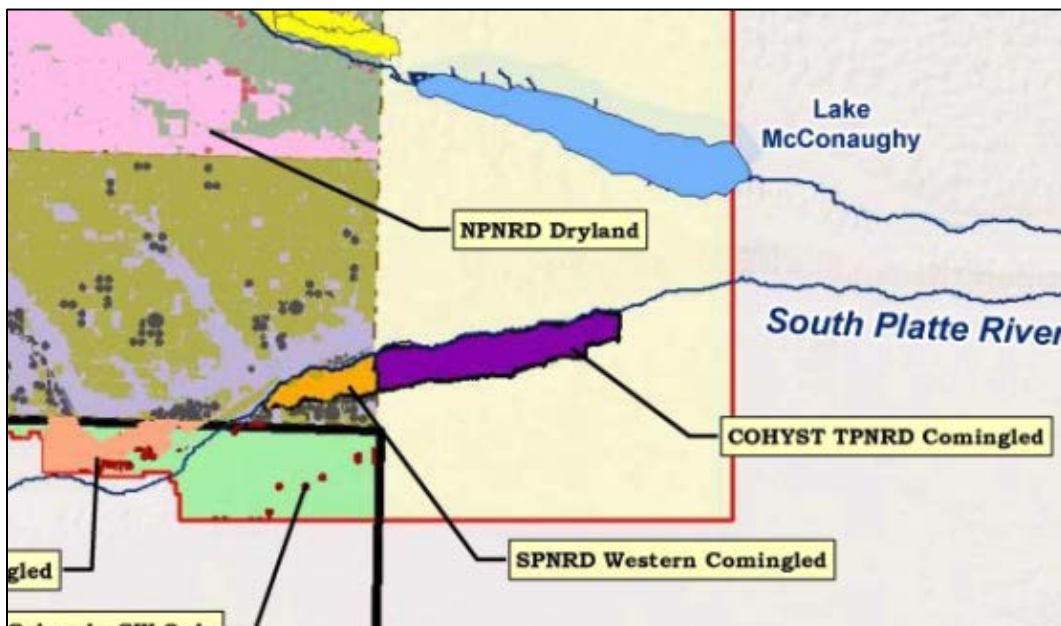


WWUM Technical Memorandum
Western Canal Co-mingled Pumping and Recharge Estimates
January 4, 2013

Overview: The Western Water Use Management Model (WWUM) ground water (GW) model extent encompasses the North Platte and South Platte NRD areas, and extends beyond the NRD boundaries to include relatively small areas of land in Wyoming, Colorado, and neighboring NRDs in Nebraska. This memorandum summarizes the approach used to estimate pumping and recharge for the Western Canal service area **Figure 1**. A portion of the Western Canal service area resides within the South Platte NRD, however the entire service area lies within the WWUM GW Model. A StateCU water balance analysis was performed to estimate canal leakage, irrigation recharge, and co-mingled pumping for each portion of the Western Canal service area in the WWUM GW Model. Acreage and NIR information for the portion in the SPNRD was developed under the WWUM Acreage Assessment and by The Flatwater Group using CropSim, respectively. For the eastern portion of the Western Canal service area located in the Twin Platte NRD, COHYST acreage and NIR information was developed by The Flatwater Group using CropSim.

Figure 1: Western Canal within the WWUM Ground Water Model Boundary



Acreage: The completion of an accurate assessment of the Western Canal requires integration of two acreage data sources. Acreage information from the *WWUM Irrigated and Dryland Acreage Assessment* and acreage data developed under the COHYST effort were integrated to represent the surface water and co-mingled acreage under the Western Canal. The maximum permitted acreage under the Western Canal that can receive surface water is 10,312 acres based on cumulative water rights under the canal. To integrate the two data sources the following algorithm was developed:

**IF SPNRD Acreage + COHYST TPNRD Acreage > 10,312 Permitted Acres,
THEN reduce COHYST TPNRD Comingled Acreage until = 10,312 Acres**

OR

**IF SPNRD Acreage + COHYST TPNRD Acreage < 10,312 Permitted Acres,
THEN COHYST TPNRD Comingled Acreage = COHYST TPNRD Comingled Acreage**

Table 1 below summarizes the total surface water and total co-mingled acreage modeled in this analysis based on this algorithm. Because field boundaries were not developed for the entire period of record for the TPNRD COHYST portion of the Western Canal the irrigated acreage was distributed on a cell level with 348 active cells representing the surface water and co-mingled irrigated acreage changes overtime.

