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Drainage Network and Hydrological Model Theory EPA SWMM

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Abstract:*Due to people's daily activities, cities, and residential areas create many sources of pollution with different characteristics. Those pollution sources include physiological wastes of humans, domestic animals, and wastes of the production process according to wastewater into the external environment. Therefore, the task of the drainage system is to quickly collect and transport all types of waste out of the area, and at the same time treat and disinfect it to meet sanitary requirements before discharging it into the receiving source. On the basis of an overview assessment of the drainage network, this study focuses on theoretical analysis of the Epa Swmm hydrological model and its application in practice.*
Keywords*: Drainage Network, hydrological, model theory, Epa Swmm*

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I. INTRODUCTION

A water supply system is a system of structures (or equipment) that do the following tasks: water collection – water transport – water treatment – conditioning and distribution to smaller areas, or to where there is a need. use water.

The causes of flooding from rainwater and wastewater in Vietnamese cities are usually: inadequate drainage system; the original design did not match; runoff coefficient in drainage basin increases due to change of cover surface; leaking water supply pipe; clogged drains, sedimentation; damaged drainage works; incidents at pumping stations to drain rainwater and wastewater; due to climate change leading to increased rainfall and irregular urban hydrology, sea level rise.

The drainage system is specified in Clause 10, Article 2 of Decree 80/2014/ND-CP on drainage and wastewater treatment [1].

Accordingly, the drainage system includes the drainage network (pipes, culverts, canals, ditches, regulation lakes, etc.), and pumping stations to drain rainwater, wastewater, wastewater treatment facilities, and other facilities. other ancillary works for the purpose of collecting, conveying, draining rainwater and wastewater, preventing flooding, and treating wastewater. Drainage systems are divided into the following types:

The standard drainage system is a system in which wastewater and rainwater are collected in the same system;

A separate drainage system means a different drainage system for rainwater and wastewater;

The semi-private drainage system is a standard drainage system with an enclosed sewer line to separate wastewater and bring it to the treatment plant.

II. RESEARCH RESULTS

Drainage system

The drainage system is a combination of equipment works and technical solutions organized to perform the task of drainage.

Based on the purposes and requirements of making use of wastewater sources of the development areas adjacent to cities, towns, and townships, etc., [2]requirements on sanitation techniques, and principles of wastewater discharge into urban drainage networks, Drainage systems are distinguished: common drainage system, separate drainage system, semi-separate drainage system, and mixed system [3].

Common drainage system (Figure 1): is a system where all types of wastewater discharge into a network and lead to a treatment facility. The common drainage system has the advantage of ensuring the best in terms of hygiene because all dirty water is treated before being discharged into the source.

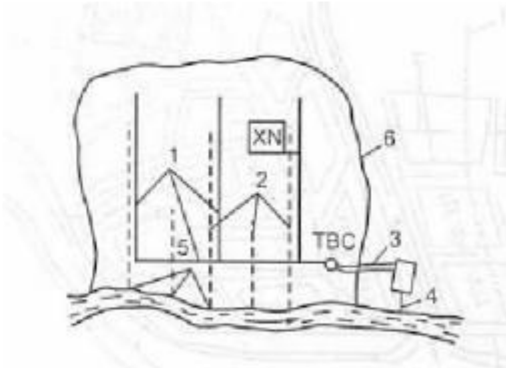

Figure 1. Separate drainage system

Separate drainage system (Figure 2): is a system with two or more separate networks: One is used to transport dirty water when it is discharged into the source for treatment, and the other is used to transport less dirty water for treatment discharge directly to the source [4]. Compared with the common drainage system, the separate drainage system is more beneficial in terms of construction and management, but in terms of sanitation, it is inferior, but the advantage is that it reduces the initial investment capital and the working regime. the work of the system is stable. The disadvantage is the existence of two or more urban drainage networks.

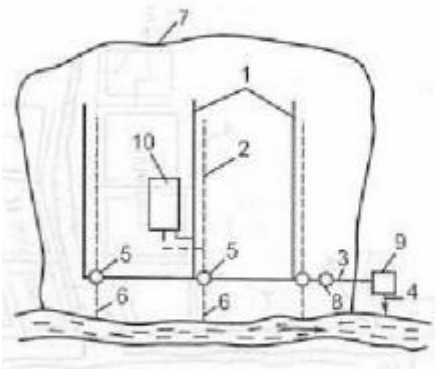

Figure 2. General drainage system

Mixed drainage system: is a combination of the above types of systems, commonly found in expanded cities.
The drainage system and diagram selection must be based on the long-term and stable service nature of the equipment works on the system. Depending on the local conditions, on the basis of comparing economic, technical, and sanitary, we choose this or that system as appropriate.

