3.5 ACTION PLAN TASKS

As described above, there are many activities associated with the objective of reducing & controlling UFW. Those primarily implicated in the implementation programme for stage 1 are presented in this section in a summary task matrix, followed by a brief description of the work to be carried out. These tasks have been divided into four groups, based on the general type of activity, as follows:

- Policy — Legislation & policies required to set the right context for effective implementation of UFW control
- Preliminary — Activities that are to be done before the main programme, because:
  - YCDC has the existing capacity to achieve results
  - The outputs are essential for a number of other tasks
- Preventative — Standards & good practice for design & installation to minimise and delay the occurrence of leaks in the network
- Practice — Operational measures to deal with UFW

The list of tasks with brief details of the activity plus the constraints and resource requirements is given in the table 3.5.1 below. The following section provides an explanation of the items on the task matrix

3.5.1 Group 1 Policy

Principal elements of this category include:

- Commitment to effective UFW Control policy & its implementation
- Tariff Structure
- Customer metering policy
- Byelaws & Regulations

(1) Commitment to UFW Control Policy

The 'sine qua non' for this UFW control action plan is the political will and commitment of the YCDC to its effective implementation. The reduction of UFW to the target levels will take time, effort & money and will need strong support from the Senior Management of the Water Supply Department. There will be no benefit gained from the action plan unless it is actively and strongly supported. So the leaders of the Water Supply department and YCDC committee need to be convinced that:

- Demand management & UFW control is part of the solution
- Without achieving the UFW reduction targets, there will not be enough water supply resources available to meet demand by 2020
- Leakage reduction is a lot cheaper than building an equivalent new supply source and pipeline

Table 3.5.1: Specific task list summary matrix

Group	Task	Activity Description	Problems & Constraints	Requirements & Resources	Inputs	Dept.	Phasing of Work Stage 1, 2 or 1&2
	UFW Control Policy	Decide UfW is serious problem & will be tackled	Policy decision	Political Will	YCDC	Directors of YCDC	Continuous
1) Policy							
	Standards & Byelaws	Prepare specifications for minimum standards of materials and installation & repair of service lines	Policy decision	technical review	YCDC	Directors of YCDC	Immediate
	Customer Metering	Decide to actively implement Customer metering	Policy decision	planning & resource capacity	YCDC	Directors of YCDC	Immediate
	Tariff Structure	Review & revise tariff structure	Policy decision	technical review	YCDC	Directors of YCDC	Stage 1
2) Preliminary							
2a) PreCursor for Other Operations							
	Network & Customer Survey	Detailed Complete survey of entire system to obtain accurate, up-to -date data on network & connections co-ordinate with Urban planning to use common GIS platform and share data	Planning, equipment & capacity	Equipment	YCDC + TA	Distribution Dept	Immediate
	Large User Monitoring	*Identify, meter & monitor large users*			YCDC (+TA)	UCU	Stage 1
2b) Part measures possible with existing capacity							
	Improve Network Data	Update & improve the maps etc. as much as possible to give accurate information co-ordinate with Urban planning to use common GIS platform and share data	None	Design/plan dept	YCDC	Distribution dept	Stage 1
	Connections review	Check, update & record all connections	None		YCDC	Distribution dept.	Stage 1
	Pressure Measurement	Campaign of pressure measurement around network using pressure loggers for 24 hr profiles plus spot readings with gauges		Leakage teams		UCU	Stage 1
	Trunk Mains Survey	Trunk mains inspection including: thorough inspection recording of all connections, fittings etc on network maps Removal of refuse tips at pipe overbridges etc. causing pipe corrosion Rationalisation & control of all connections made to trunk mains	None None None Planning & materials	*Trunk mains teams*	*YCDC*	*Trunk main section*	*Stage 1*
	Visible Leak location	Actively locate & report all visible leaks on distribution mains and service lines	None	Leakage teams	YCDC	Distribution dept.	Stage 1
	Leak Repairs Part 1	Timely & effective repair of ALL leaks located on network from above	*Equipment & materials: organisation*	*Training, proper repair fittings & equipment*	YCDC	Major repairs Section	Stage 1
	Service Reservoir Leakage Inspection	Inspect & Drop test Service reservoirs to check that there is no excessivewater loss	None	Trunk mains teams	YCDC	Trunk main section	Stage 1
3) Preventative							
	Planning & Design	Plan & Design Network construction works	No existing organistion	Design/plan dept	YCDC + TA	Planning & Design Team	Stage 1
	Design Criteria & spec	Develop & prepare specifications for design, supply, materials & installation of pipework, services & fittings	No existing organistion	Design/plan dept		*Planning & Design Team*	Stage 1
4) Practice (O&M)							

Table 3.5.1: Specific task list summary matrix

Group	Task	Activity Description	Problems & Constraints	Requirements & Resources	Inputs	Dept.	Phasing of Work Stage 1, 2 or 1&2
4a) UfW Reduction							
	UCU Setup & Operate	Create specialist unit for UfW Control to: Plan & implement work Advise & co-ordinate with others	No existing organistion	Training & Equipment	YCDC + TA	UCU	Immediate
	Leak Detection by Routine sounding	Divide network into nightly routes and send teams on routine basis	Training & equipment	Supply & pressure at night	YCDC + training	UCU & Leak teams	Stage 1 & 2
	Leak Repairs	Strengthen & Improve repair organisation to ensure proper and timely repairs	Equipment & materials: organisation	Training, proper repair fittings & equipment	YCDC + training	Major repairs Section	Stage 1 & 2
	Measurement campaign (aquaprobe)	Carry out measurement campaign to identify probable high leakage areas - temporary action until district metering established	Training & equipment	Training & equipment	YCDC	UCU	Stage 1
	Pilot areas setup	Start range of UfW activities in Pilot area(s) to be set up with sectorisation & metering			YCDC + TA	UCU	Stage 1
	NPL monitoring & control		Training, lack of data	Training, data collection		UCU	Stage 1 & 2
4b) UfW Monitoring							
	Network Sectorisation	Divide network into zones & districts over time with metering of each discrete section			YCDC + TA	UCU to Plan; Repair Section to install	Stage 1 & 2
	Bulk Metering 1	Install flow meters at existing key points: Pump stations, service reservoirs etc.	Capacity & equipment	Select & procure meters	YCDC + TA	UCU to Plan; Repair Section to install	Stage 1
	Bulk Metering 2	Install more flow meters as network is divided up into zones & districts			YCDC + TA	UCU to Plan; Repair Section to install	Stage 1 & 2
	Tubewell metering	Programme of installing flow meters on YCDC tubewells		Meters	YCDC	Tubewell Section	Stage 1
	Rehabilitation Areas	Monitoring & control of areas that have been rehabilitated under the new works programme			YCDC + TA	UCU	Stage 2
4c) Customer Metering							
	Customer Metering	Plan & implement metering policy (inc replacement)	capacity		YCDC + TA		Stage 1 & 2
	Non-Domestic Consumers	Implement metering for ALL non-domestic consumers		Meters	YCDC		Stage 1
	Large Users Monitoring	Identify, meter & monitor large users			YCDC	UCU	Stage 1 & 2
	Meter repair & test	Set up workshop(s) for cleaning and calibration checks on customer meters	Equipment & organisation	Test Equipment & Training	YCDC + TA	Meter repair Workshops	Stage 1 & 2
4d) Other O&M Activities							
	Control Room	Set up & operate central control room for network			YCDC	Distribution Dept	Stage 1 & 2

(2) Tariff Structure

The tariff structure has an indirect effect on UFW control as well as many other things. This is to be reviewed and revised to be better adapted to requirements. Details of the proposed revised structure are presented elsewhere.

UFW Control staff have the role of providing advice on the effect of different measures. From this perspective, a clear and effective tariff policy and structure is essential. It should:

- Charge realistically related to the real cost and value of drinking water supply
- Recognise the basic social need for limited volumes of drinking water, BUT NOT price all consumption at this level
- Recognise the need for capital investment to improve and maintain the drinking water supply and so the tariff includes operating costs plus some contribution to investment
- Guarantee that the revenues generated are reserved for the Water Supply Department and do not go to the general funds
- Discourage waste or undue consumption for non-essential purposes (in the context of a city where nearly 2/3 of the population do not get any service and much of the rest is inadequate)
- One method of contributing to this is to structure the tariff so that the more extravagant the consumer, the higher the unit cost of water.
- Take realistic account of the fact that universal metering will not be achieved for many years and therefore a reasonable system of assessed charges is required

(3) Metering Policy

Policy commitment will be required to implement universal metering for all customers along with preparation of an effective and realistic strategy to ensure that it is achieved according to a set of targets.

Without universal metering (or development of alternative consumption assessment methods) there will never be sufficient data on consumption to properly determine the correct UFW ratio.

The present YCDC 'policy' for universal metering is not proving fully effective, because it is at present a statement of intent and is not backed up by planning and resource commitment, due to lack of capacity & resources.

The action plan proposes such a timetable and estimate of resources to achieve a high level of customer metering within the Phase 1 period, but the support of political will and commitment to the policy is essential to success.

(4) Standards & Byelaws

Generally, new or modified legislation is to be sought from the authorities to put in place a simple and effective system of regulations, enforcement and standards for water supply. These must make clear the respective responsibilities, requirements and obligations of the customer and of YCDC.

To this end, YCDC must

- Draft technical documents for the legislators setting out the details
- Put in place measures to implement the requirements of the regulations once enacted.

It is beyond the scope of this report to detail such byelaws, though immediate requirements to be dealt with include:

1) Defining the division of responsibility between the customer and YCDC. Almost universally, this is at or close to the property boundary between the public land and the private property (or the meter) see figure 3.5.1.

2) Specifying permitted materials and methods for installation & repair of service lines. This may include
   - No GI pipe to be installed underground
   - No PVC pipe to be installed overground unless adequately protected by duct or sleeve
   - Minimum specification for PVC pipe (Class, pressure rating etc.)
   - No repairs permitted using bicycle rubber inner tube

A set of byelaws from the UK is attached as an example in Appendix Q.

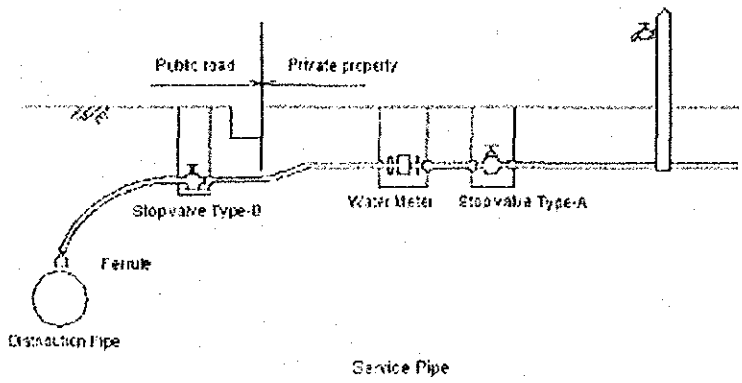


Figure 3.5.1 Sketch of service line showing division of responsibility

The ultimate effect of (1) above is to put the responsibility for the public street section of the service line on YCDC, who will therefore need to implement

- A repair programme in the interim

- Strengthen the system of secondary mains to remove the problem

Along with the necessary regulatory framework, adequate resources should be allocated to ensure effective enforcement. It should be noted that:

a) Enforcement is not restricted to punishment and shall include a large amount of encouragement and education of customers
b) Enforcement applies equally to the customers and YCDC, who must accept their responsibilities e.g. requirements concerning service lines cannot be respected if YCDC does not invest in sufficient secondary mains

A large part of the losses on any water supply system occur in service lines. Reducing and controlling this component can only succeed if the regulations are effective.

Regulation 6/99 is an enabling document, but requires additional, more specific documents such as a set of water supply byelaws, material specifications etc.

3.5.2 Group 2 Preliminary

Principal elements of this category include:

- Full Network & Customer Property survey to get necessary accurate data for planning, design and operational activities as well as UFW control
- Initial improvement of network data by review of available information (maps, local knowledge etc.)
- Preliminary improvement of customer data by review of connections & billing data combined with site checking
- Pressure measurement campaign around the network to further develop the work done in the study period
- Trunk mains survey as a first step to locate & repair leaks improve operations
- Visible leak detection work on the existing network
- Preliminary leak repair work to properly & quickly repair all leaks located
- Service reservoir inspection & drop test to check for leaks

(1) Network & Customer Survey

A detailed survey of the water supply service area is required and should be undertaken as soon as possible as an essential first step to improving:

- Network rehabilitation & extension design and planning
- Network modelling
- UFW control & leak detection

The essential starting point for much of this project is to establish the necessary basic data on which to build. In order to be able to design network improvements, plan and properly

manage the network and services, better and more accurate information is needed than is currently available.

Thus, one of the first tasks is to undertake a comprehensive survey of:

- Pipe network of transmission, distribution, secondary mains and service lines and all related equipment, fittings and installations (valves, hydrants, pumping stations etc.)
- Customers/ connections and properties within the service area even if not connected
- And ensure
- Proper recording of the information collected, so that staff have easy access to correct, up-to-date information
- That it can be kept up-to-date, especially with the large changes that will occur from:
- Major network rehabilitation and extension programmes
- Increasing population and service levels

To do this, the survey work will be divided into two parts reflecting the different aspects of the work to be undertaken. These are:

- Field work to collect all the required data
- Office Work to record and collate the data

Field Survey Work

Field Work will entail the location and identification of all:

Network

- Pipes
- Valves, fittings etc
- Connections
- Hydrants

Properties

- Properties in the service area
  - Connected with meter
  - Connected and unmetered
  - Unconnected
- Service line routes and stopcock locations

This will be done by surveying the whole area in separate teams for the network and property surveys. The network will be surveyed using specialist equipment including electronic pipe tracers, valve box locators etc.

All data found is to be recorded on site on working copies of the area being surveyed each day. These working maps will show the base map of streets, buildings etc and be printed at scale

1:1000. This will then be transferred to the computerised mapping system – the same as or compatible with that already in service in the urban planning department.

Office Support

The fieldwork teams will be supported and managed by an office that:

- Provides copies of base maps
- Plans survey routes
- Manages data collation and transfer

An adequate and appropriate organisation is required to manage and support the field work teams, so that they are able to keep working effectively. It is also important that there is a system capable of taking the information collected and processing it in a timely manner and without losing any.

For this, an office-based team will be required, whose duties include:

- Daily route planning & preparation of maps, customer lists etc.
- Record keeping / progress checking
- Receipt and processing of marked up drawings

From the survey team, copies of data will be passed on to other departments as appropriate for:

- Updating of records
- Maps (with pipes, fittings, connections, properties etc.)
- Customer database

The figure 3.5.2 gives a diagram of the information to be collected and way in which it is to be used.

This will be computerised on some form of CAD or GIS system & various CIS systems, which will have their own teams; according to the final structure and arrangement of the water supply department.

Refer to Appendix Q for information on a typical example of a computerised mapping & GIS system, 'Resocad'.

Planning & Scheduling

As this work is required for so many other functions, it will be scheduled to start immediately on initiation of the project.

