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Streams~Wetlands~Water Resources

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Memorandum

Date: May 26, 2009

To: Manuel Montoya, FRICO
Laurie Rink, Mile High Wetlands Group

From: Heather Thompson

Re: **Review of Barr Lake Water Balance for Water Quality Evaluation**

A water quality assessment was completed for Barr Lake and the Burlington O'Brian Canal by AMEC Earth & Environmental (AMEC, 2008). At the request of Manuel Montoya and Laurie Rink, the hydrologic data and water balance that was conducted for Barr Lake and the Burlington O'Brian Canal to support the water quality assessments were reviewed.

BARR LAKE

Table 4 of the AMEC report presents a summary of average annual inflow to Barr Lake from the Burlington-O'Brian Canal and total releases from Barr Lake for the period from 1985 through 2005. Tables 9, 10 and 11 of the AMEC report present hydrologic data for a Barr Lake water balance, which was developed by Duane Helton from FRICO records. The water balance was conducted for Barr Lake for irrigation years 2000 through 2005. Each of the following terms of the Barr Lake water balance were reviewed and compared with values for the longer period of record in Table 4.

Inflows

1. Burlington-O'Brian Canal
2. Precipitation
3. Subsurface Inflow

Outflows

1. East Outfall
2. West Outfall
3. Beebe Canal Releases
4. Toe Drain Seepage
5. Subsurface Losses
6. Evaporation

Inflow Terms

Table 9 in the AMEC report shows the average annual inflow to Barr Lake from the Burlington-O'Brian Canal is 40,181 AF for the period from 2000 through 2005. This compares reasonably well with the annual average for the period from 1985 through 2005, which was 45,020 AF.

Table 9 in the AMEC report shows the average annual inflow to Barr Lake from precipitation is 1,938 AF based on precipitation records for Denver International Airport. This value appears reasonable, however, it may be slightly high since the average annual precipitation at the Brighton weather station, which is located closer to Barr Lake, is approximately 1 in/yr less.

Table 9 in the AMEC report shows the average annual subsurface inflow from the Denver-Hudson Canal to Barr Lake is 945 AF based on 8% of the deliveries to the Denver-Hudson Canal. This value appears reasonable, however, it may be slightly high given the length of the canal adjacent to Barr Lake and the total losses along the Denver-Hudson Canal from the Barr bifurcation to Horse Creek Reservoir.

Outflow Terms

Table 10 in the AMEC report shows the total average annual release from Barr Lake to the east and west outlets and Beebe Canal was 28,586 AF for the period from 2000 through 2005. This is approximately 3,500 AF less than the average release from 1985 through 2005.

Table 10 in the AMEC report shows the average annual toe drain seepage was 3,004 AF, which equates to a daily average of approximately 4 cfs. Toe drain seepage varies based on the contents in the reservoir and is highest when the reservoir is full. The estimate of toe drain seepage used in the water balance appears reasonable since toe drain seepage typically ranges from about 2 to 4 cfs.

Table 10 in the AMEC report shows the average annual evaporation was 5,140 AF. Assuming an average surface area of approximately 1,400 acres and an average annual gross evaporation rate 41 inches, the annual evaporation from Barr Lake would be approximately 4,800 AF. The estimate of evaporation used in the water balance appears reasonable.

Table 10 in the AMEC report shows the average annual subsurface loss from Barr Lake was 7,186 AF. Duane Helton concurs with AMEC's estimate of subsurface losses from Barr Lake.

Previous Barr Lake Water Balance

A similar water balance was conducted for Barr Lake by Hydro-Triad for the Beebe Draw Diversion and Augmentation Program (Hydro-Triad, 1984). The water balance for the AMEC study was completed for the period from 2000 through 2005 while the water balance completed by Hydro-Triad was for the period from 1927 through 1981. The following table compares the two balances.

Water Balance Terms	AMEC Study	Hydro-Triad
Inflows		
Burlington O'Brian Canal	40,180	37,950
Precipitation	1,938	1,260
Subsurface Inflow	945	0
Total Inflow	43,063	39,210
Outflows		
Total Release	28,586	27,550
Seepage (toe drain & Subsurface)	10,190	7,890
Evaporation	5,139	3,720
Total Outflow	43,915	39,160

In general, the two water balances compare reasonably well given that they cover two different study periods. The Hydro-Triad estimate of average toe drain and subsurface losses is 7,890 AF/yr which is 2,300 AF/yr less than the estimate presented in the AMEC study.

