# Appendix 16.

Highlights of significant spatial and seasonal differences of each of the constituents considered during the combined sewer overflow study in Omaha, Nebr.

## Spatial Comparisons

Student's t-tests were used to compare groups of sample results for each water-quality constituent to determine whether or not these groups came from the same underlying population with the same mean (appendices 12, 13, and 14). If the probability ($p$) associated with the t-test result was less than 0.05, the sample groups were considered to be significantly different. Comparisons were made to determine spatial differences among all the data, all scheduled samples (if applicable), scheduled wet-weather samples (if applicable), scheduled dry-weather samples (if applicable), and storm samples. The results of t-tests are highlighted only if there were at least 50 percent detections in one of the groups, and if there was a significant difference between the groups.

### Combined Sewer Overflows

Spatial comparisons of the combined sewer overflow (CSO) water-quality results were completed by testing differences between the data for each individual site data set and the combined data from the rest of the CSO sites (appendix 12). The constituents with mean concentrations at a single CSO site that was significantly different compared to the mean concentration of all the rest of the CSO sites combined, and had more than 50 percent detection in one of the data sets in the comparison are shown in table A16–1.

For each organic compound, appendix 17 lists the CSO sites that are statistically different from the rest of the CSO sites, the site names, p-values, and geometric mean of each of the comparison data sets. The CSO site with the most organic compounds results that were statistically different from the rest of the CSO sites was site CSO119 (23 compounds), whereas site CSO105 had the least amount of statistically different compounds (3); however, the concentrations of only 4 of the 23 compounds in site CSO119 were significantly greater than the other rest of the CSO sites. The sites with the most compounds with concentrations that were significantly greater than the rest of the CSO sites were site CSO109 (21 of 21 compounds; all grab samples) and site CSO106 (18 of 19 compounds).

### Stormwater Outfalls

Comparisons were made between the two stormwater sites to determine if the results from the two sites were significantly different (table A16–2). T-tests also were completed between the data set from the SWO sites and the CSO sites (table A16–3). Those constituents that are not significantly different or were significantly less in CSO sites may indicate those compounds that are largely affected by stormwater as opposed to the influent sewage. When comparing the SWO and CSO site results for organic compounds, 35 of 69 compounds that were detected were not significantly different (appendix 12). Constituents that were significantly less in CSO sites than SWO sites, and therefore also would be derived mostly from stormwater, were antimony and bromacil (table A16–4). Thirty-six constituents were significantly greater in CSO sites than SWO sites, and therefore would be derived more from sewage (table A16–4).

## Papillion Creek Basin Surface Water

### Sampling Type Comparisons

Comparisons between types of samples can give clues as to the sources and persistence of constituents in the environment. Student's t-test comparison have been completed on the data set comparing dry-weather scheduled samples, wet-weather scheduled samples, and storm samples collected from sites in the Papillion Creek watershed (appendix 13).

Comparisons that were significantly different when comparing dry-weather scheduled stream samples to wet-weather scheduled stream samples are shown in table A16–5. Of the metals that were significantly different, only selenium and uranium were greater in dry-weather conditions compared to wet-weather conditions. Selenium and uranium have been shown to occur in ground water in this part of the country (Verstraeten and Ellis, 1995). Constituents that were derived more from CSO sites based upon t-test comparisons that were significantly greater in wet weather samples compared to dry weather samples were ammonia, total phosphorus, copper, silver, caffeine, *p*-cresol, and *E. coli*.

All constituents analyzed during the study were significantly different when comparing scheduled dry-weather samples to storm samples in the Papillion Creek Basin are shown in table A16–6.

All of the comparisons between wet-weather scheduled samples and storm samples in the Papillion Creek Basin were significantly different for constituents not sub-grouped as nutrients or organic compounds. Nutrients that were significantly different when comparing wet-weather scheduled samples and storm samples were ammonia ($p$ = 0.000; geometric means of 0.028 and 0.083 mg/L as N for wet-weather and storm samples, respectively), total nitrogen ($p$ = 0.000; geometric means of 2.56 and 3.68 mg/L for wet-weather and storm samples, respectively), and total phosphorus ($p$ = 0.000; geometric means of 0.23 and 0.83 mg/L for wet-weather and storm samples, respectively). Thirty-two organic compounds were significantly different when comparing wet-weather and storm samples (appendix 13).

