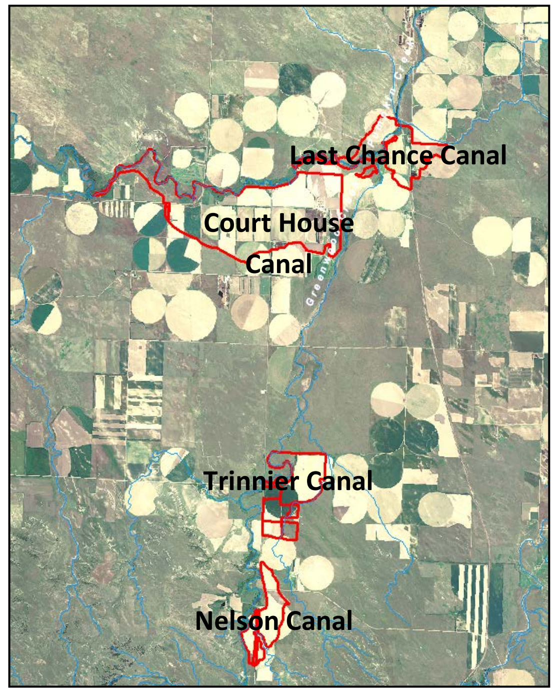
WWUM Technical Memorandum
Pumpkin & Greenwood Creek Pumping and Recharge Estimates
January 3, 2013

Overview: Supplemental pumping and canal recharge associated with irrigated lands served by surface water in the Greenwood Creek and Pumpkin Creek basins impact the Western Water Use Management Model (WWUM) ground water model. This technical memorandum discusses the general approach to develop the consumptive use (CU) analysis for these irrigated lands, and summarizes the resulting pumping and recharge information from the analysis. Note that these lands were not included in the WWUM surface water modeling efforts; the analysis was completed for integration in the WWUM ground water model only; and the supplemental pumping estimate was used for the pre-2003 period prior to the availability of metered pumping.

Figure 1: Greenwood and Pumpkin Creek Surface Water Structures



Approach: The CU analysis was performed using StateCU, a generic data-driven CU modeling software, which calculates supply-limited CU based on externally processed net irrigation water requirement (NIR), efficiency information, diversion records, and well information. This CU analysis was performed on a monthly timestep for the 1953 through 2010 period and used data developed through concurrent WWUM modeling efforts, including the WWUM acreage assessment and NIR estimates from CropSim modeling efforts.

Structures: Canal systems (termed as structures) were selected for inclusion in this CU analysis based on the availability of recent diversion records from the Nebraska Division of Natural Resources (NDNR). Based on a review of these diversion records, the following structures were selected: Courthouse Canal, Last Chance Canal, Nelson Canal, and Trinnier Canal. The service areas associated with these canals are shown in **Figure 1**.

Acreage: Irrigated acreage for these structures was delineated and attributed with crop type, surface/ground water supplies, and irrigation method through the *WWUM Irrigated and Dryland Acreage Assessment* efforts. The associated report documents the acreage delineation and attribution approach for the 1953 to 2010 period in detail; this detail is not reiterated in this technical documentation. **Table 1** summarizes the amount of acreage served by each canal in select years, and illustrates how the amount of acreage has changed through the study period. Note that acreage served by ground water only is excluded from this analysis; pumping and recharge from this acreage is discussed in the WWUM technical memorandum for ground water only acreage in the North Platte NRD.

Table 1: Pumpkin Creek & Greenwood Creek Structure Acreage

Year	Courthouse	Last Chance	Nelson	Trinnier
1953	1,084	277	282	324
1975	1,185	193	241	331
1984	1,180	257	261	330
1993	1,226	317	263	331
1997	1,240	300	263	375
2001	1,241	306	303	376
2005	1,241	306	299	376
2010	1,214	306	337	375

