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Natural Flood Management: A restatement of the Natural Science Evidence

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ABSTRACT

Flood events often have severe socio-economic impacts, such as loss of lives and livelihoods, food, water and energy scarcity, and adverse impacts on human health and the environment. As far as feasible, human interference into the processes of nature should be reversed, compensated and, in the future, prevented. This study explores the possible solutions for the drainage system to ensure peak performance that might be adopted in España Boulevard, Manila. It aims to describe the wastewater management system 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**:** Drainage, flood, floodwater management, natural science, stormwater, wastewater, waste water management

1. INTRODUCTION

In the Philippines, rainy season is always a couple of days where the streets in many cities of Metro Manila get so flooded that schools and offices are kept and life virtually grinds to a halt.

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 and as long as a person do not live in said danger zones, he will experience the floods as an annoyance that might complicate his routine for a couple of days, rather than as a life-threatening catastrophe.

Many Manileños still move from other places as long as the water is only up to around one foot. Those days mean a little gold rush for the drivers of non-motorized pedicabs. In case one did not build up enough stocks beforehand, pedicabs are often the only vehicles that are still able to bring passengers more or less dry-shod to the next convenience store or fast food restaurant. A lot of restaurant chains keep delivering, but please do not call them if the weather is heavy and the water deep: delivery boys are often among the casualties when Metro Manila gets flooded.

Taxis also still drive in streets where the water is low enough, but they might not bring the passenger up to the door in a flooded neighborhood. In general, the price for transportation rises with the water, and a generous tip is appropriate.

Floods also occur in low-lying areas that serve as natural depositional environments. In the Northern part of the Philippines, notable examples are the Agno River, the Pampanga river basin, the Marikina River and the Pasig delta where the city of Manila was built.

Based on the analysis of the present conditions of drainage laterals in Manila and suburbs were made considering the run-off and flow capacity of existing drainage channels, the flow of direction in the drainage laterals, interconnectivity within each drainage block, and topography of the catchment area. The analysis results show the discharge and flow capacity of the drainage laterals in Manila and suburbs to be the inadequacy of several channels for 2 years and 10-year floods (Acosta et al., 2016).

Because of the inadequacy capacity of drainage storm water of the most drainage laterals, drainage mains, and open channels, the low-lying areas of Manila and suburbs such as Sampaloc (North of the Pasig river) and San Antonio-Palanan Pio Del Pilar (South of the Pasig River) become prone to flooding (Bankoff, 2013). The limited flow capacity of drainage channels was found out to be the caused by one or several combinations of the following: undersized drainage channels, unevenly laid slope of the conduit, irregular channel profile inconsistent drain size, clogged manholes, sediments deposits along the drainage channels, overflowing of the estuary, flood water spilling to neighboring areas and submerged crown elevation at the outlet. Also contribute the significant reduction of their carrying capacity, and thereby aggravating the problem of flooding in the most part of Manila and suburbs area: the encroachment of estuary and waterways by informal settlers, uncoordinated infrastructure development activities by various public utility agencies, indiscriminate disposal of garbage, and increased runoff resulting from rapid urban development (Bankoff, 2012).

Considering that the flooding problem is regional in the scope and involves several closely connected drainage blocks, drainage mains, estuary, and pumping stations that are necessary to comprehensive drainage planning should be undertaken through a master plan study (Catane et al., 2012). With the view towards formulating long-term solutions to the flooding problem, the master plan should come up with a balance or combination of structural and nonstructural measures. The structural ones should include the following: construction of additional drainage channels, improvement of the estuary, and rehabilitation and improvement of existing drainage mains such as rerouting of flows to less stressed lines, compartmentalization of drainage blocks to reduce the problems areas to manageable levels, or possibly redesign or reconstruction of the whole drainage system. The study of drainage system along España Boulevard aims to improve the health of the society, safety, and quality of life (Ganiron Jr, 2012). It helps to reduce flood in generally affected areas and reduces the damages caused by the flood. In achieving these goals, adequate drainage facilities, a proper place for dumping the garbage, better relocation of the squatters, and a comprehensive study plan for the assessment of this plan is a top priority.

The Manila Metropolitan areas suffer from the flood in every rainy season, which is mainly attributed to the malfunctioning of the existing drainage system due to the adequate maintenance under these circumstances. The government plans to improve the existing drainage system (Ganiron Jr, 2015). The availability of proper equipment is indispensable to accomplish the above objectives in this sense; this project plays an important as a pilot project providing importance in drainage problem in España (Easton, 1999). The project includes the procurement of equipment and transfer of technology required for the operation and implementation. The study shall confirm the maintenance of the pumping station and floodgates to determine if there is a need for the repair and rehabilitation of the pumping station and floodgates equipment.

