Percent Treated Analysis of Demonstration Combined Sewer Overflow Control Facilities

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The Rouge River National Wet Weather Demonstration Project (Rouge Project), which began in 1992, is sponsored by the U.S. Environmental Protection Agency (USEPA) and is charged with developing a watershed plan to manage wet weather pollution in the Rouge River Watershed. The project is a cooperative regional effort led by the Wayne County Department of Environment and involving three counties, 48 communities including the City of Detroit, the USEPA, the Michigan Department of Environmental Quality (MDEQ) and a number of other private and government agencies.

There are 11 demonstration CSO projects, ten basins and one tunnel (collectively referred to herein as basins), in various stages of construction within the Rouge Watershed. While these basins were in the early design stages a Rouge Project model was developed and used to provide some early predictions as to how these basins would measure up to the U.S. Environmental Protection Agency (USEPA) CSO policy (USEPA, 1994). Specifically, the percent of combined sewer flow treated, as defined in the CSO policy, and the number of overflow events per year were calculated on an average annual basis using model simulations with 33 years of hourly rainfall data (Kluitenberg, et. al., 1994).

The Rouge Watershed

The highly urbanized Rouge Watershed encompasses 467 square miles in Southeast Michigan and is home to 1.5 million residents. The Rouge River, which is one of the state's most publicly accessible rivers, flows into the Detroit River several miles downstream of downtown Detroit and is a source of pollution to the Great Lakes system. Approximately 20 percent of the watershed is served by combined sewers. Urban storm water runoff, combined sewer overflows, failing septic systems, illicit connections from sanitary leads to storm drain systems, and increased flow variability have led to the gradual degradation of water quality and habitat in the Rouge River and impaired uses in many reaches.

Demonstration Combined Sewer Overflow Control Facilities

For several years there has been much debate in Michigan as to what is a reasonable design criteria for sizing CSO basins. This debate is reflected in the 11 demonstration CSO basins currently under construction in the Rouge Watershed. Three basins are sized to provide complete capture of a 1 year, 1 hour design storm and provide at least 30 minutes of detention for a 10 year, 1 hour design storm (Criterion 'A'), as required by an early unofficial criterion used by the MDEQ. Seven basins are sized to a smaller criterion (Criterion 'B') of providing 20 or 30 minutes of detention for the 1 year, 1 hour storm. One basin was sized even smaller than Criterion 'B' due to site limitations. The basis of design and sizes of the demonstration CSO basins are summarized in Table 1. All the facilities are designed to provide settling, skimming, and disinfection to overflows.

In general, there are two types of CSO basins under construction. Four CSO basins will have a shunt channel, as shown schematically in Figure 1, and the rest will not. The shunt channel will allow the facility operator to route a portion of the combined sewer overflow around the basin during certain peak flow conditions. The main purpose of the shunt channel is to prevent resuspension of settled solids in the basins during peak flow conditions by "shaving the peak" off of the influent hydrograph. For the basins without shunt channels, during certain peak flow conditions, velocities in the basin may be high enough to prevent complete settling or cause resuspension of previously settled solids.

Table 1. Rouge Watershed Demonstration CSO Control Facilities.

Basin Name	Drainage Area (acres)	Basin Volume (mg)	Basin Volume (in)	Shunt Channel	Basis of Design (Criterion*)
River Rouge	929	5.2	0.21	No	'A'
Dearborn Heights	340	2.7	0.29	No	'A'
Redford Twp.	551	1.9	0.13	Yes	'B'
Inkster	833	3.1	0.14	No	'B'
Hubbell-Southfield	14,431	22.0	0.06	Yes	'B'
Seven Mile	463	2.2	0.17	Yes	'B'
Puritan/Fenkell	649	2.8	0.16	Yes	'B'
Dearborn - Tunnel	2,057	28.5	0.51	No	'A'
Acacia Park	816	4.0	0.18	No	'B'
Birmingham	1,185	5.5	0.17	No	'B'
Bloomfield Village	2,326	10.0	0.16	No	'B'

* Criterion 'A' provides complete capture of the 1 year, 1 hour storm and 30 minutes of detention for the 10 year, 1 hour storm. Criterion 'B' provides 20 or 30 minutes of detention for the 1 year, 1 hour storm.

The USEPA CSO Policy

The USEPA CSO Policy issued in 1994 (USEPA, 1994) allows for a demonstration approach or a presumption approach to CSO control. The presumption approach specifies that a CSO control facility must meet any one of three criteria. The focus of this analysis was on two of these three presumptive criteria. One criteria is to provide treatment to 85 percent of all combined sewer flows during wet weather events. Another is to allow no more than four overflow events per year which do not receive the equivalent of primary clarification.

