HanzeKenniscentra
University of Applied Sciences

NoorderRuimte

Hanzehogeschool Groningen

# Clean Water Manila

## Improving water quality in the Pateros river

Image: Pateros river ©SK


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Civil Engineering

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Group number: 40

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# Clean Water Manila

**Bachelor thesis Civil Engineering**

**S. Kloppenburg**

Research for the improvement of the water quality in the Pateros river in the Philippines.

Initial project which made Clean Water Manila possible:

# Flood Free Manila


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# Pre-face

During my bachelor civil engineering I got the pleasure to work with many different people and join them in all kinds of projects. One of these projects is my bachelor thesis. My thesis project is called CWM (Clean water Manila) but the project that brought me to the Philippines is called FFM (Flood Free Manila). With the FFM project I got the opportunity to go to the Philippines together with other students from different universities. With the FFM project and in the Philippines I had a great time and learned many things such as stepping outside my comfort zone and what it requires to do a proper research. Much of the information I was able to obtain during the FFM project I am able to use within my own CWM project. I am grateful for the opportunities given and with this report I will show what I made from these opportunities and the information obtained to complete the CWM project.

## Summary

Manila has experienced exponential growth in residents and city-area. This growth has led to problems such as flooding and pollution. Pateros, a river in Manila, experiences pollution and flooding caused by the growth in Manila. To think of solutions the Filipino club named Rotary club started the IWASTO project (which means to correct and prevent). Part of the IWASTO project is the involvement of Dutch and Filipino researchers for a Flood and Pollution Free Manila project. That was the birth of the Flood Free Manila (FFM) project. Leading from the FFM project is the Clean water Manila (CWM) project. The FFM project has the focus on solid waste and the CWM project has the focus on wastewater.

The objective of the CWM project is to improve the water quality of the Pateros river in Manila. Due to the large subject of water quality, the focus is put on the source of the wastewater pollution. Literature and field research provides the background information to create the state of requirement. The state of requirements will be used for the selection process between the possibilities. The best solution will be designed in detail. In order to evaluate the finished design, additional assessment points will be created.

The mandatory requirements include the subjects; costs, simplicity, water quality and trueness to the focus of the CWM project.
The additional assessment points include the subjects; Aesthetics, illegal settlers, cooperation with nature and locals and flooding.

The best solution is the wastewater gutter. The wastewater gutter collects wastewater in a gutter system before the wastewater enters the Pateros river. Three detailed designs based on the wastewater gutter will be compared using the assessment points and state of requirements. The three designs are called the Closed River Wastewater Transport (CRWT), Green Open Wastewater Transport (GOWT) and Minimized Open Wastewater Transport (MOWT).

Using the state of requirements and assessment points in a multi criteria analysis (MCA) it is determined that the three designs are all viable but one design does has the preference. This is the MOWT.

The MOWT has the lowest costs and best overall performance.

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# 1. Introduction

This report is the written result for the CWM (Clean Water Manila) project. The CWM project is a bachelor thesis in which research has been done on how to improve the water quality in the Pateros river in the Philippines. Shown in this report will the process of the research and the final result. The build of the report follows the standard build. Starting with the introduction which contains background information and the objective of the research. Following the introduction is the design, execution and results of the research. At the end will be the discussion, recommendations, references, abbreviations, a glossary and the necessary appendices.

# 2. Project background

The republic of the Philippines (or just Philippines) is a country in southeast Asia with a tropical climate (Image 1). The Philippines location on the tectonic plate near the equator makes the country prone to earthquakes and typhoons. Nevertheless is the population of the Philippines over 100 million (census 2015) and still a vastly growing country.

Image 1: Manila location (©Google maps)

According to the national statistics office (2014) the Philippines consist out of roughly 7500 islands, 18 regions and 81 provinces. The largest region is Metro Manila and the largest city is Quezon City (located in Metro Manila).

## 2.1 Metro Manila

Within Metro Manila lies a total of seventeen cities and municipalities including: City of Manila (the capital of the Philippines), Quezon city, the municipality of Pateros and the cities of Makati, Taguig and Pasig.

From the moment of establishment in 1975 (Presidential decree 1975) Metro Manila has shown exponential growth in population coming to almost 13 million people in 2015 without showing signs of stopping in growth (Image 2). The infrastructure that was not able to keep up with the large growth in urbanisation, combined with an unforgiving tropical climate caused problems within Metro Manila. These problems range from pollution (in air, water and general nature) caused by the high density population to flooding caused by tropical storms striking urbanised area.

Metro Manila is still a developing country and as time passes by the Filipino people begin to change their behaviour, thought process and infrastructure to do something about the many different problems that occur in Metro Manila. These changes can come in the form of projects, including the current CWM project focused on the Pateros river located in Metro Manila.

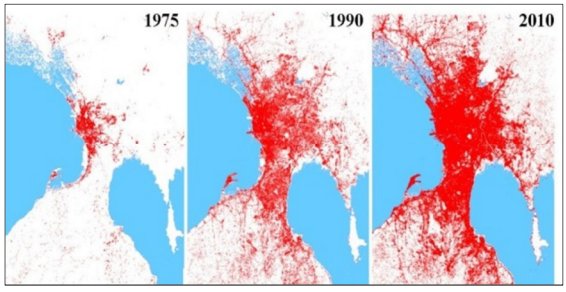


Image 2: Metro Manila growth (©Charlotte)

## 2.2 Pateros river

The Pateros-river is a river in Metro Manila that runs through the three cities Makati, Pasig ,Taguig and the municipality of Pateros (Image 3). The river has a length of nine kilometres and begins as an exit from Laguna de Bay flowing into the Pasig river towards the sea. The Pasig river is one of the largest rivers in Metro Manila, flowing from Laguna de Bay into Manila bay. Laguna de Bay is the largest freshwater lake in the Philippines (Laguna lake development authority, LLDA). Currently the Pateros river is overgrown with water hyacinths, filled with solid and liquid waste, high flooding rate area and home to many illegal settlers.

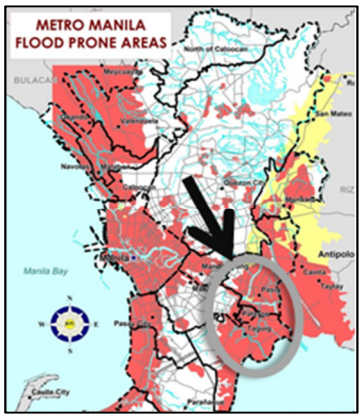



Image 3: Pateros river in Manila

### 2.2.1 Illegal settlers

Quoting from to the Presidential decree no. 1067 December 31, 1976. Article 51:

*"The banks of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters… …No person shall be allowed to stay in this zone longer than what is necessary for recreation, navigation, floatage, fishing or salvage or to build structures of any kind."*

People that live within this three meter zone are considered illegal settlers. The Pateros river contains a large number of illegal settlers (Image 4). The law is poorly enforced allowing illegal settlers to remain in the river bed. The majors de not want to lose voters due to receiving feedback from the illegal settlers not much change is seen. There was an attempt at relocating the illegal settlers outside the city but due to work and family being located within the city the illegal settlers have no intention of moving away.

The illegal settlers are in danger because they live too close to the river in a high flooding area. At the same time the illegal settlers are part of the problem. Illegal settlers are dumping waste (solid and liquid) into the Pateros river. The legal residences within the Pateros river area are just as guilty as the illegal settlers of throwing waste into the river, but since the illegal settlers are living outside of the standard infrastructure (since they are illegal) it is difficult to prevent the pollution from occurring and improving the water quality.

Image 4: Illegal settler Pateros river (©SK)

### 2.2.2 Water quality

There is a large amount of visible solid waste in the Pateros river and the water has a dark colour. Additionally there is an overwhelming amount of water hyacinths. The solid waste, liquid pollutants and overwhelming water hyacinths are some of the causes for a river which is uninhabited by fish and ducks and causes sickness for the residences that use the water.

### 2.2.3 Flooding

The Pateros river and the region around the river is a delta area which means the area is relative low compared to some other areas in Metro Manila (source Noah project map). According to the tagalog dictionary, backlash in the Pateros river flow during high tide in Laguna de Bay combined with heavy rainfall causes heavy flooding in the area around the Pateros river. The flooding is a danger for the residences, causes damage to buildings and spreads sickness due to polluted water. Flooding near the rivers occur on a regular basis (Flood maps for 5 and 25 year rain event is shown in appendix 8).

### 2.2.4 Project origin

In order to improve and clean up the Pateros river the Filipino club named the Rotary club (which has big influences in Manila) started up a project called IWASTO (which means to correct and prevent) . During the kick-off of the IWASTO project on November 2015 a MoU (Memorandum of Understanding) was signed on the involvement of Dutch and Filipino researchers and young professionals for a Flood and Pollution Free Manila project. This agreement would improve the collaboration between the Dutch and Filipino universities on the fields of climate adaptation and urban planning.

Leading from the MoU is the FFM (Flood Free Manila) project where Dutch and Filipino universities work together in a joined project. Within the FFM project the students had one week to design and present a possible solution that will tackle one of the multiple problems within the Pateros river (Appendix 1: Flood Free Manila). In addition to the FFM project the CMW project begin. The CWM project involves the same river as the FFM project but focusses on water pollution caused by wastewater.

# 3. Research design

The CWM (Clean Water Manila) research is to address the issue of water pollution in the Pateros river. Below is descript the objective of the project, pre-set requirements for the project and how a proper result will be achieved.

## 3.1 Objective

The objective of the CWM project is to create a written solution for the local government in Manila that will improve the water quality in the Pateros river. This solution can range from a concrete design within the river towards a community approach outside the river. Due to the broad subject of water quality the solution will focus on liquid waste. The solution will have to follow the pre-set requirements described below. Other requirements will be researched within CWM.

With the large number of possibilities within the subject of water quality a focus will be put on tackling the source. In order to improve the water quality there are roughly two possibilities. Either the solution tackles the source of the pollution or the solution accepts the pollution entering the river and tackles the improvement of the water inside the river. Due to the belief that prevention is better than restoration the focus for the CWM project will be on tackling the source of the pollution.

## 3.2 Pre-set requirements

Before the start of the research there are a number of pre-set requirements for the project result. These requirements are made in collaboration with the client dr. ir. F.C. Boogaard.

The first requirement is that the project needs to be unique and useful. Unique so that the project will not be a copy or minor variation from an existing finished project. This way the CWM project has a meaning outside of study purposes. When the result of the CWM cannot be used by the local government in Manila the result of the CWM project is useless and CWM loses its purpose of existence. In order to prevent this from happening the results is required to be understandable and applicable in the local environment of the Pateros river.

What the client wants to see as a result of the CWM project is: '*A minimum of one in detailed finished solution taken out of a pool of different solutions.'* The detailed finished solution and the process that created the solution should be understandable, traceable and visual appealing.

# 4. Main question

Leading from the pre-requirements, objective and background information the main question for the CWM project is as following:

***How can the water quality of the Pateros river be improved with a solution that is understandable and visual appealing for the people in Manila in order for themselves being capable of implementing the solution?***

The goal of the CWM project is to improve the water quality of the Pateros river. The solution that will fulfil this goal has to be executed by the local people in Manila. In order to achieve this goal two things are important. The locals in Manila need to be technically able to implement the solution and the wiliness to take action and physically realise the solution.

## 4.1 Sub-questions

In order to find an answer to the main questions there are a number of sub-questions. These sub-questions will aid in the creation of a detailed solution. Each sub-questions is followed with an annotation which contains the method of execution and expected result.

1. ***How can the local citizens of Manila get involved in the CWM project?***

**Method:**

During the FFM project there is a collaboration with a local university in Metro Manila. This collaboration and the FFM research can provide contact with the local citizen in the Pateros area. During a study trip to the Philippines these contacts with locals can be used to do interviews with stakeholders and conversations with locals in the area.

**Result and expected product:**

The result will be new contacts and interviews. The newly obtained information will be used in the CWM research in order to answer the sub-questions. The local citizens of Manila serve as input for this information.

2. ***What is the current situation with the water quality of the Pateros river?***

**Method:**

The current situation with the water quality will be estimated with observations and literature research. This method will aid in determining the sources of the pollution and will give insight in the current situation of the river.

**Result and expected product:**

The ending product will be an understanding of the situation combined with literature and numbers.

3. ***What is the state of requirements for the solution to improve the water quality in the Pateros river?***

**Method:**

Using the network resulting from sub-question one, it will be possible to make contact with locals from the Pateros river area and do interviews with stakeholders. Combining the obtained knowledge from the locals and stakeholders with literature research and the pre-set requirements from the previous chapter it will be possible to make a state of requirements for the result of the CWM project.

**Result and expected product:**

The result will be a list of requirements for the final solution which will serve as a weighting stone for the comparison and scoring of the different solutions.

4. ***What is causing pollution in the Pateros river?***
    a. *Which pollution streams end up in the Pateros river?*
    b. *What are the sources of pollution in the Pateros river?*

**Method:**

There are two parts to this sub-question. The first part is the research on the current waste management system. Knowing the flow of the waste, potential bottlenecks can be discovered. Through means of observations and interaction with locals in the Pateros river area it is possible to see if the waste management system functions or not. With the knowledge of the waste management system the second part can be addressed. The research to the situation with the water quality will give an understanding for the biggest sources of pollution.

**Result and expected product:**

The result will be a list of pollution sources that pollute the Pateros river. Using this result can help focus the solution for pollution down to the most influential source.

5. ***What level of water quality does Metro Manila aim for in rivers?***

**Method:**

Through means of literature, references and interviews it will be deducted what for quality Metro Manila wants for its rivers. Additionally a meeting with a city mayor can assist with receiving information.

**Result and expected product:**

The result will be an understanding for the minimum water quality level to aim for and what for water quality in Metro Manila is considered normal.

6. ***How can the local environment of the Pateros river contribute to the improvement of the water quality in the Pateros river?***

**Method:**

In the design process for the solution it is beneficial to make optimal use of the surrounding environment. This reduces costs and increases the involvement with the Pateros river area. The best means to achieve this is through visual inspection of the river and interacting with locals in Metro Manila.

**Result and expected product:**

The result will be a solution for the Pateros river water quality that cooperates with the local environment. Increasing the involvement of locals and creating an aesthetic appealing solution.

7. ***What are understandable and visual appealing presentation techniques?***

**Method:**

With literature research and hands-on experience techniques can be learned that will teach how to present a solution in an understandable and visual appealing manner.

**Result and expected product:**

The result will be knowledge in presentation techniques and experience with presenting in a formal setting.

8. ***What are the estimated costs involved with the solution that would improve the water quality of the Pateros river?***

**Method:**

Finances will influence the decision process for the solution to the water quality. Ideally the cost estimation should be with Philippine pricing, but it is possible to use Dutch prising and focus on the comparison. Using Dutch pricing will provide an estimate price but will not give an exact number.

**Result and expected product:**

The result will be an estimation for the costs that are involved with the execution of the solution that would improve the Pateros river. This cost estimation will be based on a detailed solution where the costs will be numbers for comparison purposes.

9. ***What for alternative solutions are there that will improve the water quality of the Pateros river?***

**Method:**

Solutions that will improve the water quality in the Pateros river can range from a concrete design within the river towards a community approach outside the river. The differences between the solutions will be evaluated. The method to create the different solutions will be a quantitative research which uses the feedback from locals and the best practise method.

**Result and expected product:**

The result will be a long list of solutions possible that will impact the water quality of the Pateros. from this list there will be multiple selections to decide which solutions to expand upon and finalize.

# 5. Method

The CWM (Clean Water Manila) research will start with a qualitative research. Using observations and interviews to design different possible solutions that will improve the water quality in the Pateros river. This method involves the locals in the Pateros river area to provide local input, ensuring a solution that is executable by Metro Manila. The FFM (Flood Free Manila) project helps realise this through the means of connections with stakeholders. With connections from the FFM project questionnaires can be used to obtain knowledge from stakeholders in the Pateros river area. The result from the qualitative research will be multiple solutions that tackles the water quality problems of the Pateros river.

