Hendrix Wai Engineering, Inc.

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To: Deb Daniel – Manager – Republican River Water Conservation District

From: Randy L. Hendrix, Ayrton M. Hendrix – Hendrix Wai Engineering, Inc.
Willem Schreuder – Principia Mathematica

Date: January 7, 2019

Subject: Water Balance by Groundwater Management Districts for 1998 to 2017

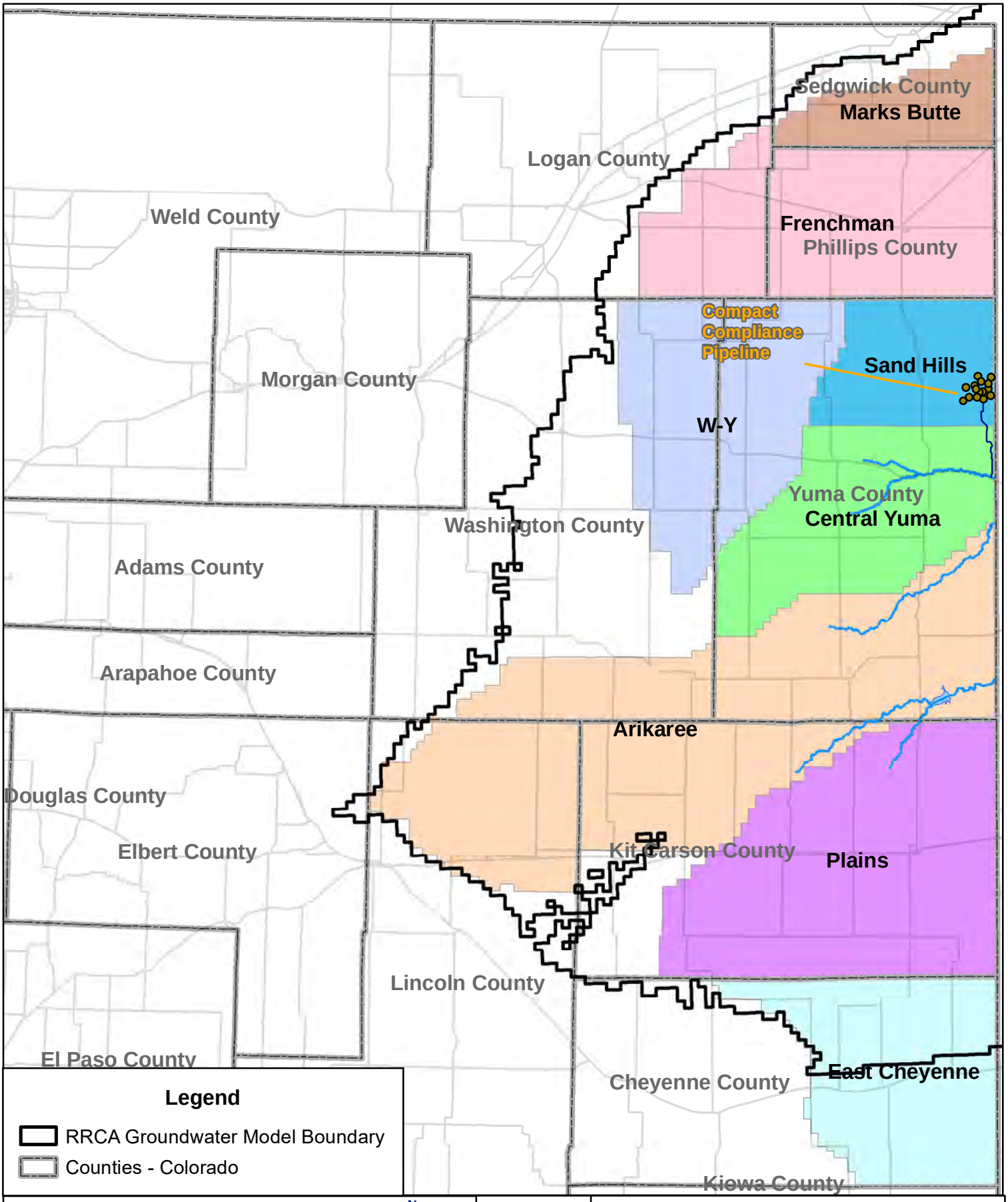
This memorandum summarizes the water balances by groundwater management district for the 20-year period from 1998-2017. Previously, the water budgets were reported for the 1993 to 2012 period by Jim Slattery at the "State of the Basin" symposium held in Wray on March 17, 2014 and 1996 to 2015 period in a memorandum prepared by Jim Slattery, Willem Schreuder, and Randy Hendrix on October 11, 2016. The methodology in preparation of the water budgets has not changed but only extended to include 2017 data. A comparison of the updated water budgets components of total inflow, total outflow, and storage loss to the 1996 to 2015 study period are as follows:

1. A general increase of total inflows of 1.0% (ranging from an increase of 5.4% in Central Yuma District to a decrease of 6.6% in the Marks Butte District);
2. An overall decrease in total outflows of 0.4% (ranging from a decrease of 4.5% in the Plains District to an increase of 2.1% in the Sand Hills District);
3. An overall decrease in groundwater storage loss of 2.4% (ranging from a decrease of 10.5% in the Arikaree District to an increase of 12.7% in the Marks Butte District).

The relatively minor changes to the three components was expected because the updated study period still uses 18 years of the same data, 1998 to 2015. The two years of data from 1995 to 1996 are replaced with the two years of data from 2016 and 2017. As a result, 90% of the data is the same between the two different study periods.

Figure 1 shows the study area for each of the water balances presented in this analysis. Note that the groundwater management districts do not cover the entire High Plains aquifer in Colorado. As a result, the sum of the groundwater management district water balances does not match the water balance for the entire High Plains Aquifer within Colorado. Figure 2 shows the entire modeling domain of the Republican River Compact Administration groundwater model as a point of reference.

The water balances are summarized on a 20-year average for the portion of the High Plains Aquifer in Colorado that is included in the Republican River Compact Administration groundwater model domain and for each individual groundwater management district as shown in Exhibits 1 through 9 with additional bar graphs prepared by Principia Mathematica for each groundwater management district showing the annual water budget components.



Job No. R1601

File: Presentation Figure 1.mxd

Date: 10/11/2016

Prepared For: RRWCD

Figure 1

Colorado Republican River Basin

Republican River Ground Water Model and Groundwater Management Distrtict Boundaries

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Figure 2

RRCA Ground Water Model Domain

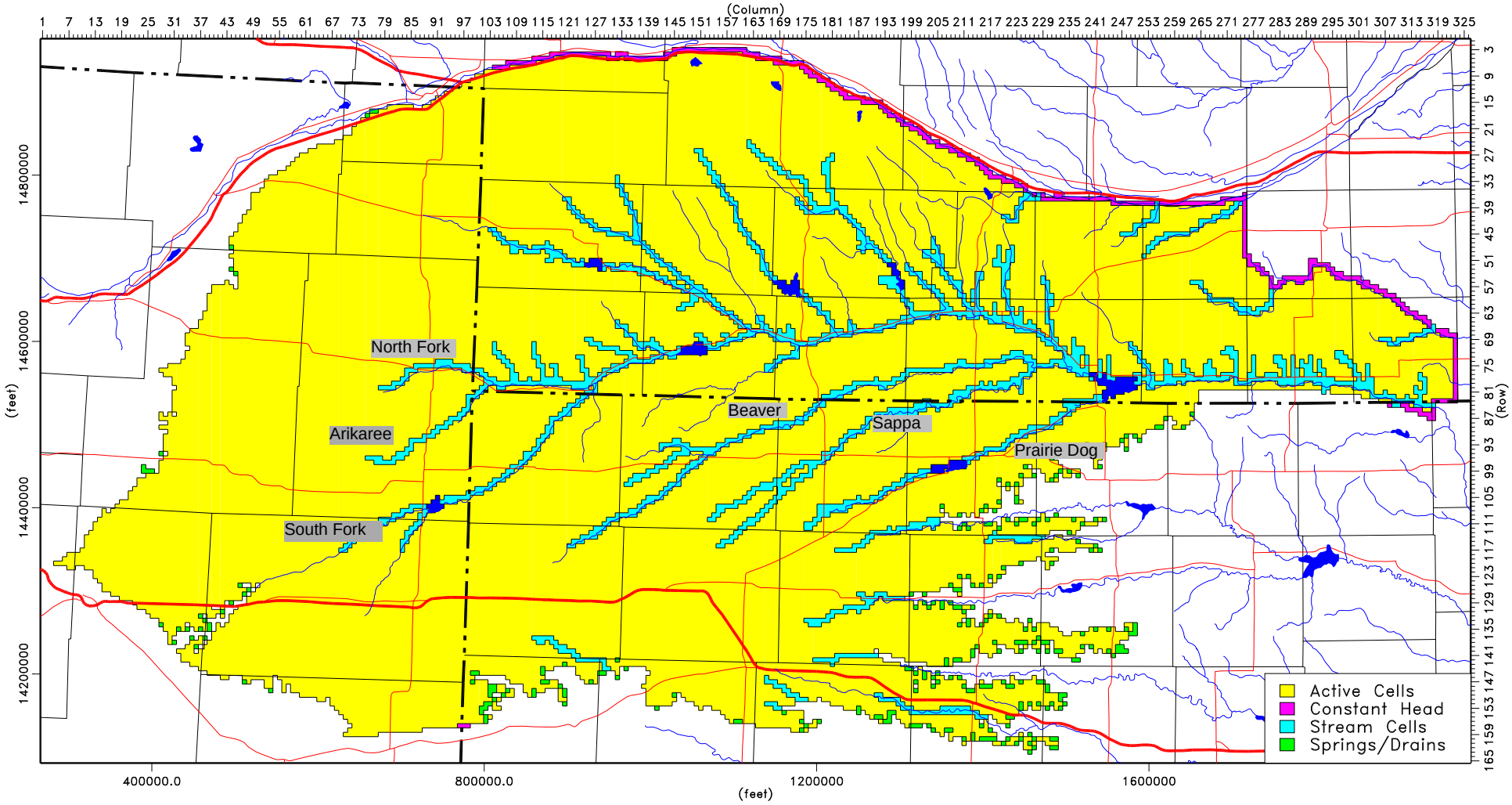
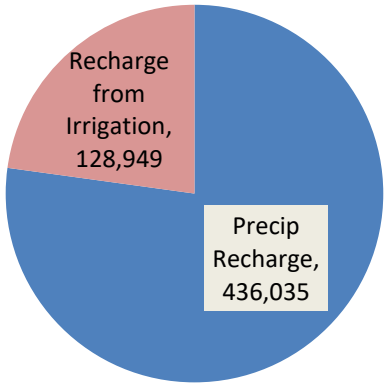
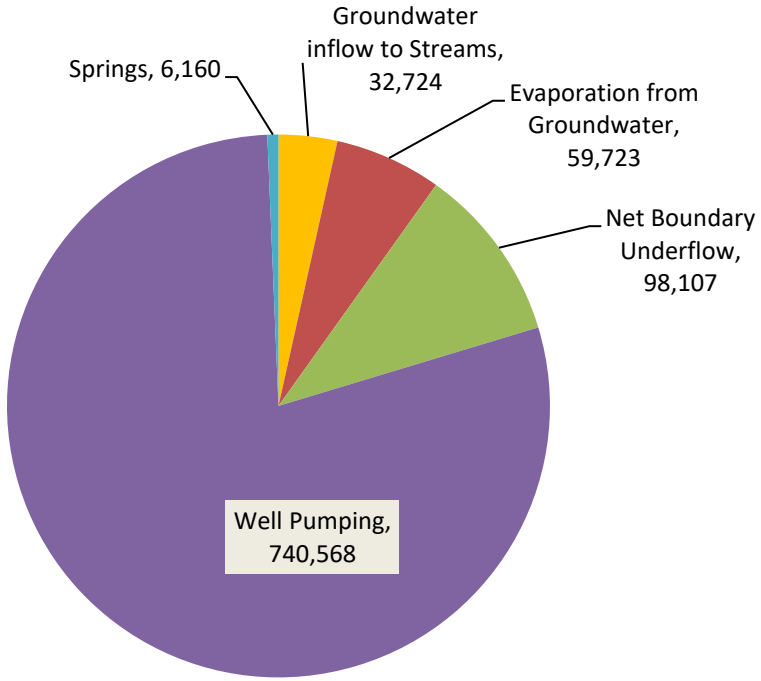