Table 1: Western Canal Acreage and Diversion Splits

Year	TPNRD (COHYST)			SPNRD			Western Total	Diversion Split	
	SW	CO	Total	SW	CO	Total		TPNRD %	SPNRD %
1953	679	2,276	2,955	1,626	2,887	4,513	7,468	0.40	0.60
1954	685	2,515	3,201	1,544	2,982	4,526	7,727	0.41	0.59
1955	643	2,796	3,439	1,544	2,982	4,526	7,965	0.43	0.57
1956	617	2,814	3,431	1,406	3,151	4,557	7,988	0.43	0.57
1957	595	2,716	3,312	1,406	3,151	4,557	7,869	0.42	0.58
1958	588	2,681	3,269	1,211	3,365	4,575	7,845	0.42	0.58
1959	591	2,769	3,360	1,000	3,331	4,331	7,691	0.44	0.56
1960	581	2,988	3,569	976	3,359	4,335	7,904	0.45	0.55
1961	579	3,192	3,771	969	3,634	4,604	8,375	0.45	0.55
1962	585	3,225	3,811	969	3,635	4,604	8,415	0.45	0.55
1963	591	3,375	3,966	969	3,634	4,604	8,570	0.46	0.54
1964	601	3,652	4,253	969	3,634	4,604	8,857	0.48	0.52
1965	604	3,842	4,445	969	3,634	4,604	9,049	0.49	0.51
1966	619	3,938	4,556	969	3,634	4,604	9,160	0.50	0.50
1967	621	4,280	4,901	915	3,690	4,605	9,505	0.52	0.48
1968	608	4,312	4,920	867	3,848	4,715	9,635	0.51	0.49
1969	603	4,362	4,966	867	3,848	4,715	9,680	0.51	0.49
1970	602	4,542	5,144	867	3,848	4,715	9,858	0.52	0.48
1971	584	4,749	5,332	867	3,848	4,715	10,047	0.53	0.47
1972	578	4,854	5,432	867	3,855	4,721	10,153	0.54	0.46
1973	570	4,785	5,354	867	3,855	4,721	10,075	0.53	0.47
1974	559	4,969	5,528	867	3,855	4,721	10,249	0.54	0.46
1975	560	5,031	5,591	867	3,855	4,721	10,312	0.54	0.46
1976	564	5,027	5,591	785	3,936	4,721	10,312	0.54	0.46
1977	583	5,418	6,001	370	3,941	4,311	10,312	0.58	0.42
1978	641	5,360	6,001	370	3,941	4,311	10,312	0.58	0.42
1979	635	5,367	6,001	370	3,941	4,311	10,312	0.58	0.42
1980	636	5,365	6,001	220	4,091	4,311	10,312	0.58	0.42

