Description of Lovewell net evaporation and Courtland Canal outflow charged to Republican River

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**Summary**

This note is in response to Willem’s request for us to clarify how we calculate CBCU charges to the Republican River for Lovewell reservoir evaporation and diversions to Courtland Canal below Lovewell. These CBCU charges have been calculated annually in sheet Computations of Excel files Lovewell\_Ops\_YYYY.xls for years YYYY = 2003 to 2017 according to a procedure that maintains storage accounts for both Republican R (RR) and White Rock C (WRC) inflows with monthly time steps. For years 1995-2002, a simpler procedure was used to calculate these charges retrospectively with annual time steps in file Lovewell1995-02.xls. Based on a review of these procedures, we propose to use the simpler

CBCU charges to Kansas associated with Lovewell Reservoir evaporation of Republican R water and diversions to Courtland Canal below Lovewell are identified in RRCA Accounting Procedures under Part B.15, “Specific Formulas” for the North Fork and the Main Stem. The FSS Appendix C specifies that net evaporation be split according to inflows from Republican R via Courtland Canal and White Rock Creek.

form of CBCU calculations with annual time steps as implemented in the file Lovewell1995-2017.xlsx.

Some of the data sources for the updated version differ from the original 1995-2002 calculations. For the update, WRC inflow is given by flow at the USGS Burr Oak gage instead of BOR calculated WRC inflow; and total Lovewell outflow is based on BOR instead off the USGS gage below Lovewell, which terminated operation in September 2002.

Entries to the RRCA compliance accounting Input sheet include the following three items:

RR inflow from Courtland Canal to Lovewell (cell J19): line 269

Net reservoir evaporation assigned to RR (EvapRR, cell O19): line 228

RR water diverted to lower Bostwick district (cell S19): line 270

**Data sources and calculations**

RR Inflow from Courtland Canal is given by sheet ‘C-LOV’ of BOR file BOST-MISC3MWD.xlsx.

White Rock Creek (WRC) inflow to Lovewell is assumed to be the flow at Burr Oak, USGS gage 06853800.

Lovewell discharge to lower KS Bostwick District [BOR: from sheet ‘C-BELOW’, file KS-BOST3MWD.xlsx (Courtland Canal, Mile 38.0).

Lovewell reservoir Net evaporation (= evaporation – direct precipitation) is calculated in sheet Net\_Evap, file Lovewell.xls.

[A question for EC: why is precipitation subtracted? Since direct precipitation on the reservoir is included in the forebay elevation measurement, is precipitation counted twice?]

The fraction of net evaporation charged to RR is given by the RR inflow fraction, RR / (RR + WRC).

RR diversions to the Bostwick district below Lovewell are given by the minimum of (a) RR inflow to Lovewell minus RR evaporation charge, and (b) Lovewell discharge to the lower district. This is based on the assumption that all spills to WRC are from WRC water, consistent with original calculations for 1995-2002 (file Lovewell1995-02.xls).

The above data and calculations are in sheet RR\_CBCU, columns a through k of Excel file Lovewell1995-2017.xlsx; values for the previous versions are in columns P:W. The following descriptions for columns a through k are repeated in sheet Doc of the Excel file.

1. Calendar year
2. Lovewell Net evaporation (NetEvap), [EC]: calculated in sheet Net\_Evap of file Lovewell.xlsx, given by Lovewell evaporation – direct precipitation as prescribed by RRCA EC for federal reservoirs.
3. RR Inflow from Courtland Canal [BOR: sheet ‘C-LOV’, file BOST-MISC3MWD.xlsx.] **compliance accounting input line 269.**
4. WRC Inflow [USGS]: mean annual flow at Burr Oak USGS gage 06853800 and converted to acre-feet.
5. Lovewell discharge to lower KS Bostwick District [BOR: from sheet ‘C-BELOW’, file KS-BOST3MWD.xlsx (Courtland Canal, Mile 38.0).
6. Lovewell outflow, af [BOR: file Lov-outfl.xlsx; copy: sheet LVKS\_Out\_AF Lovewell1995-2017.xlsx]
7. fRR = RR/(RR+c\*WRC) [RR: col. C, WRC: col. D, c = A2/A1 = 1.52, ratio of basin drainage areas for USGS White Rock C gages at Lovewell and Burr Oak]
8. RR Evap charge, EvapRR = fRR\*NetEvap (cols. G and B); **compliance accounting input line 228.**
9. Diversion to Lower District = Min (RR – EvapRR, Outflow to lower district) [cols. C, H, E]; **compliance accounting input line 270.**
10. WRC diversion to Lower District = [col. E] – [col. I]
11. WRC spill: Lovewell total discharge – Lovewell discharge to Lower District = [col. F] – [col. E].

