OPERATION AND MAINTENANCE MANUAL

San Vicente Street, Poblacion 1, Carcar City, 6019 Cebu
Phone: (032) 487 8500
Fax: (032) 487 8525
Email: info@carcarwaterdistrict.com
Web: www.carcarwaterdistrict.com

TABLE OF CONTENTS

Operations and Maintenance Manual

Appendices

A. Preventive Maintenance Log
   1. Daily Operational Duties and Preventive Maintenance
   2. Weekly Operational Duties and Preventive Maintenance
   3. Monthly Operational Duties and Preventive Maintenance
   4. Quarterly Operational Duties and Preventive Maintenance
   5. Annual Preventive Maintenance
   6. Exercise of Mainline Valve Log
   7. Exercise of Hydrants Log
   8. Flushing Distribution Line Log
   9. Flushing Dead End Log
   10. Valve Card

B. Approval Page

SECTION I - WD GENERAL INFORMATION

1.0 WATER DISTRICT PROFILE

Name of Company: CARCAR WATER DISTRICT

A government-owned and controlled corporation (GOCC) created under PD 198 commonly known as the Provincial Water Utilities Act of 1973. Its purpose is to acquire, install, improve, maintain and operate water supply and distribution system for domestic, commercial, industrial, and municipal uses for residents within the boundaries of the City of Carcar, Cebu.

Date Created: March 1980

Conditional Certificate of Conformance No. 117

Water District Category: Category B

Present Served Barangay:

Poblacion 1	Bolinawan
Poblacion 2	Ocana
Poblacion 3	Tuyom
Can-asujan	Napo
Guadalupe	Perrelos
Liburon	Valladolid

Governing Body:

The Board of Directors (BOD)
The BOD exercises and performs all the powers, privileges and duties of the Water District through the establishment of policies.

Management:

The General Manager (GM)
The GM of the Water District has the full supervision and control of the operation and maintenance of the water district facilities and has the power to appoint all personnel of the water district.

Regulatory Bodies:

Local Water Utilities Administration (LWUA)
National Water Resource Board (NWRB)
Department of Budget and Management (DBM)
Civil Service Commission (CSC)
Commission on Audit (COA)
Bureau of Internal Revenue (BIR)

2.0 Organizational Structure

Board of Directors

Chairman:	Atty. Democrito C. Barcenas
Vice Chairman:	Engr. Marcelo P. Cabalquinto
Secretary:	Danilo A. Ledesma
Member:	Alexis Y. Trinidad
Member:	Mercucio R. Tangkay

General Manager
Engr. Edward L. Remo

Administrative and Human Resource Division
Atty. Hervy A.B. De Dios

Finance Division
Josefa SN Manugas

Commercial Division
Ruby Angelica C. Galicano

Engineering and Operations Division
Engr. Henry A. Cui

3.0 Basic Information on WD Operation (as of November 2015)

Number of Employees	73	nos
Ratio of Connection per Employee	176	
Average Monthly Salary per Employee, P	16,297.25	P
Total Number of Active Service Connections	12,837	nos
Number of Domestic Connection	12,004	nos
Number of Commercial Connection	715	nos
Population Served	71,675	nos
Sources of Supply		
A. Spring Sources	3	nos
B. Deep Wells	8	nos
C. TOTAL	11	nos
Average Monthly Production	319,232	cu.m
Average Monthly Billed Water	264,487	cum
Unaccounted for Water	17.1	%
Average Monthly Consumption per Connection	21	cu.m
Average per Capita per Day Consumption	143	lpcd

Table 1.1 -Basic Information on WD Operation

SECTION II - INTRODUCTION

2.0 GENERAL

This **Operations and Maintenance Manua**l is intended to be the guide and reference for use by the operators, supervisors, managers and directors of the Carcar Water Districts and by other stakeholders of the water system. The main purpose is to assure efficient and continuous operation of the water supply system with outmost task of delivering safe and potable water at adequate quantity and pressure.

Covered by this manual are all aspects relating to the operation and maintenance of Carcar Water Supply System including water quality monitoring, and leak detection program.

This manual will set the standard in the operating conditions, limits and target outputs of the water system. As such, this manual should be updated whenever operational level and conditions changes that warrants an upgrade.

This manual was primarily based on the Rural Water Supply Manual as published by The World Bank Office in Manila for the purpose of providing the water providers in the Philippines the guiding principles in the operation and maintenance of a water system. It includes best practices and management principles to be adopted to attain viability and sustainability of water supply utilities in the Philippines.

2.1 OBJECTIVES OF OPERATION AND MAINTENANCE

Operation of a water system requires that all facilities, equipment and personnel are all functioning properly at any given time and delivering the required capacity and quality of water for the concessionaires.

An operating procedure are activities carried out with specific instructions. The procedure defines who will be responsible in the conduct of an activity, when will the activity be conducted, what resources are required and the prerequisite activities to complete the said procedure.

Maintenance is keeping the facilities, plants, and equipment in good working condition. Preventive maintenance and corrective maintenance are tasks to extend the usefulness of the facilities. The goal of maintenance is to avoid or minimize the consequences of facilities failure.

Improper operation and lack of maintenance of water supply system facilities leads to high cost of operation, high water losses, early deterioration and disfunction of the system facilities.

2.2 NECESSITY OF OPERATION AND MAINTENANCE MANUAL

This Manual on Operation and Maintenance of the Water System has long been a necessity of the Carcar Water District to institutionalize the operation and maintenance of its water system. By using this manual as a guide, and keeping this updated, the WD and its personnel will truly benefit in the ease of operation of the system and will assure every facilities of the system is given the required maintenance.

The manual will likewise determine the level of spare parts required to guarantee availability of stocks particularly during emergencies.

2.3 STRATEGY FOR AN EFFICIENT O&M

For an efficient and effective operation, the WD should adopt, aside from this O&M Manual, a water safety plan and service improvement plan.

Water Safety plan should ensure that water supplied by the WD is of good quality at all times. The focus is on how to protect the water and its sources from contamination. The quality test at the end of the pipelines should provide the WD an indication of how effective is their water safety management.

Service improvement plan focuses on the best commercial practices in service application requests, standard procedure in dealing with complaints and concerns of customers, and billing and collection procedures.

SECTION III - GENERAL DESCRIPTION OF OPERATION

3.0 GENERAL

The water system of Carcar Water District can be considered as a complex system composed of a main system and six independent sub-systems but are somehow interconnected with the main system of the city proper.

The main system serves the city center which covers Brgy. Poblacion I, Poblacion II, Poblacion III, Valladolid, Liburon, Bolinawan, Tuyom, and Perellos. Its main water source is the Mabugnao Spring located about 15 kms West-Northwest of the city center.

The six sub-systems are the following:

System	Source	Service Area
Venancia System	Venancia Spring	Elevated areas of Poblacion I and II
Napo System	Kabituhan Spring	Brgy. Napo and Ocana
Magsipit System	Magsipit Deepwell Bahabaha Deepwell San Roque Well	Sitio Magsipit and Upper Perrelos
Can-asujan System	Canasujan Deepwell LAngub Deepwell	Brgy. Can-asujan
Maximina System	Maximina Well	Sitio Maximina
Guadalupe System	Venancia Spring	Part of Brgy Guadalupe

Figure 3.1 shows the layout of the seven systems and Figure 3.2 presents the schematic diagram.

3.1 SYSTEM OPERATION

1. Main System/ Mabugnao Spring

The Mabugnao Spring has a capacity of 240 lps but only about 80 lps is diverted for drinking water supply system. The spring is enclosed in a concrete intake box and the area is enclosed by cyclone wire fence for security.

Water from Mabugnao Spring flows by gravity to the demand center through the 300mm transmission main. The supply is reinforced by Bahabaha pumping station in Brgy. Liburon and by another pumping station in Upper Perrelos. It has a twin 500 cum concrete ground reservoir in Brgy. Tuyom and a 250mm reservoir in Brgy Bolinawan.

For disinfection purposes, a hypochlorinator is installed on the transmission main near the intake box . For flow rate and flow totalizer measurement, a digital flowmeter is installed along the transmission line. A number of air release valves and blow-off assemblies can be found along the transmission main.

The Bahabaha Pumping Station is directly connected to the main distribution line. Its operation is limited to peak hours only as its purpose is to augment supply to the main system during high demand. The pump is shut-off when the Tawog reservoir started filling-up.

With the Tawog storage tanks and Bolinawan tank located beyond the demand center, the tanks are floating on the line with a single inlet/outlet pipe.

Figure 3.3 shows the layout of the transmission pipelines from Mabugnao Spring and Figure 3.4 shows the pipeline elevation profile.

2. Venancia Spring and Transmission Line

The Venancia sub-system utilizes the Venancia Spring in Brgy. Guadalupe as its water source. It provides water to the elevated areas of Poblacion I and II through a 100mm transmission mains. The transmission line is interconnected to the main distribution system at the city center, however, a normally closed valve prevents water of Venancia to flow to the city proper. Opening this valve will create low pressure in the elevated areas.

The Venancia Spring has a discharge capacity of 12 lps but only 6 lps is diverted for water supply. It is enclosed in a concrete structure which was previously used as a pool. The area of the pool is about 6m wide by 12m long and with a depth of 1.2m. The pool, which was converted as an intake box is covered by GI roofing on steel roof frame.

The whole area is fenced with cyclone wire for security. A hypochlorinator is installed within the facility.

Air release valves and blow-off valves are installed along the transmission line.

3. Guadalupe System

The Venancia Spring also serves the Guadalupe sub-system which covers some areas of Barangay Guadalupe. A submersible pump was installed at the intake box and lifted the water to a tank in Sitio Venancia. Water then flows by gravity to the service area of Brgy Guadalupe.

4. Kabituhan Spring and Transmission Line

Kabituhan Spring serves Brgy Napo and Ocana. Water flows by gravity to a 120 cum reservoir located in Napo before distribution to the demand center of Napo and Ocana.

