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Proposed Drainage System in Purok 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga

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Abstract:

Barangay Sta. Tereza 2nd is one of the barangays in Lubao, Pampanga. The barangay does not have a drainage system, which is one of the vital structures for a community. One of the proponents travels every day in the Sta. Tereza 2nd area, which often experiences flooding and stagnant water. As an answer to the problem, a drainage system was proposed. The topography was obtained through a survey of the site. Barangay Sta. Tereza 2nd has a population of 4255. The rational method was used to determine the stormwater flow and domestic sewage flow. The computed maximum dimension of the rectangular channel, 0.3 m x 0.6 m, was adopted for the whole structure. The analysis of the study narrows down to the computation and design of the drainage system. After preparing the complete plan and requirements relating to drainage distribution, the investigation would provide the measures required for the successful completion of the project.

Keywords ***—Drainage System, Water Stagnant, Stormwater***

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I. INTRODUCTION

Over time, civil engineering has continued to develop quickly. The construction of roads, bridges, and other structures has greatly helped society and accelerated the development of early civilizations. The fields of civil engineering have played an important role in our lives by constructing complex structures that enhance and improve the quality of life for everyone. The drainage system's construction is one of the most significant stages in structural design that has been completely utilized and developed, focusing on the drainage system's importance.

The Philippines is one of the Asia-Pacific nations vulnerable to recurring climatic hazards such as tropical cyclones, which cause periods of severe rain. (RV Macalad et. al 2021). The Philippines is prone to tropical cyclones due to its geographical location, which regularly results in heavy rainfall, floods across large areas, and powerful winds that cause serious damage to crops and buildings. (PAGASA).

In addition, one of Lubao's 44 barangays, Brgy. Sta. Tereza 2nd is located at 14° 53' North and 120° 34' East, at a height of 6.8 meters or 22.3 feet above mean sea level (Philatlas.com), as shown in Fig. 1.

Figure 1. Map of Sta. Tereza 2nd, Lubao, Pampanga
Reference: OpenStreetMap

The illustration above demonstrates that the area is surrounded by a variety of bodies of water, making it more vulnerable to floods. Global warming and sea level rise can impact coastal ecosystems, posing a hazard to habitation and raising the likelihood of floods. The tidal effect and salt wedge in rivers shift landward due to sea level rise. This compromises the safety of freshwater intakes for home, industrial, and agricultural water supply systems (Integrated Flood Management Tools Series, 2013).

According to Philatlas.com, the population of Santa Tereza 2nd arose by 2,307 people over three decades, from 1,948 in 1990 to 4,255 in 2020. The most current census numbers for 2020show a 5.01% growth rate or a rise of 882 people over the

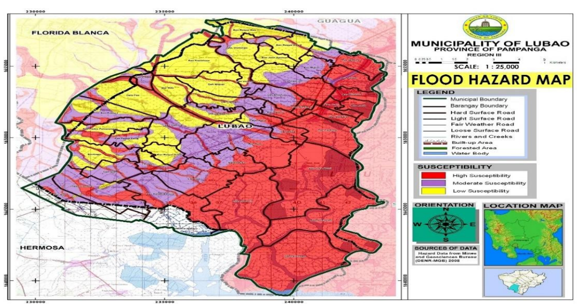


Figure 2. Flood Hazard Map of Lubao, Pampanga
Reference: LDRRMO

2015 population of 3,372.

Furthermore, river levels are too high during the flood season, allowing water to surge onto a roadway, creating longitudinal floods and water erosion. The pavement receives part or all of the damage. The embankment fails, creating road damage; instability causes subgrade filling. Water scour produces cracks, deformations, and possible road breakdowns (J. Liu et al., 2015)

A drainage system transfers water from areas no longer needed for disposal to suitable sites. A drainage system may consist of anything from residential gutters and drains to stormwater systems that drain rainfall from highways and roadside drains. Drainage systems may also take sewage from homes and dispose of it in municipal "sewers." An efficient drainage system drains all flood waters without producing any design issues. Poor drainage may cause low-lying regions to flood, destroying property and causing safety dangers. (Byjus, 2023. *Drainage System*)

In recent years, flooding and waterlogging have grown more common and frequent; thus, appropriate measures should be taken to boost subsurface drainage capacity and mitigate flooding and waterlogging disasters caused by short-term heavy rainfall. (XiaoleiRen et al., 2022)

Flooding disasters have also increased due to the Philippines' hydrological condition. Hence, a drainage system plays a vital role in preventing flooding. The purpose of constructing a drainage system is to increase the management and storage capacity of rainwater in the community. (Ye-ShuangXu et. al., 2018).

Thus, the construction of a drainage system is essential:

1. It is essential to protect the population's health, and if the drainage does not exist, water will remain on the surface and provide breeding grounds for hazardous insects.

2. It is essential for the correct disposal of wastewater, rain, and runoff and the effective management of flooding.

It prevents soil erosion that
may result in soil breakdown, which ultimately causes muddy surfaces, followed by soil erosion.

3. This research aims to propose a drainage system to help the locals and offer it to community leaders.

This study focuses solely on proposing the design of a drainage system to prevent the risk of flood disasters, road damage in the village, posing a serious risk to human health, and water stagnation in Puroks 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga.

