

Appendix I  
Uncertainty Assessment  
Tables and Figures

## Appendix I. Uncertainty Assessment Tables and Figures

As described in Section 7.3 of the main report, primary pathways (sewage, infiltration, or stormwater) were estimated using the mean loading rates from each flow condition. This appendix presents the uncertainty in the primary pathway estimates based on the variability of loading rate estimates from each flow condition. The infiltration pathway is only included for sites where a signal of infiltration was observed (Corson & Eddy and Juneau; Section 7.1 of the main report). Dry and wet baseflow sample results were combined at Homer to estimate the sewage pathway. Only parameters with greater than 75% frequency of detection at a given site were included. More information on this assessment can be found in Section 7.4 of the main report.

To evaluate the uncertainty in mean loading rates within the Michigan Basin, an uncertainty range of loading rates and the relative variability were established for each parameter and pathway. Tables I-1 and I-2 describes the calculations used to generate these metrics at each site. As seen in this table, the relative variability for sewage is simply the relative standard deviation, but since infiltration and stormwater were not sampled directly, relative variability is based on the standard deviation of wet baseflow or stormflow sampling and the infiltration or stormwater mean estimate. Tables I-3 through I-7 present the results of this uncertainty assessment for conventionals, metals, and organics at each location.

**Table I-1. Calculations for uncertainty assessment of pathway loading rates during stormflow conditions at Corson & Eddy and Juneau.**

	<b>Sewage Calculations</b>	<b>Infiltration Calculations</b>	<b>Stormwater Calculations</b>
Mean Estimate	DB Mean = Sewage Mean	WB Mean – DB Mean = Infiltration Mean	Stormflow Mean – WB Mean = Stormwater Mean
Uncertainty Range	± DB St Dev	± WB St Dev	± Stormflow St Dev
Relative Variability	DB St Dev / Sewage Mean	WB St Dev / Infiltration Mean	Stormflow St Dev / Stormwater Mean

DB = dry baseflow; WB = wet baseflow; St Dev = standard deviation

**Table I-2. Calculations for uncertainty assessment of pathway loading rates during stormflow conditions at Homer.**

	<b>Sewage Calculations</b>	<b>Stormwater Calculations</b>
Mean Estimate	Combined Baseflow Mean = Sewage Mean	Stormflow Mean – WB Mean = Stormwater Mean
Uncertainty Range	± Combined Baseflow St Dev	± Stormflow St Dev
Relative Variability	Combined Baseflow St Dev / Sewage Mean	Stormflow St Dev / Stormwater Mean

St Dev = standard deviation

**Table I-3. Uncertainty assessment for estimated pathway loading rates for conventional parameters during stormflow conditions.**

Analyte	Location	Sewage Loading Rate (kg/hr)			Infiltration Loading Rate (kg/hr)			Stormwater Loading Rate (kg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
TOC	Corson & Eddy	6.65	± 2.04	0.31	3.59	± 2.19	0.61	4.76	± 12.8	2.69
	Homer	0.170	± 0.0654	0.38	No signal of infiltration.			0.566	± 0.371	0.65
	Juneau	0.908	± 0.383	0.42	-0.137	± 0.183	1.34	0.757	± 0.703	0.93
DOC	Corson & Eddy	3.79	± 1.14	0.30	4.35	± 1.06	0.24	-2.90	± 2.72	0.94
	Homer	0.0878	± 0.0201	0.23	No signal of infiltration.			0.305	± 0.243	0.80
	Juneau	0.480	± 0.0759	0.16	0.0533	± 0.105	1.97	0.246	± 0.417	1.69
TSS	Corson & Eddy	23.1	± 11.3	0.49	11.1	± 10.4	0.94	63.2	± 64.1	1.02
	Homer	0.633	± 0.351	0.55	No signal of infiltration.			5.62	± 5.36	0.95
	Juneau	2.26	± 0.979	0.43	0.198	± 0.590	2.98	7.89	± 9.63	1.22

**Table I-4. Uncertainty assessment for estimated pathway loading rates for metals during stormflow conditions.**

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Total Arsenic	Corson & Eddy	409	± 456	1.11	-35.9	± 102	2.83	941	± 531	0.56
	Homer	2.10	± 0.568	0.27	No signal of infiltration.			214	± 441	2.06
	Juneau	18.1	± 5.47	0.30	8.97	± 9.47	1.06	222	± 172	0.77
Dissolved Arsenic	Corson & Eddy	161	± 109	0.68	114	± 91.2	0.80	224	± 166	0.74
	Homer	1.20	± 0.310	0.26	No signal of infiltration.			25.1	± 14.5	0.58
	Juneau	13.6	± 3.01	0.22	5.59	± 8.98	1.61	117	± 69.2	0.59
Total Cadmium	Corson & Eddy	38.2	± 23.5	0.62	8.70	± 18.9	2.18	114	± 74.0	0.65
	Homer	0.297	± 0.0896	0.30	No signal of infiltration.			19.9	± 19.6	0.99
	Juneau	1.64	± 0.549	0.34	0.154	± 0.608	3.95	12.8	± 11.1	0.87
Dissolved Cadmium	Corson & Eddy	Not calculated due to <75% FOD.								
	Homer									
	Juneau									
Total Chromium	Corson & Eddy	554	± 315	0.57	-11.2	± 373	33.4	3,330	± 2,240	0.67
	Homer	3.61	± 1.28	0.35	No signal of infiltration.			319	± 290	0.91
	Juneau	24.1	± 11.4	0.47	3.41	± 18.0	5.28	329	± 325	0.99

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Dissolved Chromium	Corson & Eddy	57.0	± 39.7	0.70	43.0	± 54.6	1.27	69.9	± 90.9	1.30
	Homer	0.863	± 0.291	0.34	No signal of infiltration.			26.3	± 15.8	0.60
	Juneau	5.44	± 1.44	0.26	2.06	± 3.52	1.71	28.2	± 18.4	0.65
Total Copper	Corson & Eddy	7,130	± 5,010	0.70	397	± 3,490	8.79	23,400	± 20,100	0.86
	Homer	87.6	± 28.4	0.32	No signal of infiltration.			2,830	± 2,520	0.89
	Juneau	375	± 122	0.32	-67.3	± 126	1.87	6,510	± 13,900	2.13
Dissolved Copper	Corson & Eddy	493	± 145	0.29	657	± 419	0.64	739	± 1,180	1.60
	Homer	14.3	± 10.8	0.75	No signal of infiltration.			342	± 161	0.47
	Juneau	119	± 16.2	0.14	29.4	± 59.4	2.02	3,210	± 8,640	2.70
Total Lead	Corson & Eddy	Not calculated due to illicit discharges.								
	Homer	17.3	± 13.5	0.78	No signal of infiltration.			3,940	± 7,560	1.92
	Juneau	202	± 314	1.56	-112	± 50.7	0.45	1,340	± 1,400	1.04
Dissolved Lead	Corson & Eddy	Not calculated due to illicit discharges.								
	Homer	1.27	± 0.834	0.66	No signal of infiltration.			40.0	± 23.6	0.59
	Juneau	11.9	± 2.78	0.23	3.32	± 9.60	2.89	41.8	± 34.0	0.81

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Total Nickel	Corson & Eddy	734	± 390	0.53	1,700	± 980	0.58	11,500	± 25,000	2.18
	Homer	14.0	± 2.99	0.21	No signal of infiltration.			364	± 339	0.93
	Juneau	48.3	± 20.0	0.41	12.2	± 29.1	2.39	376	± 308	0.82
Dissolved Nickel	Corson & Eddy	274	± 128	0.47	1,390	± 986	0.71	1,370	± 5,470	4.00
	Homer	10.2	± 2.15	0.21	No signal of infiltration.			75.2	± 60.4	0.80
	Juneau	24.4	± 3.90	0.16	19.9	± 20.5	1.03	107	± 94.2	0.88
Total Silver	Corson & Eddy	24.9	± 10.4	0.42	-0.0174	± 8.52	490	63.2	± 50.5	0.80
	Homer	Not calculated due to <75% FOD.								
	Juneau									
Dissolved Silver	Corson & Eddy	Not calculated due to <75% FOD.								
	Homer									
	Juneau									
Total Vanadium	Corson & Eddy	587	± 330	0.56	289	± 487	1.68	3,030	± 2,350	0.77
	Homer	5.77	± 1.85	0.32	No signal of infiltration.			381	± 348	0.91
	Juneau	25.4	± 11.9	0.47	10.8	± 20.7	1.91	467	± 438	0.94

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Dissolved Vanadium	Corson & Eddy	216	± 120	0.56	202	± 119	0.59	229	± 256	1.12
	Homer	1.28	± 0.228	0.18	No signal of infiltration.			31.7	± 17.9	0.56
	Juneau	8.75	± 0.880	0.10	13.2	± 12.8	0.97	93.0	± 59.8	0.64
Total Zinc	Corson & Eddy	22,100	± 12,000	0.54	3,330	± 9,310	2.80	71,700	± 49,700	0.69
	Homer	195	± 45.8	0.23	No signal of infiltration.			10,600	± 11,000	1.03
	Juneau	1,290	± 297	0.23	-135	± 454	3.38	5,210	± 4,850	0.93
Dissolved Zinc	Corson & Eddy	1,910	± 1,160	0.61	5,450	± 1,430	0.26	2,640	± 10,100	3.84
	Homer	20.7	± 13.7	0.66	No signal of infiltration.			1,870	± 1,130	0.60
	Juneau	331	± 63.9	0.19	135	± 187	1.39	1,100	± 953	0.87
Total Mercury	Corson & Eddy	9.29	± 2.91	0.31	4.74	± 6.16	1.30	57.6	± 53.5	0.93
	Homer	0.0688	± 0.0229	0.33	No signal of infiltration.			1.58	± 1.57	0.99
	Juneau	0.667	± 0.364	0.55	-0.0263	± 0.576	21.9	2.38	± 1.88	0.79
Dissolved Mercury	Corson & Eddy	Not calculated due to <75% FOD.								
	Homer									
	Juneau									

**Table I-5. Uncertainty assessment for estimated pathway loading rates for PAHs and phthalates during stormflow conditions.**

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Naphthalene	Corson & Eddy	Not calculated due to illicit discharges.								
	Homer	0.375	± 0.193	0.52	No signal of infiltration.			3.03	± 2.50	0.82
	Juneau	1.28	± 0.659	0.51	0.986	± 1.40	1.42	2.59	± 3.13	1.21
Phenanthrene	Corson & Eddy	Not calculated due to illicit discharges.								
	Homer	Not calculated due to <75% FOD.								
	Juneau	1.73	± 1.24	0.71	1.01	± 1.68	1.67	4.37	± 3.80	0.87
Bis (2-ethylhexyl) phthalate	Corson & Eddy	2,520	± 4,030	1.60	-1,390	± 454	0.33	820	± 1,160	1.41
	Homer	10.3	± 10.7	1.04	No signal of infiltration.			152	± 293	1.93
	Juneau	57.6	± 12.1	0.21	-12.7	± 23.2	1.82	147	± 271	1.85
Diethyl Phthalate	Corson & Eddy	270	± 15.0	0.06	355	± 309	0.87	-170	± 245	1.45
	Homer	12.0	± 4.05	0.34	No signal of infiltration.			6.67	± 12.3	1.85
	Juneau	75.9	± 34.0	0.45	-16.4	± 16.7	1.02	39.8	± 68.5	1.72



**Table I-6. Uncertainty assessment for estimated pathway loading rates for PCBs and total dioxin/furans during stormflow conditions.**

Analyte	Location	Sewage Loading Rate (mg/hr)			Infiltration Loading Rate (mg/hr)			Stormwater Loading Rate (mg/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Total PCBs	Corson & Eddy	7.26	± 3.58	0.49	21.9	± 24.8	1.13	72.4	± 94.6	1.31
	Homer	0.838	± 0.274	0.33	No signal of infiltration.			70.7	± 90.0	1.27
	Juneau	0.389	± 0.0794	0.20	-0.157	± 0.0861	0.55	4.48	± 5.02	1.12
Total Dioxin/Furans	Corson & Eddy	0.0761	± 0.0177	0.23	0.00827	± 0.0414	5.01	0.508	± 0.0953	0.19
	Homer	Not analyzed.								
	Juneau									

**Table I-7. Uncertainty assessment for estimated pathway loading rates for total dioxin TEQs during stormflow conditions.**

Analyte	Location	Sewage Loading Rate (ng TEQ/hr)			Infiltration Loading Rate (ng TEQ/hr)			Stormwater Loading Rate (ng TEQ/hr)		
		Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability	Mean Estimate	Uncertainty Range	Relative Variability
Total Dioxin TEQs	Corson & Eddy	331	± 21.6	0.07	226	± 111	0.42	2,750	± 205	0.07
	Homer	Not analyzed.								
	Juneau									

Next, the relative magnitude of each pathway (sewage, infiltration, or stormwater) was calculated with six different scenarios in addition to the mean estimate (best estimate; Section 7.3). These include (1) a high sewage estimate, (2) a low sewage estimate, (3) a high infiltration estimate, (4) a low infiltration estimate, (5) a high stormwater estimate, and (6) a low stormwater estimate. Table I-8, also provided in the main report as Table 7-5, explains how these were calculated.