After the assessment of the multiple solutions from the qualitative research a small number of solutions will remain. These few solutions will be compared through the means of a quantitative research. This quantitative comparison will be done with a detailed design, cost calculation and a multi criteria-analysis (MCA).

## 5.1 Flood Free Manila

FFM is a project in Metro Manila where a group of students from different universities have one week to design and present a possible solution that will tackle one of the multiple problems within the Pateros river. The focus area is the Municipality of Pateros. Within the FFM project multiple connections with stakeholders are made which will provide the opportunity to use those same connections for the CWM project. Additionally, the presentation for FFM provide hands on experience regarding presentation skills and delivering a design in a understandable and appealing manner (Result from the FFM project is in appendix 1 and 2).

## 5.2 Project area

The Pateros river is a river with a length of nine kilometres and flows through four different areas of Metro Manila. The large scale of the area and the small time frame in the Philippines requires a project focus area to ensure a good quality solution for the water quality. The focus area will be the Municipality of Pateros. Reasoning for choosing Pateros is as following.

A large part of the Pateros is connected to the Pateros river (hence the name of the river). This makes visual inspection convenient as it is possible to stay within a single municipality. Secondly, the project area for the FFM project is Pateros. The overlapping project area makes it possible to share the information and connections between the FFM project and the CWM project.

## 5.3 Questionnaires

Using the connections from the FFM project it is possible to interview stakeholders to obtain information. This is a great way to involve the locals in Pateros with the project and it can provide valuable information for the sub-questions. It can help discover the current waste management system, discover sources of pollution, what for idea’s the stakeholders have to improve the Pateros river and helps create the state of requirements for the solution (Full questionnaire in appendixes 3, 4 and 5).

## 5.4 Referencing rivers in Metro Manila

There are many rivers in Metro Manila. Some appear to be cleaner than others. Researching other rivers in Metro Manila will provide information about the process of improving the rivers for other cities and what for quality the locals in Metro Manila are satisfied with. A visit to the Mayor of a city provides additional information regarding the measures against polluted rivers.

## 5.5 Long list

A mind map in the form of a list will assist with the creation process. This list is made during the qualitative research and is called the long list due to the long amount of possibilities it contains. The different possible solutions to the water quality will be evaluated based on the mandatory requirements from the locals in Pateros. The different possibilities, which can range from a concrete design within the river towards a community approach outside the river, will be made based on the information gathered through: literature research, interviews, visual inspections and the interaction with the locals of Metro Manila. Flowing from the long list will be a small number of possible solutions for the quantitative research.

## 5.6 Overlap other thesis projects

Within the FFM project there are three thesis projects including the CWM project. The other two thesis projects are done by Ch. E de Jong (A waste resistant urban drainage system) and J.D. Prabowo (Pateros River Rehabilitation in Reference of its Capacity, Maintenance, and Sustainability). These three projects involve the same Pateros river and the three students contributed to the FFM project.

There is overlap within these three thesis projects. The overlaps are shared stakeholders, the focus area and the river. This allows for river data, findings regarding the river and connections to be shared. Combining all the questions into a single questionnaire will increase the success rate in receiving answers from the stakeholders.

# 6. Literature review

## 6.1 Municipality of Pateros

With a population of 63 840 people (census 2015) and an area of 1.76 km$^2$ Pateros is the smallest independent area of Metro Manila and the only municipality (Image 5). With a density of thirty-six thousand people per square kilometre Pateros is the second most dense area in Metro Manila. The west side is bordered by the Pateros river and due to Pateros being a delta area there is flooding every couple years. Within Pateros there are 10 barangays varying in size.


Image 5: Pateros (©Google maps)

### 6.1.1 Scenery, history & economy

Pateros has a scenery free from skyscrapers and the tallest buildings are two floors high. This setting gives a rural feeling of locals playing around, working and doing their own things. Pateros is not a tourist depended area and western people are a rare view. Pateros is famous for their duck raising industry from the past (no ducks reside in the Pateros river anymore) and the Balut eggs (Image 6). Other well know products are: Red salty eggs, Inutak (local rice cake) and Alfombra footwear (Type of slippers). Currently the Balut eggs are import eggs from Laguna de Bay since there are no ducks or fish living in the Pateros river.

Image 6: Historical Pateros river painting (©SK)

### 6.1.2 Internal relation

Pateros is according to an ABC-CBN News report poorer than the surrounding cities in Metro Manila. This is causing internal struggles between the involved cities and the municipality. The cities connected to the river do not want to spend money based on how much money they have but on how much the river effects the city. Since Pateros is the largest area connected to the Pateros river, Pateros is expected to invest an large amount of money even though Pateros is the poorest of the cities involved.

There are more struggles between the involved parties. The mayors of the cities and the barangay captains are blaming each other for polluting the river. Due to waste in the river flowing freely through different cities and barangays, the barangay captains and mayors have the feeling they are cleaning up waste caused by neighbouring cities. According to the vice president of the Rotary club it took them half a year to get all the involved barangay captains and mayors together and talk without needless arguing and accusations.

## 6.2 Waste management

### 6.2.1 Solid waste

According to captain [redacted] (Barangay captain in Pateros, interview notes in appendix 4) there is currently a system in place for the collection of waste. The system boils down to the residents having the opportunity to bring waste to collecting points where small vehicles can collect the gathered waste from the locals and bring it to a garbage disposal area. Even though there is a system in place for the collection of waste, the garbage that is supposed to be collected ends up in the streets and river. The result is a polluted Pateros river.

The solid waste lingering in the streets glugs the gutters and drains. Glugged gutters and drains are disadvantageous when trying to prevent flooding. Fighting flooding by fighting solid waste is a focus point for the Flood Free Manila (FFM) project. The FFM project fights and prevents waste from the river and streets by raising public awareness and clean up actions organised by the Rotary club.

The Clean Water Manila (CWM) project does not aim at improving flooding or removing solid waste but the solid waste does potentially influence the CWM solution at improving the Pateros river. Solid waste is a pollution source that influences the water quality (which will be discussed in the next chapter) and the solid waste can cause glugging for the solution.

### 6.2.2 Organic waste

In one barangay there is currently an organic waste processing facility where organic waste is processed into compost. There is only one barangay which uses an organic waste processing facility due to space limitation and that composting is a new idea for Pateros. This means there is organic waste going into the Pateros river, but not as much as before the processing facility.

The organic waste which does not go to a processing facility follows the same path as the solid waste described above. A major difference is that the organic waste will decompose in the river. If there is no organic waste going to the Pateros river, the existing organic waste inside the river will eventually decompose.

Similar as the solid waste does the CWM project not aim at removing and preventing organic waste entering the Pateros river. Organic waste can potential glug the solution and will have an impact on the water quality of the Pateros river. Due to the similarities in organic waste and solid waste, starting from this chapter the solid waste will include the organic waste and will be seen as a single problem instead of two separated.

### 6.2.3 Wastewater

One of the pollutant sources in the Pateros river is wastewater from the sewage. After attempts to recover information from the MMDA it was discovered that the current knowledge about the sewage system is very limited. With literature research from the Environmental Management Bureau and observations at the Pateros river the following situation is assumed for the wastewater.

The wastewater coming into the Pateros river is from houses in the area. No wastewater from the industry or other business related companies flow into the river. The wastewater that enters the Pateros river is mostly untreated. There are houses that use septic tanks but the majority is untreated wastewater. This leads to the creation of image 7;

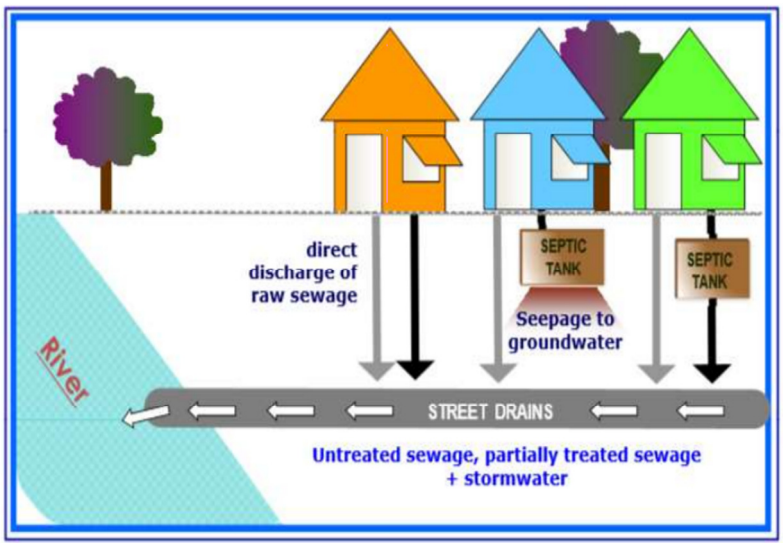



Image 7: Wastewater management in the Philipines (©Lormelyn E. Claudio)

Water entering the Pateros river is a mixture of raw sewage, semi treated sewage and stormwater. The stormwater can contain solid waste creating a mixture of solid and liquid waste. According to Jan Spit who wrote a paper on sanitation technologies, liquid waste containing raw or poorly treated sewage from houses contains bacteria which causes sickness for humans. Tackling the problem of wastewater means intervening the waste flow at the houses, in the street drains or at the river.

### 6.2.4 Industry and business

A heavy pollutant for many rivers is untreated industrial waste discharging into the river. According to Laguna Lake Development Authority (LLDA) and Tagalog Dictionary the only industries in Pateros that discharge into the Pateros river are the following:

- Nutri-licious Food Corporation - fruit juice, processed fruit, and purified water manufacturer;
- Reed and Decker Industries, Inc. - paint manufacturing;
- Ballet Plastic Packaging - plastic bottles manufacturing; and
- Lavandero Industrial, Inc. - laundry services.

The industries listed do not contain heavy industry, which is in line with the statement made by the vice president of the rotary club stating that there is no heavy industry in Pateros.

The discharge by the industries located in the Pateros river area are a potential source of pollution. The LLDA monitors and regulates the allowed discharge sewage effluent for industries. In a report posted by the LLDA it is stated that the industries listed above do not dispose sewage effluent beyond the set standard.

As there is no heavy industries and the smaller industries are regulated and do not discharge sewage effluent beyond set standards the industry is not an issue for the water quality in the Pateros river.

## 6.3 Water quality

There is knowledge on polluting sources for the Pateros river. The polluting sources do not solely indicate the state of the water quality inside the Pateros river. Other indicators for the current water quality are observations and reference rivers.

### 6.3.1 Observations Pateros river

The observations are evaluated with a Dutch tool called Biotoets used in the Netherlands. The biotoets is used in the evaluation of water quality for rivers. Based on five characteristics (Colour, Smell, plants, vision depth and Water depths) an evaluation is made. Each characteristic is scored which accumulated gives a final score for the water quality (The higher the score, the better the water quality). The evaluation is based on observations which is ideal for this situation. Other observations which indicate a level of water quality will be looked at after the Biotoets.

There will be looked at two different situations present in the Pateros river. Situation one where the entire river is overgrown with plants (image 8) and situation two where there nearly no plants present (image 9).

Image 8: Pateros river overgrown with plants. (©SK)

Image 9: Pateros river with nearly no plants. (©SK)

***Water colour***

The water colour in both situations is in between a dark grey and black colour. The only location where the colour had a lighter green colour was a small place inside the river where the river current was relative high and the water was forced through the plants. As soon as the water with the green colour joined the rest of the river it returned to a dark grey / black colour.

According to the Biotoets, a dark gray / black colour receives a score of 1 out of 3 points. This is a low score but depending on the other characteristics it does not have to indicate anything.

***Smell***

During the time of observation a sewage like smell was observed. The smell was not demandingly present, but according to the locals who live there the smell is usually a lot worse. The Biotoets has a clear distinction between an unpleasant smell or no smell. Since an unpleasant smell was observed the score is a 0 out of 1.

### *Plants*

There are two situations in the Pateros river. The first situation where the Pateros is overgrown with plants (image 8) and the second situation where there are barely no plants present (image 9).

In the first situation there are no river bank plants, considering the river bank is a concrete wall. However the river is overrun with plants. The plants are mostly water hyacinths, mixed with grass in some areas. Water hyacinths, which are the fastest growing water plants in tropical countries, are a double edged sword for a river. Controlled water hyacinths purify rivers by extracting nutrients from the water, reducing algae growth and providing cover for varied organisms. Excess water hyacinths that are removed can be used in the production for products such as organic sandals, bags and mats. In an uncontrolled situation (the Pateros river) the water hyacinths provide too much shade, preventing any growth of algae and reducing the oxygen levels below the required amount for organism such as fish to survive.

The second situation is rather bare. No plants can indicate an environment unfit for plants to grown and with no plants there is less shade on the river and less cover for animals.

According to the Biotoets, both the first and second situation receives a score of 5 out of 13 points. For a river it is not a good indication to have no plants, but at the same time an overrun amount of plants is equally bad.

### *Vision depth and water depth*

Based on the observations made from the Pateros river it can be said that the vision depth in the water ranges from 5cm up until 35cm depth. The Biotoets groups vision depths into: less than 25cm, 25 – 50 cm and more than 50cm vision depth. On average the Pateros river has a vision depth below 25cm. A low vision depth is a bad indication for a river, indicating pollutants and other material floating in the water. According to the Biotoest, below 25cm is a score of 1 out of 3 points.

### *Solid waste*

The next observation is the large amount of solid waste. Throughout the whole river there is a clear vision of garbage and solid waste (Image 10 and 11). This reduces the water quality due to creating an imbalance in the river eco system and adding unnatural products in the river which are harmful for animals.

Image 10: Solid waste in Pateros river (©SK)

Image 11: Solid waste in Pateros river (©SK)

### *Water animals*

The last important observation is the lack of animals. There are flies and mosquitos, but no fish, ducks or other swimming animals that would be expected from a river. Besides the plants and bugs there appears to live nothing inside the Pateros river. Fish and ducks require healthy river with a bare minimum of food, shelter and oxygen. Considering the Pateros river does not contain many fish and ducks there is a basic need that the animals are missing in order to live in the Pateros river.

### *Conclusion*

The accumulated score for the Biotoest is 7 points out of a potential 20 (With a minimum of 5 points) which is a bad score. The evaluation based on the observation indicates a bad river water quality. The result of the Biotoets is in line with the other observations such as the lack of animals and the vast amount of solid waste.

### 6.3.2 Reverence water quality

Aside from observations it was not possible to receive trusted data about the Pateros river water quality. To make a statement about the water quality it will be looked at referencing water bodies in Metro Manila. Connected water bodies will share characteristics in water quality. Connected to the Pateros river is the Pasig river and Laguna de Bay. These two water bodies are directly related to the Pateros river which allows to make a statement on water quality in the Pateros river based on the data available from the Pasig river and Laguna de Bay.

The water in the Pateros river comes from Laguna de Bay and flows into the Pasig river. There are multiple rivers flowing into the Pasig river, however the scenery in the Pasig river resembles the Pateros river and since the two water rivers are connected, there is a direct relation in water quality between the Pasig river and the Pateros river.

