Wayne County Rouge Program Office (RPO) Memorandum

To: *Rouge Stream Data Committee*

From: *Carol Hufnagel*

Date: *May 23, 2003*

Subject: *Field Survey of the Total Residual Chlorine (TRC) Plume in the Rouge River from the Hubbell-Southfield CSO Detention Basin Overflow*

OBJECTIVE

The objective of this field survey and evaluation was to establish the extent of the total residual chlorine (TRC) plume in the ambient water of the Rouge River, downstream of the Hubbell-Southfield CSO Detention Basin (H-S basin) discharge outfall.

The field survey was conducted during a wet weather event where the H-S basin was discharging (overflowing) to the Rouge River. The field survey measured TRC concentrations in the receiving waters at various locations along the Rouge River (both upstream and downstream of the H-S Basin discharge) and at various points in the cross-section at each location. The basin effluent discharge was also monitored for TRC during this time. The extent of mixing between the ambient water and the H-S basin discharge was estimated from these TRC measurements.

BACKGROUND

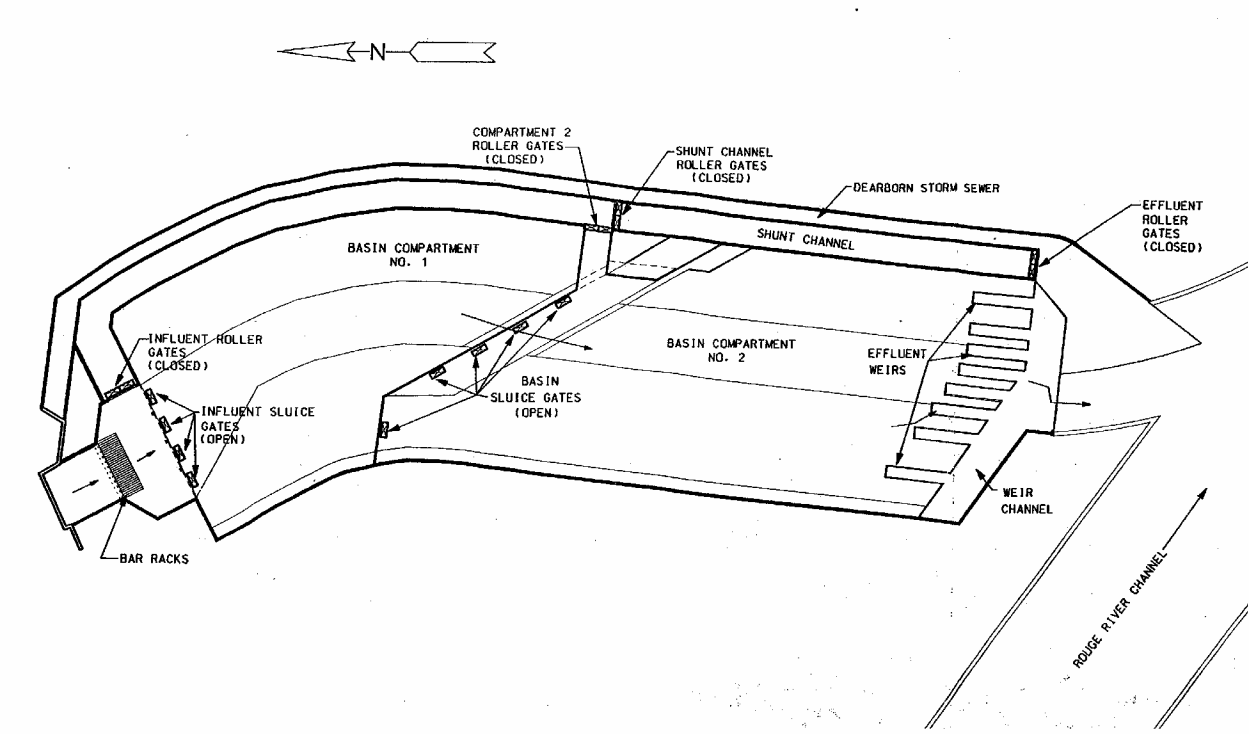
The H-S CSO Basin is one of the three CSO detention basins built by the Detroit Water and Sewerage Department (DWSD) along the Rouge River, as part of DWSD's implementation of its 1996 Long Term Combined Sewer Overflow Control Plan (LTCSOCP) for the Rouge and Detroit Rivers.

