DATA COLLECTION SUEVEY ON WATER SUPPLY IN TEGUCIGALPA IN THE REPUBLIC OF HONDURAS

FINAL REPORT

DECEMBER 2021

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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SUMMARY

Summary

1.Background and Purpose of Survey

The city of Tegucigalpa is facing the problem of chronic water supply shortage, and there is an urgent need to meet the water supply demands of the rapidly growing population. In addition, the high non-revenue water rate (32.9%) in the distribution network is also leading to deterioration in management. In accordance with the Framework Law on the Potable Water and Sanitation Sector enacted in 2003, it was decided to implement the orderly transfer of potable water and sanitation services from the Autonomous Water and Sewerage Service (SANAA) to the municipalities in charge of the national water supply business (including Tegucigalpa City: AMDC), and the transfer is scheduled to be completed by the end of 2021. From 2019 to 2025, the World Bank will support the transfer and rehabilitation of water treatment plants, water source maintenance, DMA of water distribution areas and leakage control.

This study aims to summarize the current status and issues of the water supply business in Tegucigalpa City, and to improve the water supply service.

The purpose of this project is to clarify the direction of support for the improvement of water supply services in Tegucigalpa City. In examining the direction of support, in addition to the above hardware measures, we will also consider soft support through technical cooperation, and propose a comprehensive support plan to improve the water supply service in Tegucigalpa.

2.Overview of Water Sector in Honduras

(1) National Policy

The government of Honduras enacted the Water and Sanitation Sector Framework Law (2003), which established the National Water and Sanitation Council (CONASA). Then in 2014, the Honduras National Vision and National Planning Act enacted the vision that "by 2038, all citizens will have access to improved drinking water and sanitation services."

(2) Development Plan

The National Water and Sanitation Plan (PLANASA) was developed by CONASA in December 2014 and sets out plans, strategies, targets and required investments until 2022.

3. Current Status and Issues of Water and Wastewater Systems in Tegucigalpa City

(1) Outline

The water is taken from four sources and treated at four water treatment plants before being supplied. The San Jose Water Treatment Plant is scheduled to be completed in 2024.

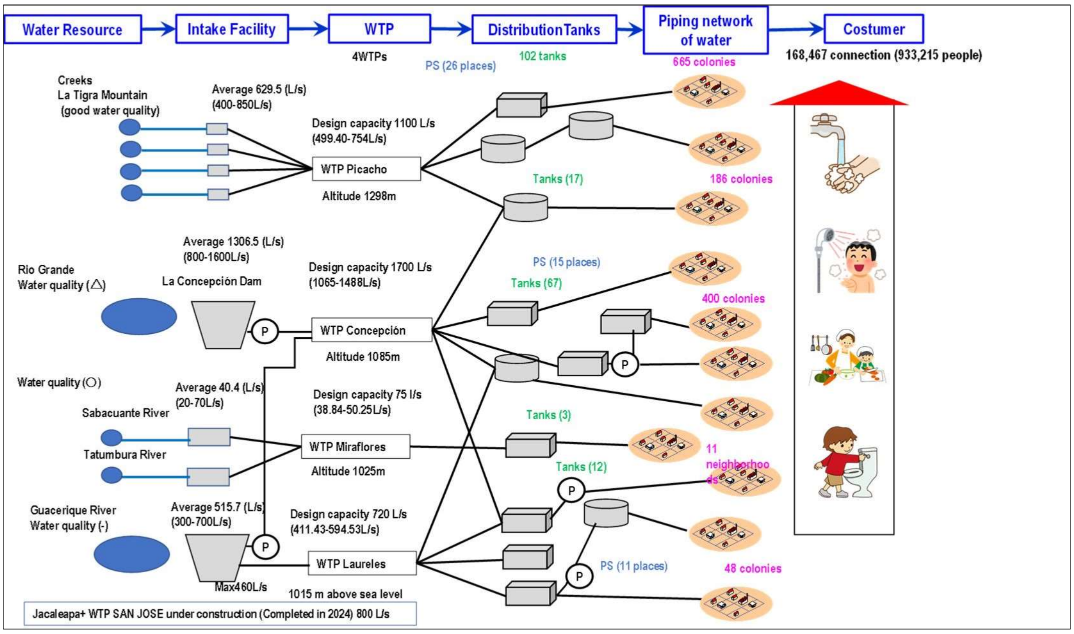

Figure S-1: Overview of Water Supply System

(2) Current Status and Issues at Each Facility

1) Water Source

A summary of the water sources is shown in the table below.

Table S-1 Summary of Water Sources

Water Conveyance System	Percentage (%)	Source	Features
Picacho	25.1	La Tigra mountain streams	Water quantity: There is a difference between the dry and rainy seasons. Water quality: Low turbidity (3-20 NTU) The bedrock is exposed and has a low water source recharge function.
Concepcion	52.1	Grande de Concepción River	Water quantity: Relatively stable (due to low rainfall in 2019) Water quality: High turbidity (20-150 NTU) with signs of eutrophication Occurrence of blue-green algae
Laureles	20.6	Guacerique River	Water quantity: Water intake decreases during the dry season. Water quality: High turbidity (50-150 NTU) Inflow of domestic wastewater to cause eutrophication (strange odor and taste) Occurrence of blue-green algae and water hyacinth
Miraflores.	1.6	Sabacuante and Canoas rivers	Water quantity: Relatively stable Water quality: Low turbidity (less than 10 NTU) Water intake suspended when turbidity is high
Wells (4 wells)	0.5	Ground water	Water volume: Stable Water quality: Drinkable, but no chlorine injection system To be discontinued in the future.

2) Water Treatment Plant

A summary of the water treatment plants is shown in the table below.

Table S-2 Summary of Water Treatment Plants

Water Treatment Plant	Flow	Features
Picacho (1100L/s)	Aerator + admixture tank + floc formation tank + inclined tube sedimentation tank + gravity type rapid sand filtration tank + chlorine disinfection	Expanded in 2010 at no cost to JICA. Water quality standards for treated water: Generally OK Aging of electrical and mechanical equipment: needs to be renewed
Concepcion (1500L/s)	Aerator + admixture tank + high-speed coagulation sedimentation tank (inclined plate type) + gravity-type rapid sand filtration tank + chlorine disinfection	Up to 1,700 L/s can be handled operationally. Water quality standards for treated water: Generally OK, but treatment function is limited 10 times the cost of Picacho due to high turbidity and color Aging of electrical and mechanical equipment: needs to be renewed
Laureles (820L/s)	Aerator + admixture tank + high-speed coagulation sedimentation tank + gravity-type rapid sand filtration tank + chlorine disinfection	Deterioration of raw water quality (powdered activated carbon, polymer) Water quality standards for treated water: Generally OK, but treatment function is limited 10 times the cost of Picacho due to high turbidity and color Aging of electrical and mechanical equipment: needs to be renewed
Miraflores. (75L/s)	Coagulation sedimentation + pressure filtration system + chlorine disinfection (Unit Type)	Scheduled to stop after completion of Jacaleapa Dam + water treatment plant Water quality standards for treated water: Generally OK, but there is an exceedance of the allowable chromaticity value during the rainy season.
Chimbo (25L/s)	Coagulation sedimentation + pressure filtration system + chlorine disinfection (Unit Type)	Current operating hours are 8 hours during the day. Water quality standards for treated water: Generally OK Aging of electrical and mechanical equipment: needs to be renewed

3) Water Transmission Facilities

In the water supply system, there are 26 pumping stations, and the pumps are high-head vertical-shaft pumps. The pump is operated manually on site, and there is no flow meter, so it is not possible to confirm the amount of water being pumped. As a result of the energy audit of the pumps, the pump specifications do not match the required flow rate and head, and the efficiency has decreased due to aging and low prices. In addition, the electricity consumption of the pumping station is approximately 70% of that of the waterworks system.

4) Water Distribution Facilities

The distribution tanks are made of RC, steel, and concrete block. In terms of age, 18.6% are more than 40 years old, 47.1% are between 20 and 40 years old, and 28.4% are less than 20 years old. All of the distribution reservoirs have flow meters that are either out of order or missing, making it impossible to properly determine the amount of water distributed. About 5,000 leaks in distribution pipes are repaired every year. Eighty-five percent of the leaks occur in the distribution pipe network with a diameter of 80 mm or less. The main cause is water pressure. In the future, it is necessary to develop an appropriate water distribution system.

5) Water Distribution Status

The water is supplied 12-15 hours once every 3-5 days. However, during the dry season from April to June, the water is supplied once every 5 to 9 days for 12 to 15 hours. There are three water supply stations for water trucks in the city, and water is distributed by the trucks in areas where pipes are not installed or according to the needs of residents.

(3) Sewerage System

The sewage pipe network is about 1,500 km long. The main body of the pipes and joints are leaking due to damage caused by age-related deterioration, and the accumulation of dirt and sediment in the pipes causes blockages and sewage retention. The La Vega Sewage Treatment Plant located in the city is treating only 2,000 m^3/day out of the planned flow of 25,450 m^3/day due to the failures of the treatment facilities.

4.Current Status and Issues of Implementing Agencies in Tegucigalpa

(1) Business Transfer

During the study phase, the project has been transferred from SANAA to the municipality of Tegucigalpa (AMDC) and is expected to be completed by the end of December 2021. In the future, the Municipal Unit of Water Supply and Sanitation (UMPAS) within AMDC will maintain the water supply and sewerage system, and the Water Supply and Sanitation Administration (UGASAM) will be in charge of water supply and sewerage system policy. The transfer has been underway since 2003, but the issue of retirement benefits for SANAA employees has been a hindrance to the transfer to UMAPS.

(2) Organizational Capacity

As a result of capacity assessment (CA) using JICA's "Handbook for Capacity Assessment of Urban Water Supply Sector and Water Utilities in Developing Countries," the average of items that can be improved by facility investment FI was 2.3, the average of items that can be improved by capacity development CD was 2.3, and the average of items that can be improved by program approach was 3.5.

(3) Financial Condition

In 2020, revenue from water charges decreased due to a flat-rate system because meter reading is not possible due to the new coronavirus pandemic, but revenue increased from the previous year due to government subsidies from the transfer of operations. On the other hand, expenditures have been on an upward trend due to an increase in administrative expenses from 2016 to 2018.

Operating office expenses have increased due to an increase in the payment of retirement benefits to retired SANAA staff (administrative expenses).

5.Results of Demonstration using Japanese Equipment and Materials

(1) Background and Purpose

In this study, we conducted a demonstration test using materials and equipment procured from Japan, keeping in mind the possibility of utilizing Japanese technology in the proposed yen loan and technical cooperation projects.

In the demonstration, the most effective leakage countermeasure was selected. The leakage countermeasure that can be implemented in a short period of time and the most effective measure to improve the water supply service in Tegucigalpa was selected for demonstration.

Since the city of Tegucigalpa has an intermittent water supply of about 12 hours every 3-5 days, we demonstrated leak detection using a tracer gas leak detector that can detect leaks even on days when there is no water supply.

(2) Implementation Results

As a result of demonstrations in the Miraflores, Monteverde, and Buenos Aires districts from August to October, leaks were detected even on days when there was no water supply, and C/P is eager to continue using the provided equipment to conduct tracer gas leak detection.

(3) Japan Technology Seminar

On September 8, 2021, we introduced the products used in the demonstration and the superior Japanese technology in supporting the improvement of water supply service in Tegucigalpa City. Forty-nine members of the government participated in the seminar. The products explained were: (1) Tracer gas leak detector (Goodman Co., Ltd.), (2) Surface water transfer system (Zeniya Marine Service Co., Ltd.), and (3) Small hydroelectric power generation: Power Archimedes (Hokuriku Seiki Co., Ltd.) and 4) Portable ultrasonic flowmeter (Tokyo Keiki Co., Ltd.)

6. Proposal for Support Measures to Improve the Water Supply Business in Tegucigalpa

After setting goals, analyzing the current situation, identifying issues, and discussing support measures, we propose the implementation of hardware and software projects as shown in the table below.

Table S-3 Summary of Proposals

NO.	System Name	Description	Beneficiary Population	Effects
Scenario 1	Concepcion	<u>**Structural components**</u> PJ-1 Study on water supply facility improvement plan for medium and long term plan in Tegucigalpa city (all subsystems) PJ-3 Installation of water quality improvement system in dam reservoir PJ-4 Rehabilitation of existing water treatment plant In the event that the World Bank cannot implement it. PJ-5 Renewal of water transmission and distribution facilities PJ-6 Improvement of water distribution network Improvement of water distribution network (expected in 10/114 sectors) (In PJ-1, it is necessary to scrutinize the amount based on a highly accurate estimate.) <u>**No Structural components**</u> PJ-7 Project on non-revenue	422,403 Water distribution pipe maintenance (37,052)	PJ-1: Develop a detailed update plan PJ-3: Reduction of chemical costs at water treatment plants <u>*Reduction of 54-75.8 million yen/year*</u> PJ-4 Securing water purification volume PJ-5 Improvement of energy efficiency in water transmission and distribution PJ-6: Reduction of water leakage Installation of long life cycle pipes and water meters **NRW will decrease from 32.9% to 10%.** <u>*104 million yen/year reduction*</u> **PJ-7** Reduction of water leakage Improvement of

NO.	System Name	Description	Beneficiary Population	Effects
		reduction measures and strengthening of water transmission and distribution network management capacity (all subsystems)		financial condition Appropriate maintenance and management
Scenario 2	Laureles	<u>**Structural components**</u> PJ-1 Study on water supply facility improvement plan for medium and long term plan in Tegucigalpa city (All subsystems) PJ-2 Construction of sewage treatment facilities in the upper reaches of Laureles Dam PJ-3 Installation of water quality improvement system in dam reservoir PJ-4 Rehabilitation of existing water purification plant In the event that the World Bank cannot implement it. PJ-5 Renewal of water transmission and distribution facilities PJ-6 Improvement of water pipe network Improvement of water distribution network (all implemented) <u>**No Structural components**</u> PJ-7 Project on non-revenue reduction measures and strengthening of water transmission and distribution network management capacity (all subsystems)	206,290 Total	PJ-1: Develop a detailed update plan PJ-2: Reduction of chemical costs at water treatment plants <u>*29 to 40.9 million yen/year reduction*</u> PJ-3 Securing water purification volume PJ-4 Improvement of energy efficiency in water transmission and distribution PJ-5: Reduction of water leakage Installation of long life cycle pipes and water meters **NRW will decrease from 32.9% to 10%.** <u>*Reduction of 134.8 million yen/year*</u> **PJ-7** Reduction of water leakage Improvement of financial condition Appropriate maintenance and management
Scenario 3	Concepcion and Laureles	<u>**Structural components**</u> PJ-1 Study on water supply facility improvement plan for medium- and long-term planning in Tegucigalpa city (all subsystems) PJ-5 Renewal of water transmission and distribution facilities (Laureles strain, Concepcion strain)	628,693 (Water distribution network maintenance: 0)	PJ-1: Formulate a detailed update plan PJ-5: Improvement of energy efficiency in water transmission and distribution, and appropriate monitoring of water delivery volume PJ-7: Leakage reduction,

NO.	System Name	Description	Beneficiary Population	Effects
		<u>No Structural components</u> PJ-7 Project for non-revenue reduction and capacity building of water transmission and distribution network management (All subsystems)		improvement of financial status, proper maintenance and management

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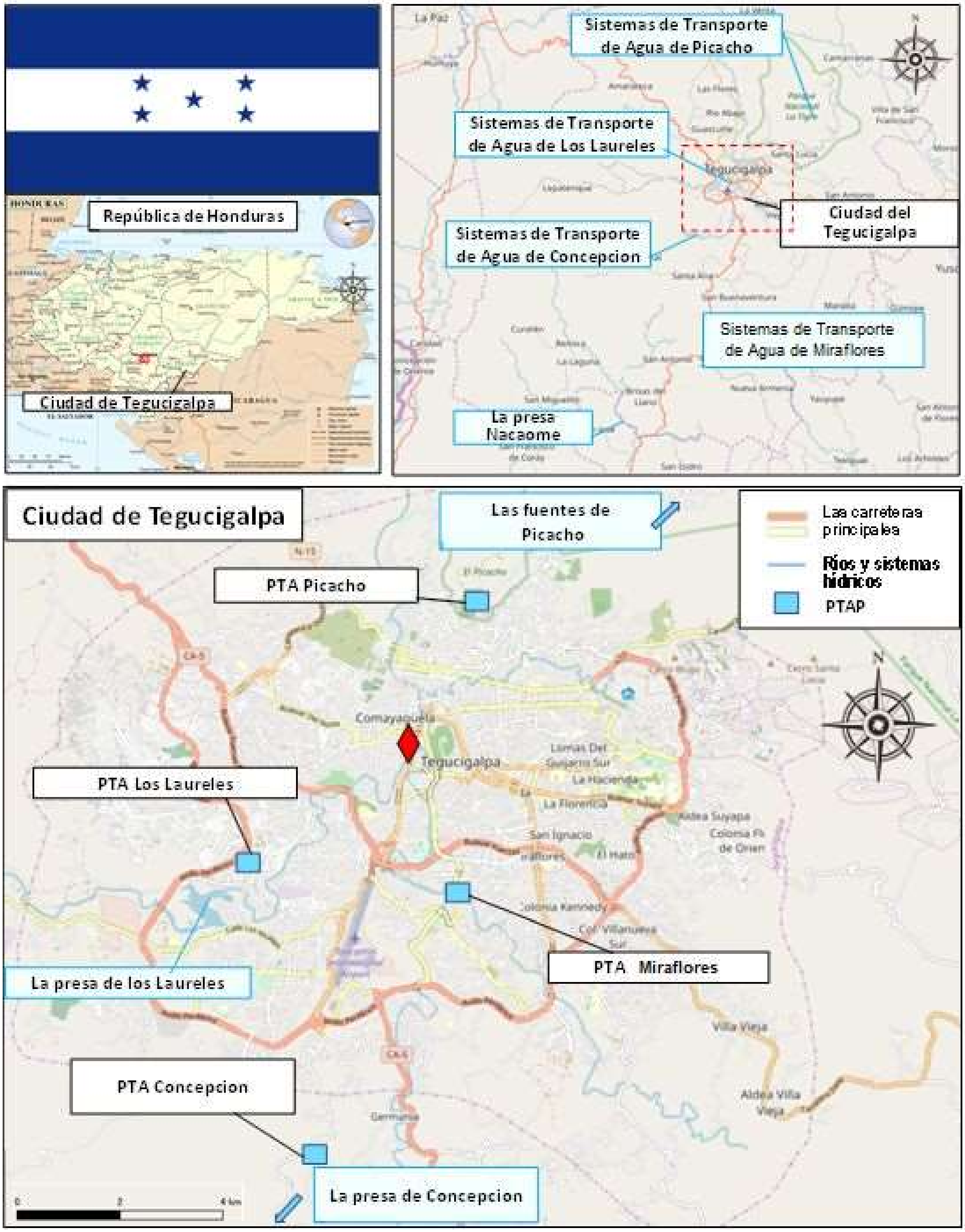
Survey Area Map



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Abbreviations

ADB	Asian Development Bank,
AMDC	Alcaldía Municipal del Distrito Central:
BCIE	Banco Centroamericano de Integracion Economica
C/A	Capacity Assessment
C/P	Counter Part
CONASA	Consejo Nacional de Agua y Saneamiento
CORE	Cofinancing for Renewable Energy and Energy Efficiency
DMA	District Metered Area
ERSAPS	Ente Regulador de los Servicios de Agua Potable y Saneamiento
IDB	Inter-American Development Bank
IWA	International Water Association
JICA	Japan International Cooperation Agency
MI AMBIENET	Secretaria de Recursos Naturales y Ambiente
MINSALUD	Secretaria de Sallud
NRW	Non-Revenue Water
PLANASA	Plan Nacional de Agua Potable y Saneamiento
PROMOSAS	Proyecto de Modernización del Sector Agua Potable y Saneamiento
SANAA	Servicio Autónomo Nacional de Acueductos y Alcantarillados
SCADA	Supervisory Control And Data Acquisition
SDGs	Sustainable Development Goals
SEFIN	Secretaria de Finanzas
SINEIA	Sistema Nacional de Evaluación de. Impacto Ambiental
STEP	Special Terms for Economic Partnership
UGASAM	Unidad de Gestión de Agua y Saneamiento Municipal
UMAPS	Unidad Municipal de Agua Potable y Saneamiento:
VFD	Variable Frequency Drives
WSP	Water Service Provider

CHAPTER 1 WORK SUMMARY

Chapter 1 Work Summary

1-1 Background of the Survey

The Government of the Republic of Honduras (hereinafter, "Honduras"), among the 11 strategic guidelines included in the 2010-2022 National Plan, emphasizes the guideline "Health as a foundation for the improvement of living conditions" and aims to reduce by half the population without access to safe drinking water by 2022, and to less than 10% by 2034. Under this plan, the National Drinking Water and Sanitation Council (CONASA) elaborated in December 2014 the "National Drinking Water and Sanitation Plan: PLANASA" and has established the strategies, detailed goals, amount of investments needed, etc. In addition, the "Ley Marco del Sector Agua Potable y Saneamiento", put into effect in 2003, determined to transfer the powers of the Servicio Autónomo Nacional de Acueductos y Alcantarillados: SANAA, the entity that until then had been in charge of the country's drinking water service, to the municipalities and to that effect they are gradually working.

In the drinking water sector of the capital Tegucigalpa, in 2015 the Municipal Unit of Drinking Water and Sanitation: UMAPS, which would be the recipient of the powers transferred from SANAA, and the Municipal Water and Sanitation Management Unit: UGASAM, which is the unit in charge of policy measures, were created. However, at present the transfer of SANAA is not completed, and therefore, the municipality of Tegucigalpa is managing the drinking water service through an agreement with SANAA.

The population of the municipality of the Central District (Tegucigalpa) is growing year after year and was expected to reach 1.4 million inhabitants in 2020, corresponding to 18% of the national population, and in 2030 approximately 25% will settle in the metropolitan area. Water supply to the metropolitan area comes from surface water sources (San Juancito-Picacho), 2 reservoirs (Los Laureles and Concepción) and other smaller scale sources (reservoirs built on the Sabacuante and Tatumbla rivers and wells), but the water supply capacity in 2020 was 1.47 m^3/s in the rainy season and just 0.77 m^3/s in the dry season, much lower than the water demand of 4.05 m^3/s, which is why the water supply schedule in the municipality is limited to every 3 to 5 days, depending on the time of year; there are even districts that need to be supplied with tanker trucks due to the reduced hours of water service in the dry season. Thus, Tegucigalpa faces a chronic problem of quantitative water supply deficiency and there is an urgent need to meet the demand for water supply as a result of rapid population growth.

In addition to the quantitative deficiency, another problem is the high rate of unbilled water due to leaks in obsolete water pipes. It was estimated that the rate of unbilled water in Tegucigalpa is 32.9%, and in addition, a low percentage of installed meters (approx. 39%) does not allow for correct metering, so it is assumed that the real rate of unbilled water would be higher. The high rate of non-revenue water causes a decrease in income, thus deteriorating the administrative aspect (the profitability obtained from the potable water service cannot cover the cost of operation and in 2020 the commercial deficit reached 80 million USD), and it is urgent to improve the efficiency of the potable water service by proposing measures to reduce leaks and water waste, in order to counteract the non-revenue water.

In view of this situation, with technical assistance from the World Bank, a business plan for Tegucigalpa's potable water service for the next 10 years was prepared in 2018. The plan establishes the guideline to improve the water supply system and the efficiency of the water service in the first 5 years and to carry out investments in infrastructure construction, such as the expansion of distribution tanks or construction of new reservoirs in the next 5 years in coordination with other cooperating institutions, in order to increase the total volume of water supply. In order to achieve the improvement of the water supply system and the efficiency of the drinking water service and following this guideline, the municipality of Tegucigalpa now sees the need to collect and analyze information to put in order the current situation of the service and its pending problems and to clarify the priority issues to be addressed.

1-2 Objectives of Survey

The objective of this survey is to make a diagnosis of the current situation and pending problems of the drinking water service in the municipality of the Central District and to determine a direction for assistance aimed at improving the water supply service. To determine the type of assistance, we will analyze in addition to measures in structural components through the renovation of facilities, equipment and materials related to the drinking water service, the integral support in non-structural components through technical cooperation, and we will present proposals aimed at the improvement of the water supply service in the municipality of the Central District.

1-3 Counterpart Agencies and Involved Institutions

Table 1-3-1 lists the counterpart agency and institutions involved. In 2015, the Municipal Drinking Water and Sanitation Unit (UMAPS) was created, the entity to which operations will be transferred from SANAA, and the Municipal Water and Sanitation Management Unit (UGASAM) in charge of developing and implementing related policies. However, the transfer process has not been completed as of the date of this survey, and UMAPS and UGASAM are hiring human resources from SANAA and other entities.

Table 1-3-1 Counterpart Agency and Institutions Involved

Institutions	Acronyms
Mayor's Office of the Central District	AMDC
Municipal Drinking Water and Sanitation Unit	UMAPS
Municipal Water and Sanitation Management Unit	UGASAM
National Autonomous Service of Aqueducts and Sewage Systems (Servicio Autónomo Nacional de Acueductos y Alcantarillados)	SANAA

1-4 Methodology of Survey

This survey consists of the first and second stages.

(1) First Stage of the Survey (October 27, 2020 to June 30, 2021)

In the first stage of the survey, the current situation and challenges of the potable water service in the municipality of Tegucigalpa were recognized and analyzed, and the structural and non-structural components necessary to improve the potable water service were systematized. The survey has been implemented remotely through videoconferences and field reconnaissance through the service of local consultants hired for this purpose. The videoconferences were organized every Thursday, between 17:00-19:00 (Honduras time) starting December 2020. The Survey Team including the local contracted staff conducted the interviews based on the information collected through questionnaires to UGASAM and SANAA, and held discussions based on the results of the field reconnaissance executed by the local contracted staff. The discussions also included requests for future cooperation from JICA expected by the local counterpart. This report systematizes and analyzes the content obtained through these discussions.

(2) Second Stage of the Survey (July 13 to December 24, 2021)

In the second stage of the Survey, a demonstration of water leak detection was carried out using the equipment and materials acquired in Japan, with the objective of exploring the possibility of introducing Japanese technologies. Likewise, the information systematized in the first stage of the Survey was updated through field reconnaissance and discussions. The results of the Survey will be integrated into the Draft Final Report that will be presented to the Honduran governmental institutions, and a basic agreement will be obtained. After integrating the comments of the related persons of the local counterpart on the Draft Final Report, the Final Report will be elaborated and delivered to the related institutions.

1-5 Survey Team Members

The following table lists the members of the Survey Team.

Table 1-5-1 Survey Team Members

Charges	Name	Organization
Consultant Team Leader/Aqueduct Plan	Sato Nobuyuki	Japan Techno Co.,Ltd.
Deputy Consultant Team Leader/Aqueduct Plan 2 / Equipment Plan /Cost Estimation	Horie Toshiki	Japan Techno Co.,Ltd.
Infrastructure Construction Plan	Fujiwara Hiroki	NJS Co.,Ltd.
Analysis of Institutions Operating Water Supply Service.	Takamizawa Kiyoko	Japan Techno Co.,Ltd.
Demonstration	Nakanosono Kenji	Japan Techno Co.,Ltd.

1-6 Survey Schedule

(1) First Stage of Survey

In the first stage of the Survey, videoconferences were held with AMDC and SANAA. Table 1-6-3 shows the schedule of the Survey. Field reconnaissance was executed by local contracted personnel under the instructions of the Survey Team.

Table 1-6-1 Study Schedule and Contents

Date	Content
3/Dec/2020	Explanation of the Study to local counterparts
10/Dec/2020	Explanation of data by the Honduran Government (organization and M/P)
10/Dec/2020	Explanation of data by the Honduran Government (water sources, water treatment plants)
8/Jan/2021	Explanation of data by the Honduran government (pipelines, transmission and distribution facilities), explanation of the indicators of the Water Service Provider (WSP) analysis
15/Jan/2021	Explanation of data by the Honduran government (customer registry, finances, water demand), analysis of the WSPs
22/Jan/2021	Explanation of data by the Honduran government (customer registry, finances, water demand), analysis of the WSPs
29/Jan/2021	WSP analysis, additional questions (volume of water sources, micro hydropower plant, water treatment plants, finances)
5/Feb/2021	Development of water sources, results of the field survey at the water treatment plants, interview of commercial and financial department personnel
12/Feb/2021	Analysis of the WSP, results of the field survey at the water treatment plants, interview of the commercial and financial department personnel, and interviews with the water treatment plants' personnel.
19/Feb/2021	Requests by the Honduran Government, interview on water treatment plants and M/Ps, interview on candidate sites for demonstration of leak detection equipment
26/Feb/2021	Requests by the Honduran government, interview on WSP analysis
5/March/2021	Interview on distribution pipe networks, consultation on water treatment plants, interview on the financial situation, explanation of the results of the analysis of the institutional organization.
12/March/2021	Interview with the World Bank on the progress, results of the analysis of water quality in distribution pipeline networks
19/March/2021	Interview on the status of the construction of the new water sources, consultation on the results of the field survey at the water treatment plants, interview on M/P
8/Apr/2021	Consultation on plant site visits, etc., status of transfer from SANAA to UMAPS, questions on M/P donors, etc.
15/Apr/2021	Upcoming trip to Honduras, interview on drinking water treatment plants, interview on water demand
22/Apr/2021	Interview on the operation and management of the transmission system, interview on the supply areas of the distribution tanks, interview on the total length of the distribution pipelines, interview on the status of the transfer of the organization
29/Apr/2021	Interview on the EIA, interview on the distribution piping networks, interview on the transmission system, energy consumption of the pumps
6/May/2021	Consultation on the possibility of conducting the remote leak detection demonstration, interview on the status of the UMAPS relocation, consultation on pipeline repair

20/May/2021	Confirmation of AMDC applications
3/Jun/2021	Consultation on dates, visits to plant sites, tanks, etc., consultation on leak detection demonstration.
17/Jun/2021	Consultation on suspension of trip to Honduras, consultation on leak detection demonstration.
24/Jun/2021	Explanation of the demonstration, equipment and materials
9/Jul/2021	Explanation on the summary of the Interim Report, explanation on the Survey Team's submission schedule
23/Jul/2021	Compilation of comments and opinions on the Interim Report

(2) Second Stage of the Survey

Table 1-6-2 shows the schedule for Phase II of the Survey.

Table 1-6-2 Survey Schedule and Contents

Name	Date	Content
Sato Nobuyuki	13/July - 15/Nov/2021	Consultation with the Honduran Government, internal meeting of the Study Team, confirmation and correction of the data from the consultations with the Honduran Government and JICA (in Japan), explanation to the Honduran Government on the Draft Final Report and the Final Report.
Horie Toshiki	20/Aug - 15/Nov/2021	Consultation and interview with the Honduran Government, demonstration, field reconnaissance at water sources, water treatment plants, pumping stations, distribution tanks and purification plants, technical seminar on Japanese technology, explanation to the Honduran Government on the Draft Final Report and the Final Report.
Fujiwara Hiroki	20/Aug - 23/Sep/2021	Interview on the facilities, field reconnaissance of water sources, water treatment plants, pumping stations, distribution tanks and wastewater treatment plants, technical seminar in Japan
Takamizawa Kiyoko	23/Aug - 13/Sep/2021	Interview on WSP analysis, demonstration, field survey at water treatment plants, technical seminar on Japanese technology.
Nakanosono Kenji	13/Jul - 13/Sep/2021	Interview on measures against water leaks, demonstration, field survey at water treatment plants, technical seminar on Japanese technology.

CHAPTER 2 DESCRIPTION OF THE WATER SECTOR IN HONDURAS

Chapter 2 Description of the Water Sector in Honduras

2-1 National Policy

The Government of Honduras enacted the Drinking Water and Sanitation Sector Framework Law in 2003, creating the National Drinking Water and Sanitation Council (CONASA) as the planning body for the drinking water and sanitation sector. The Government drafted the National Drinking Water and Sanitation Sector Policy in 2014 under the leadership of CONASA, establishing the sector's development policies and goals. This policy instrument also includes the main strategic elements to comply with the policy goals, and constitutes the general conceptual and methodological guideline for the elaboration of development programs and plans, through inter-institutional coordination.

The aforementioned policy covers the entire national territory with a broad approach and establishes 2038 as the target year, as stipulated in the Law for the Establishment of a Country Vision and the Adoption of a National Plan for Honduras.

This policy presents a general guideline for the development of the entire sector, involving all municipal governments. However, due to the peculiarity and complexity of the sector in a large metropolitan area, it establishes that it is necessary to elaborate specific and concrete development strategies and plans for Tegucigalpa and San Pedro Sula.

Vision

In the year 2038, the Honduran population has access to improved drinking water and sanitation services that meet service quality standards, promote the country's socio-economic development, and are developed through actors capable of fulfilling their responsibilities efficiently and effectively, within the framework of sustainable water resource management and risk prevention.

Policy Guidelines and Specific Objectives

1. Achieve universal access to drinking water and sanitation services with a focus on social inclusion, taking into account the priorities and specific conditions of the different categories of localities.
2. Improve drinking water and sanitation service levels in existing systems, according to the conditions of the different categories of localities.
3. To achieve integral sustainability of drinking water and sanitation services.
4. To develop the provision of drinking water and sanitation services within the framework of sustainable management of water resources.
5. Achieve sector governance through institutional strengthening and capacity building at the municipal level.
6. Strengthen the governance of the sector at the national level through institutional strengthening.
7. To operate the sector through a transparent, adequately managed and administered financial framework that covers all categories of costs and investments.

The strategic framework provides the basis for all actions and interventions of the sector's stakeholders and defines how specific objectives will be achieved. The strategies are aimed at developing the following components:

1. Strategy for infrastructure development
2. Strategy for service delivery
3. Strategy for decentralization and local development
4. Strategy for institutional development and governance of the sector
5. Strategy for capacity development and strengthening
6. Financial strategy of the sector

2-2 Development Plans

(1) National Policies for the Water and Sanitation Sector in Honduras

The government of Honduras and CONASA has developed in December 2014 the National Drinking Water and Sanitation Plan (PLANASA) based on the National Policies mentioned above, which sets out the plans, strategies, goals and required investments until 2022.

PLANASA analyzes the national approach, the sector's progress and the related legal instruments, identifying the difficulties for the proper fulfillment of the functions established by law, such as the following:

a) Lack of an institutionalized operational body of CONASA to prepare proposals, formulate regulations, make its resolutions and provisions viable, carry out monitoring and evaluation, and coordinate actions with other national, regional and municipal entities, in addition to managing and implementing financing for the benefit of the sector.

b) ERSAPS does not have sufficient resources to carry out the regulation of the sector, which would allow it to verify compliance with the law by municipalities and water and sanitation service providers throughout the country.

c) SANAA does not have the organization or resources to act as the Technical Secretariat of CONASA, and as a technical assistance agency it has no formal processes for its operation.

d) In order for the Health Surveillance and Regulation System for drinking water and sanitation services to operate efficiently, SESAL (Ministry of Health) requires trained financial and human resources, adequate technologies and instruments for data collection, designed for this purpose, as well as adequate mechanisms for the flow of information at the different levels.

The purpose of the Plan is to establish the sectoral framework for the development of drinking water and sanitation services, prioritizing the areas and investments in response to the human right to these services, promoting actions for the sustainability and governance of the services, thus contributing to the country's economic and social growth, to the sectoral institutional framework and to the environmental preservation of water resources.

For the formulation of the PLANASA, the guidelines of the National Plan have been considered, which establishes national planning by hydrographic regions and, in turn, by population categories, as follows

i) Metropolitan cities;
ii) Major cities (population over 30,000 inhabitants);
iii) Small cities (population between 5,000 and 30,000 inhabitants);
iv) Smaller urban centers (2,000 to 5,000 inhabitants);
v) Concentrated rural (250 to 2,000 inhabitants); and
vi) Dispersed rural areas with a population of less than 250 inhabitants.

PLANASA presents the following list of Strategic Guidelines, in accordance with the guidelines of the National Policy of the Drinking Water and Sanitation Sector of Honduras.

1. Decentralization of services (decentralization and autonomy of services, municipal development plans).
2. Citizen participation and social auditing.
3. Institutional and sectoral governance (leadership, institutional consolidation and coordination, sectoral regulations, dissemination and monitoring, knowledge management and sectoral information systems).
4. Service delivery (Sustainability, governance in service delivery)
5. Capacity building in the provision of services (Institutional strengthening of water service EPSs, capacity building of local governments, and promotion of qualified supply).
6. Infrastructure development (principles and requirements, safe and potable water, water supply continuity and efficiency, and universalization of services).
7. Sectoral financing (Levels of financing for the sector)

Based on these strategies, the Plan establishes the following quantitative goals of the National Sector Plan 2014- 2022.

Table 2-2-1 Potable Water and Sanitation Service Coverage Goals

	Potable Water Coverage Target (%)			Sewerage and Sanitation Target Coverage **(%)		
	2013*	2018	2022	2013*	2018	2022
Metropolitans	62	63	**81**	40	43	**60**
Major cities (> 30,000)	69	75	**84**	40	50	**60**
Small towns (5,000-30,000)	80	85	**91**	21	43	**60**
Urban minor (2,000-5,000)	84	90	**93**	59	65	**71**
Concentrated and dispersed rural (<2,000)	87	89	**93**	68	69	**74**

Baseline: 2011 coverage data, **Metropolitan, major cities and small cities figures correspond to sewerage coverage, while minor urban, concentrated and dispersed rural figures correspond to sanitation coverage.

Source: Prepared by the Study Team based on PLANASA.

Based on the table above, the Plan estimates the investments needed to achieve the goals for the 2014-2018 and 2018-2022 periods. The investment for the 2014-2018 period reaches US$ 503 million, equivalent to US$ 126 million per year, which represents a sectoral challenge that requires intensifying the management and execution capacity, while maintaining the investments required in the decentralization axes. For the following period 2018-2022, although, with the investments of the adjusted scenario, it is still pending to make progress in improving the continuity of the service and the reduction of non-revenue water (unaccounted for), being possible through the execution of sectorization actions and rehabilitation of existing systems. With this, it will have been achieved that rural drinking water coverage will reach 93% in 2022, as well as reducing by half the gap of lack of access to water services in urban areas. Likewise, at the urban level, sewerage coverage will have reached 60 % (including small cities) and wastewater treatment will have reached 50 % of the total volume collected.

(2) Master Plan

The following table presents a summary of the master plans for potable water service in the City of Tegucigalpa.

Table 2-2-2 Master Plans for Potable Water Service in the City of Tegucigalpa

Name	Year of Production	Author/ Donor	Description
P/M JICA (JICA Master Plan)	2001	PCI/JICA	It establishes as goals: (1) Achieve stable water supply service with 99% reliability against drought, which is equivalent to the driest month in 10 years; and (2) Continuous, 24-hour water supply service with adequate quantity and quality. The Plan estimated the production in 2000 and the production required for the year 2015 based on projected population and demand and performed the comparative technical and economic analysis of the following Master Plan candidate projects. The dredging project at Los Laureles Reservoir; - - Los Laureles II Project (consisting of the construction of Los Laureles II Dam and the necessary water supply facilities as well as the excavation of the existing Los Laureles reservoir). - - Quiebra Montes Project, which consists of the construction of the Quiebra Montes Dam and the necessary water supply facilities; - - Sabacuante Project, which consists of the construction of the Sabacuante Dam and the necessary facilities for water supply; - - Tatumbla Project, which consists of the construction of the Tatumbla Dam and the necessary water supply facilities; and - Tatumbla Dam, which consists of the construction of the Tatumbla Dam and the necessary water supply facilities. - - Water leakage reduction project (replacement of water pipes of a certain diameter). The Los Laureles II Project was selected as the priority project for which the Feasibility Study was conducted.
P/M SOGREAH	2004	SOGREAH/France	Master Plan on the development of water sources. A study of the primary water supply system (water

Name	Year of Production	Author/ Donor	Description
(SOGREAH Master Plan)			sources - reservoirs), population projection and water demand, and hydrological analysis, among others, was carried out, proposing four alternative sources, namely the Hombre, Guacerique, Sabacuante and Nacaome rivers, which were subjected to a comparative analysis from the technical, economic and environmental perspectives. The study analyzed the hydrological information, hydrological functions of the dams, construction of the dams, adduction lines and water treatment plants for each of the identified sources. It also included the estimation of the cost of the project and the economic analysis, leading to the selection of Guacerique II as the priority project, for which the preliminary design was carried out.
P/M AQUARUM (AQUARUM Consolidated Master Plan)	2011	AQUARUM/Spain	It includes an extensive study and analysis of the distribution networks and proposes a master plan. The diagnosis of the existing potable water supply system included the projection of water demand, evaluation of sources and their productive capacity, distribution system, losses and current state of distribution pipes, hydrological analysis through modeling, measures against water leakage and ANF, and the study of pump energy. It proposes to improve the aqueduct system by managing water pressure with sectorization (distribution blocks), improvement measures in low pressure areas, and improving the pressure regulation capacity of the distribution networks.
Action plan (Climate Change Action Plan)	2018	NDF/BID	This plan has been developed as a regional plan for climate change adaptation with a focus on watersheds. The plan serves as a means of multidisciplinary coordination for climate change adaptation in the central municipalities, including Tegucigalpa. The plan identifies integrated management of drinking water security and sanitation as one of the priority components.

2-3 Relevant Laws and Regulations

(1) Laws and Regulations related to Drinking Water and Sanitation

The following table lists the legal instruments related to drinking water and sanitation.

Table 2-3-1 Laws and Regulations related to Drinking Water and Sanitation

	Laws and Regulations	Year Enacted	Decree
1	Constitution of the Republic	2012	No. 270-2011
2	Drinking Water and Sanitation Sector Framework Law	2003	No. 118-2003
3	Law for the Establishment of a Country Vision and the Adoption of a National Plan for Honduras	2010	No. 286-2009

4	General Environmental Law	1993	No. 104-93
5	General Regulations of the General Environmental Law	1993	No. 109-93
6	General Water Law	2009	No. 181-2009
7	Constitutive Law of the National Autonomous Service of Aqueducts and Sewerage (SANAA)	1961	No. 91
8	Municipalities Law	1990	No.134-90
9	Land Management Law	2003	No. 180-2003
10	Forestry, Protected Areas and Wildlife Law	2008	No.98-2007
11	National Strategy for Watershed Management in Honduras	2011	(Ministerial Agreement) No.014-2011
12	Health Code	1991	No.65-91
13	General Environmental Health Regulations	1998	(Agreement) No.0094

a) Amendment of Article 145 of the Constitution of the Republic of Venezuela

The Constitution of the Republic of Honduras, in its Title III "On Declarations, Rights and Guarantees", Chapter VII "On Health", establishes the following: "The right to health protection is recognized. It is the duty of all to participate in the promotion and preservation of personal and community health. The State shall preserve an adequate environment to protect the health of the people. Consequently, access to water and sanitation is declared a human right, whose development and use shall be equitable, preferably for human consumption. Likewise, the preservation of water sources is guaranteed so that they do not endanger life and public health. The stipulations herein are applicable to all activities of the State, public and private. The provisions herein shall be regulated by law".

b) Framework Law for the Drinking Water and Sanitation Sector (Framework Law)

This Law establishes the norms applicable to drinking water and sanitation services in the national territory. The provision of these services shall be governed under the principles of quality, equity, solidarity, continuity, generality, environmental respect and citizen participation.

The objectives of the Law are:

i) Promote the expansion of service coverage; ii) ensure water quality and potability; iii) establish the environmental management framework, both for the protection and preservation of water sources and for sanitation and effluent discharge management; iv) establish the criteria for the valuation of services and tariff schemes; v) strengthen service management planning and governance; vi) establish the integration of responsibilities for environmental management and the operation of service infrastructure; vii) establish the conditions for the regulation and technical control of the activity of those who build and operate drinking water and sanitation systems; viii) establish the conditions for the regulation and technical control of the activity of those who build and operate drinking water and sanitation systems; vi) to establish the integration of responsibilities for environmental management and operation of service infrastructure; vii) to establish the conditions for regulation and technical control of the activity of those who build and operate drinking water and sanitation systems; viii) to establish mechanisms for the provision of services in rural areas that operate efficiently; ix) to promote citizen participation in the provision of services; and x) to promote the efficient operation of drinking water and sanitation systems.

The Law created the National Council of Potable Water and Sanitation (CONASA) and the Regulatory Entity of Potable Water and Sanitation Services (ERSAPS). It also reformed the powers of the Servicio Autónomo Nacional de Acueductos y Alcantarillados (SANAA) transferring the responsibilities for potable water and sanitation to the municipal governments, also transferring the systems operated by SANAA to the municipal governments.

The Framework Law transfers the capacities for potable water and sanitation services to the municipal governments, in accordance with the state decentralization policy, and establishes the conditions for the creation and strengthening of service providers for both urban and rural areas. In relation to the sustainability of services, the Law includes provisions related to environmental and financial sustainability. On the other hand, it establishes governance conditions to achieve citizen participation in the service provision process, transparency of EPS management, accountability of performance.

c) Law for Establishment of a Country Vision and Adoption of a Nation Plan for Honduras

The purpose of this Law is to approve the Country Vision for the year 2038 and the National Plan for the year 2022, with which the planning process for the economic, social and political development of the country begins.

This law stresses the need to double the capacity of drinking water and sanitation services, which are currently deficient in terms of scope, quality and continuity in the face of rapid urbanization. Within this context, the Law proposes to adopt a differentiated approach prioritizing the population living in cities with more than 5,000 inhabitants connected with paved roads and their surroundings (in an area of influence of 10 kilometers parallel to their location). In this way, two thirds of the national population would be covered. It also establishes the goals of universal drinking water and sanitation coverage to be achieved by 2022 and 2034. Additionally, the Law establishes the goal to be achieved in relation to water sources, as well as a series of considerations to be taken into account for adaptation to climate change.

d) General Environmental Law

Article 1 of the General Environmental Law establishes that "The protection, conservation, restoration, and sustainable management of the environment and natural resources are of public utility and social interest. Likewise, Article 30 states that "The State and the municipalities in their respective jurisdictions are responsible for the management, protection and conservation of watersheds and natural water deposits, including the preservation of the natural elements involved in the hydrological process.

The General Environmental Law includes several provisions to protect water supply sources and manage the quality of effluents discharged into natural water bodies. In order to promote the improvement of the quality of drinking and wastewater, it establishes some fiscal incentives to direct natural and legal persons that use water sources or discharge effluents to an adequate treatment.

e) General Regulations of General Environmental Law

The purpose of this Regulation is to develop its precepts, which hereinafter will be identified as the General Environmental Law. It establishes the infractions derived from acts that may damage water sources and rivers due to illegal discharge and pollutants, as well as the sanction system.

f) General Water Law

The purpose of this law is to establish the principles and regulations applicable to the adequate management of water resources for the protection, conservation, valorization, and use of water resources in order to promote integrated water resource management at the national level. The Law prioritizes the protection of water sources and declares that human consumption has a preferential and privileged relationship over other uses, as well as establishing provisions on payment for environmental services to raise funds to be used for the protection and conservation of water sources. It also includes provisions on the creation and preservation of protected areas, prohibition of effluent discharge, etc.

g) Constitutive Law of National Autonomous Service of Aqueducts and Sewerage (SANAA)

The Law creates the National Autonomous Service of Aqueducts and Sewage Systems (SANAA) to promote the development of public drinking water supplies and sanitary and storm sewage systems throughout the country. Considering that drinking water, sewage and storm water services cannot be considered and resolved from a local or municipal point of view, but from a national one, the Law establishes its objectives and powers taking into account that: 1) to achieve greater economy and efficiency, the supply sources must be interconnected to serve two or more communities; 2) uniformity of standards must be ensured in the application of the principles of Sanitary Engineering to achieve economy and efficiency in the planning, design, construction and administration of the services.

