6. Estimated Pollutant Loadings and Predicted Water Quality

This section presents estimated pollutant loads and their predicted impact on water quality in the Mississippi River and its tributaries, which serve as a baseline condition for comparison to the selected control alternative. Pollutant loads are based on a "typical year," and are determined by application of event mean concentrations (EMCs) to the overflow volumes predicted by the collection system model. In the case of the tributaries, the impact of these pollutant loads is determined by application of the calibrated water quality models. Mississippi River impacts were not modeled, however, because the *Water Quality Study Report* (LimnoTech, 2006) concluded that there were no parameters of concern that required modeling to assess. The baseline condition for the Mississippi River is considered to be the same as described in the Existing Conditions section of this report.

6.1 Determination of Typical Year

The typical year was initially selected based on rainfall characteristics, with the focus on collection system behavior. A 57-year history (1949 to 2005) of hourly rainfall data for Lambert-St. Louis International Airport was analyzed and a variety of statistical measures were determined, including total number of precipitation events, total annual precipitation, average event precipitation, average event rainfall intensity, total rainfall duration, average event duration, and average time between events. Individual years' data were then examined to identify the year in which precipitation patterns best matched the "typical" or average of the 57 year history. The distribution of individual-event rainfall depths in the selected year was also compared to the historical distribution to verify that the rainfall record in the selected year was not overly influenced by abnormal events. Based on this analysis, the year 2000 was selected for use in typical year simulations; section 3.1.4.4 presents a comparison between the rainfall characteristics of the typical year and the long-term average.

During development of the water quality models it became apparent that the presence of high backwater stage had important effects on water quality, and it was desired to confirm that the downstream stage characteristics of the typical year were, in fact, representative of typical conditions. The question is not trivial because the stage in the Mississippi River at St. Louis is not strongly tied to local rainfall, owing to the river's large drainage area. Stage data from USGS gage 07010000 (St. Louis at Market St.) was obtained covering 1933 through 2007 and various analyses were conducted to determine what constituted typical conditions.

A seasonal pattern emerges when long-term monthly averages are calculated, consisting of higher spring levels followed by lower levels from late summer through fall. However, individual years seldom exhibit this exact pattern, so it is impractical to define "typicalness" based on a resemblance to long-term averages. Instead, the occurrence of backwater events was taken to be analogous to flood events, so that a probability of exceedance could be assigned to the backwater conditions of year 2000. For the purposes of this analysis, a backwater event was defined as a period of two or more consecutive days over which the Mississippi River stage exceeded a specified level. For each year, the durations of all backwater events relative to a given stage level were computed, and the longest duration was taken to be the maximum event, analogous to the peak annual flood discharge. The maximum events were then ranked, and return probabilities computed as is typically done for flood frequencies.

Table 6-1 summarizes the longest backwater event from year 2000, and shows its probability of exceedance; this information is shown along with the probability curves in Figure 6-1. For example, during the longest backwater event of year 2000 the stage at the Market Street gage exceeded 15 feet for 38 consecutive days; the probability of an event equaling or exceeding this in any given year is 47%. At higher stages, the duration is shorter, and the probability of occurrence is generally higher. From this perspective it is asserted that the backwater conditions of year 2000 are not atypical, because there is at least a 50% chance that they would be equaled or exceeded in any given year. Note also that the backwater events used to develop the probabilities in Table 6-1 were limited to the months of May through October, which were considered to be more critical times with respect to water quality. If the analysis considers the entire year, the probabilities associated with the year 2000 event is actually even higher.

Stage Level (feet)	Duration (days)	Probability of Exceedance
15	38	47%
18	22	53%
20	13	58%
21	11	57%
22	10	54%
23	6	57%