Exhibit 1 - Water Balance for the High Plains Aquifer in Colorado

1998-2017 Average Annual Values in ac-ft/yr

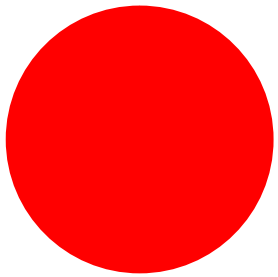


Aquifer Inflow = 564,984



Aquifer Outflow = 937,283

Ground Water Storage Loss = 372,299



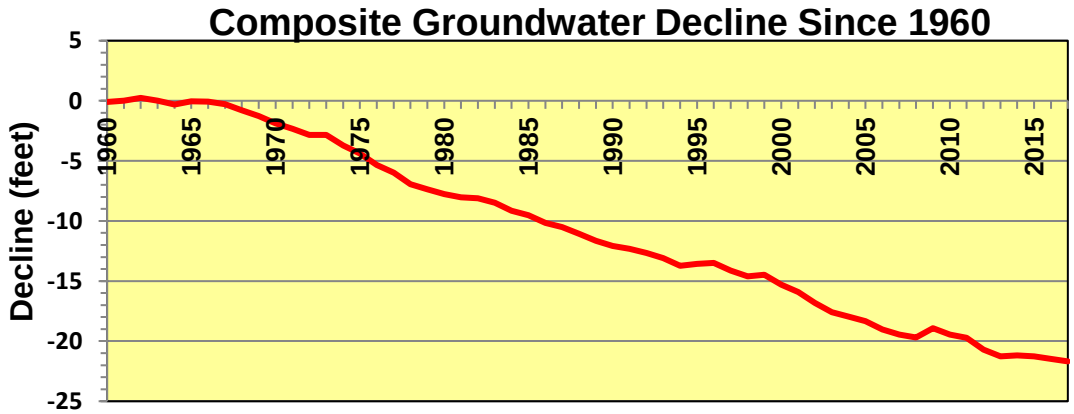
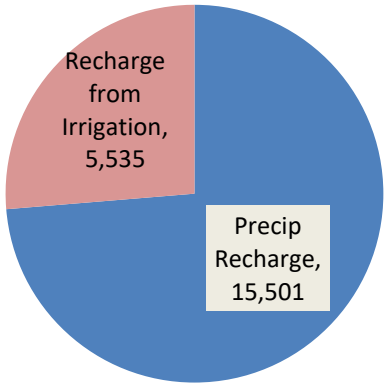
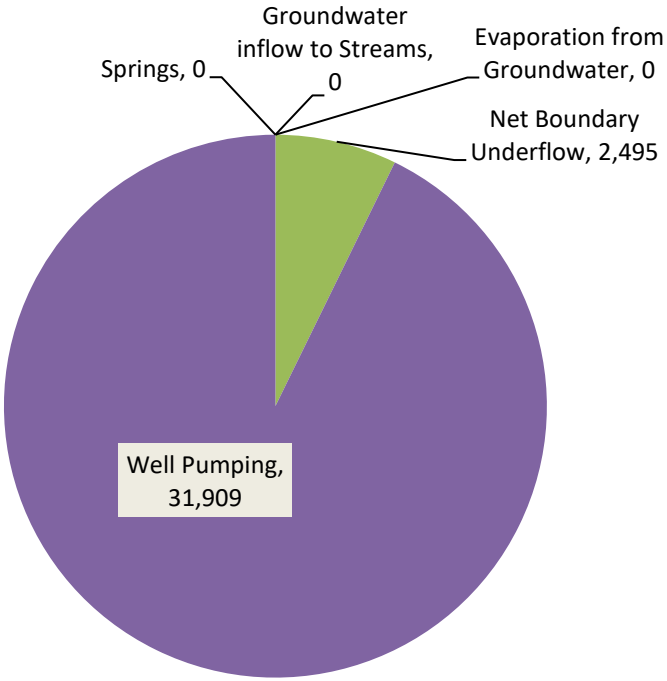