The order/sequence of carrying out the survey is to be the same as the priorities for rehabilitation & new works. In this way, the data is available to the design teams as soon as

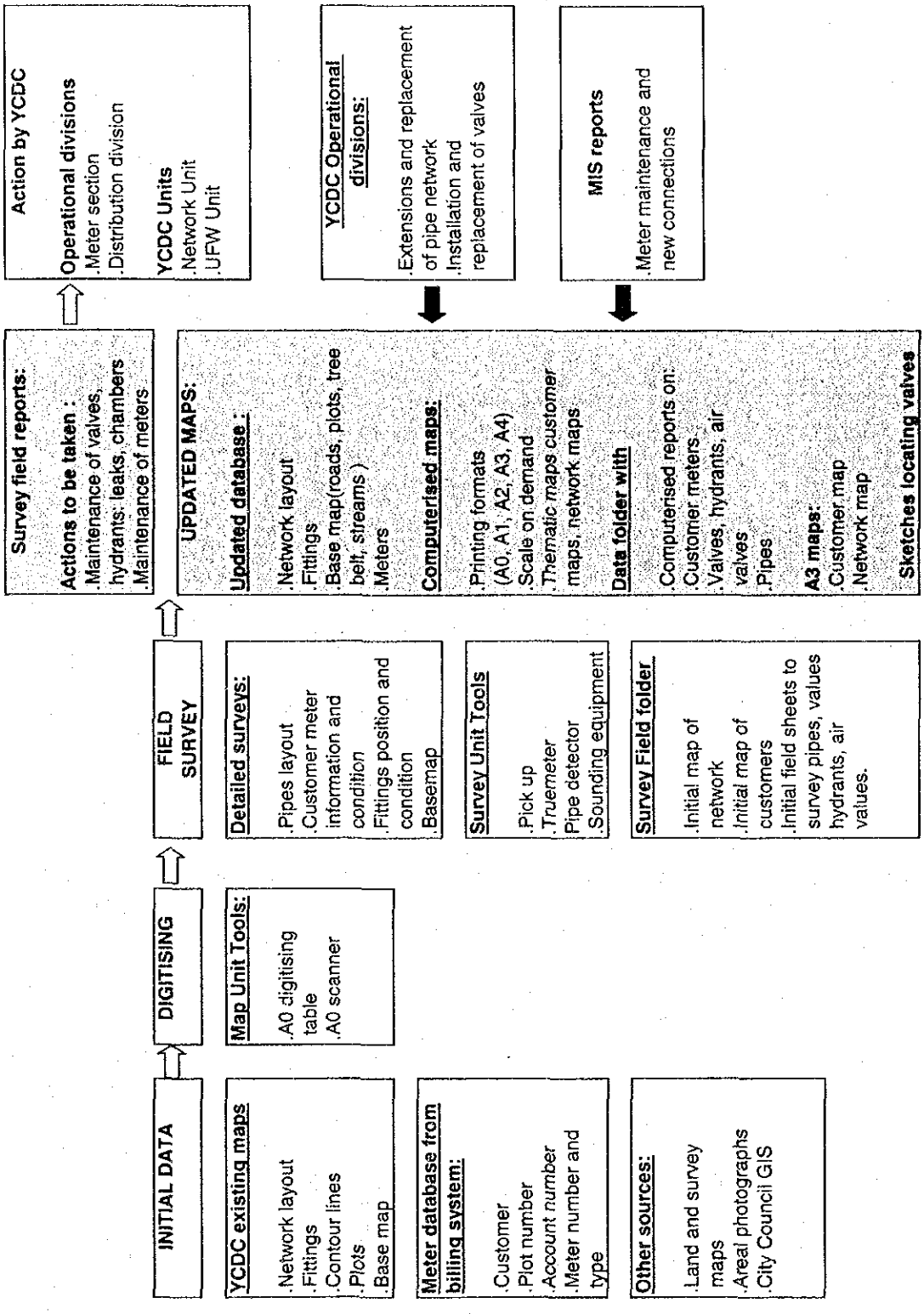


Figure 3.5.2 Schematic of Network & Customer Survey Arrangements

possible. The updated drawings are to provide the basis for the rehabilitation work and so must be completed first

The time period estimated for completion of the works is 1 to 2 years (2003/2004). The exact programme will depend on the requirements and scheduling of the rehabilitation programme.

Presentation of Information Required

Maps — Level of detail to show and scale

Water distribution Maps — 1 :10000 or 1 :20000 scale

The distribution piping network in the complete water supply area should be shown on one or two maps. Maps should contain such information as distribution piping type, diameter, fire hydrants, control valves etc. to enable use for water distribution planning proposals and overall water control

Distribution Piping Maps — 1 :2500 scale

These maps provide detailed information on the relationship between distribution piping networks as well as associated facilities (control valves, fire hydrants, washout valves, drains etc) in the vicinity of the pipe network. They are useful for planning leakage surveys and improvements to distribution piping.

Distribution Piping Maps — 1 :1000 scale

These maps provide detailed information as to the location of distribution piping. They are drawn based on the data obtained with pipe location detectors used on-site and therefore show location with considerable accuracy.

As positions of control valves and fire hydrants are as measured (distance, depth) on-site, high accuracy is assured.

Service Piping Maps — 1 :1000 scale

These maps show not only distribution piping but also the locations of the associated service piping, stopcocks and meters. They are useful in obtaining information as to the relationship between distribution and service piping

Service Piping Maps — 1 :500 scale

These maps are the most detailed and show not only the distribution and supply piping but also the location of the piping and its depth etc.. Each property has an identification number and also indicates on the map whether the house is connected to the water supply system or not

Valve Details — 1 :200 scale

Where necessary, detailed drawing showing the exact layouts of intersections and control valves etc. are prepared.

Customer & connection data

In order to get and maintain control of customer management a database (information system) of all consumers is required containing all pertinent information about the connection as well as the consumption record. This includes but is not limited to;

- Name of customer
- Address
- Type/ Class of property or Non-domestic connection.
- Connection Length of service pipe
- diameter of service pipe
- metered / unmetered
- meter size
- Electric pump fitted
- DMA ID - to identify which DMA it is supplied from
- meter reading route or billing / collection route
- Meter reading record.

Also in order to facilitate control and identification of anomalies all streets and properties should be surveyed and mapped. Then those properties that have a connection identified in some way (seeded).

(2) Large User Monitoring

As a first step towards controlling non-physical losses and maximising revenue within limited resources, initial efforts will be focussed on the 'large user' category of customers.

Since relatively few consumers will take an appreciable proportion of total consumption, action on these few will yield the best results, especially in the context of Yangon where no customer monitoring systems exist at present and metering is not universal even for non-domestic consumers.

A survey of large consumers initiated immediately will provide a list from which a number will be selected (say 100 to 200) will be more closely investigated.
This group will have correctly sized meters installed and will be closely monitored for consumption & revenue.

In order to ensure the maximum return on revenues with limited resources, efforts will be concentrated on identifying and monitoring the large user category of consumers.

To set up the system, the large user category will be identified and categorised by review of customer database and consumption records, in terms of :

- Consumption volumes or revenue
- Meter or connection size

This list will be amended with data from the connection survey. The present YCDC list of large users only contains 12 items and of these 8 are unmetered.

All connections identified as large users will be inspected and checked by a site visit and details verified and recorded. Each of these connections will have meter installed, suitably sized & located.

The "large user category" will initially include:

- Connection/meter of 50 mm and over
- Top 200 consumers in terms of revenue & consumption

Once the meters are installed and the monitoring set up, these customers will be closely monitored by:

- Frequent consumption checks monthly readings
- Analysis of consumption patterns & history
- Annual checks on meters including calibration checks

The list will be subject to constant review & modification as required.

(3) Improve Network Data

The existing drawings and network data will be upgraded and updated as much as possible by:

- Collecting & reviewing all existing maps and records
- Discussing with township and other network staff to gain the best possible "local knowledge"
- Checking queries on-site
- Gather all information together in one place and preparing
- An integrated set of maps and drawings to cover the whole network at a large scale (e.g. 1:1000) to show all details clearly
- Associated records/databases

Particularly, the present maps are very unclear about pipe nodes such as connections, crossovers, valves etc. For example, it must be made clear by standard symbols such things as whether

1) When two pipes cross they form:

- A crossover (no connection)

- A cross (connected)
- A crossover with an inter-connection (valved connection)

2) Tees on drawings are valved or not
3) Lines on drawings that do not meet – is this really a dead end or just an intersection that is not correctly drawn
4) Valves are shown in their correct position and their normal status (open or closed)

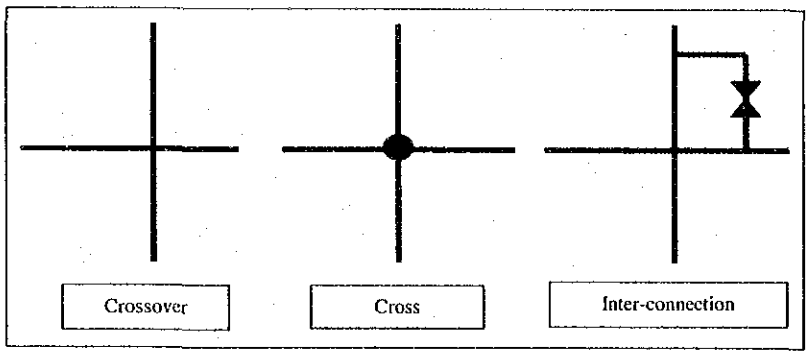


Figure 3.5.3 Representation of Different Possibilities for Pipes Corssing

The basis of this work will be the original set of 1963 network drawings, plus the AutoCAD and MapInfo network plans. The results will be transferred to new media (computerised system), updated as much as possible and progressively extended to cover the whole network.

This is a first step and partial preparation for the full network survey when implemented, but shall be done as soon as possible, whatever the plans are for the full survey. It will be superseded by the detailed network & customer survey.

The choice of new media should be a computerised CAD or GIS system, to be either the same as or compatible with that in service in the Urban Planning department. The base maps, showing streets, buildings etc. will be provided by this department. Co-ordination and an integrated approach is required for sharing and exchange of information.

Updates and network information obtained by the preliminary survey works is to be included on the updated maps and drawings. So procedures will need to be put in place for communication of this information.

(4) Connections Review

A team working on non-physical losses will work on an initial review and updating of customer and connections information. This will be in parallel to the network visual leakage inspection.

Tasks will include:

- Review and assess the existing customer records & database; checking for consistency and highlighting anomalies
- The records will be categorised and evaluated from this review
- Connections will be verified on-site by inspection
- Records will be updated or compiled with information collected during site inspection
- Maps will be marked up to show connections etc.

From this work, a report will be prepared detailing problems and anomalies found, such as:

- Unregistered connections
- Illegal connections
- Broken meters
- Empty properties
- Others

(5) Pressure Measurement Campaign

This task is a continuation and development of the pressure survey carried out as part of the Master Plan Study. YCDC will:

- Take a large number of pressure readings all around the network. using pressure gauge readings
- Plot the readings on a network map to establish isobaric contours and help to show the extent of low pressure problems
- Install loggers for pressure recording at some points to establish daily pressure profiles

The sequence of taking the readings will be:

- Large Diameter Transport mains
- Other trunk mains
- Inlet points to townships / hydraulic areas
- Target points of townships / hydraulic areas
- Average points of townships / hydraulic areas
- Further points in problem areas to investigate hydraulic gradients

The pressure logger data will be used to:

- Define limits of pressurised areas at night for leak detection activities
- Identify areas where zero night pressure is caused by valve operation

Estimate

Initial Set of Pressure measurements:

- Trunk Mains	50 places	
- Distribution Network	150 places	(6/township)

(6) Trunk mains Survey

The trunk main survey will be carried out as follows:

Inspection

One or more teams will visually inspect the full length of all the trunk mains routes by walking along 1 section each day. Initially, this will be for large diameter pipes of over 36 inch – being mostly the main transmission lines from the reservoirs to the city. Afterwards, the second level of trunk mains over 18 inch diameter can be checked.

The teams will take with them large scale network maps of the section to be inspected. On these they will make detailed notes and mark up the drawings to show any points of interest found during the inspection, including:

- Leaks, seeping joints etc.
- Signs of ground movement affecting the pipeline
- Problems & hazards e.g. buildings over the route of the pipeline
- All connections and off-takes
- All fittings etc. e.g. Air valves, line valves, washouts, connection valves

For all leaks a leak report will be prepared, similar to the examples used in the leakage survey for the Master Plan.

Maps and Records

The network maps and records will be updated to reflect all relevant information collected during the inspection.

Flow Measurement

With some extra resources, trunk main flow measurement at selected points is recommended. Insertion points, similar to the few already fitted will be installed. Insertion probe flowmeters with flow recording loggers will be placed for a minimum of 3 days at each point to show flow profiles and indicate sections with hidden leakage or consumption.

Remedial Action

Following inspection, any leaks located will be stopped using an effective, approved repair method, such as to give a prolonged, trouble-free life. After repair, a repair report will be completed and matched with the leak report.

Preventative Action

Even when no leaks are found, appropriate preventative action will be taken to avoid future problems and improve the management of the trunk mains. This includes:

- Reinforcing support or other remedial measures to points where the ground has moved, causing pipe joints to be deflected, to prevent further pipe movement

- Removing problems & hazards where practicable
- Removing all direct connections to the trunk mains except for distribution mains. The removed connections should be transferred to a distribution main or cut off completely.

A specific example of (2) will be clearing refuse tips at pipe overbridges on the 56 inch Gyobyu pipeline. The pipe is designed to rest on its supports with free air circulation all round. The refuse build up in contact with the pipe holds water and provides good corrosion conditions, leading to leaks and finally major bursts.

Any leakage or serious corrosion revealed will be repaired.

Estimates

Daily Inspection	5 km
Total length of Trunk Mains	150 km

(7) Visible Leak Location

A campaign to locate and repair all visible and obvious leaks will be undertaken. Township by township, the whole network, including service lines as far as the property boundary will be inspected by leakage teams.

These teams will work with the network inspectors for the respective townships.

All leaks and other problems (e.g. broken meters, open ends, inner tube repairs) located outside the property boundary will be reported and recorded, whether the responsibility of the consumer or YCDC.

Working copies of large scale maps of the section will be taken on site and marked up and notes taken of all useful information. Leak reports will be completed for all leaks found.

Maps and Records

As well as leaks this will include location of distribution mains, valves, service lines, stop taps etc. where found omitted or not as shown on the drawings. This information will be used to update the network maps and customer records.

Prioritisation & Order of Work

Work will start with the townships that have good supply and pressure, then to low pressure areas with extensive network and finally to townships with small lengths of pipe network.

Estimates

Daily Inspection	5	km / day
Total length of Trunk Mains	725	km

(8) Service Reservoir Inspection & Testing

At the start of the programme, all service reservoirs are to be inspected and tested for leakage by drop testing.

The test sequence is:

- Visually inspect externally, looking for leaks, wet ground etc.
- Clean inspect and disinfect internally
- Drop test by:
  - Ensure reservoir water level is high (full or nearly full)
  - Close all inlets and outlets to the reservoir
  - Measure change in water level over as long a period as possible (min 2 hour)
  - Slowly open inlets and outlets to return to service
- Take necessary remedial measures

(9) Leak Repairs - Preliminary

In association with the initial, mainly visible leak detection activities, repair work is essential to physical loss reduction. Efforts are required to ensure that all leaks identified are repaired in a timely and effective manner.

YCDC has existing capacity for repairs and can carry out the work with the existing resources. However, the repairs could be improved by training the staff in new techniques and the provision of tools, equipment and repair materials. It is strongly recommended that some resources are directed to this immediately in order to make the best job.

For this it will be necessary to equip the repair teams with all necessary:

- Staff of suitable capacity
- Equipment
- Materials
- Transport
- Other resources

The requirements are considered in more details in the longer term O&M tasks group.

Service Pipe Repairs

It is apparent that many of the visible leaks will be found on service pipes and so these are to receive as much attention as the network, because of the amount of water loss experienced.

This is based on having one of the repair teams concentrate on repairing leaks on and improving the standard of installation of service pipes outside the property boundary; notwithstanding any question of the responsibility.

3.5.3 Group 3 Preventative

The items in this category are very important in UFW control and so are described briefly here. The associated resources and details are included within the facilities plan.