The H-S basin was constructed and put in operation in December 1998 to discharge through a new Outfall 101A. The H-S basin eliminated untreated combined sewage overflow discharges during wet weather events from DWSD Outfall No. 058 (Location B53), which had a tributary area of 14,600 acres of combined sewer area. The H-S basin has a retention volume of approximately 22 million gallons, and was designed to maximize the amount of storage that could be provided on the available property between the existing outfall and the Rouge River. The H-S basin is located along the east side of Rouge River, between Michigan Avenue and Rotunda Drive.

The H-S basin consists of an influent structure with bar racks and sodium hypochlorite addition and feed system, two basin compartments in series (Nos. 1 and 2), a shunt channel that can be used to bypass either compartment, effluent weir at the end of compartment No. 2, weir channel, and backwater weir with backwater gates. The H-S basin discharges through the backwater gates and/or the shunt channel to the Rouge River.

Figure 1 is a schematic of the H-S basin.

Figure 1. H-S Basin Schematic (Source: DWSD LTCSOCP Update, November 2001)



When sodium hypochlorite is added to raw combined sewage entering the H-S basin, the hypochlorous acid/hypochlorite ion reacts with various organic and inorganic compounds to form organo-chlorinated compounds and chloraminated compounds. The latter is formed in the presence of organic nitrogen and ammonia (TKN). These compounds are termed combined available chlorine and have reduced disinfectant potential as compared to free available chlorine. The H-S basin operation staff maintains a combined residual chlorine (or, total residual chlorine assuming no free residual chlorine is present in raw sewage at the amount dosed, which is much less than the chlorination break point) concentration of 1 to 3 mg/L within the basin to ensure the necessary inactivation/kill of fecal coliforms and *Eschericia coli* (*E. coli)*. During large storm events, the H-S basin can get filled resulting in a discharge to the Rouge River.

REGULATORY ISSUES

The 1997 NPDES permit for DWSD (Permit No. MI0022802) required the construction of the H-S Basin by December 15, 1998. Further, the permit required the submittal of a Retention Basin Evaluation Report for H-S Basin by April 15, 2001. This report was submitted by DWSD as part of its LTCSOCP update in November 2001.

The facility NPDES permit does not have an effluent limit for TRC; however, a TRC goal of 1 mg/L was stated in the permit. The H-S Basin operation staff maintains a TRC of approximately 1 mg/L in the basin effluent discharge.

The Michigan Rule 82 (R 323.1082) of Part 31 of Act No. 451 of the Public Acts of 1994 deals with the Mixing Zone. This study was performed to survey the basin effluent discharge plume, to define the plume configuration, and the extent of the TRC plume. The result of the study will be utilized to assess future control on TRC in intermittent discharge from CSO retention treatment facilities during wet weather events. Presently residual chlorine in final effluent discharge is regulated for continuous effluent discharge from wastewater treatment facilities under the Michigan regulations.

FIELD PROCEDURES

In the area where the H-S basin discharges, the Rouge River is a paved concrete channel with a trapezoidal cross-section. The H-S basin discharges only after a rainfall event that exceeds the design storm or if there have been significant back-to-back rainfall events and the basin contents cannot be dewatered to the interceptor. Usually, when the H-S basin discharges, the Rouge River flow upstream of the H-S basin is also quite high.

During the two events monitored in 2001, the Rouge River free water surface width varied from 118 ft to 153 ft (compared to a dry weather flow river width of 25 to 50 ft). The high river flow required the field crew to collect river water samples from a motor-powered boat, launched upstream of the H-S basin discharge location.

A prior visit to the site during a wet weather event provided an estimate of the river width and river velocity. A boat launch location was selected approximately 150 feet upstream of the H-S basin discharge point, which was selected as the upstream river sampling location (Location 0, "L0").

The H-S basin discharges into the Rouge River at an angle of approximately 45-degrees, in the same direction as the river flow. The center of the H-S basin discharge channel mouth was labeled as Location 1 (L1). From this location, downstream locations in the Rouge River were marked every 100 ft for the first 1,200 ft, at the Rotunda Bridge (approximately 2,200 ft downstream of the H-S basin discharge – where Rouge River flows under Rotunda Drive), and at the I-94 bridge (approximately 5,500 ft downstream of the H-S basin discharge – where the Rouge River flows under Interstate 94). These locations were painted on the side slopes on both sides of the river channel for easy identification.