The Rouge Project TRTSTORM Model

The analysis was conducted using a mass balance approach as is used in the HEC STORM model (HEC, 1976), except a modified version of the program named TRTSTORM was developed to account for several operational options of the proposed basins. The operational options include: the ability to specify a basin treatment capacity which differentiates between overflows and treated overflows to the receiving water; the ability to shunt excess flows around the basin to the receiving water when the sum of interceptor capacity and basin treatment capacity is exceeded; and the ability to decant flow from the storage basin to the receiving water. The TRTSTORM model, which is written in the Pascal programming language, permits a quantity analysis using what is referred to in the HEC-STORM documentation as the coefficient method. The model outputs include total volume of overflows and untreated overflows per year, the number of overflow and untreated overflow events per year, the number of storage events per year, etc.

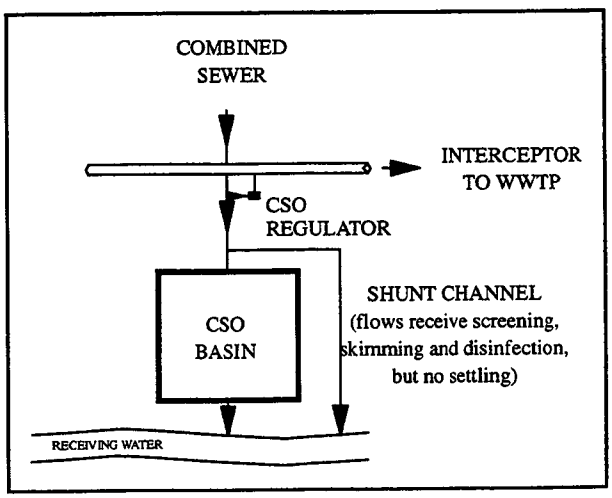

Figure 1. Typical CSO Basin with Shunt Channel.

Analysis and Results

To determine how the demonstration basins measure up against the two criteria of interest in EPA CSO policy, percent treated and the number of overflow events per year were calculated on an average annual basis for all 11 basins using 33 years of hourly National Weather Service precipitation data from Detroit Metropolitan Airport. The analysis was performed for each facility on an individual basis, since it was not feasible within the scope of this effort to do the analysis on a system wide basis as stated in the policy. The analysis was conducted for three different scenarios, each of which represents a different method or approach to operating the facility. Two of the scenarios are discussed below.

Scenario 2

Scenario 2 evaluates percent treated and the number of overflow events per year for the case where the entire basin is operated in a first flush capture operating mode. In this operating mode, once the basin is full, all flows in excess of the interceptor capacity are considered overflows to the receiving water. The combined sewer flows which eventually receive primary clarification are the flows to the interceptor, which includes all flow dewatered from the basin.

The calculated values of percent treated for Scenario 2 are shown on Figure 2, and indicate that seven of the eleven basins meet EPA's 85 percent treated criterion when operated purely as retention basins. The three basins sized to Criterion 'A' all meet EPA's 85 percent treated criterion and have an average percent treated of 97 percent, while the seven basins sized to Criterion 'B' have average 84 percent.

Scenario 3

Scenario 3 simulates operation of the basins for the case where the entire basin is operated in a flow through operating mode. In this mode of operation, the basins are used to provide primary clarification to some flows which pass through the basin and are discharged to the receiving water. Four values of basin treatment capacity, representing four different ways of defining primary clarification, were calculated for each basin based on hydraulic detention times of ½, 1, 2, and 3 hours. Percent treated and the number of overflow events per year were then evaluated for the four different values of basin treatment capacity. The results below are based on hydraulic detention times of 2 hours.

In this operating mode, once the basin is full, the basin discharges to the receiving water at a rate up to the defined basin treatment capacity. If the combined sewer flow exceeds the interceptor plus basin treatment capacity, excess flows are handled differently based on the different basin designs.

For basins with shunt channels, combined sewer flows in excess of interceptor plus basin treatment capacity are shunted to the receiving water and considered overflows. The combined sewer flows which receive primary clarification (either at the wastewater plant or the basin) are the flow to the interceptor, including all flow dewatered from the basin, and all discharges from the basin to the receiving water. The ability to shunt a desired flow rate allows the basin to be operated in a way which maximizes the percent treated value as defined in this analysis.

