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## Environment and Natural Resources: Pump Station Flooding Impact Assessment

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### ABSTRACT

Floods have large environmental consequences for communities and individuals. As most people are aware, the immediate impacts of flooding include loss of human life, damage to property, destruction of plants and trees, and deterioration of health conditions owing to waterborne diseases. For decades, Manila City has been battling with flood risk. The area has been inundated with flood waters several times, whether it is due to tropical weather, strong rain fall events, or rising waters. This has resulted in millions of pesos in damages, and in some instances, the same home has been affected multiple times. Given the age of the existing Quiapo pump station even with current upgrades and the potential development of other areas within the catchment area, there is a need to identify, review, and recommend some alternatives solution for the future of the Quiapo pump station. The researcher is thus undertaking this study to review alternatives for upgrades or replacement of the existing Quiapo pump station. It aims also to describe the common plants and trees damaged by typhoons and floods, animals affected by devastating floods, common diseases during floods, effectiveness of existing pumping stations and advantages of the new pumping station, the effects of high floods on trees, animals and human health, and the impact of some alternatives solutions of the Quiapo pump station on natural environment to prevent and protect the adverse impact of flood events on human health and safety, on valuable goods and property, and on the aquatic and terrestrial environment.

**Keywords:** Environment, flood, human health, Lagunilad underpass, pump station, natural resources, Quiapo district, typhoon

## **1. INTRODUCTION**

Rainy season is always a couple of days where the streets in many cities would expect flooding on floodplains. Floodplains are the flat areas beside rivers, naturally liable to flooding if any overflow occurs. They are there to catch the river as it spreads out during times of high flow. Floods influence river ecology. Animals and plants in riparian areas have spent millions of years adapting to conditions around them and this includes floods. Many fish wait for the first sign of the annual spring flood to start breeding. Many insect larvae wait for flooding to begin to lay eggs, hatch or metamorphose. Floods provide a smorgasbord of new food sources for river life as they wash insects and bugs from land to the stream. Floods wash dead brush and trees into the stream.

This debris provides important habitat for river dwelling organisms. Floods carry and deposit rich sediment, making a nutrient rich habitat for riparian plants. A local example of the importance of floods is the white silk cotton wood along the Bolo River. These are the trees people see as they spelunk through the river valley on the way to Adams, Ilocos Norte. Silk cotton woods are one of the few native species of trees people see on the prairies. Silk cotton wood seed requires wet mud to germinate. This process of germination is more complex than it seems.

The seed dispersal and time of wet mud must coincide. Floods aren't scheduled and seed release is hit and miss. If people are observing these trees, look to see if there are different sizes (ages) of trees. If the area is healthy and has flooded over the past decades, they will see different age categories of trees. With no floods, people will notice a lot of big, older trees and no small younger ones. The silk cotton woods have declined over the past century. One factor that has played a role in this decline is the creation of dams. Dams interrupt the natural flooding process that allows the riparian areas to grow and replace itself. As people become more aware of this effect, dam managers have been trying to recreate the natural water flow. The biodiversity along rivers and streams is the highest than any other place in Ilocos Norte. These areas depend on flooding cycles for their existence.

The Department of Environment and Natural Resources (DENR) monitors potential flood-related problems at more than 15 dams subject to provincial oversight. In some cases, Environment and Natural Resources orders local dam to lower water levels to reduce the pressure behind a dam. This is done to protect human life, property, and environmental health.

The Environment and Natural Resources handles potential problems with underground storage tanks, particularly at gas and fueling stations affected by floods. Flood waters can cause underground tanks to break to the surface or inundate fuel tanks containing gasoline, diesel fuel, and other petroleum products. They helped businesses understand what they need to do to safely operate their storage tanks and locate contractors who can pump out water or repair damaged tanks.

After floods and severe storms, communities, businesses, and homeowners often must cope with damaged dwellings, downed trees, and other potential problems related to handling non-hazardous solid waste (Bankoff, 2003).

Floods also can interrupt highway traffic and rail lines. When this happens, Environment and Natural Resources works with local communities and businesses to help find solutions for managing and disposing of debris in ways that are environmentally safe during emergencies.

This includes safely disposing of sand from used sandbags (Ganiron Jr., 2016).

Sometimes, livestock dies during floods and their bodies need to be safely disposed of to prevent illness or disease. The Environment and Natural Resources work with local governments and private solid-waste disposal companies to help transport and properly get rid of dead animals.

Floods pose special problems to homes and all businesses with hazardous materials. The Environment and Natural Resources maintains a list of businesses that produce a large amount of hazardous waste and the agency contacts those in the flood-affected areas and helps with accumulated debris after a flood.

Public wastewater treatment plants can be affected impacted by flood waters and surface water runoff (Ganiron Jr., 2017). To help protect and track water quality impacts, the Environment and Natural Resources monitors reports from public wastewater treatment plants, and provides technical assistance to plant operators who are trying to keep untreated wastewater from entering public waterways.

## **2. GENERAL**

In Manila, there is another more or less devastating flood caused by typhoons or just heavy rain. During the rainy season from June to September, there are always a couple of days where the streets in many cities of Metro Manila get so flooded that schools and offices are kept closed and life virtually grinds to a halt (Megacities, 2016). Sadly, these floods often cause casualties, mainly in poor squatter areas that were erected in danger zones alongside riverbanks, lakes, and sewers. Experts agree that the catastrophic consequences of the floods in Metro Manila are to a large extent man-made, caused by poor urban planning and badly maintained drainage systems. In early August 2012, 80 percent of Manila was covered in water after heavy rain falls, in some parts nearly two meters deep. Nevertheless, this was quite an extreme case. as long as Filipinos do not live in said danger zones, they will experience the floods as an annoyance that might complicate their routine for a couple of days, rather than as a life-threatening catastrophe.

According to Alcasaren (2013), the reason for floods in the metropolis is the rains and the typhoons that bring them have increased in magnitude. The paths of typhoons have also become unpredictable. Typhoons now cross parts of the archipelago that did not use to have them regularly and so people are caught unprepared. Despite these changes in patterns, Metro Manila still gets dumped with rain, especially since its total area, and population in this area, is equivalent to or larger than most provinces and many regions in the country.

Metro Manila has a population of 12 million (Alcasaren, 2013). Urbanization, specifically urban sprawl is a manifestation of all these millions living together and needing houses, buildings, roads, parking lots, and infrastructure. All these cover ground that used to be open and able to absorb much of the storm water that fell on the metropolis. In lifetimes, Filipinos have seen fringes of the metropolis gobbled up and transformed from cogon and rice fields to thousands of subdivisions, hundreds of shops and malls, hectares of paved-over parking lots, dozens of business districts. All this hard covering serves to channel all the storm water much faster into an already inadequate drainage system designed when the reality was much more open land and much less rain. The open ground before served to mitigate the volume of rain that flowed into these drains, tidelands and the rivers. Filipinos also had more plant cover and trees in the metropolis to help sop up all this water.

