Journal of Engineering and Applied Sciences 13 (Special Issue 10): 8178-8187, 2018
ISSN: 1816-949X

Estimation of the Floods that Occur in the Drainage Network During the Rainy Season

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Abstract: Surface overland flow direction in urban area is altered by anthropogenic factors such as land use, drainage systems, roads and other concrete structures and therefore, modeling surface runoff phenomena in urban catchment is much difficult. Complexity of modeling urban runoff has made the designing of urban drainage system a challenging task. A study has been carried out in this study to simulate rainfall driven flow in a sewer system that can cause overflow through manhole and flooding. The simulation is carried out in the Karbala city of Iraq where storm water network is not fully developed. Used Storm Water Management Model (SWMM5.1) for this purpose. The study reveals that a 80 percentile rainfall event causes sewer overflow and surface in the area. It is expected that the study will help in designing and management of urban sewerage system of Iraq.

Key words: Sewerage system, urban drainage, SWMM, Arc-GIS, rainfall, anthropogenic factors

INTRODUCTION

By the late 19th century, engineers in the United States generally recognized topography, population density and future growth as key components in sewer design (Burian *et al*., 2000). Block was modified runoff of Water Management Model EPA storm (SWMM) to allow alternative routes through the flow overland flow which allows directing the flow of areas of inaccessible areas on the former, for example. Been described modifications the quantity and quality in this study. And those changes should makes it easier to evaluate the storm water management technologies new, like a low impact development (Huber, 2001).

For improving the reliability of the Storm Water Management Model (SWMM), it is necessary to approach the optimal parameter to identify the “Best” sets of the input parameter. Within SWMM, unit runoff is the best filter unit to reduce uncertainties parameter optimization (Wan and James, 2002). The simulation of rainfall runoff relations the primary focus of the hydrological. SWMM paper summarizing the ability to simulate the control options and Controls Wet Weather (WWCs) preferred by existing practice, including those related to low impact development (cover). This form is able to simulate certain practices well, like storage and other options are not as well, like land and wetland filtration. Modern gravity sanitary sewers are designed by considering peak and average flows from various sources, infiltration, topography and slope, pipe material and roughness, pipe size, minimum velocity, maximum velocity and other factors (Bizier, 2007). These various design choices and data are input to hydraulic equations to calculate flow and ensure compliance with design criteria (Bizier, 2007). Research for many decades, and has led to an abundance of models that were proposed yet (Kokkonen and Jakeman, 2001).

US EPA SWMM5 has been used new model on projects related to the management of rainwater in urban environments and highways specific public to assess the effects of hydrological and water quality Controls Wet Weather (WWCs), known in the United States on behalf of the, so-called Management Best Practices (BMPs) and low impact development (cover) (Huber *et al*., 2005). Running Storm Water Management Model and the Environmental Protection Agency (SWMM5) for the implementation of hydrological and hydraulic analyzes. Model calibration determines the optimal set of calibration parameters that best matches the notes field of flow, depth or speed to accurately reflect the actual performance of the system. Have shown optimized calibration of the proposed models and design through the application to the system to collect rainwater for example in urban areas. Enhance urban planning, the sewage system and the design, operation and management is a major gain for the methodology

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proposed (Muleta *et al.*, 2006). The main objective of project was to change the timeliness and quality of the water flowing into the channel C-44 which has improved the water quality to SLE by using more than 3,000 acres of the tank and 6,000 acres of rain water cells treated area (STA) (Gibney and Zhao, 2007). Been created continuous stream flow records for a period of 20 years for each watershed using EPA Storm Water Management (SWMM5) Models calibration of 18 months from the flow of the measured data. Demersal indicator was used an indicator dynamic integrity and health of water ecosystems and calculated from aquatic macro invertebrate sampling data gathered by the Geological Survey in the United States in 8 watersheds, ranging from 3.8 km^2 in size. Furthermore, it was also examined the effects of management practices such as rain water detention conventional rain water and water quality control development of a low impact on the hydrological and Geomorphology standards. The metric values were compared hydrological and geomorphological resulting from various practices for those that were created along the gradient of urbanization for the very best administrative practices generated conditions conducive to achieve environmental objectives.