It is established that SANAA will be in charge of the study, construction, operation, maintenance and administration of all projects and works of aqueducts and sewage systems belonging to the Central District, Municipalities, Water Boards, Development Boards or any governmental agency, and will represent the interests of the State with respect to water supply and sewage systems in private companies that provide public services.

h) Municipalities Law

The purpose of this Law is to develop the constitutional principles related to the Departmental and Municipal Regime. The Law establishes the concept of the Municipality as an independent organ of the state authority that will function to achieve the well-being of the inhabitants, promote their integral development and the preservation of the environment.

It establishes the functions of the departmental head and the relationship with the municipalities, as well as the terms for integrating the associations of municipalities (Council and Intermunicipal Technical Unit). On the other hand, it establishes the functions of the constituent bodies including the municipal mayor, vice mayor, councilors, auxiliary mayors, etc., as well as the functions of the main resources such as the secretary, auditor, treasurer, and members of the municipal corporations, among others. On the other hand, it establishes the integration and operation of the Municipal Development Council and the Citizen Transparency Commission.

Its functions include the provision of drinking water and sanitation services, establishing the powers of the municipalities to form specialized units for the provision of services.

This Law attributes to the municipalities the power to define the rates for direct and indirect municipal services, which must be published in the planning phase. The municipalities are also empowered to collect the contribution for improvements, until it totally or partially recovers the investment, to issue bonds for the financing of works and services, and to enter into financing contracts with national and foreign financial institutions.

(3) Standards related to Drinking Water and Sanitation

The following table presents the standards related to drinking water and sanitation.

Table 2-3-2 Drinking Water and Sanitation Standards

	Standards	Year Established	Decree
1	National technical standard for drinking water quality	1995	No. 84-1995
2	Technical standards for wastewater discharges to receiving bodies and sanitary sewers	1996	No. 58-1996
3	Regulation on Quality of Service of Potable Water and Sanitary Sewage Service	2005	No. 001-2006
4	Design standards for drinking water systems	2004	- —
5	Design standards for sanitary sewerage, storm sewerage and wastewater treatment	2004	- —
6	Technical guidelines for the incorporation of disaster mitigation measures in the design and construction of water and sanitation systems.	2005	- —

a) National Technical Standard for Drinking Water Quality

The purpose of this standard is to protect public health by establishing the appropriate or maximum levels of those components or characteristics of water that may represent a risk to the health of the community and inconvenience for the preservation of water supply systems. The Water Quality Standard establishes the basic requirements to which the quality of water supplied for human consumption and for all domestic use must respond, regardless of its state, origin or degree of treatment. For all purposes of regulations on the quality of the water supplied, this Quality Standard contains the values for physical, chemical, and organoleptic parameters, as well as the parameters of organic substances, pesticides, disinfectants and disinfection by-products with significance for health.

b) Technical Standards for Wastewater Discharges to Receiving Bodies and Sanitary Sewers

The purpose of these standards is to regulate wastewater discharges to receiving bodies and sanitary sewers, and to promote the creation of waste minimization programs and the installation of wastewater treatment and disposal systems. Any natural or legal, public or private person that carries out activities that generate discharges must comply with the provisions described in the regulations. When the discharges do not comply with the standards, the necessary corrective measures must be incorporated within a period of no more than 18 months from the effective date of this Agreement. Each direct or indirect discharge to a receiving body must comply with the general physical, chemical and bacteriological characteristics whose maximum permissible ranges and concentrations are specified in these standards.

c) Regulation of Quality of Service of Potable Water and Sanitary Sewage Service

The "General Regulations for the Quality of Drinking Water and Sewerage Service" establishes the control parameters and recommendations for the specific Service Quality Regulations, which should regulate the activities of each EPS in this aspect, and the relations between the EPS, the respective Municipal Control Committee, in relation to the Quality of Service. These Regulations define the conditions and characteristics to which the provision of public drinking water and sanitary sewerage services must tend, within the reasonableness and possibility based on the capacity of the EPSs. This General Regulation defines the requirements to be met by water and sewerage service providers, classifying operators into metropolitan, urban and rural, in order to justify the flexibility and gradual application of the Regulation's requirements. The regulated technical aspects of service quality of metropolitan EPSs are: quality of drinking water; water pressure; continuity of service; absence of sanitary sewer overflows; quality of wastewater discharge; and attention to users' technical queries and complaints.

d) Aqueduct Design Standards

These design standards establish the technical requirements that aqueduct systems must meet. They establish the specifications and design criteria for water sources, design period, design population served, water demand, hydrological analysis, drinking water treatment process, disinfection, storage, distribution pipelines and pumping stations.

e) Sewage, Storm and Wastewater Treatment Design Standards

These standards establish the basic design parameters for storm sewer and wastewater treatment facilities and works to treat wastewater and efficiently dispose of stormwater. Specifically, they establish the standards and guidelines applicable to conventional sewer systems (design periods, population served, area served, flow velocity, pipe diameter, slopes, etc.), sewer systems, mini sewer systems, wastewater treatment systems, selection of wastewater treatment technology, wastewater treatment process, sludge treatment, stormwater and wastewater disposal systems, and effluent pumping stations.

f) Technical Guidelines for Incorporation of Disaster Mitigation Measures in the Design and Construction of Water and Sanitation Systems.

Drinking water and sanitation systems in Honduras have been vulnerable to environmental risks and natural disasters, with a lack of environmental and social considerations in their design, construction, maintenance and operation. Therefore, this technical guide establishes the rules and standards to mitigate the negative impact caused by disasters. Specifically, it presents the norms, variables, guidelines and proposals in each phase of planning, design, construction, operation, maintenance and monitoring, taking into account the measures against damage to drinking water and sanitation systems at the national level.

2-4 Organization and Institutionalization

The following table presents the list of relevant agencies and institutions in the water and sanitation sector in Honduras. These agencies and institutions exercise powers attributed by the legal framework, establishing the respective functions and responsibilities in the area of drinking water and sanitation.

Table 2-4-1 Drinking Water and Sanitation Sector Agencies and Institutions

No.	Organizations and Institutions / Official Name	Acronyms
1	Secretary of Health	SESAL
2	Secretary of Natural Resources and Environment	MIAMBIENTE
3	Secretary of Finance	SEFIN
4	Secretary of State in the Offices of the Interior and Justice	SGJD
5	National Water and Sanitation Council	CONASA
6	Drinking Water and Sewage Services Regulatory Entity	ERSAPS
7	National Autonomous Service of Aqueducts and Sewage Systems (Servicio Autónomo Nacional de Acueductos y Alcantarillados)	SANAA
8	National Institute of Forest Conservation and Development, Protected Areas and Wildlife (INCAFE)	ICF
9	Municipal Governments	GM
10	Service Providers	EPS
11	Water Management Boards	JAA
12	Regional Development Councils	CRD
13	Forest Advisory Councils	CCF
14	Basin Organizations	CO

Source: Luis Moncada Gross 2019 [1]

Of these agencies and institutions, the National Water and Sanitation Council (CONASA) is responsible for managing, planning and financing the drinking water and sanitation sector; the Regulatory Agency for Drinking Water and Sanitation Services (ERSAPS) is responsible for granting permits and authorizations, regulating, managing, sanctioning, providing technical assistance, etc.; and finally the National Autonomous Service for Aqueducts and Sewerage (SANAA) is responsible for managing the sector, developing infrastructure and providing technical assistance at the national level. At the regional level, local governments assume the management and coordination of the drinking water and sanitation sector, and their functions include planning, financing, infrastructure development, permitting and authorization, regulation, financial management, land-use planning, environmental protection, technical assistance, etc. Under the respective municipal government, the

[1] Prontuario de Disposiciones Legales Atinentes a los Servicios de Agua Potable y Saneamiento, Luis Moncada Gross 2019

water and sewerage service providers are responsible for planning, financing, regulation, management, financial management, public awareness, etc., as stipulated by law.

The operation of water and sewerage services had been assumed by SANAA at the national level. However, as a result of the Framework Law enacted in 2003, the powers to operate the services have been transferred to each local government. Therefore, currently all drinking water and sanitation services have been progressively transferred to each local government, except for four cities, including Tegucigalpa (Ceiba, Amapala, Progreso, Metropolitan District).

In the City of Tegucigalpa, water and sewerage services will be transferred to the Municipal Mayor's Office of the Central District (AMDC), for which the Municipal Drinking Water and Sanitation Unit (UMAPS) and the Municipal Water and Sanitation Management Unit (UGASAM) were created, where the former is the unit to which the operations of the Metropolitan Division of SANAA will be transferred, and the latter is in charge of sectoral policies. UGASAM currently functions as the unit responsible for policies, but due to financial constraints, the process of transfer to UMAPS has not progressed as scheduled, but only a part of the Metropolitan Division of SANAA as of May 2021. Therefore, Tegucigalpa's aqueduct and sewerage services continue to be operated by the Metropolitan Division of SANAA. Details on these agencies are provided in Chapter 4.

2-5 Trends in Assistance from Japan and Other Donors

Japan has been implementing projects, mainly within the framework of the Non-Reimbursable Financial Cooperation (Grant Aid), for the potable water and sanitation sector in Tegucigalpa, which include the construction of micro-hydroelectric plants, reconstruction of the water conduction and distribution lines, construction of water supply stations, supply of equipment and materials, etc. On the other hand, the Government of Spain, the World Bank, the Inter-American Development Bank (IDB) and the Central American Bank for Economic Integration (CABEI) have implemented loan projects for the construction of treatment plants, study of the distribution network, reconstruction works and capacity building. Currently, the World Bank is implementing the Project for the Strengthening of the Potable Water Service in Tegucigalpa that will be completed in 2025. Table 2-5-1 presents a list of the assistance provided to the aqueduct and sewerage sector in Tegucigalpa.

Table 2-5-1 Assistance Projects Executed in the Potable Water and Sanitation Sector in Tegucigalpa

No.	Year of Execution	Executing Agency	Project	Estimated Cost (US$)	Modality	Description
1	2011	JICA	Water Supply Project for Tegucigalpa's Urban Area	17 million	Grant	- Reconstruction of El Picacho water treatment plant - Construction of pipelines and reservoirs
2	2011	World Bank	PROMOSAS	1.0	Loan	Study of existing

No.	Year of Execution	Executing Agency	Project	Estimated Cost (US$)	Modality	Description
				million		distribution networks
3	2009-2012	Government of Spain	Optimization of Drinking Water Supply System and Improvement of Distribution Pipelines	17 million	Loan	- Analysis of the distribution network - Leak investigation program - Plan of hydrometric areas (75 sectors) - Diagnostics of energy consumed by pumps
4	2012	World Bank	PROMOSAS	1.3 million	Loan	Drinking water services optimization study
5	2013	World Bank	PROMOSAS	0.65 million	Loan	Study of existing sewerage networks
6	2013	World Bank	PROMOSAS	6.5 million	Loan	- Plan of hydrometric areas (53 sectors) - Study of distribution networks - Study of reservoirs and pumping stations
7	2013	CABEI	Reconstruction of the Los Laureles Dam floodgate	4.2 million	Loan	Reconstruction of the Los Laureles Dam floodgate
8	2014	KOICA	Feasibility study for Guacerique II Dam	0.9 million	Grant aidGrant	Upgrade study for dam construction
9	2014	World Bank	Water leakage reduction program	1.1 million	Loan	Supervision of water leakage reduction works
10	2015	CABEI	Reconstruction of Los Laureles catchment facilities	1.2 million	Loan	Reconstruction of intake facilities
11	2015	JICA	Micro-Hydroelectric Power Generation Project in the Metropolitan Area of Tegucigalpa	12.7 million	Grant	Supply of micro-hydroelectric power generation equipment for the Picacho and Concepción water treatment plants.
12	2015	JICA	Extension of the L22 pipeline system	0.7 million	Grant	
13	2015	CABEI	Reconstruction of the Colonia Villanueva tank and pumping station	2.3 million	Loan	Reconstruction of the Colonia Villanueva tank and pumping station
14	2015	IDB	Rio del Hombre dam	0.82 million	Loan	Detailed design and environmental study

No.	Year of Execution	Executing Agency	Project	Estimated Cost (US$)	Modality	Description
			feasibility study			of the Rio del Hombre Dam
15	2016	CABEI	Community capacity building	0.8 million	Loan	Reforestation for the protection of aquifer recharge areas
16	2016	World Bank	PROMOSAS	0.52 million	Loan	Diagnosis for the transfer of SANAA to AMDC
17	2018	CABEI	Optimization of Los Laureles drinking water treatment plant	1.4 million	Loan	Reconstruction of Los Laureles drinking water treatment plant
18	2018	CABEI	Reconstruction of the water treatment plant in La Concepción	1.4 million	Loan	Reconstruction of the water treatment plant in La Concepción
19	2018	CABEI	Reconstruction of Los Laureles drinking water treatment plant	1.5 million	Loan	Reconstruction of Los Laureles drinking water treatment plant
20	2018	CABEI	Project to transfer raw water from Los Laureles reservoir to the aerator of the Concepción reservoir water treatment plant.	9.7 million	Loan	Detailed design and execution of raw water transfer works.
21	2019	IDB	Institutional strengthening of the drinking water and sanitation sector	30 million	Loan	- AMDC - Financial policy - Strengthening operation and maintenance
22	2019-2024	World Bank	Project for the Strengthening of the Potable Water Service in Tegucigalpa	50 million	Loan	- Assistance in the transfer to UMAPS - Upgrading of water treatment plants and distribution networks - Strengthening of dam operation and maintenance capabilities - Strengthening of operation and maintenance capabilities

Source: AMDC

CHAPTER 3 CURRENT SITUATION AND CHALLENGES OF THE POTABLE WATER SYSTEM IN THE MUNICIPALITY OF TEGUCIGALPA

Chapter 3 Current Situation and Challenges of the Potable Water System in the Municipality of Tegucigalpa

3-1 General Situation of Survey Area

3-1-1 Basic Data

The Republic of Honduras is located in the center of Central America and has an area of 112,490 km^2 (approximately one third of Japan). It borders Guatemala to the west, El Salvador to the southwest and Nicaragua to the southeast. It is also bordered to the north and east by the Caribbean Sea and to the south by the Pacific Ocean through the Fonseca Gulf.

The territorial division of Honduras is distributed into 18 Departments. Table 3-1-1 shows the location, area and population of each Department. Figure 3-1-1 shows the map locations of the Departments.

Table 3-1-1 Area and Population of Each Department of Honduras

No	Department Name	Surface Area (km^2)	Population (2018)
①	Atlantida	4,251	471,575
②	Choluteca	4,211	464,372
③	Colón	8,875	335,233
④	Comayagua	5,196	541,711
⑤	Copán	3,203	400,947
⑥	Cortes	3,954	1,718,881
⑦	El Paraíso	7,218	480,700
⑧	Francisco Morazán	7,946	1,625,663
⑨	Gracias a Dios	16,630	100,304
⑩	Intibucá	3,072	255,658
⑪	Bay Islands	261	71,296
⑫	La Paz	2,331	217,204
⑬	Lempira	4,290	351,652
⑭	Ocotepeque	1,680	159,816
⑮	Olancho	24,351	562,626
⑯	Santa Barbara	5,115	455,891
⑰	Valle	1,565	185,227
⑱	Yoro	7,939	613,473
Total			9,012,229

Source: National Institute of Statistics (INE) of Honduras.

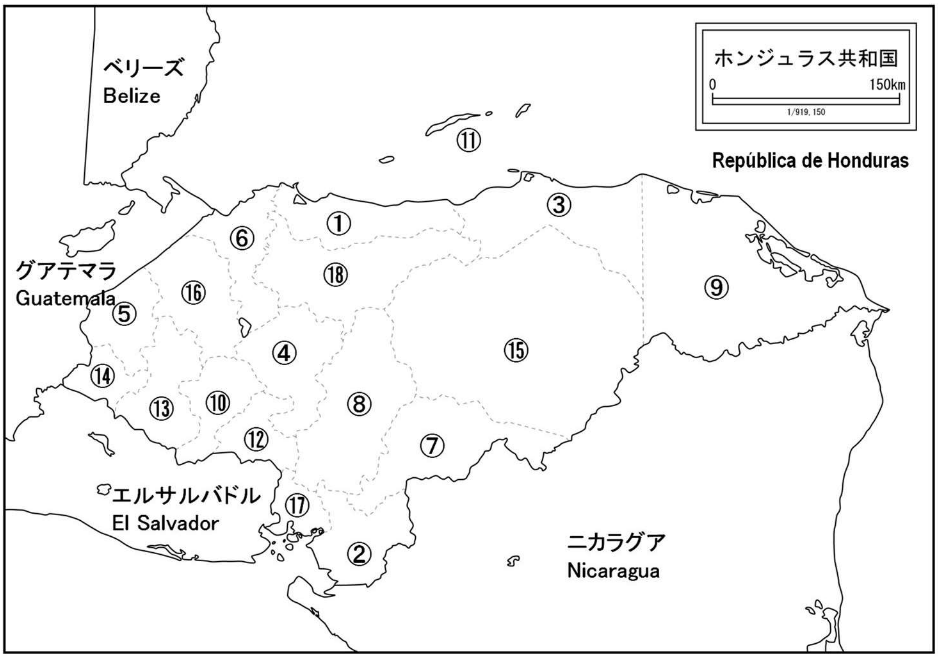


Figure 3-1-1 Map Locations of Departments of Honduras

3-1-2 Natural Conditions

(1) Topography

The Honduran territory is divided into three zones: Northern Coastal Plain (Caribbean Coast), Central Mountain Region and Southern Coastal Plain (Pacific Coast). Sixty-five percent of the national territory is mountainous and the rest are plains between 1,000 - 1,500 m in elevation extending from the center to the south. The Central District (Tegucigalpa), the survey area, has an area of approximately 120 km^2 (10 km from east to west and 12 km from north to south). The city is surrounded by hills of 1,200 - 1,800 m in elevation, the urban center area has steep hills and the periphery also have a wavy topography, i.e., the topography of the area is complex. The geological structure is divided into two parts, the eastern and western parts, due to the division made by the Choluteca River that flows from south to north almost through the middle of the city. The eastern part consists of many strata of sedimentary rocks of different types of conglomerate and the western part is composed mainly of volcanic rocks.

(2) Weather

It is classified as a tropical zone. The climate of the northern Coastal Plain is humid tropic, characterized by high temperatures and high humidity with a rainfall of more than 100 mm all year round. The northern Coastal Plain has tropical rainy season and dry season with a temperature above 20 ℃ all year round, being the dry season from November to April.

The Central District (Tegucigalpa), which belongs to the Central Mountain Region has a temperature above 20 ℃ all year round. The rainy season is from May to October and the dry season is from November to April. Figure 3-1-2 shows the average temperatures from 2016 to 2020. From September through November is the most humid season of the year due to hurricanes and other weather systems. In 1998, Hurricane Mitch caused devastating damages. In 2020, hurricanes Eta and Iota caused enormous damages. Flooding has occurred in the coastal regions and landslides and mudslides have occurred in the urban area of the municipality of the Central District (Tegucigalpa). Figure 3-1-3 shows the annual precipitation. In 2019, precipitation was lower than other years and the catchment volume in La Concepción Reservoir and Los Laureles Dam dropped considerably. On the other hand, in 2020 precipitation was more than double in relation to 2019 due to hurricanes. All this indicates that Honduras is susceptible to the effects of climate change.

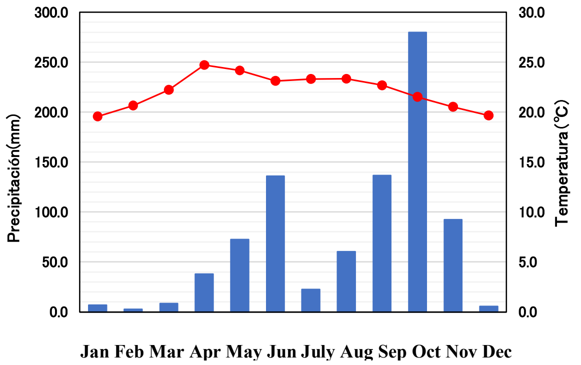


Figure 3-1-2Precipitation (Monthly) and Temperature

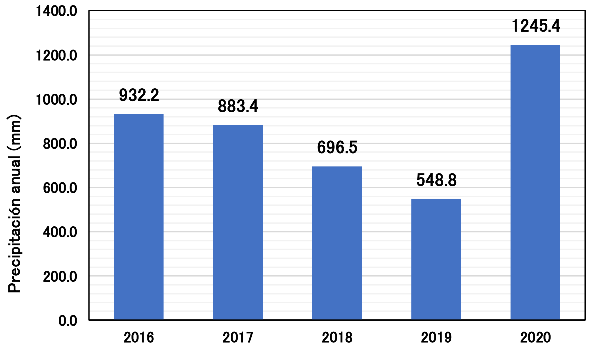


Figure 3-1-3 Annual Precipitation

3-1-3 Socio-economic Status

(1) Summary

Honduras is the third poorest country in the Latin America and Caribbean Region. In recent years, Honduras has registered the second highest economic growth in Central America, after Panama. Honduras' GDP growth rate has reached 4.84 % in 2017, 3.69 % in 2018 and 2.63 % in 2019, higher than the average for Central America and well above the average for the Latin America and Caribbean Region. However, it faces a high level of poverty and inequality. At the national level, approximately 48.3% of people are in poverty, and the percentage of people in poverty is higher in rural areas than in urban areas. In 2020, due to the COVID-19 pandemic, there have been large drops in foreign trade, investment and consumption, and GDP is expected to fall by 7.1 % and the unemployment rate will rise by 9.31 %. Table 3-1-2 shows the main economic indicators.

Table 3-1-2 Main Economic Indicators

Indicator	2015	2016	2017	2018	2019	2020
GDP (US$ million)	20,980	21,718	23,136	24,024	25,095	23,827

GDP per capita (US$)	2,302.2	2,342.5	2,453.7	2,505.7	2,574.9	2,405.7
Economic growth rate (%)	3.84	3.89	4.84	3.69	2.63	-8.965
Inflation (%)	3.158	2.725	3.934	4.347	4.366	3.468
Unemployment rate (%)	6.15	6.73	5.53	5.65	5.57	9.39

Source: World Bank Open Data

(3) General Economic Situation

The main industries are coffee, banana, palm oil and shrimp industries, and as secondary industries, the textile and apparel industry as well as the export of electronic products for automobiles are noted. These are produced in free trade zones (hereinafter referred to as "maquiladoras") where incentives are granted to foreign companies to attract their investments. As a tertiary industry, tourism can be mentioned.

Dependence on traditional industries such as coffee and bananas remains high, however, attempts are being made to overcome this by developing new industries, among them the maquiladora manufacturing industry (especially textiles) and tourism. On the other hand, there is a large amount of remittances sent from Hondurans living in the U.S. (approximately one million people), and in 2019, the amount sent was around 5,400 million USD. This amount is equivalent to approximately 20% of GDP. Table 3-1-3-2 shows the summary of foreign trade.

Honduras is part of the HIPC (Highly Indebted Poor Countries) initiative; however, the IMF Board of Directors in March 2005 and the World Bank Board of Directors in April of the same year decided that the country had reached the termination point. As a result, debts owed to international organizations (commitment amount: about US$ 300 million) and bilateral debts (expected amount: US$ 940 million) were condoned. Japan forgave an approximate amount of 58.1 billion yen. Honduras' official external debt in 2019 was US$ 7,699 million.

Table 3-1-3 Summary of Foreign Trade (2019)

Item	Content
Total amount of foreign trade	(1) Exports (F.O.B) 2019: US$ 8,714.9 million, 2020: US$ 7,732.9 million (2) Imports (C.I.F) 2019: US$ 11,853.9 million, 2020: US$ 9,871.1 million
Main trading partners	(1) Export 1st place USA (33.0 %); 2nd place El Salvador (9.1 %); 3rd place Germany (8.3 %) (2) Import 1st place USA (31.2 %); 2nd place China (19.2 %); 3rd place Guatemala (8.9 %). (31.2 %)

Source: Web page of the Ministry of Foreign Affairs, Foreign Trade Report, Central Bank of Honduras.

3-1-4 Socio-environmental Considerations

In Honduras, the General Environmental Law (Decree 104-93) establishes that the National Environmental Impact Assessment System (hereinafter, "SINEIA") is under the responsibility of the Secretary of Energy, Natural Resources, Environment and Mines (hereinafter, "MiAmbiente"). Decree 189-2009 stipulates that the SINEIA is responsible for the Environmental Impact Assessment (hereinafter, "EIA") and the management of private and public sector projects that may affect the environment.

To obtain an environmental license in "MiAmbiente", the procedures are carried out at the General Directorate of Environmental Evaluation and Control (DECA) and at the Environmental Units (UNA). The DECA reviews the EIA and performs the technical supervision of the licenses. The UNAs carry out the regulation and monitoring processes. In accordance with the Regulations of the National Registry of Environmental Service Providers (Agreement 1205-2002), environmental consultants registered in MiAmbiente's environmental service provider system may conduct the EIA and submit it for review for environmental licensing.

(1) Environmental License Application

Project executing agencies must obtain an environmental license before implementing the project. The necessary information must be provided to the SINEA by category classification. Table 3-1-4 shows the category classification and the documents to be submitted.

Table 3-1-4 Classification of Categories and Documents to be Delivered

Category	Environmental Impact	Documents to be Submitted to MiAmbiente	EIA
1	Low	Form F-01	Not necessary.
2	Medium	Form F-02, Environmental management plan	Not necessary.
3	High		Necessary depending on the situation.
4	Very high	FormF-02, Environmental impact study	Not necessary.

Source: MiAmbiente data edited by the Study Team.

The categories are established for each project. Also, when the project involves the construction of reservoirs and dams, as well as the relocation of inhabitants, the EIA is required to be implemented. The categories for water and sanitation related projects are shown below.

Table 3-1-5 Water and Sewerage Facilities

Category	1	2	3	4
Surface area of the WTP	500-1,000 m^2	1,000-5,000 m^2	5,000-10,000 m^2	More than 10,000 m^2

Source: Ministerial Agreement No. 0740-2019

Table 3-1-6 Sewage Facilities

Category	1	2	3	4
Wastewater plant treatment volume	Less than 250 (m^3/day)	251-400 (m^3/day)	More than 401 (m^3/day)	-

Source: Ministerial Agreement No. 0740-2019

(4) Evaluation

MiAmbiente reviews the documents submitted and comments on whether or not it is necessary to correct the environmental management plan. Once the submitted documents are approved, the environmental license is granted.

(5) Citizen Participation

Citizen participation is required at all stages. Especially, in case of categories 2, 3 and 4, it is necessary to notify NGOs and local inhabitants about the implementation of the EIA. In particular, in case of category 4, it is necessary to publish all EIA information. When MiAmbiente determines necessary, an open discussion should be held.

3-2 Summary of Potable Water System

Section 3-2-1 describes the Water Demand Projection, 3-2-2 describes the improvement plan and progress, and 3-2-3 describes the requests given by AMDC.

3-2-1 Water Demand Projection

Regarding population statistics in water demand forecasting, the National Census has been conducted in 2003 and 2013. To date, the AMDC and SANAA have made the projections of water demand through different studies by JICA, World Bank, Spain and IDB, among others. However, there is no consistency between the reports in terms of population growth rate, unit water consumption rate, water calculation method for industrial and commercial use, the concept of maximum daily consumption coefficient, etc.

Table 3-2-1 and Figure 3-2-1 show the projected population growth rate and projected water demand currently in use at AMDC and SANAA. The population growth rate ranges from 3.00 % to 4.70 % and the non-revenue water (NRW) rate ranges from 15 % to 23.57 %. On the other hand, the NRW rate in 2020 was 32.9 % (average between 2016 and 2020) and is distant from the current situation, so it is necessary to revise the plan. The water demand in 2030 is 6,446 L/s and the average water production between 2016 and 2020 is around 2,500 L/s, so there will definitely be a lack of water supply in the future.

When creating a new AMDC system in the future, new water demand projection parameters should be established including target year, distribution areas to be expanded in the future, population growth rate, water leakage rate forecast, calculation method, etc.

Table 3-2-1 Water Demand Projections

Year	Population (million)	Water Demand (L/s)	Population Growth Rate (%)	ANF Rate (%)
2010	1.160	3,871	3.22	23.57
2011	1.198	3,973	3.23	22.86
2012	1.254	3,973	4.70	22.14
2013	1.275	4,136	1.71	22.43
2014	1.316	4,216	3.20	20.71
2015	1.357	4,290	3.13	20.00
2016	1.400	4,398	3.12	19.67
2017	1.443	4,523	3.11	19.33
2018	1.488	4,651	3.10	19.00
2019	1.534	4,781	3.09	18.67
2020	1.581	4,915	3.08	18.33
2021	1.630	5,053	3.07	18.00
2022	1.680	5,193	3.06	17.67
2023	1.731	5,337	3.06	17.33
2024	1.784	5,485	3.05	17.00
2025	1.838	5,636	3.04	16.67
2026	1.894	5,791	3.03	16.33
2027	1.951	5,949	3.02	16.00
2028	2.010	6,111	3.01	15.67
2029	2.070	6,277	3.00	15.33
2030	2.132	6,446	3.00	15.00

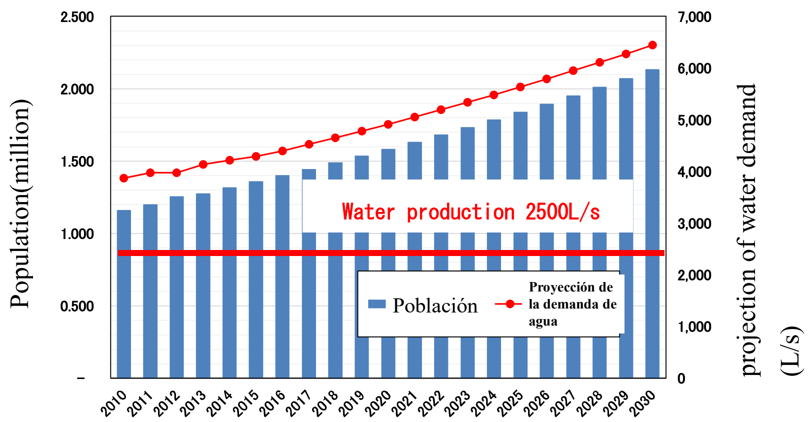


Figure 3-2-1Population and Water Demand Projection

3-2-2 Improvement Plans and Progress

The most recent Master Plan (MP) is AQUARUM's 2011 Consolidated Master Plan, which summarizes the results of all existing studies of the supply system. To improve the supply system, this document proposes short-, medium- and long-term activity plans (Table 3-2-2). However, in the development of the MP, there was insufficient discussion with SANAA engineers, so currently only part of the activities have been implemented, and AMDC believes that the proposed activities need to be revised.

Table 3-2-2 Proposed AQUARUM MP Activity Plans

Period	Activity	Content	Implementation Status
[Short term] Urgent	Establish 75 hydraulic sectors (distribution areas)	Installation of valves, monitoring and control through the SCADA system.	It has only been implemented in three distribution areas through the demonstration project. The SCADA installed at Picacho requires replacement due to failures.
	Mixture of water supply from different distribution centers	Installation of the valves in the above mentioned distribution areas	Partially implemented.
	Replacement of pipes of different diameters	Correction of the bottleneck due to unplanned expansion of the pipeline network and correction of areas with small diameter pipes	Partially implemented.
	Replacement of pumps at pumping stations	Increased efficiency for small and inefficient pumps	Not implemented.
	Tank discharge simplification	Organization of several pipelines at the tank outlet according to the distribution area to simplify the job	Not implemented.
	Relocation and increase of pressure reducing valves	Relocation of unnecessary pressure reducing valves due to population growth, establishment of adequate pressure reduction and addition of the valves where they are needed	Not implemented.
	Coverage of micro-meters	Installation of micro-meters and maintenance of faulty equipment	Coverage of meters: approximately 30%.
[Medium term] 5 years	Construction of new reservoirs	Construction of a pipeline between Los Laureles and Concepción and a reservoir, construction of new tanks in the sectors of La Travesía, La Sosa and Cerro el Brujo, respectively.	The pipeline between Los Laureles and Concepción and the tank in the Cerro el Brujo sector have been built. No other tanks have been built.
	Construction of Guacerique II Reservoir	Increase capacity to 45-50 Mm^3 and production volume to 1.04 m^3/s	KOICA will conduct the feasibility study (F/S).
	Sabacuante Reservoir Expansion	Increase the production volume of the Miraflores plant to 0.23 m/s.[3]	The project was cancelled due to

Period	Activity	Content	Implementation Status
			the construction of the San José Dam in the upper course.
	Replacement of obsolete pipelines	Replacement of pipelines in El Bosque and Buenos Aires neighborhoods	Already implemented
[Long term] 20 years	Rehabilitation of the entire pipeline network in the water supply area.	For the neighborhoods of Los Pinos and Villanueva administered by the Water Committees and the "Barrios en Desarrollo" (SANAA unit). In these neighborhoods, the population density is high and development has been inefficient, thus affecting other neighborhoods in the same supply system. It is also necessary to change the size of the pumping stations that increase the pressure in these two neighborhoods, as well as the expansion and relocation of the tank.	Not implemented.
	Construction of the Río del Hombre Dam	Increase production volume from 1.5 to 2.3 m ^{3}/s	Not implemented.

It should be noted that AQUARUM's MP also mentions about the implementation of the financial assessment to reduce the deficit and the scenario of increasing the production volume in the short, medium and long term to increase the volume of water production However, these are also distant from the current source development planning and implementation made by AMDC, i.e., it has low effectiveness.

Table 3-2-3 AQUARUM MP Proposed Source Water Development Plans

Term	Activity	Content	Implementation Status
Short-term	Integral management of water leaks	On the condition that the supply is guaranteed for 24 - 36 hours to be able to detect water leaks with acoustic water leak detection methods.	The Water Leakage Management Division is executing it.
	Strengthening of groundwater pumping volume	According to the SANAA study, it is possible to increase to 0.38 m ^{3}/s.	Not implemented.
	Dredging of Los Laureles Dam	Increase in supply by 4,057 m ^{3}/day	The dredging system has been constructed, but its use was suspended due to algae blooms.
	Ojojona Dam	Increase of 0.3m ^{3}/s, it is necessary to perform the environmental F/S.	Not implemented.
	Fish Lagoon (Laguna del Pescado)	Increase of 0.08 m ^{3}/s	Not implemented.

Term	Activity	Content	Implementation Status
	Strengthening of Los Laureles II Dam	It was proposed in the JICA Master Plan in 2001. Not reviewed due to the complexity of operations in the event of the construction of the Quiebra Montes or Guacerique II reservoir in the upper reaches.	Not implemented.
Medium and long term	Construction of Guacerique II Reservoir	Capacity increase by 45-50 Mm^3, 1.04 m^3/s	The plan has been formulated with Korean cooperation.
	Construction of the Río del Hombre Dam	Increased production volume of the Picacho plant to 1.5 - 2.3 m^3/s	The plan has been formulated.
	Sabacuante Reservoir Expansion	Increase the production volume of the Miraflores plant to 0.23 m/s.[3]	The project was cancelled.
	Construction of the Tatumbla Dam	Increase of 0.21 m^3/s	Under construction
	Construction of the Nacaome Dam	45.3 km pipeline extension, five pumping stations, 0.4 - 0.5 m^3/s	The plan has been formulated, but requires economic revision.

3-2-2-1 Development of Water Sources and Construction of New Water Treatment Plants

Table 3-2-4 shows the current source development plans. Also, Figure 3-2-2 shows the map locations of water source development plans.

Table 3-2-4 Source Water Development Plans

NO.	Name of Source	Summary	Implementation Status
1	Nacaome	Water is captured from the Nacaome River in the lower channel of the existing José Cecilio del Valle Dam built for hydroelectric generation (1,800 L/s). The water is conveyed to the water treatment plant, and then from the conveyance facilities to the existing conveyance areas. The distance between the water treatment plant and the urban center of Tegucigalpa is 44 km and it is planned to send water from 271 m elevation to the urban center of Tegucigalpa at 1,571 m elevation. For water conveyance, six stations with start-up pumps are planned, but this implies a conveyance cost.	A study and design has been carried out in 2020. (US$ 197.10 million) The plan is unrealistic due to the high cost of operation and maintenance and the strong opposition of the inhabitants in the lower channel that prevent the formation of social consensus, so the AMDC intends to discontinue the plan.
2	Jiniguare	A concrete gravity dam will be built to retain water from the San José River located near the existing La Concepción reservoir, a pipeline	A study and design has been carried out in 2020, and funding is being sought. (US$ 144.70 million)

NO.	Name of Source	Summary	Implementation Status
		and a water treatment plant (900 L/s).	
3	Jacaleapa	A concrete gravity dam retaining the water from the Sabacuante River, a pipeline and a water treatment plant will be built. After completion, the use of the existing Miraflores Water Treatment Plant will be suspended.	A study and design has been carried out in 2020. The bidding process was carried out in 2020. Work began in March 2021. Temporary suspension of work in June 2021. Completion scheduled for August 2024. (US$ 220 million)
4	Guacerique	A dam will be built on the upper course of the existing Los Laureles Dam.	Study and design has been carried out in 2019. They are seeking financial support. (US$ 378.9 million) Due to the generation of many relocation cases, the AMDC intends to discontinue the plan.
5	Rio del Hombre	A reservoir will be built on the Rio del Hombre to convey the water. Construction is planned after 2035.	A study and design was carried out in 2015. They are seeking financial support. For the AMDC, it is the most promising project.

Source: Data from AMDC

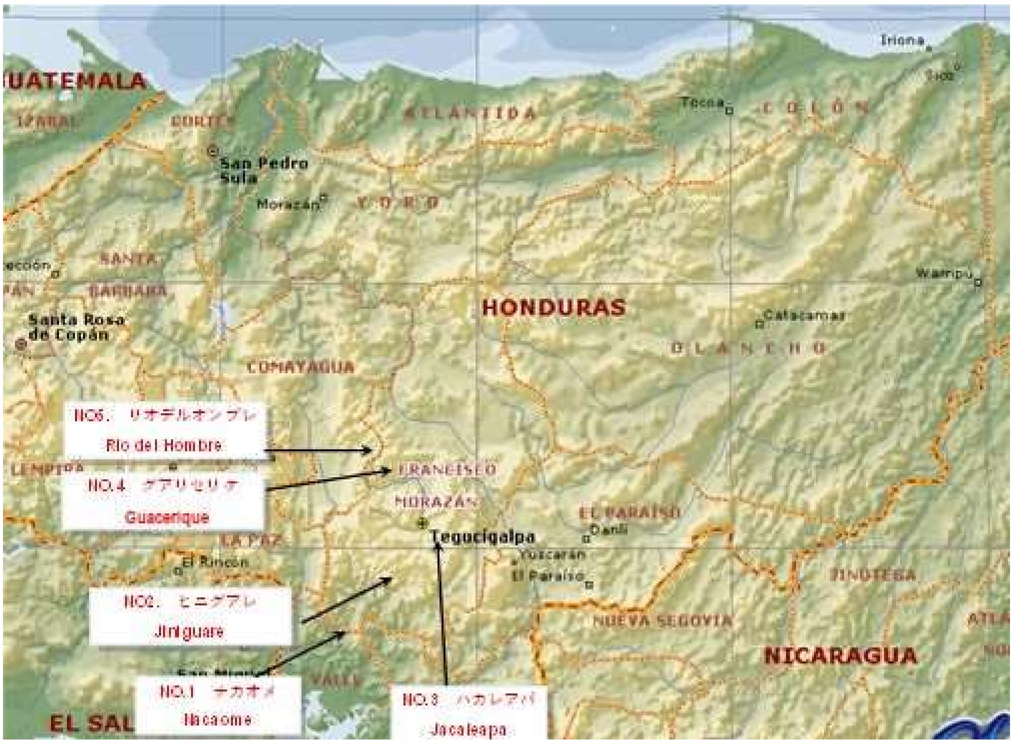


Figure 3-2-2 Water Source Development Plan Location Map

(1) Nacaome Project

Table 3-2-5 shows the specifications for the Nacaome Project. It should be noted that the cost of water pumping is very high, requiring US$35.9 million annually for electricity alone at six pumping stations to send water from the water treatment plant to the urban center of Tegucigalpa.

The Nacaome Dam is for hydroelectric generation and the discharged water is used for irrigation in the lower river basin. The Choluteca and Valle Departments located in the lower river basin are opposing the use of the water source for drinking water for the municipality of Tegucigalpa in the Nacaome Project. There is the possibility of a social conflict over water in the future, and this project involves a high cost of operation and maintenance, and therefore, the AMDC intends to discontinue the plan.

Table 3-2-5 Main Specifications of Nacaome Project

Installation	Specifications
Spillway	Width: 115 m Height: 3.8 m
Pumping station for catchment	Receiving well: L17 m×W6 m×H7.1 m, pump: six 370 kW units.
Adduction piping	φ1800×255 m, DIP
Purification plant	Treatment volume: 1800 L/s Treatment flow: Aeration → Coagulation and sedimentation tank → Rapid filtration tank.
Pumping stations	Six pumping stations (1600 L/s) PS1: 11 pumps (elevation 120 m, total length 6.4 km, 4,045 kW) PS2: 16 pumps (elevation 271 m, total length 5. km, 5,885 kW) PS3: 14 pumps (elevation 767 m, total length 3.49 km, 5,148 kW) PS4: 16 pumps (elevation 1,028 m, total length 8.1 km, 5,884 kW) PS5: 17 pumps (elevation 1,313 m, total length 4.49 km, 5,884 kW)
Treatment tank	Five tanks, circular (4,200 m^3) Connected to the existing pipeline network (around La Concepción Water Treatment Plant).

Source: Data from the AMDC edited by the Study Team.

(2) Jiniguare Project

It is planned to construct a concrete gravity dam retaining water from the San Jose River about 2.0 km south of the existing La Concepcion reservoir, a 6.8 km pipeline, and a new water treatment plant to convey water to the existing pipeline system. The following table shows the main specifications.

Table 3-2-6 Jiniguare Project

Installation	Specifications
Storage tank	Concrete gravity type dam Length: 298 m Height: 90 m Total storage volume: 2.28 km^3 Effective storage capacity: 2.09 km^3 Catchment volume: 1,000 L/s
Conduction piping	φ800×6800 m Steel pipe

Installation	Specifications
	Booster pumps: Three units
Water treatment plant	Capacity: 900 L/s

Source: Data from the AMDC edited by the Study Team.

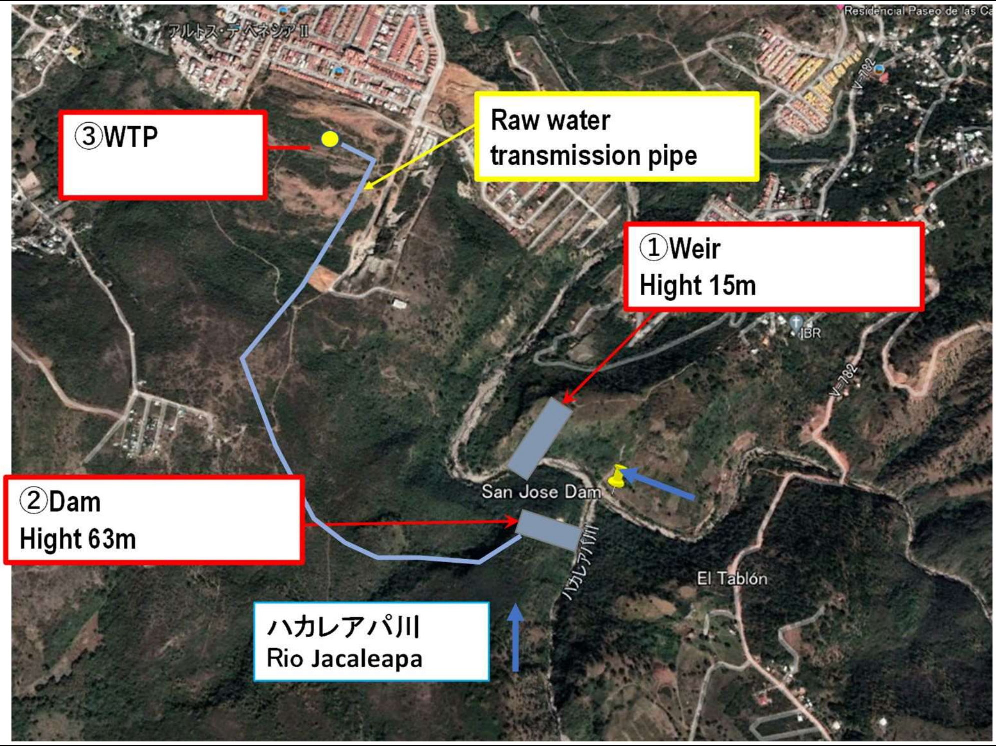
(3) Jacaleapa Project

A dam will be built downstream of the confluence of the Sabacuante River and Canoas River. The water will be collected, processed at the water treatment plant, and sent to the existing pipeline system. After completion of this project, the use of the existing Miraflores Water Treatment Plant will be suspended. On March 11, 2019, AMDC issued the call for expressions of interest for the bidding, and in March 2021, a contractor from Ecuador won the bid and started the works. Construction of the dam and water treatment plant is scheduled to be completed within two years. It should be noted that this is a turnkey contract, so AMDC specified the objectives and basic conditions in the bidding documents, after which the contractor must carry out the detailed design. Due to the design change made in June 2021, the works were temporarily suspended. In July 2021 the works were restarted, however, the initial plan changed, and now it is planned to capture water in two dams, pump and send by gravity to the water treatment plant. The following table and figure show the main specifications. Completion of the works is scheduled for August 2024.

Table 3-2-7 Jacaleapa Project

Installation	Specifications
Storage tank	Type: gravity dam Material: concrete Storage capacity : 9,200 km ^{3} Length : 62 m Elevation of the sill : 1,062.30mm Intake design flow : 800 L/s
Water treatment plant	Production flow : 800 L/s Type: modular plant Aerator, coagulation, rapid sedimentation, chemical injection, sand filtration, control panel, supply piping, backwashing system, water quality testing equipment, etc.

Source: Data from the AMDC edited by the Study Team.



Jacaleapa Dam and water treatment plant construction site

Spillway construction site (①).

Dam construction site (②).

Water treatment plant construction site (③).

Temporary office for construction

Figure 3-2-3 Overview of Jacaleapa Project

(4) Guacerique Project

This project was mentioned in the Water Supply Master Plan formulated as a result of the Water Supply Plan Study in the Municipality of Tegucigalpa in 2001, where it was proposed to build a dam upstream of the existing Los Laureles Dam and expand the existing Los Laureles Water Treatment Plant, called Los Laureles II Project, and to build a dam and a water treatment plant (1,250 L/s) in Quiebra Montes. Subsequently, as a result of the internal review at AMDC, it was proposed to build four small dams in Guacerique, upstream of Los Laureles Dam, to guarantee the missing volume of water in the dry season and to convey the water to the existing Los Laureles Water Treatment Plant. In 2020, the bidding process was carried out under a turnkey contract. However, it was declared deserted. This plan will generate many cases of relocation of inhabitants, and therefore, the AMDC intends to discontinue the plan. The following table shows the main specifications.

