# Appendix C

# Comparison of Lincoln Stormwater Quality Data with National Urban and Denver Metropolitan Data

# MEMORANDUM DRAFT

TO: Olsson Associates
Bob Wolf and John Cambridge

FROM: Wright Water Engineers, Inc. (WWE)
Jonathan Jones, P.E. and Ted Brown

DATE: February 28, 1997

RE: Comparison of Lincoln Stormwater Quality Data with National Urban Runoff and Denver Metropolitan Data and Recommendations for Future Monitoring Efforts in the Beal Sough Drainage

## INTRODUCTION

This memorandum summarizes a series of water quality evaluations that WWE performed on the Lincoln stormwater quality data (1992-1995) to provide initial insight on watershed factors that should be targeted in the preparation of the Beal Slough Master Drainage Plan and Drainage Criteria Manual. In addition, and in response to a request by the City of Lincoln, WWE recommends additional sampling in the Beal Slough drainage to provide supplemental information that may be instrumental in the development of the Master Plan and Criteria Manual.

## WATER QUALITY DATA COMPARISON

The stormwater quality data from Lincoln, Nebraska were compared with national urban runoff data (NURP and other data) and Denver Metropolitan data (i.e., Denver, Lakewood, and Aurora). The NURP data provide a good baseline measure to compare Lincoln data with the national norm, while the Denver Metropolitan data provide a more contemporary "measuring stick." Similar to Lincoln, the Denver Metropolitan data were collected for the National Pollution Discharge Elimination System (NPDES) stormwater permit application and include similar land-use types and pollutants that were monitored. The national data (mean values and ranges) were taken from the *Fundamentals of Urban Runoff Management: Technical and Institutional Issues, by* Richard R. Horner, Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, Terrene Institute, Washington, DC, 1994. Only the parameters common to Lincoln and the national or Denver data are included in the attached tables (Tables A through D).

The Lincoln stormwater quality data were collected from 1992 through 1995 at a total of seven stations along Beal Slough and Salt Creek. Stations 6 and 7 only have data for





1995--these stations apparently replaced stations 1 and 4 in the 1995 sampling. Consequently, only five stations were monitored for each year of sampling. The Denver municipal stormwater quality data were collected in 1992 and are presented in the 1996 Municipal Stormwater NPDES Permits for the municipalities.

For each year of Lincoln data there were three to four sampling events at the five stations in the metropolitan area. Non-detects were treated as zero when calculating mean concentrations. Except for 1992, rainfall data are not available for the sampled storm events.

### *Lincoln vs. NURP*

The following summarizes key water quality observations based on a comparison of the individual years of Lincoln data with the national data. If no observation is made below for a specific parameter, it can be assumed that the mean concentration and range for that parameter are within, or very close to, the national mean and range.

**1992 Data (Table A)**

- Total suspended solids (TSS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) mean concentrations were generally higher than the national mean; however, the concentrations were within the range of national values.
- Mean metals concentrations were generally below the national mean.

**1993 Data (Table B)**

- Mean oil and grease concentrations were as much as three orders of magnitude greater than the national means.
- Heavy metals such as Cadmium (Cd), Nickel (Ni), Copper (Cu), and Chromium (Cr) were higher than national means and, in the case of Ni, exceeded the national range.
- Mean total nitrogen values at some stations were greater than the high-end range of the national values (20 ppm).

**1994 Data (Table C)**

- Mean COD values for most stations were slightly elevated relative to the national mean
- Oil and grease values were again significantly higher than the national mean; however, not to the same extent as the 1993 data.

1995 Data (Table D)

- Mean TSS and total phosphorus values at some stations were slightly elevated relative to the national mean, yet within the national range.
- Oil and grease mean concentrations decreased significantly from the 1993 and 1994 levels and were below the national mean.

In summary, the Lincoln stormwater quality appears to be similar to and, in some instances, slightly better than national runoff quality. There does not appear to be any trend indicating an improvement or impairment of stormwater quality over the four year sampling period. The parameters that are most frequently observed at elevated concentrations include: TSS, COD, oil and grease, and nutrients. The high concentrations observed for several parameters in 1993 may, in part, be explained by the heavy rains and local flooding that occurred in the region.