Metro Manila floods come from elevated surrounding regions, all the way up to the Sierra Madres (Alcasaren, 2013). Filipinos have lost almost all of their original forest cover from illegal logging. All this forest cover lost makes millions of hectares of upland a bald watershed that flows freely into the metropolis. This situation is repeated around almost all major urban areas in the country. The source is upstream and this is where solutions should start, although it is among the longest-term solutions. Filipinos need to recover their forest cover to reduce the amount of rain that floods our low-level metropolis. **Figure 1** shows the worst floods in 50 years hit the Manila City.



**Figure 1.** Worst floods in 50 years hit the Manila City

Metro Manila is not only low but it is sinking (Alcasaren, 2013). Ground water extraction due to deep wells is causing major areas of the metropolis to sink. The north section of “Camanava” and the southern cities from Pasay City onwards have sunk from a foot to over a meter and this has made those areas more vulnerable to floods and storm surges. Scientists have pointed to the fact that this flattening has increased the reach of storm surges from the seaside to as much as 20 kilometers inland. So Filipinos get it from both ends in a perfect storm from the mountains and from the sea. The ground is also sinking due to the weight of all that concrete, buildings and infrastructure.

In the early 60’s, Filipinos used pumping stations in a water distribution system where water is pumped directly into the system where pressure has to be increased because there is an insufficient difference in water levels in gravity flow distribution systems. It is very important that pumps have a high degree of efficiency and are maintained properly. To guarantee safe water quality, a cross connection of drinking water and waste removal systems must be avoided. The 3 pumping stations in Metro Manila, which have been in operation for more than 45 years used to consume diesel to operate but are now powered by electricity.

In 2013, efforts to pump out floodwater from “Lagusnilad” underpass in Manila continued despite flood levels in other areas in Metro Manila caused by heavy rains brought by southwest monsoon enhanced by tropical storm “Maring” had generally subsided (Elona, 2013).



The vacuum equipment's from water companies were deployed to pump out the roughly 500,000 liters of floodwater that submerged the Lagusnilad underpass. Seventy percent (70%) of the drain pipes in Manila are made of single barrels 24 inches in diameter, similar to the size of the opening of a container drum (Ganiron Jr, 2017). The actual and ideal size is 3 meters by 4 meters or visually similar to the size of a car. **Figure 2** shows the Floods in Lagusnilad's drainage system.



**Figure 2.** Floods in Lagusnilad's drainage system

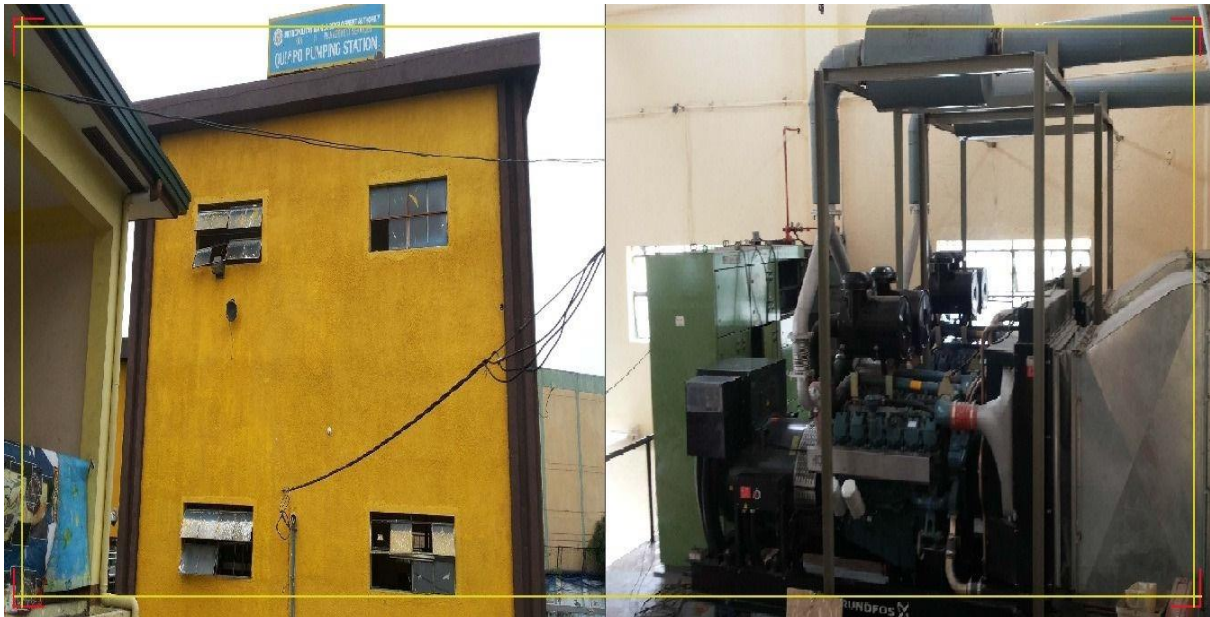
Most of the drain pipes were built in the 1960s (Amrbosio, 2013). The Department of Public Works and Highways (DPWH) had done an upgrade on the drainage system. Canals are also now being declogged by the MMDA. Some steel manhole filters had been stolen; therefore, garbage continues to flow toward the drain pipes, causing clogging. All Manila roads including the Lagusnilad underpass are now passable, according to the Manila Disaster Risk Reduction Management. Meanwhile, the Metropolitan Manila Development Authority (MMDA) also brought the news team to the Aroceros pumping station in Manila near the Pasig River where it was still high tide.

As shown in figure 4, the capacity of the Binondo pumping station at the Muelle de Binondo was increased from 2.37 to 3.6 cubic meters per second while the Quiapo pumping station on Elizondo Street covers 256 hectares (Frialde, 2015). Quiapo pumping station cuts through Sampaloc, Quiapo and the Malacañang area and part of España Boulevard. The Metropolitan Manila Development Authority (MMDA) states that indiscriminate throwing of garbage, which clogs the drainage system and the pumping stations, is the primary cause of flooding in Metro Manila. To help alleviate flooding in the metropolis during the rainy season, the Metropolitan Manila Development Authority (MMDA) has started clean up drives and the repair of pumping stations in Manila. They had collected around 770 tons of garbage during their clean up drives in 11 creeks.

The Flood Control and Sewerage Management Office started the total rehabilitation of 7 water pumping stations in Metro Manila. Of the Metropolitan Manila Development Authority

(MMDA)'s 54 water pumping stations, a total of 12 stations are undergoing repairs while 3 repaired pumping stations in Aviles, Valencia, and Pandacan in Manila had been completed (Francisco, 2015). The repairs include increasing the capacity of the pumping stations and installing new computerized systems imported from the Netherlands. The pumping station in Aviles pumped floodwaters from Estero de Aviles, Estero de Sampaloc, Estero de Uli-Uli and Estero de Calubcub. It covers an area of 356 hectares from Sampaloc to the University Belt. The Valencia pumping station pumps floodwaters in Sta. Mesa district, while the Pandacan station covers 180 hectares in the district. With the rehabilitated pumping stations, floodwaters in these areas subsided quickly.

