REPUBLIC OF THE PHILLIPINES

# DATA COLLECTION SURVEY FOR SEWERAGE SYSTEM DEVELOPMENT IN DAVAO CITY

# FINAL REPORT (VOLUME 1 MAIN REPORT)

MARCH 2020

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd. (NK)

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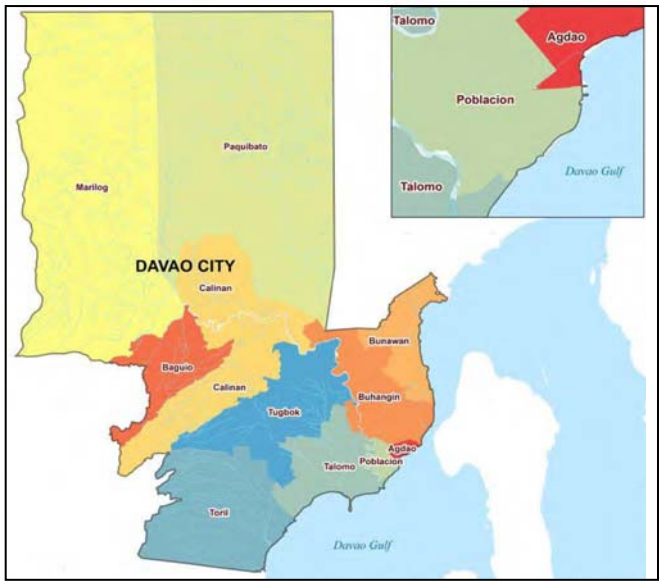
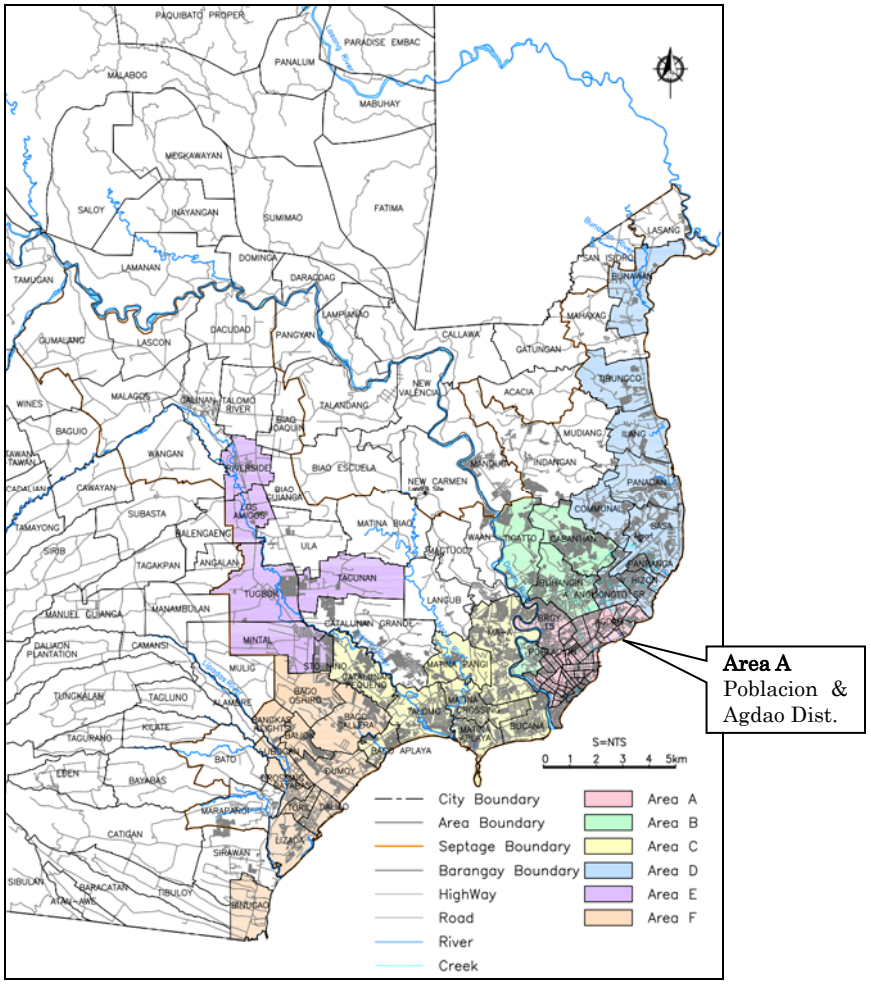



**Entire Davao City Area Map**




**Sewerage System Development Area**

**Location Map of the Study**

# REPUBLIC OF PHILIPPINES
# DATA COLLECTION SURVEY FOR SEWERAGE SYSTEM DEVELOPMENT IN DAVAO CITY

# FINAL REPORT

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# Abbreviations

| Abbreviation | Original |
|---|---|
| ACD | Activated Carbon Deodorizer |
| ADB | Asian Development Bank |
| AIP | Annual Investment Plan |
| ASEAN | Association of South-East Asian Nations |
| ATP | Affordability to Pay |
| BIMP-EAGA | Brunei Darussalam, Indonesia, Malaysia and the Philippines-East Asean Growth Area |
| BNR | Biological Nutrient Removal |
| BOD | Biochemical Oxygen Demand |
| BOT | Build-Operation-Transfer |
| CAAP | Civil Aviation Authority of the Philippines |
| CAPEX | Capital Expenditure |
| CAS | Conventional Activated Sludge |
| CBD | Central Business District |
| CBO | City Building Office |
| CCA | Climate Change Adaptation |
| CENRO | (Davao) City Environment and Natural Resources Office |
| CEO | City Engineer's Office |
| CHO | City Health Office |
| CLUP | Comprehensive Land Use Plan |
| CNC | Certificate for Non-Coverage |
| COD | Chemical Oxygen Demand |
| CPDO | (Davao) City Planning and Development Office |
| CSO | Combined Sewer Overflow |
| CSR | Corporate Social Responsibility |
| CY | Calendar Year |
| CZ | Conservation Zone |
| DCAFDP | Davao City Agriculture and Fishery Development Plan |
| DAO | DENR Administrative Order |
| DBP | Development Bank of Philippines |
| DCCR | Davao City Coastal Road |
| DCWD | Davao City Water District |
| DENR | Department of Environment and Natural Resources |
| DF/R | Draft Final Report |
| DILG | Department of Interior and Local Government |
| DO | Dissolved Oxygen |
| DOA | Department of Agriculture |
| DOF | Department of Finance |
| DOH | Department of Health |
| DPWH | Department of Public Works and Highway |
| DRSDF | Davao Region Spatial Development Framework |

| Abbreviation | Original |
|---|---|
| ECAs | Environmental Critical Areas |
| ECC | Environmental Compliance Certificate |
| ECP | Environmentally Critical Project |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| E&M | Electromechanical |
| EMB | Environmental Management Bureau |
| EMoP | Environmental Monitoring Plan |
| EMP | Environmental Management Plan |
| EO | Executive Order |
| ESC | Environmental and Social Considerations |
| ESSF | Environmental and Social Safeguards Framework |
| FIRR | Financial Internal Rate of Return |
| F/R | Final Report |
| FRP | Fiber Reinforced Plastics |
| F/S | Feasibility Study |
| FY | Financial Year |
| GCA | Government Contracting Agency |
| GL | Ground Level |
| GRDP | Gross Regional Domestic Product |
| GVA | Gross Value Added |
| HHs | Households |
| HIS | Household Interview Survey |
| HUCs | Highly Urbanized Cities |
| IC/R | Inception Report |
| IEE | Initial Environmental Examination |
| IFAS | Integrated Fixed Film Activated Sludge |
| IM4D | Infrastructure Modernization for Davao<br>(Davao City Infrastructure Development Plan and Capacity Building Project) |
| IRA | Internal Revenue Allotment |
| IRR | Implementing Rules and Regulations |
| IT/R | Interim Report |
| JICA | Japan International Cooperation Agency |
| JPY | Japanese Yen |
| L/A | Loan Agreement |
| LBP | Land Bank of Philippines |
| LCC | Life Cycle Cost |
| LCE | Local Chief Executive |
| LFC | Local Financial Committee |
| LGU | Local Government Unit |
| LIG | Low Income Group |
| LWUA | Local Water Utilities Administration |
| MBR | Membrane Bio Reactor |
| MBBR | Moving Bed Biofilm Reactor |

| Abbreviation | Original |
|---|---|
| MDFO | Municipal Development Fund Office |
| MLSS | Mixed Liquor Suspended Solids |
| MOA | Memorandum of Agreement |
| MP | Master Plan |
| MPN | Most Probable Number |
| MRF | Material Recovery Facility |
| MSL | Mean Sea Level |
| MWSS | Metropolitan Waterworks and Sewerage System |
| N/A | Not Available |
| NAMRIA | National Mapping and Resource Information Authority |
| NEDA | National Economic and Development Authority |
| NPCC | National Pollution Control Commission |
| NPV | Net Present Value |
| NRW | Non Revenue Water |
| NSSMP | National Sewerage and Septage Management Program |
| O&M | Operation and Maintenance |
| OCA | Office of City Architect |
| ODA | Official Development Assistance |
| OIC | Officer-in-Charge |
| OPEX | Operating Expense |
| PAGASA | Philippine Atmospheric, Geophysical, and Astronomical Services Administration |
| P.D. | Presidential Decree |
| PDP | Philippine Development Plan |
| PEISS | Philippine Environmental Impact Statement System |
| PEZA | Philippine Economic Zone Authority |
| PHIVOLCS | Philippine Institute of Volcanology and Seismology |
| PHP | Philippine Peso |
| PM | Permanent Magnet |
| PNSDW | Philippine National Standards for Drinking Water |
| PPP | Public-Private Partnership |
| PNB | Philippine National Bank |
| P/S | Pumping Station |
| PSIF | Private Sector Investment Finance |
| PTF | Pre-treated Trickling Filtration |
| RA | Republic Act |
| RAS | Return Activated Sludge |
| RCBC | Reinforced Concrete Box Culvert |
| RCPC | Reinforced Concrete Pipe Culvert |
| ROA | Revenue on Asset |
| ROE | Revenue on Equity |
| RPF | Resettlement Policy Framework |
| SBR | Sequencing Batch Reactor |
| SCA | Septage Collection Area |
| SCADA | Supervisory Control and Data Acquisition |

| Abbreviation | Original |
|---|---|
| SCR | Supreme Court Ruling |
| SDGs | Sustainable Development Goals |
| SGMP | Strategic Growth Management Plan |
| SLA | Service Level Agreement |
| SMF | Septage Management Fee |
| SMR | Self-monitoring Report |
| SPC | Special Purpose Company |
| SPT | Standard Penetration Test |
| SpTP | Septage Treatment Plant |
| SS | Suspended Solids |
| STF | Sludge Treatment Facilities |
| STP | Sewage Treatment Plant |
| TN | Total Nitrogen |
| TP | Total Phosphorus |
| TOR | Terms of Reference |
| TSL | Two Step Loan |
| TSS | Total Suspended Solids |
| UPMin | University of the Philippines Mindanao |
| USAID | US Agency for International Development |
| USD | United States Dollar |
| VS | Volatile Solids |
| WDs | Water Districts |
| WQG | Water Quality Guideline |
| WRZ | Water Resource Zone |
| WSS | Water Supply System |
| WTE | Waste to Energy |
| WTF | Water Treatment Facilities |
| WTP | Willingness to Pay |
| WWTP | Wastewater Treatment Plant |

# CHAPTER 1 INTRODUCTION AND COLLECTION OF BASIC INFORMATION

This chapter includes the introduction for this survey report and basic information on Davao City.

## 1.1 Introduction

### 1.1.1 Objectives of the Survey

Basic information is collected to determine the feasibility of implementing a comprehensive sewerage and septage management plan and priority development project (sewerage development project in the priority area) in Davao City, which is a major city where sewage and septage treatment has not yet been developed.

Also, the possibility of introducing advanced Japanese technology, development policies, and business options are considered from the issues of limited land for sewerage facilities in the priority development area and the development conditions of sewer networks in the city center.

Based on the information and considerations above, the promising funding schemes, including ODA loan by Japan International Cooperation Agency (JICA), were studied and organized.

### 1.1.2 Survey Area

The survey area is Davao City, which is located in the island of Mindanao. The total land area includes zones for residential, industrial, institutional, and agricultural uses as well as unclassified public forests. Areas A to F in the sewerage development area, which were proposed in the "Davao City Infrastructure Development Plan and Capacity Development Project" (hereinafter called as "IM4D") (see Figure 1.2.1), were studied. The septage management area, which was proposed in the feasibility study for the Septage Management Project by USAID, was also studied for the comprehensive sewerage and septage management plan. Area A is the priority development area which was proposed in IM4D. The area is studied carefully in this survey for the planning of the priority development project.

Details of the natural and physical conditions as well as the social and environmental conditions are described in Chapter 2.

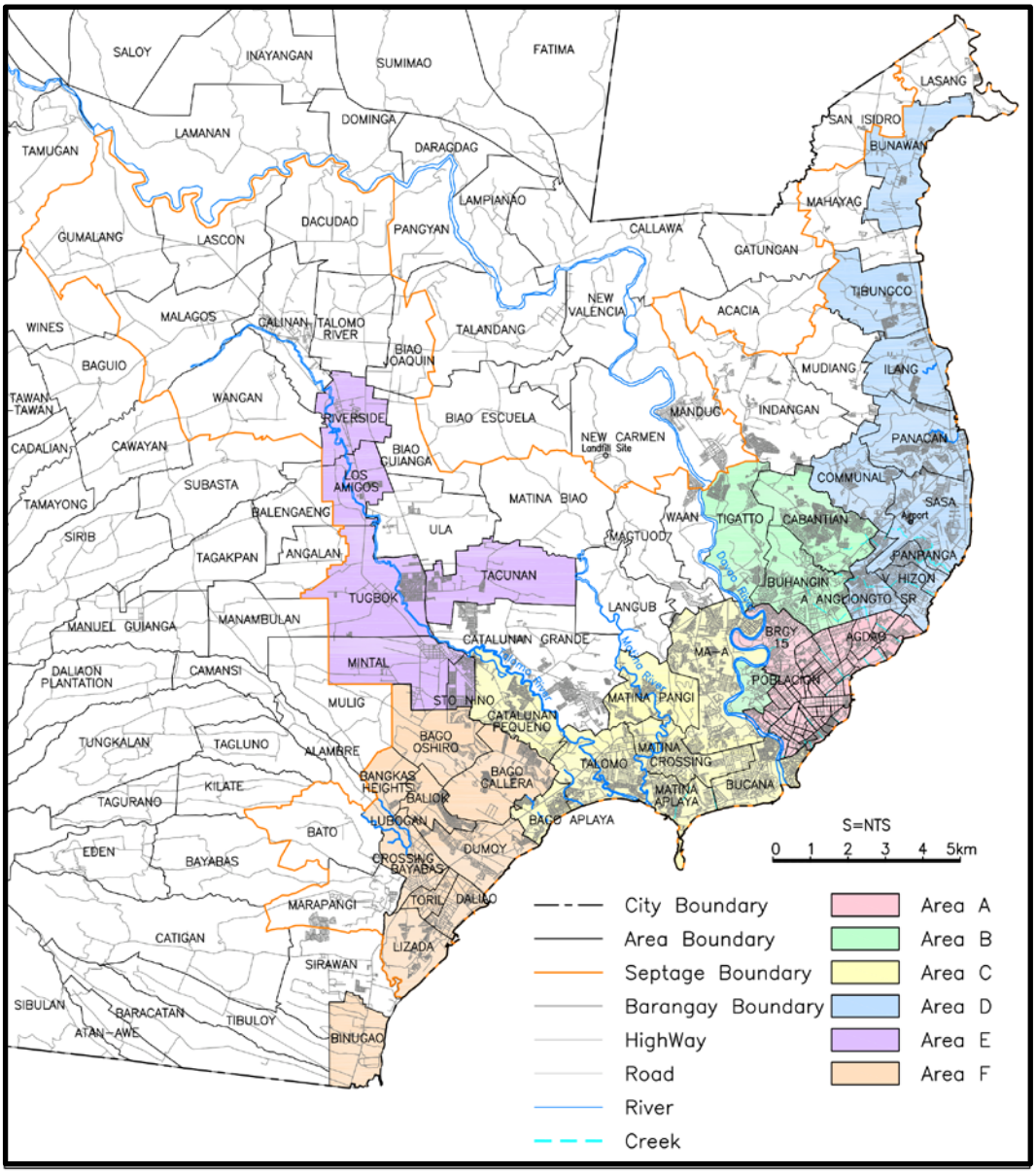
## 1.2 Social, Environmental, and Economic Conditions in Davao City

### 1.2.1 Socio-economic Condition

(1) Ethnicities

Residents of Davao City and the corresponding Davao Region are colloquially known as Davaoeños. Nearly all local Davaoeños are Visayans (majority are Cebuanos, with the rest being Hiligaynons), while others of different ethnicities, collectively categorized as the Lumads, make up the remainder of the local population. Non-Filipino Asians, such as Indonesians, Malaysians, Chinese, Koreans, Japanese,

and Indians, have settled and made small communities in Davao City. Non-Asian foreigners such as Americans and Europeans are also present in the city.




Source: JICA Survey Team

**Figure 1.2.1 Location Map of the Survey Area**

(2) Languages

Cebuano is the most widely used language in the city and in its satellite cities and towns. English is the medium of instruction in schools and is widely understood by residents, who often use it in various professional fields. Aside from Cebuano, Chavacano, and Hiligaynon are also widely used in addition to languages indigenous to the city, such as the Giangan, the Kalagan, the Tagabawa, the Matigsalug, the Ata Manobo, and the Obo.

(3) Religion

Majority of inhabitants in Davao City are Roman Catholic, comprising 80% of the population. Other Christian groups, such as the Iglesia ni Cristo and Miracle Crusade, comprise 18% of the religious

background in the city. The remaining two percent belong to non-Christian faiths, mainly Islam. Some of the other faiths are Sikhism, Hinduism, Buddhism, Animism, Judaism, and the non-religious.

(4) Economy

Davao City has been named the "Asian City of the Future" and the "Crown Jewel of Mindanao" since it is the richest city in Mindanao in terms of income. Thus, it is recognized as the largest city in the Brunei Darussalam, Indonesia, Malaysia, and the Philippines-East Asean Growth Area (BIMP-EAGA) Economic Circle, or the sub-regional economic cooperation initiative in Southeast Asia.

Like the rest of the country, Davao City operates on an economic system that is market-oriented, although pricing mechanisms remain regulated in a few sectors, particularly on basic commodities, to protect consumers. The city has a projected average annual growth of 2.53% over a 15-year period (2006-2020), and it is 87$^{th}$ rank in all the cities worldwide.

(5) Industry

1) GRDP

With the Gross Regional Domestic Product (GRDP) in Davao City during the year 2000, constant prices grew steadily by an average annual rate of nearly 9% from PHP 281.4 billion in 2014 to PHP 333 billion in 2016. (See Table A1.1.1 in Appendix 1.1) This regional growth was mainly fueled by the industry (secondary) and services (tertiary) sectors, which had gross value added (GVA) shares of 36.7% and 51.1%, respectively. The industry sector grew by 14.4% on average during this period, while the services sector expanded by 7.5%. However, the primary sector (agriculture, fishery, and forestry) recorded a minus 1.3% contraction in 2016, which was attributed to the declining production of rice, corn, livestock, particularly hogs and cattle, and fishery subsectors. It is argued, however, that the economy of Davao Region as a whole grew at a steady pace.

2) Registered Capitalization

For the 3-year period covering 2013 to 2015, business capitalization registered yearly at the Business Bureau of the city grew by 1.4% per year on the average. As of 2016, the total capitalization stands at PHP 176 billion. At the administrative district level, it is apparent that the concentration of commercial activities is highest in the Poblacion, and industrial activities are more pronounced in the Toril District. Details on capitalization categorized by the broad economic sector for 2016 is given in Table A1.1.2 in Appendix 1.1.

3) Characteristic of Industry

a) Primary Industry (Agriculture, Fishery, and Forestry)

The main products of the primary industry in Davao City include pineapple, vegetables, durian, cacao, coffee, banana, mango, pomelo, fish, and aquaculture.

b) Secondary Industry (Manufacturing, Construction, etc.)

The main products of the secondary industry in Davao City include food processing (chocolate, fruits, vegetables, coconut, and fish), beverage, and construction materials (cement, steel rolling).

c) Tertiary Industry (Service, Trade, etc.)

The main business types of tertiary industry in Davao City is trade and repair, real estate, and rentals.

### 1.2.2 Administrative Division and Population

The city is comprised of 182 barangays grouped into 11 administrative districts and 3 political (or congressional) districts, as shown in Table 1.2.1 and Figure 1.2.2. The total population in Davao City is 1,632,991 in 2015, and the annual average growth of the population from 2010 to 2015 was 2.3%. The detailed administrative division, population, and land area data in barangays are shown in Appendix 1.2.

The area and population densities in Davao City are shown in Table 1.2.2. Davao City has a massive area of 244,000 ha (or 2,440 $km^2$), which is the largest city area in the world. Around 50% of the area is occupied with plantation and tropical rainforest. The population projection of Davao City is shown in Appendix 1.3. The land use in each district is shown in Appendix 1.4.

**Table 1.2.1 Administrative Division and Population in 2000, 2010, and 2015**

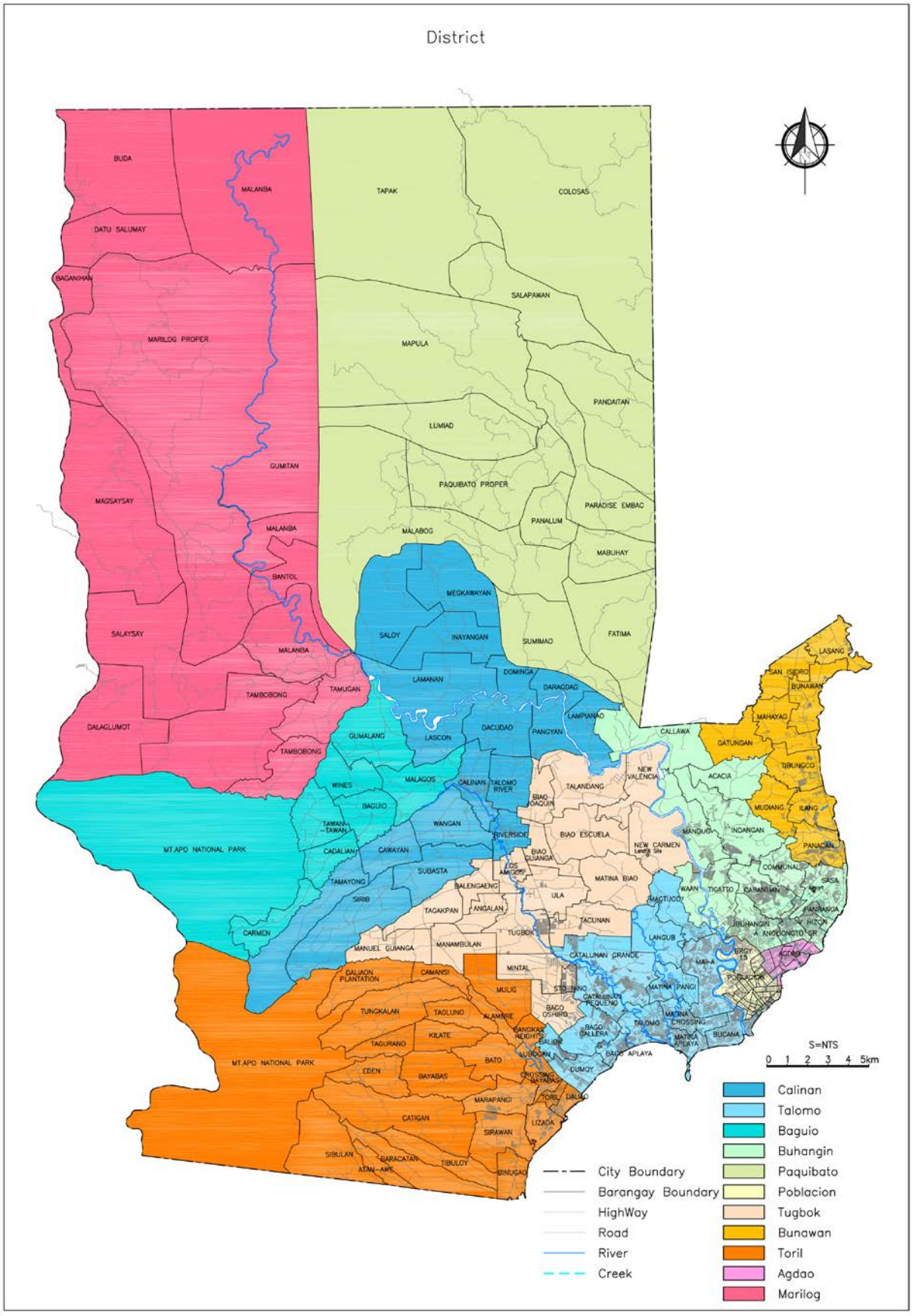
| Congressional District | Administrative District | No. of Barangays | No. of HHs, 2015 | Total Population by Census Year | | | Annual Ave. Growth (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | | 2000 | 2010 | 2015 | 2000–2010 | 2010–2015 |
| 1 | Poblacion | 40 | 43,712 | 133,639 | 156,450 | 174,121 | 1.6 | 2.2 |
| | Talomo | 14 | 105,090 | 284,100 | 382,652 | 418,615 | 3.0 | 1.8 |
| 2 | Agdao | 11 | 25,673 | 91,397 | 99,406 | 102,267 | 0.8 | 0.6 |
| | Buhangin | 3 | 73,585 | 193,519 | 256,959 | 293,118 | 2.9 | 2.7 |
| | Bunawan | 9 | 38,185 | 97,641 | 103,615 | 152,102 | 0.6 | 8.0 |
| | Paquibato | 13 | 11,237 | 35,270 | 39,698 | 44,763 | 1.2 | 2.4 |
| 3 | Baguio | 8 | 8,503 | 24,379 | 30,384 | 33,873 | 2.2 | 2.2 |
| | Calinan | 19 | 23,115 | 67,077 | 81,844 | 92,075 | 2.0 | 2.4 |
| | Marilog | 12 | 13,105 | 42,736 | 45,125 | 52,201 | 0.5 | 3.0 |
| | Toril | 25 | 37,285 | 108,054 | 133,452 | 148,522 | 2.1 | 2.2 |
| | Tugbok | 18 | 30,460 | 69,304 | 91,622 | 121,334 | 2.8 | 5.8 |
| Davao City | | 182 | 409,951 | 1,147,116 | 1,421,207 | 1,632,991 | 2.4 | 2.3 |

Sources: IM4D based on Primary data from PSA and calculations for 2015 households used average household size of 4 persons.

**Table 1.2.2 Area and Population Densities in Davao City by District in 2000, 2010, and 2015**

| Congressional District | Administrative District | Area (ha) | Population Densities (person/ha) | | |
|---|---|---|---|---|---|
| | | | 2000 | 2010 | 2015 |
| 1 | Poblacion | 1,138 | 117 | 168 | 172 |
| | Talomo | 8,916 | 32 | 43 | 47 |
| 2 | Agdao | 593 | 154 | 168 | 172 |
| | Buhangin | 9,508 | 20 | 26 | 30 |
| | Bunawan | 6,694 | 15 | 15 | 23 |
| | Paquibato | 66,242 | 0.5 | 0.6 | 0.7 |
| 3 | Baguio | 19,023 | 1 | 2 | 2 |
| | Calinan | 23,236 | 3 | 4 | 4 |
| | Marilog | 63,800 | 0.7 | 0.7 | 0.9 |
| | Toril | 29,459 | 4 | 5 | 5 |
| | Tugbok | 15,391 | 5 | 6 | 8 |
| Davao City | | 244,000 | 5 | 6 | 7 |
| City of Manila[1] | | 43 | 369 | 385 | 415 |
| Quezon City[1] | | 165 | 131 | 167 | 178 |

[1] Comparison with two highly urbanized cities in northern Philippines (in Luzon) is given here.
Source: IM4D based on PSA and CPDO of Davao City




Source: JICA Survey Team

**Figure 1.2.2 Administrative District and Barangay**

## 1.3 Existing Plans in Davao City

### 1.3.1 Overall Plan

(1) The Davao Region Spatial Development Framework 2015-2045 and Updated Regional Physical Framework Plan XI

As the regional level spatial plan formulated by NEDA XI, the Davao Region Spatial Development Framework (DRSDF) for the period 2015–2045 focuses on the National Spatial Strategy (NSS) principles of concentration, connectivity, and vulnerability reduction. In the plan, the Davao Region is envisaged as the logistics hub of Southern Philippines, resilient and with a rich biography, a haven for human growth and development. Moreover, the framework defines the space where the initiatives under the Davao Regional Development Plan can be pursued.

### 1.3.2 Development Plan

(1) Davao City Infrastructure Development Plan and Capacity Building Project by 2045

The development plan considered as the master plan of all the infrastructure development works. including sewerage development by 2045, was prepared by JICA and is called the “Infrastructure Modernization in Davao (IM4D)”. The master plan was published in June 2018. The plan was composed of the infrastructure development/improvement in 1) land development, 2) transportation, 3) water supply, 4) sewerage, and 5) solid waste.

The details of the sewerage development master plan are explained in Chapter 4, and the priority development projects in Agdao and Poblacion Districts are presented in Chapter 6.

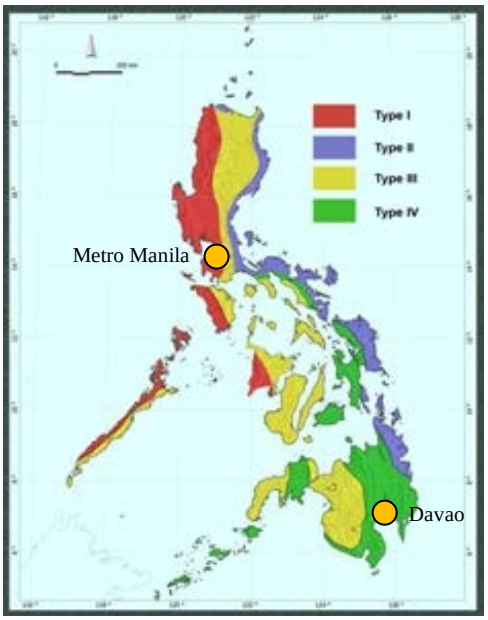
(2) Septage Management Program by 2030

The “Davao City Water District and the Philippine Water Revolving Fund Follow-on Program: Davao City Septage Management Project: Feasibility Study” was prepared in June 2013 and was financed by USAID. In the report, the Septage Management Program until 2030 was prepared with the concept of collecting and treating septage from septic tanks mainly in the DCWD service area. The contents are explained in Section 4.6.

## 1.4 Natural and Physical Conditions of Davao City

### 1.4.1 Climate

The Philippines has a tropical maritime climate. It is characterized by relatively high temperature, high humidity, and abundant rainfall. Based on the Modified Coronas Climate Classification of the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), the climate in the study area falls under Type 4, as shown in Figure 1.4.1. This means that rainfall is more or less evenly distributed throughout the year. This type resembles Type 2, which has a description of "no dry season with a very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May."




Note: 1. Type I: dry from November to April
2. Type III: dry for one to three months
Source: PAGASA

**Figure 1.4.1 Climate Map of the Philippines**

Davao has a tropical rainforest climate, with little seasonal variation in temperature. As shown in Table 1.4.1, the average monthly temperatures are always above 27°C, and the average monthly rainfall is above 100 millimeters. The values were recorded in June.

**Table 1.4.1 Climate in Davao City (1981–2010)**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Record high °C | 35.0 | 36.7 | 36.7 | 37.0 | 37.3 | 35.2 | 35.6 | 36.0 | 35.1 | 35.6 | 36.2 | 35.0 | 37.3 |
| Average high °C | 30.8 | 31.2 | 32.2 | 33.0 | 32.6 | 31.8 | 31.5 | 31.7 | 31.9 | 32.3 | 32.1 | 31.4 | 31.9 |
| Daily mean °C | 27.1 | 27.3 | 27.9 | 28.6 | 28.6 | 28.0 | 27.7 | 27.9 | 27.9 | 28.1 | 28.0 | 27.5 | 27.9 |
| Average low °C | 23.3 | 23.3 | 23.6 | 24.2 | 24.6 | 24.2 | 23.9 | 24.0 | 23.9 | 23.9 | 23.9 | 23.7 | 23.9 |
| Record low °C | 17.0 | 16.1 | 17.4 | 19.1 | 20.2 | 20.3 | 20.0 | 18.5 | 20.0 | 19.2 | 19.1 | 16.2 | 16.1 |
| Average rainfall mm | 140.3 | 109.4 | 108.4 | 124.7 | 158.7 | 186.7 | 165.0 | 170.0 | 170.4 | 174.8 | 138.1 | 112.6 | 1,759.1 |
| Average rainy days (≥ 0.1 mm) | 14 | 12 | 11 | 11 | 16 | 18 | 16 | 15 | 15 | 16 | 16 | 14 | 174 |
| Average relative humidity (%) | 82 | 81 | 78 | 77 | 80 | 82 | 83 | 82 | 82 | 81 | 82 | 81 | 81 |

Source: PAGASA

### 1.4.2 Geography

(1) Geographic Condition

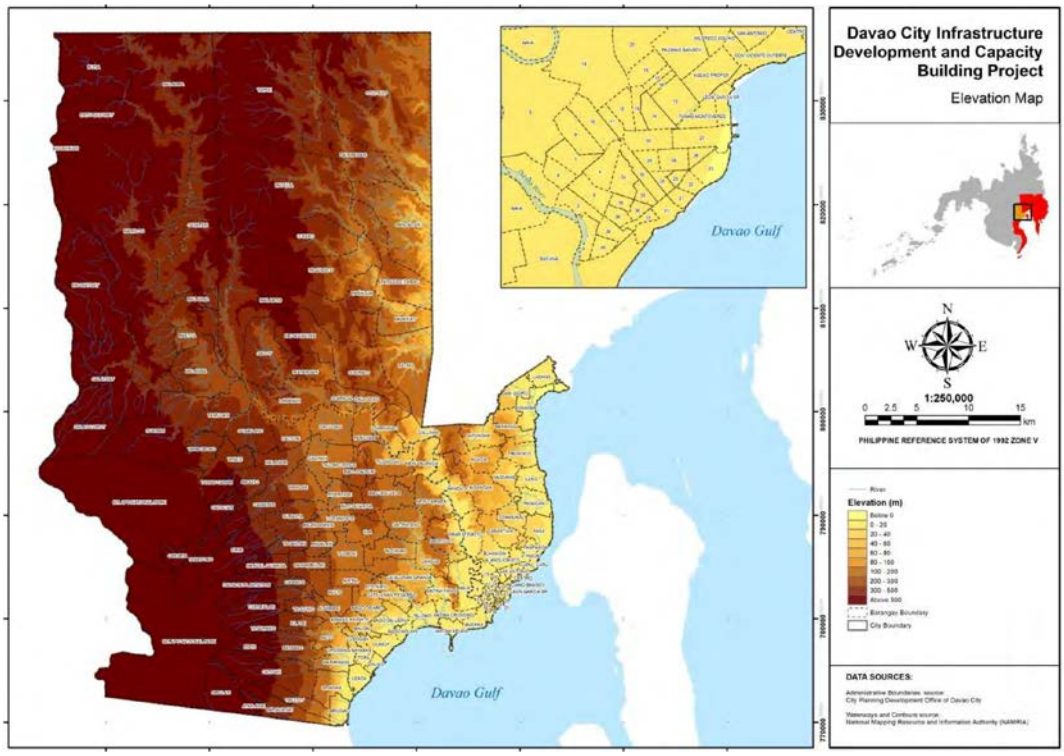
Davao City is approximately 946 km (588 mi) southeast of Manila over land and 971 km (524 NM) by sea. The city is located in southeastern Mindanao, on the northwestern shore of Davao Gulf, opposite Samal Island.

The geographical features of Davao City show hilly terrain and mountains with volcanic complex consisting of two inactive volcanoes, namely Mt. Sibulan and Mt. Talomo, and one semi-active volcano, Mt. Apo. Mt. Apo is also the highest mountain in the country, straddling parts of Davao City, North Cotabato, and Davao del Sur.

(2) General Topographic Condition in Entire Davao City

The topographical profile of the study area shows that it is composed of mountains and lowlands, with mountains dominating the north and extending to the southwest closer to Mt. Apo. Covering the southeast section of the city, on the other hand, are flat areas where urbanization continues to expand. Flat areas are distributed along the coastline facing Samal Island and the Davao Gulf.

Given the landforms comprising Davao City, the elevation ranges from below 0 m to as high as 1,385 m. Areas with high elevation are found mostly in Congressional District 3 and some in District 2. Low-elevation areas are distributed along the coastline barangays of District 1 and District 2, as shown in Figure 1.4.2.




Source: IM4D based on NAMRIA data

**Figure 1.4.2 Elevation Map of Davao City**

(3) Topographic Condition in Proposed Sewerage Development Area in IM4D

The topographic map of NAMRIA covers most parts of the proposed sewerage development area in IM4D and is shown in Figure 1.4.3. The topographic condition in the Agdao District and Poblacion District, which belong to Area A and has the highest priority area, shows that the land is flat with less than 10 m elevation. The south part of Barangay Buhangin, which belongs to Area B, is also flat with around 10 m elevation with the northern part having a hilly area towards Tigatto District, which shows an elevation of nearly 100 m.

Barangays Bucana and Matina Aplaya, which belong to Area C, are located beside the sea. The area shows a flat condition, but towards the northern side, the elevation rapidly increases and reaches up to 100 m elevation. Barangay Matina Pangi, which is north of Area C, is in a hilly and mountainous area.

Barangays Panganga, Sasa, and Panacan belong to Area D. Barangay Panpanga, part of the southern part of Area D, is almost flat with less than 10 m elevation. However, towards the north, the lowland decreases gradually, and a low area with less than 10 m elevation is limited to the seaside area.

From Area F, with the seaside area to Area E in the inland, the elevation rapidly increases with most of Area E located in area having an elevation of more than 100 m.

### 1.4.3 Geology

(1) Geology in Davao City

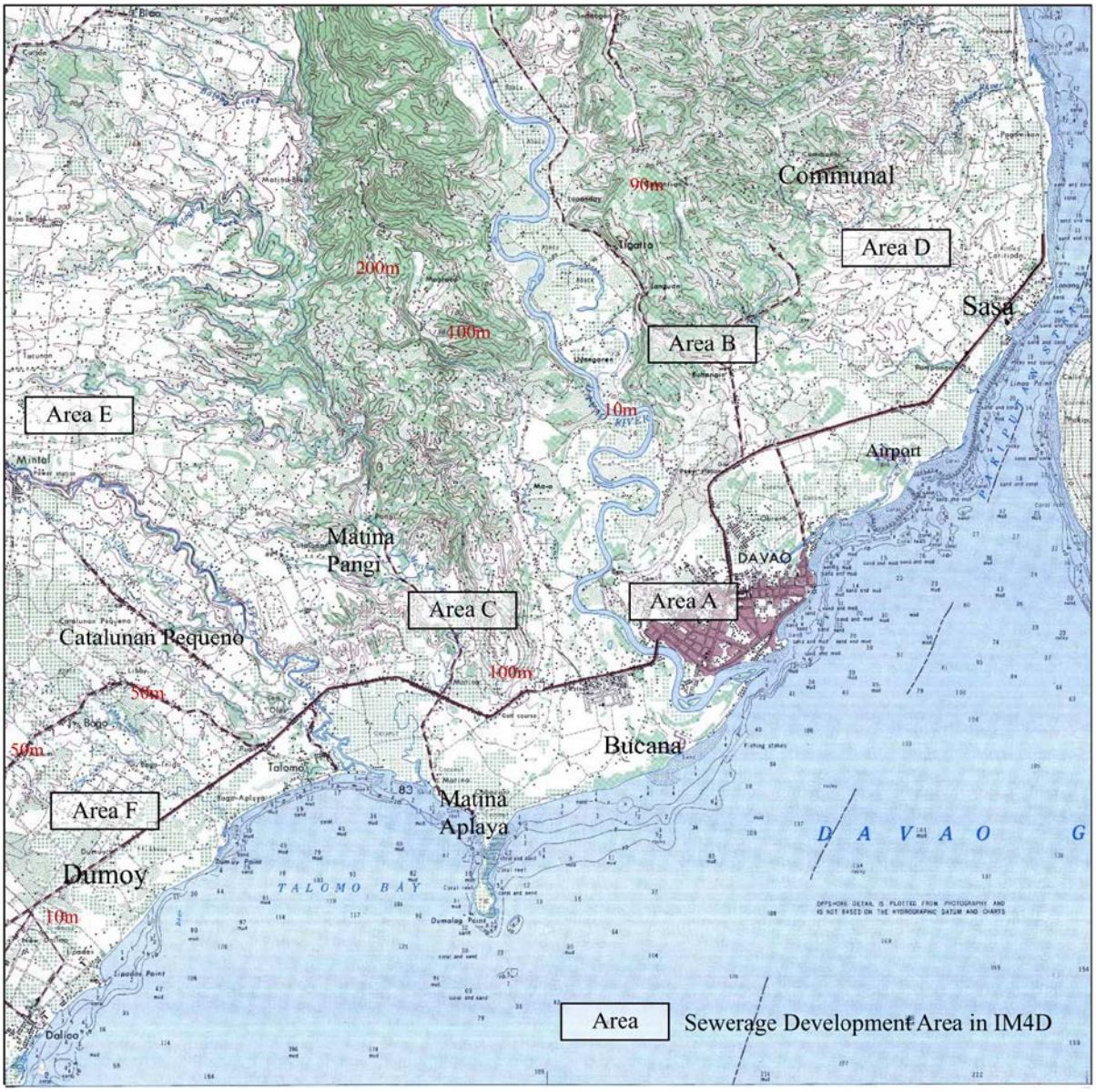
Most parts of the mountainous slopes of the Davao provinces are generally covered with a sequence of sedimentary rocks and volcanic sediments.

The physiography of Davao River Basin and other river systems of Mt. Talomo, Mt. Apo, and Mt. Tipolog and its immediate surroundings are primarily the product of several events of volcanism, erosion process, sedimentation, and minor uplifts. Talomo River used to flow towards the east, but recent volcanism and erosion in the area shifted its flow direction towards the south (Davao Gulf). Evidences of old river channels south and southeast of the present course of the Talomo River main channel likewise indicated the occurrence of several episodes of volcanic activities in the past.

The city is abundant in metallic minerals, such as chromium, copper, gold, silver, and lead, as well as nonmetallic minerals, such as limestone, white clay, molybdenum, phosphate, and sulfur.

(2) Earthquake

The strongest recorded earthquake that had hit Davao City occurred on 4 December 2013. According to the Philippine Institute of Volcanology and Seismology (PHIVOLCS) website, the 5.7-magnitude earthquake not only hit the city but other cities and municipalities comprising the Davao Region as well. The earthquake was classified as moderate (Intensity V), which can cause minimal damage in areas near the epicenter.




Source: NAMRIA

**Figure 1.4.3 Topographic Map of the Proposed Sewerage Development Area in IM4D**

### 1.4.4 Hydrology/Water Body

(1) Classification of Water Bodies in the Philippines

Surface waters are classified to maintain a safe quality and satisfactory condition according to their best usage. Table 1.4.2 shows the current classification for fresh surface water and coastal and marine waters, accordingly.

**Table 1.4.2 Current Classification of Water Bodies for Fresh Surface Water According to Beneficial Use**

| Classification | Beneficial Use |
|---|---|
| **Inland Surface Water** | |
| Class AA | Public Water Supply Class I. This class is intended primarily for waters having watersheds that are uninhabited and otherwise protected and that require only approved disinfection in order to meet the Philippine National Standards for Drinking Water (PNSDW) |
| Class A | Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the PNSDW |
| Class B | Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes) |
| Class C | 1) Fishery Water. For the propagation and growth of fish and other aquatic resources<br>2) Recreational Water Class II (e.g., boating, etc.)<br>3) Industrial Water Supply Class I (For manufacturing processes after treatment) |
| Class D | 1) For agriculture, irrigation, livestock watering, etc.<br>2) Industrial Water Supply Class II (e.g., cooling, etc.)<br>3) Other inland waters, by their quality, belong to this classification |
| **Marine Water** | |
| Class SA | 1) Waters suitable for the propagation, survival, and harvesting of shellfish for commercial purposes<br>2) Tourist zones and national marine parks and reserves established under the Presidential Proclamation No. 1801; existing laws and/or declared as such by appropriate government agencies<br>3) Coral reef parks and reserves designated by law and concerned authorities |
| Class SB | 1) Recreational Water Class I (Areas regularly used by the public for bathing, swimming, skin diving, etc.)<br>2) Fishery Water Class I (Spawning areas for *Chanos chanos* or *"Bangus"* and similar species) |
| Class SC | 1) Recreational Water Class II (e.g., boating, etc.)<br>2) Fishery Water Class II (Commercial and sustenance fishing)<br>3) Marshes and/or mangrove areas declared as fish and wildlife sanctuaries |
| Class SD | 1) Industrial Water Supply Class II (e.g., cooling, etc.);<br>2) Other coastal and marine waters, by their quality, belong to this classification |

Source: DAO No. 1990 – 34, Revised Water Usage and Classification Water Quality Criteria Amending Section Nos.

(2) River

Davao City has six major rivers, namely Davao River, Talomo River, Lipadas River, Matina River, Bunawan River, and Lasang River, as shown in Figure A1.5.1 in Appendix 1.5. The northern area of Davao City is part of the Tuganay River Watershed, while the southern area is part of the Sibulan Watershed. Out of six major rivers, only Davao River flows in Area A.

Davao River

Davao River originates from its headwater or source in some small portions lying within the mountain ranges in the provinces of Davao del Norte and Bukidnon on the northern boundary, North Cotabato on the western boundary, and the major portion within the territory of Davao City. It flows southward, meandering through the central part of Davao City and finally flows eastward, emptying into Davao Gulf at the southern periphery of the city proper.

The Davao River catchment is considered to be the third largest river basin in the Southern Philippines, Mindanao, covering an area of over 1,623 $km^2$ (627 sq mi). Most of the area is upland.

The river was officially classified as Class A water for upstream and Class B for downstream through the DENR Memorandum Circular No. 97-08 dated 20 May 1997.

The Davao River WQMA covers 43 barangays out of the 182 barangays in Davao City and traverses in the three ($1^{st}$, $2^{nd}$, and $3^{rd}$) congressional districts.

# CHAPTER 2 LEGISLATION RELATED TO SEWAGE AND SEPTAGE MANAGEMENT

This chapter is composed of legislation in the Philippines related to sewage and septage management, including environmental and social consideration. The past water sector projects by concerned donors in Davao are also mentioned.

## 2.1 Legislation related to Sewage and Septage Management

### 2.1.1 Governmental Policy

1) Philippine Development Plan (PDP) 2017-2022

The National Economic and Development Authority (NEDA) has published the 6-year development plan for 2017 to 2022. This plan is a main guideline for the policy making of all the industrial and infrastructure sectors and as well as the implementation of development works. It also takes into account the country's international commitments, such as the 2030 Sustainable Development Goals (SDGs).

In the part regarding water resources, the low nationwide coverage (4.4%) of the sewerage system and the lack of implementation of any project by the National Sewerage and Septage Management Program (NSSMP) were introduced as issues. The target for the water and sanitation sectors is shown in Table 2.1.1 which serves as basic indicators; however, the targeted percentage of sewerage coverage was not mentioned. As a measure for improving the sanitation condition, the strengthening of NSSMP, which promises 1) to include septage projects, 2) to expand eligibility to less urbanized cities and municipalities, and 3) to allow water districts (WDs) to directly apply for the grant, were mentioned in the Philippine Development Plan (PDP).

**Table 2.1.1 PDP Targets to Accelerate Infrastructure Development (Water and Sanitation)**

| Indicators | Baseline | | End of Plan Target | |
|---|---|---|---|---|
| | Year | Value | Year | Value |
| **Water and Sanitation** | | | | |
| Percentage of households (HHs) with access to safe water supply increase | 2014 | 85.50 | 2022 | 95.16 |
| Percentage of HHs with access to basic sanitation increase | 2014 | 94.10 | 2022 | 97.46 |

Source: PDP 2017-2022 compiled by JICA Study Team

2) National Sewerage and Septage Management Program (NSSMP)

The National Sewerage and Septage Management Program (NSSMP) was prepared by the Department of Public Works and Highways (DPWH) and was approved by the NEDA Board in May 2010 to improve water quality and to protect public health in urban areas of the Philippines. The program operation manual was issued in March 2013, and the program was amended in 2017.

NSSMP requires Highly Urbanized Cities (HUCs), including Davao City, to provide sewerage and septage services to minimize the adverse impacts of domestic wastewater discharges on water quality and water resources in general. One of the NSSMP targets for areas outside Metro Manila is "Target 1". In the original version of NSSSMP, it was planned that all LGUs should develop septage management systems. The 17 HUCs should have developed sewerage systems by 2020, and the applicability of septage services were also expanded to other HUCs in the 2017 amendment. The organizations responsible for the project implementation of sewerage/septage services shall be the local government units (LGUs) and water districts (WDs).

To support the projects, DPWH provides financial support under the NSSMP scheme to implementers, with 40% grant fund from the national government. It was later increased to 50% in the 2017 amendment. The comparison of the NSSMP subsidy before and after amendment can be summarized as follows:

**Table 2.1.2 Comparison between Original Program and Amendment in NSSMP**

| Item | Original Program 2010 | Amendment 2017 |
|---|---|---|
| Subsidy Coverage | 40% of total project cost | 50% of total project cost |
| Project Coverage | Sewerage Projects only | Sewerage and Septage Projects |
| Target Beneficiaries | 17 HUCs outside Metro Manila | 17 HUCs outside Metro Manila<br>Non-HUCs<br>1st Class Municipalities |

Source: DPWH

When applying for a grant fund, the LGU should be the applicant, and the WD should support the LGU's application.

The JICA Survey Team conducted interviews with DPWH[1] to confirm the details of the NSSMP. The confirmed contents are as follows:

- Due to the application rule, only the LGUs can receive the NSSMP grant fund. Basically, the LGUs should be the implementating agency for the sanitation project. There is no legal base for DPWH to pay the grant fund to the WDs directly.
- In case the WD takes a partial role in implementation and needs the NSSMP grant fund, the funded amount to the LGU can be transferred to the WDs under the basic concept of cooperation between the LGU and the WD for any sanitation project.
- As of 2019, only the LGU of Zamboanga City received a grant fund for sewerage. The application by Cotabato City is near approval. The grant can be applied along with the phasing of the project like the case of Zamboanga. The second and latter phases, not only the first phase, can be applied to the NSSMP.
- There is no cap for the NSSMP budget, but the NSSMP grant application shall be subjected for final approval by NEDA.

[1] The interview was conducted on 25th March and 19th August 2019, to a head and engineers in NSSMP section - Environmental & Social Safeguards Division (ESSD) of DPWH. A project manager of Unified Project Management Offices (UPMO) - Flood Control Management Cluster (FCMC), Flood Control and Sabo Engineering Center. (FCSEC) of DPWH also joined to provide inputs on ODA loan.

Regarding the Zamboanga City case above, there was a financial plan of 50% from NSSMP and 50% from Zamboanga City for capital cost, but because of the delay of the subsidy (NSSMP), Zamboanga City intends to finance the whole CAPEX by loan from a commercial bank

### 2.1.2 Water Related Laws/Ordinance

(1) National Laws/Ordinance

1) "An Act Providing for a Local Government Code of 1991" (Republic Act No. 7160)

The Act providing for a Local Government Code (RA7160) was published on 10 October 1991. The act stipulated the mandates of local governments in the Philippines, including provinces, municipalities, and barangays with the concept of decentralization of various roles from the national government. Regarding infrastructure development, the act mentioned on basic services and facilities in Section 17 are as follows:

Therefore, the local governments have mandates for sewerage developments in their territories.

Section17：Basic Services and Facilities

(a) Local government units shall endeavor to be self-reliant and shall continue exercising the powers and discharging the duties and functions currently vested upon them. They shall also discharge the functions and responsibilities of national agencies and offices devolved to them pursuant to this Code. **Local government units** shall likewise exercise such other powers and discharge such other functions and **responsibilities** as are necessary, appropriate, or incidental to **efficient and effective provisions of the basic services and facilities** enumerated herein.

(b) Such basic services and facilities include, but are not limited to, the following:

*snip*

(2) For a Municipality:

*snip*

(viii) Infrastructure facilities intended primarily to service the needs of the residents of the municipality and **which are funded out of municipal funds including but not limited to**, municipal roads and bridges; school buildings and other facilities for public elementary and secondary schools; clinics, health centers and other health facilities necessary to carry out health services; communal irrigation, small water impounding projects and other similar projects; fish ports; artesian wells, spring development, rainwater collectors and water supply systems; seawalls, dikes, drainage and **sewerage**, and flood control; traffic signals and road signs; and similar facilities;

2) "Philippine Clean Water Act (CWA) of 2004" (Republic Act No. 9275)

The Clean Water Act of 2004 provides the necessity of protecting large bodies of water from the pollution coming from land-based sources, such as industries, commercial establishments, agriculture, and community/household activities. It provides a directive for the government to execute a

comprehensive and integrated strategy to prevent and minimize pollution through a multi-sectoral and participatory approach involving all stakeholders.

In the "SEC7. National Sewerage and Septage Management Program", the following is stated:

> Each LGU shall appropriate the necessary land, including the required rights-of way/road access to the land for the construction of the sewage and/or septage treatment facilities. **Each LGU may raise funds to subsidize necessary expenses for the operation and maintenance of sewerage treatment or septage facility** servicing their area of jurisdiction through local property taxes and enforcement of a service fee system.

In "Rule 8. Domestic sewage management. 8.6 Role of Water Supply Utilities" under "Implementing Rules and Regulations of the Philippine Clean Water Act of 2004 (Republic Act No. 9275)" (DENR, DAO2005-10), the following is stated:

> In the case of HUCs, non-HUCs, and LGUs where Water Districts, Water Utilities, and LGU Water Works have already been constituted and operational, the Water Supply Utility provider shall be responsible for the sewerage facilities and the main lines pursuant to PD 198 and other relevant laws. **In areas where there are no existing facilities, the LGUs, water districts, or water utilities may adopt septage management program or other sanitation alternatives.**

The understanding of this part (who should be responsible for the sewerage development in a LGU with WD) should be confirmed to DENR.

3) "Provincial Water Utilities Act of 1973" (Presidential Decree No. 198)

The decree declared a national policy favoring local operation and control of water systems, authorizing the formation of local WDs and providing for the government and administration of such districts. It chartered a national administration to facilitate improvement of local water utilities. The granting said administration of such powers are necessary to optimize public service from water utility operations and for other purposes as well.

In "CHAPTER VII – Powers of District, SEC. 28. Sewerage", the following is stated;

> **A district may require, construct, operate, and furnish facilities and services, within or without the district, for the collection, treatment, and disposal of sewerage, waste, and stormwater.** The district may only furnish such services outside the district by means of facilities designed primarily to serve inside the district. Upon providing a sewer system in any area of the district, the district may require all buildings used by human beings to be connected to the sewer system within such reasonable time as may be prescribed by the district, provided that the property upon which such building to be connected stands is located within 35 meters of an existing main of the district's sewer system. After due notice thereof and refusal on the part of the property owner to so connect with the district's sewer system, the district may declare the further maintenance or use of cesspools, septic

tanks, or other local means of sewerage disposal in such area to be a public nuisance and, after notice in writing of at least 10 days, deprive said property owner of any and all services provided by the district, which sanction may be co-extensive with the period during which the property owner persists in refusing to connect with the district's sewer system.

In "CHAPTER VIII – Financial Provisions, SEC. 38. Service and Stand-by Charges – Sewer.", the following is mentioned regarding sewerage:

**A district may prescribe and collect rates and other charges for sewer services furnished.** A district may also fix, levy, and collect a sewerage and wastewater service stand-by or availability charge in the event sewer service is available and no connection is made. **Such rates and charges may be collected with the water charges of the district.** In the event of failure to pay the whole or any part thereof, the district may discontinue any and all services for which such bill is rendered, including water, shall not be construed to prohibit the district from collecting rates and other charges in any other lawful manner.

4) Understandings of 1) to 3)

From the study of 1) Local Government Code 1991 (RA7160), 2) Clean Water Act 2004 (RA9275), and 3) Provincial Water Utilities Act of 1973" (PD198) above and the city resolution for forming the Davao City Water District (DCWD) (see subsection 3.6.1 in this report), the following understanding can be concluded: (See Appendix 2.1 for more detail of legal understanding)

**1. Local governments still have the authority to operate waste water treatment services in an area covered under an existing local water district.**

**2. The local government may be an investor in the creation and operation of wastewater treatment facilities and services.**

(2) City Ordinance

1) Rule IX, Section 22 of City Ordinance No. 0363-10

a.) Establishment

The Septage, Sewerage, and Sewage Treatment Plant/Facility shall be established pursuant to a Memorandum of Agreement entered into by and between the City Government of Davao and the Davao City Water District in accordance with Section 28 of PD 198 and Section 8 of RA 9275. The city government shall provide an appropriate land which shall serve as the site of the septage, sewerage, and sewage treatment plant/facility; and

b.) Operation, Maintenance and Management

The Septage, Sewerage and Sewage Treatment Plant/Facility shall be operated, maintained, and managed by the Davao City Water District and/or Septage and Sewage Management Department of the accredited service provider.

### 2.1.3 Water Related Guideline

(1) LWUA Guideline

As for water, the "Manual on Water Rates and Related Practices (2000)" by the Local Water Utilities Administration (LWUA) stipulates the guidelines on how to set water rates and the procedure to implement water rate increase. For sewerage, LWUA's BOT Resolution No.59, series 2017 "Revised Implementing Guidelines for Approval of Septage and/or Sanitation Fees of Local Water Districts" provides the guidelines on the sewerage tariff setting. Key articles that are common to both tariff settings are:

a.) Affordability Standard

The minimum charge (up to first 10 $m^3$ of water consumption) for size 1/2" residential connection, for combined water and wastewater tariff, should not exceed 5% of average income of the low-income group (affordability level).

b.) Tariff rate increase

Tariff rate increase should not exceed 60% of the current tariff.

c.) Cost recovery level

Water districts should aim for full cost recovery.

d.) Ring-fencing of revenues

WDs should separate water revenue and sewerage/septage revenue (ring-fencing).

The JICA Survey Team looked into this particular article since it indicates that WDs cannot cross-subsidize water revenue to cover sewerage project cost. During the interview with LWUA, the JICA Survey Team found that:

- The article is mainly created to protect the water supply function of WDs, and has not been adjusted to the septage and sewerage sector which are new to LWUA.
- The LWUA was also negative in the possibility of using an internal reserve which WDs have accumulated from water revenue.
- For Tarlac City septage case, LWUA advised the WD to temporarily divert water revenue to septage revenue and directed to put it back within 3 to 5 years. That method cannot be applied when an operation deficit is expected to constantly occur.
- LWUA occasionally reviews its regulation. The board of directors is responsible for approval. It is unlikely that the review of this article would happen sometime soon to accommodate one local

city's situation.

- LWUA is aware that in Metro Manila (under MSWW regulation, not LWUA), all water customers pay an environmental fee (20% of water tariff) to cover the sewerage service cost even when they are not connected to a sewerage service. LWUA commented that applying the environmental fee will face significant resistance.

Therefore, even PD198 indicates WDs' responsibility for sewerage, it is actually impossible to do by WDs.

## 2.2 Environmental and Social Consideration Regime of the Philippines regarding Sewage and Septage Management

### 2.2.1 Legislative Framework on Environment Management in Philippines

(1) Domestic Laws and Regulations

Relevant policy/framework, Environmental Impact Assessment (EIA), environmental conservation, pollution control and standards on environment management of the Philippines are shown in Appendix 2.2.

(2) International Agreements and Treaties

In addition, there are lots of international agreements and treaties in the field of environmental and natural resources ratified by the Republic of the Philippines and those entered by DENR which are classified into four categories as summarized in Table 2.2.1. Such individual agreements are summarized in Appendix 2.3.

**Table 2.2.1 International Agreements and Treaties on Environment**

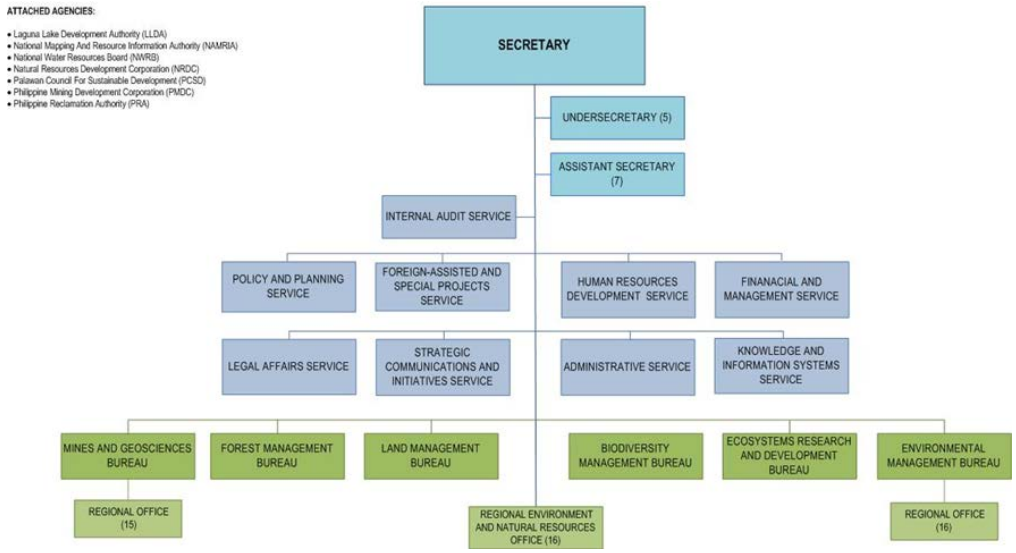
| No. | Category | Such as |
|---|---|---|
| 1. | United Nations (UN) conventions ratified by the Philippine Government | The United Nations Framework Conventions on Climate Change and commitments to international organizations such as the International Tropical Timber Organization (ITTO) |
| 2. | Asia Pacific agreements, declarations and statements on environmental and natural resources | Those in the Asia-Pacific Economic Cooperation (APEC), Coral Triangle Initiative and other ENR related groups in the Asia-Pacific region |
| 3. | Association of Southeast Asian Nations (ASEAN) and sub regional cooperation initiatives | The Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA). |
| 4. | Bilateral or those between the Philippines and individual countries. | See Appendix 2.1 |

Source: Office of the Undersecretary for Environment and International Environmental Affairs DENR (http://intl.denr.gov.ph/)

### 2.2.2 Institutional Framework

(1) Department of Environmental and Natural Resources (DENR)

The nodal administrative organization in charge of environmental management in the Philippines is the Department of Environment and Natural Resources (DENR) which was reorganized in 1987 from the former Department of Environment, Energy, and Natural Resources by Executive Order No.192. The organizational chart of DENR as of April 2016 is shown in Figure 2.2.1.




Source: DENR (https://www.denr.gov.ph/index.php/about-us/organizational-structure)

**Figure 2.2.1 Organization Chart of DENR**

(2) Environmental Management Bureau (EMB)

The Environmental Management Bureau (EMB) of DENR performs various mandates on environmental management based on the relevant environmental laws of the Philippines as follows.

- Philippine Environmental Impact Statement System (PEISS) (PD 1586)
- Toxic Substances and Hazardous and Nuclear Waste Control Act of 1990 (RA 6969)
- Clean Air Act of 1999 (RA 8749)
- Ecological Solid Waste Management Act of 2000 (RA 9003)
- Philippine Clean Water Act of 2004 (RA 9275)
- Environmental Awareness and Education Act of 2008 (RA 9512)
- To provide research and laboratory services; and serve as secretariat in the adjudication of pollution cases (under EO 192)
- Designated as the secretariat of the Designated National Authority for CDM of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (under EO 320)

(3) Environmental Management Bureau (EMB) Region XI

EMB through its regional offices is strictly implementing the six mandated national environmental laws, namely PD 1586, RA 6969, RA 8749, RA 9003, RA 9275, and RA 9512 (See sub-section (2) EMB).

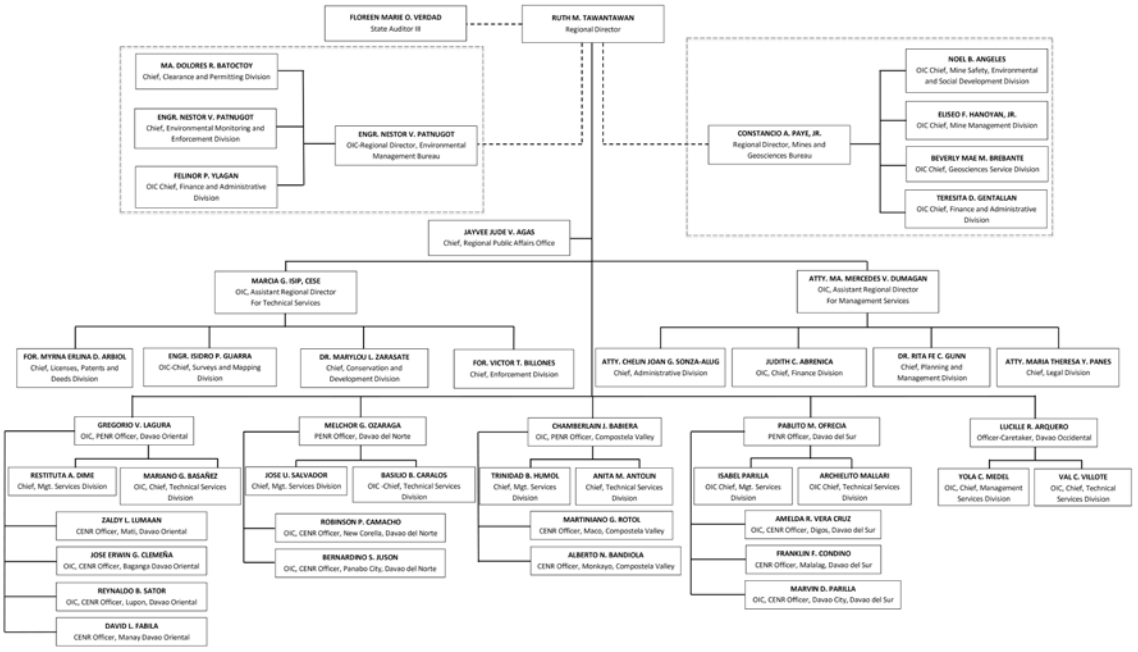
EMB operates offices at the central and regional levels throughout the Philippines, where it is divided into 17 regions (16 administrative and one autonomous). Davao City is in Southern Mindanao, thus belongs to Region XI (or Davao Region). In January 2000, EMB Region XI was formally set up as the line bureau for EMB in the region. Presently, the operation of EMB Region XI is under the leadership of the regional director whose vision, mission, and policy are shown in Table 2.2.2.

**Table 2.2.2 Vision, Mission and IMS Policy of EMB Region XI**

| Item | Description |
|---|---|
| Vision | A model regional office providing quality pubic service for a sustainable, clean and health environment. |
| Mission | To protect, restore and enhance environmental quality, and enable public participation for a sustainable development of Region XI. |
| IMS Policy | EMB XI comments to provide prompt, economical and quality public service trough;<br>- systematic improvement of its work processes, extensive capacitation and protection of its employees;<br>- compliance of the Office and its Laboratory to all statutory and regulatory requirements;<br>- efficient execution of services to advocate environmental protection and conservation; and<br>- effective information dissemination and awareness-raising of the citizenry on environmental protection, and maintenance, all anchored on applicable environmental laws. |

IMS: Integrated Management System
Source: WILSON L. TRAJECO, PME, Ph.D., Regional Director, EMB Region XI

Figure 2.2.2 shows the organization chart of EMB Region XI at present. EMB Region XI carries out the monitoring of air quality and water quality in Davao City as summarized in Subsection 3.2.2.




Source: EMB Region XI (https://r11.denr.gov.ph/images/docs/e-library/orgchart_nov2017.pdf)

**Figure 2.2.2 Organization Chart of EMB Region XI**

(4) Relevant Divisions and Activities on Environmental and Social Considerations of DCWD

Relevant divisions and activities on environmental and social considerations of the DCWD operation are shown in Subsection 3.7.1.

(5) City Environment and Natural Resources Office (CENRO) of the City of Davao

The City Environment and Natural Resources Office (CENRO), in Davao City, was originally created in 1993 in compliance with Sections 16 and 17 of Republic Act No. 716, otherwise known as the "Local Government Code of 1991". The details of CENRO are shown in Appendix 3.13 (4).

### 2.2.3 Philippine Environmental Impact Statement System (PEISS)

EIA in the Philippines is officially referred to as the Philippine Environmental Impact Statement System (PEISS). This was set up by Presidential Decree 1586 in the year 1987, under the legislative framework on PEISS.

Summarized in Appendix 2.4 are the latest updates as of June 2019 and the procedures on PEISS, including environmental permissions (Environmental Compliance Certificate (ECC) and Certificate for Non-Coverage (CNC)), Environmentally Critical Project (ECP) types and Environmental Critical Areas (ECAs) categories, EIA process, project categorization, standardized requirements, review of ECC application, coverage for sewerage system projects, and online application for CNC/ECC/Compliance Monitoring Report (CMR).

### 2.2.4 Land Acquisition and Resettlement System of the Philippines

Relevant policies and laws on land acquisition and resettlement in the Philippines are described in Appendix 2.5.

### 2.2.5 Other Guidelines on Environmental and Social Considerations

(1) JICA Guidelines for Environmental and Social Considerations

1) Objectives of the considerations

Any project to be financed by JICA loan and/or grant is required to comply with the JICA Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred to as "the JICA ESC Guidelines") in addition to the relevant laws and regulations in recipient countries such as PEISS in the Philippines.

The objectives and project categories of the JICA ESC Guidelines are shown in Appendix 2.6 (1).

Examples of the JICA environmental and social considerations procedures by the category are shown in Appendix 2.6 (2).

(2) Development Bank of Philippines (DBP) Policy and Requirements on Environment

The Development Bank of Philippines (DBP) is one of the leading financial intermediaries in the Philippines which has employed the bank's policy on environmental and environmental requirements for sanitation projects. The policy and requirements of DBP are shown in Appendix 2.6 (3).

(3) Land Bank of Philippines (LBP) Policy and Requirements on the Environment

The Land Bank of Philippines (LBP) is also one of the leading financial intermediaries in the Philippines which has employed the integrated quality and environmental policy as well as the bank's Corporate Social Responsibility (CSR) in which individual policies on environment are discussed. The policy and CSRs of LBP are shown in Appendix 2.6 (4).

(4) Environmental and Social Safeguards Framework (ESSF) (reference)

The Environment and Social Safeguards Framework (ESSF) was prepared in February 2012 for the World Bank's Metro Manila Wastewater Management Project.

According to the ESSF, the team that worked on the preparation of the document comprised of staff from the LBP, Manila Water Company Inc., (MWCI), and Maynilad Water Services Inc., (MWSI). Notably, the ESSF was prepared by these prominent and specialized organizations which conduct sewerage projects as financial or business operators in the Philippines. Therefore, ESSF can be used as a reference for environmental and social safeguards for wastewater management projects of cities in the Philippines (See Appendix 2.6 (5)).

### 2.2.6 Regulations

(1) Environmental Regulations Related to the Project

Water quality regulations are explained in subsection 3.2.1.

(2) Regulation on Septic Tank

The Department of Health (DOH) Operations Manual on the Rules and Regulations Governing Domestic Sludge and Septage (2008) prescribed that regular desludging of the septage from septic tank shall be done at least once every three to five years.

## 2.3 Trend of Concerned Donors/Relevant Projects for Water Sector in the Target Area

(1) World Bank

The World Bank has historically supported some water sector projects in Davao. In the 1980s, the World Bank financed the development of main drains, such as Roxas Creek and Agdao Creek, which was proposed in the drainage master plan in 1982.

World Bank supported the study of "Sewerage and Sanitation Project" and "Water District Development Project" in 1997. The project included two portions, i.e., 1) sewerage component and 2) sanitation and drainage component. The sewerage project was composed of the construction of a sewer network that would discharge wastewater to an integrated pond system designed to treat both wastewater and septage. The sewerage part was not executed, and only the sanitation components with on-site treatment, such as septic tanks, pit latrines, and pour flush toilets, were financed. Several candidate sites for wastewater treatment plant beside the Davao River were proposed in the report.

(2) USAID

USAID supported the feasibility study project for Davao City Septage Management Project until June 2013 (hereinafter called as "Septage Management F/S by USAID"). The septage management program with septage collection and sewerage treatment plant construction was proposed in the project. The

details of the septage management program is explained in Chapter 6.

(3) ADB

The "Urban Water Supply and Sanitation Project" has been conducted by ADB as a Technical Assistance (TA) project. The project started from 2011 and ended in 2014. The target cities were Metro Cebu and Davao City. The objective of the TA was to prepare a multi-tranche financing facility (MFF) for water supply and sanitation investments in the said two project locations, both of which was facing pending water crisis due to water shortage, and a sanitation crisis due to the complete lack of investment in sanitation, and continuing rapid urban expansion. The budget was USD 2 million and the utilized amount was around USD 1.68 million. The expected project outputs were as follows:

1) Increased quantity of raw water

2) Increased water supply distribution capacity

3) Raising of awareness of the benefits of sanitation services

4) Operational wastewater collection and disposal facilities

5) Operational sanitation strategy

The contents of Output-4 above, regarding wastewater, were mainly an identification of urgent needs for sanitation and wastewater treatment works.

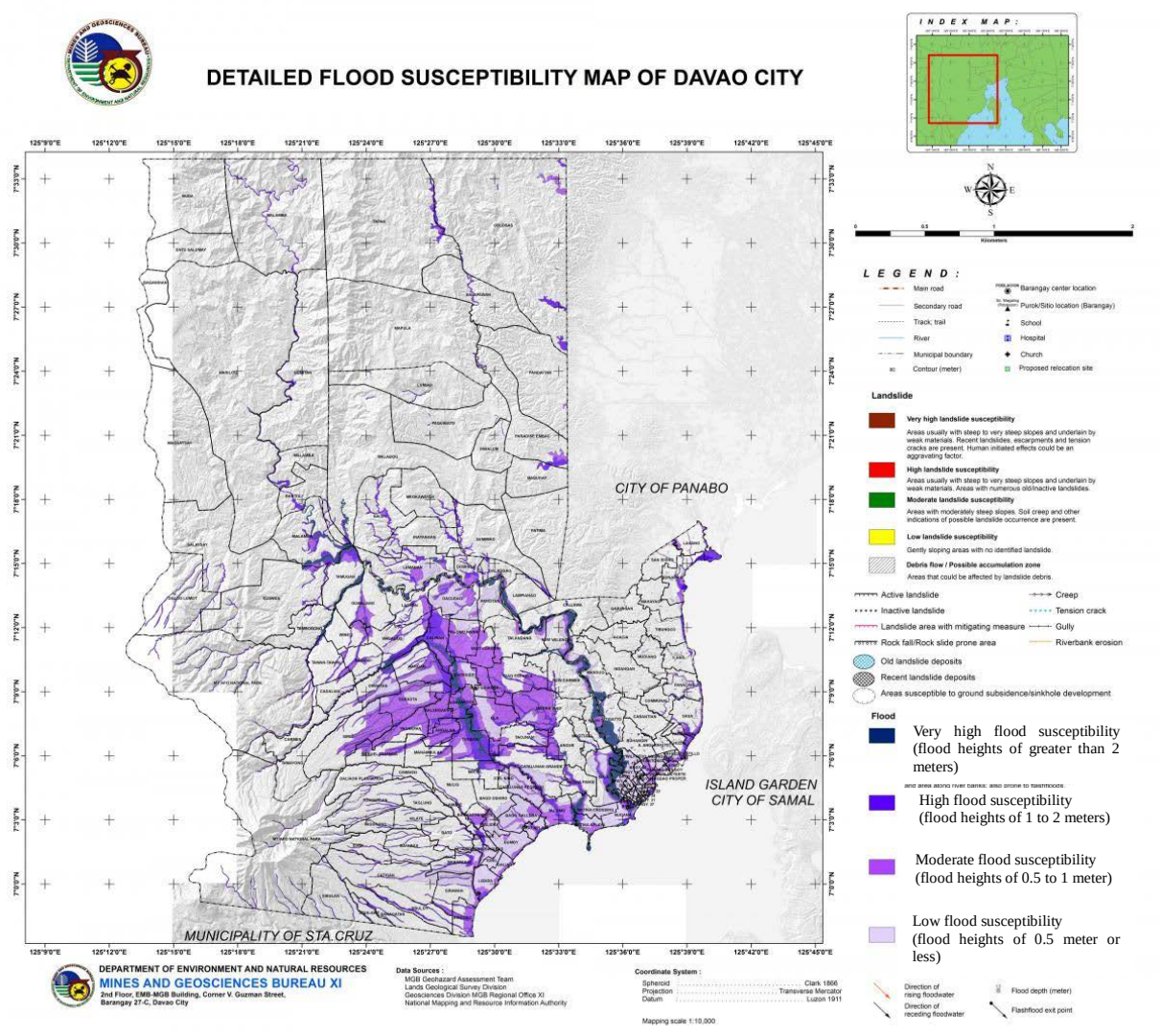
# CHAPTER 3 CURRENT STATUS OF WATER SECTOR AND SEPTAGE MANAGEMENT

This chapter includes the current status and plan of the water sector, septage management, and solid waste management in Davao City. The existing plans on sewerage development and septage management are separately mentioned in the next chapter.

## 3.1 Flood Condition

(1) Flood Hazard Map for Entire Davao City

The flood susceptibility map of Davao City that was prepared by DENR is shown in Figure 3.1.1. The areas beside Davao River and Talomo River show the highest risk for floods having a height of more than 2 m. The flood hazard map obtained from a private company website is shown in Appendix 3.1.




Source: DENR

**Figure 3.1.1 Flood Susceptibility Map of Davao City**

(2) Flood Record

Davao City Drainage has been monitoring the flood records in the urban area and have identified the "Monitored Flood Prone Area" in 45 locations. The record is shown in Table 3.1.1. The highest flooding in 2018 occurred around Davao Light and Power Company (DLPC) beside JP Laurel Avenue in the north of the Poblacion District (Barangay 20-B). The record was 0.70 m and continued for one hour.

**Table 3.1.1 Flood Record in Davao City Urban Area (2018)**

| | Street/Location | Flood Level | Outfall | Length | Period Of Descent |
|---|---|---|---|---|---|
| 1 | RIZAL EXTENTION | ANKLE HIGH (0.20m.) | RIZAL OUTFALL | 100 m. | 1 hour |
| 2 | ROXAS COR. QUEZON BLVD. | 0.35 m. | ROXAS CREEK | 50 m. | 1 hour |
| 3 | AURORA ST. | 0.20m. | PONCE OUTFALL | 50 m. | 1 hour |
| 4 | FROM COR. PONCE ST.-SUAZO ST. | 0.50m. | PONCE OUTFALL | 120 m. | 1 hour |
| 5 | JUAN LUNA ST. | 0.50m. | PONCE OUTFALL | 120 m. | 1 hour |
| 6 | SUAZO ST. COR. MAGSAYSAY | 0.50m. | PONCE OUTFALL | 120 m. | 1 hour |
| 7 | MONTEVERDE- COR. SUAZO | 0.20 to 0.30m. | PONCE OUTFALL | 100 m. | 1 hour |
| 8 | SALES ST. | 0.20 to 0.30m. | PONCE OUTFALL | 80 m. | 1 hour |
| 9 | C. LIZADA ST. (NCCC) | 0.20 to 0.30m. | PONCE OUTFALL | 100 m. | 1 hour |
| 10 | R. MAGSAYSAY ST. COR. LIZADA ST. | 0.20 to 0.30m. | PONCE OUTFALL | 100 m. | 1 hour |
| 11 | INFRONT OF SAN PEDRO HOSP. | ANKLE HIGH (0.20m.) | AGDAO CREEK | 30 m. | 30 minutes |
| 12 | VELOSO CORNER PORRAS ST. | 0.30m. | DACUDAO OUTFALL | 300 m. | 1 hour |
| 13 | COR. PORRAS ST. - LACSON ST. | 0.30m. | DACUDAO OUTFALL | 300 m. | 1 hour |
| 14 | ALZATE ST. - COR. PORRAS | 0.30m. | DACUDAO OUTFALL | 200 m. | 1 hour |
| 15 | IÑIGO ST. INFRONT USEP | 0.30m. | DACUDAO OUTFALL | 50 m. | 1 hour |
| 16 | INFRONT OF EVIBE (F. TORRES) | 0.10m. | DACUDAO OUTFALL | 50 m. | 1 hour |
| 17 | J.P. LAUREL ( DLPC ) | 0.70 m. | GOTAMCO OUTFAL | 100 m. | 1 hour |
| 18 | VILLA ABRILLE FROM COR. J.P. LAUREL TO GUERERRO ST. | 0.20m. | AGDAO CREEK | 250 m. | 1 hour |
| 19 | QUEZON BOULEVARD (COR. ROXAS) | 0.30 m. | BUCANA OUTFALL | 1 km. | 3 hours |
| 20 | DON JUAN DELA CRUZ / TORIL POB. | 0.20m. | DAVAO GULF | 500 m. | 15 minutes |
| 21 | SAN JOSE ST. / BRGY. DALIAO | 0.30m. | DAVAO GULF | 400 m. | 20 minutes |
| 22 | DE GUZMAN ST. / TORIL POB. | 0.30m. | VALES OUTFALL | 700 m. | 30 minutes |
| 23 | TORIL PUBLIC MARKET | 0.35m. | DAVAO GULF | 600 m. | 3 hours |
| 24 | LIZADA PERIOLS / BRGY. LIZADA | 0.50m. | DAVAO GULF | 1 km. | 1 hour |
| 25 | JV FERIOLS / BRGY. LIZADA | 0.20m. | DAVAO GULF | 300 m. | 30 minutes |
| 26 | SITIO KANIPAAN / BRGY. DALIAO | 0.25m. | DAVAO GULF | 200 m. | 15 minutes |
| 27 | GTH / BRGY. LUBOGAN | 0.30m. | VALES OUTFALL | 1 km. | 15 minutes |
| 28 | DACOVILLE IWHA / BRGY. DUMOY | 0.30m. | 72'Ø DPWH | 800 m. | 15 minutes |
| 29 | BETTER LIVING / BRGY. DUMOY | 0.15m. | 48'Ø DPWH | 100 m. | 10 minutes |
| 30 | NHA BANGKAL | 0.20m. | PANGI RIVER | 2 kms. | 30 minutes |
| 31 | SHANGHAI / BRGY. MATINA APLAYA | 0.30m. | SHANGHAI OUTALL | 2 kms. | 1 hour |
| 32 | GUADALUPE / MATINA CROSSING | 0.25m. | PANGI RIVER | 800 m. | 15 minutes |
| 33 | STO. NIÑO SAN ANTONIO ST. | 0.30m. | PANGI RIVER | 600 m. | 10 minutes |
| 34 | KAWAYAN DRIVE / LAZONA | 0.20m. | 1.5 x 1.2 OPEN CANAL | 2 kms. | 15 minutes |
| 35 | DIHO IV SUBD. / BRGY. MA-A | 0.25m. | DAVAO RIVER | 600 m. | 15 minutes |
| 36 | GEM VILLAGE / BRGY. MA-A | 0.30m. | DAVAO RIVER | 1 km. | 30 minutes |
| 37 | S.I.R PHASE I / BRGY. 76-A | 0.35m. | SIR CREEK | 800 m. | 30 minutes |
| 38 | S.I.R PHASE II / INFRONT PSCC | 0.30m. | SIR CREEK | 400 m. | 20 minutes |
| 39 | MANGGA ST. / JUNA SUBD. | 0.35m. | ACASIA ST. PETRON | 400 m. | 15 minutes |
| 40 | LUISA ST. / JUNA SUBD. | 0.30m. | ACASIA ST. PETRON | 200 m. | 15 minutes |
| 41 | ECOLAND / BRGY. 76-A | 0.25m. | ECOLAND CREEK | 500 m. | 15 minutes |
| 42 | GRAVAHAN / MATINA CROSSING | 0.30m. | DAVAO RIVER | 200 m. | 30 minutes |
| 43 | SPED & MABINI BANGKAL | 0.50m. | OPEN CANAL DPWH | 800 m. | 15 minutes |
| 44 | PONCIANO ST. / BRGY. POBLACION | 0.50m. | ROXAS CREEK | 250 m. | 35 minutes |
| 45 | V MAPA ST. / J.P. LAUREL AVE. | 0.40 m. | 36'Ø DPWH | 100 m. | 1 hour |

Source: Davao City Drainage

## 3.2 Current Status of Water Environment

### 3.2.1 Regulations

(1) Categorization of Water Bodies and Effluent Standard

The Effluent Standards (DENR Administrative Order No. 35 Series of 1990) were revised and issued in 1990. In March 2010, DENR issued an order which stated that effluent into the Davao Gulf should be categorized as Class SB under the category of protected water bodies instead of Class SC which is

under the category of usual coastal waters.

"The Water Quality Guidelines and General Effluent Standards of 2016" (DENR Administrative Order No. 2016-08: DAO2016-08) was issued on the 24 May 2016 and applied on 14 June 2016. In the order, criteria for water qualities in water bodies, such as rivers and sea, with various categories were stipulated depending on the water use from the water bodies. The Davao River upstream is categorized as Class A, and the downstream and Talomo River are categorized as Class B. The water quality guidelines for each class of rivers is shown in the monitoring results of rivers in Subsection 3.2.2 and Appendix 3.2. The effluent standards for water bodies are shown in Table 3.2.1.

All the wastewater treatment facilities should meet the requirements in the table. The value of nitrates should be less than 20 mg/L, and phosphorus should be less than 1.0 mg/L in case of Class SB for discharge to Davao Gulf. Meanwhile, Class B is applied for direct discharge to Davao River (downstream), and Class C is applied for discharge to creeks.

**Table 3.2.1 Effluent Quality Standards for Each Category (DAO 2016-08)**

| Parameter | Unit | Water Body Classification | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | AA | A | B | C | D | SA | SB | SC | SD |
| Ammonia as $NH_3$-N | mg/L | NDA | 0.5 | 0.5 | 0.5 | 7.5 | NDA | 0.5 | 0.5 | 7.5 |
| BOD | mg/L | NDA | 20 | 30 | 50 | 120 | NDA | 30 | 100 | 150 |
| Boron | mg/L | NDA | 2 | 2 | 3 | 12 | NDA | 2 | 20 | 80 |
| Chloride | mg/L | NDA | 350 | 350 | 450 | 500 | NDA | n/a | n/a | n/a |
| COD | mg/L | NDA | 60 | 60 | 100 | 200 | NDA | 60 | 200 | 300 |
| Color | TCU | NDA | 100 | 100 | 150 | 300 | NDA | 100 | 150 | 300 |
| Cyanide as Free Cyanide | mg/L | NDA | 0.14 | 0.14 | 0.2 | 0.4 | NDA | 0.04 | 0.2 | 0.4 |
| Fluoride | mg/L | NDA | 2 | 2 | 2 | 4 | NDA | 3 | 3 | 6 |
| Nitrate as $NO_3$-N | mg/L | NDA | 14 | 14 | 14 | 30 | NDA | 20 | 20 | 30 |
| pH (Range) | | NDA | 6.0-9.0 | 6.0-9.0 | 6.0-9.5 | 5.5-9.5 | NDA | 6.5-9.0 | 6.0-9.0 | 5.5-9.5 |
| Phosphate | mg/L | NDA | 1 | 1 | 1 | 10 | NDA | 1 | 1 | 10 |
| Selenium | mg/L | NDA | 0.02 | 0.02 | 0.04 | 0.08 | NDA | 0.02 | 0.2 | 0.4 |
| Sulfate | mg/L | NDA | 500 | 500 | 550 | 1,000 | NDA | 500 | 550 | 1,000 |
| Surfactants (MBAS) | mg/L | NDA | 2 | 3 | 15 | 30 | NDA | 3 | 15 | 30 |
| Temperature[h] | °C change | NDA | 3 | 3 | 3 | 3 | NDA | 3 | 3 | 3 |
| Total Suspended Solids | mg/L | NDA | 70 | 85 | 100 | 150 | NDA | 70 | 100 | 150 |
| Arsenic | mg/L | NDA | 0.02 | 0.02 | 0.04 | 0.08 | NDA | 0.02 | 0.04 | 0.08 |
| Barium | mg/L | NDA | 1.5 | 1.5 | 6 | 8 | NDA | 1.5 | 2 | 8 |
| Cadmium | mg/L | NDA | 0.006 | 0.006 | 0.01 | 0.02 | NDA | 0.006 | 0.01 | 0.02 |
| Chromium as Hexavalent Chromium ($Cr^{6+}$) | mg/L | NDA | 0.02 | 0.02 | 0.02 | 0.04 | NDA | 0.1 | 0.1 | 0.2 |

Source: Department of Environment and Natural Resources (DENR) Water Quality Guideline and General Effluent Standards of 2016

### 3.2.2 Water Quality Monitoring

(1) Water and Air Quality Monitoring Framework in Davao City

Water quality monitoring for freshwater and marine waters is carried out in accordance with the Water Quality Guidelines (WQG) stipulated in Tables 3 to 6, Section 6.1 of DAO 2016-08.

The parameters defining the WQG are categorized as primary or secondary parameters, as summarized in Table 3.2.2.

**Table 3.2.2 Parameters of Water Quality Monitoring**

| Item | Primary Parameters | Secondary Parameters |
|---|---|---|
| Monitoring Purpose | Primary parameters are the required minimum water quality parameters to be monitored for each water body. | Secondary parameters are the water quality parameters to be used in the baseline assessment as part of the Environmental Impact Assessment (EIA) and other water quality monitoring purposes. |
| Monitoring Parameter | Biochemical Oxygen Demand (BOD), chlorine (Cl), Color, Dissolved Oxygen (DO), Fecal Coliform, Nitrate, pH, phosphate, Temperature, and Total Suspended Solids (TSS) | Heavy metals and inorganics. For better assessment of the water quality of the river heavy metals such as zinc, copper, cadmium, lead, and mercury have been added. |

Source: Water quality management, Home Page of EMB Region XI (http://r11.emb.gov.ph/water-quality-management/)

1) River Water Quality

For CY 2017, Environmental Management Bureau (EMB) Region XI monitored 24 rivers in the region. Two of the rivers have been designated as Water Quality Management Areas, namely Davao River and Talomo River.

Regarding the Davao River, there are 17 sampling stations in which nine stations (Stations 1-4a) are in the downstream, and eight stations (Stations 5-11) are in the upstream.

2) Recreational Water Quality in Davao Gulf

Region XI has three main areas where recreational waters or beaches are being monitored by EMB Region XI. In Davao City, there are 11 reactional water bodies (beaches), each having one water quality monitoring station, as shown in Table 3.2.3. The locations of sampling points are shown in Figure A3.3.1 in Appendix 3.3.

**Table 3.2.3 Recreational Waters and Water Quality Monitoring Stations in Davao City**

| No. | Name of Recreational Water | Sta. No. | No. | Name of Recreational Water | Sta. No. |
|---|---|---|---|---|---|
| 1 | Kalayaan Beach Resort | 1 | 7 | Coaco Beach Resort | 7 |
| 2 | Megrande Ocean Beach Resort | 2 | 8 | Gumio-o Beach Resort | 8 |
| 3 | Seagull Beach Resort | 3 | 9 | Bago Beach Resort | 14 |
| 4 | Bonguyan Beach Resort | 4 | 10 | Lanang Aplaya Beach Resort | 16 |
| 5 | Liberty Beach Resort | 5 | 11 | Talomo Beach Resort | 21 |
| 6 | Marina Axul I | 6 | - | - | - |

Source: Water quality management, Home Page of EMB Region XI (http://r11.emb.gov.ph/water-quality-management/)

3) Creek Water Quality

Eight points in five creeks are monitored by EMB Region XI, and the locations of the points in creeks are shown in Figure A3.3.2 in Appendix 3.3. EMB basically tests four times a year in each sampling point.

