CHAPTER 6 OPERATION/MAINTENANCE IMPROVEMENT PROGRAMME

6.1 REGULAR OPERATION AND MAINTENANCE WORKS

6.1.1 WATER VOLUME

After the rehabilitation work in the Upper Ruvu treatment plant was completed at the end of 1990, the three treatment plants are producing water at full design capacity. NUWA has and will continue to give considerable attention to production of water. For example, the low-lift pump in the Mtoni was replaced in 1989. The Upper Ruvu system has 100 % standby pumps. In order to keep the plants working properly for longer periods, maintenance of not only the existing equipment but also new equipment is to be improved.

6.1.2 WATER QUALITY

(1) TURBIDITY

The quality of raw water is characterized by high turbidity and iron and manganese content. In the past, removal of turbidity, iron etc. was unsatisfactory due to inadequate injection of aluminum sulfate, resulting in insufficient flocculation. As a result, the treated water had high turbidity and iron. The pH of the treated water was low due to the addition of aluminum sulfate to the high-turbidity raw water. Since the water output fluctuates markedly due to frequent suspension of water supply during power service interruptions, corrosion of the distribution pipes and the consequent release of red water from consumer taps took place. The countermeasures for this are as follows:

(a) By proper use of an alkaline agent, pH of the treated water should be raised to 7.5 - 8.0.
(b) Through injection of optimal coagulation agent, all unwanted components should be eliminated from the treated water by sedimentation and filtration.
(c) The consumption of chlorine in the distribution pipeline network should be minimized. This will come consequent to implementation of (b), and will ensure that the necessary amount of residual chlorine can be kept at the end-use points.

(2) ALKALINITY

The treatment process includes addition of sodium carbonate as a post-filtration chemical agent to reduce the aggressive nature of the filtered water.

Its continued use is vital to (a) avoid deterioration of the mortar lining of the principal high pressure

trunk main, the overall distribution system, and commercial, residential, and industrial appurtenances at user end-points, and (b) to ensure that high quality treated water, expected to be produced at the Lower Ruvu plant, reaches the consumer.

Alkalinity in raw water ranges from 80 to 100 mg/l. Alkalinity is low when turbidity is high and vice versa. This is problematic in coagulation where higher alkalinity would be consumed by high dosing rates of alum, which in turn hinders effective coagulation. Care must be taken, therefore, to control pH, particularly during periods of high turbidity, in order to remove turbidity effectively.

pH values after dosing alum are between 6.6 to 6.8. These values are not necessarily too low to obtain optimum coagulation. Nevertheless, it is advisable to determine the optimum pH for coagulation so that effective coagulation can be obtained during periods of high turbidity.

(3) CHLORINATION

Residual chlorine in the treated water is to be maintained at around 1 mg/l. This is necessary since there are consumers between the plant and the University reservoir. The residence time in the transmission main at an output of 40 mgd is about 11 hours. Hence, it is apparent that further chlorination at the service reservoirs is necessary to ensure the presence of residual chlorine throughout the system.

(4) MTONI OPERATION *

The capacity of the Mtoni plant represents only 3% of the total current water supply. Shortage of raw water during the dry-season, coupled with the poor condition of the facilities will make the contribution from the plant even less significant in the future.

The proposed policy would be to prolong this plant with as minimum rehabilitation work as possible until it is decided whether Mtoni will continue operations in the long-term or is to be abandoned. To this end, the following improvements in the plant operation is proposed (refer also to section 1, Appendix E).

(a) To initiate water quality monitoring
(b) To measure flowrates and dosing rates
(c) To carry out jar test
(d) To monitor and control chemical dosing

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* Details are shown in section 1, Appendix E.

(e) To log records
(f) Purchasing chemicals for analysis

6.1.3 DISTRIBUTION SYSTEM

(1) PIPES AND APPURTENANCES

Since only the general location of pipes/valves are shown on NUWA drawings, the pipe locator proved to be of great value during the study. The valves were then excavated manually. In practice, it was, however, extremely difficult to find valves.

Valve marker posts were missing and valve boxes were completely covered by dirt and refuse. When valve boxes were located in their correct positions it was invariably found that the boxes were filled with dirt, rubbish, stagnant water and, in some instances, even concrete. To gain access to the valves required considerable time and effort in cleaning out the boxes which, in many cases, were several feet deep. It was often found that either the valve or the flanges were heavily leaking, when the valve was opened. Valves that open both in the clockwise and anticlockwise directions were found throughout the system.

(2) PERIODICAL MEASUREMENT OF FLOW AND PRESSURE

There appears to be highly uneven distribution of pressure, unduly high pressures and flows at certain places and very low pressures and flows at other places. In a few areas, water is available for 24 hours a day, while in other areas, water flow is highly intermittent. Since water is scarce and further rehabilitation work will take some time, pressure control or even "time-restricted supply" in the current 24-hours-supply-areas will be an effective measure for achieving equal-supply to all consumers. To enable it to work effectively, field flow and pressure measurements at critical points in the system need to be measured and maintained regularly.

(3) WATER QUALITY MONITORING

Water quality, particularly residual chlorine needs to be monitored regularly to ensure that safe water is being supplied. The responsibility for treated water quality control should be assumed by the treatment plants. Water quality monitoring is better performed by personnel of the distribution section with portable test equipment, who then report to the plants, since the staff of the distribution section will often go out to the sites and they can do the requisite testing with very little loss of time.

6.2 LEAKAGE CONTROL

6.2.1 NECESSITY

The post-rehabilitation output of the plants will not change. However, reliability of the systems, from the point of view of water output, will improve. Since, the absolute output will not increase, there must be an increase in the amount of water available within the water supply system, particularly within the distribution system, through leakage control. If leakage control measures are not undertaken, the leakage level will increase. Assuming that the leakage level increases to 40 % compared to the current 35 %, and consumption increases at 3.5% per year, the water deficit (supply minus demand) will continue to become larger. As shown in Figure 6.1 and Table 6.1, deficit against daily average demand, represented as curve 2 minus curve 4 (while curve 3 minus curve 4 represents that against the daily maximum demand), will equal net supply to the city in the year 2006.

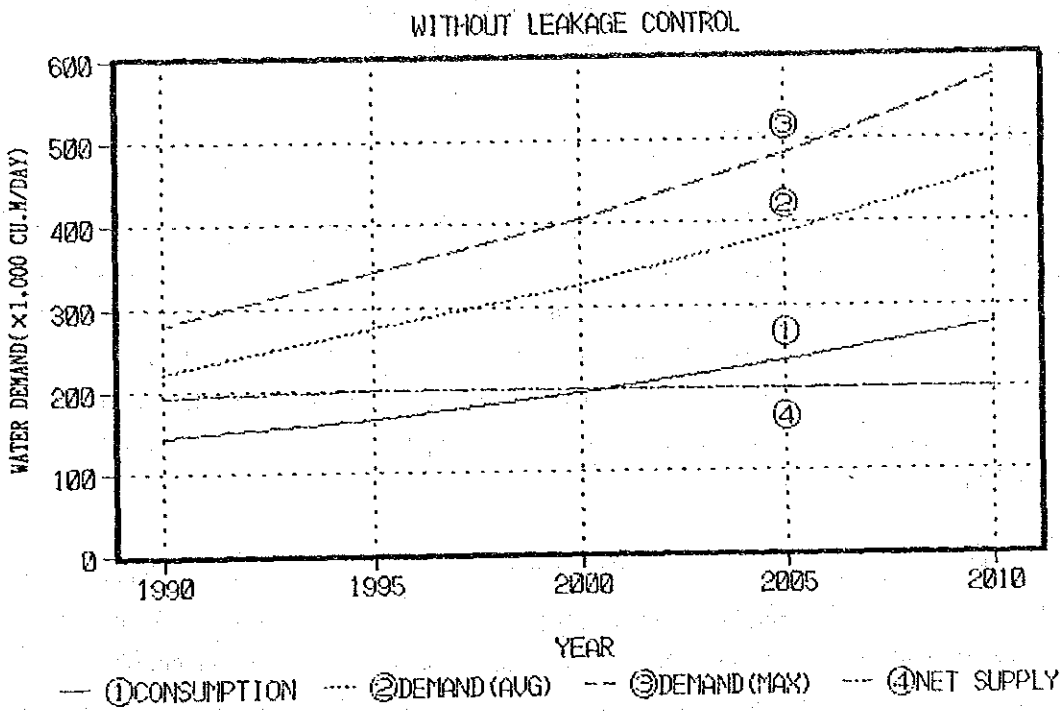
TABLE 6.1 WATER DEMAND & SUPPLY

(Unit : thousand m^3/day)

	1990*1	1995*1	2000	2005	2010
CASE1(WITHOUT LEAKAGE CONTROL)					
CONSUMPTION *2	144	164	195	232	276
(WASTAGE)	(11)	(12)	(20)	(23)	(28)
LEAKAGE	78	109	130	155	184
DEMAND(AVERAGE)	222	273	325	387	460
DEMAND(MAXIMUM)	278	341	406	484	575
NET SUPPLY	193	199	199	199	199
SHORTAGE(AVERAGE)	-29	-74	-126	-188	-261
SHORTAGE(MAXIMUM)	-85	-142	-207	-285	-376
WASTAGE RATIO	5%	6%	6%	6%	6%
LEAKAGE RATIO	35%	40%	40%	40%	40%
CASE2(WITH LEAKAGE CONTROL)					
CONSUMPTION *2	144	152	175	209	248
(WASTAGE)	(11)	(0)	(0)	(0)	(0)
LEAKAGE	78	51	31	23	28
DEMAND(AVERAGE)	222	203	206	232	276
DEMAND(MAXIMUM)	278	254	258	290	345
NET SUPPLY	193	206	206	206	206
SHORTAGE(AVERAGE)	-29	3	0	-26	-70
SHORTAGE(MAXIMUM)	-85	-48	-52	-84	-139
WASTAGE RATIO	5%	0%	0%	0%	0%
LEAKAGE RATIO	35%	25%	15%	10%	10%

Note : *1 No suppression. *2 including wastage

On the other hand, if leakage control is undertaken, the water deficit will be alleviated considerably. The target level of leakage and wastage control will vary, depending upon the efforts to be expended by NUWA. The target proposed is to decrease leakage and wastage from 40 % to 25 %. This 15 % reduction is from reduction of leakage by 10 % and that of wastage by 5 %. When this is achieved, the



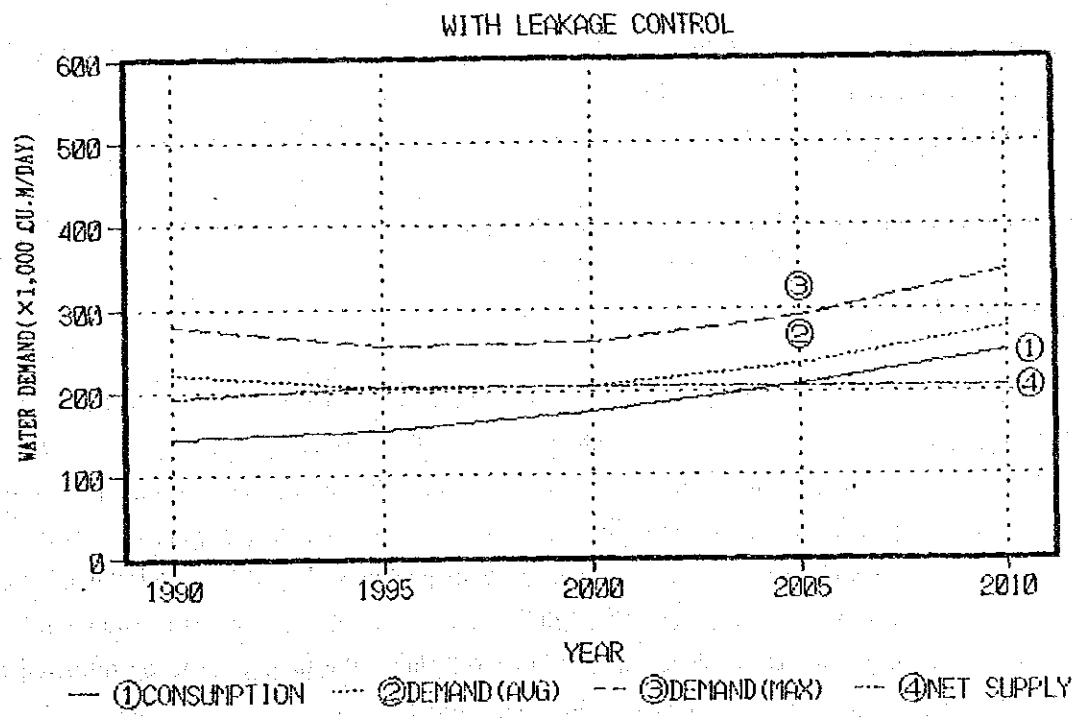


FIG. 6.1	DEMAND VS SUPPLY 'WITH' AND 'WITHOUT' LEAKAGE CONTROL

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

supply available in 1995 can meet the daily average demand, as shown in Figure 6.1. The leakage level is assumed to be 25 % in 1995, 15 % in 2000 and 10 % in 2005 and onwards.

6.2.2 LEAKAGE CONTROL STRATEGY

The total wastage and unaccounted for water can be assessed and controlled by systematic waste and leakage survey and detection, followed by prompt corrective action and consumer education. Such a program has to be continuing in nature; careful planning and preparatory work, plenty of time-consuming and labor-intensive field surveys and intelligent investigations are required in embarking on a program of leak reduction and control. This leak detection exercise, once established, will need to be an on-going commitment from NUWA. Initial training will be required, but ultimately NUWA should be able to continue the work on its own.

The choice of methodology must be made in light of the fact that this will be a long term venture. It would be impractical to change adopted methods every few years, in view of the investment required to be made in water meters and in training personnel. The change from one leakage control method, a passive leakage control, to a more intensive method, will create a short-term increase in the number of leaks requiring repair. However, once the more intensive leakage control method becomes established, the rate of leak repair in the long-term will remain substantially unchanged.

A suitable strategy has to be evolved for implementation of measures for conservation of water. The proposed strategy must tackle two basic problems:

- the provision of reliable data and records to monitor leakage levels so as to be able to establish priorities
- the establishment of leak detection teams to identify the source of leakage and to supervise repairs

6.2.3 PROCEDURE

Leaks are of two kinds - visible, or those that are above-ground and invisible, or those that are underground. Leakage control measures should start with the former. The former can start easily and will be very effective, especially during the initial stages. An example is the replacement of packings in privately-owned consumer taps, in addition to distribution pipes and valves. Since there is no metering system in place for the majority of consumers, replacement of packings should be at NUWA expense. Another example is the provision of free water through kiosks, which will replace water collection from holes that are intentionally dug around water pipes. Figure 6.2 shows the procedure to be followed for above-ground leakage control, consisting of patrolling, detection and repair.

Nevertheless, preparation should start for underground leakage control simultaneously. As illustrated in

Figure 6.3, it needs to be conducted systematically. The creation of "waste districts" covering the whole network is an effective way. "Waste districts" need to be worked out during the "establishment of the leakage control strategy", as a first step by NUWA. It enables routine monitoring of night-time flows into the districts. Permanent sites should be constructed where portable flow measurement equipment can be installed.

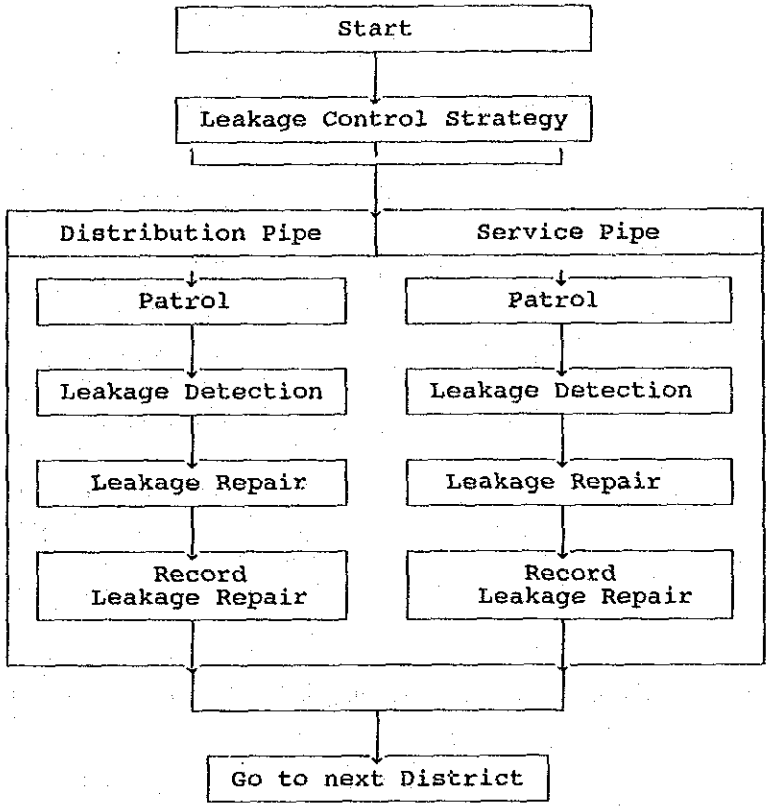


FIGURE 6.2 PROCEDURE OF ABOVE-GROUND LEAKAGE CONTROL

Each "waste district" should be completely "isolated hydraulically", preferably by closing all stopcocks to consumer connections, as well as the boundary valves from other districts. The supply of water is allowed through a single feed pipe, on to which a flow meter is fixed. The continuously recorded flow in the meter indicates wastage due to leaks in the mains. In residential areas with a 24 hour supply, minimum night flow (MNF) indicates the amount of wastage. Exact location of leaks in mains is carried out during the night time, by means of sounding rods and electronic leak detectors, after the exact alignment of pipes is traced by electronic pipeline detector, as well as from the records. Also, after leakage repair, MNF is measured to confirm that leakage drops to within an allowable degree. Leakage detection and leakage repair is continued until observed MNFs are within allowable ranges.

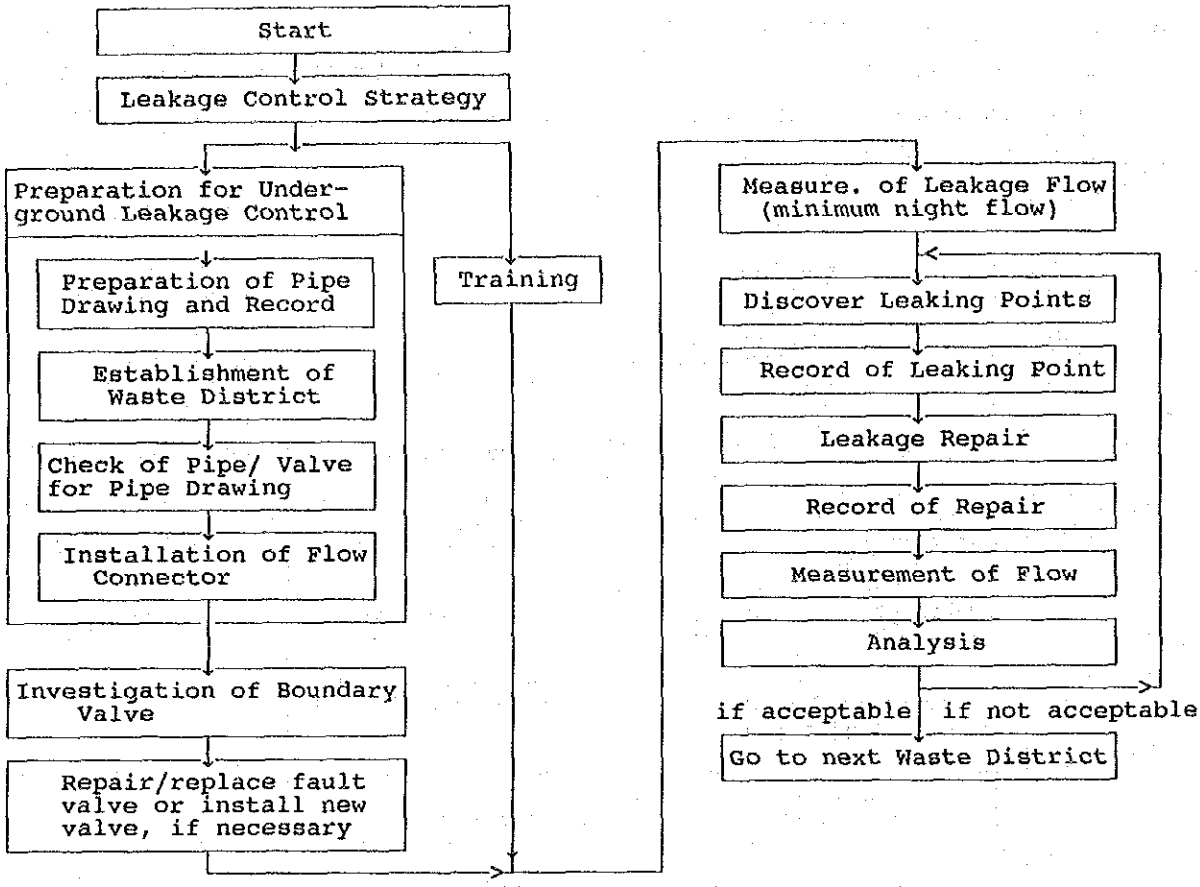


FIGURE 6.3 PROCEDURE OF UNDERGROUND LEAKAGE CONTROL

Exact alignments of pipes and valves, particularly those of boundary pipes and valves are a prerequisite to making waste districts. However, since the NUWA pipe drawings are inadequate, preparing correct drawings must be the first step in underground leakage control. This is discussed in a separate section entitled "Mapping".