But barely two months after conducting the Metropolitan Manila Development Authority (MMDA) clean-up operations in Pasay City and Manila City, the garbage had piled up again and the Metropolitan Manila Development Authority (MMDA) received a request to go back and do it all over again. The Metropolitan Manila Development Authority (MMDA) had started their flood mitigation measures ahead of the onset of the rainy season to make it easier for officials to respond to emergencies. **Figure 3** shows the Quiapo pumping station.



**Figure 3.** Quiapo pumping station

Source: Metropolitan Manila Development Authority (MMDA)

Today, the Metropolitan Manila Development Authority (MMDA) operates several pumping stations in strategic areas of Metro Manila, with the aim of mitigating flooding risks, particularly during inclement weather. Brand new pumping stations were also constructed in flood-prone areas as part of the agency's flood-mitigation program (Ganiron Jr., 2016). In addition, they also scheduled a regular maintenance of 54 pumping stations across the Philippines with 12 stations being equipped with new pumps (**Figure 4**).





**Figure 4.** Binondo pumping station

Source: Metropolitan Manila Development Authority (MMDA)

### **3. RESEARCH METHODOLOGY**

The researcher employed a descriptive method of research in the study. The focus of concern of the research is to determine the impacts of floods in the environment and natural resources, the environmental impact assessment of the new pump station and its' advantages, and the effectiveness of the existing pump stations in the City of Manila. Every year the Lagusnilad underpass in Manila is submerged, while floods were knee-high near City Hall of Manila and the Intramuros district. After these surveys, the researcher identified the Village No. 384 as one of the most vulnerable communities in Quiapo district, lies along the shores of the Pasig River and is still submerged in waist-deep water long after life in the other communities

Accidental sampling under the category of non-probability sampling was adapted. The researcher went through the area on the subject and conducted a survey to those who gave them a chance. A total of 162 responses were collected, all of which were valid ( $n=162$ ). The population consists of eighty (80) males and eighty-two (82) females who were all residents of Manila City or adjacent districts in Metro Manila. Most respondents were of working age, with 75.6% are being between 22 to 47 years old. The majority of the respondents were Village No. 384.

The structured questionnaire was administered by three enumerators, based on an original drafted in English that was then translated into Filipino, the national language of the Philippines.

### **4. RESULTS AND DISCUSSION**

#### **4. 1. Common plants and trees damage by typhoons and floods**

In 2014, one of the most powerful storms hit the Metro Manila is the typhoon 'Glenda', only a glancing blow of about three hours. In its wake, lives have been lost and Manila has been pummeled by winds of destruction, albeit not as strong as Yolanda's 300-kph gusts (Alcazaren, 2014). The lessons from that disaster made for better preparation and fewer fatalities, but there is much to improve by way of disaster-risk management and preparedness (Ganiron Jr., 2017).

One of the effects of typhoons that could be mitigated is the loss of plants and trees, especially in Metro Manila. A huge number of herbs, shrubs, and trees have been felled and damaged by the typhoons and high floods. Out in the street, several fell was damaging many plants. Around the metropolis, the same situation is evident felled trees; even the Malacañang Palace in Manila was not spared. **Figure 5** shows how banana plants and trees damaged by the typhoons and floods.



**Figure 5.** Banana plants and trees damaged by the typhoons and floods

Respondents were asked to choose the following plants based on growth habit that they owned and had been damaged due to heavy rains and high floods

As shown in figure 6, the majority of the respondents with the percentage of 33% have damaged their shrubs plants. Most of them are ornamental plants like rose, hardy hibiscus, and fragrant shrubs. 32% answered that they loss their herbs plants and 17% of the residents' large trees uprooted or badly damaged: a young "balete", a mango and a star apple.

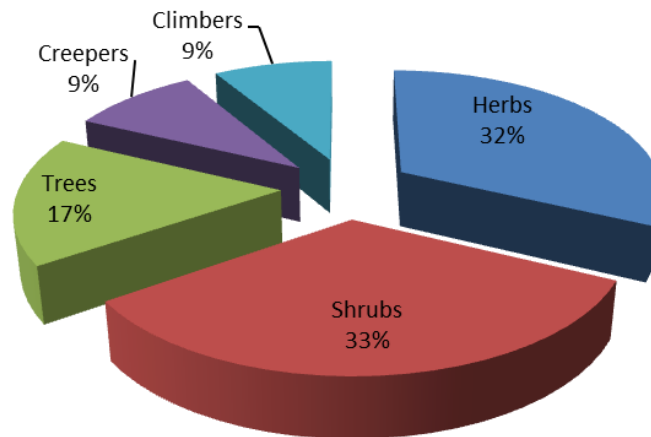
On the other hand, respondents revealed that 9% for both of their creepers plants and climbers' plants were damaged by high floods. This is because of the excessive amounts of water can cause both creepers plants and climbers' to become stressed and even die.

There are many ways that flooding can damage plants and trees. Excessive moisture in soil decreases oxygen levels. This impedes respiration where energy is released from sugars in the roots leading to the build-up of carbon dioxide, methane and nitrogen gases. Ultimately, the roots can suffocate and die. Toxic compounds such as ethanol and hydrogen sulfide can also build up in the soil and damage plants. If leaves and stems are submerged, photosynthesis can be inhibited and plant growth can slow or even stop.



Plants that are suffering from excessive-water stress are more prone to infection by disease-causing organisms such as fungi or insects. Also, the excessively wet soil tends to favor the growth of soil-microbes which can infect plant roots leading to diseases such as root and crown root. The deposition of soil and rocks onto plants during flooding can damage plants and trees, as can the exposure of roots to the air by the washing away of surrounding soil. Also, even after the flood waters recede the damaged plants can be more vulnerable to other stresses. For example, trees with substantial root damage are more likely to be uprooted in windy weather

### **Plants based on growth habit damage by typhoons and floods**



**Figure 6.** Percentage of plants based on growth habit damaged by typhoons and floods

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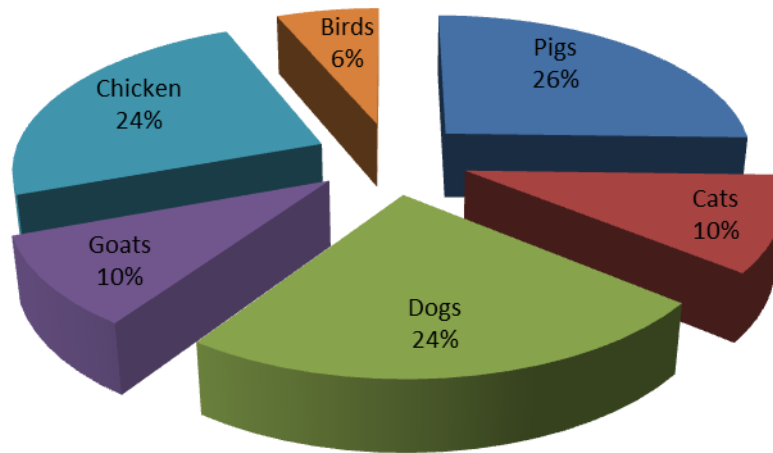
#### **4. 2. Animals affected by devastating floods**

As shown in **Figure 7**, Typhoon Koppu, the second strongest storm hit the disaster-plagued Southeast Asian archipelago last 2015 and bringing winds of close to 200 km/h (Guinto, 2015). In Metro Manila, pigs, goats, dogs, cats and, birds lined the sides of a storm-tossed highway, where about more than 150 residents had been seeking refuge from the floods.