4) Effluents from Firms

All the industrial and commercial firms which discharge wastewater more than 100 $m^3$/day should have a full-time Pollution Control Officer (PCO) and should submit the self-monitoring reports (SMRs) to EMB on a quarterly basis based on DAO 2003-27 “Amending DAO 26, DAO29 and DAO 2000-81 among Others on the Preparation and Submission of Self-Monitoring Report (SMR)”.

5) Air Quality Monitoring

In 2013, EMB XI established a new monitoring network called the “Davao City Air Quality Monitoring Network (DC AQMN)”. Sampling sites and parameters of DC AQMN are listed in Table 3.2.4.

**Table 3.2.4 Davao City Air Quality Monitoring Network (DC AQMN)**

| Sampling Sites | Type of Monitoring | District | Type of Monitor | Parameters |
|---|---|---|---|---|
| DC Station No. 02 | Long term trending | Bunawan | Manual | $PM_{10}$, $SO_2$, $NO_2$, $O_3$ |
| DC Station No. 07 | Roadside | Poblacion | Manual | $PM_{10}$, $SO_2$, $NO_2$, $O_3$ |
| DC Station No. 11 | Long term trending | Talomo-Toril | Manual | $PM_{10}$, $SO_2$, $NO_2$, $O_3$ |
| DC Station No. 14 | Roadside | Talomo-Toril | Manual | $PM_{10}$, $SO_2$, $NO_2$, $O_3$ |
| DC Station No. 15 | General ambient | Buhangin | Automatic | $PM_{10}$, $SO_2$, $NO_2$, $O_3$, CO, BTX |
| DC Station No. 16 | General ambient | Calinan | Automatic | $PM_{10}$, $PM_{2.5}$ |

BTX: benzene toluene xylene
Source: Air quality management, Home page of EMB Region XI, (http://r11.emb.gov.ph/programs/air-quality-management/)

(2) Water Quality of Rivers

Davao River flows down to the west edge of the proposed sewerage development Area B and subsequently Area A and Area C. The water quality records in Davao River downstream in years 2016, 2017, and 2018 are shown in Table 3.2.5. The values in fecal coliform have greatly exceeded the permissible limit every year. The total suspended solids, nitrate, and phosphate also exceeded the values every year or two. The water qualities in the other rivers are shown in Appendix 3.2.

**Table 3.2.5 Annual Average Concentration per Parameter of Davao River Downstream**

| Parameters | **Water Quality Guideline for Class B** | **Davao River Downstream** | | |
|---|---|---|---|---|
| | | **Class B (Station 1 - Station 5)** | | |
| | | **2016 Ave. Concentration** | **2017 Ave. Concentration** | **2018 Ave. Concentration** |
| **Primary Parameters** | | | | |
| Dissolved Oxygen, mg/L | min. 5 mg/L | 6.9 | 7.25 | 7.09 |
| Biochemical Oxygen Demand, mg/L | max. 5 mg/L | 1.3 | 2.8 | 4.0 |
| Total Suspended Solids, mg/L | 65 | **141** | **617** | **115** |
| pH | 6.5-8.5 | 8.3 | 8.2 | 8.3 |
| Temp., ◦C | 26-30 | 28.8 | 27.7 | 29 |
| Color, TCU | 50 | 34.1 | **121.4** | 29 |
| Chloride, mg/L | 250 | 17.5 | 121.5 | 107 |
| Nitrates (NO3), mg/L | 7 | **11.83** | **10.9** | **23.9** |
| Phosphate (PO4), mg/L | 0.5 | **0.80** | **3.41** | 0.3 |
| Fecal Coliform, MPN/ 100 ml | 100 | **107,562** | **69,670** | **5,312** |
| **Secondary Parameters** | | | | |
| Cadmium, mg/L | 0.003 | <0.003 | <0.003 | 0.003 |
| Copper, mg/L | 0.02 | 0.013 | **0.021** | 0.007 |
| Lead, mg/L | 0.01 | <0.01 | <0.01 | <0.01 |
| Zinc, mg/L | 2 | 0.029 | 0.057 | <0.002 |

Source: EMB Region XI

(3) Water Quality of Davao Gulf

The water quality of recreational water in the Davao Gulf in 2018 is shown in Table 3.2.6.

Station No. 5 Liberty Beach Resort showed the highest values of fecal coliform. Station No. 6 Marina Azul I and Station No. 1 Kalayaan Beach Resort also showed high values.

## Table 3.2.6 Water Quality in Davao Gulf (2018)

SUMMARY REPORT OF WATER QUALITY MONITORING DATA
in Region XI
4th Quarter CY 2018

| Region | Parameter | Stn. No. | Sta. ID | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ave | Min | Max | Water Quality Guideline |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Davao City Recreational Waters | | | | | | | | | | | <1600 | | | <3 | | | | | |
| Class SB (10 Stations) | | | | | | | | | | | | | | | | | | | |
| | DO, mg/L | 1 | Kalayaan Beach Resort | 6.3 | 6.4 | 6.4 | 6.2 | 5.9 | 6.5 | 5.4 | 8.1 | 7.4 | 6.8 | - | 5.9 | 6.5 | 5.4 | 8.1 | 6 (minimum) |
| | | 2 | Mergrande Ocean Beach Resort | 6 | 6.3 | 6.3 | 6.6 | 5.8 | 6.5 | 6 | 7.4 | 8.1 | 7.1 | - | 6.2 | 6.6 | 5.8 | 8.1 | |
| | | 3 | Seagull Beach Resort | 6.6 | 6.2 | 6.2 | 6.2 | 6.2 | 7 | 5.9 | 8.5 | 10 | 7 | - | 6.9 | 7.0 | 5.9 | 10.0 | |
| | | 4 | Bonguyan Beach Resort | 6.2 | 6.2 | 6.2 | 6.4 | 6.0 | 8.3 | 5.9 | 5.7 | 7.4 | 5.7 | - | 5.6 | 6.3 | 5.6 | 8.3 | |
| | | 5 | Liberty Beach Resort | 5.2 | 5.8 | 5.8 | 9.6 | **3.9** | 5.3 | 5.7 | 7.3 | 7.5 | 5.1 | - | 7 | 6.2 | 3.9 | 9.6 | |
| | | 6 | Marina Azul I | 9.8 | 5.8 | 5.8 | 9.2 | 6.2 | 7.2 | 5.9 | 5.3 | 7 | 6.8 | - | 6.1 | 6.8 | 5.3 | 9.8 | |
| | | 7 | Coaco Beach Resort | - | 6.0 | 6 | 6.1 | 6.5 | 6.3 | 5.2 | 6 | 6.6 | 8.8 | - | 6.8 | 6.4 | 5.2 | 8.8 | |
| | | 7a | Dagat Fiesta Beach Resort | - | 6.2 | 6.2 | 5.7 | 6.5 | 6.4 | 5.4 | 5.8 | 7.1 | 7.3 | - | 7.6 | 6.4 | 5.4 | 7.6 | |
| | | 14 | Bago Beach Reosrt | 6.6 | 6.4 | 6.4 | 6.7 | 5.9 | 6.2 | 6 | 6 | 8.4 | 6.8 | - | 5.8 | 6.5 | 5.8 | 8.4 | |
| | | 16 | Lanang Aplaya Beach Resort | 6.9 | 6.3 | 6.3 | 6.8 | 7.6 | 6.4 | 5.8 | 7.3 | 9.5 | 7.1 | - | 7.4 | 7.0 | 5.8 | 9.5 | |
| | pH | 1 | Kalayaan Beach Resort | 7.5 | 7.8 | 7.8 | 4.6 | 7.2 | 8.1 | 8.1 | 8.2 | 8.1 | 8.3 | - | 8.1 | 7.6 | 4.6 | 8.3 | 7.0-8.5 |
| | | 2 | Mergrande Ocean Beach Resort | 7.6 | 7.2 | 7.2 | 6.9 | 5.5 | 8.2 | 8.2 | 8.2 | 8.1 | 8.5 | - | 8.2 | 7.6 | 5.5 | 8.5 | |
| | | 3 | Seagull Beach Resort | 7.9 | 7.4 | 7.4 | 6.5 | 6.8 | 7.1 | 8.1 | 8.3 | 8.1 | 8.4 | - | 8.0 | 7.6 | 6.5 | 8.4 | |
| | | 4 | Bonguyan Beach Resort | 7.7 | 7.5 | 7.5 | 6.4 | 6.3 | 8.1 | 8.2 | 8.2 | 8.1 | 8.5 | - | 8.2 | 7.7 | 6.3 | 8.5 | |
| | | 5 | Liberty Beach Resort | 7.9 | 7.7 | 7.7 | 8.4 | 6.8 | 7.6 | 8.1 | 8.3 | 8.2 | 8.2 | - | 8.2 | 7.9 | 6.8 | 8.4 | |
| | | 6 | Marina Azul I | 7.9 | 7.5 | 7.5 | 6.7 | 6.4 | 8.1 | 8.2 | 8.3 | 8 | 8.6 | - | 8.3 | 7.8 | 6.4 | 8.6 | |
| | | 7 | Coaco Beach Resort | 8.3 | 7.7 | 7.7 | 5.9 | 6.9 | 8.1 | 8.3 | 8.2 | 8.2 | 8.5 | - | 8.3 | 7.8 | 5.9 | 8.5 | |
| | | 7a | Dagat Fiesta Beach Resort | 8.3 | 7.6 | 7.6 | 8.1 | 6.6 | 7.3 | 8.4 | 7.9 | 8.2 | 8.5 | - | 8.2 | 7.9 | 6.6 | 8.5 | |
| | | 14 | Bago Beach Reosrt | 7.5 | 7.9 | 7.9 | 6.7 | 6.8 | 7.9 | 8.2 | 8.2 | 8.1 | 8.5 | - | 8 | 7.8 | 6.7 | 8.5 | |
| | | 16 | Lanang Aplaya Beach Resort | 7.9 | 7.7 | 7.7 | 7.8 | 7.9 | 8.1 | 8.2 | 8.2 | 8.2 | 8.5 | - | 8.3 | 8.0 | 7.7 | 8.5 | |
| Davao City Recreational Waters | | | | | | | | | | | | | | | | | | | |
| Class SB (10 Stations) | | | | | | | | | | | | | | | | | | | |
| | Temp., °C | 1 | Kalayaan Beach Resort | 30 | 28 | 28 | 30 | 31 | 31 | 29 | 29 | 29 | 30 | - | 29 | 29 | 28 | 31 | 26-30 |
| | | 2 | Mergrande Ocean Beach Resort | 31 | 28 | 28 | 30 | 33 | 31 | 30 | 29 | 29 | 30 | - | 31 | 30 | 28 | 33 | |
| | | 3 | Seagull Beach Resort | 30 | 27 | 27 | 31 | 31 | 31 | 31 | 29 | 29 | 30 | - | 29 | 30 | 27 | 31 | |
| | | 4 | Bonguyan Beach Resort | 31 | 28 | 28 | 31 | 30 | 32 | 30 | 31 | 32 | 31 | - | 30 | 30 | 28 | 32 | |
| | | 5 | Liberty Beach Resort | 30 | 28 | 28 | 32 | 32 | 32 | 30 | 30 | 30 | 31 | - | 31 | 30 | 28 | 32 | |
| | | 6 | Marina Azul I | 30 | 28 | 28 | 31 | 33 | 32 | 31 | 30 | 32 | 31 | - | 34 | 31 | 28 | 34 | |
| | | 7 | Coaco Beach Resort | - | 28 | 28 | 29 | 30 | 29 | 30 | 29 | 30 | 29 | - | 30 | 29 | 28 | 30 | |
| | | 7a | Dagat Fiesta Beach Resort | - | 28 | 28 | 29 | 29 | 29 | 30 | 31 | 30 | 29 | - | 32 | 30 | 28 | 32 | |
| | | 14 | Bago Beach Reosrt | 30 | 28 | 28 | 31 | 32 | 31 | 30 | 30 | 30 | 30 | - | 29 | 30 | 28 | 32 | |
| | | 16 | Lanang Aplaya Beach Resort | 29 | 28 | 28 | 29 | 31 | 29 | 31 | 29 | 30 | 29 | - | 31 | 29 | 28 | 31 | |
| | Fecal Coliform, MPN/100mL | 1 | Kalayaan Beach Resort | <180 | 260 | 260 | 350 | - | 330 | 220 | 27 | 240 | 130 | - | 1600 | 237 | 27 | 1600 | 100 |
| | | 2 | Mergrande Ocean Beach Resort | <180 | <18 | <18 | 4 | - | <180 | 7.8 | 2 | 130 | 33 | - | 33 | 14 | 2 | 130 | |
| | | 3 | Seagull Beach Resort | <180 | 18 | 18 | 350 | - | 130 | 7.8 | <1.8 | 110 | 4 | - | 2 | 24 | 2 | 350 | |
| | | 4 | Bonguyan Beach Resort | <180 | 230 | 230 | 23 | - | <180 | 79 | 49 | 240 | 170 | - | 23 | 90 | 23 | 240 | |
| | | 5 | Liberty Beach Resort | 28000 | 3500 | 350000 | 2300 | - | 160,000 | 49000 | <180 | >1600 | >16000 | - | 92000 | 34391 | 2300 | 350000 | |
| | | 6 | Marina Azul I | 180 | 140 | 140 | 110 | - | 1,100 | 920 | 31 | 3500 | 220 | - | 540 | 295 | 31 | 3500 | |
| | | 7 | Coaco Beach Resort | 33 | 330 | 330 | 110 | - | 45 | 540 | 11 | 23 | 17 | - | 920 | 91 | 11 | 920 | |
| | | 7a | Dagat Fiesta Beach Resort | 23 | 78 | 78 | 17 | - | 20 | 22 | 350 | 79 | 33 | - | 6.8 | 38 | 7 | 350 | |
| | | 14 | Bago Beach Reosrt | <180 | 20 | 20 | 22 | - | 170 | 79 | 23 | 350 | 130 | - | 280 | 69 | 20 | 350 | |
| | | 16 | Lanang Aplaya Beach Resort | <1.8 | <18 | <18 | 110 | - | <18 | 170 | 280 | 49 | 49 | - | 33 | 86 | 33 | 280 | |
| | Oil & Grease mg/L | 7 | Coaco Beach Resort | - | <1 | - | <1 | - | - | - | <1 | - | <1 | - | - | <1 | <1 | <1 | 1 |
| | | 7a | Dagat Fiesta Beach Resort | - | <1 | - | <1 | - | - | - | <1 | - | <1 | - | - | <1 | <1 | <1 | |

Source: EMB Region XI

(4) Water Quality of Creeks

The water qualities (BOD values) in creeks in Davao City for 2012 to 2018 is shown in Table 3.2.7. Although the values have fluctuated depending on the timings of samplings, Hizon Creek (No.2) showed the highest value (132 mg/L) in 2017, and San Isidro Creek showed the second highest value (84 mg/L) in 2013 out of all the data. From the general circumstances of wastewater discharge in Davao City, these values seem to show the quality of gray water with some groundwater and septage from septic tanks.

**Table 3.2.7 BOD in Creeks in Davao City as of May 2019**

| Station No. | 2012 | | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | | 2018 | | 2012-2018 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) | Max. (mg/L) | Ave. (mg/L) |
| Hizon Creek | | | | | | | | | | | | | | | | |
| 1 | 30.0 | 23.8 | 36.0 | 24.8 | 48.0 | 32.0 | 50.0 | 36.4 | 22.0 | 14.6 | 38.0 | 23.7 | 18.0 | 11.1 | 50.0 | 23.8 |
| 2 | 30.0 | 23.8 | 36.0 | 24.8 | 48.0 | 32.0 | 25.0 | 19.7 | 22.0 | 14.6 | 132.0 | 57.7 | 23.0 | 17.3 | 132.0 | 27.1 |
| Mamay Creek | | | | | | | | | | | | | | | | |
| 1 | 29.0 | 23.2 | 36.0 | 28.9 | 58.0 | 40.8 | N/A | N/A | 40.0 | 26.8 | 65.0 | 39.3 | 26.0 | 19.7 | 65.0 | 29.8 |
| Pampanga Creek | | | | | | | | | | | | | | | | |
| 1 | 19.0 | 15.5 | 26.6 | 15.0 | 27.0 | 22.5 | 33.0 | 33.0 | 21.0 | 15.2 | 14.0 | 12.0 | 15.0 | 11.4 | 33.0 | 17.8 |
| San Isidro Creek | | | | | | | | | | | | | | | | |
| 1 | 40.0 | 29.1 | 84.0 | 42.7 | 54.0 | 40.0 | N/A | N/A | 59.0 | 46.1 | 42.0 | 40.0 | 40.0 | 31.0 | 84.0 | 38.1 |
| 2 | 54.0 | 36.8 | 54.0 | 37.7 | 58.0 | 39.8 | N/A | N/A | 59.0 | 46.1 | 30.0 | 27.3 | 40.0 | 30.3 | 59.0 | 36.3 |
| Shanghai Creek | | | | | | | | | | | | | | | | |
| 1 | 44.0 | 32.0 | 70.0 | 37.3 | 60.0 | 38.3 | 37.2 | 26.1 | 75.0 | 47.3 | 37.0 | 24.7 | 39.0 | 24.8 | 75.0 | 32.9 |
| 2 | 42.0 | 27.6 | 56.0 | 35.0 | 48.0 | 35.0 | 68.1 | 39.8 | 49.0 | 29.0 | 35.8 | 24.5 | 35.0 | 23.5 | 68.1 | 30.6 |

Source: EMB compiled by JICA Survey Team

(5) Groundwater Quality

1) Coliform

The coliforms in groundwater supply sources (untreated/raw water) as of May 2019, which were confirmed by DCWD for the water supply system, is shown in Table 3.2.8. The locations of water sampling points are shown in Figure A3.3.3 in Appendix 3.3. The location named “Malagos” shows high value of coliform due to the existence of some pig farms near the groundwater spring, but according to DCWD it was an accidental case during the year.

**Table 3.2.8 Coliform in Groundwater Sources (Untreated/Raw Water) as of May 2019**

| Water Supply System (WSS) | Most Probable Number (MPN) per 100 ml (MTFT), Enzyme Substrate Coliform Test (EST) | |
|---|---|---|
| | Total Coliform (MPN/100ml) | Fecal Coliform (MPN/100ml) |
| Dumoy | <1.1 to **>8.0** | <1.1 to **>8.0** |
| Tugbok | <1.1 to **2.6** | <1.1 |
| Panacan | <1.1 to **200.5** | <1.1 |
| Cabantian | <1.1 to **36.4** | <1.1 |
| Malagos | **2419.6** | **980.4** |
| Calinan | <1.1 | <1.1 |
| Riverside | **>8.0** | <1.1 to **8.0** |
| Toril | <1.1 | <1.1 |
| Lubogan | <1.1 | <1.1 |
| Tibungco | <1.1 | <1.1 |

Note: Drinking Water Standard Value (MPN/100ml): <1.1 MPN/100ml
(DAO2017-0010: Philippine National Standards for Drinking Water)
Source: DCWD

2) Parameters with Physical and Chemical Analysis

The physical and chemical analyses in groundwater sources (untreated/raw water) as of May 2018 is shown in Table 3.2.9 and Table 3.2.10. In general, almost all the parameters do not exceed the permissible limits in water quality standard. Only arsenic in the Tugbok Water Supply Scheme shows a much higher value compared to the standard.

**Table 3.2.9 Physical and Chemical Analyses in Groundwater Sources (Untreated/Raw Water) as of May 2018 (1/2)**

| PARAMETERS | Maximum Level | Unit | Method of Analysis | Water Suppy System (WSS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Dumoy | Tugbok | Calinan | Riverside | Toril | Lubogan |
| **PHYSICAL ANALYSIS** | | | | | | | | | |
| Color (Apparent) | 10 | CU | Visual Comparison | 0 - 5 | 0 | 0 | 0 | 0 - 5 | 0 |
| Turbidity | 5 | NTU | Nephelometric | 0 - 2 | 0 | 0 - 1 | 0 | 0 - 4 | 0 |
| Temperature | - | $^0$C | Electrometric | 22.1 - 27.4 | 25.10 - 26.30 | 26.10 - 27.40 | 26.90 - 27.20 | 26.70 - 26.90 | 26.30-26.50 |
| Total Dissolved Solids | 600 | ppm | dried at 180 $^0$C | 117 - 427 | 125 - 240 | 137 - 178 | 102 - 144 | 180 - 230 | 141-194 |
| Conductivity | - | µS/cm | Electrometric | 156.9 - 1001 | 208.5 - 419 | 266 - 271 | 172.5 - 186 | 236 - 361 | 177.6-252 |
| Total Hardness | 300 | ppm | EDTA Titrimetric | 61.61 - 180.34 | 84.86 - 167.69 | 112.61 - 117.10 | 53.86 - 62.42 | 85.68 - 141.98 | 71.4-100.78 |
| Acidity | - | ppm | Titrimetric | 0 - 28.18 | 6.22 - 13.91 | 13.91 - 29.65 | 5.86 - 7.32 | 4.76 - 5.12 | 5.49-10.61 |
| Alkalinity | - | ppm | Titrimetric | 73.5 - 265.86 | 94.92 - 202.44 | 97.86 - 125.16 | 79.38 - 85.26 | 94.50 - 132.72 | 79.80-99.96 |
| **CHEMICAL ANALYSIS** | | | | | | | | | |
| pH | 6.5 - 8.5 | | Electrometric | 6.84 - 8.15 | 6.9 - 7.68 | 6.48 - 7.27 | 7.96 - 8.07 | 7.70 - 8.09 | 7.26-7.66 |
| Dissolved Oxygen | - | ppm | Electrometric | 2.12 - 9.17 | 3.16 - 8.03 | 4.23 - 4.41 | 3.74 - 8.06 | 7.04 - 7.94 | 7.92-8.23 |
| Chloride | 250 | ppm | Argentometric | 3.11 - 120.08 | 4.14 - 7.66 | 4.14 - 10.56 | 3.93 - 5.18 | 8.07 - 13.04 | 3.93-8.49 |
| Bicarbonates | - | ppm | Titrimetric | 85.70 - 322.92 | 117.42 - 235.80 | 126.42 - 151.51 | 92.8 - 116.95 | 0 - 158.14 | 0-120.74 |
| Sulfate | 250 | ppm | Turbidimetric | <0.001 - 48.00 | <0.001 | <0.001 - 5 | <0.001 | 5 - 11 | <0.001-6 |
| Nitrogen Nitrate | 50 | ppm | Cadmium Reduction | 0.20 - 1.40 | 0.40 - 0.70 | 0.30-0.80 | 0.20 | 0.40 - 1.00 | 0.30-1.20 |
| Nitrogen Nitrite | 3 | ppm | Diazotation | 0.001 - 0.007 | 0.002 - 0.003 | 0.003 | 0.002 - 0.004 | 0.002 - 0.004 | 0.002-0.003 |

Source: DCWD

**Table 3.2.10 Physical and Chemical Analyses in Groundwater Sources (Untreated/Raw Water) as of May 2018 (2/2)**

| PARAMETERS | Maximum Level | Unit | Method of Analysis | Water Suppy System (WSS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Dumoy | Tugbok | Calinan | Riverside | Toril | Lubogan |
| Chlorine, total | - | ppm | DPD | <0.001 - 0.04 | 0.02 | 0.02 | 0.02 | 0.02 - 0.03 | 0.02 |
| Flouride | 1.5 | ppm | SPADNS | <0.006 - 0.45 | <0.006 - 0.43 | 0.22 - 0.39 | 0.19 - 0.42 | 0.26 - 0.28 | 0.11-0.24 |
| Cyanide | 0.5 | ppm | Pyridine-Pyrazalone | 0.001 - 0.006 | 0.001 - 0.002 | 0.002 - 0.003 | 0.001 - 0.002 | 0.002 - 0.003 | 0.001-0.002 |
| Aluminum | 0.2 | ppm | Eriochrome Cyanine R | <0.001 - 0.029 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Orthophosphate | - | ppm | PhosVer III | 0.33 - 1.99 | 0.35 - 1.13 | 0.48 - 0.73 | 0.35 - 0.45 | 0.26 - 0.40 | 0.25-0.47 |
| Bromine | - | ppm | DPD | 0.02 - 0.07 | 0.02 - 0.03 | 0.03 - 0.04 | 0.03 - 0.04 | 0.03 - 0.05 | 0.02-0.03 |
| Nitrogen Ammonia | - | ppm | Nessler | <0.005 - 0.62 | <0.005 - 0.96 | <0.005 - 0.01 | <0.005 | <0.005 | <0.005 |
| Silica | - | ppm | Silicomolybdate | 24 - 76 | 43 - 90 | 66 - 93 | 44 - 46 | 29 - 33 | 46-61 |
| Iron | 1.0 | ppm | Flame Atomic Absorption Spectrometric | <0.003 - 0.044 | <0.003 - 0.015 | <0.003 | <0.003 | <0.003 | <0.003 |
| Manganese | 0.4 | ppm | Flame Atomic Absorption Spectrometric | 0.005 - 0.062 | 0.003 - 0.127 | <0.001 | <0.001-0.004 | <0.001 | <0.001-0.002 |
| Copper | 1.0 | ppm | Flame Atomic Absorption Spectrometric | <0.001 - 0.009 | <0.001 - 0.005 | <0.001 | <0.001 | <0.001 - 0.003 | <0.001 |
| Chromium | 0.05 | ppm | Flame Atomic Absorption Spectrometric | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Zinc | 5 | ppm | Flame Atomic Absorption Spectrometric | <0.001 - 0.012 | <0.001 - 0.016 | <0.001 | <0.001 | <0.001 | <0.001-0.008 |
| Calcium | - | ppm | Flame Atomic Absorption Spectrometric | 11.686 - 32.771 | 13.821 - 30.083 | 17.360 - 19.454 | 8.999 - 9.304 | 17.607 - 23.982 | 13.135-22.025 |
| Magnesium | - | ppm | Flame Atomic Absorption Spectrometric | 2.373- 2.689 | 2.416 - 2.582 | 2.388 - 2.452 | 2.210 - 2.263 | 2.320 - 2.444 | 2.276-2.401 |
| Potassium | - | ppm | Flame Atomic Absorption Spectrometric | 1.878 - 10.515 | 1.928 - 2.925 | 2.761 - 3.206 | 1.464 - 1.966 | 2.723 - 4.365 | 2.194-3.604 |
| Sodium | 200 | ppm | Flame Atomic Absorption Spectrometric | 6.464 - 13.270 | 6.232 - 10.905 | 7.482 - 8.688 | 10.159 - 10.022 | 9.648 - 11.815 | 6.780-7.962 |
| Arsenic | 0.01 | ppm | Electrothermal Atomic Absorption Spectrometric | <0.001 | 6.232 - 10.905 | <0.001 | <0.001 - 0.002 | <0.001 | <0.001 |
| Lead | 0.01 | ppm | Electrothermal Atomic Absorption Spectrometric | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Cadmium | 0.003 | ppm | Electrothermal Atomic Absorption Spectrometric | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

Source: DCWD

## 3.3 Development Status of Sewage/Septage Treatment Facilities

### 3.3.1 Sewerage Facility

(1) Sewage Treatment Plant

Public sewage treatment plants do not exist in Davao City. Only some large-scale shopping malls, hotels/condominiums/hospitals have sewage treatment plants (STPs) with an aeration facility (such as sequencial batch reactor (SBR) process in case of shopping malls), and many hotels have large-scale (or multiple) septic tanks with oil trap tanks for removal of oils and greases generated in kitchen and laundry services. Industries and public facilities also have large-scale septic tanks. Neither the Davao City nor EMB possess a comprehensive list of existing treatment facilities in private companies with details of the treatment process, capacities, and effluent water qualities. Appendix 3.4 shows the list of facilities which have treatment facilities in the Poblacion and Agdao Districts with an estimated volume of wastewater based on the data from Davao City Water District (DCWD). A summary of the existing treatment plants is shown in Table 3.3.1.

**Table 3.3.1 Existing Treatment Facilities in Poblacion and Agdao Districts**

| District | Number of STPs | Assumed wastewater treatment (m3/day) |
|---|---|---|
| Poblacion | 14 (+1 non-operational) | 2,859 |
| Agdao | 6 | 747 |
| Total | 20 | 3,606 |

Source: JICA Survey Team based on CBO and DCWD data

Therefore, the Japan International Cooperation Agency (JICA) Survey Team tried to obtain detailed data through interviews with private companies introduced by Davao City and EMB. Table 3.3.2 shows the examples of treatment facilities in Davao City which were confirmed through the interviews, through the Self-Monitoring Report (SMR) submitted to EMB on a quarterly basis every year, and from the data provided by the companies.

**Table 3.3.2 Example of Sewage Treatment Facilities of Private Companies**

| Facility Name | Location | Treatment Process | Nutrient Removal | Capacity/ Flow Record ($m^3$/day) | Influent (mg/L) | | | Effluent (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | BOD | COD | TSS | BOD | COD | TSS |
| Abreeza Mall | Poblacion 20-B | SBR | None | 1,308/ 580 | 533 | 626 | 224 | 49 | 58 | 43 |
| SM Lanang | Agdao San Antonio | SBR | None | >1,000/ 557 | N/A | N/A | N/A | 10 | 20 | 8 |
| Applied effluent standard (Class C) | | | | | - | - | - | 50 | 100 | 100 |

Note:
1) Sewerage Treatment Plant (STP) in Abreeza Mall was constructed in 2005 and expanded in 2011.
2) Flow record of Abreeza Mall is actual average daily discharge in 2018 and influent/effluent values are ones as of Oct 3, 2018
3) Flow record and effluent values of SM Lanang are largest ones in Oct 18, Nov 21, and Dec 13, 2018
Source: JICA Survey Team based on interviews and Self-Monitoring Report (SMR) imposed by EMB

The major treatment process in shopping malls is the Sequential Batch Reactor (SBR), but many facilities were constructed before the latest water quality standard DAO 2016-08, published in 2016, which requires the removal of nitrogen and phosphorus. According to the interviews with private companies, new buildings, such as housing complexes, shall have treatment facilities with biological

nutrient removal, and the existing facilities shall also be upgraded to the treatment facilities to the ones with the capacity to meet the additional requirements. In case of the Abreeza Mall, DENR-EMB ordered them to pay a penalty of PHP 10,000/day for the non-compliance of the effluent standard, but they prepared and submitted the "Compliance Report" mentioning the upgrade plan of the plant by 2022 to EMB, so the requirement of paying the penalty has been postponed.

According to the interviews, Abreeza Mall does not reuse the treated water due to relatively high values of BOD, COD, and TSS, but SM Lanang used it for other purposes, such as for the cooling tower and for wash water.

(2) Sewer Pipeline

Only pipe and box culverts used to convey both wastewater and stormwater exist in the city for main drains, such as the Bucana Main Drain and Mabini Main Drain (see Table 3.4.2 in Subsection 3.4.2), and pipes at the connections of road side drains to creeks.

Some private complexes of shopping malls have sewer pipelines in their properties. In the case of Abreeza Mall, the collection system is a separate sewer system, and most of the downstream sanitary sewer network (inlet pipe to STP) has a diameter of 250 mm.

### 3.3.2 Status of Septic Tank

Instead of sewerage facilities, the septic tank is broadly used as the main sanitary facility in Davao City. The status of septic tank was confirmed from existing reports, such as IM4D and household interview surveys.

(1) Household Interview Survey (HIS)

To identify the existing status of septic tanks in households and other related information on the water sector, the results of the barangay-wide household interview survey (HIS) in IM4D that was conducted in 2017 were carefully studied. To update and supplement the outputs of HIS in IM4D, particularly wastewater management, the JICA Survey Team conducted the HIS in this survey selecting the target barangays with existing sanitary issues and using the interview sheet shown in Appendix 3.5. The barangays mainly targeted were those in Agdao and Poblacion Districts in Area A as top priority area of sewerage development. However, barangays in Areas B, C, and D, which are adjacent to Area A, and high priority areas of sewerage development were also added. Table 1.1 in Appendix 3.6 shows the target barangays and the number of households of the survey with the dates of each survey and main features of barangays in the IM4D HIS result as reasons for the selection in this survey.

(2) Coverage of Septic Tank

Many households installed their own septic tanks for excreta treatment/disposal in Davao City. In the result of IM4D household interview survey, the coverage rate of septic tank was around 94% all over Davao City (2014 samples). The ownership (possession) of septic tanks and accessibility to septic tanks were confirmed in the household interview survey, and the results are shown in Table 3.3.3.

**Table 3.3.3 Ownership of Septic Tank and Access to Septic Tank**

| Item | Ownership pf Septic Tanks | | | | Access to Septic Tanks | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | | IM4D | | 2019 | | IM4D | |
| | No. | % | No. | % | No. | % | No. | % |
| Yes | 443 | 85.5 | 1,865 | 92.6 | 225 | 43.4 | 1,559 | 77.4 |
| No | 72 | 13.9 | 126 | 6.3 | 247 | 47.7 | 386 | 19.2 |
| No Response | 3 | 0.6 | 23 | 1.1 | 46 | 8.9 | 69 | 3.4 |
| Total | 518 | 100.0 | 2,014 | 100.0 | 518 | 100.0 | 2,014 | 100.0 |

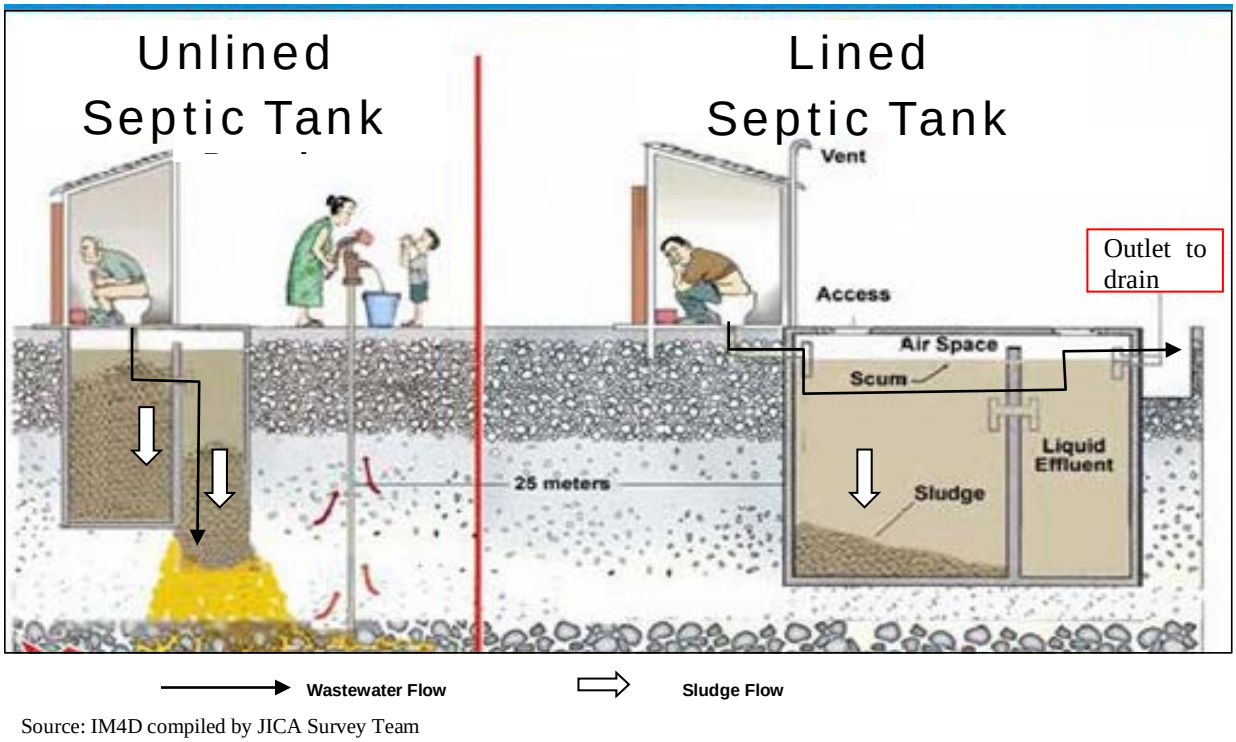
Note: "Access to Septic Tank" means possibility of desludging from septic tanks
Source: JICA Survey Team and IM4D

Compared to IM4D, the coverage ratio of septic tank slightly decreased. The possible reason is that in this study, the ratio of congested areas was high since the target areas were limited to Areas A, B, C and D, and some houses do not have enough space to install a septic tank. Such houses may flush the septage to drains or backyards directly without septic tanks or they may use the community toilets.

Regarding access to the septic tank, the ratio of those who answered "yes" decreased significantly. Since it is generally quite difficult to find the opening of a septic tank at site, the result seems to reflect the impression at the site. According to the resident interviews in household survey, many houses block the opening with a mortar to prevent the smell from coming inside. Every several years, they destroy the mortar or remove the toilet itself in the house in order to extract the septage.

(3) Types of Septic Tank

Two types of septic tanks exist – the unlined and the lined (Figure 3.3.1). The use of an unlined septic tank can easily contaminate groundwater because the liquid part of the excreta infiltrates down to the ground. With the lined septic tank, on the other hand, treated water (actually overflow without enough treatment) flows out from the septic tank and is discharged to the roadside ditch and/or rainwater drainage.




Source: IM4D compiled by JICA Survey Team

**Figure 3.3.1 Type of Septic Tank**

To reconfirm the exact conditions, the types of septic tanks were asked again in the household interview survey in this survey for Area A, B, C, and D, and the result is shown in Table 3.3.4. The result of the ratio of the lined septic tank increased from the IM4D survey. However, there was almost no case that the discharge point from the septic tank to the drain was found. The major condition for a lined septic tank is that there is supposed to be a floor at the bottom of the septic tank, but there is no outlet from the septic tank, or the outlet was clogged to act as a countermeasure for the smell. From such situation, the answer "I don't know" should have been more than the results tabulated in Table 3.3.4.

**Table 3.3.4 Type of Septic Tank**

| Type | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Unlined Septic Tank | 108 | 20.8 | 825 | 44.2 |
| Lined Septic Tank | 318 | 61.4 | 848 | 45.5 |
| I Don't Know | 23 | 4.4 | 114 | 6.1 |
| Other | 17 | 3.3 | 7 | 0.4 |
| No Response | 52 | 10.0 | 71 | 3.8 |
| Total | 518 | 100.0 | 1,865 | 100.0 |

Source: JICA Survey Team and IM4D

(4) Discharge Point from Septic Tank

The discharge points from the septic tank in the household are shown in Table 3.3.5. Of all the persons that answered, 45% said that they do not know where the discharge point is. This is in contrast with IM4D where nearly half of the residents answered that it infiltrated to the ground. After discussion with DCWD, it is assumed that a large portion of the households who answered that they do not know have a discharge that is likely to infiltrate the ground.

Many residents also answered discharge to sewer pipe, but the pipe does not exist in the city except for the pipes connecting to the roadside drains and channels.

**Table 3.3.5 Discharge Point of Septic Tank Effluent**

| Discharge Point | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Discharge to sewer pipe | 104 | 20.1 | 596 | 32.0 |
| Discharge to roadside ditch | 2 | 0.4 | 114 | 6.1 |
| Discharge to road | 1 | 0.2 | 8 | 0.4 |
| Infiltrate to ground | 110 | 21.2 | 883 | 47.3 |
| Discharge to public water body (river, sea,etc.) | 34 | 6.6 | 21 | 1.1 |
| I don't know | 233 | 45.0 | 167 | 9.0 |
| other | 4 | 0.8 | | |
| No response | 30 | 5.8 | 184 | 9.9 |
| Total | 518 | 100.0 | 1,865 | 100.0 |

Source: JICA Survey Team and IM4D

### 3.3.3 Desludging of Septage

(1) Desludging Company

Only private companies have conducted the desludging of septage from septic tanks. There is no official information about the desludging companies in Davao City. The JICA Survey Team contacted a company in Poblacion District and had an interview with them. The acquired knowledge is as follows.

1) Approximate number of companies

There is a total of six desludging companies with business permits (legally operating) as shown in Table 3.3.6, and more than 20 without permits (illegal) exist in Davao City. It is assumed that the illegal companies are not granted permits due to the lack of proper disposal facilities.

**Table 3.3.6 Desludging Companies in Davao City**

| No. | BUSINESS NAME | DISTRICT | BARANGAY | BUSINESS ADDRESS | NO. OF STAFF |
|---|---|---|---|---|---|
| 1 | A SEPTIC TANK EXCAVATOR AND PLUMBING SERVICES | Poblacion | 37-D | PUROK 5 (NEAR BRGY. HALL) | 2 |
| 2 | B SEPTIC TANK CLEANING AND PLUMBING SERVICES | Poblacion | 8-A | PUROK 9-B, LOWER MADAPO | 1 |
| 3 | C SEPTIC TANK EXCAVATOR & PLUMBING SERVICES | Talomo | Bucana | PUROK 12 ST. JOHN | 4 |
| 4 | D SEPTIC TANK CLEANING & PLUMBING SERVICES | Talomo | Bucana | PUROK 12B PASIL | 3 |
| 5 | E SEPTIC TANK AND PLUMBING SERVICES | Talomo | Bucana | PUROK 12-A ST. JOHN | 3 |
| 6 | F SEPTIC TANK AND PLUMBING SERVICES | Talomo | Matina Crossing | KM 5, GUADALUPE VILLAGE | 2 |

Source: Davao City Business Bureau

2) Territory/service area of each company

There are no territories. Companies offer services to any client in any area, even in other nearby cities.

3) Collection of septage

- Septage of around two households is collected daily, but the schedule is not consistent.

- There is difficulty in accessing tanks in areas with small alleys and roads as well as tanks with access covers inside houses and are further covered. Basically, only clients with functional septic tanks call the companies for service.

- The interviewed company has only one vacuum truck with a six-cubic-meter capacity, but most service providers have trucks with less capacity.

4) Management/dumping of septage

- The proper company has to own septage disposal facilities. The companies do not have equipment such as sludge dewatering machine but large tanks to store the collected septage.

- There are those who sometimes illegally dump the collected septage in rivers, including Davao River at night, but mostly in blind drains in private properties located in elevated areas, such as Calinan. Basically, no company sells the collected septage to farmers.

(2) Frequency of Desludging

According to the result of the HIS in IM4D, many households have not desludged their septic tanks appropriately and regularly. Around 50% infiltrate to the ground, and the percentage of those who

answered “Never” and “Not sure” regarding the frequency of desludging septic tanks is over 80%.

This matter was reconfirmed in HIS in this survey, and the result is shown in Table 3.3.7. The majority of the answer was they have “never experienced desludging” and is the same with IM4D HIS. The ratio of “once per more than 5 years” increased from IM4D. From such a circumstance, the actual ratio of unlined septic tanks should be more than the above answer.

**Table 3.3.7 Frequency of Desludging from Septic Tank**

| Frequency | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Anually | 6 | 1.2 | 36 | 1.9 |
| Once per 2 years | 10 | 1.9 | 91 | 4.9 |
| Once per 3-5 years | 30 | 5.8 | 109 | 5.8 |
| Once per more than 5 years | 69 | 13.3 | 86 | 4.6 |
| Never | 325 | **62.7** | 1,105 | 59.2 |
| Not sure | 28 | 5.4 | 341 | 18.3 |
| No response | 50 | 9.7 | 97 | 5.2 |
| Total | 518 | 100.0 | 1,865 | 100.0 |

Source: JICA Survey Team and IM4D

(3) Payment for Desludging Service of Septic Tanks

The payment for desludging service of septic tanks is shown in Table 3.3.8. The ratio of households that paid for desludging service increased from IM4D.

**Table 3.3.8 Payment for Desludging Service of Septic Tanks**

| Payment | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Yes | 114 | 26.4 | 269 | 14.4 |
| No | 317 | 73.4 | 1,466 | 78.6 |
| No Response | 1 | 0.2 | 130 | 7.0 |
| Total | 432 | 100.0 | 1,865 | 100.0 |

Note: Payment Amount (2019)
Maximum: PHP 10,000, Minimum: PHP 500, Average: PHP 3,818
Source: JICA Survey Team and IM4D

According to an aforementioned interview with a company, the basic charge is PHP 7,000, but it varies based on the volume collected (and sometimes ease of access), especially in the case of businesses such as small hotels and stores without sewage treatment plants.

### 3.3.4 Septage Treatment Facility

There is no existing septage treatment facility in Davao City. Therefore, a septage management program, including sludge collection and construction of septage treatment plants, was considered by DCWD with the USAID fund. The contents are summarized in Section 6.2 in this report.

### 3.3.5 Septage Quality in Davao City

After the preparation of the Septage Management F/S in 2013 supported by USAID, DCWD analyzed the actual septage sampled from 141 households in Davao City in 2015 in order to specify the design level of the septage treatment plant. The target barangay for the septage quality analysis is shown in

Table 3.3.9, and the results of septage quality is shown in Table 3.3.10.

**Table 3.3.9 Target Barangay and Number of Samples for Septage Quality Analysis**

| Septage Collection Area | District | Barangay | (Sewerage Area) | Number of Samples |
|---|---|---|---|---|
| SCA 1 | Poblacion | 9-A | Area A | 4 |
| | Talomo | Bucana | Area A/B | 17 |
| | | Ma-a | Area C | 11 |
| | | Matina Aplaya | Area C | 4 |
| SCA 2 | Talomo | Catalunan Grande | - | 11 |
| | | Catalunan Pequeno | Area C | 10 |
| | | Baliok | Area F | 2 |
| | Toril | Crossing Bayabas | Area F | 7 |
| | Tugbok | Sto. Nino | Area E | 7 |
| SCA 3 | Agdao | Tomas Monteverde | Area A | 6 |
| | | Ubalde | Area A | 5 |
| | Buhangin | Cabantian | Area B | 12 |
| | | Buhangin Proper | Area B | 1 |
| | | Pampanga | Area D | 3 |
| | | Sasa | Area D | 9 |
| SCA 4 | Tugbok | Tacunan | Area E | 3 |
| | Calinan | Riverside | Area E | 4 |
| | | Calinan Poblacion | - | 23 |
| | | Dacudao | - | 5 |
| Total | | | | 144 |

Source: Report on Septage Characterization (DCWD 2015)

**Table 3.3.10 Result of Septage Quality Analysis by DCWD**

| Parameters | Unit | No. of samples | Mean | Estimate | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| pH | | 144 | 7 | 7 | 7 |
| BOD5 | mg/L | 144 | 462 | 372 | 552 |
| COD | mg O2/L | 144 | 834 | 342 | 1,326 |
| Ammonia Nitrogen | mg/L | 142 | 160 | 140 | 181 |
| Phosphorus as phosphate | mg/L | 144 | 47 | 37 | 57 |
| Oil & Grease | mg/L | 141 | 6 | 3 | 9 |
| TS | mg/L | 144 | 4,602 | 3,029 | 6,174 |
| TSS | mg/L | 143 | 945 | 393 | 1,498 |
| VS | mg/L | 144 | 2,698 | 1,685 | 3,711 |
| Total Coliform | MPN/100ml | 144 | >14,000,000 | 14,396,225 | >14,000,000 |

Source: Report on Septage Characterization (DCWD 2015)

### 3.3.6 Discharge of Gray Water

The discharge point of gray water from households confirmed in HIS is shown in Table 3.3.11. Of all the interviewed households, 70% answered roadside ditch. The ratio of direct discharge to public water body increased from the IM4D.

**Table 3.3.11 Discharge Point of Gray Water**

| Discharge Point | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Discharge to sewer pipe | 25 | 4.8 | 316 | 15.7 |
| Discharge to roadside ditch | 365 | 70.5 | 780 | 38.7 |
| Discharge to road | 30 | 5.8 | 12 | 0.6 |
| Infiltrate to ground | 25 | 4.8 | 768 | 38.1 |
| Discharge to public water body (river, sea,etc.) | 56 | 10.8 | 62 | 3.1 |
| I don't know | 0 | 0.0 | 51 | 2.5 |
| other | 16 | 3.1 | 0 | 0.0 |
| No response | 1 | 0.2 | 25 | 1.2 |
| Total | 518 | 100.0 | 2,014 | 100.0 |

Source: JICA Survey Team

## 3.4 Development Status, Operation and Maintenance, Development Plan of Stormwater Drainage Network

### 3.4.1 Construction, Operation and Maintenance Regime

The concerned agencies related to drainage development, improvement and maintenance are 1) Department of Public Works and Highways (DPWH) Region XI (the nation-wide organization is shown in Appendix 3.7), 2) Davao City, 3) barangays, and 4) private developers. Based on the interviews to each agency, the confirmation of their plans, budget, and roles of the agencies was summarized in Table 3.4.1.

"Creeks" mean open channel, and "drains" mean road side drain, pipe, and box culvert of a relatively large scale and in national or city roads. Meanwhile, "Ditches" mean small-scale drains and gullies 1) under/beside the barangay roads and small alleys in congested area including illegal settlers' area, and 2) roadside drains in housing estates by private developer. In general, barangays do not have a mandate of constructing roads with drains because it is undertaken by DPWH or the city. Only the maintenances of roads and drains are mandated. (RA7160)

According to an interview with DPWH and the city, there is no boundary of construction costs for deciding an implementation agency of construction/improvement works of city road drains. Almost all the drainage works in the city avenues, excluding side drains, are conducted by DPWH.

**Table 3.4.1 Roles of Drainage Works in Davao City by Concerned Agencies**

| Agency | Creeks, Pumping Stations | Drains | Ditches (in residential area) |
|---|---|---|---|
| DPWH (Region XI) | - Construction and Rehabilitation of major creeks<br>- Construction and O&M of P/S | - Drains in national roads<br>- Large scale construction/improvement of city road drains | (Construction of barangay road side drains: undertaken) |
| Davao City (CEO) | - Construction (minor creeks not in drainage master plan)<br>- Maintenance including cleaning | - Construction, maintenance of drains in city roads<br>- Maintenance and cleaning of all the main drains | (Construction of barangay road side drains: undertaken) |
| Barangays/residents | - | Cleaning of small-scale drains in city roads (depending on barangays) | - Construction in case of illegal residential areas and private roads<br>- Maintenance and cleaning |
| Private Developer | - | - | Construction, rehabilitation, and maintenance in their own housing estate |

Source: JICA Survey Team

### 3.4.2 Development Status of Drainage System

(1) Main Drainage Channels/Culverts in Poblacion and Agdao Districts

Several drainage channels have been developed by DPWH in the Poblacion and Agdao Districts (see drainage map obtained from DPWH in Appendix 3.8). The names, type (open/underground), and discharge points are shown in Table 3.4.2. According to DPWH, some drains, such as Roxas Creek and Agdao Creek, as proposed main drains in the Drainage Master Plan 1982 were developed with a World Bank loan.

**Table 3.4.2 Main Drainage Channels/Culverts discharged to Davao Gulf and Davao River**

| No. | Main Drainage Channels/Culverts | District | Type | Discharge to |
|---|---|---|---|---|
| 1 | Barangay Bucana Main Drain | Poblacion | RCPC-D36 x 2 | Davao Gulf |
| 2 | Mabini Main Drain | Poblacion | Box culvert (2.0 x 2.0) | Davao Gulf |
| 3 | Roxas Creek | Poblacion | Open channel /Box culvert | Davao Gulf |
| 4 | Suazo Outfall | Poblacion | Box culvert (2.0 x 1.5) | Davao Gulf |
| 5 | Ponce-Gempesaw Creek | Poblacion | Open channel | Davao Gulf |
| 6 | Santa Ana Main Drain | Poblacion /Agdao | Box culvert | Davao Gulf |
| 7 | Agdao Creek | Poblacion /Agdao | Open channel | Dacudao Creek |
| 8 | Dacudao Creek | Agdao | Open channel | Davao Gulf |
| 9 | Gotamco Outfall | Agdao | RCPC-D60 | Davao Gulf |
| 10 | Techno Trade Outfall | Agdao | RCPC-D48 | Davao Gulf |
| 11 | Jerome Creek | Agdao | Open channel (4.22 x 2.0) | Davao Gulf |
| 12 | Quirino Main Drain | Poblacion | RCPC-D72 /Box culvert | Davao River |
| 13 | Gov. Generoso Main Drain | Poblacion | RCPC-D72 /Box culvert | Davao River |
| 14 | Anda Main Drain | Poblacion | RCPC-D72 | Davao River |
| 15 | Bolton Main Drain | Poblacion | Box culvert (2.0 x 2.0) | Davao River |

Note: listed from southwest to northeast (Davao Gulf), from north to south (Davao River)
Source: JICA Survey Team

(2) Past and Ongoing Drainage Projects by DPWH

The various drainage projects that have been conducted and will be conducted by DPWH were tabulated. The number of projects in each year is shown in Table 3.4.3. The design capacities of pumping stations are all 1 $m^3/s$ with a head of 7 m, which means there is a small scale for stormwater drainage pumping stations.

**Table 3.4.3 Number of Recently Completed, Ongoing, and Planned Drainage Improvement by DPWH**

| Year | Channel Improvement/ Drainage Construction | Pumping Station |
|---|---|---|
| 2016 | 5 | 1 |
| 2017 | 11 | 0 |
| 2018 | 15 | 6 |
| 2019 (ongoing) | 5 | 2 |
| 2020 (plan) | 14 | 0 |

Source: JICA Survey Team based on DPWH project lists

The detailed lists of past, ongoing, and future projects by DPWH is shown in Appendix 3.9.

The detailed list of past projects for FY2016-2018 is shown in Table A3-9-1 in Appendix 3.9. The amounts increased from 2016 (PHP 162 million) to 2018 (PHP 952 million). However, the drain improvement works in Poblacion and Agdao Districts are basically to rehabilitate, widen, and cover the drains and insufficient slopes of existing drains were not improved. The pumping stations that were installed act as gate pumping stations in the mouths of creeks and in flood prone areas to drain the flood

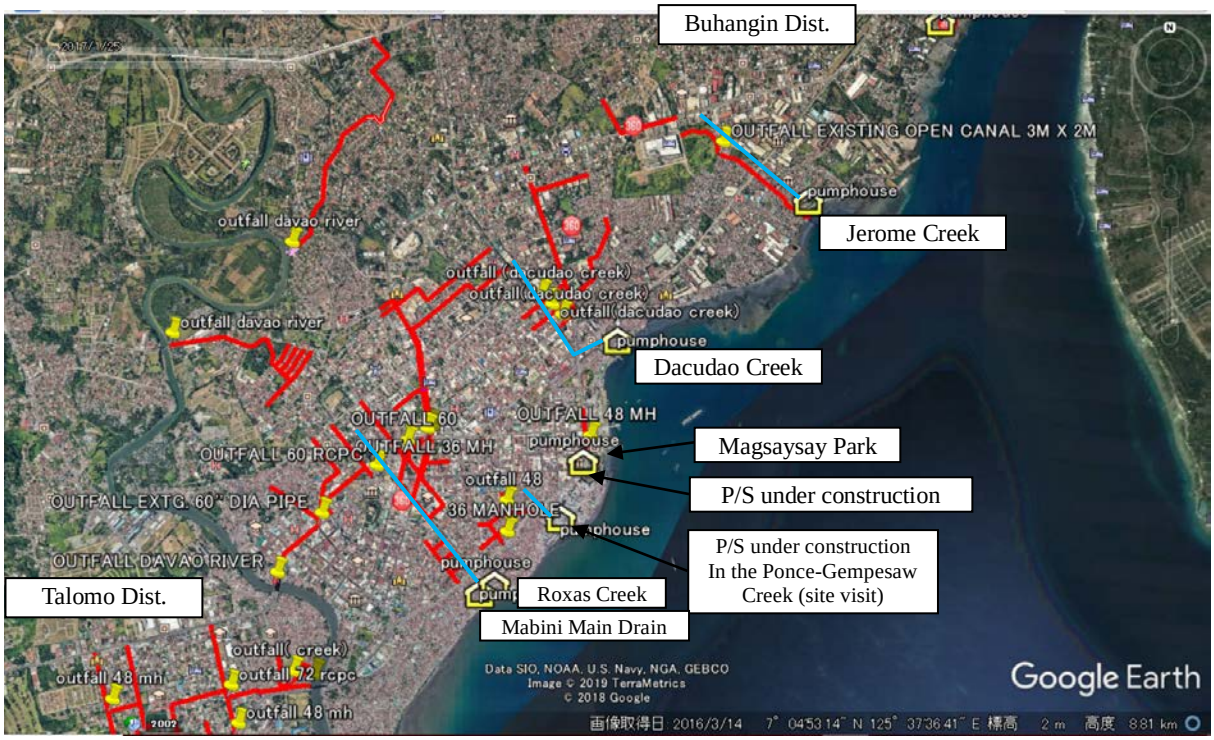
water. The works that entail increasing the slopes of existing drains and downstream pumping station in the flat area are not included. Therefore, effects from the drainage works are limited except for inland areas with enough slope and areas without any existing drains, however, certain effects by facilities with larger capacities such as new box culverts are expected.

The drainage pumping stations have been constructed for flood prone areas, particularly in the mouths of creeks and outfalls, and are shown in Table 3.4.4 and Figure 3.4.1.

**Table 3.4.4 Construction of Drainage Pumping Station (Recent, Ongoing)**

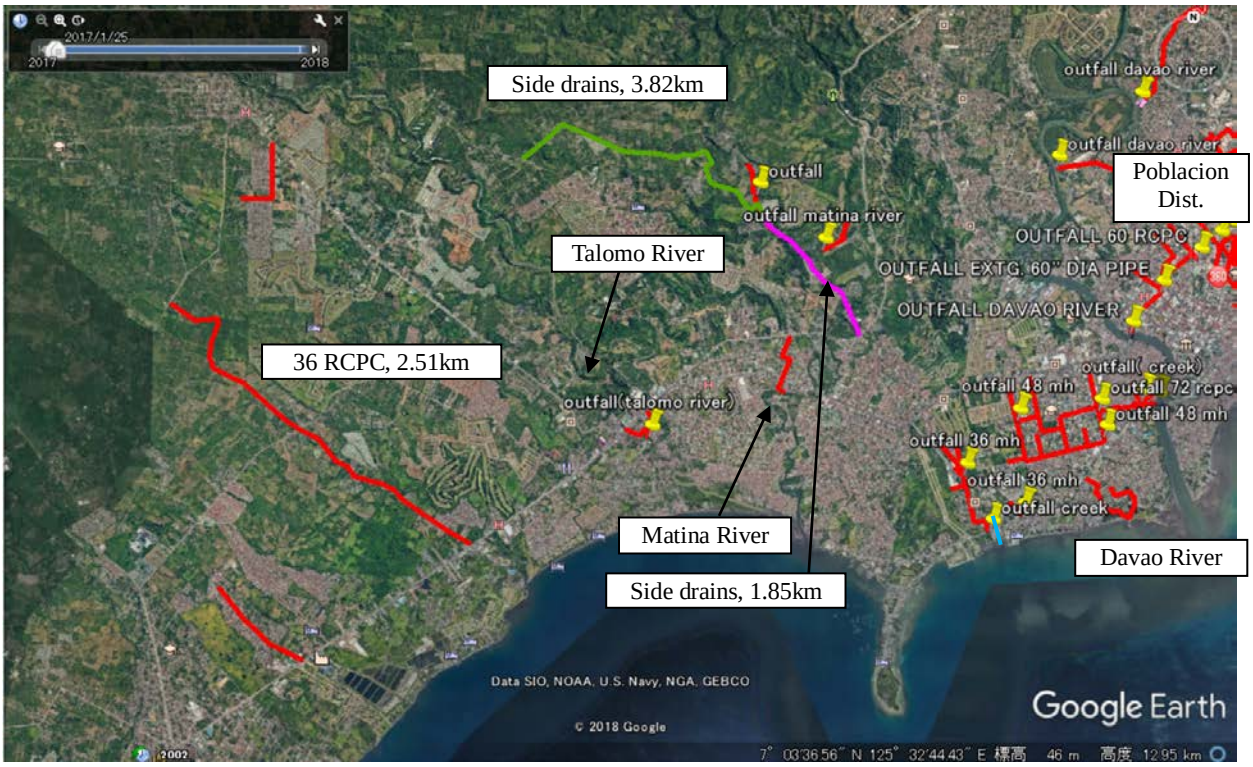
| Year | Pumping Station | District | Specification |
|---|---|---|---|
| 2016 | 1) Near airport | Buhangin | N/A |
| 2018 | 1) Mabini Outfall | Poblacion | 1 $m^3$/sec, H=7 m |
| | 2) Roxas Creek | Poblacion | 1 $m^3$/sec, H=7 m |
| | 3) Ponce-Gempesaw Outfall | Poblacion | 1 $m^3$/sec, H=7 m |
| | 4) Agdao/Dacudao Creek | Agdao | 1 $m^3$/sec, H=7 m |
| | 5) Jerome Creek | Agdao | 1 $m^3$/sec, H=7 m |
| | 6) Mamay Creek | Buhangin | 1 $m^3$/sec, H=7 m |
| 2019 | 1) Sasa Creek | Buhangin | 1 $m^3$/sec, H=7 m |
| | 2) Beside Davao River | Buhangin | N/A |

Note: all pumping station on drainage channels are together with flood gates in river mouth
Source: JICA Survey Team based on DPWH data



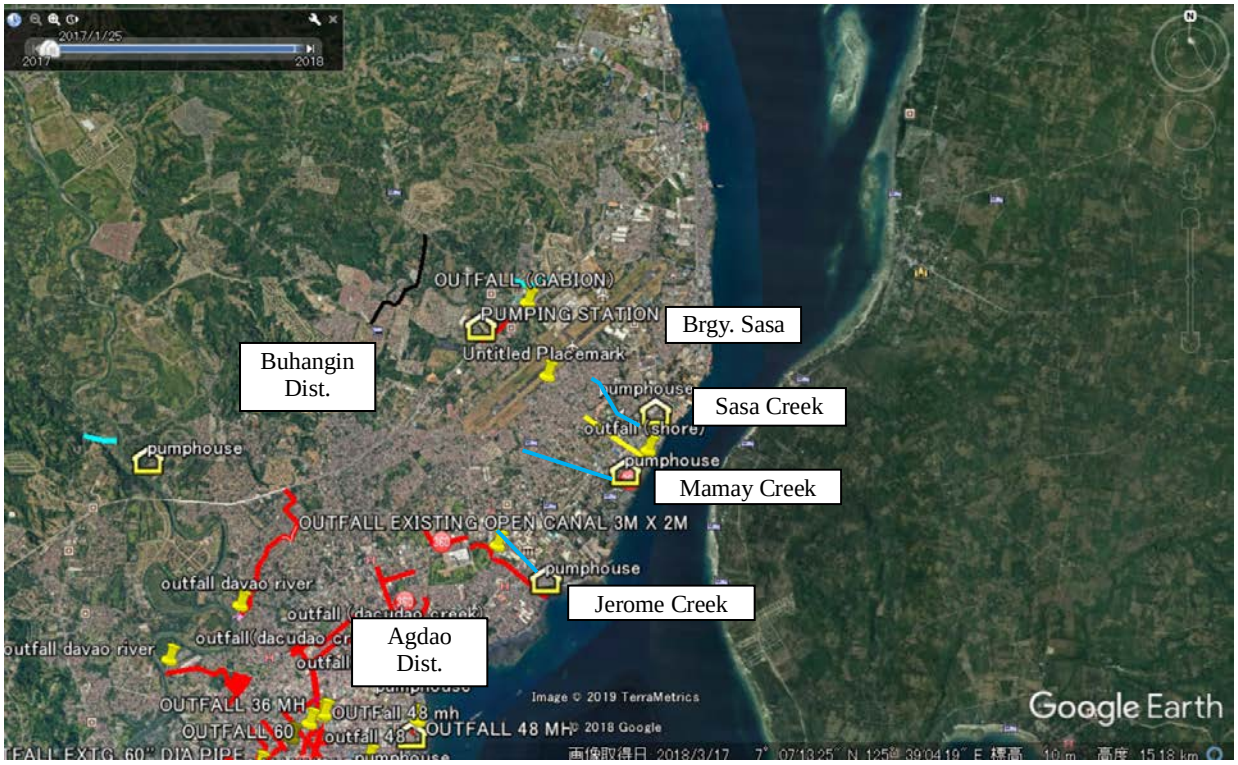

Note: Red line: drains to be developed/improved, Yellow house: pumping station (P/S), Yellow pin: outfall to river/creeks/main drains, light blue line: creek (open channel)
Source: DPWH on Google Earth image supplemented by JICA Survey Team

**Figure 3.4.1 Drainage Development/Improvement Projects in Poblacion and Agdao Districts**




Note: Red line: drains to be developed/improved, Yellow pin: outfall to river/creeks/main drains, light blue line: creek (open channel)
Source: DPWH on Google Earth image supplemented by JICA Survey Team

**Figure 3.4.2 Drainage Development/Improvement Projects in Talomo District**




Note: Red line: drains to be developed/improved, Yellow house: pumping station (P/S), Yellow pin: outfall to river/creeks/main drains, light blue line: creek (open channel)
Source: DPWH on Google Earth image supplemented by JICA Survey Team

**Figure 3.4.3 Drainage Development/Improvement Projects in Buhangin District**

(3) Past and Ongoing Drainage Projects by the City Government

The city has conducted small-scale drainage construction/improvement projects. The list of the projects from FY 2014 to 2019 are shown in Appendix 3.10 for annual budget and supplemental budget. The annual budgets and executed amount for drainage works are shown in Table 3.4.5. The budget (particularly executed works) is less than 10% of the drainage works by DPWH. However, the amount is certainly increasing every year, and the figure increased significantly in 2019.

**Table 3.4.5 Budget for Drainage Works by City**

| | Annual Budget (PHP) | | Supplemental Budget (PHP) | | Total (PHP) | | Reference: Works |
|---|---|---|---|---|---|---|---|
| FY | Budget | Executed | Budget | Executed | Budget | Executed | by DPWH (PHP) |
| 2014 | 10,040,000 | 10,005,726 | 1,000,000 | 996,937 | 11,040,000 | 11,002,663 | - |
| 2015 | 5,855,000 | 5,831,484 | 10,500,000 | 9,407,308 | 16,355,000 | 15,238,792 | - |
| 2016 | 3,850,000 | 3,835,013 | 20,950,000 | 11,990,910 | 24,800,000 | 15,825,923 | 162,390,000 |
| 2017 | 40,050,000 | 36,435,521 | 23,500,000 | 497,171 | 63,550,000 | 36,932,692 | 208,995,000 |
| 2018 | 76,164,153 | 78,640,920 | 10,250,000 | 149,842 | 86,414,153 | 78,790,762 | 951,640,000 |
| 2019 | 203,902,000 | 9,603,151 | | | 203,902,000 | 9,603,151 | 355,807,000 |
| 2020 | - | - | - | - | - | - | 396,200,000 |
| | | | | | | | |
| 2016-2019 | 323,966,153 | 128,514,605 | 54,700,000 | 12,637,923 | 378,666,153 | 141,152,528 | 1,678,832,000 |

Source: JICA Survey Team based on the City Drainage Data

(4) Planned Drainage Capacity for Existing Drains

Due to the insufficient slope in the seaside area, securing the long return period for drainage facilities has been quite difficult in Davao. “Davao City Urban Drainage and Flood Control Project, Storm Drainage Master Plan, 1998 (Drainage M/P 1998)” was planned with the return periods shown in Table 3.4.6. Therefore, it can be understood that capacities of the recently constructed/improved drains are based on the design return periods shown in Table 3.4.6. However, majority of old drains without improvement is supposed to have less capacity than tabulated.

**Table 3.4.6 Return Periods of Drainage Facilities planned in Drainage M/P 1998**

| Type of Waterway | Return Period |
|---|---|
| Main drain channel | 25 years |
| Lateral drains | 2 years |

Source: IM4D based on Drainage M/P 1998

(5) Development Plan for Drainage by DPWH

DPWH will continue to develop/improve the drainage facilities, but DPWH does not have future plans with specific drainage names, locations, and dimensions. The future works will be incorporated with the latter proposal by the Flood Control M/P Team.

DPWH follows the design guideline on drainage works shown in Table 3.4.7 when constructing new facilities, such as the side drain of national roads. The return periods for the designs of drains in national roads are 10 years for road side ditches of national road and 25 years for culverts.

**Table 3.4.7 Design Storm Frequency for Drainage System for DPWH Works**

**5.7 Design Storm Frequency**

The design of drainage structures considers estimates of the magnitude of floods based on frequency of occurrence. The selection of flood frequencies normally differ depending on the type of drainage structure or condition being considered.

The design storm frequencies considered desirable for use in the Philippines are provided in Table 5-3.

**Table 5-3 Design Flood Frequency**

| DESIGN FLOOD FREQUENCIES (MINIMUM REQUIREMENTS) FOR ROAD | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road Classification | Culverts | | Roadside Ditches & Inlets | | Median Ditches & Inlets | | Curb Drop Inlets | |
| | Design Flood | Check Flood | Design Flood | Check Flood | Design Flood | Check Flood | Design Flood | Check Flood |
| Expressway | 50 yr | 100 yr | 25 yr | 50 yr | 25 yr | 50 yr | 25 yr | 50 yr |
| National Road | 25 yr | 50 yr | 10 yr | 25 yr | 10 yr | 25 yr | 10 yr | 25 yr |
| Other Roads | 20 yr | 50 yr | 5 yr | 10 yr | 5 yr | 10 yr | 5 yr | 10 yr |

Source: DPWH Design Guideline

### 3.4.3 Flood Control Master Plan Project by JICA

(1) General Scope

In parallel with this study, the master plan project for flood control and drainage has been conducted by JICA. The features of the project are as follows:

Project Name: Master Plan and Feasibility Study on Flood Control and Drainage in Davao City (hereinafter called as “Flood Control M/P”)

Project Period: November 2018 to October 2020

- Stage 1 - Basic Study: November 2018 to August 2019
- Stage 2 - Master Plan Study: September 2019 to February 2020
- Stage 3 – Feasibility Study: March 2020 to October 2020

Local Counterpart Agencies (C/P): DPWH, Davao City Government

Main Contents of Project:

1) Flood control for the rivers of Davao, Matina, and Talomo (Priority Project in F/S: Davao River)

2) Analysis and proposal for drainage improvement downtown including Poblacion and Agdao Districts

3) Seaside protection and measures for high tide

In cooperation with the project team, the current status of ongoing and future projects mainly by DPWH in stormwater drainage sector were confirmed in this study.

(2) Drainage Inventory

The Flood Control M/P Team has been preparing the drainage inventory reflecting existing, ongoing, and future drainage facilities in the target area. An inventory for the Poblacion and Agdao Districts, excluding northern Poblacion and eastern Agdao, has been prepared with the dimensions (type, material, and length of pipes, ground elevation and assumed depths of connection points) and routes (planar image) of the drainage facilities of around 131 km in total. The image with arranged and supplemented information by the JICA Survey Team is shown in Figure 3.4.5, and the enlarged image is in Appendix 3.11. The type and ratio of the main drainage facilities are shown in Table 3.4.8. The dimensions of the facilities were provided from the M/P team and DPWH as a drawing/Google Earth base, but flow analysis data has not been provided.

**Table 3.4.8 Type and Ratio of Main Drainage Facilities in Poblacion and Agdao**

| Type of Main Drainage Facility | | | Total (km) |
|---|---|---|---|
| Open Channel | Box Culvert | Pipe Culvert | |
| 22.8% | 6.9% | 70.3% | 131.1 |

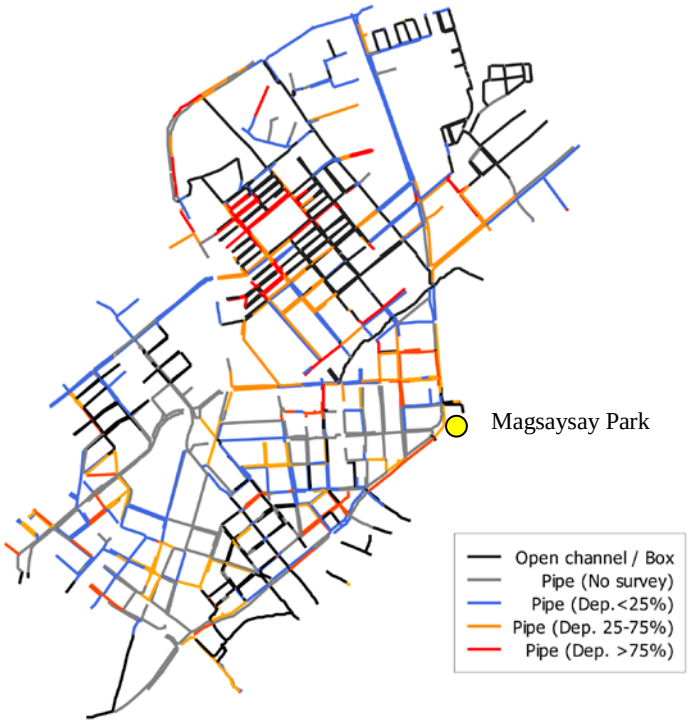
Source: JICA Flood Control M/P Team compiled by JICA Survey Team

The condition of the existing drainage pipes based on the inventory data and field survey are shown in Table 3.4.9 and Figure 3.4.4. Clogging can be observed in nearly 70% of all the drainage facilities. The roadside drains are assumed to be with more clogging as the smaller dimensions and less gradients than the main facilities.

**Table 3.4.9 Clogging Status of Existing Drainage Pipes in Poblacion and Agdao**

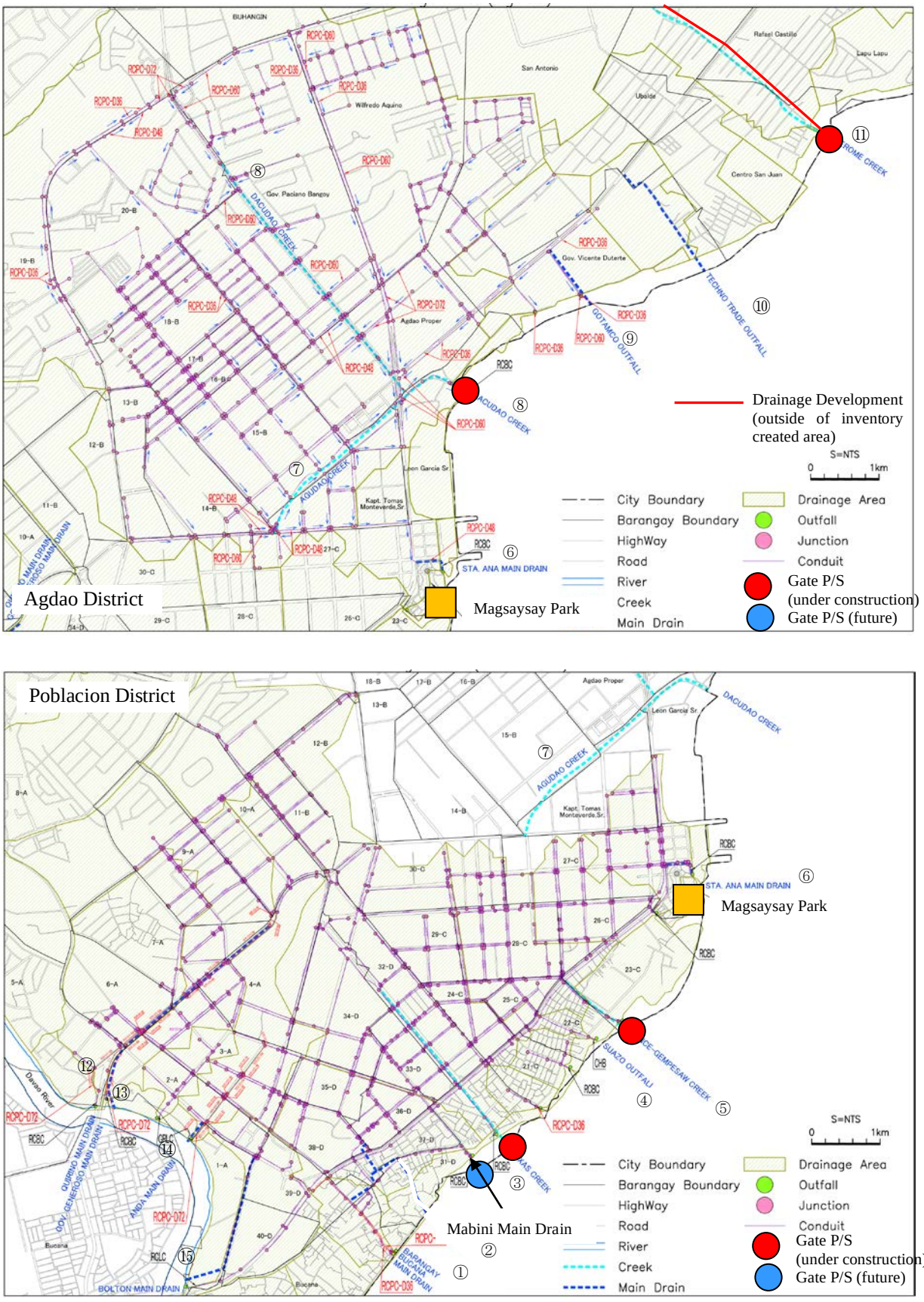
| Clogging of Section | Less than 25% | **25-75%** | **More than 75%** | Total |
|---|---|---|---|---|
| Ratio of Drainage | 33.1% | **47.9%** | **19.0%** | 100% |

Source: JICA Flood Control M/P Team compiled by JICA Survey Team




Source: JICA Flood Control M/P Team

**Figure 3.4.4 Clogging Status of Existing Main Drainage Facilities in Poblacion and Agdao**




Note: ①: Number of main drains in Table 3.4.2
Categorizations of Creek is "Main Drainage" and Main Drain is "Sub-main Drainage" in Flood Control M/P.
Source: JICA Survey Team with Flood Control M/P Team inventory

**Figure 3.4.5 Drainage Inventories in Area A (Poblacion and Agdao Districts)**

(3) Preliminary Drainage Improvement Plan by the Flood Control M/P Team

The contents of the proposal are under consideration and are being organized by the Flood Control M/P Team. According to them, the tentative idea for the drainage improvement is as follows:

a) Maintenance including cleaning for open channels, main drains, and lateral drains (top priority as easiest and most effective measure)

b) Improvement of lateral drains and storage facilities in flood prone areas

c) Seaside flood prone area: construct gate to stop high tide and pumping stations in outlet of creeks (only possibility)

d) Upgrade of main drain capacities up to 25-year return period levels with creek improvements, construction of bypass drains, storage tanks in inland flood prone area

e.g.1) Additional culverts along with Jerome Creek with insufficient capacity

e.g.2) Additional channels along with Roxas Creek and Agdao Creek with insufficient capacities or stormwater storage facilities under the roads beside the creeks

The Flood Control M/P Team does not propose the installation of stormwater lateral pipes except for locations along with creeks. The upgrade of the roadside drains will not be proposed by the team. Meanwhile, the cleaning of drains will also be proposed since the major causes of flooding are: 1) clogging of drains, 2) sedimentations in the downstream and bottom of creeks and main drains, and 3) ground condition. The Flood Control M/P Team conducted the analysis of the stormwater drainage capacity without wastewater.

## 3.5 Status and Plan of Solid Waste Landfill Site

(1) Existing New Carmen Sanitary Landfill

The proposed wastewater treatment plant, which is explained in Chapter 6 in this report, will generate sludge daily. The sludge should be transported to a sanitary landfill operated by Davao City. The existence and sufficient capacity of the landfill site to accept the sludge has an impact to the feasibility of the project. Therefore, the existing status of the landfill site was confirmed in this study.

There is only one operational landfill site for Davao City. The existing New Carmen Sanitary Landfill is located in Barangay New Carmen, Tugbok District (see Figure 3.5.1). It is around 15 km away from the Poblacion District and the city center. The outline of the facility is shown in Table 3.5.1. The original area was 3.8 ha, but it has been repeatedly expanded to the west side and has reached to 11 ha.

**Table 3.5.1 Outline of Existing New Carmen Sanitary Landfill**

| Item | Description |
|---|---|
| Total land area | 11 ha |
| Area of original cell (dumping area) | 38,077 $m^2$ (=3.8 ha) |
| Depth of cell | 60 m |
| Capacity | 4.28 million $m^3$ (2018) |
| Operation | December 2010 to present |

Source: JICA Survey Team based on CENRO document

1. Overload for existing landfill area

2. Preparation for slight expansion of area

**Photo: Existing Condition of New Carmen Sanitary Landfill**

The City Environment and Natural Resources Office (CENRO) has been trying to find a new site, and around 20 sites had been considered, but none was found suitable. Therefore, the site is continuously used, prolonging the service life by expanding and increasing the landfill height. According to CENRO, the site is almost fully occupied with solid waste as of 2019.

The current lifetime of a landfill site is approximately one year from the middle of 2019. However, due to the required period to purchase land for a new site (six months), and the study, design, and development of the site (two years in total), it shall be utilized for more than two years.

Therefore, purchasing and developing a new site by CENRO is a critical and urgent issue in order to ensure the transportation of the sludge generated from the future Septage Treatment Plants and Wastewater Treatment Plant (WWTP).

For reference, the estimated solid waste generation from 2011 to 2016 and future generation projection is shown in Table 3.5.2, and sludge generation from WWTP is around 30 $m^3$/day in the dry sludge base (3% to 5% of total solid waste generation).

**Table 3.5.2 Estimated Municipal Solid Waste Generation**

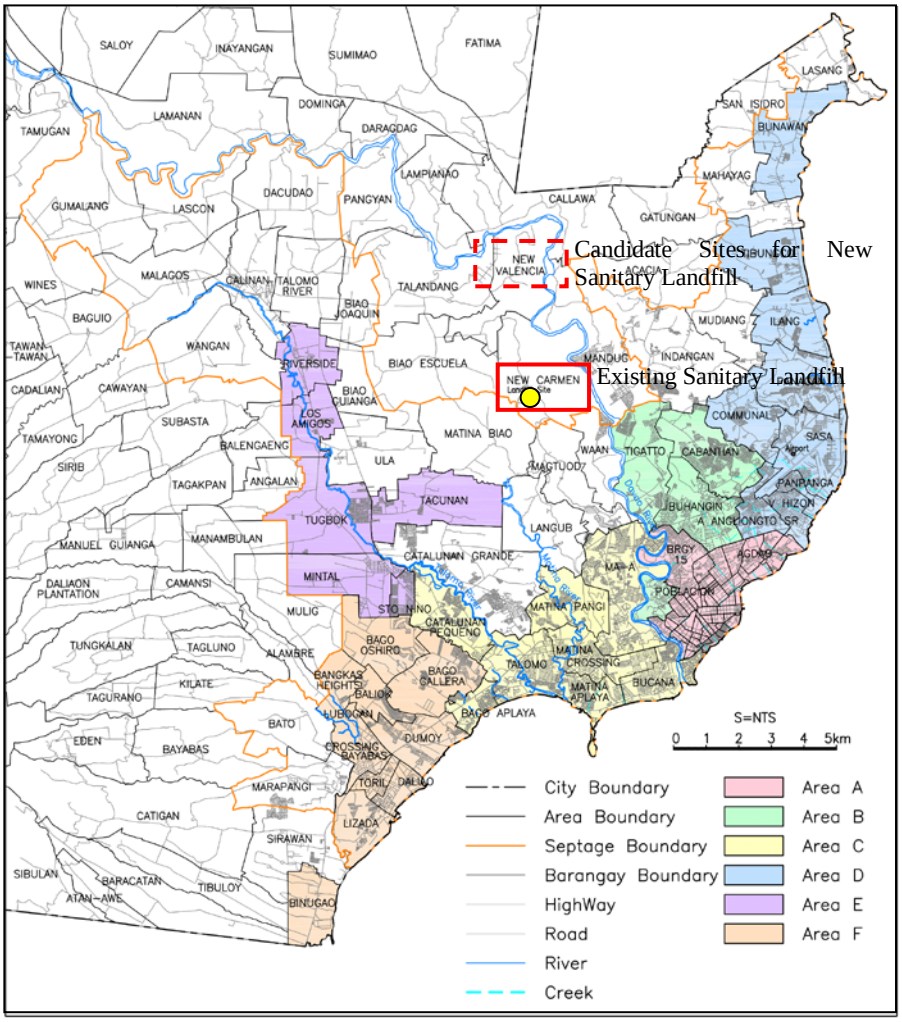
| Year | Estimated | | | | | | Projection | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2020 | 2025 |
| Generated Waste (ton/day) | 418 | 413 | 443 | 428 | 604 | 639 | 931 | 1,165 |

Source: IM4D compiled by JICA Survey Team

(2) Waste-to Energy (WTE) Project

As for the introduction of WTE technology, on 20 March, 2018, the exchange notes between the Government of the Philippines and the Government of Japan relative to PHP 2.5 billion grant was signed by both governments. With this grant aid, Davao City will operate the first WTE facility in the Philippines in 3 to 4 years (2022 or later). At present, the JICA Technical Cooperation Team for the WTE Project has been supporting Davao City.

The WTE site of approximately 9 ha was found by the city as a high priority matter, and land acquisition is under process.




Source: JICA Survey Team

**Figure 3.5.1 Location of Existing Sanitary Landfill Site in New Carmen**

(3) New Sanitary Landfill Site

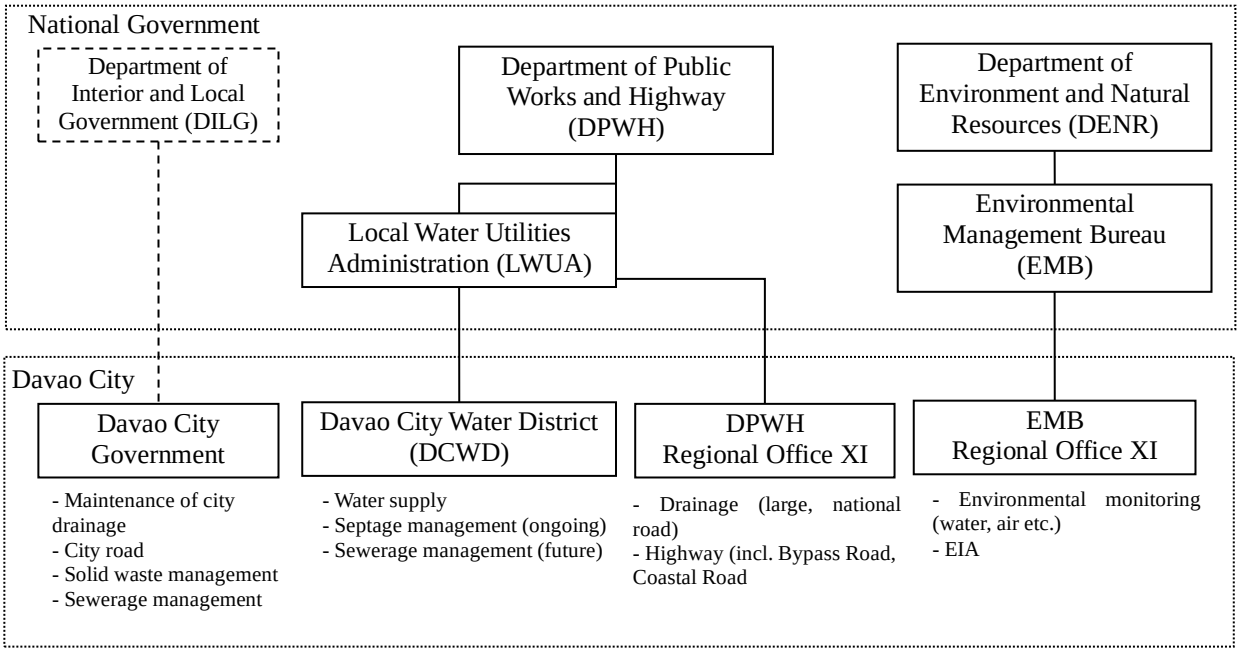
CENRO revealed the following information on the new sanitary landfill site:

- Two candidate sites were found in Barangay New Valencia, which is adjacent to Barangay New Carmen (see the location of Barangay in Figure 3.5.1). The areas are around 19 ha and 10 ha and both are private lands.
- The budget for purchasing the land is around PHP 60 million out of the PHP 100 million as original budget in 2019. PHP 40 million is used for purchasing the WTE site.
- CENRO tries to purchase the land within 2019 so that the completion of the landfill site can be done earlier than the one from WTE (2022). After purchasing the land, the preparation of F/S and B/D (1 year) and construction of the site (1 year) will follow it.
- As much as possible, solid waste will be transported to the WTE to reduce the volume and the sludge generated in the wastewater treatment plant (WWTP), and ash from the WTE will be transported to a new landfill site.

Therefore, once the new landfill site will be developed, the space for receiving biosolid (dried sludge) will be secured.

## 3.6 Relevant Organizations for the Water Sector in Philippines and Davao City

The institutional framework of relevant organizations in the water sector in the national government and Davao City is shown in Figure 3.6.1. The main tasks of each relevant organizations are shown in Table 3.6.1.