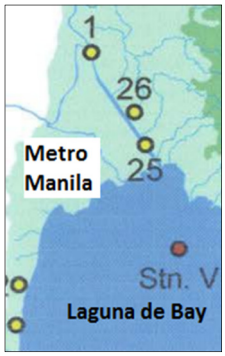


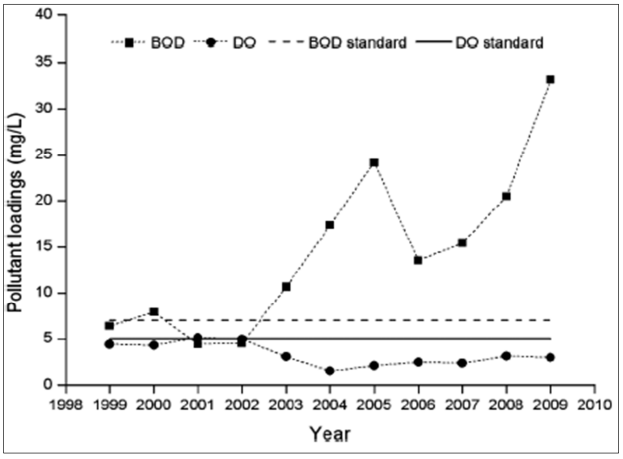

Image 12: Measure points (©LLDA)

Following is data about the water quality in Laguna de Bay and the Pasig river (Based on data form the Laguna Lake Development Authority (LLDA), Kongju National University and Pasig monitoring report (Larger graphs in appendix 7).

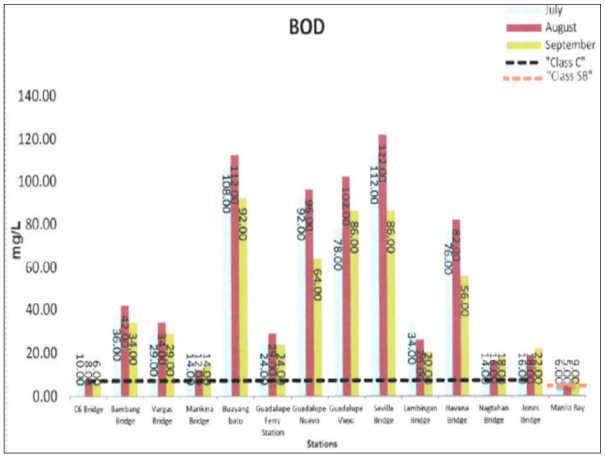
*Average of oct, nov, dec. 2015*

| **Measure point (Image 12):** | **pH (Units)** | **BOD (mg/L)** | **DO (mg/L)** |
|---|---|---|---|
| Stn. V (Bay area) | 8.0 | 3 | 6.8 |
| 25 (Manggahan Floodway (Tatay)) | 7.3 | 11.7 | 0.6 |

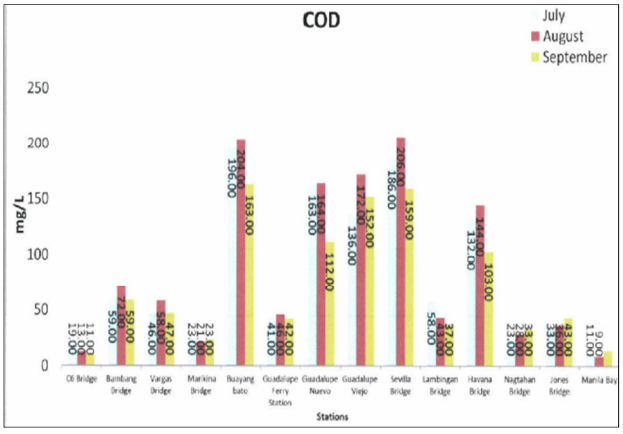
Table 1: Laguna de Bay water quality (BOD = Bio chemical oxygen demand, DO = Dissolved oxygen)



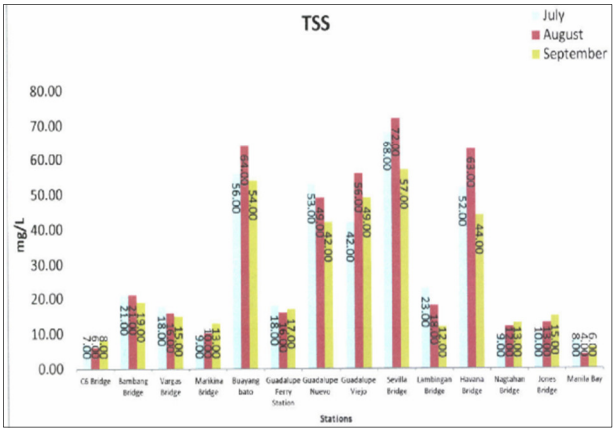

Graph 1: Pasig BOD and DO levels over the course of 12 years




Graph 2: BOD measurements Pasig river 2015




Graph 3: COD measurements Pasig river 2015




Graph 4: TSS measurements Pasig river 2015

According to the research from the Kangju National University (2010) (Graph 1) the BOD (Bio chemical oxygen demand) has shown increasingly high values over the past 12 years. The value has risen far beyond the standard threshold. The other three graphs, which are from the Pasig monitoring report (2015) show that the BOD level in 2015 still far beyond the set standard is. Calculating the average values for the BOD, COD (Chemical oxygen demand) and TSS (Total suspended solids) shows for 2015 the following numbers:
BOD= 46 mg/L , COD= 76 mg/L and TSS= 27 mg/L.

The LLDA report did not show TSS and COD levels but comparing the BOD levels between the Pasig river and Laguna de Bay shows a large increase in BOD level in the Pasig river. The water entering Metro Manila seems to be of a relative better quality than the water inside Metro Manila (but still polluted).

The water quality in Laguna de Bay near Metro Manila is according the LLDA of a bad quality. The rivers inside Metro Manila are of an even worse water quality. Metro Manila is polluting the water bodies inside and outside the city. Generally speaking the water quality of rivers in Metro Manila is bad. Within the Pasig river there are spikes in quality but on average the water quality in the Pasig is worse than the water quality in Laguna de Bay. Most likely the rivers which flow into the Pasig river are polluted which contributes to the pollution of the Pasig. Polluted water from Laguna de Bay flow into the Pateros river. The water inside the Pateros river increases in Pollution and flows into the Pasig river. Since the Laguna de Bay and the Pasig river both are polluted, generally taken the Pateros river is polluted. Seeing Pateros contains sources of pollution, the level of pollution will be closer to the Pasig river.

### 6.3.3 Observations rivers Metro Manila

Many rivers in Manila have seen improvement. Most of these improvement have been aimed at removing the (solid) waste and adding greenery around the river (Image 13 and 14). Examples for these are the Estero de Aviles, Estero de San Miguel and Estero de Paco, which are rivers in Manila where waste has been removed and the greenery increased. However this method does not improve the water quality to normal standards. The focus for improvement in rivers for Metro Manila lies in the improvement of aesthetics. The liquid pollution is not addressed and continuous to pollute the water inside the river.

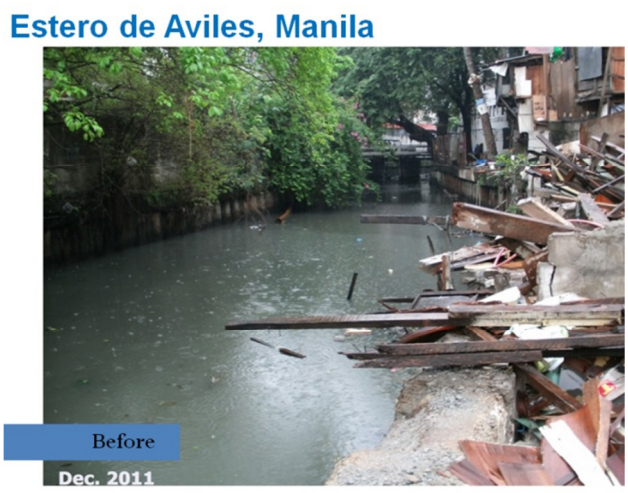



Image 13: Before rehabilitation
(©Pasig River Rehabilitation Commission)

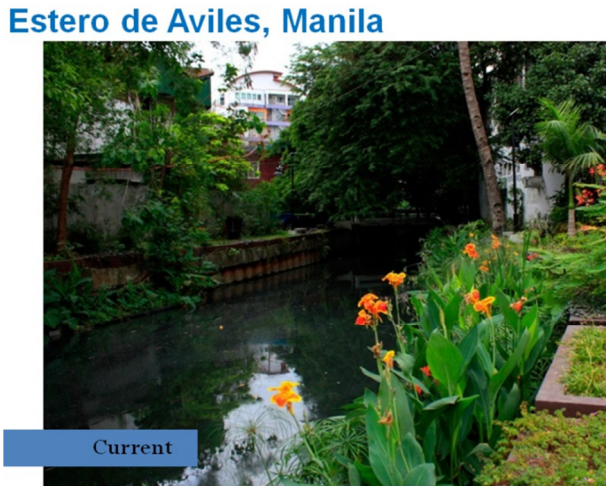



Image 14: After rehabilitation
(©Pasig River Rehabilitation Commission)

## 6.4 Best Practise

There are different ways to improve the water quality of a river. The idea is to not invent something that is already invented. Therefore it is required too research used methods throughout the world that improve the water quality of a river. In order to keep the research relevant the focus is put on areas which have been in a similar state as Metro Manila and ideas coming from Metro Manila. The result of this chapter are varied ideas that are a source of inspiration for the result of the CWM project.

a. Many rivers in Metro Manila focusses on removing the visible waste but disregard the liquid waste and micro pollutants. Usually this goes accompanied with the removal of illegal settlers and the increase in greenery. This method increases the aesthetics of a river and removes pollution. Many sources of the pollution (example untreated sewage) are disregarded resulting in a continuous pollution of the Pateros river.

b. In order to tackle the liquid waste F.H. Maletsky wrote an article about the concept of adding a gutter in the riverbank that will catch and transport the liquid waste that normally flows into the river (Image 15). Barangay captain Artemio A. Contreras II from the barangay East Rembo in Makati City had a similar idea but for reasons unknown did not decided to pursuit this idea further. This idea disregards solid waste but does tackle the issue with untreated sewage.

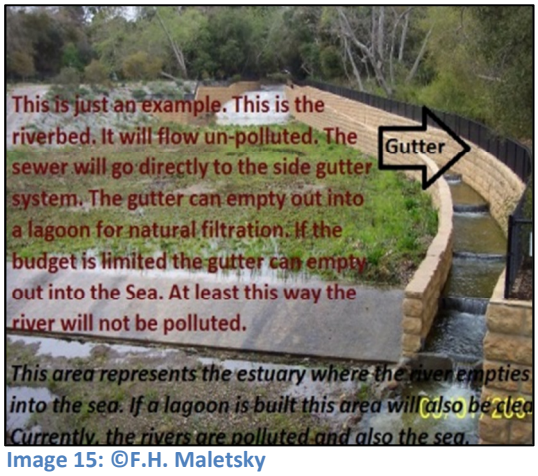


Image 15: ©F.H. Maletsky

c. In the history of Netherlands they constructed new sewage systems that would not flow into the channel but towards a sewage treatment facility outside the city. This improved the water quality in the channels but was extremely cost and time consuming.

d. According to Republic Act No. 9275 (March 22, 2004) people are to be encouraged to use septic tanks as treatment for the wastewater. In reality many houses do not have a septic tank and according to F.H. Maletsky and the Environmental Management Bureau, houses that do have a septic tank often lack a proper leach field. The idea is good but requires reinforcement and proper execution. The extra costs for adding septic tanks is not appealing for existing houses and will require positive reinforcement.

e. In the river Estero de Pandacan in Metro Manila an attempt to improve the river quality has led to the implementation of controlled floating green inside the river (Image 16). The goal of the floating green is to improve the water quality of the river. Controlled use of plants improves the water quality of a river however it ignores the source of pollution and requires large area and time to make substantial difference in water quality.


Image 16: Estero de Pandacan in Manila (©Pasig River Rehabilitation Commission)

# 7. Research results

## 7.1 State of requirements

Based on the rivers in Metro Manila, and the state of rehabilitated rivers, aesthetics are very important. However, new improvements to rivers (including the Pateros river) should aim at improving the water quality. Taking this in consideration, combined with the pre-requirements from the beginning, the following requirements are made. The requirements must be fulfilled with the result of the CWM project. The requirements will be used the selection process of the following chapter.

### 7.1.1 Mandatory requirements

**M1. The design is required to be cost efficient.**

High costs on a design can complicate the implementation. A cost efficient design is required to make the design implementable and not impossible. Cost efficiency means to create a solution that requires minimum effort and minimum impact on the current situation (which will keep the costs low) while delivering an optimal result. An example would be how it is more efficient to re-use a building instead of building a new one.

**M2. The design is required to be simple and understandable.**

The design needs to be executed by Filipino technicians and implemented by the local government. Governmental politicians are not technicians and need to be able to understand the design. The Filipino technicians need to be able to execute the design. An over complex design will unnecessarily increase costs and makes the implementation difficult.

**M3. The design is required to improve the water quality in the Pateros river.**

The goal of the CWM project is to improve the water quality of the Pateros river. A single design will not be the full solution to the water quality problems but rather a step towards the correct direction. As long as the design tackles one of the many sources of the pollution (and thus slightly and slowly improves the water quality) it is a step forward towards a clean Pateros river.

**M4. The design follows the focus of the CWM project**

The focus of the CWM project is to prevent liquid pollution at the source of the pollution. The research has been done on a focus area, therefore it would be inefficient to create a solution outside the focus area.

## 7.2 Qualitative result (Long List)

The long list is the result of the qualitative research. Based on questionnaires, Literature research and observations multiple possibilities that will improve the Pateros river are compiled into a single list. This is called the long list and is shown below. Each possibility on the long list will receive four votes based on the Mandatory requirements. If one of those four votes is a *No* it indicates that the option does not comply with the Mandatory requirements and will not be taken into the next stage. Extended reasoning for voting yes or no is added in appendix 6.

### *Focus on solid waste and aesthetics*

Aesthetics are important for the locals in Metro Manila. Removing solid waste is a fast and efficient method in improving the aesthetic while removing pollution. Additional greenery will improve the aesthetics and create the delusion that the river is not polluted.

The downside is the liquid pollution. Many sources of the pollution (example untreated sewage) are disregarded resulting in a continuous pollution of the river. Additionally disregarding the liquid waste and focusing on the solid waste does not align with the focus for the Clean Water Manila (CWM) Project.

**Pros:** Fast, cheap and easy.
**Cons:** No improvement in micro pollutants or prevention from liquid waste.

| **Requirement:** | M1 (Cost efficient) | M2 (Simple & understandable) | M3 (Improves WQ) | M4 (Follows focus CWM) |
|---|---|---|---|---|
| **Score:** | *Yes* | *yes* | *Yes* | *No* |

### *Removal illegal settlers*

Illegal settlers are a pollution source. The houses from Illegal settlers will not become officially recognized which causes the houses to remain outside the standard wastewater treatment infrastructure. Removing the illegal settlers would make the wastewater management easier and would remove a pollution source.

From a moral and community aspect it is difficult to remove illegal settlers. Most government agencies do not want to interfere more than needed due to the fear of feedback from the illegal settlers. When everyone is moved it requires effort and money to reinforce the rule and prevent illegals settlers returning to their old locations.

**Pros:** Low cost, more area around the river for wastewater management.
**Cons:** Loss of voters for Mayor election, difficult and expensive to enforce and morally difficult.

| **Requirement:** | M1 (Cost efficient) | M2 (Simple & understandable) | M3 (Improves WQ) | M4 (Follows focus CWM) |
|---|---|---|---|---|
| **Score:** | *Yes* | *yes* | *No* | *No* |

### *Wastewater gutter*

As shown in chapter 6.2 Wastewater management system, all the wastewater flows through single point pipes into the Pateros river. There are many pipes along the river. Each transports wastewater from different houses. To borrow the idea from F.H. Maletsky a single gutter along the riverbank will be able to collect the wastewater and transport the wastewater to a processing facility. The gutter prevents wastewater from entering the river. When the source of liquid wastewater is removed less pollutants enter the river and the opportunity arises for the water to improve in quality.

