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REGIONAL CENTRE FOR THE PROMOTION OF ENVIRONMENTAL PLANNING AND APPLIED STUDIES (PEPAS)
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MISSION REPORT

Subject	:	National workshop on operation and maintenance of water supply and sanitation systems
Place visited	:	Manila, Philippines
Dates of mission	:	15 - 25 July 1992
Authors and designations	:	Mr T. Dafoe, Water Quality Management Adviser, WHO (PEPAS) Mr B. Fisher, Sanitary Engineer, WHO(PEPAS)
Title of project	:	WHO Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS)
Participating agencies	:	Department of Health Government of the Philippines World Health Organization
Source of funds	:	Regular budget

Key words

Water supply - operation, maintenance, workshop / Sanitation - operation, maintenance, workshop

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WORLD HEALTH ORGANIZATION
REGIONAL CENTRE FOR THE PROMOTION OF ENVIRONMENTAL PLANNING AND APPLIED STUDIES (PEPAS)

EXECUTIVE SUMMARY OF A MISSION REPORT

Messrs T. Dafoe and B. Fisher Authors	Manila, Philippines Place visited	15 - 25 July 1992 Dates of mission
RS/92/0119 Report series number	WP/ICP/RUD/001/RB/92 Project identifier	01.203.DT.01 & 02 Activity codes

Objectives of mission:

To collaborate in a national workshop with the following objectives:

(1) to review and identify institutional, human resource, financial and technical aspects and constraints affecting the efficiency and effectiveness of the water supply and sanitation sector;

(2) to present possible strategies for the implementation of operation and maintenance programmes;

(3) to present techniques of common use in the operation and maintenance of water supply and sanitation systems;

(4) to discuss financial issues linked to sustainability of water agencies; and

(5) to formulate exchange of information amongst national agencies aiming at the improvement of mechanisms of cooperation.

Summary of activities, findings, conclusions and recommendations:

The workshop on operation and maintenance of water supply and sanitation systems was held from 20 to 24 July 1992 for 28 participants. During the workshop, in addition to the technical papers presented, the participants identified constraints in the sector leading to poor operation and maintenance and formulated recommendations and action plans to carry out after the workshop. The recommended actions covered virtually all management aspects of operation and maintenance in the sector. In addition to these plans, the following recommendations were made:

(1) A cost-benefit analysis should be carried out to determine whether fluoridation of the water supply should be recommenced using the existing facilities of the Water Treatment Plant.

(2) An engineering study of the Magellan Sewage Treatment Plant should be undertaken to determine the measures to be taken to make the plant operational.

(3) Preventive maintenance procedures at both the above water and sewage plants should be established and implemented.

(4) A working group of the agencies responsible for water supply and sanitation should be formed to address the remedial measures identified and ensure action is taken for their implementation.

Key words: Water supply - operation, maintenance, workshop / Sanitation - operation, maintenance, workshop

CONTENTS

1. PURPOSE OF MISSION

The mission was undertaken from 15 to 25 July 1992 within the framework of collaboration of the World Health Organization (WHO) Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS) in providing technical services to Member States. It was carried out in response to a request from the Government of the Philippines for consultant services in conducting a national workshop on operation and maintenance of water supply and sanitation systems. The activity was covered by an exchange of correspondence dated 18 March 1992. WHO provided local costs amounting to US$4 000 and the services of two staff members from PEPAS.

The workshop was held from 20 to 24 July 1992, and had the following objectives:

(1) to review and identify institutional, human resource, financial and technical aspects and constraints affecting the efficiency and effectiveness of the water supply and sanitation sector;

(2) to present possible strategies for the implementation of operation and maintenance programmes;

(3) to present techniques of common use in the operation and maintenance of water supply and sanitation systems;

(4) to discuss financial issues linked to sustainability of water agencies; and

(5) to formulate exchange of information amongst national agencies aiming at the improvement of mechanisms of cooperation.

2. BACKGROUND

The course was organized as a follow-up activity to the Regional Workshop on Operation and Maintenance of Water Supply and Sanitation Systems held in PEPAS from 6 to 10 May 1991. During this Regional workshop, several participants considered that national workshops should be held in their own countries with WHO collaboration, to provide additional depth of training in all aspects of operation and maintenance that apply in their respective countries.

3. ACTIVITIES AND FINDINGS

The participants at the workshop were comprised of senior engineers and project managers from the five national agencies dealing with water supply and sanitation in the Philippines as follows:

	No. of participants
Department of Public Works and Highways	6
Local Water Utilities Administration	2
Department of Interior and Local Government	3
Metropolitan Waterworks and Sewerage Systems	2
Department of Health	15
Total:	28

Engineers M. R. Agdeppa and R.D. Tuason ably acted as facilitators for the workshop and Engineer J.M. Riego de Dios was chairman throughout the proceedings. The Director, Environmental Health Service, Department of Health, Dr W. Asoy opened the workshop and the Undersecretary of Health, Dr M. Roxas gave an early closing address and conducted a discussion session on required actions during the morning of the last day of the workshop.

A list of officials contacted is presented in Annex 1.

The workshop programme was jointly formulated with the Department of Health in advance of the assignment and is given in Annex 2. Additionally, at the outset of the workshop, participants were asked to write down their expectations from both the workshop, and all the participants. Evaluations of the results actually achieved were also prepared by the participants after the fourth day of the workshop.

Following the opening ceremony and the introduction of participants and resource persons, representatives of the Metropolitan Waterworks and Sewerage Systems, Department of Public Works and Highway, Department of Interior and Local Government and the Department of Health gave an overview of the operation and maintenance activities supported by their own agency. Following these presentations, Mr Fisher gave an overview of operation and maintenance problems in the WHO Western Pacific Region. Mr Dafoe then provided a background paper on strategies for implementing operation and maintenance programmes.

The workshop participants then split into two groups to summarize the main problems in both technical and institutional aspects of operation and maintenance in the water supply (group 1) and sanitation (group 2) sectors together with suggested remedial measures.

The main technical problems in the water supply sector were encountered in locating adequate water sources, defective distribution systems and major constraints in carrying out effective treatment processes. Institutional problems identified were inadequate and delayed funding, training problems and various management constraints. A basic need of remedial measures proposed was increased funding. It was considered that economies in training activities could be achieved by integrating some of the water related training activities carried out by the different agencies, thus avoiding redundant inputs.

Problems identified in the sanitation sector were:

(1) laxity in enforcement policies

(2) funding constraints

(3) poor implementation of plans

The identification of problems and remedial measures served as a guideline for the remainder of the workshop and the formulation of plans of action.

On the second day of the workshop, presentations on technical aspects of operation and maintenance were made. These included sessions on water treatment and sewage plants, reticulation systems, preventive maintenance, metering, cost-benefit analysis and leakage control. Cost-benefit analysis was described in relation to varying operation and maintenance costs and initial capital costs, and with respect to metering of water supply systems. At the end of the day, the aspects of operation and maintenance which should be observed during the field trips scheduled for the next day were described.