Principal elements of this category include:

- Principles & criteria for design of network to minimise and avoid UFW problems
- Specification and standards for design, supply, installation and workmanship for new works programme of network improvement

(1) Network Design & Planning

The planning & design of construction works on the water supply network will take account of the 3 elements:

1) Layout of the network to optimise monitoring & control of UFW by:

- Loops for security of supply
- Adequate number and location of valves for sectioning & isolation for maintenance
- Division of network into a hierarchy of sections, with the smallest component being districts of 1000 to 3000 properties
- Inlet point(s) to each section to be equipped with a meter in a chamber with a bypass

Typical diagrammatic drawings are shown for:

- Zoning of a network by division into sectors Figure 3.5.4
- Hierarchy of metering in smaller & smaller sectors Figure 3.5.5

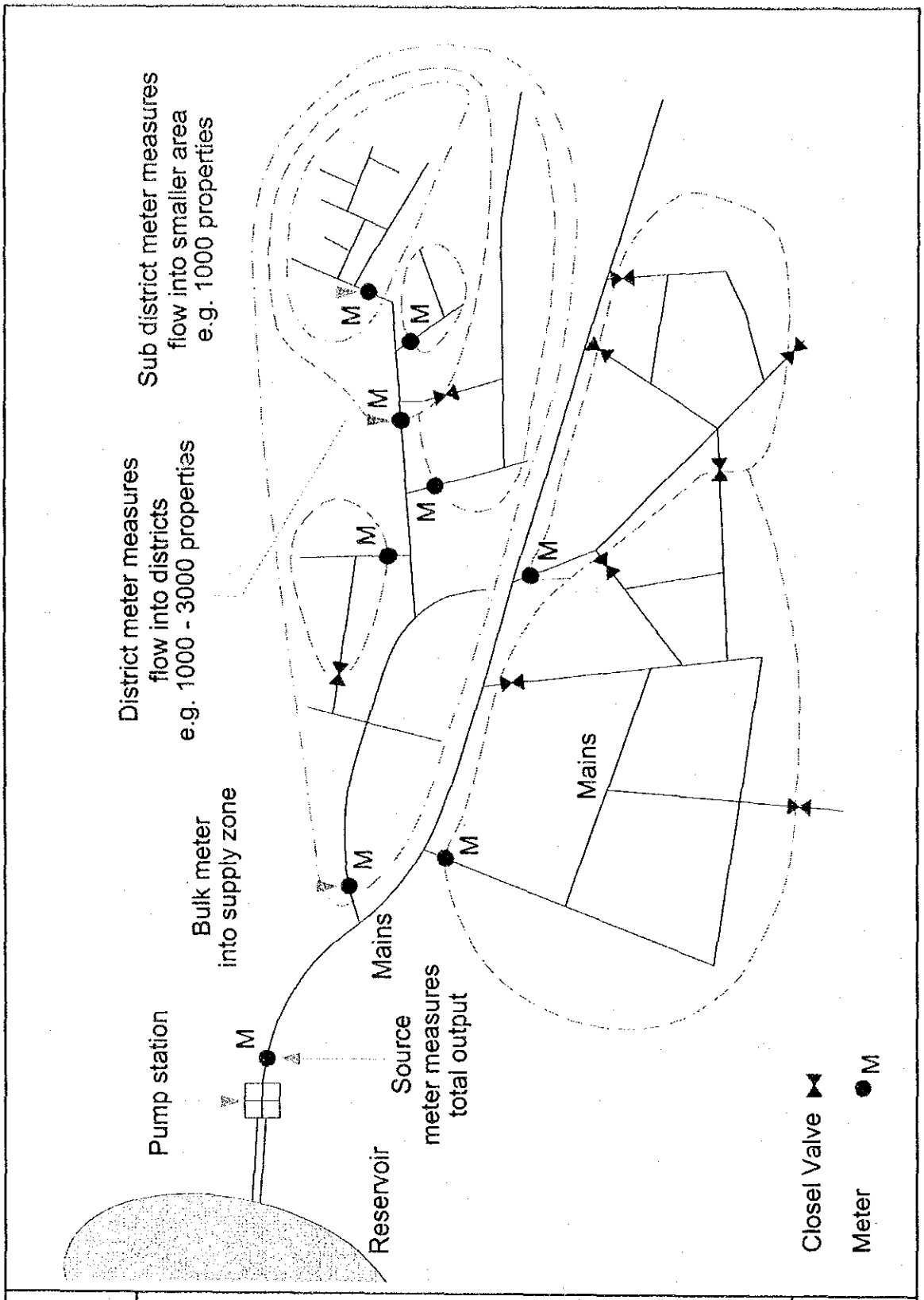
2) Setting design principles & criteria to be applied including for example:

- Short service lines
- Network design with loops for security of supply
- High number of network vales to allow separation of loops into different areas
- Valves at all junctions
- Air valves & washouts at high & low points respectively of trunk mains
- Target minimum service pressure at the ferrule of 15 to 20 m
- Pressure rating of material for service to be 10 bar
- Secondary mains on both sides of main roads and asphalted side roads to keep services short and minimise traffic disruption for access
- Valve chambers on large mains
- Valve boxes on small mains
- No connections directly to a trunk mains – if required put in a parallel distribution main

- Division of responsibility (& ownership) at the property boundary unless special case
- Universal metering with ownership of meter kept by YCDC

3) Improvement of network standards by:

- Planning of developments
- Increase of secondary mains to serve every street
- Elimination of excessive length of service lines
- Improvement of connections & service lines

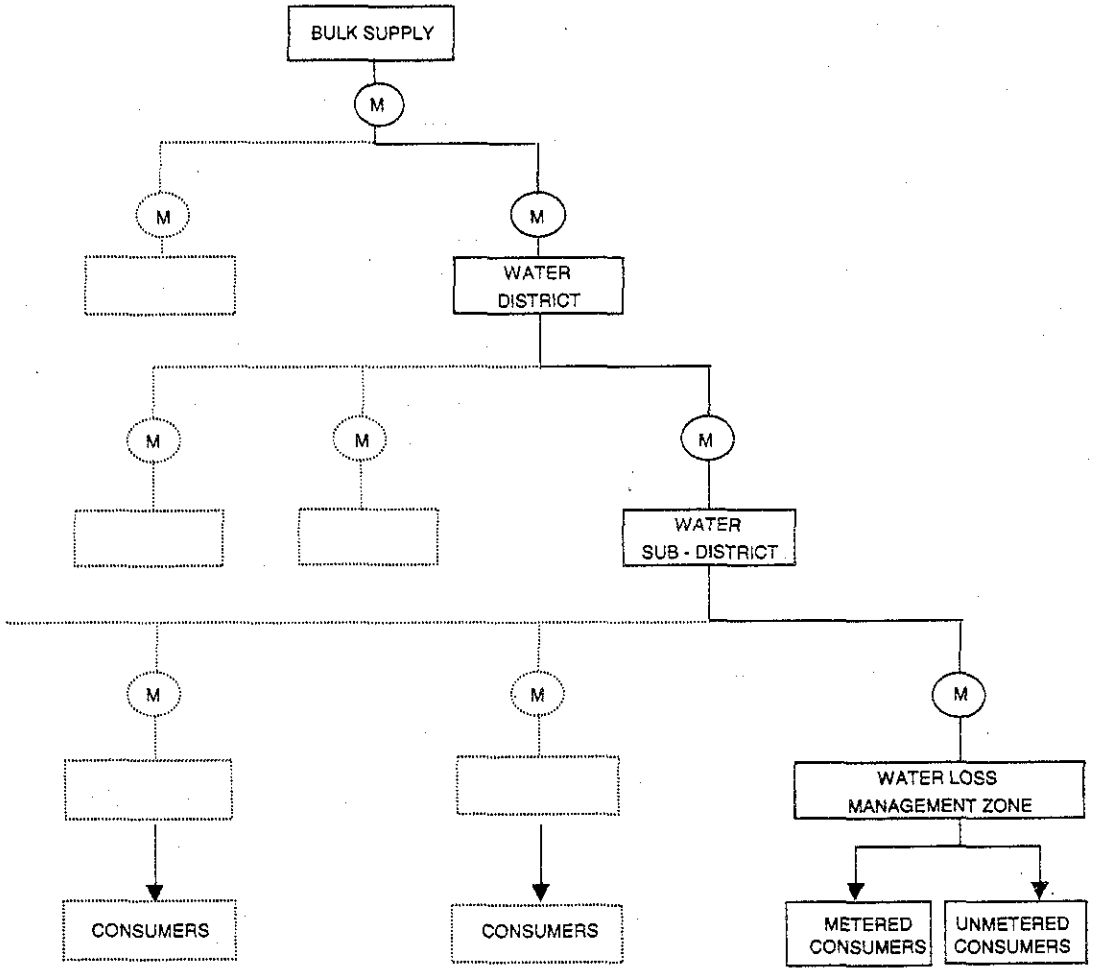


THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM
IN YANGON CITY IN THE UNION OF MYANMAR

Typical Schematic Showing
Division of Network into Metered Areas by
Installation of Meters and Valving Off.

FIG 3.5.4

Figure 3.5.5: Typical Metering Hierarchy



TOTAL WATER FROM WATER BOARD or OWN SOURCES

DISCRETE LARGE AREAS WITH INDIVIDUAL DEDICATED BULK SUPPLY AND BOUNDARIES USUALLY FIXED BY TOPOGRAPHICAL FEATURES

SUB-DIVISIONS DEPENDENT ON THE SIZE OF THE WATER DISTRICTS AND IDENTIFIED BY REZERVOIR, TOWER, PUMP, PRESSURE ZONE OR TOPOGRAPHICAL FACTORS,
(TYPICALLY 3000-30 000 CONNECTIONS)

CONVENIENT AREAS SIZES FOR GROUPS TYPICALLY NUMBERING UP TO 3000 INDIVIDUAL METERED CONNECTIONS

(2) Design Criteria & Principles for New Works Programme

Leakage Prevention & avoidance is greatly enhanced by means of ensuring new works are to a high enough standard for a long, trouble-free life by :

- Specifications & standards for
  - Materials good quality, long-life underground, suitable for conditions
  - Installation standards for trenching, backfill, compaction, jointing, site works etc
  - Workmanship
- Ensuring network drawings are updated with as-built details

Some examples of the considerations for specification include:

Material specification

- DICL to be used for distribution mains
- UPVC or MDPE for secondary mains
- MDPE to be used for services
- Customer meters to be ISO4064 or equal Class C
- All non-metallic pipe to have tracer wire attached or laid just above in trench

Good quality, high specification material should be selected so that it is installed on a "bury and forget basis". It is a false economy to save on material cost and have to keep digging it up for repair during its working life

Installation

- DICL pipe to be sleeved
- UPVC requires special care for good bedding
- Sand bedding around pipe
- Consolidation to be high standard
- Cover – depth & backfill to be specified clearly
- Installation to be by cut & cover except in special cases
- Care for good jointing with correct lubricants etc.
- Use self-restraining joints
- As built drawings to be prepared regularly on a rolling programme – including service pipe positions (to allow network drawings to be kept up-to-date)

To minimise development of leaks it is essential to ensure good workmanship and a high standard of installation. So standards should be used that set out the best practice for installation of pipework, fittings etc. for each material (DICL, UPVC, MDPE etc)

Implementation of the above tasks for design and specification will be carried out by the planning & design department. One of their first jobs will be the preparation of detailed

documents for design criteria and specifications to be applied to the new works programme. They will be supported to do this by a technical assistance programme.

This will provide a standardised approach for the detailed design stage and the basis of tender documentation for the supply and installation contracts to be awarded.

Once installation work is in progress, staff from the design department should be involved in the works to benefit from seeing the application of the criteria.

3.5.4 Group 4 Practice

Principal elements of this category include:

UFW Control

- Creation of a special team specially for UFW Control, the UFW control unit (UCU)
- *Introduction of active leak detection*
- Campaign of setting up pilot areas and flow measurement
- Installing & monitoring bulk flow metering in the network stage 1 Production
- Installing & monitoring bulk flow metering in the network stage 2 Supply areas
- Division of network into sectors
- Investigation, analysis and correction of non-physical loss anomalies

Network Repair

- Improvement & upgrading of leak repair capacity

Customer Metering

- Installing & monitoring customer meters
- Small domestic meters
- Non-domestic meters
- Setting up a special Large user category for monitoring
- Setting up workshops for test & repair of meters

(1) Setting up of Special Unit for UFW Control (UCU)

The prerequisite to initiating active UFW control in an organisation where there is no existing arrangement is to establish, train and give adequate authority and resources to a dedicated, specialist unit for UFW control. This team is charged with developing and implementing a strategy for UFW Control within the water supply and the operating organisation.

This UFW Control Unit (UCU) will have considerable autonomy initially, though its functions will eventually be absorbed back into the mainstream structure of network operations and maintenance, as over time the tasks and principles of UFW control become accepted as normal, everyday practice.

The duties and scope of work of the UCU, with associated issues of resources, will develop throughout phase 1 (and phase 2), but the urgency is to get it set up, trained and operating effectively as soon as possible; set up immediately on starting the programme.

The function of the UCU will be to act as the focal point for all issues related to UFW control and to ensure that the objective of reducing losses can be achieved. Not only will the team plan and implement their own programme of action, they will also act as advisers to the senior management and will co-ordinate efforts & information transfer between other departments.

UCU Activities in Stage 1

- Network survey
- Customer survey
- Trunk main survey
- Large user category
- Co-operate on network design
- Supervise service pipe renewal programme
- Leak detection
- Monitoring/control/prioritisation
- Temporary network division & flow measurement
- Production metering initial – using insertion probe meters in some places
- Consumption assessment work until universal metering is predominant

During the first eighteen months of operation, the UFW control unit will be set up, trained, developed and become firmly established. Within this period, it is expected that the first half will be principally occupied with setting up, preparing and training and the latter half will be practice and implementation.

For this first stage, the team will be kept relatively small and exclusive, so that it remains manageable and all its members can be properly trained. This is a relatively long lead-in time, because YCDC is starting from zero and a sea change in approach is needed.

At the end of this period, a review will be carried out to determine the future direction of efforts and reinforcement of the team that is needed, along with the additional resources required. The role of the original core team will then be modified to include training and supervising additional staff brought in to cope with the expanded work programme.

(2) Active Leak Detection

Active leak detection is the work of systematically searching for leaks by inspecting the network using a range of specialist tools & techniques. Guidelines on these techniques and information on some of the equipment used is given in Appendix Q of this report and Appendix G of the Master Plan Report.

For the purposes of task description active leak detection is divided into two categories according to how the efforts are directed, though the task itself remains the same.

Regular or Routine

In the absence of methods such as district metering to identify and prioritise areas with high levels of leakage, routine sounding can be used. Therefore, this will be applied in Yangon as an interim measure:

- After visible leakage survey
- Before networks sectors and zone & district metering are effectively implemented

The normal range of techniques are used to detect and locate hidden leaks, including

- Sounding direct & indirect with sounding bars
- Leak location detectors applied to hydrants etc
- Indirect location using ground amplifiers
- Acoustic loggers
- Leak noise correlation for pinpointing located leaks

These methods are applied on a regular basis, where leak detection teams work on a pre-planned block by block basis each day (or night).

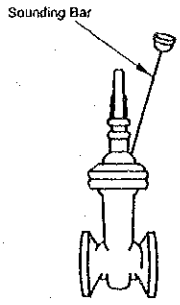
Each night, one team will do leak detection on a section of the network, with a length of about 2 km of pipework. This continues on a regular basis until the whole area to be checked has been completed and then the cycle is repeated.

Leak detection requires pressure and flow and low noise levels so is carried out at night. Initially, this work will be restricted to parts of the network satisfying these conditions. The extent of the area and the sequence will be confirmed after the pressure survey.

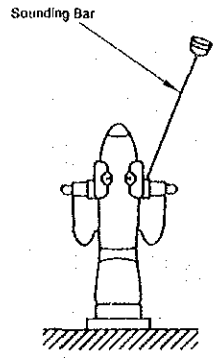
In routine or regular sounding, leaks are located by deploying teams of inspectors who systematically work their way around the system sounding all stopcocks, hydrants, valves and other convenient fittings listening for the characteristic noise of leaking water. Sounding points are shown diagrammatically in Figure 3.5.6.

Directed

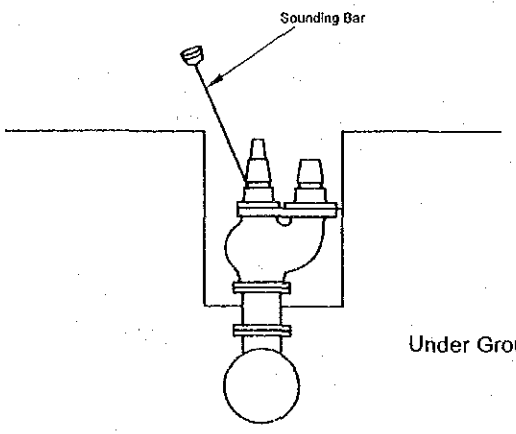
The effectiveness of leak detection teams is improved when they can be directed to work in areas of higher leakage. Leak detection efforts are prioritised by analysing flow measurement data to determine where leak levels are highest.



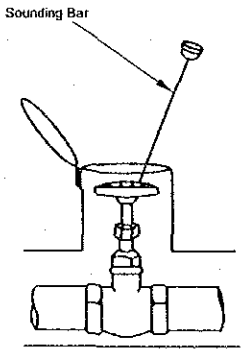
Valve



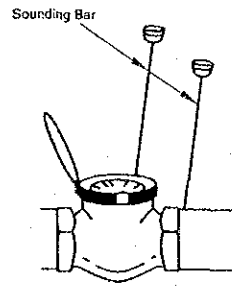
Ground Type Hydrant



Under Ground Type Hydrant



Customer Connection



Meter

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.5.6
	Typical Direct Contact Sounding Points	

Figure 3.5.7: EXAMPLE OF LEAK REPORT FORM

LEAK DETECTION FORM

LEAK No. [ ]

I - LEAK DETAILS

DATE :		ZONE n°:	
NAME :		AREA :	

LOCATION :

SKETCH :

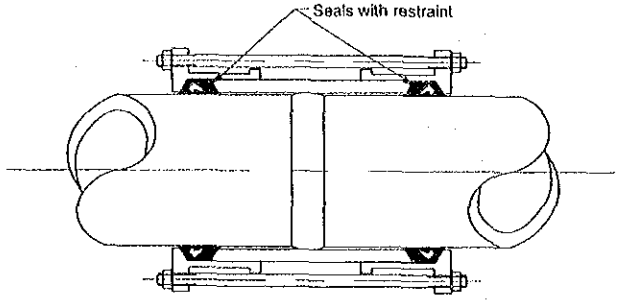
DESCRIPTION OF LEAK :	METHOD :	Sounding ☐	Correlator ☐
	LEAK :	Invisible ☐	Visible ☐
	PRIORITY :	A ☐ B ☐	C ☐

II - REPAIR DETAILS

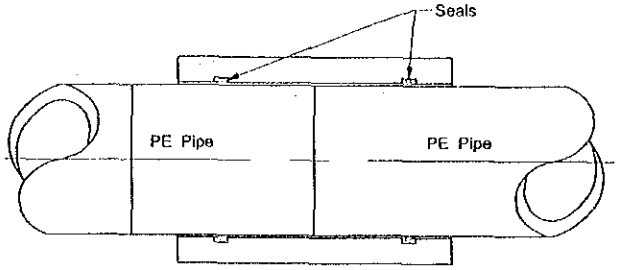
DATE :	.....
NAME :	.....