Table 3-2-8 Guacerique Project

Installation	Specifications
Storage reservoirs	・Four dams in the Guacerique River basin. ・Total capacity: 12 million m^3

Source: Data from the AMDC edited by the Study Team.

(5) Rio del Hombre Project

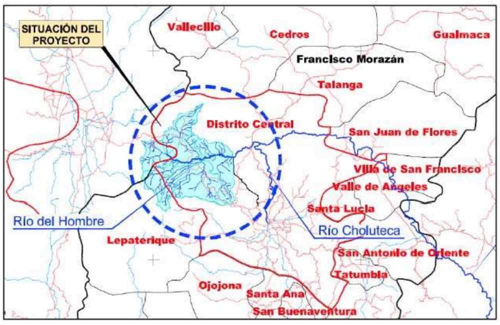
The plan is to build a reservoir on the Río del Hombre and convey the water to a new water treatment plant. In 2014, the Basic Plan was formulated. For the AMDC, it is the most effective plan at this time. The following Table shows the main specifications. The potabilization method proposed is ozonation. It is an advanced potabilization method. For ozonation, the activated carbon filter is usually installed in the downstream process to remove the ozonolysis product. It is necessary to review again the construction costs, functions, operation and maintenance costs, including the costs of other potabilization processes.

Table 3-2-9 Río del Hombre Project

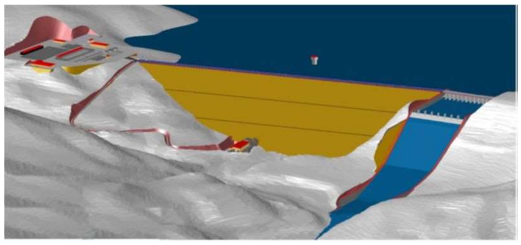
Installation	Specifications
Reservoir	Type: rockfill dam (Height 89.4 m, length 675 m) Storage capacity: 124 million m^3
Catchment facilities	Catchment tower: Height 90 m Capture pipe: 1,200 mm Catchment volume: 2,100 m^3/s Pumps: 4+1 (reserve) units Uptake pipe: 356 m (φ1200)
Water treatment plant	Capacity: 2,000 L/s Ozonation → Coagulation tank → Sedimentation tank → Rapid filtration → Ozonation → Chlorination. Potable water tank: 20,000m^3
Transmission facilities	① Pumping (358.00 m elevation) Pumps: 8＋1 (reserve) pcs. Specifications of pump: 250 L/s×300 m Transmission tube: φ1200

Installation	Specifications
	Total length: 3,931 m ② Relief tank (by gravity from the relief tank to the city) Tank capacity: 4,500 m^3 Diameter of transmission tube: φ1200 Total length of transmission pipeline: 10,510 m (33,000 ft) Diameter of transmission tube: φ1200
Distribution tank	Tank capacity: 30,000 m^3 (1255 m elevation)

Source: Data from the AMDC edited by the Study Team.

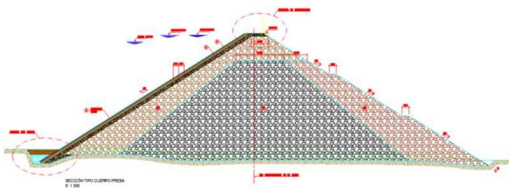


Project area



Illustrative image of the dam

Floor plan



Dam section plan

Figure 3-2-4 General Description of Rio del Hombre Facilities

3-2-2-2 Rehabilitation of Existing Potable Water Treatment Plants

The rehabilitation of the existing water treatment plants is implemented with the purpose of improving their efficiency and increase the production volume up to 95% of the design capacity, according to the "Project for the Strengthening of the Potable Water Service in Tegucigalpa" of the World Bank. Although not yet started to date, it is projected to start the study from 2022 and execute the rehabilitation works between 2023 and 2024 according to the results of the study. The following table shows the details of the rehabilitation.

Table 3-2-10 Details of Existing Water Treatment Plant Rehabilitation

Plant Name	Details
Los Laureles Drinking Water Treatment Plant	・Rehabilitation of chlorination plant. ・Installation of pretreatment filter to remove algae. ・Sand filtration rehabilitation (change of filtration media to double bed filtration with anthracite and rehabilitation of the strainer). ・Partial wastewater reuse. ・Enhanced energy efficiency (condenser installation, pump motor replacement). ・Installation of flowmeter and communication device for data control. ・Incorporation of administrative equipment (communication environment for information management and monitoring, introduction of computers, etc.). ・Incorporation of water quality laboratory equipment.
La Concepción Water Treatment Plant	・Rehabilitation of chemical injection facilities. ・Rehabilitation of chlorination facilities. ・Installation of the pump for the common use of the raw water detour aqueduct from La Concepción Drinking Water Treatment Plant to Los Laureles Drinking Water Treatment Plant. **Already built the diversion from Los Laureles reservoir to La Concepción Water Treatment Plant.** ・Roof installation on the sedimentation tank (solar panel). ・Partial wastewater reuse. ・Strainer rehabilitation for rapid filtration. ・Installation of flowmeter and communication device for data control. ・Incorporation of administrative equipment (communication environment for information management and monitoring, introduction of computers, etc.). ・Incorporation of water quality laboratory equipment.
Picacho Water Treatment Plant	・Rehabilitation of pipeline facilities (Jutiapa line) Monitoring is carried out for the installation of meters due to water theft on the distribution route to nearby towns. ・Rehabilitation of chemical injection facilities. ・Rehabilitation of chlorination facilities. ・Rehabilitation of coagulation facilities. ・Replacement of valves at the water treatment plant. ・Sand replacement in rapid filtration systems. ・Partial wastewater reuse. ・Strainer rehabilitation for rapid filtration. ・Enhanced energy efficiency (condenser installations, pump motor replacement). ・Installation of flowmeter and communication device for data control. ・Incorporation of administrative equipment (communication environment for information management and monitoring, introduction of computers, etc.). ・Incorporation of water quality laboratory equipment.

Source: Data from the AMDC edited by the Study Team.

3-2-2-3 Sectorization of Distribution Areas into Blocks

In 15 distribution areas of the Picacho conduction system, supply areas will be sectorized into Hydrometric Districts (hereinafter, "DMA") to measure and control the volume of supply with water meters. Likewise, the baseline of non-revenue water (NRW) will be established and activities will be carried out to detect the causes of water leaks and to reduce NRW. The following table shows the areas to be sectorized. These activities will also be completed between 2023 and 2024, as will the construction of the water treatment plant.

Table 3-2-11 Areas Subject to Sectorization in WB

Sector	Sector name	Number of Connections
1	Channel 11 (2 sectors)	4,514
2	Sosa	9,097
3	Travesía	6,222
4	Molinón	322
5	Linderos I	2,658
6	Linderos II	621
7	Leona I	4,711
8	Leona II	4,181
9	Leona III	1,632
10	Olimpo Center 1	3,381
11	Olimpo Center 2	5,678
12	Porvenir	555
13	Rincón	216
14	Canaan	1,101

Source: AMDC data edited by the Study Team.

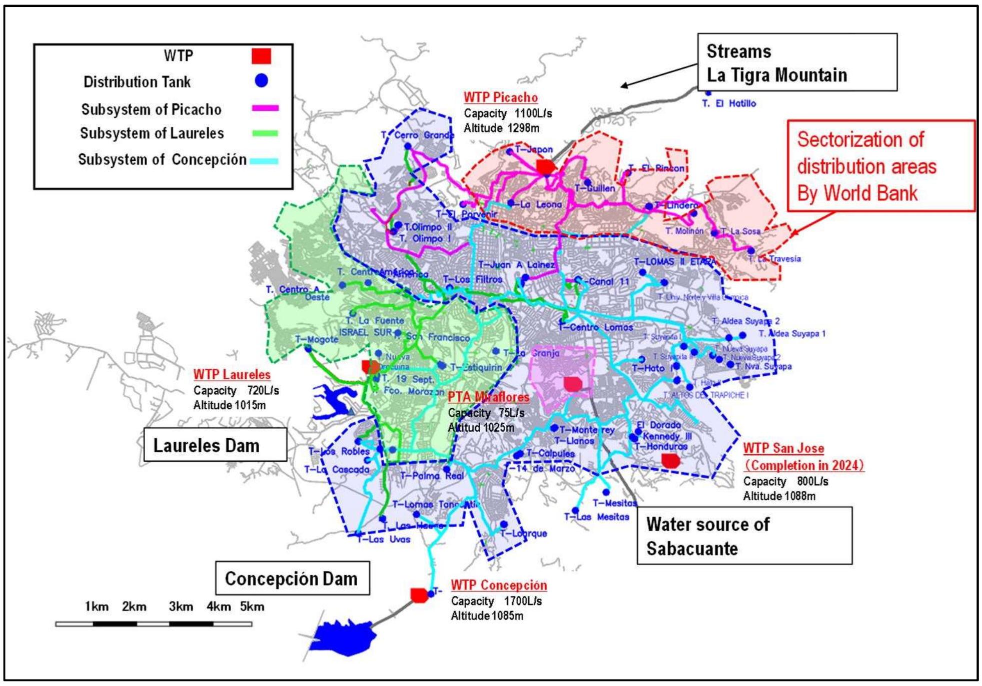


Figure 3-2-5 Areas Subject to Sectorization in WB

3-2-3 Requests from AMDC

In January 2021, the AMDC submitted to JICA the details of the assistance it wishes to receive in the future. The requests are categorized into short, medium and long term plans, and the water and sanitation projects are 22 in total. The following table shows the summary of the requests.

Table 3-2-12 Summary of Requests from AMDCs

Urgency	NO	Project Details	Amount (US$ million)
Short term Phase 1	R-1	Sectorization of distribution areas in blocks (seven areas)	1.2
	R-2	Rehabilitation of the Picacho conduction system (seven areas)	1.2
	R-3	Rehabilitation and new construction of reservoirs (reservoirs: four)	0.6
	R-4	Increase efficiency in the operation of the pumping stations of the distribution system (10 areas)	3.0
	R-5	Water meter installation (smart meter, macro meter) (one sector)	2.0
	R-6	Restoration and expansion of SCADA (Picacho Drinking Water Treatment Plant)	1.0
	R-7	Formulation of the Water and Sanitation Master Plan based on integrated water resources management.	4.0
	R-8	Water demand management (policy planning, measures against water leakage and awareness-raising activities for water saving)	2.0
Short term Phase 2	R-9	Sectorization of distribution areas in blocks (the entire urban area)	1.4
	R-10	Increase efficiency in the operation of the pumping stations of the distribution system (8 areas)	2.0
	R-11	Rehabilitation and construction of new distribution tanks, Phase 2 (13 sectors)	8.4
	R-12	Expansion of the pipeline system (four pipelines)	1.0
	R-13	Supply piping system pipe installation (two pipelines)	0.9
	R-14	SCADA reset (Picacho)	0.3
	R-15	Replacement of the obsolete pipeline network of the distribution network (8 sectors)	2.0
	R-16	Water demand management, Phase 2 (policy planning, anti-leakage measures and water-saving awareness activities)	1.0
Medium term	R-17	Expansion of reservoir capacity	11.43
	R-18	Replacement of obsolete pipelines (Buenos Aires, El Bosque)	3.06
	R-19	Guacerique Reservoir construction project (upstream of Los Laureles Dam)	50
	R-20	Rehabilitation works at La Vega wastewater treatment plant, rehabilitation of sewage system	104.13
Long term	R-21	Replacement of distribution pipeline network (entire area)	2.2
	R-22	Construction of rockfill dam and water treatment plant (2,000 L/s) (Río del Hombre).	302.4

Source: AMDC data edited by the Study Team.

3-3 Current Situation of Drinking Water Systems and Challenges

The following is a description of the current situation of the drinking water system and the challenges: 3-3-1 refers to the water sources, catchment facilities and pipelines, 3-3-2 refers to the drinking water treatment plant facilities and 3-3-3 refers to the transmission and distribution facilities.

Figure 3-3-1 shows the general scheme of the drinking water system. Also shown in Figure 3-3-2 is the map locations of the drinking water system facilities. Water is conveyed by gravity from four water sources consisting of creek, dam and river to the water treatment plants. From the El Picacho Water Treatment Plant, water is distributed by gravity to the distribution tanks. La Concepción Water Treatment Plant is the largest plant in the city and sends water to the distribution tanks by gravity and by pumping for the eastern zone. From the Los Laureles Water Treatment Plant, water transmission is mainly through pumping to the distribution tanks. The Miraflores Water Treatment Plant has a potable water tank inside the plant, and from there it is distributed only to the Miraflores sector.

The municipality of Tegucigalpa is a valley with steep hills and undulating topography; therefore, water is pumped to the city using 26 pumping stations. The Los Laureles Water Treatment Plant, located in the southwest zone at a low elevation of 1,015m, sends water by pumping to the north and west. Similarly, the Concepción Water Treatment Plant, located in the southern zone at an elevation of 1,085 m, sends water to the north and east through distribution tanks and pumping stations. Another source of water for the city, although smaller in comparison to the four water treatment plants, are four wells to distribute water only to the Satélite sector, which is a distribution area. Outside the city, to the northeast, the Chimbo Water Treatment Plant distributes water only to its surrounding sectors.

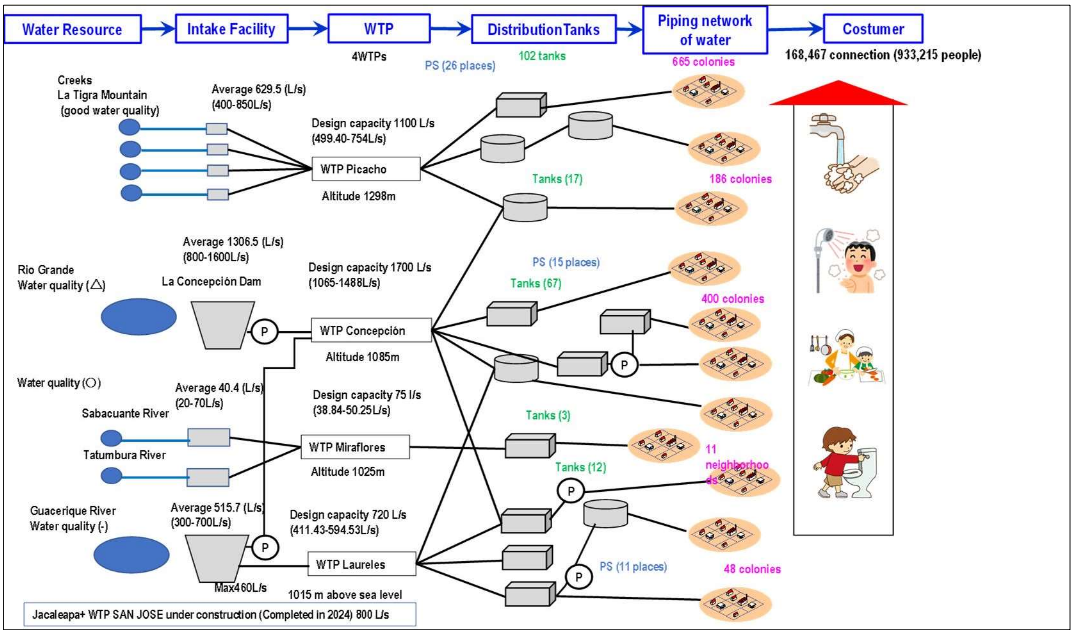


Figure 3-3-1 Drinking Water System Schematic Diagram

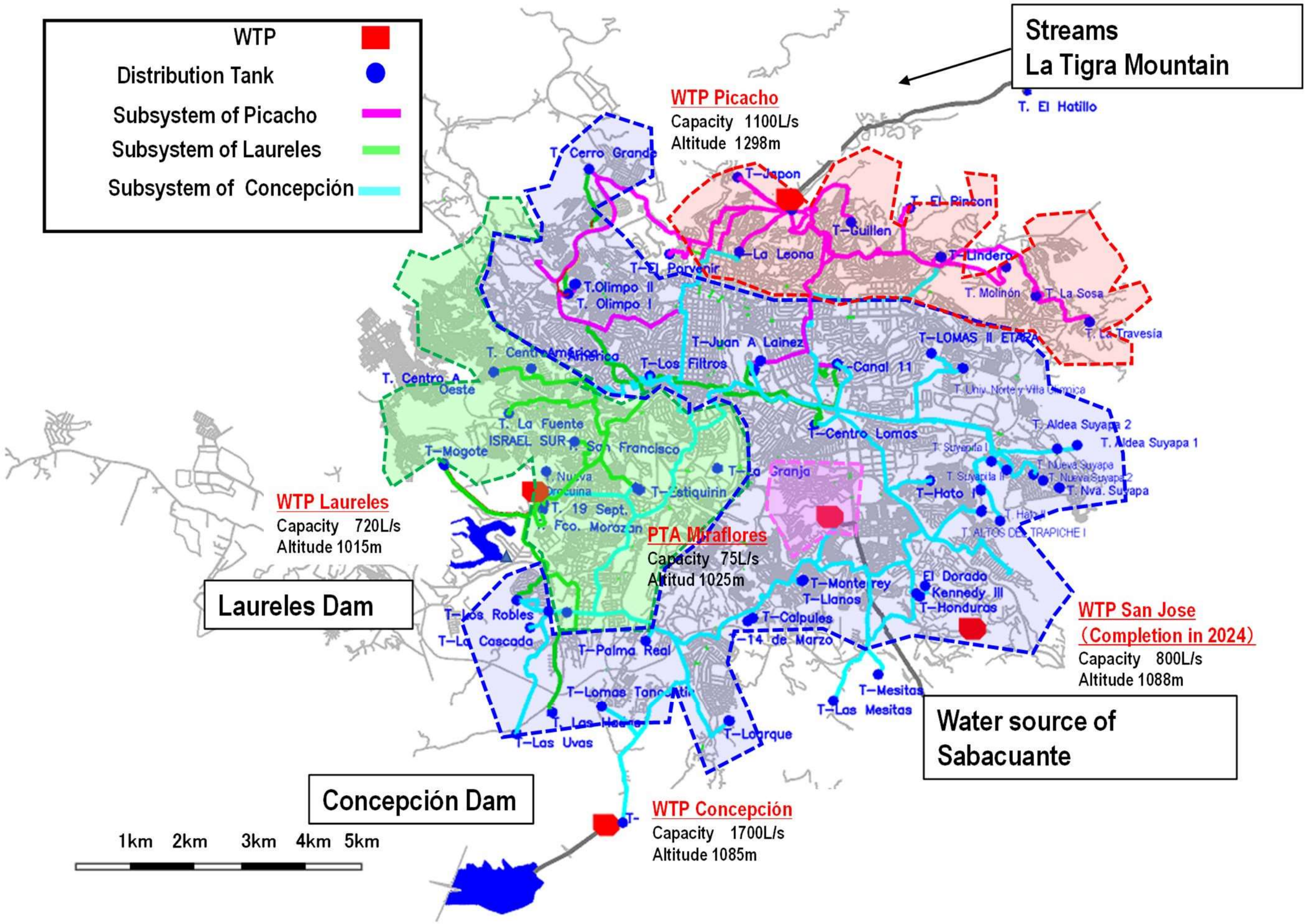


Figure 3-3-2Map Locations of Drinking Water System Facilities.

3-3-1 Water Sources, Catchment Works and Conduction Pipelines

3-3-3-1 describes Water Sources and Catchment Facilities and 3-3-3-2 describes Operation and Maintenance.

3-3-1-1 Water Sources and Catchment Works

There are five water sources that supply water to the municipality of Tegucigalpa: 1) Picacho Conduction System, which captures water from the streams of La Tigra Mountain, located north of the city; 2) Los Laureles Conduction System, which captures water from Los Laureles Dam whose source is the Guacerique River, located west of the city; 3) La Concepción Reservoir System, which captures water from La Concepción Reservoir whose source is the Grande River located south of the city; 4) Miraflores Conduction System, which captures water from the Sabacuante River and Canoas River; and 5) Satellite Sector Well Field, in the vicinity of the Toncontín International Airport located in the center of the city. Table 3-3-1 shows a summary of the water sources and Figure 3-3-3 shows the map location of the water sources and water treatment plants.

Table 3-3-1 Summary of Water Sources

N	Conduction System Name	Water Source	Year of Construction	Catchment Work	Water Treatment Plant
1	Picacho	La Tigra mountain streams	1957	Diversion Dams	Picacho
		1) San Juancito			
		2) Jucuaras			
		3) Jutiapa			
		4) Carrizal			
		4) Carrizal It is conducted to the WTP by diverting a part of it.	2004		El Chimbo
2	La Concepción	Rio Grande	1993	Concrete gravity dam	La Concepción
3	Los Laureles	Guacerique River	1976	Rockfill dam	Los Laureles
4	Miraflores	Sabacuante River Canoas River	1976	Diversion Dam	Miraflores
5	Satellite	Wells	2000	4 wells	-

Source: Edited by the Study Team based on interviews with SANAA.

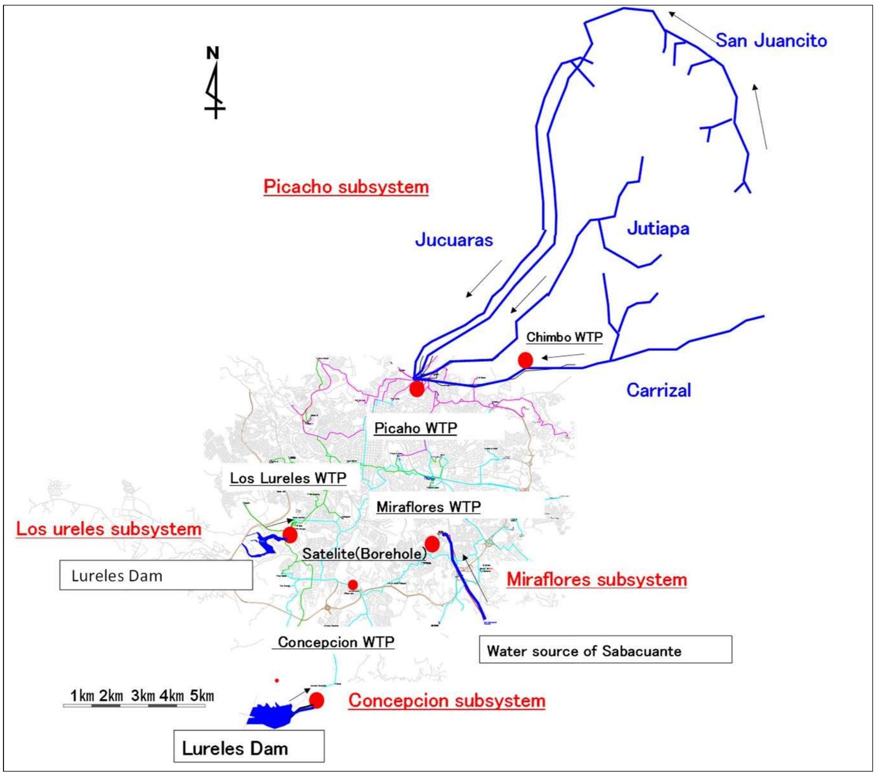


Figure 3-3-3Map Showing Locations of Water Sources and Drinking Water Treatment Plants

Table 3-3-2 shows the summary of the pipelines of the conduction systems. The Picacho pipeline from the La Tigra Mountain springs to the Picacho Water Treatment Plant has a diameter of 250 mm to 600 mm, and the total length is 93 km. The pipeline from La Concepción Reservoir to La Concepción Water Treatment Plant has a diameter of 1,500 mm, and the total length is 1.8 km. The pipeline from Los Laureles Dam to Los Laureles Water Treatment Plant has a diameter of 1000 mm, and the total length is 0.8 km. The pipeline from the Sabacuante water source to Miraflores has a diameter of 500 mm, and the total length is 19 km. The type of pipe used in all the pipelines is ductile iron (DIP).

Table 3-3-2 Summary of Conduit Pipelines

No.	Conduction System	Conduction Piping		
		Diameter (mm)	Pipeline Distance (km)	Tube type
1	Picacho	600-500	36.0	DIP
		350-300	24.0	
		250	13.0	
		400	20.0	
2	La Concepción	1,500	1.80	
3	Los Laureles	1,000	0.80	
4	Miraflores	500	19.00	

Source: Edited by the Study Team based on interviews with SANAA.

Table 3-3-3 shows the average catchment volume of the conduction systems between 2016 and 2020 and the catchment volume during rainy and dry seasons. The average annual catchment volume of the Picacho conduction system is 631.74 L/s and occupies 25.2 % of the total, the average annual catchment volume of the Concepción conduction system is 1,306.53 L/s and occupies 52.1 % of the total, the average annual catchment volume of the Laureles conduction system occupies 20.6 % of the total, the average annual catchment volume of the Miraflores conduction system is 40.49 L/s and occupies 1.6 % of the total, and the total supply volume of Satélite (wells) is 11.34 L/s and occupies 0.5 % of the total. The above indicates that the La Concepción, Picacho and Los Laureles conduction systems occupy 97.8% of the total.

Figure 3-3-3 shows the annual catchment volume between 2016 and 2020. Compared to previous years, the second half of 2019 and the first half of 2020 saw little precipitation, as a result, the annual catchment volume in 2019 and 2020 was reduced by 25% in comparison to 2018.

Table 3-3-3 Average Volume of Catchment of Conduit Systems

(Unit: L/s)

NO	Water Conduction System	WTP Volume (2016-2020)			Percentage of Total (%)
		Annual Average	Dry Season (November - April)	Rainy Season (May - October)	
1	Picacho Upstream Downstream	629.51	601.72	657.30	25.1
	Chimbo	2.23	2.25	2.20	0.1
2	La Concepción	1,306.53	1,291.28	1,321.78	52.1
3	Los Laureles	515.68	479.32	552.04	20.6
4	Miraflores	40.39	42.17	38.62	1.6
5	Satellite	11.34	11.25	11.42	0.5
Total		2,506	2,428	2,583	-

Source: Edited by the Study Team based on interviews with SANAA.

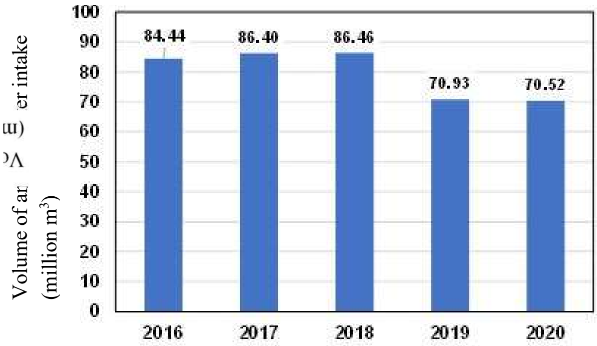


Figure 3-3-4Annual Catchment Volume

3-3-1-1-1 Picacho Drive System

The sources of water for this system are streams between 1,000 m - 1,200 m elevation belonging to the La Tigra Mountain system located north of the municipality of Tegucigalpa. The water treatment plant and pipelines are located within the ecological reserve of La Tigra National Park. Water is collected from 23 concrete diversion works installed on more than 20 streams. The system consists of four pipelines: San Juancito, Jucuaras, Jutiapa and Carrizal; and the water is sent by gravity to the water treatment plant. The total length of the San Juancito line is 36 km, the total length of the Jucuaras line is 24 km, the total length of Jutiapa is 13 km, and the total length of Carrizal is 20 km. La Tigra Mountain has a low vegetation geology with outcropping rocks, and its geology and topography do not allow for rainwater storage, and therefore, aquifer recharge in the water source is not favorable. In the rainy season, the stream flows instantaneously as surface water. On the other hand, since the top of the mountain has difficult access that makes it difficult for heavy machinery to enter, it is difficult to develop a new water source, for example, a surface water storage dam.

Figure 3-3-5 shows the monthly variations of the catchment volume between 2016 and 2020 and Figure 3-3-6 shows the total annual catchment volume. The catchment volume increases in the rainy season from August to December, but in the dry season from February to April it decreases to half. The total annual catchment volume between 2016 and 2018 was between 21-24 million m^3 and in the years 2019 and 2020 it was reduced to 15-17 million m^3 due to low rainfall, registering a decrease of 20 % - 30 % compared to other years.

Figure 3-3-7 shows the monthly variations in raw water quality (turbidity, color, pH, and alkalinity) between 2016 and 2020. The turbidity level of raw water is low, with 3 - 10 NTU or less in the dry season and 10 - 20 NTU in the rainy season. In case of 2020, the maximum turbidity level of 99 NTU was recorded due to hurricanes. The color level is 10 - 20 UC in dry season and 20 - 40 UC in rainy season. In 2020, like turbidity, the maximum color level of 116 UC was recorded due to hurricanes. The pH is about 6.2 - 6.8 leaning to mild acidity, which is assumed to be due to past mining activities. Alkalinity tends to be low all-year round with 5 - 15 mg/L.

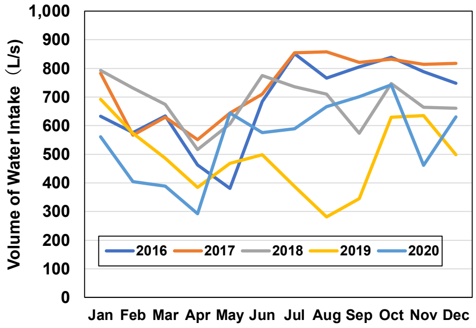


Figure 3-3-5Monthly Variations in Catchment Volume

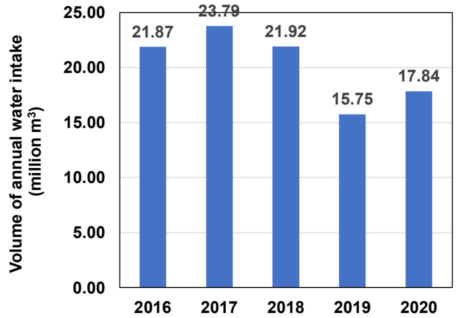


Figure 3-3-6Total Annual Catchment Volume

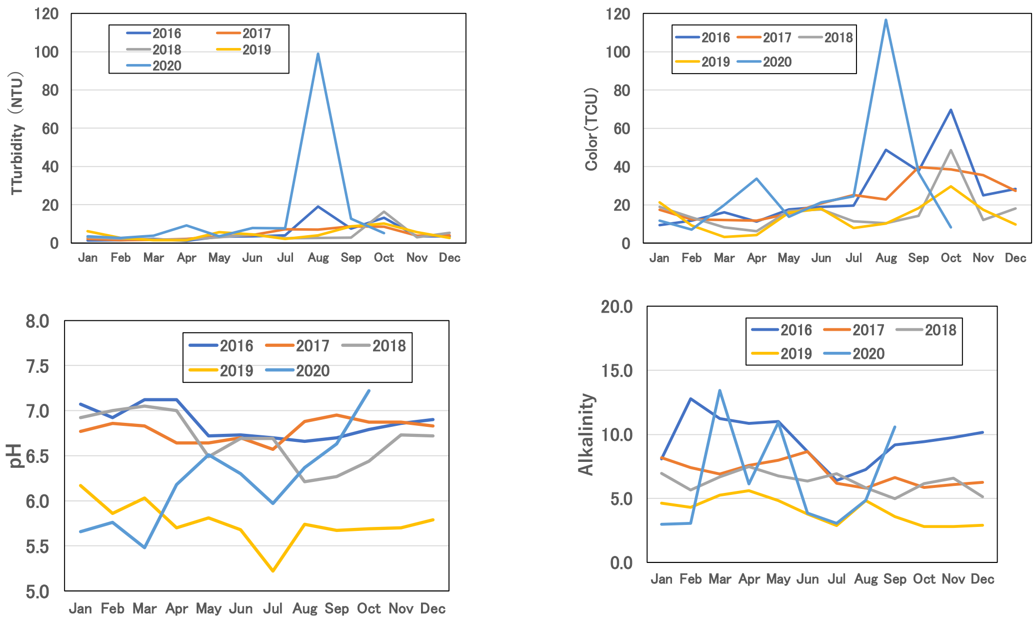


Figure 3-3-7Monthly Variations in Raw Water Quality (Turbidity, Color, pH, and Alkalinity).

	
El Aguacatal Diversion Dam	El Rosario water catchment

3-3-1-1-2 La Concepción Pipeline System

La Concepción Reservoir is a gravity dam that retains water from the Rio Grande. It is located southwest of the municipality of Tegucigalpa and occupies half of the water supply. It was built between 1989 and 1992 with financing from the Italian and French governments and partially with local funds. Table 3-3-4 shows the specifications of the reservoir.

As a result of Hurricane Mitch in 1998, the river flow was reduced and could not fill the reservoir, so it was decided to build a diversion dam on the adjacent Ojojona River to divert the flow to The Concepción Reservoir. Currently, the water captured in the Ojojona River is sent directly to the pipeline coming from La Concepción Reservoir, as there is water contamination in the Ojojona River and massive algae blooms in La Concepción Reservoir due to eutrophication. In the future, there are plans to change the intake pipe to a larger diameter to increase the intake volume. In 2006, the reservoir was reinforced and 3 automatic gates were installed. In 2018, a new pipeline (Trasvase) was built, from Los Laureles Dam to La Concepción Water Treatment Plant, to convey the surplus water from Los Laureles Dam to La Concepción Water Treatment Plant. It should be noted that in the lower channel of La Concepción Reservoir, there are three starter pumps to convey water to the Concepción Water Treatment Plant. During the period from January to April when the reservoir water level drops, water is sent with three 9.46 m^3/min x 45.7m starter pumps (one is a reserve).

Table 3-3-4 Dam Specifications

Parameter	Specification
Height (m)	64
Crest length (m)	710
Type	Concrete gravity dam
Catchment area (km^2)	140
Total storage capacity (million m^3)	From 36 to 40
Spillway (m^3/s)	923
Inlet flow rate (m^3/s)	1.32
Number of gates	4

Source: Edited by the Study Team based on interviews with SANAA.

Figure 3-3-8 shows the monthly variations of the catchment volume between 2016 and 2020 and Figure 3-3-9 shows the total annual catchment volume. The average catchment volume is 1,306.53 L/s. In the rainy season, the average volume is about 1,100 - 1,400 L/s and in the dry season, between 950 - 1,300 L/s. Between August and December of 2019, in the middle of the rainy season, the catchment volume was reduced by 40 %, registering about 800 L/s. If we compare the total annual catchment volume, due to the low rainfall in 2019, the volume was reduced by 15% and 28% in 2019 and 2020, respectively.

The monthly variations in raw water quality (turbidity, color, pH, and alkalinity) between 2016 and 2020 are shown below in Figure 3-3-10. Both turbidity and color levels increase in the rainy season from August to October. The maximum turbidity level is 140 NTU and color is 400 UC. On the other hand, in the dry season, the turbidity level is 30 - 60 NTU and the color level is 100 - 150 NTU. The pH is 6.8 - 7.8. From January to April of 2020, the pH tendency is to alkalinity. It should be noted that in recent years the watershed has been reforested once a year for the environmental conservation of the water source.

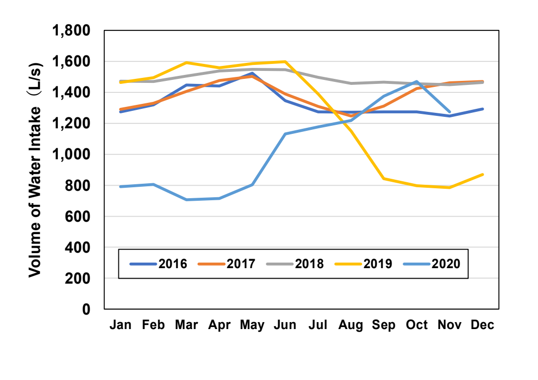


Figure 3-3-8 Monthly Variations in Catchment Volume

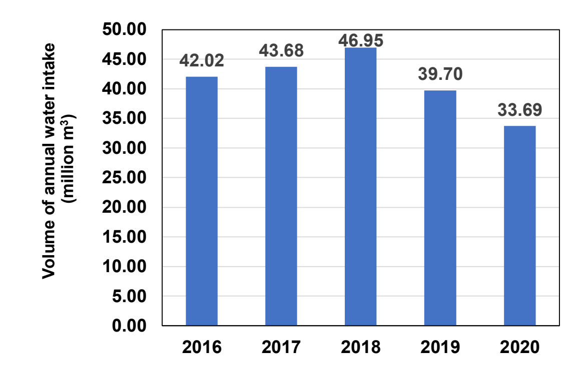


Figure 3-3-9Total Annual Catchment Volume

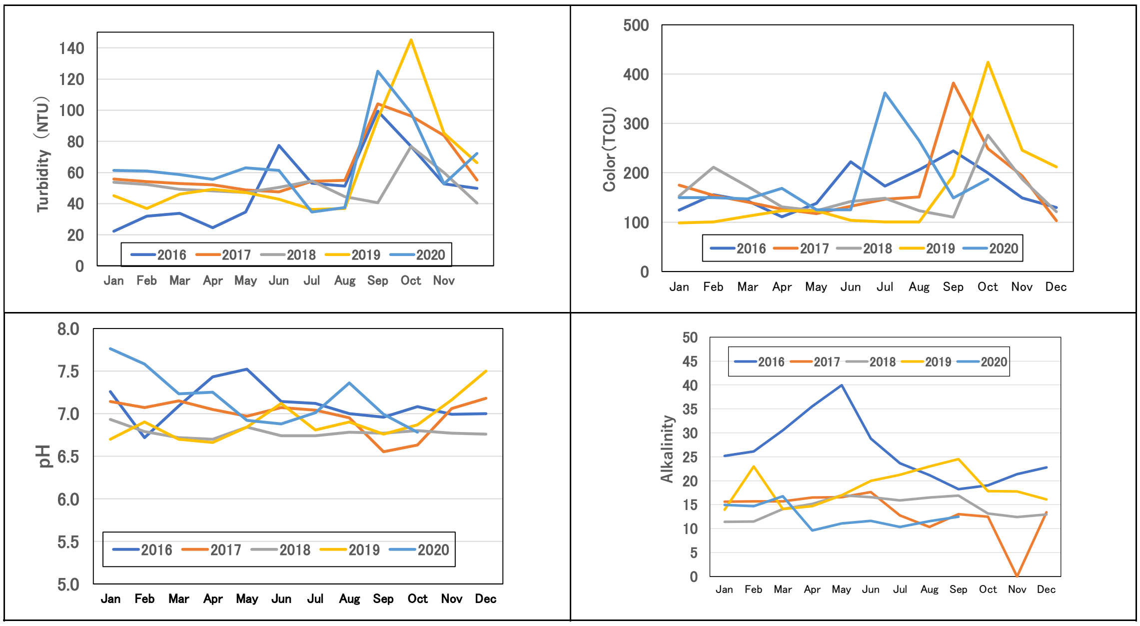


Figure 3-3-10Monthly Variations in Raw Water Quality (Turbidity, Color, pH and Alkalinity).

Aerial view of the reservoir

Front view of the reservoir

	
Conduit (φ1100)	Starter pumps

3-3-1-1-3 Los Laureles Pipeline System

Los Laureles Dam is a rockfill dam that retains water from the Guacerique River. It is located west of the municipality of Tegucigalpa and occupies 20.6% of the water supply. It was built between 1976 and 1978 with an IDB loan as a reservoir for drinking water supply. Table 3-3-5 shows the specifications of the dam.

Since its construction to date, the following improvements and rehabilitations have been carried out. In 1997, a 3m inflatable dam was installed in the discharge channel with a loan from the IDB to increase the storage volume. Also, due to the deterioration of water quality, in 2004 the catchment method was modified, changing the facilities that capture water from the bottom to a floating type facility that captures surface water. Subsequently, the catchment pipeline suffered a drop in yield due to clogging of the pipeline and was damaged in 2009, and so the form of catchment was changed again to bottom water catchment. However, the water quality at the bottom of the reservoir is poor, and the odor and strange taste of the drinking water became problematic. For this reason, in 2015, the floating-type catchment facilities were restored to return to surface water catchment. In the same year, a dredging barge was installed to remove sediment in the water collection area of the dam. Around 2016, the dredging system was damaged and has not been repaired since. It should be noted that raw water from Los Laureles Dam is sent to La Concepción Water Treatment Plant with three 225 L/s x 100 m x 300kW starter pumps (one is reserve) during the period from October to January mainly.

Table 3-3-5 Dam Specifications

Parameter	Specifcation
Height (m)	39
Crest length (m)	112
Type	Rockfill dam
Catchment Area (km^2)	194
Total storage capacity (million m^3)	12 million
Overflow (m^3/s)	720
Inlet flow rate (m^3/s)	0.9

Source: Edited by the Study Team based on interviews with SANAA.

Figure 3-3-11 shows the monthly variations of the catchment volume between 2016 and 2020 and Figure 3-3-12 shows the total annual catchment volume. The average catchment volume is 515.68 L/s. In the rainy season, the average volume is about 550 - 600 L/s and in the dry season, between 400 - 550 L/s. Due to the low rainfall in 2019, the catchment volume was reduced compared to other years.

Regarding the total annual catchment volume, in 2019 it was reduced by 11% compared to the previous year due to the low rainfall recorded. In 2020, due to the hurricanes and not having a strong dry season like the previous year, a similar volume of catchment to other years was recorded. There is a plan to build the Guacerique reservoir to increase the storage volume in the future. However, the increased cases of relocation of inhabitants means that this plan lacks feasibility.

Figure 3-3-13 shows the monthly variations in raw water quality (turbidity, color, pH and alkalinity) between 2016 and 2020. The turbidity level and color level tends to increase in the rainy season from August to October between 100 - 150 NTU and 100 - 300 UC, respectively. The maximum turbidity level is 258 NTU and color is 350 UC. On the other hand, in the dry season, the turbidity level varies between 30 - 50 NCU and color 100 - 150 UC. The pH is 6.3 - 7.5.

The inflow of wastewater into Los Laureles Dam from houses, military installations, and industrial facilities located in the upper watershed of the dam has caused water quality to deteriorate. As a result, nitrogen and phosphorus levels tend to increase. During the dry season, the concentration of dissolved oxygen in the water is reduced and eutrophication causes the proliferation of diatoms, resulting in the strange odor and taste of drinking water. For this reason, the cost of water treatment at the water treatment plant has increased. In recent years, the massive proliferation of water lilies has become problematic. To improve water quality, construction of a sewer and wastewater treatment plant (19,246 m3/day) is planned in the upstream watershed. However, it is still being financed. Figure 3-3-14 shows the outline of the sewerage improvement plan.

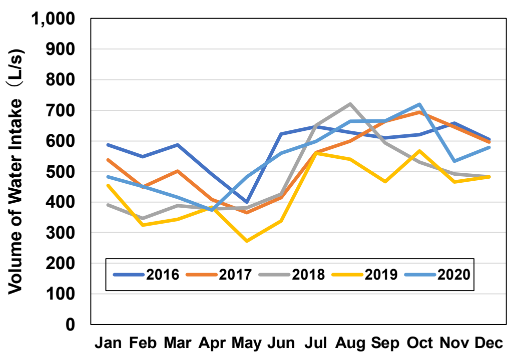


Figure 3-3-11Monthly Variations in Catchment Volume

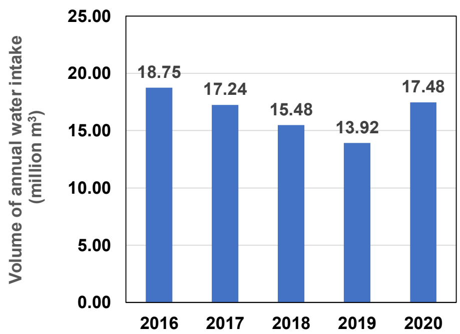


Figure 3-3-12Total Annual Catchment Volume

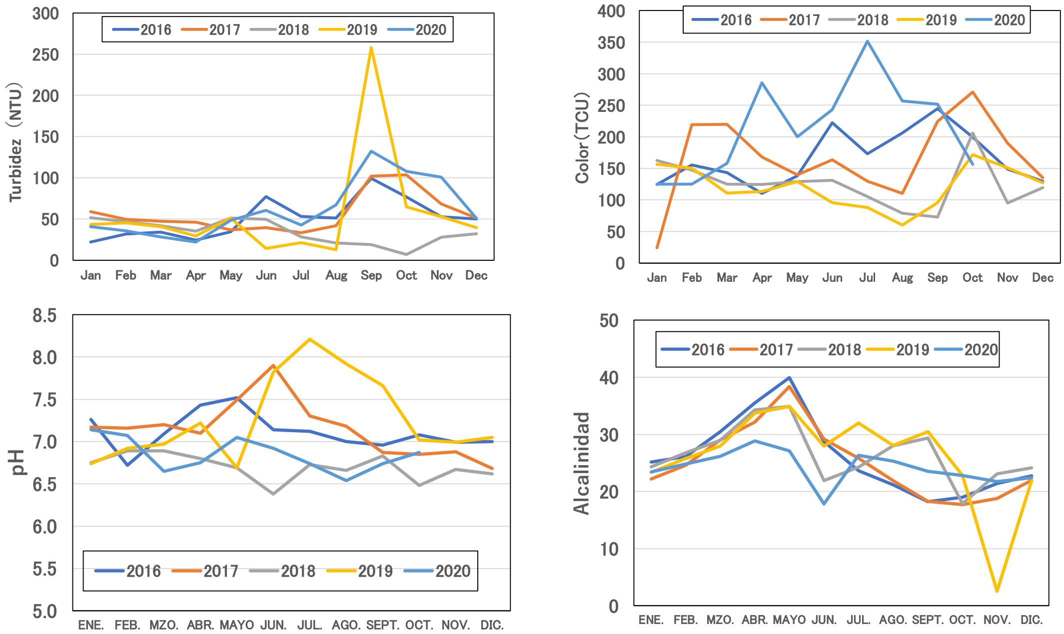


Figure 3-3-13Monthly Variations in Raw Water Quality (Turbidity, Color, pH and Alkalinity).

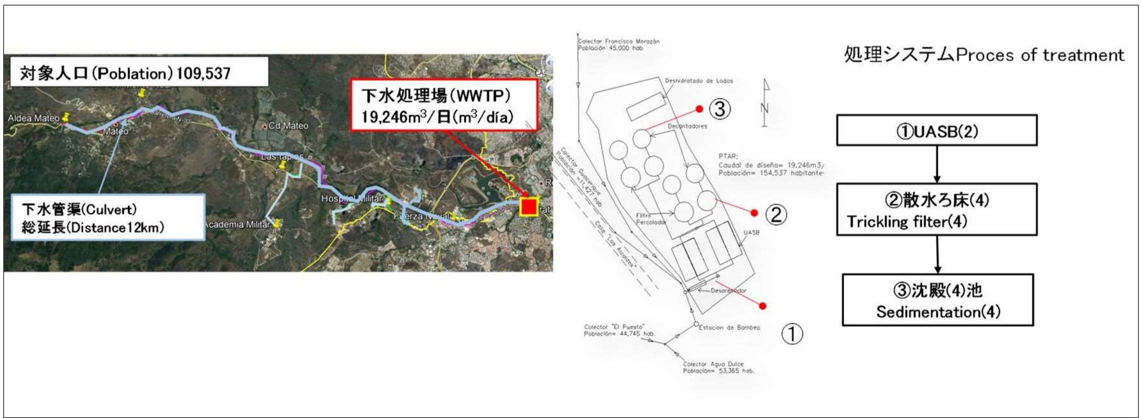


Figure 3-3-14 Outline of the sewerage improvement plan

Aerial view of the dam

Front view of the dam

	
Inflatable dam	Starter pumps

3-3-1-1-4 Miraflores Conduction System

The water sources for the Miraflores conveyance system are diversion dams installed on the Sabacuante and Canoas rivers. They are located southeast of the municipality of Tegucigalpa and occupy 1.6% of the water supply given. They were built in 1976. The diversion dams are of concrete gravity type and are 8 m high and 40 m wide. The 1998 hurricane destroyed the pipeline, but it was subsequently repaired. However, the concrete curtain was undermined by the flow of water and is in a markedly deteriorated state due to the passage of time. During the rainy season, catchment is suspended to clean sediment and plants accumulated in the intake.

