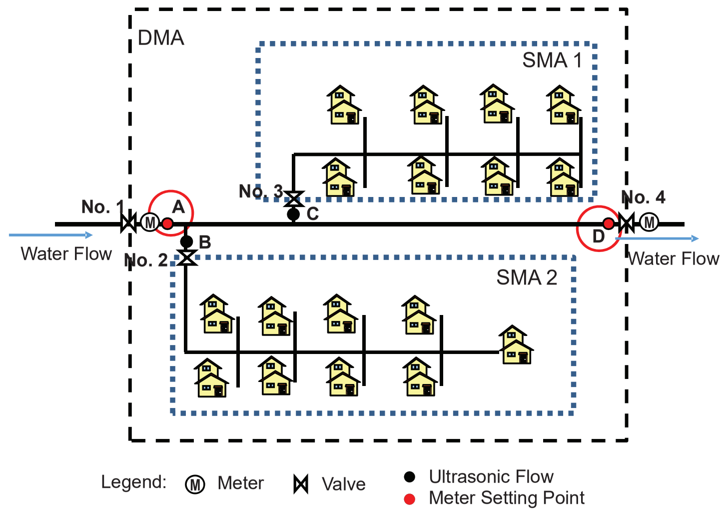


Fig.4-5 Setting Points of Ultrasonic Flow Meter

- To start ultrasonic flow meter for measuring water flow and set logging data.
- To close valve no. 2 and measure water flow volume in 5 minutes.
- Decreased water volume from DMA input volume is expected to be leakage volume at SMA 1.
- To close valve no. 3 and measure water flow in 5 minutes.
- Decreased water volume from DMA input volume is expected to be leakage volume at SMA 2.
- To measure water flow volume at A point and D point.
- The volume at A minus at B is leakage on the main distribution pipeline between A and D.
- To open vale no. 3 and measure water flow in 5 minutes.
- Increased water volume from DMA input volume is expected to be leakage volume at SMA 2.
- To open valve no. 2 and measure water flow in 5 minutes.
- Increased water volume from DMA input volume is expected to be leakage volume at SMA 1.
- To make a report of result from step test.

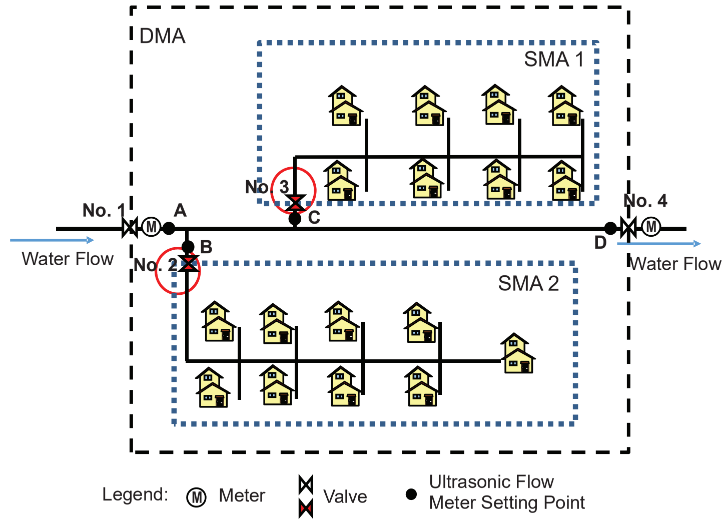


Fig.4-5 Operation Valves

5 Water balance analysis

5.1 Water balance analysis

When we consider reducing NRW, it is very important to know its components. Water balance analysis shows which components should be reduced for NRW reduction. International Water Association (IWA) has a water balance analysis sheet.

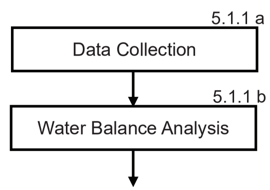


Fig. 5-1 Flow Chart of Water Balance Analysis

Table 5-1 IWA Water Balance Table

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Un-Metered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Un-Metered Consumption	
	Water Losses	Apparent Losses (Commercial Losses)	Unauthorized Consumption	
			Customer Meter Inaccuracies and Data Handling Errors	
		Real Losses (Physical Losses)	Leakage in Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Point of Customer Metering	

Table 5-2 Definition of Water Balance Components

Water Balance Components	Definition
System Input Volume	The annual volume input to the water supply system
Authorized Consumption	The annual volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are authorized to do so
Water Losses	The difference between System Input volume and Authorized Consumption, consisting of Apparent Losses Plus Real Losses
Apparent Losses	Unauthorized Consumption, all types of metering inaccuracies and systematic data handling errors
Real Losses	The annual volumes lost through all types of leaks, breaks and overflows on mains, service reservoirs and service connections, up to the point of customer metering
Revenue Water	Those components of System Input Volume which are billed and produce revenue
Non-Revenue Water (NRW)	The difference between System Input Volume and Billed Authorized Consumption

5.1.1 Procedure

a. Data collection: Commerce staff at the HQ and Area Office, Distribution staff at Area Office

Data collection procedure is already explained above chapter. In this chapter, we will discuss which data is used in the component of water balance analysis. Necessary procedure is as follows:

- Usually annual data of "2.1.1 c. Preparation of customer list in DMA and data of annual water consumption" is used for the component "Billed Metered

Consumption" and "Billed Un-Metered Consumption".

- But in the NRW Reduction activities, data of "4.1.1 a. One-week interval meter reading" is used for the component "Billed Metered Consumption" and "Billed Un-Metered Consumption". Because, we must know consumption compare before and after NRW reduction activities.

Table 5-3 Water Balance Analysis Sheet

System Input Volume	Revenue Water	Billed Authorized Consumption	Billed Metered Consumption	
			Billed Un-metered Consumption	Flat rate tariff converted to metered volume
	Non-Revenue Water (NRW)			Excess use of Flat rate
		Unbilled Authorized Consumption	Unbilled Un-Metered Consumption	
		Commercial Losses	Customer Meter Inaccuracies	
			Illegal Connection	
			Unidentified Consumption	
		Physical Losses		
			Leakage	

a-1 Billed Metered Consumption

- "Billed Metered Consumption" is conventional metered consumption, AMR metered consumption and prepaid metered consumption in FCTWB.

a-2 Billed Un-Metered Consumption

- "Billed Un-Metered Consumption" is flat rate consumption in FCTWB.
- Consumption of flat rate customer should be divided two portions. One is flat rate tariff converted to metered volume. The other one is excess use of it.
- The flat rate tariff in terms of metered volume is revenue water volume.
- Excess use of flat rate is non-revenue water volume.

a-3 Unbilled Metered Consumption

- Usually this component is settlement of water rate when water utility supply dirty water to customers after construction of leakage repair work, the customer complains about that and the water charge is settled by negotiation.
- Its volume is very small part of water balance. It is almost 0%.

a-4 Unbilled Un-Metered Consumption

- This component is water volume used by water utilities such as flash water after

- pipe laying work, pipe replacement work and leakage repair work
- Consumption at religious facilities, staff houses and facilities which authorized by welfare policy in FCTWB, should be metered.

a-5 Unauthorized Consumption

- This component is illegal water use (illegal connection) and unidentified water volume.
- In this manual, this component is separate illegal water use (illegal connection) and unidentified water volume.

a-6 Customer Meter inaccuracies and Data Handling Errors

- Data of "2.1.1 c. Meter error test" is used for the component "Customer meter inaccuracy".
- Volume of data handling error is very small part of water balance. It is almost 0%.

a-7 Leakage in transmission and Distribution Mains

- In case of analysis for total system, this component is used.
- In case of analysis for DMA, leakage of distribution is used

a-8 Leakage and Overflows at Utility's Storage Tanks

- In case of analysis for total system, this component is used.
- In case of analysis for DMA, there is no Utility's Storage tank.

a-9 Leakage on Service connections up to point of Customer metering

- Most of leakages occur at service connections.
- Leakage survey should be done at service connections.

a-10 Components used for water balance analysis of NRW reduction activities

- In the activities, water balance sheet should be simple like below. Because some of components are small volume compare to total volume.

b. Water Balance Analysis

Water balance analysis is calculated using collecting data which is collected above mentioned procedure. The water balance analysis is explained by example data. One day's water volume is used for the analysis. Example procedure is as follows:

Table 5-4 Water Balance Analysis (m3/day)

1 System Input Volume	4 Revenue Water	Billed Authorized Consumption	Billed Metered Consumption	2
			Billed Un-metered Consumption	3 Flat rate tariff converted to metered volume
				7 Excess use of Flat rate
	5 Non-Revenue Water (NRW) 6 (NRW Rate)	Unbilled Authorized Consumption	Unbilled Un-Metered Consumption	8
		Commercial Losses	Customer Meter Inaccuracies	9
			Illegal Connection	10
			Unidentified Consumption	12
		Physical Losses	Leakage	11

b-1 System input volume

- Total volume by one-week input volume (4.1.1 b.) = 22,554m3
- 22,554m3 is total volume of 7days
- System input volume is 3,222m3/day. (22,554m3 / 7days = 3,222m3/day) 1

b-2 Billed metered consumption

- Billed metered consumption consists of conventional and prepaid customer.
- The volume of one-week interval meter reading (4.1.1 a.9) is used for billed consumption.
- The data should be completed. So, that water balance analysis is accurate.
- Even if you make effort to get all data, some customer's meter is not able to be read, consumption of meter unread customer is estimated by average consumption of meter read customer.

b-2-1 Domestic customer

- Number of meter read customers is 424

- Their total consumption is 4,970m3/day
- One day' volume is 710m3/day
- Average consumption volume of meter read domestic customer is 1.67m3/day (710m3/day / 424 = 1.67m3/day) 13
- Number of meter unread customer is 352
- Total Consumption of Meter Unread Customer is 587.84m3/day. (1.67m3/day x 352 = 587.84m3/day) 14

b-2-2 Commercial customer

- Number of meter read customers is 8
- Their total consumption is 20.26m3/day
- Average consumption volume of meter read commercial customer is 2.53m3/day (20.26m3/day / 8 = 2.53m3/day) 15
- Number of meter unread customer is 10
- Total Consumption of Meter Unread Customer is 25.3m3/day. (10 x 2.53m3/day = 25.3m3/day) 16

- Total volume of Billed Meted Customer is 1,343.40m3/day (710 + 587.84 + 20.26 + 25.3 = 1,343.40m3/day) 2

Table 5-5 Water Volume of Billed Metered Consumption

(m3/day)

Categories			Number of customers	Volume
Billed Metered Consumption	Domestic	meter read	424	710
		average volume of meter read	---	13 (1.67)
		meter unread	352	14 587.84
	Commercial	meter read	8	20.26
		average volume of meter read	---	15 (2.53)
		meter unread	10	16 25.30
	Total			2 1,343.40

b-3 Billed un-metered consumption (flat rate)

- Billed un-metered consumption is flat rate.

b-3-1 Conventional

- Conventional customer's flat rate tariff is 5,500N/month

- Metered tariff is 80N/m3
- It is converted to metered volume is 68.75m3/month. (5,500N/month / 80N/m3 = 68.75m3/month)
- It's one day's volume is 2.26m3/day. (68.75m3/month x 12month / 365days/month = 2.26m3/day)
- Excess from 2.26m3/day becomes commercial loss
- Number of Conventional flat rate customer is 10.
- Total volume of conventional flat rate converted to metered volume is 22.6m3/day. (2.26m3/day x 10 =22.6m3/day) 17

b-3-2 Prepaid

- Prepaid customer's flat rate tariff is 3,000N/month
- Metered tariff is 80N/m3
- It is converted to metered volume is 37.5m3/month. (3,000N/month / 80N/m3 = 37.5m3/month)
- It's one day's volume is 1.23m3/day. (37.5m3/month x 12month / 365days/month = 1.23m3/day)
- Excess from 1.23m3/day becomes commercial loss
- Number of Conventional flat rate customer is 54.
- Total volume of conventional flat rate converted to metered volume is 66.42m3/day. (1.23m3/day x 54 = 66.42m3/day) 18

b-3-3 Major Consumer

- Major consumer's flat rate tariff is 78,000N/month
- Metered tariff is 150N/m3
- It is converted to metered volume is 520m3/month. (7,800N/month / 150N/m3 = 520m3/month)
- It's one day's volume is 17.10m3/day. (520m3/month x 12month / 365days/month = 17.10m3/day)
- Excess from 17.10m3/day becomes commercial loss
- Number of major flat rate customer is 1.
- Total volume of conventional flat rate converted to metered volume is 17.10m3/day. (17.10m3/day x 1 = 17.10m3/day) 19

- Total volume of Billed Un-Meted Customer which is converted to metered volume is 106.12m3/day (722.6 + 66.42 + 17.1 = 106.12m3/day) 3

Table 5-6 Water Volume of Billed Un-Metered Consumption

(m3/day)

Categories			Number of customers	Volume
Billed Unmetered Consumption	Flat Rate	conventional	10	17 22.6
		prepaid	54	18 66.42
		major	1	19 17.1
	Total			3 106.12

b-4 Revenue water

- Billed metered consumption is 1,343.40m3/day. 2
- Billed un-metered consumption is 106.12m3/day. 3
- Revenue water volume is 1,449.52m3/day. (1,343.40 + 106.12 = 1,449.52m3/day) 4

b-5 Non-Revenue water

- System input volume is 3,222m3/day. 1
- Revenue water volume is 1,430.52m3/day. 4
- Non-Revenue water volume is 1,772.48m3/day. (3,222 – 1449.52 = 1,772.48m3/day) 5
- Non-revenue water rate is 55.01%. (1,772.48 / 3222 x 100 = 55.01%) 6

b-6 Excess use of flat rate

- Consumption volume of one week temporally meter reading (3.1.1 d.) is 284.2m3.
- Number of temporally meter is 10.
- The average consumption volume of temporally meter reading is 4.06m3/day. (284.2m3 / 10 / 7days = 4.06m3/day)

b-6-1 Excess use of conventional flat rate

- One day's volume converted to metered consumption is 2.26m3/day.
- Excess use volume of conventional flat rate customer is 1.8m3/day. (4.06 – 2.26 = 1.8m3/day)
- Number of conventional flat rate customer is 10.
- Total excess volume of conventional flat rate customer is 18.0m3/day. (1.8m3/day x 10 = 18.0m3/day)

b-6-2 Excess use of prepaid flat rate

- One day's volume converted to metered consumption is 1.23m3/day.
- Excess use volume of prepaid flat rate customer is 2.83m3/day. (4.06 – 1.23 = 2.83m3/day)
- Number of prepaid flat rate customer is 54.
- Total excess volume of prepaid flat rate customer is 18.0m3/day. (2.83m3/day x 54 = 152.82m3/day)

- Total excess use volume of flat rate is 170.82m3/day (18.0 + 152.82 = 170.82m3/day) 7

b-7 Unbilled unmetered consumption (authorized)

- Consumption at religious facilities, staff houses and facilities which authorized by welfare policy in FCTWB. They should be metered.
- Before meter installing, their consumption volume is estimated.
- There is one small church and 9 staff houses.
- Their consumption should be estimated same volume to domestic average consumption.
- Average consumption volume of domestic customer is 1.67m3/day. 13
- Total estimated water consumption is 16.7m3/day. (1.67m3/day x (1+ 9) = 16.7m3/day) 8

b-8 Customer meter inaccuracy

Table 5-7 Result of Meter Error Test

Items	Number of Samples	%
Allowable Errored Meter (in +-4% error)	72	54.1
Over 4% Errored Meter	32	24.1
Under -4% Errored Meter	29	21.8
Total	133	100
Average of Error Percentage	20 -1.54%	

- Result of meter error test (3.1.1 c.) is as follows:
- Average actual meter error is NRW.
- Allowable error of using meter is 4%. (ISO Standard)
- Actual Number of tested meter is 133 (95% reliable number of statistics is about 400 for total meter number of FCTWB. 400 / 3 = 133)

b-8-1 Average of total error Percentage

- To calculate total volume of customer's meter reading.
- To calculate total volume of test meter reading.
- Total volume of customer's meter reading is 13,245.5m3/day.
- Total volume of test meter reading is 13,453.1m3/day.
- Average of total error percentage is minus 1.54%. ((13,245.5 - 13,453.1) / 13,453.1 x 100 = -1.54%) (20)

b-8-2 Volume of customer meter inaccuracies

- Meter inaccuracies are related to total measured consumption.
- Total measured consumption consists of Billed Metered Consumption, Billed Unmetered Consumption, excess of Billed Unmetered Consumption and Unbilled Authorized Consumption.
- Billed metered consumption is 1,343.40m3/day. (2)
- Billed un-metered consumption is 106.12m3/day.(3)
- Excess use volume of flat rate is 170.82m3/day. (7)
- Unbilled unmetered consumption is 16.7m3/day. (8)
- Total target volume of meter inaccuracies is 1,637.04m3/day. (1,343.40 + 106.12 + 170.82 + 16.7 = 1,637.12m3/day)
- Average of total error percentage is minus 1.54%. (20)
- Volume of customer meter inaccuracies is 25.21m3/day. (1,637.04 x 1.54 / 100 = 25.21m3/day) (9)

b-9 Illegal connection

- Actual consumption of illegal connection is not able to be measured.
- Consumption of illegal connection should be estimated.
- Consumption of illegal connection for domestic use is estimated same as average consumption.
- The average of illegal connection customer's meter reading is 0.5 m3/day.
- The difference volume between average consumption and meter read volume should be added.
- Average consumption volume of domestic customer is 1.67m3/day. (13)
- The deference volume is 1.17m3/day. (1.67 – 0.5 = 1.17m3/day)
- There are 10 illegal connections for domestic use.
- Added consumption volume for domestic use is 11.7m3/day. (1.17m3/day x 10 = 11.7m3/day)

- There is one illegal connection for commercial use.
- Average consumption volume of meter reading commercial customer is 2.53m3/day
- The average of illegal connection customer's meter reading is 0.5m3/day.
- The deference volume is 2.03m3/day. (2.53 – 0.5 = 2.03m3/day)
- Added consumption volume for commercial use is 2.03m3/day. (2.03m3/day x 1 = 2.03m3/day)
- The total volume of Illegal connection is 13.73m3/day. (11.7 + 2.03 = 13.73m3/day) (10)

b-10 Leakage

- When leakage is found, leakage volume should be measured by measuring device.
- The deference in volume of minimum night flow between baseline and after leakage repair is estimated as leakage volume.
- The volume of baseline minimum night flow is 64.42m3/hr.
- The volume of baseline minimum night flow converted to day volume is 1,546.08m3/day. (64.42m3/day x 24hr. = 1,546.08m3/day)
- The volume of minimum night flow after leakage repair is 44.42m3/hr.
- The volume of minimum night flow after leakage repair converted to day volume is 960.0m3/day. (44.42m3/hr. x 24hr. = 1,066.08m3/day)
- The deference volume of minimum night flow between baseline and after leakage repair is 480m3/day. (1,546.08 – 1,066.08 = 480m3/day)
- The volume of leakage is 480m3/day. (11)

b-11 The volume of unidentified consumption

- The volume of unidentified consumption is the rest of other components of non-revenue water volume.
- The volume of unidentified consumption is 1,066.02m3/day. (1,772.48 – 170.82 -16.7 – 25.21 – 13.73 – 480 = 1,066.02m3/day) (12)

b-12 The volume of components for water balance analysis

- System input volume is 3,222m3/day. (1)
- Billed metered consumption is 1,343.40m3/day. (2)
- Billed un-metered consumption is 106.12m3/day. (3)

- Revenue water volume is 1,430.52m3/day. 4
- Non-Revenue water volume is 1,772.48m3/day. 5
- Non-revenue water rate is 55.01%. 6
- Excess use volume of flat rate is 170.82m3/day. 7
- Unbilled unmetered consumption is 16.7m3/day. 8
- Volume of customer meter inaccuracies is 25.21m3/day. 9
- The volume of Illegal connection is 13.73m3/day. 10
- The volume of leakage is 480m3/day. 11
- The volume of unidentified consumption is 1,066.02m3/day. 12
- The water balance analysis sheet is as follows:

Table 5-8 Water Balance Analysis (m3/day)

System Input Volume 1 3,222	Revenue Water 4 1,430.52	Billed Authorized Consumption	Billed Metered Consumption	2 1,343.40
			Billed Un-metered Consumption	3 106.12
	Non-Revenue Water 5 (NRW) 1,772.48 (NRW Rate) 6 55.01%			7 170.82
		Unbilled Authorized Consumption	Unbilled Un-Metered Consumption	8 16.7
		Commercial Losses	Customer Meter Inaccuracies	9 25.21
			Illegal Connection	10 13.73
			Unidentified Consumption	12 1,066.02
		Physical Losses	Leakage	11 480

b-13 Study from the water balance analysis

- Flat Rate Customer use more water than customers charged be meter reading.
- Average of customer inaccuracies is not so high in the DMA. But its value is minus, it means non-revenue water.
- About 46% of meter are inaccurate in the DMA
- Exceeded standard value errored meter must be changed.
- The Volume of unidentified consumption and illegal connection is very high. It's about 70 % of non-revenue water. There might be many illegal connections. Therefore, illegal connection survey should be continued.
- The volume of minimum night flow is very high. Therefore, 24 hours' water flow measurement should be done to know trend of water usage.

6 Leakage Survey

Leakage survey is very important measure to reduce NRW. The purpose of leakage survey is to prevent caving in road and to reduce NRW which can be used for new water resources. There are three types of leakage survey methods. The first one is point survey. Second one is line survey. Third one is area survey. Usually, the point leakage survey and the line leakage survey methods are adopted. The information from leakage survey, combined with other information such as record of leakage, pipe materials, pipe age, is utilize for making pipe replacement plan and leakage survey plan. Refer to Annex "Leakage Detection Technology" for details of leakage survey.

6.1 Leakage survey method

Leakage survey should be carried out in structured and systematic way.

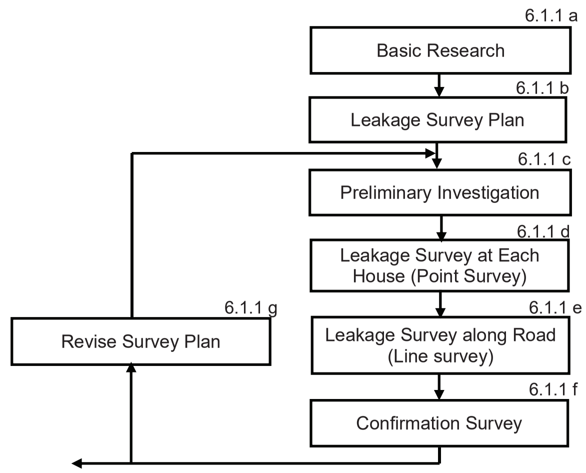


Fig. 6-1 Flow Chart of Leakage Survey

6.1.1 Procedure

Leakage survey should be carried out in structured and systematic way.

a. Basic Research: Distribution staff at the HQ and Area Office

Basic research is water balance analysis (5.1.1). Study of water balance analysis

(5.1.1 b-12) is utilized for leakage survey plan.

- To analyze water balance.
- To grasp and analyze volume of leakage.

b. Leakage Survey Plan: Manager and distribution manager at area office
Leakage survey should be implemented follow the leakage survey plan. Necessary procedure is as follows:

- To plan survey area, survey methods, number of survey teams.
- To consider frequency of leakage occurrence, pipe materials, pipe age, NRW rate.
- Frequency of leakage occurrence: The area where many leakages occurred should be given priority.
- Pipe materials: weak materials such as: galvanized steel pipe, asbestos cement pipe, PVC and pipe materials which occur leakage many times. They should be considered to be given priority to survey.
- Pipe age: Old pipeline should be considered to be given priority to survey.
- NRW rate: High NRW rate area should be given the first priority.
- By step test of each SMA, the SMA with the highest NRW rate should be given top priority to survey and repair.
- Other SMAs also should be surveyed after top priority.

c. Preliminary Investigation: Distribution staff at area office
Before leakage survey, it is necessary to confirm site condition. Necessary procedure is as follows:

- To go to the site and confirm differences between the site and pipe line map (GIS).
- To confirm pipe materials, pipe laying depth, terrain and existence of obstacles for survey.

d. Leakage Survey at Each House (Point Survey): Distribution staff at area office
Many leakages occur at service connections. Point survey can detect service pipe line and also distribution line. The acoustic bar is used for point survey to hear leak noise. Necessary procedure is as follows:

- To visit customer's house and inform the customer the purpose of leakage survey and get permission to get in the property and check meter and stop valve.
- To hear leak noise at customer's meter or stop valve using an acoustic bar or an electro listening stick.
- To stop valve and hear the noise again when the leak noise is detected, if leak noise stops, leakage occurs after stop valve. If the leak noise continues, leak occurs before stop valve.
- At same time, to observe around the meter and confirm existence of illegal connection. (3.1.1 b.)
- When leakage is found, to measure leakage volume using measuring device and repair the leakage.

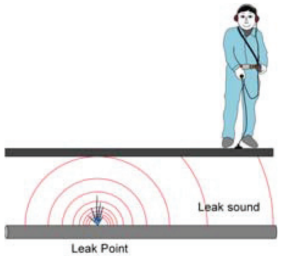

Acoustic Rod (Listening Stick)


Electro Listening Stick

Fig. 6-1 Devices for Point Survey

e. Leakage Survey along Road (Line survey): Distribution staff at area office
It is necessary to survey on the road for detecting leakage on distribution pipeline survey using a leak detector (ground microphone). Necessary procedure is as follows:

- To hear leak noise on the road using a leak detector.
- To walk along pipeline, stop and touch ground microphone on the surface of the ground about 5 seconds and hear the noise at every step.
- When leak noise is detected, mark the point on the ground and write report about the place.
- After checking leakage by confirmation survey, measure leakage volume and repair leakage.



Leak Detector (Ground Microphone) Image of Listening Leak Sound

Fig. 6-2 Devices for Line Survey and It's Image

f. Confirmation survey: Distribution staff at area office

After door to door noise hearing survey and road surface noise hearing survey, confirm leakage point by digging a hole using earth drill. Necessary procedure is as follows:

- To make a hole at the point where leakage is detected using earth drill.
- To check the hole which is dug by earth drill whether clean water is attached to the earth drill or not
- If clean water is attached to earth drill, there is a leakage at the point.
- To dig and measure leakage volume and repair leakage.

g. Revise survey plan: Distribution staff at area office

After leakage survey activities, much information is grasped. That information should be utilized to revise survey plan. Necessary procedure is as follows:

- To analyze information that grasped from leakage survey.
- Information about pipe condition, result of survey area and pipe surrounding are used for revising survey plan.
- Utilization of information from leakage survey is as follows.

Table 7-1 Utilization of Information from Leakage Survey

Utilization of Information from Leakage Survey		
Purpose	Necessary Information	Methods
Revise of Leakage Survey Plan	・ All information	To confirm whether the GIS information is utilized or not for O&M and review the information revising method and providing method
Basic information for replacement plan and repair plan	・ Information about pipe condition ・ Information about result of survey area	On the information about pipe and fittings, surrounding of laying pipe and leakage condition, to reflect their information for judgement of priority of repair and replacement plan
Revise of information of GIS and pipe drawings	・ Information of location ・ Information of pipeline ・ Information of pipe surrounding	To confirm the information about pipe network map and GIS, and revise them if necessary

h. Record of leakage survey: Distribution staff at area office

It is necessary to make a leakage survey report for revising survey plan, making pipe replacement plan and O&M. Necessary items for report are as follows:

- Location: address, name
- Category of facilities: trunk main pipeline, distribution pipeline, service pipeline
- Category of road: public road, private road, in property
- Road surface condition: asphalt, concrete, soil, others
- Pipe information: pipe material, pipe diameter, pipe laying year
- Estimated leakage volume
- Location map, plan drawing, photo

7 Measure to reduce NRW

By above mentioned activities, we can know the target of NRW reduction. If we don't take countermeasures against NRW, NRW will increase year by year. Even we take countermeasures against NRW, when we stop them, NRW will increase again. We have to continue NRW reduction activities.

7.1 Countermeasure method

It is important to know the target which is more efficient to reduce NRW in DMA and

SMAs.

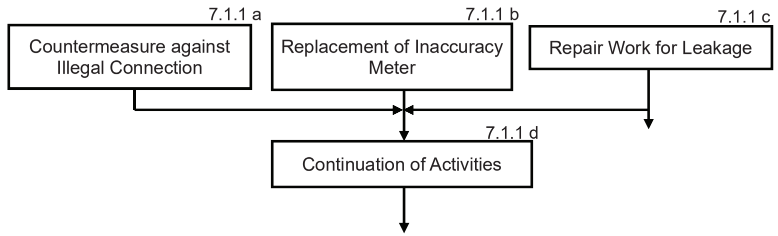


Fig. 7-1 Flow Chart of Measure to reduce NRW

7.1.1 Procedure

a. Countermeasure against Illegal connection: Commerce and distribution staff at the HQ and Area Office

- To inform and make the illegal user to confirm there is an illegal connection or illegal use.
- To disconnect an illegal connection after confirmation by illegal user.
- To consider penalty for illegal water use.
- To contract with the illegal user, if there is no contract with the illegal user.
- To continue checking water consumption of illegal user every month.

b. Replacement of inaccuracy meter: Distribution staff at the HQ and Area Office
Inaccuracy meter is explained in “3.1.1 c Meter error test”. Necessary procedure is as follows:

- Inaccuracy meter is not justice in terms of trading.
- Allowable using meter error range is plus minus 4% on International Waterworks Association (IWA) standard.
- There are many meters which error is out of allowable using meter error range.
- At the first step, the meter which excess from plus minus 10% should be changed.
- When meters are procured, they have to be checked meter error by test meter.

c. Repair Work for Leakage: Distribution staff at the HQ and Area Office Necessary procedure is as follows:

- To repair leakage after confirmation of pipe condition and leakage volume.

- To make pipe joint (spigot and pipe end) to clean and to dry, when adhesive is used for jointing. And also, to make gasket and joint to clean, when gasket is used for sealing.
- To wash out dirty water of repaired pipeline

d. Continuation of activities: commerce and distribution staff at the HQ and Area Office
Most important matter to reduce NRW is to continue NRW reduction activities. If it is not continued, NRW ratio will be raise again. Necessary procedure is as follows:

- To continue activities for NRW reduction.
- To make a plan to continue NRW reduction activities such as: Meter error test and replacement of inaccuracy meter, Illegal connection survey and measure against illegal connection and Leakage survey and repair work for leakage..

8 Water Consumption Measurements after countermeasure

After taking countermeasure against NRW, it is necessary to measure water consumption in DMA and SMAs again and compare values before and after countermeasure.

8.1 Methods of water Consumption Measurements Method after countermeasure

Same method to “4.1 Methods of water consumption measurements”.

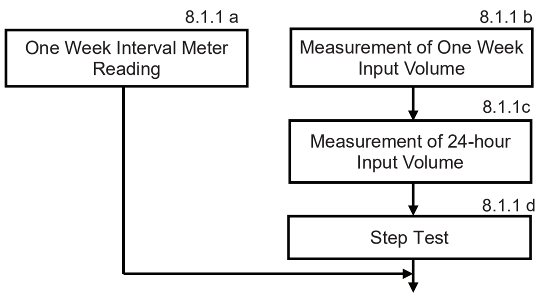


Fig. 8-1 Flow Chart of Water Consumption Measurements

8.1.1 Procedure

a. One week interval meter reading
The procedure is same to “4.1.1 a. One-week interval meter reading”.

b. Measurement of one week input volume

The procedure is same to “4.1.1 b. Measurement of one-week input volume “.

c. Measurement 24-hour input volume
The procedure is same to “4.1.1 c. Measurement 24-hour input volume “.

d. Step test
The procedure is same to “4.1.1 d.”

9 Water balance analysis after countermeasure

After taking countermeasure against NRW, it is necessary to analysis water balance of DMA and SMAs again and compares values before and after countermeasure.

9.1 Methods of water balance analysis after countermeasure

Same method to “5.1Water balance analysis”.

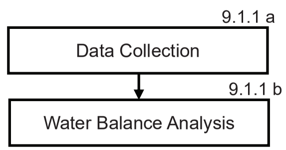


Fig. 9-1 Flow Chart of Water Balance Analysis

9.1.1 Procedure

a. Data collection
The procedure is same to “5.1.1 a. Data collection”.

b. Water balance analysis
The procedure is same to “5.1.1 b. Water balance analysis

10 Patrols of Surface Leakage and Illegal Connections

Even there are no leakage detection devices; it is possible to reduce NRW. Patrol of surface leakage and illegal connections are also important and effective methods to reduce NRW.

10.1 Patrols of Surface Leakage and Illegal Connections Methods

Patrols of surface leakage and illegal connections should be done systematically and regularly (once a week). Patrol should be done by a team (two or three person). Patrol should be done on foot and carry network drawings.

10.1.1 Procedure

a. Surface leakage: Distribution staff at Area Office.

- To make a plan and schedule of patrol area
- To prepare pipeline network drawings.
- To patrol and observe surface of road and check the pipeline drawings.
- To mark the leakage place on the pipeline drawings, when surface leakage is found.
- To make a report of patrol.

b. Illegal connections: Distribution staff and commercial staff at Area Office.

- To observe along the boundary of each house whether unusual pipe is exists or not, when distribution staff observes surface leakage on the road.
- To observe surroundings of meter carefully weather unusual pipe is connected to service pipeline or not, when a meter reader reads meter every month.
- To report the area manager results of observation.
- To check unusual pipe whether it is illegal connection or not by digging surround of it.

11 Basic Data for future Plan

For making future plan (pipe replacement plan), it is important to collect data to prioritize pipelines for replacement. We can get much information by analysis of leakage repair reports.

11.1 Methods of using basic data for future plan

It is necessary to analyze information on leakage repair reports such as: leakage area, pipe age, pipe materials, leakage part of pipeline, circumstance of pipe lying and leakage condition.

11.1.1 Procedure

a. Data Collection and Summarize: Distribution Staff of Area Office and HQ.
Necessary procedure is as follows:
- To submit leakage reports to the area manager.

- To mark leakage place and write leakage repair report number on the pipeline network map.
- To summarize data on leakage reports and categorize them by area manager.
- To submit summarized and categorized data to HQ.

b. Data Analysis: Distribution staff of HQ.
Necessary procedure is as follows:

- To make evaluation items as follows:
  - ✓ Number of Leaks and Bursts per kilometer by (pipeline length)
  - ✓ Number of Leaks and Bursts in each area
  - ✓ Number of Leaks and Bursts by each pipe material (per kilometer)
  - ✓ Number of Leaks and Bursts by each pipe laid year (per kilometer)
  - ✓ Number of Leaks and burst by each fitting

12 Revising GIS Data

GIS data (distribution network drawings and customer maps) should be updated at least every year.

12.1 Methods of GIS Data Revising

Area offices have to submit pipeline data that is changed, replaced, unregistered to GIS and repaired to HQ. And also area offices have to submit customer data that is changed on customer map to HQ. GIS unit have to update GIS data.

12.1.1 Procedure

a. Data Collection and Submission: Distribution and Commercial Staff of Area Office and HQ.
Necessary procedure is as follows:

- About customer data explained in “2.1.1 c-1 Customer Map”
- To submit information about pipelines which is changed from the distribution drawings to HQ.

b. Revising GIS Data: GIS Unit
Necessary procedure is as follows:
- To revise (update) GIS data that submitted from area offices

- To print and distribute copy of updated distribution drawings and customer maps.

13 Pipe Replacement Plan

Pipe replacement plan should be considered data on leakage repair report as follows: Pipeline on which leaks occur frequently: because cause of leaks is considered to be pipe material or poor plumber's skill. Pipeline on which leaks occur at pipe body: because cause of leaks is considered to be pipe material. It is also important to consider evaluation items explained in "11.1.1 b Data Analysis" for making the plan.

13.1 Methods of making Pipe Replacement Plan

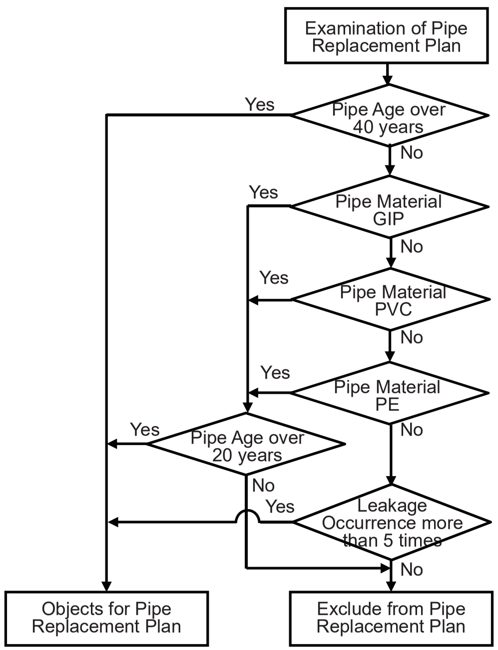


Fig. 13-1 Flow Chart of Pipe Replacement Plan

13.1.1 Procedure

a. Prioritize pipe replacement: Distribution Staff of HQ.
   Necessary procedure is as follows:

   - To compare each evaluation items explained in "11.1.1 b data analysis"
   - To prioritize pipelines which has higher number of evaluation items to be replaced

b. Objects for pipe replacement plan: distribution Staff of HQ
   Necessary procedure is as follows:

   - To confirm pipeline age. When it is over 40 years, the pipeline is object for pipe replacement.
   - To confirm pipe line material. When it is Galvanized Steel, Poly Vinyl Chloride and Polyethylene (low density or middle density) and age of pipeline is over 20 years, the pipeline is object for pipe replacement.
   - To confirm frequency of leakage and burst on same pipeline. When it is over 5 times, the pipeline is object for pipe replacement.

Annex (Manual for Action Team)

Annex-1

Manual for Commerce (Action Team)

Index

1.1.1 Procedure

e. Conventional Meter

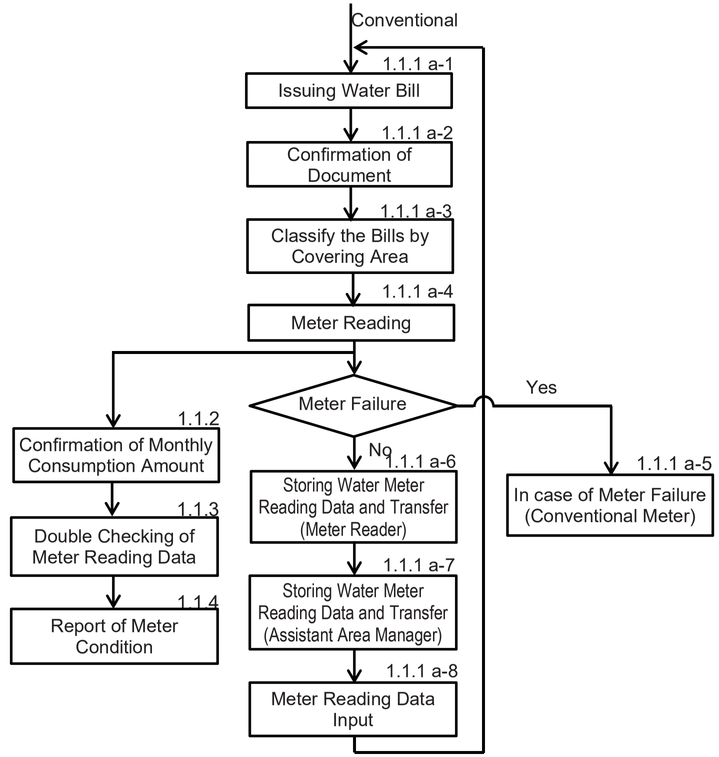
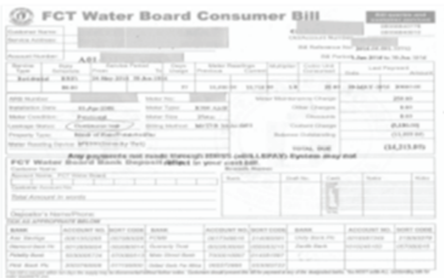


Fig. 1-2 Flow Chart of Conventional Meter Reading

a-1 Issuing Water Bill: Officer in charge at HQ

- The office makes “FCT Water Board Consumer Bill” shown as Fig. 1-3 in which, customer’s previous month’s consumption amount and water rate are written, and “Meter Reader’s Form” shown as Fig. 1-4 in which, customer’s previous month’s consumption is written and this month’s consumption will be calculated by filling in meter reading, and sends them to each area office.



FCT Water Board Consumer Bill

Fig. 1-3 FCT Water Board Consumer Bill

Fig. 1-5 Conventional Meter

Fig. 1-4 Meter Reader's Form

a-2 Confirmation of document: Assistant Area Manager of Commerce at Area Office:

- The assistant area manager checks the issued bill which is for his office and comparing the names on the list of "Meter Reading Record Book" and sends them to meter readers.

a-3 Classify the bills by covering area: Meter Readers at Area Office

- The meter reader collects "FCT Water Board Consumer Bill" within his covering areas and prepares distribution of bills to each customer.
- The meter reader prepares a "Hand Book" on which he/she fills in meter reading for reading water meter.

a-4 Meter Reading: "Procedures for Water Meter Reading": Meter Readers at Area Office

- In case the water meter is installed inside the premises, the meter reader informs the owners of the premise that it is the regular water meter reading of WB and enters into the premises. The meter reader must be careful of watchdogs.

Fig. 1-6 Meter Reading Record Book

- The meter reader reads meters installed inside or outside of the premises and records it in the "Hand Book"
- Check the number recorded on the "Hand Book" and value of the water meter by reading out.

- In case the meter reader confirms former month's consumption, calculate this month's consumption and compare both months' consumption. If there are big differences between this consumption, it shows that there is meter failure or leakage inside the house. The meter reader should inform the customers about the leakage and confirm the reason, and also report it to their office around that area and prompt countermeasure.
- Observe circumstance of the meter, meter condition, illegal connection etc.

a-5 In case of meter failure: Meter Readers at Area Office

- When water meter reading is not completed because of water meter failure, the meter reader should send back "Meter Reader's Form" to Billing Unit with blank [unfilled] at the present meter reading. Consumption amount of the customer will be calculated automatically as meter estimated at Billing Unit.

a-6 Storing water meter reading data and transfer (Meter reader): Meter Readers at Area Office

- The meter reader transfers meter reading data written in "Hand Book" to "Meter Reading Record Book"

a-7 Storing water meter reading data and transfer (Assistant area manager): Assistant Area Manager of Commerce at Area Office

- The assistant area manager transfers data of the meter reader's "Meter Reading Record Book" to "Meter Reader's Form" The assistant area manager calculates the meter reading difference of both month and determines the consumption amount.
- These data of "Meter Reading Record Book" should be stored in PC for improving efficiency.
- The assistant area manager should check abnormal (huge) differences in consumption.
- The original "Meter Reader's Form" will be sent to the office at WB in charge and carbon copy of it will be stored at the area office.
- The area office manager should check "Meter Reader's Form" if abnormal (huge) difference is recorded or not. If no abnormal record is found, the area office manager sends "Meter Reader's Form" to the office at WB in charge.

a-8 Meter reading data input: The staff of Billing Unit at HQ

- The staff of Billing Unit inputs the data of "Water Reader's Form" to PC. Monthly water consumption amount of each customer will be calculated automatically. Monthly water consumption amount of customer without meter reading or with the same meter reading as former month will be classified as "Estimate" and consumption amount will be calculated according to the last three month's customer's consumption.

f. Prepaid Meter

Prepaid

1.1.1 b-1

In case of Meter Failure (Prepaid Meter)

Fig. 1-7 Flow Chart of Prepaid Meter

Fig. 1-8 Prepaid Meter

Prepaid Meter system is not the required meter reading for determining water rate. <u>Prepaid Meter system is not the required meter reading for determining water rate but for counting consumption amount and checking meter condition, regular meter reading should be carried out.</u>

Fig. 1-9 User Card

The customer charges some amount of money to his special "User Card" for prepaid meter at bank, and charges the amount to his prepaid meter with the "User Card" at home. When consumption amount reaches the charged amount, the meter shuts water supply automatically.

b-1 In case of Meter Failure (Prepaid Meter): Prepaid meter unit at HQ

・ The water bill of customers with meter failure will be classified as Flat Rate.

① The meter reader checks and confirms the Bills in the area he/she is in charge of.

② The meter reader hands the bill to customer with the explanation that the bill is from Water Board.

【Meter Reading Flow】

① The meter reader copies customer data in the area he is in charge of to a flash memory from System Computer at AMR Meter Billing Unit and input the data to Meter Reading Device.

② The meter reader drives a vehicle along the planned route with the meter reading device and collects AMR Meter signals at every check points. Distance the communication signal from an AMR meter reaches is from 500m to 1,000m. The meter reader must confirm that all customers' data is collected after finishing data collection at every check point.

Fig. 1-9 AMR Meter Reading Device

③ If the meter reader finds out about any missing data, he goes to the meter with "Hand Held Device" and collects the missing data But If he fails to collect the data again in the meter, the meter will be classified as a faulty meter.

④ The meter reader transfers the collected data from the Meter Reading Device to the System Computer with the flash Memory.

Fig. 1-10 Hand Held Device

【In case of meter failure】

Water bill for the customer's meter failure will be classified as estimated.

1.1.2 Confirmation of monthly consumption amount

・ Abnormal (huge) big difference of monthly consumption amount, compared to the former month means meter failure or leakage. If the meter reader finds a big difference, he should report it to the customer and check the reason.

・ When the assistant area manager calculates consumption amount and compiles "Meter Reader's Form", he should try to find abnormal big difference in consumption amount of each customer.

1.1.3 Double checking of meter reading data

・ When the meter reader writes down the meter reading on his "Hand Book", he should read aloud and confirm the meter reading for preventing error in writing.

- When the assistant area manager posts meter reading from "Meter Reading Record Book" to "Meter Reader's Form", he should check for correction with other staff.

1.1.4 Report of Meter Condition

- Meter reading is the best opportunity for confirming meter condition. The meter reader should check condition of meter and surroundings at meter reading as follows. If he/she finds something wrong, he/she should report them to the area office.
- The area office should check the meter at the site and instruct improvement of installation of the meter to the customer or replace the meter.
- Make a report "Meter Inspection Sheet" shown as Table 1-1.

≪Surrounding condition of meter installation≫

- Is it easy to reach the meter and read the meter?
- ・Are there any obstacles on the meter box?
- Is there any abandoned rubbish on the meter manhole or meter box?
- Is structure of meter manhole or meter box preventing an inflow of rubbish from outside?

≪Condition of meter itself≫

- Is there any leak from joint or meter itself?
- Are there any stain or dirt on the inside surface of glass?
- Is rotation of pilot regular?
- Is indicator of volume regular?

- Prepaid Meter system was introduced to reduce water bill collection work (labor), but the achievement of the purpose is not so easy because meter failure occurs so many times.

g. AMR Meter

The meter reader does not read meter directly at the site. Meter reading of AMR meter is done by driving a vehicle within the supply area and collecting signal which AMR meter sends with radio wave. The duty of meter reading for AMR meter belongs to AMR section and the duty of "FCT Water Board Customer Bill" distribution to customer belongs to the area office.

Fig. 1-10 AMR Meter

Work flow for AMR meter section and the area office are as follows.

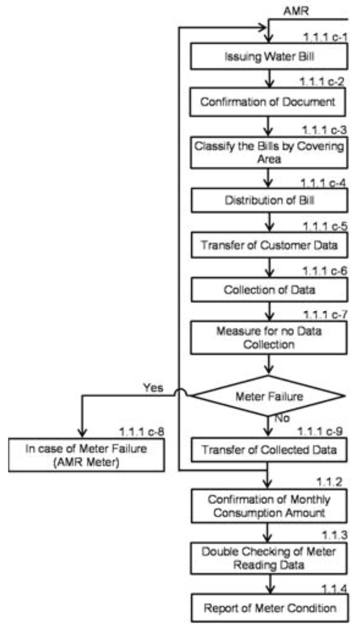


Fig. 1-11 Flow Chart of AMR Meter Reading

【Billing Flow】

c-1 Issue Bill: AMR Meter Billing Unit at HQ

・ AMR Meter Billing Unit; makes “FCT Water Board Customer Bill” and sends it to the area office.

c-2 Confirmation of Document: Assistant Area Manager of Commerce at Area Office

・ The Assistant Area Manager of Commerce checks the document sent from AMR Meter Billing Unit.

c-3 Classify the Bills by Covering Area: Meter Readers at Area Office

・ The meter reader checks and confirms the Bills in the area he/she is in charge of.

c-4 Distribution of Bill: Meter Readers at Area Office

・ The meter reader hands the bill to customer with the explanation that the bill is from Water Board.

・ Observe circumstance of the meter, meter condition, illegal connection etc.

【Meter Reading Flow】

c-5 Transfer of Customer Data: Meter Reader of AMR Billing Unit at HQ

・ The meter reader copies customer data in the area he is in charge of to a flash memory from System Computer at AMR Meter Billing Unit and input the data to Meter Reading Device.

Fig. 1-12 AMR Meter Reading Device

c-6 Collection of Data: Meter Reader of AMR Billing Unit at HQ

・ The meter reader drives a vehicle along the planned route with the meter reading device and collects AMR Meter signals at every check points. Distance the communication signal from an AMR meter reaches is from 500m to 1,000m. The meter reader must confirm that all customers' data is collected after finishing data collection at every check point.

Fig. 1-13 Hand Held Device

c-7 Measure for no Data Collection: Meter Reader of AMR Billing Unit at HQ

・ If the meter reader finds out about any missing data, he goes to the meter with “Hand Held Device” and collects the missing data But If he fails to collect the data again in the meter, the meter will be classified as a faulty meter.

c-8 In case of meter failure (AMR Meter): AMR Billing Unit at HQ

・ Water bill for the customer's meter failure will be classified as estimated.

c-9 Transfer of Collected Data: AMR Billing Unit at HQ

・ The meter reader transfers the collected data from the Meter Reading Device to the System Computer with the flash Memory.

1.1.5 Confirmation of monthly consumption amount

・ Abnormal (huge) big difference of monthly consumption amount, compared to the former month means meter failure or leakage. If the meter reader finds a big difference, he should report it to the customer and check the reason.

・ When the assistant area manager calculates consumption amount and compiles “Meter Reader's Form”, he should try to find abnormal big difference in consumption amount of each customer.

1.1.6 Double checking of meter reading data

・ When the meter reader writes down the meter reading on his “Hand Book”, he should read aloud and confirm the meter reading for preventing error in writing.

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・ Meter reading is the best opportunity for confirming meter condition. The meter reader should check condition of meter and surroundings at meter reading as follows. If he/she finds something wrong, he/she should report them to the area office.

・ The area office should check the meter at the site and instruct improvement of installation of the meter to the customer or replace the meter.

・ Make a report “Meter Inspection Sheet” shown as Table 1-1.

≪Surrounding condition of meter installation≫

・ Is it easy to reach the meter and read the meter?

・ ・Are there any obstacles on the meter box?

・ Is there any abandoned rubbish on the meter manhole or meter box?

・ Is structure of meter manhole or meter box preventing an inflow of rubbish from outside?

≪Condition of meter itself≫

- Is there any leak from joint or meter itself?
- Are there any stain or dirt on the inside surface of glass?
- Is rotation of pilot regular?
- Is indicator of volume regular?

Table 1-1 Meter Inspection Sheet

Meter Inspection Sheet						No.	
Account No.				Date			
Name of Meter User				Tel.			
Address							
Meter Serial No.							
Type of Meter	1. Conventional 2. AMR 3. Prepaid						
Reason of Inspection	1. Request from User 2. Meter Reader's Report 3. Inspector 4. Others ( )						
Meter Manufacturer							
Product Year							
Meter Size (mm)				Service Pipe Diameter (mm)			
Meter Installation Condition	1. Surface 2. Underground (No Box) 3. Meter Box 4. Manhole 5. Others ( )						
Meter Condition	1. Not Visible 2. Not Moving 3. Malfanction 4. Not Accurate 5. Crack of Grass 6. Leakage 7. Others ( )						
Cause	1. Deterioration (Ageing) 2. Wrong Fitting 3. Sand or Debris 4. Defective Mater 5. Vandalism 6. Unknown 7. Others ( )						
Meter Accuracy Test	Date						
	Name of Inspector						
	Section			Name			
	Tested Meter			Reference Meter			Result
	Before	After	Difference	Before	After	Difference	% of Error
Decision	1. Replace			2. Reinstallation		3. Retest	
Approval	Name		Section		Signature		
	Name		Section		Signature		
	Name		Section		Signature		
	Name		Section		Signature		
	Name		Section		Signature		
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2 Meter error

2.1 Meaning and definition of Meter error

Water meter is equipment which measures the amount of water consumption accurately. Accurate measurement of water consumption amount is very important to build a mutual relationship between WB and customers. Accuracy of water meter at purchasing is below (within) plus/ minus two percent. On the other hand, accuracy of existing water meter is evaluated with error below plus /minus ten percent. Water meters which seem to be faulty by customer's declaration, then meter reading and inspection of WB staff must be taken as meter error test.

If water meter with error that is more than standard is found by meter error test while purchasing, WB should request the supplier to supply new meter and carry out meter error test on it. If existing water meter with error that is more than standard is found at meter error test at the site, WB should replace it with new meter tested.

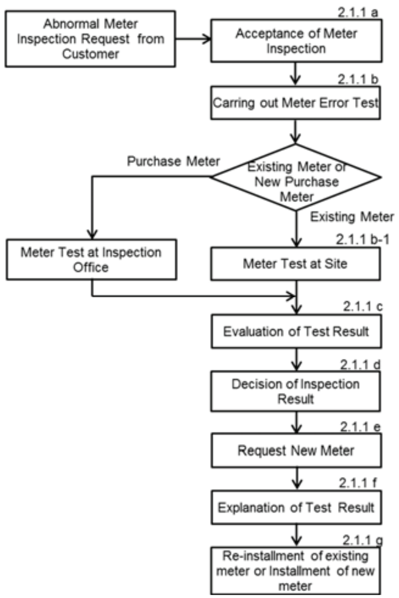


Fig. 2-1 Flow Chart of Meter Error Measuring Method

Meter error is evaluated by running the same amount of water and comparing

the difference with reference meter. Allowable meter error is different with flow amount, so meter error test should be carried out with flow amount at around 30l/min.

2.1.1 Procedure

a. Meter error test receiving: Assistant area manager

- When the area office manager receives request of meter error test from customer or report of meter trouble, he / she should record it on "Meter Inspection Sheet" and order carrying out of meter error test.
- Confirm AC No, Customer's name, meter number and record in Meter Inspection Sheet shown as Table 1-1.

b. Carrying out meter error test: The finder of faulty meter and plumber

- Meter error test is carried out at the site or at the area office without removing the meter.
- Meter error test is done by connecting the targeted meter and the reference meter with more than 100L of flow amount and the result of test should be recorded on "Meter Inspection Sheet" shown as table 1-1
- Confirm if pipes don't have some remaining extraneous materials, such as mud, small trash metal or tapes after pipe connection works. After connection of reference mete, joint to service pipe without leakage.

b-1. Meter test at site: The finder of faulty meter and plumber

- Remove air in pipe between existing meter (test meter) and reference meter by the flow of suitable water.
- After that close valve B at reference meter shown on Fig. 2-3.
- Record both meters' count.
- After allowing the flow of suitable water (more than 100 liters), close valve B under water pressure at two meters.
- Record both meters' count.

Fig. 2-2 Meter Inspection at the Customer's House

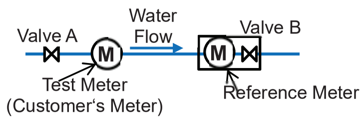


Fig. 2-3 Image of Reference Meter Setting

b-2 Meter test at inspection office: Meter inspection office

- Decide inspection meter number
- In case there are many test meters, those meters should be connected serially and use one reference meter. In case of new meter test, number of test meters should be chosen randomly.
- Arrange object meters between reference meter and valve B shown on Fig. 2-5.
- After removing air in pipe, close valve A and B.
- Record all meters' count.
- After allowing the flow of suitable water, close valve A and B under water pressure at all meters.
- Record both meters' count.
- Order the supplier to replace low quality meters

Fig. 2-4 Meter Inspection at the Office

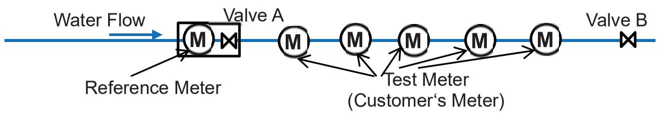


Fig. 2-5 Image of Reference Meter Setting for Multi Meters' Test

c. Evaluation of test result: The assistant area manager and the area manager

- After meter test, the assistant area manager and the area manager have to evaluate the test result with "Meter Inspection Sheet" shown as table 1-1.

d. Decision of inspection result: Assistant Area Manager or Area Manager

- Decide the error range within ＋－10％.
- 【error＜＝±10％】Re-installment of existing meter
- 【error＞±10％】Replacement of inferior meter

e. Request new meter: WB section in charge

- Request new meter to WB division with a copy of Meter Inspection Sheet.
- WB section in charge, supplies new meters according to necessary steps and informs new meter numbers to Billing Unit. Billing Unit will then register these new meter numbers in the system and confirms continuation from existing meters to new meters.

f. Explanation of Test Result: The finder of faulty meter and plumber, WB Responsible section

- In case of existing meter, it is important to explain result of meter test to the customer and inform reinstalling or replacement of meters.
- The finder of faulty meter and plumber explains reinstalling or replacement of meters to customer with presentation of "Meter Inspection Sheet" shown as Table 1-1.
- In case of purchase meter, it is necessary to change low quality meter with good quality one and inform that to the supplier. The exchanged meter also should be tested at the office.

g. Re-installment of existing meter or Installment of new meter: The finder of faulty meter and plumber

- He or she should confirm that there is no leakage from the meter after reinstalling or replacement.
- The finder of faulty meter and plumber records meter reading of the existing meter and starting meter reading of the new meter in "Meter Inspection Sheet" and informs the assistant area manager about it.

2.2 Meter error

Meter error will be calculated with the following formula and expressed with percent.

[(Flow amount of the target meter] - (Flow amount of the reference meter)] / (Flow amount of the reference meter) x 100

Decision of meter by test result:

a. Used meter :> 10%, <-10%: Reject. Between 10% to -10%: Accept
b. New meter: >2％,<-2%: Reject. Between 2% to -2%: Accept

2.2.1 Report of Meter Accuracy Test

After meter accuracy test, make a report “Meter Inspection Sheet” shown as Table 1-1.

3 Illegal connection

3.1 Illegal connection and wrong usage of water;

Is when a customer uses water with direct connection from the service pipeline without WB's approval or a customer intends to decrease consumption amount with other connection from service pipeline before the water meter are classified as illegal connection.

- Example of illegal connections are as follows;.
- Direct connection from service pipeline: A customer uses water with direct connection from service pipeline or connection from service pipeline before water meter.
- Installing bypass connection: A customer uses water with installing bypass pipeline between before and after the water meter.
- Removing water meter: A customer removes water meter and uses water by direct connection.
- Illegal manipulation of the water meter 1: A customer dismantles the water meter and manipulates meter reading.
- Illegal manipulation of the water meter 2: A customer dismantles water meter and reinstalls it backward to decrease meter reading.

When the area office finds out about this kind of actions, the office disconnects and takes legal measures against the customer.

3.2 Investigation method of illegal connection

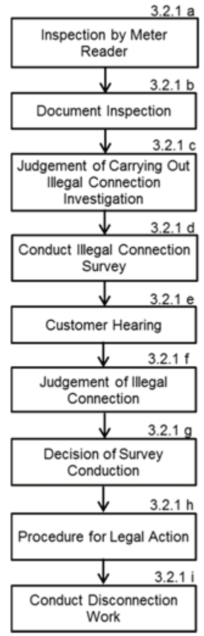


Fig. 3-1 Flow Chart of Basic flow of Illegal Connection Survey

3.2.1 Procedure

It is very difficult to find illegal connection but the staff of area offices should put more effort in finding it as much as possible by paying attention to the following;

a. Inspection by Meter Reader: Meter reader

- Meter reader should be observant when taking meter reading
- If consumption amount is abnormally small to compare to other customers.
- There is a suspected pipe connected directly from service pipeline besides the pipe which goes through the water meter.

b. Investigation of document: The assistant area office manager and investigator:

- The assistant area office manager and investigator check the meter reading report.
- Are there any abnormally small consumption amount records, compare with the previous month or compare with other customers?

c. Judgement of carrying out illegal connection investigation: The assistant area office manager and the area office manager:
- If the assistant area office manager and the area office manager suspects illegal connection, he/she writes it down on "Illegal Connection Report" and orders carrying out investigation.

d. Illegal connection investigation: The assistant area office manager and investigator
- The assistant area office manager and investigator carry out illegal connection investigation at the site.
- Is there any suspected pipe within the property?

e. Customer Hearing: The assistant area office manager and investigator
- Does water supply continue after closing stop valve before the water meter? Be careful about judgement at this case because there are two ways to supply to water taps. One is supplied with pressure from service pipeline and the other is supplied from elevated water tank.
- When the water meter is removed for replacement and water supply still continues. Be careful about judgement at this case because the water may flow back from the elated water tank.

f. Judgement of illegal connection: The assistant area office manager and investigator
- When the assistant area office manager and investigator confirm illegal connection, he / she should report it to the office in charge at WB' with "Illegal Connection Report" and order disconnection of the customer.

g. Decision of survey conduction: Assistant Area Manager, Area Manager
- Confirmation of site, order for disconnection『Illegal Connection Report』or report to WB

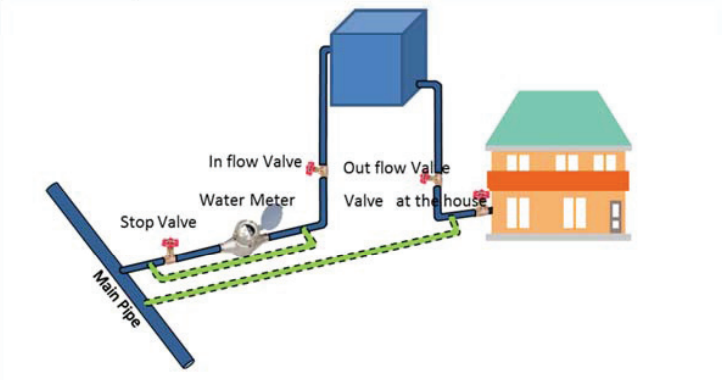
h. Procedure for Legal Action: WB's section in charge
- WB's section in charge will take a legal measure against the customer.

h. Disconnection: the area office manager, the assistant area office manager, plumber:
- The plumber disconnects the customer. It is important to disconnect tightly so that it won't be easy for the customer to get back on water supply.

After illegal connection survey, make an "Illegal Connection Report" shown as Table 3-1.

Table 3-1 Illegal Connection Survey Report Sheet

Illegal Connection Report				No.	
Account No.			Date		
Name of Meter User			Tel.		
Address					
Type of Meter	1. Conventional 2. AMR 3. Prepaid				
Meter Size (mm)		Service Pipe Diameter (mm)			
Last three (3) Months' Water Consumption	1.	2.	3.		
Initial Report	1. Other User 2.Meter Reader 3. Inspector 4. Area Office Staff 5. Others ( )				
Illegal Connection Situation	1. Direct from Distribution Pipe 2. Meter By-pass 3. Meter Direct Connection 4. Illicit Meter Counter Operation 5. Revers Meter Installation 6. Others ( )				
Inspection Date					



Decision						
Approval	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	

Annex-2

Manual for Leakage Survey (Action Team)

< Leakage Detection Technology >

Index

1. Mechanism of water leakage

The fig. 1-1 shows the mechanism of the water leakage on a pipe.

Water leakage from the buried pipe's spot by the pressure of water in the pipe, and it generates a noise, compounding four elements which consist of; **flow noise, impact noise, friction noise and vibration noise** around the water leak point.

These noises mix up and propagate pipe inside, pipe wall and ground surface through the soil. This is called "leak sound". The leak sound is also detected at pipe fittings propagated by pipe wall.

Leak sounds like "Hiss" or "Whoosh" serves as a representative sound.

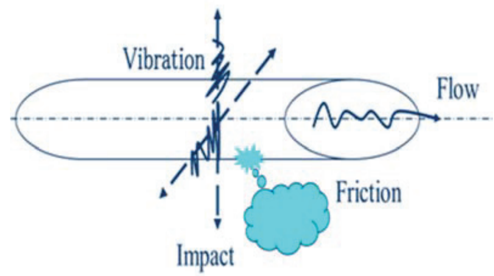


Fig. 1-1 Mechanism of water leakage

2. Characteristic of leak sound

There are some key points to detect the water leakage easily or accurately at actual site. It is necessary to understand the characteristics of leak sound that occurs on the water pipe before the explanation of leakage detection work.

(1) Sound loudness and water pressure

When water spouts from the hole or crack on pipe with high pressure, it makes a large noise with vibration;

The fig. 2-1 shows that there is a relationship between water pressure and sound intensity. The leak sound is low and difficult to detect when the pressure is below 0.1MPa. This is the reason why leakage detection work should be conducted at mid-night when water pressure becomes high due to the small water consumption and silent circumstances.

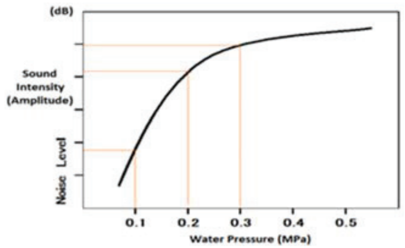


Fig. 2-1 Relationship between noise level and water pressure

Leak noise becomes larger abruptly in the range between 0.1 and 0.3Mpa of water pressure.

(2) Water quantity and water pressure

For the leak detection work, it is easy to detect leak sound in high water pressure because of its big noise. However, when the water pressure becomes higher, the leakage water quantity also becomes more. This increase of water quantity becomes increase of water loss.

The fig. 2-1 shows how leak quantity changes when water pressure becomes twice from the original pressure. Water quantity is proportion to the square root of water pressure.

The original water pressure is at 0.1MPa and leakage water quantity is 10l/min. When water pressure changes from 0.1 to 0.2MPa (twice), the leakage water quantity changes 10 to 14.1l/min (1.41 times).

With this reason, it is effective to reduce water loss by water pressure control to keep proper pressure in the high water pressure area.

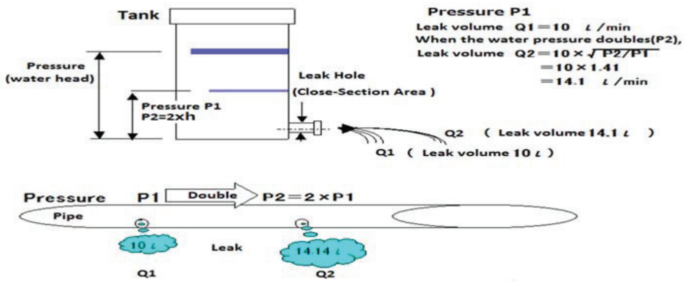


Fig. 2-2 Water pressure and quantity

(3) Propagation distance of leak sound

Fig. 2-3 shows sound sensors installation on two points 1m and 10m distance from the leak point, and analyzing their frequency spectrums and sound levels.

The propagation distance from the leak point differs depend on pipe materials.

Fig. 2-4 shows the frequency of leak sound at 1m and 10m distance from the leakage (4mm diameter) point on CIP. High frequency noise 10 KHz can be transmitted to 10m.

Fig. 2-5 shows the frequency of leak sound at 1m and 10m distance from the leakage (7.5mm diameter) point on PVC. High frequency noise over 5 KHz cannot be transmitted to 10m; it means leak sound of PVC cannot be transmitted long distance.

The leakage water volume from PVC is about 3.5 times compared with the leakage water volume from CIP. But sound levels at 1m of them are almost same; it means leak sound of PVC much smaller than CIP's.

If cracking size and water pressure of pipes are same, the transmission distance of leak sound will be changed depend on pipe materials.

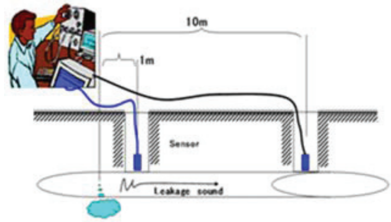


Fig. 2-3 Analyzing Frequency Spectrums

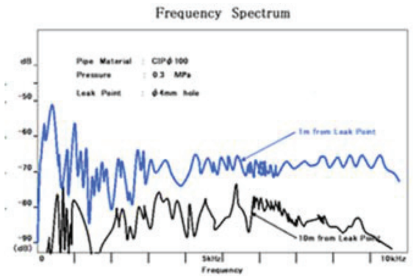


Fig. 2-4 Frequency spectrums on the CIP

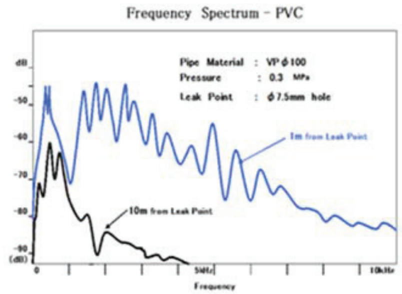


Fig. 2-5 Frequency spectrums on the PVC

Fig. 2-6 shows leak sound levels and their attenuation depends on pipe materials. And it also shows propagation distance of each pipe material. Soft pipe materials such as PEP and PVC, their leak sound attenuate rapidly and cannot be transmitted to long distances. On the other hand, hard pipe materials such as CIP and SP, their leak sound attenuate gradually and can be transmitted to long distance. The leak sound of asbestos cement pipe (ACP) has a middle characteristic compared to them.

Fig. 2-7 shows propagation distance depends on pipe materials. In the same condition, leak sound on CIP propagates to 100m, the sound on ACP propagates to 80m and the sound on PVC propagates to only 30m from the leak point.

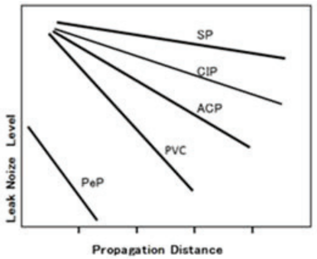


Fig. 2-6 Propagation distance (1)

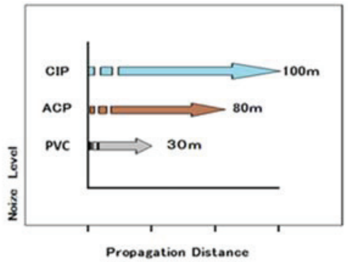


Fig. 2-7 Propagation distance (2)

(4) Relationship between leak sound and depth

Fig. 2-8 shows sensors installation on 3 points 50cm, 1m and 2m above the leak point of buried pipe, and analyzing attenuation of each leak sound frequencies.

Leak sounds decrease in accordance with increasing distance.

The leak sound level at 50cm above the leak point is 1/10 of the original sound level. The sound level at 1m above the leak point is 1/100 of original sound level. The sound level at 2m above the leak point is 1/10,000 of original sound level. For leakage survey, leak sound should be distinguished more clearly and bigger. If leaking point is deeper than 1m, it becomes small and unclear.

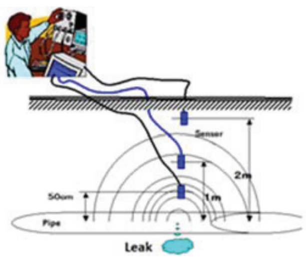


Fig. 2-8 Difference in depth

The operation frequency range of water leak detector should be between 100Hz to 20 kHz because of human audible range. Some water leak detectors have frequency filter

to distinguish leak noise more clearly depend on different pipe materials.

Fig. 2-10 shows frequency filter ranges depend on pipe materials.

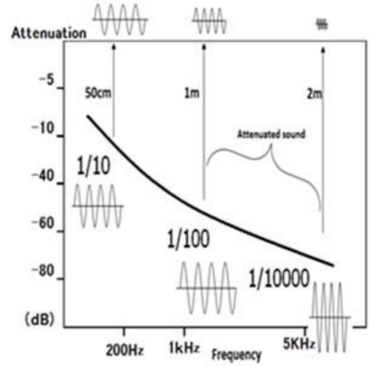


Fig. 2-9 Curve of frequency in depth

A: The peak of leak noise frequency on non-metallic pipe is about 400Hz, so it is better to adopt the filter range low and high frequency of it.

B: The peak of leak noise frequency on concrete pipe is about 800Hz, so it is better to adopt the filter range low and high frequency of it.

C: The peak of leak noise frequency on metallic pipe is about 1.5 kHz, so it is better to adopt the filter range low and high frequency of it.

Metallic pipes such as ductile cast iron, cast iron, lead, copper and steel pipes and their leak sound are bigger and higher frequency than PVC, polyethylene or asbestos-cement pipes. Thus, the information of the pipe material is important to detect the leak correctly.

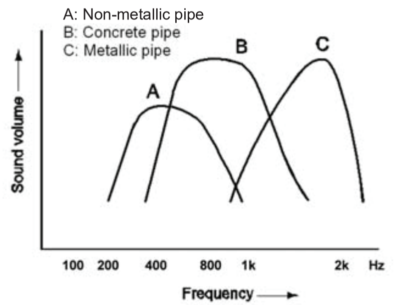


Fig. 2-10 Frequency filter of the water leak detector

The leak noise of large diameter pipes is transmitted shorter distance than small diameter's pipe with low frequency.

Key points of leak sound

- The higher water pressure is, the higher leak sound level becomes.
- Attenuation of the leak sound on the Metallic pipe is lower than PVC pipe.
- Leak sound on the PVC pipe does not propagate to long distance.
- Leak sound decreases significantly in the soil, it becomes very small and unclear deeper than 1.5m; its sound level is 1/1,000 compared with original.

3. **Similar sound to water leakage at actual site**

Leak noise is mixed with various noises generated at the leaking point.

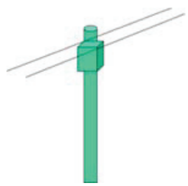
Leak detector's operators sometime detect a similar sound on the pinpoint survey.

Operator should know the difference between a real leak sound and other similar leak sounds.

The similar sounds are as follows;

(1) Transformer's noise

Transformers generate electromagnetic vibration and it cause low frequency around 300 Hz, and they are transmitted to the underground through electric pole. When the leak detector's operator detects the low frequency and vibration near electric pole, contact the leak detector's sensor to the electric pole, and check whether same low frequency and vibration can be detected or not.



(2) Motor sound (Air conditioner unit)

When motor is rotating, it generates vibration with a low frequency. Motor rotating sound sometime propagates to the buried pipe through the soil.

The frequency of motor rotating sound is around 500Hz with a continuously vibration.

(3) Sewage sound

Sewer pipe and water pipe sometimes are laid side by side. In generally, sewer pipe has no pressure inside. However, the drop point or shallow point makes flowing sound. Characteristic of swage sound has 500HZ to 2 kHz frequency with sound like "SHARA" "SHARA".

(4) Using water sound

When the water faucet is open, it makes a sound at the branch point of the pipe itself with a friction and a vibration. The usage water sound should be checked whether it is real leak or usage water by the rotating of the water meter indicator is in a normal way. As customers use the water, indicator must be moved. There is a possibility of illegal connection even though the valve is close to where the meter is and still flowing. Characteristic of usage water has 600 Hz to 1.5Kzh frequency. This is the most similar sound to real leak sound.

4. **Leakage detection survey**

(1) Preparation work

Method of water leakage detection is to narrow down from the large area to the pinpoint using leak detection devices by the proper planning.

A leak detection team should know how much leakage water volume is, how much NRW ratio is or where leaks are expected in the planed survey area for the preparation work before the leakage detection survey.

① **Selection of survey area**

Before the survey, the team should plan the area considering budget, period and staff arrangement as a preparation work.

Generally, District Metered Area (DMA) is divided by area which has about 10km distribution pipe length or 1000 to 3000 properties. The inflow water volume or leakage water volume is measured by the bulk meter at the inlet point. NRW reduction activities can be operated easily in DMA.

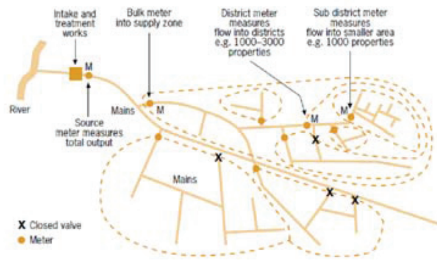


Fig. 4-1 Image of DMA

② **Survey map on the preparation work**

Before the survey, the team should prepare the survey area map indicated information such as pipe lines layout, pipe material, pipe diameter, location of valves and fire hydrants.

1/2500 to 1/5000 scale of survey area map should be required.

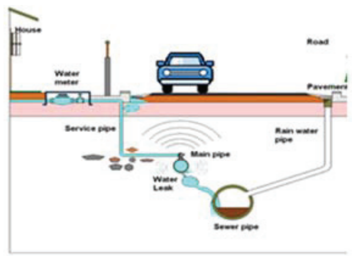


Fig. 4-2 Image of occurring leakage

(2) Visible survey (Patrol)

Leakage can be divided into two categories: a) visible leakage identified without any devices by patrol or customer's information, and b) invisible leakage detected by special devices required survey skills.

Water leakage survey team can find visible leakage by patrolling day and night without special devises.

- Day time: Distribution network has low water pressure and loudness circumstances
  Key Points: Check the wet place even in the sunshine.
  Check the caving place on the road surface.

- Night time: Water pressure rises, darkness, and no consumption.
  Key points: Check the wet place (not wet in the day time)
  Check the over flow water from elevated tank or reservoir due to broken float valves.
  Open the manhole cover of drain pit and check whether clear water is flowing or not.


Fig. 4-3 Leak water flow into drain pit


Fig. 4-4 Clear water flow into drain pit

Large leakage water sometime flows into the sewer pipe, and it is difficult for visible identification. To check the drain pit effectively, visible survey should be done in the mid night.

(3) Determination of unknown water

At wet place it should be confirmed whether its water is potable water or not. Collect water flowing up to the ground surface and check whether it contains residual chlorine ore not using reaction reagent.

5. Deliberation of leak detection method

There are basic methods of water leak detection they are: Area survey method, Line survey method and Point survey method.

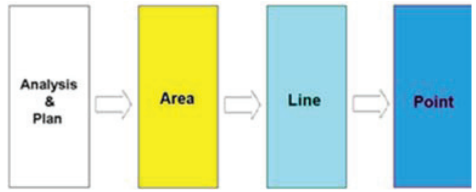


Fig. 5-1 Image of basic methods

(1) Preparation work

Water leak survey team should prepare the work before the leak detection survey as follows;

Collect the facility data such as inflow volume to DMA (area), estimated leakage volume, distribution pipe length and number of houses in the survey area.


Fig. 5-2 View of preparation work

- Prepare the survey map indicated pipeline layout, pipe material, pipe diameter and location of valves.
- Detect the buried valve which is needed for isolation of DMA and step test.

① Valve and pipe detection (Metal Detector)

Metal detector can detect the buried metallic manhole cover. 70cm diameter's manhole cover is detectable to 100cm depth as shown in Fig. 5-4.

Principle of metal detector is to generate electromagnetic induction from the antenna. When the antenna crosses above the metal materials, the sensor catches the electromagnetic induction and sounds alarm.

View

② **Pipeline Detection**

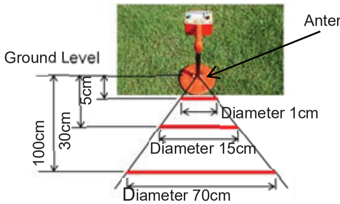


Fig. 5-3 Detectable depth and target

Fig. 5-5 View of pipe locating

➢ **Radio wave type (Iron Pipe Detector)**

When radiofrequency of current flow is sent to the buried metallic pipe from the transmitter, it makes inductive loop around the pipe and the receiver unit receives it. Iron pipe detector can detect not only pipe location but also its depth.

There are two ways to detect the metallic pipe, one is the direct method: connecting transmitter to the valve or meter (metallic part) directly, the other way is the inductive method: the receiver gets the inductive loop without direct connecting to fittings of pipeline.

- Make a sound on the pipe

When the water faucet is open, friction or water flowing sound is generated and transmitted to the brunch of service pipeline on the distribution pipe and it is detected by the water leak detector. The location of the brunch point should be marked on the ground and the map. Each detected point should be connected as a line: the line is the location of distribution pipeline.

(2) Area method

As mentioned before about area survey, it is important to know the size of the survey area, survey period and staff arrangement. They are required for the effective activity in the target area. And, it is important to prepare the budget before the survey.

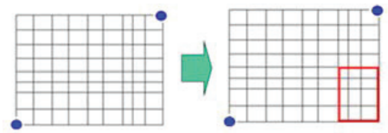


Fig. 5-6 Area method

For the area method, flow meter should be installed at the inlet of DMA or Sub Metered Area (SMA). DMA is consisting of SMAs. The meter at inflow point of DMA or SMAs is for measurement of minimum night flow (MNF) which is the minimum water flow in the middle of night. Generally, water flow rate decreases in the middle of night because most customers sleep and don't use water. The volume of MNF sometimes contains usage water volume. However, it is close to leakage volume.

If there are large consumers like a factory or apartment which have tanks in the SMA, exclude the average consumption or close the valves of service line to them during the MNF survey.

➢ Sub metered area (SMA)

In the preparation work before the leak detection, it is necessary to divide DMA into SMAs of 2 to 5 km of distribution pipe length and less than 1000 houses.

Bulk meter or other measurement device should be installed at the inlet of the SMA.

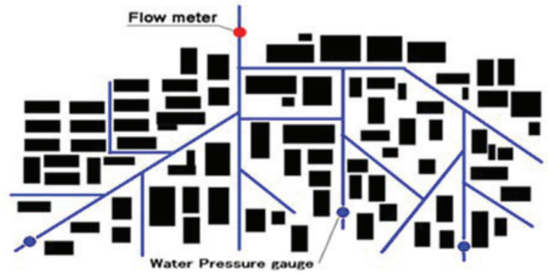


Fig. 5-7 Image of SMA

➢ **Portable type flow meter (24 hours survey)**

(Ultra-sonic flow meter)

The portable ultrasonic flow meter is used to know the 24 hours water flow trend and water pressure recorder is used to know the 24 hours trend of water pressure.

The revenue water ratio can be calculated as follows: one-month billing data (water volume) divided by one-month inflow water volume.

