Annex F

Planning Overview for Water Supply and Sanitation Systems

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Planning for Water Supply Systems

Part 1

1 Introduction

This annex to the PWSSMP aims to give an overview of the key concepts and considerations employed in planning for a water supply system. While this document would not be enough reference in the design and construction of a system, it endeavors to aid the reader, especially non -technical ones, in formulating a preliminary plan that shall involve the design demand, intended source of water, and indicative cost of the development among others. It also aspires to be useful to readers in understanding and in making decisions that would enable them to avail more usefully of the services of technical consultants and contractors they must deal with in the next stages of the water supply development.

The planning and design of a water supply system (Level II or III) or a water point source (Level I) considers a variety of factors to ensure that the resulting system is sustainable and could adequately deliver the water needs of its intended consumers.

Among the considerations[1] to ensure a water supply system is sustainable are the following:

- Technical Considerations – These include proper and thorough conduct of preparatory works (feasibility studies, water source assessment, etc.) to sufficiently prepare the system preliminary plan and detailed design. Design and construction of the system should also be done in accordance with the standards and employ appropriate technologies, equipment, and materials.
- Financial Considerations – These involve developing the water system in the most cost-effective manner while meeting the necessary standards and customers' requirements. The system's development costs and resulting tariff structure must strike a balance between the customers' affordability levels and the utility's cost recovery. The latter ensures that the system can earn funds that can sustain its operations, maintenance, and future requirements.
- Social Considerations – These consider the interests and concerns of the various stakeholders involved in the development and operation of the water system (local officials, businesses, community leaders, and households).
- Environmental Considerations – These ensure that the development and operation of the system consider their effects on the environment. It also entails that the use of water sources is within its safe yields and will not compromise its current and future viability to promote its long term sustainability.

The succeeding sections shall give an overview of the various components necessary in planning a water supply system.

[1] *Water Partnership Program – Rural Water Supply Design Manual*

Water Demand

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In planning water supply systems, the first factor to be determined is how much water is needed by the intended population to be served. The water should be sufficient to cater to the existing and future consumers at the end of the specified design year horizon (e.g. 5, 10, 25 years, etc.). Besides the projected consumption of water users, the design water demand should also allow for non-revenue water, leakages, and other losses in the system.

Water demand of a service area is dependent on various factors including but not limited to: a) service levels to be implemented; b) size of service area; c) standard of living of intended water consumers; and d) quantity and quality of water available in the area.

2.1 Service Level Definitions

Water consumption of a household (HH) is dependent on the service level of water system it has access to. The Philippines has three types[2] of water service levels defined as follows:

- **Level I (Point Source)** – This service level provides a protected well or a developed spring with an outlet but without a distribution system. Hence, the users go to the source to fetch water. Level I sources are generally adaptable in rural areas where the houses are thinly scattered. These sources serve an average of 15 households within a radius of 250 meters.
- **Level II (communal faucet system or stand posts)** – A piped system composed of a source, a reservoir, a piped distribution network, and communal faucets. Each communal or public faucet usually serves four to six households within a radius of 25 meters. Users still go to the supply point (communal faucet) to fetch water. This type of system is generally suitable for rural and urban fringe areas where houses are clustered densely to justify a simple piped system.
- **Level III (Waterworks System or Individual House Connections)** – This system includes a source, a reservoir, a piped distribution network, and individual household taps. It is generally suited for densely populated urban areas where the population can afford individual connections.

Community-level piped water systems are categorized as either Level II or Level III water systems. Those with individual house connections are Level III, and those with communal faucets are Level II. Point sources without water distribution piping are Level I. Level I also includes small-scale water sources within the yard with piping or plumbing installations.

[2] *NEDA Resolution No.5, Series 1998*

2.2 Design Period

In designing water supply systems, the concept of having a master plan for each utility with a design horizon of 10 – 20 years may be adopted but implemented in phases. The initial phase could be designed to address only the service demand projected for the initial years, but will be provided for eventual expansion. The implementation of subsequent phases may depend on the increases of revenue base and service demand, as well as on the capacity of the utility to sustain expanded operations. By doing such, a realistic and comprehensive approach is employed that aids in preventing overdesign of the system at the outset thereby reducing investment costs and promoting reasonable cost recovery tariffs.

In a rural community setting where a small water utility would normally operate, a design period of 5 to 10 years is usually suggested. These shorter design periods are both beneficial to the utility (better financing terms) and consumers (more considerate of potential consumers' capability and willingness to pay the amounts needed to support repayment).

2.3 Design Population

The overall capacity of a water supply system shall depend on the design population it intends to serve. This would entail the projection of the total population of a community, barangay, or municipality, and determining the service area[3] and the served population.

The growth rates of barangays and municipalities could be determined based on the latest censual period[4] of the study area (in this case from 2010 to 2015) by using the formula below. Census data can be obtained from Philippine Statistics Authority (PSA).

$$P_{2015} = P_{2010}\,(1 + GR)^n$$

or

$$GR = \left(\frac{P_{2010}}{P_{2015}}\right)^{\frac{1}{n}} - 1$$

Where:

P_{2010} = *population in 2010*

P_{2015} = *population in 2015*

GR = annual growth rate (multiply by 100 to get percent growth rate)

n = number of years between two census, in this case n = 5

Using the above equations, the latest average annual growth rate GR for the municipality and its barangays (potential service area) can be determined. If a new census report is released by PSA say for the year 2020, the above formula should be adjusted accordingly.

The future population of the study area up to the design year can be projected using the computed growth rate with the latest census year as the base year. It should be noted, however, that the resulting growth rate should be examined if reasonable and realistic to be applied moving forward. These should be compared with projections, if any, from the Provincial and Municipal Planning and Development Offices. Adjustments on the computed GRs should be made as considered necessary.

After projecting the total population, the actual population to be served must be established as well. Determining the actual users involves but is not limited to the following activities:

- Delineation of proposed service area (determining where the pipes shall be laid);
- Assessment of the level of acceptance of the water supply

[3] *Areas with pipes*

[4] *As of December 2018, the available census data are for years 2010 and 2015.*

project by the residents. This would typically entail a market survey, in which the respondents shall be asked questions if they are willing to avail of the service, and how much they are willing to pay per month for a Level II or a Level III service.

The percentage of those willing to connect to the system could be adopted as the initial served population for the initial year of operation. From then on, the served population percentage will gradually increase depending on the judgement of the water supply planner based on existing socio-economic conditions and projected study area activities.

2.4 Total Water Demand

The total water demand of a study area is made up of various kind of uses – domestic, commercial institutional, and/or industrial. Considerations for unit consumptions and other demand parameters are discussed in the succeeding sections.

2.4.1 Unit Consumption

The unit consumption per water use discussed below can be employed in the total water demand estimation if no definitive data are available.

Domestic Demand

Unit consumption for domestic water demand is expressed in per capita consumption per day. The commonly used unit is liters per capita per day (lpcd). The unit consumption assumptions recommended for Level II and Level III domestic usages are as follows:

- Level II Public Faucets (rural areas): 50 – 60 lpcd (each public faucet should serve 4-6 HHs);
- Level III House Connection (rural areas): 80 – 100 lpcd
- Level III House Connection (urban areas): 100 – 150 lpcd

Institutional, Commercial, and Industrial Demand

Rural Areas:

Public schools and health centers in the area shall be considered as institutional connections. Commercial establishments can also be assumed to be served within the initial 5-year design period. The unit consumptions of institutional and commercial connections are, in terms of daily consumption per connection, usually expressed in cubic meters per day (m^3/d). For rural areas, the values to be used are as follows:

- Institutional Connections: 1.0 m^3/d;
- Commercial Connections: 0.8 m^3/d

This unit consumption can be assumed to be constant during the design period under consideration, unless available information indicates otherwise.

Urban Areas:

Experience shows that there is a relation between the level of commercial and industrial activities and the service area population. These ratios vary from a minimum level of 0.3 commercial and industrial connections per 100 inhabitants to a maximum level of 1.2 connections per 100 inhabitants with the more developed cities having higher levels of connection density. For commercial connections, a unit consumption of 1.5 – 3.0 m3/d may be used for urban areas.