### *Lincoln vs. Denver Metropolitan*

WWE compared the Lincoln stormwater data to the 1992 Denver municipal stormwater quality data. This evaluation provides a more contemporary comparison (i.e., the NURP data was collected in the early 1980s). The Denver data were collected over a six-month time period in 1992 for similar land-use types that Lincoln targeted.

The following summarizes key water quality observations based on the comparison of the individual years of Lincoln data with the 1992 Denver data. If no observation is made below for a specific parameter, it can be assumed that the mean concentration and range for that parameter are within, or very close to, the national mean and range.

1992 Data (Table A)

- Overall, 1992 stormwater runoff quality of the 5 Lincoln stations was as good as, and generally better than, the runoff from similar land-use types in metropolitan Denver.
- Most metals concentrations for the Lincoln stormwater were significantly less than those for Denver.
- Lincoln Station 5 (commercial) had high TSS and arsenic concentrations (means of 1,892 mg/L and 13 µg/L, respectively) compared to the Denver data.

1993 Data (Table B)

- There were noticeable increases in metals concentrations compared with the other annual data. Nickel, in particular, had very high concentrations.



- The oil and grease concentrations are significantly elevated, exceeding the upper range of the Denver data.
- The TSS concentration at Station 5 remained high relative to the Denver data.

1994 Data (Table C)

- The TSS concentrations substantially decreased to levels below the Denver concentrations.
- Metals concentrations were typically lower than the Denver values.
- Oil and grease concentrations continued to be about an order of magnitude higher than Denver values.

1995 Data (Table D)

- The most noticeable parameter of concern in the 1995 Lincoln data was TSS. Mean concentrations at the residential and commercial stations were considerably higher than the Denver mean concentrations.
- Other parameter concentrations tended to be lower than the previous years and lower than the Denver data. Of particular note, oil and grease concentrations decreased to levels comparable with the Denver data.

In summary, the Lincoln stormwater quality generally appears to be of better quality than the Denver data. However, for some years, TSS and oil and grease concentrations were elevated, indicating that control measures for these parameters are warranted.

## BEAL SLOUGH STORMWATER RUNOFF DATA AND RECOMMENDATIONS FOR FUTURE SAMPLING IN THE WATERSHED

WWE narrowed the above stormwater runoff quality evaluations by isolating on the Beal Slough watershed data to provide some initial direction for water quality considerations in the development of the Beal Slough Master Drainage Plan and Drainage Criteria Manual. In addition to looking at the Beal Slough stormwater data, WWE provides recommendations for additional sampling that would generate useful data for refining the water quality and habitat quality objectives of the Master Plan and Criteria Manual.

### *Beal Sough Stormwater Runoff Data*

Two of the five historical Lincoln monitoring stations are located within the Beal Slough drainage, one in a residential area (130 acre drainage area - station 2) and one in an

industrial setting (90 acre drainage area - station 4). It should be noted that there are no available data for station 4 in 1995.

Based on the above observations and review of the City of Lincoln NPDES permit application, the following observations can be made about the Beal Slough stormwater runoff quality:

- TSS concentrations, at times, were higher than the NURP mean. Concentrations appeared to increase each year (1994, however, was an exception to this trend), with a high concentration of 5000 ppm measured in 1995. In 1992, the estimated TSS load from the Beal Slough drainage was about 1100 pounds per acre per year (lbs/ac/yr). This loading is greater than the highest typical pollutant loading rate reported by Horner et al (1994) for different land uses (1000 lbs/ac/yr).

- Mean COD concentrations at station 4 were typically higher than mean NURP concentrations. The mean concentrations at station 2 (residential) were well below NURP mean values, except for 1992.

- Total phosphorus levels were somewhat elevated (i.e., greater than 300 µg/L) at both sampling locations, but more so in the residential drainage. This could be a concern, depending upon the residence time for water in Beal Slough, particularly during periods of low flow.

- On occasion, certain metals concentrations were elevated. Specifically, in 1992 selenium concentrations were more than three times the stream standard during one storm (July 22). In 1993, nickel concentrations were approximately ten times higher than average NURP concentrations.

- Oil and grease mean concentrations were significantly higher than the national mean at both stations in 1993 and 1994. However, in 1995 the concentrations were consistent with the national data. Oil and grease data were not reported for 1992.