The supply is augmented by the Ocana deepwell pumping station which is directly connected to the distribution pipelines of Ocana. The main distribution line is also connected to the main system of Poblacion.

5. Magsipit System

The elevated area of Sitio Magsipit in Liburon is served by another sub-system (Magsipit sub-system) which derives water from Magsipit deepwell pumping station. The Bahabaha pumping station also provides additional water to Magsipit system during off-peak hours (during peak hours, it serves the main system). Water from both wells are diverted to a 120 cum reservoir before distribution to Sitio Magsipit and Upper Perrelos area. The San Roque pump station, which utilizes a shallow well as source, also adds supply to the system.

6. Canasujan System

Another system, the fifth, is serving the Can-asujan area. The Can-asujan system takes its source from Can-asujan deepwell and diverting it to a high level reservoir. Supply is augmented by the Langub deepwell where water is pumped directly to the reservoir.

7. Maximina System

A small system serving Sitio Maximina in Poblacion III is operating independently. The system has its own deepwell source and a reservoir.

3.2 THE WATER SOURCES

The Carcar Water District draws its water from the three spring sources and six deepwells. The combined production capacities of these sources total to 11,923 cum/d (138 lps). Mabugnao Spring has the highest production share (58% of the total) with a capacity of 6,900 cum/d (80 lps) as shown in the following table.

Water Sources	Capacity
Mabugnao Spring	75 lps
Venancia Spring	7.3 lps
Kabituhan (Napo) Spring	5.6 lps
Baha-baha Deepwell	40 lps
Canasujan Deepwell	2.1 lps
Ocana Deepwell	19 lps
Perellos Deepwell	1 lps
Magsipit Deepwell	6.7 lps
Maximina Deepwell	0.87 lps
San Roque Well	2.5 lps
Langub Deepwell	4.5 lps
TOTAL	164.57 lps

The location of water sources of the water district is shown in Figure 3.3.

3.3 TRANSMISSION PIPELINES

The transmission pipelines from the water sources of Carcar WD to the reservoirs or to the demand center are broken down in the following table.

Source	Size (mm)	Length (M)	Material
Mabugnao	300	4,847	Steel Pipe, CLSP
	250	1,250	Steel Pipe
Bahabaha	250	580	PVC Pipe
Venancia	100	2,950	GI Pipe
	100	1,484	PVC Pipe
Napo	100	1,170	PVC Pipe
Magsipit	150	451	PVC Pipe
	100	179	PVC Pipe
Can-asujan	100	89	PVC Pipe
Langub	100	270 / 30	PVC Pipe / GI Pipe

Ocana	150	48	PVC Pipe
Venancia Booster	100	423	GI Pipe
	100	133	PVC Pipe
Maximina	50	300	PVC Pipe

3.4 RESERVOIRS

Carcar WD has 7 reservoirs and three of which, the two Tawog reservoirs and the Bolinawan reservoir are floating on the line.

Location	Capacity	Description	Dimension
Tawog (Tuyom) Reservoir	2 units 500 cu.m	Circular Concrete Ground	D13.0m , H4.0m
Bolinawan Reservoir	250 cu.m	Circular Concrete Ground	D8.0m, H5.0m
Napo Reservovir	120 cu.m	Rectangular Concrete Ground	W5mxD5mxH5m
Magsipit Reservoir	120 cum	Concrete Ground Reservoir	W5mxD5mxH5m
Can-asujan Reservoir	120 cu.m	Concrete Ground Reservoir	W5mxD5mxH5m
Maximina Reservoir	20 cum	Concrete Ground Reservoir	W3mxD3mxH3m
Venancia Reservoir	120 cu.m	Concrete Ground Reservoir	W5mxD5mxH5m

The location of the reservoirs is indicated in Figure 3.3.

3.5 DISTRIBUTION SYSTEM

The Water District has distribution pipelines that run along the major roads of the city with pipe sizes that ranges from 50mm to 300mm in diameter. Most of their pipes are of PVC material particularly the sizes from 50mm to 250mm in diameter. .

Table 3.1 shows the breakdown of pipelines of the distribution system of CWD.

	250mm	200mm	175mm	150mm	100mm	75mm	50mm
Main System	3,360	12,904	1,363	7,717	11,611	18,807	30,638
Venancia					1,204		3,892
Napo				308	257	1,708	2,277
Magsipit-Can-asujan				204	4,496	715	9,364
Saay Can-asujan					1,884	410	5,226
Total	3,360	12,904	1,363	8,229	19,452	21,640	51,397

As can be noticed in the Figure 3.1, the distribution network of Carcar WD covers most of the road networks of Carcar. This indicates that the distribution system in Poblacion proper is sufficient.

3.6 SERVICE CONNECTIONS

The water district has adopted a meter clustering scheme where a 1” or 2” diameter stand pipe can accommodate 8 to 16 service connection meters. The scheme minimizes direct tapping to the mainline that requires demolition of road pavement.

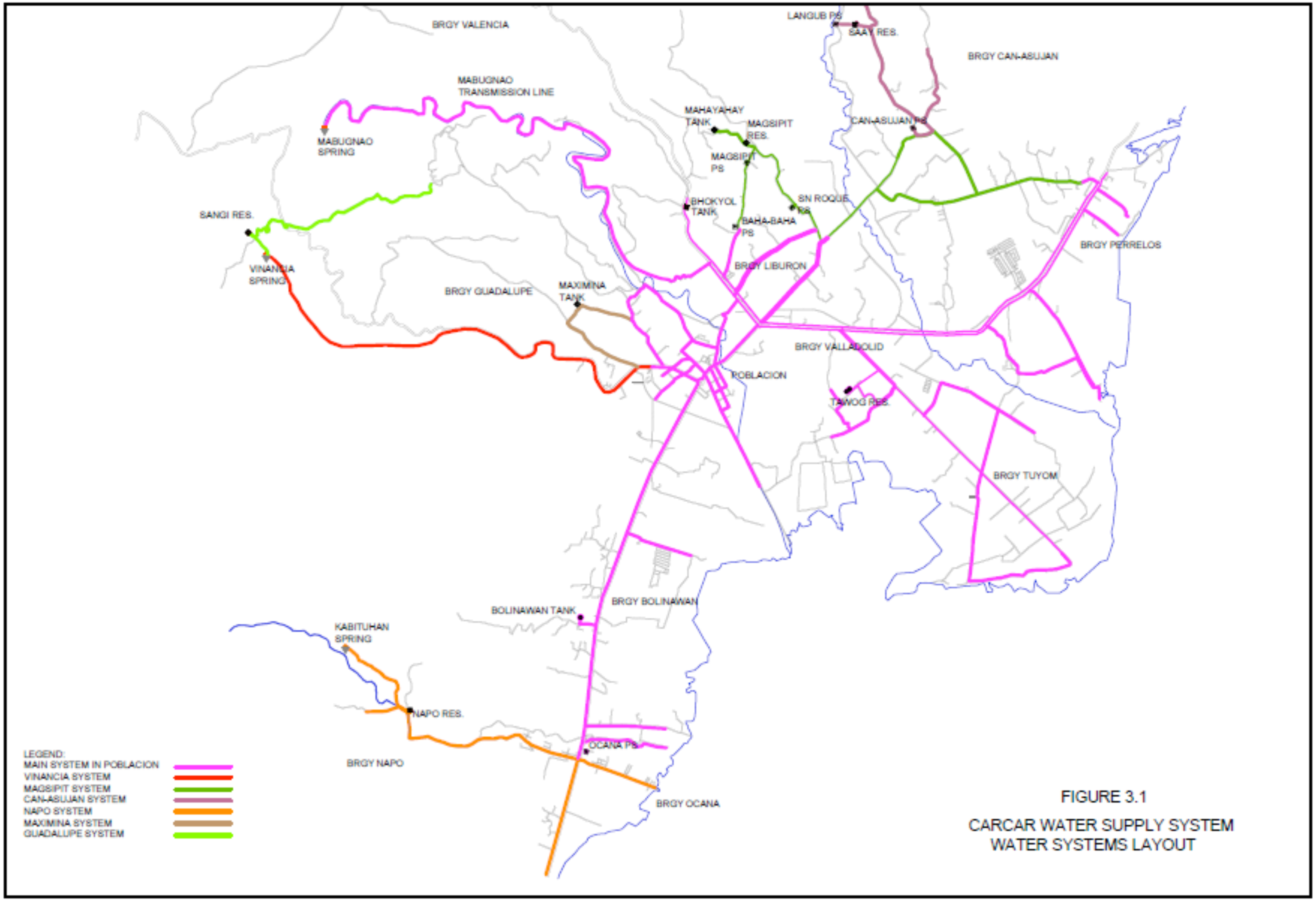
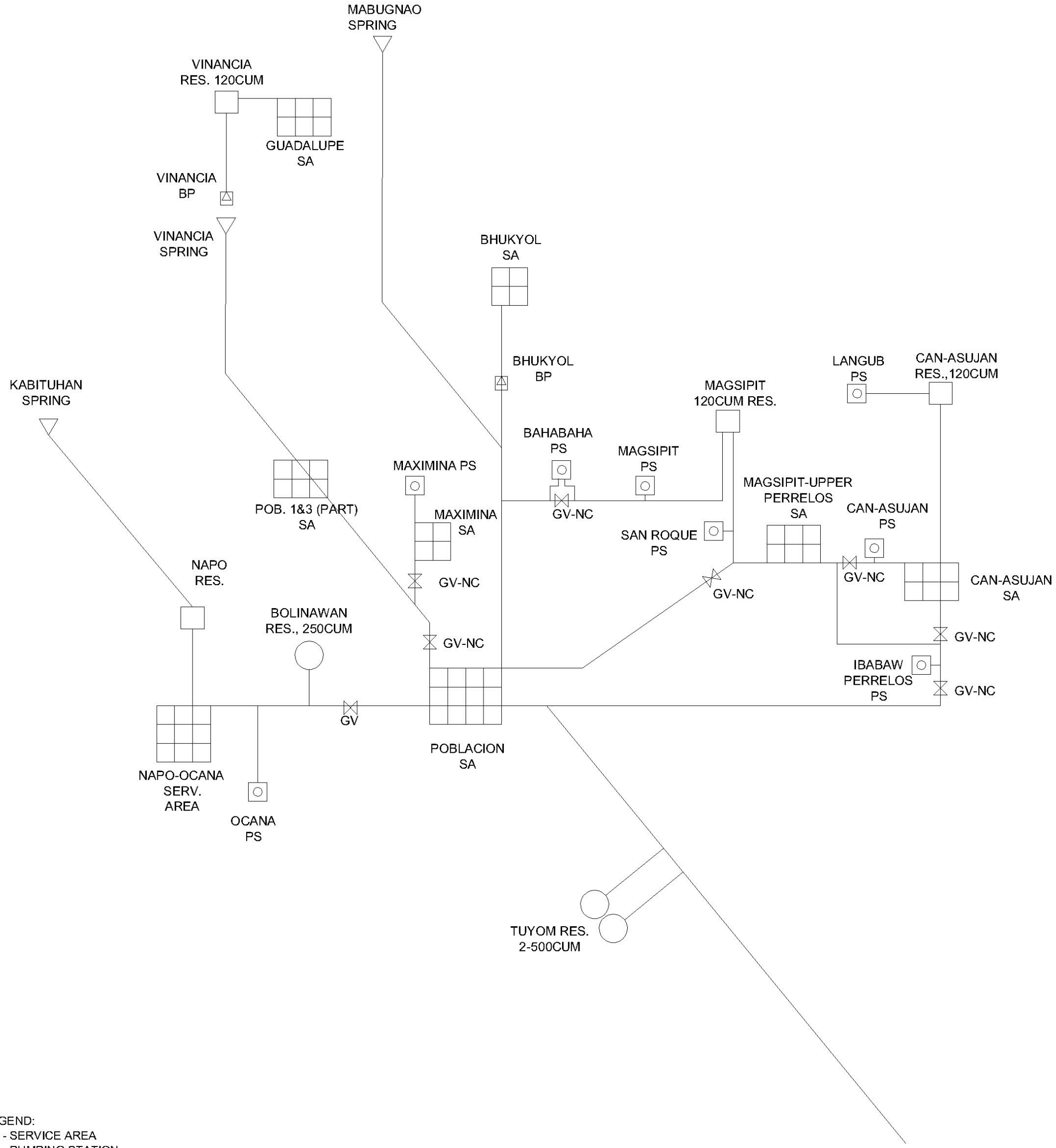