Simulation model of rainfall, runoff used in the design of these ponds is the arrest of the three Storm Water Management Model (SWMM) 5 (Park *et al.*, 2007). Satisfactory results has been getting from the hydraulic model calibration and verification processes have been found but some of the restrictions in SWMM watershed description. The simulation allows for long-term comparison of the benefits of variety of scenarios for the storage and treatment plant for sewage capacity in order to reduce secretions exceeded (Cambez *et al.*, 2008). Simulate rain event in EPA SWMM -5 assess the results of each entry model sub-catchment and estimated percentage of potential to reduce runoff and downside potential in peak flow and timing of flows (Abi *et al.*, 2009). As part of a larger project to raise the level of water services in the city of Liepaja, Latvia. Identify the appropriate programs to use and had two key objectives that need to be considered: rapidly building a model to permit upgrade works to be designed and implemented in the timeframe specified in the credit agreement in the European Union and the provision of affordable design and evaluation tool for use in the future by the water company. To achieve these goals, the use of Info works CS Software to build and model checking was later exported to the model freely available Storm Water Management Model (SWMM) 5. The results were compared and the predictive models of form validation SWMM5 (Koudelak and West, 2008).

The damage has been integrated within the code block calculation model to assess the cost of damage caused by floods in planning optimal drainage systems in urban areas. This is reflected in the application form by application to a case study in Brazil. Pathirana *et al.* (2008, 2011). Model calibration site for Birkdale showed prediction of precisely of system response for both individual storms and continuous simulation (long-term). Model accurately predicts the peak flow of the system response to the events of frequent high (>30% likelihood of excess) with measured flow frequency curves and style matching on this scale (Hohaia *et al.*, 2011).

Seyoum *et al.* (2011) presented details of the model and the newly developed 2D and describes the way in which the model coupled with a 1-Dimensional (1D) Model of the drainage network (SWMM5). Models were tested on the case study of a virtual one and one case study of a real life. For reasons of accuracy, the time step is limited and controlled by the use of repetition to home in on a solution minutes in each sweep. Calculated secretions interaction according to the water level differences between the flows in the network flows above ground.

Problem statement: During the peak seasons for rain exposed drainage system, including the sewers to flood and overflow of water on the streets task which leads to pollution of the environment, influences psychological and social, especially in areas that are nowhere sewerage rain in addition to the increase in operational problems in pumping stations and treatment plants.

Objectives of study: Due to shortcomings, derivation and processing of these data by surface analysis techniques of statistical news and topographical and structural expected to contribute to the public understanding of the drainage system and a credible assessment of the hydraulic properties. With the aid of assessing supported by geographic information systems will be enhanced and the ability to analyze with regard to the network topology, for the query and mapping in view of the results in other words, making the analysis process at the fingertips of the user. This use of the study: calculation of the amount of rain water entering the sewers during the peak season. Identify the places where the flood gets in the wastewater network during peak time and provide these phenomena through thematic maps and graphs.

Model description

Digital Elevation Model (DEM): DEM was obtained through the USGS National Map Seamless Server. For modeling purposes, the slope was calculated by road to the whole catchment and then separation from each sub-catchment. Digital images are a common example of raster data (each pixel is a cell). Other examples of raster data include scanned and georeferenced aerial photographs or paper maps, satellite imagery and Digital Elevation Models (DEMs) (Lillesand, 2000).

ArcGIS basic: GIS is especially, useful in analyzing water and wastewater flows (Shamsi, 2002). Modern Geographic Information Systems (GIS) employ a user-friendly software interface to allow analysis of spatial data (Longley *et al*., 2005). By referencing each of the various data included in the GIS according to a common coordinate system, rich maps can be created that incorporate a number of information types into a single map having the common coordinate system. For example, a user might be interested in conducting a hydrologic analysis and decide to create a map that includes roads, land cover, watershed boundaries, political boundaries and soil types. These various types of information are not typically found together on existing maps. GIS allows users to include all of the data the user determines is relevant to the user's needs, creating a custom map. In addition to allowing users to create custom maps, GIS software provides functionality to perform a variety of spatial analyses on data in the map.

Hydraulic routing: Contrary to the catchment of undeveloped and watersheds in urban areas to provide an additional component to be styled, the sewerage network. However, until whether there GIS based rings with all the links and their corresponding geometric features, modeling may a whole network ineffectual big catchment. Since, the task represents a large engineering effort to model the structure of each rain water drainage and one (i.e., Flow to the bottom drop inlet). Therefore, should be done simplification and unrealistic. Brink proposed with the aim of establish a channel of routing in the accountancy system of stored and attenuation that could occur within an area semi-catchment due (A).

Characteristic width estimation: Wayne and Robert (1988) proposed to combine several sub-watersheds collected in one calibration of the display-sub-catchment. Supply reduction increases height and flow within the storage sub-region, leading to an effective way to alleviate runoff water without modeling of storage networks in the piping system and for this reason, the parameter show is often the basic parameter average to get required flow rates peak shapes and watery.