Figure 1. Flash floods soak in España Boulevard, Manila

2. GENERAL

Flooding may happen in the area when large amounts of rain occur over a short period of time or from a single, heavy storm, tropical system, or hurricane. After these storms, people rely on a man-made flood control system to drain excess water from the low, flat lands (Dettinger, 1999). Flood control is achieved through an interconnected drainage system. The three-tiered system can be compared to a roadway system. Small streets in neighborhoods and towns carry traffic to larger, secondary highways. Secondary highways, in turn, connect and carry traffic to turnpikes and superhighways, or the primary vehicle transport system. Similarly, neighborhood ditches, swales, and conduits referred to as the tertiary system carry excess storm water to secondary canals (Elly et al., 1993). In turn, secondary canals operated by water control districts, cities, or counties connect and carry excess water to the primary canal system. Primary canals operated by the Water Management District are the drainage superhighways for the region (Gaillard et al,. 2008).

Large and small structures, culverts, gates, weirs, pumps, and levees, even street grates are all components of the drainage system. Water bodies such as ponds, lakes, and lagoons also play a role in water management (Ganiron Jr, 2016). While they do provide a beautiful view, their real function is to hold excess rainwater or to carry it off to regional storage areas or to the ocean.

Swales and grassed water storage areas are important features in water management systems (Haraguchi et al., 2015). In addition to storing and conveying water, they help recharge water in the underground aquifer and improve water quality by catching sediment and filtering nutrients. The interconnected system achieves maximum benefit when all components are well maintained and kept in good working order (Israel et al., 2012). As in a chain of dominoes, each component must properly function and connect to the next to allow for optimum drainage conditions. However, even with well-engineered systems, flooding may still occur during and after extreme rain events (Moya et al., 2004).

Existing levels in surface waters and groundwater affect the ability of drainage systems to receive or store new rainfall. If surface waters such as canals, lakes, and rivers are already full, they cannot receive or transport additional water. Just like the highways, when they cannot receive more cars from feeder roads because they are jammed or have reached their carrying capacity, water cannot flow into primary canals if they are full or if the flow has become blocked (Ganiron Jr, 2017). Additionally, if the underground water table is already high, water cannot soak into the saturated ground. After a heavy rain, water in streets, swales, yards, and low-lying areas is expected and normal.

During and after storms, excess rainwater is typically discharged through canals and structures to the ocean. However, tides, winds, and even the phase of the moon can affect discharge to the sea. When tides are high, the same floodgates that allow for the flow of excess freshwater to the ocean become salinity barriers preventing salt water from entering, or intruding into our underground, freshwater aquifers (Rodolfo, et al., 2006).

Development activities that affect how much rain soaks into the ground, how much water leaves a property, and where it will go must be permitted by water management districts. Permits protect the water resources of the state and provide for adequate drainage while ensuring that other people or properties are not adversely affected. Permits also address water quality issues and protect wetlands. Water leaving a property can transport excess nutrients from fertilizers or animal wastes, herbicides, pesticides, oil, gasoline or other substances that can pollute water and cause problems downstream.

Wetlands are vital natural resources protected by the state. They provide for wildlife habitat, flood protection, groundwater recharge, and water quality benefits.

Drainage factors considered when issuing permits are based on historical rainfall data and generally address the following three levels of storm conditions (Todd, 1978): (a) a road storm – 4 to 6 inches of rainfall, in a 24-hour period. Water remains standing in yards, swales, and ditches, but the crowns of roads remain passable, (b) a design storm – 7 to 10 inches of rainfall in a 72-hour period. Roads, as well as swales, ditches and yards flood, but buildings usually remain dry and, (c) hundred-year storm – 10 to 20 inches or more of rainfall in a 72-hour period. Many houses and businesses can be expected to flood.

In every county, some areas remain prone to flooding (Yumul et al., 2012). Most are in older neighborhoods where drainage systems were in place before surface water permitting requirements were established.

To address the increasing accumulation of sediments and garbage in drainage channels, the Department of Public Works and Highway (DPWH) carried out the project for retrieval of flood prone areas in Metro Manila (Jacinto et al., 2006). The Phase 1 of the project was implemented in 1990 and Phase 2 is in 1994 for this project, which was also meant to complement the gains made in other flood control projects. The Government of Philippines (GOP) sought and obtained GOP helps in getting the necessary equipment through Government of Japan (GOJ) general grant program round. In given this background, the present conditions of drainage laterals in Manila and suburbs were ascertained through the field survey (Lantican et al., 2003). The various data sets generated from the survey entered in the lateral database, together with the location maps, they collectively form the basis for the analysis of existing conditions of drainage laterals and drainage blocks in Manila and suburbs.