- High concentrations for several parameters, including fecal coliform, were observed in 1993. This may be explained in part by the heavy rains and local flooding that occurred in the region.

### *Suggested Monitoring in Beal Slough Drainage*

WWE was recently asked by the City of Lincoln to recommend additional sampling measures that would provide valuable information for the determination of watershed factors that have the greatest effect/impact on water quality and habitat quality within the Beal Slough drainage. The recommended data collection efforts will be useful in



defining the water quality and habitat quality objectives of the Master Plan and Criteria Manual.

Using the stormwater evaluation discussed above, observations collected from previous field visits to the Beal Slough drainage, photo documentation of the watershed, and engineering experience gained from working with similar watersheds, WWE made the following recommendations to the City:

1. Perform a *biological assessment* of Beal Slough. As part of the biological assessment, habitat suitability should also be evaluated. This will assist in determining whether impaired stream reaches are habitat-limited. Habitat-limited reaches can then be targeted for potential restoration or improvements.

2. Perform *sediment monitoring* and a *stream channel stability evaluation* for identifying the significant sediment contributors to the drainage and to identify those areas where channel improvements are most needed.

3. Collect *baseflow water quality data*. Perhaps there are existing data that WWE does not know about. Regardless, these data would be useful for comparative purposes with the runoff data. With strategic sampling locations, it may be possible to identify pollutant sources (point or nonpoint) and determine effective ways to mitigate their influence.

In summary, WWE views the data collection effort on Beal Slough as a critical diagnostic tool. A fairly broad *biological* and *physical* data collection effort, if coordinated and performed appropriately, will provide valuable information to supplement the wet weather chemical data that currently exist on Beal Slough. These data will be very useful in the development of the Master Plan and Criteria Manual and will help provide the direction necessary to determine what watershed factors should be targeted for improving the water quality and habitat in the Beal Slough drainage.

Attachments

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## Table A: Comparison of 1992 Averaged Urban Runoff Data From Lincoln, Nebraska With National and Denver Urban Runoff Data