Exhibit 2 - Water Balance for the Marks Butte GMD

1998-2017 Average Annual Values in ac-ft/yr

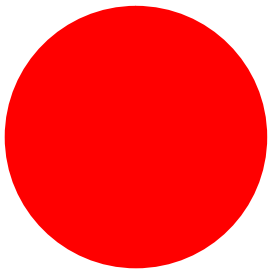


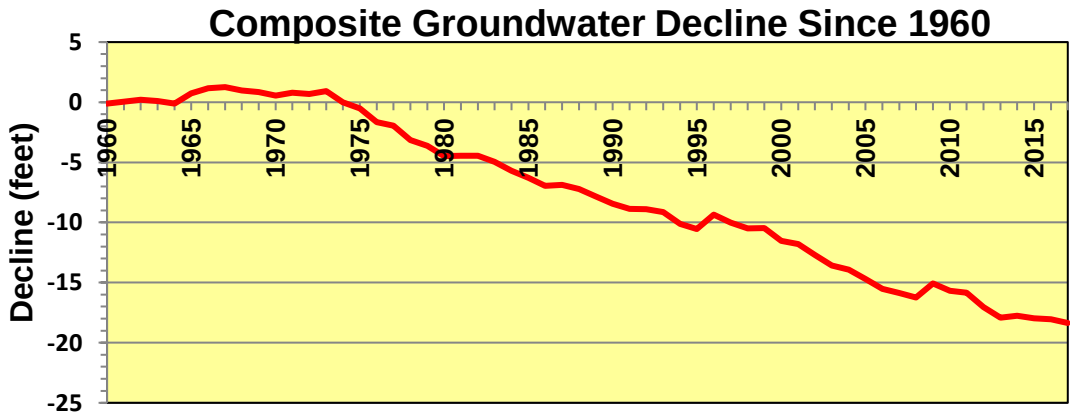
Aquifer Inflow = 21,036



Aquifer Outflow = 34,404

Ground Water Storage Loss = 13,368





Model Water Budget: Marks Butte GWMD

Republican River Compact Administration Groundwater Model

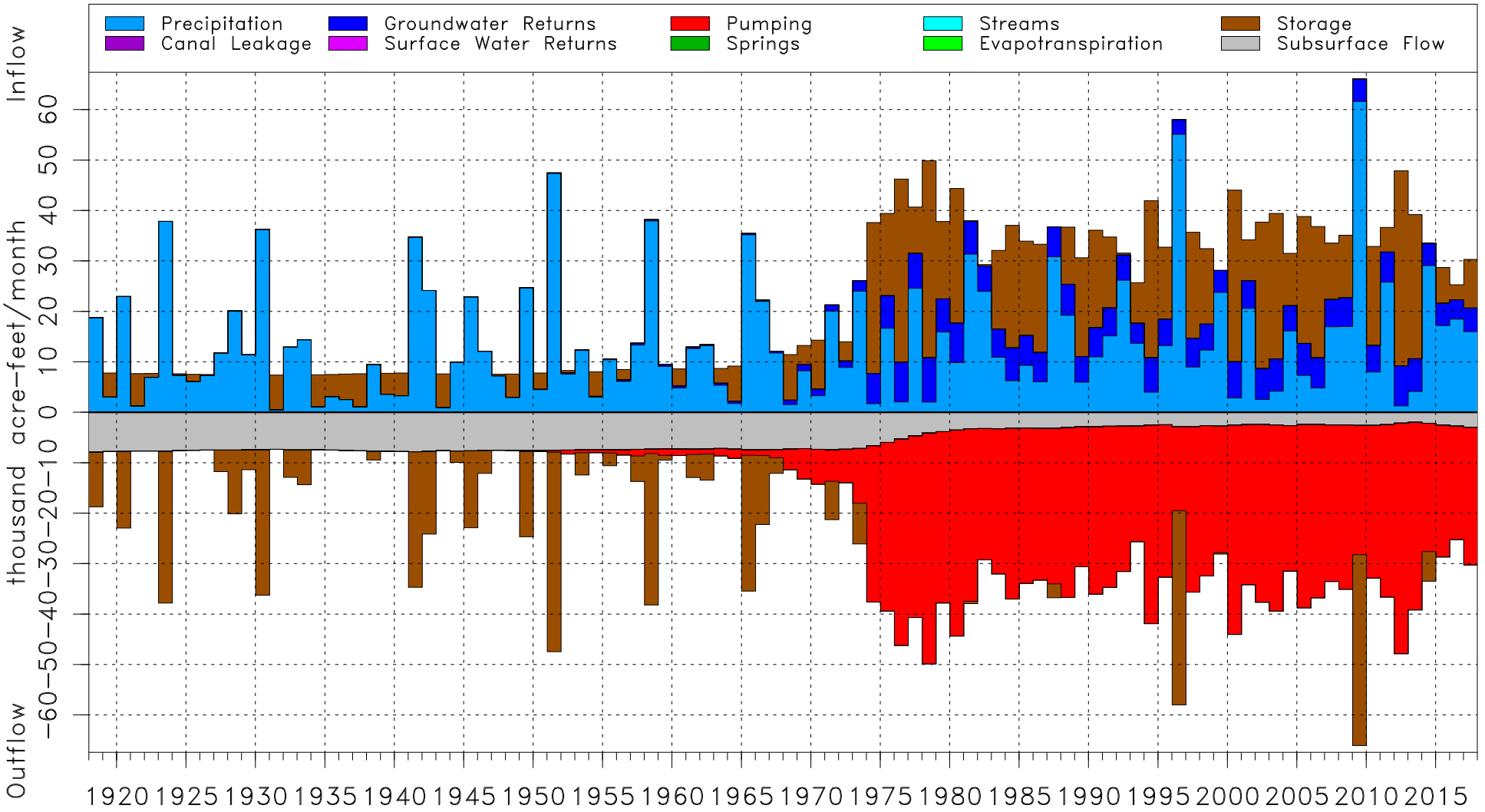
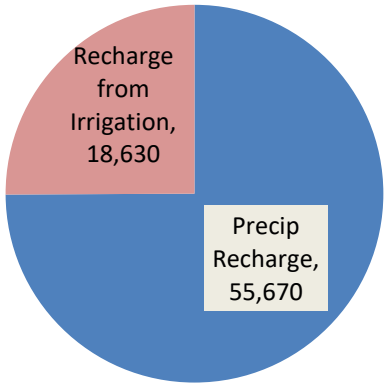
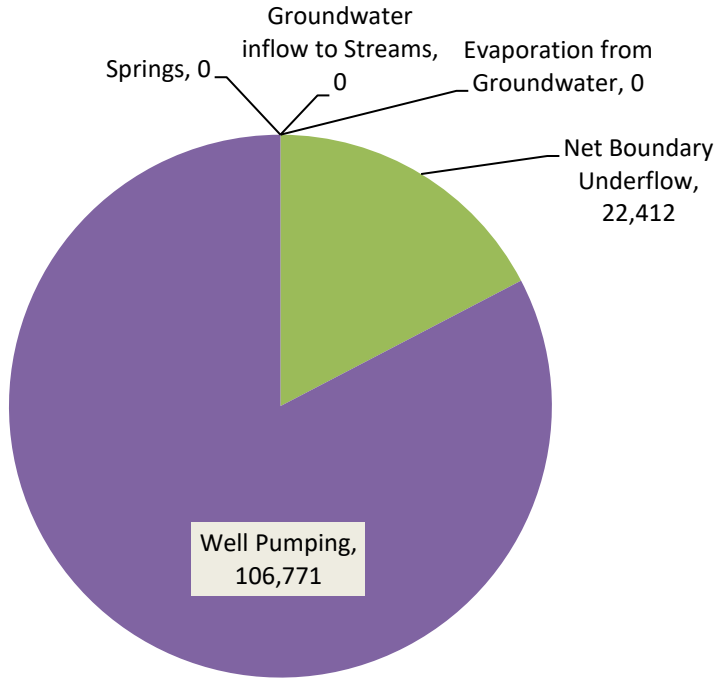


