Rural Water Supply

Volume III

Operation and Maintenance Manual

WATER
PARTNERSHIP
PROGRAM

Disclaimer

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Cover Design: The images on the cover were derived from two photographs courtesy of the DILG. The inset photo with a girl is from "The Innocent" by Mr. Jason Cardente. The boy filling water bottles is from "Water for Drinking" by Mr. Dan Ong. Some elements in the originals may have been altered for purposes of the design.

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MALACAÑAN PALACE
MANILA

MESSAGE

I congratulate the institutions, agencies, and individuals of the water sector for your collaborative publication of the **Rural Water Supply Manual**.

This Manual is the latest of many multi-sectoral efforts to extend the availability of safe water to our countrymen. Water security is a critical issue that we must address, for it is essential to maintaining the well-being and dignity of human life. Thus, I am heartened by our steady progress in this regard—significantly decreasing the number of families without access to water from over 27 million in the 1990s to less than 16 million at present. These accomplishments are in no small part due to the cooperation among agencies and institutions and the support given by their leadership, who have established the necessary programs and administrative mechanisms to enable a dynamic exchange of skills and expertise.

To sustain the gains that we have achieved in securing the safety and accessibility of our water resources, our government is set on formulating and implementing a unifying framework that will harmonize the work of all engaged stakeholders in the water sector, in order to enhance support and ensure that the provision of safe water becomes a universal, self-sustaining aspect of our total development as a nation.

With your continued enthusiasm, I am confident that we can meet and perhaps even surpass our Millenium Development Goal for safe water. Equitable growth can only be accomplished by integrating social justice as the central component of our development agenda, applying a fair and equal treatment of every individual under the law and by our institutions. Let us work together to realize our shared aspiration of a sustainable Philippines.

BENIGNO S. AQUINO III

MANILA
February 2012

Foreword

Purpose of this Manual

This **RURAL WATER SUPPLY OPERATION AND MAINTENANCE MANUAL** is the third of three related volumes prepared for the use of prospective and actual owners, operators, managements, technical staff, consultants, government planners and contractors of small Level III and Level II water supply systems[1] in the Philippines.

Its purpose is to introduce the institutional models available and the legal requirements that apply to small scale water supply utilities; the operational and maintenance principles and issues relating to water supply; and the management principles and good practices that must be adopted in order to attain viability and sustainability in the small water supply utility business. Hopefully, this Manual will facilitate the work of the professional managers and staff engaged in running the water enterprise by putting in their hands a ready resource reference for their everyday use. For those who are new or less exposed to the demands of the small water supply utility business – including those who sit as board members of community based organizations and cooperatives as well as those in local governments and NGOs who have joined the efforts to ensure safe water for the communities they serve – hopefully it will be an aid in understanding the institutional, operational, financial, and management issues involved, and thus enable them to participate more effectively in advancing the objectives of the water sector.

Overall, the local and international partners who cooperated in making these Manuals possible hope that they will help the participants in the rural water supply sector to understand better the nature of the water supply business, its responsibilities to the stakeholders, and the role of the government agencies and regulatory bodies that seek to help them operate sustainably while protecting the consumers.

On the Use of the Manual

This **RURAL WATER SUPPLY OPERATION AND MAINTENANCE MANUAL** and the companion volumes in the series can at best serve as a general reference and guide. As they refer to the information, recommendations, and guidelines contained in them, readers are urged to consider them always in relation to their own specific requirements, adapting and applying them within the context of their actual situation.

Even as they refer to this Manual for information, its users are advised to consult with qualified professionals – whether in the private sector, in the local governments, or in the regulatory and developmental agencies concerned with the water sector – who

[1] A few of the topics covered may also be relevant to Level I systems, which consist of a single well or pump serving a limited number of beneficiaries at source. However, it was felt unnecessary to focus on Level I systems requirements in this work as the design, engineering, operational and maintenance requirements of Level I systems – as well as the organizational and training support – are adequately provided by the relevant government agencies and supported by non-government agencies.

have had actual experience in the construction, management, operation, maintenance, and servicing of water supply systems and utilities – including those other professionals who can help them in the financial, legal and other aspects of their small water supply business.

Manual Organization

The three volumes in this series of RURAL WATER SUPPLY MANUALS are as follows:

Volume I: DESIGN MANUAL. – Its purpose is to introduce and give the reader the key design concepts in the design of waterworks facilities. For non-technical readers who are involved in the management and operation of small water supply systems, rather than in their actual design and construction, the text of Volume I will be useful in understanding and in making decisions that would enable them to avail more usefully of the services of the technical consultants and contractors they must deal with.

Volume II: CONSTRUCTION SUPERVISION MANUAL. – This volume presents the considerations, requirements, and procedures involved in supervising a waterworks project. How these are implemented should be clear to one who supervises, inspects, or manages such a project. For this reason, the details of implementation are covered in the chapters on Pipeline and Pumping Facilities Installation, Concrete and Reservoir Construction, Water Sources, Metal Works, and Painting.

Volume III: OPERATION AND MAINTENANCE MANUAL. – This volume focuses on the small water system as a public utility, and answers the question "What are the requirements to effectively manage and sustainably operate a small utility?" It covers the institutional and legal requirements of setting up a water supply business, the demands of ensuring water safety through proper treatment, the nature and requirements of operating and maintaining the water distribution system, and its administration, commercial, financial, and social aspects.

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Acronyms & Abbreviations

Government and Other Organizations

ASTM	American Standard for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
BIR	Bureau of Internal Revenue
CDA	Cooperative Development Authority
DAR (ARISP)	Department of Agrarian Reform, Agrarian Reform Infrastructure Support Program
DILG	Department of Interior & Local Government
DOH	Department of Health
DPWH	Department of Public Works & Highways
LWUA	Local Water Utilities Administration
NIOSH	National Institute for Occupational Safety and Health (United States)
NSO	National Statistics Office
NWRB	National Water Resources Board (formerly NWRC)
NWRC	National Water Resources Council
SEC	Securities & Exchange Commission
WHO	World Health Organization

Technical & Operational Terms, Units of Measure

AC	alternating current
ADD	average daily demand
AL	allowable leakage
BOD	Biological Oxygen Demand
CAPEX	capital expenditure
CBO	Community-Based Organization
cc	cubic centimeter
CIP	cast iron pipe
cm	centimeter
COD	chemical oxygen demand
CPC	Certificate of Public Conveyance
CT	Contact Time
cumecs	cubic meters per second
dam	dekameter
Dep	depreciation expenses
D or diam	diameter
dm	decimeter
Elev	elevation
EV	equivalent volume
F/A	Force/Area
g	grams
G.I. pipe	Galvanized iron pipe
GPM	gallons per minute
HGL	hydraulic grade line
hm	hectometer
HP	horsepower
HTH	High-Test Hypochlorite
IDHL	Immediately Dangerous to Life and Health
kg	kilograms
kgf	kilogram force

km	kilometer
kPa	kilopascals
KPIs	key performance indicators
LGUs	Local Government Units
lm	linear meter
lpcd	liters per capita per day
lps	liters per second
m	meter
m^2	square meter
m^3	cubic meter
m^3/d	cubics meter per day
MaxNI	maximum allowable net income
MDD	maximum day demand
mg/l	milligrams per liter
mm	millimeter
mld	million liters per day
mm/hr	millimeters per hour
MOA	Memorandum of Agreement
N/m^2	Newtons per square meter
NGO	Non-Government Organization
NPSH	net positive suction head
NPSHa	net positive suction head available
NPSHr	net positive suction head requirement
NRW	non-revenue water
NTU	Nephelometric turbidity unit
O&M	operation and maintenance
OD	outside diameter
Opex	operational expenses
Pa	Pascal
PE pipe	polyethylene pipe
PEER	property and equipment entitled to return
PNS	Philippine National Standards
PNSDW	Philippine National Standards for Drinking Water
psi	pounds per square inch
PVC pipe	polyvinyl chloride pipe
PWL	pumping water level
ROI	return on investment
RR	revenue requirements
RWSA	Rural Water & Sanitation Association
SCBA	self-contained breathing apparatus
SMAW	shielded metal arc welding
SSWP	Small-Scale Water Provider
SWL	static water level
TDH	total dynamic head
TDS	total dissolved solids
VC	volume container
VIM	variation in mass
Wc	container
Wcm	container + material
WHP	water horsepower
WL	water level

Table of Contents

List of Tables

List of Figures

Chapter 1

Institutional and Regulatory Requirements

This Chapter describes the institutional requirements that a small-scale water provider (SSWP)[1] must meet and the steps it must take to legalize its existence and operations.

It must be clearly understood that the business of selling water is by nature a public utility, and under Philippine law the SSWP is considered a public utility enfranchised and regulated as such.[2]

A. INSTITUTIONAL MODELS

In general, there are three types of institutional models that SSWPs can adopt in setting up a Level II or Level III water utility system[3]:

- **Community-Based Organization (CBO):** CBOs include the Rural Water & Sanitation Associations (RWSAs) and Water Cooperatives, including Homeowners Associations, which are organized to provide water service to their members and are responsible for the operation and management (O&M) of the water system.
- **Local Enterprise:** This model includes water supply businesses operated generally by small private entrepreneurs, examples of which are water truckers, carriers or vendors, and other private individuals who provide water services at times and in places that main water utilities are unable serve. (Some examples of larger private water service enterprises that may still be classified, as SSWPs are those operated by private developers.) These are businesses run with profit as the main consideration. They obtain water from nearby water utilities or from their own source.
- **LGU-Model:** Some LGUs establish, own, and/or operate their own water utilities. These utilities are a part of the LGU organizational hierarchy.

The sector benchmarking experience is that among the various water utility management models, the LGU Model has generally fallen short of expectations. Among the many reasons for this failure, the most prevalent is that a water system will find it difficult to operate within a political environment and fiscal restrictions that apply to government entities. The LGUs had been tasked to provide the basic water and

[1] A utility with less than 5,000 connections. Can be a community-based model, privately owned, a water district, or an LGU-run system.

[2] "Enfranchised…regulated". The law encourages public utilities, giving a franchise (right, privileges and protection) so that they can operate sustainably and deliver essential services. However, the law also ensures that the utility businesses do not overcharge consumers, and that the services they provide meet the applicable standards of quality and public safety (in the case of water, potability and health).

[3] Water Districts are basically formed for Level III systems in semi-urban or urban areas.

sanitation services by the Local Government Code, but nowhere is it written that the LGUs have to provide these services *directly.* LGUs can create water districts or CBOs or contract out or partner with the private sector for these services. The LGU Model should only be adopted as a last recourse when all the other options are not possible or viable.

B. INSTITUTIONAL REQUIREMENTS

At the outset, the organizers, LGUs, and community members will need to choose whether to set up a RWSA, Cooperative or another type of organization to operate their water system. This choice will be based on their own perception of needs, their relationships and capabilities, their desired level of participation, and preferences. The following sections describe some of the options and considerations in making their choice.

1. Rural Water and Sanitation Associations

The Rural Waterworks and Sanitation Association (RWSA) is a non-stock, non-profit association organized and registered with the Local Water Utilities Administration (LWUA) in accordance with the provisions of EO 577. As an entity designed for the single purpose of establishing and/or operating a small-scale water system, the RWSA is relatively simple and easy to organize. It enjoys the advantages of technical, organizational and financial support from LWUA.

In applying for LWUA registration, the RWSA needs to submit to the LWUA the following documents in two (2) copies each:

- Articles of Incorporation
- By-laws
- Minutes of Organizational meeting
- Minutes of First Board Meeting
- Feasibility Study, if available
- Certificate of Availability of loan funds if funding is to be provided by other agencies.

More complete information about these and other requirements can be obtained from the LWUA website at LWUA.gov.ph.

Note that the Barangay Water and Sanitation Association (BAWASA), which is also a CBO, is similar to the RWSA in many respects and could be used in lieu of a RWSA, particularly if the SSWP is confined within a single barangay.

2. Cooperatives

Cooperatives may be chosen by organizers and member-beneficiaries who want greater flexibility in their organization's scope, and who are willing to participate closely in its affairs. While a cooperative may be set up initially just to set up a water system for their needs, it may also be expanded into a vehicle to address other needs that they may have.

Among the advantages that they may expect from the cooperative model, as provided in the Cooperative Code of the Philippines (RA 6938), are the following:

- Coops are tax-free up to a certain limit;
- Coop members have shares and can literally sell their shares or even the entire system to a willing private operator;
- Coops can declare dividends based on members' shares.

The cooperative law prescribes very clear-cut steps for the cooperative organizers and members:

First: At least 15 members are needed to organize a cooperative.

Second: The cooperative by-laws, which state the rules and regulations governing the operation of the cooperative, must be drafted.

Third: The Articles of Cooperation must be drafted. Mandatory contents of the articles of cooperation are the following: (a) the name of the cooperative, which must include the word "cooperative"; (b) the purpose or purposes and scope of business of the cooperative; (c) the term of existence of cooperative; (d) the area of operation and the postal addresses of the registrant-cooperators; (e) the common bond of membership; (f) the names of the directors who shall manage the cooperative; (g) the amount of share capital; (h) the names and residences of its contributors, and (i) the type of cooperative, whether it is primary, secondary or tertiary.

Fourth: Bonds must be secured for the accountable officers, usually the Treasurer and the Manager. The amounts are to be decided upon by the Board of Directors based on the initial net worth of the cooperative, which includes the paid-up capital, membership fees, and other assets of the cooperative at the time of registration.

The following documents are needed for registration purposes.

- Four (4) copies each of the Economic Survey, Articles of Cooperation and By-Laws duly notarized;
- Bonds of accountable officers (any directors, officers and employees) handling funds, securities, of properties in behalf of the cooperative;
- Sworn statement of the treasurer duly notarized showing that at least 25% of the authorized share capital has been subscribed, and at least 25% of the total subscription has been paid. The paid-up capital must not be less than Ph₱ 2,000.00.

It is important to note that no member may own more than 20% of the subscribed share capital and that each share must not be less than Ph₱1.00.

Additional information is available at the CDA website at:

http://www.cda.gov.ph

3. LGU Model

Should the LGU decide to operate its own system, the following options can be adopted:

1. Form an LGU Corporation: The LGU can form an LGU corporation which will own the facility, have its own governing boards and operate like any government owned corporation.
2. Form a water supply unit under the Economic Enterprise Office. This structure assumes that this Office had already been created by an appropriate ordinance to house all revenue generating units of the LGU like markets, slaughter house, fish landing, transport terminals, etc.
3. Place the WSS unit under either the Municipal Engineer or Planning Office.

The models so enumerated above are ranked according to their viability and sustainability potentials.

A water supply system must be in control of its water revenues so it can do its programming, budgeting and monitoring functions effectively. Unless the water supply operations and accounts are *ring-fenced*, the system will not be self-liquidating or even viable.

Ring-fencing often denotes that funds set aside for an activity will not be spent on anything else, and that revenues generated by those activities are invested back.

Ring Fencing is a legal or financial arrangement of separating the activities, assets and liabilities, revenues and costs, and so on, generated by the water supply business from the other businesses of the LGU. Ring fencing includes the separation of financial accounts through the use of a subsidiary accounting system. For more details on the ring-fencing process, please refer to the manual, "A Guide to Ring-Fencing of Local Government Run Utilities", prepared by the IBRD-WSP and PPIAF, or the Toolbox Kit of the DILG or the NWRB's list of Accredited Technical Service Providers.

C. OWNERSHIP ISSUES

A major issue that an SSWP must tackle from the start is *who owns the system, particularly, the physical assets and land.* Ownership is very crucial to minimizing political interference and ensuring independence in operating and management decisions, particularly in the timely collection of water service fees.

The officers of the SSWP must ensure that they obtain proper documentary proof/s of ownership. This is especially critical if majority of the funds used to build the system come from grants or contributions from the local government unit (LGU) or from some other funding channeled through the LGU.

Ownership can be manifested in various ways, such as:

- Deed of Donation (or Transfer)
- Memorandum of Agreement
- Proof of Purchase

Without documented proof of ownership of the system (land assets and facilities), an adverse turn in political power could result in an adverse LGU administration making claims on or taking over the RWSA's assets. Moreover, the utility may find it difficult to borrow without documents showing ownership of the assets.

It is however possible for SSWPs to operators of water utilities that they do not own. Usually, these are owned by LGUs. An SSWP engaged by an LGU for this purpose must have a Memorandum of Agreement (MOA) or a formal contract[4] with the LGU specifying the period of the contract, the duties and obligations of each party, and what would constitute default in operations.

D. REGULATORY REQUIREMENTS

SSWPs are legal entities that must be formally incorporated and registered in order to exist legally. They operate within particular areas, and thus are subject to the local laws and ordinances that apply in those areas. They use an important national resource whose use must be managed by the State, and thus they must obtain the right to use such resource and comply with the purpose and manner of its use. The Level II/III systems they operate are water utilities; hence their costs of services as well as the quality of their product (water) are subject to regulation.

In view of these considerations, the State has established a Regulatory Framework for the operation of water utilities like SSWPs.

1. Regulatory Framework

The regulatory framework that applies to SSWPs has three interrelated components:

- **Legal Framework** – the set of laws and regulations that prescribe the registration requirements, regulatory procedures, licenses and contracts that define how the SSWP entity should be established and operate to comply

[4] Under the Local Government Code of 1991 (RA 7160), an LGU may enter into a concession, management or lease contract with an operator of its facility.

with the applicable legal parameters. This framework defines what is to be regulated, who should be regulated, and who will regulate.

- **Institutional Framework** – composed of the regulatory bodies tasked with administering the regulatory laws. At present, the national economic regulatory agency is the National Water Resources Board (NWRB).
- **Regulatory Practices** – the rules, guidelines, and procedures in the application and issuance of the required licenses and permits, and the monitoring and enforcement practices adopted by the regulatory bodies to carry out their responsibilities.

The regulatory framework and its components are designed not just for the benefit of the consumers but also to provide a supportive climate by which the utility itself can operate and render its services viably while meeting the health and quality standards of the water they supply. It is essential for SSWPs to operate within the ambit of the law to protect the investments made and ensure continuity of their operations.

Failure to comply with regulations opens the operators/owners to legal actions either by the regulatory bodies, LGUs, or other affected parties.

Within the current Regulatory Framework described above, there are four types of registrations, licenses and permits that an SSWP must obtain to legalize its operations. These include:

1. Business registration;
2. The local licenses and permits to operate;
3. License or franchise to engage in the business of selling water, which is a public utility. The right to engage in the business of selling water is conditioned on its adherence to the health and quality standards for potable water, and thus may be suspended or revoked if these standards are not met;
4. Water Right/Permit (in case of raw water abstraction).

The small water service utility needs to acquire legal status by registering formally, as well as obtain the business licenses and permits necessary to operate. Failure to do so opens it to the risk of being slapped a huge fine, or being issued a Cease and Desist Order, or expropriation.

2. Business Registration

Without formal registration, the water service provider will not be able to deal legally with government and financing institutions. Government will not provide its services, issue permits, or transact with non-registered entities, and banks and other financing institutions do not lend to illegal or unregistered operators. Neither will it be able to obtain from the Bureau of Internal Revenue (BIR) the official receipts and Tax Information Number (TIN) which are essential in doing business.

Thus, in deciding which institutional setup to adopt, the SSWP should consider the registering authority for that model. A cooperative must be registered with the CDA. A RWSA must be registered with the LWUA, or with the Securities and Exchange Commission (SEC) as a non-profit organization.

3. Local Business Permits, Licenses and Clearances

A utility will operate within the locality of its franchise area. Thus, it must comply with the local laws or ordinances that apply within that locality. These invariably include business permits[5], location and other municipal clearances, and barangay clearance. Since requirements may vary from one LGU to another, the organizers or management of the SSWP must look into these requirements and be sure it is able to comply with them.

4. Certificate of Public Conveyance (CPC)

After registering and securing its business permit, an SSWP can operate within the territory of an LGU. The next step would be to secure clearance on its franchise area and the water tariff from the NWRB or LWUA. Being engaged in the business of selling water, the operator must secure a franchise to operate as a public utility. Such franchise is issued in the form of a Certificate of Public Conveyance (CPC)[6] from the NWRB or a Certificate of Registration from the LWUA[7]. LWUA registration is effectively also a CPC, and does not require further application for a CPC from NWRB. Nonetheless, the SSWP must apply for a Water Right with the NWRB and comply with its annual reporting requirements.

To process an application for a CPC and issue approval of a tariff proposal, the NWRB will require the following documents to be submitted:

1. Registration (with SEC, LWUA or CDA);
2. Articles of Incorporation and By-laws;
3. Water Permit, if the utility has its own source;
4. Plan of the water distribution system;
5. Plan, elevation and cross sectional views of reservoir and pump house;
6. Certificate of potability;
7. Business Plan for 5 years; and

[5] Sometimes referred to as "Mayor's Permit" or "Business License".
[6] Certificate of Public Conveyance is a permit allowing the utility (permittee) to operate a water system for a certain period in a given area.
[7] For RWSAs only.

8. Service levels agreed with consumers commensurate with proposed rates

The NWRB has the authority to set rules on maximum return on investments for all SSWPs. It should be noted that the current policy of the national government is to set tariffs on the basis of cost recovery. SSWPs are allowed to have a maximum of 12% return on assets.

Once it has obtained its CPC, the SSWP is required to submit an Annual Report to the NWRB. The Annual Report is a compilation of data pertaining to a water utility operator. It depicts the financial condition and other information that will be used in the regular monitoring of the utility's performance. The Annual Report is a formal and legal document that must be audited by an external auditor, and whose accuracy and completeness the operator must swear to before a notary public.

5. Water Right/Permit

Any system extracting water directly from its source (groundwater or surface water) needs to secure a water right from the NWRB. This water right is important to establish the legal right of the abstractor and prevent any legal or water rights conflicts that may arise in the future. In entertaining an application for water right, the NWRB usually requires the submission of data regarding the place of abstraction, method and volume of abstraction, and purpose.

The NWRB website at www.nwrb.gov.ph provides full information on how to secure this right.

6. Water Quality Regulation

Any system needs to be able to prove that the quality of water it supplies meets certain minimum health requirements or standards set by the country's health authorities. The Philippine National Standards for Drinking Water (PNSDW) requires chemical and physical tests to be conducted once a year, and micro-biological tests to be conducted monthly or quarterly, with the number of test samples dependent on the served population. The monitoring protocol usually calls for test results to be submitted to the regulatory office, as required, and for the test results to be posted in conspicuous places within the Utility's office.

The posting of test results is intended to protect both the consumers and the system itself, and to inform the consumers and the regulatory agency that the water conforms to health and water quality standards. The regularity and frequency of monitoring and information updates help to head off possible outbreaks of diseases that may be attributed to the system's water quality. They are meant to trigger timely interventions by the health authorities and corrective measures on the part of the SSWP, and to give customers the information they need to protect themselves and their families against water-related health problems.

E. INSTITUTIONAL PROBLEMS AND PRACTICAL SOLUTIONS

1. Political Interference

The management and human resource capabilities of the SSWP should be strengthened for it to be operationally autonomous. The LGU and other institutions concerned with the water sector can assist in the formation of the community based organization (CBO), provide or finance the initial assets, extend technical assistance, and create linkages between the SSWP and financial institutions.

Quite often, it is expedient, desirable – and even necessary for the LGU to help organize the water service organization and support the acquisition of its assets. However, the operations of the SSWP should be independent of the LGU. To the extent possible, operating subsidies from the LGU should not be sought. The SSWP should have clear contracts, deeds of sale and/or donations, and the ownership documents of the assets of the Utility.

2. Lack of Management Skills

The SSWP's management and policy-making capabilities should be enhanced through management skills training being offered by the Department of Interior & Local Government (DILG) or LWUA. Study tours to main utilities or any nearby, successful SSWP which has expanded and been operating for some time would also be very useful.

The success of any organization depends on the capabilities and commitment of the people running it.

3. Lack of Cooperation among the Management Team Members

Usually the cause is a lack of understanding of the various roles and responsibilities. If possible, these roles/responsibilities should be set in writing during the organizational or early phases of the SSWP. If these are not properly understood, a reorientation, coupled with events designed to build team effort, should be conducted.

4. Lack of Support and Cooperation of the Member-Users

The members/beneficiaries should be oriented on their roles and responsibilities in relation to the services of the SSWP. At the same time, the SSWP management should engage them and listen to their views on issues affecting them. These can be done through general assembly's or consultation meetings that the SSWP or those assisting it could initiate. It is important for the SSWP management to be responsive to the views of its members. When existing policies are not responsive to the members' needs, efforts should be taken to craft more responsive, more effective ones.

5. No Full-Time or Operational Staff

If the system really needs full-time staff, then they should be compensated for their time through allowances or salaries. Their compensation can be included in the tariff calculations.

6. No Organizational Records and Minutes of Meetings

The concerned staff or officers should be fully trained to carry out their essential tasks and functions. The utility should buy or acquire a filing cabinet in which it can keep all its records. If it has no office, it should arrange to keep the filing cabinet in the house of one of the officers. Upon election of new officers, the filing cabinet and its contents should be transferred to the new officer responsible for custody of the files.

7. No Management Information System in Place

Professional support in the development and installation of a simple and effective management information system should be sought from national agencies, NGOs or nearby utilities.

Chapter 2

Operational Mathematics

This Chapter provides a reference and guide to the basic mathematics needed for operational purposes of the Utility.

A. INTRODUCTION

The two main systems of measurement are the metric and the English systems. The metric system is also called the International Standard (SI) system. It has been accepted officially by practically all countries (a notable exception is the United States) and is used by all international scientific institutions and the United Nations. However, not all countries who have accepted it have been able to take the steps needed to fully convert from their previous system to the metric.

This Manual will use the metric system primarily. It must be considered, however, that much of the calibration of equipment in use in the water industry, as well as references, information, and standards (of which the US is a leading source) use measurements based on the English system. Thus, it is important to know both systems, and to be able to convert the measurements of one system to the other.

The metric system is a decimal system based on 10, in which the higher- or lower-value units of measure are scaled by raising or reducing by a factor of 10. The basic measures of time, expressed in seconds, minutes, hours, days, months, and years, are common to both systems. However, decades (10 years), centuries (100 years), and millennia (1000) are graduated values that use the decimal or metric scale.

This Chapter introduces the important units of measure that are frequently used in the establishment and operation of SSWP facilities. It also presents conversion tables and gives samples of how to convert from the English to the metric system.

B. MEASURES OF LENGTH

Length is a measurement of the distance from one point to another, and is the basis also for measuring area and dimension.

1. Metric Units of Length

In the metric system, the basic unit is the Meter. Graduated multiples or fractions of the meter are designated by prefixes as shown in Table 2.1 below. The higher values are on the left, and the lower values are on the right:

Table 2.1: Metric Units of Length							
SI Prefix	kilo	hecto	deka	meter	deci	centi	milli
Unit	kilometer	hectometer	dekameter		decimeter	centimeter	millimeter
Multiplier	1,000	100	10	1	0.1	0.01	0.001
Symbol	**km**	**hm**	**dam**	**m**	**dm**	**cm**	**mm**

2. English Units of Length

In the English system, length is expressed in inches, feet, yards and miles. The useful common units and their relationships are as follows:

Table 2.2: English Units of Length				
	inch (in)	foot (ft)	yard (yd)	mile (mi)
1 foot	12 in	**1 foot**		
1 yard	36 in	3 ft	**1 yard**	
1 mile		5,280 ft	1,760 yd	**1 mile**

3. Converting Between Metric and English Units of Length

The conversion chart that follows gives the basic equivalents of the metric and the English units of length, to make conversions easy.

Basic Conversions:

Table 2.3: Converting Between Metric and English Units of Length				
	millimeters	centimeters	meters	kilometers
1 inch	25.40 mm	2.540 cm		
1 foot		30.48 cm	0.3048 m	
1 yard		91.44 cm	0.9144 m	
1 mile			1609 m	1.609 km
	inches	feet	yards	miles
1 meter	39.37 in	3.281 ft	1.094 yd	
1 kilometer		3281 ft	1094 yd	0.6214 mi

Examples:

Example 1: Pipes delivered had diameters of 4 and 6 inches. What are the diameters in mm?

Since 1 in = 25.4 mm, a 4-in pipe would be:

$$4\ in \times 25.4\ {}^{mm}/_{in} = 101.6\ mm$$
$$which\ is\ nominally\ refered\ to\ as\ a\ 100\ mm\ pipe.$$

A 6-in pipe would be:

$$6\ in \times 25.4\ {}^{mm}/_{in} = 152.4\ mm, nominally\ 150\ mm$$

Example 2: The 10 pipes delivered were 20 ft each in length. What is the total length in meters?

Since there are 3.281 ft in one meter:

$$10\ pipes \times 20\ ft\ each = 200\ ft \div 3.281\ {}^{ft}/_{m} = 60.96\ m$$

C. MEASURES OF VOLUME

Volume can be defined as the amount of space occupied by an object, or conversely, the amount of space available to accommodate materials. For SSWPs, volume measurements of containers and water are important.

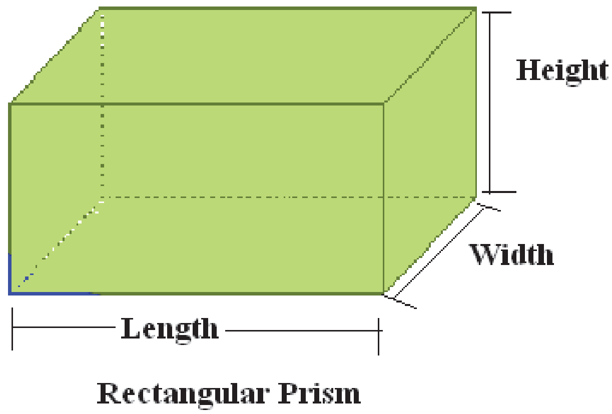
In the case of solids and the internal space (capacity) of containers, the common basic unit is the cubic meter (m^3). In the case of liquids like water, it is the liter (l). One liter is equal to 1,000 cubic centimeters (cm^3) and 1,000 liters is equivalent to one kiloliter (kl) or 1 cubic meter (m^3).

In conventional and water industry use, large volumes of water are expressed in terms of cubic meters – in other words, in terms of the capacity (volume) of the containers they would fill. (It is easier to measure the 3 dimensions of a container, than it is to measure uncontained water.) Since 1 kl of water, in standard testing conditions, is equal to one cubic meter (m^3), it is common to use cubic meters to refer to larger volumes of water, although in many instances thousands and millions of liters are the more impressive expressions used.

1. Volume of Containers

The measurement of volume for simple box-like containers (rectangular prisms) involves the measurement of three dimensions, namely length, width, and height.

Figure 2.1: Rectangular Prism



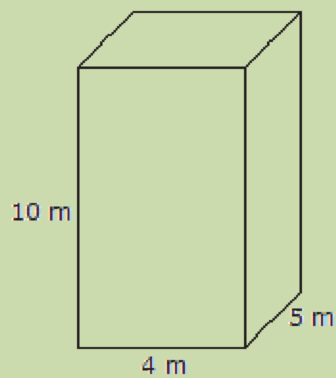
$$V = l \times w \times h$$

Where:

$$V = volume\ of\ rectangular\ prism$$
$$l = length$$
$$w = width$$
$$h = height$$

Example:

Find the volume of a rectangular prism that is 10 m tall and has a base that measures 4 m by 5 m.



Solution:

$$V = l \times w \times h = 5\ m \times 4\ m \times 10\ m$$
$$= \mathbf{200\ m^3}$$

In liters,

$$200\ m^3 \times \frac{1{,}000\ l}{1\ m^3} = 200{,}000\ liters$$

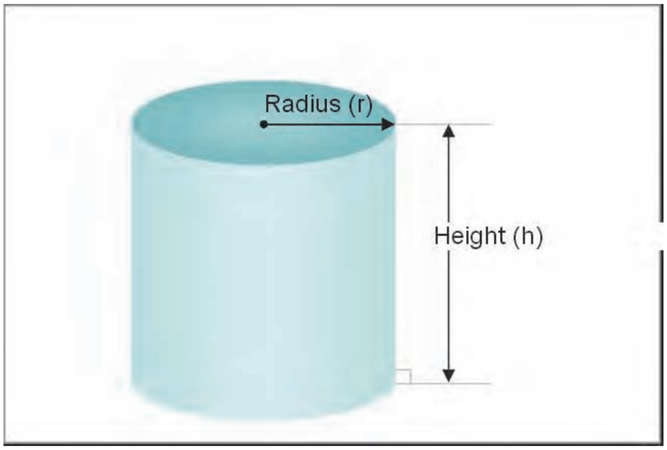
In the case of cylindrical containers, which are common in the water business, the calculation of internal volume involves measuring the radius and applying the formula:

$$\boldsymbol{V = \pi r^2 h}$$

Where:

$$V = volume\ of\ cylinder$$
$$\pi = 3.1416$$
$$r = radius\ \left(= {}^{1}/_{2}\ diameter\right)$$
$$h = height$$

Figure 2.2: Volume of a Cylinder



Example:

Find the volume of a cylindrical reservoir with a radius of 7 m and a height of 12 m.

Solution:

$$V = \pi r^2 h = 3.1416 \times 7^2\ m \times 12\ m$$
$$= 1{,}847.2608\ m^3\ or\ 1{,}807{,}206.8\ l$$

Note that the illustrations seem to indicate external dimensions. In the case of containers, the measurements should be of the internal dimensions. Where precision of internal capacity is an issue but the container does not allow direct internal measurement, simply measure the outside dimensions but deduct the thickness of the container walls to obtain the exact internal dimensions.

2. Metric Units of Volume for Water

Table 2.4: Metric Units of Volume

Prefix	kilo	hecto	deka	liter	deci	centi	milli
Unit	kiloliter	Not widely used in the water industry, except hectoliter in Australia. (1 hl = 100 l)			deciliter	centiliter	milliliter
Multiplier	1,000			1	0.1	0.01	0.001
Symbol	kl			l or L	dl	cl	ml

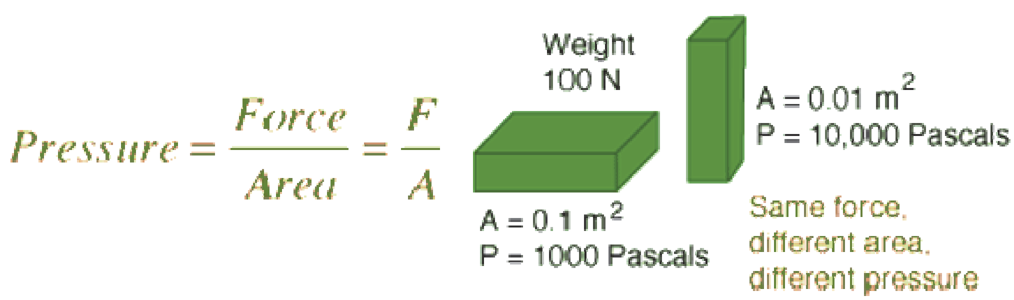
D. PRESSURE/HEAD

Pressure is defined as force per unit area. It is usually more convenient to use pressure rather than force to describe the influences of fluids. The standard unit for pressure in the English system is pounds per square inch (psi) while in the metric system it is the Pascal (Pa), which is a **Newton per square meter (N/m^2).**

Pressure gauges in the Philippines are usually scaled in **psi** or **N/cm^2** or bars. Just remember that one bar or **14.7 psi** = **10.1 N/cm^2**. So if a pressure gauge reads **22 N/cm^2**, it is equivalent to **14.7 x 22/10.1** = **32 psi**.

For an object sitting on a surface, the force pressing on the surface is the weight of the object, but in different orientations it might have a different area in contact with the surface and therefore exerts a different pressure.

Figure 2.3: Pressure



Note that bar refers to atmospheric pressure, which is equivalent to 14.7 psi. This means that under standard measurement conditions, a column of air with one square inch area, sitting on the Earth's surface and extending to space - weighs 14.7 pounds.

One bar is 100,000 Pa, and for most practical purposes can be considered equivalent to one atmosphere[8] .

1. Converting Head to Pressure

Head and pressure are used almost interchangeably with respect to water systems. Since pressure gauges often are calibrated in psi or bar, it may be necessary to convert to head in meters or in feet

- **Converting head in feet to pressure in psi:**

  Feet of head can be converted to pressure - psi - by the expression:

$$p = 0.424h\ SG$$

[8] 1 Bar = 0.9869 atm

Where:

$$p = pressure\ (psi)$$
$$h = head\ (ft)$$
$$SG = specific\ gravity$$
$$*\ In\ the\ English\ system, the\ SG\ of\ water\ is\ 1$$

Example:

The pressure gauge on the discharge pipe from the reservoir reads 30 psi. How high is the water level from the gauge level?