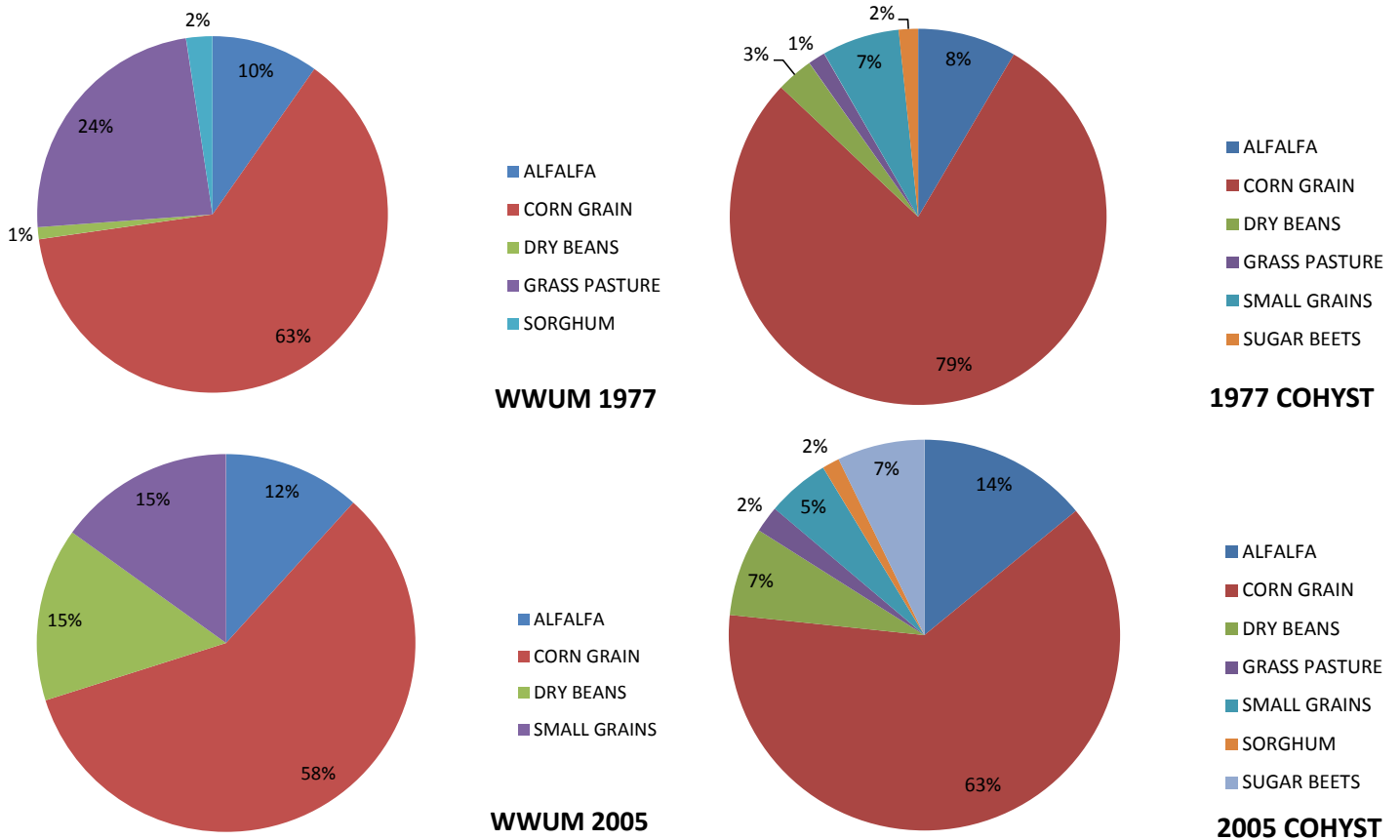
Year	TPNRD (COHYST)			SPNRD			Western Total	Diversion Split	
	SW	CO	Total	SW	CO	Total		TPNRD %	SPNRD %
1981	628	5,373	6,001	220	4,091	4,311	10,312	0.58	0.42
1982	644	5,358	6,001	220	4,091	4,311	10,312	0.58	0.42
1983	637	5,364	6,001	220	4,091	4,311	10,312	0.58	0.42
1984	633	5,477	6,110	104	4,098	4,202	10,312	0.59	0.41
1985	630	5,480	6,110	20	4,182	4,202	10,312	0.59	0.41
1986	629	5,481	6,110	20	4,182	4,202	10,312	0.59	0.41
1987	626	5,484	6,110	20	4,182	4,202	10,312	0.59	0.41
1988	632	5,478	6,110	20	4,182	4,202	10,312	0.59	0.41
1989	634	5,476	6,110	20	4,182	4,202	10,312	0.59	0.41
1990	639	5,471	6,110	20	4,182	4,202	10,312	0.59	0.41
1991	646	5,464	6,110	20	4,182	4,202	10,312	0.59	0.41
1992	659	5,451	6,110	20	4,182	4,202	10,312	0.59	0.41
1993	660	5,494	6,153	14	4,145	4,159	10,312	0.60	0.40
1994	659	5,494	6,153	14	4,145	4,159	10,312	0.60	0.40
1995	660	5,493	6,153	14	4,145	4,159	10,312	0.60	0.40
1996	662	5,492	6,153	14	4,145	4,159	10,312	0.60	0.40
1997	670	6,136	6,806	0	3,506	3,506	10,312	0.66	0.34
1998	669	6,137	6,806	0	3,506	3,506	10,312	0.66	0.34
1999	668	6,138	6,806	0	3,506	3,506	10,312	0.66	0.34
2000	666	6,140	6,806	0	3,506	3,506	10,312	0.66	0.34
2001	662	6,981	7,643	0	2,669	2,669	10,312	0.74	0.26
2002	660	6,983	7,643	0	2,669	2,669	10,312	0.74	0.26
2003	658	6,985	7,643	0	2,669	2,669	10,312	0.74	0.26
2004	653	6,991	7,643	0	2,669	2,669	10,312	0.74	0.26
2005	653	7,445	8,098	0	2,065	2,065	10,163	0.80	0.20
2006	657	7,490	8,147	0	1,077	1,077	9,224	0.88	0.12
2007	674	7,675	8,348	0	1,078	1,078	9,427	0.89	0.11
2008	674	7,675	8,348	0	1,034	1,034	9,382	0.89	0.11
2009	674	7,675	8,348	0	1,034	1,034	9,382	0.89	0.11
2010	674	7,675	8,348	0	1,116	1,116	9,464	0.88	0.12
AVE	629	5,115	5,744	474	3,446	3,920	9,644	0.59	0.41