Exhibit 3 - Water Balance for the Frenchman GMD

1998-2017 Average Annual Values in ac-ft/yr

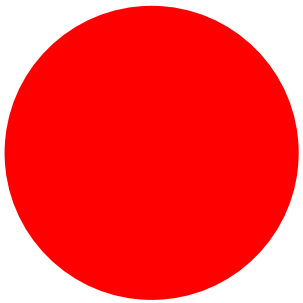


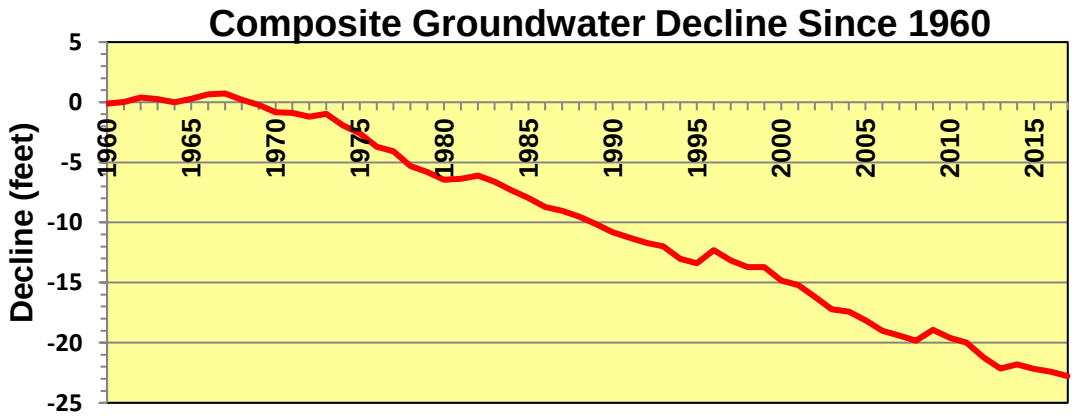
Aquifer Inflow = 74,299



Aquifer Outflow = 129,183

Ground Water Storage Loss = 54,884





Model Water Budget: Frenchman GWMD

Republican River Compact Administration Groundwater Model

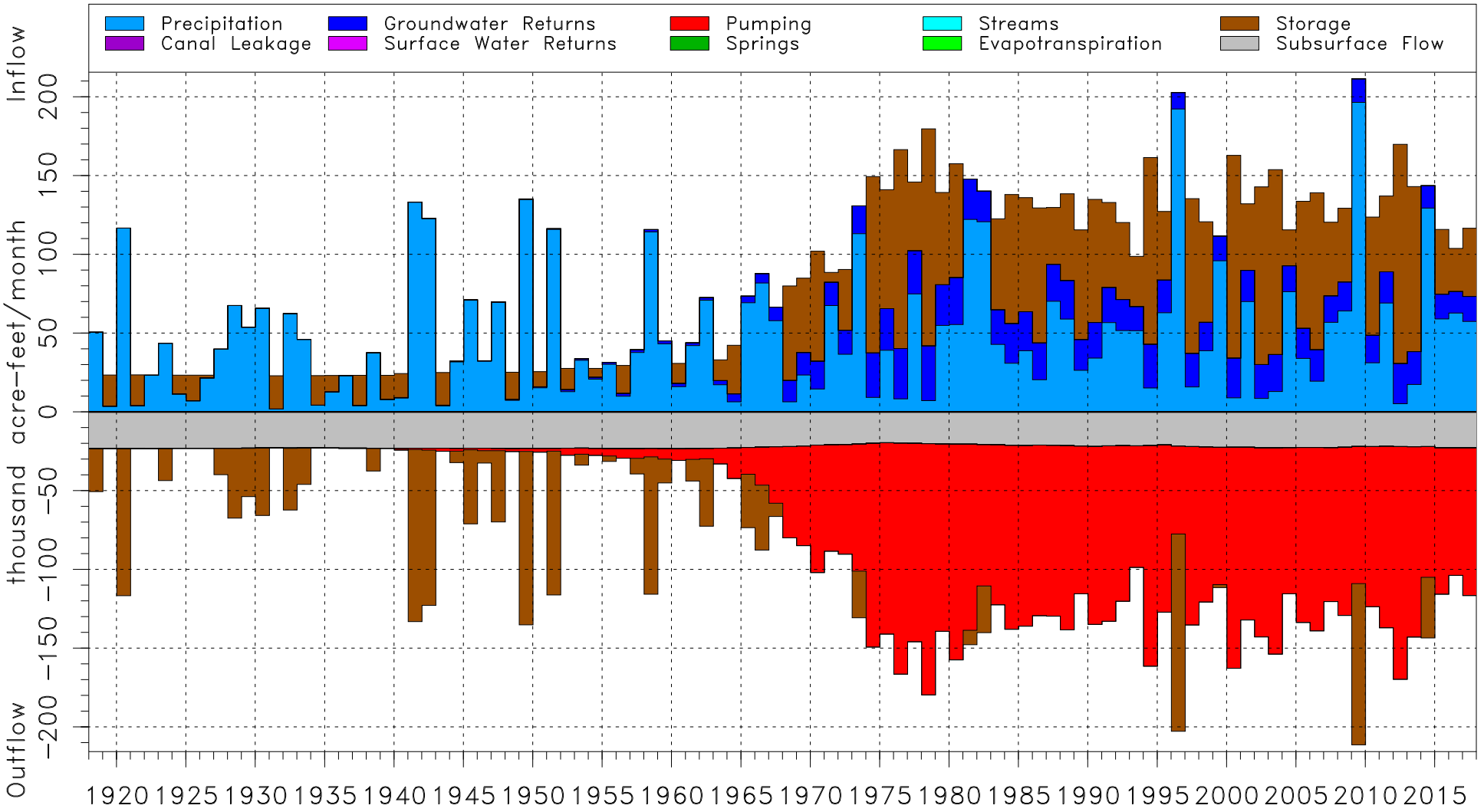
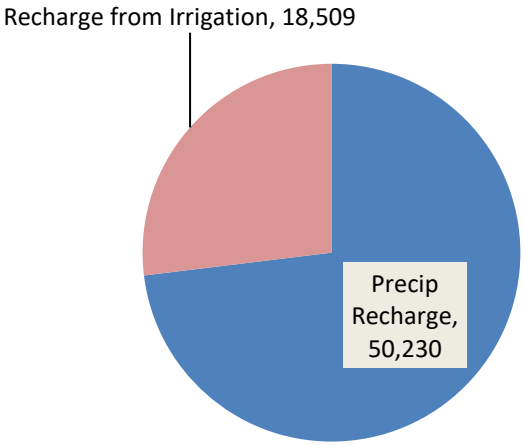
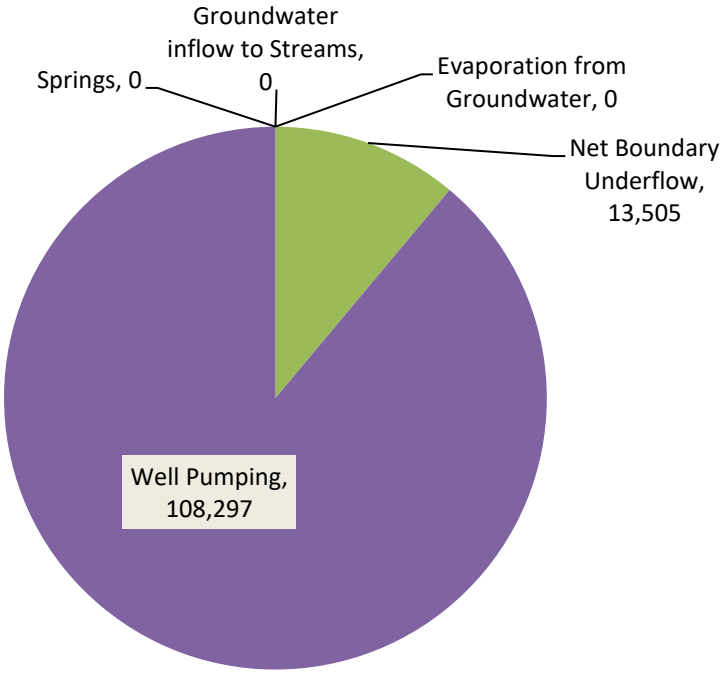


Exhibit 4 - Water Balance for the W-Y GMD

1998-2017 Average Annual Values in ac-ft/yr

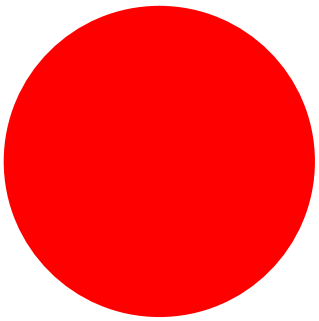


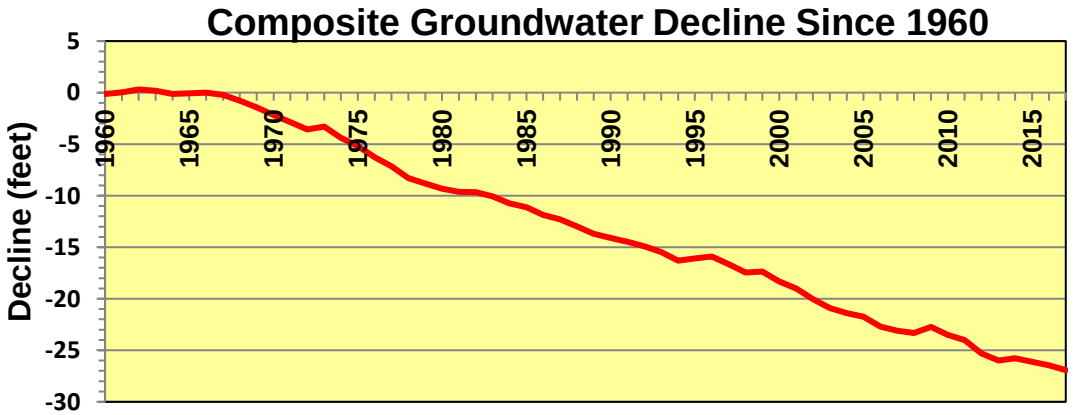
Aquifer Inflow = 68,739



Aquifer Outflow = 121,802

Ground Water Storage Loss = 53,063





Model Water Budget: W-Y GWMD

Republican River Compact Administration Groundwater Model

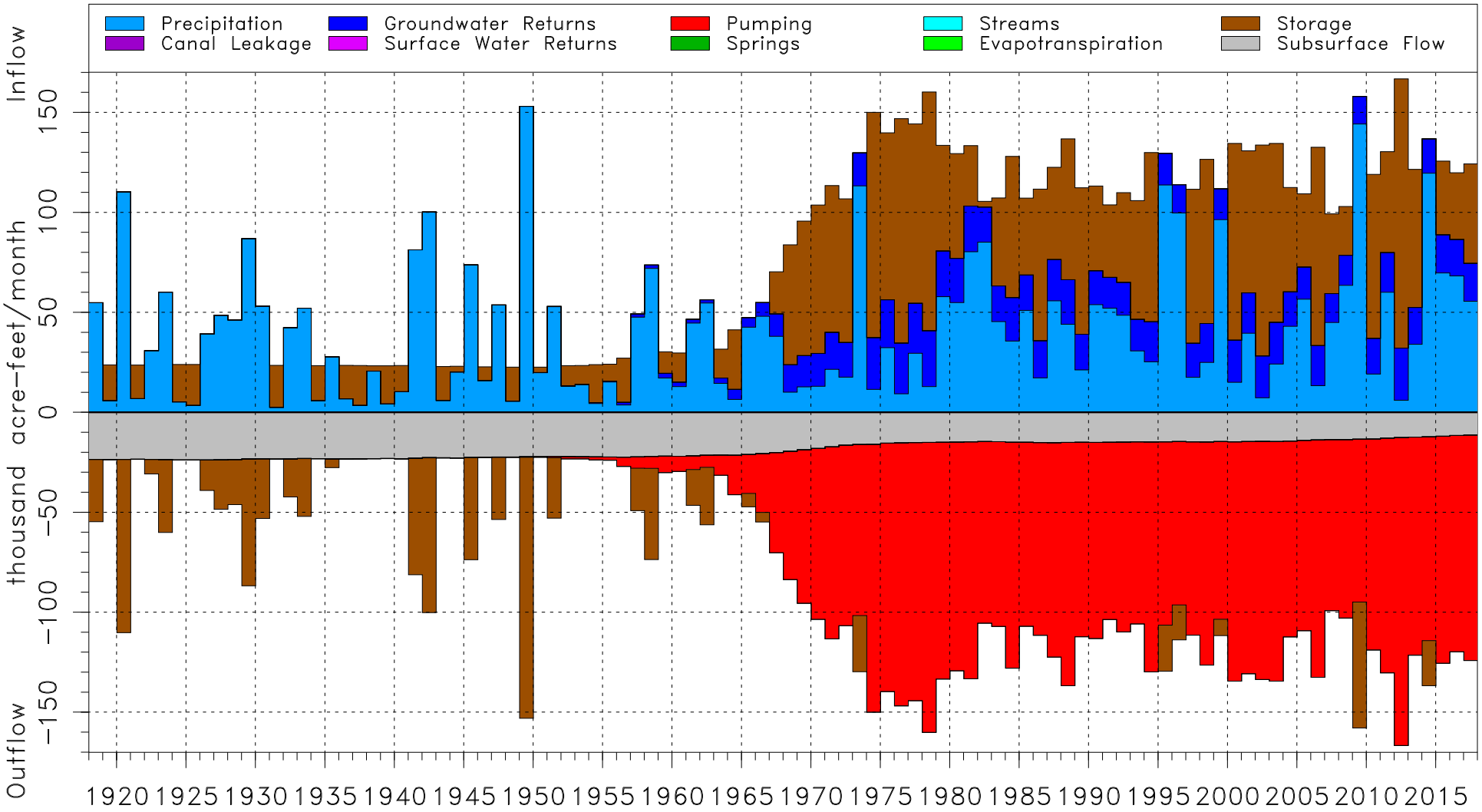
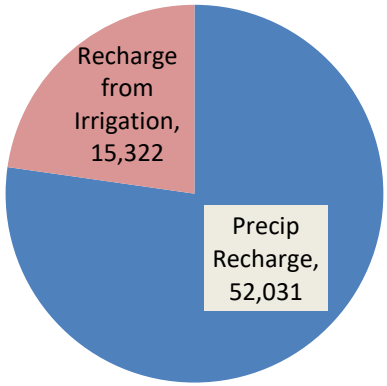
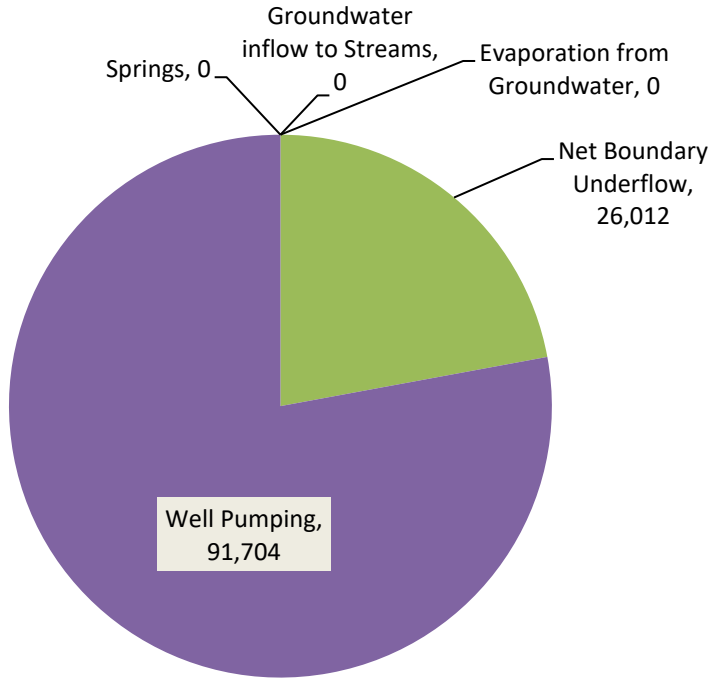