On Wednesday morning, 22 July, La Mesa Water Treatment Plant was visited. Many examples of inadequate operation and management were evident at this plant including defective instrumentation, inadequate preventive maintenance, unattended-to repairs and poor records. The management system for plant maintenance, whereby maintenance staff are based elsewhere in Manila, appears inefficient. Fluoridation of the supply had been discontinued some years previously because of the expense of materials although the equipment is still in working order.

During the afternoon, the sewage treatment plant for Magellan village in Manila was visited. This facility was found to be in extremely poor condition and was not operating as an activated sludge process because of the failure of several pieces of equipment. This plant had been turned over to the Metropolitan Waterworks and Sewerage Systems for operation approximately one year previously, after having been operated by the Ayala Corporation for 20 years. It now requires extensive renovation to become operational and is a good example of how prolonged poor operation and maintenance can lead to plant failure and expensive rehabilitation.

The formal sessions on Thursday were preceded by a short presentation by one of the participants on the progress towards achieving the expectations of the workshop participants. In general, it was concluded that the activities planned over the next two days would complete the work required to meet the workshop objectives and the participants' own expectations.

The opening session on Thursday, 23 July consisted of group discussions on operation and maintenance aspects of the treatment plants visited on the previous day as well as on the responsibilities of community water supply and sanitation agencies in the Philippines. Emphasis was made on identification of areas of overlap and possible future collaboration and improvement. Plenary discussions were then held on remedial measures required to improve operating standards at the plants and coordination of the various agencies. The recommendations on the treatment plants emphasized the need for development of a decentralized operation and maintenance programme including retraining of staff on standards and skills including preventive maintenance. Records and process testing should be improved considerably. An extensive discussion was held on possible areas of collaboration and improvement of operations of the various agencies. Collaboration on training activities, planning of programmes and logistic support were identified as the main areas for joint programmes.

In the afternoon, technical presentations were resumed covering maintenance of handpumps, water quality monitoring, sanitary surveys and mangement of information systems.

A presentation by Ms P. Enriquez, Head of the UNDP/World Bank supported International Training Network for Water and Wastewater Management in the Philippines, commenced on the final day of the workshop. The main tasks of the International Training Network are as follows:

to inform decision-makers and to educate and train practicing and student engineers and other field staff, in the use of low-cost appropriate technologies and approaches;

to promote the introduction of a multidisciplinary approach emphasizing sociocultural and health considerations in the planning, implementation, and maintenance of water supply and sanitation systems;

to support the collection and active dissemination of information on low-cost technologies and their successful applications; and

to undertake research leading to further improvements in the cost-effectiveness, large-scale implementation, and replication of basic water supply and sanitation programmes.

Activities are mainly directed at training on appropriate low-cost technoloiges, dissemination of information, applied research and promotion of sociocultural and health considerations in the planning implementation and maintenance of community water supply and sanitation projects.

Following this presentation, two technical papers on Demand Management and Priority Projects on Community Water Supply and Sanitation were presented.

The Undersecretary for Health, Dr Roxas then conducted an open discussion period on problems in the water and sanitation sector. The main problems identified in this session were:

(1) No actual data is available on the number of level 1 (point sources) facilities.

(2) The Department of Interior and Local Government's involvement in the sector is confined to only areas in Luzon.

(3) There is no involvement of the Department of Health in site selection.

(4) The Department of Health's representatives were not normally informed of meetings of the provincial development councils in advance.

(5) Spare parts, tools and equipment were too often unavailable.

(6) Sanitary inspectors had difficulty in disinfecting wells because of lack of tools.

(7) Water analysis results were often submitted very late thus greatly reducing their value.

(8) There is no inventory of functional and non-functional level II (communal faucet) schemes.

The Undersecretary urged the participants to consider these problems when forming their action plans.

The participants then prepared their action plans in their respective agency groupings. During the final session, the main problems were listed and solutions, responsible agencies and completion date targets were identified. It was decided that the participants should form a core group with the responsibility of promoting the remedial measures proposed.

After the discussion period, evaluation forms of the course implementation were collected and summarized. The participants unanimously agreed that the workshop had been well run, the technical material appropriate and the workshop objectives and expectations had been achieved. Two participants considered that more time would have been preferable.

The workshop was finally closed at 6.15 p.m. following various votes of thanks.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

During the workshop, the participants each prepared action plans to implement activities to solve or alleviate problems identified during the discussions. Based on these proposals and the evaluation of the workshop carried out by the participants, the workshop was a useful exercise which will serve as a basis for improved operation and maintenance of water supply and sanitation facilities in the future.

4.2 Recommendations

The recommendations of the participants covered virtually all management aspects of operation and maintenance in the water and sanitation sector. The following recommendations are mainly based on the observations made during the field trips to the La Mesa Water Treatment Plant and the Magellan Sewage Treatment Plant.

(1) A cost-benefit analysis should be carried out to determine whether fluoridation of the water supply should be recommenced using the existing facilities of the Water Treatment Plant.

(2) An engineering study of the Magellan Sewage Treatment Plant should be undertaken to determine the measures to be taken to make the plant operational.

(3) Preventive maintenance procedures at both the above water and sewage plants should be established and implemented.

(4) A working group of the agencies responsible for water supply and sanitation should be formed to address the remedial measures identified and ensure action is taken for their implementation.

5. ACKNOWLEDGEMENTS

The writers wish to express their appreciation to the organizers of the workshop for their excellent preparation and support during the assignment. Their particular thanks go to Mrs R. Tuason and Mr M. Agdeppa, Environmental Health Service, Department of Health, who acted as facilitators of the workshop.

ANNEX 1

OFFICIALS CONTACTED

DEPARTMENT OF HEALTH

1.	Dr M.G. Roxas	Undersecretary for Public Health Service
2.	Dr W.S. Asoy	Director, Environmental Health Service (EHS)
3.	Engineer R. Tuason	EHS
4.	Engineer M.R. Agdeppa	EHS

WORLD HEALTH ORGANIZATION

5.	Dr A. Romualdez Jr.	Acting WHO Representative, Manila

ANNEX 2

WORKSHOP PROGRAMME

Monday, 20 July 1992

0800 - 0900	Registration of participants
0900 - 0930	Opening ceremony
0930 - 0945	Break
0945 - 1015	Overview of operation and maintenance of water supply in the Western Pacific Region B. Fisher
1015 - 1115	Overview of operation and maintenance of water supply in the Philippines Department of Public Works and Highways Department of Interior and Local Government Local Water Utilities Administration Metropolitan Waterworks and Sewerage Systems Department of Health
1115 - 1200	Strategies for implementing operation and maintenance programmes T. Dafoe
1200 - 1300	Lunch
1300 - 1545	Discussion groups - Identification of operation and maintenance problems in the Philippines B. Fisher and T. Dafoe
1545 - 1600	Break
1600 - 1700	Planning for maintenance T. Dafoe