NIR: Monthly NIR information was provided by CropSim based on climate data, crop type, and acreage totals. NIR for each irrigated parcel was then aggregated by structure and by month resulting in NIR for each structure in this analysis. Note that the change in acreage over time, as discussed above, was used to correctly tabulate the total NIR for each structure in each year.

Crops: Cropping patterns are used to calculate NIR totals and define the available soil moisture reservoir based on rooting depths. Cropping patterns were developed for both the SPNRD and TPNRD portion of the Western Canal under two separate efforts. Crops were attributed for the SPNRD portion of the Western Canal under the *WWUM Irrigated and Dryland Acreage Assessment* efforts. For the TPNRD portion of the Western Canal,

COHYST was used to populate cropping information. **Figure 2** below shows the average cropping patterns for the 1977 and 2005 irrigated acreage snapshots for both efforts under the Western Canal.

Figure 2: Cropping Patterns for Western Canal, 1977 and 2005



Diversions: Daily surface water diversions were obtained from the NDNR Stream Gaging Data Bank (<http://dnr.ne.gov/docs/hydrologic.html>), visually reviewed for errant data points, and aggregated into monthly data. Total monthly diversions were divided based on acreage located within each portion of the canal. **Table 1** above shows the transition of acreage and the corresponding diversion percentages over time. Note that in 2010, only a small amount of acreage in the SPNRD receives surface water, this trend was confirmed by NRD staff. Groundwater diversions were estimated by StateCU to meet the remaining NIR, based on a Mutual Ditch pumping approach.

Efficiencies: Conveyance efficiency of 63 percent was used for all structures based on previous modeling COHYST/STELLA modeling efforts on Western Canal. Maximum flood application efficiency of 65 percent and maximum sprinkler application efficiency ranging from 70 to 85 percent was used for all structures. The sprinkler application efficiency ranged over the 1953 to 2010 period to capture the advances in sprinkler technology and efficiency over time. In months when surface water supply is less than NIR, the maximum application efficiency is used in the water balance. In water-long months, the efficiency is calculated based on the amount of surface water supplies and the NIR and will result in an application efficiency less than the maximum application efficiency calculated.