Answer:

$$Since\ p = 0.434h, therefore\ h = p/0.434$$
$$h = 30\ psi/0.434 = 69.ft \times \frac{1\ m}{3.28\ ft} = 21\ m$$

Useful to remember:

$$\mathbf{4.34\ psi\ is\ equal\ to\ 10\ feet\ or\ 3\ meters\ head\ of\ water}$$

- **Converting head in meters to pressure in bar:**

  Meters of head can be converted to pressure-bars - by the expression:

$$\mathbf{p = 0.0981h\ SG}$$

Where:

$$p = pressure\ (bar)$$
$$h = head\ (m)$$

2. Converting Pressure to Head

- **Converting pressure in psi to head in feet:**

$$\mathbf{h = 2.31p\ SG}$$

Where:

$$p = pressure\ (psi)$$
$$h = head\ (ft)$$

- **Converting pressure in bar to head in meters:**

$$\mathbf{h = 10.197p/SG}$$

Where:

$$p = pressure\ (bar)$$
$$h = head\ (m)$$

- **Converting pressure in kg/cm² to head in meters:**

$$\boldsymbol{h = 10p/SG}$$

Where:

$$p = pressure\ (kg/cm^2)$$
$$h = head\ (m)$$

Example: Determining Pressure Gauge Accuracy

The pressure gauge beside the elevated reservoir reads 40 psi. But the operator doubts the accuracy of the pressure gauge. How can he determine the accuracy of the gauge?

To convert psi to head in feet the formula is $h = 2.31p$, therefore the height of the water level should be $h = 2.31 \times 40 = 92.4\ ft$

The operator has to measure the height of the water level in the reservoir from the gauge level. If the measured height is not 92.4 ft (or 28.2 meters), then the gauge accuracy is in question.

E. FLOW MEASUREMENTS

For liquids, various units are used depending upon the application and industry, but might include gallons per minute (gpm), liters per second (lps), or, when describing river flows, cumecs (cubic meters per second) or even million liters per day (mld).

Perhaps the simplest way to measure volumetric flow is to measure how long it takes to fill a known volume container. A simple example is using a container of known volume, filled by a fluid. The stopwatch is started when the flow starts, and stopped when the container starts to overflow. The volume divided by the time gives the flow. This method can be employed for measuring the flow of well sources.

To convert gpm to lps, divide gpm by 15.852.

Example:

A pump is rated at 200 gpm. ***Convert to lps:***

$$lps = \frac{gpm}{15.852} = \frac{200}{15.852} = 12.6\ lps$$

F. ELECTRICAL CALCULATIONS

1. kW and hp

Horsepower (hp) is a unit of work originally established to measure the amount of energy required to raise coal out of a coal mine. One horsepower is equivalent to 33,000 foot-pounds of work performed in one minute. This is equivalent to lifting 454 kg, 101 meters in ten minutes[9]. It was estimated then that one hp was equivalent to the amount of work a strong horse could perform.

Pumps are rated according to their hp capacity. Pump hp is a function of its head and flow capacity. (Refer to Volume I, Design Manual Chapter 14).

One hp is equal to 746 watts or 0.746 kW. Given the pump hp, multiply hp by 746 to get watts.

2. Power, Voltage and Current

The relationships among Power, Current and Voltage are shown in the following three expressions:

$$\boldsymbol{Power} = \boldsymbol{Current} \times \boldsymbol{Voltage}\ or\ \boldsymbol{P} = \boldsymbol{I} \times \boldsymbol{V}\ or\ \boldsymbol{I} = \frac{\boldsymbol{P}}{\boldsymbol{V}}\ or\ \boldsymbol{V} = \frac{\boldsymbol{P}}{\boldsymbol{I}}$$

Where:

$$P = power\ in\ watts\ (W)$$
$$V = voltage\ in\ volts\ (V)$$
$$I = current\ in\ amperes\ (A)$$
$$(sometimes\ referred\ to\ as\ amps\ in\ the\ English\ system)$$

Example:

A 700-watt, 220-volt electric iron is to be used.

What should be the minimum amp rating of an electric power extension cord, if one has to be used?

$$I = \frac{P}{V} = \frac{700\ W}{220\ V} = 3.2\ A$$

3. Energy and Power

The amount of energy used (or supplied) depends on the power and the amount of time it is used:

$$Energy = Power \times Time$$

[9] Or 454 kg, 10 m in one minute or 45 kg, 10 m in 6 minutes

The standard unit for energy is the joule (J), but a J is a very small amount of energy for mains electricity. For utility use, electrical energy in kilowatt-hours (kWh) is used. 1 kWh is the energy used by a 1 kW power equipment when it is switched on for 1 hour:

1 kWh = 1 kW × 1 hour

Examples:

A 100 W (0.1 kW) bulb switched on for 8 hours uses $0.1 \times 8 = 0.8\ kWh$

A 3 hp motor used for 12 hours uses $3\ hp \times 0.746\ kW/hp \times 12\ hrs = 27\ kWh$

Chapter 3

Disinfection

This Chapter details the procedures for using chlorine safely as a disinfectant and the methods of calculating the chlorine dosages required in the water system.

A. GENERAL

Disinfection is necessary to ensure that drinking water is free from disease-causing microorganisms. Water disinfection means the removal, deactivation or killing of pathogenic[10] microorganisms. Disinfection is often universally employed by water distribution systems, even when water at the source is deemed already potable – as a precautionary measure to control the spread of waterborne diseases. In Level III Systems, this precaution is particularly important because of the risk of contamination due to breaks and other types of seepages anywhere throughout the extensive pipe network, and the magnified impact of this risk due to the number of users.

B. CHLORINE DISINFECTION (CHLORINATION)

Chlorination is the process of adding the element chlorine to water to make it safe for human consumption as drinking water. Chlorine (and its compounds) is the most widely used disinfectant for water systems because of its effectiveness, cheap cost and availability.

Chlorination has the advantage of oxidizing bacteria and virus even after the point of application due to its residual action. Hence any bacteria introduced to the system after the point of chlorination can still be eliminated by the residual chlorine in the water.

C. DETERMINANTS OF CHLORINE EFFECTIVENESS

1. **Contact Time (CT) & Dosage** – Contact time refers to the period of time allowed for the disinfectant to react with the microorganisms that may be in the water. Dosage refers to the amount of chlorine infused in relation to the volume of the water being treated.
2. **The Type of Microorganism** – Chlorine is quite effective in destroying the most significant pathogenic organisms that are dangerous to humans and are commonly borne in water. Different pathogens and parasites, however, have different levels of resistance to it. Thus, the dosages, the CT, and other conditions of the water that intensify or inhibit the oxidizing action of chlorine such as temperature and pH (acidity or alkalinity) need to be

[10] Disease-causing microorganisms, such as bacteria, fungi, and viruses

considered in order to be sure that the harmful organisms and undesirable substances are eliminated.

3. **Characteristics of the Source Water** – The nature of the water that requires treatment influences the disinfection. Materials in the water, for example, iron, manganese, hydrogen sulfide and nitrates often react with disinfectants, effectively increasing the chlorine demand. Turbidity of the water also reduces the effectiveness of disinfection.
4. Usually, the tests on the water from a new source are the basis for prescribing the dosage and CT needed to eliminate the harmful and undesirable substances. Additional tests on the water at source need to be conducted when there are indications that the source water characteristics have changed. The possibility of contaminants (whether pathogens or minerals that change its acidity or turbidity) in the path of the water or in the proximity of the spring box or reservoir need to be checked.
5. **Temperature of Water** – Higher temperatures usually increase the speed of reactions and of disinfection.

D. TERMINOLOGY AND DEFINITIONS

1. **Available Chlorine Content** – is amount of chlorine in a chlorine compound, which determines its potential disinfecting power.
2. **Chlorine Demand** – is the total amount of chlorine needed to oxidize all the materials in the water that react with chlorine within a given period. After all the reactions within that period are completed, the pathogens and undesirable organic substances, as well as the soluble iron, manganese and hydrogen sulfides are deemed to have been destroyed, neutralized, or eliminated. Chlorine demand is the difference between the amount of chlorine added to water and the amount of residual (remaining) chlorine at the end of a specific contact period. If no residual chlorine is detected, it means that the chlorine demand was so great it exhausted the chlorine; thus the chlorine infused into the water (dosage) was insufficient.
3. **Chlorine Residual** – is the total amount of chlorine (combined and free available chlorine) remaining in water at the end of a specific contact period following the infusion of chlorine. The chlorine residual is an important indicator of safe water because as long as the residual chlorine is present in the water, disinfection is a continuing process.
4. **Dosage of Chlorine** – is the quantity of chlorine applied to a specific quantity of water. Dosage is expressed in milligrams per liter (mg/l) of chlorine.
5. **Dosage Rate** – is the amount of chlorine applied per unit time. It is usually in grams/day or kg/day.

6. **Superchlorination** – this means applying chlorine at very much higher than the usual dosages. If a system design or requirements do not allow adequate contact time for the normal dosages of chlorine to eliminate the pathogens and undesirable substances in the water, superchlorination could be resorted to. Superchlorination provides a chlorine residual of 3.0-5.0 mg/l, which is 10 times the recommended minimum breakpoint chlorine concentration[11]. Retention time for superchlorination is approximately 5 minutes.

7. **Dechlorination** – removes excessive levels of chlorine from the water. Dechlorination is considered a necessary phase after superchlorination in order to remove the odor, taste and the other objectionable traces of excess chlorine in the water. Dechlorination commonly involves the use of an activated carbon filter.

8. **Shock Chlorination** (dosage of 200 mg/l for 3-4 hrs) is recommended whenever a well, reservoir or pipeline is new, repaired, or found to be contaminated. This treatment introduces high levels of chlorine to the water. Unlike superchlorination, shock chlorination is a "one time only" occurrence, and chlorine is depleted as water flows or is flushed through the system. If bacteriological problems persists following shock chlorination, the source of the contamination of the system should be determined and eliminated.

E. CHLORINE DOSAGE AND DEMAND

1. Relationship of Chlorine Dosage, Demand and Residual

When chlorine is added to water, some of it is used up immediately by the water and the substances that are in it. This is known as the chlorine demand of the water. There must be sufficient chlorine left to kill bacteria and viruses not just at the reservoir but even in the distribution system.

$$\boldsymbol{Dosage = Demand + Residual}$$

Even if the chlorine demand of a particular source does not change much over the years, it is still good to be vigilant to prevent any serious outbreaks of diseases. An increase in organic matter in the water source will increase chlorine demand. And this means measuring the chlorine demand and residual almost every day to determine the accurate chlorine dosage to be used.

2. Determining Chlorine Demand

There are two ways of determining the chlorine dosage.

[11] Breakpoint chlorination uses the continual addition of chlorine to the l water to the point where chlorine demand is met and all ammonia is oxidized, so that only free chlorine remains.

Method 1:

1. Dose the water supply with an arbitrary amount, say 1mg/l;
2. Wait for 30 minutes and measure the chlorine residual.
3. If residual is zero or less than 0.2 mg/l, increase the dosage until the right residual is obtained.
4. If residual is more than 0.5 mg/l, then the dosage can be reduced.

Method 2:

Use a 1% chlorine solution[12] to conduct the following procedures:

1. Prepare a 1% chlorine solution, the quantity depending upon type of chlorine used (see Table 3.1 below);
2. Take 3 or 4 non-metallic containers of known volume (e.g. 20 liter buckets);
3. Fill the containers with some of the water to be treated and check the pH of the water;
4. Add to each bucket a progressively greater dose of 1% solution with a measuring device:
   - 1st container: 1 ml
   - 2nd container: 1.5 ml
   - 3rd container: 2 ml
   - 4th container: 2.5 ml
5. Wait 30 minutes. (This is essential as this is the minimum contact time for the chlorine to react. If the pH of the water is high, this minimum time will increase);
6. Measure the free chlorine residual in each bucket;
7. Choose the sample which shows a free residual chlorine level between 0.2 mg/l and 0.5mg/l;
8. Extrapolate the 1% dose to the volume of water to be treated;
9. Check chlorine demand at several water distribution points and adjust if required.

F. CHLORINE/CHLORINE COMPOUNDS USED IN DISINFECTION

1. **Chlorine** – Chlorine is a poisonous yellow-green gas with a penetrating, pungent odor. It is extracted from chlorides through oxidation and electrolysis. In water, chloride (chlorine compounds) hydrolyses to form

[12] A 1% chlorine solution contains 10 grams active chlorine per liter

hypochlorous acid and the hypochlorite ion (free available residual chlorine), which are very toxic to bacteria.

2. **Bleaching Powder or Chloride of Lime** – Bleaching powder or calcium hypochlorite is a yellow white solid which has a strong smell of chlorine. It is not highly soluble in water, and is preferably used in soft to medium-hard water. Bleaching powder loses strength rapidly whenever it is exposed to moist air so that it should be kept in closed containers.

3. **High-Test Hypochlorite (HTH)** – It is a more stable and stronger compound than bleaching powder.

4. **Sodium Hypochlorite (NaOCl)** – This is a highly corrosive, slightly yellow liquid. It is used extensively in many industries as a disinfectant, deodorizer, bleach, and to neutralize certain undesirable chemicals and compounds used or formed in productions processes. For households, it is supplied as the common households bleach.

Table 3.1 shows the percent available chlorine of various chlorine compounds.

Table 3.1: Percentage of Available Chlorine

Material	Available Chlorine	Quantity to Make a Liter of 1% Chlorine Solution
Chlorine gas	100%	-
Calcium Hypochlorite	70 – 74%	14 grams
Bleaching powder	34 – 37%	30 grams
Sodium Hypochlorite (HTH)	12 – 15%	80 grams

G. CHLORINE DOSAGES

The commonly used dosages for various disinfection requirements are as follows:

1. For disinfection of water supplies:
   - Dosage: 0.5 – 2.0 mg/l
   - Contact Time: 20 – 30 minutes

2. For disinfection of newly constructed/repaired wells, storage tanks, pipelines, spring box, etc.:
   - Dosage: 50 mg/l
   - Contact Time: 24 hours

   or
   - Dosage: 300 mg/l
   - Contact Time: 1 hour

3. Sample Calculations:

The examples on the following pages illustrate the mathematical methods applied in arriving at the disinfection dosages and rates of dosage using chlorine gas and some of the typical chlorine compounds used by water systems in the Philippines.

Example: Calculation of Dosage

Given:

Water Consumption: 10,000 liters per day (lpd)

Required Residual : 0.3 mg/l

Chlorine Demand: 0.5 mg/l

Required:

Dosage in mg/l

Dosage rate in gm/day

Using Chlorine gas

Using Bleaching powder

Analysis:

$$Dosage = Chlorine\ Demand + Chlorine\ Residual$$
$$Dosage = 0.5 + 0.3 = 0.8\ mg/l$$

Using Chlorine Gas:

$$Available\ chlorine = 100\%$$
$$Dosage\ rate = \frac{dosage}{available} \times volume\ of\ water\ to\ be\ treated$$
$$= \frac{0.8\ mg/l}{100\%} \times 10{,}000\ lpd = 8{,}000\ mg/day = \mathbf{8\ g/day}$$

Using Bleaching Powder:

$$Available\ chlorine = 35\%$$
$$Dosage\ rate = \frac{dosage}{available} \times volume\ of\ water\ to\ be\ treated$$
$$= \frac{0.8\ mg/l}{0.35} \times 10{,}000\ lpd = 22{,}857\ mg/day = \mathbf{22.9\ g/day}$$

Example: Dosage for Disinfection of Well

Given: Well Diameter = 0.3 m

Static Water level = 6 m

Total Well Depth = 50 m

Required: Amount of HTH required

Disinfection Specifications:

Dosage = 50 mg/l

Contact time = 24 hrs

Analysis:

1. Calculate water volume in well

$$Volume = \pi \times 0.15^2 \times (50 - 6) = 3.11\ m^3 = 3{,}110\ liters$$

2. Determine amount of chlorine compound using HTH (70% chlorine)

$$Amount = \frac{dosage \times volume}{available\ Chlorine}$$
$$= \frac{50\ mg/l \times 3{,}110\ l}{0.70} = 222{,}142\ mg = \mathbf{222\ g}$$

Example: Reservoir Disinfection

Given: Diameter = 4 m

Height = 3 m

Required: Amount of Sodium Hypochlorite Needed

Disinfection Specifications:

Contact time = 1 hour

Dosage = 300 mg/l

Analysis:

$$Volume = \pi \times 2^2 \times 3 = 37.70\ m^3 = 37{,}700\ liters$$
$$Sodium\ Hypochlorite\ availability = 15\%$$
$$Amount = \frac{300\ mg/l \times 37{,}000\ l}{0.15} = 75{,}398\ mg = 75.4\ g$$

H. MEASURING CHLORINE RESIDUAL

1. What Is Chlorine Residual

The word "residual" means "remainder" or "that which is left", and as the name suggests the chlorine residual test is used to measure the amount of chlorine remaining in the water at a certain point of time when the test is made. When chlorine cannot be detected within the distribution system, it means that it has reacted more or less completely with the water and the impurities in the water. At this point, there is no more free chlorine to act effectively as a disinfectant.

Three types of chlorine residuals can be measured:

- **Free chlorine:** which kills microorganisms most effectively;
- **Combined chlorine:** formed when free chlorine reacts with other chemicals in water, forming other types of chlorine-based compounds;
- **Total chlorine:** the sum of free and combined chlorine.

Free chlorine is very unstable and is prone to be reduced quickly, especially in warm countries. Sunlight and the stirring of the water will cause free chlorine to react with the water and other matter, and thus disappear more quickly. For this reason, chlorine should be tested on site. Do not take the water sample to the laboratory for testing, as the results could be misleading.

Figure 3.1: Chlorine Comparator

AppChem LR Color Comparator

2. Using a Chlorine Comparator

Measuring chlorine residual on site is done with a device known as a chlorine comparator, using a chemical known as DPD. Figure 3.1 shows a simple Chlorine Comparator. The comparator uses a reagent which reacts with the chlorine to give the water a reddish color. A color chart is then used to compare the color of the mixture to different colors with given pH values.

The general procedures in measuring the free chlorine residual using a comparator is as follows[13]:

1. Fill a viewing tube with 5 ml sample water and place this tube in the top left opening of the comparator;
2. Fill a second viewing tube with 5-ml sample water;
3. Add the contents of one DPD Free Chlorine Reagent sachet to the second tube and swirl to mix;
4. Place the second tube in the top right opening of the comparator;
5. Hold comparator up to a light source (sky, window or lamp) and look through the opening in front;
6. Rotate the color disc until the colors in the 2 openings match;
7. Read the mg/l free chlorine in the scale window. (This reading must be done within one minute after adding the powder reagent);
8. If the free chlorine residual is lower than 0.1 mg/l, proceed with the total chlorine residual test using the same procedures as above but with the Total Chlorine Reagent sachet;
9. If the total chlorine level is higher than free chlorine, it is obvious that combined chlorine is present. In that case you need to add more chlorine or increase dosage.

Chlorine residuals in water of greater than 0.7 mg/l can already be tasted. Unless otherwise indicated for health reasons, it is best to keep residuals below this level to avoid taste issues and to reduce chemical costs.

3. Measuring Acidity Level (pH) of the Water

It is useful to take the pH (acidity value) while measuring chlorine levels since chlorine works effectively at neutral pH (between 6.5 and 8.5). At a pH value of 6.5 and below, water is considered acidic and beyond 8.5 is considered alkaline. Some chlorine comparators allow the measurement of pH using a tablet reagent known as phenol red.

[13] Keep in mind that different models of comparators may require particular procedures. Refer to the manual of the unit that you will use. The unit's supplier, too, should be able to give you the most applicable information.

I. EQUIPMENT USED IN CHLORINATION

For continuous chlorination in smaller systems, hypochlorinators are generally used; however, chlorinators are considered more economical when the supply source is greater than 8 lps, but sometimes may be used in smaller systems as well. Anticipated pumping periods and chlorine demand (based on the chlorine residual test) determine whether a hypochlorinator or chlorinator should be used in each situation.

In rural areas, the use of chlorine gas is to be avoided whenever possible due to operational requirements and safety reasons. Instead, chlorine compounds and hypochlorinators are recommended.

1. Hypochlorinator

The hypochlorinator is a pump used to add hyphochlorite solutions to water at a manually adjustable feeding rate. As in the setup shown in Figure 3.2, the pump draws the hypochlorite solution from a container and transfers it into the water being treated.

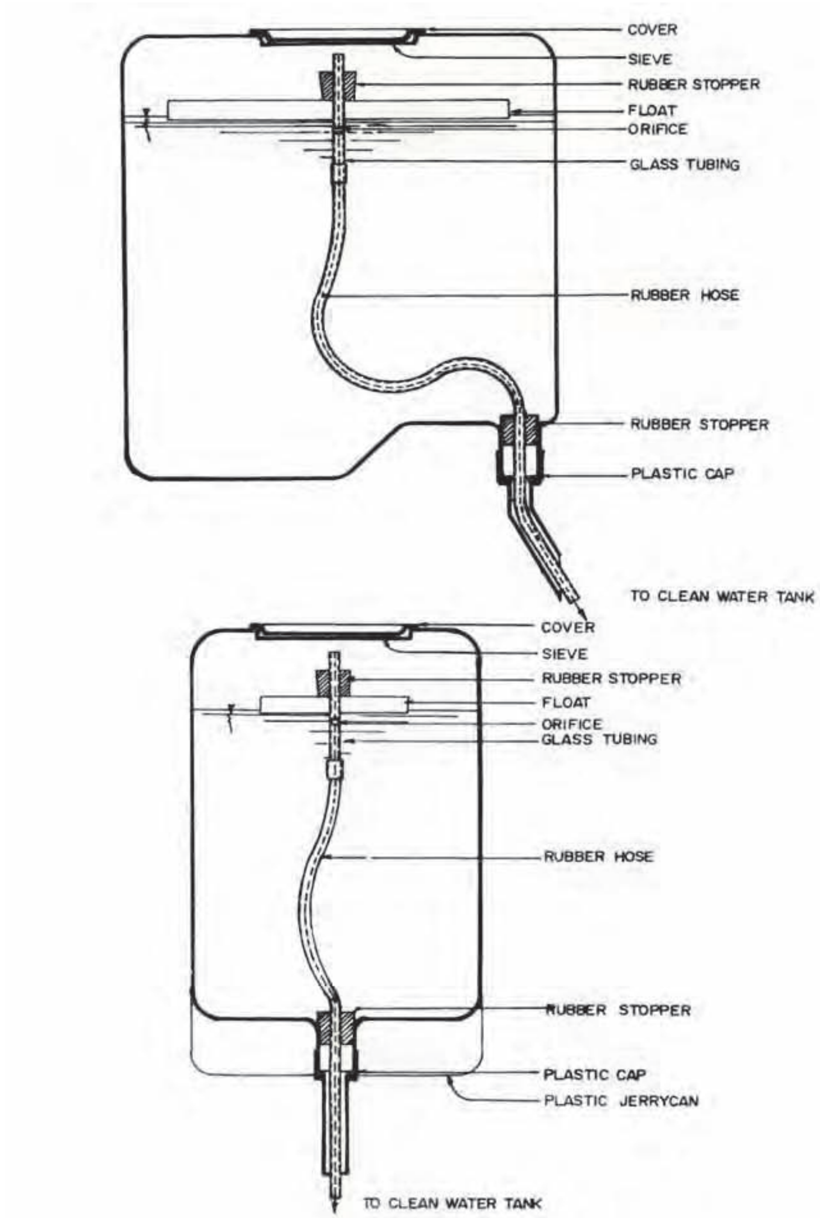
Due to the corrosiveness of the hyphochlorite solutions, the critical parts of the pump are made of chemically resistant plastic and synthetic rubber.

Figure 3.2: A Hypochlorinator in Action

Photo courtesy of Water Solution Partners Inc.

Hypochlorinators should not be placed or kept in the same room as other equipment like the switchboard, other types of pumps, meters, tools, and the like because of the corrosiveness of the solutions. In any case, wherever the hypochlorinator is placed, adequate floor drains should be provided to carry away wastewater, spillage, sludge, and wash-down water.

Figure 3.3: Drip-Type Chlorinator



NWRC RWS Volume III, Operation and Maintenance Manual

2. Drip-Type Chlorinator

A drip-type chlorinator can be used for disinfecting small reservoirs, wells and cisterns. To make a simple drip type chlorinator, refer to Figure 3.3 and follow these steps:

1. Use a plastic water container of about 6-18 liters volume capacity with a spout. The spout of the container will act as the outlet for the chlorine solution.
2. Cut open the bottom of the container to provide a solution inlet and to be able to access the inside of the container.
3. Guided by Figure 3.3, prepare the needed supplies like the tubing, hose, rubber stopper, and sieve, and prepare the chlorine feed equipment that will fit inside the container as follows:
   - Choose or cut out a piece of polystyrene (e.g., Styrofoam) or wood to act as the float.
   - In the center of the float, place a rubber stopper or cork and pass a piece of hard tubing through it. The tubing should be long enough to extend beyond the rubber stopper and below the float.
   - Make a small hole in the tubing below the float to act as the inlet for the chlorine solution, which will fill the container.
4. Fill the container with the chlorine compound and fill with water until the float reaches the top. Then cover the top of the container.
5. To control the flow, use a small clamp. Place the clamp around the hose and tighten it to clamp off all flow during installation. Loosen the clamp to get the flow rate desired.
6. Install the container over the facility to be disinfected. The rubber outlet hose should reach into the water.

J. EFFECTIVENESS OF CHLORINATION

Generally, chlorination without filtration or other pre-treatment is effective and adequate only under the following conditions:

1. The degree of bacteriological pollution of the water is moderate, reasonably uniform, and not imbedded in suspended solids, for example, within the bodies of worms;
2. The turbidity and color of the water do not exceed 5-10 units;
3. The content of iron or manganese or both do not exceed 0.3 mg/L; and
4. Taste- or odor-producing substances are absent or do not require chlorine doses that inevitably produce a chlorine taste in the treated water.

There is a contact period of at least 20 minutes between the point of chlorination and the first service connection supplied with the water. In cases where water is pumped directly from the source (e.g. well) into the distribution system, chlorine may be applied directly into the pressure main, provided this minimum contact time of 20 minutes is met.

Table 3.2: Chlorination Guidelines
1. Chlorine solutions lose strength while standing or when exposed to air or sunlight. Make fresh solutions frequently to maintain the necessary residual. 2. Maintain a free chlorine residual of 0.3 mg/l after 30 minutes contact time. Residual chlorine should be measured every day. 3. Once the chlorine dosage is increased to meet greater demand, do not decrease it unless the raw water quality improves. 4. When there is a risk of cholera or an outbreak has already occurred, maintain the chlorine residuals as follows: • Distribution system: 0.5mg/l • Tanker trucks at filling point: 2 mg/l

Chapter 4

General Operation and Maintenance

This Chapter presents the general concepts and practices that must be adopted for effective Operation and Maintenance (O&M). The O&M specifics for the supply sources, transmission and treatment facilities will be covered in Chapter 5 while the distribution facilities (storage, pipelines, connections, valves) will be covered in detail in Chapter 6.

A. BASIC O&M CONCEPTS

Operation refers to the procedures and activities involved in the actual delivery of services, for instance pumping, treatment, transmission and distribution of drinking water. On the other hand, Maintenance refers to the activities aimed at keeping existing facilities (physical assets) in serviceable condition, for instance painting of steel reservoirs, and repair of leaking pipes and worn out pumps.

O&M aims to provide continuous and sustainable water supply services with the perspective that

1. The useful life of the water supply facilities needs to be extended and their service quality enhanced;
2. The health of the population must be maintained;
3. The quality of the environment must be preserved and protected; and
4. The marginalized should be benefitted.

There are undesirable consequences of poor O&M:

1. Intermittent water supply due to wastage and depletion;
2. Poor water quality due to inadequate treatment and contamination;
3. Deterioration of pipes, equipment, and service;
4. Increased cost of maintenance; and
5. Failure to secure consumers' acceptance when tariff increases are needed to sustain viability.

B. WHY MAINTENANCE

Maintenance of the facilities is essential in preventing component failure, extending the useful life of the facilities, and minimizing disruptions in services. Good maintenance involves the following:

1. Quick repair/replacement of any failed component;
2. Up-to-date training of maintenance personnel;

3. Adequate inventory of parts and tools needed for repairs;
4. Efficient mobilization practices in emergencies; and
5. Valve exercising (single most important form of preventive maintenance for reliability of service).

There are two general types of maintenance: Preventive and Reactive (or Repair) maintenance.

1. Preventive Maintenance

Preventive or routine maintenance involves tasks and activities carried out according to pre-established schedules to ensure the quality and reliability of operating facilities. It is based on rational considerations such as the manufacturer's recommendations for servicing equipment, industry standards and practices (which are based on collective experience), and the SSWP's own experience on the performance, durability, and reliability of the different equipment and their parts and components. Once established, these schedules need to be kept and the results recorded.

2. Unscheduled Maintenance

Unscheduled maintenance (also called Emergency or Repair maintenance) is a reactive intervention forced on the Utility when equipment, components, or parts either break down or malfunction. The activities and tasks are unplanned and generally unexpected, thus taking the nature of emergencies. They tend to be disruptive, inefficient, and often costly – not only to undertake but also in terms of lost revenues and goodwill. These occur most frequently when preventive maintenance has been poor or inadequate, after accidents and natural force majeure events, and when aging facilities are kept in service without replacement beyond their useful life.

All unscheduled maintenance situations need to be analyzed and the causes of the malfunction or breakage recorded. These records are important as they help in deciding whether part or all of a network or plant should be upgraded or replaced, and serve as a guide in future procurement decisions (for instance, sourcing of new equipment and of parts and supplies), as well as in related management decisions (e.g., inventory lists and levels).

C. WATER QUALITY

The sole product of the Utility is water and it is mandatory for this product to meet at least the minimum standards specified by the PNSDW[14] . The SSWP utility is required to have a sample of its water tested by an accredited DOH laboratory for bacteriological presence at least once a month. Should a sample test positive for coli forms, the Utility must immediately have a re-sampling done and, without waiting for the results, take the

[14] Philippine National Standards for Drinking Water

actions needed to determine the possible source of contamination in order to eliminate the cause.

Where the sampling method indicates that customers are at risk of using unsafe water, the SSWP itself must take measures to warn its customers to take the necessary precautionary measures, such as boiling their drinking water before using, until there is assurance that the risk has been eliminated.

In case of a second positive testing, the SSWP should consider suspension of operations until the problem is solved, and if this is not possible, it should reinforce its advisory to all customers to boil their drinking water until they receive notice that the problem is solved.

The SSWP's responsibility for safe water makes it imperative to eliminate harmful organisms by some means, of which the standard is treatment with chlorine, as thoroughly discussed in Chapter 3. As part of its routine water quality maintenance procedures, the SSWP should routinely, on a daily basis, take readings of chlorine residuals at different distribution points using a chlorine comparator.

D. FIELD TOOLS

The Utility should have all the necessary and proper field tools for operational and maintenance work. The cost of these tools should be considered an investment that will improve maintenance work and minimize downtime.

Every SSWP must have the following maintenance tools:

• Ratchet threader	• Mattock (Piko) and Shovels
• Adjustable wrenches	• Crowbar
• Pipe wrenches	• Screwdrivers
• Pipe threader	• Pliers
• Pipe cutter	• Open Wrenches
• Shovels	• Saws and hammers
• Crowbars	• Bench Vise

E. OTHER OPERATIONAL CONSIDERATIONS

1. Monitoring

1. Operators must monitor readings on gauges and respond to alarms and warning signals. Failure to heed these could result in otherwise minor problems escalating into major problems.
2. Operators must be trained to respond instantly to emergencies, and should be given the means to communicate without delay, so they can call out repairs and inform supervisory personnel.

3. Whenever practical, well output and discharge pressures ideally should be recorded daily. If a flow meter is not available, the method given in Chapter 2 can be used to measure flows from the well.

2. Emergency Provisions

To minimize the failure of operations during emergencies, the following should be observed:

1. Reservoirs should never go below half full before the pumps are restarted. If the operator knows the schedule of a power outage, he must ensure that the reservoir is full by the time the power is out. For power outages or calamity repairs that could last for more than a day, the operator should limit or ration the supply of water by valve throttling.
2. Fuel (if used by the system) should always be on stock for at least 2 days of operational needs.
3. The Utility should have an Emergency Plan, clearly designating the emergency team members, their specific functions, and a backup office or meeting place.
4. The Utility should have the contact numbers of those who can assist during emergencies (nearby utilities, private deep well owners, well drillers, pump suppliers, water tankers, treatment equipment suppliers, power suppliers, government agencies, etc). The personnel designated to respond to emergencies should have these numbers.
5. After a calamity, the operator must conduct a field survey to determine damaged facilities and the extent of leakage, and to conduct emergency repairs.

3. Common Problems and General Solutions

Table 4.1 presents some useful and practical solutions to address O&M problems.

F. RECORDS AND REPORTS

An effective maintenance program starts with the collection, proper filing, and safekeeping of the Utility's records. For the O&M function, the following records are particularly important and, as a minimum, should be kept and available:

1. All pamphlets/manuals of pumping equipment, including pump curves;
2. As-built plans of the system or plans and engineering drawings;
3. Capital expenditure disbursements;
4. Water meter data such as type, when installed, and serial number; and
5. Well design, logs and results of pumping tests.

Table 4.1: Practical Solutions to Common O & M Problems		
Common O&M Problems		Practical Solution
Technical	Lack of skills in preventive maintenance and repair work	Provide hands-on O&M skills training for the System Operator/Caretaker
	No available tools and spare parts	Set aside funds for tools and spare parts, otherwise rent
	No full time System Operator or Caretaker to undertake repairs	Hire full time System Operator/ Caretaker to undertake the repair
	No available expert in the community for emergency repairs or source problems	Anticipate problems & network With other utilities or government agencies who can provide these services when needed
Financial	Lack of funds for O&M or system upgrading	Review tariff levels, improve collections and look for funds from LGUs or banks or use supplier credits
	Lack of funds for repair and maintenance	Set aside budget exclusively for repair and maintenance

A simple records management system should be set up for the following purposes:

1. Clear, systematic filing of records;
2. Provide easy access by the personnel concerned with O&M;
3. Protect the records from being lost/not returned, or misfiled, or damaged;
4. Update those that need to be updated, like maps; and
5. Dispose of records that are outdated and not needed.

RECORDS ARE MEANT TO BE USED

Records are not simply materials that are filed away and forgotten, but an active reference source that both the O&M personnel and the Utility's management as a whole need in order to keep the Utility operating at peak performance levels.

Records are

- Essential to an effective maintenance program;
- Required to comply with certain water quality regulations; and
- Necessary for planning purposes.

For these reasons, a good, user-friendly filing system that is both understandable to users and allows easy access *but good control* of the filed records is essential.

Chapter 5

Supply Source and Disinfection Facilities

This Chapter covers the basic concepts and procedures for proper O&M of water sources and the equipment used at these sources to prepare the water for distribution. It covers O&M of wells, infiltration galleries, springs and their pumps, motors and chlorinators. A section on the O&M aspects of slow sand filters is also included.

A. WELLS

A properly designed and constructed well can give many years of trouble-free service. Good O&M seeks to avert well failures, which are usually indicated by reduced (if not complete loss of) pump discharge, or deterioration in the quality of the water.

Good O&M actually begins even before a well is put into operation. Before actually operating a well, the SSWP must determine/obtain the following information which will guide its well operating and O&M procedures:

- Safe pumping level
- Pump curves
- Well design
- Location of discharge line shut-off valve and pressure gauge.

1. Pumping Tests

Pumping tests are carried out to determine the safe pumping yield, which establishes how much groundwater can be taken from a well, and what effects pumping will have on the aquifer and neighboring well supplies. It is one of the design parameters for selecting the pump to be used.

The pumping tests are usually done by well drilling contractors who are knowledgeable and who possess the required tools and equipment for the tests.[15] It is rare for an SSWP to conduct this test itself. However, should this become necessary, the general procedure for conducting such a test is illustrated in Annex A-IV.