| Date | 1992 | 1992 | 1992 | 1992 | 1992 | General Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 1 (Residential) | 2 (Residential) | 3 (Industrial) | 4 (Industrial) | 5 (Commercial) | | | Residential | | Industrial | | Commercial | |
| PARAMETERS | | | | | | | | | | | | | |
| Organic and Inorganic | mean/range | mean/range | mean/range | mean/range | mean/range | mean | range | EMC | range | EMC | range | EMC | range |
| TSS (mg/L) | 388/303-448 | 172/87 - 176 | 70/20 - 128 | 131/91 - 218 | 1892/932 - 2510 | 150 | 2 - 2,890 | 325 | 50 - 458 | 399 | 126 - 944 | 165 | 41 - 291 |
| BOD (mg/L) | 36/7-73 | 19/4-37 | 22/3-36 | 21/5-38 | 33/7-68 | 9 | 0.41 - 159 | 17 | 8 - 54 | 29 | 9 - 82 | 33 | 9 - 116 |
| COD (mg/L) | 82/54-124 | 82/20-141 | 20 4/6-34 | 112/24-191 | 92/67-132 | 65 | <10 - 1,031 | 95 | 56 - 235 | 232 | 36 - 392 | 173 | 59 - 457 |
| total P (mg/L) | 0.7/0.5-1.0 | 0.4/0.1-0.5 | 0.1/0.10-0.12 | 0.3/0.2-0.5 | 0.19/0.1-0.3 | 0.33 | 0.01 - 4.3 | 0.87 | 0.16 - 1.4 | 0.43 | 0.14 - 1.3 | 0.34 | 0.5 - 1.0 |
| total N (mg/L-N) | 2.6/2-3 | 1.3/0.9-1.7 | 0.9/0.2-1.9 | 1.4/0.5-2.3 | 0.9/0.4-1.3 | 1.5 | 0.34 - 20 | 4.7 | 1.6 - 9.1 | 2.7 | 1.2 - 8.7 | 3.9 | 0.8 - 8.4 |
| alkalinity (mg/L) | --- | --- | --- | --- | --- | 38.2 | 5.5 - 87 | --- | --- | --- | --- | --- | --- |
| oil and grease (mg/L) | --- | --- | --- | --- | --- | 7.8 | up to 35.7 | --- | 2 - 9 | --- | 3 - 11 | --- | 2 - 27 |
| organic pesticides (µg/L) | nd | nd | nd | nd | nd | -- | 0.002 - 0.35 | --- | --- | --- | --- | --- | --- |
| phthalate esters (µg/L) | 4.0/0.6-71 | 2.5/0.2-13 | 0.1/0.04-0.3 | 17/0.3-100 | 2/0.2-12 | --- | 0.06 - 160 | --- | nd - 64 | --- | nd - 30 | --- | nd - 76 |
| phenols (µg/L) | nd | nd | nd | nd | nd | --- | 8 - 115 | --- | 2 - 9 | --- | 4 - 18 | --- | 4 - 6 |
| PAH (µg/L) | nd | nd | nd | nd | nd | --- | <0.01 - 12 | --- | nd | --- | nd - 58 | --- | nd |
| pH | --- | --- | --- | --- | --- | --- | 6.2 - 8.7 | --- | 6.5 - 7.5 | --- | 6.4 - 7.2 | --- | 6.4 - 7.3 |
| Metals | | | | | | | | | | | | | |
| arsenic (µg/L) | 0.6/0.5-0.7 | 5.9/0.2-17 | 4.8/0.1-7.4 | 6.5/0.4-19 | 15/9-18 | 13 | 10-130 | --- | nd - 3 | --- | nd - 8 | --- | nd - 3 |
| cadmium (µg/L) | 0.3/0.2-0.4 | 0.3/0.2-0.4 | 1.5/0.8-2.6 | 0.7/0.1-1.6 | 1.3/0.6-2.5 | 0.7 | 0.7 - 30 | 0 | nd - 1 | 3 | 1 - 6 | 1 | nd - 3 |
| chromium (µg/L) | 8/2-14 | 4/3-13 | 6/3-13 | 5/1-9 | 9/7-11 | 7 | <10 - 110 | --- | 3 - 12 | --- | 10 - 27 | --- | nd - 24 |
| copper (µg/L) | 12/7-19 | 8/4-17 | 13/9-18 | 9/3-16 | 14/4-25 | 34 | 4 - 560 | 31 | 10 - 44 | 84 | 39 - 130 | 81 | 10 - 340 |
| lead (µg/L) | 5/4-6 | 2/0.3-3 | 7/6-8 | 3/2-7 | 26/10-36 | 140 | 3 - 28,000 | 53 | 18 - 95 | 128 | 63 - 170 | 59 | 16 - 150 |
| nickel (µg/L) | 7/4-13 | 1.5/0.7-2 | 5/2 9 | 4/3-6 | 2.0/1.7-2.2 | 12 | <2 - 126 | --- | 3 - 9 | --- | 7 - 21 | --- | 2 - 12 |
| zinc (µg/L) | 18/13-25 | 10/8-12 | 40/35-43 | 26/20-29 | 43/36-47 | 160 | 10 - 5,750 | 182 | 50 - 230 | 520 | 340 - 740 | 294 | 80 - 730 |

nd = non-detect

National Urban Runoff Data is from: Fundamentals of Urban Runoff Management: Technical and Institutional Issues, Richard R. Horner, Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, Terrene Institute, Washington, DC, 1994.

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## Table B: Comparison of 1993 Averaged Urban Runoff Data From Lincoln, Nebraska With National and Denver Urban Runoff Data