Figure 2 is a schematic of the Rouge River and the H-S basin discharge channel, showing the various sampling locations and a cross-section (transect) of the Rouge River with the six sample collection points at that transect.

Figure 2. Rouge River and H-S Basin Discharge Channel Schematic

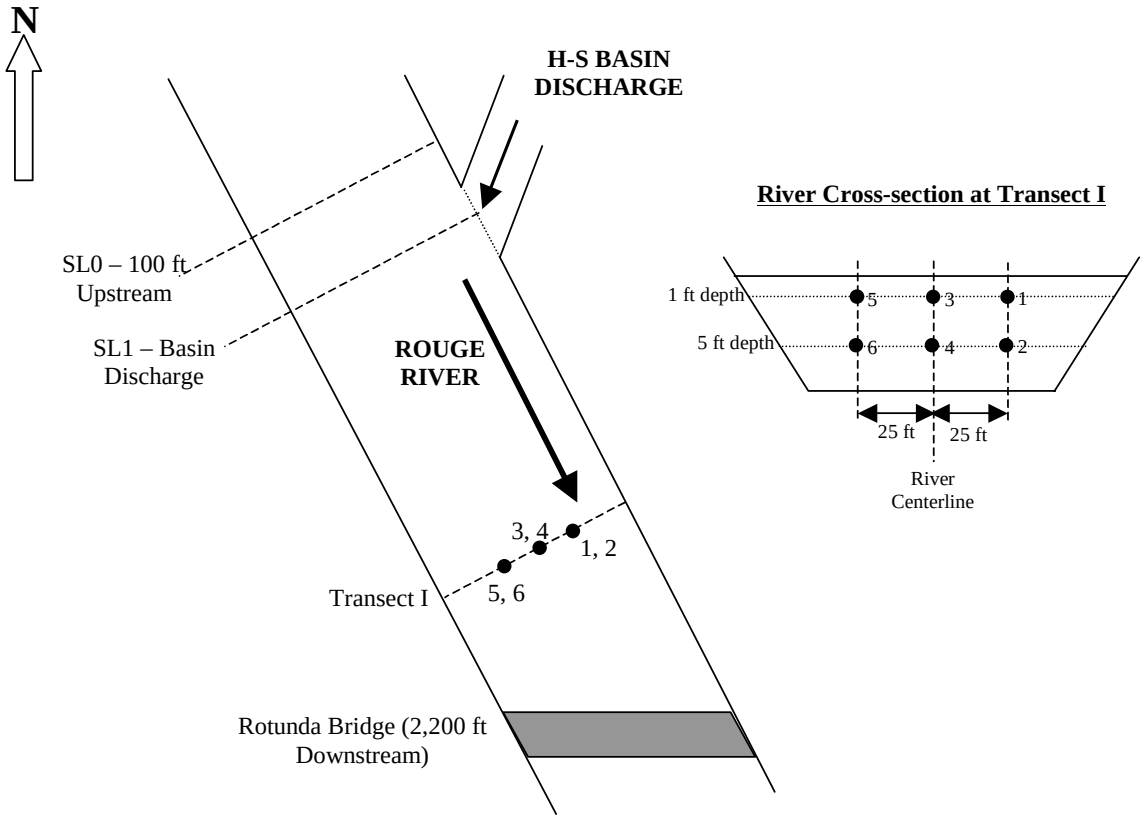


Table 1 describes the six sample collection points at a particular transect (or cross-section).

Table 1. Description of the Six Sample Collection Points at Any Transect

Sample Collection Point	Description
1	Located 25 ft east of the river centerline, at a depth of one foot.
2	Located 25 ft east of the river centerline, at a depth of five feet.
3	Located along the river centerline, at a depth of one foot.
4	Located along the river centerline, at a depth of five feet.
5	Located 25 ft west of the river centerline, at a depth of one foot.
6	Located 25 ft west of the river centerline, at a depth of five feet.

The field crew consisted of a coordinator, three people on the boat, one person to relay samples from the boat to the analysts, and two analysts (including the coordinator) – total of six.