MATERIALS AND METHODS

In this study, the use of GIS system and SWMM5 as tools to facilitate the process of data entry, analysis and comparison among them in the case of rainfall and the lack thereof, as shown in the flow chart of methodology in Fig. 1. The EPA SWMM5.1 is used for simulation of storm-sewer discharge, velocity, surcharge , …, etc. in order to evaluate the sewage network hydraulic performance induced and Rainfall Dependent Inflow and Infiltration (RDII) for overflow simulation. The runoff module of SWMM works on the sub-catchments that generate runoff and pollutant loads. The routing module of SWMM transports the generated runoff through a network of channels and pipes, storage and treatment devices, pumps and regulators. SWMM5.1 keeps the track of the flow rate, flow depth, runoff volume generated within each sub-catchment and the quality of water in each pipe and channel at different time steps of the simulation.

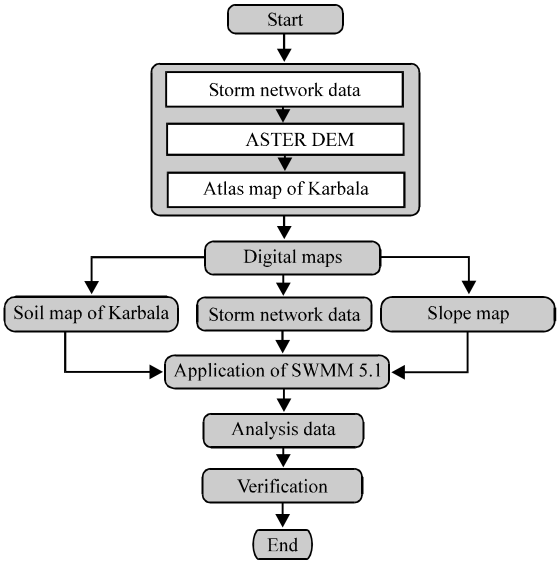

Fig. 1: Flow chart

Study area and data source: Geographically speaking Karbala is a city in Iraq with an area of 5,034 km^2 which is located about 100 km South West of Baghdad. It is often seen as one of Iraq's richest cities benefiting from both Religious and agricultural factors. Karbala experiences a cool Winters and hot desert climate with extremely hot, dry Summers. Almost all of the yearly precipitation is received between November and April, though no month is truly wet. Map of Karbala generated by GIS as shown in Fig. 2.

Location of watershed: The case study is Kerbala city as shown in Fig. 3. The main properties of this catchment are described in Table 1.

Routing channel: Natural streams are part and parcel of the sewer system. The estimated channel manning roughness during field work by pursuing guidelines

Table 1: Watersheds properties (McMahon and Cuffney, 2000)

Watershed name	Kerbala city
Area (ha)	7.120
Total impervious area (%)	75
Population density (per/ha)	260
Housing density (homes/ha)	27.3
Population of district	8505
UII 2	100

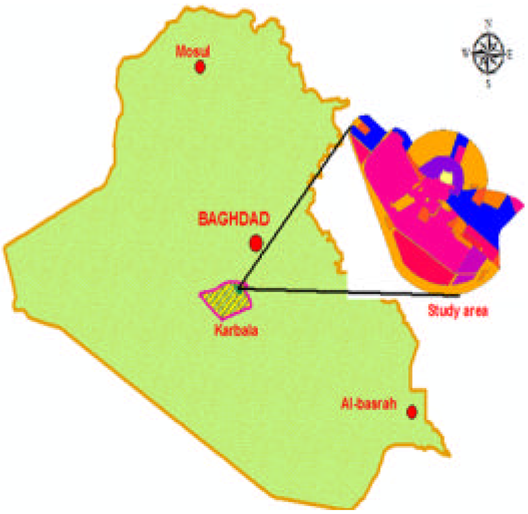

Fig. 2: Map of Karbala city in Iraq

provided by Chow (1959) and Arcement and Schneider (1989). An initial site the investigations were conducted to determine the main features of the main transfer Streams. Field work has been during the month of in Nov. 2005 to obtain transects in major channels using standard and rod as described by Harrelson *et al*. (1994).