Once the safe pumping level is established, it should be compared with the design pump curves of the equipment to be used. This will guide the operational parameters for pumping water from the well.

[15] The importance and vital nature of the work of professional well drillers is underscored by the NWRB, which imposes standards for their activities, regulating and requiring them to register with it.

2. Major Causes of Deteriorating Well Performance:

At the outset, in designing and constructing a well, care should be taken to prevent the major causes of eventual well deterioration. Following are five of the main causes of deterioration in well performance. Consider that the first four of these major causes of well deterioration are greatly influenced by the care taken in constructing the well.

1. Well yield reduction due to incrustation and growth of iron bacteria;
2. Plugging of well screen due to build up of fine particles;
3. Sand pumping;
4. Structural collapse of the well casing and screen; and
5. Condition of the pump.

3. Prevention and Remedial Measures:

a. Prevention and Treatment of Iron Bacteria:

1. Care should be taken to avoid introducing iron bacteria into the well during drilling and repair work. For this purpose, equipment and materials (drill rods, filter pack) should be chlorinated prior to drilling or repair;
2. Chemical treatment (application of strong oxidizing agent such as chlorine and chlorine compounds) to clear contaminating bacteria; and
3. Physical treatment (jetting, air or surge block surging, air lift pumping) to clear blockages.

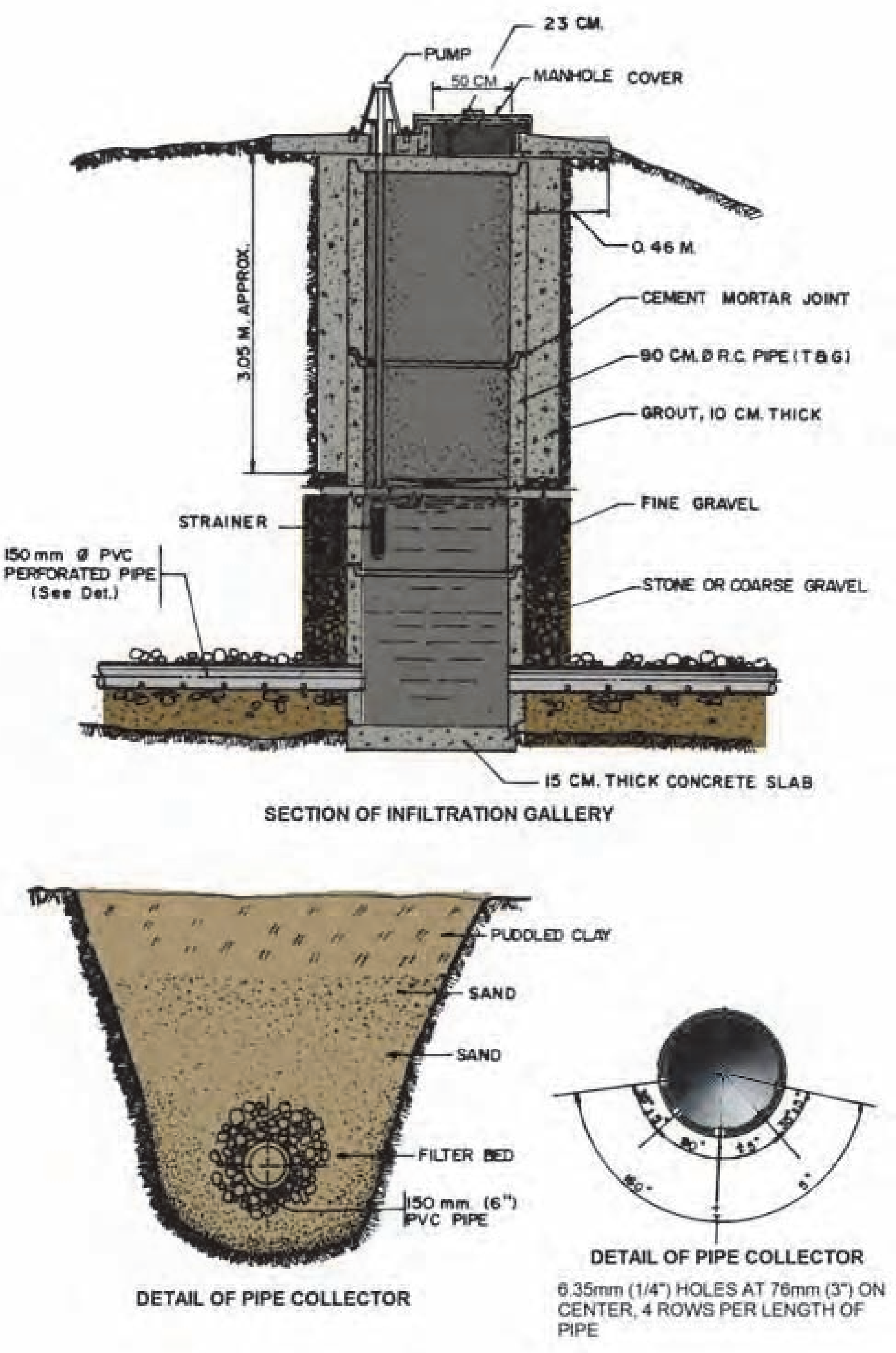
b. Prevention and Treatment of Physical Plugging

1. Thorough development of a well by
   - Treatment using polyphosphate compounds; and
   - Proper well design (filter pack, screen placement, slot selection and sampling of well cutting).
2. Treatment of Incrustation
   - Treatment with acid (hydrochloric, sulfamic, hydro-acetic);
   - Wire brushing

B. INFILTRATION GALLERIES

An infiltration gallery is a horizontal well which is used to collect naturally filtered water. It consists of a main collection sump and perforated pipe water collectors, which are surrounded by a blanket of sand and gravel (Figure 5.1).

Figure 5.1: Details of an Infiltration Gallery



NWRC RWS Volume III, Operation and Maintenance Manual

1. Operation

Water enters the perforated pipe collectors and then flows by gravity to the main collection sump or well. From this sump or well, water is pumped out to the distribution system.

2. Common Causes & Corrective Measures for Infiltration Gallery Failure

1. **Clogging of the Filter Bed** – The clogging of the filter blanket surrounding the collector pipes is indicated by the lowering of the water level in the main sump/well while pumping at the normal rate. This clogging is due to the deposition of fine silt on the filter blanket.

   The clogging material usually can be dislodged by surging, using compressed air or a force pump. If these methods will not work, the only remedy is to dig up and clean the sand/gravel blanket.

2. **Poor Quality of Water Yield** – The most probable cause of the deterioration in water quality is a defective filter bed, which allows contaminants to pass through. The water yield may be rendered safe again either by repairing the filter bed or by continuous chlorination.

C. SPRINGS

If a natural spring is the source of the SSWP's water, the area should be enclosed with a fence to prevent animals from contaminating the water and polluting the surrounding area.

1. The Spring Box

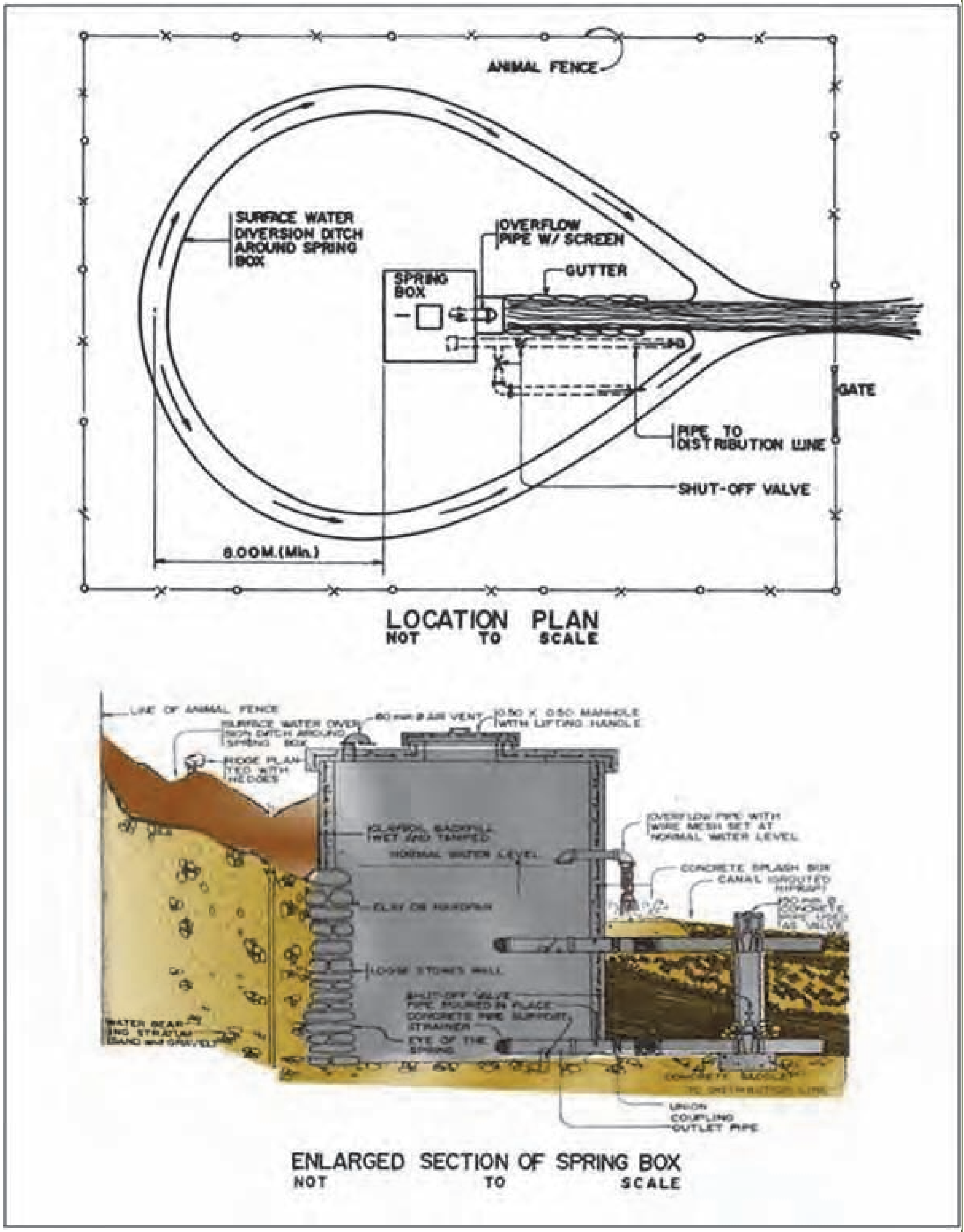
To enhance the spring's utility as a source, as well as to protect it from erosion, it should be provided with a spring box, which is a concrete structure that serves three purposes:

1. Protect the water source from contamination;
2. Collect the water; and
3. Allow sediments to settle to the bottom of the box instead of being carried with the water.

Figure 5.2 on the following page shows a spring box. In its construction, care must be taken to avoid or uproot surrounding trees whose roots could eventually damage the concrete spring box. The design should include a drain pipe and valve that will allow it to be drained easily for maintenance.

O&M of a well-designed and constructed spring box is relatively simple and can be done fast. A poorly designed or constructed box makes O&M a costly, time consuming effort.

Figure 5.2: Spring Box Site Plan and Design



NWRC RWS Volume III, Operation and Maintenance Manual

2. Common Spring Box Failures and Remedies

Table 5.1 lists the common causes of failure in the spring box and its surroundings with suggestions for their remedies.

Table 5.1: Common Spring Box Failures and their Remedies	
Defect	**Remedy**
1. Crack or leak.	1. Plug crack or leak with Portland cement mortar.
2. Damaged overflow and screen vents.	2. Replace damaged screen with a new one.
3. Clogging of drainage canal.	3. Clean drainage canal from all obstruction and check its slope.
4. Dilapidated fence.	4. Replace all worn-out posts and repair fence.
5. Reduction of spring discharge due to clogging	5. Clean the "eye" of the spring.

NWRC RWS Volume III, Operation and Maintenance Manual

3. Maintenance of Spring Boxes

1. While properly installed spring boxes require little maintenance, it is recommended that the water quality be checked before one is put into use. Water quality should also be checked at least once a year, and more often if needed.
2. The uphill diversion ditch should be inspected to ensure that it is not eroding and that it is adequately diverting surface runoff away from the spring box.
3. For hillside collection boxes, the uphill wall should be periodically inspected to ensure that it is not eroding and its structural integrity is maintained.
4. The animal fence should always be kept in good repair. If animals are allowed to get close to the spring, they could contaminate the water and ground surrounding the spring, and cause the compacting of soil, which in turn could lead to decreased flow rates.
5. The cover should be checked frequently to ensure that (a) it is in place and watertight (b)water is not seeping out from the sides or from underneath the spring box, and (c) the screening is in place on the overflow pipe.

REPAIRING A SPRING BOX

When the concrete sides of the spring box show damage, take the following steps:

1. Drain the spring box. If it was originally constructed with a drain pipe and valve, you will have no difficulty draining the water and repairing it. If the box does not have a drain pipe or if the leaks are below the water level of the drain pipe, you must siphon the water out. If the volume of water is too great for a water hose to siphon the water out, you will have to use a water pump.
2. Mix an appropriate amount of water and concrete. Trowel the concrete onto the spring box's cracks and damaged areas on both the inside and outside of the box.

3. Attend to the spring box to keep water from damaging the newly laid concrete, which usually takes 5 to 6 hours to cure. If you had to siphon the water out, make sure that the hose does not clog or stop siphoning, or that the pump does not stop working.

6. Once a year, the system should be disinfected and the sediment removed from the spring box.

REMOVING SEDIMENT AND DISINFECTING A SPRINGBOX

1. Open the valve on the outlet pipe, allowing the spring box to drain.
2. Remove any accumulated sediment from the box and wash the interior walls with a chlorine solution. The solution for washing the spring box should be mixed at a ratio of 10 L water with 0.2 L chlorine bleach. Caution: *Chlorine and chlorine compounds irritate the eyes and skin. Wear protective clothing and equipment such as gloves and safety glasses when dealing with chlorine.*
3. After the spring box has been cleaned, 100 mg/l chlorine should be added directly to the water in the spring box, followed by a second application after 12 hours these consecutive applications should provide for adequate disinfection. If possible, water samples should be analyzed periodically for contamination.

D. PUMPS IN GENERAL

1. Manufacturer's Recommendations

Pump manufacturers always provide a manual for the operation and maintenance of their pumps. The instructions in these manuals, including the recommended maintenance schedule, should be followed. The instructions include greasing, oil inspection, checking of voltage at power source, adjustments and repairs.

If during inspection a defect is found, it should be repaired immediately. The operator should pay attention even to small defects, and not wait for them to worsen, as these could cause other parts or units to fail, resulting in larger damage and more costly repairs.

2. Pump Station Data

Every pump station must have complete data as shown in Form 5.1.

Form 5.1: Pump Station Data	
PUMP STATION NO.	
Location	
Date	
A. SOURCE DATA	**B. PUMP DATA**
Well Casing Diameter	Type:
Well Depth:	Brand Model:
Well SWL:	No. of Stages:
Specific Capacity:	Pump Setting:
Water Quality:	Column Assembly Size:
Year Drilled:	Discharge Head Size:
Driller:	Supplier:
Remarks:	Remarks:
C. MOTOR DRIVE DATA	**D. CHLORINATOR**
Type:	Type of Booster:
Brand/Model:	Booster Rated HP:
Rated HP @ rpm:	Chlorinator Brand:
Volts/Amperes:	Model/Series:
Hollow Shaft Diameter:	Year Installed:
Year Installed:	Remarks:
Remarks:	

3. Pump Log

A pump log should be maintained to record the daily pressure and flow readings of the pump. The time of the day when these readings are made should also be reflected. Form 5.2 shows a format of a Daily Operation Log.

The schedule for operating and stopping the well pumps should relate the pump capacity to the data on daily water demand and the water levels of the reservoirs.

Form 5.2: Daily Operation Log										
Date	Time Start	Time Stopped	Pressure Reading	Flow Reading		Cl Usage		KW Reading[16]		Remarks
				Start	Final	Initial	Final	Initial	Final	

[16] Fuel consumption columns may be added if generators and diesel engines are used.

4. Pump Operations

It is simple to operate the intake pumps used for water wells or surface water. They are automatically started by the low level pressure and shut down by the high level pressure switches installed in the water storage or receiving tank. These pumps may set for manual operation by turning the control switch mounted on the pump base from the "Auto" to "Manual" setting, and using the start/stop buttons for the pump motor. However, care must be observed in stopping pump operation.

Table 5.2: Steps for Manually Stopping Pump Operation
1. Gradually turn the discharge valve until it is only about 1/4 open. Do not close the valve suddenly, as sudden shut-off could create back pressure and flow surges.
2. Use the "Stop" push button to stop the motor.
3. Totally close the discharge gate valve to prevent possible back flow.

5. Pump Trouble Checklist

The manufacturer or supplier of the pump always provides the pump design curve which is the basic reference for evaluating actual performance. In addition to the comparison of actual performance against the design curve, the operator should be alert to the following indications of pump problems:

1. Excessive heating of the motor;
2. Change in the bearing noise level;
3. Change in the pattern of oil consumption of the motor;
4. Excessive vibration;
5. Change in amperage or voltage load;
6. Cavitation noise or other unusual noise; and
7. Presence of cracks or uneven settlement of the pad or ground around the pump.

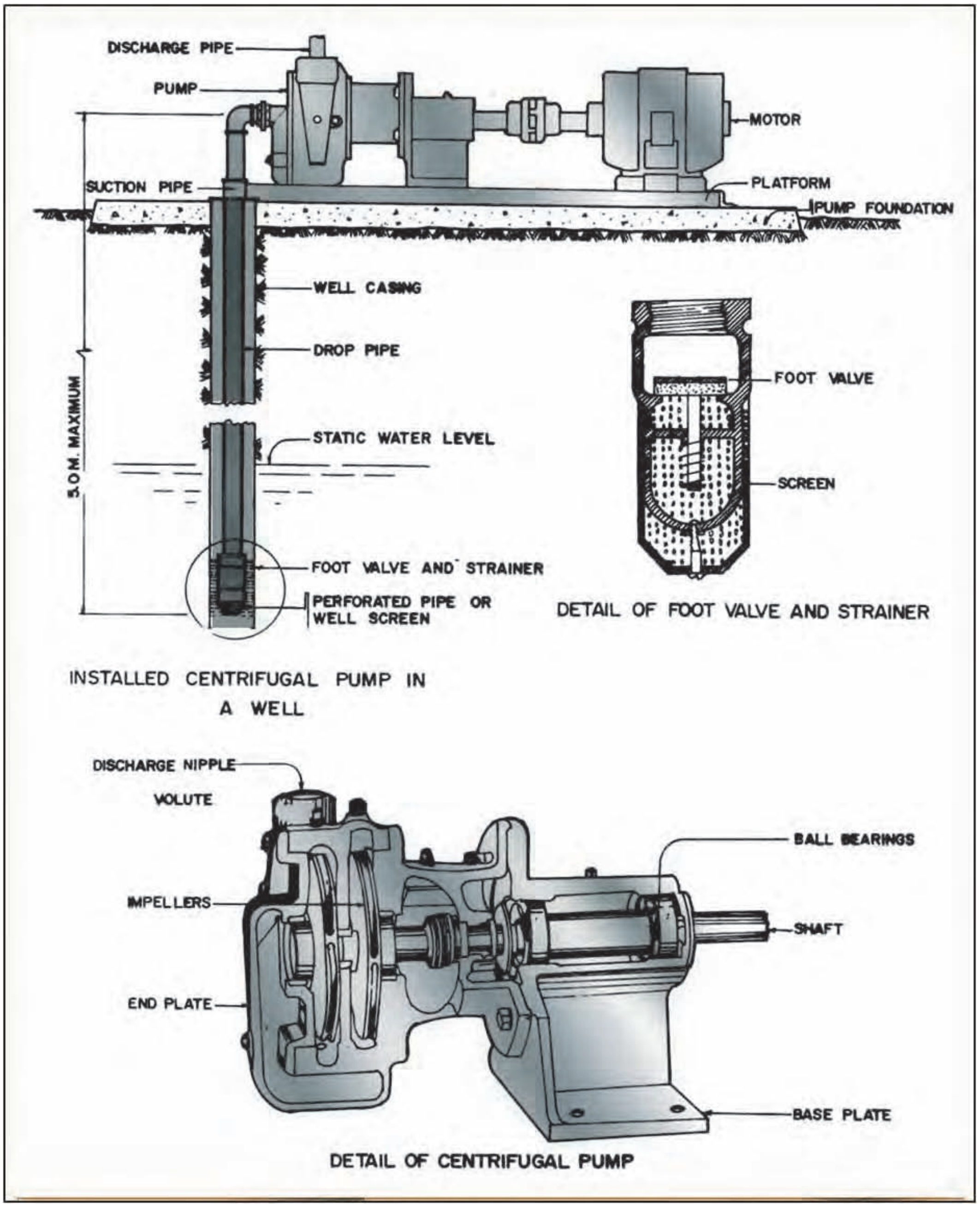
E. CENTRIFUGAL PUMPS

A typical centrifugal pump and its component parts are shown in Figure 5.3 on the following page.

1. Operation

To operate a centrifugal pump, certain procedures need to be followed, which are found in the manual supplied by the manufacturer. They generally involve the steps outlined in Table 5.3.

Figure 5.3: Centrifugal Pump Details



NWRC RWS Volume I, Design Manual

Table 5.3: Steps in Operating Centrifugal Pumps
1. Before starting the motor, make sure that the discharge gate valve is closed. 2. If the pump is not self-priming or has defective suction line or foot valve, add priming water. Priming displaces the air in the suction line or drop pipe of the pump with water. Refer to Figure 5.3 for details of a centrifugal pump. 3. Allow the pressure to build up, and then slowly open the discharge valve. Doing this slowly avoid water hammer, which could destroy the pipes and valves. 4. Start the pump motor. 5. After the pressure has built up, slowly open the discharge gate valve. In case the pump has been primed with water, waste the water pumped during the first 1-2 minutes by opening the drain valve. 6. Make a routine check for faults in the operation of the system (abnormal noise, vibration, heat, and odor).

2. Maintenance & Repair

Bearings, gears and other pump moving parts should be lubricated on the regular schedules, using the lubricants recommended by the supplier. The following are specific actions to remedy centrifugal pump problems.

a. Low Pump Efficiency

If the pump performance tests reveal that the pump is operating at significantly lowered efficiencies, the pump should be pulled out, inspected and repaired or reconditioned. This work is best referred for servicing to the manufacturer or a pump repair specialist.

b. Packing Adjustment

The water flowing through the stuffing box should be maintained at a level just enough to prevent overheating. The gland nuts should be loosened or tightened one-quarter turn only to allow the packing to equalize against the pressure.

c. Checking and Adjusting Misaligned Head Shaft

Pump vibrations could indicate a misalignment of the head shaft. This can be checked by the following procedure:

1. Remove the motor dust cover, motor head nut and key, and take out the motor drive flange.
2. Check if the head shaft is concentric with the motor hollow shaft bore.
3. If needed, adjust by using shims.

3. Other Common Problems

Other common problems and their remedies are summarized in Table 5.4 on the following page.

Table 5.4: Common Troubles in Operating Centrifugal Pumps and their Remedies

Trouble	Likely Cause of Trouble	Remedy
Pump Motor fails to start	Blown fuse or open circuit breaker.	Replace fuse or reset circuit breaker.
	Motor or starting switch out of order.	Inspect /repair. Refer to equipment supplier or experienced mechanic or electrician.
	Break in wiring.	Repair circuit wires.
	Stuffing box may be binding or tightly packed	Check packing by manually rotating shaft.
		Loosen packing nut just enough to allow a slow seepage of water and free the shaft.
	Scale or sand in the impeller.	Open pump and remove scale by acid treatment and/or sand.
Pump runs but delivers no water	Pump lost first priming.	Repeat priming. Follow manufacturer's priming instructions.
	Pump repeatedly loses priming due to leaky drop pipe or suction pipe.	Pull out drop pipe and seal the leaks.
	No water at source due to overpumping	Reduce pumping rate or deepen the well.
	Collapse of well casing or screens	Replace with new one. If diameter of old casing is large, insert new casing inside the damaged casing. Consult driller.
	Clogging of well screens	Surging or acid treatment. Consult driller.
Pump runs but delivers only a small amount of water	Well not yielding enough water.	Do pumping test or deepen the well.
	Air leaks in suction pipe.	Pull the drop pipe from the well & seal leak/s.
	Incrustation or partial clogging of well screens.	Surging or acid treatment. Consult driller.
	Impeller is worn out or lugged with scale or trash.	Open the pump and clean/replace impellers.
	Foot valve may be obstructed.	Clean foot valve.
Noisy Pump	Bearing or other working parts of pumps are loose or need to be replaced	Tighten or replace defective parts.
	Pump motor is loosely mounted.	Tighten mounting.
	Low water level in well.	Reduce pumping rate.
	Presence of air in suction line.	Repair air leaks.

NWRC: RWS O & M Manual, Vol III

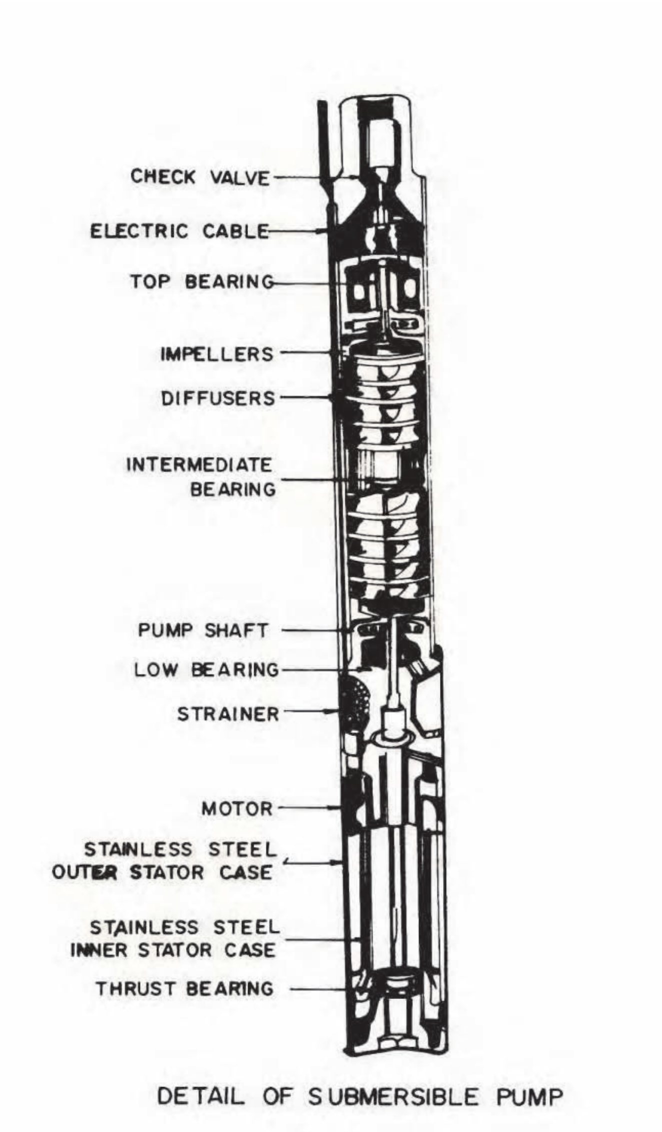
F. SUBMERSIBLE PUMPS

1. Operation

Submersible pumps may be operated manually with a switch located above ground level or automatically with a pressure switch, electrodes or float control devices. (Refer to Figure 5.4)

Submersible pumps should always be operated below the water level. The pump should be installed higher than the well screen to prevent pump break suction which will lead to a burned pump motor.

Figure 5.4: Details of a Submersible Pump



NWRC RWS Volume III, Operation and Maintenance Manual

2. Maintenance & Repair

To begin a maintenance job analysis, the assigned person needs the following information:

- Pump motor unit size and type;
- Static and pumping water level of the well;
- Size of drop pipe;
- Pump setting;
- Discharge pressure required;
- Capacity pumped;
- Line voltage; and
- Operating Manual

3. Common Troubles of Submersible Pumps and Their Remedies

Table 5.5 summarizes the common problems of submersible pumps and their remedies.

G. POSITIVE DISPLACEMENT PUMP

Positive displacement pumps are either reciprocating or rotary types (Figure 5.5) A positive displacement pump causes a fluid to move by trapping a fixed amount of it then forcing (displacing) that trapped volume into the discharge pipe. The, flow is directly related to RPM and pressure by the restriction of the flow in the discharge line. Once the system pressure is set, any change in flow will result in a change in pressure. These changes in flow can occur from certain conditions in the pump inlet line, the pump itself, the pump drive or in the pump discharge line.

1. Pump Inlet Problems

The inlet conditions are often among the first items to investigate when a system loses pressure. Many things can cause cavitation or starvation and result in a gradual loss or fluctuation of system pressure.

Problems in other inlet accessories can also contribute to losing system pressure. Clogged filters are a prime target. These should be inspected and cleaned regularly. All fittings and hoses should be periodically inspected for air leaks as this will also contribute to a loss in system pressure.

2. Pump Drive Problems

Changes in the RPM of the pump's drive may contribute to a loss of system pressure. A proper and secure drive for the pump is needed to maintain a consistent flow and the required system pressure. Replace belts on a regular schedule to maintain maximum HP. Worn or slipping belts, the wrong pulley sizes for the pump and/or motor, and an undersized drive can alter the desired pump output and directly affect the system's pressure.

Table 5.5: Common Troubles in Operating Submersible Pumps and their Remedies

Trouble	Likely Causes	Remedies
Pump motor fails to start	Motor Overload	Overloaded contacts close automatically. Check cause of overload.
	Low voltage	Check voltage.
	Blown fuse, broken or loose connections	Check fuses, relays, electric condensers and all electrical connections.
	Motor control box not in proper position	Ensure box is in right position.
	Damaged cable installation	Locate and repair the damaged cable.
	Cable, splice or motor windings may be grounded or wet.	Check the ground by using an ohmmeter. If grounded, pull out the unit and inspect cable and splice. Cut the unit loose from the cable and check each part separately using an ohmmeter.
	Pump stuck by corrosion or abrasive	Pull out pump, examine and remove foreign matter.
Pump runs but delivers little or no water	Pump not submerged	Lower the unit into the well or replace by a smaller capacity pump
	Discharge pipe may be leaking	Examine discharge line by pulling out one joint at a time.
	Check valve may be clogged or corroded	Pull out pump and clean or replace check valve
	Pump badly worn-out by sand or abrasive	Replace pump. Clean well thoroughly of abrasive before putting the new unit in.
	Strainers or impellers clogged with sand or scale	Pull out pump unit and remove the scale/sand.
	Scaled or corroded discharge pipe	Replace pipe.
Pressure valve fails to shut	Switch may be defective or out of adjustment	Adjust or replace pressure switch.
	Discharge pipe may be leaking	Raise unit one pipe joint at a time until leak is found. Repair leaks.

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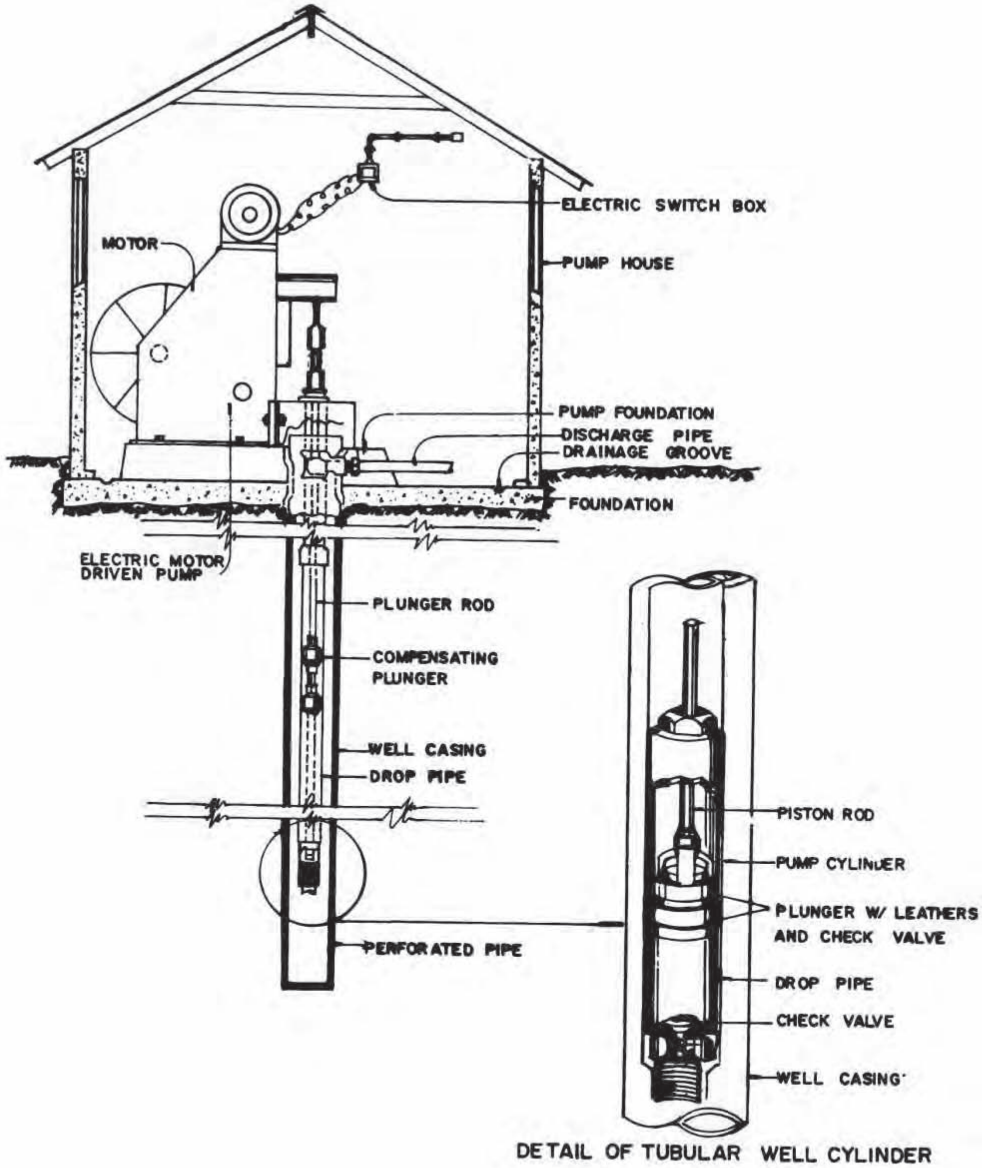
Figure 5.5: Positive Displacement Pump



3. Main Pump Problems

Changes within the pump can also affect system pressure. Good pump maintenance is an essential element in maintaining consistent flow and system pressure. Regular servicing of the V-Packings [seals] and valves will assure good sealing and seating surfaces within the pump and optimum performance. Pump maintenance should be established specifically for each system as liquid, temperature, operating cycles and system accessories all affect the wear on a system. With a pressure gauge at the pump, it is easy to see when the system pressure drops or fluctuates. This is the time to do maintenance. Do not wait until the pump leaks externally or quits running completely to do maintenance. Excessive and expensive damage may occur.

4. Discharge Line Problems

This is a primary place to investigate when the system begins to lose pressure. Most often, worn nozzles are at the source of a system pressure loss and too often adjustments are made in the regulating and relief valves to compensate for this nozzle wear. This can put unnecessary stress on the pump. If there is no pressure gauge in the system, you may exceed the pressure limit of the pump when making adjustments. Always replace nozzles as a first step to correct a pressure loss. If the nozzle does not restore the system pressure to the original setting, then proceed to other inlet, pump or discharge conditions.

Internal seats, pistons and o-rings can wear and reduce the ability of the device to hold the set system pressure. Worn check valves can cause a device to cycle and give erratic pressure readings. System accessories should be checked when pump maintenance is performed.

It is best to establish a complete maintenance routine for the entire system that includes the pump, filters, hoses, connections, valves and nozzles. Regular maintenance is far less expensive and time consuming than major overhauls or replacement.