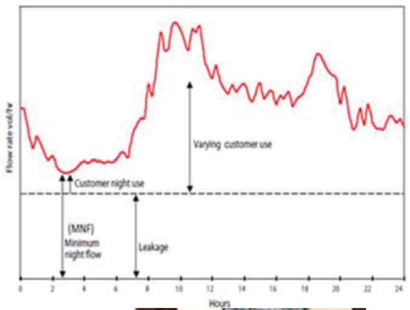


Fig. 5-9 Image of flow trend in the SMA

Fig. 5-8 Flow meter in the measurement pit

The ultrasonic flow meter is used for MNF survey in the middle of night to measure leakage volume. It contains water usage in the house, filling water volume to elevated tank and leakage in the house. Therefore, it is necessary to pay attention to the ratio of leakage volume of the minimum night flow volume in the residential area. The graph in Fig. 5-9 is 24 hour's water flow trends in the SMA which is measured flow at the inlet point. MNF value is recorded around 2:30am, and peak flow volume around 9:00am.

(3) Line method

Line method is to identify the pipe line which causes the water leak in the SMA.

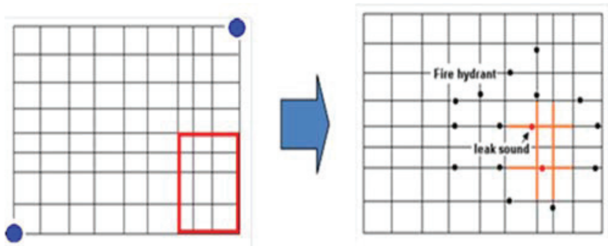


Fig. 5-10 Image of line method

➢ **Step test**

Step test is to identify the leaking line by the changed flow volume when the valve is closed at the branch point in the middle of night.

If there is a leak in the line after the closed valve, the flow volume decreases.

It is equivalent to leak volume of the pipe line.

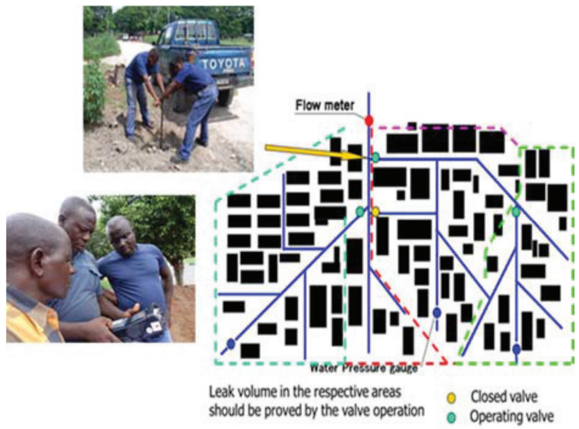


Fig. 5-11 Image of step test

The graph in Fig. 5-12 shows changing water flow on the step test when some valves are closed and opened and flow is stable

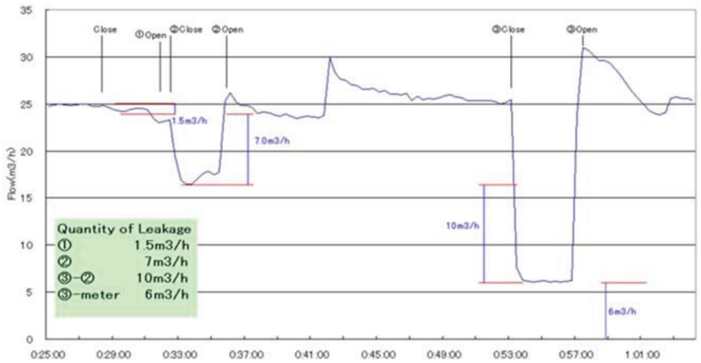


Fig. 5-12 Graph of step test

(4) Acoustic survey

As explained before, leak sound is propagated to the valve or water meter from the leak point.

Accordingly, propagated sound at the fitting is identified as the leak sound by the acoustic survey devices. Leak sound is checked by the listening stick at the meter or valve. It is the loudest which is nearest to the leak point.

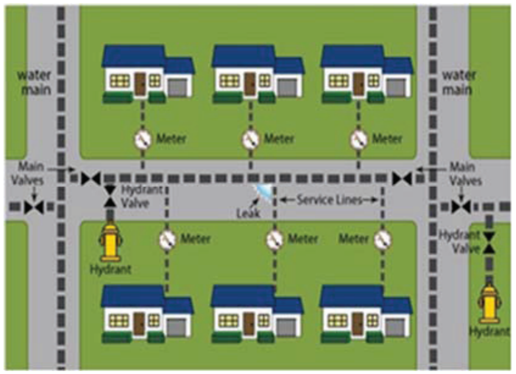


Fig. 5-13 Image of acoustic survey

➢ **Listening stick**

Listening stick is the basic device used for the leak detection survey. Listening stick is a very simple device without electronic parts and maintenance for a long time.

However, it is the most basic device for leak detection.

Fig. 5-14 Listening stick

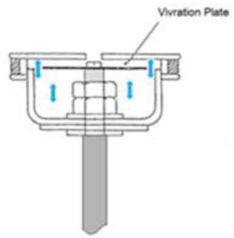


Fig. 5-15 Structure of listening stick

Listening stick consists of acoustic bar which is made of stainless steel or steel and head part which has a room and a vibration plate.

When listening stick is contacted to fittings, leak sound is propagated to the bar and amplified the sound by the vibration plate in the head part.

There is no sound if there is no leak.

When a leak generates on the fitting, it has sounds like a "SHEE" or "HUEE". Surveyor should check the sound at all fittings, and if a strange sound is heard, mark it on the survey map. It is identified as a leak point by the confirmation survey.

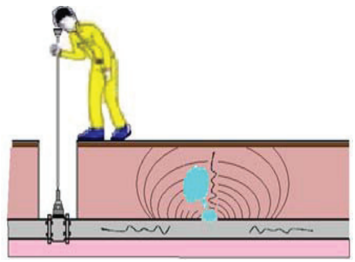



Fig. 5-16 View of acoustic survey

➢ **Electrical listening stick**

As above-mentioned, leak sound on the PVC is small with low frequency. It is difficult to distinguish for small sound. Electrical listening stick can amplify such a small sound and easy to distinguish through the head phone or sound level meter.

Fig. 5-17 Electrical listening stick

Fig. 5-18 View of Acoustic survey

Acoustic survey using electrical listening stick is to make contact to the valve or meter and check the sound and level meter. Fig. 5-19 shows nearest point from which leak a largest sound with 75other points further from the leak point has, the sound becomes smaller.

Leak surveyor can identify the rough leak point by the sound level.

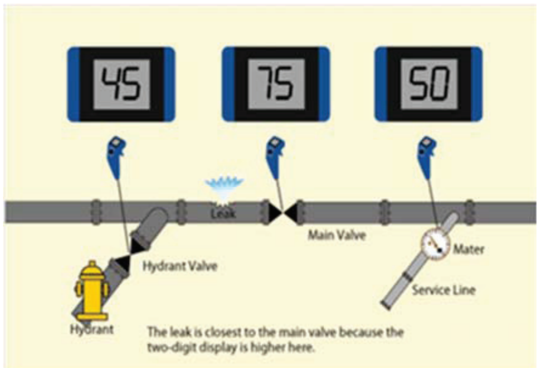


Fig. 5-19 Image of sound level check

(5) Pinpoint method

Pinpoint method is to identify the exact leak point which could not be confirmed by acoustic survey.

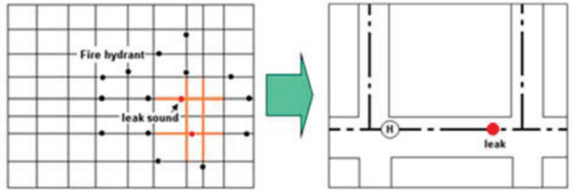


Figure 5-20 Image of pinpoint method

➢ **Water leak detector**

Water leak detector is the representative device for the pinpoint method. It has a long history and has been used on the leak detection survey.

Fig. 5-21 shows the detection of the peak point on the ground surface by the sensor of water leak detector.

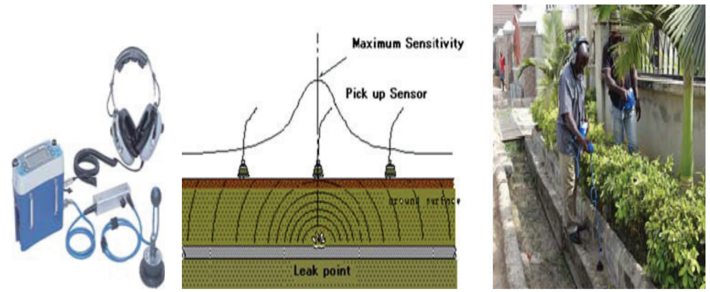


Fig. 5-21 View of using water leak detector

Generally, the above leak point has loud sound, and water leak detector can identify the peak point.

Water leak survey team should consist of at least two staff, and separate each other. One staff walk along the main pipe and detect leakage, the other staff detect the leak on the service pipe. They keep a distance to avoid foot noise of each other. If a strange sound is heard, mark the place on the survey map.

- **Leak noise correlator**

  Leak noise correlator identifies the exact leak point even in noisy condition of daytime.

  Water leak noise correlator consists of two amplifiers with sensors and the main unit which is a built-in microprocessor.

Fig. 5-22 Leak noise correlator

- **Principle**

  Leak sounds travel to both sides from the leak point at the same speed if pipe material and diameter are same. When leak point is just center between two sensors blue and red, leak sound travels to both sensors at same time.

  However, leak point is close to the red side as Fig. 5-23, leak sound travels to the red sensor faster than blue sensor. The traveling time at blue sensor delayed from red sensor. It is called "Time of delay (Td)". Leak noise correlator calculates Td from data transmitted from the preamplifiers every second.

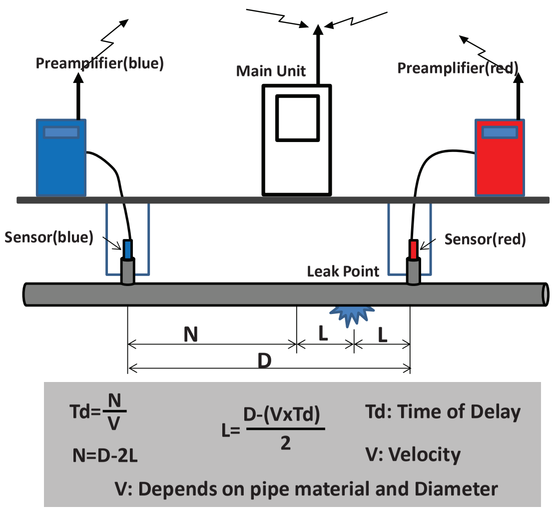


Fig. 5-23 Principle of leak noise correlator

Definitions of different distance for correlator
D: Total distance between two sensors: measured exactly along the pipeline by a measuring wheel or measuring tape
L: Distance from the leak point to the nearer sensor: calculated by correlator.
V: velocity of leak sounds transmitted on pipe wall
Td: Traveling time difference of leak sounds between red sensor and blue sensor
N: Different distance between red sensor and bleu sensor from leak point
Distance from red sensor to leak point: $L = \frac{D-N}{2}$
Distance from blue sensor to leak point: N+L=D-L
Distance (Sound travels) ＝ Sound Velocity (m/ms) ×Time(ms)
Difference (in distance travels) = Sound velocity (m/ms) ×Time of delay (ms)
ms: microsecond
$N = V \times Td$
Distance from red sensor to leak point $L = \frac{D-(V \times Td)}{2}$

- **Benefit**

  Leak noise correlator is not affected by surrounding noise such as traffic and factory, therefore survey is possible in noisy condition. It is possible to detect the pinpoint even though leak sound doesn't reach to the surface of ground.

- **Condition**

  Leak noise correlator should be used with the following conditions; Leak sound must reach both sensors.

◆ Leak point must be between Blue and Red sensors.
If not, one of the sensors should be moved out of leak point.

- **Required data should be input**

◆ Pipe material
◆ Pipe diameter
◆ Distance of two sensors.

(6) Confirmation survey

Identified leak point should be confirmed by the confirmation survey. When the confirmation survey is done, it is necessary to minimize excavation.

➢ **Drilling work**

Using drill with generator, make a hole at the marked point detected by pinpoint survey.

➢ **Boring work**

Insert boring bar into the hole and bore deeper hole carefully to avoid breaking pipe. Before the boring work, pipe depth has to be measured at the valve near the boring point

➢ **Checking work**

Listening stick should be inserted into the hole until it touches the pipe position carefully, and listen the leak sound and check wet condition.

Fig. 5-24 View of confirmation survey

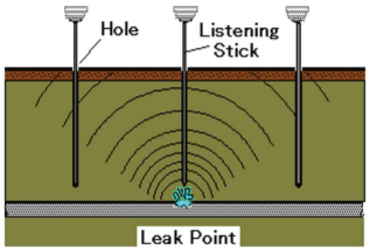


Fig. 5-25 Image of confirmation survey

6. Causes of water leak

Buried water pipe is damaged externally or internally by following causes such as: corrosion, heavy traffic load, vibration, poor construction work and water-hammer.

(1) Corrosion

Corrosion is well known as the cause of the water leakage on the metallic pipe.

It is caused by ionization reaction of metal by electrochemical mechanism. Corrosion occurs on metallic pipe such as: galvanized iron, steel, cast iron, lead and copper pipe. Corrosion makes hole on the surface of metallic material under the low pH, wet soil, and high conductivity condition.

Especially, corrosion occurs when pipe is laid in the boundary between dry and wet conditions or breathing soil and non-breathing soil, it becomes a kind of battery and generates an electrical circuit on the pipe.

Fig. 6-1 shows how electrical circuit makes an electrical flow from the positive pole to negative pole under the different soil conditions.

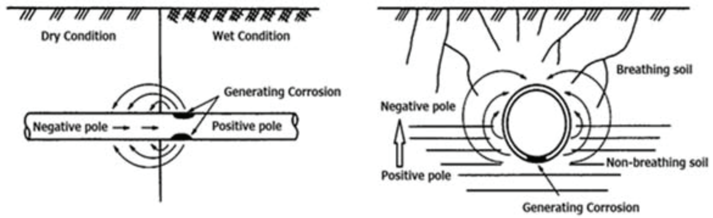


Fig. 6-1 Mechanism of Corrosion

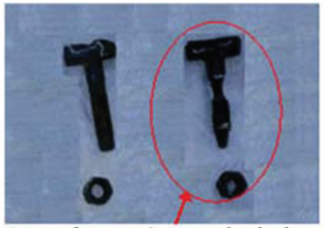


Fig 6-2 Corrosion on the bolt

Fig. 6-3 Hole on the galvanized iron pipe

The picture Fig 6-2 shows the corrosion that occurred on the bolts and nuts of pipe joint. The picture Fig. 6-3 shows the hole made by corrosion and its size was enlarged by long time friction of water and water pressure.

➢ Countermeasure against corrosion

- Replace metallic pipe to non-metallic pipe.
- Cover pipeline with the plastic film (polyethylene sleeve) to avoid contacting corrosive soil (surroundings).

(2) Traffic load

The pipe should be laid deeper than one meter or more under the road to avoid the damage by the traffic load.

When pipes are laid underground less than one-meter depth, it is easy to break a pipe or loose the joint due to the traffic load and its vibration.

The picture Fig. 6-4 is the leak on main PVC pipe, which was laid shallow depth, caused by heavy traffic load. The heavy traffic load sometimes makes crack on the PVC pipe.

Fig. 6-4 Crack on PVC pipe due to traffic load

(3) Rapid water stops or water pressure fluctuation

The picture Fig. 6-6 shows crack on the asbestos Cement Pipe (ACP) caused by shock wave which is generated by the rapid water flow stop in pipeline. When a valve is closed or a pump stops rapidly on the network, water flow moves backward and forward repeatedly inside the pipe with a strong energy; it is called water hammer phenomenon.

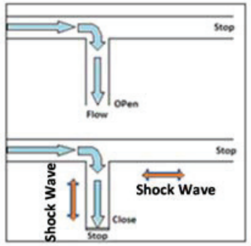


Fig. 6-5 Image of water hammer

Fig. 6-6 Crack by the water hammer

When water hammer occurs, it gives a large power to pipe joint and bends of pipe line with strong impact wave, it causes pipe break frequently.

(4) Others

Poor construction work sometimes causes leakage on the joints or connections, examples of poor construction are as follows;

➢ Joint PVC pipe with less adhesive or in wet condition.
➢ The incomplete bolts clamping or gaskets setting of pipe joint.
➢ The backfilling contains sharp stones around pipe they damage to the pipe.

Fig. 6-7 Leak on PVC joint due to less adhesive

7. Leakage information

Once the pipe is buried in the ground, its information is not available. However, it is easy to get the pipe information or its surroundings condition during leak repair work. Leak information should be recorded on the record sheet, it is necessary for pipe replacement plan in the future. Information that should be collected is as follows;

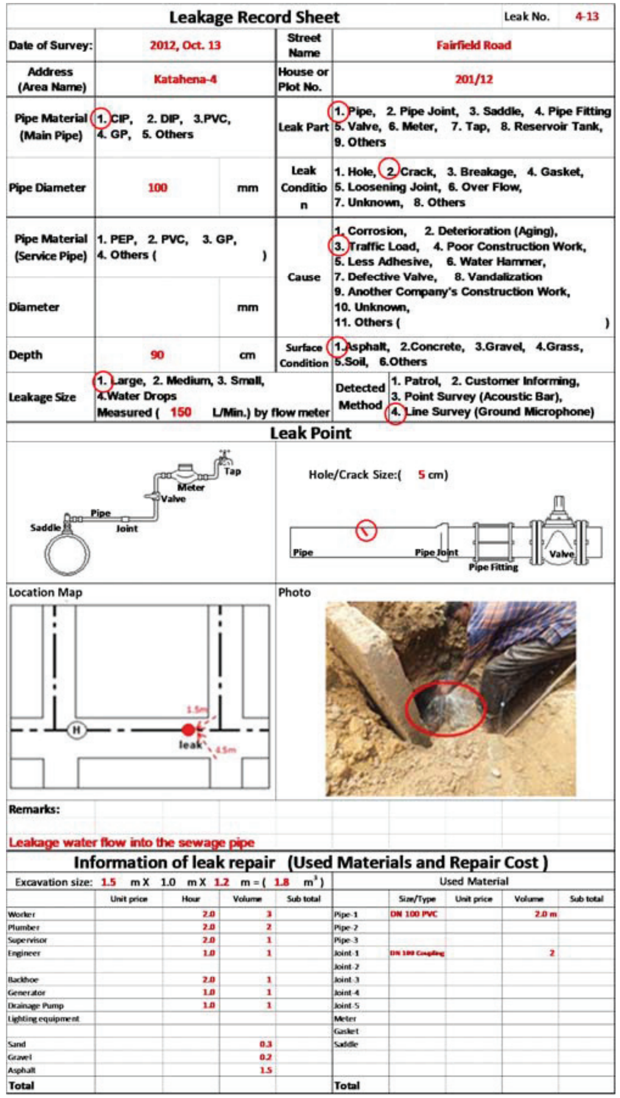
- **Pipe information:**
  - Main or service pipe
  - Material (DIP, CIP, ACP, PVC, GP, SP, PEP, Lead, CP,)
  - Diameter
  - Depth

- **Leak information**
  - Main or service
  - Location (Pipe, Connection, Meter Valve, Fire hydrant, Washout)
  - Condition (Hole, Crack, Brakeage, Loose connection, Packing)
  - Causes (Corrosion, Water Pressure, Aging, Wrong construction, Traffic load)
  - Quantity

- **Road or ground information**
  - Road condition (Asphalt, Concrete, Gravel, Grass, Soil)
  - Ground water level (Above the pipe)
  - Soil condition (Sand, Clay, Rubble, Rock)

- **Leak repair information**
- Excavation size
- Back foe working hour
- Fill buck sand (m3) gravel(m3)
- Surface compaction
- Material (kind , Diameter mm , length m)
- Joint (Elbow Tee, Socket, Nipple,)
- Workers (Supervisor , fitter , Worker ,)(working hour)
- Leakage data

  Leakage data which is collected at leak point should be recorded on the leakage record sheet clearly with figure or picture, which include pipe information, leakage information and subsurface information as seen in the sheet next page.



Leakage Record Sheet Leak No. 4-13

Date of Survey:	2012, Oct. 13	Street Name	Fairfield Road
Address (Area Name)	Katahena-4	House or Plot No.	201/12
Pipe Material (Main Pipe)	1. CIP, 2. DIP, 3.PVC, 4. GP, 5. Others	Leak Part	1. Pipe, 2. Pipe Joint, 3. Saddle, 4. Pipe Fitting 5. Valve, 6. Meter, 7. Tap, 8. Reservoir Tank, 9. Others
Pipe Diameter	100 mm	Leak Condition	1. Hole, 2. Crack, 3. Breakage, 4. Gasket, 5. Loosening Joint, 6. Over Flow, 7. Unknown, 8. Others
Pipe Material (Service Pipe)	1. PEP, 2. PVC, 3. GP, 4. Others ( )	Cause	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Poor Construction Work, 5. Less Adhesive, 6. Water Hammer, 7. Defective Valve, 8. Vandalization 9. Another Company's Construction Work, 10. Unknown, 11. Others ( )
Diameter	mm		
Depth	90 cm	Surface Condition	1. Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Medium, 3. Small, 4.Water Drops Measured (150 L/Min.) by flow meter	Detected Method	1. Patrol, 2. Customer Informing, 3. Point Survey (Acoustic Bar), 4. Line Survey (Ground Microphone)

Leak Point

Remarks:

Leakage water flow into the sewage pipe

Information of leak repair (Used Materials and Repair Cost)

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

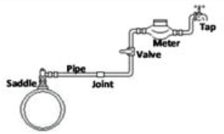
	Unit price	Hour	Volume	Sub total	Used Material	Size/Type	Unit price	Volume	Sub total
Worker		2.0	3		Pipe-1	DN 100 PVC		2.0 m	
Plumber		2.0	2		Pipe-2				
Supervisor		2.0	1		Pipe-3				
Engineer		1.0	1		Joint-1	DN 100 Coupling		2	
					Joint-2				
Backhoe		2.0	1		Joint-3				
Generator		1.0	1		Joint-4				
Drainage Pump		1.0	1		Joint-5				
Lighting equipment					Meter				
					Gasket				
Sand			0.3		Saddle				
Gravel			0.2						
Asphalt			1.5						
Total					Total				

Fig. 7-1 Image of leakage record sheet

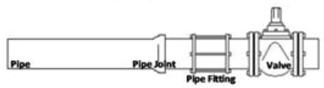
Leakage Record Sheet

Date of Survey:		Street Name	Leak No.
Address (Area Name)		House or Plot No.	
Pipe Material (Main Pipe)	1. CIP, 2. DIP, 3.PVC, 4. GP, 5. Others	Leak Part	1. Pipe, 2. Pipe Joint, 3. Saddle, 4. Pipe Fitting 5. Valve, 6. Meter, 7. Tap, 8. Reservoir Tank, 9. Others
Pipe Diameter	mm	Leak Condition	1. Hole, 2. Crack, 3. Breakage, 4. Gasket, 5. Loosening Joint, 6. Over Flow, 7. Unknown, 8. Others
Pipe Material (Service Pipe)	1. PEP, 2. PVC, 3. GP, 4. Others ( )	Cause	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Poor Construction Work, 5. Less Adhesive, 6. Water Hammer, 7. Defective Valve, 8. Vandalization 9. Another Company's Construction Work, 10. Unknown, 11. Others ( )
Diameter	mm		
Depth	cm	Surface Condition	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Medium, 3. Small, 4.Water Drops Measured (L/Min.) by flow meter	Detected Method	1. Patrol, 2. Customer Informing, 3. Point Survey (Acoustic Bar), 4. Line Survey (Ground Microphone)

Leak Point



Hole/Crack Size:(cm)



Location Map	Photo

Remarks:

Information of leak repair (Used Materials and Repair Cost)

Excavation size: m X m X m = (m^3)					Used Material				
	Unit price	Hour	Volume	Sub total		Size/Type	Unit price	Volume	Sub total
Worker					Pipe-1				
Plumber					Pipe-2				
Supervisor					Pipe-3				
Engineer					Joint-1				
					Joint-2				
Backhoe					Joint-3				
Generator					Joint-4				
Drainage Pump					Joint-5				
Lighting equipment					Meter				
					Gasket				
Sand					Saddle				
Gravel									
Asphalt									
Total					Total				

Fig. 7-2 Leakage record sheet (blanc)

8. Pictures of water leak quantity

It is difficult to measure water volume of leaks. So, it is important to guess the water volume.

Samples of water volume are as follows:

Diameter: 100mm

Diameter: 75mm

Discharge distance: 130cm	Discharge distance: 60cm	Discharge distance: 20cm
P: 0.2MPa, Q: 75m3/h (photo)	P: 0.2MPa, Q: 40m3/h (photo)	P: 0.2MPa, Q: 8m3/h (photo)
P1:0.3MPa, Q: 92m3/h	P1:0.3MPa, Q: 49m3/h	P1:0.3MPa, Q: 10m3/h
P1:0.4MPa, Q: 106m3/h	P1:0.4MPa, Q: 56m3/h	P1:0.4MPa, Q: 12m3/h

Diameter: 50mm

Discharge distance: 150cm

P: 0.2MPa, Q: 40m3/h (photo)

P1:0.3MPa, Q: 49m3/h

P1:0.4MPa, Q: 56m3/h

Discharge distance: 80cm

P: 0.2MPa, Q: 20m3/h (photo)

P1:0.3MPa, Q: 24m3/h

P1:0.4MPa, Q: 28m3/h

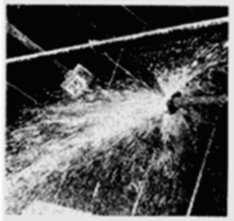
Discharge distance: 40cm

P: 0.2MPa, Q: 10m3/h (photo)

P1:0.3MPa, Q: 12m3/h

P1:0.4MPa. Q: 14m3/h

Diameter: 150mm leakage at joint (loosening bolts and nuts of mechanical joint)



P: 0.2MPa, Q: 25m3/h (photo)

P1: 0.3MPa, Q: 31m3/h

P1: 0.4MPa, Q: 35m3/h

P: 0.2MPa, Q: 15m3/h (photo)

P1: 0.3MPa, Q: 18m3/h

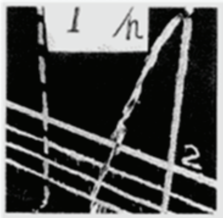
P1: 0.4MPa, Q: 21m3/h

P: 0.2MPa, Q: 5m3/h(photo)

P1: 0.3MPa, Q: 6m3/h

P1: 0.4MPa, Q: 7m3/h

Diameter: 13mm



P: 0.2MPa, Q: 1.0m3/h(photo)

P1: 0.3MPa, Q: 1.22m3/h

P1: 0.4MPa, Q: 1.41m3/h

P: 0.2MPa, Q: 0.4m3/h (photo)

P1: 0.3MPa, Q: 0.49m3/h

P1: 0.4MPa, Q: 0.57m3/h

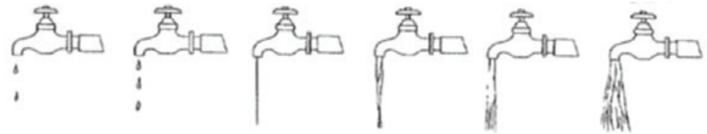
P: 0.2MPa, Q: 0.1m3/h (photo)

P1: 0.3MPa, Q: 0.12m3/h

P1: 0.4MPa, Q: 0.14m3/h

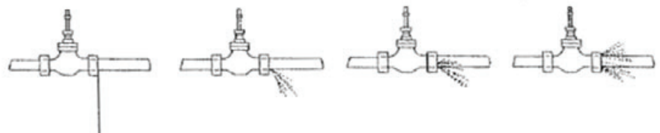
Leakage Water Volume on 13mm diameter's pipe and fittings

Faucet



Water Drop 30drops/min Q: 0.0005m3/h	Water Drop 95drops/min Q: 0.0015m3/h	Thread Water Q: 0.004m3/h	Opening 90 degrees Q: 0.129m3/h	Opening 180 degrees Q: 1.65m3/h	Opening fully Q: 2.36m3/h

Valve



Thread Water Q: 0.002m3/h	Splaying partly Q: 0.096m3/h	Splaying half around Q: 0.125m3/h	Spouting all around Q: 0.296m3/h

Polyethylene Pipe

Pin hole	Crack (1cm)	Crack (2cm)	Crack (3cm)	Crack (4cm)	Crack (5cm)
Q: 0.001m3/h	Q: 0.113m3/h	Q: 0.64m3/h	Q: 1.18m3/h	Q: 1.83m3/h	Q: 2.86m3/h

9. Contact List

List of equipment for leakage detection and their related devices are as follows:

Contact List

Item	Type	Manufacturer	Website
Ultrasonic Flowmeter	UPF-20	TOKYO KEIKI	www.tokyo-keiki.co.jp/
Correlation Type Leak Detector	LC-2500	FUJITECOM	www.fujitecom.co.jp/
Ground Microphone Type Leak Detector	DNR-18	-ditto-	
Time Integration Type Leak Detector	FSJ-1&FSB-8D	-ditto-	
Listening Stick	LSP-1.5	-ditto-	
Iron Pipe and Cable Detector	PL-960	-ditto-	
Metal Detector	F-90M	-ditto-	
Leakage Meter	FLQ-2	-ditto-	
Water Pressure Data Logger	Textlog Multi	ASHRIDGE	
Nonmetallic Pipe Detector	D-305	Goodman	www.goodman-inc.co.jp/
Test Meter	TR-III	Aichi Tokei	www.aichitokei.co.jp/

10. Setting a large sensor of ultrasonic flow meter and its fitting belt

(1) How to set the sensors

- A large sensor (UP04AST) is used for the pipes which diameter is DN 300mm and over.
- The way to set a large sensor is as follows (see photos).

a. Insert the belt into the slit of wind axis. (see photo 1-1)
b. Pull out the belt through the opening space of operation lever. (see photo 1-2)
c. Adjust remain length to tighten belt to the pipe. (see photo 1-3)
d. Hook the hook of the belt to the wires of both sides of the sensor holder. (see photo 1-4)
e. Tighten the belt by operation lever (explain in the next section) (see photo 1-5)
f. Set the sensor in the sensor holder and fix it. (see photo 1-6)

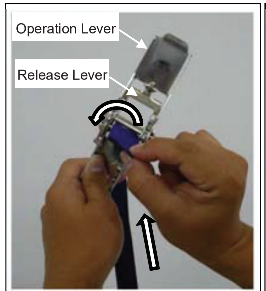


Photo 1-1

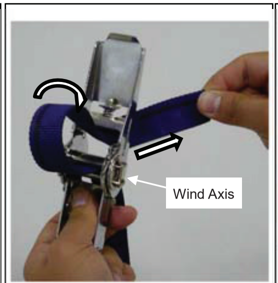


Photo 1-2

Photo 1-3

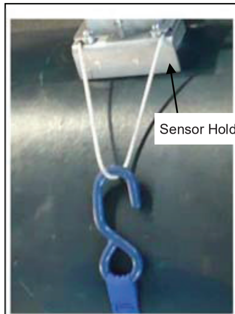


Photo 1-4

Photo 1-5

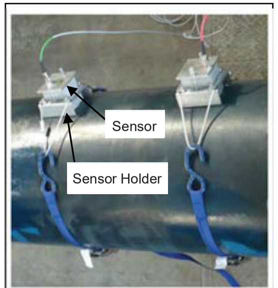


Photo1-6

(2) How to tighten and loosen the belts

- The way to tighten and loosen the belt is as follows (see in photos).

a. Insert the belt into the slit of wind axis. (see photo 2-1)
b. Move operation lever forward and back like the arrow on photo 2, and the belt is tightened. (see photo 2-2)
c. Wind up the belt **about 2 rounds** to the wind axis and push operation lever to the arrow's direction on photo 3 for finish to tighten the belt. (see photo 2-3)
d. Hold operation lever and release lever and push operation lever to arrow's direction on photo 4 to open **180 degrees**. And confirm the release stopper fixed the gear. (see photo 2-4)
e. Pull the belt and release. (see photo 2-5)

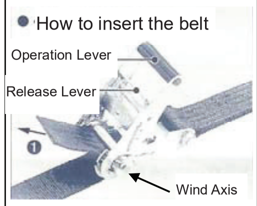


Photo 2-1

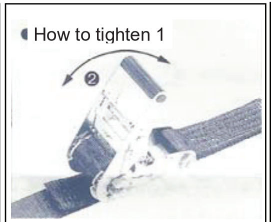


Photo 2-2

Photo 2-3

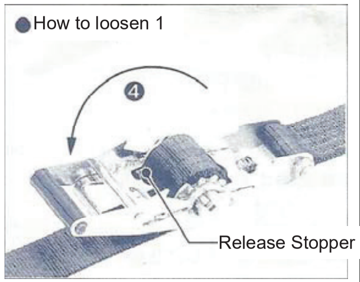


Photo 2-4

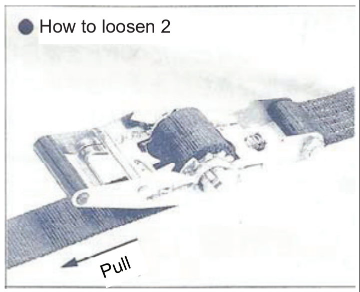


Photo 2-5

Annex-3

Manual for GIS (Action Team)

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1. Management by the Basic Grid

(1) Setting the grid

The management area should be managed by creating three different size of grids, the large grid shall be a square of 10km x 10km, second grid 1,000m × 1,000m, third grid 250m x 250m (or 200m x 200m) covering all the administrative districts. The grids shall be numbered in order from the top left. The next step set up a sub-grid: a width of 200m or 250m. Examples of Grid creation for all Districts of the FCT are shown as follows.

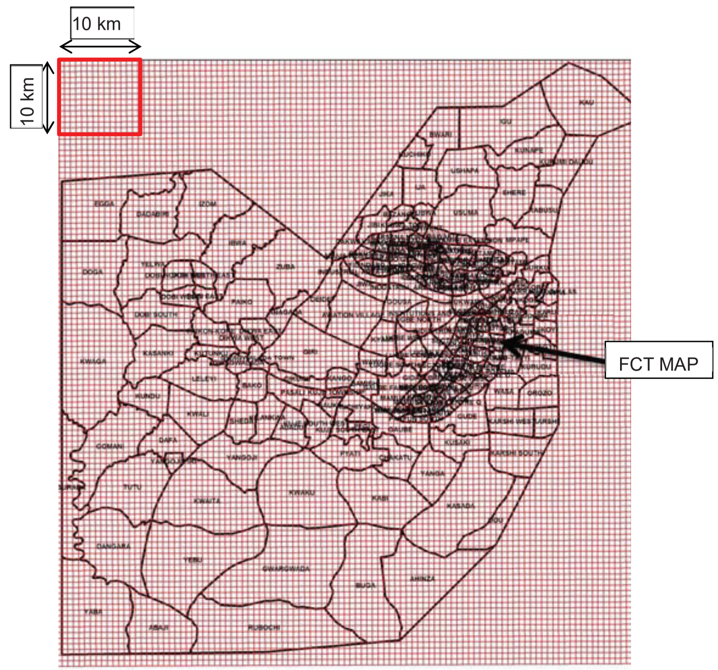


Fig. 1-1 Example of setting the grid covering all FCT Districts

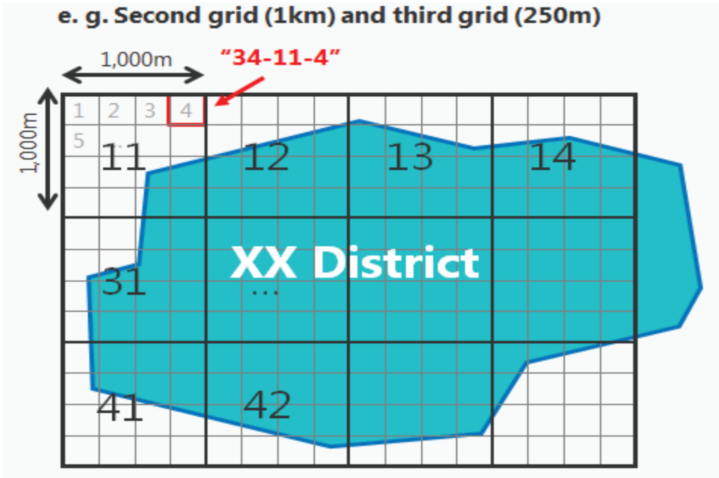


Fig. 1-2 Example of grid setting

(2) Setting the basic scale of GIS

Since the scale of the final printing is 1: 2,000, therefore FCTWB should do all GIS work with the basic scale as 1: 2,000.

2. Map data and attribute data

GIS is composed of background data, map data and attribute data.

(1) Background data (Image data)

Background data of AGIS is an aerial image taken in 2010. Since then, it has not been updated, development of infrastructure has progressed, and this aerial image and current situation was greatly divergent. In this project, WB can utilize this aerial image as input assistance, but use the map by maintenance works hide aerial image when printing.

Google Map and OpenStreetMap are often used as background supplement data, but it is important to note that AGIS adopted MINNA datum as coordinate axes and the coordinate axes are different from Google Map and OpenStreetMap.

(2) Map data (Geographic data)

Map data are represented by polygon, line, or node. Examples of main map data

related to water supply facilities are as follows.

Table 2-1 Examples of map data

Item	Sort of Data
Polygon data	Water treatment facility, Reservoir, Distribution tank, Customer plot, Street, etc.
Line data	Transmission line(From Water Treatment Plant or Reservoir to Reservoir), Distribution trunk main(>=DN400mm), Distribution pipe, Service pipe, etc.
Node data	Valve, Fire hydrant, Washout, Meter, Stopcock, etc.

Transmission line, distribution trunk mains, distribution pipes and their fittings are highly required to conduct the water supply management activities, therefore, this information should be inputted first. And as next step it is preferable adding service pipe and customers data with its accessories.

(3) Attribute data (Property data)

Attribute data is inputted as a feature in graphic data. Sort of data is as follows.

Table 2-2 Examples of attribute data

Item	Sort of Data
Water Treatment facility	Capacity, construction year
Distribution reservoir(Tank)	Capacity, construction year, operation water level
Transmission line	Name of line, Pipe size, pipe material, installation year, depth, off-set
Distribution pipe	Pipe size, pipe material, installation year, depth, off-set
Service pipe	Pipe size, pipe material, installation year
Valve, fire hydrant, washout	Size, state (open/close, functional/nonfunctional), installation year, off-set
Customer meter	Meter size and type (mechanical, AMR, PPM), installation year, customer information, etc.

Sample transmission line name is shown Table 2-3.

Table 2-3: Name of Pipe line (suggestion sample)

Name of Pipe Line	Starting point	Ending point
Transmission Line		
Buwari Transmission Line (BUTL)	Usuma Distribution Point	Buwari Reservoir
T2&5 Transmission Line (T2&5TL)	Usuma Distribution Point	Brach point of T2Transmittion Line and T5 Transmission line
T2 Transmission Line (T2TL)	Brach point of T2&T5TL	Tank 2 Reservoir
T5 Transmission Line (T5TL)	Brach point of T2&T5TL	Tank 2 Reservoir
T3&4 Transmission Line (T3&4TL)	Usuma Distribution Point	Brach point of T3Transmittion Line and T4 Transmission line
T3 Transmission Line (T3TL)	Brach point of T3&T4TL	Tank3 Reservoir
T4 Transmission Line (T4TL)	Brach point of T3&T4TL	Tank4 Reservoir
Kubuwa Transmission Line (KUTL)	Usuma Distribution Point	Kubuwa Reservoir
Main Distribution Line		
T4 Out Main	T4 Reservoir	Branch Point of Mohamed Main
Mohamed Main		
Shehu Shagari Main	Branch Point of Mohamed Main	

In FCTWB, pipe data such as pipe size and pipe material can be obtained from As-built drawings and memories of staff of O&M sectors; however there are many ambiguous points such as installation year, depth, off-set, etc. So, it is required that confirmation work by field survey accompanied with staff who has pipe information is done and update when information obtained.

Regarding valves, fire hydrants and washouts, in order to improve accuracy, it is necessary to conduct field surveys as often as possible.

In addition, meter and customer information are not well organized with the billing unit data and area office's data, therefore, on-site surveys are also necessary to harmonize them.

3. Collection of necessary information

It is common to use data of As-built drawings for data input to GIS, nonetheless FCTWB has not collected enough As-built drawings to build up the distribution maps. Therefore, in order to collect map data and attribute data, it is necessary to collect all the staff's memory and records in FCTWB in addition to As-built drawings.

Fig. 3-1 shows the work flow of GIS development based on the staff's memory and records.

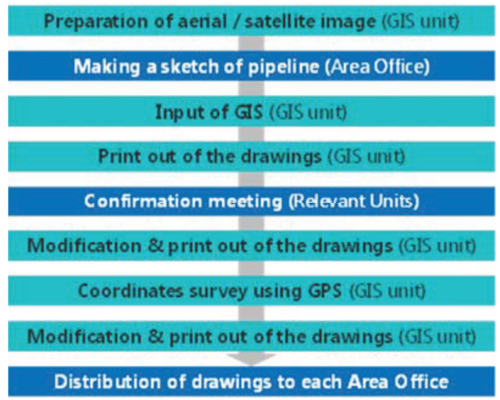


Fig. 3-1 The workflow of GIS development

(1) Preparation of aerial / satellite image

GIS unit print out the AGIS aerial images or satellite images such as Google Map® and distribute it to each Area Office. It is not a matter of scale of the background of the data map, but GIS unit should consider the visibility and workability for the work of Area Offices.

Fig. 3-2 Preparation of aerial images / satellite images

(2) Making a sketch of pipeline

An Area Offices must set up a sketch of pipeline information such as the pipe location, pipe size, pipe material, valve, fire hydrant, washout, etc. on the distributed aerial / satellite images. The pipe location should be illustrated where the pipeline is installed at the right side, the left side or center of the street.

Fig.3-3 Making a sketch of the pipeline information

(3) Data Input to GIS

GIS unit inputs the all information into GIS based on the sketch data made by the Area Offices.

The input operation should be carried out with a scale of 1:1,000 to eliminate variation of data. The symbols of water supply facilities are shown in Table 3-1.

Table 3-1 DESCRIPTION OF LEGEND FOR WATER DISTRIBUTION FACILITIES

S/NO	SYMBOL	DESCRIPTION
1		Permanently closed valve
2		Valve
3		Service Pipe Valve
4		Service Pipe Cock
5		Pipe size reducer
6		Pressure reducing valve
7	Z	Non-Return Valve
8	U	Ultrasonic Flow Meter
9	C	Conventional Meter
10	M	Household or Commercial Water Meter
11	A	Air release valve
12		Fire Hydrant
13		Drain or Washout valve
14		Public Tap or Supply standing Tap
15		Transmission Pipe
16		Distribution Pipe
17		Service pipe

18		Branch Pipe
19		Crossing Pipe
20		Pipe end cap
21	D250, VP, Dpl. 8m, 1995	Diameter, Material, Depth, Year of Installation
22		Culvert or Sheath pipe
23	DTS, VP, 1995 0.6m	Offset of Valve, Fire hydrant, etc.
24	P	Pump
25		Valve or Meter Chamber

It is better to describe pipe size, pipe material, depth of pipe, install year and off-set data in some representative place alongside the pipeline like C/No 21 and 23 of Table 3-1 and Fig. 3-4, other detail attribute information should be written separately as character data.

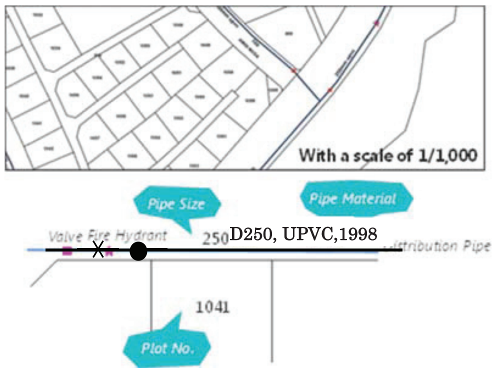


Fig. 3-4 Example of inputting the pipeline information

(4) Print out of the drawings
GIS unit prints out the index map and detail map except aerial / satellite image.

(5) Confirmation meeting
To confirm the result inputted by GIS, GIS unit should hold the confirmation meeting with Pipeline unit and Area Office. If necessary, site survey should be conducted such as valve chambers, etc. Refer to Chapter 3 for details of the confirmation method.

(6) Modification and print out of the drawings (based on the confirmation meeting)
GIS unit modifies the GIS based on the confirmation meeting.

(7) Coordinates survey using GPS
[> This step is to be done after all pipe network drawings in FCTWB management area have been created]
In order to grasp the exact location of pipeline, GIS unit should collect the coordinate information using a GPS terminal at the site of the facilities such as valve, fire hydrant and washout. In this investigation, GIS unit should collect not only coordinates but also height information.


Fig. 3-5 Coordinates survey

(8) Modification & print out of the drawings (based on the coordinates survey)
[> This step to be done after all pipe network drawings in WB management area have been created]
Based on the result of coordinate survey, GIS unit modifies the location of the valve etc. and also modifies the pipeline location. After this, GIS unit prints the 1,000m x 1,000m grids on a scale of 1:2,000 on A1 size paper, and provides the district name as a title, legend, scale, direction to the map.

(9) Distribution of maps to each Area Office
The printed maps should be owned by three sections, GIS unit, Pipeline unit and Area Offices.
The maps should be kept as A1 hung on drawing rack or large flat drawer or be bound and folded to A4.

Fig.3-6 Image of drawing rack

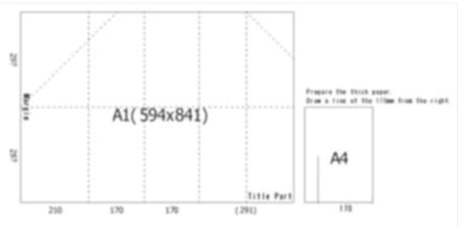


Fig. 3-7 Binding and folding method

4. Key points of GIS development

Key points to keep in mind when creating drawings are listed below.

(1) Key points for making a sketch of pipeline information

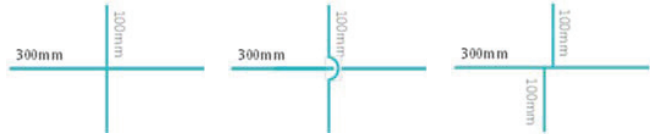
a) Data supplement by human memory

A sketch of pipeline information is made on the aerial / satellite image prepared by GIS unit. After that, to sketch pipeline, area offices should be given a detailed description of the pipe location, pipe size, pipe material of the transmission line, distribution trunk main and other distribution pipe, reflecting most recent information. In addition, location of all valves, fire hydrants and washouts should be described correctly.

Various operation and maintenance works have been carrying out by staff in area offices such as operation of valves, repairing of pipes, and connection work for customers, etc. When sketching pipeline information, all staff of area office should be involved, have discussion amongst each other, and all information should be collected from them so as to make an accurate map.

b) Accurate intersection point of pipeline

Accurate pipeline data contribute not only O&M of water supply but also various analysis such as hydraulic analysis. On the map, at the intersection point of pipeline and actual situation must be reflected on the map. Figure: 9 shows conceivable pattern and it is necessary to strictly express by these three patterns.



Cross pipe Crossing Two T-branches

Fig. 4-1 Patterns of the intersection point

c) Pipe end and distribution boundary

The maps made by Area Offices contain only the districts that they are managing. It is strictly required that accurate information of the pipe end, end or continues to next area, and location of boundary valves.

5. Future prospects

(1) Reflecting of customer information

GIS can reflect customer information as well as pipeline information. By associating a tariff system and customer ledger with GIS, GIS can also reflect the customer water consumption. At this moment, FCTWB did not input customer information into AGIS.

For customer information, customer name, account number, contract type (domestic/un-coded commercial/coded commercial, flat rate/metering), meter installation location, meter type (mechanical/AMR/prepaid), service pipe information etc. should be reflected.

(2) A3 map book

Current drawings of A1 with 1:2,000 scales are inconvenient to bring them to the site. Therefore, create A3 map book of pipeline with high portability is recommended.

(3) Establishment of organizational structure for data aggregation / update

To complete all maps and to keep updating at all times, it is necessary that establish a standardized process to collect the updated information to GIS unit from the Area Offices, making a rule for updating for GIS and considering the personnel for GIS updating.

Annex-4

Manual for Hydraulic Analysis
(Action Team)

Nov. 2017

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1. Outline of hydraulic analysis

(1) Purpose of Hydraulic Analysis

Hydraulic Analysis gives information about water flow rate, water quality (concentration of residual chlorine) and water pressure on a pipeline network.

Hydraulic Analysis is used for as follows:

- Designing a new water supply system that meets water demand, such as reservoirs and distribution pipeline network.
- Examination of existing pipeline network to confirm water pressure whether it's too low or high and find the place where water shortage will be occurred when changing the water supply network.
- Confirmation of water supply ability of the existing pipeline network to supply new development area such as large-scale living quarters and shopping complex where water demand will be added to the existing network.
- Designing of pipe replacement plan in existing pipeline network.
- Required data and Obtained data of Hydraulic analysis.

Required data (Input)
- Coordinates, especially elevation of nodes
- Water demand of nodes
- Pipe length of links
- Pipe size of links
- Roughness coefficient of links

Obtained Data (Output)
- P: Water pressure of nodes
- Q: Flow rate of links
- V: Flow velocity of links
- Flow direction of links
- Δh: Head loss of links
- I: hydraulic gradient

Fig. 1-1 Input and Output Data

(2) Software Program of Hydraulic Analysis

- There are many software programs on Hydraulic Analysis. One of the famous software "EPANET" can be used free of charge. It was developed by the United States Environmental Protection Agency (EPA) Water Supply and Water Resources Division. This manual explains analytical procedures in line with "EPANET".
- It can be downloaded from the website: https://www.epa.gov/water-research/epanet.

(3) Data Collection for Analysis

It is necessary to get accurate data for analysis. If the data is inaccurate, the result is also inaccurate.

a. Distribution Pipeline Network

a-1 Pipe network information

- Pipe Diameter, Length, Roughness coefficient of pipe (between Each Node)
- Location of Distribution reservoir, Branch of pipeline, Reducer and Pipe end including Boundary valve
- Position of pump and booster pump station if there
- Boundary of area
- Position of service connections

b. Water Demand

b-1 Water Demand of an area

- Water demand of all customer (households including major consumers)
- Water consumption of miscellaneous use (not measured by meter but consuming daily)
- Location of water user

c. Node

c-1 Elevation of each node (High water level of distribution reservoir (in case of water receiving point), Low water level of distribution reservoir (in case of water supply point), or Operational water level of reservoir, Branch of pipeline, Reducer and pipe end including Boundary valve)

- Aggregated and allocated water demand of node

c-2 Pumping station and booster pump station information if there

- Position of pump and booster
- Performance of pump (pumping water level)

c-3 [For Water Quality Analysis]

- Concentration of residual chlorine at water source such as clear water tank and reservoir
- Reduction rate of residual chlorine concentration

2. Data Collection Methods

(1) Procedure of Data Collection and Confirmation

Procedure of Data Collection and Confirmation is as follows:

[Pipe Network]

- Obtain latest network data from the GIS team and check the boundary of distribution area on the map.
- It is important investigate the boundary on site with the area officer staff who operate the boundary valve most recently.
- Other than boundary, collect any information from the area office about the pipeline (valve condition, location of pipe, diameter etc.).
- To confirm pipeline length and its elevation "Google Map" or "Google Earth" is available.

[Water Demand]

- Consumption data can be obtained from the billing unit, in a situation that it cannot be obtained from the billing unit, it could be gotten from area office and confirm the data with the person in charge (such as reader from meter reading unit, and sub area manager).
- It is difficult to get prepaid meter consumption, ask the prepaid meter unit how to deal with this situation.
- Major customers are managed by the HQ, collect data from the responsible section in the HQ.
- In case customer record have only monthly charged amount instead of consumption volume.

Table 2.1 Calculation of Water Consumption

Item	Water charge	Meter reading
Charge amount	4,250NGN (usually one-month rate)	
Previous date	1 June, 2017	11 Aug. 2017: **800m^3**
Current date	1 Aug. 2017	11 Sep. 2017: **872m^3**
Calculation	4,250NGN / 80NGN / m^3 = 53.1m^3 / 2months 53 / 61days = 0.871m^3 / day 0.871m^3 / day / 24hour / day = **0.036m^3 / hour**	72m^3 / 30days 2.4m^3 / day / 24hour / day = **0.1m^3 / hour**

・In case Consumption data is zero" 0" or no data, you can assume consumption as below:

- Major consumer：20m^3/day(source from PMA investigation by JICA team)
- -Resident：2.0m^3/day(source from measurement result of average by JICA team)

3. Model creation of pipeline network

In this manual, only the key points are described. For the details on model construction of distribution pipe network, refer to the EPANET manual.

(1) Setting of nodes

To create the model network, it is not necessary to construct an accurate model of all water distribution networks. In modeling, it is desirable to extract only the minimum necessary nodes and simplify them as much as possible.

The following items can be cited as the minimum necessary nodes.

- Branch points
- Pipe ends (including boundary valve)
- Changing points of pipe size and pipe materials (roughness coefficient may be changed)
- Greatly changing points of elevation on the pipeline (about10m and more)
- Large water demand points (major consumer with demand amount of about 10m3/h and more)

A model network and node setting is shown Fig. 3-1.

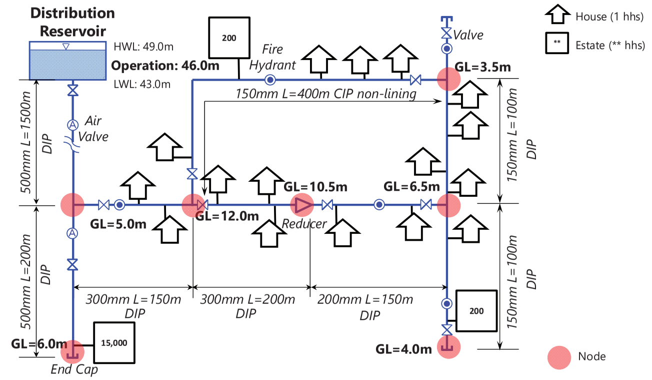


Fig. 3-1 Setting of the nodes

In the distribution pipeline network, it is necessary to set at least one distribution reservoir (water resource). The operation water level should be set in the distribution reservoir.

✧ Attention points: High Water Level of Distribution Reservoir (in case of water receiving point), Low Water Level of Distribution Reservoir (in case of water supply point), or Operational Water Level of Reservoir)

For each node, elevation, water demand (refer to (3)) must be set. Fig 3-2 shows elevation of nodes.

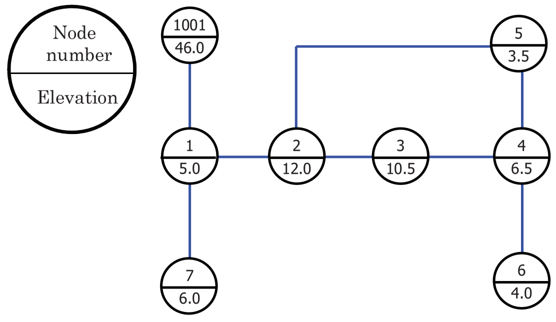


Fig. 3-2 Modeling of the nodes, elevation, etc.

4. Setting of the links (pipeline)

Nodes are connected and links (pipelines) are set. In the links, the pipe length, pipe size, roughness coefficient must be set.

In general, for the hydraulic analysis, the Hazen-Williams equation is used.

$I = 10.666C^{-1.85}D^{-4.87}Q^{1.85}$ (Hazen-Williams Equitation)

Though, the roughness coefficient differs depending on piping, pipe material and aging of the pipe, roughness coefficient, C=110 is commonly used in consideration with curved pipe. In model network fig 3-3, C=100 is used for the aged metal pipe (Upper line).

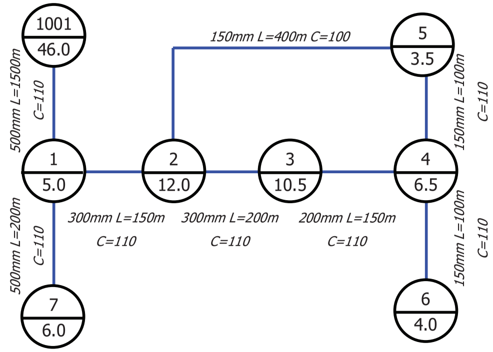


Fig. 4-1 Setting of the pipeline information

5. Allocation of water demand

(1) Sample Model

Water demand should be allocated to the closest node, however if it locates large water demand consumer such as estates or a large shopping mall, it can be split and allocate to two nodes. Also, when it is too far from the node, it is possible to make new node with a large demand. It is important to allocate so as not to be complicated.

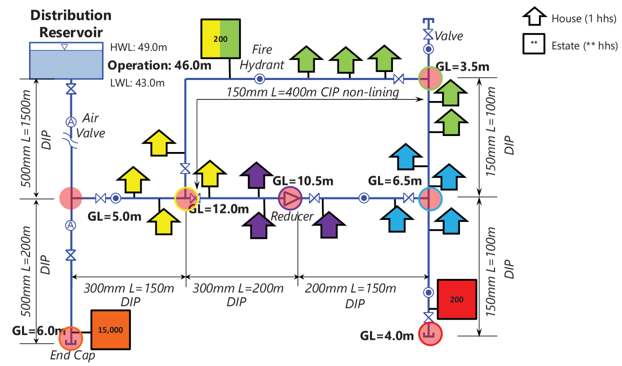


Fig. 5-1 Allocation of water demands

In this sample model water demand assumed that is 1.0 m3/household/day, it can be inputted as shown in Fig. 5-2.

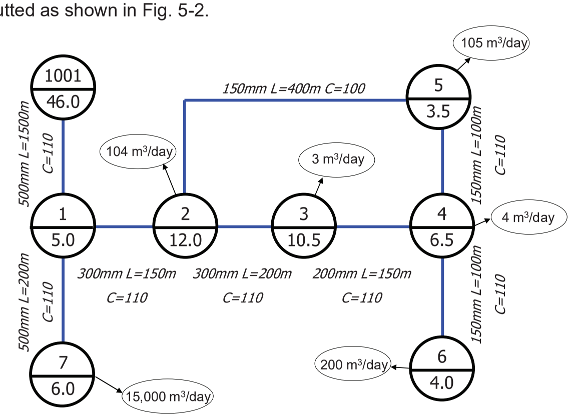


Fig. 5-2 Input of water demands

(2) Another model

In case of FCTWB, meter reader records their reading data street by street, therefore, data should be aggregated by streets as well as. Example of allocation model is shown below.

- Example 1: Total water demand of the certain road, data is divided into 3, and then allocates the nearest node.

Total water demand of street is 15m^3/h

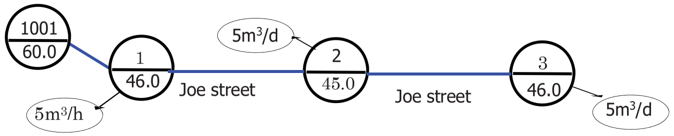


Fig. 5-3 Sample allocation 1

- Example 2: There are two nodes (node no.1, 2) in one street and Major consumer is located near the node no.1 side.

Total water demand is 250m^3/h=50(Resident customer) +200(Major customer). 50m^3/h, resident customer's water demand, is divided into two and allocated to node 1 and 2. 200m^3/h, major customer's water demand, is allocated to node 1.

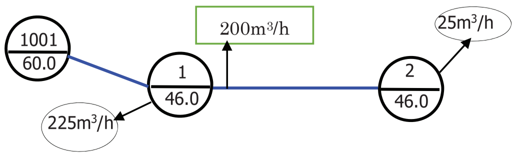


Fig. 5-4 Sample allocation 2

6. Implementation of hydraulic analysis by the EPANET

(1) Drawing the network

[Detail of implementation procedures refer the Manual of the EPANET, Chapter 2]
When you're ready to begin the drawing use toolbars of the EPANET, add the reservoirs, nodes and then add pipes (links).

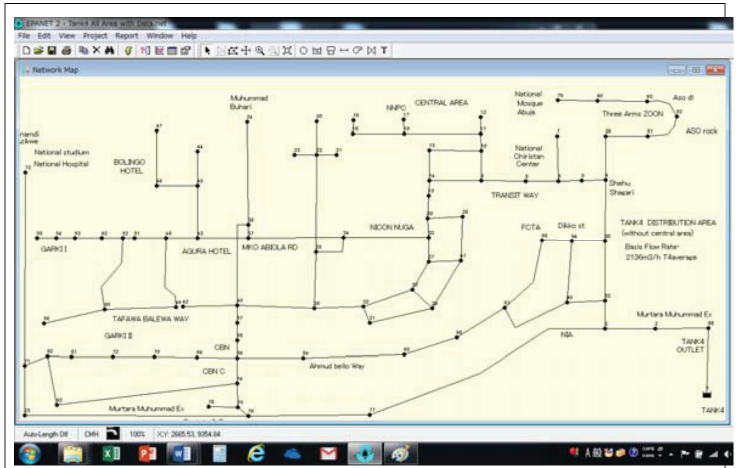
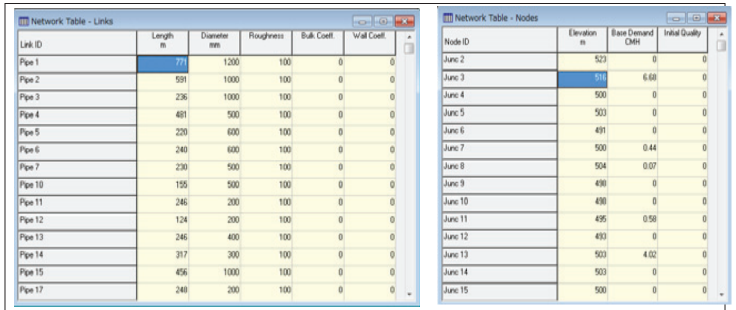


Fig. 6-1 Drawing the network

(2) Put Data to the Properties

Then put data of reservoir (Total head), node (Elevation, Base demand, etc.) and pipe (Length, Diameter, Roughness).
Before running the analysis reconfirm the input data using "Network table Links & Nodes"
Sample Network table and drawings are shown Fig9 and Fig10 and 11

a. Sample Network Table.



Network Table - Links

Link ID	Length m	Diameter mm	Roughness	Bulk Coeff.	Wall Coeff.
Pipe 1	771	1200	100	0	0
Pipe 2	591	1000	100	0	0
Pipe 3	236	1000	100	0	0
Pipe 4	481	500	100	0	0
Pipe 5	220	600	100	0	0
Pipe 6	240	600	100	0	0
Pipe 7	230	500	100	0	0
Pipe 10	155	500	100	0	0
Pipe 11	246	200	100	0	0
Pipe 12	124	200	100	0	0
Pipe 13	246	400	100	0	0
Pipe 14	317	300	100	0	0
Pipe 15	456	1000	100	0	0
Pipe 17	248	200	100	0	0

Network Table - Nodes

Node ID	Elevation m	Base Demand CMH	Initial Quality
Junc 2	523	0	0
Junc 3	516	6.68	0
Junc 4	500	0	0
Junc 5	503	0	0
Junc 6	491	0	0
Junc 7	500	0.44	0
Junc 8	504	0.07	0
Junc 9	498	0	0
Junc 10	498	0	0
Junc 11	495	0.58	0
Junc 12	493	0	0
Junc 13	503	4.02	0
Junc 14	503	0	0
Junc 15	500	0	0

Fig.6-2 Sample Network table (Links and Nodes)

b. Sample Drawings Large scale (Zone)

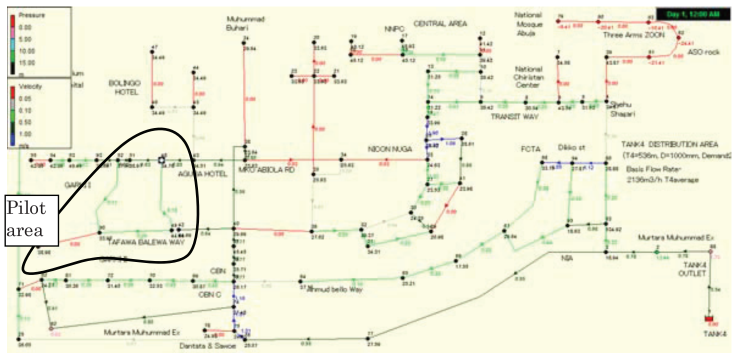


Fig. 6-3 Drawings Large scale (Zone)

c. Sampl drawing : Smal scale (Pilot area)

In case there are no water resevoir to supply target area, imaginary reservoir should be set. Total head of imaginary reservoir should be asuumed as the result of lage scale analysis.

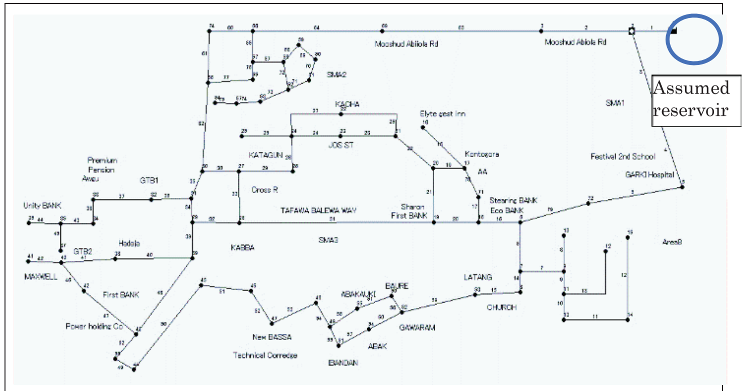


Fig. 6-4 Small scale (Pilot area)

(3) Hourly Factor

Usually, the water use behavior of customers varies with time. FCTWB should distribute sufficient water to the customers even at the time of maximum water supply. Therefore, it is necessary to consider the hourly factor.

Hourly factor is the maximum daily water supply divided by the average daily water supply. Usually, hydraulic analysis is carried out in a scenario where the water demand is multiplied by the hourly factor so that water can be distributed even at the time of maximum water supply.

Hourly factor differs depending on the regional features, for example, in the case of Japan; it is 1.4 in a commercial area, 1.7 in a large residential area and 2.5 in a small residential area. Investigation is required in the FCT area based on the water reservoir supply area to find the factor individually. The EPANET can reflect the behavior pattern of the water demand.

In the sample model of this manual, when the hourly factor is 1.8, the simulation result is shown in fig 7. Water pressure, direction of flow, flow velocity, etc. can be analyzed.

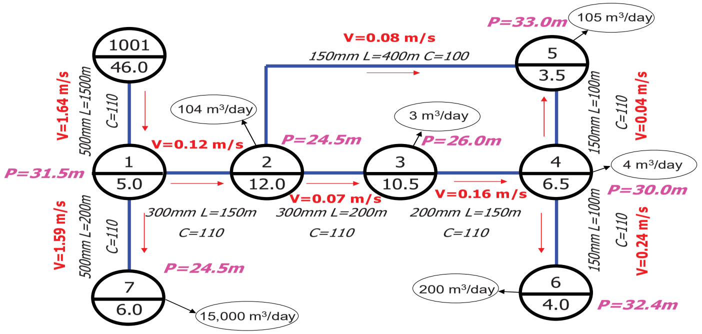


Fig. 6-5 Example of the simulation results

7. Evaluation of output

(1) Calibration of result by water pressure

Because hydraulic analysis is a just simulation calculated with various preconditions and assumptions, it is unknown whether the current situation is reflected properly in the calculation. Therefore, it is necessary to evaluate the validity of the simulation result by comparing the actual situation.

Water pressure can be used to compare this. Water pressure is comparatively measured easily at the site, result is compared with simulation result and the validity of the result should be evaluated. To measure water pressure, there are two ways:

- Pressure gage: Pressure gage will be installed at the fire hydrant, etc. and read meter at the site.
- Pressure logger: Pressure logger will be installed at the fire hydrant, etc. and get record of pressure then it can be seen by a computer.

a. Sample comparison of pressure

Pressure measured at 24hrs on the pipe line by the pressure logger where shown Fig 13 and result shows 0.17~0.22MPa. On the model network, calculation result is 0.172MPa.

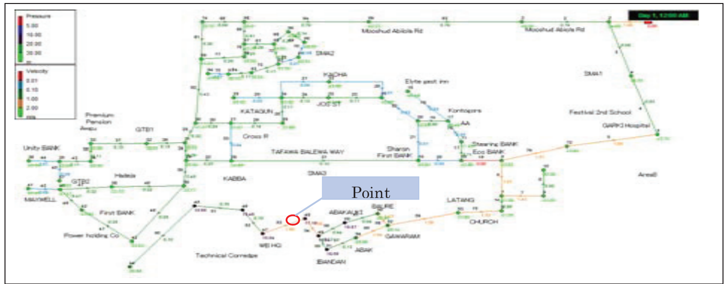


Fig. 7-1 Pressure measurement point on the network

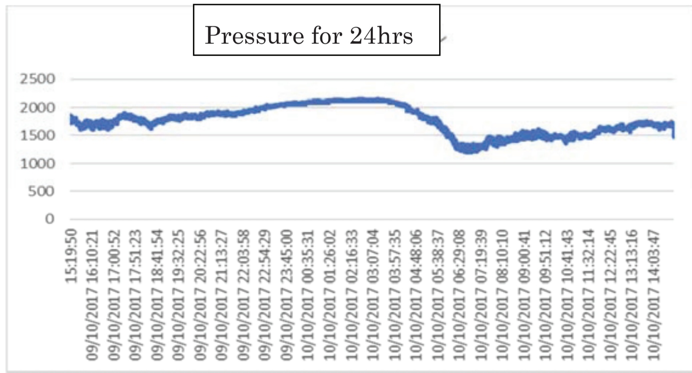


Fig. 7-2 Pressure measurement result

(2) Evaluation of results

Hydraulic analysis is a tool to examine the optimal facility size and facility placement. From the following points, the analysis results should be evaluated.

b. Water pressure within the appropriate range

The water pressure should be confirmed within appropriate pressure range. FCTWB should create appropriate water pressure in the management area and mange pressure to be adapted in the range.

In the existing network, when water pressure at the node is negative, water supply failure has occurred, so urgent improvement should be necessary. In the case of low water pressure, improve the setting such as installing a new pump with increasing pipe size or installing another pipe, hydraulic analysis should be calculated again, and simulate so that the optimum water pressure will be obtained.

c. The velocity within the appropriate range

Where the velocity is close to zero "0", it becomes stagnant water, which causes deterioration of water quality, so velocity should be confirmed. And it is necessary to avoid damage to the water supply facilities and house-use apparatus, too much velocity should be refrained.

(Example; DN50~150mm: 0.7~1.0m/s, DN200~400mm: 0.9~1.6m/s, DN450~800mm: 1.2~1.8m/s)

8. Attention Points at the Saving

When saving the result, some items should be paid more attention:

- Name of a model diagram should be named distinguishably, such as original or modified model.
- Modify the data with one's responsibility when something need to be changed on the network model (Water Demand, Pipeline and others).
- Keep the only one original network as a basic network model.

9. Make effective use of current water demand in FCTWB

(1) Re-establishment of planned water demand

At present, forecasting water demand of FCDA based on the planned water demand of 230 L/c/d and determines the number of residents per plot, and calculates the total water demand of whole of FCT. However, growth of population, distribution of settlement and constituent number of households are greatly different from the current situation and the forecasting. Also, since hourly factor is not taken into consideration, capacity of the water supply facility is not enough at present.

After conducting hydraulic analysis of the current situation, it is necessary to simulate future situation with consideration of fresh water demand that FCTWB assumes the demand under the current consumption. For that purpose, it is necessary to grasp the actual water demand without flat rate customers and water consumption pattern and hourly factor.

10. Procedure for setting of "Ashridge" pressure and flow logger

[Pressure logger]

(1) Main flow of procedure

① **Setup**: Connect the Logger to PC⇒Setup the Logger("Read from Logger"⇒[Clock] set "Logging Interval"⇒ "Send to Logger") ⇒ Set the Logger on a Pipe

② **Data extraction**: Connect the Logger to PC ⇒"Read from Logger"⇒[Log] Download

③ **Data conversion to Excel file**: Find the File(Drive:C, Ashridge, Textlog, Manual) ⇒Data transfer to Excel sheet with [Use Text Import Wizard]

(2) Details of procedure

a. Connect the logger to the PC

① Find appropriate connection USB port on "Utility" (refer to Fig. 10-1) Port is different from PCs, try some times till find suitable port. If you select not correct port, a cation appears, and connect an appropriate port no warning and you can go next step.

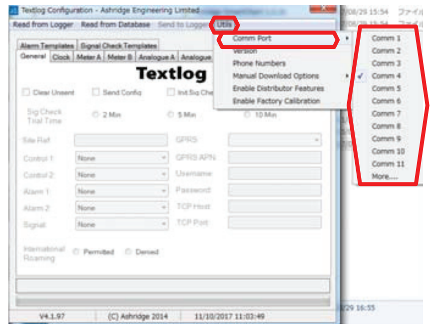


Fig. 10-1 Finding USB Port

b. **Set up the Logger**

① Transfer the Logger information to the PC. (refer to Fig.10-2 and 3)

- Select “Read from Logger” from top menu bar>>>Green sign belt show progress
- Select “General”. Confirm no check(□) of “Suspend logging”

Fig. 10-2 Transfer Logger Information 1

- Select “Utility” > “Manual Downloading Options” >
- Select “Time Format” > Check on “Human readable”

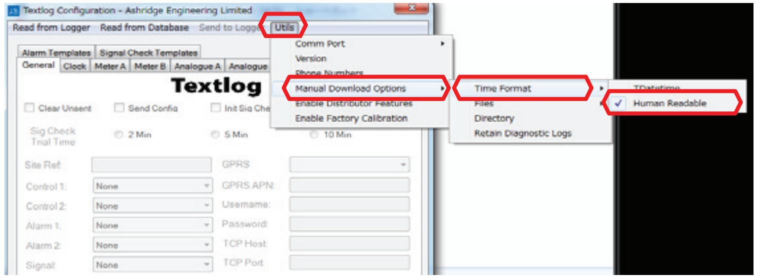


Fig. 10-3 Transfer Logger Information 2

② Setting (refer to Fig. 10-4)

- Select “Clock” ”Logging Interval”.
- Confirm time setting, usually <u>15 minutes.</u>

<u>This is option</u>
If you want record detail pressure data such as certain period and more frequent interval. Set logging interval, start o’clock and duration hour

- *Select “Windowed logging” “Start Window”, “Window Duration”.*

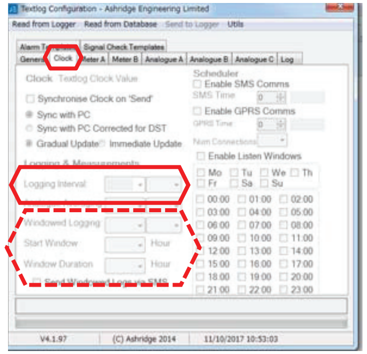


Fig. 10-4 Setting of Time

(refer to Fig. 10-5)

- Select “Analog A”, Confirm “Input type” as “Int Pressure 1”,(Not certain but chose “Normal Enabled” and “Win Enabled”)
- Click “Zero Internal Pressure Transducer for atmospheric Condition”. Massage appear’>>>OK, Message appear>>>OK

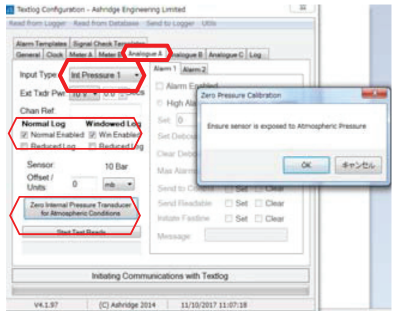


Fig. 10-5 Setting of pressure

③ Data transfer from PC to the Logger

- Select “Send to Logger”

c. **Data collection from the Logger**

(refer to fig. 10-6)

① Connect the logger to the PC ---- Same

② Transfer the Logger information to a PC

- Select "Read from Logger" from top row.>>>Green sign belt show progress
- Select "Log"
- If you chose "Download from", it need at least 2days data, adjust calendar from dropdown.>>>Counter of "Decoding Log Block" start,
- When transfer finish, appear "Completed"

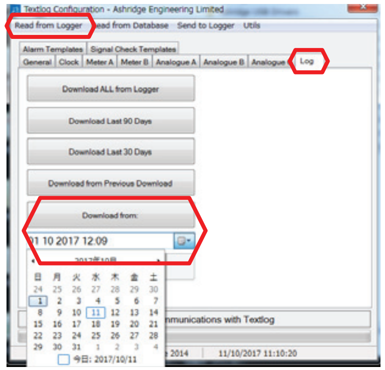


Fig. 10-6 Data collection

@ Data is saved in the C drive of PC, [Folder Ashridge, Textlog, Manual]

(3) Data conversion to Excel file

a. **Conversion to Text file (refer to Fig. 10-7)**

① Select a file which you need (Find Serial number of logger and date & time, Name off place, if you named previously)

- Open file from the C drive of PC, [Folder: Ashridge,> Textlog,> Manual]
- *@This step need only one time. After once you done this step, all files automatically will be converted as Text file*
- Select File> Click right mouse button "Open with"> Select "Notepad"

  Some case: "Open with"> Select "Notepad" or "Property" > "Change" > Other program, Select "Notepad"
- Confirm the check "use same program when open same kind file box on ☑"

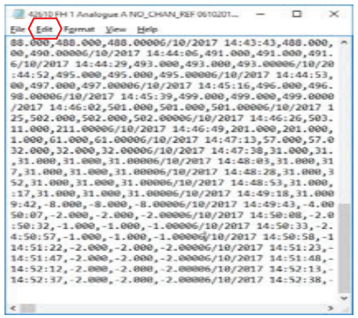


Fig. 10-7 Conversion to Text file

- Open File which you need. You can find like a sample list
- @Already data can be treated as Text data

  Open file > Select "Edit" from the menu bar > "Select all" from the menu list > Select "Edit" from the menu bar > "Copy" from the menu list

  OR
- Open File > Select the first column (date & time) and the second column(pressure) data area > Select "Edit" from the menu bar > "Select "Copy"" from the menu list

In the case of data doesn't order in column, like sample "Select all" is recommended

② Conversion (refer to Fig.10-8 and 9)

- Open Excel sheet and select a cell > Select " ▼" Down Arrow Under "Past" from menu bar > Select "Use Text Import wizard" from menu list > Sample window appear
- First, Step 1 "Next".

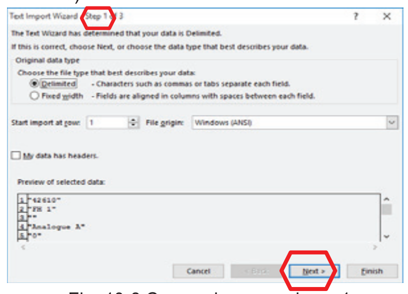


Fig. 10-8 Conversion procedures 1

- Second , Step 2, check on [comma box ☑] and check off [space box ☐] > "finish"

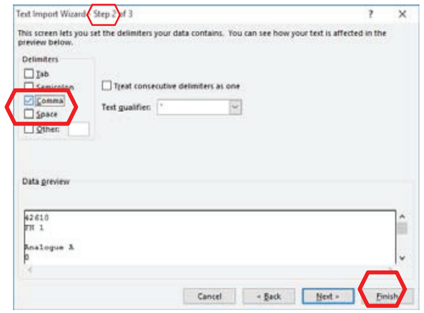


Fig. 10-9 Conversion procedures 2

After that, if you want to draw a line graph, do same procedure as Ultrasonic flow measurement.

(refer to Fig. 10-10 and 11)
To draw a graph, use First column and Second column.
Don't forget erase "date" of first data's sell, but remain hour and minutes.
(second data can be find on the text file but after converted to Excel file, second data will disappear. It is not a matter for any analyzation. we don't need such detail.)

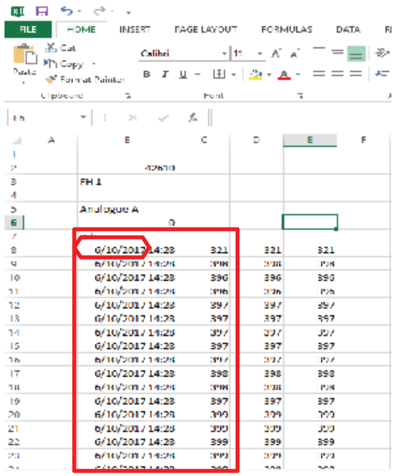


Fig. 10-10 Making graph procedures

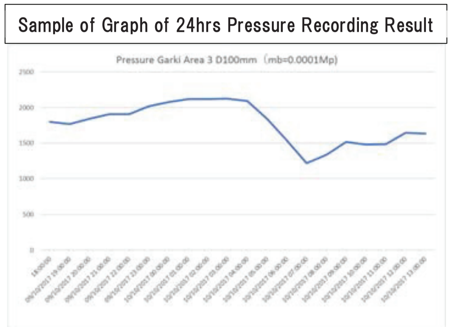


Fig. 10-11 24 hour pressure's graph

[Flow Volume Logger]
At present Flow volume logger is "Serial No 38708" (gray caller) only. (refer to Fig. 10-12)

(4) Set up

a. After connecting to a PC which has "Textlog PC configuration" software. Connecting procedure is same as the pressure logger. And do same steps of (2)Set up① of the pressure logger.

Fig. 10-12 Flow volume logger

b. Select "Meter B", confirm "Input Type" as [Pulse], "Pulse Mult" [100 litres] or suitable unit of flow volume.
- Select "Send to Logger"

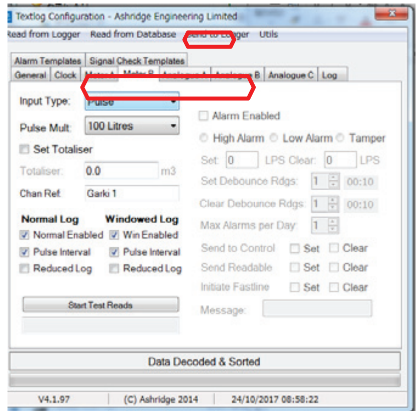


Fig. 10-13 Setting

(5) Data transfer to a PC

a. Select "Log" > Select period of data collection same as the pressure logger.

(6) Data conversion

a. Same as the pressure logger.

The Federal Capital Territory Reduction of Non-Revenue Water Project (Phase-2)

Operation Manual of the Pilot Remote Monitoring (Telemetry) System

JICA EXPERT TEAM

1. Category of the Monitoring Equipment

Monitoring equipment is categorized as follows, according to the application.