**Table I-8. Scenarios Used in the Uncertainty Assessment**

Scenario	Calculated from Sampling Results			Resulting Estimates		
	Dry Baseflow Loading Rate (= A)	Wet Baseflow Loading Rate (= B)	Stormflow Loading Rate (= C)	Sewage Loading Rate (= A)	Infiltration Loading Rate (= B - A)	Stormwater Loading Rate (= C - B)
Mean Estimate	Mean	Mean	Mean	Mean	Mean	Mean
1. High Sewage	Mean + St Dev	Mean	Mean	High	Biased low	Mean
2. Low Sewage	Mean - St Dev	Mean	Mean	Low	Biased high	Mean
3. High Infiltration	Mean	Mean + St Dev	Mean	Mean	High	Biased low
4. Low Infiltration	Mean	Mean - St Dev	Mean	Mean	Low	Biased high
5. High Stormwater	Mean	Mean	Mean + St Dev	Mean	Mean	High
6. Low Stormwater	Mean	Mean	Mean - St Dev	Mean	Mean	Low

St Dev – Standard Deviation

Note: “Biased low” is the result of subtracting a high baseflow loading estimate from the mean stormflow loading estimate. “Biased high” is the result of subtracting a low baseflow loading estimate from the mean stormflow loading estimate.

Figures I-1 through I-32 illustrate the relative magnitude of the pathways estimated during stormflow based on the above scenarios for all parameters with greater than 75% FOD at a given sampling location. For most parameters, there was a greater range of uncertainty in relative magnitude of the pathway when stormflow loading estimates were manipulated. In the figures, sewage is abbreviated “Swg.,” infiltration is abbreviated “Infiltr.,” and stormwater is abbreviated “SW”. These results are discussed further in the main report (Section 7.4.4).

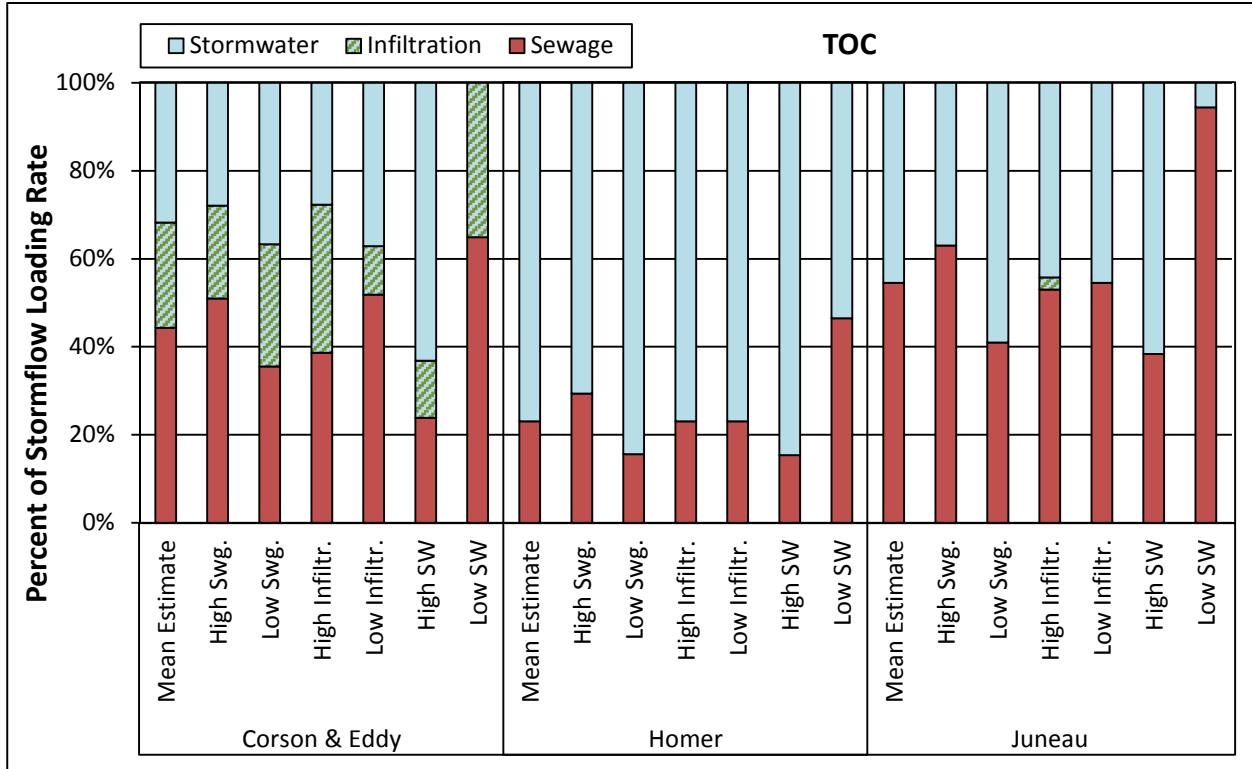


Figure I-1. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Organic Carbon Estimated Under Different Scenarios.

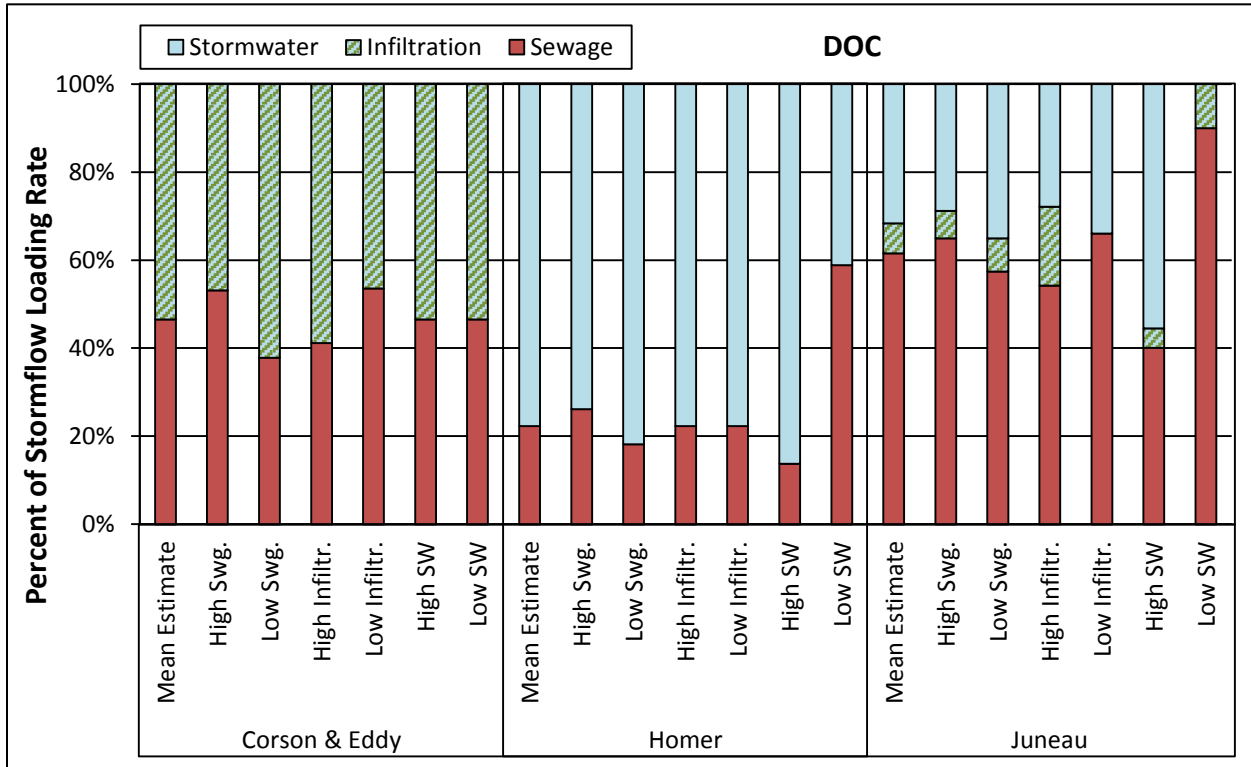


Figure I-2. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Organic Carbon Estimated Under Different Scenarios.

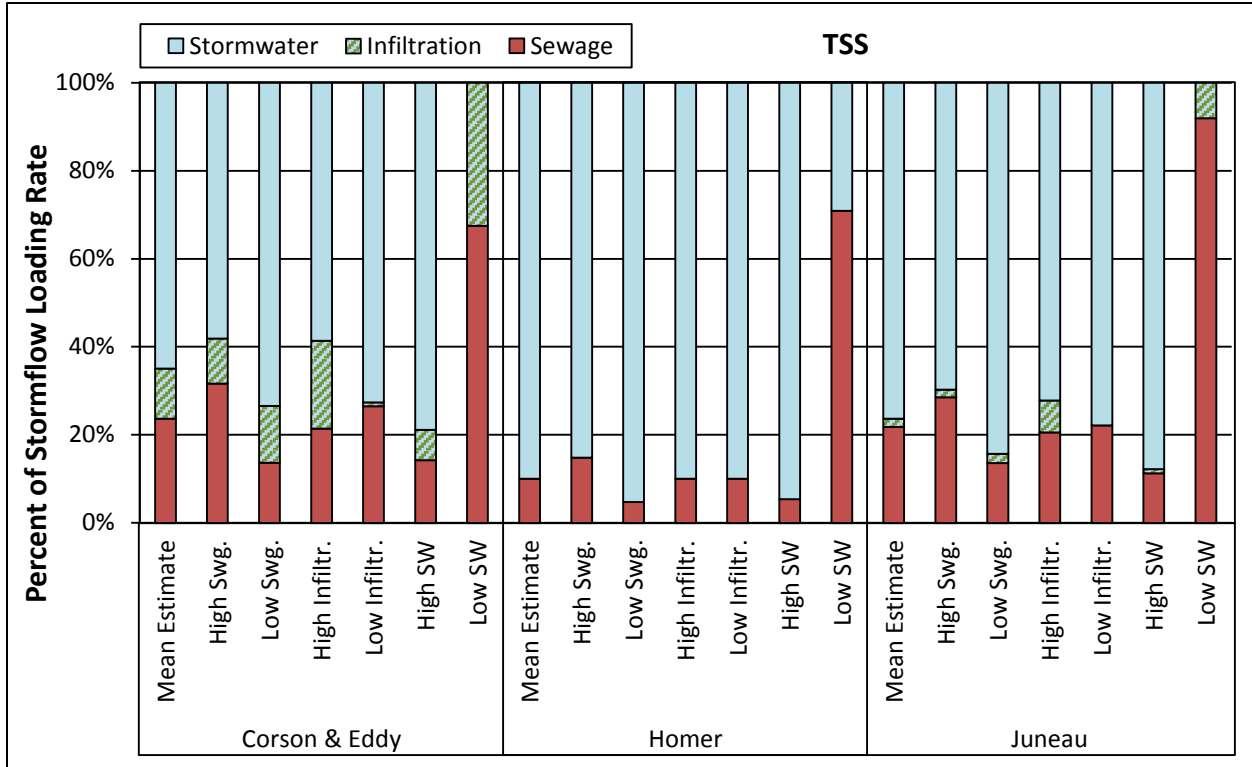


Figure I-3. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Suspended Solids Estimated Under Different Scenarios.