AWC: Available water content (AWC) is important in defining the available soil moisture reservoir for each crop type. The irrigated acreage assigned to each structure was used to determine the AWC information, used by StateCU to determine the volume of the soil moisture zone available to store excess irrigation for each structure. AWC values were estimated through a spatial intersection between the Western Canal service area and a soil coverage provided by the The Flatwater Group. The average AWC assigned to the Western Canal was 0.145 in/in.

Wells: Well coverages were developed as a part of the *WWUM Irrigated and Dryland Acreage Assessment* efforts, and active wells located in the SPNRD were queried to create the SPNRD Western Canal well coverage. Simulated and metered pumping was assigned to SPNRD wells based on certificates assigned to each parcel. Although DNR well capacity information was assigned, it was determined that the aggregate well capacities did not limit simulated pumping. Simulated pumping was assigned to active cells in each year in the TPNRD COHYST portion of the Western Canal service area. No DNR well capacity information was established for the TPNRD Western Canal wells.

Meter Data: Meter pumping data was provided by SPNRD for certificates under the Western Canal for 2009 and 2010. This data was used in place of the simulated pumping when available. No meter data was assessed for the TPNRD COHYST portion of the Western Canal. Annual meter data was received from SPNRD and required that a monthly distribution be applied. A monthly distribution based on average monthly simulated pumping (1953-2008) was developed and used to distribute 2009 and 2010 meter data (**Table 2**).

Table 2: Western Canal Monthly Pumping Distributions for 2009 and 2010

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	0%	0%	0%	0%	2%	37%	59%	2%	0%	0%	0%

Results: The StateCU water balance analysis was performed to estimate co-mingled pumping for each portion of the Western Canal service area in the WWUM GW Model. **Table 3** below summarizes the average annual diversions and co-mingled pumping for both the SPNRD and TPNRD portions of the Western Canal. **Figure 3** shows average annual diversions, co-mingled pumping, and NIR in aggregate over the study period. Additional results from the analysis include estimates of historical crop consumptive use from surface and ground water supplies, shortages, system efficiencies, and non-consumed water. Results presented herein summarize information for the CU analysis as a whole and focus on the primary requested information; additional summaries and structure-specific information can be accessed by obtaining the StateCU input files and StateCU model.

Table 3: Western Canal Average Annual Diversions, Pumping, and NIR (1953 – 2010)

Natural Resource District	Acreage	Diversions (ACFT)	Co-mingled Pumping (ACFT)	NIR (ACFT)
SPNRD (WWUM)	3,920	9,925	1,025	4,222
TPNRD (COHYST)	5,744	13,581	6,785	10,512
Total	9,664	23,506	7,810	14,734

Figure 3: Western Canal Average Annual Diversions, Pumping, and NIR (1953 – 2010)