For proposed industrial areas, a unit consumption of 1 to 3 liters per second per hectare (85-260 m^3 per day per hectare) depending on the nature and pattern of industrial growth in the area will be assumed.

2.4.2 Total Consumption

The sum of the above water uses will comprise the total water consumption of the service area. This number will then be used to estimate the unaccounted-for-water to include allowance for system losses.

2.4.3 Unaccounted-for-Water / Non-Revenue Water (NRW)

Non-revenue water is the amount of water that is produced but not billed as a result of losses due to leaks, pilferages, free water, utility usages, etc. Giving allowance to NRW ensures that the design source capacity is sufficient to supply the total required consumption of consumers.

An allowance of 15% of the total consumption (start of operation) up to 20% (end of a 10-year design period) may be assumed to estimate the NRW of a new system.

2.4.4 Total Water Demand

The total water demand is the summation of the total consumption and the allowance for NRW expressed in $m^{3/}$day or lps. Computing for the total water demand can use the following equation. Note that NRW is in percentage and the unit of the total consumption (either $m^{3/}$day or lps) dictates the unit of the total water demand.

$$Total\ Water\ Demand = \frac{Total\ Consumption}{(1 - NRW)}$$

2.5 Demand Variations

The total water demand is considered as the average day demand (ADD) of the service area. But actual water demand fluctuates within the day and the year. As such, demand variations are considered in the design to ensure that sufficient water is being delivered to the consumers.

Four demand variations are considered and estimated as a factor of the ADD. Its various uses are also shown in the table below.

Demand Parameter	Demand Factor	Use
Minimum day demand	0.3 x ADD	The pipe network system is analyzed under a minimum demand condition to check on possible occurrence of excessive static pressures that the system might not be able to withstand. No point in the transmission and distribution system should be subjected to pressure more than 70 m.
Average day demand (ADD)	1.0 x ADD	Annual estimates and projections on production, revenues, non-revenue water, power costs, and other O&M costs are based on the average day demand.
Maximum day demand	1.3 x ADD	The total capacity of all existing and future water sources should be capable of supplying at least the projected maximum day demand at any year during the design period. The design of treatment plants, pump capacity and pipelines considers the maximum day demand supply rate as an option in the optimization analysis.
Peak hour demand	2.5 x ADD (> 1,000 connections) 3.0 x ADD (< 1,000 connections)	The pipeline network should be designed to operate with no point in the system having pressure below 3 meters during peak hour conditions. If there is no reservoir, the power ratings of pumping stations should be sufficient for the operation of the facilities during peak hour demands.

Water Source Selection and Development

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The development of a water source is an essential element of a water supply system. Selection of water sources for water supply must be primarily based on adequacy and reliability. Without these, the system would not be viable.

Aside from adequacy and reliability, other considerations in selecting sources include quality, development cost, legality, and politics. Also, selected sources should be adequate enough to supply the existing and future water demand of the service area without risking the resource's sustainability and its ability to provide the needs of future users beyond the design horizon.

Typical sources of water supply include groundwater and surface water sources. Succeeding sections shall give an overview of these.

3.1 Water Resources

Typical sources of water supply include groundwater and surface water sources.

3.1.1 Groundwater

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. The upper surface of groundwater is the water table. Groundwater is often clear, free from organic matter and bacteria due to the filtering effect of soil on water percolating through it. It also contains minerals dissolved from the soil.

Because of its storage/location, groundwater is often better in quality than surface waters, and less expensive to develop for use. Most rural and small water supply systems use groundwater as their source. However, in highly urbanized areas where water demand is much higher, the use of surface water source is recommended due to its quantity and sustainability with regard to long term use. The use of surface water sources in these areas also aids in the prevention of over-pumping groundwater sources to accommodate high demand. This also reduces the risks of saline water intrusion, water table degradation, and land subsidence.

Types of groundwater sources include:

- Spring – is a point where groundwater flows out of the ground, and is thus where the aquifer surface meets the ground surface. A spring may be ephemeral (intermittent) or perennial (continuous).
- Well – is a hole constructed by any method such as digging, driving, boring, or drilling for the purpose of withdrawing water from underground aquifers. Wells can vary greatly in depth, water volume and water quality. Well water typically contains more minerals in solution than surface water and may require treatment to soften the water by removing minerals such as arsenic, iron and manganese.

3.1.2 Surface Water

Surface water includes lakes, rivers, and spring streamflow. The use of river water in water supply depends mostly on regime, discharge, water quality, solid load, turbidity, and the distance of the river intakes from the service area.

It must be noted that rivers and lakes are highly vulnerable to pollution, and the quality of surface water is determined by the amount of pollutants and contaminants picked up by the water in the course of its travel up to the point of extraction. This means that employing surface water sources for water supply shall require considerable and costly treatment processes. The system shall also require specific expertise in operating and maintaining appropriate treatment facilities. This renders the system more expensive to develop and operate than traditional groundwater-sourced water supply systems. Hence, for the project to be viable, the use of surface water supply system is mostly recommended for urban areas that would entail many connections and high water consumption. The resulting water sales shall rationally recover the capital and operation costs of the system.

3.2 Water Quality

"Water quality" is a measure of how good the water is, in terms of supporting beneficial uses or meeting its environmental values. Potable water is water suitable for drinking and cooking purposes. Potability considers both the safety of water in terms of health, and its acceptability to the consumer – usually in terms of taste, odor, color, and other sensible qualities.

In the selection of a water source, the quality of raw water must be considered. A source which requires a minimum amount of treatment is preferable to one which requires the installation of sophisticated treatment plants. Water quality tests of potential sources must be conducted through representative samples.

Samples from the potential surface and groundwater sources should be collected and analyzed for several quality parameters. These include the following:

Critical Parameters:	1. Microbiological (Total Coliform, Fecal Coliform)	8. Turbidity
	2. Arsenic	9. Iron
	3. Cadmium	10. pH
	4. Lead	11. Manganese
	5. Nitrate	12. Chloride
	6. Benzene	13. Sulfate
	7. Color	14.Total Dissolved Solids (TDS)
Other Parameters:	1.Temperature	6. Sulfide
	2. Biological Oxygen Demand	7. Dissolved Silica
	3. Ammonia as NH3-N	8. Total Mercury
	4.Total Hardness	9. Pesticides
	5. Chromium	

The results of the quality tests shall be the basis of the treatment processes required to make water safe and potable and in accordance with the standards set by the Philippine National Standards for Drinking Water (PNSDW) of 2017.

3.3 Water Source Development

3.3.1 Surface Water

Employing surface water as a water supply source would require in-depth analysis and assessment to determine the dependable quantity that could be extracted all year long. Evaluation of adequacy of a surface water source and the design measures involved in its development are complex and would require technical expertise. Perennial stream sources must be studied to determine minimum flows expected and frequency of occurrence.

Hydrologic investigations are required to determine: a) streamflow yield; b) reservoir yield; c) water requirements; d) maximum and minimum flows; e) surface water/ ground water interrelations; and f) sediment load of water.

The flow of any stream is determined by the climate with special reference to precipitation and the physical characteristic or physiographic factors of the catchment area.

Water supply systems usually design its facilities, service area, and operations based on the dependable flow of the river (occurring 80% of the time) to as low as the minimum flow (occurring 100% of the time). This ensures design flow shall always be reliable and could be delivered to consumers at all times.

3.3.2 Groundwater

Tapping groundwater sources for water supply may be explored in two ways – spring and well development. As with surface water, extensive studies and assessment shall have to be done to determine the dependable and allowable extraction from the selected groundwater sources.

Spring

Ideally, flows of potential spring water sources should be measured monthly for a year to determine the spring's design yield. Hydrogeologic study of the spring's surrounding area and catchment is also in order.

To obtain satisfactory water, it is necessary to find the properly develop the source (i.e. enlarging the spring eye to increase yield quantity and constructing a spring box around it to protect from contamination), eliminate surface water intrusion, and prevent animals from gaining access to the spring. There should also be no immediate upstream settlements, as these would pose the risk of biological contamination.