Table 6-1 Probabilities Associated with Maximum Year 2000 Backwater Event

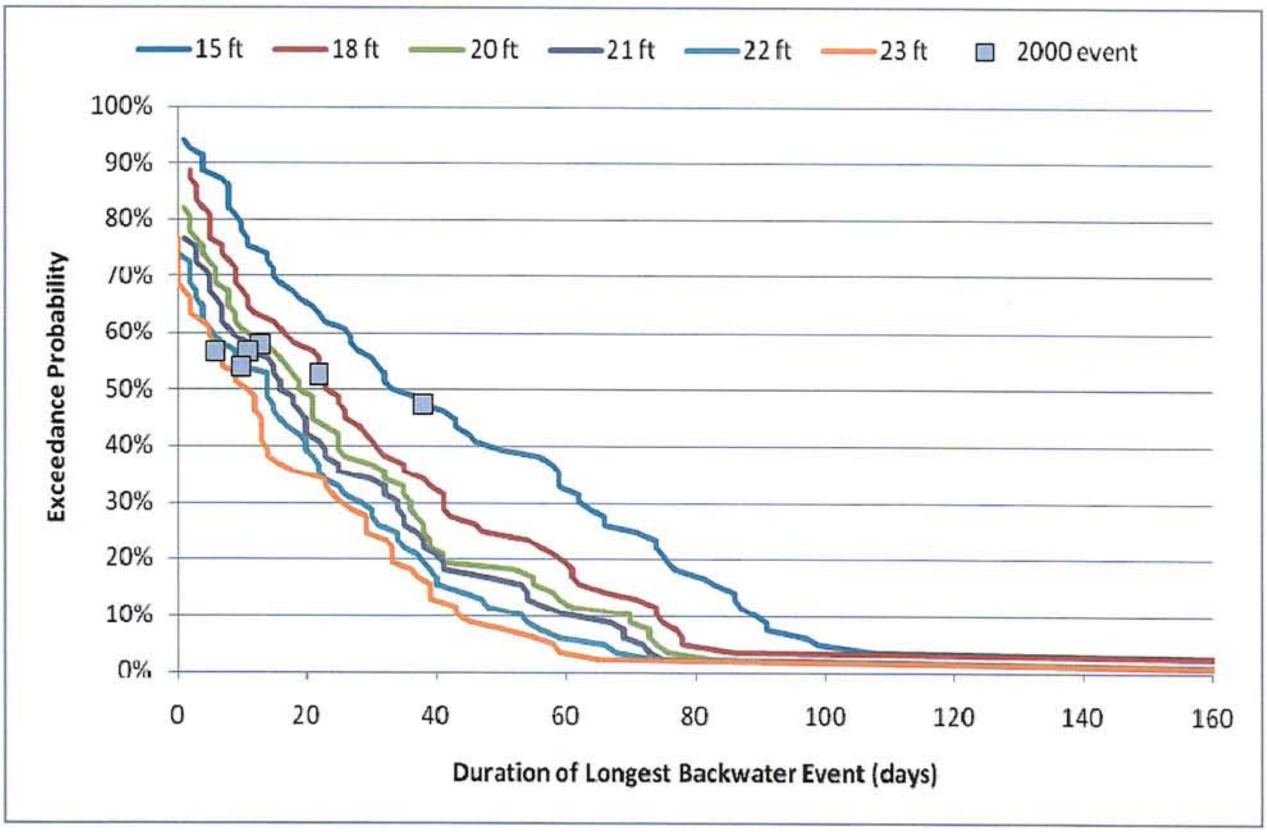

Figure 6-1 Assessment of Probability of the Year 2000 Backwater Event

6.2 Lower and Middle River Des Peres

The calibrated FEQ/EUTRO model of the Lower and Middle River Des Peres was used to evaluate the impacts of pollutant loads on water quality for the typical year. Table 6-2 summarizes the total annual volumes and pollutant loads included in the model, divided among CSO, stormwater and base flow sources. CSO loads are derived from flows provided by the XP-SWMM model of the collection system (see Section 4). Stormwater loads were derived from flows provided by the SWMM5 model of the watershed (see Section 5). Base flow loads represent the dry weather contribution from Deer Creek and Gravois Creek to the River Des Peres. Note that because sanitary sewer overflows (SSOs) were not explicitly modeled, their potential presence was covered by using elevated levels of bacteria for the stormwater sources; that is, the stormwater loads reflect the potential contributions of SSOs. Note also that for the purposes of calculating loads, all discharge from the Forest Park Tubes (Lemay Outfall 063) was assumed to be CSO, although this discharge does include a component of stormwater from the Upper River Des Peres.

Table 6-2 shows that the volume of stormwater, in the typical year, is roughly two-thirds again as large as that of CSO, whereas the stormwater load is generally less than half the CSO load. This is a result of the different pollutant concentrations used for the two sources. The base flow loads are trivial by comparison, and are included for completeness only.

Parameter	Units	Source		
		CSO	Stormwater	Base Flow
Volume	MG	6,149	10,470	2,314
$CBOD_5$	tons	609	378	19.3
Ammonia N	tons	33.0	10.5	0.96
Organic N	tons	123.0	43.7	4.82
E. coli	million counts	5.61×10^{10}	1.45×10^{10}	1.75×10^{7}

Table 6-2 Modeled Pollutant Loads to River Des Peres in Typical Year

Predicted water quality is represented by assessing compliance with applicable water quality standards for the pollutants of concern. For DO, comparisons are made both with Missouri's daily minimum criterion of 5 mg/L, and with USEPA's National Recommended Criteria of 4 mg/L as a daily minimum and 5 mg/L as a daily average. The compliance assessment involves calculating the average and minimum values for each day of the year, and determining a percent time in compliance; that is, if there are no exceedances, the percent time in compliance is 100%. For *E. coli* bacteria, the water quality standard (based on a recreational use designation) is expressed as the geometric mean for the recreational season, and this value is calculated from the model output. For ammonia, 30-day average concentrations are calculated and compared to the chronic criterion, while daily maximum concentrations are compared to the acute criterion. Note that the ammonia criteria are temperature and pH specific; the seasonally-varying model temperature was used, along with a pH value that represented the 85th percentile of observed values.

A bounding assessment of the effect of CSOs was obtained by running the same typical year scenario with all CSO inputs removed. With the exception of the upstream model boundary at the Forest Park Tubes outlet (Lemay Outfall 063), all CSO flows and pollutant loads were set to zero, and not replaced with any stormwater loads (which is likely a conservative assumption). At the upstream boundary, a no-CSO discharge was developed from the output of the Upper River Des Peres model, also with CSO inputs removed.

Figures 6-2 and 6-3 show the percent time of compliance with the average and minimum DO criteria, respectively; two pairs of lines are shown in Figure 6-3, corresponding to the two different minimum criteria. The plots are limited to the lower reach of the River Des Peres below Deer Creek, because the middle reach (above Deer Creek) is unclassified. Two conclusions can be readily made from these results: 1) that exceedances of both acute and chronic criteria occur regularly during a typical year, and 2) that removal of CSOs does not greatly increase the time of compliance (although the difference is slightly greater when the Federal value of 4 mg/L is used as a minimum criterion, versus the State value of 5 mg/L). Most exceedances occur during wet weather, but some occur during dry weather as well, primarily during periods of backwater influence. In certain reaches of the river, dry weather exceedances of the minimum criterion as a result of wide diurnal variations are not infrequent (see Figure 5-54), and are not changed by removal of wet weather loads. Exceedances of both criteria in backwater-affected reaches results from a combination of wet weather loads and sediment oxygen demand (SOD). The long-term effects of complete CSO removal on SOD and PR were not simulated by the model.