Solar System

Solar power systems were installed for stable power supply to pilot remote monitoring (telemetry) system.

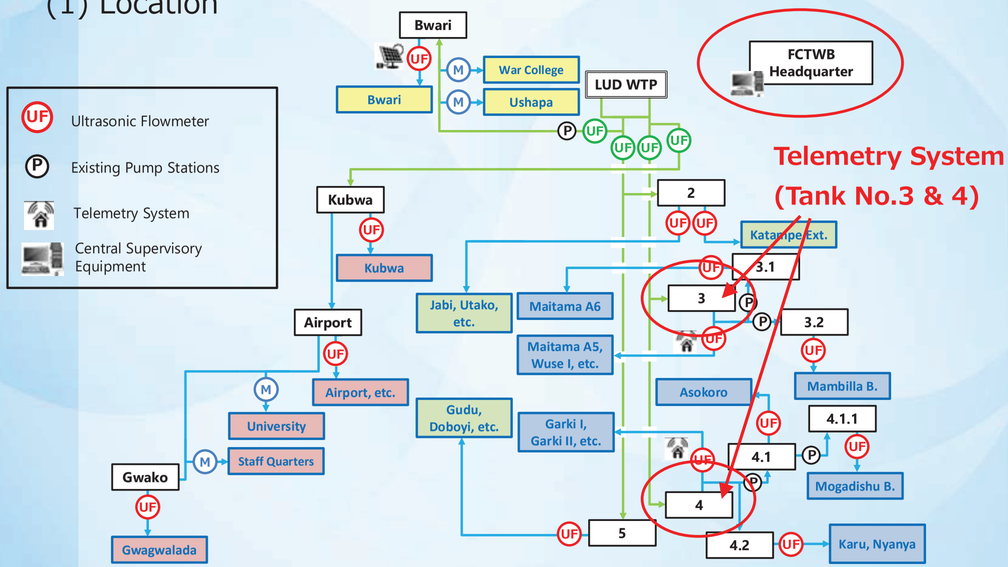
Monitoring (Telemetry) System

Monitoring (telemetry) system consists of telemetry equipment and central supervisory equipment.

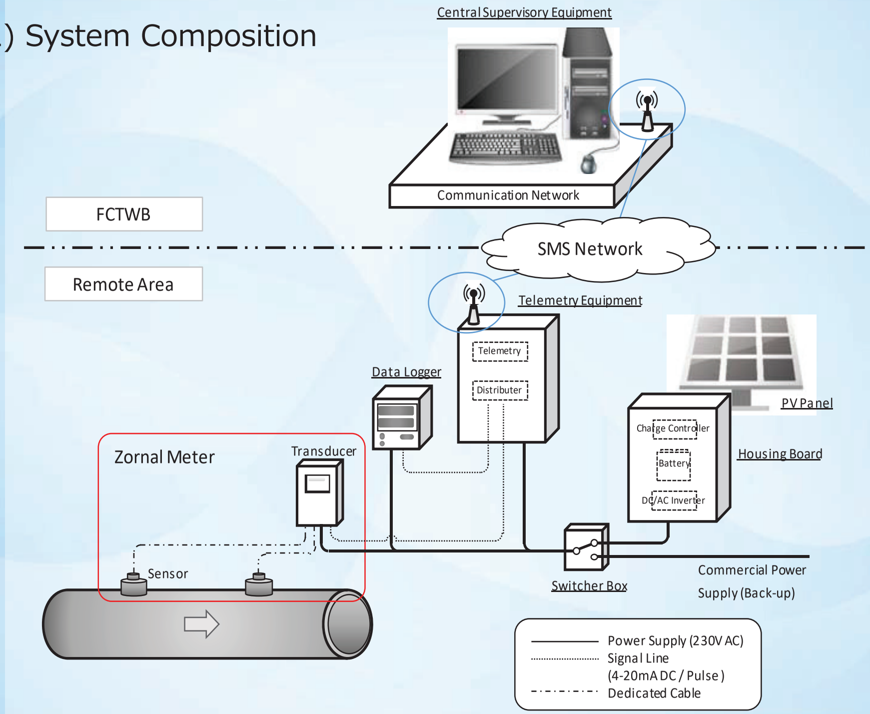
Distributer assembled in the telemetry equipment receives flow rate measured by zonal meter, and flow data is transmitted to the central supervisory equipment via telemetry equipment. Central supervisory equipment has functions to display and analyze flow data and to print the report.

2. Summary of Pilot Remote Monitoring (Telemetry) System

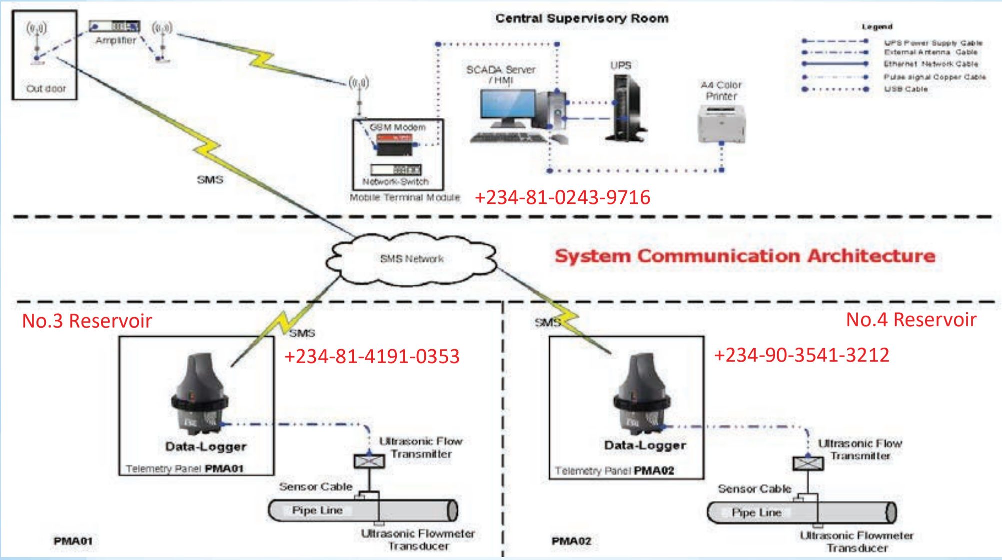
(1) Location



(2) System Composition

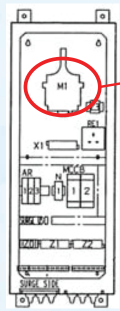


(3) Configuration of Instrumentation



3. Function of Telemetry Panel (Data Logger)

- Flow data measured by zonal meter is sampled at 15-minute intervals and stored in the data logger built in the telemetry panel.
- Accumulated data is transferred to the Central Supervisory Equipment once a day via SMS network.



Internal Structure of Telemetry Panel

Data Logger
Battery-Powered Type
Battery Life: 10 years
(Data Transmission once a day)

(1) Setting of Data Logger

After the initial setting of Data Logger, configuration changes are not required.

However, configuration change is required, limited in the following situation;

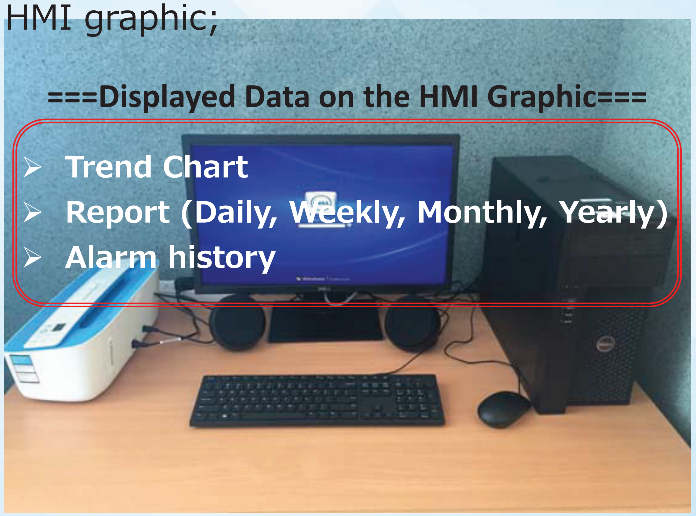
- Change of SIM Card
  (Change of mobile Number)
- Change of the Battery

Note)

Software, USB bluetooth kit and activation key for the data logger is provided as an accessories. Utilize these accessories in accordance with detailed manual by Yokogawa When you communicate with data logger.

4. Function of Central Supervisory Equipment

Central Supervisor equipment collects the flow data and diagnostic data from the data logger in No.3 & 4 Reservoir. These data are displayed on the HMI graphic;



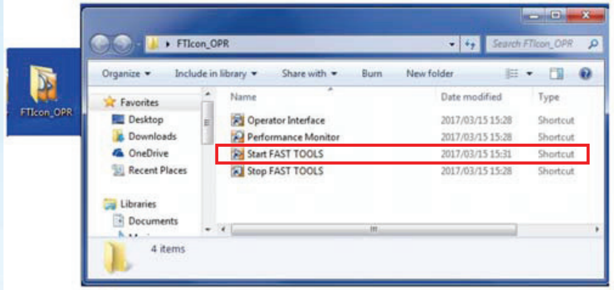
5. HMI (Human Machine Interface) Graphics

HMI is established by Fast/Tools web-based SCADA system under the license of Yokogawa Electric Corporation.

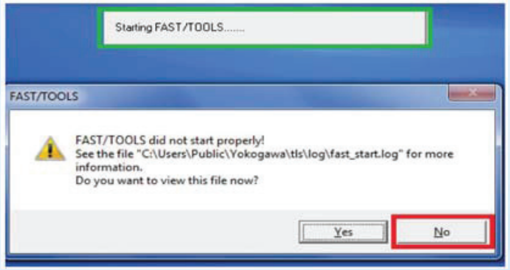
(1) Login Password for the PC

(2) Start up Fast/Tools

Select "Start Fast Tools"

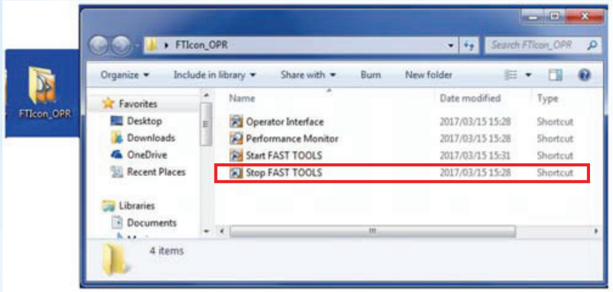


Fast/Tools processing, Select "No" on the following Screen.

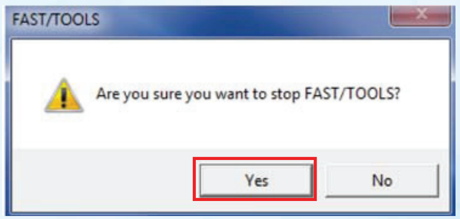


(3) End of Fast/Tools

Select "Stop Fast Tools"

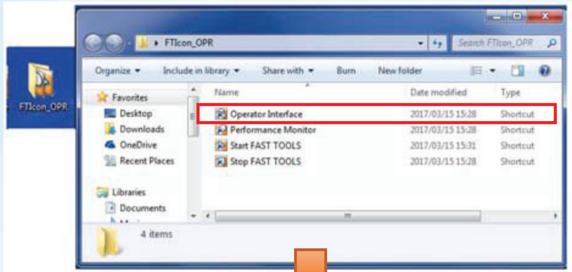


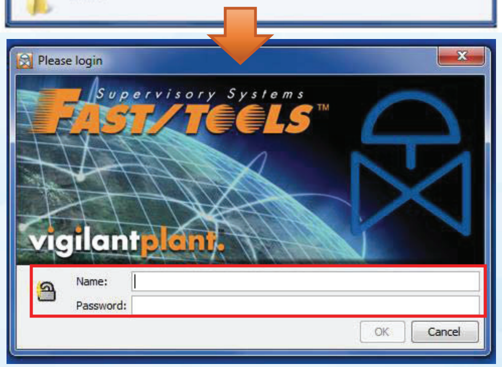
Fast/Tools processing, Select "Yes" on the following Screen.



(4) HMI Operation

Select "Operator Interface"





Authorization Group

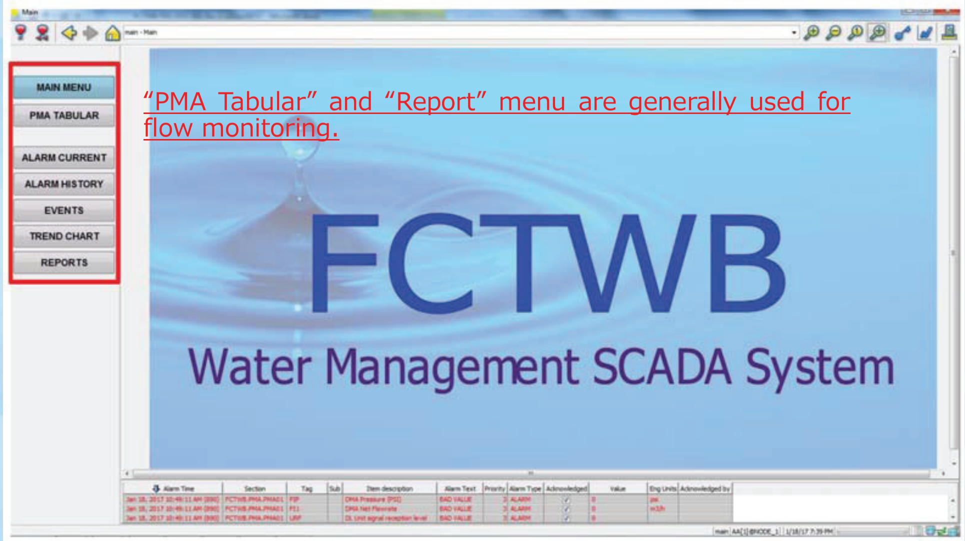
Authorization groups are defined to distinguish different access right to the Databases and Graphic Display.

User Group	Access Right
View Only	View-Only user is allowed to: - View the HMI screen and - View the trends chart. 1. User is not allowed to modify, insert and add the database. 2. User is not allowed to print the flow reports.
Operator	The Process Operator is allowed to: - View the HMI screen, Alarm screen - Operate the trends chart - Generate the Reports - Acknowledge the alarm User is not allowed to modify, insert and add the database.
Supervisor	The Supervisor is allowed to: - View the HMI screen, Alarm screen - Operate the trends chart - Generate the Reports - Acknowledge the alarm User is not allowed to modify, insert and add the database.
System Engineer	User has the right of Full access and control to the database

User Name & Password

Authorization	User Name	Password
View Only	FCTWB_G	fctwb_g
Operator	FCTWB_O	fctwb_o
Supervisor	FCTWB_S	fctwb_s
System Engineer	FCTWB_E	fctwb_e

Main Menu



6. Trend Chart (Flow Rate Graph)

This display function shows the trend line or curve of water flow rate that reveals a general pattern of change.

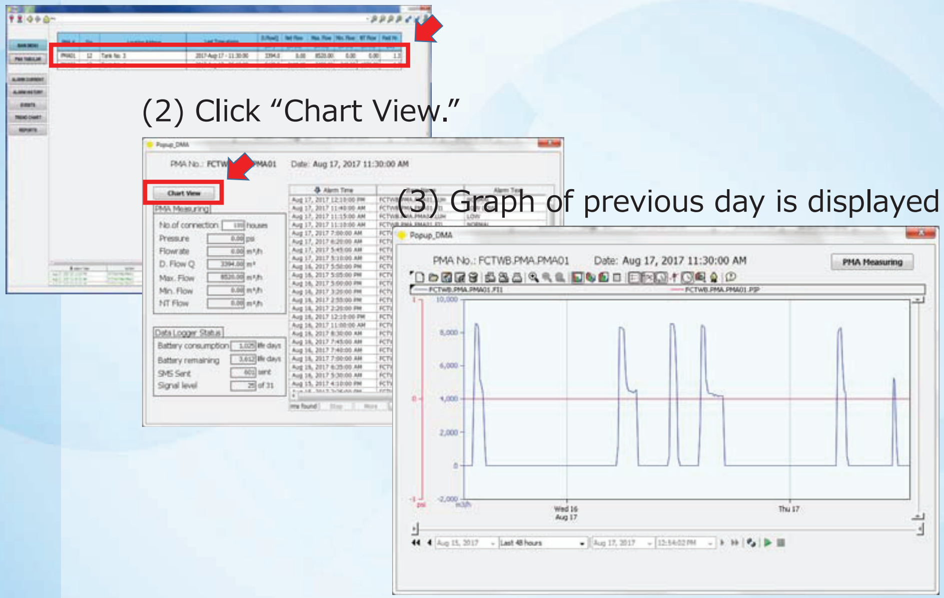
(1) Click "PMA TABULAR." at main menu

Example of Tanks No.3 (PMA-01)

(1) Click PMA01

(2) Click "Chart View."

(3) Graph of previous day is displayed

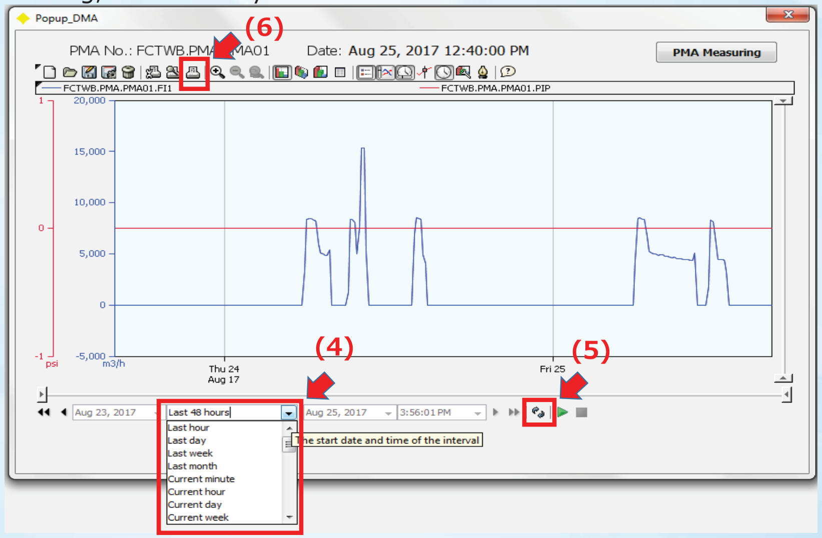


Example of Tanks No.3 (PMA-01)

(4) Select date you want to displayed by pull-down menu

(5) Updating

(6) Printing, as necessary



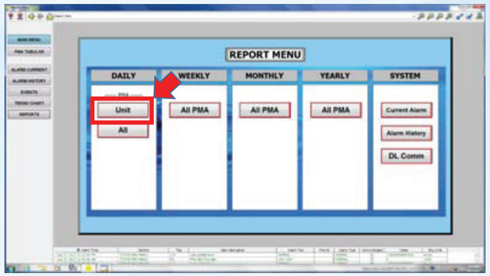
7. Report (Daily Report)

Daily report provide with 2 outputs, which are (a) individual output of Tank No.3 & 4 with trend chart and (b) unification output of Tank no.3 & 4.

Click "Report." at main menu

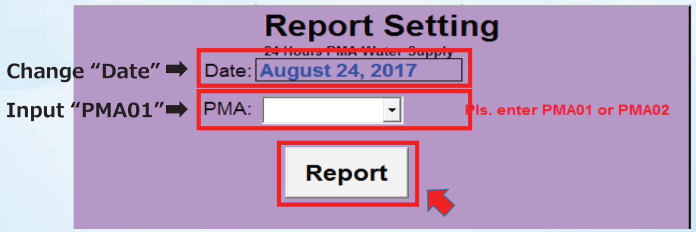
(a) Individual Output: Example of Tanks No.3 (PMA-01)

(1) Click "Unit"



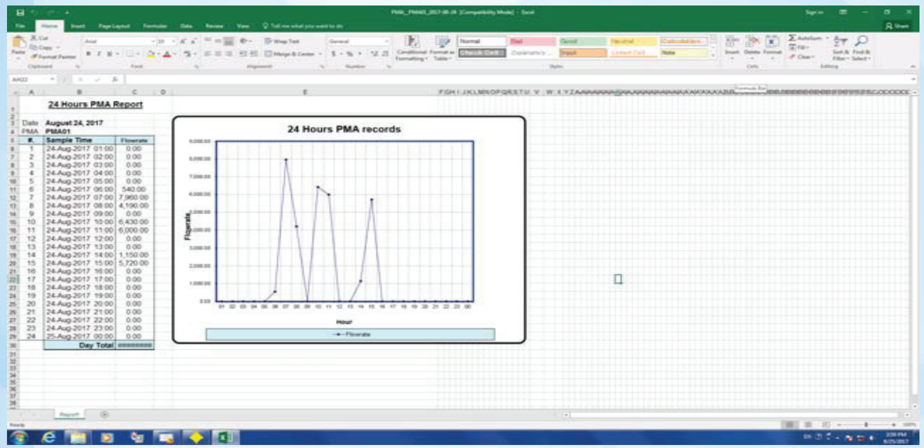
(2) Selection & Input : "Date" and "PMA"

(3) Click "Report"



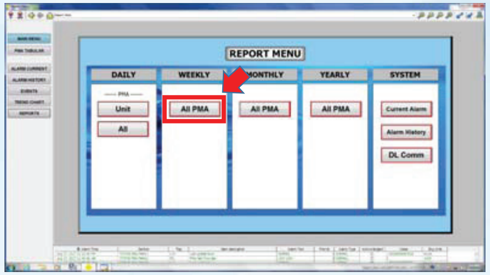
(a) Individual Output: Example of Tanks No.3 (PMA-01)

(4) Save as file



(b) Unification Output

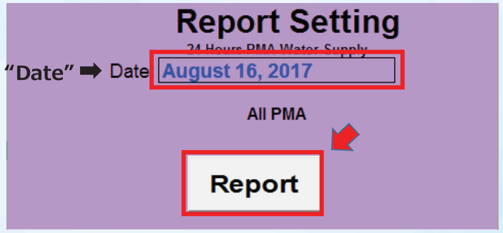
(1) Click “All”



(2) Selection & Input : “Date”

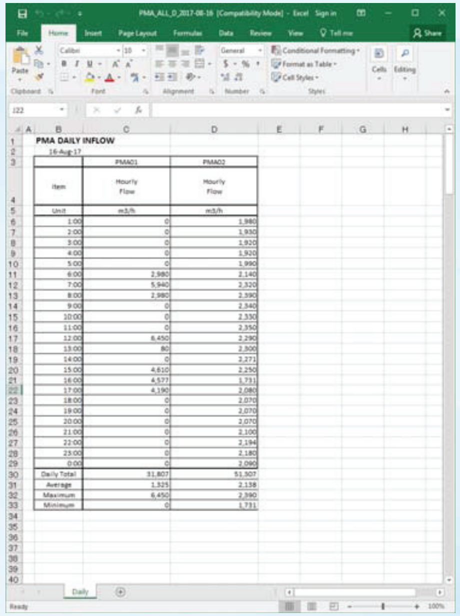
(3) Click “Report”

Change “Date” ➡



(b) Unification Output

(4) Save as file



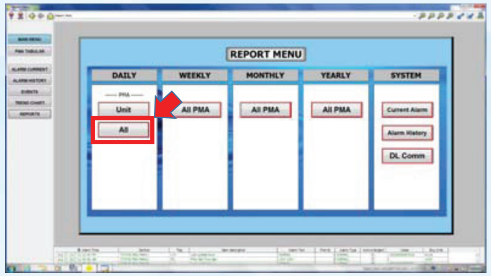
Item	PMA01 Hourly Flow	PMA02 Hourly Flow
Unit	m3/h	m3/h
1:00	0	1,980
2:00	0	1,930
3:00	0	1,920
4:00	0	1,920
5:00	0	1,990
6:00	2,980	2,140
7:00	5,940	2,320
8:00	2,980	2,390
9:00	0	2,340
10:00	0	2,330
11:00	0	2,350
12:00	6,450	2,290
13:00	80	2,300
14:00	0	2,271
15:00	4,610	2,250
16:00	4,577	1,731
17:00	4,190	2,080
18:00	0	2,070
19:00	0	2,070
20:00	0	2,070
21:00	0	2,100
22:00	0	2,194
23:00	0	2,180
0:00	0	2,090
Daily Total	31,807	51,307
Average	1,325	2,138
Maximum	6,450	2,390
Minimum	0	1,731

8. Report (Weekly Report)

Weekly Report shows total flow volume of Tank No.3 & 4 in selected week.

Click “Report.” at main menu

(1) Click “All PMA”

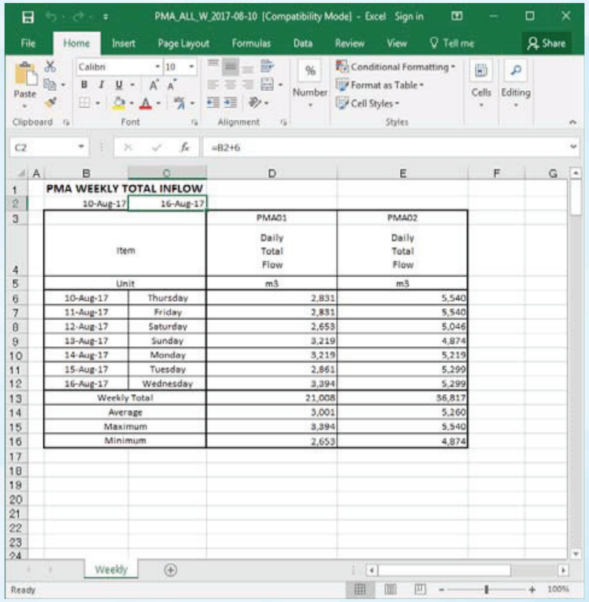


(2) Selection & Input : “Date”

(3) Click “Report”

Change “Date” ➡

(4) Save as file



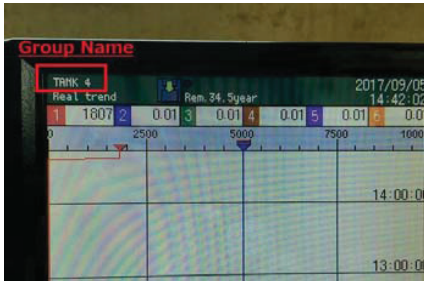
Parameter Setting of Data Logger (Tank No.3 & No.4)

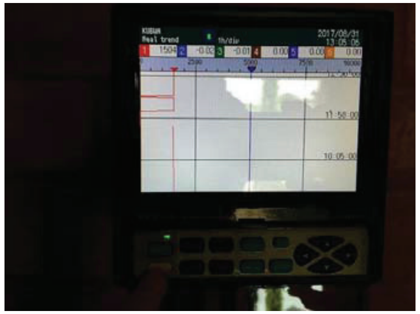
Category in SOFTOOLS	Setting value		Remarks
	PMA01 (Tank No.3)	PMA02 (Tank No.4)	
Properties			
General properties			
Name of RTU	PMA01	PMA02	
Comment	FCTWB	FCTWB	
Connection properties			
Site's GSM number	+2348141910353	+2349035413212	Mobile phone number of sim card at PMA01(Tank3) / PMA02(Tank4)
Connect			
Exceptions			
PERIODIC TRANSMISSIONS TO PC			
Duration	1 hour	1 hour	
Period	5 minutes	5 minutes	
MAIN PERIOD EXCEPTION			
AI			
Duration	1 day	1 day	
Period	5 minutes	5 minutes	
Meters and average flowrates			
Duration	1 day	1 day	
Period	5 minutes	5 minutes	
Configure			
Communication			
General			
Access code	0	0	
Site number	1	2	
Communication			
GSM network	Africa (900/1800 MHz)	Africa (900/1800 MHz)	
Call number	+2348102439716	+2348102439716	Mobile phone number of sim card at SCADA Server (FCTWB HQs)
Transmissions	Scheduled	Scheduled	
Hour(s)	06:05	06:15	
Security			
Maximum number of SMS per day	100	100	
Archiving and reports			
Meters and average flowmeters			
Archiving period	10 minutes	10 minutes	
AI			
Archiving period	10 minutes	10 minutes	
Reports	ON	ON	
Daily report at	06:00	06:00	
Night time flow from	02:00	02:00	
to	04:00	04:00	
Warning			
SMS transmission to			not decided
Warning 1 on appearance of	Not used	Not used	
Message	PMA01	PMA02	
Warning 2 on appearance of	Not used	Not used	
Message	PMA01	PMA02	
Processing			
Threshold 1	Flowrate 1	Flowrate 1	
	Greater than	Greater than	
to	19,000.000	9,000.000	
from	00:00	00:00	
to	24:00	24:00	
Appearance timer:	3 archiving period(s)	3 archiving period(s)	

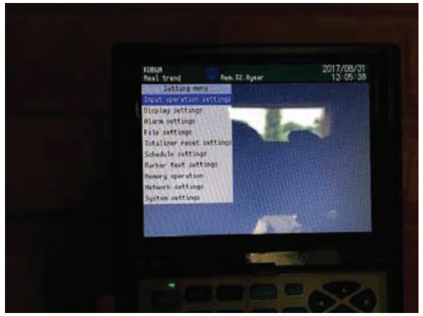
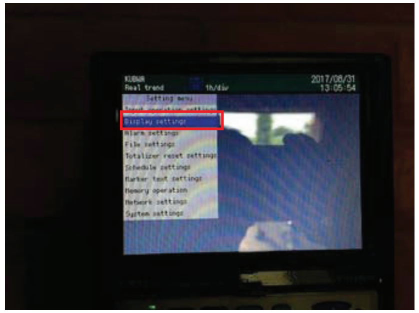
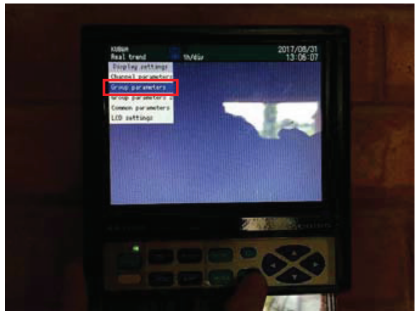
Category in SOFTOOLS	Setting value		Remarks
	PMA01 (Tank No.3)	PMA02 (Tank No.4)	
Transmission on each data status change	ON	ON	
Threshold 2	Flowrate 1	Flowrate 1	
	Less than	Less than	
to	10.000	10.000	
from	00:00	00:00	
to	24:00	24:00	
Appearance timer:	3 archiving period(s)	3 archiving period(s)	
Transmission on each data status change	ON	ON	
Threshold 3	Not used	Not used	
Threshold 4	Not used	Not used	
DI 1			
DI type:	Standard meter	Standard meter	
1 pulse =	10,000.00 liter(s)	10,000.00 liter(s)	
Average flowrate calculation	ON	ON	
DI 3			
DI type:	Signaling	Signaling	
Timeouts			
Appearance:	15 seconds	5 seconds	
Disappearance:	15 seconds	15 seconds	
Communication			
Transmission on each data status change	ON	ON	
AI 1			
Sensor type	Other sensor	Other sensor	
Sensor supply	No power supply	No power supply	
Sensor supply time	-	-	
Maximum value	10.000	10.000	

<u>Group Name (Reservoir Name) Setting of Data Logger</u>

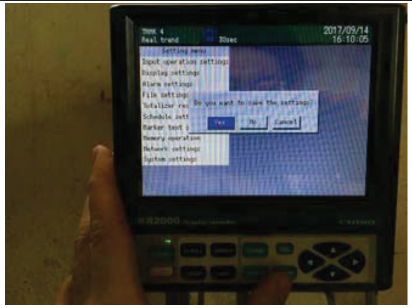
Group Name (Reservoir Name) of Data Logger has not been applied as default configuration. If group name will be applied in a data logger as shown in the following picture, that name is added into a data file to be transferred to USB Memory. It might be helpful for data management in each reservoir.



Setting Procedure		
1		Push “STOP” button and stop the recording
2		Select “Yes” and push “ENTER” button

3		Push “MENU” button
4		Select “Display Settings” and push “ENTER” button
5		Select “Group Parameters” and push “ENTER” button

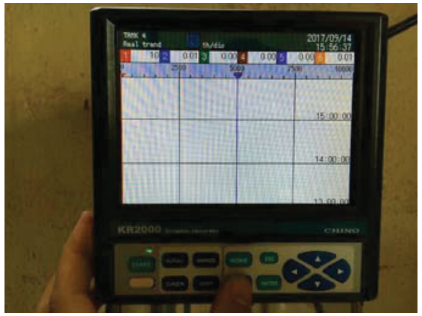
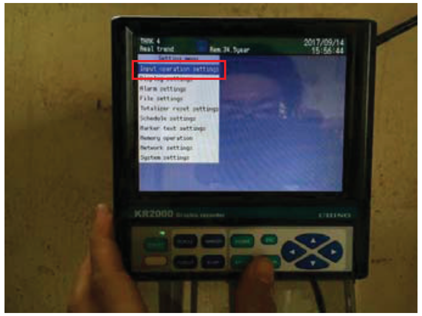
6		Select “Group Name” and push “ENTER” button
7		Input a Tank Name
8		Then, select “Set” and push “ENTER” button

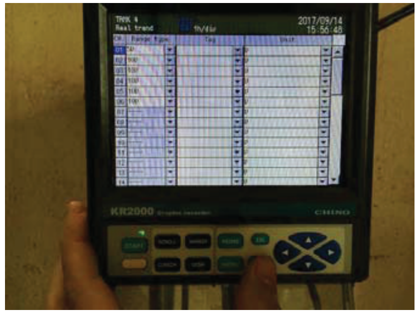
9		Push “ESC” button several times. If message of “Do you want to save the setting?” appears, select “Yes”. And then return to monitoring Display by pushing “ESC” button several times.

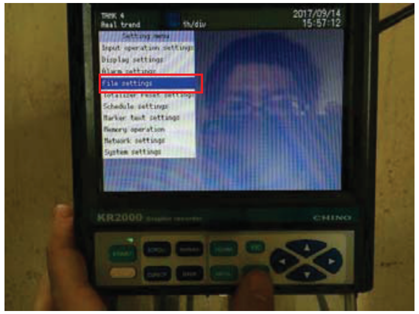
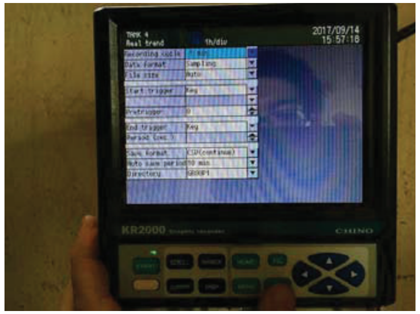
Initial Parameter Setting of Data Logger

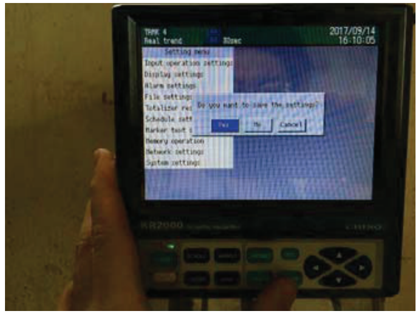
Initial step to display the measurement data to be indicated on the transducer of ultrasonic flowmeter is shown as follows;

Setting Procedure

1		Push “STOP” button and stop the recording
2		Push “MENU” button
3		Select “Input Operation Setting” and push “ENTER” button

4		Select “CH01” and push “ENTER” button * If you want to display data from several flowmeters, use channels as much as the installation numbers of flowmeter. [Example in Tank No.2] Since 2 flowmeters are installed, 2 channels, CH1 & CH2”, are used.
5		Set the parameter; (1) Range Type Select “5V” (2) Range Input “1.000” to “5.000” (3) Scale Input “0” to “Max. Range” Maximum range shall be checked from the setting of ultrasonic flowmeter. (4) Calculation Select “ON” (5) Formula (CH(X)>=Y)*CH(X) X: Selected Channel (Refer to the left Pic.) Y: Number of the nearest thousand (Refer to the left Pic.)
6		After the setting, Push “ESC” button twice

7		Select “File Settings” and push “ENTER” button
8		Then, select “1” and push “ENTER” button
9		Set the parameter; (1) Recording Cycle Selelct “1 min” (2) Save Format Select “CSV (Continue)”

10		Push “ESC” button several times. If message of “Do you want to save the setting?” appears, select “Yes”. And then return to monitoring Display by pushing “ESC” button several times.

Standard Operating Procedures (SOP) on Water Distribution Management

1. Concept of Water Distribution Management

FCTW as a water supply utility should control water volume, water pressure and water quality under quantitative & scientific comprehensive method.

(1) **Water Volume**: To supply necessary and sufficient water even at peak and in future.
(2) **Water Pressure**: To supply water at proper water pressure at each service point.
(3) **Water Quality**: To supply safety water (Ensuring residual chlorine at each service point).

Under the Federal Capital Territory Reduction of NRW Project (the Project), FCTWB established the cross-organizational committee consisting of Distribution, Commerce and Quality Control staff shared information. The committee enhanced common understanding among members and concluded to create hereafter the platform of water distribution management in considering problems and measures:

(1) Calculation/estimation of **NRW ratio** at the zone level
(2) Creation of **water pressure map** by utilizing GIS
(3) Creation of **residual chlorine concentration map** by utilizing GIS

By the platform, gap between the plan/design and the actual situation can be understood, as well as taking budgetary steps, the necessary for project is explained standing in scientific knowledge.

2. Abuja's Urban Water Supply System

Table 1 and Figure 1 show water supply areas in which water is supplied from Lower Usuma Water Treatment Plants.

Table 1 List of Water Supply Areas

Development	Areas (including Districts)
Phase 1	Maitama、Wuse I、Wuse II、Central Area、Asokoro、Garki I、Garki II
Phase 2	Jahi、Katampe、Katampe Ext.、Kado、Mabushi、Jabi、Utako、Dakibiyu、Wuye、Durumi、Gudu、Duboyi、Gaduwa、Dutse、Kukwaba、Kaura、Apo
Phase 3	Gwarinpa I、Gwarinpa II、Karmo (*temporarily from Tank 2 of Phase 2)
Phase 4	
Satellite	Bwari、Ushafa、Kubwa、Gwagwalada、Karu、Nyanya、Barracks
Others	Airport, Abuja University, KCK School

Remarks: Intermittent supply by rationing.in outside area of Abuja master plan such as Bwari, Karu and Nyanya.

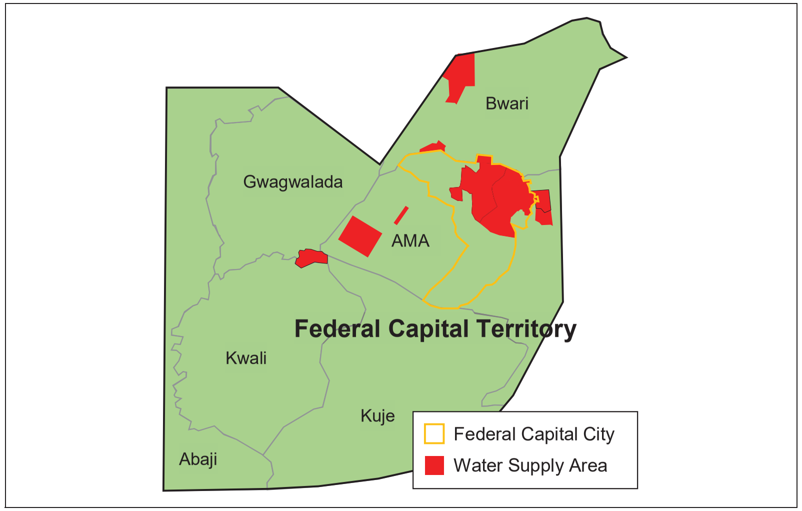


Figure 1 Water Supply Area from LUD Water Treatment Plants

Figure 2 shows zones by service tank from which water is supplied.

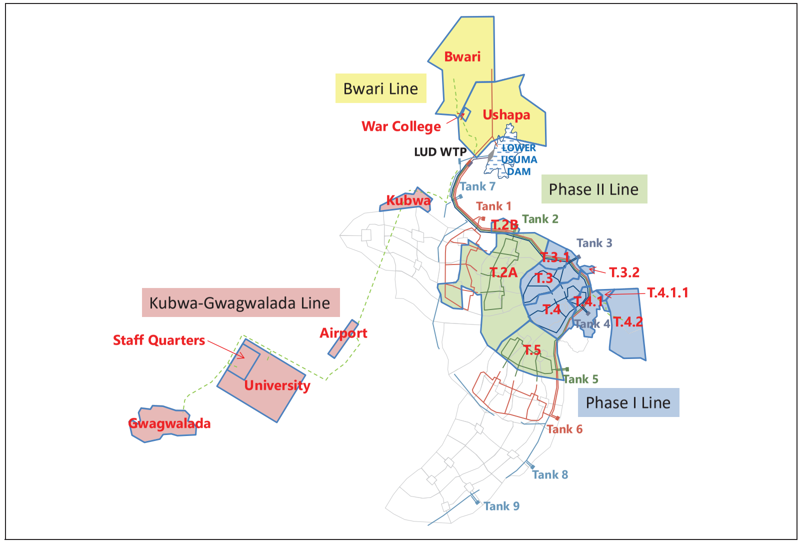


Figure 2 Water Distribution Zone

Figure 3 and Figure 4 show location of bulk and zonal flow meters at outlet of service tank from which water is supplied, pilot telemetry systems for pilot telemetry system for further application in the future.

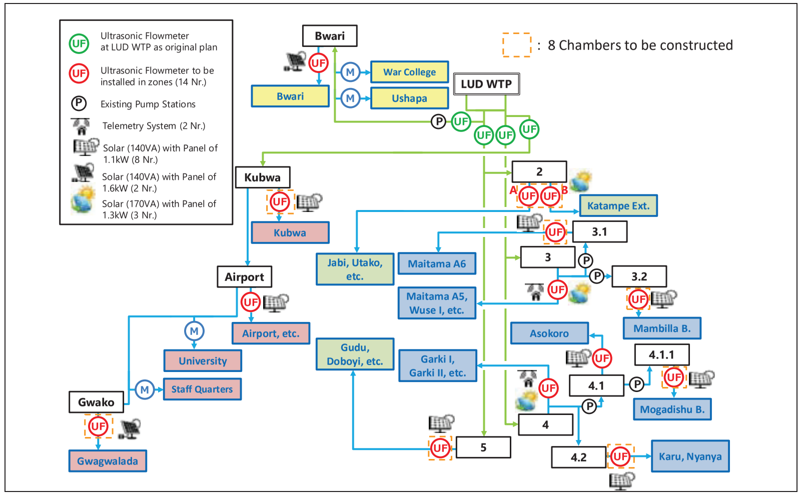


Figure 3 Location of Bulk and Zonal Flow Meters

Table 2 shows booster pump specifications obtained from the Electro-Mechanical Unit. Operational control is based on the number of pump operated. Figure 4 shows location of booster pump.

Table 2 Booster Pump Specifications

	Location	Capacity (m3/hr)	Head (m)	Power (kW)	Nos.	Speed (rpm)
1	Bwari					
2	Tank 3 main	280	88	110	4	1,480
3	Tank 3 ext.	200	64	55	3	1,480
4	Tank 4	280	60	75	3	1,480
5	Tank 4.1	100	50	37	3	1,480
6	Hamza Hill	26	50	11	3	2,935
7	Minister Hill	26	50	11	3	2,935
8	ECOWAS	Under construction				
9	Dantata	80	68	37	3	2,945
10	Berger	26	50	11	3	2,935
11	Udo Udoma	Non-operation				

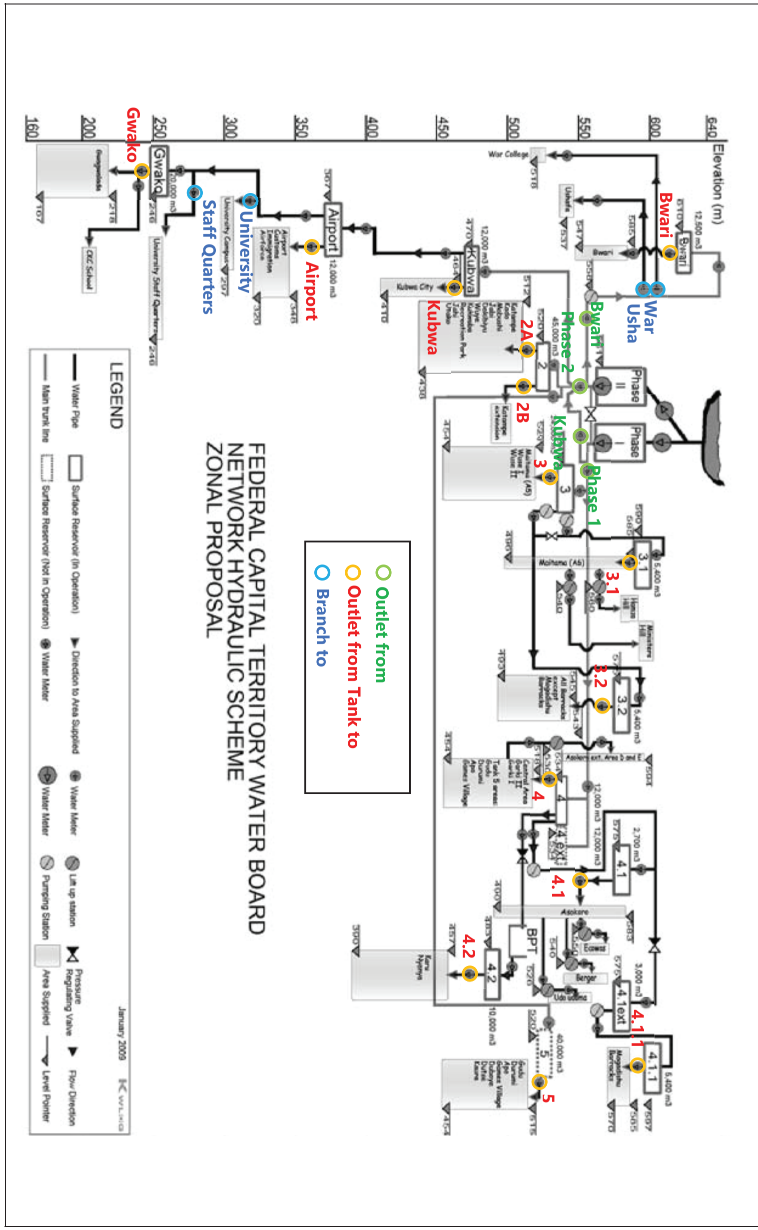


Figure 4 Location of Bulk and Zonal Flow Meters

Table 3 shows tank specifications. All of them is composed of coupled-cisterns and made of semi-underground reinforced concrete structure. Water is fed by gravity from LUD water treatment plants to tanks excluding Tank 3.1, 3.2, 4.1, 4.1.1 and Bwari.

Table 3 Tank Specifications

	Name	Capacity (m3)	Water Level in Full (m)	Year of Construction
1	Tank 2	45,000	520	2003
2	Tank 3 Main	12,000	534	1984
3	Tank 3 Ext.	12,000	534	1984
4	Tank 3.1	5,400	590	1987
5	Tank 3.2	5,400	575	1990
6	Tank 4 Main	12,000	534	1984
7	Tank 4 Ext.	12,000	534	1994
8	Tank 4.1 Main	2,700	575	1984
9	Tank 4.1 Ext.	10,000	575	1990
10	Tank 4.1.1	5,400	597	1990
11	Tank 4.2	10,000	483	1993
12	Tank 5	40,000	520	
13	Bwari	12,500	610	2006
14	Kubwa	12,000	470	1993
15	Airport	12,000	367	1994
16	Gwako	20,000	246	1994

3. Part-1: How to calculate/estimate NRW Ratio

FCTWB should measure/estimate water volume “System Input Volume (SIV)” and NRW ratio regularly by recording or reading water flow at bulk/zonal meters and PMA meters, as well as by tallying billed water consumption data in cubic m to be obtained from the billing system for conventional and AMR meters or bank statement for prepaid meters, at the different level of area: the entire system, zones and three Pilot Metering Area (Gudu, Jabi and Garki I).

Monitoring water volume and NRW ratio can contribute to:

(1) Learning the status of water volume and NRW ratio.
(2) Understanding the necessity of implementing NRW reduction effectively (prioritization).
(3) Learning about challenges of NRW reduction]
(4) Verifying necessary actions such operational change and facility development/ improvement

All bulk and zonal flow meters installed by the Project are ultra-sonic type with data logger for

measuring not only accumulative flow but also instantaneous flow for analysis of daily factor and hourly factor in the future. Two locations particularly Tank 3 and 4 covering Phase 1 development area include pilot telemetry system for further application in the future.

However, these ultra-sonic flow meters and data loggers are vulnerable to unstable power supply from grids (extreme voltage fluctuation and inrush current), lightning, harsh environment for accurate instrument. So, FCTWB should check their conditions regularly, at least in data extraction from loggers every month.

3.1 How to measure/estimate Monthly Water Flow by using Bulk/Zonal Flow Meters and PMA Meters.

3.1.1 Workflow for measuring/estimating Monthly Water Flow

Figure 5 shows the workflow for measuring/estimating monthly water flow.

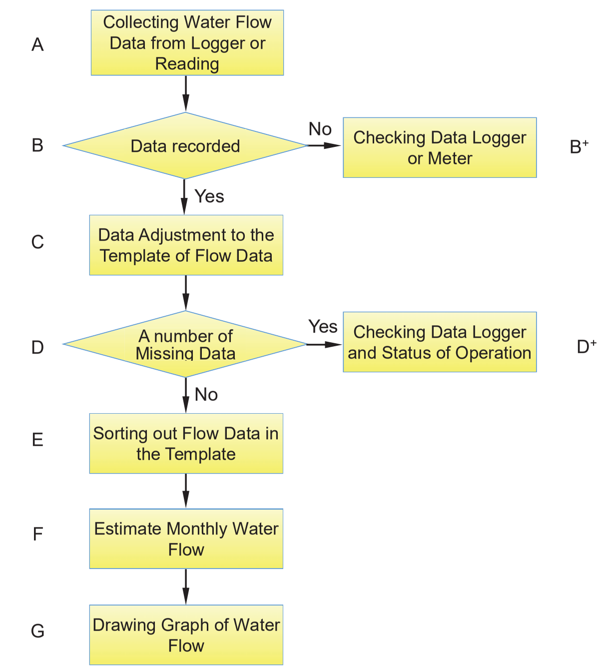


Figure 5 Workflow for measuring/estimating Monthly Water Flow

3.1.2 Steps of measuring/estimating Monthly Water Flow

Based on “Figure 1”, each step is described as below.

A. Collecting Water Flow Data from Logger or Reading

Basically, the NRW Reduction Unit collects water flow data from the data loggers or reading monthly. However, the NRW Reduction Unit monitor the data loggers and mechanical meters often to check its function and takes necessary actions against some troubles such as malfunction.

B. Data Recorded

If possible, the NRW Unit checks if data is recorded or not by using PC at sites, so that the Unit can save time efficiently.

B⁺. Checking Data Logger and Meter

Observing non-recorded data, the NRW Reduction Unit should check the function of the data loggers or meters and takes necessary actions quickly.

C. Data Adjustment to the Template of Flow Data

After collecting data, the NRW Reduction Unit downloads monthly raw flow data through memory stick to PC or inputs reading data manually, and then makes the data adjusted to the template as shown in Table 1. In addition, since raw data of water flow are missing or unread, the Unit should estimate water flow based on the measured flow data which should be reliable.

D. A number of Missing Data

The NRW Reduction Unit looks through the template entirely whether a number of missing data exist or not.

D⁺. Checking Data Logger and Status of Operation

Observing a number of missing data, the NRW Reduction Unit should check the function of the data loggers and confirms status of valve control and other operations with the concerned operators.

E. Sorting out Flow Data in the Template

After data adjustment in the template, the NRW Reduction Unit sorts out in order to estimate monthly flow rate and make a graph. For example, since unit of flow rate measured in every minute is ‘m^3/hr’, flow rate unit ‘m^3/hr’ must be converted to ‘m^3/min’ to accumulate flow rate per minute for a day. Table 4 shows further more details.

Table 4 Template (Sample) for summarizing Monthly Flow Data

Time	Monthly Average Flow Rate (m^3/hr) =Average flow rate from 1 to 30 April (For Instance)	1-Apr.		2-Apr.		…	30-Apr.	
		m^3/hr	m^3/min	m^3/hr	m^3/min	…	m^3/hr	m^3/min
0:00	0					…		
0:01	0					…		
0:02	No.5 0	No.1	No.2			…		
0:03	0					…		
0:04	0					…		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
10:18		2,588	43.1			…		
10:19		2,623	43.7	563	9.4	…		
10:20		2,606	43.4	594	9.9	…	2,338	39.0
10:21				600	10.0	…	2,374	39.6
10:22				618	10.3	…	2,328	38.8
10:23		No.6		599	10.0	…	2,330	38.8
10:24				570	9.5	…	2,346	39.1
10:25						…	2,303	38.4
10:26		2,596	43.3			…	2,340	39.0
10:27		2,555	42.6			…		
10:28		2,507	41.8			…		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
18:34	7,117	7,520	125.3	7,339	122.3	…		
18:35	7,088	7,587	126.5	7,326	122.1	…	7,422	123.7
18:36	7,025			7,407	123.5	…	7,444	124.1
18:37	7,058			7,296	121.6	…	7,510	125.2
18:38	7,044			7,356	122.6	…	7,519	125.3
⋮	⋮	⋮		⋮		⋮		
23:55	0					…		
23:56	0					…		
23:57	0					…		
23:58	0					…		
23:59	0					…		
Total (m^3/day)		No.3	**25,289**		**34,990**			**18,153**
Total (m^3/hr)		No.4	**1,054**		**1,458**			**756**

Processing of data from data logger is as follows:

No.1: The flow rate data (m^3/hr) should be pasted into the template from memory stick without any consideration.

No.2: The pasted raw flow rate data (m^3/hr) should be converted to ones (m^3/min). This is used for summing daily flow rate for 1,440 minutes.

No.3: Summing all the flow rate (m^3/min) from 0:00 to 23:59 results in daily flow rate.

No.4: If necessary, daily flow rate (m^3/day) can be converted into hourly flow rate (m^3/hr).

No.5: The flow rate data is an average flow rate by minute for a month and is used for a graph of monthly average flow rate.

No.6: Missing data for a few minutes is observed between excel files downloaded from the data loggers because of logger system process. In such case, an average flow rate should be filled in the template based on the last data (indicated in red color) before suspension of measuring flow rate and the initial data (indicated in blue) after suspension of that.

F. Estimating Monthly Water Flow

After filling raw data collected from the data loggers in the template, the NRW Reduction Unit accumulates water flow (m^3/min) for 1,440 minutes to estimate daily water flow.

G. Drawing Graph of Water Flow

As an option, in order to visualize daily flow rate, the NRW Reduction Unit makes a graph of daily average flow rate (m^3/hr) for a month (see Figure 6 as a sample).

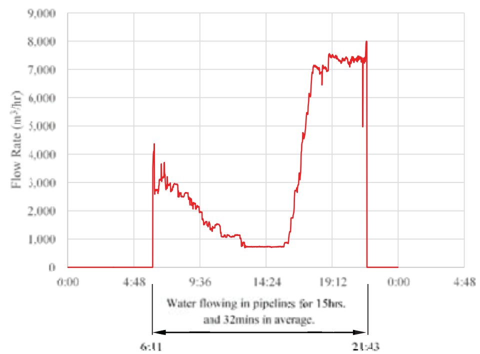


Figure 6 Daily Average Water Flow

3.2 How to calculate/estimate Monthly Water Consumption

3.2.1 Workflow for calculating/estimating Monthly Water Consumption

Figure 7 shows the conceptual workflow for calculating/estimating monthly water consumption by meter category such as Conventional, AMR and Prepaid.

Data collection in Microsoft Excel format from relevant Units

- Conventional meter: Billing Unit / MIS
- AMR meter: Billing Unit / AMR Unit / MIS
- Prepaid meter: Department: Finance / Prepaid Meter Unit

Billing system:

- Conventional meter: Puma Ver.4
- AMR meter: Puma Ver.4
- Pre-paid meter: No billing system (bank statement)

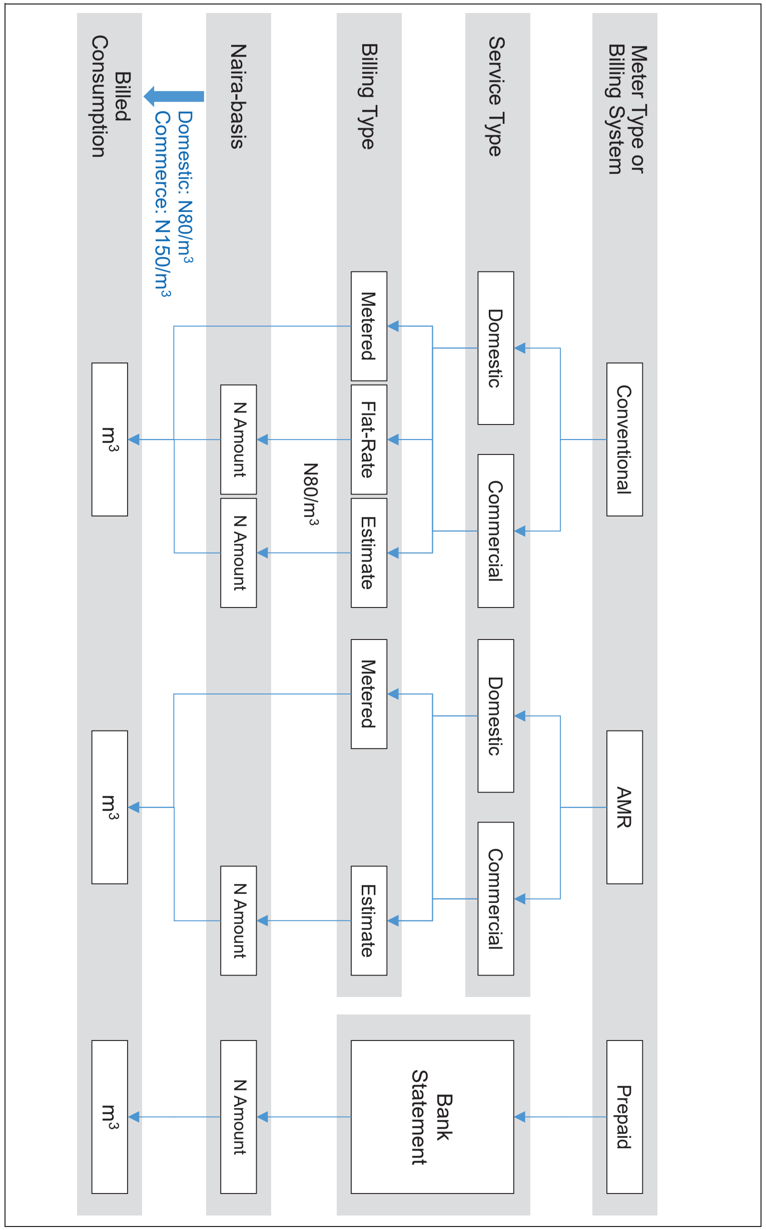
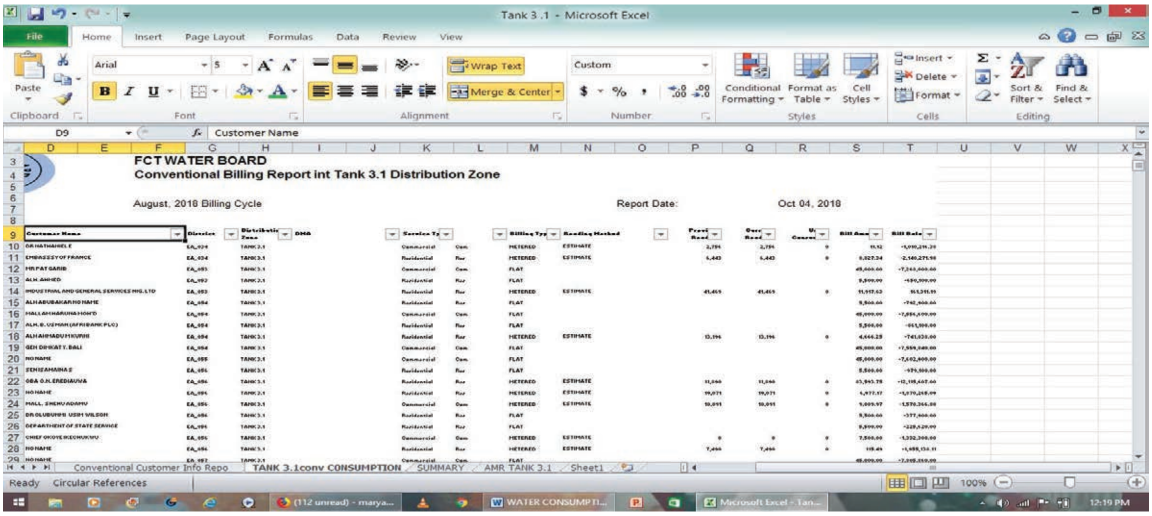


Figure 7 Conceptual Workflow for calculating/estimating Monthly Water Consumption

3.2.3 Conventional Meters

1) Calculate the numbers of customers that are residential and are metered, you go to the data select service type (see example of raw data below)

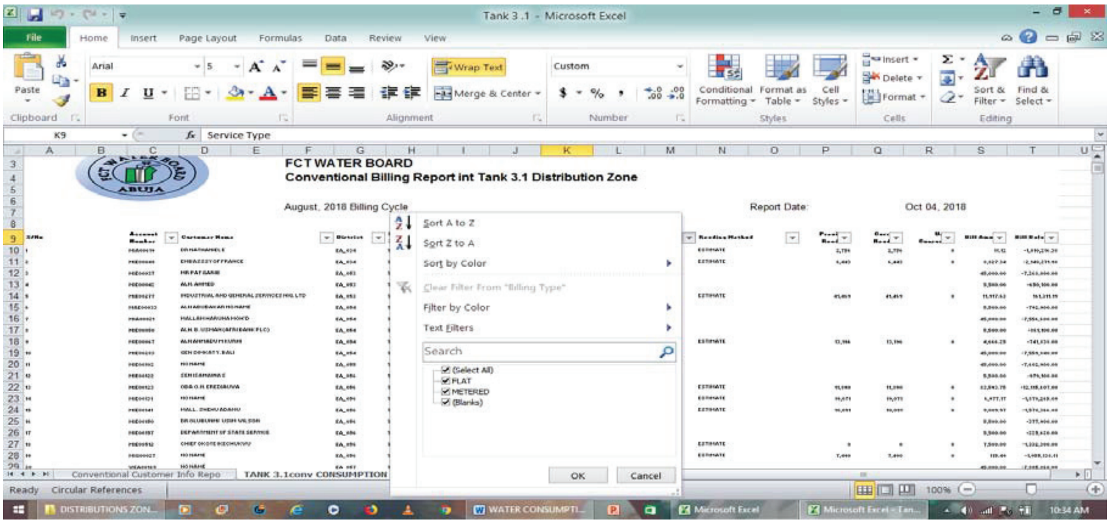


2) Click on sort and filter a dialog box will appear with different service type e.g. commercial, residential, institutions etc. (see the picture below)

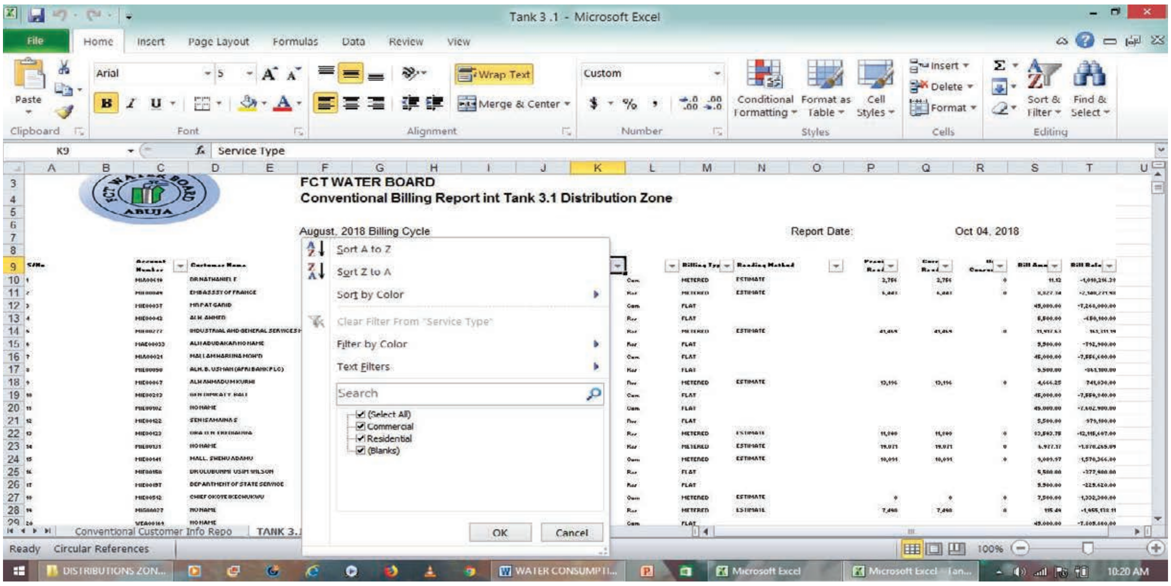
3.2.2 Customer data attributes (what attributes to sort for)

- Account number
- Customers name
- Service type
- Billing type
- DMA
- Previous Reading date
- Current reading date
- Unit consumed
- Billed amount
- Distribution zone
- Reading method

When the above are confirmed, select a particular meter type to begin your calculations.



- ➢ Select metered and click OK
- ➢ Back to the data select reading method and sort a dialog box will appear click on Reading and click OK.
- ➢ Go back to the data and select monthly consumption column, then press control+shift+down arrow. Excel will automatically calculate the numbers of customers that are residential with a billing type (Metered) and reading method (Reading), and the water consumed in M^3. Write down the detail.
- ➢ For customers with ZERO CONSUMPTIONS

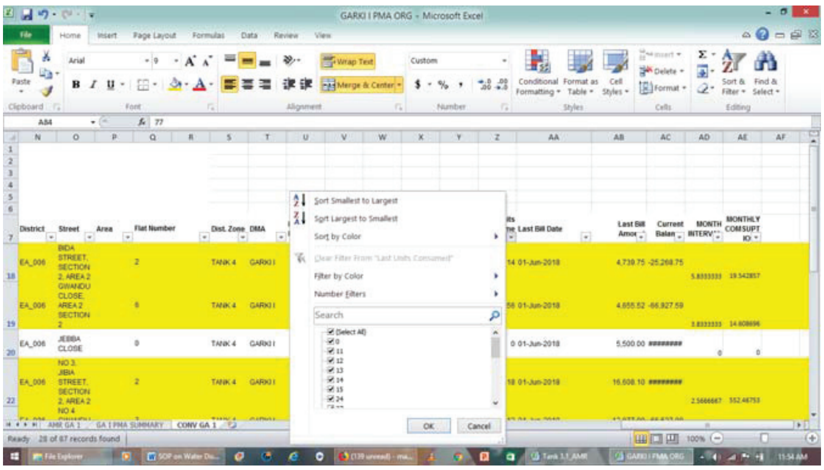


- ➢ Select residential and click OK
- ➢ Select billing type, click on sort and filter a dialog box will appear with different billing type e.g. metered, flat, etc. .(see picture below)

TANK 4: WATER CONSUMPTION SUMMARY Month of Billing Cycle: **Aug-18**

Zone	Category	Service Type	Billing Type	No of Customer	Water Consumed (Naira/Month)	Water Consumed (m3/month) Straightforward/As-it-is Estimation (Divided by Naira/m3)	Water Consumed (m3/month) Metered-Average-based Estimation	Metered-Average Consumption (m3/customer/month)
Tank 4	Conventional	Residentianl (Domestic)	Metered	534	-	277.62	277.62	0.52
			Flat-Rate	688	4,033,080.00	50,413.50	357.69	
			Estimate	1,721	14,981,906.36	187,273.83	894.73	
		Commercial	Metered	18	-	20.47	20.47	1.14
			Flat-Rate	123	4,486,200.00	29,908.00	139.90	
			Estimate	241	7,859,302.03	52,395.35	274.11	
		Institutions	Metered	0	-	0.00	0.00	
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	0	0.00	0.00	0.00	
		Sub-Total		**3,325**	-	**320,288.77**	**1,964.52**	
		Unbilled	Metered	0	-	0.00	0.00	
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	0	0.00	0.00	0.00	
		Sub-Total		**0**	-	**0.00**	**0.00**	
	AMR	Residentianl (Domestic)	Metered	1,116	-	129,197.00	129,197.00	115.77
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	2,331	9,496,000.00	118,700.00	269,855.02	
		Commercial	Metered	94	-	42,495.00	42,495.00	452.07
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	319	6,970,000.00	46,466.67	144,211.76	
		Institutions	Metered	8	-	2,519.00	2,519.00	314.88
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	27	602,000.00	7,525.00	8,501.63	
		Sub-Total		**3,895**	-	**346,902.67**	**596,779.40**	
		Unbilled	Metered	0	-	0.00	0.00	
			Flat-Rate	0	0.00	0.00	0.00	
			Estimate	0	0.00	0.00	0.00	
		Sub-Total		**0**	-	**0.00**	**0.00**	
	Pre-paid		Metered			0.00	0.00	-
			Flat-Rate	-	-	-	-	
			Estimate	-	-	-	-	
		Sub-Total		**0**	-	**0.00**	**0.00**	
Total Billed				**7,220**	-	**667,191.44**	**598,743.93**	
Total Unbilled				**0**	-	**0.00**	**0.00**	

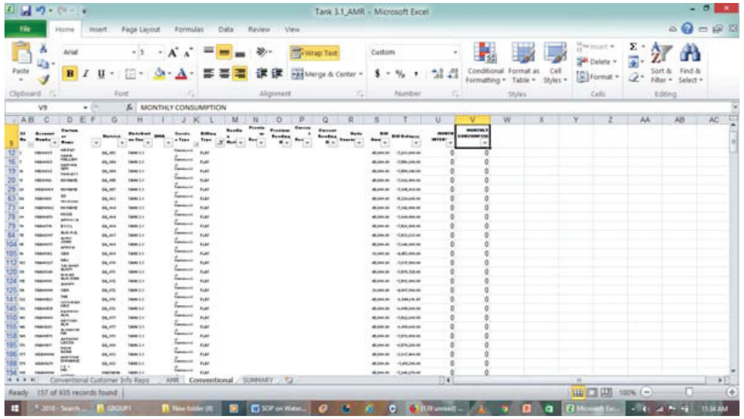
- Select residential from the service type, click on billing type and select flat, (in an ideal situation where the billing data is correct the column for unit consumed will be blank. But if there are some discrepancy in the billing data, then click on unit consumed column, click on sort, a dialog box will appear. see example below



- Select all, then click on zero (0) and click OK. All the customers that are residential with billing type flat which have zero consumption will appear.
- Then click on last billed amount column to get their total consumption in Naira.

3) For others service category repeat the same procedure above to get customers with service type **Residential**, billing type **Flat** and customers with service type residential, billing type metered and reading type Estimate. Same procedures are applied for commercial and institutions service type.
4) Summary Table (Sample)

5) For the number of customers on flat rate, unit consumed is zero. sum up the last billed amount in Naira and divide it by 80 for residential and 150 for commercial customers. See example of flat rate customers with zero consumption below



Note: Step 5) above procedure is applied on customers with estimated billed.

3.2.4 AMR Meters

Same procedures above is applied for AMR calculations**.**

3.2.5 Challenges encounter during the water consumption calculations

1. Uncompleted data from the billing unit
2. Discrepancy in the data. For example some customers, **Service type:** Residential, **Billed type:** Metered, but **Unit consumed:** Flat rate. Etc.
3. Different service types, with different billed rate which make it more difficult to get the actual consumption
4. So many customers on estimated bill and flat rate, which does not show their actual consumptions.

3.3 How to calculate NRW Ratio

NRW ratio is define as 'Percentage of billed water consumption to system input volume (volume of distributed water)'.

Calculation formula is as follows:

$$\text{Non-Revenue Water (NRW) Ratio} = \frac{\text{System Input Volume - Billed Water Consumption}}{\text{System Input Volume}} \times 100$$

Unit: %

4. Part-2: How to create Water Pressure Map

Maximum allowable water pressure of pipelines is 10 bar (1.0 MPa) as a design criteria, however, FCTWB had not measured water pressure due to no pressure gauge or no logging. Actually, customers' complaints on water supply have been observed which may be related to pressure inadequacy. On the other hand, higher pressure causes leakage as well as damage to facilities, equipment and water meters.

FCTWB needs to ensure water supply at appropriate pressure through measurement, water pressure mapping by GIS (Point, 0-5m, 5-10m, 10-15m, etc) for geographical analysis and necessary actions such operational change and facility development/improvement.

The procedures is simple. FCTWB should measure water pressure by using gauges and potable data loggers procured by the Project, and accumulate data, then reflect them into observation points in GIS database.

The Project suggested the NRW Reduction Unit to start data collection in Tank 4 Zone where hydraulic analysis including pipeline information update in GIS database was completed.

5. Part-3: How to create Residual Chlorine Concentration Map

Residual chlorine concentration at end users shall be 0.2 mg/L or more in service delivery of FCTWB. FCTWB has measured residual chlorine concentration at some sampling points (customers' taps) monthly. Actually, values have been observed at 0.2 to 0.5 mg/L.

FCTWB needs to keep ensuring safe water through measurement, additionally to develop residual chlorine concentration mapping by GIS (Point, 0.1mg/L, 0.2mg/L, 0.3mg/L, 0.4mg/L, 0.5mgL or more, etc.) for geographical analysis and necessary actions such operational change and facility development/improvement.

The procedures is simple. FCTWB continues to measure residual chlorine concentration, and accumulate data, then additionally reflect them into sampling points in GIS database.

The Project suggested the NRW Reduction Unit to start data collection in Tank 4 Zone, same as the above water pressure mapping.

6. Recommendations

The following efforts are keys to success of water distribution management:

- To repeat calculation/estimation of NRW ratio straight by measuring SIV and tallying billed consumption regularly.
- To accumulate and monitor data straight: SIV, billed consumption, NRW ratio, pressure and residual chlorine concentration for comparison and further countermeasures.
- To update GIS database straight with accurate pipeline information of all categories (primary, secondary and tertiary).
- To update and correct customer information straight for reliable analysis.

End

Annex 16:

Medium-term Strategic Plan on NRW Reduction (2019-2023)

THE FEDERAL CAPITAL TERRITORY REDUCTION OF NON-REVENUE WATER PROJECT

THE MEDIUM-TERM STRATEGIC PLAN FOR NRW REDUCTION (2019-2023)

EXECUTIVE SUMMARY

In order to strengthen Non-Revenue Water (NRW) reduction capacity of the Federal Capital Territory Water Board (FCTWB) and ameliorate issues of NRW, the Federal Capital Territory Administration (FCTA) and the FCTWB have implemented “the Federal Capital Territory Reduction of Non-Revenue Water Project” (the Project), the technical cooperation in collaboration with Japan International Cooperation Agency (JICA). The Medium-term Strategic Plan for NRW Reduction (2019-2023) was prepared as an outcome of the Project.

Status quo of NRW

The Project estimated NRW ratio of urban water supply system for the Federal Capital City at 48.3% for the year 2014-2017 as follows:

- System Input Volume: 113.38 million m^3 per year
- Revenue Water: 58.63 million m^3 per year
- NRW: 54.75 million m^3 per year (113.38 million - 58.63 million) m^3 per year
- NRW Ratio: 54.75 / 113.38 = 48.3%

In the Pilot Metering Areas (PMA), NRW ratio varies from 45.6% to 87.6% by Sub-Metering Area (SMA) before NRW reduction operations of pilot projects.

Pilot Projects

The Project implemented the pilot projects on NRW reduction to prepare this strategic plan together with relevant Area Offices in three PMAs, which are defined as District-Metered Areas (DMA). The following table shows the results of NRW reduction operations.

Results of Pilot Project

Area Office	PMA/SMA	Before NRW Reduction Operations (%)	After NRW Reduction Operations (%)
Gudu	SMA-1	52.0	12.1
	SMA-2	53.9	29.9
	PMA	53.3	20.4
Jabi	SMA-2	45.6	21.1
	SMA-3	87.6	42.6
	PMA	70.0	30.9
Garki I	SMA-1	85.1	45.2
	SMA-2	74.8	49.3
	SMA-3	70.0	27.4
	PMA	74.8	34.7

Although causes of NRW vary in PMA, they are summarized as below:

- Billed unmetered consumption (excess use by flat-rate customers)
- Unauthorized consumption (illegal bypassing/connections)
- Customer metering inaccuracies and data handling errors, and
- Physical losses (surface/underground leaks) on network pipelines and service pipes

In consideration of cost effectiveness, even though FCTWB spends a certain amount of expenses for NRW reduction operations, FCTWB increase billed water in return for NRW reduction operations. Therefore, it is desirable that FCTWB positively takes NRW reduction operations, and elimination of illegal connection and leakage is efficient operations compared with mitigation of nominal excess use and unbilled unmetered & meter inaccuracy.

Scenarios of the Medium-term Strategic Plan

The Project prepared six scenarios such as Scenario-a to Scenario-e for NRW reduction operations in order flexibly to cope with influence due to various conditions such as budget disbursement, appointment of trained appropriate staff, progress of database for the existing pipelines in future. Especially, the Project set condition for the criteria in terms of the following five aspects: Budget release, Appointment of well-trained staff for leakage survey, Appointment of trainers required for Area Office's staff, Inventory management of equipment in Area Office, and Development of pipeline data.

The following table shows the target NRW ratio, which excludes details of NRW reduction operations. The target NRW ratio indicates percentage unless scenario is changed the year 2019 through 2023. Therefore, target NRW ratio should be reviewed and setup in the annual action plan based on the first six-month activities of the previous year. Even if FCTWB does not achieve targeted NRW ratio for the year of 2023, the common objective of NRW reduction operation among five scenarios is to achieve the following activities which are significant for FCTWB to learn status of NRW ratio: Data collection of monthly system input volume, Data collection of monthly billed consumption, and Monthly water balance analysis.

Scenarios for NRW Reduction Operations

Items	Scenario				
	a	b	c	d	e
Target Year	2023	2023	2023	2023	2023
Baseline NRW Ratio (%)	48.3	48.3	48.3	48.3	48.3
Target NRW Ratio in 2023 (%)	31.9	32.4	36.9	35.1	42.8
Reduction Approach	DMA	Zone	Zone	Zone	Zone
Main Body for Operations (Supervision)	HQ's NRW Unit	HQ' NRW Unit	HQ's NRW Unit	HQ's NRW Unit	HQ's NRW Unit
Main Body for Operations (Field Actions)	Area Offices	Area Offices	Area Offices	HQ's NRW Unit	HQ's NRW Unit

The following table shows overall cost-effectiveness of scenarios for five years. Scenario-d indicates the highest cost-effectiveness at 18.9.

Cost-Effectiveness by Scenario

Items		Scenario				
		a	b	c	d	e
Cost (mil. NGN)	I	883.2	804.5	326.9	222.7	123.5
Revenue yielded (mil. NGN)	Ii	4,822.60	4,752.60	3,636.90	4,198.40	1,698.80
Direct benefit (mil. NGN)	iii=ii-i	3,939.40	3,948.10	3,310.00	3,975.70	1,575.30
Cost-Effectiveness	iv=ii/i	5.5	5.9	11.1	18.9	13.8

Source: Project Team

The following table shows the summary of the Profit and Loss (P/L) statement for the year 2023. With-project cases (five scenarios) will obviously make a larger profit than without-project case (no scenario).

P/L Statement of the Year 2023 by Scenario (Million Naira)

Account Items	No Scenario	Scenarios				
		a	b	c	d	e
1.Revenues	7,829	10,306	10,239	9,547	9,824	8,668
2.Expenditures	2,799	2,895	2,886	2,844	2,824	2,815
3.P/L = 1-2	5,030	7,411	7,353	6,703	7,000	5,853

Source: Project Team

The following table shows the summary of the Cash Flow (C/F) Statement for the year 2023. With-project cases (five scenarios) will apparently generate the net C/F more than without-project case (no scenario). Moreover, the net C/F will surely soar if reducing the number of un-paid customers.

C/F Statement of Year 2023 by Scenario (Million Naira)

Activities	No Scenario	Scenarios				
		a	b	c	d	e
1.Operational	714.5	1,451.3	1,434.6	1,220.4	1,325.0	965.1
2.Investment	0	- 100.0	- 91.0	- 18.9	- 38.4	- 20.5
3.Financial	0	0	0	0	0	0
4. Net C/F = 1+2+3	714.5	1,351.3	1,343.6	1,201.5	1,286.6	944.7

Scenario selected by FCTWB

In order to carry out NRW reduction operations, considering the following factors, the Management of FCTWB selected "Scenario-d" which states that, "Only FCTWB Headquarters will take NRW reduction operations such as systematic leakage survey, illegal connection survey, and installation of water meters but NOT create DMAs. FCTWB will target on NRW ratio of 35.1% for the year 2023".

- Practical goal of NRW ratio
- Insufficient data of the existing water supply facilities
- Vulnerable structure and limited discretion in budget use of Area Offices
- Insufficient number of skilled staff of Area Offices
- Expected accommodation of disbursement due to approved autonomy of FCTWB and appointment of board members
- Making the most use of skills and know-how which were obtained through the Project as much as possible so that FCTWB's capacity on NRW reduction especially at individual level is sustained

Implementing Schedule and Budget Allocation

In the past three years, FCTWB made a budget of 40million to 50million yearly, but has suffered from delayed or no release of the budget to implement the pilot projects as scheduled. Therefore, the Project allocated a budget up to about 35million apart from Scenario-a, b and c which requires huge initial investment for the first year in accordance with FCTWB's prospect. The following table shows budget allocation for five years. The budget was estimated based on the cost to be incurred for NRW reduction operations of each scenario and the cost (about 7.5millions) of training for five years as human resource development.

