MEMORANDUM

To: Big Dry Creek Watershed Association Board of Directors

From: Wright Water Engineers, Inc.
Jane Clary

Date: March 15, 2007

Re: Big Dry Creek Water Quality Summary for 2006

This memorandum summarizes the water quality monitoring program conducted by the Big Dry Creek Watershed Association during 2006, including these topics:

- Data summary and comparison to stream standards
- Key constituents of interest
  - Bacteria
  - Selenium
  - Iron
  - Others
- Flow conditions
- Quality assurance/quality control

Data Summary and Comparison to Stream Standards

During 2006, the cities of Broomfield, Northglenn, Thornton and Westminster (Cities) worked together to collect water quality and flow data along the main stem of Big Dry Creek (Figure 1). Water quality samples were analyzed for a variety of constituents, resulting in over 4,800 records being added into the Big Dry Creek Watershed Association (BDCWA) database. Metals were monitored on a quarterly basis with the exceptions of iron and selenium, which were monitored monthly. All other constituents were monitored on a monthly basis. The Cities and BDCWA also helped to fund operation of the U.S. Geological Survey (USGS) gauging station at Westminster behind Front Range Community College. Key findings related to the 2006 data are the subject of this memorandum.

Three summary tables and multiple figures are attached to this memorandum providing key supporting information for purposes of this water quality assessment, including:

Wright Water Engineers, Inc., 2490 W. 26th Avenue, Ste. 100A, Denver, CO 80211
Tel. 303/480-1700; Fax. 303/480-1020, e-mail:clary@wrightwater.com

- Table 1 identifies the Colorado Water Quality Control Commission (CWQCC) stream standards on Segment 1 of Big Dry Creek, the frequency with which standards were exceeded and whether the stream attained the standard for each constituent.

- Table 2 provides a summary of the numbers of samples collected and the average, minimum and maximum concentrations for each constituent at each monitoring location. The relevant regulatory statistic (e.g., 85th percentile) for constituents with stream standards is also provided.

- Table 3 provides a summary of the quality assurance (QA) sampling and analyses conducted during 2006.

Attainment of stream standards is evaluated based on comparison of specific statistical values to chronic stream standards and determining whether acute standards are exceeded in any samples. For most constituents, the relevant statistic for comparison to the chronic standard is the 85th percentile value. Exceptions include use of the 50th percentile value for metals with standards in the total recoverable form, the geometric mean for *E. coli* and fecal coliform, and the 15th percentile value for dissolved oxygen (DO) and the lower acceptable range for pH. (*It should be noted that from a regulatory perspective, five years of data would be used in such a comparison*.)

In keeping with the Colorado Water Quality Control Division's (CWQCD's) current wastewater discharge permits for Broomfield and Westminster, a hardness value of 256 mg/L was used to calculate the hardness-based stream standards. The CWQCD used a value of 359 mg/L for the city of Northglenn's permit. The mean hardness value for the stream as a whole during 2006 was 342 mg/L. Figure 2 shows relatively high hardness values upstream of the wastewater discharges, as well as in the lower portion of the creek in the agricultural area.

Segment 1 (the main stem) of Big Dry Creek is listed on the 2006 303(d) List for Colorado for non-attainment of stream standards for fecal coliform, *E. coli* and selenium. Each of these constituents has a temporary modification to the stream standard currently in place. Additionally, a portion of the stream downstream of the Weld County line is listed on the Monitoring and Evaluation (M&E) portion of the 303(d) list for total recoverable iron. Based on review of the 2006 BDCWA data set, a summary of findings related to these listings includes:

- Segment 1 of Big Dry Creek does not attain the currently assigned acute or chronic standards for dissolved selenium at bdc1.5. Although the stream segment as a whole attained the temporarily modified chronic stream standard for dissolved selenium, it did not meet the underlying chronic standard at any monitoring location on the stream except at the upstream-most location (bdc0.5).

- Although the overall stream segment met the temporarily modified fecal coliform and *E. coli* standards, the stream slightly exceeded the underlying (unmodified) *E. coli* standard. The geometric mean concentrations of *E. coli* for the past five years exceeds the underlying stream standard at all locations on the stream except for bdc1.0 and bdc4.0.

- Total recoverable iron met the stream standard at all locations during 2006; however, the five-year 50th percentile value of 1.17 exceeds the stream standard at bdc6.0.

- One sample at bdc6.0 in the agricultural area detected mercury above the acute standard; however, this site does not have a history of detections of mercury.