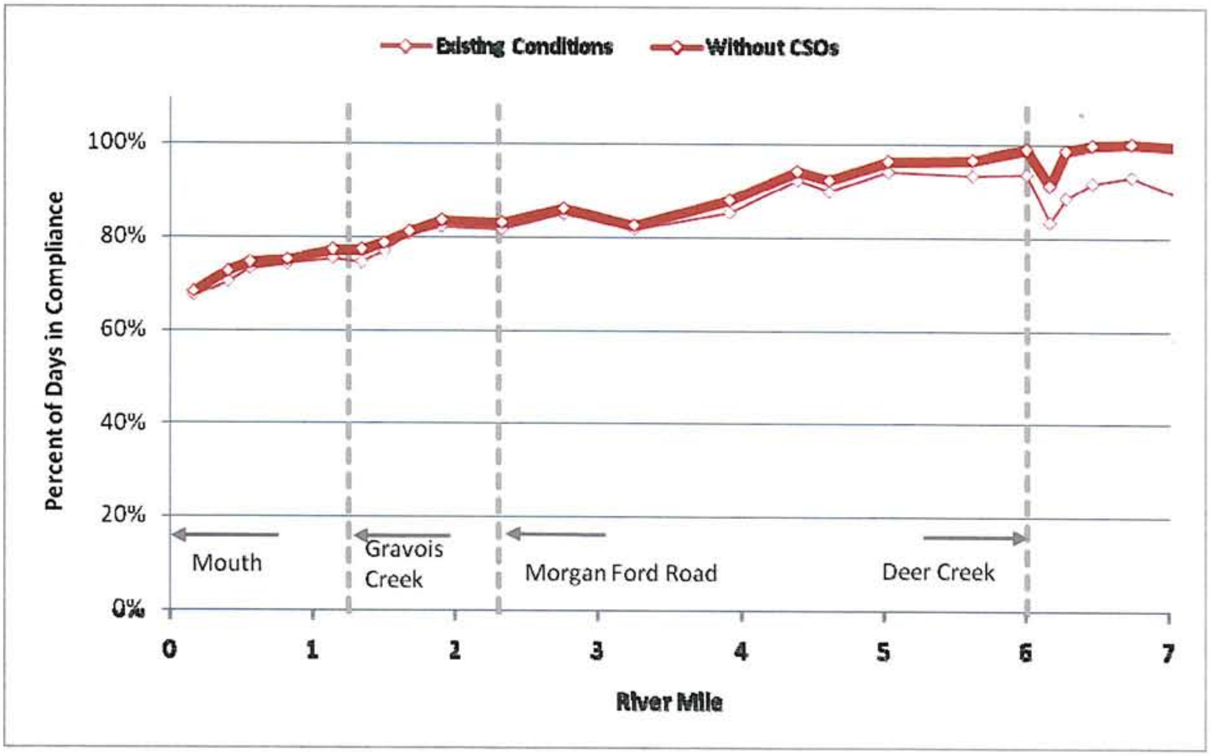

Figure 6-2 Typical Year Average DO Compliance for Lower River Des Peres (Daily Average of 5 mg/L)

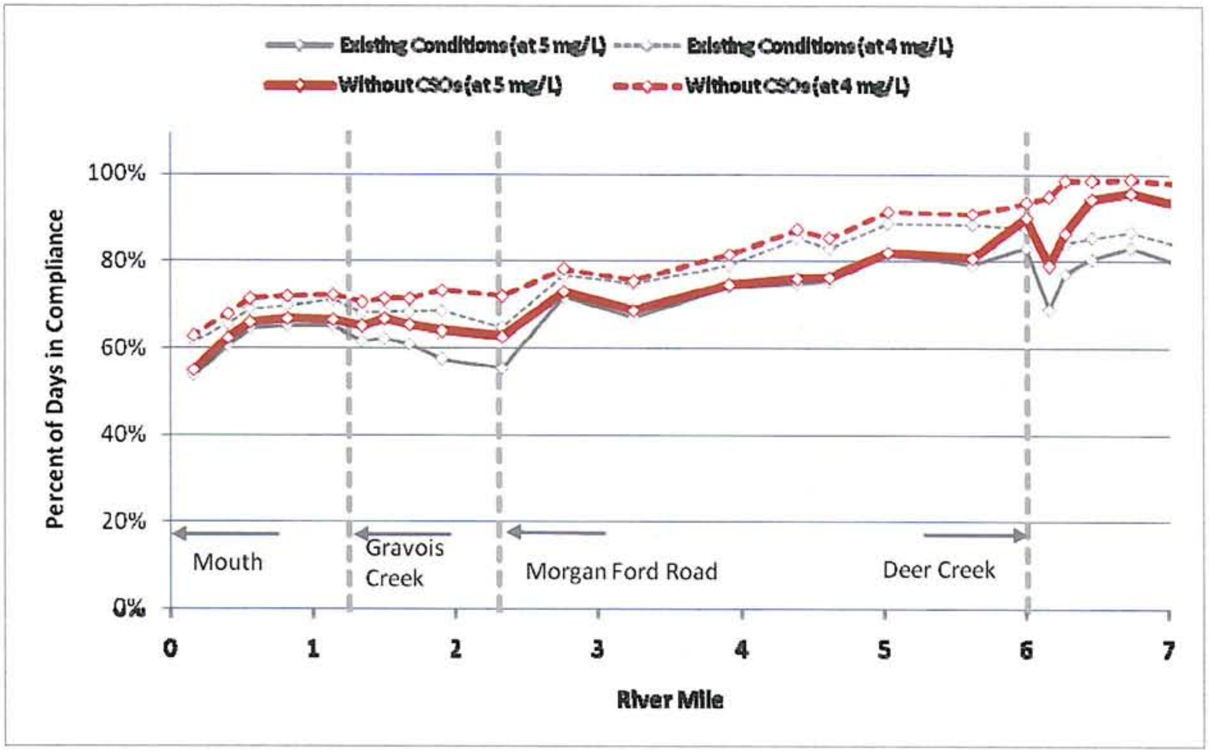

Figure 6-3 Typical Year Minimum DO Compliance for Lower River Des Peres

Figure 6-4 shows the geometric mean *E. coli* concentration from the river mouth upstream to the confluence with Deer Creek, calculated for the recreational season (April 1 through October 31); included for comparison is the secondary contact recreation (SCR) criterion of 1,134 #/100 mL. Compliance with this criterion in the typical year is not an issue, and complete removal of CSOs has a relatively minor effect. This is largely because wet weather effects are highly transient, and dry weather conditions prevail most of the time. The difference between dry and wet weather conditions is shown in Figure 6-5, which compares a dry weather profile to a peak condition from the typical year simulation. The instantaneous bacteria levels are high, and the difference between the existing conditions and the no-CSO simulation is readily apparent. Peak bacteria levels from stormwater alone, while lower than CSO-affected levels, are still high enough to discourage contact recreation.

The typical year results were also evaluated for compliance with acute and chronic concentration criteria for ammonia. Both criteria depend on pH, and the chronic criterion is also dependent on temperature. The criteria were calculated using a pH value of 8.3, which represents the 85th percentile of observed values in the receiving waters; temperature (where applicable) was taken from the model input values. The evaluation showed 100% compliance with both the acute criteria (based on daily maximum concentrations) and the chronic criteria (based on 30-day average concentrations). The results are not depicted here because the 100% compliance situation is identical both with and without CSOs.