Implementing Schedule and Budget Allocation

Scenario	Total Cost (mil. NGN)	2019	2020	2021	2022	2023
Scenario-a	883.3	241.7	185.4	178.1	139.7	138.4
	100%	*27%*	*21%*	*20%*	*16%*	*16%*
Scenario-b	804.5	225.2	169.0	161.7	123.8	124.8
	100%	*28%*	*21%*	*20%*	*15%*	*16%*
Scenario-c	326.9	115.8	59.3	50.7	50.7	50.5
	100%	*35%*	*18%*	*16%*	*16%*	*15%*
Scenario-d	222.7	34.1	34.6	50.7	51.4	52.0
	100%	*15%*	*16%*	*23%*	*23%*	*23%*
Scenario-e	123.5	14.2	14.7	30.9	31.5	32.2
	100%	*12%*	*12%*	*25%*	*26%*	*26%*

Staffing Plan and Human Resource Development Plan

To implement NRW reduction operations, the strategic plan includes staffing plan for relevant Units and Area Offices as well as human resources development plan.

Recommendations

FCTWB has a number of challenges to not only implement NRW reduction in the long term but also become an autonomous body pursuing revenue. The strategic plan includes recommendations in terms of Distribution, Commerce, Finance and Administration.

Federal Capital Territory
Administration

ABUJA
The Heart of Nigeria

Federal Capital Territory
Water Board

Japan International
Cooperation Agency

The Federal Capital Territory Reduction of Non-Revenue Water Project

THE MEDIUM-TERM STRATEGIC PLAN FOR NRW REDUCTION (2019-2023)

SUMMARY

June 2018

By: Project Team

Table of Content

1. Introduction to NRW Reduction

1.1 Background

The Federal Capital Territory Water Board (FCTWB) was established in October 1989, saddled with the responsibility of supplying potable water to inhabitants of the Federal Capital Territory (FCT). In carrying out this responsibility, the FCTWB has been facing challenges of operation and maintenance of facilities as well as large proportion of non-revenue water (NRW). The FCTWB could not effectively mitigate NRW because of limited experience, insufficient knowledge and unskilled personnel on planning and execution of NRW reduction.

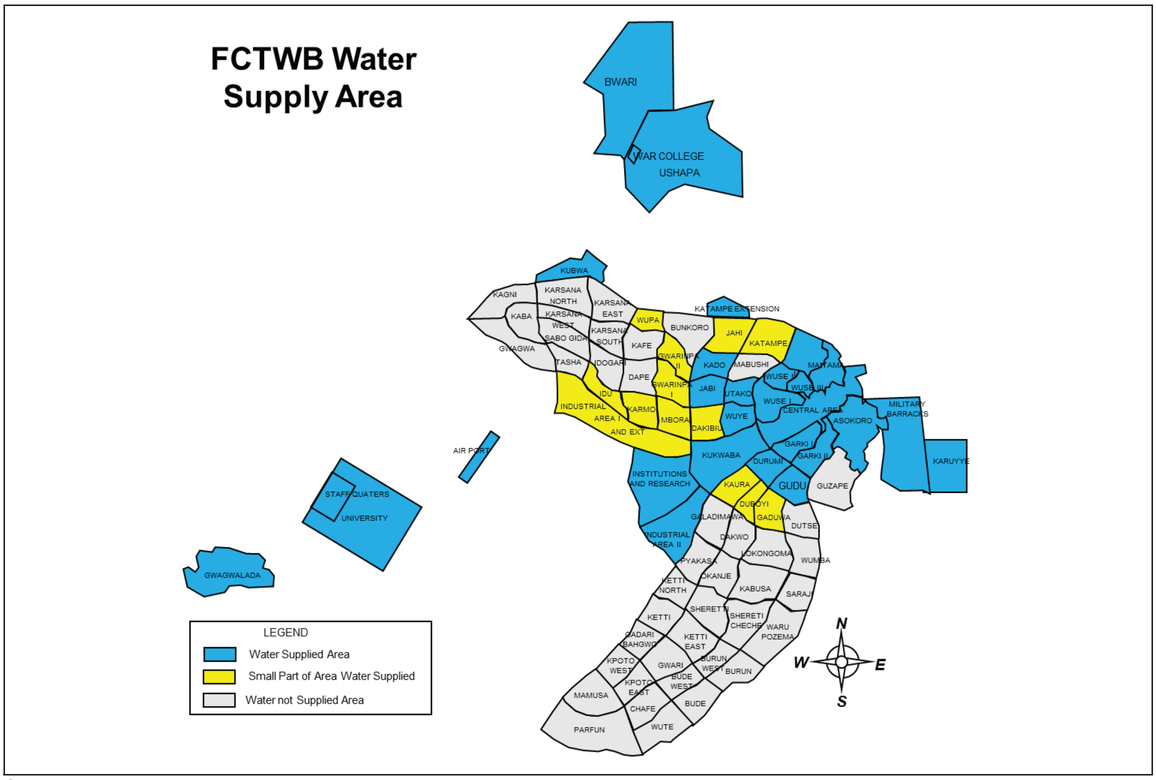
Based on the above, in order to strengthen NRW reduction capacity of the FCTWB and ameliorate issues of NRW, the Federal Capital Territory Administration (FCTA) and the FCTWB has implemented “the Federal Capital Territory Reduction of Non-Revenue Water Project” (the Project), the technical cooperation in collaboration with Japan International Cooperation Agency (JICA).

1.2 Water Supply Facility

The FCTWB’s urban water supply system for the Federal Capital City (FCC) relies on two water sources: Lower Usuma Dam (Capacity: 100 million m^3) and Gurara Dam (Capacity: 850 million m^3). The current system consists of Lower Usuma Dam Water Treatment Plants (Design Production: 240,000 m^3/day from Phase 1&2 and 480,000 m^3/day from Phase 3&4) including service reservoirs (24,000 to 45,000 m^3), transmission mains (44 km), distribution mains (635 km) and network pipelines which supplies water to about 47,000 customers (connections) in FCC Phase 1 development area, and a part of FCC Phase 2 area and some satellite towns.

1.3 Water Supply Area

Figure 1-1 shows current FCTWB’s water supply areas by District.



Source: Project Team

Figure 1-1 FCTWB’s Water Supply Area by District

1.4 Water Supply Situation

Table 1-1 shows water supply situation by Area Office and District.

Table 1-1 Water Supply Situation by Area Office and District

	Area Office	District or Suburb served	Water Supply Situation
1	Abaji	Abaji Town	Hand pumps and motorized boreholes.
2	Asokoro	Asokoro District	Improved supply (gravity and pump)
3	Bwari	Bwari Town	Intermittent by rationing (booster pumping from LUD)
4	Gwagwalada	Gwagwalada Town	Regular with network challenges
5	Garki I	Area 1,2,3,8,11 & 10	Regular
6	Garki II	Garki II, Central Area	Regular
7	Gudu	Gudu District/Games Village	Regular
8	Gwarimpa	Gwarimpa District	Regular
9	Jabi	Utako District, Life Camp & Idu/Karmo, Kado Estate, Katampe and Katampe Extension.	Regular
10	Karu/Nyanya	Karu & Nyanya Towns	Intermittent by rationing
11	Kubwa I	Kubwa I Town	Regular
12	Kubwa II	Kubwa II Town	Regular
13	Maitama	Maitama District	Regular with challenges
14	Wuse I	Wuse I District	Regular with high rises issue and network challenges in parts of zone 3 & 6
15	Wuye	Wuye District	Regular
16	Wuse II	Wuse II District	Regular with challenges in A8 (low pressure)

Source: Project Team

1.5 Current NRW Situation

The Project estimated NRW ratio of urban water supply system for the FCC at 48.3% for the year 2014-2017 as follows:

- System Input Volume: 113.38 million m^3 per year
- RW: 58.63 million m^3 per year
- NRW: 54.75 million m^3 per year (113.38 million - 58.63 million) m^3 per year
- NRW Ratio: 54.75 / 113.38 = 48.3%

Remarks: A considerable number of return bills exist in the billing system of FCTWB, which make analysis inaccurate. “Return (or duplicated) bills” mean the bills which are supposed to be eliminated or deactivated from billing system but have remained. If FCTWB eliminates these bills from billing system, NRW ratio gets higher than this.

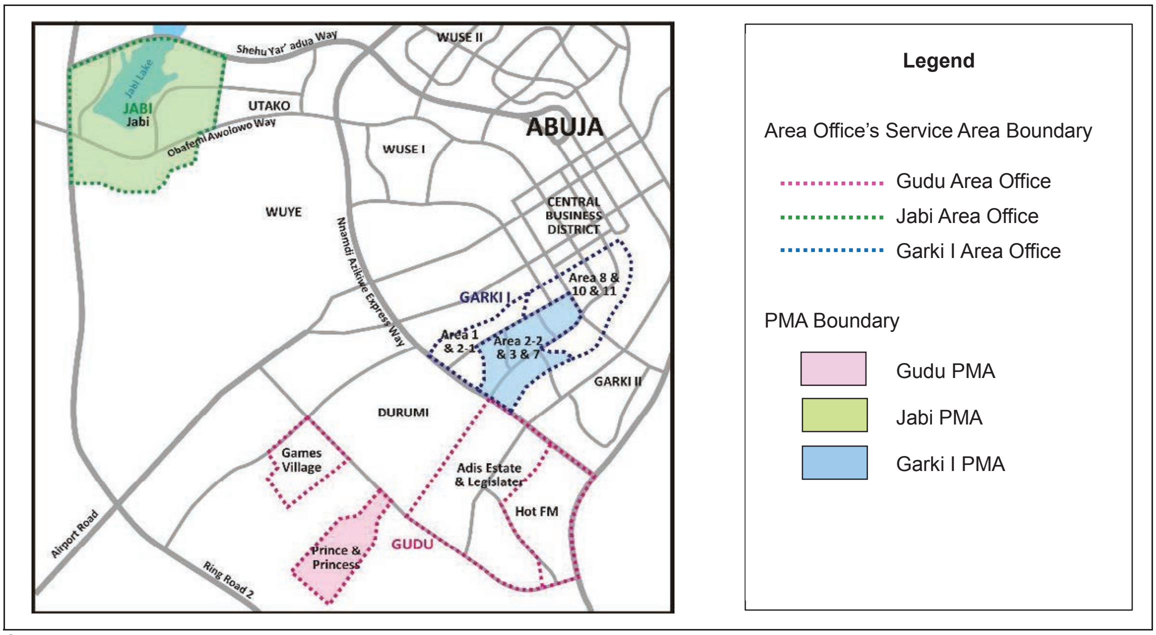
NRW ratios varies from 45.6% to 87.6% in Pilot Metering Areas (PMA) before NRW reduction operations.

2. Assessment of the Pilot Projects

2.1 Overview of the Pilot Projects

The Project implemented the pilot projects on NRW reduction to prepare this strategic plan together with relevant Area Offices in three PMAs, which are defined as District-Metered Areas (DMA).

Figure 2-1 shows location of PMAs and Table 2-1 shows their features.



Source: Project Team

Figure 2-1 Location of PMAs

Table 2-1 Features of PMAs

Pilot Area Office	No. of Customer in PMA	Max. Pipe Dia. (mm)	Total Distance of Pipes (m)	Number of In/out-flow (Places)	Predominant Type of Water Meters in PMA (% of the total installed water meters)
Gudu	784	DN200	14,150	1 / 0	Prepaid (83.0%)
Jabi	604	DN300	23,781	1 / 2	Conventional (96.5%)
Garki I	452	DN450	11,858	1 / 2	AMR (57.7%)
Total	**2,001**	-	**49,789**	-	-

Source: Project Team

2.2 Result of the Pilot Projects

Table 2-2 shows results of NRW reduction operations. NRW ratio after NRW reduction operations apart from SMA-2 of Garki I were achieved successfully.

Table 2-2 NRW Ratio (%) and Reduction Points in PMAs

Area Office	PMA/ SMA	Before NRW Reduction Operations (%)	After NRW Reduction Operations (%)	Percentage-Reduction Point	Target after Reduction (%)	Achievement
Gudu	SMA-1	52.0	12.1	39.9	31.2	OK
	SMA-2	53.9	29.9	24.0	32.3	OK
	PMA	53.3	20.4	32.9	32.0	OK
Jabi	SMA-2	45.6	21.1	24.5	27.4	OK
	SMA-3	87.6	42.6	45.0	52.6	OK
	PMA	70.0	30.9	39.1	42.0	OK
Garki I	SMA-1	85.1	45.2	39.9	51.1	OK
	SMA-2	74.8	49.3	25.5	44.9	Non
	SMA-3	70.0	27.4	42.6	42.0	OK
	PMA	74.8	34.7	40.1	44.9	OK

Source: Project Team

2.3 Causes of NRW and their Patterns by Features of the Pilot Projects

As a result of the pilot projects, causes of NRW and their patterns by features are summarised as follows:

(1) Gudu PMA

In the area like Gudu PMA in Phase 2 development area where prepaid meters were installed by private developers, the following components contribute to NRW:

- Billed unmetered consumption (excess use by flat-rate customers)
- Unauthorized consumption (illegal bypassing/connections), and
- Physical losses (surface/underground leaks) on network pipelines and service pipes

(2) Jabi PMA

In the area like Jabi PMA in Phase 2 development area where conventional meters are common, the following components contribute to NRW:

- Unauthorized consumption (illegal bypassing/connections)
- Customer metering inaccuracies and data handling errors
- Physical losses (surface/underground leaks) on network pipelines and service pipes

(3) Garki I PMA

In the area like Garki I PMA in Phase 1 development area where Automatic Meter Reading (AMR) meters were introduced and a number of major consumers exist, the following components contribute to NRW:

- Billed unmetered consumption (excess use by flat-rate customers)
- Unauthorized consumption (illegal bypassing/connections), and
- Physical losses (surface/underground leaks) on network pipelines and service pipes

2.4 Cost Effectiveness of the Pilot Project

Cost incurred for three pilot projects and envisaged increased revenue were sorted out as shown in Table 2-3. The Project applies the following conditions to cost-benefit analysis:

After initial NRW reduction operations, the improved NRW ratio will be maintained through routine monitoring and maintenance activities. Monitoring and maintenance activities for three years are assumed as same as the initial cost spent in the NRW reduction operations.

Even though FCTWB spends a certain amount of expenses for NRW reduction operations, FCTWB increase billed water in return for NRW reduction operations. Therefore, it is desirable that FCTWB positively takes NRW reduction operations. However, it is essential that FCTWB seeks to apply the activities apart from the NRW reduction operations taken in the pilot project in the light of delay or no release of the Nigerian budget to implement NRW reduction operations.

Table 2-3 Cost Effectiveness of the Pilot Project

PMA	1) Initial Cost incurred for the Pilot Project (K. NGN)	2) Initial & Recurrent Cost for NRW Reduction Operation* (K.NGN)	3) Estimated Revenue Increase for three years (K. NGN)	3) Cost Effectiveness (Dimensionless) 3) / 2)
Gudu	40,949	81,898	100,576	1.2
Jabi	47,498	94,996	274,317	2.9
Garki-I	48,937	97,874	112,426	1.1

Source: Project Team

* Recurrent cost for NRW reduction required to maintain conditions well for three years is estimated as 100% of the initial cost spent in the Pilot projects.

Furthermore, Table 2-4 shows direct benefit by NRW reduction operation for three years in terms of recurrence of NRW. Elimination of illegal connection and leakage is efficient operations compared with mitigation of nominal excess use and unbilled unmetered & meter inaccuracy.

Table 2-4 Direct Benefit by NRW Reduction Operation

No.	Items	Main Causes of NRW	Gudu	Jabi	Garki I
(1)	Initial & Recurrent Cost for NRW Reduction Operation* (k. NGN)	Nominal Excess Use	19,164	24,604	46,294
		Unbilled Unmetered & Inaccuracy	1,966	28,499	17,813
		Illegal & Physical Losses	60,686	42,843	33,767
		Total	81,816	95,946	97,874
(2)	Expected Water Sales for three years (k. NGN)	Nominal Excess Use	1,833	6,312	20,796
		Unbilled Unmetered & Inaccuracy	1,833	-28,065	1,686
		Illegal & Physical Losses	96,600	296,064	89,940
		Total	100,266	274,311	112,422
(3)	Direct Benefit (k. NGN) (2) - (1)	Nominal Excess Use	-17,331	-18,292	-25,498
		Unbilled Unmetered & Inaccuracy	-133	-56,564	-16,127
		Illegal & Physical Losses	35,914	253,221	56,173
		Total	18,450	178,365	14,548

Source: Project Team

2.5 Findings and Lessons Learnt

2.5.1 Findings

The following findings were obtained through the overall activities

(1) Lack of Feedback between FCTWB and FCDA

The pilot project observed that as-built drawings of the laid pipeline networks have not been handed over from FCDA to FCTWB properly, and also problems and issues in O&M have not been fed back to FCDA for improvement in services.

(2) As-Built Drawings

Drawings of pipelines are supposed to be managed and stored in Pipeline Unit of FCTWB Headquarters (HQ) and/or Area Offices. However, most of existing drawings are not soft copies but hard copies and are not well organized. Most of drawing copies are only one set in FCTWB.

As far as it goes, FCTWB has maintained the facilities by relying on pipeline information based on individual knowledge or using design drawings which is often different from actual situation of the constructed facilities.

This was one of facts which forced the pilot projects to redo NRW reduction operations.

(3) GIS

During pilot projects, FCTWB shifted own GIS system being free from AGIS security which was an obstacle for smooth GIS operation and data transfer. However, GIS Unit of FCTWB is still an interim unit consisting of one staff plus a casual staff.

(4) Inefficient Management of Customer Data

While HQ staff make use of customer data computed from database (billing system), Area Offices manually deal with customer data by using “Customer Notes (List)” transcribed from printed bills by Commerce staff in Area Offices, which is an inefficient procedure and causes data handling errors, then may lead to wrong billing.

This was one of facts which forced the pilot project to redo NRW reduction operations.

(5) Complexity in Customer Category

Customers are categorized variously. These category mixture caused difficulty in data assembling in the pilot project.

(6) Several Types of Customer Meter

Customer meter types are; conventional including flat-rate, AMR and prepaid meters. This mixture makes O&M and financial analysis difficult.

(7) Estimate Billing System

A considerable number of estimate bills caused by no meter reading, which sometimes lead to unexpected billed amount to customers and then their complaints, hamper calculation of revenue water. No meter reading usually results from absence of customer, inaccessibility to customer meter, infrequent meter reading due to non-provision logistics, and probably dereliction of meter reader.

(8) Duplicated / Return Bills

A number of duplicated/return bills exist in billing system of FCTWB, which make analysis inaccurate. “duplicated/return bills” mean the bills which are supposed to be eliminated or deactivated from billing system but have remained, then have resulted in being returned or not delivered. Existence of duplicated/return bills in billing system causes wastefulness and unreliable financial analysis statement, NRW and collection ratio.

(9) Complexity in Water Tariff

Water tariff are, as standard, N80/m^3 or N5,500/month for domestic, N150/m^3 or N45,000/month for commercial, and N150/m^3 or various prices per month for major consumers. This mixture makes financial analysis complicated.

(10) Customer Meter Inaccuracy

Inaccuracy of conventional meter is higher than that of AMR and prepaid meters. After replacement of those meters in the pilot projects, NRW ratio was improved certainly. However, meters will be getting inaccurate gradually without regular maintenance and periodical replacement.

(11) Unauthorized Consumption

Illegal bypassing/connections were found in all the three PMAs, particularly often in Gudu and Garki I PMAs where prepaid or AMR meters were installed. These were caused by non-reading or non-inspection by water board’s staff and non-existent regular monitoring in the field.

(12) Leakage

The pilot project observed water leaks on both network pipelines and service pipes up to customer meters, and surface leakage because of low-quality in appurtenant/meter materials, installation and workmanship, and non-standard situations such as service pipes laid from the back side. The pilot project also observed an inflow pipeline over a ditch without a sheath pipe and bursts due to substandard materials and no thrust block.

(13) Quality Failure in Facility and Workmanship

Low quality in construction and plumbing works including materials was observed across the pilot projects, which causes pipe burst and leakage.

2.5.2 Lessons learnt

The following lessons learnt were obtained through implementation of the pilot projects. The lessons learnt were basis of setting-up the various scenarios.

(1) Delayed or No Release of the Nigerian Budget to implement NRW Reduction Operations

The pilot project suffered from delayed or no release of the Nigerian budget to implement NRW reduction operations such as chamber construction for flow-meters and valves to create PMA (DMA), leak repair by using materials and logistics including fuel. Budget constraint always hampered implementation of the pilot projects.

(2) Area Office's Capability, Logistics and Staff Skills

Budget allocation is limited for the routine services which Area Offices are in charge, and as an organization capacity, Area Offices are not equipped well with personal computer, material stocks, tools and devices, as well as their logistics including vehicles, fuel, electricity and in-house power generation are not enough at all to provide adequate and quality services for O&M and meter reading.

As an individual capacity, staff such as plumbers and water meter readers have attended limited systematic employee training under the human resources development programme of FCTWB. They can learn skills through on-the-job training or apprenticeship from superiors. In addition, most of staff are not good at mathematics, reading drawings, maps and operate personal computer, even basic word-processing and spreadsheet programmes due to their educational background and inadequate training. It was also observed that, although staff are willing to learn and contribute, staff have little responsibility and motivation because of no incentives, poor logistics and working conditions of Area Offices. Consequently, skill development was limited to some staff in each pilot Area Office.

(3) Difficulties in isolating PMAs and SMAs

The pilot projects faced difficulties in isolating PMAs and SMAs due to lack or discrepancy of the existing pipeline information among design drawings and staff's knowledge. The existing GIS pipeline network data has never been updated and doesn't reflect correct information in Garki I, meanwhile FCTWB doesn't have any drawings and GIS data in Gudu and Jabi.

Customer location maps are not available because FCTWB has never positioned customers on drawings or GIS. This also caused difficulties in identifying customers inside PMAs and SMAs.

(4) Meter Reading Divisions and Flat-Rate

Several divisions of FCTWB, such as Area Offices, AMR Unit, Prepaid Unit and nine Units for major consumers in HQ are responsible for meter reading. This kind of segmentation causes inefficiency of the billing.

Flat-rate customers tend to consume water more than the expected as excess use, a part of NRW.

(5) Billed Unmetered Consumption (Nominal Excess Use)

A certain number of flat-rate (unmetered) customers existed and resulted in spending much time on calculation of revenue water in baseline analysis. They tend to consume water more than one which is converted from set tariff as nominal excess use according to measurement in the pilot projects, so installing meters to flat-rate customers contributes to NRW reduction.

(6) Unbilled Unmetered Consumption

The pilot projects observed some unbilled unmetered consumption from major consumers, public institutions because of procedural omission and also from FCTWB offices and its staff quarters. FCTWB needs to install meters, shift them to the billed or unbilled metered consumers at least by installing meters to measure water consumption.

3. Scenario, Goal and Cost-Effectiveness

3.1 Overall Scenarios

From lessons obtained through the pilot project, it is very difficult for Project Team to determine the particular NRW reduction activity. Project Team, therefore, prepared six scenarios such as Scenario-a to Scenario-e for NRW reduction operations in order flexibly to cope with influence due to various conditions such as budget disbursement, appointment of trained appropriate staff, progress of database for the existing pipelines in future. Figure 3-1 shows criteria for selecting scenario of NRW Reduction Activity as aspects of financial, human resources, etc. are changed.

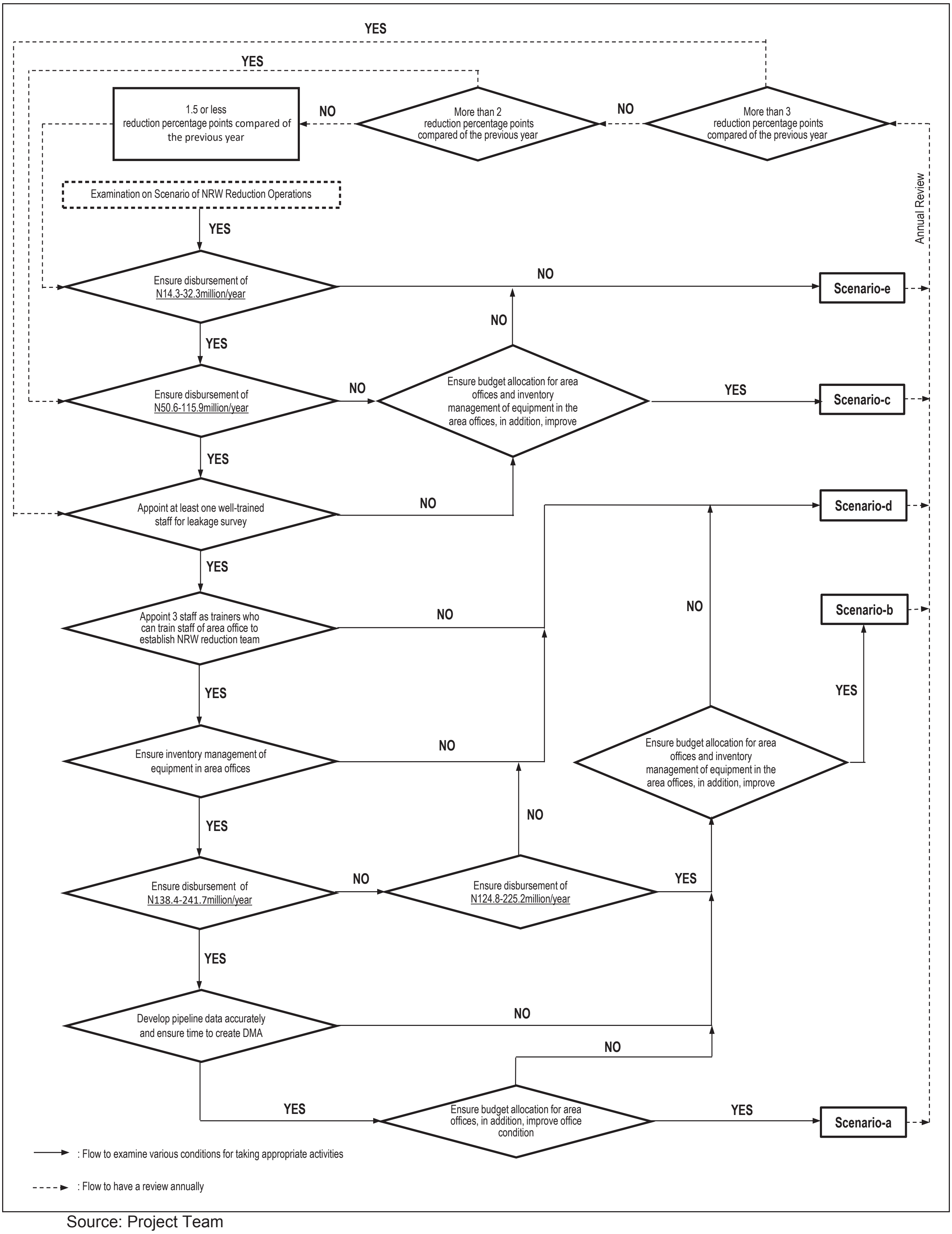
Especially, Project Team set condition for the criteria in terms of the following five aspects:

- Budget release
- Appointment of well-trained staff for leakage survey
- Appointment of trainers required for Area Office’s staff
- Inventory management of equipment in Area Office
- Development of pipeline data

Table 3-1 summaries main activities and procurement of equipment of all the scenarios as well as target NRW ratio. The target NRW ratio shown in Table 3-1 indicates percentage unless scenario is changed the year 2019 through 2023. Therefore, target NRW ratio should be reviewed and setup in the annual action plan based on the first six-month activities of the previous year.

Even if FCTWB does not achieve targeted NRW ratio for the year of 2023, the common objective of NRW reduction operation among five scenarios is to achieve the following activities which are significant for FCTWB to learn status of NRW ratio.

- Data collection of monthly billed consumption
- Data collection of monthly System Input Volume (SIV)
- Monthly IWA water balance analysis



Source: Project Team

Figure 3-1 Criteria for selecting Scenario of NRW Reduction Activity

Table 3-1 Features of Scenarios for NRW Reduction Operations

Items	Scenario				
	a	b	c	d	e
1. Target					
1.1 Target Year	2023	2023	2023	2023	2023
1.2 Baseline NRW Ratio (%)	48.3	48.3	48.3	48.3	48.3
1.3 Target NRW Ratio in 2023 (%)	31.9	32.4	36.9	35.1	42.8
1.4 Reduction Approach	DMA	Zone	Zone	Zone	Zone
2. Main Body for NRW Reduction Operations					
2.1 Main Body for Operations (Supervision)	HQ's NRW Unit	HQ' NRW Unit	HQ's NRW Unit	HQ's NRW Unit	HQ's NRW Unit
2.2 Main Body for Operations (Field Actions)	Area Offices	Area Offices	Area Offices	HQ's NRW Unit	HQ's NRW Unit
3. NRW Reduction Operations					
(1) Network Drawings and Data	X	X	X	X	X
(2) Customer Enumeration					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(3) DMA Design, Creation and Prioritization	X	-	-	-	-
(4) Zonal Prioritization	-	-	-	X	X
(5) Field Inspection	X	-	-	-	-
(6) Isolation by installing Flow Meters and Valves	X	-	-	-	-
(7) Step Test in DMA	X	-	-	-	-
(8) Zonal Measurement	-	-	-	X	X
(9) Leakage Detection					
a) by Area Office (DMA)	X		-	-	-
b) by Area Office (Zone)	-	X	-		-
c) by NRW Unit (Zone)	-	-	-	X	X
(10) Patrol of Surface Leaks	-	-	X	-	-
(11) Repair of Leaks and Recording					
a) for (9)-a)	X	-	-	-	-
b) for (9)-b)	-	X	X	-	-
c) for (10)	-	-	X	-	-
d) for (9)-d)	-	-	-	X	X
(12) Identification of Illegal Connection and Inaccuracy Meters					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Inaccuracy Meters	X	X	X	X	-
d) Labo Test of Meter Inaccuracy for Meter Standardization	X	X	X	X	-
(13) Measures against Illegal Connection and Meter Inaccuracy					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Meter Inaccuracy	X	X	X	X	X
(14) Data Collection of Monthly Billed Consumption					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(15) Data Collection of Monthly SIV					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
c) Bulk Meters	X	X	X	X	X
(16) Monthly Water Balance Analysis	X	X	X	X	X
(17) Measurement of 1-week SIV (DMA)	X	-	-	-	-
(18) Installing Water Meters	X	X	X	X	-
(19) Survey on Trunk, Distribution Mains and Reservoirs	X	X	X	X	X
(20) Preparation for Pipe Replacement Plan	X	X	X	X	X
4. Procurement of Equipment					

Items	Scenario				
	a	b	c	d	e
4.1 Flow Meters and Valves for Isolation	X	-	-	-	-
4.2 Leak Detection Equipment	X	X	-	-	-
4.3 Water Meters	X	X	X	X	-
5. Place where equipment is stocked					
5.1 Existing Equipment	3 Pilot A.O.	3 Pilot A.O.	NRW Unit	NRW Unit	NRW Unit
5.2 Newly-procured Equipment	A.O.	A.O.	-	-	-

Source: Project Team

3.2 Scenarios

(1) Scenario-a

1) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will create DMA and take NRW reduction operations like the Pilot Project targeting on NRW ratio of 31.9% for the year 2023.

2) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-a.

- Develop data on the existing water supply pipelines accurately ensure time to create DMA.
- Appoint staff who were involved in The Federal Capital Territory Reduction of Non-Revenue Water Project in FCTWB HQ.
- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint well- trained staff for installation of flow meters and leakage survey.
- Ensure enough budget of about N883million for five years for allowance and equipment such as flow meters, isolation valves, leak detectors, customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

3) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

4) Challenges in Future

FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(2) Scenario-b:

1) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will NOT create DMA, but will take NRW reduction operations such as leakage survey, illegal connection survey and water meter survey by zone targeting on NRW ratio of 32.4% for the year 2023.

2) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-b.

- Appoint staff who were involved in The Federal Capital Territory Reduction of Non-Revenue Water Project in FCTWB HQ.
- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint well- trained staff for leakage survey
- Ensure enough budget of about N805million for five years for allowance and procurement of equipment such as leak detectors, customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

3) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

4) Challenges in Future

FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(3) Scenario-c:

1) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will NOT create DMA, but will take NRW reduction operations such as water meter survey, monitoring for surface leakage and illegal connection by zone targeting on NRW ratio of 36.9% for the year 2023.

2) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-c.

- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint staff who were involved in the Project in FCTWB HQ.
- Ensure enough budget of about N326million for five years for allowance and equipment such as customer water meters, meter boxes, fuel, pipes, their fittings, etc.

- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

3) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.
In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

4) Challenges in Future

FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(4) Scenario-d:

1) Summary of Scenario

Only FCTWB HQ will take NRW reduction operations such as leakage survey, illegal connection survey and water meter survey systematically by zone but NOT create DMA. FCTWB will target on NRW ratio of 35.1% for the year 2023. Area Offices patrol for detect surface leakage and illegal connection.

2) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-d.

- Appoint staff who were involved in the Project in FCTWB HQ.
- Appoint well- trained staff for leakage survey
- Ensure enough budget of about N223million for five years for allowance and equipment such as customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure vehicle and PC.

3) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

4) Challenges in Future

FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(5) Scenario-e:

1) Summary of Scenario

FCTWB HQ will focus on developing fundamental information of the existing water supply pipelines and customer enumeration required for future NRW reduction operations. HQ will also conduct leakage detection and measures against illegal connections for NRW reduction as much as possible. FCTWB will target on NRW ratio of 42.8% for the year 2023.

2) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-e.

- Appoint staff who were involved in the Project in FCTWB HQ.
- Ensure enough budget of about N124million for five years for allowance and fuel and equipment such as pipes, their fittings, etc.
- Ensure vehicle and PC.

3) External Factors

NRW reduction operations, particularly leakage detection and countermeasures against illegal connection, may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

4) Challenges in Future

FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

In addition, staff who were trained through the pilot project have no an opportunity to take major activities for NRW reduction for the time being unless FCTWB applies other scenario. This may result in loss of staff's skill on NRW reduction operations.

3.3 Cost-Effectiveness by Scenario

Overall cost-effectiveness for five years was worked out in Table 3-2. Scenario-d indicates the highest cost-effectiveness at 18.9.

Table 3-2 Cost-Effectiveness by Scenario

Items		Scenario				
		a	b	c	d	e
Cost (mil. NGN)	i.	883.2	804.5	326.9	222.7	123.5
Revenue yielded (mil. NGN)	ii.	4,822.60	4,752.60	3,636.90	4,198.40	1,698.80
Direct benefit (mil. NGN)	iii=ii.-i.	3,939.40	3,948.10	3,310.00	3,975.70	1,575.30
Cost-Effectiveness	iv. = ii./ i.	5.5	5.9	11.1	18.9	13.8

Source: Project Team

3.4 Financial Consideration based on the Scenarios

The Financial statements of the five scenarios such as "Profit and Loss" and "Cash Flow" were examined and summarized scenario-wisely in this section.

(1) Conditions

Table 3-3 presents various conditions set out for the study.

Table 3-3 Conditions for preparing Financial Statement

Items	Conditions
1. Baseline of NRW ratio	48.3%
2. Incremental O&M expenditures	Scenario-wise
3. Capital Investment expenditures	
1) Construction works in 2019 for the switch over of the water supplied by LUD-WTP Phase-3&4	NGN673Mil.
2) Procurement in connection with the scenarios	Scenario-wise
4. Depreciation	
1) Procurement of above 3-2)	10 years
2) Other assets including the construction of switch-over and Phase-3&4	20 years
5. Price escalation	Not applied
6. Tariff: weighted average between the domestic and commercial customers	NGN90/m^3
7. Collection ratio of water tariff against bills raised	31.3%
8. Allocation and remittance to FCTA	Not applied

Source: Project Team

(2) Profit and Loss (P/L) Statement

Table 3-4 shows the summary of the P/L statement for the year 2023. With-project cases (five scenarios) will obviously make a larger profit than without-project case (no scenario).

Table 3-4 Summary of P/L Statement of the Year 2023 by Scenario (Million Naira)

Account Items	No Scenario	Scenarios				
		a	b	c	d	e
1.Revenues	7,829	10,306	10,239	9,547	9,824	8,668
2.Expenditures	2,799	2,895	2,886	2,844	2,824	2,815
3.P/L = 1-2	5,030	7,411	7,353	6,703	7,000	5,853

Source: Project Team

(3) Cash Flow (C/F) Statement

The C/F Statement refers to cash-inflows and cash-outflows in a given period categorizing such activities as operational, investment and financial. The difference between the cash-inflows and the cash-outflows comes out to “net cash flow” at the end. Table 3-5 presents the C/F Statement for the year 2023.

With-project cases (five scenarios) will apparently generate the net C/F more than without-project case (no scenario). Moreover, the net C/F will surely soar if reducing the number of un-paid customers.

Table 3-5 Summary of C/F Statement of Year 2023 by Scenario (Million Naira)

Activities	No Scenario	Scenarios				
		a	b	c	d	e
1.Operational	714.5	1,451.3	1,434.6	1,220.4	1,325.0	965.1
2.Investment	0	- 100.0	- 91.0	- 18.9	- 38.4	- 20.5
3.Financial	0	0	0	0	0	0
4. Net C/F = 1+2+3	714.5	1,351.3	1,343.6	1,201.5	1,286.6	944.7

Source: Project Team

4. NRW Reduction Operations Plan

Overall NRW reduction operations from Scenario-a to Scenario-e are shown in Table 3-1. All the NRW reduction operations contains 20 operations. Scenario-a consists of most operations among five scenarios, while Scenario-e consists of least ones.

5. Scenario that FCTWB selected and the Background

In order to carry out NRW reduction operations, considering the following reasons, the Management of FCTWB selected “Scenario-d” which states that, “Only FCTWB HQ will take NRW reduction operations such as systematic leakage survey, illegal connection survey, and installation of water meters but NOT create DMAs. FCTWB will target on NRW ratio of 35.1% for the year 2023”.

- Practical goal of NRW ratio
- Insufficient data of the existing water supply facilities
- Vulnerable structure and limited discretion in budget use of Area Offices
- Insufficient number of skilled staff of Area Offices
- Expected accommodation of disbursement due to approved autonomy of FCTWB and appointment of board members
- Making the most use of skills and know-how which were obtained through the Project as much as possible so that FCTWB’s capacity on NRW reduction especially at individual level is sustained

6. Implementing Schedule and Budget Allocation

In the past three years, FCTWB made a budget of 40million to 50million yearly, but suffered from delayed or no release of the budget to implement the pilot projects as scheduled. From the current condition of release, Budget for the year 2018 has not been approved and released as of April 2018. It is most likely that approval and release of budget for the year 2019 will be delayed. Therefore, the Project Team allocated a budget up to about 35million apart from Scenario-a, b and c which requires huge initial investment for the first year in accordance with FCTWB’s prospect. Table 6-1 shows budget allocation for five years. The budget was estimated based on the cost to be incurred for NRW reduction operation of each scenario and the cost (about 7.5millions) of training for five years as human resource development.

Table 6-1 Implementing Schedule and Budget Allocation

Scenario	Total Cost (mil. NGN)	2019	2020	2021	2022	2023
Scenario-a	883.3	241.7	185.4	178.1	139.7	138.4
	100%	27%	21%	20%	16%	16%
Scenario-b	804.5	225.2	169.0	161.7	123.8	124.8
	100%	28%	21%	20%	15%	16%
Scenario-c	326.9	115.8	59.3	50.7	50.7	50.5
	100%	35%	18%	16%	16%	15%
Scenario-d	222.7	34.1	34.6	50.7	51.4	52.0
	100%	15%	16%	23%	23%	23%
Scenario-e	123.5	14.2	14.7	30.9	31.5	32.2
	100%	12%	12%	25%	26%	26%

Source: Project Team

7. Staffing Plan

Number of staff is calculated as following conditions:

- National Holiday: Total 13 days
- Annual Leave: 30 days include Saturday and Sunday (Eight non-working days): 22 days
- Working days per week: 5 days per week x 52 weeks = 260 working days
- Working days per year: 260 days -13 days - 22 days = 225 working days per year

Table 7-1 Necessary No. of Staff by Scenario

Unit	2019					2020					2021					2022					2023				
HQs	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
NRW reduction	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9
GIS	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Distribution	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2
Billing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Commerce	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0
HQs Sub-total	**13**	**11**	**11**	**19**	**16**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**
Area Offices																									
Distribution	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Commerce	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1
Area Office Sub-total	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**
Total	**21**	**19**	**18**	**26**	**23**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**

Source: Project Team

8. Human Resource Development (HRD) Plan on NRW Reduction

8.1 Necessity of HRD on NRW Reduction

Human resource management is recruiting, hiring and managing employees. Project Team focused on human resource development in terms of staff's individual capacity in NRW reduction.

At present, there is no systematic HRD plan for NRW reduction in FCTWB, but It is necessary to create systematic HRD plan and deepen staff's understanding of NRW, so that NRW ratio will be decreased in FCTWB's service area.

The purpose of the plan is to deepen understanding of NRW among staff of FCTWB and to contribute to NRW reduction.

8.2 Training Curriculum on NRW Reduction

The HRD plan consists of the following seven curriculums:

1) Training Curriculum 1: Basic and Common Knowledge about NRW
2) Training Curriculum 2: Management of Pipelines
3) Training Curriculum 3: Management of Data
4) Training Curriculum 4: Leakage and Illegal Connection Survey
5) Training Curriculum 5: Streamlining of billing system and examination on unifying water meters
6) Training Curriculum 6: Plumbing for repair and or replacing pipelines
7) Training Curriculum 7: Basic operation of personal computer, graphing by using excel

Table 8-1 shows the training curriculums on HRD of FCTWB in 2019 and 2020.

Table 8-1 Training Schedule (Tentative)

Curriculums	2019				2020			
	1/4	2/4	3/4	4/4	1/4	2/4	3/4	4/4
Curriculum 1: Basic and Common Knowledge about NRW								
➢ Meaning of NRW Reduction	■	■	■		■			
➢ Outline of Water Balance analysis	■	■	■		■			
➢ Outline of NRW Reduction Operation	■	■	■		■			
Curriculum 2: Management of Pipelines								
➢ Outline of GIS		■	■	■	■			
➢ Outline of Water Balance analysis		■	■	■	■			
➢ Outline of NRW Reduction Operation		■	■	■	■			
Curriculum 3: Management of Data								
➢ Meter Reading				■ ■	■	■		
➢ Meter Test				■ ■	■	■		
Curriculum 4: Leakage and Illegal Connection Survey								
➢ Kinds of Illegal Survey Equipment					■		■	■
➢ Leakage Survey Methods					■		■	■
➢ Illegal Connection Survey					■		■	■
Curriculum 5: Streamlining of billing system and examination on unifying water meters								
➢ Examination on unifying water meters						■	■	■
➢ Streamlining of Meter reading & billing						■	■	■
➢ Development of customer data						■	■	■
Curriculum 6: Plumbing for repair and or replacing pipelines								
➢ Repair jointing for large scale and small scale						■	■	■
➢ Laying pipelines						■	■	■
➢ Install valves, flow-meters, saddle, etc.						■	■	■
Curriculum 7: Basic operation of personal computer, graphing by using excel								
➢ PC operation						■	■	■
➢ Calculation by using Excel						■	■	■
➢ Drawing graph by using Excel						■	■	■

Source: Project Team

9. Recommendation

Generally, FCTWB has a number of challenges to not only implement NRW reduction in the long term but also become an autonomous body pursuing revenue.

9.1 Distribution

(1) Improvement in As-Built Drawings and Drawing Management

FCTWB has operated and maintained facilities, while FCDA has been in charge of development.

It is important for FCTWB to review and improve procedures of drawing collection from FCDA and feedback issues in O&M to FCDA.

(2) Calibration of Customer Meters

Even though water meters are replaced with new ones and or installed newly, meters will be inaccurate gradually without regular maintenance and periodical replacement, for example every eight years, regardless of meter types. Conventional meters available in local markets vary in quality, so FCTWB needs to establish a simplified meter laboratory for meter-accuracy test by using reference meters, and also prepare a fact-finding report for guideline on meter standardization in the future.

9.2 Commerce

(1) Improvement in Update of Customer Database

Management of customer data including meter-reading data and payment records has not been unified timely among HQ and Area Offices.

FCTWB HQ should unify database of customers’ information among HQ and Area Offices, update, improve it and well-manage customer data.

(2) Streamlining of Customer Category

Customers are categorized as domestic, commercial (un-coded), major consumer (co-operate body, mini-hotel / restaurant, major consumer, petrol station / plaza, private school / clinic), institution (embassy / high commission, ministry, liaison office, religion), public tap / convenience & kiosk, and lifting point (bulk selling. This mixture caused difficulty in data assembling in the pilot project.

FCTWB should lessen a number of categories for simplified customer management.

(3) Simplification and Quality Assurance of Customer Meter

The strategic plan includes an operation to review customer meter types by meter laboratory using reference meters so that FCTWB brings the future metering policy, standardization and licensing in view.

(4) Elimination of Estimating Billing System

In order to bill the amount accurately, FCTWB should give responsibilities of reading to Area Offices close to customers, then HQ’ Units should specialise supervision of them.

The strategic plan includes an operation to eliminate flat-rate customers by installing or replacing meters, but FCTWB should prevent reoccurrence thoroughly.

To reduce estimating bills, FCTWB should discuss enhancement in staff’s performance of duties with awareness-rising, adequate logistics, thorough monitoring of reading regardless of meter types, review of reading frequency (i.e. once a month to once in two months), meter installation and replacement of malfunctioning maters, and meter reposition to outside property or empowering FCTWB for reading accessibility or illegal connection check.

(5) Duplicated / Return Bills

In order to ensure correct billing and avoid complain from customers, FCTWB should deactivate or eliminate duplicated/return bills promptly, and establish proper addressing, procedures and management of billing information to prevent reoccurrence.

(6) Simplification and Revision of Water Tariff

To simplify financial analysis, FCTWB should review water tariff for simplification on the occasion of autonomy as well as revision (reduction) in tariff as a result of financial analysis.

(7) Elimination of Unauthorized Consumption

Regardless of meter types and customer categories, technical staff and meter readers need to inspect water meters, surroundings and monitor consumption data routinely to track irregularities. FCTWB should pay attention to possible illegal connections on service pipes extended to public taps located in informal settlements, so-called “villages”.

9.3 Finance

The following management of the FCTWB is not functioned effectively; this caused us a great deal of difficulty for the financial study. Regardless to say, a quick and timely provision of the data and information to the managerial officers is also an important role. The enhancement of the functions is duly taken account as well as the regular financial activities of the Department.

(1) Fixed Asset Management

Every fixed asset must be booked and managed properly in the following manners envisaging a regular maintenance and future renewal.

- Entry: acquisition date and price, specification, place located, department responsible, etc.
- Disposal: sale, disuse and retirement, etc.
- Inventory check: periodically once a year visa-vis the fixed assets book

(2) Water Cost Management

A cost center has to be functionalized to learn the actual water cost of FCTWB; the unit cost, Naira/m^3, should be calculated at least once a year. The data in chronological order will suggest a lot of managerial information through analysis on why increased or decreased and setting a water tariff as well.

9.4 Administration

(1) Improvement in ICT System and Intranet

FCTWB have no well-established system using information and communication technology as well as an intranet and or internet with security protection, so FCTWB should develop them for smooth information sharing and communication.

(2) Improvement in Office Environment

HQs' office is composed of small rooms which are not suitable for a water utility office, and also Area Offices use ordinary flat house, prefabricated house or container. FCTWB should improve office environment as electric power is stabilized for doing with daily work efficiently.

(3) Human Resource Development

FCTWB should prepare comprehensive training programme based on assessment for each level of staff in accordance with business plan and the strategic plan.

ABUJA
The Heart of Nigeria

Federal Capital Territory
Administration

Federal Capital Territory
Water Board

Japan International
Cooperation Agency

The Federal Capital Territory
Reduction of Non-Revenue Water Project

THE MEDIUM-TERM STRATEGIC PLAN FOR NRW REDUCTION (2019-2023)

September 2018

By: Project Team

Preface

NRW reduction is one of serious and urgent challenges for FCTWB focusing on sustainability, stabilization and development of water supply service in FCT.

In order for FCTWB to take NRW reduction operation for next five years and to prepare annual NRW reduction plan, Project Team formulated Mid-term Strategic Plan (2019-2023) based on lessons learned through the pilot project in collaboration with the Project working group and JICA Expert Team. FCTWB will not only take the operation with the Mid-term Strategic Plan but also review the Plan according to the achievement of NRW reduction.

To utilize this Mid-term Strategic Plan practically and appropriately, it is essential that FCTWB makes the working group & relevant organization such as FCDA, Federal Ministry of Water Resources understand, receives technical assistance from them and makes a budget arrangement for NRW reduction operations. In addition, Prompt financial release is one of fundamental challenges as pre-condition for NRW reduction operation.

In the Technical Cooperation Project, the NRW Unit of FCTWB led the pilot project and formulation of Mid-term Strategic Plan in cooperation with JICA Expert Team. After the Project terminates, the NRW Unit will lead and manage NRW reduction operation as well as the Project as a driving force by utilizing the Mid-term Strategic Plan. The NRW Unit will furthermore be forced to communicate with advisory members such as FCTWB’s board members, FCTA, Engineering Service Department of FCDA and Federal Ministry of Water Resource.

Finally, Project Team hopes that Mid-term Strategic Plan will contribute to NRW reduction in future in FCT as an overall plan of annual NRW reduction plan.

Contents

1. Introduction to NRW Reduction

1.1 Background

In the Abuja Federal Capital City (FCC) located in the north-east of the Federal Capital Territory (FCT), the Federal Republic of Nigeria, water supply facilities have been developed by Federal Capital Development Authority (FCDA) based on water supply master plan prepared in 1980 and reviewed in 2010. Although existing water sources “Lower Usuma Dam and Gurara Dam” and treatment plants can meet water demand increasing by mass-migration and urbanization, water distribution facilities such as service reservoirs and networks have been behind schedule in development.

Meanwhile, the FCT Water Board (FCTWB) was established in October 1989, saddled with the responsibility of supplying potable water to inhabitants of the FCT. In carrying out this responsibility, the FCTWB has been facing challenges of operation and maintenance of facilities as well as large proportion of non-revenue water (NRW) in water trunk mains, distribution mains and networks, water reservoirs, service pipelines and water meters. The FCTWB could not effectively mitigate NRW because of limited experience, insufficient knowledge and skilled personnel on planning and execution of NRW reduction. NRW ratio of urban water supply system for the FCC was estimated at 48.3% based on year 2014-2017 data.

Based on the above, in order to strengthen NRW reduction capacity of the FCTWB and ameliorate issues of NRW, the Federal Capital Territory Administration (FCTA) and the FCTWB has implemented “the Federal Capital Territory Reduction of Non-Revenue Water Project” (the Project), the technical cooperation in collaboration with Japan International Cooperation Agency (JICA).

This plan “The Medium-Term Strategic Plan for NRW Reduction (2019-2023)” was prepared in the Project for the Nigerian side to carry out NRW reduction operations with aiming at project’s overall goal “Non-Revenue Water reduction activities are routinely implemented in the service area of FCTWB”.

1.2 Non-Revenue Water (NRW)

In plain words, NRW is attributed to the following:

- Construction defects (poor workmanship)
- Aging of pipes
- Corrosion of galvanize iron pipes and appurtenances
- Use of sub-standard materials
- Water pressure
- Soil condition (erosion effect)
- Construction work/traffic load
- Water theft
- Illegal connection
- Meter inaccuracy
- Overflow at water treatment plants or tanks

Definition and details are described technically below:

(1) Definition

NRW can be defined as: “the water which is produced at the costs but lost before reaching customers, or but not used effectively”.

International Water Association (IWA) clarifies NRW by using water balance sheet as shown in Table 1-1, but FCTWB modifies it by adding “b. Billed Unmetered Consumption (Nominal Excess Use)” as a component of NRW as shown in Table 1-2 in consideration of actual situation.

Table 1-1 IWA's Water Balance Sheet

<table>
<tr><td rowspan="9">System Input Volume (SIV)</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td rowspan="2">1) Revenue Water</td></tr>
<tr><td>b. Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>c. Unbilled Metered Consumption</td><td rowspan="7">2) Non-Revenue Water (NRW)</td></tr>
<tr><td>d. Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Commercial (Apparent) Losses</td><td>e. Unauthorized Consumption</td></tr>
<tr><td>f. Customer Metering Inaccuracies and Data Handling Errors</td></tr>
<tr><td rowspan="3">Physical (Real) Losses</td><td>g. Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>h. Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>i. Leakage on Service Connections up to Point of Customer Use</td></tr>
</table>

Source: International Water Association

Table 1-2 FCTWB's Water Balance Sheet

<table>
<tr><td rowspan="10">System Input Volume (SIV)</td><td rowspan="5">Authorized Consumption</td><td rowspan="3">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td rowspan="2">1) Revenue Water</td></tr>
<tr><td>b. Billed Unmetered Consumption</td></tr>
<tr><td>b. Billed Unmetered Consumption (Nominal Excess Use)</td><td rowspan="8">2) Non-Revenue Water (NRW)</td></tr>
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</table>

Source: Project Team

Various issues related to NRW to be addressed reside in FCTWB, and factors causing NRW exist extensively in terms of both commercial and physical aspects.

Results of review of situation and existing NRW reduction operations in FCTWB by component in water balance sheet are as follows:

1) Revenue Water

a. Billed Metered Consumption

FCTWB has billed based on metered consumption as revenue water, however, it is not necessarily properly-read consumption.

A certain number of “return bills” in the billing system hampers accurate calculation of revenue water, which have been generated automatically by estimating billing as a result of duplication and lack of deactivation. FCTWB has not dealt with them properly in spite of moving, change in address indication, conversion of meter type of customers.

Consumption includes one by “estimate bills” automatically-generated by billing systems namely the Puma 4 in case of unreadable or inaccessible meters and also zero consumption. A certain number of estimate bills have been issued continuously in both conventional meter and Automatic Meter Reading (AMR) meter. If the estimate billing repeats over a long period of time, a large amount of gap between actual meter-read bill and estimate bill might happen then cause trouble with customers.

Prepaid meters installed in some estates are categorized in this component, but obtaining water consumption data is difficult because of system design and its independent feature from the billing system.

Consumption by the estimate billing and prepaid meter causes inaccurate calculation of revenue water within specific period. The estimate billings should be reduced.

b. Billed Unmetered Consumption

Regardless of category such as domestic or commercial customers and major consumers such as hotel, plaza, school, public tap, bulk selling and etc., FCTWB has a certain number of flat-rate customers and consumers. As long as they consume water within an amount converted by dividing flat rate by unit price, this category has no particular problem. However, if they consume water more than the nominal quantity, excess use is categorized as a component of NRW.

2) Non-Revenue Water (NRW)

c. Unbilled Metered Consumption

In principle, no cases exist in FCTWB.

d. Unbilled Unmetered Consumption

Water for maintenance of pipelines such as pipe cleaning by FCTWB as well as water extraction for emergent fire-fighting are categorized here, but they are not recurring consumption. These water consumption should be treated as Unbilled Metered Consumption by installing meter and reading.

Water discharging from washout or air valves along transmission or distribution mains for breaking water pressure is considerable consumption by FCTWB. Also, water supply to FCTWB staff quarters is exempt from billing as welfare. These should be metered and recorded.

Other than these cases, as mentioned in the above b) Billed Unmetered Consumption, excess use by flat-rate customers or major consumers is categorized here and should be captured then prevented by installing water meters. About 7,000 customers or major consumers remain in flat-rate ones.

e. Unauthorized Consumption

Illegal connections to air valves and drain/washout valves along transmission mains have been sometimes found out when the FCTWB does maintenance.

In distribution network, illegal connection or tampering, for example, bypass connection by customer to avoid meter-read consumption or direct connection by non-customer, is identified as unauthorized consumption in FCTWB. But, efficient countermeasures have not been taken systematically and actively. Track record of billed consumption and numbers of customers are useful to identify irregularity.

And, customers of flat-rate, AMR meter and prepaid meter are not monitored physically due to their conditions or product features, which may lead to illegal connection or tampering.

f. Customer Metering Inaccuracies and Data Handling Errors

FCTWB does not have only equipment or laboratory to test customer meters but also meter standardization. Particularly, the deteriorated meters which gets worse in accuracy, are supposed to be replaced with new ones by Metering Unit, but replacement has not been regulated in FCTWB. It is generally said that customer metering accuracy differs from meter type and product quality.

Data handling errors may arise in the manual process such as meter reading and writing in memo paper in the field, transcription to reading form in the office and then data entry to billing system.

g. Leakage on Transmission and/or Distribution Mains

FCTWB and Area Offices do not have equipment and skilled staff for leakage detection, and especially Area Offices are not equipped for prompt and smooth repair of leaks due to lack of logistics and material stock.

Pipeline Unit of the Headquarters is in charge of transmission and distribution mains or network of diameter 300mm or more. Whenever obviously-visible considerable leaks and pipe bursts occur along the mains or someone reports, Pipeline Unit repairs them.

Area Offices take care of distribution network of less than diameter 300mm. Same as the above, whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them.

h. Leakage and Overflows at Utility's Storage Tanks

Overflow from clear water tanks of water treatment plants (Phase-3&4) have been observed frequently, with which FCDA will cope by switch-over of outlet pipelines. Some distribution tanks have constant leak which is inconsiderable unless amount of leak is severe.

i. Leakage on Service Connections up to Point of Customer Use

Area Offices in charge of service connections (service pipes from branches along distribution network to water meters) do not have equipment and skilled staff for leakage detection, and they are not equipped for prompt and smooth repair of leaks due to lack of logistics and material stock.

Whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them. But, repair is not always appropriate in quality.

(2) Impact of NRW Reduction

Impacts of NRW reduction are as follows:

- Reduction of maintenance and production cost
- Increase in revenue generation
- Contribution to water conservation
- Improvement in efficiency and financial sustainability of utility organization
- Increase in water supply coverage
- Improvement in customer satisfaction

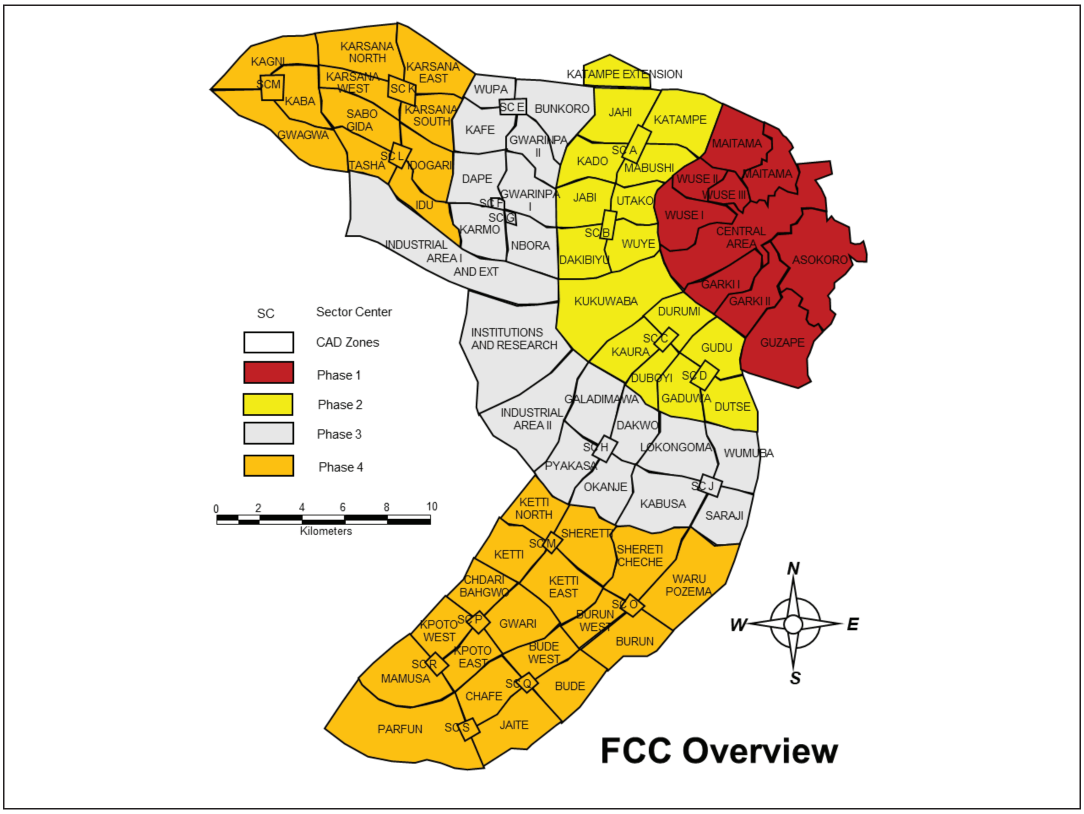
1.3 Urban Water Supply in Federal Capital City (Abuja) by FCTWB

The FCTWB's urban water supply system for the Federal Capital City (FCC) relies on two water sources: Lower Usuma Dam (Capacity: 100 million m^3) and Gurara Dam (Capacity: 850

million m^3). The current system consists of Lower Usuma Dam (LUD) Water Treatment Plants (Design Production: 240,000 m^3/day from Phase 1&2 and 480,000 m^3/day from Phase 3&4) including service reservoirs (24,000 to 45,000 m^3), transmission mains (44 km), distribution mains (635 km) and network pipelines which supplies water to about 47,000 customers (connections) in FCC Phase 1 development area, and a part of FCC Phase 2 area and some satellite towns.

(1) Development Phases and Districts

Figure 1-1 shows development phases and districts of the FCC master plan excluding suburbs.



Source: Project Team

Figure 1-1 Development Phases and Districts

(2) Water Supply Facilities

Table 1-3 shows existing major water supply facilities of FCTWB.

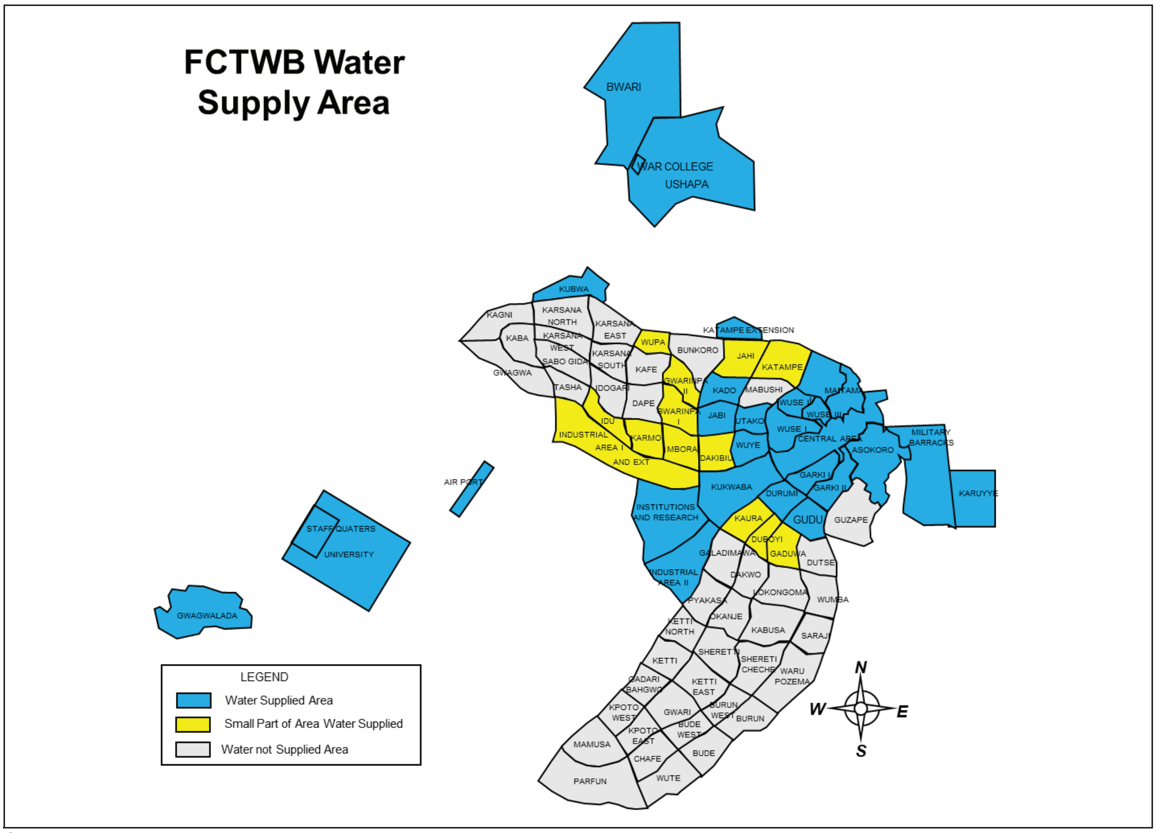
Table 1-3 Water Supply Facilities of FCTWB

Category	Facilities	Capacity	Remarks
Water Source	Lower Usuma Dam	100 Million m^3	
	Gurara	850 Million m^3	
Water Treatment Plant	Phase 1 & 2	240,000m^3/day	Constructed in 1987 & 2000
	Phase 3 & 4	480,000m^3/day	Constructed in 2014
	Final Stage	-	Proposed
Service Reservoir	No. 1 (under construction)	40,000m^3	Supply to the north of Phase 3
	No. 2	45,000m^3	Supply to the north of Phase 2
	No. 3	24,000m^3	Supply to the north of Phase 1
	No. 4	24,000m^3	Supply to the south of Phase 1, the south of Phase 2 (partially) and suburbs
	No. 5	40,000m^3	Supply to the south of Phase 2
	No. 6 (under construction)	40,000m^3	Supply to the south of Phase 3
	No. 7 (propose)	-	Supply to the north of Phase 4
	No. 8 (propose)	-	Supply to the south of Phase 4
	No. 9 (propose)	-	Supply to the south of Phase 4
	No. 10 (propose)	-	Supply to the south of Phase 4
Trunk Main and Distribution Main	Phase 1&2 system (partially under development in Phase 2)	T. Main: 44km D. Main: 296km 2nd D. Main: 339km	Secondary distribution mains under development partially in Phase 2.
	Phase 3 system	-	Partially developed. Under development by Greater Abuja Water Supply Project
	Phase 4 system	-	Partially developed. Under development by Greater Abuja Water Supply Project

Source: Project Team

(3) Water Supply Area

Figure 1-2 shows current FCTWB's water supply areas by District. The Districts where distribution networks have not been developed, specifically, a part of Phase 2, a large part of Phase 3 and entire Phase 4, will be developed by Greater Abuja Water Supply Project.



Source: Project Team

Figure 1-2 FCTWB's Water Supply Areas by District

(4) Water Supply Situation

Table 1-4 shows water supply situation by Area Office and District.

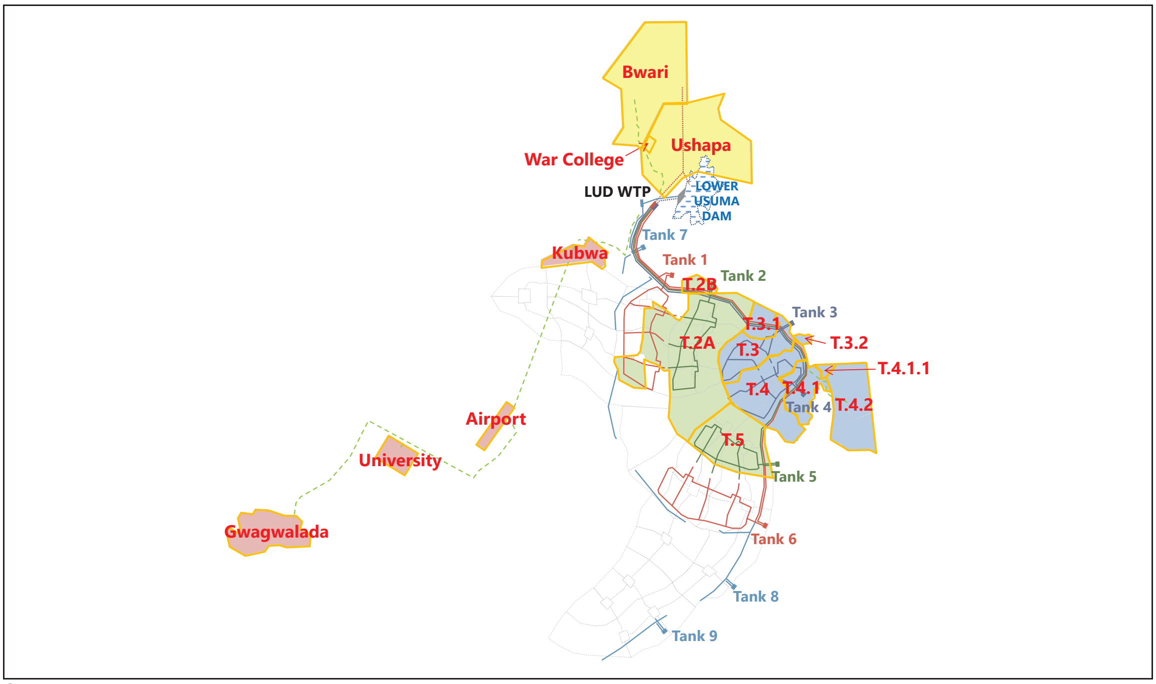
Table 1-4 Water Supply Situation by Area Office and District

	Area Office	District or Suburb served	Water Supply Situation
1	Abaji	Abaji Town	Hand pumps and motorized boreholes.
2	Asokoro	Asokoro District	Improved supply (gravity and pump)
3	Bwari	Bwari Town	Intermittent by rationing (booster pumping from LUD)
4	Gwagwalada	Gwagwalada Town	Regular with network challenges
5	Garki I	Area 1,2,3,8,11 & 10	Regular
6	Garki II	Garki II, Central Area	Regular
7	Gudu	Gudu District/Games Village	Regular
8	Gwarimpa	Gwarimpa District	Regular
9	Jabi	Utako District, Life Camp & Idu/Karmo, Kado Estate, Katampe and Katampe Extension.	Regular
10	Karu/Nyanya	Karu & Nyanya Towns	Intermittent by rationing
11	Kubwa I	Kubwa I Town	Regular
12	Kubwa II	Kubwa II Town	Regular
13	Maitama	Maitama District	Regular with challenges
14	Wuse I	Wuse I District	Regular with high rises issue and network challenges in parts of zone 3 & 6
15	Wuye	Wuye District	Regular
16	Wuse II	Wuse II District	Regular with challenges in A8 (low pressure)

Source: Project Team

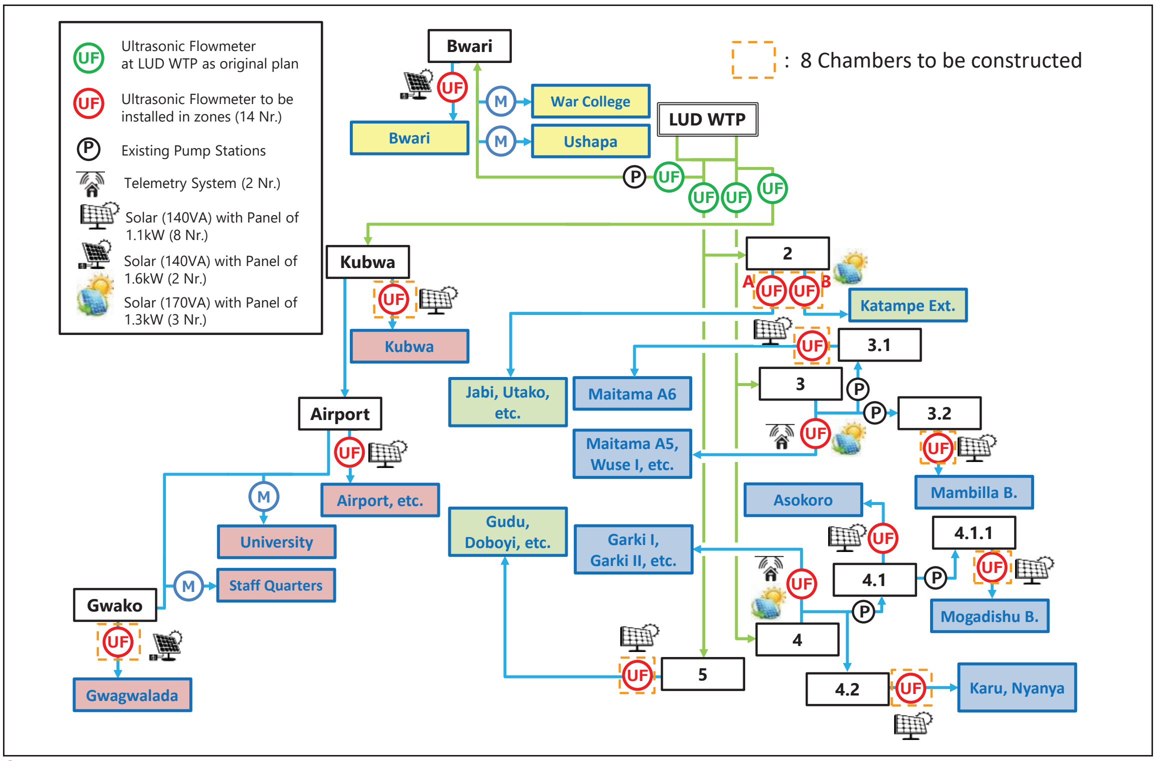
(5) Water Distribution Zone

Figure 1-3 shows distribution zones which are demarcated in order for water distribution to be managed with zonal meter at each tank (service reservoir). Figure 1-4 shows location of zonal meters.



Source: Project Team

Figure 1-3 Demarcation of Water Distribution Zone



Source: Project Team

Figure 1-4 Location of Zonal Meters

1.4 Current NRW Situation

The Project estimated NRW ratio of urban water supply system for the FCC at 48.3% for the year 2014-2017 as follows:

- System Input Volume: 113.38 million m^3 per year
- RW: 58.63 million m^3 per year
- NRW: 54.75 million m^3 per year (113.38 million - 58.63 million) m^3 per year
- NRW Ratio: 54.75 / 113.38 = 48.3%

Remarks: A considerable number of return bills exist in the billing system of FCTWB, which make analysis inaccurate. "Return (or duplicated) bills" mean the bills which are supposed to be eliminated or deactivated from billing system but have remained, then have resulted in being returned or not delivered. If FCTWB eliminates these bills from billing system, NRW ratio gets higher than 48.3%.

Table 1-5 shows NRW ratio varying from 45.6% to 87.6% in Pilot Metering Areas (PMA) and Sub-Metering Areas (SMA) before NRW reduction operations by the pilot projects. See "2. Assessment of Pilot Projects" for details.

Table1-5 NRW Ratio (%) in PMAs and SMAs

Pilot Area Office	PMA and SMA	Before NRW Reduction Operations (%)
Gudu	SMA-1	52.0
	SMA-2	53.9
	PMA	53.3
Jabi	SMA-2	45.6
	SMA-3	87.6
	PMA	70.0
Garki I	SMA-1	85.1
	SMA-2	74.8
	SMA-3	70.0
	PMA	74.8

Source: Project Team

2. Assessment of the Pilot Projects

The Project implemented the pilot projects on NRW reduction together with relevant Area Offices to prepare this strategic plan in three PMAs, which are defined as District-Metered Areas (DMA).

2.1 Overview of the Pilot Projects

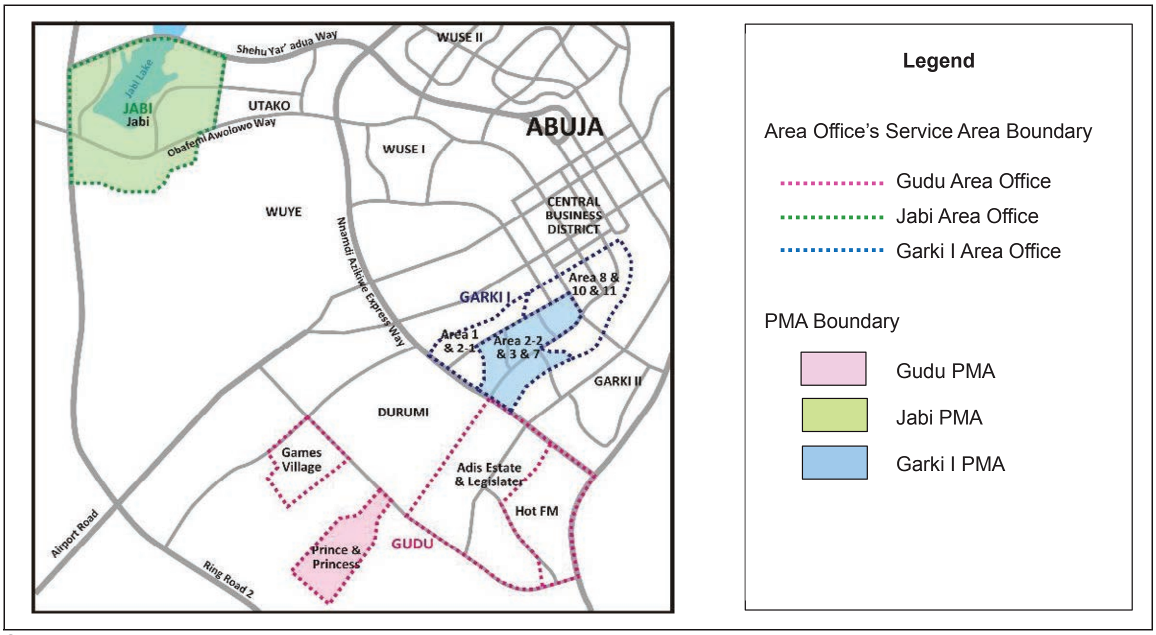
A PMA is located in each Area Offices' service area; Gudu, Jabi and Garki I.

Gudu is a district under Abuja master plan's Phase 2 development which has been developed since 2000's as a dwelling area with Apo legislative quarters, some commercial facilities, public institutions and also informal settlements. Gudu PMA "Prince & Princess" is an estate developed by a private developer in which prepaid meters were installed through public-private partnership (PPP).

Jabi is a district under Abuja master plan's Phase 2 development which has been developed since 2000's as a dwelling area with Jabi Lake, a large shopping mall, some commercial facilities, public institutions and also informal settlements, sometime called villages. Jabi PMA "Jabi" is an area developed by FCDA in which conventional meters were installed.

Garki I is a district under Abuja master plan's Phase 1 development which has been developed since 1980's as an administrative and commercial area with some public institutions and also dwellings. Garki I PMA "Area 2-2 & 3 & 7" is an area developed by FCDA in which AMR meters and conventional meter were installed.

Figure 2-1 shows location of PMAs and Table 2-1 shows their features.



Source: Project Team

Figure 2-1 Location of PMAs

Table 2-1 Features of PMAs

Pilot Area Office	MP's Develop't Phase	PMA Name	No. of Customer in PMA	Max. Pipe Dia. (mm)	Total Distance of Pipes (m)	Number of In/out-flow (Places)	Predominant Type of Water Meters in PMA (% of the total installed water meters)
Gudu	2	Prince & Princess	784	DN200	14,150	1 / 0	Prepaid (83.0%)
Jabi	2	Jabi	604	DN300	23,781	1 / 2	Conventional (96.5%)
Garki I	1	Area 2-2 & 3 & 7	452	DN450	11,858	1 / 2	AMR (57.7%)
Total	**-**	**-**	**2,001**	**-**	**49,789**	**-**	**-**

Source: Project Team

Of total customers of FCTWB as of 2017, ratio of consumption measuring ways such as conventional, AMR, prepaid meters and flat rate to charge water tariff are about 45.4%, 24.8%, 12.2% and 17.6% respectively. Table 2-2 also shows details of customers such as category and meter type in PMAs. A certain number of commercial customers and major consumers exist in Jabi and Garki I PMAs, and major consumers such as hotel, plaza, restaurant, public institutions, etc. consume a large quantity of water compared with domestic and commercial customers.

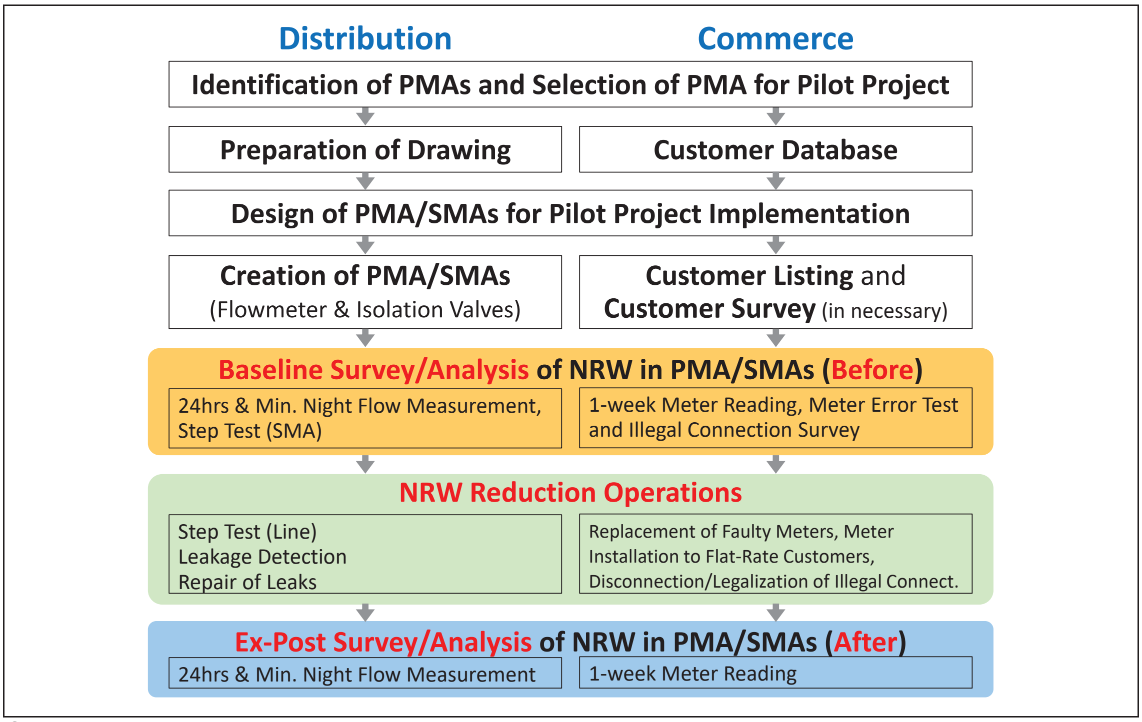
Table 2-2 Customer Category and Meter Type in PMAs

Customer Category	Meter Type	Gudu	Jabi	Garki I	Remarks
Domestic	Conventional	64	535	47	Estimate bills included
	Flat-Rate (No-meter)	57	5	103	
	AMR	0	0	239	Estimate bills included due to meter malfunction
	Prepaid	643	0	0	
	Unidentified	6	0	0	
	Sub-Total	770	540	389	
Commercial	Conventional	4	32	4	Estimate bills included
	Flat-Rate (No-meter)	0	1	11	
	AMR	0	0	14	Estimate bills included due to meter malfunction
	Prepaid	8	0	0	
	Unidentified	1	0	0	
	Sub-Total	13	33	29	
Major Consumers	Conventional	0	16	8	Estimate bills included
	Flat-Rate (No-meter)	1	15	18	
	AMR	0	0	8	Estimate bills included due to meter malfunction
	Prepaid	0	0	0	
	Unidentified	0	0	0	
	Sub-Total	1	31	33	
Total	**Conventional**	**68**	**583**	**59**	
	Flat-Rate (No-meter)	**58**	**21**	**132**	
	AMR	**0**	**0**	**261**	
	Prepaid	**651**	**0**	**0**	
	Unidentified	**7**	**0**	**0**	
	Total	**784**	**604**	**452**	

Source: Project Team

2.2 Procedures of the Pilot Projects

Figure 2-2 shows procedures of pilot project in a PMA in terms of physical loss (leakage) and commercial loss.