The following should be considered in creating and operating waste districts;
- Total length of pipes within a waste district should be less than 2,000 meters.
- Valves should be provided to enclose a waste district.
- Inflow valve and inflow meter should branch off from adjacent distribution mains, so as not to result in low pressures in the waste districts.

Figure 6.4 shows a typical waste district with the typical location of a meter connector in Oyster Bay, Msasani, while Figure 6.5 shows the typical structure of a meter chamber.

Leakage control should start with districts where leakage is high. Hence, patrolling the whole distribu-

tion area for above-ground leakage control should come first. However, for underground leakage, patrolling is not effective. It needs area-wise analysis of leakage level through measurement of minimum night flow preferably during the "Establishment of Leakage Control Strategy", although, this will take a considerable amount of time. Alternately, high-leakage areas have to be identified empirically, based on experience and prior information, both formal and informal.

Such high leakage will occur in areas with 1) PVC pipes, 2) old pipes, 3) long, small service pipes instead of distribution pipes and 4) high pressures. The areas covered by items 1) and 3) above are generally in the center while those covered by 2) are outlying areas. Study on the three model areas does not give sufficiently conclusive data as to which areas have high leakage levels, and therefore needs to be confirmed during leakage control. Nevertheless, it is proposed that underground leakage control start from outlying areas with the objective of shooting the item 2), judging from the fact that few areas have enjoyed high pressures and that little external corrosion has been observed. The proposed implementation order is shown in Figure 6.6.

6.2.4 SCHEDULE

To attain the target leakage level, about half the underground leaks and all the above-ground leaks must be identified and repaired by the target year. The schedule to achieve this objective is shown in Figure 6.7. In the first year, above-ground leakage detection and repairs should start, which will take 55 months or approximately 5 years for the entire distribution area. The basic preparatory work for the underground leakage control, such as establishment of strategy, pipe drawings, procurement of equipment, waste districts establishment and training should also start in the first year. Underground leakage detection should start in the second year, and will take 4 years to cover about the half the distribution area. This schedule is a bigger challenge for NUWA, since other rehabilitation work such as air scouring, pipe drawings and detection of unregistered connections also need considerable manpower. It is noted, however, that most of the other work could be better done concurrently by the same personnel, because all involve field work and household visits.

Even though leakage control requires vigorous efforts, it is recommended because this alone could produce sufficient water within the distribution system. Most of the other work like laying pipes, which aims at providing sufficient carrying capacity in the system, would be useless without availability of sufficient water. Further, this work will not be costly, but labour-intensive. Therefore, NUWA should be able to complete leakage control successfully.

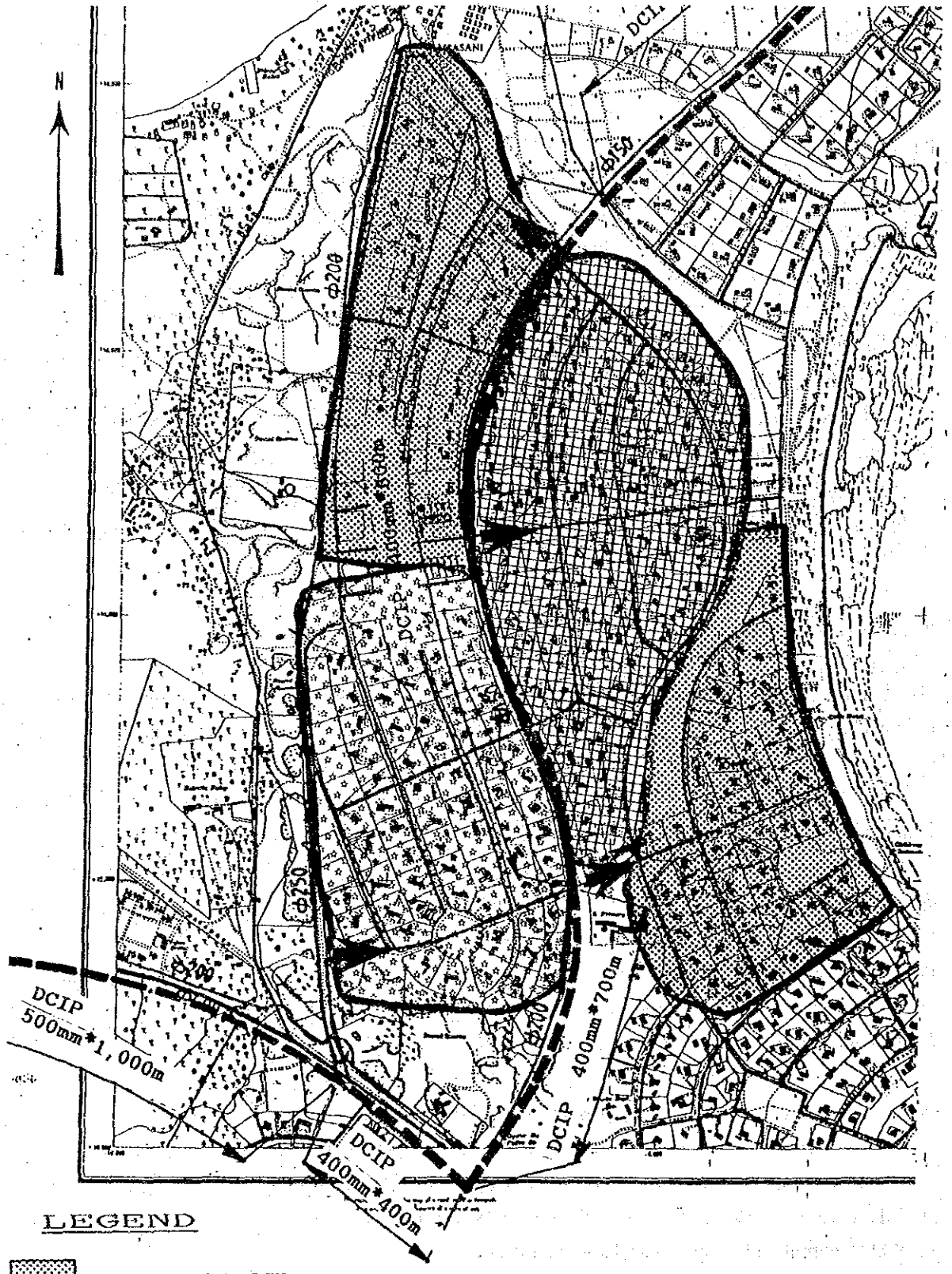
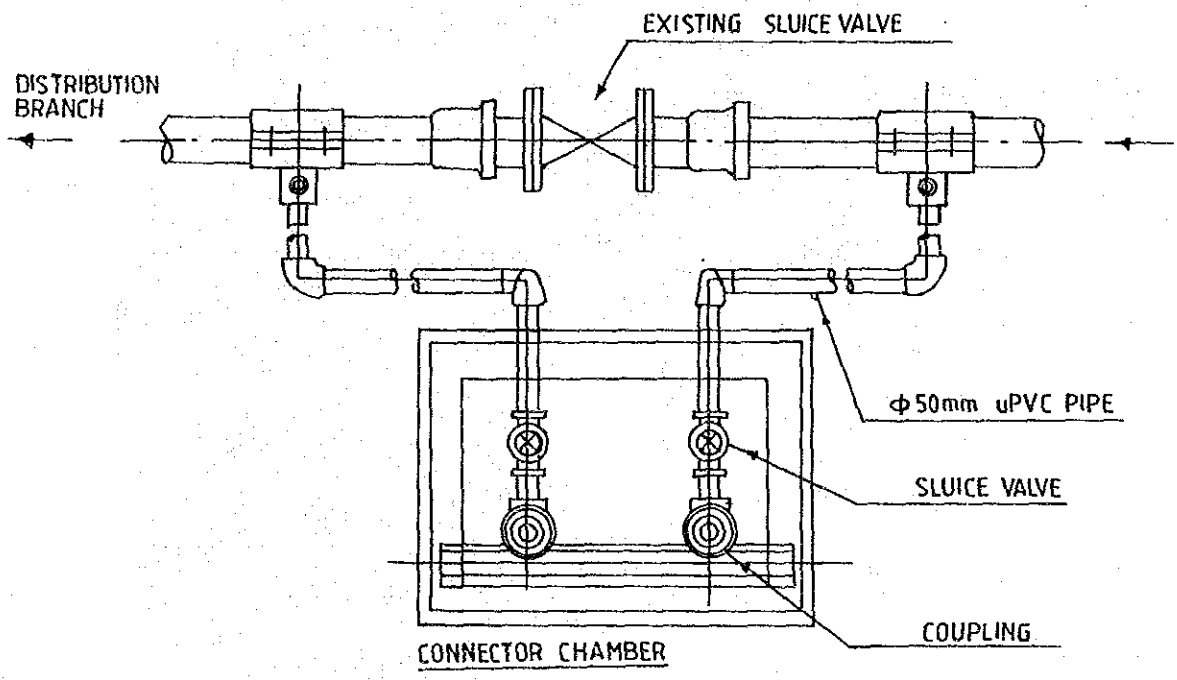


FIG. 6.4 TYPICAL WASTE DISTRICT IN MSASANI



DETAILED PLAN

FIG. 8.5	TYPICAL PLAN OF FLOW METER CONNECTOR

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

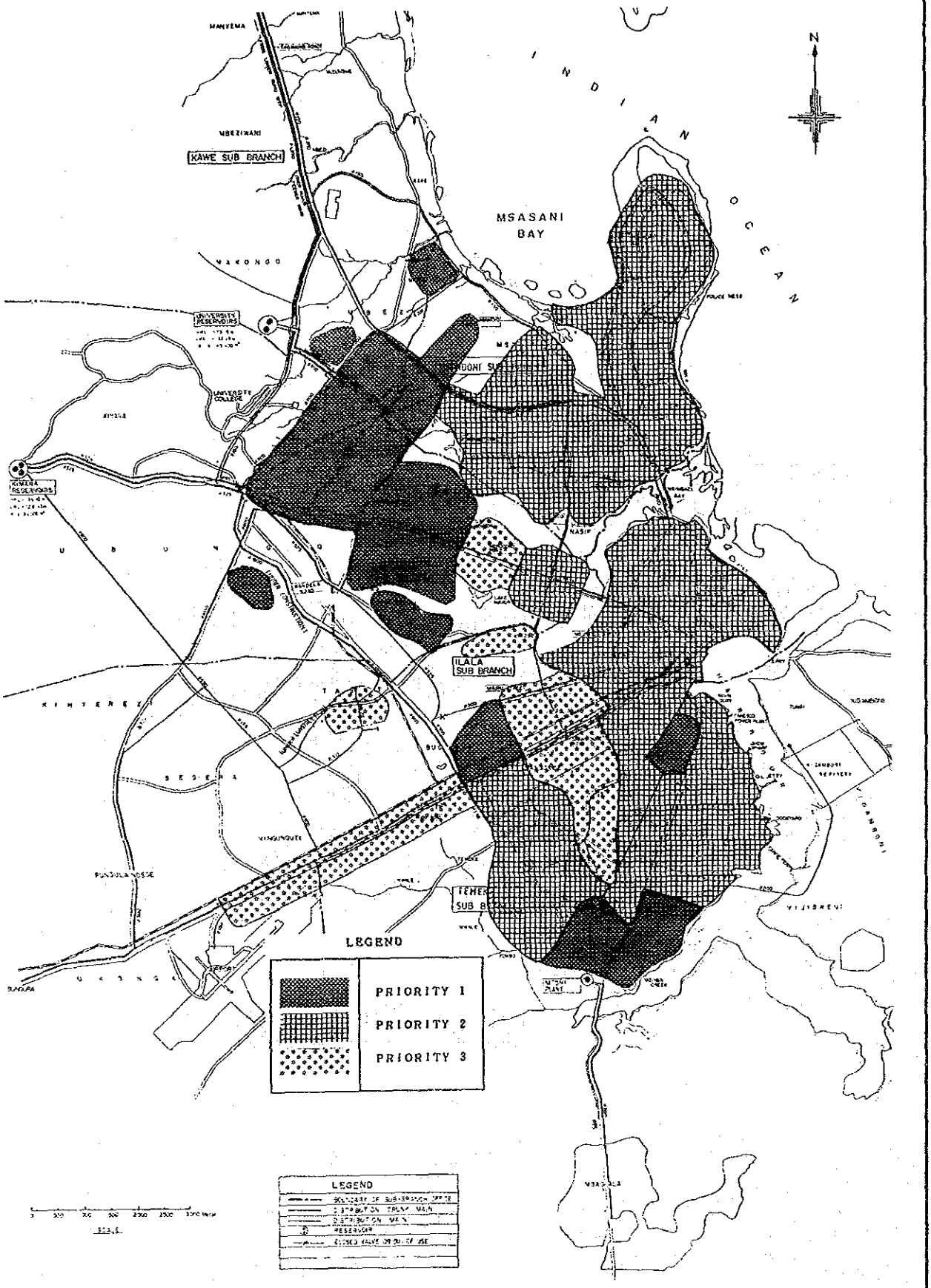


FIG. 6.6	IMPLEMENTATION ORDER OF LEAKAGE CONTROL

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

FIGURE 6.7 LEAKAGE CONTROL SCHEDULE

Description	1991	1992	1993	1994	1995
A) Establish Leakage Control Strategy	======	------	------	------	------
B) Prepare Pipe Drawing and Record (Mapping; refer to section 6.5)	======	======	======	======	======
C) Perform Above-ground Leakage					
1) Service Pipe					
Leakage Detection @	======	======	======	======	======
Repair	======	======	======	======	======
2) Distribution Pipe					
Leakage Detection	======	======	======	======	======
Repair	======	======	======	======	======
D) Perform Underground Leakage					
1) Establish Blocks (Waste district)	===				
2) Install Flowmeter	===	======	======	======	===
3) Training	===				
4) Measure Night Flow and Leak Detection		======	======	======	======
5) Repair		======	======	======	======

Note: @ conduct, during this activity, finding illegal connections and converting them into legal ones.

6.2.5 MANNING, EQUIPMENT, TOOL AND MATERIAL

Leakage control has not been successful so far. This failure is apparently due to the fact that even passive control has not been done by a special task force, but rather it has been done under conditions similar to ordinary work like service pipe connections. Leakage control must be initiated at the engineer level at NUWA. The work must be executed as a team or organization, with daily and routine work performed by well-trained technicians monitored by engineers. Creation of a pipe inventory, formulation of "waste districts", measurements of flow and pressure etc. must accompany leakage control. Leak detection teams should be established under the direct control of NUWA DSMB. Liaison with the sub-branches must also be maintained. Teams should be dispatched to "waste districts" exhibiting the highest levels of leakage.

From experiences during the Study, it takes about a half month to complete an area of 0.5 km^2. The most critical part is trial digging. The area required for the placement of the waste districts is half of the

entire distribution area, which is estimated as 150 km^2. It will therefore take 150 months or 13 years for one team to complete the total area, which is inordinately long. Leakage control requires achievement of a 25 % leakage level and a 0 % wastage level within 5 years. Underground leakage control, including formulation of waste districts, needs to be completed in four years. Accordingly, four teams need to be established; one team for formulation of waste districts and three teams for leakage detection and repair. Similarly, 10 teams are to be established for above-ground leakage control; each five for distribution pipes and service pipes. An engineer can oversee the teams and the proposed organization is shown in Figure 6.8, which also indicates staffing levels, tools, equipment and materials required.

Leakage control teams must be equipped with suitable tools, materials and transportation to enable them to carry out repairs quickly and efficiently. Sophisticated equipment should generally be avoided because of maintenance problems, although due to the low system pressures initially, some form of leak noise amplification device may be required.

For planning purposes, the number of waste districts are estimated at 300. The three model areas of Kariakoo, Magomeni and Kinondoni were selected as waste districts for measurement of leakage during the Study. The areas are, however, too large for precise location of leaks. It is better to divide them into two areas, as shown in Figure 6.9. In doing so, additional valves become necessary for waste districts that need to be hydraulically isolated. Eight valves are necessary in the three model areas and, the ratio of additional valves to pipe lengths are 0.6 valves per kilometer. From this ratio and the total length of secondary pipes in DSM, 350 valves are estimated to be additionally required.

TABLE 6.2 VALVE DETAILS FOR WASTE DISTRICTS (SECONDARY PIPE)

	Kariakoo	Magomeni	Kinondoni	Total	Dar es Salaam
Pipe length (meter)	4,670	4,400	4,230	13,300	583,832
Block number proposed	2	2	2	6	---
Existing valve used for boundary	14	4	1	19	---
Additional valve proposed	3	2	3	8	350
Valve per pipe length (No./km)	0.64	0.45	0.71	0.60	0.60

During the leakage survey which was conducted in March and August, 1990 in the three model areas, the number of connections, taps and taps leaking were surveyed on a house-to-house basis, in addition to other data like the number of inhabitants. The ratio of the number of taps leaking per connection range from 33 to 51 % with an average of 42 %, as shown in Table 6.3. Connections, including those registered and unregistered, will be 120,000 in 1990. Therefore, 50,000 tap packings will be required by 1995.