Burlington O'Brian Canal Water Balance

A water balance was conducted around the Burlington-O'Brian Canal for the period from 2001 through 2005 for the AMEC study. Sources of inflow into the canal include diversions from the South Platte River, pumping from the MWRD, and storm water runoff from the canal watershed. Outflows from the canal include waste gate outflows, deliveries to Thornton, SACWSD, the Little Burlington Canal, the Denver-Hudson Canal, and Barr Lake, and conveyance loss. The following table presents average annual values for the inflow and outflow terms for the period from 2001 through 2005.

<u>Inflow Terms</u>	<u>Average</u>
South Platte Diversion	109,900 AF
MWRD Facility	14,333 AF
Storm Water Inflow	10,595 AF
Total Inflow	134,828 AF

<u>Outflow Terms</u>	<u>Average</u>
Waste Gate Outflow	15,942 AF
Deliveries to Thornton	8,522 AF
Deliveries to SACWSD	846 AF
Deliveries to Little Burlington	10,874 AF
Deliveries to Denver-Hudson	27,250 AF
Deliveries to Barr Lake	41,072 AF
Conveyance Loss	30,322 AF
Total Outflow	134,828 AF

The bulk of the inflow and outflow terms reflect flow measurements, therefore, the terms which were reviewed in detail consist of values that were calculated as opposed to measured.

The South Platte River diversion was calculated to be the Sand Creek Flume minus MWRD pumping plus the waste gate flow. The AMEC report acknowledges that there is concern regarding the level of accuracy of the measurement of the waste gate flow. The AMEC report states that the waste gate flows may be under-estimated, however, this is the best data available.

The average annual storm water inflow to the Burlington Canal of 10,595 AF appears very high. During the summer of 2002 there was very little precipitation, yet the inflow from storm water runoff was estimated to be 8,038 AF. FRICO staff indicate that First, Second and Third Creeks and the watershed above the Burlington Canal do not contribute a significant amount of runoff into the canal during the majority of storm events. The estimate of storm water runoff does not appear consistent with what FRICO staff has observed historically. Duane Helton believes there may be an error in the estimate of storm water inflows due to the uncertainty in flow measurements at the Barr Lake bifurcation. The weir at the inlet to Barr Lake becomes submerged when the Barr Lake gage height exceeds approximately 29.0 feet. When this occurs, the inflow to Barr Lake must be estimated. If the inflow to Barr Lake is inaccurate, this results in errors in the storm water inflow term in the mass balance calculation of inflows minus outflows for the Burlington Canal.

Conveyance losses were assumed to be 28% of the flow in the Burlington Canal. Recent accounting data for 2006 through 2008 suggests that these losses may be less due to improvements that have been made to the canal from the headgate to Barr Lake. To the degree that conveyance losses are less, the total average annual outflow from the Burlington O'Brian Canal would be less. This would reduce the average annual contribution from storm water runoff since the remaining outflow terms are measured values.

Summary

The data used for the Barr Lake water balance presented in the AMEC report was reviewed and compared with a previous water balance conducted by Hydro-Triad. The average annual values for the inflow and outflow terms appear reasonable and compare well with the previous water balance conducted by Hydro-Triad.

The water balance conducted for the Burlington O'Brian Canal presented in the AMEC report was also reviewed. The estimated average annual inflow to the Burlington Canal from storm water runoff of 10,595 AF appears too high given the period from 2001 through 2005 contained 2002 and 2004, which were dry years. The estimate of storm water runoff also does not appear consistent with what FRICO staff have observed historically. The error in the estimation of storm water inflow is most likely due to the uncertainty in flow measurements at the Barr Lake bifurcation. The estimated average annual conveyance loss from the Burlington Canal also appears high based on recent accounting data and improvements made to the canal. If the average annual

conveyance loss was less, the contribution from storm water runoff would be less by a commensurate amount. However, despite these possible discrepancies, it does not appear that differences in the magnitude of these values would significantly impact the Phosphorus and Nitrogen balances, which were conducted.

The water balance conducted by AMEC was based on data from 2000 through 2005. Since that time, several improvements have been made to flow measurement and data recording devices throughout the Barr Lake system. For example, an additional weir was installed at 120th Street along the Burlington Canal to provide a better estimate of inflow to Barr Lake when the weir at the inlet to Barr Lake is submerged. The Barr Lake staff gage has been resurveyed to allow for more accurate measurements of storage contents on a daily basis. In addition to improvements in flow measurement devices and structures, the accounting of inflows and outflows in the Barr Lake system has also been improved and expanded significantly as a result of several on-going water court cases. Recent improvements in flow measurement and accounting since 2007 will significantly improve the accuracy of the water balance information that is relied on for water quality analyses.

References

AMEC Earth and Environmental. May 2008. Milton Reservoir Water Quality Assessment Weld County, Colorado.

Hydro-Triad. 1984. Beebe Draw Diversion and Augmentation Program Report No. 1 The Water Resources of Beebe Draw.