FIGURE 3.1

CARCAR WATER SUPPLY SYSTEM
WATER SYSTEMS LAYOUT



LEGEND:
SA - SERVICE AREA
PS - PUMPING STATION
RES - RESERVOIR/TANK
GV/NC - GATE VALVE NORMALLY CLOSE
BP - BOOSTER PUMP

FIGURE 3.2

CARCAR WATER SUPPLY SYSTEM
SCHEMATIC DIAGRAM

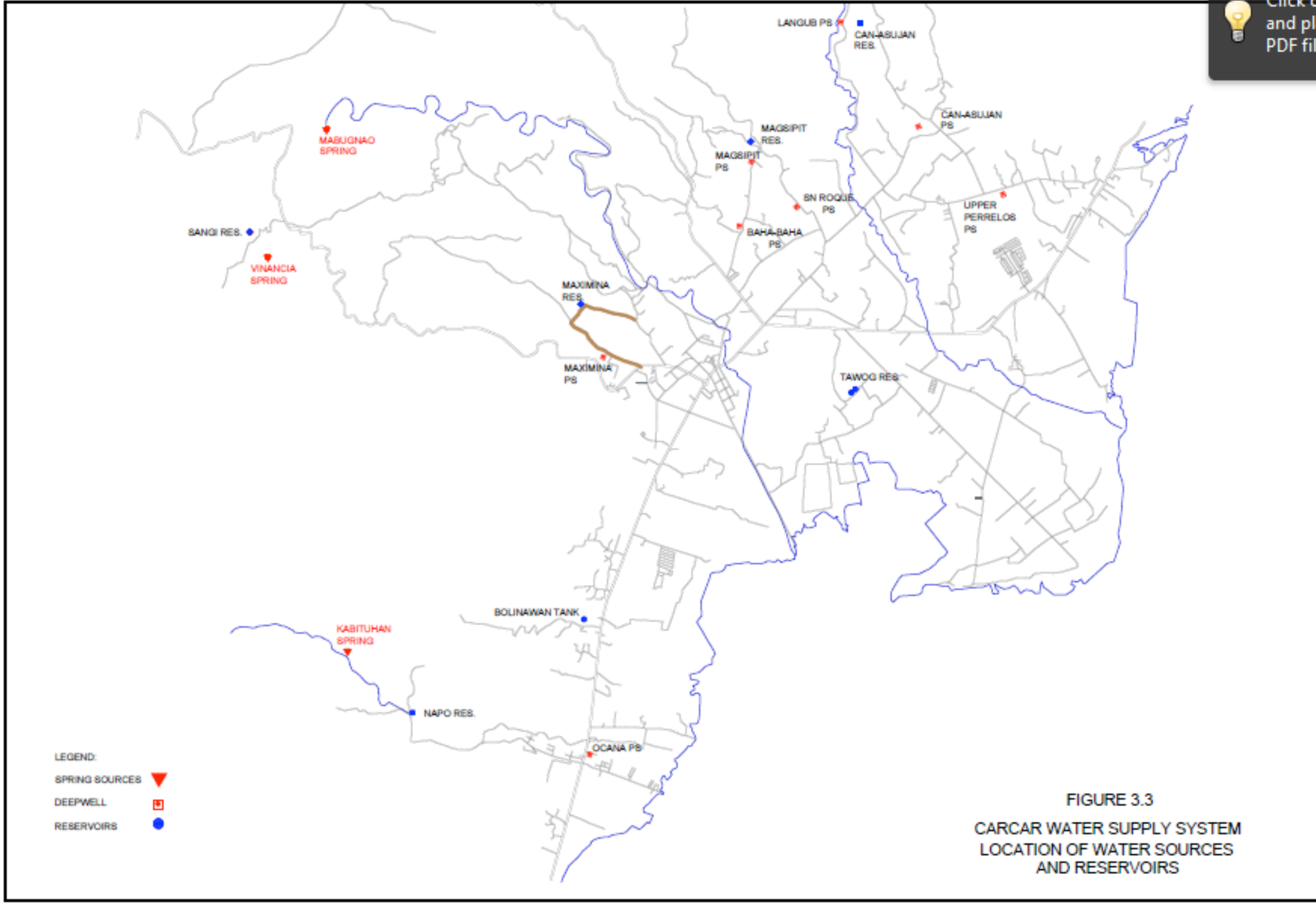


FIGURE 3.3

CARCAR WATER SUPPLY SYSTEM
LOCATION OF WATER SOURCES
AND RESERVOIRS

SECTION 4 - WATER SOURCES O&M

4.1 SPRING SOURCES

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.

4.1.1 Common Spring Box Failures and Remedies

Table 4.1 lists the common causes of failure in the spring box and its surroundings with suggestions for their remedies.

Defect	Remedy
1. Crack or leak.	1. Plug crack or leak with Portland cement mortar.
2. Damaged overflow and vent screen.	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.

4.1.2 Maintenance of Spring Boxes

1. Water quality of the sources should be checked at least once a year; more often if needed.

2. Ensure that surface run-off is diverted 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.

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

4.1.3 Repairing a Spring Box

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

Drain the spring box. Use water pump if necessary.

Mix an appropriate amount of water and cement. Trowel the concrete onto the spring box's cracks and damaged areas on both the inside and outside of the box.

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.

4.1.4 Removing Sediment and Disinfecting the Spring Box

1. Open the valve on the drain pipe, allowing the spring box to drain.

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, add 100 mg/l chlorine 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.

4.2 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.

The following information will be a guide in the operation and maintenance of wells.

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

4.2.1 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 parameters for selecting the pump to be used.

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.

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. 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

b. 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.

c. 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.

d.. 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 – 10	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).

4.2.2 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.

4.2.3 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

SECTION V - PUMPING STATIONS

5.0 PUMPS IN GENERAL

5.0.1 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.

5.0.2 Pump Station Data

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

Form 5.1

Pump No.	
Location	
Date	
A. SOURCE DATA	B. PUMP DATA
Well Casing Diameter	Type:
Well Depth	Brand Model
Well Static Water Level	No Of Stages
Specific Capacity	Pump Setting
Water Quality	Column Pipe Size
Year Drilled	Discharge Head Size
Driller	Supplier
Remarks	Remarks
C. MOTOR DATA	D. CHLORINATOR
Type	Type
Brand/Model	Rated HP
Rated HP @rpm	Brand
Volts/ Amps	Model/Series
Shaft Diameter	Year Installed
Year Installed	
Remarks	Remarks

5.0.3 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.

Date	Time Start	Time Stop	Pressure	Flow		Chlorine Use		KW Reading		Remarks
				Start	Final	Start	Final	Initial	Final	

5.0.4 Pump Operations

The specified O&M procedure and schedule as provided by the manufacturers of pump shall always be followed. However, the following points shall be observed in the operation of the pumping equipment:

1. Avoid dry running of pumps
2. Centrifugal Pumps must be primed
3. Pumps should be operated only within the recommended range of head-discharge. If a pump is operated at a point away from the duty point, the pump efficiency reduces. Likewise, operation near the shut-off point causes substantial recirculation within the pump resulting to overheating.
4. Voltage during operation should be within +10% of rated voltage. Similarly, current should be below the rated current of the motor.

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.

5.0.5 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.

5.1 SUBMERSIBLE PUMPS

5.1.1 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.