Construction is currently underway of the San José Dam in Jacaleapa on the lower channel of the Sabacuante River intake works (construction began in March 2021). Completion is scheduled in two years, in March 2023. Upon completion of the San José Dam, the use of the Sabacuante intake works will be suspended.

Figure 3-3-14 shows the monthly variations of the catchment volume between 2016 and 2020 and Figure 3-3-15 shows the total annual catchment volume. The average catchment volume is 40.39L/s. Throughout the year, the average volume is between 35 L/s and 50 L/s.

Regarding the total annual catchment volume, it was not greatly affected by the low rainfall in 2019, and in 2020 it registered 1.23 million m^3.

Figure 3-3-17 shows the monthly variations in raw water quality (turbidity, color, pH and alkalinity) between 2016 and 2020. The turbidity level of the source water is very low, less than 10 NTU is recorded all year. The maximum color level is 20 UC. However, when there is temporary high turbidity in the rainy season, catchment is suspended. The pH varies between 6.8 - 7.5.

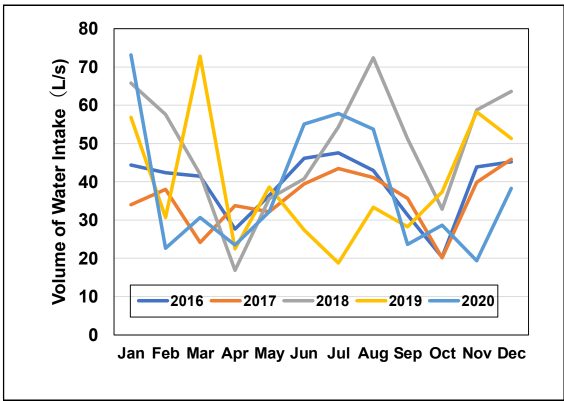


Figure 3-3-15Monthly Variations in Catchment Volume

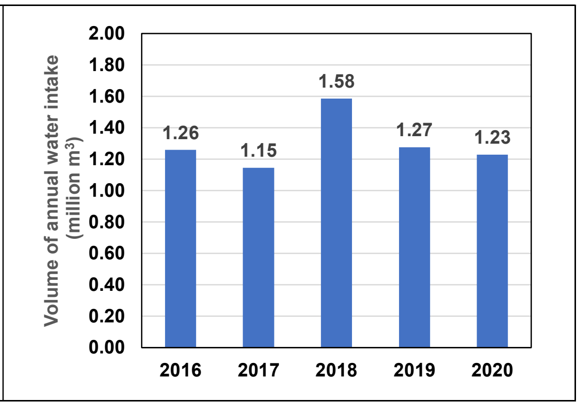


Figure 3-3-16Total Annual Catchment Volume

Figure 3-3-17Monthly Variations in Raw Water Quality (Turbidity, Color, pH, and Alkalinity).

Intake work (front view)

Intake work (side view)

3-3-1-1-5 Wells

In the Satélite sector, in addition to the water supply from the Concepción Water Treatment Plant, wells are used. The Satélite well system is located near the Toncontín International Airport to the south of the city. It operates from 0:00 to 5:00. Currently, four wells are in operation. Each well has a diameter of 200 mm, the casing is made of PVC and the depth of the well is 91.5 m. The well involves a high operation and maintenance cost to work, so SANAA plans to discontinue its use in the future. The future plan is unknown at this time, as operation and maintenance will be transferred to the municipality of Tegucigalpa in the future.

Figure 3-3-18 shows the monthly variations of the catchment volume between 2016 and 2020 and Figure 3-3-19 shows the total annual catchment volume. The total annual catchment volume is about 0.2 million m^3 pumping from four wells as of 2019, an amount that decreased due to the failure of the pumps that used to take water from eight wells until 2018. The catchment volume has been stable throughout the year.

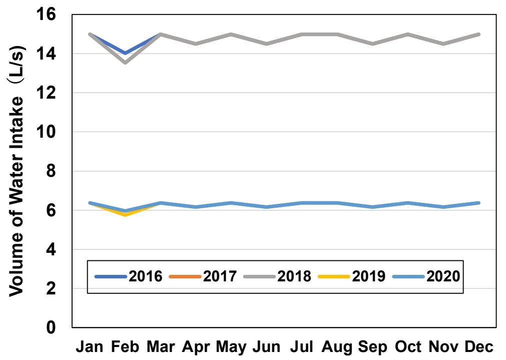


Figure 3-3-18Monthly Variations in Catchment Volume

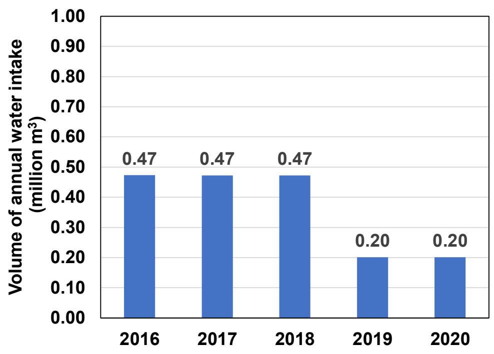


Figure 3-3-19Total Annual Catchment Volume

	
Well (Satellite #2)	Well (Satellite #4)

3-3-1-2 Operation and Maintenance

The following is a description of the operation and maintenance of the pipeline systems.

3-3-1-2-1 Picacho Pipeline System

The Picacho pipeline system consists of 23 intake works and an DIP pipeline with a total length of 93 km. Maintenance is ongoing, for example, when the 1998 hurricane damaged a portion of the pipeline, a new pipeline was constructed. Table 3-3-6 shows the operation and maintenance status of the Picacho pipeline system. The main activities are cleaning of the intake works and flow measurement of the pipeline.

Table 3-3-6 Operating and Maintenance Status

NO	Installation	Operation and Maintenance
1	Intake Work	Once a month, SANAA cleans 23 intake works to remove leaves, small branches and sludge accumulated in the intake.
2	Conduction piping	Measurement of flow rates in the pipeline of four systems.

Source: Edited by the Study Team based on interviews with SANAA.

3-3-1-2-2 La Concepción Pipeline System

The Concepción conveyance system consists of a gravity dam and a 1500 mm diameter DIP pipeline, with a total length of 1.8 km. Water is discharged periodically. The concrete structures and others have not been inspected and an operation and maintenance manual is needed.

3-3-1-2-3 Los Laureles Pipeline System

A dredging barge was introduced to dredge sediments from the dam. However, due to budgetary reasons, the 2016 failure could not be repaired. This affects the storage volume as dredging is currently not possible. There is a need to have an operation and maintenance manual, and to secure the budget to replace the equipment and plan how to raise funds.

3-3-1-2-4 Miraflores Conduction System

Periodic cleaning of sand and trash at the intake is performed. The concrete structures at the intake works have been greatly damaged due to water flow and factors. However, no repairs have been made to date.

3-3-1-2-5 Wells (Satellite Sector)

Each time there are breakdowns, pumping from the wells is suspended due to poor operation and maintenance of the impulsion pumps. Previously, 8 wells were being used, but currently only 4 pumps are being operated. In the future, the guideline is to suspend the use of the wells due to high electric power and operation and maintenance costs.

3-3-2 Water Treatment Plant facilities

In the following, 3-3-2-1 describes the Facilities and 3-3-3-2 describes the operation and maintenance.

3-3-2-1 Facilities

Table 3-3-7 and Figure 3-3-20 show the average annual production water volume between 2016 and 2020 by the water treatment plants. The production water volume for 2019 and 2020 decreased by approximately 20% compared to previous years. This decrease in precipitation happened due to climate change. The total production water volume is generally around 60 - 70% of the design capacity.

In 2015, small hydropower facilities were installed in the transmission line of the Picacho Water Treatment Plant (Line 22) and the pipeline of the Concepción Water Treatment Plant with JICA Grant -in-aid Project.

Table 3-3-7 Average Annual Water Production of Water Treatment Plant (2016-2020)

(Unit: L/sec)

Water Treatment Plant	2016	2017	2018	2019	2020	Design capacity
Concepción Water Treatment Plant	1,332.33	1,385.07	1,488.67	1,258.94	1,065.41	1,500 (Max 1,700)
Laureles Drinking Water Treatment Plant	594.53	546.66	490.80	441.53	552.82	720 + 100 (Unit type)
Picacho Water Treatment Plant	693.51	754.24	695.18	499.40	564.07	1,100
Miraflores Drinking Water Treatment Plant	39.88	36.32	50.25	40.43	38.84	75
El Chimbo Water Treatment Plant	2.31	2.35	1.89	2.34	2.45	25
Total	2,662.56	2,724.64	2,726.79	2,242.64	2,223.59	3,520

Source: SANAA statistical data

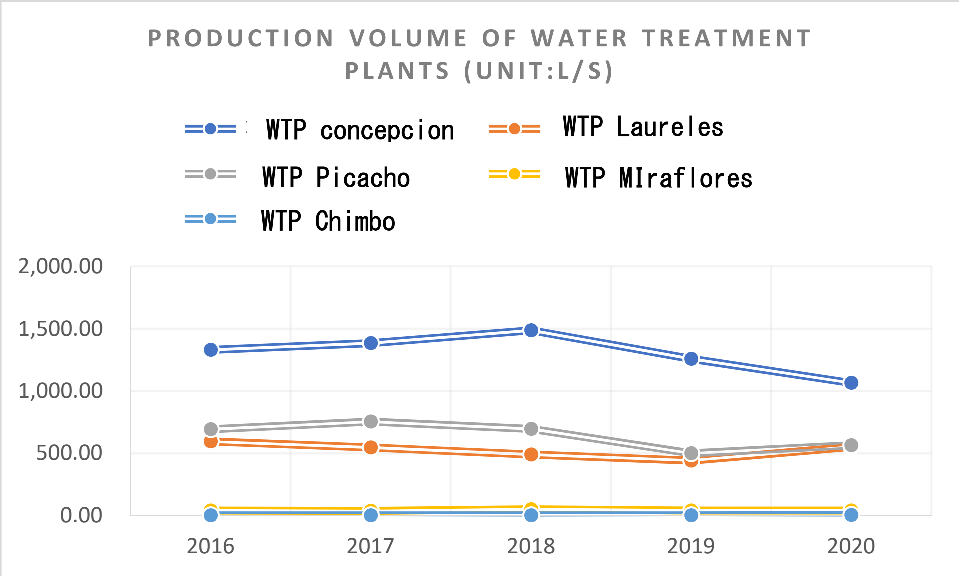


Figure 3-3-20Average Annual Water Production of Water Treatment Plant (2016-2020).

3-3-2-1-2 Picacho Water Treatment Plant

(1) Outline

The Picacho Water Treatment Plant is located in the northern part of the city at an elevation of about 1,300 m, the highest of 5 water treatment plants, and has a geographically advantageous condition that allows it to send water by gravity to many areas of the city. The water sources are streams from La Tigra Mountain system and water is captured from four pipelines. However, there are many variations in raw water volumes between dry and rainy seasons.

The water treatment plant was built in the 1920s, with only the chlorination facility at the beginning of construction. Subsequently, as water demand increased, water sources were developed and purification facilities were built with IDB support in 1997 (design capacity: 900 L/s).

In addition, to improve the water supply situation in the city, between 2006 and 2010 the "Grant-in aid, Tegucigalpa Emergency Water Supply Project " was executed, where the water treatment plant facilities were expanded and rehabilitated (design capacity increased to 1,100 L/s.), along with construction of distribution tanks, installation of water transmission and distribution lines, and construction of the water supply station.

The purification process consists of aerator + mixing tank + flocculation tank + sedimentation tank with inclined tube + gravity type rapid sand filter + chlorination. Figure 3-3-21 shows the flow diagram of the Picacho water treatment plant, Figure 3-3-22 shows the general plan, Figure 3-3-23 shows the hydraulic profile, Table 3-3-8 shows the specifications of the main facilities, and Figure 3-3-24 shows the current status of the facilities.

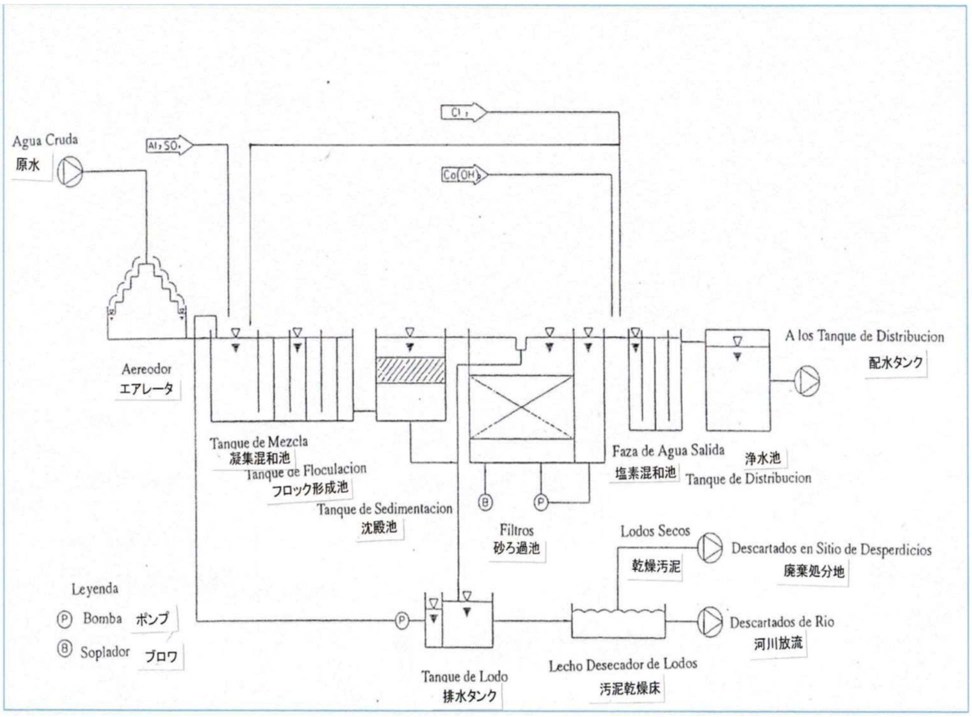


Figure 3-3-21Picacho Water Treatment Plant Flow Diagram

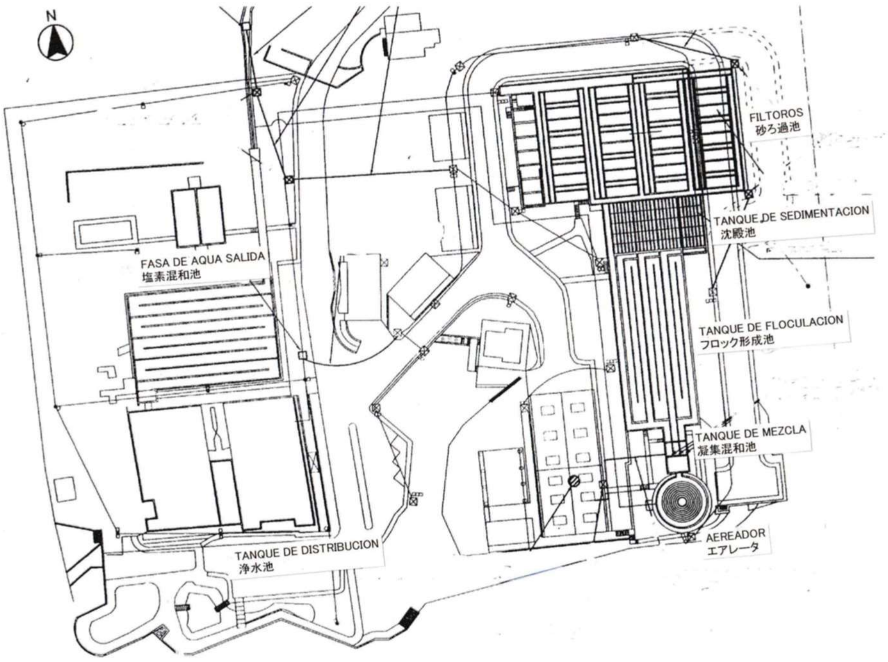


Figure 3-3-22 General Plan of Picacho Drinking Water Treatment Plant

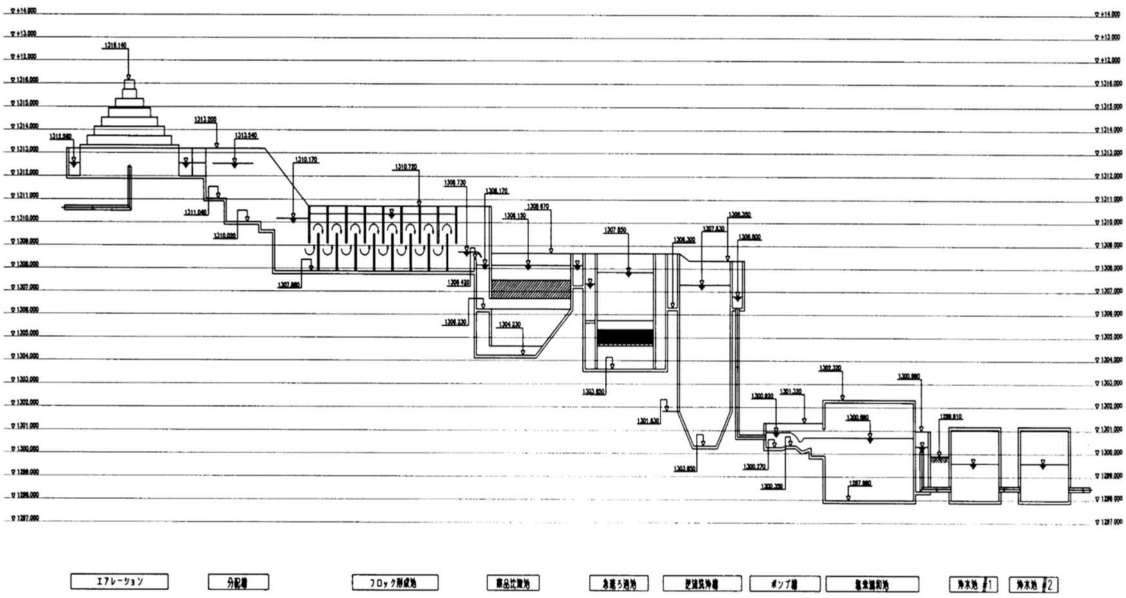


Figure 3-3-23Picacho Water Treatment Plant Water Hydraulic Profile

Table 3-3-8 Specifications of Main Facilities of Picacho Water Treatment Plant

No.	Facility	Specifications	Main Equipment	Remarks
	Production volume	1,100 L/s (95,040 m ^{3}/day)		
1	Aerator	・Circular cascade tank made of reinforced concrete (RC). ・1 tank		
2	Flocculation tank	・Vertical baffling type flocculator made of RC ・Width 1.5 m x Length 38.3 m x Depth 3.0 m x 3 channels	・Aluminum sulfate dosing equipment: 1 set ・Calcium hydroxide dosing equipment: 1 set. ・Polymer dosing equipment: 1 set	
3	Sedimentation tank	Upward flow tube sedimentation tank made of Reinforced Concrete (RC) ・Width 4.9 m x Length 12.0 m x Depth 4.6 m x 4 tanks		Grant-in-aid (2010): one tank added, roof was installed as a measure against algae.
4	Filtration tank	・Gravity type rapid sand filter with air washing made of RC. ・Width (2.5 m + 2.5 m) x Length 7.5 m x 16 tanks ・Filtration area: 37.5 m ^{2}/tank. Filtration rate: 158 m/day (when all tanks are operated).	・Air washing blower x 4 pcs.	Grant-in aid (2010): 4 tanks added Of the 12 tanks in the old series, 8 tanks are suspended for repairs.
5	Chlorine mixing tank	・Made of RC: 1 tank.	・Chlorine gas dosing kit: 1 set	

No.	Facility	Specifications	Main Equipment	Remarks
6	Drainage treatment facilities	・Sludge discharge tank. ・Sludge drying bed.	・Discharge pump	
7	Power receiving facilities		・Transformer: 13.8 kV x 300KVA x 1 pc.	
8	Emergency power generation system		・For process: 285KVA x 1 unit ・For chlorination equipment: 100KVA x 1 unit	The process system is faulty.
9	Monitoring and control equipment		・Control panel: 1 set (graphic panel: None)	SCADA System: None
10	Water quality laboratory	Available	・Turbidity level, residual chlorine, jar test, etc.	

Source: Prepared by the Study Team based on interviews with AMDC.

Aerator and top view of flocculation tank

Aerator

Coagulant dosing point

Flocculation tank

Sedimentation tank	Filtration tank
	
Filtration tank backwash drain channel	Chlorination equipment

Figure 3-3-24Current Status of Picacho Water Treatment Plant

(2) Operation and Maintenance System

The Picacho Water Treatment Plant is currently operated and maintained by the Picacho subsystem of the AMDC Water Management Unit, and this subsystem is also responsible for the operation and maintenance of the water source facilities related to Picacho, El Chimbo Water Treatment Plant, and the Miraflores Water Treatment Plant. The Picacho subsystem has 35 employees for operation and maintenance, and Table 3-3-9 shows their duties. The person in charge of water quality testing in the Table belong to the AMDC Central Water Quality Laboratory and is stationed at the Picacho Water Treatment Plant.

Table 3-3-9 Picacho Subsystem Operation and Maintenance System

	Staff Responsibilities	Remarks
1	Subsystem Administrator	
2	Subsystem Assistant	
3	Secretary	
4	Procurement warehouse keeper	
5	Facility cleaning	
6	Picacho Water Treatment Plant Operator	
7	El Chimbo Water Treatment Plant Operator	
8	Miraflores Water Treatment Plant Operator	
9	Mechanical and electrical Team	
10	Water source facilities inspection and management	
11	Driver	
12	Facilities inspection and management	
13	Field Worker	
	Water quality test	

Source: Prepared by the Study Team based on interviews with AMDC.

The water treatment plant operates in two shifts, from 8:00 a.m. to 4:00 p.m. and from 4:00 p.m. to 8:00 a.m. Water treatment plant operators inspect the main mechanical and electrical equipment once a week. Repairs on faulty equipment are carried out by the responsible section at AMDC headquarters. The staff reports daily data on water levels and volume from the water source to the AMDC, as well as the volume, water quality, water levels, etc. of the water treatment plant in digital format via online media. It should be noted that there is no communication system such as SCADA between AMDC and the water treatment plants. The personnel perform operation and maintenance work based on the AMDC operation and maintenance manual, however, the content is basic and insufficient in practice.

(3) Status of Operations

a) Water Volume

Table 3-3-10, shows the raw water volume and production volume (2016-2020) of the Picacho Water Treatment Plant and Figure 3-3-25 shows the monthly variations in production volume. The water production volume varies each year, but on average it is recorded at approximately 50 - 70% of the design capacity of 1,100 L/s. The maximum volume is about 80%, and in minimum volume months, it can drop to 30% of capacity. Relatively little rainfall has been recorded in 2021. The August water inflow was 401 L/s (18 days) and 440 L/s (19 days), trending similar to 2019.

Table 3-3-10 Raw Water Volume and Production Volume of Picacho Water Treatment Plant (2016-2020) (Unit: L/s)

Fiscal year	Average Annual Volume of Raw Water	Average Annual Production Volume	Production Volume/ Raw Water (%)	Average Annual Production Volume per Season		Minimum Volume of Production
				Rainy Season (May - October)	Dry Season (November - April)	
2016	724	694	95.9	729	657	382 (May)
2017	788	754	95.7	795	711	570 (April)
2018	730	695	95.2	699	693	533 (April)
2019	510	498	97.6	440	560	283 (August)
2020	577	564	97.7	660	466	303 (April)

Source: Statistical data from AMDC

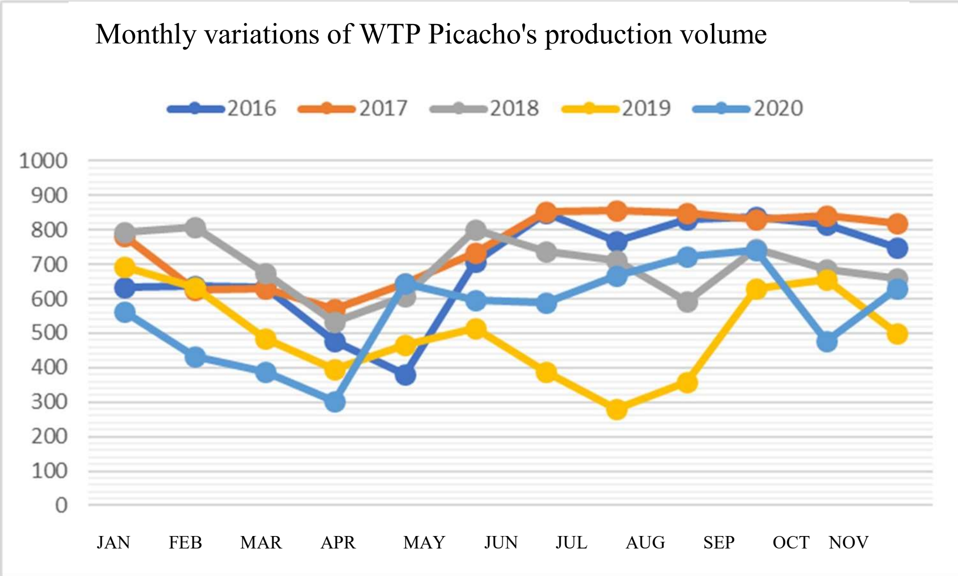


Figure 3-3-25Monthly Variations in Production Volume of Picacho Water Treatment Plant (2016-2020).

b) Water Quality

Water quality testing is performed in the in-plant water quality laboratory and in the central water quality laboratory. In the in-plant water quality laboratory, operating parameters such as turbidity, color, pH, electrical conductivity, alkalinity, and hardness are analyzed three times a day. In the central laboratory, samples are sent once a week from the water treatment plant, analyzed for iron, manganese, bacteriological and cross-checked for other items in the in-plant laboratory. Table 3-3-11 shows the main raw and purified water quality parameters (turbidity, color, pH, iron and manganese) obtained from 2016 to 2020 (monthly average values).

The quality of the purified water from this water treatment plant is generally good and adequate purification treatment is provided. The Picacho system's water source is mountain stream water and is characterized by high turbidity in the rainy season, often exceeding the 5 NTU turbidity standard level. However, during most of the year, the turbidity level is low and it is a good source of water. In the rainy season, sometimes the turbidity level exceeds 20 NTU, but the treatment absorbs it without any major problems. Regarding the color level, it often exceeds 15 TCU and is relatively high, which is thought to be caused by factors such as humic substances, however, it can be treated with coagulation, sedimentation and filtration. The pH is moderately low, so pH adjustment is carried out. As an additional reference, Table 3-3-2-5 shows the field survey data (August 18 and 19, 2021).

Table 3-3-11 Picacho Water Treatment Plant Water Quality (Monthly Average Values, 2016-2020).

Water Quality Parameter			Turbidity	Color	pH	Iron	Manganese	Remarks
Unit			NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water			5	15	6.5 - 8.5	0.3	0.5	
2016	R	Maximum	19.09	68.71	6.66 - 7.12	0.06	0.10	
		Average	5.26	26.16	6.85	0.03	0.10	
	Purified water		0.60 - 3.07	3.70-3.57	6.79-7.36	0.00-0.02	0.03 - 0.06	
2017	R	Maximum	8.70	39.90	6.57 - 7.21	0.15	0.10	
		Average	4.46	22.37	6.80	0.04	0.07	
	Purified water		0.79 - 4.53	2.69-4.83	6.51-6.92	0.00-0.04	0.00-0.05	
2018	R	Maximum	16.34	48.58	6.21-7.37	0.14	0.03	
		Average	4.09	16.37	6.76	0.04	0.03	
	Purified water		0.80 - 1.98	3.02-2.69	6.20-6.91	0.00-0.06	0.00 - 0.08	
2019	R	Maximum	10.07	29.69	5.22-6.17	0.07	0.04	
		Average	4.55	3.30	5.76	0.00	0.04	
	Purified water		0.72 - 4.06	2.50-6.44	6.21-6.84	0.00-0.11	0.03 - 0.12	
2020	R	Maximum	14.92	33.75	5.48-7.21	0.13	-	
		Average	6.96	19.11	6.20	0.06	-	
	Purified water		1.34 - 5.24	2.9-11.50	5.42-7.22	0.00-0.28	-	
18 /Aug /2021	*Raw water*		3.39	12.5				Good weather
	Purified water		2.73	5.0				
19 /Aug /2021	*Raw water*		12.6	62.5				After rain
	Purified water		1.95	5.0				
Evaluation			Only once above 5, otherwise good.	Good	Few times below 6.5, otherwise good.	Generally good	Good	

Source: Prepared by the Study Team based on data from AMDC's Water Quality Management Department.

c) Operation and Dosing of Chemicals

In August 2021, out of 16 sand filtration tanks, 8.5 tanks are out of service for various problems. At this moment, the treatment capacity is 650 L/s, and with this capacity it is not possible to respond to the future increase in water volume. The problems include gate failures, damage to the nozzle, damage to the joint between the bed and the structure (large bubbles are produced when air is flushed out), and lack of replacement of filter media, among others. Some filtration tanks that do work also have similar failures, so repairs are urgently needed.

Sludge discharge from the sedimentation tank is performed every six months. Backwashing of the filtration tank is performed every 24 hours in the rainy season and every 30 hours during the dry season. The backwashing operation consists of Air washing (5-8 minutes) + Water washing (10 minutes). Replacement of the filter sand is supposed to be done about every 10 years, however, it was replaced in 2011 after the installation in 1997 and has not been replaced since then. Periodic replacement of the filter media has been insufficient, and as a result, the media thickness in some filter tanks has been reduced. Wastewater and sludge are gravity-flowed to the discharge tank and then discharged directly to the waterways. Although a recycle pump is installed, it is not used at this time due to the high turbidity level.

Power is received on a single line, 13.8kV, and distributed at 440V/220v. Power outages occur approximately 30 times/year. Planned work power outage is 2 to 3 hours/1 time, and in case of accident, etc., it is 30 minutes to 10 hours/1 time. There are two electric generators for emergencies, one for the plant (285 kVA) and another auxiliary generator (for the chlorination equipment, 100 kVA). However, at this time the generator assigned for the plant cannot be used because it is out of order, and the auxiliary generator has capacity limitations to operate the equipment in case of blackouts. Table 3-3-12 shows the energy consumption of this water treatment plant. The unit energy consumption ranges from 0.0048 - 0.0062 kWh/m 3.

Table 3-3-12 Energy Consumption of Picacho Water Treatment Plant (2017-2020)

Fiscal Year	Energy Consumption	Production Volume	Unit Energy Consumption
	kWh/year	m^3 /year	kWh/m^3
2017	147,520	23,785,595	0.0062
2018	111,200	21,923,047	0.0051
2019	90,526	15,749,133	0.0057
2020	85,282	17,837,161	0.0048
Average			0.0055

Source: Prepared by the Study Team based on interviews with AMDC.

The monitoring and control system of this water treatment plant consists of a system based on a Programmable Logic Controller (PLC), with only field data collection and monitoring functions on an LCD (liquid crystal display) attached to the PLC control panel. A full-scale SCADA system has not been installed.

The chemicals used are aluminum sulfate, lime hydrate and chlorine gas. Polymer is sometimes used to improve the sedimentation effect when the water quality deteriorates, and sodium hypochlorite is sometimes used as a backup for chlorine gas. As a guideline for flocculant injection, when the inflow turbidity is less than 5 NTU, no flocculant is injected, when it is more than 5 NTU, aluminum sulfate is injected, and when the water quality deteriorates (generally during rainfall), polymer is injected. At the time of the field survey (August 2021), no chemicals were injected on the 18th, and aluminum sulfate and polymer were injected on the 19th.

Table 3-3-13 shows the cost of chemicals and the chemical dosage rate of this water treatment plant. It should be noted that polymer and sodium hypochlorite are omitted due to low usage. The chemical cost is 0.05 - 0.10 HNL/m3, although it depends on the quality of the raw water. When the quality of the raw water is good, aluminum sulfate and lime hydrate are not dosed during a certain period, generally in the dry season.

Table 3-3-13 Chemical Cost and Chemical Dosage Rate of Picacho Water Treatment Plant (2016-2020).

Item	Cost of Chemicals	Aluminum Sulfate		Calcium Hydroxide		Chlorine Gas	
Unit	HNL/m ^{3}	mg/L		mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average
2016	0.08	2.97	2.10 - 4.80	2.06	1.74 - 3.31	0.96	0.60 - 1.43
2017	0.10	2.61	1.97 - 3.40	1.45	0.00 - 2.11	1.03	0.81 - 1.35
2018	0.05	1.04	0.03 - 4.62	0.35	0.00 - 1.12	0.72	0.42 - 1.05
2019	0.05	0.90	0.00 - 2.69	0.77	0.16 - 1.49	0.63	0.42 - 1.15
2020	0.06	1.39	0.03 - 4.85	0.76	0.06 - 3.45	0.59	0.43 - 0.90

Source: Prepared by the Study Team based on interviews with SANAA.

d) Status of Major Facilities and Equipment

Table 3-3-14 and Figure 3-3-26 show the current status of the major facilities and equipment of this water treatment plant. Some equipment has been replaced; however, most of the equipment is the same one as at the start of the construction 25 years ago, requiring repair or replacement due to breakdown and aging. In 2012, flow meters were installed in the raw water and transmission/distribution systems, but many of them are not working due to malfunctions. Current influent flows are measured at the aerator outflow channel weir. There is an urgent need to upgrade or install chemical dosing equipment to ensure reliable treatment operation, power generator equipment to secure power supply during power outages, and flow meters to monitor water volume. As for the filtration tanks, eight of the 16 tanks are currently idle due to problems with the gates and water collection equipment. It is reported that this is because the existing water collection system is not suitable for water/air washing. Some of the filtration tanks that are still in operation are not being cleaned effectively due to problems with the water collector (nozzle). The current inflow of water is small compared to the design capacity, so it can be dealt with, but as the water volume will increase in the future, it is necessary to repair it as soon as possible.

Table 3-3-14 Status of Major Facilities and Equipment of Water Treatment Plant

	Facility	Major Equipment	Year of Installation	Current Status, Failure/Repair History
1	Flocculation tank	・Motorized inlet gate x6	1996	・Manual operation due to control panel and motor failures, aging, repair required.
2	Aluminum sulfate dosing equipment	・Dissolving tank x1 ・Water pump x2 ・Dosing device (large) x1 ・Dosing device (small) x1	1996 1996 1996 2010	・Updated mixer (Grant-in-aid, 2010) ・Removal of one broken, aging, replacement required. ・Aging, replacement required. ・Already replaced. (Grant-in-aid)
3	Lime hydrate dosing equipment	・Storage tank x1 ・Feeder x1 ・Dissolving tank x3 ・Compressor x1 ・Metering pump x2	2018 2018 1996 2018 1996	・Already replaced. ・Chemical clogging, manual loading, repair required. ・Updated mixer (Grant-in-aid, 2010) ・Already replaced. ・One unit is out of order, aging, replacement required.
4	Polymer dosing equipment	・Dosing device x1 ・Metering pump x1	2012 1996	・Already replaced. ・Aging, replacement required.
5	Sand filtration	・Sand filtration tank Old system x12 tanks, new system x4 tanks ・Old system motorized gate x24 ・New system motorized gate x16 ・Air washing blower x4	1996 2010 1996 2010 1996	・Old system: 8 tanks are suspended due to failures in the gates and water collecting device, repair required. New system: Grant-in-aid 2010. ・6 units are out of order, repair required. ・Grant-in-aid, 2010
6	Chlorination equipment	・Chlorine injector x1 ・Chlorine dosing pump.	1996 1996	・Aging, replacement required. No measuring and neutralizing device. ・One failed unit removed. aging, replacement required
7	Power receiving system	・Transformer 300 kVA x1	1996	・Replacement of aerial cable to underground cable
8	Emergency power generation system	・Main (for plant) 285 kVA x1 ・Auxiliary (for chlorine dosing) 100 kVA x1	1996 2007	・Starter panel failure, repair required. ・The capacity of the auxiliary generator is limited to operate some equipment.
9	Monitoring and control equipment	・Aluminum sulfate dosing equipment control panel x1. ・Lime hydrate dosing equipment control panel x1.	2010 1996 2010	・Grant-in-aid ・Aging ・Old system: Aging

	Facility	Major Equipment	Year of Installation	Current Status, Failure/Repair History
		・Sand filtration tank control panel x16		
10	Flow meter	・Conduction pipeline x 4 ・Transmission and distribution piping x 16	2012 1996/2012	・Electromagnetic, poor connection, failure due to voltage variations, not usable, repair and replacement required. ・5 units failed, aging, replacement required.
11	Water quality laboratory	Turbidity meter, color meter, chlorine residual meter, electrical conductivity meter, jar tester, etc.	1996 2012	Aging, some are out of order, calibration and repair required.

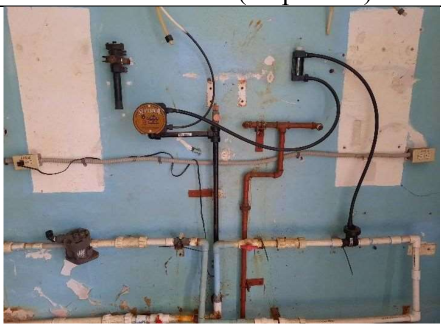
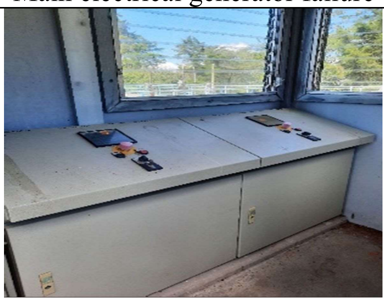
Source: Prepared by the Study Team based on interviews with AMDC.

Flocculation tank inlet gate: Failure

Aluminum sulfate dosing equipment

Lime hydrate dosing equipment (feeder)

Lime hydrate dissolving tank

Lime hydrate dosing pump	Polymer dosing device
	
Filtration tank (suspended)	Filtration tank air washing blower
	
Chlorine dosing device : aging	Transformer
	
Main electrical generator failure	Chemical dosing equipment control panel
	
Sand Filtration Tank Control Panel	Flowmeter (raw water, purified water and pipeline) failure

	
Flow meter (distribution lines) : failure	Water quality laboratory : aging, failure

Figure 3-3-26Status of Major Facilities and Equipment of Picacho Water Treatment Plant

(4) Problems at Picacho Water Treatment Plant and World Bank Improvement Plan

a) Problems at Picacho Water Treatment Plant

Table 3-3-15 shows the problems and possible countermeasures at this water treatment plant identified from the results of the field survey and interviews with maintenance staff. Many of the issues are associated with the aging and failure of the water pipes and facilities.

Table 3-3-15 Problems at the Picacho Water Treatment Plant

Issue	Current Problems	Possible Measures	Remarks
1.Water source and water quality	・Aging pipelines that are vulnerable to heavy rains and landslides.	・Reinforcement of the base structure is required to support and protect the pipeline or build a new structure.	If even one pipe fails, the raw water volume will decrease.
2. Facility scale	・The raw water volume is 50 - 70 % of the design capacity of 1,100 L/s, the available treatment volume varies due to climate change.	・Construction of new reservoirs to secure raw water supply, especially during the dry season.	
3. Treatment function	・The current treatment process satisfies the drinking water standard.		
4. Facilities and equipment	a. Many pieces of equipment are the same as at the beginning of construction and are 25 years old, aging, or have broken down. b. The lime hydrate feeder device is clogged. c. Only one aluminum sulfate and polymer metering pump is operational. d. 8 sand filtration tanks are suspended due to failures in the drainage collection device.	a. Repair or replacement is required after detailed study. b. Addition of vibration and heating device. c. Installation of standby equipment to ensure operation in case of breakdowns. d. Replace the current nozzle of the drainage collection device that is for water to the nozzle for water/air, in all tanks including those that are	

Issue	Current Problems	Possible Measures	Remarks
	e. Leaks from the air piping around the sand filtration tank. f. Partial damage to equipment due to power surge from voltage variations caused by poor grounding. g. Lack of capacity due to the failure of the main generator (285 kVA). h. Deficient measurement and safety measures and aging of chlorination equipment. i. Aging and failure of the flow meter makes it difficult to measure the volume of water. j. Failure in operation and handling due to failure of aging control panel. k. Some water quality test equipment is out of order, repair required. l. Cracks and water leaks in the structure of the sand filtration tank and the purification tank.	not being used (about 15,000). e. Pipe repair is required. f. Study of situation and adequacy of grounding. g. Repair h. Replacing and upgrading by adding more measuring and safety equipment. i. Improvement of the instrumentation system for flow rates and water levels. j. Construction of systems considering the adequacy of operation and handling and efficiency. k. Replacement and repair l. Adequate remediation at any time after the situational study.	
5. Operation and maintenance system, etc.	・There are no particular problems with the current system for facility operation, but equipment maintenance and repair is not being carried out systematically, and there may be problems in responding to breakdowns and emergencies. ・O&M manual with insufficient content.	・It is required to perform asset management and establish a preventive maintenance program for systems and equipment. ・Development of an adequate O&M manual.	

b) World Bank Improvement Plan

The World Bank's "Tegucigalpa Water Supply Strengthening Projecto" (2019) also proposes the improvement plan for the water treatment plants. Of these, Table 3-3-16 shows the specific items related to the Picacho Water Treatment Plant. Note that implementation of this plan is behind schedule.

Table 3-3-16 Picacho Water Treatment Plant Improvement Plan Proposed by the World Bank

	Proposal	Details
1	Rehabilitation of the Jutiapa-Picacho pipeline and regulation of water use	This pipeline crosses private properties and there are many illegal connections. To guarantee raw water for the drinking water treatment plant, the pipeline is repaired and an appropriate water use agreement is signed with the landowners.
2	Upgrading of chemical dosing equipment	Many equipment failures and this hinders water purification. Necessary repairs and improvements are made to improve reliability.

	Proposal	Details
3	Chlorination equipment upgrade	Equipment failures and lack of safety. Equipment should be upgraded by replacing it, installing the chlorine neutralizing device, chlorine tank scale, etc.
4	Improvement of the coagulation device	Damage to the screen and short circuit affects efficiency, this needs to be improved.
5	Replacement of motorized actuators for valves and gates	Manual operation due to deterioration and many breakdowns. Replacement for simplified handling and greater efficiency.
6	Replacement of the filter media for the filtration tank	The filter sand has reached its useful life, the sand needs to be replaced in all tanks. It is not necessary in case of multi-layer filtration due to the quality of the raw water.
7	Replacement of nozzles in the lower water collection system of the filtration tank	Poor performance due to clogging or damage. All of them are renewed.
8	Sludge management and reuse of backwash wastewater	Proper sludge management and reuse of overflow water for treatment process
9	Operations and energy efficiency improvement	To improve system efficiency, installation of load factor reduction condenser, the pumps and blowers are replaced with high-efficiency motor, and reviewed filtration pond cleaning operations and chemical injection operations.
10	Effective measurement of water production volume	Improvement of flow metering system and linkage with network SCADA system for water supply optimization.
11	Office equipment	Provision of equipment and software for proper information management, monitoring and surveillance of the process and improved communications.
12	Water quality testing equipment	Revision of procedures and standards in the transfer of the water quality management function, installation of new laboratory equipment to monitor treatment processes and purified water quality.

(5) Picacho Micro Hydroelectric Plant

The El Picacho micro hydroelectric plant is installed in one of the nine distribution pipelines coming from the El Picacho Water Treatment Plant, on the L22 system line, with a diameter of 400 mm. In August 2021, the transformer suffered a malfunction and the micro hydroelectric plant is not working. When the survey was conducted on August 19, 2021, the flow rate was 186 L/s. This flow is within the range of flows between 120-300 L/s that allow power generation, and therefore, if the transformer is repaired, power can be generated. Regarding the repair, according to the interview with UMAPS, it can be repaired at a cost of HNL 196,225.00. The electrical generator is in good condition with no damage observed.

	
Transformer (damage to neutral and ground terminal)	Electric generator

3-3-2-1-3 La Concepción Water Treatment Plant

(1) Outline

The Concepcion Water Treatment Plant is located in the downstream of Concepcion reservoir and was built in 1991 with financing from the Italian and French governments (service began in 1993). Initially, the design capacity was 1,200 L/s, but in 2006, with support from Italy, the treatment capacity was increased by 300 L/s, and the current design capacity is 1,500 L/s (start of service in 2008). This was in response to the reservoir elevation/increase in storage volume with the new construction of the tumble gate at the reservoir overflow spillway and the plan to divert water from other water sources. Subsequently, in order to respond to the diversion from the Laureles system, the inclined plate was installed in the suspended solid contact type sedimentation tank in 2017 to improve efficiency and treatment capacity. As a result, the maximum treatment capacity for the operation increased to 1,700 L/s. This water treatment plant is the largest in the municipality and water production is stable throughout the year. Additional to this, in 2017, the booster pumping station was installed to send a portion of treated water to the Laureles Water Treatment Plant.

The water purification process consists of aerator + mixing tank + suspended solid contact type sedimentation tank (with inclined tube) + gravity type rapid sand filter + chlorination. Figure 3-3-27 shows the flow diagram of the Concepcion water treatment plant, Figure 3-3-28 shows the general plan, Figure 3-3-29 shows the hydraulic profile, Table 3-3-17 shows the specifications of the main facilities, and Figure 3-3-30 shows the current situation of the facilities.