Hydro climatology: Hydrology is the science which treats of the water of the earth and its occurrence as rain, snow and other forms of precipitation. It includes study of the movement of water on the ground surface and underground to the sea, transpiration from vegetation, and evaporation from land and water surface, back to the atmosphere analysis has led to improved understanding of hydrology cycle. In recent years systems physical and theoretical standpoint of hydrology use of mathematical or computer simulation models which can predict hydrologic events. Precipitation data constitutes the main input to the model, it comes in a spatial distribution of precipitation over time. Climate is defined as the weather changes in a vast area and for a period of time long enough to identify all its statistical features. Climatologically change represents the differences in the data of the average climatic readings or among sequential climatological times (Kite, 1989). The climate information

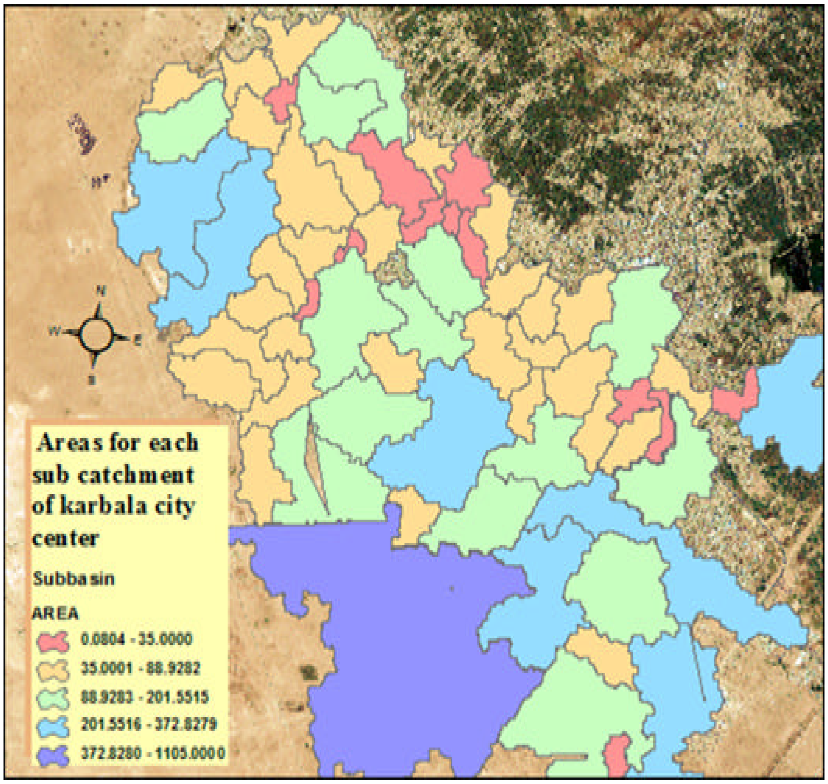

Fig. 3: Karbala watershed generated by GIS

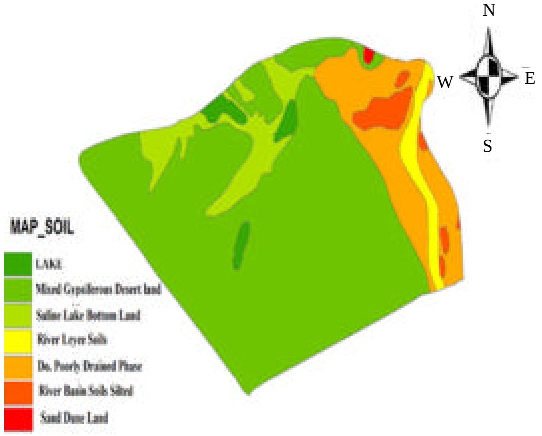

Fig. 4: Soil map generated by GIS

was tacked for period of 30 years (1980-2010) which gained from Iraqi Meteorological Organization, the climate of the studied area is characterized as being continental, dry and relatively hot in summer, cold and with little rain in Winter and it is believed to be influenced by the Mediterranean Sea climate. In addition to the remarkable difference in the temperature between day and night.

Precipitation: It which include rainfall, snow, hail and sleet, is the primary source of water in streams, lakes, spring and wells and the engineer is concerned principally with precipitation data in the absence of stream-flow records. The US geological survey operates an extensive network of stream-flow gauging stations thought the country usually are not gauged, although, the country and use of their records many make it unnecessary to study precipitation records and estimate runoff therefrom. The smaller streams of the country usually are not gauged, although, short-term records for specific streams may be available precipitation data must be obtained and the watershed studies in order to determine the stream-flow characteristics. This is less desirable than the use of actual runoff data and even a few years of stream-flow records are of great value in relating precipitation and runoff (Tchobanoglous, 1981).

Rainfall: Rainfall is one of the significant climatic factors where rainfall period in the area of study is restricted to the months from October-January for the period from 1980-2010; The highest rainfall average recorded in January was (16.0 mm) while the lowest average has been recorded in July and August as it were (0 mm). The rainfall of the area under study is characterized by heavy rainfall for short periods of time Fig. 4. One of the important factors affecting the quantities of rainfall, other than difference in location is the different frequency from one year to another.