In order to process the wastewater multiple smaller scaled processing facility can be used (located within different barangays) or the wastewater can be transported through a pipe towards a general wastewater treatment plant.

**Pros:** Easy implementable system which improves the water quality.
**Cons:** Requires a building area inside the river.

| **Requirement:** | M1 (Cost efficient) | M2 (Simple & understandable) | M3 (Improves WQ) | M4 (Follows focus CWM) |
|---|---|---|---|---|
| **Score:** | *Yes* | *yes* | *Yes* | *Yes* |

#### *New sewage system*

The current sewage system transports wastewater into the Pateros river and is combined with the rainwater. A new separate sewage system that will transport wastewater to a wastewater treatment facility without the addition of rainwater would prevent wastewater from entering the Pateros river. No more wastewater entering the river will help in the improvement of water quality.

A new sewage system is not cost efficient because it is very expensive to replace the entire sewage system of a dense populated area. Additionally it requires a lot of effort and arrangements for the implementation.

**Pros:** New system that can be designed close to perfection.
**Cons:** High costs and time consuming.

| **Requirement:** | M1 (Cost efficient) | M2 (Simple & understandable) | M3 (Improves WQ) | M4 (Follows focus CWM) |
|---|---|---|---|---|
| **Score:** | *No* | *No* | *Yes* | *Yes* |

#### *Septic tanks and leach fields*

Currently there are many houses without a proper septic tank and leach field for a septic tank. Providing septic tanks and leach fields for residents of Pateros prevents wastewater from entering the Pateros river.

With no knowledge regarding who has and who does not have a septic tank it is difficult to provide septic tanks. That is disregarding the required space for septic tanks and leach fields in a high density populated area as Pateros. When every house does have a septic tank, illegal settlers will not be attached to a septic tank and thus there will always remain an amount of wastewater entering the Pateros river.

**Pros:** Wastewater treatment that is not depended on others.
**Cons:** Lack of ground area in high dens area and lack of proper assessment of numbers resolves into high cost and time consuming.

| **Requirement:** | M1 (Cost efficient) | M2 (Simple & understandable) | M3 (Improves WQ) | M4 (Follows focus CWM) |
|---|---|---|---|---|
| **Score:** | *No* | *No* | *Yes* | *Yes* |

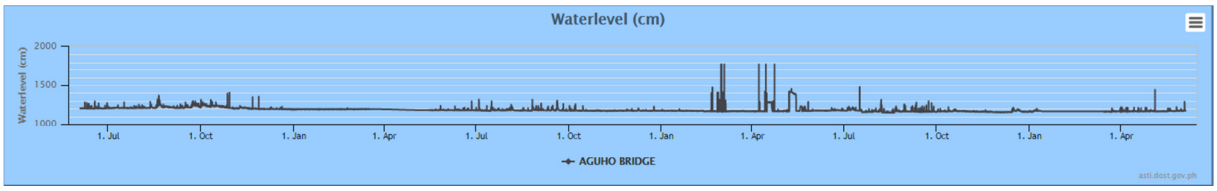
### 7.2.1 First selection

The result of the long list indicates that only one design fully complies with the mandatory requirements. This is the Wastewater gutter. The qualitative research gives rough solutions that require further designing. Based on the outcome of the qualitative research three final designs will be made. These three final designs will be compared on a quantitative scale using new requirements based on the mandatory requirements.

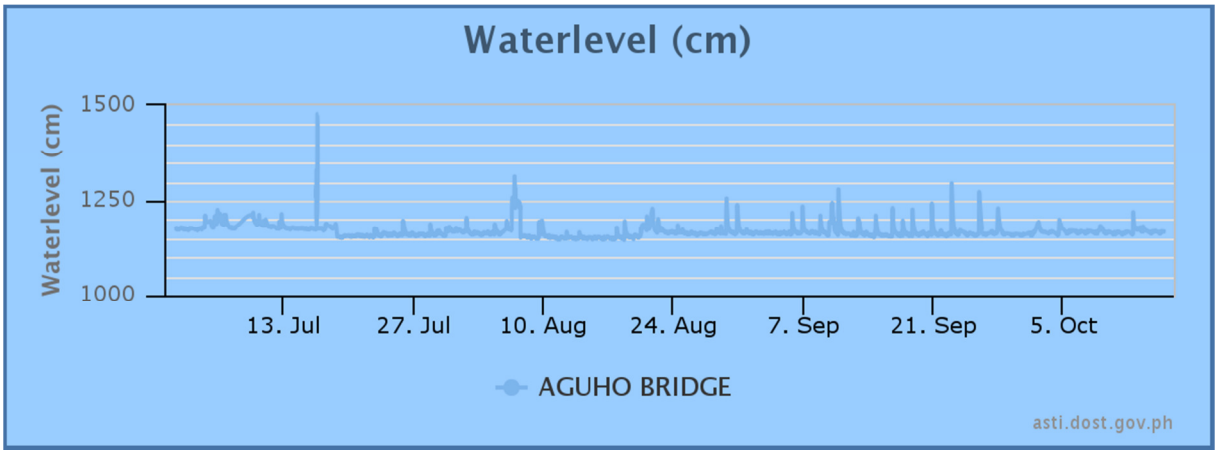
## 7.3 Necessary data

Before being able to properly create three designs more information is required. Required are the average water levels in the Pateros river (outside of typhoons) and a rough idea for the wastewater flow.

Graph 5 and 6 shows a variance in water level of 1,5 meter (excluding big rain events caused by typhoons). There are some differences in the river soil height, but the average required total height for the design will be a minimum of two meters, but some extra margin will be taken into account.




Graph 5: Water levels in the Pateros river (2012 - 2015). ©http://fmon.asti.dost.gov.ph




Graph 6: Water levels in the Pateros river ( 2015). ©http://fmon.asti.dost.gov.ph

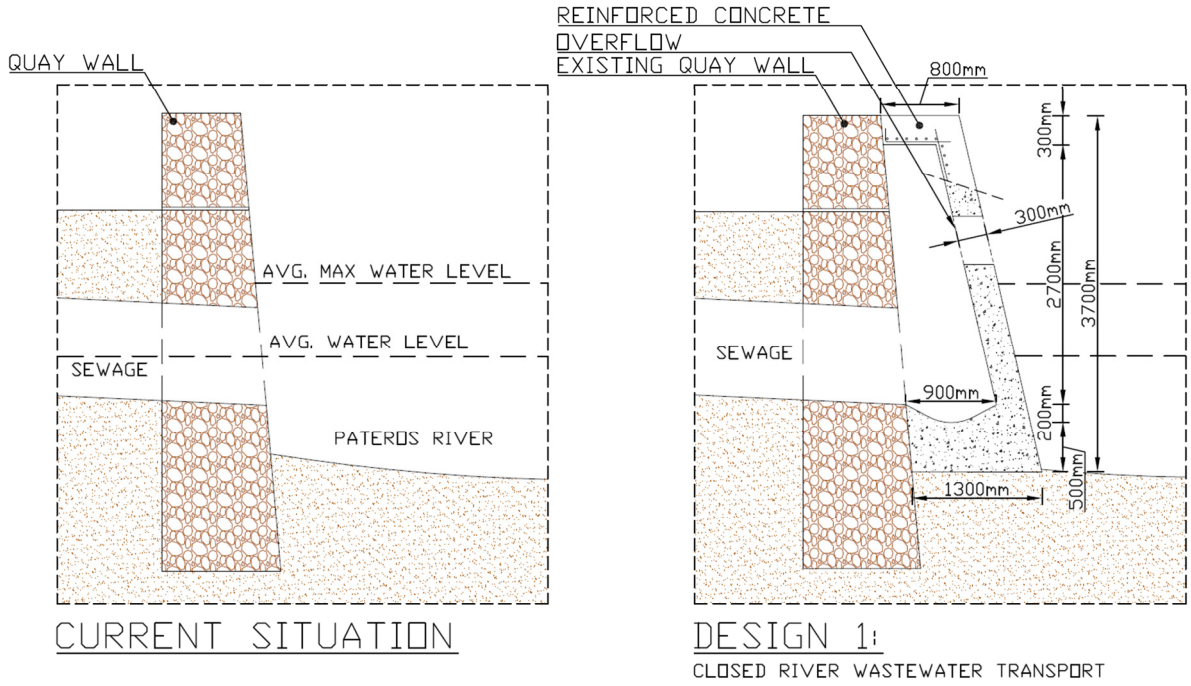
During the research of J.D. Prabowo he made a calculation for the wastewater flow. According to his research the wastewater flow is roughly 0,66 m3/s for the whole Pateros river (all areas). There are some issues with the credibility for the number due to a lack of information and a scaling issue due to the value being for the whole river but based on this information it is determined that with the widths taken for the designs there should not be any problems with the transport of the wastewater regarding the wastewater flow.

Following are three designs named *'Closed river wastewater transport (CRWT)', 'Green open wastewater transport (GOWT)'* and *'Minimized open wastewater transport (MOWT)*. These three designs will be explained including the pros and cons. In the end follows a detailed comparison.

## 7.4 Final designs

Following are the detailed designs explanation. Designs are additionally added in appendix 10.

### 7.4.1 Design one: Closed River Wastewater Transport (CRWT)




The wastewater is collected in a closed system and proceeds to be transported to a wastewater processing facility either in the Barangay or towards a pipe which leads to the wastewater processing plant. To counter high water flows during rainfall there is an overflow system. When the water level in the system reaches a certain point the water flows into the river. The water inside the CRWT is not influenced by the river.

Benefits to the CRWT system is the resilience it offers. Being closed gives a secure setting from outside influences such as waste and vandalism. Being closed-off it allows for better control and a multifunctional purposed design if so desired. It is a design that can be invisible.

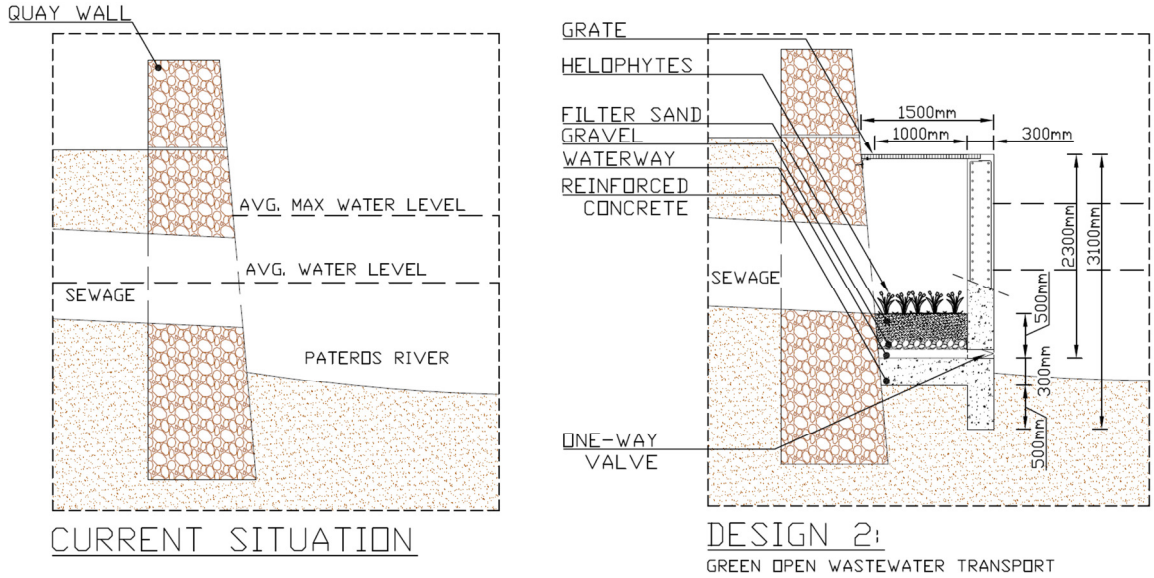
Downside: The large size that takes up space in the river. When a closed object is placed in the river there is less room for the water flow inside the river. Less room for the river reduces the wet surface and potentially increases the flooding problem (Wet surface is the area being used by the water in the river).

**Pros and cons:**

**+ It prevents wastewater from entering the Pateros river**
**+ It is cut-off from outside influences providing security and stability**

**- Requires building space inside the river reducing the wet surface of the river**
**- The larger design making it closed requires large amount of building material and thus increasing the costs as well as not being aesthetic appealing and more difficult to excess for maintenance**

### 7.4.2 Design two: Green Open Wastewater Transport (GOWT)




The wastewater is collected in a closed system and proceeds to be transported to a wastewater processing facility either in the Barangay or towards a pipe which leads to the wastewater processing plant. To counter high water flows during rainfall there is an overflow system. When the water level in the system reaches a certain point the water flows into the river.

The GOWT includes a small scale vertical water filter. The water that passed the filter ends up at the bottom of the GOWT where the water can flow out into the river through a one-way valve. The water that does not pass through the filter will flow to a processing facility. The result is a lower amount of wastewater flowing towards the processing facility. The top of the design is covered with a grate for protection and to prevent garbage falling into the system.

Benefits include green aesthetics due to the plants, smaller amount of water that needs purification and a visual appealing system. Due to everyone being able to see the wastewater flow in a separated system the GOWT is easy to understanding.

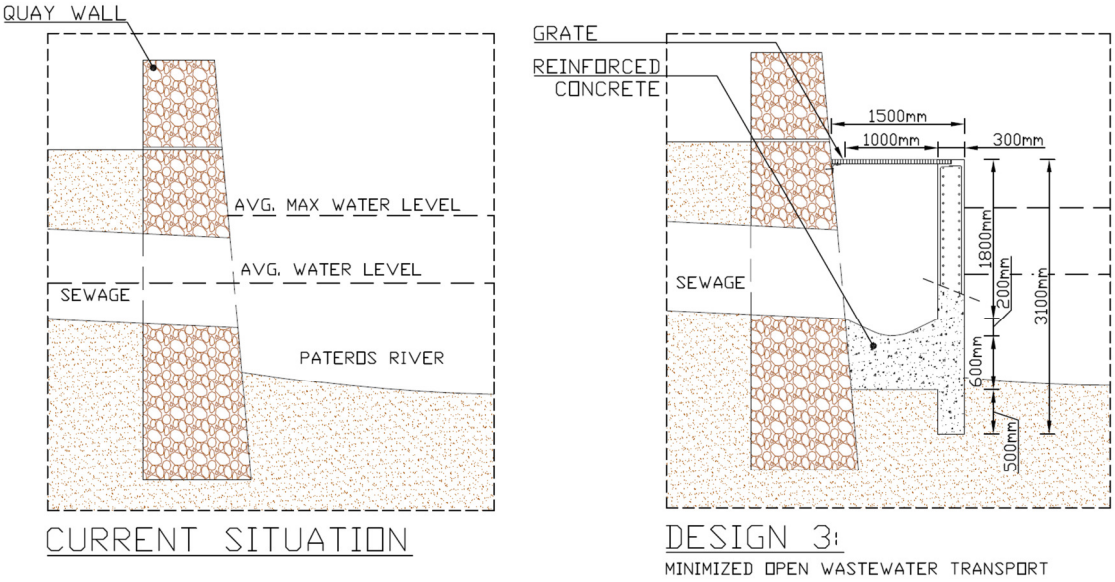
Downside: The required maintenance of the plants. During heavy rainfall and flooding, plants have the possibility to be damaged due to the increased flow speed of the river. These plants will have to be restored during dry season. Similar to the previous design, this design requires an area inside the Pateros river.

**Pros and cons:**

**+ Green efficient system that purifies the water before it reaches a processing facility**
**+ Design which is aesthetical appealing and the most environmental friendly.**

**- Required maintenance on the plants with a possible needed replanting after flooding**
**- A more complex system where the locals might not understand why the plants are there**
**- Requires building area inside the river reducing the wet surface of the river**

### 7.4.3 Design three: Minimized Open Wastewater Transport (MOWT)




The wastewater is collected in a closed system and proceeds to be transported to a wastewater processing facility either in the Barangay or towards a pipe which leads to the wastewater processing plant. To counter high water flows during rainfall there is an overflow system. When the water level in the system reaches a certain point the water flows into the river.