Well

A well is a hole which has been dug, bored, driven or drilled beneath the ground for the purpose of extracting ground water. Wells can be classified into three:

- Shallow wells – well with a depth less than 20 meters; Shallow wells tap the upper water-bearing layer underground that usually has limited safe yield due to its great dependence on seasonal rainfalls. Therefore, the supply capacity of shallow wells could be unreliable and sometimes intermittent. Also, the water extracted from the upper strata is usually more affected by contamination since the aquifer being tapped is near the ground surface where possible sources of contamination abound. Protection against contamination is therefore one of the main considerations in constructing a shallow well.
- Deep wells – wells over 20 meters deep that tap the deeper unconfined aquifer; A deep well is less susceptible to surface contamination because of the deeper aquifer. Also, its yield tends to be more reliable since it is less affected by seasonal precipitation.
- Artesian wells – wells like the deep wells except that the water extracted is from a confined aquifer. The confining impermeable layers are

above and below the aquifer. Groundwater recharge enters the aquifer through permeable layers at high elevations causing the confined groundwater at the lower elevations to be under pressure. In some cases, the hydraulic pressure of the aquifer is sufficient for a well to flow freely at the well head.

Identification of a potential well site is usually determined by the assessment of the study area's hydro-geological conditions which will indicate the viable sites for well exploration in terms of capacity and water quality. Hydro-geological studies are conducted by knowledgeable professionals or drillers, who assess available information on existing wells. These examine well data such as water quality, well yield, seasonal fluctuations, water table depth, and well drilling logs showing geologic layers. A geo-resistivity survey of the areas being considered for possible well sites will indicate the depth and thickness of aquifers.

For shallow ground water wells, they should be located at certain distance from any pollutant source such as toilets, pig or livestock farms, fertilizer-intensive farms, and the like. They should also be away from big trees whose root systems may affect the stability of the well.

Other important factors to be considered in the selection of a drilled well site include: a) proximity to the planned service; b) local hydrogeological conditions; c) right-of-way and site ownership issues; d) distance/ security from potential sources of surface contamination; e) proximity to existing electric power lines; and f) terrain and ground slope of the site.

A survey of existing wells in the proposed area should also be conducted to determine: a) typical yields and water quality; b) depths and which aquifer to tap; and c) prior drilling success rates.

For selected well sites, the following shall also be done to determine its suitability as a source:

- Pumping (Safe Yield) Test - The well's safe yield can be roughly determined by operating a test pump with capacity at least equal to the system peak demand and operating it for 24 to 48 hours. After 24 hours pumping, the drawdown should be measured at several time intervals to determine if it has stabilized. The pumping rate at a stabilized pumping water level is the so called maximum pumping level and the safe yield is about 60 - 80% of the figure.
- Water Quality Test - This is done to determine if the physical and chemical characteristics of the groundwater meet the parameters set by the PNSDW.

3.4 Water Treatment

Water treatment ensures that the quality of the water to be supplied to the consumers is within acceptable standards. The cost and complexity of treatment facilities to be used for a water supply system depend on the quality of raw water being extracted.

3.4.1 Groundwater Sources

Groundwater usually has better quality than surface water due to its subsurface location. The most common type of water quality problems of groundwater sources, especially wells, is the excessive amount of iron and manganese in the raw water.

When water supply is tapped from a good quality aquifer, there will no need for a treatment process, except for disinfection prior to water distribution.

3.4.2 Surface Water Sources

Surface runoffs bring turbidity, organic matter, pathogenic organisms, and other pollutants. As such, the ideal treatment method for a surface water source depends on the impurities that are expected to contaminate the water.

For surface water source, a conventional treatment process may be used. Conventional treatment is often preceded by pre-sedimentation to remove/reduce sediment load of raw water. Other various processes involved include:

Coagulation. In coagulation, a positively charged coagulant (usually an aluminum or iron salt) is added to raw water and mixed in the rapid mix chamber. The coagulant alters or destabilizes negatively charged particulate, dissolved, and colloidal contaminants.

Flocculation. During flocculation, gentle mixing accelerates the rate of particle collision, and the destabilized particles are further aggregated and enmeshed into larger precipitates.

Clarification. Following flocculation, agglomerated particles enter the clarification unit where they are removed by sedimentation by gravity or are floated and skimmed from the surface of the clarification unit.

Filtration. In the sedimentation processes, the majority of the solids are removed by gravitational settling; particles that do not settle and are still suspended are removed during the filtration process. During filtration, the majority of suspended particles are removed in the top portion of the filter media. Filters are backwashed to dislodge and remove particles trapped within the filter bed, to reduce head loss (pressure build up), and to keep the filter media clean.

Disinfection. Lastly, water is dosed with chlorine for disinfection before it could be delivered/supplied to the service area.

4 Water Supply System Components

After source development and treatment, treated water can be delivered for use to the service area which would require other water supply components and facilities. Overview and considerations in the planning of these components are discussed below. Design and construction, on the other hand, must be done by technical, design, and construction consultants.

4.1 Storage Facilities

Reservoirs and/or storage facilities are important in a system mainly to: a) balance the supply and demand considering variations that may be 3 times the ADD; and b) provide and maintain adequate pressure in the system. It could be elevated or ground-level, but its location must be primarily considered for its significance elevation over the service area.

As a rule of thumb, the storage volume should be at least equal to one-fourth (25%) of average day demand of the community.

4.2 Pipelines and Appurtenances

Transmission and distribution systems vary in size and complexity but they all have the same basic purpose, which is to deliver water from the source(s) to the customers.

Various pipelines include:

- Transmission mains connect a distant water source to the balancing storage reservoir. They are characterized by a fairly constant flow throughout the day. In some cases, the most economical solution is to connect the transmission main directly to the distribution system and to supply excess water to the storage reservoir.
- Distribution pipes carry the water from the balancing storage reservoir and/or from the transmission mains to the consumers' service connections and to the hydrant. Flow and pressure may be controlled through operation of faucets and hydrants.
- The primary distribution system (or distribution mains) comprises the part of the distribution pipes which form the main grid. They are considered in hydraulic network analysis.

Water can be transported to the consumers through one of each following methods:

- Through gravity flow – the ideal set-up when the location of the water source is at a considerably higher elevation than the area to be served. This system has low operation costs, as it does not have energy (pumping) requirements.
- Through pumping with storage – Water is either (a) pumped to a distribution pipe network, then to consumers, with excess water going to a storage tank, or (b) pumped to a

storage tank first, then water is distributed by gravity from the tank to the consumers. The maintenance and operation cost of this system is higher than a gravity system.

- Through direct pumping to the distribution system: In this system, water is pumped directly from the source to the distribution system to the consumers.

The distribution pipelines must be designed to handle the peak hour demand of the system. Other design criteria to be considered are the following:

1. Minimum pressure at the remotest end of the system = 3 m
2. Maximum velocity of flow in pipes
   a. Transmission Line = 3.0 m/s
   b. Distribution Line = 1.5 m/s
3. Minimum velocity of flow in pipes = 0.40 m/s
4. Demand Factor: varies from 0.3 (minimum demand) to 3.0 (peak-demand)
5. Allowable head loss: minimum = 0.50 m/1,000 m, maximum = 10 m/1,000 m
6. Allowable pressure: minimum = 3 m, maximum = 70 m

4.3 Pumping Facilities

Costly facilities and operating problems may be eliminated or reduced if supply could be conveyed to the distribution system by gravity. In most systems, however, the supply must be pumped into the distribution system.

Pumps are devices used to transferring water (or other liquids) from point A to point B with pressure to overcome the resistance along its path (in this case, it would be the total head due to elevation difference and conveyance losses).

In the design of pumping stations, it is necessary to determine the a) most suitable location; b) best source of power; c) conditions of operation; and d) most appropriate type of pump.

5 Development Costs Estimation

For general planning purposes, water supply system development costs may be stated using the infrastructure unit cost per household derived for the PWSSMP. The table below shows the derived unit cost per household per water level of service specified per region. Derivation methodology of these costs is found in Annex D.