In evaluating the adequacy of the drainage channel, the blocks to be drained, and a non-uniform flow is adopted in the calculation of flow capacity (Yumul et al., 2013). A pressure flow condition is considered in cases where a submerged outfall is likely to occur. These are the following adopted assumptions: roughness coefficient (open channels) = 0.025, roughness coefficient (box culvert) = 0.015, hydraulic boundary condition gravity system = EL. 11.30 meters for Manila bay tide pumped system = pumping station.

The delineation of drainage blocks in this study resembles the delineation of DPWH drainage blocks, which is based on the pumping service area. The delineation of drainage blocks for a 10-year flood vanishes because the flow capacities of drainage channels for draining the floodwaters to spill over to a neighboring drainage blocks, thus resulting in wide-scale flooding of low-lying drainage blocks (Delos Reyes et al., 2015).

Surface runoff generally follows the topography and thus collected by a system of street inlets and tertiary roadsides drain. It is then conveyed into the drainage mains and laterals to the disposed and ultimately to Pasig river or Manila bay either by gravity or pumping (Taniguchi et al., 2008)

As mentioned above, because of the insufficient flow capacity of drainage channels, surface runoff of 10-years flood likewise flows along roadways following the topography from drainage block to drainage block (Boardman et al., 1994). The flow continuous up to a low lying drainage blocks where two drainage blocks may share the same estuary, thus stressing or putting pressure on the pumping station. Whether the capacities of pumping stations are inadequate or not after taking note of the difference between the drainage areas determined in this study and the design drainage further details.

3. RESEARCH METHODOLOGY

The researcher employed a descriptive method of research in the study. The focus of concern of the research is the study of the effectiveness of drainage system along España Boulevard. Every year, its' residents and public is affected by floods and the problem is causing a big concern among them. Accidental sampling under the category of non-probability sampling was adopted. The researcher went through the area on the subject and conducted a survey to those who gave them a chance. Fifty (50) respondents who are making a living nearby the location of the subject and also the everyday passers-by were selected and employed in the study. The population consists of twenty-five (25) males and twenty-five (25) females. They belonged to almost all walks of life including vendors, teachers, workers, students, ordinary housewives, and businessman. A structured interview was conducted among the fifty respondents guided by a specifically prepare questionnaires.

4. RESULTS AND DISCUSSION

4. 1. Structure

Table 1 implies that respondents viewed structure as very adequate. This is because DPWH personnel maintain their monitoring and supervision on the specified location through the DPWH post located along España, in front of University of Santo Tomas (UST).

Table 1. Frequency distribution of adequacy of structure

Adequacy of structure	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Monitoring and supervision of maintenance from the Regional office	37	13	0	0	50
2. Response for the implementation of the project	41	9	0	0	50

4. 2. Management

Table 2. Frequency distribution of adequacy in management

Adequacy in management	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Planning	9	33	6	2	50
2. Setting of goals to be followed	8	31	9	2	50
3. Establishment of goals procedure	4	6	35	5	50

Table 2 implies that respondents indicate as adequacy both “planning and setting of goals to be followed” are adequate and “establishing of goals and procedures” are less adequate, this is due to the budgetary constraint.

4. 3. Personnel

Table 3 implies that respondents indicate as very adequate in “proper training and motivation of personnel involved in the project”.

Table 3. Frequency distribution of adequacy of personnel

Adequacy of personnel	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Availability of the skilled worker	41	9	0	0	50
2. Proper training and motivation of the personnel involved in projects	44	6	0	0	50

4. 4. Financial Resources

Table 4 implies that respondents viewed "sufficiency of financial resources" as inadequate, this may be due to the budgetary constraints that will eventually affect the implementation of the project since the Philippines is facing the financial assistance distress due to peso devaluation

Table 4. Frequency distribution of adequacy of financial resources

Adequacy of financial resources	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Sufficient of financial resources	0	0	4	46	50
2. Availability of the funds for the implementation of projects	32	17	1	0	50

4. 5. Technical

Table 5 implies that respondents viewed “personnel technical expertise and assistance, and guidance” as very adequate but it is not enabled to execute model work with the aim of the technology transfer, this is due to the budgetary constraints.