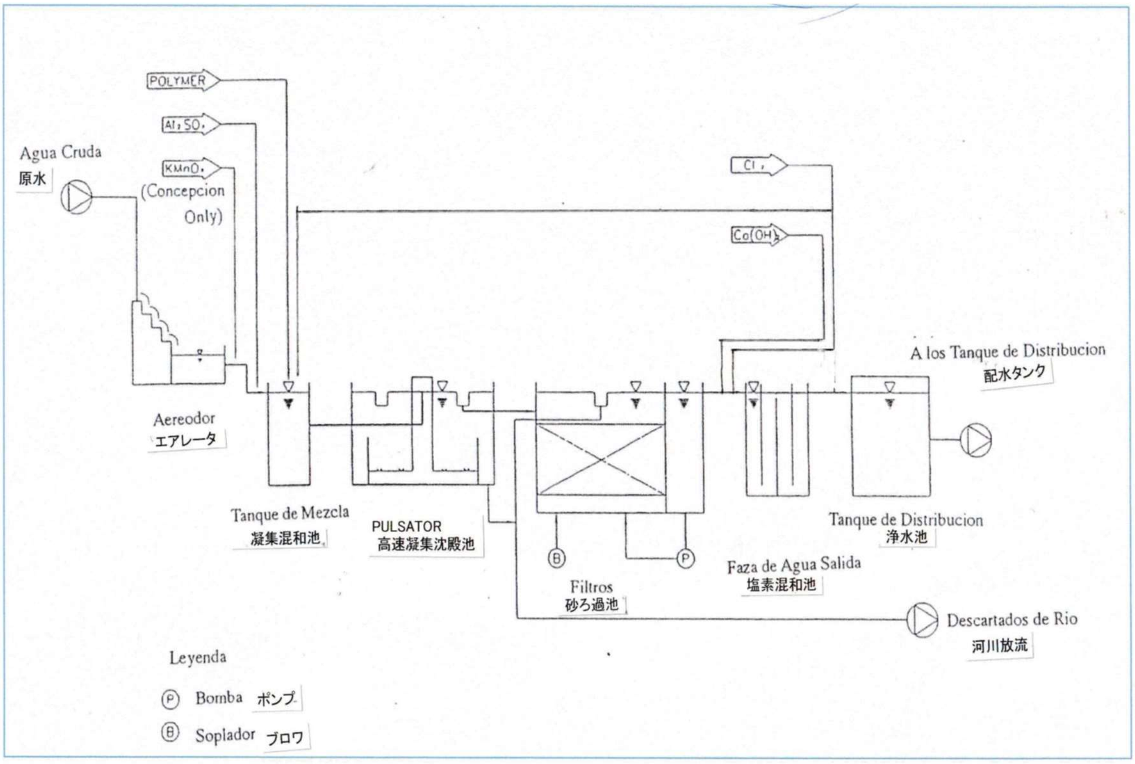


Figure 3-3-27Flow Diagram of Concepción Water Treatment Plant

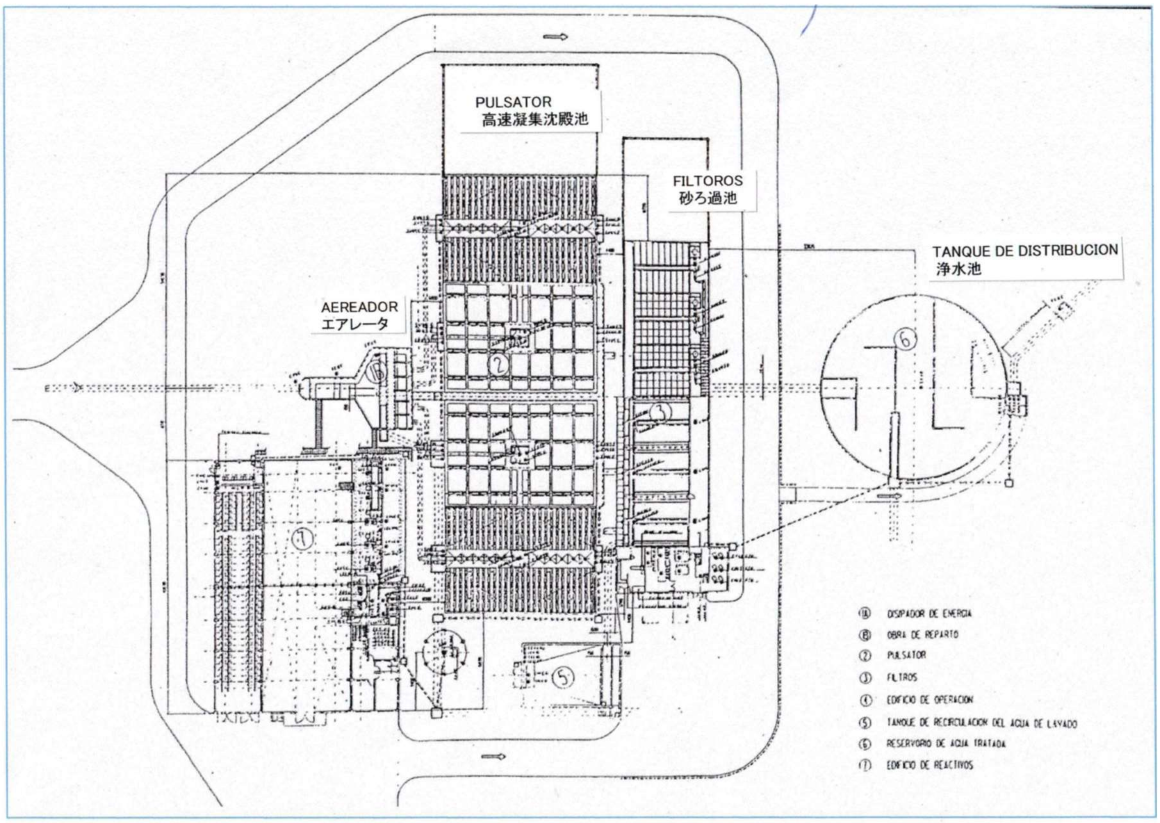


Figure 3-3-28General Plan of Concepción Water Treatment Plant

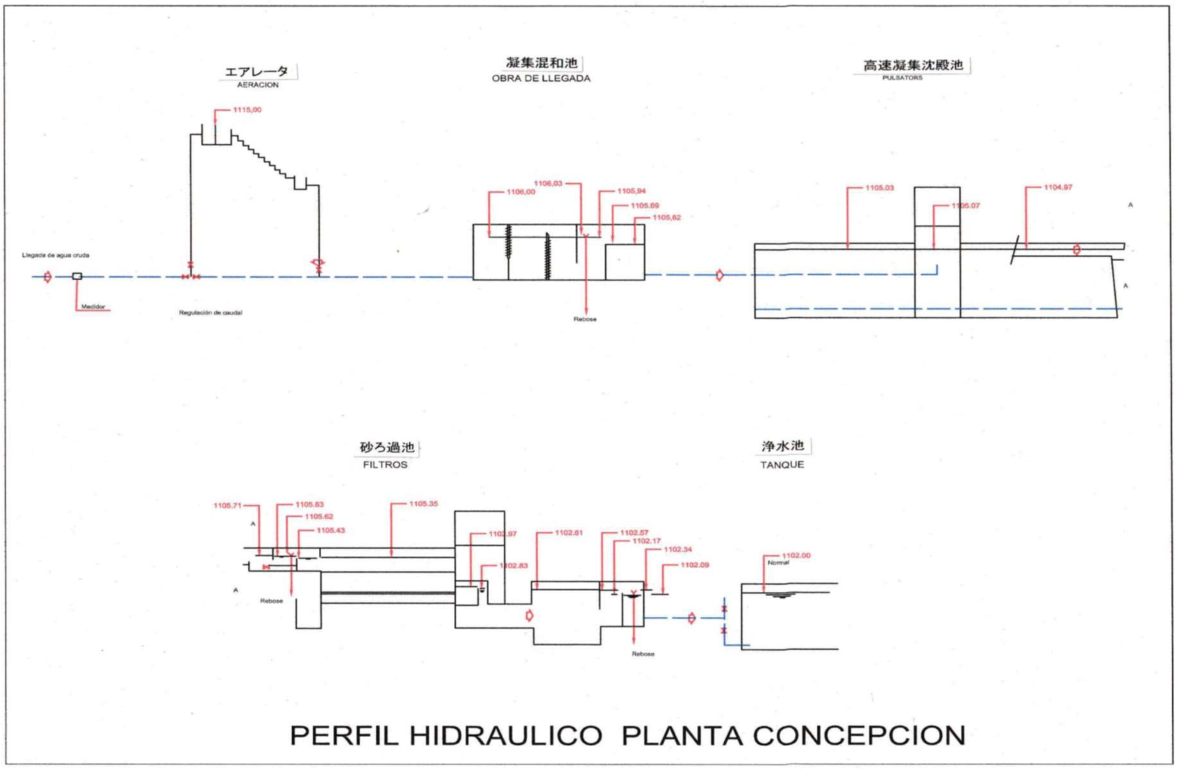


Figure 3-3-29Hydraulic Profile of Concepcion Water Treatment Plant

Table 3-3-17 Specifications of Main Facilities of Concepción Water Treatment Plant

No.	Facility	Specifications	Main Equipment	Remarks
	Production volume	1,500 L/s (129,600 m^3/day)		Maximum for the operation, 1,700 L/s
1	Aerator	・Rectangular cascade tank, made of reinforced concrete (RC). ・1 tank		
2	Suspended solid contact type sedimentation tank	・Suspended solid contact type sedimentation tank with inclined plate, made of RC (pulsation type). ・Width 17.0 m x Length 25.0 m x Depth 3.7 m x 5 tanks ・Surface load: 36 mm/min. ・Detention time: 1.5 hours	・Aluminum sulfate dosing equipment: 1 set ・Lime hydrate dosing equipment: 1 set. ・Polymer dosing equipment: 1 set ・Potassium permanganate dosing equipment is diverted for activated carbon dosing equipment: 1 set.	・Pulsator type. ・One tank added in 2006. ・Potassium permanganate is currently not used. ・Activated carbon is used only for raw water coming from the Laureles system to remove odor.
3	Sand filtration tank	・Gravity type rapid sand filter with air washing made of RC ・Width (3.44 m + 3.44 m) x Length 9.0 m x 8 tanks ・Filtration surface area: 62 m ^{2}/tank.	・Air washing blower x 4 units.	・Aquazur type ・2 tanks added in 2006. ・Sand layer thickness: 1.4 m

No.	Facility	Specifications	Main Equipment	Remarks
		Filtration rate (all tanks in operation): 260 m/day, maximum 290 m/day.		
4	Chlorine mixing tank	・Made of RC: 1 tank.	・Liquid chlorine dosing set: 1 set	
5	Lime saturation tank	・Made of RC: 1 tank.		
6	Backwash tank	・Made of RC: 1 tank.	・Recovery pump	
7	Power receiving system		・Transformer: 34.5 kV x 500KVA x 1 unit	
8	Emergency power generation system		・285KVA x 1 unit	
9	Monitoring and control equipment		・Control panel: 1 set (graphic panel: existing)	SCADA System: None
10	Water quality laboratory	There is	・Turbidity, residual chlorine, jar test, etc.	
11	Booster pumping station		Vertical pump 9.46 m3/min x 45.7 m x 94kW x 2 units (1 standby) 18.93 m3/min x 45.7 m x 188 kW x 2 units (1 standby)	It sends a portion of treated water to the Laureles Water Treatment Plant.

Source: Prepared by the Study Team based on interviews with AMDC.

Mixing tank inlet

Overview of sedimentation tank and sand filtration building

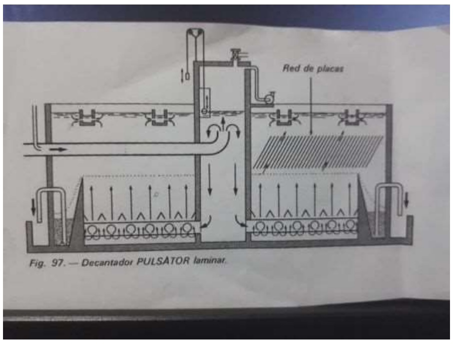
	
Suspended-solid contact sedimentation tank with inclined plate	Flow diagram of sedimentation tank
	
Sand filtration tank	Chlorination equipment
	
Monitoring and control room	Lime saturation tank

Figure 3-3-30Current Status of Concepción Water Treatment Plant

(2) Operation and Maintenance System

Currently, the Concepcion Water Treatment Plant is operated and maintained by the Concepción subsystem of the AMDC Water Management Unit, and this subsystem is also responsible for the operation and maintenance of the water source facilities related to Concepcion. The Concepción subsystem has 29 personnel for operation and maintenance, and Table 3-3-18 shows their duties. The water quality test personnel listed in the Table belong to the AMDC Central Water Quality Laboratory and is stationed at the Concepcion Water Treatment Plant.

Table 3-3-18 Operation and Maintenance System for Concepción Subsystem

	Staff Responsibilities	Remarks
1	Subsystem administrator	
2	Subsystem assistant	
3	Secretary	
4	Procurement warehouse keeper	
5	Facility cleaning	
6	Water Treatment Plant operator	
7	Mechanical and electrical team	
8	Water source facilities inspection and management	
9	Driver	
10	Facilities inspection and management	
11	Field worker	
	Water quality test	

Source: Prepared by the Study Team based on interviews with AMDC.

The water treatment plant is operated in two shifts, from 8:00 a.m. to 4:00 p.m. and from 4:00 p.m. to 8:00 a.m. of the following day. Water treatment plant operators inspect the main mechanical and electrical equipment once a week. Repairs to faulty equipment are carried out by the responsible section at AMDC headquarter. The staff reports daily to AMDC the data on water levels and volume of water from the water source, as well as the volume, water quality, water levels, etc. of the water treatment plant in digital format via online. There is no communication system such as SCADA between AMDC and the water treatment plants. The personnel perform operation and maintenance work based on the AMDC operation and maintenance manual.

(3) Status of Operations

a) Water Volume

Table 3-3-19, shows the raw water volume and production volume (2016-2020) of the Concepcion Water Treatment Plant and Figure 3-3-31 shows the monthly variations in production volume. The water production volume varies each year, but from January to June 2018 and 2019 it exceeded the design capacity of 1,500 L/s and approached the maximum capacity for operation (1,700 L/s). Although in the months of minimum volume this can drop to 50% of capacity, in the high water season, the plant is generally operating at maximum capacity. Relatively little rainfall has been recorded in 2021. The incoming volume at the time of the field survey (August 20, 2021) was 1,373 L/s, trending similar to the period between 2016 and 2018.

Table 3-3-19 Raw Water Volume and Production Volume of Concepción Drinking Water Treatment Plant (2016-2020) (Unit: L/s)

Fiscal Year	Average Annual Volume of Raw Water	Average Annual Production Volume	Production Volume/ Raw water (%)	Average Annual Production Volume per Season		Minimum Volume of Production
				Rainy Season (May - October)	Dry Season (November - April)	
2016	1,360	1,332	97.9	1,327	1,337	1,247 (November)
2017	1,417	1,385	97.7	1,364	1,406	1,425 (October)
2018	1,519	1,489	98.0	1,495	1,482	1,464 (November)
2019	1,285	1,259	98.0	1,227	1,293	784 (November)
2020	1,089	1,065	97.8	1,196	933	706 (March)

Source: Prepared by the Study Team based on AMDC statistical data.

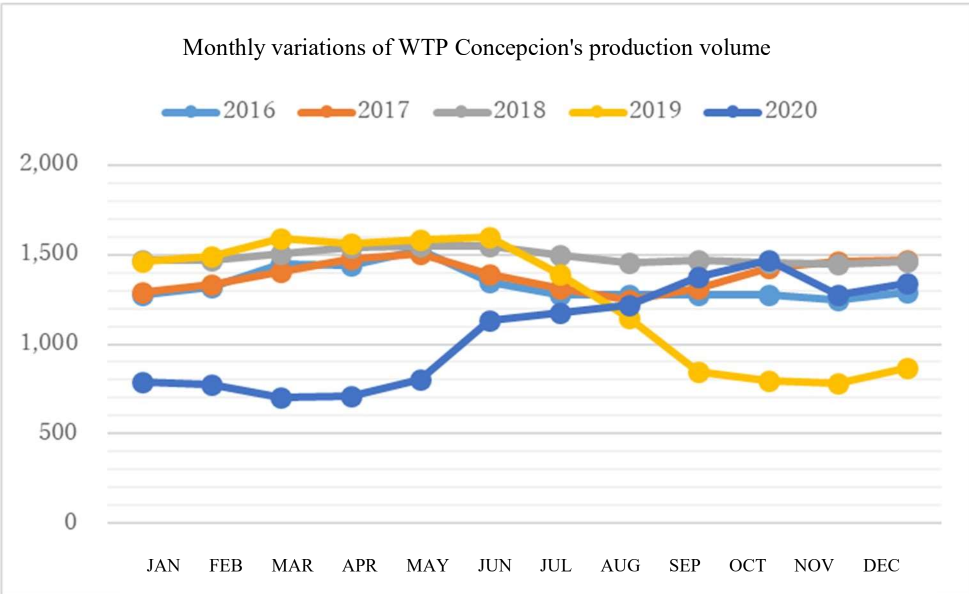


Figure 3-3-31Monthly Variations in Production Volume of Concepcion Water Treatment Plant (2016-2020).

b) Water Quality

Water quality testing is performed in the in-plant water quality laboratory and in the central water quality laboratory. In the in-plant water quality laboratory, operating parameters such as turbidity, color, pH, electrical conductivity, alkalinity, and hardness are analyzed three times a day. In the central laboratory, samples are sent once a week from the water treatment plant, analyzed for iron, manganese, bacteriological and cross-checked for other items in the in-plant laboratory.

Table 3-3-20, shows the main raw and purified water quality parameters (turbidity, color, pH, iron and manganese) obtained from 2016 to 2020 (monthly average values).

The source of water for this water treatment plant is the Concepcion reservoir. Throughout the year, the raw water has fairly high levels of both turbidity and color, and algae is observed. In the last five years, these values were generally maintained, and especially in the rainy season the turbidity level rises to 100-150 NTU and the color, 300-400 UC. Likewise, the values of the analysis of nutritive salts in the raw water in 2020 (monthly average) show the results of ammonium nitrogen between 0.51 - 2.18 mg/L (average: 1.23 mg/L), nitrate nitrogen between 0.01 - 0.08 mg/L (average: 0.05 mg/L) and phosphoric acid between 0.05 - 0.30 mg/L (average 0.17 mg/L), indicating symptoms of water quality contamination and eutrophication due to various wastewaters. On the other hand, the turbidity and color level of the purified water is lower than the permitted value for drinking water and it is treated by coagulation, sedimentation and filtration. The pH is adjusted, although sometimes the value of the purified water is lower than the standard value. Also the iron and manganese values are lower than the standard value.

Table 3-3-20 Water Quality at Concepción Water Treatment Plant
(Monthly Average Values, 2016-2020)

Water Quality Parameter			Turbidity	Color	pH	Iron	Manganese	Remarks
Unit			NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water			5	15	6.5 - 8.5	0.3	0.5	
2016	Raw	Maximum	94.42	261.99	6.81-7.09	0.35	0.44	
		Average	56.60	168.55	6.95	0.24	0.30	
	Purified water			2.50 - 3.95	6.21-6.75	0.00-0.01	0.00 - 0.21	
2017	Raw	Maximum	108.00	382.40	6.55-7.18	0.52	0.57	
		Average	63.26	174.68	6.98	0.27	0.13	
	Purified water			2.56 - 8.59	6.14-6.67	0.00	0.00 - 0.32	
2018	Raw	Maximum	78.77	276.30	6.70-6.93	0.55	0.13	
		Average	52.25	158.20	6.78	0.25	0.05	
	Purified water			2.50 - 4.53	6.31-6.61	0.00-0.02	0.03 - 0.18	
2019	Raw	Maximum	145.27	424.38	6.62-7.50	0.52	0.11	
		Average	60.85	165.12	6.89	0.34	0.06	
	Purified water			2.50 - 4.10	6.43-6.78	0.00-0.01	0.01 - 0.19	
2020	Raw	Maximum	125.02	361.86	6.78-7.76	0.45	0.02	
		Average	70.19	182.66	7.19	0.30	0.01	

Water Quality Parameter		Turbidity	Color	pH	Iron	Manganese	Remarks
Unit		NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water		5	15	6.5 - 8.5	0.3	0.5	
	Purified water		2.5 - 5.51	6.29-6.97	0.00	0.00 - 0.02	
20 /Aug /2021	*Raw water*	*35.00*	*125.00*				
	Purified water	*0.72*	*2.50*				
Evaluation		Lower than allowed value	Lower than allowed value	Sometimes it is less than 6.5	Good	Good	

Source: Prepared by the Study Team based on data from AMDC's Water Quality Management Department.

c) Operation and Dosing Chemicals

The sludge unloading work of the sedimentation tank is performed every six months. Backwashing of the filtration tank is performed every 24-28 hours, and the backwash operation consists of 5-minute air flushing + 3-minute air and water flushing + 5-12 minute water flushing. The filter sand has not been completely replaced since service began; however, approximately 10% is replaced each year. Sludge is discharged directly to the nearby river. Wastewater from the wash flows by gravity to the recovery tank and is returned to the inlet side through the recovery pump.

As an anti-algae measure, the sedimentation tank and sand filtration tank channels are washed 4-5 times a year and pre-chlorination is performed. They are requesting the installation of a roof for both facilities as a measure against algae. The facilities and the enclosure are well cleaned.

Power is received on a single line, 34.5 kV, and distributed at 440V/220v. Power outages occur approximately 12 times/year. Planned work power outage is 2 to 3 hours/interruption, and in case of accident and emergencies, it is 30 minutes to 10 hours/interruption. There is an electric generator for emergencies with a capacity of 295 kVA. Table 3-3-21 shows the energy consumption of this water treatment plant. Unit energy consumption ranges between 0.0088-0.0118kWh/m^3.

Table 3-3-21 Energy Consumption of Concepción Water Treatment Plant (2017-2020)

Fiscal Year	Energy Consumption	Production Volume	Unit Energy Consumption
	kWh/year	m^3 /year	kWh/m^3
2017	383,600	43,679,632	0.0088
2018	389,280	46,946,802	0.0083
2019	-	-	-
2020	396,000	33,690,952	0.0118
Average			0.0096

Source: Prepared by the Study Team based on interviews with the AMDC.

This water treatment plant does not have a SCADA system for monitoring and control of equipment operations; monitoring is carried out with a conventional graphic panel as a structural component. The status of operations and malfunctions can be monitored with the operation and malfunction indicator lights installed on the equipment control panel. The operation of the equipment is carried out with the structural component control circuit through the auxiliary electrical relay. The data of raw water flow rates, delivered water and purified water tank levels are stored in the digital data logger installed on the instrument panel adjacent to the graphic panel and are indicated on the LCD display.

The chemicals used are aluminum sulfate, lime hydrate and liquid chlorine. In addition, polymer is always used to improve the sedimentation effect when the turbidity level is high. At the beginning of construction, potassium permanganate dosing equipment was used to remove manganese, but it is no longer used. When the raw water enters from the Laureles system, powdered activated carbon dosing equipment is also used to eliminate odor, which uses the facilities of the potassium permanganate dosing equipment. Pre-chlorination is performed as a measure against algae.

Table 3-3-22 shows the cost of chemicals and the chemical dosage rate of this water treatment plant. The dosing rate is quite high for all chemicals due to the quality of the raw water with high turbidity and color. The chemical cost is 0.64 - 0.86 HNL/m^3, although it depends on the quality of the raw water, and is approximately 10 times higher than the Picacho Water Treatment Plant which has relatively good water quality.

Table 3-3-22 Chemical Cost and Chemical Dosage Rate of Concepción Water Treatment Plant (2016-2020).

Item	Cost of Chemicals	Aluminum Sulfate		Calcium Hydroxide		Chlorine Gas		Polymer	
Unit	HNL/m ^{3}	mg/L		mg/L		mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average
2016	0.86	32.90	27.29 - 39.67	10.63	8.84 - 13.03	4.10	3.63 - 4.58	0.14	0.11 - 0.18
2017	0.71	36.04	30.42 - 45.54	7.28	4.10 - 13.35	4.10	3.62 - 4.61	0.15	0.11 - 0.19
2018	0.64	34.17	31.35 - 38.52	9.53	6.35 - 11.74	3.37	1.73 - 4.68	0.14	0.11 - 0.13
2019	0.67	33.74	28.18 - 52.18	11.13	7.79 - 14.72	3.96	3.00 - 4.43	0.13	0.10 - 0.18
2020	0.70	35.14	29.95 - 43.83	9.82	2.57 - 14.75	4.10	3.22 - 4.59	0.13	0.09 - 0.18

Source: Prepared by the Study Team based on interviews with AMDC.

d) Status of Major Facilities and Equipment

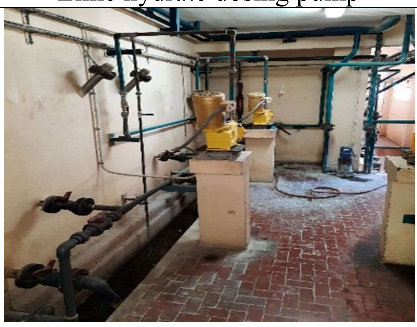
Table 3-3-23 and Figure 3-3-32 show the current status of the major facilities and equipment of this water treatment plant. Some equipment has been replaced; however, most of the equipment is the same one since the beginning of construction 28 years ago, requiring repair or replacement due to breakdown and aging. Above all, there is an urgent need to upgrade the chemical dosing equipment to ensure the treatment operation and the flow meters, etc. to monitor water volume.

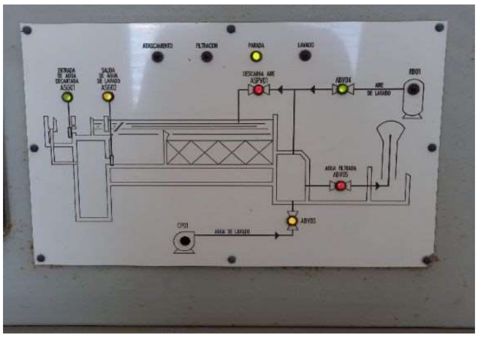
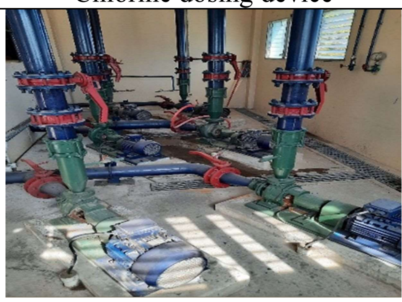
Table 3-3-23 Status of Main Systems and Equipment at La Concepción Water Treatment Plant

	Facility	Major Equipment	Year of Installation	Current Status, Failure/Repair History
1	Suspended solid contact type sedimentation tank	・Vacuum pump x 5	1992/2006	・1 unit is in process of adjustment
2	Aluminum sulfate dosing equipment	・Dissolving tank x2 ・Metering pump	1992 1992/2016	・Aging of mixer, replacement required. ・Already replaced, 1 unit, aging, replacement required.
3	Lime hydrate dosing equipment	・Dissolving tank x3 ・Dust collector x3 ・Metering pump	1992 1992 1992/2016	・Mixer: 1 unit is in operation, 2 units are out of order, replacement is required. ・Already replaced, 1 unit, aging, replacement required.
4	Polymer dosing equipment	・Dissolving tank x2 ・Metering pump x2	1992 2017	・Aging of mixer ・Already replaced.

	Facility	Major Equipment	Year of Installation	Current Status, Failure/Repair History
5	Activated carbon dosing equipment	・Dissolving tank x2 ・Metering pump x2	1992 1992	Used for odor removal only when raw water from the Laureles system flows in. ・One mixer is out of order, replacement required.
6	Sand filtration	・Air washing blower x2 ・Air compressor x2 ・Backwash pump x2 ・Pneumatically actuated valve x24	1992 2017 1992 1992/2006	・Already replaced. ・Aging, replacement required. ・Partly inoperative, repair required.
7	Chlorination equipment	・Chlorine injector x4	1992	・Two units are out of order, replacement required, gas leaks occurring.
8	Lime hydrate saturation tank	・Mixer x1	1992	
9	Water pump for miscellaneous use	・Chemical dosing water pump x2 ・Chlorination water pump x2 ・Saturated water pump x2	1992 1992 1992	
10	Booster pump	・Raw water pump x4	2017	To transfer a portion of treated water to the Laureles Water Treatment Plant.
11	Power receiving system	・Transformer 500 kVA x1	1992	
12	Emergency power generation system	・Generator 295 kVA x1	1992	Lack of capacity
13	Monitoring and control equipment	・Central monitoring panel x1 set ・Chemical dosing equipment control panel x1 set. ・Sand filtration tank control panel x8	1992 1992 1992/2006	Aging
14	Water quality laboratory	Turbidity meter, color meter, residual chlorine meter, electrical conductivity meter, jar tester, etc.		Partial failure, calibration and repair required.

Source: Prepared by the Study Team based on interviews with AMDC.

	
Sedimentation tank vacuum pump	Aluminum sulfate dilution tank
	
Aluminum sulfate metering pump	Lime hydrate dilution tank
	
Lime hydrate dosing pump	Polymer dissolution tank
	
Polymer metering pump	Activated carbon dissolution tank (for permanganate)

	
Activated carbon dosing pump	Sand filtration tank diagram
	
Air wash blower	Filtration tank valve room
	
Backwash pump	Chlorine dosing device
	
Lime hydrate saturation tank mixer	Water pump for miscellaneous use

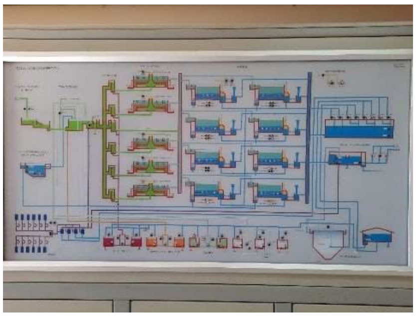
	
Booster pump	Transformer
	
Electric generator for emergencies	Central monitoring room panel
	
Chemical dosing equipment control panel	Sand Filtration Tank Control Panel
	
Water quality laboratory	Turbidity meter

Figure 3-3-32Status of Major Facilities and Equipment at Concepcion Water Treatment Plant

(4) Problems at La Concepción Water Treatment Plant and Central Bank Improvement Plan

a) La Concepción Water Treatment Plant Problems

Table 3-3-24 shows the problems and possible countermeasures at this water treatment plant identified from the results of the field survey and interviews with maintenance staff. Many of the issues are associated with the aging and failure of the water pipes and facilities.

Table 3-3-24 Problems at Concepcion Water Treatment Plant

Issue	Current Problems	Possible Measures	Remarks
1.Water source and water quality	a. In the season of abundant water, the facility operates at its maximum capacity and sometimes the water overflows, but in the low water season, it operates at approximately 50% of its capacity. b. In the current situation, it can generally purify the water while maintaining values below the drinking water standard, but contamination, algae blooms and eutrophication are observed in the water source. The cost of chemicals is about ten times higher than the Picacho plant with good water quality.	a. Divert water to other facilities in the season of abundant water, increase storage tank capacity in the season of low water, convey water from other water sources, etc. b. Measure to improve water pollution at water sources. It is effective to install a roof on the facility as well as Laureles WTP as a measure to prevent algae.	
2. Facility scale	a. In the season of abundant water, the facility operates at maximum capacity.	a. Consider the need for expansion in the master plan.	
3. Treatment function	a. In the current treatment process, treatment is given to keep the values below the drinking water standard, but it is reaching the treatment limit and the cost of chemicals is high.	a. Improve raw water quality and review the need for pretreatment.	
4. Facilities and equipment	a. Many pieces of equipment have been in operation since the beginning of construction (1996), aging/many breakdowns. b. Part of the chemical dosing system is replaced, but there are many breakdowns, no standby, lack of function. c. There are failures in the vacuum generator device No.5 of the sedimentation tank, device No.4 is used. d. Damage and blockages in the nozzle of the sand filtration tank drain collection device, many valve failures, filter sand has not been replaced. e. Lack of capacity of the main generator (295 kVA) for a 500 kVA transformer, unable to operate some equipment.	a. Repair or replacement is required after detailed study, also considering improving performance. b. Improvement of facilities, such as renewal and repair, after considering appropriate and efficient treatment operation c. Repair and renewal after checking the function d. Replace all nozzles, replace valves and filterer sand.	

	f. Chlorine injection facilities are outdated and inadequate for metering and safety measures. g. Obsolete and faulty flow meter makes it difficult to measure water volume. h. Failure in operation and handling due to failure of obsolete control panel. i. Some water quality test equipment is out of order, repair is required.	e. Check the capacity, then replace for higher capacity or install a new one. f. Replacing and upgrading by adding more measuring and safety equipment. g. Improvement of the instrumentation system for flow rates and water levels. h. Construction of systems considering the adequacy of operation, handling, and efficiency. i. Replacement and repair	
5. Operation and maintenance system, etc.	・ There are no particular problems with the current system for facility operation, but equipment maintenance and repair is not being carried out systematically, and there may be problems in responding to breakdowns and emergencies. ・O&M manual with insufficient content.	・It is required to perform asset management and establish a preventive maintenance program for systems and equipment. ・Development of an adequate O&M manual.	

b) World Bank Improvement Plan

The World Bank's "Project for the Strengthening of the Drinking Water Service in Tegucigalpa" (2019) also proposes the improvement plan for the water treatment plants. Of these, Table 3-3-25 shows the specific items related to La Concepción Water Treatment Plant. It should be noted that the implementation of this plan is behind schedule.

Table 3-3-25 Improvement Plan for La Concepción Water Treatment Plant Proposed by the World Bank

NO	Item	Details
1	Upgrading of chemical dosing equipment	Many equipment failures and this hinders water purification. Necessary repairs and improvements are made to improve reliability.
2	Chlorination equipment upgrade	Equipment failures and lack of safety. Equipment should be upgraded by replacing equipment, installing the chlorine neutralizing device, chlorine tank scale, etc.
3	Reverse delivery of raw water from the Concepcion WTP to the Laureles WTP	A water diversion facility was built from Laureles to Concepción, but the cost of pumping is high and there are few situations when water can be diverted at Laureles. On the other hand, at Concepción reservoir, water overflows due to the lack of capacity of the water treatment plant. If the reverse delivery of raw water can be accomplished using the existing pipeline, the raw water could be effectively utilized.
4	Installation of a cover on the sedimentation tank	Although pre-chlorination is performed at this water treatment plant as a measure against algae, to alleviate this process, a cover

NO	Item	Details
		could be installed on the sedimentation tank. Install a light roof or solar panel.
5	Replacement of nozzles in the lower water collection system of the filtration basin	Poor performance due to clogging or damage. Renewal of all units. Re-filling of filter sand.
6	Sludge management and reuse of backwash wastewater	Proper sludge management and reuse of overflow water for treatment process
7	Effective measurement of water production volume	Improvement of flow metering system and linkage with network SCADA system for water supply optimization.
8	Office equipment	Provision of equipment and software for proper information management, monitoring and surveillance of the process and improved communications.
9	Water quality testing equipment	Revision of procedures and standards in the transfer of the water quality management function, installation of new laboratory equipment to monitor treatment processes and purified water quality.

Source: World Bank data

(5) Concepcion Micro Hydroelectric Plant

The Concepcion Micro Hydropower Plant is installed upstream of the aerator, about 6.3 km downstream from the Concepcion reservoir, and is planned to generate electricity using the unused fall in this section.

As of August 23, 2021, the flow rate is 1300 L/s and the water level of Concepcion reservoir is 1141.51 m. The power generation range of this generator is from 600 to 1500 L/s flow rate, and the flow rate meets the power generation requirements. However, the water level of the reservoir must be above 1152m to generate electricity. At the time of the survey, power generation was not possible because the water level of the dam did not meet the requirements, but it is expected to be possible when the water level rises. In addition, the operation of the plant has not been possible because the operation manager has been absent since 2020 due to personnel reduction following the transfer of UMPAS from SANAA. It is necessary to assign personnel in the future. The condition of the power generation facilities is good.

	
Micro hydroelectric plant	Control panel

3-3-2-1-4 Laureles Water Treatment Plant

(1) Outline

The Laureles Water Treatment Plant is located approximately 800 m downstream of the Los Laureles Dam. The design capacity at the beginning of construction (1976) was 670 L/s, later in 2000, it was increased to 720 L/s when the dam was enlarged with IDB support. In addition, in 2007, the unit-type water purification facilities were built with the support of Spain (25 L/s x four units) to respond to the volume of water in the rainy season, and currently the total design capacity is 820 L/s. Subsequently in 2012, with support from Spain, the unit-type ultra-high speed coagulating sedimentation system (75 L/s x 1 unit) was installed. The operation of these integrated type devices has been suspended since 2013 for the former and 2017 for the latter due to various failures. In 2017, a pumping station was built for the transmission of raw water to the Concepcion Water Treatment Plant.

The purification process is the same as that of the Concepción Water Treatment Plant, consisting of aerator + mixing tank + suspended solid contact type sedimentation tank + gravity-type rapid sand filtration tank + chlorination. Initially, both the sedimentation tank and the sand filtration tank were open, but a roof was installed to prevent algae proliferation. Figure 3-3-33 shows the flow diagram of the water treatment plant, Figure 3-3-34 shows the general plan, Figure 3-3-35 shows the hydraulic profile, Table 3-3-26 shows the specifications of the main facilities, and Figure 3-3-36 shows the current status of the facilities.

The purification process in the unit-type purification plant consists of coagulation and sedimentation + pressure type filtration system + chlorination.

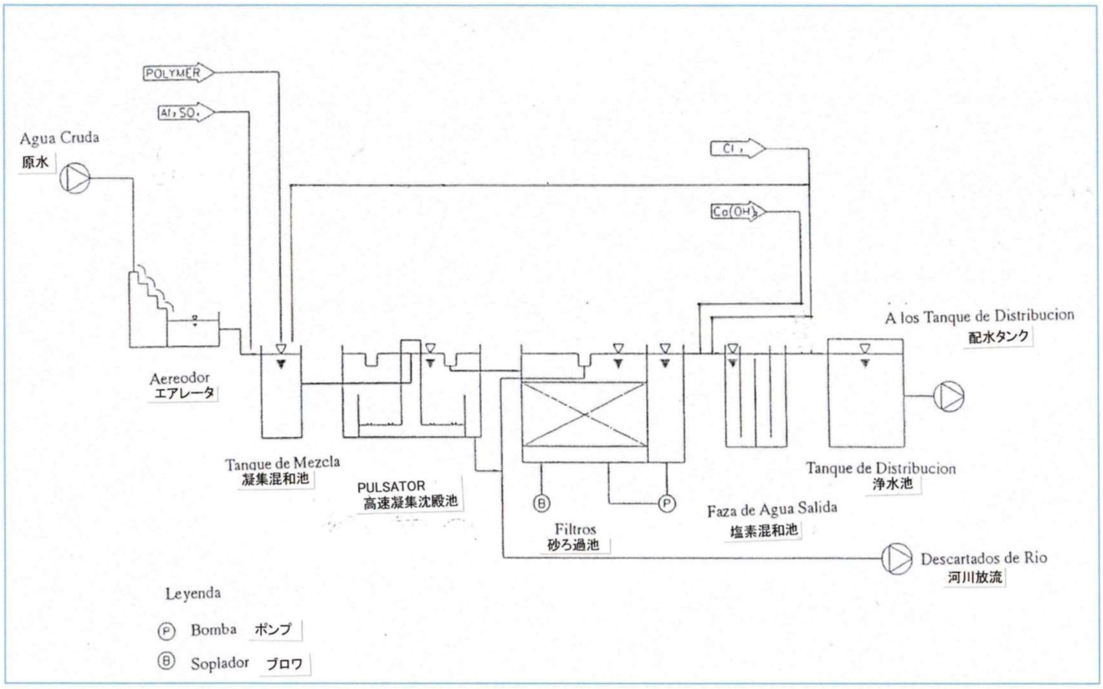


Figure 3-3-33Laureles Water Treatment Plant Flow Diagram

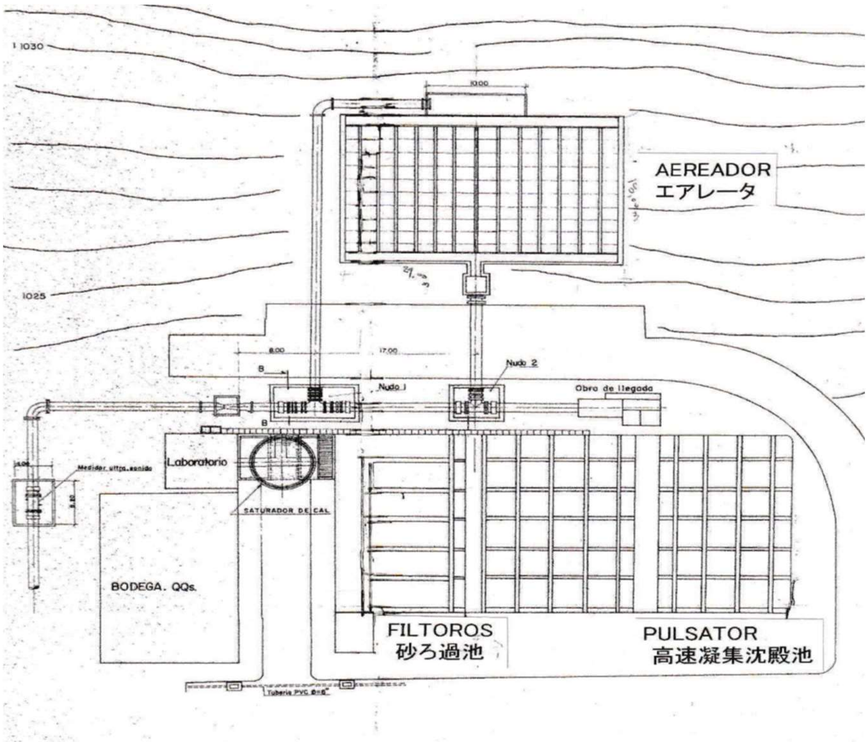


Figure 3-3-34General Plan of Laureles Water Treatment Plant

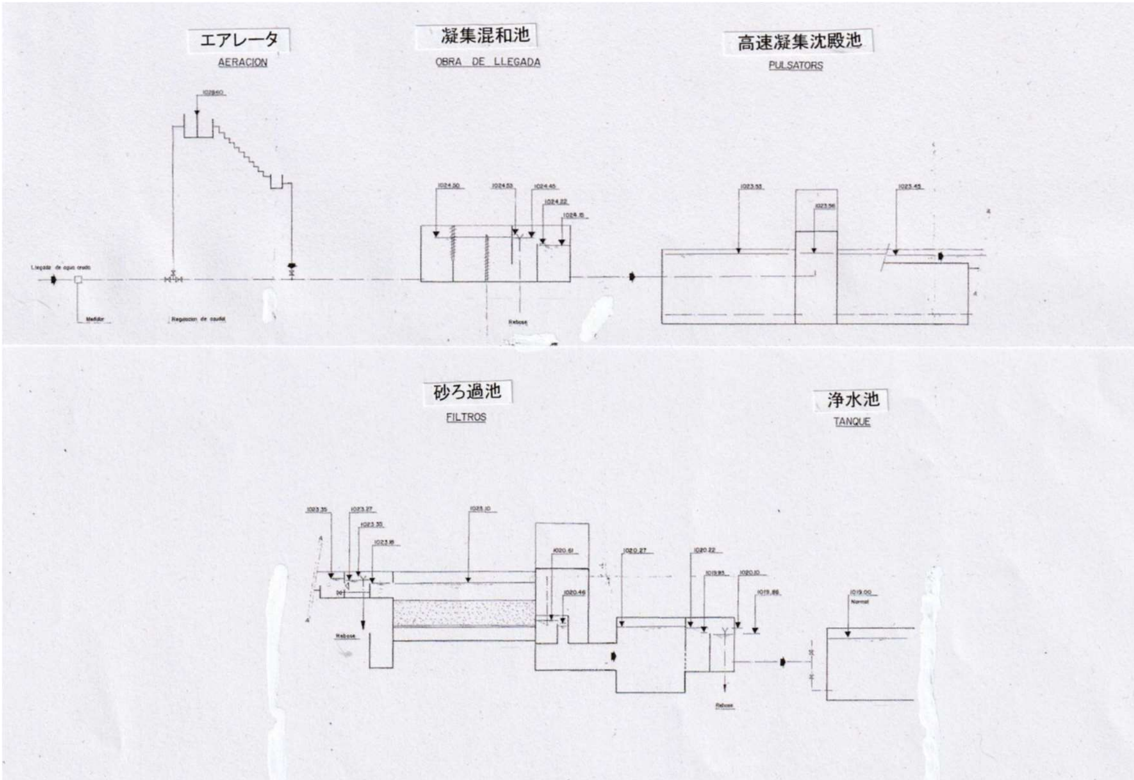


Figure 3-3-35Hydraulic Profile of Laureles Water Treatment Plant

Table 3-3-26 Specifications of Main Facilities of Laureles Water Treatment Plant

No.	Facility	Specifications	Main Equipment	Remarks
	Production volume	・Main system: 720 L/s (62,208 m ^{3}/day) ・Unit-type purification system: 100 L/s		
1	Aerator	・Rectangular cascade tank made of reinforced concrete (RC). 1 tank		
2	Suspended solid contact type sedimentation tank	・Suspended solid contact type sedimentation with inclined plate, made of RC (pulsation type) ・Width 17.0 m x Length 24.7 m x Depth 4.12 m x 2 tanks ・Surface load: 50 mm/min. ・Detention time: 1.3 hours	・Aluminum sulfate dosing equipment: 1 set ・Lime hydrate dosing equipment: 1 set. ・Polymer dosing equipment: 1 set ・Activated carbon dosing kit: 1 set	・Pulsator type.
3	Sand filtration tank	・ Gravity type sand filtration tank with air washing, made of RC ・6 tanks ・Filtration area: 31.5 m ^{2}/tank.	・Air washing blower x 2 units.	・Aquazur type

No.	Facility	Specifications	Main Equipment	Remarks
		Filtration rate (when operating all tanks): 260 m/day, maximum 329 m/day.		
4	Chlorine mixing tank	・Made of RC: 1 tank.	・Liquid chlorine dosing set: 1 set	
5	Power receiving system		・Transformer: 13.8 kV x 100 kVA x 3 units.	
6	Emergency power generation system		・150 kVA x 1 unit	
7	Monitoring and control equipment		・SCADA system	
8	Water quality laboratory		・Turbidity, residual chlorine, jar test, etc.	
9	Unit-type purification systems	・Steel plate unit ・Filtration system : 25 L/s x 4 units.	Chemical dosing + coagulation and sedimentation + pressure filtration + chlorination	Suspended operation in 2013
10	Unit-type ultra-high speed coagulating sedimentation system	・Steel plat unit ・Capacity :75 L/s	Chemical dosing + rapid agitation tank + flocculation tank + sedimentation tank	・Actiflo type Suspended operation in 2016
11	Raw water pumping station		Vertical pump 440 L/s x 110 m x 180 kW x 3 units (1 unit as standby)	Operation from February to October
12	Transmission pumping station		Vertical pump 225 L/s x 100 m x 300 kW x 3 units (1unit as standby)	Transmission of raw water to the Concepción Water Treatment Plant.

Source: Prepared by the Study Team based on interviews with AMDC.

	
Aerial view of the water treatment plant (2018, before installing the roof).	Aerator

	
Sedimentation tank	Sand filtration tank
	
Water treatment building	Liquid chlorine storage room
	
Unit-type purification systems (pressure filtration device)	Unit-type ultra-high speed coagulating sedimentation system
	
Raw water pumping station	Transmission pumping station (delivery to the Concepción WTP)

Figure 3-3-36Current Status of Laureles Water Treatment Plant

(2) Operation and Maintenance System

Currently, the Laureles Water Treatment Plant is operated and maintained by the Laureles subsystem of the AMDC Water Management Unit, and this subsystem is also responsible for the operation and maintenance of the Laureles Dam water source facilities. The Laureles subsystem has 17 maintenance operation personnel, and Table 3-3-27 shows their duties. The water quality control personnel listed in the Table belong to the AMDC Central Water Quality Laboratory and is stationed at the Laureles Water Treatment Plant. In addition, the Limnological Study Section was established in 2019 and conducts research on the biological, chemical, and physical conditions of the reservoir.

Table 3-3-27 Operation and Maintenance System for Laureles subsystem

	Staff Responsibilities	Remarks
1	Subsystem administrator	
2	Subsystem assistant	
3	Limnological study	
4	Secretary	
5	Procurement warehouse keeper	
6	Facility cleaning	
7	Water Treatment Plant operator	
8	Mechanical and electrical team	
9	Water source facilities inspection and management	
10	Driver	
11	Facilities inspection and management	
12	Field worker	
	Water quality test	

Source: Prepared by the Study Team based on interviews with AMDC.