1.1 Review of Related Literature and Studies

Emerging problems in urban areas today and in the future may lead to a drop in the quality of service for critical infrastructure like urban drainage systems (or urban wastewater systems). Several things, like climate change, population growth, and urbanization, could hurt the performance of these systems in the future in a big way (Zimmerman et al., 2013). Because we have yet to determine how harmful or significant the long-term effects will be, the nature of future uncertainty may also make us question how well traditional and alternative methods will work to adapt to future changes (Urich& Rauch, 2014).

In light of these possible dangers, it may be necessary to change urban wastewater infrastructure to make it more resistant to the effects of typical and extreme weather (Ferguson et al., 2013). The urban wastewater system is expected to be reliable and resilient. Reliable in the sense that it will have fewer breakdowns and provide enough service most of the time. Resilient in the sense that when it does break down, it will be less severe and last less time (Butler et al., 2017).

Flooding can cause bad things to happen. Big storms can cause much damage, which can cost a lot to fix. Well-designed drainage systems can quickly eliminate stormwater, causing less building damage and saving money on repairs. However, a lack of empirical studies on the topic has made it hard to figure out which drainage system might best prevent or limit property damage from floods (Sohn et al., 2020).

Floods are the most dangerous natural disaster because they happen often and in many places. Several new technologies and scientific studies have made flood damage less harmful. The government has told people who live in areas likely to flood to get flood insurance and build homes that can withstand floods. Several engineering projects tried to reduce the effects of flooding and change the paths of waterways. Researchers now put much effort into finding ways to reduce flood damage and keep people safe. They look for the causes of floods and evaluate drainage systems (Apat et al., 2013).

The study by Hsiang-Kuan et al. (2013) used an integrated drainage-inundation model, which combines a drainage flow model with a two-dimensional overland-flow inundation model. This model determines how to stop floods and how much damage they cause. Methods on the table include building more drainage systems, turning fishponds into retention ponds, setting up pumping stations, and building culverts to divert flood water. Each method was run through a computer simulation to estimate the likely depth and width of flooding in terms of damage losses. This was done to determine how vulnerable the drainage system is to the expected rise in rainfall due to climate change.

Sustainable drainage systems (SuDS) can slow down and clean surface water, which makes them a valuable tool for dealing with too much rain. However, implementing the plan is complex and needs help from many different groups. Getting support from stakeholders is often hard to do when there needs to be more proof or monitoring of the SuDS that have been put in place. Flow levels measured in utility holes downstream of SuDS treatments differed statistically significantly from baseline levels (Cotterill et al., 2020).

Casal-Campos et al. (2018) looked at how sustainable, resilient, and reliable solutions were in different future scenarios. They found that the exact solutions were resilient. Strategies that were tried, tested, and found to be resilient and incredibly reliable only sometimes showed to be decisive regarding their ability to last. Traditional gray infrastructure techniques were shown to be fragile in terms of their ability to last because of their uneven economic, environmental, and social performance.

Domestic wastewater could be better for water supplies and urban infrastructure, making installing sustainable drainage systems more critical. The environmentalists, hydrologists, city developers, and stormwater and wastewater managers must evaluate the present drainage system and forecast how the surroundings will react to urban drainage system discharges in order to build a better design and guarantee a community expands sustainably. (Dibaba, 2018).

When a road does not have enough drainage, water stagnant happens. As a result of mosquito breeding on roadways in cities with insufficient drainage capacity, roads collapse in various ways and economic hardship for the people of impacted neighborhoods. Putting in sound drainage systems could make roads last longer. Still, the road's edge fails early because the drainage system needs to improve. Thus, proper engineering methods should be considered throughout the road and drainage channel design, construction, and management processes (Vitalis, 2016).

Schmitt et al. (2022) used a complex dual drainage simulation model to explain surface and sewer flow interaction. This was done to calculate the most accurate water depths above the surface of the ocean and to estimate the potential harm that floods brought on by overworked sewage systems would inflict. The project collaboration comprises institutions that work in industrial math and water engineering, as well as municipal drainage works and insurance companies.

It is tough to deal with flooding in cities with many people. Computer modeling is a big part of how drainage systems in cities are managed. Rai's study combined hydraulic results from the SWMM model with a Proportional Integral Derivative (PID) controller to make an effective urban drainage model for dealing with floods. The developed model could help reduce flood levels in urban waterways, making it a useful tool in the fight against urban flooding (Rai et al., 2017).

1.2 Objective of the Study

This study aims to propose a drainage system in Purok 1, 2, and 3 of Sta. Tereza 2nd, Lubao, Pampanga. To achieve the study's goal, the objectives were identified as follows.

General Objective:

- To avoid the possibility of stagnant water and to maintain the healthy conditions of the residents and community by proposing a drainage system in Purok 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga

Specific Objective:

1. Determine the characteristics of the location concerning the following

   1.1 Topography of the site location

   1.2 Existing actual condition of Purok 1, 2, and 3 of Barangay StaTereza 2nd, Lubao, Pampanga

   1.3 Expected maximum stormwater flow based on Return Period

2. To present an appropriate design of a rectangular drainage channel

3. To present the complete drainage plan of Purok 1, 2, and 3 of Barangay StaTereza 2nd, Lubao, Pampanga

1.3 Significance of the Study

This study focused on the proposed drainage system in Purok 1, 2, and 3 of Barangay Sta. Tereza, 2nd Lubao, Pampanga, will help the community reduce the risk of flooding and water stagnation. The following are among the benefits of this research:

Environment. The study's findings will aid in the elimination or reduction of floods, eliminating potential harm to freshwater ecosystems in the locality and lowering the danger of water pollution, which causes germs and illnesses.