The system consists out of a simple concrete structure at the side of the river. The top is covered with a grate for protection and preventing garbage from glugging the system.

Benefits include a simple design that is cost efficient and easy to understand. Due to a simple design the MOWT is flexible in maintenance and very durable. The simple design allows locals to understand the concept of the MOWT making it easier to implement the design. Locals might use the opportunity to dispose of effluents in an illegal matter (buckets with waste). This is beneficial since instead of the waste being thrown into the river it ends up in the system.

Downside: The simple design does not have the green aesthetic appeal the locals in Manila are looking for. The open design creates a possibility of bad odours. Similar to the previous designs, this design requires an area inside the Pateros river.

**Pros and cons:**

**+ Cheap and simple design to implement and maintain**
**+ Understandable for the locals in the area**

**- Simple design which does not build with nature but has a natural stance (Not with or against nature)**
**- Requires building area inside river reducing the wet surface of the river**

## 7.5 Comparisons

The quantitative comparison will be done based on a multi criteria analysis (MCA). The assessment points which are used for the criteria are listed below.

### 7.5.1 Assessment points

The Assessment points are used for assessing the final design choices before making a final conclusion. These are the following assessment points.

**A1. The design should be esthetical appealing.**
Aesthetics are important for the locals in Metro Manila. The locals that live at the Pateros river want a visual appealing river. The details about water quality go beyond the understanding of most locals that live in the Pateros area but everyone can understand and appreciate a clean looking river.

**A2. The design should work with the illegal settlers and not against.**
There are a lot of illegal settlers in the Pateros area. Removing the illegal settlers is execution wise and morally difficult. A design that does not require the removal of illegal settlers will have a higher success rate.

**A3. The design should cooperation with locals and nature.**
When the locals in the Pateros area cooperate with the project the design has a higher change of finding support. Cooperation with nature benefits the aesthetics and helps implementing the design.

**A4. The design should not worsen the flooding problem of the Pateros river and be flood resistant.**
Currently flooding is a big issue in Metro Manila as well as the Pateros river. Flooding and Water quality are both important issues, but flooding is generally the highest priority since it carries the most short term risks. Therefore a design should abide the highest priority (flooding) and not create a situation where the risk and scale of flooding is increased. Additionally the design will encounter strong forces due to flooding. The design should be able to withstand these forces.

### 7.5.2 Multi criteria analysis

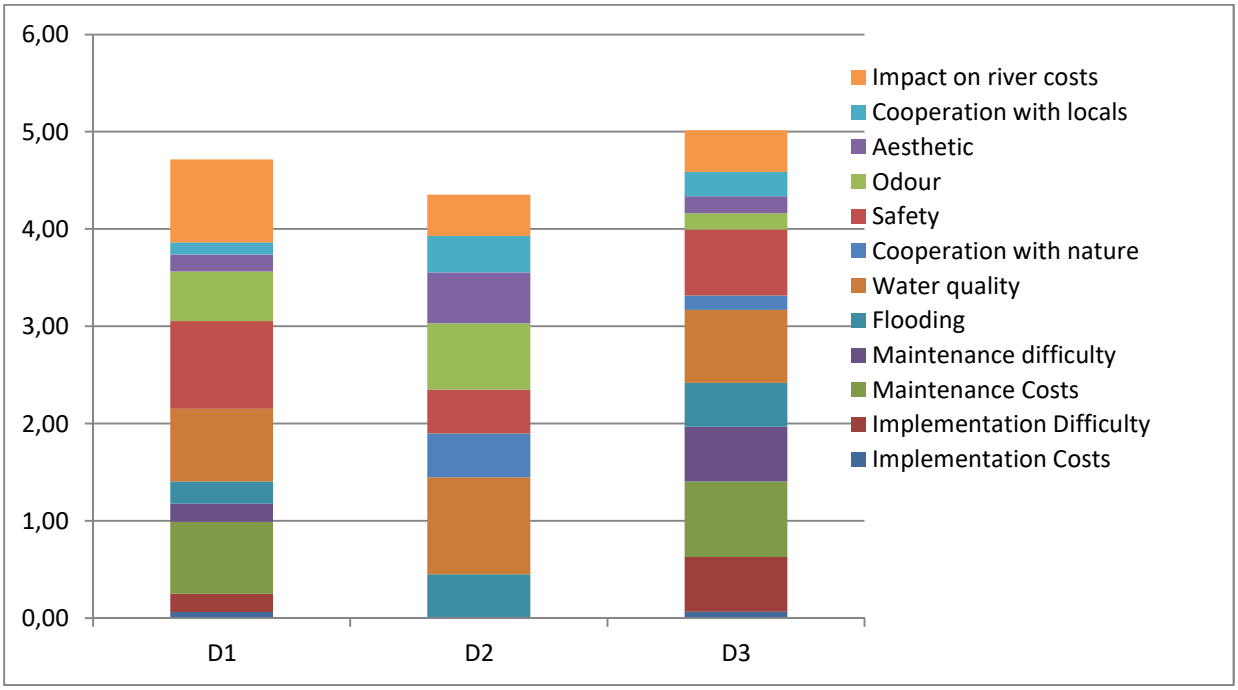
The weighting for the criteria in the MCA is based on personal choices and thus will differ from proper weighting done by a team of Locals from the Philippines. The weighting and reasoning is shown in appendix 9. The costs in the MCA are based on a cost calculation shown in appendix 11.

The following criteria's has been evaluated in the MCA:
Implementation costs, Implementation difficulty, Maintenance costs, Maintenance difficulty, Impact on flooding, Impact on water quality, Cooperation with nature, Safety risk, Odour, Aesthetic, Cooperation with locals.

Each criteria has been given a score for each design option, leading to the following table.

| Multi Criteria Analysis | D1<br>CRWT | D2<br>GOWT | D3<br>MOWT |
|---|---|---|---|
| Implementation Costs | € 8.640.000 | € 9.320.000 | € 8.580.000 |
| Implementation Difficulty | - | -- | + |
| Maintenance Costs | € 108.000 | € 850.000 | € 74.000 |
| Maintenance difficulty | - | -- | + |
| **Impact on river** | | | |
| Flooding | - | 0 | 0 |
| Water quality | + | ++ | + |
| Cooperation with nature | -- | + | - |
| Costs | ++ | 0 | 0 |
| **Impact on locals** | | | |
| Safety | ++ | 0 | + |
| Odour | + | ++ | - |
| Aesthetic | - | + | - |
| Cooperation with locals | - | + | 0 |

The scores has been standardized to a number between 1 and 0. Following to the standardization different criteria got different weights. Graph 7 is the result.




Graph 7: MCA result

The results of the MCA indicate that the best design is D3: Minimized Open Wastewater Transport (MOWT). The MOWT received generally good scoring for all criteria with exceptions for the odour, aesthetics and cooperation with nature.

# 8. Conclusion and discussion

In chapter four different questions were asked which contribute to properly ending the Clean Water Manila project. At first the sub-questions will be answered after which the main question will be tackled.

## 8.1 Sub-questions

1. ***How can the local citizens of Manila get involved in the CWM project?***

Local citizens can be involved in the Clean water Manila (CWM) project during three different stages. The design phase, the execution phase and the maintenance phase.

During the design phase locals have been involved through the means of interviews and excursions. The information gained from locals have been an inspirational source and input for the creation of the different possible solutions that are listed in chapter 7.2 *Qualitative result (Long List).*

Within the execution and maintenance phase there will be the need for Filipino labourers. These Filipino labourers are locals in Manila who implement and maintain the CWM design.

2. ***What is the current situation with the water quality of the Pateros river?***

In chapter *6.3.2 Reverence water quality* it shows that the only successful water quality testing was through observations at the river. Using a Dutch tool called Biotoets to make an assessment for the water quality based on the observations, it was concluded that the water quality in the Pateros river is in a bad state. In order to reinforce this conclusion, references where made at other water bodies in Metro Manila.

The water from Laguna de Bay flows into the Pateros river and ends up in the Pasig river. The result from the reverence water quality shows high numbers indicating a polluted river. This lines up with the observations concluding that the water quality in the Pateros river is bad.

3. ***What is the state of requirements for the solution to improve the water quality in the Pateros river?***

The state of requirements are shown in chapter 7.1 *State of requirements.* The state of requirement exists out of mandatory requirements which are requirements that need to be fulfilled within the design. The mandatory requirements include the subjects; costs, simplicity, water quality and trueness to the focus of the CWM project.

4. ***What is causing pollution in the Pateros river?***
    a. *Which pollution streams end up in the Pateros river?*
    b. *What are the sources of pollution in the Pateros river?*

The problem of the pollution is due to a number of different reasons (Chapter 6.2 *Waste management*). A combination of solid waste and liquid waste are the cause of the pollution in the Pateros river. Solid waste end up in large quantities in the river, together with untreated waste water. The waste water (the focus of the CWM project) is coming from mostly households.

5. ***What level of water quality does Metro Manila aim for in rivers?***

It seems that for many locals aesthetics are the most important part of a river. This is shown through examples of rivers that have been improved on aesthetics but show no improvement in water quality. This observation means that the minimum standard for a river would be an aesthetic appealing river. Purely focussing on aesthetic is insufficient for a proper water quality improvement and thus the CWM project aims to improve the water quality beyond what is visible to the naked eye.

6. ***How can the local environment of the Pateros river contribute to the improvement of the water quality in the Pateros river?***

A large polluting source is solid waste. If it is possible through means of education and awareness to prevent solid waste entering the rivers, a major source of pollution will be removed. However this awareness and education is something that needs to be done by locals in Metro Manila.

Currently the Pateros river is being overrun by water hyacinths. When the source of pollution is reduced or removed, controlled water hyacinths are an excellent green solution for improving the water quality in a river. Within the designs of the CWM project, a green solution has been implemented through the means of a water filter (chapter 7.4.2 *Design two: Green Open wastewater Transport (GOWT)).*

7. ***What are understandable and visual appealing presentation techniques?***

A number of techniques where picked up through the means of hands on experience within the FFM project. Using banners during a symposium gives the audience a physical object to touch and see. Presenting at a symposium and the preparation towards the symposium has shown different styles and techniques that contribute towards a visual appealing and understandable presentation.

8. ***What are the estimated costs involved with the solution that would improve the water quality of the Pateros river?***

In chapter 7.5 *Comparison* final costs where shown. A more detailed list of costs is in appendix 11.
The final cost for the implementation comes to: Design 1 € 8,6 mil., Design 2 € 9,3 mil., and Design 3 € 8,6 mil.
The yearly costs for maintenance comes down to: Design 1 € 108.000,- Design 2 € 850.000,- Design 3 € 74.000,-
Important notice is the pricing in euro. Reasoning for this is that in the small time frame available in the Philippines it was not possible to get an understanding what the costs would be in the Philippines with local material and local contractors. Therefore the prices are purely based on the market in Europe and the prices are rough with the intention to serve for comparison and nothing else.

9. ***What for alternative solutions are there that will improve the water quality of the Pateros river?***

There are alternative solutions to improve the water quality in the Pateros. An example is tackling the source at the community through means of education. This is a measure which is ideal for a long term solution. A more technical long term solution would be to enforce septic tanks. Making sure septic tanks are implemented at new houses and slowly, when old houses are rebuild and streets are improved, add more septic tanks. Other different ideas can be found in chapter 6.4 *Best Practice* and chapter 7.2 *Qualitative result (long list).*

## 8.2 Main question

***How can the water quality of the Pateros river be improved while the solution is understandable and visual appealing for the people in Manila in order for themselves being capable of executing the solution?***

As shown in chapter 7.4 *Final designs* there are three designs that improve the water quality in the Pateros river. The three designs (CRWT, GOWT and MOWT) improve the water quality in the Pateros river by removing the wastewater component out of the equation. Following the comparison from chapter 7.5 *Comparison* it shows that the third design (MOWT) has the preference with a small margin. The small margin indicates that all three designs are possible depending on changes in pricings due to material becoming cheaper or more expensive.

## 8.3 Discussion

As answered in the main question, all the final three designs are viable depending on changes in economy. As it stands with the current settings and preferences, the third design (MOWT) is the best option.

Due to the three designs being close together, their arises a potential margin for error. Pricing has been done based on the pricing in Europe. The weighting of importance for the categories within the MCA has been decided by a single person where ideally you would have a team of locals. This means that there should be a margin of error. This margin for error is the same size as the differences between the three designs, concluding  all three designs are equally viable.

Since there is no large scale wastewater treatment plant near the Pateros river it is required to use smaller scale processing facilities or transport the wastewater through additional pipes. In the future it would be more ideally to construct a new large scale wastewater treatment plant.

# 9. Recommendations

As it is now, the designs made within the CWM project cannot be implemented yet as there is not a single best design. The proper method for determining which design to choose would be through close teamwork with Filipino researchers and locals in Pateros. Aside from knowing which design to implement there is something more important to do before preventing wastewater going into the Pateros river.

Currently flooding and solid waste are a large issue with the Pateros river. These issues are larger and more important than the issue of wastewater. Flooding causes many deaths in a short time period. Water quality caused by wastewater is an issue that effects more than Pateros river and on a longer time period. The water quality in whole Metro Manila and outside needs to be improved. For the Pateros river the priority should be flooding after which solid waste. After those two the Pateros river can focus on wastewater.

Lastly it is important to realise the power of education. The issue with solid waste (and liquid waste to an extend) can be resolved with proper education and communication with the locals who live in the Pateros river area. It is more sustainable, cheaper and long lasting to educate instead of hard technical measures.

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## Abbreviations & Glossary

| | |
|---|---|
| **Barangay** | Smaller community within a municipality or city. |
| **IWASTO** | Filipino word that stands for cleaning up the river. |
| **M.o.U .** | Memorable of Understanding. For example: agreement between two parties that they have the same vision wanting to achieve. |
| **Solid waste** | Waste that is solid for example plastic. |
| **MMDA** | Metropolitan Manila Development Authority. |
| **Liquid waste** | Liquid waste such as sewage wastewater. |
| **Wet surface of river** | The area of the river being used by the water to flow. |
| **CRWT** | Closed river wastewater transport system |
| **GOWT** | Green open wastewater transport system |
| **MOWT** | Minimized open wastewater transport system |

# Appendix 1: Flood Free Manila

During the FFM project a diverse team of students worked together for one week to design and present an idea that would tackle one of the problems of the Pateros river.

There were two students (J.D. Prabowo and S. Kloppenburg) who arrived one week earlier than the rest of the group. This head start allowed them to make first contact with parties such as the Barangay captains and get an understanding for the situation. When all the students and participants arrived the project had its official start.

## The beginning

The official start began with introductions. To assist with this we did a game called 'The Market Game'. Another exercise was done to help start the flow of creativity.

### The market game

The market game is a game where there are two posters on the wall. One poster with everyone strengths and one poster with everyone needs. All the participants write down on a piece of paper what they are good at and put that on the first poster. On a second piece of paper they write down skills they are looking for within a group.

The idea is that the students that participate look at both posters and start conversations with each other. This is a method to learn each other's strengths and weaknesses.

### Once upon a time

*Once upon a time* is a game that helps gathering inspiration, start the creative flow and realise what is important about the Pateros river from different perspectives (a fish, a local and a government official). The game exists out of writing a fairy tale, written from different perspectives. The rules state that the story needs a moral and a happy ending. The result is a fairy tale about the Pateros river.