For basins without shunt channels, combined sewer flows in excess of interceptor plus basin treatment capacity will continue to flow through the basin, even though the basin's treatment capacity is exceeded. The combined sewer flows which receive primary clarification (either at the wastewater plant or the basin) are the flow to the interceptor, including all flow dewatered from the basin, and basin discharges occurring at times when the discharge rate is below the basin treatment capacity. When the basin discharge rate exceeds the basin treatment capacity, the overflow is assumed to receive no treatment.

The calculated values of percent treated for Scenario 3 are shown on Figure 2. All of the basins except the Hubbell-Southfield basin, whose size is limited due to site constraints, meet EPA's 85 percent treated criterion with primary clarification assumed to occur with a hydraulic detention time of at least 2 hours. The three basins sized to Criterion 'A' have an average percent treated of 99 percent, while the seven basins sized to Criterion 'B' have average 93 percent.

Conclusions

The model predictions gave an early indication that all of the demonstration CSO control facilities will meet EPA's 85 percent treated criterion **if** pri-

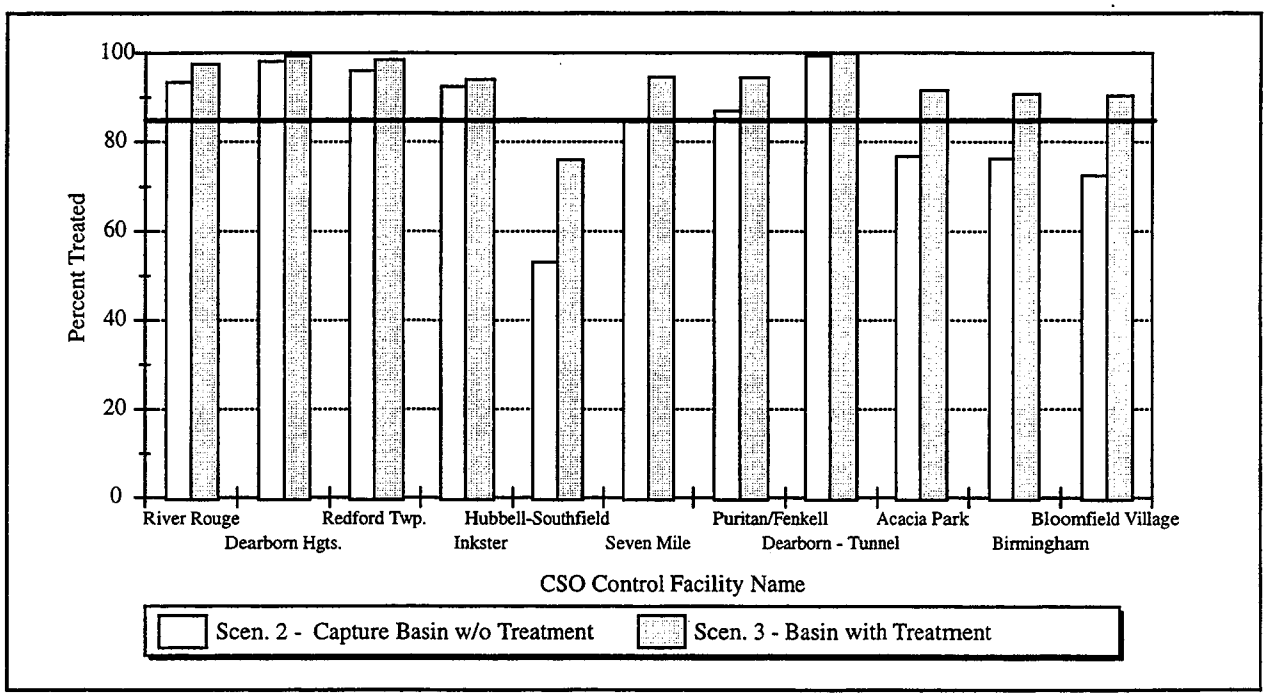

Figure 2. Percentage of CSO Treated.

mary clarification is assumed to occur with a hydraulic detention time of at least 2 hours. The model results also helped quantify the incremental percent treated benefit of basin sizing Criterion 'A' versus Criterion 'B'. Finally, the model demonstrated that, although providing a shunt channel and its associated valves/gates and controls adds significant cost to a CSO basin, a shunt channel increases operating flexibility and allows basin performance, as defined herein by the percent treated value, to be increased. In summary, the TRTSTORM model is a simple analysis tool which can be readily applied in CSO control facility planning and design by others.

References

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