Community. This project's outcome will be useful since it will prevent flooding issues caused by constant rainfall.

Local Government Unit (LGU). The study's result will benefit them as they can establish a more effective and efficient drainage system to ensure the entire town's safety.

Future researchers. This study may benefit and assist future researchers in gathering the data and knowledge needed to conduct a drainage system study.

1.4 Scope and Limitation

The researchers focused on designing an effective and efficient drainage system exclusively in puroks 1, 2, and 3 of barangay Sta. Tereza 2nd, Lubao, Pampanga. Domestic sewage from residential and stormwater has been computed depending on water supply percentage and rainfall quantity.

The study does not include the project implementation, waste management, or road pavement improvement and will not estimate the project's cost.

1.5 Conceptual Framework

This chapter of the research will serve as a summary to better understand of drainage design.

Input	Process	Output
A. Gathering of data • Topography • Identify the Maximum Flood Elevation Experienced in the Area • History of Rainfall Intensity B. Interviews • Residents of Purok 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga • Employees of Municipal Government of Lubao, Pampanga • Engineers from Department of Public and Highways (DPWH) C. Site Visitation	A. Prepare a research plan B. Data Collection C. Analyzing of Data D. Computing the required capacity of the drainage system E. Design of Structure F. Conclusion	A. Proposed design of drainage system in Purok 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga

The Input-Process-Output (IPO) is used to illustrate the study's conceptual framework. The input consists of data gathering, interviews, and site visitation. The process contains the research plan, collection, and analyzing data. It also includes here the design of the drainage system and the conclusion. The output consists of the proposed design drainage system.

1.6 Definition of Terms

1. **DPWH** – Department of Public Works and Highways
2. **Drainage System**- is the system or process by which water or other liquids are drained from a place.

3. **Embankment** - relates to a measurement of earthen material poured and compact to raise the level of a highway (or railway) over its surrounding ground surface.
4. **LDRRMO** – Local Disaster Risk Reduction and Management Office
5. **Pavement** - is a concrete or asphalt-covered hard surface, such as a pavement or a driveway.
6. **Pavement Failure** - pavement failure is caused by inadequate soil support. Hydraulic binders that stabilize the soil can guard against moisture-induced soil deterioration.
7. **Pluvial flood** - When an intense rainfall storm causes a flood in the absence of an overflowing body of water.
8. **Storm water** - is a type of water that results from precipitation, such as hail, snow, and severe rain.
9. **Wastewater** - is a type of water that is produced as a result of the deliberate use of clean water, natural drinking water, or salt water in several applications or processes.
10. **Water stagnation** - happens when the water stops moving. Water that is stagnant can seriously harm the natural environment.

II. METHODOLOGY

This chapter focuses on the research design, research locale, research instrument, data gathering, and data analysis. The following describes particulars:

2.1 Research Design

The research strategy used by the researcher was the development study method. Although the method of instructional technology is constantly evolving, the researcher continues to iron out some elements. Research development is vital for researchers' work to address technological and engineering concerns. A scientific study called on the conclusions of fundamental ideas and principles to aid research and development professionals in thinking about them and moving forward. It needs a methodical investigation with expertise or insight to determine the mines that could complete a certain project. Its goal was to complete the "proposed drainage system in Puroks 1, 2, and 3 of Barangay Sta. Tereza 2nd, Lubao, Pampanga." After the investigation was completed, this kind of material was utilized to create the drainage system.

2.2 Research Locale

The researchers conducted the study in Puroks 1, 2, and 3 of Brgy. Sta. Tereza 2nd, Lubao, Pampanga. One of the fishing areas in Lubao, Pampanga, is Barangay Sta. Tereza. At 14° 53' North and 120° 34' East, Barangay Sta. Tereza 2nd is home to around 2.45% of the municipality's population. Narrow streets have some concrete in them. Large areas of fishponds surround the village, which is also surrounded by small rivers. Local government members, known as barangay officials, served as the community's leaders and were in charge of the village's growth and development. To increase public knowledge of floods, water stagnation, and their impacts, the community voluntarily cooperated with the research of the planned drainage system in Puroks 1, 2, and 3.

Figure 3. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Reference: Google Earth Pro

2.3 Research Instrument

The researchers learned about the area through interviews and questions to the barangay officials. Researchers asked residents a set of questions based on their own experiences to get the information they needed.

The researchers used the data gathered to obtain runoffs. Microsoft Excel, Google Earth, and AutoCAD are the software used in designing the drainage system.

Microsoft Excel was used to calculate flow conditions and the hydraulic parameters necessary to establish the drainage inflow or inlets. Google Earth will identify the area, and Topographical Map Online was used to survey or locate the contour or geospatial map. AutoCAD was used to make an outline from the result for the working drawing as a final output of the project. In getting the actual discharge parameters, the Kirpich Equation was used for the time of concentration, the rainfall intensity of Pampanga for the past years for rainfall intensity, the Rational Method for the peak discharge, and Manning's Equation for the allowable discharge. From the values obtained, we assumed parameters for our proposed drainage.