Summarized Regional Unit Development Costs for Water Supply

Region	Development Costs Per Household (in PhP)			
	Level I	Level II	Level III Low	Level III High
NCR (Base Costs)	8,400	18,700	28,600	31,800
CAR	8,200	18,200	27,900	31,000
1	8,400	18,800	28,800	32,000
2	8,300	18,400	28,200	31,300
3	8,400	18,600	28,500	31,700
4-A	9,100	20,300	31,200	34,600
4-B	8,900	19,900	30,400	33,800
5	8,800	19,600	30,000	33,300
6	9,000	20,100	30,800	34,300
7	8,800	19,600	30,000	33,300
8	8,700	19,500	29,800	33,100
9	9,100	20,200	31,000	34,500
10	9,300	20,700	31,700	35,200
11	8,600	19,100	29,200	32,500
12	9,400	21,000	32,200	35,800
CARAGA	9,900	22,000	33,800	37,500
ARMM	9,400	21,000	32,200	35,800

Using these unit costs may be employed to estimate the preliminary total development costs of a proposed water supply system. This shall still be subject for updating, however, when the in-depth feasibility studies and detailed design works are conducted.

References

1. Water Partnership Program. (2012, February). Rural Water Supply: Design Manual, Volume 1. WSP.
2. National Water Resources Council. (1979, March). Rural Water Supply: Design Manual, Volume 1. NWRC.
3. Local Water Utilities Administration. (2006, May). Water Supply Feasibility Study and Methodology Manual. LWUA
4. Web Source: https://iaspub.epa.gov/tdb/pages/treatment/treatmentOverview.do

Planning for Sanitation Systems

Part 2

1 Sanitation Planning Framework

1.1 Legal and Regulatory Framework

Sanitation is addressed by several laws and policies provided by the Philippine Constitution which includes the Local Water District Law, Local Government Code, Sanitation Code and Philippine Clean Water Act.

1.1.1 Local Water District Law of 1973 (Presidential Decree 198)[5]

Presidential Decree 198 established the framework on the formation of water districts to provide services on both water and sanitation, as well as the creation of Local Water Utilities Administration (LWUA), which will observe and regulate its activities.

Title II or Local Water District Law necessitates water districts to "provide, maintain, and operate wastewater collection, treatment and disposal facilities", *(Chapter 2, Section 5)*.

Title III or Local Water Utilities Administration Law is required to "establish standards as well the monitoring and evaluation, provide technical assistance, effect system integration and serve as a specialized lending institutions for the local water utilities" *(Chapter 2, Section 49)*.

The following functions/powers of a water district are provided in the Local Water District Law:

- *Section 27* – "purchase, construct, or otherwise acquire works, water, water rights, land, rights and privileges useful or necessary to convey, supply, store, collect, treat, dispose of or make other use of water for any purpose".
- *Section 29* – "require, construct, operate and furnish facilities and services, within or without the district, for the collection, treatment and disposal of sewerage, waste, and storm water"
- *Section 30* – "the right is hereby granted to locate, construct and maintain works of the district on any land which is now, or hereafter may be, owned by the Government of the Philippines or by any of its political subdivisions, and/or instrumentalities"
- *Section 32* – "may commence, maintain, intervene in, defend and compromise actions, and proceedings to prevent interference with or deterioration of water quality or the natural flow of any surface, stream or ground water supply which may be used or useful for any purpose of the district or be a common benefit to the lands or its inhabitants".
- *Section 38* – "may prescribe and collect rates and other charges for sewer services furnished, or fix, levy and collect a sewerage and waste-water service stand-by or availability charge in the event sewer service is available and no connection is made".
- *Section 40* – "shall have the power to establish by resolution of the board of directors the area to be benefited from such facilities. After a hearing and upon notice to all parties affected, the district may levy and

[5] *Source: https://www.lawphil.net/statutes/presdecs/pd1973/pd_198_1973.html*

collect assessment, or stand-by charges based upon available capacities or upon selected characteristics of property benefited by said improvements, as determined by the board".

1.1.2 Local Government Code of 191 (Republic Act 7160)[6]

The Local Government Code enables the improvement of local government units' (LGUs) capabilities to fully achieve their potential in terms of development by providing them with opportunities to participate actively in the implementation of national programs and projects (item g); share with the national government the responsibility in the management and maintenance of ecological balance within their territorial jurisdiction (item i); and participation of the private sector in local governance, particularly in the delivery of basic services (item l).

Under *Section 17*, LGUs are required to provide basic services and facilities;

- For Barangay, provide services and facilities related to general hygiene and sanitation, beautification, and solid waste collection (item iii).
- For Municipality, provide solid waste disposal system or environmental management system and services or facilities related to general hygiene and sanitation (item vi); and infrastructure facilities intended primarily to service the needs of the residents of the municipality and which are funded out of municipal funds including drainage and sewerage systems (item viii).
- For province, infrastructure facilities intended to service the needs of the residents of the province and which are funded out of provincial funds including inter-municipal waterworks, drainage and sewerage system (item vii).

1.1.3 Philippine Clean Water Act of 2004 (Republic Act No. 9275)[7]

The Philippine Clean Water Act of 2004 was enacted to "pursue a policy of economic growth in a manner consistent with the protection, preservation and revival of the quality of our fresh, brackish and marine waters (*Section 2*)", through a national program on sewerage and septage management by directing LGUs to 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; and 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 (*Section 7*)". The act also requires the agency to "to provide water supply and sewerage facilities in highly urbanized cities (HUCs), in coordination with LGUs, to connect the existing sewage line found in all subdivisions, condominiums and commercial centers, among other establishments, to available sewerage system, subject to sewerage services charge/fees (*Section 8*)".

In addition, "…areas not considered as HUCs, the DPWH in coordination with the Department, DOH and other concerned agencies, shall employ septage or combined sewerage-septage management system".

1.1.4 Code on Sanitation of the Philippines (Presidential Decree 856)[8]

The Code of Sanitation of the Philippines was signed to address the importance of the public's health through proper sanitation. On Chapter XVII (Sewage Collection and Disposal, Excreta Disposal and Drainage), which served as the guiding principles for the establishment of sewerage and septage management programs. It shows the requirements in the operation of sewage treatment works and sewage treatment plants, septic tanks, disposal of septic tank effluent, determination of septic tank capacity, sanitary privies and drainage.

[6] Source: https://www.officialgazette.gov.ph/1991/10/10/republic-act-no-7160/
[7] Source: https://www.lawphil.net/statutes/repacts/ra2004/ra_9275_2004.html
[8] Source: https://www.lawphil.net/statutes/presdecs/pd1975/pd_856_1975.html

1.2 Specific Rules and Regulations

Specific rules and regulations governing the operation of septage management programs are the following:

- Section 6 of the IRR of Republic Act No. 9275, states that “in the case of HUCs, non-HUCs and LGUs where water districts, water utilities and LGU waterworks have already been constituted and operational, the water supply utility provider shall be responsible for the sewerage facilities and the main lines pursuant to Presidential Decree No. 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.”
- Specific provisions of the IRR of the Code on Sanitation that shall be enforced by the Regional Offices of DOH and by the City/Municipal Health Offices include:
    - Untreated sewage and effluent of septic tank or other putrescible or offensive wastes shall not be discharged into the surface of the ground or into any street, road, alley, open excavation, storm water sewer, land drain ditch, adjoining property, watercourse or body of water (Section 3.2.3).
    - Septic tanks shall be cleaned before excessive sludge or scum is allowed to accumulate and seriously reduce the settling efficiency and shall be inspected at least once a year. Sludge from septic tanks shall be disposed of by burial or by any other method approved by DOH and not by being emptied into open field, ditches or bodies of water (Section 4.1.7).
- DENR Administrative Order No. 1990-35 (Revised Effluent Regulations), implemented by the Environmental Management Bureau (EMB) Regional Offices, provides the discharge limits of regulated water pollutants for compliance of various wastewater and septage treatment plants. The effluent standards prescribe the limits on conventional pollutants such as organic content, suspended solids, nutrients, heavy metals as well as pathogenic microorganisms associated with sewage and septage.

DENR Administrative Order 2003-30, likewise, implemented by the

EMB Regional Offices, is the IRR for the Philippine Environmental Impact Statement System established under Presidential Decree No. 1586. It presents the detailed guidelines in securing environmental compliance certificate for various projects including septage management facilities under the Philippine Environmental Impact Assessment system.