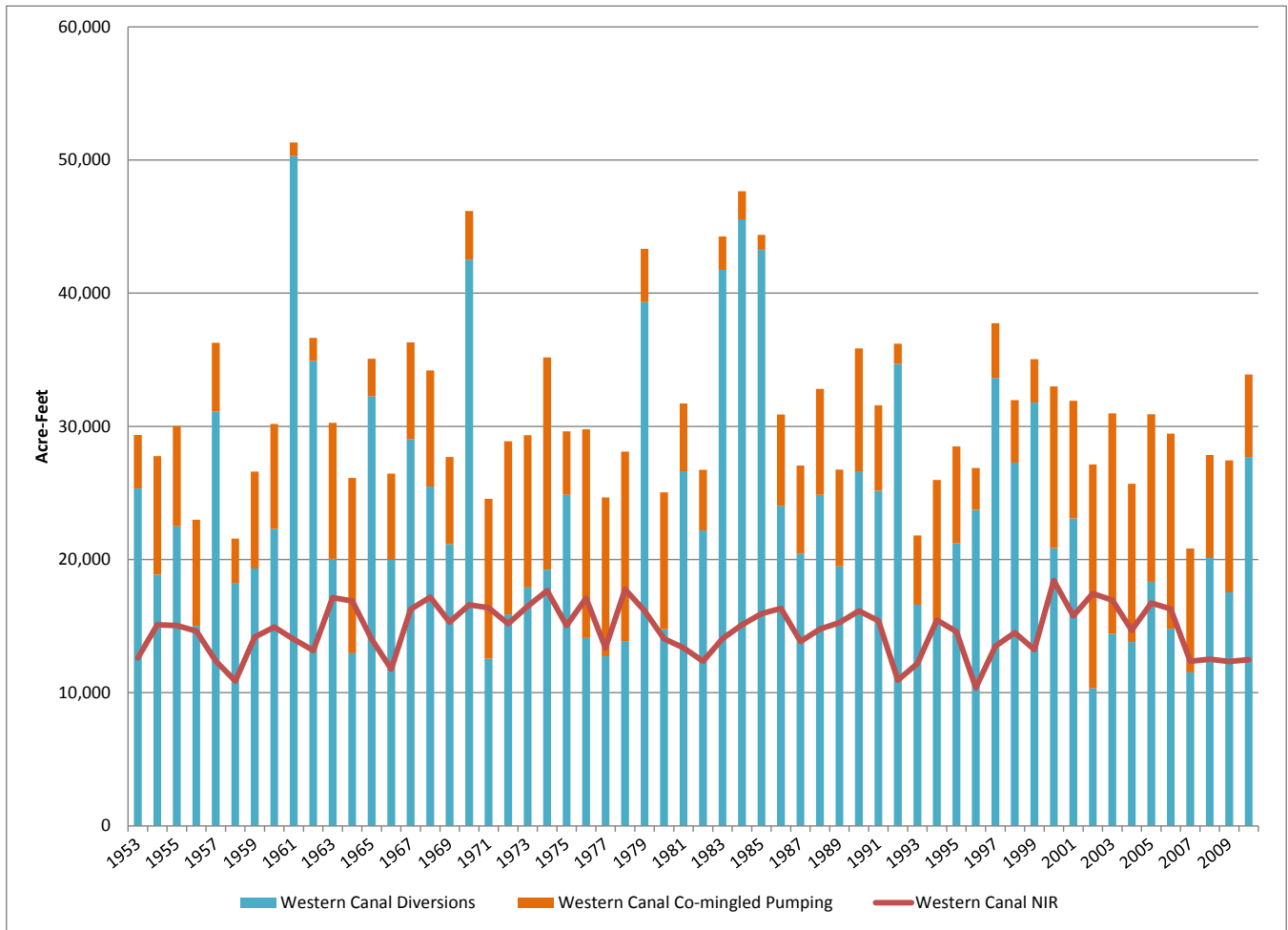
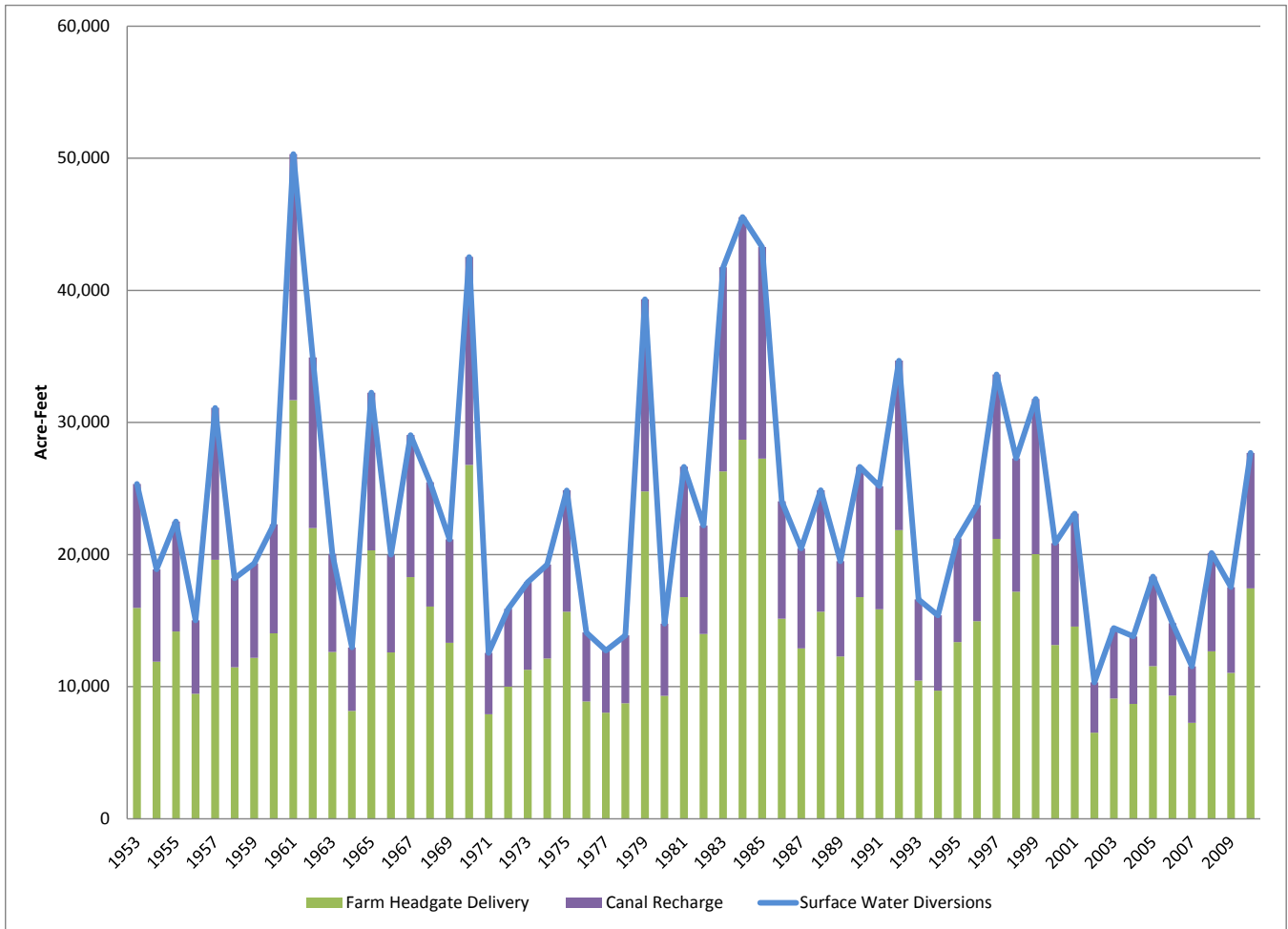