Duties of drainage systems and types of wastewater

Due to people's daily activities, cities and residential areas create many sources of pollution with different characteristics. Those pollution sources include physiological wastes of humans, domestic animals, and wastes of the production process according to wastewater into the external environment.

Supply water after being used for domestic and production purposes and rainwater flowing on roofs, road surfaces, gardens, etc., becomes wastewater containing many inorganic and organic compounds that are easily decomposed and stored. Many bacteria cause and transmit dangerous diseases [3]. If one of these types of wastewater is discharged indiscriminately, it will pollute the water, soil, and air environment, arise and spread harmful pathogens affecting human health. On the other hand, if not collected and transported, it can cause flooding in residential areas, urban areas, factories, industries, etc., limiting construction land and affecting the foundation [5]. The construction obstructs traffic and harms a number of other economic sectors.

Therefore, the task of the drainage system is to quickly collect and transport all types of waste out of the area, and at the same time treat and disinfect it to meet sanitary requirements before discharging it into the receiving source.

Wastewater has many different types depending on its nature and origin, people distinguish the following three main types:

Domestic wastewater: Discharge from sinks, toilets, toilets, etc. contains many organic substances and bacteria.

Production wastewater: Discharged after the production process. The composition and nature of this water depend on the industrial sector, raw materials consumed, technology, etc. varies greatly. People often distinguish production wastewater into two groups: heavily polluted water and less polluted water.

Rainwater: Rain falls on rainwater flowing on the surface of roofs, streets, squares, hospitals, schools, residential areas, and industrial parks...contaminated. In urban areas, domestic and production wastewater is carried together, the mixture is called urban wastewater.

Principles of routing the drainage network

The drainage network can be one (if the object is small) or several major culverts serving several drainage basins. A drainage basin is an area of an urban area or industrial enterprise in which wastewater flows to a main culvert. Basin demarcations are watersheds. The main culverts are usually located along the conduit.

Drainage systems are usually designed on the principle of self-flow, when the drain is set too deep, the pump is used to raise the water and then let it flow again [6]. Network mapping should be done in the following order:

Division of drainage basins.

Determine the location of the treatment station and the location of the water discharge to the source.

Line up main culverts, basin culverts, and street culverts and follow the following principles:

Must take full advantage of the terrain to place sluices in the direction of water flowing from the high ground to the low ground of the drainage basin, ensure that the largest amount of wastewater flows by itself, avoid digging and embankments, and avoid placing many stations waste pump;

The culvert must be placed reasonably so that the total length of the culvert is minimized, avoiding the case of water flowing around, and avoiding placing deep culverts. Depending on the topography of the ground and the Box Diagram, when culverts are placed along the roads surrounding the neighborhood;

Low boundary map, when it is placed along the road to the low terrain side of the neighborhood;

The main culverts drain to the treatment station and the outlet to the source. The treatment station is located on the low side compared to the city's terrain, but not flooded, at the end of the main wind direction in summer, at the end of the water source, ensuring the distance of sanitation, away from residential areas and industrial enterprises is 500m [7];

Minimize culverts going through rivers and lakes, ferry bridges, roads, dams, and underground works. The arrangement of sewers must know how to closely combine with other underground works of the city.

Theory of hydrological model EPA SWMM

The drainage network in the hydrological model includes the following attributes: rain data, the properties of the basin: roughness coefficient, groundwater, evaporation, impermeable area, permeable area, and upper depressions. basin, catchment slope, and the average width of the basin, etc. the above factors combined with rainfall create runoff on the surface of the basin and then flow to the manholes, sewer, and drainage network. out the outlet [8].

Rain data was investigated and data collected, based on the current survey and future planning, attributes of the basin [9]. The properties of the basin are important because it determines the amount of water flowing into the network and out of the basin.

In this section, we will focus on clarifying the properties of the basin with the presentation of calculation formulas, experience coefficients, etc. in order to help the hydrological simulation of the drainage network as close to reality as possible.

Rain on the basin

Select the data type for rain:

Rain data is the most important of the hydrological data. For the EPA SWMM hydrological method, the rain data must be a rain graph showing the intensity relative to the simulated period. The simplest form is to use a typical rain for the whole city, with a time step of 15 minutes or hours corresponding to the rain history according to the hydrological data of each region.