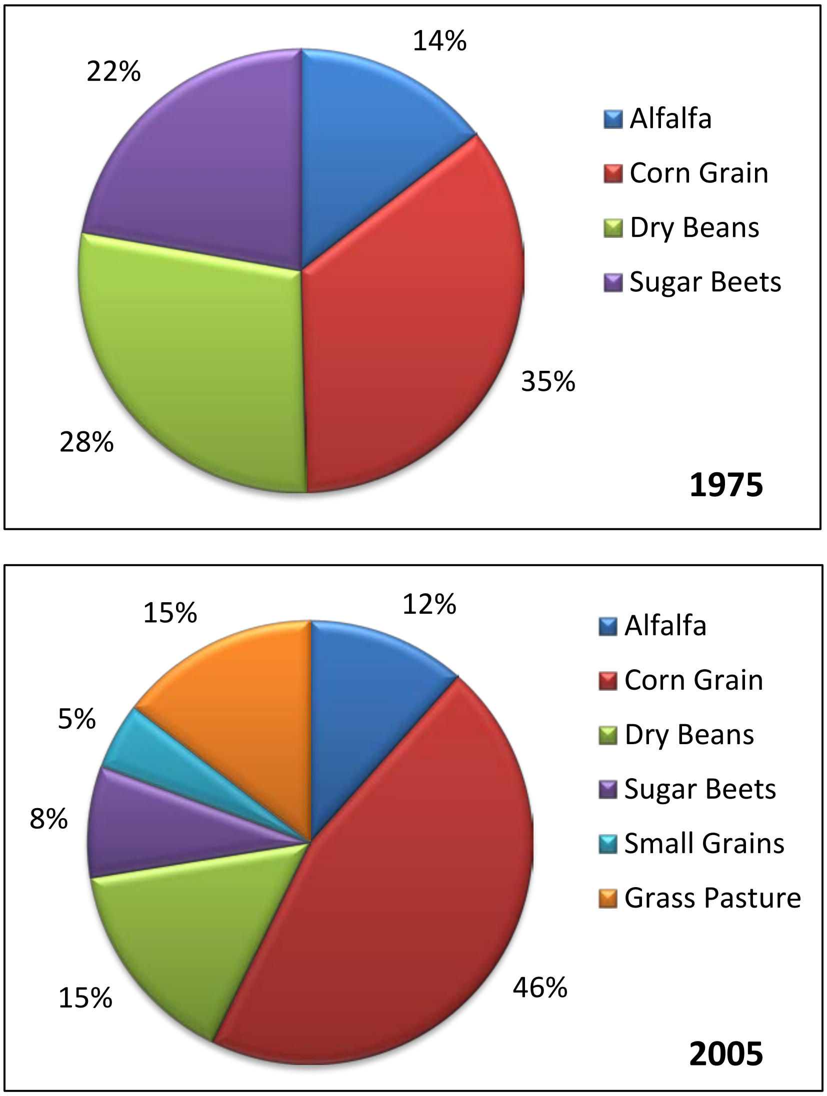
The irrigated acreage assigned to each structure was used to determine the available water capacity (AWC) information, used by StateCU to determine the volume of the soil moisture zone available to store excess irrigation for each structure. AWC values were estimated through a spatial intersection between the 2005 irrigated lands coverage and a soil coverage provided by the The Flatwater Group. The average AWC of the irrigated land assigned to the structure and used in the analysis is shown in **Table 2**.

Table 2: Pumpkin Creek & Greenwood Creek AWC Values

Structure	AWC (in/in)
Courthouse	0.125
Last Chance	0.125
Nelson	0.145
Trinnier	0.146

Crop and acreage information was used to develop the NIR estimate by structure, as discussed in the *WWUM Irrigated and Dryland Acreage Assessment* report. It is also used in the water balance analysis by StateCU to determine the soil moisture storing capacity available to each structure. **Figure 2** summarizes the average cropping pattern, as a percentage of total acreage, for the 1975 and 2005 irrigated acreage for this analysis. As shown, the predominant crops of corn, alfalfa and dry beans remain relatively consistent over the years. It appears that sugar beet acreage has been transitioned over, in part, to small grains and grass pasture. Additional discussion on the crop information data sources and the complete trend of crops through the study period is available in Appendix C of the *WWUM Irrigated and Dryland Acreage Assessment* report.

Figure 2: Pumpkin Creek & Greenwood Creek Crop Types 1975 vs. 2005



Attribution of supply type and irrigation method to acreage allows StateCU to calculate a representative system efficiency each year for each structure. In the beginning of the study period, the acreage under each canal was primarily served by surface water only with flood irrigation practices. Over time, as advancements were made in well and sprinkler technologies and streamflow in Pumpkin and Greenwood Creek decreased, the acreage served by the canals was supplemented by ground water supplies and sprinkler acreage increased. **Figures 3 and 4** graphically depict total annual acreage served by surface water or co-mingled supplies, and acreage that is flood or sprinkler irrigated, respectively. The increase in surface water only acreage in 2010 can be attributed to certified parcels (i.e. co-mingled acreage) that have inactive pumping for that year and were represented as surface water only acreage. See the *WWUM Dryland and Irrigated Acreage Assessment* documentation for more information on certified parcels and inactive pumping.