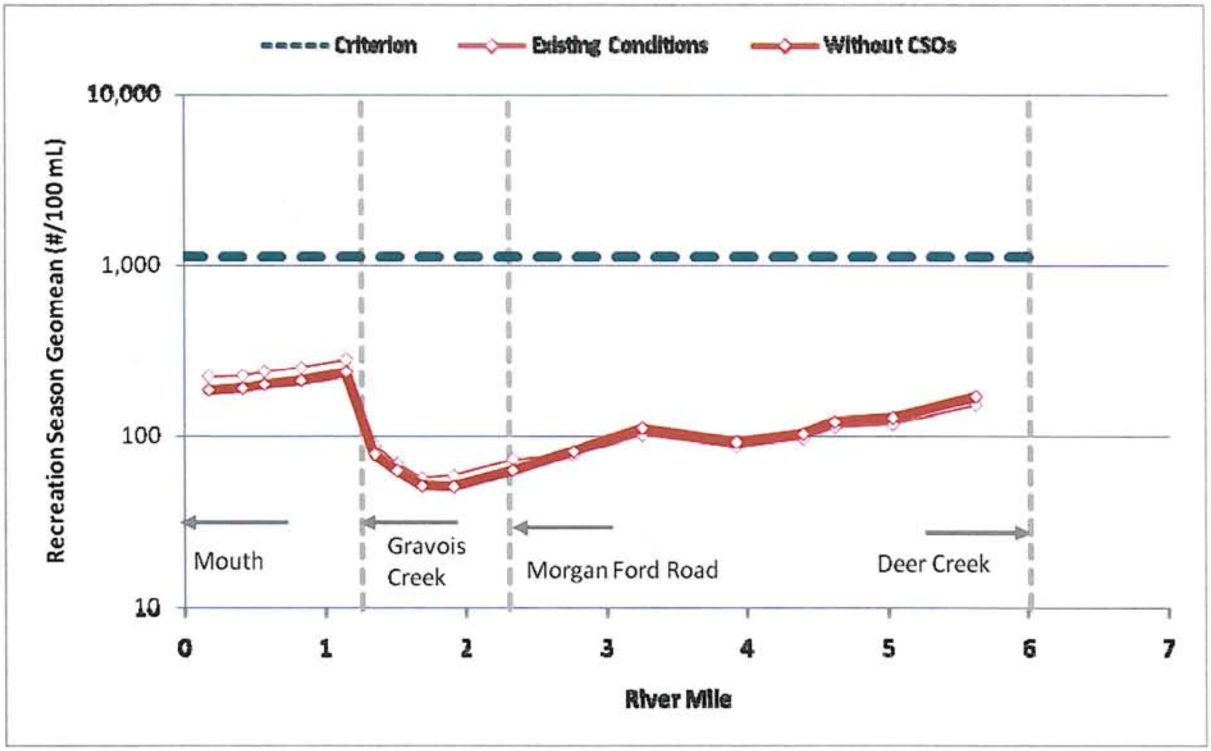

Figure 6-4 Typical Recreation Season Geometric Mean E. coli for Lower River Des Peres

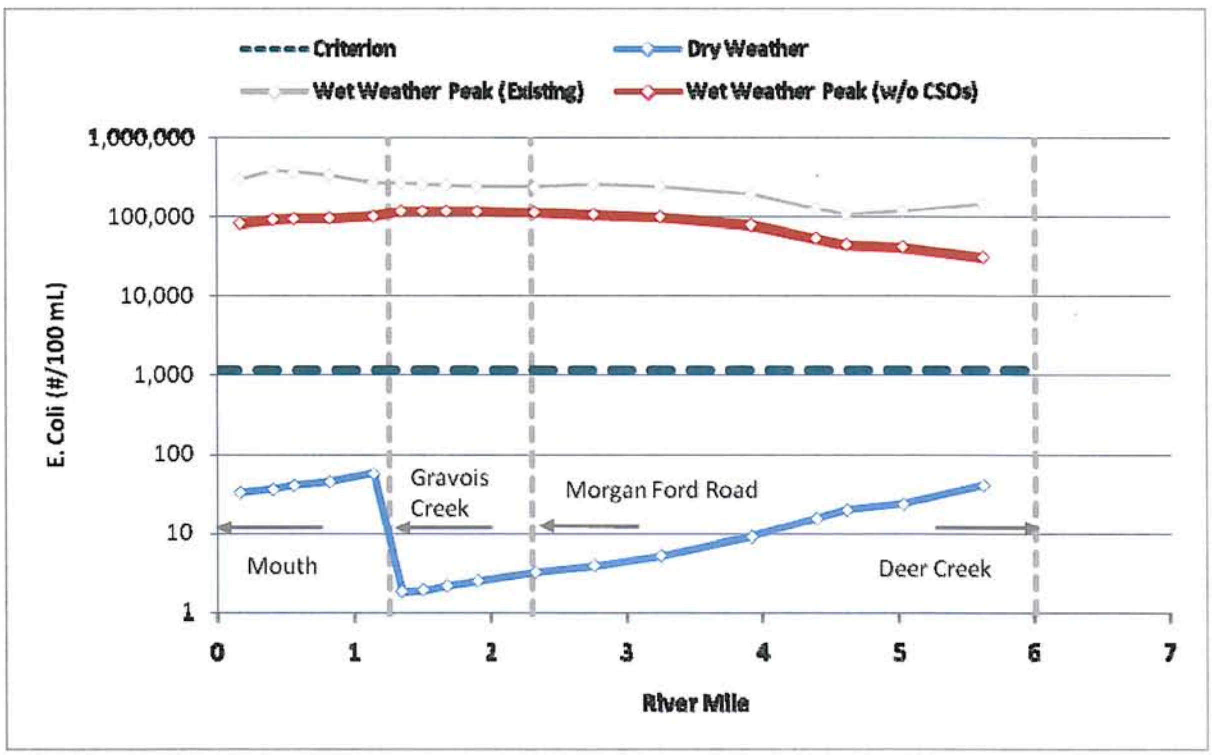

Figure 6-5 Comparison of Peak Wet Weather and Dry Weather E. coli Concentration Profiles for the Lower River Des Peres

6.3 Maline Creek

A similar approach was used to evaluate the impacts of CSO loads on Maline Creek in a typical year. Table 6-3 lists the total annual pollutant loads, divided among CSO, stormwater and base flow sources. The total CSO volume is much smaller, relative to other sources, than in the River Des Peres. CSO impacts can be expected to be small as well. Figures 6-6 and 6-7 show the percent time of compliance with the average and minimum DO criteria, respectively. Figure 6-8 shows the recreational season geometric mean *E. coli* bacteria concentration. In all three figures, the influence of CSOs is difficult to perceive because of their small volume relative to upstream and stormwater sources. The approach to CSO control on Maline Creek, therefore, is not predicated on water quality in a direct sense. Compliance with ammonia criteria was also evaluated for Maline Creek and, like with the Lower River Des Peres, compliance with the criteria was predicted to occur 100% of the time, both with and without CSOs.

