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The National Stormwater Quality Database, Version 3.1

The characteristics of stormwater discharges vary considerably. Geographical area and land use have been identified as important factors affecting base flow and stormwater runoff quality, for example. Many studies have investigated stormwater quality, with the EPA's Nationwide Urban Runoff Program (NURP) being the best known and earliest effort to collect and summarize these data. Unfortunately, NURP was limited in that it did not represent all areas of the US or all important land uses. More recently, the National Stormwater Quality Database (NSQD) compiled runoff characteristics information from more than 8,000 events from throughout the US. Most of these data were from the EPA's NPDES stormwater permit program for Phase 1 communities. These permits are needed for all large municipal areas having >250,000 in population. The Phase II permit program requires permits from small communities.

As a condition for these permits, municipalities were required to establish a monitoring program to characterize their local stormwater quality for their most important land uses discharging to the municipal separate storm sewer system (MS4). Although only a few samples from a few locations are required each year from these communities, the ten plus years of MS4 data included in the NSQD comprise a suitable number of samples from many locations. Recently, version 3 of the NSQD was completed, and besides expanding to include additional stormwater NPDES MS4 permit holders, most of the older NURP data, and some of the International BMP database information was also added, along with data from some USGS research projects. A number of land uses are represented in these data, with most data from residential, commercial, and industrial areas, and less data from freeways, institutional and open space areas. These observations were all obtained at outfall locations and do not include snowmelt or construction erosion sources. This version contains the results from about one fourth of the total number of communities that participated in the Phase I NPDES stormwater permit monitoring activities. The database is located at: http://unix.eng.ua.edu/~rpitt/Research/ms4/mainms4.shtml.

Figure 1 is a map showing the EPA Rain Zones in the US (not to be confused with EPA administrative regions), along with the locations of the communities containing data in the NSQD, ver 3. Recent revisions to the database have included additional quality control evaluations. In the near future, additional supplemental data from under-represented regions (especially southern California) will also be added to the database.

Tables 1 through 7 summarize the data observations for selected stormwater characteristics (volumetric runoff coefficient, TSS, TKN, TP, Cu, Zn, and fecal coliforms). These data are separated by the six land used represented and geographical area (shown by EPA Rain Zones). Rain Zones 8 and 9 have very few samples, and institutional and open space areas are poorly represented. However, residential, commercial, industrial, and freeway data are plentiful, except for the few EPA Rain Zones noted above. The yellow high-lighted cells indicate rain zone-land use combinations having at least 40 events represented, a value expected to result in more reliable concentration estimates than for conditions having very few data.