Source: JICA Survey Team

**Figure 3.6.1 Institutional Regime of Water Sector (National, Davao City)**

**Table 3.6.1 Relevant Organization and Roles for Water and Sanitation Sector**

| Organization | Comments/Main Tasks |
|---|---|
| **National government in Metro Manila** | |
| Department of Public Works and Highway (DPWH) | - Management of national roads<br>- Management of overall flood control and drainage |
| Local Water Utilities Administration (LWUA) | - Subsidiary organization of DPWH for water supply and sanitation works in local cities<br>- Monitoring of water supply and sanitation works by water districts |
| Department of Environment and Natural Resources (DENR) | - Establishment of legal framework regarding environmental management |
| Environmental Management Bureau (EMB) | - Preparation of plan and environmental criteria regarding water, air, and soil |
| **Local agencies in Davao City** | |
| Davao City Government | - Overall development plan for infrastructure in Davao City (e.g. IM4Davao)<br>- Approval of infrastructure projects to commence (e.g. septage management program by DCWD)<br>- Water supply in rural area outside of DCWD service area (around 40% of the city area)<br>- Small scale maintenance and cleaning of drains belonging to the city (e.g. drains beside city roads)<br>- Solid waste management (collection of non-recyclable wastes, construction and operation of landfill site)<br>- Sewerage management<br>- Issuance of city ordinance for facilities (e.g. installation of septic tanks in buildings) |
| Barangays | - Area wise administration works in the city<br>- Self-cleaning of small drains in the barangay<br>- Solid waste management (collection and intermediate treatment of recyclable and biodegradable wastes) |

| | |
|---|---|
| Davao City Water District (DCWD) | - Development and management of the water supply system including tariff collection (service area is around 60% of city area)<br>- Septage management program (ongoing plan)<br>- Management of the sewerage system in future (roles to be discussed with city) |
| DPWH Regional Office XI | - Development and maintenance of the drainage system (channels and pumping stations, drains beside national road)<br>- Development of the drainage system in city roads based on requests by the city and observance of the drainage master plan<br>- Development and maintenance of highways (incl. Bypass Road, Davao City Coastal Road (DCCR) |
| EMB Regional Office XI | - Environmental monitoring (water, air, soil etc.) for water bodies such as river and sea water qualities, discharge from industries<br>- Approval of EIA in construction works |
| Private companies | - Collection and dumping of septage based on request by citizens (current) (sanitation related companies)<br>- Installation of septic tanks in houses (septic tank companies)<br>- Treatment of wastewater generated in large scale buildings with basic septic tanks (shopping malls, industries etc.) |

Source: JICA Survey Team

## 3.7 Organization, Water Supply and Financial Status of DCWD

### 3.7.1 Organization

The Davao City Water District (DCWD) was created in 1974 with City Resolution No. 1283 (see Appendix 3.12) as a quasi-public corporation or a semi-government status, pursuant to Presidential Decree No. 198 (Provincial Water Utilities Act of 1973). DCWD was formed for the following purposes:

1) Acquiring, installing, improving, maintaining, and operating water supply and distribution systems for domestic, industrial, municipal, and agricultural uses for residents and lands within the boundaries of such districts;

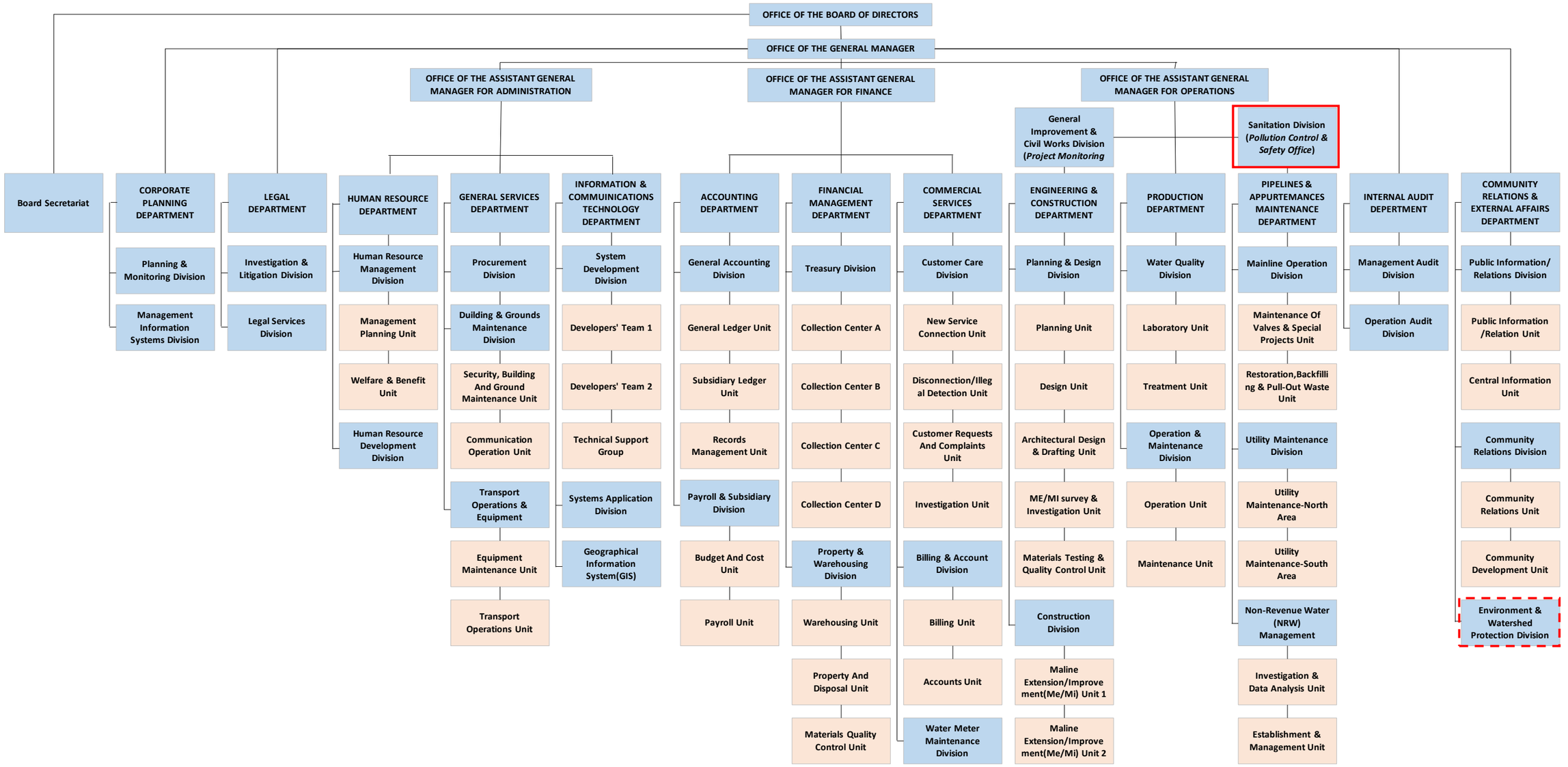
2) Providing, maintaining, and operating wastewater collection, treatment, and disposal facilities; and

3) Conducting such other functions and operations incidental to water resource development, utilization, and disposal within such districts, as necessary or incidental to said purpose.

The organization structure of DCWD is shown in Figure 3.7.1. The “Sanitation Division” was newly established in 2018 under the Office of the Assistant General Manager for Operations. The division is also called as the Pollution Control & Safety Office. The Sanitation Division is in charge of septage management. They have been updating the plan of the Septage Management Program for the upcoming implementation of the project. Once the sewerage project commences, the same division would be in charge of the project for at least the operation and maintenance of facilities.

The number of staff in each department is shown in Appendix 3.13 (1). The total number of staff in DCWD as of 5 July 2019 is 1,181, and there are 13 employees in the Sanitation Division.

Table 3.7.1 summarizes the relevant divisions and activities on the environmental and social considerations (ESC) for the DCWD operation.




Source: DCWD

**Figure 3.7.1 Organization Structure of DCWD**

**Table 3.7.1 Relevant Division and Activity**

| Division | Office/Department | Activities | | |
|---|---|---|---|---|
| | | EIA | Monitoring | Grievance Redress |
| Sanitation Division | Office of the Assistant General Manager for Operations | | ✓* | ✓** |
| Pubic Information Relation Division | Community Relations and External Affairs Department | | | ✓*** |
| Environmental and Watershed Protection Division | | ✓ | | ✓**** |

Note: * Water and Environmental Quality, ** Grievance on sanitation matter, ***Grievance on general matter, ****Grievance on Environment and Watershed
Source: Result of Hearing with DCWD

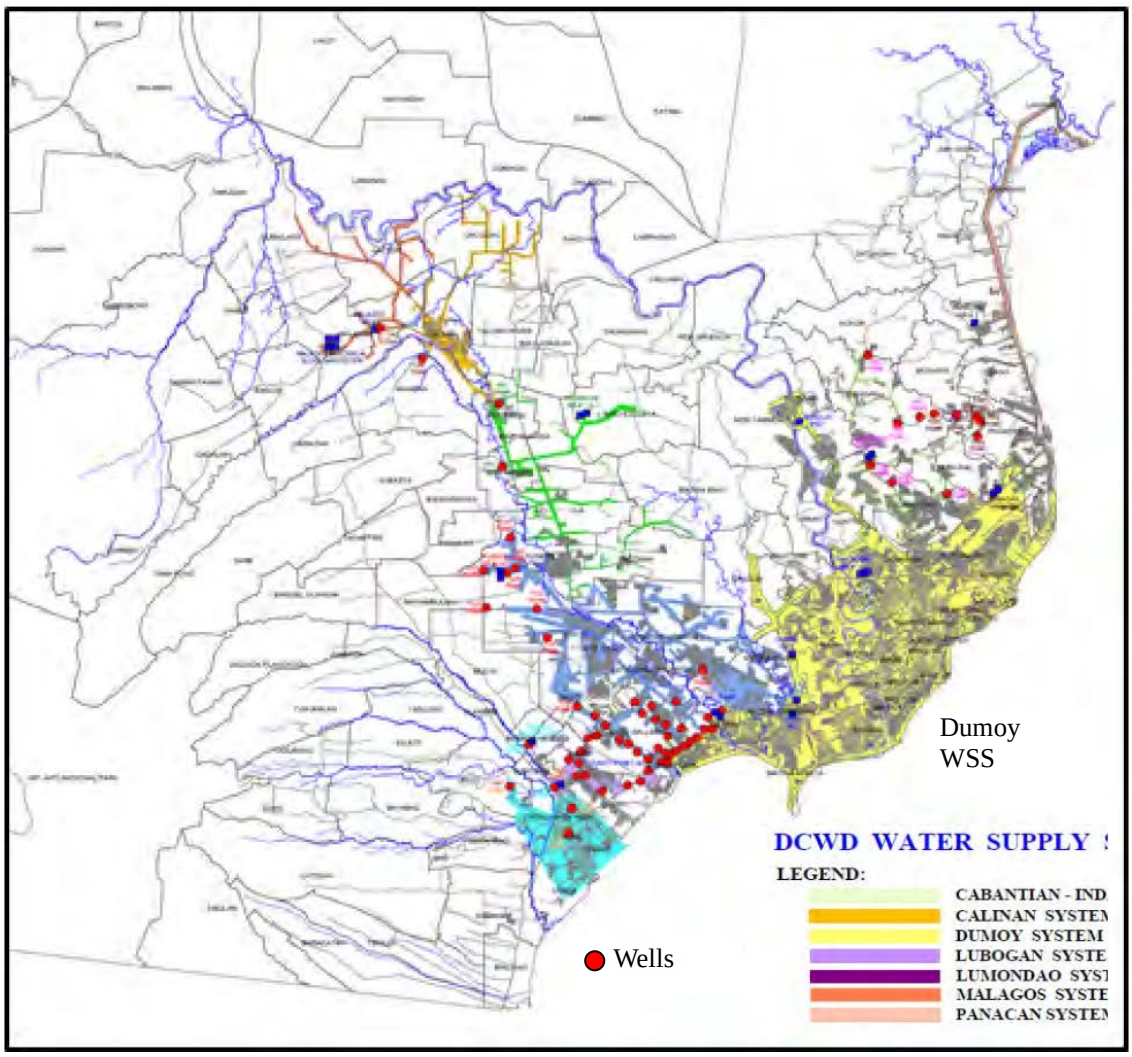
### 3.7.2 Status of Water Supply

1) Water Supply System (WSS)

DCWD maintains and operates 54 production wells, 19 booster pumps, 23 chlorinating facilities, two sedimentation basins, and four slow sand filters, as shown in Figure 3.7.2. These facilities were installed/constructed in nine independent water systems (with complete water sources). The eight operational systems are supplied with groundwater abstracted by means of tube wells equipped with either submersible pumps or vertical turbine pumps, comprising 99% of the total water production, while only 1% came from surface water (Malagos System). Of the eight systems, the Dumoy system is the biggest with 36 wells. The schematic distribution system of the Dumoy Booster Pumps is shown in Figure 3.7.3.

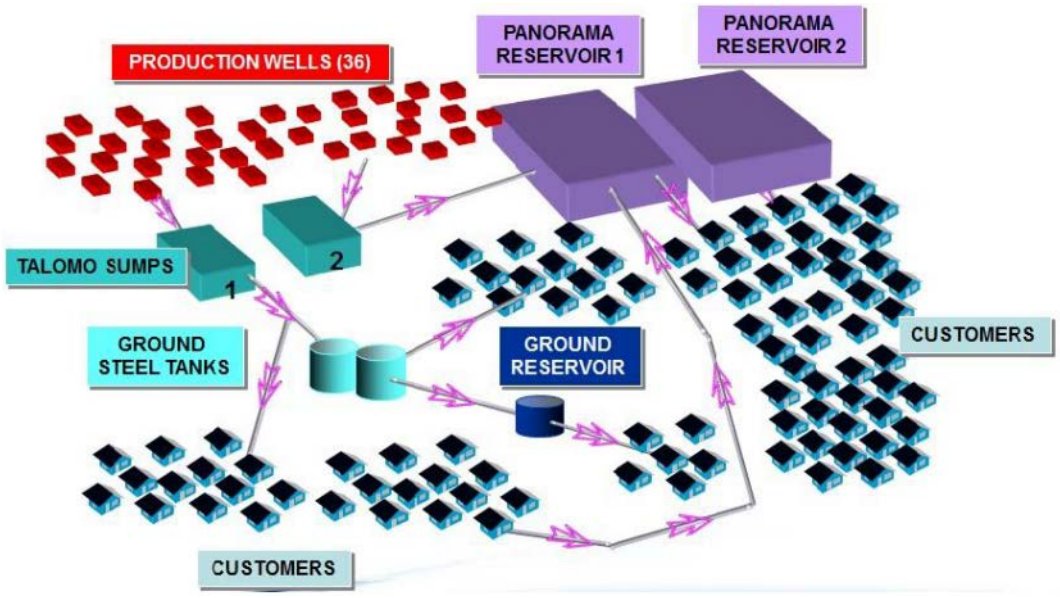
The Dumoy Water Supply System (WSS) (Line 2: production wells 20-38) supplies to the Agdao and Poblacion Districts in the Sewerage Development Area A (priority area). Meanwhile, Line 1 supplies to areas in Talomo District where Barangay Dumoy is located.

Table 3.7.2 shows the water production of DCWD's water system and Table 3.7.3 shows the water supply facilities in WSSs.




Source: IM4D

**Figure 3.7.2 DCWD Water Supply System**




Source: Septage Management F/S

**Figure 3.7.3 Schematic Distribution System of the Dumoy Booster Pumps**

**Table 3.7.2 DCWD Water Production in the Water Supply System (2007-2012)**

| Water System | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Dumoy | 59,264,414 | 58,908,288 | 60,468,788 | 64,858,169 | 66,946,280 | 67,235,140 |
| Panacan | 2,531,967 | 2,723,978 | 2,856,609 | 3,045,523 | 3,511,067 | 3,427,603 |
| Tugbok | 7,547,207 | 7,755,363 | 7,648,058 | 7,797,186 | 8,026,960 | 8,656,969 |
| Malagos | 595,324 | 665,220 | 623,083 | 755,149 | 692,111 | 696,628 |
| Calinan-Riverside | 2,343,042 | 2,521,905 | 2,387,346 | 2,451,467 | 2,560,316 | 2,290,918 |
| Cabantian | 1,216,882 | 1,875,288 | 2,194,130 | 2,669,249 | 2,907,355 | 3,271,380 |
| Toril | 2,160,067 | 2,359,770 | 2,308,177 | 2,299,670 | 2,617,177 | 3,203,882 |
| Lomondao | 2,057 | 814 | 2,803 | 2,307 | 63 | - |
| Lubogan | 2,196,259 | 2,395,567 | 2,741,054 | 3,277,348 | 2,964,078 | 2,642,795 |
| Dacoville | - | - | 145,132 | - | - | - |
| Tibungco (WfL) | - | - | - | - | - | 4,697 |
| **Total** | **77,857,219** | **79,206,193** | **81,375,179** | **87,156,068** | **90,225,407** | **91,430,012** |

Source: Septage Management F/S 2013

**Table 3.7.3 Water Supply Facilities in Water Supply Systems (WSS)**

| No. | Name of WSS | Production Well | Booster P/S | Chlorinating Facility | Reservoir | SSF |
|---|---|---|---|---|---|---|
| 1 | Dumoy WSS | 37 | 6 | 4 | 10 | |
| 2 | Tugbok WSS | 9 | - | 9 | 3 | |
| 3 | Panacan WSS | 4 | - | 4 | 1 | |
| 4 | Cabantian WSS | 5 | - | 5 | 2 | |
| 5 | Lubogan WSS | 3 | - | 3 | 1 | |
| 6 | Toril WSS | 2 | - | 2 | 1 | |
| 7 | Calinan WSS | 1 | - | 2 | 1 | |
| 8 | Riverside WSS | 1 | - | 2 | 2 | |
| 9 | Malagos WSS | - | - | 1 | - | 1 |
| 10 | Tibungco | 1 | - | 1 | 1 | |
| 11 | Total | 67 | 6 | 32 | 22 | 1 |

Source: IM4D based on DCWD

2) Service Profile of DCWD

Table 3.7.4 shows the service profile of DCWD in 2012-2016.

The total water production volumes have increased every year. Based on DCWD data, the ones for 2017 and 2018 were 306,159 and 302,614 $m^3$/day, respectively, and the metered (billed) water consumptions for 2017 and 2018 were 208,218 and 219,581 $m^3$/day, respectively.

The non-revenue water (NRW) ratio has increased every year and is around 30%. According to the financial data of DCWD, the ratios for 2017 and 2018 were 32.0% and 27.4%, respectively.

The latest data on the numbers of connections in the sewerage area, with categories and water consumptions, were obtained in this study for the financial analysis (See Chapter 8). As mentioned in Chapter 3, as of July 2019, the number of staff is 1,181.

**Table 3.7.4 Service Profile of DCWD in 2012–2016**

| Item / Year | | | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| City Population | | | 1,542,542 | 1,579,036 | 1,616,393 | 1,648,531 | 1,686,432 |
| | Served by DCWD | No. | 924,775 | 953,500 | 981,135 | 1,013,005 | 1,048,990 |
| | | (%) | 60.0 | 60.4 | 60.7 | 61.4 | 62.2 |
| Barangays in Davao City (no.) | | | | | | | 182 |
| | Served by DCWD | | | | | | 110 |
| Service Connections (no.) | Residential | | 162,334 | 173,948 | 178,560 | 182,698 | 188,613 |
| | Commercial/Industrial | | 21,785 | 15,810 | 16,977 | 19,211 | 20,473 |
| | Others (Government) | | 569 | 677 | 689 | 691 | 711 |
| | Total | | 184,688 | 190,435 | 196,226 | 202,600 | 209,797 |
| Water Sources (no.) | Deep Wells | | 54 | 57 | 57 | 60 | 62 |
| | Springs | | 1 | 1 | 1 | 1 | 1 |
| Water Production Volume (1,000 $m^3$/day) | Deep Wells | | 247.9 | 253.6 | 262.7 | 273.5 | 289.2 |
| | Springs | | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| | Total | | 249.8 | 255.6 | 264.8 | 275.7 | 291.5 |
| Metered Water Consumption (1000 $m^3$/day) | | | 187.9 | 188.7 | 188.3 | 193.7 | 201.7 |
| Non-revenue Water (%) | | | 25.0 | 26.2 | 28.9 | 29.8 | 30.8 |
| Total No. of Staff | | | 1,072 | 1,083 | 1,034 | 1,067 | 1,083 |

Source: IM4D

The water production for the Agdao and Poblacion Districts in Dumoy WSS (Line 2) and the entire DCWD service area are shown in Table 3.7.5.

**Table 3.7.5 Water Production for Agdao and Poblacion Districts, and Entire Service Area**

| Water Supply System | Annual Water Production ($m^3$/year) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Dumoy Line 2 | 30,474,034 | 31,020,676 | 29,535,093 | 32,806,772 | 31,485,437 |
| Entire DCWD | 96,655,246 | 100,636,204 | 106,707,620 | 111,747,969 | 110,454,046 |

Source: DCWD

3) Davao City Bulk Water Supply Project

The Davao City Water Supply Project is an ongoing project implemented through a joint venture between the DCWD and Apo Agua Infrastructure Inc. (AAII). AAII is a joint venture between Aboitiz Equity (AVE) and JV Angeles Construction Corporation (JVACC). The joint venture agreement (JVA) between the DCWD and AAII was signed on 17 March 2015 and took effect on 13 July 2015. The project is composed of two parts. Part A components include the water intake, raw water transmission line, water treatment plant, and treated water supply facilities funded by AAII with a development cost of PHP 10 billion. Part B components include the primary pipe mains, storage facilities, and pipeline appurtenances to be funded by the DCWD at a development cost of PHP 2 billion.

The purpose and features of the project are as follows:

- The water source is Tamugan River;

- Protects the long-term security of Davao's groundwater source;

- Reduced groundwater use and thus, savings on power in the end;

- Improved water quality in Panacan and Cabantian WSS;

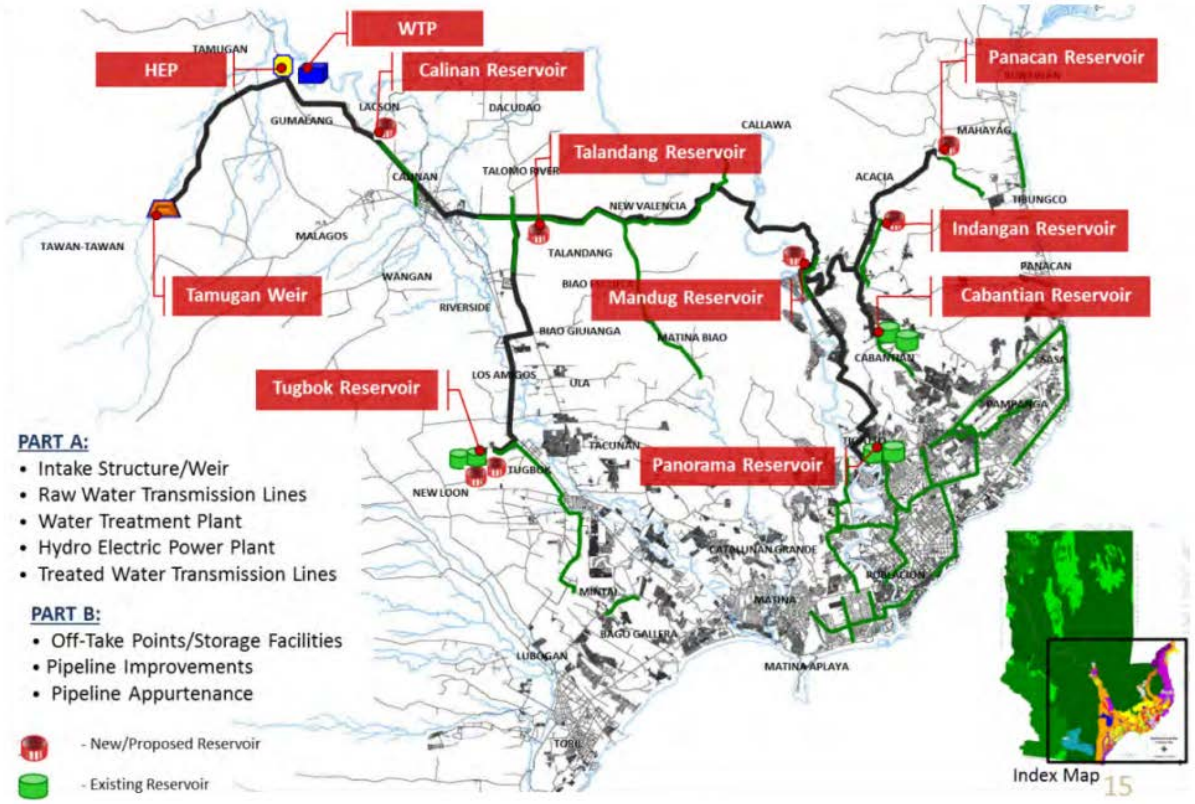
- Piped water for 114 out of 182 barangays;

- Benefits more than 1,000,000 people; and

- Improved water pressure and volume for existing consumers.

Once the Davao City Bulk Water Supply Project is completed in the first half of 2021 (plan), an additional production amount of 300,000 $m^3$ will be supplied by bulk water.

The new treatment plant and the new pipeline below (black color) will be owned and operated/maintained by AAII. The bulk water produced in the new plant will be purchased by DCWD. Since the old distribution pipeline has a risk of water loss, DCWD will rehabilitate the pipeline (green line below) to reduce the potential water leakage.




Note: black line: new pipes of AAII, green line: improved pipeline of DCWD
Source: IM4D

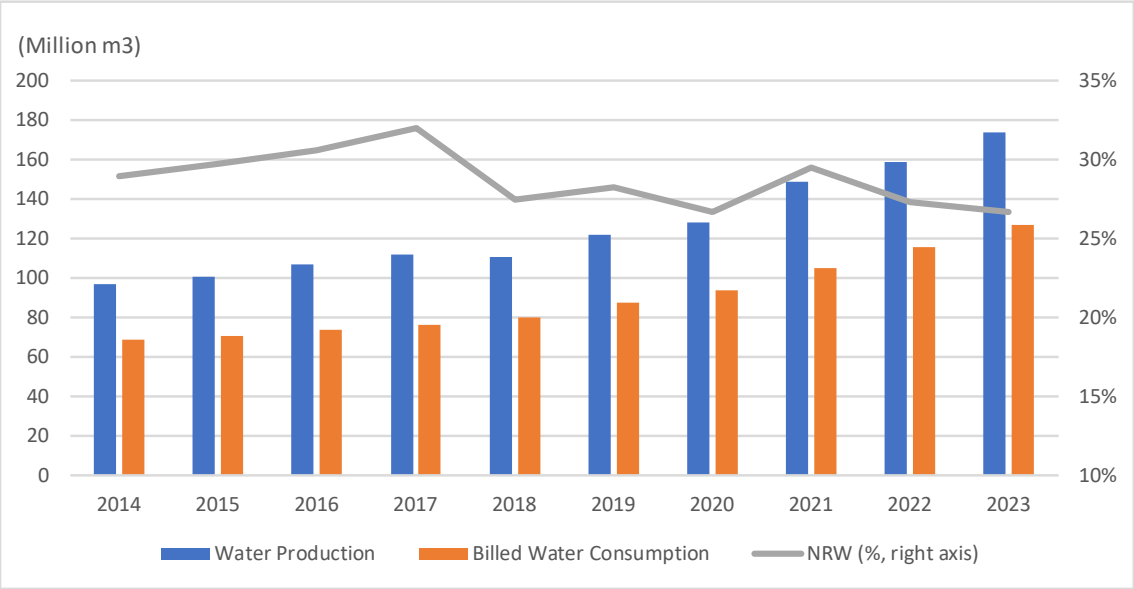
**Figure 3.7.4 Davao City Bulk Water Supply Project**

### 3.7.3 Financial Situation of DCWD

(1) Water Production, Billed Consumption and Non-Revenue Water

The Davao City Water District (DCWD), the largest water district in the Philippines, has 223,530 active service connections and serves an estimated population of 1,117,650 as of December 2018.[1] Figure 3.7.5 shows the water production volume, billed consumption volume, and NRW from year 2014 to 2023.

[1] DCWD financial report 2018




Note: 2019 data based on approved 2019 Plans, Programs and Budget (PPB); 2020 data based on proposed PPB, 2021 – 2023 data based on Mid-term Development Plan projections.
Source: JICA Survey Team based on DCWD data

**Figure 3.7.5 Water Production, Billed Water Consumption Volume and NRW of DCWD**

(2) Income Statement

The income statement and financial indicator in Table 3.7.6 shows that DCWD is not receiving any subsidy and is able to sustain its operation using its own revenue. The operating ratio is over 1.0, indicating that the revenue is sufficient to cover operational expenses. However, the decreasing trend of operating ratio shows that expense is increasing more than the revenue increase. The unit water revenue (revenue/water production) is PHP 22 (as of CY2018) and unit water cost (OPEX/billed water consumption) is PHP 21 for the same year. The margin would increase by reducing NRW and decreasing the cost of water production. The cost of water production is expected to decrease since DCWD has entered into a JVA with Apo Agua Infrastructure Inc. (AAII) in 2015[2], wherein AAII builds and operates to provide bulk water (300 million litter/day) for DCWD to distribute for the period of 30 years. After the ground breaking in 2018, the operation is expected to start in 2021. According to the interview with DCWD[3], the purchase price of the bulk water would be 12.25 PHP/$m^3$ (excluding VAT), down from the current production cost of 20 PHP/$m^3$.

[2] DCWD financial report 2018
[3] June 18, 2019 with DCWD Accounting dept, planning dept and sanitation division.

**Table 3.7.6 Income Statement and Financial Indicators of DCWD**

| | CY 2015 (Audited) | CY 2016 (Audited) | CY 2017 (Audited) | CY 2018 (Audited) | CY 2019 (Approved) |
|---|---|---|---|---|---|
| **Income Statement** | | | | | |
| **Revenue** | **2,023** | **2,170** | **2,283** | **2,439** | **2,648** |
| Business Income | 1,992 | 2,123 | 2,232 | 2,378 | 2,583 |
| Other Income | 31 | 47 | 52 | 61 | 65 |
| Gain/Loss on FOREX | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| **Operating Expenses** | **-1,168** | **-1,389** | **-1,452** | **-1,705** | **-2,175** |
| Personal Service | -395 | -425 | -471 | -459 | -663 |
| Maintenance & Operating Expenses | -747 | -924 | -964 | -1,227 | -1,433 |
| Financal Expenses | -26 | -39 | -17 | -20 | -80 |
| **Net Profit/(Loss) Before income tax** | **854** | **781** | **831** | **734** | **473** |
| **Income Tax(exempted)** | 0 | 0 | 0 | 0 | 0 |
| **Net Profit/(Loss)After Income Tax** | **854** | **781** | **831** | **734** | **473** |
| **Subsidies** | 0 | 0 | 0 | 0 | 0 |
| **Net Profit and Subisies** | **854** | **781** | **831** | **734** | **473** |
| **Indicator** | | | | | |
| Water Production (million m3) | 101 | 107 | 112 | 110 | 122 |
| Billed Water Consumption (million m3) | 71 | 74 | 76 | 80 | 87 |
| Non Revenue Water | 30% | 31% | 32% | 27% | 28% |
| Operating Ratio | 1.73 | 1.56 | 1.57 | 1.43 | 1.22 |
| Revenue/Water production (peso/m3) | 20 | 20 | 20 | 22 | 22 |
| OPEX/Water Production (peso/m3) | 12 | 13 | 13 | 15 | 18 |
| OPEX/Billed Water Consumption (peso/m3) | 17 | 19 | 19 | 21 | 25 |

Source: JICA Survey Team based on DCWD data

(3) Balance Sheet and Debt Situation

Table 3.7.7 shows the balance sheet of DCWD. The high current ratio shows DCWD has enough liquidity to pay off current debt, and the relatively low long-term liability ratio shows DCWD's less dependence on debts for its business needs. The long-term loan is listed in Table 3.7.8. The total loan balance as of 2018 is PHP 1,785.6 million. The latest and largest loan, the "Tamugan Surface Water Development", is a fund for the joint agreement project with Apo Agua: DCWD invests in water distribution.

**Table 3.7.7 Balance Sheet of DCWD**

| | CY 2015 (Audited) | CY 2016 (Audited) | CY 2017 (Audited) | CY 2018 (Audited) | CY 2019 (Approved) |
|---|---|---|---|---|---|
| **Balance Sheet** | | | | | |
| **Assets** | **5,002** | **6,156** | **7,700** | **9,682** | **10,430** |
| **Current Assets** | 695 | **838** | **987** | **930** | **1,136** |
| Cash | 336 | 495 | 556 | 398 | 652 |
| Receivables | 165 | 156 | 164 | 176 | 212 |
| Inventories | 161 | 157 | 161 | 260 | 163 |
| Prepayments | 32 | 30 | 106 | 96 | 109 |
| **Non-Current Assets** | **4,307** | **5,317** | **6,713** | **8,752** | **9,293** |
| Investments/Restricted Fund | 2,081 | 2,317 | 2,837 | 3,552 | 3,947 |
| Property,Plant and Equipment | 1,269 | 1,494 | 1,718 | 3,550 | 2,313 |
| Construction in Progress | 933 | 1,481 | 2,133 | 1,649 | 3,011 |
| Other Assets | 24 | 25 | 25 | 0 | 22 |
| **Liabilities** | **638** | **1,016** | **1,765** | **2,040** | **2,466** |
| **Current Liabilities** | **143** | **176** | **315** | **282** | **297** |
| Payable Accounts | 42 | 45 | 51 | 76 | 62 |
| Inter-Agency Payables | 25 | 28 | 32 | 24 | 42 |
| Other Liability Accounts | 76 | 71 | 198 | 154 | 166 |
| Current Portion of Long Term Debt | 0 | 32 | 34 | 27 | 27 |
| **Long Term Liabilities** | **496** | **839** | **1,451** | **1,758** | **2,170** |
| Loans Payable-Domestic | 496 | 839 | 1,451 | 1,758 | 2,170 |
| **Equitiy (Government equity)** | **4,363** | **5,140** | **5,935** | **7,642** | **7,963** |
| Donated Capital | 51 | 51 | 51 | 51 | 51 |
| Restricted Capital | 65 | 128 | 193 | 320 | 362 |
| Retained Earnings | 4,248 | 4,961 | 5,691 | 6,367 | 7,551 |
| Revaluation Surplus | 0 | 0 | 0 | 904 | 0 |
| **Total Liability + Equity** | **5,002** | **6,156** | **7,700** | **9,682** | **10,430** |
| **Indicator** | | | | | |
| Current Ratio | 4.87 | 4.75 | 3.14 | 3.30 | 3.83 |
| Long-term Liability /Total Assets | 0.10 | 0.14 | 0.19 | 0.18 | 0.21 |
| ROE | 20% | 16% | 15% | 11% | 6% |
| ROA | 17% | 14% | 12% | 8% | 5% |

Source: JICA Survey Team based on DCWD data

**Table 3.7.8 Long-term Loan of DCWD**

| Lender | Project | Loan Balance | | Principle repayment | Year of maturity | Terms & Conditions |
|---|---|---|---|---|---|---|
| | | Million PHP | | | | |
| | | Original | 2018 | 2018 | | |
| PNB | Comprehensive Mainline Replacement Program | 100 | 25.3 | 11.1 | 2020 | 10 yrs, 9% p.a.(float.) |
| PNB | Calinan Riverside Water Supply System Expansion | 90 | 54.8 | 9.8 | 2024 | 10 yrs, 9% p.a.(float.) |
| PNB | Tigatto – Mandug Expansion | 70 | 39.5 | 6.5 | 2024 | 10 yrs, 9% p.a.(float.) |
| DBP*[1] | DCWD Mid-Rise Building Construction | 600 | 571.2 | 0 | 2036 | 20 yrs, g.p 5 years, 4.25% p.a.(float.) |
| DBP*[1] | Tamugan Surface Water Development | 2,000 | 1,094.8 | 0 | 2036 | 20 yrs, g.p 5 years, 4.25% p.a.(float.) |
| | Total | - | 1,785.6 | 27.4 | | |

*1: In disbursing period

Source: DCWD

(4) Water Tariff and Sewerage Tariff Setting

1) Current Water Tariff

The current water tariff rates (became effective in 2016) are tabulated in Table 3.7.9 (see Appendix 3.13 (2) for more detail). The residential rate is set at factor rate 1, and the commercial/industrial rate is set as twice of the residential rate (i.e. factor rate 2). Usage in commercial/industrial purposes includes but is not limited to food and beverage service, accommodation, amusement and recreation activities, agriculture, forestry, and fishery[4]. The same table applies to Commercial A, B, C, and Bulk/Wholesale with different factor rates. Initially there was no classification of usage, then "Commercial/Industrial" and "Commercial A" classifications were introduced in 2013. "Commercial B" and "Commercial C" classifications were introduced in 2016.

**Table 3.7.9 Water Tariff Rate**

| RESIDENTIAL / GOVERNMENT (2018 ) | | | | | | | COMMERCIAL / INDUSTRIAL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FACTOR RATE** | **SIZE** | **MINIMUM CHARGE** | **COMMODITY CHARGE** | | | | **FACTOR RATE** | **SIZE** | **MINIMUM CHARGE** | **COMMODITY CHARGE** | | | |
| | | **0-10 cu.m.** | 11-20 cu.m. | 21-30 cu.m. | 31-40 cu.m. | above 40 cu.m. | | | **0-10 cu.m.** | 11-20 cu.m. | 21-30 cu.m. | 31-40 cu.m. | above 40 cu.m. |
| 1 | 3/8" | 54.9 | 14.4 | 18.6 | 24.7 | 36 | 2 | 3/8" | 109.8 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 1/2" | 137.3 | 14.4 | 18.6 | 24.7 | 36 | 2 | 1/2" | 274.6 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 3/4" | 219.65 | 14.4 | 18.6 | 24.7 | 36 | 2 | 3/4" | 439.3 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 1" | 439.3 | 14.4 | 18.6 | 24.7 | 36 | 2 | 1" | 878.6 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 1 1/2" | 1,098.40 | 14.4 | 18.6 | 24.7 | 36 | 2 | 1 1/2" | 2,196.80 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 2" | 2,746.00 | 14.4 | 18.6 | 24.7 | 36 | 2 | 2" | 5,492.00 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 3" | 4,942.80 | 14.4 | 18.6 | 24.7 | 36 | 2 | 3" | 9,885.60 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 4" | 9,885.60 | 14.4 | 18.6 | 24.7 | 36 | 2 | 4" | 19,771.20 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 6" | 16,476.00 | 14.4 | 18.6 | 24.7 | 36 | 2 | 6" | 32,952.00 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 8" | 26,361.60 | 14.4 | 18.6 | 24.7 | 36 | 2 | 8" | 52,723.20 | 28.8 | 37.2 | 49.4 | 72 |
| 1 | 10" | 37,894.60 | 14.4 | 18.6 | 24.7 | 36 | 2 | 10" | 75,789.60 | 28.8 | 37.2 | 49.4 | 72 |

| COMMERCIAL A | | COMMERCIAL B | |
|---|---|---|---|
| FACTOR RATE | Subject activities (partial list) | FACTOR RATE | Subject activities (partial list) |
| 1.75 | e.g.) Wholesale, warehousing, financial service, legal and accounting , engineering activities, scientific research, office administration, private medical clinics, tour activities, advertising | 1.5 | e.g.) maintenance and repair of motor vehicles, postal, publishing, telecommunicatinos, consultancy, hair dressing |
| **COMMERCIAL C** | | **BULK / WHOLESALE** | |
| FACTOR RATE | Subject activities | FACTOR RATE | Subject activities |
| 1.25 | renting of residential properties whose owners assume payment of water using one central meter | 3 | private water collection, treatment and supply |

Source: DCWD

2) Affordability and Willingness to Pay for Sewerage Service

a) Monthly Income

Resolution No. 2/2016 II defines the Low-Income Group (LIG) as the lowest 30% income group. According to Philippine Regional Statistics Authority, the average monthly income of LIG in the Davao Region was PHP 9,383 in 2015 as shown in Table 3.7.10. The income of Davao Region is increasing more rapidly compared to the national average; however, this survey estimated the 2019 figure by applying a national yearly increase rate of 4.4% to be conservative. The LIG's monthly income in 2019 is estimated at PHP 11,154.

[4] Sunstar Davao Nov. 8, 2012 "DCWD classifies service connections".
https://www.pressreader.com/philippines/sunstar-davao/20121108/page/11

**Table 3.7.10 Monthly Income of Davao Region and Nation (PHP)**

| Year | Davao Region | | Philippines | |
|---|---|---|---|---|
| | Average | LIG | Average | LIG |
| 2009 | 13,833 | 4,472 | 17,167 | 5,167 |
| 2012 | 16,417 | 7,058 | 19,583 | 7,475 |
| 2015 | 20,583 | 9,383 | 22,250 | 9,250 |
| Average yearly increase | 6.8% | 13.1% | 4.4% | 10.2% |
| 2019 (estimated) | 24,464 | **11,154** | - | - |

Source: JICA Survey Team based on Philippine Statistics Authority[5]

The figure (PHP 11,154) is relatively high compared to the result of Household Interview Survey (PHP 9,015), conducted in Davao City in June 2019 during this survey (see Table 3.7.11). DCWD during the interview mentioned the LIG monthly income is PHP 10,000, which is about half-way of the two figures (PHP 11,154 and PHP 9,015).

**Table 3.7.11 Monthly Income of Davao City (PHP)**

| Year | Davao City | |
|---|---|---|
| | Average | LIG |
| 2017 (HIS in IM4D) | 14,666 | 5,009 |
| 2019 (HIS in this Survey) | 21,474 | **9,015** |
| 2019 (Interview to DCWD) | - | **10,000** |

Source: JICA Survey Team

b) Affordability to Pay (ATP)

- **LWUA guideline on minimum charge cap**

The LWUA's BOT Resolution No.59, series 2017 stipulates that the minimum charge (up to the first 10 $m^3$) for combined water and wastewater service, should not exceed 5% of the average income of the Low-Income Group. When PHP 10,000 is the average monthly income of the LIG, PHP 500 (5%*10,000) is the cap of the minimum total charge for water and wastewater service. Since the minimum charge for water (1/2") is PHP 137.3 (Table 3.7.9), the cap of the minimum charge (up to 10 $m^3$) of sewerage tariff would be PHP 362.7 (500 – 137.3) per month. If DCWD raises the water minimum charge when income level stays the same, the minimum charge of sewerage tariff needs to be lower than PHP 362.7. LWUA only caps the charge of the first 10 $m^3$; therefore, if a low income household consumes more than 10 $m^3$ per month, there is no guideline on the setting of tariffs which reflects their affordability.

- **Estimation of Affordability to Pay (ATP)**

The JICA Survey Team estimated the affordability to pay (ATP) of the Davao citizens based on JICA guideline[6] which suggests that 2% of the disposable income as the threshold of ATP on sewerage service. Disposable income was estimated by applying a personal tax income rate[7] to each income class of the Household Income Survey data. The weighted average of disposable income of Davao

[5] Family Income and Expenditure Survey (FIES) https://psa.gov.ph/content/family-income-and-expenditure-survey-fies-0
[6] IRR calculation manual (2017)
[7] Philippine applies progressive personal income tax (0% - 35%). Source: KPMG Philippine Income Tax (2019)

City was derived at PHP 18,149 per month, and the ATP per cubic meter was estimated as PHP 15.1[8]. The monthly water consumption is assumed to be 24 $m^3$/household[9].

c) Willingness to Pay (WTP)

Table 3.6.12 shows the HIS result of willingness to pay (WTP) in this survey compared with the results collected from the IM4D. The majority of the answer was PHP 100/month, and the ratio increased from IM4D. In addition, the result of "None" (don't want to pay) decreased from IM4D. Table 3.7.13 shows the average WTP based on the figures in Table 3.7.12.

**Table 3.7.12 HIS Result of Willingness to Pay for Sewerage Service**

| Monthly Fee (PHP) | Willingness to Pay (PHP) | | | |
|---|---|---|---|---|
| | 2019 | | IM4D | |
| | Nos. | % | Nos. | % |
| >600 | 0 | 0.0 | 21 | 1.0 |
| 501-600 | 0 | 0.0 | 13 | 0.6 |
| 401-500 | 26 | 5.0 | 11 | 0.5 |
| 301-400 | 3 | 0.6 | 40 | 2.0 |
| 201-300 | 20 | 3.9 | 245 | 12.1 |
| 101-200 | 63 | 12.2 | 420 | 20.8 |
| 1-100 | 343 | 66.2 | 793 | 39.2 |
| None | 56 | 10.8 | 481 | 23.8 |
| No response | 7 | 1.4 | 0 | 0.0 |
| Total | 518 | 100.0 | 2024 | 100.0 |

Source: JICA Survey Team with IM4D Data

**Table 3.7.13 Monthly Willingness to Pay for Sewerage Service (PHP)**

| Year | WTP | WTP/$m^3$ |
|---|---|---|
| 2017 (HIS in IM4D) | 101 | 4.2 |
| 2019 (HIS in this Survey) | 113 | 4.7 |

Source: JICA Survey Team

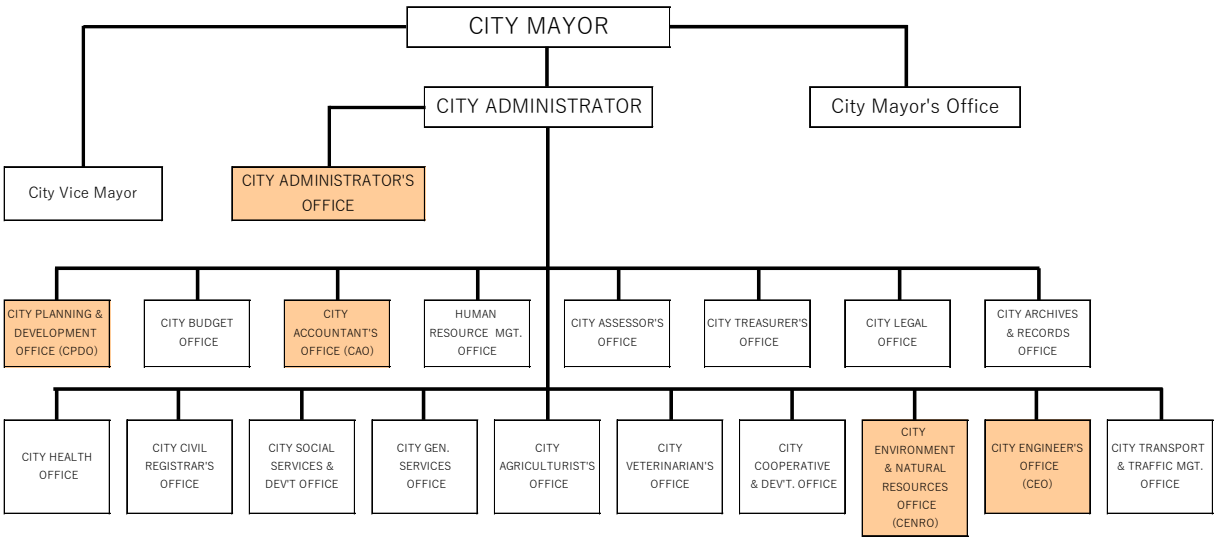
Assuming that the average monthly water consumption is 24 $m^3$/household[10], willingness to pay is 4.7 PHP/$m^3$ (113/24 = 4.7). The result of HIS in Table 3.7.13 shows that the willingness to pay for sewerage services is much lower than the affordability to pay. It is a common view that respondents have incentive to answer a low level or price of willingness to pay when they know a new tariff might be introduced. The city/DCWD will need to take time and effort to increase public awareness on the necessity of sewage treatment.

[8] 18,149*2% / 24 $m^3$ = 15.1
[9] 200 litre/person *4 persons as average household size (from IM4D)*30 days=24 $m^3$
[10] 200 litre/person *4 persons as average household size from IM4D*30 days=24 $m^3$

## 3.8 Organization and Financial Status of Davao City Government

### 3.8.1 Organization

Figure 3.8.1 shows the general organization structure of the Davao City government. The detailed structure is shown in Appendix 3.13 (3).




Source: JICA Survey Team based on the organization chart by Davao City Government

**Figure 3.8.1 General Organization Chart of Davao City Government**

Table 3.8.1 shows the major roles of concerned departments for the water and sanitation sector in the Davao City government. At present, the collection of septage from septic tanks is conducted by the private sector based on requests by house owner. The City Health Office (CHO) and CENRO are not involved in septage management.

**Table 3.8.1 Major Offices in Davao City Government concerning Sewerage Development**

| Office/Department | Major Area of Responsibility/Concern |
|---|---|
| City Administrator's Office | Assistant City Administrator (for administration) as a top counterpart of this study belongs in the office |
| City Planning and Development Office (CPDO) | - Overall planning including climate change adaptation<br>- Once future development plan is drafted from each office (e.g. future landfill site by CENRO), it shall be approved by CPDO.<br>- "Interim Office of the City Architect" which is in charge of future design of parks belongs to this office. |
| City Engineer's Office (CEO) | - Construction, maintenance, water resources, building, Electrical Engineering<br>- Drainage Section which is in charge of maintenance and cleaning of drainage belongs to "Maintenance Division". |
| City Health Office (CHO) | - General monitoring of medical data and social hygiene |
| City Environment & Natural Resources Office (CENRO) | - Parks, greening, watershed, solid waste, pollution<br>- Related on particularly dumping of biosolids from wastewater treatment plant |
| City Accountant's Office (CAO) | - Accounting, financial management<br>- Preparation of financial report, development fund |

Source: JICA Survey Team

Regarding environmental and social considerations, the organization and role of CENRO is summarized in Appendix 3.13 (4).

### 3.8.2 Financial Situation of Davao City

(1) Income Statement

The city revenue consists of the local revenue source (tax and service revenue) and share from the national tax (Internal Revenue Allotment (IRA)). The city's total revenue jumped in Calendar Year (CY)[11] 2018 to PHP 8,682 million, 21% higher from the PHP 7,183 million value in FY 2017 due to the implementation of local revenue code 2017. The operating ratio (revenue/expense) is well above 1.0 which shows that the city's revenue is sufficient to pay for annual operation. Local revenue source accounts for 48% of total revenue in CY 2018, up from the previous year (42%) due to the said revenue reform.

**Table 3.8.2 Income Statement of Davao City**

| | CY 2014 (Audited) | CY 2015 (Audited) | CY 2016 (Audited) | CY 2017 (Audited) | CY 2018 (Audited) |
|---|---|---|---|---|---|
| **Income Statement** | | | | | |
| **Revenue** | **5,272** | **5,799** | **6,284** | **7,183** | **8,682** |
| **Tax Revenue** | **4,752** | **5,285** | **5,745** | **6,560** | **7,560** |
| **Local Tax Revenue** | **1,824** | **1,954** | **2,117** | **2,384** | **3,086** |
| Individual and Corporation | 46 | 49 | 54 | 59 | 64 |
| Property | 527 | 472 | 536 | 569 | 819 |
| Goods and Services | 1,181 | 1,347 | 1,457 | 1,662 | 2,090 |
| Others | 0 | 0 | 3 | 1 | 4 |
| Fines and Penalties | 70 | 86 | 68 | 93 | 108 |
| **Share from National Tax** | **2,928** | **3,330** | **3,627** | **4,176** | **4,474** |
| Share from IRA | 2,919 | 3,330 | 3,623 | 4,167 | 4,474 |
| Others | 10 | 0 | 4 | 9 | 0 |
| **Service and Business Income** | **520** | **514** | **540** | **624** | **1,122** |
| **Current Operating Expenses** | **-4,380** | **-4,651** | **-4,924** | **-5,403** | **-6,589** |
| **Personal Services** | **-1,049** | **-1,135** | **-1,265** | **-1,343** | **-1,315** |
| **Maintenance and Other Operating Expenses** | **-3,011** | **-3,257** | **-3,322** | **-3,697** | **-4,769** |
| **Non-Cash Expenses** | **-246** | **-212** | **-290** | **-330** | **-479** |
| **Financial Expense** | **-75** | **-47** | **-46** | **-33** | **-25** |
| **Surplus/(Deficit) from Current Operations** | **892** | **1,148** | **1,360** | **1,780** | **2,093** |
| **add:Subsidy** | **28** | **1** | **5** | **4** | **0** |
| **deduct: Subsidy and Transfer** | **-97** | **-131** | **-88** | **-69** | **-158** |
| **Surplus/(Deficit) for the period** | **823** | **1,018** | **1,277** | **1,715** | **1,936** |
| **Indicator** | | | | | |
| **Operating Ratio** (Revenue/Expense) | **1.20** | **1.25** | **1.28** | **1.33** | **1.32** |
| **Local Revenue Source/Total revenue** | **44%** | **43%** | **42%** | **42%** | **48%** |

Source: JICA Survey Team based on Davao City data

(2) Balance Sheet and Debt Situation

The balance sheet below shows that the city has more than enough liquidity (cash and cash equivalent to pay off short-term obligation) since the current ratio is far over 1.0. Also, the low long-term liability ratio shows the city has enough capacity to pay off long-term debt and still have space to borrow.

[11] Philippine government fiscal year is same as calendar year: January to December

**Table 3.8.3 Balance Sheet of Davao City**

| | CY 2014 (Audited) | CY 2015 (Audited) | CY 2016 (Audited) | CY 2017 (Audited) | CY 2018 (Audited) |
|---|---|---|---|---|---|
| **Balance Sheet** | | | | | |
| **Assets** | **4,441** | **5,389** | **7,372** | **10,207** | **13,005** |
| **Current Assets** | **1,994** | **2,923** | **3,721** | **5,344** | **6,434** |
| Cash&Cash Equivalent | 1,422 | 1,971 | 2,447 | 3,850 | 5,973 |
| Others (Receivables & Inventories) | 572 | 951 | 1,274 | 1,494 | 462 |
| **Non-Current Assets** | **2,447** | **2,467** | **3,651** | **4,863** | **6,571** |
| Property, Plant and Equipement | 2,443 | 2,463 | 3,647 | 4,859 | 6,567 |
| Others | 4 | 4 | 4 | 4 | 4 |
| **Liabilities** | **2,006** | **2,106** | **2,671** | **2,666** | **2,595** |
| **Current Liabilities** | **1,090** | **1,287** | **1,209** | **1,248** | **2,014** |
| Financial Liabilities | 914 | 1,044 | 1,014 | 1,149 | 1,859 |
| Others | 175 | 244 | 195 | 99 | 155 |
| **Long Term Liabilities** | **917** | **819** | **1,462** | **1,419** | **582** |
| Financial Liabilities | 746 | 537 | 681 | 469 | 260 |
| Deferred Credits/Unearned Income | 160 | 270 | 773 | 939 | 288 |
| Other Payables | 11 | 13 | 8 | 10 | 34 |
| **Equity** | **2,434** | **3,283** | **4,701** | **7,540** | **10,410** |
| **Government Equity** | **2,434** | **3,283** | **4,701** | **7,540** | **10,410** |
| **Total Liability+ Equity** | **4,441** | **5,389** | **7,372** | **10,207** | **13,005** |
| **Indicator** | | | | | |
| **Current Ratio** (current assets/current liabilities) | **1.83** | **2.27** | **3.08** | **4.28** | **3.20** |
| **Long Term Liabilities /Total Assets** | **0.21** | **0.15** | **0.20** | **0.14** | **0.04** |

Source: JICA Survey Team based on Davao City data

As of 2018, Davao City's outstanding loan is PHP 469.3 million from the Land Bank of the Philippines.

**Table 3.8.4 Long-term Debt of Davao City**

| Lender | Project | Loan Balance | | Debt service | Year of maturity | Terms & Conditions |
|---|---|---|---|---|---|---|
| | | Million PHP | | | | |
| | | Original | 2018 | 2018 | | |
| LBP | Rehabilitation of Magtuod, New Carmen Road Section | 22.9 | 0 | 2.4 | 2018 | Fully paid pack in 2018 |
| LBP | Various infrastructure projects | 643 | 68.8 | 72.3 | 2019 | 10 yrs, 5.00% p.a.(float.) |
| LBP | Road Improvement and Maintenance project | 437 | 66.7 | 48.2 | 2020 | 10 yrs, 4.00% p.a.(float.) |
| LBP | Acquisition and development of relocation/resettlement sites for the city shelter program | 39 | 6.8 | 4.2 | 2020 | 10 yds, 4.75% plan (float.) |
| LBP | Solid Waste Management project | 600 | 327.0 | 108.9 | 2022 | 7 yrs, 6.30% p.a.(float.) |
| | Total | - | 469.3 | 236.0 | | |

Source: Davao City

LGUs are subject to the borrowing capacity limits reckoned by the annual debt service to be no more than 20% of their regular income[12]. The debt service of Davao City in 2018 is PHP 236 million, or only 2.7% of the city's revenue. The city has the ability to borrow more. However, in the interview with the city budget office, it was found that the current administration sees loan taking as unfavorable practice.

[12] IM4D Part II Ch19-5

(3) Development Fund

Local government code 1991 (section 287) requires each LGU to appropriate no less than 20% of its IRA for development projects (20% development fund). As shown in Table 3.8.5, Davao City allocates about 40% of the share from IRA to the development fund, where 50% of which was allocated to infrastructure in CY 2018. In the same year, PHP 12 million was secured for investment in water supply programs for non-DCWD covered area.

According to the city budget office, when the sewerage system development project is financed by the city (LGU), it will be budgeted under this development fund. Moreover, if the operation subsidy would ever be provided by the city to DCWD (which never happened before[13]), the budget should be recognized in the development fund.

**Table 3.8.5 Development Fund Allocation of Davao City**

(unit: Million PHP)

| Program | CY 2015 | CY 2016 | CY 2017 | CY 2018 | CY 2019 |
|---|---|---|---|---|---|
| **Total Non-infrastructure fund (I)** | **1,354** | **764** | **961** | **879** | **615** |
| 1) Debt Servicing Program | 50 | 497 | 321 | 152 | 228 |
| 2) Social Development | 84 | 90 | 260 | 209 | 171 |
| 3) Economic Development | 82 | 74 | 108 | 109 | 83 |
| 4) Development Administration | 88 | 87 | 150 | 309 | 71 |
| 5) Environmental Development Program | 600 | 16 | 122 | 100 | 62 |
| **Total Infrastructure fund (II)** | **431** | **423** | **560** | **877** | **685** |
| 1) Road Development Program | 248 | 256 | 175 | 313 | 396 |
| 2) Building and Other Structure | 150 | 126 | 207 | 337 | 50 |
| 3) Drainage Program | 21 | 24 | 94 | 142 | 204 |
| 4) Electrification Ptogram | 1 | 2 | 2 | 0 | 1 |
| 5) Water System Program | 11 | 12 | 74 | 12 | 29 |
| 6) Bridge Program | 0 | 4 | 8 | 74 | 5 |
| **Total Annual Develompent Fund (I+II)** | **1,785** | **1,187** | **1,521** | **1,756** | **1,301** |

Source: Davao City

(4) Budget Approval Process

The city budget including the development fund allocation is approved under the following procedure and schedule (Table 3.8.6).

[13] JICA Study Team confirmed though it never happened, there is no regulation which restricts operation subsidy from City to DCWD

**Table 3.8.6 Budget Approval Process**

| Activity | Indicative Schedule | Responsible Officials |
|---|---|---|
| Issue the Budget Call | Mid-June | Local Chief Executive (i.e. City Mayor) |
| ↓ | | |
| Conduct Budget Forum | Mid-June | LCE & Local Financial Committee* Department Heads |
| ↓ | | |
| Prepare and Submit Budget Proposals | Mid-July | Department Heads |
| ↓ | | |
| Conduct Budget Hearing | Mid-August | LCE & LFC |
| ↓ | | |
| Prepare Executive Budget & Budget Message | Late September | LCE & LFC |
| ↓ | | |
| Submit Executive Budget to the Sanggunian (City Council) | Early October | LCE |
| ↓ | | |
| Approved by City Council | December | City Council |
| ↓ | | |
| Approved Budget Implementation | January (start of fiscal year) | |

*Local Financial Committee is composed of Department of Administration (Chair), Budget, Treasury, Accounting and City Planning
Source: JICA Survey Team

Once approved by the city council, the city submits the budget to national government (i.e. Department of Budget Management). The DBM will review it but usually will not intervene with the city budget policy.

## 3.9 Issues of Current Condition on the Sanitation Sector

(1) General Issues Common with Other Highly Urbanized Cities (HUCs)

The development status of sewerage and septage treatment facilities as of 2016 and the development targets in major cities all over the Philippines is shown in Table 3.9.1. As mentioned in Subsection 3.3.1, there are no treatment facilities in Davao except for septic tanks.

**Table 3.9.1 Development Status of Sewerage and Septage Treatment Facilities as of 2016 and Development Target**

| Area | Sewerage Facility（%） | Sludge Treatment Facility（%） | Development Target |
|---|---|---|---|
| Eastern area of Metro Manila | 18.5 | 96.0 | Manila Water Company shall achieve 100% development by 2037 under the concession contract. |
| Western area of Metro Manila | 13.6 | 49.7 | Maynilad Water Services shall achieve 100% development by 2037 under the concession contract. |
| Regional main cities in Philippine （17 highly urbanized cities (HUCs)） | Less than 0.1 | 4.0% | Sewerage shall be developed at 100% by 2020 with NSSMP scheme. (In the Philippine development plan 2017, the plan is to develop simple sanitary facilities to 100% by 2022.) |

Source: Data Collection Survey for Formulating Development Policy of Water and Sewerage System in the Philippines (Phase 2)

The problems concerning sewerage and septage management in the main regional cities in the Philippines are shown in Table 3.9.2. The cases in Davao were confirmed for each problem as commented in the table. With regard to the financial state of the city and the water district, the ones in Davao are good as mentioned in Subsections 3.7.3 and 3.8.2, but the budgets for the sanitation sector is limited due to the increasing demand of infrastructure development (transportation, solid waste, water supply etc.) and due to rapidly increasing population.

**Table 3.9.2 Problems Concerning Sewerage and Septage Treatment in Regional Main Cities in Philippines**

| Aspects to be considered | General Problems in Regional Main Cities | Case in Davao |
|---|---|---|
| Development | ・Difficult site acquisition due to land price increase and construction urban area (limited open land) | True |
| | ・Hard to construct sewer pipe because of narrow roads and chronic traffic congestion | True |
| | ・Large amount of garbage in flow from illegal dumping leads to pipe clogging | True |
| | ・Because of the lack of administrator's knowledge, development has not proceeded | True |
| O&M and Organization | ・High electricity price leads to expensive O&M cost | True |
| | ・Difficult to secure skilled O&M workers | True |
| | ・Hard to vacuum septage from septic tanks due to congestion in residential neighborhoods and locations of septic tanks in houses | True |
| | ・Cleaning of drains and pipes are required frequently, because they are often filled with garbage from dumping and rainfall. | True |
| | ・Water supply and septage treatment are mainly operated by a water administrator (WD). Organization integration and reorganization will be required in order to conduct the sewerage project. | True |
| Environment | ・Discharge standard has become stricter from 2016, and the construction cost of treatment facility has increased. | True |
| | ・Due to the lack of dumping site for collected septage, illegal dumping of septage happens. | True |
| Finance | ・On the account of severe financial state of each city/water district, the financial burden of loan for construction of expensive facility is high. | Partly True |
| | ・There is a concern on business operation, because sufficient revenue from sewerage tariff cannot be expected. | True |

Source: JICA Study Team

(2) Issues in Davao City

The specific issues confirmed in Davao City are described as follows. For general identification of wastewater related issues including drainage conditions, the general site visits, and confirmations in household interview survey, have been conducted. The pictures at the sites are shown in Appendix 3.14.

1) Wastewater Discharge

a) Wastewater, particularly gray water, is discharged without treatment. (see Photo 1 in Figure 3.9.1)
⇒Creeks, rivers including Davao River, and sea is being polluted. (See Subsection 3.2.2)

b) Septage management is inappropriate, and results to infiltration of excreta to the ground and discharge of almost untreated wastewater to the drains.
⇒It causes environmental deterioration. (See Subsection 3.2.2)

c) Though septage management project has been planned, it's not materialized.

⇒It may take further time. Even after the completion of septage treatment plant, the gray water cannot be collected and treated.

2) Wastewater Treatment

a) Land price in urban area is rapidly increasing.
⇒Land acquisition for sewerage facilities is difficult in the priority development area, and the available area of public land is limited. (See Section 6.2 for candidate sites of WWTP Area A)

b) Strict effluent standard (DAO-008, DENR) is also applied for Davao City (Davao Gulf). (See Subsection 3.2.1)
⇒WWTP construction cost will increase for biological nutrient removal (BNR). (See Subsection 6.3.1)

c) Electricity cost is high
⇒ It becomes a burden for the O&M of future sewerage facilities.

3) Wastewater Collection

a) The existing drains do not have enough capacities in terms of insufficient slope and dumping of garbage. As a result, much wastewater is stagnant in the drains. (See Photo 2 and 3 in Figure 3.9.1)
⇒Utilization of existing drains for sewers is difficult.

b) The backwater from the sea in the channels and sometimes in further drains can be found during the high tide due to several submerged outfalls from drains. (See Photo 4 in Figure 3.9.1)
⇒ Countermeasure is required when intercepting wastewater from drains. (mainly seawater)

c) Residential/slum areas have relatively high density due to population increase and many illegal settlers. (See Photo 5 and 6 in Figure 3.9.1)
⇒Sewer planning, sewer pipe laying, and septage collection are difficult in this area.

d) The coverage rate of septic tank is high, but accessible septic tanks are very few, particularly in congested areas without enough space. (See Subsection 3.3.2) Many septic tanks are under the houses.
⇒The collection of septage via the septage management program, or connection to future sewerage system is difficult in such areas.

e) Traffic has been increasing and it's hard to implement traditional construction work.
⇒Sewer planning is difficult and trenchless method should be introduced in congested roads.

f) Many drainage projects are ongoing. (See Photo 7 and 8 in Figure 3.9.1)
⇒ Coordination between sewerage planning and drainage upgrade is required. However, the implementation agencies for sewerage work and drainage work (City/DCWD, DPWH, respectively) are different.

4) Project Implementation

a) An implementing agency for sewerage development work has not been determined between the City and the DCWD. Although the WD is generally appointed as the implementation agency in the LWUA guideline and City Resolution No. 1283, it is difficult for DCWD to bear all the development cost.
⇒Sewerage planning and development has been delayed so far, and adequate cost sharing between city and DCWD should be considered.

Photo 1. Discharge of gray water to road side drain

Photo 2. Stagnant wastewater in existing side drain (insufficient slope)

Photo 3. A lot of garbage in the drain

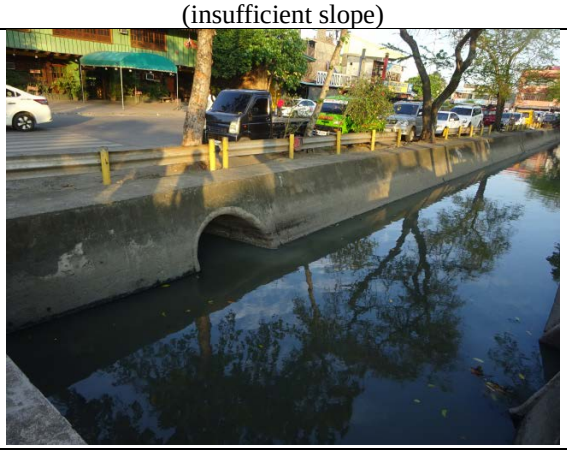


Photo 4. Backwater from sea to creeks and drains was confirmed in such as Roxas Creek and Dacudao Creek

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Photo 5. Inside the congested slum area with small ditch for drain and graywater</td><td>Photo 6. Many houses beside Agdao Creek</td></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td>Photo 7. Ongoing Construction of Gate Pumping Station in the mouth of creek</td><td>Photo 8. Ongoing drain development/improvement works beside roads</td></tr>
</table>

**Figure 3.9.1 Photos Showing the Existing Wastewater/Drainage Issues in Davao City (Particularly Priority Area A)**

# CHAPTER 4 REVIEW OF EXISTING PLANS FOR SEWERAGE DEVELOPMENT AND SEPTAGE MANAGEMENT

This chapter includes the summary of contents and review results of the sewerage development plan in the Davao City Infrastructure Development Plan and Capacity Development Project (hereinafter referred to as "IM4D") and the septage management plan in the USAID F/S.

## 4.1 Design Parameters of Sewage Generation

The design parameters of sewage generation were established in IM4D, as shown in Table 4.1.1. The figures for each item were reviewed in this project.

**Table 4.1.1 Sewage Discharge Rate proposed in IM4D**

| Item | | Amount (liter/person/day) |
|---|---|---|
| 1. Daily average amount | | |
| Water supply amount | | 190 |
| Daily average amount sewerage amount | 80% of water supply amount | ≒150 |
| 2. Daily maximum amount | 150% of daily average | 225 |
| 3. Ground water infiltration amount | 10% of daily maximum | 22.5 |
| 4. Wastewater from business entities | 10% of daily maximum | 22.5 |
| Daily maximum sewerage amount | | 270 |

Source: IM4D

The amount of water supply (190 lpcd) did not consider the water supply system master plan in IM4D. These are 200 lpcd in 2030 and 210 lpcd in 2045. The JICA Survey Team reflected the same for 2030 and 2045 and has setup the daily maximum amount to a moderate level to consider the original plan (=270 lpcd). They have also referred to the planned value for target cities in Metro Manila West (Las Pinas City, Imus City, and Kawit Town), which is 200 lpcd.

**Table 4.1.2 Revised Sewage Discharge Rate in this Study**

| Item | | Amount (liter/person/day) | | |
|---|---|---|---|---|
| | | 2015 | 2030 | **2045** |
| 1. Daily average amount | | | | |
| Water supply amount (IM4D Water Supply) | | 190 | 200 | **210** |
| Daily average amount sewerage amount | 80%of water supply amount | 152 | 160 | **168** |
| 2. Daily maximum amount | 130% of daily average | 198 | 208 | **218** |
| 3. Ground water infiltration amount | 10% of daily maximum | 20 | 21 | **22** |
| 4. Wastewater from business entities | 10% of daily maximum | 20 | 21 | **22** |
| Daily maximum sewerage amount | | 238 | 250 | **262** |

Note: Amount adopted in West Metro Manila was 200 liter/person/day
Source: JICA Survey Team

## 4.2 Study on Planning Framework

(1) Domestic, Commercial, and Industrial Wastewater Flow

The domestic wastewater flow is 218 lpcd for 2045, as mentioned in Table 4.1.2. The general idea is that 10% of wastewater flow is added to the domestic (residential) wastewater flow as wastewater from business entities (commercial, industrial) in accordance with the IM4D concept. This is even if the actual ratios of service connection and water consumption are around 18% and 38%, respectively, in Area A (Table 4.2.1) and 7.4% and 21%, respectively, in Area B (Table 4.2.2). The application of the 10% is assumed to be reasonable due to the following reasons:

1) Large scale industries do not exist in Area A, and many small offices/shops with residential space are counted in the congested commercial location of Area A.

2) The trial flow calculation for Area A revealed that the estimated total daily average water supply with an additional 10% for commercial use in 2015 (290,502 persons x 190 liter/person/day x 1.1 = 60,715 $m^3$/day) is greater than the actual water supply recorded by DCWD in 2019 (55,567 $m^3$/day).

3) The other areas show less than 10% in connection and around 20% in consumption for commercial use. The water supply for commercial use is less in the case of Area A. This generates more allowance to cope with the future expansion of the commercial area and industrial wastewater generation (e.g. estimation in 2015: 30,105 $m^3$/day, actual water consumption in 2019: 25,564 $m^3$/day in Area B).

**Table 4.2.1 Actual Record of Water Consumption in Area A**

| Category | No. of Connections | Consumption (m3/day) |
|---|---|---|
| Residential | 44,153 (81.6%) | 32,505 (58%) |
| Commercial | 9,728 (18.0%) | 21,034 (38%) |
| Government | 260 (0.5%) | 2,027 (4%) |
| Total | 54,141 | 55,567 |

Source: JICA Survey Team based on DCWD Data 2019

**Table 4.2.2 Actual Record of Water Consumption in Area B**

| Category | No. of Connections | Consumption (m3/day) |
|---|---|---|
| Residential | 25,409 (92.4%) | 18,500 (72%) |
| Commercial | 2,036 (7.4%) | 5,488 (21%) |
| Government | 58 (0.2%) | 1,575 (6%) |
| Total | 27,503 | 25,564 |

Source: JICA Survey Team based on DCWD Data 2019

**Table 4.2.3 Actual Record of Water Consumption in Area C**

| Category | No. of Connections | Consumption (m3/day) |
|---|---|---|
| Residential | 54,010 (90.4%) | 41,951 (73%) |
| Commercial | 5,619 (9.4%) | 13,608 (24%) |
| Government | 139 (0.2%) | 1,684 (3%) |
| Total | 59,768 | 57,242 |

Source: JICA Survey Team based on DCWD Data 2019

(2) Land Development Plan

The land development plan is mentioned in Chapter 1. The population projection in IM4D shown in Section 4.3 has been reflected on the land development plan.

## 4.3 Study on Design Sewage Flow

Based on the revised sewage discharge rates in section 4.1, the required sewage treatment amounts for Areas A to F were reviewed as shown in the following tables.

**Table 4.3.1 Future Population and Revised Sewage Treatment Amount (Area A)**

| Area A | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Agdao | 593.0 | 102,267 | 111,300 | **124,800** | 124,800 |
| Poblacion | 1,138.2 | 174,121 | 188,100 | **208,700** | 208,700 |
| Poblacion 8 | -159.1 | -11,075 | -11,964 | **-13,274** | -13,274 |
| Sub-total Poblacion | 979.1 | 163,046 | 176,136 | **195,425** | 195,425 |
| Part of BUCANA (East:30%) | 120.6 | 25,189 | 35,009 | **49,558** | 49,558 |
| Total | 1,692.6 | 290,502 | 322,445 | **369,783** | 369,783 |
| Population density | - | 171.6 | 190.5 | **218.5** | 218.5 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | - | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 69,174 | 80,482 | **96,913** | 99,841 |
| (round) | | | 80,000 | **97,000** | 100,000 |

Source: JICA Survey Team based on IM4D population projection

**Table 4.3.2 Future Population and Revised Sewage Treatment Amount (Area B)**

| Area B | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Cabantian | 758.7 | 43,758 | 67,193 | **101,917** | 101,917 |
| Poblacion 8 | 159.1 | 11,075 | 11,964 | **13,274** | 13,274 |
| Tigatto | 770.0 | 36,387 | 55,874 | **84,749** | 84,749 |
| Buhangin | 682.0 | 57,606 | 88,457 | **134,169** | 134,169 |
| Total | 2,369.8 | 148,826 | 223,489 | **334,109** | 334,109 |
| Population density | | 62.8 | 94.3 | **141.0** | 141.0 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 35,438 | 55,783 | **87,563** | 90,209 |
| (round) | | | | **88,000** | 90,000 |

Source: JICA Survey Team based on IM4D population projection

**Table 4.3.3 Future Population and Revised Sewage Treatment Amount (Area C)**

| Area C | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Matina Pangi | 641.4 | | | **35,573** | 35,573 |
| Catalunan Pequeno | 617.8 | 22,809 | 31,700 | **44,875** | 44,875 |
| Ma-a | 1,014.9 | 59,803 | 83,115 | **117,659** | 117,659 |
| Talomo | 659.7 | 59,678 | 82,942 | **117,413** | 117,413 |
| Matina Crossing | 529.3 | 32,436 | 45,080 | **63,816** | 63,816 |
| Matina Aplaya | 306.6 | 33,384 | 46,398 | **65,681** | 65,681 |
| Bago Aplaya | 221.5 | 15,918 | 22,123 | **31,318** | 31,318 |
| Bucana (West: 70%) | 281.4 | 58,775 | 98,674 | **159,310** | 159,310 |
| Total | 4,272.6 | 282,803 | 426,904 | **635,645** | 635,645 |
| Population density | | 52.4 | 99.9 | **148.8** | 148.8 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 67,307 | 106,555 | **161,155** | 171,624 |
| (round) | | | | **161,000** | 172,000 |

Source: JICA Survey Team based on IM4D population projection

**Table 4.3.4 Future Population and Revised Sewage Treatment Amount (Area D)**

| Area D | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Tibungco | 780.5 | 41,864 | 60,194 | **87,360** | 87,360 |
| Panacan | 726.1 | 35,806 | 51,484 | **74,719** | 74,719 |
| Ilang | 597.7 | 24,947 | 35,870 | **52,058** | 52,058 |
| V. Hizon | 212.0 | 11,265 | 17,298 | **26,237** | 26,237 |
| A. Angliongto | 495.3 | 13,539 | 20,790 | **31,534** | 31,534 |
| Pampanga | 94.7 | 14,381 | 22,083 | **33,495** | 33,495 |
| Communal | 570.8 | 16,740 | 25,705 | **38,989** | 38,989 |
| Sasa | 695.0 | 52,386 | 80,442 | **122,012** | 122,012 |
| Bunawan | 774.1 | | 33,782 | **49,028** | 49,028 |
| Total | 5,798.0 | 262,541 | 426,904 | **519,480** | 519,480 |
| Population density | | 45.3 | 73.6 | **109.6** | 109.6 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 62,485 | 106,555 | **136,145** | 140,260 |
| (round) | | | | **136,000** | 140,000 |

Source: JICA Survey Team based on IM4D population projection

**Table 4.3.5 Future Population and Revised Sewage Treatment Amount (Area E)**

| Area E | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Tacunan | 823.0 | | | **40,172** | 40,172 |
| Sto. Nino | 152.8 | 20,103 | 37,477 | **63,225** | 63,225 |
| Los Amigos | 480.6 | | | **30,576** | 30,576 |
| Tugbok | 994.9 | | | **47,537** | 47,537 |
| Mintal | 768.2 | | | **41,599** | 41,599 |
| Total | 3,219.5 | 20,103 | 37,477 | **223,109** | 223,109 |
| Population density | | 6.2 | 11.6 | **69.3** | 69.3 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 4,785 | 9,354 | **58,472** | 60,239 |
| (round) | | | | **58,000** | 60,000 |

Source: JICA Survey Team based on IM4D population projection

**Table 4.3.6 Future Population and Revised Sewage Treatment Amount (Area F)**

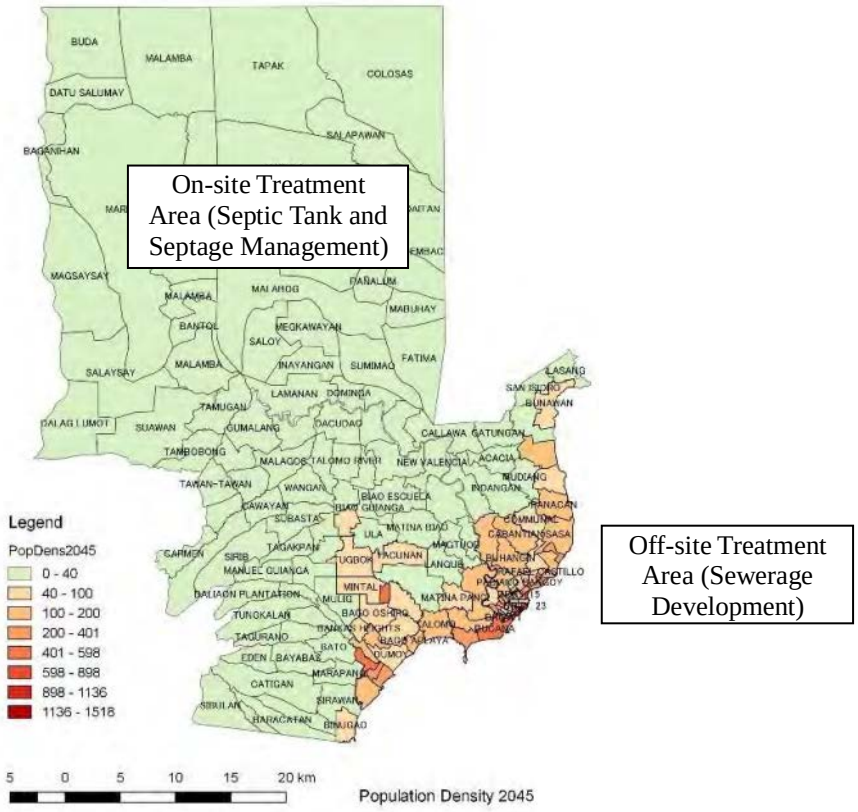
| Area F | Zone Area (CLUP, ha) | Population | | | |
|---|---|---|---|---|---|
| | | 2015 | 2030 | **2045** | 2045 (IM4D) |
| Bago Oshiro | 720.4 | | | **37,527** | 37,527 |
| Bankas Heights | 251.3 | | | **25,050** | 25,050 |
| Toril | 170.4 | 12,140 | 23,222 | **39,643** | 39,643 |
| Lubogan | 357.5 | 12,156 | 23,253 | **39,696** | 39,696 |
| Lizada | 421.7 | 20,112 | 38,471 | **65,676** | 65,676 |
| Daliao | 184.5 | 21,124 | 40,407 | **68,981** | 68,981 |
| Crossing Bayabas | 84.0 | 11,490 | 21,979 | **37,521** | 37,521 |
| Baliok | 238.4 | 16,140 | 22,432 | **31,754** | 31,754 |
| Bago Gallera | 761.0 | 17,378 | 24,152 | **34,190** | 34,190 |
| Dumoy | 593.2 | | | **36,638** | 36,638 |
| Binugao | 502.9 | | | **22,643** | 22,643 |
| Total | 4,285.2 | 110,540 | 193,916 | **439,318** | 439,318 |
| Population density | | 25.8 | 45.3 | **102.5** | 102.5 |
| **Sewage Treatment Amount** | | | | | |
| Daily max. $m^3$/person/day | | 0.238 | 0.250 | **0.262** | 0.27 |
| Daily max. $m^3$/day | | 26,309 | 48,401 | **115,137** | 118,616 |
| (round) | | | | **115,000** | 119,000 |

Source: JICA Survey Team based on IM4D population projection

## 4.4 Study on Offsite and Onsite Treatment Areas

The deciding factor i making the sewerage system an offsite treatment facility is the projected population density of the IM4D in the year 2045. The appropriate area to introduce a sewerage system must have a population density of 40 persons/ha or more, while the proper management of the septic tank system as an onsite treatment should be introduced in areas with less than 40 persons/ha. Therefore, IM4Davao recommended to continue the septic tank system and the future septage management program (see subsection 4.6.1) for all the barangays that were not listed in Table 4.3.1 to Table 4.3.6. The map with offsite and onsite treatment areas is shown in Figure 4.4.1.

The JICA Survey Team follows the basic policy in the IM4D but is to propose a slight revision of the sewerage development area with community plants based on the site conditions.




Source: IM4D

**Figure 4.4.1 Population Density in 2045 and On-site/Off-site Treatment Areas in IM4D**

## 4.5 Study on Design Conditions and Plan for Sewerage Development

### 4.5.1 Wastewater Treatment Plants

(1) WWTP Capacity

Table 4.5.1 shows the summary of total wastewater treatment volumes in each area, which were reviewed in section 4.3. The most appropriate zonings in the areas should be considered for Area B to F in the feasibility studies for each area in the future.

**Table 4.5.1 Proposed Treatment Capacities in Area A to Area F**

| Area | Population (2045) | Proposed Treatment Capacity ($m^3$/day) | |
|---|---|---|---|
| | | This Survey | IM4D |
| Area A | 369,783 | **97,000** | 100,000 |
| Area B | 334,109 | **88,000** | 90,000 |
| Area C | 635,645 | **161,000** | 172,000 |
| Area D | 515,432 | **136,000** | 140,000 |
| Area E | 223,109 | **58,000** | 60,000 |
| Area F | 439,318 | **115,000** | 119,000 |
| Total | 2,517,397 | **655,000** | 681,000 |

Source: JICA Survey Team and IM4D

(2) Wastewater and Sludge Treatment Methods

The IM4D proposed the following treatment methods for Areas A to F. The JICA Survey Team gives comments for each policy as shown below.

1) Wastewater Treatment Method

IM4D Proposal:

Anaerobic Oxygen-free (Anoxic) Aerobic Activated sludge process (A2O)

Comment:

The biological nutrient removal (BNR) is required due to the effluent standard in Philippines. Therefore selection of A2O, which can remove the nitrogen and phosphorus is appropriate. However, since it requires enough space, the process should be properly selected depending on the condition of the candidate site.

2) Sludge Treatment Method

IM4D Proposal:

Concentration (thickening) and dehydration

Comments:

The sludge treatment should be properly selected depending on the site condition and sludge volume. The following are taken into account:

1. Consideration of adding a sludge digestion process depending on the available space, sludge volume, and possibility of power generation from digestion gas

2. Consideration of adding a sludge drying bed in when there is enough land

3. Consideration of adding mechanical sludge drying or even incineration in the future depending on the requirement of minimizing the sludge volume

(3) Influent and Effluent Water Quality

The influent and effluent water qualities in WWTPs were not stipulated in the IM4D. Only the discharge standard from the treatment plant was mentioned. The effluent water quality depends on the locations of candidate sites for Areas B to F and the required levels of discharged water for different water bodies (river, sea).

In this report, the influent and effluent water qualities are established for the Priority Project in Area A of Chapter 6.

### 4.5.2 Study on Design Conditions for Sewage Collection System

(1) Types of Sewage Collection Systems

In the sewerage system, sewage is collected from households, public buildings, commercial buildings, and factories to the wastewater treatment plant (WWTP) through a sewage collection system that consists of sewer lines and pumping stations. Basically, the sewage collection system is divided into 1) a combined sewer system and 2) a separated sewer system. It is necessary to select and decide the type of sewage collection system first to prepare the development plan of the sewage collection system.

The outline of each sewage collection system is summarized as follows:

1) Combined Sewer System

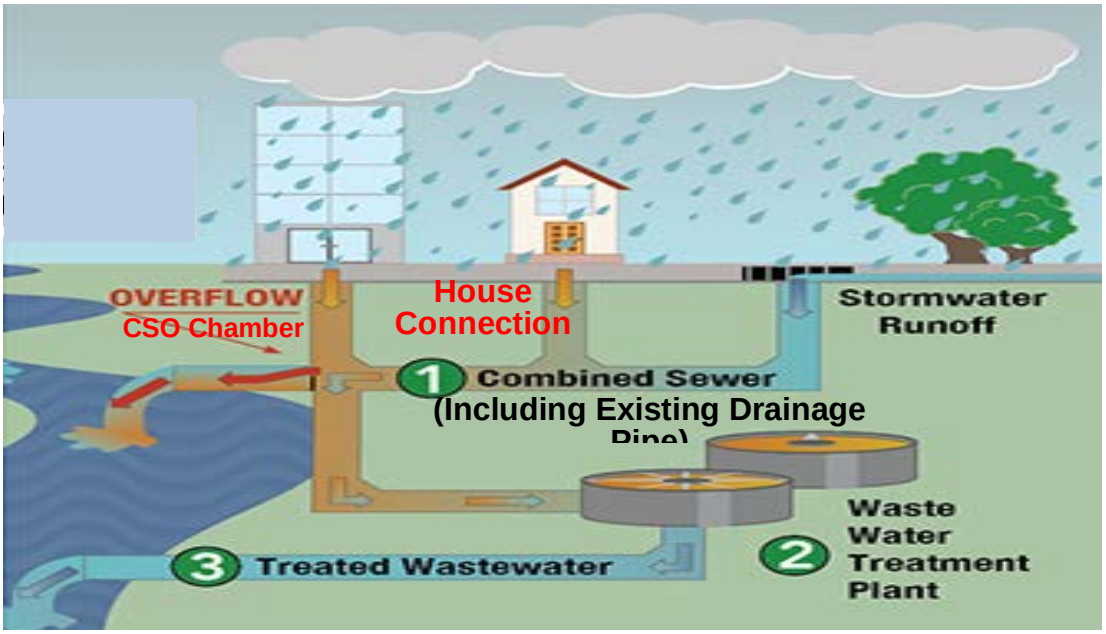
The combined sewer system is a sewage collection system in which wastewater and stormwater are collected in one common sewer pipe. The wastewater diluted by the stormwater is discharged to a public water body through a combined sewage overflow chamber (hereinafter called CSO chamber) at the time of wet weather.

The combined sewer system is divided into two types including the 1) “combined sewer system” to flow sewage from house connections and stormwater and the 2) “interceptor system” based on the interception of sewage from existing drains where the pipe capacity is limited to sewage flow. Here, the interceptor system with the limited capacity of pipes is also called a combined sewer system. This is because a certain amount of stormwater, where its volume depends on pipe design, can flow into the system.

The features, advantages, and disadvantages of these two types of combined sewer system are summarized below.

1-1) Combined Sewer System

An image of the combined sewer system with house connections is shown in Figure 4.5.1.




Source: JICA Survey Team

**Figure 4.5.1 Outline of Combined Sewer System**

The following structures and facilities are constructed in the normal combined sewer system:

i) Combined sewer to collect both wastewater and stormwater

ii) CSO chamber to separate wastewater and stormwater and to discharge stormwater and diluted wastewater

iii) Interceptor to collect wastewater for the STP

iv) Pumping station, if necessary

v) Connecting pipe from household to the newly-installed combined sewer

[Advantage]

i) The necessary period and cost to construct sewer lines are smaller than the separate sewer system.

ii) Basically, newly installed combined sewers have enough capacity to flow the designed amount of wastewater and stormwater. Therefore, wastewater will not accumulate in the combined sewers as much as what can happen in an interceptor system at the time of fine weather.

iii) The same amount and quality of wastewater as separate sewer system is expected to be collected at the time of fine weather on the assumption that the connection between the household, and the combined sewer is completed.

[Disadvantage]

i) Untreated wastewater diluted by stormwater is discharged to public bodies of water at the time of wet weather, which causes water pollution.

ii) To mitigate the pollution load on public water bodies at the same level as the separate sewer system at the time of wet weather, additional structures and facilities, such as a diluted wastewater retention tank, are required to be constructed. This requires an additional investment cost.

iii) Sediment is easy to accumulate at the time of fine weather compared to the separate sewer system because the actual flow velocity of wastewater in the combined sewer is much smaller than the design flow velocity.

1-2) Interceptor System

An image of an interceptor system is shown in Figure 4.5.2. The system is widely adopted in Metro Manila in both the Western (Maynilad service area) and Eastern areas (Manila Water service area). A separate sewer system, which is explained in 2), is quite limited in the existing sewerage area in Manila City. Recently, the system is also adopted for provincial areas (e.g. Cavite Province). Basically, the interceptor pipe has a design flow of only up to 1Q (hourly maximum dry weather flow). However, there is still some stormwater inflow due to the pressure flow and the design allowance of the pipe.

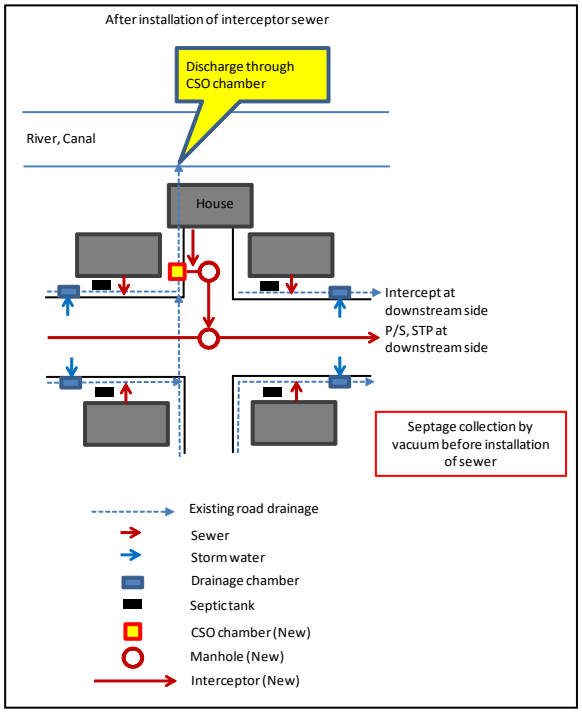
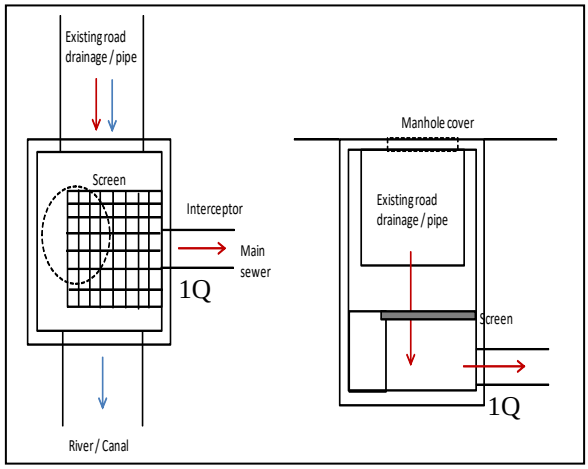



Diagram of Interception System




Planar and Sectional Image

Note: 1Q: Dry weather flow of sewage (hourly maximum)
Source: JICA Survey Team

**Figure 4.5.2 Outline of Interceptor System**

The interceptor system is an incomplete combined sewer system where both wastewater and stormwater are collected with the use of the existing drainage system. Basically, wastewater is collected through drainage pipes or ditches on the assumption that household and existing drainage pipes or ditches are connected. However, there are many cases where they are not connected.

In such cases, the connection of septic tanks to the drainage system should be done in order to switch from septic tank (on-site) to sewerage system and to collect the septage through pipes (off-site). However, due to the difficulty of the switching work in all houses, a septic tank and septage collection by vacuum trucks are still used in some cases.

The following structures and facilities are utilized and constructed in the interceptor sewer system:

i) Existing road side drains, to which gray water and septage is discharged from houses, is cleared once switching works from septic tanks is finished.

ii) Interceptor to collect wastewater to STP

iii) CSO chamber to separate wastewater and stormwater and to discharge stormwater and diluted wastewater

iv) Pumping station, if necessary

[Advantage]

i) The necessary construction period and cost are smaller than the normal combined sewer system. Therefore, the operation of the STP can be started earlier than the normal combined sewer system and separated sewer system.

[Disadvantage]

i) Untreated wastewater diluted by stormwater is discharged to public bodies of water at the time of wet weather, which causes water pollution. This is the same as the normal combined sewer system.

ii) The amount of wastewater collected for the STP is much smaller than the design wastewater inflow, and the wastewater quality collected for the STP is much lower than the design influent quality for the following reasons. Due to this, the newly-developed STP and interceptor cannot fulfill their expected functions.

   a) There are many cases that household and existing drainage pipes are not connected.