Parameter	Units	Source		
		CSO	Stormwater	Base Flow
Volume	MG	151	2,740	420
$CBOD_5$	tons	19.9	49.1	3.50
Ammonia N	tons	0.94	3.47	0.087
Organic N	tons	2.02	2.31	0.175
E. coli	million counts	1.57×10^9	1.21×10^9	1.59×10^6

Table 6-3 Modeled Pollutant Loads to Maline Creek in Typical Year

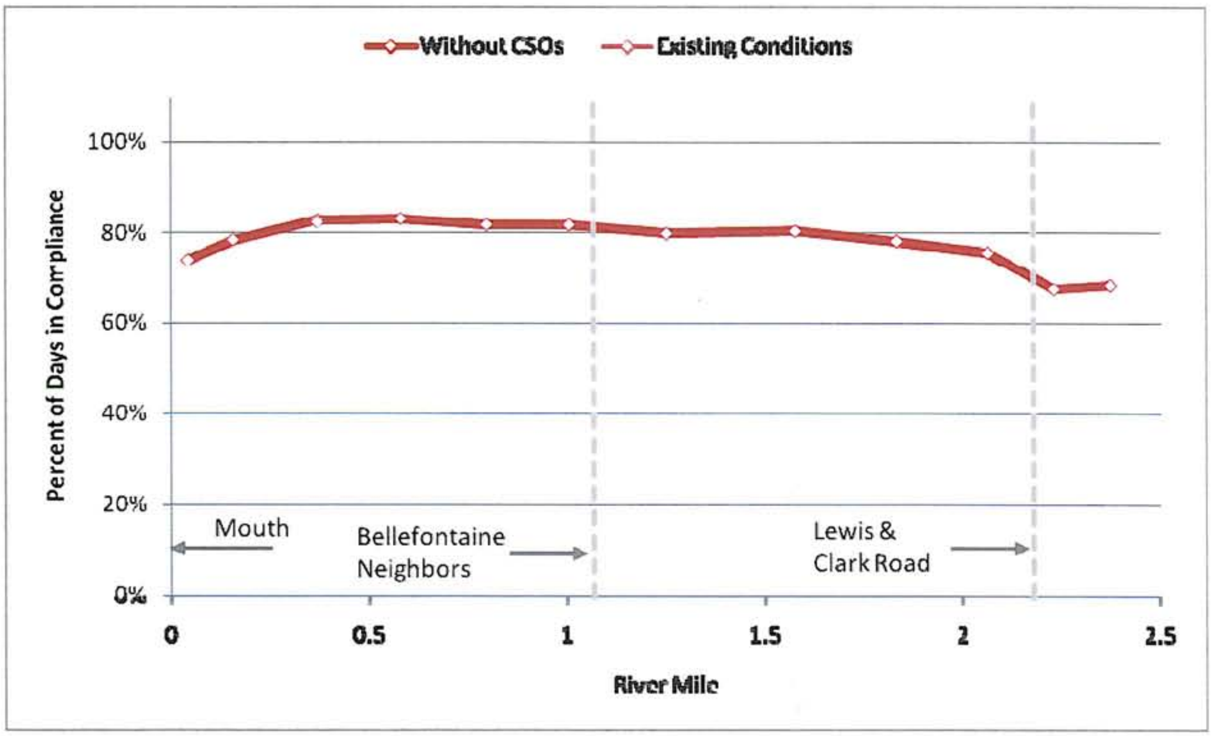

Figure 6-6 Typical Year Average DO Compliance for Maline Creek (Daily Average of 5 mg/L)