- Due to uncertainty related to the regulatory status of the new total ammonia standard, compliance with this standard was not assessed. The stream continues to comply with the pre-2006 unionized ammonia standard.

- All other constituents attained the stream standards during 2006.

As a general note, the Big Dry Creek monitoring program is an ambient-based program. Nine of the twelve sampling dates occurred during dry weather conditions, with three sampling events within a day following rain or snow in March, May, and October. The July and September sampling events occurred several days after precipitation events and may represent conditions under the tail end of the hydrograph.

Selenium

Dissolved selenium concentrations during 2006 exceeded the underlying chronic stream standard of 4.6 µg/L at all locations on the creek except for bdc0.5 (below Standley Lake), based on comparison of the 85th percentile value at each monitoring location to the stream standard as shown in Figure 3. The 85th percentile value met the temporary modification to this standard of 11 µg/L, which was assigned by the CWQCC in 2004, at all locations except bdc1.5. Two exceedances of the acute dissolved selenium standard also occurred at bdc1.5 during January (21 µg/L) and February (19 µg/L). During 2003 through 2005, similar trends were present on the stream. Figures 4a and 4b demonstrate seasonal variation in selenium concentrations during 2006 with lower concentrations during the irrigation season (May-October) and higher concentrations during the non-irrigation season (November-April). (Based on review of stream gage data, it appears that irrigation releases from Stanley Lake in April did not begin until after the April 2006 sampling event; therefore, April was included in the non-irrigation season graph.) Monitoring location bdc1.5 is located just downstream of Front Range Community College, upstream of both the wastewater discharges and agricultural influences.

During 2005-2006, the BDCWA worked to develop a better understanding of selenium sources in the watershed and provided a technical memorandum to the CWQCD regarding study findings in December 2006 (WWE 2006a). BDCWA requested an ambient based standard for selenium based on the study findings. The 2006 sampling results for selenium remain consistent with the technical memorandum provided to CWQCD. The executive summary of the memorandum (WWE 2006a) summarizes the findings as follows:

> *The Big Dry Creek Watershed Association (BDCWA) has conducted research and field sampling to develop a better understanding of selenium concentrations in Big Dry Creek, as well as to identify potential sources of selenium in the*

> *watershed. This memorandum presents the results of these efforts, which included review of geologic conditions, biological data, groundwater data and supplemental sampling of tributaries, springs, wells and ponds throughout the Big Dry Creek watershed, among other activities. Based on the body of data assimilated, analyzed and presented in this technical memorandum, elevated selenium in the Big Dry Creek watershed is believed to be due primarily to naturally occurring conditions in the watershed. In particular, the data indicate that the reach of the stream with the highest concentrations of selenium is most likely attributable to elevated selenium in groundwater contributing to stream flows. The dominant land use adjacent to this stream reach is unirrigated open space. Although land use in the lower watershed is irrigated agriculture, selenium concentrations do not increase or show significant seasonal patterns in this portion of the stream. Selenium concentrations in Big Dry Creek appear to be diluted by wastewater discharges from Broomfield and Westminster, as well as from releases from Standley Lake during the irrigation season.*

From a regulatory perspective, it is important to note that EPA's revised criteria for selenium were issued in draft form in 2004 and are tentatively scheduled to be finalized in 2008. Revised selenium criteria, whatever they may ultimately be, would not be adopted into the *Basic Standards and Methodologies for Surface Water* (Basic Standards) until 2010 and would not be incorporated into Big Dry Creek's Stream Standards until 2014. Elevated selenium on Big Dry Creek was listed as a "low priority" on the 2006 303(d) list. Nonetheless, because Big Dry Creek has a temporary modification in place, the BDCWA moved forward with completing analysis of selenium conditions to develop a better scientific understanding of sources and impacts of selenium on the creek. The monthly water quality monitoring data and fish tissue sampling will continue to support this effort. Findings from fish tissue analysis are expected to become available in May 2006.

One final note with regard to selenium data analyzed during both 2005 and 2006 is that a subset of the samples was collected at two separate laboratories: ACZ and the Broomfield Wastewater Treatment Plant (WWTP) laboratory. The variation in sample results between the two laboratories averaged 16 percent in 2005 and 12 percent in 2006. During 2006, mean concentrations between the two laboratories varied by only 0.0002 mg/L, and there was not a systematic difference between the two (Figure 5). The ACZ data set was used for purposes of the discussion in this memorandum due to the larger sample size. In the future, WWE believes that it would be acceptable to use the Broomfield WWTP as the sole analysis laboratory for selenium so that funds associated with outside laboratory costs can be allocated toward other purposes such as fish tissue analyses.