H. JET PUMPS

1. Operation

Jet pumps can be operated manually, or automatically with a pressure switch, electrodes or a float control switch.

a. Operating the Non-Self-Priming Jet Pump:

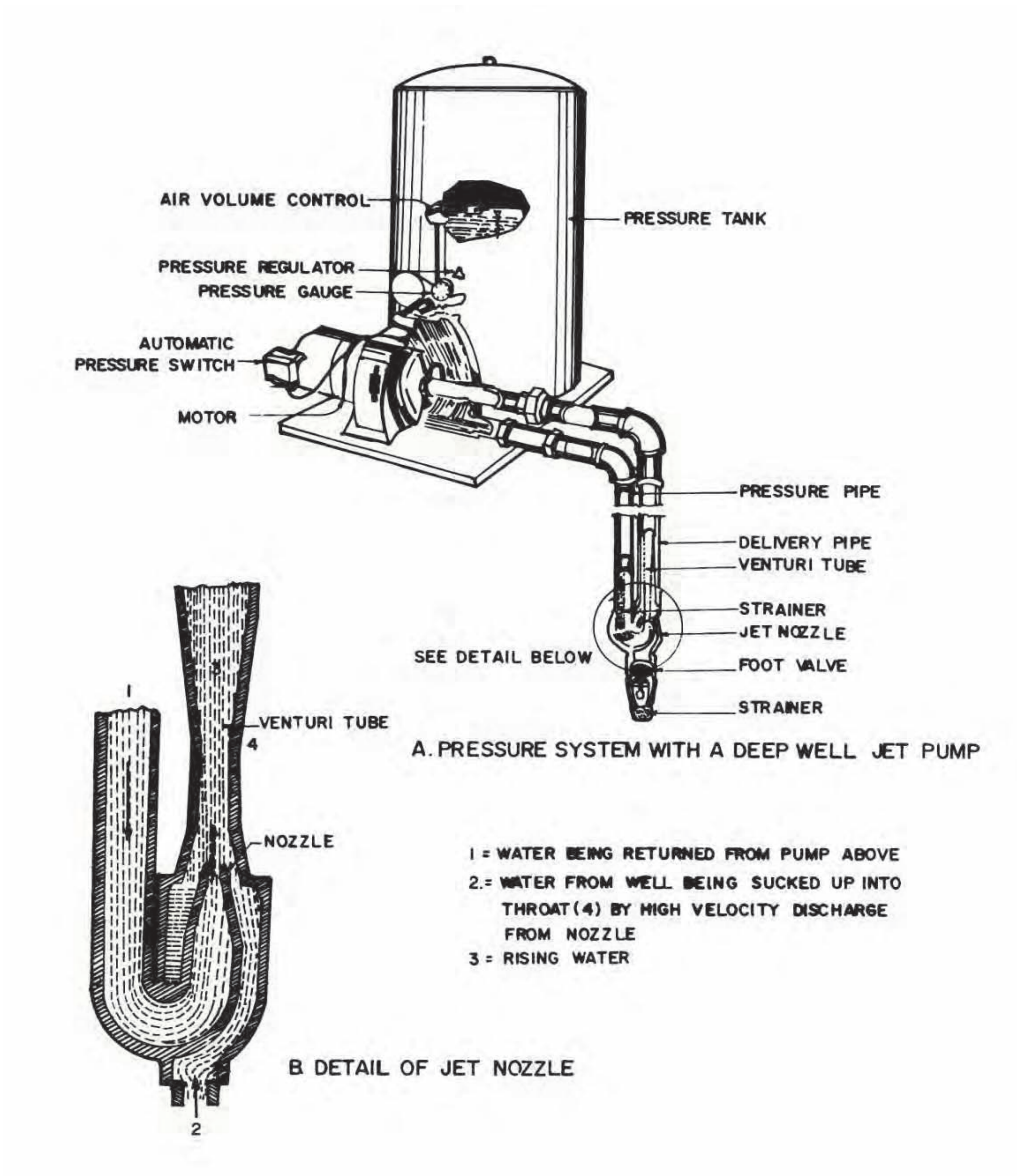
1. Initially inspect the assembly. Make sure that the power supply to the motor is off;
2. Check lubrication. Make sure that the pump rotates fully by manually turning the shaft. (For more details, refer to the pump manual);
3. Remove pressure gauge bushing and prime pump with clean water. Never start the motor until the pump has been filled with water;
4. Replace pressure gauge bushing and close the discharge gate valve;
5. Start the pump motor. Note build-up of pressure in the pressure gauge. Open the discharge valve slowly;
6. If discharge pressure is lost and fails to build up again after a short time, the system still contains air. Stop the pump motor and repeat operating procedures starting from item #3. It may be necessary to repeat the procedure several times until the system is completely filled with water.

b. Operating the Self-Priming Pump

1. Routinely inspect the assembly. Make sure power supply to motor is off;

2. Check lubrication. Make sure that the pump rotates fully by manually turning the shaft;
3. Start the pump motor.

Figure 5.6: Details of an Installed Jet Pump



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2. Maintenance of Jet Pumps

The manufacturer or equipment supplier always provides the client with the Operation and Maintenance manual upon purchase of their product. Refer to this manual for the proper operation and maintenance of your pump.

Table 5.4 for centrifugal pumps may be also used as a guide for troubleshooting operational problems of jet pumps. Additional troubleshooting information for jet pump problems is presented in Table 5.6.

Table 5.6: Troubleshooting Jet Pump Problems

Problem	Likely Causes of Trouble	Remedy
Pump runs but delivers only a small amount of water	Nozzle – diffuser or jet may be partially plugged with scale or trash.	Remove and clean
	Pressure regulator for jet may be set too low for existing water level.	Set regulator for higher pressure.
Pump fails to pump up to full pressure and shut off.	Jet pressure regulator is set too low.	Set regulator for higher pressure.
	Jet nozzle is plugged with scale or trash.	Remove and clean jet.
	Water level in well has dropped too low.	Reduce pumping rate; lower jet or find a new source.

NWRC RWS Volume III, Operation and Maintenance Manual

I. OTHER CAUSES OF PUMP FAILURES

1. Overpumping

Overpumping means more water is pumped than the capacity of the well. Overpumping will lower the water level in the well, consequently reducing the discharge, and in the case of submersible pumps, damage the pump motors. It will also result in sand clogging the well screen.

Overpumping problems can be avoided by reducing the pump discharge or increasing the well capacity (rehabilitating or deepening the well). The safe pumping level should first be determined from the well driller or from the well drilling records.

2. Corroded Well Casing

A well casing is used to prevent the collapse of the hole and entrance of undesirable water into the well. Corrosion is caused by the direct reaction between the water and casing material.

The problem of corroded well casing can only be solved by drilling a new well or inserting a smaller diameter casing inside the corroded one. In such a case, it is necessary to consult with an experienced driller.

3. Incrustation or Clogging of Well Screens

Incrustation or clogging of the well screen may be caused by direct deposition of suspended fine sand, formation and deposition of calcium carbonate, and deposition of slimy matter resulting from the biological activity of bacteria.

Incrustations caused by the deposition of suspended matter and/or scale can be corrected by surging or by muriatic acid treatment. Clogging due to bacteria can be corrected by chlorination. This procedure must be referred to an experienced driller.

4. Cavitation

Cavitation is one of the most serious operational problems with centrifugal pumps. When it happens, *cavities* or bubbles of vapor form in the liquid. The bubbles collapse against the impeller, making a sound as though there were rocks in the pump. If left uncorrected, cavitation will seriously damage the pump. Cavitation develops when normal pump operating conditions are exceeded. The results are noise, vibration, impeller erosion, and reduction in total head and efficiency.

TYPICAL CAUSES OF CAVITATION

1. The pump is operating with too great a suction lift.
2. A suction inlet is not sufficiently submerged.
3. The impeller vane is traveling at higher revolutions per minutes (rpm) than the liquid.
4. Suction is restricted (Note: Do not throttle the suction of a centrifugal pump.
5. The specific pump speed is too high for the operating conditions.
6. The liquid temperature is too high for the suction conditions.

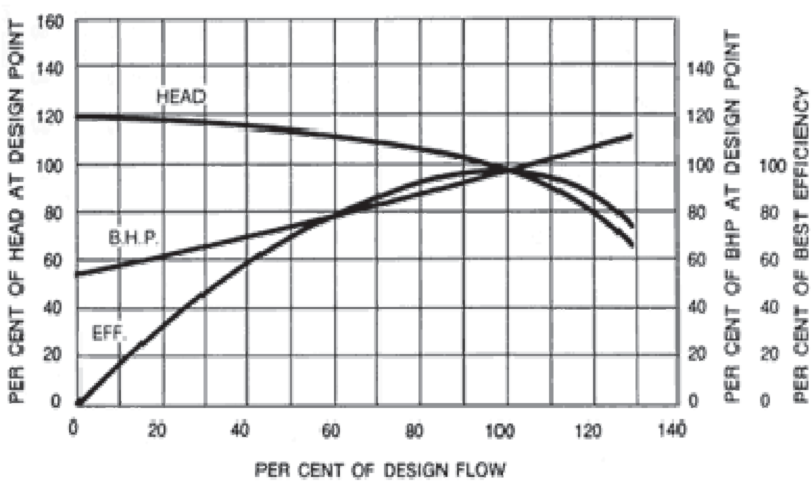
J. PUMPSET PERFORMANCE TESTING

Pumps are always supplied with pump curves data when newly purchased. The pump curve shows the pump efficiency at its operating conditions. In the example in Figure 5.7, note that the head curve for a radial flow pump is relatively flat and that the head decreases gradually as the flow increases. Note also that the brake horsepower increases gradually over the flow range with the maximum normally at the point of maximum flow. The three pump characteristics shown in the graph are:

- Head Capacity
- Power Capacity
- Efficiency Capacity

As the pump ages or is affected by operating problems, its efficiency will drop causing reduced pump capacity and higher operating cost. This loss of pump capacity can be determined by a pumpset performance testing.

Figure 5.7: Sample Curves for a Centrifugal Pump



Periodic checking of the pumpset (pump and motor) will disclose deterioration of operation before any serious problems develop. A performance check should be carried out every year or as often as required, especially when the pump is subjected to severe conditions such as corrosion, sand pumping, abrasion or cavitation.

K. GUIDELINES FOR PERFORMANCE TEST

1. The test should be carried out at the pump's normal operating conditions and at 2 points above and below this condition.
2. Shut-off and fully-open discharge valve positions should also be checked (do not exceed 3 seconds for shut off).
3. Test data are recorded and compared with the previously obtained ratings or original pump curve points.

The pump station normally has 2 devices for measuring flow measurement: one uses the orifice equipped by-pass and table values; and the other uses the flow meter which is read directly. If there is no flow meter or orifice device in the by-pass pipe, flow measurements can still be made using volumetric measurements or horizontal flow measurements. Refer to Annex B for an explanation of the horizontal flow method.

1. Test Procedure Using an Electric Motor as Prime Mover

1. Close the distribution discharge valve and half open the by-pass valve;
2. Start operating the pumpset and let it run for about 5 minutes for water level to stabilize;

3. Manipulate the discharge valve to the following settings while taking pressure and flow measurements:
   - Operating pressure
   - Operating pressure less 10 psi
   - Operating pressure plus 10 psi
   - Operating pressure plus 20 psi;
4. Shut off pressure (do not exceed 3 seconds for this setting).

2. Analysis of Pumpset Testing Results

1. Reduced Head Curve, Pump Efficiency and bhp – Reduction on all 3 curves is brought about by worn impellers. Ample clearance should be provided to prevent impeller abrasion by sand. Impeller abrasions will result in reduced water yield. In such a case, the pump should be pulled out and repaired.
2. Reduced Head Curve and Pump Efficiency at Constant bhp – Accumulated mineral deposits in bowl wall, eyes and at impeller shrouds cause restrictions and inflow turbulence resulting in a reduced Q versus TDH curve and reduced pump efficiency. In this case, the pump should be pulled out for cleaning.

L. MAINTENANCE OF PUMP STATION AND SURROUNDINGS

The operator should at all times maintain the cleanliness of the pump station and its surroundings not only for aesthetic reasons but also for sanitary reasons. Water users usually associate the quality of the water with the condition and cleanliness of the facilities. If these are in poor condition, the water quality will be subject to doubt.

The pump station and the surroundings should be periodically cleaned. Rubbish should be disposed off, the dust swept out. The pump house should be kept in good repair and, when needed, painted. Ideally, trees and plants should be planted in the premises.

M. ELECTRIC MOTOR ROUTINE MAINTENANCE

The most important items for good maintenance of an electric motor, aside from checking for bearing wear, are regular use, and keeping it warm (from operation), clean, and dry. Moisture is an enemy of insulation along with oil and dust. Every motor should be operated for 5-6 hours at least every week. The longest useful life of a motor is obtained from a unit which is never shut down and cooled off, especially in a humid climate. Listed below are some maintenance tips.

- **Every Day:**
  1. Check temperature of motor housing with hand.
  2. Check lubrication reservoir level.
  3. Check air vents for blockage.
  4. Check external wiring for frayed insulation or loose connections.

5. Check voltage and current at each leg of the three phases.

- **Every Month:**
  1. Check motor housing temperature.
  2. Check shaft alignment.
  3. Check input horsepower under load.
- **Every Year:**
  1. Vacuum all dust out of windings and motor case.
  2. Drain lubricant, flush out oil reservoir with kerosene, and replace with factory- approved lubricant.
- **Every Three Years:**
  1. Examine winding insulation for damage.
  2. Clean oil connectors and contact points with fine emery cloth.
  3. Inspect shaft and bearings for scour, wear or damage.
  4. Check input horsepower under load.

N. DIESEL ENGINE MAINTENANCE

In almost all cases, diesel engine prime movers are designed as standby units, these must be given proper care to prolong their life and for their efficient operation. In the absence of the equipment operating manual, listed below are suggested preventive maintenance practices.

- **Every Third Day:**

  Operate the diesel engine at about 1,000 rpm for at least 5 minutes or until warm. This would allow the lubricant and coolant to circulate around the engine.
- **Every 8 hours Operation:**

  Check coolant level, sump oil level, oil reservoirs, for oil, water or fuel leaks and clean oil bath cleaner.
- **Every 200 hours of Operation:**
  1. Drain and renew engine lubricating oil.
  2. Renew lubricating oil canisters.
  3. Check tension of drive belt
  4. Clean fuel water trap.
  5. Lubricate dynamo rear brush.
  6. Clean air filter element.
- **Every 400 hours of Operation:**
  1. Renew fuel and air filter elements.
  2. Check hoses and clips.
  3. Clean lift pumps sediment chamber.

- **Every 2,400 Hours of Operation:**
  1. Check and adjust valve clearances.
  2. Service injector units.

O. O&M OF SLOW SAND FILTER

Slow sand filtration is a system of water purification which, since the beginning of the nineteenth century, has been proven to be effective under widely different circumstances. It is simple, inexpensive and reliable and is still used for purifying the water supplies in many cities and municipalities in both developed and developing countries.

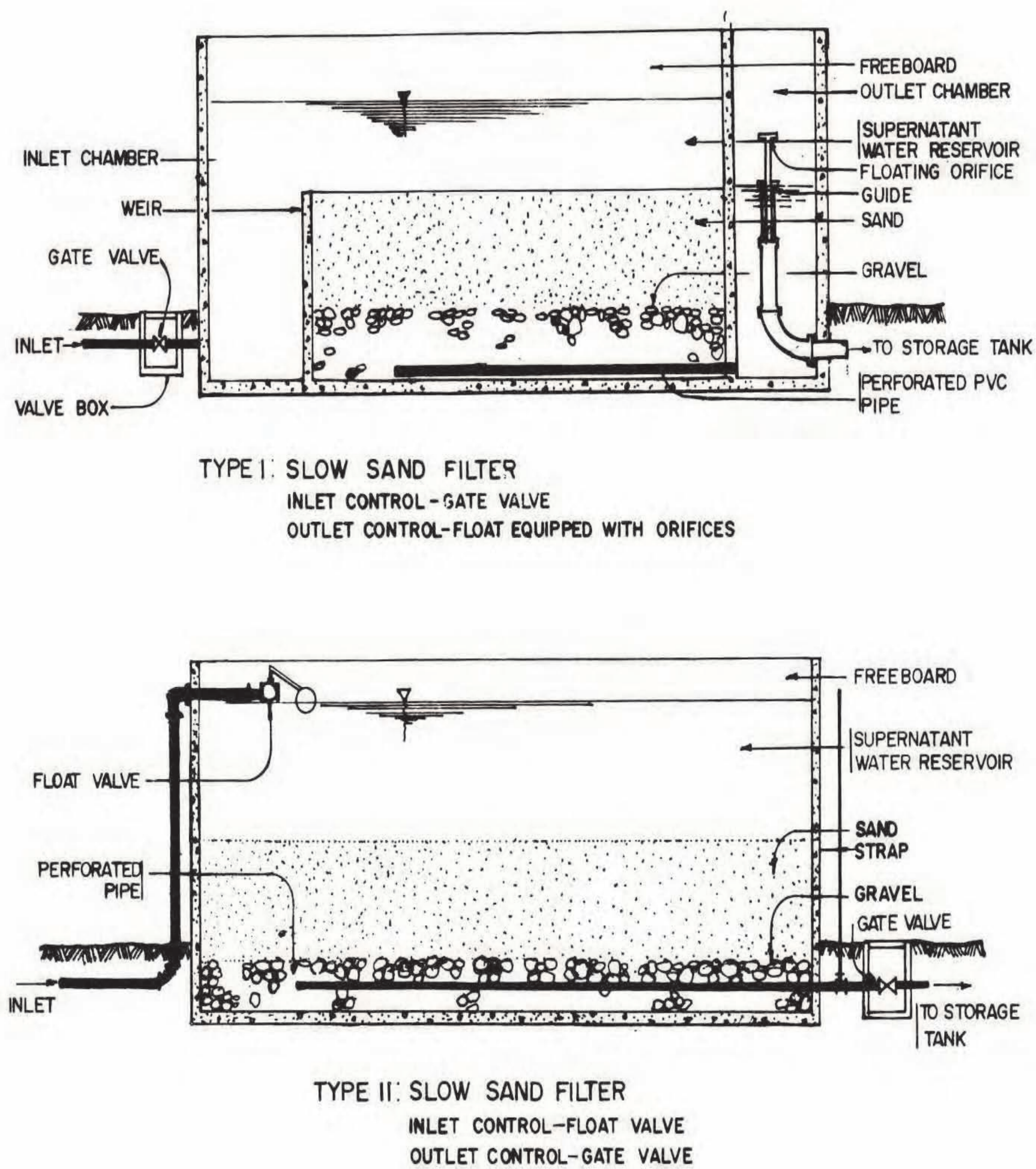
Slow sand filtration combines within itself most of the purification functions that occur in nature such as settlement, straining, filtration, chemical change and to some extent, storage, resulting in an effluent with a high degree of quality. It is also efficient in the removal and/or inactivation of organisms because of "Biological Filtration".

1. Elements of a Slow Sand Filter

The various elements that make up a slow sand filter are shown in Figure 5.8 and described below. These details should provide sufficient background for their construction, proper operation, and maintenance.

1. **Filter Box** – is a concrete, open-topped structure which houses the supernatant water reservoir, filter bed and the underdrainage system. It is usually rectangular in shape with a depth from 2.5 to 4.0 meters and built wholly or partly below ground.
2. **Supernatant Water Reservoir** – is an upward extension of the walls of the filter box from the sand-bed surface, the principal function of which is to maintain a constant head of water above the filter medium. In practice, a head of between 1.0 M and 1.5 M is usually selected.
3. **Filter Bed** – is a bed of sand, usually graded. It should be composed of hard and desirable grains preferably rounded and free from silt, clay, loam and organic matter. Ideally, the effective diameter of the sand lies within 0.3 – 0.5 mm.
4. **Under-drainage System** – consists of a false floor of porous concrete or perforated pipes, surrounded and covered with graded gravel to support the sand bed and prevent fine grains from being carried into the drainage pipes.
5. **Filter Controls** – A system of control valves used to regulate the flow of water through the bed. Figure 5.8 presents two methods of controlling water flow rate.

Figure 5.8: Elements of a Slow Sand Filter



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2. Starting-Up a Newly Constructed/Cleaned Slow Sand Filter

1. Introduce water at the bottom of the filter through the outlet chamber. The purpose of adding water from the bottom is to get rid of all entrained air in the sand pores and the underdrainage system which may cause air binding. Continue until the water begins to show on the filter surface;
2. Level the top of the sand by raking;
3. Resume adding water through the outlet chamber until the water level is at least 10 cm above the sand bed. The purpose of raising water up to this level is to protect the sand surface from being scoured out of level when water is introduced from above;
4. Open inlet valve and start feeding water slowly from the top until the maximum water level in the supernatant water reservoir is reached;
5. Open the outlet valve and let the effluent run to waste until the filter gives clear water;
6. Start operating the filter.

3. Ripening the Filter

When first constructed or just after cleaning, the slimy layer on the sand bed does not yet exist. Building up this slimy layer is a slow process called “ripening” and entails running the filter continuously and without interruption discharging filtered water to waste for at least one or two weeks.

As ripening proceeds, there will be a slight increase in the bed resistance. The organisms build up and the forming slimy layer will gradually become visible. These are signs that ripening is proceeding well, but only after comparative chemical and bacteriological analyses of raw and treated water may the waste valve be closed and the effluent be directed to the distribution system. In case water supply distribution is interrupted for a long period, filtration should be continued with the effluent discharging to waste. Any shutdown for an extended period must be followed by further ripening if the quality of the effluent is to be maintained.

4. General Operating Procedure

The operation of the filter is determined by the filtration rate, which is controlled at the effluent outlet by a regulating valve. Initially, this valve is partially closed. As the run continues, this valve must be checked and opened fractionally to compensate for the choking of the filter and to maintain a constant filtration rate. In case the valve is already fully opened and yet the design flow rate is still unattainable, the filter operation should be stopped and the filter cleaned.

Inflow is likewise adjusted by means of a simple manually operated valve so that the level of water in the supernatant reservoir remains constant. The valve will need periodic checking in order not to waste raw water through excessive delivery or to avoid diminishing output through a dropping water level over the filter bed.

5. Filter Cleaning

Filter cleaning will be necessary when the top 1-2 cm of the filter bed becomes choked. If a gate valve is used for effluent control, the indicator of a choked filter bed is the continued reduction of the effluent flow rate even when the valve is fully open. If the floating orifice is used for effluent control, a choked bed will be apparent when the orifice drops significantly (near the level of the mount of the guide) due to the reduction of water level in the outlet chamber. Choking usually takes place after one or two months of continuous filter operation depending on the turbidity of raw water treated.

The filter bed is cleaned as follows:

1. Close the raw water inlet valve and allow the water level in the supernatant water reservoir to drop to the filter bed surface;
2. Close the outlet valve and open the drain valve. Allow the water level to drop further to at least 10 cm below the filter bed surface;
3. As soon as the biological layer is dry enough to handle, immediately scrape off the upper 25 to 50 mm layer of the filter bed using flat square-bladed shovels. If cleaning is delayed, scavenging birds will pollute the filter surface and disturb the sand;
4. After removing the scrapings, smooth the bed to a level surface. Also, inspect for the presence of mud ball cracks in the sand which may result in channeling, which would cause the deterioration of effluent quality.

The newly cleaned filter bed may now be put back into operation following the procedure outlined for start-up of newly cleaned filters, including a re-ripening process.

The re-ripening period will depend on the degree of disturbance or the amount of the remaining bacteria in the bed. The quicker the filter bed is cleaned, the less will be the disturbance and the shorter the period of re-ripening.

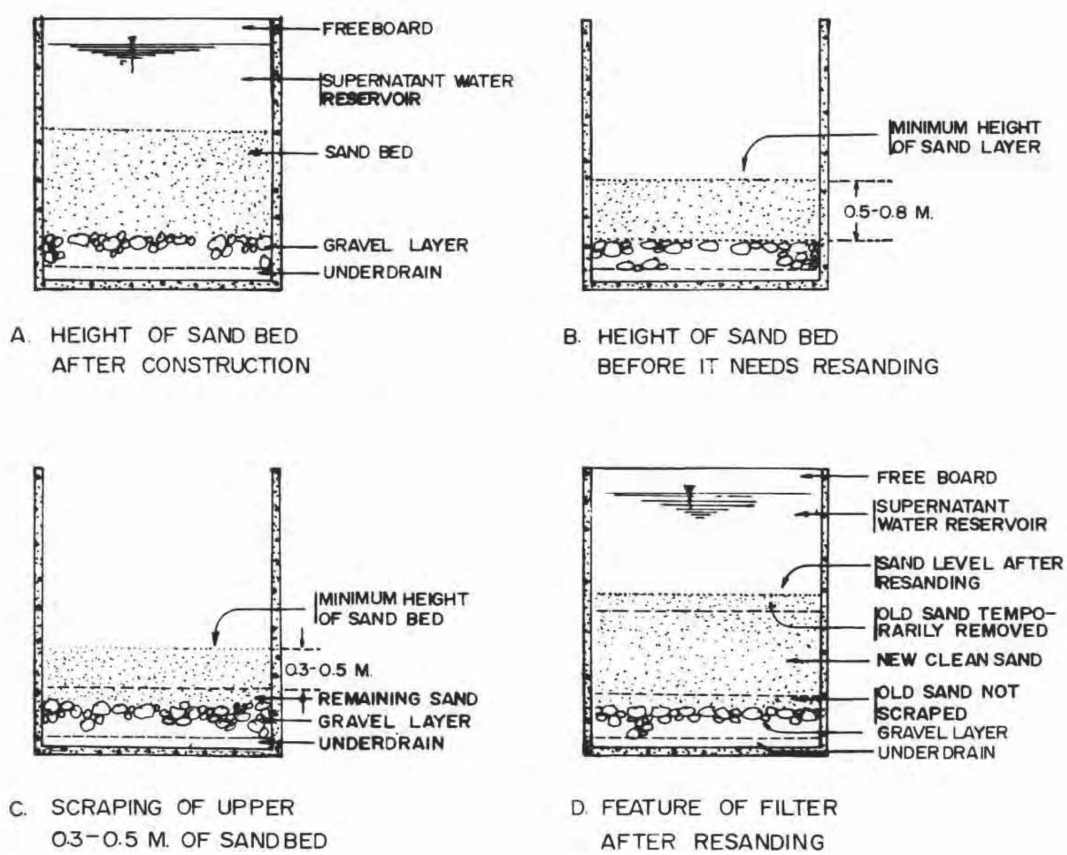
6. Re-sanding

Re-sanding becomes necessary when the depth of the sand bed drops to its minimum designed level (usually about 0.6 – 0.8 m above the supporting gravel, depending on the grain size of the filter sand). This depth is usually indicated by a marker set in the structure during the original construction. Re-sanding may be done completely or by a "throwing-over" procedure described below.

a. Complete Re-sanding

In this method, the upper 0.3-0.5 meter layer of the sand bed is scraped before new clean sand is added. It should be emphasized that it is necessary to scrape the said layer to avoid fouling and to reduce the greater resistance in the filter due to the raw water impurities and some products of biochemical degradation which may have penetrated the sand bed to this depth. After scraping, add new clean sand up to a level shown in Figure 5.9 and place back the old sand that was scraped off the top. The old sand will reduce the number of days needed for ripening the filter.

Figure 5.9: Details of Sand Filters



NWRC RWS Volume III, Operation and Maintenance Manual

b. "Throwing Over" Re-sanding

This is carried out in strips. The old filter sand is moved to one side, then the new clean sand is added, and finally the old filter sand is replaced on top of the clean sand. This is to retain the active material found in the old filter sand so that the re-sanded filter will become operational with a minimum re-ripening time. The procedure is as follows:

1. With a flat square-nosed shovel, scrape 50-100 mm of the upper layer of sand bed. Place the scrapings in a box for cleaning;
2. Divide the whole length or width of filter into strips;
3. With a flat square-nosed shovel, scrape 0.3 – 0.5 meter of the upper layer of the first strip and stack it to one side;
4. Fill the excavated trench with the new clean sand and scrape 0.3 – 0.5 meter of the adjacent or second strip and place it on top of the first strip;
5. Fill the second strip with new sand and scrape 0.3 – 0.5 meter of the adjacent or third strip and place it on top of the second strip;
6. When the whole bed has been re-sanded, use the material scraped from the first strip to cover the new sand in the last strip;
7. Operate the filter as described in sub-section 2.

7. Washing Filter Sand

In areas where sand is expensive or difficult to obtain, surface scrapings or used sand should be recycled. Scrapings should be washed immediately to remove organic matter. . Filter sand may be washed manually or mechanically:

a. Manual Washing

1. Transfer the scrapings to a box;
2. Fill the box with clean water;
3. Stir the sand in the box with a spade or shovel vigorously enough to separate the sand particles from the impurities;
4. Transfer the sand into the second box and add clear water. Stir the contents of the box to separate the organic matter from sand particles;
5. Repeat the above procedure until the wastewater is fairly clear;
6. Store the sand.

b. Mechanical Washing

A machine called the ejector type, mechanical sand washing machine is used for this purpose. The machine consists of a cylindrical drum with conical bottom and stirrers. The used sand is fed at the top and at the same time, clean water is injected under pressure at the bottom of the drum. The impurities are removed in the overflow while the clean sand is discharged at the bottom of the drum. The stirrers inside the drum aid in dislodging undesirable substances from the sand particles.

P. CHLORINATOR OPERATION AND ROUTINE MAINTENANCE

1. Hypochlorinator

1. Read the Instructions provided in the manufacturer's Manual.
2. For maintenance purposes, it is essential to clean the strainers and tubings as often as necessary or at least twice monthly. If the tubings are not cleaned, the chlorine granules can re-solidify and cause blockages.

2. Gas Chlorinator

For operating and maintenance, carefully read the Instructions provided in the manufacturer's Manual. Generally start-up is as follows:

1. Turn on water supply to the ejector;
2. Open the chlorine cylinder valve not more than ½ turn then close immediately. Check for leaks. A smell of chlorine gas indicates a leak in the set-up. To confirm, dip a cotton or piece of cloth in ammonia solution and expose it near the leakage. Ammonia vapor reacts with chlorine gas to form white fumes;
3. If leak is confirmed, allow the chlorine gas to dissipate from the air before undertaking any repair;
4. After the repair, repeat steps #2 and #3 until no more leak is detected;
5. Set the feed rate at the computed or desired chlorine dose level.
6. **Chlorinator Shutdown:**
   i. When pressure in cylinder reaches zero or flow drops as indicated by flow tube, close cylinder valve;
   ii. If valve does not close tightly, open and reclose lightly several times until it closes properly;
   iii. Do not use over-size wrench to force valve closed;
   iv. Leave chlorinator operating with ejector water on for a few minutes after closing the cylinder valve, to exhaust Cl_2 from chlorinator before disconnecting it;
   v. Replace outlet cap and protective bonnet immediately after disconnecting the chlorinator;
   vi. Do not leave chlorinator or chlorine lines open to the atmosphere for any extended period. If they are reconnected to a new cylinder, cap the open ends to prevent moisture from the air from entering and causing corrosion.

7. Chlorine Leaks

    i. A chlorine gas leak usually is first detected by smell. ***If you smell chlorine, move to safety and keep others away from the area, get help, and put on a gas mask before trying to pinpoint the leak.***
    ii. Large leaks show as escaping green gas or liquid, with frost from the atmosphere forming around the leak.
    iii. Small leaks can be located by spraying ammonium hydroxide (aqua ammonia) vapor from a plastic squeeze bottle, or by passing a cloth soaked in the ammonia solution. Ammonia vapor reacts with chlorine gas to form white fumes.

3. Routine Maintenance

1. **Strainer:** Clean the strainer in the ejector water supply line every six months.

2. **O-Rings:** O-rings showing the first sign of damage or brittleness should be replaced. Faulty O-rings result in vacuum leakage. O-rings should be routinely inspected whenever an opportunity presents itself in the course of repairs or maintenance of other parts.

3. **Vacuum Regulator Valve and Ejector**: Clean the vacuum regulator and ejector throat and nozzle at least once a year. The need for cleaning may be indicated by insufficient ejector vacuum, resulting in lowered maximum capacity of the feeder.

4. **Hose Lines.** Inspect all hose lines at least weekly for cracks or weak spots that develop with aging. ***Faulty lines should be replaced. Use only hoses supplied by the manufacturers of chlorine equipment.*** Never use ordinary rubber hoses except for a very short period in an emergency situation. Rubber used for chlorine service is a special type.

Chapter 6
Distribution System

This Chapter discusses the proper operation and maintenance of the various components of a water distribution system.

A. INTRODUCTION

The O&M of a water distribution system is directed at the following general objectives:

- To ensure adequate pressure in the system 24/7;
- To minimize non-revenue water (NRW);
- To ensure that the water delivered is potable.

The distribution system consists of four components, whose O&M requirements are based on their unique characteristics as well as their function and contribution to the total system. They are:

1. Distribution pipelines
2. Storage tanks or reservoirs
3. Service connections or standpipes
4. Valves and other appurtenances

B. DISTRIBUTION PIPELINES

Distribution pipelines must be able to convey quality water reliably and efficiently to the consumers and keep it from being contaminated along the way.

1. Sound Operation Practices

Properly constructed, pipelines can provide years of trouble-free operations. However, sound operation practices need to be observed, both to ensure water quality and to prevent the deterioration of pipeline efficiency. Sound operation practice can be summarized as follows:

1. Always maintain positive line pressure. Negative pressure could result in backflow from private storage and the intrusion of foreign water/matter that may pollute or contaminate the system.
2. Always open and shut off valves gradually. Abruptly opening or shutting off a valve can cause sudden surges, changes in water velocity, and reversals of flow that might produce water hammer effects that could stir up sediments, making the water dirty, and damage valves and weaken the pipe joints.

3. Implement an appropriate flushing program to clear sediments from the system. Such a program should institute the regular, periodic flushing of the pipes, as well as prescribe the maintenance measures for those sections of the system that are more prone to sediment build-up, such as dead-end pipes and low sections. These sediment-prone sections should be pre-identified and, if needed, provided with additional blow-offs and hydrants to facilitate flushing and disinfection.

2. Preparation for Repairs

Regardless of their construction and the best operational and maintenance practices, pipes are subject to the aging process, to accidents, and to other adverse factors including force majeure. Thus, the SSWP should accept the fact that pipeline leaks and breakages can and will happen, and be prepared to handle them. Since water main breaks need to be repaired with as little delay as possible, it is important to have contingency plans in place, and for the SSWP personnel are trained to work with minimal delay based on the plans.

The following tasks should be done in advance in order to eliminate delays in getting the needed repair work started:

1. Post the phone numbers of key maintenance personnel conspicuously in the pumping station or office.
2. Keep the following items available and ready for use at all times: valve keys, hand tools, digging tools, pavement breakers, trench-shoring material, a portable centrifugal pump, floodlights, an emergency chlorinator, and calcium hypochlorite.
3. Keep a stock of split-sleeve and mechanical-joint repair fittings in sizes that fit critical mains.
4. Make advance arrangements with the municipal engineer's office, DPWH, or an outside contractor for the use of equipment that may be needed but are not normally owned by the SSWP. Keep an inventory of the type of equipment that is available at these sources whether for borrowing or renting. The contact details of the persons in charge of the equipment at these sources should also be posted conspicuously at the pumping station.

3. Locating Water Mains

The exact location of pipes can be determined by referring to records or as-built plans of the water supply system. In cases where records are inadequate or lost, underground pipes might be pinpointed

- By asking old residents who witnessed their installation;
- By using pipe locators;
- By trial excavation.

Plan of the Distribution Facilities

Ideally, the SSWP should have a clear, detailed plan of its distribution facilities, as well as information about the appurtenances like valves. If a pipeline problem is reported, the first thing to do is to ascertain the exact location of the main involved.

Without a plan of the distribution facilities, the repair crew will have to take the extra step of locating the main where the problem has occurred, before it can start the repairs.

a. Locating Pipes with Pipe Locators

The position of water mains can easily be pinpointed with the use of a pipe locator. A small water utility, however, is unlikely to own this very expensive piece of equipment. It may have to rent one, unless it can be borrowed from a government agency that has one.

b. Locating Pipelines by Trial Excavation

1. In the vicinity of the reported problem, select a primary reference point that you can use to establish the position of the problem pipeline. An exposed pipe section, a gate valve, or gate valve box would be a good primary reference point;
2. Where there is no exposed pipe section, select any point on the north or east side of the road and make an excavation. In the Philippines, water mains are usually installed at the north or east side of the road;
3. If a water main is not found at the first point excavated, try again at another point on the north or east side of the road within the same vicinity. Continue the trial and error process until a water main is located;
4. Using the water main just located as reference point, select a second point 50 to 100 meters from it and make another excavation;
5. Once a second excavation point reveals the water main, draw an imaginary line connecting the successful excavation points 1 and 2. The connection of the two points is the exact position of the buried pipe;
6. Repeat the above process using the identified points as reference until all pipelines are pinpointed.