The H-S basin operation staff (DWSD) would call the coordinator after a large rainfall event to be on notice. The coordinator would in turn notify the remaining team members. Due to high river and wind velocities after a rainfall event, it was essential to have three people on the boat –

one to operate the boat, and the other two to collect samples. All three people on the boat and sample relay person wore life vests for safety. A peristaltic pump was used to collect samples, and the pump tubing was sufficiently flushed before collecting samples in 500-mL plastic bottles.

At each transect, a rope was held across the river to determine the river midpoint and points 25 ft to the east and west of the midpoint. For each transect, six samples were collected – midpoint of the river, and 25 ft to the east and west of the midpoint; and at each of these three points, samples were collected at depths of one foot and five feet. Sample collection at each transect lasted approximately 15 to 30 minutes depending on the prevailing river flow and winds. The sampler on the boat would measure the temperature for each sample using a temperature probe. The analysts in the truck would fix the chlorine residual using an iodometric method and measure the TRC using a combination platinum and iodide-ion electrode (Standard Method No. 4500-CI).

The TRC probe used was an Orion 290A concentration meter with an Orion combination platinum and iodide-ion electrode. The probe was calibrated to provide an adequate mV slope in the lab, prior to arrival at the H-S basin site. Upon arriving at the field site, the calibration standards were cooled to river water temperature and calibration checks were performed every 2 hours. All TRC readings were blank corrected.

SAMPLING EVENTS

Two sampling events were performed as part of this study. The first sampling was conducted on October 16, 2001 and the second sampling was conducted on November 30, 2001.

RESULTS

<u>October 16, 2001 Sampling:</u>

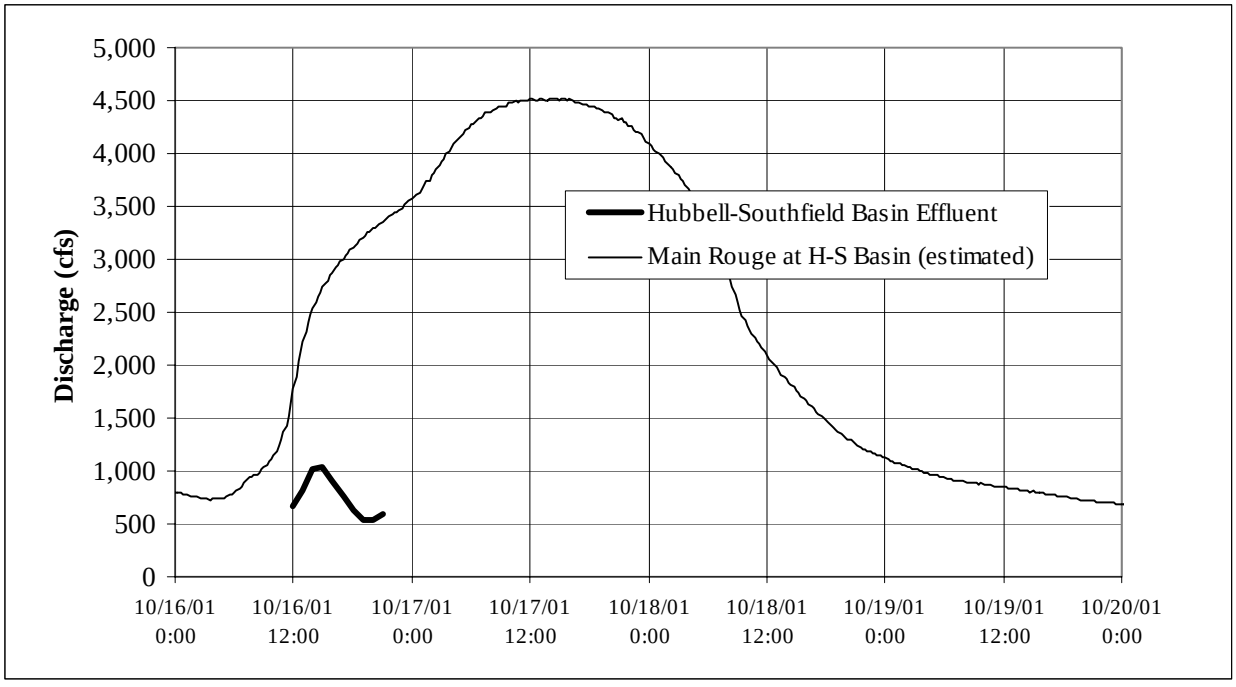
The H-S basin started discharging into the Rouge River at around 10:45 am. Table 2 shows the hourly discharge flows (in cfs) from the H-S Basin along with TRC measurements (in mg/L) in the effluent.