**Figure 7.** Some animals affected by floods

### **Animals affected by devastating floods**



**Figure 8.** Percentage of animals affected by devastating floods

As shown in **Figure 8**, the majority of the respondents with the percentage of 26% revealed that their pigs were affected by devastating floods. 24% for both dogs and chicken that their animals were affected by floods. According to Guinto (2015), there were chicken and dogs being carried off by the rampaging waters and some neighbors pushed pigs placed on top of truck tire inner tubes through chest-deep floods in a valiant attempt to save the animals

On the other hand, respondents revealed that 10% for both of their goats and cats were affected by high floods. The least number of answered variables that are affected by high floods are the birds garnered 6%. Birds, though their habitats may remain intact and safe, lose a

significant source of their nourishment. Water logged grass and land is not a feasible place to forage for insects. This means that birds have to relocate or be at risk for starvation and malnourishment.

#### **4. 3. Common diseases during floods**

In 2015, the Department of Health (DOH) identified six (6) diseases common during rainy days and high floods known as WILD - an acronym that stands for Water-borne diseases, Influenza, Leptospirosis, and Dengue. The water-borne diseases are cholera, hepatitis A and typhoid fever (Rappler, 2015). **Figure 9** shows how human health was affected by the floods.

Respondents were asked to choose the following common diseases that they experienced during the rainy days and high floods. As shown in Table 1, the majority of the respondents with the percentage of 38.89%, or 63 out of 162, have experienced dengue. Dengue is a disease common in tropical and sub-tropical countries in the world like the Philippines. It is transmitted through the bite of an *Aedes* mosquito. Dengue fever is potentially fatal and mainly affects children.

There are also 24 or 14.84% experienced to have typhoid fever during the rainy season. Typhoid fever is an infectious disease, also known as enteric fever or just typhoid, that spreads through contaminated food and water or through close contact with someone who is infected.

23 of them or 14.20% answered that they got cholera waterborne disease from high floods. Cholera is an acute intestinal infection caused by ingestion of food or water contaminated with the bacterium *Vibrio cholera*. People who eat food or drink water contaminated by this bacterium have a high chance of getting infected.



**Figure 9.** Human health affected by floods

Meanwhile, 20 or 12.35% experienced to have influenza disease. This influenza disease is a viral infection that attacks the respiratory system. It is transmitted through contact with a person who coughs or sneezes, or with surfaces, material, and clothing contaminated with the discharges of an infected person. Young children, the elderly, pregnant women, and people who have weakened immune system are at risk for this disease.



**Table 1.** Frequency distribution of adequacy in management

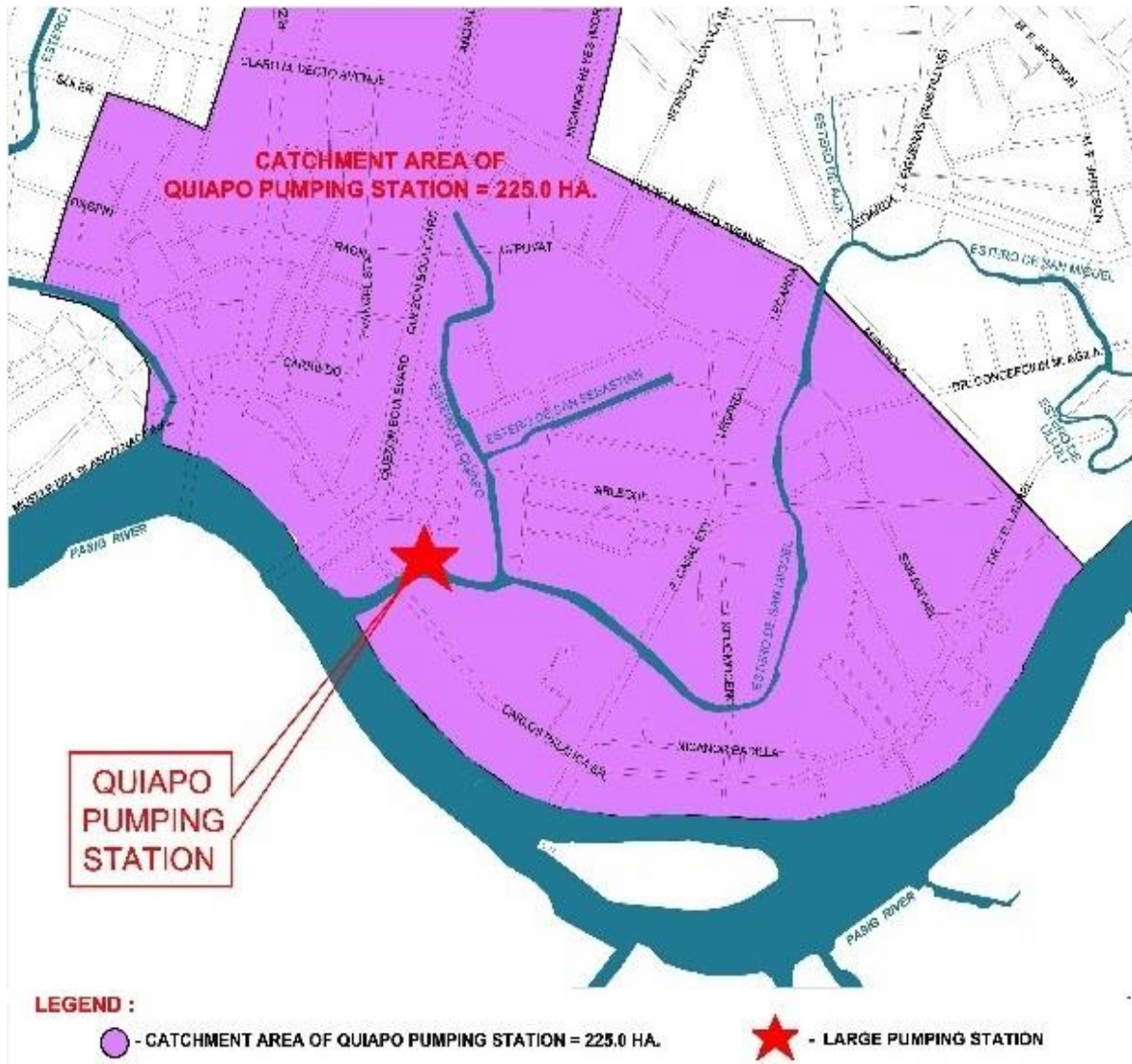
Common diseases	Frequency	Percentage (%)
1. Cholera	23	14.20
2. Hepatitis A	15	9.26
3. Typhoid fever	24	14.81
4. Influenza	20	12.35
5. Leptospirosis	17	10.49
6. Dengue	63	38.89
Total	162	100