The water treatment plant is operated in two shifts, from 8:00 a.m. to 4:00 p.m. and from 4:00 p.m. to 8:00 a.m. of the following day. Water treatment plant operators inspect the main mechanical and electrical equipment once a week. Repairs to faulty equipment are carried out by the responsible section at AMDC headquarter. The staff reports daily data on water levels and volume from the water source to SANAA central, as well as the volume, water quality, water levels, etc. of the water treatment plant in digital format via online. There is no communication system such as SCADA between AMDC and the water treatment plants. The personnel perform operation and maintenance work based on the AMDC operation and maintenance manual.

(3) Status of Operations

a) Water Volume

Table 3-3-2-28 shows the raw water volume and production volume (2016-2020) of the Laureles Water Treatment Plant and Figure 3-3-37 shows the monthly variations of the production volume. The water production volume varies each year, but in some months of the rainy season it is close to the design capacity and during rest of the months it is well below its capacity. In the months of minimum volume, it drops between 40 - 50 % of its capacity. At the time of the field survey (August 24, 2021), the incoming volume was 497 L/s, a low volume compared to other years for August.

Table 3-3-28 Raw Water Volume and Production Volume of Laureles Water Treatment Plant (2016-2020) (Unit: L/s)

Fiscal Year	Average Annual Volume of Raw Water	Average Annual Production Volume	Production Volume/ Raw Water (%)	Average Annual Production Volume per Season		Minimum Volume of Production
				Rainy Season (May - October)	Dry Season (November - April)	
2016	612	595	97.2	595	595	507 (April)
2017	569	547	96.1	556	537	365 (May)
2018	510	491	96.3	424	556	384 (February)
2019	462	440	95.2	462	419	272 (May)
2020	564	553	98.0	622	483	386 (April)

Source: Prepared by the Study Team based on AMDC statistical data.

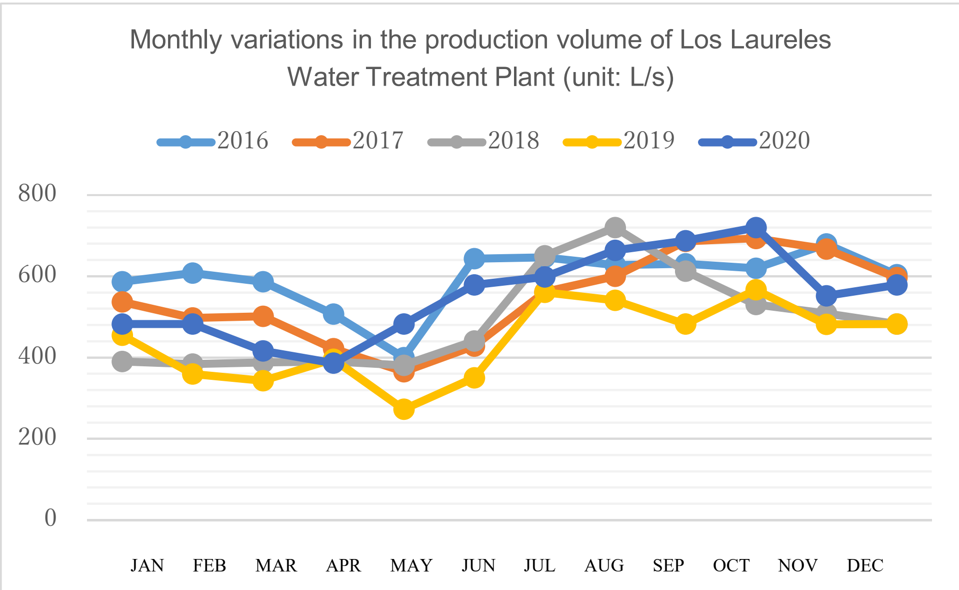


Figure 3-3-37Monthly Variations in Production Volume of Laureles Water Treatment Plant (2016-2020).

b) Water Quality

Water quality testing is performed in the in-plant water quality laboratory and in the central water quality laboratory located on site. In the in-plant water quality laboratory, operating parameters such as turbidity, color, pH, electrical conductivity, alkalinity, and hardness are analyzed three times a day. In the central laboratory, samples are sent once a week from the water treatment plant, analyzed for iron, manganese, bacteriological and cross-checked for other items in the in-plant laboratory parameters.

Table 3-3-2-29, shows the main raw and purified water quality parameters (turbidity, color, pH, iron and manganese) obtained from 2016 to 2020 (monthly average values).

The water source for this water treatment plant is the Laureles Dam. Throughout the year, the raw water has fairly high levels of both turbidity and color, and algae is observed. In the last five years, these values are generally maintained, and especially in the rainy season, the turbidity level rises between 100 - 130 NTU and the color, 200 - 350 TCU. Likewise, the values of the analysis of nutritive salts in the raw water in 2020 (monthly average) show the results of ammonium nitrogen of 0.19 - 1.77 mg/L (average: 0.86 mg/L), nitrate nitrogen of 0.01 - 0.08 mg/L (average: 0.04 mg/L) and phosphoric acid of 0.02 - 3.74 mg/L (average: 0.59 mg/L), indicating water quality contamination and eutrophication due to various wastewaters. On the other hand, the turbidity and color level of the purified water is lower than the permissible value for drinking water and the water is treated with coagulation, sedimentation and filtration. The pH adjustment is performed, though sometimes the value of the purified water is lower than the permitted value. Also the iron and manganese values are generally lower than the standard value.

Table 3-3-29 Water Quality at Laureles Water Treatment Plant
(Monthly Average Values, 2016-2020)

Water Quality Parameter			Turbidity	Color	pH	Iron	Manganese	Remarks
Unit			NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water			5	15	6.5 - 8.5	0.3	0.5	
2016	Raw water	Maximum	99.40	244.50	6.72 - 7.52	0.36	1.15	
		Average	50.61	166.31	7.11	0.21	0.68	
	Purified water		0.84 - 1.28	3.40 - 7.40	6.25 - 6.68	0.00	0.03-0.09	
2017	Raw water	Maximum	103.60	270.95	6.68 - 7.90	0.80	0.65	
		Average	56.51	166.21	7.15	0.33	0.42	
	Purified water		0.71 - 1.61	2.96 - 6.96	6.31 - 6.75	0.00-0.02	0.00-0.12	
2018	Raw water	Maximum	51.45	206.08	6.38 - 6.89	0.55	0.29	
		Average	34.31	124.78	6.70	0.25	0.11	
	Purified water		0.41 - 1.33	2.50 - 4.84	6.32 - 6.71	0.00-0.01	0.03-0.12	
2019	Raw water	Maximum	62.75	171.80	6.74 - 8.19	0.87	0.24	
		Average	34.08	117.99	7.37	0.33	0.09	
	Purified water		0.15 - 1.33	2.50 - 4.37	6.36 - 7.32	0.00-0.02	0.03-0.70	
2020	Raw water	Maximum	130.16	342.27	6.65 - 7.14	0.42	0.06	
		Average	61.40	195.57	6.90	0.24	0.04	

Water Quality Parameter		Turbidity	Color	pH	Iron	Manganese	Remarks
Unit		NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water		5	15	6.5 - 8.5	0.3	0.5	
	Purified water	0.79 - 2.43	2.60 - 7.44	5.25 - 6.77	0.00	0.00	
23 /Aug /2021	*Raw water*	*33.00*	*100*				*Reference*
	Purified water	*0.96*	*2.50*				*Reference*
Evaluation		Lower than allowed value	Lower than allowed value	Some are less than 6.5	Good	Generally good	

Source: Prepared by the Study Team based on data from AMDC's Water Quality Management Department.

c) Operation and Chemical Dosing

In this water treatment plant, the number of tanks used is adjusted according to the volume of raw water. It operates with two coagulation and sedimentation tanks in the rainy season and one tank in the dry season. The number of sand filtration tanks used is adjusted according to the volume of raw water. The unit-type purification and unit-type ultra-high speed coagulation and sedimentation facilities are not in use at this time due to equipment failures.

The sludge unloading work of the sedimentation tank is performed every two months. Backwashing is performed every 30 hours, the backwash operation consists of 4 minutes air flushing + 2 minutes air and water flushing + 10-13 minutes water flushing. The bubbles are not equal. Since the start of service, the filter sand has been replaced in 2000 and 2018. Wastewater and sludge are discharged directly to the nearby river.

Power is received on a single line, 13.8 kV, and distributed at 440V/220v. Power outages occur approximately 20 times/year. Planned work power outage is 2 to 3 hours/interruption, and in case of accidents, it is 30 minutes to 10 hours/interruption. There is an electric generator for emergencies with a capacity of 150 kVA; however, the capacity is insufficient.

Table 3-3-2-24 shows the energy consumption of the treatment process of this water treatment plant. The unit energy consumption is 0.014 kWh/m3 . It should be noted that the data from 2018 are not accounted for in this document since the consumption includes that of several pumping stations that are not related to the treatment process due to the change in electricity meter coverage.

Table 3-3-30 Energy Consumption of Los Laureles Water Treatment Plant (2016-2017)

Fiscal Year	Energy Consumption	Production Volume	Unit Energy Consumption
	kWhr/Year	m^3 /Year	kWh/m ^{3}
2016			
2017	243,269	17,239,590	0.014
Average			

Source: Prepared by the Study Team based on interviews with the AMDC.

The monitoring and control system of this water treatment plant is a SCADA system with one PLC (Programmable Logic Controller) and one operation station as the main devices, but the electric/pneumatic operated devices such as the high-speed coagulation sedimentation tank, the mud drain valve, and the sand filtration tank are operated manually on site due to malfunctions. The operator station has a monitoring function. At the operator station, the monitoring functions include graphical display of each process facility, equipment operation status, and flow rate. LCD touch panels as HMI (Human Machine Interface) function are also installed on the control panel of the power receiving and transforming facilities and the water quality instrument panel, and they have the same display function as the screen of the operator station.

The chemicals used are aluminum sulfate, lime hydrate and liquid chlorine. In addition, polymer is always used to improve the sedimentation effect when the turbidity level is high, and mainly during the rainy season, powdered activated carbon is used to eliminate odor. Pre-chlorination is used for algae control.

Table 3-3-31 shows the evolution of the cost of chemicals and the chemical dosage rate of this water treatment plant. The dosing rate is quite high for all chemicals due to the quality of the raw water with high turbidity and color. The chemical cost is 0.69 - 0.95 HNL/m^3, although it depends on the quality of the raw water. It is approximately 10 times higher than the Picacho Water Treatment Plant which has relatively good water quality and is similar to the Concepcion Water Treatment Plant with symptoms of water quality contamination.

Table 3-3-31 Evolution of Chemical Cost and Chemical Dosage Rate of Los Laureles Water Treatment Plant (2016-2020)

Item	Cost of Chemicals	Aluminum Sulfate		Lime Hydrate		Liquid Chlorine		Polymer		Activated Carbon	
Unit	HNL/m3	mg/L		mg/L		mg/L		mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average
2016	0.95	42.9	27.7-50.5	4.5	0.0 - 14.0	2.8	1.6 - 4.1	0.07	0.05-0.10	1.5	0.00-5.82
2017	0.85	46.1	37.9-52.8	7.1	0.6 - 13.2	2.5	1.8 - 3.5	0.08	0.06-0.10	0.6	0.00-4.07
2018	0.69	34.7	29.4-42.0	3.6	0.0 - 8.0	3.2	2.2 - 3.6	0.07	0.05-0.09	1.0	0.00-5.91
2019	0.69	34.7	29.4-42.0	3.6	0.0 - 8.0	3.2	2.2 - 3.6	0.07	0.05-0.09	1.0	0.00-5.91
2020	0.94	42.6	35.1-57.8	0.5	0.0 - 3.5	3.8	2.8 - 5.8	0.08	0.06-0.12	2.3	0.00-6.62

Source: Prepared by the Study Team based on interviews with AMDC.

d) Status of Major Facilities and Equipment

Table 3-3-32 and Figure 3-3-38 show the current status of the major facilities and equipment of this water treatment plant. Some equipment has been replaced; however, most of the equipment is the same one since the beginning of construction 40 ago, requiring repair or replacement due to breakdown and aging. Above all, there is an urgent need to upgrade the chemical dosing equipment to ensure the treatment operation and the flow meters, etc. to monitor water volume.

The suspension of operations of the unit-type system is due to the following reasons:

・Purification system: failure of the automatic operation equipment, failure of the pressure filtration device, difficulty in obtaining spare parts, etc.

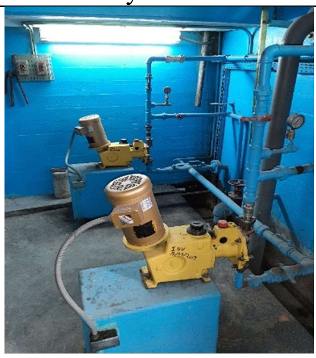
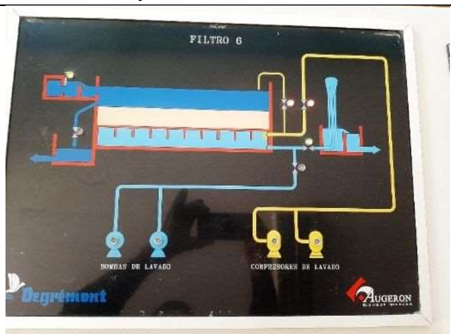
・Ultra-high speed coagulation and sedimentation system: failure of automatic operation equipment /SCADA system, difficulty in obtaining micro-sand and spare parts, etc.

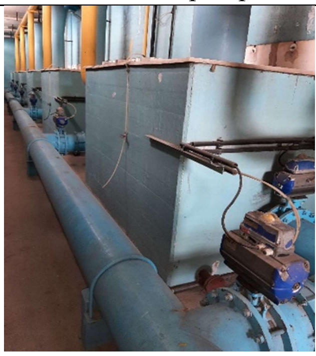
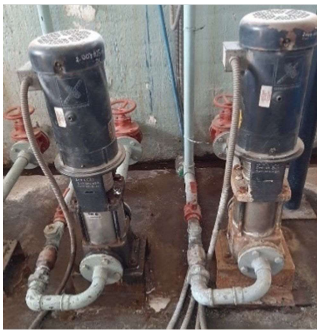
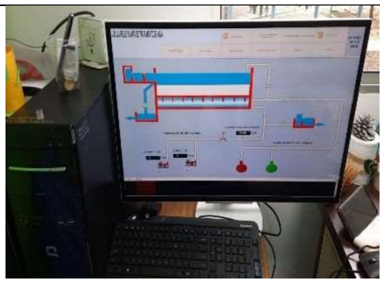
Table 3-3-32 Status of Major Facilities and Equipment at Laureles Water Treatment Plant

	System	Main Equipment	Year of Installation	Current Status, Failure/Repair History
1	Suspended solid contact type sedimentation tank	・Vacuum device x2	1976	・Aging, 1 unit failure, operated with only one unit.
2	Aluminum sulfate dosing equipment	・Feeder x2 ・Dissolving tank x2 ・Metering pump x2	1976 2012 2012	・Aging ・1 unit failure
3	Lime hydrate dosing equipment	・Dissolving tank x2 ・Feeder x2 ・Metering pump x5	1976 1976 2004	・Aging ・Aging
4	Polymer dosing equipment	・Dissolving tank x2 ・Feeder x2 ・Metering pump x2	1989 1989 2012	・Aging ・Aging

	System	Main Equipment	Year of Installation	Current Status, Failure/Repair History
5	Activated carbon dosing equipment	・Feeder x1 ・Dissolving tank x1 ・Metering pump x2	2011	
6	Sand filtration	・Air washing blower x2 ・Air compressor x2 ・Backwash pump x2 ・Pneumatic actuated valve x18	1998 2010 2016 1976	・Damage and obstructions in the nozzle of the drain collecting device. ・Aging ・Many damages due to pipe deterioration.
7	Chlorination equipment	・Chlorine injector x2	1976	・Aging, no measurement, neutralizing device suspended due to failure.
8	Lime hydrate saturation tank	・Mixer x1	2004	
9	Water pump for miscellaneous use	・Chemical dosing water pump x2 ・Chlorination water pump x4 ・Lime saturated water pump x2	2011 2011 2011	
10	Power receiving system	・Transformer 100 kVA x3	2018	Old transformer 300 kVA: It is used for unit-type system.
11	Emergency power generation system	・Generator 150 kVA x1		Lack of capacity
12	Monitoring and control equipment	・SCADA system x1 set ・Chemical dosing equipment control panel x1 set. ・Sand filtration tank control panel x8	2011	
13	Water quality laboratory	Turbidity meter, color meter, residual chlorine meter, electrical conductivity meter, jar tester, etc.		Some broken, calibration and repair required.
14	Raw water pump	・Vertical pump x 3 units.	2000	Only one pump is operated in case of power outages due to lack of generator capacity.
15	Transmission pump	・Vertical pump x 3units.	2017	None electric generator, so it cannot be operated in case of power outages.

Source: Prepared by the Study Team based on interviews with AMDC.

	
Suspended solid contact type sedimentation tank vacuum device	Dissolving tank/aluminum sulfate dosing pump
	
Lime hydrate feeder	Lime hydrate saturation tank
	
Dissolving tank/polymer dosing pump	Polymer Feeder/Mixer
	
Activated carbon dosing equipment	Sand filtration flow chart

	
Backwash pump	Air wash pump
	
Pneumatically actuated sand filtration valve	Chlorine dosing device
	
Water pump for chemical dosing	Transformer
	
Emergency power generator	SCADA System 1

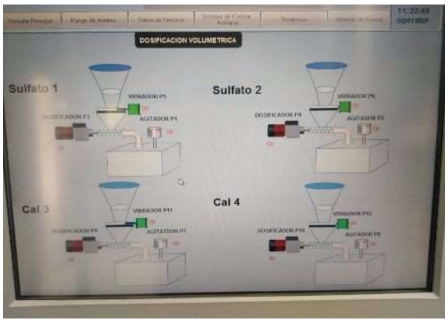
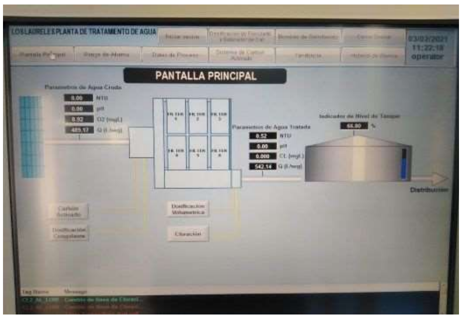
	
SCADA System -2	SCADA System -3
	
Water quality laboratory-1	Water quality laboratory-2
	
Water quality laboratory-3	Coagulation and sedimentation tank of the unit-type purification system (suspended)
	
Chemical tank of the unit-type purification system (suspended)	Unit-type ultra-high speed coagulation and sedimentation system (suspended)

Figure 3-3-38Status of Major Facilities and Equipment at Laureles Water Treatment Plant

(4) Problems at Los Laureles Water Treatment Plant and World Bank Improvement Plan

a) Laureles Water Treatment Plant Problems

Table 3-3-33 shows the problems and possible measures for this water treatment plant identified from the results of the field survey and interviews with management staff. Many of the issues are associated with the aging and failure of the facilities.

Table 3-3-33 Los Laureles Water Treatment Plant Problems

Issue	Current Problems	Possible Measures	Remarks
1.Water source and water quality	a. In some months of the rainy season, almost the design capacity, and in the dry season, approximately 40 - 50 % of its capacity. b. In the current situation, it can generally purify the water while maintaining values below the standard value for drinking water, but the cost of chemicals is about ten times higher than the Picacho plant with good water quality. c. Deterioration of water quality due to eutrophication caused by the inflow of agricultural and industrial wastewater and sewage. This is due to non-functioning or improperly managed sewage facilities in surrounding towns and military installations. Increased sediment in the reservoir due to deforestation. 40% of the forests have been lost to agriculture and cattle ranching.	a. Increase in reservoir capacity during low water season, water supply from other water sources, etc. b. Measures to improve water pollution at water sources c. Proper application of the General Environmental Law to regulate the treatment of wastewater from various facilities and the application of legal devices related to water, management of deforestation, establishment of a limnological monitoring system at the reservoir inflow (it is necessary to support with equipment, etc.). Improvement of sewerage system in the Guacerique river basin where it discharges, install equipment to improve water quality in the reservoir.	c. From 2020 the limnological study is carried out.
2.Facilitiy scale	a. In the rainy season, the facilities operate at their maximum capacity.	a. Consider the need for expansion in the master plan.	
3. Treatment function	a. In the current treatment process, treatment is given to keep the values below the drinking water benchmark, but it is reaching the treatment limit and the cost of chemicals is high.	a. Review the need to improve raw water quality and review the need for pretreatment such as coarse filtration and DAF (dissolved air flotation), modification of the filter media from single layer to multilayer, etc.	
4. Facilities and equipment	a. Many pieces of equipment have been in operation for more than 30 years, aging/many breakdowns.	a. After detailed study, repair or replacement is required, considering also to improve the performance.	

Issue	Current Problems	Possible Measures	Remarks
	b. Some of the chemical dosing equipment is replaced, but there are many breakdowns, no standby, lack of function c. There are failures in the sedimentation tank vacuum generating device, one unit is used for all. d. Damage and blockages in the nozzle of the sand filtration tank drain collection device, many valve failures, filter sand has not been replaced. e. Deficient measurement and safety measures due to chlorination equipment aging. f. Aging and failure of the flow meter makes it difficult to measure water volume. g. Some water quality test equipment is faulty, repair required. h. Deterioration of structures	b. Review how to achieve a more adequate and efficient treatment operation, then upgrade and replace equipment. c. Check the function, then repair or replace d. Replacement of nozzles, valves, replace single-layer filter media (sand) to multi-layer filter media (sand + anthracite). e. Replacing and upgrading by adding more measuring and safety equipment. f. Upgrading of instrumentation equipment such as flow meters and level meters. g. Replacement and repair h. Implementation of the renovation diagnosis	
5. Operation and maintenance system, etc.	a. Lack of mechanical and electrical staff b. Equipment maintenance and repair is not systematically carried out, resulting in malfunctions and emergency response problems. c. O&M Manual with insufficient content	a. Staffing review b. It is required to perform asset management and establish a preventive maintenance program for systems and equipment. c. Development of an adequate O&M manual	

b) World Bank Improvement Plan

The World Bank's "Tegucigalpa Water Supply Strengthening Project" (2019) also proposes the improvement plan for the water treatment plants. Of these, Table 3-3-34 shows the specific items related to the Laureles Water Treatment Plant. The implementation of this plan is behind schedule.

Table 3-3-34 Improvement Plan for Los Laureles Water Treatment Plant Proposed by the World Bank

	Item	Details
1	Chlorination equipment upgrade	Equipment failures and lack of safety. Equipment should be upgraded by replacing equipment, installing the chlorine neutralizing device, chlorine tank scale, etc.
2	Installation of dynamic filter (coarse filtration facility)	A coarse filtration facility is added to remove algae from the inflow. This makes it possible to reduce the amount of pre-chlorine injected, which is the current countermeasure against algae.
3	Change from single-layer filter media (sand) to multi-layer filter media (sand + anthracite)	Change from single-layer filter media (sand) to multilayer filter media (sand + anthracite) to improve the suspended particle removal effect and eliminate odor of purified water derived from organic matter.
4	Replacement of nozzles in the lower water collection system of the filtration tank	Performance degradation due to clogging or damage, renewal of about 30%.
5	Sludge management and reuse of backwash wastewater	Proper sludge management and reuse of overflow water for treatment process
6	Improved operations and energy efficiency	To improve system efficiency, condenser is installed to reduce the load, the pump and blower motor is replaced with high-efficiency motor, and reviewed filtration tank washing operation and chemical dosing operation.
7	Effective measurement of water production volume	Improvement of flow metering system and linkage with network SCADA system for water supply optimization.
8	Office equipment	Provision of equipment and software for proper information management, monitoring and surveillance of the process and improved communication.
9	Water quality testing equipment	Review of procedures and standards associated with the transfer of the water quality management function, and installation of new laboratory equipment to monitor the treatment processes and purified water quality.

Source: World Bank data

3-3-2-1-5 Miraflores Water Treatment Plant

(1) Outline

The Miraflores Water Treatment Plant treats water from the weir installed on the Sabacuante River, which is one of the water sources of the Picacho subsystem. At the beginning of the construction in 1996, the design capacity was 25 L/s, but in 2002, with the support of Spain, the unit-type purification facilities were built, same as the facility in the Laureles Water Treatment Plant, and currently the capacity increased to 75 L/s. The purification process of the unit-type purification facility consists of coagulation and sedimentation + pressure filtration + chlorination.

In addition, it is under consideration whether to dispose of this water treatment plant after the completion (2023) of the Jacaleapa (San Jose) project (including the construction of a new water treatment plant), which is currently under construction, or to continue it as a backup.

Table 3-3-35 shows the specifications of the major facilities of the water treatment plant and Figure 3-3-39 shows the current status of the facilities.

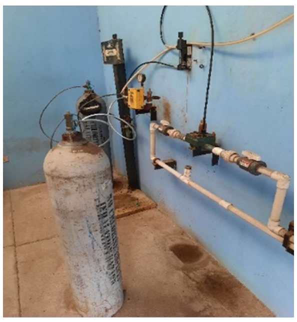
Table 3-3-35 Specifications of Main Facilities of Miraflores Water Treatment Plant

No.	Facility	Specifications	Main Equipment	Remarks
	Production volume	・Unit-type purification plant: 75 L/s (6,480 m^{3}/day)		2002
1	Coagulation and mixing tank	・Rectangular tank, made of steel plate. ・Width 1.6 m x Length 8.4 m x Depth 1.6 m x 2 tanks	・Aluminum sulfate dosing equipment: dissolving tank, dosing pump.	Aluminum sulfate dosing equipment: installed in 1996, aging, also mixer aging and faulty.
2	Sedimentation tank	・Rectangular sedimentation tank with inclined plate, made of steel plate. ・Width 0.62 m x Length 8.4 m x Depth 2.45 m x 1 tank		Sludge discharge valve failure
3	Sand filtration	・Pressure sand filtration, made of steel plate ・3 units/1 series x 3 series	・Air washing blower x 2units. ・Backwash pump x2 units.	Blower and pump aging, refilling of filter sand required.
4	Chlorination equipment		・Liquid chlorine dosing equipment: liquid chlorine tank. 50 kg, injector x 1 set	Aging
5	Electricity receiving system		・Transformer: 13.8kV x 100kVA x 1 unit and 75kVA x 1 unit	Installed in 1996
6	Monitoring and control equipment		・Control panel	No SCADA System
7	Water quality laboratory		・Turbidity, residual chlorine, jar test, etc.	

Source: Prepared by the Study Team based on interviews with AMDC.

1. Coagulation and mixing tank

2. Sedimentation tank



3. Pressure filtration	4. Chlorination equipment
	
5. Aluminum sulfate dosing equipment	6. Control Panel
	
7. Transformer	8. Water quality testing laboratory

Figure 3-3-39Current Status of Miraflores Water Treatment Plant

(6) Operation and Maintenance System

Currently, the operation and maintenance of the Miraflores Water Treatment Plant is carried out by the Picacho subsystem of the AMDC Water Management Unit, and there are 3 operators in charge at this water treatment plant. Water quality tests are carried out by the resident staff at the Picacho water treatment plant.

The water treatment plant is operated in two shifts, from 8:00 a.m. to 4:00 p.m. and from 4:00 p.m. to 8:00 a.m. the following day. Water treatment plant operators inspect the main mechanical and electrical equipment once a week. Repairs to faulty equipment are carried out by the responsible section at AMDC headquarters. The staff reports daily data on water levels and volume from the water source to the central SANAA, as well as the volume, water quality, water levels, etc. of the water treatment plant in digital format through the online medium. It should be noted that there is no communication system such as SCADA between AMDC and the water treatment plants. The personnel perform operation and maintenance work based on the AMDC operation and maintenance manual.

(7) Status of Operations

a) Water Volume

Table 3-3-36, shows the raw water volume and production volume (2016-2020) of the Miraflores Water Treatment Plant and Figure 3-3-40 shows the monthly variation of the production volume. The water production volume varies considerably each month and each year, where in some months, it is close to the design capacity of 75 L/s, but the rest of the year it is well below this capacity. Especially around April and October it drops to 20 - 30%. At the time of the field study (August 25, 2021), the incoming volume was 50 L/s.

Table 3-3-36 Raw Water Volume and Production Volume of Miraflores Drinking Water Treatment Plant (2016-2020)

(Unit: L/s)

Fiscal Year	Average Annual Volume of Raw Water	Average Annual Production Volume	Production Volume/ Raw Water (%)	Average Annual Production Volume per Season		Minimum Volume of Production
				Rainy Season (May - October)	Dry Season (November - April)	
2016	40.64	39.88	98.1	37.87	41.97	20.32 October)
2017	37.09	36.32	97.9	35.75	37.03	20.08 October)
2018	52.54	50.25	95.6	48.36	52.22	17.44 (April)
2019	42.16	40.32	95.6	30.93	49.71	18.83 (July)
2020	40.02	38.84	97.1	42.28	35.09	20.00(November)

Source: Prepared by the Study Team based on AMDC statistical data.

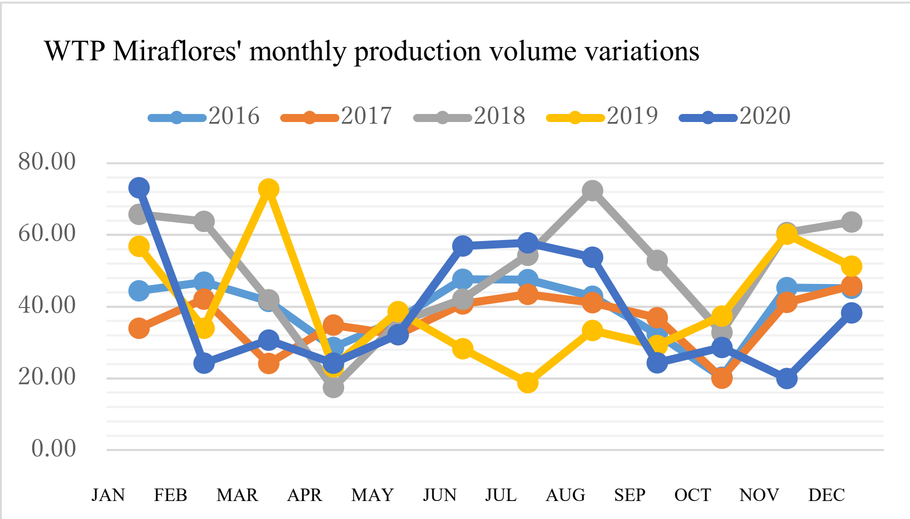


Figure 3-3-40Monthly Variations in Production Volume of Miraflores Water Treatment Plant (2016-2020).

b) Water Quality

Water quality testing is performed in the in-plant water quality laboratory and in the central water quality laboratory. In the in-plant water quality laboratory, only turbidity and residual chlorine levels of the filtered water are analyzed when the turbidity level in the raw water is low, and when the turbidity level is high in the rainy season, operating parameters such as turbidity, color, pH, electrical conductivity, alkalinity, and hardness are analyzed three times a day only. The central laboratory performs cross-tests of iron, manganese, bacteriological and plant laboratory parameters.

Table 3-3-37, shows the main raw and purified water quality parameters (turbidity, color, pH, iron and manganese) obtained from 2016 to 2020 (monthly average values).

The water source for this water treatment plant is river water, which has low levels of both turbidity and color in the dry season, but quite high levels in the rainy season. These values are generally maintained every year, and especially in the rainy season, the turbidity level rises between 60 - 80 NTU and color, 200 - 400 UC. The turbidity level of purified water is lower than the permitted value, but many times the color level exceeds the permitted value in the rainy season. Iron and manganese values are also below the permitted value.

Table 3-3-37 Water Quality of Miraflores Water Treatment Plant
(Monthly Average Values, 2016-2020)

Water Quality Parameter			Turbidity	Color	pH	Fe	Mn	Remarks
Unit			NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water			5	15	6.5 - 8.5	0.3	0.5	
2016	Raw water	Maximum	69.50	422.73	7.24 - 7.68	0.49	0.10	
		Average	19.38	115.59	7.48	0.10	0.10	
	Purified water		0.59 - 2.92	10.36 - 19.0	6.37 - 7.33	0.00 - 0.01	0.03	
2017	Raw water	Maximum	60.06	320.08	7.38 - 7.92	0.24	0.32	
		Average	20.40	120.30	7.60	0.04	0.17	
	Purified water		0.26 - 2.58	7.55 - 14.70	5.96 - 7.50	0.00 - 0.02	0.00 - 0.18	
2018	Raw water	Maximum	67.80	224.58	6.43 - 8.17	0.12	0.05	
		Average	11.22	51.59	7.51	0.03	0.02	
	Purified water		0.32 - 2.71	7.18 - 15.75	6.58 - 7.73	0.00 - 0.03	0.00	
2019	Raw water	Maximum	55.57	215.45	7.00 - 7.78	0.29	0.02	
		Average	10.41	45.32	7.57	0.03	0.02	
	Purified water		0.77 - 4.59	3.81 - 16.30	6.58 - 7.42	0.00 - 0.11	0.02 - 0.03	
2020	Raw water	Maximum	78.64	328.57	6.63 - 8.02	0.33	-	
		Average	23.41	91.89	7.34	0.13	-	
	Purified water		0.81 - 5.90	5.00 - 19.44	6.63 - 7.64	0.00	0.01	
Evaluation			Generally good	There are values above the permitted value.	Generally good	Good	Good	

Source: Prepared by the Study Team based on data from AMDC's Water Quality Management Department.

c) Operation and Chemical Dosing

This water treatment plant operates 24 hours a day. The sludge discharge work of the sedimentation tank is performed every six months. Backwashing of the filtration tank is performed every 26 hours, and the backwashing operation is 20 minutes (air flushing + water flushing). Replacement of the filter sand is performed about every five years. Wastewater and sludge are discharged directly into the nearby river.

Electricity is received on a 13.8kV circuit and distributed at 440V/220v. Outages occur approximately eight times/year. When scheduled power outages occur due to electrical work, the duration is 2 to 3 hours/interruption and if it is an interruption due to an accident, it lasts between 30 minutes and 10 hours/interruption. It does not have an electric generator for emergencies, and when the power is suspended, the plant stops.

The unit energy consumption is 0.04 - 0.05kWh/m^3 and this is 3 - 4 times higher than other water treatment plants such as Picacho. This is due to the scale disadvantage of being a small scale facility, the pump for pressure filtration, and other factors.

The monitoring and control system of this water treatment plant consists of a PLC (programmable logic controller) whose main function is the automatic control of the sand filtration plant. There is a monitoring function on the LCD (liquid crystal display) screen installed on the PLC control panel, however, the SCADA system has not been introduced.

The chemicals used are aluminum sulfate and liquid chlorine, and the polymer or calcium hydroxide dosing equipment used to enhance the sedimentation effect when turbidity is high is not installed. Sodium hypochlorite is also used as a backup to the liquid chlorine dosing equipment.

Table 3-3-38 shows the evolution of the cost of chemicals and the chemical dosage rate of this water treatment plant. The monthly variations of the aluminum sulfate dosing rate is large, in the dry season when the turbidity level of the raw water is lower than the permitted value (5.0 NTU) it is not dosed and in the rainy season when the turbidity level is high, it is dosed about 30 - 40 mg/L.

Table 3-3-38 Evolution of Chemical Cost and Chemical Dosage Rate of Miraflores Water Treatment Plant (2016-2020).

Item	Cost of Chemicals	Aluminum Sulfate		Calcium Hydroxide	
Unit	HNL/m^3	mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average
2016	0.50	21.94	1.4 - 41.4	1.61	1.2 - 2.0
2017	0.28	17.43	0.0 - 42.0	1.87	1.4 - 2.6

Item	Cost of Chemicals	Aluminum Sulfate		Calcium Hydroxide	
Unit	HNL/m ^{3}	mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average
2018	0.13	7.48	0.0 - 31.1	1.61	1.2 - 3.9
2019	0.12	3.96	0.0 - 30.86	1.67	0.6 - 2.8
2020	0.18	8.71	0.0 - 34.9	1.28	0.73 - 2.24

Source: Prepared by the Study Team based on interviews with AMDC.

d) Status of Major Facilities and Equipment

Most of the equipment at this water treatment plant is the same as that when it was constructed back in 1996 and 2002 with some 20 years, and very little equipment has been replaced. Many require replacement due to breakdown or aging, however, as mentioned above, this water treatment plant will probably be out of use once the San Jose project is completed, and so what is needed is minimal repair or replacement to continue operation until then. Above all, there is an urgent need to improve the chemical dosing equipment to ensure the treatment operation and the flow meters, etc. to confirm the volume of water.

(8) Problems at Miraflores Water Treatment Plant

Table 3-3-39 shows the problems and possible measures for this water treatment plant identified from the results of the field survey and interviews with management staff. Many of the issues are associated with the aging and failure of facilities and equipment, inappropriate equipment specifications, etc., but the proposed disposal of the equipment will also be considered.

Table 3-3-39 Miraflores Water Treatment Plant Problems

Issue	Current Problems	Actions that can be Taken	Remarks
1.Water source and water quality	a. In some months, it reaches almost design capacity and in other months it works at approximately 30 - 50 % of its capacity. b. Although it is a stream water from the Picacho watershed system, turbidity and color are considerably high during the rainy season	a. Increase reservoir capacity in low water season, drive water from other water sources, etc. b. Water pollution survey of water sources	
2.Facility scale	a. In most of the year, the facility operates without reaching its maximum capacity.	a. Review of the method of operation	
3. Treatment function	a. In the current treatment process, the turbidity level is	a. The chemical currently used for coagulation is	

Issue	Current Problems	Actions that can be Taken	Remarks
	lower than the standard value for drinking water, but the color level sometimes exceeds the permitted value.	solely aluminum sulfate, but the use of polymer and others will be reviewed.	
4. Facilities and equipment	a. Most of the equipment has been in operation for more than 20 years, and are aging or have many breakdowns. b. Some of the chemical dosing equipment is replaced, but there are many breakdowns, no standby, lack of function. c. There are many failures in the coagulation and mixing tank, sedimentation tank, valves, mixer, etc. d. Replaced filter sand in sand filtration tank was 4 years ago, many valve failures. e. Chlorine injection facilities are outdated and lack of metering and safety measures. f. Aging and failure of the flow meter makes it difficult to measure water volume. g. Some water quality test equipment is out of order, repair required.	a. After detailed study, repair or replacement is required considering also to improve the performance. b. Improvement of facilities, such as renewal and repair, after considering appropriate and efficient treatment operation c. Repair and renewal after checking the function d. Replace valves and filter sand. e. Replacing and upgrading by adding more measuring and safety equipment. f. Upgrading of instrumentation equipment such as flow meters and level meters. g. Replacement and repair	no
5. Operation and maintenance system, etc.	a. Equipment maintenance and repair is not systematically carried out, resulting in malfunctions and emergency response problems. b. O&M Manual with insufficient content	a. It is required to perform asset management and establish a preventive maintenance program for systems and equipment. b. Development of an adequate O&M manual	

3-3-2-1-6 Chimbo Water Treatment Plant

(1) Outline

The Chimbo Water Treatment Plant is treating water from the Jutiapa system, one of the water sources of the Picacho subsystem. Initially, there was only a chlorination facility, but in 2009 the unit-type purification facility was built with the support of Spain with a design capacity of 25 L/s. The purification process in the unite-type purification facility consists of coagulation and sedimentation + pressure filtration + chlorination. The current operating time is 8 hours during the day.

Table 3-3-40 shows the specifications of the main facilities and Figure 3-3-41 shows the current status of the facilities.

Table 3-3-40 Specifications of Main Facilities of El Chimbo Water Treatment Plant

No.	Installation	Specifications	Main Equipment	Remarks
	Production volume	・Unit-type purification system: 25 L/s (2,160 m^{3}/day)		2009
1	Coagulation and mixing tank	・Rectangular sedimentation made of steel sheet. ・Width 2.06 m x Length 6.63 m x Depth 1.95 m x 1 tank	・Aluminum sulfate dosing equipment: dissolving tank, dosing pump. ・Polymer dosing equipment. ・Calcium hydroxide dosing equipment.	
2	Sedimentation tank	・Rectangular settling tank in laminar regime made of steel sheet. ・Width 0.90 m x Length 6.63 m x Depth 1.95 m x 1 tank		
3	Sand filtration tank	・Pressure sand filtration system made of steel sheet ・2 units	・Air washing blower x 1 unit. ・Backwash pump x2 units.	Filter media: 1 unit that was to replace the filter media is suspended due to breakdowns
4	Chlorination equipment		・Liquid chlorine dosing equipment: 50 kg cylinder, dosing unit x2 units, dosing pump x2 units.	One metering unit and one pump damaged
5	Electricity receiving system		・Transformer: 13.8kV x 100kVA x2 units	The power generation equipment was moved to Picacho.
6	Monitoring and control equipment		・Control panel	SCADA System: None
7	Water quality laboratory equipment		・Turbidity, residual chlorine, etc.	Damaged

Source: Prepared by the Study Team based on interviews with AMDC.

	
1. View of Chimbo Water Treatment Plant	2. Coagulation and mixing tank and sedimentation tank

	
3. Pressure filtration (one unit suspended)	4. Chlorination equipment
	
5. Chemical dosing system	6. Water feeder pump
	
7. Control panel	8. Graphic panel

Figure 3-3-41Current Status of Chimbo Water Treatment Plant

(2) Operation and Maintenance System

Currently, the operation and maintenance of El Chimbo Water Treatment Plant is in charge by the Picacho subsystem of AMDC's Water Management Unit. There are currently 4 operators in charge of this water treatment plant. The manager who remains at the Picacho Water Treatment Plant performs water quality testing.

The water treatment plant is operated in a single shift, from 8:00 a.m. to 4:00 p.m., with no operator assigned during the night. Water treatment plant operators inspect the main mechanical and electrical equipment once a week. Repairs to faulty equipment are carried out by the responsible section at AMDC headquarters. The staff reports daily to AMDC the data on water levels and volume of water from the water source, as well as the volume, water quality, water levels, etc. of the water treatment plant in digital format through the online medium. It should be noted that it does not have a communication system such as SCADA between AMDC and the water treatment plants. The personnel perform operation and maintenance work based on the AMDC operation and maintenance manual.

(3) Status of Operations

a) Water Volume

Table 3-3-41 shows the raw water volume and production volume (2016-2020) of the Chimbo Water Treatment Plant and Figure 3-3-42 shows the monthly variations in production volume. Only the volume of water needed in the surrounding supply areas is treated. In this water treatment plant, only one sand filtration device unit operates and the current operating time is eight hours/day. The water production volume, daily volume equivalent, is approximately 40 - 60% of the design capacity of the sand filtration device (12.5 L/s per unit).

Table 3-3-41 Volume of Raw Water and Production Volume of Chimbo Water Treatment Plant (2018-2020)

(Unit: L/s)

Fiscal Year	Average Annual Volume of Raw Water	Average Annual Production Volume	Production Volume/ Raw Water (%)	Average Annual Production Volume per Season		Minimum Volume of Production
				Rainy Season (May - October)	Dry Season (November - April)	
2018	1.96	1.89	96.4	1.78	2.00	1.66 (August)
2019	2.39	2.33	97.5	2.32	2.36	2.29 (December)
2020	2.73	2.45	89.7	2.39	2.52	2.04 (February)

Source: Prepared by the Study Team based on AMDC statistical data.

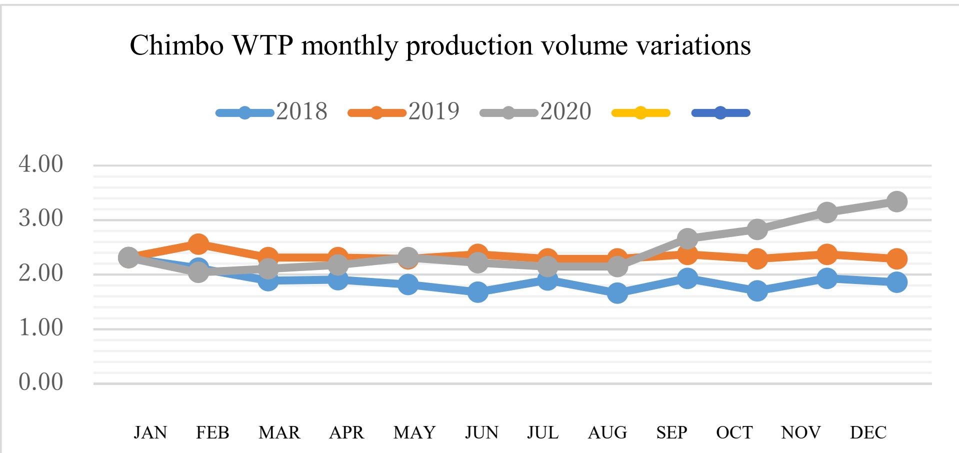


Figure 3-3-42Monthly Variations in Production Volume of Chimbo Water Treatment Plant (2018-2020).

b) Water Quality

Water quality testing is performed in the central water quality laboratory once a week. Operating parameters such as turbidity, color, pH, electrical conductivity, alkalinity, and hardness, as well as iron, manganese, bacteria, etc., are analyzed.

Table 3-3-42, shows the main raw and purified water quality parameters (turbidity, color, pH, iron and manganese) obtained during 2018 - 2020 (monthly average values).

The water source for this water treatment plant is the stream water from the Picacho system, and is characterized by high turbidity in the rainy season, and many times exceeds the turbidity level of 5 NTU which is the standard value for water quality. Throughout most of the year, the turbidity level is low and it is a good source of water. The color level exceeds 15 UC in the rainy season, but the water can be treated with coagulation, sedimentation and filtration. Iron and manganese are not observed, or are observed in small amounts.

Table 3-3-42 Water Quality of Chimbo Water Treatment Plant (Monthly Average Values, 2016-2020)

Water Quality Parameter		Turbidity	Color	pH	Iron	Manganese	Remarks
Unit		NTU	TCU	-	mg/L	mg/L	
Maximum Allowable Value of Honduras for Drinking Water		5	15	6.5 - 8.5	0.3	0.5	
2018	Raw water	0.71 - 7.27	2.50 - 20.62	6.41 - 7.79	0.00	0.00 - 0.03	
	Purified water	0.41 - 1.46	2.50 - 7.50	6.12 - 7.79	0.00	0.00 - 0.03	
2019	Raw water	0.48 - 5.73	2.50 - 15.0	6.66 - 8.01	0.00 - 0.07	0.00	
	Purified water	0.32 - 2.28	2.5 - 7.50	6.72 - 7.91	0.00 - 0.02	0.00	
2020	Raw water	0.50 - 7.55	2.50 - 40.00	6.25 - 7.45	0.00	-	
	Purified water	0.40 - 2.62	2.5 - 12.5	6.08 - 7.36	0.00	-	
Evaluation		Lower than allowed value	Lower than allowed value	Sometimes less than 6.5	Good	Good	

Source: Prepared by the Study Team based on data from AMDC's Water Quality Management Department.

c) Operation and Dosing of Chemicals

The current operating time of this water treatment plant is eight hours per day. Sludge discharge from the sedimentation tank is performed every six months. Backwashing of the filtration tank is done every 20 hours and replacement of the filter sand is done about every five years. Wastewater and sludge are discharged directly to the nearby river.

Electricity is received on a 13.8kV circuit and distributed at 440V/220v. Outages occur approximately 10 times/year. When scheduled power outages occur due to electrical work, the duration is 2 to 3 hours/interruption and if it is an interruption due to an accident, it lasts between 30 minutes and 10 hours/interruption. It does not have an electric generator for emergencies, and when the power is suspended, the plant stops. The unit energy consumption of this water treatment plant is quite large compared to other water treatment plants because it is an extremely small facility.