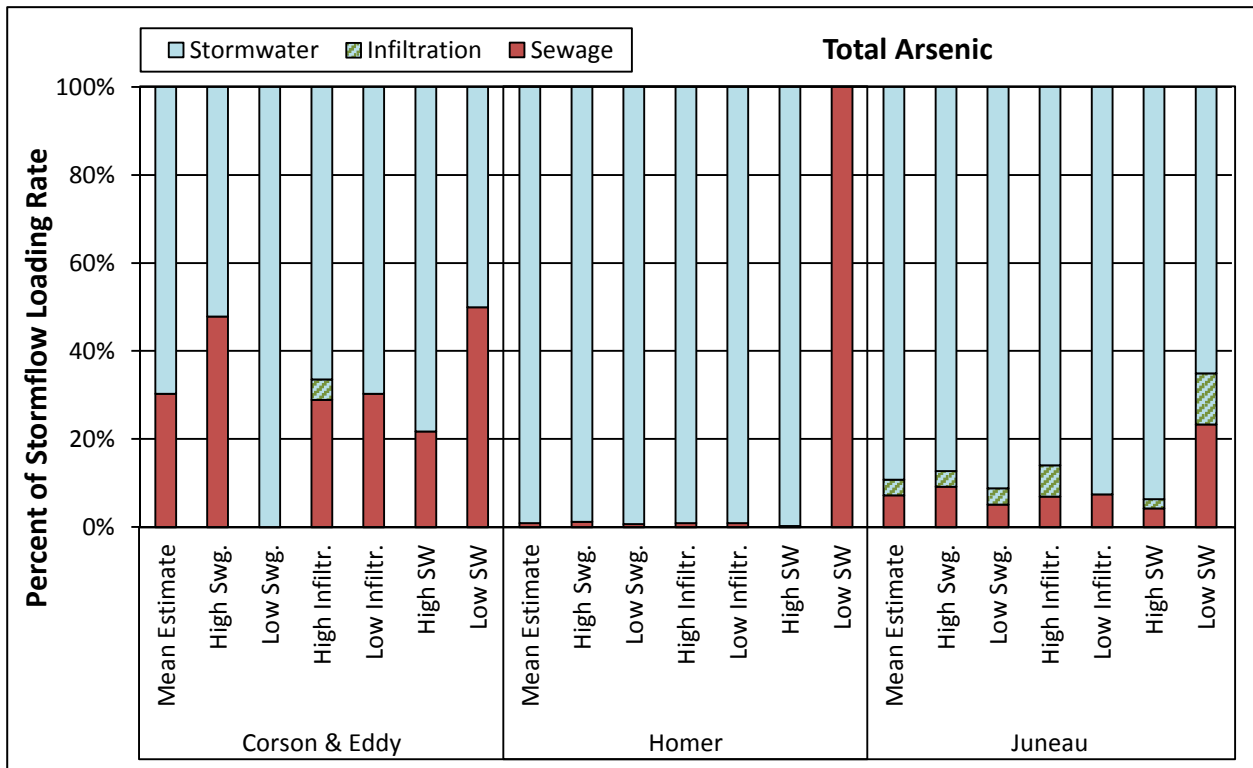


Figure I-4. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Arsenic Estimated Under Different Scenarios.

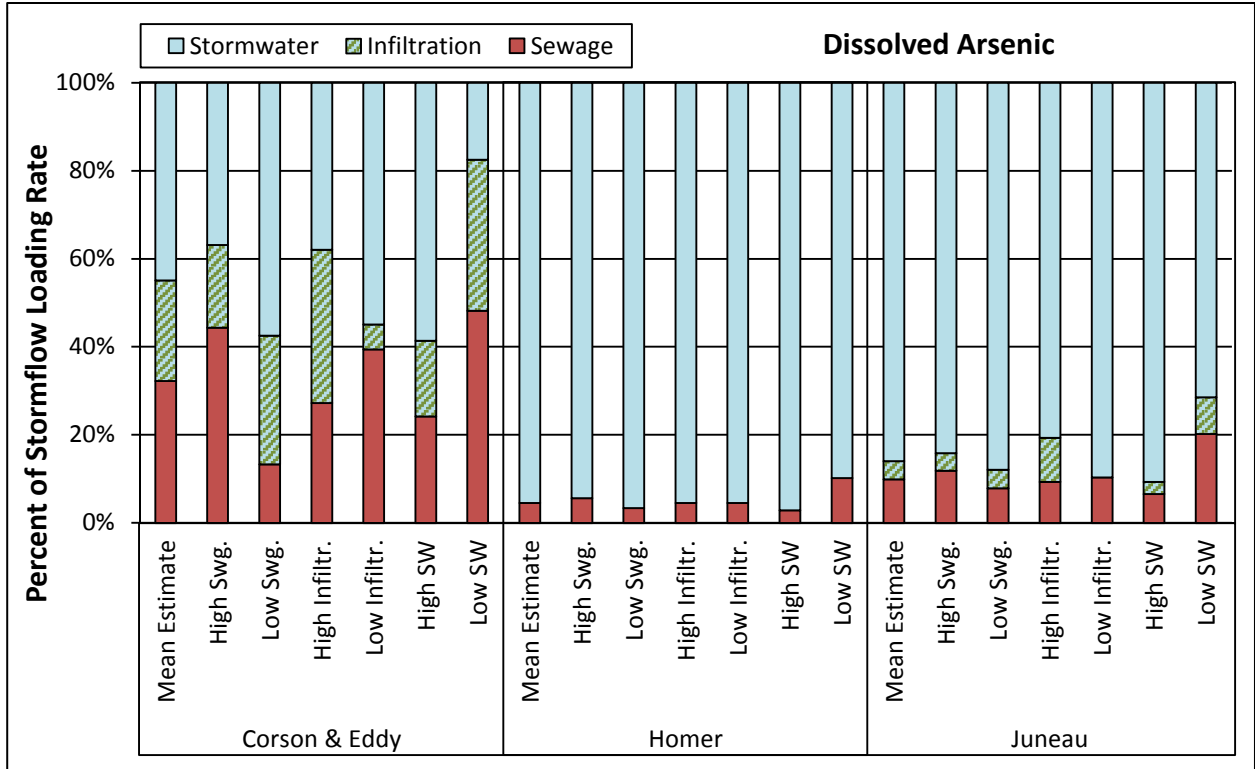


Figure I-5. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Arsenic Estimated Under Different Scenarios.

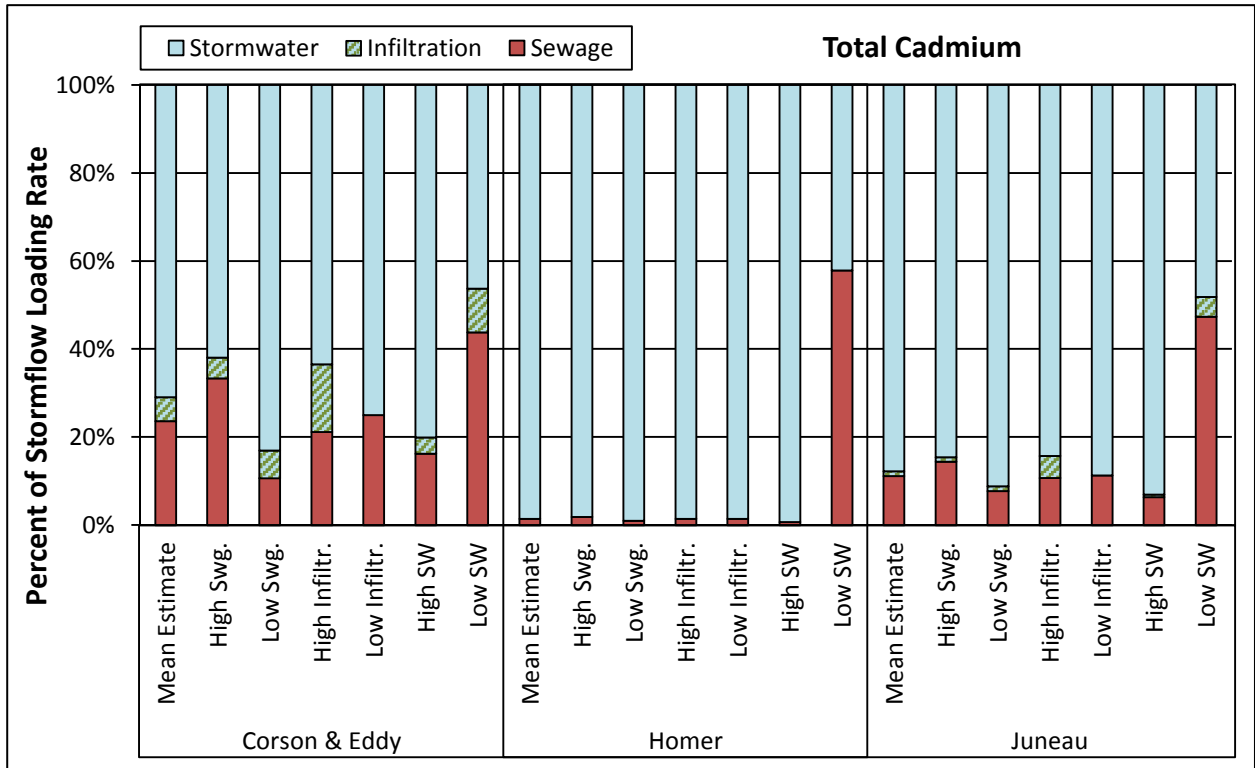


Figure I-6. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Cadmium Estimated Under Different Scenarios.

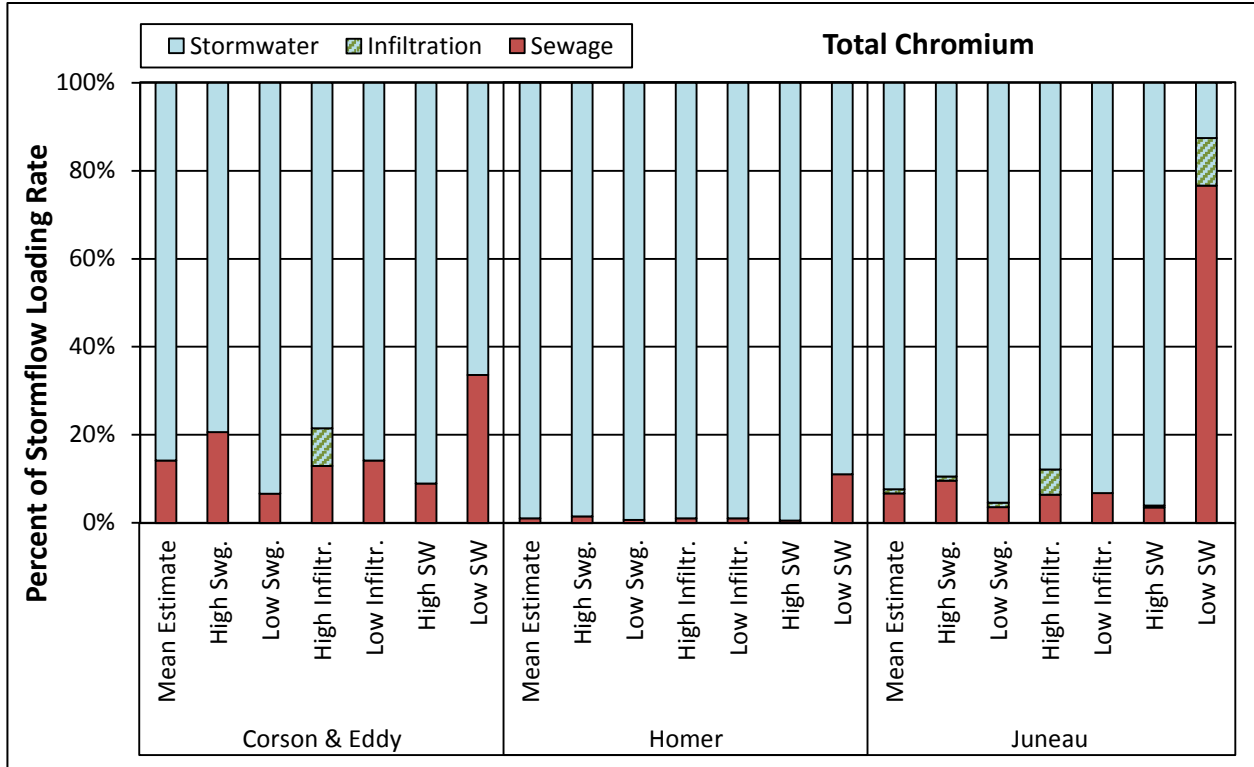


Figure I-7. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Chromium Estimated Under Different Scenarios.