**Comparison of results with previous calculation of RR evap charge and diversion to lower district**

Fig. 1 plots annual calculation of the RR evaporation charge with previously calculated results for 1995-2017 that include an annual calculation for 1995-2002 and monthly accounting of stored RR and WRC water for 2003-2017. The comparison shows that the proposed annual calculation of the RR evaporation charge closely approximates the previous calculation with annual time steps for 1995-2002, but differs significantly from monthly calculations based on RR and WRC storage accounts in files Lovewell\_Ops\_YYYY.xls for years YYYY = 2003 to 2017. RR evap charge averaged over 2000-2016 is 1575 ac-ft as revised, compared with 908 ac-ft for original calculations.

Fig. 2 plots annual calculation of RR diversion to the Lower District (column I of RR\_CBCU), and compares these with previously calculated values from Lovewell\_Ops\_YYYY.xls. Discrepancies for 1995-2002 are significant and likely due to the change in data sources for WRC inflow and Lovewell total outflow. Discrepancies in most subsequent years are small, and average RR diversions over 2000-2016 are nearly the same: 26.4 KAF for revised calculations and 26.6 KAF for original calculations.

Fig. 3 superimposes annual plots of RR and WRC inflows to Lovewell, RR evaporation charge, Lovewell discharge to the Lower District and RR diversion to the Lower District.

The following table summarizes inflow to Lovewell from Courtland Canal (RR) and White Rock Creek (WRC); evaporation charged to RR (EvapRR); and diversions to the Lower District below Lovewell from RR and WRC, averaged over years 2000-2016.

Average inflows from RR and WRC to Lovewell, RR CBCU charge for net evaporation and diversions to lower district from RR and WRC; averages over years 2000-2016. [from line 33 of sheet RR\_CBCU]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| units | Inflow to Lovewell | | EvapRR | Diversions to Courtland below Lovewell | |
|  | RR | WRC |  | RR | WRC |
| vol. afy | 28,499 | 13,311 | 1,587 | 26,360 | 10,960 |
| ratios | 68.16% | 31.84% |  | 70.63% | 29.37% |

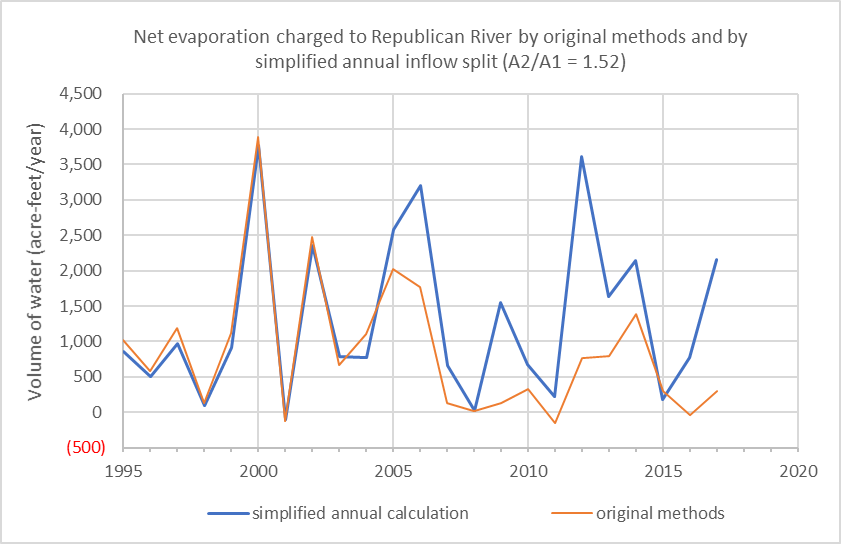


Fig. 1. Lovewell net evaporation charged to Republican River 1995-2017. Comparison of simplified annual calculation based on RR fraction of inflow vs. previous method of tracking RR and WRC storage accounts. [sheet RR\_CBCU at P42 in Lovewell1995-2017.xlsx]