The monitoring and control system for this water treatment plant consists of a PLC (programmable logic controller) and is fully automatic. Currently the automatic control only works on the sand filtration facilities, and the chemical dosing equipment is operated manually. There is a monitoring function on the LCD (liquid crystal display) screen installed on the PLC control panel, however, SCADA has not been introduced.

The chemicals used are aluminum sulfate, lime hydrate and chlorine gas, and polymer dosing equipment is available to enhance the settling effect when the turbidity level is high, but is not used. Sodium hypochlorite is also available as a backup to liquid chlorine dosing equipment.

Table 3-3-43 shows the evolution of the cost of chemicals and the chemical dosage rate of this water treatment plant. The dosing rate is quite high for all chemicals compared to the Picacho Water Treatment Plant, despite the fact that the quality of the raw water is almost similar to that of Picacho, and appropriate dosing control is not being performed.

Table 3-3-43 Evolution of Cost of Chemicals and Chemical Dosage Rate of Chimbo Water Treatment Plant (2018-2020).

Item	Cost of Chemicals	Aluminum Sulfate		Calcium Hydroxide		Liquid Chlorine	
Unit	HNL/m ^{3}	mg/L		mg/L		mg/L	
		Annual Average	Monthly Average	Annual Average	Monthly Average	Annual Average	Monthly Average
2018	0.67	22.5	19.0 - 27.9	5.5	3.3 - 7.0	6.7	3.8 - 8.9
2019	0.57	18.9	18.8 - 20.0	3.5	3.3 - 3.9	4.2	4.1 - 4.6
2020	0.48	17.6	13.3 - 22.2	1.9	0.0 - 3.7	4.2	3.0 - 7.5

Source: Prepared by the Study Team based on interviews with SANAA.

d) Status of Major Facilities and Equipment

Some equipment at this water treatment plant has been suspended due to breakdowns, but has not been repaired. One of the two pressure filtration device units has been suspended since March 2021, awaiting replacement of the filter media. The chlorination equipment was installed in 2003 and is obsolete.

(4) Problems at Chimbo Drinking Water Treatment Plant

Table 3-3-44 shows the problems of this water treatment plant and the possible measures that were identified during the field survey and from the results of the interviews with the maintenance staff. Many concern with aging and breakdowns of facilities and equipment, as well as inadequate equipment specifications.

Table 3-3-44 Chimbo Water Treatment Plant Problems

Issue	Current Problems	Possible Measures	Remarks
1.Water source and water quality	a. The only water source is the Jutiapa system of the Picacho water source. b. It is stream water from the water sources of the Picacho system, and the water quality is similar to that of Picacho.	a. If necessary, convey water from other water sources, etc.	
2.Facility scale	a. Currently operating 8 hours/day, the facility does not reach its maximum capacity.	a. Consideration of operation methods and coordination with water supply areas to be served.	
3. Treatment function	a. In the current treatment process, values lower than the standard value for drinking water are maintained.		
4. Facilities and equipment	a. Many equipment is aging/ breakdowns, not repaired. b. No proper coagulation and mixing operation/handling. No standby. c. A sand filtration unit is suspended due to failure. d. Deficient measurement and safety measures due to aging of chlorination equipment. e. Aging and failure of the flow meter makes it difficult to measure the volume of water. f. Some water quality test equipment such as the turbidity meter is faulty, repair is required.	a. After detailed study, repair or replacement is required, considering also to improve the performance. b. Improvement of facilities such as renewal and repair, repair of the automatic operation function of the control panel, and expansion of each injection pump after considering appropriate and efficient treatment operation. c. Repair and replacement of filter sand d. Improvement by adding more measuring and safety equipment. e. Upgrading of instrumentation equipment such as flow meters and level gauges. f. Replacement and repair	b. Check the chemical dosage rate.
5. Operation and maintenance system, etc.	a. They are not performing maintenance/upgrading of equipment on a	a. A preventive maintenance program for systems and equipment needs to be established.	

Issue	Current Problems	Possible Measures	Remarks
	scheduled basis, so failures occur in case of breakdowns and emergencies.		

3-3-2-1-7 Central Water Quality Laboratory

(1) Outline

The central water quality laboratory is located within the Laureles Water Treatment Plant area, but it is a separate organization from the water treatment plant. This laboratory is a supervisory body for the water quality testing of the water treatment plants. It performs the analysis of physical, chemical and biological parameters of drinking water, manages the laboratory equipment of the water treatment plants and collects various data for analysis. Only this laboratory has the capacity to perform biological and heavy metal tests. The laboratory has 2 buildings, the biological and chemical testing building built in 2001 and the heavy metal testing building built in 2005 with Spanish cooperation. In this laboratory, 50-60 samples from water sources and water treatment plants are analyzed weekly. The equipment is aging and some of it is out of order, so it is necessary to replace it at the appropriate time. Figure 3-3-43 shows the current status of the central water quality laboratory.

	
1. View of the central water quality laboratory	2. Inside the laboratory
	
3. pH meter and color meter	4. Scales and others

	
5. Biological testing equipment	6. Capacity meters and others

Figure 3-3-43Current Status of Central Water Quality Laboratory

3-3-2-2 Operation and Maintenance

(1) Treatment Operation for Water Treatment Plants

With respect to treatment for purification, AMDC has considerable knowledge and experience with some 40 years of operations conducted in the current process (previously the trained personnel were part of SANAA). Some of the institution's technicians have experience from training in Japan and other countries. The current AMDC operation and maintenance manual was prepared based on the manual "Operation and Maintenance of Water Treatment Plants, Training Manual for Operators" of the Pan-American Center for Sanitary Engineering (CEPIS); however, the contents of this manual are basic issues, so it is necessary to improve the contents according to current operations.

At Laureles and Concepción plants, contamination of the raw water quality is advancing. If a new process is added at the water treatment plant to counteract this, in addition to improving the quality of the water at the water source, it will be necessary to acquire knowledge of the new process and learn the new method of operation.

(2) Inspection and Repair of Equipment

The departments in charge of the AMDC (previously assigned to SANAA) and the personnel at the water treatment plants inspect and repair the equipment; however, equipment maintenance and rehabilitation are not performed on a scheduled basis and failures may occur in the event of breakdowns and emergencies that will hinder the continuity of operations. No plant has an elaborate breakdown and repair history. It is necessary to establish a systems and equipment inspection protocol, as well as a preventive maintenance program. Equipment repair and replacement, due to budgetary problems, is difficult to carry out in a timely manner in the current situation and this sometimes hinders the continuity of operations. Existing plants are 20 - 30 years old since their installation and there are many breakdowns, etc. due to aging, which is a challenge to be solved. Major repairs and replacements are done on an ad hoc basis, guaranteeing a project budget including funds from the Government of Honduras and donors.

AMDC has equipment workshops, and the main equipment in the workshop are welding machine, pipe cutter, pipe threader and pipe wrench. Mainly pipe repair work is performed.

(3) Procurement of Equipment and Materials

AMDC has equipment and materials warehouses in two locations, one at Los Laureles Water Treatment Plant and the other at La Vega Water Treatment Plant. They mainly store pipes, valves, small pumps, miscellaneous accessories and consumables.

PVC and DIP pipes up to a diameter of 8" (200 mm) can be purchased locally, however, pipes and equipment larger than 200 mm in diameter are imported, which are purchased through bidding each time they are needed.

Chemicals are acquired through competitive bidding and are currently purchased from the following countries: Aluminum sulfate from Finland;, Lime hydrate from Guatemala; liquid chlorine from United States of America; polymer from United Kingdom; and powdered activated carbon from Mexico.

3-3-3 Piping and Distribution Facilities

Piping and distribution facilities in the municipality of Tegucigalpa consist of 4 piping systems from the water treatment plants to 102 distribution tanks, distribution pipes from the distribution tanks to 665 distribution areas, and service pipes to households. In areas that do not have a distribution pipeline network, water is supplied by water tank trucks.

3-3-3-1 Facilities

In the following, 3-3-3-1 describes Facilities and 3-3-3-2 describes Operation and Maintenance.

3-3-3-1-1 Pipeline Installations

The conveyance systems are shown in Figure 3-3-44. Water is sent through the Picacho conveyance system from the Picacho Water Treatment Plant, Los Laureles conveyance system from Los Laureles Water Treatment Plant and La Concepción conveyance system from La Concepción Water Treatment Plant. These conduction systems have 26 pumping stations where water is sent with increased pressure to some tanks. In the case of the Miraflores Water Treatment Plant, water is sent from this plant to the distribution tank located inside the water treatment plant and distributed to the surrounding areas.

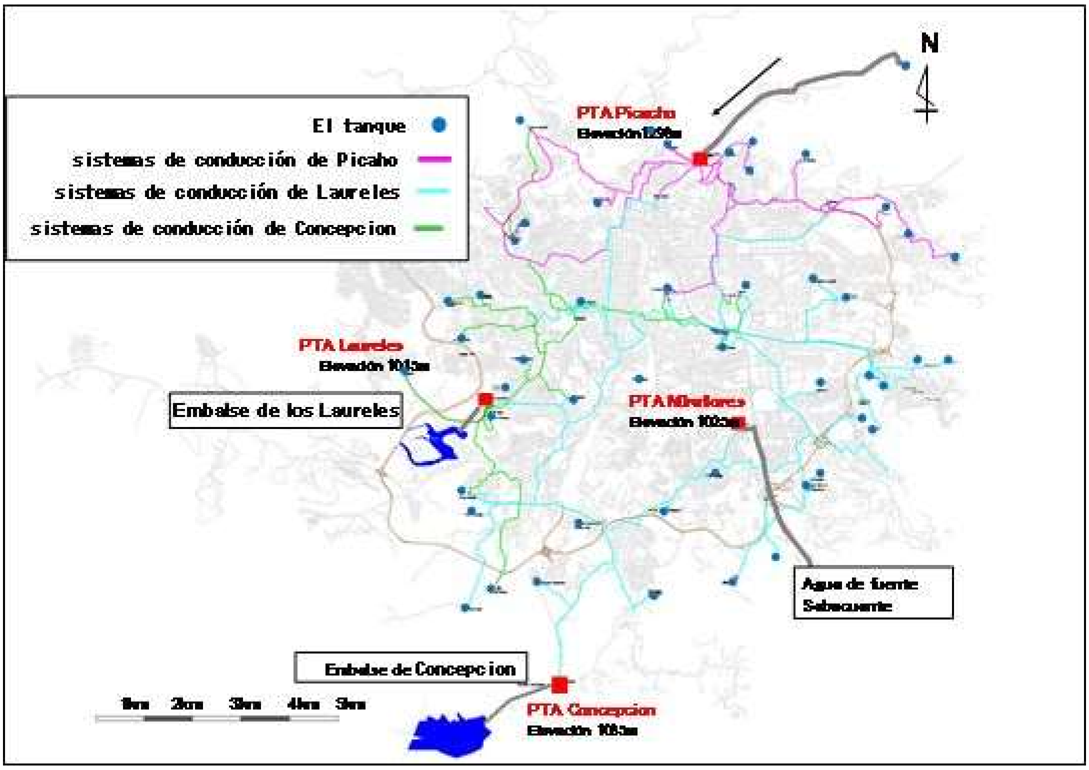


Figure 3-3-44Piping Systems

Table 3-3-45 shows the total length of the conduction systems. The total length of the Picacho conduction system is 37.7 km, the total length of La Concepción conduction system is 65.0 km and the total length of Los Laureles conduction system is 29.2 km. The pipes of the conduction systems are made of ductile iron (DIP).

Table 3-3-45 Total Length of Piping Systems

Conduction System	Diameter	Total Length (m)	Total (m)
Picacho	400	6,739.34	37,766.81
	300	27,522.23	
	150	3,505.24	
La Concepción	1000	5,150.80	65,001.03
	800	7,836.40	
	700	4,140.18	
	600	7,587.99	
	500	1,060.37	
	400	7,557.98	
	300	2,752.44	
	250	3,086.41	
	200	7,118.98	
	150	18,709.49	
Los Laureles	1000	3,141.43	29,262.46
	600	5,195.95	
	500	3,691.00	

Conduction System	Diameter	Total Length (m)	Total (m)
	400	914.01	
	300	4,314.99	
	200	5,711.36	
	150	6,293.72	

Source: SANAA

(1) Piping Systems

a) Picacho Conduction System

Figure 3-3-45, Figure 3-3-46 shows the conceptual scheme of the conveyance systems. The Picacho Water Treatment Plant sends water by gravity from Picacho Hill, located to the northwest of the city, to the distribution tanks in the sectors located to the northeast of the city, such as La Leona, Linderos, Molinón, La Sosa and La Travesía. In the dry season, water is sent from the La Concepción conduction system to the La Leona and Linderos distribution tanks.

In the Picacho pipeline system, the pipelines are damaged in the relatively high frequency due to water hammer impacts. It is assumed that the cause is air deposits in the pipeline as shown in Figure 3-3-47 and when the valve is opened or closed at the start of operation, water hammer occurs inside the pipeline. For operation, it is recommended to open and close the valve slowly with sufficient time. In this pipeline system, there are few air valves, so it is necessary to install them properly.

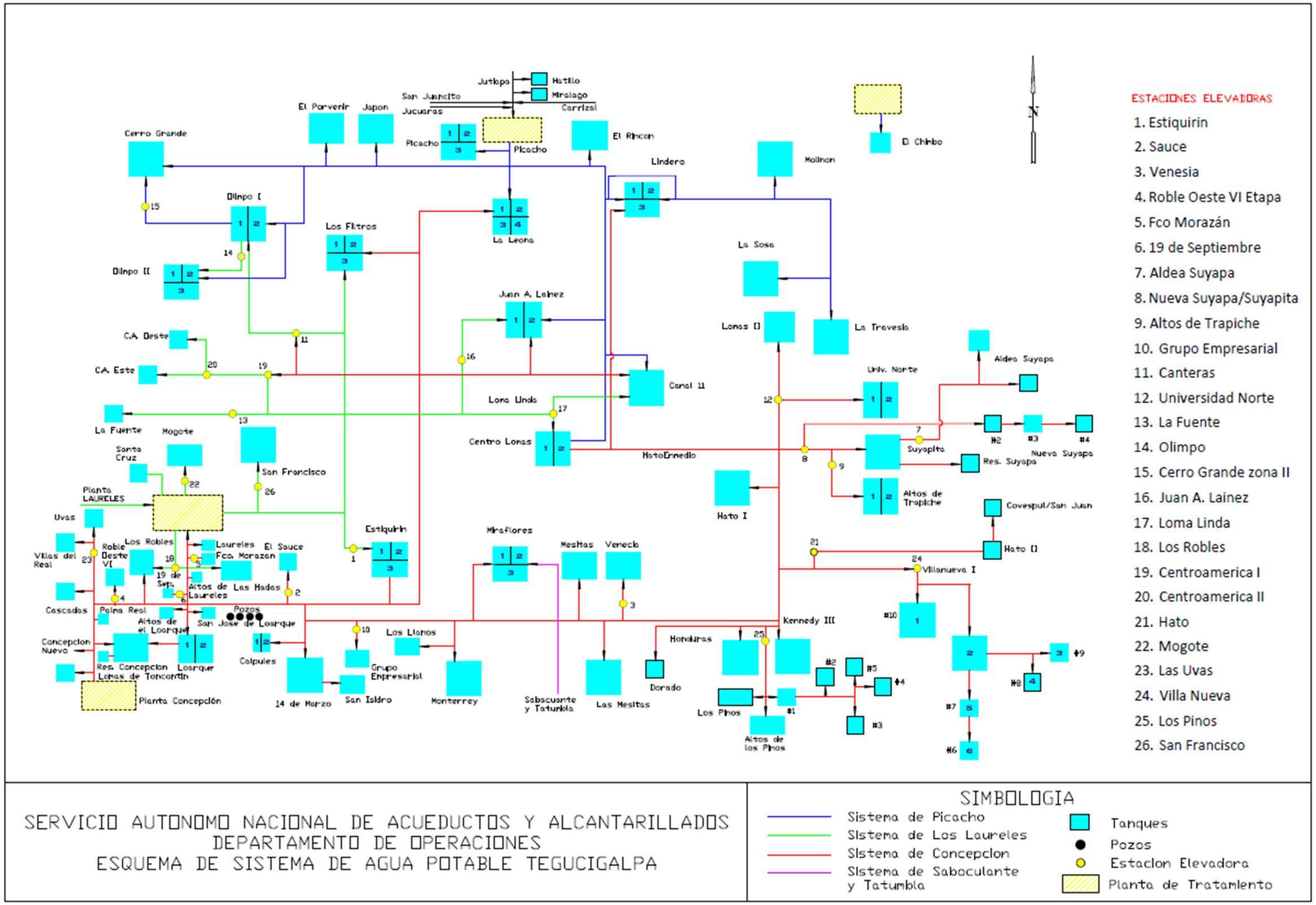


Figure 3-3-45 Water Level Schematic of Conduction System

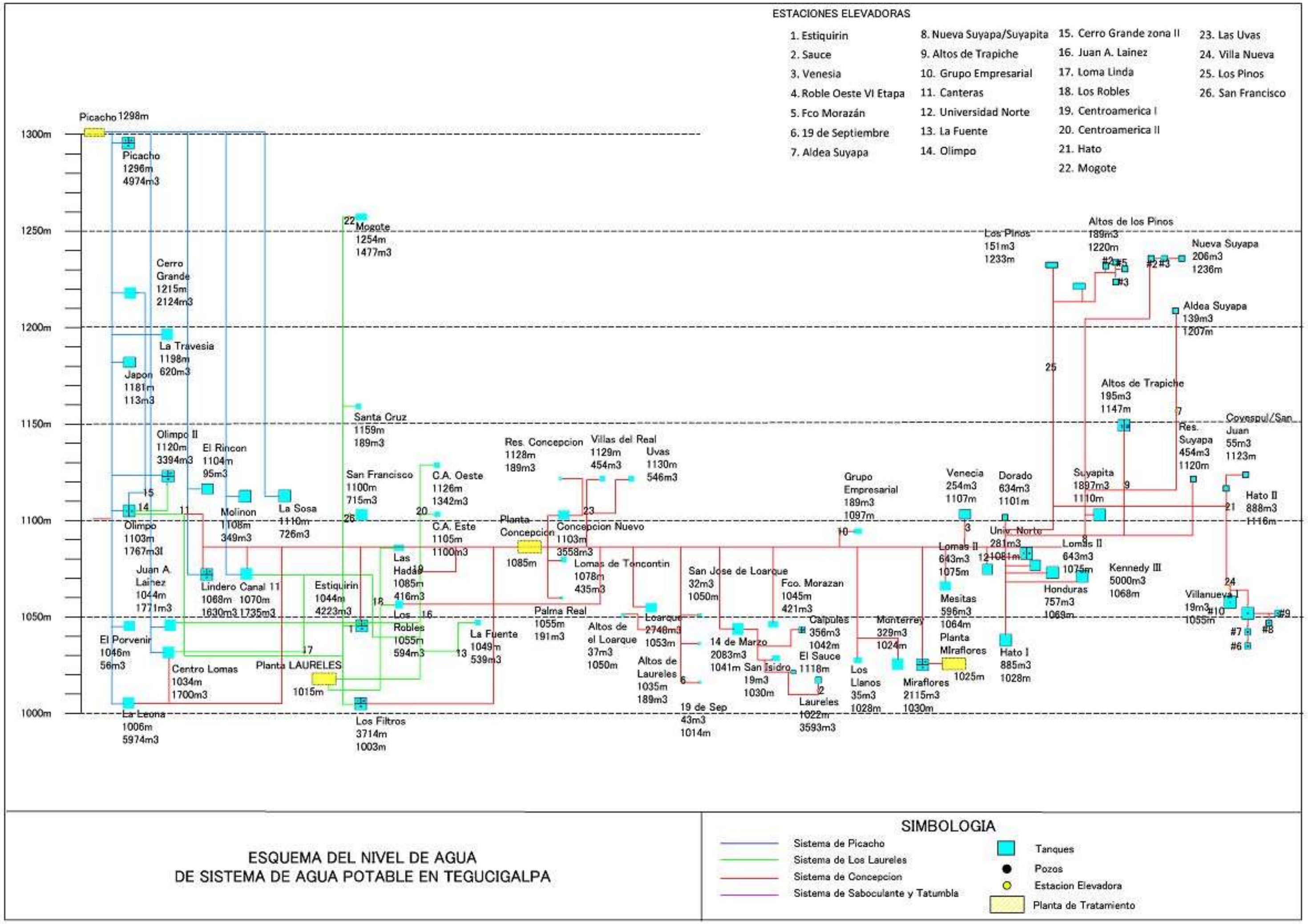
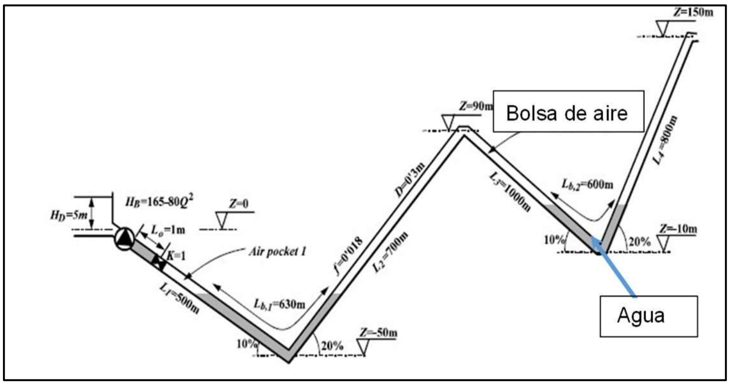


Figure 3-3-46 Water Level Schematic of Conduction System



Source: SANAA AQUARUM (Project for the Optimization of Water Supply Services in Tegucigalpa).

Figure 3-3-47 Air Reservoir Schematic Diagram

It is to be mentioned that the SCADA system was built within the Picacho Water Treatment Plant for remote monitoring and control through the AQUARUM program in 2012. However, it is currently not operational since 2015 due to various factors, and is in the process of transition from SANAA to AMDC. The summary of the SCADA system is as follows.

- The system consists of 2 operating stations, a rack-type data server and radio equipment for data communication in UHF frequencies from the signal emission points, among others.
- The parameters monitored are water levels in the distribution tanks, water flow rates at the distribution points including the water treatment plant (31 points) and residual chlorine concentrations in the water treatment plants. These data are transmitted via radio on UHF frequencies to the station.
- At the operator station, the LCD display is used as the HMI (Human Machine Interface) where water levels and flow trends and instantaneous values are displayed. The data stored on the server is used to produce daily, monthly and annual reports. Three persons are assigned as system operators including the person in charge. The existing system has the following challenges which require study and analysis:

1. An imperfect operation carried out by the operators due to the lack of technological transfer by the system's contractors.
2. Failures in sensors such as flow meters and application software.
3. UHF antenna connection cable not suitable for outdoor use (not weather compatible).
4. Lack of system server capacity

Figure 3-3-48 shows the current status of the existing SCADA system.

	
SCADA Station inside the Picacho Water Treatment Plant	Operating station

	
Transmission panel to water treatment plants	Chlorine residual concentration sensor
	
Water level sensor in the distribution tank	UHF connection cable

Figure 3-3-48 Current Status of Existing SCADA System

e) Los Laureles Pipeline System

Los Laureles Water Treatment Plant transports water to the western, central and southwestern areas of the city. Specifically, it is transported to the distribution tanks located to the west of the city, San Francisco, La Fuente, and Centroamérica Este, and to the distribution tank located in the center of the city, Canal 11. The Laureles Water Treatment Plant has an elevation of 1,015 m, the lowest of the four water treatment plants. For this reason, booster pumps are required to send water to the distribution tanks at higher elevations, consisting of 12 pumping stations in the Los Laureles conveyance system. Water can be sent to some distribution tanks, such as the Estiquirín distribution tank, from La Concepción conduction system.

f) La Concepción Pipeline System

La Concepción Water Treatment Plant supplies water to half of the city and has the largest production volume. It supplies water to the southern, eastern, and central areas of the city. In the dry season, it also supplies water to La Leona tank. Basically the water is sent by gravity, however, to the higher elevation areas in the eastern zone, water is pumped using 13 pump stations.

(2) Pumping Stations

Table 3-3-46 and Figure 3-3-49 show the operating status results obtained during field visits and personnel interviews at 26 pump stations

a. Most of the pumps are high-head vertical shaft pumps. All pumping stations are in operation, but 19 out of 76 pumps are out of service due to breakdowns. Some of the pumps in operation are more than 15-20 years old, and some of them have deteriorated or broken down, and some of them do not have standby equipment. Repair and renewal of valves and piping are also necessary. Maintenance, management, and repair are insufficient due to difficulties in procuring parts and securing budgets. Some pumping stations have automatic alternating operation for water levels, although most are operated manually on site. In most of the pumping stations, flow and pressure measurements are not taken, and some stations do not even know the pump specifications, i.e., pump operation control is not being carried out properly.
b. At some stations, electromagnetic flowmeters were installed for use in the SCADA system through the AQUARUM program; however, their use is currently suspended. At other stations,

some do not have flowmeters, or even if they have mechanical flowmeters, many are not properly working. Consequently, the exact volume of water pumped is not known.

c. With respect to the electric power situation, every month there is a scheduled suspension of electric power due to electrical work. No pumping station has an emergency generator except for No.8 pumping station, so operation is suspended when there is no power.

d. The operation time of the pumps is established according to the demand requirements of each supply area.

As a general rule, AMDC manages the operation of the lift stations, however, in three stations the management is in charge of the water user communities to which AMDC provides technical assistance.

e. The issues are as follows:

・Many equipment is more than 20 years old (working since installation) and shows deterioration/failure. Repairs and replacements including working equipment are necessary, and in addition, it is necessary to repair/replace broken equipment to ensure backup availability.

・When replacing, it is important to properly set the specifications.

・It is recommended to establish a preventive maintenance program including the periodic implementation of the energy diagnosis and to conduct training to guide on how to prepare an adequate O&M program/specifications.

Table 3-3-46 Current Status of Existing Pumping Stations

No	Name of Pumping Station	System Name	Year of Installation	Pump Specifications: No. x Q (m^3/min) x P (kW), V/H	Flow meter	Generator	No. of Pumps Running	Operating Time (Hours/day)	No. of Operators	Frequency of Outages	Destination	Remarks
1	Estiquirín	Los Laureles	1975	2xQx112, V	Exists, Aquarum	None	1	9	3	3 times/month	Estiquirín Tank	1 unit faulty, Aquarum suspended
2	El Sauce	La Concepción		2x1.06x56, V	Exists, mechanical	None	2	8 Tuesday, Friday, Sunday	3	6 times/year	El Sauce Tank	Alternate operation
3	Venecia	La Concepción	2006	2xQx55, V	None	None	2	7.5/2 days	3	2 times/month	Venecia Tank	Automatic for levels and alternate operation
4	Roble Oeste VI Etapa	La Concepción	2008	2xQx30kW, V	Exists, electric	None	2	9 Every 3 days			Roble Oeste VI	Automatic for levels and alternate operation
5	Francisco Morazán	Los Laureles		2x0.34x15, V	None	None	2	21 Thursday, Friday	3	3 times/month	Morazán tank and others	Alternate operation
6	19 de Septiembre	Los Laureles	2005	1xQx11, S	None	None	1	7-23 Tuesday, Friday	3	2-3 times/month	Los Laureles Tank	Administration: community
7	Aldea de Suyapa	La Concepción	1997	2x0.93x22.38, V	None	None	2	20-6/7 days	2	1 time/month programmed	Nueva Suyapa tank and others	Administration: community, alternate operation
8	Nueva Suyapa/Suyapita	La Concepción	2000	2x2.24x93.25, V 2x6.18x112,V	Exists, Aquarum	Exists, 300kVA	2 2	10 24	3	2 times/month	Suyapa/Suyapita	Alternating operation, 2 units down, Aquarum suspended
9	Altos del Trapiche	La Concepción	2002	2x3.0x44.74, V	Exists, electric		2	5-17 Every 3 days	2	2 times/month programmed	Altos de Trapiche, etc.	Alternate operation
10	Grupo	La	2010	2x4.16x14.92,V	Exists,	None	2	4-5/3 days	2		Aguacatal	Administration

No	Name of Pumping Station	System Name	Year of Installation	Pump Specifications: No. x Q (m^3/min) x P (kW), V/H	Flow meter	Generator	No. of Pumps Running	Operating Time (Hours/day)	No. of Operators	Frequency of Outages	Destination	Remarks
	Empresarial	Concepción		2x4.16x14.92,V	mechanical		Not used	-			company tank	: community, alternate operation
11	Canteras	La Concepción and Los Laureles	1977	4x6.18x186.5, V 3x7.20x150,V	None	None	1 3	24	3	3 times/month	Olimpo I	3 failed units, alternating operation
12	Universidad Norte	La Concepción	2002 renewed	4x4.0x33.58, V	Exists, mechanic	None	3	8-20/3 days 8-13,17-8/3 days	2	2 times/month programmed shutdown	Universidad Norte/Lomas Tank #2	2 units defective, flow meter defective
13	La Fuente	Los Laureles		2xQx37.3, V 2xQx22.38, V	None	None	1 2	15	3	10 times/year	La Fuente Tank	1 failed unit
14	Olimpo	La Concepción/Los Laureles/Pica		2x6.0x37.3, V	Exists, Aquarum	None	2	24	3	6 times/year	Cerro Grande Tank	Alternate operation, Aquarum suspended
15	Cerro Grande Zona II	La Concepción/Los Laureles/Pica		2x4.92x74.6, V	Exists, Aquarum	None	1	24 6 days/week	3	6 times/year	Cerro Grande Tank	1 failed unit, Aquarum suspended
16	Juan A Laínez	Los Laureles	1996	2x4.16x65.32, V	Exists, Aquarum	None	1	18-7 Every 3 days	2	1 times/month	Laínez tank and others	1 failed unit, Aquarum suspended
17	Loma Linda	Los Laureles	1996	1x2.27x74.6, V 2xQx2.27x44.76, V 2xQx2.27x14.92, V	Exists, mechanic	None	1 2 2		3	4-5/month 4-6 hours	Centro Lomas tank and others	Of which, 2 units installed in 2017, flowmeter malfunctioning
18	Los Robles	Los Laureles	2011 renewed	2x1.14x26, V 2x0.95x18.5, V	None	None	1 2	In a timely manner 15-7/3 days	3 3	Scheduled suspension, 8 hours	Las Hadas, Los Robles	1 failed unit
19	Centro America I	Los Laureles		2x5.68x112, V 1xQx55, V	None	None	1	24	3	3 times/month	Centro America II	2 failed units
20	Centro America II	Los Laureles - Central	1996	2x2.84x55, V 2x2.84x55, V	Exists (broken)	None	2 2	24	3	Some times/year	Central America	Alternating operation,

No	Name of Pumping Station	System Name	Year of Installation	Pump Specifications: No. x Q (m^3/min) x P (kW), V/H	Flow meter	Generator	No. of Pumps Running	Operating Time (Hours/day)	No. of Operators	Frequency of Outages	Destination	Remarks
		America I									East/West	obsolete, there is a drop in capacity
21	Hato	La Concepción	1992	2x2.0x37.3, V	None	None	1	8	No	2 times/month	Hato Tank II	1 faulty unit, operated by the tank manager
22	Mogote	Los Laureles	1995	4x4.0x199.6, V	None	None	2	24	3	2-3 times /month 30 min	Mogote Tank	2 failed units
23	Las Uvas	La Concepción		2x1.7x67, V	None	None	2	24	3	3 times/year	Las Uvas Tank	Alternate operation
24	Villa Nueva	La Concepción		2x3.54x74.6,V 2x4.11x112, V	None	None	1 2	7-8	3	2 times/month	Villa Nueva Tank	1 faulty unit, alternating operation
25	Los Pinos	La Concepción	1996	2xQx55, V	Exists, mechanical	None	2	23 Thursday to Saturday	3	4 times/year	Los Pinos tank and others	Alternate operation, donated by JICA
26	San Francisco	Los Laureles		2x3.30x55,H	Exists, Aquarum	None	2	24	3		San Francisco	Alternate, obsolete operation, Aquarum suspended

Source: Prepared by the Study Team based on interviews with SANAA Note) Pump specifications: V: vertical pump, H: horizontal pump, S: submersible pump.

1. Pumping Station No.4 Roble Oeste VI (the most recent one)

2. Same as left, pump (vertical)

3. Pump at Nueva Suyapa pumping station No.8.

4. Same as left, Aquarum flowmeter.

5. Pumping station No.25 Los Pinos

6. Same as left, vertical pump, donated by JICA.

	
7. San Francisco Pumping Station No. 26	8. Same as left, pump (horizontal), obsolete.

Figure 3-3-49Status of Pumping Stations

Figure 3-3-47 shows the energy consumptions of pumping stations between 2016 and 2019. The energy consumption of the pumping stations occupies approximately 70 % of the drinking water system; in other words, the pumping stations occupy most of the energy consumption. This corresponds to approximately 10% of the operation and maintenance cost of the AMDC.

Table 3-3-47Energy Consumption of Existing Pumping Stations (Kwh)

NO	Pumping Station	2016	2017	2018	2019
1	Estiquirín	792,360	757,080	661,800	527,640
2	El Sauce	-	-	-	-
3	Venecia	-	-	-	-
4	Roble Oeste VI Etapa*	-	-	-	-
5	Francisco Morazán*	-	-	-	-
6	19 de Septiembre	-	-	-	-
7	Aldea de Suyapa*	-	-	-	-
8	Nueva Suyapa/Suyapita	717,520	792,720	872,640	787,197
9	Altos de Trapiche	41,304	50,015	48,749	45,914
10	Grupo Empresarial*	-	-	-	-
11	Canteras	2,976,120	4,362,036	3,929,780	3,877,800
12	Universidad Norte	5,268	5,359	5,534	4,943
13	La Fuente	63,543	75,335	71,878	51,281
14	Olimpo	140,280	142,720	280,920	309,828
15	Cerro Grande Zona II	364,640	375,560	437,400	384,960
16	Juan A Laínez	11,944	11,928	11,631	10,373
17	Loma Linda	556,680	503,160	370,320	383,316
18	Los Robles	135,200	128,320	141,080	135,480
19	Centro America I	453,200	475,600	518,480	500,840
20	Centro America II	451,960	470,560	475,720	420,320
21	Hato	174,065	171,814	158,305	184,360
22	Mogote	753,600	1,799,520	1,124,800	854,640
23	Las Uvas	190,115	204,906	203,855	202,690

NO	Pumping Station	2016	2017	2018	2019
24	Villa Nueva	17,765	4	2	188,552
25	Los Pinos	194,931	204,223	203,358	43,708
26	San Francisco	424,259	437,797	3,929,780	427,556
Total		8,464,754	10,968,657	13,446,032	9,341,398

*This is due to the fact that the AMDC does not have data since it is held by the Water Administration Boards.

Source: Prepared by the Study Team based on interviews with AMDC.

(3) Energy Diagnosis of Pumping Stations

In order to know the operation situation of existing pumping stations and energy consumption situation, energy diagnosis was carried out. The diagnostic method is as follows: measure the inlet voltage/current and discharge flow rate/total head to calculate the actual pump efficiency, compare it with the standard efficiency of a similar size pump (according to JIS standards) and diagnose the energy consumption. Diagnostics of the operations were also performed by measuring vibration and shaft temperatures. The power analyzer was used to measure the input voltage/current, the portable ultrasonic flowmeter was used to measure the discharge flow rate, and the pressure gauge was used to measure the discharge pressure.

The energy diagnosis was performed in 10 pumping stations out of a total of 26 existing stations. Out of a total of 26 pumps, 17 were operating and 9 were out of service or suspended, and metering was possible on 14 pumps. The pumps that could not be metered had problems that did not allow installing a pressure gauge or measuring the flow rate.

Figure 3-3-50 shows the diagnostic images and Table 3-3-48 shows the diagnostic results.

For efficiency rating, it was rated as Good if the pump had more than 50%-60% of the standard efficiency of a similar size pump (according to JISB8313, Centrifugal pump). For vibration assessment, the standards of JISB0906 (ISO10816-1) were used.

1. Flow measurement

2. Vibration measurement

Figure 3-3-50Energy Diagnosis Images

Table 3-3-48 Results of Energy Diagnosis of Existing Pumping Stations

No.	Name of Pumping Station		Specifications		Diagnostic Results			Evaluation
			Discharge Flow Rate	Total Height	Discharge Flow Rate	Total Height	Pump Efficiency	
			M^3 /min	m	M^3 /min	m	%	
3	Venecia	1	Unknown	Unknown	1.80	60.2	47.23	Not good
		2	Unknown	Unknown	1.92	58.1	43.93	Not good
6	19 de Septiembre	1	Unknown	Unknown	0.84	40.6	43.16	Not good
8	Nueva Suyapa	2	6.84	76	2.64	96.7	55.95	Good
		3	2.22	170	2.04	145.5	65.57	Good
9	Altos del Trapiche	1	3.0	58.2	1.86	65.0	64.16	Good
		2	3.0	58.2	1.86	65.0	66.74	Good
12	Universidad Norte	1	2.84	Unknown	1.74	60.5	46.95	Not good
17	Loma Linda	C-4	2.27	150	1.44	88.6	40.96	Not good
		L-1	Unknown	Unknown	0.66	50.8	30.04	Not good
		C-1	Unknown	Unknown	1.08	8.9	30.90	Not good
		C-2	Unknown	Unknown	0.96	6.9	35.11	Not good
18	Los Robles	1	0.95	82.3	0.90	68.0	59.60	Good
		2	0.95	82.3	0.96	70	63.67	Good

Source: Prepared by the Study Team

Evaluation of pump efficiency: Out of 14 pumps, 8 had an efficiency of 50% or less, which results in energy waste. The reasons could be as follows:

・Pump specifications are not compatible with the required flow/head, causing low efficiency at actual operating points.

・Low efficiency due to deterioration and damage to impellers and bearings.

Assessment of vibration and bearing temperature: According to the results of this measurement, no values above the parameters were observed.

If low efficiency and vibration problems are detected during the periodic implementation of this type of energy diagnosis as part of preventive maintenance, the pump might be damaged. It is important to perform this type of energy diagnosis for proper operation and maintenance.

3-3-3-1-2 Distribution Facilities

Purified drinking water at the water treatment plants is sent from the purified water tanks to the conveyance systems and stored in the distribution tanks. The distribution of water from the distribution tanks to the distribution areas is done manually by manipulating various valves installed in the tanks. The manipulation of the valves in the distribution tanks has an established schedule, and SANAA publishes monthly information on the service days and the water supply schedule to the population through its website and social networks (SNS).

(1) Distribution Tanks

Table 3-3-49 shows the names of 102 distribution tanks in the municipality of Tegucigalpa, the number of distribution areas, capacity, material and year of construction. Distribution tanks that are 40 - 50 years old since their construction occupy 18.6%, distribution tanks that are 20 - 40 years old occupy 47.1% of the total and those that are 1 - 20 years old occupy 28.4% of the total. Likewise, tanks made of concrete occupy 49 % of the total, tanks made of brick occupy 30 %, tanks made of steel sheet occupy 16 % and tanks made of concrete block, 5 %. In total, there are 665 neighborhoods. Distribution from the storage tanks to the neighborhoods is done by manually operating the valves. It should be noted that the flow rates are unknown due to the absence of meters at the outlet of the storage tanks.

Table 3-3-49 List of Distribution Tanks

No.	Sector	Name of Distribution Tank	No. of Distribution Areas	Capacity (m^3)	Elevation (m)	Material	Year of Construction
1	1	El Chimbo	5	189	1,259	concrete	1981
2	1	El Molinón	4	349	1,108	concrete	1961
3	1	Japon	1	113	1,181	brick	2005
4	1	La Sosa	17	726	1,110	steel	2003
5	1	La Travesía 1	17	620	1,198	concrete	1990
6	1	Linderos 1	29	622	1,069	concrete	1966
7	1	Linderos 2		369	1,070	concrete	1971
8	1	Linderos 3		639	1,069	concrete	1971
9	1	Picacho 1	52	1,697	1,298	concrete	1946
10	1	Picacho 2		1,650	1,297	concrete	1946
11	1	Picacho 3		1,627	1,297	concrete	1946
12	1	Rincón	2	95	1,104	brick	1991
13	2	Canal 11	21	1,735	1,070	concrete	2009
14	2	El Porvenir	1	56	1,046	concrete	2006
15	2	La Leona 1	42	1,477	1,006	concrete block	1981
16	2	The Leona 2		1,294	1,006	concrete block	1981
17	2	The Leona 3		1,100	1,007	concrete block	1981
18	2	The Leona 4		2,103	1,007	concrete	2009
19	3	Covespul/San Juan	1	945	1,110	concrete	1991
20	3	Covespul	1	55	1,123	steel	1991
21	3	Hato de Enmedio 1	2	885	1,028	steel	1981
22	3	Hato de Enmedio 2		888	1,116	steel	1991
23	3	Los Llanos	1	35	1,028	steel	1991
24	3	Universidad Norte 1	9	209	1,081	concrete	2004
25	3	Universidad Norte 2		72	1,081	concrete	2004
26	3	Suyapita	12	1,897	1,110	concrete	1986
27	3	Kennedy 3	34	5,000	1,068	concrete	1976
28	3	Honduras Res.	1	57	1,080	concrete	2001

No.	Sector	Name of Distribution Tank	No. of Distribution Areas	Capacity (m^3)	Elevation (m)	Material	Year of Construction
29	3	Honduras Res.		757	1,069	brick	2001
30	3	Lomas 2da Etapa	9	643	1,075	concrete	1996
31	3	Los Pinos	1	151	1,233	brick	1996
32	3	Dorado	2	634	1,101	brick	2001
33	3	Venecia (tank)	2	254	1,107	concrete	2006
34	3	Aldea de Suyapa (tank)	1	139	1,207	brick	1991
35	3	Nueva Suyapa (tank)	8	206	1,236	brick	1991
36	3	Altos del Trapiche (Tank 1)	4	195	1,147	brick	1991
37	3	Villa Nueva 1	1	19	1,055	brick	1996
38	3	Villa Nueva 2		95	1,099	brick	1996
39	3	Villa Nueva 3		95	1,179	brick	1996
40	3	Villa Nueva4		95	1,205	brick	1996
41	3	Villa Nueva 5		113	1,219	brick	1996
42	3	Villa Nueva 6		113	1,118	brick	1996
43	3	Altos de Los Pinos Tank	1	189	1,220	brick	1996
44	3	Centro Lomas Nuevo	4	840	1,034	brick	2009
45	3	Centro Lomas		860	1,034	concrete	1991
46	3	Juan A. Laínez 1	21	1,167	1,045	concrete	1961
47	3	Juan A. Laínez 2		604	1,045	concrete	1961
48	3	Los Filtros 1	45	161	1,007	concrete block	1966
49	3	Los Filtros 2		3,497	1,003	concrete	1981
50	3	Los Filtros Nuevo		56	1,019	concrete	2009
51	3	Miraflores 1	11	735	1,026	concrete	1981
52	3	Miraflores 2		319	1,031	concrete	1981
53	3	Miraflores New		1,061	1,030	concrete	2004
54	4	Loarque 1	12	157	1,053	concrete	1981
55	4	Loarque 2		2,591	1,057	concrete	1976
56	4	Monterrey	2	329	1,024	concrete	1991
57	4	La Cascada	1	339	1,070	concrete	1996
58	4	Concepcion	6	2,520	1,099	concrete	1994
59	4	Concepción New		3,558	1,103	concrete	2004
60	4	14 de Marzo	10	820	1,042	concrete	2004
61	4	14 de Marzo New		2,626	1,042	concrete	2004
62	4	Calpules 1 Alto	1	95	1,047	steel	1991
63	4	Calpules 2 Bajo		261	1,042	steel	1991
64	4	Lomas Toncontín 1	8	435	1,078	brick	1991
65	4	Palma Real	1	191	1,055	steel	1986
66	4	Las Uvas 1	6	546	1,130	brick	1991
67	4	* Yaguacire	1	141	1,112	brick	1996
68	4	Mesitas	3	596	1,064	brick	2001

No.	Sector	Name of Distribution Tank	No. of Distribution Areas	Capacity (m^3)	Elevation (m)	Material	Year of Construction
69	4	Grupo Empresarial (tank)	1	189	1,097	concrete	2011
70	4	Altos de Loarque (tank)	2	37	1,051	brick	2001
71	4	San José de Loarque	1	32	1,051	brick	2001
72	4	Res. Concepcion 1	2	189	1,128	brick	2006
73	4	Villas del Real	1	454	1,130	brick	2001
74	4	Las Hadas 1	12	416	1,085	steel	2001
75	4	Los Robles	8	594	1,056	concrete	1981
76	4	Roble Oeste VI Etapa (tank)	1	30	1,093	concrete	2013
77	4	Estiquirin 1	88	969	1,044	concrete block	1986
78	4	Estiquirin 2		3,254	1,045	concrete	2004
79	4	Estiquirín New		3,883	1,044	concrete	2004
80	4	La Fuente	5	539	1,049	steel	1981
81	4	Los Laureles 1	1	3,593	1,022	concrete	1976
82	4	San Francisco	6	715	1,100	concrete	2004
83	4	Mogote 1	19	744	1,254	concrete	1991
84	4	Mogote 2		733	1,250	steel	1991
85	4	El Sauce (tank)	1		1,118	concrete	2015
86	4	Francisco Morazán (tank)	1	421	1,045	brick	2006
87	4	19 de Septiembre (tank)	1	43	-	concrete	2001
88	4	Altos de los Laureles	4	113	1,035	concrete	2018
89	4	San Isidro	1	19	1,030	brick	2001
90	4	Santa Cruz (tank)	1	189	1,159	concrete	2016
91	5	Cerro Grande 1	11	2,124	1,215	brick	1991
92	5	Olimpo I	29	1,767	1,103	steel	2004
93	5	Olimpo 2 Old	21	851	1,121	steel	1991
94	5	Olimpo 2 (Old 2)		851	1,024	steel	1991
95	5	Olimpo 2 (New 1)		846	1,120	steel	2004
96	5	Olimpo 2 (New 2)		846	1,120	steel	2004
97	5	Canteras	10	250	991	concrete	1991
98	5	PRRAC-ASAN	1	360	1,097	concrete	2005
99	5	Centro America Este	9	1,100	1,105	brick	1991
100	5	Centro America Oeste		1,342	1,127	brick	1991
101	6	El Hatillo	14	779	1,432	brick	1971
102	6	Miralago	1	189	1,421	concrete	2011

The administration of the operations is not the responsibility of SANAA but of the Water Administration Boards (Juntas Administradoras de Agua).

Source: Prepared by the Study Team based on SANAA data.

(2) Distribution Piping Network

For the distribution pipe network, mostly PVC, steel and asbestos (AC) pipes are used. The pipe type, diameter and total length has been recorded in the "Project for the Optimization of the Supply Services of Tegucigalpa and Renovation of the Distribution Networks of Colonias 15 de Septiembre and 21 de Octubre of Tegucigalpa" with the assistance of Spain through the AQUARUM program in 2011. Table 3-3-50 shows the total length by pipe type. Of the total, 68 % are PVC pipes, 15 % are galvanized steel pipes (SGPW) and 14 % are DIP. By diameter, 50 % are 50 mm diameter, 14 % are 100 mm diameter and 13 % are 80 mm diameter.

As of 2011, SANAA has not updated pipeline length data, so the current situation is unknown. The results of interviews with SANAA are based on 2011 data, and it is currently estimated that the total pipeline length will be about 2,000 km.