4. Cleaning Pipelines

Water going through the pipelines may sometimes carry sand, sediments, and organic and other objectionable matter. When water velocity is low, these tend to get deposited and build up inside the pipes. The built-up deposits decrease the carrying capacity of the pipes and increase internal friction, making the pipelines less efficient. Less water can be delivered per given time, pumping costs increase, and the added and uneven pressure within the pipelines increases the likelihood of breaks and leaks. These effects are complicated when magnesium and calcium salts are present in the water (hard water), as their precipitation results in scaling inside the pipes. Likewise, when organic matter is present in the deposits, bacteria proliferate, causing undesirable odors, and an off-taste and color in the delivered water.

The method for removing solids which are not cemented to the inside surface of pipes is to flush with water at high velocity. Annual flushing is generally sufficient to maintain the pipelines clean. (But note that different water and pipe materials may need a different schedule.) Dead end pipes should be flushed and disinfected at least once a year. Furthermore, whenever mains are opened for repair, they should also be flushed and disinfected.

The flushing procedure is as follows:

1. Isolate the water mains to be cleaned by closing the appropriate control valves;
2. Empty the water mains by opening the blow-off valve or other temporary outlet at the lower end of the pipeline. In some cases, to expedite the emptying of water mains without pumping, compressed air may be introduced at the highest point of the isolated system;
3. Inject water at high-induced velocity (1.0 meter per second or higher) until the objectionable materials are expelled;
4. As needed, disinfect the pipelines. After disinfection, flush the pipeline with clean water until the chlorine-odor is hardly detectable;
5. Put pipelines back to operation.

Conditions That Require Frequent Flushing

When recurring complaints about water quality are received despite regular flushing, the SSWP should investigate the possibility that stagnant water in dead-end lines may be the cause. It should determine and eliminate conditions that make repeated flushing necessary, among them: (a) a dead end or low point in the main that allows sediment to accumulate; and (b) insufficient chlorination, which enables slime organisms to grow inside the pipes.

5. Repairing Pipe Leaks

Leaks in water mains should be fixed as soon as they are detected. Once the leak is pinpointed, the water in the isolated main must be removed (see items #1 and #2 of flushing procedure above). The repair job then consists of sealing the leaks and/or replacing the defective pipe section. The different methods of fixing leaks are as follows:

a. Using Epoxy (for Small Leaks)

1. Dry the surface of the area to be repaired;
2. File the surface to make it rough, and slightly enlarge the crack or hole;
3. Apply the epoxy, forcing some of it into the crack or hole to produce a seal;
4. Normally, the epoxy will set in 2 to 4 hours before the pipe can be disinfected and put back into service, However, be sure to check the directions for use of the epoxy as some types may require more or less time.

b. Using Sleeve Type Coupling /Repair Clamps

Put a split sleeve/repair clamp around the leak opening.

c. Using Strips from the Inner Tube ("Interior") of a Rubber Tire

In emergency work when no other repair materials are available, cut a discarded inner tube of a rubber tire into strips and wind the strong, flexible rubber strips tightly around the pipe to cover the leak and its surrounding surfaces.

d. After the Leak Is Repaired

1. Open the control valve to allow water to flow into the repaired section;
2. Observe carefully to verify if the leak is completely sealed;
3. After sealing, backfill the excavation and restore the surface to its former condition;
4. Apply the disinfection procedures.

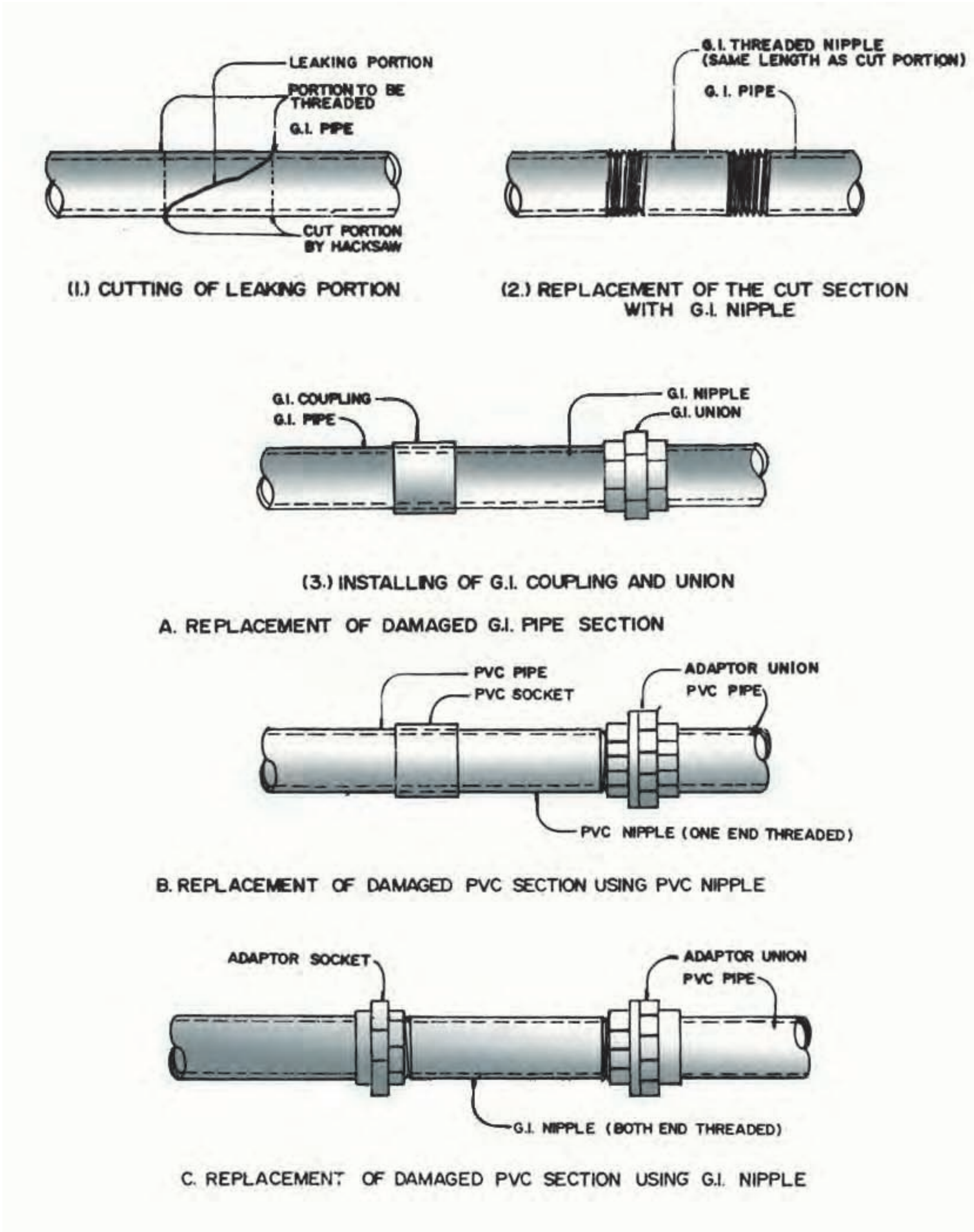
6. Replacing Damaged Sections of Pipelines

When the damage in a certain section of a water main is extensive, repair may involve cutting off and replacing the damaged section. The procedures for repairs are as follows:

a. For Galvanized Iron (G.I.) Pipes

1. Isolate the defective section by closing appropriate control valves;

Figure 6.1: GI Pipe Repairs



NWRC RWS Volume III, Operation and Maintenance Manual

2. Excavate the water main;
3. Determine the exact location of the leak;
4. Cut the defective portion of the water main;

5. If a nipple of appropriate length is not available, prepare a substitute nipple using a short pipe of the same kind, diameter and length as the cut off defective pipe;
6. Thread the ends of pipe to be joined;
7. Install G.I. coupling and union parts;
8. Assemble them as shown in Figure 6.1;
9. Open the control valve to allow water to flow into the repaired section. Observe carefully if the repaired section is not leaking;
10. If there is no more leak, backfill the excavation and restore the surface to its former condition;
11. Disinfect the repaired section.

b. For Polyvinyl Chloride (PVC) Pipes

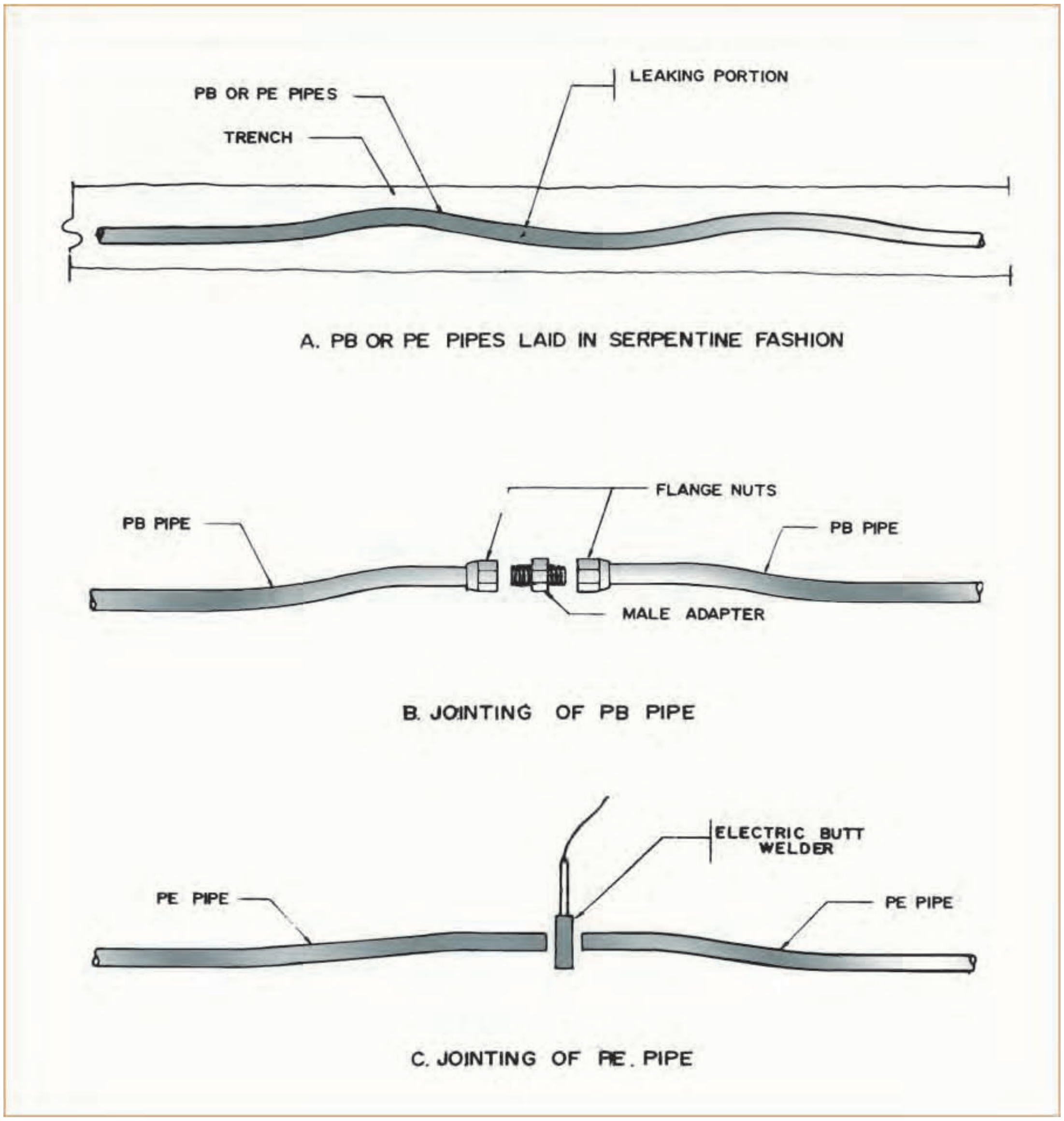
1. Isolate the defective section by closing the appropriate control valves.
2. Excavate the water main;
3. Pinpoint the leak;
4. Measure and cut the defective portion of the pipeline. The length of the pipe cut should have an equivalent commercially available threaded nipple;
5. Install the PVC socket and adaptor union;
6. Join the two cut portions of the water main with the nipple in between. (In case PVC threaded nipple is not available, use the equivalent G.I. threaded nipple);
7. Open the control valve to allow water to flow into the repaired section and observe if it is not leaking;
8. If there is no more leak, backfill the excavation and restore the surface to its former condition;
9. Disinfect the repaired section.

c. For Polybutylene (PB) and Polyethylene (PE) Pipes

1. Isolate the defective section by closing the appropriate valves and excavate main;
2. Cut the defective portion of the water main;
3. Check if the two separate ends of the cut can be pulled together to be joined. (This is usually possible because PB and PE pipes are laid in serpentine fashion as shown in Figure 6.2.) Otherwise, a small connecting section must be inserted;
4. Join the 2 separated ends. For PB, use the flaring method. For PE pipes, use the butt-welding method;
5. Open the control valve to allow water to flow and observe for leaks;

6. Backfill and restore surface to its former condition;
7. Disinfect the repaired section.

Figure 6.2: PE/PB Pipe Repairs



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7. Disinfecting Pipelines after Repairs

After a repair job, it is essential to disinfect the repaired sections of the water distribution system with chlorine or chlorine containing compounds. Refer to Chapter 3 for complete disinfection procedures.

C. RESERVOIRS

1. Operation

Water for distribution is pumped from the water source to the system's water tank or reservoir, from which it is delivered to the consumers through the pipelines. The reservoir is designed, based on the requirements of the system, to distribute the water by gravity or by pumping.

2. Cleaning

The quality of water coming from the reservoir must be maintained within the standards for potable water. To ensure the quality of the water supply, the reservoir must be cleaned and disinfected periodically. Failure to apply this routine will result in the accumulation of solids and proliferation of bacteria in the tank, making the water unsafe for drinking.

Cleaning is usually done once a year, but it always must be done whenever the water in the reservoir contains an appreciable amount of dirt.

Important Safety Precautions

When cleaning reservoirs, workers must work in pairs – one to go down and the other to keep watch over the one inside the reservoir. Proper ventilation must be ensured at all times during the cleaning or repair operations.

a. Checking Sediment Levels

1. Reduce the water level down to 15-20 cm above the bottom of the tank;
2. Stir up the water;
3. If the bottom appears to be clean and sediments are either minimal or not present, cleaning is not needed.

b. Cleaning

1. When the check confirms that an appreciable amount of sediments has accumulated in the reservoir, cleaning should proceed;
2. Brush the walls, column, ladders, and other parts of the reservoir to remove adhering dirt particles and algae, if any;
3. Open the drain valve to drain the remaining water to waste. While draining, agitate the water to keep the dirt particles from settling, and sweep the sediments in the water towards the outlet;
4. Disinfect the tank by any of the following methods:
   - Fill the tank with 50-mg/l chlorine solutions and allow the solution to stand for 24 hours before draining it to waste;
   - Alternatively, mix bleaching powder and water in a pail or bucket to form a thin paste. Using a brush, apply the thin paste forcefully

on the interior surfaces of the reservoir. Allow one hour to pass before rinsing the tank with clean water;

5. Put the tank back into operation after rinsing it with clean water.

Important Precaution on Chlorine

During the work of disinfection (which includes the task of rinsing of the reservoir to remove the bleach), the working men must be wear breathing apparatus and full protective clothing. The SSWP should equip them with these.

In case the bleaching powder solution accidentally gets into contact with the eyes, immediately wash eyes with copious amounts of clean water. After the disinfection job, all men involved in the work must shower or wash their entire bodies thoroughly.

3. General Precautions

1. Storage facilities tend to attract children who like to play around the facilities, climb the ladders, and play on top of concrete roof, oblivious of the serious hazards involved. All gates, access hatches and manholes of reservoirs should be locked. Never leave a storage facility for even a few minutes without locking all access openings.
2. Vandals are known to intentionally damage storage facilities. Utilities should keep watch against vandalism to protect the stored water and the public from health hazards. If a covered storage facility is found to have been forced open, it must be assumed that the water has been contaminated. Therefore the reservoir should be drained to waste and disinfected before being refilled with new water. All fences should be maintained in good condition. Do not allow any materials to be staked out on fences, as these could aid trespassers to climb over.
3. Keep reservoir roof ladders and walkways free of dirt, debris and grease to prevent slipping and contamination.
4. Never enter a closed reservoir alone without someone standing by to help if you get in trouble.
5. Keep alert for cracks/leaks in the reservoir and repair these at once.
6. Never store unchlorinated water in a reservoir for more than 72 hours.
7. The foundations of concrete reservoirs and elevated steel tanks are subject to differential settlement when the soil beneath one part of the foundation compresses more than the soil at another part. A differential of only 1- 2 cm can cause large stresses in the reservoir wall or legs. When differential settlement is discovered, corrective measures are urgent. These require the services of a soil engineer and special equipment.

4. Detecting and Repairing Leaks in Steel Tanks

Reservoirs made of steel are usually installed above ground, making it possible to visually detect any leaks. Leaks in steel tanks can be repaired as follows:

1. Small leaks may be sealed with epoxy or by welding.
2. Larger leaks may require covering the damaged section with a steel plate larger than the hole, and welding it to the tank to seal the leak.

5. Detecting and Repairing Leaks in Concrete Reservoirs

Leaks in concrete reservoirs can be repaired with cement mortar. Concrete reservoirs may be elevated or installed at ground level. If the concrete reservoir is elevated, leaks can be detected visually. If it is at ground level, leaks can be detected by either of these methods:

- <u>Marking the Water Level in the Reservoir</u> – Close the discharge pipe control valve. Fill the tank with water up to a certain level and mark the water level. After one or two days, check the water level. If there is an appreciable decrease in water level, the tank has leaks. During the entire process, the outlet control valve should be closed.
- <u>Checking the Discharge in the Underdrains</u> – If the tank has underdrains, observe the discharge in them. An appreciable discharge indicates leaks in the tank.

6. Maintenance of Reservoir Appurtenances

a. Monthly Maintenance Tasks

1. Lubricate float control pulleys.
2. Inspect float for leaks.
3. Check level indicator for free operation.
4. Sweep roof, catwalks and ladder landings.

b. Manholes

Manholes should always be covered and locked to keep out foreign materials that could contaminate the water supply and also to prevent accidents.

c. Overflow Pipe and Air Vents

1. Covered reservoirs or tanks should be vented to allow the passage of air to and from the reservoir as the water level changes. Use fine screens on the vents to prevent the entrance of animals and insects, and keep the screens in good repair.

2. Keep access manhole covers in place to prevent accidents and contamination.
3. Slope the ground away from the reservoir in all directions to prevent surface water from flowing towards it.
4. Leaks in the cover or walls that allow surface water or shallow groundwater to seep in are dangerous. Repair leaks at once.

7. Repairing Leaks in Reservoirs

a. Repairs Using Cement Mortar

1. Drain the reservoir;
2. Using a cold chisel, make a cut on the reservoir leak with the following dimensions: Width 19-25 mm and depth 19-25 mm;
3. Prepare a stiff cement mortar paste by mixing 1 part of Portland cement, 2 parts of fine sand and sufficient water;
4. Clean and wet the holes cut in the reservoir and apply the cement mortar paste. Allow the mortar to set for 24-28 hours;
5. Disinfect the tank;
6. Rinse the tank with clean water;
7. Put the repaired tank back into operation.

b. Repairs Using Proprietary Fast-Setting Cements

There are a number of proprietary fast-setting hydraulic cements specially formulated to quickly stop leaks and the seepage of moisture through holes or cracks in concrete or masonry walls. The most widely available in the Philippines is the “Waterplug” brand. Some other brands are “Quickrete”, “Parson Quick Plug”, and “Dry Lok Fast Plug.” These are generally based on Portland cement, but have ingredients that make the compound expand as it sets. Most of these proprietary blends are supplied as a dry powder to be mixed with clean water, and set within 3 to 15 minutes depending on the brand.

These formulations are durable and can be expected to last for the life of the concrete structure being repaired. They do not contain toxic elements, are highly impervious to water, and thus are suitable for use with potable water systems.

Application Procedure:

1. Open up the crack or hole by making a cut along the damaged area using a cold chisel. This will make it possible for the compound to form a plug. As the compound sets, it expands to complete the seal;
2. Before applying the compound, brush away all loose particles;

3. Mix the compound in accordance with the manufacturer's directions, which usually results in a paste of sticky consistency. The compound is hydraulic cement that begins to bind once it comes into contact with water. Once the water is mixed in, the paste must be used within minutes;
4. Apply the paste and force it into the crack. Start from any edge;
5. When sealing leaks beneath the water level in an undrained reservoir, use a trowel or your hand with a glove. Hold the mixture in place for 3 to 5 minutes or until no water passes through the leak;
6. Keep the repaired leak damp for 15 or more minutes (see directions).

c. Repairs Using Epoxy

Epoxy is an adhesive sealant available commercially in plastic packs of 15 grams or more. It consists of two components: A (Resin) and B (Hardener). Epoxy is generally used in repairing small leaks. Repairing a reservoir using this compound requires the following steps:

1. Drain the reservoir;
2. Dry and clean the surface to be repaired. In the case of steel tanks, roughen the surface to ensure good adhesion. In the case of concrete surfaces, clean out all loose particles;
3. Squeeze equal amounts of component A (Resin) and B (Hardener) on a suitable palette, and mix thoroughly;
4. Apply the mixture immediately to the leak;
5. Allow 2 to 4 hours for the epoxy to set. (Check instructions on the package if more or less setting time is needed);
6. Put the reservoir back to operation.

d. Repairs on Steel Tanks Using Electric or Acetylene Welding

1. Drain the reservoir;
2. Dry the surface to be repaired;
3. Weld the hole or break directly if small. If the leak is large, cut a metal plate with size lightly greater than the hole and then weld it in place;
4. Clean and smoothen the welded surface;
5. Paint the repaired area;
6. Disinfect the reservoir;
7. Put the reservoir back into operation.

8. Painting of Reservoirs

Painting is necessary to prevent corrosion and to prolong the life of steel tanks used as water reservoirs. Painting is recommended at least once every five years, after the annual cleaning and inspection of the reservoir. The procedure is as follows:

1. Dry, clean and smooth all surfaces to be painted. Remove all dirt, scale and rust by scraping or fine brushing. Remove oil/grease by using an appropriate solvent;
2. Paint the surfaces of the reservoir with a lead-free, food-grade coating material. Usually this is a polyurethane elastomeric paint or a high gloss epoxy coating;
3. *Make sure that the paint to be used is free from any substance deleterious to human health, and that it will not impart taste or odor to the water*;
4. After the paint has cured, disinfect the reservoir;
5. Put the reservoir back to operation.

D. SERVICE CONNECTIONS

In general, domestic meters should be taken out of service every 5 to 7 years and completely overhauled. The systematic inspection and replacement of consumption meters is an important aspect of routine maintenance. Records should be kept on the condition of meters to guide future procurement and enable the Utility to take measures against water loss.

Representative pothole checking of service connections within 5 years of service (avoid leaks due to deterioration) should also be done.

1. Inspection of Water Meters

1. Clean all water meter parts thoroughly;
2. Make sure the gear train runs freely;
3. Check the action of the disc in the chamber;
4. Remember that friction is just as detrimental to correct registration (reading) as slippage;
5. Store meters away from heat;
6. Use a calibrated meter as a standard of comparison for tolerances and clearances;
7. After every repair, retest the meter for accuracy;
8. If necessary, call the manufacturer for advice.

2. Types of Water Meter Testing

1. Meter Shop Test – pull out meter and send it to testing laboratories/shops for testing/recalibration (equipment and service available usually at large utilities).
2. Volumetric Method (no dismantling) – using a container with known volume, a variance of +/- 4% should be pulled out for recalibration)
3. Using a Calibrated Test Meter – the meter should be put in series with a calibrated meter. In principle, readings should be the same. Record the difference; +/- 4% off should be re-calibrated.

3. Water Meter Testing (If a test bench is available)

1. Install/fix water meter on test bench;
2. Open supply valve, close end valve and inspect for leaks;
3. Record the initial reading;
4. Open end valve, run the test and close end valve at desired volume.
5. Record the final reading;
6. Compute meter accuracy;
7. Identify Over/Under registering meters;
8. Calibrate by adjusting regulator or rheostat (+/-);
9. Re-test the water meter;
10. Seal the water meter cover and regulator plug.

E. VALVES AND PUBLIC FAUCETS

Valves and public faucets are flow control devices in the water distribution system. Their useful life depends to a large extent on the manner they are operated and maintained.

Valves installed in a small water supply system may be manual or automatic. The valves commonly used are the manual type. Globe, gate, angle and blow-off valves are manually operated, while check, air vacuum, foot and float valves regulate the flow of water automatically.

Prior to system operation, all manually operated valves should be located and data recorded on the direction of opening and number of turns to either close or open each one.

The operability of air release valves, special valves and other appurtenances with mechanical components must be checked twice a year.

1. Valve Operation

1. Valves operated manually should be opened all the way, then closed one-quarter turn of the hand wheel to prevent the valve from sticking in the open position;
2. Valves should be opened and closed slowly at an even rate to reduce the risk of water hammer;
3. Unless otherwise indicated, valves are opened by turning the hand wheel or key counterclockwise; and
4. Always consult the manufacturer's instructions for operating a specific type of valve. It is good practice to operate (exercise) valves periodically (or at least 2 times a year).

a. To check whether a valve is operational or not:

1. First close the valve completely and then open it completely;
2. Back off on the valve about one turn to avoid locking it in an open position; and
3. If the valve does not operate properly, repair or replace at once.

b. Things to check:

1. Ensure that the valve boxes are not full of mud or debris, or become buried;
2. Inspect the valves for leaks around the valve stem;
3. Ensure that the valve handles are intact;
4. Ensure that each valve can be fully opened and fully closed;
5. Record the inspection date, whether the valve is right- or left-handed, and whether it is normally open or normally closed;
6. Record any needed repairs or replacements.

2. Common Causes of Failure and Their Remedies

a. Corrosion

If valves are not operated or lubricated for a long time, they may become inoperable due to corrosion. If the corrosion damage is not extensive, the valve may be made operable again by pouring kerosene or dilute lubricating oil down the valve key to lubricate the joint between the stem and packing. However, if the valve is still inoperable after this procedure, it should be replaced.

b. Closing the Valve Too Tightly

Closing the valve too tightly may damage the valve washer, the valve seat, or the threads of the valve stem, causing the water to leak. To solve this problem, it is suggested to put markers showing the direction of opening and closing and to close the valve just tight enough to stop the flow of water.

c. Worn-Out Washer or Loose Packing

Worn-out washers or loose packing should be replaced to prevent the loss of water.

d. Cavitation

Cavitation results when a valve is left partially closed or open for a long period. Leaving a valve partially closed or open will cause a partial vacuum or void in the downstream side that may eventually be filled with low-pressure vapors from water. When these vapor pockets collapse, a mechanical shock (cavitation) is created, this may produce cavities. After some time, the valve will be destroyed and even the pipelines may be affected. Cavitation can be avoided by keeping the valves fully closed or fully opened at all times.

e. Water Hammer

Water hammer is caused by sudden closing of valves. When the flow of water is suddenly stopped, enormous pressure is created which may damage the pipe or valves. This problem can be prevented by closing the valve slowly.

3. Repair of Globe Valves, Public Faucets and Other Related Valves

a. Tools Needed:

1. Flat jawed or monkey wrench (large enough to fit the packing nut of the valve/faucet)
2. Rubber sheet or soft cloth (to protect the finish of the faucet or packing nut)
3. Screw driver
4. Faucet seat dresser.

b. Materials Needed:

1. New faucet washer or valve seat and disc
2. Lubricated candle wick for stem packing
3. Waterproof grease
4. Washer screws.

c. Procedure:

1. Familiarize yourself with the different parts of the faucet or valve;
2. Examine and find out the location of the leak. If water is coming out from the mouth or outlets, the trouble is due to a damaged washer or damaged seat or both. If water is coming out from around the stem when the valve is open, the stem packing is defective;
3. Close the control valve to cut off water supply to the defective valve/faucet;
4. Open the packing nut with a wrench. Place a piece of rubber sheet or cloth over the wrench jaws to avoid marring the valve/faucet finish;
5. Repair the defective valve/faucet;
6. Replace the handle and tighten the handle screw;
7. Turn on water supply and observe for leaks.

F. HYDRANTS

Fire hydrants are mainly used for fire protection. Other uses include flushing water mains and sewers, and filling tank trucks for street washing and tree spraying. Hydrants may also be used as a temporary water source for construction jobs.

Hydrants should be inspected and tested by water utility personnel accompanied by a fire department representative. Hydrants can usually be maintained by replacing all worn parts and seats through the top of the hydrant. The operator is generally responsible for ensuring that the proper tools are used. Each year, the hydrant should be tested to ensure that the joints and fittings are tight.

G. REDUCING NRW

Non-revenue water (NRW) is water that has been produced but does not result in revenues for the Utility. NRW may be due to “real losses” (as a result of leaks and wastage, sometimes called “physical losses”) or “apparent losses” (for example through theft or metering inaccuracies). High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself. NRW is typically measured as the volume of water "lost" as a share of net water produced.

1. Analyzing NRW Level

The percentage NRW can be determined by the formula:

$$NRW\ (\%) = \left\{\frac{Production\ (m^3) - Billed\ Consumption\ (m^3)}{Production\ (m^3)}\right\} \times 100$$

If NRW for a new system is more than 10%, or for an old system more than 25%, the Utility can benefit from an NRW reduction program.

To accurately determine NRW, reliable and functional meters must be installed at all sources and service connections.

2. Better to Prevent than to Cure

For water supply pipelines, always remember that "an ounce of prevention is worth a pound of cure". If, in the first place, the facilities were not constructed properly, there is probably very little that can be done to reduce NRW. Therefore for pipeline installation, all materials should pass quality control/testing and should undergo pressure tests prior to backfilling.

Many leaks emanate from service connections joints. When installing service connections do not skimp on Teflon tape on threaded joints and inspect for leakage before backfilling.

3. Benefits of NRW Reduction

- Financial gains from increased water sales or reduced water production, including possibly the delay of costly capacity expansion;
- Reduced operational cost which will result in a lower tariff;
- Increased firefighting capability due to increased pressure;
- More consumers can be served, or longer operational hours;
- Easier to sell increased tariffs; and
- Reduced risk of contamination.

Leakage reduction may also be an opportunity to improve relations with the public and employees. A leak detection program can be made highly visible so that water conservation can be at the forefront in people's awareness. The reduction of commercial losses, while politically and socially challenging, can also improve relations with the public, since some consumers may be reluctant to pay their water bills knowing that many others use services without being billed or being underbilled.

4. Sources of NRW

NRW can be analyzed on whether they are physical or actual losses or losses due to commercial policies or deficiencies.

a. Physical Losses

- Leaks/breaks
- Illegal connections
- Water usage by utility (flushing, etc.)

b. **Commercial Losses**

- Non-metered connections
- Under-registration of meters
- Poor collection performance

5. NRW Reduction Approaches

A number of approaches have been used successfully by some of the major water utility companies. These can be adopted by the SSWPs to control their NRW ratios.

1. Isolation of zones and the continuous measurement and analysis of inflows to determine areas with high NRW.
2. Programs to improve the reliability of customer metering and reading.
3. Hydraulic analysis of the distribution system to determine calculated versus actual pressures. (This requires updated system maps.)
4. Analysis of maintenance records to determine what repairs have been done, where, and their frequency. This may lead to decisions to replace rather than repair some pipelines. (For this reason, it is important to inculcate among field personnel the value of clear, reliable reports, and to have a good user-friendly repository of records.)
5. Leak detection programs. While there should be a continuing program of leak detection, periodic high-visibility campaigns involving the public have also been found to be effective.
6. Modulation of pressure in the pipelines. Higher pressures will naturally increase the rate of leakages.
7. Strengthening the procurement and stock management of critical and often-used repair and maintenance materials, so that these will always be available when needed. While many repairs can be done with readily available substitute materials, temporary stop-gap solutions cannot be relied upon to fix long term and recurring problems.
8. Continuous management attention: The reduction of NRW should be considered by management and the board as a continuing oversight concern.

6. NRW Survey

When NRW is analyzed to have increased, due likely to pipeline leaks, an NRW survey should be carried out to pinpoint the problem. The steps are as follows:

1. Divide the entire distribution system into zones;
2. Isolate the different zones by closing or installing appropriate control valves. Observe the water consumption rate in each zone and compare with billed consumption. Determine the zones with abnormally high NRW;
3. Divide the pinpointed zones, which consume a large quantity of water into sub-zones. The water inflow can be measured using zone and sub-zone meters;

4. Isolate these different sub-zones and study their respective NRW;
5. Select the sub-zones(s) with unusually high water consumption rates. Sub-divide further and measure their water consumption rate;
6. Repeat the above process until the locations of leak(s) are pinpointed.

7. Location of Leaks

Leaks in water mains cause the loss of good water, and at the same time increase the risk of contaminants in the ground entering the piping system. These leaks may be due to ruptures or disintegration of pipes and pipe joints, usually caused by corrosion, vibrations from vehicular traffic, stresses generated by expansion and contraction, or ground movements.

a. Locating Leaks by Direct Observation

This method is the simplest and most applicable leak detection technique for use in small water supply systems. This requires being alert to the following signs of leaks:

1. Appearance of wet spots at early dawn during dry season;
2. Greening of patches of ground in areas where plants generally could hardly grow;
3. A soft wet spot in the ground during dry season;
4. Abnormal drops in pressure.

The consumers can help detect leaks if they are made aware of these indicators. If they look at the Utility's water service in a positive light, and consider it to be to their benefit, there is no reason why they would not go out of their way to inform the operator if they notice any of these signs.

b. Finding the Exact Location of Leaks in Pipelines

After finding the approximate location of leaks in the water distribution system, their exact location can be determined by using a sounding rod. Leaks in water pipes usually make sound – small leaks make more noise than large ones. The sounding rod is a pointed metal rod used to relay to the observer the sound caused by leaks in buried pipes. The procedure involves the following:

1. Push the sounding rod into the ground until its end touches the buried pipe. Be careful not to push it too hard in order not to destroy a PVC water main when its point strikes the pipe;
2. Put your ear to the exposed end of the rod and listen for the sound. If the sound is too faint, a hearing aid such as a stethoscope would be helpful;
3. Push the rod into the ground against the same pipe at a different location. If the sound is louder, they you are getting closer to the leak. If the sound is fainter, it means you are moving away from the location of the leak.

8. Illegal Connections

Illegal connections can be detected by any of the following methods:

a. Block Census

The block census is described in Chapter 6, which deals with the management aspects of the Utility. Key in the information to be obtained in a block census is where those who are not connected to the system are getting their water. If their source cannot be determined, the dwelling unit is considered suspect.

b. Reward system

Offering rewards to those who can pinpoint illegal connections has been known to be effective. The reward can be a portion of the collectibles.

c. Monitoring Consumption

A high NRW within a sub-zone without any leaks indicates the presence of illegal connections. Any customer whose consumption drops to a small percentage of his average consumption without any adequate cause should be suspect.

The Board should come up with a policy on penalties for those caught with illegal connections, which would be the basis of management action.

d. Optimum Meter Replacement Cycle

Every utility must have a meter replacement program. Depending on the tariff and type of meters used, Table 6.1 illustrates the viability of replacing meters or calibrating same.

Table 6.1: Optimum Meter Replacement Cycle (years)

Meter Losses	Average Tariff Pesos/m³		
	8.00	10.00	12.00
3%	8	6	4.5
5%	4	3	2.5
10%	2	1.5	1

Table 6.1 was derived based on present value analysis at 12% cost of money and at an average consumption of 30 m^3 per month. The table shows that at ₱10 per m^3, if the meters are registering a 5% loss, a replacement cycle of 3 years would enable the Utility to pay for the cost of the replacement meters.