Table 5. Frequency distribution of adequacy in technical

Adequacy in technical	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Technical expertise	38	12	0	0	50
2. Technical assistance and guidance	33	17	0	0	50

4. 6. Maintenance and Operation

Table 6 implies that respondents indicate as adequate in "repair and rehabilitation of the equipment, pumps, and electric motor" which may be due to the government agencies concerned which are not prioritizing the allocation of the budget, maintenance, and care of the equipment. Likewise due to budgeting constraints, "actual budget for the equipment" is inadequate. Maintenance has been considerably reducing the impact of which will eventually affect the level of equipment available for the repair and maintenance.

Table 6. Frequency Distribution of Adequacy in Repair and Rehabilitation

Adequacy in repair and rehabilitation	Very adequate	Adequate	Less adequate	Inadequate	Total
1. Pumps	11	39	0	0	50
2. Engines	17	33	0	0	50
3. Electric motors	14	36	0	0	50
4. Budget for the equipment	0	0	20	30	50

4. 7. Reduction of Volume of Floodwater

Table 7 implies that respondents indicate “availability of equipment and other facilities” and, viewed “removal of sediments” as satisfactory.

However, “sufficient of financial resources” as unsatisfactory, this is due to the lack of funds or budgetary allocation since the Philippines has fallen to the financial distress.

Table 7. Frequency distribution of satisfaction in reduction of volume of floodwater

Reduction of volume of floodwater	Very satisfactory	Satisfactory	Uncertain	Unsatisfactory	Total
1. Availability of equipment and other facilities	18	32	0	0	50
2. Removal of sediments	13	37	0	0	50
3. Sufficient final resources	0	0	9	41	50

4. 8. Reduction of Flood Damage

Table 8 implies that respondents indicate that the "improvement of the drainage will reduce damage to houses and public facilities, and private properties" as satisfactory, this is because of the contribution to the improvement in the life of a large number of people.

Table 8. Frequency distribution of satisfaction in reduction of flood damage

Reduction of flood damage	Very satisfactory	Satisfactory	Uncertain	Unsatisfactory	Total
1. Reduce damage to houses and public facilities	17	33	0	0	50
2. Reduce damage to private facilities	15	35	0	0	50

4. 9. Economic Aspects

Table 9 implies that respondents viewed the "stimulate the economy through the stabilization of the people livelihood" as satisfactory. However, "restore existing drainage" is unsatisfactory; this is because of the sediments from the waste disposal that blocked the drainage which causes flooding.

4. 10. Health

Table 10 implies that respondents viewed "health" as satisfactory. Most of the respondents feel that dredging and undocking of the existing drains will result in the removal of the foul odor which causes the epidemics leading to the improvements of the sanitary condition of the residents

4. 11. Traffic

Table 11 perceived that "public convenience safety" is satisfactory. However, "helping to remove the traffic congestion" as uncertain; this is because of heavy traffic will occur resulting from long term storm water inundation.

Table 9. Frequency distribution of satisfaction in economic aspects

Satisfaction in economic aspects	Very satisfactory	Satisfactory	Uncertain	Unsatisfactory	Total
1. Stimulate economic through the stabilization of the people livelihood	4	46	0	0	50
2. Restore existing drainage	0	0	9	31	50

Table 10. Frequency distribution of satisfaction in health

Satisfaction in health	Very satisfactory	Satisfactory	Uncertain	Unsatisfactory	Total
1. Reduce epidemic infection	4	46	0	0	50
2. Raise level of awareness for the need of sanitation	0	0	9	31	50

Table 11. Frequency distribution of satisfaction in traffic

Satisfaction in traffic	Very satisfactory	Satisfactory	Uncertain	Unsatisfactory	Total
1. Help erase traffic congestion	2	1	34	13	50
2. Public convenience safety	7	33	4	6	50

5. WASTE WATER MANAGEMENT SYSTEM

To function properly, stormwater drainage systems must be kept in good working order. Homeowners' Associations, property managers, and residents play a role in managing flood situations by becoming familiar with the drainage system in their own area and taking action when needed. Just as northerners check their heating systems prior to weather conditions, those who reside in depressed areas in Metro Manila should inspect, maintain and repair drainage systems before the rainy season. Inspections should be repeated when a major storm threatens. As shown in Figure 2, the following statements should concern citizen do:

- Find out if neighborhood system is inspected regularly.
- Check to see if trash, dead vegetation and sediments are being removed.
- Become familiar with the permits that authorize drainage in owns area
- Note the changes that may go beyond the specifics or intent of the permit
- Keep a record of the names, addresses and phone numbers of the local drainage district, etc. to report potential problems