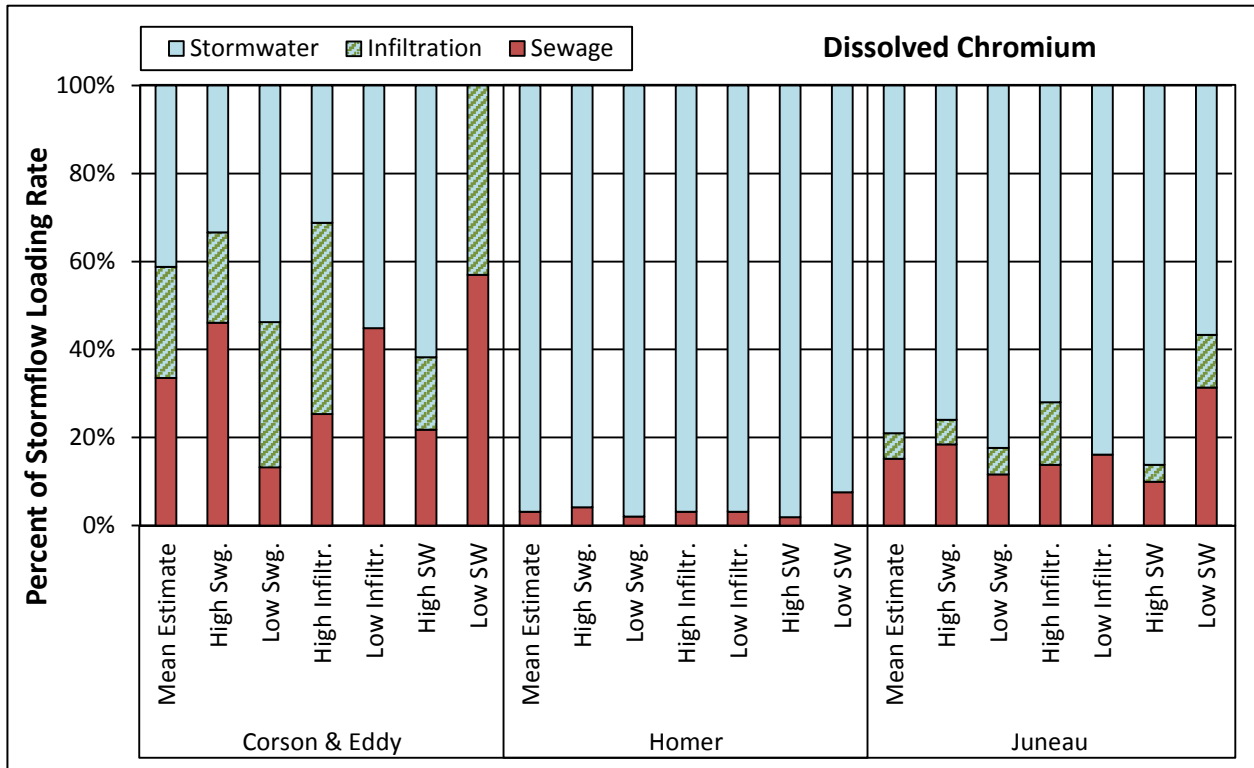


Figure I-8. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Chromium Estimated Under Different Scenarios.

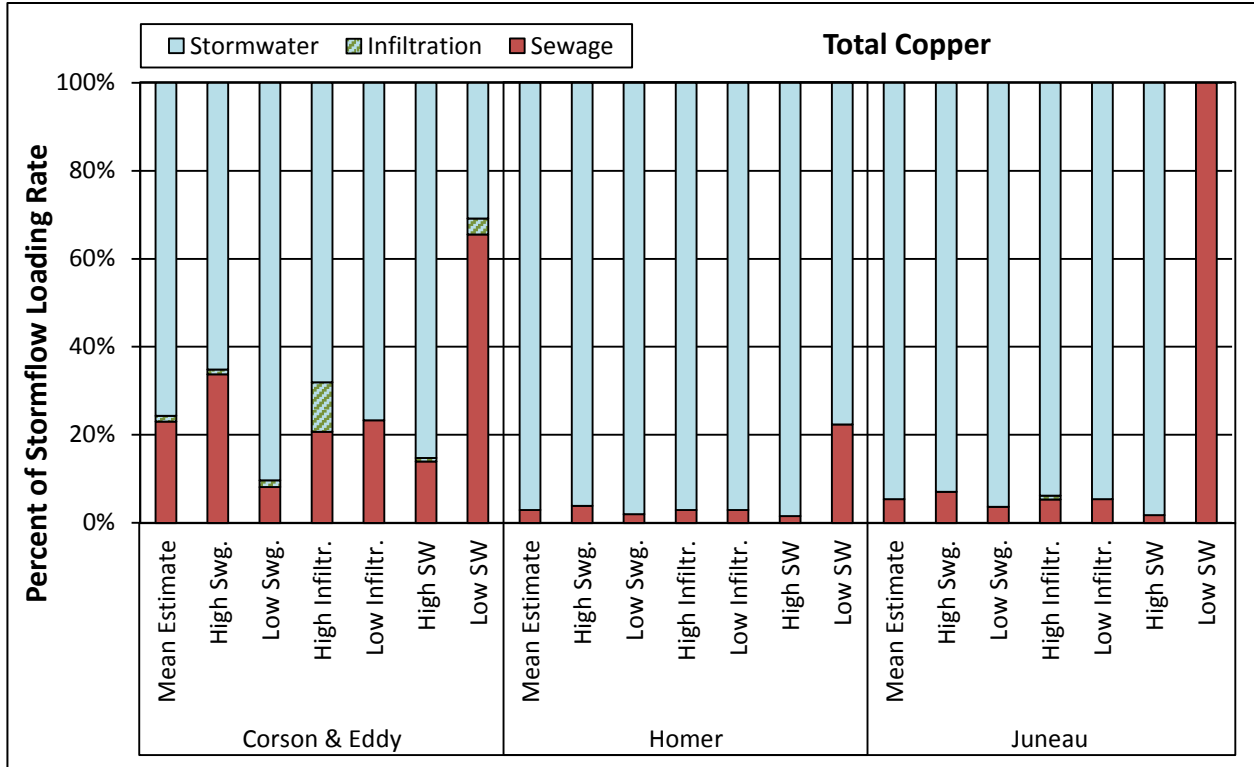


Figure I-9. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Copper Estimated Under Different Scenarios.

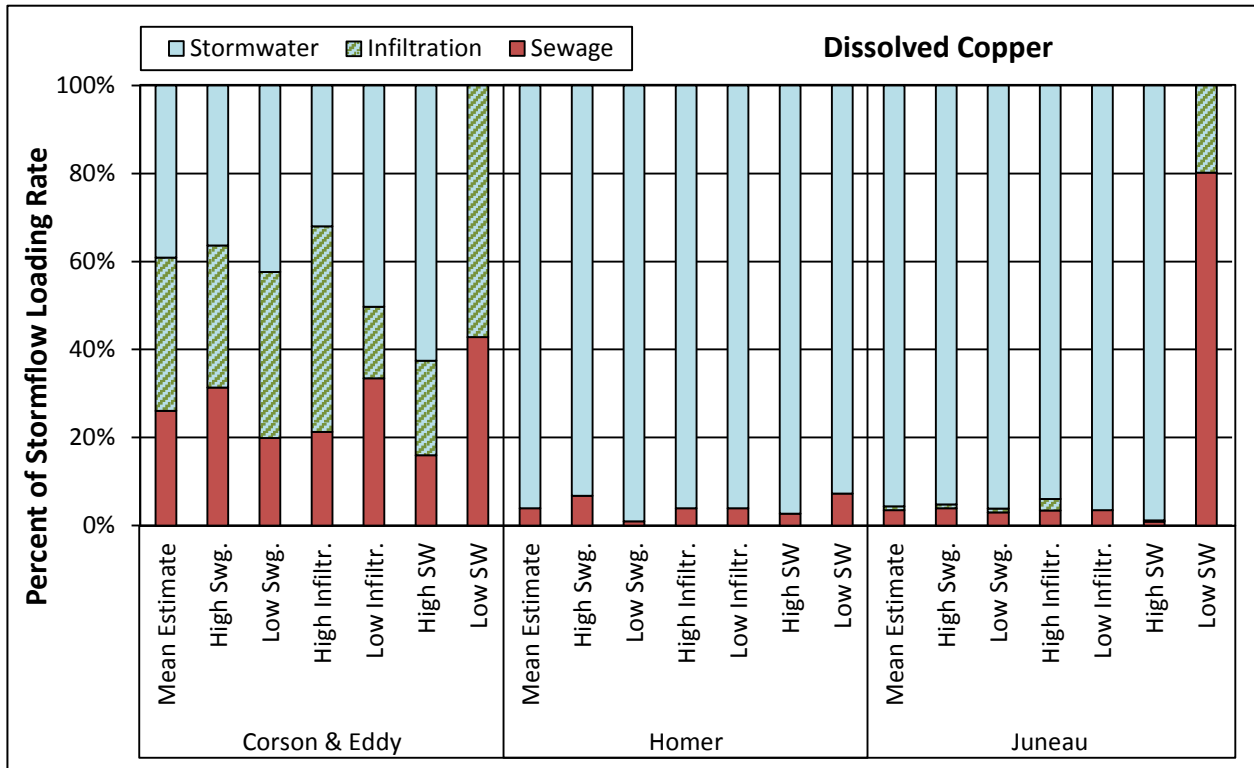


Figure I-10. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Copper Estimated Under Different Scenarios.

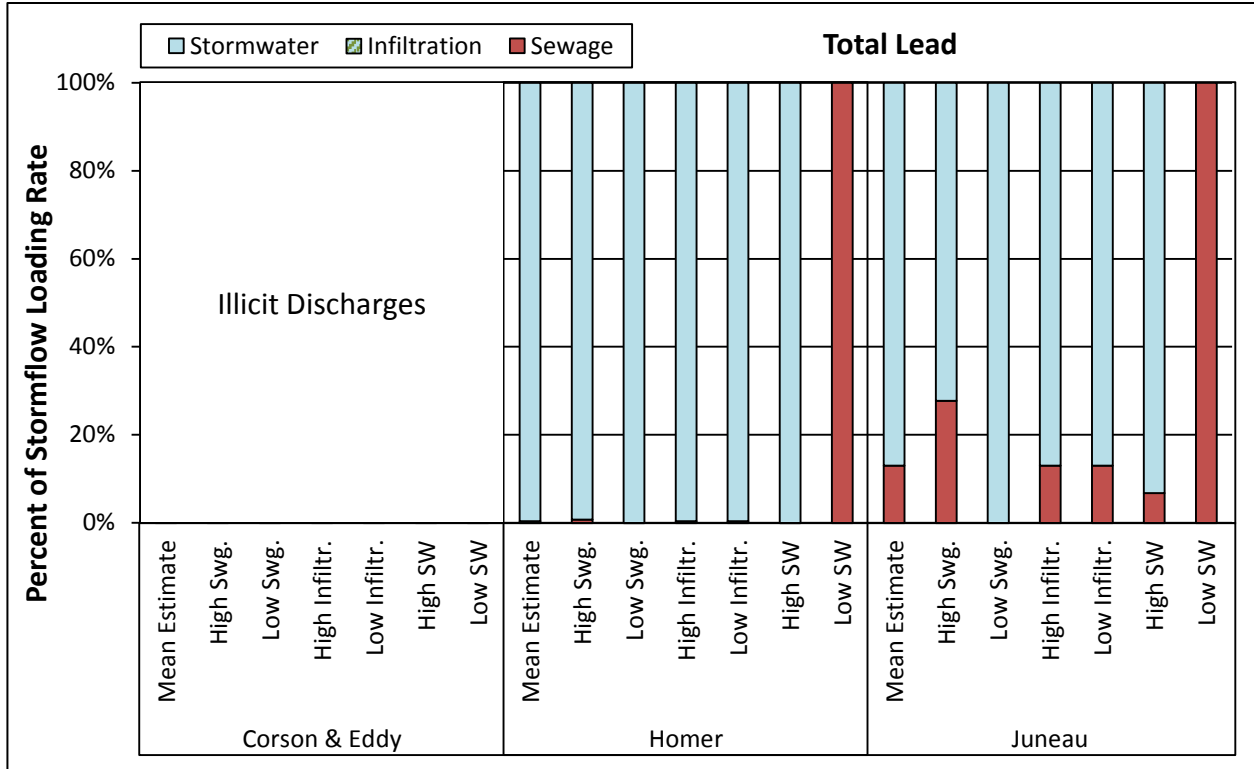


Figure I-11. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Lead Estimated Under Different Scenarios.