| Date | 1993 | 1993 | 1993 | 1993 | 1993 | General Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 1 (Residential) | 2 (Residential) | 3 (Industrial) | 4 (Industrial) | 5 (Commercial) | | | Residential | | Industrial | | Commercial | |
| PARAMETERS | | | | | | | | | | | | | |
| Organic and Inorganic | mean/range | mean/range | mean/range | mean/range | mean/range | mean | range | EMC | range | EMC | range | EMC | range |
| TSS (mg/L) | 85/1 - 2311 | 146/95 - 214 | 140/103 - 143 | 105/81 - 141 | 1,722/59 - 4931 | 150 | 2 - 2,890 | 325 | 50 - 458 | 399 | 126 - 944 | 165 | 41 - 291 |
| BOD (mg/L) | 4.4/2.4 - 7.8 | 4.4/3.8 - 5.2 | 12/0.4 - 29 | 4.5/2.5 - 6.2 | 2.9/3.6 - 10 | 9 | 0.41 - 159 | 17 | 8 - 54 | 29 | 9 - 82 | 33 | 9 - 116 |
| COD (mg/L) | 30/10 - 66 | 14/4 - 34 | 55/29 - 96 | 55/3.1 - 111 | 28/2.1 - 84 | 65 | <10 - 1,031 | 95 | 56 - 235 | 232 | 36 - 392 | 173 | 59 - 457 |
| total P (mg/L) | 0.9/0.5 - 1.1 | 0.7/0.6 - 1.0 | 0.2/0.1 - 0.3 | 0.4/0.3 - 0.5 | 0.5/0.3 - 0.7 | 0.33 | 0.01 - 4.3 | 0.87 | 0.16 - 1.4 | 0.43 | 0.14 - 1.3 | 0.34 | 0.5 - 1.0 |
| total N (mg/L-N) | 21/10 - 31 | 21/6 - 33 | 20/7 - 39 | 11/9/1.3 | 14/5 - 23 | 1.5 | 0.34 - 20 | 4.7 | 1.6 - 9.1 | 2.7 | 1.2 - 8.7 | 3.9 | 0.8 - 8.4 |
| alkalinity (mg/L) | --- | --- | --- | --- | --- | 38.2 | 5.5 - 87 | --- | --- | --- | --- | --- | --- |
| oil and grease (mg/L) | 263/55 - 543 | 43/5 - 90 | 163/42 - 339 | 170/2 - 361 | 555/285 - 733 | 7.8 | up to 35.7 | --- | 2 - 9 | --- | 3 - 11 | --- | 2 - 27 |
| organic pesticides (µg/L) | nd | nd | nd | nd | nd | --- | 0.002 - 0.35 | --- | --- | --- | --- | --- | --- |
| phthalate esters (µg/L) | 0.11/0.03 - 0.2 | 0.021/nd - 0.04 | 0.06/0.01 - 0.1 | 0.05/0.03 - 0.08 | 0.007/0.003 - 0.01 | --- | 0.06 - 160 | --- | nd - 64 | --- | nd - 30 | --- | nd - 76 |
| phenols (µg/L) | nd | nd | nd | nd | nd | --- | 8 - 115 | --- | 2 - 9 | --- | 4 - 18 | --- | 4 - 6 |
| PAH (µg/L) | nd | nd | nd | nd | nd | --- | <0.01 - 12 | --- | nd | --- | nd - 58 | --- | nd |
| pH | 7.2 - 8.1 | 7.4 - 7.6 | 6.3 - 7.7 | 7.4 - 8.3 | 5 - 7.9 | --- | 6.2 - 8.7 | --- | 6.5 - 7.5 | --- | 6.4 - 7.2 | --- | 6.4 - 7.3 |
| Metals | | | | | | | | | | | | | |
| arsenic (µg/L) | 0.4/--- | --- | 0.3/--- | 0.5/--- | 8/0.8 - 15 | 13 | 10-130 | --- | nd - 3 | --- | nd - 8 | --- | nd - 3 |
| cadmium (µg/L) | 2.6/2.4 - 2.9 | 2.0/1.3 - 2.5 | 2.7/2.0 - 3.5 | 3.1/2.4 - 3.6 | 2.9/1.8 - 3.8 | 0.7 | 0.7 - 30 | 0 | nd - 1 | 3 | 1 - 6 | 1 | nd - 3 |
| chromium (µg/L) | 13/10 - 17 | 13/12 - 14 | 14/13.9 - 14.1 | 16/14 - 18 | 22/16 - 27 | 7 | <10 - 110 | --- | 3 - 12 | --- | 10 - 27 | --- | nd - 24 |
| copper (µg/L) | 68/39 - 120 | 57/50 - 67 | 60/53 - 65 | 67/58 - 83 | 105/69 - 152 | 34 | 4 - 560 | 31 | 10 - 44 | 84 | 39 - 130 | 81 | 10 - 340 |
| lead (µg/L) | 11/6 - 19 | 10/8 - 13 | 15/3 - 27 | 8/6 - 11 | 21/19 - 23 | 140 | 3 - 28,000 | 53 | 18 - 95 | 128 | 63 - 170 | 59 | 16 - 150 |
| nickel (µg/L) | 122/118 - 129 | 119/115 - 126 | 119/110 - 129 | 121/119 - 123 | 130/96 - 178 | 12 | <2 - 126 | --- | 3 - 9 | --- | 7 - 21 | --- | 2 - 12 |
| zinc (µg/L) | 73/41 - 145 | 44/38 - 51 | 102/79 - 128 | 81/69 - 91 | 81/76 - 89 | 160 | 10 - 5,750 | 182 | 50 - 230 | 520 | 340 - 740 | 294 | 80 - 730 |

