Software Determines Storm Drainage and Pumping Needs

The Port Authority of New York and New Jersey was confronted with the problem of developing an adequate drainage system to meet the needs of the Elizabeth Port Authority Marine Terminal project.

Redevelopment of the Elizabeth Port Authority Marine Terminal involves rail expansion and relocation. The railway line crosses the main North-South roadway, Corbin Street, at the same grade level, delaying traffic as trains travel through the intersection. Due to design constraints related to how steeply this rail track can rise, it would be necessary to lower McLester Street below its current level to create a fly-over.

Port Authority engineers needed to know the hydraulic feasibility of their proposed pumping station, which would remove water from the section of McLester Street to be lowered. Storm runoff would flow into a 2,000-gallon wet well, and then pumps would direct it into Elizabeth's existing drainage system. This system would run south into a large box culvert that would discharge into Newark Bay. They also needed to see how the addition of the pumping station would affect the existing drainage system, a gravity flow system designed for a 10-year storm.

Pump Wear a Big Concern

Because the depressed section of road has no gravity outlet, the Port Authority wanted to look at the performance of the entire drainage system during a more severe, 25-year storm. Their concern was what would happen when very heavy rainfall exceeded the capacity of the gravity flow system. That would cause the pipes to fill up, and water to flow out of the catch basins. The water would travel overland, and because the depressed area of the road was the lowest spot in the area, the water would flow in that direction. Even though the pumps would remove it, the water would flow back in. This recycling would wear out the pumps, designed to handle the small drainage area for the depressed section of the street, not flow from the entire drainage area.

DMJM Architects and Engineers (Newark, NJ) were brought in to determine water surface elevations in the drainage area during 25-year storm conditions, as well as evaluate the current drainage system, and a system with the proposed pumping station.

A partial view of the Port Authority's project.

Modeling Municipal Hydraulic Systems

DMJM used HYDRA, a sewer-modeling program from Pizer (Seattle, WA), to maintain consistency with sewer models created for the storm water drainage system at Newark International Airport. An analysis and planning tool, HYDRA models the hydraulics in municipal storm, sanitary and combined sewer systems.

Using HYDRA, a DMJM engineer created a digital model of the collection system. The area he needed to model was one that discharged into the box culvert at the south end of the marine terminal. This included a major arterial sewer serving McLester Street, the street where the future pumping station would be located, as well as several collector sewers on either side of McLester. The engineer used record drawings and aerial photographs provided by the Port Authority to create the model, including all pipes 30 inches in diameter and larger.

The next step was loading the sewer model with rainfall amounts. The engineer used the Soil Conservation Service's Type 3 distribution, representing the northeastern coast of the U.S., which is subject to high-intensity storms. This distribution is based on geographic location, and determines how the rainfall is spread over 24 hours.

In addition, the DMJM engineer needed to enter the software related to the tailwater in the box culvert. This represents the hydraulic grade line at the final discharge point into the bay. Tailwater is affected by tidal fluctuations, so it was necessary to enter a starting point for the tailwater. This way, the analysis could take into account the effect of the bay water on the discharge from the culvert. The engineer used mean tide level, elevation 297.35 feet, as the starting tailwater.

The engineer ran the first analysis evaluating the ability of the existing collection system to handle the 25-year storm. Results depicted the hydraulic grade line, or elevation of the water surface, at every pipe in the model. If the system had been unable to handle the rainfall, he would have seen hydraulic grade lines that were higher than the ground elevations at the catch basins, indicating water coming out of the catch basins. The analysis showed a surcharge, indicating water rising higher than the tops of the pipes and putting them under pressure, but not overflowing at any point in the system.

Next, the engineer had to add the proposed pumping station to the computer model. The engineer preliminarily-sized a 2,000-gallon wet well with two, 450 GPM pumps. He entered the volume of the wet well, the small reservoir that feeds water to the pumps, as well as the discharge capacity of the two pumps. The pumping action would cause water to enter the existing drainage system in slugs of larger volume and velocity than the relatively consistent pattern of rainfall.

The engineer then repeated the analysis with the same Type 3 rainfall distribution. The new results plot showed no appreciable increase in the hydraulic gradient due to the pumping, leading DMJM to conclude that no overflow would occur during a big storm.

DMJM budgeted more than 300 hours for this study. However, in 80 hours, the report was complete. The study demonstrated that the original design for the McLester Street pumping station was feasible, and construction of the fly-over is scheduled to begin in 2001, with the entire redevelopment project completed in 2003. FC

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