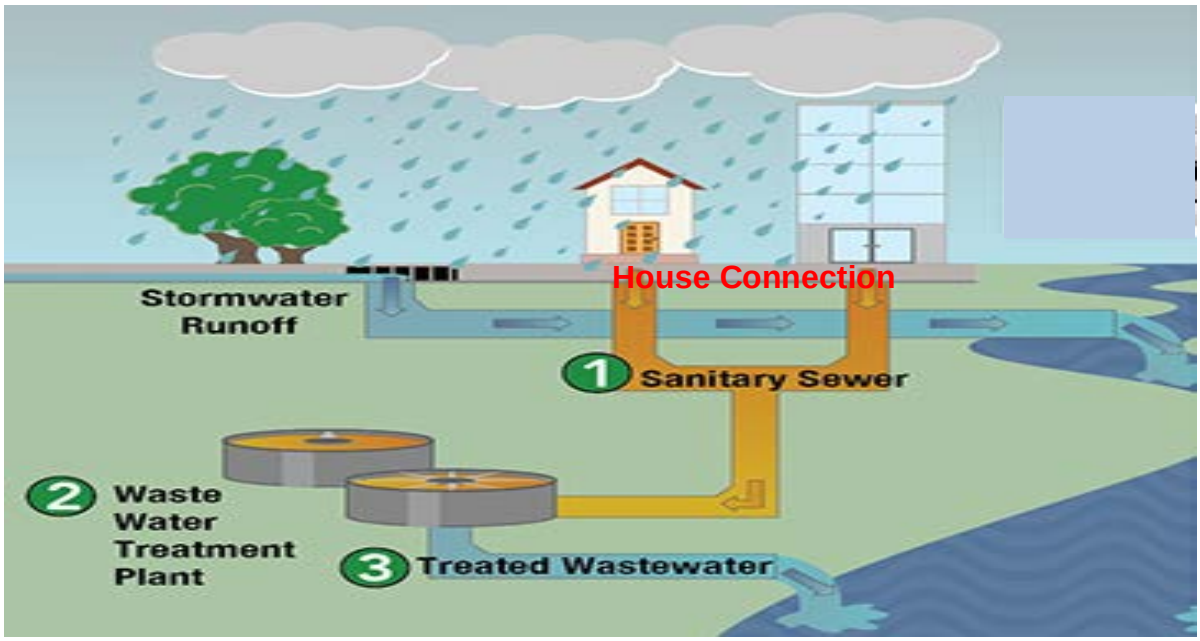
   b) Some existing drainage pipes do not have enough capacity to flow the designed amount of wastewater. Therefore, wastewater does not flow at the time of fine weather.

   c) Similarly, there is an abundant accumulation of garbage in existing drainage pipes and ditches. Due to this, wastewater does not flow at the time of fine weather.

   d) Even if household and existing drainage pipes are connected, there are many cases that only gray water flows in existing drainage pipes.

2) Separate Sewer System

A separate sewer system is a sewage collection system in which wastewater and stormwater are collected in separate pipes as described in Figure 4.5.3.




Source: JICA Survey Team

**Figure 4.5.3 Outline of Separate Sewer System**

To collect sewage with a separate sewer system, it is necessary to install sanitary sewers in the whole target area and to install connecting pipes between every household and newly installed sanitary sewer.

Additionally, to collect and drain stormwater and to mitigate the inundation, it is necessary to install stormwater drainage pipes separately.

The advantages and disadvantages of a separate sewer system are summarized below.

[Advantage]

i) The water quality of public bodies of water and the living environment of the target area will be drastically improved because no untreated wastewater will be discharged to public bodies of water.

ii) The water quality of the STP influent is as expected, resulting in the good performance of the treatment facility.

iii) The construction work of sewer is easier than the combined sewer system because sizes of sewers are small.

iv) The required area of STP is smaller than the combined sewer system.

[Disadvantage]

i) The necessary period and cost in constructing sewer lines are bigger than that of the combined sewer system because of the necessary development of the two kinds of pipelines. These are to collect both wastewater and stormwater.

ii) It is necessary to maintain both sanitary sewer and stormwater drainage pipes.

1-1) Combined Sewer System and 3) Separate Sewer System require a long time for construction and involve additional costs for house connection works. To legalize the connections, a new ordinance by

the LGU should be developed. Due to many individual connections and the burden of the work itself, sometimes wastewater cannot be collected efficiently at the initial stage.

(2) Design in IM4D

1) Adopted Collection System in IM4D

The interception system was proposed in IM4D due to the quick development and lower cost for the initial stage.

2) Proposed Sewer Network

a) General Concept

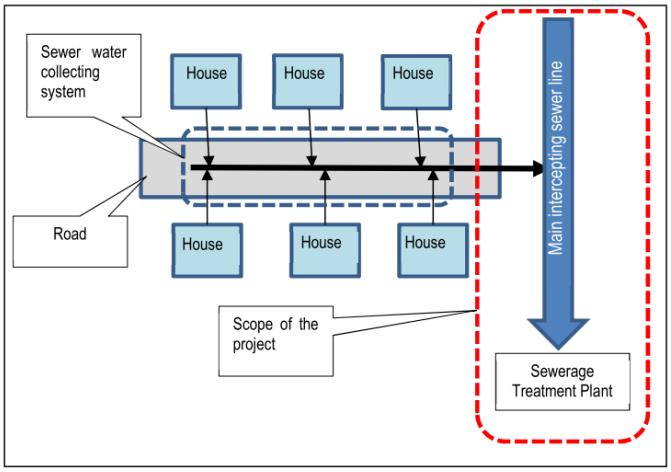
The image of the general sewer network concept is shown in Figure 4.5.4.

- The “main intercepting sewer lines” to collect wastewater from residential areas to WWTPs were proposed. This is included in the master plan project component and the cost.

- In each residential area sewage is collected from each house. The “sewer water collecting system” has a pipe diameter of 250 mm, which is installed under the road. This is excluded from the project component and proposed to be developed with local funds.

- In case drains have been developed beside the road and houses discharge wastewater to the drains, the drains are utilized as sewers and sewage is intercepted from the drains. But the IM4Davao Team assumed that many septic tanks are connected to the drains and wastewater from toilets, except for sedimented solids, can be collected from the drains.

Therefore, IM4D proposed the interceptor system as a project component. However, as a long-term plan, the combination of an interceptor system and separate sewer system depends on the existence of a road side drainage system and the wastewater discharge status.




Source: IM4D

**Figure 4.5.4 “Sewer Water Collecting System” in IM4D**

b) Main Interceptor Sewer (Project Component)

The scale of the main intercepting sewer lines in IM4D is shown in Table 4.5.2. The total length is

76.9 km for Areas A to F. Since these intercepting lines are installed in the main streets, the adoption of pipe jacking method for all the sections were proposed.

**Table 4.5.2 Outline of Main Intercepting Sewer Line and Construction Method in IM4D**

| Area | Diameter of the Main Intercepting Line | Total Length (m) | Construction Method |
|---|---|---|---|
| A | 500 to 1650 mm | 7,300 | Jacking method |
| B | 400 to 1350 mm | 6,500 | Jacking method |
| C | 400 to 1350 mm | 13,700 | Jacking method |
| D | 400 to 1200 mm | 18,800 | Jacking method |
| E | 400 to 1000 mm | 16,600 | Jacking method |
| F | 400 to 1350 mm | 14,000 | Jacking method |
| Total | 400 to 1650 mm | 76,900 | Jacking method |

Source: IM4D compiled by JICA Survey Team

c) Sewer Water Collection System (Locally Developed Component)

The development scale and preliminary cost for sewer water collection system were estimated in IM4D. The assumed total length of pipe installation is 3,354 km, and the development cost is around PHP 110 billion, as shown in Table 4.5.3.

**Table 4.5.3 Outline of Sewer Water Collection System in IM4D**

| Area | (1) Zone area (ha) | Assumed pipe length incl. drain (km) | (2) Unit Cost (PHP 1000/ha) | (3) Present Drain Installation Ratio | Assumed pipe installation (km) | (4) Cost (PHP million) |
|---|---|---|---|---|---|---|
| A | 1,693 | 576 | 11,118 | 85.8% | 81.6 | 2,667 |
| B | 2,370 | 806 | 11,118 | 58.6% | 333.4 | 10,903 |
| C | 5,798 | 1,971 | 11,118 | 56.0% | 867.1 | 28,355 |
| D | 4,672 | 1,588 | 11,118 | 54.2% | 726.9 | 23,771 |
| E | 3,219 | 1,094 | 11,118 | 44.5% | 607.7 | 19,872 |
| F | 4,285 | 1,457 | 11,118 | 49.4% | 737.7 | 24,122 |
| Total | 22,037 | 7,493 | - | - | 3,354 | 109,690 |

Source: JICA Survey Team based on IM4D

### 4.5.3 Review of Project Implementation Schedule and Cost in IM4D

(1) Project Implementation Schedule of Mater Plan Component

The proposed project implementation schedule of the sewerage development in IM4D is shown in **Table 4.5.4**. This schedule does not include the development work and period for sewer water collection system in each residential area.

**Table 4.5.4 Implementation Plan for Six Areas by 2045 in IM4D**

| Year | Area A | Area B | Area C | Area D | Area E | Area F |
|---|---|---|---|---|---|---|
| 2018 | Preparation (5 years) | | | | | |
| 2019 | | | | | | |
| 2020 | | | | | | |
| 2021 | | | | | | |
| 2022 | | | | | | |
| 2023 | Construction of intercepting sewer line and sewerage treatment plant | Preparation (3 years) | | | | |
| 2024 | | | | | | |
| 2025 | | | | | | |
| 2026 | | Construction of intercepting sewer line and sewerage treatment plant | Preparation (3 years) | | | |
| 2027 | | | | | | |
| 2028 | Operation | | | | | |
| 2029 | | | Construction of intercepting sewer line and sewerage treatment plant | Preparation (3 years) | | |
| 2030 | | | | | | |
| 2031 | | Operation | | | | |
| 2032 | | | | Construction of intercepting sewer line and sewerage treatment plant | | Preparation (3 years) |
| 2033 | | | | | | |
| 2034 | | | Operation | | | |
| 2035 | | | | | | Construction of intercepting sewer line and sewerage treatment plant |
| 2036 | | | | | | |
| 2037 | | | | Operation | Preparation (3 years) | |
| 2038 | | | | | | |
| 2039 | | | | | Construction of intercepting sewer line and sewerage treatment plant | Operation |
| 2040 | | | | | | |
| 2041 | | | | | | |
| 2042 | | | | | | |
| 2043 | | | | | | |
| 2044 | | | | | | |
| 2045 | | | | | Operation | |

Source: IM4D

(2) Project Cost for Sewerage Development

The estimated project cost for sewerage development in IM4D is PHP 99 billion, excluding the sewer water collection system as shown in Table 4.5.5. In case the system development is added, the total cost is PHP 209 billion.

**Table 4.5.5 Sewerage Development Cost in IM4D**

| Item \ Area | Construction Cost (million PHP) | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | Total |
| **Master Plan Component** | | | | | | | |
| Main intercepting line | 1,329 | 1,145 | 2,273 | 3,259 | 2,086 | 2,344 | 12,435 |
| Sewerage treatment plant | 11,491 | 10,764 | 14,167 | 16,111 | 8,378 | 12,803 | 73,715 |
| Contingency | 1,923 | 1,786 | 2,466 | 2,906 | 1,570 | 2,272 | 12,923 |
| **Total** | **14,743** | **13,695** | **18,906** | **22,276** | **12,033** | **17,419** | **99,073** |
| **Locally Developed Component** | | | | | | | |
| Sewer Water Collection System | 2,667 | 10,903 | 28,355 | 23,771 | 19,872 | 24,122 | 109,690 |
| **Total incl. Local** | **17,410** | **24,598** | **47,261** | **46,047** | **31,905** | **41,541** | **208,763** |

Source: IM4D compiled by JICA Survey Team

## 4.6 Review and Current Status of Septage Management Program

### 4.6.1 Study on Septage Management Program F/S by USAID

The "Septage Management Program" was prepared in a project named "DAVAO CITY SEPTAGE MANAGEMENT PROJECT FEASIBILITY STUDY" supported by USAID. The report was published in June 2013.

(1) Objective of the Program

The operational objectives of the Septage Management Program of DCWD are:

1. Reduce pollution attributed to untreated septage discharge or overflow from households by offering an appropriate septage desludging service to DCWD customers;

2. Provide efficient and affordable septage desludging service initially to existing DCWD customers and ultimately to all targeted areas within the service coverage of DCWD;

3. Comply to all existing local and national environmental laws and regulations on effluent and sludge disposal by construction and operation of efficient treatment plants and sludge disposal facility; and

4. Improve water quality, sanitation and public health conditions to enhance economic productivity in the general areas of Davao City.

(2) Outline of the Program Policies

The outline of the program is as follows;

1. All the DCWD service area for water supply was selected as Septage Collection Area (SCA).

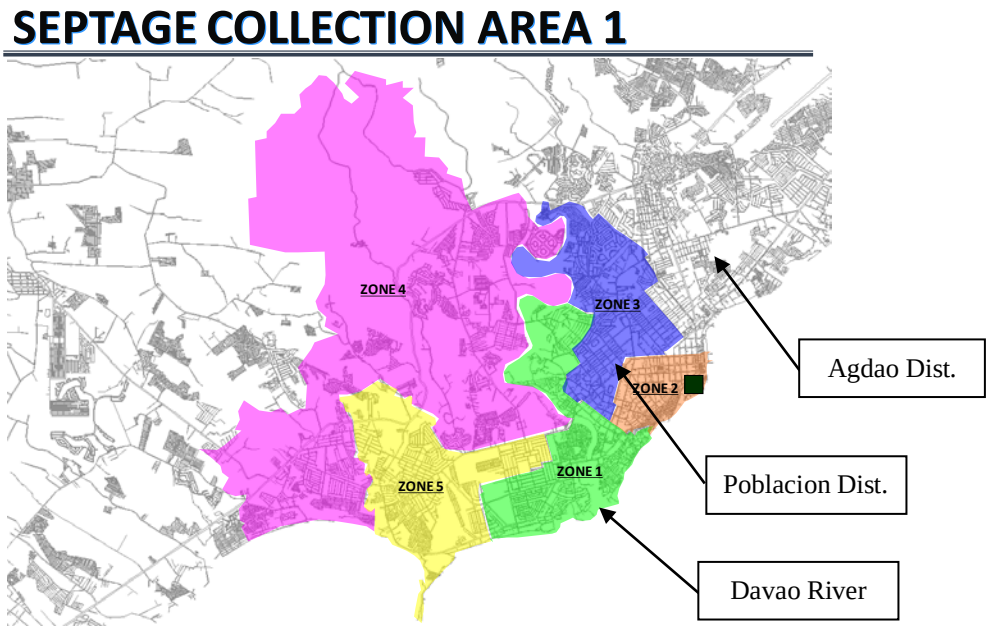
2. The SCA was divided into four areas, namely SCA-1 to SCA-4. SCA-1 and most of SCA-2 are composed of areas from the Dumoy Water Supply System, which is the main water supply system of DCWD.

3. Some barangays adjacent to the SCA also were selected to collect the septage.

4. All the target barangays were categorized into SCA-1 to SCA-4 as shown in Figure 4.6.2.

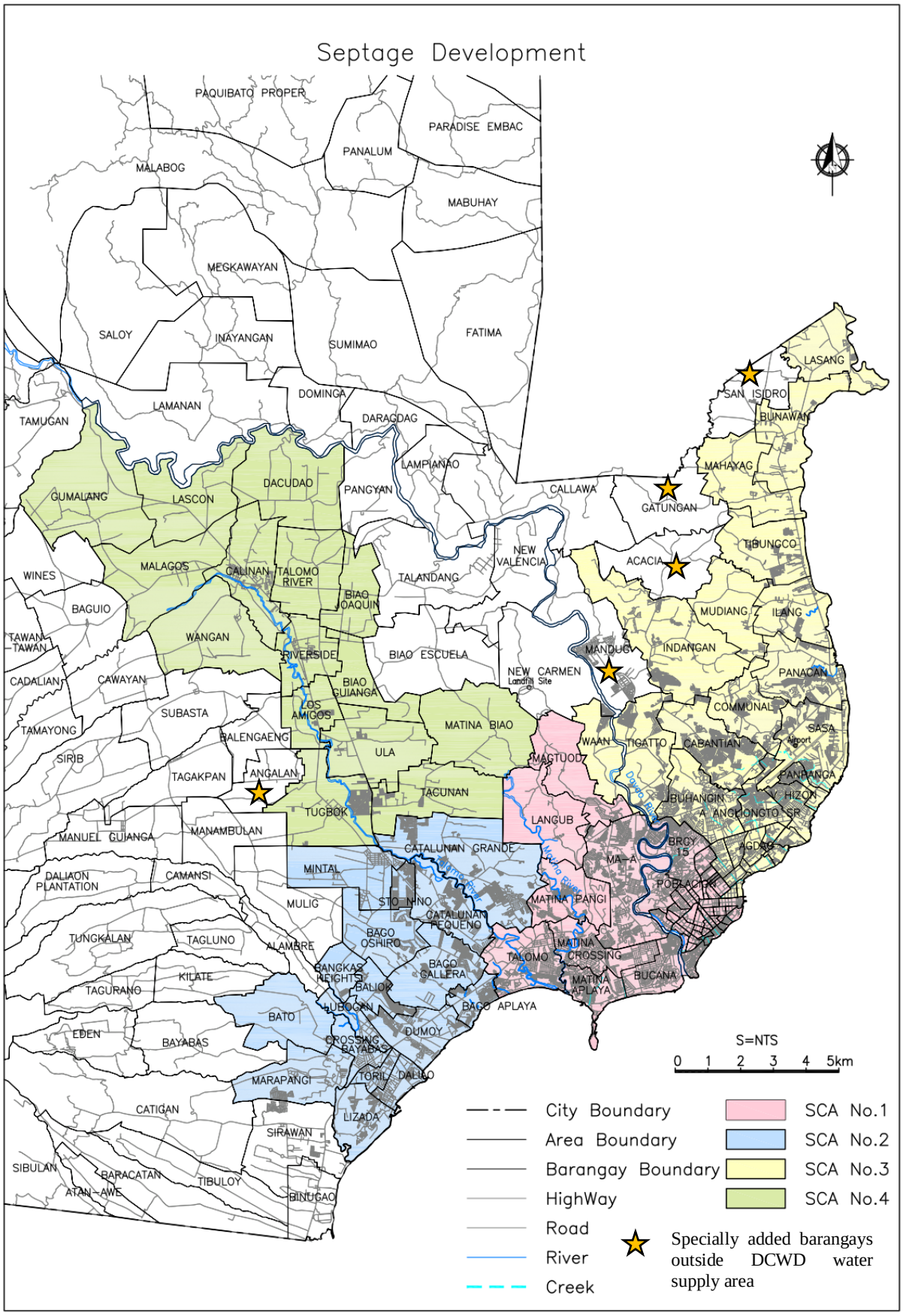
5. The target year of SCA-1 and SCA-2 is 2030 and one of SCA-3 and SCA-4 is 2032.

6. Septage is collected every 5 years from each household. For that reason, each SCA is divided into five zones to conduct the collection one by one in every year. The example of SCA-1 as top priority area including Poblacion District is shown in Figure 4.6.1.




Source: DCWD supplemented by the JICA Survey Team

**Figure 4.6.1 Example of Five Zones in SCA-1**




Source: JICA Survey Team based on IM4D

**Figure 4.6.2 Target Barangays of Septage Management Program**

7. The total populations and service connections in each SCA until 2032 were projected as shown in Table 4.6.1 and Table 4.6.2.

**Table 4.6.1 SCA Population Projections in Septage Management F/S**

| SCA | 2015 | 2017 | 2020 | 2022 | 2025 | 2027 | 2030 | 2032 |
|---|---|---|---|---|---|---|---|---|
| SCA-1 | 473,659 | 494,247 | 527,460 | 551,286 | 589,794 | 617,466 | 662,271 | 694,528 |
| SCA-2 | 282,231 | 300,482 | 330,721 | 352,992 | 389,958 | 417,230 | 462,573 | 496,079 |
| SCA-3 | 527,374 | 556,245 | 603,767 | 638,551 | 695,949 | 738,064 | 807,720 | 858,945 |
| SCA-4 | 99,289 | 105,740 | 116,383 | 124,187 | 137,084 | 146,560 | 162,248 | 173,795 |
| **Total** | **1,382,553** | **1,456,714** | **1,578,331** | **1,667,016** | **1,812,785** | **1,919,320** | **2,094,812** | **2,223,347** |

Source: Septage Management F/S

**Table 4.6.2 Projection of Total Service Connections in Septage Management F/S**

| SCA | 2015 | 2017 | 2020 | 2022 | 2025 | 2027 | 2030 | 2032 |
|---|---|---|---|---|---|---|---|---|
| SCA-1 | 83,925 | 87,663 | 93,629 | 97,863 | 104,624 | 109,424 | 117,094 | 122,542 |
| SCA-2 | 39,314 | 42,427 | 47,616 | 51,460 | 57,876 | 62,635 | 70,591 | 76,502 |
| SCA-3 | 67,580 | 71,793 | 78,769 | 83,908 | 92,454 | 98,780 | 109,350 | 117,212 |
| SCA-4 | 8,322 | 9,209 | 10,751 | 11,946 | 14,039 | 15,674 | 18,566 | 20,848 |
| **Total** | **199,140** | **211,092** | **230,765** | **245,176** | **268,993** | **286,512** | **315,602** | **337,104** |

Source: Septage Management F/S

8. Based on the projections above, the design septage volumes were planned with the following factors:

a) Services to non-water district connection customers increase by 5% every 5 years.

b) Households/buildings with septic tanks are assessed as 86.3% in 2015 from the survey, and it increases to 89.6% in 2020 (example in SCA-1)

c) Accessible septic tank increases gradually with DCWD and house owner efforts (2015: 60%, 2020: 68% in SCA-1)

d) The average volume of a septic tank is 5.57 $m^3$ for residential units and 11.14 $m^3$ for non-residential units. The septage volume to be vacuumed is 50% of the capacity of each unit and is to be done every five years.

e) The operational days per year for septage collection work is 221 days.

Based on the above assumptions, the design septage volume in the Septage Management F/S is shown in Table 4.6.3. The total requirement for septage collection and treatment from 2016 to 2020 is 240 $m^3$/day for septage treatment plants in SCA-1 and 2. For SCA-3 and SCA-4, 170 $m^3$/day (= 410 $m^3$/day - 240 $m^3$/day) is required for 2018 to 2022. After that, the treatment capacity of 80 $m^3$/day for SCA-1 and SCA-2 should be added by 2021 for an increased demand in those areas.

**Table 4.6.3 Design Septage Volume in Septage Management F/S**

| Year | Design Septage Volume (m3/day) | | | | |
|---|---|---|---|---|---|
| | SCA-1 | SCA-2 | SCA-3 | SCA-4 | Total |
| 2016 | 160 | 80 | 0 | 0 | 240 |
| 2017 | 160 | 80 | 0 | 0 | 240 |
| 2018 | 160 | 80 | 150 | 20 | 410 |
| 2019 | 160 | 80 | 150 | 20 | 410 |
| 2020 | 160 | 80 | 150 | 20 | 410 |
| 2021 | 210 | 110 | 150 | 20 | 490 |
| 2022 | 210 | 110 | 150 | 20 | 490 |
| 2023 | 210 | 110 | 190 | 30 | 540 |
| 2024 | 210 | 110 | 190 | 30 | 540 |
| 2025 | 210 | 110 | 190 | 30 | 540 |
| 2026 | 270 | 150 | 190 | 30 | 640 |
| 2027 | 270 | 150 | 190 | 30 | 640 |
| 2028 | 270 | 150 | 260 | 50 | 730 |
| 2029 | 270 | 150 | 260 | 50 | 730 |
| 2030 | 270 | 150 | 260 | 50 | 730 |
| 2031 | 270 | 150 | 260 | 50 | 730 |
| 2032 | 270 | 150 | 260 | 50 | 730 |

Source: JICA Survey Team based on the Septage Management F/S

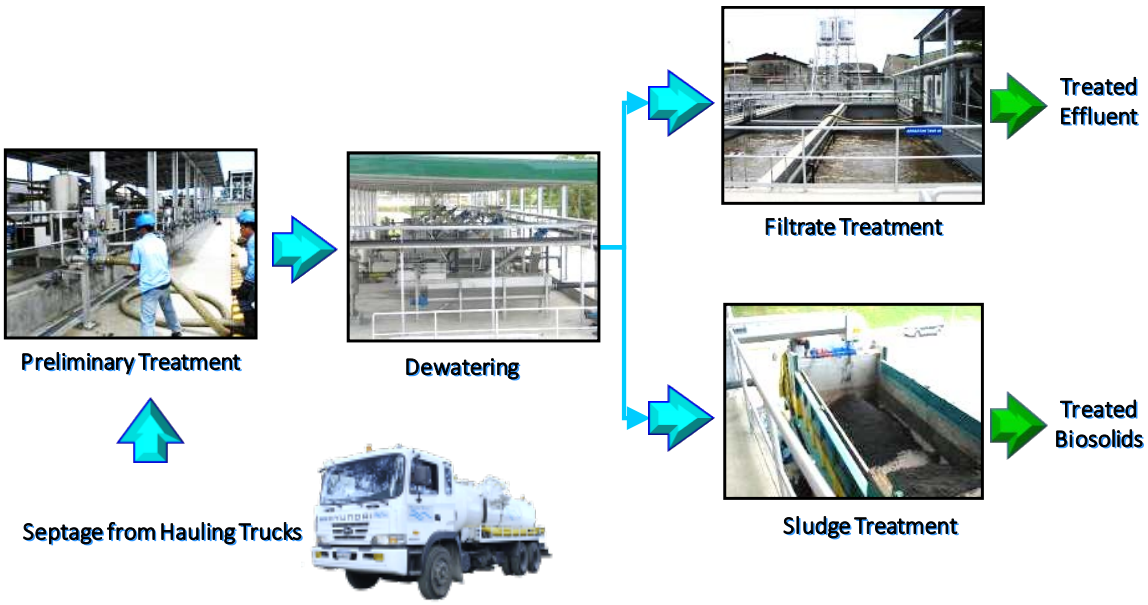
(3) Latest Schedule

Due to the delay of initiating the program from the original schedule, DCWD has revised the program milestones as follows:

1) Preliminary Period (2019)
Until 2019: such as land acquisition for SpTPs, Procurement of Hauling Trucks
2) Construction Period (2021-2023)
- Phase 1a: 1st Quarter of 2021 until 2nd Quarter of 2022 @ 240 $m^3$/day (Phase 1a for SCA-1,2)
- Phase 1b: 3rd Quarter of 2022 until 4th Quarter of 2023 @ 170 $m^3$/day (Phase 1b for SCA-3,4)
3) SMP Operation Period (2022-2028)
- Phase 1a: From 3rd Quarter of 2022
- Phase 1b: From 1st Quarter of 2024

(4) Project Components

Capital Expenditures:
- Land and Vacuum Trucks (10 $m^3$ x 5 nos., 5 $m^3$ x 9 nos., 2.5 $m^3$ x 6 nos.)
- Dump Trucks (2 units)
- Fully-Mechanized Septage Treatment Plant (Phase 1a: 1st Quarter of 2020: 240 $m^3$/day, Phase 1b: 3rd Quarter of 2021: 170 $m^3$/day). An image of the SpTP is shown in Figure 4.6.3.




Source: DCWD

**Figure 4.6.3 Image of Fully-Mechanized SpTP**

(5) Financial Plan

The estimated capital cost (CAPEX), O&M cost (OPEX), and expected revenue for Phase 1 (410 $m^3$/day) and Phase 2 (130 $m^3$/day) in the Septage Management F/S are shown in Table 4.6.4. Based on these figures, the septage management program is designed to profit on the 7th year from commencement.

As a base of this assumption, project revenues will come from the environmental fee charged to customers of the Water District. Full cost-recovery of unescalated costs implies a base environmental fee of only PHP 1.23 per $m^3$ of billed water or 6.63% of the average water tariff. This fee will be included in the monthly bill of the customers.

**Table 4.6.4 Financial Plan of Septage Management Program**

| Period | Year | Capex (cumulative) | Opex (cumulative) | Vehicle Re-fleeting Cost | Total Cost (cumulative) | Environemtal Fee (cumulative) | Balance |
|---|---|---|---|---|---|---|---|
| 0 | 2015 | 243,880,926 | | | 243,880,926 | | (243,880,926) |
| 1 | 2016 | 323,408,811 | 33,983,910 | | 357,392,721 | 103,094,197 | (254,298,524) |
| 2 | 2017 | 336,160,269 | 71,224,506 | | 407,384,775 | 209,276,463 | (198,108,312) |
| 3 | 2018 | 344,311,843 | 111,876,849 | | 456,188,692 | 318,639,644 | (137,549,048) |
| 4 | 2019 | 344,311,843 | 154,155,286 | | 498,467,129 | 431,279,099 | (67,188,030) |
| 5 | 2020 | 424,993,068 | 198,286,223 | | 623,279,291 | 547,292,886 | (75,986,405) |
| 6 | 2021 | 440,321,041 | 248,331,876 | | 688,652,917 | 692,842,467 | 4,189,550 |
| 7 | 2022 | 453,415,510 | 302,663,550 | | 756,079,060 | 842,930,130 | 86,851,070 |
| 8 | 2023 | 459,632,536 | 360,350,351 | | 819,982,887 | 997,697,538 | 177,714,651 |
| 9 | 2024 | 472,563,950 | 422,802,894 | | 895,366,844 | 1,157,290,627 | 261,923,783 |
| 10 | 2025 | 472,563,950 | 487,753,539 | | 960,317,489 | 1,321,859,108 | 361,541,619 |
| 11 | 2026 | 472,563,950 | 555,302,210 | 117,720,697 | 1,145,586,857 | 1,522,081,828 | 376,494,971 |
| 12 | 2027 | 472,563,950 | 625,552,828 | 130,472,155 | 1,228,588,933 | 1,722,304,548 | 493,715,615 |
| 13 | 2028 | 472,563,950 | 698,613,470 | 138,623,729 | 1,309,801,149 | 1,922,527,268 | 612,726,119 |
| 14 | 2029 | 472,563,950 | 774,596,538 | | 1,247,160,488 | 2,122,749,988 | 875,589,500 |
| 15 | 2030 | 472,563,950 | 853,618,929 | | 1,326,182,879 | 2,322,972,708 | 996,789,829 |

Source: JICA Survey Team based on the Septage Management F/S (2013)

### 4.6.2 Current Status and Issue of Septage Management Program

(1) Memorandum of Agreement (MOA)

The draft Memorandum of Agreement (MOA) for the Sewerage and Septage Management Program was prepared by DCWD in 2015. The responsibilities of the City and DCWD mentioned in the MOA are summarized in Table 4.6.5.

**Table 4.6.5 Responsibilities of Davao City and DCWD in Draft MOA**

| Davao City | DCWD |
|---|---|
| (A) Grant and Support<br>1. Grant DCWD the construction and O&M of Septage Treatment Plant (SpTP), desludging<br>2. Support DCWD's implementation of Septage Management Program<br>(B) Survey and Property Owner Relation<br>3. Conduct a survey of all properties in the city to determine if septic tanks are present and accessible for desludging in cooperation with barangays. Records should be kept for reference.<br>4. Conduct a periodic survey to update above every 5 years.<br>5. Issue a certificate of compliance to the property owners of septic tanks | (A) SpTP<br>1. Construction of SpTP (work, cost)<br>2. O&M of SpTP (work, cost)<br>(B) Collection of Septage and Fee<br>3. Impose the Septage Management Fee (SMF) added up to the monthly water bill (DCWD customers)<br>4. Collect septage from non-DCWD customers as per job order and charge a Septage Management Fee (SMF)<br>5. Impose the Treatment Fee to accredited private desludging service providers<br>6. Reserve the right to review/adjust the SMF and Treatment Fee<br>(C) Payment to City<br>7. Pay the Desludging Fee to the City (As per Ordinance 0363-10) |

Note: The accredited private desludging service providers will (continue to) collect the septage from DCWD customers.
Source: JICA Survey Team based on draft MOA

Although it was not clearly mentioned in the MOA, the construction of SpTP and the procurement of desludging trunks and vacuum trucks are also the responsibility of DCWD.

The MOA has not been signed by both parties. The city government suggested DCWD to share the profit from the septage management program with a 50%-50% sharing in the payment of the desludging fee to the City through the initiative of the council (Committee on Environment and Natural Resources). However, DCWD has not agreed to it.

The issue was supposed to be discussed as one agenda in the Watershed Council in Davao City with the attendance of DCWD on 3 October 2019. However, it was not discussed, and the agenda was transferred to the Environment Committee. The schedule of the discussion has not been fixed.

(2) Review of Feasibility Study for Septage Management Program

DCWD is still on the process of revisiting the Feasibility Study and eventually updating it since the data used for the F/S was obtained in 2013. Therefore, DCWD is under review on its financial plan including the appropriate setup of the SMF and Treatment Fee.

(3) Financial Source for Septage Management Program

There has been no discussion with the City about the application of NSSMP to the program. This is

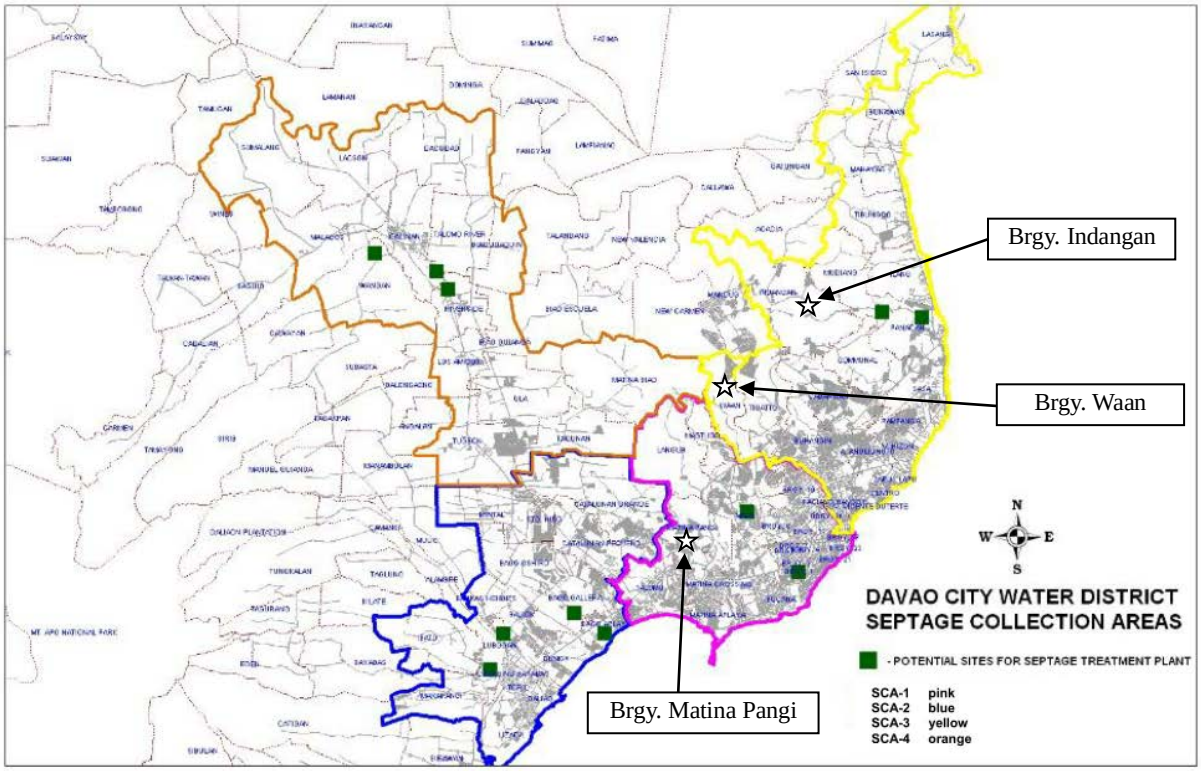
because the DCWD will be covering all costs. Construction costs will be covered by a PHP 300 to 400 million loan. DCWD will apply the loan from the Development Bank of the Philippines (DBP).

(4) Candidate Sites for Septage Treatment Plant

According to the interview with DCWD, the following three candidate sites which are all private lands are under consideration for the first septage treatment plant. However, since the MOA for commencing the program has not been signed between the City and DCWD, DCWD has not started any step for acquiring the land.

1. Brgy. Matina Pangi SCA-1 1 ha.
2. Brgy. Waan SCA-3 4 ha.
3. Brgy. Indangan SCA-3 4 ha.

All the potential sites are newly selected after the septage management F/S in 2013 and all are located inland as shown in Figure 4.6.4.




Note: The star marks do not show exact locations of current potential sites
Source: IM4D

**Figure 4.6.4 Potential Sites for SpTPs as of Septage Management F/S in 2013 and 3 Barangays of Current Potential Sites**

# CHAPTER 5 STUDY FOR COMPREHENSIVE SEWAGE AND SEPTAGE MANAGEMENT PROGRAM

This chapter includes the study for a comprehensive sewage and septage management program in the Davao City Infrastructure Development Plan and Capacity Development Project Davao City (hereinafter referred to as "IM4D") and the septage management program (USAID F/S).

## 5.1 Target Year, Targets of BOD Reduction and River Water Quality

### 5.1.1 Target Year

The target year of all the land and infrastructure development projects is 2045. The year is based on the National Physical Framework Plan (NPFP) 2016–2045, which intends to guide the national physical and land use planning. The National Spatial Strategy (NSS) is the core strategy of the NPFP and it defines the country's desired spatial structure based on population trends, economic activities, and services. The year 2030 was also setup as an intermediate target year of several priority development projects including sewerage works. It came from the target year of the previous NPFP for 2001-2030.

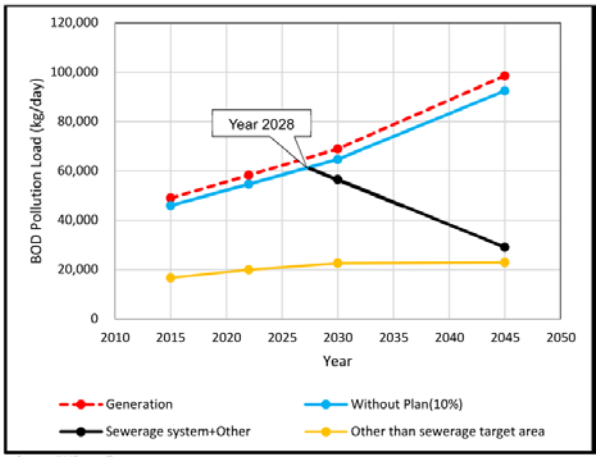
### 5.1.2 Targets of BOD Reduction

The future BOD generations and discharge amounts in 2030 and 2045 with future sewerage systems were estimated in IM4D, as shown in Table 5.1.1 and Figure 5.1.1. The IM4D calculated the BOD reduction amounts and the reduction ratio as shown in Table 5.1.1. This is around 70% in 2045 after the completion of sewerage development in the proposed sewerage area (Areas A to F).

**Table 5.1.1 Future BOD Generation and Reduction Amount based on IM4D**

| Item | | Year | | | |
|---|---|---|---|---|---|
| | | 2015 | 2022 | 2030 | 2045 |
| BOD Generation amount | | 48,990 | 58,311 | 68,964 | 98,562 |
| BOD discharge amount (kg/day) | 1. Without Plan (10%*) | 45,952 | 54,696 | 64,688 | 92,451 |
| | 2. From Sewerage System Area | 30,313 | 36,016 | 35,379 | 7,564 |
| | 3. From Other than Sewerage System Area | 15,640 | 18,679 | 21,203 | 21,498 |
| | Sum of 2. and 3. | 45,952 | 54,696 | 56,582 | 29,062 |
| BOD Reduction Amount (kg/day) | | 3,038 | 3,615 | 12,382 | 69,500 |
| BOD Reduction Ratio (%) | | 6.2 | 6.2 | 18.0 | 70.5 |

Note: * Assumed septic tank BOD removal ratio: 10%
Source: IM4D compiled by JICA Survey Team




Source: IM4D

**Figure 5.1.1 Future BOD Generation and Discharge Amount in IM4D**

## 5.2 Proposal on Onsite and Offsite Treatment Areas

The JICA Survey Team visited the barangays in the sewerage development area together with the barangays outside the sewerage development area. These include the ones around the New Carmen Landfill Site. The pictures taken in general site visits and household interview surveys are shown in Appendix 3.14. In the visits to barangays, the following factors were confirmed:

1. Topographic and land use condition
2. Population density (congestion)
3. Drainage condition
4. Septic tank and gray water discharge condition
5. Environmental condition including wastewater flows in drains and pollution of rivers

After the visits and general consideration, the JICA Survey Team proposes to apply the categorization of 1) terminal wastewater treatment plants and 2) community treatment plants at the offsite treatment areas. The proposed area-wide categorizations for all the barangays are shown below.

(1) Sewerage Development Area A

**Table 5.2.1 Treatment Policy for Area A**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Agdao | 11 barangays | 593.0 | 124,800 | 210 | Off-site (1 WWTP) 97,000m3/day |
| 2 | Poblacion | 39 barangays excl. 8-A | 979.1 | 195,425 | 200 | |
| 3 | Talomo | Part of Brgy. Bucana (30%) | 120.6 | 49,558 | 411 | |
| Total Area A | | | 1,692.6 | 369,783 | 218 | 97,000m3/day |

Source: JICA Survey Team

Comments:

The general concept of wastewater treatment with one wastewater treatment plant (WWTP) is the same with IM4D. However, the wastewater collection policy was considered in detail in Chapter 7 as a high

priority and urgent project.

(2) Sewerage Development Area B

**Table 5.2.2 Proposal on Treatment Policy for Area B**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Buhangin | Buhangin Proper | 682.0 | 134,169 | 197 | Off-site (1 WWTP) 65,000m3/day |
| 2 | Buhangin | Cabantian | 758.7 | 101,917 | 134 | |
| 3 | Poblacion | Brgy. 8-A | 159.1 | 13,274 | 83 | |
| 4 | Buhangin | Tigatto | 770.0 | 84,749 | 110 | Community 22,000m3/day |
| Total Area B | | | 2,369.8 | 249,360 | 141 | 87,000m3/day |

Source: JICA Survey Team

Comments:

- Barangay Tigatto is a remote area from Buhangin Proper, and there is a large deviation in elevation in the conveyance of wastewater to the WWTP site (basically Poblacion 8-A). Many large-scale pumping stations are required to convey the wastewater, which is not reasonable.

- At present Barangay Tigatto has a large open land suitable for a community treatment plant. With this, it is also easy to discharge the treated water to Davao River. However, there is a need to expedite the acquisition of land to secure the property for the future.

(3) Sewerage Development Area C

**Table 5.2.3 Proposal on Treatment Policy for Area C**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Talomo | Catalunan Pequeno | 617.8 | 44,875 | 73 | Off-site (1 or 2 WWTP) 157,000m3/day |
| 2 | | Ma-a | 1,014.9 | 117,659 | 116 | |
| 3 | | Talomo | 659.7 | 117,413 | 178 | |
| 4 | | Matina Crossing | 529.3 | 63,816 | 121 | |
| 5 | | Matina Aplaya | 306.6 | 65,681 | 214 | |
| 6 | | Bago Aplaya | 221.5 | 31,318 | 141 | |
| 7 | | Bucana (West 70%) | 281.4 | 159,310 | 566 | |
| 8 | | Matina Pangi | 641.4 | 35,573 | 55 | Community 9,000m3/day |
| Total Area C | | | 4,272.6 | 600,072 | 149 | 166,000m3/day |

Source: JICA Survey Team

Comments:

- Barangay Matina Pangi is almost a mountain area with many sloping regions, which makes it difficult to convey wastewater. Since there is a massive land area for a community plant, it is proposed that the use of community plant(s) be applied for this barangay.

- There are several communities in Barangay Matina Pangi. The community plant can be separated in each community with a total capacity of 9,000 $m^3$/day.

- Since there are sloping areas in the east-west direction and in the coastal region of Area D, a possible

option is to separate areas into west and east zones to construct WWTPs for each area.

(4) Sewerage Development Area D

**Table 5.2.4 Proposal on Treatment Policy for Area D**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Buhangin | V. Hizon | 212.0 | 26,237 | 124 | Off-site (1 WWTP) 122,000m3/day |
| 2 | | A. Angliongto | 495.3 | 31,534 | 64 | |
| 3 | | Pampanga | 94.7 | 33,495 | 354 | |
| 4 | | Communal | 570.8 | 38,989 | 68 | |
| 5 | | Sasa | 695.0 | 122,012 | 176 | |
| 6 | Bunawan | Panacan | 726.1 | 74,719 | 103 | |
| 7 | | Ilang | 597.7 | 52,058 | 87 | |
| 8 | | Tibungco | 780.5 | 87,360 | 112 | |
| 9 | | Bunawan | 774.1 | 49,028 | 63 | Community 13,000m3/day |
| Total Area D | | | 4,946.2 | 466,404 | 104 | 135,000m3/day |

Source: JICA Survey Team

Comments:

- Barangay Bunawan is the most remote place in Area D. This is located in the north edge with a future industrial area. It is proposed that a community plant be applied for Barangay Bunawan since there is still a massive land fit for such cause.

(5) Sewerage Development Area E

**Table 5.2.5 Proposal on Treatment Policy for Area E**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Tugbok | Sto. Nino | 152.8 | 63,225 | 414 | Off-site (1 WWTP) 40,000m3/day |
| 2 | | Mintal | 768.2 | 41,599 | 54 | |
| 3 | | Tugbok | 994.9 | 47,537 | 48 | |
| 4 | | Tacunan | 823.0 | 40,172 | 49 | Communities 11,000m3/day |
| 5 | | Los Amigos | 480.6 | 30,576 | 64 | Community 8,000m3/day |
| Total Area E | | | 3,219.5 | 223,109 | 69 | 59,000m3/day |

Source: JICA Survey Team

Comments:

- Barangay Tacunan has a sloping region in the east-west direction. The collection and conveyance of wastewater towards Barangay Tugbok, as planned in IM4D, is quite difficult. A community treatment plant should be the appropriate solution. Even a unique plant in barangay is difficult. Since Barangay Tacunan has a promising future residential development, wastewater should be treated in each community.

- There are large distances between the central communities of Barangays Tugbok and Los Amigos.

Although the topographic condition is good allowing wastewater to flow continuously, the long pipeline for rural areas is not economical. Barangay Los Amigos should have a separate community treatment facility.

- Barangays Sto. Nino, Mintal, and Tugbok can also adopt the barangay-wide or community-wide treatment plants.

(6) Sewerage Development Area F

**Table 5.2.6 Proposal on Treatment Policy for Area F**

| No. | District | Barangay | Land Area (ha) | Population 2045 (persons) | Population Density 2045 (persons/ha) | Treatment Policy |
|---|---|---|---|---|---|---|
| 1 | Tugbok | Bago Oshiro | 720.4 | 37,527 | 52 | Off-site (1 WWTP) 109,000 m3/day |
| 2 | Toril | Bankas Heights | 251.3 | 25,050 | 100 | |
| 3 | | Toril | 170.4 | 39,643 | 233 | |
| 4 | | Lubogan | 357.5 | 39,696 | 111 | |
| 5 | | Lizada | 421.7 | 65,676 | 156 | |
| 6 | | Daliao | 184.5 | 68,981 | 374 | |
| 7 | | Crossing Bayabas | 84.0 | 37,521 | 447 | |
| 8 | | Baliok | 238.4 | 31,754 | 133 | |
| 9 | | Bago Gallera | 761.0 | 34,190 | 45 | |
| 10 | | Dumoy | 593.2 | 36,638 | 62 | |
| 11 | | Binugao | 502.9 | 22,643 | 45 | Community 6,000 m3/day |
| Total Area F | | | 4,285.3 | 439,318 | 103 | 115,000 m3/day |

Source: JICA Survey Team

Comments:

- Barangay Binugao is the most remote place in Area F. It is located in the south edge with a future industrial area. It is proposed that a community plant be applied for Barangay Binugao since there is still a massive land fit for such cause.

(7) Septage Management Area

The 28 barangays in 7 administrative districts outside of sewerage development areas will be managed with only a septage management program (less than 40 persons/ha population density in 2045). The list of barangays and the projected wastewater generation are shown in Table 5.2.7.

If any housing complex and/or large facility exists/will be developed in the area, the small-scale community treatment plant should be constructed.

**Table 5.2.7 Septage Management Area outside Sewerage Development Area**

| Septage Collection Area | Zone | District | Barangay | Area (ha) | Population | | Wastewater Generation (m3/d) |
|---|---|---|---|---|---|---|---|
| | | | | | 2015 | 2030/2032 | 2030/2032 |
| SCA-1 | Zone 5 | Talomo | Langub | 853.2 | 2,883 | 7,103 | 1,861 |
| | | | Magtuod | 462.9 | 5,058 | 10,122 | 2,652 |
| SCA-2 | Zone 4 | Toril | Bato | 851.6 | 10,007 | 18,926 | 4,959 |
| | | | Marapangi | 703.8 | 6,889 | 16,259 | 4,260 |
| SCA-3 | Zone 3 | Buhangin | Indangan | 1,474.1 | 14,867 | 26,716 | 7,000 |
| | | | Mudiang | 686.3 | 2,937 | 7,518 | 1,970 |
| | | | Tigatto | 761.3 | 36,387 | 25,560 | 6,697 |
| | | Buhangin | Waan | 437.0 | 3,925 | 7,358 | 1,928 |
| | Outiside SCA | Buhangin | Acacia | 920.3 | 3,262 | 6,173 | 1,617 |
| | | | Mandug | 969.2 | 13,594 | 17,811 | 4,666 |
| | | Bunawan | Gatungan | 887.0 | 1,190 | 1,929 | 505 |
| | | | San Isidro | 630.3 | 5,333 | 10,617 | 2,782 |
| SCA-4 | Zone 1 | Calinan | Calinan Proper | 830.6 | 23,052 | 36,318 | 9,515 |
| | Zone 2 | Tugbok | Tugbok | 1,333.4 | 3,392 | 26,640 | 6,980 |
| | | Marilog | Tacunan | 906.7 | 12,773 | 5,335 | 1,398 |
| | | | Matina Biao | 1,578.2 | 1,811 | 1,431 | 375 |
| | Zone 3 | Tugbok | Ula | 941.3 | 4,130 | 10,783 | 2,825 |
| | | | Biao Guianga | 500.9 | 3,664 | 3,847 | 1,008 |
| | | Calinan | Los Amigos | 445.5 | 9,722 | 15,273 | 4,002 |
| | Zone 4 | Marilog | Riverside | 514.9 | 5,450 | 10,721 | 2,809 |
| | | | Talomo River | 810.9 | 6,846 | 15,171 | 3,975 |
| | | Calinan | Dacudao | 1,247.1 | 4,418 | 7,392 | 1,937 |
| | | | Biao Joaquin | 551.6 | 2,289 | 2,691 | 705 |
| | | Tugbok | Wangan | 1,181.5 | 5,821 | 5,902 | 1,546 |
| | Zone 5 | Calinan | Lacson | 897.0 | 5,873 | 6,135 | 1,607 |
| | | | Gumalang | 1,572.8 | 5,081 | 9,725 | 2,548 |
| | | | Malagos | 1,210.6 | 6,524 | 16,430 | 4,305 |
| | Outside SCA | Tugbok | Angalan | 481.3 | 2,475 | 3,068 | 804 |
| Total | | | | 24,641.1 | 209,653 | 332,954 | 87,234 |

Note: Land area and population in 2015 are based on Census 2015.
Future populations in SCA-1 and 2 are ones in year 2030 and SCA-3 and 4 are 2032
Source: JICA Survey Team based on Septage Management F/S 2013

(8) Septic Tank Area

The barangays without sewerage development area or septage collection area have to rely on the use of septic tanks. The coverage rate of septic tanks should reach 100%. The households in the area will continue to use septic tanks but should employ private desludging service providers once the tanks become full.

If any housing complex and/or large facility exists/will be developed, the small-scale community treatment plant should be constructed as well as the septage management area, particularly when the

area is near the drinking water source. Meanwhile, if the residents in barangays/communities hope to develop the community treatment plant for environmental improvement or to reduce space from the use of septic tanks, the barangay/community may install the small-scale plant and pipeline. However, such development in scattered houses should be carefully considered from the financial viewpoint. CPDO is recommended to establish the development policy of treatment plants in the rural area, which will be shared with barangays.

The construction of community toilets with septic tanks is one option in quite rural and poor communities.

The barangays that belong to the Septic Tank Area (tentative) are listed in the following table.

**Table 5.2.8 Barangays outside Sewerage Development and Septage Management Program**

| District | Barangay |
|---|---|
| Buhangin | Callawa (1 barangay) |
| Paquibato | All 13 barangays |
| Baguio | Baguio Proper, Cadalian, Carmen, Tambobong, Tawan-tawan, and Wines (6 barangays) |
| Calinan | Cawayan, Dalagdag, Dominga, Inayangan, Lamanan, Lampianao, Megkawayan, Pangyan, Saloy, Sirib, Subasta, and Tamayong |
| Marilog | All 12 barangays |
| Toril | Alambre, Atan-Awe, Baracatan, Bayabas, Camansi, Catigan, Daliaon Plantation, Eden, Kilate, Mulig, Sibulan, Sirawan, Tagluno, Tagurano, Tibuloy, and Tungkalan (16 barangays) |
| Tugbok | Balengaeng, Biao Escuela, Manambulan, Manuel Guianga, New Carmen, New Valencia, Tagakpan, and Talandang (8 barangays) |
| Total: 68 barangays, land area = 174,531 ha, population (2015) =232,268 | |

Source: JICA Survey Team

## 5.3 Comparison of Sewerage Development and Septage Management, and Proposal of Development Policy

### 5.3.1 Comparison of Sewerage System Development and Septage Management

The septage management is quite easy and is a low-cost option compared to the sewerage system development in terms of cost and manpower. However, its effect on environmental improvement is limited. Table 5.3.1 shows the overall comparison of following the three methods below (comparison of three sewage collection systems was made in subsection 5.3.1 and recommended separate sewer system is representing the systems):

1) Continue to use increase the coverage rate of septic tanks in residential, commercial, and industrial buildings without commencing septage management program (Septic Tanks Only)

2) Implement the septage management program and collect and treat the septage in septage treatment plants (Septic Tank & SpTP)

3) Develop the sewerage system with separate (sanitary) sewers with house connections and treat all the wastewater in the treatment plants (separate sewer & WWTP)

**Table 5.3.1 Comparison of Water Quality Improvement Effect between Septic Tank, Septage Management and Sewerage Development**

| No. | Option | Black Water (Night Soil) | | | Gray Water | | Note |
|---|---|---|---|---|---|---|---|
| | | SS | BOD | Coliform | SS | BOD | |
| 1 | Septic Tanks Only<br>: **Septic Tank (Present)** | △ | × | × | × | × | Pollution of creek and groundwater |
| 2 | Septic Tank & SpTP<br>: **Septage Management Program** | ○ | △ | × | × | × | Still much overflow from septic tanks due to limited capacity and desludging frequency |
| 3 | Separated Sewer & WWTP (with house connection)<br>: **Sewerage Development** | ○ | ○ | ○ | ○ | ○ | 1) Only non-point source load is discharged from the sewer<br>2) Take time for house connection |

Note: × : cannot treated, △: partly treated, ○ : treated
Source: JICA Survey Team

The features of each system are as follows;

- Septic Tank: Only the septic tank case provides almost no treatment of pollution load. It is assumed that only 10% to 20% of BOD is dissolved in the tanks even though the percentage is relatively higher in tropical climates areas like in Davao than it is in colder regions. The suspended solid (SS) can be removed than BOD, in caseseptage collection and dumping is conducted properly. But if the management is not good, pollution loads infiltrate the ground. Examples of these are when septic tanks are unlined and cause the seepage of septage. This is also true when wastewater overflow because of poor and infrequent desludging.
- Septage Management Program: Even with septage management, including SpTP construction, all the gray water cannot be treated, and much BOD infiltrate the ground if septic tanks remain unlined. From household interviews and site visits, a large percentage of households use unlined septic tanks and many septic tanks are not accessible to vacuum septages.
- Sewerage Development (Separate Sewer System): Pollutant loads discharged to creeks is quite small. The only pollution loads are the ones discharged on the roads when organic substances in garbage pass through stormwater pipes after rainfall. The small percentage of BOD, which cannot be treated in WWTPs, is also discharged. However, such percentage is only around 10% of all the pollutant generation. The issue is that the separate sewer system requires a long time to construct and there is a higher cost for lateral pipe developments and house connections.

Based on the facts above, the estimated BOD loads and treatment ratio in each system are estimated as shown in Table 5.3.2. The treated ratio is calculated as less than 90% as the least level, but in case of applying the advanced wastewater treatment technology, such as the MBR system, it must exceed 90%.

**Table 5.3.2 Comparison of Estimated BOD Load and Treated Ratio**

| Year | | | 2030 | | | | 2045 | | | | Treatment Ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Option | Origin | Generation (kg/day) | Removed/Decomposed (kg/day) | | Discharged (kg/day) | Generation (kg/day) | Removed/Decomposed (kg/day) | | Discharged (kg/day) | Treated Ratio(%) | Untreated Ratio(%) |
| | | | | Night Soil | Gray Water | | | Night Soil | Gray Water | | | |
| 1 | Septic Tanks Only | - | 9,673 | 1,218 | 0 | 8,455 | 11,093 | 1,397 | 0 | 9,696 | 12.6% | 87.4% |
| 2 | Septic Tank & SpTP | - | 9,673 | 5,804 | 0 | 3,869 | 11,093 | 6,656 | 0 | 4,437 | 60.0% | 40.0% |
| 3 | Sewerage System | Sewer | 9,673 | 0 | | 406 | 11,093 | 0 | | 466 | 86.2% | 13.8% |
| | (Separated Sewer) | WWTP | | 8,340 | | 927 | | 9,565 | | 1,063 | | |

Note: Assumptions
20% of BOD in night soil is decomposed in septic tank in hot climate all the year in Davao City.
Treated ratio in WWTP itself is 90% as Conventional Activated Sludge level (MBR is more)
Source: JICA Survey Team

Based on the comparison above, the development of a separate sewer system in long term is recommended in terms of environmental improvement particularly in case Davao City aims to be an environmentally advanced city in Philippines and also ASEAN countries.

Meanwhile, because sewerage development requires a large amount of cost and a long period, Septage Management Program was considered with the support of USAID with the aim of improving public health and living environment. Currently, DCWD is considering the program. As a first step, the implementation of the program after agreement with the city in the near future will be also important from the viewpoint of achieving SDG 6.2 “By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations”. However, as the second step at earliest stage, the sewerage system development shall be commenced as proposed above.

### 5.3.2 Comparison of Sewage Collection System

In this section, the sewage collection system to be applied in Davao City is proposed through the comparative study on the combined sewer system, interceptor system, and separate sewer system.

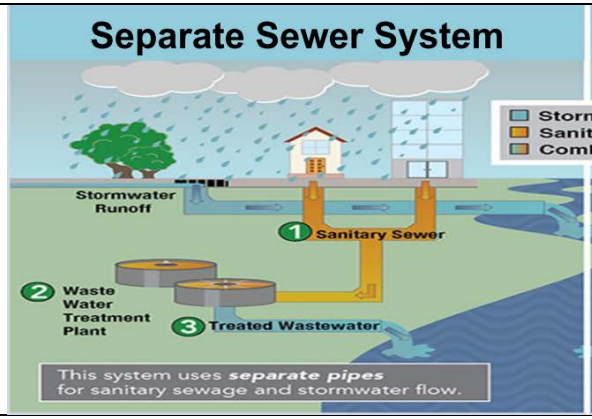
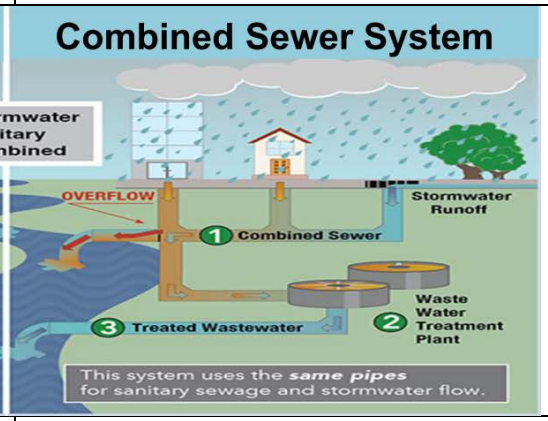
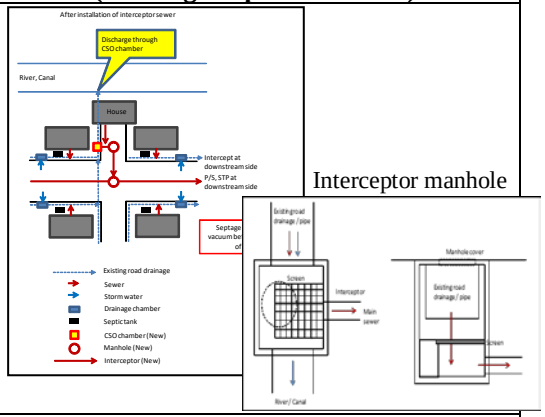
In the preliminary quantitative comparisons, such as environmental loads and costs, Area A as priority development area in IM4D was selected for consideration as a case study, and the base of pre-feasibility study of the area can be found in the later chapters.

(1) General Comparison

The general comparison between three systems are shown in Table 5.3.3.

The detailed case studies of the “Impact to Receiving Body” (pollution loads) and development costs in Area A are shown in Appendix 5.1.

**Table 5.3.3 General Comparison of Sewage Collection System**

| Item | Option 1: Separate Sewer System | Option 2: Combined Sewer System | Option 3: Interceptor Sewer System (Existing Proposal in IM4D) |
|---|---|---|---|
| Image |  |  |  |
| Feature | ◆ Sewage including both black and grey water can be treated.<br>◆ There is no influence of rainwater for the treatment system | ◆ In wet-weather condition, sewage that exceeds the capacity of sewer pipe will be discharged partially at CSO (Combined Sewer Overflow) chambers<br>◆ Countermeasures against wastewater and rainwater can be implemented with one system. | ◆ The wastewater flowing in the roadside drains is intercepted with the construction of interception chambers. It will flow into interceptor sewers under the streets.<br>◆ In wet-weather condition, sewage that exceeds the capacity of sewer pipe will be discharged partially at the chambers |
| Impact to Receiving Body | **<u>No untreated wastewater will be discharged</u>** because of the development of the sewer pipeline and the wastewater treatment plant with a separate sewer system.<br><br>Treatment ratio of generated BOD: 86%<br>Pollution load to public water body: 170,000 kg/year (Appendix 5.1)<br>   | Reducing pollution load is realized earlier in the dry-weather condition, however, **<u>untreated wastewater will be discharged partially in wet-weather condition.</u>**<br>Treatment ratio of generated BOD: 76%<br>Pollution load to public water body: 612,000 kg/year (Appendix. 5.1)<br>  | Reducing pollution load is realized earlier in the dry-weather condition, however, **<u>untreated wastewater will be discharged partially in wet-weather condition. (more than Opt-2)</u>**<br>Treatment ratio of generated BOD: 70%<br>Pollution load to public water body: 796,000 kg/yr (Appendix. 5.1)<br>  |
| | ○ (Good) | △ (Not Good) | × (Bad) |

| Item | Option 1: Separate Sewer System | Option 2: Combined Sewer System | Option 3: Interceptor Sewer System (Existing Proposal in IM4D) |
|---|---|---|---|
| Impacts by Garbage | The sewer is not necessary to connect the road side ditch and/or channel. Therefore, there is a possibility of pipe clogging due to garbage.<br>○ (**Good**) | The stormwater is mainly collected from stormwater inlet chambers in roadsides (e.g. L-shape ditch). There is a possibility of the sedimentation of solids.<br>△ (**Not Good**) | The sewer is necessary to connect the road side ditch and/or channel. Therefore, there is a big possibility of pipe clogging due to garbage.<br>× (**Bad**) |
| House Connection | Necessary between every household and newly-developed sanitary sewer. Long time and manpower are required. DCWD (assumption) needs to implement all the connection works. Also, each household need to pipework within its premises. For such works, coordination time is required.<br>△ (**Fair**) | Necessary between every household and newly-developed sanitary sewer. Long time and manpower are required. DCWD (assumption) needs to implement all the connection works. Also, each household need to pipework within its premises. For such works, coordination time is required.<br>△ (**Fair**) | Not necessary, but septage collection should be continued.<br>○ (**Good**) |
| Required Area for WWTP | ◆ Scale of the WWTP will be slightly smaller than Option 2 and 3.<br>◆ Total required area for WWTP will be smaller than Option 2.<br>○ (**Good**) | ◆ Primary sedimentation tank will be bigger than Option 1. Also, an emergency bypass channel/pipe is required for discharging rainwater.<br>◆ Total required area for WWTP will be about 20% larger than Option 1.<br>△ (**Fair**) | ◆ Primary sedimentation tank will be bigger than Option 1 for the inflow of stormwater.<br>◆ Total required area for WWTP will be larger than Option 1.<br>△ (**Fair**) |
| Treatment in WWTP | More stable treatment than Option 2 and 3 due to stable inflow and high density wastewater<br>○ (**Good**) | Less stable treatment due to much inflow of rainwater and low density wastewater (not good for activated sludge: bacteria to treat water)<br>△ (**Not Good**) | Less stable treatment due to much inflow of rainwater and low density wastewater (not good for activated sludge: bacteria to treat water)<br>△ (**Not Good**) |
| Composition of Sewer Network | ◆ Total sewer length will be longer than Option 3 for lateral pipes for house connections.<br>◆ Pipe diameter is smaller than Option 2.<br>◆ The pipe slope is smaller than Option 3.<br>◆ Installation of connection pits/chamber for each household will be required.<br>△ (**Fair**) | ◆ Total sewer length will be longer than Option 3 for lateral pipes for house connections.<br>◆ The diameter/slope of sewer gets bigger than Option 1 and 3 to accept much stormwater and flush sands. The cost is highest.<br>◆ Installation of CSO Chambers are necessary to discharge the stormwater into the public water body.<br>△ (**Fair**) | ◆ The existing drains shall be utilized as a part of the sewer. However, the capacities are insufficient in Davao City particularly in the seaside area with a flat land condition and insufficient slope.<br>◆ Total sewer length is shorter than Option 1 and 2 because lateral pipes are not necessary.<br>◆ The slope of sewer gets bigger than Option 1 to flush sands (required flow velocity is bigger).<br>◆ Installation of interception chambers are necessary to intercept wastewater and discharge the stormwater into the public water body.<br>△ (**Fair**) |
| Ease and Efficiency of Project Implementation | ◆ The smooth implementation of sewerage system development can be expected because the planning of sewerage system and flood control/drainage system can be conducted individually by each responsible agency. (DPWH, City Government, DPWD) *DPWH has its | ◆ The combined sewer system is closely related to flood control/drainage system. The close coordination between each responsible agency will be required.<br>◆ The cost allocation between the project for | ◆ The interceptor sewer system is related to flood control/drainage system, the close coordination between each responsible agency will be required.<br>◆ The construction period is shortest without |

| Item | Option 1: Separate Sewer System | Option 2: Combined Sewer System | Option 3: Interceptor Sewer System (Existing Proposal in IM4D) |
|---|---|---|---|
| | own projects which are on-going for flood control and drainage.<br>◆ The cost allocation between the projects for construction works will not be required (or can be minimized).<br>◆ Manpower and budgets for house connections by the implementing agency shall be secured, In case of the delay, the collected wastewater flow becomes small.<br>○ (Good) | construction work will be required. But it seems difficult.<br>◆ Manpower and budget for house connections by the implementing agency shall be secured, In case of the delay, the collected wastewater flow becomes small.<br>◆ The construction period is longest due to large pipe diameters.<br>× (Bad) | lateral pipes and house connections.<br>◆ The collected wastewater flow itself will reach quickly to WWTP capacity. Meanwhile, the loads are not enough due to less septage and more stormwater.<br>◆ The construction period is shortest without lateral pipes and house connections.<br>△ (Fair) |
| Ease of O&M | ◆ O&M work is much easier once connected. The frequency of cleaning can be minimum without sedimentation of sands and garbage.<br>○ (Good) | ◆ More manpower and/or equipment shall be secured for cleaning of sewer pipes (O&M) than Opt-1. But it is easier than Opt-3 due to larger pipe diameter and less inflow of garbage.<br>△ (Fair) | ◆ Many manpower and/or equipment shall be secured for cleaning of sewer pipes (O&M).<br>◆ Due to the smaller diameter, it is more difficult than Opt-2<br>◆ The maintenance of pumps also is most frequent.<br>× (Bad) |
| Initial Cost | ◆ Higher than Opt-3 due to longer pipeline<br>Preliminary cost estimate: 120<br>(See Appendix 5.1)<br>△ (Fair) | ◆ Highest due to longer pipeline than Opt-3 and largest diameter. However, the total cost with stormwater management is less than that of Opt-1.<br>Preliminary cost estimate: More than 150<br>△ (Fair) | ◆ Lowest due to shortest sewer length<br>Preliminary cost estimate: 100<br>(See Appendix 5.1)<br>○ (Good) |
| O&M Cost | ◆ Smallest due to small pumping cost and least frequency of cleaning work<br>○ (Good) | ◆ Highest due to large pumping cost and more cleaning than Opt-1.<br>◆ The mandate/sharing of the cost is complicated for sewerage and drainage sectors.<br>△ (Fair) | ◆ Higher than Opt-1 due to much more cleaning of pipe and sometimes maintenances of pumps due to massive inflow of sand and garbage.<br>△ (Fair) |
| Necessity for Future Investment | ◆ No special investment for sewers for at least 50 years. Only renewal of pumps after service life (Cumulative investment cost image is shown (3) in this subsection and the schedule image is shown in Appendix 5.5)<br>○ (Good) | ◆ Large investment is required for the combined sewer improvement to reduce environmental impact. (See (2) and (3) in this subsection and development schedule image is shown in Appendix 5.5)<br>△ (Fair) | ◆ Shall be switched to a separate sewer system to reduce environmental impact after the initial development.<br>△ (Fair) |

Source: JICA Survey Team

(2) Additional Cost required for Combined Sewer System and Interceptor System

As described in Table 5.3.3 and Appendix 5.1, the pollution load for public bodies of water from the combined sewer system is assumed to be more than three times compared to the separate sewer system, and the one from the interceptor system is more than four times in Davao. To mitigate the pollution load for the same level as the separate sewer system, additional structures and facilities are required to be developed.

Examples of additional facilities for Combined Sewer Improvement:

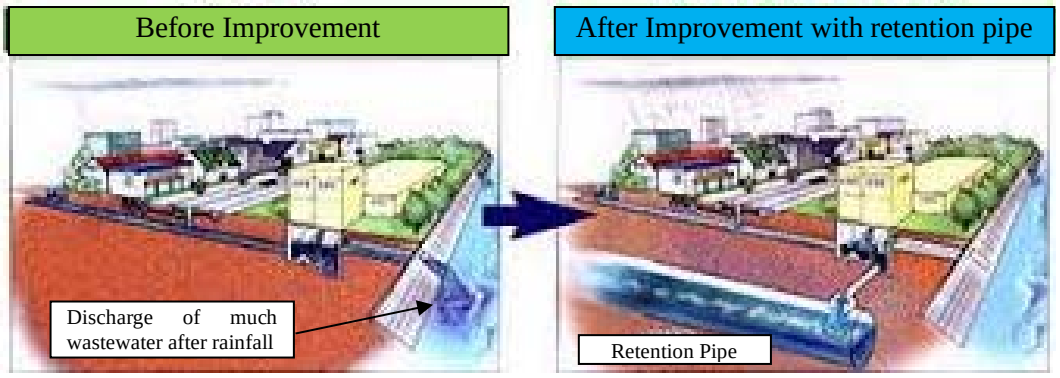
1. Installation of retention tank/pipe to store mixed wastewater/stormwater (diluted wastewater) during rainfall events and pump up water after rainfall near outfalls to public bodies of water or at WWTPs (see Figure 5.3.1)

2. Increase the capacity of sewer by upgrading or adding pipes

3. Add rapid treatment facility for diluted wastewater at WWTP

4. Installation of mechanical screens in the interception chambers (*can control only SS, impossible to install in interception structure without weir) (see Figure 5.3.2)

5. Installation of on-site stormwater infiltration facilities for buildings/drains/roads to reduce the volume of stormwater inflow to the sewer (see Figure 5.3.2)




Source: Sewerage Bureau, Sapporo City, Japan

**Figure 5.3.1 Image of Combined Sewer Improvement with Retention Pipe**

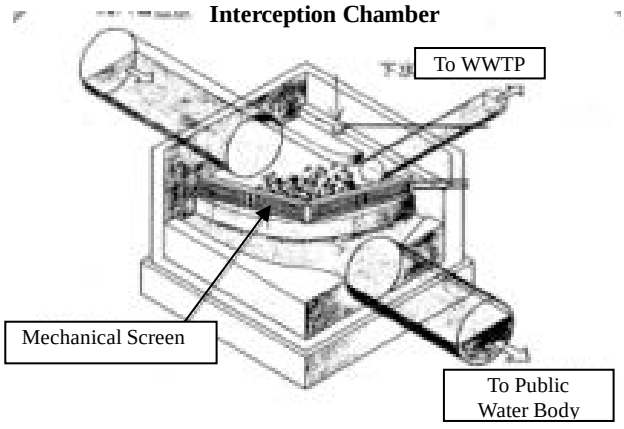
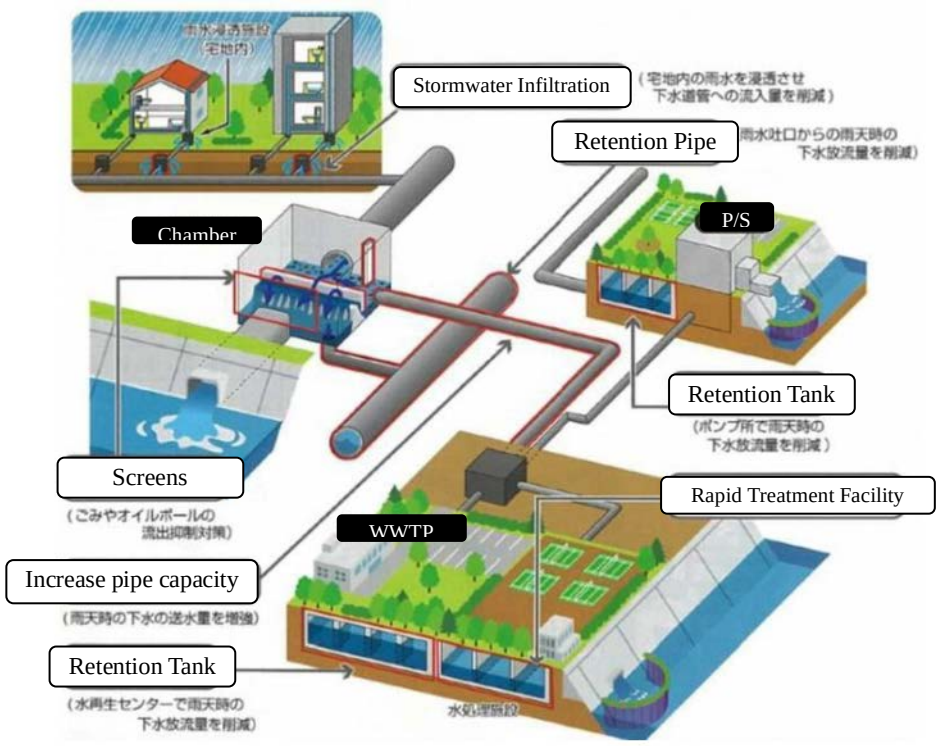



**Image of Mechanical Screen in Interception Chamber**

**Image of Stormwater Infiltration**

Source: Obihiro City, Japan

**Figure 5.3.2 Image of Other Measures for Combined Sewer Improvement**




Note: P/S: Pumping Station
Source: Sewerage Bureau, Tokyo Metropolitan Government

**Figure 5.3.3 Image of Comprehensive Combined Sewer Improvement**

If diluted wastewater retention pipe is constructed for Area A, the expected size and construction cost are calculated as given below:

Diameter = 3,000 mm, Length = 40 km, Construction cost: PHP 24 billion

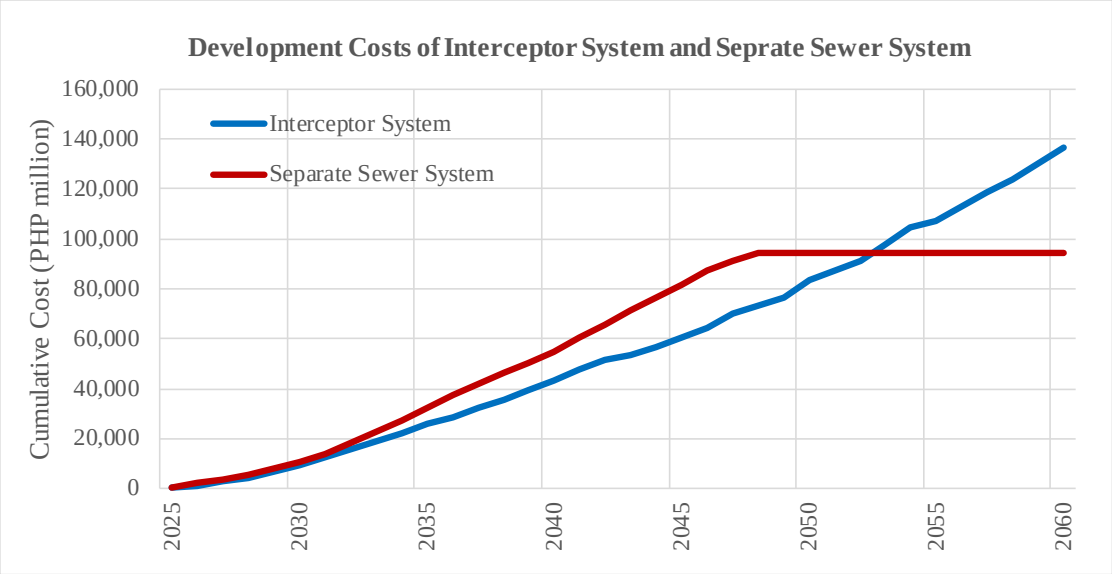
(3) Cumulative Cost Comparison of Sewage Collection Systems

The comparison of cumulative development costs of interceptor sewer and separate sewer system for the entire sewerage development area (Area A to Area F) in Davao are shown in Figure 5.3.4 based on followings items and assumption in Table 5.3.4. The scales of sewer facilities and the cost breakdown for this cost estimation is shown in Appendix 5.2.

**Table 5.3.4 Items and Assumptions for Preliminary Cost Estimates for Sewer Systems**

| Separate Sewer System | Interceptor System (with partly combined sewer) |
|---|---|
| 1) Trunk sewers (Dia. 400-1800)<br>* based on lengths and widths of areas<br><br>2) Lateral sewers (Dia. 200-450)<br>* based on road lengths in the areas<br>3) House connections<br>* number of households | 1) Interceptors/Trunk sewers (Dia. 400-1800)<br>* 1.5 times of trunk sewers in separate system for interceptors<br>2) Combined sewers in insufficient drain capacity areas (Dia. 250-450, 50% of lateral sewer length)<br>3) Connection from septic tanks to drains and house connections for combined sewers *same with separate<br>4) Miscellaneous costs such as covers on open side drains, improving ditches in slum areas<br>5) Future retention pipe (Dia. 3000) *after 2045 in case of Area A, storage capacity of two times of daily maximum flow in each area |

Source: JICA Survey Team




Source: JICA Survey Team

**Figure 5.3.4 Cumulative Development Costs of Interceptor System and Separate Sewer System**

As mentioned before, the development cost of the interceptor sewer is smaller than the separate sewer due to a decrease in pipeline length. However, for the improvement of the developed system, next works such as retention pipe installations will start even if parts of the separate sewer system is still working. This is due to the lifespan of pipes of more than 50 years.

(4) Rough Comparison of Cost-Benefit (B/C)

In assuming that the benefit of sewerage development is the amount of treated environmental loads (BOD) generated in the area, the case study for Area A between the interceptor system and separate sewer system can be summarized as shown in Table 5.3.5. These are based on the costs and environmental loads in Appendix 5.1 and 5.2.

**Table 5.3.5 Rough Comparison of Cost-Benefit (B/C) between Separate Sewer System and Interceptor System**

| Sewage Collection System | Separate Sewer System | Interceptor System (with partly combined sewer) |
|---|---|---|
| Treated BOD load (kg/day) in 2030 | 8,340 | 6,732 |
| Rough construction cost (PHP million) | 13,900 | 10,800 |
| Cost-benefit (B/C) (kg/year/PHP million) | 219 | 228 |

Note: Rough construction cost for interceptor system but does not include the future retention pipe
Source: JICA Survey Team

Even if the cost-benefit of the interceptor system slightly exceed that of the separate sewer system, the difference is quite small. In case the future countermeasure for the combined sewer overflow is started, the value will be less than that of the separate sewer since the additional cost is almost the same with initial cost (double in total). However, the additional treated environmental load is less than double.

(5) Proposal based on the Overall Comparison of Sewage Collection Systems

The above comparisons can be summarized in the following table.

**Table 5.3.6 Summary of Sewage Collection System Comparison**

| Item | Option 1: Separate Sewer System | Option 2: Combined Sewer System | Option 3: Interceptor System (Existing Proposal: IM4D) |
|---|---|---|---|
| **Points** | **General**<br>• Sewage can be collected and treated almost completely<br>• It can save the time for coordination with the drainage projects compared to Option 2 and leads to a smoother development | **General**<br>• Sewage cannot be treated fully in wet-weather condition<br>**Davao**<br>• Close and careful coordination will be required among the projects and between relevant agencies (City/DCWD/DPWH) | **General**<br>• Sewage cannot be treated fully in wet-weather condition (need to be switched to separate sewer system in future)<br>**Davao**<br>• The existing drains in Davao with insufficient slopes and many clogging from garbage is not reliable to utilize for a part of sewer. |
| | **Recommendation** | | |

Source: JICA Survey Team

Based on the above-described comparisons, it is appropriate to select a separate sewer system to mitigate the pollution load on public bodies of water from a long-term viewpoint. Although the interceptor system is preferable in order to start the operation of the sewerage system early, congested areas, such as the coastal area and Davao River side in Area A, need to be accommodated first because additional house connection work is not implemented in the interceptor system.

Additionally, if the combined sewer system is selected, DCWD will manage both wastewater and rainwater. However, at present, DPWH has its own on-going projects related to flood control and drainage. Therefore, if the combined sewer system is selected, both DCWD and DPWH will manage rainwater, and the close and cumbersome coordination between each responsible agency will be required.

Moreover, looking back at Japanese experiences, although a combined sewer system has been developed long ago mainly in urbanized areas, a separate sewer system is currently selected in principle to develop the sewerage system. This is because it became clear that the mitigation of pollution load on public bodies of water at the time of wet weather from the combined sewer system was not easy from the financial aspect and technical aspect.

The JICA Survey Team proposes the following policy of sewage collection system for Davao City based on the above comprehensive comparison, which includes mitigating the effect of pollution load, the total required cost including the countermeasure against combined sewage overflow, ease and the efficiency of project implementation for both wastewater management and flood control/drainage, problems resulting from combined sewer system, and Japanese experiences.

**Policy for Sewage Collection System in Davao**

1) Separate sewer system will be introduced in principle.
2) Interceptor system will be introduced and existing drainage pipes will be utilized temporarily for areas where it is difficult to install new sanitary sewers and to implement house connection works because of the close proximity of houses and their narrow roads.
3) When these areas will be redeveloped in the future, the sewerage system will be developed with separate sewer system

The points for the combination of separated sewer system and interceptor system are discussed below.

Point 1:

For the area where wastewater directly discharged to creeks (e.g., Agdao Creek), wastewater shall be collected individually by house connections (separate sewer pipe beside the creek)

**Photo 5.3.1 Agdao Creek**

Point 2:

With the narrow and curving roads in congested areas, it is quite difficult to install sewers. The wastewater can be intercepted at the exit. However, to improve ditch and cover in congested areas, it is recommended that wastewater be collected as soon as possible to promote environmental improvement. However, since many congested locations are slum areas with squatters, such areas would be redeveloped by the city, and a separate sewer system will be adopted after that.

**Photo 5.3.2. Narrow and Curving roads where Wastewater flows in Barangay Tomas Monte Verde in Area-A Agdao**

**Photo 5.3.3 One Exit of Wastewater from a Congested area in Barangay Tomas Monte Verde**

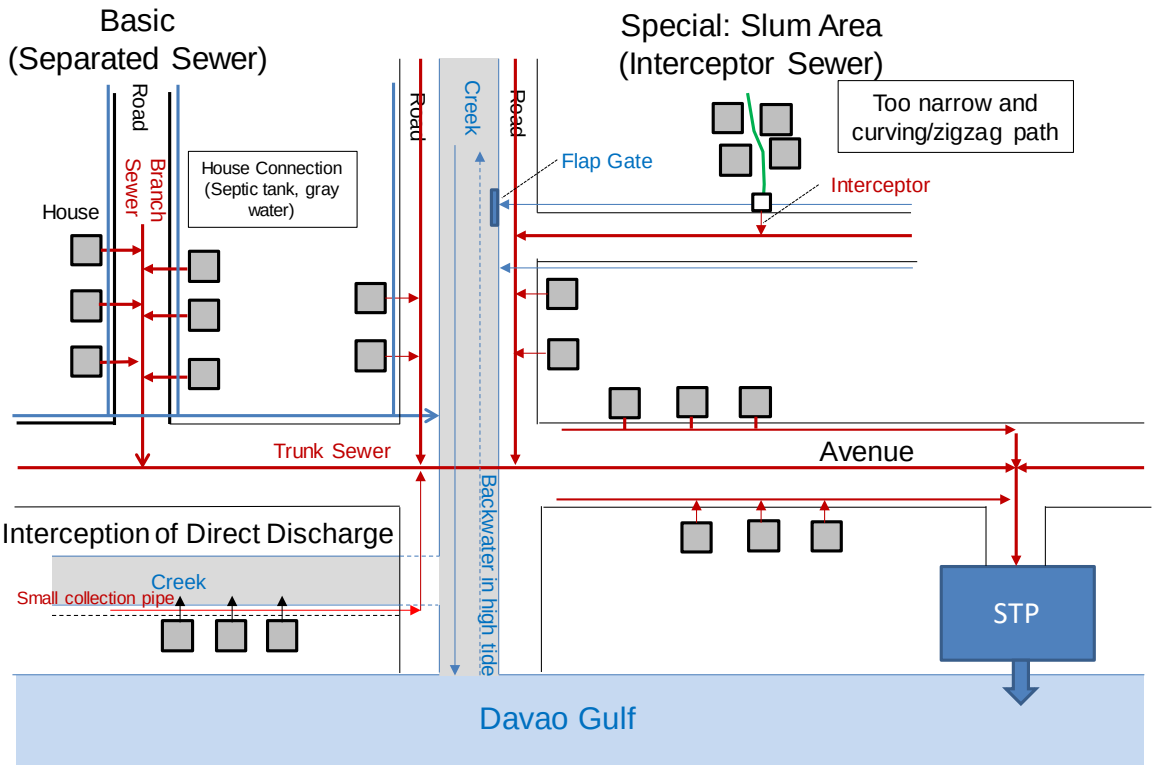
Point 3:

Flap gates should be attached in outfalls to avoid inflow of seawater (salt water) into sewerage system due to back flow in high tide even in the case to adopt interception system.

**Photo 5.3.4 Submerged Outfall in Dacudao Creek**

**Photo 5.3.5 Example of Flap Gate in a Channel in Japan**

The image of these points as integrated sewage collection system for quick sewerage development can be illustrated as shown in Figure 5.3.5.




Source: JICA Survey Team

**Figure 5.3.5 Image of Integrated Sewage Collection System in Area A**

## 5.4 Study on Stepwise Sewerage and Septage Management in Sewerage Development Area

### 5.4.1 Assumed Revised Schedule on Septage Management Program

In this sub-section, a comprehensive sewerage and septage management program is considered. Due to the delay of the implementation of the septage management program, the revised completion time of septage treatment plants in each septage collections areas (SCAs) should be assumed based on the information in subsection 4.6.1. However, certain details are still under consideration by DCWD Sanitation Division and revised the program has not been opened except for first phase (2019-2028). The revised schedule of septage management program (assumed) is shown in Table 5.4.1.

**Table 5.4.1 Assumed Revised Schedule of Septage Management Program**

| SCA | Major Target District | SpTP Capacity (m3/day) | Completion of SpTP | |
|---|---|---|---|---|
| | | | Original (F/S) | Revised (assumed) |
| **Phase 1a** | | | | |
| SCA-1 | Poblacion, Talomo | 160 | 2016 | 2022 |
| SCA-2 | Toril | 80 | 2016 | 2022 |
| **Phase 1b** | | | | |
| SCA-3 | Agdao, Buhangin, Bunawan | 150 | 2018 | 2024 |
| SCA-4 | Tugbok, Calinan | 20 | 2018 | 2024 |
| **Phase 2a** | | | | |
| SCA-1 | Poblacion, Talomo | 50 (210) | 2021 | 2027 |
| SCA-2 | Toril | 30 (110) | 2021 | 2027 |
| **Phase 2b** | | | | |
| SCA-3 | Agdao, Buhangin, Bunawan | 40 (190) | 2023 | 2029 |
| SCA-4 | Tugbok, Calinan | 10 (30) | 2023 | 2029 |
| **Phase 3a** | | | | |
| SCA-1 | Poblacion, Talomo | 60 (270) | 2026 | 2032 |
| SCA-2 | Toril | 40 (150) | 2026 | 2032 |
| **Phase 3b** | | | | |
| SCA-3 | Agdao, Buhangin, Bunawan | 70 (260) | 2028 | 2034 |
| SCA-4 | Tugbok, Calinan | 20 (50) | 2028 | 2034 |

Note: in brackets of SpTP Capacity are total capacities
Source: JICA Survey Team

### 5.4.2 Comprehensive Sewerage and Septage Program in each Sewerage Development Area

The septage management program shall be implemented in broad area which is larger than one sewerage development area. Due to difference of proposed sewerage development areas and septage management areas, the schedule and area of septage management and sewerage development should be arranged and coordinated for each area. The development steps due to the arrangement of the schedule is proposed with tables for each sewerage development area how the septage and sewerage development should be proceeded and switched from septage management to sewerage development in order.

(1) Area A

The details of the steps of sewerage development in Area A is described in Chapter 6 (sewerage development in the entire Area A) and Chapter 7 (stepwise development in Area A) based on the setup of temporal interception areas, separate sewer areas, and the highest priority area. In this chapter, the overall schedule of sewerage system development and septage management was organized as shown in Table 5.4.2. The terms of house connection works of sewerage development and septage collection works will be overlapped. During the term, house connections to the sewerage system should be prioritized, but depending on the drain and house conditions in particularly congested areas, either way

should be flexibly adopted. If sanitary sewer installations and house connections, which require a long time for completion, would finish on time, then the septage collection will finish by 2030 to 2031, except for cases where cases in congested areas where it is impossible to flush septage properly.

