Design standard for stormwater management facility by-pass systems

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Municipalities are starting to show an increasing interest in the installation of by-pass systems to divert runoff from smaller, more frequent storm events around stormwater management (SWM) facilities during maintenance periods to avoid nuisance flooding and conditions which would hinder the progress of, for instance, removal of accumulated sediment.

Those charged with funding these works, whether they be developers or municipalities undertaking capital works projects, naturally view such measures as overly costly given their infrequent use. There is, therefore, an incentive to keep such systems economical in terms of initial capital cost, although there will clearly be a savings in the long-term maintenance costs which are difficult to quantify and may commonly appear to be negligible, depending on the discount rate applied.

While the design standards for storm sewers, overland conveyances and stormwater management facilities are typically well established, less attention has been given to the design of the by-pass system. At present, only a few municipalities in Ontario require the design and installation of by-pass systems. Many engineers intuitively recognize that the by-pass pipe need not be designed to the same standard as the upstream drainage works since it will only be called into use for short periods of time (in the order of weeks) whenever maintenance is required (on the order of tens of years). However a method for establishing the required design standard would be of assistance to designers and reviewers alike.

Fundamentally, the specification of a return-period for a design storm event is risk-based. The risk (*R*) of a storm event of a specified return period (*T*, years) during a period of interest (*n*, years) is calculated as follows (see MTO Drainage Management Manual):

$$R = 1 - \left(1 - \frac{1}{T}\right)^{n}$$

Many jurisdictions in Ontario require that the combined conveyance capacity of a storm drainage system, consisting of both minor (sewer) and major (overland flow routes on roads, for instance) sub-systems, be equal to or greater than the runoff generated from a 100-year return period storm. Similarly, it is common to protect against basement flooding due to storm sewer surcharging during the same storm event, often accomplished with the assistance of dual drainage system hydraulic models. It, therefore, is reasonable to extend this design standard (i.e., acceptable risk level) to the design of the by-pass system.

The risk of such a 100-year return period event occurring in any given year is calculated to be:

$$R = 1 - \left(1 - \frac{1}{100}\right)^{1} = 0.01 \text{ or } 1\%$$

Assuming that maintenance activities would require three weeks to perform (i.e., $n = 3/52$ years), and rearranging the above expression to calculate the return period (*T*) to achieve an equivalent level of risk as the balance of the storm drainage system yields the following:

$$T = \frac{1}{1 - (1 - R)^{1/n}} = \frac{1}{1 - (1 - 0.01)^{52/3}} = 6.25 \text{ years}$$

Based on this example, a by-pass system designed to safely convey the runoff from a storm event with a 6.25 year return period provides the same level of service (or risk) as the drainage system (i.e., 100-year) by virtue of the shorter duration during which the by-pass system is in operation. In order to facilitate calculations and add a buffer for safety, a munici-

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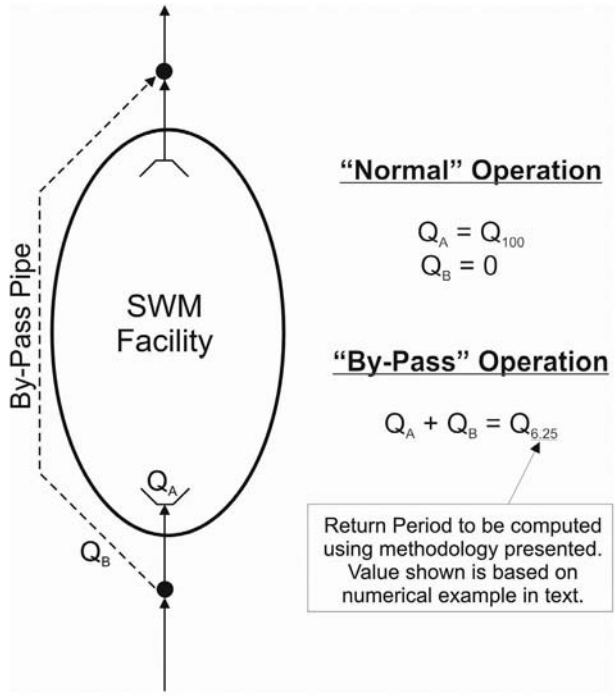

Schematic representation of SWM facility by-pass system.

pality could simply bump the required return period up to 10 years, as an example.

The following points are important to note when applying this methodology:

• The total capacity of a by-pass system, depending on how it is designed, often consists of the by-pass pipe itself as well as an emergency overflow to the SWM facility. Following the scenario illustrated above, it is conceivable that the by-pass pipe could be designed to convey a portion of this flow (e.g., 1 year or 2 year) while the emergency overflow would be responsible for the balance of the flow. Hence, the system cost could be controlled quite reasonably.

• The calculations presented herein are based on a passive system, which is typically the case for storm drainage works. It is reasonable to assume that maintenance personnel would often be able to anticipate heavy rainfall events and schedule activities around these events and/or switch the operation of the by-pass to "normal" to mitigate the risk of flooding.

In conclusion, this is a fundamentally sound approach, derived from first principles, for designers and municipal regulators to apply to the design of SWM facility by-pass systems.

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