Chapter 7
Chlorine Safety

This Chapter introduces the reader to the hazards of using chlorine gas, which is essential for the treatment of raw water, and provides guidelines and practices that must be adopted to prevent chlorine related accidents and injuries.[17] The use of chlorine as a gas is not recommended for the smaller utilities because of the safety issues and the fairly complicated facilities required. Instead, the smaller utilities should use chlorine compounds. In this Chapter, the discussion is based on the use of chlorine as a gas. The considerations and precautions regarding its use in gaseous form apply even when the chemical is used as a compound whether in liquid or powdered form.

A. HAZARDS OF CHLORINE

Above all, keep in mind that chlorine gas was used in World War I as a poison gas weapon, and that it killed, maimed, or caused permanent injuries to many soldiers.

1. Human Safety and Health

In both its liquid and gaseous form, chlorine is classified as a poisonous or toxic substance. When it gets into contact with moist body surfaces such as the eyes, nose, throat, lungs, and wet skin it reacts with the moisture, forming harmful acids that can cause severe damage to these organs and even be fatal.

Repeated exposure to chlorine does not produce an immunity or tolerance. Long-term exposure even to low concentrations of chlorine may cause a gradual decrease in lung efficiency. A single exposure to a high concentration can cause permanent lung damage.

Table 7.1 presents the toxic effects of chlorine at different levels of concentration.

Table 7.1: Toxic Effects of Chlorine

Concentration	Effects
1 – 3 mg/l	May cause mild irritation of the eyes, nose, and throat
3 – 5 mg/l	Burning in eyes, nose, and throat; may cause headache, watering eyes, sneezing, coughing, breathing difficulty, bloody nose, and blood-tinged sputum
5 – 15 mg/l	Severe irritation of the eyes, nose, and respiratory tract
30 – 60 mg/l	Immediate breathing difficulty resulting in pulmonary edema (fluid buildup in lungs), possibly causing suffocation and death
430 mg/l	Lethal after 30 minutes

Workers Compensation Board of British Columbia – Chlorine Safe Work Practices, 2006

[17] Adapted from “Chorine Safe Work Practices” published by the Workers Compensation Board of British Columbia (Canada).

Table 7.2 presents the human exposure limits to chlorine.

Table 7.2: Chlorine Exposure Limits	
Exposure level	**Exposure Limit**
0.5 mg/l	Maximum allowable concentration averaged over an Eight-hour period
1.0 mg/l	Maximum allowable short-term exposure (15 minutes)
10 mg/l	IDLH "Immediately Dangerous to Life and Health" (as published by the United States National Institute for Occupational Safety and Health)

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Note: The IDHL ("*Immediately Dangerous to Life and Health*") exposure level is the point at which a person without appropriate respiratory and skin protection could be fatally injured or could suffer irreversible or incapacitating health effects.

2. Fire and Chemical Reactions

1. Chlorine will not burn by itself, but will support combustion when it comes into contact with many combustible materials, including acetylene, kerosene, most hydrocarbons like solvents, greases and oils, finely divided metals and organic matter, and materials containing potassium and phosphorous. It can explode when it reacts with high concentrations of ammonia or hydrogen peroxide ("agua oxigenada").

Never store acetylene, solvents, and the other materials enumerated above in the same building or area as chlorine.

2. In both gas and liquid forms, chlorine reacts with almost all chemicals, usually releasing heat. At high temperatures, chlorine reacts vigorously with most metals. For instance, a chlorine reaction can cause stainless steel to catch fire or melt.

3. Reaction to Water

Chlorine reacts with water or moisture in the air to form highly corrosive acids. Every precaution must be taken to keep chlorine and chlorine equipment moisture-free.

Never use water on a chlorine leak. Moist chlorine is more corrosive than dry chlorine and the leak will worsen rapidly if water is applied to it.

B. WORKING SAFELY AROUND CHLORINE GAS

1. General

Any water utility that uses chlorine should have written procedures for its chlorine system operation. Even the use of powdered chlorine should have written procedures.

Before starting any chlorination process, take the following precautions:

1. If a faucet with good flowing water is not available close by, make ready a 5-gallon container of fresh water, but make sure it is away from the chlorine cylinder or storage area. This is to ensure that if the chlorine accidentally comes in contact with your eyes or skin, you can flush the affected areas with copious amounts of fresh water for at least 10-15 minutes.
2. Flush the chlorine out. Do not just soak the affected surface. If you get some of the chlorine solution in your eyes, flush it out and immediately see your doctor.
3. Wear the prescribed safety clothing and equipment, specifically:
   - Goggles to protect your eyes from contact with the chlorine in any form.
   - Rubber gloves and rubber boots certified for use around the chemical to protect your hands and feet.
   - Waterproof suit, coveralls or a full-length apron.

2. Housekeeping/Chlorine Storage

1. Use signs to clearly identify all areas where chlorine is used or stored. Only qualified personnel should be permitted to enter these areas.
2. Do not store materials that may react violently with chlorine in the same room as chlorine. Put up visible warning signs prohibiting persons from taking these materials where the chlorine is stored.
3. Do not store chlorine near busy roadways or where vehicles operate. Chlorine reacts with carbon monoxide to produce phosgene, an extremely poisonous gas.
4. Store chlorine cylinders and containers in a cool, dry, and relatively isolated area, protected from weather and extreme temperatures.
   - When storing cylinders and containers outside, shield them from direct sunlight.
   - When storing chlorine containers inside, store the containers in a well-ventilated building, away from any heat sources.
5. Use cylinders and containers on a “FIRST-IN, FIRST-OUT” basis.
6. Clearly tag or mark empty cylinders and separate them from full cylinders.

7. Determine the most appropriate location for emergency equipment. Emergency equipment and a faucet should be available in a readily accessible location, but not inside the chlorine room because a worker (and emergency response staff) trying to use the emergency equipment or faucet during a chlorine leak risks further exposure.
8. Store cylinders upright and secure them against tipping over and rough handling. Cylinders will discharge vapor when upright and discharge liquid when upside-down. Since chlorine gas tends to sink, provision should be made for low-placed ventilation near the floor that allows it to dissipate outward, as well as high-placed ventilation that allows the chlorine mist (the gas mixed with air) which tends to go upward, also to dissipate.

3. Handling Chlorine Cylinders

1. Handle containers with care while moving or storing them. Do not drop or allow containers to strike objects.
2. Use new gaskets as recommended by the chlorine supplier each time a cylinder or container is connected.
3. Follow the chlorine supplier's recommended disposal procedures for leaking containers. Do not modify, alter, or repair containers and valves. Only the supplier should carry out these tasks.
4. Ensure that cylinders have valve protection hoods in place when not connected to a system.
5. Do not lift a cylinder by its valve protection hood. The hood is not designed to carry the weight of a cylinder.
6. If possible, open valves by applying a steady force to a 200 mm (8 in) wrench, without applying an impact force and without using an extension on the wrench. If this does not work, apply a light impact force by smacking the wrench with the heel of your hand.
7. Do not use a wrench longer than 200 mm (8 in) to open or close valves. To prevent valve damage that could cause leaks do not use tools such as pipe wrenches or hammers. Valves on cylinders are designed to deliver full volume after one complete counterclockwise turn. Valves may be damaged if turned beyond this point. Immediately return containers with damaged or inoperable (but not leaking) valves to the supplier.
8. If the valve is very difficult to open, loosen the packing nut slightly. Tighten the packing nut after the valve is opened or closed.

C. LEAK DETECTION AND CONTROL

It is important to follow the right procedures in replacing an empty cylinder with a new one. Nonetheless, after the new cylinder has been installed, it is essential to ensure that there is no leak in the new hook up.

1. Detecting Leaks

Chlorine leaks can be determined by soaking a rag on the end of a stick in aqua ammonia (ammonium hydroxide, not pure ammonia) and holding it next to the pipes, cylinder or dosing equipment. (A plastic squeeze bottle containing the aqua ammonia can also be used.) A white cloud will show the location of the leak.

This test is safe because ammonium hydroxide (ammonia dissolved in water or moist air) is used rather than pure ammonia. Chlorine reacts readily with ammonium hydroxide to form ammonium chloride, a relatively harmless compound. This reaction forms a visible white cloud, indicating a chlorine leak. The ammonia test is useful for pinpointing the exact location of a leak.

2. What to Do If a Leak Is Indicated After Installing a New Cylinder

1. Wear a respirator and immediately close the main cylinder valve;
2. As long as the monitor reads less than 10 mg/l, the cylinder hookup procedure may be repeated;
3. Open (and close) the main cylinder valve and repeat the ammonia test;
4. If a leak is still indicated, make a third and final attempt to get a good seal using a new lead washer;
5. If the leak cannot be corrected after three attempts, remove the cylinder from service and contact the supplier. Ensure that there is no leak from this cylinder with the main valve closed. A different cylinder must be connected to the chlorination system;
6. Leave the chlorine room and remain nearby to restrict access to the room or provide other assistance, as directed.

D. REPAIR AND MAINTENANCE

Employers, in this case the water utility, are responsible for training and providing written operational, preventive maintenance and emergency procedures to any person who works on a chlorine system. Employers, in consultation with equipment manufacturers or suppliers, must ensure that all equipment are inspected regularly and replaced when necessary.

The utility's management must make these written procedures readily available to all workers required to work on the chlorine system. Workers should not only understand but be thoroughly familiar with these procedures before carrying out repairs or maintenance on the chlorine system.

Only qualified workers must supervise the cleaning and repair of chlorine systems. All assigned workers must be familiar with all the hazards and adhere to the safeguards necessary to perform the work safely.

1. Cylinder Repair Kit

Ideally, a chlorine container repair kit should be available on-site. If a container repair kit is not available, the utility's response team must be aware of the nearest readily available kit. There are three types of repair kits (A, B, and C), each with materials specific to the type and size of the chlorine container. The "A" kit is for the 68 kg (150 lb) cylinder commonly used by the smaller utilities.

The following may be used as a lubricating pipe dope for threaded joints:

- Linseed oil with graphite or white lead
- Freshly mixed glycerin
- Teflon tape

2. Hazard Recognition

Written procedures for the repair or maintenance of chlorine systems must consider the following hazards and include procedures that will help workers avoid these hazards.

1. **Moisture** – Chlorine reacts with moisture to form corrosive acids. Every precaution must be taken to keep chlorine and chlorine equipment free of moisture, including the following steps:
    - Close pipes, lines, valves, and containers tightly when not in use to keep moisture out of the system;
    - Before starting repair, take the measures needed to prevent chlorine coming into contact with any residual material that may drip from the equipment when pipes or lines are being dismantled.
2. **Foreign Material** – Pipes, lines, and fittings must have all cutting oils, grease, and other foreign material removed from them before use. Trichloroethylene or other recommended chlorinated solvents may be used; however take special precautions because these solvents can produce serious health effects. Never use hydrocarbon or alcohol solvents for cleaning because they can react violently with chlorine
3. **Heat** – Because iron and steel will ignite in chlorine at about 230°C (450–500°F), all welding or burning must only be done after the chlorine equipment are completely emptied and purged with dry air.

3. Personal Protective Equipment

Controlling exposure requires strict attention to the chlorine exposure limits (see Table 7.2). Appropriate eye, skin, and respiratory protection are essential. Workers must be familiar with their use and understand the equipment limitations or capacities.

a. Basic Protection

When chlorine gas is in the air, safety glasses and face shields will not protect the eyes and respiratory passages. Workers in an area where the concentration of chlorine may cause mild to moderate irritation must wear eye protection with a tight seal around the eyes as well as a respirator that prevents inhaling the gas. If a full face respirator is not available, a half-face respirator and vapor-tight chemical goggles should be worn.

b. Skin Protection

Emergency response workers who are engaged in controlling a serious chlorine leak must have access to full-body protective suits.

c. Full-face Respirators

Full-face respirators, either with cartridges or canisters, may be used only if the chlorine concentration is determined to be below 10mg/l.

- **With Cartridges** – A worker must wear a full-face respirator fitted with acid gas cartridges during any hazardous work where there is a chance of a chlorine leak. Full-face respirators are also appropriate for leak control where tests show the chlorine concentration to be less than 10 mg/l. Workers required to use a respirator must be clean-shaven where the respirator seals with the face to ensure a proper fit.
- **With Canisters** – Although cartridges are preferable, a worker may use a full-face respirator fitted with an air-purifying canister for leak control and repair or maintenance procedures in chlorine concentrations less than 10 mg/l.

  Canisters with an indicator window must be replaced when the material in the window has changed color. Canisters without an indicator window must be replaced after each use. In either case, canisters must never be used beyond the expiration date stamped on the label.

d. Self-contained Breathing Apparatus (SCBA)

A worker must use an SCBA when a chlorine leak is suspected and the airborne chlorine concentration is unknown or is measured at more than 10 mg/l. This means that an IDLH situation prevails in the area. A worker wearing an SCBA must not enter a contaminated atmosphere until a second, qualified person is present, also equipped with an SCBA, and ready to perform a rescue.

SCBA air cylinders should be refilled every six months or after each use, whichever comes first. Cylinders must have a hydrostatic test at least every five years. Since workers rely on this equipment in IDLH conditions, it is essential that maintenance and inspections be carried out according to the manufacturer's instructions.

e. Person-check Radio or Telephone

Employers must establish a check system to ensure the continued well-being of workers who are working alone or at an isolated worksite. Where visual checks are not possible, the check system may require a radio or telephone. Workers who will need to use such a system must be trained in emergency procedures.

f. Emergency equipment

Emergency equipment includes eyewash and shower facilities, first aid kits, and container repair kits. Workers must have immediate access to each of these items and must know how to use them in case of emergency.

SCBA. Workers Compensation Board of British Columbia – Chlorine Safe Work Practices, 2006

E. FIRST AID

When someone is injured in a chlorine-related incident, first aid can help reduce the impact of their injuries and prevent further injuries from occurring. The following steps apply to any situation in which someone is injured:

1. ***Do not panic.***
2. ***Ensure that there is no more danger to yourself or the victim.***
3. ***Using appropriate safety gear, remove the victim from the contaminated area.***
4. ***Send for medical help.***

1. Chlorine Inhalation

A person who has inhaled chlorine may be unconscious, and may have difficulty breathing or may have stopped breathing completely. Follow these steps when treating a victim of chlorine inhalation:

1. Assess the victim's breathing. If breathing has stopped, begin artificial respiration and continue until the victim resumes breathing. Pocket masks are recommended for artificial respiration, although the mouth-to-mouth method may also be used;
2. If the victim is having difficulty breathing (for example, gasping or coughing), place the victim in the most comfortable position, usually semi-sitting;

3. If an oxygen therapy unit and trained personnel are available, administer oxygen at a 10-litre flow;
4. Ensure that the victim is transported to hospital in case the victim suffers a delayed reaction in the form of pulmonary edema. Any physical exertion, excitement, or apprehension increases the chance and severity of a delayed reaction. Keep the victim warm and completely at rest. Reassure the victim while waiting for assistance and transportation to hospital.

2. Skin Contact

Skin contact with chlorine can result in severe burns. Before attempting to flush a victim's contaminated skin, make sure the victim is breathing properly. Follow these steps:

1. Assess the victim's breathing. If breathing has stopped, begin artificial respiration and continue until the victim resumes breathing. Pocket masks are recommended for artificial respiration, although the mouth-to-mouth method may also be used. If the victim is having difficulty breathing (for example, gasping or coughing), place the victim in the most comfortable position, usually semi-sitting;
2. As soon as the victim resumes breathing, flush the victim's contaminated skin and clothing with large amounts of water for 30 minutes. Remove all contaminated clothing while flushing. Continue flushing until all traces of chlorine have been removed;
3. Dress obvious burns with sterile gauze and bandage them loosely. Apply insulated cold packs to help reduce pain;
4. Get the victim to hospital.

Take Note:

1. Do not attempt to neutralize the chlorine with other chemicals.
2. Do not apply salves, ointments, or medications unless prescribed by a doctor.
3. Skin contact with liquid chlorine coming straight out of a cylinder can result in frostbite.

3. Eye Contact

Eye contact with chlorine (liquid or gas) for even a short period can cause permanent disability. Flushing must begin within 10 seconds. Follow these steps:

1. Flush the eyes immediately with large amounts of running water (preferably lukewarm) for 30 minutes. Hold the eyelids forcibly apart to ensure full flushing of the chlorine from the eyes and eyelids;

2. After flushing has removed all traces of chlorine, cover both eyes with moistened sterile gauze pads and bandage, enough to keep light out;
3. Apply insulated cold packs to help reduce pain;
4. Get the victim to hospital.

4. Unconscious Patients

1. As soon as an unconscious victim of chlorine inhalation resumes breathing, place the person in the drainage position (lying on one side, so fluids can drain from the mouth and airways). Never give an unconscious patient anything by mouth;
2. Keeping the victim in the same position, flush the victim's contaminated skin and clothing with large amounts of water for 30 minutes;
3. Remove all contaminated clothing while flushing. Continue flushing until all traces of chlorine have been removed;
4. Dress obvious burns with sterile gauze and bandage them loosely. Apply insulated cold packs to help reduce pain;
5. Get the victim to hospital.

Chapter 8
Administration

This Chapter presents certain rules and practices that should be adopted by a SSWP to achieve efficiency and effectiveness as it carries out its administrative, management and operating functions.

A. GENERAL

Regardless of the service level of any utility, the most important factor for its success is the quality of the people who manage and operate it. They need, however, to work within a clear, supportive administrative system that channels their capabilities and enables them to fulfill their unique functions within the organization.

All SSWP organizations are made up of a Board of Directors, a system manager, and the operating staff. The Board establishes policies and regulations to carry out the business affairs of the Utility, while the management and operating staff, headed by the manager, handle the day-to-day operations.

B. DELINEATION OF BOARD AND MANAGEMENT FUNCTIONS

The Board of Directors is the policy setting and legislative body of the SSWP. The operational staff, headed by the Manager (whose title may be General Manager, President, Systems Head, Superintendent, etc.), constitutes the Utility's executive arm.

1. Board Functions

While all powers and authority of the SSWP are vested in its Board, its specific and proper functions are the following:

1. To enact policies and rules for the SSWP;
2. To set the overall goals and objectives of the organization;
3. To approve budgets, plans, major contracts, and undertakings; and
4. To evaluate the performance of the SSWP and its management.

The Board should limit itself to fulfilling these functions, using Board meetings as their venue. These Board meetings are recommended not to exceed two in a month. Holding meetings too frequently would force management to spend an excessive amount of time on preparing for and attending them, thereby undermining management performance.

2. Management Functions

The Manager, on the other hand is responsible for the following functions:

1. Implementing the policies and rules set by the Board;
2. Fulfilling the goals and objectives of the SSWP;
3. Preparing effective plans and recommendations for Board approval;
4. Making accurate and timely reports to keep the Board updated on the SSWP's performance in relation to fulfilling its goals and objectives.

Most of these functions he fulfills not directly but through the management team and the operating staff. As such, leadership, decision-making, communication, staff development, and problem solving are the focus of his day-to-day activities. Being in charge of the day-to-day operations of the SSWP, it is the manager's responsibility to ensure the success and sustainability of the public utility.

While the Board may not interfere in the way the manager runs day-to-day operations, the manager must answer to the Board for results.

C. POLICY FORMULATION

1. What Are Policies?

A policy is a committed guideline. It is a principle that guides the performance of certain activities leading to the attainment the Utility's goals. It may be a broad statement of general guidelines, or a specific set of procedures detailing how certain tasks (e.g., handling of the Utility's funds) must be done.

Whether they are broad or specific statements, policies are best communicated and implemented in written directives or resolutions. Written rules provide a ready reference for the management and staff, and make it possible to ascertain whether they are being followed or not, and to hold the persons concerned accountable.

Verbal policies are not effective, as they have a way of being misinterpreted. As time passes, even the initiators themselves sometimes get lost as to their original intent or interpretation.

In general, policies may be classified into three types as to their origin:

1. **Originated policy** – This type of policy comes from the Board. It is designed to provide guidelines to management in the operation of the system.
2. **Appealed policy** – This type of policy arises when problems of operation at the lower level cannot be properly or consistently handled. Management therefore "appeals" to the Board for guidelines.

3. **Imposed policy** – This type of policy is set to comply with existing laws, government regulations, court rulings and the like. Social practices and public influence may result in imposed policies.

Some of the important areas that should be covered by written SSWP policies are outlined in the box with the caption “IMPORTANT SSWP POLICY AREAS” on the following page.

2. Policy Review

In any progressive undertaking, policies need to evolve in response to changing conditions and needs. Thus, aside from periodic reviews to evaluate how effectively established policies contribute to the achievement of goals, there may be changes in national policies, laws and ordinances, as well as in economic conditions, that may dictate the adjustment, amendment, or formulation of new policies.

In reviewing a policy, the first step is to consider the spirit, intent, wisdom and fairness of a policy, and then its relevance. The way the policy is being implemented should also be reviewed. The intention of even the best-conceived policy may be negated due to the manner in which it is implemented. The Board should not hesitate to review, restate, amend, or even reverse existing policies if it believes that by doing so, the best interest of both the Utility and the public will be served.

D. FIRST THINGS FIRST

Upon the incorporation of the Utility, the Board (or governing body) should have their organization meeting to decide on key policy matters and actions to get the business on track.

They have to immediately address at least 7 policy and action areas:

1. Getting an Adviser
2. Organizational Structure
3. Operating Budget
4. Tariff level
5. Staff Recruitment
6. Applications for House Connection
7. Utility Rules & Regulations

In a major review of policies, these same policy and action areas should be considered as well. Note that some of the items outlined above apply particularly to Level III Systems. For Level II Systems, the non-applicable items can be disregarded.

IMPORTANT SSWP POLICY AREAS

1. **By-Laws:** Establish internal guidelines for the Board itself; e.g., how often and where to meet, establishment of a quorum, board elections, etc.
2. **Utility Rules and Regulations:** Establish policies and procedures for dealing with the public.
3. **Personnel Rules/Regulations:** These policies seek to ensure proper code of conduct among the staff.
4. **Staffing Patterns/Remunerations:** Establish guidelines on the number and qualifications and remuneration of staff to be hired.
5. **Hiring:** These policies set guidelines and checks on the hiring of new staff. As a rule, all requirements for additional staff must be cleared with the Board, usually through the proposed plantilla which, once approved, can then be already implemented without further clearance. However, specific Board approval must be obtained before the actual appointment of higher level staff.
6. **Tariff Formulation:** Establish guidelines on tariff formulation. Tariff strategy must enable the Utility to operate sustainably and effectively in relation to its purpose of supplying water. It must consider the requirements to obtain approval from NWRB, and often, the measures needed to gain acceptance by the public.
7. **Budgets:** Establish guidelines on budget formulation, timetable and content.
8. **Delegation of Authority:** Establish guidelines on what decisions are to be delegated and to whom.
9. Example: Delegated Transactional Amount: "Any capital disbursements which are not in the capital budget or which are greater than ₱ XXXXX need specific Board approval. Those in the budget and do not exceed the stated ceiling can be decided by management."
10. **Matters Requiring Board Action:** Establish guidelines on what need to be submitted for Board clearance before management can act on it.
11. Example: Matters needing Board Approval/Clearance: Any undertaking which will bind the SSWP for over a 3-month period must be cleared with the Board. This means major construction contracts, loans and MOAs with government or NGOs which will bind the SSWP for an undertaking greater than 3 months will need Board clearance.
12. **Public Faucets:** Policies should define the accountability for collections and establish the manner by which the utility shall collect fees and exact responsibility from the persons concerned.
13. Example: Caretaker for Public Faucets: Each public faucet shall be registered to a caretaker who will be billed on a weekly (or daily) basis. If the caretaker is not a staff of the SSWP, a contract shall be drawn specifying the

obligations of both parties.

14. **New Connections and Disconnections:** Establish guidelines on the requirements for new connections, how much to be charged; as well as when to disconnect.
15. <u>Example:</u> Connection policy: All connection costs are to be borne by the customer. This is translated in the connection rules/regulations and amount of connection fees.
16. **Delinquent Accounts:** Set guidelines for handling delinquent accounts, including when a delinquent account is to written off as bad debts. It is futile to maintain long standing debts as active as they will only distort the financial figures. However records should still be kept and diligent attempts made to collect these accounts as if they were not written off.
17. **Dealing with Illegal Connections:** The penalty should include penal and financial impositions based on provisions of prevailing laws.
18. **Goal Setting:** Normally, these establish annual and intermediate goals (e.g., semi-annual, quarterly) for the SSWP. Goals can be set based on the number of people to be served or number of connections and on the target performance parameters outlined in Section G of this chapter.
19. **Performance Standards:** The Board should define performance standards for the SSWP that management should attain, and monitor results against these standards at least on a quarterly basis.
20. **Funding Sources:** Board policies should be established on where to get funds for meter replacement or expansion projects or emergency repairs if the SSWP does not have those funds.
21. **Use of Booster Pumps by Customers:** The use of booster pumps by individual customers on their connections worsens the pressure conditions in part or through the entire system. It could likewise cause negative pressures in the lines that would induce infiltration of non-potable water as well as other problems for the system.

    The Board should institute a policy banning the use of booster pumps without a specific permit from the SSWP. Boosters strictly may only be permitted when the customer constructs a cistern to collect the normal flow of water from the SSWP system. The inlet tube of the booster then sucks water only from the cistern. The policy should emphasize that:

    a. the official permit document must be obtained from the Board,
    b. the SSWP may conduct unscheduled inspections of the booster setup, and
    c. a heavy fine and/or disconnection will be imposed for the unauthorized installation or modified operation of a booster.

1. Getting an Adviser

Very often, community-based boards of SSWPs lack formal business experience and are not familiar with the multifarious requirements of running a small water utility. For this reason, it is usually essential to engage expert advice to guide the Board and management during the organizational stages of the Utility. Advisers can be drawn from the LGU or national agencies like the DILG, LWUA, CDA and DPWH or from NGOs. Very useful operational manuals can also be obtained from the DILG.

2. Organizational Structure

The starting structure need not be complicated. For an SSWP with about 10 public faucets or 200 connections, the only personnel initially required are the manager, one system operator and one bookkeeper. These 3 key people, once appointed by the Board, should be given the responsibility of conducting the operations. The manager, in consultation with his initial staff, should select and appoint any additional operational staff when they become necessary. Board approval, however, must be obtained for the number and qualifications of staff to be hired.

It is important to note that at the level of a 3-staff utility, the manager should carry out a weekly sampling audit of the customer ledger cards and check the daily cash position report, as the minimum level of check and balance.

3. Operating Budget/Tariff levels

Tariff design should have a sound basis and its effects on the viability of the utility business should be carefully considered. It should never be set in an arbitrary manner. A wrong tariff design at the outset will be very difficult to remedy, especially if the initial tariffs were set at an arbitrary low level. It is for this reason that community meetings and consultations are very important at the proposal stage of the utility.

Refer to Chapter 8 for a comprehensive discussion on tariff design.

4. Staff Recruitment

There are two basic questions that need to be asked in selecting operational staff:

1. Does the person know what and how to do the tasks required in the job?
2. Is he/she willing to do the job under the current situation and remuneration?

a. Job Description

A Job Description for each of the jobs being filled is an essential tool for the recruiter and the Utility itself. A job description details the education/training and experience required, and describes the tasks involved in the job. Annex C through Annex E show examples of the job descriptions of the three operational staff needed to start up the system. As the system grows, more staff can be recruited and the job descriptions streamlined or specialized.

b. Job Interview

Once the basic information submitted in an application form indicates that the person may be considered for the job, an interview should be conducted with the following objectives:

1. Validate the person's ability and experience to do the job;
2. Determine willingness to do the job;
3. Determine attitude to work in the group and attain utility objectives.

c. Other Considerations

In many cases, no applicants with the necessary experience and education are available. An assessment of the general aptitude of the applicant, which indicates how easily they can learn on the job, as well as attitude and willingness to learn, may have to be the deciding factors. In such a case, emphasis should be on the multi-tasking requirements of the job. In an SSWP, the operator will have to double as the plumber and meter reader while the bookkeeper will need to do the billing and collection too. Job exposure and training will have to make up for deficiencies.

d. Probation Period

Any appointment should initially be provisional or probationary. This provides an observation and evaluation period during which the applicant's fitness for the job can be more fully appreciated. All staff should be made to undergo a probationary period, usually 6 months to one year, to be set at the discretion of the Board.

5. Applications for Connection

For Level III systems, providing a service connection and service implies a contract between two parties. Hence a prospective consumer must first sign an APPLICATION/SERVICE CONTRACT with the SSWP before the SSWP provides the house connection. This is to ensure that both the SSWP and the consumer are protected and have recourse to legal action in case of a breach of contract.

Refer to Chapter 9 for a detailed explanation and a sample Application/Service Contract form.

6. Utility Rules and Regulations

Even a Level II system needs to have basic operational rules such as how much to charge; how to determine volume usage; how to manage the service; and how to collect fees from consumers. Level III SSWPs must have Utility Rules and Regulations, or a Customers' handbook, which should have the following basic contents:

1. Requirements in Applying for Service Connection;
2. Responsibilities of the Consumer;
3. Tariff levels;

4. Payment of Bills;
5. Fees for Other Services (reconnection, meter testing, etc);
6. Rule Infractions and Penalties.

After the rules have been decided, it would be best to have them in printed in a manual for easy dissemination to customers. This can help prevent future misunderstanding or conflicts. Some of the contents, such as tariff levels and penalties, will need Board resolutions or policies before management can implement them. All customers must be issued a copy of this Rules and Regulations manual.

E. STAFF TRAINING

Government agencies like the LWUA, CDA, DILG, NWRB and even some water districts and NGOs provide training and institutional development programs to assist water utilities. Even Level II utilities should seek to avail of these programs.

Among the most useful general areas of training are policy formulation, problem solving, preparation of resolutions, how to conduct meetings, business planning, and tariff setting.

On more specialized topics, the bookkeeper is trained on records keeping and the preparation of financial reports, and the System Operator on repairs and maintenance of the water system.

One of the important functions of the recommended Adviser is to provide hands-on training/on-the-job coaching for the different tasks required in O&M.

Observation visits to other nearby utilities are extremely helpful. These will give insights on the what, why and how to of the various tasks.

Annex F provides an outline of Staff Development/Training subjects to guide the SSWP in prioritizing and selecting the types of trainings that could be given to the different levels of personnel.

F. OPERATIONAL FOCUS

1. Delivering Water Service 24/7

To ensure reliable service, the thrust in the maintenance of facilities should be, as much as possible, preventive. However, the SSWP should plan ahead and have ready responses for emergencies. The aim is to enable it, ideally, to provide continuous service even during emergencies. Where this is not possible, such preparation should seek to limit the duration of interrupted service.

2. Importance of Collection Efficiency

Cash inflows are essential to enable the water utility to operate in a reliable and predictable manner. Thus, tariff levels are generally set to cover normal operation and maintenance costs, as well as to provide surplus funds to cover emergency requirements. However, regardless of how well designed the tariff structure may be, if bills are not collected, or are not collected on time, the Utility will experience cash shortages that could compromise service levels. Unfortunately, the resulting poor service often leads customers to delay or even stop payments, which leads to further deterioration of services. This cycle, if not arrested on time, will eventually lead to the system becoming non-operational or even being abandoned.

3. Preserving the Health of the Community

The sole product of the Utility is water and it is imperative for this product to meet the specified standards of the PNDSW. As a minimum, the Utility should have a sample tested in an accredited DOH laboratory for bacteriological presence at least once a month. Should a sample test positive for coli forms, a re-sampling should be done immediately, while the Utility, without waiting for the results, should simultaneously search for the possible source of contamination. A second positive test should cause the SSWP to consider suspension of operations (or advise all customers to boil their drinking water) until the problem is solved.

It is, therefore, essential to follow the procedures for chlorine water treatment to eradicate harmful organisms. Chlorine residuals should be taken at different distribution points with the use of a chlorine comparator on a daily basis. Refer to Chapter 3 for more details.

4. Reducing Non-Revenue Water (NRW)

Non-revenue water (NRW) represents water that is produced but does not bring revenues for the SSWP. It is the sum of the water lost to physical leaks, illegal connections, unauthorized withdrawals, unmetered connections and metering errors. The NRW should be kept as low as is practical, technically and economically, in order to reduce operation cost, keep tariff levels low, and conserve water.

How low should NRW be? For a new system, the NRW should be kept to less than 10%. For older systems with NRW greater than 25%, the SSWP should bring the NRW down to 20% or below. However, the cost of the efforts to reduce NRW should be guided by the principle of “not spending ₱2 in order to earn ₱1”.

For further details, refer to Chapter 6.

G. PERFORMANCE PARAMETERS (KEY PERFORMANCE INDICATORS)

Any SSWP should have at least a quarterly report of certain key performance indicators (KPIs) to enable the management/Board to determine the system's performance efficiency and to track the progress of the utility. Table 8.1 lists the minimum KPIs.

Table 8.1: Minimum Key Performance Indicators

Key Result Areas	KPIs	Formula
Service Levels	1. Water Coverage	People served by the system
	2. Water availability	Duration of water supply in hours per day
	3. Water Quality	Percentage of samples passing bacteriological testing
Operational Efficiency	4. NRW	$\frac{Water\ Produced - Billed\ Volume}{Water\ Produced}$
	5. Cost of Water Produced (per m^3 of water)	$\frac{Total\ Expenses\ (₱)}{Total\ Water\ Produced\ (m^3)}$
Financial Performance	6. Operating Ratio	$\frac{Operating\ Expense}{Operating\ Revenue}$
	7. Collection Efficiency	$\frac{Total\ Year\ to\ date\ Collection}{Total\ Year\ to\ date\ Billings}$
Customer Service	8. Percentage of Customer Complaints/ Requests (C&R) Resolved	$\frac{Customer\ C\&R\ Resolved}{Total\ C\&R\ Received}$

These KPIs should be part of the information the Board should get from its management at least every quarter. These KPIs are also required in the annual report that the Utility must submit to the NWRB to comply with regulatory reporting requirements.

H. MANAGEMENT INFORMATION SYSTEM

The Utility's management needs regular reports to give it basis for evaluating performance, formulating policies, planning, making decisions, and informing member-users of the financial status of the SSWP.

A Management Information System (MIS) is an integrated information system, which prescribes the reports that should be provided, and when and to whom they should go. When installed, an MIS simplifies the process of generating needed reports and establishes a regular flow of information that enables management to provide timely and informed responses to the requirements of the business. It is recommended that an adviser be tapped to assist the SSWP in the formulation of an MIS to address its needs.

The development of an MIS requires the following:

1. Determining what information is needed at the Board and management levels, and the format and frequency of the reports;
2. Determining how the data/information should be obtained;
3. Determining the person (or organizational unit) responsible for the obtaining the data and preparing the report; and
4. Determining where the records will be kept and those responsible for updating the files.

In large systems, the MIS is typically computer based. The collection, processing, data storage, generation of reports and even their dissemination is programmed and generally done electronically. Thus, the MIS can be set up to provide the most up-to-date information on SSWP's performance.

Refer to Annex G for a suggested monthly Form for the O&M information required by the SSWP Board and management. This form is intended to help the SSWP determine the priority data to be gathered. It will facilitate reporting to various stakeholders, make the monitoring of operations easier, and generate a recorded history of the SSWP.

I. AUDITS

All organizations, including utilities, conduct routine audits (and, as needed, special audits) to identify opportunities for improvement. Audits can be performed on an in-house basis (by the Audit or Finance Committee), or by outside experts. Audits can address various aspects of a utility's operations. The results can serve as a guide for improvement strategies.

The scope and purpose of audits may vary. The common ones for a water utility are:

1. **Technical audit** — a review of a utility's technical operations (treatment plants, water sources, pumping, storage, distribution, fire protection);
2. **Financial audit** — a review of a utility's financial condition;
3. **Management audit** — a review of utility management's practices (labor practices, customer service, billing, metering, regulatory compliance);
4. **Operations audit** — a comprehensive audit involving all operational aspects.

J. BUSINESS PLANNING

A 3- to 5-year Business Plan is essential if the SSWP plans to expand its services. The Business Plan serves to provide direction, and makes it possible to track the progress of the undertaking. It is a requirement for a loan or application for funding, if the expansion program requires outside funding. The Business Plan must be presented and approved in the general assembly for approval. Approval of the business plan will necessarily include approval of the tariff required within the planning period.