Bacteria

Since 2001, the Basic Standards have contained a dual standard for fecal coliform and *E. coli*; the standard was changed to solely *E. coli* in June 2005 (CWQCC 2005). Because fecal coliform is still listed in WWTP discharge permits to Big Dry Creek and in the Segment 1 stream standard, BDCWA has continued to monitor both constituents; however, fecal coliform is

expected to be removed from the Segment 1 stream standards at the next triennial review for the South Platte basin. BDCWA now has seven years of *E. coli* data, so primary emphasis regarding trend analysis in this memorandum is focused on *E. coli*. Additionally, *E. coli* and fecal coliform trends from 2000-2006 have been comparable. Based on review of geometric mean concentrations during the past five years (Figure 6), the following observations are noteworthy:

- Geometric mean concentrations for both *E. coli* and fecal coliform are the lowest in grab samples from the Broomfield and Westminster WWTP effluent. For the five-year time period, wastewater grab samples were well below the stream standard. For this reason, elevated geometric mean concentrations at in-stream locations below the discharges cannot be attributed to WWTP discharges during the vast majority of the sampling events.

- The highest concentrations of both *E. coli* and fecal coliform are present at bdc2.0, below the Broomfield WWTP. The five year geometric mean exceeds the temporarily modified standard of 401/100 mL at this location, whereas all other locations meet the modified standard. The underlying standard of 205/100 mL is exceeded for the five-year period at all locations except bdc4.0.

- During 2006, *E. coli* and fecal coliform concentrations were higher than typically observed at upstream open space locations bdc1.0 and bdc1.5 (Figures 7 and 8). In general, it appears that concentrations at these locations are increasing. An increase in beaver activity and dams has been noted in this area by Westminster Parks staff, Aquatics Associates, and city field staff in this area. In recent guidance by the U.S. Environmental Protection Agency (EPA) and the American Water Works Association (AWWA) (2006), beavers have been identified as a significant source of pathogens.

- Multi-year data plots show that the drought conditions in 2002 continue to show the highest *E. coli* and fecal coliform concentrations at each monitoring location (Figures 7 and 8).

- Seasonal variation is evident (Figure 9) for 2006, which is consistent with previous analyses conducted by BDCWA that showed that *E. coli* from 2000-2005 had geometric mean concentrations above the underlying stream standard during April through November and above the temporarily modified standard for June through October (WWE 2006b). The 2000-2005 analyses showed that although bdc6.0 also exhibits a seasonal trend, concentrations in the winter months still remain above the underlying stream standard at this location.

Iron

Total recoverable iron concentrations during 2006 attained the stream standard of 1 mg/L based on the 50^{th} percentile value for the overall stream (Figure 10). Nonetheless, about 20 percent of the samples collected (i.e., 18 out of 96 samples) exceeded the standard, with the elevated concentrations generally corresponding to a precipitation event in March and several days after

an event in September (Figure 11). As shown in Figure 12, total recoverable iron and total suspended solids are well correlated to each other, as has been the case in previous years. The 2006 data do not show the strong trend of increasing iron in a downstream direction, which has been consistently present in previous years. This may be due to the fact that fewer sampling events in 2006 followed significant storm events that led to increased sediment loading in a downstream direction.

As previously noted, the CWQCD placed Segment 1 of Big Dry Creek on the Monitoring and Evaluation List because one location on the stream, bdc6.0, does not meet the stream standard. As shown in Figure 13, the 50th percentile value for 2002 through 2006 at bdc6.0 is 1.17 mg/L, exceeding the stream standard. Although the highest concentrations (5-13 mg/L) over the past five years at bdc6.0 occurred during the April to July time period and are believed to be associated with sediment loads associated with summer storm events and irrigation activities, concentrations at this site have historically been elevated above the standard throughout all months of the year, even in the absence of these activities, based on previous analysis (WWE 2006b). The stream in the lower watershed is actively eroding and has unstable banks in multiple locations based on 2005 field visits. Iron that naturally occurs in the streambanks is expected to be the probable source of elevated iron in the lower watershed.