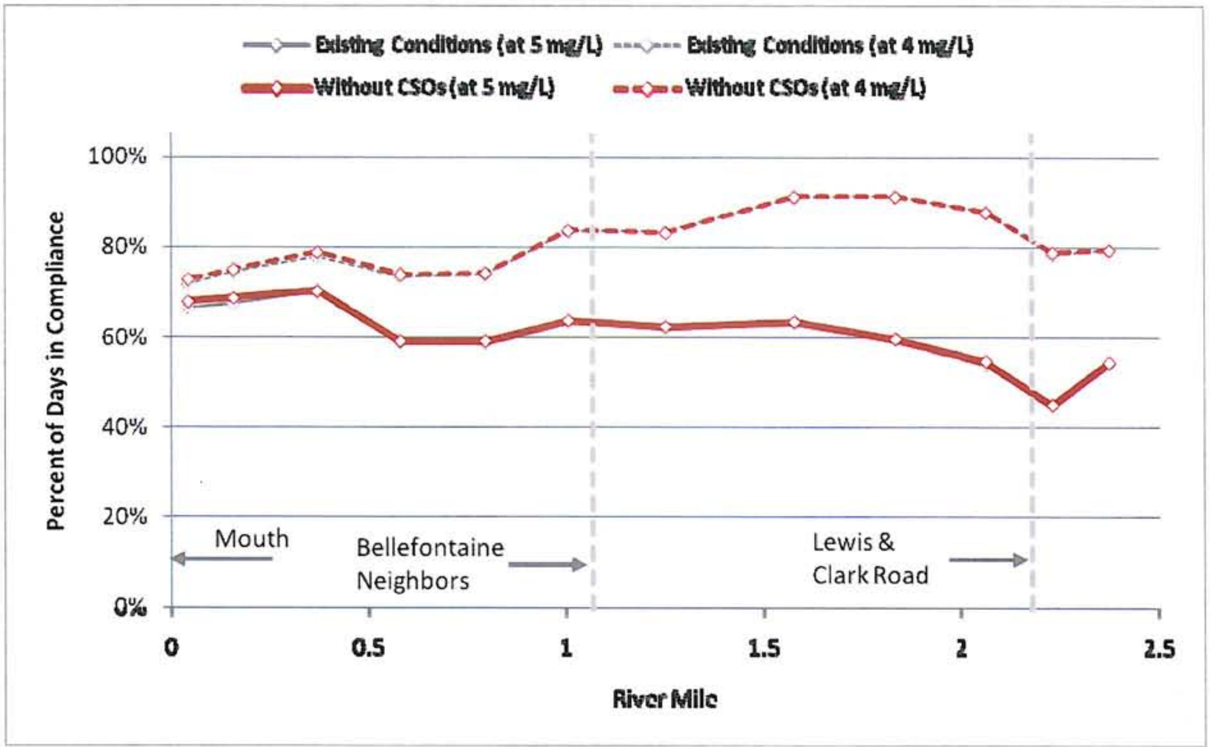

Figure 6-7 Typical Year Minimum DO Compliance for Maline Creek

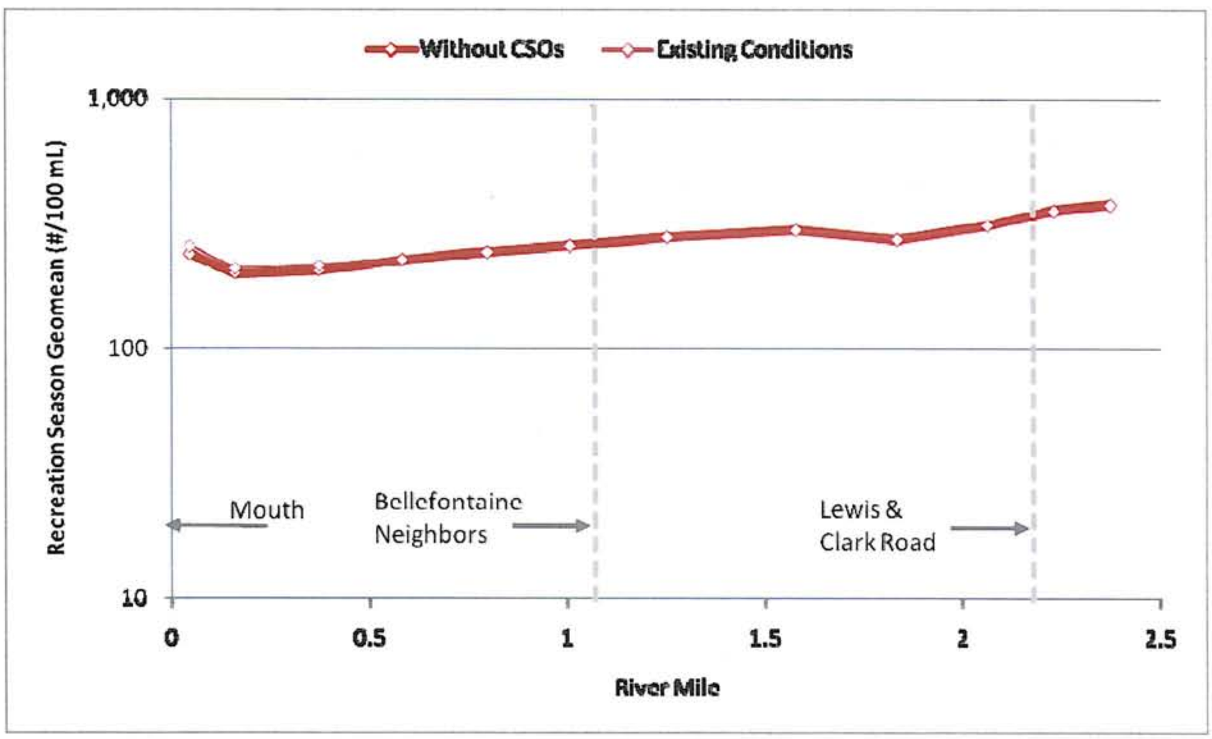

Figure 6-8 Typical Recreation Season Geometric Mean E. coli for Maline Creek

6.4 Upper River Des Peres

Total annual pollutant loads to the Upper River Des Peres are summarized in Table 6-4. As with the other receiving waters, the CSO loads were derived from collection system model output and the stormwater loads were derived from watershed model output. Base flow represents the upstream end of the three branches modeled: the main stem, the Vinita Park branch, and the Pagedale branch. Like the Lower River Des Peres, the CSO volume is about half the stormwater volume, but the pollutant loads are roughly double. Both are much smaller relative to base flow, however.

Parameter	Units	Source		
		CSO	Stormwater	Base Flow
Volume	MG	527	1,107	189
$CBOD_5$	tons	65.3	33.1	1.57
Ammonia N	tons	3.05	1.02	0.039
Organic N	tons	11.3	5.76	0.079
E. coli	million counts	5.28×10^9	1.10×10^9	7.15×10^5

Table 6-4 Modeled Pollutant Loads to Upper River Des Peres in Typical Year

Figures 6-9 through 6-12 depict the compliance evaluation results for the Upper River Des Peres and its branches. There are multiple lines on these figures that represent the multiple branches in the model. The longest line represents the main stem, the shortest line toward the left side represents the Vinita Park Branch, and the shorter line toward the right side represents the Pagedale Branch. Figures 6-9 and 6-10 show the percent time of compliance with the average and minimum DO criteria, respectively. It is notable that the State minimum criterion of 5 mg/L is met only around 70% of the time for much of the river, whereas the Federal minimum of 4 mg/L is met more often. An average daily concentration of at least 5 mg/L is maintained nearly all the time. Differences between attainment of minimum and average criteria are largely the result of PR-related diurnal variations, which can be seen in the sonde data in depicted Figure 5-58. The moderate improvement in compliance that is seen when CSOs are eliminated, however, suggests that on some occasions the stream flow is dominated by CSO flows, with DO levels below the minimum, long enough to register a minimum of less than either criterion but not long enough to drive the average below 5 mg/L. Note that analysis of model output will always pick up these minima even when stream sampling does not.