On the other hand, 17 or 10.49% had leptospirosis disease during high floods. A leptospirosis disease is a bacterial infection transmitted when urine and feces of infected animals such as rodents, contaminate the soil, water, and vegetation. A person may get leptospirosis by ingesting contaminated food or water, when broken skin and open wounds, or when eyes, nose, sinuses, and mouth come in contact with contaminated water (usually flood water) or soil. The incubation period of bacteria is 7-10 days.

The least number of answered variables that they experienced hepatitis A disease garnered 9.26% or 15 from the total number of respondents. Hepatitis A. is a virus that may be transferred from one person to another through the ingestion of food contaminated with human waste and urine of those who are already sick of Hepatitis A.

#### **4. 4. Alternative solution to the problem of floods**

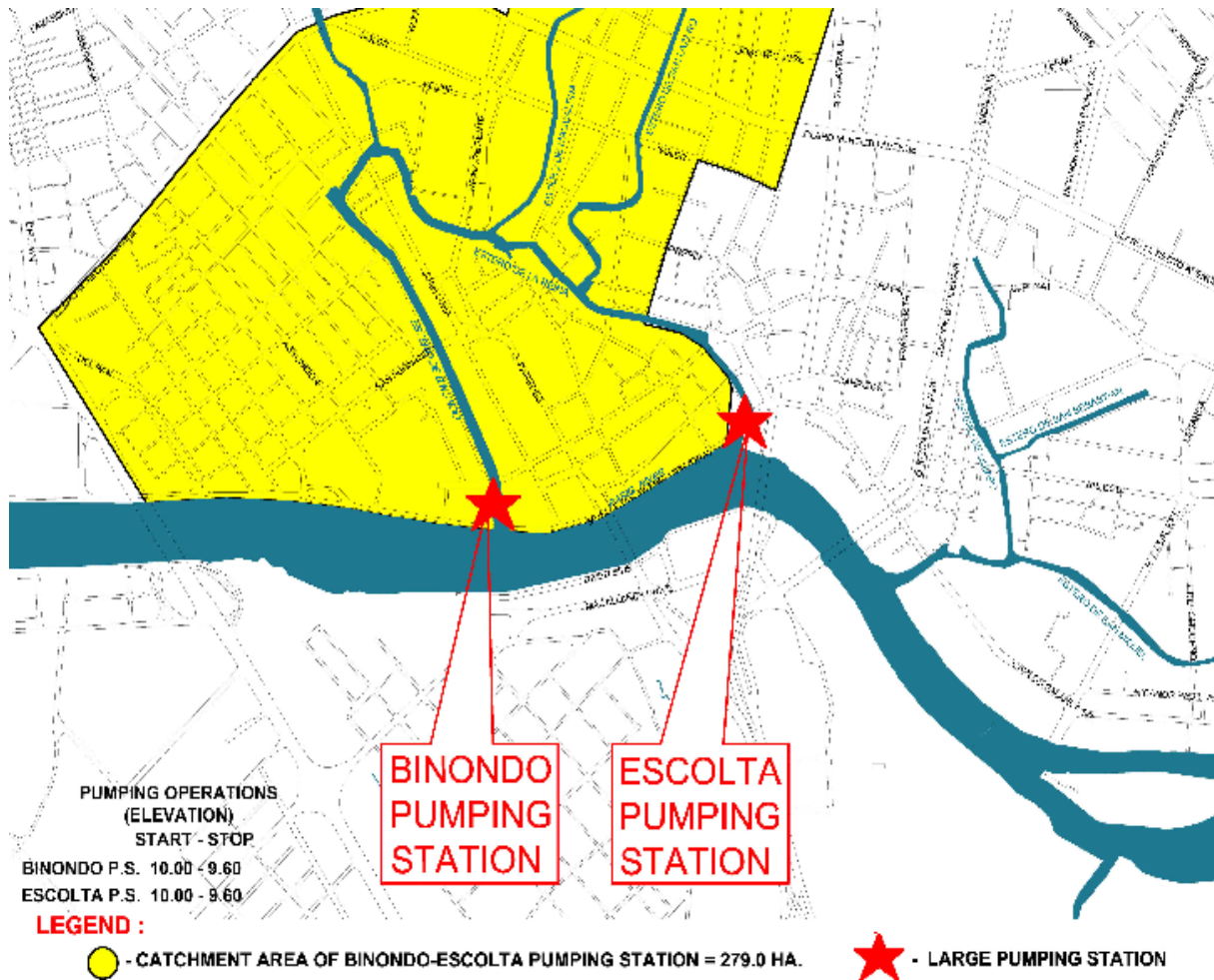
The findings also indicate that flooding causes more problems for children and female domestic helpers in wealthy neighborhoods. For instance, class cancellations due to flooding are often made in the middle of the day. Young students go to school in the morning, thus, they are often stranded in flooded areas in the afternoon. They can drop into open manholes while they are walking, or if they are stranded, on the streets. It is more difficult for them to fight for seats with adult passengers and gets a ride home using public transportation. They are easily exposed to diseases and other infections and get sick more often.



**Figure 10.** Location of catchment area of the Quiapo pumping station  
Source: Metropolitan Manila Development Authority (MMDA)

Respondents were asked to choose the following solutions to the problem of floods. Among the choices are the following:

**Alternative 1** - would involve maintaining the status quo. Under the “*Do Nothing*” alternative, the existing maintenance operator call-outs (rain events, etc.), health and safety (access, etc.) and environmental issues (overflows, failure of containment, etc.), associated with the existing pump station would not be addressed. As well, future developments would not be able to be serviced by the existing old Quiapo pumping station. The existing pumps do not have adequate capacity to pump the sewage that will be generated by future developments within the catchment area. **Figure 10** shows the location of catchment area of the Quiapo pumping station.



**Figure 11.** Location of catchment area of the Binondo pumping station  
Source: Metropolitan Manila Development Authority (MMDA)

**Alternative 2** - would involve completing upgrades to the existing pump station such as replacing the existing wet well, provide new larger capacity pumps, valve chamber with flow monitoring, force main and gravity sewer modifications, automatic transfer switch and new standby emergency generator (diesel or natural gas), upgrades to monitoring and communication (SCADA), replacing other aged equipment in need of replacement. Under this alternative, the existing maintenance, operator call-outs, health and safety and environmental issues associated with the existing pump station will be partially addressed for the long term, however, the drywell chamber would remain (i.e. older and potential to fall, possible environmental impairment, etc.).