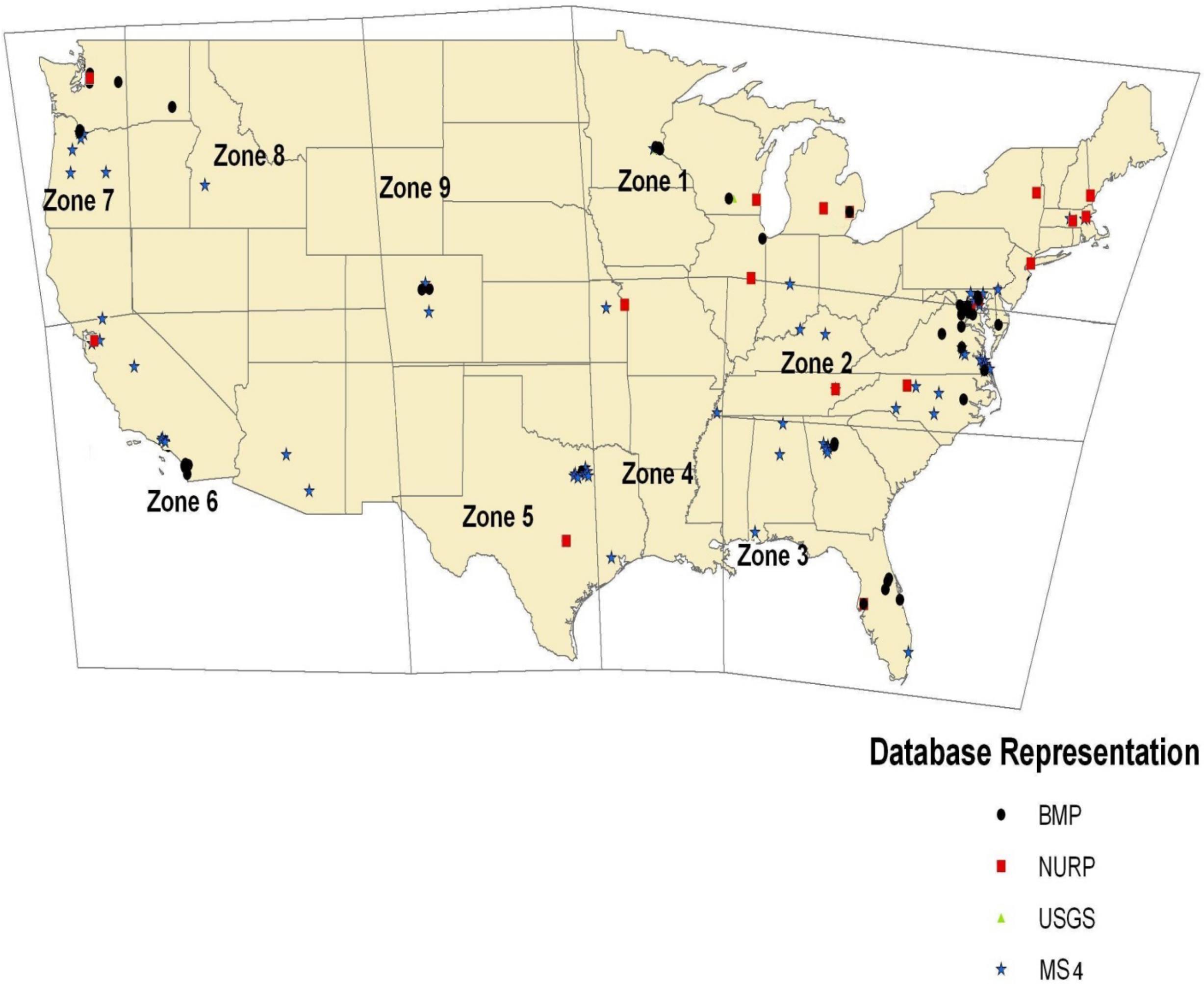

Figure 1. Sampling Locations for Data Contained in the National Stormwater Quality Database, version 3.1.

The data shown on Tables 1 through 7 are for comparison to the modeled conditions representing the standard land use files. The values on these tables are the averages, the coefficient of variation, and the number of observations. Besides each land use and rain zone combination, overall land use and overall rain zone values are also shown along with the overall database values. The average values are shown instead of the median, as the averages better represent long-term mass discharges. Median values artificially reduce the effects of the periodic unusually high concentrations that do occur in stormwater.

Figure 2 is a plot showing the calculated ratios of the average concentrations to the median concentrations for all of the cells represented in the data set summarized in the tables. The average values are all larger than the median values, so the ratios range from about 1 up to about 10. This plot shows how this ratio generally increases as the coefficient of variation (COV) values increase. The coefficient of variation is the ratio of the standard deviation to the average value (another reason why the average values are shown on these tables).

Stormwater concentrations usually have a log-normal distribution, resulting in a positive bias, resulting in the average values being larger than the median values. The greater the difference, the greater the positive bias (and the larger the COV). If the COV is less than about 0.5, there is little difference between the median and the average values. However, most of the stormwater concentration COV values are in the range of 0.5 to 1.5, as indicated on Figure 2, with some much larger. The bacteria observations have the largest variations in each sample subgroup, while the Rv and TKN have the smallest variations.