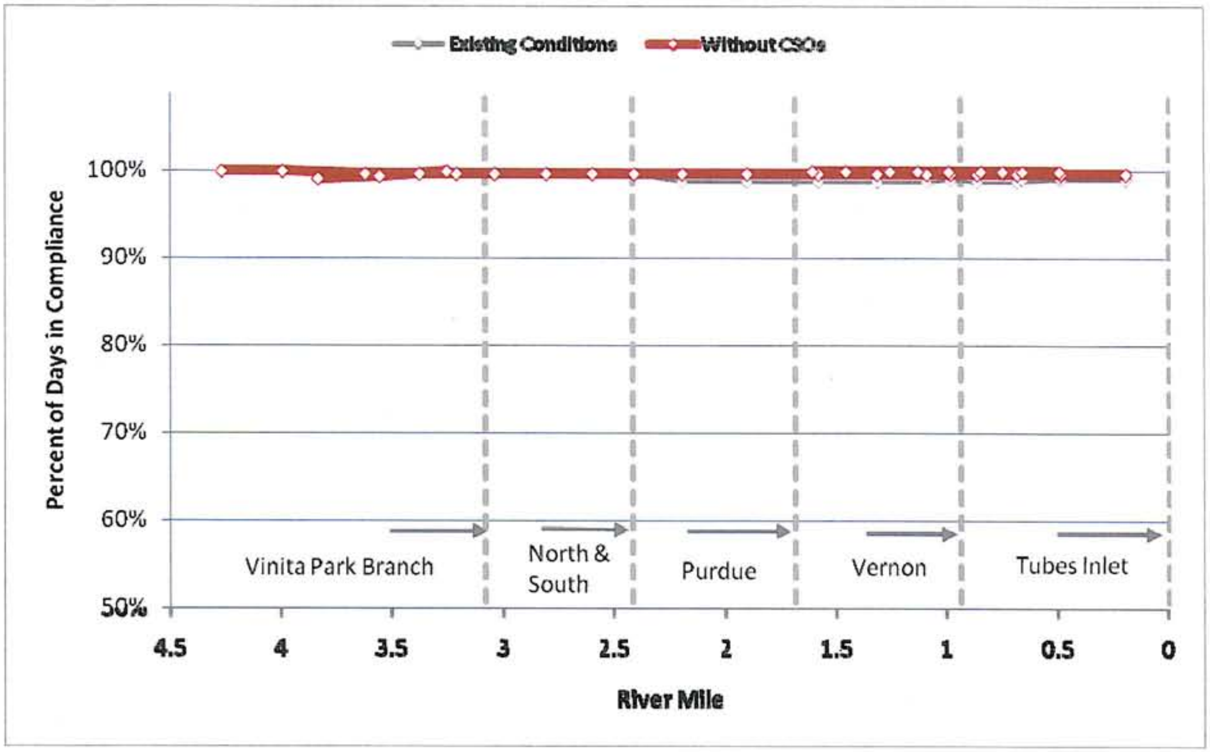

Figure 6-9 Typical Year Average DO Compliance for Upper River Des Peres (Daily Average of 5 mg/L)

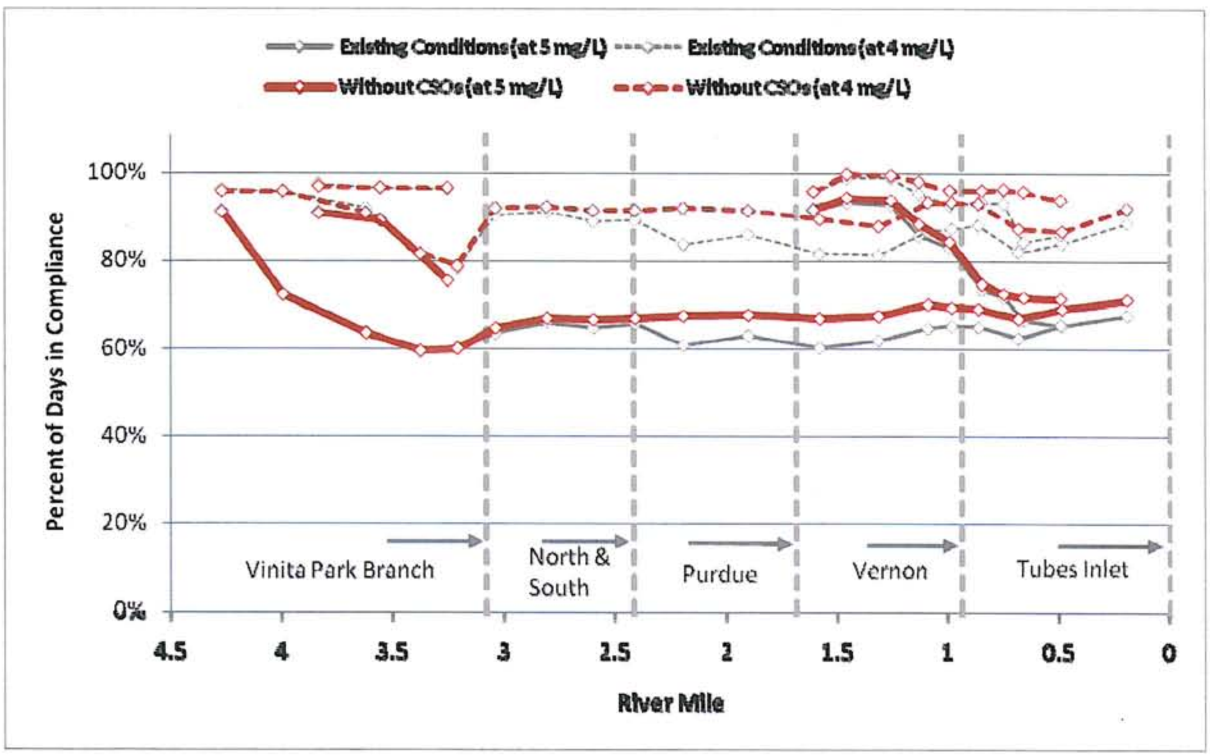

Figure 6-10 Typical Year Minimum DO Compliance for Upper River Des Peres

Figure 6-11 shows the geometric mean *E. coli* concentration for the three branches of the Upper River Des Peres modeled, calculated for the recreational season (April 1 through October 31); these results are included for illustrative purposes, as it is noted that the Upper River Des Peres is not classified and bacteria criteria do not apply. The line showing the results for the no-CSOs simulation demonstrates that the influence of CSOs begins to be noticeable downstream of North & South Road, and increases somewhat by the time the river goes underground. The difference between dry and wet weather conditions is shown in Figure 6-12, which compares a dry weather profile to a peak condition from the typical year simulation. As in the Lower River Des Peres, the instantaneous bacteria levels are high, and the difference between the existing conditions and the no-CSO simulation is also readily apparent. Peak bacteria levels from stormwater alone, while lower than CSO-affected levels, are still high enough to discourage contact recreation.