Source: Project Team

Figure 2-2 Procedures of Pilot Project

2.3 Result of the Pilot Projects

Table 2-3 shows results of NRW reduction operations. NRW ratio after NRW reduction operations apart from SMA-2 of Garki I were achieved successfully.

Table 2-3 NRW Ratio (%) and Reduction Points in PMAs

Area Office	PMA/ SMA	Before NRW Reduction Operations (%)	After NRW Reduction Operations (%)	Percentage-Reduction Point	Target After Reduction (%)*1 (80%*2)	Achievement
Gudu	SMA-1	52.0	12.1	39.9	26.0 (31.2)	OK
	SMA-2	53.9	29.9	24.0	27.0 (32.3)	OK
	PMA	53.3	20.4	32.9	26.7 (32.0)	OK
Jabi	SMA-2	45.6	21.1	24.5	22.8 (27.4)	OK
	SMA-3	87.6	42.6	45.0	43.8 (52.6)	OK
	PMA	70.0	30.9	39.1	35.0 (42.0)	OK
Garki I	SMA-1	85.1	45.2	39.9	42.6 (51.1)	OK
	SMA-2	74.8	49.3	25.5	37.4 (44.9)	Non
	SMA-3	70.0	27.4	42.6	35.0 (42.0)	OK
	PMA	74.8	34.7	40.1	37.4 (44.9)	OK

Source: Project Team

*1: A half of NRW ratio of Before NRW Reduction Operations (%)
*2: 80% achievement ratio of *1 (1.2 times of '*1') as stated in PDM

Table 2-4 shows number of customer categories such as domestic, commerce, major consumers, and that of the corresponded meter types in PMAs after NRW reduction operations.

Table 2-4 Customer Category and Meter Type in PMAs

Customer Category	Meter Type	Gudu	Jabi	Garki I	Remarks
Domestic	Conventional	59	536	46	Estimate bills included
	Flat-Rate (No-meter)	71*1	2	8	
	AMR	0	0	335	Estimate bills included
	Prepaid	635	1	0	
	Unidentified	88*2	0	0	
	Sub-Total	853	539	389	
Commercial	Conventional	4	34	1	Estimate bills included
	Flat-Rate (No-meter)	2	0	1	
	AMR	0	0	20	Estimate bills included
	Prepaid	13	0	0	
	Unidentified	4	0	0	
	Sub-Total	23	34	22	
Major Consumers	Conventional	1	38	11	Estimate bills included
	Flat-Rate (No-meter)	0	2	4	
	AMR	0	0	14	Estimate bills included
	Prepaid	0	0	0	
	Unidentified	0	0	6	
	Sub-Total	1	40	35	
Total		**877**	**613**	**446**	

Source: Project Team
Remarks
*1: Prepaid meters couldn't be installed/replaced by the private contractor under PPP as a part of NRW reduction operations during the pilot project.
*2: Unidentified customers were found out during NRW reduction operations, but the pilot project could not identify their customer category due to lack of information and non-accessibility to customers.

2.4 Causes of NRW and their Patterns by Features of the Pilot Projects

As a result of the pilot projects, the causes of NRW and their patterns by features are summarised as follows:

(1) Gudu PMA

Table 2-5 and Table 2-6 shows water balance sheet of Gudu PMA (Prince & Princess) before NRW reduction operations and ex-post operation respectively. Prince & Princess is one of the estates where prepaid-meters were introduced by PPP.

Nominal excess usage by flat-rate customers was estimated at 7.0% (224.2m^3/day) of SIV based on water consumption survey as baseline, however it couldn't almost be reduced as ex-post operation due to non-installation of prepaid meters.

Unbilled unmetered consumption by only one school was found out and then a meter was installed to measure water consumption properly, but this consumer remains in unbilled unmetered, which should be processed correctly.

Based on measured data, customer metering inaccuracies were estimated less because of sensitivity of prepaid meters, and also data handling errors rarely occur as an advantage of prepaid meter system. The meters should be replaced periodically to maintain their accuracy.

Illegal bypassing/connections along service pipes were discovered and then disconnected at totally 33 places (estimated 133m^3/day) as unauthorized consumption. These were caused by no reading or inspection by water board's staff due to prepaid meters and non-existent regular monitoring in the field.

Water leaks were detected and then repaired at totally 70 places (estimated 835.6m^3/day); 30 on network pipelines, and 40 on service pipes and valves. These were caused by low-quality of network pipeline laying, plumbing skills and materials for service pipes, valves and meters, and also lack of proper supervision of network pipeline laying.

In the area like Gudu PMA in Phase 2 development area where prepaid meters were installed by private developers, the following components contribute to NRW:

- Billed unmetered consumption (excess use by flat-rate customers)
- Unauthorized consumption (illegal bypassing/connections), and
- Physical losses (surface/underground leaks) on network pipelines and service pipes

The following NRW reduction operations are effective:

- Meter installation/replacement to flat-rate and/or meter-malfunctioning customers
- Tracking and disconnection or authorization of illegal bypassing/connections
- Patrol/detection of surface/underground leaks on network pipelines and service pipes, and
- Regular monitoring of prepaid meters in the field

Table 2-5 Water Balance Sheet of Gudu PMA (Baseline)

Component				m^3/day	%	%
System Input Volume (SIV) 3,216m^3/day	Authorized Consumption 1,830m^3/day	Billed Authorized Consumption	a. Billed Metered Consumption	1,414.0	44.0	Revenue Water 46.7
			b. Billed Unmetered Consumption	87.4	2.7	
			b. Billed Unmetered Consumption (Nominal Excess Use)	224.2	7.0	**Non-Revenue Water (NRW) 53.3**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	0.0	0.0	
			d. Unbilled Unmetered Consumption	104.0	3.2	
	Water Losses 1,386m^3/day	Commercial (Apparent) Losses	f. Customer Metering Inaccuracies and Data Handling Errors	25.7	0.8	
			e. Unauthorized Consumption	133.0	4.1	
		Physical (Real) Losses	g. Leakage on Transmission and/or Distribution Mains	641.2	19.9	
			h. Leakage and Overflows at Utility's Storage Tanks	0.0	0.0	
			i. Leakage on Service Connections up to Point of Customer Use	194.4	6.0	
		Unidentified Water Losses		392.1	12.2	

Source: Project Team

Table 2-6 Water Balance Sheet of Gudu PMA (Ex-Post)

<table>
<tr><th colspan="4">Component</th><th>m³/day</th><th>%</th><th>%</th></tr>
<tr><td rowspan="10">System Input Volume (SIV)

3,102 m^3/day</td><td rowspan="5">Authorized Consumption

2,774m^3/day</td><td rowspan="3">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td>2,373.7</td><td>76.5</td><td rowspan="2">Revenue Water
79.6</td></tr>
<tr><td>b. Billed Unmetered Consumption</td><td>97.0</td><td>3.1</td></tr>
<tr><td>b. Billed Unmetered Consumption (Nominal Excess Use)</td><td>199.6</td><td>6.4</td><td rowspan="8">Non-Revenue Water (NRW)
20.4</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>c. Unbilled Metered Consumption</td><td>0.0</td><td>0.0</td></tr>
<tr><td>d. Unbilled Unmetered Consumption*1</td><td>104.0</td><td>3.4</td></tr>
<tr><td rowspan="5">Water Losses

328m^3/day</td><td rowspan="2">Commercial (Apparent) Losses</td><td>f. Customer Metering Inaccuracies and Data Handling Errors</td><td>0.0</td><td>0.0</td></tr>
<tr><td>e. Unauthorized Consumption</td><td rowspan="4">327.7</td><td rowspan="4">10.6</td></tr>
<tr><td rowspan="3">Physical (Real) Losses</td><td>g. Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>h. Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>i. Leakage on Service Connections up to Point of Customer Use</td></tr>
</table>

Source: Project Team
Remarks
*1: Prepaid meters couldn't be installed by private company under PPP as a part of NRW reduction operations.

(2) Jabi PMA

Table 2-7 and Table 2-8 shows water balance sheet of Jabi PMA before NRW reduction operations and ex-post operation respectively.

Billed metered consumption is a component of revenue water, but billed amount includes automatically-estimated portion of conventional meters by billing system even if meters are malfunctioning. So, those meters should be replaced with new ones.

Flat-rate customers are less, so nominal excess usage by them were estimated at 1.2% (102.7m^3/day) of SIV based on water consumption survey.

Unbilled unmetered consumption by a few public institutions and staff quarters were found out, but these consumers remain in unbilled unmetered, which should be processed correctly.

Based on measured data, customer metering inaccuracies were estimated remarkably high because of deterioration of conventional meters, and also data handling errors seem to occur due to manual reading, recording, transcription and data entering on conventional meter. The meters should be replaced periodically to maintain their accuracy.

Illegal bypassing/connections along service pipes were discovered and then disconnected at totally 10 places (estimated 40m^3/day) as unauthorized consumption. Regular meter reading by meter readers have possibly made an inhibitive effect on illegal bypassing/connections. After NRW reduction operations in Jabi PMA, a certain number of illegal connections still exists, which may include possible illegal connections on service pipes extended to public taps located in informal settlements, so-called "villages".

Water leaks were detected and then repaired at totally 37 places (estimated 840.52m^3/day); none on network pipelines, and 37 on service pipes and valves. These were caused by low-quality of plumbing skills and materials for service pipes, valves and meters. Network pipelines are installed very deep (6m in depth), so it was difficult to detect underground leaks by using equipment.

In the area like Jabi PMA in Phase 2 development area where conventional meters are common, the following components contribute to NRW:

- Unauthorized consumption (illegal bypassing/connections)
- Customer metering inaccuracies and data handling errors
- Physical losses (surface/underground leaks) on network pipelines and service pipes

The following NRW reduction operations are effective:

- Meter installation/replacement to meter-malfunctioning customers, particularly major consumers who consume a large amount of water.
- Tracking and disconnection or authorization of illegal bypassing/connections, and
- Patrol/detection of surface/underground leaks on network pipelines and service pipes

Table 2-7 Water Balance Sheet of Jabi PMA (Baseline)

Component				m^3/day	%	%
System Input Volume (SIV) 8,445m^3/day	Authorized Consumption 2,807m^3/day	Billed Authorized Consumption	a. Billed Metered Consumption	2,327.8	27.6	Revenue Water 30.0
			b. Billed Unmetered Consumption	204.0	2.4	
			b. Billed Unmetered Consumption (Nominal Excess Use)	102.7	1.2	**Non-Revenue Water (NRW) 70.0**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	0.0	0.0	
			d. Unbilled Unmetered Consumption	172.1	2.0	
	Water Losses 5,638m^3/day	Commercial (Apparent) Losses	f. Customer Metering Inaccuracies and Data Handling Errors	-306.3	-3.6	
			e. Unauthorized Consumption	40.0	0.5	
		Physical (Real) Losses	g. Leakage on Transmission and/or Distribution Mains	0.0	0.0	
			h. Leakage and Overflows at Utility's Storage Tanks	0.0	0.0	
			i. Leakage on Service Connections up to Point of Customer Use	840.52	10.0	
		Unidentified Water Losses		5,064.2	60.0	

Source: Project Team

Table 2-8 Water Balance Sheet of Jabi PMA (Ex-Post)

<table>
<tr><th colspan="4">Component</th><th>m^3/day</th><th>%</th><th>%</th></tr>
<tr><td rowspan="10">System Input Volume (SIV)

7,119 m^3/day</td><td rowspan="5">Authorized Consumption

5,105m^3/day</td><td rowspan="3">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td>4,883.0</td><td>68.6</td><td rowspan="2">Revenue Water 69.1</td></tr>
<tr><td>b. Billed Unmetered Consumption</td><td>33.9</td><td>0.5</td></tr>
<tr><td>b. Billed Unmetered Consumption (Nominal Excess Use)</td><td>19.7</td><td>0.3</td><td rowspan="8">Non-Revenue Water (NRW) 30.9</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>c. Unbilled Metered Consumption</td><td>0.0</td><td>0.0</td></tr>
<tr><td>d. Unbilled Unmetered Consumption</td><td>168.2</td><td>2.4</td></tr>
<tr><td rowspan="5">Water Losses

2,015m^3/day</td><td rowspan="2">Commercial (Apparent) Losses</td><td>f. Customer Metering Inaccuracies and Data Handling Errors</td><td>0.0</td><td>0.0</td></tr>
<tr><td>e. Unauthorized Consumption</td><td rowspan="4">2,014.6</td><td rowspan="4">28.3</td></tr>
<tr><td rowspan="3">Physical (Real) Losses</td><td>g. Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>h. Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>i. Leakage on Service Connections up to Point of Customer Use</td></tr>
</table>

Source: Project Team

(3) Garki I PMA

Table 2-9 and Table 2-10 shows water balance sheet of Garki I PMA) before NRW reduction operations and ex-post operation respectively.

Billed metered consumption is a component of revenue water, but billed amount includes automatically-estimated portion of AMR meters by billing system. 50% of AMR meters' bills have been estimated in each billing cycle because of mostly malfunctioning meters. Therefore, those meters should be replaced with new ones.

Nominal excess usage by flat-rate customers were estimated higher at 12.1% (387.9m^3/day) of SIV based on water consumption survey.

Unbilled unmetered consumption by a few public institutions and staff quarters were found out, but these consumers remain in unbilled unmetered, which should be processed correctly.

Based on measured data, customer metering inaccuracies were estimated not much because of sensitivity of AMR meters, and also data handling errors rarely occur as an advantage of AMR meter system. The meters should be replaced periodically to maintain their accuracy.

Illegal bypassing/connections along service pipes were discovered and then disconnected at totally 23 places (estimated 69m^3/day) as unauthorized consumption. These were caused by no reading or inspection by water board's staff due to AMR meters and non-existent regular monitoring in the field.

Water leaks were detected and then repaired at totally 43 places (estimated 753.7m^3/day); four on network pipelines, and 39 on service pipes and valves. These were caused by deteriorating network pipelines and low-quality of plumbing skills and materials for service pipes, valves and meters.

In the area like Garki I PMA in Phase 1 development area where AMR meters were introduced and a number of major consumers exist, the following components contribute to NRW:

- Billed unmetered consumption (excess use by flat-rate customers)
- Unauthorized consumption (illegal bypassing/connections), and
- Physical losses (surface/underground leaks) on network pipelines and service pipes

The following NRW reduction operations are effective:

- Meter installation/replacement to flat-rate and/or meter-malfunctioning customers, particularly major consumers who consume a large quantity of water.
- Tracking and disconnection or authorization of illegal bypassing/connections
- Patrol/detection of surface/underground leaks on network pipelines and service pipes, and
- Regular monitoring of AMR meters in the field

Table 2-9 Water Balance Sheet of Garki I PMA (Baseline)

<table>
<tr><th colspan="4">Component</th><th>m^3/day</th><th>%</th><th>%</th></tr>
<tr><td rowspan="11">System Input Volume (SIV)

3,197m^3 /day</td><td rowspan="5">Authorized Consumption

1,220m^3/day</td><td rowspan="3">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td>409.3</td><td>12.8</td><td rowspan="2">Revenue Water 25.2</td></tr>
<tr><td>b. Billed Unmetered Consumption</td><td>396.9</td><td>12.4</td></tr>
<tr><td>b. Billed Unmetered Consumption (Nominal Excess Use)</td><td>387.9</td><td>12.1</td><td rowspan="9">Non-Revenue Water (NRW) 74.8</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>c. Unbilled Metered Consumption</td><td>0.0</td><td>0.0</td></tr>
<tr><td>d. Unbilled Unmetered Consumption</td><td>41.0</td><td>1.3</td></tr>
<tr><td rowspan="6">Water Losses

1,977m^3/day</td><td rowspan="2">Commercial (Apparent) Losses</td><td>f. Customer Metering Inaccuracies and Data Handling Errors</td><td>167.2</td><td>5.2</td></tr>
<tr><td>e. Unauthorized Consumption</td><td>69.0</td><td>2.2</td></tr>
<tr><td rowspan="3">Physical (Real) Losses</td><td>g. Leakage on Transmission and/or Distribution Mains</td><td>342.0</td><td>10.7</td></tr>
<tr><td>h. Leakage and Overflows at Utility's Storage Tanks</td><td>0.0</td><td>0.0</td></tr>
<tr><td>i. Leakage on Service Connections up to Point of Customer Use</td><td>333.7</td><td>10.4</td></tr>
<tr><td colspan="2">Unidentified Water Losses</td><td>1,050.0</td><td>32.8</td></tr>
</table>

Source: Project Team

Table 2-10 Water Balance Sheet of Garki I PMA (Ex-Post)

<table>
<tr><th colspan="4">Component</th><th>m^3/day</th><th>%</th><th>%</th></tr>
<tr><td rowspan="10">System Input Volume (SIV)

2,852 m^3/day</td><td rowspan="5">Authorized Consumption

1,861m^3/day</td><td rowspan="3">Billed Authorized Consumption</td><td>a. Billed Metered Consumption</td><td>1,580.2</td><td>55.4</td><td rowspan="2">Revenue Water 65.2</td></tr>
<tr><td>b. Billed Unmetered Consumption</td><td>280.6</td><td>9.8</td></tr>
<tr><td>b. Billed Unmetered Consumption (Nominal Excess Use)</td><td>135.2</td><td>4.7</td><td rowspan="8">Non-Revenue Water (NRW) 34.8</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>c. Unbilled Metered Consumption</td><td>0.0</td><td>0.0</td></tr>
<tr><td>d. Unbilled Unmetered Consumption</td><td>167.7</td><td>5.9</td></tr>
<tr><td rowspan="5">Water Losses

991m^3/day</td><td rowspan="2">Commercial (Apparent) Losses</td><td>f. Customer Metering Inaccuracies and Data Handling Errors</td><td>0.0</td><td>0.0</td></tr>
<tr><td>e. Unauthorized Consumption</td><td rowspan="4">688.3</td><td rowspan="4">24.1</td></tr>
<tr><td rowspan="3">Physical (Real) Losses</td><td>g. Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>h. Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>i. Leakage on Service Connections up to Point of Customer Use</td></tr>
</table>

Source: Project Team

2.5 Cost Effectiveness of the Pilot Project

Cost incurred for three pilot projects and envisaged increased revenue were sorted out as shown in Table 2-11 and Table 2-12. The Project applied the following conditions to cost-benefit analysis:

After initial NRW reduction operations, the improved NRW ratio will be maintained through routine monitoring and maintenance activities. Monitoring and maintenance activities for three years are assumed as same as the initial cost spent in the NRW reduction operations.

Even though FCTWB spends a certain amount of expenses for NRW reduction operations, FCTWB increases billed water in return for NRW reduction operations. Therefore, it is desirable that FCTWB positively takes NRW reduction operations. However, it is essential that FCTWB seeks to apply various activities apart from the NRW reduction operations taken in the pilot project in the light of delay or no release of the Nigerian budget to implement NRW reduction operations.

Table 2-11 Estimated Revenue Increase based on the Pilot Project

Items	Gudu	Jabi	Garki I
a) NRW Ratio before Operations (%)	53.3%	70.0%	74.8%
b) NRW Ratio after Operations (%)	20.4%	30.9%	34.8%
c) Reduced NRW Ratio (%) (a)-(b)	32.9%	39.1%	40.0%
d) System Input Water Volume (m^3/day)	3,102	7,119	2,852
e) Reduced NRW Volume (m^3/day) (c)x(d)/100	1,021	2,784	1,141
f) Reduced NRW Volume (k. m^3/year) (e)x 365/1000	373	1,016	416
g) Average Water Sales Price (NGN/m^3)	90	90	90
h) Expected Water Sales per year (k. NGN) (f)x(g)	33,525	91,439	37,475
i) Estimated Revenue Increase for Three Years (k. NGN) h)x three years	100,576	274,317	112,426

Source: Project Team

Table 2-12 Cost Effectiveness of the Pilot Project

PMA	1) Initial Cost incurred for the Pilot Project* (K. NGN)	2) Initial & Recurrent Cost for NRW Reduction Operation** (K.NGN)	3) Estimated Revenue Increase for three years*** (K. NGN)	3) Cost Effectiveness (Dimensionless) 3) / 2)
Gudu	40,949	81,898	100,576	1.2
Jabi	47,498	94,996	274,317	2.9
Garki-I	48,937	97,874	112,426	1.1

Source: Project Team
* Refer to Appendix-1
** Recurrent cost for NRW reduction required to maintain conditions well for three years is estimated as 100% of the initial cost spent in the Pilot projects.
*** Refer to table 2-11

Furthermore, Table 2-13 shows direct benefit by NRW reduction operation for three years in terms of recurrence of NRW. Assumed that causes of NRW is categorized into three; nominal excess use, unbilled unmetered & inaccuracy and illegal & physical losses, the direct benefit of nominal excess use and unbilled unmetered is deficit, while, that of illegal & physical losses is highly surplus. Therefore, elimination of illegal connection and leakage is efficient operations compared with mitigation of nominal excess use and unbilled unmetered & meter inaccuracy.

Table 2-13 Direct Benefit by NRW Reduction Operation

No.	Items	Main Causes of NRW	Gudu	Jabi	Garki I
(1)	Initial & Recurrent Cost for NRW Reduction Operation* (k. NGN)	Nominal Excess Use	19,164	24,604	46,294
		Unbilled Unmetered & Inaccuracy	1,966	28,499	17,813
		Illegal & Physical Losses	60,686	42,843	33,767
		Total	81,816	95,946	97,874
(2)	Expected Water Sales for three years** (k. NGN)	Nominal Excess Use	1,833	6,312	20,796
		Unbilled Unmetered & Inaccuracy	1,833	-28,065	1,686
		Illegal & Physical Losses	96,600	296,064	89,940
		Total	100,266	274,311	112,422
(3)	Direct Benefit (k. NGN) (2) - (1)	Nominal Excess Use	-17,331	-18,292	-25,498
		Unbilled Unmetered & Inaccuracy	-133	-56,564	-16,127
		Illegal & Physical Losses	35,914	253,221	56,173
		Total	18,450	178,365	14,548

Source: Project Team
Note:
* Refer to Appendix-2
** Refer to Appendix-3

2.6 Findings and Lessons Learnt

The following findings and lessons learnt were obtained through implementation of the pilot projects.

(1) Findings

1) Lack of Feedback between FCTWB and FCDA

The pilot project observed that as-built drawings of the laid pipeline networks have not been handed over from FCDA to FCTWB properly, and also problems and issues in O&M have not been fed back to FCDA for improvement in services.

2) As-Built Drawings

Drawings of pipelines are supposed to be managed and stored in Pipeline Unit of FCTWB HQs and/or Area Offices. However, most of existing drawings are not soft copies but hard copies and are not well organized. Most of drawing copies are only one set in FCTWB.

For the Phase-1 Development Area including Garki I where land development and construction of water supply facilities were mostly completed, FCTWB has converted manually as-built drawings into digital form in map book by GIS, and accomplished 95% of data input of pipeline information including valves, hydrants and service pipelines. However, the map book shows only location and size of pipelines but does not show materials, installation year and covering depth. Even as-built drawings or the map books exist, discrepancy of information such as pipeline location, size and branching point has happened often. In addition, stop cocks supposed to be on installed service pipelines are shown on water distribution networks by mistake, so it leads to difficulty in distinguishing valve from stop cock. At intersections of two pipelines, it is not clear that if they have been connected or not.

For the Phase-2&3 Development Areas including Gudu and Jabi and other satellite towns where land development and construction of water supply facilities are still ongoing by FCDA or private developers, the constructed facilities have been operated by FCTWB without as-built drawings often because of provisional transfer and other reasons.

As far as it goes, FCTWB has maintained the facilities by relying on pipeline information based on individual knowledge or using design drawings which is often different from actual situation of the constructed facilities.

This was one of facts which forced the pilot projects to redo NRW reduction operations.

3) GIS

During pilot projects, FCTWB shifted own GIS system being free from AGIS security which was an obstacle for smooth GIS operation and data transfer. However, GIS Unit of FCTWB is still an interim Unit consisting of one staff plus a casual staff. It is essential to update GIS database by reinforcing GIS Unit together with relevant Units and Area Offices.

4) Inefficient Management of Customer Data

Management of customer data including meter-reading data and payment records has not unified timely among HQs and Area Offices. While HQs staff make use of customer data computed from database (billing system), Area Offices manually deal with customer data by using “Customer Notes (List)” transcribed from printed bills by Commerce staff in Area Offices, which is an inefficient procedure and causes data handling errors, then may lead to wrong billing.

This was one of facts which forced the pilot project to redo NRW reduction operations.

5) Complexity in Customer Category

Customers are categorized as domestic, commercial (un-coded), major consumer (co-operate body, mini-hotel / restaurant, major consumer, petrol station / plaza, private school / clinic), institution (embassy / high commission, ministry / parastatals, liaison office, religion), public tap / convenience & kiosk, and lifting point (bulk selling. This mixture caused difficulty in data assembling in the pilot project.

6) Several Types of Customer Meter

Customer meter types are; conventional including flat-rate, AMR and prepaid meters. This mixture makes O&M and financial analysis difficult. Different types and products of conventional meters exist in the market without accuracy check and licensing for quality assurance.

Staff do not need manually read AMR and prepaid meters because of automatically-recording, but often suffer from communication failure with AMR meters due to trees or other obstacles such as grasses, and also malfunction with prepaid meters because of battery lifetime. In addition, prepaid meters cause free water if valve remains open or illegal bypassing as NRW unless customers report or FCTWB monitors properly.

7) Estimate Billing System

A considerable number of estimate bills caused by no meter reading, which sometimes lead to unexpected billed amount to customers and then their complaints, hamper calculation of revenue water. No meter reading usually results from absence of customer, inaccessibility to customer meter, infrequent meter reading due to non-provision logistics, and probably dereliction of meter readers.

8) Duplicated / Return Bills

A number of duplicated/return bills exist in billing system of FCTWB, which make analysis inaccurate. “duplicated/return bills” mean the bills which are supposed to be eliminated or deactivated from billing system but have remained, then have resulted in being returned or not delivered. Existence of duplicated/return bills in billing system causes wastefulness and unreliable financial analysis statement, NRW and collection ratio.

A main cause is negligence of duty in FCTWB, but the reasons why duplicated/return bills have remained are:

- In spite of conversion of meter types including flat-rate, the duplicated customer accounts have remained.
- In spite of address modification or re-subscription, old customer accounts have remained.
- In spite of move of customers or their displacement/demolition by the Government, uninhabited customer accounts have remained.
- As long as these bills have remained, billing system keeps on issuing the bills by automated estimating programme.

FCTWB has worked on elimination or deactivation by upgraded billing system, but has still kept on issuing a certain number of those bills.

9) Complexity in Water Tariff

Water tariff are, as standard, N80/m^3 or N5,500/month for domestic, N150/m^3 or N45,000/month for commercial, and N150/m^3 or various prices per month for major consumers. This mixture makes financial analysis complicated.

10) Customer Meter Inaccuracy

Inaccuracy of conventional meters is higher than that of AMR and prepaid meters. After replacement of those meters in the pilot projects, NRW ratio was improved certainly. However, meters will be getting inaccurate gradually without regular maintenance and periodical replacement, for example every eight years (in case of Japan), regardless of meter types and well-condition. Conventional meters available in local markets vary in quality.

11) Unauthorized Consumption

Illegal bypassing/connections were found in all the three PMAs, particularly often in Gudu and Garki I PMAs where prepaid or AMR meters were installed. These were caused by non-reading or non-inspection by water board's staff and non-existent regular monitoring in the field.

12) Leakage

Network pipelines and service pipes in Gudu PMA (an estate) and also inflow pipeline branched from a distribution main were installed by private developers. The pilot project observed water leaks on both network pipelines and service pipes up to customer meters surface leakage because of low-quality in appurtenant/meter materials, installation and workmanship, and non-standard situations such as service pipes laid from the back side. The pilot project also observed an inflow pipeline over a ditch without a sheath pipe and bursts due to substandard materials and no thrust block.

In Jabi and Garki I PMAs, the pilot project observed water leaks mainly on service pipes up to customer meters as surface leakage because of low-quality in appurtenant/meter materials, installation and workmanship. Also, because of installation depth of network pipelines in these PMAs, particularly in Jabi (e.g. 6m in depth) and also pipeline/valve conditions, leakage detection equipment could be fully utilized.

13) Quality Failure in Facility and Workmanship

Low quality in construction and plumbing works including materials was observed across the pilot projects, which causes pipe burst and leakage.

(2) Lessons Learnt

1) Delayed or No Release of the Nigerian Budget to implement NRW Reduction Operations

The pilot project suffered from delayed or no release of the Nigerian budget to implement NRW reduction operations such as chamber construction for flow-meters and valves to create PMA (DMA), leak repair by using materials and logistics including fuel. Budget constraint always hampered implementation of the pilot projects.

2) Area Office's Capability, Logistics and Staff Skills

Budget allocation is limited for the routine services which Area Offices are in charge, and as an organization capacity, Area Offices are not equipped well with personal computer, material stocks, tools and devices, as well as their logistics including vehicles, fuel, electricity and in-house power generation are not enough at all to provide adequate and quality services for O&M and meter reading..

As an individual capacity, staff such as plumbers and water meter readers have attended limited systematic employee training under the HRD programme of FCTWB. They can learn skills through on-the-job training or apprenticeship from superiors. In addition, most of staff are not good at mathematics, reading drawings, maps and operate personal computer, even basic word-processing and spreadsheet programmes due to their educational background and no training. It was also observed that, although staff are willing to learn and contribute, staff have little responsibility and motivation because of no incentives, poor logistics and working conditions of Area Offices. Consequently, skill development was limited to some staff each pilot Area Office.

3) Difficulties in isolating PMAs and SMAs

The pilot projects faced difficulties in isolating PMAs and SMAs due to lack or discrepancy of the existing pipeline information among design drawings and staff's knowledge. The existing GIS pipeline network data has never been updated and doesn't reflect correct information in Garki I, meanwhile FCTWB doesn't have any drawings and GIS data in Gudu and Jabi.

Customer location maps are not available because FCTWB has never positioned customers on drawings or GIS. This also caused difficulties in identifying customers inside PMAs and SMAs.

4) Meter Reading Divisions and Flat-Rate

Several divisions of FCTWB, such as Area Offices, AMR Unit, Prepaid Unit and nine Units for major consumers in HQs are responsible for meter reading or monitoring which has been not done adequately. This kind of segmentation causes inefficiency of the billing.

Flat-rate customers tend to consume water more than the expected as excess use, a part of NRW.

5) Billed Unmetered Consumption (Nominal Excess Use)

A certain number of flat-rate (unmetered) customers existed and resulted in spending much time on calculation of revenue water in baseline analysis. They tend to consume water more than one which is converted from set tariff as nominal excess use according to measurement in the pilot projects, so installing meters to flat-rate customers contributes to NRW reduction.

6) Unbilled Unmetered Consumption

The pilot projects observed some unbilled unmetered consumption from major consumers, public institutions because of procedural omission and also from FCTWB offices and its staff quarters. FCTWB needs to install meters, shift them to the billed or unbilled metered consumers at least by installing meters to measure water consumption.

3. Scenario, Goal and Cost-Effectiveness

3.1 Overall Scenarios

From lessons obtained through the pilot project, it is very difficult for Project Team to determine the particular NRW reduction activity. Project Team, therefore, prepared five scenarios such as Scenario-a to Scenario-e for NRW reduction operations in order flexibly to cope with influence due to various conditions such as budget release, appointment of trained appropriate staff, progress of database for the existing pipelines in future. Figure 3-1 shows criteria for selecting scenario of NRW reduction operation as aspects of financial condition, human resources, etc. are changed.

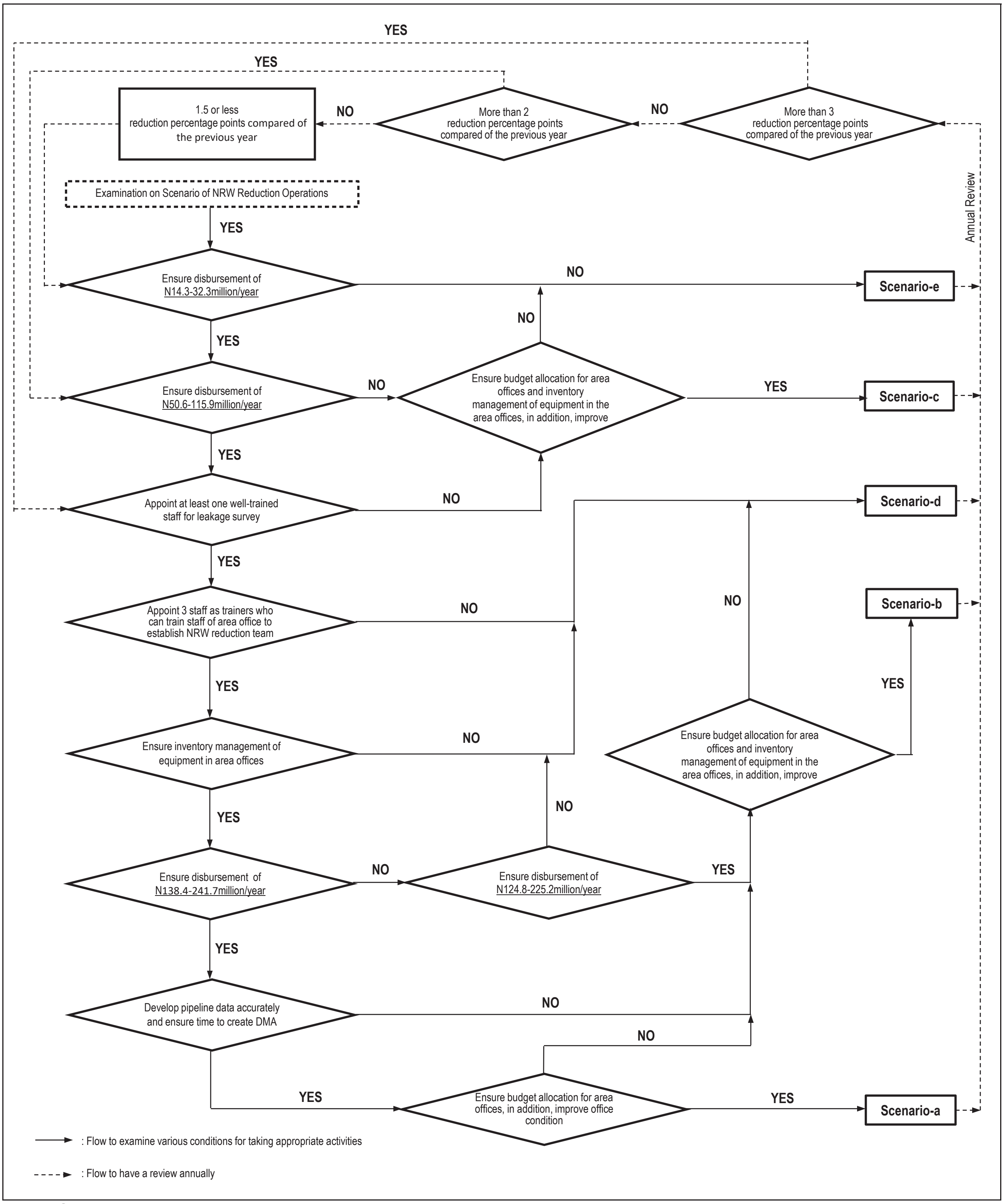
Especially, Project Team set condition for the criteria in terms of the following five aspects:

- Budget release
- Appointment of well-trained staff for leakage survey
- Appointment of trainers required for Area Office's staff
- Inventory management of equipment in Area Office
- Development of pipeline data

Table 3-1 summaries main activities and procurement of equipment of all the scenarios as well as target NRW ratio. The target NRW ratio shown in Table 3-1 indicates percentage unless scenario selected once is changed the year 2019 through 2023. Therefore, target NRW ratio should be reviewed and setup in the annual action plan based on the first six-month activities of the previous year.

Even if FCTWB does not achieve targeted NRW ratio for the year 2023, the common objective of NRW reduction operation among five scenarios is to achieve the following activities which are significant for FCTWB to learn status of NRW ratio.

- Data collection of monthly billed consumption
- Data collection of monthly System Input Volume (SIV)
- Monthly IWA water balance analysis



Source: Project Team

Figure 3-1 Criteria for selecting Scenario of NRW Reduction Operation

Table 3-1 Features of Scenarios for NRW Reduction Operations

Items	Scenario				
	a	b	c	d	e
1. Target					
1.1 Target Year	2023	2023	2023	2023	2023
1.2 Baseline NRW Ratio (%)	48.3	48.3	48.3	48.3	48.3
1.3 Target NRW Ratio in 2023 (%)	31.9	32.4	36.9	35.1	42.8
1.4 Reduction Approach	DMA	Zone	Zone	Zone	Zone
2. Main Body for NRW Reduction Operations					
2.1 Main Body for Operations (Supervision)	HQ's NRW Unit	HQ' NRW Unit	HQ's NRW Unit	HQ's NRW Unit	HQ's NRW Unit
2.2 Main Body for Operations (Field Actions)	Area Offices	Area Offices	Area Offices	HQ's NRW Unit	HQ's NRW Unit
3. NRW Reduction Operations					
(1) Network Drawings and Data	X	X	X	X	X
(2) Customer Enumeration					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(3) DMA Design, Creation and Prioritization	X	-	-	-	-
(4) Zonal Prioritization	-	-	-	X	X
(5) Field Inspection	X	-	-	-	-
(6) Isolation by installing Flow Meters and Valves	X	-	-	-	-
(7) Step Test in DMA	X	-	-	-	-
(8) Zonal Measurement	-	-	-	X	X
(9) Leakage Detection					
a) by Area Office (DMA)	X	-	-	-	-
b) by Area Office (Zone)		X	-	-	
c) by NRW Unit (Zone)	-	-	-	X	X
(10) Patrol of Surface Leaks	-	-	X	-	-
(11) Repair of Leaks and Recording					
a) for (9)-a)	X	-	-	-	-
b) for (9)-b)	-	X	X	-	-
c) for (10)	-	-	X		-
d) for (9)-d)	-	-	-	X	X
(12) Identification of Illegal Connection and Inaccuracy Meters					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Inaccuracy Meters	X	X	X	X	-
d) Labo Test of Meter Inaccuracy for Meter Standardization	X	X	X	X	-
(13) Measures against Illegal Connection and Meter Inaccuracy					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Meter Inaccuracy	X	X	X	X	X
(14) Data Collection of Monthly Billed Consumption					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(15) Data Collection of Monthly SIV					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
c) Bulk Meters	X	X	X	X	X
(16) Monthly Water Balance Analysis	X	X	X	X	X
(17) Measurement of 1-week SIV (DMA)	X	-	-	-	-
(18) Installing Water Meters	X	X	X	X	-
(19) Survey on Trunk, Distribution Mains and Reservoirs	X	X	X	X	X
(20) Preparation for Pipe Replacement Plan	X	X	X	X	X
4. Procurement of Equipment					

Items	Scenario				
	a	b	c	d	e
4.1 Flow Meters and Valves for Isolation	X	-	-	-	-
4.2 Leak Detection Equipment	X	X	-	-	-
4.3 Water Meters	X	X	X	X	-
5. Place where equipment is stocked					
5.1 Existing Equipment	3 Pilot A.O.	3 Pilot A.O.	NRW Unit	NRW Unit	NRW Unit
5.2 Newly-procured Equipment	A.O.	A.O.	-	-	-

Source: Project Team

3.2 Scenarios

In ‘Clause 3.1, the Medium-term Strategic Plan states features such as basic of setting-up scenario, summary of scenario, key activities of scenario, pre-condition & external factors for applying scenario and challenges in future. The features also contribute to the fundamental description in order for FCTWB to facilitate the NRW reduction operations.

(1) Scenario-a

1) Basis of setting-up Scenario

JICA Expert Team provided FCTWB with technical assistance in order to develop capacity on a series of NRW reduction operations as pilot project. It is expected that FCTWB will be able to carry out a series of NRW reduction operations.

2) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will create DMA and take NRW reduction operations like the Pilot Project targeting on NRW ratio of 31.9% for the year 2023.

3) Key activities

Key activities of Scenario-a are follows:

- Network Drawings and Data
- Customer Enumeration
- DMA Design, Creation and Prioritization
- Field Inspection
- Isolation by installing Flow Meters and Valves
- Step Test in DMA
- Leakage Detection
- Repair of Leaks and Recording
- Identification of Illegal Connection and Inaccuracy Meters
- Measures against Illegal Connection and Inaccuracy Meters
- Data Collection of Monthly Billed Consumption
- Data Collection of Monthly SIV
- Monthly Water Balance Analysis
- Measurement of 1-week SIV (DMA)
- Installing Water Meters
- Survey on Trunk, Distribution Mains and Reservoirs
- Preparation for Pipe Replacement Plan

4) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-a.

- Develop data on the existing water supply pipelines accurately ensure time to create DMA.

- Appoint staff who were involved in The Federal Capital Territory Reduction of Non-Revenue Water Project in FCTWB HQ.
- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint well- trained staff for installation of flow meters and leakage survey.
- Ensure enough budget of about N883million for five years for allowance and equipment such as flow meters, isolation valves, leak detectors, customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

5) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

6) Challenges in Future

If the pre-condition is met to apply for Scenario-a, NRW reduction operations based on Scenario-a will be taken for the time being. However, FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(2) Scenario-b:

1) Basis of setting-up Scenario

Project Team spent much time and cost to create DMA through the pilot project. Therefore, creation of DMA is unrealistic in terms of sustainability of NRW reduction operations. It was observed that most of water meters had been malfunctioning or not been installed. However, it is very important to learn actual water consumption to analyse IWA water balance.

2) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will NOT create DMA, but will take NRW reduction operations such as leakage survey, illegal connection survey and water meter survey by zone targeting on NRW ratio of 32.4% for the year 2023.

3) Key activities

Key activities of Scenario-b are follows:

- Network Drawings and Data
- Customer Enumeration
- Zonal Measurement
- Leakage Detection
- Repair of Leaks and Recording
- Identification of Illegal Connection and Inaccuracy Meters
- Measures against Illegal Connection and Inaccuracy Meters
- Data Collection of Monthly Billed Consumption

- Data Collection of Monthly SIV
- Monthly Water Balance Analysis
- Installing Water Meters
- Survey on Trunk, Distribution Mains and Reservoirs
- Preparation for Pipe Replacement Plan

4) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-b.

- Appoint staff who were involved in The Federal Capital Territory Reduction of Non-Revenue Water Project in FCTWB HQ.
- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint well- trained staff for leakage survey
- Ensure enough budget of about N805million for five years for allowance and procurement of equipment such as leak detectors, customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

5) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

6) Challenges in Future

If the pre-condition is met to apply for Scenario-b, NRW reduction operations based on Scenario-b will be taken for the time being. However, FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(3) Scenario-c:

1) Basis of setting-up Scenario

FCTWB needs lots of budget to procure leakage detection equipment. Therefore, it is unrealistic to procure all the equipment in terms of budget for their procurement. Meanwhile, it is desirable that FCTWB regularly patrol to find surface leakage and illegal connections. All the equipment which were provided by JICA will be utilized for the leak detection staff to be trained in future.

2) Summary of Scenario

FCTWB will establish the NRW reduction team in each Area Office. The team will NOT create DMA, but will take NRW reduction operations such as water meter survey, monitoring for surface leakage and illegal connection by zone targeting on NRW ratio of 36.9% for the year 2023.

3) Key activities

Key activities of Scenario-c are follows:

- Network Drawings and Data
- Customer Enumeration
- Zonal Measurement
- Patrol of Surface Leaks
- Repair of Leaks and Recording
- Identification of Illegal Connection and Inaccuracy Meters
- Measures against Illegal Connection and Inaccuracy Meters
- Data Collection of Monthly Billed Consumption
- Data Collection of Monthly SIV
- Monthly Water Balance Analysis
- Installing Water Meters
- Survey on Trunk, Distribution Mains and Reservoirs
- Preparation for Pipe Replacement Plan

4) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-c.

- Appoint three staff as trainers who are able to train staff of Area Offices to establish NRW reduction team in Area Office.
- Appoint staff who were involved in the Project in FCTWB HQ.
- Ensure enough budget of about N326million for five years for allowance and equipment such as customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure adequate budget allocation for Area Offices.
- Ensure inventory management of equipment such as leak detectors, flow-meters, etc. in Area Offices.
- Improve Area Offices' condition.
- Ensure vehicle and PC.

5) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

6) Challenges in Future

If the pre-condition is met to apply for Scenario-c, NRW reduction operations based on Scenario-c will be taken for the time being. However, FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure leakage survey equipment and accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(4) Scenario-d:

1) Basis of setting-up Scenario

Project Team spent much time and cost to create DMA through the Pilot Project. Pilot Project was carried out by FCTWB HQs and Area Office in cooperation with JICA Expert Team. NRW reduction operations by Area Office were limited due to insufficient skilful staff for supervising NRW reduction operations, lack of computer equipment and serious condition of power supply.

Therefore, it is unrealistic for Area Office to take various in-house and field work on NRW reduction operations and maintain all the equipment.

2) Summary of Scenario

Only FCTWB HQs will take NRW reduction operations such as leakage survey, illegal connection survey and water meter survey systematically by zone but NOT create DMA. FCTWB will target on NRW ratio of 35.1% for the year 2023. Area Offices patrol for detect surface leakage and illegal connection.

3) Key activities

Key activities of Scenario-d are follows:

- Network Drawings and Data
- Customer Enumeration
- Zonal Prioritization
- Zonal Measurement
- Leakage Detection
- Repair of Leaks and Recording
- Identification of Illegal Connection and Inaccuracy Meters
- Measures against Illegal Connection and Inaccuracy Meters
- Data Collection of Monthly Billed Consumption
- Data Collection of Monthly SIV
- Monthly Water Balance Analysis
- Installing Water Meters
- Survey on Trunk, Distribution Mains and Reservoirs
- Preparation for Pipe Replacement Plan

4) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-d.

- Appoint staff who were involved in the Project in FCTWB HQ.
- Appoint well- trained staff for leakage survey
- Ensure enough budget of about N223million for five years for allowance and equipment such as customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- Ensure vehicle and PC.

5) External Factors

NRW reduction operations may suspend for a certain period due to circumstance of cash disbursement in transition period for FCTWB's autonomy.

In addition, NRW reduction operations may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for NRW reduction operations.

6) Challenges in Future

If the pre-condition is met to apply for Scenario-d, NRW reduction operations based on Scenario-d will be taken for the time being. However, FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

(5) Scenario-e:

1) Basis of setting-up Scenario

Project Team spent much time and cost for various NRW reduction operations such as area isolation, leakage detection, illegal connection survey, water flow measurement and replacement and installation of water meters, etc. through the pilot project. Therefore, it is likely that those activities are unrealistic in terms of their sustainability and feasibility from the aspect of a delay of cash disbursement during the pilot project.

Meanwhile, since development of the existing pipeline information and customer's list was insufficient, Project Team spent much time to clarify and compile the information.

2) Summary of Scenario

FCTWB HQ will focus on developing fundamental information of the existing water supply pipelines and customer enumeration required for future NRW reduction operations. HQ will also conduct leakage detection and measures against illegal connections for NRW reduction as much as possible. FCTWB will target on NRW ratio of 42.8% for the year 2023.

3) Key activities

Key activities of Scenario-e are follows:

- Network Drawings and Data
- Customer Enumeration
- Data Collection of Monthly Billed Consumption
- Data Collection of Monthly SIV
- Monthly Water Balance Analysis
- Installing Water Meters
- Survey on Trunk, Distribution Mains and Reservoirs
- Preparation for Pipe Replacement Plan

4) Pre-condition

The following are pre-condition to take NRW reduction operations based on Scenario-e.

- Appoint staff who were involved in the Project in FCTWB HQ.
- Ensure enough budget of about N124million for five years for allowance and fuel and equipment such as pipes, their fittings, etc.
- Ensure vehicle and PC.

5) External Factors

Replacement and or installation of water meters may suspend for a certain period due to circumstance of cash disbursement for vehicle fuel and water meters in transition period for FCTWB's autonomy.

In addition, replacement and or installation of water meters may not be carried out due to objections of some of the FCTWB's board members who are concerned with budgetary fund for corresponded activities.

6) Challenges in Future

If the pre-condition is met to apply for Scenario-e, NRW reduction operations based on Scenario-e will be taken for the time being. However, FCTWB must consider the following actions as soon as possible in order to maintain NRW reduction operations.

- Procure accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need design of leakage training yard considering local condition.

In addition, staff who were trained through the pilot project have no an opportunity to take major activities for NRW reduction for the time being unless FCTWB applies other scenario. This may result in loss of staff's skill on NRW reduction operations.

3.3 Cost-Effectiveness by Scenario

(1) Cost

1) Conditions for estimating Man-Days

Project Team estimated man-days required for NRW reduction operations in order to estimate the corresponded cost as shown in Appendix-3.1.

2) Cost Comparison

Cost of each scenario for five years is summarized in Table 3-2 based on the breakdown of the operation cost shown in Appendix-4. However, expenses of excavation and backfilling for pipe repair and disconnection of illegal connection is not included in the breakdown of the operation cost, because their expenses depend on the field condition and are small amounts compared with other expenses for water meters, fittings, fuel and personnel allowance for other NRW reduction activities. Actually, the expenses was estimated at NGN0.09-0.22 per year, which may be negligible from aspect of annual total cost.

Table 3-2 Cost Comparison by Scenario (k. NGN)

Item	Scenario				
	a	b	c	d	e
a. Equipment and Materials for NRW Reduction Operations					
Leak Detectors (Equipment from Japan)	459,961	459,961	0	0	0
PMA Creation (Flow-meter, Valve)	52,996	0	0	0	0
PMA Creation (Chamber Construction)	2,773	0	0	0	0
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 5,000/year)	89,812	89,812	89,812	89,812	0
Materials for Leakage Repair	9,882	9,154	4,344	7,106	7,106
Materials for 24-hour Flow Measurement	9,115	0	0	0	0
Materials for Meter Error Test, Consumption Survey	591	227	227	227	227
Subtotal	625,130	559,156	94,383	97,146	7,333
b. Water Meter Laboratory					
Water meter laboratory (two test meter and fittings)	1,946	1,946	501	501	501
Subtotal	1,946	1,946	501	501	501
c. Field Allowance for NRW Reduction Operations					
Field Allowance for NRW Reduction Operations	118,476	111,792	106,433	39,591	33,291
Subtotal	118,476	111,792	106,433	39,591	33,291
d. Logistics					
Fuel Cost	64,947	58,858	52,808	18,551	15,470
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	57,000	57,000	57,000	57,000	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	9,750	9,750	9,750	3,900	3,900
Subtotal	131,697	125,608	119,558	79,451	76,370
Training Cost	6,034	6,034	6,034	6,034	6,034
Subtotal	6,034	6,034	6,034	6,034	6,034
Grand Total	**883,282**	**804,535**	**326,908**	**222,722**	**123,529**

Source: Project Team

(2) Revenue Yielded

1) Condition for estimating revenue yielded

The total revenue yielded through NRW reduction operations is estimated based on the following condition:

- Current NRW Ratio: 48.3%
- Total System Input (water production): About 336,000m^3/day by taking account of process loss of 10% at the LUD Water Treatment Plant
- Unit Price of Water: NGN90/m^3

2) Revenue Yielded Comparison

Revenue yielded of each scenario through NRW reduction operations for five years is summarized in Table 3-3 based on the breakdown estimated considering the condition of the above '(2)' in this section. The Breakdown is shown in Appendix-4.

Table 3-3 Revenue Comparison by Scenario

Items	Scenario-a	Scenario-b	Scenario-c	Scenario-d	Scenario-e
NRW Volume to be reduced (mil. m^3/5years)	18.7	18.1	13.0	15.0	6.3
Revenue yielded (mil. NGN/5years)	4,822.6	4,752.6	3,636.9	4,198.4	1,698.8

Source: Project Team

(3) Cost-Effectiveness

Cost-effectiveness for five years was worked out in Table 3-4. Scenario-d indicates the highest cost-effectiveness at 18.9.

Table 3-4 Cost-Effectiveness by Scenario

Items		Scenario				
		a	b	c	d	e
Cost (mil. NGN)	i.	883.2	804.5	326.9	222.7	123.5
Revenue yielded (mil. NGN)	ii.	4,822.60	4,752.60	3,636.90	4,198.40	1,698.80
Direct benefit (mil. NGN)	iii=ii.-i.	3,939.40	3,948.10	3,310.00	3,975.70	1,575.30
Cost-Effectiveness	iv. = ii./ i.	5.5	5.9	11.1	18.9	13.8

Source: Project Team

3.4 Financial Consideration based on the Scenarios

The Financial statements of the five scenarios such as "Profit and Loss" and "Cash Flow" were studied and summarized scenario-wisely in this section.

(1) Conditions

Table 3-5 presents various conditions set out for the study.

Table 3-5 Conditions for preparing Financial Statement

Items	Conditions	Sources
1. Baseline of NRW ratio	48.3%	Estimated by Project Team as shown in Chapter 1.4
2. Incremental O&M expenditures	Scenario-wise	Estimated by Project Team as shown in Chapter 3.3
3 .Capital Investment expenditures		
1) Construction works in 2019 for the switch over of the water supplied by LUD-WTP Phase-3&4	NGN673Mil.	Estimated by Project Team
2) Procurement in connection with the scenarios	Scenario-wise	Estimated by Project Team as shown in Chapter 3.3
4. Depreciation		
1) Procurement of above 3-2)	10 years	Estimated by Project Team mostly equipment and vehicle
2) Other assets including the construction of switch-over and Phase-3&4	20 years	Estimated by Project Team (mostly facilities, installations, and pipelines)
5. Price escalation	Not applied	Judged by Project Team
6.Tariff: weighted average between the domestic and commercial customers	NGN90/m^3	Estimated by Project Team
7. Collection ratio of water tariff against bills raised	31.3%	Estimated by Project Team average rate of four years from 2014 to 2017
8. Allocation and remittance to FCTA	Not applied	Assumed by Project Team

Source: Project Team

(2) Profit and Loss (P/L) Statement

Based on the above pre-conditions, the P/L statement of each scenario is estimated. Table 3-6 shows the summary of the year 2023. The details over five years from 2019 up to 2023 of each scenario are presented in Appendix-6.

With-project cases (five scenarios) will obviously make a larger profit than without-project case (no scenario).

Table 3-6 Summary of P/L Statement of the Year 2023 by Scenario (Million Naira)

Account Items	No Scenario	Scenarios				
		a	b	c	d	e
1.Revenues	7,829	10,306	10,239	9,547	9,824	8,668
2.Expenditures	2,799	2,895	2,886	2,844	2,824	2,815
3.P/L = 1-2	5,030	7,411	7,353	6,703	7,000	5,853

Source: Project Team

(3) Cash Flow (C/F) Statement

The C/F Statement refers to cash-inflows and cash-outflows in a given period categorizing such activities as operational, investment and financial. The difference between the cash-inflows and the cash-outflows comes out to “net cash flow” at the end. Table 3-7 presents the C/F Statement for the year 2023 estimated based on the above conditions. The detailed C/F statements can be referred year-wisely from 2019 up to 2023 in Appendix-7.

With-project cases (five scenarios) will apparently generate the net C/F more than without-project case (no scenario). Moreover, the net C/F will surely soar if reducing the number of un-paid customers.

It should be noted that the expenditures for switch-over construction planned in 2019 is to be funded by the Government. However, the Scenario-a and Scenario-b could remain negative even though funded because of a heavier investment amount in the year than that of other scenarios; this negative amount should be raised for from the Government or other party accordingly.

Table 3-7 Summary of C/F Statement of Year 2023 by Scenario (Million Naira)

Activities	No Scenario	Scenarios				
		a	b	c	d	e
1.Operational	714.5	1,451.3	1,434.6	1,220.4	1,325.0	965.1
2.Investment	0	- 100.0	- 91.0	- 18.9	- 38.4	- 20.5
3.Financial	0	0	0	0	0	0
4. Net C/F = 1+2+3	714.5	1,351.3	1,343.6	1,201.5	1,286.6	944.7

Source: Project Team

4. NRW Reduction Operations Plan

4.1 NRW Reduction Operations

Overall NRW reduction operations from Scenario-a to Scenario-e are shown in Table 3-1. All the NRW reduction operations contains 20 activities. Scenario-a consists of most activities among five scenarios, while Scenario-e consists of least ones.

4.2 Workflow of NRW Reduction Operations

The following show breakdown of the activities and workflows which are composed of the breakdown of each scenario are indicated in Figure 4-1 to Figure 4-5.

(1) Network Drawings and Data
(2) Customer Enumeration
(3) DMA Design, Creation, Prioritization
  (3)-1 DMA Design, Creation and Prioritization
  (3)-2 DMA Prioritization in NRW Reduction
(4) Zonal Prioritization
(5) Field Inspection
(6) Isolation by installing Flow-meters and Valves
(7) Step-Test in DMA
(8) Zonal Measurement
(9) Leakage Detection
(10) Patrol of Surface Leaks
(11) Repair of Leaks and Recording
(12) Identification of Illegal Connections and Meter Inaccuracy
  (12)-1 Identification of Illegal Connection
  (12)-2 Identification of Meter Inaccuracy
(13) Measures against Illegal Connection and Meter Inaccuracy
  (13)-1 Measures against Illegal Connections
  (13)-2 Measures against Meter Inaccuracy
(14) Data Collection of Monthly Billed Consumption
(15) Data Collection of Monthly SIV
(16) Monthly Water Balance Analysis
(17) Measurement of One-week SIV
(18) Installing Water Meters
(19) Survey on Trunk, Distribution Mains and Reservoirs
(20) Preparation for Pipe Replacement Plan

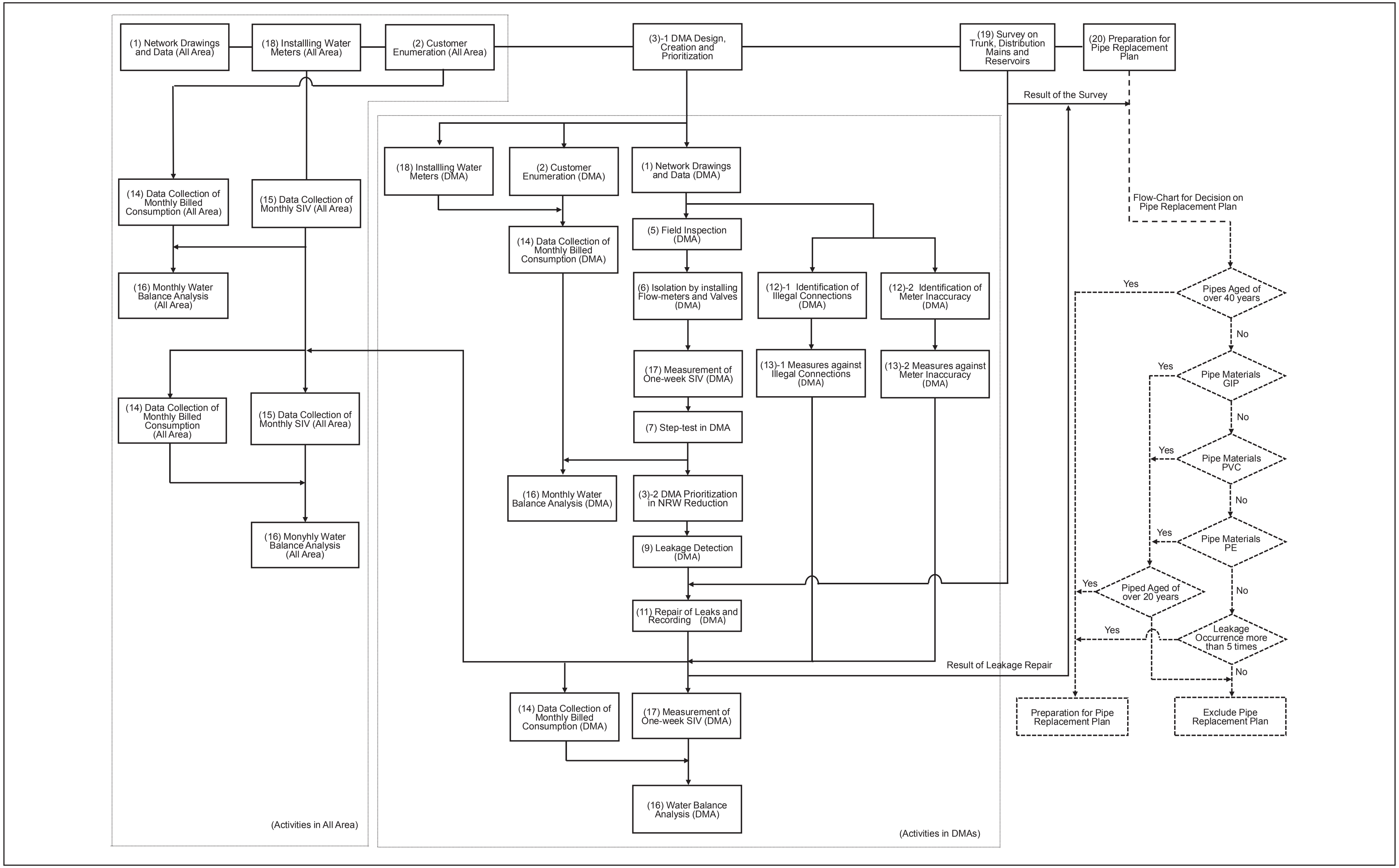


Figure 4-1 Work Flow of Scenario-a

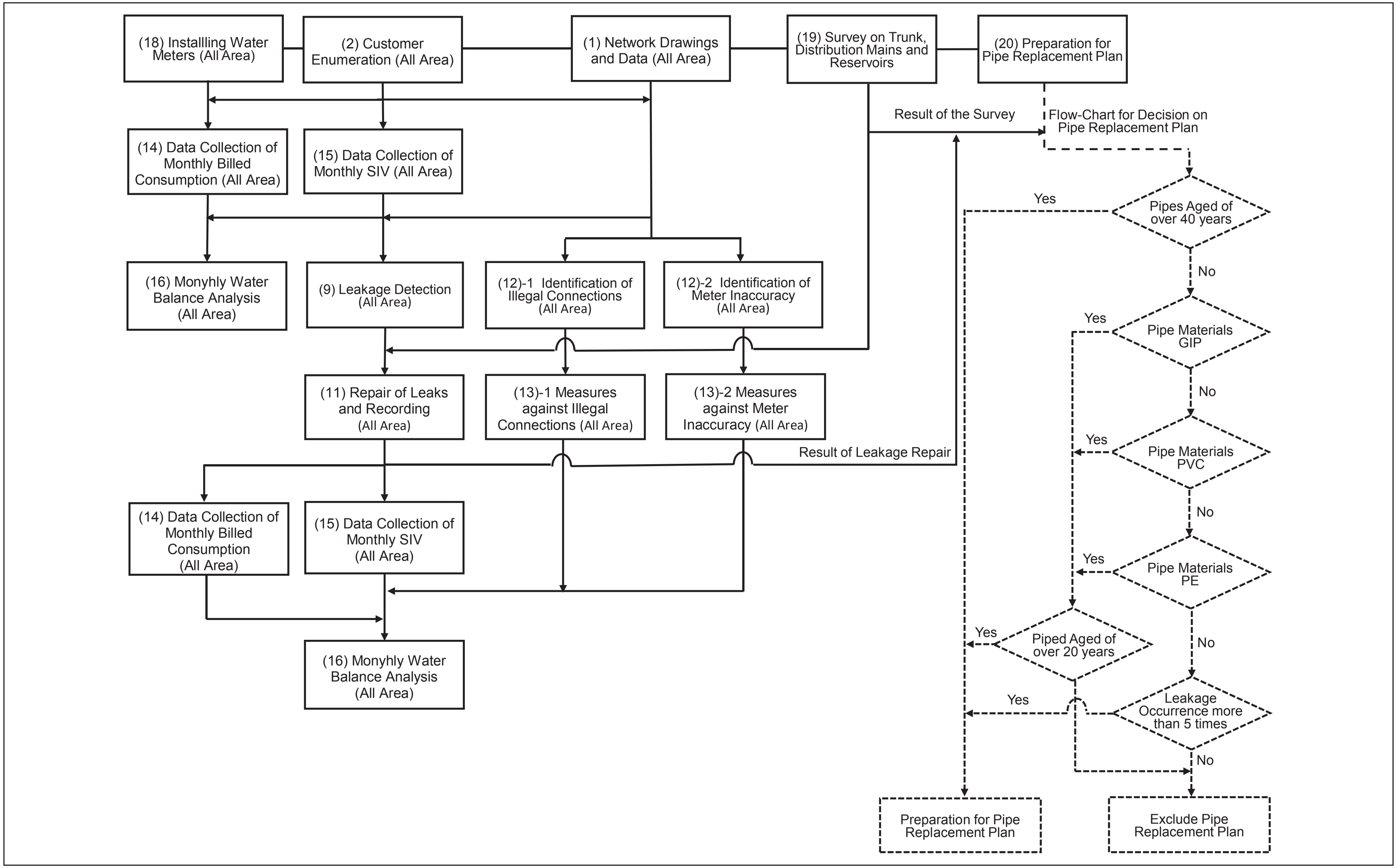


Figure 4-2 Work Flow of Scenario-b

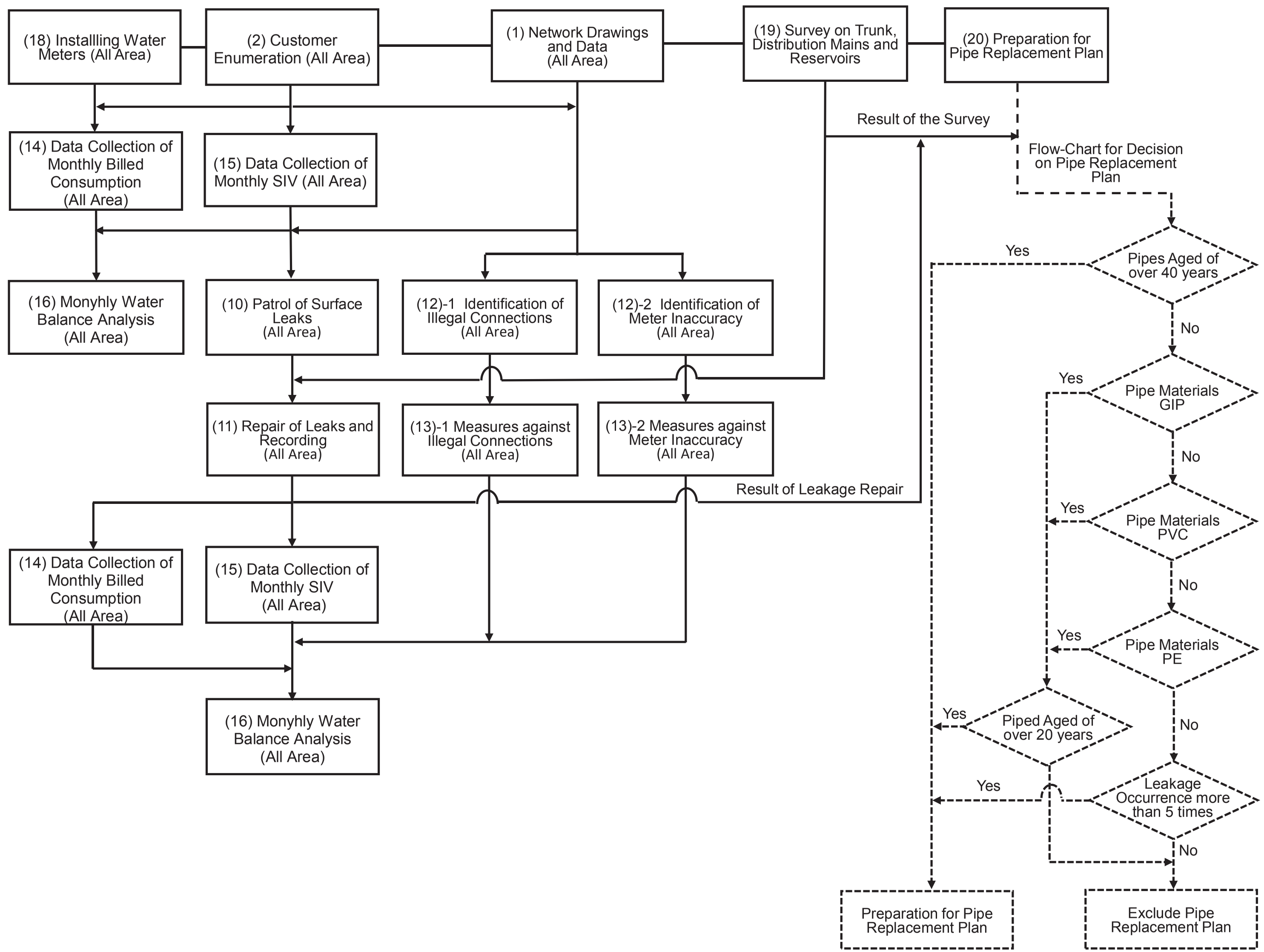


Figure 4-3 Work Flow of Scenario-c

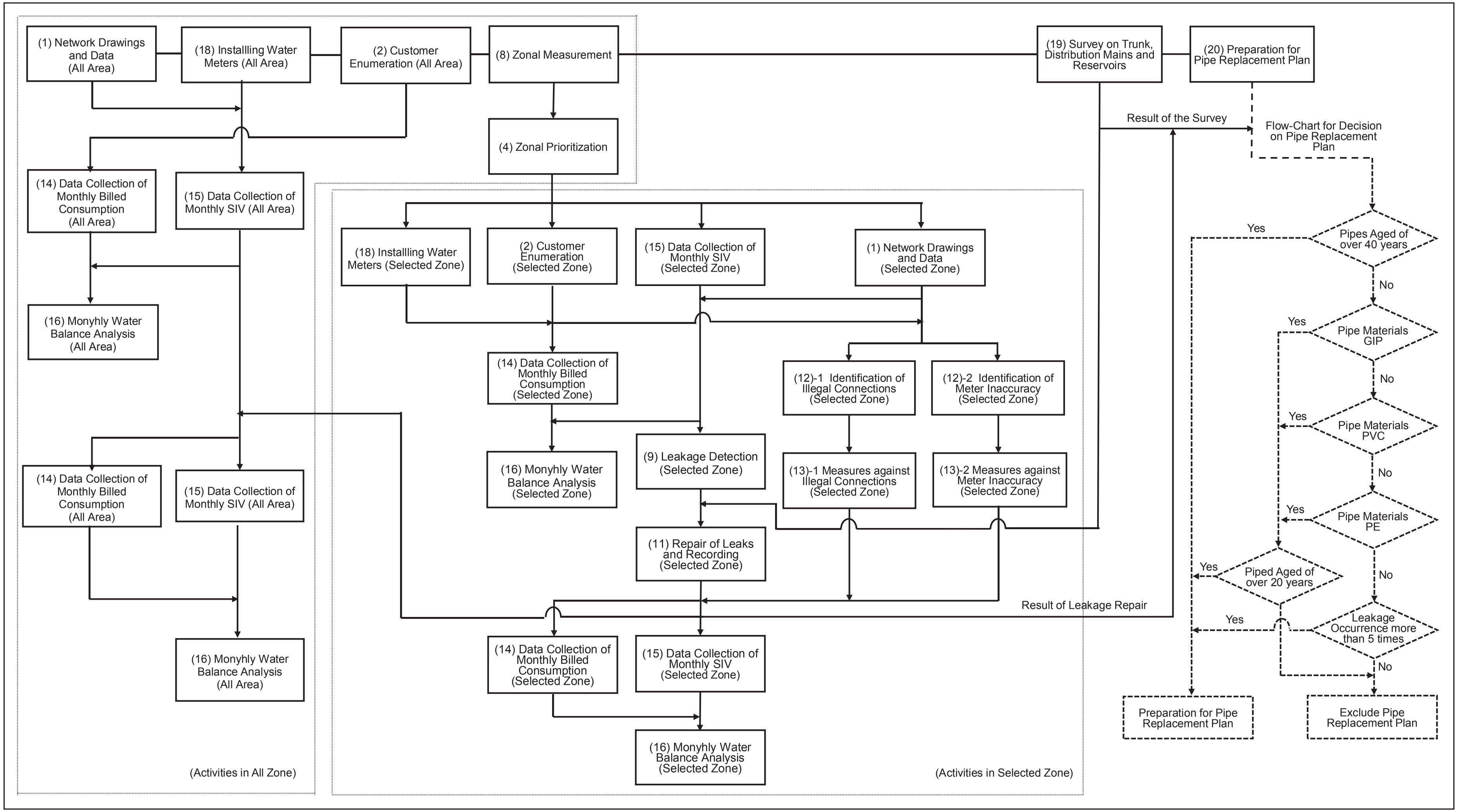


Figure 4-4 Work Flow of Scenario-d

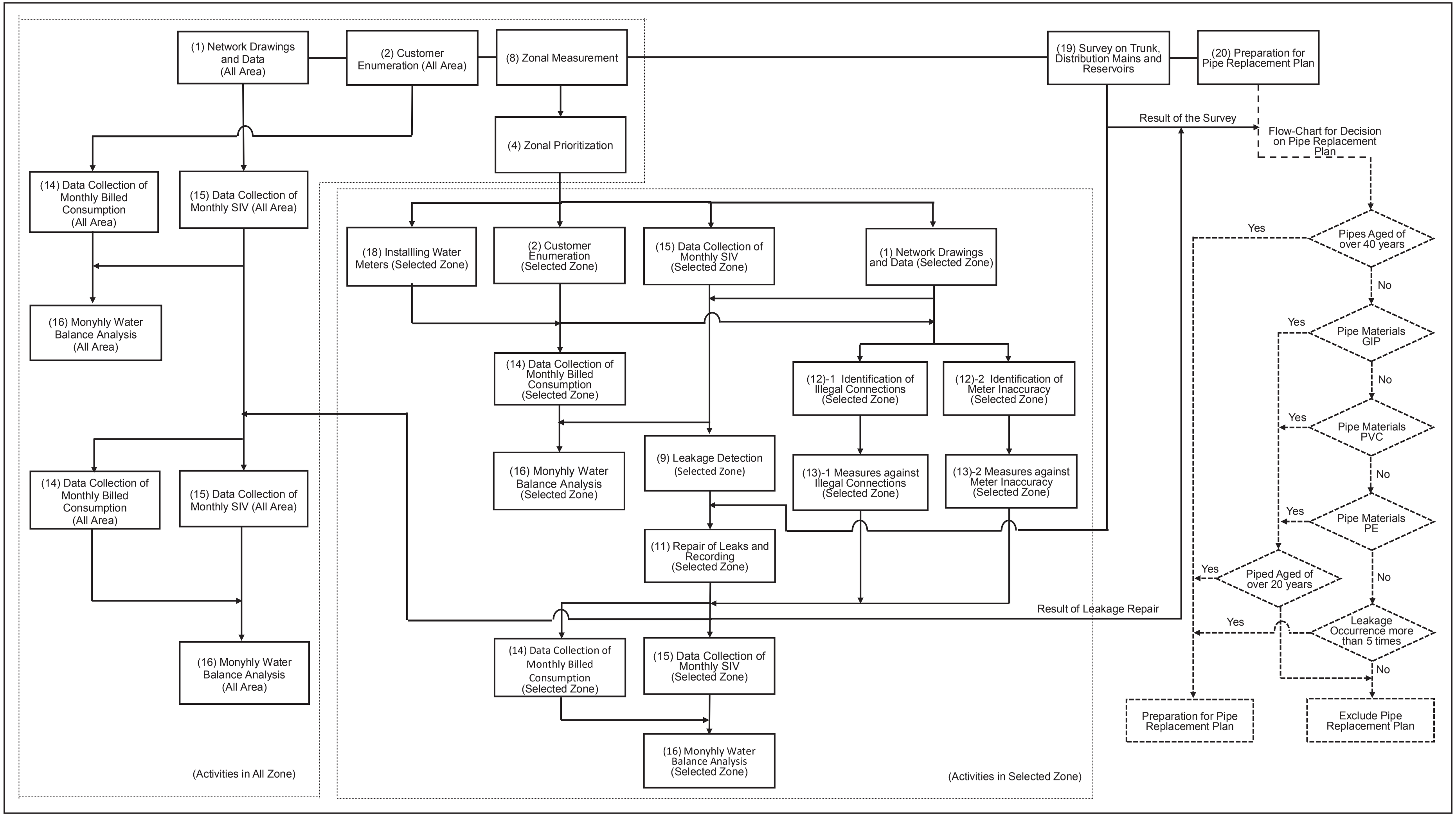


Figure 4-5 Work Flow of Scenario-e

5. Scenario that FCTWB selected and the Background

In order to carry out NRW reduction operations, considering the following reasons, the Management of the Water Board Selected “Scenario-d” which states that, “Only FCTWB HQs will take NRW reduction operations such as systematic leakage survey, illegal connection survey, and installation of water meters but NOT create DMAs. FCTWB will target on NRW ratio of 35.1% for the year, 2023”.

- Practical goal of NRW ratio
- Insufficient data of the existing water supply facilities
- Vulnerable structure of areas offices
- Insufficient number of skilled staff of Area Offices
- Expected accommodation of disbursement due to approved autonomy of FCTWB and appointment of board members
- Making the most use of skills and know-how which were obtained through the Project as much as possible so that FCTWB’s capacity on NRW reduction especially at individual level is sustained

6. Budget Allocation for Five Years

In the past three years, FCTWB made a budget of 40million to 50million yearly, but suffered from delayed or no release of the budget to implement the pilot projects as scheduled. From the current condition of release, Budget for the year 2018 has not been approved and released as of April 2018. It is most likely that approval and release of budget for the year 2019 will be delayed. Therefore, the Project Team allocated a budget up to about 35million apart from Scenario-a, b and c which requires huge initial investment for the first year in accordance with FCTWB's prospect.

Cost for NRW reduction operation is composed of the following expense items:

- Field Allowance for staff
- Equipment such as flow-meters, valves, water meters, leak detectors
- Materials such as fittings for leak repairs, 24hour-flow measurement, water meter error test, consumption survey, etc.
- Water meter laboratory
- Fuel for vehicles
- Vehicles
- Maintenance and insurance for Vehicles
- Training for human resource development

Table 6-1 shows budget allocation for five years.

Cost of Scenario-a for first three years is higher than that for other two years, because of concentrating on DMA creation. In addition, cost of Scenario-a and Scenario-b in 2019 and 2020 is higher than that of other years with procurement of leak detectors for their delivery to Area Offices. Meanwhile, cost of Scenario-d and Scenario-e from 2022 to 2023 is higher than that 2019 and 2020 with procurement of vehicles.

Table 6-1 Budget Allocation for NRW Reduction Operations

Scenario	Total Cost (mil. NGN)	2019	2020	2021	2022	2023
Scenario-a	883.3	241.7	185.4	178.1	139.7	138.4
	100%	27%	21%	20%	16%	16%
Scenario-b	804.5	225.2	169.0	161.7	123.8	124.8
	100%	28%	21%	20%	15%	16%
Scenario-c	326.9	115.8	59.3	50.7	50.7	50.5
	100%	35%	18%	16%	16%	15%
Scenario-d	222.7	34.1	34.6	50.7	51.4	52.0
	100%	15%	16%	23%	23%	23%
Scenario-e	123.5	14.2	14.7	30.9	31.5	32.2
	100%	12%	12%	25%	26%	26%

Source: Project Team

7. Staffing Plan and Responsibility

Number of staff is calculated as following conditions:

- National Holiday: New Year's Day, Good Friday, Easter Monday, Workers' Day, Democracy Day, Id el Fitr, ide-el-Kabir, National Day, Id-el-Maulud, Christmas Day, Boxing Day = Total 13 days
- Annual Leave: 30 days include Saturday and Sunday (Eight non-working days): 22 days
- Working days per week: 5 days per week x 52 weeks = 260 working days
- Working days per year: 260 days -13 days – 22 days = 225 working days per year

7.1 FCTWB Headquarters

a) NRW Unit

Staff of the Unit should carry out the plan mainly and organize other Units for the implementation of the plan. The necessary number of staff as follows:

Table 7-1 Necessary No. of Staff by each Scenario for NRW Unit

	2019	2020	2021	2022	2023
Scenario-a	4	4	4	4	4
Scenario-b	3	3	3	3	3
Scenario-c	3	3	3	3	3
Scenario-d	11	11	11	11	11
Scenario-e	9	9	9	9	9

Source: Project Team

- When FCTWB choose scenario-a, four staff will be required for all the years.
- When FCTWB choose scenario-b and c, three staff will be required for all the years.
- When FCTWB choose scenario-d, 11 staff which consists of three teams will be required for all the years.
- When FCTWB choose scenario-e, nine staff will be required for all the year.

b) GIS Unit

Staff of the Unit should work for making pipeline maps and customer maps mainly. The necessary number of staff are as follows:

Table7-2 Necessary No. of Staff by each Scenario for GIS Unit

	2019	2020	2021	2022	2023
Scenario-a	3	2	2	2	2
Scenario-b	3	2	2	2	2
Scenario-c	3	2	2	2	2
Scenario-d	3	2	2	2	2
Scenario-e	3	2	2	2	2

Source: Project Team

When FCTWB proceeds the plan, three staff will be required in the first year, but two staff will be required for the other years.

c) Distribution Unit

Staff of the Unit should work for inspection of trunk main, distribution main, their fittings, villages and public taps. The necessary number of staff are as follows:

Table 7-3 Necessary No. of Staff by each Scenario for Distribution Unit

	2019	2020	2021	2022	2023
Scenario-a	1*	1	1	1	1
Scenario-b	1	1	1	1	1
Scenario-c	1	1	1	1	1
Scenario-d	1	1	1	1	1
Scenario-e	1	1	1	1	1

Source: Project Team

Note: * Annual average necessary number of staff is one person, but for inspection of trunk mains and distribution mains two person are required.