1.3 Applicable Regulatory Standards

The DOH Operations Manual on the Rules and Regulations Governing Septage Management (2008) prescribed standards for septage handling, treatment and disposal. Specific standards were provided for the disposal of treated septage via land application for agricultural purposes. These standards refer to the chemical and microbiological composition of treated septage or bio-solids for them to be considered as compost or soil conditioners. These are shown in Tables 1 to 3 (adopted from DOH Septage Operation Manual, 2008). For agricultural applications, the treated bio-solids must meet these criteria before it can be applied in land as a soil conditioner.

Table 1: Recommended Specifications for Compost and Fertilizers[9]

Parameter	Plain Organic Fertilizer	Compost or Soil Conditioner	Fortified Organic Fertiizer
Total NPK	5-7%	3-4%	Min. 8%
C:N	12:1	12:1	12:1
Moisture Content	≤ 35%	≤ 35%	≤ 35%
Organic Matter	≥ 20%	≥ 20%	≥ 20%

NPK – Nitrogen, Phosphorus and Potassium; C:N – Carbon to Nitrogen Ration

Table 2: Limits on Heavy Metals Concentrations in Compost and Fertilizers

Parameter	Dry Weight Concentration, mg/kg
Zinc (Zn)	1,000
Lead (Pb)	750
Copper (Cu)	300
Chromium (Cr)	150
Nickel (Ni)	50
Mercury (Hg)	5
Cadmium (Cd)	5

[9] *Source: DOH Operational Manual for IRR on Septage, 2008*

For effluent standards, the limits are dictated by the DENR Administrative Order 2016-08 which the treatment should meet. The limits would also depend on the classification of the receiving body of water (Refer to DAO 2016-08 for river classification).

Table 3: Test for Pathogens for Compost and Fertilizers

Parameter	Limit
Fecal Streptococci	< 5 x 103/g compost
Fecal Coliforms	< 5 x 102/g compost
Salmonella	0
Infective Parasitic	0

Table 4: Water Quality Guidelines for Primary Parameters[10]

Parameter	Unit	Water Body Classification								
		AA	A	B	C	D	SA	SB	SC	SD
BOD_5	mg/L	1	3	5	7	15	n/a	n/a	n/a	n/a
Chloride	mg/L	250	250	250	350	400	n/a	n/a	n/a	n/a
Color	TCU	5	50	50	75	150	5	50	75	150
Dissolved Oxygen (min.)	mg/L	5	5	5	5	2	6	6	5	2
Fecal Coliform	MPN/100mL	<1.1	<1.1	100	200	400	<1.1	100	200	400
Nitrate as NO_3-N	mg/L	7	7	7	7	15	10	10	10	15
pH (range)		6.5-8.5	6.5-8.5	6.5-8.5	6.5-9.0	6.0-9.0	7.0-8.5	7.0-8.5	6.5-8.5	6.0-9.0
Phosphate	mg/L	<0.003	0.5	0.5	0.5	5	0.1	0.5	0.5	5
Temperature	°C	26-30	26-30	26-30	25-31	25-32	26-30	26-30	25-31	25-32
Total Suspended Solids	mg/L	25	50	65	80	110	25	50	80	110

1.4 Considerations for Sanitation Improvement

1.4.1 Health and Sanitation

The main purpose of sanitation projects is to prevent the spread of diseases from the human wastes that are discharge to the environment improperly. Inadequate sanitation facilities led to release of raw sewage drainage systems or directly to the ground without primary treatment. These wastes should be properly managed and handled to avoid spreading of water-borne diseases through pipe infiltration and groundwater contamination.

1.4.2 Environmental Protection

As stipulated in the Clean Water Act of 2004, prevention of pollution to the receiving water bodies should be maintained and controlled. Untreated sewage being discharged or not properly treated will have adverse impact both health and environment. This would lead to deterioration of our rivers and would greatly affect the neighboring municipalities.

1.4.3 Septic Tanks

Septic tanks are water-sealed containment with at least 2 chamber and lined-bottom which acts as the primary treatment for sewage before discharging to a sewerage system or being desludged. Septic tanks should also be accessible and available for maintenance, especially during desludging. Desludging, as required by DOH, prescribed a frequency of at least once every 3-5 years.

[10] Source: DAO 2016-08: Water Quality Guidelines and General Effluent Standards of 2016

1.5 Support Sanitation Strategies

1.5.1 Appropriate Laws

The local government units (LGUs) should pass a law and implement a city ordinance pertaining to the obligation of all households to have their septic tanks be desludged on a regular basis, as required by the DOH.

1.5.2 Fee Collection Mechanisms

The local government units (LGUs) should explore the possible cost recovery mechanisms to be able to support the operation and maintenance of the facility and to have sanitation projects more sustainable.

1.5.3 Advocacies and Awareness towards Improved Sanitation

Continuing programs that raise awareness through different sanitation programs such as Zero Open Defecation Program (ZOD Program), Behavior Change Communication and others. This should also extends up to the introduction of septage management program in their respective areas and ultimately up to the level of sewerage systems.

2 Clustering

As stated in the National Sewerage and Septage Management Program (NSSMP) Framework which emanated from the Clean Water Act of 2004, it is specified that;

- By 2020, all LGUs have developed septage management systems and the 17 highly urbanized cities (HUCs) have developed sewerage systems.
- By 2020, approximately 43.6 million people have access to septage treatment facilities and about 3.2 million will have access to sewerage treatment facilities.
- By 2020, PhP26.3 billion has been invested in sanitation improvement projects.
- By 2020, about 346 million kilograms of BOD is diverted from the environment per year as a result of the sewerage and septage management projects.

With this, LGUs are required to develop septage management and sewerage systems to comply with this national law, however, putting up a treatment facility as part of the program requires a sizeable investment. This is the reason why clustering of local government units is recommended as an approach.

Clustering of LGUs is a strategy that requires a number of adjacent LGUs to invest on a shared facility to address their common need to address an issue say wastewater management and the implementation of a septage management program. With this approach, the investment cost of the program will be divided among the LGUs who have agreed to be included in the cluster.

The regional consultations conducted for the formulation of the PWSSMP have already identified these LGU clusters per province. Information regarding this shall be found in Volume II of the PWSSMP: Philippine Water Supply and Sanitation Databook and Regional Roadmaps.

Septage Volume Projections

3

3.1 Service Delineation

Determining the service area to be covered of a septage management project is the first step to planning sanitation systems. The service area could be several barangays, an entire LGU, or a cluster of several LGUs.

3.2 Population Projections

Similar to what is being done in planning for water supply systems, information on the existing and future population within the service area shall be determined. The methodology in population projection for water supply planning may be adopted for sanitation system planning as well.

3.3 Septage Volume Projections

Septage generation varies depending on weather and geography, as well as household habits and attitudes. Listed in Table 5 are some of the approaches used to estimate the septage generation.

Table 5: Approaches in Septage Volume Projection

Approach	Description
Actual Data	the most accurate approach by taking into account the variations in septage generation data based from local septage haulers, treatment plants receiving septage and other sources
Typical tank volume/pump out frequency	estimates the number of septic tanks and assume an average tank volume and pump out frequency
Per capita generation	the least accurate approach assumes a per capita generation rate (ex. 190 to 270 li/capita/yr)

From Table 5, the most accurate data tends to be the most difficult data to acquire or with high probability of no available data, considering that most of the septage haulers are operating under the radar. Inventory of septic tanks can also be used as basis, however, most data regarding household septic tanks are not accurate and need to be verified through a baseline survey. For the purposes of planning, the projection of the daily average septage volume will be the product of typical tank capacity and pump-out frequency and using a desludging cycle of 5 years.

3.3.1 Basic Assumptions

The projections are based on the following assumptions:

- Projected Number of Septic Tanks

The initial figures can be taken from the available data on households that have individual septic tanks and those which conform to the standard design set by the National Building Code and DOH Guidelines, which is based on an actual survey by either LGU or the water service provider within the coverage area. While the projected number may be set according to the percent increase in household population over time. The coverage will have to consider both those that are connected to the established water supply system and those that are not.