5.1.2 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

5.1.3. Common Troubles of Submersible Pumps and Their Remedies

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 wornout 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.

NWRC RWS Volume III, Operation and Maintenance Manual

5.2 CENTRIFUGAL PUMPS

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

5.2.1 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

Steps in Operating Centrifugal Pumps

a. Before starting the motor, make sure that the discharge gate valve is Closed.
b. 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.
c. 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.
d. Start the pump motor.
e. 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.
f. Make a routine check for faults in the operation of the system (abnormal noise, vibration, heat, and odor).

5.2.2 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.

5.2.3 Other Common Problems

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

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.
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.
	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.

5.3 OTHER CAUSES OF PUMP FAILURES

5.3.1 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.

5.3.2 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.

5.3.3 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.

5.3.4 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.

5.4 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.

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.

5.4.1 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 (WB)

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 (WB)

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.

5.5 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.

5.6 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.

5.7 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.

SECTION VI - TRANSMISSION PIPELINES

6.0 GENERAL OBJECTIVE OF TRANSMISSION SYSTEM

The overall objective of a transmission system is to deliver water from the source to the storage reservoirs or directly to the distribution networks.

The objective of O&M of transmission system is to achieve optimum utilization of the installed transmission capacity. Over the years, the Water District has developed operation procedures on the transmission lines to ensure that the system can operate satisfactorily and function efficiently and continuously.

The water system of Carcar has three gravity transmission lines that deliver water from the three spring sources; Mabugnao, Venancia and Kalubihan in Napo. All other transmission lines are from pumping stations or booster stations. The actual location and alignment of transmission lines of Carcar WD is shown in Annex 2. This map should be updated when necessary to indicate changes or improvements in the transmission system.

6.1 PROBLEMS IN GRAVITY TRANSMISSION MAINS FROM SPRINGS

The source and the distribution system is connected by the transmission mains. Any failure in the transmission line is a failure of the whole system. Normal problems with the transmission line of a spring source are caused by heavy rains, improper operation and lack of understanding or information on the transmission system.

6.1.1 Flashfloods

Transmission pipelines of spring sources are susceptible to damage particularly during heavy rains. Most vulnerable to damage are pipe crossing the river. Flashflood or high river flow scours the river bed and exposes the pipe crossing that could lead to misalignment, displacement or total damage to the pipe crossing. These pipe river crossings should be inspected regularly especially after heavy rains. The location of pipe river crossings is indicated in the transmission system drawing.

6.1.2 Turbid Water

Spring water tend to become turbid during heavy rains. It is of utmost concern of the WD not to allow turbid water to enter the transmission line. Turbid water will make the supply not potable and will introduce sediments to the pipelines. Sediments that accumulated at low points of the transmission line will require thorough flushing. The blow-off valves are provided on the lowest point of the transmission line for flushing purposes. These points should be regularly flushed and the BOV checked for proper operation.

6.1.3 Improper Valve Operation

Improper operation of on-line valves may result to pipe damage, reduced capacity, or water contamination. For a gravity transmission line, if a downstream valve is shut off, high static pressure may occur that can damage mechanical joints or the valve itself. On the other hand if an upstream valve is turned off, vacuum may be created inside the pipe due to suction that may result to pipe damage or distortion. It may also allow entry of contaminants through the leaks on the pipelines.

6.1.4 Air Entrapment

Air may also be entrapped inside the pipe that can cause reduced discharge and high head loss. Air collects at the high points of the transmission mains. The air release valves on these points should be regularly checked for proper functioning.

6.1.5 Water Hammer

Closing a valve abruptly will create water hammer that can damage pipe. The magnitude of the water pressure created by water hammer and its oscillating effect may be sufficient to rupture the pipeline. Care should be taken in opening and closing of valves in the transmission line.

6.1.6 Leakages

Transmission lines of spring sources normally traverse unpaved areas. It is not always that leaks will be visible. Invisible leaks are hard to locate.

Most common leaks are through the welded joints of the steel pipes. Leaks also occur through flexible joints where the bolts have become loose and gland packing is not in position. Leaks through air valves occur due to improperly seated ball either due to the damage of the gasket or due to abrasion of the ball, through the gland of the isolating sluice valve or through the small orifice

Review of flow meter data will indicate possible leakages. Any abrupt increase in flow is an indication of major leak on the transmission line. Changes in pressure readings may also suggest a leak.

6.1.7 Inaccurate Maps

Generally, maps should show accurate information as to location, size, type, and material of the appurtenances of the transmission pipelines. The information on the maps should be validated in the field. Said map is a helpful tool in finding, relocating, and repairing pipeline fixtures during emergencies.

6.2 PROBLEMS IN TRANSMISSION LINE OF PUMPING STATIONS

Transmission line of pumping stations have minimal problems on contamination, turbidity, and air entrapment. The only major problem is the backflow and the water hammer it creates when the pump is suddenly turned off. The volume of water initially being pumped in the transmission pipe will backflow to the pumping station when the pump is shut off or when power failure occurs. The backflow may be so severe that can damage the pump or the discharge line appurtenances or the transmission pipe itself.

6.3 OPERATION AND MAINTENANCE ACTIVITIES

(i) Mapping and inventory of pipes and fittings

An updated transmission system map with location of valves, flow meters and pressure gauges, air release valves, blow-off valves, river crossing and other pipeline fittings is the foremost necessity for a good operation.

The valves indicated in the map should contain direction and number of turns to open, make of valve and date of the last exercise.

(ii) System pressure and Flow rate

It is essential to maintain a continuous positive pressure in the transmission main. Pressure gauges should be read and recorded daily. Low pressure incidence should be investigated immediately.

Flow measurement should be taken and recorded daily. Any abrupt change in flow rate should be investigated.

(iii) Inspection

Regular inspection of the transmission line route should be conducted to detect and correct the following:

• Any sign of deterioration of the transmission system.
• Any encroachment to the transmission system
• Unauthorized tapping or connection
• Any act of vandalism.

6.4 MAINTENANCE SCHEDULE

Activities for Preventive Maintenance

a) Servicing of valves: Periodical servicing is required for valves, expansion joints flow meter and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement and the valve can be wrapped in polythene wrap to prevent corrosion. Manufacturer's catalogues may be referred and servicing procedure should be prepared for the periodical servicing.

b) List of spare: List of spares procured for the transmission system shall be prepared and the spares shall be procured and kept for use. The spares may include check nut, spindle rods, bolt and nuts are flanged joints, gaskets for flanged joints for all sizes of sluice valves, consumables like gland rope, grease, cotton waste, jointing materials like rubber gaskets, spun yarn, pig-lead and lead wool etc.

c) List of tools: The maintenance staff shall be provided with necessary tools/equipment's for attending to the repairs in the transmission system. These tolls may include key rods for operation of sluice valves, hooks for lifting manhole covers, pipe wrench, DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools, crow bars, spades, dewatering pumps

6.5 MAINTENANCE OF PIPELINES

Pipeline bursts/main breaks can occur at any time and the O & M agencies shall have a plan for attending to such events. This plan must be written down, disseminated to all concerned and the agency must always be in readiness to implement the plan immediately after the pipe breaks reported. After a pipe break is located, determine which valve is to be closed to isolate the section where the break has occurred. Some important consumers may be on the transmission system and having an industrial process dependent on water supply which cannot be shut down as fast as the water supply lines are cut off and should be notified about the break down. These consumers have to be informed about the probable interruption in water supply and also the estimated time of resumption of water supply.

After the closure of the valve the dewatering/mud pumps are used to drain the pipe breakpoints. The sides of trenches have to be properly protected before the workers enter the pit. The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipe is replaced and the line is disinfected before bringing into use. A report shall be prepared following every pipe break about the cause of such break, the resource required.

1. Scouring of Pipeline

Scouring is done to clean the transmission lines by removing the impurities or sediment that may be present in the pipe. This is particularly essential in the case of transmission lines carrying raw water.

2. Leakage control

(i) Visible leaks: The maintenance staff during surveillance operation can report visible leaks found by him to his superiors. Critical areas where leaks often occur have to be identified and appropriate correct measures have to be implemented.
(ii) Invisible leaks: Lead detection equipment have to be procured for detection of non-visible leaks and action to control these leaks should be initiated to control the overall problem of water lost.

3. Records and Reports

1. Updated transmission system maps with alignment plans. Longitudinal sectional plans,
2. Record of daily readings of flow meter at upstream and downstream end of pipeline,
3. Record of water level of reservoir at both upstream and downstream end of transmission system.
4. Pressure reading of the transmission system.
5. Identification of persistent low pressure location along the pipeline.
6. Record of age of pipes.
7. Identify pipelines to be replaced.
8. Identify source of leaks.
9. Record of Bulk meter/water meter reading before the delivery into overhead tank.
10. Record of residual chlorine.
11. Record on when the pipeline leaks were repaired or pipe changed and the cost of materials and labour cost thereof.

4. Chlorine Residual Testing

A minimum free chorine residual of 0.2 mg/lit at the receiving reservoir of a transmission system is needed to be maintained. Absence of residual chlorine could indicate potential presence of contamination in transmission system.

The following steps which are required to be taken are:
1. Testing of residual chlorine
2. Checking the chlorination equipment at the start of the transmission system.
3. Searching for source of contamination along the transmission system which has caused the increase in chlorine demands.
4. Immediate rectification of the source of contamination

SECTION VII - DISTRIBUTION SYSTEM

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

7.0 INTRODUCTION

The O&M of a water distribution system has 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 the following components:

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

7.1 DISTRIBUTION PIPELINES

The detailed drawings of the water system of Carcar are shown in Annex A. These drawings should be maintained up-to-date. This is a useful aid in the proper operation of the system and in response to emergency situations.

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

7.1.1 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:

a. Always maintain positive pressure in the pipeline. Negative pressure could result in backflow that may contaminate the system.

b. Open and shut off the valves gradually. Abruptly opening or shutting might produce water hammer that could damage the valves and weaken the pipe joints.

c. Implement an appropriate flushing program to clear sediments from the system. Dead-end points and low level sections of pipelines are prone to sediment accumulation. Regular flushing of these sections should be implemented and if necessary permanent blow-offs must be provided.