**Alternative 3** - would involve decommissioning the existing pump station and construct a new pump station within the existing lot (or slightly expanded as required). The new pump station would be provided with new larger capacity pumps, new wet well with increased storage, addition of a valve chamber with flow monitoring capability, as well as all other associated mechanical, electrical, monitoring and communication components (SCADA). Other site work



would involve force main and gravity sewer modifications. Under Alternative 3, the new pump station would accommodate the future 20 peak flow from build out within the catchment area. Collected sewage at the new pump station would be pumped via the existing 150 mm dia. force main. **Figure 11** shows the location of catchment area of the Binondo pumping station

**Alternative 4** - would involve decommissioning both the existing Quiapo pump station and Binondo pump station and construct a new pump station at a new location approximately 30 m south, on the east side of Binondo district, Manila. This new pump station would be located adjacent to the existing residential property that the current Binondo pump station is located across the road from. The new pump station would be provided with new larger capacity pumps, new wet well with increased storage, an addition of a valve chamber with flow monitoring capability, as well as all other associated mechanical, electrical, monitoring and communication components (SCADA). Site work would involve the construction of a new 150 mm diameter force main from the new pump station for connection to the existing pump station force main. Alternative 4, the new sanitary pump station would accommodate the future 20 peak flow from the build out within the catchment Area.

As shown in **Table 2**, 61 or 41.98% answered that constructing a new pump station at a location adjacent to the existing Binondo pump station to replace both the existing Quiapo pump station and Binondo pump station (decommission existing pump stations) is more effective in reducing or minimizing flood problems, especially in Metro Manila. 51 or 31.48% believe that the solution to flooding problems is constructing a new sanitary pump station at the same location to replace the existing pump station (decommission existing pump station. On the other hand, 39 or 24.10% suggest that completing upgrades to the existing Quiapo pump station is the effective way to end the flood problem. The least number of answered variables is "Do Nothing" garnered 4 or 2.47% from the total number of respondents.

**Table 2.** Frequency and percentage distribution of Alternative Solution to the problem of floods

Solution to floods	Frequency	Percentage (%)
1. Do Nothing	4	2.47
2. Complete upgrades to the existing Quiapo pump station	39	24.10
3. Construct a new sanitary pump station at the same location to replace the existing pump station (decommission existing pump station	51	31.48
4 Construct a new pump station at a location adjacent to the existing Binondo pump station to replace both the existing pump station and Binondo pump station (decommission existing pump stations)	68	41.98
Total	162	100.0

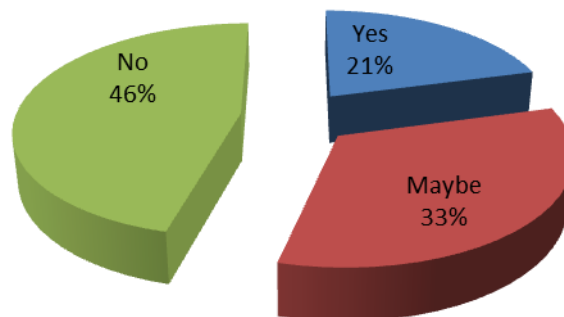
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#### **4. 5. Effectiveness of existing pumping stations**

As shown in **Figure 12**, a majority of the respondents, with the percentage of 46% or 75 out of 162 indicated, that the existing pump stations are not effective in controlling the flood in some areas in Metro Manila particularly the nearby places in Quiapo and Binondo districts. Some stated that the existing pumps do not have adequate capacity to pump the sewage and its operation is more than 45 years used to consume diesel to operate while some said that it is always that they see floods within the area of Lagusnilad underpass in Manila as a proof for their answer. 54 of them or 33% answered “yes” which means they are convinced with the efficiency of the existing pump stations while 21% or 34 of the respondents answered “maybe” due to the lack of knowledge or they simply don’t care about all.

### **Effectiveness of existing pumping stations**



**Figure 12.** Percentage distribution of effectiveness of existing pumping stations

#### **4. 6. Advantages of the new pumping station**

In 2013, the Metropolitan Manila Development Authority (MMDA) inaugurated its newest floodwater Balong Bato pumping station in San Juan City, which spared the city from flooding during the typhoon-enhanced monsoon rains. According to Tolentino (2013), this is the first time in 50 years that San Juan City did not experience flooding after this pumping station became fully operational. The Balong Bato pumping station has two pumps that siphon two cubic meters of water per second. It has a floodwater catchment area measuring 18.72 hectares. The facility, which also has two sets of trash screen for garbage retrieval, is being manned 24-hours by an 11-man MMDA team.

As shown in Table 3, 56.79% or 92 out of 162 respondents chose minimal occurrence of flood and 25 or 15.43% said that it protects the motorist and passers-by from the flow of water

during rainfall. Meanwhile, 22 or 13.48% stated that it serves as water storage station for the emergency need for water and 23 or 14.20% believes that it purifies drinking water. It is clear that the people know the advantages of the new Balong Bato pumping station nearby their places for them not to be deeply harmed during rainy seasons.

**Table 3.** Frequency and percentage distribution of advantages of pumping station

Advantages of pumping station	Frequency	Percentage (%)
1. Totally no danger of being flooded	0	0.00
2. Minimal occurrence of flood	92	56.79
3. Purifies drinking water	23	14.20
4. Lessens traffic within the area	0	0.00
5. Serves as water storage station for the emergency needs for water.	22	13.58
6. Protects the motorist and passers-by from the flow of water during rain	25	15.43
Total	162	100.0

## **5. FLOODING EFFECTS ON TREES**

Flood damage may affect tree height and diameter growth and tree survival. Such tree damage may be caused by soil changes, physical damage, insects, and diseases. The potential for damage to trees from flooding depends on flood characteristics and tree characteristics. Trees may need special care following a flood to minimize longer-term decline (Baughman, 2010).

### **5. 1. Types of flood-related damage**

Flooding may cause direct damage to trees by changing soil conditions, interrupting normal gas exchange between trees and their environment, sedimentation, and physical damage. Flooding also may weaken trees, thus making them more susceptible to indirect damage from insects and diseases. The likelihood of insect and disease damage depends upon the severity of the flood and tree health. A tree in weak condition before a flood can be further stressed by flooding and consequently susceptible to insects and diseases. A long-duration flood, especially during the growing season, may decrease height and diameter growth of tree species that are intolerant of flooding, but height and diameter growth may increase for flood tolerant species.