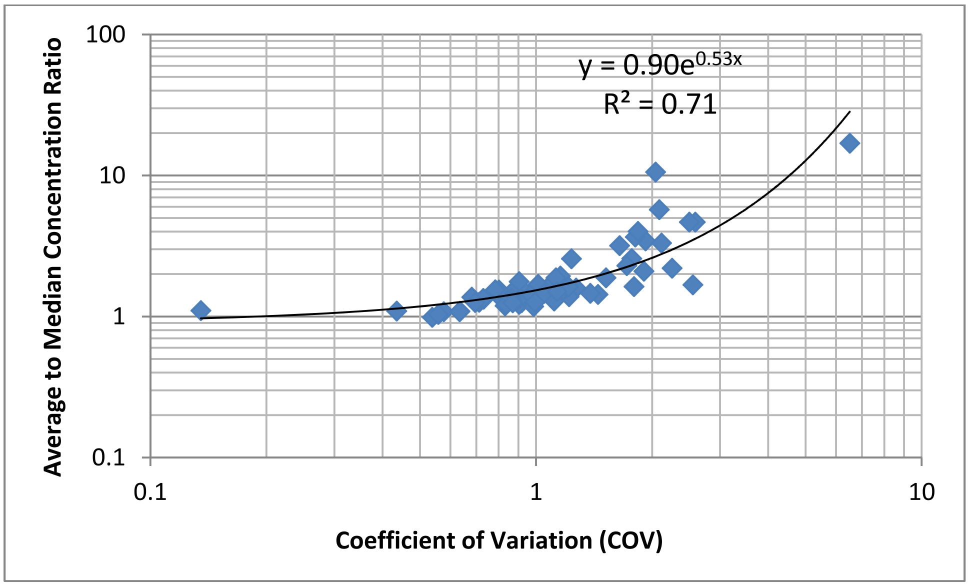

Figure 2. Relationship between the average to median concentration ratios and the COV values.

In most cases, the COV values are slightly smaller for the subgroups compared to the overall group values, indicating that the land use and geographical combinations help explain some of the large variability commonly found with stormwater concentrations. Detailed analyses have been conducted using the complete database to statistically identify significant subgroupings. In most cases, the complete matrix of 54 combinations is reduced by missing data and by combining similar conditions, resulting in many fewer significant subgroups. The following tables do not reflect these statistical groupings, as these data are being used to verify the modeling calculations for specific locations. Actual data for the areas closest in character to the standard land use file locations are desired for these comparisons; therefore, the data in high-lighted cells are compared to the calculated values. If a cell is not high-lighted, then the land use high-lighted value is used. If that is not high-lighted, then the overall value is compared.

Table 1. Volumetric Runoff Coefficients, Rv, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	n/a	0.59 (0.5) 66	0.59 (0.9) 64	0.32 (0.7) 14	0.68 (0.5) 114	0.65 (0.4) 34	n/a	0.48 (0.1) 2	0.59 (0.5) 16	0.62 (0.6) 310	100%
Freeways	n/a	0.31 (0.3) 37	n/a	n/a	0.46 (0.3) 20	0.67 (0.6) 158	n/a	n/a	n/a	0.58 (0.7) 215	100%
Industrial	0.28 (0.6) 9	0.43 (1.0) 54	0.34 (0.7) 50	0.36 (0.2) 7	0.72 (0.2) 110	0.34 (0.9) 69	n/a	n/a	0.30 (0.8) 23	0.48 (0.7) 322	100%
Institutional	n/a	0.04 (1.8) 14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.04 (1.8) 14	100%
Open Space	n/a	0.15 (0.6) 16	n/a	0.16 (1.1) 9	0.33 (0.8) 69	0.06 (0.5) 2	n/a	n/a	0.30 (0.6) 7	0.29 (0.9) 103	100%
Residential	0.30 (2.4) 88	0.28 (1.7) 403	0.18 (1.2) 209	0.34 (0.6) 30	0.33 (0.7) 184	0.20 (0.7) 51	0.23 (1.2) 30	0.55 (1.0) 5	0.24 (1.0) 54	0.27 (1.5) 1054	100%
all land uses	0.30 (2.3) 97	0.32 (1.4) 705	0.28 (1.2) 322	0.31 (0.6) 60	0.50 (0.6) 497	0.51 (0.8) 314	0.28 (1.4) 37	0.50 (1.3) 8	0.31 (0.9) 100	0.39 (1.1) 2115	100%
% detect	100%	100%	100%	100%	100%	100%	100%	100%	100%		