Tuesday, 21 July 1992

0830 - 0930	Operation and maintenance of water treatment plant B. Fisher
0930 - 0945	Break
0945 - 1030	Operation and maintenance of sewage plants T. Dafoe
1030 - 1130	Operation and maintenance of reticulation systems B. Fisher

Annex 2

1130 - 1200	Cost-benefit analysis B. Fisher
1200 - 1300	Lunch
1300 - 1330	Cost-benefit analysis (Cont'd)
1330 - 1430	Metering B. Fisher
1430 - 1515	Preventive maintenance T. Dafoe
1515 - 1530	Break
1530 - 1700	Leakage control B. Fisher
1700 - 1730	Preparation for field trips B. Fisher & T. Dafoe

Wednesday, 22 July 1992

	Field trip:
a.m.	La Mesa Water Treatment Plant
p.m.	Magellan Sewage Treatment Plan

Thursday, 23 July 1992

0830 - 0930	Review of conditions found during field trip B. Fisher and T. Dafoe
0930 - 1200	Group discussion - Interagency coordination in community water supply and sanitation in the Philippines B. Fisher & T. Dafoe
1200 - 1300	Lunch
1300 - 1400	Maintenance of handpumps T. Dafoe
1400 - 1445	Monitoring of water quality T. Dafoe
1445 - 1545	Sanitary survey B. Fisher
1545 - 1600	Break

Annex 2

1600 - 1700	Operation and maintenance management T. Dafoe
1700 - 1800	Management of information systems T. Dafoe

Friday, 24 July 1992

0830 - 0900	Priority projects B. Fisher
0900 - 0930	Role of the International Training Network in water supply and sanitation sector P. Enriquez
0930 - 1000	Demand management B. Fisher
1000 - 1200	Setting priorities for action plans Dr M. Roxas
1200 - 1300	Lunch
1300 - 1500	Preparation of action plans Participants
1500 - 1515	Break
1515 - 1615	Summary of the course Participants
1615 - 1815	Closing

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Mr T. Dafoe
Mr B. Fisher

METERING OF DRINKING WATER SUPPLIES

1. General

The use of meters dates back at least 3 000 years when in North Africa, water for irrigation was rationed out by pots of water from a spring. Since that time, much research has gone into improving the operation of meters particularly in the following aspects:

- ease of reading
- accuracy over various ranges of expected flows
- durability
- ease of replacement and repair
- cost
- resistance to interference

2. Ease of reading

Water utilities, in their efforts to reduce operating costs, have become increasingly interested in remote registration as a means of improving the efficiency of the meter-reading process, particularly in northern climates where domestic meters are installed indoors and access problems cause skipped readings, call backs, and estimated billings. Additional problems with indoor-set meters include customer concern with strangers entering the house, dirty shoes tracking up floors, and overall customer inconvenience. However, the overriding consideration of utilities choosing to use remote-reading registers has been the ability to achieve higher meter-reading rates at reduced reading costs.

Applications for remote registration have been increasing in areas where pit settings have been traditional, both in residential and commercial and industrial installations. The availability of remote-registration systems provides utilities in all climates the opportunity of installing and reading their meters in the most economical manner. For example, in areas where large meters are installed under the street, it is often necessary to send a truck and a crew to direct traffic, manipulate pit entries, and read the meters. Conveniently located remote registers make it possible for one man to obtain these meter readings without disruption of traffic or exposure to personal injury. Domestic meters can be installed indoors, in utility rooms for example, rather than in pits, if installation costs or soil conditions indicate an advantage in favour of remote registration.

3. Selection of meters

Selection involves both size and type of meter. Too often, size is chosen merely to match the pipe size. However, pipes are often installed oversize to allow for possible future increases in water use or to reduce pressure loss in a long length of pipe.

The pressure-loss data from the manufacturer's catalogues and the pressure ranges expected in the pipe should be used to correctly size the pipe. For example, a 4-in. meter should not be used in a 4-in. diameter pipe if only a 2-in. diameter meter would suffice. The former would be unnecessarily expensive, heavy to handle and probably not as accurate. However, it is advisable to allow extra space in the pipeline and meter pit for later replacement with a larger size when usage increases.

The type of meter to use is determined by the range of flow rate, allowable pressure loss, cost and durability factors. A summary of the various types is given in Table 1.

Table 1 Types of Modern Meters for Water Measurement

Types	Usual range of sizes in.
I. Displacement	
Nutating disc	5/8 - 6
Oscillating piston	5/8 - 3
II Nondisplacement	
A. Velocity	
Multi-jet	1/2 - 1
Magnetic pick-up turbine	1/4 - 12
Turbine (current)	2 - 12
Propeller	2 - 72
Proportional	3 - 10
B. Differential pressure	
(a) Fixed opening, variable differential	
Orifice	2 - 24
Venturi, flow nozzle, flow tube	2 - 72
Pitot tube	Unlimited
(b) Variable opening, fixed differential	
Rotameter	1/4 - 4
C. Mass flow	1/2 - 6
D. Level measurement	
Weir, Parshall flume, etc.	Unlimited
III Compound	
Standard compound	2 - 10
Fire service	3 - 10

The most used type of meter is 1-in. and smaller sizes has been the displacement type, of which there are two variations - the nutating piston (disc) and the oscillating piston. Essentially equal in performance, experience has shown that they are unrivalled for their combination of accuracy, long life, simple design, moderate cost, and ease of maintenance. Tens of millions of these meters are in use. Since the 1960s, multi-jet meters have been successfully used in the same applications.

Most residential services are metered with the 5/8-in. size, having 3/4-in. connections. Note that normal flows should not be more than approximately one half of the maximum capacity of long life is the objective.

In dry climates where water usage is unusually heavy, such as for lawn sprinkling, the full 3/4-in. or 1-in. size is often preferred. However, the need for this size in new services is not as great for a given flow rate as it was several years ago.

For services that can be metered with 1 1/2-in. meters, the displacement or multi-jet type can be used. The low-flow accuracy of modern 1 1/2-in. meters is excellent, and compound meters are not usually manufactured in sizes less than 2 in. Where low-flow accuracy is not important, as in services used only for filling tanks at rapid flow, the 1 1/2-in. turbine type may be operated safely at a higher average than the displacement meter.

For 3-in. or larger lines, instead of one meter being used to measure the entire flow, two or three meters are sometimes manifolded, or installed as a battery. For 3-in. lines, two 2-in. meters are used; and for 4-in. lines, three 2-in. meters are used. These meters are usually displacement meters. For large lines, such as 6-in. to 10-in. lines, the battery may be composed of compound meters as needed. Details of such installations should be worked out with the representative of the meter manufacturer. A manifold battery of 2-in. displacement meters is often used in 3-in. or 4-in. services for the following reasons:

1. One meter can be removed for servicing merely by closing its valves, and the water supply is still left in metered operation.