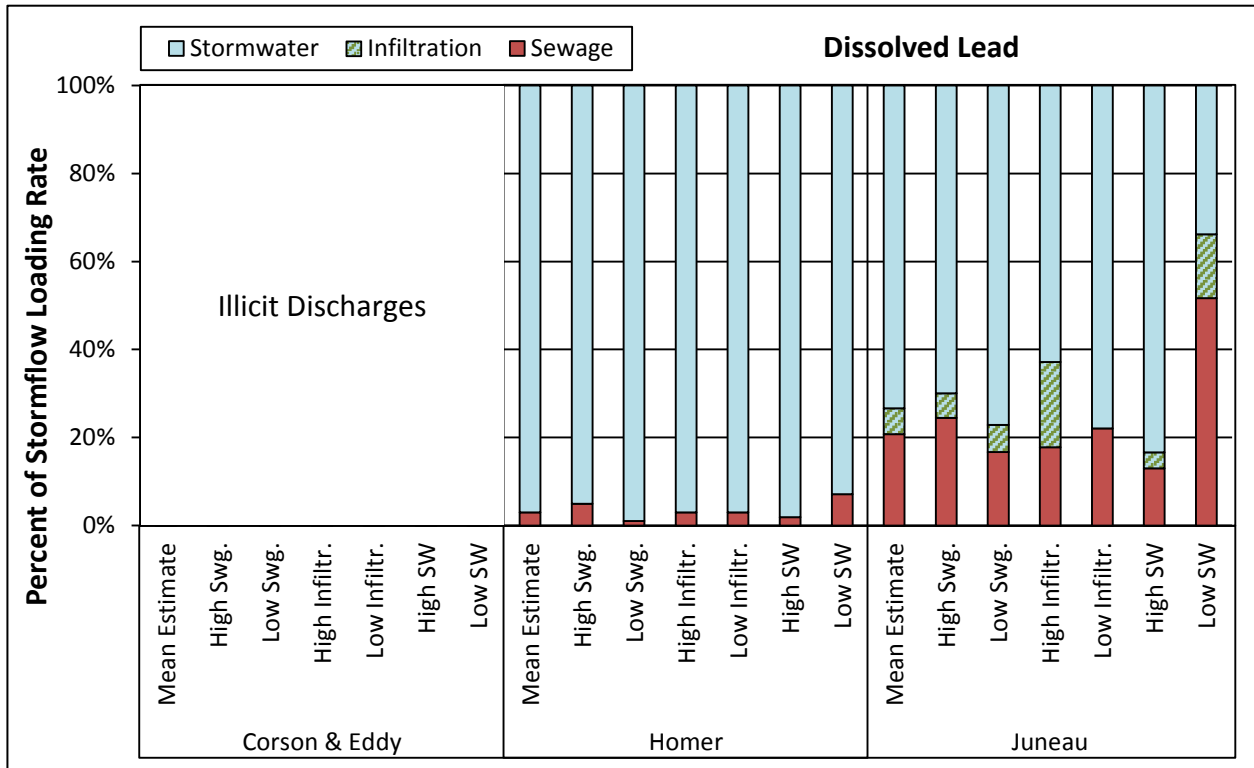


Figure I-12. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Lead Estimated Under Different Scenarios.



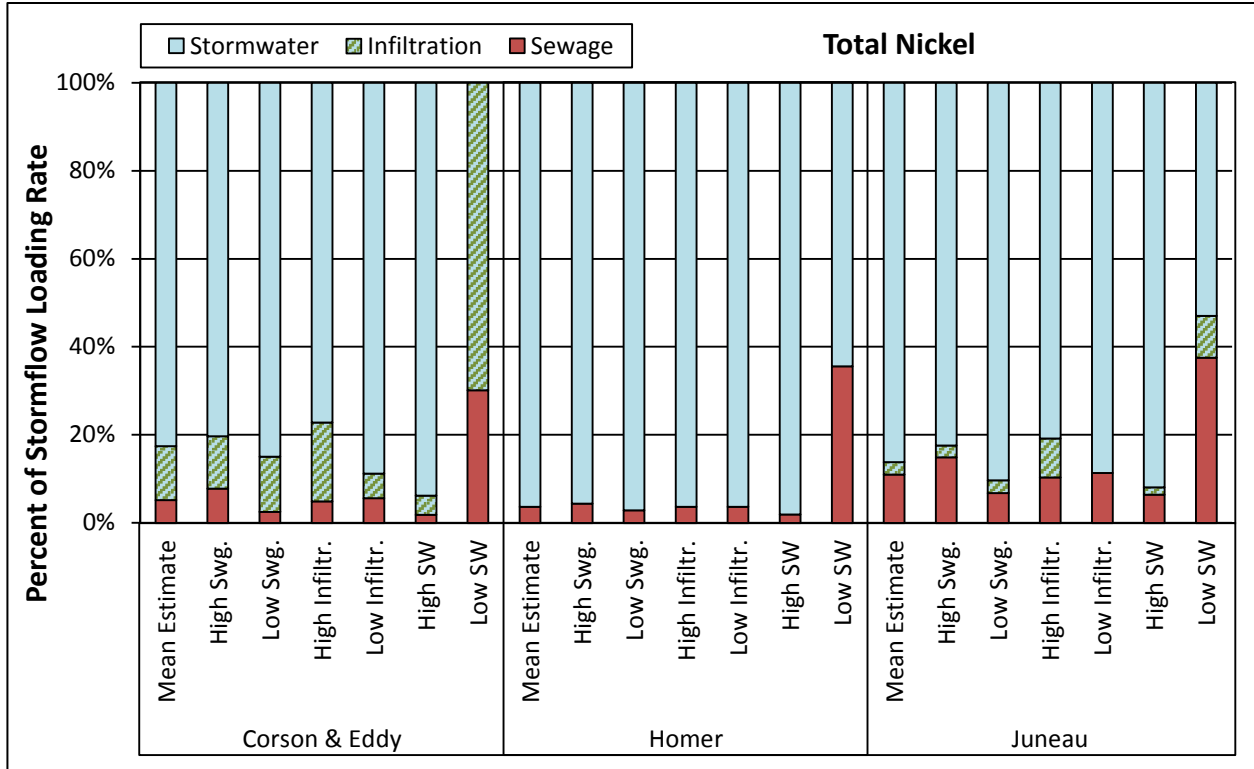


Figure I-13. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Nickel Estimated Under Different Scenarios.

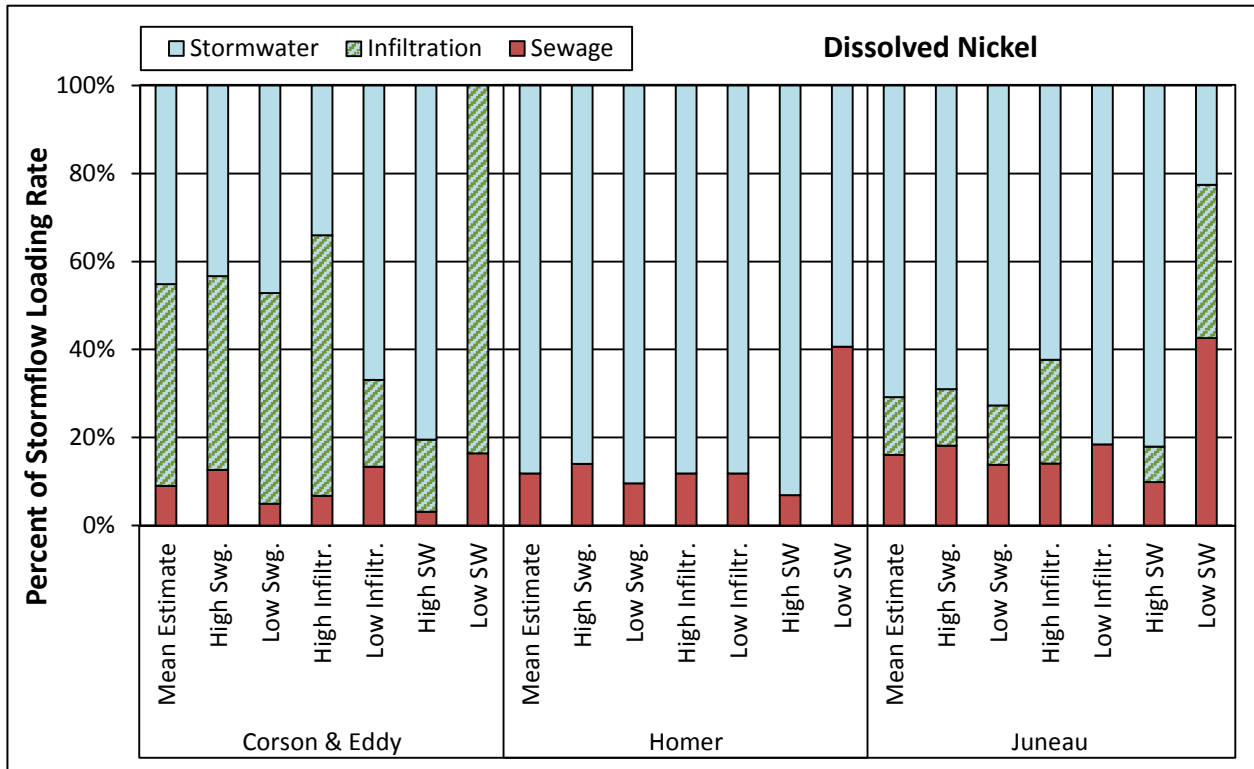


Figure I-14. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Nickel Estimated Under Different Scenarios.

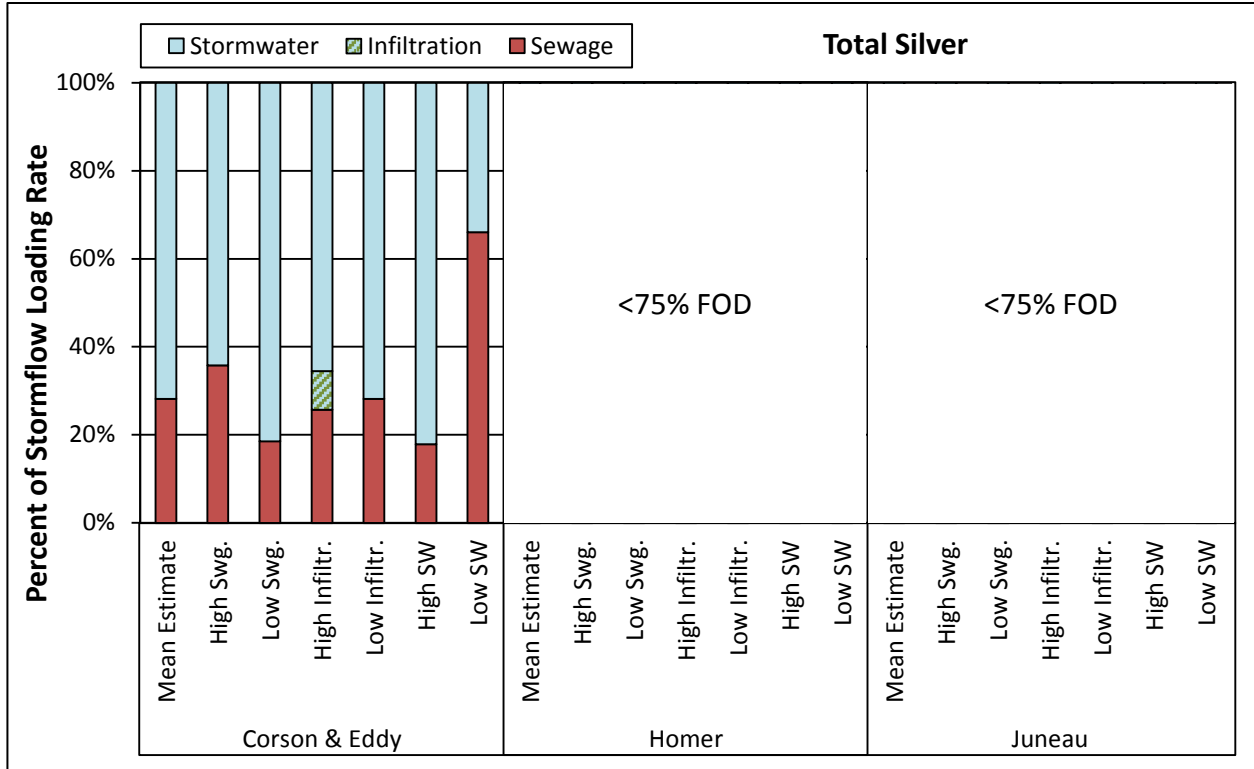


Figure I-15. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Silver Estimated Under Different Scenarios.