Temperature: Temperature represents an important factor in the evaporation and evapotranspiration which results in worming air. The annual average temperature for the period from (1980-2010) in Karbala city is high in summer; the highest degree of temperature has been recorded in August 2010 which was 47.4°. The lowest degree has been recorded in January 1983 which was 1.6°.

Evaporation: The process of evaporation is normally related with the temperatures where it increases as the temperature increase and inversely with the rainfall and the relative humidity. The amount of water evaporated from land surface depends upon the amount of moisture available which depends upon the rainfall and those characteristics of the soil which affect infiltration, absorption and percolation. Climatic conditions, particularly radiation and humidity also play an important part. Such evaporation also includes interception or the precipitation which lodges upon leaves of trees, blades of grass, etc. and is quickly evaporated. Shading by vegetation can greatly reduce evaporation from underlying soil. Soils in contact with a free water surface will replace surface moisture by capillary action and evaporation will continue as long as a difference in vapor pressure exists if the water surface is reasonably close to the soil surface. Even under these conditions evaporation is less significant than transpiration. Tchobanoglous (1981). Evaporation is one of the significantly important climatological factors that influence environment and is strongly connected to the other factors (temperature, relative humidity, wind speed, air pressure, evaporation surfaces and nature of evaporation surface). The process of evaporation affects the chemistry of the ground water. The strong evaporation leads to deposit the salts in the soil like the gypsum, calcite and chlorides consequently. The monthly evaporation rates in the Iraqi General Atmospheric Karbala Station for the period from (1980-2010) were between (486.9 mm) in July and (67.7 mm) in January.

RESULTS AND DISCUSSION

Preparation of maps: The maps of slope, soil, sewer and storm networks of the study area were prepared in ArcGIS 9.3. The maps are described below.

Soil map: Soil texture has a significant effect on groundwater potential. The soils with high porosity are considered as good for the extraction of groundwater. The soil map of the study area is classified into seven types of soil as shown in Fig. 4 was prepared by digitizing from soil map of Karbala city in ArcGIS.

Slope map: The slope is one of the important factors for the direct effect on runoff velocity and flow size. If the slope is steep the runoff will be high and infiltration will be less. The slope map of study area was prepared from ASTER DEM data in ArcGIS as shown in Fig. 5.

Comparison between the state of the sewerage network before and through rainfall: After input all data: rainfall, temperature, sewer and storm networks in SWMM5 and running it we get results before and through rainfall.

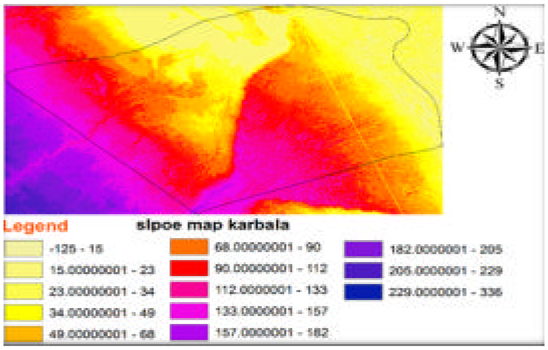

Fig. 5: Slope map generated by GIS

Depth of water: The depth of the sewage manholes changes with time in both cases before the downpour clarified in Fig. 6. The second case, during a moment of rainfall as shown in Fig. 7. For example were taken manholes MR-24 to MR-32 being one of the more web sites where they got the rash.

Total flow: The total flow from a sub-catchment is the sum of the flow from the impervious area with and without depression storage and the pervious area with depression storage. The same slope, width but different roughness applies to the pervious and impervious portions of the sub-catchment (Fig. 8 and 9).

Flooding in nodes: The flooding and rash in drainage systems for this area of study during the rainy season was specified in manholes MR-24 to MR-32: 91 as the highest state in which it gets a rash as well as the fact that the network of sewage filled completely. As illustrated in Fig. 10 before for flood (without rain) and Fig. 11 during the rainy season.