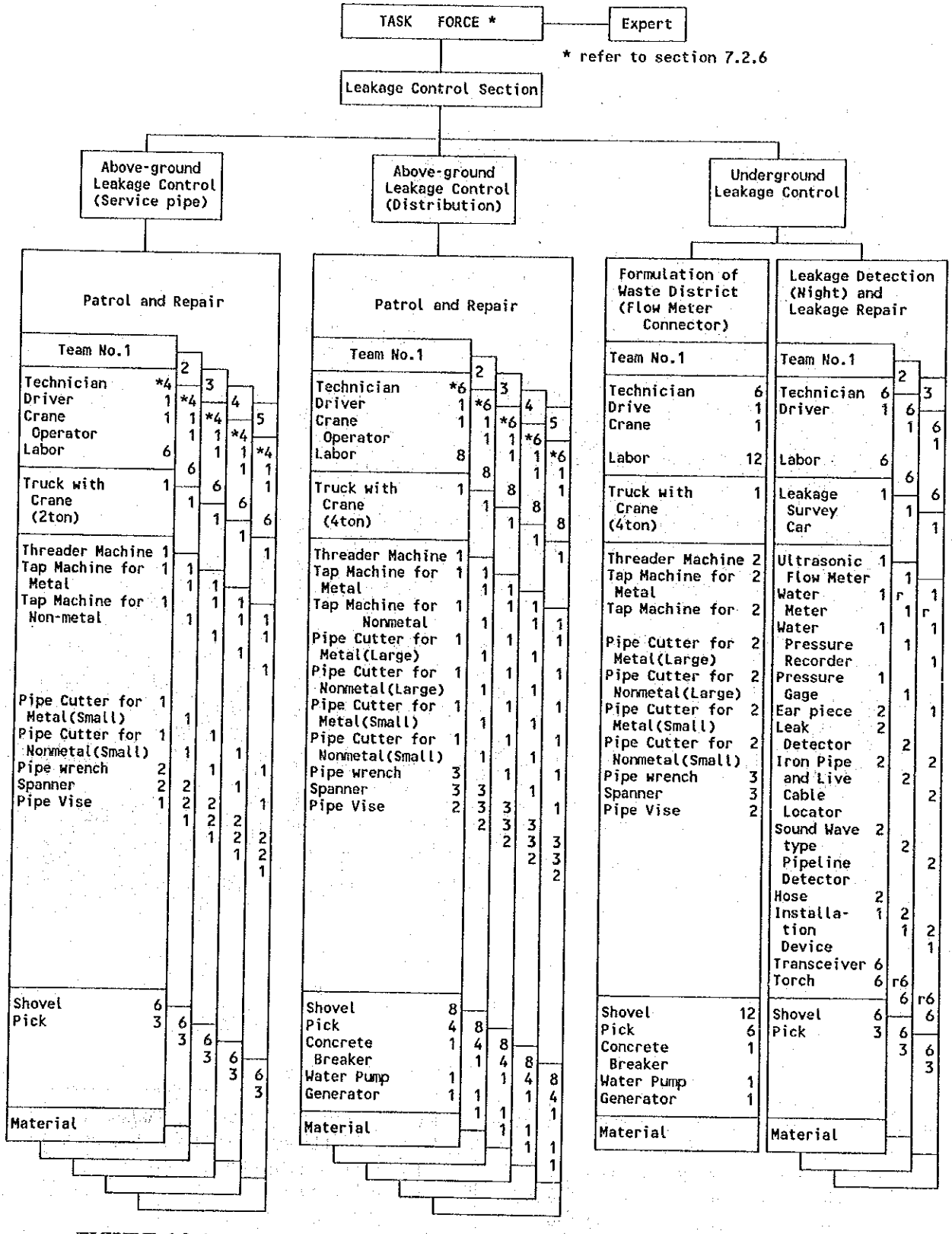
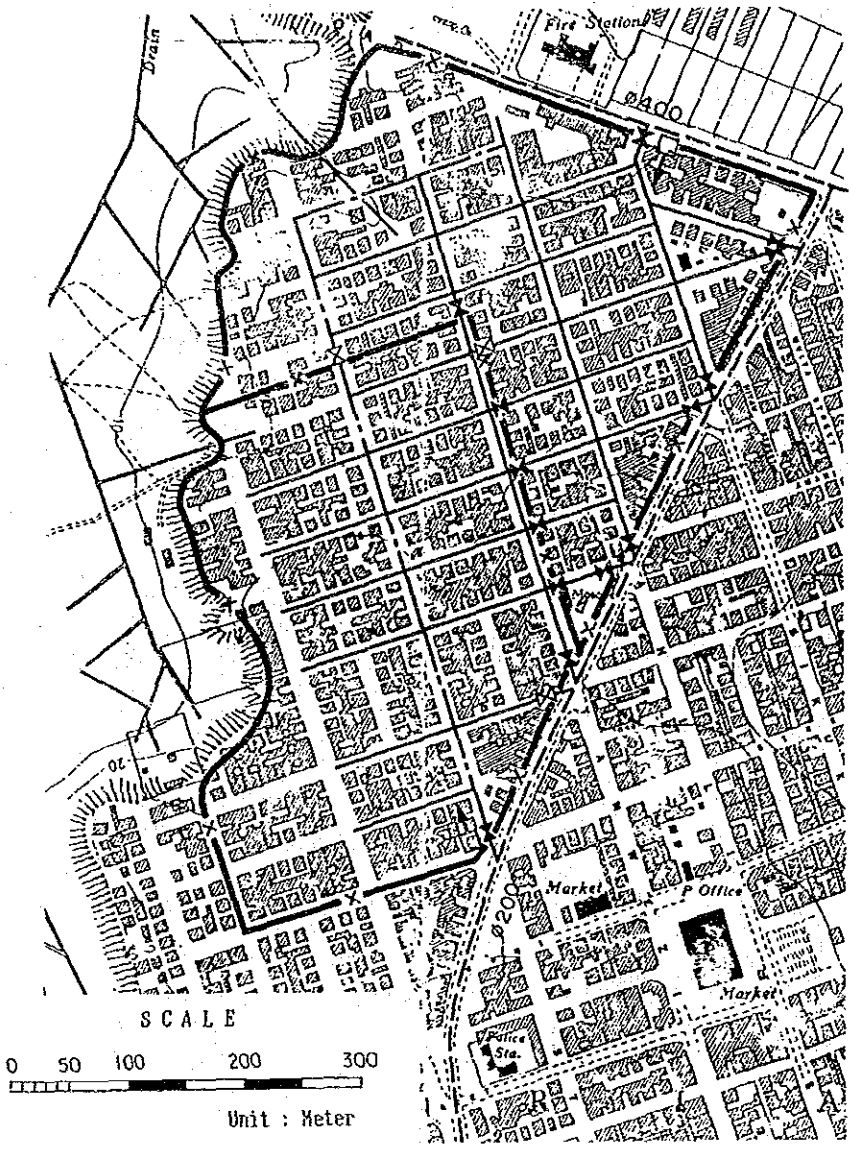
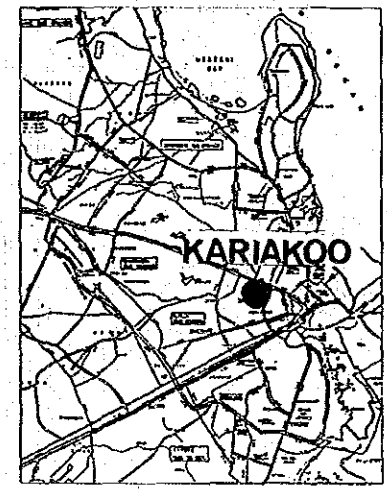


FIGURE 6.8 MANNING, EQUIPMENT AND TOOLS FOR LEAKAGE CONTROL



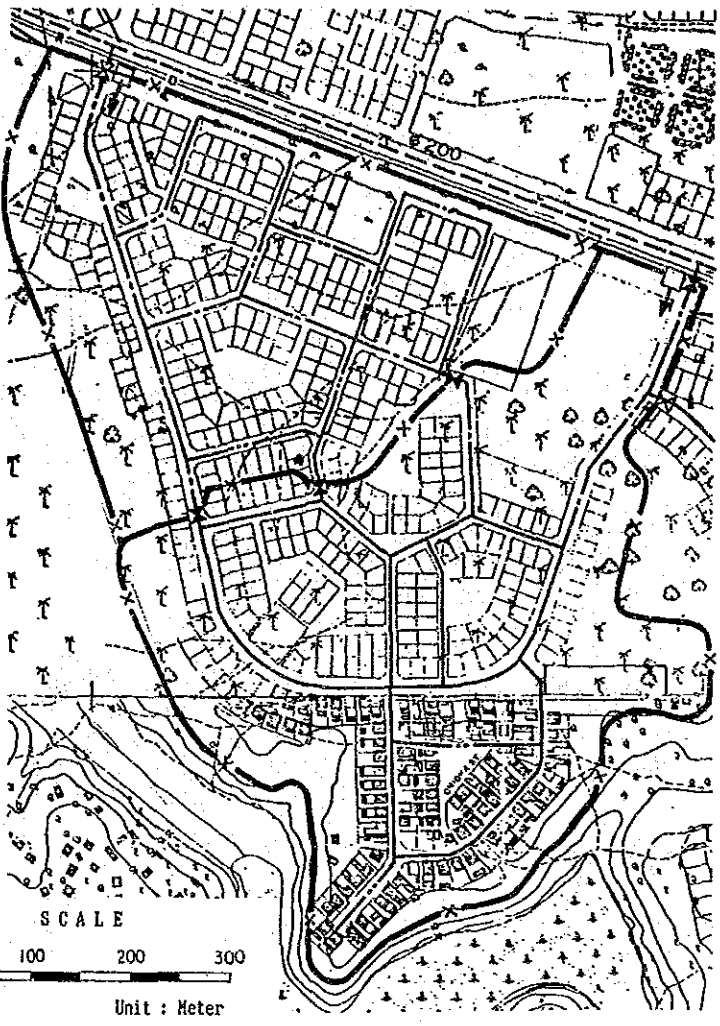


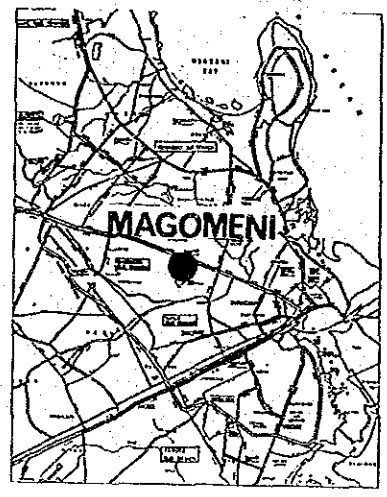
LEGEND

——×——	Waste District Boundary	⋈	Existing Valve for Boundary
– – – – –	Primary Pipe	⋈	Additional Valve for Boundary
——·——	Secondary pipe (φ150)	□	Flow Meter Connector
———	Secondary pipe (φ100)	——→	Inflow
—— – – ——	Secondary pipe (φ 75)		

FIG. 6.9(1) WASTE DISTRICT IN KARIAKOO MODEL AREA

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY



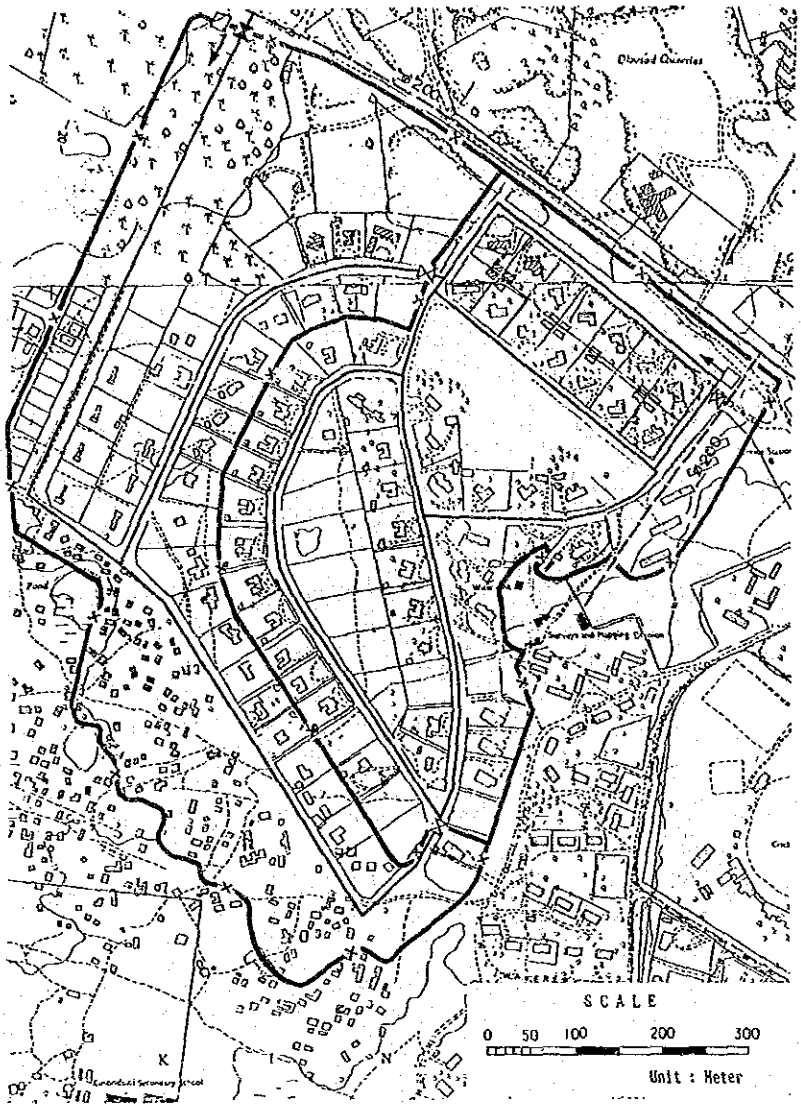


LEGEND

——×——	Waste District Boundary	⋈	Existing Valve for Boundary
– – – – –	Primary Pipe	⋈	Additional Valve for Boundary
——·——	Secondary pipe (ϕ150)	□	Flow Meter Connector
———	Secondary pipe (ϕ100)	→	Inflow
—— – ——	Secondary pipe (ϕ 75)		

FIG. 6.9(2) WASTE DISTRICT IN MAGOMENI MODEL AREA

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY



LEGEND

——×——	Waste District Boundary	⋈	Existing Valve for Boundary
– – – – –	Primary Pipe	⋈	Additional Valve for Boundary
——·——	Secondary pipe (ϕ150)	□	Flow Meter Connector
———	Secondary pipe (ϕ100)	——►	Inflow
——– – ——–	Secondary pipe (ϕ 75)		

FIG. 6.9(3) WASTE DISTRICT IN KINONDONI MODEL AREA

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

TABLE 6.3 PROPORTION OF TAP LEAKING IN MODEL AREAS

	Kariakoo	Magomeni	Kinondoni	Total	Dar es Salaam
Connection (No.)	358	221	301	880	120,000
Tap with leakage (No.)	119	113	140	372	50,000
Tap with leakage per connection	33%	51%	47%	42%	0.42

6.2.6 TRAINING

Teams should be proficient in the use of sounding techniques to detect leakage and should carry out routine visual inspections of all mains and service lines. Any identified leakage should be reported to the branch. The teams should be provided with facilities, equipment, materials and the training necessary to carry out a wide variety of repairs including the rehabilitation and the replacement of washouts, fire hydrants, gate valves and air valves.

Pipe fitters must be confirmed to be 'acceptable' for repair work and bad practices, if found, must be pointed out. All valves must be located and operated. Any leaking valves should be repaired and defective valves replaced. All air valves must be located, inspected and probably replaced. Spares for old parts are now difficult, if not impossible, to obtain. All fire hydrants must be located, cleaned and operated and any defects repaired.

6.3 MAPPING

6.3.1 INFORMATION ON MAPS

Maps and drawings are vital tools for leakage control as well to record detected leak locations, and to establish and operate "waste districts", etc. The benefits accruing from an accurate system of mapping records include reduction in time and cost for design of new installations, excavation and reinstatement work, improvement in management of the distribution network and efficient running of the undertaking.

Generally, in urban areas, maps of at least 1:2,500 scale and preferably larger are normally considered necessary. Precise details should be recorded in 1:2,500 scale pipeline drawings, which are the most fundamental maps for managing the distribution system. All details of waterworks' properties are to be recorded in them and they are to be used for confirming locations of distribution and service installations, for indexing as-built drawings and for selecting houses affected by water supply cut-off. Each plan should preferably be drawn on a standard A1 sheet, this size being the optimal balance between the two main requirements of a single sheet drawing - small enough for ease of handling in the field but with sufficient clarity for identifying system details. The following information is to be recorded on

the maps/drawings:

(i) Pipelines
- schematic alignment, - street name - diameter, - material - age (year laid),
- owner's name, address, P.O.Box number and account number (if used for accounting purpose)
- size and number of meter (if used for accounting purpose)

(ii) Valves, fire hydrants and air valves
- location, - diameter, - type
- clock-wise or anti-clock-wise direction of opening/closing

Large-scale drawings can be utilized for accounting purposes also. The 1:2,500 scale maps based on aerial photographs taken in the early 1980s and issued by the Survey Department can provide a convenient base on which to superimpose pipe and system facilities, with the majority of roads, railways and buildings detailed. If accounting number and other information for service pipe connections is superimposed on the 1:2,500 maps which clearly show houses, each house will be identified as either connected or not, billed or not if connected, paid or not if billed.

The served area is covered by 15 sheets on a scale of 1:5,000 and these maps can be conveniently used when zone-wise distribution plans and supply cut-off plans for a large area is needed. On the other hand, the whole system has to be plotted onto A0-size tracing paper on a scale of 1:25,000, which is used for coordination and integration of distribution plans of the water works. The maps of both 1:5,000 and 1:25,000 have been prepared on a preliminary basis in the Study (see drawings in section 4.6, Appendix C), and should be updated regularly, based on 1:2,500 maps.

The above maps/drawings are to be organized by the distribution section of the DSM branch, as shown in Figure 6.10.

Apart from maps/drawings, ledgers are also useful for maintaining facilities and providing information for planning and overall management of the waterworks, stabilization of long term supply, improvements in the distribution system, provision of emergency supply and preparation of statistical data.

The ledgers are:
* quantitative information (pipelines ledger)
* functional information (records on leakage, burst and survey reports of pipe conditions)
* information for pipeline improvement (renovation or renewal pipes ledger)
* information for the analysis of the distribution system (survey reports of high pressure areas and iso-pressure contour maps)

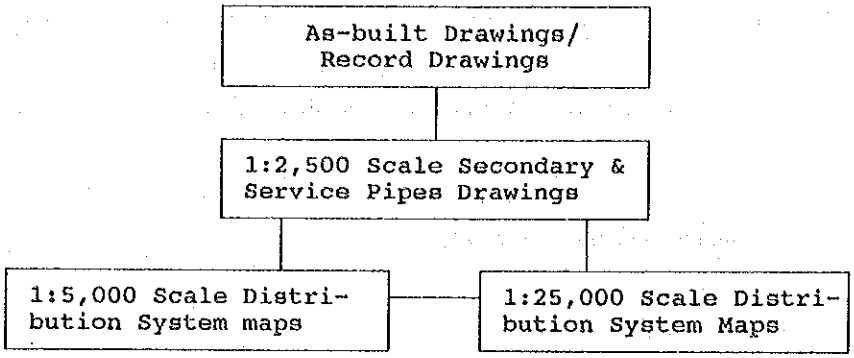


FIGURE 6.10 STRUCTURE OF MAPS/DRAWINGS

6.3.2 PROCEDURE

EXPERIMENTAL WORKS PERFORMED

Many difficulties were encountered in making maps due to the lack of accurate pipe drawings. It was adopted, firstly, to consult with NUWA engineers for pipe information, followed by a technician or a retired technician belonging to the respective sub-branches. With this information, verification was mostly by trial digging and using pipe locators. In particular, pipes connections needed to be verified. The maps prepared were 1:25,000 and 1:5,000 scale drawings. The latter number fifteen sheets in all and one index map.

Different drawings have also been produced on a 1:500 scale for the three model areas - part of Kariakoo, Magomeni and Kinondoni. A start was made for use of 4 sets of metallic pipe locators and 4 sets of non-metallic pipe locators to trace the pipe alignment and location of pipelines in the existing system. Where necessary, trial pits were excavated to confirm locations of pipes, valves and fire hydrants. A common problem was the valve surface boxes were either missing or had been paved over during road re-surfacing work. Locations of all service pipes were also surveyed. Field surveys were then undertaken to record the locations of pipes and appurtenances.

PRELIMINARY WORK BY NUWA

Work required to be performed before making new pipe maps and drawings are;

* Collection of maps.
* Evaluate past records and information about pipes, both formal and informal.
* Confirm doubtful records and information, particularly regarding pipe connections, by trial diggings.
* Off-set survey for location of service pipes, meter boxes, taps, stand pipe.
* Enter pipe information onto 1:2,500 scale drawings.

Accuracy is the most important requirement for pipeline maps and drawings. Failure or delayed updating of maps and drawings can decrease their utility and reliability. Correction and updating of maps/drawings are to be made whenever new pipes are installed and repairs are made on existing pipes.

In order to rectify and update maps/drawings correctly and efficiently henceforth, as-built drawings should be made in compliance with the following rules;

* Alignment of pipeline shall be accurately recorded.
* As-built geographical conditions are input on geographical maps, which are a component of 1:2,500 scale pipeline drawings.
* As-built drawings shall be marked in accordance with the coordinates system.

Based on large-scale 1:2,500 drawings, 1:5,000 scale distribution system maps and 1:25,000 scale distribution are to be modified. Geographical features are also to be corrected on the basis of the latest information, which is to be given by the Ministry of Land, City Council and other relevant authorities.

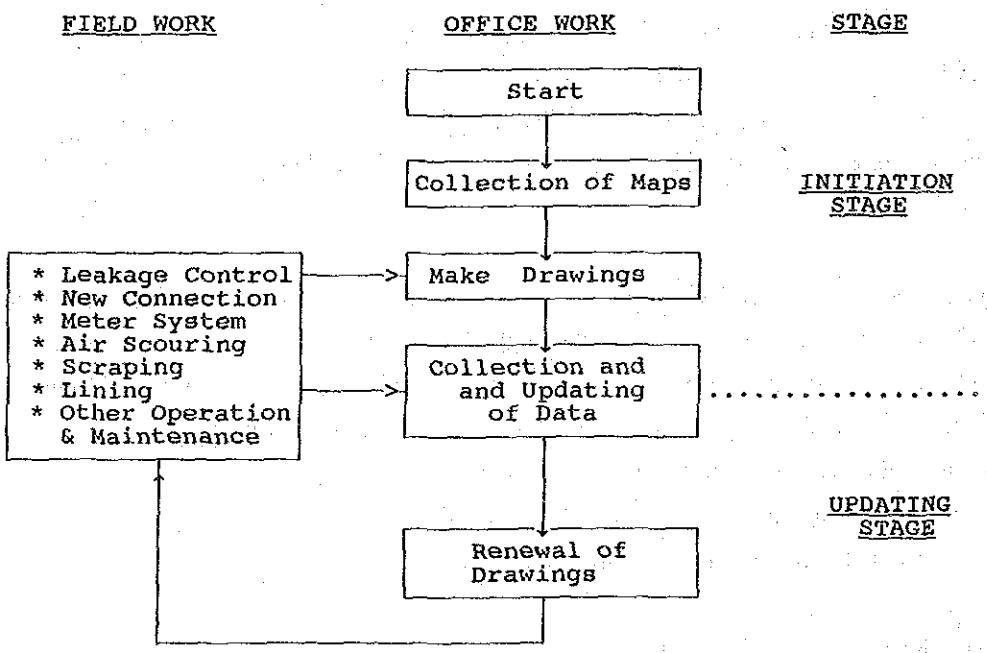


FIGURE 6.11 MAPPING SYSTEM FLOW CHART

6.3.3 MANNING, ORGANIZATION AND EQUIPMENT

The confirmation of pipe alignments etc., with trial diggings in the fields is to be performed not by the mapping section, but under such activities as waste districts placement, conducting air scouring and lining. Instead, the mapping section will act as an information center for pipes and appurtenances.