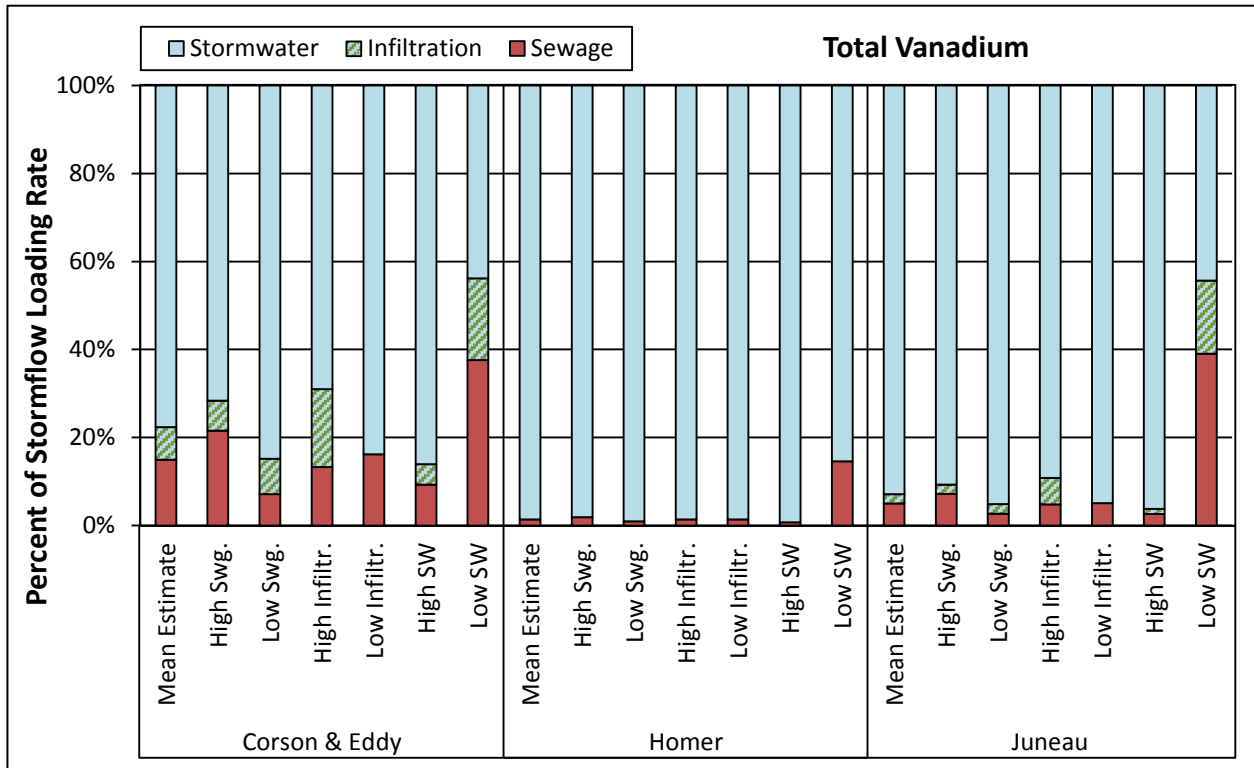


Figure I-16. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Vanadium Estimated Under Different Scenarios.

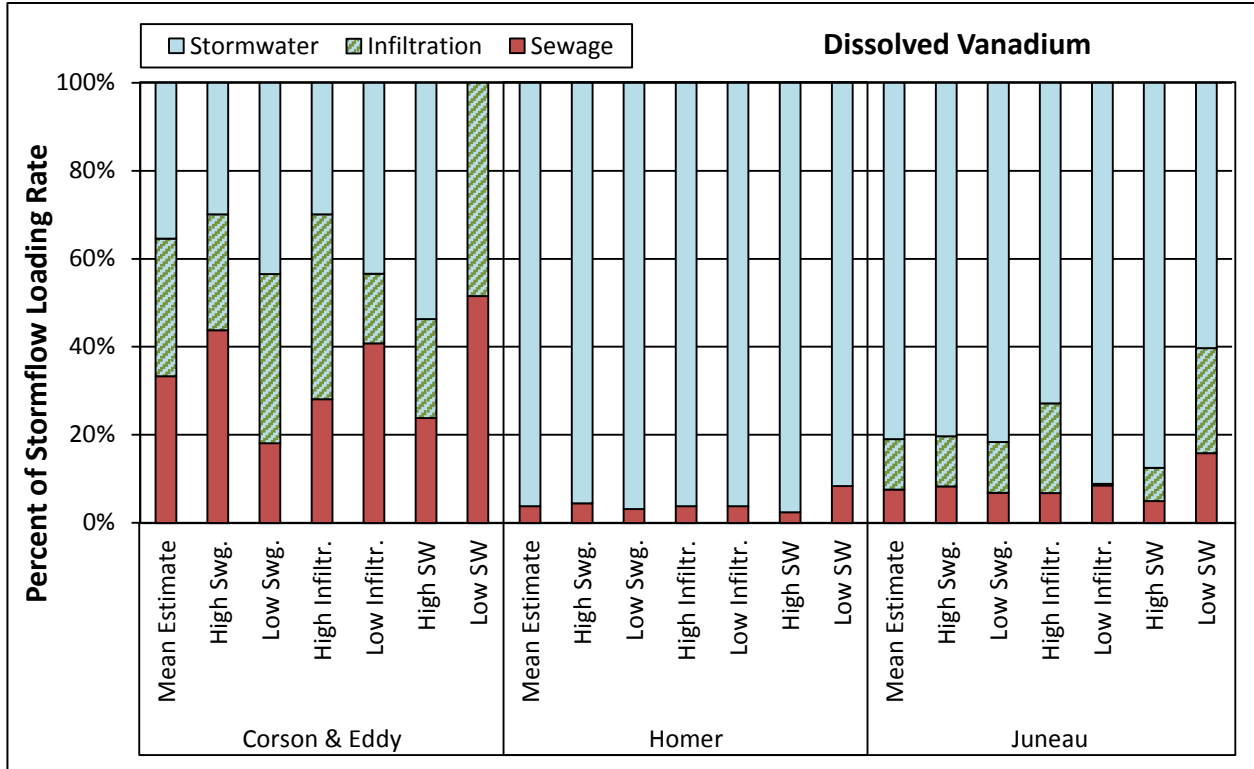


Figure I-17. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Vanadium Estimated Under Different Scenarios.

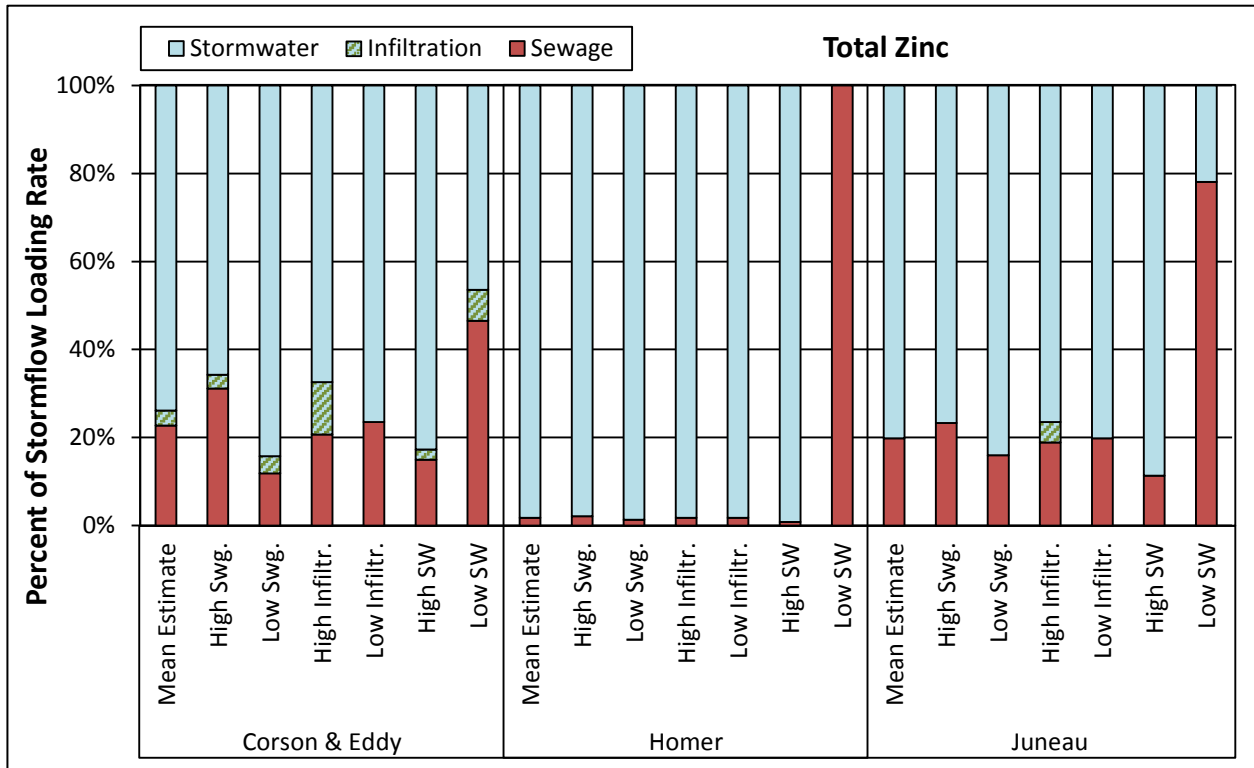


Figure I-18. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Zinc Estimated Under Different Scenarios.

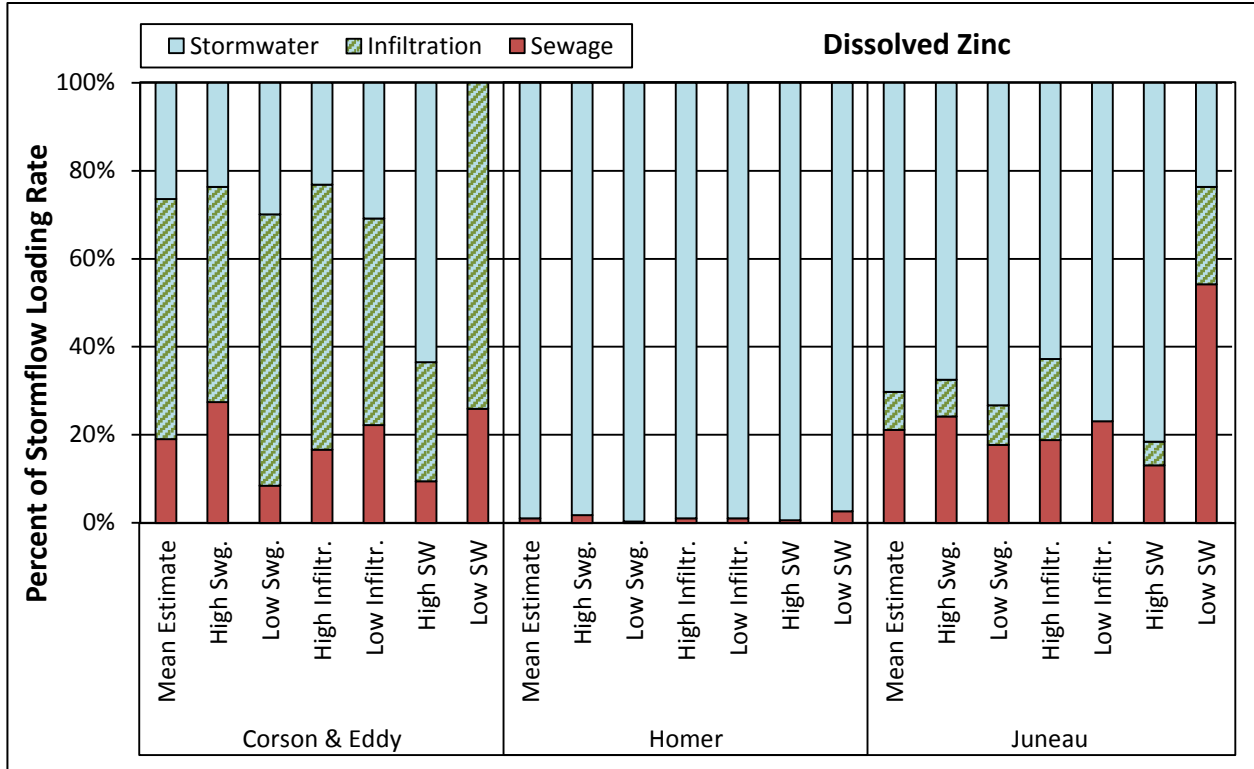


Figure I-19. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Dissolved Zinc Estimated Under Different Scenarios.