Exhibit 5 - Water Balance for the Sandhills GMD

1998-2017 Average Annual Values in ac-ft/yr

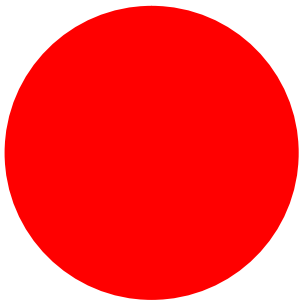


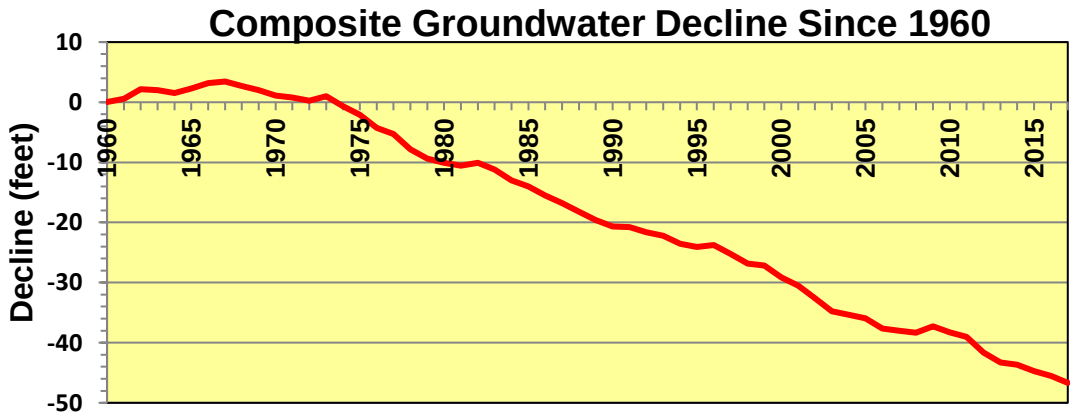
Aquifer Inflow = 67,353



Aquifer Outflow = 117,716

Ground Water Storage Loss = 50,362





Model Water Budget: Sand Hills GWMD

Republican River Compact Administration Groundwater Model

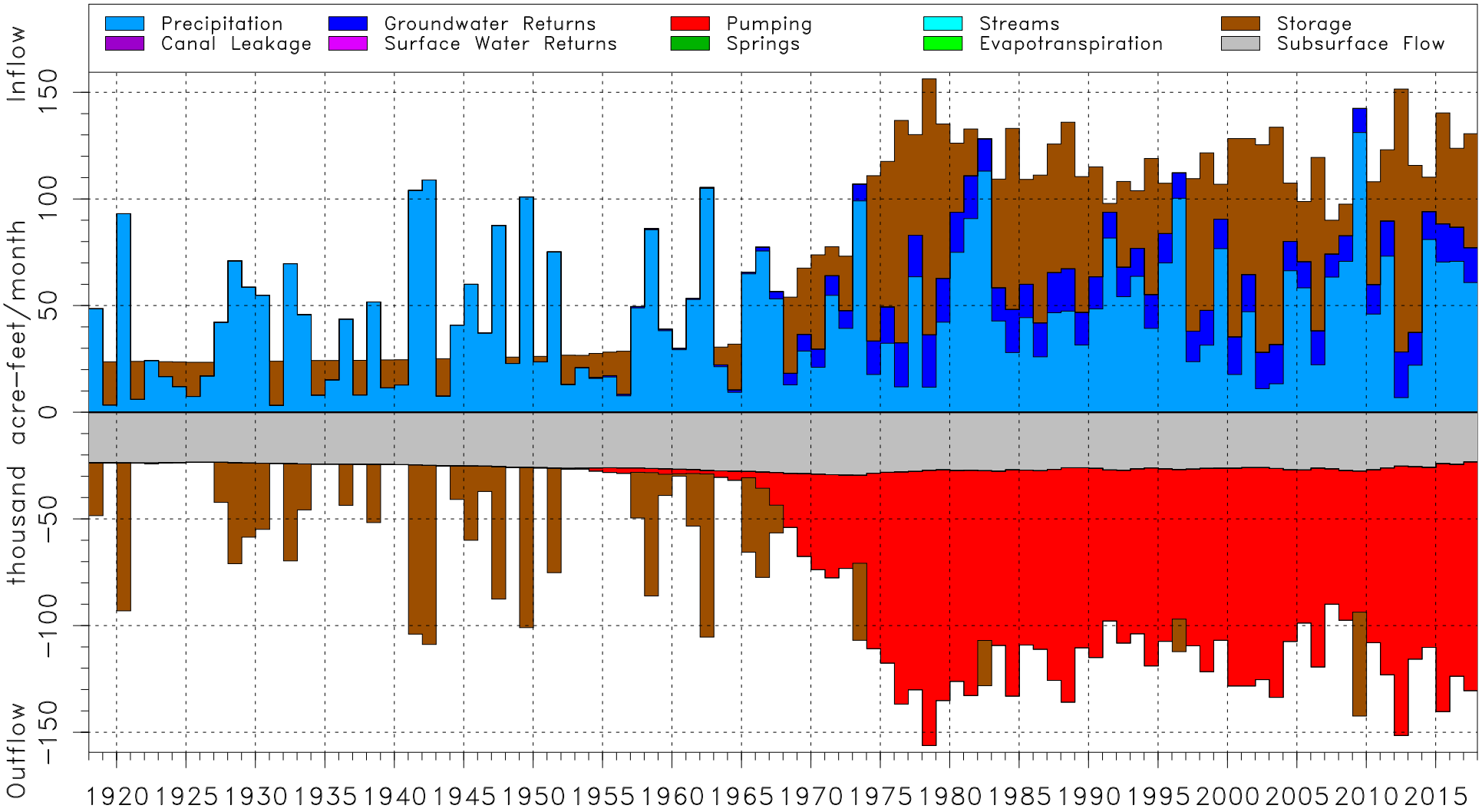
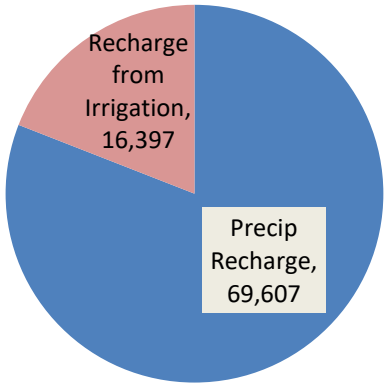
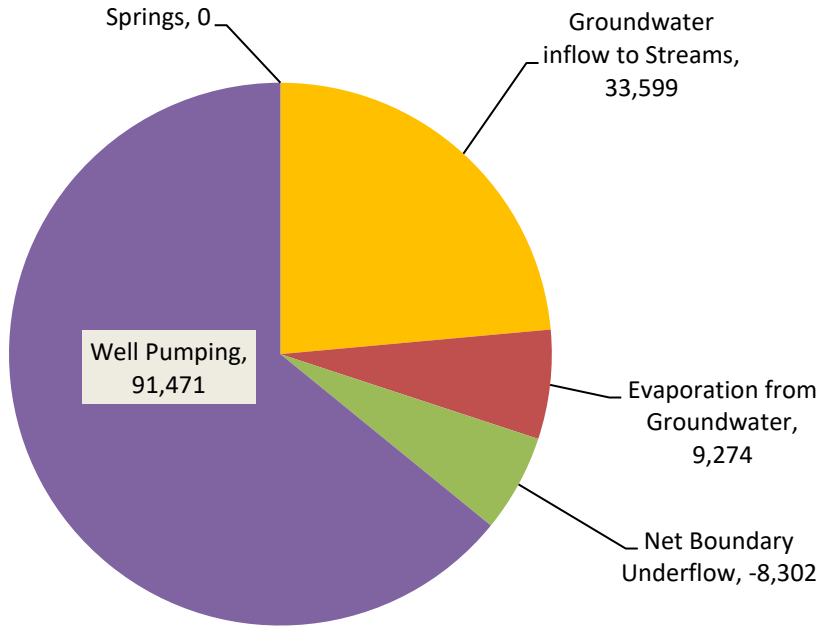