**Table 5.4.2 Image of Comprehensive Sewerage and Septage Management in Area A**

| Work Item | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A) Poblacion District (except for Brgy. 8-A) | | | | | | | | | | | | |
| **(1) Septage Management** | | | | | | | | | | | | |
| Construction of SpTP | ■ | ■ | | | | | | | | | | |
| Collection of septage | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| (Poblacion: SCA-1 Zone-1,2,3) | | | | | | | | | | | | |
| Decrease of septage collections | | | | | | | | ■ | ■ | ■ | | |
| End of collections except for un-connected customers to sewerage system | | | | | | | | | | ☆ | | |
| **(2) Sewerage Development** | | | | | | | | | | | | |
| Construction of WWTP | | | | | ■ | ■ | ■ | | | | | |
| 1) Interceptor area (mainly seaside) | | | | | | | | | | | | |
| Installation of interceptor | | | | | ■ | ■ | ■ | | | | | |
| Connect septic tank to drain | | | | | | | ■ | ■ | ■ | ■ | | |
| * Depend on drain and house conditions | | | | | | | | | | | | |
| 2) Separate sewer area | | | | | | | | | | | | |
| Installation of sanitary sewer | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | |
| House connection | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| * Prioritize connection than septage collection | | | | | | | | | | | | |
| (B) Agdao District | | | | | | | | | | | | |
| **(1) Septage Management** | | | | | | | | | | | | |
| Construction of SpTP | | | ■ | ■ | | | | | | | | |
| Collection of septage | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| (Agdao: SCA-3 Zone-4,5) | | | | | | | | | | | | |
| Decrease of septage collections | | | | | | | | ■ | ■ | ■ | | |
| End of collections except for un-connected customers to sewerage system | | | | | | | | | | ☆ | | |
| **(2) Sewerage Development** | | | | | | | | | | | | |
| Construction of WWTP | | | | | ■ | ■ | ■ | | | | | |
| 1) Interceptor area (mainly seaside) | | | | | | | | | | | | |
| Installation of interceptor | | | | | ■ | ■ | ■ | | | | | |
| Connect septic tank to drain | | | | | | | ■ | ■ | ■ | ■ | | |
| 2) Separate sewer area | | | | | | | | | | | | |
| Installation of sanitary sewer | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | |
| House connection | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| * Prioritize connection than septage collection | | | | | | | | | | | | |

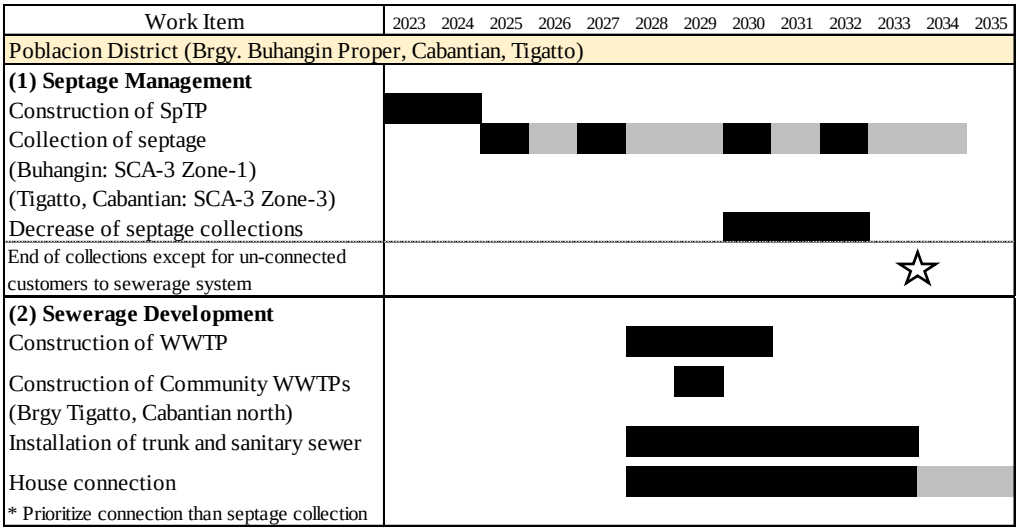
Note: Gray color means provisional period in case the septage collections, house connections would be behind the schedule.
Source: JICA Survey Team

(2) Area B

The image of a comprehensive sewerage and septage management in Area B is shown in Table 5.4.3. Area B as inland region without congested areas, most of the sewer development should be separate sewer systems.

The terms of house connection works of sewerage development and the 2nd term of septage collection works will be overlapped. During the term, the house connections to the sewerage system should be prioritized considering the effect of environmental improvement by a separate sewer system. If sanitary sewer installations and house connections, which require a long time for completion, would finish on time, the septage collection will be completed by 2033 to 2034.

**Table 5.4.3 Image of Comprehensive Sewerage and Septage Management in Area B**




Source: JICA Survey Team

(3) Area C to Area F

The comprehensive sewerage development and septage management in Area C to Area F, where developments will be conducted in much more future than Area A and B in IM4D plan, were also prepared in the similar manner with Area A and B. The images are shown in Appendix 5.3.

## 5.5 Study on Environmental and Social Conditions (Preliminary Baseline Data)

In order to understand the environmental and social conditions in Davao City, mainly the relevant official publications, such as IM4D as well as otherrelated reports and documents were reviewed preliminary together with several site reconnaissance carried out in the survey.

Table 5.5.1 shows a list of the environmental and social items reviewed in the Survey.

**Table 5.5.1 Reviewed Items for the Environmental and Social Conditions**

| Category | Items Reviewed | |
|---|---|---|
| Pollution | (1) Air Pollution | (4) Soil Characteristic |
| | (2) Water Pollution | (5) Noise |
| | (3) Waste | - |
| Natural Conditions | (1) Climate | (4) Protected Areas |
| | (2) Geology | (5) Flora and Fauna |
| | (3) Topographical Aspect | (6) Hydrology |
| Social Conditions | (1) Demographic Situation and Community | (3) Heritage |
| | (2) Land Use | - |

Source: JICA Survey Team

According to the reviews, the environmental and social conditions in Davao City can be summarized as shown in Appendix 5.4.

# CHAPTER 6 STUDY AND PLANNING OF SEWERAGE SYSTEM IN AREA A

In this chapter, the results of studies and plannings on sewerage system in the priority area, specifically the sewerage development Area A proposed in IM4D, are described.

## 6.1 Design Sewage Flow and Water Quality

(1) Design Sewage Flow

The design sewage flow and treatment capacity in Area A is shown in Table 6.1.1. The projected population in 2045 is around 370,000 based on IM4D, and the required treatment capacity for target year 2045 is 97,000 $m^3$/day as the daily maximum flow.

**Table 6.1.1 Design Sewage Flow and Treatment Capacity in Area A**

| No. | Area A | | Zone Area (CLUP, ha) | Reviewed in this Survey | | | Source /Note |
|---|---|---|---|---|---|---|---|
| | | | | 2015 | 2030 | 2045 | |
| | Agdao | person | 593.0 | 102,267 | 111,300 | 124,800 | IM4D P15-11 |
| | Poblacion | person | 1,138.2 | 174,121 | 188,100 | 208,700 | IM4D P15-11 |
| | Poblacion 8 | person | -159.1 | -11,075 | -11,964 | -13,274 | IM4D P15-11 |
| | **Sub-total Poblacion** | person | 979.1 | 163,046 | 176,136 | 195,425 | IM4D P15-11 |
| | Part of BUCANA (30%) | person | 120.6 | 25,189 | 35,009 | 49,558 | IM4D P15-11 |
| 1 | Total | | 1,692.6 | 290,502 | 322,445 | 369,783 | |
| | Population density | person/ha | - | 171.6 | 190.5 | 218.5 | |
| 2 | Water supply amount | m3/person/day | - | 0.190 | 0.200 | 0.210 | IM4D P14-5 (Water Demand) |
| | | m3/day | - | 55,195 | 64,489 | 77,654 | |
| 3 | Daily average flow (Domestic) | m3/person/day | - | 0.152 | 0.160 | 0.168 | (2) x 0.8 |
| | | m3/day | - | 44,156 | 51,591 | 62,124 | |
| 4 | Daily maximum flow (Domestic) | Peak factor | | 1.3 | 1.3 | 1.3 | |
| | | m3/person/day | - | 0.1976 | 0.208 | 0.2184 | (3) x 1.3 |
| | | m3/day | - | 57,403 | 67,069 | 80,761 | |
| 5 | Wastewater from business entities | m3/person/day | - | 0.01976 | 0.0208 | 0.02184 | (4) x 0.1 |
| | | m3/day | - | 5,740 | 6,707 | 8,076 | |
| 6 | Ground water infiltration amount | m3/person/day | - | 0.01976 | 0.0208 | 0.02184 | (4) x 0.1 |
| | | m3/day | - | 5,740 | 6,707 | 8,076 | |
| 7 | Daily average flow (Total) | m3/person/day | - | 0.192 | 0.202 | 0.212 | |
| | | m3/day | - | 55,637 | 65,005 | 78,276 | (3) + (5) + (6) |
| 8 | Daily maximum flow (Total) | m3/person/day | - | 0.238 | 0.250 | 0.262 | (4) + (5) + (6) |
| | | m3/day | - | 69,174 | 80,482 | 96,913 | |
| | Treatment Capacity | m3/day | | | **80,000** | **97,000** | Daily maximum |
| | | m3/day | | | | 78,000 | Daily average |

Source: JICA Survey Team

(2) Design Water Quality

The influent and effluent water quality for the wastewater treatment plant (WWTP) was not established in IM4D. Based on the record of water qualities in creeks (Sub-section 4.1.1), the examples in Metro Manila, and the DAO2016-08 (Class SB for discharge to the sea) in Sub-section 3.2.3, the values were established as shown in Table 6.1.2.

The effluent standards, DAO2016-08 in the table, was issued on 24 May 2016 and applied on 14 June 2016. Therefore, all new sewage treatment facilities should meet the requirements. The value of nitrogen should be less than 20 mg/L, and phosphorus should be less than 1.0 mg/L in Class SB.

**Table 6.1.2 Design Water Quality for Wastewater Treatment Plant in Area A**

| Parameter | Unit | Value | Note |
|---|---|---|---|
| Influent Water Quality | | | |
| BOD5 | mg/L | 200 | Creek water quality |
| COD | mg/L | N/A | |
| TSS | mg/L | 200 | Creek water quality |
| TN | mg/L | 40 | Metro Manila |
| TP | mg/L | 5 | Metro Manila |
| Effluent Water Quality | | | |
| BOD5 | mg/L | 30 | DAO2016-08 Class SB |
| COD | mg/L | 60 | DAO2016-08 Class SB |
| TSS | mg/L | 70 | DAO2016-08 Class SB |
| Nitrate as NO3-N | mg/L | 20 | DAO2016-08 Class SB |
| Phosphate | mg/L | 1 | DAO2016-08 Class SB |
| Fecal Coliform | mg/L | 200 | DAO2016-08 Class SB |

Source: JICA Survey Team

## 6.2 Study on Candidate Sites for Wastewater Treatment Plant in Priority Development Area

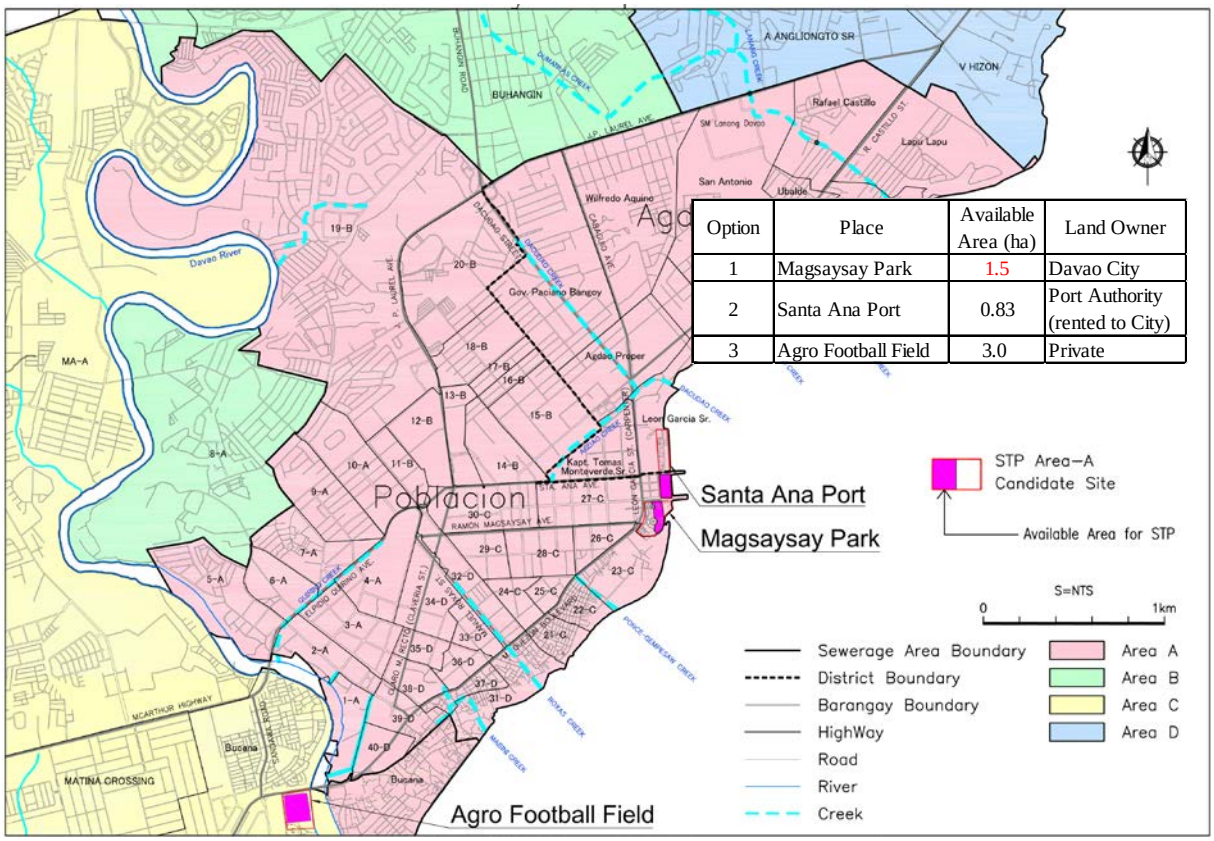
(1) Candidate Sites

Three candidate sites in Table 6.2.1 were selected and compared. The locations of the sites are shown in Figure 6.2.1.

**Table 6.2.1 Candidate Sites for Wastewater Treatment Plant in Area A**

| No. | Location | Note |
|---|---|---|
| 1 | Magsaysay Park | Proposed candidate site in IM4D |
| 2 | Santa Ana Port | North of Magsaysay Park with some open land (Introduction by City Architect) |
| 3 | Agro Football Field | One candidate site in M/P 1998 with large open land |

Source: JICA Survey Team




| Option | Place | Available Area (ha) | Land Owner |
|---|---|---|---|
| 1 | Magsaysay Park | 1.5 | Davao City |
| 2 | Santa Ana Port | 0.83 | Port Authority (rented to City) |
| 3 | Agro Football Field | 3.0 | Private |

Note: Available area in Magsaysay Park is tentative and the boundary of the available space needs to be confirmed.
Source: JICA Survey Team

**Figure 6.2.1 Location of Candidate Sites for WWTP Area A**

1) Magsaysay Park

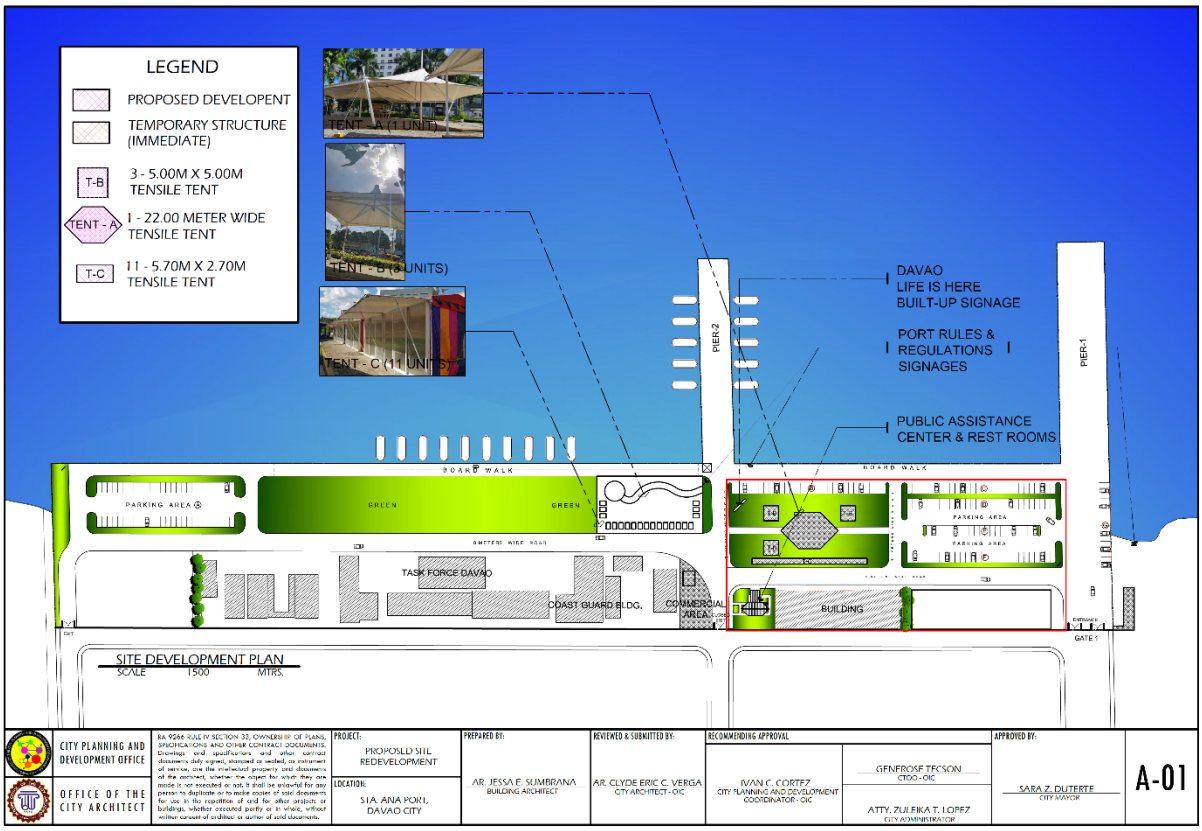
Magsaysay Park is located in the north of Barangay 23-C in Poblacion District. It was proposed as the candidate site for the WWTP in IM4D. The half underground type and full underground type options were proposed in IM4D for landscape and recreation purposes in the park. The Ramon Magsaysay Monument, a symbol of the park, was avoided not to be removed for construction, and the preliminary layout, with the concept of the Conventional Activated Sludge Process, was designed between the monument and the future Davao City Coastal Road (DCCR). The City Architect is planning to improve the park by constructing an additional parking building in the southwest area of the park, but it has not been finally approved by the city administration.

2) Santa Ana Port

Due to the difficulty of removal/relocation of the monument and many existing structures and the number of citizens visiting Magsaysay Park, the Santa Ana Port, which is adjacent to the northern part of Magsaysay Park, was introduced by the City Architect. The JICA Survey Team considered the possibility of using the said port.

There is an open land in the port but existing offices of Task Force Davao remain a concern as they are difficult to relocate. Therefore, the possible land to be used for the WWTP is limited to the south side

(right side in Figure 6.2.2). As well as the case of Magsaysay Park, the City Architect has a plan to develop the area as shown in Figure 6.2.2, but it is not finally approved by City Administration. Since some parts are already under development with temporary structures, a tent for events, a public assistance center, and restrooms are already existing in the area.




Source: City Architect

**Figure 6.2.2 Plan of Santa Ana Port**

3) Agro Football Field

The Agro Football Field was one of the candidate sites in the Sewerage Master Plan in 1997 by the World Bank (SC1). The field is located in the southwest side of the Bolton Bridge, or the farthest downstream bridge on Davao River (See Figure 6.2.1). There is a large open land with more than 3 ha. Since it is located in the opposite side of Area A, the river crossing with trenchless method is required for the installation of the sewer to the site. The general features based on the reviews of the river cross sections around the Bolton Bridge are shown in Table 6.2.2.

**Table 6.2.2 Feature of Agro Football Field and Nearby Davao River**

| Item | Description |
|---|---|
| Ownership | Private |
| Available land | Around 3 ha |
| Length of river crossing | 180-200 m |
| Ground Level (GL) | +2.8 m |
| Levels in Davao River | WL: MSL+0.40 m, Bed: MSL-2.8 m |
| Water Depth | 3.2 m |

Source: JICA Survey Team

For the use of this site for the WWTP, the points to be cleared on this option were organized as follows:

Technical

1. Crossing Davao River of large-scale sewer pipe (IM4D: Dia.1650, L=200 m) has a risk with insufficient experience of trenchless method in the Philippines and it may get deep (high pumping cost)

* Soil is gravel/silty sand, which is more difficult to work with than silt/clay ⇒Condition of pipe jacking is more than 15% content of silt/clay.

2. Difficulties in maintenance work of sewer pipe will arise due to deep location of the pipe and massive wastewater flow in the pipe.

**Table 6.2.3 Soil Condition around Bolton Bridge in Davao River**

Table 2: BH-1 Summary of Results

| Depth, m | | SPT N-value | Consistency/ Compactness | USCS classification | Soil Description |
|---|---|---|---|---|---|
| From | To | | | | |
| 0.00 | 6.00 | 19 | Medium | SP-SM | Black, Poorly Graded Sand with Silt and Gravel |
| 6.00 | 9.00 | 24 | Medium | SM | Black, Silty Sand |
| 9.00 | 10.50 | 33 | Dense | SP-SM | Black, Poorly Graded Sand with Silt |

Table 3: BH-2 Summary of Results

| Depth, m | | SPT N-value | Consistency/ Compactness | USCS classification | Soil Description |
|---|---|---|---|---|---|
| From | To | | | | |
| 0.00 | 10.50 | 24 | Medium | SM | Black, Silty Sand with Gravel |

Table 4: BH-3 Summary of Results

| Depth, m | | SPT N-value | Consistency/ Compactness | USCS classification | Soil Description |
|---|---|---|---|---|---|
| From | To | | | | |
| 0.00 | 3.00 | 18 | Medium | SM | Black, Silty Sand |
| 3.00 | 6.00 | 21 | Medium | SP-SM | Black, Poorly Graded Sand with Silt |
| 6.00 | 10.50 | 30 | Medium | SM | Black, Silty Sand |

Table 5: BH-4 Summary of Results

| Depth, m | | SPT N-value | Consistency/ Compactness | USCS classification | Soil Description |
|---|---|---|---|---|---|
| From | To | | | | |
| 0.00 | 3.00 | 17 | Medium | SM | Black, Silty Sand with Gravel |
| 3.00 | 6.00 | 20 | Medium | SP | Black, Poorly Graded Sand with Gravel |
| 6.00 | 10.50 | 29 | Medium | SM | Black, Silty Sand |

Source: Geotechnical Investigation Report Construction of Flood Control Projects, Bolton Bridge Upstream & Downstream Sections, Davao River

Financial, Implementation

1. Since it is a private land, land acquisition is required, and the cost is assumed to be high.

2. Acquisition of vertical shaft site for trenchless sewer installation in the east side of the Davao River is also required.

Therefore, the JICA Survey Team explained these points to the Davao City Government and suggested this option as the final alternative in case the Magsaysay Park and the Santa Ana Port cannot be used.

(2) Latest Plan on Davao City Coastal Road (DCCR) Project

The Davao City Coastal Road (DCCR), which is under construction and planning, is an important factor related to the WWTP construction in Magsaysay Park or Santa Ana Port since it will pass or is near the sites. The latest plan was confirmed with the DPWH Region XI Office, which is designing and constructing the road, and the latest image is shown in Figure 6.2.3. The features of the current plan are as follows:

1. It will pass the nearby sea (east) of Magsaysay Park and the Santa Ana Port itself;

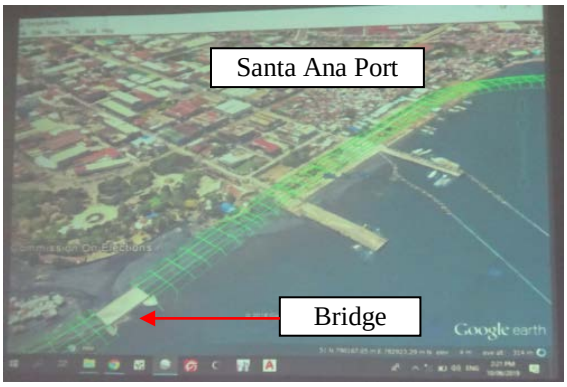
2. The road will be constructed in the reclaimed land (Magsaysay Park side) and the existing land (Santa Ana Port side);

3. The bridge section around this area is only one area in the northeast of Magsaysay Park to interconnect the sea side and the inner remaining sea.

4. According to the Davao City Government, the inner remaining sea will be reclaimed by the city after construction of the DCCR.

As of May, the plan has not been approved by the City Administration and DPWH, and the City started discussion and coordination in June.


**Alignment of DCCR near Magsaysay Park**




**Development Image of DCCR**

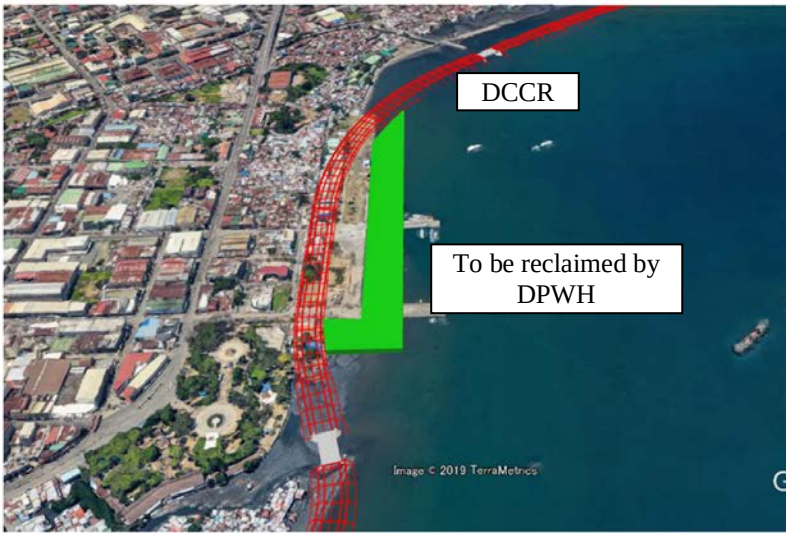
Source: DPWH Region XI on Google earth images

**Figure 6.2.3 Plan of DCCR as of beginning of June**

In the discussion between the City and DPWH on June 11, both parties agreed as follows:

- DCCR will pass through the west area in the port, including existing Davao Task Force offices.

- Due to the large-scale road, the park area and offices should be located in the seaside area for the view. So, as compensation for the occupied area by DCCR, DPWH will reclaim the sea as shown in Figure 6.2.4, and the Davao Task Force office will be laid there for monitoring of ships in Davao Gulf.




Source: DPWH Region XI on Google earth images

**Figure 6.2.4 Latest Plan of DCCR and Santa Ana Port Area based on Agreement between City and DPWH**

(3) Comparison of Three Candidate Site

Three candidate sites for WWTP Area A (Option-1: Magsaysay Park, Option-2: Santa Ana Port, Option-3: Agro Football Field) were compared as shown in Table 6.2.4, in terms of the items below, and explained to the City Administration.

1. Available area (ha)
2. Land ownership
3. Advantage
4. Disadvantage

For reference of the City Administration, the figures were also prepared as shown in Appendix 6.1. The points of advantage and disadvantage are as follows:

1) The advantage of Magsaysay Park and Santa Ana Port is easy land use as city lands, but land acquisition is required for the Agro Football Field as it is on a private land. The Magsaysay Park has a larger available area than the Santa Ana Port.

2) The Agro Football Field has advantage of large open area without much demolishment works.

3) A disadvantage of Magsaysay Park is the existence of Ramon Magsaysay Monument as a permanent structure.

4) The disadvantages of Magsaysay Park and Santa Ana Port are the possibility of compact type treatment processes with higher cost (e.g., CAPEX, OPEX) due to the limited available spaces.

5) As a cost disadvantage, the Magsaysay Park and the Santa Ana Port require fully underground structures and odor control for the recreation space with citizens.

6) A disadvantage of the Agro Football Field is the crossing of Davao River with long distance and subsequent difficult maintenance work for sewer.

(4) Selection of Candidate Site

Based on the comparison above, Magsaysay Park was selected as the final candidate site due to the following reasons:

1. Magsaysay Park, as the proposed site in IM4D, is the city's property that can be secured. Therefore, land acquisition is not required.

2. Santa Ana Port is difficult to use due to the mentioned future DCCR matter.

3. The Agro Football Field is difficult to use due to the land acquisition cost and river crossing of the sewer pipe.

Meanwhile, the Davao City Government requested the following three points as conditions of using the Magsaysay Park:

1) The existing Ramon Magsaysay Monument shall remain including the construction period, and the national flag pole shall also remain after the construction.

2) Since it is one of most important parks in the city with many visitors, foul odor generated from the WWTP shall be minimized.

3) From the points above, in terms of landscape and odor, structures of the WWTP shall be located underground as much as possible.

**Table 6.2.4 Comparison of Three Candidate Sites for WWTP Area-A**

| Option | 1. Magsaysay Park | 2. Santa Ana Port (South) | 3. Agro Football Field |
|---|---|---|---|
| | | | |
| Site Map |  Total land Assumed available land |  Total land Assumed available land |  Total land Assumed available land |
| Site Pictures |   |   |   |

| Option | 1. Magsaysay Park | 2. Santa Ana Port (South) | 3. Agro Football Field |
|---|---|---|---|
| **Administrative Location** | **Barangay 27-C, Poblacion District** | **Barangay 27-C, Poblacion District** | **Barangay Bucana, Talomo District** |
| **Total Area (ha)** | **2.68** | **2.55** | **3.19** |
| **Available Area assumed (ha)** | **1.50** | **0.83** | **3.0** |
| **Land Ownership** | **City** | **Philippine Port Authority (Rental to city)** | **Private** |
| **Advantage** | 1) The land belongs to City. The land acquisition is not required.<br>2) The available land area is larger than Option-2.<br>3) The treated water can be utilized for landscape work in the park.<br>4) As a center of the sewerage area, conveyance of sewage to the site is easy. | 1) The land is rental from Philippine Port Authority. With necessary procedure for extending the contract, the land use is relatively easy.<br>2) There is more open land than Option-1. Therefore demolishment/recovery work is less than Option-1.<br>3) As a center of the sewerage area, conveyance of sewage to the site is easy. | 1) The land area is largest among all the options. Due to that reason, conventional type wastewater treatment process with less CAPEX and OPEX can be adopted. And there is room for future expansion of facilities.<br>2) The existing land is almost open land without demolishment work. |
| **Disadvantage** | 1) Ramon Magsaysay Monument is quite important. It shall be avoided to demolish or move for construction. Therefore, the shape of available land for STP does not become simple one.<br>2) For that reason, compact type treatment process with higher cost (CAPEX, OPEX) than conventional type will be adopted. (please see layout image in the reference figures)<br>3) Because many citizens come to this park, the water treatment facilities shall be fully underground structure except for sludge treatment and administration building, and strict odor control is required.<br>4) Many existing structures and trees in the park shall be temporary demolished/moved and recovered after construction. | 1) The available land for STP is less than Option-1. It causes no room for future expansion of facilities.<br>2) Compact type treatment process with higher cost (CAPEX, OPEX) than conventional type will be adopted as well as Option-1. (please see layout image in the reference figures)<br>3) Because many citizens come to this port park, the water treatment facilities shall be fully underground structure except for sludge treatment and administration building, and strict odor control is required as well as Option-1. | 1) The land acquisition for private land is required. It may be the risk for delay of project.<br>2) The land belongs to Sewerage Area C in IM4D. For the acceptance by nearby residents, the wastewater from some part of Area C should be conveyed and treated.<br>3) The sewer pipe shall cross Davao River from Area A (East) to Area C (West) with trenchless method. (River crossing around 200m)<br>4) The soil condition under Davao River contains much gravel and sand. The difficulty of construction cannot be assumed before detailed soil analysis. The local contractor's experience is also concern for the installation work of around Dia. 1.65m sewer pipe.<br>5) The maintenance work after installation becomes quite difficult for the sewer under the river. |
| **Remark** | Coastal Road is planned to pass in the seaside. | The Coastal Road is planned to pass in this site. The coordination with DPWH is required. | |

Source: JICA Survey Team

## 6.3 Planning of Wastewater Treatment Plant (WWTP)

### 6.3.1 Study for Wastewater Treatment Facility (WTF)

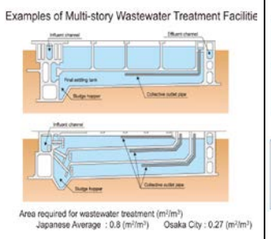
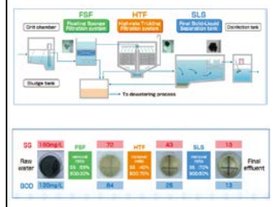
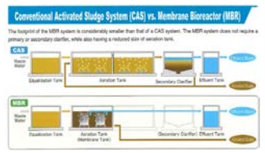
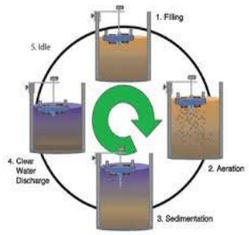
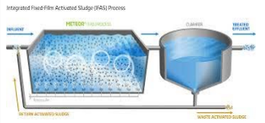
(1) Primary Comparative Study for the Selection of Wastewater Treatment Process

The primary comparative study was conducted for six wastewater treatment processes, which are the major processes applied in the world, as shown in Table 6.3.1.

In this study, the conditions for selection of the treatment process are as follows:

- The effluent water quality value should comply with the standard of DENR-DAO-008, which regulated to remove nitrogen and phosphorus by advanced treatment method.
- The WWTP, which consists of the wastewater treatment facility (WTF) and the sludge treatment facility (STF), should be placed underground as much as possible in the limited area of the Magsaysay Park as required by Davao City in order to reserve a larger area for the public.

**Table 6.3.1 Primary Comparative Study for Selection of Wastewater Treatment Process**

| No. | Subject | Wastewater Treatment Process | | | | | |
|---|---|---|---|---|---|---|---|
| | | **CAS (incl. deep type)** | **PTF (Pre-treated Trickling Filter)** | **MBR (Membrane Bioreactor)** | **SBR (Sequencing Batch Reactors)** | **OD (Oxidation Ditch)** | **IFAS (Integrated Fixed-Film Activated Sludge)** |
| | **Process Image** |  |  |  |  |  |  |
| **0** | **Feature** | The deep type conventional activated sludge process, which uses a multi-layered sedimentation tank and a deep layer reactor, is a method which has been developed in 1960's. It is applicasble in case available land/space is limited.<br>It can be applied for advanced treatment and several technologies/equipment which contribute to saving power consumption.<br>This method is appllied in the major cities such as Tokyo, Osaka, Japan. | The PTF method is a treatment method developed for ASEAN nations and has the advantage that the power consumption is lower compared to the conventional methods.<br>Considering the limited construction sites and high power cost in the target area, this method will be a very effective technology because the facility with this method will be compact and can save power consumption. However, this technology cannot support advanced treatment. | A technology which uses a space-saving and compact treatment method and supports advanced treatment is required for the treatment plant planning. MBR method can fulfill the both requirements.<br>With the MBR method membrane units are set in a reactor tank and no final sedimentation tank will be necessary. As the primary sedimentation tank is not mandatory, this treatment method can greatly save space. | SBR is considered a fill-and-draw activated sludge system. The processes of equalization, aeration, and clarification are all achieved in the same tank, unlike a conventional activated sludge system, in which the same processes are accomplished in separate tanks.<br>However, this process is not suitable for advanced treatment. (Skilled technique is required for the operation.) | The oxidation ditch (OD) is a sort of equipment used for a long-term aeration. It consists of a long channel of an elliptical or circular shape equipped with an aeration equipment called a rotor for generating a water flow and stirring water in the channel to supply oxygen. Thought it requires a relatively large area, it has a simple structure and can be easily operated as well as being able to remove nitrogen easily. Thus, it has recently been widely used in relatively small wastewater treatment plants. | The Integrated Fixed-Film Activated Sludge (IFAS) process is typically installed as a retrofit solution for conventional activated sludge systems that are at or beyond capacity. IFAS upgrades offer an extremely cost-effective retrofit solution to municipal wastewater plant expansion, taking full advantage of existing systems, equipment, process knowledge, training, and operator skills. The technology is compatible with plug flow and complete mix configurations; IFAS hybrid processes are designed for complete compatibility with fine bubble aeration systems, providing demonstrated long-term operational cost savings. |
| **1** | **Operation Skill** | Fair | Easy | Fair | Fair | Easy | Fair |
| **2** | **Generated Sludge Volume (ratio to CAS)** | 1 | 0.8 | 0.8 | 0.9 | 0.75 | 1.1 |
| **3** | **Unit Energy Consumption (kWh/m$^3$)** | 0.3 | 0.15 | 0.5 | 0.45 | 0.9 | 0.3 |
| **4** | **O&M Cost** | Middle | Small<br>(smallest energy)<br>(expensive media) | Middle to High<br>(higher energy)<br>(membrane exchange) | Middle to High<br>(higher energy) | High<br>(highest energy) | Middle to High<br>(expensive media) |
| **5** | **Required Land Area for Typical Layout** | Small to Middle | Small to Middle | Small | Middle | Large | Small to Middle |
| **6** | **Applicability to Advanced Treatment** | Applicable | Not Applicable | Applicable | Applicable, but treatment capacity is halved. (Operational adjustment is necessary) | Applicable, but treatment capacity is halved. (Operational adjustment is necessary) | Applicable |
| **7** | **Applicability to Under Ground** | Applicable | Not Applicable | Applicable | Not Applicable | Not Applicable | Applicable |
| | **Selection for Primary Comparative Study** | *Selected* | | *Selected* | | | *Selected* |

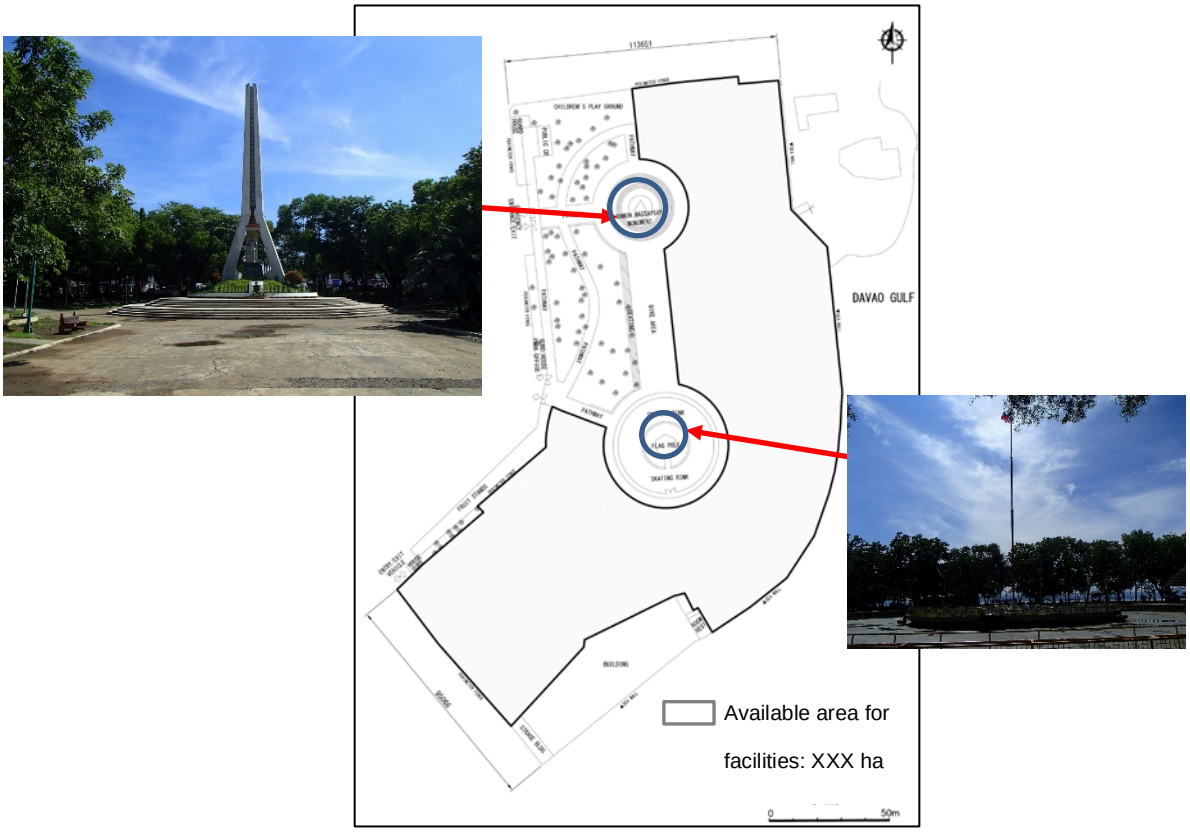
Source: JICA Survey Team

(2) Secondary Comparative Study for the Selection of Wastewater Treatment Process

1) Available Space for Wastewater Treatment Facilities (WTFs)

Following the result of the primary comparative study, the secondary comparative study for the selection of the wastewater treatment process shall be carried out.

WTF is only required to be placed within the area shown in Figure 6.3.1 in order to preserve the existing historical monuments which cannot be relocated as requested by the city.




Source: JICA Survey Team

**Figure 6.3.1 Available Space for Wastewater Treatment Facilities (WTF)**

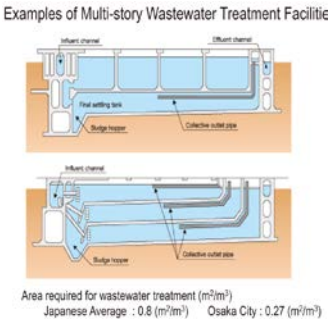
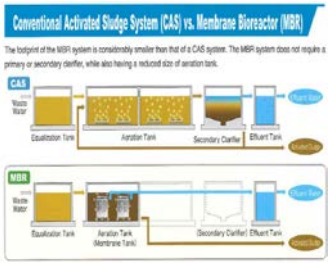
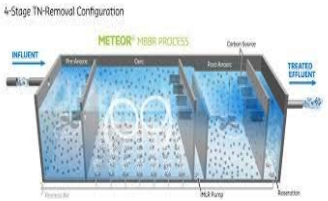
2) Selection of Wastewater Treatment Process

The comparison of three wastewater treatment processes, which were selected in the primary comparative study, is shown in Table 6.3.2.

As a result, only the membrane bioreactor (MBR) process can be installed in the available area in Magsaysay Park to satisfy the required conditions. Therefore, an MBR is proposed to be applied.

As mentioned in Table 6.3.1, the O&M cost of the MBR process is higher than CAS. However, the difference has been decreasing in recent years due to the improvement of technology. The required energy is still higher than CAS, but the chemical cost is similar due to less chlorine consumption for disinfection despite some chemical cost for the periodic washing of membrane. In addition, since the volume of sludge is less than CAS, the sludge treatment cost gets smaller than CAS.

## Table 6.3.2 Secondary Comparative Study on Wastewater Treatment Process

| Item | Wastewater Treatment Process (100,000m3/day, for Area A) | | |
|---|---|---|---|
| | CAS<br>(Deep type / Muliti-stories) | MBR<br>(Membrane Bioreactor) | IFAS<br>(Integrated Fixed-Film Activated Sludge) |
| Process Image |  |  |  |
| Required Area | 1.9ha | 0.9ha | 2.1ha |
| Condition of Facility Layout | The existing monuments should not be demoished/replaced. | The existing monuments should not be demoished/replaced. | The existing monuments should not be demoished/replaced. |
| Layout Image |  |  |  |
| Applicability | Not Applicable | Applicable | Not Applicable |

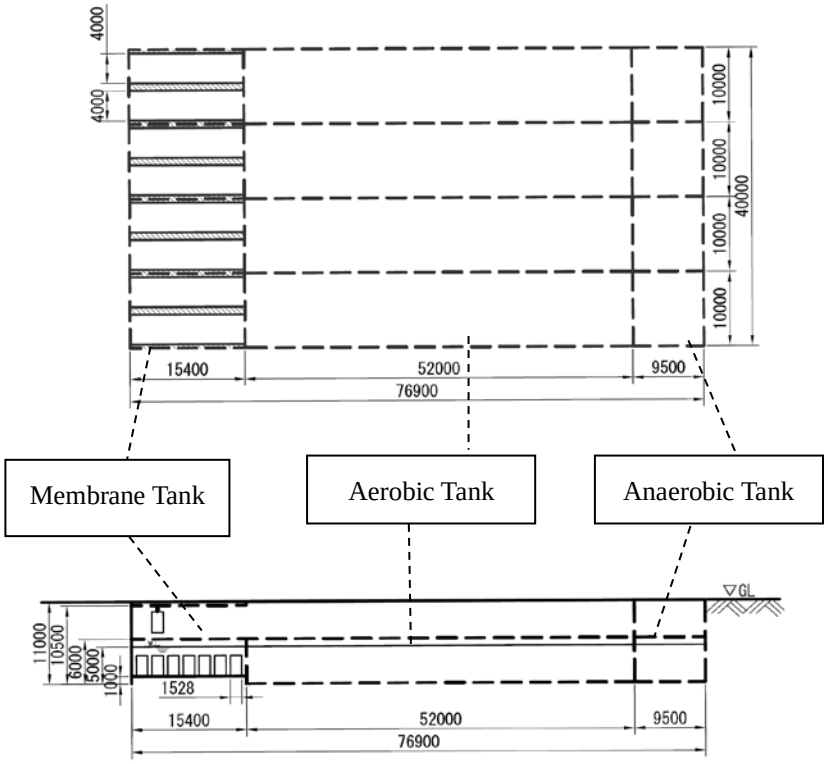
Source: JICA Survey Team

3) Selection of Type of Membrane of MBR Process

There are two types of membranes, namely the hollow fiber membrane and the flat sheet membrane. After the comparison shown in Appendix 6.2.1, hollow fiber membrane was selected.

(3) Proposed Wastewater Treatment Facilities

As a result of the comparative study, the MBR process (Hollow Fiber Membrane type) shall be applied for the project as required. The general facility plan is shown in Figure 6.3.2. As explained in "(1) Primary Comparative Study for the Selection of Wastewater Treatment Process", the facilities shall be installed underground. The capacity calculation of the WTF is shown in Appendix 6.2.2.




Source: JICA Survey Team

**Figure 6.3.2 General Plan of Proposed Wastewater Treatment Facilities**

### 6.3.2 Study for Sludge Treatment Facility (STF)

In this sub-section, the STF is studied and planned as follows:

(1) Comparative Study for Selection of Applicable Sludge Treatment Process

After wastewater treatment, excess sludge will be generated.

Sludge treatment is a combination of unit processes which comprises mostly of the reduction of volume and the stabilization of sludge.

The optimum combination of the processes is dependent on the type of disposal method, including the recycle policy. Representative examples of the combination are further discussed.

In this Survey, the following alternatives are considered in accordance with the conditions requested by Davao City: 1) reduction of generated sludge due to lack of landfill site, and 2) reduction of odor.

The comparative study was conducted as shown in Table 6.3.3.

Option 1: Thickening + Dewatering

Option 2: Thickening + Dewatering + Sun Drying

Option 3: Thickening + Digestion + Dewatering + Sun Drying

Option 4: Thickening + Dewatering + Mechanical Drying

Option 5: Thickening + Dewatering + Incineration

Sludge drying should be conducted in the WWTP site, and dried sludge will be disposed of at suitable sites which will be developed by Davao City.

As a result, Option 1 is not suitable from the environmental point of view due to the odor generated, and Options 2 and 3 are not applicable because the sludge drying bed, which will occupy an area of 6,600 $m^3$ (for 30-day drying period), cannot be placed within the area. Also, it is not recommended to install a sun-drying bed, in consideration of the environmental impact to the surrounding residential area.

Also, maintenance work for the sun-drying bed is very difficult for the staff because the area is very large and safety is a concern due to the bad environmental conditions.

On the other hand, Option 5, which requires the installation of incinerators, should be excluded at this time since the waste-to-energy (WtE) project with incinerator is now at planning stage in Davao City.

Accordingly, Option 4 with mechanical drying machine is recommended to minimize the sludge volume and odor generation.

(2) Proposed Sludge Treatment Facilities

As a result of the comparative study in (1) above, Option 4 is recommended. The following topics on STFs based on the option were studied as shown in Appendix 6.3:

1) Type of Mechanical Sludge Drying Machine

2) Process Flow Diagram of STFs

3) General Layout of STFs

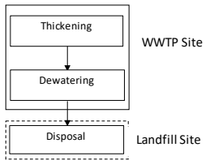
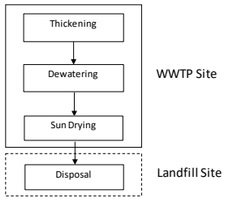
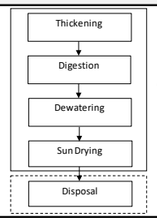
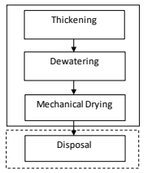
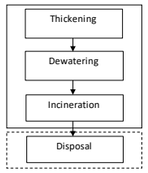
With respect to 1) above, out of four options, the inclined paddle disc dryer type is selected for the project.

(3) Necessity of Disposal Facility for the Future

Davao City envisages that they would, as much as possible, utilize sludge generated from the WWTP enhanced by the project instead of simply disposing it as solid waste. While the JICA Survey Team respects their idea, it may not be possible to utilize all of the sludge from the facility. The amount of dried sludge generated from WWTP is preliminarily estimated at about 30 $m^3$/day in its full operation years.

Therefore, it is necessary to secure disposal site to prepare for future sludge generation.

## Table 6.3.3 Comparative Study on Sludge Treatment Facility

| | | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
|---|---|---|---|---|---|---|
| | | **Thickening + Dewatering** | **Thickening + Dewatering +Sun Drying** | **Thickening + Digestion + Dewatering + Sun Drying** | **Thickening + Dewatering + Mechanical Drying** | **Thickening + Dewatering + Incineration** |
| **Process Flow** | |  |  |  |  |  |
| **Overview** | **Thickening**<br>*Outputted sludge Moisture*<br>(97.5 %) | Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the Dewatering Equipment. | Same as Option 1 | Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the digester. | Same as Option 1 | Same as Option 1 |
| | **Digestion**<br>*Outputted sludge Moisture*<br>(99%) | No digestion process applicable to Option 1 | No digestion process applicable to Option 2 | The organic content in sludge is reduced and the volume of sludge is stabilized in the digester. The odour from sludge is also reduced in this process and the digested sludge of about 2.5% concentration is loaded into the sludge dewatering machine. | No digestion process applicable to Option 4 | No digestion process applicable to Option 5 |
| | **Dewatering**<br>*Outputted sludge Moisture*<br>(82%) | Being dewatered, sludge cake with about 82% water content by using mechanical dewatering equipment, sludge is disposed offsite. | Same as Option 1 | Same as Option 1 | Same as Option 1 | Same as Option 1 |
| | **Drying**<br>(Natural or Mechanical)<br>Sludge Moisture<br>(60%) | Dewatered sludge is disposed at the landfill site.<br>(The sludge is dried at landfill site) | Being delivered to the existing dumping site (Htein Bin Fial Disposal Site), then being dried for about 30 days on the sludge drying bed, sludge reaches down to 40 % of water content approximately. Sludge Drying time is 30 days. | Same as Option 2 | Mechanical Drying inside the territory of existing WWTP reduces the dewatered sludge volume. | No Drying process applicable to Option 5 |
| | **Incineration** | No incenertion process applicable to Option 1 | No incenertion process applicable to Option 2 | No incenertion process applicable to Option 3 | No incenertion process applicable to Option 4 | To reduce drastically the dewatered sludge volume by introducing incineration process to the other process |
| **General Features of Process** | | - Since the dewatered sludge contains a large quantity of undissolved organic, it is volatile and generates odor.<br>- After dewatering, the sludge is transported by dump truck.<br>- The necessary area will be smallest among options. | - Since the dewatered sludge contains a large quantity of undissolved organic, it is volatile and generates odor.<br>- Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications. | - Possible to reduce solid waste volume in digested sludge by drying bed and improve the volatility<br>- Large space for the premises is necessary<br>- Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications. | - Possible to reduce sludge volume<br>- Space for the premises is necessary | - Possible to extremely reduce solid waste volume<br>- Large space for the premises is necessary |
| **Required Space in WWTP** | | 1,000m2 | N/A (7,200m2 (Drying bed cannot be placed)) | N/A (9,500m2 (Drying bed cannot be placed)) | 1,500m2 | 2,800m2 |
| **Sludge Volume** | | After Dewatering: 60m3/day | After Dewatering: 120m3/day, Sun Drying: 30m3/day | After Dewatering: 60m3/day, Sun Drying: 20m3/day | After Dewatering: 120m3/day, Mechanical Drying: 30m3/day | After Incineration: 9m3/day |
| **Initial Cost** | | 10 million USD | N/A | N/A | 29 million USD | 58 million USD |
| **Running Cost** | | 1.0 million USD | N/A | N/A | 3.5 million USD | 4.5 million USD |
| **Advantages** | | - The required area for the sludge treatment facility is the smallest among all options.<br>- The initial cost and running cost will be lowest among all options. | N/A | N/A | - Drying process can be placed within WWTP site, so, the sludge generation volume can be reduced.<br>- Duration for mechanical drying process is much shorter than sun-drying process.<br>- Odor impact is much less than sun-drying process. | - The generated sludge volume will be much less than Option 4.<br>- Transportation cost to dumping site will be reduced less than Option 4. |
| **Disadvantages** | | - The enviromental impact will be big during the transportation of dewatered sludge.<br>- Special dump track (closed type) will be required for transportation of the dewatered sludge which contains a lot of moisture.<br>- The generated sludge volume from WWTP is the biggest, so, big volume of sludge is required to be disposed at the landfill site. | N/A | N/A | - Running cost is much higher than sun-drying process.<br>- Building for the mechanical drying process is requred. | - Running cost is higher than Option 4 because fuel will be necessary for incineration.<br>- Moisture content should be reduced for efficient incineration. (i.e. to add drying process, however, sun-drying process cannot be placed due to land limitation as mentioned in Option 2 and 3.) |
| ***Selection*** | | - This is not recommendable considering the environmental impact and lack of landfill site. | - The sun drying bed cannot be placed because the huge area is required.<br>- The sun dring process is not recommended considering the environmental impact surround the area. | - The sun drying bed and digestion facility cannot be placed because the huge area is required.<br>- The sun dring process is not recommended considering the environmental impact surround the area. | - The cost is less than Option 5.<br>- The slyudge volume generated can be minimized considering the situation of lack of landfill site.<br>- Environmental impact will be much smaller than Option 1 during transportation of sludge to landfill site.<br>**Recommendation** | - A study on the integrated sludge management master plan for the entire Davao city is necessary separately from this study for future installation of incineration process.<br>- Therefore, the installation of incineration process will not be considered only for this WWTP. |

Source: JICA Survey Team

### 6.3.3 General Facility Layout Plan of Wastewater Treatment Plant (WWTP)

(1) Process Flow

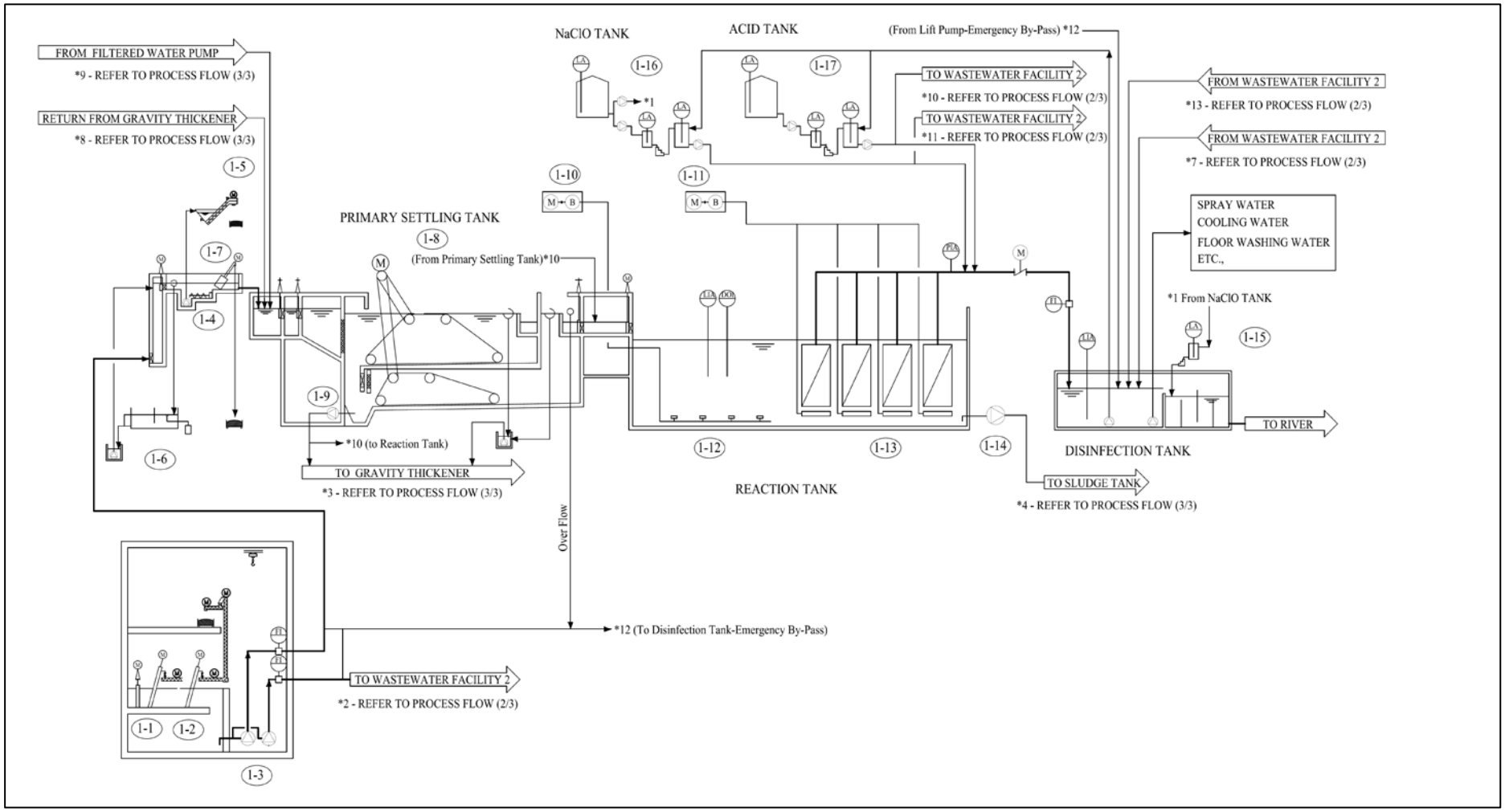
The diagrams of the wastewater treatment and sludge treatment processes are shown in Figure 6.3.3, Figure 6.3.4, and Figure 6.3.5.

(2) General Facility Layout Plan of the WWTP

The options of the general facility layout plan of the WWTP are shown in Table 6.3.4.

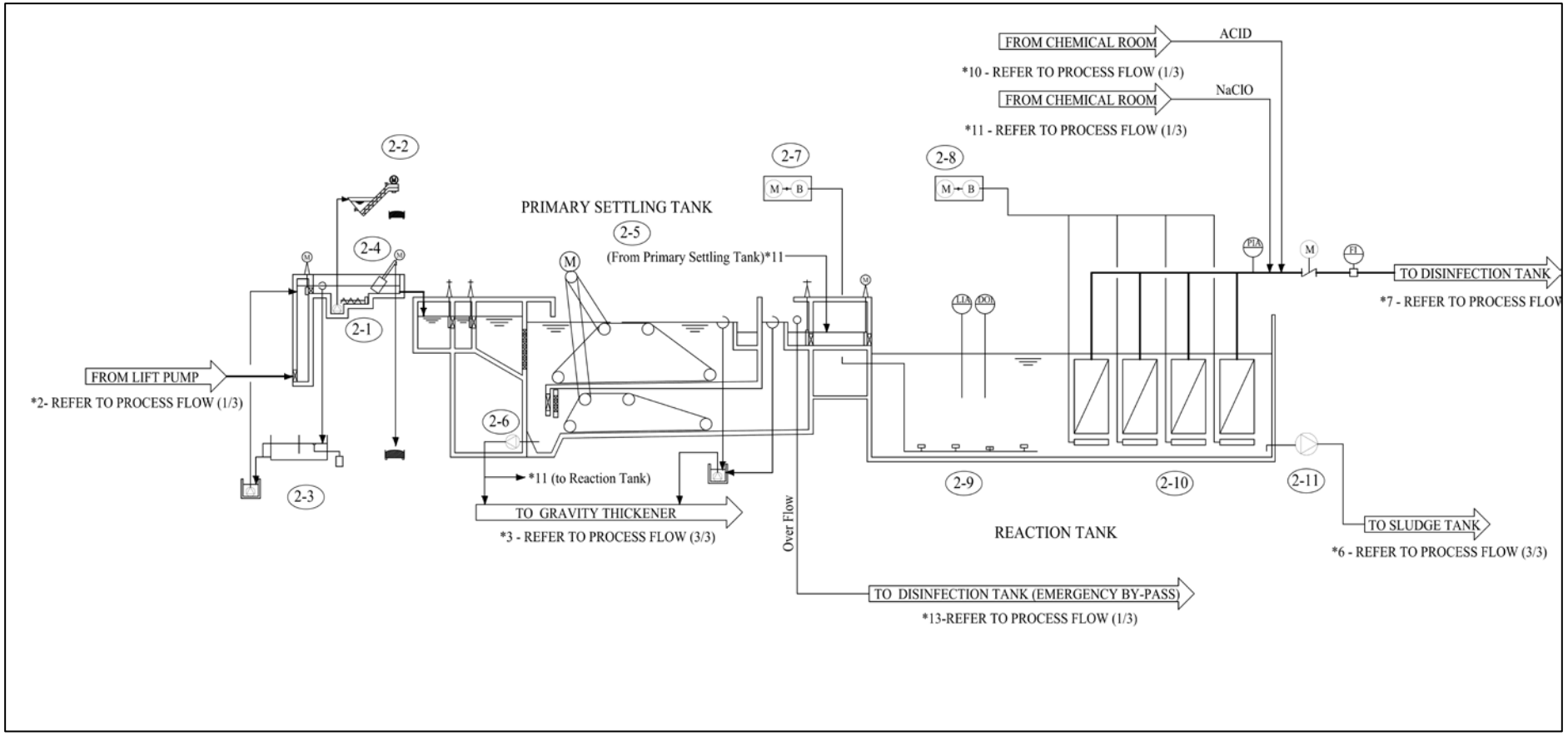
Option 1 is considered to have better processing efficiency. In addition, maintenance work is easier because the two facilities are adjacent to each other.

Therefore, Option 1 is selected for the general playout planning of WWTP as shown in Figure 6.3.6.



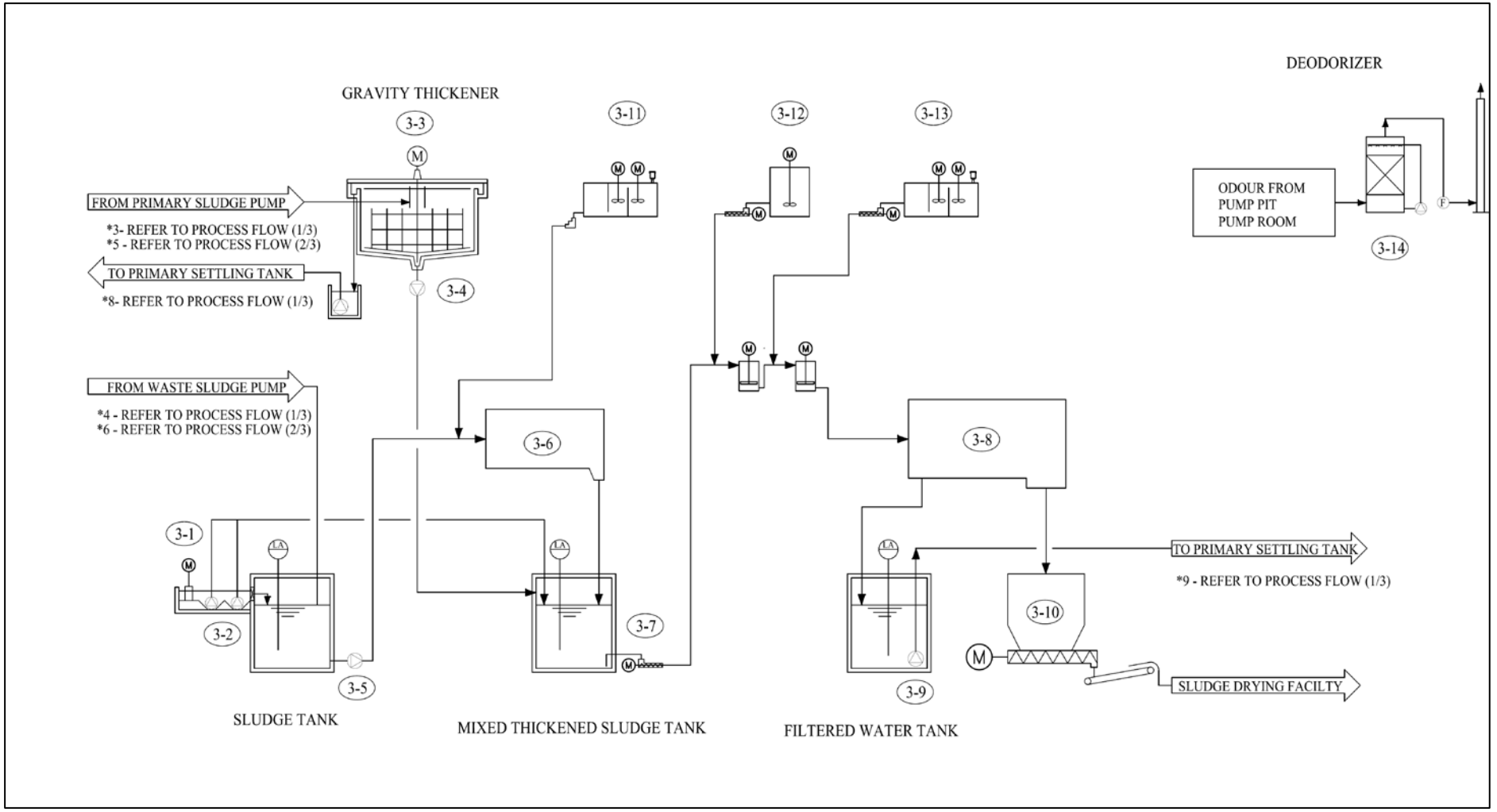

Source: JICA Survey Team

**Figure 6.3.3 Process Flow Diagram 1**




Source: JICA Survey Team

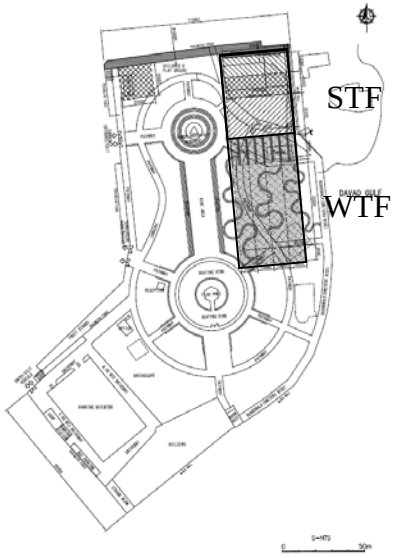
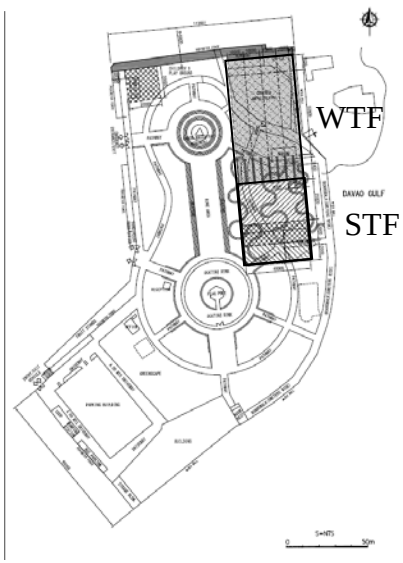
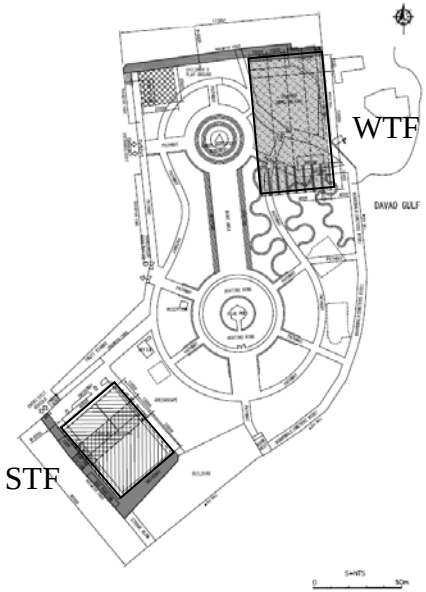
**Figure 6.3.4 Process Flow Diagram 2**



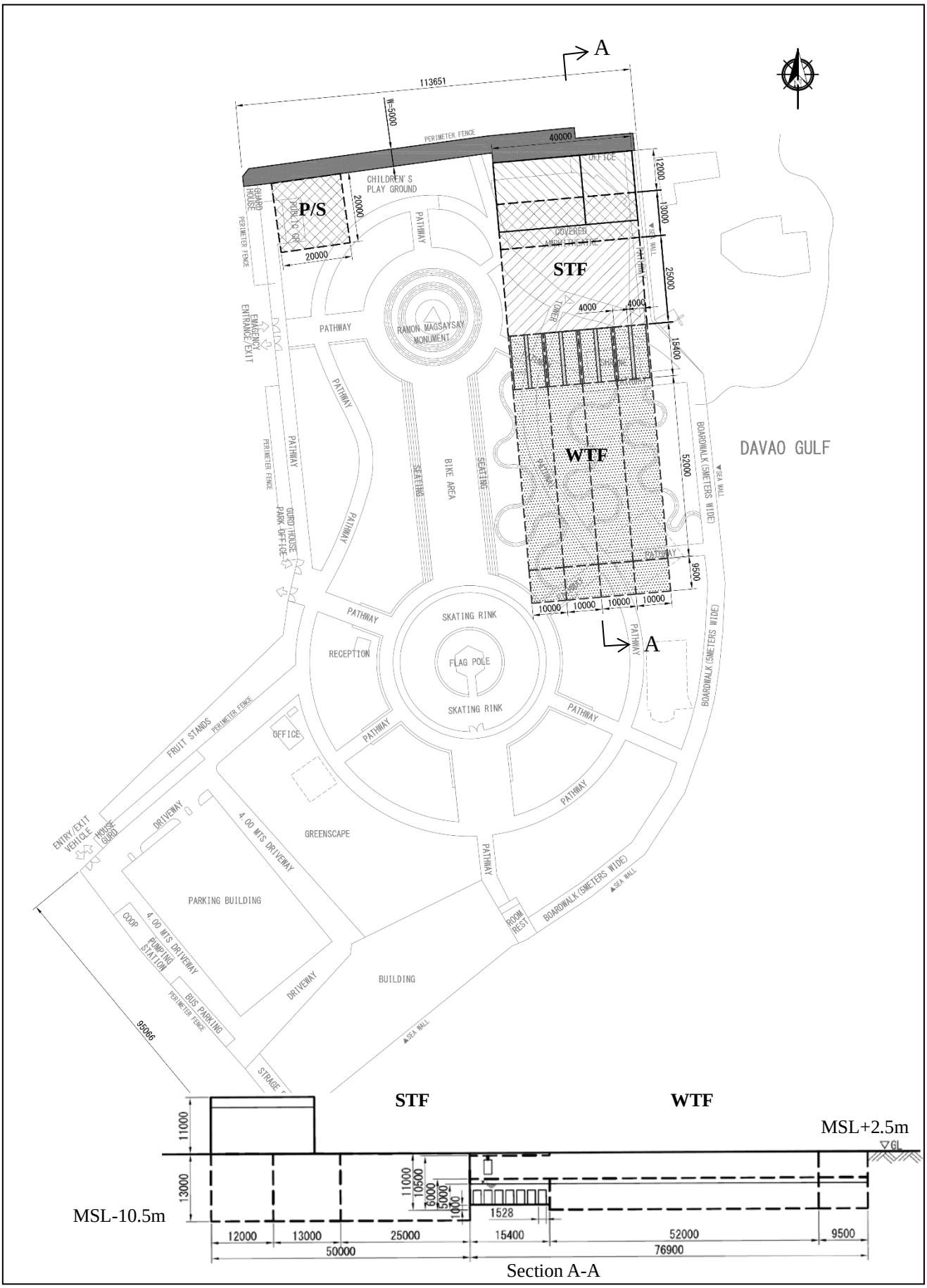

Source: JICA Survey Team

**Figure 6.3.5 Process Flow Diagram 3**

**Table 6.3.4 Comparative Study on General Layout Plan of WWTP**

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| **Layout Image** |  |  |  |
| **Feature** | • The vehicle can access the sludge collection and maintenance building without entering the park. Security/safety for residents can be maintained.<br>• The administration building is located at the corner of the park, and it does not obstruct the area and view. | • The vehicle has access to the sludge collection and maintenance building by passing through the park. Therefore, the space for the individual access road, which maintains the security and safety for the residents, will obstruct the area.<br>• The administration building is located at the center of the park, and it will obstruct the area and view. | • The vehicle needs access to both WTF and STF. Therefore, two access roads will be necessary at the least.<br>• The sludge pipe is required to be installed between WTF and STF.<br>• The administration building is located at the corner of the park, and it does not obstruct the area and view. |
| **Evaluation** | **Recommendation** | | |

Source: JICA Survey Team




Source: JICA Survey Team

**Figure 6.3.6 Proposed General Layout Plan of WWTP**

(3) Location of Outlet Facility (Effluent Point)

The outlet facility will be installed in the location shown in Figure 6.3.7. The facility will be installed at the shore revetment; therefore, discussion with the Davao City Port Authority will be required in the detailed design stage.


Source: JICA Survey Team

**Figure 6.3.7 Proposed Location of Outlet (Effluent Point)**

### 6.3.4 Points to be Noted for Construction

The WTF will be constructed as a fully underground structure, and the STF will also have an underground floor of the same depth with the WTF. The depth will reach more than 14 m from the ground, including foundation work, and it is approximately 12 m from the mean sea level. Therefore, it should be noted that there will be a large-scale earth retaining work for the construction of the WWTP.

### 6.3.5 Landscape Improvement of Magsaysay Park

(1) Improvement for Recreational Space

The landscape improvement of Magsaysay Park is proposed at the same time as the installation of the WWTP. This proposal makes the project more acceptable to the residents.

As mentioned, the WWTP is to be installed underground, and it is proposed to use treated wastewater for the park's recreational spaces. This can further enhance the value of the project to the residents.

In addition, clearer treated wastewater can be produced by the MBR than other methods which can be utilized for the recreational space in the park.

The images of landscape improvement are shown in Figure 6.3.8, which are examples in Japan.

Source: Official Web-site of LGUs in Japan

**Figure 6.3.8 Image of Recreation Space after Installation of WWTP**

(2) Installation of Public Facilities in Administration Building

The installation of public facilities in the administration building is proposed for the following purposes:

- Prevention of throwing garbage into the sewer,
- Promote importance of development of sewerage system,
- Environmental protection, and
- Collection of sewerage tariff.

It will contribute to the understanding of the future development of a sewerage system in other areas of Davao City.

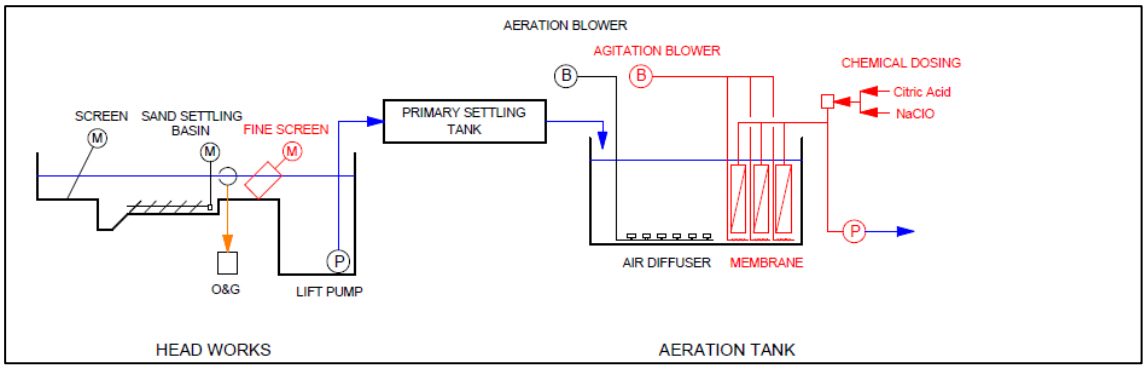
| | |
|---|---|
|  |  |
| Displays | Model of Facilities |
|  |  |
| Study Room | Visualization of Sewer Pipe |

**Figure 6.3.9 Image of Publication Facilities in Administration Building**

### 6.3.6 Operation and Maintenance of the WWTP

In this section, the O&M of the MBR is described.

The equipment marked as red in Figure 6.3.10 are the main facilities which should be noted in the O&M.




Source: JICA Survey Team

**Figure 6.3.10 Diagram of MBR Process**

(1) Important Points of Operation of WWTP

Important points for operation of the MBR are shown in Table 6.3.5.

**Table 6.3.5 Important Points of Operation of MBR**

| Important Points | Matters on Operation | Method/Countermeasure |
|---|---|---|
| **Avoid Membrane Fouling** | Bacteria, calcium, etc., will adhere on the surface of the membrane and will clog in membrane pores.<br>Prolonged adherence in pores becomes difficult to remove.<br>Thus, membrane flux reduces. | Periodic chemical cleaning is required.<br>Normally, it should be done every 3 months.<br>Chemicals used are citric acid and NaClO. |
| **Avoid Flocculant Leak** | When there is an overdose of flocculant for the dewatering unit, residual flocculant will leak to the aeration tank.<br>If flocculant adheres on the membrane, flux will reduce. | Flocculant for the dewatering unit shall be properly adjusted.<br>Never drain unused flocculant solution. |
| **Avoid No-Flow Agitation** | If there is no filtering but agitation is still continuous, the membrane will be damaged physically. (for flat type) | While there is no filtering done, agitation shall be operated intermittently.<br>MBR shall operate always. Avoid low flow rate of control operation for the membrane. |
| **Agitation Air Pipe Drain** | Diffusers of agitation air will be clogged by sludge accumulated at the bottom of the membrane unit.<br>If diffuser is clogged and there is less agitation, membrane fouling will occur faster. | Diffuser cleaning-flush shall be done manually daily to remove accumulated sludge. |
| **Fine Screen** | The membrane will be clogged in case there is no coarse and fine screen. The membrane requires 1-2 mm of opening screen before the aeration tank. | Proper maintenance for fine screen as well as coarse screen is needed. |
| **Oil and Grease Removal** | If oil attaches on the membrane surface, it will not be removed easily. Sometimes, special cleaning is required. | An oil separator, which is placed before membrane, shall operate properly. Separated oil shall be transferred to the dumping site. |

Source: JICA Survey Team

In order to continue proper operations for stable treatment, the following additional back-up measures will be necessary and are proposed to be discussed in the detailed design stage.

**Table 6.3.6 Proposed Additional Back-up**

| Proposed Additional Back-up | Description |
|---|---|
| **Training** | Operator's training for membrane treatment conducted by manufacturer is recommended.<br>Example:<br>• Two to three months off-shore on the job in-hand training for O&M team |
| **Manufacturer's Inspection** | Manufacture inspection is recommended.<br>Example:<br>• One year after commissioning<br>• Every two years<br>• Internet data transfer and checked and commented by manufacturer |
| **Instrument Engineer** | Instrument engineer shall join in O&M team.<br>• MBR system is 90% automatically operated.<br>• Programming of operation is in PLC and/or SCADA.<br>• In case a circuit board in PLC/SCADA is multifunctional, the instrument engineer shall rectify it. |

Source: JICA Survey Team

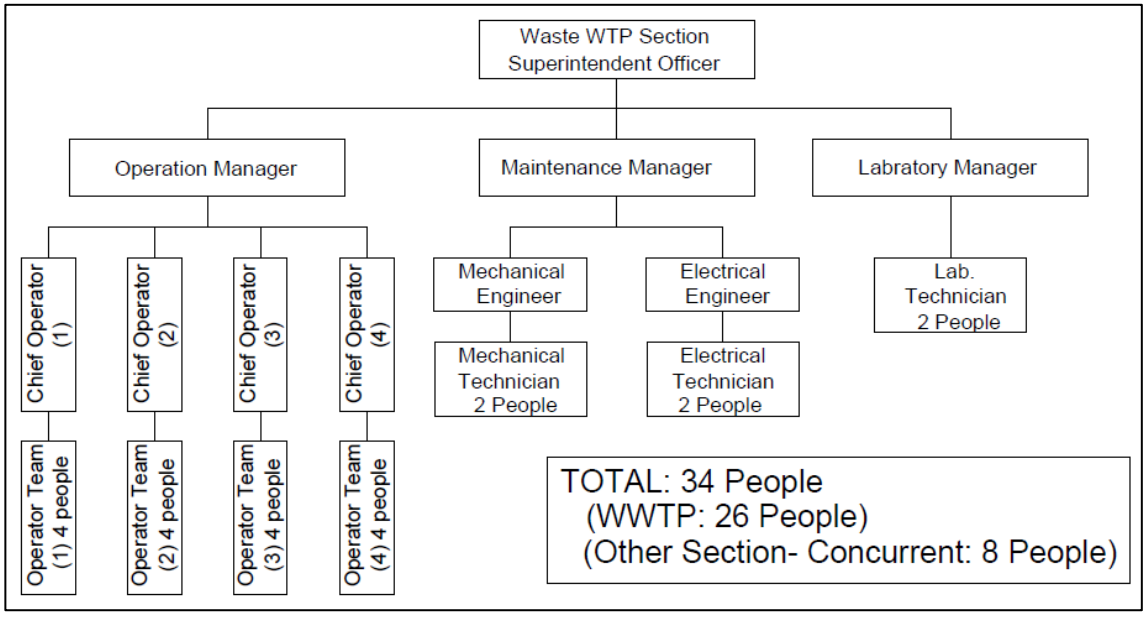
(2) Proposed O&M Structure for WWTP

This section describes the organization requirements for O&M works for the new WWTP.

1) Recommended O&M Structure

There are three parties involved for WWTP O&M works as follows:

a. Operation Team
b. Maintenance Team
c. Laboratory Team




Source: JICA Survey Team

**Figure 6.3.11 Recommended O&M Structure**

2) O&M Consideration

The main considerations of the O&M method are listed below.

i) Overall

a. Problem identification of any kind shall be done by the Operation Team.
b. Repairing and rectification shall be done by the Maintenance Team.

ii) Emergency System

a. When an emergency occurs, the Superintendent Officer and the Operation Manager shall lead to take action.
b. An Emergency Organization shall be established.

iii) Role of Each Team

a. The Superintendent Officer shall work as the leader of the entire O&M Team. All information shall be conveyed to the Superintendent Officer and the Operation Manager.
b. The Operation Manager shall work as the leader of the Operation Team as well as an assistant to the Superintendent Officer. If the Superintendent Officer is absent, the Operation Manager shall act in behalf of the Superintendent Officer.
c. The Operation Team shall operate all equipment and check treatment conditions with the cooperation of the Laboratory Team.
d. The Laboratory Team shall analyse raw and treated water contents periodically and inform the Superintendent Officer and the Operation Manager.
e. Also, the Laboratory Team shall check the required chemical amounts through a Jar Test for sludge treatment and shall inform the Operator to adjust the chemical dosing rate accordingly.
f. The Maintenance Team shall conduct periodic routine maintenance.
g. Also, the Maintenance Team shall rectify/repair mechanical/electrical machines as soon as possible upon request of the Superintendent Officer/Operation Manager.

3) Roles and Tasks of Each Personnel

The roles and tasks of each personnel are shown in Table 6.3.7.

**Table 6.3.7 Roles and Tasks of Each Personnel**

| No. | Position | Required Skill | Station | Roles and Tasks | Report to |
|---|---|---|---|---|---|
| 1 | Superintendent Officer | Full knowledge of processes and mechanical works (Univ. Level) | WWTP | - Overall responsible person for WWTP O&M<br>- To organize and lead O&M teams<br>- To organize and lead the emergency system | Deputy Head of Department |
| 2 | Operation Manager | Full knowledge of processes and mechanical works (Univ. Level) | WWTP | - To lead operators for smooth operation<br>- To find problems and report to each related personnel<br>- To adjust machines/valves according to information received from other teams<br>- To record and check operation conditions | Superintendent Officer |
| 3 | Maintenance Manager | Knowledge of mechanical equipment, especially rotating machine, and basic knowledge of electrical works and instruments (Univ. Level) | Other Section in DCWD | - To lead the Maintenance Team<br>- To conduct routine maintenance according to the O&M Manual<br>- To receive information from the Operation Manager regarding defective items<br>- To rectify and repair defective items and/or inform manufacturer/supplier regarding repair works or spare parts | Superintendent Officer |
| 4 | Laboratory Manager | Full knowledge of analysis method (Univ. Level) | WWTP | - To lead the Laboratory Team<br>- To check analysis results and inform the Operation Manager<br>- If treated water analysis results are over the expected values, inform related personnel including the Superintendent Officer | Superintendent Officer |
| 5 | Chief Operator (four teams, eight-hour shifts) | Basic knowledge of processes and mechanical works (Polytechnic Level) | WWTP | - To record operation data as routine works<br>- To check operation conditions and report to the Operation Manager<br>- To conduct a Jar Test with the Lab. Team and adjust chemical dosing rate for sludge dewatering unit<br>- To check dewatered sludge conditions and record data | Operation Manager |
| 6 | Operator (four teams, eight-hour shifts) | Basic knowledge of operation method | WWTP | - To monitor sludge dewatering unit<br>- To record daily routine works<br>- To check sludge volume observation condition and record<br>- To identify problems of process/equipment and inform the Chief Operator<br>- Cleaning for plant. | Chief Operator |
| 7 | Mechanical Engineer | Full knowledge of mechanical machines (Polytechnic Level) | Other Section in DCWD | - To conduct routine maintenance<br>- To check and repair machines | Maintenance Manager |
| 8 | Mechanical Technician | Knowledge of routine maintenance works and repairing works | Other Section in DCWD | - To conduct periodic maintenance work for machines<br>- Repairing small defects at the site<br>- Piping repair, etc. | Maintenance Manager and Operation Manager at site |
| 9 | Electrical Engineer | Full knowledge of electrical panel and machines (Polytechnic Level) | Other Section in DCWD | - To conduct routine maintenance<br>- To check and repair panel/machine | Maintenance Manager |
| 10 | Electrical Technician | Knowledge of routine maintenance works and repairing works | Other Section in DCWD | - To conduct periodic maintenance work for machines<br>- Repairing small defects at the site<br>- Piping repair, etc. | Maintenance Manager and Operation Manager at site |
| 11 | Laboratory Technician | Knowledge of laboratory test | WWTP | - To conduct regular laboratory test<br>- Preparation of laboratory test result | Maintenance Manager and Operation Manager at site |

Source: JICA Survey Team

### 6.3.7 Possibility for Reuse of Treated Water

(1) Recycle Water Use in Magsaysay Park

As explained in Subsection 6.3.4, it is proposed to build the aquatic recreational spaces in Magsaysay Park. Treated water could be utilized most possibly in the recreational spaces. As an example of recreational water use, the Ochiai Water Reclamation Plant in Tokyo uses 50 $m^3$/day of water with necessary advanced (membrane) treatment out of the 450,000-$m^3$/day treatment capacity. In case of the proposed WWTP in Magsaysay Park, the treated water quality is quite good because of the use of MBR technology. Water can be used after necessary disinfection of water.

(2) Recycle Water Use in Santa Ana Port

Adjacent to the Magsaysay Park, the Santa Ana Port is also a candidate site for utilization of treated water. A pipeline will be connected to the port. The possible uses of treated water are as recreational/maintenance water in the green area and wash water for buildings/ships.

(3) Recycle Water Use in Industry

The JICA Survey Team tried to visit the ANFLO Industrial Estate/Damosa Land Inc., which is located in the north of Davao City. They tried to ask cooperation for the questionnaire survey for companies to confirm the demands for reuse of treated water in the WWTP. The request letter for meetings and cooperation was sent to the estate in the beginning of July, but the answer was not favorable for reuse of treated water, mainly due to the long distance from the WWTP site. Since there are few large-scale industries in the Poblacion and Agdao districts, the reuse of treated water in industries is quite difficult.

(4) Recycle Water Use in Shopping Mall

As mentioned in Subsection 3.3.1, it was confirmed that one shopping mall (SM Lanang in Agadao) has been using treated water from their own WWTP. The interview in the mall revealed that the company is interested in the utilization of treated water in the proposed WWTP, but it depends on the future upgrade (i.e., of treatment level, capacity) of their existing WWTP to comply with DAO 2016-08. In case their own WWTP will be enough for utilization of treated water, the company will use the treated water for the garden in the mall.

## 6.4 Study and Planning of Sewage Collection Method

### 6.4.1 General Concept

As proposed in Chapter 6, based on the comparison of the collection system and the case study in Area A, the JICA Survey Team proposes the following development methods.

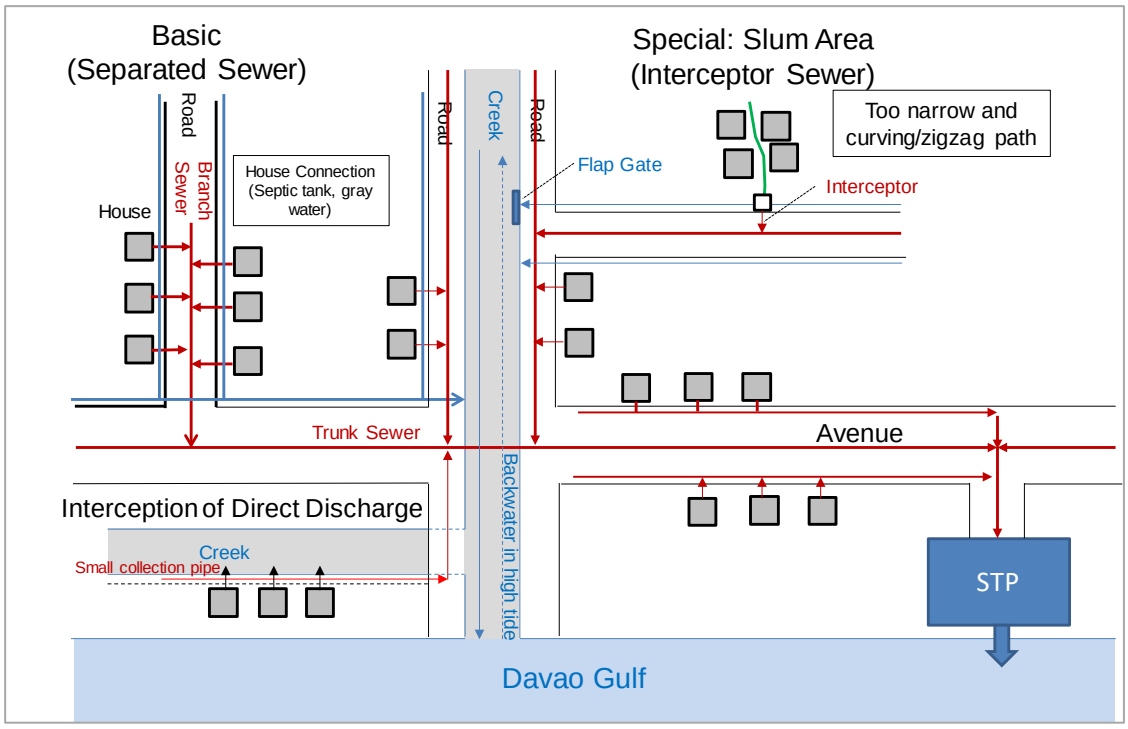
1) The separate sewer system is adopted as the final goal for the overall development concept for all the sewerage areas (Area A to F).

2) For rapid development and to secure enough wastewater flow for commissioning of the WWTP, specifically in the priority development area (Area A) and also in the other areas, the interceptor system can also be temporarily adopted in particularly congested areas depending on the site conditions (such as slope and cover of drains, existing drains, and back flow of sea water in drains by high tide) as shown in Figure 6.4.1. The interceptor will be utilized as a trunk sewer/sanitary sewer after land redevelopment and connection to individual buildings.

3) When these interception areas are redeveloped in the future, a separate sewer system will be introduced through the installation of sanitary sewers and the implementation of house connections. The interceptors will be utilized as a sanitary sewer.

4) The house connections to sewers are conducted with a local fund (i.e., assume it is funded by DCWD who would be the operator of the sewerage system and tariff collection), including switching of septic tanks to sewerage. However, the house connections in pilot area in commercial area are conducted with the JICA project fund (i.e., the location and scale of the pilot area is mentioned in Chapter 7).

5) The ditches in the slum areas should be improved with the local fund. The source and responsible agency should be discussed among concerned agencies, and it shall be clarified whether it is conducted as drainage improvement or sewerage work.