Water covering the soil reduces the supply of oxygen to tree roots. Roots must have oxygen to survive and grow. Sediments carried by the water and deposited over the roots also



reduce the supply of oxygen to tree roots. As little as three inches of sediment can be harmful. Tree species vary in their tolerance to sedimentation, but all seedlings are susceptible to root injury from sediment. Flooding increases the pH of acid soils and decreases the pH of alkaline soils. Tree species vary in their pH tolerance. The rate of decomposition of organic matter in flooded soil tends to be only half that in the unflooded soil. The major end-products of decomposition of organic matter in the flooded soil are: carbon dioxide, methane, and humic materials. In addition, the high concentrations of ethanol and hydrogen sulfide that are produced in the waterlogged soil can damage tree roots. Floodwaters may contain chemicals from urban areas or agricultural fields that may be harmful to trees when absorbed by their roots.

Strong currents, waves, or suspended particles may cause soil around the base of trees to be washed away, exposing their roots. Exposed roots can stress trees and make them more vulnerable to wind throw. Debris carried by rushing waters can remove bark and damage tissues. Such wounds may then be subject to wood stain and decay organisms. Flood waters that cover foliage on lower branches will interfere with photosynthesis and gas exchange, leading to the death of those branches.

It is unknown whether leaf-feeding (caterpillars) or sucking insects (scales and aphids) will become more of a problem following flooding. Plant stress can alter the biochemistry of trees making nutrients and sugars more available to insects feeding on leaves or sap. This could increase survival of these insects and increase their population size. Outbreaks of caterpillars or scales and aphids could further increase stress levels on trees severely weakened by a flood. Control of these insects should be considered a priority on high-value trees for one to three years after a flood. This may require the application of insecticides following label directions.

Several diseases may weaken or kill trees following flooding. They mainly affect the tree's roots, root collar, and lower stem. Free-standing water aids in both the reproduction and dissemination of the fungi. Oxygen starvation, wounding, and loss of cell permeability due to flooding provide ideal infection sites for these organisms to colonize.

## **5. 2. Effects of flood characteristics**

Trees are more likely to be damaged by flooding during the growing season than by flooding during the dormant season. Trees are most susceptible to flood damage in late spring just after the first flush of growth. Tree species begin their spring flush at different times so the timing of a flood influences the species that are likely to be damaged. The duration of a flood affects tree health and survival. During photosynthesis, green leaves absorb carbon dioxide and release oxygen to produce sugar. But all tree cells, including those in the roots, use oxygen and release carbon dioxide in the process of respiration. This gas exchange by cells requires access to air. Flooding displaces air in the soil leading to root decline or death.

A well-drained soil (for trees and shrubs) allows water to drain (percolate) at a rate of one inch per hour. To test the drainage rate of your soil, dig a hole 24 inches deep, fill with water, let it drain completely and then fill once again. If the 24-inch deep hole drains within 24 hours, this well-drained soil is considered close to optimum for most landscape trees and shrubs.

A poorly-drained soil will take more than 24 hours to drain a 24-inch deep hole, but there are degrees of poor drainage. A soil that takes 36-48 hours to drain is not nearly as bad for trees as a soil that percolates at a rate of 24 inches in seven to ten days.

If trees are flooded by heavy rain when the trees and shrubs are not actively growing, and the water recedes before growth begins, flooding usually is not a problem. Most tree species can withstand one to four months of flooding during the dormant season. However, when

flooding occurs during the growing season, especially during warmer weather, one to two weeks of flooding can cause major, long-term damage to sensitive trees and shrubs, even death with some species. Other species can survive as long as three to five months in flooded situations.

The oxygen content of flood water affects tree survival. Cold water holds more dissolved oxygen than warm water and rapidly flowing water with higher oxygen content is less harmful than stagnant water.

### **5. 3. Effects of tree characteristics**

Tree tolerance to flooding depends on many characteristics including tree height, crown class, age, vigor, and species. Tree injury increases in proportion to the percent of crown covered by water. Some trees can survive with their main stems standing in several feet of water for months but may die in less than one month if their foliage is completely covered. Few species can tolerate more than one month of complete submersion during the growing season.

Trees in a woodland can be rated according to their crown classes which indicate where a tree's crown is placed with respect to nearby competitors. Trees in the dominant crown class survive flooding much better than trees with a crown class of intermediate or suppressed.

Adult trees survive flooding better than over mature trees or seedlings of the same species. For example, some species rated as flood tolerant may be quite sensitive in the seedling stage. Seedlings often die because they are pushed over, buried in mud, uprooted, or smothered from lack of air.

Vigorously growing, healthy trees withstand flooding better than less vigorous trees, although vigor may be irrelevant if a tree is totally submerged in water.

## **6. FLOODING EFFECTS ON ANIMALS**

Flooding can have a massive effect on the lives of animals. Those that spend a lot of time underground, particularly during the rainy months when storing food, can drown or be washed away when water infiltrates their habitat.

Bird populations feel the strain because clouded flood waters make hunting for fish extremely difficult. Birds' plumages become saturated with water from repeated rain and wet weather, and baby birds can be washed out of nests. Animals are trapped and eventually die of starvation from being unable to access food, whilst food sources are washed away when shelters and habitats become waterlogged and are destroyed. Pesticides and other toxic chemicals carried in the water can saturate grassland and plants, only for animals to consume them after the water has cleared. There have been links between lead poisoning in animals and flooding that preceded it.

Domestic pets like dogs and cats also suffer. A flooded home means animals and their owners have to stay somewhere else until the problem can be rectified, creating a lot of confusion and stress for pets. Food, bedding, and other items may be damaged, and pets can be become trapped or lost. Many others are abandoned, resulting in animals struggling to survive alone after relying on humans and leading to an increase in a number of animals taken in by shelters.

## **7. EFFECTS OF FLOODS ON HUMAN HEALTH**

The health impacts of floods are wide ranging, and depend on a number of factors. However, the health impacts of a particular flood are specific to the particular context. The immediate health impacts of floods include drowning, injuries, hypothermia, and animal bites.

According to the World Health Organization (WHO), floods can potentially increase the transmission of water-borne diseases such as typhoid fever, cholera, leptospirosis and hepatitis A and vector-borne diseases like malaria, dengue fever, and yellow fever. Flooding is associated with an increased risk of infection. However, this risk is low unless there is significant population displacement and/or water sources are compromised.

The major risk factor for outbreaks associated with flooding is the contamination of drinking-water facilities, and the risk of outbreaks can be minimized if the risk is well recognized and disaster-response addresses the provision of clean water as a priority. There is an increased risk of infection of water-borne diseases contracted through direct contact with polluted waters, such as wound infections, dermatitis, conjunctivitis, and ear, nose and throat infections.

However, these diseases are not epidemic-prone. Perhaps, the only epidemic-prone infection, which can be transmitted directly from contaminated water is leptospirosis, a zoonotic bacterial disease. Transmission occurs through contact with the skin and mucous membranes with water, damp soil or vegetation (such as sugar cane) or mud contaminated with rodent urine. The occurrence of flooding after heavy rainfall facilitates the spread of the organism due to the proliferation of rodents, which shed large amounts of leptospires in their urine.