Other Constituents

Ammonia

Stream standards for ammonia on Big Dry Creek are undergoing changes. In June 2005, the CWQCC adopted revised ammonia criteria for the Basic Standards based on EPA's *1999 Update of Ambient Water Quality Criteria for Ammonia*. The new criteria are in the form of total ammonia and are more stringent for warm water streams. During the March 13, 2007 Rulemaking Hearing, the WQCD proposed temporary modifications to WWTP discharge permits, including the cities of Broomfield, Westminster and Northglenn to remain at the "old" ammonia standard until December 31, 2011. This proposal was based on the CWQCC's acknowledgement that there is substantial uncertainty regarding the appropriateness of and cost of compliance with the new criteria. The temporary modification allows time to reassess what standards are appropriate on a site-specific basis and also provides dischargers additional time to address treatment facility modification that may be needed (CWQCD 2007). Total ammonia concentrations for Big Dry Creek are plotted in Figure 14. Dr. Bill Lewis at University of Colorado is conducting a more detailed analysis of the total ammonia standards for the wastewater dischargers on Big Dry Creek.

Unionized ammonia concentrations were well below the "old" stream standards in 2006, as shown in Figure 15. Like 2003 through 2005, the stream continued to show an improvement in unionized ammonia conditions in the creek relative to 2002, when the 85th percentile value exceeded the chronic standard and several exceedences of the acute standard occurred. During 2002, several of these exceedances were attributed to operational challenges during the Broomfield WWTP plant expansion and upgrade, which is now complete. The 2003 through

2006 data are relatively consistent with Big Dry Creek data prior to 2002, which indicated very few unionized ammonia concentrations above the stream standard.

Nitrate

Although Big Dry Creek does not have a drinking water classification or a corresponding in-stream nitrate standard, the Middle South Platte River Segment 1 downstream of Big Dry Creek has a drinking water classification and a nitrate standard of 10 mg/L. This standard is applied based on a single day combined total of nitrite and nitrate at the point of intake to the domestic water supply. Figure 16 provides a scatter plot of nitrate grab samples collected at the farthest downstream sampling point (bdc6.0) in the Big Dry Creek monitoring program. The scatter plot indicates that over the past five years, nitrate grab samples reached or exceeded 10 mg/L seven times at this location, or in about 12 percent of the samples. From another perspective, Figure 17 shows that, at the confluence with the South Platte River, Big Dry Creek average nitrate concentrations were below 10 mg/L with an average concentration of 6.6 mg/L over the last five years. Figure 17 shows that grab samples from the Broomfield (bdc10.0) and Westminster (bdc11.0) wastewater discharges are higher than the downstream drinking water standard; however, dilution from stream flows and natural losses associated with the nitrogen cycle result in lower concentrations at the confluence with the South Platte River. Additionally, no samples from Northglenn's WWTP effluent were included in the 2006 analysis because Northglenn did not discharge to Big Dry Creek in 2006 during BDCWA sampling events, but this may change in the future and could influence concentrations at bdc6.0.

Phosphorus

The Barr-Milton Watershed Association (BMW) is addressing pH exceedances in the Barr-Milton reservoir system. These pH exceedances are attributed to excessive algal growth from nutrient loading. BMW is establishing a database for modeling conditions in the reservoirs and has requested water quality data from Big Dry Creek to include in their modeling effort. Since most Front Range reservoirs with these types of concerns have ultimately been assigned either a total phosphorus or chlorophyll-a standard, phosphorus data collected during 2006 for Big Dry Creek have been plotted on Figure 18 for general reference. For purposes of a general frame of reference, WWTPs discharging to Front Range reservoirs such as Chatfield, Bear Creek and Cherry Creek have total phosphorus discharge limits ranging from 0.2 to 1 mg/L in their discharge permits.

Mercury

All samples analyzed for mercury were below detection limits with the exception of one sample collected at bdc6.0 (agricultural area) on September 14, 2006. No trend of elevated mercury is present at this site, so at this time, no further action is recommended other than continued observation of mercury at this location.

Temperature

At the January 2007 CWQCC Rulemaking Hearing, the CWQCC adopted new temperature standards that take effect on July 1, 2007. Because Big Dry Creek is in the South Platte River Basin in a warm water stream, temporary temperature standards of 30 degrees C will be in place until December 31, 2009; however, much more restrictive standards will potentially apply in the future, with potential implications for WWTP discharges on Big Dry Creek. Figures 19a and 19b show how 2006 temperatures compare to standards that may be applied to Big Dry Creek in the future. Because of the documented presence of the common shiner (and occasional Johnny darter) on Big Dry Creek, relatively low temperature standards could potentially be applicable. More detailed analysis of the implications of the temperature standards will be needed in the future due to potentially significant implications to WWTP dischargers on the creek. One provision of the temperature standards that could be worth exploring for Big Dry Creek includes the following:

> *No temperature effluent limit will be applied if a discharge is to an effluent dependent stream and there is no evidence that the aquatic life use may be negatively affected by the thermal component of the discharge. In implementing this provision, the Division will consider all readily-available and pertinent evidence regarding the potential for the thermal properties of a discharge to affect aquatic life.*

Additional temperature monitoring will likely be needed in the vicinity of the WWTP discharges on Big Dry Creek, along with an integrated review of fish sampling conducted to date on Big Dry Creek. Opportunities for potential inclusion of temperature probes in Broomfield's proposed new gauging stations on Big Dry Creek could also be beneficial.