2. Meters can be added and the system expanded if required in the future. This growth can best be provided for at the time of initial installation.

3. One person can handle any system component.

4. There is no need to buy or stock parts for several different sizes of meters; all meters and valves are the same size.

5. The battery can be side-wall mounted to conserve floor space.

Information on durability is generally learned by experience with the different models. There has been a gradual increase in the use of plastic at first for the internal parts and finally for the bodies. Plastic body meters require careful handling in the field during insertion into the meter setting to avoid damage by misaligned meter settings. Register lens of plastic type material are more easily scratched than glass and care is needed during cleaning.

4. Meter records

A suitable record of meters is one that provides full and complete information on the installation, repair, and testing of each meter with a minimum of expense. The time and effort devoted to maintaining meter records are considerable, at best, because of the number of units involved and because meters, unlike other items of water utility facilities, do not remain at one location during their useful life but are frequently moved.

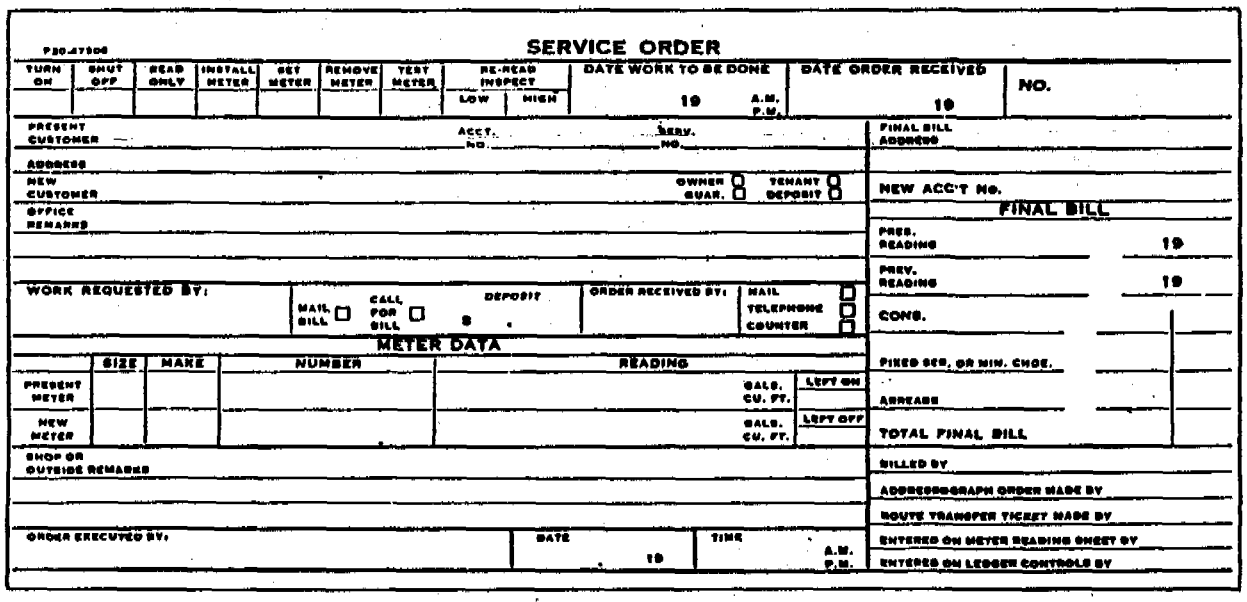
Any system of meter record should provide such basic data for each meter as size, make, type, date of purchase, where the meter is located at all times, and information on all tests and repairs. One method of maintaining such records is by use of a meter history card. Basic meter data are inserted at the top of the form, and the remainder of the card is designed to record the various installations and test and repair work in chronological order. Each line of the test and repair record section is divided into two segments, the upper being used to record the test results for the meter on its removal from service and the lower to record the final test results before the meter is reinstalled. These meter history cards are filed in sequence, either according to the manufacturer's serial number or the utility's number, if the utility has its own system of meter numbers. Although this method of maintaining meter records is a good one, it requires transcribing information from other primary records.

MFR. NO.		CO. NO.		MAKE							SIZE				
DATE PURCHASED			COST								STYLE				
INSTALLATION RECORD								TEST AND REPAIR RECORD							
Installed		NAME	ADDRESS	Top No.	Reason for Removal	Removed		Date	Rate of Test			Repairs		Cost of Repair		Tested By	REMARKS
Date	Reading					Date	Reading		Min. Flow	Inter. Flow	Max. Flow	% Accuracy Before Repair	% Accuracy After Repair	Mtl.	Labor		

Figure 1 Meter History Record

Since more and more water utilities are using computers in their operation, the logical place for keeping permanent records is in the computer. The same information that is on the meter history card (Figure 1) is fed into the computer with a control number, which could be the manufacturer's serial number. All future tests, repairs, change of location, etc., for this particular meter can then be fed into the computer as part of the permanent record, which also affords an easy way to keep up with the cost of repairs for each meter. When desired, a printout on the cost of meter repairs can be obtained to decide whether it would be more economical to make further repairs or to scrap the meter.

The service order (Figure 2), which usually is prepared by the commercial department, authorizes the work to be done. Regardless of origin, a service order is used to cover all types of work involving the installation, removal, or change of meters. On completion of installation or removal of a meter, this information is posted to the meter history record. The service order then continues through the commercial department for further processing.



SERVICE ORDER

TURN ON	SHUT OFF	READ ONLY	INSTALL METER	SET METER	REMOVE METER	TEST METER	RE-READ INSPECT LOW	RE-READ INSPECT HIGH	DATE WORK TO BE DONE 19 A.M. P.M.	DATE ORDER RECEIVED 19	NO.

PRESENT CUSTOMER — ACCT. NO. — SERV. NO.

ADDRESS

NEW CUSTOMER — OWNER GUAR. ☐ TENANT DEPOSIT ☐

OFFICE REMARKS

WORK REQUESTED BY:

MAIL BILL ☐ CALL FOR BILL ☐ DEPOSIT $.

ORDER RECEIVED BY: MAIL ☐ TELEPHONE ☐ COUNTER ☐

METER DATA

	SIZE	MAKE	NUMBER	READING		
PRESENT METER				GALS. CU. FT.	LEFT ON	
NEW METER				GALS. CU. FT.	LEFT OFF	

SHOP OR OUTSIDE REMARKS

ORDER EXECUTED BY: — DATE 19 — TIME A.M. P.M.

FINAL BILL ADDRESS

NEW ACC'T No.

FINAL BILL

PRES. READING 19

PREV. READING 19

CONS.

FIXED SER. OR MIN. CHGS.