Figure 3: Pumpkin Creek & Greenwood Creek Total Structure Acreage by Supply Type

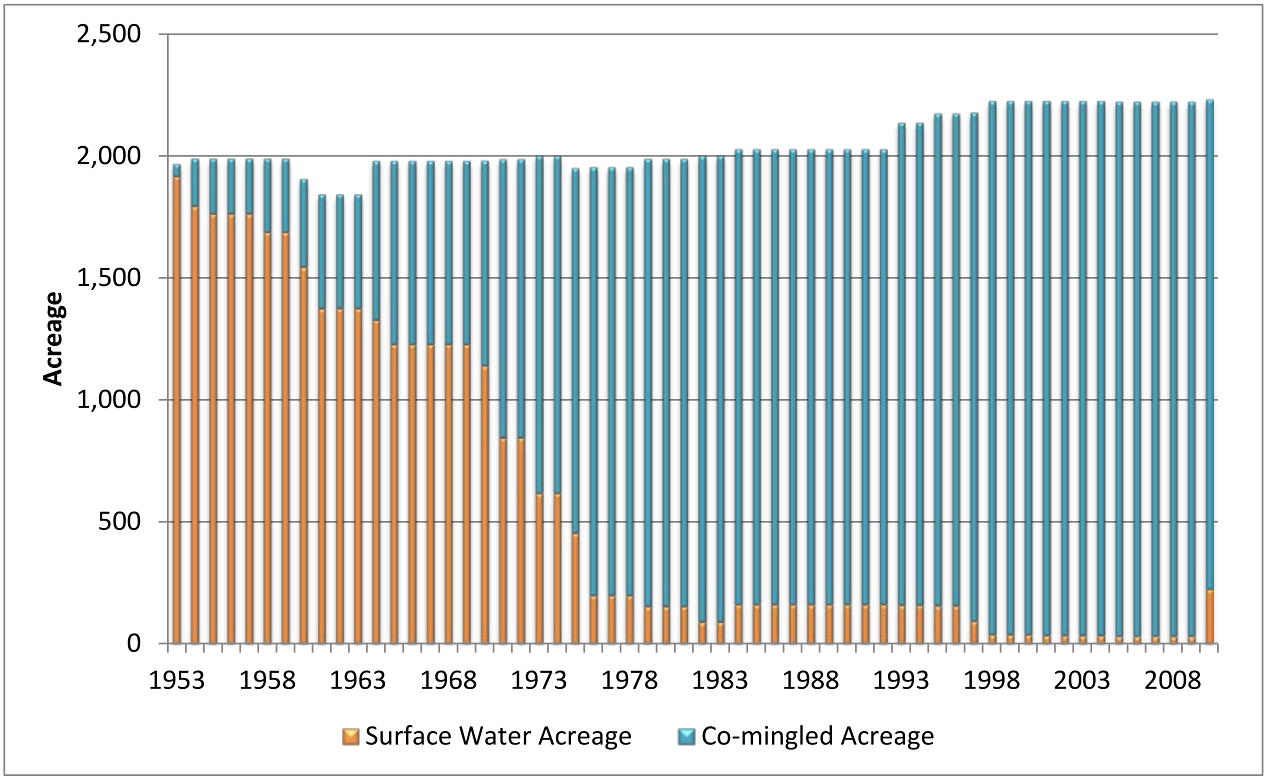
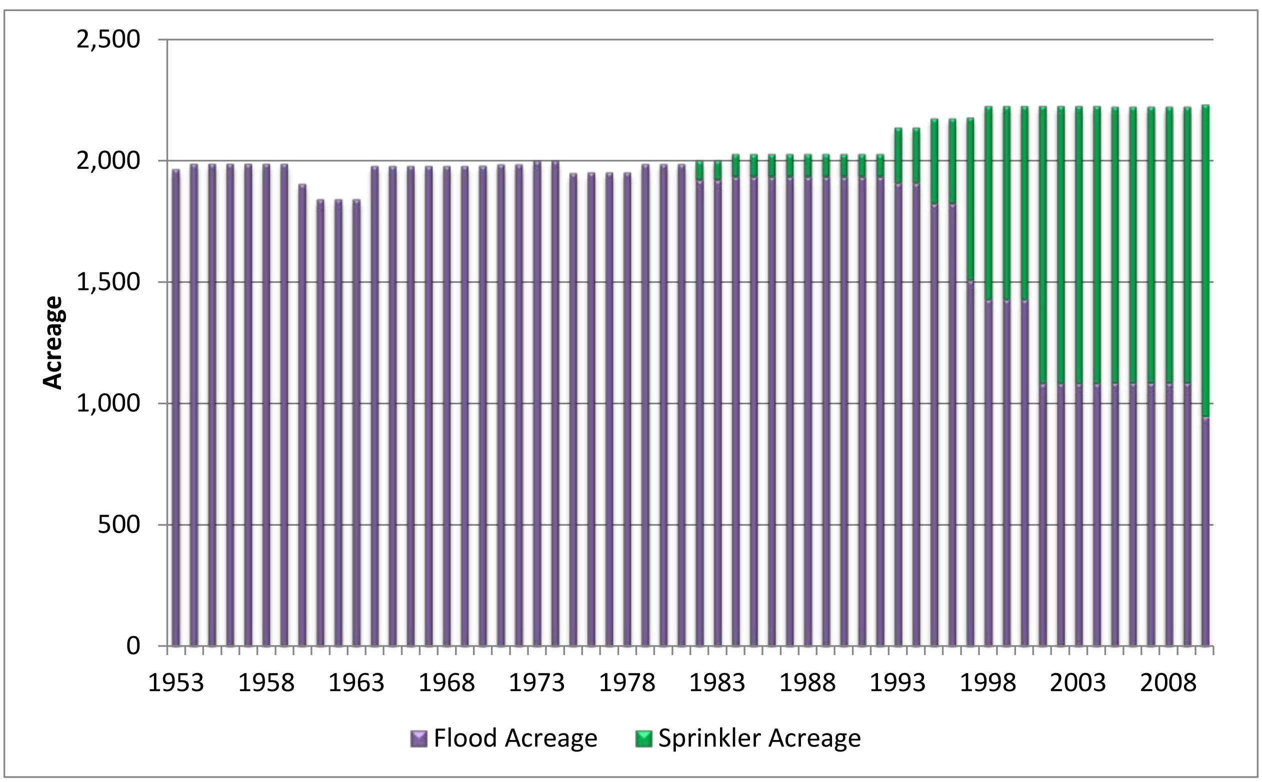