The Rouge River flow was quite high on this day, and the river free water surface width was 153 ft. Figure 3 shows the H-S basin effluent flow plotted with estimated river flow for the October 16 wet weather event. While there is no measurement of river flow at the H-S basin, it was approximated as the sum of the flow at three upstream gages (Main Rouge at Plymouth Rd., Middle Rouge at Hines Dr. near Ford Rd., and Lower Rouge at Military Rd.), without any adjustments for the travel time from each gage to the basin. Therefore, actual river flow at the basin would lag the plotted flow by several hours. The H-S effluent flow rate was about 35 percent of the flow from the upstream watershed when the river TRC measurements began and decreased to about 20 percent of the upstream flow by the time the measurements ended.

Table 2. Effluent Flow and Effluent TRC for the H-S Basin (10/16/2001)

Time (hh:mm)	Effluent Flow (cfs)	Effluent TRC (mg/L)
11:00	667	2.00
12:00	812	1.24
13:00	1026	0.50
14:00	1044	0.72
15:00	907	1.10
16:00	751	1.90
17:00	633	1.26
18:00	533	1.45
19:00	540	1.02
20:00	589	0.96

Figure 3. Effluent Flow and River Flow (10/16/2001)



The field crew arrived at the site at 1 pm. Samples at the upstream location (L0) were collected at 3:25 pm and the total chlorine residuals at all six sample collection points at this transect showed non-detectable TRC (less than 0.03 mg/L). Similarly, samples were collected at location L1, and at locations 100 ft, 200 ft, 400 ft, 600 ft, 1000 ft and 2200 ft downstream of location L1. These results are summarized in Table 3.

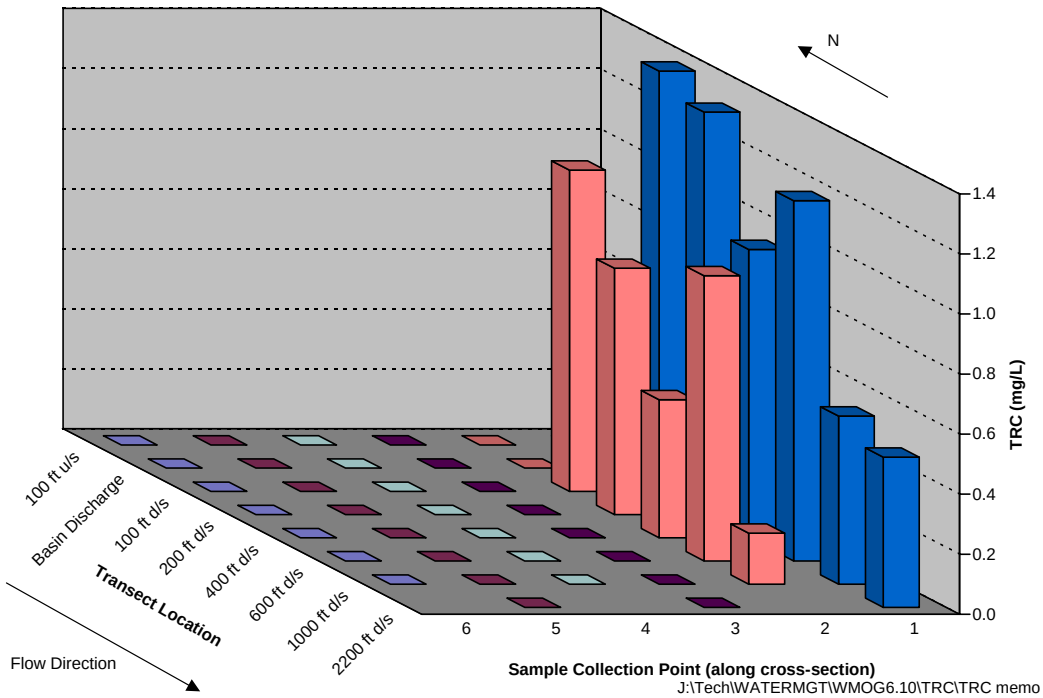
Table 3. Summary of TRC Measurements in the Rouge River (10/16/2001)