ARREARS

TOTAL FINAL BILL

BILLED BY

ADDRESSOGRAPH ORDER MADE BY

ROUTE TRANSFER TICKET MADE BY

ENTERED ON METER READING SHEET BY

ENTERED ON LEDGER CONTROLS BY

This form, usually prepared by the commercial department, authorizes work to be done. After pertinent information has been posted onto other records in the maintenance shop (such as the meter history record), the form is returned to the commercial department for billing or other processing.

Figure 2 Service Order

The meter history card should contain all information needed, if it is properly maintained. Those utilities using computers will need the same information as that sorted on the meter history card, but will have this stored in the computer and available on printouts.

Although there are innumerable systems of meter records, many of which might be considered better than the one described, this particular system is one that provides all pertinent information with a minimum of effort. A review of almost any system of meter records will reveal unnecessary duplications or more elaborate and detailed records than are required. A little time and effort devoted to this problem may result in elimination of a large amount of clerical work with only slight changes in the system or method. At least, a review will show whether or not current methods are being followed simply because "it's always been done that way."

5. Meter maintenance

The mechanics of the repair and testing techniques involved in the various types of meter are beyond the intent of this paper. The following items list the main requirements of a maintenance system.

5.1 Staff

A highly skilled mechanic may be able to do satisfactory work with poor equipment and inadequate tools, but the average worker needs the best equipment and tools available. While meter repair is a specialized skill, it is not ordinarily considered a trade where an extended apprenticeship is required. Any person who has above-average mechanical aptitude, good mental attitude, a will to learn, proper training, and who is provided good equipment and tools can do an excellent job of water-meter repair.

5.2 Repair shop

Meter shops come in all sizes and shapes with the capability of handling from a few dozen to many thousands of meters each year. In addition to the number of meters handled, other conditions that can affect the size, equipment, and layout of a meter repair shop include:

- o number of makes and types of meters used, which, to a great extent, governs the size of the repair part inventory and the space required to store spare parts;
- o the quality of water served, which determines the amount of corrosion, lining incrustation, and wear;
- o location and type of meter settings, which control the condition of the meter register and the outside of the casing;
- o local practice or state requirements specifying how often meters must be tested;
- o private ownership of meters, which may call for identification and segregation of meters so that they can be returned to the proper owners;
- o special cleaning/painting requirements to satisfy company policy;

- o general plant services available such as:
  - air at appropriate pressure and volume,
  - water at appropriate pressure and volume,
  - available electric energy and lighting;
- o meter inventory handling and control procedures.

5.3 Equipment

1. Test bench and accessories

This should include a test bench for proving meter performance. An adequate flow of water, a rate-of-flow indicator, quick-acting valves, large calibrated tanks, and a simple method for adapting to the various sizes of meters to be tested are basic requirements. A meter of proven accuracy can be used in series to the meter on test in a small repair unit.

2. Meter cleaning equipment

Chemical cleaning or hand wire brushings are generally the quickest and easiest methods of cleaning.

3. Work bench for each meter repairer

Each bench must be equipped with hand tools such as wrenches, screwdrivers, pliers, scrapers, files and a vice.

4. Pneumatic grinder with wire brush

5. Drills

6. Storage bins and drawers for spares

7. Tools - soldering irons, socket, wrenches, etc.

It is important that meters are not allowed to become uneconomic with the repairs costing more than replacement. The greater the standardization of procedures and materials, the more efficient is the operation and maintenance of the metering system.

6. Viability of metering

The practice of charging for water by metering its use was questioned by water utilities for quite some time. One of the chief objections was that occupants of metered homes would try so hard to keep water charges at a minimum that they would not use enough water for sanitary purposes. It was even reported that some users placed a tub under a faucet and allowed water to drip into the tub at a rate too slow for the meter to register. Water was dipped from the tub with a pail as needed.

This problem was solved by establishing a monthly minimum charge, for which enough water was furnished to provide for reasonable sanitary needs. No carryover of unused allowance to the next month was permitted. This method opened the way to universal metering, once good meters were available, and it was found that the total cost of operating a metered system was usually less than the cost without meters since waste was reduced.

However, an economic appraisal of costs and benefits is necessary to decide whether metering is justified or not. The costs of metering are relatively easy to establish. A present value of the metering project is calculated by adding the initial cost to the present value of annual costs due to billing, maintenance, replacement, legal fees, etc. The benefits are harder to [illegible] from making the consumer pay for the water he uses which is a more equitable system, the real benefit is the resultant economic use of water whereby people pay for the water they consider worthwhile to use.

The benefits of metering is therefore the resultant value of water saved each year because of consumers' reduction of excessive use and wastage. The metered cost is naturally more important to the lower income groups. The overall relationship between price and consumption is difficult to assess. The best way of analysing the benefits is to assume a reduction in consumption of say 20% and calculate the resultant cost benefit ratio i.e. the ratio of the cost of metering divided by the value of the reduction in water consumption.

STRATEGIES TO IMPROVE OPERATION AND MAINTENANCE OF WATER SUPPLY AND SANITATION FACILITIES

1. INTRODUCTION

This document approaches the needs for improving efficiency and effectiveness of water supply and sanitation agencies in urban areas to make it possible to extend water supply and sanitation services to those living in less privileged urban/poor or rural areas. These populations are poorly served by public facilities and therefore are highly exposed to health risks. The following are the main expected benefits from the implementation of Operation and Maintenance programmes:

- by reducing water losses in urban systems, it should be possible to extend coverage to fringe and poor areas without constructing new production facilities;

- by increasing water revenue, by reducing operational costs and by postponing investments for the expansion of production works, it should be possible to shift financial resources to increase coverage in periurban and rural areas;

- as a result of improved Operation and Maintenance of piped networks and treatment plants, water quality should also improve. Risks of contamination in distribution systems due to intermittent services, negative pressures and inadequate operation can be minimized.

The importance of Operation and Maintenance is widely recognized by multilateral and bilateral agencies and governments, and concerns have been expressed in meetings of External Support Agencies (ESAs), in the reports on regional and international consultations and in a number of resolutions of the World Health Organization. The reports on the Regional External Support Consultations of Asia, America and Africa, and the report on the Interlaken Consultation have stressed this constraint as follows:

- The Americas Regional Consultation (Washington, D.C., 21-24 April 1986) identified six key constraints related to progress in the water supply and sanitation sector development in the Latin American and Caribbean Regions. Among them was found: "insufficient attention to operation, maintenance and rehabilitation of existing water supply and sanitation systems". (page 2, item 1.7)

- The Asia Regional Consultation document (Manila, 21-25 October 1985) states on page 7, item 4.3, when referring to the sector's major constraints: ".... while analysis has shown improvement between 1980 and 1984 in the percentage of people having access to safe water supply and sanitation, the functioning of water supply and sanitation systems was often disrupted by inadequate operation and maintenance....."