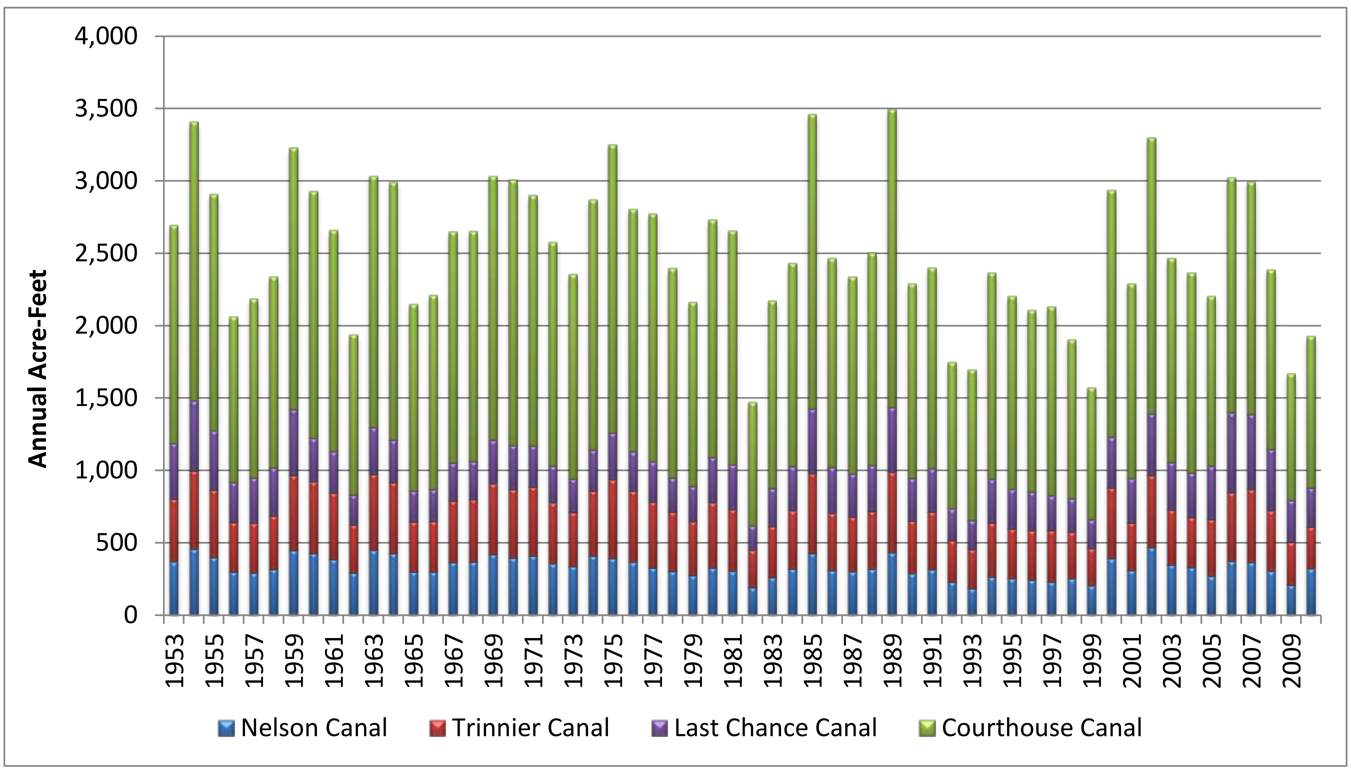
Figure 4: Pumpkin Creek & Greenwood Creek Total Structure Acreage by Irrigation Method