Loc.	Description	Time (hh:mm)	Temp (°C)	TRC (in mg/L) for the six sample collection points					
				1	2	3	4	5	6
L0 (SL0)	Upstream of discharge	15:25	12.1	BDL	BDL	BDL	BDL	BDL	BDL
L1 (SL1)	At H-S Discharge	16:20	12.0	BDL	BDL	BDL	BDL	BDL	BDL
(SL2)	100 ft d/s of L1	16:45	11.9	1.40	1.07	BDL	0.03	BDL	BDL
(SL3)	200 ft d/s of L1	17:00	12.0	1.34	0.82	BDL	BDL	BDL	BDL
(SL4)	400 ft d/s of L1	17:30	11.8	0.96	0.46	BDL	BDL	BDL	BDL
(SL5)	600 ft d/s of L1	18:15	11.8	1.20	0.95	BDL	BDL	BDL	BDL
(SL6)	1000 ft d/s of L1	19:00	NM	0.56	0.17	BDL	BDL	BDL	BDL
(SL7)	2200 ft d/s of L1 (Rotunda Bridge)	18:45	NM	0.50	NM	BDL	NM	BDL	NM

SL – Sampling Location
BDL – Below Detection Limit (0.03 mg/L)
NM – Not Measured

Figure 4 is a plot of the TRC concentrations measured at the seven transect locations. For each transect, TRC concentrations are shown for each of the six sample collection points.

Figure 4. Measured TRC Concentrations in the Rouge River (10/16/01)



November 30, 2001 Sampling:
On this day, the H-S basin started overflowing to the Rouge River around 2:30 am and continued until around 6 pm. The field crew arrived at the site around 11 am. At that time, the basin effluent flow was 565 cfs and the last TRC measurement for the basin effluent was 0.48 mg/L (at 10:30 am). By this time, the rain event had almost stopped and the basin effluent flow had started to drop.

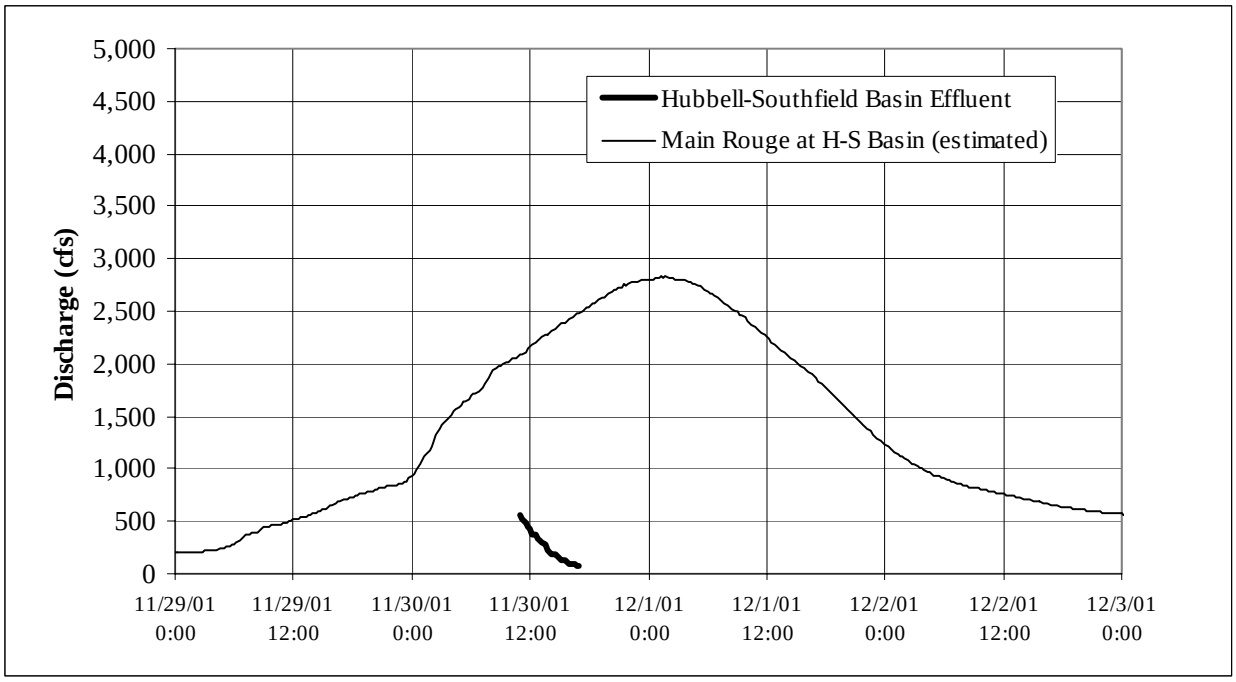
The storm event was smaller (compared to the October 16, 2001 event) and the river free water surface width was 118 ft. Table 4 is a summary of the H-S basin effluent flow and effluent TRC during the overflow time period.