Table 2. TSS Concentrations, mg/L, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	201 (1.5) 310	101 (1.7) 669	56 (2.0) 55	232 (1.9) 67	108 (1.6) 100	132 (1.0) 41	87 (0.9) 61	98 (0.8) 7	247 (1.2) 32	133 (1.7) 1342	98%
Freeways	24 (0.3) 3	80 (1.6) 225	36 (1.4) 13	n/a	144 (1.1) 12	183 (2.8) 105	n/a	n/a	n/a	114 (2.5) 381	100%
Industrial	177 (1.4) 100	97 (1.6) 375	105 (1.2) 105	164 (1.4) 68	155 (1.7) 106	385 (1.2) 95	164 (1.2) 30	n/a	360 (0.9) 39	160 (1.6) 918	97%
Institutional	91 (0.7) 8	86 (1.0) 46	68 (1.4) 15	n/a	n/a	n/a	n/a	n/a	n/a	83 (1.0) 69	99%
Open Space	176 (2.4) 128	98 (1.5) 107	n/a	370 (0.8) 18	202 (1.6) 67	330 (n/a) 1	n/a	n/a	846 (0.4) 7	182 (1.9) 329	98%
Residential	135 (1.2) 507	102 (1.7) 1893	102 (1.6) 207	374 (1.8) 140	129 (0.9) 203	162 (1.0) 75	130 (1.8) 315	140 (0.9) 16	528 (2.5) 116	137 (2.4) 3472	99%
all land uses	156 (1.6) 1132	97 (1.7) 3468	93 (1.6) 395	293 (1.8) 293	141 (1.5) 488	235 (1.7) 318	126 (1.7) 443	140 (1.0) 24	460 (2.3) 194	135 (2.2) 6682	99%
% detect	99%	99%	98%	99%	99%	90%	100%	100%	99%		

Table 3. Total Phosphorus Concentrations, mg/L, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	0.25 (2.2) 311	0.37 (1.3) 641	0.39 (1.1) 141	0.38 (1.6) 50	0.64 (3.0) 112	0.57 (0.7) 37	0.35 (1.3) 84	0.57 (0.6) 7	0.34 (0.7) 16	0.37 (2.0) 1399	96%
Freeways	0.43 (0.5) 3	0.95 (1.3) 186	0.16 (0.7) 14	n/a	0.22 (0.7) 245	0.49 (1.6) 135	0.35 (0.6) 24	n/a	n/a	0.50 (1.7) 604	99%
Industrial	0.33 (0.8) 100	0.36 (1.6) 370	0.20 (0.9) 108	0.36 (1.2) 49	0.25 (1.2) 108	1.3 (0.9) 63	0.33 (0.9) 76	n/a	0.46 (0.7) 23	0.39 (1.5) 897	95%
Institutional	0.21 (0.4) 8	0.24 (0.8) 45	0.19 (0.5) 15	n/a	n/a	n/a	n/a	n/a	n/a	0.23 (0.17) 68	99%
Open Space	0.18 (1.7) 139	0.33 (1.1) 106	n/a	0.31 (0.6) 17	0.40 (1.0) 67	0.65 (0.3) 2	n/a	n/a	0.60 (0.5) 7	0.29 (1.2) 338	96%
Residential	0.40 (1.1) 565	0.43 (1.7) 1956	0.20 (1.4) 410	0.70 (1.2) 91	0.47 (0.9) 206	0.54 (1.1) 70	0.30 (1.2) 331	0.85 (0.7) 15	0.81 (1.1) 75	0.71 (1.5) 3719	98%
all land uses	0.32 (0.4) 1203	0.42 (1.7) 3572	0.24 (1.3) 688	0.51 (1.3) 207	0.38 (2.2) 738	0.68 (1.3) 307	0.31 (1.1) 539	0.74 (0.8) 23	0.67 (1.1) 121	0.40 (1.7) 7295	97%
% detect	97%	97%	95%	98%	99%	97%	99%	100%	100%		