- The Africa Regional Consultation document (Abidjan, 25-29 November 1985) recognizes that "many installations were out of order soon after their implantation, mainly due to lack of local expertise to adequately operate and maintain them". The same document referring to the second half of the Decade strategies and approaches points out four major issues on which future sector inputs should concentrate. One of them is: "Rehabilitation and maintenance of existing water supply and sanitation installations, rather than investments in new capacity, to maximize the output of limited resources and to prevent recurrent project costs from soaring to unaffordable levels".

- The International Drinking Water Supply and Sanitation consultation (Interlaken, Switzerland, 13 to 16 October 1987) has recognized that "operation, maintenance and rehabilitation receive insufficient attention, and the problem is aggravated by application of inappropriate and often too sophisticated technologies (which are neither affordable nor manageable)". In accordance with this Consultation, Operation and Maintenance represents one of the six major constraints to sector development.

The approach presented in this document considers the development of operation and maintenance and the optimization of water supply and sanitation systems as an important stage of an institutional development process. At this stage, the most important constraints for achieving a better efficiency and effectiveness of the water agency would be identified and minimized. Therefore, Operation and Maintenance programmes should not be confined to the technology aspects of the problem. In this strategy, the concept of Operation and Maintenance has been expanded to embrace priority factors which affect the efficiency and effectiveness of the water agencies. The approach is flexible and is to be adapted to meet the requirements of each institution in which it is to be applied.

2. SECTOR SITUATION

The present situation of the water supply and sanitation sector is characterized by lack of adequate criteria for the application of suitable technology, by institutional deficiencies, by lack of trained personnel at both managerial and operative levels, and by insufficient financial resources for both construction of new facilities and operation and maintenance. These constraints are forcing government agencies to promote policy changes in order to make the best possible use of existing resources (human resources, equipment, installations).

In urban areas where coverage has experienced significant progress since the start of the Decade, the inhabitants of urban fringes still lack public facilities, and therefore are highly exposed to health risks. Such urban dwellers frequently have to pay the market price for insufficient amounts of unsafe water which is sold by private companies. The price of water sold by private vendors in several large cities in developing countries reaches frequently 10 or 20 times the price paid by regular customers of the water authorities. Paradoxically, within the served areas the waste of water is enormous, the unaccounted for water is exceedingly high and tariffs subsidized. Unaccounted for water, representing more than 50% of the produced water, have been reported in a number of large cities of developing countries.

Poor Operation and Maintenance has been identified as one of the major causes of this situation. Actions directed at the promotion of efficient use of existing facilities have not kept pace with the great efforts made at national and international levels to construct new systems and to increase population coverage. The following characterizes the present situation of the water supply and sanitation sector in many developing countries.

- unaccounted for water frequently representing more than 50% of the produced water
- high operational costs, directly influencing tariff rates
- poor quality of delivered water
- poor water supply coverage, particularly in periurban areas due to wastage of water by already connected consumers

It is possible to relate this situation to the following:

- institutional deficiencies leading to poor operation and maintenance
- lack of training programmes
- inadequate personnel development policy including inadequacy of training programmes, lack of career development plans and inadequate salary policies
- insufficient and poor use of financial resources
- lack of operational and managerial instruments for programming, evaluating and controlling activities
- inadequate information flow leading to insufficient and poor quality of information
- lack of community participation
- lack of manuals and inventories of technical information
- recurrent mistakes in layout, design and construction of water supply and sewerage facilities

3. PAST EXPERIENCES

There are several cases of success in the implementation of programmes directed towards the optimization of existing facilities. One of the most impressive cases deals with a city of 8 million inhabitants with a 95% coverage, with water supply and unaccounted-for water reaching about 37%. From the beginning of the programme's implementation in 1977 to the end of its first phase in 1982, the unaccounted for water was reduced from 37% to 26%. The number of house connections increased from 1.023 million to 1.423 million. The water produced increased from 22.3 m3/sec in 1983 to 25.4 m3/sec in 1980 and was subsequently gradually reduced until it reached 25.1 m3/sec in 1982. Therefore with a relatively small increase in the production of water, it was possible to extend water coverage to an additional 2.0 million inhabitants in the fringe and poor areas. This experience was part of the government's national policy for optimizing the existing sector capacity.

The above experience jointly with other relevant experiences leading to a better use of water supply and sanitation facilities have been used as basis for the preparation of this strategy paper. However, despite the fact that the mentioned experiences are important and should be used to provide guidance on the formulation of strategies, they are not necessarily applicable universally. Managerial and technological shortcomings in the water agencies frequently call for the design of programmes to meet their specific requirements.

4. OBJECTIVES

4.1 GENERAL

Programmes for the optimization of water supply and sanitation systems are aimed at improving the efficiency of institutions to achieve the best possible utilization of the existing capacity of the systems. Such programmes, despite being focussed on management and operative aspects related to operation, maintenance and rehabilitation, also involve specific projects related to other areas. The projects and activities which are normally considered in the formulation of an Operation and Maintenance programme are directed towards the elimination or reduction of the major constraints for the achievement of sustainability and improved efficiency and effectiveness of the water agencies. These projects and activities should be organized to be gradually implemented in accordance with priority requirements and also, in accordance with the limitations of the water agencies.

The Operation and Maintenance programmes should be considered as a stage of an institutional development process. At this stage efforts would be oriented to the priority areas of the water agencies, which would facilitate the implementation of a more comprehensive institutional development programme.

4.2 SPECIFIC

The specific objectives of the Operation and Maintenance programme are:

- to promote and support the efforts for strengthening the managerial and operational capability of water supply and sanitation institutions in order to improve their efficiency and effectiveness
- to improve Operation and Maintenance services and related support areas
- to optimize the installed capacity of the services and to seek for the financial self sufficiency of the water agencies
- to extend the coverage, regularize the service rendered to the population and delay investments for new constructions
- to achieve control and reduction of unaccounted for water
- to identify basic requirements as needed by operational staff to perform improved operation and maintenance work, e.g. tools, equipment and transport.

5. PROGRAMMES AND PROJECTS

The improvement of Operation and Maintenance and the optimization of water supply and sanitation systems should be adopted as a priority phase in an institutional development process. The development of this process implies in the formulation and implementation of priority programmes and projects.

Although several constraints are basically the same for a broad range of water agencies in developing countries, the constituent elements of the Operation and Maintenance programmes, as well as the strategies and resource requirements can vary widely from one institution to another. Therefore the priority projects and programmes should be selected, formulated and implemented to meet the particular requirements of each institution. These programmes are multidisciplinary. At the various stages of their promotion, formulation, implementation and monitoring, a great amount of work will be required, involving professionals dealing with different expertise areas.

It is important to emphasize that this strategy does not promote the preparation of standardized projects for application in all cases. Although it is possible to make an attempt to foresee all possible, frequent and common problems and to design similar solutions to them, each programme formulation should meet the specific requirements of the focused water agency.