On the other hand, floods may indirectly lead to an increase in vector-borne diseases through the expansion in the number and range of vector habitats. Standing water caused by heavy rainfall or overflow of rivers can act as breeding sites for mosquitoes, and therefore enhance the potential for exposure of the disaster-affected population and emergency workers to infections.

Flooding may initially flush out mosquito breeding, but it comes back when the waters recede. The lag time is usually around six to eight weeks before the onset of a malaria epidemic.

The risk of outbreaks is greatly increased by complicating factors. Among these change in human behavior such as increased exposure to mosquitoes while sleeping outside, a temporary pause in disease control activities, overcrowding), or changes in the habitat which promote mosquito breeding such as landslide, deforestation, river damming and rerouting.

Other health risks posed by flooding include drowning and injuries or trauma. Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods. There may also be an increased risk of respiratory tract infections due to exposure such as loss of shelter, exposure to flood waters and rain.

Health risks also are associated with the evacuation of patients, loss of health workers, and loss of health infrastructure including essential drugs and supplies. In the medium-term, infected wounds, complications of injury, poisoning, poor mental health, communicable diseases, and starvation are indirect effects of flooding. In the long-term, chronic disease, disability, poor mental health, and poverty-related diseases including malnutrition are the potential legacy.

## **8. EFFECT OF ALTERNATIVE SOLUTIONS TO THE EXISTING PUMP STATION ON NATURAL ENVIRONMENT**

### **8. 1. Alternative 2: Completing upgrades to the existing pump station**

The impact is limited as the existing drywell for the pump station would be reused, with the replacement of the existing wet well adjacent and some local yard piping.

Construction of the new wet well and yard piping would require by-passing of the incoming sewage flow from the collection system for a time frame until it can be directed to the upgraded pump station. Special measures would be taken to minimize any impact during the by-passing of the sewage.

Drywell component of existing pump station structure remains original (i.e. potential failure in future due to age and possible environmental impairment).

Installation of emergency standby generator poses some environmental impact, i.e. noise and air pollution, spill risk, depending on fuel type, etc.

Rock removal (minimal if any) and dewatering for the construction of the new pumping station and yard piping will be required. If all requirements of approved Permit To Take Water (PTTW) are met for dewatering, along with mitigation measures as needed, no long term impacts are anticipated.

### **8. 2. Alternative 3: Decommissioning the existing pump station and constructing a new pump station within the existing lot**

Majority of impact is limited to the existing lot for the pump station for construction of the new pump station and local yard piping.

Construction of the new pump station and yard piping would require by-passing of the incoming sewage flow from the collection system for a time frame until it can be directed to the new pump station. By-passing would be minimal compared to “completing upgrades to the existing pump station as the existing sanitary pump station” can operate for longer while the new sanitary pump station is being built. Special measures would be taken to minimize any impact during the by-passing of the sewage. Rock removal and dewatering for the construction of the new pumping station and yard piping will be required. If all requirements of approved Permit To Take Water (PTTW) are met for dewatering, along with mitigation measures as needed, no long term impacts are anticipated.

Installation of emergency standby generator poses some environmental impact, i.e. noise and air pollution, spill risk, depending on fuel type, etc.

### **8. 3. Alternative 4: Decommissioning both the existing Quiapo pump station and Binondo pump station and constructing a new pump station**

Quiapo pump station and Binondo pump station and constructing a new pump station are expected. The impact is the largest for all alternative solutions, including the proposed new lot for construction of the new pump station and local yard piping, connection to existing gravity sanitary main for north residential lots, and the new force main and gravity sanitary sewer and from the existing Quiapo pump station area.

Trees and shrubs will need to be removed to construct the new pump station and yard piping. Vegetation buffers will be keeping and or restored upon completion of the new pump station's construction.



Construction of the new pump station and yard piping would require by-passing of the incoming sewage flow from the collection system for a time frame until it can be directed to the new pump station. By-passing would be more difficult compared to “decommissioning the existing pump station and constructing a new pump station within the existing lot”. Special measures would be taken to minimize any impact during the bypassing of the sewage.

Rock removal and dewatering for the construction of the new pumping station and yard piping will be required. If all requirements of approved Permit To Take Water (PTTW) are met for dewatering, along with mitigation measures as needed, no long term impacts are anticipated.

Installation of emergency standby generator poses some environmental impact, i.e. noise and air pollution, spill risk, depending on fuel type, etc.

More significant construction impacts would be caused due to the construction of the new gravity sewer modifications and force main replacement. Full road closure for the section of Binondo pump station between the existing Quiapo pump station and new combined pump station location is anticipated to be required in order to accommodate the installation of the new sewage gravity main and force main.

Minor construction impacts would be caused due to the construction of the new pump station, local yard piping, and decommissioning of the existing pump stations.

Location of new pump station would be out of visual view of local residential lots, compared to existing Binondo pump station including visiting maintenance and operation vehicles, etc.

Installation of emergency standby generator poses some social impacts, i.e. added noise and air pollution. Type of fuel supply may increase social impact, i.e. propane versus natural gas versus diesel. The location would be closer to residential development as opposed to “completing upgrades to the existing pump station and decommissioning the existing pump station and constructing a new pump station within the existing lot”.

## **9. CONCLUSIONS AND RECOMMENDATIONS**

Flood is one of the perennial problems here in the Philippines, especially in Metro Manila. Filipinos are affected in many aspects, such as human health, animals, plants and trees, and livelihood. Every time a heavy rain pours that many activities are delayed, some are stopped, others destroyed. Calamities are striking in Manila and leave lots of homeless, hopeless, and in the deep depression. To see the effects after a flood is not a pretty site. Water has to be pumped out of flooded civilian areas. During floods, humans can lose so much.

One of the most dangerous things a person could lose would be their life. If people get caught in a flood and are swept away, they have the risk of drowning in the water. Aside from the obvious immediate danger that flood present, the secondary effects can be just as damaging.

Severe flooding can result in stagnant water that allows breeding of water-borne diseases, influenza, leptospirosis, and dengue. Many animals, like the dogs, pigs, and chickens have died in flash floods. Much more are injured and others made homeless. Water supply and electricity are disrupted and people struggle and suffer as a result.

To the extreme, very heavy rainfall followed by flooding could kill plants and trees, while other plants remain unaffected. Most plants can tolerate a couple of days of flooding during the growing season, but for some plants, a week or more of flooding can cause severe injury and death, particularly for sensitive tree and shrub.

In resolving the high flooding problems in the Manila City is by implementing the additional construction and rehabilitation of pumping stations. The major problem with the operation and maintenance of the old Quiapo pumping station is the handling of waste discarded in the estuary. It was concerned that the large volume of wastes generated had been impeding the operation of the pumping stations resulting from the disposal of wastes into the estuary by large numbers of squatters concentrated along the estuary. In addition to the waste collection problem, there is a shortage of dump trucks to carry the wastes and there are problems with the disposal sites. The problem should require a systematic effort by the Government of the Philippines in cooperation with the local government.

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