Efficiencies: Conveyance efficiency of 59 percent was used for all structures based on an analysis of USBR conveyance efficiency information in the North Platte River Valley. 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.

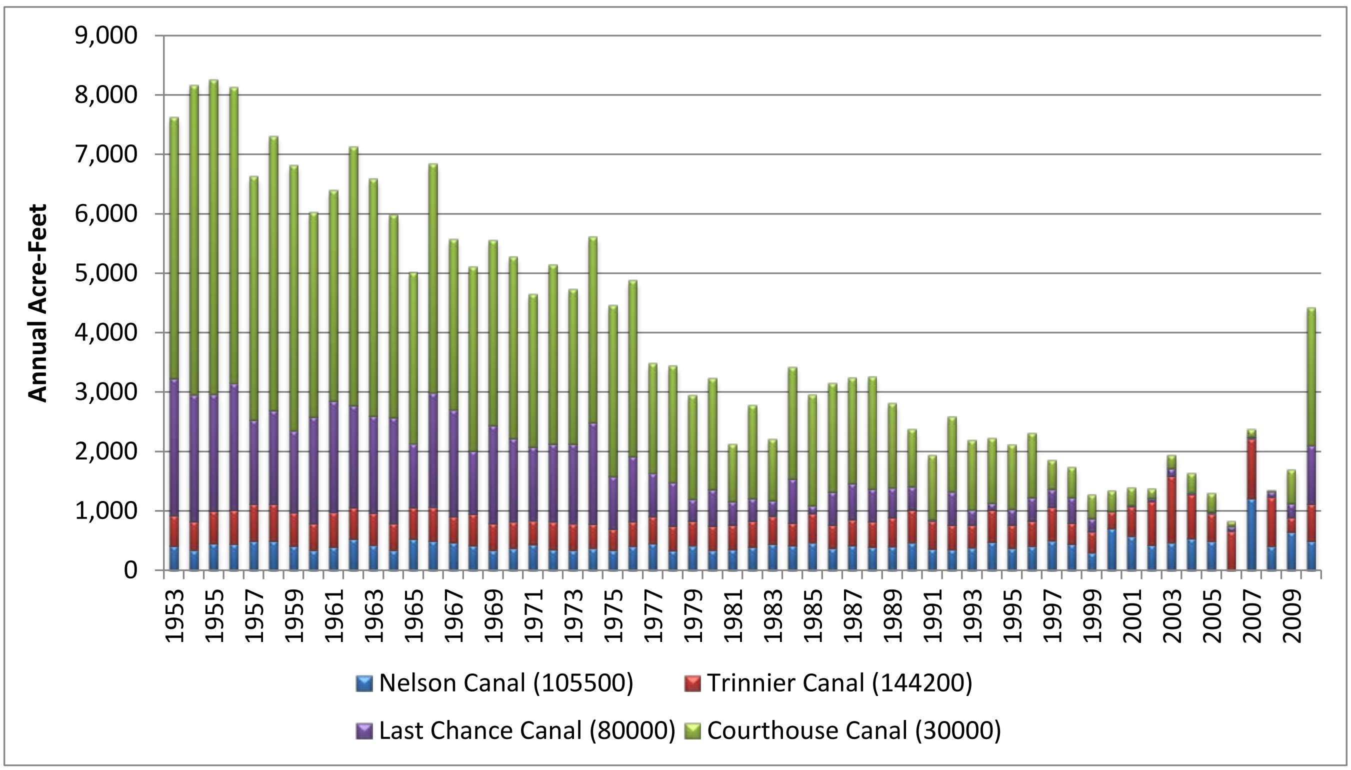
NIR: Monthly NIR information was provided by CropSim, which used the Hargreaves consumptive use methodology and factors calibrated to the ASCE Penman-Montheith method based on daily climate data to estimate potential ET. CropSim then accounts for varying soil conditions that impact soil moisture, and uses soil moisture along with effective precipitation to estimate NIR on a daily basis for each irrigated parcel in the NPNRD area. NIR for each irrigated parcel was then aggregated by structure and by month resulting in NIR for each structure in this analysis. **Figure 5** graphically presents the annual NIR for each structure for the 1953 to 2010 period.