Source: JICA Survey Team

**Figure 6.4.1 General Concept of Sewage Collection**

### 6.4.2 Preliminary Categorization of Separate Sewer System and Temporal Interceptor System

The categorization of separate sewer development and temporary utilization of interceptor system is shown in Table 6.4.1 and Figure 6.4.2. The categorization is based on the following factors:

a) Population density: It is difficult to lay lateral sewer and house connections in high-density barangays with slum areas.

b) Road condition and site condition: It is difficult to lay sewer pipes in very narrow roads and private roads leading to the slums.

c) Seaside roads: In case there is a seaside road, interception of wastewater from the inside slum areas to the sea is relatively easy by installing an interception pipe under the seaside road.

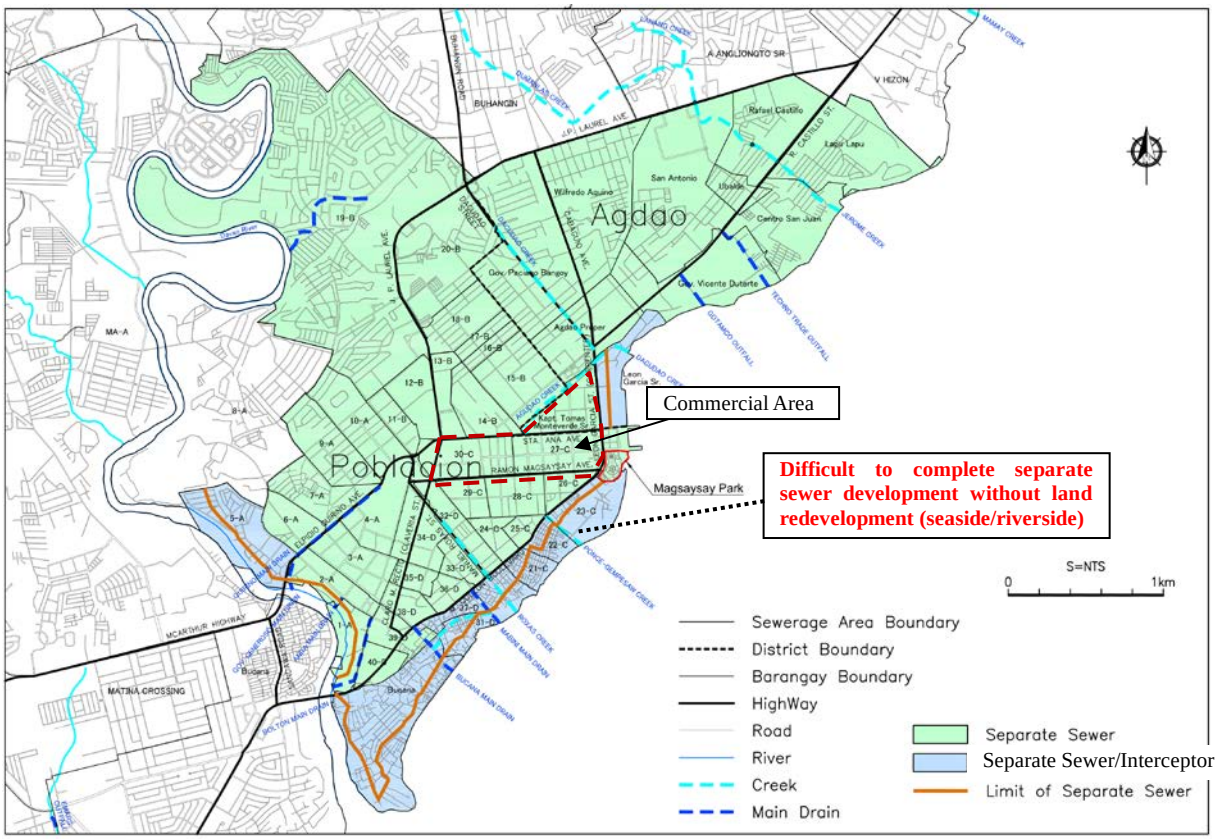
d) Drainage condition: Open channels (creeks) are difficult to intercept directly due to the flow volume and influence of backwater from the sea (salt water, dilution of wastewater). However, the main drains (underground culverts) are relatively easy to intercept and are able to efficiently collect wastewater from the scale and depth in congested areas. The groundwater level and invert level against seawater level and nearby trunk sewer should be considered for connection.

e) Land use (existing/future plan): Commercial and institutional areas are relatively more efficient to collect wastewater than residential areas due to large wastewater generation in one connection. The existence of large drain culverts in front of the buildings is a concern for house connections in commercial areas.

## Table 6.4.1 Categorization of Separate and Temporary Interceptor Sewer System for Area-A

| District | Barangay | Land Area | Population | Population Density 2030 | Assumed Household | Wastewater Generation 2030 | Large-scale Slum/Congested Area | General Policy for Collection System |
|---|---|---|---|---|---|---|---|---|
| | | (ha) | (2030) | (person/ha) | (2030) | (m3/day) | | |
| Agdao | Agdao Proper | 38.29 | 9,683 | 252.9 | 2,026 | 2,402 | | Separate |
| | Tomas Monteverde | 19.52 | 6,221 | **318.7** | 1,301 | 1,543 | Inland | Separate/Intercept |
| | Leon Garcia | 19.03 | 14,858 | **780.8** | 3,108 | 3,686 | Seaside(large) | Intercept/Separate |
| | Paciano Bangoy | 81.47 | 9,595 | 117.8 | 2,007 | 2,380 | | Separate |
| | Wilfredo Aquino | 72.26 | 10,778 | 149.1 | 2,255 | 2,674 | | Separate |
| | Centro San Juan | 43.48 | 16,963 | 390.1 | 3,549 | 4,209 | | Separate |
| | Lapu Lapu | 59.99 | 12,775 | 212.9 | 2,673 | 3,169 | | Separate |
| | Rafael Castillo | 44.54 | 6,294 | 141.3 | 1,317 | 1,562 | | Separate |
| | San Antonio | 89.88 | 11,216 | 124.8 | 2,347 | 2,783 | | Separate |
| | Ubalde | 9.98 | 3,228 | 323.4 | 675 | 801 | | Separate |
| | Gov.Vicente Duterte | 52.02 | 9,690 | 186.3 | 2,027 | 2,404 | | Separate |
| | Sub-total | 593.00 | **111,300** | | | | | |
| Poblacion | 1-A | 15.36 | 3,352 | 218.3 | 701 | 832 | River side | Separate/Intercept |
| | 2-A | 16.38 | 3,877 | 236.7 | 811 | 962 | River side | Separate/Intercept |
| | 3-A | 20.78 | 400 | 19.2 | 84 | 99 | | Separate |
| | 4-A | 23.51 | 1,818 | 77.3 | 380 | 451 | | Separate |
| | 5-A | 38.10 | 12,354 | **324.3** | 2,585 | 3,065 | River side | Separate/Intercept |
| | 6-A | 15.00 | 2,251 | 150.1 | 471 | 559 | | Separate |
| | 7-A | 22.50 | 4,304 | 191.3 | 900 | 1,068 | | Separate |
| | 8-A (Area B) | 159.10 | 11,964 | 75.2 | | | | |
| | 9-A | 27.50 | 6,155 | 223.8 | 1,288 | 1,527 | | Separate |
| | 10-A | 28.64 | 7,307 | 255.2 | 1,529 | 1,813 | | Separate |
| | 11-B | 9.57 | 2,054 | 214.7 | 430 | 510 | | Separate |
| | 12-B | 17.54 | 907 | 51.7 | 190 | 225 | | Separate |
| | 13-B | 11.26 | 461 | 41.0 | 97 | 114 | | Separate |
| | 14-B | 18.41 | 1,269 | 68.9 | 266 | 315 | | Separate |
| | 15-B | 31.54 | 3,123 | 99.0 | 653 | 775 | | Separate |
| | 16-B | 5.53 | 907 | 164.2 | 190 | 225 | | Separate |
| | 17-B | 5.63 | 875 | 155.5 | 183 | 217 | | Separate |
| | 18-B | 19.80 | 1,979 | 100.0 | 414 | 491 | | Separate |
| | 19-B | 362.55 | 34,316 | 94.7 | 7,179 | 8,514 | | Separate |
| | 20-B | 56.58 | 4,949 | 87.5 | 1,035 | 1,228 | | Separate |
| | 21-C | 8.56 | 8,078 | **943.4** | 1,690 | 2,004 | Seaside | Separate/Intercept |
| | 22-C | 8.71 | 7,167 | **822.6** | 1,499 | 1,778 | Seaside | Separate/Intercept |
| | 23-C | 21.31 | 17,813 | **835.8** | 3,727 | 4,419 | Seaside(large) | Intercept/Separate |
| | 24-C | 7.72 | 2,811 | 364.1 | 588 | 697 | | Separate |
| | 25-C | 4.96 | 2,125 | 428.7 | 445 | 527 | | Separate |
| | 26-C | 8.05 | 2,712 | 336.8 | 567 | 673 | | Separate |
| | 27-C | 30.99 | 2,325 | 75.0 | 486 | 577 | | Separate |
| | 28-C | 15.71 | 2,452 | 156.1 | 513 | 608 | | Separate |
| | 29-C | 10.20 | 1,682 | 164.9 | 352 | 417 | | Separate |
| | 30-C | 23.50 | 1,737 | 73.9 | 363 | 431 | | Separate |
| | 31-D | 22.60 | 8,989 | **397.8** | 1,881 | 2,230 | Seaside | Separate/Intercept |
| | 32-D | 17.90 | 2,144 | 119.8 | 449 | 532 | | Separate |
| | 33-D | 7.74 | 2,196 | 283.7 | 459 | 545 | | Separate |
| | 34-D | 19.63 | 1,817 | 92.6 | 380 | 451 | | Separate |
| | 35-D | 7.00 | 624 | 89.2 | 131 | 155 | | Separate |
| | 36-D | 6.93 | 1,708 | 246.5 | 357 | 424 | | Separate |
| | 37-D | 7.10 | 7,281 | **1025.5** | 1,523 | 1,806 | Inland | Separate/Intercept |
| | 38-D | 9.00 | 1,626 | 180.6 | 340 | 403 | | Separate |
| | 39-D | 12.80 | 5,556 | **434.1** | 1,162 | 1,378 | Inland | Separate/Intercept |
| | 40-D | 10.02 | 2,633 | 262.8 | 551 | 653 | | Separate |
| | Sub-total (incl. 8-A) | 1,138.20 | 188,100 | | | | | |
| | Sub-total (excl. 8-A) | **979.10** | **176,136** | | | | | |
| Talomo | Bucana (East:30%) | **120.60** | **35,009** | 290.3 | 7,324 | 8,686 | Seaside/ Riverside | Separate/Intercept |
| | | | | | | | | |
| | Area A Total | **1,692.70** | **322,445** | | **67,457** | **80,000** | | |

Source: JICA Survey Team




Source: JICA Survey Team

**Figure 6.4.2 Categorization of Separate and Interceptor Sewer System for Area-A**

In Table 6.4.1, "Separate/Intercept" means that the main development method is a separate sewer system, but the wastewater from the slum area should be intercepted. "Intercept/Separate" means that due to too high density and a few public roads with enough width, wastewater should be collected with interception as much as possible, and only the buildings beside the national road can use a separate sewer system. Therefore, 100% collection of wastewater is quite difficult in the "Intercept/Separate" barangays without redevelopment of the land, including resettlement of squatters.

Mentioned below are specific concepts for barangays which are difficult to develop with only a separate sewer system.

1) Agdao District

- Barangay Tomas Monteverde: Since the barangay includes a large commercial area, such as the Agdao Public Market, basically most of the area can be a separate sewer system. However, since one large slum exists in the barangay, wastewater should also be collected with interception.
- Agdao District, Barangay Leon Garcia: As the north side of Magsaysay Park is the opposite of Barangay 23-C in Poblacion District, its slum area is quite large. The wastewater from the slum area should be collected with interception as much as possible, but, basically, wastewater collection is limited to buildings beside the national road and a few public roads by a separate sewer.

2) Poblacion District

- Barangays 1-A, 2-A, and 4-A: The slums exist beside the Davao River, but it is limited in all the areas of barangays. Basically, a separate sewer can be adopted but the wastewater collection in the riverside slums are quite difficult due to the low discharge points towards river. It should also be intercepted from roads as much as possible if some wastewater flows from slums to roads. Otherwise, the slums should be resettled under the city ordinance to keep setbacks from the rivers/waterways.
- Barangays 21-C, 22-C: Located in the seaside, the barangays show relatively high population densities. However, those barangays have enough public roads which allow the collection of wastewater by a separate sewer system. Wastewater from inside slums, which are far from public roads, should be collected as much as possible with interception manholes after flowing towards drains in public roads.
- Barangay 23-C: Similar to Barangay Leon Garcia in Agdao District, it has a relatively large slum area without enough wide public roads. The measure is the same with Barangay Leon Garcia.
- Barangay 31-D: It is located in the seaside, and the population density is high but less than Barangays 21-C and 22-C. Much wastewater can be collected with a separate sewer but much wastewater should be intercepted from the Mabini Main Drain and interceptor under the seaside road (see the location in Figure 6.5.1 and the images in subsection 7.2.4).
- Barangays 37-D, 39-D: The barangays are located not directly beside but still near the sea. The population densities are high, and collection of wastewater with a separate sewer is impossible. Wastewater from scattered slum areas should be collected with interception manholes.

Talomo District

- Barangay Bucana (East Side): The barangay has slums beside both the Davao Gulf and the Davao River. Most of the wastewater can be collected with a separate sewer system due to enough wide public roads, but wastewater in the east side slums near the seaside should be intercepted from the Bucana Main Drain and the interceptor under the seaside road (see Figure 6.5.1 and subsection 7.2.4). Wastewater in the slums beside the Davao River should be collected as much as possible with interception manholes, as in the case of Barangays 1-A, 2-A, and 4-A.

## 6.5 Planning of Sewer Facility

### 6.5.1 Trunk Sewer

The trunk sewer routes conveying the wastewater from barangays to the WWTP in Magsaysay Park are shown in Figure 6.5.1. It also shows the interception points from the main drains.

The pipe jacking method is proposed to be applied in the following cases:

1) There is heavy traffic in roads where the pipe is installed, such as in national roads.

The impact of excavation to the traffic in the road should be minimized.

2) The planned invert level of the sewer is very low.

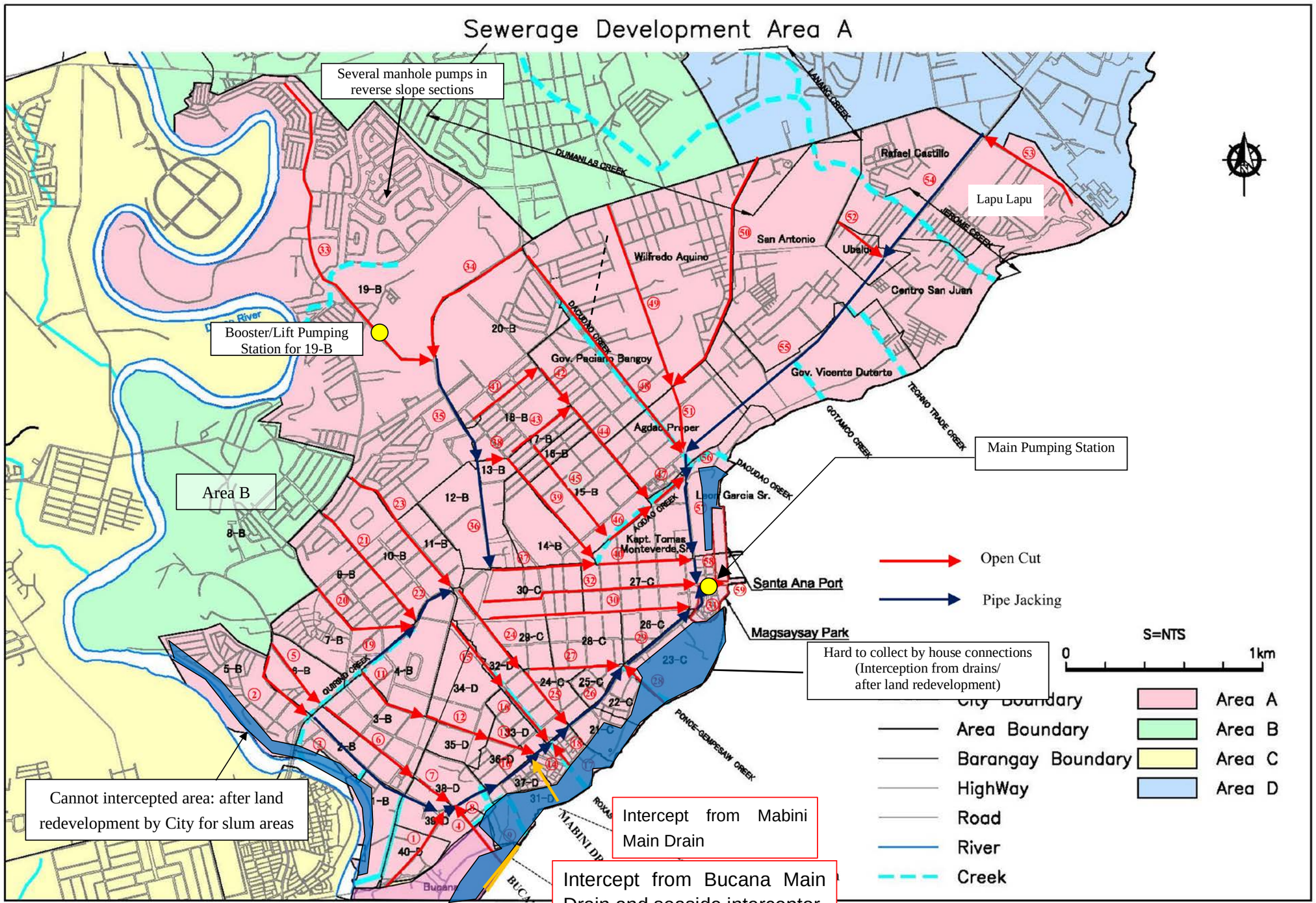
In case the pipe position is quite deep in the ground, the excavation width gets larger, and the impact to the traffic is large in case the road does not have enough width. In such cases, the pipe jacking method, instead of the open cut method, can shorten the construction period.

The summary of trunk sewer lengths per diameter and open cut/trenchless is shown in Table 6.5.1. The flow calculation and the longitudinal profile are shown in Appendix 6.4.

**Table 6.5.1 Summary of Trunk Sewer Length in Area-A**

| No. | Diameter | Length (m) | | | Note |
|---|---|---|---|---|---|
| | | Open | Trenchless | Total | |
| 1 | 400 mm | 23,100 | 500 | 23,600 | No.52 |
| 2 | 450 mm | 0 | | 0 | |
| 3 | 500 mm | 600 | 1,500 | 2,100 | No.53,54 |
| 4 | 600 mm | 1,300 | 1,200 | 2,500 | No.3,4 |
| 5 | 700 mm | 3,200 | 800 | 4,000 | No.28, 35,51 |
| 6 | 800 mm | 1,300 | 2,200 | 3,500 | No.36,37,40,55 |
| 7 | 900 mm | 0 | 0 | 0 | |
| 8 | 1000 mm | 0 | 0 | 0 | |
| 9 | 1100 mm | 300 | 0 | 300 | |
| 10 | 1200 mm | 0 | 700 | 700 | No.56,57 |
| 11 | 1400 mm | 0 | 300 | 300 | No.8,10,14 |
| 12 | 1500 mm | 0 | 800 | 800 | No.18,26,58 |
| 13 | 1650 mm | 0 | 800 | 800 | No.29,31 |
| 14 | 2000 mm | 100 | | 100 | No.59 to WWTP |
| | Total | 29,900 | 8,800 | 38,700 | |

Source: JICA Survey Team




Source: JICA Survey Team

**Figure 6.5.1 Trunk Sewer Map in Area A**

### 6.5.2 Lateral Sewer and House Connection

(1) Lateral Sewer

The development of lateral sewers in barangays is necessary to collect wastewater from households with a separate sewer system. The estimated lateral sewer lengths per diameter in the entire Area A are shown in Table 6.5.2. The details of the total sewer lengths in barangays are shown in Appendix 6.5. The lateral sewer lengths were estimated based on the existing road network length in barangays obtained from the CPDO.

**Table 6.5.2 Summary of Lateral Sewer Length in Area A**

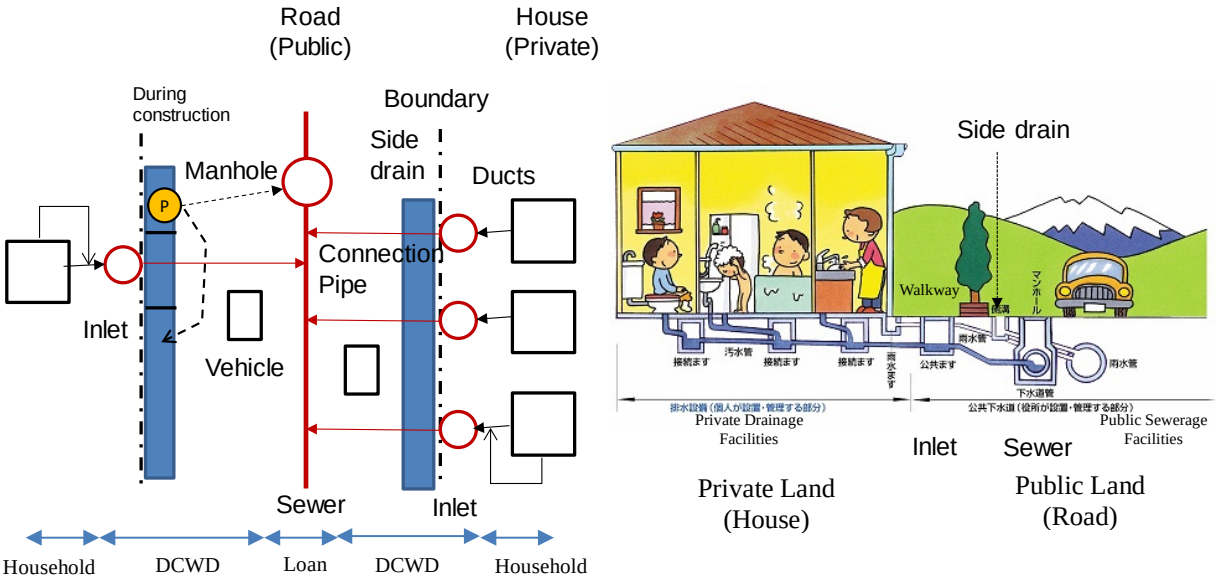
| No. | Diameter | Installation Method | Length (km) | | |
|---|---|---|---|---|---|
| | | | Poblacion | Agdao | Total |
| 1 | 200 mm | Open cut | 120 | 56 | 176 |
| 2 | 250 mm | Open cut | 29 | 18 | 47 |
| 3 | 300 mm | Open cut | 16 | 8.9 | 25 |
| 4 | 350 mm | Open cut | 9.9 | 4.9 | 15 |
| 5 | 400 mm | Open cut | 5.7 | 2.9 | 8.6 |
| 6 | 450 mm | Open cut | 4.7 | 0 | 4.7 |
| 7 | 500 mm | Open cut | 1.5 | 0 | 1.5 |
| | Total | | 187 | 91 | 278 |

Note: Poblacion includes Bucana (East) in Talomo District
Source: JICA Survey Team

(2) House Connection

House connections are required to collect wastewater from buildings. An image of the house connection is shown in Figure 6.5.2. The connection pipes between the lateral sewer and inlets are developed by the implementation agency. The ducts from the house to the inlet is basically developed by house owners. The inlets should be basically installed in public lands (ideally walkway in front of houses as shown in right side figure). However, in Davao, where many large-scale side drains are beside the public-private boundary without walkway or under the walkways, the inlets would be installed on the edge of the private land as shown in the left side of the figure. This is to mitigate the burden of connection works to inlets by building owners, as is the usual case of water supply valves in such area.

The house connection work requires greater time and funds for completing the work since around 67,000 connections shall be achieved in the entire Area A as shown in Table 6.4.1. The various aspects should be discussed and planned by the implementing agency for efficient and continuous development of sewer connections (domestic/commercial) and understanding/cooperation of customers in the early stage. Table 6.5.3 shows the issues and assumed responsible agency after general discussion with Davao City and DCWD.




Source: JICA Survey Team

**Figure 6.5.2 Image of House Connection**

**Table 6.5.3 Issues and Assumed Actions for Sewer Connection Works**

| No. | Technical/Implementational Issue | Assumed Responsible Agency and Actions |
|---|---|---|
| 1 | Establishment of city ordinance for redevelopment of drainage facilities (kitchen, toilet, rainwater) in the buildings | City Administration will issue the new ordinance separate from the one for septic tanks and septage collections since sewer pipes are new facilities. |
| 2 | Approval for application of appropriate drainage facility structures | City building office (CBO) will be in charge of approval. |
| 3 | Preparation of guideline for pipe material and sewer inlet structure | DCWD would be in charge of sewer connections and prepare the guideline based on one for water supply connections. |
| 4 | Training of contractors for sewer connection works | DCWD would list the contractors from the existing ones for water supply connections and septic tank installation/septage collection and train after preparation of training manual. (Technical cooperation by JICA if necessary). |
| 5 | Announcement to public on the above matters | City and DCWD will jointly announce to citizens in the offices and seminars since the connection costs will be basically owed by citizens. |
| 6 | Organization of implementation regime for the works | DCWD will be the implementing agency in general for connection works. Appropriate sharing of roles between city and DCWD should be discussed in the next stage in case the City will be the implementation agency for construction. |

Source: JICA Survey Team

Notes on Wastewater Collection from Industries

The wastewater collection from industries is important theme for future sewerage development in entire sewerage development area which is not limited to only Area A. The following matters are to be considered;

1) When connecting to the sewer, the necessity of pre-treatment will be examined by EIA, etc., and then inflow volume and water quality to the treatment plant, treatment fee, etc. will be examined. If food

wastewater inflows to the sewer, the inflow load to the treatment plant may increase due to high BOD. Since the wastewater is treated with biological treatment at the WWTP, most of high BOD wastewater can be treated but heavy metals cannot be treated.

2) After connection of sewer to industry, regular monitoring of industrial wastewater is required.

3) If not connected, own treatment facilities shall be constructed so that the effluent can meet the water quality standards of the public water bodies.

4) If interceptor sewer system with utilization of existing drains will be adopted partly, the inflow of industrial wastewater to the sewer may occur by existing or future connections to drain.

### 6.5.3 Pumping Station

(1) Pumping Station on Trunk Sewer Routes

Due to the relatively low level of WWTP with the fully underground structure of the WTF, the intermediate and main pumping stations are not required according to the estimation. It should be confirmed in next stage with planning (downstream elevation) of lateral sewers in barangays.

Since there is a hill between Poblacion 19-B and Poblacion 20-B, a pumping station or trenchless pipe installation is required to cross the hill and convey wastewater to Poblacion 20-B.

(2) Manhole Pumping Stations in Barangays

The manhole pumping stations should be installed at the connection points of lateral sewers to trunk sewers in case the invert elevation of the lateral sewer is lower than the trunk sewer. Since the invert level of the trunk sewer in seaside area is as low as around 10 m underground, the requirement of the pumping stations in barangays is low enough. Therefore, the JICA Survey Team assumes that the total number of the required manhole pumping stations is less than 10 in the entire Area A.

## 6.6 Preliminary Estimation of Project Cost and Study on Implementation Schedule

The project cost (capital cost and O&M cost) for the priority development work in Area A is preliminary estimated as follows.

### 6.6.1 Capital Cost

As a preliminary level, the estimated total capital cost for the project is around PHP 18 billion (= JPY 38 billion) as shown in Table 6.6.1. The amount is almost the same scale with the one in IM4D, which was PHP 17.4 billion, adding the “Sewer Water Collection System” in each area as the locally developed part.

### 6.6.2 O&M Cost

The preliminary estimate of operation and maintenance cost is shown in Table 6.6.2. The total cost of the WWTP and the Sewer/Pumping Station (P/S) is around PHP 430 million/year (= equivalent to around JPY 900 million/year).

**Table 6.6.1 Preliminary Estimation of Capital Cost for Sewerage Development in Area A**

| No. | Item | Capital Cost | | Note |
|---|---|---|---|---|
| | | (PHP million) | (JPY million equivalent) | |
| 1 | Construction Cost | 16,475 | 34,598 | |
| (1) | Wastewater Treatment Plant (WWTP) and remodeling of Magsaysay Park | 7,381 | 15,500 | 97,000 m3/day |
| 1) | Land acquisition | 0 | 0 | |
| 2) | Land foundation, temporary soil retaining | 112 | 234 | |
| 3) | Civil and Building | 2,135 | 4,483 | Underground |
| 4) | Water treatment facility | 2,407 | 5,054 | MBR |
| 5) | Sludge treatment facility | 1,498 | 3,146 | Thickening, Dewatering, Drying (all mechanical) |
| 6) | Park remodeling | 1,230 | 2,583 | Utilize treated water |
| (2) | Sewer pipeline (interceptor, separate sewer) | 9,095 | 19,099 | |
| 1) | Trunk sewer | 4,505 | 9,460 | Dia 400-2000, 38.7km inc. pipe jacking |
| 2) | Sanitary sewer in separate sewer area | 3,793 | 7,965 | Dia 200-500, 278km |
| 3) | Temporal interceptor sewer and manholes | 77 | 161 | Dia 400 x 350m, Dia 500 x 800m, CSOs, flap gate |
| 4) | Pumping stations | 637 | 1,339 | Main P/S in STP, Manhole pumps |
| 5) | House connection in pilot area | 83 | 174 | 2,400 connections from lateral sewer to inlet |
| 2 | Consulting services | 1,318 | 2,768 | |
| | Total Project Cost | 17,793 | 37,366 | |
| | House connections outside JICA Project | 2,070 | 4,346 | Around 59,000 connections |
| | Total Project Cost | 19,863 | 41,713 | |

Note: 1. PHP/JPY = 2.10 as of July 2019
2.All sewers include manholes/interception chambers
3. Cost for house connections from buildings to inlets are owned by building owners incl. pilot area
4. Construction cost includes administration cost
Source: JICA Survey Team

**Table 6.6.2 Preliminary Estimation of O&M Cost for Sewerage Development in Area A**

| No. | Item | O&M Cost | | Note |
|---|---|---|---|---|
| | | (PHP million/year) | (JPY million equivalent) | |
| **1** | **Wastewater Treatment Plant (WWTP)** | **343.9** | **722.3** | 97,000 m3/day |
| 1) | Energy Cost | 135.8 | 285.1 | |
| 2) | Chemical Cost | 38.9 | 81.7 | |
| 3) | Sludge disposal cost | 2.2 | 4.7 | |
| 4) | Manpower cost | 10.9 | 22.8 | |
| 5) | Maintenance cost | 156.2 | 328.0 | |
| **2** | **Wastewater Collection Facility** | **112.1** | **235.4** | |
| 1) | Energy Cost for Pumping Stations | 32.0 | 67.2 | Main P/S in WWTP, Brgy 19-B, Manhole pumps |
| 2) | Maintenance Cost for Sewer and P/S | 80.1 | 168.2 | |
| | **Total O&M Cost** | **456.1** | **957.7** | |

Note: PHP/JPY = 2.10 as of July 2019, Energy charge = PHP 7.67 /kwh
Maintenance works for sewer and P/S are cleaning, exchange of small parts of pumps etc.
Source: JICA Survey Team

### 6.6.3 Renewal Cost

For the financial analysis for 30 years in Subsection 6.7.2, the renewal cost of electromechanical equipment was initially estimated as shown in Table 6.6.3. To simplify the condition, all the equipment is assumed to be renewed after 20 years from commissioning of WWTP. The civil/architectural structures and pipes continue to be used after 20 years with proper annual maintenance (the costs are included in O&M cost).

**Table 6.6.3 Preliminary Estimation of Renewal Cost for Sewerage Facilities in Area A**

| No. | Item | Renewal Cost (after 20 | | Note |
|---|---|---|---|---|
| | | (PHP million) | (JPY million equivalent) | |
| (1) | Wastewater Treatment Plant (WWTP) | 2,892 | 6,074 | 97,000 m3/day |
| 1) | Civil and Building | 640 | 1,345 | Architectual equipment (lighting, fans, etc.) |
| 2) | Water treatment facility | 1,203 | 2,527 | MBR |
| 3) | Sludge treatment facility | 1,049 | 2,202 | Thickening, Dewatering, Drying (all mechanical) |
| (2) | Sewer pipeline | 858 | 1,803 | |
| 1) | Trunk sewer from each area | 347 | 728 | Minor replacements such as manhole covers, Survey, large scale cleaning & repair |
| 2) | Sanitary sewer in separate sewer area | 0 | 0 | |
| 3) | Interceptor sewer in interceptor area | 2 | 4 | Flap gate |
| 4) | Pumping stations | 510 | 1,071 | Pumps and misc. equipment in Main P/S, Manhole pumps |
| | Total Renewal Cost | 3,751 | 7,876 | |

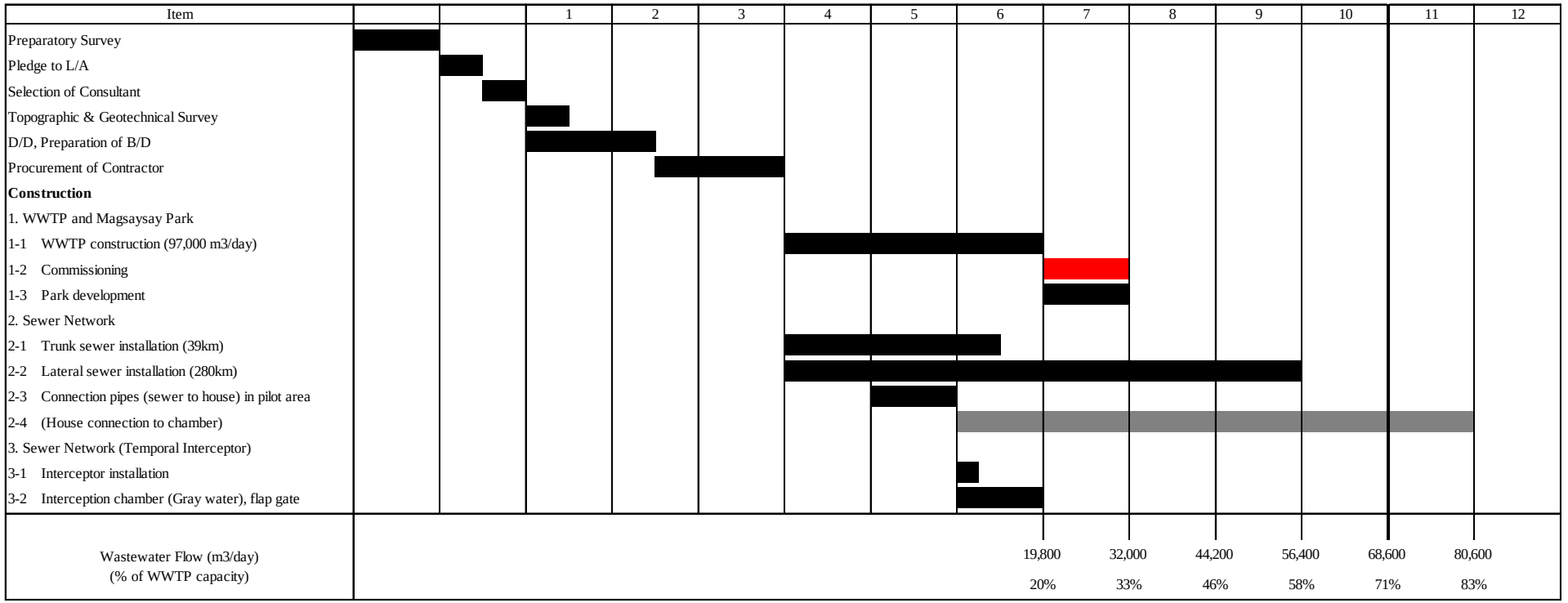
Note: PHP/JPY = 2.10 as of July 2019
Source: JICA Survey Team

### 6.6.4 Implementation Schedule

As shown in Table 6.5.1, the trunk sewer length is 39 km, and the lateral sewer length is 280 km. Under these assumptions and based on the following assumption for construction works, the preliminary and minimum installation schedule is shown in Figure 6.6.1.

Since the timing of commencement of sewer installation/house connection should be closely related with commissioning of WWTP, the rough and tentative schedule of the WWTP was included in the schedule. As much as possible, wastewater should be collected at the initiation of commissioning.

The separate sewer installation is at least six years with the rapid installation of 20 m/day/party x 10 parties for the separate sewer part only. The house connection is more than six years with the rapid connection works of 2 household/day x 20 parties. Therefore, completion of all the construction works by the end of defect notification period (DNP) (i.e., ten years from initiation of project) is quite difficult. It is realistic that 1) to finish interceptor parts within the project period, 2) to establish the priority development areas of separate sewer system and to finish works within project period, and 3) implementation agency start works of separate sewers and house connections in the project period and continue even after the end of project.




Note: * Lateral sewer installation with 20 m/day/party by 10 construction parties (total 80,600 $m^3$/day) in 2030 *97,000 $m^3$/day in 2045
Source: JICA Survey Team

**Figure 6.6.1 Preliminary Project Implementation Schedule in Area A**

## 6.7 Study on Financial Scheme and Preliminary Financial Analysis of the Priority Project

### 6.7.1 Implementing Agency and Financing Scheme

(1) Study on Potential Financing Schemes

The JICA Survey Team studied several potential implementing agencies (i.e., DPWH, DCWD, and LGU) and applicable financing schemes. Both public financing and private financing schemes were examined (see Table 6.7.1).

**Table 6.7.1 Financing Scheme Options**

| Public/PPP | Scheme No. | Implementing Agency | Loan Type | Loan Flow |
|---|---|---|---|---|
| Public Project | 1 | DPWH | ・Direct ODA loan | ・JICA→DOF→DPWH |
| | 2-1 | DCWD | ・Two Step Loan (TSL) | ・JICA→LBP/DBP→DCWD |
| | 2-2 | LGU | ・Two Step Loan (TSL) | ・JICA→LBP/DBP→LGU |
| | 3 | LGU | ・ODA loan to fund DOF's Municipal Development Fund | ・JICA→DOF（Municipal Development Fund）→LGU |
| PPP Project | 4 | Gov: DPWD<br>Private: SPC | ・PSIF<br>・TSL<br>・Commercial bank loan | ・JICA→SPC<br>・JICA→LBP/DBP→SPC<br>・Bank→SPC |
| | 5 | Gov: LGU<br>Private: SPC | ・PSIF<br>・TSL<br>・Commercial bank loan | ・JICA→SPC<br>・JICA→LBP/DBP→SPC<br>・Bank→SPC |

Source: JICA Survey Team

Note that this survey assumes the project will utilize the Philippine national government grant from the National Sewerage and Septage Management Program (NSSMP), which covers 50% of the initial cost. The remaining initial cost is assumed to be funded by either or combination of equity and debt by the implementing agency. Table 6.7.1 describes the probable loan type and loan flow for the debt portion.

(2) National Sewerage and Septage Management Program (NSSMP) Grant

As per the National Economic and Development Authority (NEDA) Board Resolution No.3/2012 and 2017 amendment, NEDA approved that the Philippine national government provides 50% of the initial cost of the sewerage and septage project for 17 Highly Urbanized Cities (which includes Davao City). The key findings[1] of the NSSMP grant are as follows:

- Grant Amount

  ・It covers 50% of initial cost of the project. No ceiling to the amount is set.

  ・To get approval, the LGU needs to prove in the application documents that it has a funding source for the remaining initial cost (can be general budget or loan).

- Eligible Applicant

  ・The LGU needs to apply and receive the grant, not DCWD, since DPWH does not have a legal basis of providing grant to water districts.

[1] Based on interview with DPWH NSSMP grant office held on 19 August 2019.

・When DCWD becomes the implementing agency, the LGU needs to authorize DCWD to apply for the grant. Even so, the grant first will be downloaded to the LGU, then passed onto DCWD[2].

・The guideline of NSSMP with the PPP scheme is in the draft. Until finalized and approved, usage of the grant within the PPP framework is not possible.

■ Budgeting of NSSMP grant

・NEDA grants final approval.

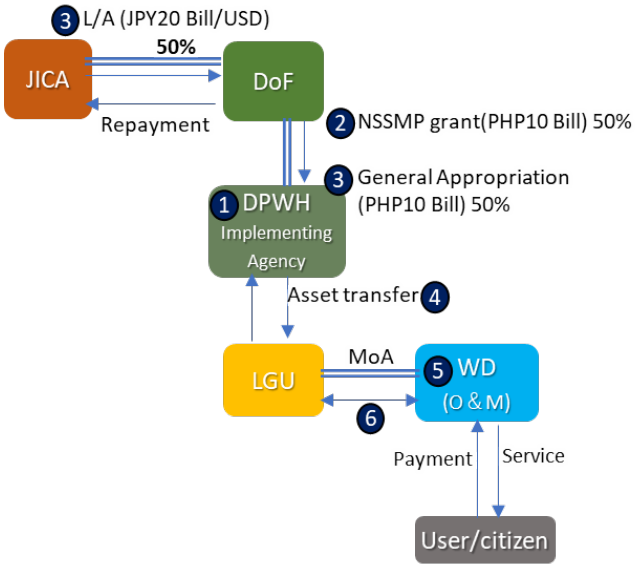
・From 2019, DPWH will request the grant budget for the approved project only (since DBM now applies cash base policy). Therefore, the application needs to be approved at least a year before construction starts.

(3) Public Financing Schemes

In August 2019, the JICA Survey Team conducted information hearing from relevant agencies of each potential financing scheme.

**1) DPWH as Implementing Agency**

Since the Clean Water Act (2004) mandates DPWH to establish NSSMP, the JICA Survey Team sought for the possibility of DPWH becoming the implementing agency, in addition to using the NSSMP grant. That way, the LGU (and DCWD) would only finance the O&M part which would significantly reduce their financial burden (Figure 6.7.1).

| Scheme Diagram | Key Description |
|---|---|
|  | **【Construction period】**<br>① DPWH as implementing agency<br>② 50% of CAPEX is funded by NSSMP grant *1<br>③ The rest of CAPEX (50%) is funded by DOF as general appropriation, sourced by ODA loan (JPY/USD)<br>④ Asset transfer to LGU after construction<br><br>**【Operation period】**<br>⑤ WD conducts O&M and tariff collection based on MoA<br>⑥ If tariff revenue is:<br>- Less than OM cost, LGU shall provide subsidy to WD |

Note:
Source: JICA Survey Team

**Figure 6.7.1 Scheme Diagram with DPWH as Implementing Agency**

DPWH responded that this is a highly unlikely institutional arrangement. In principle, DPWH's priorities are highways, bridges, and flood management. Hence, the sewerage sector is not one of them.

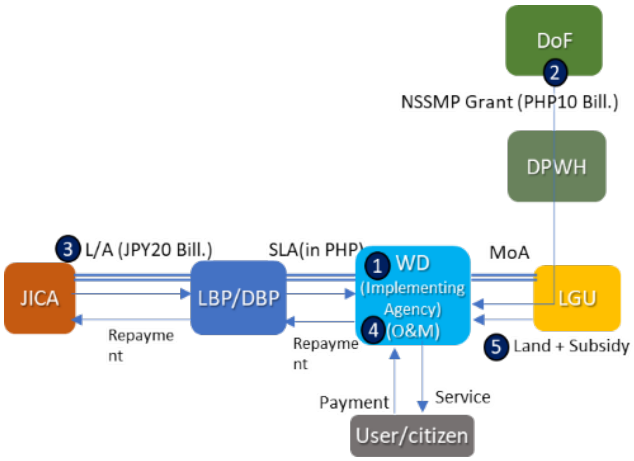
[2] Zamboanga LGU and WD were approved of the grant, with WD being project owner authorized by LGU.

DPWH already has many ODA projects in the pipeline, and adding this huge CAPEX project for one local government will cause controversy among stakeholders. Also, DPWH commented that the NSSMP grant is designed for the LGU to utilize, not for DPWH.

Based on the viewpoints of DPWH, the JICA Survey Team concluded that this scheme is highly unlikely and not to be further pursued.

**2-1) DCWD as Implementing Agency (Two Step Loan)**

In this scheme, DCWD becomes the implementing agency and funds the initial cost with NSSMP grant and loan (Figure 6.7.2). It is assumed that the LGU would provide necessary land to DCWD based on Clean Water Act 2004, which stipulates that the LGU shall do so.

| Scheme Diagram | Key Description |
|---|---|
|  | **【Construction period】**<br>① WD as implementing agency<br>② 50% of CAPEX is funded by NSSMP grant *1<br>③ WD takes loan to fund the rest of CAPEX<br><br>**【Operation period】**<br>④ WD conducts O&M and tariff collection based on MoA with LGU<br>⑤ If tariff revenue is:<br>- Less than OM cost, LGU shall provide O&M subsidy + CAPEX repayment subsidy to WD<br>- More than OM cost, LGU shall provide CAPEX repayment subsidy to WD |

Source: JICA Survey Team

**Figure 6.7.2 Scheme Diagram with DCWD as Implementing Agency (Two Step Loan)**

The main comment of DPWH was that the LGU needs to apply and receive the NSSMP grant as aforementioned, which could be passed to DCWD based on the MoA. To enable this, close communication and coordination between LGU and DCWD is crucial.

The Two Step Loan is the probable loan scheme since there is no precedent case in which JICA extends direct loan to local governments (i.e., LGUs) or government-owned and controlled company (i.e., water districts) without guarantee from recipient government. The Philippine government does not have legal basis (or mandate) to do so[3].

Government banks (i.e., LBP and DBP) have been the intermediary banks in the existing Two Step Loan projects in the country. Table 6.7.2 shows the indicative financial cost of Two Step Loan for DCWD as of October 2019.

[3] Based on interview to DOF on 19th August 2019.

**Table 6.7.2 Indicative Financial Cost of Two Step Loan (DBP to DCWD)**

TWO STEP LOAN (DBP to DCWD)

| Breakdown | % | Note |
|---|---|---|
| Yen Loan | 1.2% | 30 yrs incl. grace period 10 yrs |
| Consulting fee | 0.01% | |
| Front End fee | 0.20% | Initial year only |
| Governement guarnatee | 1.5% | Indicated range :0.25% - 1.5%, Determined by DOF |
| Foreign exchange risk coverage fee | 3.5% | Indication from past rate. Determined by DOF |
| 100% | 0.5% | based on Sep 25th interview to DBP Davao Lending Center |
| Indicated financial cost | 6.71% | p.a. （excl. front end fee) |

Source: JICA Survey Team

The DBP Headquarters (HQ) expressed that the size of the previous JICA-DBP Two Step Loan (i.e., Environmental Development Program) was PHP 1.5 billion, and it was implemented in multiple projects. DBP is looking for a big-ticket project and will seek for the possibility of funding one specific project through the TSL. The DBP HQ also mentioned that due to the single borrower's limit (around PHP 10 billion)[4], DBP is interested in the syndication loan.

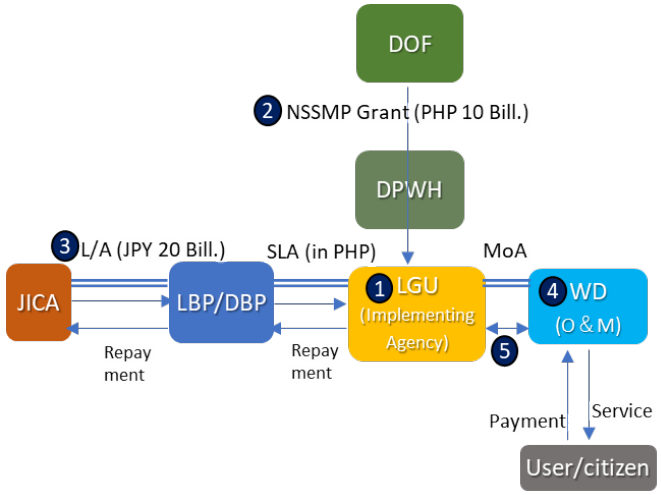
During an interview in the DBP Davao Lending Centre, it was discovered that DCWD's strong financial statement will avail of the prime rate on the DBP spread. Also, DCWD's borrowing capacity of DCWD is approximately PHP 15 billion, which is derived by the current equity amount and outstanding loan of DCWD.

DCWD acknowledges that it is their mandate to provide wastewater treatment service. However, DCWD is currently focusing on a septage project since it is less costly and can expect full cost recovery by an affordable tariff rate. DCWD expresses that under LWUA ring-fencing regulation, they cannot increase the water tariff to cover the sewerage project cost, and, under such condition, it is difficult for DCWD to enter into this capital-intensive sewerage project.

**2-2) LGU as Implementing Agency (Two Step Loan)**

In this scheme, the LGU becomes the implementing agency and avails of the NSSMP grant and the Two Step Loan (Figure 6.7.3).

[4] Central Bank Regulation (Circular No.425/2004) "credit accommodations and guarantees that may be extended by a bank to any person, partnership, association, corporation or other entity shall at no time exceed twenty-five percent (25%) of the net worth of such bank"

| Scheme Diagram | Key Description |
|---|---|
|  | **【Construction period】**<br>① LGU as government contracting agency<br>② PPP (Availability Payment) contract between LGU and SPC<br>③ SPC designs, builds and finances the project facility<br>④ City provides 50% of CAPEX through NSSMP grant<br>⑤ City provides land + permits<br><br>**【Operation period】**<br>⑥ SPC (mainly WD) collects tariff and revenue will be transferred to LGU.<br>⑦ LGU provides availability payment to SPC based on SPC's performance<br>⑧ SPC repays to lender and provides dividend to investor |

Source: JICA Survey Team

**Figure 6.7.3 Scheme Diagram with LGU as Implementing Agency (Two Step Loan)**

DPWH agrees with this institutional arrangement and expresses that this is the intention for the NSSMP grant.

Based on the interview with LBP (i.e., HQ and Davao Lending Center), is the indicative financial cost of the Two Step Loan.

**Table 6.7.3 Indicative Financial Cost of Two Step Loan (LBP to LGU)**

TWO STEP LOAN (LBP to LGU)

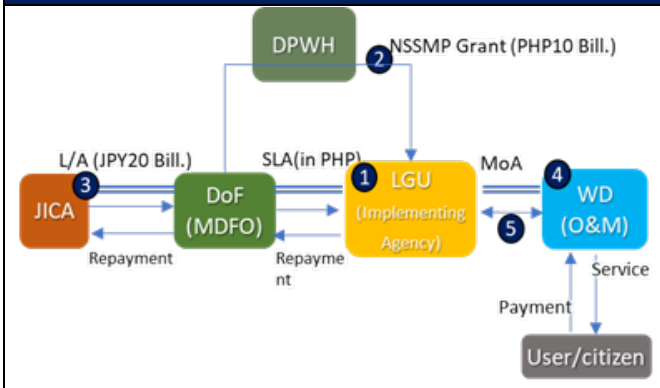
| Breakdown | % | Note |
|---|---|---|
| Yen Loan | 1.2% | 30 yrs incl. grace period 10 yrs |
| Consulting fee | 0.01% | |
| Front End fee | 0.20% | Initial year only |
| Governement guarnatee | 1.5% | Indicated range :0.25% - 1.5%, Determined by DOF |
| Foreign exchange risk coverage fee | 3.5% | Indication from past rate. Determined by DOF |
| LBP Spread | 0.5% | based on Aug 23th interview to LBP Davao Lending Center |
| Indicated financial cost | 6.71% | p.a. （excl. front end fee) |

Source: JICA Survey Team

### 3) LGU as Implementing Agency (Municipal Development Fund)

In this scheme, the LGU is the implementing agency, and it utilizes the MDFP[5], which is offered by DOF to provide a concessional loan for projects involving a sewerage and sanitation facility (Figure 6.7.4).

[5] http://www.mdfo.gov.ph/download/new/mdfp.pdf

| Scheme Diagram | Key Description |
|---|---|
|  | **【Construction period】**<br>① LGU as implementing agency<br>② 50% of CAPEX is funded by NSSMP grant *1<br>③ LGU takes MDFP loan to fund the rest of CAPEX<br><br>**【Operation period】**<br>④ WD conducts O&M and tariff collection based on MoA<br>⑤ If tariff revenue is:<br>- Less than OM cost, LGU shall provide OM subsidy to WD<br>- More than OM cost, WD shall pay LGU the surplus which will become part of debt service. |

Source: JICA Survey Team

**Figure 6.7.4 Scheme Diagram with LGU as Implementing Agency (Municipal Development Fund Project)**

The key findings from interview[6] with DOF are as follows:

- The JICA loan can fund MDFP to be sub-lent to the LGU for this project. The sub-loan can have a longer validity and grace period than the original MDFP (i.e., 20 years with grace period of 3 years), to accommodate the needs of the project.
- In such case, the financial cost would be different from the original MDFP terms (i.e., 4.25%). The final figure will be determined by the DOF Secretary based on the funder's cost, DOF administration cost, FX risk coverage cost, etc.[7]
- DOF does not have a mandate to guarantee the LGU's debt; however, DOF can explore an alternative mechanism. For example, in the event of default, DOF would temporarily repay and (through DBM) deduct the LGU's Internal Revenue Allotment from the next fiscal year.
- Utilizing NSSMP grant along with the MDFP loan should not be a problem.
- When the LGU takes a loan, two certificates need to be issued by the Bureau of Local Government Financing (under DOF). The certificates are 1) borrowing capacity of LGU[8] (i.e., amount that the LGU can still borrow), and 2) net debt service capacity (i.e., amount of annual debt service that the LGU can afford). The preliminary estimation (i.e., calculated during the interview) is 1) PHP 15.7 billion and 2) PHP 1.32 billion, which means that the LGU is eligible to take a loan for the remaining CAPEX of the priority project (PHP 8.89 billion).

(4) Private Financing Scheme

The JICA Survey Team also conducted informational interviews toward relevant agencies to have a sense of whether the PPP scheme could be applied to the project. Since a preliminary financial analysis showed that the project is commercially unviable, the applicability of the availability payment (AP)

[6] Conducted on 20th August, 2019
[7] Although indictive figure was not given at this stage of the survey, DOF commented that it will be concessional terms.
[8] Calculated based on the past three years IRA and local tax and service revenue of LGU together with current annual debt service.

scheme was sought. As for the Government Contracting Agencies, the JICA Survey Team looked for two possible scenarios: 1) DPWH and 2) LGU.

Although the availability payment scheme has legal basis in the Philippine PPP regulation (BOT Law 2012), the JICA Survey Team found it difficult to materialize for this project. The main reasons are that 1) private firms seemed reluctant to participate unless it concerns the water and sewerage combined project; 2) the LGU has neither become the government contracting agency (GCA) of a PPP project nor had a multi-year budget commitment for a project; 3) the justification of DPWH becoming a GCA of a local project and procuring AP budget is difficult; and 4) the NSSMP grant will not be applied to PPP projects until its guideline is finalized and approved. Information collected regarding the PPP Availability Scheme is described in Appendix 6.6.

(5) Summary

Since it is deemed unlikely for DPWH to become the implementing agency of the local sewerage project, the JICA Survey Team omitted that option. The discussion as to which agency, namely; LGU and DCWD, should become the project owner is yet to be settled. DCWD's function is focused on providing water and sewerage service, and the tariff collection network that DCWD has developed is an effective way of collecting sewerage tariff. On the other hand, LWUA's ring fencing regulation continues to be the bottleneck. DCWD insisted that unless the project has full cost recovery prospectus, then they cannot invest.

For financial analysis purposes, this study sets the LGU as implementing agency. The LGU is the most eligible to utilize the NSSMP grant, and it can allocate part of its development fund to the project. The LGU is most capable to designate land for the project and to facilitate the relevant permits. The LGU would still need the expertise and human resource of DCWD to implement and operate the facilities and to use the tariff collection network, which DCWD has developed.

Since the terms and conditions of the MDFP loan (financed by JICA loan) is unclear at this stage of the study, **the JICA Survey Team assumes that the Two Step Loan is applied for the loan portion of the project. This does not mean we have omitted the option of that MDFP loan. It is suggested that the LGU seeks the best financing option by further discussing with DOF the terms and conditions of MDFP.**

### 6.7.2 Preliminary Financial Analysis of Priority Area (Area A)

(1) Costs

Table 6.7.4 shows the costs for the priority project (Area A). Assuming that 50% of the initial costs are covered by NSSMP, the remaining CAPEX is estimated at PHP 8,897 million.

**Table 6.7.4 Costs of Priority Project (Area A)**

| Item | Unit | Area A |
|---|---|---|
| Initial Cost before NSSMP Grant | PHP mil | 17,793 |
| **Initial Cost after the Grant** | **PHP mil** | **8,897** |
| OPEX (annual) | PHP mil | 456 |
| Renewal Cost (at 20th year) | PHP mil | 3,751 |

Source: JICA Survey Team

(2) Revenue Water Consumption Projection

The table below shows the revenue water consumption in Area A. Commercial user ratio is assumed to be 20% of the residential user ratio, based on current DCWD ratios in the area.

**Table 6.7.5 Estimated Revenue Water Consumption**

| | Class | unit | 2015 | 2022 | 2030 | 2045 |
|---|---|---|---|---|---|---|
| Area A | Resi. | mil m3/year | 20 | 22 | 24 | 28 |
| | Comm | mil m3/year | 4 | 4 | 5 | 6 |
| | Total | mil m3/year | 24 | 26 | 28 | 34 |

Source: JICA Survey Team

(3) Case Setting and Financing Scheme

1) Case Setting

The JICA Survey Team estimated project cashflow and fiscal burden of the LGU and DCWD based on the case setting.

- Base Case: Remaining CAPEX (after NSSMP Grant) is shouldered by the LGU budget (Development Fund)
- Case 1: Remaining CAPEX is shouldered by LGU loan (Two Step Loan)
- Case 2: Remaining CAPEX is shouldered by LGU budget (Development Fund) and loan (50% each)
- Case 3: Remaining CAPEX is shouldered by LGU (70%) and WD (30%). Each agency shall split the cost into budget (Equity) and loan (50% each).
- Reference Case: Case 1 when tariff is collected from Area A to F as environmental fee

Initial cost allocation of each case is shown in Table 6.7.6.

**Table 6.7.6 Initial Cost Allocation of Each Case**

| Case | Agency | Initial Cost Share | Equity/Loan | million PHP |
|---|---|---|---|---|
| Base Case | LGU | 100% | Equity | 8,897 |
| | | | Loan | 0 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 1 | LGU | 100% | Equity | 0 |
| | | | Loan | 8,897 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 2 | LGU | 100% | Equity | 4,448 |
| | | | Loan | 4,448 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 3 | LGU | 70% | Equity | 3,114 |
| | | | Loan | 3,114 |
| | DCWD | 30% | Equity | 1,335 |
| | | | Loan | 1,335 |

Source: JICA Survey Team

2) Financing Scheme for Loan Portion

As mentioned, the Two Step Loan is assumed to be applied for the loan portion of the financing scheme. The financial cost of the loan is described in Table 6.7.3.

(4) Key Assumptions

Assumptions for the cashflow projection are as follows:

- Project Life : 30 years
- Construction：2022 - 2030 (9 years)
- Operation starts：2028
- 50% of Initial Cost is covered by NSSMP grant
- Major renewal in Operation Year 20
- 2019 Constant Price (Inflation not included)
- Discount rate：6%[9]
- Interest rate : 6.46 % p.a. (Two Step Loan, fixed)[10]
- Front end fee : 0.20% of total amount (only initial year)
- Tariff rate: 10 peso/$m^3$ for residential, 20 peso/$m^3$ for commercial.

The tariff rate was initially set at 5 PHP/$m^3$ for residential and 10 PHP/$m^3$ for commercial to reflect willingness to pay, but it is modified based on the LGU comments[11].

[9] 10-year average of long term (20yrs) government bond yield
[10] Breakdown explained in Table 6.7.2 and Table 6.7.3
[11] General meeting held on 2nd October 2019.

(5) Results

1) Cashflow Projection of the Project (Base Case)

The cashflow projection of the project for the Base Case when the sewerage tariff is 10 PHP/$m^3$ for residential (20 PHP/$m^3$ for commercial) is shown in table below.

The NPV is PHP -8,413 million, while the FIRR could not be calculated. The OPEX recovery rate is 79%, meaning that with tariff level of 10 PHP/$m^3$, even the O&M cost would not be recovered, and the LGU needs to tap some form of operation subsidy.

The calculations show that a tariff rate of 12.7 PHP/$m^3$ is necessary for OPEX recovery, and a rate of 36.5 PHP/$m^3$ is necessary for full cost recovery.

**Table 6.7.7 Project Cashflow _Base Case**

(unit:million PHP)

| Project Year | Year | CAPEX | NSSMP Grant | OPEX | Renewal Cost | Revenue (Residential) | Revenue (Commercial) | Net Cashflow |
|---|---|---|---|---|---|---|---|---|
| 1 | 2022 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 2 | 2023 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 3 | 2024 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 4 | 2025 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 5 | 2026 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 6 | 2027 | -1,977 | 989 | 0 | 0 | 0 | 0 | -989 |
| 7 | 2028 | -1,977 | 989 | -456 | 0 | 231 | 92 | -1,121 |
| 8 | 2029 | -1,977 | 989 | -456 | 0 | 233 | 93 | -1,118 |
| 9 | 2030 | -1,977 | 989 | -456 | 0 | 235 | 94 | -1,115 |
| 10 | 2031 | 0 | 0 | -456 | 0 | 239 | 95 | -122 |
| 11 | 2032 | 0 | 0 | -456 | 0 | 242 | 97 | -118 |
| 12 | 2033 | 0 | 0 | -456 | 0 | 245 | 98 | -113 |
| 13 | 2034 | 0 | 0 | -456 | 0 | 248 | 99 | -109 |
| 14 | 2035 | 0 | 0 | -456 | 0 | 251 | 101 | -104 |
| 15 | 2036 | 0 | 0 | -456 | 0 | 255 | 102 | -100 |
| 16 | 2037 | 0 | 0 | -456 | 0 | 258 | 103 | -95 |
| 17 | 2038 | 0 | 0 | -456 | 0 | 261 | 104 | -91 |
| 18 | 2039 | 0 | 0 | -456 | 0 | 264 | 106 | -86 |
| 19 | 2040 | 0 | 0 | -456 | 0 | 267 | 107 | -82 |
| 20 | 2041 | 0 | 0 | -456 | 0 | 271 | 108 | -77 |
| 21 | 2042 | 0 | 0 | -456 | 0 | 274 | 110 | -73 |
| 22 | 2043 | 0 | 0 | -456 | 0 | 277 | 111 | -68 |
| 23 | 2044 | 0 | 0 | -456 | 0 | 280 | 112 | -64 |
| 24 | 2045 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| 25 | 2046 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| 26 | 2047 | 0 | 0 | -456 | -3,751 | 283 | 113 | -3,810 |
| 27 | 2048 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| 28 | 2049 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| 29 | 2050 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| 30 | 2051 | 0 | 0 | -456 | 0 | 283 | 113 | -59 |
| | NPV | -13,447 | 6,724 | -4,035 | -824 | 2,264 | 906 | -8,413 |
| | | | | | | | FIRR | #NUM! |
| | | | | | | | Revenue/OPEX | 79% |

Source: JICA Survey Team

2) Case Comparison

Other cases (i.e., Case 1, 2, and 3) also showed negative cashflows at a tariff rate of 10 PHP/$m^3$. The table below summarizes the NPV for each case and the tariff needed to recover OPEX and full cost. Case 1 (funding 100% of initial cost by taking loan) shows the least project deficit (NPV – PHP 6,861 million) and the smallest tariff rate needed for full cost recovery (31.6 PHP/$m^3$).

**Table 6.7.8 Case Comparison Summary**

| Item | unit | Base | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|---|
| NPV (at 10 peso/m3) | million PHP | -8,413 | -6,861 | -7,637 | -7,637 |
| Tariff needed for OPEX recovery | peso/m3 | 12.7 | 12.7 | 12.7 | 12.7 |
| Tariff needed for full cost recovery | peso/m3 | 36.5 | 31.6 | 34.1 | 34.3 |

Source: JICA Survey Team

The financial burden to the LGU and DCWD in each case is summarized in the table below. The burden for LGU would naturally be less if DCWD could take part of the initial cost. As of October 2019, DCWD expresses that they would invest when full cost recovery is expected; however, the sewerage tariff cannot be set at a high value due to affordability of users. Moreover, LWUA's ring-fencing regulation restricts DCWD to cross-subsidize the sewerage revenue from the water revenue. Further negotiation and arrangement between relevant agencies must be made.

**Table 6.7.9 Financial Burden of LGU and DCWD in Each Case**

| | NPV (mil PHP) | |
|---|---|---|
| | LGU | DCWD |
| Base | -8,413 | 0 |
| Case 1 | -6,861 | 0 |
| Case 2 | -7,637 | 0 |
| Case 3 | -5,853 | -1,784 |

Source: JICA Survey Team

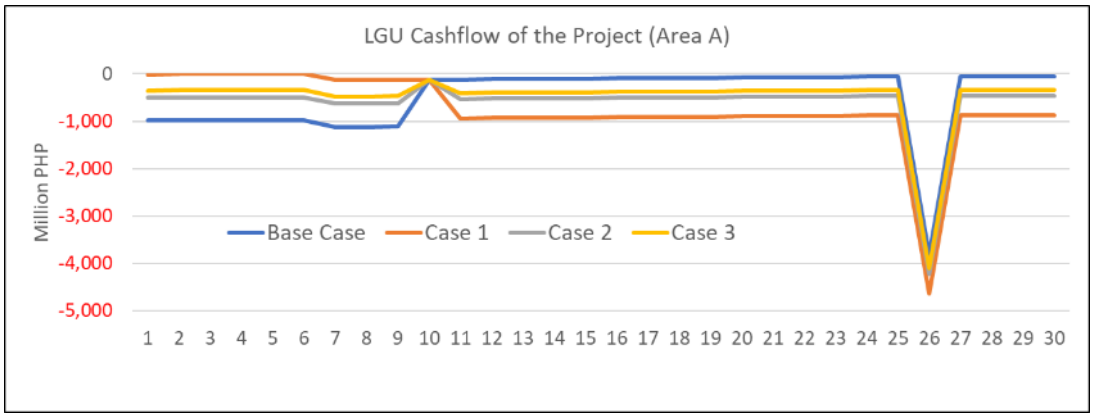
Table 6.7.10 shows the breakdown of Case 1 LGU cashflow and the item the LGU needs to spend. Since the remaining CAPEX is funded by the loan, the equity injection during construction is zero. The front end fee is accounted in Year 1, and the debt service starts in Year 11. From the first year of operation (i.e., Year 7), the operation subsidy is required since the tariff revenue is not enough to cover the OPEX.

**Table 6.7.10 Breakdown of Financial Burden of LGU (Case 1)**

| Financial Burden of LGU (Area A ) (Unit: PHP million) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Equity Injection during Construction | Principle Repayment | Interest Payment | Operation Subsidy | Renewal Cost Payment | Total |
| 1 | 0 | 0 | -18 | 0 | 0 | -18 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | -133 | 0 | -133 |
| 8 | 0 | 0 | 0 | -130 | 0 | -130 |
| 9 | 0 | 0 | 0 | -127 | 0 | -127 |
| 10 | 0 | 0 | 0 | -122 | 0 | -122 |
| 11 | 0 | -230 | -575 | -118 | 0 | -922 |
| 12 | 0 | -245 | -560 | -113 | 0 | -918 |
| 13 | 0 | -261 | -544 | -109 | 0 | -913 |
| 14 | 0 | -278 | -527 | -104 | 0 | -909 |
| 15 | 0 | -296 | -509 | -100 | 0 | -904 |
| 16 | 0 | -315 | -490 | -95 | 0 | -900 |
| 17 | 0 | -335 | -470 | -91 | 0 | -896 |
| 18 | 0 | -357 | -448 | -86 | 0 | -891 |
| 19 | 0 | -380 | -425 | -82 | 0 | -887 |
| 20 | 0 | -404 | -401 | -77 | 0 | -882 |
| 21 | 0 | -430 | -374 | -73 | 0 | -878 |
| 22 | 0 | -458 | -347 | -68 | 0 | -873 |
| 23 | 0 | -488 | -317 | -64 | 0 | -869 |
| 24 | 0 | -519 | -286 | -59 | 0 | -864 |
| 25 | 0 | -553 | -252 | -59 | 0 | -864 |
| 26 | 0 | -589 | -216 | -59 | -3,751 | -4,615 |
| 27 | 0 | -627 | -178 | -59 | 0 | -864 |
| 28 | 0 | -667 | -138 | -59 | 0 | -864 |
| 29 | 0 | -710 | -95 | -59 | 0 | -864 |
| 30 | 0 | -756 | -49 | -59 | 0 | -864 |
| | | | | | NPV | -6,861 |

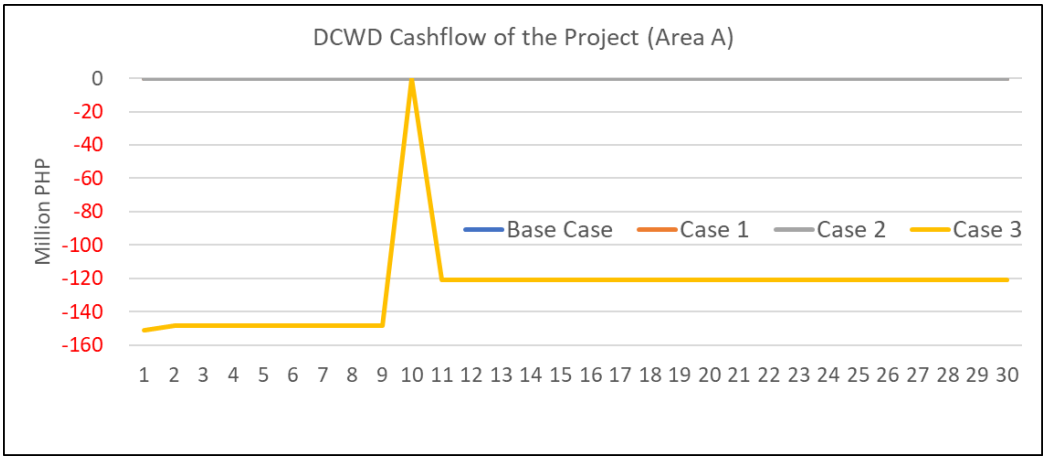
Source: JICA Survey Team

Figures 6.7.5 and 6.7.6 compare the cashflow of each case from the LGU and WD point of views when the tariff rate is 10 PHP/$m^3$ (residential) and 20 PHP/$m^3$ (commercial).




Source: JICA Survey Team

**Figure 6.7.5 LGU Cashflow of the Project (Area A) Each Case**




Source: JICA Survey Team

**Figure 6.7.6 DCWD Cashflow of the Project (Area A) Each case**

3) Reference Case

For reference purpose, the JICA Survey Team simulated the case in which the tariff is collected from Areas A to F as environmental fee. In this case, the initial cost (i.e., PHP 8,897 million) is borne by the LGU debt. The revenue source will be much larger compared to targeting only Area A service beneficiaries (Table 6.7.11). For this case, the commercial user ratio is assumed 10% of the residential user ratio.

**Table 6.7.11 Estimated Revenue Water Consumption**

| | Class | unit | 2015 | 2022 | 2030 | 2045 |
|---|---|---|---|---|---|---|
| Area A - F | Resi. | mil m3/year | 77 | 94 | 119 | 202 |
| | Comm | mil m3/year | 8 | 9 | 12 | 20 |
| | Total | mil m3/year | 85 | 103 | 131 | 222 |

Source: JICA Survey Team

Calculation showed that 2.5 peso/$m^3$ (residential) and 5 peso/$m^3$ (commercial) would recover O&M costs. Also, 6.1 peso/$m^3$ (residential), 12.2 peso (commercial) would recover full cost.

4) Summary

The financial analysis showed that 10 PHP/$m^3$ will not be sufficient to even recover O&M costs (12.7 PHP/$m^3$ is needed). For the LGU, it is recommended to fund the initial cost by taking a loan since the overall expenditure (i.e., life cycle cost) is the least (PHP NPV 6,861 million). It is hoped that DCWD would take its share and reduce the financial burden of the LGU; however, the ring-fencing regulation is still the bottleneck.

## 6.8 Study on Project Implementation Regime

Figures 6.8.1 and 6.8.2 show the project implementation regime during 1) design and construction and 2) O&M of facilities.

As mentioned in Subsection 6.7.1, the LGU is the implementation agency in the construction stage, and DCWD is the one for O&M. To manage the large-scale project, a Project Management Unit (PMU) should be established in Davao City. For smooth coordination and approvals of various designs and documents, the PMU should be under the City Administrator's Office. The PMU will conduct various coordination with departments in the city and with other agencies, such as DCWD, DPWH, EMB, and DBP/LBP. The mandates and financial sharing of each party shall be stipulated in the Memorandum of Agreement (MOA) between Davao City and DCWD before the commencement of the project.

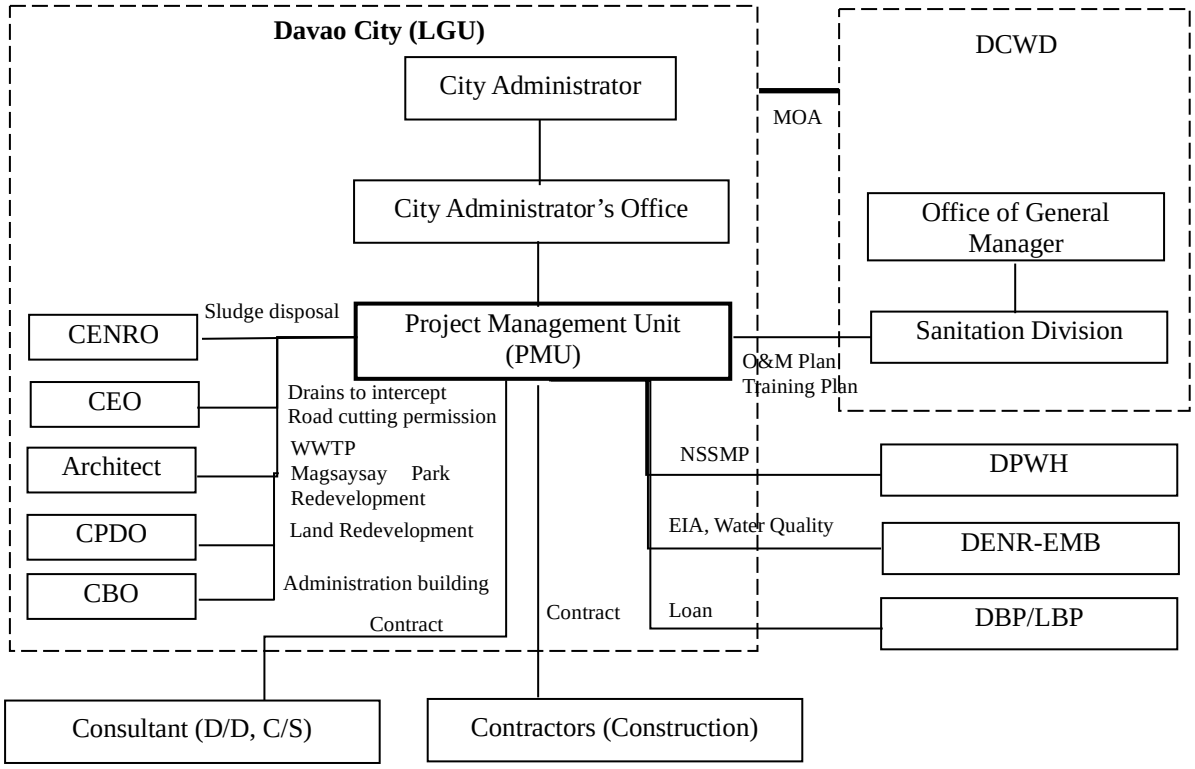
The required number of staff and roles in the PMU shall be considered in the next study.

The PMU members would be composed of departments highly involved in the project, such as the 1) City Engineering Office (CEO) (e.g., for general engineering matter and road cutting permissions), 2) City Architect (e.g., for redevelopment of Magsaysay Park), 3) City Environment and Natural Resources Office (CENRO) (e.g., for sludge management, environmental management for matters such as foul odor and noise during construction, compensations), 4) City Planning and Development Office (CPDO) (e.g., for future land use and land redevelopment, including resettlement plan of squatters in target area), and 5) City Budget Office (CBO) (e.g., for administration building in WWTP and house connections, including switching from septic tanks).

Since Davao City has not implemented large-scale infrastructure projects even though DPWH has been developing drainage facilities and roads (Davao Bypass Road, Davao City Coastal Road), there is concern on the capacity of CEO engineers for the sewerage project. Likewise, CENRO is not that accustomed with environmental management (including EIA), but mainly handles solid waste management matters. This is because basically DENR-EMB is the environmental monitoring agency. Trainings of the PMU members for project management are required before the project, and, if possible, members should be supplemented from DCWD, which is accustomed with pipelaying for water supply projects.

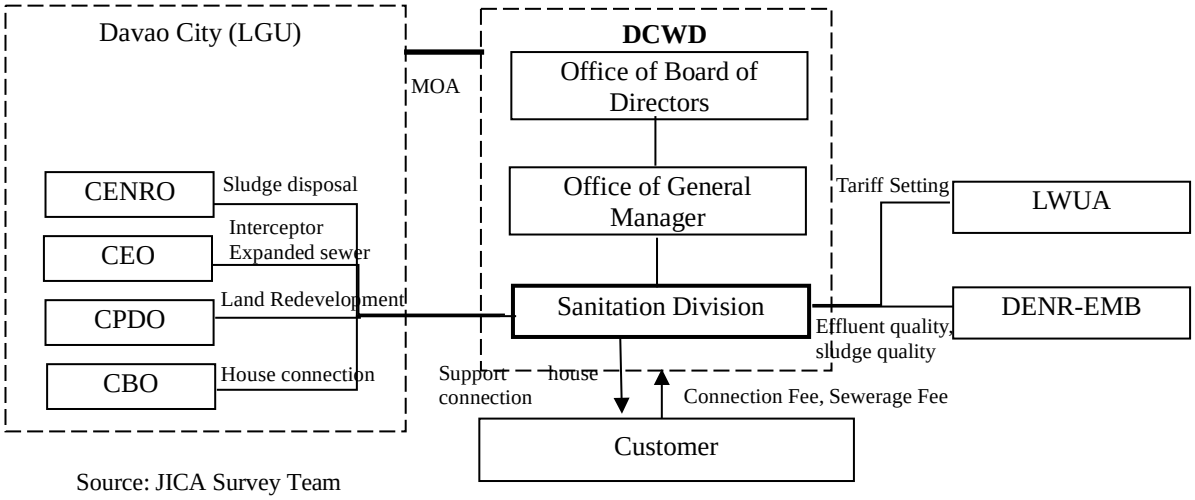
In the O&M stage, DCWD should be in charge of O&M of facilities (e.g., WWTP, P/S, sewer), tariff setting and collection from customers, and house connection of sewers. Basically, after the completion of the JICA project, the lateral sewer development (expansion for newly developed areas and buildings) should also be conducted by DCWD.

Only the O&M structure for WWTP is described in this report as shown in subsection 6.3.6 but in the process of formulating a sewerage plan in the future, it is necessary to consider an integrated O&M structure for WWTP and sewer pipeline.




Source: JICA Survey Team

**Figure 6.8.1 Project Implementation Regime during Construction (Draft)**




Source: JICA Survey Team

**Figure 6.8.2 Project Implementation Regime during O&M (Draft)**

## 6.9 Preliminary Scoping and Points to Consider on Environmental and Social Consideration

Based on collected information from this Data Collection Survey and in reference to the JICA Guidelines, an Initial Environmental Examination (IEE) level study, which is not same as the IEE required in PEISS, was made as an attempt in preparing a preliminary scoping, a rough draft of the Terms of Reference (TOR) for an environmental and social considerations study, and points to consider to serve as reference to a further feasibility study for the Project.

### 6.9.1 Project Components and Land

(1) Project Components

Project components for Davao City will be composed of a WWTP and sewage collection facilities (e.g., pumping stations and sewer lines), as well as the land for WWTP as summarized in Table 6.9.1.

**Table 6.9.1 Project Component (to be updated)**

| WWTP | | Sewage Collection Facility | | |
|---|---|---|---|---|
| Process | Planned Capacity ($m^3$/day) | Total Number of Pump Station | Total Length of Sewer line | |
| | | | Trunk(km) | Branch(km) |
| MBR | 97,000 | 2 | 39 | 280 |

Source: JICA Survey Team

(2) Project Land

Environmental and social situations of the proposed WWTP land in Davao are summarized in Table 6.9.2.

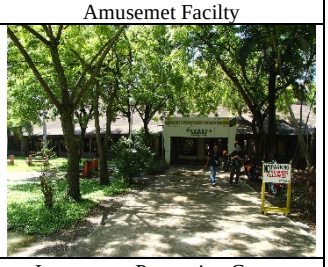
### 6.9.2 Without Project

Consequences for selection of Without-the-Project are considered as follows:

- ✓ Sewage from the existing sewer lines in the Davao City will not be treated appropriately. Such circumstances will aggravate environmental sanitation and health situations in the study area of Davao City and is expected to cause delay in the further development of the City.
- ✓ The proposed land of one of the properties in Davao City will not be improved to be used for the WWTP facility.
- ✓ Due to Without-the Project, impacts on natural and social environment caused by the construction and operation of the Project in Davao City will not occur at all.
- ✓ Davao City will study and find other technical solutions especially for treating the sewage from the existing sewers to satisfy the growing demands of sewage treatment in accordance with future population expansion in the study area of the city. Further, the budget of Davao City will be required for solutions.

Considering a minor extent of environmental and social impacts anticipated by the Project and financial and technical constraints of Davao City, it is concluded that Without-the Project is not realistic.

**Table 6.9.2 WWTP Land Situations**

<table>
<tr><td rowspan="2">WWTP Site in Davao City</td><td>Available Land Area (ha)</td><td>Required Land Area (ha)</td><td>Land Status</td><td>Landowner</td></tr>
<tr><td>2.68</td><td>1.50</td><td>Public Park</td><td>Davao City</td></tr>
<tr><td>Environmental Situation</td><td colspan="4">• Flat land of the Ramon Magsaysay Park (Property of the Davao City)<br>• Planted trees<br>• East: Davao Bay</td></tr>
<tr><td>Social Situation</td><td colspan="4">• Some facilities (a Monument, a Christianity chapel, a Tribal Village as temporal attraction, City Government Offices of Commission of Election and Davao Investment Promotion Centre, a small amusement facility, a small store, a rest-bar and an ice cream shop) are in the Park.<br>• North: T. Monteverde Street, Office of Philippines Port Authority and office of Private Tour<br>• West: Quezon Blvd Street, Magsaysay Fruit Vender association and fruit shops.<br>• South: Low Incomer and Slum Areas</td></tr>
<tr><td rowspan="6">Photographs</td><td colspan="2">  <br>Magsaysay Monument</td><td colspan="2">  <br>Amusemet Facilty and Flagpole</td><td>  <br>Amusemet Facilty</td></tr>
<tr><td colspan="2">  <br>Open Air Christianity Chapel</td><td colspan="2">  <br>Tribal Village</td><td>  <br>Investment Promotion Centre</td></tr>
<tr><td colspan="2">  <br>Rest-bar</td><td colspan="2">  <br>East Area: Davao Bay</td><td>  <br>South Area: Slum Area</td></tr>
</table>

Source: JICA Survey Team

### 6.9.3 Preliminary Scoping

The definition of “Scoping” in the environmental and social considerations study, in accordance with the JICA Guidelines, is “choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods”.

Table 6.9.3 shows a draft of the preliminary scoping results for the Project in Davao City.

## Table 6.9.3 Preliminary Scoping Results for the Project in Davao City (Draft)

| Category | No. | Environmental Item | Rating | | Reasons |
|---|---|---|---|---|---|
| | | | Con. Phase | Ope. Phase | |
| Pollution Control | 1 | Air Quality | B- | D | Construction Phase: Worsening of surrounding ambient air caused by exhaust gases and dusts emitted from operation of heavy vehicles, equipment, and trucks is predicted during periods of construction of WWTP and installation of sewage collection facilities.<br>Operation Phase: There is no possibility of generation of air pollutants which have negative impacts on ambient air caused by the operation of WWTP and the sewage collection facilities which are basically constructed under the existing roads. |
| | 2 | Water Quality | C | D | Construction Phase: Water pollution caused by construction work and installation work, operation of heavy vehicles, equipment and trucks, and wastewater of workers and labors is predicted.<br>Operation Phase: There is no possibility of groundwater pollution caused by WWTP operation and sewage collection facilities. |
| | 3 | Wastes | B- | C | Construction Phase: Generation of construction waste soil, demolition waste, and debris are expected.<br>Operation Phase: Generation of domestic waste from WWTP is expected. |
| | 4 | Soil Contamination | C | D | Construction Phase: There is possibility of soil contamination due to oil spills from relevant construction vehicles, equipment, and transport trucks.<br>Operation Phase: There is no possibility of soil pollution caused by operation of WWTP and sewage collection facilities. |
| | 5 | Noise and Vibration | C | C | Construction Phase: Generation of noise caused by construction vehicles and heavy equipment is expected.<br>Operation Phase: Earth-based pumping facilities will create noise. |
| | 6 | Subsidence | D | D | Construction Phase: Construction works and installation works, which cause of subsidence, are not predicted.<br>Operation Phase: Ground water is not used for operation of WWTP and sewer lines at all. |
| | 7 | Odor | D | C | Construction Phase: Construction work and installation work of WWTP and swage collection facilities which cause of bad odor are not expected<br>Operation Phase: Operation of WWTP with digestion processes may discharge bad odor if designs of WWTP do not consider odor control equipment and layouts. |
| Natural Environment | 8 | Protected Areas | C | D | Protected area and national parks are not existed in and around WWTP site, and sewage collection facilities. However, the land for WWTP is planned to be in the Ramon Magsaysay Memorial Park in Davao City. |
| | 9 | Ecosystem | D | D | Rare and protected species and habitats of flora and fauna have not been identified in and around the WWTP site, and sewage collection facilities. |
| | 10 | Hydrology | C | D | Construction Phase: There is no river stream and river on the premises of the WWTP site. Therefore, impact on hydrology in the WWTP construction site is not expected.<br>On the other hand, sewer lines are planned to be installed under the existing roads where there may be possibilities that several rivers/streams in the City are crossed. Therefore, there may be some impacts on such rivers/streams during the construction phase.<br>Operation Phase: No impact on hydrology is expected from the operation of WWTP and the sewage collection facilities. |
| | 11 | Topography and Geology | D | D | Large-scale excavation and earth fill are not expected due to construction of WWTP and installation of sewage collection facilities. |
| Social Environment | 12 | Land Acquisition /Resettlement | C | D | No land acquisition and resettlement is predicted by use of the Magsaysay Park as the project site. However, some of the trees in the park may be cut for the WWTP construction. |
| | 13 | Impoverished Peoples Ethnic Minorities and Indigenous Peoples | D | D | Impoverished (absolute deprivation) people and PAPs (Project Affected Peoples) are not identified in the project site. Also, ethnic minorities and indigenous peoples are not identified in and around the project site. |
| | 14 | Living and Livelihood | B+/- | B+ | Construction Phase: Temporary employment of the surrounding villagers is expected for the construction work and installation work.<br>There may be negative social impacts on the surroundings of the existing roads (negative impacts on traffic and commercial activities) caused by installation of sewer lines.<br>Operation Phase: Employment (e.g., security guards and gardeners) of the surrounding barangays of WWTP site are expected. |
| | 15 | Land use and Regional Resources | B- | C | Construction Phase: There is possibility of negative impact on surrounding environment caused by discharge of wastewater from construction work and installation work and worker's office and sleeping quarters (if any).<br>Operation Phase: No impact on land use and regional resources is predicted by the operation of the WWTP and sewage collection facilities. |
| | 16 | Water Right/Use of | D | D | Construction Phase: There is no irrigation channel and surface stream in the WWTP site. |

| Category | No. | Environmental Item | Rating | | Reasons |
|---|---|---|---|---|---|
| | | | Con. Phase | Ope. Phase | |
| | | Water | | | Operation Phase: There is no impact on groundwater in the site. |
| | 17 | Social Infrastructures and Services | B- | D | Construction Phase: Negative impacts on surrounding road traffic congestion by increase in the number of heavy vehicles, equipment, and transport trucks are temporally predicted during construction period for WWTP and sewage collection facilities. |
| | | | | | Operation Phase: No impact on social infrastructure and services is predicted in the operation phase. |
| | 18 | Heritage | D | D | Local archeological, historical, cultural, and religious heritages are not existed in the WWTP site. Existing roads for the sewer lines and lands for larger scale pumping station for which vacant lands will be selected based on the basic policy of the land acquisition for such pumping stations. |
| | 19 | Social Capital and Social Organization such as decision making bodies | D | D | No impacts on social capital and social organization are expected by the projects. |
| | 20 | Damage and Benefit | D | D | The project is construction and operation of the WWTP, and sewage collection facilities by which such inequality of damage and benefit is not predicted around the project sites. |
| | 21 | Landscape | D | D | No negative impacts on the surrounding landscape are expected by the construction of the WWTP under the gland level of the Magsaysay Park sewer lines (including an underwater pump) which are planned to be constructed under existing roads. |
| | 22 | Gender Issue | D | D | Impacts on gender are not expected by the project |
| | 23 | Rights of the Child | D | D | Impacts on rights of the child are not expected by the project |
| | 24 | Risk of infectious diseases such as HIV/AIDS | B- | D | Construction Phase: Temporary influxes of migrant labors increase the risks of STD such as HIV/AIDS during the construction period. |
| | | | | | Operation Phase: No migrant labors are expected in the operation phase of the projects |
| | 25 | Working Conditions/ Work Safety | C | D | Construction Phase: Deterioration of occupational safety and working condition associated with the construction work is anticipated if not properly managed. |
| | | | | | Operation Phase: There will be general educational related activities for the WWTP staff during the operation phase. Therefore, it is considered that the working conditions for the staff will be moderate. |
| Others | 26 | Accidents | C | C | Construction Phase: Accidents associated with construction work are predicted. |
| | | | | | Operation Phase: Accidents associated with operation work are predicted. |
| | 27 | Transboundary or Global Issues | D | D | This project is the construction and operation of the WWTP with digestion process, and sewer lines by which such impacts on transboundary or global issues, such as climate change, are not predicted during the construction and operation phases. |

| | |
|---|---|
| A+/- | : Significant positive/negative impact is expected. |
| B+/- | : Positive/negative impact is expected to some extent. |
| C | : Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses) |
| D | : No impact is expected. |

Note: Con. Phase: Construction Phase (includes Construction work and Installation work), Ope. Phase: Operation Phase

Source: JICA Survey Team

### 6.9.4 Rough Draft TOR for Environmental and Social Considerations Study

In accordance with the Preliminary Scoping Results shown in Table 6.9.3, a rough draft of the Terms of Reference (TOR) on the environmental and social consideration studies to be carried out at that time of the feasibility study stage for the projects is prepared. The reference is shown in Table 6.9.4.

