Appendix H

Estimation of SSO Impacts in Streams and Rivers

H.1 Introduction

The often unpredictable nature of SSO events can make it difficult to monitor and collect the data needed to measure the occurrence and severity of any attendant environmental impacts. In the absence of specific national data on the location of SSOs and the environmental impacts caused by SSOs, EPA applied statistical methods and a simple dilution model to estimate environmental impacts. Estimated impacts were approximated with respect to violations of water quality standards for bacteria.

This analysis is intended to provide a broad, initial assessment of environmental impacts that might be expected when SSOs discharge to waterbodies across the nation. The analysis is based upon the distribution of observed SSO volumes described in Chapter 4, typical concentrations of bacteria in dilute and more concentrated wastewaters, and varying receiving water flow rates. This appendix documents the methodology EPA used in this analysis.

H.2 Technical Approach

As described in Section 4.7 of this report, EPA was able to compile a substantial amount of information on the frequency, volume, and cause of SSO events. From these data, EPA also found nearly three-quarters of reported SSO events reach a surface water. This dataset was used to develop a frequency distribution characterizing typical SSO volumes. Using this national data, EPA applied a simple dilution model in an iterative manner to estimate the likely impact of SSO events on streams and rivers based on reasonable assumptions about SSO event duration, the concentration of bacteria in SSO discharges, and stream flow. For the purpose of this report, modeled impacts associated with SSO events were evaluated in terms of violations of the single sample maximum water quality criteria for fecal coliform (FC). That is, a predicted concentration of greater than 400 counts per 100 mL would be considered to be a water quality standards violation.

H.3 Description of Simple Model and Inputs

Application of the simple dilution model to assess environmental impacts in terms of exceedance of a single sample maximum water quality criteria for fecal coliform is described as follows:

1. Individual SSO volumes were generated using the statistical distribution of reported SSO values as described in Chapter 4.
2. The duration of SSO events was developed from a distribution of reported SSO durations.
3. Monte Carlo techniques were applied to generate hundreds of thousands of SSO volume and duration combinations that were used as input to the simple dilution model.
4. Three concentrations of fecal coliform were used to represent dilute, medium strength, and concentrated SSO discharges.
5. The model was run under three different scenarios: one that assumed the entire volume of each modeled SSO discharge reached a surface water (100% delivery), a second that assumed half the volume of each modeled SSO discharge reached a surface water (50% delivery), and a third that assumed 10 percent of the volume of each modeled SSO discharged reached a surface water (10% delivery).
6. SSO loads were delivered to receiving waters with a range of stream flow rates.
7. A simple mass-balance calculation was applied where the instream concentration is a function of SSO volume, SSO duration, SSO concentration, and stream flow.
8. Results were grouped by receiving water stream flow rate.

This model includes the following simplifying assumptions:

- Upstream flow was assumed to be free of fecal coliform (i.e., no background fecal coliform in the upstream water) to isolate SSO impacts.
- The decay of fecal coliform bacteria was not simulated.

Additional information on specific model inputs is summarized below:

<u>SSO volume</u>
Direct characterization of SSO event data is limited to a frequency distribution of overflow volume. The dilution model presented herein is based on analysis of reported SSO data. Volumes for SSO (V_{SSO}) events in gallons are taken from a transformed normal distribution:

$$V_{SSO} = -1/\mathrm{Min}(-0.4343, N(-0.729383, 0.086845))^{22.222222}$$

<u>SSO Duration</u>
The dilution model calculation expects pollutant loads to be expressed in terms of flow (volume per time) and concentration (mass per volume). Based on analysis of duration data provided by the states, the estimation model assigns durations in hours (Tsso) selected from a log-normal distribution:

$$Tsso = \mathrm{Max}(2, e^{\mathrm{Min}(6,\ N(1.081, 1.344))})$$

<u>SSO Fecal Coliform Concentration</u>
The estimation considers the impacts on streams of three representative fecal coliform concentrations:

- Dilute wastewater, with a fecal coliform concentration of 500,000 counts per 100 mL (typical for a wet weather SSO).
- Medium strength wastewater, with a fecal coliform concentration of 10,000,000 counts per 100 mL (middle range for dry-weather SSOs).
- Concentrated wastewater, with a fecal coliform concentration of 1,000,000,000 counts per 100 mL (upper range for dry-weather SSOs).

The decay of fecal coliform bacteria was not included because the analysis was limited to the point of mixing where impacts are likely greatest, and did not consider effects, if any, as the bacteria moved downstream.

<u>Delivery Ratio</u>
The location of SSOs with relation to receiving waters is not available. Further, EPA has no information about the percentage of the volume that reaches a receiving water for a particular event. For this reason, the model was run under three delivery scenarios: 10 percent, 50 percent, and 100 percent of the volume of each modeled SSO discharge.

<u>Stream Types and Upstream Flow</u>
The simple dilution model looks at the impact of a given SSO event that is characterized by estimated volume, duration, and concentration on waterbodies with different flow rates. The flow rates represent the range of flow conditions found in stream reaches within U.S. Impacts of individual SSO events are calculated for each flow rate.

All receiving waters were assumed to have good water quality upstream of the point where SSO discharges are delivered. That is, the ambient fecal coliform concentration was assumed to be zero. As a result, the estimate quantifies only those water quality standards violations caused solely by SSOs, absent background levels and contributions from other sources.

Simple Dilution Model

The simple dilution model consists of a mass-balance calculation where the instream concentration is a function of SSO volume, SSO duration, SSO concentration, and upstream flow:

$$C = C_{sso} * ((V_{sso}/T_{sso}) / (Q + (V_{sso}/T_{sso}))$$

where:
C = resulting instream concentration of fecal coliform in counts/100mL
C_{sso} = concentration fecal coliform in the SSO in counts/100mL
V_{sso} = volume of individual SSO event in cf (converted from gallons)
T_{sso} = duration of the SSO event in seconds (converted from hours)
Q = upstream flow in cfs

Using Monte Carlo techniques, percentages of exceedances (C > 400 counts per 100 mL) were tracked for 100,000 different simulated SSO events for three different SSO concentrations across each of the stream classifications.

H.4 Results

As shown in Table H.1, the potential impact of a particular SSO event is tied to the flow in the receiving water at the time this discharge occurred as well as to the strength of the wastewater discharged and the amount reaching the receiving water. No comparable analysis of SSO discharges to lakes or estuarine waters was undertaken.

Table H.1 Estimated Percentage of Time SSOs Would Cause Water Quality Standards Violations in Varying Sizes of Receiving Waters

Flow Rate (cfs)	Dilute Wastewater (FC = 500,000 #/ml)			Medium Strength Wastewater (FC = 10,000,000 #/100 ml)			Concentrated Wastewater (FC = 1,000,000,000 #/ml)		
	10% Delivery	50% Delivery	100% Delivery	10% Delivery	50% Delivery	100% Delivery	10% Delivery	50% Delivery	100% Delivery
50	12%	27%	36%	45%	68%	77%	95%	99%	100%
100	9%	20%	27%	36%	58%	68%	92%	98%	99%
250	5%	12%	18%	25%	45%	55%	84%	95%	97%
500	3%	9%	12%	18%	36%	45%	77%	92%	95%
1000	2%	6%	9%	13%	27%	36%	68%	86%	92%
5000	1%	2%	3%	5%	13%	18%	45%	68%	77%
10000	0%	1%	2%	3%	9%	13%	36%	58%	68%