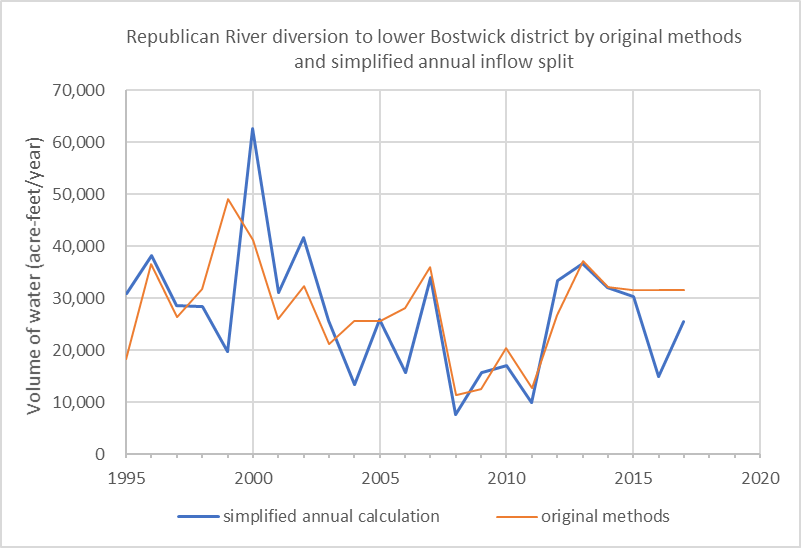


Fig. 2. Republican River diversion to lower Bostwick district 1995-2017. Comparison of simplified annual calculation based on RR fraction of inflow vs. previous method of tracking RR and WRC storage accounts. [sheet RR\_CBCU at P68 in Lovewell1995-2017.xlsx]

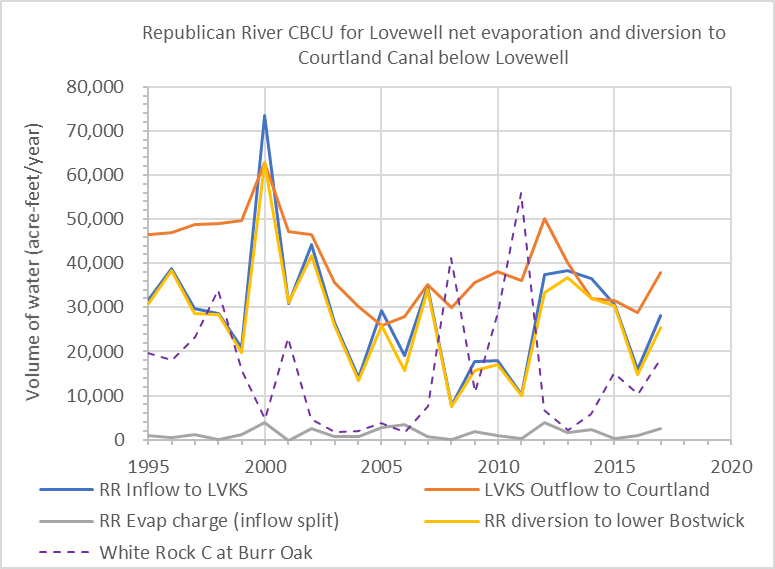


Fig. 3. RR diversion to Courtland bl Lovewell (yellow), RR evap charge (gray), RR inflow (blue), WRC inflow (dashed) and Lovewell discharge to Lower District (orange). [sheet RR\_CBCU at I42 in Lovewell1995-2017.xlsx]