**Table 6.9.4 Rough Draft TOR for Environmental and Social Considerations Study**

| Environmental Item | Study Item | Study Method |
|---|---|---|
| Air Pollution | i. Present traffic volume<br>ii. Air quality in and around the site<br>iii. Impact during construction and installation | i. Review of existing available data and others<br>ii. Review of existing data and others, site reconnaissance and monitoring surveys (if necessary)<br>iii. Based on the above surveys, simple calculation of necessary numbers of construction vehicles and equipment, and trucks to be used for the construction and installation is evaluated. |
| Water Pollution | i. Water quality in and around the site<br>ii. Impacts during construction and operation phases | i. Review of existing data and others and site reconnaissance<br>ii. Based on the reviews and reconnaissance as well as construction methods, the impacts during construction and operation are evaluated. |
| Wastes | i. Construction solid waste management<br>ii. Domestic solid waste management | i. Interviews with relevant official entities<br>ii. Interviews with relevant official entities |
| Soil Contamination | i. Construction method to be applied<br>ii. Construction vehicle and equipment to be used | i. Site reconnaissance and construction plans<br>ii. Site reconnaissance and construction plans |
| Noise and Vibration | i. Construction method to be applied<br>ii. Construction vehicle and equipment to be used<br>iii. Pump facilities | i. Site reconnaissance and construction plans and designs<br>ii. Site reconnaissance and construction plans<br>iii. Site reconnaissance and construction plans and designs |
| Odor | i. Designs of WWTP | i. Site reconnaissance and construction plans, designs and layouts |
| Ecosystem | i. Present condition of flora and fauna in the project site and surrounding marine environment | i. Review of existing data, field reconnaissance and review of relevant report and EIS |
| Hydrology | i. River crossing points in the sewer line routs<br>ii. Construction method and period in such points | i. Site reconnaissance<br>ii. Construction plans |
| Land Acquisition/ Resettlement | i. Tree cutting in the Magsaysay Park | i. Site reconnaissance<br>ii. Construction plans and layouts<br>iii. Relevant laws and regulations<br>iv. Stakeholder meetings |
| Living and Livelihood | i. Project policy<br>ii. Impacts on Livelihood | i. Discussion with relevant official entities<br>ii. Prediction of impacts on livelihood |
| Land use and Regional Resources | i. Construction method and equipment<br>ii. Wastewater treatment facility | i. Site reconnaissance and construction plan<br>ii. Site reconnaissance and construction plan |
| Social Infrastructures and Services | i. Present traffic volume<br>ii. Construction vehicle and equipment to be used | i. Review of existing data and construction plan<br>ii. Site reconnaissance and construction plan |
| Risk of infectious diseases such as HIV/AIDS | i. Heath situation in the project area and the Philippines<br>ii. Health education activates | i. Review of relevant documents<br>ii. Review of relevant laws and regulations |
| Working Conditions/Work Safety | i. Occupational safety systems<br>ii. Relevant to law and regulation | i. Review of relevant laws and regulations<br>ii. Review of relevant documents |
| Accidents | i. Present traffic volume | i. Review of existing data and interviews |

Source: JICA Survey Team

### 6.9.5 Points to Consider

(1) Procedures on ECC/CNC

- A matrix guideline for determining the category in which the projects fall is prepared and attached as “Annex A Project Thresholds for Coverage Screening and Categorization” in the “Revised Guidelines for Coverage Screening and Standardized Requirements, MC005 July 2014 EMB DENR”. In accordance with Annex A, the sewerage system projects are subject to “3.8.5 Domestic wastewater treatment facility” under “3.8 Waste Management Projects” in “3. Infrastructure Projects”.

- As for sewer line systems, according to EMB/DENR, the line systems are regarded as part of the WWTP facilities.
- Therefore, the proposed projects, including sewer lines, are under Category B (Non-ECP)
- In addition, project sites in Davao City are to be located in “areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity etc.)” as specified in DAO 03-30.
- Therefore, the proposed project in Davao City is expected to fall under Environmentally Critical Areas (ECAs).

✓ **Points to consider on ECC/CNC**

- Based on the recognition above, projects of Category B in ECA are required to secure ECC.
- Namely, the proposed sewerage project in Davao City is subject to ECC in the PEISS.

(2) Odor Control of WWTP

In the Philippines, according to EMB/DENR, there are no specific standards being used to control the odor of WWTP as stated below.

- The national standard on ambient air quality under the IRR of the Philippine Clean Air Act, Hydrogen Sulfide ($H_2S$) Concentration (100μg/Ncm, 0.07ppm, average time of 30 min) can serve as reference.
- Other than this, there are no standards for odor emission, citing that industrial facilities just have to make sure that odor is "not that too obnoxious" for the neighboring community.

Meanwhile, Maynilad, the water and wastewater services provider for the West Zone of the Metropolitan Manila area, has provided some guidelines for contractors on odor control methods as summarized below. The guidelines can be utilized as reference for the sewerage systems in Davao.

1) Employer’s Requirement for Plant Odor control system

- Foul-smelling air generated throughout the treatment process and from around the site shall be collected and treated with a dedicated odor control treatment process.
- The odor control unit shall be of biological process type and shall be designed and installed such that the maximum odor level condition outlined in Table 6.9.5 is consistently and strictly followed.
- The Contractor shall be required to estimate the design load conditions based on the proposed treatment process and shall have sole responsibility for the sizing and design of the assumptions made.
- All ducting for odor shall be of FRP material or approved equivalent.

**Table 6.9.5 Odor Standard Description**

| Odoriferous Substance | Unit | Comment |
|---|---|---|
| Ammonia<br>(At the Stack/Discharge Point) | 0.50 ppm | • Using Nesslerization/Indo Phenol of analysis/measurement[2] (Averaging Time, 30mins)[1]<br>• Continuously monitored by gas detector at the stack (fits times per hour, once every 15mins)<br>• The Contractor shall install the gas detector for ammonia gas monitoring with calibration certification. |
| Hydrogen Sulfide<br>(At the Stack/Discharge Point) | 0.10 ppm | • Using Methylene Blue of analysis/measurement[2] (Averaging Time, 30mins)[1]<br>• Continuously monitored by gas detector at the stack (four times per hour, once every 15mins)<br>• The Contractor shall install the gas detector for hydrogen sulfide gas monitoring with calibration certification. |
| Ammonia<br>(At the Site Boundary) | 0.28 ppm | • Average time: 30 minutes*1, using nesslerization/indo phenol method of analysis/measurement*2. |
| Hydrogen Sulfide<br>(At the Site Boundary) | 0.02 ppm | • Average time: 30 minutes*1, using methylene blue method of analysis/measurement*2 |
| 1: Ninety-eight percentile (98%) values of 30-minute sampling measured at 25oC and one atmosphere pressure.<br>2: Other equivalent methods approved by the DENR may be used. | | |

Source: Maynilad/Data Collection Survey for Sewerage Systems in West Metro Manila, Final Report, September 2016, JICA

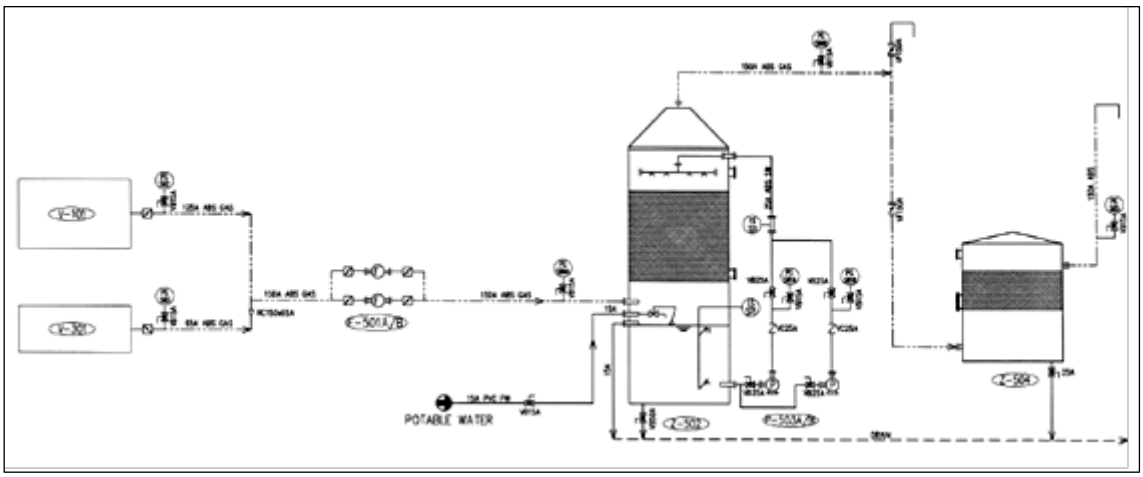
- The odor control system shall be designed such that routine monitoring and maintenance can be carried out on each major equipment or process within the system while still adhering to the Odor Quality Standard identified in Table 6.9.5.
- The Contractor shall provide, for the purpose of evaluation, the estimated chemical consumption rates and chemical and energy costs for the dedicated odor control facility, if any.
- It is assumed that there will be one centralized odor control facility at the site.
- The Odor Control Facility shall include the following minimum provisions:
  1. Duty and standby recirculation pumps
  2. Extraction fans with spare units for main equipment
  3. Chamber covers, enclosures, and connections to the odor ductwork
  4. Ductwork (FRP or approved equivalent) and control dampers to facilitate the collection and balancing of the flows of contaminated air drawn from all of the various covered areas/enclosures connected to the Odor Control Plant
  5. Local Odor Control panel(s) and all associate electrical installations
  6. Instrumentation, monitoring, and data logging equipment, including connection to the site SCADA system
  7. Power and instrument cabling
  8. Drain pipe to the equalization tank
- The odor control plant will be tested as part of the Process Acceptance Test for the system.
- Critical control points on the odor control facility shall be visible on the SCADA interface, and appropriate levels of monitoring of odorous air volumes, mechanical failure, and one point of online quality measurement shall be provided.
- Prior to commissioning, the Contractor shall demonstrate the efficiency of the odor control facility through a computer simulation.

(Source: Maynilad/Data Collection Survey for Sewerage Systems in West Metro Manila, Final Report, September 2016, JICA)

2) Talayan Odor Control System (as a reference of Sewerage project in Talayan City) (See Figure 6.9.1)

- The Deodorizer system consists of two units in series, a Scrubber Deodorizer, which does not require any chemicals in principle, and an Activated Carbon Deodorizer, which will further remove odor from the air.
- Malodorous air generated in the WWTP shall be collected and treated in the Deodorizer System to attain the required set odor standard.
- Malodourous air will be collected from the grit chamber and waste sludge storage tank by odor piping made of ABS material.
- Malodourous gas is collected and passed through the deodorizer system using a deodorizer fan.
- The scrubber deodorizer is composed of a scrubber tank with net packing ring, spray nozzles, and deodorizer pump. In the scrubber, the odorous air stream is brought into contact with the scrubbing water by spraying water from nozzles with media.
- This will promote the contact of odorous air and water. The odorous air is immediately adsorbed by water, and the microorganisms in the media dissolve organic matter with anabolism and catabolism.
- Scrubbing water is circulated in the process and automatically supplemented with potable water against evaporation. Draining of scrubbing water is required once a week or if necessary.
- This can be done by opening a valve of drainpipe connecting to the water treatment facility.
- The treated air from scrubber deodorizer will go to Activated Carbon Deodorizer (ACD) for further removal of odor from air.
- ACD removes more pollutant gases from odorous air by means of adsorption.
- Pollutant gases from odorous air will be adhered to a surface of the activated carbon.
- After some time, there will be saturation of adhered gases on the activated carbon in which regeneration of media replacement is needed.

(Source: Maynilad/Data Collection Survey for Sewerage Systems in West Metro Manila, Final Report, September 2016, JICA)




Source: Maynilad/Data Collection Survey for Sewerage Systems in West Metro Manila, Final Report, September 2016, JICA

**Figure 6.9.1 Piping and Instrumentation Diagram of Talayan Odor Control System**

✓ **Points to consider on odor control**

- For the design of WWTP, the employer's requirement for plant odor control system of Maynilad can be utilized by the contractors to be included in the project in Davao City.
- Past engineering designs on the odor control systems in the WWTP of Maynilad can serve as reference to the Project in Davao City.

(3) Utilization of Sewage Sludge

In general, utilization of treated sewage sludge has potentials for energy recovery and material recovery as summarized in Table 6.9.6.

**Table 6.9.6 Potential of Sludge Reuse in General**

| Potential of Sludge Reuse | | Utilization |
|---|---|---|
| Energy Recover | Digestion Gas | Gas power generation, Fuel for gas powered vehicles, raw materials for utility gas. |
| | Sludge Derived Fuel | Coal substitute fuel |
| | Combustion Waste Heat | Waste-heated power generation, heat supply to local communities |
| Material Recover | Construction Material | Bricks, Cement materials |
| | Compost | Useful components such as phosphorus for fertilizer, Composting |

Source: Ministry of Land, Land, Infrastructure, Transport and Tourism of Japan, March 2007 modified by the JICA Survey Team

Among those sludge reuse potentials listed in the table, there may be possibilities that the sewage sludge in Davao City can be used for composting and raw/fuel materials for cement materials in consideration of the following circumstances:

- Relevant laws and regulations on compositing from biodegradable waste in the Philippines.
- There is a private cement factory in Davao City.
- Composting of biodegradable domestic waste is carried out in Material Recovery Facilities (MRFs) at the barangay level, as well as the landfill site in Carmen, Davao City.

1) Relevant Laws and Regulations on Waste Management and Incineration

Table 6.9.7 summarizes the principal laws and regulations on waste management, including recycling and incineration in the Philippines.

**Table 6.9.7 Laws and Regulations on Waste Management and Incineration**

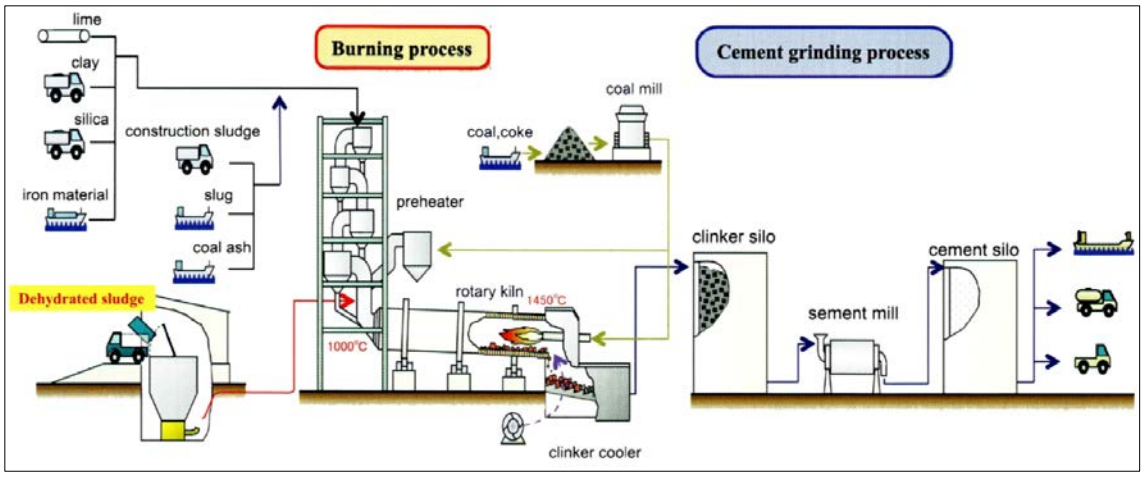
| Laws and regulations | | Year | Description |
|---|---|---|---|
| Waste Management | RA6969 | 1990 | Act for Toxic Substances and Hazardous and Nuclear Wastes Control. |
| | RA9003 | 2001 | Act for Non-Hazardous Solid Waste Management of "Ecological Solid Waste Management Act" |
| | DENR/DAO No.49 | 1998 | Technical Guidelines for Solid Waste Management |
| | DENR/DAO No.36 | 2004 | Manual for RA6969 |
| Waste Incineration | RA8749 (Clean Air Act) | 1999 | Article 20 prohibits incineration of municipal waste, medical waste and hazardous waste which emit harmful gases. The Act had been recognized in the Philippines that the incineration of waste was prohibited. |
| | DENR/MC005 | 2002 | MC005 states that incineration is not prohibited but incineration that emits toxic or harmful exhaust gas is prohibited. |
| | DAO No. 06 | 2010 | DAO No. 15 issued the Guidelines on the use of alternative fuels and raw materials in Cement kilns. |

Source: RA 6969, RA 9003, RA 8794, MC 005, DAO No.06 and JICA Survey Team

2) Possibility of Sewage Sludge utilization as raw/fuel materials for Cement Factory

As shown in Figure 6.9.2, in cases where sewage sludge is utilized as raw/fuel materials at a cement

factory, additional facilities and processes for accepting and burning dewatered sewage sludge are normally required to be set up in the factory.




Source: Kitakyushu City in Japan

**Figure 6.9.2 Sample of Cement Manufacturing Process by use of Sewage Sludge**

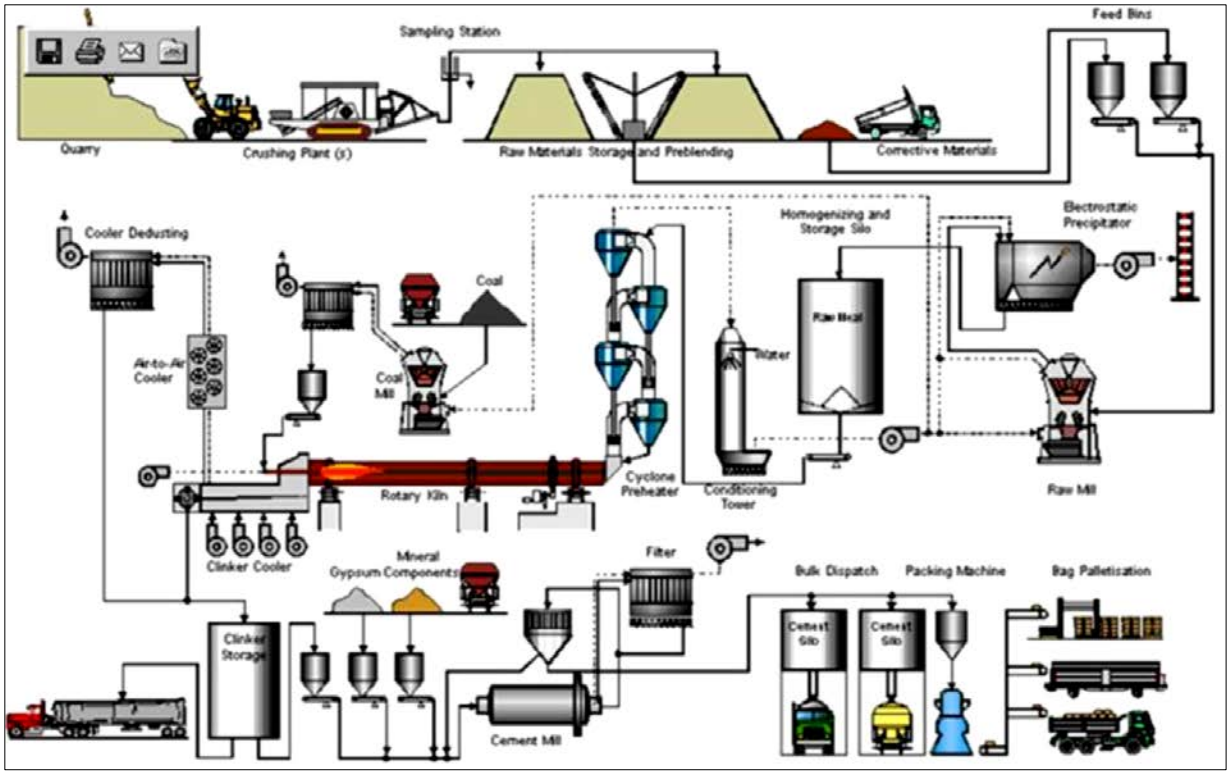
Since the mechanical sludge drying process is recommended to reduce the volume of sludge generation in the Sludge Treatment Facility (STF), as explained in subsection 6.3.2 in this chapter, the facility might be enough for the requirements, but the optimal reduction of water content of sludge requires additional energy.

In Davao City, there is a private cement factory of "Davao Plant" of the Holcim Philippines, Inc. The JICA Survey Team conducted an interview with the cement factory with the purpose of determining if there is a possibility on the sewage sludge utilization as raw/fuel materials in the plant.

The interview results are summarized below.

a. Overview of the Holcim Davao Plant

- Holcim Philippines, Inc. was initially founded in 1969 as Holcim (then Holderbank) and took a minority position in Alsons Cement Corporation, which operated the Lugait Plant.
- In the Davao Plant, there are three cement production lines, but only one line is currently in operation.
- The Davao Plant operates 24 hours a day, 7 days a week, and produces approximately 3,780 tons of cement per day.
- There are about 150 full-time staff at the Davao Plant.
- Currently, fuel for the Davao Plant are coal and Petcoke (Petroleum coke).
- However, biogas, waste oil, and RDF/RPF (fuel made of solid waste) are accepted as fuel, but only those sources energy (combustion temperature) exceeded a certain level.
- Currently, raw materials for cement are gypsum, limestone, pozzolan, and silica.
- Sample inspection is conducted to ensure the quality of cement, and there is an analytical laboratory in the Davao Plant for inspection.
- Figure 6.9.3 shows the process flow of the Davao Plant in which there is no facility to accept sludge.




Source: Holcim Philippines, Inc. Davao Plant

**Figure 6.9.3 Process Flow of the Holcim Davao Plant**

b. Possibility of accepting sewage sludge in the Holcim Davao Plant

- The Davao Plant has never considered or assumed the acceptance of sewage sludge as a fuel or cement raw material.
- For this reason, it is unclear under what conditions and specifications the sewage sludge is received as fuel or raw material.
- Assuming that sludge is received as fuel, it is necessary to confirm whether a certain amount of heat (combustion temperature) can be secured, as described above.
- On the other hand, in cases where sewage sludge is used as a raw material, the current manufacturing process should be reviewed, and it is necessary to change the sludge drying facility, receiving facility, and rotary kiln furnace.
- In addition, in cases where sewage sludge is used as a raw material, it is necessary to evaluate its appropriateness to combustion or whether it can be ensured that the cement to be manufactured is of a certain level of quality.
- If the rotary kiln of the Davao Plant is shut down, this will cause a loss of about PHP 8 million per day.
- In addition, since the distance from the Magsaysay Park to the Davao is about 13 km, the transportation costs should be considered.

3) Possibility of Sewage Sludge Utilization as Composting

a. Composting at the Carmen landfill Site

Based on RA 9003, composting of biodegradable domestic waste (non-hazardous) is promoted in the Philippines. At the landfill site in Carmen, Davao City, there is a composting facility and MRF as shown in Figure 6.9.4.

Carmen Landfill Site

Compositing & Material Recovery Facility in the Landfill

Source: JICA Survey Team

**Figure 6.9.4 Composting Facility in the Carmen Landfill Site**

According to an interview with CENRO staff, the following points have been confirmed:

- Compost produced at the facility is mostly used for plants in the city parks.
- However, compositing activity is not currectly active at the facility in the Carmen landfill site.
- The Carmen landfill site cannot accept sewage sludge.

b. Composting at Barangay MRF

In addition, based on RA9003, each barangay is obligated to install and operate one MRF. However, according to the CENRO, composting of biodegradable waste at MRF of each barangay in Area A is not carried out because it is in the urban area of Davao City and there is not enough area secured for this purpose. Thus, the JICA Survey Team observe an MRF in Barangay Vicente Hizon SR where composting is active in Area B.

- The barangay, with a population of about 11,000, is located about 30 minutes away by car to the southeast from Area A in Davao City. One MRF is installed in a wealthy residential area in the barangay.
- The MRF, including composting equipment, was granted by JICA as a pilot project in a JICA technical cooperation project of “Establishment of Ecological Solid Waste Management in Three Cities” conducted between 2007 and 2011.
- The Barangay Environmental and Natural Resources Office (BENRO) has purchased a Chinese compactor truck (6 tons) for collecting and transporting biodegradable waste. The equipment costs about PHP 2.2 million using the Barangay Development Fund.
- The process of composting of biodegradable waste in the MRF consists of mixing with humus, crushing it with a dedicated shredder, laying it in a yard, turning it over, and fermenting it.

Fermentation will be over in about 45 days. Effective Microorganism (EM) bacteria is used for accelerating the fermentation.

- The compost produced is only used for vegetable gardens and planting in the MRF, and the amount of treatment is small, with an average of 2 tons/day, although it varies depending on the day, and sludge treatment is not possible.

MRF granted by JICA

Compactor Truck


Composting Activity (1)


Composting Activity (2)

EM Product


Vegetable Garden in MRF

Source: JICA Survey Team

**Figure 6.9.5 Composting Activities at MRF in the Barangay Vicente Hizon SR**

Regarding composting at MRFs in Davao City, the JICA WTE project team suggested the following points:

- Of the 182 barangays in Davao City, 23 have an MRF.
- Some MRFs have stopped composting operation because of complain due to odor and presence of flies.
- Very few barangays implement composting.

c. Composting by Private Company (Davao Thermo Biotech Corp) in Davao City

The JICA Survey Team conducted an interview with Davao Thermo Biotech Corp., a private company, to confirm the company activities on composting. The interview is summarized below.

<Composting Activities by Davao Thermo Biotech Corp >

- In August 2016, a compost plant was built in Barangay Binugao, located approximately one hour away from Davao City by car, and the plant operations started two years ago.
- The composting plant has obtained all the necessary permits (e.g., business licenses, certifications of FDA and DOA standards, etc.) including environmental permit (ECC) from DENR.
- At present, raw materials (biodegradable waste) are purchased based on contracts from a total of 50 customers (Sam Miguel Brewery, SM shopping mall, etc.) around Davao City.
- For purchase of raw materials, collection costs, transportation costs, and processing costs are

collected from customers. Note that these costs are confidential based on the contract.

- Land for composting facilities is secured by long-term lease from the LGU, and business funds are procured by borrowing from investors and LBP (i.e., debt financing).
- The manufactured compost is sold at the Eco-land, an indoor shopping mall, in Davao City under the trade name of "*Dr. Bos Bio Fertilizer*". The sale to a large-scale farm, such as *Del Monte*, is a future market.
- In addition, environmental education, including introduction of composting technology and facilities of the plant to neighboring residents and farmers, has been conducted to build a better relationship with those residents; thus, there are few complaints.

<Composting Technology of Davao Thermo Biotech Corp >

- The composting plant has a roof and consists of a weigh bridge (vehicle weight measuring device), a receiving section, a crusher and turnover section, a composting section and an aeration machine by which 50 tons/day of raw materials (bio-degradable waste) can be processed in the plant.
- A license on YMO composting technology using the *hyperthermophilic YM* bacteria, patented by Kyowa Vaccine and Kyowa Kako in Japan, was obtained from both companies in 2015. The plant receives technical cooperation on composting from the company. YM is imported from Kyowa Kako, but the price is confidential.
- Hygienic compost can be produced in 45 days by obtaining a fermentation heat temperature of about 100℃ by aerobic fermentation with YM bacteria.
- In terms of quality of the compost, to meet the relevant standards of the Philippines, Kyowa Kako analyzes samples of the compost weekly.
- The biggest constraining factor in the promotion of composting business is the securing of financing.

<Possibility of accepting sewage sludge at the compost plant of Davao Thermo Biotech Corp >

- Sewage sludge composting is considered technically feasible, but it depends on the amount per day.
- The plant capacity of composting can be up to 200 tons/day, and, in some cases, a sludge receiving section in the plant will be constructed separately.
- Davao City shall bear the initial investment and the cost of collection, transportation, and processing for the composting of the sludge in the plant.

### d. Agricultural Use of Sewerage as Compost or Soil Conditioner in Davao City

Table 6.9.8 summarizes the City's ordinance and resolution which promotes organic-agriculture.

**Table 6.9.8 Laws and Regulations on Cutting of Trees**

| Ordinance and Resolution | Year | Description |
|---|---|---|
| City Ordinance No. 0384-10 Series of 2010 | 2010 | An ordinance institutionalizing, promoting and developing organic agriculture in Davao City, providing funds therefore and other purposes |
| City Ordinance No. 0384-10 Series of 2010 | 2011 | The Implementing Rules and Regulations of the Organic Agriculture Ordinance of Davao City |
| Resolution No. 02610-18 Series of 2018 | 2018 | Enacting an Ordinance Declaring Barangay Sibulan, Toril District, this City, as Agricultural Organic Zone and for Other purposes |

Source: City of Davao

The land use capability and environmental management areas of the City is divided into agricultural land use capable areas, conservation areas, and resource conservation areas as shown in Table 6.9.9.

**Table 6.9.9 Land Area by Land Use Capability and Environmental Management Category**

| Category | | Land Area (hectare) in Davao City |
|---|---|---|
| Agricultural areas | Non-tillage areas | 105,599.54 |
| | Tillage areas | 58,830.56 |
| | For rice, corn, and fishponds | 2,811.80 |
| Conservation areas | | 46,241.71 |
| Resource conservation areas | | 11,155.60 |

Original Source: CLUP 2013-2022
Source; Davao City Agriculture and Fishery Development Plan for 2018-2022

As for organic agricultural practices in the City, there were 480 farmers in the city that cultivate 719 hectares of land for production of organic crops in 2016 as summarized in Table 6.9.10.

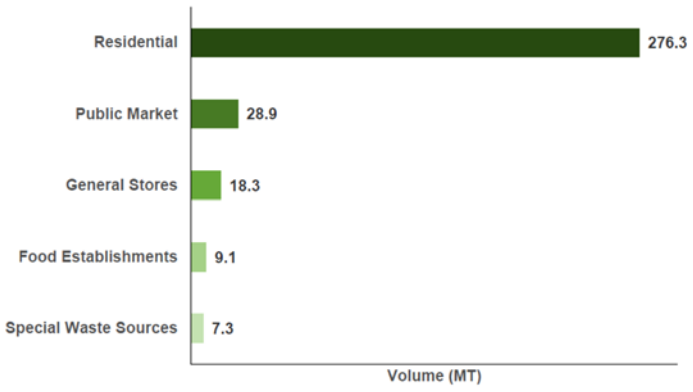
**Table 6.9.10 Organic Production in Davao City by district**

| District | Number of Farmers | Area Planted (ha) |
|---|---|---|
| Baguio | 24 | 37.46 |
| Bunawan | 32 | 48.66 |
| Buhangin | 22 | 19.86 |
| Calinan | 33 | 34.09 |
| Marilog | 72 | 98.09 |
| Talomo | 7 | 7.55 |
| Toril | 25 | 44.38 |
| Paquibato | 265 | 429.12 |
| Total | 480 | 719.22 |

Source; Davao City Agriculture and Fishery Development Plan for 2018-2022

In addition, according to the Davao City Agriculture and Fishery Development Plan (DCAFDP) for 2018-2022, some of biodegradable garbage (solid waste) in the City were processed into soil conditioners or composts. Significant points are summarized below.

- The city generated 366 metric tons of solid waste in 2012.
- Among the solid garbage, residential waste contributed the largest amount with 276.3 metric tons, which is 76% of the total.
- Solid waste from public markets, general stores, food establishment, and special waste sources complete the top 5 sources of waste with 28.9, 18.3, 9.1, and 7.3 metric tons, respectively (See Figure 6.9.6).
- Solid waste from slaughterhouses and dressing plants, public market, and farms may fall under agricultural waste, which individually contribute 1%, 8%, and less than 1%, respectively.




Original Source: Davao CENRO
Source; Davao City Agriculture and Fishery Development Plan for 2018-2022

**Figure 6.9.6 Top 5 Sources of Solid Waste in Davao City in 2012**

With regard to fertilizer usage for agriculture, DCAFDP 2018-2022 states the following:

- Application of fertilizer among farmers is greatly affected by its price.
- Increase in price forces farmers to stop, reduce, or improperly apply fertilizer – usage of unprescribed kind and quantity.
- Organic fertilizers, like vermicast and shredding of cacao pods as substrate for the vermiculture, are being utilized by farmers as substitute to chemical fertilizer.
- However, issues such as production becoming more labor intensive, limited knowledge and tools, and limited distribution channels in organic fertilizer production hamper the utilization of organic fertilizers among farmers.

An interview with the City Agricultural Office conducted by the JICA Survey Team confirmed the following points:

- There is currently no information and idea on the sewerage sludge utilization as compost or soil conditioner for the organic agriculture.
- As far as they know, at present, a small-scale vermicomposting from biodegradable solid waste is being practiced by some farmers in Davao.

✓ **Points to consider on utilization of sewage sludge**

In consideration of the above situations on composting from waste in Davao City, the following points regarding composting of sewage sludge in the City shall be further discussed:

- Necessary studies on the feasibility and technical specifications on the sludge utilization as fuel/law materials at the private cement factory in Davao City
- Possibility of treating sewage sludge at each MRF in Area A considering capabilities and spaces of MRFs or construction of a sludge composting yard and plant in Davao City
- Environmental and social considerations on construction and operation of a composting yard and plant (if the City is to do so) as well as quality assurance and marketing of compost produced from sewage sludge
- Necessary budget allocations for (if the City considers) utilization of the private composting plant in Davao City
- Constraints (e.g., knowledge, techniques, facilities, competitive nature with chemical fertilizer, sludge quality, transportation system, willingness of farmers, etc.) on utilization of the sludge for promoting the organic agriculture in the City (to be studied furthermore by agricultural experts)

(4) Cutting of Trees for WWTP Construction

According to Davao City, a total of 488 trees is planted on the premises of the Magsaysay Park (See Appendix 5.4). Some of the trees may be cut down depending on the layout of the WWTP to be constructed for the Project.

Table 6.9.11 summarizes the principal laws and regulations on cutting of trees in the Philippines.

**Table 6.9.11 Laws and Regulations on Cutting of Trees**

| Laws and regulations | Year | Description |
|---|---|---|
| Constitution of the Philippines | 1987 | SECTION 2 of ARTICLE XII: "All lands of the public domain, waters, minerals, coal, petroleum, and other mineral oils, all forces of potential energy, fisheries, forests or timber, wildlife, flora and fauna, and other natural resources are owned by the State". |
| Republic Act No. 3571 | 1963 | An Act to Prohibit the Cutting, Destroying or Injuring of Planted or Growing Trees, Flowering Plants and Shrubs or Plants of Scenic Value Along Public Roads, in Plazas, Parks, School Premises or in Any Other Public Pleasure Ground. |
| Presidential Decree No. 705 | 1975 | Forestry Reform Code of the Philippines. |
| Executive Order No. 263 | 1995 | Community-based Forest Management as the National Strategy to Ensure the Sustainable Development of the Country's Forest Land Resources and Providing Mechanisms for Its Implementation. |
| Republic Act No. 8048 | 1995 | Coconut Preservation Act. |
| Republic Act No. 9175 | 2002 | An act regulating the ownership, possession, sale, importation and use of chain saws, penalizing violations thereof and for other purposes. |
| Republic Act No. 10593 | 2013 | Amending Certain Sections of RA 8048 entitled "Regulation of the Cutting of Coconut Tess, its Replenishment, Providing Penalties therefore, and for other purposes". |
| Forestry Related DENR Policies | - | See Appendix 6.7 |

Source: National Constitution 1987, RA 3571, PD 705, ED 263, RA 8048, RA 9175, RA 10593, DENR Home Page

As shown in Table 6.9.11, the highest law governing forests in the Philippines is the 1987 Constitution, of which Section 2 of Article XII stipulates that "forests or timber, wildlife, flora and fauna, and other natural resources are owned by the State". Therefore, it is legally interpreted that "not only trees in the national forest but also trees on private land are national properties".

✓ **Points to consider on cutting of trees**

- In general, even though trees are on the premises of private lands in the Philippines, necessary permission relating to cutting of tree shall be obtained from DENR (See Appendix 6.7).
- Trees planted in public areas, such as the Ramos Magsaysay Memorial Park, may be considered as "public domain" by the citizens.
- In this regard, social considerations, such as public consultations and/or stakeholder meetings, on the cutting of tree shall be held by the initiative of Davao City before construction commences.

(5) Impacts on Business by WWTP Construction

There are small scale commercial establishments, such as a rest-bar, a small attraction facility, and a retailer shop and offices in the Magsaysay Park as summarized in Table 6.9.12.

**Table 6.9.12 Facility and Woker in Magsaysay Park**

| Facility | Eateries/Renters | Park Attraction | Government Office | |
|---|---|---|---|---|
| | | | National | LGU |
| Total number (facility) | 8 | 2 | 8 | 9 |
| Total worker (person) | 33 (39*) | 14 | 128 | 330 |

* +6 workers: temporarily hired during festivals or holiday seasons
Source: City Government of Davao

Caused by the WWTP construction, those facilities in the park may experience impacts on their businesses temporarily (i.e., during construction stage) or permanently. In this regard, the JICA Survey Team has proposed a WWTP layout having less impacts on those facilities considering the JICA Guidelines. However, the WWTP layout will interfere with a private owner facility (as shown in Appendix 6.8, No. E2 in which eight private people work) and with LGU facilities (No. GL 7 in which

20 LGU officials work, and No. GL 3 in which 50 LGU officials work).

According to Davao City, procedures on actions against impacts on the businesses, including demolition and/or relocation of the facilities, as consequences of the WWTP construction in the park come into compliance with the relevant laws and regulations shown in Table 6.9.13. (Refer to Appendix 2.5 Land Acquisition and Resettlement System of the Philippines).

**Table 6.9.13 Laws and Regulations on Procedures against Impact on Business**

| Laws and regulations | Year | Description |
|---|---|---|
| Republic Act No. 7279 | 1992 | IRR to "Ensure the Observance of Proper and Human Relocation and Resentment Procedures manded by the Urban Development and Housing Act of 1992" of the Department of Interior and Local Government (DILG) and the Housing and Urban Development Coordinating Council (HUDCC). |
| Republic Act No. 10752 | 2016 | Act Facilitating the Acquisition of Right-of-Way Site or Location for National Government Infrastructure Projects |
| DPWH D.O. No. 327 (series of 2003) * | 2003 | Guidelines for Land Acquisition and Resettlement Action Plan (LAPRAP) for Infrastructure Projects |

* In case of NSSMP
Source; City Government of Davao

As far as the private owners with business in the park are concerned, the City Economic Enterprise Office (CEEO) explained the following:

- Private businesses in the park are operating with permission from the city government of Davao.
- Those private businesses in the park pay the usual taxes and fees.
- Those private business can be asked to vacate or stop operations anytime.

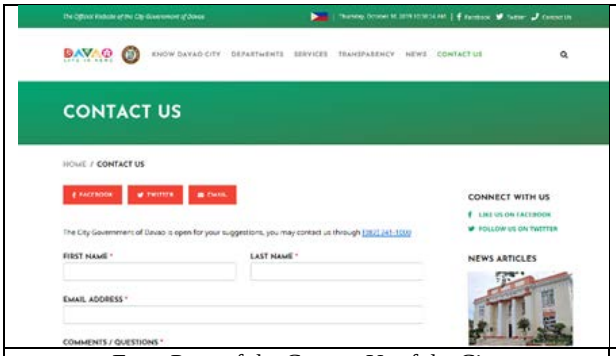
✓ **Points to consider on impacts on business in the park**

- Compensation and/or livelihood restoration programs shall be discussed and developed as a Resettlement Action Plan (RAP) for the impacts on the business circumstances in the park.
- In this regard, social considerations, such as public consultations and/or stakeholder meetings, on the businesses shall be held by the initiative of Davao City before the construction.

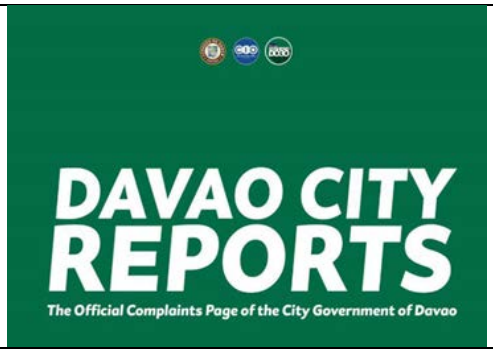
(6) Environmental and Social Management System

In the implementation of the Project, an Environmental and Social Management System (ESMS), including a grievance redress, is necessary to be set up in order to satisfy all environmental and social requirements in accordance with PEISS and the JICA ESC Guidelines.

As for the grievance redress, the city government is open for people's suggestions. Namely, those who would like to express their opinions and grievances can communicate with the city through the hotline (082-241-1000), e-mail (cio@davaocity.gov.ph), and other social networking services as shown in Figure 6.9.6 (See https://www.davaocity.gov.ph/contact-us/). Also, the Facebook page of "Davao City Reports" at https://www.facebook.com/davaocityreports/ was launched in 2017 as the "Official Complaints Page of the City Government of Davao". The page is maintained by the City Information Office, which will also forwards the collated reports to the concerned offices and agencies for necessary action.




Front Page of the Contact Us of the City




Front Page of Facebook on the Official Complaints

Source: Davao City

**Figure 6.9.7 Contact Page and Facebook Page for Complaints on the City Home Page**

Complaints are also received by the Public Information and Complaints Desks stationed in each building of the city government offices.

✓ **Points to consider on environmental and social management system (ESMS)**

- An Environmental Management Plan (EMP), including its monitoring plan (EMoP), will be proposed in EIS and approved by EMB/DENR as requirements based on PEISS of the Philippines for the Project.
- In addition, a JICA Environmental and Social Considerations (ESC) Study to be carried out in the near future in a JICA Preparatory Survey (or Feasibility Study) will propose JICA's EMP/EMoP to satisfy environmental and social requirements based on the JICA Guidelines for the JICA-funded loan project.
- In this regard, for the realization of the respective EMP and EMoP, Davao City, as the project proponent, must set up an ESMS, including a grievance redress mechanism exclusively for the Project.
- Present "Davao City Reports" in official complaint page on the website of Davao City can be upgraded to such systems of EMS for the proposed Project. (JICA Survey Team Proposal)

### 6.9.6 Environmental Check List (No. 15 of JICA Guidelines)

Based on the results of this JICA Survey, an "environmental checklist (No. 15 for wastewater projects)", one of the JICA documents related to the JICA Guidelines, was developed by the JICA Survey Team (See Appendix 6.9).

# CHAPTER 7 STUDY AND PLANNING OF STEPWISE SEWARAGE SYSTEM DEVELOPMENT IN AREA A (PHASE-1 PROJECT)

In this chapter, the study and planning of a step-wise sewerage system development are described in detail, particularly for the work of Phase-1 in Area A.

## 7.1 Selection of Phase-1 Development Area in Area A

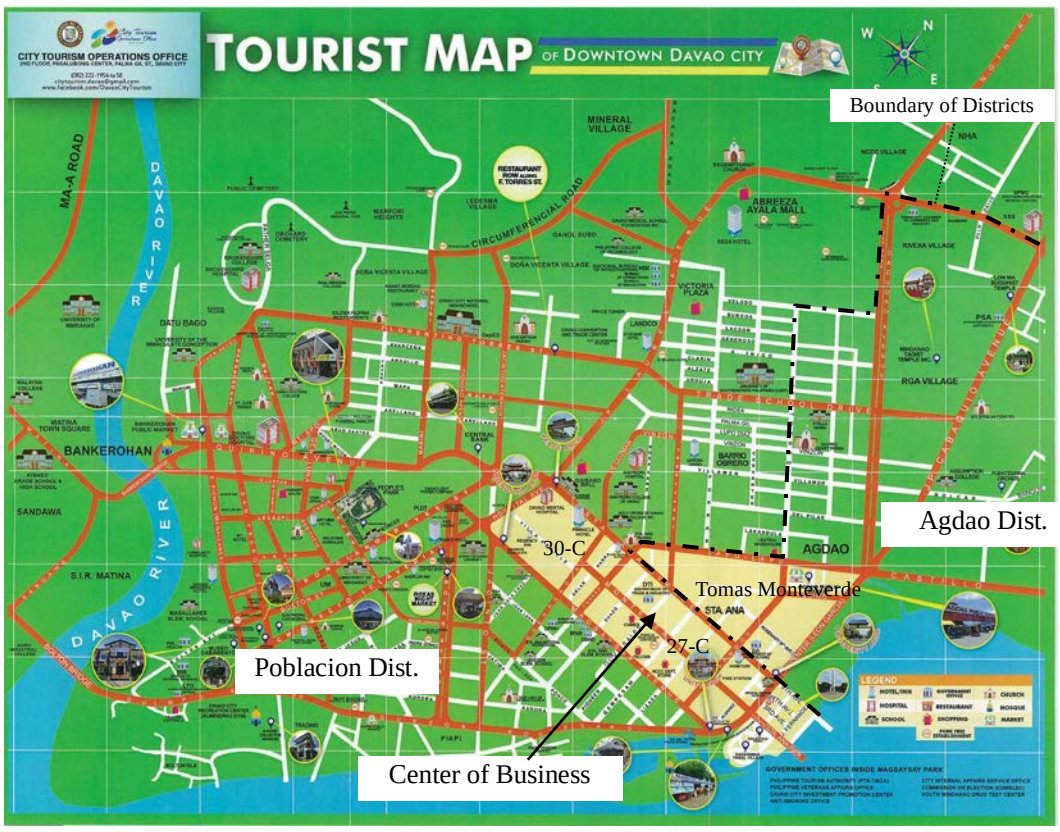
(1) Base Information for Selecting the Main Target Area

Table 7.1.1 shows the number of connections in categories to the DCWD water supply system in the Poblacion and Agdao Districts as of April 2019. The data shows that the Poblacion District has more commercial and large-scale customers than the Agdao District. Figure 7.1.2 shows the center of business in Davao City.

**Table 7.1.1 Numbers of DCWD Connections in Categories in Poblacion and Agdao**

| District | Residential | Commercial /Industrial | Government | Total | Large Scale Customer |
|---|---|---|---|---|---|
| Poblacion | 27,557 | 7,365 | 204 | 35,126 | 173 |
| | 78.5% | 21.0% | 0.6% | 100% | 0.49% |
| Agdao | 15,708 | 2,608 | 65 | 18,381 | 25 |
| | 85.5% | 14.2% | 0.4% | 100% | 0.14% |
| Total | 43,265 | 9,973 | 269 | 53,507 | 198 |

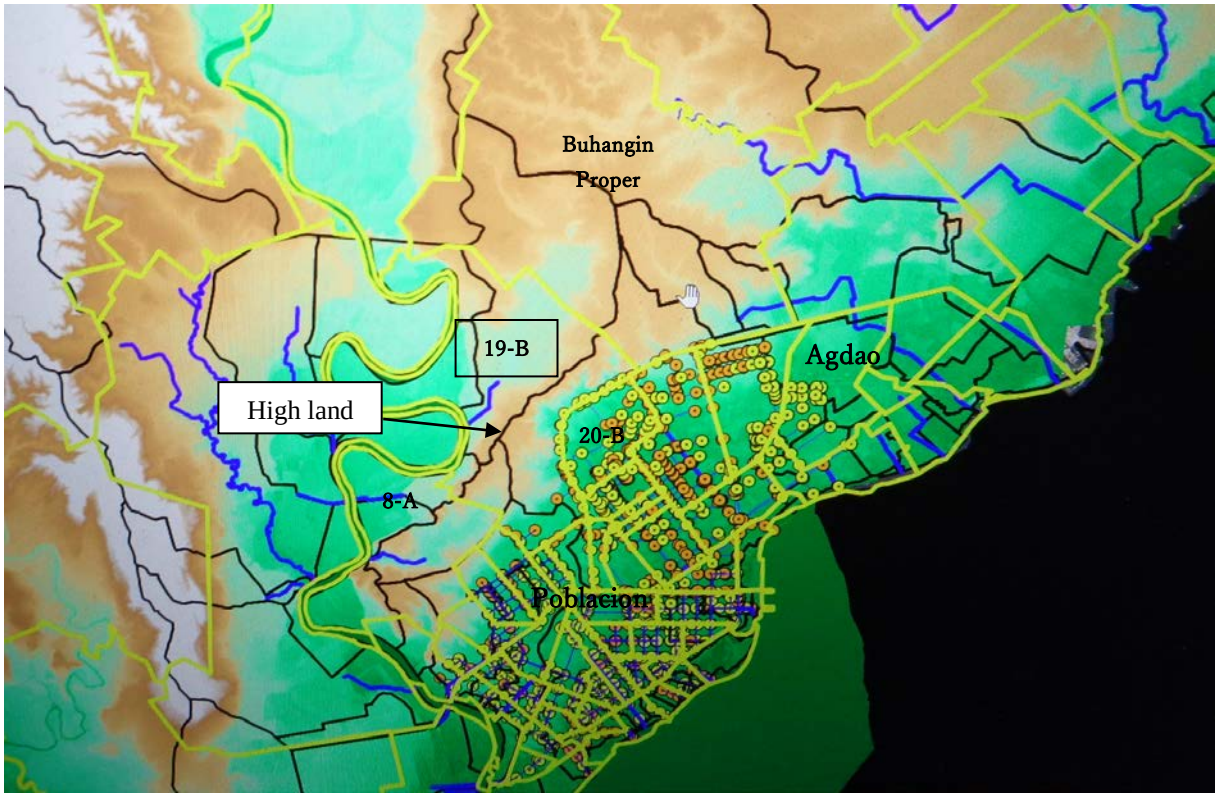
Note: Large scale customer is more than 500 $m^3$/month water consumption
Source: JICA Survey Team based on DCWD data as of April 2019




Source: JICA Survey Team based on tourist map of City Tourism Operations Office

**Figure 7.1.1 Center of Commercial Area in Area A**

Poblacion District has 40 barangays (1-A to 40-D) in total. Barangays 8-A and 19-B are located in the north edge of the district. Poblacion 8-A belongs to Area B in the sewerage development plan in IM4D, and 19-B has a high elevation area (around MSL+30m) in the boundary with other barangays compared to around a 12-m elevation in the main land of the barangay. It means that at least an 18-m pump up or deep laying of pipe with a shield tunneling method is needed to cross the high land and flow the wastewater in 19-B down to the southern adjacent barangay (20-B). (see Figure 7.1.2)




Source: JICA Survey Team on topographic map from Flood Control M/P Team

**Figure 7.1.2 Topographic Condition in North of Poblacion District**

(2) Options Compared

Option-1 to Option-3 based on Option-0 as all of Area A were compared as shown in Table 7.1.1. The boundaries of the target areas are shown in Figure 7.1.3. The main targets are barangays in the Poblacion District in Option-2 and Option-3. However, the following barangays were adjusted in the options.

1) Based on the business center range in Area A, Barangay Tomas Monteverde in Agdao District was considered as a part of the main target of Option-2 and Option-3.

2) Due to the easiness of a sanitary sewer development due to wide roads and the absence of slums, the left side of the Dacudao Creek (a part of Agdao Proper and Paciano Bangoy) is also added from the Agdao District.

3) Barangay Leon Garcia in Agdao District is an extremely high-density area with roads that are not wide enough. However, since it is adjacent to a trunk sewer and the Magsaysay Park, the barangay is

added to the target areas. It is important to note that only buildings beside sufficiently wide roads can be connected to the sewerage system. This is because temporal interception is quite difficult without main drains.

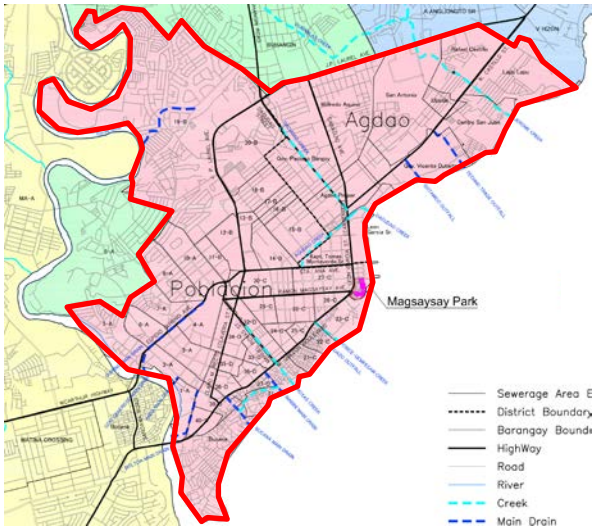
4) Poblacion 19-B is excluded in Option-3 because of the topographic condition and requirement of quite long sewer networks (around 57 km) for the wide residential area without commercial areas and apartments.

5) Poblacion 8-A in Area B in IM4D was excluded in all the options and in the study in Chapter 6.

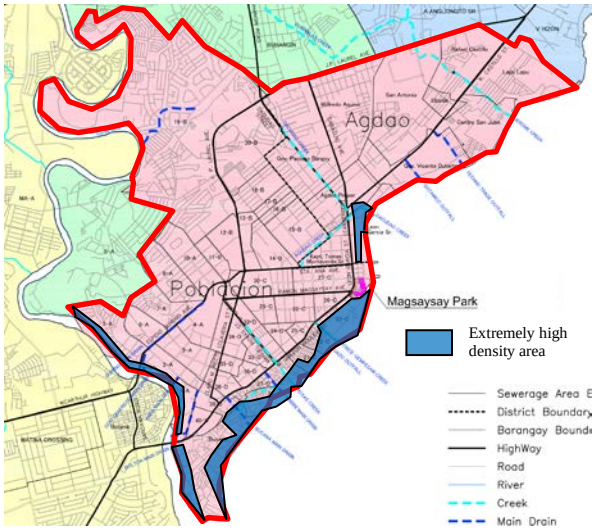
**Table 7.1.2 Options of Target Area compared for Stepwise Development**

| Option | Main Target | Excluded | Added |
|---|---|---|---|
| Option-0 | The entire Area A | Pob 8-A (Area B) | - |
| Option-1 | Area A excluding slum areas beside the sea and river | Pob 8-A | - |
| Option-2 | Poblacion<br>Tomas Monteverde (Agdao) | Pob 8-A | Part of Agdao Proper, Paciano Bangoy |
| Option-3 | Poblacion<br>Tomas Monteverde (Agdao) | Pob 8-A<br>**Pob 19-B** | Ditto |

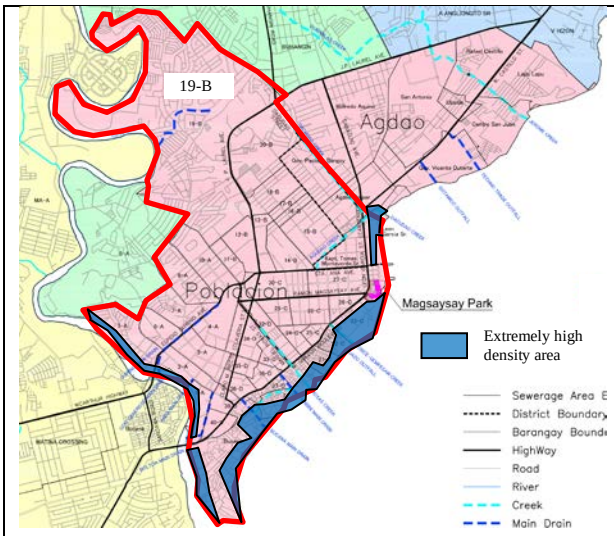
Note: Option-2 and Option-3 also exclude the slum areas beside sea and river for individual connections but intercept the wastewater in those areas at the initial stage as a temporary measure.
Source: JICA Survey Team



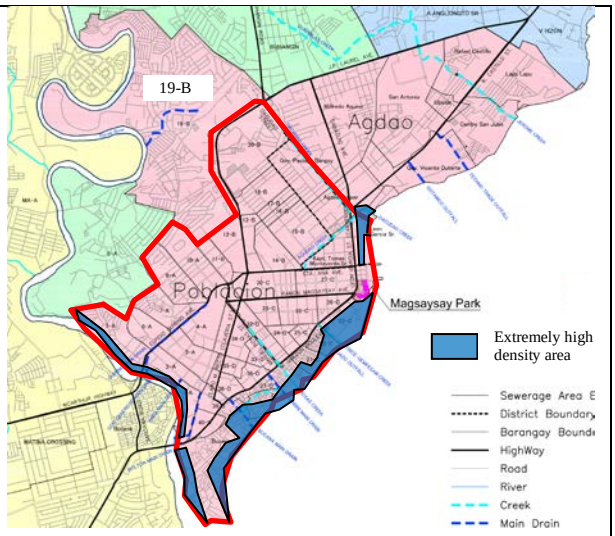

Option-0: Entire Area A




Option-1: Entire Area A but exclude seaside/riverside areas with too high density




Option-2: Exclude most of Agdao District




Option-3: Exclude most of Agdao District and 19-B

**Figure 7.1.3 Boundaries and Target Area in Option-0 to Option-3**

**Table 7.1.3 Comparison of Target Area Options (1/2)**

| Option | Population (2045) | Nos. of Connection (2045) | WWTP Capacity ($m^3$/day) | Trunk Sewer (km) | Sanitary Sewer (km) | Interceptor (m) | Total (km) | Required Period (year) |
|---|---|---|---|---|---|---|---|---|
| Option-0 | 369,784 | (>94,173) | 97,000 | 38.7 | >278 | 1,350 | >318 | **>14.0** |
| Option-1 | 309,664 | 94,173 | 64,000 | 38.7 | 278 | 1,350 | 318 | **14.0** |
| Option-2 | 230,115 | 70,139 | 46,000 | 31.0 | 166 | 550 | 198 | **7.6** |
| Option-3 | 192,041 | 59,697 | 40,000 | 28.7 | 109 | 550 | 139 | **5.6** |

Note: The wastewater inflow to WWTP would be 64,000 $m^3$/day in 2045 in case redevelopment in all the extremely high density areas will be abandoned and only a part of wastewater in the areas will be intercepted. Option-2 and Option-3 also have the same baseline.
Required construction period is in case of 6 parties, progress of 10 m/day/party for trunk sewer and 20 m/day/party for sanitary sewer and interceptor
Source: JICA Survey Team based on existing service connection data from DCWD

**Table 7.1.4 Comparison of Target Area Options (2/2)**

| Option | CAPEX (PHP million) | CAPEX incl local (PHP million) | OPEX (PHP million/yr) | LCC (20 years) (PHP billion) | Commercial & Government (%) | Cost Recovery with NSSMP | Treated BOD in Area A (%) | Treated BOD per Cost | Evaluation |
|---|---|---|---|---|---|---|---|---|---|
| Option-0 | 17,351 | 19,420 | 465 | 29.6 | **20** | **(0.46)** | (95.0) | - | - |
| Option-1 | 17,351 | 19,420 | 274 | 25.7 | **20** | **0.46** | 70.3 | **303** | Moderate |
| Option-2 | 11,575 | 13,021 | 236 | 17.7 | **22** | **0.59** | 49.9 | **312** | Better |
| Option-3 | 9,306 | 10,272 | 195 | 14.2 | **30** | **0.65** | 40.1 | **314** | Best |

Note:
1) CAPEX incl. local is composed of (JICA) project portion and local portion of all the house connections continued after the project by implementing agency
2) Cost recovery is based on only tariff revenue from Php 10/$m^3$ for residential and Php 20/$m^3$ for commercial
3) Cost recovery 0.65 means that 65% of LCC (20 years) can be recovered
4) Evaluation of Option-0 is impossible because collection of all the BOD load is impossible without redevelopment of slum areas
Source: JICA Survey Team

Based on the comparison above, Option-3 is selected due to the high efficiency of development in terms of expected income from the high ratio of commercial and government customers and its environmental benefit (treated BOD loads) per cost (LCC). From the high ratio of commercial and government customers, the quick increase of connection ratio to sewerage system and high cost recovery also can be expected.

## 7.2 Planning of Sewer Facility in Phase-1 Area

### 7.2.1 Planning of Sewer Facility

The target area and population, wastewater flow to be treated, sewer lengths in Phase-1, and the remaining of Area A (Phase-2) is shown in Table 7.2.1.

**Table 7.2.1 Phasing Plan of Sewer Facilities**

| Type of Sewer | Phase-1 | Phase-2 | Total |
|---|---|---|---|
| Target Area | Poblacion Dist. (excl. 19-B) and a part of Agdao Dist. | - Poblacion 19-B and most of Agdao Dist.<br>- Existing slum areas after re-development<br>- Increased population in Phase-1 target area | The entire Area A |
| Target Population | 165,178 (2030) | 204,605 (2045) | 369,784 (2045) |
| Wastewater generation (Daily maximum) | 38,000 $m^3$/day (2030)<br>40,000 $m^3$/day (2045) | 57,000 $m^3$/day (2045) | 97,000 $m^3$/day (2045) |
| Trunk Sewer | Dia 400-2000, 28.7 km incl. pipe jacking | Dia. 400-800, 10 km incl. pipe jacking | Dia. 400-2000, 38.7 km incl. pipe jacking |
| Lateral Sewer | Dia 200-500, 109 km | Dia 200-400, 169 km | Dia 200-500, 278 km |
| Interceptor | - Dia 400 m x 650 m in Bucana<br>- 2 interception chambers from Bucana MD, Mabini MD<br>- Flap gates (in chambers or seaside) | None (all separate sewer)<br>* after some scattered slums resettled in future | (Dia 400 m x 650 m)<br>* Switch to sanitary sewer in future |
| Pumping Station | 1) Main Pumping Station (1)<br>2) Lift pumping stations in barangays to trunk sewers (manhole pumps) | 1) Booster/lift pumping stations in 19-B (1)<br>2) Lift pumping stations in barangays to trunk sewers (manhole pumps) | 1) Main P/S (1)<br>2) Booster/lift P/S in Poblacion 19-B (1)<br>3) Lift pumping stations in barangays |
| House Connection | - 2,100 connections in pilot area (Poblacion 27-C, 30-C, Agdao Tomas Monteverde) (JICA project)<br>- Around 25,000 connections in other area (local project) | Around 50,000 connections | Around 77,000 connections (as of 2045) |

Note: Dia.: Diameter, MD: Main Drain, P/S: Pumping Station
Source: JICA Survey Team

### 7.2.2 Trunk Sewer

The trunk sewer routes that convey wastewater from barangays to WWTP were prepared along with the proposed trenchless installations with the pipe jacking method. The trunk sewer sections No. 33 and 49 to 55 were excluded from the trunk sewer plan for Area A in Chapter 6. The trunk sewer plan is shown in Figure 7.2.1. The flow calculation and longitudinal profile of the trunk sewer in Phase-1 is shown in Appendix 7.1.

The diameters and slopes of trunk sewers are kept large enough to cope with the future inflow from the Agdao District (mainly Phase-2 area) and wastewater from slum/congested areas in Poblacion District after the redevelopment of land and additional house connections are made in developed areas. The wastewater inflow and velocities are small in the initial stage against the design capacity of sewers and it may cause the sedimentation of solids in the pipes. Therefore, the flow velocities were set up with more than 1.0 m/s with allowance in general for design inflow in 2045, in order to keep the

required velocity of 0.6 m/s at initial stage.

Due to the relatively low level of WWTP with a fully underground water treatment facility, the intermediate and main pumping stations are not required for the current estimation. It should be confirmed in next stage with the planning (downstream elevation) of lateral sewers in barangays.

**Table 7.2.2 Summary of Trunk Sewer Length in Phase-1**

| No. | Diameter (mm) | Length (m) | | | Note |
|---|---|---|---|---|---|
| | | Open Cut | Trenchless | Total | |
| 1 | 400 | 19,600 | 500 | 20,100 | |
| 2 | 450 | 0 | 0 | 0 | |
| 3 | 500 | 0 | 200 | 200 | |
| 4 | 600 | 1,300 | 1,200 | 2,500 | |
| 5 | 700 | 500 | 800 | 1,300 | No.28, 35 |
| 6 | 800 | 1,300 | 600 | 1,900 | No.36,37,40 |
| 7 | 900 | 0 | 0 | 0 | |
| 8 | 1000 | 0 | 0 | 0 | |
| 9 | 1100 | 0 | 0 | 0 | |
| 10 | 1200 | 0 | 700 | 700 | No.56,57 |
| 11 | 1400 | 0 | 300 | 300 | No.8,10,14 |
| 12 | 1500 | 0 | 800 | 800 | No.18,26,58 |
| 13 | 1650 | 0 | 800 | 800 | No.29,31 |
| 14 | 2000 | 100 | 0 | 100 | No.59 to WWTP |
| | Total | 22,800 | 5,900 | 28,700 | |

Source: JICA Survey Team

### 7.2.3 Lateral Sewer and House Connection

The estimated lateral sewer lengths per diameter and the number of house connections for the work at Phase-1 are shown in Table 7.2.3 and Table 7.2.4. The detail of total sewer lengths in barangays are shown in Appendix 7.2. The lateral sewer lengths were estimated based on existing road network lengths in barangays obtained from CPDO. The total number of connections are based on the existing water supply connection data from DCWD and population projection in 2030.

**Table 7.2.3 Summary of Lateral Sewer Length in Phase-1**

| No. | Diameter (mm) | Installation Method | Length (m) | | |
|---|---|---|---|---|---|
| | | | Poblacion | Agdao | Total |
| 1 | 200 | Open cut | 84,186 | 5,761 | 89,947 |
| 2 | 250 | Open cut | 10.176 | 1,876 | 12,052 |
| 3 | 300 | Open cut | 3,581 | 938 | 4,519 |
| 4 | 350 | Open cut | 925 | 741 | 1,665 |
| 5 | 400 | Open cut | 802 | 65 | 867 |
| 6 | 450 | Open cut | 246 | 0 | 246 |
| 7 | 500 | Open cut | 123 | 0 | 123 |
| | Total | | 100,039 | 9,380 | 109,419 |

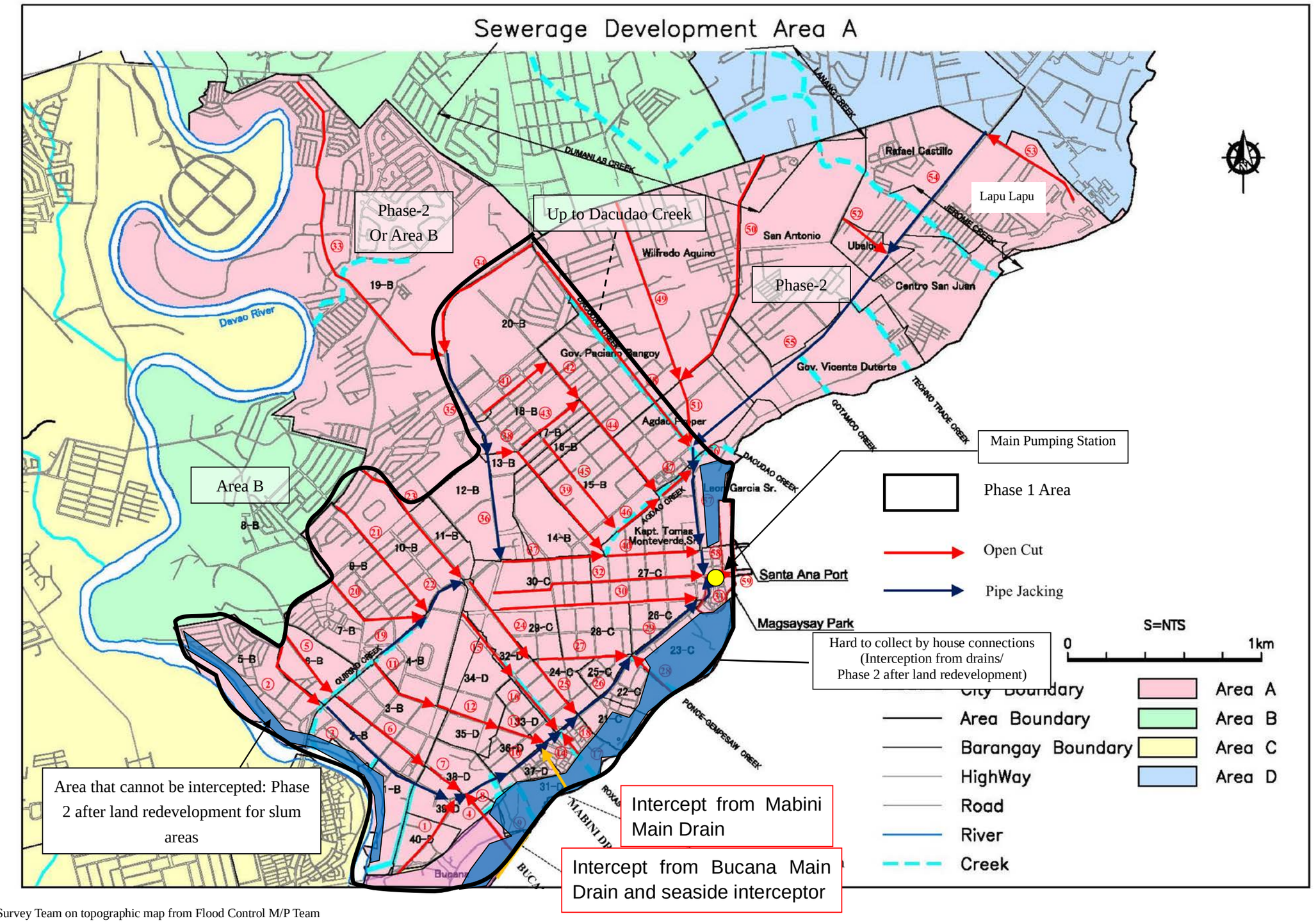
Note: Poblacion inludes Barangay Bucana (Talomo District)
Source: JICA Survey Team

**Table 7.2.4 Summary of Connections in Phase-1**

| Target Area | Poblacion | Agdao | Total |
|---|---|---|---|
| Pilot Area (Barangays 27-C, 30-C, Tomas Monteverde) | 1,696 (752) | 411 (241) | 2,107 (993) |
| Others (with local fund) | 23,386 | 1,958 | 25,344 |
| Total | 25,082 | 2,369 | 27,451 |

Note:
1) Poblacion inludes Barangay Bucana (Talomo District)
2) Tomas Monteverde (Agdao) is assumed to be 40% connections of all the residentials due to congested area
3) Inside brackets are numbers of commercial and government office connections

Source: JICA Survey Team



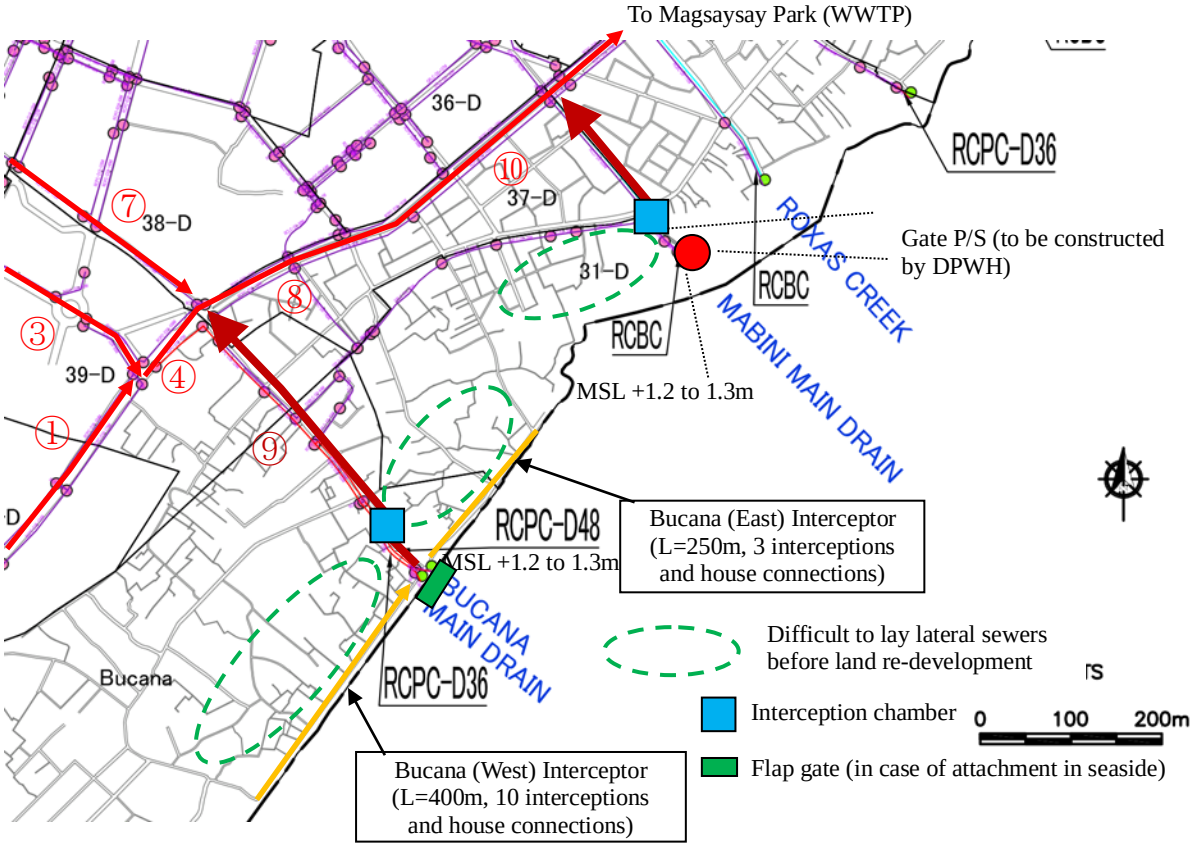

Source: JICA Survey Team on topographic map from Flood Control M/P Team

**Figure 7.2.1 Trunk Sewer Map in Phase-1 Area**

### 7.2.4 Main Drains for Temporal Interception

(1) General Location of Interceptors

Due to the highly congested houses including slums, the collection of wastewater in the seaside area is quite difficult before any land redevelopment. The interception from the open channel is also impossible due to a very large flow, particularly in rainfall events. However, there are some underground culverts (main drains) which are possible to intercept. As a temporary measure before land redevelopment, the interception from the main drains are proposed to collect wastewater from the seaside area efficiently and to secure enough flow for commissioning of WWTP. The proposed main drains are 1) Bucana Main Drain in the east of Barangay Bucana and 2) Mabini Main Drain in Barangay 31-D to collect wastewater from East of Bucana, 31-D, and a part of 37-D. The locations and image of interceptions are shown in Figure 7.2.2.

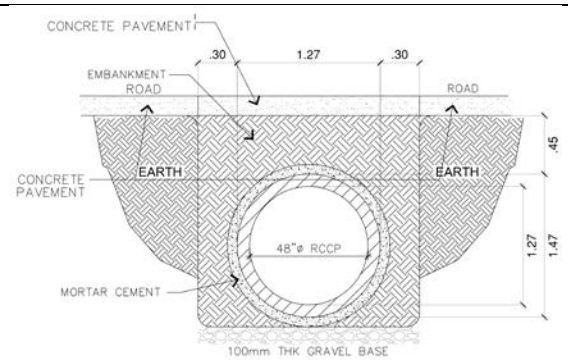



Source: JICA Survey Team

**Figure 7.2.2 Locations of Interceptions from Bucana Main Drain and Mabini Main Drain**

(2) Interception from Bucana Main Drain and Seaside Interceptor for Barangay Bucana (East)

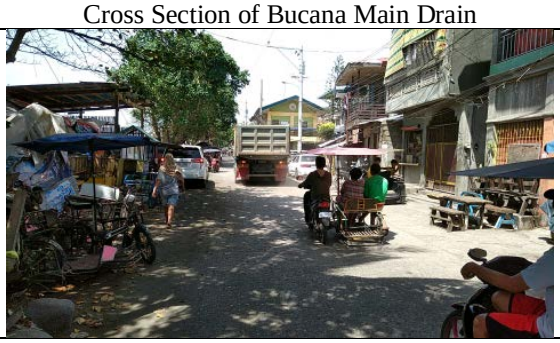
The Bucana Main Drain to be intercepted has a diameter of 48 inches (= D1220 mm). The cross section is shown below. It is composed of 2 lines x 36 inches (= D910 mm). The invert level is around 1.4 m from the ground level (MSL+1.2 m to 1.3 m) at the outlet and the elevation is around MSL-0.1 m. Therefore, seawater can enter the drain from the outlet during high tide events. (The record and analysis of high tide and low tide is described in Chapter 8.) The flap gate should be installed in the outlet of the drain as detailed in (4) in this subsection.




Source: Davao City Engineering Office (CEO)

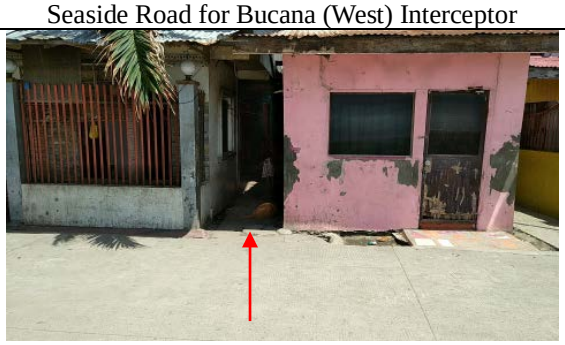
Cross Section of Bucana Main Drain

Outlet of Bucana Main Drain



Seaside Road for Bucana (West) Interceptor

San Pedro Street for No. 9 Trunk Sewer



Small drain flow from inside slum

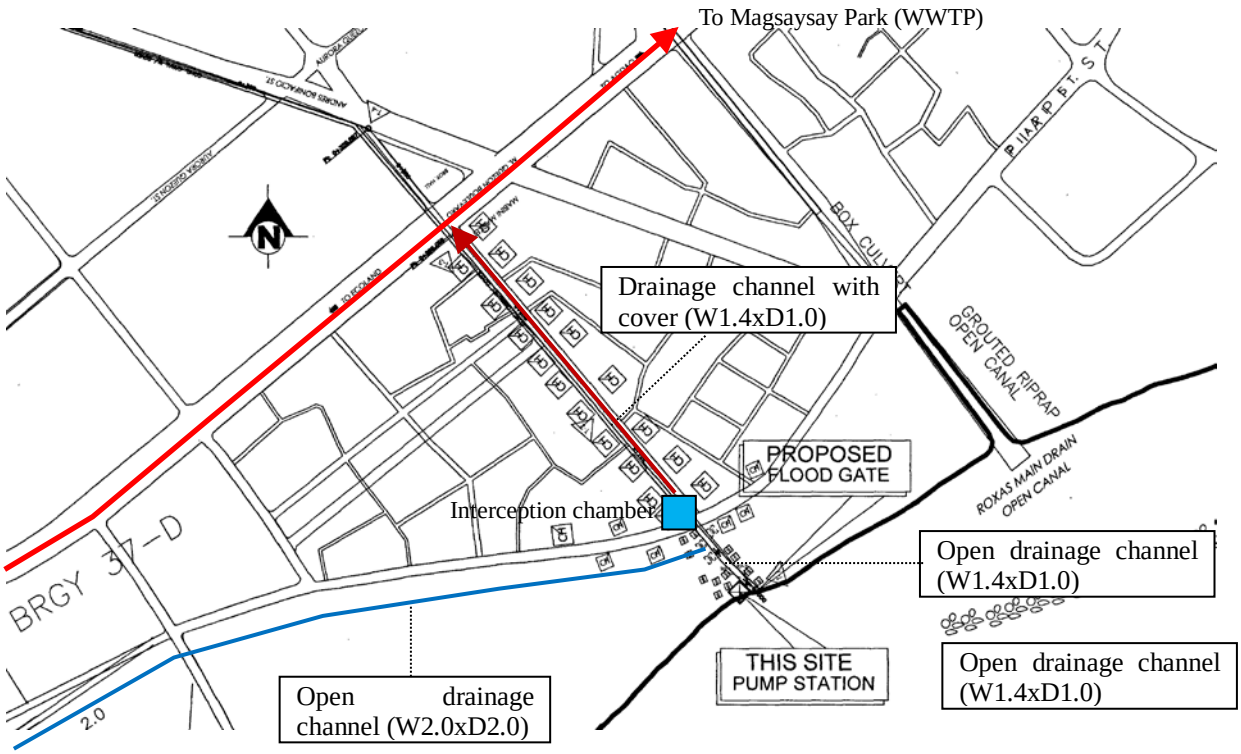
Outlet of small drain from inside slum

Source: JICA Survey Team

**Figure 7.2.3 Drain Structure and Site Condition for Interceptions in Barangay Bucana (East)**

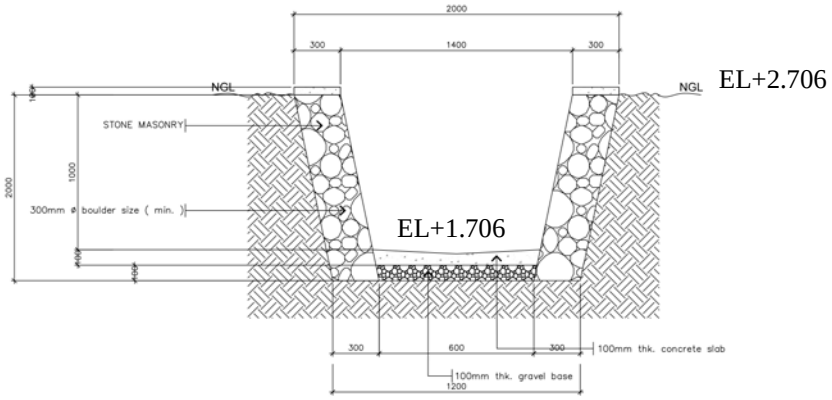
(3) Interception from Mabini Main Drain

The enlarged plan of the Mabini Main Drain is shown in Figure 7.2.4, and the typical cross section is shown in Figure 7.2.5. The gate pumping station will be constructed at the mouth of the drain. The progress and working condition of the pumping station shall be confirmed, and the appropriate interception structure in terms of preventing back flow and securing the existing structure after remodeling should be considered in next stage.




Source: JICA Survey Team on DPWH Drawing (Improvement/Rehabilitation of Mabini Extension Outfall, 2018)

**Figure 7.2.4 Concept of Interception from Mabini Main Drain**




Note: Elevations above are at the most downstream of drain
Source: City Engineering Office

**Figure 7.2.5 Typical Structure of Mabini Main Drain (Open Channel Part)**

(4) Interception Chambers

The chambers (manholes) that will intercept wastewater from the Bucana Main Drain and the Mabini Main Drain (and other drain if added in next stage) should have a gate or orifice to control the water flow. Too much interception of wastewater with stormwater in heavy rainfall events will become a risk for the operation of WWTP (limit of capacity). This should be noted together with the high pressure in the upstream of lateral sewers including house connections. The various types of interception chambers in Japan and Metro Manila with such flow controls is shown in Appendix 7.3.

(5) Flap Gate

To avoid the inflow of seawater in interception points, flap gates should be installed at the outlet of the main drains or inside the interception chambers as shown below. The issue of flap gates in seaside walls is that there is a risk of clogging due to seaside sand. Moreover, in Davao's case, one flap gate in the chamber is too low for the manhole wall to attach to the gate due to the shallow position of the drain from the ground.

Flap gate example 1 (river wall)

Flap gate example 2 (seaside wall)

Flap gate example 3 (inside interception chamber: stormwater outlet side)

Source: Websites of Japanese LGUs and Nippon Koei (in Tokyo Metropolitan Area)

**Figure 7.2.6 Examples of Flap Gate**

## 7.3 Planning of Stepwise Development in WWTP

### 7.3.1 Stepwise Development of the WWTP

The image of the step-wise development for the work of Phase-1 is shown in Figure 7.3.1. The points of development are as follows:

(1) Civil and Building Structure

- For the ease of future development in Phase-2, all of underground structures for WTF and STF for Area A WWTP (Chapter 6) will be developed in Phase-1.
- On-ground building (architectural structure) for STF and the Administration Building will also be constructed in Phase-1.

(2) Water Treatment Facility (WTF)

- Out of the four lines (units) of the entire Area A WWTP, two lines will be constructed in Phase-1.
- The electromechanical (E&M) equipment, such as diffusers and membrane units, will be installed for the treatment of 40,000 $m^3$/day in the first two lines in Phase-1.
- The E&M equipment will be installed for the remaining two lines together with additional equipment for the first two lines in Phase-2.
- The preliminary installation plan of tanks and major equipment in several phases in WTF is shown in following table.

**Table 7.3.1 Preliminary Installation Plan of Tanks and Major Equipment in Phases (WTF)**

| No. | Tank/Major Equipment | Number of Tank/Equipment | | |
|---|---|---|---|---|
| | | Phase 1 (40,000 $m^3$/day) | Phase 2 (57,000 $m^3$/day) | Total (97,000 $m^3$/day) |
| Tank | | | | |
| 1 | Anoxic tank | 2 | 2 | 4 |
| 2 | Anaerobic tank | 2 | 2 | 4 |
| 3 | Membrane tank | 3 | 5 | 8 |
| Major Equipment | | | | |
| 1 | Anoxic tank mixer | 2 | 2 | 4 |
| 2 | Aeration tank blower | 2 | 2 | 4 |
| 3 | Membrane module | 24 | 32 | 56 |
| 4 | Permeate pump | 7 | 9 | 16 |
| 5 | Membrane tank blower | 7 | 9 | 16 |
| 6 | RAS pump | 3 | 5 | 8 |

Note: Preliminary specification of each equipment (unit) is shown in Appendix 6.2.
Source: JICA Survey Team

(3) Sludge Treatment Facility (STF)

- E&M equipment, such as sludge dehydrator and drier, will be installed for a capacity of 40,000 $m^3$/day or with some allowance of up to 48,500 $m^3$/day for half of the entire Area A in Phase-1.
- The remaining equipment will be installed in Phase-2. In case Phase-2 would be more than 15 years after the completion of Phase-1, the renewal of Phase-1 equipment should be considered with an upgrade in capacity.
- The preliminary installation plan of major equipment in phases in STF is shown in Table 7.3.2.

**Table 7.3.2 Preliminary Installation Plan of Major Equipment in Phases (STF)**

| No. | Tank/Major Equipment | Number of Tank/Equipment | | |
|---|---|---|---|---|
| | | Phase 1 (40,000 $m^3$/day) | Phase 2 (57,000 $m^3$/day) | Total (97,000 $m^3$/day) |
| 1 | Sludge thickener | 1 (16 $m^3$/hr) | 1 (25 $m^3$/hr) | 2 |
| 2 | Sludge dehydrator | 1 (5 $m^3$/hr) | 1 (7 $m^3$/hr) | 2 |
| 3 | Sludge dryer | 1 (0.9-1.2 $m^3$/hr) | 1 (1.4-2.0 $m^3$/hr) | 2 |
| 4 | Boiler | 1 unit | 1 unit | 2 units |
| 5 | Thickening sludge feed pump | 2 | 2 | 4 |
| 6 | Thickened sludge feed pump | 2 | 2 | 4 |
| 7 | Dewatered sludge feed pump | 2 | 2 | 4 |

Source: JICA Survey Team

(4) Inlet Pumping Station (P/S)

- Civil structure (fully underground) will be developed for the entire Area A in Phase-1. This is equivalent to 97,000 $m^3$/day of daily maximum flow.
- The pumps will be installed for Phase-1 treatment capacity (40,000 $m^3$/day) as well as E&M equipment in WTF and STF. The capacity of pumps should be reconsidered for renewal when the work of Phase-2 is conducted after the general service life of pumps (15 years).
- Since the trunk sewer diameters (from Poblacion, Agdao) have a large allowance for the future entire Area-A (97,000 $m^3$/day) than one for Phase-1 (40,000 $m^3$/day), a large volume of stormwater can enter and flow down to the pumping station from the interception points. The operation of pumps or gates should be properly controlled to avoid too much inflow of wastewater to the WWTP together with proper structures of interception chambers.

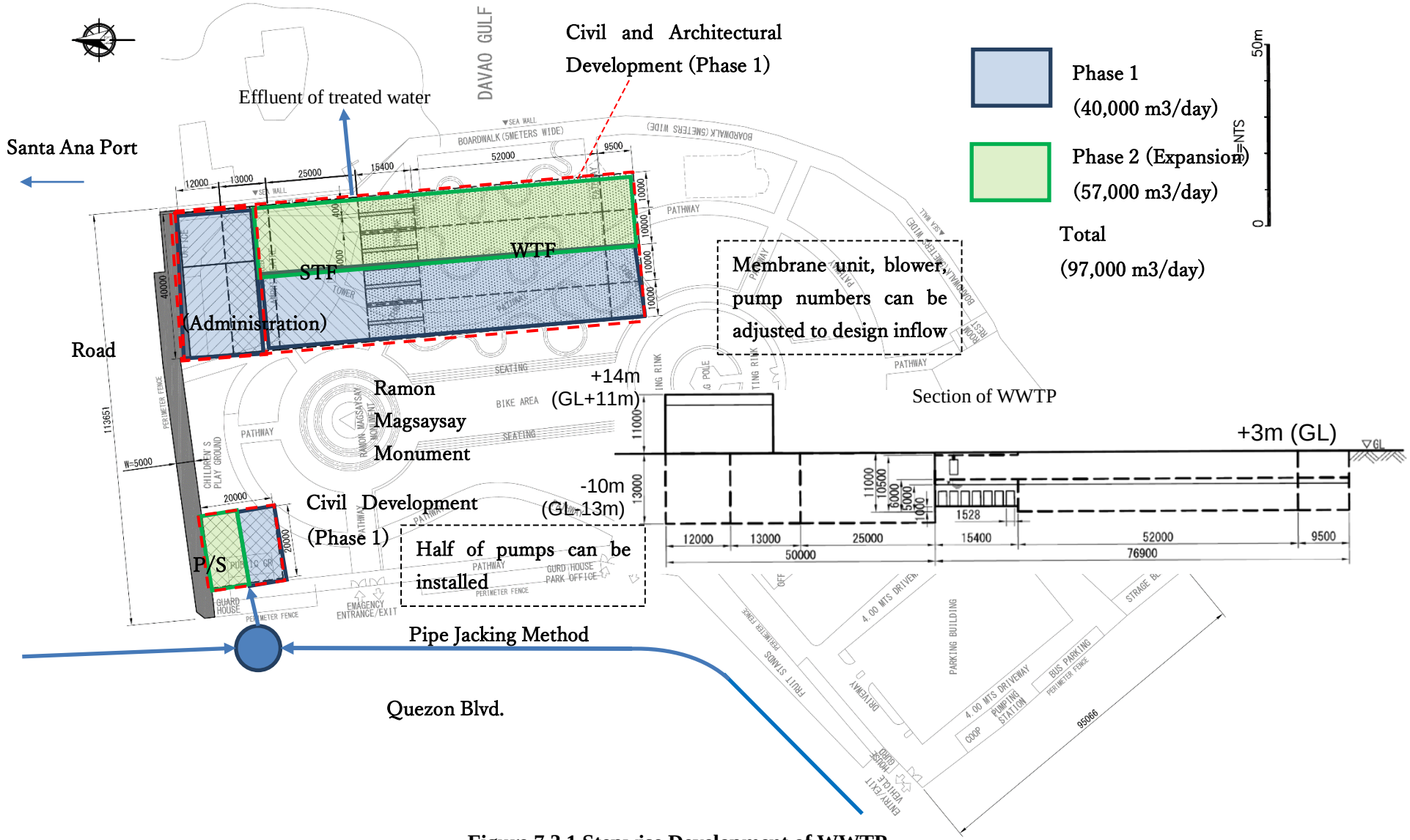



**Figure 7.3.1 Stepwise Development of WWTP**

### 7.3.2 Operation and Maintenance of the WWTP

In this section, O&M of the WWTP are described.

(1) Important Points of Operation of WWTP

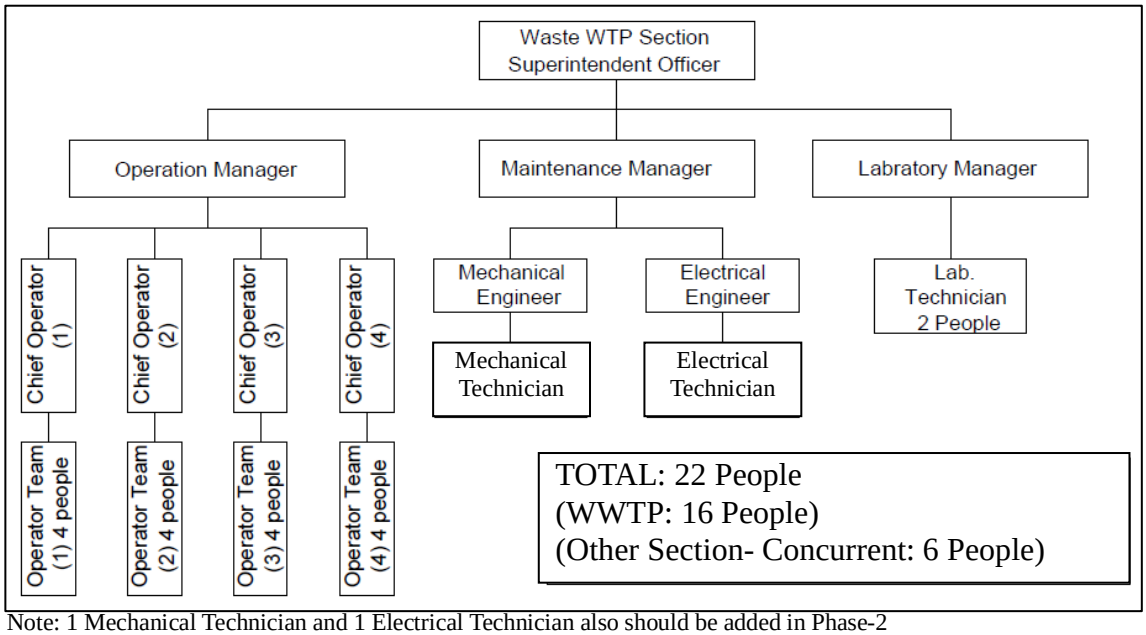
Important points of the operation of WWTP are common with the ones in Chapter 6.

(2) Proposed O&M Structure for WWTP

This section describes organizational requirements for O&M works for the new WWTP.