nd = non-detect

National Urban Runoff Data is from: Fundamentals of Urban Runoff Management: Technical and Institutional Issues, Richard R. Horner, Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, Terrene Institute, Washington, DC, 1994.

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## Table C: Comparison of 1994 Averaged Urban Runoff Data From Lincoln, Nebraska With National and Denver Urban Runoff Data

| Date | 1994 | 1994 | 1994 | 1994 | 1994 | General Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 1 (Residential) | 2 (Residential) | 3 (Industrial) | 4 (Industrial) | 5 (Commercial) | | | Residential | | Industrial | | Commercial | |
| PARAMETERS | | | | | | | | | | | | | |
| Organic and Inorganic | mean/range | mean/range | mean/range | mean/range | mean/range | mean | range | EMC | range | EMC | range | EMC | range |
| TSS (mg/L) | nd | nd | 86/nd - 173 | nd | 87/nd - 174 | 150 | 2 - 2 890 | 325 | 50 - 458 | 399 | 126 - 944 | 165 | 41 - 291 |
| BOD (mg/L) | 3/1 - 6 | 3/1 - 7 | 2/2 - 3 | 2/1 - 3 | 2/1 - 3 | 9 | 0 41 - 159 | 17 | 8 - 54 | 29 | 9 - 82 | 33 | 9 - 116 |
| COD (mg/L) | 79/17 - 191 | 17/15 - 20 | 22/13 - 26 | 84/17 - 199 | 98/9 - 246 | 65 | <10 - 1,031 | 95 | 56 - 235 | 232 | 36 - 392 | 173 | 59 - 457 |
| total P (mg/L) | 0.7/0.5 - 1.0 | 0 7/0 3 - 0.9 | 0.3/0.2 - 0 3 | 0.3/0.1 - 0 4 | 0 3/0 1 - 0.4 | 0 33 | 0.01 - 4.3 | 0.87 | 0.16 - 1.4 | 0.43 | 0.14 - 1.3 | 0 34 | 0 5 - 1 0 |
| total N (mg/L-N) | 0 7/0 6 - 0 9 | 0 5/0 5 - 0.6 | 0.6/0 4 - 1 1 | 0.5/0.4 - 0.7 | 0 5/0 4 - 0.7 | 1 5 | 0 34 - 20 | 4 7 | 1 6 - 9 1 | 2.7 | 1 2 - 8.7 | 3 9 | 0 8 - 8 4 |
| alkalinity (mg/L) | --- | --- | --- | --- | --- | 38.2 | 5 5 - 87 | --- | --- | --- | --- | --- | --- |
| oil and grease (mg/L) | nd | 7/nd - 140 | 33/nd - 100 | 47/nd - 100 | 145/10 - 280 | 7 8 | up to 35.7 | --- | 2 - 9 | --- | 3 - 11 | --- | 2 - 27 |
| organic pesticides (µg/L) | --- | --- | --- | --- | --- | --- | 0.002 - 0.35 | --- | --- | --- | --- | --- | --- |
| phthalate esters (µg/L) | --- | --- | --- | --- | --- | --- | 0.06 - 160 | --- | nd - 64 | --- | nd - 30 | --- | nd - 76 |
| phenols (µg/L) | nd | nd | nd | nd | nd | --- | 8 - 115 | --- | 2 - 9 | --- | 4 - 18 | --- | 4 - 6 |
| PAH (µg/L) | nd | nd | nd | nd | nd | --- | <0 01 - 12 | --- | nd | --- | nd - 58 | --- | nd |
| pH | 7.4 - 8.3 | 6 9 - 8.9 | 7.0 - 9.0 | 7.3 - 8.1 | 7 5 - 8.0 | --- | 6.2 - 8.7 | --- | 6.5 - 7.5 | --- | 6.4 - 7.2 | --- | 6.4 - 7.3 |
| Metals | | | | | | | | | | | | | |
| arsenic (µg/L) | 0.9/0 7 - 1.1 | 0.6/0.4 - 0.7 | 0.4/0 3 - 0 6 | 0 5/0 2 - 1.1 | 7 1/3 3 - 10.3 | 13 | 10-130 | --- | nd - 3 | --- | nd - 8 | --- | nd - 3 |
| cadmium (µg/L) | 0.4/0.3 - 0 4 | 0.5/0 2 - 0 6 | 0.6/0 4 - 0 9 | 3.4/0.6 - 8.3 | 0.8/0 5 - 1.1 | 0.7 | 0.7 - 30 | 0 | nd - 1 | 3 | 1 - 6 | 1 | nd - 3 |
| chromium (µg/L) | 4/3 - 6 | 3/2 - 3 | 3/2 - 3 | 2/2 - 3 | 7/5 - 8 | 7 | <10 - 110 | --- | 3 - 12 | --- | 10 - 27 | --- | nd - 24 |
| copper (µg/L) | 18/16 - 20 | 20/16 - 24 | 31/15 - 57 | 23/9 - 48 | 45/30 - 71 | 34 | 4 - 560 | 31 | 10 - 44 | 84 | 39 - 130 | 81 | 10 - 340 |
| lead (µg/L) | 4/4 - 5 | 6/2 - 9 | 11/4 - 26 | 17/2 - 38 | 34/16 - 59 | 140 | 3 - 28,000 | 53 | 18 - 95 | 128 | 63 - 170 | 59 | 16 - 150 |
| nickel (µg/L) | 6/4 - 7 | 4/4 - 5 | 4/3 - 6 | 4/3 - 5 | 4/4 - 5 | 12 | <2 - 126 | --- | 3 - 9 | --- | 7 - 21 | --- | 2 - 12 |
| zinc (µg/L) | 31/25 - 35 | 50/25 - 81 | 112/78 - 171 | 66/36 - 126 | 125/81 - 203 | 160 | 10 - 5,750 | 182 | 50 - 230 | 520 | 340 - 740 | 294 | 80 - 730 |