Table 4. Total Kjeldahl Nitrogen Concentrations, mg/L, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	1.5 (1.1) 185	2.0 (0.9) 625	1.2 (0.7) 41	1.8 (0.9) 47	1.1 (0.6) 112	4.3 (0.7) 39	1.6 (1.0) 61	3.7 (0.7) 5	2.6 (0.6) 16	1.9 (0.9) 1131	97%
Freeways	3.6 (0.3) 3	2.4 (1.1) 100	n/a	n/a	2.0 (0.9) 204	3.3 (1.4) 122	1.7 (0.6) 24	n/a	n/a	2.4 (1.2) 450	99%
Industrial	1.9 (0.9) 100	1.8 (1.5) 338	1.5 (0.8) 99	1.6 (0.6) 46	1.2 (0.9) 109	4.2 (0.8) 76	1.9 (0.6) 33	n/a	2.5 (0.6) 23	1.9 (1.2) 824	96%
Institutional	0.79 (0.6) 7	1.6 (0.8) 46	1.4 (0.5) 15	n/a	n/a	n/a	n/a	n/a	n/a	1.5 (0.8) 68	97%
Open Space	0.79 (0.7) 100	1.2 (0.8) 77	n/a	1.9 (0.7) 18	1.7 (0.9) 67	1.8 (0.2) 2	n/a	n/a	3.3 (0.6) 7	1.3 (1.0) 271	91%
Residential	1.9 (0.9) 434	1.8 (1.1) 1783	1.0 (0.9) 335	2.3 (1.5) 74	2.1 (0.9) 183	3.2 (2.7) 74	1.1 (0.9) 318	5.7 (0.8) 15	3.8 (0.7) 64	1.8 (1.1) 3280	98%
all land uses	1.6 (0.9) 834	1.9 (1.1) 3067	1.2 (0.9) 490	2.0 (0.7) 185	1.7 (0.9) 675	3.6 (1.0) 313	1.3 (0.9) 460	5.0 (0.8) 21	3.3 (0.7) 110	1.9 (1.1) 6095	97%
% detect	100%	97%	93%	97%	96%	99%	98%	100%	100%		

Table 5. Total Copper Concentrations, µg/L, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	58 (0.8) 141	33 (1.2) 502	7.4 (1.4) 106	69 (1.2) 47	61 (3.5) 109	21 (1.1) 40	29 (1.1) 84	42 (1.2) 7	46 (1.6) 32	37 (2.3) 1068	88%
Freeways	54 (0.1) 3	28 (2.0) 103	1.1 (0.5) 13	n/a	7.4 (1.7) 117	62 (1.4) 101	32 (0.8) 26	n/a	n/a	30 (2.0) 360	98%
Industrial	25 (1.5) 83	22 (1.3) 257	18 (1.0) 106	99 (2.3) 49	17 (0.7) 107	78 (0.9) 93	42 (0.8) 34	n/a	46 (1.0) 39	36 (2.0) 768	86%
Institutional	33 (0.4) 7	25 (0.7) 45	7.3 (0.6) 15	n/a	n/a	n/a	n/a	n/a	n/a	21 (0.8) 67	85%
Open Space	9 (0.1) 6	9 (0.8) 58	n/a	20 (0.8) 12	12 (0.9) 70	119 (1.1) 2	n/a	n/a	28 (0.7) 7	14 (1.5) 155	84%
Residential	34 (1.8) 333	30 (1.6) 1340	10 (2.6) 396	52 (1.8) 111	16 (1.8) 164	36 (1.4) 66	13 (0.7) 24	22 (0.4) 15	28 (0.9) 103	27 (1.8) 2613	88%
all land uses	33 (1.6) 644	29 (1.5) 2339	10 (2.1) 636	65 (2.1) 219	23 (4.3) 567	56 (1.4) 302	26 (1.1) 253	28 (1.0) 23	35 (1.2) 181	30 (2.1) 5087	88%
% detect	78%	89%	79%	89%	98%	99%	93%	90%	83%		