Hence, stock drawings and correction of maps/drawings are to be centralized at the DSMB. The mapping section has to collect the necessary information through the sub-branch offices and make corrections, following standard procedures and distribute the corrected maps/drawings to each branch office.

Figure 6.12 shows a proposed organization, and manning and equipment requirements for the mapping section.

6.3.4 SCHEDULE

Making new maps and drawings starts in 1991. Information will be collected from various field activities - waste district, metering, air scouring and lining. After or even during new maps construction, updating should be performed as shown in Figure 6.13.

6.3.5 TRAINING

The previous sections dealt with the methods for arrangement and drafting of maps/drawings, and for this, the waterworks depends on the skills of individuals involved. Therefore, it would require some training under experts to make maps/drawings, so that the distribution section can expect to obtain the latest information about its network system for emergencies, planning and daily operations.

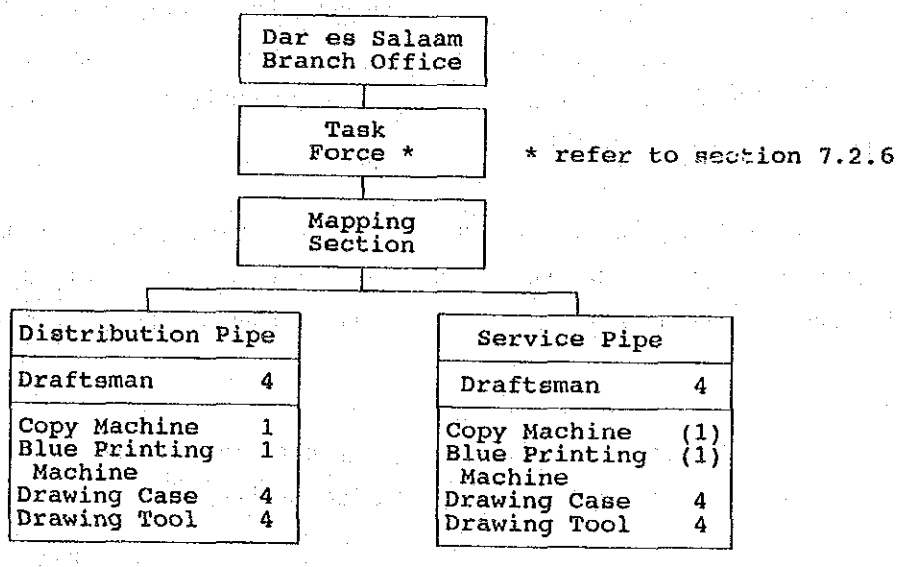


FIGURE 6.12 ORGANIZATION OF MAPPING SECTION

FIGURE 6.13 MAPPING SCHEDULE

Description	1991	1992	1993	1994	1995
A) Collection of Map	==				
B) Make a Drawing/Map according to Waste District (ref. to Leakage Control)	======	======	======	======	======
C) Renewal of Drawing/Map	------	------	------	------	------
D) Manning Schedule					
Engineer	1	1	1	1	1
Draftsman (technician)	8	8	8	8	8
E) Equipment Schedule					
Copy Machine	1	1	1	1	1
Blue Printing Machine	1	1	1	1	1
Drawing Case	8	8	8	8	8
Drawing Tool	8	8	8	8	8

6.4 METERING SYSTEM

6.4.1 GENERAL

Studies on metering carried out worldwide indicate that universal water metering would not be feasible. In the history of the DSM water supply system, maintenance and repair of water meters have left much to be desired. Nevertheless, apart from these two drawbacks, i.e., a general observation and the one based on local realities, metering has had a great impact on consumers. Many studies on metering have revealed that the impact has been considerable, with the effect felt even soon after initiation of a metering programme. The fact that it is most effective in external-to-house-use and use during peak periods would lend metering more credibility.

Metering is aimed at water conservation and revenue increase. Our study shows that it will result in a 10 % reduction in high-house connection consumption (refer to section 4, Appendix E). Meter installation of domestic consumers is considered to be effective due to the following points.

-Equitable:

* Consumers are charged depending on the actual quantity of water used and measured by meters.
* Reduction of consumer complaints arising out of assessed charges.

-Efficient:

* It is necessary to examine the balance between the cost and revenue from metering. It should be noted that meter installation increase costs (fitting of meter and replacement, repair and maintenance

fee, labour costs for meter reading, etc.),

* Meter installation does not always increase the revenue.
* From the economic point of view, reduction of water loss is a monetary gain in the form of saved water.

6.4.2 SELECTIVE METERING

Metering is not always practical in DSM because water pressure is too low or costs of metering are prohibitive. Accordingly, selective metering is essential for meter installation, and target areas for the metering should be chosen carefully from the start.

The following assumptions are adopted to examine whether the proposed metering will be profitable or not for NUWA:

- Meters are installed at 15,000 "high" income households.
- Consumption per capita per day is estimated to be 400 liters as analyzed in Demand Analysis.
- Metering cost including operation and maintenance cost has been prepared for 10 years, as the depreciation period of meters is 10 years, according to NUWA regulations.
- Water tariff is assumed to increase at a rate of 68 % from July 1, 1991.
- Bad debts have not been taken into account to calculate the incremental revenue. All of the incremental revenue can not be collected. However, metering would reduce the bad debts arising out of assessed charges.

Economic Benefits

By meter installation, water losses is expected to reduce by 10 % according to the survey by the Study Team. Therefore consumption per capita will decrease from 400 liters per day to 360 liters per day after metering. Water saved in 15,000 households will amount to 1,196 thousand m^3 per year and monetary gain by distributing 1,196 thousand m^3 of saved water to other consumers is calculated to be T.Shs. 65 million per year.

Financial Benefits

Water charges for high income household are usually calculated by adopting assessed charges as same as other domestic consumers. Average consumption per connection per month is 30,330 liters(6,666 gallons) in Rank 9, as mentioned in section 3.3.1. As the number of persons per household in high income group is estimated to be 5.46 persons, water consumption paid is 185 liters per person per day, which only amounts to 46 % of the actual consumption(400 liters). 215 liters of water are consumed without charge per capita per day by high income households.

Table 6.4 shows the increased revenue per connection resulting from meter installation.

TABLE 6.4 INCREASED REVENUE BY METERING

	PRESENT SYSTEM		METERING SYSTEM		INCREMENTAL	
	Assessed Consumption (liter)	assessed (2) revenue (T.Shs.)	consumption (liter)	revenue (T.Shs.)	billing consumption (liter)	revenue (T.Shs.)
Per Day per Person	185		360		175	
Per Day per Connection (1)	1,011		1,966		955	
Per Month per Connection	30,330	641	58,968	1,246	28,638	605
	(6,666 Gallons)	(381.6 x1.68	(12,960)		(6,294)	

(1) The average number of population per household in "high" group is estimated to be 5.46 persons
Population: 78,915 (refer to Table D.1.1 in Appendix)
Household: 14,461 (refer to Table D.1.2 in Appendix)
Population/Household: 5.46 persons
(2) Refer to rank 9 in Table 3.7, Monthly Average Gallons and Minimum Charge by Rank.
Monthly Average Gallons of Rank 9: 6,666 gallons
Monthly Charge of Rank 9: T.Shs.381.6

Increase of monthly billing per person and per connection is 175 liters and 955 liters, respectively and the increased revenue per connection result is T.Shs.500 per month, as calculated in Table 6.4.

Table 6.5 gives the comparison of costs and increased revenue for meter installation. The revenue for metering exceeds its cost discounted at 10 %. The financial internal rate of return calculated to be 11.0%.

TABLE 6.5 COMPARISON OF COSTS AND REVENUE

(Unit: T.Shs. million)

	NUMBER OF CONNECTION	INCREASED REVENUE	CAPITAL COST	COST O & M COST	TOTAL	PROFIT PROFIT
1 1991	3,750	27.2	315.1	3.3	318.4	-291.2
2 1992	11,250	81.7	287.0	3.3	290.4	-208.7
3 1993	15,000	108.9	0.0	3.3	3.3	105.6
4 1994	15,000	108.9	0.0	3.3	3.3	105.6
5 1995	15,000	108.9	10.9	3.3	14.3	94.6
6 1996	15,000	108.9	17.8	3.3	21.2	87.7
7 1997	15,000	108.9	0.7	3.3	4.0	104.9
8 1998	15,000	108.9	0.0	3.3	3.3	105.6
9 1999	15,000	108.9	10.9	3.3	14.3	94.6
10 2000	15,000	108.9	-34.2	3.3	-30.9	139.8
TOTAL		980.1	608.3	33.4	641.6	338.5
NPV (3%)		848.7			631.1	217.6
NPV (10%)		629.6			608.1	21.5
B/C (3%)						1.34
B/C (10%)						1.04
FIRR						11.0%

The water consumption to balance costs and revenue at a discount rate of 10 % is 400 liters per capita per day. Accordingly, metering to "high" income customers is evaluated to be acceptable from economic point of view, but it must be stressed that water billings from metering must be collected without fail.

6.4.3 INSTALLATION

The target for meter installation is therefore large consumers. Households classified as "high" in Table D.1.2, Appendix D, are regarded as large consumers. The number of such houses are approximately 15,000, the break-down of which is as given below :

- Upanga east 920 households
- Upanga west 1,999 "
- Msasani 7,323 "
- Kinondoni 4,219 "
- Total 14,461 " , approximately 15,000 households

It should be noted that the areas where meter installation is recommended are all concentrated in certain parts of DSM; Msasani, Kinondoni, Upanga east and west.

The location of the water meter affects the efficiency of meter reading, meter replacement and repair. The following are to be considered in meter installation work;

- installing meters within premises but as near as possible to the boundary with public roads so as to enable easy access for meter reading;
- installing meters horizontally, at a lower level than water tap elevation
- installing meters at a clean and dry location where dirt or wastewater will not soil meters
- installing meters in accordance with the flow direction mark so that water will not flow in the reverse direction

In selecting the type of water meter, its characteristics should be considered in selection. Even when the selected type is appropriate, if it is undersized with respect to consumption, it may lead to malfunctioning during very high instantaneous flows and possibly, failure of measurement. If, on the contrary, it is oversized, the measurement may become inaccurate for very low flow. Selection of meter size requires careful considerations.

The size should be selected based on the planned maximum daily demand. Table 6.6 gives guidelines for selection.

Of the various types of water meters available, it is proposed to adopt two types, viz. the dual-pipe inferential type and the vertical axial (Woltman) flow type, after considering accuracy, performance durability, economy and maintenance. Both are wet types.

TABLE 6.6 SELECTION OF TYPE OF METER

Size (mm,inch)	TYPE	Max. Daily Demand (m^3/day)	Regulated Max. Flow (m^3/hour)
13(1/2)	Straight line, inferential	6.0	1.0
20(3/4)	Dual-pipe, inferential	12.0	1.5
25(1)	-ditto-	15.0	2.0
40(1+5/8)	Vertical, axial flow (Woltman)	48.0	8.0
50(2)	-ditto-	120.0	25.0
75(3)	-ditto-	240.0	40.0
100(4)	-ditto-	360.0	60.0
150(6)	-ditto-	720.0	120.0

6.4.4 REPAIR

Meters will gradually become inaccurate with time. Also, the filter provided in the water inlet of the meter will gradually be choked with silt, more so in DSM. In practice, very few meters of the many installed in the City are in working order. Most of the meters which were replaced by new meters during the study, were found to be clogged with sand (see section 5, Appendix E). The various factors and reasons for meter malfunction are given in Table 6.7. In order to identify the cause, the meter should be investigated.

In order for meter to work properly, its regular monitoring and calibration, when needed, is necessary. Monitoring will efficiently be conducted during regular meter reading (see Figure 6.14).

6.4.5 EQUIPMENT AND TOOL

Required spare parts and equipments are (see also Figure 6.16);

* Gear * Axial bearing * Meter cover
* Pivot * Packing * Standard meter
* Cleaning equipments * Tools for repair of meter

The following is to be taken care of to ensure long meter life;

* Not to subject the meter to intense impact
* Use appropriate packing in case of leakage and/or over estimation.
* Confirm the plan configuration.
* Flange bolts should be tightened uniformly.
* Air should be released from the inside of the meter.

It is hoped that these will be performed by the soon to be completed meter shop. Some spare parts and equipment required should be kept in the meter workshop for meter repairs. New foremen will be required to carry out these tasks.

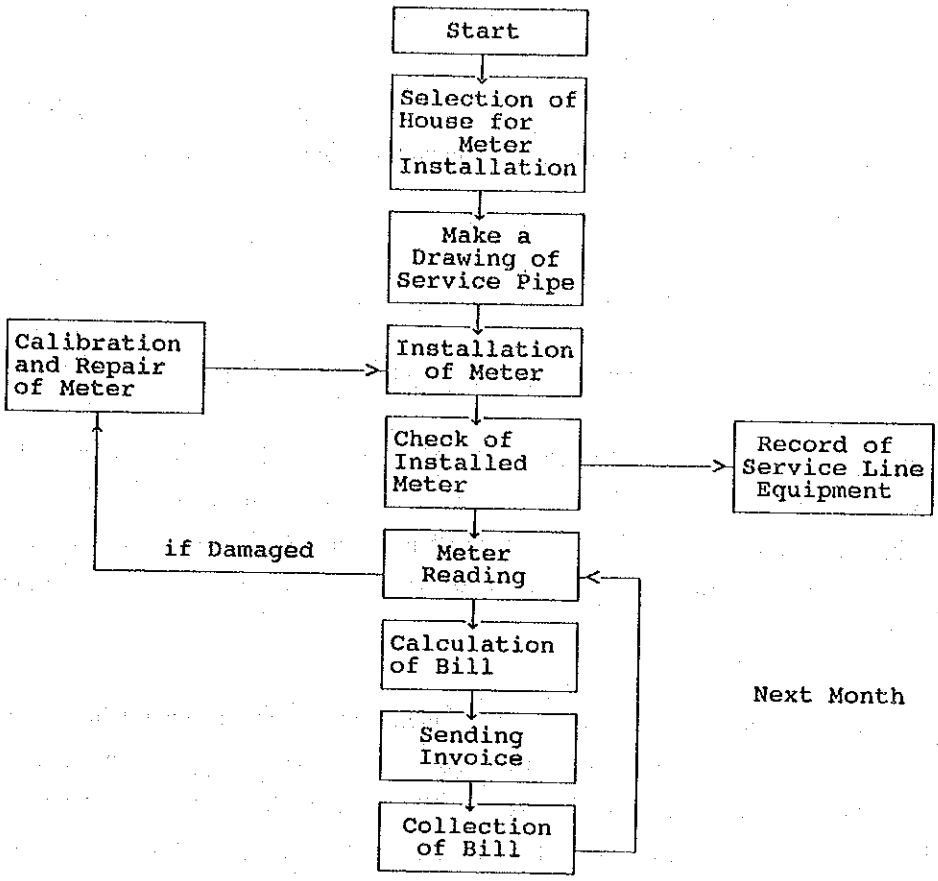


FIGURE 6.14 METERING SYSTEM FLOW CHART

TABLE 6.7 METER PROBLEMS, CAUSES AND SOLUTIONS

	ITEMS	CAUSEMEASURES
Slow of fast rotation	* Clogging due to silt and fine sand * Overload and high pressure * Slippage of packing * Encrustation	* Change the axial bearing, pivot rotation and gear * Control pressure * Change of packing * Cleaning
Running idle and no rotation	* Something wrong with rotating part	* Change axial bearing and gear
Broken cover or unreadable cover	* too high pressure or breakdown	* Change meter cover
Leakage from gasket	* loose gasket between water and gear	* Cleaning and meter test. chamber

6.4.6 MANNING, ORGANIZATION AND SCHEDULE

Several staff members were involved in meter installations during the Study. The experiences during the period indicate that the following staff combination would make a good team;

* 1 supervisor
* 2 technicians
* 2 labourers

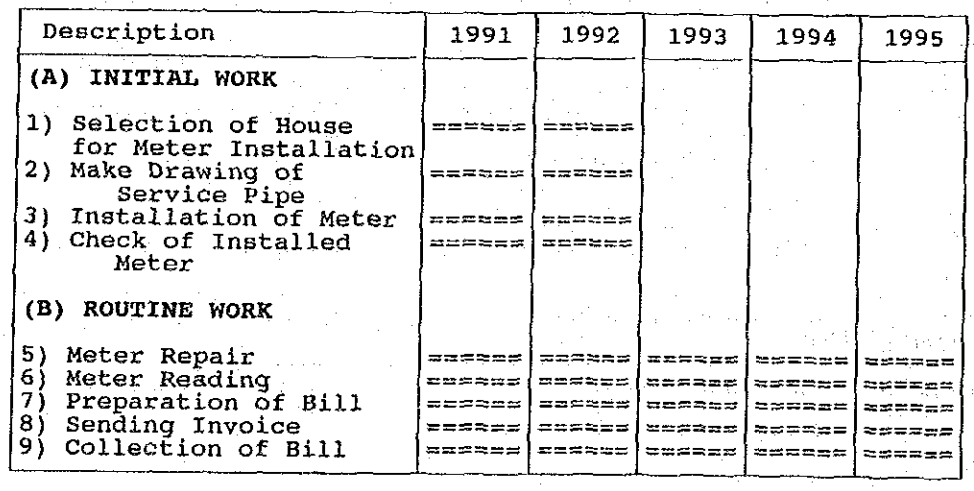
Based on meter installation work during the study, the time frame required for meter installation can be calculated as follows:-

Assuming 6 meters can be installed in 1 working day, 6 meters x 25 days x 12 months = 1,800 meters per year by one team. Five teams will be able to install 15,000 meter in two years.

After completing meter installation, it should be reported to the distribution department and the meter reading section in order that pipe ledger work, drawings/maps renewal and computerization of water bill be made.

Meter reading need to be carried out regularly. The time required for a meter reading greatly depends on the relative location of houses. Since large users are not scattered in the city, but are instead concentrated in specific areas, ten readings per hour would not be an unrealistic figure if appropriate transportation is provided. If commuting time to and from the sites is excluded, the time available in a working day is five hours. Then 300 days or ten months will be required for reading 15,000 meters. Hence ten meter readers are sufficient in the case of monthly reading and five in the case of bimonthly reading.