The following headings of programmes and projects usually meet most of the requirements of a wide range of water agencies in developing countries.

5.1 Operational Development Programme (Unaccounted for Water Programme)

This programme comprises projects on the following areas:

5.1.1 Operation of Water Supply Systems

- Network Survey
- Control of Leakage
  - visible
  - not visible
- Macrometering (production and distribution systems)
- Network Mapping
- Control of Operation
- Design and Construction Criteria

5.1.2 Maintenance of Water Supply Systems

- Preventive and Corrective Maintenance (electrical, mechanical, civil and instrumentation)
- Distribution Network Maintenance
- Maintenance of Flowmeters (including house meters)
- Improvement and Rehabilitation of House Connections, Transmission Lines and Distribution Network Pipelines
- Improvement of Material and Equipment Quality

5.1.3 Metering and Billing and Collection

- Promotion of the Service
- Customers' Registering
- Metering
- Billing and Collection

5.2 Programme for the Improvement of Operation and Maintenance of Sewerage Systems

This programme comprises projects on the following areas:

5.2.1 Operation of Sewerage Systems

- Operation Control of Collection and Disposal Facilities
- Operation Control of Pumping Stations
- Record Keeping

5.2.2 Maintenance of Sewerage Systems

- Emergency Service and Repairs
- Preventive Maintenance

5.3 Programme of Operation and Maintenance and Optimization of Treatment Plants

The treatment plants programme comprises projects on the following:

- Evaluation and Upgrading of Treatment Plants
- Operation of Treatment Plants
- Maintenance of Treatment Plants

6. SUPPORT PROJECTS

The adequate formulation of programmes for the improvement of Operation and Maintenance and optimization of water supply and sanitation systems should possibly include actions to support and facilitate their implementation, as follows:

- Organizational Arrangements, particularly with regard to the units which deal with Operation and Maintenance and related areas
- Development of Human Resources, including the improvement of managerial performance; training courses; elaboration of post profiles and personnel profiles and reorientation of cadres; improvement of Human Resources Development service
- Development of an Information System destined to collect, process and disseminate information on operation, maintenance and related areas
- Improvement of the Transport Service, including the adequacy of the transport facilities, in terms of quality and quantity and the improvement of the vehicles' maintenance service
- Improvement of the Material and Equipment Supply, in order to ensure a timely delivery of spare parts and maintenance material
- Community Involvement and Participation in Operation and Maintenance programmes

Again, it would be important to emphasize that despite the present attempt to identify the most common deficiencies of water agencies in developing countries, it should be recognized that they are not necessarily entirely applicable to all institutions. Specific programmes have to be formulated, organized and implemented for each country and for different sector institution in each country. Such programmes might include all or only some of the projects listed in the sections 5 and 6 or eventually others which are not listed.

The quality of water is also connected to operation, maintenance and optimization of water and sanitation systems. A better quality of water implies better condition of piped systems which facilitates the operation and the maintenance of the systems. Conversely, improved operation and maintenance services imply less risk of contamination of drinking water. Despite this, drinking water quality monitoring and related activities will not be addressed in this document as they are out of the scope of this strategy paper.

7. TRAINING MATERIAL

The implementation of Operation and Maintenance programmes usually involve huge changes in organization and management and engineering procedures and therefore it should be supported by activities directed towards motivation, creation of awareness and training of personnel.

In order to facilitate and provide a uniform level in personnel training, the development of basic instructional material is required. This material will be prepared to avoid the quality of the training dependent exclusively on the personal skills and capacity of trainers and facilitators. It will minimize the possible negative effects due to lack of experienced trainers acquainted with
the agreed approach.

It is well known that training material is more effective when designed to solve problems concerning situations in which current performances are not in accordance with performance expectations. Therefore, the preparation of a complete set of training packages for each water agency, designed after an analysis of constraints, post profiles and personnel profiles and also after the formulation of the Operation and Maintenance programmes would be ideal. However, WHO would not be in a position to provide support to the water agencies for the preparation of this material, in this manner, due to the huge resources required if this procedure is to be adopted. Instead, this strategy proposes the preparation of training material for broader application. The instruction material will be grouped into specific training packages, embracing the various areas which are usually included in an Operation and Maintenance programme. They will facilitate the conveyance and comprehension of the information and skills which are related to a better performance which should be expected from the water agencies.

The training material will be formed by modules and submodules, organized in a such a flexible manner that it will be possible to assemble different sets of training packages to meet the requirements of a wide range of water agencies.

The courses/workshops/seminars will be directed to managers, engineers and technicians. This initial target population is expected to become a core group of trainers, which would exert a multiplying effect in disseminating the proposed knowledge to national water agencies and other users.

Training packages will be prepared to support the undertaking of courses/workshops/seminars directed to managers or engineers or technicians depending on the problem analysis for each situation. The following are headings of training material under preparation:

- Operation and maintenance management
- Hydraulic survey (pitometric survey)
- Control of leakage
- Macrometering

- Network mapping
- Operation control
- Preventive maintenance
- Instrumentation
- Pipe network maintenance
- Maintenance of consumption meters
- Metering and billing
- Operation and maintenance of sewerage systems
- Operation and maintenance of treatment plants
- Evaluation and upgrading of treatment plants

Each package might include the preparation of the following group of elements:

- Conceptual texts
- Transparencies and slides
- Working material for office practice
- Working material for field practice
- Microcomputer software
- Video cassettes

Substantial efforts have been made during the last few years to generate training material on Operation and Maintenance. Sets of training material have been developed concerning some of the issues mentioned above. Unfortunately, some packages have not yet been developed and others do not contain all of the required elements. Therefore, the organization of existing material and preparation of other elements will involve considerable efforts and important financial resources.

8. THE PROPOSED STRATEGY

The complexity of arrangements and great number of activities involved in the formulation and implementation of Operation and Maintenance programmes require very well concerted efforts amongst the involved organizations at the country and international levels. WHO is expected to play a major role in the organizing of efforts, in the promotion of programmes, in the generation of awareness, in the promotion of suitable strategies and in the formulation and implementation of programmes.

The following are logical steps to be followed in this process of involvement of External Support Agencies and developing countries for the organizing of actions aimed at the implementation of programmes of this nature:

8.1 Promotion of Operation and Maintenance Programmes

The resolute support of Sector representatives is an essential condition to the sustainability of the Operation and Maintenance programmes. Therefore the first major achievement to be sought is the involvement and commitment of top managers dealing with water authorities and national agencies. A political decision should be taken which will precede concrete actions directed towards programmes formulation and implementation.

The main activities regarding the promotion of the programmes would be as follows:

- To establish contact with national officials through the WHO Regional Offices and the WHO Country Representatives to discuss the mutual interest of developing joint activities in the field of Operation and Maintenance. The role of WHO and national agencies as well as the role of other ESAs should be approached as precisely as possible during these consultative meetings.