RESULT					
NIL	PIPE	VALVE	HOUSE CONNECTION	METER	TAP
OTHER	.....				
DESCRIPTION OF FAUT FOUND :					

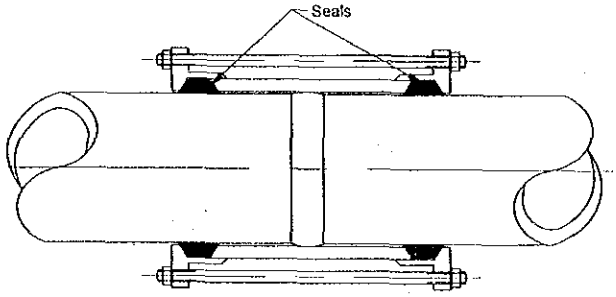
PIPE REPAIR COUPLINGS



End load resistant coupling

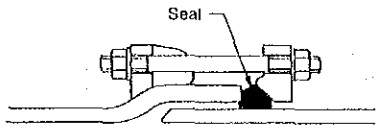


'O--ring' repair coupling

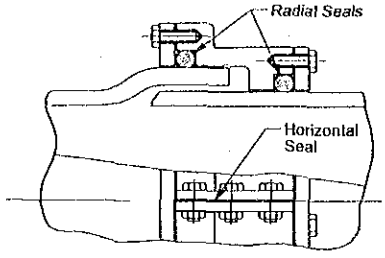


Bolted mechanical coupling

SOCKET REPAIR CLAMPS

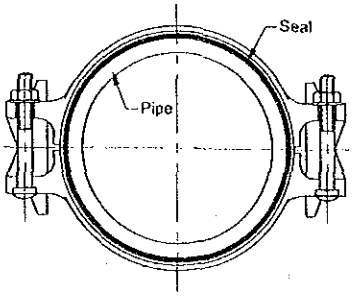


Socket repair clamp (type A)

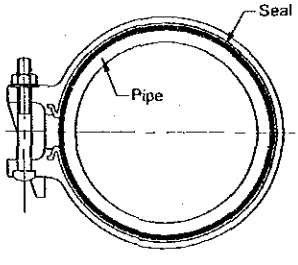


Socket repair clamp (type B)

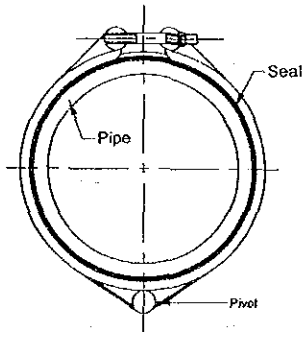
PIPE REPAIR CLAMPS



Typical split collar
Socket repair clamp (type B)



Wraparound repair clamp
(type A)



Wraparound repair clamp
(type B)

JICA

THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.5.8

Typical Repair Material

As the project progresses the leak detection teams will gradually be redeployed from routine sounding to directed sounding, using results from

1) Measurement campaign and pilot area result
2) Monitoring of district meters

Leak Reporting

For effective control and providing good information to the repair teams, a leak report is completed for each leak located, irrespective of size. A copy of this report is passed to the repair team engineer for preparation of a work order to get the job done promptly.

Once the repair has been completed the report is returned to the leakage teams with details of the repair work carried out. A typical example of the report form is shown in figure 3.5.7

(3) Leak Repairs

In order to deal with the increased level of leaks and other pipework problems located by the leak detection activities, it will be necessary to enhance the capacity of the existing network repair organisation.

This group will be responsible for all non-minor repair work and may also be used for installation of equipment and fittings applied for monitoring & control of UFW. This second item includes boundary valves, district meters, measuring point tapping saddles etc.

It is also proposed that the repair teams be closely involved with the new works so they can be familiar with and trained on the new sections of the network.

To achieve this, it will be necessary at an early stage to re-organise the repair section to be supplied with all necessary:

- Good staff
- Equipment
- Materials
- Transport
- Other resources

The staff should be adequately trained in

- Principles
- Repair methods
- Specifics of equipment & repair materials to be used

Figure 3.5.8 illustrates the typical repair fittings most commonly used. Further information and guidelines on the causes & effects of breaks and the techniques used for their repair are given in Appendix Q of this report.

There is no benefit in identifying many leaks if they either go unrepaired for a long time or are ineffectively repaired and will leak again soon. To achieve this requires attention to three aspects of repair activity:

Network Repair Team

- Set up repair team(s) organised in teams of 4
- Order & Supply Equipment
- Train team in good practice and correct use of materials & equipment
- Implement procedures to ensure teams can do their work effectively

Network Repair Materials

- Review repair supplies required
- Order & Supply repair supplies
- Set up stores system for repairs
- Implement procedures to ensure repair teams have the right material available when they need it

Repair Reporting

- Monitor repair team
  - Record Leak repair data
  - analyse leak repair data for action

Service Pipe Repair Programme

Service pipes are to receive as much or more attention as the network, because of the amount of leakage experienced.

A provisional programme for service pipe repairs is to be instigated. This is based on having a repair team set up on the same criteria as for network repairs, to concentrate on repairing leaks on and improving the standard of installation service pipes outside the property boundary.

Experience shows that most leakage problems are due to innumerable small leaks on service connections. Even when domestic consumption is metered, these small leaks can often be found on the consumer's pipework.

(4) Measurement Campaign

The procedure is broadly an extension of the work done in the master plan study on leakage survey for the model blocks.

The network is divided into distinct sectors and the flow rate measured into an isolated pilot area over a 3 day period to very precisely determine for each sector the maximum flow rates during the day and the minimum flow rates at night. If the measurements taken are an accurate reflection of network operating conditions, the night-time flow rates are representative of the sum of the leaks on the network, plus the leaks which occur after the meter in customers' homes (leaky faucets).

Typically, the principal steps of the work method, carried out successively, are as follows :

(1) Identifying the sectors where the amount of water lost justifies further investigations; this is accomplished by:
- Revewing the existing mapping, checking its accuracy and updating it,
- subdividing the network shown on the layout into sectors which are then isolated, and briefly stopping water distribution to each sector (pressure zero test) to check the accuracy of the maps and their conformity with the actual situation,
- measuring maximum flow rates during the day and minimum flow rates at night at each sector entry. Night-time flow rates represent night-time consumption plus leaks on the network plus leaks on services
- making a comparison between the average flow rate entering the sector and the estimated value based on the number of customers. In this way sectors where the amount of water lost are identified for further investigation.

(2) When the sectors with the greatest losses have been identified, the leaks are located by :
- carrying out step tests by successively isolating pipe sections within a given sector to identify areas on the network where night flows are abnormal,- detecting leaks on the sections of network identified as presenting losses and repairing the leaks when the cost of the repair work is compensated by savings in water.

(3) Once the leaks detected have been repaired :
- new flow rate measurements are taken at the same measurement points and under the same conditions at the entries to each sector to evaluate the effectiveness of the repairs carried out,
- and spot measurements are effected to check if the results initially obtained are reliable. In the event of an increase in night flow rates, new step tests are carried out following by leak detection and repair work.

In application to Yangon, the measurement campaign is to be used as an interim measure using temporary flow measurement to prioritise the work of the leak detection teams – sending them to areas of known high leakage for maximum results. Eventually, permanent district metering will provide continuous monitoring and flow data trends.

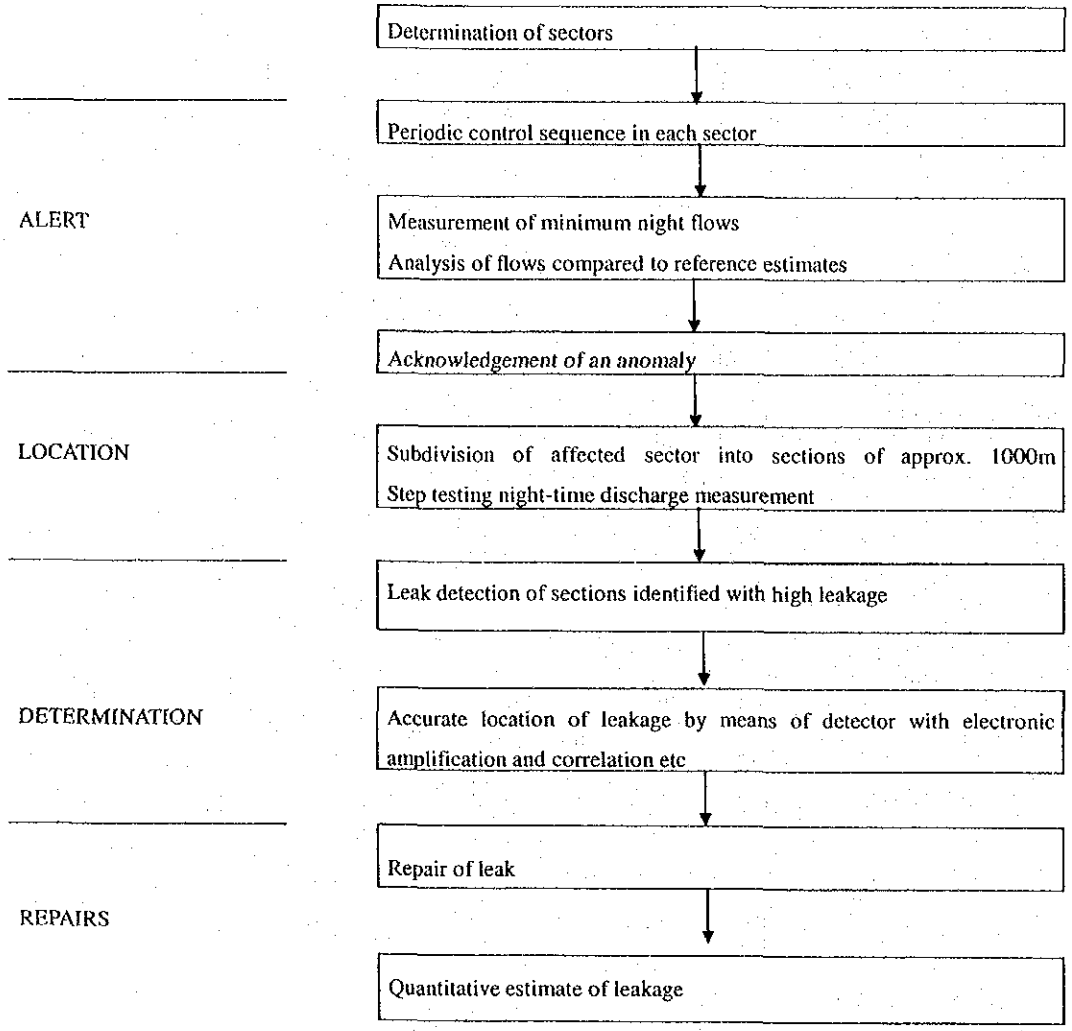


Figure 3.5.9 Diagram of Sequence of Activities for Measurement Campaign

Factors to be considered include:

- cannot do the whole network because of lack of valves
- can identify and plan to successively investigate:
  - areas already able to be investigated where no additional boundary valves are required
  - areas where only a small number of new boundary valves need to be installed
  - areas requiring a large amount of work to form isolated sections
- cannot do this work in areas being rehabilitated

For this task insertion probe flowmeters or strap-on ultrasonic flowmeters are to be used on temporary installation

Further information and guidelines on the techniques used for this work are given in Appendix Q of this report.

(5) Set up Pilot Areas

The setting up of pilot areas is inter-related with the measurement campaign. Sectors identified for isolation for measuring of lows and leakage assessment are in the early stages of the project the same as pilot areas.

So in each pilot area set up, the whole range of relevant UFW tasks will be carried out, both PL and NPL, to begin to build up information and to control the network. This setting up process is repeated successively, increasing the number of area and comparing results to prioritise actions and interventions.

(6) Sample Pilot Area - Mayangone

To illustrate the arrangements and sequence of actions for setting up a pilot area and so also dividing the network into sectors, an example in Yangon is shown.

This is intended as a model to make the processes described previously easier to understand and is not necessarily the optimum size and location for an area. Nonetheless, it is a good place to start in order to get practice and experience.

The chosen area is in Mayangone township, where there is a section of the network that is connected to the 66 inch Hlawga – Yegu Pipeline. It is suitable for two reasons:

- Self-contained & independent part of the network
- Supply & pressure should be assured because of the direct connection to the trunk main pipeline

The general sequence of tasks for setting up a pilot area and then investigating for leakage and other unaccounted for water losses is given in the form of a checklist in Table 3.5.2

The layout of the Mayangone pilot area(s) is given in Figure 3.5.10, showing the sectors created, Boundary Valves, step valves and metering points. At this stage, these are based on the assumption that the map is correct and up-to-date. If not, then these details will be modified.

Once the area has been identified and evaluated on the map, in order to set up the area, the stages are:

1) Boundary Valve checks
   - Check the existing valves and make sure they are as shown on the map and operate properly
   - If necessary install extra or replacement boundary valves

For this pilot area there are four boundary valves, BV1 BV2 BV3. BV4.

It is also recommended that the pipework is modified so that Area B is supplied from the same connection to the 66" pipe as Area A. This will involve laying about 70 meters of pipe and transferring the connection.

Area by area - for each area, close the relevant boundary valves for about 15 minutes

Area A	BV1 & BV2
Area B	BV4
Area C	BV3

Check that the water stops flowing into the area. This is done by measuring the pressure inside the area: If the water is stopped, the pressure in the pipes will drop to zero. This is called a pressure zero test (PZT)

If water is still entering the area, it means that there is a pipe or pipes somewhere, that is not shown on the map. These pipes have to be found and a valve fitted on each pipe and these valves are then closed.

The PZT is repeated. If there is still a problem, the search for hidden pipes is continued and the tests repeated until it is successful and no water enters the area during the test.

When everything is OK for the PZT test, then the metering point is installed and the flow into each area is measured with a flow meter and logger that can record the flow every 15 minutes. All boundary valves for the area are closed, except the one at the measuring point, so that all the water entering the area goes through the meter (this is called the inlet point).

Area	Location of Metering Point	Boundary valves to close for test
A	At BV 2	BV 1
B	At BV 4	None
C	At BV 3	None

2) The results of the measurement are compared with the estimate of expected flow (based on number of connections or length of mains pipe)

Result	Action	Meaning
Measured flow is a lot higher than expected flow	Investigate leaks by step testing and leak detection	There are lots of leaks in the area
Measured flow and expected flow are similar	Leave the area until the next check	Leaks are only small and will not be able to be found easily
Measured flow is less than expected	Recheck expected flow and if OK then use measured flow as baseline leak level	Leaks are less than average and so area is in good condition

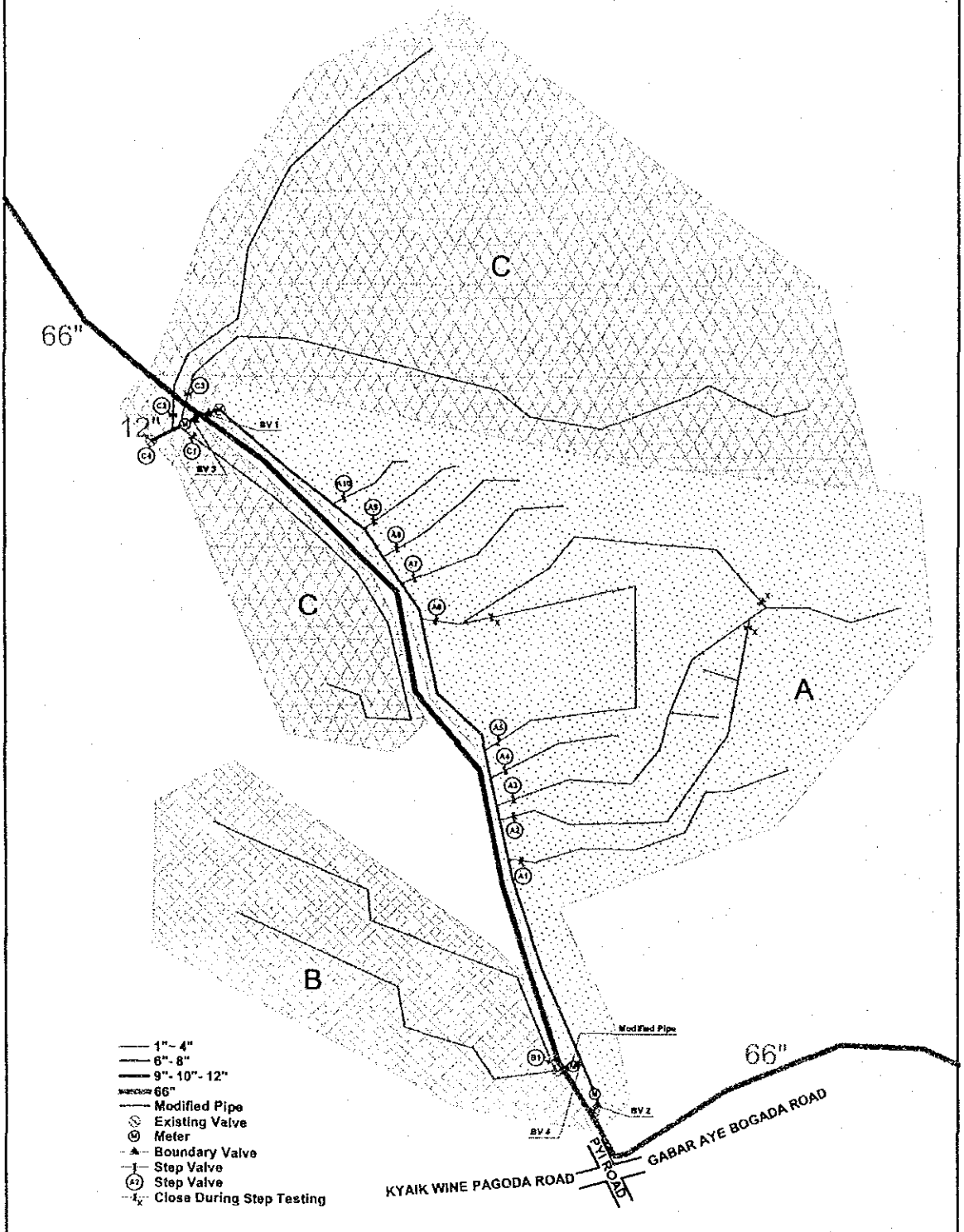
Investigation of the leaks in an area are described elsewhere in this report, in Appendix Q and in Appendix G of the Master Plan report

The end result of this set of tasks is that this section of the network is now divided into 3 separate and independent areas. Each area can be checked periodically over time to see if the leakage has increased to a high level and so leak detection is needed.