2.4 Data Gathering

The drainage system's design was decided upon after conducting a site analysis and consulting with local officials and other relevant groups. The goal of the visit is to collect data and details about the current situation, including information on river flow, damage from floods, and their causes. The design and planning phases of the construction will be built upon this knowledge and data. The following are some of the site investigation's activities:

- Verifying the site's location on a Google Map.
- Using a topographic map in Google Earth Pro.
- Taking photos around the area.
- Interviewed the residents, barangay officials, LDRRMO, and Engineers in DPWH.
- Considering private property that might have an impact on the proposal.
- Measuring the river's depth.

2.5 Data Analysis

Rainfall Intensity

Since there are no other readily available statistics that can be compared with discharge, rainfall data was utilized as the basis for figuring out when floods return.

If rainfall data is unavailable, discharges for catchment regions up to 100 kilometers squared can be calculated using the Rational Formula and the RIDF Curve.

For areas of catchment larger than 20 kilometers in area, the following procedure must be followed:

- The catchment area's boundaries
- Using the catchment area, determine the usual annual rainfall for the region.
- Compute the maximum normal rainfall per year. Using the various return periods, calculate the annual average amount of rain.
- Develop an average precipitation accumulation mass curve based on every duration by compiling hyetographs—typical rainfall patterns—from big floods that have happened in the past.
- Develop a hyetograph for every possible period and return interval combination.

DESIGN CRITERIA

Rainfall Intensity

Rainfall intensity, often known as storm intensity, is the typical amount of rain during a specific period. Rainfall intensity can be defined as the ratio of total amount of precipitation (rainfall depth) occurring during a particular period to period duration. It is stated in depth units per unit time, commonly in millimetres per hour (mm/h).

Time of Concentration

Time of concentration, one of the most essential hydrologic factors for runoff computation and modelling, can be defined as how long it takes for a drop of rainwater to travel from the drainage basin's most hydraulically distant point to its outflow or point of research. For the entire stormaffected watershed, the time of concentration indicates the minimum amount of time for rain to fall. The storm will not completely protect the watershed if its duration is less than its concentration. The amount of precipitation intensity cannot be highest if the storm's duration time is longer than the concentration period. In both situations, the maximum discharge from the watershed will be underestimated. In conclusion, the period when the expected rainfall length equals the time of concentration is the crucial condition for delivering the highest peak runoff.

Kirpich Equation:

$$t_c = \left(\frac{L^{1.15}}{51H^{0385}}\right)$$

Where:
t_c = time of concentration in minutes
L = Length of watercourse in meters
S = average basin slope (S=L/H)
H = difference in elevation (H= L/S)

Rational Method

One of the earliest techniques was the rational method, which was initially restricted to estimating the peak release based on a mass balance connecting runoff to rainfall intensity.
For S.I. units, the rational formula is expected as

Qp= (1/3.6)CIA

Where:
Q = runoff in m/s
C = runoff coefficient
I = mean intensity of rainfall in mm/hr = H/L
A = drainage area in km

The basic assumptions for using the rational formula are:

1. For a period of time at least equivalent to the period of concentration, the intensity of the rainfall must remain constant.
2. When rainfall intensity continues for the same duration as the period of concentration, runoff is at its peak.
3. During the storm, the runoff coefficient is constant.
4. During the storm, the watershed area stays the same.

Determination of Canal Size

$$Q = AV$$

Where:
Q = Flow rate (m^3/s)
A = Cross-sectional Area of flow m^2
V = Mean velocity across cross-section (m/sec)
V = 1/n $R^{2/3}S^{1/2}$
n = manning coefficient of roughness
R = hydraulic radius
S = Slope of the hydraulic gradient (non-dimensional)

Manning's Equation

Manning's equation is essential in designing a drainage system. We can use this formula to determine the flow rate with respect to the area, wetted perimeter, and slope.

$$Q = \frac{1}{n} AR^{\frac{2}{3}}S^{\frac{1}{2}}$$

Where:
Q = the flow rate
n = Manning's roughness coefficient
R = ratio bet area & wet perimeter
A = area of catchment specified
S = the slope

Table 1. Manning's Roughness Coefficient Table
(**source:** Engineering ToolBox, (2004). *Manning's Roughness Coefficients*)

Surface Material	Manning'sRoughness Coefficient - *n* -
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick and cement mortar sewers	0.015
Canvas	0.012
Cast or Ductile iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011
Rubble Masonry	0.017 - 0.022
Steel - Coal-tar enamel	0.010
Steel - smooth	0.012
Steel - New unlined	0.011
Steel - Riveted	0.019
Vitrified clay sewer pipe	0.013 - 0.015
Wood - planed	0.012
Wood - unplaned	0.013
Wood stave pipe, small diameter	0.011 - 0.012
Wood stave pipe, large diameter	0.012 - 0.013

Graphical Peak Discharge

The graphical method is only applicable to watersheds with uniform runoff characteristics and only one runoff curve number (CN) that can be used to represent all the soil types, land uses, and ground covers in the watershed. The graphical method only delivers a peak discharge and is inapplicable when the hydrograph is required.

Design Return Period

An estimate of the probability that a situation, including an earthquake, flood, landslide, or stream flow, will occur is known as a return period, also known as a recurrence interval. According to the relevant intensity-duration-frequency curves, in small catchment hydrology, the peak discharge is connected to the amount of rainfall, which is related to the period of concentration. Small drainage regions will concentrate for a brief period of time, resulting in increased strength and maximum flow per unit area. However, the area's tiny size also contributes to the peak discharge's small size. Therefore, designing for extended return durations for tiny regions with intensity measured in minutes is typically not cost-effective.