Table7-4 Required No. of Staff by each Scenario for Distribution Unit

	2019	2020	2021	2022	2023
Scenario-a	3	3	3	3	3
Scenario-b	2	2	2	2	2
Scenario-c	2	2	2	2	2
Scenario-d	2	2	2	2	2
Scenario-e	2	2	2	2	2

Source: Project Team

d) Billing Unit

Staff of the Unit should work for customer enumeration and data collection of billed consumption mainly. The necessary number of staff are as follows:

Table 7-5 Necessary No. of Staff by each Scenario for Billing Unit

	2019	2020	2021	2022	2023
Scenario-a	2	2	2	2	2
Scenario-b	2	2	2	2	2
Scenario-c	2	2	2	2	2
Scenario-d	2	2	2	2	2
Scenario-e	2	2	2	2	2

Source: Project Team

When FCTWB proceed the plan, two staff will be required in the first year.

e) Commerce Unit

Commerce staff should work on eliminating illegal connections. The necessary number of staff are as follows:

Table 7-6 Necessary No. of Staff by each Scenario for Commerce Unit

	2019	2020	2021	2022	2023
Scenario-a	1	1	1	1	1
Scenario-b	1	1	1	1	1
Scenario-c	1	1	1	1	1
Scenario-d	1	1	1	1	1
Scenario-e	1	1	1	1	1

Source: Project Team

7.2 Area Offices

a) Distribution Staff of Area Offices

Distribution staff of Area Offices should work on leakage survey and repairing, meter installation and so on. The necessary number of staff are as follows:

Table 7-7 Necessary No. of Staff by each Scenario for Distribution Staff of Area Office

	2019	2020	2021	2022	2023
Scenario-a	5*	5	5	5	5
Scenario-b	5	5	5	5	5
Scenario-c	5	5	5	2	2
Scenario-d	2	2	2	2	2
Scenario-e	1	1	1	1	1

Source: Project Team

Note: * Annual average necessary number of staff is 1-5 person, but for leakage repair 6 person are required.

Table 7-8 Required No. of Staff by each Scenario for Distribution Staff of Area Office

	2019	2020	2021	2022	2023
Scenario-a	6	6	6	6	6
Scenario-b	6	6	6	6	6
Scenario-c	6	6	6	6	6
Scenario-d	6	6	6	6	6
Scenario-e	6	6	6	6	6

Source: Project Team

b) Commerce Staff of Area Offices

Commerce staff of Area Offices should work on sorting out customer map and accompany with distribution staff when necessary. The necessary number of staff are as follows:

Table7-9 Necessary No. of Staff by each Scenario for Commerce Staff of Area Office

	2019	2020	2021	2022	2023
Scenario-a	2	2	2	2	2
Scenario-b	2	2	2	2	2
Scenario-c	1	1	1	1	1
Scenario-d	1	1	1	1	1
Scenario-e	1	1	1	1	1

Source: Project Team

8. Human Resource Development (HRD) Plan

8.1 Background

FCTWB was established in October 1989, saddled with the responsibility of Medium Strategic Plan.

8.2 Scenarios and Goal

Scenario d has been proposed and accepted by the FCTWB Management, and that implies that FCTWB Headquarters will coordinate the activities of NRW including leakage detection survey, illegal connection survey and water meter survey but not to create the DMA. FCTWB will target on NRW ratio of 35.1% for the year 2023.

8.3 Human Resource Development

Human resource management is recruiting, hiring and managing employees. Project Team focused on human resource development in terms of staff's individual capacity in NRW reduction.

8.4 Content of Human Resource Development

(1) Necessity of HRD for NRW Reduction

At present, there is no systematic HRD plan for NRW reduction in FCTWB, but It is necessary to create systematic HRD plan and deepen staff's understanding of NRW, so that NRW ratio will be decreased in FCTWB's service area.

The purpose of the plan is to deepen understanding of NRW among staff of FCTWB and to contribute to NRW reduction.

(2) Training Curriculum

The HRD plan consists of seven curriculums. The curriculums are as follows:

A. Training Curriculum 1: Basic and Common Knowledge about NRW

The lecture "Basic and Common Knowledge about NRW" consists of three contents such as Meaning of NRW Reduction, Outline of IWA Water Balance Analysis and Outline of NRW Reduction Operation.

A.1 Target and Style of Curriculum 1

A.1.1 Target Staff:

Area Manager, Assistant Area Manager, Staff at HQ

A.1.2 Lecturer:

Staff of NRW Unit

A.1.3 Number of Participants of one Training Course:

Maximum 10 Persons

A.1.4 Style and Duration of Training:

Lecture: One Day

A.2 Contents 1-1: Meaning of NRW Reduction

Explanation of effect from NRW Reduction: Increase Revenue, New Water Resources Development

A.2.1 Expected Effect:

Participants can understand about NRW Reduction and its effect.

A.2.2 Items on the lecture of Meaning of NRW Reduction:

Effects of NRW Reduction

A.3 Contents 1-2: Outline of IWA Water Balance Analysis

Explanation about each item, discussion and question about each item to know what is NRW and Revenue Water.

A.3.1 Expected Effect:

Participants can get the knowledge about IWA Water Balance Analysis and image NRW and Revenue Water.

A.3.2 Items on Outline of Water Balance Analysis:

- Authorized Consumption:

  Billed Authorized Consumption (Billed Metered Consumption, Billed Un-Metered Consumption), Unbilled Authorized Consumption (Unbilled Metered Consumption, Unbilled Un-Metered Consumption)

- Water Losses:

  Apparent Losses (Unauthorized Consumption, Customer Meter Inaccuracies Data Handling Errors)

  Real Losses (Leakage in Transmission and Distribution Mains, Leakage and Overflow at Utility's Storage Tanks, Leakage on Service Connections up to Point of Customer Metering)

A.4 Contents 1-3: Outline of NRW Reduction Operation

Explanation about each activities, discussion and question about each activity to know what is NRW Reduction Operation.

A.4.1 Expected Effect:

Participants can understand NRW Reduction Operation and involve it.

A.4.2 Items on the lecture of Outline of NRW Reduction Operation:

- Network Drawings and Data
- Customer Listing
- Design and Creation of DMA
- Prioritization of each Zone
- Field Inspection of Existing Valves, etc.
- Installation of Flow-meter and Isolation Valves
- Step-test in DMA
- Measurement of Minimum Night Flow (MNF) by Zone
- Leakage Detection
- Patrol of Surface Leakage and Illegal Connections
- Repair of Leaks and Recording
- Identification of Illegal Connection and Meter Inaccuracy
- Data Collection and Billed Consumption Before/After NRW Reduction
- Measures against Illegal Connections and Meter Inaccuracy
- Water Balance Analysis before/after NRW Reduction Operations
- Examination of Replacement Plan

B. Training Curriculum 2: Management of Pipelines

The lecture "Management of Pipelines" consist of three contents as follows: Outline of GIS, Outline of Pipe Materials and Outline of Hydraulic Analysis.

B.1 Target and Style of Curriculum 2

B.1.1 Target Staff:

Area Manager, Technical Assistant Area Manager, Technical Staff at HQ

B.1.2 Lecturer:

Staff of GIS Unit and Staff of NRW Unit

B.1.3 Number of Participants of one Training Course:

Maximum 5 Person

B.1.4 Style and Duration of Training:

Lecture: One Day
Work Shop: Two Days (GIS and Hydraulic Analysis)

B.2 Contents 2-1: Outline of GIS

Explanation and workshop of GIS information and its utilization: Data Collection assisted by Area Office, Necessary Data for NRW Reduction Operation.

B.2.1 Expected Effect:

Participants can understand about GIS and effect of it.

B.2.2 Items on the lecture of Outline of GIS:

- Necessary Data
- How to create network drawings
- Update of GIS Data
- Base Map

B.3 Contents 2-2: Outline of Pipe Materials

Explanation about pipe materials: Characteristics of pipe materials, Jointing methods.

B.3.1 Expected Effect:

Participants can get knowledge about pipe materials and its characteristic.

B.3.2 Items on the lecture of Meaning of NRW Reduction:

- Kinds of pipe materials
- Jointing methods
- Leakage caused by poor joint skills

B.4 Contents 2-3: Outline of Hydraulic Analysis:

Explanation and practice about hydraulic analysis: consideration upon analysis, Necessary data and Confirmation of analysis result.

B.4.1 Expected Effect:

Participants can get knowledge about Hydraulic Analysis.

B.4.2 Items on the lecture of Meaning of NRW Reduction:

- Necessary data
- Data collection methods
- Data confirmation methods
- Use Pressure Data Logger
- Practice

C. Training Curriculum 3: Management of Data

The lecture “Management of Data” consist of two contents as follows: Meter Reading and Meter Test (Meter Inaccuracy).

C.1 Target and Style of Curriculum 3

C.1.1 Target Staff:

Area Manager, Commercial Assistant Area Manager, Meter Reader

C.1.2 Lecturer:

Staff of NRW Unit

C.1.3 Number of Participants of one Training Course:

Maximum 10 Person

C.1.4 Style and Duration of Training:

Lecture: One Day
Work Shop: One Day

C.2 Contents 3-1: Meter Reading

Explanation and Workshop of Meter Reading: Importance of meter reading, visible leakage survey and illegal connection survey.

C.2.1 Expected Effect:

Participants can understand about Importance of meter reading and visible survey.

C.2.2 Items on the lecture of Meter reading:

- Customer Map
- Meter Check
- Compare Current Meter Reading and Former Meter Reading
- Make Excel format of Meter Reading Results
- Visible Leakage and Illegal Connection Survey
- Report faulty meter and unreadable meter

C.3 Contents 3-2: Meter Test

Explanation and Practice of Meter Test: Meter Inaccuracy, Practice of meter test.

C.3.1 Expected Effect:

Participants can understand about Importance of meter accuracy and how to test meter.

C.3.2 Items on the lecture of Meter Test:

- Meter inaccuracy
- How to test meter
- Practice of meter test

D. Training Curriculum 4: Leakage and Illegal Connection Survey

The lecture "Leakage and Illegal Connection Survey" consist of three contents as follows: Kinds of leakage survey equipment, Leakage Survey methods and Illegal connection survey.

D.1 Target and Style of Curriculum 4

D.1.1 Target Staff:

Area Manager, Technical Assistant Area Manager, Plumbers

D.1.2 Lecturer:

Staff of NRW Unit

D.1.3 Number of Participants of one Training Course:

Maximum 10 Person

D.1.4 Style and Duration of Training:

Lecture: One Day
Work Shop: Two Days

D.2 Contents 4-1: Kinds of Leakage Survey Equipment

Explanation of Kinds of Leakage Survey Equipment: Kinds and how to use leakage survey equipment.

D.2.1 Expected Effect:

Participants can understand about kinds of leakage survey equipment.

D.2.2 Items on the lecture of kinds of leakage survey equipment:

- Acoustic Bar
- Electro Listening Stick
- Leak Detector (Ground microphone)
- Correlator
- Ultrasonic Flow Meter

D.3 Contents 4-2: Leakage Survey Methods

Explanation and practice of Leakage Survey Methods: How to detect leakage.

D.3.1 Expected Effect:

Participants can get knowledge about leakage survey methods.

D.3.2 Items on the lecture of leakage survey methods:

- Point Survey using Acoustic Bar or Electro Listening Stick
- Line Survey using Leak Detector (Ground Microphone)
- Confirmation Survey
- Water Flow Measurement using Ultrasonic Flow Meter

D.4 Contents 4-3: Illegal Connection Survey

Explanation and practice of Illegal Connection Survey: How to find illegal connection.

D.4.1 Expected Effect:

Participants can get knowledge about Illegal Connection Survey.

D.4.2 Items on the lecture of Illegal Connection Survey:

- Listing of Target Customer (Small Consumption Customer)
- Visible Inspection
- Checking Water Flow Sound (When Water Meter Stop)
- Checking Residual Chlorine (Borehole User)

E. Training Curriculum 5: Streamlining of billing system and examination on unifying water meters

The lecture “Streamlining of billing system and examination on unifying water meters” consist of three contents as follows: Examination on unifying water meters, Streamlining of meter reading and billing and development of customer data.

E.1 Target and Style of Curriculum 5

E.1.1 Target Staff:

Area Manager, Commercial Assistant Area Manager, Meter Readers

E.1.2 Lecturer:

Staff of Billing Unit, Staff of distribution Unit and Staff of NRW Unit

E.1.3 Number of Participants of one Training Course:

Maximum 10 Person

E.1.4 Style and Duration of Training:

Lecture: One and half Days

Work Shop (discussion): One and half Days

E.2 Contents 5-1: Examination on unifying water meters

Explanation and discussion about each meter type

E.2.1 Expected Effect:

Participants can understand about characteristic of each water meter and merit of unifying water meter.

E.2.2 Items on the lecture of Examination on unifying water meters:

- Characteristic of each meter type
- Advantage and disadvantage of each meter type
- Merit of unifying water meter

E.3 Contents 5-2: Streamlining of meter reading and billing

Explanation and discussion of present condition of meter reading and billing: How to streamline them.

E.3.1 Expected Effect:

Participants can get knowledge about streamlining of meter reading and billing.

E.3.2 Items on the lecture of Streamlining of meter reading and billing:

- Present condition and process of meter reading and billing
- Challenges of meter reading and billing
- Explanation of handy terminal

E.4 Contents 5-3: Development of customer data

Explanation and discussion about customer data: How to develop customer data.

E.4.1 Expected Effect:

Participants can understand about importance of customer data.

E.4.2 Items on the lecture of Development of customer data:

- Making customer map
- Arrangement of customer data using PC
- Analysis of customer data

F. Training Curriculum 6: Plumbing for repair and or replacing pipelines

The lecture “Plumbing for repair and or replacing pipelines” consist of three contents as follows: Repair jointing for large scale and small scale pipeline, Laying pipelines and Install valves, flow-meters, saddle, etc.

F.1 Target and Style of Curriculum 6

F.1.1 Target Staff:

Area Manager, Technical Assistant Area Manager, Plumbers

F.1.2 Lecturer:

Staff of distribution Unit

F.1.3 Number of Participants of one Training Course:

Maximum 5 Person

F.1.4 Style and Duration of Training:

Lecture: One Day

Work Shop: Two Days

F.2 Contents 6-1: Repair jointing for large scale and small scale pipeline

Explanation and practice about repair jointing for large scale and small scale pipeline

F.2.1 Expected Effect:

Participants can get knowledge of repair jointing for large scale and small scale pipeline.

F.2.2 Items on the lecture of Repair jointing for large scale and small scale pipeline:

- Type of pipeline materials
- Characteristics of pipe materials
- Repair methods of each pipe materials
- Procedure of pipe repair

F.3 Contents 6-2: Laying pipelines

Explanation and practice of laying pipelines: How to lay pipelines.

F.3.1 Expected Effect:

Participants can get knowledge about laying pipelines.

F.3.2 Items on the lecture of laying pipelines:

- Safety measures for laying pipelines
- Pipe joint type
- Pipe laying standard

F.4 Contents 6-3: Install valves, flow-meters, saddle, etc.

Explanation and discussion about customer data: How to develop customer data.

F.4.1 Expected Effect:

Participants can get knowledge about Install valves, flow-meters, saddle, etc..

F.4.2 Items on the lecture of Install valves, flow-meters, saddle, etc.:

- Characteristics of Gasket type
- Allowable Water Pressure for Flange
- Type of valves, flow-meters saddle, etc.

G. Training Curriculum 7: Basic operation of personal computer, graphing by using excel

The lecture “Basic operation of personal computer, graphing by using excel” consist of three contents as follows: PC operation, Calculation by using Excel and Drawing graph by using Excel.

G.1 Target and Style of Curriculum 7

G.1.1 Target Staff:

Area Manager, Technical Assistant Area Manager, Commercial Assistant Manager Staff of HQ

G.1.2 Lecturer:

Staff of NRW Unit or a right person

G.1.3 Number of Participants of one Training Course:

Maximum 5 Person

G.1.4 Style and Duration of Training:

Lecture and Practice: Two Days

G.2 Contents 7-1: PC operation

Explanation and practice about PC operation

G.2.1 Expected Effect:

Participants can get knowledge about PC and use PC.

G.2.2 Items on the lecture of PC Operation:

- Data saving to flash memory (USB memory)
- Getting data using internet.
- Using Wi-Fi and tethering

G.3 Contents 7-2: Calculation by using Excel

Explanation and practice of excel: How to use excel.

G.3.1 Expected Effect:

Participants can get knowledge about excel and use excel.

G.3.2 Items on the lecture of Calculation by using Excel:

- Basic function of excel
- Making table using excel
- Reference to another sheet

G.4 Contents 7-3: Drawing graph by using Excel.

Explanation and practice of Drawing graph by using Excel: How to make graph by using excel.

G.4.1 Expected Effect:

Participants can get knowledge about graph types make graph by using excel.

G.4.2 Items on the lecture of Drawing graph by using Excel:

- Suitable type of graph to present result of making tables
- Making graph of water input volume for analyse water consumption and minimum night flow.

(3) Training Schedule

The HRD plan consists of seven curriculums which will be conducted within two years. Curriculums and their tentative schedule are as follows:

Table 8-1 Training Schedule

Curriculums	2019				2020			
	1/4	2/4	3/4	4/4	1/4	2/4	3/4	4/4
Curriculum 1: Basic and Common Knowledge about NRW								
➢ Meaning of NRW Reduction	■	■	■		■			
➢ Outline of Water Balance analysis	■	■	■		■			
➢ Outline of NRW Reduction Operation	■	■	■		■			
Curriculum 2: Management of Pipelines								
➢ Outline of GIS		■	■	■	■			
➢ Outline of Water Balance analysis		■	■	■	■			
➢ Outline of NRW Reduction Operation		■	■	■	■			
Curriculum 3: Management of Data								
➢ Meter Reading				■ ■	■	■		
➢ Meter Test				■ ■	■	■		
Curriculum 4: Leakage and Illegal Connection Survey								
➢ Kinds of Illegal Survey Equipment					■		■	■
➢ Leakage Survey Methods					■		■	■
➢ Illegal Connection Survey					■		■	■
Curriculum 5: Streamlining of billing system and examination on unifying water meters								
➢ Examination on unifying water meters						■	■	■
➢ Streamlining of Meter reading & billing						■	■	■
➢ Development of customer data						■	■	■
Curriculum 6: Plumbing for repair and or replacing pipelines								
➢ Repair jointing for large scale and small scale						■	■	■
➢ Laying pipelines						■	■	■
➢ Install valves, flow-meters, saddle, etc.						■	■	■
Curriculum 7: Basic operation of personal computer, graphing by using excel								
➢ PC operation						■	■	■
➢ Calculation by using Excel						■	■	■
➢ Drawing graph by using Excel						■	■	■

Source: Project Team

(4) Training Cost

Cost of seven curriculums for HRD plan is shown in Table 8-2. The cost estimated based on the training schedule is to be about NGN6.0million (NGN2.5mil. for the year 2019 +NGN3.5mil. for the year 2020) for two years.

Unit prices (as of May 2018) applied for the Mid-term Strategic Plan 2019-2023 are as follows:

- Fuel: NGN145 per litter
- Stationery: NGN500 per set
- Daily allowance for lecturer: NGN5,000 per lecturer
- Refreshment: NGN2,000 per person

Other conditions such as daily driving millage, etc. are as below:

- Daily driving millage: 50km per vehicle
- Fuel consumption: 5km per litter
- Number of participants for a lecture: 15 persons (Max.)

Table 8-2 Training Cost

Training Curriculum	2019						2020					
	Number of Subjects	Days of Lecture	Fuel for lecture (attending lecture and going sites) (k. NGN)	Stationery	Field allowance for lecturers (k. NGN)	Refreshment (k. NGN)	Number of Subjects	Days of Lecture	Fuel for lecture (attending lecture and going sites) (k. NGN)	Stationery	Field allowance for lecturers (k. NGN)	Refreshment (k. NGN)
Curriculum 1: Basic and Common Knowledge about NRW (5 Area Offices)	3	1	22	23	15	90	1	1	7	8	5	30
Curriculum 2: Management of Pipelines (3 Area Offices)	3	3	39	68	45	270	1	3	13	23	15	90
Curriculum 3: Management of Data (5 Area Offices)	2	2	29	30	20	120	2	2	29	30	20	120
Curriculum 4: Leakage and Illegal Connection Survey (5 Area Offices)							3	3	65	68	45	270
Curriculum 5: Streamlining of billing system and examination on unifying water meters (5 Area Offices)							3	3	65	68	45	270
Curriculum 6: Plumbing for repair and or replacing pipelines (5 Area Offices)							3	3	65	68	45	270
Curriculum 7: Basic operation of personal computer , graphing by using excel (3 Area Offices)							3	2	26	45	30	180
Sub-total (k. NGN)			90	120	80	480			271	308	205	1,230
						770						**2,014**
Materials for training	Number of PCs & anti-virus to be purchased		Unit price (k. NGN)		Total Price (k. NGN)		Number of PCs & anti-virus to be purchased		Unit price (k. NGN)		Total Price (k. NGN)	
PC (Laptop PC) to be purchased	7		250		1,750		6		250		1,500	
Sub-total (k. NGN)					**1,750**						**1,500**	
Ground-total (k. NGN)					**2,520**						**3,514**	

Source: Project Team

9. Recommendation

Generally, FCTWB has a number of challenges to not only implement NRW reduction in the long term but also become an autonomous body pursuing revenue.

9.1 Distribution

(1) Improvement in As-Built Drawings and Drawing Management

FCTWB has operated and maintained facilities, while FCDA has been in charge of infrastructure development.

It is important for FCTWB to review and improve procedures of drawing collection from FCDA and feedback issues in O&M to FCDA. In addition, all the documents required for O&M should be sorted out so that everyone can access information avoid monopolization for information at individual level.

(2) Calibration of Customer Meters

Even though water meters are replaced with new ones and or installed newly, meters will be inaccurate gradually without regular maintenance and periodical replacement. For example, the participants for the training in Japan observed that replacement of water meters are regulated in Japan every eight years, regardless of meter types. Conventional meters available in local markets vary in quality, so FCTWB needs to establish a simplified meter laboratory for meter-accuracy test by using reference meters, and also prepare a fact-finding report for guideline on meter standardization in the future.

9.2 Commerce

(1) Improvement in Update of Customer Database

Management of customer data including meter-reading data and payment records has not been unified timely among HQ and Area Offices.

FCTWB HQ should unify database of customers' information among HQ and Area Offices, update, improve it and well-manage customer data.

(2) Streamlining of Customer Category

Customers are categorized as domestic, commercial (un-coded), major consumer (co-operate body, mini-hotel / restaurant, major consumer, petrol station / plaza, private school / clinic), institution (embassy / high commission, ministry, liaison office, religion), public tap / convenience & kiosk, and lifting point (bulk selling. This mixture caused difficulty in data assembling in the pilot project.

FCTWB should lessen a number of categories for simplified customer management.

(3) Simplification and Quality Assurance of Customer Meter

The strategic plan includes an operation to review customer meter types by meter laboratory using reference meters so that FCTWB brings the future metering policy, standardization and licensing in view.

In order to simplify billing system of FCTWB, the best way is to unify water meters. However, if it difficult for FCTWB to unify them from political aspect in terms of procurement of water meters, FCTWB should establish a work process of periodical field monitoring with function check of AMR and prepaid meters and improve bank statement monitoring for prepaid meters against technical issues of AMR and prepaid meters for the time being.

(4) Elimination of Estimating Billing System

In order to bill the amount accurately for computing IWA water balance, FCTWB should give responsibilities of reading to Area Offices close to customers, then HQ' Units should specialise supervision of them.

The strategic plan includes an operation to eliminate flat-rate customers by installing or replacing meters, but FCTWB should prevent reoccurrence thoroughly.

To reduce estimating bills, FCTWB should discuss enhancement in staff's performance of duties with awareness-rising, adequate logistics, thorough monitoring of reading regardless of meter types, review of reading frequency (i.e. once a month to once in two months), meter installation and replacement of malfunctioning maters, and meter reposition to outside property or empowering FCTWB for reading accessibility or illegal connection check.

(5) Duplicated / Return Bills

In order to ensure correct billing for computing IWA water balance and avoid complain from customers, FCTWB should deactivate or eliminate duplicated/return bills promptly, and establish proper addressing, procedures and management of billing information to prevent reoccurrence.

(6) Simplification and Revision of Water Tariff System

To simplify financial analysis for computing IWA water balance, FCTWB should review water tariff system for simplification on the occasion of autonomy as well as revision (reduction) in tariff as a result of financial analysis as stated in '3.4'.

(7) Elimination of Unauthorized Consumption

Regardless of meter types and customer categories such as domestic and large consumers, technical staff and meter readers need to inspect water meters, surroundings and monitor consumption data routinely to track irregularities. FCTWB should pay attention to possible illegal connections on service pipes which may be extended to public taps located in informal settlements, so-called "villages".

9.3 Finance

The following management of the FCTWB is not functioned effectively; this caused us a great deal of difficulty for the financial study. Regardless to say, a quick and timely provision of the data and information to the managerial officers is also an important role. The enhancement of the functions is duly taken account as well as the regular financial activities of the Department.

(1) Fixed Asset Management

Every fixed asset must be booked and managed properly in the following manners envisaging a regular maintenance and future renewal.

- Entry: acquisition date and price, specification, place located, department responsible, etc.
- Disposal: sale, disuse and retirement, etc.
- Inventory check: periodically once a year visa-vis the fixed assets book

(2) Water Cost Management

A cost center has to be functionalized to learn the actual water cost of FCTWB; the unit cost, Naira/m^3, should be calculated at least once a year. The data in chronological order will suggest a lot of managerial information through analysis on why increased or decreased and setting a water tariff as well.

9.4 Administration

(1) Improvement in ICT System and Intranet

FCTWB have no well-established system using information and communication technology as well as an intranet and or internet with security protection, so FCTWB should develop them for smooth information sharing and communication.

(2) Improvement in Office Environment

HQs' office is composed of small rooms which are not suitable for a water utility office, and also Area Offices use ordinary flat house, prefabricated house or container. FCTWB should improve office environment as electric power is stabilized for doing with daily work efficiently.

(3) Human Resource Development

FCTWB should prepare comprehensive training programme based on assessment for each level of staff in accordance with business plan and the strategic plan.

Appendix-1: Cost for NRW Reduction Operations in PMA

Table A1-1 PMA (Gudu)

Area Office								
Items	Commercial			Distribution			Cost	
	Man	Days	Man-days	Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
One Week Interval Meter Reading	16	14	224	14	14	196	1,000	420
Leakage Survey	3	21	63	14	21	294	1,000	357
Leakage Repair	1	10	10	13	10	130	1,000	140
Illegal Connection Survey	1	21	21	14	21	294	1,000	315
Measures against Illegal Connection	2	6	12	8	6	48	1,000	60
Meter Installation	0	0	0	10	3	30	1,000	30
Tank Investigation	16	5	80	14	5	70	1,000	150
Meter Test (Meter Inaccuracy)	1	21	21	14	21	294	1,000	315
Measurment of 24 hours Water Flow	1	7	7	7	7	49	1,000	56
Step Test	4	10	40	6	10	60	1,000	100
Fuel for Operations			2,500	L	145	NGN/L		363
Sub-Total Cost								2,306
HQ								
Items				Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
One Week Interval Meter Reading				0	0	0	1,000	0
Leakage Survey				3	21	63	1,000	63
Leakage Repair				3	10	30	1,000	30
Illegal Connection Survey				3	21	63	1,000	63
Measures against Illegal Connection				3	6	18	1,000	18
Meter Installation				3	3	9	1,000	9
Tank Investigation				0	0	0	1,000	0
Meter Test (Meter Inaccuracy)				3	21	63	1,000	63
Measurment of 24 hours Water Flow				3	7	21	1,000	21
Step Test				3	10	30	1,000	30
Fuel for Operations	10.5	L/day	99	days	145	NGN/L		151
Sub-Total Cost								448
Equipment and Materials (k.NGN)								
Survey Equipment from Japn								35,382
Equipment for PMA Making (Valves, Flowmeters etc.)								623
Materials for MPA Making (Chamber Making)								120
Materials for NRW Reduction Activities								2,071
Sub-Total Cost								38,196
Ground Total (k. NGN)								40,949

Source: Project Team

Table A1-2 PMA (Jabi)

Items	Man	Days	Man-days	Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
Area Office								
	Commercial			Distribution			Cost	
One Week Interval Meter Reading	12	5	60	0	0	0	1,000	60
Leakage Survey	8	10	80	8	12	96	1,000	176
Leakage Repair	0	0	0	8	13	104	1,000	104
Illegal Connection Survey	8	4	32	6	10	60	1,000	92
Measures against Illegal Connection	0	0	0	4	8	32	1,000	32
Meter Installation	6	7	42	9	26	234	1,000	276
Tank Investigation	0	0	0	0	0	0	1,000	0
Meter Test (Meter Inaccuracy)	8	14	112	10	14	140	1,000	252
Measurment of 24 hours Water Flow	3	2	6	6	2	12	1,000	18
Step Test	4	3	12	8	2	16	1,000	28
Fuel for Operations			3,000	L	145	NGN/L		435
Sub-Total Cost								1,473
HQ								
Items				Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
One Week Interval Meter Reading				0	0	0	1,000	0
Leakage Survey				3	12	36	1,000	36
Leakage Repair				3	13	39	1,000	39
Illegal Connection Survey				3	10	30	1,000	30
Measures against Illegal Connection				3	8	24	1,000	24
Meter Installation				3	26	78	1,000	78
Tank Investigation				0	0	0	1,000	0
Meter Test (Meter Inaccuracy)				3	14	42	1,000	42
Measurment of 24 hours Water Flow				3	2	6	1,000	6
Step Test				3	2	6	1,000	6
Fuel for Operations	22.1	L/day	87	days	145	NGN/L		279
Sub-Total Cost								540
Equipment and Materials (k.NGN)								
Survey Equipment from Japn								35,382
Equipment for PMA Making (Valves, Flowmeters etc.)								2,638
Materials for MPA Making (Chamber Making)								280
Materials for NRW Reduction Activities								7,186
Sub-Total Cost								45,485
Ground Total (k. NGN)								47,498

Source: Project Team

Table A1-3 PMA (Garki I)

Area Office								
Items	Commercial			Distribution			Cost	
	Man	Days	Man-days	Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
One Week Interval Meter Reading	8	6	48	0	0	0	1,000	48
Leakage Survey	5	10	50	7	10	70	1,000	120
Leakage Repair	0	0	0	7	20	140	1,000	140
Illegal Connection Survey	5	5	25	7	5	35	1,000	60
Measures against Illegal Connection	0	0	0	7	5	35	1,000	35
Meter Installation	0	0	0	7	25	175	1,000	175
Tank Investigation	0	0	0	0	0	0	1,000	0
Meter Test (Meter Inaccuracy)	6	50	300	4	50	200	1,000	500
Measurment of 24 hours Water Flow	2	1	2	7	1	7	1,000	9
Step Test	2	1	2	7	1	7	1,000	9
Fuel for Operations			2,500	L	145	NGN/L		363
Sub-Total Cost								1,459
HQ								
Items				Man	Days	Man-days	Field Allowance (NGN)	Cost (k. NGN)
One Week Interval Meter Reading				0	0	0	1,000	0
Leakage Survey				3	10	30	1,000	30
Leakage Repair				3	20	60	1,000	60
Illegal Connection Survey				3	5	15	1,000	15
Measures against Illegal Connection				3	5	15	1,000	15
Meter Installation				3	25	75	1,000	75
Tank Investigation				0	0	0	1,000	0
Meter Test (Meter Inaccuracy)				3	50	150	1,000	150
Measurment of 24 hours Water Flow				3	1	3	1,000	3
Step Test				3	1	3	1,000	3
Fuel for Operations	12.9	L/day	117	days	145	NGN/L		219
Sub-Total Cost								570
Equipment and Materials (k.NGN)								
Survey Equipment from Japn								35,382
Equipment for PMA Making (Valves, Flowmeters etc.)								8,969
Materials for MPA Making (Chamber Making)								240
Materials for NRW Reduction Activities								2,318
Sub-Total Cost								46,909
Ground Total (k. NGN)								48,937

Source: Project Team

Appendix-2: Initial & Recurrent Cost and Yielded Revenue by NRW Reduction Operations

Table A2-1 Initial & Recurrent Cost of the NRW Reduction Operation

No.	Items	Main Causes of NRW	Gudu	Jabi	Garki I
(1)	Initial Cost incurred for the Pilot Project (k. NGN)		40,949	47,498	48,937
(2)	Ratio of Cost (%)	Nominal Excess Use	23.4	25.9	47.3
		Unbilled Unmetered & Inaccuracy	2.4	30	18.2
		Illegal & Physical Losses	74.1	45.1	34.5
(3)	Initial Cost by Measure (k. NGN) (1) x (2) /100	Nominal Excess Use	9,582	12,302	23,147
		Unbilled Unmetered & Inaccuracy	983	14,249	8,907
		Illegal & Physical Losses	30,343	21,422	16,883
(4)	Initial & Recurrent Cost for NRW Reduction Operation (k. NGN) (3) x 2 times	Nominal Excess Use	19,164	24,604	46,294
		Unbilled Unmetered & Inaccuracy	1,966	28,499	17,813
		Illegal & Physical Losses	60,686	42,843	33,767
		Total	81,816	95,946	97,874

Source: Project Team

Table A2-2 Yielded Revenue by NRW Reduction Operations

No.	Items	Main Causes of NRW	Gudu	Jabi	Garki I
(1)	Baseline	Nominal Excess Use (%)	7.0	1.2	12.1
		Unbilled Unmetered & Inaccuracy (%)	4.0	-1.6	6.5
		Illegal & Physical Losses (%)	42.2	70.5	56.1
		Total (%)	53.2	70.1	74.7
(2)	Ex-Post	Nominal Excess Use (%)	6.4	0.3	4.7
		Unbilled Unmetered & Inaccuracy (%)	3.4	2.4	5.9
		Illegal & Physical Losses (%)	10.6	28.3	24.1
		Total (%)	20.4	31.0	34.7
(3)	Reduction Percentage (1)-(2)	Nominal Excess Use (%)	0.6	0.9	7.4
		Unbilled Unmetered & Inaccuracy (%)	0.6	-4.0	0.6
		Illegal & Physical Losses (%)	31.6	42.2	32.0
		Total (%)	32.8	39.1	40.0
(4)	System Input Water Volume (m^3/day)		3,102	7,119	2,852
(5)	Reduced NRW Volume (m^3/day) (3) x (4) /100	Nominal Excess Use	19	64	211
		Unbilled Unmetered & Inaccuracy	19	-285	17
		Illegal & Physical Losses	980	3,004	913
		Total	1,017	2,784	1,141
(6)	Reduced NRW Volume (m^3/year) (5) x 365 days	Nominal Excess Use	6,793	23,386	77,033
		Unbilled Unmetered & Inaccuracy	6,793	-103,937	6,246
		Illegal & Physical Losses	357,785	1,096,540	333,114
		Total	371,371	1,015,988	416,392
(7)	Average Water Sales Price (NGN/m^3)		90	90	90
(8)	Expected Water Sales per year (k. NGN) (6) x (7) / 1,000	Nominal Excess Use	611	2,104	6,932
		Unbilled Unmetered & Inaccuracy	611	-9,355	562
		Illegal & Physical Losses	32,200	98,688	29,980
		Total	33,422	91,437	37,474
(9)		Nominal Excess Use	1,833	6,312	20,796

No.	Items	Main Causes of NRW	Gudu	Jabi	Garki I
	Expected Water Sales for three years (k. NGN) (8) x 3 years	Unbilled Unmetered & Inaccuracy	1,833	-28,065	1,686
		Illegal & Physical Losses	96,600	296,064	89,940
		Total	100,266	274,311	112,422

Appendix-3.1: Conditions for estimating Man-day required for NRW Reduction Operations

Table A3-1 Condition for estimating Man-day

Condition for estimating Man-day	Scenario				
	a	b	c	d	e
(1) Network Drawings and Data (all Scenarios)					
1) Print base maps: One person for Area Office x 5 days = 5 man-days/Area Office (GIS Unit) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 5 man-days/Area Office x 4 Area Offices = **<u>20 man-days (GIS Unit)</u>** - 2nd to 5th year: 5 man-days/Area Office x 3 Area Offices = **<u>15 man-days (GIS Unit)</u>**	X	X	X	X	X
2) Site investigation and drawing pipelines: 3 persons for Area Office x 5 days = 15 man-days/Area Office (Area Office) Number of Area Office where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 15 man-days/Area Office x 4 Area Offices **= <u>60 man-days (Area Office)</u>** - 2nd to 5th year: 15 man-days/Area Office x 3 Area Offices **= <u>45 man-days (Area Office)</u>**	X	X	X	X	X
3) Confirmation and revising of drawings at the site: 1 person per Area Office x 2 days = 2 man-days/Area Office (GIS Unit) 2 persons per Area Office x 2 days = 4 man-days (Area Office) Input data of the handwriting drawings to GIS mapping 3 persons per Area Office x 10 days = 30 man-days/Area Office (GIS Unit) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: **[For GIS Unit]** - 1st year: (2 + 30) man-days/Area Office x 4 Area Offices = **<u>128 man-days</u>** - 2nd to 5th year: (2 + 30) man-days/Area Office x 3 Area Offices = **<u>96 man-days</u>** **［For Area Office］** - 1st year: 4 man-days/Area Office x 4 Area Offices = **<u>16 man-days</u>** - 2nd to 5th year: 4 man-days/Area Office x 3 Area Offices = **<u>12 man-days</u>**	X	X	X	X	X
(2) Customer Enumeration					
a) Customer Map (all Scenarios)					

1) Print plots maps: 1 person for Area Office x 5days = 5 man-days/Area Office (GIS Unit) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: -1st year: 5 man-days/Area Office x 4 Area Offices **= 20 man-days (GIS Unit)** - 2nd to 5th year: 5 man-days/Area Office x 3 Area Offices **=15 man-days (GIS Unit)**	X	X	X	X	X
2) Site investigation and writing customer information on plots maps: 3 persons for Area Office x 5days = 15 man-days/Area Office (Area Office) Number of Area Offices where the work will be done by year: - 1st year:4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 15 man-days/Area Office x 4 Area Offices **= 60 man-days (Area Office)** - 2nd to 5th year: 15 man-days/Area Office x 3 Area Offices **= 45 man-days (Area Office)**	X	X	X	X	X
3) Input data of the handwriting drawings to GIS mapping: 3 persons for Area Office x 10 days = 30 man-days/Area Office (GIS Unit) Number of Area Offices where the work will be done by year: - 1st year:4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 30 man-days/Area Office x4 Area Offices **= 120 man-days (GIS Unit)** - 2nd to 5th year: 30 man-days/Area Office x3 Area Offices **= 90 man-days (GIS Unit)**	X	X	X	X	X
b) Customer Enumeration (DMA, Scenario-a)					
1) Prepare customer lists and annual water consumption of customers: 1 person for Area Office x 10 days = 10 man-days/Area Office (Area Office) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 10 man-days/Area Office x 4 Area Offices **= 40 man-days (Area Office)** - 2nd to 5th year: 10 man-days/Area Office x 3 Area Offices **= 30 man-days (Area Office)**	X				
2) Calculate hourly water consumption: 1 person for Area Office x 1 day = 1 man-day/Area Office (Area Office) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 1man-day/Area Office x 4 Area Offices **= 4 man-days (Area Office)** - 2nd to 5th year: 1man-day/Area Office x 3 Area Offices **= 3 man-days (Area Office)**	X				
c) DMA Coding (DMA, Scenario-a)					

DMA coding by data from Area Offices: 1 person for area x 5 days = 5 man-days/Area Office (Billing Unit) Number of Area Offices where the work will be done by year: - 1st year: 4 Area Offices - 2nd to 5th year: 3 Area Offices each year Total man-days: - 1st year: 5 man-days/Area Office x 4 Area Offices **= <u>20 man-days (Billing Unit)</u>** - 2nd to 5th year: 5 man-days/Area Office x 3 Area Offices **= <u>15 man-days (Billing Unit)</u>**	X				
d) Customer Enumeration (Zone, all Scenarios)					
1)-1. Prepare customer lists and annual water consumption of customers from billing system: 1 person for office x 1 day = 1 man-day/Area Office (Billing Unit) **1)-2. Elimination of return/duplicated bills:** 1 person for Area Office x 5 days = 5 man-days/Area Office (Billing Unit) Number of Area Offices where the work will be done by year: - 1st to 5th year: 16 Area Offices each year Total man-days: - 1st to 5th year: (1+5) man-days/Area Office x 16 Area Offices **= <u>96 man-days (Billing Unit)</u>**	X	X	X	X	X
2) Calculate hourly water consumption: 1 person for Area Office x 1 day = 1 man-day/Area Office (Billing Unit) Number of Area Offices where the work will be done by year: - 1st to 5th year: 16 Area Offices each year Total man-days: - 1st to 5th year: 1 man-day/Area Office x 16 Area Offices **= <u>16 man-days (Billing Unite)</u>**	X	X	X	X	X
(3) DMA Design, Creation and Prioritization					
a) The choice of DMA (Scenario-a)					
1) Choose DMA: 3 persons for Area Office x 1 day = 3 man-days/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days (NRW Unit)</u>** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days (Area Office)[For NRW Unit]</u>** **<u>[For Area Office]</u>** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days (Area Office)</u>** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days (Area Office)</u>**	X				

2) Print pipeline network drawings: One person for Area Office x one day = 1 man-day/Area Office (GIS Unit) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days (GIS Unit)</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days (GIS Unit)</u>**	X				
3) Enumeration of existing and required flow meter and valves for isolation: 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 1 person for Area Office x 1day = 1 man-day/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>**	X				
4) Confirmation of inlet and outlet points of pipeline network boundary: 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days</u>** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days</u>**	X				
5) Preparation/Update of customer information within the DMA: 1 person for Area Office 1 day = 1 man-day/Area Office (commercial staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days (Commercial Staff of Area Office)</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days (commercial Staff of Area Office)</u>**	X				

6) Identification of functional customer water meters and valves: 3 persons for Area Office x 5 days = 15 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: - 1st to 3rd year:15 man-days/Area Office x 3 Area Offices **= <u>45 man-days(Distribution Staff of Area Office) (Area Office)</u>** - 4th to 5th year:15 man-days/Area Office x 2 Area Offices **= <u>30 man-days (Distribution Staff of Area Office) (Area Office)</u>**	X				
7) Request quotation and purchase flow meters and valves: 1 person for Area Office x 5 days = 5 man-days/Area Office (NRW Unit) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Tota man-days: - 1st to 3rd year: 5 man-days/Area Office x 3 Area Offices **= <u>15 man-days (NRW Unit)</u>** - 4th to 5th year: 5 man-days/Area Office x 2 Area Offices **= <u>10man-days (NRW Unit)</u>**	X				
8)-1. Design chambers for flow meters and valves: 1 person for Area Office x 10 days = 10 man-days/Area Office (NRW Unit) **8)-2. Inspect building chambers and installation of flow meters and valves:** 1 person for Area Office x 5 days = 5 man-days/Area Office (NRW Unit) 3 persons for Area Office x 5 days = 15 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: (10 + 5) man-days/Area Office x 3 Area Offices **= <u>45 man-days</u>** - 4th to 5th year: (10 + 5) man-days/Area Office x 2 Area Offices **<u>= 30 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 15 man-days/Area Office x 3 Area Offices **= <u>45 man-days</u>** - 4th to 5th year: 15 man-days/Area Office x 2 Area Offices **=<u> 30 man-days)</u>**	X				
b) Prioritization in NRW Reduction in DMA (Scenario-a)					

1) Make SMAs two or three in DMA: 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 1 person for Area Office 1 day = 1 man-day/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>**	X				
2) Measure night water flow of each SMAs by step test: 3 persons for Area Office x 1 day = 3 man-days/Area Office (NRW Unit) 5 persons for Area Office 1 day = 5 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 3man-day/Area Office x 3 Area Offices **= <u>9 man-days</u>** - 4th to 5th year: 3 man-day/Area Office x 2 Area Offices **= <u>6 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 5 man-day/Area Office x 3 Area Offices **= <u>15 man-days</u>** - 4th to 5th year: 5 man-day/Area Office x 2 Area Offices **= <u>10 man-days</u>**	X				
3) Prioritize SMA by MNF and customer data: 3 persons for Area Office x 1 day = 3 man-days/Area Office (NRW Unit) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days (NRW Unit)</u>** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days (NRW Unit)</u>**	X				
(4) Zonal Prioritization (Scenario-d and e)					
1) Collect data: 1 person for all zone x 1day/time = 1 man-day/all zone/ month (NRW Unit) Number of times how often the work will be done by year: - 1st to 5th year: 1 time/ month x 12 months in a year Total man-days: - 1st to 5th year: 1 man-day/time x 12 times/year **= <u>12 man-days (NRW Unit)</u>**				X	X

2) Prioritize zone: 1 person for all zone x 1day/time = 1 man-day/all zone/ month (NRW Unit) Number of times how often the work will be done by year: - 1st to 5th year: 1 time/ month x 12 months in a year Total man-days: - 1st to 5th year: 1 man-day/time x 12 times/year **= <u>12 man-days (NRW Unit)</u>**				X	X
(5) Field Inspection (Scenario-a)					
a) Confirm existing flow meters and valves at the site					
Confirm existing flow meters and valves at the site: 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year:1 man-day/Area Office x 3 Area Offices **= <u>3 man-days</u>** - 4th to 5th year: 1 man-day/Area Office x 2 Area Offices **= <u>2 man-days</u>** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days</u>** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days</u>**	X				
b) Procurement of necessary flow meters and valves for making DMA					
Request quotation and purchase flow meters and valves: 1 person for Area Office x 5 days = 5 man-days/Area Office (NRW Unit) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: - 1st to 3rd year: 5 man-days/Area Office x 3 Area Offices **=<u>15 man-days (NRW Unit)</u>** - 4th to 5th year: 5 man-days/Area Office x 2 Area Offices **= <u>10 man-days (NRW Unit)</u>**	X				
(6) Isolation by Installing Flow-meters and Valves					

1) Design chambers for flow meters and valves: 1 person for Area Office x 10 days = 10 man-days/Area Office (NRW Unit) **2) Inspect building chambers and installation of flow meters and valves:** 1 person for Area Office x 5 days = 5 man-days/Area Office (NRW Unit) 3 persons for Area Office x 5 days = 15 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: (10 + 5) man-days/Area Office x 3 Area Offices **= 45 man-days** - 4th to 5th year: (10 + 5) man-days/Area Office x 2 Area Offices **= 30 man-days** [**For Distribution Staff of Area Office)** - 1st to 3rd year: 15 man-days/Area Office x 3 Area Offices **= 45 man-days** - 4th to 5th year: 15 man-days/Area Office x 2 Area Offices **= 30 man-days**	X				
(7) Step-test in DMA (Scenario-a)					
a) Step-testing DMA					
Step-test in DMA: 3 persons for Area Office x 1 day = 3 man-days/Area Office (NRW Unit) 5 persons for one Area Office x 1 day = 5 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= 9 man-days** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= 6 man-days** **[For Distribution Staff of Area Office]** - 1st to 3rd year: 5 man-days/Area Office x 3 Area Offices **= 15 man-days** - 4th to 5th year: 5 man-days/Area Office x 2 Area Offices **= 10 man-days**	X				
b) Measurement of Minimum Night Flow in DMA					
Measurement of Minimum Night Flow in DMA: 3 persons for Area Office x 1 day = 3 man-days/Area Office (NRW Unit) 5 persons for Area Office x 1 day = 5 man-days/Area Office (Distribution Staff of Area Office) Number of Area Offices (except Jabi, Gudu, Garki I) where the work will be done by year: - 1st to 3rd year: 3 Area Offices each year - 4th to 5th year: 2 Area Offices each year Total man-days: **[For NRW Unit]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= 9 man-days** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= 6 man-days** **[For Distribution Staff of Area Office]** - 1st to 3rd year:5 man-days/Area Office x 3 Area Offices **= 15 man-days**	X				

- 4th to 5th year: 5 man-days/Area Office x 2 Area Offices **= 10 man-days**					
(8) Zonal Measurement (Scenario-d and e)					
1) Download water flow data from data logger at each tank: 1 person for all tanks x 3 days/time = 3 man-days/all tanks/month (NRW Unit) Number of times how often the work will be done by year: - 1st to 5th year: 1 time/ month x 12 months in a year Total man-days: - 1st to 5th year: 3 man-day/time x 12 times/year **= 36 man-days (NRW Unit)**				X	X
2) Make a graph and analyze data: 1 person for all zones x1 days/time = 1 man-days/all zones/month (NRW Unit) Number of times how often the work will be done by year: - 1st to 5th year: 1 time/ month x 12 months in a year Total man-days: - 1st to 5th year: 1 man-day/time x 12 times/year **= 12 man-days (NRW Unit)**				X	X

(9) Leakage Detection

a) Scenario-a (DMA approach, Zone approach, and Patrol)

Year	2019	2020	2021	2022	2023
1st 3 area offices (A, B, C office)	DMA	DMA	Zone (2)	Zone (2)	Zone (2)
2nd 3 area offices (D, E, F office)	Patrol	DMA	DMA	Zone (2)	Zone (2)
3rd 3 area offices (G, H, I office)	Patrol	Patrol	DMA	DMA	Zone (2)
4th 2 area offices (J, K, L office)	Patrol	Patrol	Patrol	DMA	DMA
5th 2 area offices (M, N office)	Patrol	Patrol	Patrol	Patrol	DMA

Note: Zone (1) means Training period (accompany with trainer)
Note: Zone (2) means Individual survey (without trainer)

[DMA] (1st year) (3 DMAs: 3 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team for 1 DMA x 2 days/ week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** 1st year: 6 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 1,872 man-days/year** **[For Distribution Staff of Area Office]** - 1st year: 2 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 624 man-days/year**	X				
[DMA] (1st year) (3DMAs: 3 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 1 day/week = (2+1) man-days/team/week = 3 man-days/team/week (distribution staff of Area Office) Total man-days: - 1st year: 3 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 936 man-days (Distribution Staff of Area Office)**	X				

[DMA] (2nd-3rd year) (6 DMAs: 6 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team for 1 DMA x 2 days/week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of area Office]** - 2nd to 3rd year: 6 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>3,744 man-days/year</u>** **[For Commercial Staff of Area Office]** - 2nd to 3rd year: 2 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,248 man-days/year</u>**	X				
[DMA] (2nd-3rd year) (6DMAs: 6 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 1 day/week = (2+1) man-days/team/week =3 man-days/team/week (distribution staff of Area Office) Total man-days: - 2nd to 3rd year: 3 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **<u>= 1,872 man-days/year (distribution staff of Area Office)</u>**	X				
[DMA] (4th year) (5 DMA: 5 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 2 days/week = (2+1)x2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team for 1 DMA x 2 days/week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 4th year: 6 man-days/team/week x 2 teams/Area Office x 5 Area Offices x 52 weeks/year **= <u>3,120 man-days/year</u>** **[For Commercial Staff of Area Office]** - 4th year: 2 man-days/team/week x 2 teams/Area Office x 5 Area Offices x 52 weeks/year **= <u>1,040 man-days/year</u>**	X				
[DMA] (4th year) (5 DMAs: 5 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 1 day/week = (2+1) man-days/team/week = 3 man-days/team/week (distribution staff of Area Office) Total man-days: - 4th year: 3 man-days/team/week x 2 teams/Area Office x 5 Area Offices x 52 weeks/year **= <u>1,560 man-days/year (distribution staff of Area Office)</u>**	X				

[DMA] (5th year) (4 DMAs: 4 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 2 days/week = (2+1)x2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team for 1 DMA x 2 days/week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 5th year: 6 man-days/team/week x 2 teams/Area Office x 4 Area Offices x 52 weeks/year **= 2,496 man-days/year** **[For Commercial Staff of Area Office]** - 5th year: 2 man-days/team/week x 2 teams/Area Office x 4 Area Offices x 52 weeks/year **= 832 man-days/year**	X				
[DMA] (5th year) (4 DMAs: 4 Area Offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for 1 DMA x 1 day/week = (2+1) man-days/team/week = 3 man-days/team/week (distribution staff of Area Office) Total man-days: - 5th year: 3 man-days/team/week x 2 teams/Area Office x 4 Area Offices x 52 weeks/year **= 1,248 man-days/year (distribution staff of Area Office)**	X				
[Patrol] (1st year) (10 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Patrol of Surface Leakage and Illegal Connections:** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for Area Office x 5 days/week = (2+1) x 5 man-days/week/Area Office = 15 man-days/week/Area Office (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 1st year: 15 man-days/week/ Area Office x 10 Area Offices x 52 weeks/year **= 7,800 man-days/year** **[For commercial Staff of Area Office]** - 1st year: 5 man-days/week/ Area Office x 10 Area Offices x 52 weeks/year **= 2,600 man-days/year**	X				
[Patrol] (2nd year) (7 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Patrol of Surface Leakage and Illegal Connections:** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for Area Office x 5 days/week = (2+1) x 5 man-days/week/Area Office = 15 man-days/week/Area Office (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 2nd year: 15 man-days/week/ Area Office x 7 Area Offices x 52 weeks/year **= 5,460 man-days/year** **[For commercial Staff of Area Office]** - 2nd year: 5 man-days/week/ Area Office x 7 Area Offices x 52 weeks/year **= 1,820 man-days/year**	X				

[Patrol] (3rd year) (4 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Patrol of Surface Leakage and Illegal Connections:** 2 persons for Area Office x 5 days/week = 10 man-days/week/Area Office (distribution staff of Area Office) 1 person for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[Distribution Staff of Area Office]** - 3rd year: 10 man-days/week/ Area Office x 4 Area Offices x 52 weeks/year **=2,080 man-days/year** **[Commercial Staff of Area Office]** - 3rd year: 5 man-days/week/ Area Office x 4 Area Offices x 52 weeks/year **=1,040 man-days/year**	X				
[Patrol] (4th year)(2 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Patrol of Surface Leakage and Illegal Connections:** 2 persons for Area Office x 5 days/week = 10 man-days/week/Area Office (distribution staff of Area Office) 1 person for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[Distribution Staff of Area Office]** - 4th year: 10 man-days/week/ Area Office x 2 Area Offices x 52 weeks/year **=1,040 man-days/year** **[Commercial Staff of Area Office]** - 4th year: 5 man-days/week/ Area Office x 2 Area Offices x 52 weeks/year **=520 man-days/year**	X				
[Zone] (3rd year) (3 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 2 days/week = 2 x2 man-days/team/week = 4 man-days/team/week (distribution staff of Area Office) 1 person/team for 1 DMA x 2 days/week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 3rd year: 4 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 1,248 man-days/year** **[For Commercial Staff of Area Office]** - 3rd year: 2 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 624 man-days/year**	X				
[Zone] (3rd year) (3 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 1 day/week = 2 man-days/team/week (distribution staff of Area Office) Total man-days: -3rd year: 2 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= 624 man-days/year (distribution staff of Area Office)**	X				
[Zone] (4th year) (6 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 2 days/week = 4 man-days/team/week (distribution staff of Area Office) 1 person/team x 2 days per week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]**	X				

-4th year: 4 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>2,496 man-days/year</u>** **[For Commercial Staff of Area Office]** - 4th year: 2 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,248 man-days/year</u>**					
[Zone] (4th year) (6 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 1 day per week = 2 man-days/team/week (distribution staff of Area Office) Total man-days: - 4th year: 2 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,248 man-days/year (distribution staff of Area Office)</u>**	X				
[Zone] (5th year) (9 Area offices) : refer to NRW Reduction Operation Schedule Scenario-a **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 2 days/week = 4 man-days/team/week (distribution staff of Area Office) 1 person/team x 2 days/week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Aea Office]** - 5th year: 4 man-days/team/week x 2 teams/Area Office x 9 Area Offices x 52 weeks/year **= <u>3,744 man-days/year</u>** **[For Commercial Staff of Aea Office]** - 5th year: 2 man-days/team/week x 2 teams/Area Office x 9 Area Offices x 52 weeks/year **= <u>1,872 man-days/year</u>**	X				
[Zone] (5th year) (9 Area offices: refer to NRW Reduction Operation Schedule Scenario-a) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons/team x 1 day/week = 2 man-days/team/week (distribution staff of Area Office) Total man-days: - 5th year: 2 man-days/team/week x 2 teams/Area Office x 9 Area Offices x 52 weeks/year **= <u>1,872 man-days/year (distribution staff of Area Office)</u>**	X				

b) Scenario-b (Zonal Approach and Patrol)

Year	2019	2020	2021	2022	2023
1st 3 area offices (A, B, C office)	Zone (1)	Zone (1)	Zone (2)	Zone (2)	Zone (2)
2nd 3 area offices (D, E, F office)	Patrol	Zone (1)	Zone (1)	Zone (2)	Zone (2)
3rd 3 area offices (G, H, I office)	Patrol	Patrol	Zone (1)	Zone (1)	Zone (2)
4th 2 area offices (J, K, L office)	Patrol	Patrol	Patrol	Zone (1)	Zone (1)
5th 2 area offices (M, N office)	Patrol	Patrol	Patrol	Patrol	Zone (1)

Note: Zone (1) means Training period (accompany with trainer)
Note: Zone (2) means Individual survey (without trainer)

[Zone] (1st year) (3 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team x 2 days/ week = 2 man-days/team/week (commercial staff of Area Office of 3 offices: refer to NRW Reducti) Total man-days: **[For Distribution Staff of Area Office]** - 1st year: 6 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= <u>1,872 man-days/year</u>** **[For Commercial Staff of Area Office]** - 1st year: 2 man-days/team/week x 2 teams/Area Office x3 Area Offices x 52 weeks/year **= <u>624 man-days/year</u>**		X			
[Zone] (1st year) (3 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 1 day/week = (2+1)x1 man-days/team/week = 3 man-days/team/week (distribution staff of Area Office) Total man-days: - 1st year: 3 man-days/team/week x 2 team/Area Office x 3 Area Offices x 52 weeks/year **= <u>936 man-days/year (distribution staff of Area Office)</u>**		X			
[Zone] (2nd year) (6 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of Area Office) 1 person/team x 2 days/ week = 2 man-days/team/week (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 2nd year: 6 man-days/team/week x 2 teams/Area Office x6 Area Offices x 52 weeks/year **= <u>3,744 man-days/year</u>** **[For Commercial Staff of Area Office]** - 2nd year: 2 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,248 man-days/year</u>**		X			
[Zone] (2nd year) (6 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 1 day/week = (2+1) x 1 man-days/team/week = 3 man-days/team/week (distribution staff of Area Office) Total man-days: - 2nd year: 3 man-days/team/week x 2 team/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,872 man-days/year (distribution staff of Area Office)</u>**		X			

[Zone] (3rd year) (9 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of 6 Area Offices) 2 persons/team x 2 days/week = 4 man-days/team/week (distribution staff of 3 Area Offices) 1 person/team x 2 days/week = 2 man-days/team/week (commercial staff of 9 Area Office) Total man-days: **[Distribution Staff of Area Office]** - 3rd year: 6 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>3,744 man-days/year</u>** - 3rd year: 4 man-days/team/week x 2 teams/Area Office x 3 Area Offices x 52 weeks/year **= <u>1,248 man-days/year</u>** **[Commercial Staff of Area Office]** -3rd year: 2 man-days/team/week x 2 teams/Area Office x 9 Area Offices x 52 weeks/year **<u>= 1,872 man-days/year</u>**		X			
[Zone] (3rd year) (9 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 1 day/week = (2+1)x1 man-days/team/week = 3 man-days/team/week (distribution staff of 6 Area Offices) 2 persons/team x 1 day/week = 2 man-days/team/week (distribution staff of 3 Area Offices) Total man-days: - 3rd year: 3 man-days/team/week x 2 team/Area Office x 6 Area Offices x 52 weeks/year **= <u>1,872 man-days/year (distribution staff of Area Office)</u>** - 3rd year: 2 man-days/team/week x 2 team/Area Office x 3 Area Offices x 52 weeks/year **<u>= 624 man-days/year (distribution staff of Area Office</u>**)		X			
[Zone] (4th year) (11 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with one trainer/team x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of 5 Area Offices) 2 persons/team x 2 days/week = 4 man-days/team/week (distribution staff of 6 Area Offices) 1 person/team x 2 days/week = 2 man-days/team/week (commercial staff of 11 Area Office) Total man-days: **[Distribution Staff of Area Office]** - 4th year: 6 man-days/team/week x 2 teams/Area Office x 5 Area Offices x 52 weeks/year **= <u>3,120 man-days/year</u>** - 4th year: 4 man-days/team/week x 2 teams/Area Office x 6 Area Offices x 52 weeks/year **= <u>2,496 man-days/year</u>** **[Commercial Staff of Area Office]** - 4th year: 2 man-days/team/week x 2 teams/Area Office x 11 Area Offices x 52 weeks/year **=<u> 2,288 man-days/year</u>**		X			

[Zone] (4th year) (11 Area office: refer to NRW Reduction Operation Schedule Scenario-b s) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 1 day/week = (2+1)x1 man-days/team/week = 3 man-days/team/week (distribution staff of 5 Area Offices) 2 persons/team x 1 day/week = 2 man-days/team/week (distribution staff of 6 Area Offices) Total man-days: - 4th year: 3 man-days/team/week x 2 team/Area Office x 5 Area Offices x 52 weeks/year **= 1,560 man-days/year (distribution staff of Area Office)** -4th year: 2 man-days/team/week x 2 team/Area Office x 6 Area Offices x 52 weeks/year **= 1,248 man-days/year (distribution staff of Area Office)**		X			
[Zone] (5th year) (13 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey at Each House:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 2 days/week = (2+1) x 2 man-days/team/week = 6 man-days/team/week (distribution staff of 4 Area Offices) 2 persons/team x 2 days/week = 4 man-days/team/week (distribution staff of 9 Area Offices) 1 person/team x 2 days/week = 2 man-days/team/week (commercial staff of 11 Area Office) Total man-days: **[Distribution Staff of Area Office]** - 5th year: 6 man-days/team/week x 2 teams/Area Office x 4 Area Offices x 52 weeks/year **= 2,496 man-days/year** - 5th year: 4 man-days/team/week x 2 teams/Area Office x 9 Area Offices x 52 weeks/year **= 3,744 man-days/year** **[Commercial Staff of Area Office]** - 5th year: 2 man-days/team/week x 2 teams/Area Office x 13 Area Offices x 52 weeks/year **= 2,704 man-days/year**		X			
[**Zone]** (5th year) (13 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Leakage Survey along Road:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team x 1 day/week = (2+1) x 1 man-days/team/week = 3 man-days/team/week (distribution staff of 4 Area Offices) 2 persons/team x 1 day/week = 2 man-days/team/week (distribution staff of 9 Area Offices) Total man-days: - 5th year: 3 man-days/team/week x 2 team/Area Office x 4 Area Offices x 52 weeks/year **= 1,248 man-days/year (distribution staff of Area Office)** - 5th year: 2 man-days/team/week x 2 team/Area Office x 9 Area Offices x 52 weeks/year **= 1,872 man-days/year (distribution staff of Area Office)**		X			

[Patrol] (1st year) (10 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Patrol of Surface Leakage and Illegal Connections:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for Area Office x 5 days/week = (2+1) x 5 man-days/week/Area Office = 15 man-days/week/Area Office (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 1st year: 15 man-days/week/ Area Office x 10 Area Offices x 52 weeks/year **= <u>7,800 man-days/year</u>** **[For Commercial Staff of Area Office]** - 1st year: 5 man-days/week/ Area Office x 10 Area Offices x 52 weeks/year **= <u>2,600 man-days/year</u>**		X			
[Patrol] (2nd year) (7 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Patrol of Surface Leakage and Illegal Connections:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for Area Office x 5 days/week = (2+1) x 5 man-days/week = 15 man-days/week (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week/Area Office = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 1st year: 15 man-days/week/ Area Office x 7 Area Offices x 52 weeks/year **= <u>5,460 man-days/year</u>** **[For Commercial Staff of Area Office]** - 1st year: 5 man-days/week/ Area Office x 7 Area Offices x 52 weeks/year **= <u>1,820 man-days/year</u>**		X			
[Patrol] (3rd year) (4 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Patrol of Surface Leakage and Illegal Connections:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons for Area Office x 5 days/week = 10 man-days/week/Area Office (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 3rd year: 10 man-days/week/ Area Office x 4 Area Offices x 52 weeks/year **= <u>2,080 man-days/year</u>** **[For Commercial Staff of Area Office]** - 3rd year: 5 man-days/week/ Area Office x 4 Area Offices x 52 weeks/year **= <u>1,040 man-days/year</u>**		X			
[Patrol] (4th year) (2 Area offices: refer to NRW Reduction Operation Schedule Scenario-b) **Patrol of Surface Leakage and Illegal Connections:** ***Leakage survey will be done by 2 teams/Area Office** 2 persons for Area Office x 5 days/week = 10 man-days/week (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week/Area Office = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 4th year: 10 man-days/week/ Area Office x 2 Area Offices x 52 weeks/year **= <u>1,040 man-days/year</u>** **[For Commercial Staff of Area Office]** - 4th year: 5 man-days/week/ Area Office x 2 Area Offices x 52 weeks/year **= <u>520 man-days/year</u>**		X			
c) Leakage Survey by NRW Unit (Scenario-d)					

Leakage Survey at Each House: ***Leakage survey will be done by 3 teams/NRW Unit and Area Office** 2 persons/team x 3 days/week = 6 man-days/team/week (NRW Unit) 1 person/team x 3 days/week = 3 man-days/team/week (commercial staff of Area Office) Total man-days: **[NRW Unit]** -1st to 5th year: 6 man-days/team/week x 3 teams x 52 weeks/year **= 936 man-days/year** **[Commercial Staff of Area Office]** - 1st to 5th year: 3 man-days/team/week x 3 teams x 52 weeks/year **= 468 man-days/year**				X	
Leakage Survey along Road: ***Leakage survey will be done by 3 teams/NRW Unit and Area Office** 2 persons/team x 1day/week = 2 man-days/team/week (NRW Unit) Total man-days: - 1st to 5th year: 2 man-days/team/week x 3 teams x 52 weeks/year **= 312 man-days/year (NRW Unit)**				X	
d) Leakage Survey by NRW Unit (Scenario-e)					
Leakage Survey at Each House: ***Leakage survey will be done by 3 teams/NRW Unit and Area Office** 2 persons/team x 3 days/week = 6 man-days/team/week (NRW Unit) 1 person/team x 3 days/week = 3 man-days/team/week (commercial staff of Area Office) Total man-days: **[NRW Unit]** -1st to 5th year: 6 man-days/team/week x 3 teams x 52 weeks/year **= 936 man-days/year** **[Commercial Staff of Area Office]** - 1st to 5th year: 3 man-days/team/week x 3 teams x 52 weeks/year **= 468 man-days/year**					X
Leakage Survey along Road: ***Leakage survey will be done by 3 teams/NRW Unit and Area Office** 2 persons/team x 1day/week = 2 man-days/team/week (NRW Unit) Total man-days: - 1st to 5th year: 2 man-days/team/week x 3 teams x 52 weeks/year **= 312 man-days/year (NRW Unit)**					X
(10) Patrol of Surface Leaks (Scenario-c)					
1)-1 Patrol of Surface Leakage and Illegal Connections: - 1st to 2nd year: 13 Area Offices except Jabi, Gudu, Garki I each year 2 persons with 1 trainer (from Jabi, Gudu, Garki I)/team for Area Office x 5 days/week = (2+1) x 5 man-days/week/Area Office = 15 man-days/week/Area Office (distribution staff of Area Office) 1 person/team for Area Office x 5 days/week/Area Office = 5 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 1st to 2nd year: 15 man-days/week/ Area Office x 13 Area Offices x 52 weeks/year **= 10,140 man-days/year** **[For Commercial Staff of Area Office]** - 1st to 2nd year: 5 man-days/week/ Area Office x 13 Area Offices x 52 weeks/year **= 3,380 man-days/year**			X		

1)-2 Patrol of Surface Leakage and Illegal Connections: - 3rd to 5th year: 16 Area Offices each year 2 persons for Area Office x 5 days/week /Area Office = 10 man-days/week/Area Office (distribution staff of Area Office) 1 person for Area Office x 5 days/week = 5 man-days/week /Area Office (commercial staff of Area Office) Total man-days: **[For Distribution Staff of Area Office]** - 3rd to 5th year: 10 man-days/week/Area Office x 16 Area Offices x 52 weeks/year **= <u>8,320 man-days/year</u>** **[For Commercial Staff of Area Office]** - 3rd to 5th year: 5 man-days/week/ Area Office x 16 Area Offices x 52 weeks/year **= <u>4,160 man-days/year</u>**			X		
(11) Repair of Leaks and Recording					
a) Repair for Leakage survey by Area Offices (DMA Scenario-a)					
1)-1 Leakage Repair and Recording by Area Office (see Table A3-2): - 1st year: *Number of leakage repair is 178 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-a 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 1st year: 7 man-days/leak x 178 leaks/year: **= <u>1,246 man-days/year (distribution staff of Area Office)</u>**	X				
1)-2 Leakage Repair and Recording by Area Office: - 2nd year: *Number of leakage repair is 241 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-a 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 2nd year: 7 man-days/leak x 241 leaks/year **= <u>1,687 man-days/year (distribution staff of Area Office)</u>**	X				
1)- 3 Leakage Repair and Recording by Area Office: - 3rd year: *Number of leakage repair is 308 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-a 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 3rd year: 7 man-days/leak x 308 leaks/year **= <u>2,156 man-days/year (distribution staff of Area Office)</u>**	X				
1)-4 Leakage Repair and Recording by Area Office: - 4th year: *Number of leakage repair is 354 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-a 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 4th year: 7 man-days/leak x 354 leaks/year **= <u>2,478 man-days/year (distribution staff of Area Office)</u>**	X				
1)-5 Leakage Repair and Recording by Area Office: - 5th year: *Number of leakage repair is 400 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-a 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 5th year: 7 man-days/leak x 400 leaks/year **= <u>2,800 man-days/year (distribution staff of Area Office)</u>**	X				

b) Repair for Leakage survey by Area Offices (Scenario-b)					
1)-1 Leakage Repair and Recording by Area Office(see Table A3-3): - 1st year: *Number of leakage repair is 182 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-b 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 1st year: 7 man-days/leak x182 leaks/year **= <u>1,274man-days/year (distribution staff of Area Office)</u>**		X			
1)-2 Leakage Repair and Recording by Area Office: - 2nd year: *Number of leakage repair is 249 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-b 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 2nd year: 7 man-days/leak x 249 leaks/year **= <u>1,743 man-days/year (distribution staff of Area Office)</u>**		X			
1)-3 Leakage Repair and Recording by Area Office: - 3rd year: *Number of leakage repair is 316 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-b 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 3rd year: 7 man-days/leak x 316 leaks/year **= <u>2,212 man-days/year (distribution staff of Area Office)</u>**		X			
1)-4 Leakage Repair and Recording by Area Office: - 4th year: *Number of leakage repair is 282 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-b 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 4th year: 7 man-days/leak x 282 leaks/year **= <u>1,974 man-days/year (distribution staff of Area Office)</u>**		X			
1)-5 Leakage Repair and Recording by Area Office: - 5th year: *Number of leakage repair is 343 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-b 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 5th year: 7 man-days/leak x 343 leaks/year **= <u>2,401 man-days/year (distribution staff of Area Office)</u>**		X			
c) Repair for Patrol by Area Offices (Scenario-c)					
1)-1 Leakage Repair and Recording by Area Office(see Table A3-4): - 1st to 2nd year: *Number of leakage repair is 114 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-c 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 1st to 2nd year: 7 man-days/leak x 114 leaks/year **= <u>798 man-days/year (distribution staff of Area Office)</u>**			X		

1)-2 Leakage Repair and Recording by Area Office: - 3rd to 5th year: *Number of leakage repair is 141 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-c 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 3rd to 5th year: 7 man-days/leak x 141 leaks/year **= 987 man-days/year (distribution staff of Area Office)**			X		
d) Repair for Leakage Survey by NRW Unit (Scenario-d)					
Leakage Repair and Recording by Area Office (see Table A3-5): 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak *Number of leakage repair is 213 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-d and e = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 1st to 5th year: 7 man-days/leak x 213 leaks/year = 1,491 man-days/year (distribution staff of Area Office)				X	
e) Repair for Leakage Survey by NRW Unit (Scenario-e)					
Leakage Repair and Recording by Area Office (see Table A3-5):: 7 persons (consist of one assistant area manager and six distribution staff) x 1 day/leak * Number of leakage repair is 213 leaks/year: refer to Number of Survey Customers and Leakage Repair for Scenario-d and e = 7 man-days/leak (distribution staff of Area Office) Total man-days: - 1st to 5th year: 7 man-days/leak x 213 leaks/year = 1,491 man-days/year (distribution staff of Area Office)					X
(12) Identification of Illegal Connections and Meter Inaccuracy					
a) Identification of Illegal Connection (Scenario-a, b, and c)					
1) Identification of small consumption user: - 1st to 5th year: 16 Area Offices each year 1person for Area Office x 1day = 1 man-day/Area Office (commercial staff of Area Office) Total man-days: - 1st to 5th year: 1 man-day/Area Office x 16 Area Offices **= 16 man-days (commercial staff of Area Office)**	X	X	X		
2) -1 Illegal connection survey: - 1st to 2nd year (13 Area Offices except Jabi, Gudu, Garki I): 2 distribution staff with 1 trainer (from Jabi, Gudu, Garki I) for Area Office x 1 day/week = (2+1) x 1 man-days/week/Area Office = 3 man-days/week/Area Office (distribution staff of Area Office) 2 commercial staff for Area Office x 1 day/week) = 2 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For distribution staff of Area Office]** - 1st to 2nd year: 3 man-days/Area Office/week x 13 Area Offices x 52 weeks/year **= 2,028 man-days/year** **[For commercial staff of Area Office]** - 1st to 2nd year: 2 man-days/Area Office/week x13 Area Offices x 52 weeks/year **= 1,352 man-days/year**	X	X	X		

2)-2 Illegal connection survey: - 3rd to 5th year (16 Area Offices): 2 distribution staff for Area Office x 1 day/week = 2 man-days/week/Area Office (distribution staff of Area Office) 2 commercial staff for Area Office x 1 day/week) = 2 man-days/week/Area Office (commercial staff of Area Office) Total man-days: **[For distribution staff of Area Office]** - 3rd to 5th year: 2 man-days/Area Office/week x 16 Area Offices x 52 weeks/year **= <u>1,664 man-days/year</u>** **[For commercial staff of Area Office]** - 3rd to 5th year: 2 man-days/Area Office/week x16 Area Offices x 52 weeks/year **= <u>1,664 man-days/year</u>**	X	X	X		
b) Identification of Illegal Connection (Scenario-d and e)					
1) Identification of small consumption user: - 1st to 5th year: 16 Area Offices each year 1 person for Area Office x 1 day = 1 man-day/Area Office (commercial staff of Area Office) Total man-days: -1st to 5th year: 1 man-day/Area Office x 16 Area Offices **= <u>16 man-days (commercial staff of Area Office)</u>**				X	X
2) Illegal connection survey: *** Illegal connection survey will be done by 3 teams/NRW Unit and Area Office** 2 persons/team x 1 day/week = 2 man-days/week/team (NRW Unit) 2 persons/team x 1day/week = 2 man-days/week/team (commercial staff of Area Office) Total man-days: **[For NRW Unit)]** - 1st to 5th year: 2 man-days/team/week x 3 teams x 52 weeks/year **= <u>312 man-days/year</u>** **[For commercial staff of Area Office]** - 1st to 5th year: 2 man-days/team/week x 3 teams x 52 weeks/year **= <u>312 man-days/year</u>**				X	X
c) Identification of Inaccuracy Meter (all Scenarios)					
1) Meter test at site: 3 persons for one to five meters in a same day x 1 day/week = 3 man-days/week (NRW Unit) 1 person for one to five meters in a same day x 1 day/week = 1 man-day/week (commercial staff of Area Office) Total man-days: **[For NRW Unit]** - 1st to 5th year: 3 man-days/ week x 52 weeks/year **= <u>156 man-days</u>** **[For commercial staff of Area Office]** - 1st to 5th year: 1 man-day/week x 52 weeks/year **= <u>52 man-days</u>**	X	X	X	X	X
2) Meter test at inspection office (Test meters and record meter inaccuracy 10% of procured meters) : 3 persons for 10 meters in a same day = 3 man-days/10 meters/day (NRW Unit) Number of inspection meters: 2,000 meters in a year Total man-days: - 1st to 5th year: 2,000 meters/year x 10/100(10%)/10 meters/day x 3 man-days **= 60 man-days** (NRW Unit)	X	X	X	X	
d) Inspection of Meter Inaccuracy for the preparation of Meter Standardization (all Scenarios)					

1) Record product year, maker name, meter type of all tested meters: 1 person x 1 day/week = 1 man-day/week (NRW Unit) 2) Analyze data and make a report for standardization of meters: 1 person x 1day/month = 1 man-day/month (NRW Unit) Total man-days: - 1st to 5th year: 1 man-day/week x 52 weeks/year + 1 man-day/month x 12 months **= <u>64 man-days (NRW Unit)</u>**	X	X	X	X	X
(13) Measures against Illegal Connections and Meter Inaccuracy					
a) Measures against Illegal Connections (Scenario-a, b and c)					
1)-1 Inform the illegal user disconnection of illegal connection and disconnect it (see Table A3-6): - 1st to 2nd year: * Number of counter measure is 68 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person for 1 illegal connection x 0.5 day = 0.5 man-days/illegal connection (commercial staff of Area Office) 2 persons for illegal connection x 0.5 day = 1 man-days/illegal connection (distribution staff of Area Office) Total man-days: **[For commercial staff of Area Office]** - 1st to 2nd year: 0.5 man-days/illegal connection x 68 illegal connections/year **= <u>34 man-days/year</u>** **[For distribution staff of Area Office]** - 1st to 2nd year: 1 man-days/illegal connection x 68 illegal connections/year **= <u>68 man-days/year</u>**	X	X	X		
2)-1 Legalize illegal user (see Table A3-6): - 1st to 2nd year: * Number of counter measure is 68 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person x 0.5 day/illegal connection (user) = 0.5 man-day/illegal connection (Commerce) Total man-days: 0.5 man-day/illegal connection x 68 illegal connections/year **= <u>34 man-days/year (Commerce)</u>**	X	X	X		
1)-2 Inform the illegal user disconnection of illegal connection and disconnect it (see Table A3-6): - 3rd to 4th year: * Number of counter measure is 104 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person for 1 illegal connection x 0.5 day = 0.5 man-days/illegal connection (commercial staff of Area Office) 2 persons for illegal connection x 0.5 day = 1 man-days/illegal connection (distribution staff of Area Office) Total man-days: **[For commercial staff of Area Office]** 0.5 man-days/illegal connection x 104 illegal connections/year **= <u>52 man-days/year</u>** **[For distribution staff of Area Office]** 1 man-days/illegal connection x 104 illegal connections/year **= <u>104 man-days/year</u>**	X	X	X		
2)-2 Legalize illegal user (see Table A3-6): - 3rd to 4th year * Number of counter measure is 104 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person x 0.5 day/illegal connection (user) = 0.5 man-day/illegal connection (Commerce) Total man-days: 0.5 man-day/illegal connection x 104 illegal connections/year **= <u>52 man-days/year (Commerce)</u>**	X	X	X		

1)-3 Inform the illegal user disconnection of illegal connection and disconnect it (see Table A3-6): **:** - 5fth year: * Number of counter measure is 44 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person for 1 illegal connection x 0.5 day = 0.5 man-days/illegal connection (commercial staff of Area Office) 2 persons for illegal connection x 0.5 day = 1 man-days/illegal connection (distribution staff of Area Office) Total man-days: **[For commercial staff of Area Office]** 0.5 man-days/illegal connection x 44 illegal connections/year **= <u>22 man-days/year</u>** **[For distribution staff of Area Office]** 1 man-days/illegal connection x 44 illegal connections/year **= <u>44 man-days/year</u>**	X	X	X		
2)-3 Legalize illegal user: - 5th year: * Number of counter measure is 44 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-a, b and c) 1 person x 0.5 day/illegal connection (user) = 0.5 man-day/illegal connection (Commerce) Total man-days: 0.5 man-day/illegal connection x 44 illegal connections/year **= <u>22 man-days/year (Commerce)</u>**	X	X	X		
b) Measures against Illegal Connections (Scenario-d and e)					
1) Inform the illegal user disconnection of illegal connection and disconnect it **(see Table A3-7)**: - 1st to 5th year: * Number of counter measure is 20 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-d and e) 1 person for 1 illegal connection x 0.5 day = 0.5 man-days/illegal connection (commercial staff of Area Office) 2 persons for illegal connection x 0.5 day = 1 man-days/illegal connection (distribution staff of Area Office) Total man-days: **[For commercial staff of Area Office]** 0.5 man-days/illegal connection x 20 illegal connections/year **= <u>10 man-days/year</u>** **[For distribution staff of Area Office]** 1 man-days/illegal connection x 20 illegal connections/year **= <u>20 man-days/year</u>**				X	X
2) Legalize illegal user (see Table A3-7): - 1st to 5th year: * Number of counter measure is 20 in a year: refer to Number of Survey Customers and Countermeasure for Illegal Connection (Scenario-d and e) 1 person x 0.5 day/illegal connection (user) = 0.5 man-day/illegal connection (Commerce) Total man-days: 0.5 man-day/illegal connection x 20 illegal connections/year **= <u>10 man-days/year (Commerce)</u>**				X	X
c) Measures against Meter Inaccuracy (all Scenarios apart from Scenario-e)					
Exchange a new meter for meter inaccuracy: - 1st to 5th year: 16 Area Offices each year 1 person for Area Office (one to five meters in a same day) x 1 day/month =1 man-days/month /Area Office (commercial staff of Area Office) 2 persons for Area Office (one to five meters in a same day) x 1 day/month =2 man-days/month /Area Office (distribution staff of Area Office) - 1st to 5th year: Total man-days: **[For commercial staff of Area Office]** 1 man-day/month/Area Office x 16 offices x 12 months **= <u>192 man-days</u>** **[For distribution staff of Area Office]**	X	X	X	X	~~X~~