Table 4. Effluent Flow and Effluent TRC for the H-S Basin (11/30/2001)

Time (hh:mm)	Effluent Flow (cfs)	Effluent TRC (mg/L)
11:00	565	0.48 (10:30)
11:15	531	
11:30	491	0.87
11:45	447	
12:00	421	0.87
12:15	380	
12:30	366	
12:45	339	
13:00	318	
13:15	297	
13:30	274	1.27
13:45	218	
14:00	212	
14:15	194	
14:30	181	1.11
14:45	169	
15:00	144	
15:15	135	
15:30	122	1.22
15:45	113	
16:00	102	
16:15	93	
16:30	86	1.17
16:45	80	
17:00	72	1.02 (17:30)

Figure 5 shows the H-S basin effluent flow plotted with estimated river flow for the event. The H-S effluent flow rate was about 15 percent of the flow from the upstream watershed when the river TRC measurements began and decreased to less than 5 percent of the upstream flow by the time the measurements ended.

Figure 5. Effluent Flow and River Flow (11/30/01)



The boat was launched around 1 pm. An initial sample was collected on the north side of the Rotunda Bridge, on the east side of the Rouge River. This sample had a TRC of 0.34 mg/L. At that time, the basin effluent flow was 318 cfs.

Samples were collected at the upstream (L0) location at 1:30 pm and showed non-detectable TRC for all six sample collection points. Samples at the L1 location (discharge point of H-S basin) were collected at 2 pm and all six samples had non-detectable TRC. By this time, the basin effluent flow had dropped significantly (to 212 cfs).

Samples were collected at the I-94 bridge (5,500 downstream of location L1) at 2:30 pm. By this time, the basin effluent flow had dropped to 181 cfs. All six samples from this location had non-detectable TRC.

Samples were then collected at the Rotunda Bridge; and at locations 1200 ft, 3500 ft and 4500 ft downstream of location L1. The last set of samples was collected at 4:40 pm and the basin effluent flow had tapered off to 80 cfs by that time. Results of the measured TRC are summarized in Table 5.

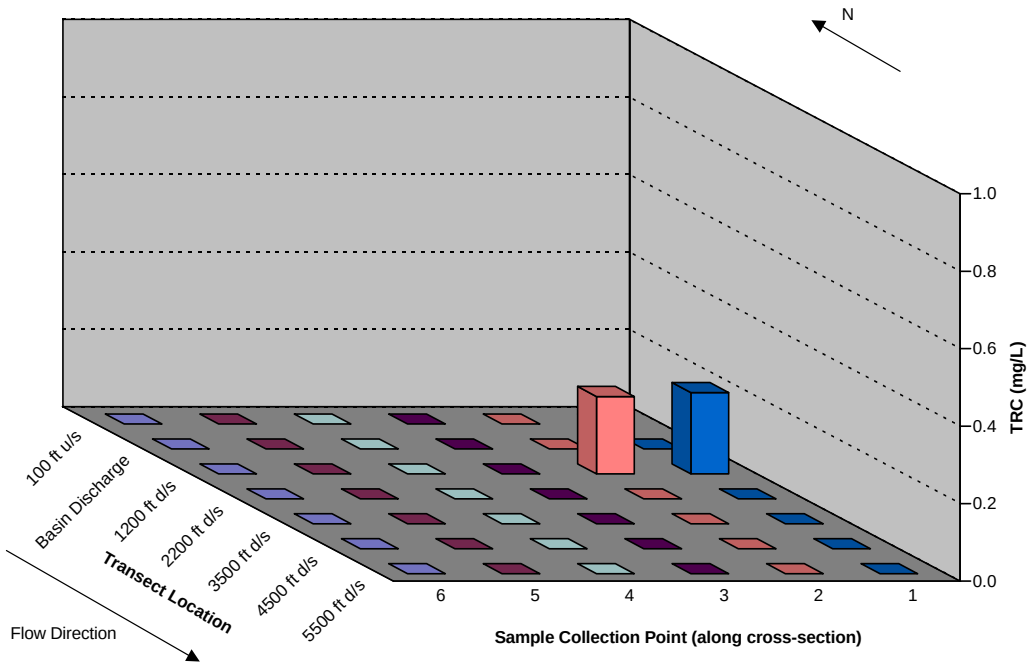
Table 5. Summary of TRC Measurements in the Rouge River (11/30/01)