FIGURE 6.15 METERING SCHEDULE



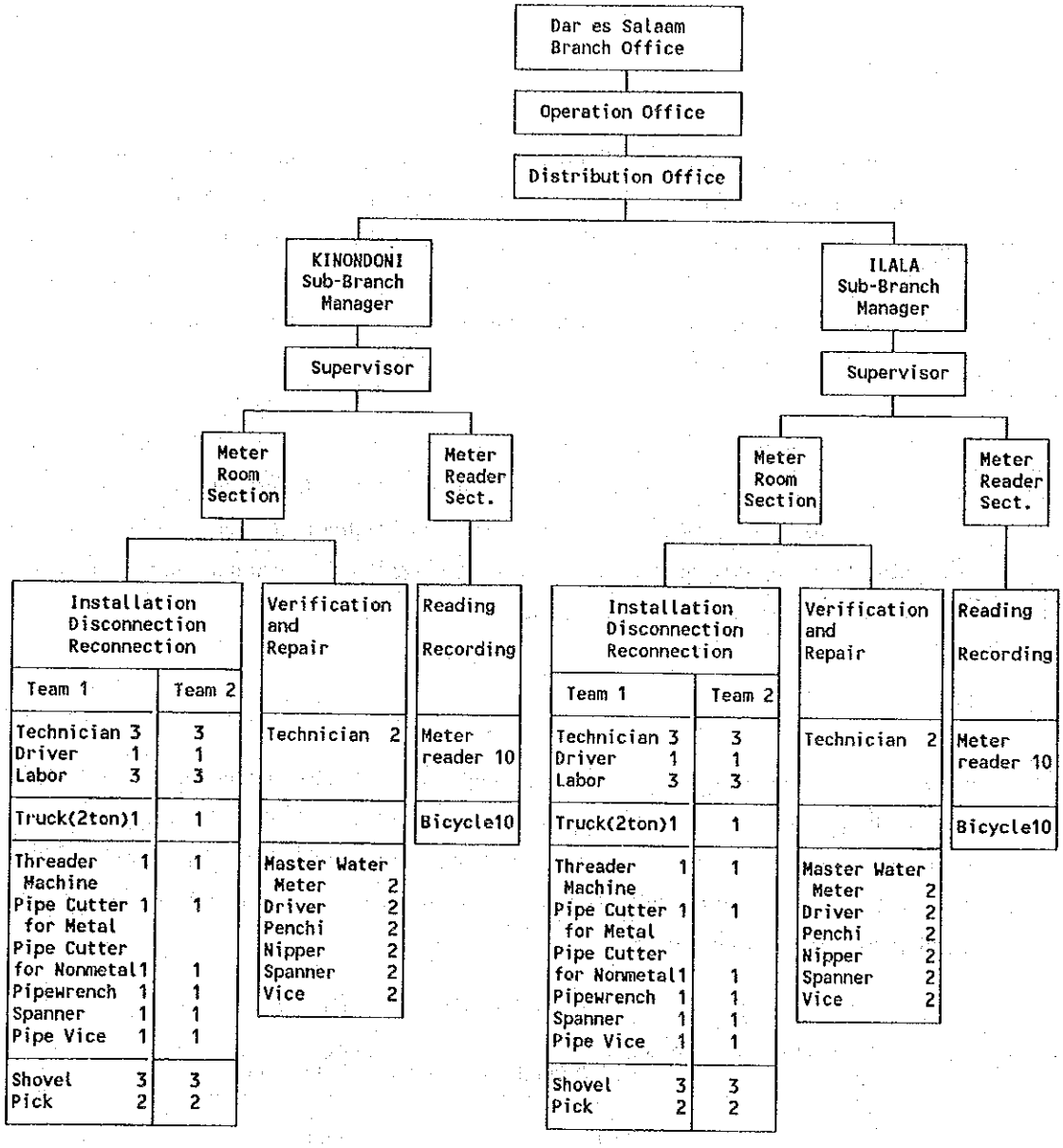


FIGURE 6.16 MANNING AND EQUIPMENT FOR THE METERING SYSTEM

6.5 PIPE CLEANING

6.5.1 AIR SCOURING *

(1) GENERAL

Before water of an acceptable quality can be delivered to the consumer, the large amounts of accumulated silt must be removed from the mains. Although flushing -- the traditional method of cleaning loose deposits from water mains -- will remove appreciable quantities of silt, low pressures in the network mean that flushing velocities will not be high enough for effective cleaning. Among the various alternative methods for cleaning small diameter mains such as swabbing, air scouring and scraping (refer to section 2, Appendix E), air scouring is proposed.

Air scouring is a technique to generate flushing velocities in the mains in excess of those obtained by conventional flushing. Injection of air increases the velocity of water, which suspends and removes all loose deposits in pipes. At the time of air scouring, all valves and fire hydrants, including their chambers or access pits, should be rehabilitated where possible and replaced where necessary. Drawings should also be updated during the air scouring exercise.

(2) EQUIPMENT

Air scouring involves continuous injection of filtered, compressed air into a water main with a small continuous water flow to generate an increased water velocity which is greater than the minimum velocity required to suspend particulate matter of specific gravity 2.7 (a typical value for deposits). The minimum velocities and flows are shown in Table 6.8. Air is injected at a rate of 0.9 m^3/min for 100 mm pipe and at 2.5 m^3/min for 150 mm pipes.

TABLE 6.8 VELOCITY AND FLOW REQUIRED

PIPE DIAMETER (mm)	VELOCITY REQUIRED (m/s)	FLOW REQUIRED (m^3/min)
75	1.60	0.43
100	1.80	0.90
150	2.20	2.46

(Source: Technical Report, TR 179, WATER RESEARCH CENTRE)

The equipment required is a fast towing packaged unit including air compressor, after-cooler and filtration/control unit (see Figure 6.17). The size of the compressor increases with increase in pipe diameters

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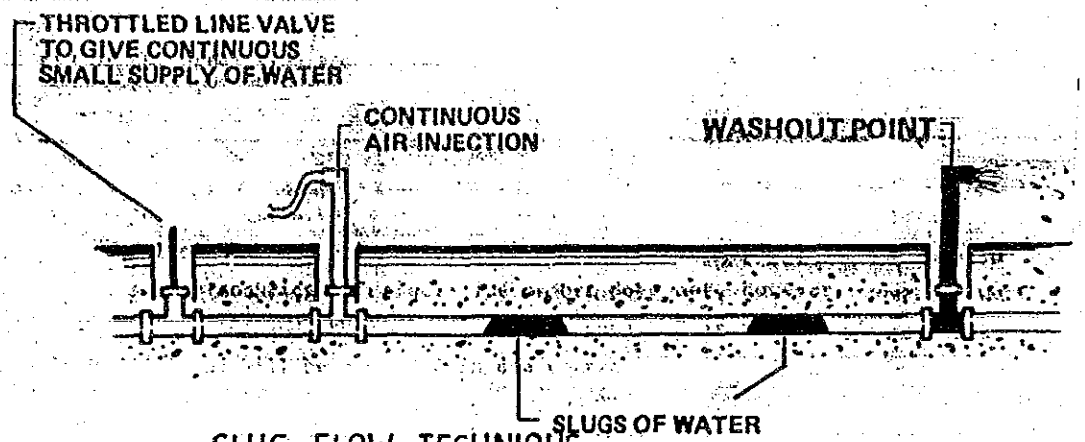
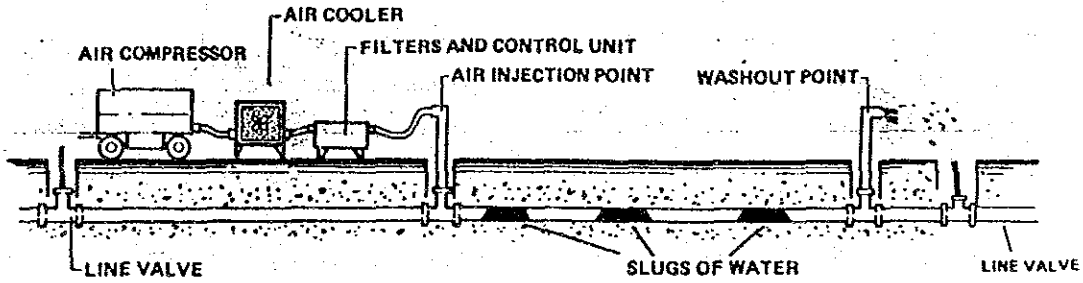
* Details are explained in section 3, Appendix E.



SLUG FLOW TECHNIQUE



ARRANGEMENT OF EQUIPMENT

FIG. 6.17	SLUG FLOW TECHNIQUE AND ARRANGEMENT OF EQUIPMENT

and pipe lengths. Typical sizes of air compressors for different pipe diameters are as follows;

Air Compressor size	38 l/sec.	59 l/sec.	118 l/sec.
Pipe diameter	75-100mm	100-150mm	150-200mm

(3) PREPARATION

Air scouring needs careful planning to prevent problems such as; 1) air or dirty water entering other parts of the distribution system, 2) valves, hydrants, or wash-outs not operating correctly or not being positioned according to the distribution maps and 3) consumers complaining of the operation.

Whenever possible, air scouring should be done in a systematic manner to ensure that a pipe being cleaned draws water from previously cleaned pipes. The distribution network should be checked to determine the accuracy of the plans.

The length to be cleaned at any one time should be determined and injection and discharge points decided upon. Any valves or hydrants needed during the air scouring exercise should be inspected to ensure correct operation and if found to be faulty, it should be repaired or replaced.

Consumers should be informed in advance of the cleaning exercise. Generally, a two-stage warning is used. The first would be a letter or card giving general background details of the work. This warning would go out one to two weeks before the cleaning is to take place. A second warning should be sent to the consumers shortly before cleaning takes place, indicating when not to draw water.

Air scouring is normally done during the day as manning is generally cheaper and the problem of disturbance caused by the compressors can be minimized.

A schedule of valve operations for a complex area is often useful to ensure the smooth running of the operation.

(4) LENGTH

Pipes to be air scoured are those of metal and less than 150 mm in diameter since 1) loose deposits are built-up in pipes with low velocity and 2) pipes that are less than 150 mm in diameter generally have low velocities in DSM. The total length of such pipes is 418 km, from the inventory of the distribution network. Such pipes are mainly cast iron pipes. Table 6.9 shows the distribution of pipes by diameter and year of installation.

The length of main which can be effectively air scoured depends on four factors:-

1) Static water mains pressure - at the start of the air scouring exercise, the injected air pressure is set 0.5 bars below the measured mains static pressure. This should prevent the pressure in the main rising above the static pressure and prevent air traveling backwards along the main. The length of main which can be air scoured increases with increasing static pressure.

2) Friction - the air injection pressure required to produce slug flow of sufficient velocity will increase according to the headloss developed along the pipe. Therefore, with the maximum available pressure, the length of main which can be effectively cleaned decreases with increasing friction in the pipe.

3) Compressor size - increasing the compressor size will generate higher slug velocities in a particular main. The higher velocities would, however, generate a greater headloss.

4) Pipe gradient - to set up slug flow downhill requires more water entering the length being cleaned than when setting up slug flow along a horizontal pipe or a pipe running uphill. The extra water causes an increase in headloss and therefore, with a limited availability of water pressure, the length of main which can be successfully air scoured downhill is less than uphill.

It is possible to determine this length knowing the available static pressure, estimating the friction factor. The maximum length is normally about 1000 m. For planning purposes, 300 m is adopted considering that fire hydrants are located at an average interval of 300 meters in the three model areas.

TABLE 6.9 LENGTH OF DISTRIBUTION PIPE (ϕ < 150 mm) IN DAR ES SALAAM IN 1990

(Unit: meter)

Dia. (mm)	Material	PIPE LAID YEAR -60	61-65	66-70	71-75	76-80	TOTAL
150	Steel(GP)	0	0	400	0	0	400
150	Ductile iron	0	0	0	5,445	600	6,045
150	Cast iron	68,470	7,350	23,995	19,760	5,705	125,280
125	Cast iron	250	0	1,875	0	0	2,125
100	Ductile iron	0	0	1,550	0	0	1,550
100	Cast iron	86,090	26,975	47,620	47,770	17,265	225,720
75	Steel(GP)	0	0	5,500	6,650	0	12,150
75	Cast iron	12,000	4,825	23,500	3,760	0	44,085
50	Cast iron	350	0	0	0	0	350
Total (50 - 150 mm)		167,160	39,150	104,440	83,385	23,570	417,705
Total (100 - 150 mm)		154,810	34,325	75,440	72,975	23,570	361,120

(5) PROCEDURE

Having set up the equipment, an air scouring exercise can then be divided into four main steps:

1) Measuring the static pressure and setting the pressure regulator to below the static pressure.
2) Driving all of the water out of the main.
3) Setting up slug flow.
4) Dismantling the equipment after the main has been cleaned.

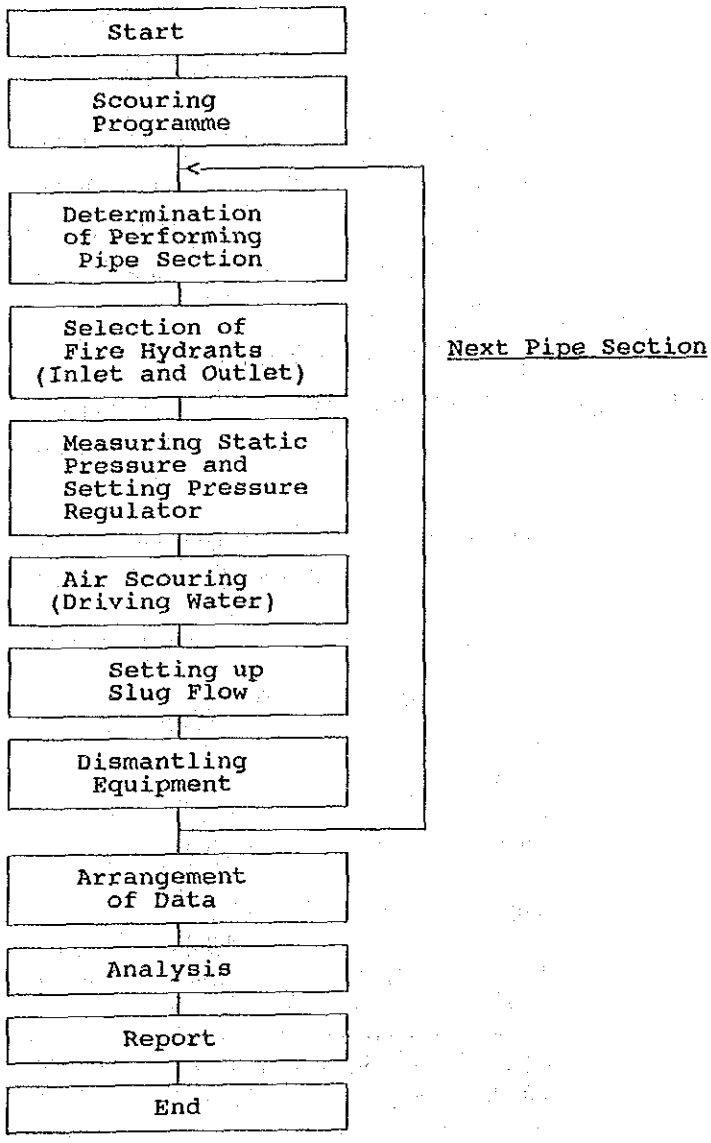


FIGURE 6.18 AIR SCOURING FLOW CHART

(6) MANNING

The ideal air scouring team should consist of three technicians: two technicians initially to offload the equipment and set it up, one of which then becomes the control unit operator, whilst the second alters the valves in the system to suit the particular length of main being cleaned. Meanwhile, the third technician sets up the discharge hydrant which must be securely wedged as the discharge from it can be particularly forceful during air scouring. This third man then observes the hydrant and decides when the correct flow exists. It is essential that the three technicians can quickly communicate with each other, preferably by direct radio contact, either over the water undertaking's main radio or by portable radios on a separate frequency. The latter may be more efficient particularly when the main radio is busy. In addition, three labourers and one driver are also to be allocated to one team.

(7) SCHEDULE

It is difficult to determine how much of the distribution system could be cleaned by one team. Nevertheless, it is estimated that one team could perform 1 length each day, i.e., 300 meters per day.

Preparatory work usually involves checking and repairing fire hydrants/valves. If one week is assumed for preparatory work at the site and air scouring itself, the time period required for about 418 kms of pipeline are 418 km/300 m/week = 1,400 weeks = 27 years. To complete the air scouring exercise by 1995, six teams, consisting of 3 technicians, 3 workers and one driver are proposed. Figure 6.19 indicates overall schedule of air scouring while Figure 6.21 shows an organization where an organization for scraping and lining is also included.

FIGURE 6.19 AIR SCOURING SCHEDULE

Description	1991	1992	1993	1994	1995
OVERALL PREPARATION					
Procurement of Equipment	===				
Set up Air Scouring Team and training of Team	======				
Check of distribution network (under leakage control)	======				
Perform Air Scouring including following site preparation; (1.Determination of length per one performance) (2.Check valve & Hydrant) (3.Repair or replace faulty vale & hydrant) (4.Inform to consumer)		======	======	======	======

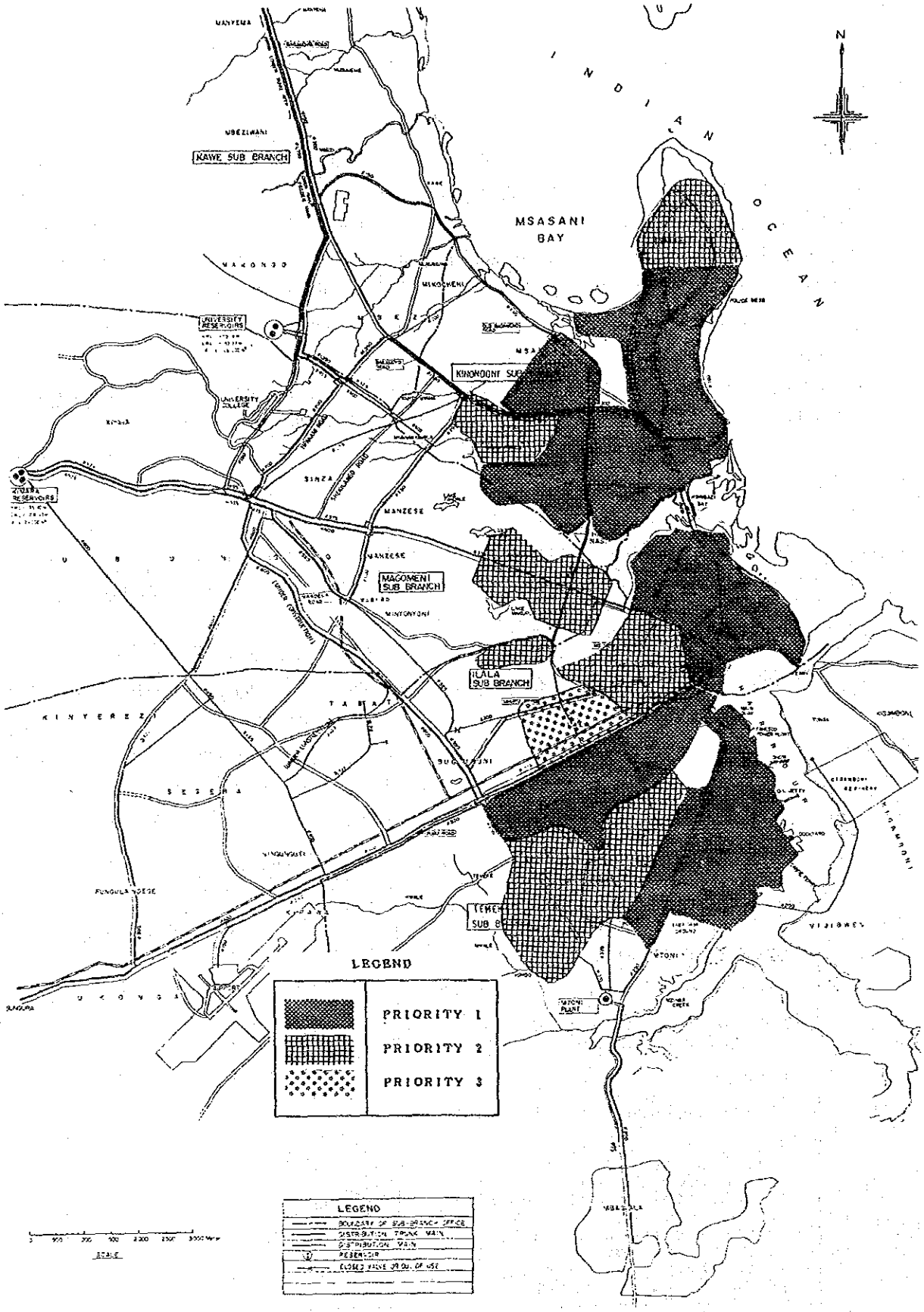


FIG. 6.20	IMPLEMENTATION ORDER OF AIR SCOURING

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

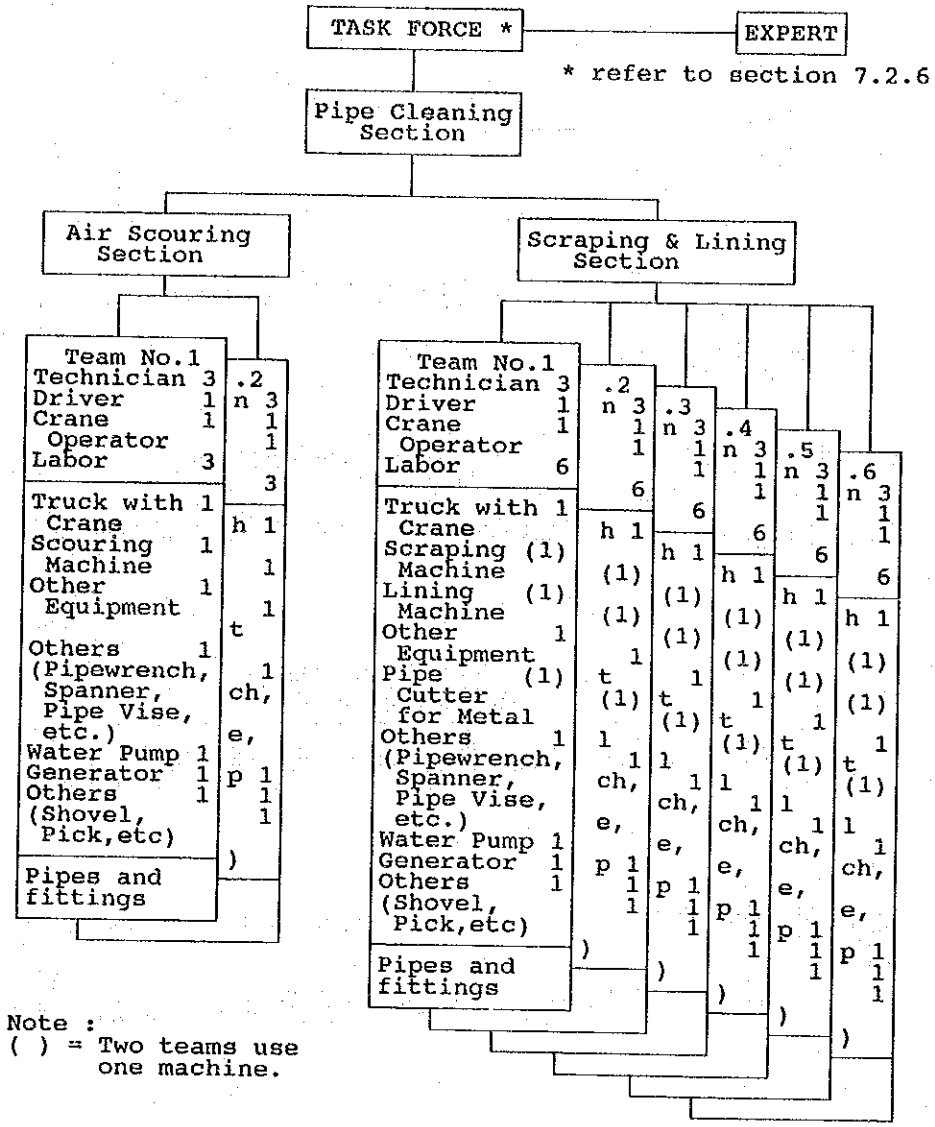


FIGURE 6.21 MANNING AND EQUIPMENT FOR PIPE CLEANING

6.5.2 SCRAPING AND LINING [1]

(1) GENERAL

Scraping will be required to remove hard encrustations in the pipe, even though this will involves excavation, since pipes have to be removed every 100m or so. Re-lining should also be carried out. Otherwise, scraping increases internal corrosion rates considerably.