Figure 4 summarizes the annual canal recharge as a portion of the total Western Canal surface water diversions and the remaining portion available at the farm headgate. The annual average canal recharge for the Western Canal is 8,697 acre-feet.

Figure 4: Western Canal Average Annual Canal Recharge (1953 – 2010)



Integration: The monthly estimates of supplemental pumping and canal recharge are distributed to a spatial level for use in the ground water model. Note that pumping in the SPNRD is distributed to active well locations within SPNRD and pumping within TPNRD is distributed to active model cells due to lack of known pumping location information. Supplemental pumping results from this StateCU analysis are limited by well capacity, and replaced with metered pumping generally available for 2009 and 2010. Meter pumping data was provided by SPNRD for certificates under the Western Canal for 2009 and 2010. This data was used in place of the simulated pumping when available. No meter data was assessed for the TPNRD COHYST portion of the Western Canal. The refined monthly pumping information is then distributed spatially to well locations based on their assignment to SPNRD certified parcels.

Canal recharge from this StateCU analysis is distributed to the ground water model cells that spatially intersect with the canals based on the length of canal located in each ground water model cell in both SPNRD and TPNRD. Additional detail regarding the integration of information from StateCU with concurrent WWUM modeling efforts can be found in the *WWUM Calibration and Integration Plan* report.