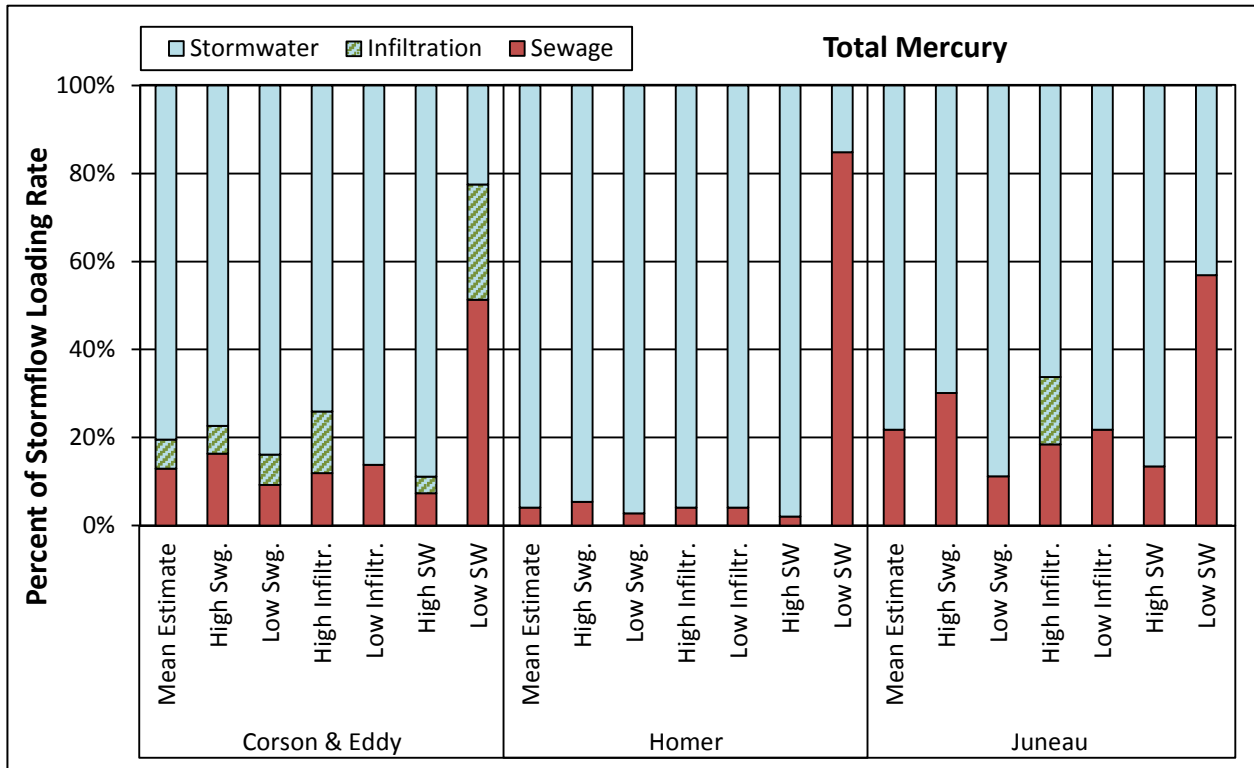


Figure I-20. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Mercury Estimated Under Different Scenarios.

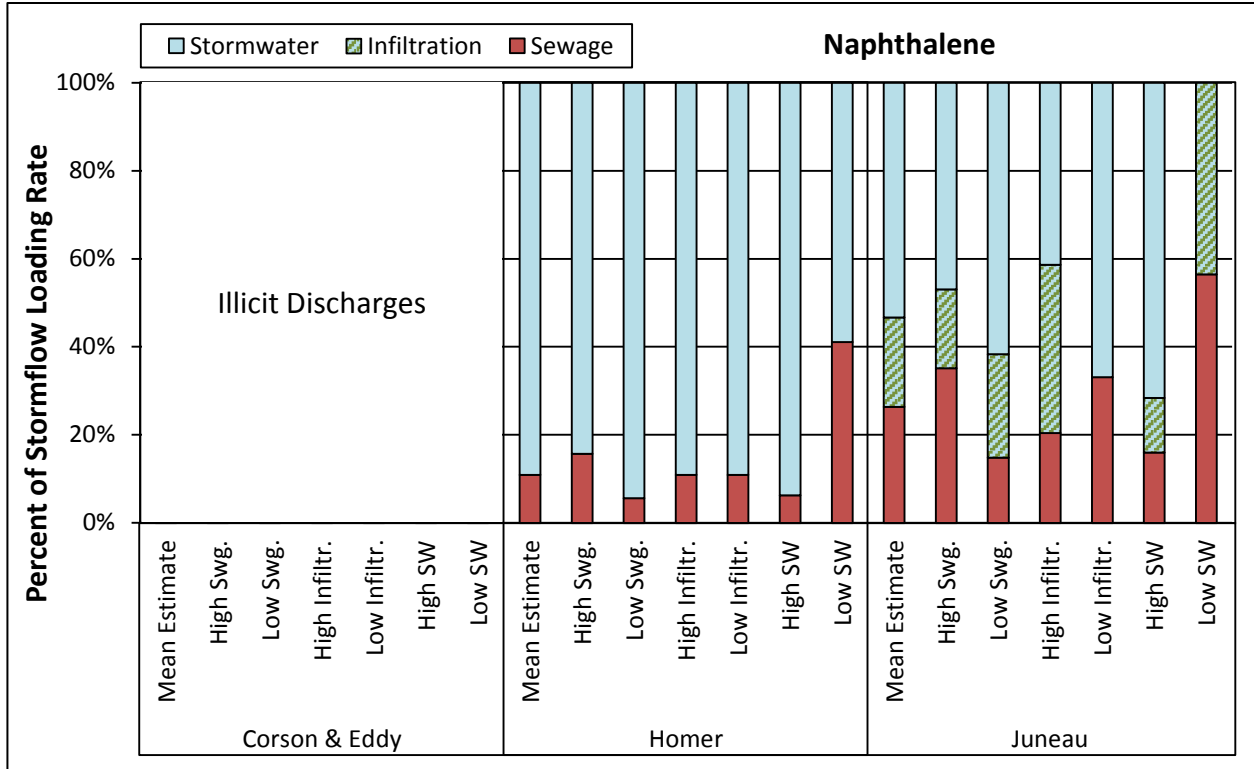


Figure I-21. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Naphthalene Estimated Under Different Scenarios.

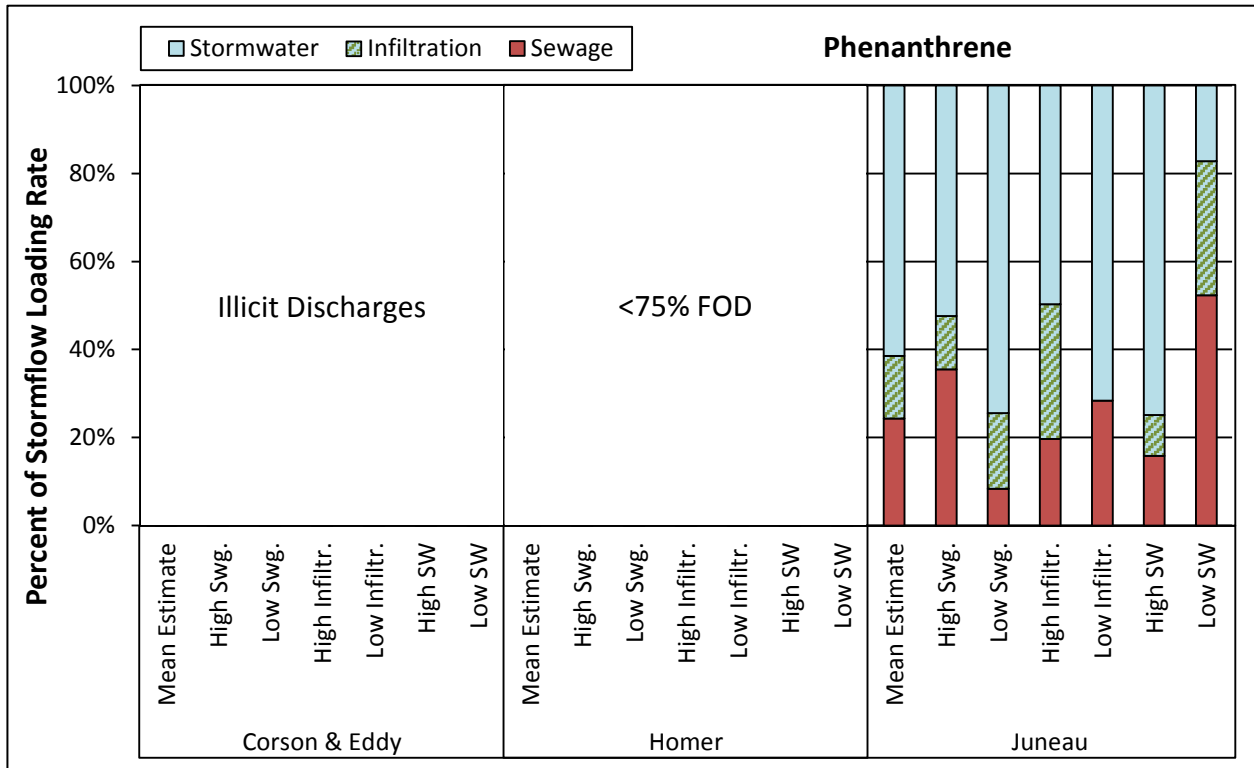


Figure I-22. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Phenanthrene Estimated Under Different Scenarios.

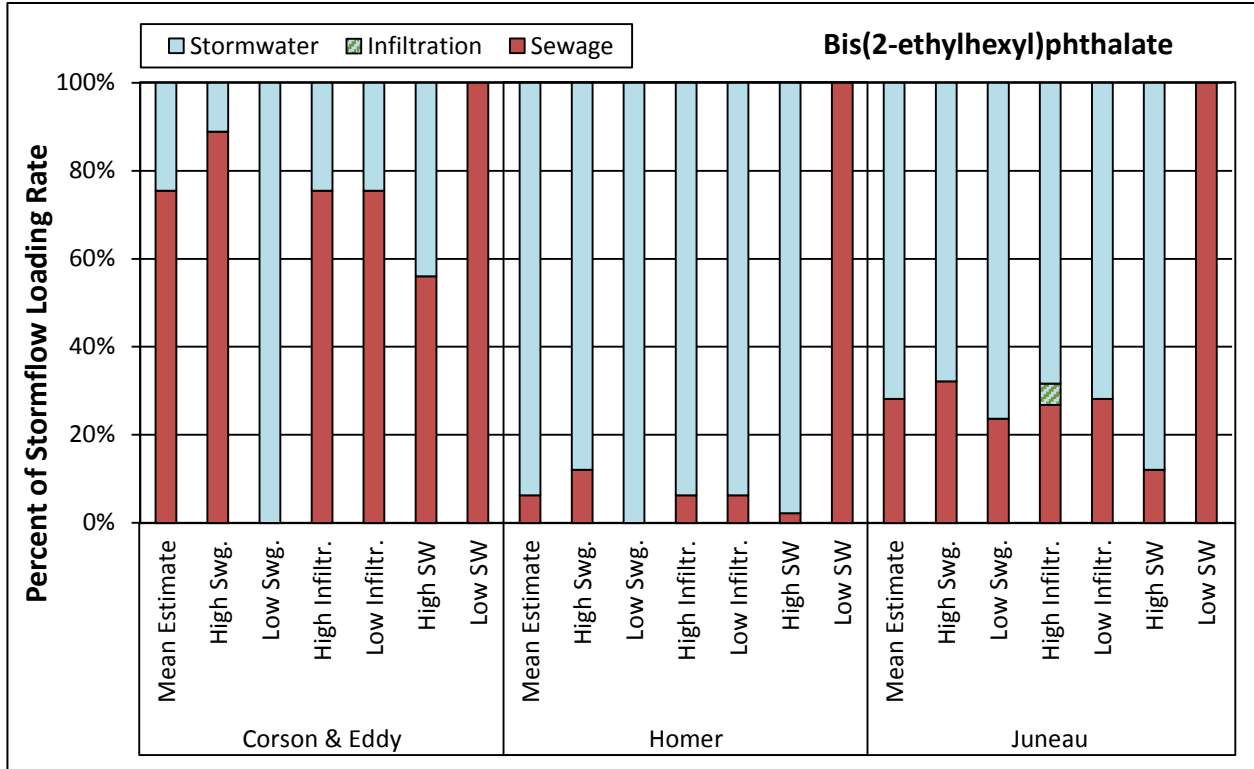


Figure I-23. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Bis(2-ethylhexyl)phthalate Estimated Under Different Scenarios.