Exhibit 6 - Water Balance for the Central Yuma GMD

1998-2017 Average Annual Values in ac-ft/yr

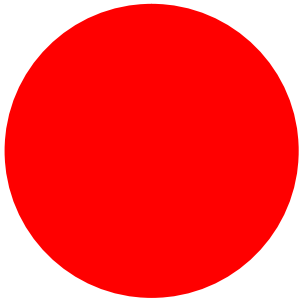


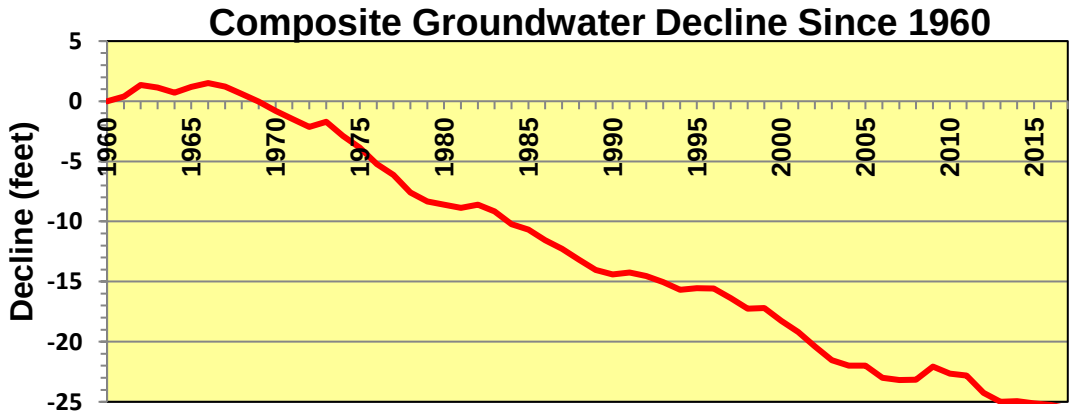
Aquifer Inflow = 86,004



Aquifer Outflow = 126,043

Ground Water Storage Loss = 40,039





Model Water Budget: Central Yuma GWMD

Republican River Compact Administration Groundwater Model

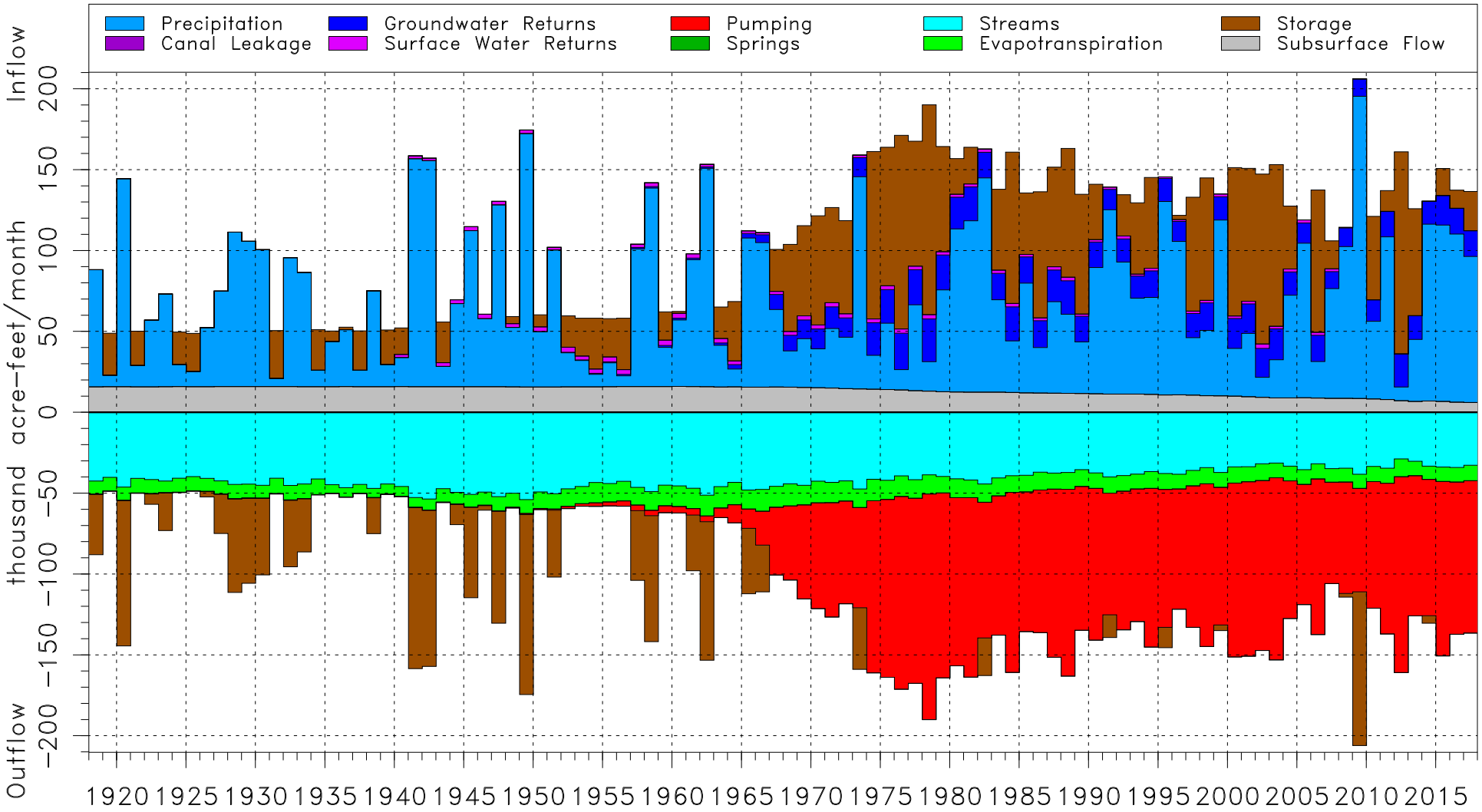
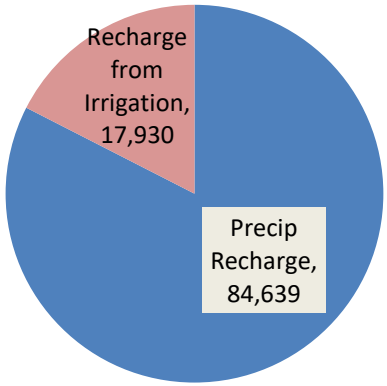
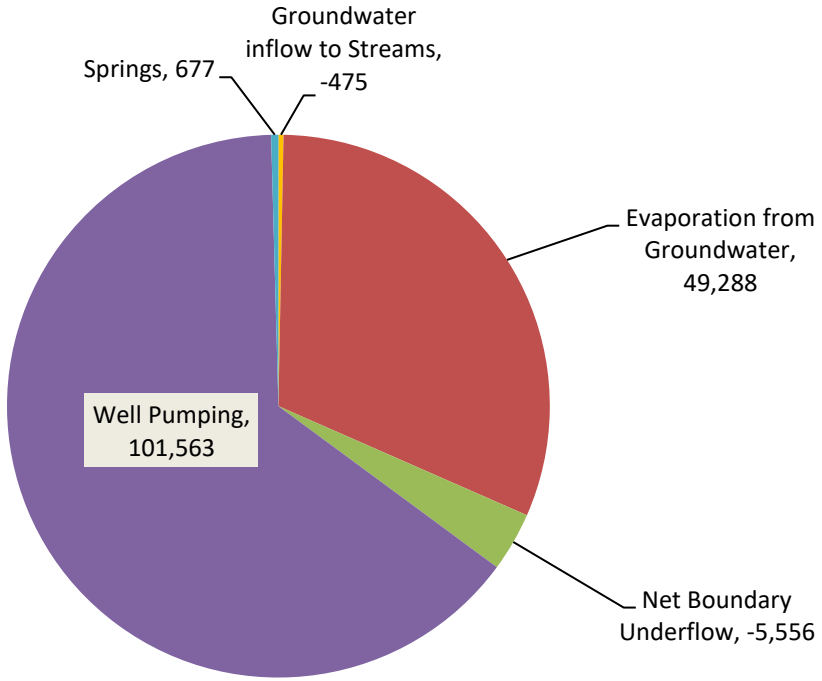