Loc.	Description	Time (hh:mm)	Temp (°C)	TRC (in mg/L) for the six sample collection points					
				1	2	3	4	5	6
L0 (SL0)	Upstream of discharge	13:30	8.3	BDL	BDL	BDL	BDL	BDL	BDL
L1 (SL1)	At H-S Discharge	14:00	NM	BDL	BDL	BDL	BDL	BDL	BDL
(SL2)	1200 ft d/s of L1	16:20	8.7	0.21	0.20	BDL	BDL	BDL	BDL
(SL3)	2200 ft d/s of L1 (Rotunda Bridge)	13:00	NM	0.34	NM	NM	NM	NM	NM
		16:40	9.4	BDL	BDL	BDL	BDL	BDL	BDL
(SL4)	3500 ft d/s of L1	16:00	9.2	BDL	BDL	BDL	BDL	BDL	BDL
(SL5)	4500 ft d/s of L1	15:40	9.1	BDL	BDL	BDL	BDL	BDL	BDL
(SL6)	5500 ft d/s of L1 (I-94 Bridge)	14:30	9.2	BDL	BDL	BDL	BDL	BDL	BDL

SL – Sampling Location
BDL – Below Detection Limit (0.03 mg/L)
NM – Not Measured

Figure 6 is a plot of the TRC concentrations measured at the seven transect locations. For each transect, TRC concentrations are shown for each of the six sample collection points.

Figure 6. Measured TRC Concentrations in the Rouge River (11/30/01)



CONCLUSIONS

The Hubbell-Southfield CSO basin discharges only during storm events that generate combined sewage in excess of the 22 million gallon storage volume, or when there are back-to-back significant rainstorms. During a wet weather event that creates a basin overflow, the river flow, river depth and river free water surface width increase significantly. These conditions provide significant dilution of the ambient TRC concentration.

The Rouge River was sampled on two days in late 2001 (October 16th and November 30th) when the H-S basin was discharging to the river. The October 16, 2001 event resulted in large basin overflows to the Rouge River (550 to 1050 cfs) with TRC of 0.5 to 2.0 mg/L in the basin effluent. The basin overflows (80 to 550 cfs) during the November 30, 2001 event were lower than the October 2001 event with TRC of 0.5 to 1.25 mg/L in the basin effluent.

During both the October and November events, TRC levels greater than 0.1 mg/L were observed only for sample collection points 1 and 2 (25 ft east of the river centerline, and at 1 ft and 5 ft depths).

During the October event, the measured TRC was 1.4 mg/L at 100 feet downstream of the basin discharge entry point (at a sample collection point 25 ft east of the river centerline and 1 ft depth). The TRC dropped steadily at locations farther downstream from the basin outfall. At the Rotunda Bridge location (2,200 ft downstream of the discharge entry point), the TRC at the east sample collection point and 1 ft depth was 0.5 mg/L. For the east sample collection point, samples at 5 ft depth had slightly lower TRC compared to samples at 1 ft depth (1.07 mg/L at 100 ft downstream, and 0.17 mg/L at the Rotunda Bridge).

The TRC plume appeared to be horizontally narrow and was contained within the east half of the Rouge River. Its isopleth did not extend to the center of the river. It is evident that the river flow is not allowing the TRC plume to spread over the entire width of the river. This has an advantage as it keeps the majority of the river section free of the TRC plume.

During the November event, the basin discharge tapered off significantly as the sampling progressed. At the beginning of sampling, the basin discharge was 318 cfs and a sample at the Rotunda Bridge location on the east side of Rouge River had a TRC of 0.34 mg/L. However, as the basin discharge kept dropping, significant chlorine residual was measured at only one location – 1200 ft downstream of the basin discharge point and 25 ft east of the Rouge River centerline. This again indicated that the TRC plume was being contained within the east half of the Rouge River.