- To seek an agreement concerning the organizing of a country workshop which should be attended by managers from water agencies, representatives from national sector institutions and representatives from external support agencies. In this workshop, the participants would discuss policies and strategies for improving sector performance with emphasis on aspects of Operation and Maintenance and related areas. At the end of the seminar the major lines of a strategy for Operation and Maintenance would be conveniently addressed.

- To promote the importance of a political decision in support to the launching of the Operation and Maintenance programmes. This political decision is of great relevance if sustainability and the involvement of sector institutions are sought for.

Summarizing, the following achievements are considered essential for launching and implementing an Operation and Maintenance programme:

- A state of awareness of managers on the importance of the problem and on alternatives to overcome such a problem.

- A political decision which enables and enforces the adoption of policies at a national level.

- Identification and commitment of financial institutions for implementation of the programmes.

- Willingness of managers and sector institutions to participate in the elaboration of a strategy for the organization of the sector for undertaking Operation and Maintenance programmes.

8.2 Formulation of the Operation and Maintenance Programmes

The Operation and Maintenance programmes should be managed at a national level under the coordination of a leading sector institution. The programmes formulation and implementation should be selective and gradual and at the start of the process, they should cover only a few water agencies. During this phase, the infrastructure of technological and human resources will be established and then expanded on a national level.

The main aspects involved in the formulation of the Operation and Maintenance programmes are the following:

- Definition of a national agency which would be the focal institution for activities concerning promotion and coordination of the programmes at the national level.

- Establishment of organizational arrangements aimed at the following: to facilitate the undertaking of projects; to improve exchange of information; to facilitate the conveying of financial resources to the programmes and to facilitate the undertaking of cooperative activities among water agencies;

- Carrying out of a survey on the situation of the involved water agencies with emphasis on the aspects of operation and maintenance and related areas.

- Formulate the Operation and Maintenance programmes, including the definition of priority projects and activities with respective required resources (human, financial, equipment, material, vehicles and installations). The formulation should be undertaken by managers from the sector agencies and the leading agency. Representatives from national financing agencies should also attend together with representatives from external support agencies which may have expressed interest in assisting in the funding of the programme. A two or three-week workshop which the above representatives should attend, would be sufficient for the formulation of the Operation and Maintenance programme. The report produced from the survey on the situation of the involved water agencies should reach the participants prior to the workshop.

8.3 Implementation of Operation and Maintenance Programmes

The implementation of the programme should be undertaken through the coordination of a leading national sector agency, initially in a few water services and later at the national level.

At the first phase of the implementation process other water agencies could join the original agencies in the development of the programme. The duration of this first phase would be defined in accordance with each situation but it should not last for more than 5 years.

Once a core group of agencies have developed experience, the second phase would gradually include other water authorities until the whole sector would interact in a common effort to achieve the programme's objectives.

8.4 Training Activities

The infrastructure to be generated in the water and sanitation agencies will include skilled personnel who will apply the new technology in their own institutions and also disseminate such technology to other institutions in order to achieve a multiplying effect.

The support supplied by the training packages mentioned in (7) will be important for the technology transfer process. The training activities should be included in the programme's implementation strategies and should embrace managerial and operational areas.

The external cooperating agencies will play an important role in the process of training trainers and creating the critical mass of resources in the base institutions for the programme's implementation at the country level.

8.5 Required Financial Resources

Although the Operation and Maintenance programmes are aimed at improving the efficiency and effectiveness of the water agencies to extend the coverage to fringe and poor areas and reducing their operational costs, a significant amount of investment is required to achieve the targets as follows:

- Training packages: preparation of training material for supporting courses/workshops/seminars. Although some base material is available, the preparation of adequate training material for the mentioned courses/workshops/seminars is required. The funds for the preparation of training packages should be provided by ESAs interested in supporting the Operation and Maintenance approach. It is not necessary that the same ESA would finance all the training packages. Some could be developed within existing and already funded Operation and Maintenance projects.

- Operation and Maintenance programme promotion: one-week seminar (for each country) for managers aimed at generating awareness, motivation and a political decision in support of the programme's launching. The funds for the promotion of the Operation and Maintenance programmes should be drawn from WHO's regular budget and supported by local government funds.

- Programme formulation: two or three week managerial workshop for the formulation of programmes. National participants and advisers from external cooperation agencies should be involved. The funds for these workshops should be shared by local governments, funding agencies and WHO.

- Programme implementation: the required financial resources for the implementation of programmes will be defined by the time the programmes have been formulated. The implementation costs will be significant and external funding will certainly be required.

The amount of work and financial resources involved in this kind of programme are substantial. However, the benefits expressed in terms of both financial aspects and improvement of health mainly for those people living in fringe and poor areas easily compensate for the required efforts.

8.6 Monitoring of Operation and Maintenance Progress

The progress of the Operation and Maintenance programmes should be monitored. An evaluation manual should be prepared whose objective is to support the activities directed towards the monitoring of the programmes. This manual would be applied to the water agencies in which Operation and Maintenance programmes are to be implemented.

8.7 Resources Mobilization

In summary, the mobilization of resources and undertaking of actions would be as follows:

External Cooperation

The international support agencies will play an important role in the process of promotion, formulation and implementation of Operation and Maintenance and optimization of programmes. Specifically their cooperation will be required on the following:

- promotion of Operation and Maintenance and optimization programmes at a high governmental level, generation of awareness, willingness and commitment at the main government levels in order to create the required conditions for the formulation and implementation of the programmes

- provision of the financial resources for the formulation and implementation of programmes at a national or institutional level

- provision of technical cooperation for the formulation and implementation of programmes

- development of instructional packages as described in (7)

- promotion and coordination of intercountry seminars aimed to create awareness and motivation at managerial level and to encourage the execution of bilateral or multilateral cooperation agreements

- training of national personnel who would be in charge of carrying out the seminars, courses and workshops with the support of the instructional packages described in (7)

- implementation of a monitoring system which would provide information on the progress of the Operation and Maintenance programmes

National Agencies Requirements

The water supply and sanitation sector authorities will organize efforts for the Operation and Maintenance programme's implementation at a national level. It includes the adoption of national policies, definition of responsible institutions and managers, description of functions, promotion of training and motivation events, identification of available national financial resources, technology dissemination.

Actions of Drinking Water Supply and Sanitation Agencies

The water agencies will make use of the results achieved by international and national efforts. They will thus play the most important and complex role in the action chain aimed at improving efficiency and effectiveness of the service provided to the population. With the support of infrastructure developed at international and country level, the water agency would perform its operational situation diagnosis, formulate the programmes of Operation and Maintenance and optimization of water supply and sanitation systems, survey and strengthen the organizational structure, promote the development of human resources, develop a managerial information system for Operation and Maintenance and implement a process of programme implementation, evaluation and adjustment.