Runoff Coefficient

The runoff coefficient is a ratio without dimensions used to show how much runoff drainage systems produce at a given average rainfall intensity. The runoff coefficient (C) expresses the relationship between the amount of discharge and the rate of rainfall.

Table 2. Coefficient of Runoff based on Land Use
(Source: LMNO Engineering, Research, and Software, Ltd (2003). Runoff Coefficient)

Ground Cover	Runoff Coefficient, c
Lawns	0.05 - 0.35
Forest	0.05 - 0.25
Cultivated land	0.08-0.41
Meadow	0.1 - 0.5
Parks, cemeteries	0.1 - 0.25
Unimproved areas	0.1 - 0.3
Pasture	0.12 - 0.62
Residential areas	0.3 - 0.75
Business areas	0.5 - 0.95
Industrial areas	0.5 - 0.9
Asphalt streets	0.7 - 0.95
Brick streets	0.7 - 0.85
Roofs	0.75 - 0.95
Concrete streets	0.7 - 0.95

III. RESULT

The information, our research, and the findings of our inquiry into the suggested drainage system are presented in this chapter. The research was intended to offer a solution to the Proposed Drainage System in Purok 1, 2, and 3 of StaTereza 2nd, located in Lubao, Pampanga.

3.1 Site Observation

In order to maintain gravity flow, the drainage system's design was chosen based on elevation. It was expected that the storm runoff would naturally flow into the river.

3.2 Analysis and Calculation

Hydrologic Manual Computation of Proposed Line Canal

Fig

For Line 1 (408mx3m)

Table 3. Summary of Details in Line 1

Summary of Details of Line 1	
Total Area (km)	$0.0018km^2$
Slope %	0.25
Time of Concentration (mins)	19.71 min
Runoff Coefficient	0.75
Return Period (15 years)	49.70
Can	
Peak discharge runoff (Qp)	0.185 m^3/sec
Manning's formula (Q-15yrs)	0.2088 m^3/sec
Q-15yr >Qp	S A F E

Figure 5. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

It shows that line 1 has an area of 0.0018 km^2 and a slope of 0.25%. The runoff is

0.75 (residential area), and the time concentration is 19.71 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.185 m^3/sec, with a flow rate of 0.2088 expected in 15 years. As a result, the canal's design, which measures 0.3 m by 0.6 m, is safe.

For Line 2 (59m x 3m)

Figure 6. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

Time of Concentration (mins)	2.14 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Canal Size	0.1m x 0.2m
Peak discharge runoff (Qp)	0.02786 m^3/sec
Manning's formula (Q-15yrs)	0.029m^3/sec
Q-15yr >Qp	S A F E

Table 4. Summary of Details of Line 2

It shows that line 2 has an area of 0.00561km^2 and a slope of 1.69%. The runoff is 0.75 (residential area), and the time concentration is 2.14 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.0278 m^3/sec, with a flow rate of 0.029 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.1 m by 0.2 m, is safe.

For Line 3 (41m x 3m)

Table 5. Summary of Details of Line 3

Summary of Details of Line 3	
Total Area (km)	0.0052925 km^2
Slope	2.43 %
Time of Concentration (mins)	1.40 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Can	
Peak discharge runoff (Qp)	0.0259 m^3/sec
Manning's formula (Q-15yrs)	0.025m^3/sec
Q-15yr >Qp	N O T S A F E

Figure 7. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

It shows that line 3 has an area of 0.00529 km^2 and a slope of 2.43%. The runoff is 0.75 (residential area), and the time concentration is 1.41 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.0259 m^3/sec, with a flow rate of 0.025m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.09 m by 0.18 m, is not safe.

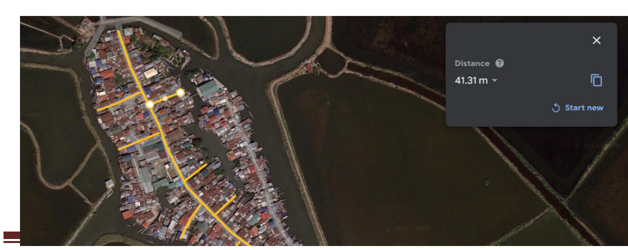


Figure 8. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

For Line 4 (55m x 3m)

Table 6. Summary of Details of Line 4

Summary of Details of Line 4	
Total Area (km)	0.0056 km^2
Slope	3.77 %
Time of Concentration (mins)	1.44 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Peak discharge runoff (Qp)	0.0274 m^3/sec
Manning's formula (Q-15yrs)	0.023m^3/sec
Q-15yr >Qp	N O T S A F E

It shows that line 4 has an area of 0.0056 km^2 and a slope of 3.77%. The runoff is 0.75 (residential area), and the time concentration is 1.44 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.0274 m^3/sec, with a flow rate of 0.023 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.08 m by 0.16 m, is not safe.

For Line 5 (35m x 3m)

Figure 9. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

Table 7. Summary of Detail in Line 5

Summary of Details of Line 5	
Total Area (km)	0.0025365 km^2
Slope %	2.85%
Time of Concentration (mins)	1.17 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Peak discharge runoff (Qp)	0.01241 m^3/sec
Manning's formula (Q-15yrs)	0.014 m^3/sec
Q-15yr >Qp	S A F E

It shows that line 5 has an area of 0.00253 km^2 and a slope of 2.85%. The runoff is 0.75 (residential area), and the time concentration is 1.17 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.01241 m^3/sec, with a flow rate of 0.014 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.07 m by 0.14 m, is safe.