The same procedure of setting up areas can now be repeated in another part of the network and then when that is done a third area can be set up. This continues until all the network is done, so that there will finally be about 300 separate District Metered Areas (DMA's) in Yangon, all independent of each other.

The most important point in designing and setting up these areas is that there should only be 1 or 2 inlet points, which are then fitted with flow meters. More inlet points than this causes problems and also becomes expensive for costs of meters.

The DMA's are monitored on a regular basis to see which ones have high leakage and then leak detection and repair efforts are concentrated in these places.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.5.10
	Water Supply Net Work (A Part of Myangone)	

Table 3.5.2 Sequence Checklist for Pilot Area Setup and Leak Detection

Item	Task	Sub-Task	Period
	Set up & Check Area		
Setup & Preparation			
	Select Pilot Area		
	Study existing maps		
	Site survey	Valve location & check	
		Large users check	
		Exceptional Night users	Night
	Remedial Works	Install or repair valves	
	Pressure Zero Test (PZT)	If Pass OK	Night
		If fail investigate & rectify	
Measurement			
	Install Measuring Point		
	Insert flow meter		
	Isolate Pilot area		
	Measure flow for 3 days		
Analysis			
	Establish reference flow (ERF)		
	Compare ERF with measured flow		
	Determine need for leak detection		
	Investigate for High Leakage		
Leak Detection			
	Step Testing Preparation	Identify Steps on map	
		Verify steps on site	
		PZT steps	
		Rectify/ install valves	
	Step testing	Insert flow meter	Night
		Close step valves successively	
		Record Flow for each step	
	Analyse step data		
	Identify high leak flow steps		
	Leak detection teams		Night
Repair			
	Repair all leaks found		
Remeasure			
	Repeat night flow measurement		
	Establish baseline leakage flow		
	Associated Activities in Area		
Investigation & Survey			
	Check all connections		
	Check lengths/size of mains		
	Check lengths/size of services		
	Verify Night users		Night
Network Data Updating			
	Update Records		
	Update Maps		

(7) Network Sectorisation

The principle of network sectorisation is to divide the network into discrete sections with only one or two inlet points for the flow into that area. These inlet points are then equipped with flow metering in some form. This enables operations staff to improve:

- Network Management
- UFW monitoring and
- Prioritisation of leakage detection work

Accepted best practice internationally is that the network be divided as:

- Water supply Area (WSA) 8000 to 12000 connections Average 10000
- District metered area (DMA) 2000 to 5000 connections Average 2500

The actual ratio will be affected by the network layout and the potential for sectorisation as well as the connection density. Dense urban DMA's will be smaller than rural ones. Using the average as a basis for estimation, Yangon network is eventually to be divided as per the following Table.

Table 3.5.3 Estimated Number of DMA's & WSA's

Zone	Population served 2020	Connections	Sub- zones	Districts
	(Projected)	6 person/connection	(1/10,000)	(1/2500)
1	1074279	179046.5	18	72
2	832363	138727.2	14	55
3	680016	113336	11	45
4	705303	117550.5	12	47
5	64204	10700.67	1	4
6	363526	60587.67	6	24
7	161441	26906.83	3	11
8	150671	25111	5	19
9,10,11	280539	46756	3	10
TOTAL	4312342	718723.7	72	287

The population estimates are taken from the master plan data and use an average of 6 persons per household to estimate the number of connections.

Work on sectorisation will begin early in stage 1 and progress until completion. This work will be accomplished in two parts.

1) A great deal of the sectorisation will be achieved by inclusion of the necessary work as part of the new works network rehabilitation programme. Design and installation is to include:

- Metering
- Boundary valving
- Division of the network into sub-zones
- Provision for districts – valves, meter chambers etc.

The design & planning department will be responsible for ensuring that these principles are included in the design and contracts, so that retrospective work is avoided. UFW control staff will liase with them to give nay necessary advice and assistance.

These rehabilitation areas will not generally be included in UFW control activities until the new works is complete and the WSA's and DMA's are handed over and monitoring can be initiated.

2) Sectorisation will be integrated with pilot area and measurement campaign work and gradually spread in association with them. So the same criteria apply, that the sectors will be set up in areas with service and pressure AND that are not due for rehabilitation until late in Phase 1 or in Phase 2.

A programme is to be developed by the UCU for implementation of (2) comprising the following steps :

- Plan sectorisation of an area by selection of suitable areas from the network maps
- Install any valves and fittings required
- Test for integrity (PZT)
- Identify & rectify any problems
- Test the area to ensure service is maintained satisfactorily
- Install metering point or meter & chamber

District metering

Flow meters are installed at strategic points within the system so that areas of about 2,000 to 5,000 properties are supplies via meters and the integrated flow into each area measured.

District Meters are normally read at regular periods, weekly or monthly, and the results analysed to determine any areas in which significant increases in supply have occurred. If no legitimate reason can be found for the increase in an area, the leak inspection teams sound all stopcocks, hydrants, valves and other fittings searching for the characteristic noise of leaking water.

This method of leakage control has the advantage that the inspectors are always working in those districts where leakage is anticipated to be highest and therefore are likely to return the greatest benefits for their efforts. It also has the added advantage that information regarding

flows and use of water within the network is obtained which can be useful for the day to day running of the network and for the planning and design of future extensions.

(8) Bulk Metering in the Network

At present there are no flow meters installed in the network of Yangon and therefore there is no reliable information on the production and distribution of water in the system. This is an urgent matter for rectification.

This is the first essential step in a programme of:

- collecting time-dependent data
- improving network management
- initiating UFW control as a prelude to improved network efficiency

Since surface water production accounts for around 90% of the total at a few sites, this will be the priority. Second to that set of meters is consideration of meter installation at boreholes, especially those connected to the network. This activity may be modified in the light of any overall strategy to increase, maintain or reduce the use of groundwater abstraction.

Clearly, any new sources developed, whether surface water or ground water must include provision of metering. The same applies to any bulk transfer that may be initiated (e.g. sale of piped water to another water supply utility).

Once there are separate districts or zones, the next step is to check the measurement of flows to each district or zone in order to locate probable problem areas.

Most bulk metering will be part of new works programme eventually. However, given the importance of obtaining production and distribution flow data it is necessary to have an "interim" phase of bulk metering (excluding pilot zones, WSA & DMA which will be adapted to suit and not defined at this stage)

This Interim phase is based on present situation and defines the requirement for installation of meters on the existing network and is not affected by the new works programme.

Bulk Metering 1st Stage

Production Metering

Permanent production metering is essential for the system. An immediate action in stage 1 will be to ensure that meters are installed at principal production sites. The measures chosen may be stop-gap in cases where the general improvement plan includes new or refurbished production facilities that will include permanent metering in the design. For example, as just cited above, "permanently" installed probe meters could be applied for a limited period.

Bulk Metering in Network

It is also urgent to install additional meters as necessary at pump stations, service reservoirs (inlets and outlets), and any other key points.

Site selection for meter installation must respect the requirements for good, accurate data and for good network operation, including :

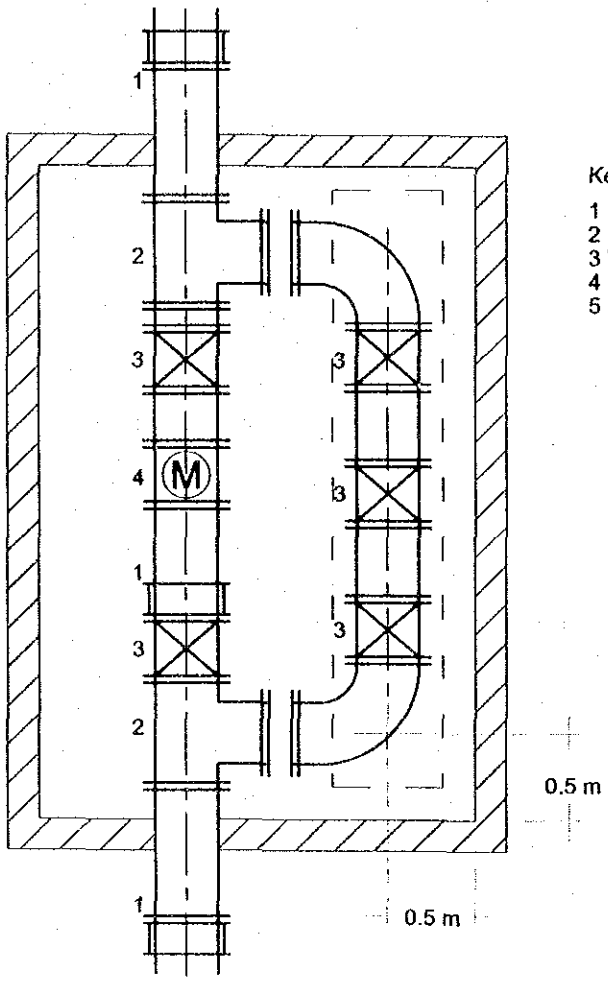
- Straight lengths of pipe for over 5 diameters upstream and 3 diameters downstream and preferably 10 upstream and 5 downstream
- Valved up and down stream for maintenance (not insertion probe flowmeters)
- Bypass installed (not insertion probe flowmeters)
- Flow data loggers fitted to meter

A diagram of the typical requirements for meter installation are shown in Figure 3.5.11

The existing network has been assessed and the following table defines a preliminary list of sites where a flow meter is to be installed during stage 1, with an indication of the size and type of meter that is likely to be selected.. The list should be reviewed and modified at the time of ordering according to updated information.

The following general considerations have been used in selection of type of meter :

- Service reservoirs are to remain in service so permanent large bore meters are to be fitted
- Off-takes are not sure maybe permanent, maybe long-term insertion probe meters
- Hlawga pump stations will be superseded when the treatment plant is built and need to operate without interruption so electromagnetic insertion probe meters installed under-pressure will be used. Once the pump station is removed from service the meters can be redeployed.



Key :

1 Flanged Adapter
2 Flanged Tee
3 Valve
4 Meter
5 Flanged Elbow

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.5.11
	Typical Network Metering Point	

Table 3.5.4 List of Key Points for Production Meter Installation

Ite Location	Pipe Diameter		Meter type	Remarks
	(mm)	(inch)		
Production Meters				
Hlawga No 1 pump station	1600	66	Insertion probe	
Hlawga No 2 pump station	1000	42	Insertion probe	
Gyobyu 56 inch pipeline north of city			Insertion probe	
Service Reservoir Sites (all inlets and outlets)				
Kokine SR				
Inlet		56	Electromagnetic	
Outlet 1		42	Electromagnetic	
Outlet 2		42		
Outlet 3		42		
Shwedagon SR				
Inlet		42	Electromagnetic	
Outlet 1		27	Electromagnetic or large helix meter	
Outlet 2		27		
Outlet 3		27		
Pump Stations				
Yegu P/S				
Inlet 1		42	Insertion Probe	
Inlet 2		56	Insertion probe	
Outlet		42	Insertion probe	
Other key points				
Thamein Jcn off-take from 66 inch		27	Large helix meter	
Ngamoyeik off-take at New Gwe		36	Insertion probe	

The water supply system is planned to be divided into 11 supply zones, centred on new service reservoirs. Supply zone metering will be installed on the inlets and outlets of the service reservoirs as part of the design and construction of these facilities.

Bulk Metering 2nd Stage

Once the high level metering has been completed on production main supply points, the second stage of bulk metering is to increase the number of bulk meters in the system, giving more information on distribution flows. This is closely linked with network sectorisation, *with each sector being metered.*

District or zone metering in Network

The process of meter selection, installation and data acquisition is the same as previously described for larger meters. Additional tasks will consist of identifying suitable areas and taking the necessary steps to ensure that each area is independent and isolated from the rest of the system except via the meter(s). Refer to network sectorisation.

A flanged, helix-type meter of the same diameter as the pipe is to be fitted on a straight section of pipe near the well-head; with 5 diameters upstream and 3 diameters downstream of straight pipe.

As described in the network sectorisation section above, the average size of sub-divisions are:
- Water Supply Zones approx. 1 per 10,000 connections
- Districts Meter Areas approx. 1 per 2 or 3000 connections
- Or 1 per 30 km of network (when secondary mains fully developed)

Most bulk meter installation for these sub-zones and district meter areas will be included in the new works programme as an integral part of the network design.

Additional bulk metering installation to be carried out under the UFW control programme will be comprised of:
- Sectorisation in areas where rehabilitation will not be carried out or will occur late in the programme
- Pilot areas to be adopted as DMA's, in which case the temporary measuring point will b e adapted to a permanent meter installation.

An initial estimate for this category gives a rate of :
- 10 DMA's per year for stage 1
- 15 DMA's per year for stage 2

More detailed estimates and plans will be made the coverage of the new works programme is further developed.

Monitoring

The purpose of bulk metering is to collect data on flow patterns, therefore as soon as any bulk meter has been installed and commissioned, flow measurement and monitoring is to begin.

The UFW control unit will be responsible for monitoring and analysing the data collected. The meters should be read regularly for total integrated flow data. The application of data loggers will enable flow patterns and minimum night flow data to be evaluated.

(9) Tubewell Metering (Groundwater Production)

This is an aspect of production metering to quantify the volumes of water put into supply. Since groundwater is only about 10% of the total, measurement is less important than for surface water production.

Nonetheless, all tube wells, particularly those connected to the central network should be metered. A programme of procurement and installation is to be implemented.

A flanged, helix-type meter of the same diameter as the pipe is to be fitted on a straight section of pipe near the well-head; with 5 diameters upstream and 3 diameters downstream of straight pipe.

A non-return valve is to be fitted if not already installed & working to prevent backflow and false readings.

If a borehole is taken out of service the meter is recycled via the repair shop as a large consumer meter.

Fitting of a meter is to be included in the design of all new tube wells.

Estimates

Quantity: About 100 total for existing tubewells, depending on programme of abandonment
Range of sizes 2 inch to 8 inch

(10) Customer Metering

Customer metering has first to be decided and confirmed at a policy level. For the master plan, universal metering is taken as a given policy. However, this will take time & money to achieve, so a commitment is required. This has been discussed earlier.

For this section the policy work is assumed to have been dealt with and consideration is given to the necessary planning required to achieve the objective of full metering within as short a timescale as possible and in the context of the water supply improvement programme.
For estimating, it has been decided that the target is to achieve a very high level of metering in Phase 1 for that part of the service area that is planned for major network rehabilitation & improvement during the same period.

In other words, meters will be installed in those areas where the network has been rehabilitated up to 2010 and metering of the other parts of the network will be completed over the second phase of the plan following the expansion and reinforcement of the network .