### Comparisons of the Papillion Creek Watershed Streams

Student's t-test were completed to determine whether or not stream reaches were significantly different from each other for each constituent. A *p*-value less than 0.05 is considered significant for these tests. In the Papillion Creek Basin, the data from all sites in a single stream (Cole Creek, Little Papillion Creek, Big Papillion Creek, or Papillion Creek) were grouped together and compared against one another (appendix 13). The results for comparisons of all samples, dry-weather scheduled samples, wet-weather scheduled samples, and storm samples are shown in tables A16–7, A16–8, A16–9, and A16–10.

Student's t-test were completed to compare the concentrations of organic compounds in each of the streams (appendix 13). Cole Creek was significantly different than Little Papillion Creek for 15 organic compounds comparing all data, for 6 organic compounds when comparing only dry-weather scheduled samples, for 12 organic compounds when comparing only wet-weather scheduled samples, and for 7 organic compounds when comparing only storm samples. Cole Creek was significantly different than Big Papillion Creek for 18 organic compounds comparing all data, for 11 organic compounds when comparing only dry-weather scheduled samples, for 7 organic compounds when comparing only wet-weather scheduled samples, and for 19 organic compounds when comparing only storm samples. Cole Creek was significantly different than Papillion Creek for 21 organic compounds comparing all data, for 6 organic compounds when comparing only dry-weather scheduled samples, for 5 organic compounds when comparing only wet-weather scheduled samples, and for 30 organic compounds when comparing only storm samples. Little Papillion Creek was significantly different than Big Papillion Creek for 8 organic compounds comparing all data, for 9 organic compounds when comparing only dry-weather scheduled samples, for 5 organic compounds when comparing only wet-weather scheduled samples, and for 7 organic compounds when comparing only storm samples. Little Papillion Creek was significantly different than Papillion Creek for 12 organic compounds comparing all data, for 9 organic compounds when comparing only dry-weather scheduled samples, for 4 organic compounds when comparing only wet-weather scheduled samples, and for 25 organic compounds when comparing only storm samples. Finally, Big Papillion Creek was significantly different than Papillion Creek for 9 organic compounds comparing all data, for 15 organic compounds when comparing only dry-weather scheduled samples, for 4 organic compounds when comparing only wet-weather scheduled samples, and for 16 organic compounds when comparing only storm samples.

### Comparisons Upstream and Downstream from Combined Sewer Overflow Sites

When analyzing constituent concentrations in stream samples, t-test comparisons of samples sets upstream and downstream from CSO sites can give an indication of those compounds that may be a result of the CSO sites if the results for the downstream samples are significantly greater than the upstream samples. All p-values from the t-tests are in appendix 13. Analyzed constituents that were significantly different upstream and downstream from CSO sites and greater than 50 percent detections when using all data are shown in table A16–11.

### Missouri River Comparisons

Comparisons between the probabilities associated with t-tests of the log-transformed data from the three Missouri River sampling sites determined the constituents that were significantly different among the three sites (appendix 14). When comparing the complete data set from the three sites, the only constituent with at least 50 percent detection at one site in the comparison that was significantly different were *E. coli* for various types of samples (table A16–12). The scheduled samples were significantly different from the storm EWI samples are shown in table A16–13. No significant differences were calculated for any constituent when comparing t-test p-values between the EWI storm sample data set and scheduled sample data set at each site (probably because of the relatively small data set at each site), or between the EWI storm samples and the right bank storm samples for all three sites combined or when using the data from each site (indicating mixing in the river).

## Seasonal Comparisons

To compare seasonally, t-tests were completed on log-transformed data sets and considered significantly different if the probability associated with the test was less than 0.05. For seasonal t-test comparisons, if at least one of the data sets did not have at least 50 percent detections, no tests were made and those constituents are not noted in this section. For the Papillion Creek samples, scheduled samples were divided into wet weather and dry weather samples as determined by stream recovery of specific conductance. However, because of the size of the basin and lack of specific conductance response in the Missouri River for all except large localized storms, the scheduled samples in the Missouri River were not broken down to dry weather and wet weather. This distinction may skew the comparison results for scheduled samples for those seasons when scheduled samples were collected shortly after a storm for constituents that derive from storms. During the study, 1 of 3, 2 of 4, and 2 of 4 scheduled sampling dates in spring, summer, and autumn, respectively, were within two days of a local rainfall. Additionally, the size of the rainfall during each of the sampled storms may have affected the concentrations of the measured constituents. For the samples collected during this study, the rainfall amounts were significantly different in all three seasons, with the most rainfall during sampled storms in the spring (geometric mean of 21 mm), followed by autumn (geometric mean of 13 mm) and summer (geometric mean of 8 mm).