1.refer to Appendix E.3

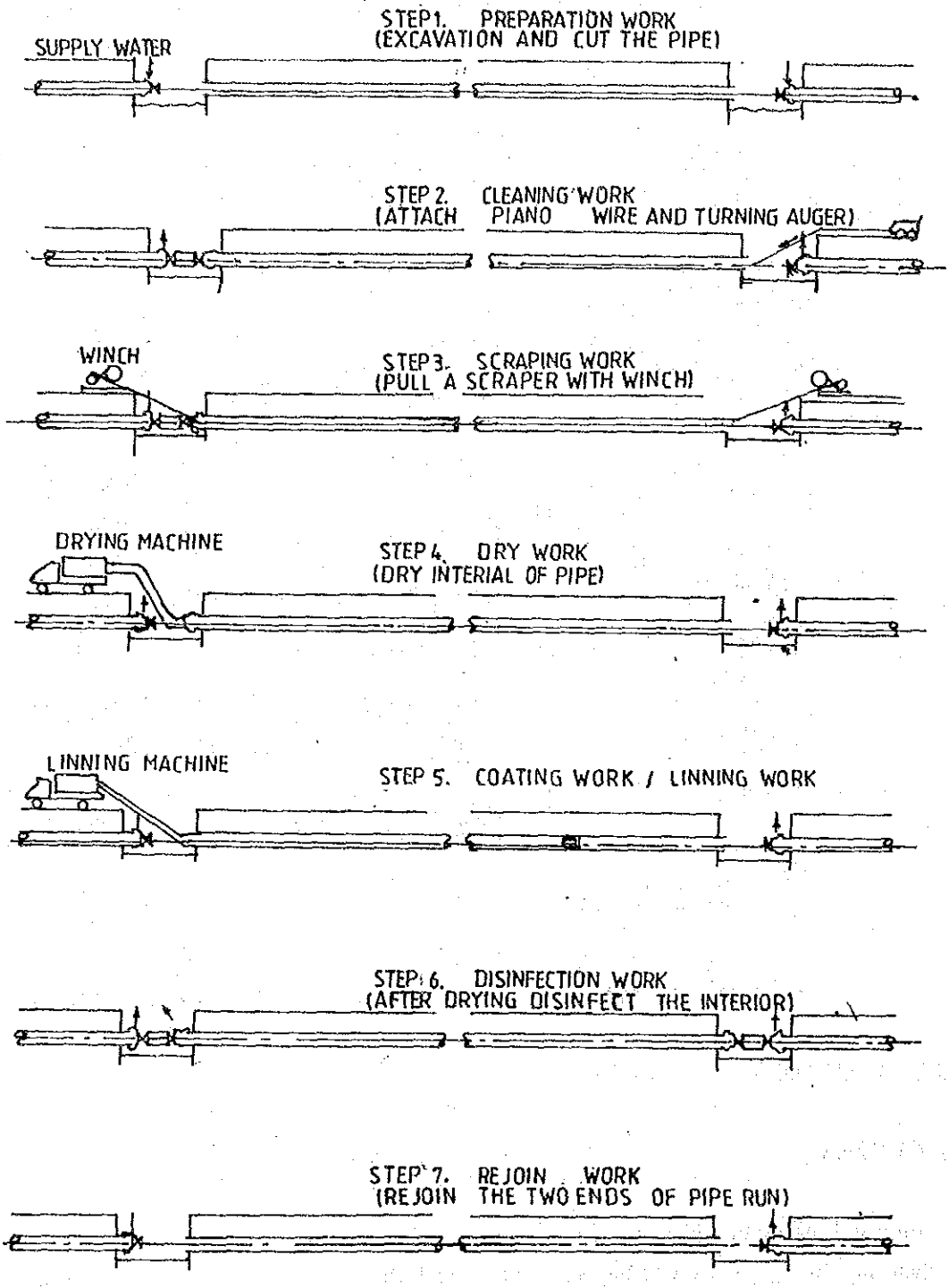


FIG. 6.22	SCRAPING AND LINING METHOD

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

Cement mortar or epoxy-resin will be used for relining, after initially power boring and/or drag scraping the internal sections, as is shown in Figure 6.22. Cement mortar lining is considered economically in spite of the following disadvantages;

a) Water must be suspended for a few days during including lining work and the mortar curing period. In case of epoxy-lining, this will be within a day.
b) Less adhesive lining and less abrasion resistance is resultant as compared with epoxy-lining.

The cement-lining method has the following advantages as well:

a) Lining can be done in the wet condition.
b) It can be expected to plug small holes.
c) It also can be expected to prevent the corrosion of pipe itself from alkalinity.

Since it is impossible to line specials for T junction and cross points, pipes shall be cut before the junction of each point. After lining, new pipes and new specials shall be connected with renewed pipes.

(2) LENGTH

Sections requiring scraping are cast iron pipes 150, 125 and 100 mm in diameter and at least 25 years old. Pipes less than 75 mm in diameter are not considered for scraping and lining, because they are usually very difficult to reline and hence, it may be more cost-effective to replace such sections with 100 mm diameter pipes, depending on the total length of such pipes.

According to the pipe inventory, the total length of pipes which have been laid before 1965 is 189 km. The older pipes have naturally been laid in developed areas as shown in Figure 6.5.3. In the Kinondoni sub-branch area, there are 70 kms to be cleaned, out of a total length of 189 kms. The Magomeni sub-branch area does not require any pipe cleaning, since there are relatively new pipes in this area.

The length that can be scraped and lined depends, to some degree, on the capacity of machine. However, the maximum span is less than 100 meters from a practical point of view, and hence the span to be used is determined to be 80 meters, on average.

(3) MANNING

One team should do only preparation work at sites, while two other teams should carry out the cleaning work. The following is the personnel required for one team.

* 1 Engineer * 3 Technicians * 3 Worker * 1 Driver * 1 Operator

(4) PROCEDURE

The following are the major steps (see Figure 6.23):

a) Selection of the section to be lined

b) Excavation and removal of pipes at the two ends of the section.

c) Attachment of piano wire and turning of the auger.

d) Initiation of scraping with winch.

* Swabbing the encrustation with scraper pulled from the winch.
* Squeezing the swabbed loose deposit with a plunger, made of rubber.

e) Drying.

f) Lining.

* Spraying cement mortar into the inside of the pipe.
* Finishing the surface of cement mortar lining to maintain the original thickness with mortar board, which is arranged at the top of the lining machine.

g) Curing.

* Drying after covering the edge of both sides of the lined pipe section with plastic sheet.

h) Disinfection work and dismantling equipment.

(5) SCHEDULE

Scraping and lining should be started from heavily rusted pipe sections, having large amounts of deposits. This is usually common in old pipes. Figure 6.24 shows the order of implementation.

Two sections can be scraped and lined by one team with one machine. It is assumed to take one week for two pipe sections, including;

- one day excavation and removal work,
- one day cleaning and scraping work,
- one day lining work,
- one day dry or curing period
- one day joint work with new collar joint.

One year is allocated for general preparatory work and four years for scraping and lining a total length of 189 km.

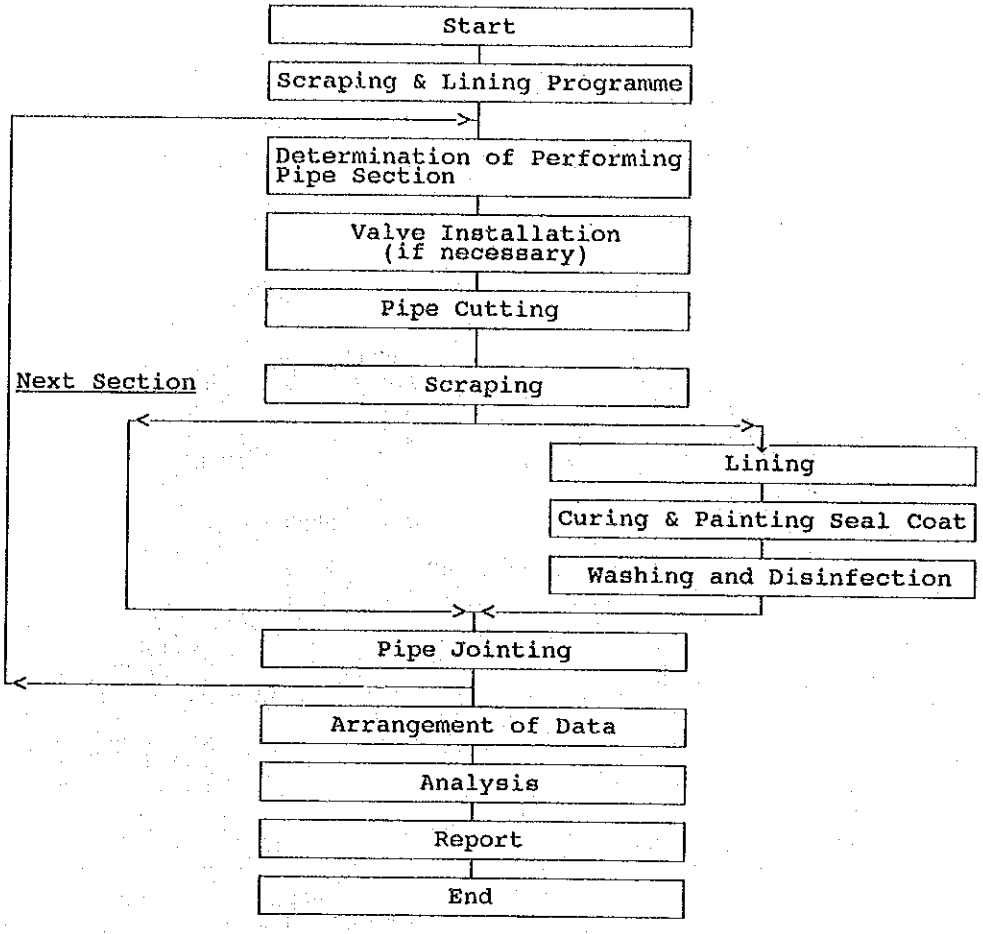


FIGURE 6.23 SCRAPING & LINING FLOW CHART

FIGURE 6.25 SCRAPING AND LINING SCHEDULE

Description	1991	1992	1993	1994	1995
OVERALL PREPARATION					
Procurement of Equipment	===				
Set up and training of Team	======				
Check of distribution network (under leakage control)	======				
Conduct scraping & lining * including following site preparation; (1.Determination of length per one performance) (2.Check pipe) (3.Excavation and removal of inlet and outlet pipe (4.scraping) (5.curing) (6.lining) (7.after-treatment)		======	======	======	======

* 160 meters per week x 52 weeks x 6 teams = 49.9 km per year
189 km ÷ 49.9 km per year = 3.8 years ≈ 4 years

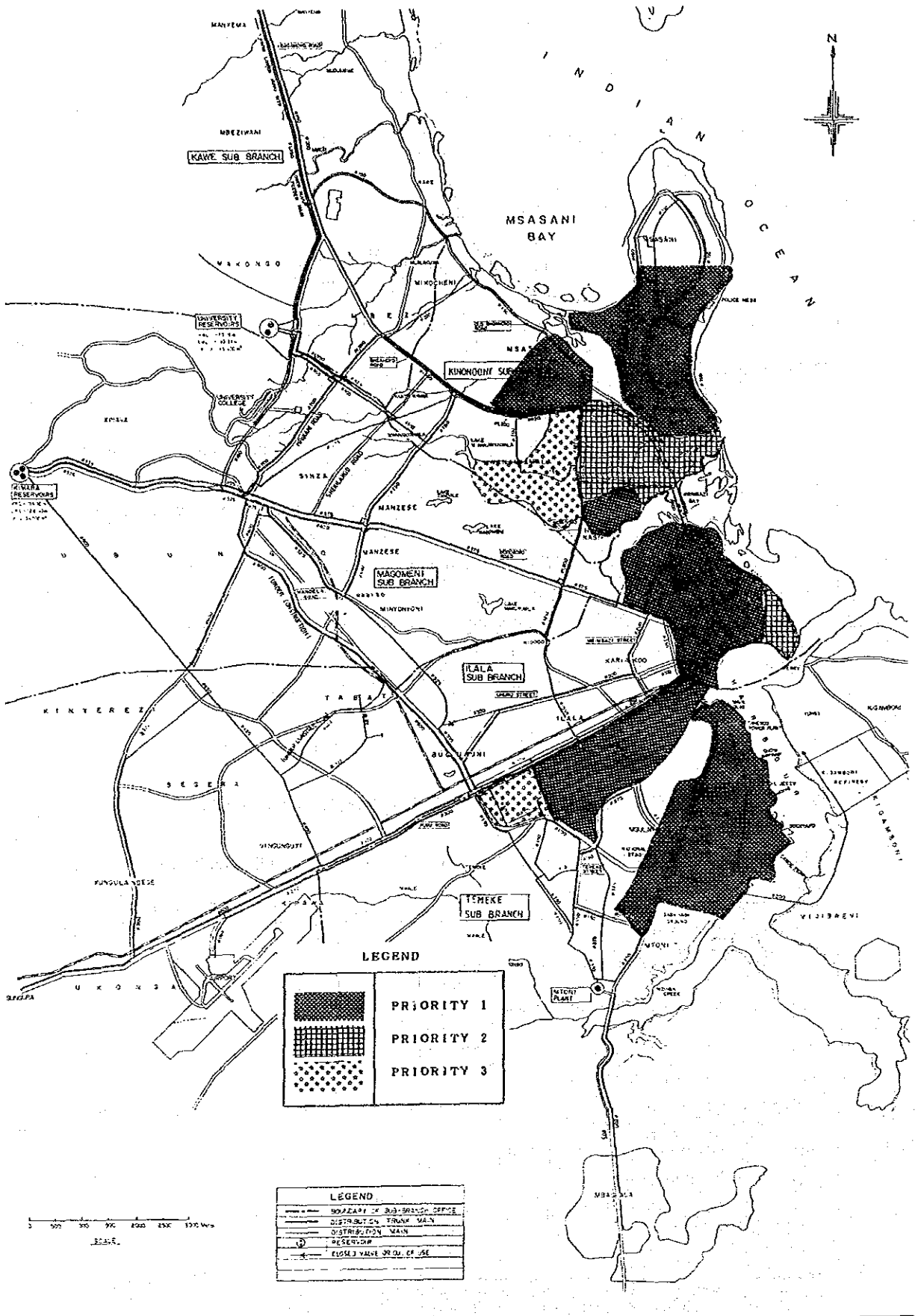


FIG. 6.24 IMPLEMENTATION ORDER OF SCRAPING AND LINING

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

CHAPTER 7

IMPROVEMENT PROGRAMME FOR NUWA

CHAPTER 7 IMPROVEMENT PROGRAMME FOR NUWA

7.1 ORGANIZATIONAL IMPROVEMENT

7.1.1 INTRODUCTION

This programme is specifically designed for the improvement of the DSMB.

An organization is established to perform the prescribed duty with which it is entrusted by interested parties. It consists of a system and staff. Both of the topics come under the category of management. Here, the need for demarcation of jurisdiction is discussed. Because most of the proposals needs approval from the higher authorities, they are listed in the long term suggestions.

Since the management has been adapting itself to cope with the changes in the environment without paying much heed to the organizational structure, it does not seem to be appropriate to advise any hasty restructuring of the organization within the NUWA. We put forward an introduction of two task forces, one for amelioration of the financial situation, and the other for leak detection, mapping and pipe cleaning teams.

7.1.2 NUWA -- ITS HQ AND DSMB

Urban water supply enterprises in the world are run by different types of organization. In Tanzania, the system is controlled by a parastatal organization, whereas in the UK it is run by private companies. Though it may sound as if privatization had gone too far, we have gone back only to the old norms of 17th, 18th centuries in London and Paris, where piped drinking water was supplied by the private companies. In many countries including Japan at present, local governments like municipalities or their cooperatives take charge of water supply enterprises. Their pros and cons will not be debated here.

Seeing NUWA at the mercy of the vicissitudes of economic turbulence, we would like to foresee NUWA's desirable setting within the administrative framework of the country because no branch office can be operated firmly without the sound existence of the headquarters. At this odd moment, when NUWA's organizational structure consists of one HQ and one oversized branch office, illusions that DSMB's performance was a direct logical consequence of the management style of the HQ may not be realistic.

It is quite clear that both have totally different perspectives in their activities: HQ for setting the national policy of planning, execution and monitoring of branch performances, which also include DSMB's, whereas DSMB is a local entity, taking care of the daily operation of facilities within its assigned serv-

ice area, and provide the HQ with feedback from its daily problem solving activities.

A brave director general would promote the status of NUWA, which is one of some 400 parastatal organizations by adopting an outward-looking approach, while a prudent branch manager would win public confidence in his service area by adopting an inward-looking approach with his 800 plus employees.

The director general should try to enhance the priority of NUWA in the list of SCOPO, by emphasizing its importance in supplying safe potable water to the population at an affordable price. By doing so, NUWA's base of maneuverability is enhanced so that it is allocated more foreign exchange. NUWA should be ensured status at least equal to other parastatals under the Ministry of Health. Good drinking water would serve to reduce the cost incurred in public health administration and in the prevention of disease. The branch manager would then be able to concentrate his efforts on improving the performance of the branch using more spare parts and chemicals, which would be more easily available then.

7.1.3 *LONG TERM SUGGESTIONS*

In a long run, NUWA has to:

1) demarcate the boundary of jurisdiction between:

a) HQ and DSMB.

HQ's involvement to DSMB would be limited to such special cases as execution of a project of sizable capital investment which is defined by UWASA like Rehabilitation Works of Upper Ruvu Treatment Plant or emergency assistance of daily operation like bailing out the financial department of DSMB from its plight.

b) Between DSMB and district water engineers of the Ministry of Water, Energy and Minerals in Kibaha and Bagamoyo.

The water supply enterprises of Bagamoyo and Kibaha in coastal region should better be under the control of two independent branches of NUWA, rather than to be under either of the district water engineers or of the sub-branches of DSMB. NUWA will allocate the quantity of water produced under DSMB management to the two towns and charge them for its cost.

2) establish a Branch Advisory Committee to encourage cooperation with the city council of DSM, which is yet free from resources constraints.