- Accessibility

Not all households would have septic tanks that are accessible. This is due mainly on too narrow access roads and improper location of septic tank manholes. This figure can be assumed as a percentage of existing septic tanks or can use an actual figure if a comprehensive survey of existing septic tanks was done. This figure can also be projected to increase or decrease over time depending on current trends in the service area.

- Average Septage Volume of Septic Tanks

The prescribed average volume of septage collected from a residential unit is 2.50m3 per septic tank and 4.00m3 per septic tank for commercial units.

- Desludging Frequency

The "DOH Operations Manual on the Rules and Regulations Governing Domestic Sludge and Septage (2008)" suggests that septic tank should be desludged when already half-full or every three to five years whichever comes first. The decision on the desludging frequency will have bearing on the investment requirement for the STP and number of desludging trucks.

- Operational Days per Year

The number of operational days will be taken from the total number of operational days per week, holidays observed, truck maintenance and downtime and inclement weather conditions. This is usually assumed to be around 230 days a year.

3.3.2 Assumed Septage Volume

Estimating the capacity of the septage treatment system shall need the following information/ assumptions:

Item	Design Parameter	Description	Symbol
1	Assumed number of households (HH) in the coverage area	Total number of HHs within coverage area at the end of the design year horizon (e.g. 5, 10, 25 years)	A
2	Assumed number of commercial/ institutional establishment in the coverage area	Assumed and projected commercial/ institutional connections at the end of the design year	B
3	What percentage of HHs are willing to participate in the septage program?	percent of the homes that are likely to participate	C
4	Of the HHs who are to participate, what percentage have their own septic tanks?	percent of homes that have septic tanks	D
5	Of the HHs who have septic tanks, what percentage is accessible to desludging trucks?	percent of the septic tanks that are desludgeable	E
6	Average volume of residential septic tanks in the target coverage area?	2.5 cubic meters	F
7	Average volume of commercial/ institutional septic tanks in the target coverage area?	2.5 cubic meters	G
8	Target desludging frequency for the septage management program?	5 years	H
9	Target operating days in a week	5 days per week	I

Using the parameters shown above, the design flow of the proposed septage treatment facility is:

$$design\ flow = \frac{A\ x\ C\ x\ D\ x\ E\ x\ \frac{F}{H}}{no.\ of\ operating\ days\ per\ year} + \frac{B\ x\ \frac{G}{H}}{no.\ of\ operating\ days\ per\ year}$$

The design flow shall be expressed in cubic meters per day. The total number of operating days per year may be assumed to be 245 days.

For the estimation of the number of desludging trucks required, the following sample computation can be used as a guide considering the required parameters:

Items	Required	Assumption	Description
1	Capacity of Truck*	5.0 m^3	Assumed volume of truck;
2	Number of Loads Per Day per Truck	2	Computed by dividing truck capacity by average septic tank volume used (i.e. 2.5m3)
3	Estimated drive time to the home or business	0.5 hrs	Assumption, must be estimated depending on the site conditions
4	Estimated time to pump the tank	0.5 hrs	Assumption
5	Estimated drive time from collection site to treatment plant	0.5 hrs	Assumption, must be estimated depending on the site conditions
6	Estimated unloading time at the treatment facility	0.5 hrs	Assumption
7	Estimated drive time to the next home or business	0.5 hrs	Assumption, must be estimated depending on the site conditions
8	Hours of operation per day	10 hrs	Assumption
9	Number of loads per day per truck	4	no.of loads per day per truck = $\frac{\text{Hours of operation per day}}{sum\ of\ estimated\ durations\ in\ Items\ 3\ to\ 7}$
10	Efficiency of trucking operation	85%	Efficiency of the trucking operation. No trucking operation is 100% efficient. Use 80% efficiency for new trucks. Older trucks are less efficient and this can be reflected by lowering the efficiency value.
11	Adjusted loads per day per truck		Computed by: $\frac{\text{Number of loads per day per truck}}{\text{Efficiency of trucking operation}}$

The total number of trucks can now be estimated using the equation below:

$$number\ of\ trucks = design\ flow\ /\ average\ septic\ tank\ volume\ /\ number\ of\ tank\ volumes\ accommodated\ in\ the\ truck\ /\ adjusted\ loads\ per\ day\ per\ truck$$

4 Development of Technical Options

The planning is anchored on the Philippine Water Supply and Sanitation Master Plan (PWSSMP). The target access rates for the cluster for year 2022 and year 2030 should be the same as in the national plan, All LGUs should have at least 97% access to basic sanitation by 2022 and universal access (100%) to safely managed sanitation by 2030.

4.1 Key Considerations

In creating development options, different factors are considered and these items are discussed below:

- *Location of Septage Treatment Facility* – STP shared by a cluster should be within 7-15 km of every LGU involved; it should be accessible through an established road network, in an agricultural or agro-industrial land, in mid-land to low-land and possibly co-located with a sanitary landfill.
- *Septage Collection Area Expansion* – Population will increase as well as buildings and residences, not only being physically expansive or geographically dispersed but also intensively within the service area.
- *Mechanized or Natural Treatment* – in selecting which technology is appropriate in an area, characteristics of the service area, population density, and financial and technical capacity need to be considered. Mechanized systems are usually compact and require very minimal land, however, it entails higher capital and operating expenses. On the other hand, natural systems require relatively large land footprint which would cost more but the operational expenses would be lower because these systems will require lower energy and equipment input. It may require more manpower for maintenance activities, but not necessarily highly skilled.

Table 6: Mechanized and Natural Systems Simplified Comparison Matrix

Parameter	Mechanized System	Natural System
Land Area Requirement	Lower	Higher
Process reliability and consistency of meeting effluent standards	Higher	Higher
Initial capital outlay excluding land	Higher	Lower
Operating, Maintenance and Replacement Requirements	Higher	Lower
Relative Local Experience	Higher	Lower

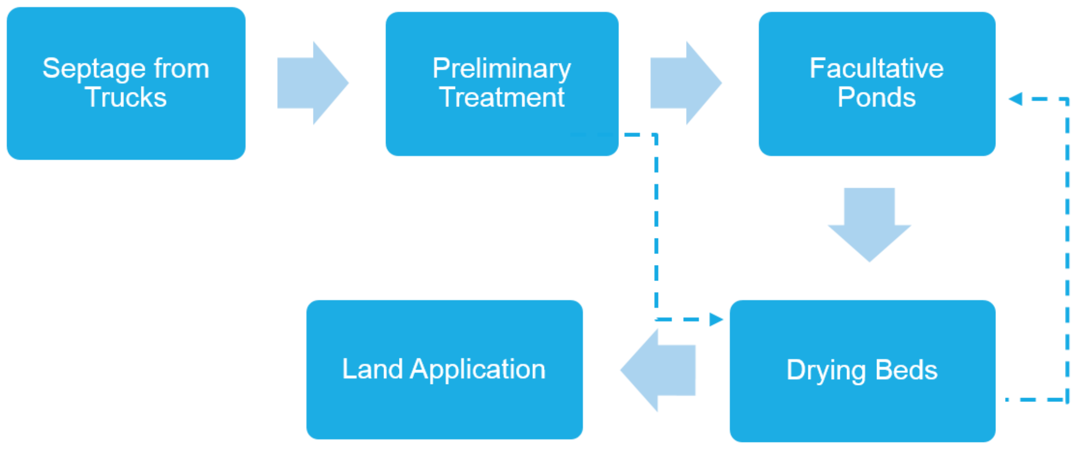
- *Disposal/Re-Use of Residual Biosolids* – Either system will produce biosolids as by-product, which should be properly disposed of or re-used, complying with the existing government regulations. Capital costs related to the management of biosolids like post -treatment equipment, storage facility and hauling trucks should be included.
- *Disposal/Re-use of Treated Effluent* – similar to the biosolids, treated effluent should be managed either through disposal or re-use and must comply with regulatory requirements and the related capital costs included in the final project cost.

4.2 Process Description

For most LGU clusters in the country, the use of natural systems or the low-cost STP technology is suggested because of its economic advantages. Not only does it require very low energy and fuel consumption, the maintenance and operation costs will also be very minimal.