Figure 2. Wastewater management system

6. RECOGNIZING DRAINAGE PROBLEM RESIDENTS

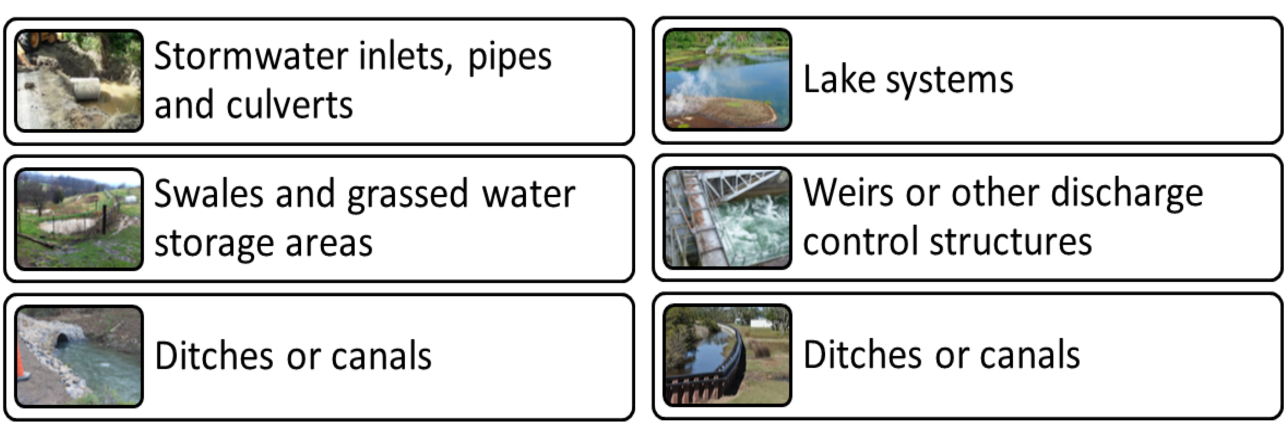

Figure 3. Components of the drainage system

Residents, property managers, or contractors should periodically check the components of the drainage system to ensure peak performance. As shown in Figure 3, inspections should include

6. 1. Stormwater inlets, pipes, and culverts

Grates should be unobstructed and sediment under the grate should be removed. Pipe openings and connections to culverts should be free of sediment, trash, and debris.

6. 2. Swales and grassed water storage areas

Swales may need to be regarded or replanted. It is a good idea to compare the existing slope to the permitted design plan before the work begins. All heights, depths, and lengths of side slopes must meet permit specifications. Grassed swales also require regular mowing, and undesirable exotic vegetation should be removed trash, sediment, and dead vegetation should be completely removed and properly disposed of so it won't affect any other water conveyance system or water storage area. Right-of way clearances should remain open and unobstructed.

6. 3. Ditches or canals

Trash, sediment, and dead vegetation should be completely removed and properly disposed of so it won't affect any other water conveyance system or water storage area. Right-of way clearances should remain open and unobstructed.

6. 4. Lake systems

Trash and dead vegetation should be cleared from the shoreline. Shoreline grasses should be mowed unless it is a wetland preserve. Side slope erosion or washouts on the banks should be repaired and replanted. Pipe or culvert connections between lakes should be clear and open.

6. 5. Weirs or other discharge control structures

Check for obstructions. Anything that hinders water flow should be removed. The structure should have a "baffle" or trash collector to prevent flow blockage and hold back floating oils and debris from moving downstream.

6. 6. Dikes and berms

Worn-down berms and rainfall-created washouts should be immediately repaired, compacted and replanted in compliance with the permit

7. CONCLUSIONS

Different wastewater management and inspection of the components of drainage system adopted in Metro Manila hold one thing in common. It is that they reflect the communities' visions of themselves. Communities must be aware of their risks and plan accordingly, weighing mitigation alternatives with community needs. Also, the decision-making process is largely energized by the availability of funding, the need for a short term of the rate of return, and the direct impacts on society, whereas the indirect social aspects and the sustain ability of the flood-protection schemes are usually forgotten. Moreover, the environmental impacts that are consequent on the application of any measure are considered a governing factor in the selection of the measure especially in this age of environmental awareness and conscientiousness. It was recommended that a thoroughly examined combination of the measures can minimize the flood losses as much as possible since every wastewater management system has benefits and harms to the flood-prone communities.

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