Table 3-3-50Total Length of Pipelines

Diameter (mm)	Total Length of Pipelines (Km)							
	Steel pipe	AC	DIP	HG	PVC	Unknown	Total Length	Percentage (%)
15					0.20		0.20	0.02 %
20				0.38	0.321		0.70	0.05 %
25				2.45	2.613		5.06	0.37 %
40				4.25	14.85		19.10	1.40 %
50		7.53	0.74	90.01	592.82	0.402	691.51	50.52 %
65				0.01	0.18		0.19	0.01 %
80		3.74	0.45	28.60	145.24		178.03	13.01 %
90			0.11				0.11	0.01 %
100	0.004	3.17	12.73	75.04	95.16	0.014	186.12	13.60 %
150		2.82	39.71	9.22	70.27		122.02	8.91 %
200	0.002	3.17	67.38	1.40	17.42		89.37	6.53 %
250		1.362	38.75	1.21	0.55		41.88	3.06 %
300			16.37		0.54		16.92	1.24 %
350		0.536	5.64				6.18	0.45 %
400			8.11				8.11	0.59 %
450			1.71				1.72	0.13 %
500			1.10				1.11	0.08 %
600			0.47				0.48	0.03 %
Total length	0.021	22.324	193.311	212.574	940.171	0.416	1,368.817	
Percentage	0.00 %	1.63 %	14.12 %	15.53 %	68.68 %	0.03 %		

Source: Prepared by the Study Team based on SANAA data.

(3) Repair History of Distribution Pipeline Network

SANAA has a record of pipe repairs. The Central District is divided into 4 areas: Northeast, Northwest, Southeast and Southwest, and in each area the diameter and type of pipe where water leaks occurred is recorded. The reason for leakage is classified, such as water pressure, pipe breaking, deterioration due to aging and micrometer theft. Each year they register about 5,000 cases of water leaks. Table 3-3-51 shows the number of water leak cases from 2018 to 2020 by pipe type and diameter and Table 3-3-52 shows the leakage reason. The decrease in leak occurrences in 2020 was especially due to the fact that not all repairs performed were recorded due to the COVID-19 pandemic.

Figure 3-3-51 shows the percentage of pipe types repaired and the percentage of causes of damage. By pipe type, PVC pipe occupies 93 % of the total, galvanized steel pipe occupies 3.6 % and DIP pipe occupies 2.9 %. DIP pipe is mainly used for conduit and distribution mains. We also believe that there are few repair cases because this type of pipe is highly resistant. By pipe diameter, water leaks in house connection pipes of diameter less than 50mm occupy approximately 75% of the total. Therefore, it is advisable to carry out a study of leaks and repairs in house connection pipes. Regarding damage reason, damage caused by excessive water pressure accounts for 85.6%, followed by deterioration caused by years of use (6.6%) and meter theft (3.5%). We believe that water pressure damage is possibly related to damage due to deterioration caused by years of use, but it is important to recognize that in order to reduce water leaks it is needed to adequately improve the distribution system and water pressure control.

Table 3-3-51 Number of Cases of Water Leaks by Type of Pipe and by Diameter

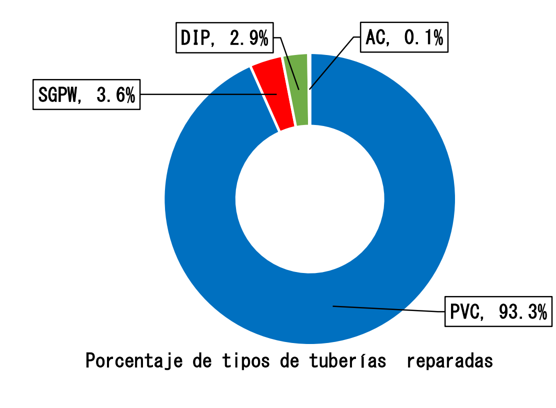
Year		2018	2019	2020	Annual Average	
Tube type	PVC	4,899	3,985	3,800	4,228	
	SGPW	184	181	127	164	
	DIP	131	168	98	132	
	AC	7	6	7	7	
Diameter (mm)	15	1,814	1,342	1,344	1,500	
	20	180	120	154	151	
	25	57	60	61	59	
	40	85	55	71	70	
	50	1,908	1,624	1,511	1,681	
	65	6	6	8	7	
	80	519	467	415	467	
	100	353	341	256	317	
	150	143	156	138	146	
	200	107	87	35	76	
	250	24	35	22	27	
	300	25	47	17	30	
Total		5,221	4,340	4,032	4,531	

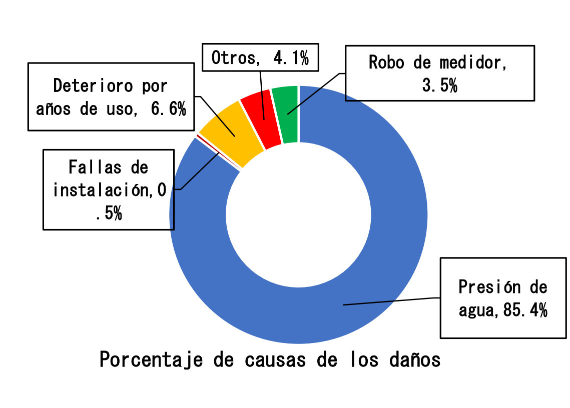
Source: Prepared by the Study Team based on SANAA data.

Table 3-3-52 Causes of Water Leaks

Year	Water Pressure	Pipe Rupture	Deterioration Due to Years of Use	Others	Meter Theft
2018	4,355	35	305	248	278
2019	3,726	28	358	168	60
2020	3,522	5	229	137	139
Annual Average	3,868	23	297	184	159

Source: Prepared by the Study Team based on SANAA data.





Source: Prepared by the Study Team based on SANAA data.

Figure 3-3-51Percentage of Pipeline Types Repaired and Percentage of Damage Causes

Case of rupture in the pipeline due to water pressure

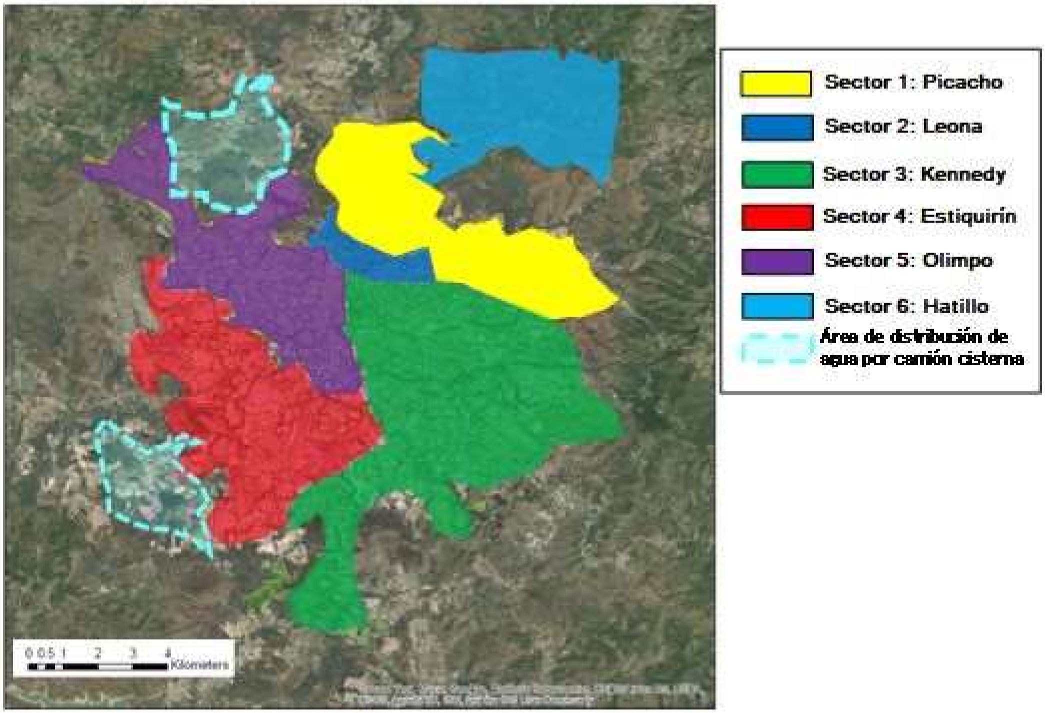
Pipe damaged by break in pipeline

(4) Water Distribution Situation

b) Water Distribution Through the Distribution Pipeline Network

The distribution areas in the municipality are divided into six large sectors. Figure 3-3-52 shows the distribution area sectors. Table 3-3-53 shows the distribution schedule to the distribution areas from the distribution tanks. Currently in 2021, SANAA, which manages the operations of the potable water facilities, publishes the distribution schedule information through its website at a frequency of once every two weeks to ensure the population is aware of the water supply schedule.

At present, in the municipality of Tegucigalpa, the supply volume is lower in relation to the water demand, regardless of the season, whether it is rainy or dry season, and the supply is carried out in a programmed manner. From April to June, when the dry season is ending, the lowest volume of water production is reported. Particularly in 2020, due to the drop in catchment volume, water was distributed once every 9 - 10 days, making the situation very difficult to the population.



Source: Prepared by the Study Team based on SANAA data.

Figure 3-3-52 Map Locations of 6 Range Sectors

Table 3-3-53 Water Distribution from Distribution Tanks to Distribution Areas (Year 2020)

Sector	Season	
	January to March, July to December	April to June
S1 Picacho	Once every 4 days (9 - 14 hours)	Once every 10 days (12 - 18 hours)
S2 Leona	Once every 2 days (10 - 16 hours)	Once every 9 days (12 - 18 hours)
S3 Kennedy	Once every 2 days (8 - 15 hours)	Once every 9 days (12 - 18 hours)
S4 Estiquirín	Once every 2 - 3 days (8 - 15 hours)	Once every 9 days (12 - 18 hours)
S5 Olympus	Once every 3 - 4 days (8 - 12 hours)	Once every 9 days (12 - 18 hours)
S6 Hatillo	Once every 6 days (9 hours)	Once every 4 days (9 - 12 hours)

Source: Prepared by the Study Team based on SANAA data.

g) Water Distribution with Water Tank Trucks

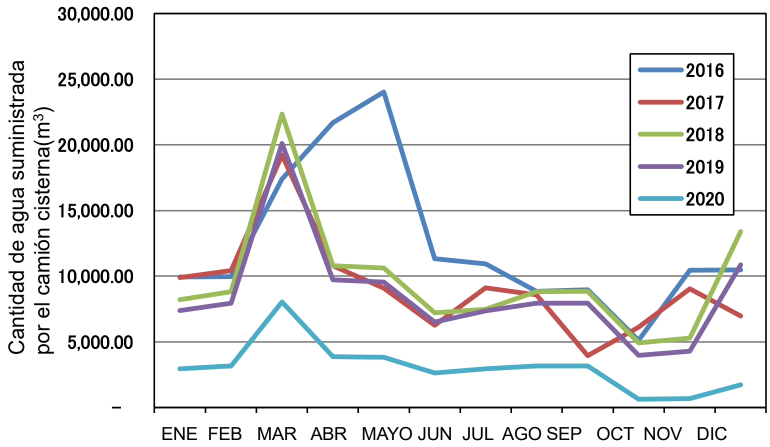
In areas where distribution pipelines have not been installed on the outskirts of the city and in areas within the distribution pipeline network that request service due to lack of supply, water is supplied by private water tank trucks authorized by SANAA. There are currently 3 water supply stations in the Los Filtros, Los Laureles, and Toncontín sectors. The capacity of the tanker supply stations is 250 to 300 water tank trucks in the case of the Los Filtros sector supply station, 200 to 300 water tank trucks in the Toncontín sector station, and 100 to 150 in Los Laureles sector station. It should be noted that the supply stations in the Los Filtros, Los Laureles and Toncontín sectors were donated by Japan in 2006 through Grant Aid.

Table 3-3-54 shows the water tank truck mobilizations carried out. It is observed that in the dry season from March through May every year, more water tank trucks are mobilized due to the lack of water distribution. The decrease in tank truck mobilizations made in 2020 is due to the COVID-19 pandemic. It should be noted that the tank truck's water tariff is 0.198HNL per liter, 15 times more expensive than the normal supply tariff of 0.013 HNL per liter.

Table 3-3-54 Water Tank Truck Supply Volume (m^3)

	2016	2017	2018	2019	2020
January	9,942.95	9,905.36	8,206.65	7,385.99	2,954.39
February	9,964.10	10,422.02	8,821.08	7,938.97	3,175.59
March	17,399.02	19,216.15	22,344.99	20,110.49	8,044.20
April	21,683.20	10,797.22	10,797.22	9,717.50	3,887.00
May	24,029.48	9,098.35	10,632.21	9,568.99	3,827.60
June	11,338.84	6,253.39	7,220.00	6,501.03	2,618.58
July	10,941.22	9,109.83	7,480.76	7,351.92	2,940.77
August	8,849.01	8,568.71	8,820.29	7,938.26	3,175.30
September	8,969.23	3,948.88	8,827.27	7,944.54	3,177.82
October	5,107.69	6,115.82	4,923.99	3,988.43	638.15
November	10,451.25	9,057.25	5,292.65	4,287.04	685.93
December	10,465.19	6,954.80	13,407.00	10,859.67	1,737.55
Total	149,141.18	109,447.79	116,774.10	103,592.83	36,862.87

Source: Prepared by the Study Team based on SANAA data.



Source: Prepared by the Study Team based on SANAA data.

Figure 3-3-53Volume of Supply by Water Tank Truck (m^3)

(5) Water Quality Monitoring

SANAA periodically performs water quality inspections in the distribution pipeline network and in water tank trucks. Basically, every week it monitors 5 - 10 different distribution tanks. Table 3-3-55 shows the number of monitoring performed in 2019 and 2020. From March to May 2020, monitoring was temporarily suspended due to the COVID-19 pandemic. Throughout the year, water quality monitoring is conducted at 60 - 70 locations.

Water quality parameters are turbidity levels, color, pH, residual chlorine, temperature, electrical conductivity, alkalinity, and fecal coliform group. Water quality reference values are generally maintained, although sometimes the turbidity level in distribution tanks exceeds 100 NTU temporarily due to water leaks in the pipes. In addition, in many distribution tanks, residual chlorine is not detected inside the distribution tank due to restricted drinking water service hours.

Table 3-3-55 Water Quality Monitoring Performed

Month	Piping Network		Tanker Truck	
	2020	2019	2020	2019
January	1	7	4	3
February	9	6	4	4
March	0	13	0	5
April	0	5	8	3
May	0	5	8	3
June	3	5	9	2
July	1	5	0	3
August	2	4	4	1
September	19	9	4	10
October	17	3	4	7
November	18	3	6	0
December	4	0	8	0
Total	74	65	59	41

Source: SANAA data edited by the Study Team.

(6) Status of Water Meter Installation

Currently, users who pay the water rate by consumption using the water meter account for 39% of all users. According to UMAPS regulations, the installation of the water meter, its operation and maintenance is the responsibility of the customer. Since there are no water meter regulations, users are not voluntarily performing water meter replacement. On the other hand, when an obsolete meter breaks down, it is possible to continue supplying water by removing the meter without replacing it. In these cases, SANAA changes the tariff regime of the user who removed the meter to fixed tariff regime. In the Miraflores sector, where a water leakage demonstration activity was conducted, many obsolete meters with more than 30 years of use were found. These meters are no longer calibrated, so it is assumed that there is a lot of unmeasured consumption. Another finding is that there are many water leaks in the connection part of the meter. Currently, SANAA is not actively conducting home visits to repair water leaks detected by the meter. On the other hand, if the water leaks originate in the connection pipe just before the meter, the leaks are not reflected in the customer's billing. Also, since unmetered users pay a flat rate, even if the water leaks originate in the connection pipe after the meter and into the house, users do not pay the higher rate for the leaks, and therefore, in many cases they leave them unattended. Especially in 2020, due to the COVID-19 pandemic, meter reading was not performed and all households paid a flat rate, where UMAPS (previously SANAA) did not check for leaks from the meter, and this situation continued. In August 2021, meter reading was resumed.

	
Water leakage from the meter (connection on the utility company side)	Water leakage from the meter (connection on the user's side)

3-3-3-2 Operation and Maintenance

(1) Water Leak Prevention

To repair water leaks, residents call SANAA, the personnel in charge arrives and repairs the pipe. The Department in charge of the measures against water leaks is the Department of Operational Optimization of SANAA. In 2017, there were about 50 people in this Department, however, with the move to UMAPS, the number of staff decreased to about 36 people in 2020. The annual budget available for water leakage is around 17 million lempiras.

For water leak detection, SANAA has acoustic rods and equipment donated by the Spanish Government in 2014, including 2 correlators for water leak location, acoustic leak detectors, 2 metal pipe detectors and plastic pipe detectors. Although they have sufficient knowledge about the handling methods of each equipment, there is no efficient water leak detection system. It should be noted that the ultrasonic flowmeters do not have a working battery, and so measurements cannot be performed if it is not connected to the power outlet.

	
Acoustic leak detector (German)	Correlator for locating water leaks (German)
	
Buried pipe detector (German)	Ultrasonic flowmeter

As prevention measures against water leakage, it is necessary to implement basic measures such as distribution volume and water leakage volume analysis, corrective measures such as detection and repair of exposed and buried water leaks, and preventive measures including improvement of distribution and service pipes. The following table shows the implementation status of these measures.

Table 3-3-56 Status of Implementation of Water Leakage Prevention Measures

Measures	Implementation Status
Basic measurements (distribution volume analysis)	The water leakage volume is analyzed based on billing. Macrometers are not installed in the distribution tanks, and the micro-meter coverage rate for users is around 30%, resulting in an inaccurate analysis of distribution volume.
Corrective actions (detection of water leaks)	Repairs are made after receiving notice of water leaks, i.e., there is no water leak detection system. It takes an average of

	48 hours to repair a water leak, so there is a need for improved water leak repair techniques and rapid response.
Preventive measures	The conduction and distribution pipelines have not been renewed on a scheduled basis. On the other hand, with regard to the distribution pipeline network, there is no organized data including plans, so there is a need to improve the capacity to properly manage the assets.

(2) Maintenance and Replacement

a) Distribution Facilities

To expedite the repair of the pipes when a water leak is reported, materials are sent to the field by motorcycle. At the SANAA office, known as Los Filtros, there is a warehouse of equipment and materials for urgent repairs. They attend to water leak incidents, but do not replace pipes on a scheduled basis.

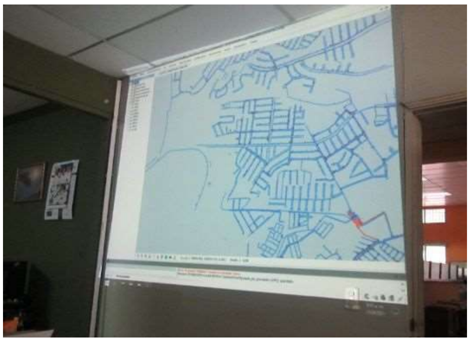
Equipment and materials warehouse

Motorcycle to attend emergencies

The piping plans are in the hands of DAHPO, Special Projects. It has the GIS system called GGS® Software, acquired by a project carried out by AQUARUM with the assistance of the Spanish Government. However, no information has been shared with the Operational Optimization Department ever since the system was delivered in 2014, and no accumulated installation works history data including replacements, leak repairs, and other information are available.

It is necessary to perform asset management based on this system, concentrating information on leakage attention and pipeline repair status.

It should be noted that in the DAHPO office there are 4 A1 scanners, but none of them have spare parts to be used.

	
GGS Software	A1 format scanner

Regarding the distribution tanks, there are many water level meter failures and damaged or missing flow meters. Damaged distribution tanks are abandoned without being repaired. In the distribution tanks, there is a permanent operator who performs valve manipulation. However, no one is aware of the current water distribution situation since no data on operations, flow meters, water level meters, etc. are recorded.

c) Pumping Stations

In the pumping stations, there are operators who take turns every 24 hours to manually operate the pumps. Basically, a system has 2 pumps, one in operation while the other remains on stand-by; however, in many cases one is out of order. Also, there is no record of pump specifications and elevation information for transmission destinations. Because of this, UMAPS cannot replace pumps properly. Some do not have flow meters and pressure gauges installed, or they are faulty, and have not been properly replaced. Even though the pumps have meters, the assigned operator does not keep an operating log of the data, so it is necessary to keep an operating log.

3-4 Current Status and Challenges of Sewerage System

3-4-1 Sewage Discharge System in Municipality of Tegucigalpa

In the municipality of Tegucigalpa, there is an estimate of 1,500 km of sewerage networks. The total length of the sewer mains is approximately 98 km. Forty-five percent of the sewer pipes are made of concrete with more than 50 years of use since their installation, exceeding the standard service life. For this reason, soil subsidence and subsidence due to water leakage, etc. caused by damage to the pipe body or joints are reported in many places. Also, operation and maintenance such as cleaning has not been properly performed, most of the pipes have accumulated dirt and soils inside the pipe, as a consequence, pipe clogging and stagnation of spilled water occur.

The San José de la Vega wastewater treatment plant is located in the southern part of the city, which is the only existing public wastewater treatment plant, and receives approximately 25% of the wastewater generated in the southern part of the city. Most of the wastewater generated in the rest of the city is discharged into the city's rivers without any treatment, causing the water quality in the rivers to deteriorate and resulting in foul odors.

The San José de la Vega WWTP is designed to receive an incoming volume of discharged water of 25,450m^3/day in total. However, due to clogging of existing sewer channels, sewer relay station failures, and sewer plant failures, it is currently only treating approximately 2,000m^3 /day. For this reason, in addition to the rehabilitation and replacement of the existing sewerage networks, it is urgent to rehabilitate the sewage treatment plants. In order to plan and formulate the plan, it is necessary to carry out a detailed study as soon as possible, including a diagnosis of the deterioration and functions of the existing facilities.

The AMDC requests the rehabilitation of the sewerage networks and wastewater treatment plants. In addition to rehabilitating and replacing the sewer networks, it would be necessary to convert the sewer system into a distributed type system. The distributed type is the method where sewer networks are divided into micro-sectors and a micro sewage treatment plant is built in each micro-sector to collect wastewater.

A new wastewater treatment plant will also be built in the Miramesí neighborhood in the northern part of the city. The plan is to provide primary anaerobic treatment and secondary aerobic treatment, followed by disinfection.

Figure 3-4-1 shows the current sanitation situation in the southern zone of the municipality of Tegucigalpa. Table 3-4-1 shows the population served by the watersheds in the southern zone.

Source: Data from AMDC

Figure 3-4-1Current Sanitation Situation in Southern Zone of Municipality of Tegucigalpa

Table 3-4-1 Population Served by Watersheds in Southern Zone

Name of Basin	Total Population (2009)	Population Served (2009)	Coverage (%)	Notes
Salt Water	155,000	80,000	51.61	There are neighborhoods not served by the sewage system
San Jose	80,200	29,674	37.0	There are neighborhoods not served by the sewage system
Choluteca right	190,255	0	0.0	Existing sewage systems discharge into the Choluteca River.
Total	425,455	109.674	25.78	

3-4-2 San José de la Vega Wastewater Treatment Plant

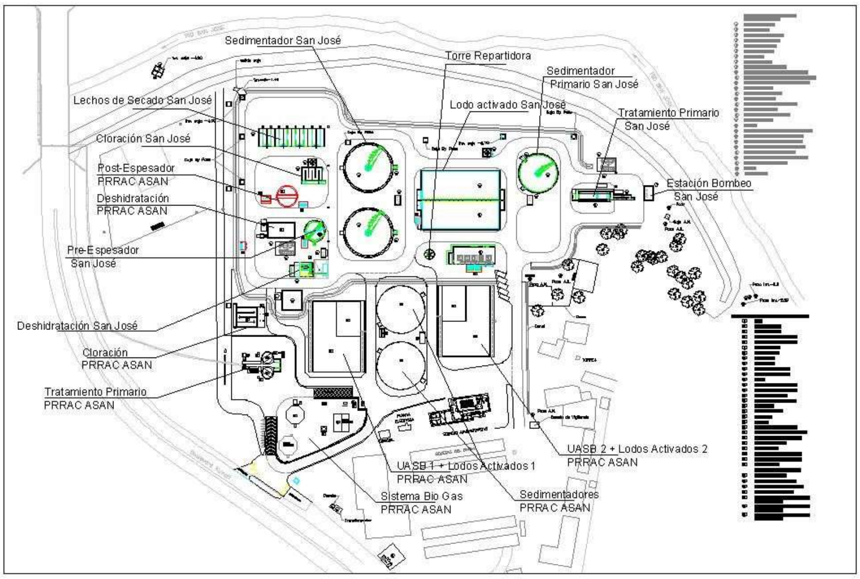
3-4-2-1 General Description

In order to improve the water quality of the Choluteca River, the receiving medium for all sewage in the municipality of Tegucigalpa, the first two wastewater treatment plants in the capital city were built, both located in the southern part of the city, in San José de la Vega. The treatment plants are the following two plants.

(1) **San José de la Vega Wastewater Treatment Plant**: This plant was built by Italian financial cooperation and began operations in 2005. With a capacity of 50,000 inhabitants, it serves the San José de Sabacuante river basin. The design capacity is 8,000 ^{3}m/day.

(2) **PRRAC-ASAN Wastewater Treatment Plant**: This plant was financed by the European Union and began operations in 2007. With a capacity of 200,000 inhabitants, it serves the Agua Salada creek basin. The design capacity is 17,450 ^{3}m/day. It should be noted that the operation of this plant has been totally suspended since 2015 due to the stoppage of two upstream pumping stations due to breakdowns.

The general plan of both plants is shown in Figure 3-4-2-1 below.



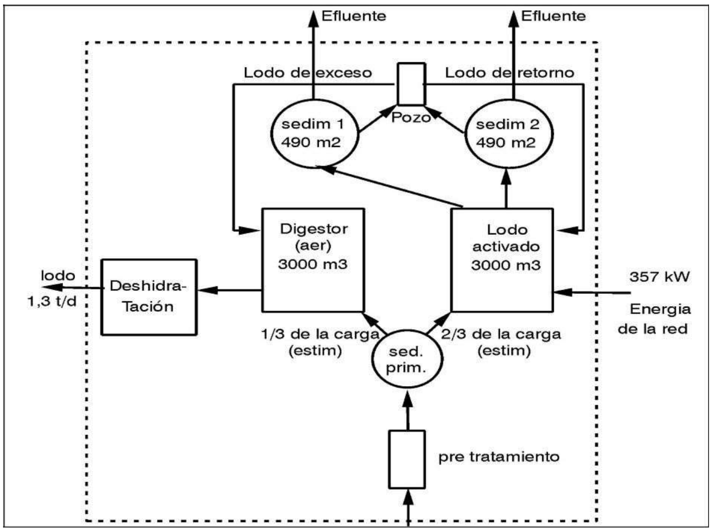
Source: Data from AMDC

Figure 3-4-2General Plan of San José de la Vega (Upper part) and PRRAC ASAN (Lower part) Plants

3-4-2-2 San José de la Vega Wastewater Treatment Plant

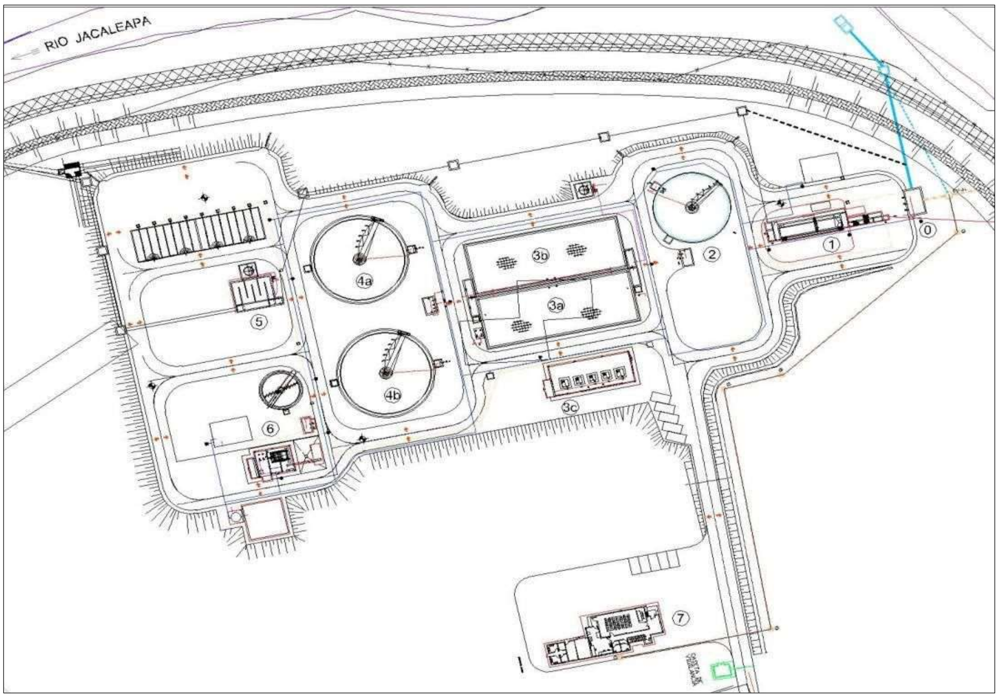
(1) General Description

The process of this plant is the conventional activated sludge system. The treatment process is Pre-treatment (Grit chamber and screen) + Primary sedimentation tank + Aeration tank + Final sedimentation tank + Chlorination. The sludge treatment process is Aerobic digester + Filter press dewatering. Figure 3-4-3 shows the flow diagram, Figure 3-4-4 shows the general plan, Table 3-4-2 shows the main components and Figure 3-4-5 shows the current status of the facilities.



Source: Data from AMDC

Figure 3-4-3San José de la Vega Plant Flow Diagram



Source: Data from AMDC

Figure 3-4-4 General Plan of San José de la Vega Plant

Table 3-4-2 San José de la Vega Plant Major Facilities

No.	Facility	Specifications				Main Equipment	Remarks
	Design capacity	Average daily volume: 8,000 m ^{3}/day					
	Design water quality		Influent mg/L	Effluent mg/L	Removal rate		
		COD	917	<100	>90		
		BOD	561	<50	>92		
		TKN	82	<30	>60		
		T-P	25	<5	>80		
1	Inlet pumping station	Qmax: 200L/s, Qm: 100L/s				・Submersible pump x 3 units	
2	Pre-treatment	・Rectangular grit chamber made of RC (Reinforced Concrete), 1 tank.				・Mechanical screen x 1 unit. ・Sand removal x 1 unit. ・Sand washer x 1 unit. ・Deodorizer x 1 set	
3	Primary sedimentation tank	・Circular sedimentation tank made of RC. ・Depth 20m, Height 3.5m, 1 tank				・Central drive sludge collector x 1 unit. ・Sludge pump	
4	Aeration tank	・Rectangular tank made of RC ・Length 40m, Width 15 m, Height 5 m, Volume 3,000 m ^{3} ・MLSS: 3,500 mg/L				・Membrane air diffuser ・Aeration blower	

No.	Facility	Specifications	Main Equipment	Remarks
5	Final sedimentation tank	・Circular sedimentation tank made of RC. ・Depth 25 m, Height 4.0 m, 2 tanks	・Central drive sludge collector x 2 units. ・Return and excess pumps.	
6	Chlorination tank	・Rectangular tank made of RC	・Sodium hypochlorite dosing equipment.	
7	Aerobic digester	・Rectangular tank made of RC ・Length 40 m, Width 15 m, Height 5 m, Volume 3,000 m^3	・Membrane air diffuser ・Aeration blower	Conversion to aeration tank when the water volume is increased in the future.
8	Sludge dehydrator		・Filter press sludge dehydrator ・1.3 m3/hr, 1 pc. ・Chemical dosing equipment	
9	Electricity receiving system		・Transformer	
10	Emergency power generation system		・Electric generator	
11	Monitoring and control equipment		・Control panel	
12	Water quality laboratory		・Testing equipment	

Source: Prepared by the Study Team based on AMDC data.


Inlet pumping station


Grit chamber and screen


Primary sedimentation tank (suspended)


Aeration tank

	
Final sedimentation tank	Final sedimentation tank overflow trough (in bad condition)
	
Chlorination tank	Sludge dehydrator (filter press)
	
Water quality sampling (influent and effluent)	Water quality laboratory (common use for both plants)

Figure 3-4-5 Current Status of San José de la Vega Plant Facilities

(2) Operation and Maintenance System

The organization for the operations control has already been transferred from SANAA to the AMDC, to the UMAPS Sub management of Sanitary Sewage and Rainfall Drainage team. The team currently has 9 staff who are also in charge of the PRRAC ASAN Plant.

(3) Status of Operations

a) Inlet Flow Rate

At the time of the field survey (September 2021), the incoming volume was about 2,000-3,000 m^3/day. This is considerably less than the design capacity, which is approximately 1/4-1/3. This is reported to be due to the small amount of discharged water reaching the WWTP due to the numerous leaks caused by damage deteriorating sewer channels in the project area (most are more than 50 years old since installation) or due to sediment clogging. The leaked sewage overflows from the manholes, infiltrates into the ground or flows into the rivers, becoming a cause of environmental deterioration.

b) Water Quality

Water quality tests are performed in the water quality laboratory within the plant. Operating indicator parameters such as COD, BOD, and SS are analyzed.

Table 3-4-3, shows the results obtained from the influent and effluent data during the period from 2016 to 2019 (monthly average).

In both cases of influent and effluent, the variations are large and often exceed the design water quality parameters. Despite proper treatment, for an efficient, effective and robust treatment operation, it is necessary to conduct a study of the influent, a study of the functions of the sewer network and the plant, and implement various improvement plans based on the results of these studies.

Table 3-4-3 San José de la Vega Plant Water Quality
(Monthly Average, 2016-2019)

Water Quality Parameter			COD	BOD	SS	Remarks
Unit			mg/L	mg/L	mg/L	
Design Water Quality		Influent	917	561	-	
		Effluent	<100	<50	-	
2016	Influent	Maximum	1,327	884	463	
		Average	958	655	321	
	Effluent		62~154	8~104	16~236	
2017	Influent	Maximum	1,625	862	1,503	
		Average	953	546	435.9	
	Effluent		8~108	2~20	10~34	
2018	Influent	Maximum	1,217	832	1,290	
		Average	930	625	381	
	Effluent		58~140	4~33	11~80	
2019	Influent	Maximum	2,194	666	1,936	
		Average	1,126	507	536	
	Effluent		41~190	4~36	10~135	
Evaluation			In both influent and	In both influent and		

Water Quality Parameter		COD	BOD	SS	Remarks
Unit		mg/L	mg/L	mg/L	
Design Water Quality	Influent	917	561	-	
	Effluent	<100	<50	-	
		effluent, many exceed design values.	effluent, many exceed design values.		

Source: Prepared by the Study Team based on data from the Plant Water Quality Control Department.

c) Operations

The operation of the primary sedimentation tank is suspended, but it is bypassed in order to secure the necessary load for biological treatment in the aeration tank due to the low inflow water volume. Considering the necessary settling time, the operation in one of two final settling tanks is also suspended.

In addition, there are other problems such as concrete corrosion and odor emanation, especially in the pretreatment facilities. Pre-treatment facilities are equipped with a deodorizer (chemical wash type).

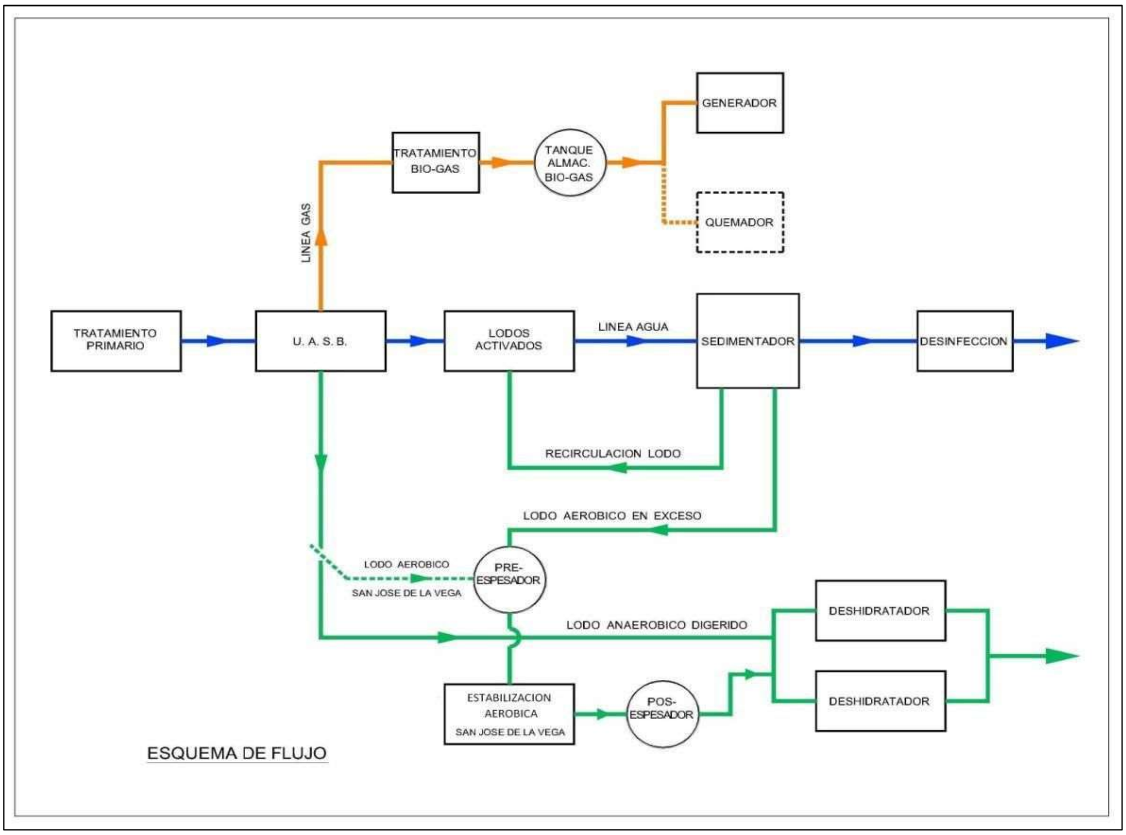
The color of the liquid inside the aeration tank is the color of activated sludge, and the concentration of MLSS (mixed liquor suspended solids) inside the tank is 3,000 mg/L, so it is presumed that the biological treatment is adequate. In the current situation, the detention time in the tank is about 24-36 hours, and in practice, they are operating with extended aeration. In this case, there is usually the situation where the production of bulking is promoted which is a factor of deterioration of the sludge settling capacity in the final sedimentation tank, and this plant is not the exception. In the final sedimentation tank, many sludge flocs overflow, causing deterioration in water quality.

The sludge dewatering operation is carried out about twice a month and the percentage of moisture in the dewatered sludge is approximately 80%. In order to carry out a good and stable treatment operation, it is necessary to permanently know the material balance within the system and to adequately dewater the excess sludge and expel it out of the system. At the moment, it appears that such operation management is not being carried out, so the operation method needs to be improved.

3-4-2-3 Treatment Plant PRRAC-ASAN

(1) General Description

The process of this plant is of the UASB type (upflow anaerobic sludge blanket reactor). The treatment process is Pre-treatment (Grid chamber and screen) + UASB + Aeration tank + Final sedimentation tank + Chlorination. The sludge treatment process is Pre-thickening + Aerobic digester + Post-thickening + Filter press dehydrator. A gas-fired electric generator is installed that uses the digested gas generated from the UASB reactor. Figure 3-4-6 shows the plant flow diagram, Figure 3-4-7 shows the general plan, Table 3-4-4 shows the main components and Figure 3-4-8 shows the current status of the facilities.



Source: Data from AMDC

Figure 3-4-6 PRRAC-ASAN Plant Flow Diagram

Source: Data from AMDC

Figure 3-4-7 General Plan of PRRAC-ASAN Plant

Table 3-4-4 PRRAC-ASAN Plant Main Facilities

<table>
<tr><th>No.</th><th>Facility</th><th colspan="4">Specifications</th><th>Major Equipment</th><th>Remarks</th></tr>
<tr><td></td><td>Design capacity</td><td colspan="4">Average daily volume: 17,450 m^3/day</td><td></td><td></td></tr>
<tr><td rowspan="5"></td><td rowspan="5">Design water quality</td><td></td><td>influent mg/L</td><td>Effluent mg/L</td><td>Removal rate</td><td></td><td></td></tr>
<tr><td>COD</td><td>825</td><td><100</td><td>>90</td><td></td><td></td></tr>
<tr><td>BOD</td><td>480</td><td><50</td><td>>92</td><td></td><td></td></tr>
<tr><td>TKN</td><td>72</td><td><30</td><td>>60</td><td></td><td></td></tr>
<tr><td>T-P</td><td>10.5</td><td><5</td><td>>80</td><td></td><td></td></tr>
<tr><td>1</td><td>Inlet pumping station</td><td colspan="4">ES-1: Qmax 186 L/s
ES-2: Qmax 614 L/s</td><td>・Submersible pump x 3 units.
・Submersible pump x 3 units.</td><td>Suspended due to breakdown</td></tr>
<tr><td>2</td><td>Pre-treatment</td><td colspan="4">・Circular grit chamber made of RC (Reinforced Concrete), 2 tanks.
・Capacity 700L/s</td><td>・Mechanical screen x 1 unit.
・Sand removal x 2 units.
・Sand washer x 1 unit.</td><td></td></tr>
<tr><td>3</td><td>UASB</td><td colspan="4">・Rectangular tank made of RC
・36.3 m x 12.3 m x 5.75 mH, 2 systems
・18 m x 12 m x 5.75 mH, 2 systems
・Total capacity Volume =7,618.62 m^3</td><td></td><td></td></tr>
<tr><td>4</td><td>Aeration tank</td><td colspan="4">・Rectangular tank made of RC
・Length 12 m x Width 18 m x Height 5.75 m x 2 systems
・Total Capacity Volume =2,400 m^3</td><td>・Membrane air diffuser
・Aeration blower</td><td></td></tr>
<tr><td>5</td><td>Final sedimentation tank</td><td colspan="4">・Circular sedimentation tank made of RC.
・Depth 25 m x Height 4.0 m, 2 tanks</td><td>・Central drive sludge collector x 2 units.
・Return and excess sludge pumps.</td><td></td></tr>
<tr><td>6</td><td>Chlorination tank</td><td colspan="4">・Rectangular tank made of RC</td><td>・Sodium hypochlorite dosing equipment.</td><td></td></tr>
<tr><td>7</td><td>Sludge thickener</td><td colspan="4">・Circular tank made of RC
・Dia. 10.9 m x V559.87 m^3</td><td>・Central drive sludge collector x 1 unit.
・Sludge pump</td><td></td></tr>
<tr><td>8</td><td>Sludge dehydrator</td><td colspan="4"></td><td>・Filter Press Dehydrator
・1.3 m3/hr, 2 pcs.
・Chemical dosing equipment.</td><td></td></tr>
<tr><td>9</td><td>Digestion gas equipment</td><td colspan="4"></td><td>・Gas tank (made of rubber).
・Desulfurizer
・Digester gas-fired electric generator.</td><td></td></tr>
<tr><td>10</td><td>Electricity receiving system</td><td colspan="4"></td><td>・Transformer</td><td></td></tr>
</table>

No.	Facility	Specifications	Major Equipment	Remarks
11	Emergency power generation system		・Electric generator	
12	Monitoring and control equipment		・Control panel	

Source: Prepared by the Study Team based on AMDC data.

Sewage pump station -1

Submersible pump of this station (suspended due to failure, buried in the sand).

Grid chamber

UASB

Top of UASB reactor (concrete corrosion and damage)

Digestion gas tank (made of rubber), gas-fired electric generator

Final sedimentation tank

Emergency power generator

Administration building (common use for both floors)

AMDC storage yard (adjoining this plant)

Figure 3-4-8 Current Status of PRRAC-ASAN Plant Facilities

(2) Situation

All influent from this plant passes through two upstream relay stations; however, due to the suspension of all pumps due to failures, all stations have been suspended since 2015.

The operation and maintenance system is under the responsibility of the UMAPS Sanitary Sewer and Rainfall Drainage Sub-Management team, as is the San José de la Vega Plant, although at this time only maintenance of the facilities is being carried out.

Table 3-4-5 shows the 2009 influent data after the start of operations.

Table 3-4-5 PRRAC-ASAN Plant Operations Data (2009, taken from AMDC data)

Parameter	Unit	Design Specifications	2009 Data
Incoming volume	m^3 /day	17,450	9,100
BOD	Mg/L	480	300
COD	Mg/L	825	600
TKN	Mg/L	72	45
T-P	Mg/L	10.5	6.6
Sulfate (SO_4)	Mg/L	35	150-250

At that time, a COD removal rate of 89 % and a high concentration of incoming sulfate were reported, which negatively affected the operating performance of the UASB reactor. In addition, the odor emanation problem was reported.

Due to sulfate ingress and anaerobic gas fumes, there is extensive corrosion of the concrete structures on top of the UASB reactor and damage to the roof. These damages need to be repaired before restarting operations.

3-4-2-4 San José de la Vega Wastewater Treatment Plant Problem

Table 3-4-6 shows the challenges of these plants identified as a result of the interviews with management personnel and the field survey, and their possible measures.

Table 3-4-6 San José de la Vega and PRRAC-ASAN Plants Challenges

Issue	Current Problems	Possible Measures	Remarks
1.Influent and water quality	・La Vega: There is little influent due to damage from deterioration of existing canals/sediment obstruction. ・PRRAC ASAN: All facilities are suspended due to breakdowns in upstream pumping stations resulting from foreign object clogging and sand wear. ・High concentration of incoming sulfate adversely affects the treatment functions.	・Most of the sewerage networks in the city (total length: about 1,500 km) are more than 50 years old since their installation. According to the AMDC study, more than 70% are reported to be non-functioning. It is necessary to carry out a deterioration and a function diagnosis, as well as to clean, repair and replace them properly. ・It is necessary to install a screen upstream of the pump and grid chamber. Also replace the pumps properly. ・It is assumed that the high sulfate concentration is due to the anaerobic process caused by prolonged stay in the canals, so it is important that the water flows quickly.	
2.Plant scale	・The total treatment capacity of the two plants is 25,450 m^3/day; on the other hand, with the increase in population in the project areas, the treatment volume required also increases.	・Review the design volume, and as necessary, upgrade the treatment level and expansion.	
3. Treatment functions	・The sludge bulking at La Vega and the inadequacy of PRRAC ASAN's UASB reactor to improve influent quality. It is inefficient to have two systems within the same site. ・High cost of electricity.	・To perform a diagnosis of the treatment functions including the material balance, review the treatment system to make it more effective, including the proposal to unify the two plants. ・Propose an energy saving system.	

Issue	Current Problems	Possible Measures	Remarks
4. Facilities and equipment	・There are breakdowns/damages to some equipment such as the screen. ・Lack of maintenance work on suspended equipment. ・The installed automatic operation system is not working due to lack of training.	・Make repairs and replacements when necessary and timely. ・It is important to perform periodic inspection, maintenance and repair of suspended equipment. ・Review the content of the automatic operation system, conduct appropriate training.	
5. Operation and maintenance system, etc.	・They are not performing maintenance/upgrading of equipment on a scheduled basis, so failures occur in case of breakdowns and emergencies. ・O&M manual with insufficient content. ・Lack of water quality test content.	・It is required to perform asset management and establish a preventive maintenance program for systems and equipment. ・Development of an appropriate O&M manual. ・Strengthening of water quality testing equipment/system.	