This means that the whole planned programme for installation is to be finished in 14 years after which installation continues at the rate required to deal with new connections. The assumption is to be based on the following:

- Metering is linked with rehabilitation works and the installation of the new or replacement service line.
- All activity of the metering programme is concentrated on these areas

- Metering teams follow directly behind the pipelaying and connections work, to make one series of work in a given area, with no later, repeat disruptions to those customers
- The great majority of connections are in the service area to be rehabilitated during Phase 1.

Estimates

Based on the above plan, it is necessary to estimate the quantities. The present situation is:

- 112,000 connections
- 23% metered (77% unmetered)

Table 3.5.5 Proportion of Connections by Zone for Rehabilitation

Block Name	Zone No	Service Reservoir	Population Served		Connections	Percentage of Total
		Year	2020		2020	2020
					6 pers/conn	
PHASE 1			***3356165***		***559360***	***78%***
Central	1	Exists	1074279		179046	25%
Central	2	2005	832363		138727	19%
Central	3	2005	680016		113336	16%
Central	4	2010	705303		117550	16%
Central	5	2010	64204		10700	1%
PHASE 2			**956177**		**1593628**	**22%**
East	6	2010	363526		60587	8%
East	7	2010	161441		26906	4%
East	8	2016	150671		25111	3%
West	9,10,11		280539		46756	7%

According to the facilities plan for new works in phase 1, the network will be rehabilitated in the zones 1 to 5 mainly. The following table gives the estimates of the number of connections for each zone, based on the respective projected populations.

Using these figures and applying some other assumptions & criteria, estimates are made of the scale of an annual installation programme for customer meters.

Given the low percentage of existing connections with meters, plus the age and condition of many of those meters, the installation programme will take no account of the existing units, which will all be renewed in the programme areas.

It is assumed also that all existing connections will be renewed as part of the rehabilitation programme, so all meter installation work is on new service lines.

The plan to achieve a high level of metering, so that customers pay for what they actually use, requires that a very large number of meters be installed each year. To undertake a programme

of this magnitude from the present low base rate, a preparation and planning period will be required. It is proposed that an initial 6 month period be used for this purpose.

After the preparation stage, the work starts at a slower rate and then builds up to a consistent annual level in Phase 1 and then continuing at a lower rate in Phase 2; once most customers are metered

Planning & Preparation		2003 (second half)
Build up phase		2004 & 2005
Phase 1	78,000 per year	2006 – 2010
Phase 2	26, 000 per year	2011 - 2020

This will achieve 94% metered customers by 2010, following the principles outlined above.

The cost estimates include paying a higher price of $20 per meter than at present ($10 per meter), so that it will last for 7 years without excessive loss of accuracy, after which it will be replaced and tested.

Eventually, about 104,000 meters will need to be replaced each year by 2020.

For the installation programme, a Meter section will be set up to supervise and support the installation and replacement teams for:

- planning
- control & monitoring
- supervision
- procurement

Details of the staffing, costs and phasing of the metering programme are given in the respective sections on staffing and costs. (Section 3.7and 3.8)

Meter Installation Design

Meter specifications and standard installation arrangements will need to be prepared in detail to take account of the range of conditions that will be met. (Figure 3.5.12)

Given the operating conditions in Yangon, each meter shall be fitted with

- Valve for isolation
- Filter for protection against sediment
- Protective cover or box to avoid damage

A range of fittings and covers will be designed to deal with different installation conditions ; mainly :

- Underground meters on buried service pipes (maybe outside property boundary)
- Above ground in private compound
- Inside building or apartment block

Meter specification should be to ISO 4064 Class C, or equal and take account of installation conditions (horizontal, vertical, inclined). Typical installation is shown in Figure 3.5.12

Replacement & Testing

Over time meters lose accuracy and the volumes measured become increasingly less reliable. As a result, international practice is to replace all small meters every 5 to 10 years.

For Yangon, it has been assumed that the interval will be 7 years, as a compromise between high replacement costs and meter deterioration caused by operating conditions, especially sediment in the water supply.

For this reason, the plan for installation has been phased to fit with this cycle period of 7 years. At the end of this period, YCDC staff will continue their work of fitting meters, but now replacement instead of new work.

Once the records show that a meter is 7 years old, a new meter will be fitted in its place and the old unit will be returned to the meter repair workshop for checking & testing. If the calibration check is OK then the meter can be re-used, otherwise it is thrown away.

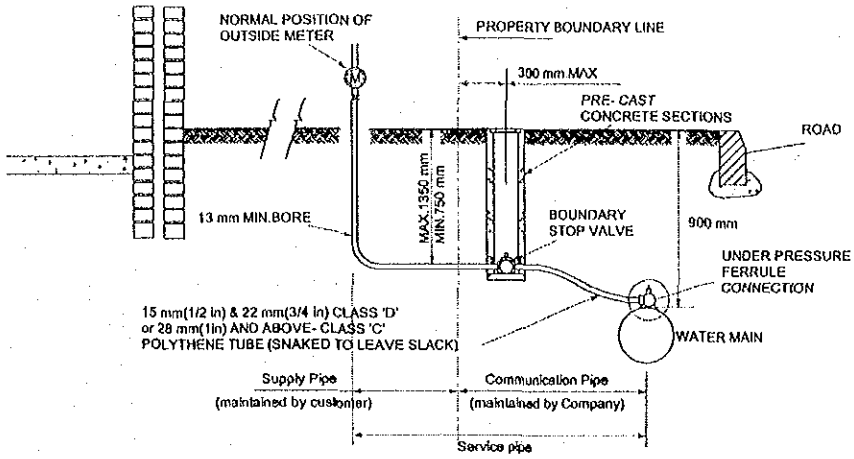
(11) Non-Domestic Consumers

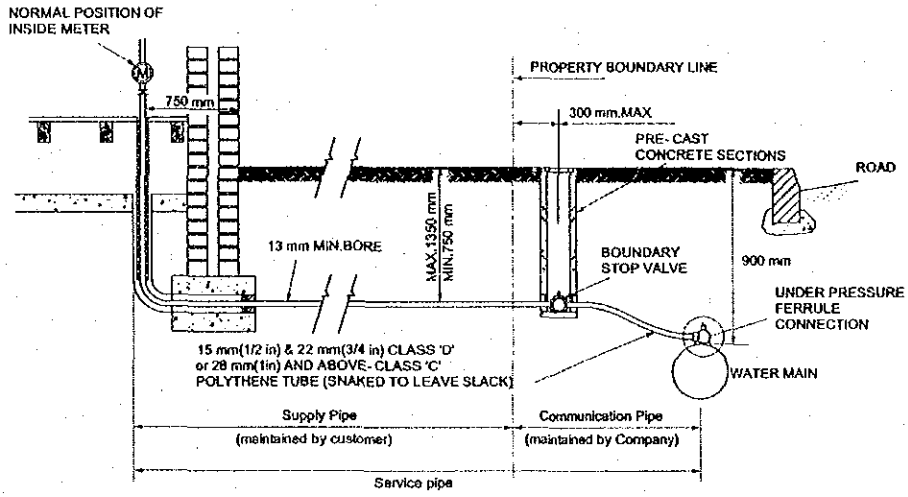
At present, YCDC does not meter all non-domestic consumers. This should be rectified in as timely a manner as possible. As a first step, a combination of records and field survey will identify all non-domestic consumers and assess their water requirements. This includes not only commercial and industrial, but also governmental, municipal and "free supply" connections. The results of this investigation will be compiled into a database for non-domestic consumers, which should then be kept up-to-date.

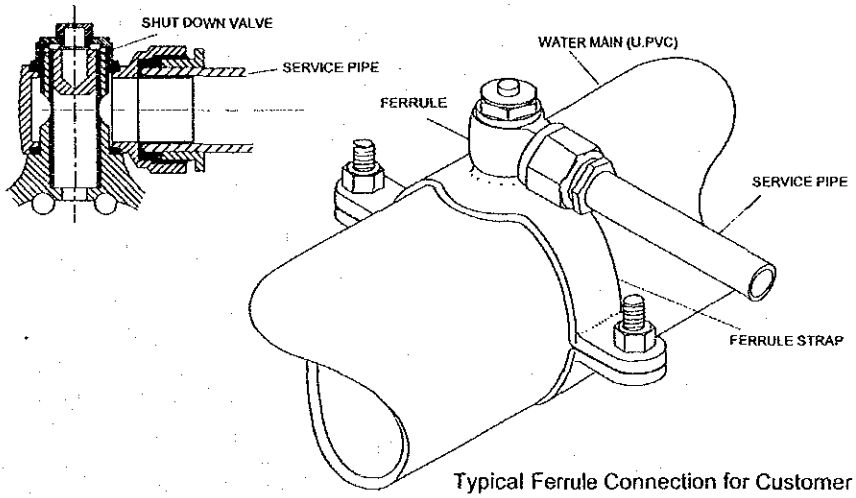
For all those identified as not having meters, the latter are to be selected, ordered and installed. For those already fitted with meters, checks are required to ensure the correct size, proper operation and calibration of the units. Replacements to be made where necessary.

Procedures for regular reading, recording and monitoring of all non-domestic consumers will be set up and maintained. This information will be used for:

- Assessing changes in consumption patterns
- Providing data for UFW calculations so that the non-domestic component is properly known.







Typical Ferrule Connection for Customer Service Line

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.5.12
	Typical Domestic Meter Installation	

Insert domestic meter installation layout
The UFW team will have responsibility for the investigation phase of this task, but it will later be handed off to another department for routine aspects (e.g. accounts or customer services department)

The present number of non-domestic consumers from YCDC data is around 7700 out of a total of approximately 112,000. This figure will be modified and updated from the information collected during the connections review and more importantly the full network and customer survey.

The large majority of non-domestic connections will be small businesses and industries that will have the same requirements for connections as domestic consumers. These can be included in the main small meter installation programme.

(12) Large Users (consumers)

From the existing list of non-domestic consumers, a category of "large users" is to be defined, possibly the top 100 to 200 customers in terms of water use. This group is to receive special attention, since a relatively few users will take an appreciable percentage of total consumption.

So this group should be given priority for installation of suitably sized water meters, in the very early stages of the project. Figure 3.5.13 shows a typical large meter installation.

Out of the non-domestic category, concentrate first on these large meters and institute a program of (a) more frequent reading according to size; (b) regular (at least annual) testing on-site or replacement; and (c) critical examination of records and follow-up. Consider monthly reading and annual in situ testing of meters 3 inches in diameter and over.

In addition to site-testing, calibration checks on the test bench every two or three years should be implemented in the longer term.

All connections in this group are to be metered in the first two years of the project and then replaced on a 5 year cycle.

For this category, it is worth investing in good quality, accurate meters to ensure that the revenue is maximised. They should be selected & size on a case by case basis before order – not as a stock item generally, though initially a small stock of most common sizes will help to accelerate the metering programme (and hence revenue collection)

Meter specification should be to ISO 4064 Class C, or equal and take account of installation conditions. These meters should have exchangeable registers to reduce replacement & repair costs. Range is probably 50 & 80 to 150 mm.

(13) Meter Testing & Repair

In association with this metering programme, meter test and repair workshops are required. Meter testing and repair will be associated with the replacement programme, with each meter being checked after 7 years service. Therefore, initially, during the installation programme the need for workshops will be less.

In phase 1, to take care of damaged and broken meters, it will be necessary to set up 1 meter repair workshop each for:

- Large meters
- Domestic meters (less than 25 mm)

Any broken, problem or suspect meters will be replaced and taken to the workshop for

- Cleaning
- Checking
- Minor repairs
- Calibration tests.

Of these the most important is calibration checks. If a meter passes the test it can be re-used otherwise it is to be disposed of. Re-using inaccurate metes is not permitted.

Each small meter workshop will have two meter test benches for calibration checks, which will be carried out at – high, normal, low flow rates.

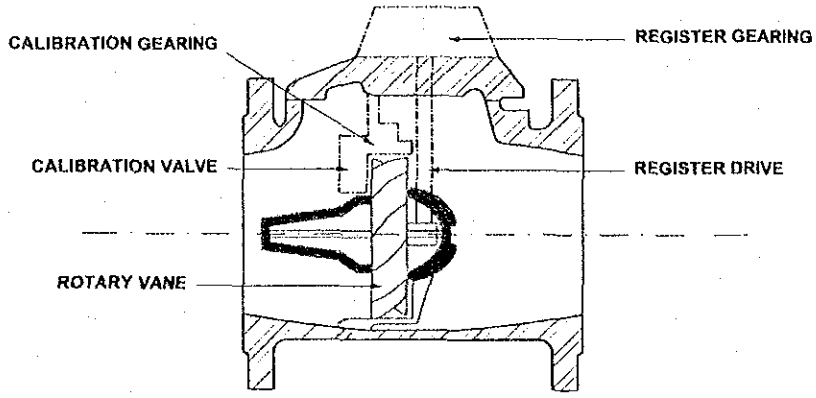
In the future, the workshop facilities will need to be increased to deal with meter testing as part of the replacement programme. After 7 years, all meters are to be tested for accuracy.

Establish a program for regular meter changing and testing. Commence colour coding or similar identification method. The replacement period can be modified according to network conditions

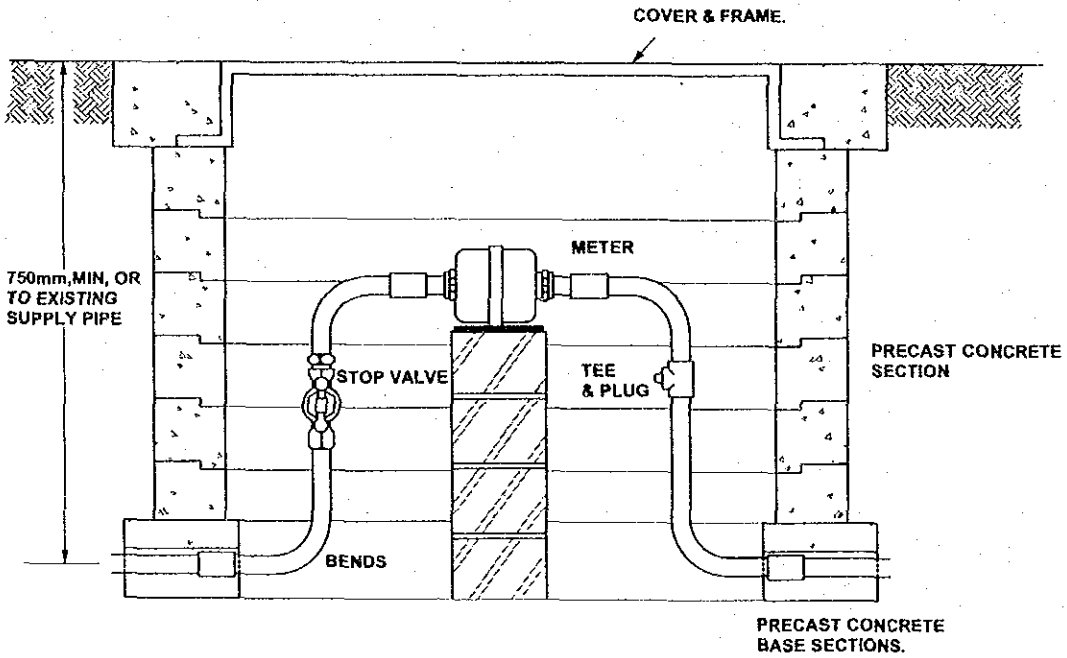
Estimates

Ultimately, the workshops will be checking around 104,000 replacement meters per year at the end of the Master Plan period in 2020. To do this, there will be a total of 7 workshops spread around the zones they serve.

In phase 2, this number of meter workshops will be increased to 4 in 2011 and further increase to 7 by 2020; each of the same size and capacity.



ROTARY VALVE (WOLTMAN) METER



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.5.13
	Typical Large User Meter Installation	

There is also a requirement for 1 workshop for large meters. This will initially be incorporated with the small meter workshop in phase 1 with a dedicated test bench for large meters.

For Stage 1, the functions of the large & small meter workshops can be combined in one.

(14) Customer Database for UFW Control

Once the field consumer survey is complete, the emphasis changes to the customer management. The purpose is to maintain the records and data relating to customers in good order and up-to-date, in much the same way as for the network.

The improvement of customer management includes:

- the keeping up to date of the customer files
- the correction of technical anomalies
- the correction of administrative anomalies
- internal organisation of customer management and the need to expand

Keeping up to Date of Customer Files

Permanent keeping up to date the customer files is important to quickly detect and correct technical or administrative anomalies, and hence to reduce losses and improve the service to the customer.