nd = non-detect

National Urban Runoff Data is from: Fundamentals of Urban Runoff Management: Technical and Institutional Issues, Richard R. Horner, Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, Terrene Institute, Washington, DC, 1994



## Table D: Comparison of 1995 Averaged Urban Runoff Data From Lincoln, Nebraska With National and Denver Urban Runoff Data

| Date | 1995 | 1995 | 1995 | 1995 | 1995 | General Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | | Denver Urban Runoff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 2 (Residential) | 3 (Industrial) | 5 (Commercial) | 6 | 7 | | | Residential | | Industrial | | Commercial | |
| PARAMETERS | | | | | | | | | | | | | |
| Organic and Inorganic | mean/range | mean/range | mean/range | mean/range | mean/range | mean | range | EMC | range | EMC | range | EMC | range |
| TSS (mg/L) | 1700/nd - 5000 | 108/3 - 300 | 992/236 - 2340 | 107/3 -430 | 237/5 - 1250 | 150 | 2 - 2,890 | 325 | 50 - 458 | 399 | 126 - 944 | 165 | 41 - 291 |
| BOD (mg/L) | 5/2 - 12 | 7/1 - 13 | 4/1 - 11 | --- | --- | 9 | 0.41 - 159 | 17 | 8 - 54 | 29 | 9 - 82 | 33 | 9 - 116 |
| COD (mg/L) | 24/15 - 33 | 18/15 - 22 | 17/16 - 19 | 87/nd - 530 | 109/nd - 250 | 65 | <10 - 1,031 | 95 | 56 - 235 | 232 | 36 - 392 | 173 | 59 - 457 |
| total P (mg/L) | 3.9/3.3 - 4.7 | 2.6/2.1 - 3 | 2.1/nd - 4.1 | 0.47/nd - 2.2 | | 0 33 | 0 01 - 4.3 | 0.87 | 0.16 - 1.4 | 0.43 | 0.14 - 1.3 | 0 34 | 0.5 - 1.0 |
| total N (mg/L-N) | 1.3/0.5 - 1.9 | 1.3/1.0 - 1.2 | 1.5/1.0 - 2.6 | 1.1/nd - 5.8 | 1.5/nd - 2.7 | 1.5 | 0.34 - 20 | 4.7 | 1.6 - 9.1 | 2.7 | 1.2 - 8.7 | 3.9 | 0.8 - 8.4 |
| alkalinity (mg/L) | --- | --- | --- | 252/16 - 291 | 264/2.4 - 312 | 38.2 | 5.5 - 87 | --- | --- | --- | --- | --- | --- |
| oil and grease (mg/L) | 6.7/0.8 - 12 | 1.5/0.4 - 3.6 | 5.6/0.1 - 14 | --- | --- | 7.8 | up to 35.7 | --- | 2 - 9 | --- | 3 - 11 | --- | 2 - 27 |