Figure 5: Pumpkin Creek & Greenwood Creek NIR by Structure



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. A threshold of 5 days was used to aggregate daily data to monthly time series; if less than 5 days is missing in a month, the daily diversion data was aggregated into a monthly value. If greater than 5 days in a month was missing, the entire month was set to missing and filled using a using a wet/dry/average pattern according to an "indicator" gage. Each month of the streamflow at the indicator gage was categorized as a wet/dry/average month; months with gage flows at or below the 25th percentile for that month are characterized as "dry", while months at or above the 75th percentile are characterized as “wet”, and remaining months are characterized as “average”. Using this characterization, missing data points were filled based on the wet, dry, or average pattern. The pattern streamflow gage used is the Pumpkin Creek near Bridgeport (06685000). If missing data still existed after filling with a pattern file, historical monthly averages were used to fill the remaining data. Data for Trinnier Canal and Nelson Canal is generally available only in more recent years, from 1998 on. Data for Courthouse Canal and Last Chance Canal was generally available for the entire study period. **Figure 6** graphically presents annual diversions for each structure, and includes the NDNR Stream Gage ID used to develop the diversion data. The general decline in diversions for Courthouse Canal and Last Chance Canal may be attributable to a decline in streamflow conditions as well as the increase in supplemental supplies over the years. A long term period of data was not available for Nelson Canal and Trinnier Canal, therefore declining trends may not be represented. Note that 2010 was an above-average year for streamflow conditions on the creeks, and the increase in surface water diversions in that year reflect an increase of water availability in that year.

Figure 6: Pumpkin Creek & Greenwood Creek Annual Diversions by Structure



Groundwater diversions were estimated by StateCU to meet the remaining NIR, based on a Mutual Ditch pumping approach and the amount of acreage that receives supplemental pumping supplies. The estimated pumping for these structures is discussed in the **Results** section below. Note that metered pumping records are available from 2003 through 2010 for the structures in Greenwood Creek and Pumpkin Creek from the North Platte NRD. This metered pumping information is not reflected in this documentation as the integration of the metered pumping data for the entire Greenwood Creek and Pumpkin Creek was completed external to this analysis. The integration of these pumping records is further discussed in the **Integration** section below.

Results: As discussed above, the primary information from this CU analysis that will be used in the WWUM ground water modeling efforts is an estimate of supplemental pumping for the pre-2003 period and canal recharge for the entire 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.