2 man-days/month/Area Office x 16 offices x 12 months = **384 man-days**					
(14) Data Collection of Monthly Billed Consumption					
a) Data Collection of Billed Consumption every month (DMA, Scenario-a)					
Data Collection of Billed Consumption (billing system): - 1st to 5th year: 16 Area Offices each year 1 person for Area Office 1 day/month = 1 man-day/Area Office/month (Billing Unit) Total man-days: - 1st to 5th year: 1 man-day/Area Office/ month x 16 Area Offices x 12 months **= 192 man-days (Billing Unit)**	X				
b) Data Collection of Billed Consumption every month (Zone, All Scenarios)					
Data Collection of Billed Consumption (billing system): - 1st to 5th year: 16 Area Offices each year 1 person for Area Office x 1day/month = 1man-day/Area Office/month (Billing Unit) Total man-days: - 1st to 5th year: 1 man-day/Area Office/month x 16 Area Offices x 12 months **= 192 man-days (Billing Unit)**	X	X	X	X	X
(15) Data Collection of Monthly System Input Volume					
a) Data Collection of System Input Volume every month (DMA, Scenario-a)					
Read meters at input to DMA and record it every month: - 1st to 5th year: 16 Area Offices each year 3 persons for Area Office 1day/month = 3 man-days/Area Office / month (distribution staff of Area Office) Total man-days: - 1st to 5th year: 3 man-day/Area Office x 16 Area Offices/month x 12 months **= 576 man-days (distribution staff of Area Office)**	X				
b) Data Collection of System input volume every month (Zone, All Scenarios)					
Download water flow data from data logger at each tank: 1 person x 3 days/month = 3 man-day / month (NRW Unit) Total man-das: - 1st to 5th year: 3 man-days x 12 months **= 36 man-days (NRW Unit)**	X	X	X	X	X
c) Data Collection of System Input volume every month (Bulk Meter, All Scenarios)					
Download water flow data from data logger at bulk meter: 1person x 1day/month = 1man-day/month (NRW Unit) Total man-days: - 1st to 5th year: 1 man-day x 12 months **= 12 man-days (NRW Unit)**	X	X	X	X	X
(16) Monthly Water Balance Analysis					
Analyze Water Balance: - 1st to 5th year: 16 Area Offices each year 1person for 4 Area Offices x 1day/month = 1 man-day/4 Area Offices/month =0.25 man-day/Area Offices/month (NRW Unit) Total man-days: - 1st to5th year: 0.25 man-day/Area Office/ month x 16 Area Offices x 12 months **= 48 man-days (NRW Unit)**	X	X	X	X	X
(17) Measurement of one week input volume (DMA, Scenario-a)					

1)-1 Setting Ultrasonic Flow Meter and Recording : - 1st to 3rd year: 3 Area Offices each year 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (distribution staff of Area Office) Total man-days: - 1st to 3rd year: **[For NRW Unit]** 1 man-days/Area Office x 3 Area Offices **= <u>3 man-days</u>** **[For distribution staff of Area Office]** 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days</u>**	X				
1)-2 Setting Ultrasonic Flow Meter and Recording: - 4th to 5th year: 2 Area Offices each year 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (distribution staff of Area Office) Total man-days: **[For NRW Unit]** - 4th to 5th year: 1 man-days/Area Office x 2 Area Offices **= <u>2 man-days</u>** **[For distribution staff of Area Office]** - 4th to 5th year: 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days</u>**	X				
2)-1 Removing Ultrasonic Flow Meter and Recording: - 1st to 3rd year: 3 Area Offices each year 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (distribution staff of Area Office) Total man-days: **[For NRW Unit]** - 1st to 3rd year: 1 man-days/Area Office x 3 Area Offices **= <u>3 man-days</u>** **[For distribution staff of Area Office]** - 1st to 3rd year: 3 man-days/Area Office x 3 Area Offices **= <u>9 man-days</u>**	X				
2)-2 Removing Ultrasonic Flow Meter and Recording: - 4th to 5th year: 2 Area Offices each year 1 person for Area Office x 1 day = 1 man-day/Area Office (NRW Unit) 3 persons for Area Office x 1 day = 3 man-days/Area Office (distribution staff of Area Office) - 4th to 5th year: Total man-days: **[For NRW Unit]** 1 man-days/Area Office x 2 Area Offices **= <u>2 man-days</u>** [For distribution staff of Area Office] 3 man-days/Area Office x 2 Area Offices **= <u>6 man-days</u>**	X				
3) Analyze one week input volume: 1 person x 1 day = 1 man-day (NRW Unit) Total man-days: - 1st to 5th year: 1 man-days x 1 time/ year **= <u>1 man-days (NRW Unit)</u>**	X				
(18) Installing Water Meters					

Installation of meters: - 1st to 5th year: 2,000 meters each year 2 person for five meters one day = 2 man-days/5 meters = 0.4 man-days/meters (distribution staff of Area Office) 1 for five meters one day = 1 man-day/5 meters = 0.2 man-day/meters (commercial staff of Area Office) Total man-days: **[For distribution staff of Area Office]** - 1st to 5th year: 0.4 man-days/meters x 2,000 meters/year **= <u>800 man-days</u>** **[For commercial staff of Area Office]** - 1st to 5th year: 0.2 man-day/meters x 2,000 meters/year **= <u>400 man-days</u>**	X	X	X	X	X
(19) Survey on Trunk, Distribution Mains and Reservoirs					
a) Collect Data of Leaks					
1) Collect and Submit Data of Leaks: - 1st to 5th year: 16 Area Offices each year 1 person for Area Office x 1 day/month = 1 man-day/Area Office/month (distribution staff of Area Office) 2) Collect and Analyze Data of Leaks: 1 person for Area Office x 1 day/month = 1 man-day/Area Office/month (NRW Unit) Total man-days: **[For distribution staff of Area Office]** - 1st to 5th year: 1 man-day/Area Office/month x 16 Area Offices x 12 months/year **= <u>192 man-days/year</u>** **[For NRW Unit]** - 1st to 5th year: 1 man-day/Area Office x 16 Area Offices x 12 months/year **= <u>192 man-days/year</u>**	X	X	X	X	X
b) Collect, Submit and Analyze Data of Pipe Line					
1) Collect and Submit Data of Pipe Lines - 1st to 5th year: 16 Area Offices each year 1 person for Area Office x 1 day/month = 1 man-day/Area Office/month (distribution staff of Area Office) 2) Collect and Analyze Data of Pipe Line: 1 person for Area Office x 1 day/month = 1 man-day/Area Office/month (GIS Unit) Total man-days: **[For distribution staff of Area Office]** - 1st to 5th year: 1 man-day/Area Office/month x 16 Area Offices x 12 months/year **= <u>192 man-days/year</u>** **[For GIS Unit]** - 1st to 5th year: 1 man-day/Area Office x 16 Area Offices x 12 months/year **= <u>192 man-days/year</u>**	X	X	X	X	X
(20) Preparation for Pipe Replacement Plan					
a) Inspect Trunk and Distribution Mains					

1) Walk and inspect along pipeline route of trunk and distribution main, check their fittings such as air release valve, stop valves and wash out to find illegal connections and leakage: 2 person x 1 day/week = 2 man-days/week (Distribution Unit) 2 persons x 1day/week = 2 man-days/week (distribution staff of Area Office) 2) Accompany with inspection team and record the position of fittings and pipeline route by GPS: 1 person x 1day/week = 1 man-day/week (GIS Unit) Total man-days: **[For Distribution Unit]** - 1st to 5th year: 2 man-days/week x 52 weeks/year **= <u>104 man-days/year</u>** **[For distribution staff of Area Office]** - 1st to 5th year: 2 man-days/week x 52 weeks/year **= <u>104 man-days/year</u>** **[For GIS Unit]** - 1st to 5th year: 1 man-day/week x 52 weeks/year **= <u>52 man-days/year</u>**	X	X	X	X	X
b) Inspect Villages and Public taps					
1) Inspect water consumption condition of villages and public taps to find illegal connections and leakage: 2 person x 1 day/month = 2 man-days/month (Distribution Unit) 2 persons x 1 day/month = 2 man-days/month (distribution staff of Area Office) 2) Accompany with inspection team and record the position of villages and public taps by GPS: 1 person x 1 day/month = 1 man-day/month (GIS Unit) Total man-days: **[For Distribution Unit]** - 1st to 5th year: 2 man-days/month x 12 months/year **= <u>24 man-days/year</u>** **[For distribution staff of Area Office]** - 1st to 5th year: 2 man-days/month x 12 months/year **= <u>24 man-days/year</u>** **[For GIS Unit]** - 1st to 5th year: 1 man-day/month x 12 months /year **= <u>12 man-days/year</u>**	X	X	X	X	X
c) Input data on GIS map					
Input collected data to GIS mapping: 1person x 2 days/month = 2 man-days/month (GIS Unit) Total man-days: - 1st to 5th year: 2 man-days/month x 12months/year **= <u>24 man-days/year (GIS Unit)</u>**	X	X	X	X	X

Source: Project Team

Appendix-3.2: Basis on Condition for estimating Man-day for required for Leakage Survey and Illegal Connection Measures

Table A3-2 Basis on Condition for estimating Man-day for Leakage Survey (Scenario-a)

Year	2019	2020	2021	2022	2023
Calculation Formula (DMA)	3 area offices x 1,000 customers/ye	6 area offices x 1,000 customers/ye	6 area offices x 1,000 customers/ye	5 area offices x 1,000 customers/yea	4 area offices x 1,000 customers/ye
Expected Survey Customers' Number /year	3,000	6,000	6,000	5,000	4,000
Calculation Formula	3,000 customers x 480 m^3/day *1 / 1,000 customers	6,000 customers x 480 m^3/day / 1,000 customers	6,000 customers x 480 m^3/day / 1,000 customers	5,000 customers x 480 m^3/day / 1,000 customers	4,000 customers x 480 m^3/day / 1,000 customers
Expected Reduced NRW Volume (m^3/day)	1,440	2,880	2,880	2,400	1,920
Calculation Formula (Patrol)	1 team x 10 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 7 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 4 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 2 area offices x 10 customers/day x 1 days/week x 52 weeks	team x area offices x customers/day x days/week x weeks
Expected Survey Customers' Number /year	5,200	3,640	2,080	1,040	0
Calculation Formula	5,200 customers x 270 m^3/day *2 / 1,000 customers	3,640 customers x 270 m^3/day / 1,000 customers	2,080 customers x 270 m^3/day / 1,000 customers	1,040 customers x 270 m^3/day / 1,000 customers	-
Expected Reduced NRW Volume (m^3/day)	1,404	983	562	281	0
Calculation Formula Zone (2)	team x area offices x customers/day x days/week x weeks	team x area offices x customers/day x days/week x weeks	2 team x 3 area offices x 5 customers/day x 2 days/week x 52 weeks	2 team x 6 area offices x 5 customers/day x 2 days/week x 52 weeks	2 team x 9 area offices x 5 customers/day x 2 days/week x 52 weeks
Expected Survey Customers' Number /year	0	0	3,120	6,240	9,360
Calculation Formula	0 customers x m^3/day / customers	0 customers x m^3/day / customers	3,120 customers x 600 m^3 *6 / 1,000 customers	6,240 customers x 600 m^3/day / 1,000 customers	9,360 customers x 600 m^3/day / 1,000 customers
Expected Reduced NRW Volume (m^3/day)	0	0	1,872	3,744	5,616
Total Expected Reduced NRW Volume (m^3/day)	2,844	3,863	5,314	6,425	7,536
Calculation Formula	2,844 m^3/day / 310,630 m^3/day *3 x 100	3,863 m^3/day / 310,630 m^3/day x 100	5,314 m^3/day / 310,630 m^3/day x 100	6,425 m^3/day / 310,630 m^3/day x 100	7,536 m^3/day / 310,630 m^3/day x 100
Expected Reduced NRW percentage	0.92%	1.24%	1.71%	2.07%	2.43%
Calculation Formula (DMA)	3,000 customers x 30 *4 / 1,000 customers	6,000 customers x 30 / 1,000 customers	6,000 customers x 30 / 1,000 customers	5,000 customers x 30 / 1,000 customers	4,000 customers x 30 / 1,000 customers
Calculation Formula (Patrol)	5,200 customers x 17 *5 / 1,000 customers	3,640 customers x 17 / 1,000 customers	2,080 customers x 17 / 1,000 customers	1,040 customers x 17 / 1,000 customers	0 customers x 17 / 1,000 customers
Calculation Formula (Zone)	0 customers x 30 / 1,000 customers	0 customers x 30 / 1,000 customers	3,120 customers x 30 / 1,000 customers	6,240 customers x 30 / 1,000 customers	9,360 customers x 30 / 1,000 customers
Total Expected Number of Leakage Repair	178	241	308	354	400

Table A3-3 Basis on Condition for estimating Man-day for Leakage Survey (Scenario-b)

Year	2019	2020	2021	2022	2023
Calculation Formula Zone (1)	2 teams x 3 area offices x 5 customers/day x 2 days/week x 52 weeks	2 teams x 6 area offices x 5 customers/day x 2 days/week x 52 weeks	2 teams x 6 area offices x 5 customers/day x 2 days/week x 52 weeks	2 teams x 5 area offices x 5 customers/day x 1 days/week x 52 weeks	2 teams x 4 area offices x 5 customers/day x 1 days/week x 52 weeks
Expected Survey Customers' Number /year	3,120	6,240	6,240	2,600	2,080
Calculation Formula	3,120 customers x 480 m^3/day *1 / 1,000 customers	6,240 customers x 480 m^3/day / 1,000 customers	6,240 customers x 480 m^3/day / 1,000 customers	2,600 customers x 480 m^3/day / 1,000 customers	2,080 customers x 480 m^3/day / 1,000 customers
Expected Reduced NRW Volume (m^3/day)	1,498	2,995	2,995	1,248	998
Calculation Formula (Patrol)	1 team x 10 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 7 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 4 area offices x 10 customers/day x 1 days/week x 52 weeks	1 team x 2 area offices x 10 customers/day x 1 days/week x 52 weeks	team x area offices x customers/day x days/week x weeks
Expected Survey Customers' Number /year	5,200	3,640	2,080	1,040	0
Calculation Formula	5,200 customers x 270 m^3/day *2 / 1,000 customers	3,640 customers x 270 m^3/day / 1,000 customers	2,080 customers x 270 m^3/day / 1,000 customers	1,040 customers x 270 m^3/day / 1,000 customers	0 customers x 270 m^3/day / 1,000 customers
Expected Reduced NRW Volume (m^3/day)	1,404	983	562	281	0
Calculation Formula Zone (2)	team x area offices x customers/day x days/week x weeks	team x area offices x customers/day x days/week x weeks	2 teams x 3 area offices x 5 customers/day x 2 days/week x 52 weeks	2 teams x 6 area offices x 5 customers/day x 2 days/week x 52 weeks	2 teams x 9 area offices x 5 customers/day x 2 days/week x 52 weeks
Expected Survey Customers' Number /year	0	0	3,120	6,240	9,360
Calculation Formula	0 customers x m^3/day / customers	0 customers x m^3/day / customers	3,120 customers x 600 m^3/day / 1,000 customers	6,240 customers x 600 m^3/day *6 / 1,000 customers	9,360 customers x 600 m^3/day / 1,000 customers
Expected Reduced NRW Volume (m^3/day)	0	0	1,872	3,744	5,616
Total Expected Reduced NRW Volume (m^3/day)	2,902	3,978	5,429	5,273	6,614
Calculation Formula	2,902 m^3/day / 310,630 m^3/day *3 x 100	3,978 m^3/day / 310,630 m^3/day x 100	5,429 m^3/day / 310,630 m^3/day x 100	5,273 m^3/day / 310,630 m^3/day x 100	6,614 m^3/day / 310,630 m^3/day x 100
Expected Reduced NRW percentage	0.93%	1.28%	1.75%	1.70%	2.13%
Calculation Formula (Zone (1))	3,120 customers x 30 *4 / 1,000 customers	6,240 customers x 30 / 1,000 customers	6,240 customers x 30 / 1,000 customers	2,600 customers x 30 / 1,000 customers	2,080 customers x 30 / 1,000 customers
Calculation Formula (Patrol)	5,200 customers x 17 *5 / 1,000 customers	3,640 customers x 17 / 1,000 customers	2,080 customers x 17 / 1,000 customers	1,040 customers x 17 / 1,000 customers	0 customers x 17 / 1,000 customers
Calculation Formula (Zone (2))	0 customers x 30 / 1,000 customers	0 customers x 30 / 1,000 customers	3,120 customers x 30 / 1,000 customers	6,240 customers x 30 / 1,000 customers	9,360 customers x 30 / 1,000 customers
Total Expected Number of Leakage Repair	182	249	316	282	343

Table A3-4 Basis on Condition for estimating Man-day for Leakage Survey (Scenario-c)

Year	2019	2020	2021	2022	2023
Calculation Formula	1 team x 13 area offices[*1] x 10 customers/day x 1 days/week x 52 weeks	- ditto -	1 team x 16 area offices[*2] x 10 customers/day x 1 days/week x 52 weeks	- ditto -	- ditto -
Expected Survey Customers' Number/year	6,760	6,760	8,320	8,320	8,320
Calculation Formula for the First Cycle	6,760 customers x 270 m^3/day[*3] / 1,000 customers	- ditto -	8,320 customers x 270 m^3/day / 1,000 customers	- ditto -	- ditto -
Expected Reduced NRW Volume (m^3/day)	1,825	1,825	2,246	2,246	2,246
Calculation Formula	1,825 m^3/day / 310,630 m^3/day[*4] x 100	- ditto -	2,246 m^3/day / 310,630 m^3/day x 100	- ditto -	- ditto -
Expected Reduced NRW percentage	0.59%	0.59%	0.72%	0.72%	0.72%
Calculation Formula	6,760 customers x 17 [*5] / 1,000 customers	- ditto -	8,320 customers x 17 / 1,000 customers	- ditto -	- ditto -
Expected Number of Leakage Repair	114	114	141	141	141

Table A3-5 Basis on Condition for estimating Man-day for Leakage Survey (Scenario-d & e)

Year	2019	2020	2021	2022	2023
Calculation Formula	3 teams x 12 customers/day x 3 days/week x 52 weeks	- ditto -	- ditto -	- ditto -	- ditto -
Expected Survey Customers' Number/year	5,616	5,616	5,616	5,616	5,616
Calculation Formula for the First Cycle	5,616 customers x 600 m^3/day[*1] / 1,000 customers	- ditto -	- ditto -	- ditto -	- ditto -
Expected Reduced NRW Volume (m^3/day)	3,370	3,370	3,370	3,370	3,370
Calculation Formula	3,370 m^3/day / ###### m^3/day[*2] x 100	- ditto -	- ditto -	- ditto -	- ditto -
Expected Reduced NRW percentage	1.08%	1.08%	1.08%	1.08%	1.08%
Calculation Formula	5,616 customers x 38 [*3] / 1,000 customers	- ditto -	- ditto -	- ditto -	- ditto -
Expected Number of Leakage Repair	213	213	213	213	213

Table A3-6 Basis on Condition for estimating Man-day for Illegal Connection Measures (Scenario-a, b & c)

Year	2019	2020	2021	2022	2023
Calculation Formula	1 team x 5 customers/day x 1 days/week x 13 area offices *1 x 52 weeks	- ditto -	1 team x 5 customers/day x 1 days/week x 16 area offices *2 x 52 weeks	- ditto -	1 team x 5 customers/day x 1 days/week x 16 area offices x 52 weeks
Expected Survey Prepaid and AMR Customers' Number/year	3,380	3,380	4,160	4,160	4,160
Calculation Formula for Prepaid and AMR	3,380 customers x 80 m^3/day *3 / 1,000 customers	- ditto -	4,160 customers x 100 m^3/day / 1,000 customers	- ditto -	1,139 customers x 100 m^3/day / 1,000 customers
Calculation Formula for Conventional	-		-		3,021 customers x 30 m^3/day *5 / 1,000 customers
Expected Reduced NRW Volume (m3/day)	270	270	416	416	205
Calculation Formula	270 / 310,630 m^3/day *6 x 100	- ditto -	416 / 310,630 m^3/day x 100	- ditto -	205 / 310,630 m^3/day x 100
Expected Reduced NRW percentage	0.09%	0.09%	0.13%	0.13%	0.07%
Calculation Formula for Prepaid and AMR	3,380 customers x 20 *7 / 1,000 customers	- ditto -	4,160 customers x 25 *8 / 1,000 customers	- ditto -	1,139 customers x 25 / 1,000 customers
Calculation Formula for Conventional	-	-	-	-	3,021 customers x 5 *9 / 1,000 customers
Expected Number of Illegal Connection Finding	68	68	104	104	44

Table A3-7 Basis on Condition for estimating Man-day for Illegal Connection Measures (Scenario-d & e)

Year	2019	2020	2021	2022	2023
Calculation Formula	3 teams x 5 customers/day x 1 days/week x 52 weeks	- ditto -	- ditto -	- ditto -	- ditto -
Expected Survey Prepaid and AMR Customers' Number/year	780	780	780	780	780
Calculation Formula for Prepaid and AMR	780 customers x 100 m^3/day *1 / 1,000 customers	- ditto -	- ditto -	- ditto -	- ditto -
Expected Reduced NRW Volume (m^3/day)	78	78	78	78	78
Calculation Formula	78 / 310,630 m^3/day *2 x 100	- ditto -	- ditto -	- ditto -	- ditto -
Expected Reduced NRW percentage	0.03%	0.03%	0.03%	0.03%	0.03%
Calculation Formula for Prepaid and AMR	780 customers x 25 *3 / 1,000 customers	- ditto -	- ditto -	- ditto -	- ditto -
Expected Numbers of Illegal Connection Finding	20	20	20	20	20

Appendix-4: Estimated Cost and Yielded Revenue by Scenario

Estimated cost is divided into six items; Leakage Detection (Equipment), Flow Measurement, DMA Creation, Meter, Data Collection & Analysis, Manpower Leakage Detection and Logistics. Some of items are not required for the particular scenario.

Estimate cost for NRW reduction operations including their training and revenue by scenario are show in Table A4-1, A4-3, A4-5, A4-7 and A4-9, while estimated revenue yielded through NRW reduction operations are indicated in Table A4-2, A4-4, A4-6, A4-8 and A4-10.

(1) Scenario-a

1) Estimated Cost

Table A4-1 Estimated Cost of Scenario-a

Item	2019	2020	2021	2022	2023	Total
a. Equipment and Materials for NRW Reduction Operations						
Leak Detectors (Equipment from Japan)	106,145	106,145	106,145	70,763	70,763	459,961
PMA Creation (Flow-meter, Valve)	12,230	12,230	12,230	8,153	8,153	52,996
PMA Creation (Chamber Construction)	640	640	640	427	427	2,773
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 2,000/year)	17,962	17,962	17,962	17,962	17,962	89,812
Materials for Leakage Repair	1,188	1,608	2,055	2,362	2,669	9,882
Materials for 24 hours Flow Measurement	1,823	1,823	1,823	1,823	1,823	9,115
Materials for Meter Error Test, Consumption Survey	136	136	136	91	91	591
Subtotal	140,124	140,545	140,992	101,581	101,888	625,130
b. Water Meter Laboratory						
Water meter laboratory (two test meter and fittings)	1,818	32	32	32	32	1,946
Subtotal	1,818	32	32	32	32	1,946
c. Field Allowance for NRW Reduction Operations						
Field Allowance for NRW Reduction Operations	23,907	24,538	23,363	23,337	23,331	118,476
Subtotal	23,907	24,538	23,363	23,337	23,331	118,476
d. Logistics						
Fuel Cost	14,416	14,791	11,748	12,821	11,171	64,947
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	57,000	0	0	0	0	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	1,950	1,950	1,950	1,950	1,950	9,750
Subtotal	73,366	16,741	13,698	14,771	13,121	131,697
Training Cost	2,520	3,514	0	0	0	6,034
Subtotal	2,520	3,514	0	0	0	6,034
Grand Total	**241,735**	**185,370**	**178,085**	**139,721**	**138,372**	**883,282**

Source: Project Team

2) Estimated Revenue

Table A4-2 Estimated Revenue of Scenario-a

Items		2019	2020	2021	2022	2023	Total
Baseline NRW Ratio	i.	48.3%	48.3%	48.3%	48.3%	48.3%	-
Target NRW Ratio	ii.	45.61%	42.60%	39.20%	35.31%	31.92%	-
Reduced NRW Ratio	iii.= i - ii.	2.69%	5.70%	9.10%	12.99%	16.38%	-
Reduced Water Volume (m^3/day)	iv. = 310,630[*1] m^3/day x iii.	8,351	17,721	28,687	40,764	51,283	146,806
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^3 x365	274,330	582,128	942,368	1,339,111	1,684,645	4,822,582

Note: *1 Distributed water in average from 2014 to 2017
Source: Project Team

(2) Scenario-b

1) Estimated Cost

Table A4-3 Estimated Cost of Scenario-b

Item	2019	2020	2021	2022	2023	Total
a. Equipment and Materials for NRW Reduction Operations						
Leak Detectors (Equipment from Japan)	106,145	106,145	106,145	70,763	70,763	459,961
PMA Creation (Flow-meter, Valve)	0	0	0	0	0	0
PMA Creation (Chamber Construction)	0	0	0	0	0	0
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 2,000/year)	17,962	17,962	17,962	17,962	17,962	89,812
Materials for Leakage Repair	1,214	1,661	2,108	1,882	2,289	9,154
Materials for 24 hours Flow Measurement	0	0	0	0	0	0
Materials for Meter Error Test, Consumption Survey	45	45	45	45	45	227
Subtotal	125,367	125,814	126,261	90,653	91,060	559,156
b. Water Meter Laboratory						
Water meter laboratory (two test meter and fittings)	1,818	32	32	32	32	1,946
Subtotal	1,818	32	32	32	32	1,946
c. Field Allowance for NRW Reduction Operations						
Field Allowance for NRW Reduction Operations	22,682	23,357	22,182	21,736	21,835	111,792
Subtotal	22,682	23,357	22,182	21,736	21,835	111,792
d. Logistics						
Fuel Cost	13,816	14,345	11,301	9,442	9,954	58,858
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	57,000	0	0	0	0	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	1,950	1,950	1,950	1,950	1,950	9,750
Subtotal	72,766	16,295	13,251	11,392	11,904	125,608
Training Cost	2,520	3,514	0	0	0	6,034
Subtotal	2,520	3,514	0	0	0	6,034
Grand Total	**225,152**	**169,012**	**161,727**	**123,813**	**124,831**	**804,535**

Source: Project Team

2) Estimated Revenue

Table A4-4 Estimated Revenue of Scenario-b

Items		2019	2020	2021	2022	2023	Total
Baseline NRW Ratio	i.	48.3%	48.3%	48.3%	48.3%	48.3%	-
Target NRW Ratio	ii.	45.59%	42.54%	38.97%	35.46%	32.37%	-
Reduced NRW Ratio	iii.= i - ii.	2.71%	5.76%	9.33%	12.84%	15.93%	-
Reduced Water Volume (m^3/day)	iv. = 310,630[*1] m^3/day x iii.	8,409	17,894	28,975	38,572	48,169	142,018
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^3 x365	276,223	587,805	951,829	1,267,088	1,582,348	4,665,293

Note: *1 Distributed water in average from 2014 to 2017
Source: Project Team

(3) Scenario-c

1) Estimated Cost

Table A4-5 Estimated Cost of Scenario-c

Item	2019	2020	2021	2022	2023	Total
a. Equipment and Materials for NRW Reduction Operations						
Leak Detectors (Equipment from Japan)	0	0	0	0	0	0
PMA Creation (Flow-meter, Valve)	0	0	0	0	0	0
PMA Creation (Chamber Construction)	0	0	0	0	0	0
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 2,000/year)	17,962	17,962	17,962	17,962	17,962	89,812
Materials for Leakage Repair	761	761	941	941	941	4,344
Materials for 24 hours Flow Measurement	0	0	0	0	0	0
Materials for Meter Error Test, Consumption Survey	45	45	45	45	45	227
Subtotal	18,769	18,769	18,949	18,949	18,949	94,383
b. Water Meter Laboratory						
Water meter laboratory (two test meter and fittings)	373	32	32	32	32	501
Subtotal	373	32	32	32	32	501
c. Field Allowance for NRW Reduction Operations						
Field Allowance for NRW Reduction Operations	21,894	21,788	20,957	20,957	20,837	106,433
Subtotal	21,894	21,788	20,957	20,957	20,837	106,433
d. Logistics						
Fuel Cost without Options	13,265	13,244	8,786	8,786	8,728	52,808
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	57,000	0	0	0	0	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	1,950	1,950	1,950	1,950	1,950	9,750
Subtotal	72,215	15,194	10,736	10,736	10,678	119,558
Training Cost	2,520	3,514	0	0	0	6,034
Subtotal	2,520	3,514	0	0	0	6,034
Grand Total	**115,770**	**59,297**	**50,673**	**50,673**	**50,495**	**326,908**

Source: Project Team

2) Estimated Revenue

Table A4-6 Estimated Revenue of Scenario-c

Items		2019	2020	2021	2022	2023	Total
Baseline NRW Ratio	i.	48.3%	48.3%	48.3%	48.3%	48.3%	-
Target NRW Ratio	ii.	45.94%	43.58%	41.17%	38.63%	36.94%	-
Reduced NRW Ratio	iii.= i - ii.	2.36%	4.72%	7.13%	9.67%	11.36%	-
Reduced Water Volume (m^3/day)	iv. = 310,630[*1] m^3/day x iii.	7,332	14,664	22,563	30,462	35,691	110,714
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^3 x365	240,863	481,726	741,208	1,000,690	1,172,461	3,636,947

Source: Project Team
Note: *1 Distributed water in average from 2014 to 2017

(4) Scenario-d

1) Estimated Cost

Table A4-7 Estimated Cost of Scenario-d

Item	2019	2020	2021	2022	2023	Total
a. Equipment and Materials for NRW Reduction Operations						
Leak Detectors (Equipment from Japan)	0	0	0	0	0	0
PMA Creation (Flow-meter, Valve)	0	0	0	0	0	0
PMA Creation (Chamber Construction)	0	0	0	0	0	0
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 2,000/year)	17,962	17,962	17,962	17,962	17,962	89,812
Materials for Leakage Repair	1,421	1,421	1,421	1,421	1,421	7,106
Materials for 24 hours Flow Measurement	0	0	0	0	0	0
Materials for Meter Error Test, Consumption Survey	45	45	45	45	45	227
Subtotal	19,429	19,429	19,429	19,429	19,429	97,146
b. Water Meter Laboratory						
Water meter laboratory (two test meter and fittings)	373	32	32	32	32	501
Subtotal	373	32	32	32	32	501
c. Field Allowance for NRW Reduction Operations						
Field Allowance for NRW Reduction Operations	8,003	7,897	7,897	7,897	7,897	39,591
Subtotal	8,003	7,897	7,897	7,897	7,897	39,591
d. Logistics						
Fuel Cost	3,727	3,706	3,706	3,706	3,706	18,551
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	0	0	19,000	19,000	19,000	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	0	0	650	1,300	1,950	3,900
Subtotal	3,727	3,706	23,356	24,006	24,656	79,451
Training Cost	2,520	3,514	0	0	0	6,034
Subtotal	2,520	3,514	0	0	0	6,034
Grand Total	**34,051**	**34,578**	**50,714**	**51,364**	**52,014**	**222,722**

Source: Project Team

2) Estimated Revenue

Table A4-8 Estimated Revenue of Scenario-d

Items		2019	2020	2021	2022	2023	Total
Baseline NRW Ratio	i.	48.3%	48.3%	48.3%	48.3%	48.3%	-
Target NRW Ratio	ii.	45.50%	42.71%	39.91%	37.12%	35.11%	-
Reduced NRW Ratio	iii.= i - ii.	2.80%	5.59%	8.39%	11.18%	13.19%	-
Reduced Water Volume (m^3/day)	iv. = 310,630*1 m^3/day x iii.	8,684	17,368	26,053	34,737	40,962	127,804
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^3 x365	285,276	570,552	855,828	1,141,104	1,345,615	4,198,375

Source: Project Team

Note: *1 Distributed water in average from 2014 to 2017

(5) Scenario-e

1) Estimated Cost

Table A4-9 Estimated Cost of Scenario-e

Item	2019	2020	2021	2022	2023	Total
a. Equipment and Materials for NRW Reduction Operations						
Leak Detectors (Equipment from Japan)	0	0	0	0	0	0
PMA Creation (Flow-meter, Valve)	0	0	0	0	0	0
PMA Creation (Chamber Construction)	0	0	0	0	0	0
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 2,000/year)	0	0	0	0	0	0
Materials for Leakage Repair	1,421	1,421	1,421	1,421	1,421	7,106
Materials for 24 hours Flow Measurement	0	0	0	0	0	0
Materials for Meter Error Test, Consumption Survey	45	45	45	45	45	227
Subtotal	1,467	1,467	1,467	1,467	1,467	7,333
b. Water Meter Laboratory						
Water meter laboratory (two test meter and fittings)	373	32	32	32	32	501
Subtotal	373	32	32	32	32	501
c. Field Allowance for NRW Reduction Operations						
Field Allowance for NRW Reduction Operations	6,743	6,637	6,637	6,637	6,637	33,291
Subtotal	6,743	6,637	6,637	6,637	6,637	33,291
d. Logistics						
Fuel Cost	3,110	3,090	3,090	3,090	3,090	15,470
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)	0	0	19,000	19,000	19,000	57,000
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)	0	0	650	1,300	1,950	3,900
Subtotal	3,110	3,090	22,740	23,390	24,040	76,370
Training Cost	2,520	3,514	0	0	0	6,034
Subtotal	2,520	3,514	0	0	0	6,034
Grand Total	**14,212**	**14,739**	**30,876**	**31,526**	**32,176**	**123,529**

Source: Project Team

2) Estimated Revenue

Table A4-10 Estimated Revenue of Scenario-e

Items		2019	2020	2021	2022	2023	Total
Baseline NRW Ratio	i.	48.3%	48.3%	48.3%	48.3%	48.3%	-
Target NRW Ratio	ii.	47.19%	46.08%	44.97%	43.86%	42.75%	-
Reduced NRW Ratio	iii.= i - ii.	1.11%	2.22%	3.33%	4.44%	5.55%	-
Reduced Water Volume (m^3/day)	iv. = 310,630[*1] m^3/day x iii.	3,448	6,895	10,343	13,790	17,238	51,714
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^3 x365	113,254	226,507	339,761	453,015	566,268	1,698,805

Source: Project Team

Note: *1 Distributed water in average from 2014 to 2017

Appendix-5: NRW Reduction Operations

(1) Network Drawings and Data

A. Purpose of developing network drawing and data

The purpose of this aspect of the strategic plan is to ensure that relevant, accurate and reliable water distribution information is collected, stored and properly managed by FCTWB to facilitate planning, analysis and decision making, not only for the NRW project but also for effective and efficient O&M, which will in turn translate to enhanced service delivery leading to customer satisfaction as well as improved revenue generation for the Federal Capital Territory Administration.

B. Procedure for Development of GIS Database

B.1 Setting the Grid

The grid shall be a square of 1,000m × 1,000m and shall be set to include all the administrative districts. The grids shall be numbered in order from the top left. In the future, it is possible to set a sub-grid with a width of 200m, 250m, and 500m. In this project, a grid of 500m x 500m was set for the entire FCT.

B.2 Setting the Basic Scale of GIS

The scale of the final printing is set at 1:2,000, therefore all GIS work shall be based on the scale of 1:2,000, and the deviation from the final printing will be less.

B.3 Mapping and Attribute Data Input

GIS data is comprised of background data, map data and attribute data.

B.3.1 Background Data (Image Data)

Background data of FCT WB, which was acquired by AGIS, is a satellite image captured in 2010. Since then, it has not been updated, development of infrastructure has progressed, and this aerial satellite image and current actual situation was greatly divergent. In this project, this satellite image can still be utilized for data input assistance.

B.3.2 Map Data (Geographic Data)

Map data are represented by polygon, line, or node. Examples of main map data related to water supply facilities are as follows.

Table A5-1 Examples of Map Data

Items	Described Data
Polygon data	Water treatment facility, distribution tank, customer plot, etc.
Line data	Trunk main, distribution pipe, service pipe, street etc.
Node data	Valve, fire hydrant, wash out, meter, stopcock, etc.

Source: Project Team

Facilities that should be inputted into GIS of FCTWB are water treatment facilities (Sedimentation, Filtration, etc.), distribution tanks, trunk mains, distribution pipes and their fittings (such as valves, fire hydrants and wash outs), service pipes and their fittings (such as meters and stopcock).

At present, trunk mains, distribution pipes and their fittings are given the highest priority in terms of data input, but in the future, it is preferable to enter the water supply pipe and its accessories.

B.3.3 Attribute Data (Property Data)

Attribute data is entered as a feature in graphic data and it include the following:

Table A5-2 Examples of attribute data

Items	Described Data
Water Treatment facility	Capacity, construction year
Distribution Tank	Capacity, construction year, operation water level
Trunk main	Pipe size, pipe material, installation year, depth, off-set
Distribution pipe	Pipe size, pipe material, installation year, depth, off-set
Service pipe	Pipe size, pipe material, installation year
Valve, fire hydrant, wash out	Pipe size, state (open/close, functional/non-functional), installation year
Customer meter	Pipe size, meter type (mechanical, AMR, PPM), installation year, customer information, etc.

Source: Project Team

Since the pipeline is installed under the ground, accurate information will be difficult to get. In FCTWB, data such as pipe size and pipe material can be acquired according to the memories of staff involved in O & M; however, there are many unclear points such as installation year, depth, off-set, etc.

Regarding the input of valve, fire hydrant and wash out, field survey is necessary to confirm from what is actually on ground.

In addition, meter and customer information are not organized data and on-site surveys are also necessary.

C. Data Collection and Management of GIS Database

Normally, as-built drawings are supposed to be the main source of pipeline data for input to GIS, but at present, FCTWB does not have enough as-built drawings, which result in contribution to difficulties in database for O&M. There are some of challenges to survey pipeline positions at sites to obtain correct information.

C.1 Proposed Solutions to Address the Problem of Isolation due to Lack of Existing Pipe Information:

C.1.1 Task of GIS Unit

GIS Unit should embark on mass data input of pipeline information and other water facilities by utilizing the memories of experience of relevant staff and any available record. The satellite image should be used as a base map on which pipeline sketches would be added including other relevant information on pipe size, pipe material, construction id, installation year etc.

C.1.2 A Well-defined Structure and Procedure

A well-defined structure and procedure should be established to ensure submission of updated pipeline information by the Area Offices to the GIS Unit for proper documentation.

C.1.3 A Dedicated Unit with Adequate Staff

A dedicated Unit with adequate staff should be provided to facilitate speedy and continuous data collection and update for the entire FCTWB service areas.

C.1.4 Others

Henceforth, FCTWB should ensure that as-built drawings are submitted by contractors before handing over facilities.

(2) Customer Enumeration

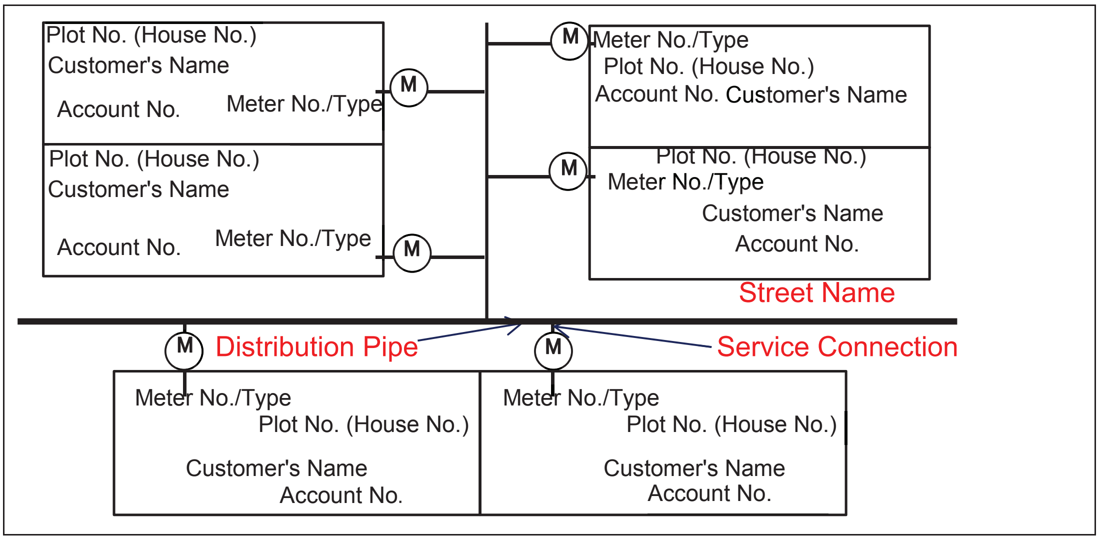
A. Purpose of Customer Enumeration

The purpose of this aspect of the strategic plan is to ensure that which customers are located in which area including DMAs and zone, and how much water customers use.

B. Procedure for Customer Enumeration

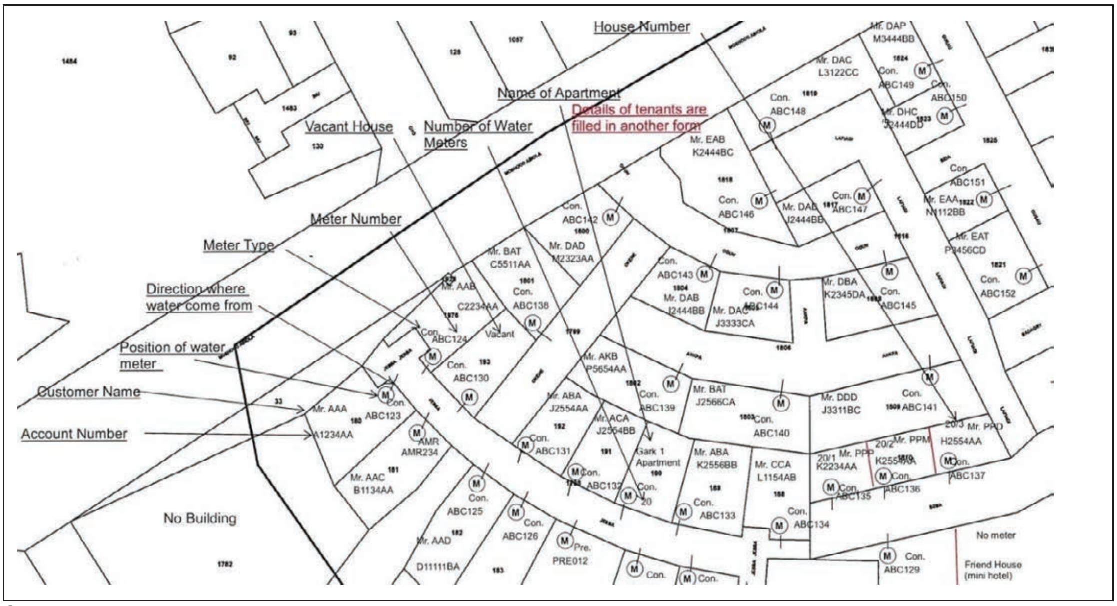
B.1 Customer Map

It is necessary to make a “Customer Map” for confirmation of customer condition. Customer maps as shown in Figure A4-1 and A4-2 should be updated regularly by FCTWB HQs as well as Area Offices. Section in Area Office as shown in Figure A4-3 is responsible for customer enumeration.



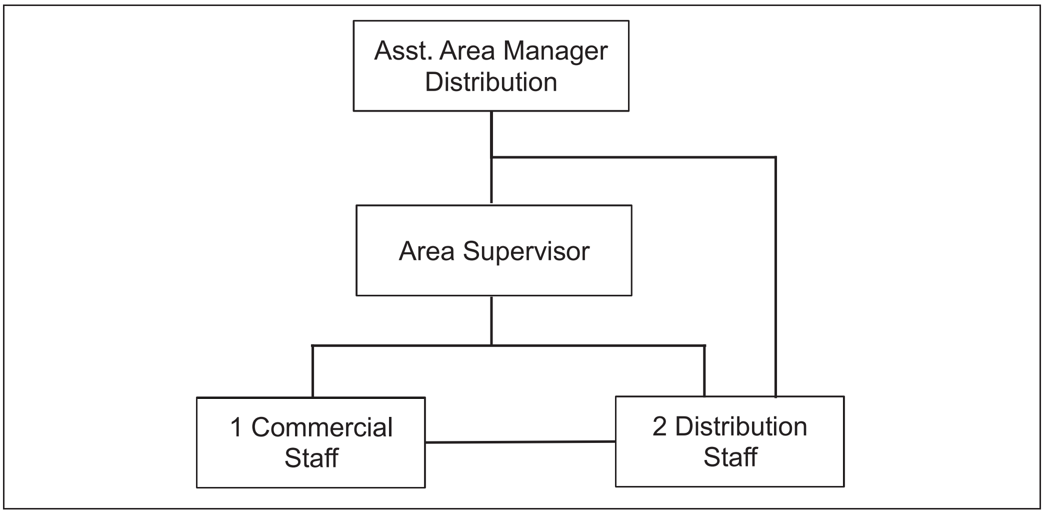
Source: Project Team

Figure A5-1 Items which should be written on Customer Map



Source: Project Team

Figure A5-2 Example of Customer Map



Source: Project Team

Figure A5-3 Managing Structure of NRW Reduction Operation

B.2 Customer Enumeration

- Prepare customer lists and annual water consumption of customers.
- Calculate hourly water consumption using annual water consumption data for each customer. The hourly water consumption data is used for hydraulic analysis and water balance analysis.
- Allocate customers to whom water supplied from which pipelines. The data is used for hydraulic analysis and water balance analysis.

(3) DMA Design, Creation and Prioritization

DMA means" District Metered Area", which is an internationally used term for an isolated area of water distribution network. The concept was developed to enable measurement of non-revenue water through a defined boundary by installations of bulk meters (usually one or more) at inlet (i.e. point of entry) and to outlet of distribution pipeline network or layout under consideration. The purpose of bulk meters installation enables the non-revenue team to be able to measure the input & output volume of water flow rate into and outside the pipeline distribution networks.

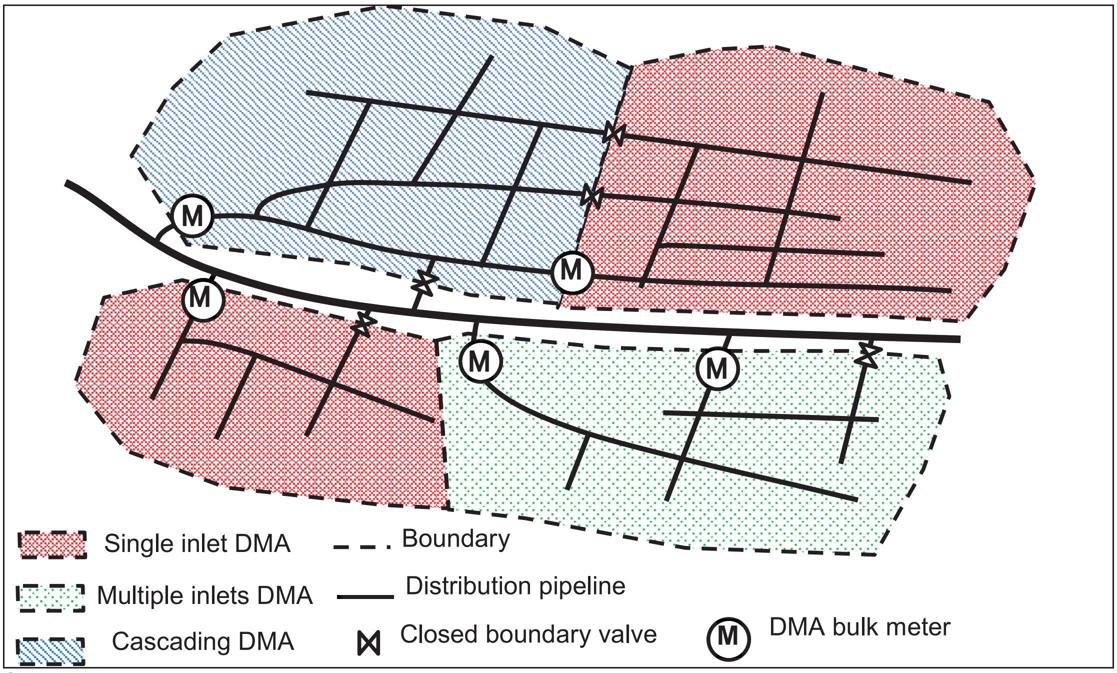
DMAs classification depends on the pipeline network system layouts and boundaries condition. There are three types of DMA layouts (Figure A5-4) and are:

- Single inlet DMA: as the name implies it has only one installed bulk meter at the entry point (inlet) and no outlet point connected to other pipeline network system.
- Multiple inlets DMA: the DMA has more than two inlets (entry point) with more than two installed bulk meters and no outlet point to the pipeline network.
- Cascading DMA: the DMA has an either single or multiple entry point with outlet point to the pipeline network that enables measuring the inlet and outlet volume to a pipeline network. This arrangement allows installation of isolation valves at boundaries between two DMAs.

(3)-1 Design, Creation and Prioritization

The choice of DMA within the FCTWB NRW team shall include consideration of the following factors such as:

General condition of the area; selection will include areas with:



Source: Project Team

Figure A5-4 Image of DMA

i. Existing household connections ranging between (1,000- 2,500). The areas to be selected shall comprise realistic number customers household connections identified with features as:
   - High number of flat rate or estimated bill
   - High discrepancies of consumption pattern
   - High volume of leakage from report enumerated through Unit heads (i.e. Customer Care Unit; Pipeline Unit and Operation & Monitoring Unit)
   - Identified with low pressure.

ii. Access to isolation by means of valves.

iii. Existence of Natural boundaries or demarcation (i.e. River, road crossing, fence etc.)

iv. Minimum number of valves needed to be closed to achieve isolation of the DMA.

v. Minimum requirement of one (1) to two (2) flow meter for installation at the boundaries so as to reduce the cost of procurement and installation; which will also enhance better flow measurement.

vi. Less effect to fluctuations in ground level and pressure for easier control

A. Enumeration of Existing and Required Flow Meter and Valves for Isolation Through:

i. Pipeline network As-built drawing of FCTWB Geographic Information System (GIS) Unit.

ii. On-Site survey and inspection by NRW Team (Headquarters' and Area office)

B. Confirmation of Inlet and Outlet Points of Pipeline Network Boundary with Installations of:

i. Flow meters at inlet and outlet point of the pipeline network system

ii. Valves at boundaries of DMA and flow meters necessary for hydraulic isolation

iii. Valves at TEEs or branches of distribution network for step test.

C. Preparation/Update of Customer Information within the DMA to Calculate Both Annual & Hourly Water Consumption through Data Entry Proposed Template of Customers Which Comprises of:

i. Customer 's Name

ii. Plot No.
iii. Location/Zone
iv. Street Name
v. Type of Meter
vi. Date of Installation of Meter
vii. Person in charge
viii. Consumption

D. Identification of Functional Customer Water Meters and Valves for Maintenance or Replacement.

E. Procurement of Non-Functional or Damaged Flow Meters, Pipes, Fittings, Meters, etc. that can neither be repaired nor maintained. All Procurement Processes shall Comply to:

i. Submission of quotations by different suppliers/companies who shall be registered under law of the land
ii. Evaluation of submission of cost estimate by the contractors
iii. Award of the contract through FCT Tenders board or FCTWB procurement Unit.
iv. Inspection/ supervision of the supply or construction work by an approved person within the board.
v. Certification for payment.

(3)-2 DMA Prioritization in NRW Reduction

Sub-Metering Areas (SMAs) are usually created in a DMA. It is important to prioritize in the activities of SMAs for effective and efficient NRW reduction. The procedure of prioritization is as follows:

- Make SMAs two or three in DMA.
- Measure night water flow of each SMAs by step test.
- Find the SMA which the largest water volume is measured by step test. It is the priority of the target SMA to take NRW reduction operations.
- Choose the SMA where many major consumers gather when the measured water volume of SMAs are almost same. It is the priority of the target SMA to take NRW reduction operations.
- After finish of NRW reduction operations in the SMA, sift another SMA which second largest water volume is measured, or major customers gather.

(4) Zonal Prioritization

The choice of areas to be prioritized for consideration shall be evaluated with respect to criteria allocated to weighting factor amounting to 100%. The prioritization shall focus on Zones with a high weighting factor necessary for having quick impact in the reducing FCTWB's Non-Revenue Water within the next five years to 40%. The criteria for consideration are shown in Table A4-3 to Table A4-7.

Table A5-3 Criteria of NRW Condition
(Weighting Coefficient: 35%)

NRW Ratio	Initial Points
More than 65%	3 points
64% to 55%	2 points
54% to 45%	1 point

Source: Project Team

Table A5-4 Criteria of Availability of Pipeline Network Drawing
(Weighting Coefficient: 30%)

Ratio of Mapping Development	Initial Points
More than 50% in mapping	3 points
50% or less in mapping	2 points
Only hard papers	1 point

Source: Project Team

Table A5-5 Criteria of Number of Major Customers
(Weighting Coefficient: 15%)

Ratio of Measure Customers	Initial Points
Area where major customers make up more than 10% of the total customers	3 points
Area where major customers make up 5 to 10% of the total customers	2 points
Area where major customers make up less than 5% of the total customers	1 point

Source: Project Team

Table A5-6 Criteria of Customer Meter Type and Conditions of Collection of Water Tariff
(Weighting Coefficient: 10%)

Ratio of One-type Customer	Initial Points
Area where one-type customer meters make up 80% of the total customers	3 points
Area where one-type customer meters make up 50 to 79% of the total customers	2 points
Area where one-type customer meters make up less than 50% of the total customers.	1 point

Source: Project Team

Table A5-7 Criteria of Security Condition
(Weighting Coefficient: 10%)

Ratio of Accessibility	Initial Points
Area where customers apart from military base and barrack make up 90%	3 points
Area where customers apart from military base and barrack make up 80%	2 points
Area where customers apart from military base and barrack and make up less than 80%	1 point

Source: Project Team

(5) Field Inspection

A. Purpose of Field Inspection of Existing Valves, etc.

The purpose of this aspect of the strategic plan is to ensure that which flow meters and valves required for isolation and step-test of DMA and SMAs. And It is necessary to confirm condition of the existing flow meters and valves whether they function well or not. If they don’t work well, isolation or step-test cannot be done.

B. Procedure of Field Inspection of Existing Valves, etc.

After confirmation of necessary numbers of flow meters and valves, it is necessary to confirm existence of them at site of DMA. Necessary procedure is as follows:

- Confirm existing flow meters and valves at inlet points and outlet points at the site.
- Confirm existing valves at boundary of DMA
- Confirm existing valves at branches of distribution pipe
- When there are existing flow meters and valves at required places, confirm their function.
- When there are not existing flow meters and valves at required places, make bill of quantities (BOQ) for procurement. (Diameter of flow meters / valves and their fittings, fittings for setting them on pipe lines)

- When flow meters and valves are not working well, make BOQ for procurement. (Diameter of flow meters / valves and their fittings, fittings for setting them on pipe lines).
- When flow meters and valves are working well, use them for creation of DMA.
- If malfunctioned flow meters and valves can work with small maintenance, they should be used after maintenance.

(6) Isolation by installing Flow-meters and Valves

A. Purpose of Installation of Flow-meter and Isolation Valves

The purpose of this aspect of the strategic plan is to ensure creation of DMA and SMAs.

B. Installation by installing Flow-meters and Valves

If flow meters and valves do not exist or work at required places, it is necessary to purchase them for creation of DMA. Necessary procedure is as follows:

- Ask for quotation from suppliers (at least three suppliers) by BOQ.
- Design and estimate cost to make chambers for flow meters and valves.
- Check and compare BOQ and quotations which are submitted by suppliers.
- Choose the supplier who submits the cheapest quotation for procurement.
- Submit the budget for procurement to the Director attaching the quotation of equipment and cost estimation for chambers.
- Purchase flow meters, valves and fittings by quotation.
- Inspect equipment which is delivered by the supplier using BOQ and the quotation
- Order the contractor to make chambers using designed drawings.
- Supervise construction work by comparing to the drawings.
- Install flow meters and valves.

(7) Step-Test in DMA

A. Purpose of Step-test in DMA

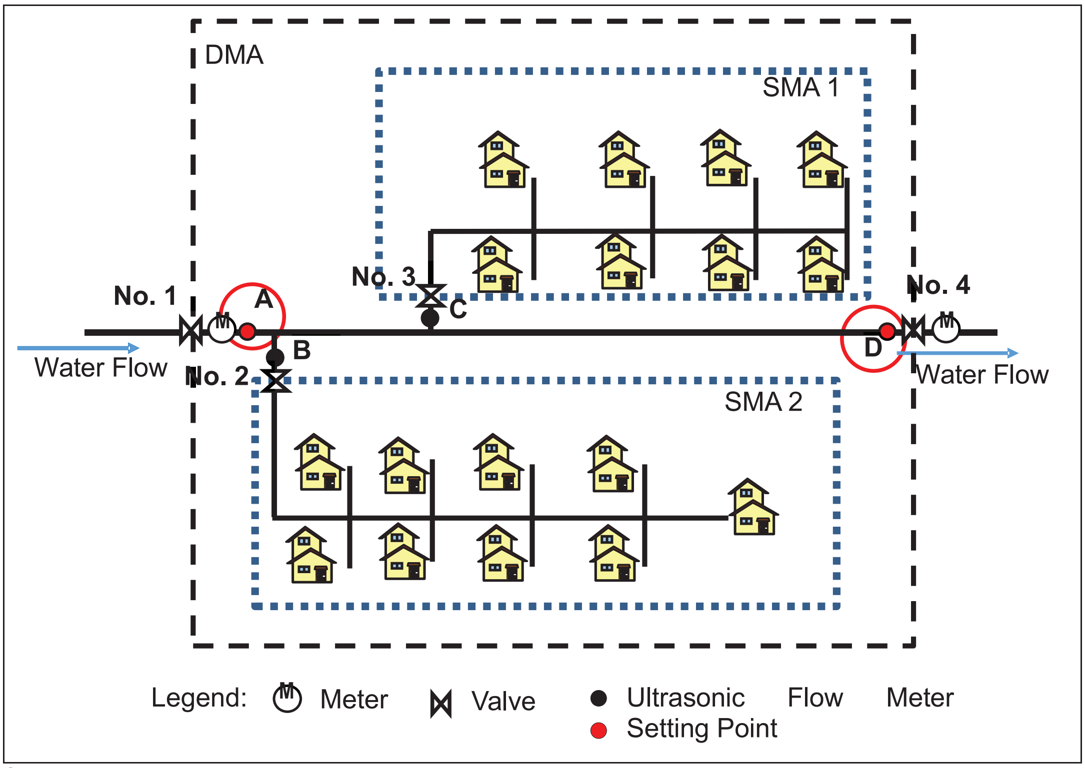
The purpose of this aspect of the strategic plan is to learn leakage volume by SMA in order.

B. Procedure of Step-test in DMA

Step-test is used for learning leakage volume in each SMA or pipeline instead of 24-hour input volume measuring. Step test is done at night time when water consumption is expected to be minimum use. Necessary procedure is as follows:

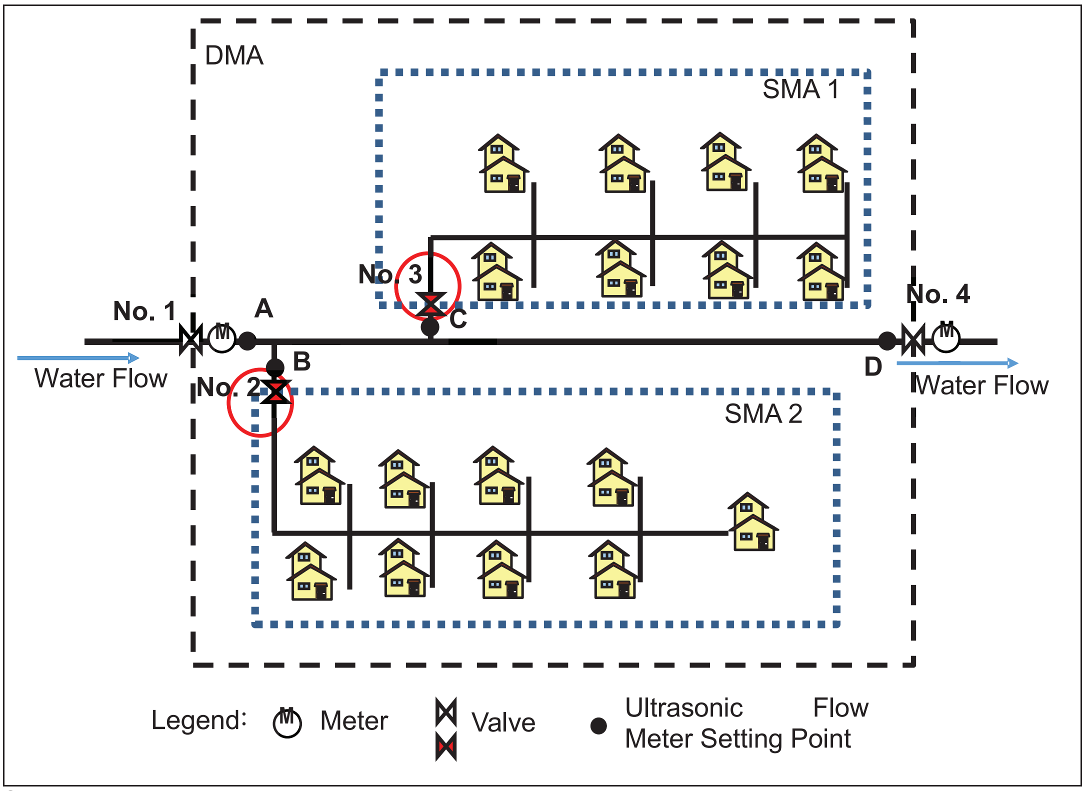
- Set ultrasonic flow meter at all inlet points and outlet points of DMA same as “b. Measurement of one-week input volume”. (Setting Points of Ultrasonic Flow Meter: point A and D as shown in Figure A5-5)
- Water flow volume at point A is inlet of DMA and passing volume to other areas.
- Water flow volume at point D is passing volume to other areas.
- The volume at point A minus at point D is input volume to DMA.
- Start ultrasonic flow meter for measuring water flow and set logging data.
- Close valve no. 2 and measure water flow volume in 5 minutes.
- Decreased water volume from DMA input volume is expected to be leakage volume at SMA 1.
- Close valve no. 3 and measure water flow in 5 minutes (see Figure A5-6).
- Decreased water volume from DMA input volume is expected to be leakage volume at SMA 2.
- Measure water flow volume at A point and D point.
- The volume at A minus at B is leakage on the main distribution pipeline between A and D.
- Open vale no. 3 and measure water flow in 5 minutes.

- Increased water volume from DMA input volume is expected to be leakage volume at SMA 2.
- Open valve no. 2 and measure water flow in 5 minutes.
- Increased water volume from DMA input volume is expected to be leakage volume at SMA 1.
- Make a report of result from step test.



Source: Project Team

Figure A5-5 Setting Points of Ultrasonic Flow Meter



Source: Project Team

Figure A5-6 Operation Valves

(8) Zonal Measurement

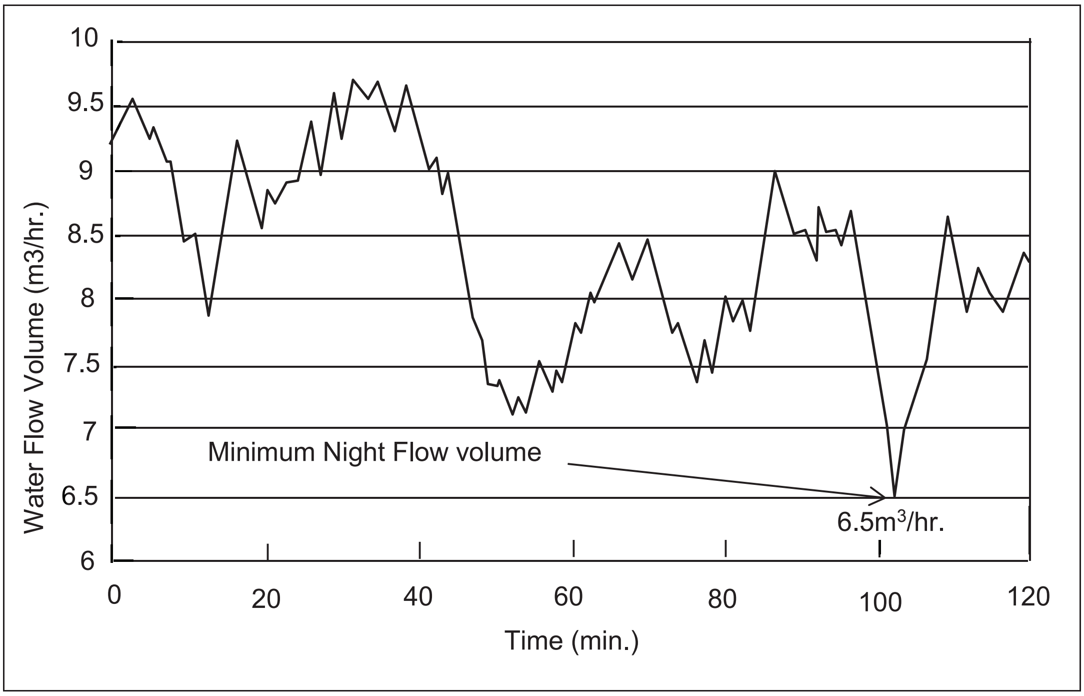
A. Purpose of Measurement of Minimum Night Flow (MNF) by Zone

The purpose of this aspect of the strategic plan is to learn NRW of each zone to prioritize zone.

B. Procedure of Measurement of Minimum Night Flow (MNF) by Zone

Step test is used for grasp leakage volume in each SMA or pipeline instead of 24-hour input volume measuring. Step test is done at night time when water consumption is expected to be minimum use. Necessary procedure is as follows:

- Usually, it is every month to download water flow data from data logger at each tank.
- See the trend of water consumption of the data and find minimum water consumption day of them.
- Convert the data to excel data and make a line graph (see Figure A4-7).
- Minimum night flow as shown in Figure A4-7 is expected to be NRW.



Source: Project Team

Figure A5-7 Minimum Night Flow Measurement

(9) Leakage Detection

A. Purpose of Leakage Detection

The purpose of this aspect of the strategic plan is to reduce NRW by detecting leak points underground and their repairs.

B. Procedure of Leakage Detection

Leakage survey should be carried out in structured and systematic way. Necessary procedure is as follows:

- Plan survey area, survey methods, number of survey teams, considering leakage occurrence, pipe materials, pipe age NRW ratio etc.
- Confirm site condition before leakage survey.

B.1 Leakage Survey at Each House (Point Survey)

Many leakages occur at service connections. Point survey can detect service pipe line and distribution line. The acoustic bar is used for point survey to hear leak noise. Necessary procedure is as follows:

- Visit customer's house and inform the customer the purpose of leakage survey and get permission to get in the property and check meter and stop valve.
- Hear leak noise at customer's meter or stop valve using an acoustic bar or an electro listening stick (see Figure A5-8).
- Stop valve and hear the noise again when the leak noise is detected, if leak noise stops, leakage occurs after stop valve. If the leak noise continues, leak occurs before stop valve.
- At same time, to observe around the meter and confirm existence of illegal connection.
- When leakage is found, to measure leakage volume using measuring device and repair the leakage.

Acoustic Rod (Listening Stick)

Electro Listening Stick

Source: Project Team

Figure A5-8 Devices for Point Survey

B.2 Leakage Survey along Road (Line survey)

It is necessary to survey on the road for detecting leakage on distribution pipeline survey using a leak detector (ground microphone). Necessary procedure is as follows:

- Hear leak noise on the road by using a leak detector (see Figure A5-9).
- Walk along pipeline, stop and touch ground microphone on the surface of the ground about five seconds and hear the noise at every step.
- When leak noise is detected, mark the point on the ground and write report about the place.
- After checking leakage by confirmation survey, measure leakage volume and repair leakage.

Leak Detector (Ground Microphone)

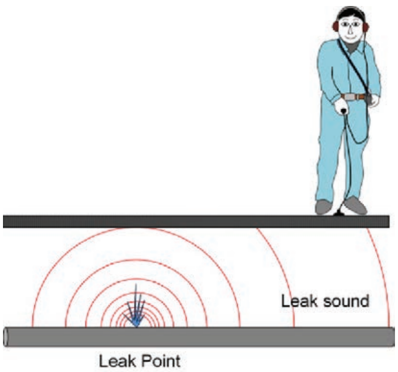


Image of Listening Leak Sound

Source: Project Team

Figure A5-9 Devices for Line Survey and It's Image

B.3 Confirmation Survey

After point survey and line survey, confirm leakage point by digging a hole using earth drill. Necessary procedure is as follows:

- Make a hole at the point where leakage is detected using earth drill.
- Check the hole which is dug by earth drill whether clean water is attached to the earth drill or not
- If clean water is attached to earth drill, there is a leakage at the point.
- Dig and measure leakage volume and repair leakage

(10) Patrol of Surface Leaks

A. Purpose of Patrol of Surface Leakage

The purpose of this aspect of the strategic plan is to reduce NRW by monitoring surface leak points and their repairs.

B. Procedure of Patrol of Surface Leakage

Patrol of surface leakage should be done regularly and all areas. Necessary procedure is as follows:

- It should be done by two activities to patrol of surface leakage survey. One is patrol by meter readers. Another is patrol by plumbers with meter reader.

B.1 Patrol by Meter Readers

Most leakage occur at service pipelines. Necessary procedure is as follows:

- Survey surface leakage on service pipelines by meter readers when they visit customer's house for meter reading.

B.2 Patrol by Plumbers with Meter Readers

When leakage occur on distribution pipelines, leakage water volume is large quantity. Necessary procedure is as follows:

- Make patrol route and schedule by assistant area manager distribution.
- Arrange the schedule and staff by area supervisor.
- Patrol of surface leak survey-of distribution pipelines along roads by plumbers with a meter reader once a week.

(11) Repair of Leaks and Recording

A. Purpose of Repair of Leaks and Recording

The purpose of this aspect of the strategic plan is to reduce NRW by repairing leak points and data collecting for revising leakage survey plan and pipe replacement plan.

B. Procedure of Repair of Leaks and Recording

It is necessary to record leakage data such as leakage condition, pipe material pipe size, etc. Necessary procedure is as follows:

B.1 Repair Work for Leakage

When leakage is detected, repair must be done. Necessary procedure is as follows:

- Repair leakage after confirmation of pipe condition and leakage volume.
- Make pipe joint (spigot and pipe end) clean and dry, when adhesive is used for jointing. And, make gasket and joint to clean, when gasket is used for sealing.
- Wash out dirty water of repaired pipeline

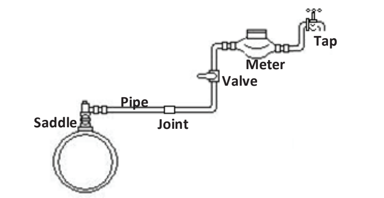
B.2 Record of Leakage Survey

It is necessary to make a leakage survey report (see Figure A5-10) for revising survey plan, making pipe replacement plan and O&M. Necessary items for report are as follows:

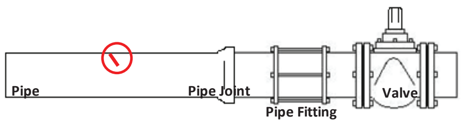
- Location: address, name
- Category of facilities: trunk main pipeline, distribution pipeline, service pipeline
- Category of road: public road, private road, in property
- Road surface condition: asphalt, concrete, soil, others
- Pipe information: pipe material, pipe diameter, pipe laying year
- Estimated leakage volume
- Location map, plan drawing, photo

Leakage Record Sheet				Leak No.	4-13
Date of Survey:	2012, Oct. 13	Street Name	Fairfield Road		
Address (Area Name)	Katahena-4	House or Plot No.	201/12		
Pipe Material (Main Pipe)	1. CIP, 2. DIP, 3.PVC, 4. GP, 5. Others	Leak Part	1. Pipe, 2. Pipe Joint, 3. Saddle, 4. Pipe Fitting 5. Valve, 6. Meter, 7. Tap, 8. Reservoir Tank, 9. Others		
Pipe Diameter	100 mm	Leak Condition	1. Hole, 2. Crack, 3. Breakage, 4. Gasket, 5. Loosening Joint, 6. Over Flow, 7. Unknown, 8. Others		
Pipe Material (Service Pipe)	1. PEP, 2. PVC, 3. GP, 4. Others ( )	Cause	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Poor Construction Work, 5. Less Adhesive, 6. Water Hammer, 7. Defective Valve, 8. Vandalization 9. Another Company's Construction Work, 10. Unknown, 11. Others ( )		
Diameter	mm				
Depth	90 cm	Surface Condition	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others		
Leakage Size	1. Large, 2. Medium, 3. Small, 4.Water Drops Measured (150 L/Min.) by flow meter	Detected Method	1. Patrol, 2. Customer Informing, 3. Point Survey (Acoustic Bar), 4. Line Survey (Ground Microphone)		

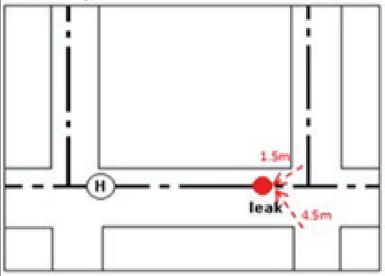
Leak Point



Hole/Crack Size:(5 cm)



Location Map



Photo

Remarks:

Leakage water flow into the sewage pipe

Information of leak repair (Used Materials and Repair Cost)

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

	Unit price	Hour	Volume	Sub total	Used Material	Size/Type	Unit price	Volume	Sub total
Worker		2.0	3		Pipe-1	DN 100 PVC		2.0 m	
Plumber		2.0	2		Pipe-2				
Supervisor		2.0	1		Pipe-3				
Engineer		1.0	1		Joint-1	DN 100 Coupling		2	
					Joint-2				
Backhoe		2.0	1		Joint-3				
Generator		1.0	1		Joint-4				
Drainage Pump		1.0	1		Joint-5				
Lighting equipment					Meter				
					Gasket				
Sand			0.3		Saddle				
Gravel			0.2						
Asphalt			1.5						
Total					Total				

Source: Project Team

Figure A5-10 Sample of Leakage Record Sheet

B.3 Utilization of Information from Leakage Survey

After leakage survey and its repair activities, much information is grasped. That information should be utilized to revise survey plan. Necessary procedure is as follows:

- Analyze information that grasped from leakage survey.
- Information about pipe condition, result of survey area and pipe surrounding are used for revising survey plan.
- Utilization of information from leakage survey is as follows;

Table A5-8 Utilization of Information from Leakage Survey

Utilization of Information from Leakage Survey		
Purpose	Necessary Information	Methods
Revise of Leakage Survey Plan	● All information	Confirm whether the GIS information is utilized or not for O&M and review the information revising method and providing method
Basic information for replacement plan and repair plan	● Information about pipe condition ● Information about result of survey area	On the information about pipe and fittings, surrounding of laying pipe and leakage condition, to reflect their information for judgment of priority of repair and replacement plan
Revise of information of GIS and pipe drawings	● Information of location ● Information of pipeline ● Information of pipe surrounding	Confirm the information about pipe network map and GIS, and revise them if necessary

Source: Project Team

(12) Identification of Illegal Connections and Meter Inaccuracy

A. Purpose of Identification of Illegal Connection and Meter Inaccuracy

The purpose of this aspect of the strategic plan is to reduce NRW by identify illegal connections and meter inaccuracy and take measure against them.

(12)-1 Identification of Illegal Connections

A. Identification of Small Consumption User

The consumer who gets water illegally, such as bypass meter, illegal connection to distribution pipe, irregular use of meter and so on, use small quantity of metered water. Therefore, it is important to inspect customer's water consumption. Small consumption customer is suspected using water illegally. They should be targets for illegal connection survey. Necessary procedure is as follows:

- Calculate the water consumption average of all customers in DMA
- To find customers who use water less than a half of average consumption compare to others
- If there are small consumption customers, illegal connection survey should be carried out on them (targets).
- To make a list of targeted customers for illegal connection survey.
- If there are many targets, prioritize them. Top priorities are customers who use water less than a quarter of average. Second priorities are rest of them.
- If there is no small consumption customer, illegal survey is not necessary.
- It is very important to check unusual condition of meter and small water consumption every month.

B. Illegal Connection Surveys

Illegal connections are usually under the ground therefore, it is difficult to find illegal connection/users. To make illegal survey easier, it is necessary to narrow down the targets to be inspected. There are two types of illegal connection survey such as: visual inspection and survey using equipment. Necessary procedure is as follows:

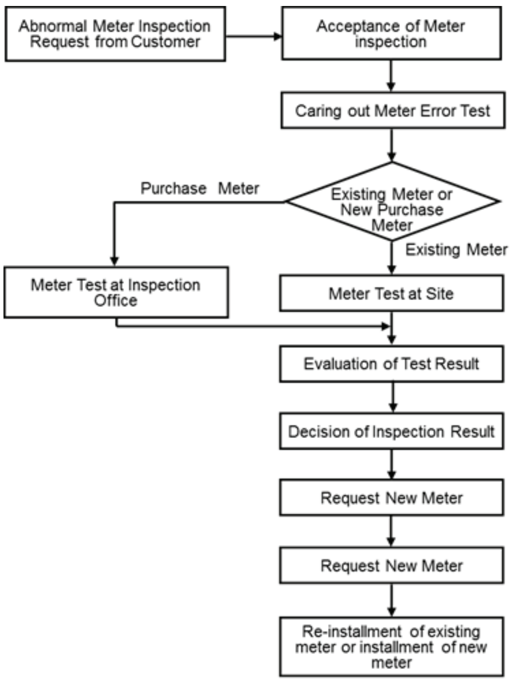
- By analysis of customer list and their consumption, the area which small consumption customer is many should be given top priority to survey.
- Other areas also should be surveyed after top priority's area.
- It is very important to check unusual condition of meter and small consumption every month.

- Inspect surroundings of meter and service pipeline whether strange pipe line is existing or not and meter is in normal condition or not. (meter readers should inspect them)
- Close stop valve on service pipeline of target house.
- Confirm stop water flow by small indicator of meter.
- Hear flow noise by acoustic bar touching stop valve.
- When flow noise can be detected, close inlet valve of water tank or inlet valve of house (in case of no water tank).
- If water flow noise stops, there is a bypass.
- Dig service pipe before stop valve to confirm bypass.
- If water flow noise continues, close outlet valve of water tank and inlet valve of house.
- If water flow noise stops, there is an illegal connection.
- Check residual chlorine of tap water if the user use borehole. When residual chlorine is detected they use WB's water.
- Dig distribution pipe around service branch to confirm illegal connection.
- Report to area manager and ask decision for the disconnection.

(12)-2 Identification of Meter Inaccuracy

A. Meter Test at Site

Water meter is equipment which measures the amount of water consumption accurately. Accurate measurement of water consumption amount is very important to build a mutual relationship between WB and customers. For confirmation of meter inaccuracy in a zone, choose about 100 samples randomly in the zone and test them by the reference meter (very accurate meter). When a meter reader finds meter error or the customer complains about water consumption volume, test the meter at the site (see Figure A5-11 and A5-12).



Source: Project Team

Figure A5-11 Flowchart of Meter Inspection

- Remove air in pipe between existing meter (test meter) and reference meter by the flow of suitable water.
- After that close valve B at reference meter as shown in Figure A5-13.
- Record both meters' count.
- After allowing the flow of suitable water (more than 100 liters), close valve B under water pressure at two meters.
- Record both meters' count.

Figure A5-12 Meter Inspection at the Customer's House

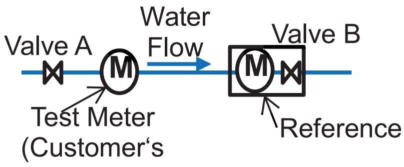


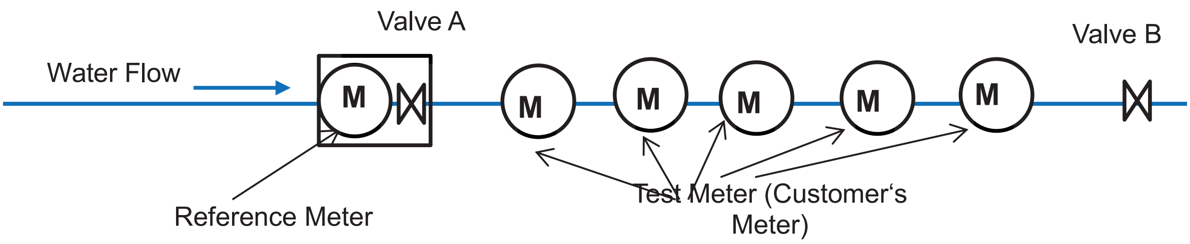
Figure A5-13 Image of Reference Meter Setting

B. Meter test at the Inspection Office

Test new purchased meters at the inspection office to check their inaccuracy.