Table 6. Total Zinc Concentrations, µg/L, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	196 (1.4) 225	237 (1.2) 513	60 (1.4) 136	270 (0.9) 51	116 (0.8) 111	343 (2.0) 42	138 (1.0) 84	434 (1.1) 7	217 (0.7) 32	197 (1.4) 1201	99%
Freeways	368 (0.1) 3	185 (1.3) 203	7.5 (0.9) 14	n/a	89 (1.2) 267	304 (1.1) 99	211 (0.8) 25	n/a	n/a	159 (1.4) 608	99%
Industrial	106 (1.2) 84	172 (0.9) 326	166 (1.3) 107	512 (2.9) 54	169 (1.1) 107	1720 (2.0) 100	306 (2.9) 81	n/a	486 (0.9) 39	382 (3.5) 898	99%
Institutional	169 (0.2) 7	254 (0.9) 46	90 (0.5) 15	n/a	n/a	n/a	n/a	n/a	n/a	210 (1.0) 68	100%
Open Space	53 (0.8) 10	93 (0.8) 109	n/a	98 (1.0) 17	100 (1.3) 69	225 (1.0) 2	n/a	n/a	439 (0.4) 7	109 (1.1) 214	91%
Residential	134 (1.2) 351	125 (3.6) 1471	61 (1.2) 384	264 (2.3) 120	95 (0.9) 183	260 (1.2) 76	120 (0.8) 328	185 (0.6) 15	139 (1.0) 100	125 (2.8) 3028	97%
all land uses	138 (1.4) 752	162 (2.3) 2711	78 (1.5) 656	310 (2.7) 242	107 (1.1) 737	746 (2.8) 319	152 (2.4) 542	264 (1.1) 22	242 (1.2) 178	178 (3.3) 6036	97%
% detect	98%	97%	95%	98%	100%	97%	100%	100%	94%		

Table 7. Fecal Coliforms, count/100 mL, for Different Land Uses and Geographical Areas (EPA Rain Zones) (average, COV, number of observations)

Land Use	RZ1	RZ2	RZ3	RZ4	RZ5	RZ6	RZ7	RZ8	RZ9	all RZ	% detect
Commercial	5,160 (2.2) 43	14,200 (2.2) 154	3,220 (1.0) 6	54,500 (1.9) 44	41,000 (2.8) 103	9,500 (1.5) 7	34,000 (4.0) 57	3,500 (1.3) 4	21,600 (1.3) 11	27,400 (3.2) 429	91%
Freeways	<1 (n/a) 3	11,400 (3.3) 18	n/a	n/a	9,000 (2.0) 13	7,900 (2.1) 26	7,060 (1.8) 23	n/a	n/a	8,600 (2.5) 80	100%
Industrial	100,000 (5.7) 44	14,000 (2.5) 150	5,500 (1.8) 65	83,400 (4.2) 46	50,200 (4.9) 109	4,190 (1.0) 22	15,100 (3.5) 34	n/a	24,200 (1.8) 15	35,900 (6.6) 485	90%
Institutional	3,100 (0.4) 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3,100 (0.4) 3	100%
Open Space	14,300 (1.7) 6	11,100 (3.1) 24	n/a	17,900 (1.0) 16	39,900 (2.1) 67	2,500 (n/a) 1	n/a	n/a	480 (0.6) 2	29,100 (2.4) 116	97%
Residential	210,000 (3.3) 156	33,100 (2.7) 380	20,300 (6.5) 90	41,700 (1.0) 91	88,500 (1.8) 165	5,970 (1.7) 10	25,400 (2.8) 68	17,800 (2.1) 10	25,600 (1.0) 8	69,600 (4.4) 978	91%
all land uses	140,000 (4.2) 301	24,100 (2.9) 731	13,700 (7.2) 161	52,600 (3.4) 197	59,300 (2.8) 457	6,520 (1.9) 66	25,000 (3.6) 191	13,700 (2.3) 14	22,400 (1.5) 36	48,400 (5.0) 2102	91%
% detect	80%	88%	91%	87%	100%	97%	95%	100%	100%		