Correction of Technical Anomalies

The technical anomalies which can be detected during the consumer survey or meter reading and checking or leak detection activities include:

- leaking connections (upstream of the meter), when visible
- leaking connections (downstream of the meter), when visible
- clogged service connection
- damaged service connection
- inaccessible meters - these meters are either buried or the utility staff cannot enter the property for some reason.
- illegal connection, including any case where water is taken upstream of water meters

Correction of Administrative Anomalies

The administrative anomalies can be:

- under-estimated flat rate consumption on un-metered consumer connections.
- non metered legal free supply
- wrong tariff category applied.

1) Under-estimated Flat Rate Consumption

If a tariff structure is applied that assesses consumption according to some set of criteria, such as number of inhabitants, plumbing installation, etc then this must be checked periodically and updated as appropriate.

2) Legal Free Supply

These can be service water use for public garden watering, street washing, fire hydrants or special consumers. These service connections, even if not billed should be equipped with meters in order that their consumption is Accounted-For.

3) Inappropriate Tariff Categories

The YCDC applies different tariff code, according to various category of customer: domestic, commercial, industry, etc

When updating consumer files the necessary consumer type and category must be checked.

(15) Control Room

It is recommended that a control room be set up, to serve as a single, central point of contact for customers and staff in dealing with network problems and operations. This is a 24 hour operation and will require shift staffing. The staff requirements are discussed in section 3.7

3.5.5 Selection of Work Areas for UFW Control Work

The various tasks to be undertaken for UFW control described above are generally applicable and will continue to be valid as the network is rehabilitated and the service improved. For the first stages of the project, it is necessary to identify and select the areas where the work will be started.

(1) Rehabilitation and New Works Programme

For Leak detection, work planning principles include the following factors:

- Cannot work in an area of the network where rehabilitation or new construction is going on – must wait till the network is back in a 'normal' state and all boundary valves have been reinstated.
- Limited benefit of major leak detection & repair if the area is soon to be rehabilitated
- Limited benefit of monitoring for UFW by installing network meters & setting up DMA's if the area is soon to be rehabilitated, when this work can be part of the construction

(2) UFW control fieldwork

Leakage control work is most effective where these conditions are met:

- Known network with up-to-date maps
- Adequate contact points for leak detection
- Good pressure especially at night (not isolated by valve operations)
- Continuous supply (or at least night time)

Using information from the pressure survey done as part of the study, a table of townships ranked according to supply and pressure and giving the rehabilitation priority is given in Table 3.5.6. This survey was not comprehensive and served as illustrative only. Further pressure data may well alter the ranking.

Table 3.5.6 Ranking of Townships by Supply, Pressure with Priority for Rehabilitation

Zone No	T/S No	Township Name	Rehabilitation Priority	Service Ratio	Supply Duration	Pressure Level	Combined service
				%	hrs	metres	m x hr
2	33	Yankin	Not included	100%	24	1.0	24
3	11	Hlaing	Not included	56%	24	1.0	24
3	13	Insein	Not included	56%	24	1.0	24
3	19	Mayangone	Not included	100%	24	1.0	24
5	20	Mingalardon	Not included	56%	24	1.0	24
1	30	Tamwe	1st	100%	24	0.7	17
1	2	Bahan	2nd	100%	15	1.0	15
1	21	Mingalartaungnyunt	2nd	100%	24	0.5	12
3	22	North Okkalapa	Not included	100%	24	0.5	12
1	3	Botataung	1st	100%	24	0.1	2
1	4	Dagon	2nd	100%	8	0.2	2
1	1	Ahlone	1st	100%	10	0.0	0
1	14	Kamayut	Not included	100%	12	0.0	0
1	15	Kyauktada	1st	100%	24	0.0	0
1	16	Kyeemyindaing	1st	90%	6	0.0	0
1	17	Lanmadaw	1st	100%	24	0.0	0
1	18	Latha	1st	100%	24	0.0	0
1	23	Pabedan	1st	100%	24	0.0	0
1	24	Pazundaung	1st	100%	24	0.0	0
1	25	Sanchaung	2nd	100%	5	0.0	0
2	29	South Okkalapa	Not included	100%	24	0.0	0
2	32	Thingangyun	Not included	100%	24	0.0	0
4	28	Shwepyitha	Not included	33%	4		0
6	10	Dawbon	Not included	56%	24	0.0	0
6	31	Thaketa	Not included	56%	24	0.0	0
7	7	Dagon Myothit Seikkan		33%	0		0
7	8	Dagon Myothit South		43%	0		0
8	5	Dagon Myothit East		33%	0		0
8	6	Dagon Myothit North		43%	0		0
9	9	Dala		48%	6		0
10	27	Seikkyi Kanaungto		33%	0		0
11	12	Hlaingthaya		33%	4		0

From consideration of these factors and in view of the planned construction works, a number of townships have been identified as available for early work on UFW control. These are given in table 3.5.7. Townships with no rehabilitation planned have a high priority, but those where this construction work will not begin until late in phase 1 are also included.

Table 3.5.7 Townships Defined as Available for UFW Control Work in Stage 1

Existing Service Area Townships with No rehabilitation work planned	Supply & Pressure	Second Level of Priority for rehabilitation work	Supply & Pressure
Mayangone	X	Bahan	X
Insein	X	Dagon	X
Kamayut		Yankin	X
South Okkalapa	X		
Thingangyun			
Mingaladon	X		
North Okkalapa	X		

Those townships marked with an X for supply & pressure are expected to be the best choices for UFW control work. The final selection of sites, which will not necessarily be complete townships, will be decided when the work actually starts, based on information from the pressure survey and study of updated maps of the network.

3.6 ACTION PLAN RESOURCE INPUTS

As has been described previously, UFW control is a relatively simple and straightforward function, but one that involves a lot of work and the application of a range of techniques, especially for collecting information and doing investigation work.

There are a number of tasks that YCDC can already undertake without any particular need for equipment, materials and technical assistance. These activities would nonetheless benefit from various inputs and in addition there is a further set of actions required that will require external inputs.

The actual work of UFW control in accounting for water used and in finding leaks, requires relatively low investments in materials and equipment. A lot can be done with a few simple tools.

The biggest costs are for materials and equipment needed for the network repairs and for the customer meters to be installed to achieve universal metering. These items are detailed in the costs section.

For UFW control work in Yangon and to achieve the objectives set, the biggest element will be technical assistance and training in the first few years to develop the capacity of YCDC to the point where they can be self-sufficient.
The following table 3.6.1 summarises the requirements for each of the tasks defined for stage 1, in terms of equipment, training and technical assistance. Supporting detail is presented in the following sections for each category.

3.6.1 YCDC Capacity & Capability

(1) Context

This plan for UFW control has been prepared to deal with the problems and set a programme to achieve the required objectives.

It must also take into account the starting point and the present actions and capacity to implement the necessary measures, in order to determine the extent of additional and external inputs that will be wanted to make the plan work.

To recap, the present situation:

- YCDC has no ongoing UFW control activities
- UFW levels are very high and represent a big problem
- UFW is not regarded as a priority issue by senior management

(2) UFW Control

UFW control is:

- a long term activity & solution
- does not necessarily require large amounts of equipment & material
- largely an attitude of mind and approach to network operations
- an activity where a lot can be done by procedural means

(3) YCDC Capacity

First & foremost, the capacity required is the determination to tackle the problem.

One part of the plan has been deliberately grouped as a series of measures that YCDC can undertake with no extra resources. This group of preliminary activities (2b) can be started immediately by the existing organisation.

These tasks could still benefit from or be capable of better results with some additional resources such as repair materials, training & technical assistance.

With the present capacity, it would also be feasible to get a lot of benefit from implementing procedures for data collection, record-keeping and analysis.

So there is quite a lot that could be done with present resources. Nonetheless, UFW is a major problem and it will not be possible to get it fully under control without the application of additional resources and external assistance in some form.

These inputs comprise elements of:

- Tools & equipment
- Training
- Technical assistance

Table 3.6.1: Resource Input summary

Group	Task	Activity Description	Equipment & Materials	Specialist Training	Recommended Technical Assistance
	UFW Control Policy	Decide UfW is serious problem & will be tackled	none	none	Water supply Management & UfW Control assistance to top management
1) Policy					
	Standards & Byelaws	Prepare specifications for minimum standards of materials and installation & repair of service lines	none	none	Water supply Management, Byelaw & regulation advice to top management & government
	Customer Metering	Decide to actively implement Customer metering	none	none	Planning & technical advice
	Tariff Structure	Review & revise tariff structure	none		Tariff structure & policy advice
2) Preliminary					
2a) PreCursor for Other Operations					
	Network & Customer Survey	Detailed Complete survey of entire system to obtain accurate, up-to -date data on network & connections co-ordinate with Urban planning to use common GIS platform and share data	Pipe Tracing & Survey Tools, Vehicles, Mapping equipment (Computer/plotter etc)	Investigative methods & use of survey equipment; records & mapping, Streetworks	Set up YCDC programme or Contract to achieve survey completion in 18 month (6 prepare & train, 12 survey)
	Large User Monitoring	Identify, meter & monitor large users	Large meters (site specific selection), general pipe tools, vehicle	Meter sizing & selection, installation & use of meters, loggers etc, data analysis	On the job training & management assistance for set up & maintain large user monitoring
2b) Part measures possible with existing capacity					
	Improve Network Data	Update & improve the maps etc. as much as possible to give accurate information co-ordinate with Urban planning to use common GIS platform and share data	drawing supplies / computer etc	general network mapping standards If use GIS system then training in use of GIS	On the job training & management assistance for collecting, collating & updating the network data Procurement, introduction, set up & operation of a GIS system for YCDC
	Connections review	Check, update & record all connections	none	general survey & record-keeping procedures, streetworks	On the job training & management assistance for collecting, collating & updating the network data
	Pressure Measurement	Campaign of pressure measurement around network using pressure loggers for 24 hr profiles plus spot readings with gauges	pressure gauges & loggers	use of pressure gauges & loggers (inc data analysis), streetworks	On the job training and assistance for planning of work and analysis of results
	Trunk Mains Survey	Trunk mains inspection including: thorough inspection recording of all connections, fittings etc on network maps Removal of refuse tips at pipe overbridges etc. causing pipe corrosion Rationalisation & control of all connections made to trunk mains	none none none pipe fittings, valves, general pipe tools etc.	none none none none	
	Visible Leak location	Actively locate & report all visible leaks on distribution mains and service lines	none	Good working practice	
	Leak Repairs	Timely & effective repair of ALL leaks located on network from leak detection above	Repair materials, repair tools & equipment, transport	Pipe repair methods- principles & modern practice, use of repair tools & equipment, fitting of pipe repair materials	On the job training & management assistance for set up & maintain effective repair methods
	Service Reservoir Leakage Inspection	Inspect & Drop test Service reservoirs to check that there is no excessivewater loss	none	Drop testing technique	

Table 3.6.1: Resource Input summary

Group	Task	Activity Description	Equipment & Materials	Specialist Training	*Recommended Technical Assistance*
3) Preventative					
	Planning & Design	Plan & Design Network construction works	none	Water supply engineering training - *principles* & practice	Formal training courses for selected staff, on the job training & management assistance for planning & design
	Design Criteria & spec	Develop & prepare specifications for design, supply, materials & installation of pipework, services & fittings	none	Water supply engineering training - principles & practice	Formal training courses for selected staff, on the job training & management assistance for specifications
4) Practice (O&M)					
4a) UfW Reduction					
	UCU Setup	Create specialist unit for UfW Control to: implement plan advise co-ordinate	Engineering office equipment (computers, printers & general equipment)	Leakage management, streetworks	Formal training for selected staff, on the job training & technical assistance for UCU
	UC U Operations	Operate & maintain the UCU to tackle UfW	Specialist UfW control equipment (loggers etc), vehicles, general network tools	Leakage management, streetworks	Technical assistance to develop capacity & techniques until UCU is self-sustaining
	Leak Detection by Routine sounding	Divide network into nightly routes and send teams on routine basis	Specialist leak detection equipment, tools, vehicles, general network tools & equipment	Leakage detection & location , use of *specialist leakage detection tools* & equipment, streetworks	On the job training & management assistance for leak detection activities
	Leak Repairs	Strengthen & Improve repair organisation to ensure proper and timely repairs	Repair materials, repair tools & equipment, transport	Pipe repair methods- principles & modern practice, use of repair tools & equipment, fitting of pipe repair materials, stock control	On the job training & management assistance for set up & maintain effective repair methods, specification & procurement of tools & materials
	Measurement campaign (aquaprobe)	Carry out measurement campaign to identify probable high leakage areas - temporary action until district metering established	Flow meters for temporary installation (insertion probe, strap-on), flow & pressure loggers, general network tools, valves & fittings	Mapping & network sectorisation, Leakage measurement techniques, use of specialist flow measurement equipment, use of loggers, general network practice, streetworks	On the job training & management assistance for leak measurement & detection activities
	Pilot areas setup	Start range of UfW activities in Pilot area(s) to be set up with sectorisation & metering	Valves & fittings, permanent flow meters	Mapping & network sectorisation, Leakage measurement techniques, selection & sizing of flow meters, use of loggers, general network practice, streetworks	On the job training & management assistance for range of leak management activities to be applied & learnt on pilot areas before general application
	NPL monitoring & control		none	NPL monitoring & control	NPL monitoring & control
4b) UfW Monitoring					
	Network Sectorisation	Divide network into zones & districts over time with metering of each discrete section	Valves & fittings etc for boundary valves; network tools & equipment	Mapping & network sectorisation, selection & sizing of flow meters, use of loggers, general network practice, streetworks	On the job training & management assistance for network monitoring & control
	Bulk Metering 1	Install flow meters at existing key points: Pump stations, service reservoirs etc.	Meters for very large diameter pipes, pipework & fittings for installation	Selection & sizing of flow meters (very large), use of loggers, general pipework installation techniques	On the job training & management assistance for network monitoring & control
	Bulk Metering 2	Install more flow meters as network is divided up into zones & districts	Meters for large diameter pipes, pipework & fittings for installation	Selection & sizing of flow meters, use of loggers, general pipework installation techniques	On the job training & management assistance for network monitoring & control

Table 3.6.1: Resource Input summary

Group	Task	Activity Description	Equipment & Materials	Specialist Training	Recommended Technical Assistance
	Tubewell metering	Programme of installing flow meters on YCDC tubewells	Meters	Selection & sizing of flow meters, general pipework installation techniques	
	Rehabilitation Areas	Monitoring & control of areas that have been rehabilitated under the new works programme	*Flow & pressure loggers etc; general tools*	District metering techniques & practice	On the job training & management assistance for network monitoring & control
4c) Customer Metering					
	Customer Metering	Plan & implement metering policy (inc replacement) minimum is to accelerate installation with existing capacity	Small domestic meters, associated fittings (valves, strainers, connectors)	Work programme planning, stock control & procurement, record-keeping	On the job training & management assistance for set up & maintain programme of meter installation
	Non-Domestic Consumers	Implement metering for ALL non-domestic consumers	Water meters, associated fittings (valves, strainers, connectors)	Selection & sizing of flow meters, general pipework installation techniques	
	Large Users Monitoring	Identify, meter & monitor large users	Large meters (site specific selection), general pipe tools, vehicle	Meter sizing & selection, installation & use of meters, loggers etc, data analysis	On the job training & management assistance for set up & maintain large user monitoring
	Meter repair & test	Set up workshop(s) for cleaning and calibration checks on customer meters	General small tools & equipment, Calibration test benches	Minor repair techniques, use of calibration test benches, stock control & record keeping, work planning	Training in repair & testing of meters, use of calibration test benches
4d) Other O&M Activities					
	Control Room	Set up & operate central control room for network	Basic control equipment & general office	Control room operations	On the job training & management assistance to set up & operate control room
	District Inspectors	concentrate network operations under responsibility of district inspectors	general network equipment	network operations & practice	On the job training & technical assistance

NOTE: Specialist training is specific to the function only and does not include other functions such as operator training for cranes, backhoes etc..
General training, procedures, good practice apply to all staff and are assumed.
Items in category 2b can be done without any training or technical assistance, though they would benefit from it

3.6.2 Equipment

The equipment and material needed for the various teams and groups that will be carrying out the tasks are given in this section. This is a basic level of equipment to be able to do the work effectively and may be modified and added to with experience.

(1) Network & Customer Survey Equipment

This survey is to be done as quickly as possible at the very beginning of the project. It will be an intensive period of work and to do a thorough job within the time available, the field work staff will need to be properly equipped, in order to investigate and locate the network etc. and to properly record their findings.

The survey teams will be working on the streets every day, locating pipes, valves, connections etc. Each team will need to be very mobile and independent and so must have all the tools to cover the range of tasks they will need to do.