Exhibit 7 - Water Balance for the Arikaree GMD

1998-2017 Average Annual Values in ac-ft/yr

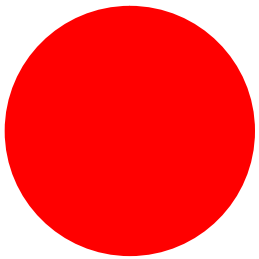


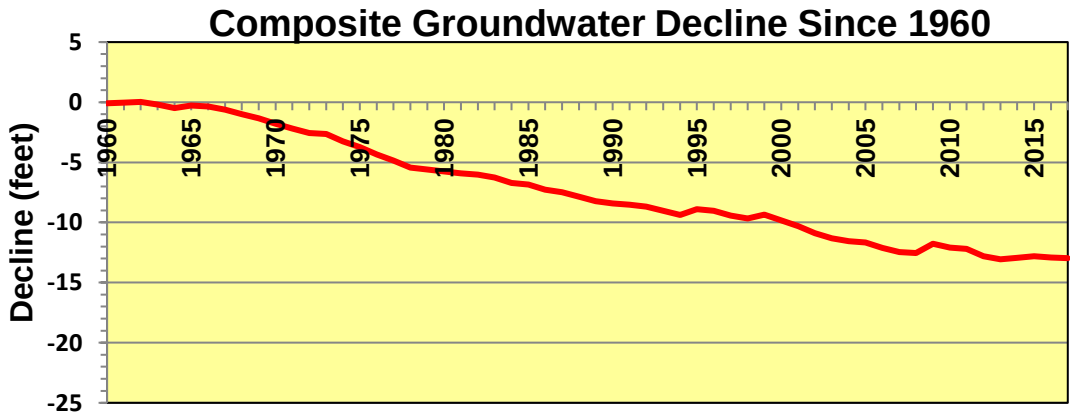
Aquifer Inflow = 102,568



Aquifer Outflow = 145,497

Ground Water Storage Loss = 42,929





Model Water Budget: Arikaree GWMD

Republican River Compact Administration Groundwater Model

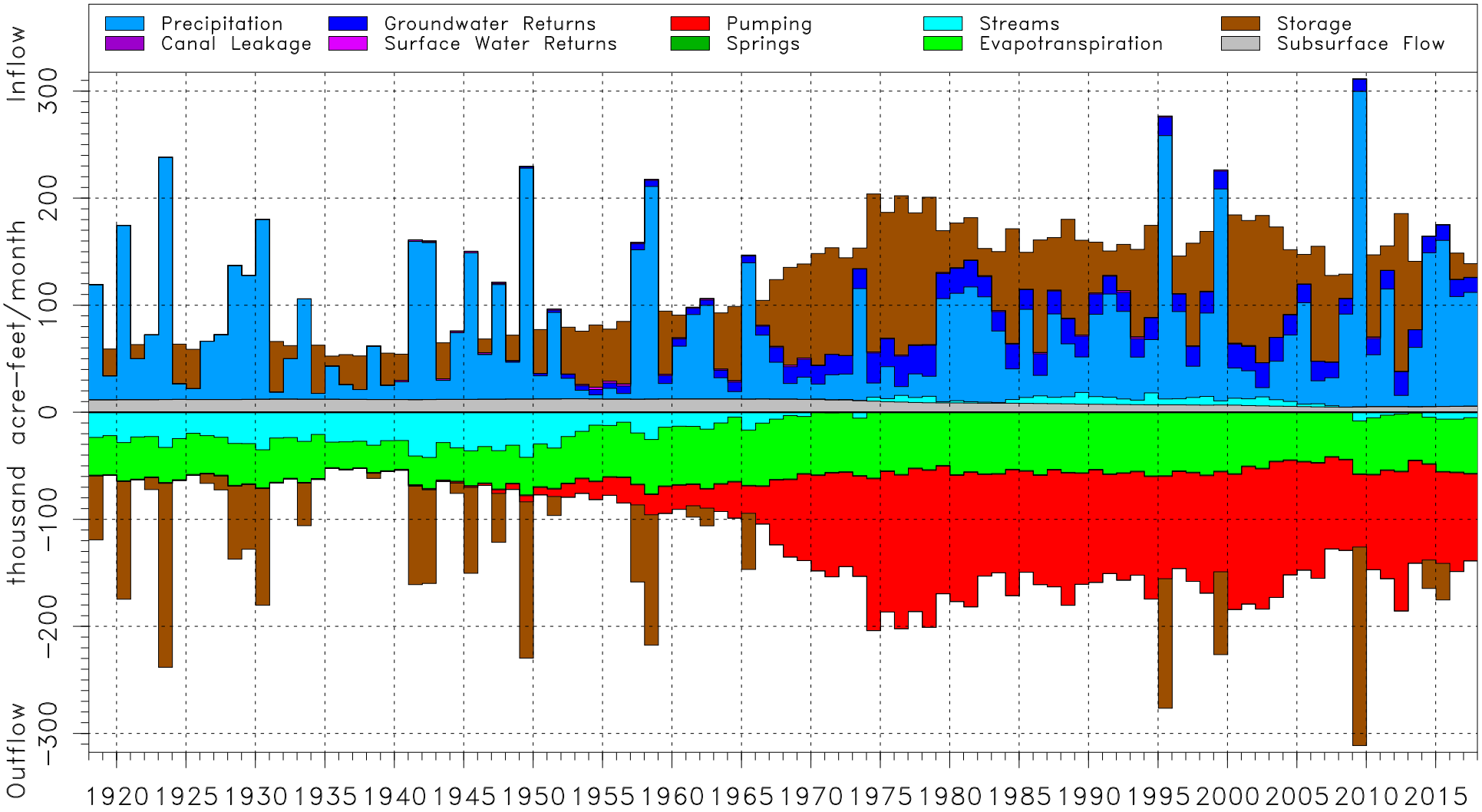
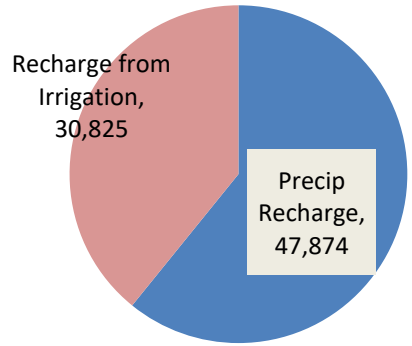
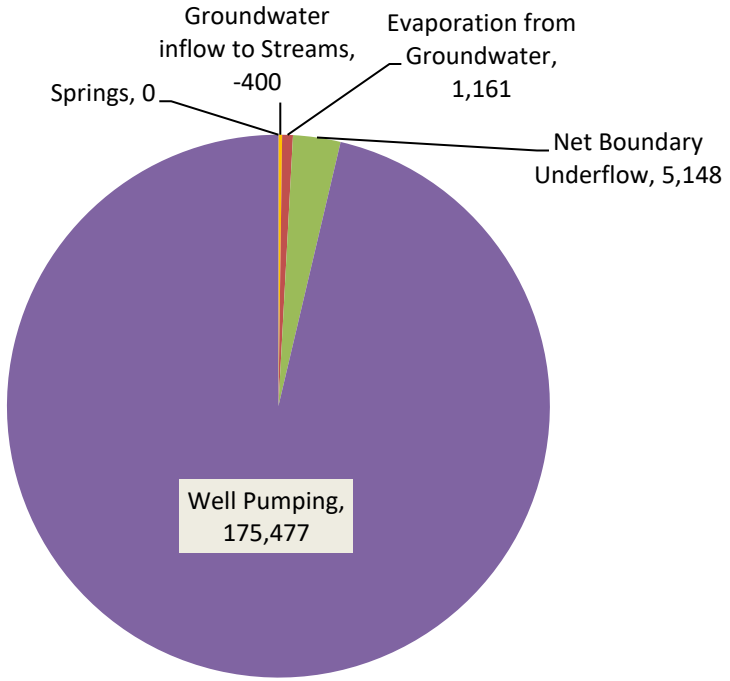