For Line 6 (50 m x 3 m)

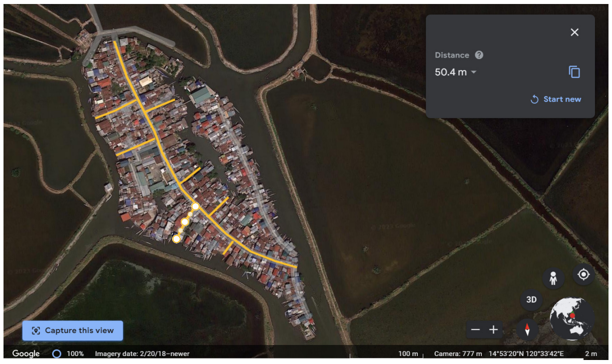


Figure 10. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

Table 8. Summary of Detail in Line 6

Summary of Details of Line 6	
Total Area (km)	0.005096 km^2
Slope %	2%
Time of Concentration (mins)	1.76 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Canal Size	0.09m x 0.18m
Peak discharge runoff (Qp)	0.0249 m^3/sec
Manning's formula (Q-15yrs)	0.0241 m^3/sec
Q-15yr >Qp	N O T S A F E

It shows that line 6 has an area of 0.00509 km^2 and a slope of 2%. The runoff is 0.75 (residential area), and the time concentration is 1.76 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.0249 m^3/sec, with a flow rate of 0.0241 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.09 m by 0.18 m, is not safe.

For Line 7 (32 m x 3m)

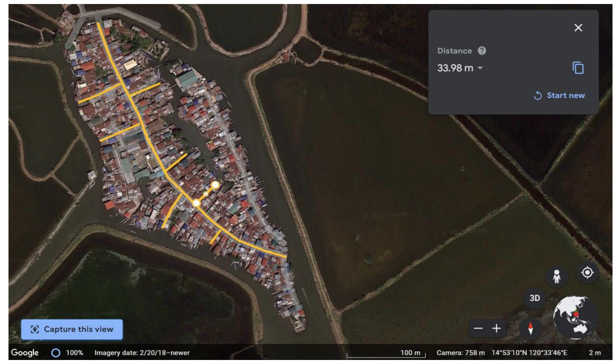


Figure 11. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

Table 9. Summary of Detail in Line 7

Summary of Details of Line 7	
Total Area (km)	0.002798 km^2
Slope %	2.94
Time of Concentration (mins)	1.13 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Canal Size	0.07m x 0.14m
Peak discharge runoff (Qp)	0.01369 m^3/sec
Manning's formula (Q-15yrs)	0.0149 m^3/sec
Q-15yr >Qp	S A F E

It shows that line 6 has an area of 0.00279 km^2 and a slope of 2.94 %. The runoff is 0.75 (residential area), and the time concentration is 1.13 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.01369 m^3/sec, with a flow rate of 0.0149 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.07 m by 0.14 m, is safe.

For Line 8 (20 m x 3m)

Figure 12. Satellite Map of Sta. Tereza 2nd, Lubao, Pampanga
Source: Google Earth Pro

Table 10. Summary of Detail in Line 8

Summary of Details of Line 8	
Total Area (km)	0.002864 km^2
Slope %	5
Time of Concentration (mins)	0.6146 min
Runoff Coefficient	0.75
Return Period (15 years)	23.5
Canal Size	0.06m x 0.12m
Peak discharge runoff (Qp)	0.014 m^3/sec
Manning's formula (Q-15yrs)	0.0129 m^3/sec
Q-15yr >Qp	N O T S A F E

It shows that line 6 has an area of 0.002864 km^2 and a slope of 5 %. The runoff is 0.75 (residential area), and the time concentration is 0.6146 minutes. The researcher set a 15-year return time to extend the drainage's life and durability. The maximum discharge rate is 0.01369 m^3/sec, with a flow rate of 0.0129 m^3/sec expected in 15 years. As a result, the canal's design, which measures 0.06 m by 0.12 m, is not safe.

3.3 Summary of Results

The proposed drainage system in Purok 1,2, and 3 of Barangay StaTereza 2nd Lubao, Pampanga, requires an accurate design flow rate to ensure that it can effectively manage the runoff during heavy rainfall events. The rational method is an effective tool for estimating the peak discharge of the proposed drainage system. The technique utilizes the rainfall intensity, drainage area, and runoff coefficient to determine the design flow rate. This thesis explains the rational method in detail, including the formula and the steps to compute the design flow rate. Moreover, the drainage area can be computed by summing up the sizes of all the points where runoff flows to the drainage.

It is important to note that the runoff coefficient depends on the type of surface and the land use of the area where the road is located. An assumed value of 0.75 is used in this thesis, but a more accurate value should be determined based on the specific conditions of the area. This thesis provides a comprehensive guide on choosing the design flow rate for the proposed drainage system in Purok 1, 2, and 3 of Barangay StaTereza 2nd Lubao, Pampanga. The rational method is essential for engineers and planners to ensure the drainage system can handle the expected runoff during heavy rainfall events

Manning's roughness coefficient of 0.012 because it is a concrete finish.