Flow

Annual average instantaneous flow measurements collected by the Big Dry Creek cities during monthly sampling since 1997 are provided in Figure 20. These data suggest that streamflows are recovering from drought conditions upstream of the Westminster WWTP. Downstream of the Westminster WWTP, flows appear somewhat lower, which could reflect changes in WWTP discharges due to reuse programs being implemented in the watershed. Care must be taken when drawing conclusions based on comparison of average flows because during high flow conditions, field staff do not measure flows for safety reasons.

The available USGS flow data for the Westminster and Fort Lupton gauges during 2006 are shown in Figures 21 and 22. During 2006, average daily flows at the Westminster gauge ranged from 0.37 cfs to 80 cfs with an average of 9 cfs. Average daily flows for the Fort Lupton gauge data ranged from 3.6 cfs to 136 cfs with an average of 37 cfs. The range of flows was lower in 2006 than is typically experienced on Big Dry Creek, with average flow values lower at the Westminster gage and comparable to the last several years at the Fort Lupton gage. The occurrence of "high" flow conditions that have previously raised concerns from downstream landowners were not present during 2006. (Gauged flows of around 270-325 cfs have historically raised concerns.) Releases from Standley Lake appear to have begun roughly the

last week of April/first week of May. Somewhat unusual December releases from Standley Lake also occurred, presumably due to heavy snowfall conditions associated with the blizzards during December.

The City of Broomfield is planning to install several new gages on the creek which should be helpful in better assessing flow conditions in the future.

Quality Assurance/Quality Control

During 2006, quality assurance/quality control (QA/QC) procedures were followed for the sampling program in accordance with the Big Dry Creek Sampling and Analysis Plan (BDCWA 2003). Under this program, field blanks are analyzed for the full suite of constituents in March, a full set of duplicate analyses are completed in September, and during June and December, field duplicates are analyzed for four locations (bdc1.5, bdc2.0, bdc3.0 and bdc5.0) for constituents of concern (selenium, *E. coli*, ammonia and iron).

Table 3 summarizes analysis of field blank and duplicate samples for 2006. Analysis of relative percent difference (RPD) for the sample duplicates generally shows acceptable accuracy. Several dissolved metals showed higher RPD values than other constituents, but this was typically at low reported concentrations with a magnitude roughly comparable to or less than the laboratory detection limit, making the variability unremarkable. For constituents such as *E. coli*, greater variability was typically measured, which is characteristic of these types of analyses.

Field blank analyses were within acceptable concentrations with the exception of the dissolved selenium analysis completed at the ACZ laboratory, which had a reported value of 0.002 mg/L.

Recommendations

1. The BDCWA should continue to monitor *E. coli* conditions along the creek and participate in regional efforts to better understand non-point sources of bacteria and potential methods to address these sources. Given the high priority status of bacteria on the 303(d) list, the BDCWA should continue to move forward with plans to conduct field investigations and collect samples in areas of consistently high bacteria, such as the reach of stream between bdc1.0 and bdc2.0. General recommendations for this analysis include:

    - Collect samples in general accordance with the CWQCD sample guidance dated February 15, 2007, or as updated by the CWQCD.

    - Focus initial efforts on the reach of stream between bdc1.0 and bdc2.0, which is readily accessible by bike path.

    - Coordinate dry weather sampling events with municipal stormwater permit holders, who have mapped outfall locations to Big Dry Creek.

    - Remain involved with the South Platte *E. coli* task force and potentially the Water Quality Forum work group on this issue.

2. For purposes of cost savings, WWE believes that it would be acceptable to stop contract laboratory analysis of selenium and use the Broomfield WWTP lab instead. WWE also concurs with Westminster's recommendation to drop fecal coliform sampling, focusing solely on *E. coli*.

3. WWE recommends continued participation in temperature work groups and possibly temperature monitoring based on ongoing work by the Water Quality Forum, the Division and others on this topic.

4. WWE recommends no further special studies regarding selenium, with the possible exception of biennial fish tissue analyses, until a response is received from CWQCD regarding the technical memorandum submitted in December 2006.

References

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TABLES

FIGURES