Image 17: Focus areas FFM designing © L. de Jong

## The designing

For the design we started with analysing the problem. Putting the problem of the Pateros river into the focus areas infrastructure, waste, awareness, river and community. Leading from the focus areas we split into different groups. One group was one focus area. Each group thought of different solutions for the problem concerning their focus area. At the end of the day we made votes on the ideas. One idea was picked for further elaboration on the design. The design chosen was the Longganisa.

Image 18: Longganisa design ©SK

## Longganisa

The Longganisa is a floating structure in the water that collects floating garbage from the river. The floating garbage that moves with the flow of the water is caught by the floating Longganisa and the net underneath the Longganisa. Since waste in a river moves on the outside of the river, the waste is caught in the Longganisa and will not bypass the structure. The net underneath the Longganisa can be taken out of the water to remove the garbage. The Longganisa itself is flexible so that it can move with the water, mobile so that it can be taken out of the water for maintenance and cost-efficient because it can be made from local material. Image 19 is a visual representation of the Longganisa.

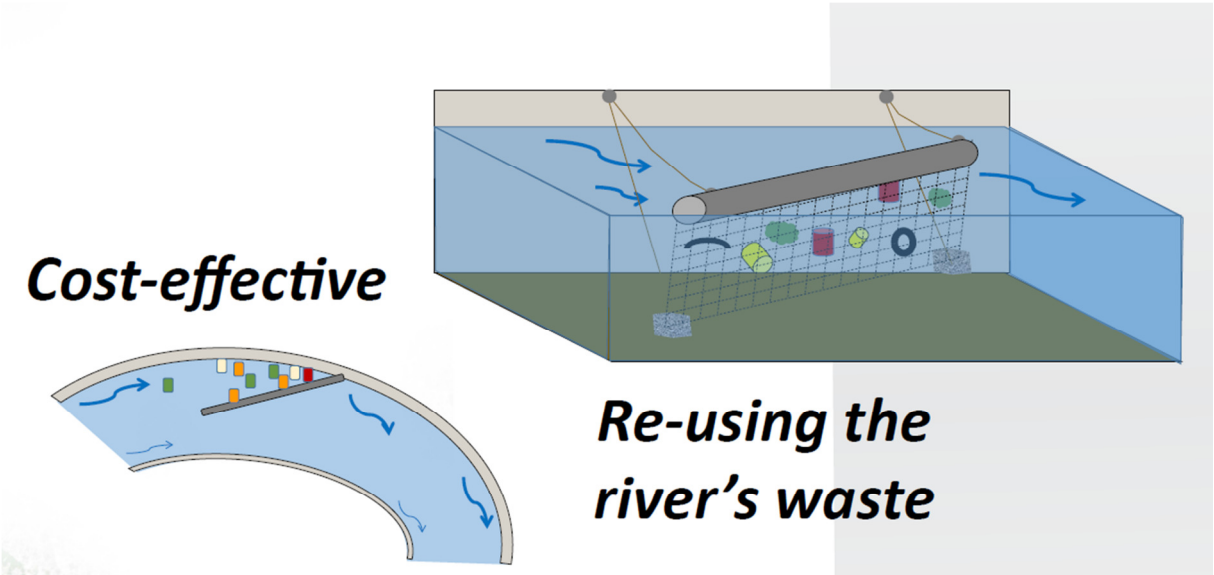



Image 19: Longganisa technical design

## The presenting

The Longganisa was presented with the help of three banners which are added in appendix 2. Each banner addresses a different part of the presentation. The first banner is for the introduction of the Pateros river and the FFM project. The second banner is about the technical details that concern the Longganisa and the last banner is about the future of the Longganisa and possible implementations.

Longganisa has been presented by one Filipino student and two Dutch students (including myself). The presentation was during a symposium organised by the Rotary club concerning the IWASTO project. During the symposium noteworthy attendees where two ministers and the Dutch ambassadress. The presentation was successful and the symposium proceeded without incidents.


Image 20: Symposium presentation. ©L. de Jong

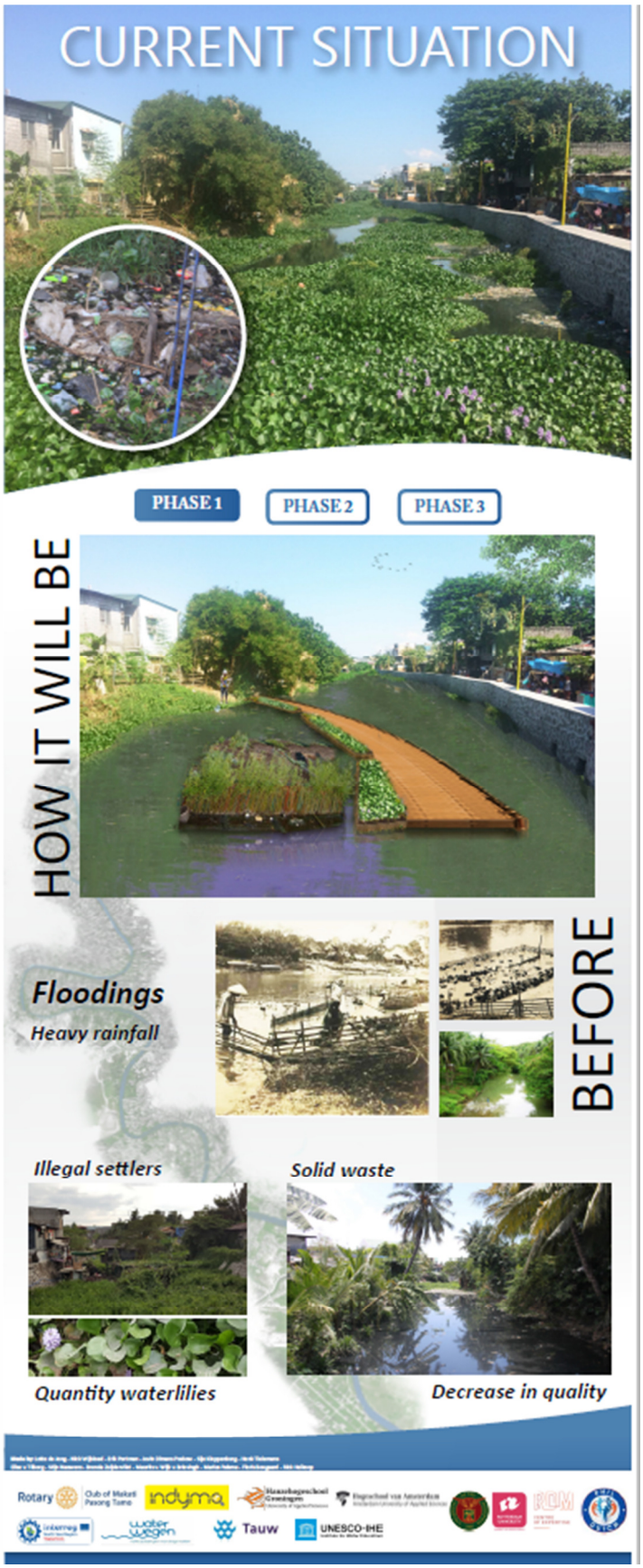
## Connection to CWM

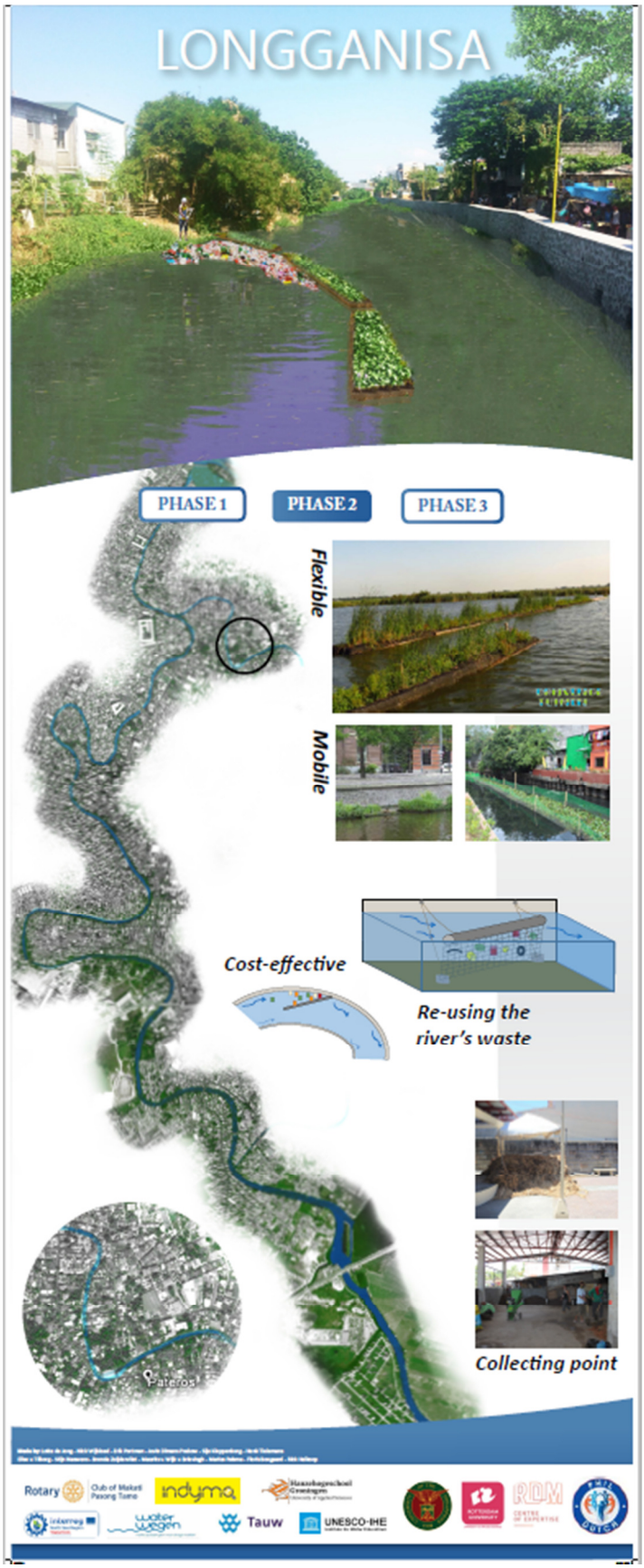
Looking at the Longganisa the FFM project has a different focus than the CWM project. However during the design process there where areas that overlap with ideas for the CWM project. The overlapping areas where useful for the progression of CWM.

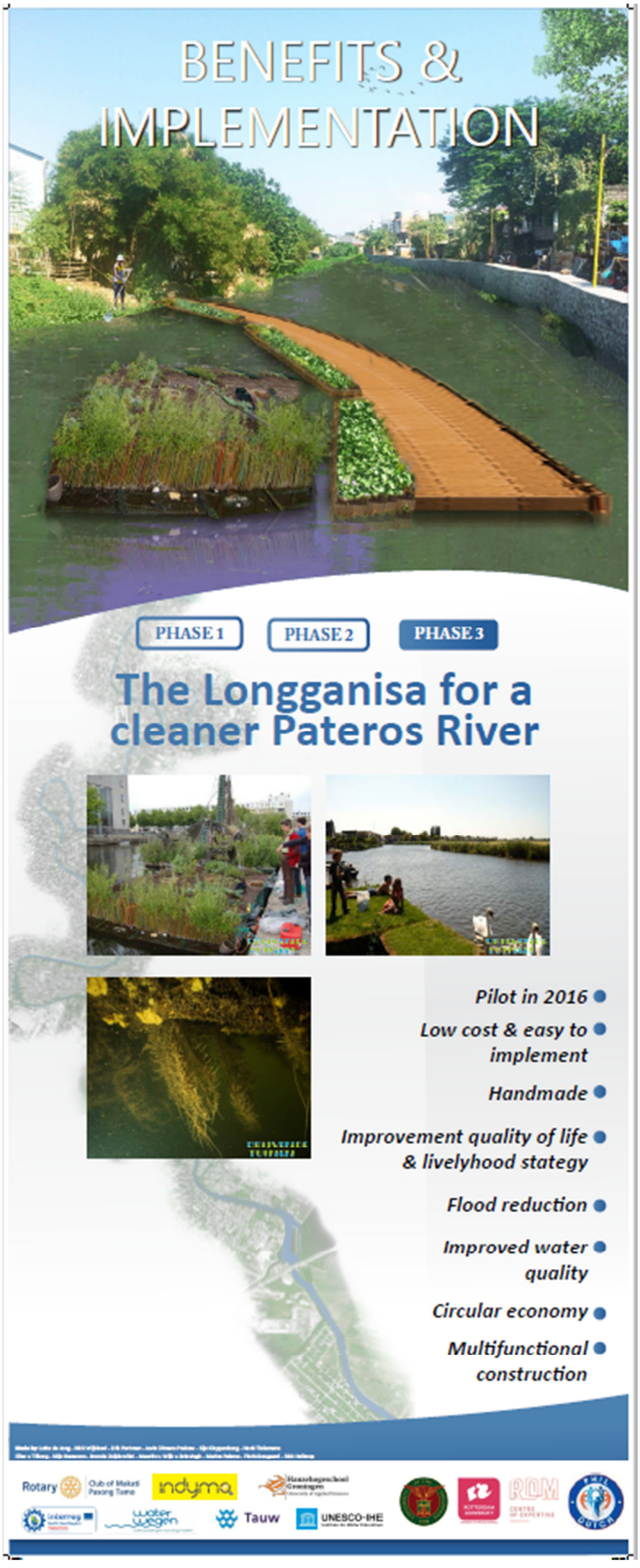
The presentation for the FFM project was very useful. With the presentation it was taught how a design can be made understandable and visual appealing with the use of banners. The banners give a physical object for the audience to see and touch. The other presentations during the symposium served as an example for presenting. Putting the focus on visuals and speech instead of text.

The fieldtrips and information gathered from FFM was very useful for CWM. During the FFM project there where fieldtrips and information collected concerning the Pateros river and Pateros area. Since the project area for FFM is the same as CWM it was possible to share information and connections between FFM and CWM.

# Appendix 2: Flood Free Manila Banners




BENEFITS & IMPLEMENTATION
PHASE 1
PHASE 2
PHASE 3
The Longganisa for a cleaner Pateros River
Pilot in 2016
Low cost & easy to implement
Handmade
Improvement quality of life & livelyhood stategy
Flood reduction
Improved water quality
Circular economy
Multifunctional construction
Rotary
indyma
Tauw
UNESCO-IHE

# Appendix 3: Questionnaire used for barangay captains interview

**IWASTO**

- What are you trying to achieve with the IWASTO program and what is required to make that happen.

**Water quality**

- In an ideal world with all the money and support, how would you improve the water quality of the Pateros river?

**Water quantity**

- What is the main problem with the water quantity (regarding flooding's) and how would you handle that problem? (Different problems between high rain season and low rain season?)

**Drainage system**

- How is the process of the drainage system? (Function, maintenance->river, problems)

**Waste**

- What has changed with the river since the start of the IWASTO program (to improve the river)?

**Captain Elmer V. Mangoba:**

- What can you tell about the segregation centre? (Type waste, amounts, area, product (compost))

**Sub-questions**

1. What do you think about the IWASTO program?
2. Do you think the program was useful in the last year?
3. Does the IWASTO project changed your look at dumping garbage in the river?
4. Are there other problems with the river besides the garbage?
5. Where are the bottlenecks in the drainage system / river?
    a. What is the cause of these bottlenecks?
6. Are there any capacity problems due to waste disposal?
    a. Where do these problems occur?
7. Is proper maintenance done on the drainage system?
    a. Who does the engineering and the maintenance of the drainage system?
8. What are your requirements for the drainage system?
9. How is the usual maintenance on the river?

# Appendix 4: Interview notes representative of [redacted]

Representative of Captain Elmer V. Mangoba. Barangay captain of the barangay Sto. Rosario kanluran in the Municipality of Pateros.