1) Recommended O&M Structure

There are three parties involved for O&M works of WWTP during Phase 1 (40,000 $m^3$/day) is shown in Figure 7.3.1. A number of operators and the team can be reduced compared to the case of WWTP for entire Area A (97,000 $m^3$/day) due to the smaller scale plant.




Note: 1 Mechanical Technician and 1 Electrical Technician also should be added in Phase-2
Source: JICA Survey Team

**Figure 7.3.2 Recommended O&M Structure (WWTP) for Phase-1**

2) O&M Consideration

The main considerations of the O&M method for WWTP are common with the ones for the entire Area-A (see Chapter 6).

3) Roles and Tasks of Each Personnel

The roles and tasks of each O&M personnel for WWTP are common with the ones for the entire Area-A (see Chapter 6).

## 7.4 Concept of Stepwise Development in Priority Area

The following step-wise development should be adopted for efficient sewerage development in case the volume of work at the start is decreased (top priority work) due to phasing.

(1) During JICA Project (Phase-1)

1) WWTP and Trunk Sewer Construction

1-1) Start construction of WWTP and trunk sewers in the Poblacion District and a part of the Agdao District (boundary up to Dacudao Creek)

1-2) Basically all of civil and architectural structures in WWTP will be constructed including the future expansion of the plant. The electromechanical works will be limited to a capacity of 40,000 $m^3$/day.

1-3) The dimension of trunk sewer, which will be constructed in Phase-1, shall be the ones in the entire Area A so that all the wastewater from Area A can be conveyed to WWTP in the future.

2) Sanitary Sewer Installation

Start sanitary (lateral) sewer development from barangays near Magsaysay Park in coordination with the progress of trunk sewers.

3) House Connection (Pilot Area)

3-1) As pilot area, house connections (lateral sewer to inlet, house/office to inlet) will be thoroughly completed in the commercial areas (Pob 27-C, 30-C, Tomas Monteverde).

3-2) To keep the fairness with other barangays, connection between house/office and inlet will be owed by the house owner and office.

The matters which are noted in subsection 6.5.2 (2) House Connection shall be taken into account.

4) Interception (mainly seaside area)

4-1) In the seaside area in Poblacion, the temporal interceptor to collect graywater in main underground drains will be constructed (e.g., from Bucana Main Drain, Mabini Main Drain). This leads to an increase in wastewater flow for the commissioning of WWTP.

4-2) House connections beside streets will be done even in the congested seaside area. The small drains from the inner parts of slum areas to the streets are also intercepted.

5) Continue the development of lateral sewers in the area of Phase-1

Up to 5) This shall be conducted through the JICA Loan Project (house connection: owed by customers)

(2) After the JICA Project (Phase-2 for Area A and later)

1) DCWD shall continue house connections in Poblacion District.

2) Seaside area will also have a fully separated sewer after the re-development of the area by the City

3) Most of Agdao District and Poblacion 19-B are developed during the second phase.

4) The development of Area B to Area F will continue in accordance with IM4D. However, on-site (small scale) treatments in some barangays in rural and residential areas, should be applied to consider the appropriate scale of development areas.

## 7.5 Preliminary Estimation of Project Cost and Study on Implementation Schedule

The project cost (capital cost and O&M cost) for Phase-1 development in Area A is initially estimated in the sections below.

### 7.5.1 Capital Cost

As a preliminary level, the estimated total capital cost for the Phase-1 project is around PHP 9.3 billion (JPY 19.5 billion) as shown in Table 7.5.1. The amount is around half of the value for Area A. Despite the planned capacity of 40,000 $m^3$/day, which is less than half of 97,000 $m^3$/day for the entire Area A, the required trunk sewer length is more than half of Area A. Moreover, the civil works and construction in WWTP shall also be regulated to keep more than half for the construction of the underground structure and to set aside an allowance for future expansion.

**Table 7.5.1 Preliminary Estimation of Capital Cost for Sewerage Development in Phase-1**

| No. | Item | Capital Cost | | Note |
|---|---|---|---|---|
| | | (PHP million) | (JPY million equivalent) | |
| 1 | Construction Cost | 8,617 | 18,095 | |
| (1) | Wastewater Treatment Plant (WWTP) and remodeling of Magsaysay Park | 3,903 | 8,196 | 40,000 $m^3$/day (Phase-1) |
| 1) | Land acquisition | 0 | 0 | |
| 2) | Land foundation, temporary soil retaining | 112 | 234 | |
| 3) | Civil and Building | 1,480 | 3,108 | Underground |
| 4) | Water treatment facility | 1,074 | 2,256 | MBR |
| 5) | Sludge treatment facility | 669 | 1,404 | Thickening, Dewatering, Drying (all mechanical) |
| 6) | Park remodeling | 569 | 1,194 | Utilize treated water |
| (2) | Sewer pipeline (interceptor, separate sewer) | 4,714 | 9,899 | |
| 1) | Trunk sewer from each area | 3,193 | 6,705 | Diameter: 400-2000, 28.7 km inc. pipe jacking |
| 2) | Sanitary sewer in separate sewer area | 1,101 | 2,311 | Diameter: 200-500, 109 km |
| 3) | Temporal interceptor sewer and manholes | 34 | 72 | Diameter: 400, 650 m, CSOs, flap gates |
| 4) | Pumping stations | 318 | 667 | Main P/S, Manhole pumps |
| 5) | House connection in pilot area | 69 | 144 | 2,300 connections upto inlet |
| 2 | Consulting services | 689 | 1,448 | |
| | Total Project Cost | 9,306 | 19,543 | |
| | House connections outside JICA Project | 966 | 2,028 | Around 27,000 connections |
| | Total Project Cost incl. local part | 10,272 | 21,571 | |

Note: 1) PHP/JPY = 2.10 as of July 2019
2) All sewers include manholes/interception chambers (CSOs)
3) Construction cost includes administration cost
Source: JICA Survey Team

### 7.5.2 O&M Cost

The preliminary estimate of operation and maintenance cost for Phase-1 is shown in Table 7.5.2. The total cost of the WWTP and Sewer/Pumping Station (P/S) is around PHP 195 million/year (equivalent to around JPY 409 million/year).

**Table 7.5.2 Preliminary Estimation of O&M Cost for Sewerage Development in Phase-1**

| No. | Item | O&M Cost | | Note |
|---|---|---|---|---|
| | | (PHP million/year) | (JPY million equivalent) | |
| **1** | **Wastewater Treatment Plant (WWTP)** | **148.7** | **312.2** | 40,000 m3/day |
| 1) | Energy Cost | 53.2 | 111.7 | |
| 2) | Chemical Cost | 15.2 | 32.0 | |
| 3) | Sludge disposal cost | 0.9 | 1.8 | |
| 4) | Manpower cost | 5.3 | 11.1 | |
| 5) | Maintenance cost | 74.1 | 155.5 | |
| **2** | **Wastewater Collection Facility** | **46.0** | **96.6** | |
| 1) | Energy Cost for Pumping Stations | 5.3 | 11.1 | Main P/S in WWTP<br>Lift stations in barangays |
| 2) | Maintenance Cost for Sewer and P/S | 40.7 | 85.5 | |
| | **Total O&M Cost** | **194.6** | **408.8** | |

Note: PHP/JPY = 2.10 as of July 2019
Source: JICA Survey Team

### 7.5.3 Renewal Cost

For the financial analysis for 30 years in Section 7.6, the renewal cost of electromechanical equipment was estimated as shown in Table 7.5.3. To simplify the condition, all equipment is assumed to be renewed after 20 years from the commissioning of WWTP, since many equipment is replaced in 15 to 20 years in Japan for best performance but in developing countries the equipment tends to be used as long as possible due to lack of budget. The civil/architectural structures and pipes continue to be used for more than 20 years with proper annual maintenance (the costs are included in O&M cost). The renewal plan of Phase-1 project and the additional facility for Phase-2 project should be jointly considered in case the commencement of Phase-2 project would be delayed.

**Table 7.5.3 Preliminary Estimation of Renewal Cost for Sewerage Facilities in Phase-1**

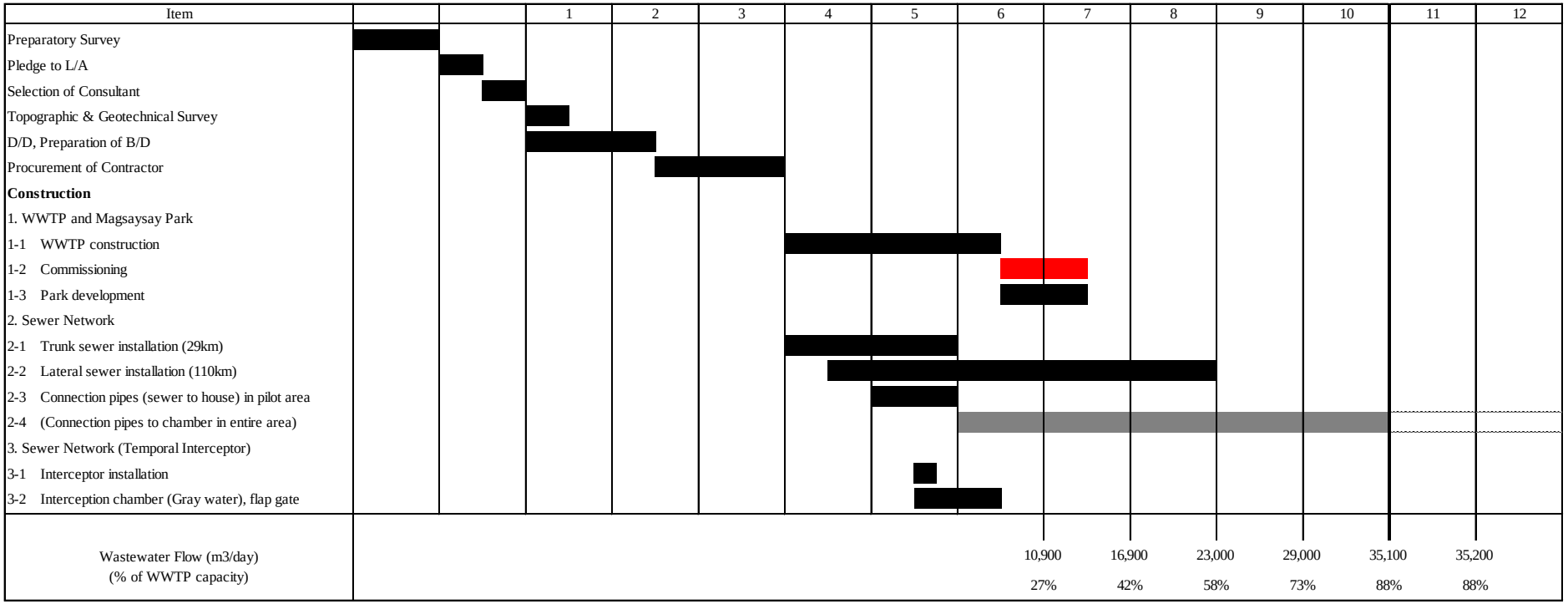
| No. | Item | Renewal Cost (after 20 | | Note |
|---|---|---|---|---|
| | | (PHP million) | (JPY million equivalent) | |
| (1) | Wastewater Treatment Plant (WWTP) | 1,449 | 3,043 | 40,000 m3/day (Phase-1) |
| 1) | Civil and Building | 444 | 932 | Architectual equipment (lighting, fans, etc.) |
| 2) | Water treatment facility | 537 | 1,128 | MBR |
| 3) | Sludge treatment facility | 468 | 983 | Thickening, Dewatering, Drying (all mechanical) |
| (2) | Sewer pipeline | 501 | 1,052 | |
| 1) | Trunk sewer from each area | 246 | 516 | Minor replacements such as manhole covers, Survey, large scale cleaning & repair |
| 2) | Sanitary sewer in separate sewer area | 0 | 0 | |
| 3) | Interceptor sewer in interceptor area | 1 | 2 | Flap gate |
| 4) | Pumping stations | 254 | 534 | Manhole pumps |
| | Total Renewal Cost | 1,950 | 4,095 | |

Note: PHP/JPY = 2.10 as of July 2019
Source: JICA Survey Team

### 7.5.4 Implementation Schedule

As shown in Table 7.2.2 and Table 7.2.3, the trunk sewer length is 29 km and the lateral sewer length is 110 km. Under these assumptions and based on the following assumption for construction works, the preliminary installation schedule is shown in Figure 7.5.1.

As much as possible, wastewater should be collected at the start of commissioning.
The separate (lateral) sewer installation is 4.5 years with the installation of 20 m/day/party x 5 parties for the part of the separated sewer, which is a less tight schedule than the one for Area A. House connection is more than 5 years with the rapid connection works of 2 households/day x 10 parties. Therefore, these measures are implemented in order to finish all the construction works by the end of the defect notification period (DNP) (10 years from initiation of project). This is more realistic than the case of the entire Area-A.




Note: * Lateral sewer installation with 20 m/day/party by 5 construction parties (total 29,000 $m^3$/day) in 2030 *40,000 $m^3$/day in 2045
Connection pipes to chambers in entire area with gray color is assumed to be local portion by implementing agency
Source: JICA Survey Team

**Figure 7.5.1 Preliminary Project Implementation Schedule in Phase-1 Project**

## 7.6 Study on Financial Scheme for Priority Project

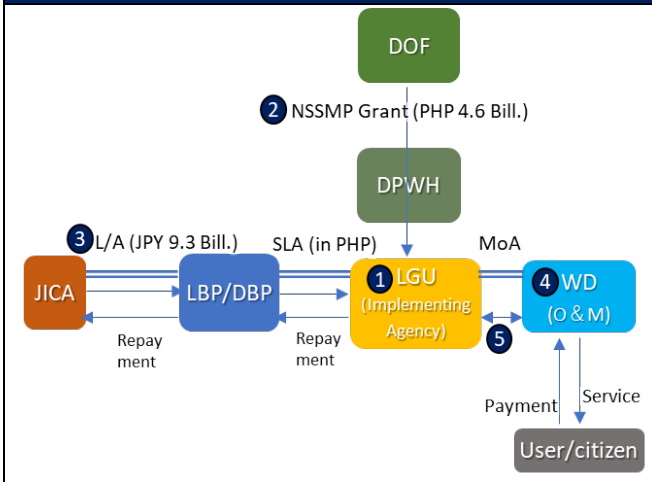
### 7.6.1 Costs

Costs for Phase-1 of the project are summarized in Table 7.6.1 and Figure 7.6.1. Assuming that 50% of the initial cost is covered by the NSSMP grant, the remaining is estimated at PHP 4,653 million. Initial cost is assumed to be disbursed equally during the eight years of construction.

**Table 7.6.1 Estimated Costs of Phase-1 Project**

| Item | Unit | Phase 1 |
|---|---|---|
| Initial Cost before NSSMP Grant | PHP mil | 9,306 |
| **Initial Cost after the Grant** | **PHP mil** | **4,653** |
| OPEX (annual) | PHP mil | 195 |
| Renewal Cost (at 20th year) | PHP mil | 1,950 |

Source: JICA Survey Team

| Scheme Diagram | Key Description |
|---|---|
|  | **【Construction period】**<br>① LGU as implementing agency<br>② 50% of CAPEX is funded by NSSMP grant *1<br>③ LGU takes loan to fund the rest of CAPEX<br><br>**【Operation period】**<br>④ WD conducts O&M and tariff collection based on MoA<br>⑤ If tariff revenue is:<br>- Less than OM cost, LGU shall provide OM subsidy<br>- More than OM cost, WD shall pay LGU the surplus which will become a part of debt service |

Source: JICA Survey Team

**Figure 7.6.1 Scheme Diagram with LGU as Implementing Agency (Phase-1 Project)**

### 7.6.2 Revenue Water Consumption

Revenue water consumption of Phase-1 project is estimated in the table below. From the DCWD data, commercial consumption of Phase-1 is estimated at 30% of residential consumption.

**Table 7.6.2 Estimated Revenue Water Consumption of Phase-1 Project.**

| | Class | unit | 2015 | 2022 | 2030 | 2045 |
|---|---|---|---|---|---|---|
| Phase 1 | Resi. | mil m3/year | 10 | 11 | 12 | 15 |
| | Comm | mil m3/year | 3 | 3 | 4 | 4 |
| | Total | mil m3/year | 13 | 14 | 16 | 19 |

Source: JICA Survey Team

### 7.6.3 Case Setting

The case setting of the Phase-1 analysis also follows the case setting of the Priority Project (Area A).

- Base Case: Remaining CAPEX (after NSSMP Grant) is shouldered by LGU's Budget (Development Fund)
- Case 1: Remaining CAPEX is shouldered by LGU Loan
- Case 2: Remaining CAPEX is shouldered by LGU Budget (Development Fund) & Loan (50% each)
- Case 3: Remaining CAPEX is shouldered by LGU (70%) & WD (30%). Each agency split the cost into budget (equity) and loan (50% each).

The table below shows the allocation of the initial cost for each case.

**Table 7.6.3 Initial Cost Allocation of Each Case**

| Case | Agency | Initial Cost Share | Equity/Loan | million PHP |
|---|---|---|---|---|
| Base Case | LGU | 100% | Equity | 4,653 |
| | | | Loan | 0 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 1 | LGU | 100% | Equity | 0 |
| | | | Loan | 4,653 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 2 | LGU | 100% | Equity | 2,326 |
| | | | Loan | 2,326 |
| | DCWD | 0% | Equity | 0 |
| | | | Loan | 0 |
| Case 3 | LGU | 70% | Equity | 1,629 |
| | | | Loan | 1,629 |
| | DCWD | 30% | Equity | 698 |
| | | | Loan | 698 |

Source: JICA Survey Team

### 7.6.4 Key Assumptions

Assumptions for the financial analysis of Phase-1 of the project follows the assumptions of the Priority Project (Area A), except for the construction period.

- Project Life : 30 years
- Construction : 2022 - 2029 (8 years)
- Operation starts : 2028
- 50% of Initial Cost is covered by NSSMP grant
- Major Renewal in Operation Year 20
- 2019 Constant Price (Inflation not included)
- Discount rate : 6%[1]
- Interest rate : 6.46% p.a. (two-step loan, fixed)

[1] 10-year average of long term (20yrs) government bond yield

- Front end fee : 0.20% of total amount (only initial year)
- Sewerage Tariff : PHP 10/$m^3$ for residential, PHP 20/$m^3$ for commercial

### 7.6.5 Results

(1) Cashflow Projection of the Phase-1 Project (Base Case)

The cashflow projection for the base case, where sewerage tariff is PHP 10/$m^3$ for residential (PHP 20/$m^3$ for commercial), is shown in table below. NPV is negative PHP 3,895 million, while the FIRR could not be calculated.

**Table 7.6.4 Project Cash Flow (Base Case)**

| Project Year | Year | CAPEX | NSSMP Grant | OPEX | Renewal Cost | Revenue (Residential) | Revenue (Commercial) | Net Cashflow |
|---|---|---|---|---|---|---|---|---|
| 1 | 2022 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 2 | 2023 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 3 | 2024 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 4 | 2025 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 5 | 2026 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 6 | 2027 | -1,163 | 582 | 0 | 0 | 0 | 0 | -582 |
| 7 | 2028 | -1,163 | 582 | -195 | 0 | 118 | 71 | -587 |
| 8 | 2029 | -1,163 | 582 | -195 | 0 | 119 | 72 | -585 |
| 9 | 2030 | 0 | 0 | -195 | 0 | 121 | 72 | -2 |
| 10 | 2031 | 0 | 0 | -195 | 0 | 122 | 73 | 1 |
| 11 | 2032 | 0 | 0 | -195 | 0 | 124 | 74 | 4 |
| 12 | 2033 | 0 | 0 | -195 | 0 | 126 | 76 | 7 |
| 13 | 2034 | 0 | 0 | -195 | 0 | 128 | 77 | 10 |
| 14 | 2035 | 0 | 0 | -195 | 0 | 129 | 78 | 13 |
| 15 | 2036 | 0 | 0 | -195 | 0 | 131 | 79 | 15 |
| 16 | 2037 | 0 | 0 | -195 | 0 | 133 | 80 | 18 |
| 17 | 2038 | 0 | 0 | -195 | 0 | 135 | 81 | 21 |
| 18 | 2039 | 0 | 0 | -195 | 0 | 137 | 82 | 24 |
| 19 | 2040 | 0 | 0 | -195 | 0 | 138 | 83 | 27 |
| 20 | 2041 | 0 | 0 | -195 | 0 | 140 | 84 | 30 |
| 21 | 2042 | 0 | 0 | -195 | 0 | 142 | 85 | 32 |
| 22 | 2043 | 0 | 0 | -195 | 0 | 144 | 86 | 35 |
| 23 | 2044 | 0 | 0 | -195 | 0 | 145 | 87 | 38 |
| 24 | 2045 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| 25 | 2046 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| 26 | 2047 | 0 | 0 | -195 | -1,950 | 147 | 88 | -1,909 |
| 27 | 2048 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| 28 | 2049 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| 29 | 2050 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| 30 | 2051 | 0 | 0 | -195 | 0 | 147 | 88 | 41 |
| | NPV | -7,224 | 3,612 | -1,722 | -429 | 1,167 | 700 | -3,895 |
| | | | | | | | FIRR | #NUM! |
| | | | | | | | Revenue/OPEX | 108% |

Source: JICA Survey Team

The net cashflow is positive from year 10 when the annual tariff revenue surpasses the operation expenditure. This partly resulted from higher commercial user ratio (30%) compared to the whole of Area A (20%). **At PHP 10/$m^3$, the O&M cost recovery rate is 108% for Phase-1** and 79% for Priority Project (Area A). Tariff revenue is still not enough for full cost recovery, for which PHP 30.9/$m^3$ (residential) is necessary.

(2) Case Comparison

Other cases also showed a negative NPV at tariff level PHP 10 /$m^3$. The table below summarizes each case's NPV and tariff necessary for to fully recover the O&M costs. NPV is least negative for Case 1 (100% loan).

**Table 7.6.5 Case Comparison Summary (Phase-1)**

| Item | unit | Base | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|---|
| NPV (at 10 peso/m3) | million PHP | -3,895 | -2,988 | -3,441 | -3,441 |
| Tariff needed for OPEX recovery | peso/m3 | 9.2 | 9.2 | 9.2 | 9.2 |
| Tariff needed for full cost recovery | peso/m3 | 30.9 | 26.0 | 28.4 | 28.4 |

Source: JICA Survey Team

Financial burden to the LGU and DCWD for each case when tariff is PHP 10/$m^3$ for residential and PHP 20/$m^3$ for commercial is summarized in Table 7.6.6.

**Table 7.6.6 Financial burden of LGU and DCWD in each case**

| | NPV (mil PHP) | |
|---|---|---|
| | LGU | DCWD |
| Base | -3,895 | 0 |
| Case 1 | -2,988 | 0 |
| Case 2 | -3,441 | 0 |
| Case 3 | -2,494 | -947 |

Source: JICA Survey Team

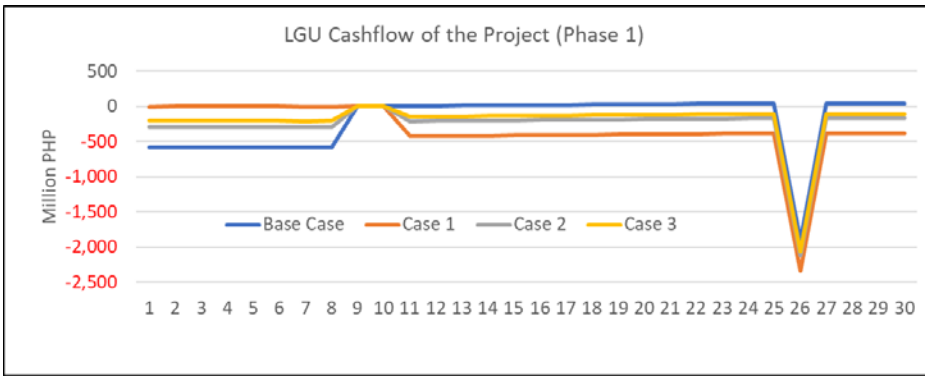
The breakdown of the financial liability of the LGU (Case 1) is shown in table 7.6.7. The annual debt service of PHP 421 million starts in year 11 (front end fee of 9 million is accounted in the initial year). This is within the LGU's development fund budget allocation. Operation subsidy is required during the first 3 years of operation, then from year 10, the O&M cost is expected to be fully covered by the tariff revenue.

**Table 7.6.7 Breakdown of Financial burden of LGU (Phase-1) Case 1**

| Financial Burden of LGU (Phase 1 ) (unit: PHP million) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Equity Injection during Construction | Principle Repayment | Interest Payment | Operation Subsidy | Renewal Cost Payment | Total |
| 1 | 0 | 0 | -9 | 0 | 0 | -9 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | -6 | 0 | -6 |
| 8 | 0 | 0 | 0 | -4 | 0 | -4 |
| 9 | 0 | 0 | 0 | -2 | 0 | -2 |
| 10 | 0 | 0 | 0 | 1 | 0 | 1 |
| 11 | 0 | -120 | -301 | 4 | 0 | -417 |
| 12 | 0 | -128 | -293 | 7 | 0 | -414 |
| 13 | 0 | -136 | -285 | 10 | 0 | -411 |
| 14 | 0 | -145 | -276 | 13 | 0 | -408 |
| 15 | 0 | -155 | -266 | 15 | 0 | -406 |
| 16 | 0 | -165 | -256 | 18 | 0 | -403 |
| 17 | 0 | -175 | -246 | 21 | 0 | -400 |
| 18 | 0 | -187 | -234 | 24 | 0 | -397 |
| 19 | 0 | -199 | -222 | 27 | 0 | -394 |
| 20 | 0 | -211 | -210 | 30 | 0 | -391 |
| 21 | 0 | -225 | -196 | 32 | 0 | -389 |
| 22 | 0 | -240 | -181 | 35 | 0 | -386 |
| 23 | 0 | -255 | -166 | 38 | 0 | -383 |
| 24 | 0 | -272 | -149 | 41 | 0 | -380 |
| 25 | 0 | -289 | -132 | 41 | 0 | -380 |
| 26 | 0 | -308 | -113 | 41 | -1,950 | -2,330 |
| 27 | 0 | -328 | -93 | 41 | 0 | -380 |
| 28 | 0 | -349 | -72 | 41 | 0 | -380 |
| 29 | 0 | -371 | -50 | 41 | 0 | -380 |
| 30 | 0 | -395 | -26 | 41 | 0 | -380 |
| | | | | | NPV | -2,988 |

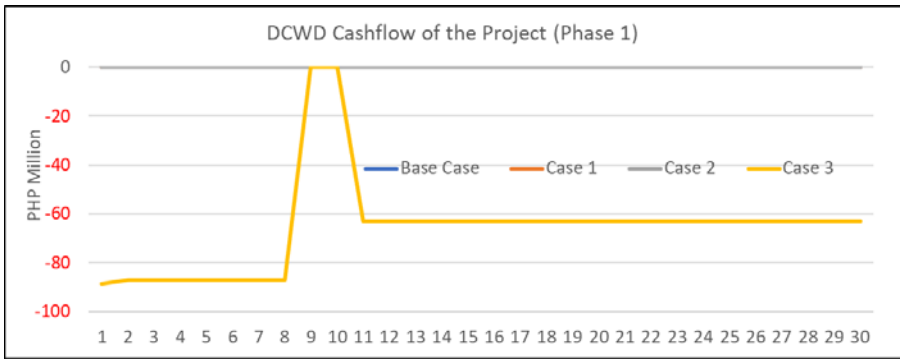
Source: JICA Survey Team

Figure 7.6.2 and Figure 7.6.3 compares each case's financial burden of LGU and DCWD respectively.




Source: JICA Survey Team

**Figure 7.6.2 Financial Burden of LGU**




Source: JICA Survey Team

**Figure 7.6.3 Financial Burden of DCWD**

(3) Summary

Phasing the project shows a positive effect on the affordability of the project cost to the LGU. This is in the sense that the project size is halved and the annual repayment amount (PHP 421 million) is comfortably within the size of LGU's development fund. Operation surplus also has a positive effect to reduce LGU's financial burden.

As was mentioned in the priority project analysis, it would help if the DCWD could participate in financing the project. It is proposed that LWUA would review its regulation to accommodate the nature of capital-intensive sewerage project and create a path for water districts to have a more flexible financial management.

## 7.7 Environmental and Social Considerations for Phase 1

At the pre-F/S stage in this survey, without project analysis, preliminary scoping, the draft TOR for the ESC study and environmental checklist prepared for Area A are discussed in Chapter 6 in this report. With the following conditions, those outputs on environmental and social considerations (ESC) for Area A can adapt to the basic idea on ESC for Phase 1.

- As shown in Table 7.2.1, the project capacity of Phase 1 is 38,000 $m^3$ and Phase 2 is 59,000 $m^3$. Thus, each phase is classified as Category B and requires EIS under the PEISS.
- In Phase 1, basically WWTP is proposed to be constructed in consideration of the expansion in Phase 2.
- Sewer pipes for both Phase 1 and 2 are set up under the existing roads in Area A.
- Environmental and social conditions of Phase 1 and Phase 2 in Area A have basically the same aspects.
- Environmental and social impacts are examined in areas out of the project site.

The following points shall be kept in mind as part of the social considerations for the stepwise approach.

- As a result of the HIS survey in 2019, 86.5% of the respondents expect the sewerage system. Therefore, it is necessary to consider "fairness" when a stepwise approach in the project is performed. Specifically, public consultations shall be held in advance to get consensus regarding the approach to be used in each area.
- The Impact assessment of Phase 1 will be re-evaluated when Phase 2 is implemented.

# CHAPTER 8 PRELIMINARY DATA COLLECTION FOR PREPARATORY SURVEY

This chapter includes the primary collected data that would be useful in JICA's preparatory survey (feasibility study) of the Sewerage System Development in Davao as a next stage.

## 8.1 Data Collection on Wastewater Treatment Plant Site for Priority Area

The site information, plan, and design of the proposed wastewater treatment plant (WWTP) in Magsaysay Park is described in Chapter 6 in terms of comparison of candidate sites.

## 8.2 Collection of Basic Information including Topography, Geology, Hydrology

### 8.2.1 Topographic Information

The topographic map in the Poblacion and Agdao Districts with contour intervals of every 5 m and the detailed land elevation data in main points were provided by CPDO as shown in Appendix 8.1. The land elevation of most of the area is less than 5 m. Only Poblacion 19-B has high land and the highest elevation is more than 30 m.

### 8.2.2 Geological Information

(1) Davao River Side

The geological data beside Davao River in two locations was collected as shown in Figure A8.2.1 in Appendix 8.2.

The data in Bolton Bridge, which is the most downstream bridge in the length of Davao River, was collected from City Engineering as shown in Table A8.2.1 in Appendix 8.2. The data reveals that the soil in Davao River is generally black and silty sand with gravel up to 10.5 m below the earth. The SPT (N-value) is more than 17 in shallow soil (0-3m) and one value in a depth more than 6 m is above 24. Therefore, it shows that the geological condition in the riverside/seaside area is stiff.

Another geotechnical data obtained in the inland area, which crosses the future Davao City Bypass Road alignment and Davao River, was the bore hole log as shown in Figure A8.2.2 in Appendix 8.2. The data shows that 1) at a depth of 0-2 m the soil is classified as silty gravel, 2) at a depth of 2-7.5 m the soil is elastic silt, and 3) in more than 7.5 m in depth the soil is silty gravel. The SPT (N-value) is more than 12, and it shows that the geological condition in the area is stiff.

(2) Davao Gulf Side

The data in the seaside area in the Poblacion and Agdao Districts were collected from DPWH. Four locations are shown in Figure A8.2.3, and the summary of the soil data is shown in Table A8.2.2 in

Appendix 8.2. The detailed bore hole logs are shown in Figure A8.2.4 to A8.2.7.

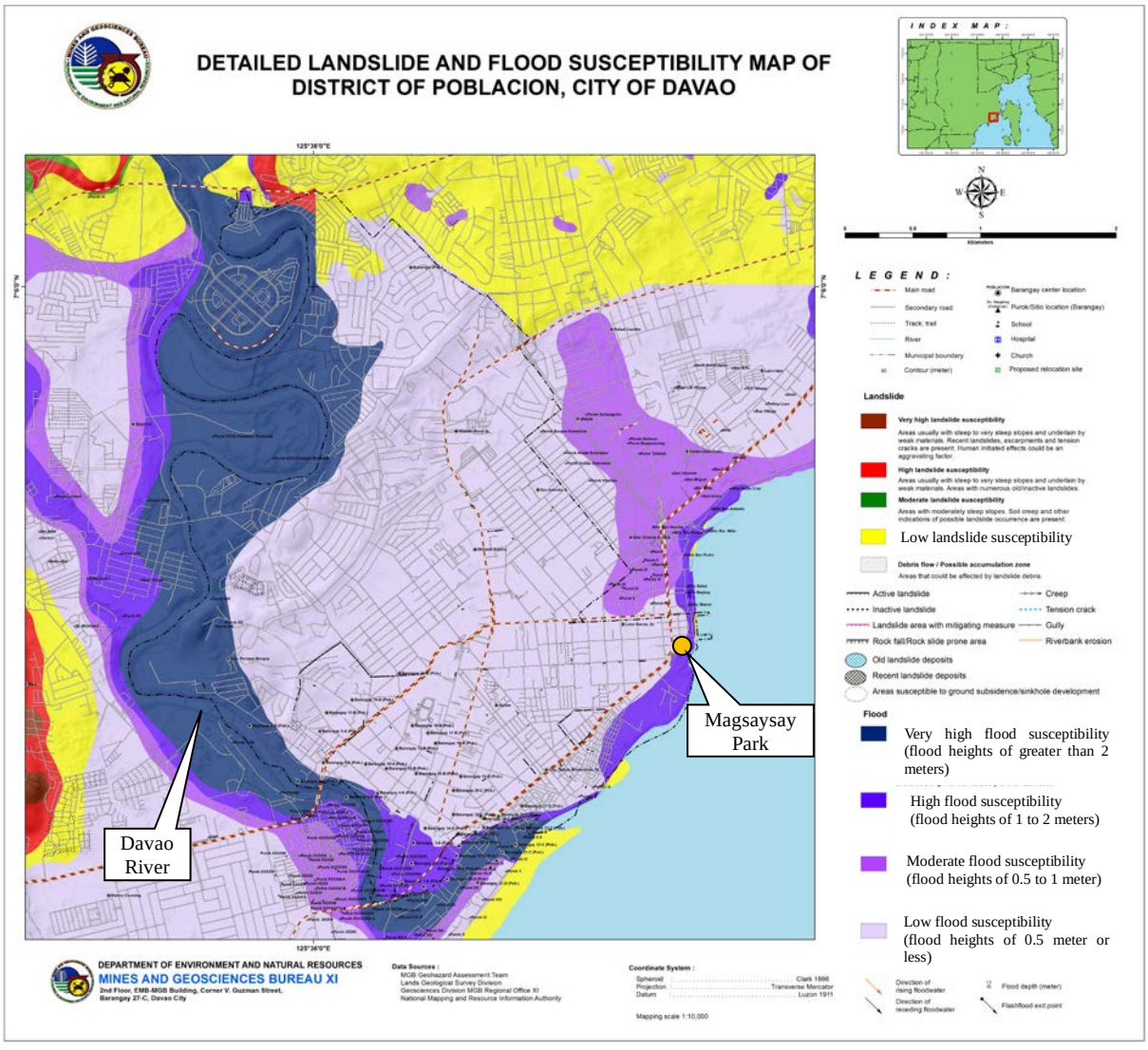
In common, the soil conditions are stiff enough even in the seaside area and the SPT N-values show more than 10 in the shallowest layer (0-3 m from the ground), and all soil up to 20 m is sand with silt.

### 8.2.3 Flooding Information

(1) Flood Hazard Map

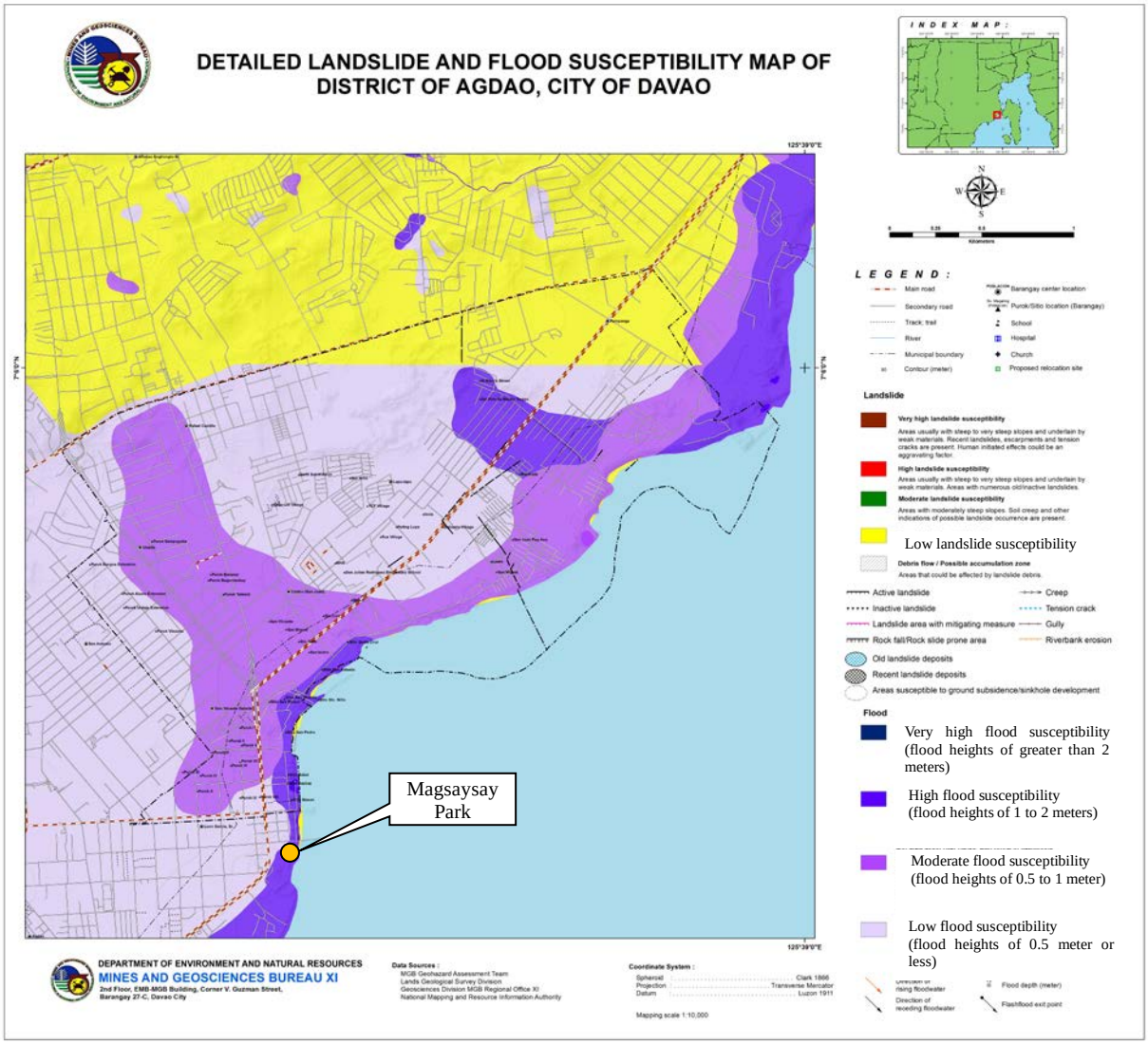
1) Area A

The flood hazard maps of the Poblacion District and the Agdao District as located in the city center are shown in Figure 8.2.1 and Figure 8.2.2, respectively. The seaside around Magsaysay Park is categorized as an area with high susceptibility to flood with 1 to 2 m inundation.




Source: Mines and Geoscience Bureau XI, DENR

**Figure 8.2.1 Flood Hazard Map for Poblacion District**




Source: Mines and Geoscience Bureau XI, DENR

**Figure 8.2.2 Flood Hazard Map for Agdao District**

2) Around Magsaysay Park

The flood hazard maps of 5-year, 25-year, and 100-year return periods around Magsaysay Park, which is located in the northeast edge of the Poblacion District and a candidate site of WWTP, are shown in **Figure 8.2.3**. The high flood area of more than 1.5 m depth does not exist in this area. The medium flood area of more than 0.5 m in depth is concentrated in the congested area in the south of the park (center of Barangay 23-C),and in some areas beside Ramon Magsaysay Avenue and Santa Ana Port.


| 5 Year Flood Hazards | 25 Year Flood Hazards | 100 Year Flood Hazards |
|---|---|---|

Source: Nationwide Operational Assessment of Hazards (NOAH) (www.nababaha.com)

**Figure 8.2.3 5 Year Flood Hazards around Magsaysay Park in North of Poblacion District**

(2) Flood Record

As shown in Table 3.1.1 in Subsection 3.1, the highest flooding in 2018 occurred around Davao Light and Power Company (DLPC) beside JP Laurel Avenue in the north of Poblacion District (Barangay 20-B). The record was 0.70 m and continued for one hour.

In the Poblacion District, there were also 0.50 m flooding records as second highest records in Juan Luna Street, Suazo Street, and Ponciano Street. Those areas are shown in Figure 8.2.4.


Source: JICA Survey Team based on Davao City Drainage document

**Figure 8.2.4 Locations of High Flooding in Poblacion District in 2018**

The JICA Survey Team also interviewed barangay officials near Magsaysay Park, which is the candidate site of wastewater treatment plant (WWTP) for the Poblacion and Agdao Districts (Area A), regarding recent flood records. The barangays do not keep the official records of flooding and answered as follows:

- Barangay 23-C (southern direction of Magsaysay Park): the area only experiences rising waters

during high tide, but the flooding due to heavy rainfall has not occurred.

- Barangay 27-C (including Magsaysay Park in the east edge): the barangay officials noted that, as far as they know, the park has not experienced any flooding. Water has risen up to 1-1.5 feet in the areas common with the other seaside area but that was during a high tide event a long time ago and not in the last five years. They added that a rise in water is only for a very short period and is usually less than 30 minutes.

(3) Summary

From the flood hazard map, flood record, and land condition, the following can be assumed regarding flooding during project:

1) Magsaysay Park as a candidate site of WWTP would not be inundated by heavy rain because it has a higher elevation compared to the surrounding area. The flooding is at most 20 cm in the low parts of the park, and it would only continue for a short time. Such a small flooding can be avoided by proper land redevelopment and clearing of drains.

2) The areas around the park such as Barangay 23-C has a low elevation with many squatters (south) and would be inundated with a 50 cm level. In addition, Ramon Magsaysay Avenue, located in the west of the park, would be inundated with up to 30 cm of water.

### 8.2.4 Tidal Data

Since the candidate site of the WWTP for priority Area A is located beside the sea, the tidal data in the Gulf of Davao was acquired for the consideration of effluent discharge from the WWTP and land development. The results are shown in Table 8.2.1. The daily fluctuation is around 1.5 m, while the monthly and yearly fluctuation is more than 2.0 m. The minimum level seems to gradually increase with yearly fluctuations (0.0031 m/year according to the Flood Control M/P Team).

**Table 8.2.1 Sea Level in Davao Gulf**

| Target Period | | Maximum (m) | Minimum (m) | Difference (m) |
|---|---|---|---|---|
| Daily example (23 May, 2019) | | 3.627 (0.826) | 2.177 (-0.624) | 1.450 |
| Monthly example (April 2019) | | 3.992 (1.191) | 1.839 (-0.962) | 2.153 |
| Yearly | 2016 | 3.969 (1.168) | 1.674 (-1.127) | 2.295 |
| | 2017 | 4.194 (1.393) | 1.785 (-1.016) | 2.409 |
| | 2018 | 4.102 (1.301) | 1.770 (-1.031) | 2.332 |
| Jan 1998- May 2019 | | 4.295 (1.494) (30/Mar/2006) | 1.616 (-1.185) (26/Nov/2015) | 2.679 |

Note: 1. Abnormal values were excluded from raw data
2. Inside brackets are elevation from mean sea level (MSL) based on NAMRIA standard
Source: Permanent Service for Mean Sea Level (https://www.psmsl.org/data/obtaining)

According to the Flood Control M/P Team, the highest tidal level in 100 years is estimated as MSL+1.43 m. Since the land elevation of Santa Ana Port in the north of Magsaysay Park is around MSL+1.2 to 1.3 m, the port would be inundated with 10 to 20 cm depth. Meanwhile, the land elevation of Magsaysay Park is around 2.2 to 2.5 m. Therefore, the sea water level due to high tide will not reach to the ground of Magsaysay Park even in the highest tidal level case. Therefore, earth filling

work is not required in WWTP.

### 8.2.5 Land Use Data

The land use (zoning) plan for 2013-2022 was obtained from the Davao City website. The plan is shown in Appendix 8.3. Most of the areas in the Poblacion District are commercial and low-density residential zones (Barangay 19-B). On the other hand, the Agdao District is composed of the Residential Zone, Commercial Zone, and Light Industrial Zone. The actual land use is much different from the zoning plan. For example, the existing industry is limited to the northeast periphery of the Agdao District. Since the existence and type of industry in target area is important in terms of inlet wastewater flow and quality, the basic information was confirmed as shown in Table 8.2.2.

**Table 8.2.2 Existing Industries in Poblacion and Agdao Districts**

| No. | Industry Name | Type | Address | Average Water Consumption ($m^3$/day) | Current Treatment |
|---|---|---|---|---|---|
| 1 | JM Agro Industrial Trading Corporation | Semi-Processing of Cacao Products (light industry) | R Castillo St., Brgy. Lapu-Lapu, Agdao District | 142 | Septic Tank |
| 2 | CMF Noodles & Food Manufacturing | MIKI (Noodles); Warehouse | R. Castillo St., Brgy. Lapu-Lapu, Agdao District | N/A | Septic Tank |
| 3 | Global VBC Herbal Products, INC | Herbal Products | IÑIGO St., BO. Obrero, Brgy. Paciano Bangoy, Agdao District | N/A | Septic Tank |

Source: JICA Survey Team with DCWD Average Form

### 8.2.6 Runoff Coefficient

The runoff coefficient of stormwater in Davao City was calculated by the Flood Control M/P Team. The runoff coefficient has a correlation with the underground penetration rate. In general, if the runoff coefficient is 0.70, the underground penetration rate is 30%.

The value in drainage areas related to Area A is shown in Table A8.4.1 in Appendix 8.4. The maximum, minimum, and average values in Area A is 0.80, 0.32, and 0.65, respectively. Therefore, the underground penetration rate of stormwater is assumed to be 30% to 35% in the area.

## 8.3 Confirmation of Public Awareness for Sewage and Septage Management

(1) General Awareness for Sanitation Condition

1) Evaluation about Sanitation Condition

The evaluation by respondents about the sanitation condition in/around houses was confirmed in HIS together with the interview on current sanitary condition mentioned in Chapter 3. The result is shown in Table 8.3.1.

The answers of “no problem” for odor, pipe clogging, and wastewater overflow increased from IM4D. In addition, the answers of always offensive odor and pipe clogging and wastewater overflow all

increased from IM4D.

**Table 8.3.1 Evaluation of HIS Respondents' about Sanitation in/around Houses**

| Day | Offensive Odor | | | | Pipe Clogging | | | | Overflow of Wastewater | | | | Mosquitoes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | IM4D | | 2019 | | IM4D | | 2019 | | IM4D | | 2019 | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| Always | 85 | 16.4 | 52 | 2.6 | 52 | 10.0 | 10 | 0.5 | 38 | 7.3 | 23 | 1.1 | 244 | 47.1 |
| Frequently | 42 | 8.1 | 81 | 4.0 | 49 | 9.5 | 65 | 3.2 | 58 | 11.2 | 92 | 4.6 | 122 | 23.6 |
| Sometimes | 167 | 32.2 | 664 | 33.0 | 110 | 21.2 | 397 | 19.7 | 175 | 33.8 | 437 | 21.7 | 100 | 19.3 |
| No problem | 220 | 42.5 | 1,189 | 59.0 | 303 | 58.5 | 1,437 | 71.4 | 244 | 47.1 | 1,375 | 68.3 | 48 | 9.3 |
| Not sure | 2 | 0.4 | 28 | 1.4 | 2 | 0.4 | 105 | 5.2 | 1 | 0.2 | 87 | 4.3 | 2 | 0.4 |
| No response | 2 | 0.4 | 0 | 0.0 | 2 | 0.4 | 0 | 0.0 | 2 | 0.4 | 0 | 0.0 | 2 | 0.4 |
| Total | 518 | 100.0 | 2,014 | 100.0 | 518 | 100.0 | 2,014 | 100.0 | 518 | 100.0 | 2,014 | 100.0 | 518 | 100.0 |

Source: JICA Survey Team

(2) Questions Regarding the Sewerage System

1) Expectation of a Sewerage System

The expectation of the development of a sewerage system is shown in Table 8.3.2. Majority (86.5%) of the respondents expect the development of a sewerage system.

**Table 8.3.2 Expectation of a Sewerage System**

| Expectation for Sewerage | 2019 | | IM4D | |
|---|---|---|---|---|
| | Nos. | % | No. | % |
| Yes | **448** | **86.5** | N/A | |
| No | 20 | 3.9 | N/A | |
| I don't know | 18 | 3.5 | N/A | |
| No response | 32 | 6.2 | N/A | |
| Total | 518 | 100.0 | N/A | |

Source: JICA Survey Team

2) Negative Reason to Sewerage

Out of the people who answered negatively to the development of a sewerage system in **Table 8.3.2**, more than 70% are satisfied with the current situation as shown in **Table 8.3.3**.

**Table 8.3.3 Reason of Negative to Sewerage System**

| Reason of Negative to Sewerage | 2019 | | IM4D | |
|---|---|---|---|---|
| | Nos. | % | Nos. | % |
| Nearby environment is enough good | 40 | 71.4 | N/A | |
| Don't want to pay for sewerage system at all | 7 | 12.5 | N/A | |
| Septage management with septic tank is enough | 1 | 1.8 | N/A | |
| Drainage improvement by the city/DPWH shoud be higher priority. | 7 | 12.5 | N/A | |
| Other | 1 | 1.8 | N/A | |
| Not applicable (positive to sewerage system) | 462 | - | N/A | |
| Total | 518 | 100.0 | | |

Source: JICA Survey Team

3) Main Reason for Expecting Environmental Improvement of Public Water Body

The main reason for expecting the environmental improvement of public bodies of water is shown in **Table 8.3.4**. A relatively large number of residents showed a positive response to environmental improvement.

**Table 8.3.4 Reason of Expectation to Environmental Improvement**

| Environmental improvement | 2019 | | IM4D | |
|---|---|---|---|---|
| | No. | % | No. | % |
| I hope to improve the public water body and can pay the certain amount for the **environmental improvement itself** | 254 | **49.0** | N/A | |
| I hope to improve the public water body and can pay the certain amount as an extension of **improvement of living condition near my house** | 224 | **43.2** | N/A | |
| I hope to improve the public water body but **don't want to owe the cost for the improvement** | 24 | 4.6 | N/A | |
| Improvement of the public water body is not my business | 2 | 0.4 | N/A | |
| Other | 0 | 0.0 | N/A | |
| No response | 14 | 2.7 | N/A | |
| Total | 518 | 100.0 | | |

Source: JICA Survey Team

## 8.4 Study on Applicable Japanese Technology in Davao City

### 8.4.1 Overview of Japanese Sewerage Technologies

JICA Survey Team conducted the preliminary organization and applicability of various sewerage technologies in Davao City based on the existing issues in section 3.9 and interviews with Japanese companies. The applicable treatment process and sewerage technologies in the survey area are summarized in Table 8.4.1. The most applicable technologies explained in this sub-section together with other technologies are introduced in Appendix 8.5.

**Table 8.4.1 Sewerage Technology to be Applicable in the Survey Area**

| Issue | Effective technologies | Applicable sewerage technologies |
|---|---|---|
| **1. Pipeline** | | |
| ➢ The rapid sewerage system development is required considering the sewerage coverage is currently 0%.<br>➢ Difficulty to install pipes by open-cut method in the urban area | ➢ Non-open cut method with less impact to residential (pipe jacking method and shield tunneling method) | (1) Pipe jacking method (Long distance and curved jacking)<br>(2) Pipe jacking method (Small diameter for house connections |
| **2. Wastewater Treatment Facility (WTF)** | | |
| ➢ Limitation of WWTP site<br>➢ Shortage of O&M staff<br>➢ Response to the strict effluent standard (Advanced treatment)<br>➢ On-site/community treatment in rural area<br>➢ High electricity cost | ➢ Compact treatment system with simple operation and maintenance<br>➢ Applicable technologies for advanced treatment<br>➢ Unit type treatment<br>➢ Energy-saving treatment process/equipment | (1) (Deep type) Conventional activated sludge process (CAS)<br>(2) Sequencing Batch Reactor (SBR)<br>(3) Pre-treated Trickling Filter method (PTF)*<br>(4) Membrane Separation Bioreactor (MBR method)<br>(5) Integrated Fixed-Film Activated Sludge (IFAS/MBBR)<br>(6) Johkaso Technology<br>(7) Other equipment (Energy-saving blower/diffuser) |
| **3. Sludge Treatment Facility (STF)** | | |
| ➢ Shortage of the sludge disposal site<br>➢<br>➢ High electricity cost | ➢ Technologies for the reduction of sludge volume and recycle<br>➢ Energy-saving equipment | (1) Energy-saving dehydrator<br>(2) Mechanical dryer<br>(3) Recycle technology (composting technology, digestion gas power generator, utilization of construction material) |

| Issue | Effective technologies | Applicable sewerage technologies |
|---|---|---|
| **(4) Operation and Maintenance** | | |
| ➢ Blockage of pipes and failure of pumps due to the inflow of sands and garbage to combined sewerage system<br>➢ Discharge of debris to the public bodies of water<br>➢ Shortage of O&M staffs<br>➢ Measure for high tide in WWTP | ➢ Technology for automating O&M<br>➢ Asset management technology for database of sewerage facilities with information aimed at efficient operation<br>➢ Pump gate for forced drainage of treated water | (1) Auto flushing device for sewer (Flash Gate)<br>(2) Vortex flow type water surface control device<br>(3) SCADA system<br>(4) Asset management system<br>(5) Sewer optical fiber network system<br>(6) Pump gate |

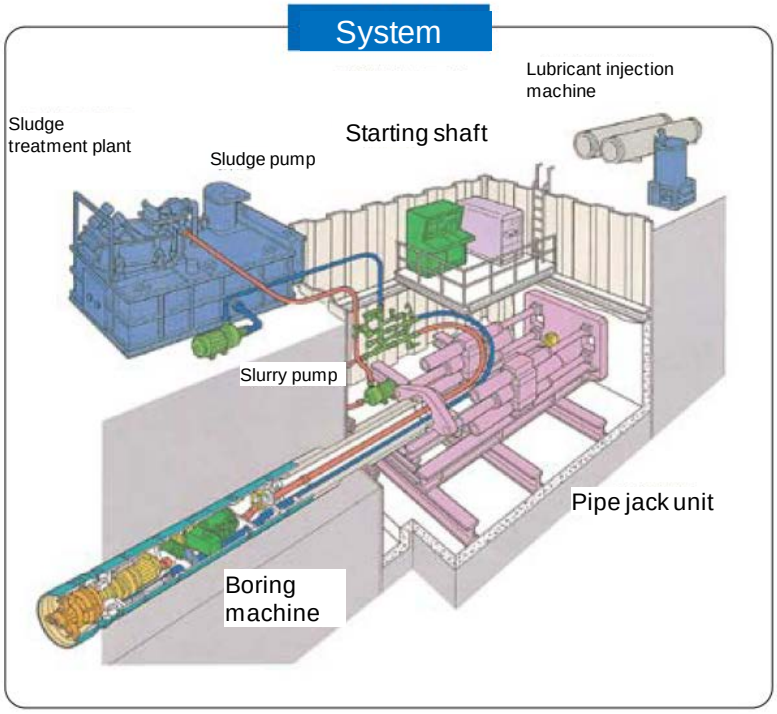
Source: JICA Survey Team

### 8.4.2 Sewer

(1) Long-distance Pipe-jacking Method

The trunk sewers will be constructed under the main busy streets in the central business district. The occupation of the large-scale roads for the open cut method cannot avoid causing heavy traffic congestion, construction noise, dust, and vibration. Therefore, the pipe jacking method would be a good solution for the pipe installation.

The overview of the pipe jacking system is shown in Figure 8.4.1. Road occupation is only required around the starting and arrival shaft. This construction method does not only help to avoid heavy traffic congestion but also help in reducing the waste generated in construction works.




Source: Manufacturer's brochure

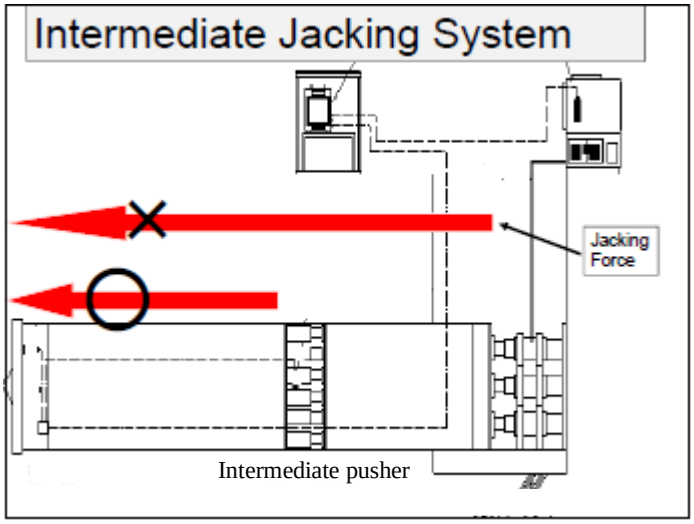
**Figure 8.4.1 Overview of Sewer Installation by Pipe-jacking Method**

One of the key factors to minimize adverse influences and risks caused by the pipe installation and construction as mentioned above is reducing the number of shafts. Installing the intermediate pusher in the middle of pipes as shown in Figure 8.4.2 will make this possible. This method is called long-distance pipe-jacking method, which is an expertise of Japan. One span can be hundreds of meters long (more than 500 m in maximum) and can be jacked by a propulsion force provided with an intermediate pusher. This technology enables the number of shafts to be possibly reduced in half. Moreover, the construction cost can be reduced because the construction period is shortened compared with the ordinal pipe-jacking method.

However, this method requires technologies where Japan has sufficient and successful experience as described below.

Lubrication is used to push a pipe without damage, which has to appropriately be applied to the surface of a pipe. As a countermeasure, an automated lubricant injection system is installed to effectively control the injected amount, points, and time.

Also, propulsion at a curve is possible by using a curve formulation unit and a gyrocompass attached to the boring machine.



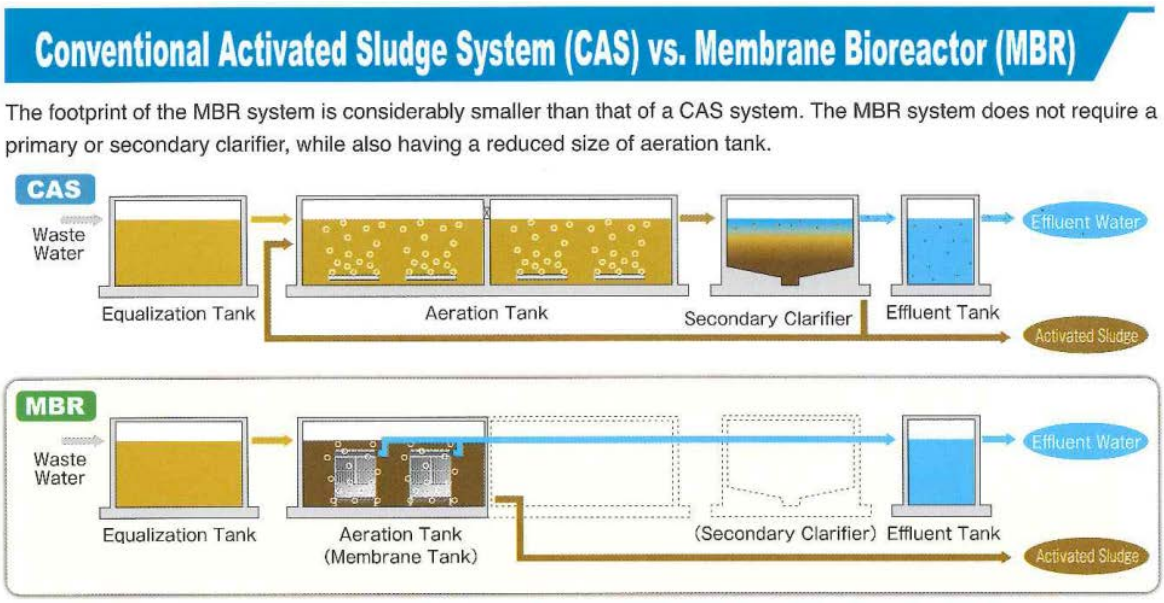

Source: Manufacturer's presentation material

**Figure 8.4.2 Image of Intermediate Pusher of Long-distance Pipe-jacking Method**

### 8.4.3 Wastewater Treatment Facility (WTF)

(1) Membrane Bio Reactor (MBR method)

The Membrane Bio Reactor (MBR) method is the most applicable technology for wastewater treatment in the limited space in such as Magsaysay Park as the proposed site for WWTP in Area A. The MBR system does not require the primary and final sedimentation tanks, while having a reduced size of reactor which has membranes (see Figure 8.4.3). This makes it possible to operate MBR processes at a higher mixed liquor suspended solids (MLSS) value compared to conventional activated sludge process, therefore, the reactor capacity can be reduced.

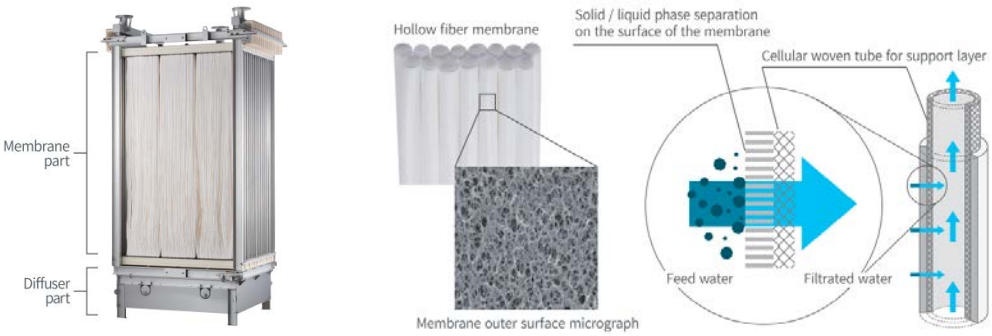



Source : Manufacturer's brochure

**Figure 8.4.3 Image of MBR Method Application**

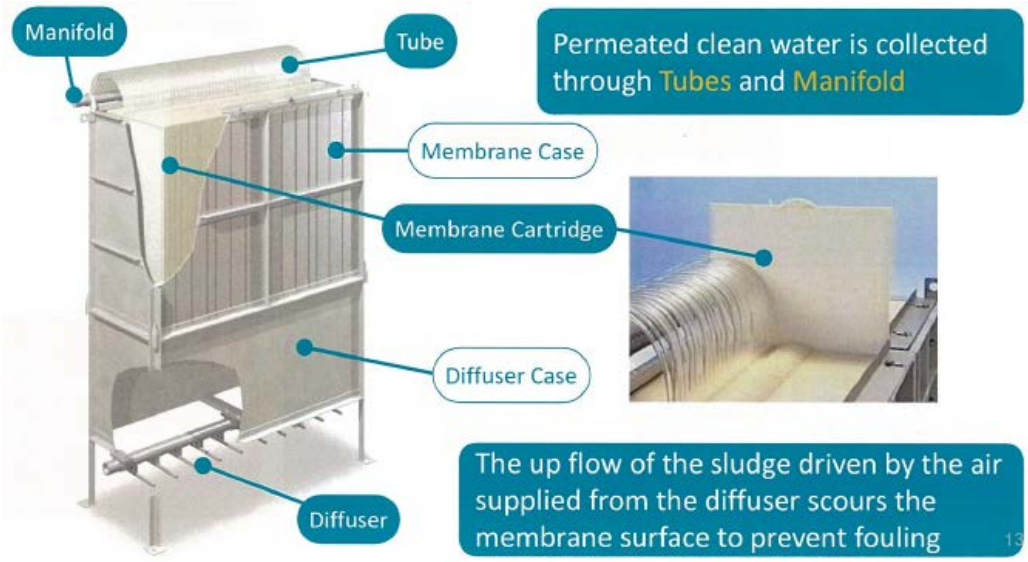
It is also possible to theoretically not install a disinfection facility because coliform bacillus cannot pass through the membrane. However, it is usually installed for emergency purposes such as power failure.

Japan is strong in the market of membrane accounts for about 40% of the share in the international market of membranes used for the MBR method (as of 2009) because of its high quality. Also, after the sales, the service provided by the manufacture is an important factor in the selection criteria since the MBR is composed of a lot of mechanical and electric equipment that need maintenance. For example, each membrane requires cleaning for the removal of fouling about once every one to two years. Services such as these are crucial. It is even better when a manufacturer with sufficient experience is located in the same country for the prompt action of repair and maintenance.




Source: Manufacturer's presentation material

**Figure 8.4.4 Overview of Hollow Fiber Membrane Unit**




Source: Manufacturer's presentation material

**Figure 8.4.5 Overview of Flat Sheet Membrane Unit**

(2) Johkaso Technology for On-site Treatment Area

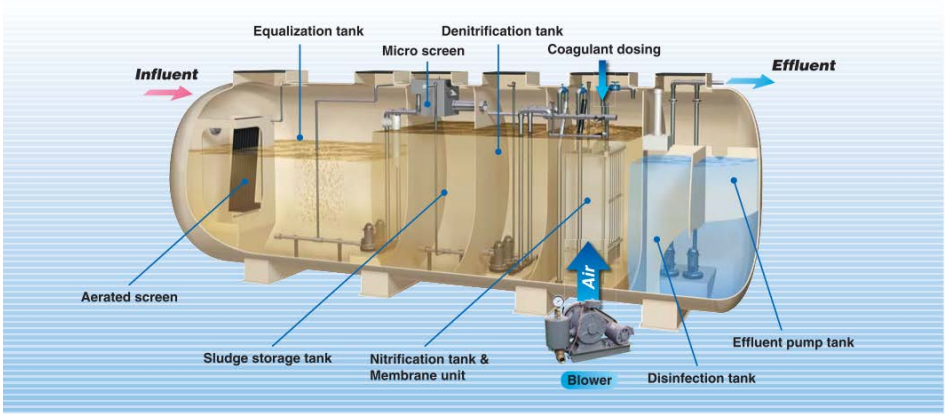
The application of on-site treatment not only off-site treatment in the rural areas of proposed sewerage development area is proposed in this report.

The on-site treatment for communities is effective and reasonable in suburbs and particularly hilly areas to avoid the installation of long pipelines and pumping stations to convey wastewater to the sole treatment plant in the large sewerage area. Johkaso technology is useful for the on-site treatment. With this technology, the installation and O&M works are easy with compact units. After many experiences of installing Johkaso for a long time in Japan, the technologies were improved, and the biological nutrient removal (BNR), which removes nitrogen and phosphorus, can be achieved with some types. Figure 8.4.6 shows an image of the BNR type Johkaso, and Table 8.4.2 shows examples of influent and effluent water qualities. Depending on the water body and the influent water quality, different types of units are available for every situation. There is a simpler unit that treats BOD and nitrogen and another one that only treats BOD. Various types can be selected and the system gets simpler and more reasonable. In case of 200 $m^3$/day unit, wastewater generated from 1,000 persons can be treated.

**Table 8.4.2 Example of Influent and Effluent Water Qualities in Johkaso (BNR Type)**

| Parameter | Influent | Effluent |
|---|---|---|
| BOD (mg/L) | 50-450 | ≦5 |
| COD (mg/L) | 100 | ≦10 |
| T-N (mg/L) | 50-100 | ≦10 |
| T-P (mg/L) | 5 | ≦ 1 |

Source: Manufacturer's brochure




Source : Manufacturer's brochure

**Figure 8.4.6 Image of Johkaso Unit (Nitrogen and Phosphorus Removal Case)**

| | | |
|---|---|---|
|  |  |  |
| External Image of Unit | Example of Installation (1) | Example of Installation (2) |

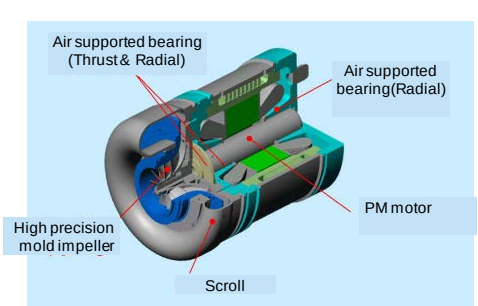
Source : Manufacturer's brochure

**Photos: Image of Johkaso System**

(3) Other Equipment (Energy saving equipment)

1) Energy Saving Type Blower

The power consumption of a blower used for a reactor is estimated to be about 20% of the total power consumption at a sewerage treatment plant. It has large impact for O&M cost in the area with high electricity tariff. An energy-saving blower has achieved about 10% to 15% energy savings by adopting an air supported bearing with no mechanical loss and a permanent magnet (PM) motor suitable for an inverter control.




**< Appearance of blower package >**

Source : Manufacturer's brochure

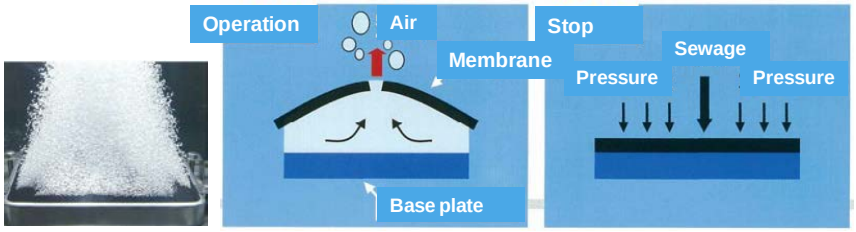
**Figure 8.4.7 Energy-saving Blower**

2) Energy Saving Type Diffuser (Membrane type)

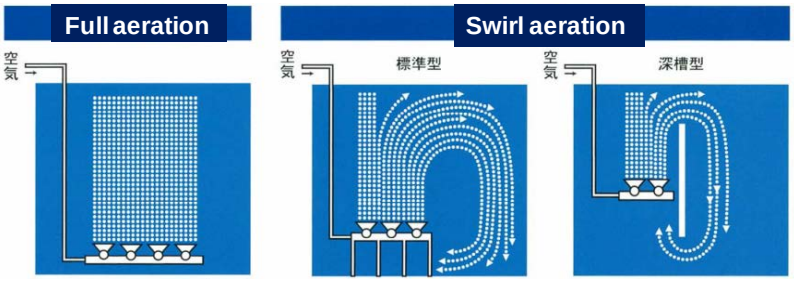
The diffuser which generates ultra-fine air bubbles using special membrane materials has higher oxygen transfer efficiency and less pressure loss compared to the conventional diffusers. Therefore, it is effective for energy saving of a blower.

The power consumption of a blower is estimated to be about 20% lower by introducing an ultra-fine air bubble diffuser plate.

The diffuser can support full aeration as well as swirl aeration.




**Ultra fine bubble** **Less clogging mechanism**




**Flow arrangement**

Source: Manufacturer's brochure

**Figure 8.4.8 Energy Saving Type Diffuser**

### 8.4.4 Sludge Treatment Facility (STF)

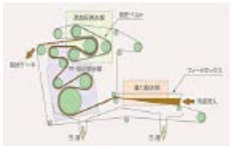
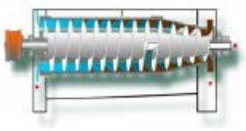
(1) Dewatering/ Energy-saving Dehydrator

1) Various Dewatering Equipment

Sludge treatment is one of the most significant processes in this project because sludge disposal is the critical point. The amount of water that is dewatered by a dehydration machine has a large effect on the following sludge treatment process, such as drying.

There are 4 types of dewatering equipment; 1) screw press with multiple layered rings, 2) screw press, 3) belt press, and 4) centrifugal as shown in Table 8.4.3.

**Table 8.4.3 Dewatering Equipment**

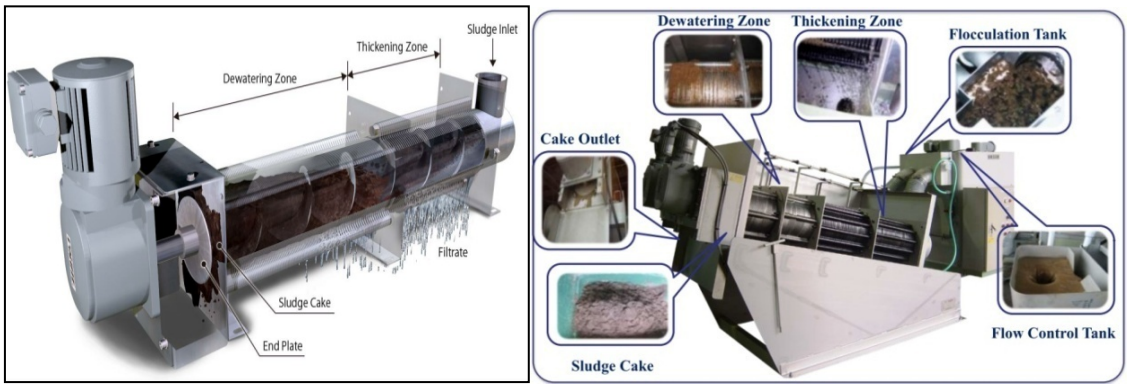
| Category | Screw Press with Multiple Layered Rings | Screw Press (Other Type) | Belt Press | Centrifugal |
|---|---|---|---|---|
| Item |  |  |  |  |
| Foot print | Small | Smallest | Largest | Large |
| Energy Consumption | Smallest | Small | Small | Largest |
| Initial cost | Smallest | Small | Largest | Largest |
| O&M cost | Smallest | Small | Largest | Largest |
| Ease of O&M | Easy | Easy | Not easy | Not easy |

Source: JICA Survey Team with manufacturers' figures

Out of the four types of equipment above, 1) screw press with multiple layered rings, and 2) other types of screw press are introduced below as the most appropriate types for this project.

2) Screw Press with Multiple Layered Rings

Sludge feed is regulated with the overflow pipe, returning the excess volume to the sludge storage tank. Next, sludge is instantly thickened at the thickening zone and dewatered at the dewatering zone in the subsequent stage under increasing inner pressure. Further pressure is applied from the outlet side with the end plate, discharging dewatered cake with 20±5% solid content.




Source: Manufacturer's presentation material

**Figure 8.4.9 Energy-Saving Dehydrator (Screw Press with Multiple Layered Rings)**

To summarize, the Japanese screw press with multiple layered rings is compact, high performing, and has the following characteristics:

- No clogging
- Easy maintenance
- Energy saving (low running cost)

- No thickened sludge storage tank required
- Continuous 24-hour unmanned operation
- Foul odor protection

The same kind of unit has already been installed 3,200 times in 70 countries, which shows the excellence of the product.

(2) Mechanical Dryer

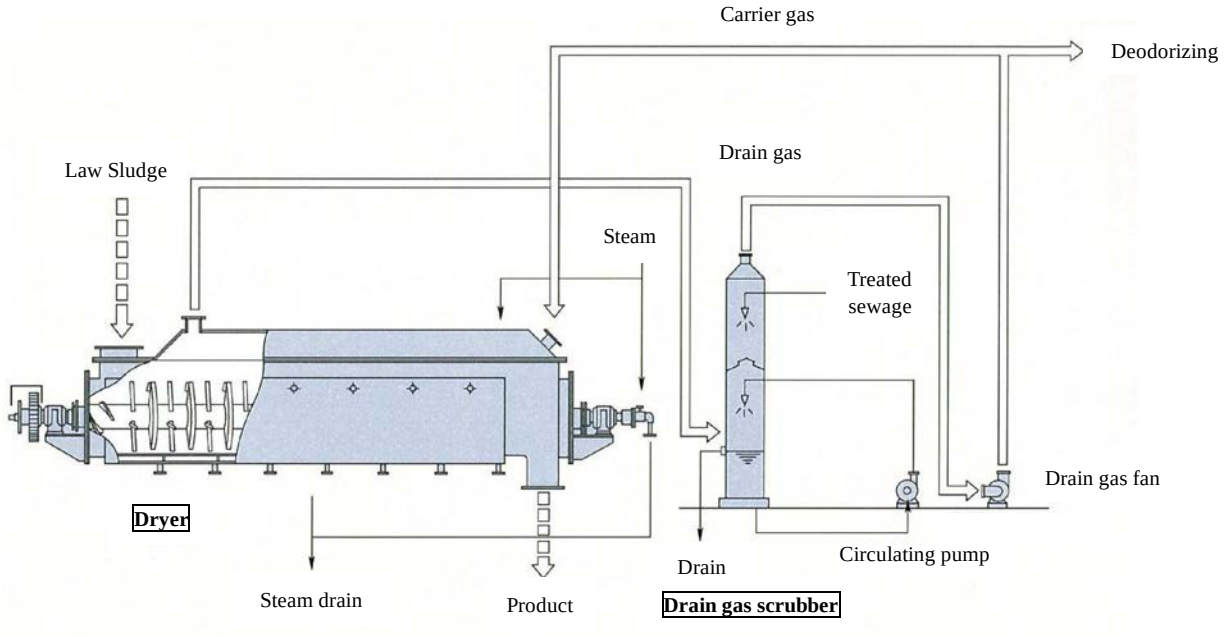
The mechanical dryer would be selected for drying process for the issues of sludge volume reduction and odor control. The overview of inclined disc dryer, which would be a suitable type for this project, is described below.

Sludge is usually dried until the moisture content reaches about 70% in case an incinerator is installed on the following process. A large amount of energy as latent heat is required in the drying process regardless of the drying method, which means energy saving technology is crucial.

The drying method can be divided into two types. These are the direct heat dryer and the indirect heat dryer. The inclined disc dryer is the latter, and high heat transfer coefficient is materialized by its disc. Thermal efficiency is extremely high as the heat losing area per effective heat transfer surface is small. These characteristics lead to save consumed energy. In addition, the Japanese inclined disc dryer has a self-cleaning system, so heat transfer efficiency will be kept high, which makes the energy-saving property even higher compared to the products of countries.

Also, a small amount of carrier gas is used, and it emits only a small volume of exhaust gas.

Japanese inclined disc dryers have been installed in many countries, for example China, and they have been running very well. Their lifetime could be 15 years if proper O&M is conducted.




Source: Manufacturer's presentation material

**Figure 8.4.10 Flow of Inclined Disc Dryer**

### 8.4.5 Operation and Maintenance

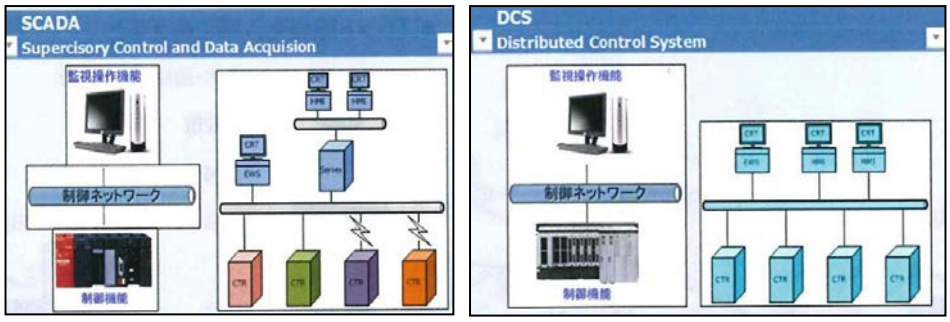
(1) SCADA System

For the water supply system, the Supervisory Control and Data Acquisition (SCADA) system has been introduced, and this makes it possible to centralize the monitoring of all facilities.

Even for the sewer system, a reliable SCADA system, which is capable of the centralized monitoring of the treatment plants and pumping stations and is likely to increase more in the future, is needed and is expected to be introduced.

The SCADA system can be structured by combining generic products at low costs by a local company. However, as the scale of the system expands, it will be more difficult to keep the reliability level high.

On the other hand, the Distributed Control System (DCS), which is one kind of SCADA system, uses a dedicated device in which high-speed data processing and a backup feature are available. Thus, it is possible to secure high reliability at a large scale facility where a lot of devices are used in one plant. Therefore, it is common to use the DCS at power plants and industrial plants where high reliability is mandatory.




Source : Manufacture's presentation material

**Figure 8.4.11 Images of SCADA and DCS**

(2) Pump Gate (full velocity and all water level type horizontal axis submersible pump)

From the location of Magsaysay Park in the seaside area, the pump gate might be applicable as a countermeasure for discharging effluent during high tide events. The feature of the pump gate is explained in Appendix 8.5.

# CHAPTER 9 CONCLUSION AND PROPOSAL FOR NEXT STAGE

From the broad data collection and pre-feasibility study, including preliminary designs in Chapters 1 to 8, the following contents are proposed to the counterpart and concerned agencies in the Philippines.

## 9.1 Sewerage System in Target Area

### 9.1.1 Neccesity of Sewerage System Development and Target Area

(1) Review of Current Situation

Davao City, which is one of the largest highly urbanized cities (HUCs) in the Philippines does not have existing public wastewater treatment plant (WWTP) and septage treatment plant (SpTP). HUCs are required to develop sewerage system by 2020 in NSSMP. A large part of the city center (particularly in the commercial area) in Poblacion District is equipped with covered drains, and it is rare to find wastewater flow in the streets. However, in the residential areas and particularly in slum areas, there are many small drains and major creeks with stagnant gray water. The Davao River, which is a major tributary in Davao City, is largely polluted by wastewater, and water quality tests show high values of coliform and other several indicators. The Davao Gulf, which is the final destination of rivers and creeks, shows pollution of seawater without observance of environmental standards in DO and fecal coliform. Even in the city center with covered drains, once flooding occurs after heavy rains, the stormwater including wastewater from drains inundates in the streets periodically. Since the city population is rapidly increasing, the situation will get worse year by year if there is no effective action taken. Currently DCWD plans to commence the septage management program, but only septage management is not sufficient to manage wastewater.

(2) Recommendation/Necessity of Sewerage System Development

The abovementioned situation can be improved by the development of a sewerage system along with the improvement of a drainage system which is mainly conducted by the Department of Public Works and Highways (DPWH). The improvement of environment conditions and better landscape of public water bodies can enhance the value of the rapidly growing city. It can not only lead to the increase of tourists and companies coming in to Davao, but also enhance the value of land. If delayed, the establishment of developments may become more difficult and more costly due to more heavy traffic in the streets and more underground utilities of other sectors (e.g., water supply, drainage, power, communication, etc.) in the future.

The positive answers and expectations by citizens to sewerage development, which were confirmed in the household survey in this study, can propel the development. Also, the commercial sector needs the system since the current penalty to the Environmental Management Bureau (EMB) for the companies against the effluent standard is quite high and since there is a need for new/upgraded treatment plants with advanced treatment. It is clearly more reasonable to connect to a sewerage system and pay the fee than to build treatment plants.

Historically, many large cities (i.e., economic centers) in developed countries, including Japan, and in developing countries all over the world have developed/been developing their sewerage system over a long period, of even a maximum of 50 years, to complete the development of all areas. Sewerage development is time-consuming due to the unprofitable characteristic and requirement of large-scale development and individual connections. An efficient method with new technology can be sought, but the work itself is inevitable. There is no large city that managed to develop soundly only with drainage system/septage management and without sewerage development. As stressed in this report, septage management cannot treat gray water. However, rapid development of sewerage system is difficult. Therefore stepwise development i.e. firstly septage management, secondly sewerage development has been adopted in many cities.

(3) Priority Area

Again, as an initial stage, it is important to start the work with appropriate scale. Once completed, area-wise development can follow to utilize the constructed facility (i.e., WWTP and trunk sewers). Although the development of the entire Area A (i.e., Poblacion and Agdao districts) in accordance with the master planning in IM4D is ideal for the development of other following areas, the JICA Survey Team also considered the stepwise development to make the initial project scale smaller than the entire Area A for the higher possibility of financial source. Davao City appreciated the consideration as one option.

### 9.1.2 Proposed WWTP with Membrane Bio Reactor Process

(1) Advanced Treatment Process

In order to clean up the Davao River and the Davao Gulf, advanced treatment processes, such as nitrogen and phosphorus removal, are required based on the environmental guidelines of DENR. Therefore, the WWTP should have advanced treatment methods. In other words, a WWTP without advanced treatment performance cannot be adopted in Davao. Due to the restriction of site for the WWTP (i.e., in Magsaysay Park), in terms of space and underground structure, the Membrane Bio Reactor (MBR) process was selected as it can solve both effluent water quality and space problems.

(2) Re-development of the Park and Utilization of High-quality Effluent Water

The construction of the WWTP in Magsaysay Park is a good opportunity to upgrade the park itself after more than 30 years since its construction. The latest development plans (i.e., Comprehensive Land Use Plan and Comprehensive Zoning Ordinance of Davao City (2013-2022)) stipulate that parks should serve as recreational spaces for citizens with the purpose of improving their health. The high-quality effluent from the MBR plant (which can achieve even BOD 1 mg/L and no coliform under good operation) is quite suitable as recreational water to be used in the water park, which was proposed for the utilization of on-ground of WWTP.

(3) Education for Environmental Improvement (Enlightenment of Public Awareness)

The training/education center will be built in the administration building. As it is inside a major park,

the WWTP can welcome Davao citizens and people from nearby LGUs and can serve as a place to advertise the sewerage technologies adopted in Davao as well as educate students and raise awareness of environmental preservation. Such an opportunity can lead to the expansion of sewerage development outside Area A, including onsite treatment in the residential complexes in remote areas, to improve the living environment. As the first to develop a sewerage system in LGUs, except for Metro Manila, Davao City can take leadership of the LGUs and the cities in nearby countries and can be the first example of an underground WWTP with on-ground utilization in a highly developing city.

### 9.1.3 Proposed Sludge Treatment Process

For countermeasures in reducing sludge volume (i.e., to reduce number of trucks transporting the biosolid) and the odor, the JICA Survey Team proposed to apply the sludge dryer after the conventional thickening-dewatering process and Davao City agreed that. It can reduce the adverse impact of WWTP operation. With appropriate handling and quality checking, the sludge can be utilized in various ways (e.g., composting of dewatered sludge and cement material of dried sludge), although these require some additional facilities and manpower. If such reutilization would be achieved, it also gets a positing impact for education of reuse and recycle for citizens and visitors.

### 9.1.4 Proposed Sewer Collection and Development

(1) Sewage Collection

The JICA survey team compared the separate sewer system and combined (interceptor) sewer system. The separate sewer system has advantage of highest effect for environmental improvement and disadvantage of long time and cost requirement for lateral sewer development and house connections. Due to the general trend of insufficient slope of drains, collection of graywater with an interceptor system is quite difficult in Davao. The team confirmed in site visits that in most highly congested/slum areas, the generated graywater is stagnant or is infiltrated to the ground. The adoption of an interceptor system cannot work to collect wastewater. Adding the adverse impact of backwater to creeks/drains from the sea, the condition for interception is much worse than in Metro Manila.

Therefore, explaining such situations in Davao and the basic of sewerage system, and prioritizing the environmental improvement effect, the application of separate sewer system was proposed and agreed with Davao City. The future redevelopment of land and separate sewer development is the only way to improve the environment completely given that septage management is difficult in such areas.

(2) Sewer Development

Due to many roads experiencing heavy traffic and deep position of laying trunk sewers as downstream sections, the trenchless sewer installation method (pipe jacking method) should be adopted in most highways and major city roads near the sea. This can minimize the adverse impact to the traffic and the economic activity in the city. Although it is more expensive than excavation, it can reduce the

construction period, particularly in the case of deep installations. The experience with a trenchless sewer will provide important feedback for future application in other sectors. From now on, the demand of underground space becomes more important as the city is rapidly growing. In general, the silty sand soil in Davao is relatively good for the trenchless method. There are many experiences with long-distance and curving pipe jacking method applied in areas without enough space for vertical shafts for jacking in Japan. Such experiences can be transferred to Davao City.

## 9.2 Project Evaluation for the Projects

### 9.2.1 Possible Financial Scheme

As a sewerage development in LGU and as a main target of the NSSMP grant, 50% of the project cost can be supported by DPWH. The remaining cost can be covered by the Two-Step Loan of JICA via the Development Bank of the Philippines (DBP) or by the Land Bank of the Philippines (LBP). After the comparison of several financial scheme options, including the Municipal Development Fund from the Department of Finance (DOF), the adoption of the scheme is recommended in terms of interest rates and repayment period.

### 9.2.2 Possible Implementation Agency

Through interviews, it was determined that DPWH has other priorities in its mandates, and private sectors do not have prefer the PPP scheme unless the project is a water and sewerage combined project. This means that it boils down to LGU or DCWD to be possible implementation agencies. The Davao City Water District (DCWD) has a mandate of sewerage service; however, with LWUA's ring-fencing regulation and DCWD's philosophy (i.e., invest only when full cost recovery is projected). Meanwhile, LGU has responsibility for sewerage development according to Local Government Code. Therefore this survey, at this stage, concludes that the LGU is the most probable implementing agency, and a Project Management Unit (PMU) shall be established within the LGU. Still, it is highly recommended that the LGU and DCWD closely coordinate to apply to NSSMP grant the procurement of contractors and the monitoring of construction. This survey concludes that DCWD would be in charge of operation and maintenance as its know-how on operation and maintenance (O&M) and tariff collection network established through water provision service is crucial.

### 9.2.3 Financing of the Project

This survey assumes that 50% of initial costs is funded by the NSSMP grant. For the remaining capital expenses (CAPEX), the Two-Step Loan and Municipal Development Fund Program can be utilized for the loan portion. Since the terms and conditions of the Municipal Development Fund Program (MDFP) was unavailable at the early stage of the survey, the TSL terms and conditions were applied for financial analysis purposes. It is suggested that the LGU seek further information from DOF on the MDFP and go with most reasonable financing options.

The project cashflow analysis found that PHP 12.7 /$m^3$ for Area A and PHP 9.2 /$m^3$ for Phase 1 are

necessary to recover the O&M costs of respective scenarios. The analysis assumed to charge PHP 10 /$m^3$ for residential users and PHP 20 /$m^3$ for commercial users based on the discussion with LGU. The tariff level would cover the Phase 1 O&M costs, but not the Area A O&M costs.

Our estimation of Affordability to Pay on sewerage service in Davao City is PHP 15 /$m^3$, which would cover the O&M cost. However, it seems extremely difficult to apply such high tariff when the willingness to pay is only PHP 5 /$m^3$. The LGU together with DCWD are expected to provide an awareness campaign on sewerage treatment and to establish an enforcement system for service connection and tariff collection.

For CAPEX financing, the LGU is expected to avail of the loan and to allocate the development fund on the debt service. When 100% of the remaining CAPEX (after NSSMP grant) is funded by TSL (Case 1), the annual debt service will be PHP 805 million for Area A and PHP 421 million for Phase 1. Since the repayment will start in year 2032, the budget of the development fund is likely to have increased by then. The debt service for Phase 1 seems to be appropriate within the development fund, but careful assessment is required for Area A. Another option that can be sought is for the LGU to collect an "environmental fee" from Areas A to F (Reference Case). This would make full cost recovery more realistic (i.e., PHP 6.1 /$m^3$ for residential, PHP 12.2 /$m^3$ for commercial); however, charging non-users for the sewerage service will provoke resistance. The LGU together with DCWD are expected to have further discussion on financing and cost recovery methods while increasing citizen's awareness on wastewater treatment.

## 9.3 Proposed Scope of Work for Next Stage

After the pre-feasibility study of the project, the JICA Survey Team prepared the draft work contents for the next stage of the project (feasibility study) as shown in Appendix 9.1. To enhance the planning and design levels, various field surveys, such as water quality tests in creeks/drains in Poblacion District as main target area and topographic survey in key points should be conducted. Based on such surveys, the planning of the treatment plant should be reviewed, and the lateral sewer design should be prepared. The financial matter can be further studied in the feasibility study.