| organic pesticides (µg/L) | --- | --- | --- | --- | --- | --- | 0.002 - 0.35 | --- | --- | --- | --- | --- | --- |
| phthalate esters (µg/L) | --- | --- | --- | --- | --- | --- | 0.06 - 160 | --- | nd - 64 | --- | nd - 30 | --- | nd - 76 |
| phenols (µg/L) | nd | nd | nd | --- | --- | --- | 8 - 115 | --- | 2 - 9 | --- | 4 - 18 | --- | 4 - 6 |
| PAH (µg/L) | nd | nd | nd | --- | --- | --- | <0.01 - 12 | --- | nd | --- | nd - 58 | --- | nd |
| pH | 6.9 - 7.6 | 7.1 - 7.9 | 7.3 - 7.8 | 7.9 - 8.8 | 7.1 - 8.6 | --- | 6.2 - 8.7 | --- | 6.5 - 7.5 | --- | 6.4 - 7.2 | --- | 6.4 - 7.3 |
| Metals | | | | | | | | | | | | | |
| arsenic (µg/L) | 0.3/0.1 - 0.5 | 0.1/0.1 - 0.2 | 0.1/nd - 0.2 | 3/nd - 7 | 4/nd - 6 | 13 | 10-130 | --- | nd - 3 | --- | nd - 8 | --- | nd - 3 |
| cadmium (µg/L) | 0.3/0.2 - 0.6 | 0.4/0.3 - 0.5 | 0.5/0.3 - 0.7 | nd | nd | 0.7 | 0.7 - 30 | 0 | nd - 1 | 3 | 1 - 6 | 1 | nd - 3 |
| chromium (µg/L) | 3.7/3.2 - 4.6 | 2.8/2.3 - 3.4 | 5.6/4.6 - 7.6 | nd | 0.5/nd - 2 | 7 | <10 - 110 | --- | 3 - 12 | --- | 10 - 27 | --- | nd - 24 |
| copper (µg/L) | 7.6/4.5 - 10 | 8.0/5.5 - 12 | 24/21 - 30 | 6/nd - 23 | 4/nd - 21 | 34 | 4 - 560 | 31 | 10 - 44 | 84 | 39 - 130 | 81 | 10 - 340 |
| lead (µg/L) | 3.9/1.2 - 9.3 | 1.4/1.2 - 1.8 | 13/14 -19 | nd | --- | 140 | 3 - 28,000 | 53 | 18 - 95 | 128 | 63 - 170 | 59 | 16 - 150 |
| nickel (µg/L) | --- | --- | --- | --- | --- | 12 | <2 - 126 | --- | 3 - 9 | --- | 7 - 21 | --- | 2 - 12 |
| zinc (µg/L) | 18/10 - 35 | 23/17 - 28 | 37/34 - 42 | --- | --- | 160 | 10 - 5,750 | 182 | 50 - 230 | 520 | 340 - 740 | 294 | 80 - 730 |

nd = non-detect

National Urban Runoff Data is from: Fundamentals of Urban Runoff Management: Technical and Institutional Issues, Richard R. Horner, Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, Terrene Institute, Washington, DC, 1994