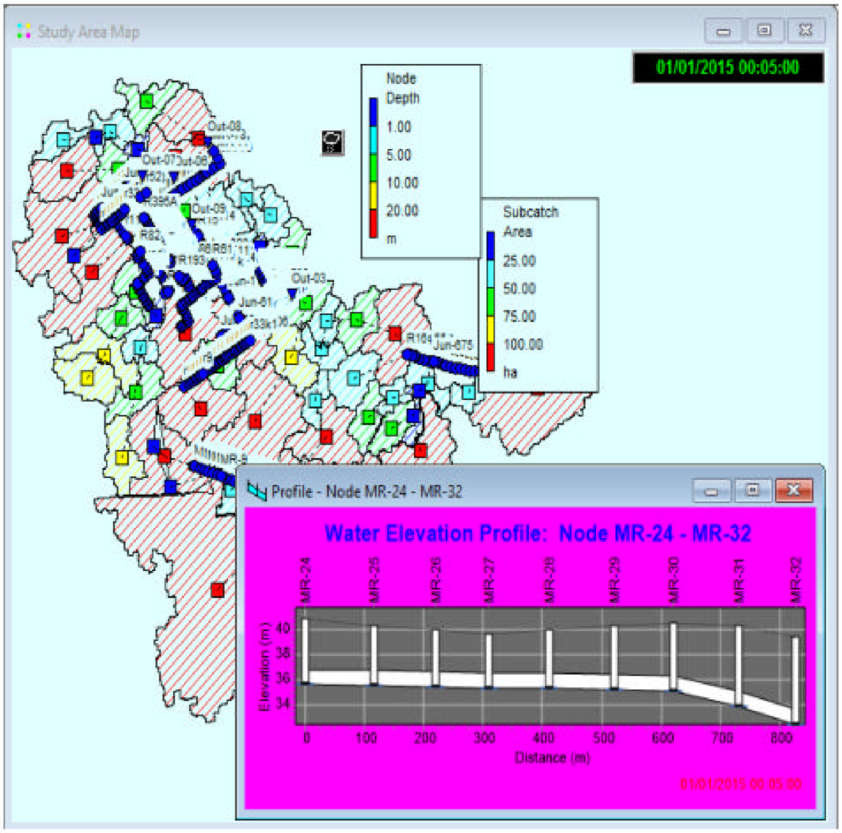

Fig. 6: Depth of water in nodes before rainfall

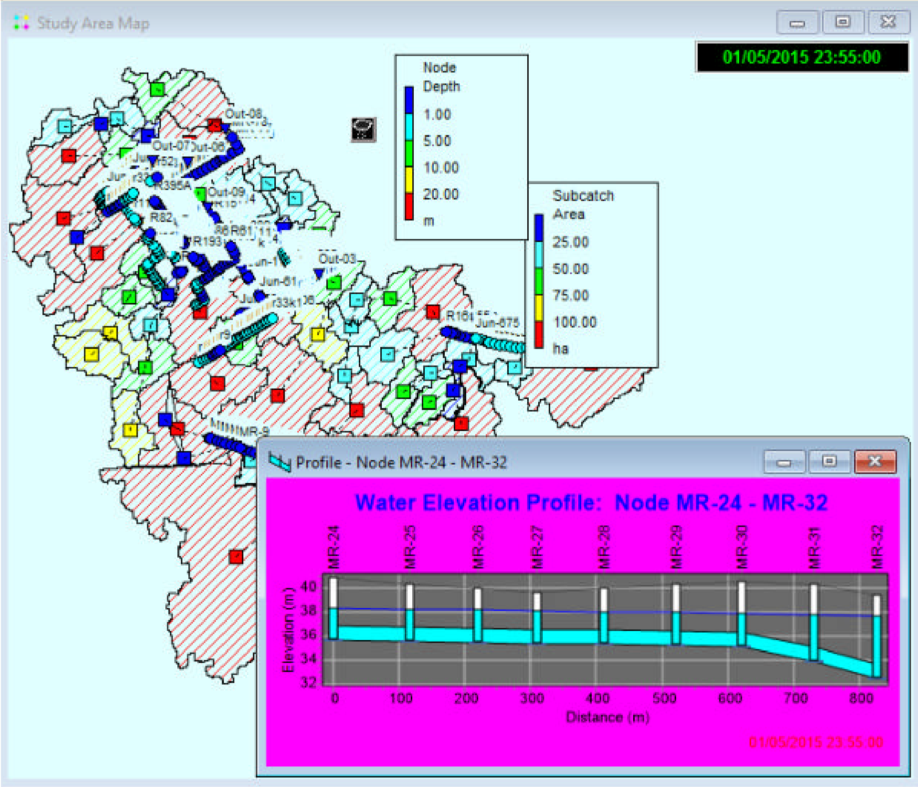

Fig. 7: Depth of water in nodes through rainfall

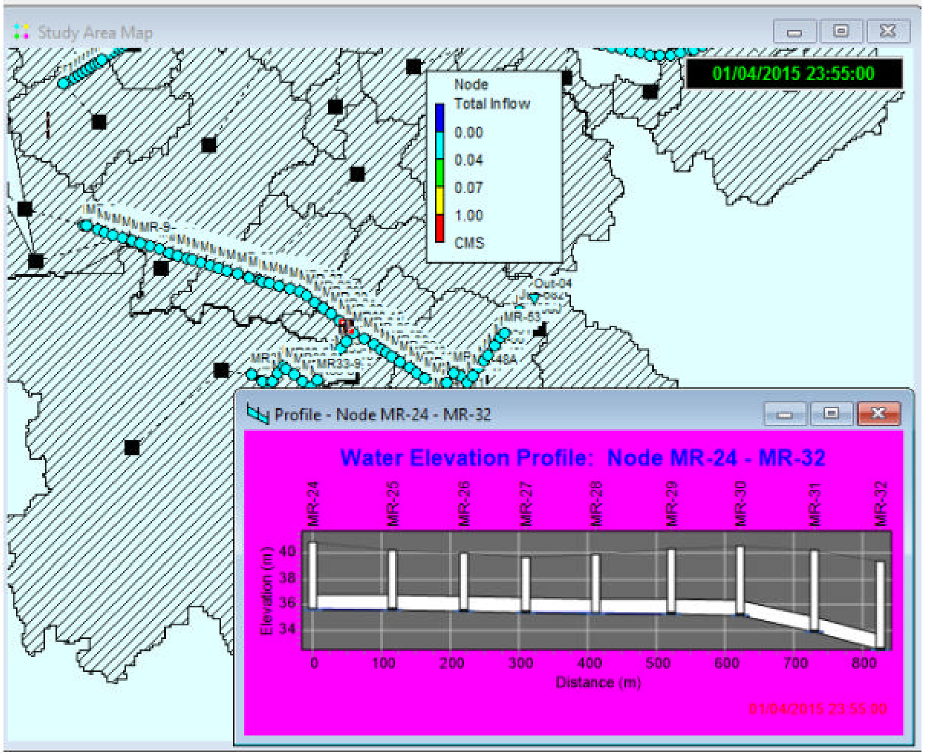

Fig. 8: Total flow in sewer networks before rainfall

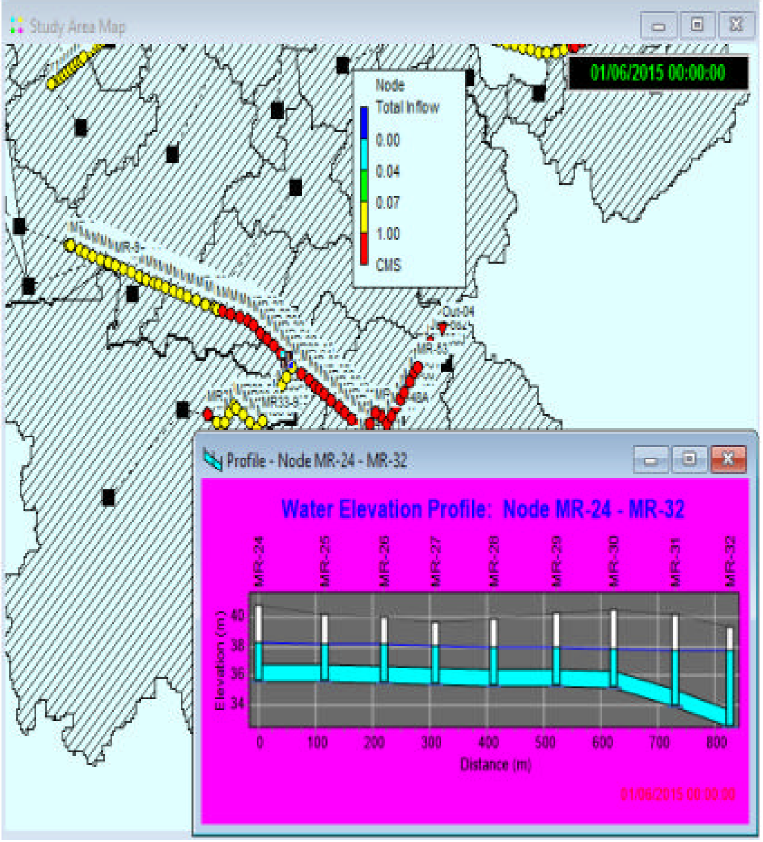

Fig. 9: Total flow in sewer networks through rainfall

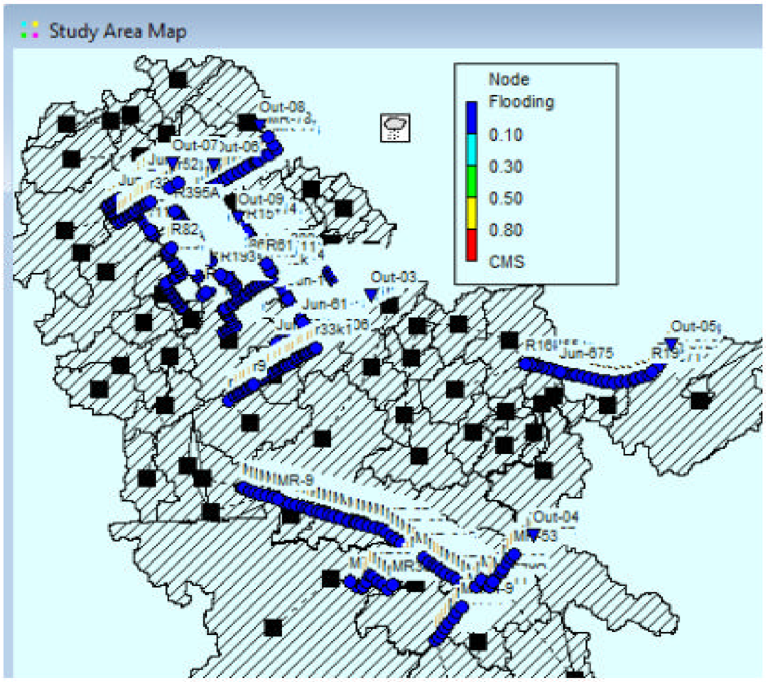

Fig. 10: No rainfall no flooding

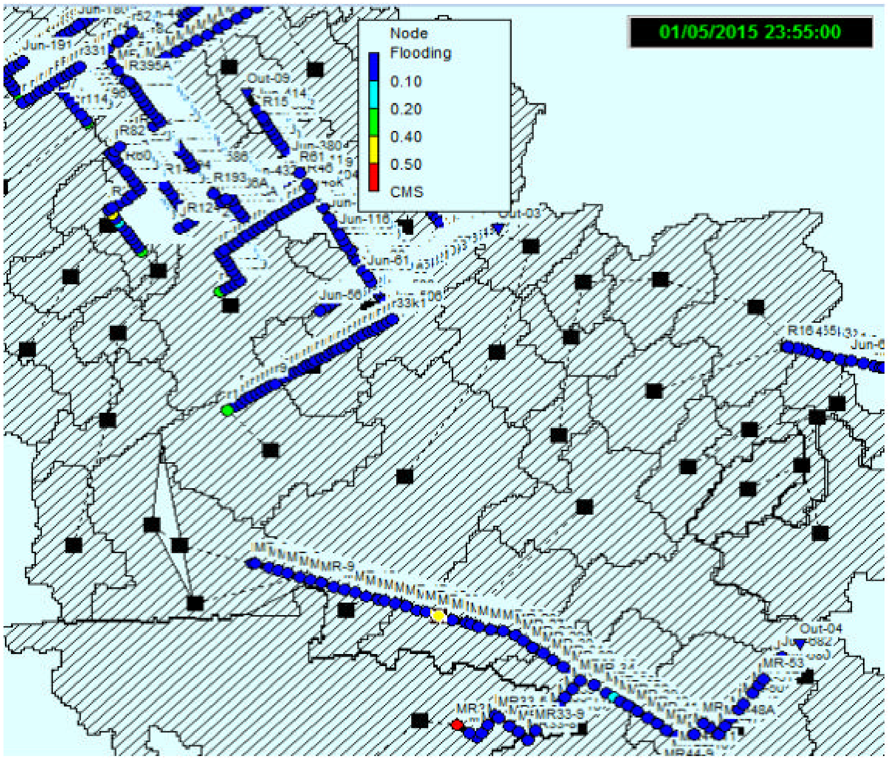

Fig. 11: Flooding when rainfall is available

Despite the existence of a network of rain on the street that contains manholes sewage MR-24 to MR-32 where there was a rash during the rains as well as filling all the drainage network, due to the fact that these manholes far from the downstream and cannot network rain water drainage that quickly, especially, most of the streets in this chord is paved watershed with asphalt which affects the flow of rain water as shown in Fig. 6-11.

CONCLUSION

Through these results above shows that the size of the rash and flood drainage systems in areas that are nowhere networks rain depends primarily on the status of the network in terms of the presence of holes and areas of weaknesses as well as the intensity rain affect the amount of flooding, especially in MR-24 to MR-32 where the manholes were more unstable as well as the network is filled with very. Therefore, we recommend that the rehabilitation of drainage systems and regular maintenance and ongoing in this study was to determine the amount of water coming into each manhole and each time entering this water, whether from rain water or groundwater.

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