Exhibit 8 - Water Balance for the Plains GMD

1998-2017 Average Annual Values in ac-ft/yr

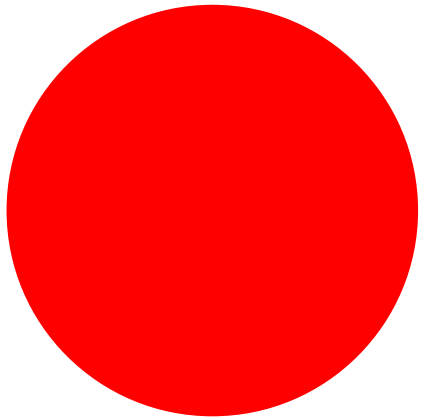


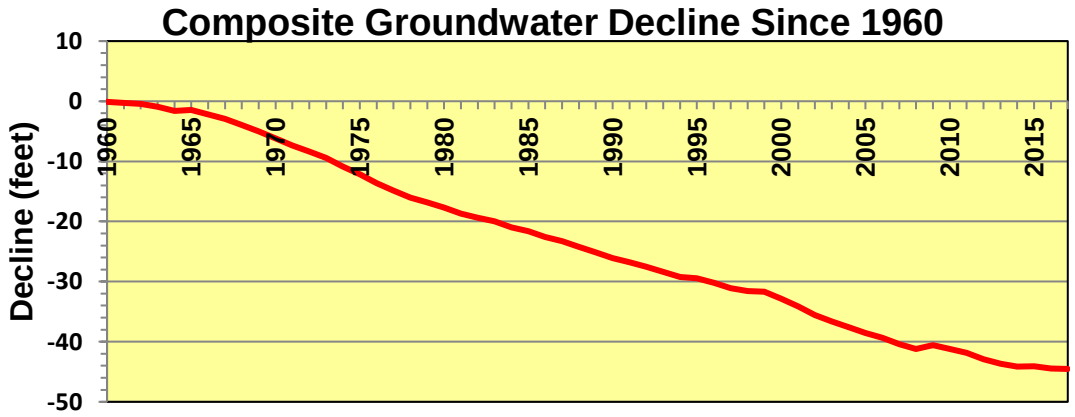
Aquifer Inflow = 78,698



Ground Water Storage Loss = 102,688

Aquifer Outflow = 181,387





Model Water Budget: Plains GWMD

Republican River Compact Administration Groundwater Model

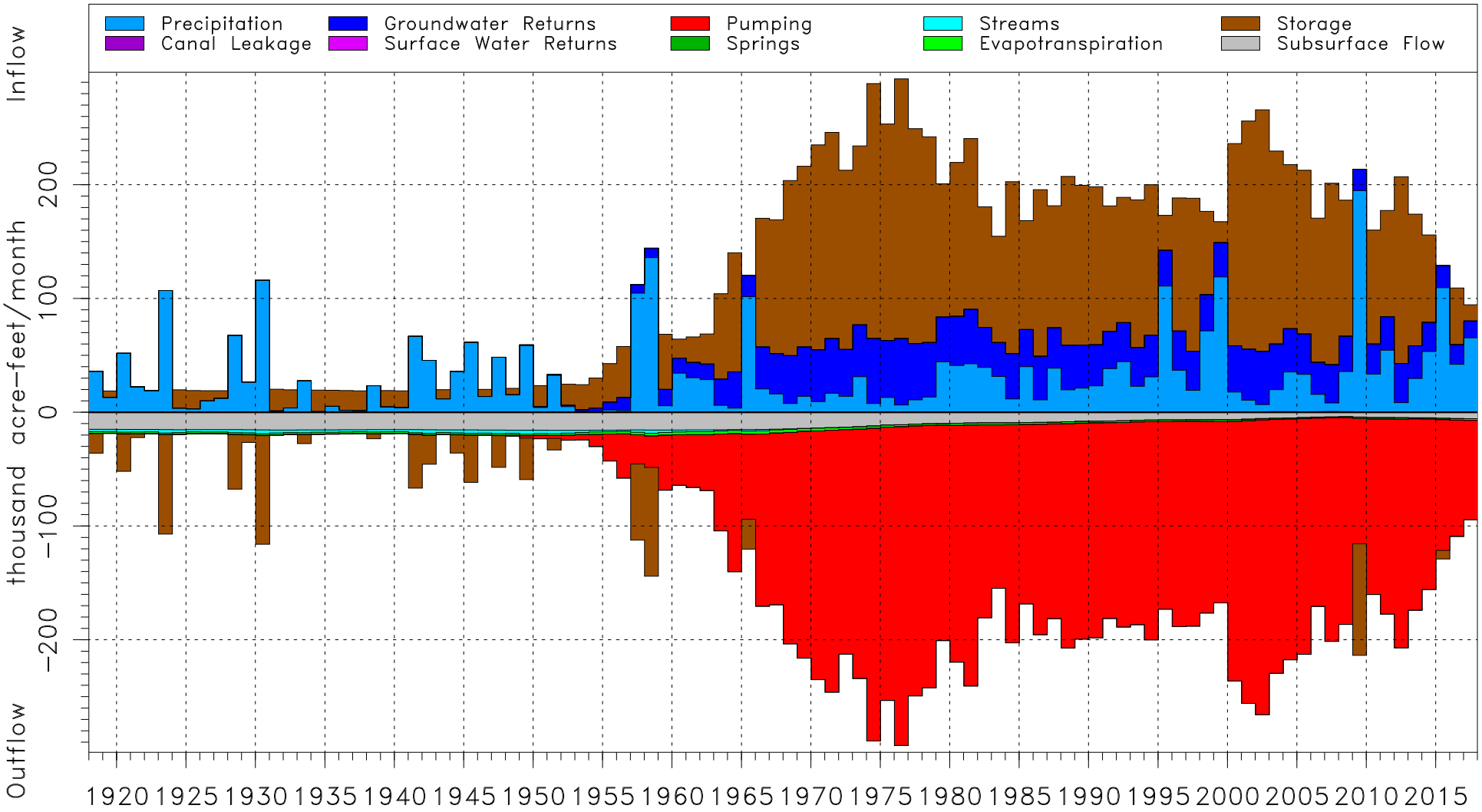
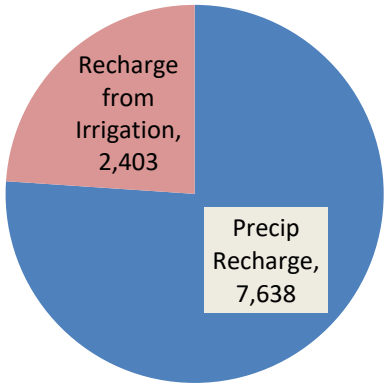


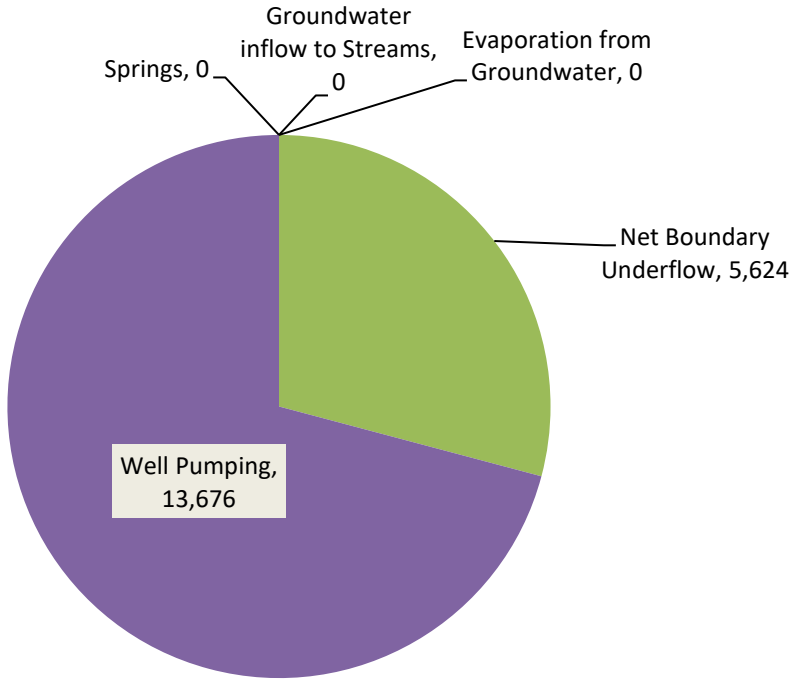
Exhibit 9 - Water Balance for the East Cheyenne GMD

1998-2017 Average Annual Values in ac-ft/yr

Note, the most southern portion of the GMD is not included in this water balance

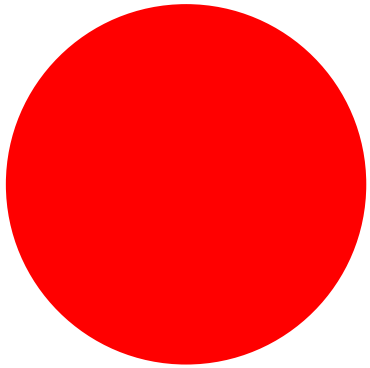


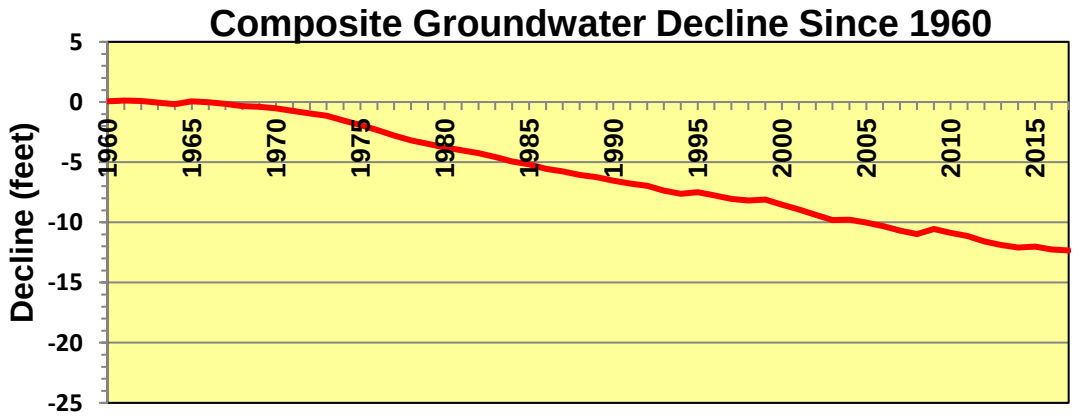
Aquifer Inflow = 10,041



Aquifer Outflow = 19,300

Ground Water Storage Loss = 9,259





Model Water Budget: East Cheyenne GWMD

Republican River Compact Administration Groundwater Model