Rain cycle repeats:

The purpose of urban drainage design is to prevent urban flooding, corresponding to how many years (for example, 5 years or 10 years for small cities and 100 years for large cities), or ensure that make sure not overload as the population grows (for shared drainage) [10]. Thus, choosing how many years the rain repeat cycle is suitable for an urban area is very important and must be considered carefully because the established network will last for hundreds of years and is difficult to change.

According to the traditional urban drainage technique, using the rain graph in the form of the IDF curve (intensity - intensity; time - duration; frequency - frequency). It is the frequency factor that creates the surface flow on the basin, the peak discharge depends on the frequency. Peak flow will enter the network and rely on it to determine the diameter of the drain.

Engineers planning and designing drainage networks must try to balance the two factors of construction cost and sustainability of the drainage system. This is a difficult problem that requires many scenarios. The factor that chooses the scenario is the repeat cycle of the rain, also known as the frequency.

It is the choice of frequency that is difficult, so the EPA SWMM has developed and allows the description of the real-time rain measured with a continuous time interval. But the important thing here is that the recorded data and rain measurement must be accurate, measured, and recorded continuously. This can easily be done with the support of modern automatic rain gauge monitoring tools [11].

Therefore, using the form of continuous rain data corresponding to an iteration cycle is no longer difficult, which shows that the EPA SWMM model that simulates rain in this form is a great advantage for the designer.

Water evaporates on the basin

The property of water evaporation on the basin occurs when the basin surface is heated, in the first events the rainwater that falls initially will partially evaporate. This data is surveyed on a month-by-month or time-series basis. The amount of water that evaporates and infiltrates the soil is the amount of water lost by rain when it falls into the basin.

And when it rains continuously, this factor is no longer important because the air temperature has dropped. However, in Ho Chi Minh City, there are usually no continuous rainy days like in the Central or Northern regions, but most of the rains occur in a short time, so this factor needs to be included. hydrological model.

Seepage on the basin: In the EPA SWMM model, there are two options for seepage models on the basin, which are the Horton and Green-Ampt seepage equations.

Horton's permeability equation:

The Horton (1940) infiltration equation used to calculate the infiltration capacity of the soil based on a function of time has been used by many hydrological models, including the EPA SWMM. Equation of the form:

$$f_p = f_\infty + (f_o - f_\infty)e^{-at} \qquad (1-22)$$

Where:

f_p : permeability, m/s

f_∞ : minimum permeability coefficient at time t = ∞, m/s

f_o : maximum permeability coefficient at time t = 0, m/s

t: rain start time, s

a: attenuation coefficient, 1/s

The permeability equation is a function of time:

$$f(t) = \min\left[f_p(t), i(t) \right] \qquad (1-23)$$

With:

f: permeability, m/s

i: rain intensity, m/s

This is a simple equation that correlates seepage capacity with rainfall intensity. The two values f_0 and fp are usually larger than the rainfall intensity. So the Horton equation uses fp as a function of time, the value of fp will decrease with the intensity of rain if the rain happens very quickly.

Boundary condition of the outlet

The boundary condition of the discharge outlet is understood as the condition that flows from the drainage network to the receiving source. With different boundary conditions, the flow regime at the junction will be different and affect the flow of the network. And there can be five kinds of conditions for the outlet:

• Fixed = the water level at the outlet is always kept at a fixed water level that does not change over time, this case applies when there is control of the water level in the lake or in the canal, always keeping the water level for traffic purposes. Water.

• Free = The water level of the outlet is the minimum height between the demarcated flow depth and the normal water depth of the sluice connected to the outlet, whichever is smaller will be selected.

• Normal = The water level of the outlet is taken according to the depth of the water layer in the sluice connected to the outlet.

• Time Series = user-defined time series of pitches.

With five types of conditions can be selected to suit the flow conditions at the receiving source. Each outlet at a time of calculation can only choose one type of boundary condition.

III. CONCLUSION

In summary, for urban drainage networks, in order to comprehensively simulate the flow regime and the influence of boundary conditions (e.g. tidal influence, etc.), a dynamic wave hydraulic model should be selected. hydrodynamic wave. With computer science's strong development, solving the dynamic wave equation is no longer difficult. Because of this, it has helped engineers involved in planning and renovating the old drainage network to have tools, so that they can get results to recognize and evaluate network planning options. network or renovate the network as comprehensively and safely as possible.

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