7.1.2 Preparation for Repairs

Pipeline leaks and breakages can and will happen. Water main breaks need to be repaired with as little delay as possible. Personnel should be trained to work with minimal delay so as not to prolong inconvenience to the public.

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

a. List of key personnel for repair works and their contact numbers should be readily available.
b. Keep the following tools available and ready for use at all times: valve keys, hand tools, digging tools, pavement breakers, dewatering pump, floodlights, etc.
c. Keep a stock of sleeve-type coupling or mechanical-joint repair fittings in different pipe sizes.
d. Keep a list of establishments where heavy equipment are available that can be rented for use by the WD in times of emergencies.

7.1.3 Location of Water Mains

The exact location of pipes should be indicated in the as-built drawings of the distribution system. The drawing should also indicate the size, material, and location of valves, fittings and appurtenances. This drawing should be readily available for use by leak repair team and service connection installation team. It has to be updated whenever additional appurtenances are installed in the system.

7.1.4 Cleaning Pipelines

When water velocity is low, sediments 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. The effects are complicated when magnesium and calcium salts are present in the water (hard water), as their precipitates result in scaling inside the pipes.

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. Dead end pipes should be flushed and disinfected at least twice a year.

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.
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.
5. Put pipelines back to operation.

7.1.5 Distribution System Flushing

The distribution system should be flushed to maintain water quality, remove sediments, maximize hydraulic capacity, and remove stagnant water at dead-ends. Watermains may also be flushed periodically throughout the year in response to customer complaints as well as non-compliant samples, and by direction from the local officials. Uni-directional flushing is recommended as it is typically the most effective method of flushing a water distribution system as it starts at the source and progresses from the largest to the smallest mains in a systematic manner. A flushing program should also incorporate hydrant maintenance and valve exercising.

7.1.6 Prior to Flushing Checklist

- Pre-plan the flushing sequence using system maps. Select the flush-out locations and consider installing new ones where necessary.
- Review drainage of flushing points.
- Notify customers in advance of possible impacts and duration.

- Ensure reservoirs are full to provide adequate amount of flushing water.

7.1.7 While Flushing Checklist

- Flushing velocity should be at minimum 0.75 m/sec (2.5 ft/s), but 1.5 m/sec (5.0 ft/sec) is preferred in order to achieve suitable biofilm removal.
- Open hydrant for a period long enough (5-10 minutes) to stir up deposits inside the watermain. Flush until the water is clear.
- Assure that system pressures in other parts of the distribution system do not drop below 140 kPa (20 psi).
- If discharging into a drainage course, check chlorine residual concentrations to ensure that chlorine has dissipated by the time the water reaches fishery habitat, or use a dechlorinating agent to consume the chlorine.
- Collect two water samples from a flowing hydrant; the first after 2 or 3 minutes of flushing and the second just prior to closing the hydrant. Sample for chlorine residual, turbidity, and iron (where applicable).
- Document results and update records. See sample Flushing Logs.

7.1.8 Repairing Pipe Leaks

Contamination can occur during repair works of watermain. To minimize the potential for contamination, ensure the following actions are taken:

- Keep sections of new pipe sealed at both ends to prevent dirt and foreign matter from entering. Plug existing open watermain ends until tie-in or repair is to be made.
- Properly excavate around pipe to mitigate against soil intrusion into opened pipe section. Use dewatering pump when necessary.
- Ensure that tools, equipment and any other items that come into contact with the watermain are properly cleaned and disinfected.
- Ensure proper disinfection of all piping, fittings and appurtenances.
- Ensure the repair is tight and not leaking.
- Investigate possible sources of cross connections after installation or repair (ex: leaking valve, backflow through distribution).
- Implement disinfection and flushing.

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. The repair job then consists of sealing the leaks and/or replacing the defective pipe section. The preferred method of fixing leaks is to provide sleeve coupling or repair clamp around the leak opening.

After the leak is repaired, open the control valve to allow water to flow into the repaired section and observe carefully if leak is completely sealed. Backfill the excavation and restore the surface to its former condition. Apply disinfection procedure.

7.1.9 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. After isolating the section by closing valves, excavate the exact location of the damage.
2. Cut the defective section and thread both ends of the cut pipes.
3. Use coupling and union to join the repair piece.
4. Open valves to verify leakproof connections.
5. Backfill and restore surface to its original condition.

b. For Polyvinyl Chloride (PVC) Pipes

1. After isolating the section by closing valves, excavate the exact location of the leak.
2. Measure and cut the defective portion of the pipeline.
3. Install a PVC socket on one cut end and a sleeve type coupling on the other end to connect the repair piece.
4. Open the control valve to allow water to flow into the repaired section and observe for connection leaks;
5. If there is no more leak, backfill the excavation and restore the surface to its former condition.

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

1. After isolating the section by closing valves, excavate the exact location of the leak.
2. Cut the defective portion of the water main;
3. Use replacement piece for repair of PE or PB tubing. Use compression type brass coupling for PE and flare type coupling for PB tubing.
4. For bigger diameter PE, use butt-welding method to the repair joints.
5. Open the control valve to allow water to flow and observe for leaks;
6. Backfill and restore surface to its former condition;

7.2 RESERVOIRS

7.2.1 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.

7.2.2 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 disinfection work (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.

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.

7.2.3 General Precautions

1. All fence gates, access hatches and manholes of reservoirs should be locked. Storage facilities tend to attract children who like to play around the facilities, climb the ladders, and play on top of concrete roof. Never leave a storage facility without locking all access openings.

2. Vandals are known to intentionally damage storage facilities. 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.

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.

7.2.4 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.

7.2.5 Detecting and Repairing Leaks in Concrete Reservoirs

Leaks in concrete reservoirs can be repaired with hydraulic cement (Waterplug).

Detecting leaks in concrete ground reservoir requires filling the tank to a certain level mark and with closed valves observe the water level after one day. Any appreciable decrease in water level indicates presence of leak on the floor slab.

7.2.6 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 walls that allow surface water or shallow groundwater to seep in are dangerous. Repair leaks at once.

7.2.7 Repairing Leaks in Reservoirs

a. 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).

b. 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.

c. 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.

7.2.8 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.

7.3 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.

7.3.1 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.

7.3.2 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.

7.3.3 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.

7.4 VALVES

The valves useful life depends largely on the manner they are operated and maintained.

7.4.1 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;

7.4.2 Common Causes of Valve Failure and Their Remedies

a. Corrosion

Corrosion will render the valve inoperable. 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.

7.4.3 Valve Maintenance

All valves in the distribution system must be exercised at least twice a year. It should be inspected for defects and any repair undertaken should be properly documented.

Valve maintenance extends valve life and will assure proper operation. This is true with isolation valves, air release valves, and blow-off valves.

7.4.4 Components of a Valve Maintenance Program

Valve maintenance program includes the following:

a. A valving system map indicating location and identification number of valves.
b. Valve card showing type, size, location, number of turns to open and close, direction of opening, and maintenance record.
c. A schedule for regular exercise and routine maintenance.

7.4.5 Components of a Routine Valve Inspection

- Verify the accuracy of the location of the valve boxes on the system map and update map where necessary.

- Remove valve box cover and inspect stem and nut for damage or obvious leakage.

- Close the valve fully and record the number of turns to the fully closed position (always close the valve slowly to prevent water hammer).

- Record whether the valve is right hand or left hand closing.

- To determine if a valve is closed, an aquaphone, or simply an ear to the gate key, can be used.

- Record condition of valve and any maintenance that is required. Any valve that does not completely open or close should be replaced.

- Clean the valve box cover seat.

- Replace any missing valve box covers.

When inspection is complete, place the valve in its operating position (open or closed).

Automatic air release, vacuum breaker, or pressure-reducing valves should be inspected at least every six months. These valves will usually have an O&M manual, which describes how they are to be inspected and maintained. Manual air releases should be opened and flushed to remove accumulated air, at least twice a year.

7.4.6 Hydrant Maintenance

Regular maintenance of hydrants will give assurance that they are functional when needed. It should be inspected and tested once a year.

Hydrant maintenance should include:

- Location map of the hydrants with identification number.
- A routine maintenance schedule and flow testing.
- Hydrant card indicating type, date installed, and maintenance record.

General Inspection and Maintenance Procedures

a. Check for leakage (use listening device to detect non-visible leaks).
b. Remove all nozzle caps and inspect threads; replace any missing caps and chains. Clean and lubricate nozzle threads.
c. Replace any missing or damaged nuts.
d. Open and close hydrant fully a few times and check for ease of operation.
e. While hydrant is flowing, test isolation valve by closing it.
f. Check for any exterior obstruction that could interfere with operation of the hydrant during an emergency.
g. If a hydrant is inoperable, tag it with a clearly visible marking and immediately report its condition and schedule it for repair.
h. Prepare record of inspection and maintenance operations and any repair work

SECTION VIII - LEAK DETECTION PROGRAM

8.0 GENERAL

Leak detection programs are an effective way to reduce operating and maintenance costs and should be carried out on a regular basis.

The program could include the following:

Water Audit. Compare the volume produced to the volume sold and other authorized water uses (flushing, fire fighting, etc.).

Visual Inspection. Looking for standing water in low areas.

Audible Inspections. Leak Detector or listening devices can be used directly over a water line, to determine if there are leaks.

Leak Repair. Document any leak repairs and ensure adequate disinfection is achieved.

8.1 WATER AUDIT

Water Audit can be defined as the assessment of the capacity of total water produced and the actual quantity of water distributed throughout the service area leading to an estimation of the losses otherwise known as non-revenue water (NRW). Non-revenue water is the volume difference of the water produced and the water billed.