During her Ph.D. research, Bochis (2010) examined all 2-way interactions between the geographical regions and the land use categories for selected constituents in the NSQD. She found that the national data could be combined into a reasonable number of significantly different subsets having similar characteristics. These groups of data have concentrations that are more similar within the group than between the groups. These groupings of the data can be used to assist local stormwater managers in estimating likely stormwater concentrations for similar local conditions. Examining 3-way interactions, by adding seasonal data to the geographical regions and land use information, did not result in many additional category distinctions associated with seasonal effects on stormwater concentrations. Table 8 shows the combined categorical groupings of the national data, with the limited seasonal distinctions. At the national level, EPA Rain Zones 1, 3, and 5 were found to have statistically significant differences in land use categories only for total suspended solids. EPA Rain Zones 1 and 2 were found to also have statistically significant differences in land use categories only for total suspended solids. Also, EPA Rain Zones 2 and 5 were not found to have statistically significant differences in land use categories, except for total copper. In addition, EPA Rain Zones 6 and 9 were not found to have statistically significant differences in land use groups, except for metals (total zinc and total copper).

Table 8. Summary Table of Homogeneous Land Uses and Seasonal Clusters

Stormwater Constituent	All EPA Rain Zones Land Use	Mean (COV)
Total Suspended Solids	1-RE,CO,ID 4-RE,CO,ID 6-RE,CO 9-CO,ID	199 (1.9)
	2-RE 3-RE,CO,ID	76 (1.6)
	2-CO,ID 5- RE,CO,ID 7- RE,CO,ID 9-RE	78 (1.9)
Total Zinc	1-RE	59 (1.9)
	1-CO,ID 2-RE 3-RE,CO,ID 5-RE,CO,ID	92 (1.6)
	2-ID 7-RE,CO,ID 9-RE,CO,ID	163 (2.3)
	2-CO 4-RE,CO,ID 6-RE,CO	261 (1.2)
Total Copper	1-RE,ID 3-RE,CO,ID 5-RE,CO,ID 6-RE,CO	11 (2.3)
	2-RE,ID 7-RE,CO,ID	25 (1.9)
	1-CO 2-CO 9-RE,CO,ID	36 (1.2)
	4-RE,CO,ID	86 (1.9)

Total Phosphorous	1-CO 3-RE,ID 5-CO	0.17 (1.2)
	1-RE,ID 2-RE,CO,ID 3-CO 4-RE,CO,ID 5-RE,ID	0.38 (1.7)
	7-RE,CO,ID	0.3 (1.2)
	6-RE,CO 9-RE,CO,ID	0.52 (0.67)
Total Kjeldahl Nitrogen	1-RE,CO,ID 2-RE,CO,ID 3-CO,ID 4-RE,CO,ID 5-RE,CO,ID 7-(RE,CO) (FA,SU), ID	1.8 (0.99)
	3-RE 7-(RE,CO) (SP,WI)	0.97 (0.90)
	6-RE,CO 9-RE,CO,ID	3.6 (0.73)
Fecal Colifom	1-(RE,CO,ID) (FA,SP,WI) 2-(RE,CO,ID) (SP,WI) 3-(RE,CO,ID) (SP,WI) 4-ID 7-RE,CO,ID 9-(RE,CO,ID) (SP)	29120 (8.2)
	1-(RE,CO,ID) (SU) 2-(RE,CO,ID) (FA,SU) 3-(RE,CO,ID) (FA,SU) 4-RE,CO 5-RE,CO,ID 6-RE 9-(RE,CO,ID) (FA,SU)	40286 (3.0)