Compliance with ammonia criteria was evaluated for the Upper River Des Peres in the same manner as for the other receiving streams. Like the others, the standards were met 100% of the time during the typical year.

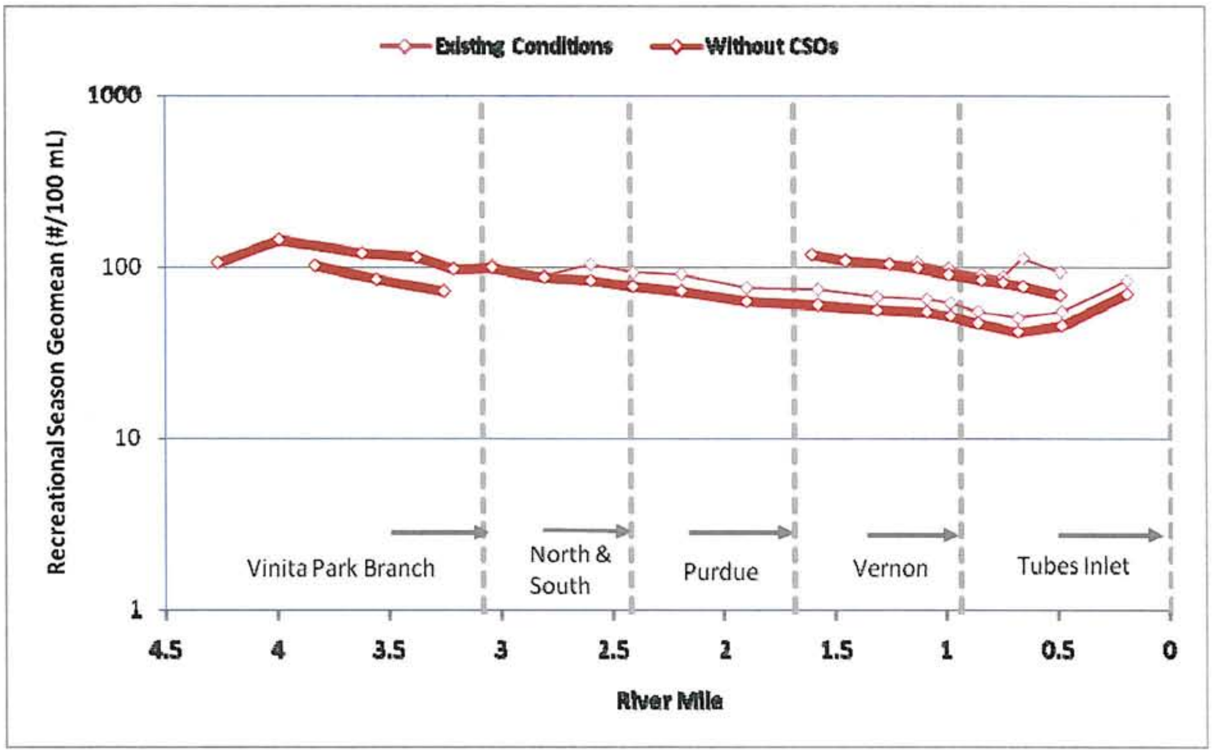

Figure 6-11 Typical Recreation Season Geometric Mean E. coli for Upper River Des Peres

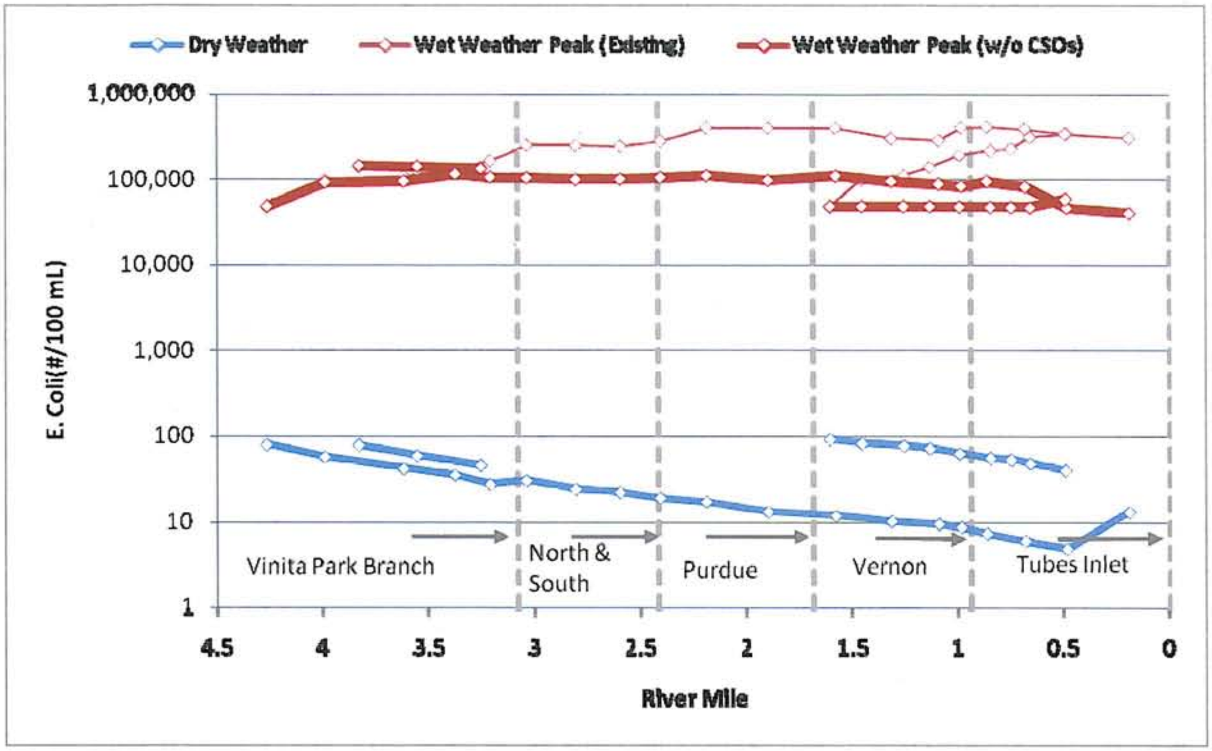

Figure 6-12 Comparison of Peak Wet Weather and Dry Weather E. coli Concentration Profiles for the Upper River Des Peres