The interviewers S. Kloppenburg and Ch. E de Jong asked the representative of the Barangay captain a number of different questions regarding the segregation / compost station, solid waste and waste water in the barangay and the Pateros river. The answers are noted down and compelled into the information below.

## *Interview*

**Compost station**

It has been a few weeks towards a month since the start of the partial material compost station (also referred to as segregation station or compost station). The station is not fully operational yet and only compost organic waste is being collected. (There is a different solid waste transport system for other garbage, but that was not discussed).

With help from the environmental agency and tricycles the organic waste is collected and transport towards the station. Only the organic waste is collected with the tricycles, no other waste. The organic waste from the barangay is being transported, but with the help of the municipality the plan is to expand the collection towards the entire Pateros municipality.

The created fertilizer is being used in gardens in the barangay and not being sold. When, in the future, there is more fertilizer than needed in gardens it will be sold. The Department of Environmental Recourses (DER) can make the fertilizer into a product fit for export outside the barangay.

**Waste removal**

With the help of the MMDA (Metropolitan Manila Development Authority) waste is being removed from the Pateros river. The removal is not being successful because when the river is being cleaned, the other side of the river (a different city) keeps throws waste into the river.

**Wastewater**

The wastewater flows directly into the river, because people do not have constructed septic tanks. Currently we (the barangay) are doing a survey to every house in preventing the waste going into the river.

In order to improve the Pateros river it is needed to do an ordnance analysis and only a proper reinforcement of this ordnance analysis can prevent the waste from going into the river.

# Appendix 5: Interview notes [redacted]

Captain Artemio A. Contreras II. Barangay captain of the barangay East Rembo in the city of Makati.

The interviewers S. Kloppenburg and Ch. E de Jong asked the Barangay captain a number of different questions regarding; What is needed for improving the Pateros river, the goals they want to achieve, what is done and what can be done. The subjects discussed are noted down and compelled into the information below.

## *Interview*

**What we want to achieve**

There are many problems that we want to achieve with the IWASTO program.

1. Bring back the condition of the river from how it used to be. In the old days people could swim, fish and was clothes in the river. We used to get drinking water from the river, but now no longer.
2. Instead of being useful, currently the river is harmful. There are sentiments, waste and many other stuff in the river. When the water rises it effects the community. The river has become a source for illness and sickness.
3. The endpoint for the river is to make it attractive for tourist.

**New purpose of the river**

Water used to flow from Laguna de Bay towards the Pasig river, since a new cannel cut off from Laguna de Bay the amount of water flow through Pateros river has immensely been reduced and the flooding problem is reduced to a minimum. The Pateros river is no longer just a river but serves as a flow/cannel/drainage system that accommodates all the effluents, household waste and wastewater in the barangay. All the wastewater from the barangay flows into the Pateros river.

**Wastewater treatment plant**

A wastewater treatment plant at the end of the river could clean the water before releasing the water into the Pasig river. It would be ideal to place gutters at both sides of the river that transport the wastewater towards a treatment plant and back to the barangay. Currently the Pasig river is known to be one of the most filthy rivers in the world.

Alongside the gutters we could plant plants. The MMDA once planted plants in the Pasig riverbed but a strong current flushed all the plants away.

**Cleaning up Pateros**

The supreme court demands barangays to clean the river bodies (including the Pateros river) quarterly. Therefore we (Makati) cleans up the Pateros river four times a year. But it is not efficient if only one city cleans up and the other cities do nothing.

# Appendix 6: Reasoning evaluation of the qualitative result

With the qualitative research (Chapter 7.2) a list was compiled which contains five different measures to improve the Pateros river. Based on the state of requirements, these five measurements have been evaluated on four requirements. Each requirements needs to be answered with a yes before the measurement can be further designed in other chapters. Below are the different measurements including the scoring and reasoning for the scoring.

### *Focus on solid waste and aesthetics*

**M1: Cost efficiency**

SCORE: *Yes*

REASONING: A community approach for this measurement would be a long term solution with a temporary investment. If successful the result is the removal of a large polluting source for the Pateros river which improves the water quality. This measure does not require the implementation of hard measures (structures) which means existing buildings and structures can stay the same. Low negative impact on the current situation with a long term solution and improvement to the Pateros river.

**M2: Simple and understandable**

SCORE: *Yes*

REASONING: The solid waste is very visible in the river and the local government knows that solid waste is an issue. For the local government it is understandable that removing the solid waste will improve the Pateros river.

**M3: Improves water quality**

SCORE: *Yes*

REASONING: Solid waste is a polluting source for the Pateros river. New water entering the Pateros river is polluted by the solid waste. Extracting the solid waste removes this polluting source and improves the water quality by not polluting new water entering Pateros river.

**M4: Follows focus clean water manila**

SCORE: *No*

REASONING: The focus area for the Clean Water Manila (CWM) project is the source of liquid pollution. Solid waste does not fall in the category of liquid waste. The measurement on solid waste does not fit within the CWM project but is does fit within the Flood Free Manila project (FFM).

### *Removal illegal settlers*

**M1: Cost efficiency**

SCORE: *Yes*

REASONING: Removing illegal settlers requires time (a week for a barangay at most) and a military or police group to reinforce it. It does not cost much to remove illegal settlers. The result are more possibilities for the implementation for measures to improve the Pateros river and the removal of a source of pollution.

**M2: Simple and understandable**

SCORE: *Yes*

REASONING: The local government is aware of the issue with illegal settlers and understands that removing illegal settlers is beneficial for the Pateros river.

**M3: Improves water quality**

SCORE: *No*

REASONING: The removal of illegal settlers does not improve the water quality in the Pateros river. The benefit for water quality from removing the illegal settlers is not major enough.

**M4: Follows focus clean water manila**

SCORE: *No*

REASONING: The CWM project aims at cooperating with locals in the area, removing illegal settlers would be the opposite of cooperation with locals in the Pateros area.

### *Wastewater gutter*

**M1: Cost efficiency**

SCORE: *Yes*

REASONING: Because the wastewater gutter is an object inside the river, the negative effects on the surrounding area is minimal. The wastewater gutter is a measure which is not difficult to implement and keeps the costs relative low.

**M2: Simple and understandable**

SCORE: *Yes*

REASONING: Barangay captain Artemio A. Contreras II has a similar idea compared to the wastewater gutter. This shows that the idea is understandable by the local government. The resembles between the gutter and a sewage pipe makes for an understandable design.

**M3: Improves water quality**

SCORE: *Yes*

REASONING: Preventing liquid waste from entering the Pateros river will improve the water quality. Fresh water which flows into the Pateros river would not get polluted by the wastewater.

**M4: Follows focus clean water manila**

SCORE: *Yes*

REASONING: Wastewater gutter prevents the wastewater from entering the Pateros river. The wastewater is being stopped at the source before pollution occurs. The focus of the CWM project (which is the liquid pollution) complies nicely with the wastewater gutter.

### *New sewage system*

**M1: Cost efficiency**

SCORE: *No*

REASONING: It is not cost efficient to create a new sewage system. There is a lot of required effort, demolition and rebuilding to replace the existing tubes and connections. The final costs of a project at this scale would be far beyond the budget of a municipality such as Pateros.

**M2: Simple and understandable**

SCORE: *No*

REASONING: The placement of a new sewage system is understandable but not simple. The local government can understand the benefits of a separated new sewage system but to implement a new sewage system it requires building permits, adjustment to buildings and much more. The political requirements and backup for a new sewage system are not simple to achieve.

**M3: Improves water quality**

SCORE: *Yes*

REASONING: A new separated sewage system prevents wastewater from entering the Pateros river. The removal of a pollution source does increase the water quality in the Pateros river.

**M4: Follows focus clean water manila**

SCORE: *Yes*

REASONING: The focus for the CWM project is tackling the liquid pollution at the source. The pollution source at the houses is removed with the addition of a new sewage system.

### *Septic tanks and leach fields*

**M1: Cost efficiency**

SCORE: *No*

REASONING: In order to add septic tanks and leach field to existing houses, it is required to do surveys in order to discover the current location of septic tanks and it is required to do a lot of demolition and rebuilding of streets for the installation. This makes it costly to implement septic tanks and leach field for an entire municipality.

**M2: Simple and understandable**

SCORE: *No*

REASONING: The septic tanks currently in use are not always optimally implemented, often lacking a proper leach field. This shows that the current understanding of septic tanks is sub-optimal. Additionally, the implementation of septic tanks and leach fields is not an easy and simple task.

**M3: Improves water quality**

SCORE: *Yes*

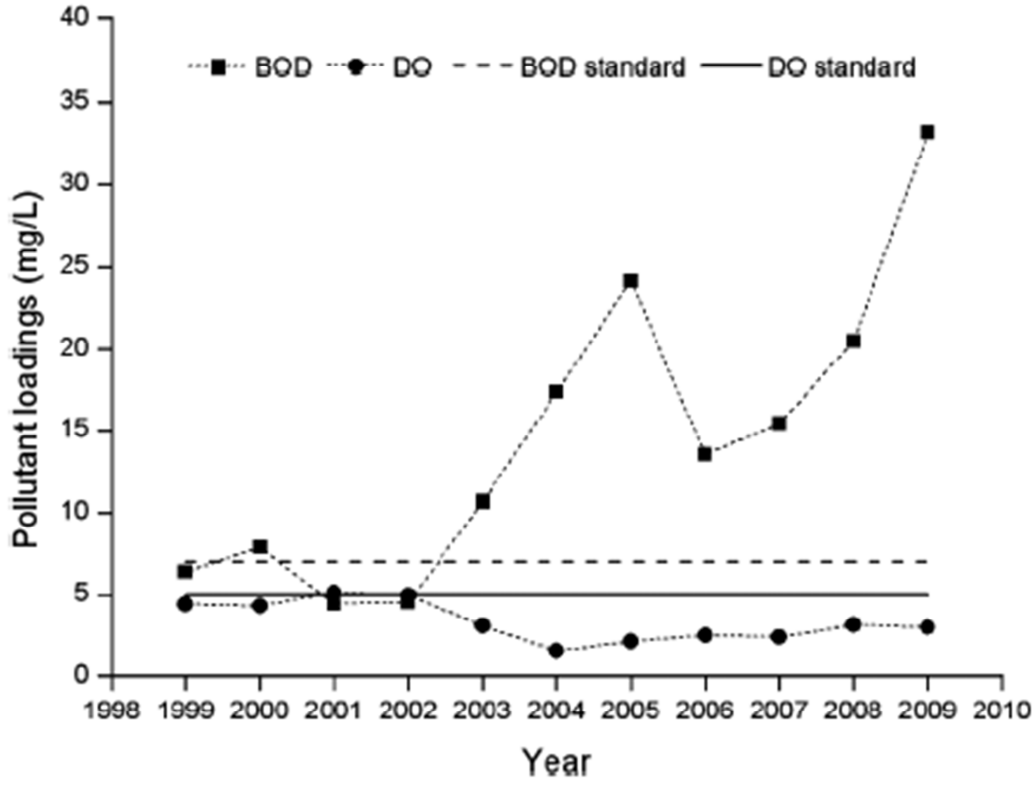
REASONING: Septic tanks improve the water quality of the wastewater which flows through the septic tanks. Effectively preventing the polluting source (waste water) from entering the Pateros river. Less wastewater in the Pateros river improves the water quality inside the Pateros river.

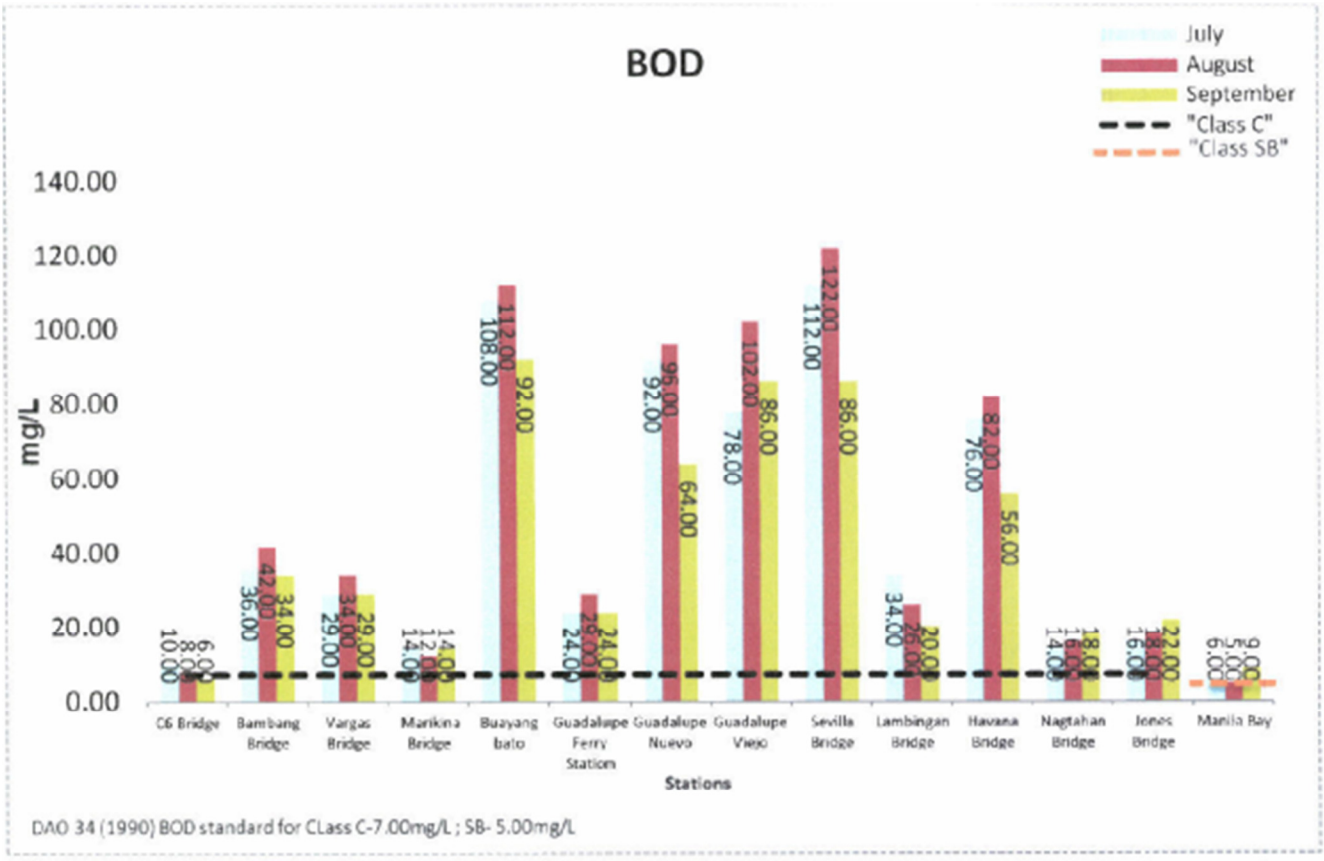
**M4: Follows focus clean water manila**