3) It would be high time that HQ gets sanction from the Ministry to oversee one of the five urban water enterprises which are to be under NUWA's jurisdiction sooner or later. Our choice is Morogoro; the scale of operation is small, but scales inside pipes etc. seem to be as much ratio as those of DSM; and it is conveniently located in the upper reaches of one of the two major tributaries of the Ruvu. So by

monitoring its activity it will give more information useful to formulate a water basin management of the Ruvu.

7.1.4 SHORT TERM PROGRAMME

1) As a short term remedial means to DSMB whose maneuverability has been hampered by financial constraint, we would like to recommend introduction of a "revenue normalization" task force as an emergency measures, which aims at, firstly, tackling the arrears of water bills and, secondly, finding the ways to reduce the number of illegal connections. It is discussed in the section 7.2.5.

2) Leakage control, pipe cleaning and mapping works in the rehabilitation projects of facilities will be organized into another "facilities rehabilitation" task force in order to minimize the structural impediments caused by the present organizational setup. The task force should be responsible to the BM directly. It is also discussed in the section 7.2.6.

7.2 IMPROVEMENT OF MANAGEMENT

7.2.1 PREAMBLE

This programme presupposes the two axioms mentioned below.

1) If the management of an organization does not understand the principles which govern the organization and its management system, then whatever their sub-ordinates do, whether they are right or wrong, does not contribute the improvement of the system as a whole.

2) On the other hand, existing policies, management practices and institutions are manifestations of the traditional cultural and social systems, as is written in "water resource management": OECD, 1989. So a casual observer needs time to scrutinize the situation with the help of people indigenous to the country so as to be able to decipher at least the basic norms of the society.

Management strives to create optimum relationship between a system and its staff. Corporate identity is a prerequisite. The management of NUWA may be able to make, for example, its DSMB's staff recite any appropriate corporate slogan every now and then or have them wear its corporate badge on the lapel of their suits as one of the means of infusing them with pep. But they have limits as to their utility. Without paying due attention to the welfare of the staff, their dignity or prestige as guardians of public health of DSM citizens would not be maintained. So, the responsibility to find the point of equilibrium between idealism and materialism is also a task for the management.

Though the problems defy solution, we try to bring clear-cut proposals for improvement. The proposals made in this chapter could be divided into two categories. The first consists of nostrums (water pricing policy, stopgap allowance and education of so-called work ethics) which are apt to either be overruled by the higher authorities or bugged down by lengthy discussions before getting approval for improved working environment. Hence, they are discussed in the long-term suggestions.

The second type of proposals could be put into practice at the discretion of NUWA alone. They are, therefore, elaborated further in the corresponding sections. The proposals are focussed on improvement of the management information system and customer relationship. Information channels are nearly choked with indifference like service pipes are with silt and scale. On top of that, whatever information they have is scattered. The proposals require more will power in the part of the staff than money to invest to the new system.

A staff-file has been created during this study period as a preliminary step to the improvement of the flow of information within DSMB and has been given a trial use in various sections of administration department and sub-branches. The file has proved to be useful.

As the next step, creation of a customer-file is proposed with relation to the formation of a task force whose objectives is to alleviate the deteriorated financial position of DSMB. We presume that it would be vital to the better functioning of the task force.

The proposals aimed at the betterment of the facilities have called for the strengthening of the present organizational structure and the middle level management staff, which is explained in section 7.2.6.

These improvement programmes would go hand in hand with the training programme, which are discussed in section 7.4.

7.2.2 WATER PRICING POLICY

(1) GENERAL

Water resources must be utilized economically so that the community concerned would get optimum benefits out of them. Any water pricing policy must reflect this principle.

A combination of user-pays principle with marginal cost pricing system would be an ideal solution to satisfy the preconditions. Though there are many obstacles in the prevailing reality, we have to go about establishing the best possible solution.

A pricing policy must also take account of the following aspects:

1) Equity: Household expenses of low-income households should be considered at the time of deciding the minimum charge.
2) Financial requirements: Clear-cut criteria must be set up for the amount of subsidy for capital expenditures by the water authority, so that it can act as the major determinant in formulating the pricing policy.
3) Consumer acceptability: The pricing system should, above all, be comprehensible to consumers.
4) Administrative costs: Gains in efficiency by adopting a pricing system must always exceed the increased administrative cost incurred by doing so.
5) Environmental considerations and other governmental policies: The pricing policy should be compatible with environmental considerations in the river basin from which the water resources are drawn, and it should also comply with general government policies.

(2) METERING

From the economic studies on metering carried out worldwide, we may draw a conclusion that universal metering would not be feasible. Besides, in the history of successive DSM water enterprises, maintenance and repair works of meters have not been encouraging.

Nevertheless, metering does produce a great impact on consumers. Many studies on metering have revealed that the impact has been considerable and quick, and at the same time, lasting. The fact is that it is most effective for external-to-the-house use, and the peak period of the daily use would lend metering more credibility. So target areas for the metering should be chosen carefully from the start. A higher return on meter installation with, naturally, stable water supply could be expected from some areas which have been getting windfall from the present fixed water rate.

The increasing block tariff system shall be introduced to the area where meters are installed, as it is based on the marginal cost pricing system.

7.2.3 MANAGEMENT

(1) GENERAL

1) One of the characteristics of the water enterprises is that it has no competition, so it tends to forget the existence of consumers, especially when it is under the management of the central government agencies.

All staff members of a water enterprise should realize that he/she is selling water. If a customer shows his/her dissatisfaction regarding water supply, he/she has to attend to the customer to remove the cause of complaint. The staff ought to realize that a leak plugged in the piping network or an inconvenience lifted from customers would be a gain to the enterprise. Management's ultimate aim would be the policy-making and to make employees perceive it. This is more important than mere transfer of technology. Education may sometimes develop these attitudes and perceptions.

2) One of the characteristics of rehabilitation project is its poor visibility. Rehabilitation is necessary as disorder in any system tends to increase if it is left unattended.

Keeping a system in good repair with patience is one thing, it is quite another to overhaul a system once neglected. It requires resources, including time. Yet when it is achieved, it usually doesn't have the proportional appeal it deserves. So people are apt to think that the value of the effort is not very much.

Our purpose is to live up to the meaning of rehabilitation so that disorder in DSMB will be reduced to an acceptable level. Without this process, the goal of integration of water and sewage enterprises of DSM stipulated at the beginning of International Drinking Water Supply and Sanitation Decade could not be achieved.

3) Management is a dynamic process, so the guidelines are of no use to the experienced management hands of the daily operation who believe in a certain value system but to the uninitiated. True infusion of new ideas, therefore, would only take place when the initiator of the new idea can completely convince the managers through daily contact at their workplaces that his proposals to change management systems would work. Friendly role playing cannot move men of conviction.

(2) A STARTING POINT

Considering the fact that management needs time to get accustomed to a new value system and that all the staff, especially low ranking staff have to cope with inflation caused by the economic restructuring process, and apart from any approach to reduce the schism between the management class and the employees, the only possible areas where we may at least be able to inflict damage to the vicious cycle of inadequate revenue, degenerating resources and poor services and to turn it into the virtuous cycle of good service, happy consumers and motivated staff are:

1) To convince all the employees:

a) that future salary raise sufficient to support his or her family could only be achieved by raising productivity, which would be the end product of their honest daily work with cost-conscious operational practice, believing in the bona fides of the management, that fair share of their efforts will be rewarded.

b) and that it is the right of all the employees to make use of time before and after office hours, whereas that it is an offense to use the equipment or materials which do not belong to them, for pecuniary gain.

2) To motivate staff that they could be of more use to the organization if they make common cause with each other with regard to the following activities, besides doing their daily job duties. These would contribute something vital to the organization, and hence to the community it serves.

i) Daily Activities:
a) reduce leakage.
b) detect illegal water connections.
c) reduce arrears of water bills.

ii) Formulation of Opinions on How to Introduce:
a) fairer and cost-effective tariff structure.
b) new easy-to-maintain, minimum-cost-recoverable public standpipes.

These will discourage free rides on the system, and at the same time, give the poorer sector access to the system with corresponding responsibility, and make DSMB's coffers less deficient.

The efforts on the part of the staff of DSMB ought to be rewarded monetarily by means of allowances. It should be independent from the basic salary scale, relatively more to the lower class staff of PGS and POS. If, for example, the amount of allowance is set in such a way that the combined monthly income of POS grade 3 (the lowest in NUWA's salary scale) is raised to T.Shs.6,000 and the allowance of PSS grade 2 (the highest) is zero, the amount needed is around T.Shs. two million per month. The HQ may feel obliged to recommend the arrangement to the SCOPO to get it approved, beside increasing its efforts to cultivate work ethics among the staff. A trial calculation is given in section 2, Appendix F.

The allowance should be linked to the performance in reduction of arrears of bills, conversion of illegal connections to legal ones, and reduction of leakage. This will result in more satisfaction for consumers as a whole, as well as for the staff of DSMB.

For effective rehabilitation work, initial stock of material and spare parts is also prerequisite. If there are no material/spare parts on hand, technicians, mechanics and artisans will not have any inner drive to work.

7.2.4 DATABASE FOR ADMINISTRATION DEPARTMENT, DSMB

At present, most of the information pertaining to the staff of the DSMB are found segmented in the files of different departments, sections; and files are neither centrally maintained nor coded or indexed,

which is one of the reasons for slow flow of inter-sectional communication.

Creation of a staff database is the first step to our attempt of writing job descriptions in the distribution and its related sections and this will further facilitate our effort to analyze jobs by providing basic information about the background of the staff members. At the same time, tactically speaking, this is one of few domains where we can expect some improvement in efficiency of administration at the moment.

In our first attempt, we have created three files, namely, basic information (job situation), background, and family. The first file consists of such fields as name, sex, unit, designation, job, and salary. The second is made up of birth date, entry date to the water industry, qualifications (educational and professional), and job history. The number of dependent members of family, present address, housing and commuting conditions form the third file.

Until all the names and the units they belong to are identified, the first two files will have to be kept merged into one file. For the time being, two fields, i.e., age and experience in the water industry substitute the birth date, and entry date to the industry; the pay roll status, which is recorded with grade, class and scale and pay-scale expressed in terms of Tanzanian shilling have been separately input, though there is a direct relationship between the two.

The advantage of introducing a relational database system is its capability of organizing files of different data and their easy updating. But the system cannot be a mollusc. It needs a structure. In order to set up the structure of the file, our first task has been to identify the name and the post of each staff. The difficulties we have encountered first are the facts that initials of a name are differently used in different lists. An example: Haji Omari in the pay-roll is Sultani Mkumburu O. in the training record.

The major part of inputting data took place just one month after the commencement of the 1990/91 fiscal year. It takes into account restructuring of the parastatal salary scale with the introduction of special and rare scales; promotion of the most of the employees, which has been suspended for some years, besides the annual entry of new employees. We have tried our best to incorporate these information into our database to make it most up-to-date, as well as comprehensive. The staff-file is given in section 1, Appendix F.

The hardware is powerful with a hard-disc of forty megabytes capacity. There will be a plenty of scope of utilizing it for strengthening the administrative ability of DSMB. Administration Department with BM's backup keeps the apparatus handy. The job of handling it may be commissioned to any secretary who is eager to learn the operation. A bright standard seven completed person can manage the job. In the first stage, the data processing manager of HQ, whose office is currently in the Gerezani Compound

will be solicited to help organize the training session. When the task force starts its operation, the hardware will also be used by its database unit.

7.2.5 ESTABLISHMENT OF A TASK FORCE

(1) TARGETS, PERIODS OF EXISTENCE AND PROCEDURES

Reduction of arrears of water bill is the primary target of the task force (TF); and conversion of illegal users into legal consumers is the secondary target.

The TF is a temporary establishment by definition and shall be dissolved either when both the amount of arrears and the numbers of illegal connections are reduced to manageable levels, and the regular staff concerned have learnt the importance of storing information for solving the problems or the end of the period of this project, whichever comes first.

Establishment of the TF is proposed within the framework of this project,

(2) ORGANIZATIONAL FRAMEWORK

BM
| <----- Advisory Committee (AC) to the TF
TF

The TF is to report directly to BM.
At the initial stage, the key staff of the team shall consist of:
Leader : A staff from Project Implementation Unit, Directorate of Planning, either an engineer or an economist.
Member: Meter Repair Foreman.
Chief Meter Reader.
A Senior Technician.
A Supply Officer.

AC to the TF will consist of :
Chairman: Director of Finance.
Advisor : an expatriate management consultant with two expatriate experts, one field worker majored in sociology, and one system analyst.
Department Heads.
JUWATA representative of DSMB.

The rationale of creating the TF is to avoid setting up a permanent additional unit to the existing organizational structure in which all the necessary sections and units are provided. Manipulating minor hierarchical changes here and there to any organization before the total system is analyzed would often bring more harm than benefit to the organization.

Proposed full-time staff of the TF except its leader are to be chosen from the present staff of DSMB. Establishment of the TF would neither jeopardize the routine work of the DSMB nor cause any friction among the staff of DSMB. They are not promoted to the member of TF. Nor are they going to give orders to the staff.

The TF will report to BM their findings about consumer-affairs, with the amount of money settled being paid through the normal channel of revenue section. All activities of the TF will be carried out by order of the BM.

First three staff members will do a similar type of job that they are doing in revenue section. Supply & store section will be benefitted as the supply officer in the TF will make flow of information faster than now, so that materials will be expedited.

The regular meeting of the AC would be held once a week. The posts of three experts are full-time jobs. They will work with the TF members, and will be responsible for keeping the database in- tact.

(3) DUTY

The TF shall be daily in contact with a certain number of householders who either have an unpaid water bill or an illegal water connection, and shall see to it that the bills and penalties to illegal connection are paid and the corresponding number of consumers increased, and shall put such acquired information into the database.

The AC shall set the overall strategy, collect information on the target households through the sub-branch concerned, analyze socio-economic, and political implications of the problems, and give the TF advice on how to approach them. A big debt itself exhibits power behind it. So it needs careful handling.

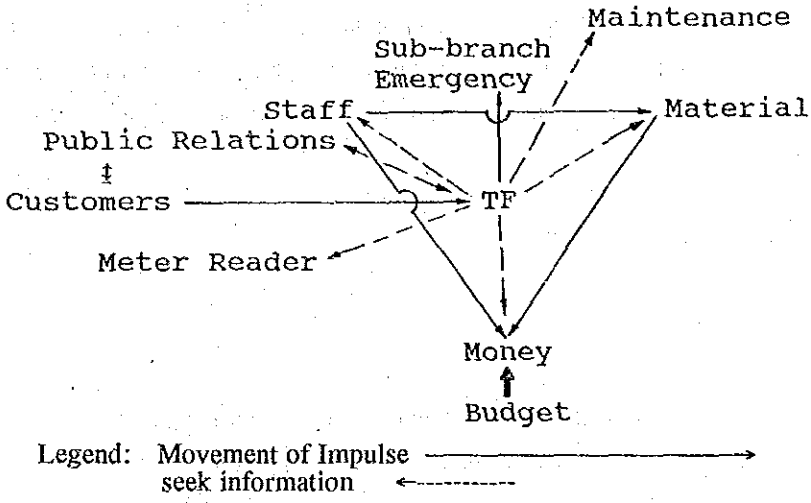
BM is visiting large arrears consumers for negotiation. Therefore, he himself has accumulated precious information on the matter.

In the normal course of events, some of the customers may demand the betterment of the service as a

condition of payment. The TF would have to look into the matter, to grasp the situation till the TF takes it well in hand and solves it as fast as possible, or to show the customers the time table for normalization.

The above mentioned activities could only be achieved when the TF functions as a hub of the information network of DSMB and to be able to respond the consumers' legitimate request precisely and promptly. The TF shall have a information network as well as stocks. When it will get the inputs from the consumers, it will trace all unsettled activities till they are completed. The diagram below shows the gist of it.

FIGURE 7.1 TASK FORCE IN DSMB



A database unit is an indispensable part of the TF. It consists of five record keeping sub-units, i.e. a) customer, b) maps and drawings for maintenance (this requires additional space to keep the originals) c) material/spare parts, d) staff, and e) budgetary control book.

As to the data on the customers, wrong information may be given at first; but something is better than nothing. If one keeps tracking and analyzing the existing data, one may come to know the nature of biased data, which can then be improved.

The TF operation will surely show up any bottlenecks, hidden overlaps and deficiencies in the structure of DSMB. Hence, the by-products of the TF operation will be:

1) Improvement of consumer relations.
2) Improvement in performance of routine maintenance.

We presume that the TF would be able to contact all the parties concerned within the five year project

life [1] and that it could solve 50 percent of the pending cases. Then, at the end of the project DSMB would still have to deal with about 32,000 illegal connections and the amount of arrears equivalent to 15 percent of the bills issued.

(4) FACILITIES AND EQUIPMENT

A room of some 30 square meters would be provided to serve for the office cum database unit of the TF in the Gerezani head office of DSMB for temporary use. Besides office equipment, a radio communication set and an extension telephone would be installed.

TF's database unit will be equipped with library facilities to keep files, copies of maps and drawings and a set of personal computer (T3000-SGT) with some software, and a copy machine, which will be presented by our team after the completion of this study. If a MO disc unit of ca.600MB capacity is added, the storing capacity is enough in the beginning. This system will not be connected to the billing computer system.

7.2.6 REHABILITATION PROJECT

(1) GENERAL

When time has come to carry out the rehabilitation project which is proposed by our team, the organizational structure and management system of the operation department ought to be strengthened. The detail description of the teams which are engaged in the rehabilitation projects is given in chapter 6. Here the human resources aspects are discussed.

A certain amount of system changes and increase in number of staff would be envisaged, though not drastic in nature, with the introduction of the following works:
(a) leakage control, (b) mapping, (c) pipe cleaning and (d) metering

In the present organizational structure, a leakage detection team is formed in the maintenance unit of each sub-branch and a survey section is under the project department. Daily routine maintenance work occupies the chief of the distribution section. Therefore, in order to ensure smooth operation of the rehabilitation works, we would like to adopt a task force system also in this case in coordinating the first three rehabilitation activities. The TF will cease to function after the project is over. The jobs carried out by the TF will continue to be done by the corresponding units of the distribution and survey

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1. 64,000 illegal connections/5 years = 13,000/year = 45/day = 9/day/sub-branch

sections. The necessary number of the staff selected or recruited will be assigned to the corresponding unit, and the remaining staff may go to other units with their newly acquired knowledge and skill.

If the library of maps and drawing is located at the survey section of the project department, the information channel between sub-branches must be kept open so that each sub-branch could update the library with the incessant inclusion of new connections or changes.

Total requirement of human resources, except labourers, is given below. We shall discuss their availability in section 7.4.

TABLE 7.1 PERSONNEL REQUIREMENT FOR REHABILITATION PROJECT

(Unit: Person)

	ENGINEER	TECHNICIAN	SURVEYOR/ DRAFTSMAN	DRIVER	CRANE OPERATOR
1.Leakage control	4	74 (24)*2	0	14	11
2.Pipe cleaning	2	24 (24)	0	8	8
3.Mapping	1	0	8 (6)	0	0
4.Metering	0	36*1 (0)	0	4	0
TOTAL	7	134	8	26	19

*1 including 12 meter readers.
*2 figures in ( ) shows required number of recruitment in "technician" and "surveyor/draftsmen" categories.

(2) TASK FORCE FOR LEAKAGE CONTROL, MAPPING AND PIPE CLEANING

(a) Leakage Control Section

Realignment of technical staff from the leak survey teams attached to the five sub-branches to the newly formed leakage control section would take place. So a new line of order and information flow should be clearly established between the TF and sub-branch managers before setting the programme in motion.

Recruitment of four engineers at a same time may be met with shortage of applicants. As a second-best short term solution, a section engineer with three FTC holders as in-charges of three units under him would be more plausible. The number of technicians in the maintenance unit of five sub-branches including members of the leak survey team totals around 100, and requirement of technicians to this section amounts to 74. So 50 would be chosen out of existing 100 and remaining 24 be recruited on the assumption that the routine maintenance work at the sub-branches can be carried out while such rehabilitation works as leakage control and pipe cleaning are going on.

(b) Pipe Cleaning Section

The section consists of two units, air scouring and scraping & lining. Filling of all the posts for two engineers and 24 technicians will depend on recruitment.

(c) Mapping Section

The section requires one engineer and eight surveyor/draftsmen. Three draftsmen and a survey assistant are posted at the survey section, project department. One or two draftsmen may be transferred to this section. If the rest and an engineer, not available, a FTC holder in civil engineering would have to be recruited.

(3) RE-INTRODUCTION OF METERING

15 thousand meters will be connected in some service areas of both Ilala and Kinondoni sub-branches during the project life. 24 technicians and 12 meter readers are required in the second year of the project. There are 40 technicians assigned to the meter room of the sub-branches and there are 22 meter readers at the sub-branches. So there won't be any difficulty in assigning the required number of them to the job.