The Water Audit Method takes the approach that all water is accounted for and quantified as either a component of beneficial consumption or a wasteful loss. By measuring (metering) or estimating water quantities under this approach, no water is unaccounted for.

This methodology not only assists the water district in identifying where their losses are occurring, but also expresses by volume how much is lost and associates a cost to those losses. It also standardizes the water audit reporting process for water utilities.

The Water Balance as shown on Figure 8.1 of the Water Audit Method fit all quantities of water into one of the boxes of the water balance. The sum of the quantities of each column in the water balance is the same; hence, all quantities balance.

Corrected input volume	Authorized consumption	Billed authorized consumption	Billed metered consumption	Revenue water
			Billed unmetered consumption	
		Unbilled authorized consumption	Unbilled metered consumption	Non-revenue Water
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Unauthorized	

			consumption	
			Customer meter under-registering	
Wholesale water imported			Billing adjustment and waivers	
		Real losses	Reported leaks	
			Unreported loss	

8.1.1 Non-revenue Water

Non-revenue water (NRW) is water that has been produced but does not result in revenues for the water district. 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 (%) = ((Water Produced - Water Billed) / Water Produced) * 100

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

2. 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.

The water district 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”.

3. Sources of NRW

NRW can be analyzed on whether they are physical 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

4. NRW Reduction Approaches

A number of approaches have been used successfully by some of the major water utility companies.

a) Isolation of zones and the continuous measurement and analysis of inflows to determine areas with high NRW.
b) Programs to improve the reliability of customer metering and reading.
c) Hydraulic analysis of the distribution system to determine calculated versus actual pressures. (This requires updated system maps.)
d) 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.)
e) 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.
f) Modulation of pressure in the pipelines. Higher pressures will naturally increase the rate of leakages.
g) 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.
h) Continuous management attention: The reduction of NRW should be considered by management and the board as a continuing oversight concern.

5. 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. Subdivide further and measure their water consumption rate;
6. Repeat the above process until the locations of leak(s) are pinpointed.

8.1.2 Illegal Connections

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

a. Block Census
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.

8.2 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 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.

8.3 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 or leak detector. 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 . If the sound is too faint, a hearing aid such as a stethoscope would be helpful;

2. Push the rod into the ground against the same pipe at a different location. If the sound is louder, then you are getting closer to the leak. If the sound is fainter, it means you are moving away from the location of the leak.

Listening devices can be placed on hydrants, valve stems, or directly over a water line, to determine if there are leaks. These devices can be as simple as a metal rod, or a more sophisticated, such as a hydro-phonic probe and amplifier, or a computerized noise correlator.

8.4 LEAK REPAIR REPORT

Every leak repair completed should be documented. Summarize the repair work done per section of the pipelines to determine frequency of repair works for a particular section. This could be made as a basis for rehabilitation works if necessary.

Record the following:

- repair date;
- location of repair;

- size of line and pipe material;
- disinfection method and flushing procedures;
- chlorine residual testing results;
- bacteriological sampling results; and
- estimated volume of water lost due to the leak and during repair, including any flushing.

SECTION IX- DISINFECTION

9.0 CHLORINATION

There are a lot of methods of water disinfection but chlorination is commonly used and the method being adopted by Carcar WD. Drinking water is chlorinated to kill bacteria, viruses and parasites, which may exist in water and may cause illness and disease.

The requirement is to maintain a minimum of 0.3 mg/l residual chlorine in potable water at consumer tap end.

Generally, chlorination without filtration or other treatment process is effective and adequate to the water of Carcar as the the degree of its bacteriological pollution is moderate. At normal weather condition, the turbidity of the spring sources of Carcar WD do not exceed the limit of 5 NTU and iron and manganese compounds do not exceed 1.0 and 0.40 mg/l limits, respectively. *However, the Water District is considering the proposed program to construct a filtration plant for the Mabugnao spring source as a measure to further improve the quality of its water and be assured of its safety.*

9.1 HYPOCHLORINATOR

The Carcar WD is using hyphochlorinator in chlorination. It is most commonly used equipment for chlorination.

The hypochlorinator is a pump used to add hypochlorite solutions to water at a manually adjustable feeding rate. The hypochlorite solution is pumped from a container into a water pipeline. Due to the corrosiveness of the hyphochlorite solutions, the critical parts of the pump are made of chemically resistant plastic and synthetic rubber.

Hypochlorinators are kept in a separate room away from other equipment, tools, controls and the like because of the corrosiveness of the solution.

9.2 CHLORINE FOR DISINFECTION

Chlorine is available in gas, powder, or liquid form.

Chlorine gas is 100% chlorine packaged in cylinders usually 68 kgs capacity. It uses cylinder mounted chlorinator and a booster pump to inject the chlorine-water solution into the water mains.

Calcium Hypochlorite is in powder form which contains 70% available chlorine by weight. It is commercially available in 45 kgs container. Calcium hypochlorite is mixed with water in a container to attain a predetermined concentration and then pumped into a water mains by a hypochlorinator.

Calcium hypochlorite loses its chlorine strength rapidly due to poor storage and hence should not be stored for more than three months.

Bleaching Powder is also a chlorine compound with available chlorine of 35%.

Sodium Hypochlorite or Liquid Bleach is commonly used in industries for disinfectants, deodorizers and bleach. For households, it is supplied as common household bleach. It has about 15% available chlorine.

9.3 CHLORINE DEMAND AND DOSAGE

Water and the substances that are in it consumes chlorine. The water chlorine demand plus a certain residual or remaining chlorine shall be the required dosage of the chlorine solution. The amount of chlorine to be used in a day (dosage rate) must be established to answer for the chlorine demand and the residual.

The required chlorine residual range is from 0.2 to 0.5 mg/l taken at the consumers faucet.

The water chlorine demand must be determined daily. Even if the chlorine demand of a particular source does not change much over the years, it is still good to measure the chlorine demand and residual every day to determine the accurate chlorine dosage to be used.

The daily chlorine dosage rate is then mixed with water to form a solution that will be fed into the system by a hypochlorinator in a rate that can be consumed in 24 hours.

There are two ways of determining the chlorine dosage.

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 to conduct the following procedures:

1. Prepare a 1% chlorine solution
2. Take 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.

9.4 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

9.4.1 Example of Dosage Calculation

Given:
Water Production: 80 lps
Required Residual: 0.2 mg/l
Chlorine Demand of Water: 0.5 mg/l

Required: Dosage and Dosage Rate

Dosage = Demand + Residual
= 0.5 + 0.2 = 0.7 mg/l

Dosage Rate using Calcium Hypochlorite:
Calcium Hypochlorite has 70% available chlorine
Water Production = 80 lps*3600sec/hr * 24hrs/day
= 6,912,000 lpd

Dosage Rate = 0.7 mg/l / 0.7 * 6,912,000 lpd
= 6,912,000 mg
= 6.92 kg per day

9.4.2 Preparation of Solution

1) The concentrated hypochlorite solution is prepared in a tank with capacity suitable for 24 hours requirement.
2) The powder is first put in the tank and water is sprinkled on the powder.
3) The solution is mixed thoroughly by hand or by a motor driven stirrer.
4) The solution is then ready for feeding in the system by hypochlorinator.

The solution should have a contact period of at least 20 minutes between the point of injection and the first service connection.

9.5 MEASURING CHLORINE RESIDUAL

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. 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.

Measuring chlorine residual on site is done with a device known as a chlorine comparator, using a chemical known as DPD. Figure 9.1 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:

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.

9.6 HYPOCHLORINATOR OPERATION AND MAINTENANCE

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.

9.7 CHLORINE RESIDUAL MONITORING AND REPORT

Generally, chlorine residual measurement are taken daily at pipeline extremities and these points correspond with the sampling points for Bacte Test.

The daily measured chlorine residual should be recorded and summarized in the chlorine residual log. Any abrupt change in chlorine residual should be reported immediately and an investigation should be initiated to find the cause.

SECTION X - WATER QUALITY MONITORING

10.0 GENERAL

The Department of Health as part of their mandate, has formulated standards for drinking water which establishes limits for different impurities found in drinking water. The Philippine National Standards for Drinking Water (PNSWD) was instituted to achieve more comprehensive parameters to address issues on water quality. It also advocates for an efficient water quality monitoring system by prioritizing the parameters that need to be monitored.

Some benefits of implementing a thorough monitoring program include:

- reducing risk to public health by early detection and mitigation of declining or unacceptable water quality;
- supporting due diligence and increasing public trust;
- maximizing the efficiency of treatment processes at the treatment facility; and
- guiding operation and maintenance activities to address water quality in the distribution system.

10.0.1 Requirements

The water produced by the Water District must undergo laboratory examination to determine fecal contamination of water or microbiological quality. Because of high probability of microbial contamination, the examination is conducted frequently. The PNSDW recommends a minimum of 1 sample per month for every 5000 population served.

The Water District is also required to conduct at least once a year, the physical and chemical quality analysis of the existing sources of the water system.

The results of the microbiological monitoring and the physical and chemical quality analysis of water must be submitted to the Local Water Utilities Administration and to the City Health Office.

10.1 MICROBIOLOGICAL QUALITY

Drinking-water supplies should be free from contamination by human and animal excreta, which can contain a variety of microbial contaminants. Practically, all pathogenic organisms that can be carried by water originate from the intestinal tract of warm blooded animals.

Water intended for human consumption should contain no indicator organisms. Frequent examinations for fecal indicator organisms remain as the most sensitive and specific way of assessing the hygienic quality of water.

To determine the safety and acceptability of drinking-water supply, appropriate laboratory examinations should be conducted on representative samples of water taken at all critical stages in the production and consumption of water supply. These stages include, and not limited to: the water sources, in the course of and after the treatment process, and from a reasonable number of points in the
distribution network.

The sampling points of CWD for microbiological testing is indicated in Figure 10.1.

Test are conducted by DOH accredited laboratories in Cebu.
Table 10.1 Standard Method of Detection and the Values for Microbiological Quality.