With the low-cost technology or natural system, treatment will start with the removal of non-biodegradable plastic materials from the septage, including grits and sand, then a succession of treatment lagoons may be considered, as shown in the figure below. The drying bed will receive partially dried biosolids from the ponds or pre-treated sludge from first pond or chamber in the case of lime stabilization approach.

Figure 1: General Treatment Process for the Septage Using Low-Cost Alternatives



5 Development Costs

Capital investment costs may be estimated using the per capita unit cost derived from the NSSMP Framework Report and the per cubic meter design flow derived in the formulation of PWSSMP.

The two approaches to determine the project cost are as follows:

1. Population-based computation – that is multiplying projected population with the derived unit cost for septage management
2. Design flow-based computation – that is multiplying the computed daily average design flow with the unit cost for septage management based

In both instances, indirect costs shall be added to the computed direct project cost to arrive at the final total project cost.

5.1 Using per capita unit cost derived from NSSMP

From the annexed Computation of Estimates and Targets[11], the assumed septage treatment project cost per capita (c. May 2011 projected to 2018) are as follows:

- PhP 250 per capita for larger systems
- PhP 270 per capita for medium sized systems
- PhP 330 per capita for smaller systems

The derived unit cost was considered as baseline cost for NCR. In order to have a regionalized cost[12], application of regional factors was considered. Each region is distinct in terms of geographical, economical and accessibility characteristics, labor, material and equipment costs tend to be different to others. The regional factors are multiplied to the NCR base costs to determine the applicable cost for that specific region.

The following table shows the derived unit costs per region per WSS service level:

[11] National Sewerage and Septage Management Program - Annex: Computation of Estimates and Targets
[12] Philippine Water Supply and Sanitation Masterplan – Chapter 5.2.1.1 Unit Development Costs

Table 7: Summarized Regional Unit Development Costs for Sanitation

Region	Improved (Whole System)	Basic	Shared/ Communal/ Limited	Sewerage	Septage
	Php/Capita	Php/Capita	Php/Capita	Php/HH	Php/HH
NCR (Base Costs)	5,300	4,500	5,300	39,500	1,650
CAR	4,950	4,200	4,490	38,530	1,730
1	5,200	4,410	4,720	40,060	1,670
2	5,060	4,300	4,540	38,990	1,630
3	5,170	4,390	4,590	39,490	1,650
4-A	5,850	4,970	5,270	43,840	1,800
4-B	5,610	4,760	5,140	42,720	1,760
5	5,490	4,660	5,040	42,040	1,730
6	5,670	4,820	5,180	43,200	1,780
7	5,480	4,650	4,920	41,740	1,730
8	5,390	4,580	4,960	41,610	1,720
9	5,650	4,790	5,190	43,400	1,790
10	5,830	4,950	5,310	44,380	1,830
11	5,200	4,410	4,680	40,330	1,690
12	5,960	5,060	5,510	45,420	1,860
CARAGA	6,360	5,400	5,890	47,910	1,950
ARMM	5,890	5,000	5,480	45,270	1,860

Employing the adjusted NSSMP unit cost of P330 per capita, the septage cost per HH 1,650 Php considering a 5-person per HH size.

5.2 Using unit cost per design flow

Technology Approach	Description	Per Cubic Meter Cost (Php)
Natural System	Usually includes pond systems which requires large land area	750,000
Mechanized System	Usually includes automated screening, dewatering and biological treatment with automation	1,000,000

Note: Unit cost shown above is direct physical cost and does not include cost for desludging trucks

6 Cost Recovery Mechanisms

The costs related to the septage management program will be distributed to the households included in the coverage area. The costs include capital cost (CAPEX), operation and maintenance cost (OPEX) and financing cost (interest/other financial charges). Charging to the public the "environmental fee" will be the method in recovering these costs. It is also preferred mode than the so-called "desludging fee" because it may confuse those households not having septic tanks and not availing such service. The environmental fee generally means the whole community included in the coverage area will benefit from this fee and will improve the environment.

From the previous Philippine Water Revolving Fund (PWRF) studies, a few septage collection/cost recovery mechanisms were developed and may be adopted for use in the PWSSMP as well.

Model 1 applies to water service provider (WSP) customers while Models 2 – 5 applies to households not connected to water service provider.

6.1 Model 1

The WSP will handle both collection and treatment of the wastewater as well as the collection of the environmental fee which will be included on the monthly bill of customers. This will be a percentage of the water charge.

6.2 Model 2

For this model, the WSP will remain in-control of the operation of septage collection and treatment, however, since not all households are connected to the WSP, collection of fees will be very difficult. With this, the LGU need to step-in and act as a "collection agent" for the environmental fees. The LGU may enter into a MOA with the WSP, allowing them to impose and collect environmental fees from the households through their regular revenue collection mechanisms (e.g., garbage fees, permits, real estate taxes). Depending on the agreement, the LGU may receive a share in the revenues.

In reality, not all households pay real estate taxes and so they will not be charged and low collection is expected. The method of this charging mechanism will only cover landowners and business establishments but not the households that are renting their residences and informal settlers

6.3 Model 3

This model transfers the responsibility of septage collection from the households not connected to the WSP to the LGU and the LGU may look to hire private contractors to do the desludging works. The WSP will then focus mainly on the treatment of the septage collected. Charging of environmental fee will be done same as Model 2. The revenues collected from the environmental fees will go to the LGU which they will pay to the private contractors hired and the WSP will earn revenues from tipping fees paid by either the LGU or the private contractors.

6.4 Model 4

In this model, the LGU as well as the WSP will be relieved from the collection of septage. The collection of septage will be done by a private sector and will charge households of the desludging works by a job order which means there will be no more monthly environmental fees. Fees will be charged per service rendered. The WSP will earn revenue from tipping fees, payment in treating the collected septage, same as Model 3.

6.5 Model 5

Septage collection and treatment will be handled by the water service provider but the desludging works will be charged per job order, or per service rendered, like a private contractor. No more monthly environmental fee will be charged to the households. The WSP may also bargain lower collection fees to those households that are connected to them, compared to those who are not connected, which may cost the same as the private contractor fees. This may encourage households not connected to the WSP to connect to avail lower rates of desludging fees.

Future considerations need to be evaluated in analysing these models, particularly service connections to WSPs. Part of the PWSSMP is an integrated approach on both water and sanitation in producing programs and projects, and so, the number of connections for the WSPs will greatly increase annually which may all lead to Model 1 approach.

Given all these models, it is up to the Northern Iloilo Cluster which of the five (5) models will be more feasible on their area or if another model will be crafted specifically for the cluster, as long as all the concerned stakeholders will have an agreement. Presented below are the details of the recovery mechanisms.

Table 8: Cost Recovery Mechanisms

Type	Model	Service		Cost Recovery	
		Septage Collection	Septage Treatment	Revenue Resources	Collection Mechanism/Agent
WSP Service Area Served Households	1	WSP	WSP	Environmental Fee (to be charged to the household) -Percentage of water charge	WSP monthly water bill
WSP Service Area Served and Unserved Households	2	WSP	WSP	Environmental Fee (to be charged to the household) -Fixed -Instalment	LGU Real estate taxes / business permit/ garbage collection fee WSP (treatment)
	3	LGU Private Desludging Companies	WSP	Environmental Fee (to be charged to the household) -Fixed -Instalment Tipping Fee (to be charged to the LGU or private desludging companies) -By volume, truck size	LGU Real estate taxes / business permit/ garbage collection fee WSP (treatment)
	4	Private Desludging Companies	WSP	Tipping Fee (to be charged to the LGU or private desludging companies) -By volume, truck size	WSP (treatment)
	5	WSP	WSP	Desludging Fee (to be charged to the household) -by volume, truck size	WSP One-time payment upon completion of desludging service

Glossary

Annual Poverty Indicators Survey	A nationwide survey that presents data on the socioeconomic profile of Filipino families, and other information that relates to their living conditions. (Philippine Statistics Authority)
Basic Sanitation Facility	Use of improved facilities which are not shared with other households
Basic Water Facility	Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing
Black Water	Wastewater containing feces or other remnants of sanitary use (UN International Groundwater Resources Assessment Center)
Biological Oxygen Demand	A measure of the amount of oxygen removed (respired) from aquatic environments by aerobic microorganisms either in the water column or in the sediments. (Department of Environment and Natural Resources)
Climate	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. In various chapters in this report different averaging periods, such as a period of 20 years, are also used. (Intergovernmental Panel on Climate Change [IPCC], 2012)
Climate Change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC, 2012)
Cold Days/ Cold Nights	Days where maximum temperature, or nights where minimum temperature falls below the 10th percentile, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period. (IPCC, 2012)
Creditworthy WSPS	Self-sustaining WSPs capable of accessing financing from GFIs and/or PFIs (Local Water Utilities Authority)
Domestic Consumption (Use)	Water used for household purposes such as washing, food preparation and showers . It is the quantity, or quantity per capita, of water consumed in a municipality or district for domestic uses or purposes during a given period. It sometimes encompasses all uses, including the quantity wasted, lost, or otherwise unaccounted for.
Disaster Risk Reduction	Denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard, or vulnerability; and improving resilience. (IPCC, 2012)
Drinking Water	Water intended for human consumption or for use in food preparation.
Effluent	Discharges from a known source passing into a body of water or land, or wastewater flowing out of a manufacturing plant, industrial plant including domestic, commercial and recreational facilities.