1. Purposes of Business Plans

Business Plans are prepared for different purposes. Typical uses and their specific requirements are as follows:

1. **Borrowing:** A summary page will have to be included detailing the specific request as well as the collaterals that can be offered. These can be in the form of real assets, locked-in deposits and the likes. A feasibility study will likewise be required by the lender to determine project viability. For non-project specific loans, such as a program loan, lenders will have to scrutinize the Utility's financial statements.
2. **Budget Approval:** After the Board has approved the 5-year plan, management must provide a detailed cash flow for the year in review. Attached to this will be the details or schedules for each budget account. If there are changes in the organizational structure or manning requirements, the new organizational chart and related information must be provided for Board approval.
3. **Tariff Adjustment Approval:** For the required tariff approval from NWRB, some specific documents may be necessary to indicate compliance with legal requirements. Among these are the Proof of Posting and minutes of the Public Hearings conducted for the purpose of any tariff adjustment.

2. Contents of Business Plans

Basically, the business plan for a water utility will address the following major issues:

1. How many more stand posts or private connections will the utility add over the planning period;
2. Where will it get its water supply;
3. What are the additional facilities required;
4. How much investments will be needed to support the expansion process;
5. How the undertaking will be funded;
6. What would be the projected operational cost; and
7. What would be the water tariff that would enable the utility to operate and at the same time recover the investments and/or pay off any borrowings?

While this manual will not tackle the detailed mechanics of preparing such a plan, there are a number of support agencies that can assist the SSWP in preparing it. The NWRB has a list of experts who can provide business planning assistance. The Return on

Investment (ROI) methodology for tariff design discussed in Chapter 8 already incorporates the elements of a business plan.

Annex H Lists the basic contents of a Business Plan.

K. DOCUMENTS

There are number of records pertaining to different aspects of the Utility's business that have to be kept and made secure.

1. Technical Aspects

Prior to system operation, the management should have the following documents properly filed:

1. Inventory of assets by type and cost;
2. As-built plans or drawings detailing the system including well design, well logs and well test data;
3. Log book of defects and repairs made; and
4. Performance Graphs of pumps and pump manuals

Management should determine who should secure, validate and update these documents. These documents are critical for assessing system efficiency, for tariff adjustments, and for securing loans.

2. Commercial/Financial Aspects

Any business will need to keep track of who their customers are and whether the business is earning or losing. While it may not be the main purpose of some SSWPs to earn profits, profits are necessary to be able to expand or rehabilitate the system at some future time and for securing external loans.

The basic financial records that should be kept and secured are the customer ledger cards, bankbooks, billing and collection data, and the financial statements.

L. PUBLIC RELATIONS

Public acceptance and support are a major concern of the Board and management. The SSWP primarily serves the public (or its members) and is funded through water revenues. To prosper and grow, it must have the support and build the goodwill of the stakeholders in the community, namely, its members and the LGU officials.

In all their dealings and exposures to the public, all persons identified with the Utility, including its Board members, management, and staff must project and maintain an image of professionalism and public responsibility. In the Philippine social setting, the image of helpfulness, fairness, friendliness, respect – as well as competence, are appreciated and rewarded with acceptance, trust and overall public support. The Board and management should define policies and take the necessary steps to secure this support.

Some of the measures that could help the Utility build a good public image are:

1. By Board Members

1. Taking the lead by setting personal examples, such as listening to suggestions and complaints directly brought to their attention and referring these to management for action;
2. Defining policies to guide the Utility's management and staff in properly dealing with its customers;
3. Being publicly visible and identified with the Utility, for instance, by attending public forums and participating in public affairs events, and disseminating information about the Utility.

2. By Management

1. Ensuring that the staff adheres to the Utility's public relations policies in carrying out their jobs, especially when they deal directly with the public. But this includes training the staff on how to deal with problematic situations involving customers, in which the Utility's legitimate interests need to be protected or its actions enforced;
2. Thoroughly training the staff about policies, procedures, and the rationale for these, and updating the staff whenever changes take place or new information must be given to the public;
3. Establishing rapport with LGUs, including barangay officials, and ensuring they are properly oriented on the requirements of a reliable water service;
4. Acting immediately on complaints and suggestions, resolving these, and giving feedback to the concerned customers about the actions taken;
5. Regularly developing materials for dissemination to the public, particularly those that could be distributed by the board and by management itself at public meetings and gatherings;
6. Managing water service problems, particularly risks to public health, to ensure that the public is properly informed on measures they should take to protect their family's health; and early warning of anticipated service interruptions to enable customers to prepare for them. When unforeseen problems occur, clear, frequent updates on what is being done, and the progress of the repair or mitigation work, are needed to reassure the public and secure their appreciation of the Utility's efforts.

3. By the Entire Utility's Personnel

1. Take responsibility for knowing the Utility's basic policies, operational procedures, history and organization; the value of its function of supplying safe, potable water to the community; and the community's responsibilities in ensuring that the Utility is both viable and sustainable;
2. Conducting themselves properly at all times, by acquiring the good habits of being respectful, accommodating of complaints and suggestions, being on time for appointments and keeping schedules, and observing respectable grooming practices and decent attire;
3. Maintaining clean, orderly office premises, and when doing field work observing respect for public and private property and seeing to it that work areas are left clean after a job is done.

M. PUBLIC CONSULTATION

Public consultation, as in public hearings or in general assembly meetings, is necessary to secure public support for any important undertaking that affects or might affect their interests. For the SSWP, they are essential for the following:

1. Formation of a community-based organization (CBO);
2. Expansion projects, particularly those requiring a tariff adjustment;
3. Tariff adjustments in general.

1. Nature of Public Consultation

Public consultation involves engaging people in dialogue – a two-way flow of information and ideas between two parties or groups, in this case the project proponent and the stakeholders. The public consultation dialogue gives the stakeholders and the concerned members of the community the opportunity to express their views and concerns. In turn, it enables the proponents to manage expectations, present information, try to resolve issues, and detect potential conflicts. The purpose of public consultation is to create an informed public that understands the tradeoffs between project benefits on the one hand, and the costs and disadvantages on the other. An informed public is better able to participate in the project, as beneficiaries, stakeholders, contributors, partners, and advocates.

Before holding a public consultation, it is important to determine

1. Who the stakeholders are;
2. The other concerned persons who should be invited to participate in the dialogue; and
3. The approach to be used in conducting the public consultation.

2. The Stakeholders and Other Participants

The choice of participants for direct consultation must be made on a fair and equitable basis. Meaningful public consultation requires the participation of people who represent a range of legitimate interests, including

1. Those who will be directly or indirectly affected, whether positively or negatively;
2. Members of the most vulnerable groups;
3. Persons who might have an interest or feel that they are affected;
4. Those who support or oppose the changes that the project will create;
5. Persons whose opposition could be detrimental to the success of the project; and
6. Persons whose cooperation, expertise, or influence would help the project succeed.

3. Approaches to Public Consultation

Aside from the direct discussions that take place during general assemblies and public meetings, there are a number of approaches to support or carry out public consultation. The main ones can be characterized as:

1. **Disseminating Information** – This may be done by distributing printed materials, volunteers going house-to-house or to small groups to distribute printed material and explain the proposed undertaking, displays, or "open house". In this approach, it is essential to provide a mechanism by which the stakeholders and other interested parties can express their responses to the information given.
2. **Soliciting Inputs** – This can be done by surveys interviews, focus group discussions (FGD), or public hearings.
3. **Getting Consensus**[18] – This can be done through an advisory panel, which interviews all the parties, tries to synthesize their positions, and proposes

[18] "Consensus" is different from majority rule. Consensus literally means that the "sense" held in common by the stakeholders is that the proposal is in the best interest of all (positive consensus) and should be approved, or not in the best interest of all (negative consensus) and should be disapproved. Even when some members of the group are opposed to the consensus (positive or negative), they may decide to support it because it serves the best interests of the entire body. In the case of majority rule, a vote is taken and the majority decision prevails, regardless of whether it will redound to the good of the entire body or not. A majority vote on a contentious issue usually cannot be peaceably enforced unless a large part of the losing minority (losing faction) accepts that it is in the best interest of the group to accept the majority vote's results. In which case, acceptance converts the decision into a consensus that can proceed with less contradiction.

compromise solutions to enable the proposal to push through. Other consensus building techniques may also be employed.

4. **Arbitration** – This employs a party or group that is acceptable to the contending parties, and is trusted to render a wise and fair decision. It is in a sense a "consensus", but not about the contentious issues themselves, but rather a consensus that the best way to resolve the issue is to entrust the decision to a mutually chosen arbiter. While the parties agree beforehand to abide by the arbiter's decision, it remains part of the arbiter's job is to convince the parties to accept the proposed solution.

In some public consultations, a combination of these approaches may be used at different stages of the overall dialogue, until the informed public can come to a final decision – usually a consensus – on the matter proposed.

Chapter 9

Commercial Operations

This Chapter presents key guidelines and practices that SSWPs need to adopt in order to ensure sound commercial operations.

A. GENERAL

Commercial Operations pertain to the systems and procedures in dealing with customers and their bills. These systems and procedures touch on the following aspects of the water Utility's business:

1. Service Connection Applications
2. Customer Classification
3. Billing and Collection
4. Customer Complaints
5. Dealing with Delinquent Accounts
6. Management Reports
7. Improving Collection Efficiency
8. Block Census
9. Use of Booster Pumps by Customers.

B. SERVICE CONNECTION APPLICATIONS

1. Service Contracts

a. Level II Systems

For level II systems, every customer goes to the public tap to get their water. The following practices are recommended:

1. The SSWP should ensure that all public taps are metered and that a Caretaker is assigned for each tap.
2. The Caretakers are responsible for controlling the water dispensed from the tap under their care and for collecting the fees based on number of containers drawn by each consumer. The Utility then bills each Caretaker and collects the payments from him/her based on the consumption registered on their assigned tap's meter.
3. The billing/collection from the Caretakers should be done on a daily basis.

4. For Caretakers who are not employees of the Utility, a service contract between them and the Utility might be necessary. (The Level III service contract could be used with some modifications for this purpose.)

b. Level III Systems

1. For Level III systems, the Utility provides the water directly to each customer through a metered connection, and bills them on a periodic basis (usually monthly).
2. The provision of a service connection and water supply service implies a contract between two parties. Hence all prospective consumers must sign an Application/Service Contract with the SSWP before the SSWP provides them with the house connection. The Application/Service Contract establishes enforceable contractual obligations between the SSWP and the customer, so either can take legal action in case of any breach of contract. (Refer to Annex I for a basic Application/Contract of Service form.)
3. It is highly recommended that the customer should not be made to pay for the water meter[19]. The logic is that the SSWP should own the water meter, and thus can install it outside the consumer's property line. If the meter is owned by the consumer, the SSWP may have difficulty reading it, making repairs, or pulling it out if it is defective – if the owner places it inside the residence or for any reason takes possession of the meter. The Utility, however, could charge a token amount for monthly maintenance of the meter.
4. Where practicable, the meters are placed in clusters for easy repair.
5. The Contract should specify the connection fees to be paid. It is recommended that an advance deposit of 2 months be included in the connection fee to guarantee payments of delinquent bills.
6. If a customer cannot pay outright for the connections, it would be a wise move if the SSWP will allow installment payments, provided a down payment is made. It would be up to management to recommend the policy for this, given the fund availability of the SSWP, the volume of pending applications and other factors.

2. Customer Briefing

It is good practice to educate the customers on the mutual obligations between themselves and their water system, and the importance of complying with these obligations in order to ensure a reliable, sustainable, predictable supply of potable water. For Level II systems, meetings with the community, as well as appropriate

[19] If necessary, a customer can pay a meter guaranty deposit.

billboards in the tap area could be used. For Level III systems, every time a new house connection is made and prior to activation, the customer should be given a briefing, even for a few minutes on the roles and responsibilities of both the SSWP and the customer. The rules of the utility can be explained and questions clarified.

Such briefings and information also serve as a public relations tool for the SSWP.

3. Assignment of Customer Account Numbers

For Level II systems, the only account numbers needed are those assigned to each public faucet.

For Level III systems, an account number is permanently issued to identify each service connection, before it is installed. The account number identifies each connection as to location, consumer class and customer number. An account number basically consists of 8 digits (000-00-000) with the following code:

First two digits	Zone number
Third digit	Meter reading book number
Fourth digit	Consumer classification code
Fifth digit	Meter size code
Last 3 digits	Concessionaire account number

C. CLASSIFICATION OF WATER CUSTOMERS

Level II systems have only one category of consumers, so that customers do not have to be classified.

Generally, Level III water customers or users drawing water from the SSWP are categorized into 3 major types or classes for purposes of billing:

1. Residential (Domestic) and Government
2. Commercial/Industrial
3. Bulk/Wholesale.

These classifications are important because Level III tariffs are different for each category. In general, Commercial/Industrial users are billed 2 times the rate and Bulk connections 3 times the rate of Domestic users.

1. Residential/Domestic

Persons and establishments drawing water from the SSWP for their day-to-day needs are classified under this category. They are charged the lowest rate. Normally, their water usage includes cooking, washing, bathing, drinking and any other domestic use to sustain everyday life.

Government offices and buildings are likewise classified under this category because they perform public services and the consumption is only in connection with the performance of their duties.

2. Commercial/Industrial

Persons and establishments drawing water from the system for use directly or indirectly either to promote their trade or business or to produce a saleable product are classified under the Commercial/Industrial category and should be charged accordingly. Included in this classification are sari-sari stores, groceries, malls, contractors, bakeries, gasoline stations, water filling stations, barbershops, beauty shops, restaurants and other businesses.

3. Bulk/Wholesale

Persons and establishments drawing water from the system for resale without transforming it into a new product are classified under the Bulk/Wholesale category. Included under this category are those providing water to carriers and to houses that are not connected directly to the system.

4. Implementation

a. Issues in Classification

When a water consumer falls distinctly under any of the above categories, classification for billing purposes becomes easy. However in some instances, a consumer may fall in-between two categories. For example, given a residential house with a small sari-sari store or carinderia, how should the connection be classified? It is usual to consider the principal purpose of the water. Somehow the SSWP would have to devise some objective means of weighing the obvious mixed use in order to decide the classification.

Questions also arise about whether a small sari-sari store should be billed the same commercial rate as a grocery, or if a small carinderia should be treated the same as a large one or a restaurant. The determination of the appropriate billing rate could be subjective if the decision were in the hands of a single person alone. Obviously, some more general guidelines must be adopted.

b. Sub-Classifications

Some SSWPs have tried to solve these quandaries by setting sub-classifications. For instance, defining Commercial A and B users, with Commercial A users being billed only 150% of the domestic rate, while applying to Commercial B users the full 200% of residential rates. The Board has to define these sub-categories and give guidelines for their application through an appropriate resolution.

c. Caution on Special Treatment

1. It is never good practice to give free water to the Board members and staff of the SSWP. Such benefits are easily subject to abuse and are bound to be used against the SSWP during tariff adjustment requests.
2. Except for emergencies, the SSWP should be very strict about the granting the use of free water. If it gives in to one request, it can expect to soon be flooded with similar requests.

D. BILLING AND COLLECTION

1. Level II Practices

To the extent practicable, the billing and collection of Level II faucets should be done on a daily basis. Each metered public faucet should be assigned to a Caretaker who will sell water to the users on a volumetric method, e.g., containers or drums with known standard volume capacities. At the end of the day, the meters are read by the Utility's Collector and the Caretaker is billed on the basis of the cubic meters of water dispensed.

The daily reading, billing and collection will help avert delinquency in payment by the Caretakers. If a Caretaker is unable to pay, the specific public faucet assigned to him/her is disconnected until a dialogue with the concerned users leads to an agreement regarding the arrears, and a new caretaker is appointed.

2. Level III Practices

a. Master List of Customers

In order to keep track of existing account numbers and control the number of customers in each Meter Reading Book, a Master List of service connections should be prepared and grouped according to areas (or zones).

Concessionaires in each meter reading book will be numbered consecutively from number 001 taking into consideration potential concessionaires within the area including vacant lots, which will be reserved with a corresponding account number.

b. Meter Reading

Service activities are best grouped to achieve a system in which meters within an area can be read within a day. (The number of meters that can be read in a day should be determined.) A group of areas lumped together, which could be read in 5 to 10 days, could be grouped into a billing zone.

The water meters are read on a monthly schedule. The area assignments of meter readers are rotated monthly, if possible, so that no meter reader will be making two consecutive readings of any meter.

Aside from reading the meters, the meter reader should take note of and report service defects, complaints from customers, and any infraction of utility rules.

c. Billing

Form 9.1: Daily Billing Report							
Date							
Account No.	**Customer**	**Bill no.**	**Consumption m^3**	**Amount**			
				Metered	Unmetered	Penalty	Others

1. Water bills are prepared not later than the day before the next meter reading. Water bills prepared for the concessionaires belonging to a zone should be checked for completeness against the total number of connections shown in the master list of service connections. Any discrepancy should be investigated and rectified.

2. Completed water bills are forwarded to the manager, then to the bill deliverers (or meter readers) at the end of the day for distribution.

Form 9.2: Customer Ledger Card								
Name				Account No				
Address								
Date Installed								
Date Disconnected								
Date Reopened								
Date	Bill #	Others	Particulars	Meter reading	Usage m^3	Billings	Collections & Others	Balance

3. A Daily Billing Report is prepared for all bills prepared for the day. This is to ensure a reporting mode, which will be very useful for analyzing collection efficiency, sales breakdown and billing efficiency. Form 9.1 shows a sample of a Daily Billing Report. This will serve as reference in the recording in the Customer Ledger Cards. Refer to Form 9.2 for a template of a customer ledger card.

4. A billing statement or Statement of Account should include the Due Date for the payment and a Notice to the customer that a penalty will apply for late payments. An example of such a billing statement is shown in Form 9.3.

Form 9.3: Sample Format of a Billing Statement

CUSTOMER'S COPY

STATEMENT OF ACCOUNT

No.xxxxxx

Account Name:	Account No:
Address:	Meter No:
Billing Period:	Present Reading:
Reading Date:	Previous Reading:
Due Date:	Consumption (m^3):

DETAILS OF CHARGES

Current Charges

Expanded VAT (EVAT)

Other Charges

Previous Unpaid Amount

TOTAL AMOUNT DUE

IMPORTANT REMINDERS:

1. 10% Penalty Charge will be imposed on payment made after due date.
2. Please bring your billing statement to avoid any delay during payment.
3. No field collector assigned. Please pay your water bills at SSWP Office.
4. Please report immediately the next time you have not received your bill 3 days after meter reading.

3. Payments from Customers

1. As a rule, customers should pay only at the SSWP office where official receipts shall be issued. There should be no collectors from the SSWP going to individual customers.
2. Customer ledger cards should be maintained (either manually or electronically) and regularly updated. Customers cannot be expected to keep records of their payments for long and there is no reason for the Utility to have incomplete or un-updated records. As soon as payments are received, they must be recorded in the customer's ledger cards. Whenever a whole booklet of receipts is used up, a routine check comparing the stub entries to the ledger entries should be conducted.
3. Collection of water bills in the office is scheduled on specific dates during the month. The Due Date is indicated on the copies of the water bills for the customer's information and as reference for the imposition of the penalty charge.

4. The bill should indicate the Penalty Charge for bills not paid on time. This will be added to and collected together with the amount of the outstanding bill.
5. An Official Receipt is issued when payment is made.
6. All daily collections are tallied with the official receipts issued and are kept in a steel safe during the night. A Daily Collection Summary is then made as shown in Form 9.4. The collections are then deposited in the bank on the morning of the next banking day.

Form 9.4: Daily Collection Summary

Date					
Account No.	Customer	Amount Collected	Account Credited		
				Arrears	
			Current	Current	Previous

4. Disconnections

1. The SSWP should set a reasonable but clear deadline for all customers to pay their dues. At the end of the deadline, the service should be disconnected, unless the debt is paid immediately. To prevent abuse and avoid setting precedents, no exceptions should be allowed. Charge a reasonable amount for re-connection. Be firm but fair.
2. A customer should be given sufficient notice before actual disconnection.
3. If payment after the due date has not yet been made, a second notice (the first notice is the original Bill itself) clearly marked “Disconnection Notice”, is sent. Such notice shall inform the customer of the deadline for payment, the penalties or interests to be paid, manner of payment, and the fee for reconnection. Refer to Form 9.5 for a sample Disconnection Notice.
4. If payment is still not yet received after the Disconnection Notice deadline, a Disconnection Job Order is issued by the Bookkeeper to the one in charge of disconnections. This person goes to the consumer abode and presents the Disconnection Order. If payment is not immediately paid, the disconnection proceeds.

Form 9.5: Sample Disconnection Notice	
DISCONNECTION NOTICE	
Account Name:	Account No:
Address:	Meter No:

Dear Customer:

Our records show that your water bill in the amount of __________ due on __________ is two (2) months overdue. We are giving you seven (7) days up to __________ to settle your account with us. Failure to settle payment will force us to disconnect our services without further notice. You will be charged a ten percent (10%) penalty upon settlement and a reconnection fee of xxx Pesos (Pxxx.00).

Please disregard this notice if payment has been made and we thank you for your payment.

Sincerely,

NOTE:

PLEASE PAY YOUR WATER BILL ONLY AT THE SSWP OFFICE. WE DO NOT HAVE ANY FIELD COLLECTORS. ANY PAYMENT MADE TO OUR FIELD PERSONNEL IS AT YOUR OWN RISK. ONLY PAYMENTS WITH OFFICIAL RECEIPTSISSUED BY OUR OFFICE SHALL BE HONORED.

The process should be clearly defined through a Board resolution that should be disseminated to the staff and all users. As such, when the conditions for disconnection take place, it shall be implemented automatically by the operating staff concerned, without any specific order or intervention by the Manager. ***The Manager should not be involved in the disconnection process for two reasons:***

1. He should be able to rightfully claim that he had no prior knowledge of the incident and that the staff are only guided by policy and standard office procedures;
2. In case a reconnection has to be made immediately, he can give the order without countermanding an earlier order to disconnect.

5. Billing Adjustments

1. If for some reason, a billing adjustment needs to be made on a customer's bill, the Bookkeeper makes the initial recommendation stating the reasons for the adjustments. The Manager reviews it, and upon approval, the Bookkeeper prepares a Billing Adjustment Memo (Form 9.6) on which the Manager must indicate his approval.
2. Upon receipt of the approved Billing Adjustment memo, the Bookkeeper notes the corresponding adjustment in the Customer Ledger Card. The adjustment is then reflected either in a new or the next billing statement.

Form 9.6: Billing Adjustment Memo

BILLING ADJUSTMENT MEMO

Memo No.

Concessionaire: Date:

Account No: Bill No:

Reason:

Consumption			Journal Entries			
As Billed	Should be	Increase (Decrease)	Account		Amount	
			Title	No.	Debit	Credit

Prepared by: Approved:

E. CUSTOMER COMPLAINTS

As a rule, every customer's complaint should be attended to as quickly as possible.

1. There are several ways by which the SSWP can receive complaints from its customers. These can be made directly to the Meter Reader, or the customer can call or report directly to the office. These complaints must be recorded, classified as to their nature and date received, and resolved or acted upon. The report for each complaint should also indicate the dates for subsequent monitoring.
2. If a service complaint is made to the Meter Reader, the Meter Reader should conduct a preliminary investigation and, whenever possible, correct the defect immediately. If the defect needs further corrections or repairs, this should be noted in a Service Request form, which should be carried when reading meters. The Meter Reader should log the Service Request in the Customer Complaint Logbook upon return to the office and convert it into a Maintenance Order. This order will be used as a basis for responding to the defect.

3. If the service complaint is made at the office, the complaint is recorded in the Complaint Logbook and used as a basis for further action. All service requests carried by the Meter Readers should also be noted in this Logbook.

F. DEALING WITH DELINQUENT ACCOUNTS

1. If the SSWP is consistently firm in implementing its disconnection policies, fewer problems will arise in dealing with delinquent accounts. For all intents and purposes and depending on Board policies, delinquent accounts are those with arrears greater than 2 months. Two months is a benchmark because the consumer gets to use water for a month without any bills, 15 days due date upon billing and another 7 – 15 days due date for a disconnection notice.
2. When the customer subsequently applies for reconnection, the reconnection fee plus the arrears should be collected before reconnection.
3. If for some reasons the number of delinquent accounts grows, the SSWP should take the following steps:
    - Ensure that the accounts have all been disconnected. Review delinquent accounts that have not been disconnected if they have been issued the appropriate collection notices.
    - *If yes*, disconnect immediately. *If not*, issue the appropriate notices.
    - If the customer has another connection (different account number), add the debt to the second account after disconnecting the delinquent account.
4. Prepare an Ageing of the Accounts Receivables. This means classifying the accounts as to age of receivables, say 2-6 months “A”; greater than 6 months to one year “B”; and accounts greater than one year “C”.
    - Starting with the “A” accounts, the SSWP should assign a representative to discuss the account with the customer and attempt to find ways and means to settle the debt. Those accounts greater than 6 months (“B” and “C” accounts) should be given to a collection agent, if available. If efforts are unsuccessful, then these should be written off as bad debts and no longer be included as part of Accounts Receivables. A Board resolution should be made to classify these accounts as bad debts with management justifying why each is no longer collectible. However the records should be kept and efforts still exerted to collect as if the accounts were not written off.

- Before the account is written off, the advance deposit[20] made by the customer upon application for service is credited to his account and the arrears settled (plus or minus). If the customer applies for reconnection, he shall be made to pay for the reconnection fee, the balance, if any, of his earlier debt (less his earlier advance deposit) and 2 months average consumption again.

G. MANAGEMENT REPORTS

1. Commercial/Operational Information

As part of the Management Information System (MIS) of the SSWP, the following commercial operational information should be summarized and reported on a monthly basis:

1. **Report on Billing and Collection.** Refer to Form 9.1 and Form 9.4 for sample source documents;
2. **Production and Per Capita Consumption.** The per capita consumption can be obtained from the total domestic consumption divided by the number of domestic persons served (no. of domestic connections x average family size). Production is from the production records;
3. **New Connections Applications.** Number filed and number of active connections per category;
4. **Complaints.** Number and nature of complaints and average resolution time.

2. Billing and Collections

The billing and collection system should be able to summarize every month the following information:

Total Billings &Collections by Type of Connections

Total Number of Connections

Collections on Current Billings and Arrears

Cubic meters Billed

Average Consumption per Domestic Connection

Connections with Arrears of More than 1 Month

The report format contained in Annex G can be utilized for this purpose.

[20] 2 months of average bill is highly recommended.

H. LOW COLLECTION EFFICIENCY

Under normal conditions, low collection efficiency in Level III services can be remedied by strict enforcement of the policies on billing, collection, penalty, disconnection, illegal connections/pilferages, etc.

If the member users find it difficult to pay water bills due to their low income, the SSWP, through their CBO should encourage member users to undertake viable economic activities to supplement their income. If majority of the users are consuming below the minimum volume, then the SSWP could study reducing the minimum volume.

Another way is to provide incentive for on-time payment.

If the SSWP is part of a CBO, the CBO might agree to have a lending program where members could apply for a loan to settle their bills.

If the community has difficulty making payments on time due to seasonal or unusual income streams, then the SSWP could study the possibility of billing earlier than a month.

I. BLOCK CENSUS

A block census is important for Level III systems. The census is merely a survey of the current and potential customers within the SSWP's service area. To do this it is necessary to have a map of the service area showing the location of the houses. Enumerators used for this purpose are trained on the survey objectives and the questioning procedures. Where advantageous, barangay or school assistance may be secured.

Steps for doing the block survey are the following:

1. Indicate on the map the existing system showing the pipelines, reservoirs and source/s.
2. Divide the entire area into blocks and number each block so it can easily be located in the field.
3. Divide each block so that each block can be covered by an enumerator within 1-2 weeks.
4. Assign enumerators to their respective zones.
5. Use a questionnaire to secure data per dwelling unit. Such as the number of persons, estimate of daily consumption, payments made for electricity, current source of water and payments made.
6. During the census taking, the enumerator should make a survey of the non-connected residents and their present source of supply.
7. After the field survey is completed, the information gathered must be consolidated.

J. USE OF BOOSTER PUMPS BY CUSTOMERS

The use of booster pumps by individual customers on their connections worsens the pressure conditions in parts or throughout the entire system. It could likewise cause negative pressures in the lines that would induce infiltration of non-potable water as well as other problems for the system.

1. The Board should institute a policy banning the use of booster pumps without a specific permit from the SSWP.
2. Boosters strictly may only be permitted when the customer constructs a cistern to collect the normal flow of water from the SSWP system. The inlet tube of the booster then sucks water only from the cistern.
3. The policy should emphasize:
    - That the official permit document must be obtained from the Board;
    - That the SSWP may conduct unscheduled inspections of the booster setup at any time; and
    - That a heavy fine and/or disconnection will be imposed for the unauthorized installation or modified operation of a booster.

Chapter 10

Financial Aspects

This Chapter presents the unique financial aspects of an SSWP, especially those elements that play an important role in the effective management of a utility and to a large extent determine its viability and sustainability. These key financial elements include the tariff-setting considerations and methodologies, and the financial management and control system, including the reporting requirements.

This Chapter is organized into three main topics:

1. Budget Preparation
2. Tariff Setting Methodologies
3. Financial Systems and Controls.

A. BUDGET PREPARATION

1. Nature of the Budget

NOTE ON THE SSWP ACCOUNTING SYSTEM

As in all businesses, the Accounting System is an important component of the SSWP's overall Financial System. Its preparation, however, is better left to a qualified accountant who can design the system according to the specific requirements of the SSWP. Nonetheless, the SSWP management and its consultant should consider three important guidelines in working out its accounting design:

1. As a strict policy, all collected funds should first be deposited in the SSWP's bank account. All disbursements should then be sourced from this account. This ensures clear, proper accounting and security for the funds.
2. The Accounting System should mesh with the overall requirements of the Financial Systems and Controls discussed in this Chapter, as well as with the commercial operations described in Chapter 9.
3. The Accounting System should similarly mesh with and be able to generate the data needed to support the SSWP's Management Information System (MIS).

See Annex J for a Conceptual Framework for a Level III system.

A Budget is merely a plan expressed in quantitative (monetary) terms. Its preparation involves setting targets for the revenues and expenditures of the Utility. Being a simulation of how the financial inflows, outflows and other accounts will behave as it implements its plan within the budget period; it also involves the analysis of trends and anticipated changes within business categories, such as operations and capital expenditures. The adoption of a relatively detailed annual budget is a key element in improving the Utility's effectiveness.

The budget is prepared by management, usually during the last quarter of the year, and should be approved by the Board before being endorsed to the stakeholders or general assembly and to the regulatory bodies like NWRB, CDA or LWUA.

The basic components of a Budget are:

1. Statement of Objectives
2. Operation and Maintenance Budget
3. Capital Expenditure Budget; and
4. Financial Statements, including the Cash Flow and Income Statement

2. Statement of Objectives

For an on-going business, the first step in any budgeting process is generally an analysis of the current year's actual expenditures as compared with the approved budget, and the presentation of objectives and goals for the coming calendar year. The deviations between the actual estimated[21] disbursements and budgeted amounts for the current year have to be explained, and related to the Utility's performance in terms of the current year's objectives.

1. These analyses need to be presented to the Board, which needs to appreciate and evaluate whether the objectives set for the following year are the right ones, are worth the budgetary outlays proposed, and are realistic in the sense that they can be supported by the revenues to be realized by the business. In other words, management should state the reasons (objectives) for having a budget.
2. Depending on management's presentation and the Board's appreciation of the budgetary proposal, the Board may request management to make the modifications it deems necessary, or approve the budgetary plan outright.
3. It generally takes a minimum of 2 to 3 Board meetings before the Board approves the budget.

3. Operation and Maintenance Budget

The O&M cost is the total estimated cost required to manage, operate and maintain the water supply system. The projection of the O&M Budget usually is fairly straightforward, unless major deteriorations of the facilities have created expectations of unpredictable

[21] Called *actual estimated* because the presentation could be made in Oct or Nov while the figures will cover up to December.

cost levels, or serious local or global events are expected to cause large spikes in the prices of some essential supplies. Otherwise, it is projected from the results of past operations and adjusted to fit the current or projected prices and costs.

a. Nature of O&M Costs

It is important to realize that in a well-managed water utility, there are only two major groups of expenditures:

1. **Capital Outlay/Investment,** the costs of which are determined at the initial stages of the business, or when it expands, upgrades, or replaces the physical facilities for water supply and distribution. The annual costs are then composed of the depreciation of the major facilities, the financial costs incurred in their acquisition and installation, and actual Capex [22] disbursements during the year.
1. **Operation and Maintenance,** which involves practically all the activities of the business whose focus is basically to employ its physical facilities to distribute the water 24/7, reliably and efficiently, and to ensure that these physical facilities remain capable of continuing to distribute the water 24/7, reliably and efficiently.

From this it will be clear that the O&M cost is one of the two major components considered in determining the initial water tariff of the system and the necessary adjustments in tariff that may be dictated by external factors and as the system expands in the succeeding years of operation.

b. Revenues Needed to Support O&M Costs

From the foregoing discussion, it becomes very clear also that SSWPs need to collect water revenues continually and promptly in order to reliably operate and maintain the water distribution facilities. In too many instances, insufficiency of funds is at the root of poor SSWP maintenance.

c. Need to Educate Users

Each member user should be made to realize the importance of a well-supported O&M on the reliability of *their* water system. They should be educated on what the O&M budget comprises and why a collection is made for the Utility's O&M.

d. O&M Cost Items

Following is a list and description of what are generally included as O&M cost items:

1. Salary/wages refers to the gross personal services expenses;
2. Power costs and related expenses refer to the total electricity and fuel, oil, and lubricants incurred in the operation;

[22] Capital expenditures

3. Maintenance expenses refer to the repairs and maintenance costs of facilities, exclusive of salaries and wages of SSWP staff who undertook the repairs and maintenance;
4. Permits/Regulatory fees are expenses incurred in obtaining or updating business permits, licenses and payments for regulatory fees;
5. Board costs are expenses incurred during Board meetings as well as board per Diems, if any;
6. Operation capex are disbursements made which do not enhance the physical distribution system but are necessary in improving the office environment, work efficiency, or security, examples of which are fax equipment, light fixtures, housekeeping equipment, vault and filing cabinets, and computers;
7. Miscellaneous costs refer to other maintenance and operating expenses like representation expenses excluding depreciation, interest and other bank charges. Capital Expenditure (Capex) Budget.

The annual capex budget summarizes the cost of the projects that the SSWP will implement during the budget year. These are cost items that involve large amounts, like pipelines, reservoir, connections, source development, major repairs or expansion of the network. The amount is determined based on the project plans and the estimates of their cost.

4. Cash Flow Statement

The Cash Flow Statement is a plan showing the sources and levels of cash revenues that will be realized, and the cash disbursements planned during the budget year. This document is essential in matching and timing the expenditures with the cash that will be available. It prevents fund shortfalls at the time critical items are scheduled to be purchased. When a cash shortfall is foreseen, the budget planners (management) can adjust spending priorities, delaying the purchase of non-critical items and, when needed, obtain additional funds from external sources. Serious prolonged cash deficiencies that are foreseen should trigger the consideration of tariff adjustments.

- The Cash Flow Statement is based on the cash method of accounting rather than on the accrual method. (See Footnote 24 for a brief explanation.)

Form 10.1 shows a format of a quarterly Cash Flow Statement.

Form 10.1: Sample Cash Flow Statement					
	1st Q	2nd Q	3rd Q	4th Q	Total
Collection %					
Receipts					
Sales Collections[23]					
Penalties					
Customer Deposits					
Loans					
Connection Fees					
Others					
Total Receipts					
Disbursements					
Operations					
Vouchers payable					
Staff advances					
Loan debt Service					
Customers Deposit Refunds					
Others					
Capex					
Total Disbursements					
Net Receipts (Disbursement)					
Cash Balance, Beginning					
Cash balance, End					

5. Income Statement

While the Cash Flow Statement may indicate cash sufficiency during the budget period, it does not show that the Utility is earning a profit. The statement designed to determine profitability is the Income Statement, which uses the accrual method of accounting[24].

[23] Requires a support table showing the types of connections and average revenue/type of connections.
[24] In the accrual method, earned revenue is recognized as income for the time period in which it was earned, even if it will only be collected (encashed) at some future time period. In the cash method, even if the income has been earned, as long as it is not received as cash, it is not reflected in the cash flow statement.

Form 10.2 shows a format of a Comparative Income Statement.