Parameters	Method of Determination	Value	Unit
Total Coliform	Multiple Tube Fermentation Technique (MTFT)	<1.1	MPN/100ml
	Membrane Filter (MF) Technique	<1	Total Coliform colonies/ 100ml
	Chromogenic substrate Test	<1.1	MPN/100ml
Fecal Coliform	Multiple Tube Fermentation Technique (MTFT	<1.1	MPN/100ml
	Membrane Filter (MF) Technique	<1	Fecal Coliform Colonies/100ml
	Chromogenic substrate Test	<1.1	MPN/100ml
Heterotrophic Plate Count	Pour Plate	<500	CFU/ml
	Spread Plate		
	Membrate Filter Technique		

The volume of sample should preferably not less than 100 ml. The sampling bottles, normally 120 ml capacity are provided by the laboratory which are already cleaned, sterilized and capped properly.

10.1.1 Sample Collection, Handling and Storage

The sample should be representative of the water under examination. Contamination during collection and before examination should be avoided.

The tap should be cleaned and free from attachments and fully opened with water allowed to waste for a sufficient time to permit the flushing/clearing of the service lines. Flaming is not necessary. Taps with a history of previous contamination may be disinfected with hypochlorite solution (NaOCl 100 mg/L). No samples shall be taken from leaking taps.

The sampling bottle should be kept unopened until it is ready for filling. Remove stopper or cap as a unit; do not contaminate inner surface of stopper or cap and neck of bottle. Fill container without rinsing, it should be filled without rinsing and ample space (at least 2.5 cm) must be left to facilitate mixing by shaking. Replace stopper or cap immediately.

Water samples should be processed promptly or within six (6) hours after collection or if not possible the use of ice coolers for storage of water samples during transport to the laboratory is recommended. The time elapsed between collections and processing should in no case exceed 24 hours.

Sample bottles must be tagged for identification.

10.2 CHEMICAL AND PHYSICAL QUALITY

10. 2.1 Chemical Contaminants

Various forms of chemicals, which occur naturally in the environment and in raw water may be found in drinking water supplies. There are few chemical constituents of water that can lead to acute health problems. Inorganic constituents suspected as carcinogenics includes arsenic, lead, chromium and cadmium among others. Organic constituents in water comes from decomposition of organic debris and from agricultural and industrial activities.

10.2.2 Acceptability Aspect

The chemical and physical quality of water may affect its acceptability by consumers. Although acceptability aspects of drinking water quality ie. taste, odor, color do not have adverse health implications, standards are set to satisfy the need of consumers for a colorless, odorless and tasteless drinking water.

LWUA has required annual submission of physical and chemical quality analysis of the water sources of the water districts. The standard values for physical and chemical quality requirements of drinking water supply based on priority parameters set by LWUA and the local health office is shown in the following table.

Table 10.2 - Standard Values for Physical and Chemical Quality on Priority Parameters

Constituents	Maximum Level	Unit
A. Inorganic Constituents		
Arsenic	.05	mg/l
Cadmium	.003	mg/l
Lead	.01	mg/l
Nitrite	3.00	mg/l
B. Organic Constituents		
Benzene	.01	mg/l
C. Aesthetic Quality		
Color	5	True Color Units
Turbidity	5	NTU
Chloride	250	mg/l
Iron	1.0	mg/l
Manganese	0.4	mg/l
pH	6.5-8.5	number
Sulfate	250	mg/l
Total Dissolved Solid (TDS)	500	mg/l

10.2.3 Water Sampling for chemical and physical analysis

Water samples for chemical and physical analysis shall be taken at all water sources of the Water District at least once a year.

Volume of Sample
Three (3) liters of sample should suffice for physical and chemical analyses.

Container
Sample containers must be carefully cleaned to remove all extraneous surface dirt, thoroughly rinsed with distilled water, and drained before use. Suitable containers may be of a chemically resistant glass, polyethylene plastic or hard rubber.

Cork stoppers wrapped with relatively inert metal foil are suitable for many samples or caps of plytetrafluorethylene (PTFE).

When filled with water sample, leave a space about 1% of the capacity to make room for liquid expansion.

Sample containers must be properly labeled with the following information:

Date and time of sampling
Source of sample
Point of sampling (in sufficient detail to enable anyone to collect a second sample from the identical spot from which the first sample was taken)
Temperature of the sample
Sampled by: (name of collector)

Sampling Collection

Collect samples from wells only after the well has been pumped sufficiently. New wells will require sufficient extraction before sampling.

Before samples are collected from distribution systems, flush the lines sufficiently to ensure that the sample is representative of the supply.

Sample Handling and Storage

In general, the shorter the time lapse between collection of a sample and its analysis, the more reliable will the analytical results be.

For certain constituents and physical values, immediate analysis in the field is required in order to obtain dependable results, because the composition of the sample may change before it arrives at the laboratory.

Changes caused by the growth of organisms may be greatly retarded by keeping the sample in the dark and at a low temperature until it can be analyzed.

It is necessary to keep the samples cool or refrigerated. Storage at a low temperature (4oC) is the best way to preserve most samples.

10.3 STANDARD REPORTING FORMAT

As prescribed by LWUA based on its Memoradum Circular 004-15, the Water District was provided with a standard format of reports to be submitted to the concerned agencies as shown in Figure 10.2.

1. CAPILAN
2. MAXIMINA
3. CARCAR ACADEMY
4. SERVAS DAM
5. UPLAND ELEM. SCHOOL
6. P. NELLAS ST.
7. DAPDAP
8. MAGSPIT
9. CAN-ASUJAN
10. NANGKAAN PERRELOS
11. VALLADOLID ELEM. SCH.
12. TANGARAN
13. CARCAR PUBLIC MARKET
14. CAMBUNTAN (ESCOR)
15. OCAÑA ELEM. SCHOOL
16. NAPO
17. ABUSON
18. BARACCA
19. OCAÑA SOLLANO
20. CARCAR CITY HALL
21. IBARAO PERRELOS
22. CAMBUNTAN AS

Figure 10.2 Standard Reporting Forms

004.15 002.08

ANNEX A – Standard Form

___________________________ WATER DISTRICT
SUMMARY REPORT ON MICROBIOLOGICAL TEST
MONTH OF _________ 200__

1) Population actually served by utility __________
(No. of service connections x average no. of persons per service connection)

2) Required minimum number of sample __________
(Based on the following table)

Population Served	Minimum frequency of sampling
Less than 5000	One(1) sample monthly
5,000 – 100,000	One(1) sample per 5000 population monthly
More than 100,000	20 samples plus 1 sample per 10,000 population monthly

3) Sample Requirement
a. No. of samples examined __________
b. Percent (%) to the minimum required __________
c. Meets Standard ☐ Yes ☐ No
(If b is 100% or more, check Yes)

4) Method
4.1 Multiple Tube Fermentation Technique (MTFT)
a. Number of samples showing presence of coliform group __________
b. Percent (%) to samples examined (4.1.a / 3.a x 100) __________
c. Meets Standard ☐ Yes ☐ No
(If b is 5% or less, check Yes)

4.2 Membrane Filter Technique (MFT)
a. Number of samples showing presence of coliform colonies __________
b. Percent (%) to the total number of samples analyzed (4.2.a / 3.a x 100) __________
c. Meets Standard ☐ Yes ☐ No
(If b is 5% or less, check Yes)

4.3 Fecal Coliform Test (FCT)
a. Number of samples showing presence of fecal coliform organisms with MPN/100 ml value of 1.1 or more __________
b. Meets Standard ☐ Yes ☐ No
(If a is Zero, check Yes)

4.4 Heterotrophic Plate Count (HPC)
a. Number of HPC tests conducted __________
b. Number of samples showing HPC value <500 CFU/ml __________
c. Percent (%) to the number of tests conducted (b / a x 100) __________
d. Meets Standard ☐ Yes ☐ No
(If c is 100 %, check Yes)

(Please attach laboratory test results with this summary form)

NOTED BY:

____
General Manager

____
Date

004.15

ANNEX B
Standard Form

______________ WATER DISTRICT
SUMMARY REPORT ON
PHYSICAL AND CHEMICAL ANALYSES
FOR YEAR ______

CONSTITUENT	PNSDW Maximum Level (mg/L) or Characteristics	Constituent Level (mg/L) or Characteristics					
		NAME SOURCE / LOCATION					
		DW / PW1	Spring# 1				
I. Priority Parameters							
Physical		[illegible]					
1. Color Apparent	10 Color Units						
True	5 Color Units						
2. Turbidity	5 NTU						
Chemical							
3. pH	6.5 - 8.5						
pH for product water that undergone RO or Distillation	5.0 - 7.0 for						
4. Nitrate	50						
5. Sulfate	250						
6. Chloride	250						
7. Total Dissolved Solids	500						
TDS for product that undergone RO or Distillation	<10						
8. Iron	1.0						
9. Manganese	0.4						
10. Arsenic	0.01						
11. Lead	0.01						
12. Cadmium	0.003						
13. Benzene	0.01						
II. Other Parameters Measured							
Category	**Action Taken**						
A. Inorganic Chemical Constituents as follows: Antimony, Barium, Boron, Chromium (Total), Cyanide, Flouride, Mercury (Total), Nickel, Nitrite & Selenium	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						
B. Organic Chemicals from Industrial Pollution. (Please refer to Table 2.10 of PNSDW for the list of parameters	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						

Prepared By:

WD Personnel Name
Designation

Approved:

WD General Manager

Page 2 of Physical-Chemical Test results
Water District: ____________________
For the year: _____

004 15 1

Others Parameters Measured - continuation							
Category	Action Taken/	Constituent Level (mg/L) or Characteristic NAME SOURCE / LOCATION					
C. Organic Chemicals (Pesticides). Please refer to Table 2.11 of PNSDW for the list of parameters	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						
D. Physical and Chemical Constituents for Acceptability Aspects (not included in priority list) such as: Taste, Odor, Aluminum, Copper, Hardness, Hydrogen Sulfide, Sodium and Zinc.	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						
E. Chemical Used in Treatment and Disinfecting and Disinfecting by-products. (Please refer to Table 2.13 of PNSDW for the list of parameters)	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						
F. Radiological Quality (Please refer to Table 3.7 of PNSDW for the list of parameters)	Analysis Done? ☐ No ☐ Yes						
	➢ complying parameters						
	➢ non-complying parameters						

(Please Attach All Laboratory Test Results)

Prepared By:

WD Personnel Name
Designation

Approved:

WD General Manager

APPENDIX A

PREVENTIVE MAINTENANCE LOG

Preventive Maintenance is a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures in water systems. Preventive maintenance activities include exercising valves and fire hydrants; equipment and tank inspections; partial or complete overhauls at regular specified periods; oil changes; lubrication; and so on. In addition, operators can record equipment deterioration so they know when to replace or repair worn parts before they cause system failure.