- In case there are many test meters, those meters should be connected serially and use one reference meter. In case of new meter test, number of test meters should be chosen randomly (see Figure A5-14).
- Arrange object meters between reference meter and valve B as shown in Figure A5-15.
- After removing air in pipe, close valve A and B.
- Record all meters' count.
- After allowing the flow of suitable water, close valve A and B under water pressure at all meters.
- Record both meters' count.
- Order the supplier to replace low quality meters

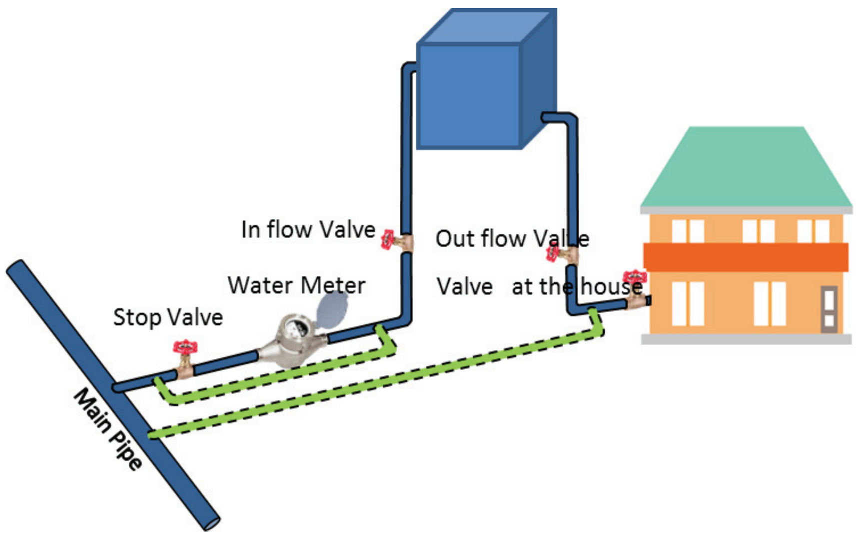
Figure A5-14 Meter Inspection at the Office



Source: Project Team

Figure A5-15 Image of Reference Meter Setting for Multi Meters' Test

Illegal Connection Report				No.	
Account No.			Date		
Name of Meter User			Tel.		
Address					
Type of Meter	1. Conventional 2. AMR 3. Prepaid				
Meter Size (mm)		Service Pipe Diameter (mm)			
Last three (3) Months' Water Consumption	1.	2.	3.		
Initial Report	1. Other User 2.Meter Reader 3. Inspector 4. Area Office Staff 5. Others ( )				
Illegal Connection Situation	1. Direct from Distribution Pipe 2. Meter By-pass 3. Meter Direct Connection 4. Illicit Meter Counter Operation 5. Revers Meter Installation 6. Others ( )				
Inspection Date					



Decision						
Approval	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	
	Name		Section		Signature	

Figure A5-16 Illegal Connection Survey Report Sheet

Source: Project Team

(13) Measure against Illegal Connection

A. Purpose of Measure against Illegal Connection and Meter Inaccuracy

The purpose of this aspect of the strategic plan is to reduce NRW by decreasing illegal connection and meter inaccuracy.

B. Procedure of Measure against Illegal Connection and Meter Inaccuracy

For NRW reduction, it is necessary to learn water consumption totally in DMA and water consumption on each pipeline in each area. Necessary procedure is as follows:

- Prepare customer lists in the area and annual water consumption of customers

(13)-1 Countermeasure against Illegal connection

The consumer who gets water illegally, such as bypass meter, illegal connection to distribution pipe, irregular use of meter and so on, use small quantity of metered water. Therefore, it is important to inspect customer's water consumption. Small consumption customer is suspected using water illegally. They should be targets for illegal connection survey (see Figure A5-16). Necessary procedure is as follows:

- Inform and make the illegal user to confirm there is an illegal connection or illegal use.
- Disconnect an illegal connection after confirmation by illegal user.
- Consider penalty for illegal water use.
- Legalize illegal user as contract with the illegal user, if there is no contract with the illegal user.
- Continue checking water consumption of illegal user every month.

(13)-2 Countermeasures against Meter Inaccuracy

Necessary procedure is as follows:

- Inaccuracy meter is not justice in terms of trading.
- Allowable using meter error range is plus minus 4% on International Waterworks Association (IWA) standard.
- There are many meters which error is out of allowable using meter error range.
- At the first step, the meter which excess from plus minus 10% should be changed.
- When meters are procured, they must be checked meter error by test meter.

(14) Data Collection of Monthly Billed Consumption

A. Purpose of Data Collection of Billed Consumption before/after NRW Reduction Operations

The purpose of this aspect of the strategic plan is to ensure that the effect from NRW reduction operations by calculation of NRW ratio using collect data.

B. Procedure of Data Collection of Billed Consumption before/after NRW Reduction Operations

For NRW reduction, it is necessary to grasp water consumption totally in the area and water consumption on each pipeline in each area. Necessary procedure is as follows:

- Prepare customer lists in the area and annual water consumption of customers
- Calculate hourly water consumption using annual water consumption data for each customer. The hourly water consumption data is used for hydraulic analysis and water balance analysis.
- Allocate customers to whom water supplied from which pipelines. The data is used for hydraulic analysis and water balance analysis.
- Evaluate the effect of NRW reduction operations by using monthly billing data.

(15) Data Collection of Monthly SIV

A. Purpose of Data Collection of Monthly SIV

The purpose of this aspect of the strategic plan is to learn monthly NRW ratio. It is important to learn NRW ratio to confirm effects of NRW reduction operations.

B. Procedure of Data Collection of Monthly SIV

There are three activities to collect monthly SIV such as: the whole system input, zonal system input, and system input of DMA.

Procedure of data collection is as follows:

B.1 Data collection of whole system input volume

Procedure of data collection of the whole system input volume is as follows:

- There are bulk meters to measure water volume flowing in trunk main pipelines distributed from LUD Water Treatment Plant to tanks (distribution reservoirs).
- Staff of NRW Unit must download water flow data from data loggers in LUD Water Treatment Plant on the first or second week of every month (one month interval).

B.2 Data collection of zone system input volume

Procedure of data collection of zone system input volume

- There are zonal meters to measure water volume flowing in distribution main pipelines distributed from tanks to each zone.
- Staff of NRW Unit must download water flow data from data loggers at each tank on the first or second week of every month (one month interval).

B.3 Data collection of DMA system input volume

Procedure of data collection of DMA system input volume:

- There are inlet and outlet meters to measure volume flowing in distribution pipelines at inlet point and outlet point of DMA.
- Distribution staff must read inlet and outlet meters of DMA and record water volume and report it to NRW Unit on the first or second week of every month (one month interval).

(16) Monthly Water Balance Analysis

A. Purpose of Water Balance Analysis before/after NRW Reduction Operations

The purpose of this aspect of the strategic plan is to ensure that how much NRW ratio is and what the challenges on reduction of NRW is.

B. Procedure of Water Balance Analysis before/after NRW Reduction Operations

Water balance analysis is calculated using collecting data which is collected above mentioned procedure. Procedure is as follows:

B.1 Data Collection

Data collection procedure is already explained above chapter. In this chapter, we will discuss which data is used in the component of water balance analysis. Necessary procedure is as follows:

- Usually annual data of billed water consumption is used for the component "Billed Metered Consumption" and "Billed Un-Metered Consumption".
- But for the NRW Reduction operation, one-month billed consumption of before/after the operation should be used.
- Water volume of each component should be convert to cubic meter per hour.

B.1.1 System Input Volume

- System input volume is measured by zonal water flow meters.
- Down load data of water flow volume at outlet of each tank every month.
- System input volume of DMA is measured by bulk meter of DMA.

B.1.2 Billed Metered Consumption

- "Billed Metered Consumption" is conventional metered consumption, AMR metered consumption and prepaid metered consumption in FCTWB.
- Prepaid metered consumption also should be converted to hourly water volume.

B.1.3 Billed Un-Metered Consumption

- "Billed Un-Metered Consumption" is flat rate consumption in FCTWB.
- Consumption of flat rate customer should be divided two portions. One is flat rate tariff converted to metered volume. The other one is excess use of it.
- The flat rate tariff in terms of metered volume is revenue water volume.
- Excess use of flat rate is non-revenue water volume.

B.1.4 Unbilled Metered Consumption

- Usually this component is settlement of water rate when water utility supply dirty water to customers after construction of leakage repair work, the customer complains about that and the water charge is settled by negotiation.
- Its volume is very small part of water balance. It is almost 0%.

B.1.5 Unbilled Un-Metered Consumption

- This component is water volume used by water utilities such as flash water after pipe laying work, pipe replacement work and leakage repair work
- Consumption at religious facilities, staff houses and facilities which authorized by welfare policy in FCTWB, should be metered.

B.1.6 Unauthorized Consumption

- This component is illegal water use (illegal connection) and unidentified water volume.
- In the manual, this component is separate illegal water use (illegal connection) and unidentified water volume.

B.1.7 Customer Meter Inaccuracy and Data Handling Errors

- Data of "(12)-2 Identification of Meter Inaccuracy" is used for the component "Customer meter inaccuracy".
- Volume of data handling error is very small part of water balance. It is almost 0%.

B.1.8 Leakage in Transmission and Distribution Mains

- In case of analysis for total system, this component is used.
- In case of analysis for DMA/zone, leakage of distribution is used

B.1.9 Leakage and Overflows at Utility's Storage Tanks

- In case of analysis for total system, this component is used.
- In case of analysis for DMA/zone, there is no Utility's Storage tank.

B.1.10 Leakage on Service Connections up to Point of Customer Metering

- Most of leakages occur at service connections.
- Leakage survey should be done at service connections.

B.1.11 Components used for Water Balance Analysis of NRW Reduction Operations

- In the activities, water balance sheet should be simple like below. Because some of components are small volume compare to total volume.

B.2 Water Balance Analysis

Water balance analysis is done using collected data of each function. Each collected data should be converted to cubic meter per hour.

- Insert each data to each column of water balance sheet.
- Calculate NRW ratio using the sheet.

(17) Measurement of One-week SIV

It is necessary to measure one-week input volume of DMA and Zones to know the trend of its water consumption in a day and a week. Average one-hour water consumption is utilized for water balance analysis. Minimum night flow volume is utilized for leakage detection.

(18) Installing Water Meters

There are no meters for flat rate customers and public taps or water kiosks. For the calculation of NRW ratio, it is very important to know actual water consumption and input water volume of the system; DMAs, Zones. So, it is necessary to install meters for all customers to know the actual water consumption.

- List flat rate customers and necessary number of meter for them
- List public taps, kiosks and other customers which have no meter and necessary number of meter for them
- Procure and install meters to them

(19) Survey on Trunk Distribution mains and Reservoirs

A. Purpose of Survey on Trunk, Distribution mains and Reservoirs

The purpose of this aspect of the strategic plan is to learn conditions of trunk/distribution main pipelines, reservoirs, villages, and public taps such as: leakage or illegal water use. When trunk, distribution main pipeline leaks, it has large effect to water supply system and citizens. There might be illegal water use at pipeline fittings, villages, and public taps.

B. Procedure of Survey on Trunk Distribution mains and Reservoirs

Procedure of Survey on Trunk Distribution mains and Reservoirs is as follows:

B.1 Survey on Trunk Distribution mains

Procedure of Survey on Trunk and Distribution mains is as follows:

- Prepare route (pipeline) map for surveying
- Walk along pipeline route and observe road surface whether there is leak water or not. Concurrently with the survey, check and record positon of pipeline route especially pipe bending point by GPS survey devices.
- At fittings such as air release valves, stop valves, wash out water meter, etc., open man-hole cover and get into the chamber. Concurrently with the survey, check and record position of a fitting by GPS survey devices.
- Check fittings and their surroundings whether there is a leakage or illegal connection or not.

B.2 Survey on Reservoirs

Procedure of Survey on Reservoir is as follows:

- Check crack of wall and leaks from wall.
- Check over flow facilities whether there is over flowing or not.
- Check pumping facilities and pipes whether there are leaks or not.

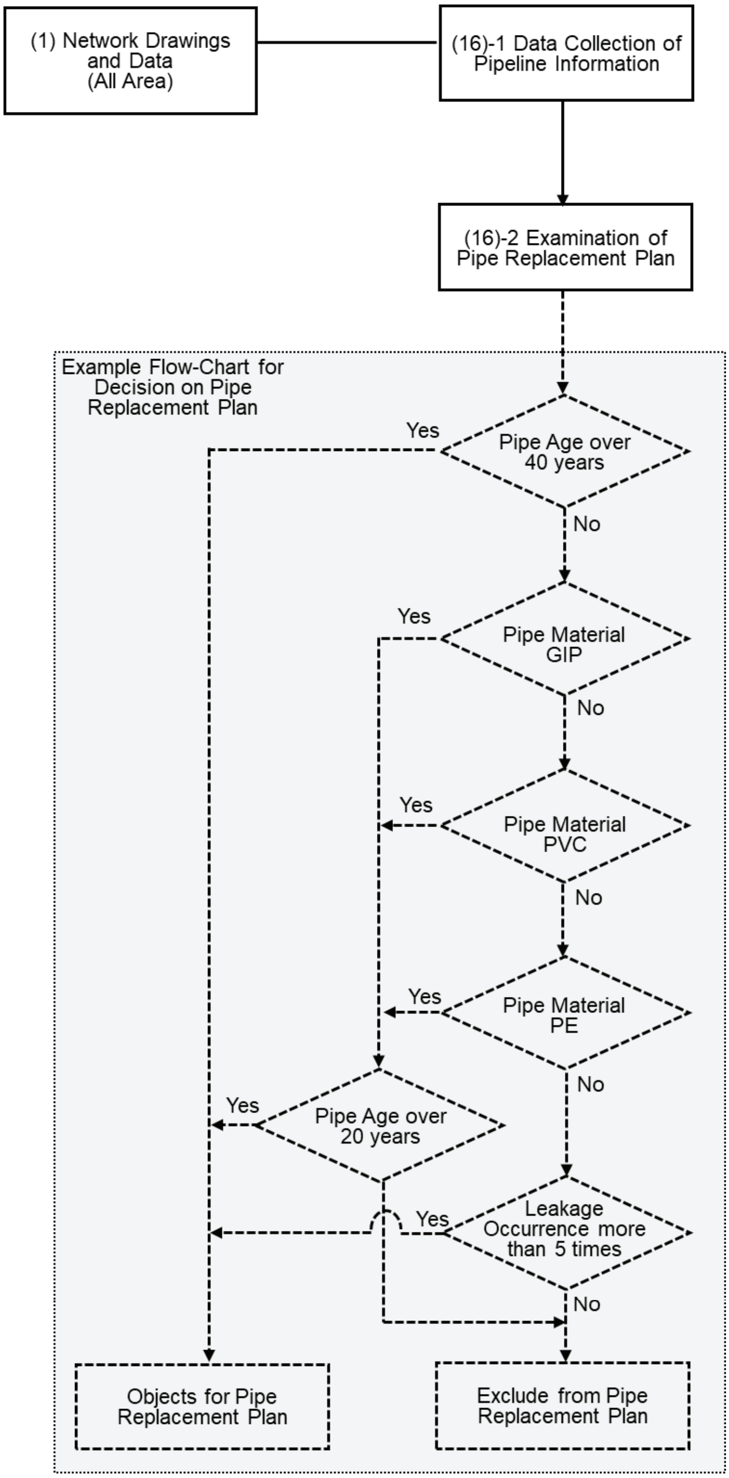
B.3 Inspection of villages and public taps

Procedure of Inspection of villages and public taps is as follows:

- Inspect how to use water at villages and public taps.

- Inspect surroundings whether there is illegal connection or not.
- If necessary, measure one-day water consumption at service pipeline for villages or public taps by ultrasonic flow meter.

(20) Preparation for Pipe Replacement Plan



Source: Project Team

Figure A5-17 Flow Chart of Examination of Pipe Replacement Plan

Pipeline on which leaks occur frequently: because leaks is caused by pipe material or poor plumber’s skill. Pipeline on which leaks occur at pipe body: because leaks is caused by pipe material.

Pipeline on which leaks occur frequently: because leaks is caused by pipe material or poor plumber’s skill. Pipeline on which leaks occur at pipe body: because leaks is caused by pipe material.

Pipe replacement plan should be considered data on leakage repair report as follows:

For the data collection, the following operations must be done:

- Make Network Drawings of All Areas (GIS Data or Handwriting)
- Make Leakage Repair Report (All Areas)

It is necessary to obtain the following data for making “Pipe Replacement Plan”:

- Age of Pipeline on Network Drawings (All Areas)
- Pipe Materials on Network Drawings (All Areas)
- Pipe Diameter on Network Drawings (All Areas)
- Leakage Occurrence on Each Pipeline (All Areas)
- Leakage Occurrence of Each Pipe Material (All Areas)
- Leakage Occurrence of Each Pipe Age (All Areas)
- Leakage Occurrence of Each Area (All Areas)
- Leakage Occurrence of Each Pipe Diameter (All Areas)

A. Network Drawings of All Areas (GIS Data or Handwriting)

See “(1) Network Drawings and Data”

B. Leakage Repair Reports

When Area Offices find and repair leaks, it is necessary to make Leakage Repair Report. Procedure and duties for each section are as follows:

- Make leakage repair reports when leaks are found and repaired from the first year to fifth year (to be continued after fifth year) (done by Area Offices)
- Describe information of leakage repair reports on the copy of network drawings (done by Area Offices)
- Submit copy of them to GIS Unit and NRW Unit every year from third year (done by Area Offices)
- Input the data to GIS mapping every year from third year (done by GIS Unit)
- Categorize (Leakage Occurrence on Each Pipeline, Each Pipe Material, Each Pipe Age, Each Area and Pipe Diameter) and make excel file of occurrence of leaks every year from the first year to fifth year (to be continued after fifth year) (done by Area Offices)
- Submit it to NRW Unit every year from the first year to fifth year (to be continued after fifth year) (done by Area Offices)
- Total submitted excel data from each Area Office and analyse them every year from the first year to fifth year (to be continued after fifth year) (done by NRW Unit)

C. Reason of data collecting

Leakage occurs by a same cause or complex causes. Each data must be collected and analysed at least in five years. Necessary data and its reasons are as follows:

- Leakage Occurrence on Each Pipeline

When leakage occurs on same pipeline, one of the causes is poor construction work. So, it is necessary to collect data how many times leaks occur on same pipeline.

- Leakage Occurrence of Each Pipe Material

Leakage sometime occurs on same pipe materials.

Low or middle density polyethylene pipe sometimes burst caused by its chemical structure and production method.

PVC pipe is week against organic solvents. It's become soft and expanded by organic solvent. It's a cause of leakage and water pollution inside of pipe. Leakage occur on PVC pipe joints, because of luck of adhesive or jointing under wet condition.

Leakage occurs on metallic pipe because of corrosion, so, it is necessary to collect data how many times leaks occur on same pipe materials.

- Leakage Occurrence of Each Pipe Age

Leakage occur because of pipe aging.

So, it is necessary to collect data how many times leaks occur on same pipe materials.

- Leakage Occurrence of Each Area

Some Leakage occur because of characteristic cause in same area such as: heavy traffic load, corrosive soil area, poor construction work area, high water pressure area, the area where sub-standard pipe material is used and so on.

So, it is necessary to collect data how many times leaks occur on same pipe materials.

- Leakage Occurrence of Each Pipe Diameter

Leakage occurrence ratio is different by pipe diameter.

So, it is necessary to collect data how many times leaks occur on each pipe diameter.

D. Data Reflection of Customer Information

Sometimes, customers complain about lack of water, low water pressure, and water leakage in their properties. Analysis of those information is very useful to consider pipe replacement plan. Because the water supply condition should be improved in the area where many customers complain about it. The pipe replacement plan is also considered for customers' satisfaction.

E. Examination of Pipe Replacement Plan

Pipe replacement plan should be considered the budget which can be allocated for the plan such as: how many kilometers of pipeline can be replaced in a year. The target of the plan should be considered from the financial condition. Prioritize the items such as: pipe materials, pipe age, some areas and pipe diameters.

The dashed line part of the flow chart as shown in Figure A5-17 is a sample of selecting items and its age. The plan must be decided by analysis of collected data.

Appendix-6: Profit and Loss (P/L) Statement

Table A6-1 No Scenario **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,276.6	7,824.6	7,824.6	7,824.6	7,824.6
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,281.5	7,829.5	7,829.5	7,829.5	7,829.5
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0.0	0.0	0.0	0.0	0.0	0.0
	Total	2,577.3	2,631.3	2,814.4	2,799.2	2,799.2	2,799.2
Profit and Loss (-)		2,704.2	2,650.2	5,015.1	5,030.2	5,030.2	5,030.2

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the track record as of 2017 (see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consist of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team

Table A6-2 Scenario a **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,550.1	8,685.6	9,200.1	9,788.7	10,301.7
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,555.0	8,690.5	9,205.0	9,793.6	10,306.6
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0	44.8	66.5	72.6	87.5	95.8
	Total	2,577.3	2,676.1	2,880.9	2,871.8	2,886.7	2,895.0
Profit and Loss (-)		2,704.2	2,878.9	5,809.7	6,333.2	6,906.9	7,411.6

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the record as of 2017 (see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consist of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team

Table A6-3 Scenario b **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,552.1	8,694.7	9,234.9	9,766.0	10,233.6
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,557.0	8,699.6	9,239.8	9,770.9	10,238.5
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0	41.0	61.6	66.5	76.8	86.5
	Total	2,577.3	2,672.3	2,876.0	2,865.7	2,876.0	2,885.7
Profit and Loss (-)		2,704.2	2,884.7	5,823.6	6,374.1	6,894.9	7,352.8

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the track record as of 2017 (see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consists of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team

Table A6-4 Scenario c **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,516.4	8,537.3	8,902.0	9,286.4	9,542.1
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,521.3	8,542.2	8,906.9	9,291.3	9,547.0
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0	40.0	49.2	41.2	43.1	44.8
	Total	2,577.3	2,671.4	2,863.7	2,840.5	2,842.4	2,844.1
Profit and Loss (-)		2,704.2	2,850.0	5,678.6	6,066.5	6,448.9	6,702.9

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the track record as of 2017 (see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consist of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team.

Table A6-5 Scenario d **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,561.3	8,669.0	9,092.7	9,514.9	9,819.0
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,566.2	8,673.9	9,097.6	9,519.8	9,823.9
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0	14.3	17.1	16.2	20.7	25.2
	Total	2,577.3	2,645.6	2,831.6	2,815.5	2,819.9	2,824.4
Profit and Loss (-)		2,704.2	2,920.6	5,842.3	6,282.1	6,699.8	6,999.5

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the track record as of 2017 (see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consist of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team

Table A6-6 Scenario e **(Million Naira)**

Account Items		2018	2019	2020	2021	2022	2023
Revenues	Water sales*1	5,276.6	5,388.9	8,159.1	8,327.0	8,495.0	8,662.9
	Others*2	4.9	4.9	4.9	4.9	4.9	4.9
	Total	5,281.5	5,393.8	8,164.0	8,331.9	8,499.9	8,667.8
Expenditures	Manpower*3	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
	Materials*4	401.4	401.4	580.5	580.5	580.5	580.5
	Depreciation*5	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
	Miscellaneous*6	75.2	75.2	75.2	75.2	75.2	75.2
	Of Scenario*7	0	12.4	13.5	10.7	13.4	16.1
	Total	2,577.3	2,643.8	2,827.9	2,810.0	2,812.7	2,815.4
Profit and Loss (-)		2,704.2	2,750.0	5,336.1	5,521.9	5,687.2	5,852.5

Note:
*1: Refer to Appendix 6-1
*2: This consists of service connection charge, analysis fee for private borehole water and tender fee as non-sale revenue. The amount is based on average between the year 2014 and 2017.
*3: This consists of salary & wages, allowance for permanent & casual staff. The amount is based on the track record as of 2017(see Appendix 6-3).
*4: Refer to Appendix 6-3.
*5: Refer to Appendix 6-3.
*6: Refer to Appendix 6-3.
*7: This is an expenditure which is incurred by the NRW reduction operation by scenario. The expenditures consist of personnel allowance, fuel and depreciation of equipment but not capital cost such as water meters, valves, etc.
Source: Project Team

Appendix 6-1: Yearly Revenue Water and Revenue by Scenario

Scenarios			2018	2019	2020	2021	2022	2023
No Scenario	Revenue Water	Mil. m^3 / year	58.63	58.63	86.94	86.94	86.94	86.94
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,277	7,825	7,825	7,825	7,825
Scenario-a	Revenue Water	Mil. m^3 / year	58.63	61.67	96.51	102.22	108.76	114.46
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,550	8,686	9,200	9,789	10,302
Scenario-b	Revenue Water	Mil. m^3 / year	58.63	61.69	96.61	102.61	108.51	113.71
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,552	8,695	9,235	9,766	10,234
Scenario-c	Revenue Water	Mil. m^3 / year	58.63	61.29	94.86	98.91	103.18	106.02
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,516	8,537	8,902	9,286	9,542
Scenario-d	Revenue Water	Mil. m^3 / year	58.63	61.79	96.32	101.03	105.72	109.10
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,561	8,669	9,093	9,515	9,819
Scenario-e	Revenue Water	Mil. m^3 / year	58.63	59.88	90.66	92.52	94.39	96.25
	Price	Naira/m^3	90	90	90	90	90	90
	Revenues	Naira/year	5,277	5,389	8,159	8,327	8,495	8,663

Note: Revenue water is based on Appendix 6-2.
Source: Project Team

Appendix 6-2: Targeted NRW Ratio and Yearly Revenue Water by Scenario

Scenarios			2017	2018	2019	2020	2021	2022	2023
No Scenario	Distribution	Mil. m^3 / year	113.38	113.38	113.38	168.13	168.13	168.13	168.13
	NRW rate	%	48.3%	48.3%	48.3%	48.3%	48.3%	48.3%	48.3%
	Revenue Water	Mil. m^3 / year	58.63	58.63	58.63	86.94	86.94	86.94	86.94
Scenario-a	NRW rate	%	48.3%	48.3%	45.6%	42.6%	39.2%	35.3%	31.9%
	Revenue Water	Mil. m^3 / year	58.63	58.63	61.67	96.51	102.22	108.76	114.46
Scenario-b	NRW rate	%	48.3%	48.3%	45.6%	42.5%	39.0%	35.5%	32.4%
	Revenue Water	Mil. m^3 / year	58.63	58.63	61.69	96.61	102.61	108.51	113.71
Scenario-c	NRW rate	%	48.3%	48.3%	45.9%	43.6%	41.2%	38.6%	36.9%
	Revenue Water	Mil. m^3 / year	58.63	58.63	61.29	94.86	98.91	103.18	106.02
Scenario-d	NRW rate	%	48.3%	48.3%	45.5%	42.7%	39.9%	37.1%	35.1%
	Revenue Water	Mil. m^3 / year	58.63	58.63	61.79	96.32	101.03	105.72	109.10
Scenario-e	NRW rate	%	48.3%	48.3%	47.2%	46.1%	45.0%	43.9%	42.8%
	Revenue Water	Mil. m^3 / year	58.63	58.63	59.88	90.66	92.52	94.39	96.25

Source: Project Team

Appendix 6-3: Expenditure by Year

Items		2016	Adjust.	2017	2018	2019	2020	2021	2022	2023
1. Manpower	Salary & allowance	921.9		1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5	1,083.5
2. Material*1	Electricity*2	4.9	10%	5.4	5.4	5.4	8.0	8.0	8.0	8.0
	Fuel*3	7.7	10%	8.5	8.5	8.5	8.5	8.5	8.5	8.5
	Chemical*4	314.6	10%	346.1	346.1	346.1	513.2	513.2	513.2	513.2
	Repair & maintenance*5	37.7	10%	41.5	41.5	41.5	50.8	50.8	50.8	50.8
	Cost incurred by Scenario									
	Total	364.9		401.4	401.4	401.4	580.5	580.5	580.5	580.5
3.Depreciation*7	Existing*6	117.2		117.2	117.2	117.1	87.5	72.3	72.3	72.3
	WTP III & IV			900.0	900.0	900.0	900.0	900.0	900.0	900.0
	On-going projects					54.1	54.1	54.1	54.1	54.1
	Switch-over						33.7	33.7	33.7	33.7
	Total	117.2		1017.2	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
4. Other recurrent cost		68.3	10%	75.2	75.2	75.2	75.2	75.2	75.2	75.2
Total		1,472.4		2,577.3	2,577.3	2,631.3	2,814.4	2,799.2	2,799.2	2,799.2

Note
*1: The track record for the year 2016.
*2: The track record for the year 2016 multiplied by 10 % makes amounts between 2017 and 2019. Estimated amount for the year 2019 multiplied by increase rate of 48% which is in proportion to the rate of distributed water to be increased, make that between the year 2020 and 2023. It is expected that distributed water increases due to switch-over construction of the transmission pipelines at LUD Water Treatment Plant.
*3: The track record for the year 2016 multiplied by 10 % makes amounts between 2017 and 2023.
*4: Same as '*2'.
*5: The track record for the year 2016 multiplied by 10 % makes amounts between 2017 and 2019. Estimated amount for the year 2019 multiplied by the increase rate which is in proportion to the about 50% of the rate of distributed water to be increased, figures out those amounts between the year 2020 and 2023. It is expected that distributed water increases due to switch-over construction of the transmission pipelines at LUD Water Treatment Plant.
*6: The track record for the year 2016.
*7: The depreciation of water supply facilities apart from the "Existing" is calculated based on the initial investment cost of NGN18,000million for WTP III&IV, NGN1,082million for the "On-going" and NGN 673million for the "Switch-over" in consideration with a depreciation period of 20 years.
Source: Project Team

Appendix 7: Cash Flow (CF) Statement

Table A7-1 No Scenario (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1.Profit and Loss	2,704.2	2,650.2	5,015.1	5,030.2	5,030.2	5,030.2
2.Depreciation	1,017.2	1,071.2	1,075.2	1,060.1	1,060.1	1,060.1
3.Total (=1+2)	3,721.4	3,721.4	6,090.3	6,090.3	6,090.3	6,090.3
4.Un-paid billed amount*1	-3,625.3	-3,625.3	-5,375.8	-5,375.8	-5,375.8	-5,375.8
5.Operational CF (=3+4)	96.1	96.1	714.5	714.5	714.5	714.5
6.Investment CF (= 1) + 2))	0.0	673.0	0.0	0.0	0.0	0.0
1) Switch-over*2	0	673.0	0	0	0	0
2) For scenario	0	0	0	0	0	0
7.Financial CF*3	0	673.0	0	0	0	0
8.Net CF (=5-6+7)*3	96.1	96.1	714.5	714.5	714.5	714.5

Note:
*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between the year 2014 and 2017) make the "Un-paid billed amount".
*2: Switch-over construction investment is to be funded by the Government.
*2 and *3: The switch-over construction investment is to be funded by the Government.
Source: Project Team

Table A7-2 Scenario a (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1. Profit and Loss	2,704.2	2,878.9	5,809.7	6,333.2	6,906.9	7,411.6
2.Depreciation	1,017.2	1,071.2	1,094.9	1,093.6	1,107.5	1,117.5
3.Total (=1+2)	3,721.4	3,950.1	6,904.6	7,426.8	8,014.4	8,529.1
4.Un-paid billed amount*1	-3,625.3	-3,813.2	-5,967.4	-6,320.9	-6,725.3	-7,077.7
5.Operational CF (=3+4)	96.1	137.0	937.2	1,105.9	1,289.1	1,451.3
6.Investment CF (= 1) + 2))	0.0	870.0	138.6	139.1	99.7	100.0
1) Switch-over*2	0	673.0	0	0	0	0
2) For scenario*3	0	197.0	138.6	139.1	99.7	100.0
7.Financial CF*4	0	673.0				
8.Net CF (=5-6+7)*5	96.1	-60.0	798.6	966.9	1,189.4	1,351.3

Note:
*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between the year 2014 and 2017) make the "Un-paid billed amount".
*2 and *4: The switch-over construction investment is to be funded by the Government.
*3: This is composed of equipment such as water meters, pipe fittings & spare-parts for repair, flow-meters, valves, etc.
*5: The negative C/F of 2019 after financing of the Government for the switch-over, 60 million Naira, should be raised for from the Government or the third party.
Source: Project Team

Table A7-3 Scenario b (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1.Profit and Loss	2,704.2	2,884.7	5,823.6	6,374.1	6,894.9	7,352.8
2.Depreciation	1,017.2	1,071.2	1,093.6	1,091.0	1,103.7	1,112.7
3.Total (=1+2)	3,721.4	3,955.9	6,917.2	7,465.2	7,998.6	8,465.6
4.Un-paid billed amount*1	-3,625.3	-3,814.6	-5,973.7	-6,344.8	-6,709.7	-7,031.0
5.Operational CF (=3+4)	96.1	141.3	943.6	1,120.4	1,288.9	1,434.6
6.Investment CF (= 1) + 2))	0.0	857.1	125.8	126.2	90.6	91.0
1)Switch-over*2	0	673.0	0	0.0	0	0
2) For scenario*3	0	184.1	125.8	126.2	90.6	91.0
7.Financial CF*4	0	673.0				
8.Net CF (=5-6+7)*5	96.1	-42.8	817.8	994.1	1,198.2	1,343.6

Note:

*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between 2014 and 2017) make the "Un-paid billed amount".

*2 and *4: The switch-over construction investment is to be funded by the Government.

*3: This is composed of equipment such as water meters, pipe fittings & spare-parts for repair, flow-meters, valves, etc.

*5: The negative C/F of 2019 after financing of the Government for the switch-over, 43 million Naira, should be raised for from the Government or the third party.

Source: Project Team

Table A7-4 Scenario c (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1.Profit and Loss	2,704.2	2,850.3	5,679.7	6,066.5	6,448.9	6,702.9
2.Depreciation	1,017.2	1,071.2	1,082.8	1,069.5	1,071.4	1,073.3
3.Total (=1+2)	3,721.4	3,921.5	6,762.5	7,136.0	7,520.4	7,776.3
4.Un-paid billed amount*1	-3,625.3	-3,790.0	-5,865.5	-6,116.1	-6,380.1	-6,555.8
5.Operational CF (=3+4)	96.1	131.5	897.0	1,019.9	1,140.2	1,220.4
6.Investment CF (= 1) + 2))	0.0	749.1	18.8	18.9	18.9	18.9
1) Switch-over*2	0	673.0	0	0	0	0
2) For scenario*3	0	76.1	18.8	18.9	18.9	18.9
7.Financial CF*4	0	673.0				
8.Net CF (=5-6+7)	96.1	55.4	878.2	1,001.0	1,121.3	1,201.5

Note:

*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between 2014 and 2017) make the "Un-paid billed amount".

*2 and *4: The switch-over construction investment is to be funded by the Government.

*3: This is composed of equipment such as water meters, pipe fittings & spare-parts for repair, flow-meters, valves, etc.

Source: Project Team

Table A7-5 Scenario d (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1.Profit and Loss	2,704.2	2,920.6	5,842.3	6,282.1	6,699.8	6,999.5
2.Depreciation	1,017.2	1,071.2	1,077.2	1,064.0	1,067.8	1,071.7
3.Total (=1+2)	3,721.4	3,991.8	6,919.6	7,346.1	7,767.6	8,071.1
4.Un-paid billed amount*1	-3,625.3	-3,820.9	-5,956.0	-6,247.1	-6,537.1	-6,746.1
5.Operational CF (=3+4)	96.1	170.9	963.6	1,099.0	1,230.5	1,325.0
6.Investment CF (= 1) + 2))	0.0	692.8	19.4	38.4	38.4	38.4
1) Switch-over*2	0	673.0	0	0	0	0
2) For scenario*3	0	19.8	19.4	38.4	38.4	38.4
7.Financial CF*4	0	673.0				
8.Net CF (=5-6+7)	96.1	151.2	944.2	1,060.6	1,192.1	1,286.6

Note:
*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between 2014 and 2017) make the "Un-paid billed amount".
*2 and *4: The switch-over construction investment is to be funded by the Government.
*3: This is composed of equipment such as water meters, pipe fittings & spare-parts for repair, flow-meters, valves, etc.
Source: Project Team

Table A7-6 Scenario e (Million Naira)

Account Items	2018	2019	2020	2021	2022	2023
1.Profit and Loss	2,704.2	2,750.0	5,336.1	5,521.9	5,687.2	5,852.5
2.Depreciation	1,017.2	1,071.2	1,075.4	1,060.4	1,062.4	1,064.5
3.Total (=1+2)	3,721.4	3,821.2	6,411.5	6,582.3	6,749.6	6,916.9
4.Un-paid billed amount*1	-3,625.3	-3,702.4	-5,605.6	-5,721.0	-5,836.4	-5,951.8
5.Operational CF (=3+4)	96.1	118.8	805.9	861.3	913.2	965.1
6.Investment CF (= 1) + 2))	0.0	674.8	1.5	20.5	20.5	20.5
1) Switch-over*2	0	673.0	0	0	0	0
2) For scenario*3	0	1.8	1.5	20.5	20.5	20.5
7.Financial CF*4	0	673.0				
8.Net CF (=5-6+7)	96.1	117.0	804.4	840.8	892.7	944.7

Note:
*1: Billed amounts (water sales) multiplied by arrear ratio (68.7%, average track record between 2014 and 2017) make the "Un-paid billed amount".
*2 and *4: The switch-over construction investment is to be funded by the Government.
*3: This is composed of equipment such as water meters, pipe fittings & spare-parts for repair, flow-meters, valves, etc.
Source: Project Team

Annex 17:

Annual NRW Reduction Plan for 2019

Federal Capital Territory Administration
ABUJA
The Heart of Nigeria
Federal Capital Territory Water Board

Japan International Cooperation Agency

The Federal Capital Territory Reduction of Non-Revenue Water Project Annual NRW Reduction Plan

June, 2018

Engr. M.K. Rabiu: HoU, NRW

1. Introduction

- Annual Non-Revenue Water Reduction Plan for 2019 is an integral part of the prepared Mid-term Strategic Plan for 2019 – 2023
- Non-revenue water ratios in Garki, Gudu and Jabi pilot areas ranges from 45.6% - 87.6% before and 20.4% - 34.7% after counter measures respectively.
- The results of outputs 1 & 2 of the pilot project were used to prepare the annual plan for reduction of NRW for the year 2019
- Out of the five Scenarios, the project prepared (Scenario a – Scenario e) in the Mid-term Strategic Plan for 2019 - 2023, the board selected Scenario d.
- Based on the Mid-term strategic plan, FCT water Board will target Non-Revenue Water Ratio of 35.1% for the year 2013 on implementation of Scenario d provisions.
- The annual NRW Reduction plans to portray relevant activities associated with the Board's chosen Scenario (Scenario d)

2. Current Situation and Challenges of NRW in FCC

For the entire system:

The Project estimated NRW ratio for the year 2014-2017 as follows:

■System Input Volume: 113.38 million m^3 per year

■RW: 58.63 million m^3 per year

■NRW: 54.75 million m^3 per year

■NRW Ratio: **48.3%**

For the Pilot Areas:

■High NRW ratio of 45.6% to 87.6% in Pilot Metering Areas (PMA) before NRW reduction operations.

■Estimated & Return bills, flat rate customers, meter inaccuracy, illegal connection, data handling errors, discrepancies between pipeline design drawings and what is obtainable on ground, intermittent power supply, non-full of pipe flow, different meter types, several customer categories.

3. Selected Scenario

- FCT Water Board selected Scenario d, considering availability of limited number trained staff for leakage survey, possibility of having enough budget of N223million for five years for allowance and equipment such as customer water meters, meter boxes, fuel, pipes, their fittings, etc.
- The selected Scenario provides that only FCTWB HQ will take NRW reduction operations such as leakage survey, illegal connection survey and water meter survey systematically by zone but NOT create DMA. FCTWB will target on NRW ratio of 35.1% for the year 2023.
- It should be noted that, implementation of NRW reduction operations may change from scenario-d to the other for a certain period for accelerating NRW reduction operation.

The FCT Water Board must consider the following actions in order to maintain NRW reduction operations:

- Procure accurate water meters.
- Ensure budget to develop meter laboratory.
- Need some technical assistance for developing meter laboratory.
- Calibrate test meters.
- Need for design of leakage training yard considering local condition.

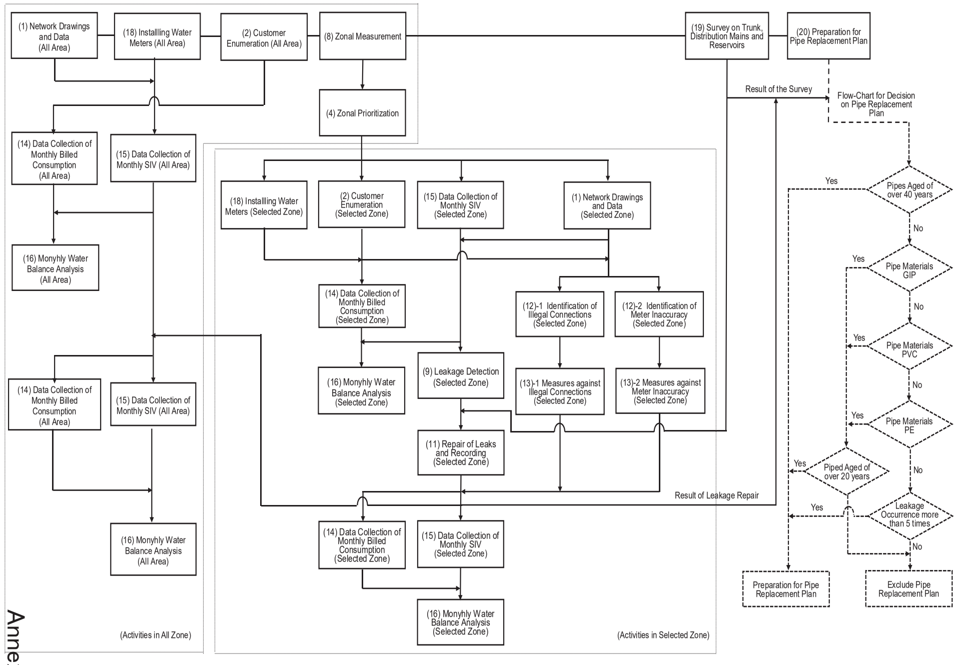
4. Annual Goal of NRW Reduction Operation and Review of Verifiable Indicators for Achievement

- Goal of NRW Ratio: 48.3% (Baseline) to 45.5% at the end of 2019
- Verifiable indicator: Report of annual operations with IWA Water Balance Analysis

Summary of the NRW Reduction Operations (Scenario d)

S/N	Description of Item
1	Network Drawings and Data
2	Customer Enumeration by Zone
3	Zonal Prioritization
4	Zonal Flow Measurement
5	Leakage Detection by Zone
6	Patrol of Surface Leaks
7	Repair of Leaks and Recording
8	Identification of Illegal Connection and Inaccuracy Meters
9	Procurement of Water Meters
10	Installation of Water Meters
11	Measures against Illegal Connection and Meter Inaccuracy
12	Data Collection of Monthly Billed Consumption by zone
13	Data Collection of Monthly SIV by Zone and Bulk meters
14	Monthly Water Balance Analysis
15	Survey on Trunk, Distribution Mains and Reservoirs
16	Preparation for Pipe Replacement Plan

Work Flow of Scenario-d



Staffing Plan

	NRW reduction Unit	GIS Unit	Distribution Unit	Billing Unit	Commerce Unit
Scenario-d	11	3	2	2	1

6. Staffing Plan (Scenario-d)

Office	NRW reduction Unit	GIS Unit	Distribution Unit	Billing Unit	Commerce Unit
HQs	**11**	**3**	**2**	**2**	**1**
Area Office	**-**	**-**	**6**	**-**	**1**

Time Schedule for NRW Reduction Operation Plan, 2019

S/N	Description	J	F	M	A	M	J	J	A	S	O	N	D
1	Network Drawings and Data												
1	Customer Enumeration by Zone												
2	Zonal Prioritization												
4	Zonal Flow Measurement												
5	Leakage Detection												
6	Patrol of Surface Leaks												
7	Repair of Leaks and Recording												
8	Identification of Illegal Connection and Inaccuracy Meters												
9	Measures against Illegal Connection and Meter Inaccuracy												
10	Data Collection of Monthly Billed by Zone												
11	Data Collection of Monthly SIV by Zone and Bulk Meters												
12	Monthly Water Balance Analysis												
13	Installation of Water Meters												
14	Survey on Trunk, Distribution Mains and Reservoirs												
15	Preparation for Pipe Replacement Plan												
16	Procurement of Materials and Equipment												
17	Water Meters												
19	Laptop PC/Desktop and consumable items												

ANNUAL COST OF NRW REDUCTION OPERATION FOR 2019

S/N	Description	Amount (N)
1	New Water Meter Installation and Replacement	17,962,400.00
2	Water meter laboratory (two test meter and fittings)	501,000.00
3	Materials for Leakage Repair	1,421,200.00
4	Materials for Meter Error Test, Consumption Survey	227,000.00
5	Field Allowance for NRW Reduction Operations	7,934,000.20
7	Laptop PC/Desktop and consumable items	1,750,000.00
8	Fuel Cost	3,710,200.00
9	Vehicle (Toyota Hilux 4x4)	19,000,000.00
10	Maintenance and Insurance Cost for Vehicle	650,000.00
11	Training Curriculum	
12	Basic and Common Knowledge about NRW	237,000.00
13	Management of Pipelines (GIS,IWA etc)	579,000.00
14	Management of Data (Meter Reading and Test)	315,000.00
	Sub-Total	**54,286,800.20**
15	Miscellaneous expenses (monthly internet subscription, SMS recharge data for telemetry equipment, maintenance of solar panels, stationery, office maintenance, excavation & backfilling, pressure measurement etc)	4,500,000.00
	Grand Total	**58,786,800.20**

Annex17-4

Cost-Effectiveness for Scenario d

Items		Scenario d
Expected Operation Cost (mil. NGN)	i.	224.2
Expected Revenue Increase (mil. NGN)	ii.	4,198.4
Expected Direct benefit (mil. NGN)	iii=ii.-i.	3,974.1
Expected Cost-Effectiveness	iv. = ii./ i.	18.7

Thank you for your attention

Annex 18:

Planning Manual of NRW Reduction

ABUJA
The Heart of Nigeria

Federal Capital Territory
Administration

Japan International
Cooperation Agency

Federal Capital Territory
Water Board

The Federal Capital Territory
Reduction of Non-Revenue Water Project

PLANNING MANUAL FOR NRW REDUCTION

June, 2018

Project Team

Contents

1. Background of NRW Reduction

The Federal Capital Territory Water Board (FCTWB) was established in October 1989, saddled with the responsibility of supplying potable water to inhabitants of the Federal Capital Territory (FCT). In carrying out this responsibility, the FCTWB has been facing challenges of operation and maintenance of facilities as well as large proportion of non-revenue water (NRW). The FCTWB could not effectively mitigate NRW because of limited experience, insufficient knowledge and unskilled personnel on planning and execution of NRW reduction. NRW ratio of urban water supply system for the FCC was estimated at 48.3% based on year 2014-2017 data.

Based on the above, in order to strengthen NRW reduction capacity of the FCTWB and ameliorate issues of NRW, the Federal Capital Territory Administration (FCTA) and the FCTWB has implemented "the Federal Capital Territory Reduction of Non-Revenue Water Project" (the Project), the technical cooperation in collaboration with Japan International Cooperation Agency (JICA).

2. Purpose of NRW Reduction and its Effect

Assumed that daily water demand per-capita is about 550litter [1] /capita-day including institutional and commercial use, and service population is about 300,000 persons, water demand comes to about 180,000m^3/day, which is less than the Phase 1&2 production capacity of 240,000m^3/day. However, FCTWB has seriously been facing water supply rationing due to shortage of water supply quantity. Therefore, FCTWB requires to eliminate NRW urgently in order for users to be satisfied at FCTWB's water supply service.

On the other hand, reduction of NRW will extensively contribute to appropriate financial status for maintaining self-support accounting system.

3. Composition of the Planning Manual for NRW Reduction

The Mid-term Strategic Plan (2019-2023) included Introduction to NRW and Assessment of the Pilot Project which is composed of current situation of water supply service in FCC, definition of NRW, and overall activities of the pilot projects. In this plan, Project Team prepared the specific planning manual of NRW reduction operation so that NRW Unit of FCTWB will be able to review the Mid-term Strategic Plan (2019-2023) and update the Strategic Plan for another five-year (from 2024 to 2028) and later on successively based on the results of the NRW reduction operations for the year 2019 to 2023.

Accordingly, this manual contains the following contents:

- Results of NRW Reduction Operation for the Previous Four-year and Future Challenges
- Scenario, Goal and Cost Effectiveness
- NRW Reduction Plan
- Implementing Schedule and Budget Allocation
- Staffing Plan and Responsibility
- Human Resource Development Program
- Recommendation

4. Users of the Planning Manual for NRW Reduction

NRW Unit of FCTWB led the pilot project and formulation of the Mid-term Strategic Plan, Annual NRW Reduction plan (2019). It is also desirable that NRW Unit of FCTWB will review the Mid-Team Strategic Plan (2019-2023) and update the strategic plan based on the lesson learned from the technical cooperation project in cooperation with JICA Expert Team. NRW reduction operation requires not only experiences of NRW Unit of FCTWB but also advices from board members of FCTWB, accurate information from relevant organizations and or

[1] According to the track record for the year 2014 to 2017, 58.63million per year divided by service population of about 300,000 is 535liter per capita per day (nearly; 550liter per capita per day).

offices such as FCDA, Area offices. In addition, budget arrangement is one of indispensable conditions to implement the NRW reduction operation.
The Planning Manual will be utilized by NRW Unit to formulate the planning of NRW reduction operation in future as a basis of its necessity in order to ensure approval the budget required for it from the board members of FCTWB.

5. Contents of the Planning Manual for NRW Reduction

5.1 Results of NRW Reduction Operation for the Previous Four-year and Future Challenges

5.1.1 Outline of the NRW Reduction Operation for the Previous Four-year

The following are included in this section:

- Scenario of NRW Reduction Operation conducted by FCTWB: Process of selection will be indicated with flow chart based on the former Mid-term Strategic Plan.
- Location of the Area: Zones or DMAs will be indicated in a plan view drawing.
- Isolation (DMA and SMA) of the Areas: To isolate DMAs and SMAs, what kind of points were considered will be described.
- Service Population and Pipe Distance by Zone or DMA: Service population and pipe distance by Zone or DMA will be summarized in one table in order to calculate NRW per capita or per km to learn NRW's scale. The detail information will be indicated in '5.1.3'.
- NRW Reduction Operations: All the operations with flow chart will be summarized in this section.

5.1.2 Result of the Pilot Projects

Summary sheet which NRW ratio before and after-NRW reduction operations and NRW reduction (percentage point) is indicated will be prepared as follows:

For DMAs to be targeted

Zone		NRW Ratio (%)		NRW Reduction (Percentage Point)
	DMA	Before-countermeasure	After-countermeasure	
Zone-5	DMA-1			
	DMA-2			
	…			
	…			
Zone-2	DMA-1			
	…			
	…			

For Zones to be targeted

Zone	NRW Ratio (%)		NRW Reduction (Percentage Point)
	Before- operations	After- operations	
Zone 4			
Zone 3			
…			
…			

5.1.3 Causes of NRW and their Patterns by Features of Targeted Areas

The following features of the areas will be summarized.

Feature of Targeted Areas

Data Parameters	Data in DMA/Zone
Service Population	
Number of Total Connections	
Year of Construction (Major pipes)	
Range of Pipe Diameter (mm)	
Total Pipe Distance (m)	
PVC (m)	
GS (m)	
DIP (m)	
CIP (m)	
P.P (m)	
S.P. (m)	
A.C. (m)	
Number of System Input (Nr.)	
Number of Isolation Valves (Nr.)	
Fulfilled customer information for domestic (%)	
Fulfilled customer information for large consumer such as commercial and institution (%)	
Availability of as-built drawings (%)	

Main parameters will be summarized in the following table to analyze what kinds of causes are related to NRW.

NRW Ratio and their Causes

Data Parameter	Before-Operations	After- Operations	Difference
NRW Ratio (%)			
Number of Authorized Customers (Domestic)			
Number of Authorized Customers (Large Consumers)			
Number of Illegal Connections (Nr.)			
Number of Defective (inaccuracy) Water Meters (Nr.)			
Number of Leaks (Nr.)			
Number of Flat Rate (Nr.)			
Number of Pre-paid Meters (Nr.)			
Number of AMRs (Nr.)			
Number of Conventional Meters (Nr.)			

5.1.4 Cost-Effectiveness

(1) Total Cost Estimate for NRW Reduction in Targeted Areas

First of all, purpose of total cost estimate for NRW reduction operations in targeted areas will be described in this section.

Unit prices (as of May 2018) applied for the pilot project as stated in the Mid-term Strategic Plan 2019-2023 are as follows:

- Fuel: NGN145 per litter
- Daily allowance for staff: NGN1,000 per staff
- Equipment and materials: Current market price or quote

Other conditions such as daily driving millage, etc. are as below:

- Fuel consumption: 5km per litter
- Daily driving millage: it depends on NRW reduction operation.

In future, the above price and conditions should be reviewed and revised, if necessary.

Cost to be spent in area offices, FCTWB headquarters and some equipment will be sorted out in the following tables:

Cost to be spent in Area office

Area Office								
Items	Commercial			Distribution			Cost	
	Man	Days	Man-days	Man	Days	Man-days	Field Allowance	Cost (k. NGN)
One Week Interval Meter Reading								
Leakage Survey								
Leakage Repair								
Illegal Connection Survey								
Measures against Illegal Connection								
Meter Installation								
Tank Investigation								
Meter Test (Meter Inaccuracy)								
Measurement of 24-hour Water Flow								
Step Test								
Fuel for Operations			XXXXX	L	XXXX	NGN/L		
A. Sub-Total Cost								

Cost to be spent in FCTWB Headquarters

HQ								
Items				Man	Days	Man-days	Field Allowance	Cost (k. NGN)
One Week Interval Meter Reading								
Leakage Survey								
Leakage Repair								
Illegal Connection Survey								
Measures against Illegal Connection								
Meter Installation								
Tank Investigation								
Meter Test (Meter Inaccuracy)								
Measurement of 24-hour Water Flow								
Step Test								
Fuel for Operations	XXXX	L/day	XXX	days	XXX	NGN/L		
B. Sub-Total Cost								

Cost of Equipment and Grand Total Cost

Equipment and Materials (k.NGN)	
Survey Equipment from XXXXX	
Equipment for DMA Making (Valves, Flow-meters etc.)	
Materials for DMA Making (Chamber Making)	
Materials for NRW Reduction Operations	
C. Sub-Total Cost	
Grand Total (k. NGN) (A. + B. + C.)	

(2) Total Revenue Estimate yielded through NRW Reduction Operation in Targeted Areas

First of all, purpose of total revenue estimate yielded through NRW reduction operations will be described in this section.

Revenue yielded through NRW reduction operation will be calculated according to the process in the following table:

Revenue yielded through NRW reduction operation

	Items	Data
(a)	NRW Ratio before Operations (%)	
(b)	NRW Ratio after Operations (%)	
(c)	Reduced NRW Ratio (%) (a)-(b)	
(d)	System Input Water Volume (m^3/h)	
(e)	Reduced NRW Volume (m^3/h) (h)x(g)/100	
(f)	Reduced NRW Volume (k. m^3/year) (e)x24x365/1000	
(g)	Average Water Sales Price (NGN/m^3)	
(h)	Expected Water Sales per year (k. NGN) (f)x(g)	
(i)	Expected Water Sales for three years (k. NGN) (h) x 3 years	

(3) Cost-effectiveness in targeted Areas

First of all, purpose of estimate of benefits in targeted areas will be described in this section.

Cost-effectiveness will be sorted out based on the above '(1) and '(2) in '5.1.4' in the following tables:

Cost-effectiveness of NRW Reduction Operations

Zone/ DMA	1) Initial Cost incurred for NRW Reduction Operations (K. NGN)	2) Initial & Recurrent Cost for NRW Reduction Operation* (K.NGN)	3) Estimated Revenue Increase for three years (K. NGN)	3) Cost Effectiveness (Dimensionless) 3) / 2)

5.1.5 Findings and Lessons Learnt

(1) Findings

Issues like the following examples are included in this section:

- Ensure budget for NRW reduction activities
- Compile information on all the customers under each area office and reflect it to billing system at FCTWB headquarters
- Develop information on the existing pipelines
- Carry on regular activities such as leakage survey and illegal connection survey
- Calibration of test meters
- Establish the systematic measures of NRW reduction operations as easy as possible.
- Others (Issues that you observed through pilot project should be described in this sections as much as possible.)

(2) Lessons Learnt

Examples of lessons learnt from NRW reduction operations in targeted areas are included in this section:

- Difficulty in isolation due to lack of the existing pipe information
  - ➢ Describe at least three solutions what we have to do in order to solve difficulties.
- Difficulty in management of customer's information
- ➢ Describe at least three solutions what we have to do in order to solve difficulties.
- Difficulty in management of multiple water meter readings such as conventional, AMR and pre-paid meters
  - ➢ Describe at least two solutions what we have to do in order to solve difficulties.
- Difficulty in smooth procurement of materials because of release of budget

- Describe at least one solution what we have to do in order to solve difficulties.
- Difficulty in operation of Personal Computer (PC) in the area offices
  - Describe at least two solutions what we have to do in order to solve difficulties.
- Others (Lessons that you learnt through pilot project should be described in this sections as much as possible.)

5.2 Scenario, Goal and Cost Effectiveness

5.2.1 Overall Scenarios

[Entire NRW Reduction Activities]

Five scenarios were setup in the Mid-term Strategic Plan (2019-2023). Each scenario is composed of some of the following basic activities.

(1) Network Drawings and Data
(2) Customer Enumeration
(3) DMA Design, Creation, Prioritization
    (3)-1 DMA Design, Creation and Prioritization
    (3)-2 DMA Prioritization in NRW Reduction
(4) Zonal Prioritization
(5) Field Inspection
(6) Isolation by installing Flow-meters and Valves
(7) Step-Test in DMA
(8) Zonal Measurement
(9) Leakage Detection
(10) Patrol of Surface Leaks
(11) Repair of Leaks and Recording
(12) Identification of Illegal Connections and Meter Inaccuracy
    (12)-1 Identification of Illegal Connection
    (12)-2 Identification of Meter Inaccuracy
(13) Measures against Illegal Connection and Inaccuracy Meters
    (13)-1 Measures against Illegal Connections
    (13)-2 Measures against Meter Inaccuracy
(14) Data Collection of Monthly Billed Consumption
(15) Data Collection of Monthly SIV
(16) Monthly Water Balance Analysis
(17) Measurement of One-week SIV
(18) Installing Water Meters
(19) Survey on Trunk, Distribution Mains and Reservoirs
(20) Preparation for Pipe Replacement Plan

It is desirable that the activities of each scenario set-up in the Mid-term Strategic Plan (2019-2023) will be sustained after the year 2023, unless the targeted NRW ratio is achieved.

For reference, feature of scenarios for NRW reduction operations of the Mid-term Strategic Plan (2019-2023) is as follows:

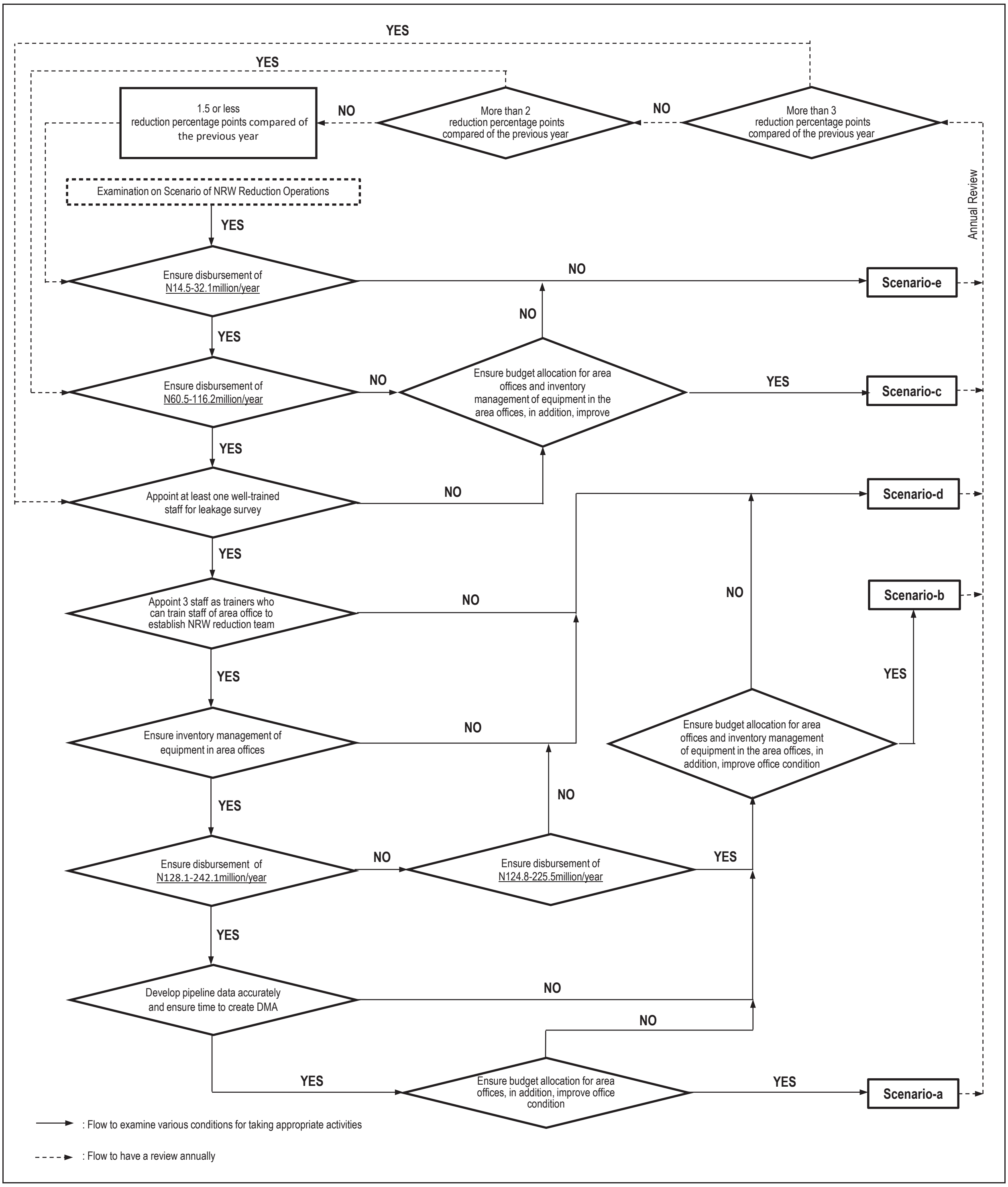
Feature of Scenarios for NRW Reduction Operations

Items	Scenario				
	a	b	c	d	e
1. Target					
1.1 Target Year	2023	2023	2023	2023	2023
1.2 Baseline NRW Ratio (%)	48.3	48.3	48.3	48.3	48.3
1.3 Target NRW Ratio in 2023 (%)	31.9	32.4	36.9	35.1	42.8
1.4 Reduction Approach	DMA	Zone	Zone	Zone	Zone
2. Main Body for NRW Reduction Operations					

Items	Scenario				
	a	b	c	d	e
2.1 Main Body for Operations (Supervision)	HQ's NRW Unit	HQ' NRW Unit	HQ's NRW Unit	HQ's NRW Unit	HQ's NRW Unit
2.2 Main Body for Operations (Field Actions)	Area Offices	Area Offices	Area Offices	HQ's NRW Unit	HQ's NRW Unit
3. NRW Reduction Operations					
(1) Network Drawings and Data	X	X	X	X	X
(2) Customer Enumeration	X	X	X	X	X
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(3) DMA Design, Creation and Prioritization	X	-	-	-	-
(4) Zonal Prioritization	-	-	-	X	X
(5) Field Inspection	X	-	-	-	-
(6) Isolation by installing Flow Meters and Valves	X	-	-	-	-
(7) Step Test in DMA	X	-	-	-	-
(8) Zonal Measurement	-	-	-	X	X
(9) Leakage Detection					
a) by Area Office (DMA)	X	-	-	-	-
b) by Area Office (Zone)	-	X	-	-	-
d) by NRW Unit (Zone)	-	-	-	X	X
(10) Patrol of Surface Leaks	-	-	X	-	-
(11) Repair of Leaks and Recording	X	X	X	X	X
a) for (9)-a)	X	-	-	-	-
b) for (9)-b)	-	X	X	-	-
c) for (10)	-	-	X		-
d) for (9)-d)	-	-	-	X	X
(12) Identification of Illegal Connection and Inaccuracy Meters	X	X	X	X	X
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Inaccuracy Meters	X	X	X	X	-
d) Labo Test of Meter Inaccuracy for Meter Standardization	X	X	X	X	-
(13) Measures against Illegal Connection and Meter Inaccuracy	X	X	X	X	X
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Meter Inaccuracy	X	X	X	X	X
(14) Data Collection of Monthly Billed Consumption					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(15) Data Collection of Monthly SIV					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
c) Bulk Meters	X	X	X	X	X
(16) Monthly Water Balance Analysis	X	X	X	X	X
(17) Measurement of 1-week SIV (DMA)	X	-	-	-	-
(18) Installing Water Meters	X	X	X	X	-
(19) Survey on Trunk, Distribution Mains and Reservoirs	X	X	X	X	X
(20) Preparation for Pipe Replacement Plan	X	X	X	X	X
4. Procurement of Equipment					
4.1 Flow Meters and Valves for Isolation	X	-	-	-	-
4.2 Leak Detection Equipment	X	X	-	-	-
4.3 Water Meters	X	X	X	X	-

[Criteria for selecting Scenario of NRW Reduction Operations]

Scenarios depend on goal of NRW, cost of NRW reduction operations, number of staff, etc. Project Team prepared the criteria for selecting scenario as below, so that FCTWB will carefully be able to select the best scenario of NRW reduction operation. It is not necessary that basic frame of criteria for selecting scenario will be revised.



Criteria for selecting Scenario of NRW Reduction Operations

(Sample as Mid-term Strategic Plan 2019-2023)

5.2.2 Scenarios

Information of each scenario includes not only summary, key activities of each scenario but also pre-condition, external factors and challenges in future, so that FCTWB will carefully be able to select scenario of NRW reduction operation. Especially, it is essential that FCTWB will consider pre-condition including budget to be required and external factors to select scenario of the operations.

5.2.3 Cost-Effectiveness by Scenario

First of all, purpose of future cost-effectiveness in the Mid-term Strategic Plan will be described in this section.

(1) Cost incurred for NRW Reduction Operations

Considering Man-Day required for the NRW reduction operation in the past year, FCTWB will estimate cost incurred for the operation for five years and sort out it in the following table.

Cost comparison by Scenario for Five Years (k. NGN)

Item	Scenario				
	a	b	c	d	e
a. Equipment and Materials for NRW Reduction Operations					
Leak Detectors (Equipment from Japan)					
PMA Creation (Flow-meter, Valve)					
PMA Creation (Chamber Construction)					
Water Meter Installation and Replacement for all Customer (Meters and Fittings for 5,000/year)					
Materials for Leakage Repair					
Materials for 24-hour Flow Measurement					
Materials for Meter Error Test, Consumption Survey					
Subtotal					
b. Water Meter Laboratory					
Water meter laboratory (two test meter and fittings)					
Subtotal					
c. Field Allowance for NRW Reduction Operations					
Field Allowance for NRW Reduction Operations					
Subtotal					
d. Logistics					
Fuel Cost					
Vehicles (Toyota Hilux 4x4) three vehicles at HQ (19mNGN x 3)					
Maintenance and Insurance Cost for Vehicles (650kNGN/year x3)					
Subtotal					
Training Cost					
Subtotal					
Grand Total					

Man-days of each NRW reduction operation was estimated based on work volume and staff number of area offices so as to compute total cost of the operation for the Mid-term Strategic Plan 2019-2023. For next five years after 2023, FCTWB should review and revise Man-day due to improvement & development in the following field conditions:

- DMA Design, Creation and Prioritization (Stated in the Mid-term Strategic Plan 2019-2023, as '(3) DMA Design, Creation and Prioritization')
- Zonal Prioritization (Ditto, as '(4) Zonal Prioritization')
- Isolation by Installing Flow-meters and Valves (Ditto, as '(6) Isolation by Installing Flow-meters and Valves')

(2) Revenue yielded through NRW Reduction Operations

For the Mid-term Strategic Plan 2019-2023, total revenue were estimated based on the following conditions:

1) Current NRW Ratio: 48.3%
2) Total System Input (water production): About 336,000m^3/day by taking account of process loss of 10% at the USUMA Treatment Plant
3) Unit Price of Water: NGN90/m^3

The conditions should be reviewed for the future after the year 2023, if necessary.

Revenue yielded through the NRW reduction operation will be sorted out by using the following table.

Estimated Revenue Yielded

Items		2024	2025	20…	20…	20…	Total
Baseline NRW Ratio (%)	i.						
Target NRW Ratio (%)	ii.						
Reduced NRW Ratio (%)	iii.= i - ii.						
Reduced Water Volume (m^3/day)	iv. = 310,630*1 m^3/day x iii.						
Revenue yielded (k. NGN/year)	v. = iv. x NGN90/m^{3}x365						

Note: *1 Distributed water in average from 2014 to 2017

Deducting cost incurred by NRW reduction operations from Revenue yielded will come to direct benefit. Direct benefit and cost-effectiveness for five years will be sorted out in the following table.

Cost-Effectiveness by Scenario for Five years

Items		Scenario				
		a	b	c	d	e
Cost (mil. NGN)	i.					
Revenue yielded (mil. NGN)	ii.					
Direct benefit (mil. NGN)	iii=ii.-i.					
Cost-Effectiveness	iv. = ii./ i.					

5.2.4 Financial Consideration based on the Scenario

Since FCTWB has been under process of autonomous establishment and there were some flow rate of distributed water estimated by FCTWB, Project Team was forced to assume some data such as value of assets, etc. in the section of financial consideration of the Mid-term Strategic Plan 2019-2023.

Project Team estimated Profit & Loss and Cash Flow based on the following fundamental conditions:

Conditions for preparing Financial Statement (for 2019-2023)

Items	Conditions	Sources	Note for another five years after 2023
1. Baseline of NRW ratio	48.3%	Estimated by Project Team	It should be reviewed and updated based on the status for another five years after 2023.
2. Incremental O&M expenditures	Scenario-wise	Estimated by Project Team	It should be reviewed and updated based on the scenario for another five years after 2023.
3 .Capital Investment expenditures			
1) Construction works in 2019 for the switch over of the water supplied by WTP phase-3 & 4	NGN673Mil.	Estimated by Project Team	It should be revised to the track record, when the construction will commence.
2) Procurement in connection with the scenarios	Scenario-wise	Estimated by Project Team	It should be reviewed and updated based on the scenario for another five years after 2023.
4. Depreciation			
1) Procurement of above 3-2)	10 years	Estimated by Project Team mostly equipment and vehicle	-
2) Other assets including the construction of switch-over and Phase-III & IV	20 years	Estimated by Project Team (mostly facilities, installations, and pipelines)	-
5. Price escalation	Not applied	Judged by Project Team	It should be reviewed and updated based on the status with consulting Finance Department of FCTWB
6.Tariff: weighted average between the domestic and commercial customers	NGN90/m^3	Estimated by Project Team	It should not be revised, unless water tariff is revised.
7. Collection ratio of water tariff against bills raised	31.3%	Estimated by Project Team average rate of four years from 2014 to 2017	It should be reviewed and updated based on the status with consulting Finance Department of FCTWB
8. Allocation and remittance to FCTA	Not applied	Assumed by Project Team	It should be reviewed and updated based on the status with consulting Finance Department of FCTWB in terms of autonomy (self-support accounting system)

5.3 NRW Reduction Operations

5.3.1 Basic NRW Reduction Operations

The specific methods of NRW reduction operations were introduced in the Operation Manual of NRW Reduction and Appendix-4 of the Mid-term Strategic Plan 2019-2023. Basically, FCTWB will take some of these NRW reduction operations continuously. In this manual, the details of NRW reduction operations were excluded from this Planning Manual apart from the following noticeable points which may be reviewed and updated in future.

- DMA Design, Creation and Prioritization (Stated in the Mid-term Strategic Plan 2019-2023, as ‘(3) DMA Design, Creation and Prioritization’)

- Zonal Prioritization (Ditto, as '(4) Zonal Prioritization')
- Isolation by Installing Flow-meters and Valves (Ditto, as '(6) Isolation by Installing Flow-meters and Valves')
- Patrol of Surface Leaks (Ditto, as '(10) Patrol of Surface Leaks')

5.3.2 NRW Reduction Operations to be reviewed and updated

(1) DMA Design, Creation and Prioritization

First of all, purpose of designing and creating DMAs will be described in this section.

In principle, FCTWB will design and create DMAs permanently to take NRW reduction operation efficiently and accurately. Therefore, once completing creation of the DMAs in FCC, FCTWB will be able to skip process of design and creation of DMAs as NRW reduction operations.

(2) Zonal Prioritization

First of all, purpose of prioritizing zone in FCT will be described in this section.

In the Mid-term Strategic Plan 2019-2023, Project Team setup the following criteria to prioritize zones based on the lessons learnt from the pilot project. The criteria should be reviewed and revised as status of water supply service and social condition change in future after the year 2023.

Summary of Zonal Prioritization

Criteria	1) Initial Points	2) Weighting Coefficient	3) Final Score = 1) x 2)
1. NRW Condition	XXX points	35%	XXX points
2. Availability of Pipeline Network Drawing	XXX points	30%	XXX points
3. Number of Major Customers	XXX points	15%	XXX points
4. Customer Meter Type and Conditions of Collection of Water Tariff	XXX points	10%	XXX points
5. Security Condition	XXX points	10%	XXX points
Total			XXX points

Criteria of NRW Condition (Weighting Coefficient: 35%)

NRW Ratio	Initial Points
More than 65%	3 points
64% to 55%	2 points
54% to 45%	1 point

Criteria of Availability of Pipeline Network Drawing (Weighting Coefficient: 30%)

Ratio of Mapping Development	Initial Points
More than 50% in mapping	3 points
50% or less in mapping	2 points
Only hard papers	1 point

Criteria of Number of Major Customers (Weighting Coefficient: 15%)

Ratio of Measure Customers	Initial Points
Area where major customers make up more than 10% of the total customers	3 points
Area where major customers make up 5 to 10% of the total customers	2 points
Area where major customers make up less than 5% of the total customers	1 point

Criteria of Customer Meter Type and Conditions of Collection of Water Tariff (Weighting Coefficient: 10%)

Ratio of One-type Customer	Initial Points
Area where one-type customer meters make up 80% of the total customers	3 points
Area where one-type customer meters make up 50 to 79% of the total customers	2 points
Area where one-type customer meters make up less than 50% of the total customers.	1 point

Criteria of Security Condition (Weighting Coefficient: 10%)

Ratio of Accessibility	Initial Points
Area where customers apart from military base and barrack make up 90%	3 points
Area where customers apart from military base and barrack make up 80%	2 points
Area where customers apart from military base and barrack and make up less than 80%	1 point

(3) Isolation by Installing Flow-meters and Valves

First of all, purpose of installation of flow-meter and isolation valves for DMA will be described in this section.

In the light of current infrastructure condition, field security, the existing pipelines, selection methods of flow-meters and isolation valves and electric power source will be described in the next Mid-term Strategic Plan as well as the current one 2019-2023. As mentioned above, once completing creation of the DMAs in FCC, FCTWB will be able to skip process of isolation by installing flow-meters and valves as NRW reduction operations.

(4) Patrol of Surface Leaks

First of all, purpose of patrol of surface leaks in zones instead of leak detection will be described in this section.

Actually, detecting leaks by using leak detectors, Project Team did not conduct patrol of surface leaks in the pilot project. However, Project Team added patrol of surface leak as one of the operations in Scenario-c from aspect of lack of equipment currently. Furthermore detail patrol of surface leak will be described in the next Mid-term Strategic Plan for future after the year 2023 based on finding and lesson learnt from the NRW reduction operations in the Mid-term Strategic Plan 2019-2023

5.4 Budget Allocation for NRW Reduction Operations

5.4.1 Composition of the Cost

In the Mid-Term Strategic Plan 2019-2023, the cost which is composed of the following expenses of NRW reduction operations for five years was estimated in terms of actual cost incurred by the pilot project:

- Field Allowance for staff
- Equipment such as flow-meters, valves, water meters, leak detectors
- Materials such as fittings for leak repairs, 24hour-flow measurement, water meter error test, consumption survey, etc.
- Water meter laboratory
- Fuel for vehicles
- Vehicles
- Maintenance and insurance for Vehicles
- Training for human resource development

However, the expenses and Man-Day required for the future operations should be reviewed and revised from the findings of NRW reduction operations from 2019 to 2023, if necessary.

5.4.2 Budget Allocation for NRW Reduction Operations

First of all, purpose of budget allocation for NRW Reduction will be described in this section.

FCTWB should consider the following factors to allocate budget:

- Yearly budget released in the past three to years
- Feasibility in terms of current finance situation of FCTWB
- Equalization of budget allocation as much as possible

Budget allocation will be sorted out in the following table:

Budget Allocation of NRW Reduction Operations for Five Years

Scenario	Total Cost (mil. NGN)	2024	2025	20…	20…	20…
Scenario-a	…	…	…	…	…	…
	100%	…%	…%	…%	…%	…%
Scenario-b	…	…	…	…	…	…
	100%	…%	…%	…%	…%	…%
Scenario-c	…	…	…	…	…	…
	100%	…%	…%	…%	…%	…%
Scenario-d	…	…	…	…	…	…
	100%	…%	…%	…%	…%	…%
Scenario-e	…	…	…	…	…	…
	100%	…%	…%	…%	…%	…%

5.5 Staffing Plan and Responsibility

Staffing plan is divided into two; respective staff of FCTWB headquarters and Area offices. There are five units which consists of NRW Reduction Unit, GIS Unit, Distribution Unit, Billing Unit and Commerce Unit in FCTWB headquarters, while there are distribution staff group and commerce staff group in each area office. It seems that responsibility and role of each unit of FCTWB headquarters and Area Offices' group cannot definitely be changed in future, but numbers of staff in each unit and group who appointed for the Mid-term Strategic Plan 2019-2023 can be revised in terms of work efficiency, effects and impact through the actual activities from 2019 to 2023.

The following table is a typical form (as an example of Billing Unit in FCTWB headquarters) of number of staff:

Necessary Number of Staff by each Scenario for Billing Unit (Example)

	2019	2020	2021	2022	2023
Scenario-a	...	...	...	...	...
Scenario-b	...	...	...	...	...
Scenario-c	...	...	...	...	...
Scenario-d	...	...	...	...	...
Scenario-e	...	...	...	...	...

5.6 Human Resource Development (HRD) Plan

5.6.1 Contents of HRD

OJT is one of the human resource development programs, but training sessions and lectures which require actual expenses for field allowance for lecturers, fuel, stationery and refreshment, etc. will be focused on in this section.

Based on the finding and lessons learnt from the pilot project, Project Team planned the following curriculums:

- Training Curriculum 1: Basic and Common Knowledge about NRW
- Training Curriculum 2: Management of Pipelines
- Training Curriculum 3: Management of Data

- Training Curriculum 4: Leakage and Illegal Connection Survey
- Training Curriculum 5: Streamlining of Billing System and Examination on Unifying Water Meters
- Training Curriculum 6: Plumbing for Repair and or replacing Pipelines
- Training Curriculum 7: Basic Operation of Personal Computer, Graphing by using Excel

In future, FCTWB should plan training programs as a human resource development plan, considering the status of staff capacity to be improved through the above seven curriculums required for NRW reduction operations. Needless to say, if an individual capacity is not strengthened, the particular curriculums must be conducted repeatedly.

To formulate HRD plan, the following information will be planned:

(1) Title of the training
(2) Target staff
(3) Number of participants
(4) Period of the training and schedule
(5) Style of the training
(6) Effects to be expected
(7) Main theme of the training

'(1)' to '(4)' may be indicated in the following diagram.

Summary of Training Program

Training	Contents	Target Staff / Nr.	2024				20 ….			
			1/4	2/4	3/4	4/4	….	….	….	…
XXX Training program	Analysis of IWA water balance and Review of NRW reduction activities	XXX of FCTWB headquarters / XXX persons	■		■					
…	…									
…	…									

5.6.2 Training Cost

The training cost is composed of fuel & daily field allowance for lecturer, stationery, refreshment and PCs.

Unit prices (as of May 2018) applied for the Mid-term Strategic Plan 2019-2023 are as follows:

- Fuel: NGN145 per litter
- Stationery: NGN500 per set
- Daily allowance for lecturer: NGN5,000 per lecturer
- Refreshment: NGN2,000 per person
- PC: NGN250,000 per PC (including anti-virus software)

Other conditions such as daily driving millage, etc. are as below:

- Daily driving millage: 50km per vehicle
- Fuel consumption: 5km per litter
- Number of participants for a lecture: 15 persons (Max.)

The following table will be utilized for estimating training cost.

Training Cost (Example for the Mid-term Strategic Plan 2019-2023)

Training Curriculum	2019						2020					
	Number of Subjects	Days of Lecture	Fuel for lecture (attending lecture and going sites) (k. NGN)	Stationery	Field allowance for lecturers (k. NGN)	Refreshment (k. NGN)	Number of Subjects	Days of Lecture	Fuel for lecture (attending lecture and going sites) (k. NGN)	Stationery	Field allowance for lecturers (k. NGN)	Refreshment (k. NGN)
Curriculum 1: Basic and Common Knowledge about NRW (5 area offices)	3	1	22	23	15	90	1	1	7	8	5	30
Curriculum 2: Management of Pipelines (3 area offices)	3	3	39	68	45	270	1	3	13	23	15	90
Curriculum 3: Management of Data (5 area offices)	2	2	29	30	20	120	2	2	29	30	20	120
Curriculum 4: Leakage and Illegal Connection Survey (5 area offices)							3	3	65	68	45	270
Curriculum 5: Streamlining of billing system and examination on unifying water meters (5 area offices)							3	3	65	68	45	270
Curriculum 6: Plumbing for repair and or replacing pipelines (5 area offices)							3	3	65	68	45	270
Curriculum 7: Basic operation of personal computer , graphing by using excel (3 area offices)							3	2	26	45	30	180
Sub-total (k. NGN)			90	120	80	480			271	308	205	1,230
						770						**2,014**
Materials for training	Number of PCs & anti-virus to be purchased		Unit price (k. NGN)		Total Price (k. NGN)		Number of PCs & anti-virus to be purchased		Unit price (k. NGN)		Total Price (k. NGN)	
PC (Laptop PC) to be purchased		7		250		1,750		6		250		1,500
Sub-total (k. NGN)						**1,750**						**1,500**
Ground-total (k. NGN)						**2,520**						**3,514**

6. Recommendation

In the light of NRW reduction operations, challenges to be improved promptly in future will be described in this section. Challenges should be categorized into four; Distribution, Commerce, Finance and Administration.