Thus, the flow rate in 15 years in the drainage channel line 1 is 0.2096 m^3/sec, line 2 is 0.029 $m^3/sec.$, line 3 is 0.025 m^3/sec, line 4 is 0.023 $m^3/sec.$, line 5 is 0.014 m^3/sec, line 6 is 0.0241 m^3/sec, line 7 is 0.0149 m^3/sec and line 8 flow rate is 0.0140 m^3/sec. This flow rate is essential in determining the drainage system's appropriate size, including the drainage pipes' capacity, channels, and other structures. Proper sizing of the drainage system is crucial in preventing flooding, erosion, and water stagnant.

Going into further detail, the proposed drainage system in Purok 1,2, and 3 of Barangay Sta. Teresa 2nd Lubao, Pampanga, is an important project that aims to address the water stagnant in the area. Using Manning's equation in computing the flow rate is a critical step in determining the appropriate size of the drainage system.

The computation of the flow rate using Manning's equation is based on the channel geometry, flow depth, and channel roughness. The channel geometry is described as rectangular with a bottom width of 0.6m with a different slope in every line. From this geometry, the cross-sectional area of flow and the hydraulic radius of the channel is computed.

The flow depth is assumed constant, and the channel roughness coefficient is set to 0.012. The computed flow rate is used as the basis for sizing the drainage system if it is safe or not. The system must accommodate this flow rate to prevent flooding and water stagnant in the area. Proper sizing of the drainage system includes the capacity of the drainage pipes, channels, and other structures. It is essential to ensure the drainage system can handle the maximum expected flow rate to prevent any adverse effects on the community. In summary, the use of Manning's equation in computing the flow rate is an essential step in designing an effective and efficient drainage system. The computed flow rate is the basis for sizing the drainage system, ensuring it can handle the maximum expected flow rate to prevent flooding and erosion problems.

The time concentration for the proposed drainage system in Puroks 1, 2, and 3 of Barangay Sta. Teresa, 2nd Lubao, Pampanga, is computed manually from each canal. This value is important in determining the appropriate storage capacity of retention ponds and other structures to prevent flooding and water stagnant.

Table 11 Note: that the runoff coefficient can vary depending on the land use and surface type, so it is important to use appropriate values based on the specific conditions of the study area.

To go into further detail, the proposed drainage system in Purok 1, 2, and 3 of Barangay Sta. Teresa 2nd Lubao, Pampanga, is crucial in addressing the flooding and water stagnation in the area. The drainage system will be designed based on the peak discharge and time concentration calculated using the Kirphic Equation. The peak discharge indicates the maximum amount of water that can flow through the drainage system during a rainfall event with an intensity of 49.5 mm/min (line 1) and 23.5 mm/min (line 2- line 8) and a runoff coefficient of 0.75. This value determines the appropriate size of drainage pipes, channels, and other structures that can accommodate the expected water flow.

Moreover, the concentration indicates the time it takes for the rainfall to reach the drainage system outlet. This value determines the storage capacity of retention ponds and other structures that can hold excess water during heavy rainfall and release it gradually to prevent flooding downstream. The proposed drainage system will also consider the slope and size of the road segments and the drainage system. The drainage system adopted a length of 0.3 m and a width of 0.6 m with a 0.2 m canal cover.

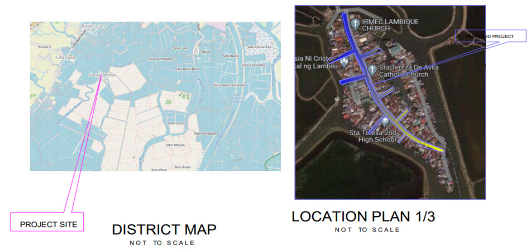
Overall, the proposed drainage system in Purok 1, 2, and 3 of Barangay Sta. Teresa 2nd Lubao, Pampanga, will be designed based on the calculated peak discharge and time concentration and other factors such as the road size, slope, and drainage size. The proper sizing and design of the drainage system will help prevent flooding and water stagnation in the area and ensure the safety and well-being of the residents.

To compute for the runoff coefficient for each road segment, we need to determine the type of surface and the land use. The runoff coefficient varies depending on these factors. The surface type for all road segments is concrete and the land use is residential so we can use a typical value of 0.75 for the runoff coefficient. The results are shown in the table below:

Table 11 Note: that the runoff coefficient can vary depending on the land use and surface type, so it is important to use appropriate values based on the specific conditions of the study area.

With a runoff coefficient of 0.75, the proposed drainage system in Purok 1,2 and 3 of Barangay Sta. Teresa 2nd Lubao, Pampanga, should be designed to handle a significant amount of runoff. This means that the drainage system should be able to accommodate and efficiently convey the expected peak discharge during a storm event to prevent flooding and related problems. The computed time concentration can also be used to design the drainage system's storage capacity, such as retention ponds, to prevent flooding in low-lying areas and water stagnation. The drainage system's design should be resilient enough to handle extreme weather events that can lead to heavy rainfall and flooding, as these can have severe consequences on the safety and livelihood of the community.