Preventive maintenance for equipment should be performed according to the manufacturer's recommendation or to a well devised plan.

Long-term benefits of preventive maintenance include: improved system reliability, decreased cost of replacement, decreased system downtime, and better spares inventory management.

Even under the best Preventive maintenance program, some breakdown maintenance will occur. Each of these events provides a learning opportunity to improve upon existing Preventive maintenance programs. The operator should evaluate every equipment breakdown situation, to determine the cause, and what measures could have been taken to prevent the occurrence. The lessons learned should then be added to the Preventive maintenance program. Building these written feedback loops into the Preventive maintenance program will yield significant returns.

The following items should be included:

- Preventive maintenance schedule ;
- List of Specifications for fuels, lubricants, filters, etc. for equipment;
- Trouble shooting charts or guides which references pages in O&M manual and manufactures O&M manual;
- Record system for each type of equipment, this should include; numbering system, catalog, nameplate data cards, maintenance record cards;
- Manufacturers' maintenance schedule for routine adjustments. A summary with references to page number in manufacturer's O&M manual needs to be provided;
- A designated responsible individual to ensure that the program tasks are being met and that timely updates are included in the program as needed

DAILY OPERATIONAL DUTIES / PREVENTIVE MAINTENANCE

Flow Meter Readings	Record Flowmeter Readings
	Calculate Total Daily Production
Pumps & Tank Levels	Inspect Pumps & Controls
	Check Chemical Solution Tanks & Record Amount Used
	Inspect Chemical Feed Pumps
	Inspect Booster Pumps & Controls
	Record Pump Run Times & Start Cycles
	Check & Record Water Levels in Storage Tanks

Sampling & Readings	Check & Record Chlorine Residual at Point of Application
	Check & Record Chlorine Residual at Nearest Customer
	Check & Record Chlorine Residual in Distribution System at Remote Points
Security	Investigate Customer Complaints
	Complete a Daily Security Check at Pumping Stations: ● Windows, Doors, Hatches, Vents, Screens for Evidence of Tampering or Vandalism ● Well Caps, Vents & Seals ● Security Lighting, Locks & Alarms ● Inspect Fences & Gates

WEEKLY OPERATIONAL DUTIES/PREVENTIVE MAINTENANCE

Inspections & Conditions	Inspect Chlorine Testing Equipment (Calibration & Reagents)
	Check & Record Pumping Rate
Cleaning	Clean Pump House / Control House
	Clean Pump Station Grounds
Security	Check Station Alarms for Proper Operation
	Check Stand-By Power Source Operation

MONTHLY OPERATIONAL DUTIES / PREVENTIVE MAINTENANCE

Inspections & Conditions	Check & Record Electric Meters
	Take Appropriate Monthly Water Quality Samples
	Check & Record Static & Pumping Levels in Wells
	Confirm Submittal of Monthly Operation Reports (MORs)
	Lubricate Pumps, Motors, & all Moving/Rotating Equipment
	Inspect all Discharge Lines, Gaskets & Fittings for Corrosion & Leaks
	Listen to Pump for Unusual Noises (signs of wear)
	Run Emergency Generator for 30-min UNDER LOAD, Check ALL Fluid and Fuel Levels
Cleaning	Clean & Inspect Wellheads
	Clean & Inspect Chlorine Injection Points
Security	Inspect Tank Overflow Vent Screens and ensure it is intact, Check Hatchway Cover & Ensure it is Secured

QUARTERLY OPERATIONAL DUTIES / PREVENTIVE MAINTENANCE

Cleaning	Flush Dead-End Lines
	Lubricate Locks

ANNUAL PREVENTIVE MAINTENANCE

January	Flush Half Distribution System
	Exercise Half Fire Hydrants
February	Flush Other Half of the Distribution System
	Exersise Other Half of Fire Hydrants
	Flush Dead-End Lines
March	Inspect Storage Tanks for Defects & Sanitary Deficiencies

	Clean Storage Tanks
	Structural Inspection of Tank & Coatings (every 5 years)
	Perform Tank Coating Repairs
April	Clean & Inspect Chemical Feed Lines
	Clean & Inspect Chemical Solution Tank
	Calibrate Chemical Feed Pumps
May	Flush Dead-End Lines
	Pump House Building Preventive Maintenance
June	Check Emergency Generator & Run on Load Bank
	Check Running Amps on Pumps
	Review Emergency Response Plan – Update as Necessary
July	Building Preventive Maintenance
August	Operate ALL Valves Inside Treatment Plant & Pump House
	Clean & Inspect ALL Safety Equipment
	Flush Dead-End Lines
September	Check and Inspect Air Release Valves
October	Overhaul Chemical Feed Pumps
	Clean & Inspect Chemical Feed Lines
	Clean & Inspect Chemical Solution Tanks
	Calibrate Chemical Feed Pumps after Overhaul
November	Exercise HALF of ALL Mainline Valves
	Check Water Meter For Accuracy
	Flush Dead-End Lines
December	Exercise Remaining HALF of ALL Mainline Valves

PREVENTIVE MAINTENANCE LOG

Category	Frequency	Last Service Date	Service (Date	Service (Date)	Service (Date)
Well					
Clean & Inspect Wellheads, Pump, Controls, Seals, Vent & Screen	Monthly				
Check & Record Static & Draw-Down (Pumping) Levels in Wells	Monthly				
Pump House					
Inspect Water Lines, Gaskets & Fittings for Corrosion & Leaks	Monthly				
Lubricate Pumps, Motors, Blowers and ALL Moving / Rotating Equipment	Monthly				
Building Preventive Maintenance	Annually (July)				
Exercise ALL Valve at Pump House	Annually (Aug)				
Check Flowmeter For Accuracy	Every 4 years (Nov)				
Booster Pumps					
Inspect Pump, Seals, Water Lines & Fittings for Corrosion & Leaks	Monthly				
Listen to Pump for Unusual Noises	Monthly				
Safety & Security					
Clean & Inspect ALL Safety Equipment	Annually - Dec				
Emergency Response Plan Review/Update	Annually - June				
Chemical Feed Systems					
Inspect Pump, Seals, Water Lines & Fittings for Corrosion & Leaks	Monthly				
Clean Chlorine Injection Points	Monthly				
Overhaul Chemical Feed Pumps	Annually - Oct				
Chemical Feed Lines - Clean & Inspect	Bi-annually (Apr & Oct				
Chemical Solution Tanks - Clean & Inspect	Bi-annually Apr & Oct				
Calibrate Chemical Feed Pumps	Bi-annually Apr & Oct				
Storage Tanks					
Inspect Overflow Vent Screens, Ensure Screen Intact, Check Manway Hatch & Ensure it is Secured	Monthly				
Inspect Storage Tanks for Defects,	Annually -				

Leaks & Sanitary Deficiencies	Mar				
Clean Storage Tanks	Annually – Mar				
Structural Inspection of Tank & Coatings	Every 5 Years- Mar				
Perform Coating Repairs	Annually - Mar				
Controls, Electrical & Stand-By Power					
Inspect, Clean & Repair Control Panels	Annually - Feb				
Run Emergency Generator 30-min under load	Monthly				
Run Generator on Load Bank	Annually - Jun				
Check Running Amps on Pumps	Annually - Jun				
Distribution System					
Exercise ALL Mainline Valves	Annually Jan & Feb				
Flush Distribution System & Exercise ALL Fire Hydrants	Annually Nov & Dec				
Flush Dead-End Lines	Quarterly - Feb, May, Aug & Nov				

MAIN VALVES EXERCISE LOG

Valve No.	Location	Last Service Date	Service Date	Service Date	Service Date	Service Date

EXERCISE OF FIRE HYDRANTS LOG

FH No.	Location	Last Service Date	Service Date	Service Date	Service Date	Service Date

DISTRIBUTION SYSTEM FLUSHING RECORD

Pipe ID No.	Pipe Segment Location	Last Service Date	Service Date	Service Date	Service Date	Service Date

DEAD-END FLUSHING RECORD

Location:					
Date	Flushing Duration (min)	Water Characteristics (color,odor)		Chlorine Residual, mg/l	
		Before Flushing	After Flushing	Before Flushing	After Flushing

VALVE CARD RECORD

Valve No.	**Location:**	
Type:	**Make:**	**Size:**
Opens: Left ☐ **Right** ☐		**No. Of Turns**
Date Installed:		

Date Exercised	Closes/Opens (Y/N)	No. Of Turns	Condition (Stem, Packing, Gear, Etc.)	Valve Status (Open or Closed)

CARCAR WATER DISTRICT

FEB. 12, 1980

CWD

CARCAR WATER DISTRICT

OPERATIONS MANUAL APPROVAL PAGE

Prepared by:

ENGR. HENRY A. CUI
(OIC) Division Manager
Operations & Maintenance

Recommending Approval:

ENGR. EDWARD L. REMO
General Manager

Adoption of this Operations Manual was duly approved by the Board of Directors per BOD Resolution No. 2 series of 2016 dated January 20, 2016.

ATTY. DEMOCRITO C. BARCENAS
BOD Chair