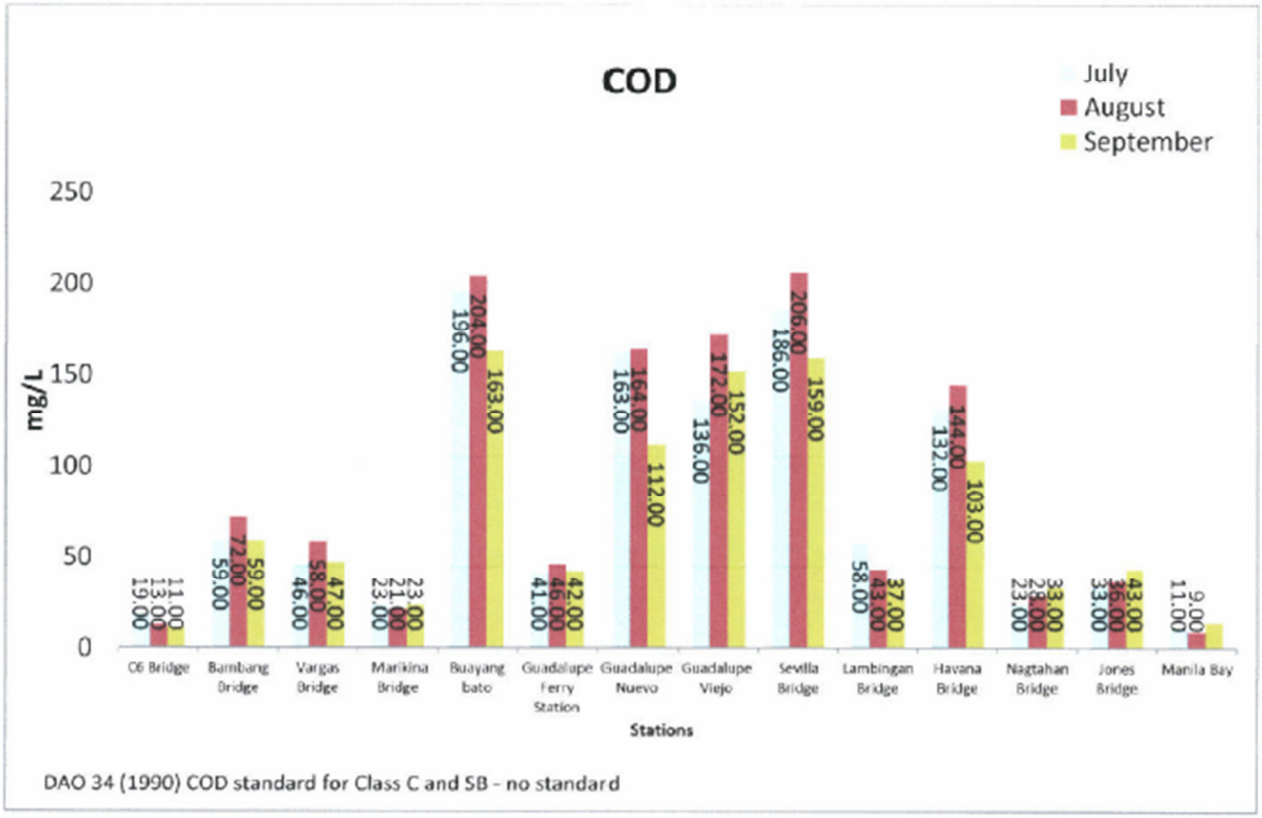
SCORE: *Yes*

REASONING: Septic tanks prevent wastewater from entering the Pateros river at the source of origin, the houses. This complies with the focus area of the CWM project which aims to prevent the pollution at the source of the liquid waste.

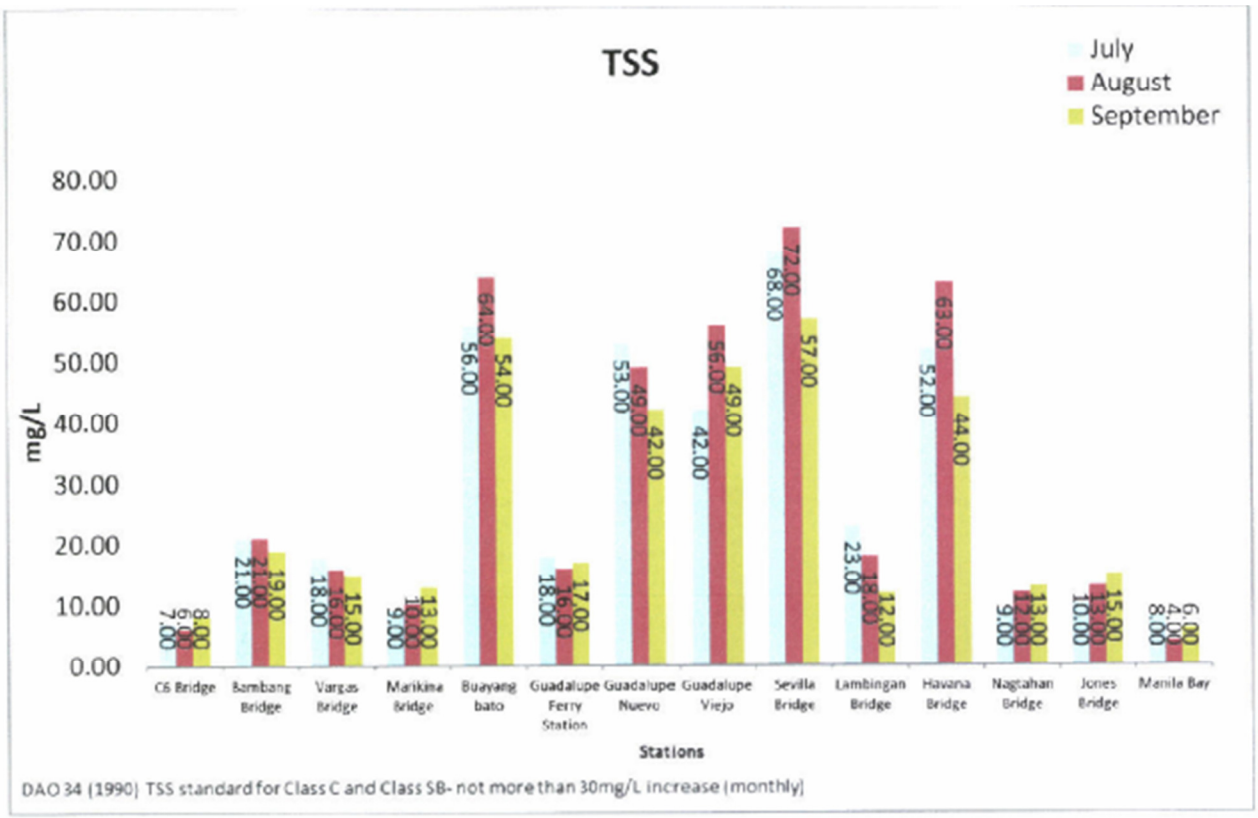
# Appendix 7: Graphs with water quality data from Pasig river.






DAO 34 (1990) COD standard for Class C and SB - no standard




DAO 34 (1990) TSS standard for Class C and Class SB- not more than 30mg/L increase (monthly)

# Appendix 8: Flood Hazard maps

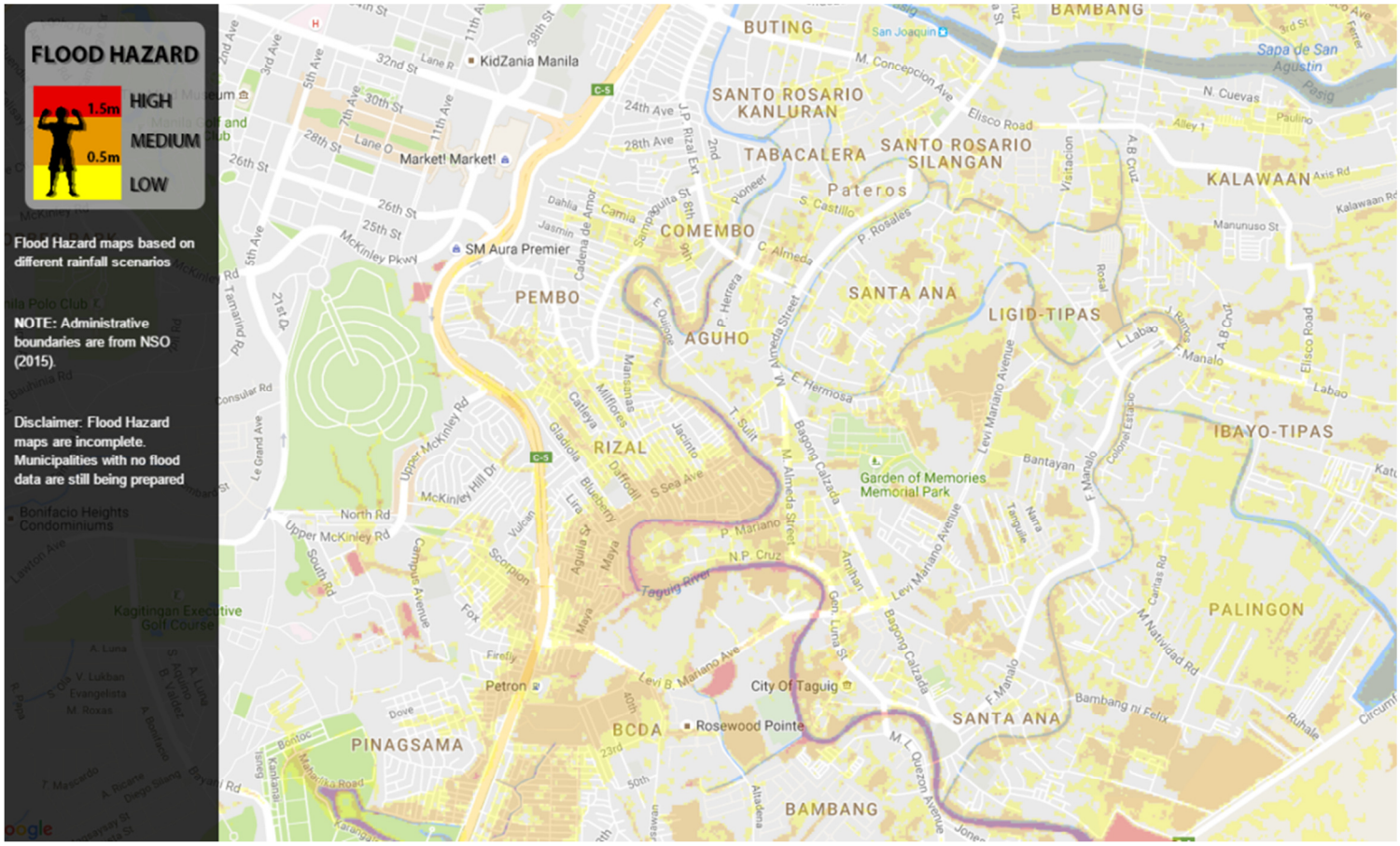



Image: 5 year rain event (© http://noah.dost.gov.ph/)

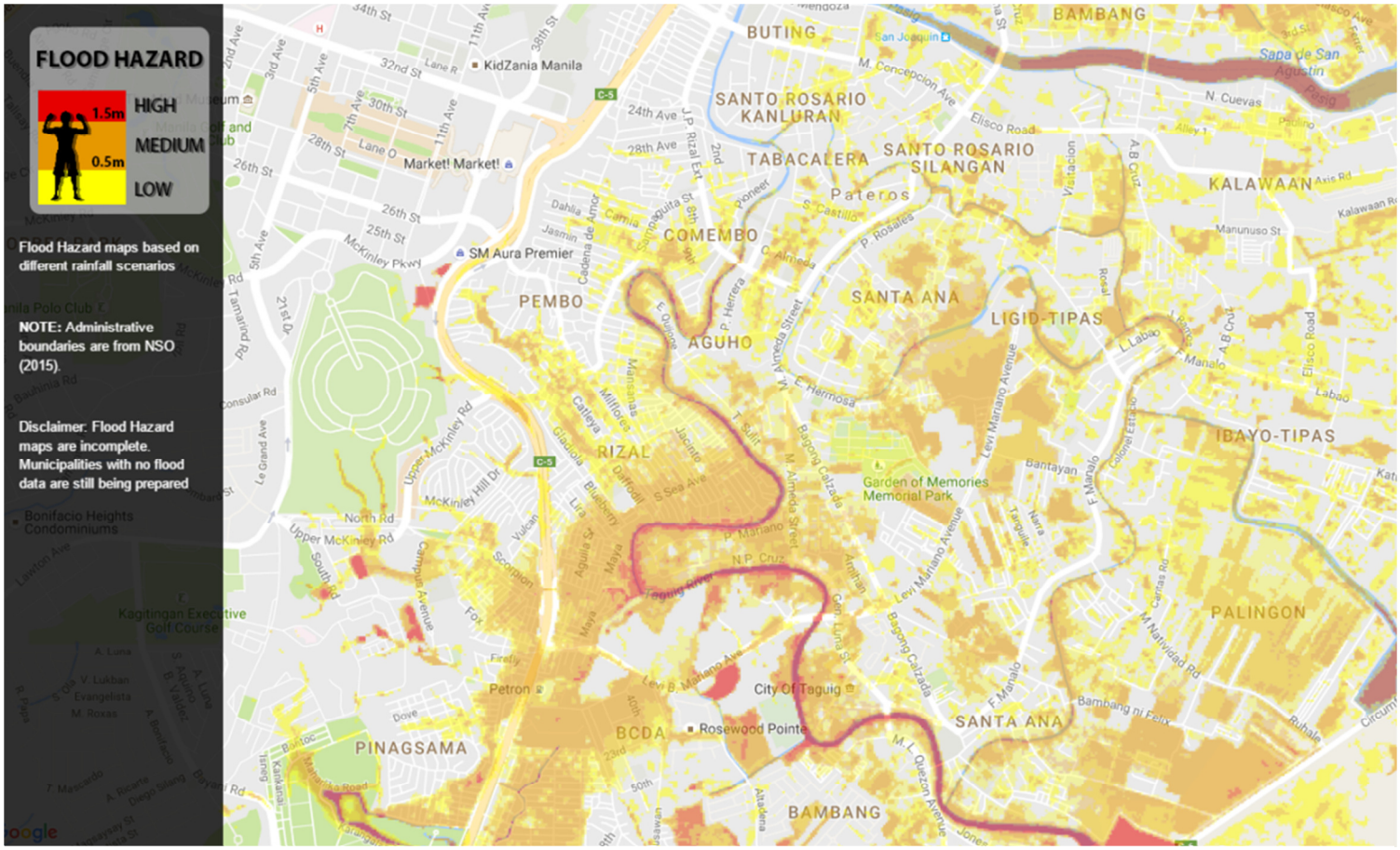



Image: 25 year rain event (© http://noah.dost.gov.ph/)

# Appendix 9: Extended MCA including weights and reasoning

The weighting for the scores in the Multi criteria analysis (MCA) is shown in the next page of this appendix. The weighting have been done based on personal choices instead of a team of locals in Metro Manila.

The reasoning for the weighting is as following.

**Weighted 1. Water quality and Maintenance costs:**

The most important aspect for the Clean Water Manila (CWM) project is the water quality. Improving the water quality is the goal of the CWM project. This is why the water quality is valued as 1, being the most important criteria.

**Weighted 0,9. Flooding and safety:**

The next two are the flooding and safety, which are weighted as 0,9. The flooding and safety are both very important which is why they are very high weighted. The reason they are below the water quality is because of the focus of the CWM project. The focus is not flooding but water quality. The weighting difference is very little and the difference it creates is minimal.

**Weighted 0,85. Costs:**

The implementation costs, maintenance costs and impact on river costs are weighted 0,85. Costs are important for the implementation of a design, but it should not dominate the decision process. It can be acceptable if a measurement costs more if the results are good.

**Weighted 0,68 – 0,75. Maintenance and implementation difficulty, aesthetics and odour:**

The maintenance and implementation difficulty are weighted at 0,75 while the aesthetics and odour are respectively weighted 0,7 and 0,68. It is important that a design can be implemented and maintained, but knew knowledge can always me obtained. Therefore the weighting ended up being medium high. The aesthetics and odour are lower because they do not influence the implemental ability of the design. For aesthetics and odour it is more important to not worsen the situation instead of improving the situation.

**Weighted 0,5 – 0,6. Cooperation with locals and nature:**

Cooperation with nature and locals is ideal and would help implement a design. It will be difficult to create a design which cooperates with nature and locals. Accepting the situation made the weighting 0,5 and 0,6.