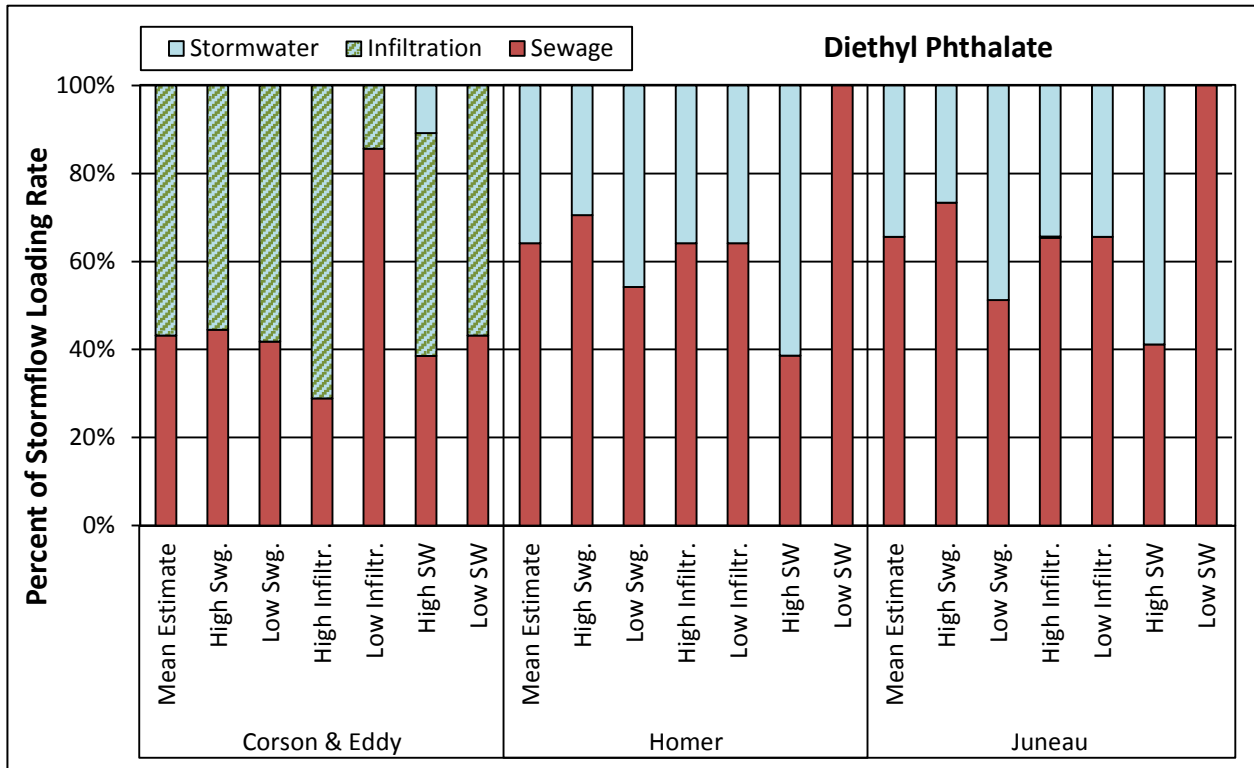


Figure I-24. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Diethyl Phthalate Estimated Under Different Scenarios.

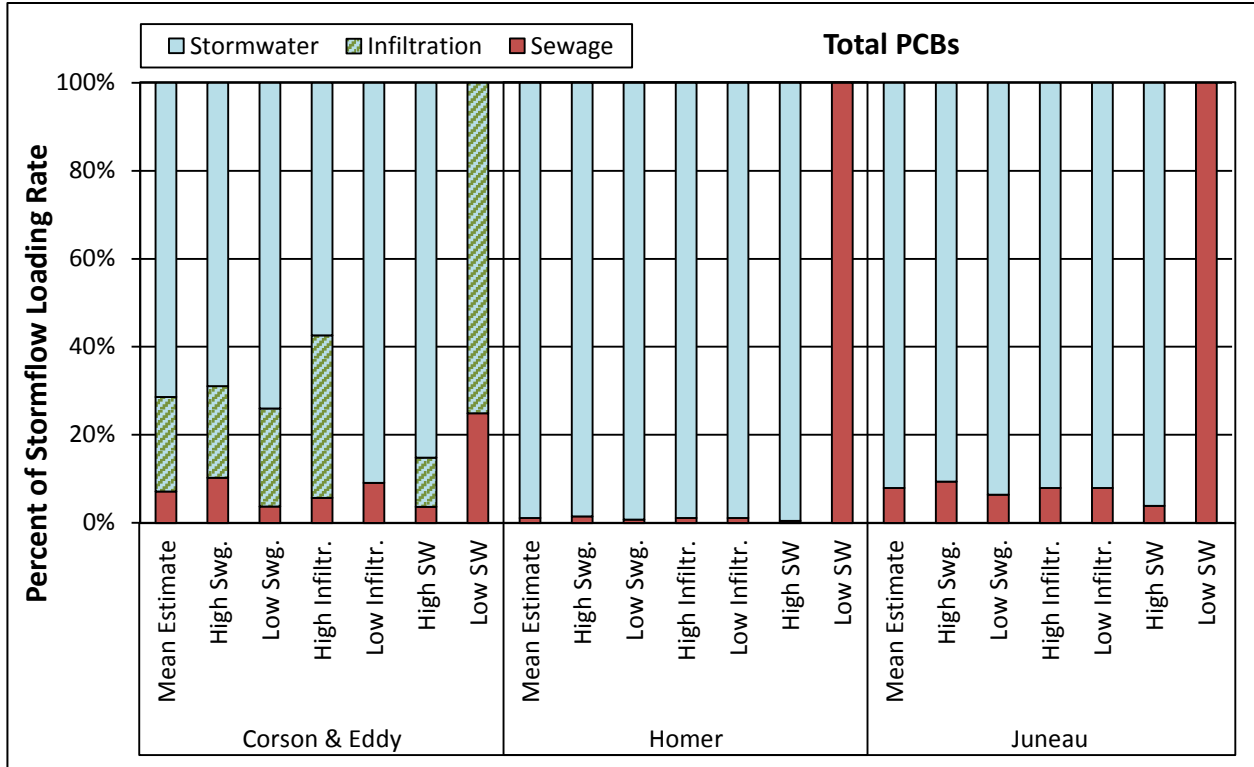


Figure I-25. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total PCBs Estimated Under Different Scenarios.

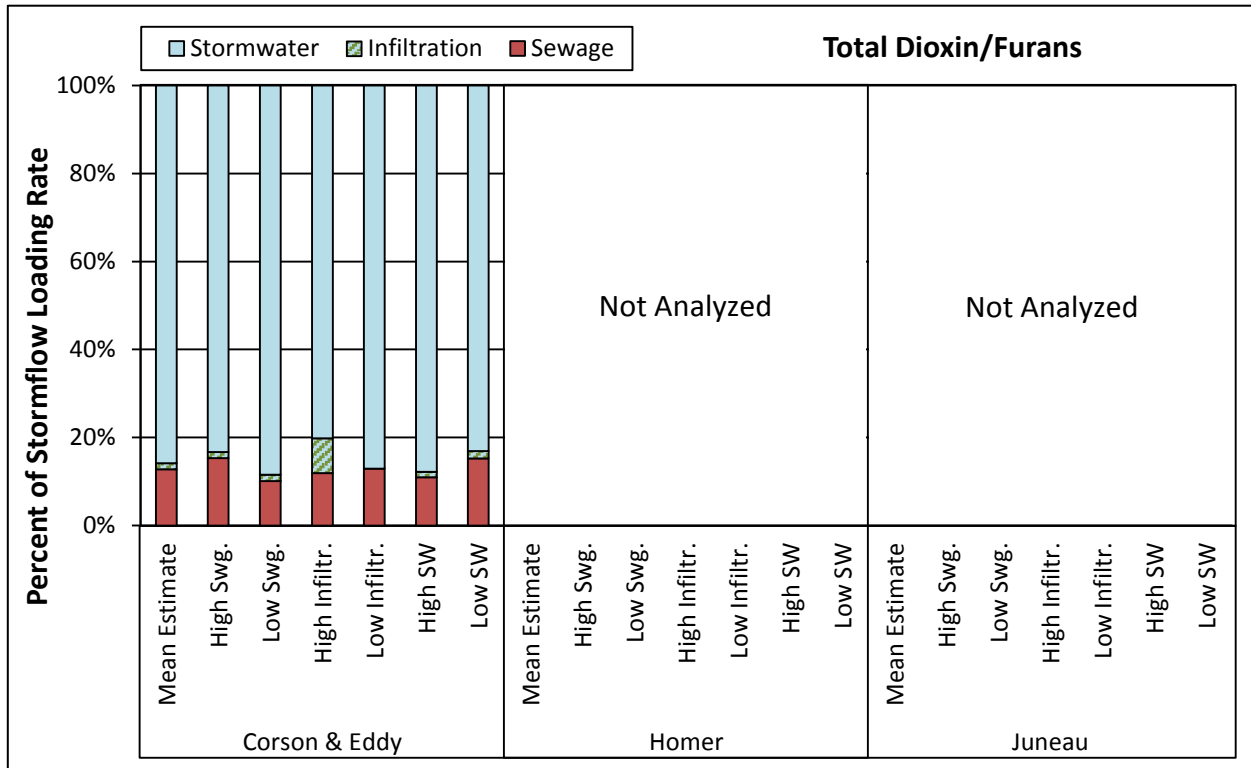


Figure I-26. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Dioxin/Furans Estimated Under Different Scenarios.

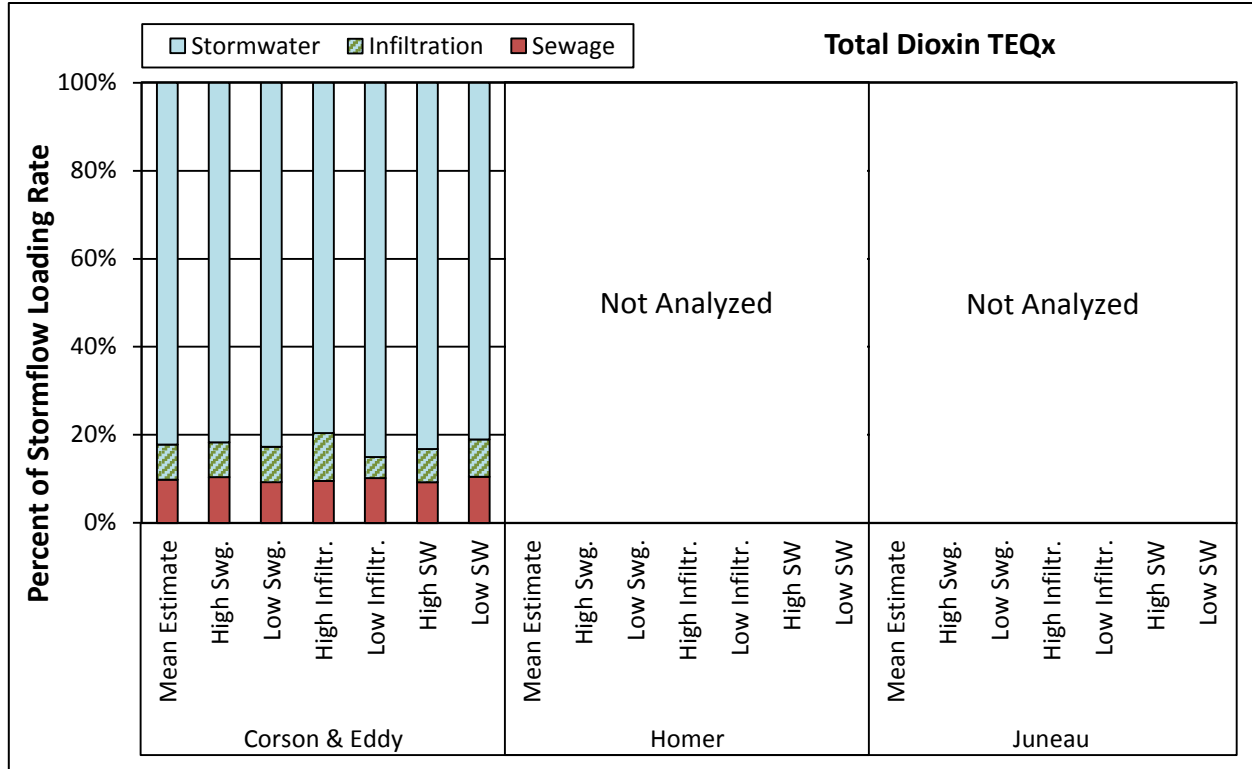


Figure I-27. Uncertainty Assessment: Relative Magnitude of Pathways During Stormflow for Total Dioxin TEQs Estimated Under Different Scenarios.