Form 10.2: Format of a Comparative Income Statement			
	This year	**Last year**	**Variance**
Operating Revenues			
Less: Operating Expenses			
Operation Expense			
Maintenance expenses			
Depreciation			
Total Operating Expense			
Operating Income			
Other Income			
Total Income			
Less: Misc Income Deductions			
Net Income before Interest			
and Taxes			
Less: Interest Charges			
Taxes			
Net Income (Loss)			

6. Budget Monitoring and Control

Management must monitor the level of expenditures against the budget on a monthly basis in order to control overruns that could lead to unexpected fund shortfalls. Monitoring the budgeted expenditures enables management to take cost reduction measures, make decisions on budget realignments, and consider the need for a supplemental budget if it is forecast that the approved budget for essential expenditures will be exceeded.

B. TARIFFS

Tariffs are the life blood of a small water utility business. Tariffs set by the regulators are basically its only source of the revenues it needs to support its capital investments, operations and maintenance. They define the contributions that the SSWP may demand from the users of the water distribution system, as their share in the cost of its construction and upkeep.

1. Tariff-Setting Requirements

Tariff setting should NOT be done in a poorly considered, arbitrary manner. A deficient tariff level, once set, will be very difficult to remedy; and an excessive level would be unsustainable for the users, be subject to complaints, and tend to result in delays of payment and bad debts.

For this reason, the practice is for the water tariff to be fixed by the Utility in consultation with the users, considering basically the capacity of the users to pay and costs of the O&M, as well as other relevant factors.

In the public consultations, the users and the Utility itself should see tariffs as instruments for recovering the cost of providing adequate water service to customers and must reflect not only the fixed costs of the supply system but also its operating expense and long-term sustainability. Tariff rates must satisfy the following requirements.

1. **Adequacy:** The revenues generated from a water rate schedule must be sufficient to meet the revenue requirements of the Utility. The rates should be able to promote the Utility's financial viability and growth.
2. **Public Service:** The tariffs must be set at a reasonable level that reflects the Utility's role as a public utility providing a public service.
3. **Equitable and Socialized Pricing:** The tariffs must equitably distribute the cost of the service to all classifications and sizes of connections. Their structure should define a relatively low fixed rate for some minimum level of consumption to benefit the low income users, and higher rates for those who use greater quantities of water.
4. **Affordability Level:** The rates must be kept affordable to the low income group (LIG). For this reason, the minimum charge for a ½" residential connection should, as a rule of thumb, not exceed 5% of the average income of the LIG within the service area.
5. **Water Conservation:** The rates must encourage the wide water usage needed to attain economies of scale, but must also discourage unreasonable and wasteful usage of water.
6. **Enforceability:** The rates must be fair, reasonable and transparent. They should be justifiable and acceptable to the consumers.

C. TARRIF SETTING METHODOLOGIES

Two nationally accepted tariff methodologies are presented here, the Return on Investment (ROI) Method adopted by the NWRB, and the Cash Flow Needs Method utilized by the LWUA/Water Districts. There are many similarities between the two methods such as the use of quantity blocks of consumption and meeting the financial requirements of the utility.

1. NWRB'S Return on Investment (ROI) Methodology

The NWRB uses this tariff methodology. While designed for Level III systems, it can be adopted for use even by Level II systems. Water systems registered with NWRB should use this method in formulating water tariffs.

> It must be taken into account that in Level III systems, the individual connections are metered, while in Level II systems, the reckoning of water use is different.
>
> Level II consumers are billed by container, based on the known volume of the containers they bring to the public faucet. (e.g., A carboy is usually 5 gallons, a drum is 55 gallons, and a pail (timba) may be 3-gallon, 5-gallon, or larger size.)
>
> The Caretaker, however, is billed by the Utility by the cubic meters of water reflected in the faucet's meter.

a. Guidelines:

The following are guidelines for the NWRB ROI method:

1. Time Span: The methodology results in a 5-year tariff level;
2. A Business Plan with detailed projected OPEX and CAPEX must be able to justify tariff levels for a 5-year period;
3. Service Levels: Tariff is computed based on agreed service levels;
4. Key Performance Indicators (KPIs) should provide a basis for projections;
5. An Excel-based tariff model is used;
6. Calculation of an average ROI to reduce price shocks within the 5-year period and to reduce administrative workloads;
7. Need for public hearings and publication.

It would be best to get the NWRB Tariff Methodology Manual with their Excel model CD. This can be obtained from the NWRB at a minimal cost. Contact information for the NWRB is available on their website (http://www.nwrb.gov.ph/contact.htm).

b. Tariff Design Process

The NWRB's tariff design process is illustrated in more detail in Annex K.

c. Legal Requisites

The proposed rates are subject to public hearing or consultation prior to approval. After approval by the NWRB, the approved rates must be posted within 7 days in a conspicuous place within the SSWP office and other public areas within the community.

2. The "Cash Flow Needs" Methodology

This method is being used by water districts whose tariffs have to follow the guidelines of the Local Water Utilities Administration (LWUA). This method may not be applicable for those registered with the NWRB.

The difference between the ROI method and this method is the enumeration of the items which can be included in the cash flow (Table 10.1) which incidentally is equivalent to the revenue requirement per year.

Table 10.1: Items Included in the Cash Flow

Cash Flow Expense Items	ROI Method
O &M	- same -
Debt Service	- n/a -
Reserves (2-5% of revenue)	- n/a -
Taxes	- same -
Other Adm Expenses	- same -
Capex	- n/a -
- n/a -	Net Income

This method also requires projections of the following:

1. Number and type of connections; estimated volume sold and population to be served;
2. Production capacity, NRW, water supply shortage/surplus;
3. Required investments; and
4. O & M expenses to be incurred.

The projected consumptions are then converted into equivalent volume units similar to the ROI method. Cash flow projections for 5 years are made with the "cash flow needs" as the revenue requirements. The annual average tariff is then calculated by getting the revenue requirements divided by the volume sold.

For more details, readers are advised to log on to LWUA's website at www.lwua.gov.ph and access their primer on Water Rates and Related Practices.

D. FINANCIAL SYSTEMS & CONTROLS

1. Cash Security

There are several instances wherein the utility can receive cash. These are from collections, donations or sales of assets. It is very important for the utility to have a procedure for each instance to ensure that the cash obtained is documented and secured.

As an example for office collections, based on the copies of the Official Receipts, the cashier prepares the Cash Collection Summary and compares collections with the Summary at the end of each day. Collections are then kept in a steel vault. The collections are then deposited the next day with a copy of the deposit slip. The deposited amount is recorded in the Daily Cash Position Report.

2. Disbursement Procedures

All utilities must maintain disbursement procedures to keep track of the expenses and accountability purposes. There are different purposes for the disbursements and the utility must ensure that their disbursement procedures cover the following purposes:

1. Payrolls
2. Operational expenses like chemicals, fuel, rentals
3. Capital Expenditures
4. Debt service
5. New connections
6. Maintenance expenditures
7. Emergency procurement

3. Asset Register

This is a list of assets currently owned by the Utility. The Register has 3 uses:

1. It documents the list of the assets owned by the utility;
2. It guides the utility in the computation of its depreciation expense; and
3. It gives the regulatory office or a lender an idea of the Utility's size and assets owned.

A format of an asset register is shown in Annex K. The SSWP should develop a procedure for updating the asset register.

4. Donated Assets

The manager should receive all donated assets. He must ensure that the donation includes the documents of the donation or title aside from the asset. Unless the accompanying documents indicate the value of the asset, a value must be assigned to it for inclusion in the Asset Register and for depreciation purposes.

The bookkeeper prepares the corresponding journal voucher and lists the asset in the Asset Register. The asset, if transportable is then consigned to a designated or accountable person or to stockyard for safekeeping.

E. OBTAINING LOAN FINANCING

Sources of commercial funds are available and it is to the Utility's advantage to be able to access these when the need arises. To be able to do this, the Utility must have both the credibility and capacity to service the loan. The Utility is then termed creditworthy.

A Utility is considered creditworthy when its financial performance and management meet the tests that reasonable lenders adopt in assessing loan applications. The Utility must be able to show a history of sound financial and operational management, usually evidenced by several years of acceptable audited financial statements.

Other factors that affect creditworthiness are management capacity and governance or accountability of the institutions and customer demographics. Utilities applying for credit must present financial projections to confirm that sufficient revenue will be generated to cover relevant costs, including routine operation and maintenance costs, renewal and replacement of assets, and system expansion and debt service. In developed markets, utilities can receive a credit rating indicating their level of creditworthiness and the level of risk involved in lending to it. The rating affects the cost of borrowing—utilities with strong credit ratings can borrow at lower interest rates, while those with less borrowing experience or poorer financial performance will have to pay higher rates. They may further be required to obtain a guarantee from the municipality or owners, or they may not be able to borrow on the market.

Annexes

TABLE OF ANNEXES

Annex A

24-Hr Constant Rate Pumping Test Procedure

A pump test consists of pumping a well at a certain rate and recording the drawdown (decline) of water level in the pumping well and in nearby observation wells over a certain time period. The responses of the water levels at and near the pumping well reflect the aquifer's ability to transmit water to the well. The response allows hydro geologists to determine the aquifer's characteristics. Water levels will drop less in more permeable aquifers than in aquifers of lower permeability. Ideally, water levels should be measured at predetermined time intervals at the pumping well and nearby observation wells.

A-I REQUIRED TOOLS AND EQUIPMENT

- Pumping unit (submersible pump with a capacity greater than the yield requirement by at least 20%)
- Water level indicator
- Stopwatch
- Containers for volumetric measurement of discharge

A-II TERMINOLOGIES

Static Water level – The vertical distance from ground level (or known measuring point) to the water surface in the well when there is no pumping.

Pumping Water Level – The vertical distance from ground level (or known measuring point) to the water surface in the well during pumping.

Drawdown – The difference between the pumping water level and the static water level.

Well Yield – The volume of water per unit time that could be pumped from the well as determined by the pumping test.

A-III DISCHARGE MEASUREMENTS

Discharge measurements are usually measured by a flow meter. If there is no device to measure the flow, then volumetric measurements will be resorted to.

The volumetric method consists of noting down the time required to fill a container (bucket or a drum). Better results are obtained with a larger container. For more accurate results, several trial measurements should be done and the average of these trials taken.

A-IV PROCEDURE

1. Prior to starting the pump, measure and record the static water level.
2. After starting the pump, measure the corresponding water levels. Discharge should be greater than the required yield and should be maintained at a constant rate during the entire duration of the test for 24 hours. Measurement intervals should be as follows:

Time from start of pumping (min)	Time intervals between measurements (min)
0 – 15	0.5 – 1
10 – 15	1
15 – 60	5
60 – 300	30
300 – end of test	60

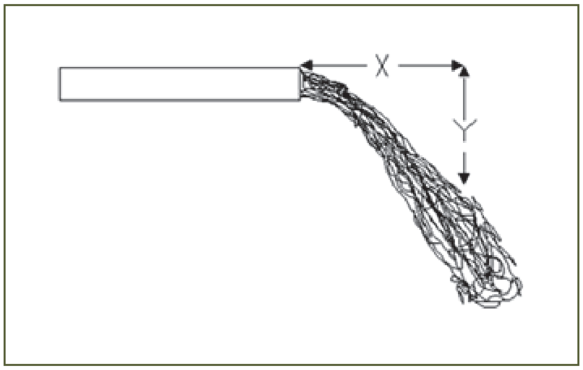
3. Simultaneous with the water level measurements, take measurements of discharge.
4. Monitor nearby wells to determine effects during pumping.
5. Right after the end of the pumping test, measure the water level recovery.
6. Plot data obtained from the test on a semi-logarithmic paper showing the time in the abscissa (x axis) and the drawdown in the ordinate axis (y axis).

Annex B

Measuring Flow from a Horizontal Pipe

The following describes the procedure for measuring pipe flow from a horizontal pipe. There are 2 conditions for this procedure to be used successfully:

- The pipe must be flowing full
- The pipe must be horizontal.



Procedure:

1. Measure the pipe distance to the ground (drop or y in meters). The pipe must be parallel to the ground.
2. With water flowing from the pipe, measure the horizontal distance from pipe nozzle to the point where the water falls to the ground (carry distance or x in meters).
3. Apply the formula:

$$Q = \frac{0.001739 d^2 x}{y^{1/2}}$$

Where:

d = pipe diameter in mm

x = carry distance in meters

y = drop in meters

Q = lps

Example:

Find the flow in a 62.7 mm (2 ½ inch) pipe flowing full where the drop is 0.50 m and the carry is 0.824 meters.

Solution:

$$Q = \frac{0.001739 \times (62.7)^2 \times 0.824}{(0.50)^{1/2}} = 7.9\ lps$$

Annex C
Sample Job Description: System Operator

Job Title: System Operator

Job Summary:

Under general supervision. Operates and maintains operational facilities. Maintains chlorine levels and water quality test results. Performs scheduled maintenance tasks and emergency repairs.

Typical Duties:

1. Maintains reservoir levels and system pressures;
2. Identifies and corrects (or cause to be corrected) malfunctioning pumps, controls, motors as well as pipe leakages;
3. Connects customers;
4. Reads meters;
5. Does preventive maintenance on all facilities;
6. Maintains operating records;
7. Performs other duties as may be assigned from time to time.

Ability To:

Trouble shoot simple mechanical and electrical malfunctions; Calculate chlorine dosages and flows; do plumbing work; lead and train subordinates.

Minimum Qualifications:

At least college level (or vocational school graduate) and 5 years experience as a plumber or mechanic or machinist.

Annex D

Sample Job Description: Bookkeeper

Job Title: Bookkeeper

Job Summary:

Under general supervision. Maintains complete financial books relative to receipts and disbursements for all utility functions; calculate water bills, Receives cash from customers and maintains billing and collection records.

Typical Duties:

1. Calculates payrolls, customer bills;
2. Maintains uniform system of utility expenditures and income accounts; prepares periodic summaries; maintains balance sheet accounts;
3. Receives cash utility accounts and receipts same;
4. Reconciles daily transactions to cash received;
5. Transfers fund receipts to bank (or to System head) and secures receipts thereof;
6. Other duties that may be assigned from time to time.

Ability to:

Maintain double entry system of bookkeeping, perform financial computation and deal amiably with the public.

Minimum Qualifications:

Bachelor's degree in Commerce or related field plus at least 1 year experience in similar functions.

Annex E

Sample Job Description: Manager

Job Title: Manager

Job Summary:

Directs the operating staff in accomplishing their functions; makes policy proposal to Board; participates in public hearings/assemblies; liaisons with LGU and other government officials.

Typical Duties:

1. Establishes office goals and objectives;
2. Ensures utility records are well maintained;
3. Prepares studies for Board consideration;
4. Makes presentations in public consultations and in other assemblies, public offices, financing institutions;
5. Ensures that the daily collections are secured and maintains daily log thereof;
6. Prepares reports to assemblies and Board;
7. Trains subordinates

Ability to:

Effectively supervise and evaluate personnel and performance, prepare reports for various stakeholders; operate system facilities

Minimum Qualifications:

Bachelor's degree in a utility related course with at least 2 years in a supervisory position.

Annex F
Staff Development & Training

F-I BASIC KNOWLEDGE (FOR ALL STAFF)

1. Utility Mission
2. Structure/Function
3. Utility Rules/regulations
4. Personnel Rules
5. Basic Public Relations

F-II REQUIREMENTS FOR SUPERVISORS

1. Roles and Functions of Supervisors
2. Interpersonal Relationship
3. Problem Solving
4. Budgeting process
5. Systems and procedures of the Utility

F-III BASIC OPERATOR REQUIREMENTS

1. Utility Mathematics
2. Pressure and Head Loss
3. Chlorination
4. Basic Plumbing
5. Maintenance Practices
6. Types of Valves. Pipes, Meters
7. Pump Characteristics
8. Troubleshooting
9. Basic Electricity

F-IV TRAINING OPTIONS

- Formal Training Programs
- (LWUA, DILG, Water Districts, Professional organizations, etc)
- One on one with an advisor or expert
- On the Job Training (OJT) in own or other utilities
- Structured Observation Tours
- Vocational Schools or Short Term Courses

Annex G

Monthly Operational Report

For the month ending ___________

1.0 WATER COVERAGE DATA

Connections	No.	Type of Connection	No.	Population Served(No.)
a) Total metered (functioning)		d) Domestic		
b) Total metered (defective)		e) Commercial		
c) Total unmetered		f) Standposts		
		g) Bulk		
TOTALS	h)		i)	j)

$$\% \, population \, served = \frac{population \, served(1.0j) \times 100}{total \, population}$$

2.0 WATER AVAILABILITY DATA

Hrs Available/day	Ave hrs (1)	Est'd Connections (2)	(3) = (1) x (2)
24	24		
> 18 to < 24	21		
> 12 to 18	15		
> 4 to 12	8		
< 4	2		
Total			

$$Water \, Availability = \frac{Col\ (3)\ Total}{Col\ (2) Total} = \_\_\_\_\_\_ hrs$$

3.0 FINANCIAL DATA (PHP)

3.1	Billings	This Month	Year-to-date (YTD)
a)	Current metered		
b)	Non-metered		
c)	Penalty charges		
d)	Billing adjustments		
e)	Others		
	TOTALS		
3.2	Collections		
a)	Current accounts		
b)	Arrears (current year)		
c)	Arrears (prior years)		
	TOTALS		
3.3	$Collection\ efficiency = 100 \times (3.2a + 3.2b) YTD / 3.1\ YTD\ Total = \%$		
$Colelction\ ratio = 100 \times 3.2\ YTD\ Totals / 3.1\ YTD\ Totals = \%$			

4.0 FINANCIAL DATA

		This Month	YTD
4.1	**Revenues**		
a)	Operating		
b)	Non-operating		
	TOTALS		
4.2	**Expenses**		
a)	Salaries and wages		
b)	Pumping costs		
c)	Chemical costs		
d)	Maintenance		
e)	Other O&M		
	TOTALS		
f)	Depreciation + Interest		
4.3	**Operating Ratio**[25]		

5.0 WATER PRODUCTION DATA (m^3)

5.1	Water Sources	Number	Total Capacity m3
	Wells		
	Springs		
	Surface		
5.2	Water Production	This Month	Year to Date
	Pumped		
	Gravity		
	TOTALS		
5.3	Accounted Water Used		
a)	Metered Billed		
b)	Unmetered Billed		
c)	Total Billed (5.3a + 5.3b)		
d)	Estimated Emergency Uses		
e)	Water Maintenance		
f)	Total Accounted (5.3c+5.3d+5.3e)		
5.4	Total Production Cost =	4.2 Total / 5.2 Total	=
5.5	Operating Revenue/Billed Volume (4.1/5.3) =		

[25] 4.2 Total / 4.1 Total

6.0 WATER USE ASSESSMENT

		This Month	YTD
a)	**Domestic consumption (house connections + standpipes) m^3**		
b)	Average per capita consumption		
c)	Revenue Producing Water (%) (5.3c x 100)		
d)	Accounted-for water (%) [5.3f x 100]/5.2 Totals		

7.0 WATER QUALITY BACTERIOLOGICAL

a) Required no. of samples ______________
b) Total Samples taken ______________
c) No. of Negative Results ______________
d) *Percentage Negative* ______________

8.0 MISCELLANEOUS DATA

8.1 Employees

a) Total ______________
b) ***Total Employee / 000 Connections***: ______________

9.0 CUSTOMER SERVICE

a) Connection Requests this month ____________
b) Feasible connection request ____________
c) Connection Request backlog ____________
d) Connections made this month ____________
e) % connections made (9d / 9b+c) x 100 ____________
f) No. of Customer Request/Complaints ____________
g) Complaint & Request Backlog ____________
h) Requests/Complaints Resolved ____________
i) $\% \ \boldsymbol{Resolved} = \frac{\mathbf{9h}}{\mathbf{9f+9g}}$

Annex H
Business Plan Contents

H-I UTILITY PROFILE:

1. General information: This is used to give some information on the utility to the reader.
2. Asset Register: This is a list of assets currently owned by the utility.

H-II BUSINESS PLAN DETAILS

1. Target Service Levels: This is to present the existing service levels of the utility and the performance targets or planned service level targets within the 5 year period. Service levels pertain to area coverage, water quality, continuity of supply, pressure and sewerage services, if any.
2. Demand/ Supply Projections: This contains an estimate of the projected demand as well as how the utility will be able to meet such demand. Any project needed to meet the demand and distribution requirements should either be presented in the list of projects or in the capex account in the cash flow.
3. Capital Projects: This lists the major projects of the utility and the funding source for each project. In case of presenting such project/s to a proposed funder, the feasibility study for the project may be attached for reference.

H-III CASH FLOW

1. Proposed Tariff Structure: There should be the calculations showing how the proposed tariff structure was derived.
2. Projected Key Performance Indicators: This gives the utility targets as well as providing a monitoring tool or a benchmark for the utility to determine its progress or performance.
3. Projected Financial Statements: This pertains to the projected Income Statement and Balance Sheets.

Annex I

Sample Application/Service Contract[26]

The undersigned hereinafter referred to as APPLICANT hereby applies for a water service connection, size XX located at ______________ from SSWP, herein referred to as the UTILITY and agrees to the following:

1. The applicant will pay the Utility the sum of PHP______ as service application fee and the sum of PHP_______ representing two months non-interest bearing guarantee deposit or the aggregate sum of PHP_____.

2. The applicant will, when water becomes available, purchase from the Utility all its water needs in the premises as described in paragraph 3, as hereinafter provided, and will pay therefore the monthly rates to be determined from time to time in accordance with the Rules and Regulations of the Utility and in accordance with provision of all laws, however, applicant agrees that the connection will not be made until all charges are paid and the application is accepted or approved.

3. The applicant will cause his premises to be installed with pipe in accordance with the specifications approved by the Utility.

4. The applicant binds to pay the monthly bills promptly and failure to pay the bills within 15 days after the due date, without the need of demand, the utility will be entitled to disconnect the service in which case, the latter will not be held liable for damages.

5. The utility shall not be liable for failure to supply water to said premises under any cause or condition.

6. The applicant will grant the utility the necessary rights and easement to construct, operate, replace and repair and perpetually maintain the facilities within the property owned by the applicant, its line of pipes for the distribution of water and will execute and deliver instrument/s which the utility shall consider necessary for the purpose. All pipes, meters or equipment of the utility installed on the property of the applicant shall, at all times be the sole property of the utility giving the latter the right of access to the property of the applicant to operate, maintain, repair or relocate. On this regard, the applicant is accountable for the water meter.

7. The applicant will not be allowed to take water before the meter and will assume responsibility for all water that passes through the meter.

[26] Adapted from the consumer contracts of SIG in Sta. Cruz, Davao

8. The applicants bind to follow the provisions found in paragraphs C and D, Section 32 of PD 678, quoted as follows:

   "C. Prohibits any persons, firm, or corporation from vending, selling or otherwise, and disposing of water for public purposes within the service area of the utility without permission from the utility where the facilities of the utility are available to provide such service or fixed terms and conditions by permit for such sale or disposition of water.

   "D. Safeguard and protect the use of water. For this purpose, any person who: Installs any water connection without the previous authority from the utility established under this case; tampers water meter or uses jumpers or other devices whereby water is stolen; steals or pilfers water or water meter; or knowingly possesses stolen or pilfered water or water meters, shall upon conviction be punished by prison correctional, in its minimum period or a fine ranging from Two Thousand Pesos (P2,000.00) to Six Thousand Pesos (P6,000.00) or both."

9. Violation by the applicant of any of these mentioned in paragraph 8 hereof, will justify disconnection of the water service by the utility in the same manner as provided in paragraph 4 hereof stated above;

10. That in case of reconnection arising from disconnection, due to any of the causes stated in paragraphs 4 and 8, the latter paragraph being in relation to paragraph 9 hereof, applicant binds himself to pay reconnection fee and guarantee consumption deposit that may be fixed from time to time by the Utility.

11. The acceptance of this application by the Company will constitute an agreement between the Utility and the applicant.

Done in _________________, this _____ day of ___________.

Conforme:

________________________________ ________________________________

(Building Owner) APPLICANT

Accepted by:

____

(SSWP)

Annex J

Conceptual Framework for an Accounting System

J-I BASIC FEATURES

1. Accrual Accounting

   Under this method, all expenses shall be recognized when incurred. All expenses shall be recognized when incurred and not necessarily as disbursed.

2. One Fund Concept

   Regardless of where the funds come from, the system should adopt a one fund system.

3. Chart of Accounts and Account Codes

   A coding structure and a new chart of accounts with a three-digit account numbering system shall be adopted.

4. Books of Accounts

   The Books of Accounts are as follows:

   a. Journals

   - Cash Receipts Journal
   - Cash Disbursement Journal
   - Check disbursement Journal
   - General Journal

   b. Ledgers

   - General Ledger
   - Subsidiary ledgers, where applicable

   c. Cashbooks

   - Cash in Bank
   - Cash advances

5. Financial Statements

   The following financial statements shall be generated:

   - Balance Sheet
   - Income statement
   - Cash flow statement

Annex K
Tariff Design – ROI Method

In this method, there are 2 general steps required. The first is to determine the average tariff and the next step is to design the rate structure. The average tariff is determined by the **Revenue Requirements (RR)** divided by the volume sold on an annual basis.

$$RR = OPEX + DEP + MaxNI$$

Where: OPEX = operational expenses + 2 months working capital

Dep = depreciation expense

MaxNI = Maximum Net Income which is 12%

K-I DETERMINING REVENUE REQUIREMENTS

The following are the specific steps to arrive at the Revenue Requirements. While some of the box illustrations cover only 3 years for clearer illustrations, the reader is advised to cover a 5 year period.

1. Service Levels

Tariffs are based on levels of service established in consultation with the customers or the community. The first page of the tariff proposal will set these goals as shown below:

Table AK.1: Service Levels

		Years				
SERVICES	**EXISTING**	**1**	**2**	**3**	**4**	**5**
No. of Connections						
Area of Coverage						
Supply Continuity[1] (no. of hrs.)						
Average[1] Pressure						
Water[2] Quality						

Note: 1 Average supply hours/pressure pertains to at least 80% of connections

2 Pertains to physical/chemical parameters that consistently are above the PNDWS

2. Demand/Supply Projections

Projections have to be made on the number of connections. It will be necessary to project the new connections that can be attained during the next 5 years broken down by customer category.

Once the demand for water has been determined, the next step is to check whether the utility has enough water to serve them.

Table AK.2 shows the items to be filled up. Table AK.2 ensures that the utility matches the demand with the supply requirements. Steps are the following:

Table AK.2: Demand/Supply Projections						
	YEAR:					
DEMAND	**0**	**1**	**2**	**3**	**4**	**5**
New Connections						
Total Connections						
Ave. Person/Connection						
Pop Served						
Ave Consumption/Conn/month						
Vol Sold/Year						
SUPPLY	**0**	**1**	**2**	**3**	**4**	**5**
Installed Production Capacity						
Percent (%) NRW						
Production Requirements ($\mathbf{m^3}$/yr)						
Bulk Water Purchase ($\mathbf{m^3}$/year)						
WD Production ($\mathbf{m^3}$/year)						
Water Surplus/Shortage/Year						

If there is a water supply shortage, the utility can do any of the following options:

- Limit growth of connections
- Ration water
- Reduce non-revenue water
- Increase its production capacity, i.e., new source, bulk supply

3. Capital Expenditures

If the utility has to spend money to improve its source capacity the disbursements are called capital expenditures. The utility has to determine the projects to be done and determine the cost estimates for each one.

A list of projects and the total costs (Table AK.3) is an output of this step.

Table AK.3: Major Capital Projects		
Project Name / Funding Source	Major Components	Cost

4. Determine OPEX

Once the demand and supply have been established, operating expenses to support them will now have to be calculated. Items that can be classified under Opex are the following:

- Personnel: cost of salaries, allowances and other benefits
- Management Fees: These are costs incurred when some services are outsourced like consultancies, accounting, collections, etc and are covered by a contract.
- Power: Electric bills or fuel costs
- Chemicals: For chlorine and other chemical costs
- Bulk Water Purchases: Costs to procure bulk water
- Repairs and Maintenance: Costs incurred to keep the assets in good condition
- Bad debts: These represent accounts which can no longer be collected. Normally, this should not be more than 2% of water revenues.
- Annual Water Charge: This is NWRB's fees based on the water permit.
- Regulatory Costs: These are costs paid to regulatory agencies for the necessary licenses, permits and other regulatory charges.
- Meeting Costs: These are costs incurred during Board meetings and for Board per diems
- Gen Admin Costs: All other expenses related to the operation of the utility not included in the other categories.
- Depreciation: This is the depreciation expense for all assets whether entitled to return or not.
- Taxes: Includes franchise, value-added and any other tax except income tax.

5. Calculating Depreciation Expense

To get the depreciation expense, it is necessary to have an Asset Register (Table AK.4) and a list of Projects detailed under section C above. The Asset Register can give us the depreciation expense and net book value for the current assets listed in it while the table of Proposed Projects can give us the depreciation expense for the proposed projects.

Table AK.4: Asset Register

	No.	Life	Year Acquired	Expired Life	Acquired Cost	Dep Exp	Acc Dep	Net Book Value
	a	b	c	d	e	f=e/b	g=f x d	h=e-g
Land								
Deepwell/Pumphouses								
Deepwells		15						
Pump and Motor		8						
Motor Controls		7						
Pumphouse		40						
Booster Station								
Pumphouse		40						
Pump and motor		20						
Motor Controls		20						
Reservoir								
Concrete Reservoir		40						
Steel Tank		30						
Impounding Structure/Dam		50						
Treatment Plant								
Structure		40						
Equipment/Controls		15						
Pipelines								
Steel Pipes		40						
PVC/PE pipes		30						
Service Connections		7						
Valves/flow meter		30						
Fire Hydrants		20						
Building/Improvements		40						
Office Furniture/fixtures		10						
Office Equipment		5						
Vehicles		5						
Tools/Equipment								
Chlorinating Equipment		10						
Inventory								
Total Property and Equipment								

6. Property and Equipment Entitled to Return (PEER).

Depreciation, however, pertains only to the Property and Equipment Entitled to Return (PEER). The PEER are those assets in service that are directly used in the operations of the water system and were funded by the owner's own funds, a loan, or internal cash generation. Assets funded by a loan are entitled to return but interests thereon are not entitled to return. A return on assets is provided to compensate the utility for the risks involved and the cost of money invested. As such, assets that have donated or turned over or are recovered via other ways other than water sales are not entitled to return.

7. Calculating Maximum Allowable net Income (MaxNI)

The MaxNI is defined below and is illustrated in Table AK.5. The MaxNI is defined as 12% ROI and is calculated as follows:

$$MaxNI = 0.12 \times (2\; months\; Working\; Capital + Net\; book\; value\; of\; PEER)$$

Table AK.5: Maximum Net Income

	Year 1	Year 2	Year 3
Beg: Property/Equipment	2,000,000	3,000,000	3,200,000
New Investments	1,000,000	200,000	400,000
Total Assets Entitled to Return	3,000,000	3,200,000	3,600,000
Less: Accumulated Depreciation	(200,000)	(250,000)	(300,000)
Net Book Value	2,800,000	2,950,000	3,300,000
Add: working capital 2 months average cash opex	240,000	250,000	260,000
Total Capital Entitled to Return	3,040,000	3,200,000	3,560,000
Max Rate of Return	0.12	0.12	0.12
MaxNI	364,800	384,000	427,200

8. Revenue Requirements (RR) and Average tariff

The RR are the costs of service to be derived from the water rates and is obtained by adding the annual Opex + Depreciation expense for that year and a maximum net income allowed.

$$RR = OPEX + Dep + MaxNI$$

Table AK.6 illustrates the computation for revenue requirements.

Table AK.6: Computation for Revenue Requirements

	Year 1	Year 2	Year 3
Max Net Income	364,800	384,000	427,200
Opex	1,440,000	1,500,000	1,560,000
Depreciation Expense	480,000	600,000	600,000
Revenue Requirements	2,284,800	2,484,000	2,587,200
Volume Sold, m^3	180,000	200,000	220,000
Required Average Tariff/m^3	12.69	12.42	11.76

K-II RATE STRUCTURING PROCESS

The water rate structure comprises two parts: the minimum charge and the commodity charge. The minimum (or service) charge covers a volume assumed to be enough for the basic needs of a low income user. The charge should not exceed 5 % of the family income of the low income group within the community served.

The commodity charge is the amount to be charged per cubic meter beyond the minimum charge.

1. Compute for Equivalent Volume

$$EV = Consumption\ in\ the\ quantity\ block \times connections\ for\ the\ meter\ size \times meter\ size\ factor$$

To be able to compute for the EV, Quantity Blocks and meter size factor are required. These are shown in Table AK.7 and Table AK.8.

Table AK.7: Quantity Blocks

Quantity Blocks	Range in m^3	Factor
Residential		
Service Block (min charge)	0 – 10	Base factor = 1
2nd Block	11 – 20	1.25
3rd Block	21 - 30	1.50
4th Block	31 – 40	1.75
5th Block	Over 40	2.00
Commercial/Industrial		
Service Block	0 – 25	Base factor = 2
2nd Block	26 – 1000	2.5
3rd Block	Over 1000	3.0

The incremental factor may be determined by the utility depending on the interval it wants between the quantity blocks. Examples of incremental factors (3rd column) are shown in Table AK.7.

The meter size factor (Table AK.8) is a multiplier applied to the consumption of a quantity block to determine its equivalent volume. These factors assume that with a higher meter size come higher initial and maintenance cost and more convenience to the consumer so that the consumers must pay a higher rate commensurate to their meter size.

Table AK.8: Meter Size Factor

Meter Size	Residential	Commercial/Industrial
1/2 "	1.0	2.0
¾"	1.6	3.2
1"	3.2	6.4
2"	20	40

2. Determine Cost per Equivalent Volume

$$Cost\ per\ EV = \frac{Annual\ Revenue\ Requirements}{Total\ Equivalent\ Volume}$$

3. Determine Tariff Rate

Compute the tariff rate for the quantity block of each consumer category by multiplying cost per EV x incremental factor.

References

1. Asian Development Bank. (n.d.). *Public Consultation and Information Disclosure.* ADB.

2. Cortez, M., Orda, E., Elvas, L., Mendoza, A. M., & Salas, S. M. (2010). *Guide to Ring-Fencing of Local Government-Run Water Utilities.* World Bank Water and Sanitation Program (WSP) and Public-Private Infrastructure Advisory Facility (PPIAF).

3. Department of Public Works and Highways. (1991). *Water Supply Manual.* Bureau of Research and Standards, DPWH.

4. Department of the Interior and Local Government, NJS Consultants, CEST, Inc., & TEST Consultants, Inc. (2007). *Upgrading Guidelines: Rural Water Supply and Sanitation Project Phase V.* DILG.

5. Hart, W. (2003). *Protective Structures For Springs: Spring Box Design, Construction and Maintenance.* School of Forest Resources & Environmental Science, Michigan Technological University.

6. Local Water Utilities Administration. (1994). *Manual on Water Rates & Related Practices.* LWUA.

7. Local Water Utilities Administration. (n.d.). *Commercial Practices Manual for Water Districts* (Vol. II). LWUA.

8. National Water Resources Board, Asian Development Bank, & IDP Consult, Inc. (2005). *Primer on Water Tariff Setting and Regulation.* NWRB, & ADB.

9. National Water Resources Board, Asian Development Bank, & IDP Consult, Inc. (2005). *Tariff Model for Private Water Utilities Regulated by the National Water Resources Board: User's Manual.* NWRB, & ADB.

10. National Water Resources Council. (1979, March). *Rural Water Supply: Design Manual, Volume 1.* NWRC.

11. National Water Resources Council. (1980). *Rural Water Supply: Construction and Installation Manual* (Vol. II). NWRC.

12. National Water Resources Council. (1981). *Rural Water Supply: Operation and Maintenance Manual* (Vol. III). NWRC.

13. US Army Corps of Engineers, Afghanistan Engineer District. (2009). *AED Design Requirements: Chlorinators.* US Army Corps of Engineers, Afghanistan Engineer District.

14. Workers' Compensation Board of British Columbia. (2002, 2006). *Chlorine Safe Work Practices.* WorkSafeBC.

15. World Health Organization. (1994). *Operation and Maintenance of Urban Water Supply and Sanitation Systems: A Guide for Managers.* WHO.

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