(4) SUPPORTING STAFF

26 drivers and 19 crane operators are required. At present, the transport section consists of about 30 drivers. In the Pugu Road compound under the transport officer, besides, several drivers are directly assigned to treatment plants and sub-branches. Though the number is more than that in the car pool, it is not enough to cover our needs. Hence, it may be necessary to recruit some 15 drivers. It is difficult to find drivers who can operate cranes in DSM. Nor is there a pay scale for a driver cum crane operator post in NUWA. Hence, all the crane operators might have to be recruited from vocational training centres.

(5) MAINTENANCE SECTION

(a) A Unit for newly brought Instruments

For the maintenance and repair of those instruments which will be used at the rehabilitation project, a new unit ought to be organized in the maintenance section, and suitable workshops may be provided and a necessary FTC class technical staff in mechanical trade would either be retrained or recruited. Without sensitive testing instruments, it may not be possible to repair such equipments there, so emphasis is to be given to the ways of careful handling of the instruments, their daily maintenance procedure according to the directions written in manuals, and identification of causes of breakdown.

(b) Maintenance and Repair of Meters

As was the case with both the meter room and the meter reader units, the organizational structure for this operation exists. The unit is under the workshop supervisor within the framework of the maintenance section. Due to the present circumstances, only a meter repair foreman, who is in charge of the unit, and a repairer is on the staff list. Hence, the required number of repairers would have to be recruited in due course.

7.3 IMPROVEMENT OF FINANCE

7.3.1 FINANCIAL REQUIREMENT

According to the study on pricing of water and related services carried out by OECD's Environment Committee, financial requirements on pricing policies in OECD countries are reported:

> "Whilst water management authorities were not usually required to cover all economic costs of their operation (resources, capital and operating), they are often required to cover a substantial proportion of their financial costs (usually operating costs and at least a proportion of their capital costs)".

Financial requirement of water management authorities vary with different types of water undertakings, however, the degrees of financial requirement are classified into followings:

- revenue from water users should cover operating costs
- revenue from water users should cover operating costs and debt service
- revenue from water users should cover operating costs, debt services and capital costs

NUWA is a parastatal organization and is required to be operated at the break even, as regulated in the "Urban Water Act". The revenue from water sale should be adequate to finance operations, including capital expenditure. The requirements on NUWA is the severest of the three classifications above.

Actually NUWA did not operate as per this requirement, except in 1988/89 fiscal year (refer to section 3.3.3 in Chapter 3).

For the improvement of NUWA under the existing water supply system, the following are the principal measures to which special attention should be paid:

- reduction of water production costs
- reduction of water losses through leakage
- reduction of illegal water connections

- reduction of bad debts
- meter installation
- tariff revision to meet the financial requirement

7.3.2 FINANCIAL FORECASTS OF NUWA

Financial forecasts of NUWA are prepared to cover the period up to 1999/96 in Table 7.2. The costs and revenue from the proposed rehabilitation projects are not included in the forecasts.

TABLE 7.2 FINANCIAL FORECASTS OF NUWA DSMB
(1990/91 - 1995/96)

(Unit: T.Shs.million)

	1990/91	91/92	92/93 (Budget)	93/94	94/95	95/96
INCOME						
OPERATING INCOME						
WATER CONSUMPTION	1,023	1,738	3,251	4,234	5,541	7,194
DOMESTIC	315	535	1,001	1,303	1,706	2,217
INDUSTRIAL	435	739	1,381	1,801	2,355	3,061
COMMERCIAL	166	282	528	687	900	1,166
INSTITUTIONAL	107	182	340	443	579	751
OTHER OPERATING INCOME	45	50	94	125	166	220
TOTAL OPERATING INCOME	1,068	1,788	3,345	4,359	5,707	7,414
REQUIRED REVENUE TO BREAK EVEN	1,041	1,117	736	961	1,242	1,644
TOTAL INCOME	2,109	2,904	4,081	5,320	6,948	9,058
EXPENDITURE						
OPERATING EXPENSES						
SALARY AND WAGES	58	68	80	93	109	128
CHEMICAL EXPENSES	976	1,302	1,708	2,241	2,940	3,856
REPAIR & MAINTENANCE	63	82	106	138	180	234
POWER COST	461	615	807	1,059	1,389	1,822
OTHER EXPENSES	0	1	1	1	1	1
TOTAL OPERATING COSTS	1,558	2,068	2,702	3,532	4,620	6,041
ADMINISTRATIVE EXPENSES						
DAR ES SALAAM BRANCH	88	108	133	165	204	254
DEPRECIATION	156	207	270	353	462	604
PROVISION OF DOUBTFUL DEBTS	307	521	975	1,270	1,662	2,158
TOTAL EXPENDITURE	2,109	2,904	4,081	5,320	6,948	9,058
TARIFF INCREASE TO COVER THE FUND REQUIRED TO BREAK EVEN		* 90%	32%	33%	32%	33%

* Tariff revision at 68% is not included in 90%.

Basic assumptions underlying the financial projections are as follows:

REVENUE

- Revenue from domestic consumers are expected to increase at a rate of 3.5 %, which is in line with the projected population growth.
- Revenue from commercial, institutional and industrial consumers is projected to increase at 3.5 % per annum. (average growth rate of GDP at 1976 constant price during last five years)
- Water tariff is projected to increase at the rate of 68 % from 1st July 1991.
- Water production and demand are taken into account, which is explained in detail in "Water Demand Analysis".
- Unaccounted for water (illegal connections and bad debts) is assumed to remain at the same level as in 1989/90, during the period (1990/91 - 1995/96)

EXPENDITURE

- Projection of operating expenditure is based on 1990/91 budget levels.
- Salary and wages are projected to increase at 17 % per annum (average increase rate of minimum wages during the last five years)
- Chemical and power costs are projected according to the estimated volume of net water supply every year and inflation at the rate of 30 %, which is the average inflation rate during the last five years.
- Other operating expenses are expected to increase at 30 % per annum.
- Concerning administrative expenses of the DSMB, salaries and other expenses are assumed to increase at 17 % and 30 %, respectively. The expenses of HQ are not included in the forecast.
- Depreciation is assumed at 10 % of total operating costs.

From 1992/93 to 1995/96, the annual tariff increase required is assumed to amount to 32 % of the level of previous year, if the resources required to break even are to be covered by tariff increase. The increase rate of tariff is almost the same as the assumed inflation rate. The tariff increase rate required in 1991/92 amounts to 158 % (68 % + 90 %) against present tariff, as the tariff revision was not approved from July 1, 1990. The approval of revision is often delayed or is granted at lower level than that requested to cover increases in water production costs by water management authorities.

7.3.3 FINANCIAL IMPROVEMENT PROGRAMME

Financial performance of a water management body can be improved by raising operating efficiency and reducing water losses. By detecting and repairing physical leakage, financial performance can be improved, However, a great deal of water loss is due to administrative programmes such as illegal connections and lack of an efficient billing and collecting system.

The rehabilitation projects have been studied from both facility improvement and administrative improvement viewpoints. In this section, the impacts of the proposed projects on the financial condition of NUWA DSMB have been reviewed.

(1) REDUCTION OF LEAKAGE AND REVENUE INCREASE

From the rehabilitation projects for the facilities, water losses are expected to reduce as illustrated in Figures 7.2, 7.3 and 7.4, and the figures are given in Table 7.3.

TABLE 7.3 WATER PRODUCTION AND WATER LOSSES IN 1990 AND 1995

(Unit: m^3/day)

	1990	1995 WITHOUT PROJECT	1995 WITH PROJECT
Water Production	296,000	271,000	271,000
Water losses by leakage			
Transmission pipes *	103,000	72,000	68,000
Distribution pipes	67,000	80,000	51,000
Wastage	9,000	12,000	0
Total of Water Losses	179,000	164,000	119,000
Consumption excluding wastage	117,000	107,000	152,000

* including consumption in Kibaha and Bagamoyo districts.

In 1995, water loss by leakage is expected to decrease from 164,000 m^3/day to 116,000 m^3/day by implementing the rehabilitation projects. Accordingly 45,000 m^3/day of water is saved.

(2) ILLEGAL CONNECTION AND BAD DEBTS

It is estimated that there are 63,000 illegal connections in DSM and 30 % of total billings were not collected in 1990.

Water revenues lost due to illegal connections and bad debts will be estimated at T.Shs.485 million and T.Shs.521 million *, respectively, taking into account of 65 % of tariff increase, in 1991/92 fiscal year. The total revenue lost amounts to T.Shs.1,006 million, which will be almost equivalent to the estimated deficit (T.Shs.1,117 million) for NUWA to break even in 1991/92, as shown Table 7.2.

Table 7.4 shows the forecast of income collected, including the incremental revenue resulting from the proposed Project by adopting the "Basic Case".

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* including the proposed tariff increase of 68 percent.

FIGURE 7.1 WATER PRODUCTION AND WATER LOSSES IN 1990

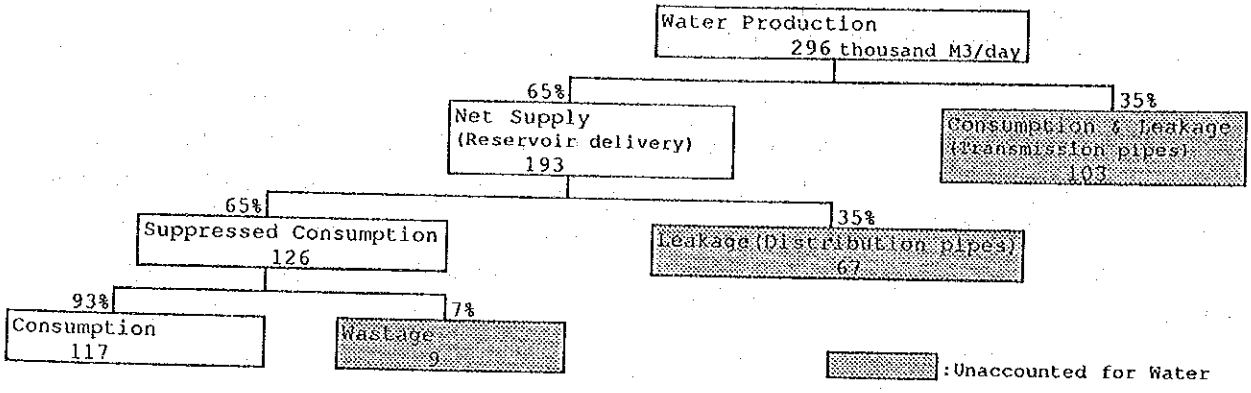

FIGURE 7.2 WATER PRODUCTION AND WATER LOSSES IN 1995

- Without the Project -

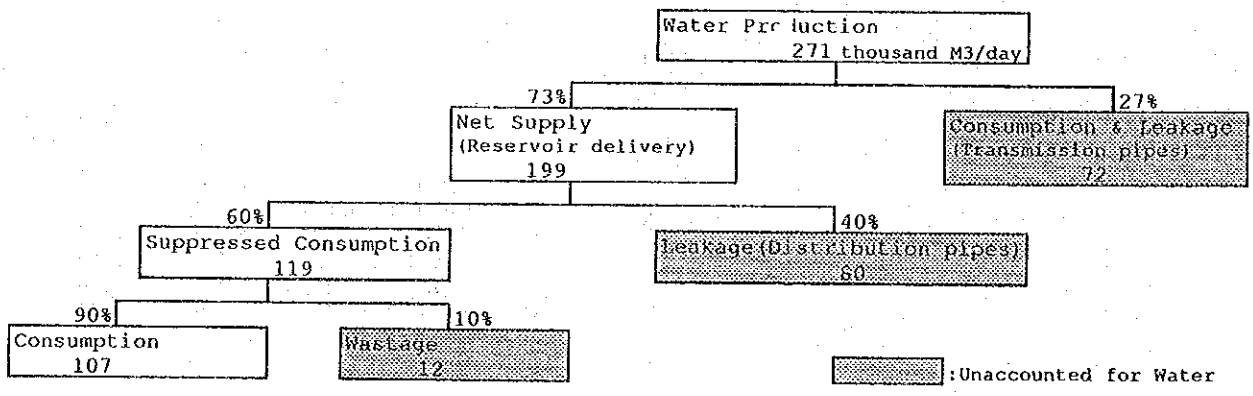

FIGURE 7.3 WATER PRODUCTION AND WATER LOSSES IN 1995

- With the Project -

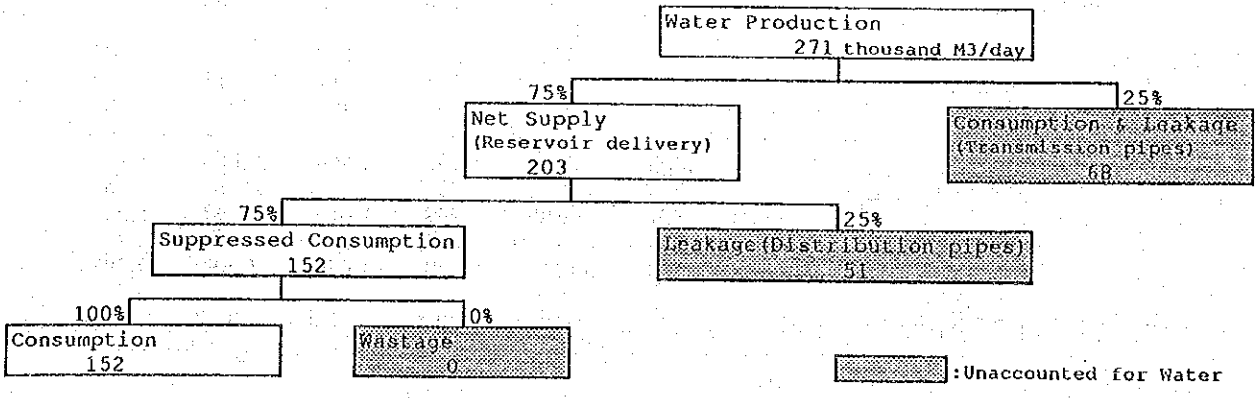

TABLE 7.4 ESTIMATED REVENUE COLLECTED FROM WATER CONSUMPTION
(Unit: T.Shs.million)

	1991	1992	1993	1994	1995
Revenue collected without the Project	1,217	1,198	1,178	1,159	1,140
Increased Revenue collected with the Project	115	354	578	780	977
	1,332	1,524	1,756	1,947	2,117

Financing of the proposed project has been estimated on two assumptions in "Financing Plan" in section 6.4, Appendix D. One is subsidized by grants and another is by soft loans. In order to estimate the forecast of NUWA with the Project, the grant case is adopted and the remainder of the capital costs, including the local currency portion, is assumed to be locally financed by long-term loans according to following conditions:

- Interest rate 15 % per annum
- Grace period 5 years
- Payment period 10 years

TABLE 7.5 FINANCIAL FORECAST OF NUWA DSMB WITH THE PROPOSED PROJECT
(1990/91 - 1995/96) (Unit: T.Shs.million)

	1990/91 (Budget)	91/92	92/93	93/94	94/95	95/96
INCOME						
OPERATING INCOME						
WATER CONSUMPTION	1,023	1,846	3,876	5,041	6,457	8,113
DOMESTIC	315	606	1,414	1,959	2,599	3,378
INDUSTRIAL	435	762	1,512	1,895	2,369	2,909
COMMERCIAL	166	291	578	723	906	1,110
INSTITUTIONAL	107	187	372	465	583	716
OTHER OPERATING INCOME	45	50	94	113	136	163
TOTAL OPERATING INCOME	1,068	1,896	3,970	5,154	6,593	8,276
REQUIRED REVENUE TO BREAK EVEN	1,040	1,161	408	494	610	1,031
TOTAL INCOME	2,108	3,057	4,379	5,649	7,203	9,307
EXPENDITURE						
EXPENDITURE WITHOUT PROJECT	1,802	2,383	3,106	4,050	5,286	6,900
TOTAL OPERATING COSTS	1,558	2,068	2,702	3,532	4,620	6,041
ADMINISTRATIVE EXPENSES	88	108	133	165	204	254
DEPRECIATION	156	207	270	353	462	604
PROJECT COST	0	165	325	514	775	1,207
OPERATION & MAINTENANCE		96	125	162	211	274
INTEREST OF LONG TERM LOAN			94	194	356	504
TOTAL PROJECT COST (a)	1,802	2,548	3,430	4,564	6,061	8,107
PROVISION OF DOUBTFUL	30%	28%	25%	22%	18%	15%
ARREARS (b)	307	509	949	1,085	1,143	1,201
TOTAL EXPENDITURE (a)+(b)	2,108	3,057	4,379	5,649	7,203	9,307
TARIFF INCREASE TO COVER		*				
THE FUND REQUIRED TO BREAK EVEN		90%	20%	20%	20%	20%

* Tariff revision at 68% is not included in 90%.

The annual tariff increase required for NUWA to break even, would decrease from 32 % without the Project (refer to Table 7.2) to 20 % with the Project. It is lower than the estimated inflation (30 % per annum), and slightly higher than the estimated increase rate of minimum wages (17 % per annum).

7.4 TRAINING PROGRAMME

7.4.1 TRAINING NEEDS

Training institutions and curricula have been well established. As far as the basic techniques or skills are concerned, generally speaking, all the staff have sufficient basic training to carry out their daily operation and maintenance duties.

Yet as of today, in the sub-branches, many experienced technicians have been reaching retirement age, whereas not all vacancies are filled. At the same time, the number of qualified staff is decreasing. These facts reveal the problems concerning recruitment as well as training, and we share in NUWA's concern over them.

Apart from the normal trade training background of the staff of sub-branches in general on the one hand and the need to provide each sub-branch with vital maps, drawings and records on the other hand, such works as more vigorous leak detection using higher technology equipment seem to be a rather tall order to the total present work force qualitatively, and maybe quantitatively, if we consider improvements in routine maintenance and new connection work.

There is obvious need of specific training to fill a simple form of skills gap at class rooms and on the job sites. This may suffice for the short term solution before subjects are taught at the WRI as far as trade skills are concerned. But it is quite another matter as far as the long-term is concerned.

7.4.2 CONTENTS

There are some factors beyond simple filling of the skills gap. If one does not understand the relationship between the accomplishment of one's duty and its consequences to the total system and to the customers, or if one doesn't identify with one's job in terms of the total system of supplying water, the gains which DSMB has got from this technical cooperation might be short lived, though the direct contact of both ways of thinking while the supervising team is at work will remain.

Till we are able to let the staff grasp the essential nature of system and to make them realize that they are an indispensable element of the system, transfer of culture will not be completed. This aspect is beyond the matter of training in trade, but of the matter of education to a new culture.

Fortunately we have Canadian example at hand. CIDA's training programme has three stages, job analysis, preparing manuals of operation and maintenance at Lower Ruvu treatment plant, then training of the staff. This is not a sequential event. Three activities go on side by side; there always have been interim or transitional phases, even now. A result or a finding from one activity will be fed back to the other two. Some of the staff of DSMB have been involved in the process for many years.

We shall follow the Canadian example, and while we are going to engage in a short-term rehabilitation project, we would initiate a job analysis as a beginning of long march to the amelioration of staff performance level.

As the primary aim of our study is for the betterment of the distribution system, we shall refrain from delving into all the contextual factors * surrounding the distribution section in relation to the training aspect of the staff of the section. We deal with the maintenance section and some related supporting units, but we do not want to confuse things in the units like financial department, which have been getting advice from other aid institutions.

In short, this section will mainly be about filling skills gap which is to be encountered with when we get going on this rehabilitation project. Unlike improvement in organization and management in which problems are manifold, filling skills gap is rather straightforward. Yet it isn't free from elements which may cause delays in cashing in the benefit of training. Hence, while running training courses on the subjects of purely technical nature by the experts who will personally oversee the actual rehabilitation project (see section 7.4.5), we have to curtail at the same time the influence of such major culprits as nominal job descriptions, lack of clear internal communications. Therefore we propose starting a programme to write specific job descriptions for the distribution section (see section 7.4.3). Meanwhile, more precise and timely management and operational information would be exchanged more frequently than before through internal communication network, if the management takes up the proposal made in section 7.2.

One more suggestion, which is apparently out of scope of training of the staff of DSMB but still we feel is relevant in relation to recruitment, is that DSMB may consider taking up apprenticeship schemes. It may contact the WRI and take a certain number of apprentices from the final year students of its FTC course to begin with, after getting approval from the Ministry; then gradually extend its scheme to students of DTC and of the engineering department, University of DSM with the concerned ministry's approval.

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* Some of the factors out of bound of the training concept like work ethics and economic adjustment allowances as a counter measure to activate the state of lack of motivation in the part of the staff is discussed in section 7.2.