## Combined Sewer Overflows

For the samples collected from CSO sites during the study, t-tests were completed to determine if there was a significant difference between seasonal sample data sets for all CSO sites combined (appendix 12). Constituents with no seasonal differences in the data set are not noted in this section.

CSO data from all three seasons were significantly different from the others for one metal and four organic compounds that were analyzed during this study (table A16–14). Many constituents measured in CSO sites indicated a specific season where the measured concentrations were significantly different than the other two seasons, but the other two seasons were not significantly different (table A16–15, A16–16, and A16–17 for spring, summer, and autumn, respectively).

## Stormwater Outfalls

Seasonal t-test comparisons were completed on the log-transformed data set from the two SWO sites (appendix 12). Spring and summer comparisons were not significantly different for any of the constituents analyzed in the study. Hardness concentrations were significantly different when comparing summer to autumn (geometric means of 102 and 27 mg/L, respectively) data sets ($p = 0.031$) as a result of different calcium concentrations ($p = 0.030$; geometric means of 36 and 9.6 for summer and autumn samples, respectively). The organic compound 3.4-dichlorophenyl isocyanate was significantly different when comparing autumn (geometric mean of 0.25 µg/L) to spring ($p = 0.016$; geometric mean of 62.8 µg/L for spring samples) and summer ($p = 0.047$; geometric mean of 23.7 µg/L for summer samples). Three additional organic compounds—cholesterol, 4-tert octylphenol, and phenol—were significantly different when comparing spring (geometric means of 0.55, 0.11, and 0.07 µg/L, respectively) to autumn (geometric means of 2.29, 0.37, and 0.71 µg/L, respectively) samples ($p = 0.025$, 0.048, and 0.039, for cholesterol, 4-*tert* octylphenol, and phenol, respectively).

## Papillion Creek Basin

Student's t-tests were performed on various seasonal subsets of the environmental data from the Papillion Creek Basin. All the p-values for the various comparisons are in appendix 13. Significantly different seasonal comparisons for all data, scheduled samples, and storm samples when there were at least 50 percent detections in one of the data sets are shown in tables A16–18, A16–19, and A16–20, respectively.

The organic compound concentrations were compared by using Student's' t-tests (appendix 13). For those compounds that had greater than 50 percent detects, the t-test comparisons are summarized in appendix 16 by using data from all the streams. When using all the data, 16, 3, and 2 compounds were significantly higher in the spring, summer, and autumn, respectively, and 1, 2, and 5 compounds were significantly lower in the spring, summer, and autumn, respectively. For scheduled samples, 12, 1, and 0 compounds were significantly higher in the spring, summer, and autumn respectively, and 0, 2, and 4 compounds were significantly lower in the spring, summer, and autumn, respectively. For storm samples, 11, 6, and 2 compounds were significantly higher in the spring, summer, and autumn, respectively, and 1, 3, and 8 compounds were significantly lower in the spring, summer, and autumn, respectively. The p-values for t-test comparisons for individual stream reaches are in appendix 13. *E. coli* concentrations were significantly larger in the summer in all four streams.

## Missouri River

Student's t-tests were performed on various subsets of seasonal environmental data from the Missouri River. All the p-values for the various comparisons are in appendix 14. Test results for all sample types combined, scheduled samples, right bank storm samples, and equal width increment storm samples when there were at least 50 percent detections in one of the data sets are shown in tables A16–21, A16–22, A16–23, and A16–24, respectively. For *E. coli*, none of the Missouri River sites were significantly different when comparing the entire data set or the EWI or right bank storm samples; however, *E. coli* concentrations in scheduled Missouri River samples were significantly different between spring and autumn and between summer and autumn. Spring and summer *E. coli* concentrations in Missouri River scheduled samples were not significantly different ($p = 0.56$). These scheduled t-test results, however, are likely an artifact of different average lag times since the last storm for each season [4.8, 6.3, and 3.5 days for spring, summer, and autumn, respectively (table 7; north part of the watershed)].