The requirements for Network & Customer survey teams are in 3 groups:

Streetworks

- Vehicles
- streetworks safety gear (cones/barriers etc)

Pipe Survey & Location

- Sounding Bars
- Pipe and Cable tracers (RD400)
- Trumeter measuring wheel
- Pipe tracing equipment with signal generator
- Vibration generator and small air compressor
- Sounding bars and/or ground microphones
- Valve box locators

The special equipment used for network survey is described in table 3.6.2 below

Network Tools

- Hydrant standpipes
- Set of general tools and equipment (hand tools, torch, etc)
- Valve keys, lifting bars etc
- Dewatering pump
- Trowel/spade/scoop etc

One set of the equipment is to be provided for each survey team unit of one network team and one customer team). They will also need to be kept supplied with working copies of maps, customer lists etc. and so the survey section will require a properly equipped office including:

Office Equipment

- Computers for map preparation, data collation and analysis
- Photocopier
- Printer & Plotter
- General office equipment for the staff

After the survey has been completed, the equipment will go to the UCU for use in UFW control.

Table 3.6.2 Specialist Equipment for Pipe & Cable Location

`Flexi Trace'	Enables non-metallic pipework to be located by the insertion of a flexible `wire'. Once inserted in the pipe a signal is induced either at the leading point of the trace wire or throughout its length. This signal can then be traced using a cable avoidance tool.	The trace wire has to be inserted into the bore of the pipe, leading to a possible contamination risk. Hygiene care needs to be taken when using the trace. Trace will not pass sharp bends or Tee's. When obstructions are met the pipe has to be excavated, the pipe cut & trace re-inserted.
Pipe & cable tools	Used for locating cables and locating / avoiding pipework	Not suitable for plastic pipes unless `flexi' trace is used.
Other pipe tracing equipment	A `vibrating' sound can be induced in the pipe to be traced via equipment attached to a hydrant. The pipe is traced by listening on the surface for sound being transmitted down the pipe	Can get complaints about noise in pipes when in use Some argument about possible damage to pipe by vibration

(2) Equipment for Leak detection & Measuring Campaign

The leak detection teams and those involved in the measuring campaign work have many of the same needs as the survey teams and also have to be very mobile.

The following lists summarise the initial general list of equipment needed by the respective teams. This is based on having a fairly modest level of investment and using the simpler special tools. This will be modified with experience to best suit the needs of YCDC.

Streetworks
- Vehicles
- Streetworks safety gear (cones/barriers etc)

Network Tools
- Hydrant caps & hoses
- Valve keys
- Hydrant standpipes
- Set of general tools and equipment (hand tools, torch, etc)
- Valve keys, lifting bars etc
- Dewatering pump
- Trowel/spade/scoop etc

Data Logging & Measurement team only
- Loggers
- Flow
- Pressure
- Pulse heads to suit loggers and meters
- Aquaprobe insertion probe flow meters
- Pressure gauges

Leak Detection teams only
- Correlator
- Ground Microphone
- Electronic Leak detector
- Sounding Bars

Support Equipment (initially with Survey teams)
- Valve box locators
- Trumeter Measuring Wheel
- Pipe and Cable tracers (RD400)

For information, the range of special tools used for leak detection is described briefly in table 3.6.2 below. Further detail is presented in Appendix Q in technical leaflets from representative manufacturers.

One set of the equipment is to be provided for each team, as appropriate. There will initially be:

1 measurement team
2 leak detection teams

The number of leak detection teams will be increased over the project period and each new team will require its own set of equipment.

These field teams will be managed by the UFW Control Unit (UCU), which will therefore require a well-equipped office including:

Office Equipment
- Computers for map preparation, data collation and analysis
- Photocopier
- Printer & Plotter
- General office equipment for the staff

(3) Equipment for repair teams

To be able to carry out effective and timely repairs on the network when leaks are located, the capacity of the existing repair teams will need to be improved. This includes, among other things, making sure the teams are properly equipped and trained and have access to the correct materials for the repair required.

In respect of equipment, the following will be needed:

Repair Equipment

Repair Equipment & Tools for each repair gang
- Pipe tools
- Pipe cutters etc
- Network Tools (2 sets per gang)
- Under pressure tapping machine
- Dewatering Pump
- Pipe Lathe
- Generator with lights
- Power cutter/grinder
- Welding Machine
- Other Equipment

Major Repair Equipment & Tools with 1 set per 4 repair gangs
- Large power cutting equipment
- Large pipe handling winches etc
- Large welding equipment
- Other large equipment
- Large Dewatering pump

There will also be need for heavy plant (digger, crane etc), which will be supplied when necessary from the plant workshop.

Table 3.6.3 Equipment for Leak Detection and Location

Equipment	Comments / Application	Limitations
`Basic' Listening Stick	Rudimentary sounding of Valves (SV's)& hydrants (FH's) etc.	Some smaller leak sounds, may go undetected (good ear required by inspector).
`Electronic' Listening Stick	General sounding of SVs, FHs, etc Few limitations, generally. Useful part of the inspectors `toolkit' Better than `Basic' Stick due to sound amplification	Is sometimes used to confirm `best leak sound' position after correlation Better than `Basic' Stick, not as good as ground microphone
Electronic ground microphone	More sensitive than the electronic stick, powerful, Enough to listen to leak sounds through `made roadways' generally used to confirm `best leak sound' after correlation. Can be used for general sounding with a probe screwed into microphone.	More `cumbersome' to use than listening stick. Some inspectors do not like to use microphones they prefer the electronic stick
Electronic ground microphone with sound frequency filters	As sensitive as the ground microphone with the added advantage of the inspector being able to adjust filters and remove some unwanted sounds. Generally used to confirm `best leak sound' after correlation. Powerful enough to listen to leak sounds through `made roadways'. Can be used for general sounding with a probe screwed into microphone.	More `cumbersome' to use than listening stick Some inspectors do not like to use microphones, they prefer the electronic stick
Acoustic Detection Loggers	`Stores' sounds within the distribution system usually between 02:00 and 04:00. Loggers are set up and. Downloaded using a PC Leak sounds are identified by the `range' of sounds recorded by the logger Useful for areas where normal leak location activities cannot be used	Does not locate actual leak position, can give identification that leak is taking place
Step Test Unit	Mobile Advanced Step Tester (MAST) system. Used for remote monitoring of flows whilst carrying out step tests within distribution networks. Allows almost instant results leading to minimum disruption to customers . Step tests can be carried out quickly rather than waiting for. `office based' analysis using data loggers.	Valve closure required, valve closure may cause discoloration / water quality problems. Difficult to use during day as some disruption of supplies will take place(unless areas are `back fed' when valve closure takes place). Leak location activityneed to be planned to gain best results of step tests

Leak Noise Correlators various	Used for general `surveying' of lengths of main for leak sounds followed by more accurate leak location. Various `models' available from easy to use menu driven machines to PC controlled FFT machines for more `difficult' jobs. Sensitive enough for quiet leak sounds, can survey long lengths of main rather than manual sounding individual valves.	Very accurate when all data inputs can be guaranteed. Limited to the fact that main material, length, velocities can cause errors in calculations if not accurately entered A reasonable level of inspector training, skill of and experience is required The better the information the better the on-site result

As well as tools and equipment, stocks of repair materials will be needed. Experience will show which items, sizes and quantities are actually required by YCDC. As an initial base of materials to make a start and provide some materials, the following set of fittings is proposed:

Table 3.6.4 Basic set of repair material

	Quantity				
Pipe Size	**4 inch**	**6 inch**	**8 inch**	**12 inch**	**18 inch**
Repair Clamp or Collar	10	5	2	1	1
Joint Collar	10	5	2	1	1
V-J Coupling	10	5	2	1	1
Dismantling Joint	10	5	2	1	1
Flange adapter	10	5	2	1	1
length of pipe	10	5	2	1	1

For the first two years it is estimated that 25 to 30 sets of the above set of repair materials need to be supplied. Also a small number of large diameter repair fittings should be ordered.

(4) Network Bulk Metering

The work entailed in bulk metering is described in section 3.5 above and the detail of the requirements for meter types and locations given there. The following is a summary list of material requirements for this task.

Bulk Metering Stage 1 (Production)

For the production meters and key supply points to be fitted with meters immediately, the quantities of meters needed are as follows:

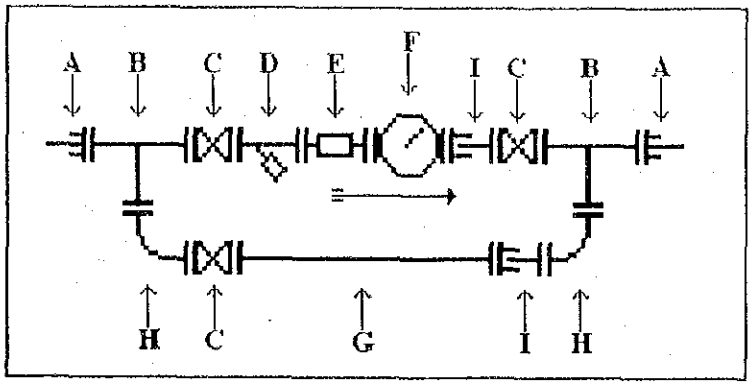
- Electromagnetic Insertion probe Meters 7
- Full bore Electromagnetic or Ultrasonic meters 5
- *Large diameter helix meters* 4

The final meter sizing and selection will be done at the detailed design stage.

Bulk Metering Stage 2 (WSA & DMA)

For stage 1, it is estimated that the requirements for meter installations will be as follows: WSA: 2, DMA: 8

Figure 3.6.1 shows the fitttings and equipment for a typical network meter installation which can be used ot prepare an order list when the pipe and meter sizes have been determined.



Ref	Description	Ref	Description
A	Flanged adaptor : Self Restrained	F	Water Meter
B	All flanged equal tee	G	Welded flanged pipe
C	Gate valve	H	90° double flanged bend
D	Filter	I	Self-restrained dismantling joint
E	Flow straightener	J	Non return valve

Figure 3.6.1 Diagram of Typical Meter Installation and Associated Fittings

3.6.3 *Training*

As far as possible, training should be done in Myanmar and preferably mostly on the job, to be as cost effective as possible. This will be an important function of the Technical Assistance consultants' work. However, some overseas training will be required at the beginning of the project.

The general training requirements for the initial Stage 1 period are summarised in the table 3.6.1 previously. Estimated numbers for particular training are as follows:

Table 3.6.5: Summary of Formal Training Requirements

Topic	Overseas training	Local Training	Remarks
UFW Control	4	4	Includes leak detection
Leak detection		4	
Network Repair	2	4	
Metering		2	Maybe part of supply contract
Meter testing		4	

(1) Training for UFW Control Unit Staff

To start with, about 4 employees should go for a period of up to three months to a developed country where they will be given special training using modern equipment and will work with trained inspectors employed by another water authority.

If two or more employees working in the area of repairs could under go similar training, it will be advantageous as they can learn the standards of workmanship required to ensure the best possible repair under difficult conditions.

Overseas training should provide short, formal courses at specialised training centres that include:

1) Theory of leakage control;
2) Practical experience in the use of a wide variety of equipment
3) Maintenance of and simple repairs to all equipment.

This is followed by a hands-on operational work during the daytime and at night, covering all forms of active control.

The technical assistance consultants should also provide on-the-job training and experience, including pipelines & cable location, flow measurements, tapping mains under pressure, use of insertion flow meters, repairs to pipes and services, flushing mains and sterilisation, testing valves to ensure tight shut-off, the use of portable test equipment and data loggers for flow and pressure, and setting up a district metering system and a waste meter district.

3.6.4 Technical Assistance

To deal with the scope of the work needed to achieve the objectives and the fact that YCDC currently lacks any of the institutional capacity required for UFW Control planning and implementation, a Technical Assistance Programme will be required to support the UCU during its early stages:

This assistance will take the form of a Technical assistance unit (TAU), providing expertise and advice to YCDC in the establishment of an effective permanent organisation in the authority and continuing advice on the detailed solutions of problems encountered during implementation. This TAU may be included with other functions and services such as planning, new works design & institutional reform.

Areas to be covered in the form of technical assistance include:

- General UFW Technical Management Assistance (e.g. Technical Assistance Unit)
- Mapping survey and capture
- DMA design & Implementation

- Design Criteria & Specification
- Meter sizing & selection
- Meter Testing & Calibration
- Metering Policy
- Byelaws & Technical standards Policy & Implementation

YCDC must ensure that staff assigned to the UCU are a sufficient number of suitably motivated, intelligent, and qualified "counterpart" employees to gain the necessary training and experience to take over the operation at the end of the technical assistance.

The initial requirement for Technical Assistance till 2010 is estimated as:

- Intensive Training and Expertise Provision, setting up period	18 month	2003/4
- Continuing support and management advisor role	3 years	2005-7

The Scope of works and person specification for each of the experts is given in Table 3.6.6 below.

Table 3.6.6 Experts Scope of Works

	Specialist Title	Major Tasks	Person Specification	First Mission start	Duration of Input (months)
Long-Term Assistance					
	UfW Team Leader	**Manage & Assist UCU & advise YCDC Management**	**Experienced UfW Control Project Manager**	**2003**	**36**
		Manage & Assist UCU Prepare & agree detailed plans for : Physical loss action programme Non-physical loss programme Advise YCDC on leakage management policy Train & asssist UCU team leader on day-to-day basis Develop reporting & UfW data collection procedures Co-ordinate & liase with other related departments	Experienced in: Leakage Management Overseas Project Work Project management Training & Technical assistance Management Information procedures Co-ordination & liaison Water Supply Company experience		
	Leakage Engineer	**Manage & assist UCU for Leakage Control Work**	**Experienced Leakage Engineer**	**2003**	**24**
		Plan & implement setting up of Pilot areas Organise & manage work in pilot areas Plan implement measurement campaign Organise network modifications & repairs with repair teams Design & test sectorisation of network Train & assist PL engineer of UCU Train & develop capacity of leakage teams	Experienced in: Leak Detection techniques & equipment Leak Localisation (step tests etc.) Network sectorisation Training & technical transfer Overseas work experience Water Supply Company experience		
	NPL Engineer	**Manage & assist UCU for Non-Physical Loss Work**	**Experienced NPL Engineer**	**2003**	**24**
		Plan & implement Non-physical loss investigations Organise & manage the asssociated staff Network metering and analysis of data obtained Cusomer & connections study work Resolution of anomalies resulting from analyses Assist with Customer metering programme	Experienced in: Management of customer connections Network metering Training & technical transfer Overseas work experience Customer metering Water Supply Company experience Meter selection & specification		

Table 3.6.6 Experts Scope of Works

	Specialist Title	Major Tasks	Person Specification	First Mission start	Duration of Input (months)
Short-Term Specialists					
1) Policy					
	Tariff Policy	Prepare draft Tariff structure & recommendations	Expert in Water Supply Tariff structures and implementation measures	2005	3
	Byelaws & Regulation	Prepare draft Byelaws & regulations for enactment	Expert in Byelaws & Regulations & implementation (enforcement, education, awareness)	2004	4
2) Preliminary					
	Network & Customer Survey				
	Office	Plan & Implement Mapping Work from Survey data	Water Supply Network Specialist	2003	18
		Plan & Manage Survey Programme Ensure quality of survey data checking & application Supervise Preparation of Support data for field teams	Experienced in: Water supply network operations Network survey & mapping		
	Field	Plan & Implement Fieldwork for Survey	Pipe Survey Specialist	2003	6
		Plan & manage day-to-day field work Train Survey staff in techniques & equipment Ensure quality of Survey fieldwork results	Experienced in: Water supply network operations Network survey & mapping practice Techniques & Equipment for Survey work Overseas work experience		
3) Preventative					
	Design & Specification Documentation	Prepare draft Tender documents, specifications & design criteria for New Works programme	Contracts & Tender Documents Specialist	2003	8
		Prepare detailed: design criteria for network materials specifications for pipe, fittings etc. tender documents for pipe installation contracts tender documents for pipe supply contracts installation specifications for network material & installation specifications for services	Experienced in: Management of contracts preparation Water Supply Network design & installation Training & technical transfer Overseas work experience Water Supply Company experience Procurement		

Table 3.6.6 Experts Scope of Works

	Specialist Title	Major Tasks	Person Specification	First Mission start	Duration of Input (months)
4) Practice (O&M)					
4a) UfW Reduction		see long term			
4b) UfW Monitoring		see long term			
4c) Customer Metering					
	Metering Programme Planner	**Prepare Detailed Plan for Implementation of Metering**	**Programme Planning Specialist**	2003	4
		Prepare Detailed Plan for Implementation of Metering Draft procurement contracts for material supply Assess capacity of YCDC & support needed for programme Prepare Plan for Meter Test & Repair Define standard installation methods to suit conditions	Experienced in: Water Supply Operations Customer Metering Programme planning Extensive Overseas Experience		
4d) Other O&M Activities					
	Network Repair Engineer	**Train staff and improve repair practices & methods**		2004	6
		Train staff in modern repair techniques Assist & advise Repair Teams Engineer Procurement requirements for repair materials & equipment	Experienced in: Water supply network operations Network Pipe repair practice Techniques & Equipment for Network Repairs work Extensive Overseas Experience		