The proposed drainage system will be critical in managing stormwater runoff and protecting the community from flood-related problems. It is essential to prioritize implementing sustainable and effective drainage systems to minimize the potential damages of flooding and water stagnant. The computed values for peak discharge, time concentration, and runoff coefficient are a basis for determining the appropriate infrastructure and capacity to prevent flooding and water damage in

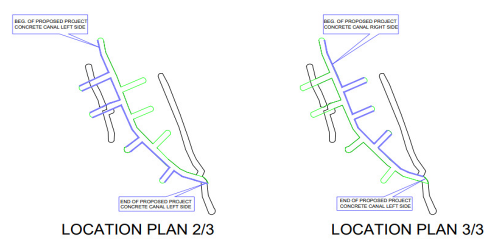


the area. It is important to note that the success of the proposed drainage system depends on the community's active participation in its maintenance and monitoring.

3.4 Proposed Drainage Design

Figure 15. Design of the drainage

efficient. The complete details of the standard drainage design channel from DPWH are shown in Figures 13 to 16. The figure shows the detailed line of the drainage canal and its removable cover.



Line 6	50 x 3	150	0.75
Line 7	32 x 3	102	0.75
Line 8	20 x 3	60	0.75

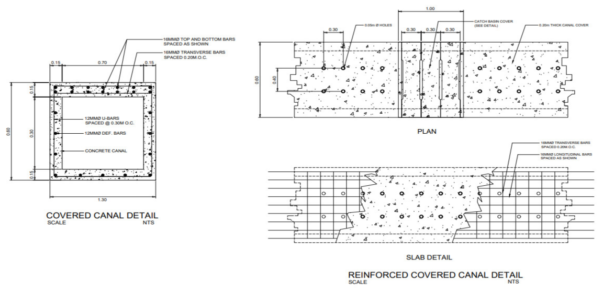


Figure 16. Design of the drainage

Iv. DISCUSSION

4.1 Summary

Following a thorough investigation of the study's data, the conclusions were summed up as follows:

1. The characteristics of the site with respect to the following:

Topography

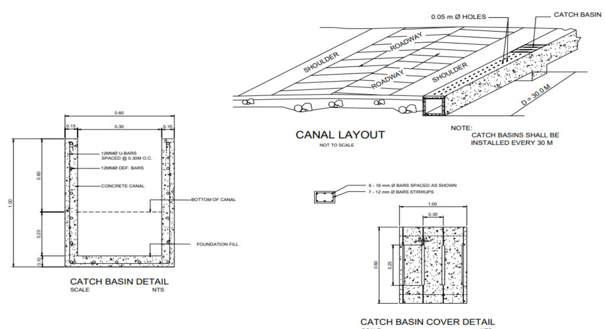
1.1 The site's peak elevation is 3 m, while its lowest elevation is 1 m. For the extended use of our suggested drainage system, we have selected a 15-year return time using an approximation of the method for predicting stormwater runoff.

Residential Area of Purok 1,2, and 3 of StaTereza 2nd, Lubao, Pampanga

1.2 The area of Purok 1, 2, and 3 of StaTereza 2nd is 700 m length x 3 m width x 1 m height.

2. The maximum discharge calculated using the rational method serves as the basis for the formula used to calculate the normal depth of flow. The most effective cross section should be considered to determine the ideal geometry. Because it is large enough and common in DPWH drainage design, the rectangular canal was the sole shape taken into consideration. The base was set at 0.6 meters with a 0.2 canal cover, and the depth was 0.3 meters. The river should receive the flow of water.

Figure 14. Location plan from right to left



3. to conform to the slopes' natural drainage in order to maintain gravitational flow. It was anticipated that the storm runoff would discharge naturally in the northeast.

4.2 Conclusion

The following findings were derived from the study:

The topography map, estimated population, expected rainfall intensity, and expected rain and water are key variables in the design of the drainage system.

0.3 x 0.6 m is the most significant determined drainage dimension that was utilized for the whole project.

According to the findings of the drainage system design, the drainage system's dimensions are enough to handle the typical rainfall. The drainage system would be able to manage even if there were constant wet weather. But this only considers rainfall data. When all other factors are added up, it may not be able to accommodate all the water inflow.

The researchers proposed a rectangular drainage since it is easier to make, maintain, and accommodates water easier. The researchers suggested a rectangular drainage system as well since it has a bigger area as compared to a circular drainage system thus, it can accommodate more water. Then again, this data will be changed when we consider all other factors of water inflow aside from rainfall.

4.3 Recommendation

The following suggestions are offered after a thorough review of the outcomes, revelations, and conclusions.

1. The 0.30 m x 0.60 m rectangular channel dimensions should be adopted throughout the whole length of the Purok 1, 2 and 3 of Barangay StaTereza 2nd, Lubao, Pampanga.

2. Since the solution was been established, the source of the barangay is now the main concern. Barangay StaTereza 2nd, Lubao, Pampanga who are concerned for better facilities of the barangay should allocate the appropriate budget.

3. When the project is implemented, the beneficiaries of the proposed drainage system should undertake the proper maintenance of the said drainage. The undertaking would include cleaning and monitoring the drainage that will ensure that the structure would last according to its design period and well serve its intended purpose.

4. Because the research only used existing rainfall analysis on DPWH, it is preferable to collect rainfall intensity data frequency (RIDF) directly from the nearest gauge station available so that the drainage system design is more accurate when implemented.

5. And future researchers would consider further approaches to eliminate the element of flooding generated by the river, as well as present a cost-analysis to figure out the cost of the project and to benefit the community in the future.

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