Effluent Standard	Any legal restriction or limitation on quantities, rates, and/or concentrations or any combination thereof, of physical, chemical or biological parameters of effluent which a person or point source is allowed to discharge into a body of water or land.
El Niño-Southern Oscillation	A warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of 2 to about 7 years, is collectively known as the El Niño-Southern Oscillation. It is often measured by the surface pressure anomaly difference between Darwin and Tahiti and the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña. (IPCC, 2012)
Environmental Management	A system which includes, but is not limited to, conservation, regulation and minimization of pollution, clean production, waste management, environmental law and policy, environmental education and information, study and mitigation of the environmental impact on human activity, and environmental research.
Flood	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods. (IPCC, 2012)
Governance	The way government is understood has changed in response to social, economic, and technological changes over recent decades. There is a corresponding shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognizing the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of nongovernmental actors, and of civil society. (IPCC, 2012)
Groundwater	Subsurface water in which the pressure is equal to or higher than the local atmospheric pressure. In other words: water below the water table or phreatic level. (UN-International Groundwater Resources Assessment Center)
Integrated Water Resources Management	A process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment.
Landslide	A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure. (IPCC, 2012)
Latrine	A structure, usually consisting of a hole in the ground that is used as a toilet.

Level I Water Source	*Point source;* This service level provides a protected well or a developed spring with an outlet but without a distribution system. Hence, the users go to the source to fetch water. Level I sources are generally adaptable in rural areas where the houses are thinly scattered. These sources serve an average of 15 households within a radius of 250 meters.
Level II Water Source	*Communal faucet system or stand post;* A piped system composed of a source, a reservoir, a piped distribution network, and communal faucets. Each communal or public faucet usually serves four to six households within a radius of 25 meters. Users still go to the supply point (communal faucet) to fetch water. This type of system is generally suitable for rural and urban fringe areas where houses are clustered densely to justify a simple piped system.
Level III Water Source	*Waterworks system;* This system includes a source, a reservoir, a piped distribution network, and individual household taps. It is generally suited for densely populated urban areas where the population can afford individual connections.
Limited Sanitation	Use of improved facilities shared between two or more households.
Limited Water	Drinking water from an improved source where collection time exceeds 30 minutes for a round trip, including queuing.
Millennium Development Goals	Eight international development goals for the poorest people for the year 2015. It was established during the Millenium Summit of the United Nations in 2000. (United Nations Development Programme)
Morbidity Rate	Number of deaths due to a disease divided by the total population. (Department of Health)
Non-Revenue Water	Water that has been produced and is "lost" before it reaches the customer.
Open Defecation	Disposal of human feces in fields, forests, bushes, open bodies of water, beaches or other open spaces or with solid waste.
Public private participation	Contractual arrangements entered into by the government with the private sector.
Runoff	That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water. (IPCC, 2012)
Safely managed Water Facility	Drinking water from an improved water source which is located within premises, available when needed and free from fecal and priority contamination.
Safely managed Sanitation Facility	Use of an improved sanitation facility which is not shared with other households and where excreta are safely disposed in situ or transported and treated off-site.
Sanitation Facilities	On-site facilities such as toilets and septic tanks for safe disposal of human waste.
Sanitation Services	Management of excreta from the facilities used by individuals, through emptying and transport of excreta for treatment and eventual discharge or reuse. (UNICEF/WHO Joint Monitoring Programme)
Sanitation	A wide range of services and arrangements pertaining to the hygienic and proper management of human excreta (feces and urine) and community liquid wastes to safeguard the health of individuals and communities; A process pertaining to preventing diseases by hindering pathogens or disease-causing organisms found in excreta and sewage from entering the environment and coming into contact with people and communities; The construction of adequate handling, collection, treatment, and disposal or reuse facilities and the promotion of proper hygiene behavior, so that facilities are effectively used at all times. (Philippine Sanitation Roadmap)
Septage	The sludge produced in individual onsite wastewater-disposal systems, principally septic tanks and cesspools.

Septage Management	Comprehensive programs for managing septic tanks and the procedures for the desludging, transporting, treating and disposing of septic tank contents.
Sewage	Water-borne human or animal wastes, excluding oil or oil wastes, removed from residences, buildings, institutions, industrial and commercial establishments together with such groundwater, surface water and storm water as maybe present including such waste from vessels, offshore structures, other receptacles intended to receive or retain wastes, or other places (or the combination thereof)
Sewerage	which include, but are not limited to, any system or network of pipelines, ditches, channels, or conduits including pumping stations, lift stations and force mains, service connections including other constructions, devices, and appliances appurtenant thereto, which involves the collection, transport, pumping and treatment of sewage to a point of disposal.
Sludge	Any solid, semi-solid or liquid waste or residue generated from a wastewater treatment plant, water supply treatment plant, or water control pollution facility, or any other such waste having similar characteristics and effects.
Sustainable Development Goals	Also known as Global Goals, which build upon the successes of the Millennium Development Goals. It has 17 goals for year 2030 that call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. (United Nations Development Programme)
Surface Water	Water located on the surface of the Earth, such as in streams, rivers, and lakes. (UN-International Groundwater Resources Assessment Center)
Treatment	Any method, technique, or process designed to alter the physical, chemical or biological and radiological character or composition of any waste or wastewater to reduce or prevent pollution.
Tropical Cyclone	The general term for a strong, cyclonic-scale disturbance that originates over tropical oceans. Distinguished from weaker systems (often named tropical disturbances or depressions) by exceeding a threshold wind speed. A tropical storm is a tropical cyclone with one-minute average surface winds between 18 and 32 m s-1. Beyond 32 m s-1, a tropical cyclone is called a hurricane, typhoon, or cyclone, depending on geographic location. (IPCC, 2012)
Unimproved Drinking Water	Drinking water from an unprotected dug well or unprotected spring.
Unimproved Sanitation Facility	Use of pit latrines without a slab or platform, hanging latrines and bucket latrines.
Vulnerability	Degree of loss to a given element or set of elements at risk resulting from a hazardous phenomenon of a given magnitude.
Warm Days/Warm Nights	Days where maximum temperature, or nights where minimum temperature exceeds the 90th percentile, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period. (IPCC, 2012)
Water Supply	The share of water abstraction which is supplied to users (excluding losses in storage, conveyance and distribution). (Global Water Partnership)
Waste	Any material either solid, liquid, semisolid, contained gas or other forms resulting from industrial, commercial, mining or agricultural operations, or from community and household activities that are devoid of usage and discarded.
Wastewater	Waste in liquid state containing pollutants.
Wastewater Treatment	A process used to convert wastewater into an effluent (outflowing of water to a receiving body of water) that can be returned to the water cycle with minimal impact on the environment or can be directly reused.
Water Pollution	Any alteration of the physical, chemical or biological or radiological properties of a water body resulting in the impairment of its purity or quality.
Water Quality	The characteristics of water which define its use in terms of physical, chemical, biological, bacteriological or radiological characteristics by which the acceptability of water is evaluated.

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