Modeling Long Term Load Reduction: The Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydrologically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. To estimate efficiencies as accurately as possible, Contech Engineered Solutions has developed the Rational Rainfall Method™ which combines site-specific information with laboratory generated performance data (see Technical Bulletin 1 for more information), and local historical precipitation records.

Short duration rain gauge records from across the United States and Canada were analyzed by Contech Engineered Solutions to determine the percent of the total annual rainfall that fell at a range of intensities. At U.S. stations, depths were totaled every 15 minutes or hourly and recorded in 0.01-inch increments. Depths were recorded hourly with 1 mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and intense storms contributed relatively little to the total depth.

These intensities along with the total drainage area and runoff coefficient for each specific site are translated into flow rates using the Rational Method. The flow rates are then used to calculate operating rates for a proposed Contech Engineered Solutions system. Finally, operating rates are paired with their corresponding removal efficiencies. See figure 4 for a graphic illustration this relationship between operating rate, removal efficiency and intensity distribution.

The net annual TSS removal efficiency is then calculated by summing the relative efficiencies at each intensity (see Table 4.1 and 4.2).

The same process was used to develop the Contech Engineered Solutions sizing methodology described in Technical Bulletin 3. The design ratio was created as a tool to help calculate an operating rate from an intensity. Maximum design ratios for different geographic regions across North America have been determined through analysis of historical precipitation records archived by the National Climatic Data Center. Depending on climatic regime, design ratio thresholds vary, with higher design ratio thresholds in areas like the Gulf Coast where high intensity precipitation is common and lower thresholds in areas like the Pacific Northwest where the vast majority of rain falls at very low.

How the Vortechs® System Removal Efficiencies and Operating Rates Relate to Rainfall Intensity Distribution

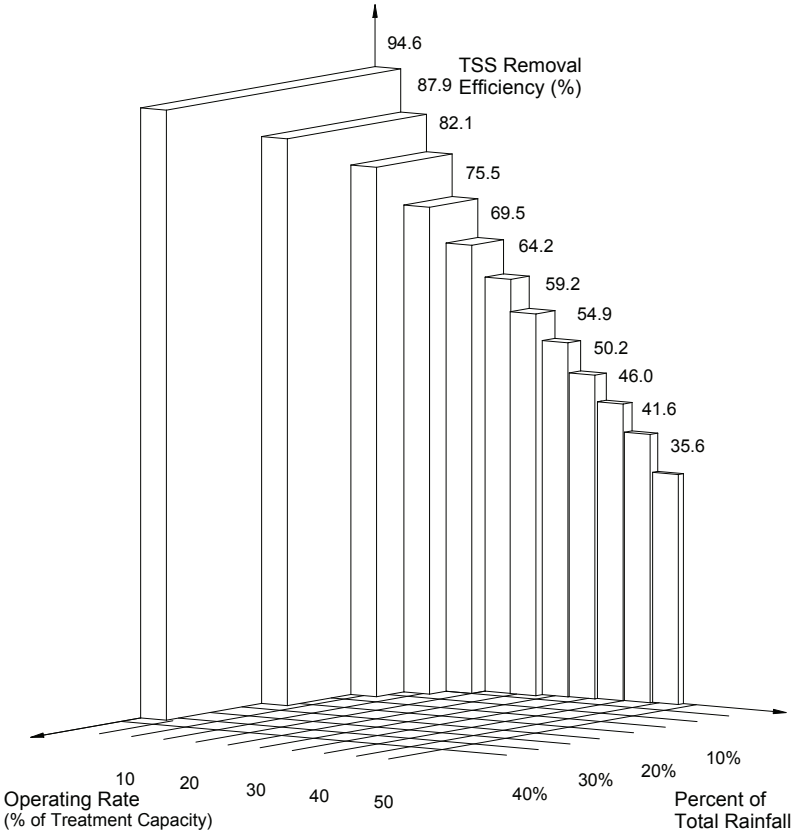

Figure 4

Table 4.1: Vortechs® Model 5000 Net Annual TSS Removal Efficiency in Portland, ME

$$\text{Design Ratio}^1 = \frac{(4.5 \text{ acres}) * (0.95) * 449 \text{ gpm/ft}^2)}{38.5 \text{ ft}^2} = 50$$

Rainfall Intensity		Operating Rate[2]	% Total Rainfall Volume[3]	Removal Efficiency[4]	Relative Efficiency
in/0.25 hr	in/hr	gpm/ft²			
0.02	0.08	4	36.9%	94%	34.7%
0.04	0.16	8	21.9%	88%	19.3%
0.06	0.24	12	11.9%	82%	9.8%
0.08	0.32	16	7.6%	76%	5.8%
0.10	0.40	20	5.0%	70%	3.5%
0.12	0.48	24	2.9%	64%	1.9%
0.14	0.56	28	3.0%	60%	1.8%
0.16	0.64	32	2.0%	55%	1.1%
0.18	0.72	36	1.8%	51%	0.9%
0.20	0.80	40	1.4%	46%	0.7%
0.22	0.88	44	1.2%	41%	0.5%
0.24	0.96	48	0.8%	36%	0.3%
				subtotal:	**80.2%**
				% rain falling at 0.96 in/hr:	**3.5%**
				assumed removal efficiency of remaining %:	**0.0%**
				net annual TSS removal efficiency:	**80%**

1 - Design Ratio = (Total Drainage Area) * (Runoff Coefficient) * (cfs to gpm conversion) / Grit Chamber Area
- Total Drainage Area and Runoff Coefficient are specified by the site engineer.
- The conversion factor from cfs to gpm is 449.

2 - Operating Rate (gpm/ft²) = Intensity (in/hr) * Design Ratio
3 - Based on 5 years of rainfall data recorded at 15 minute intervals in Portland, ME.
4 - Based on CONTECH Stormwater Solutions laboratory verified removal of 50 micron particles.

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Table 4.2: Vortechs® Model 5000 Net Annual TSS Removal Efficiency in Toronto, ON, Canada

$$\text{Design Ratio}^1 = \frac{(2.3 \text{ hectare}) * (100\%) * (2.78)}{3.58 \text{ m}^2} = 1.79$$

Rainfall Intensity mm/hr	Operating Rate[2] (L/s)	% Total Rainfall Volume[3]	Removal Efficiency[4]	Relative Efficiency
1	1.8	19.7%	97%	19%
2	3.6	18.4%	93%	17%
3	5.4	10.8%	90%	9.7%
4	7.2	9.3%	86%	8.0%
5	8.9	7.3%	80%	5.9%
6	11	6.0%	77%	4.7%
7	13	5.8%	72%	4.2%
8	14	3.2%	68%	2.2%
9	16	1.9%	65%	1.3%
10	18	4.2%	62%	2.6%
11	20	2.5%	60%	1.5%
12	21	1.9%	56%	1.0%
15	27	3.5%	47%	1.6%
20	36	2.1%	31%	0.7%
25	45	2.4%	16%	1.4%
			subtotal:	**81%**
			% rain falling at > 25 mm/hr:	**1.0%**
			assumed removal efficiency of remaining %:	**0.0%**
			net annual TSS removal efficiency:	**81%**

1 - Design Ratio = (Total Drainage Area) * (Runoff Coefficient) * (2.77) / Grit Chamber Area
- Total Drainage Area and Runoff Coefficient are specified by the site engineer.

2 - Operating Rate (L/s) = Intensity (mm/hr) * Design Ratio

3 - Based on 10 years of rainfall data from Canadian Station 6158350, Toronto, Ontario, Canada.

4 - Based on CONTECH Stormwater Solutions laboratory verified removal of 50 micron particles.

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