Figure 7 summarizes the annual NIR in contrast to the historical surface water diversions and estimated ground water diversions (i.e. Figure 7 does not reflect metered pumping records). The surface and ground water diversions exceed the NIR values because they include the amount of water lost to conveyance and application efficiencies represented in the model. The increasing trend of ground water pumping estimates shown below reflects both the decrease in surface water supplies and the transition over to supplemental ground water supplies. The reduction in total diversions (surface plus ground water) reflects increased application efficiency due to trending sprinkler use.

Figure 7: Pumpkin Creek & Greenwood Creek NIR and SW/GW Diversions

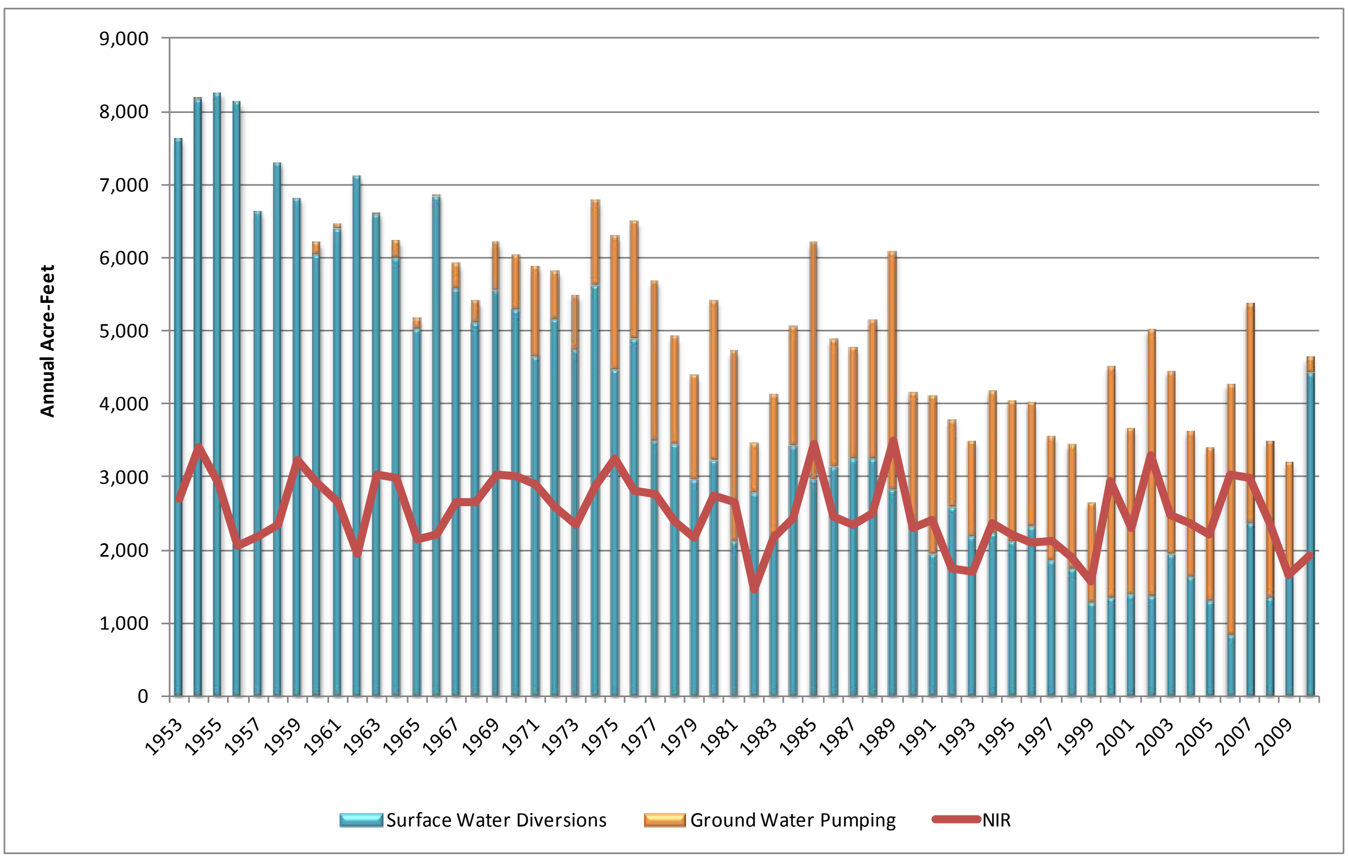
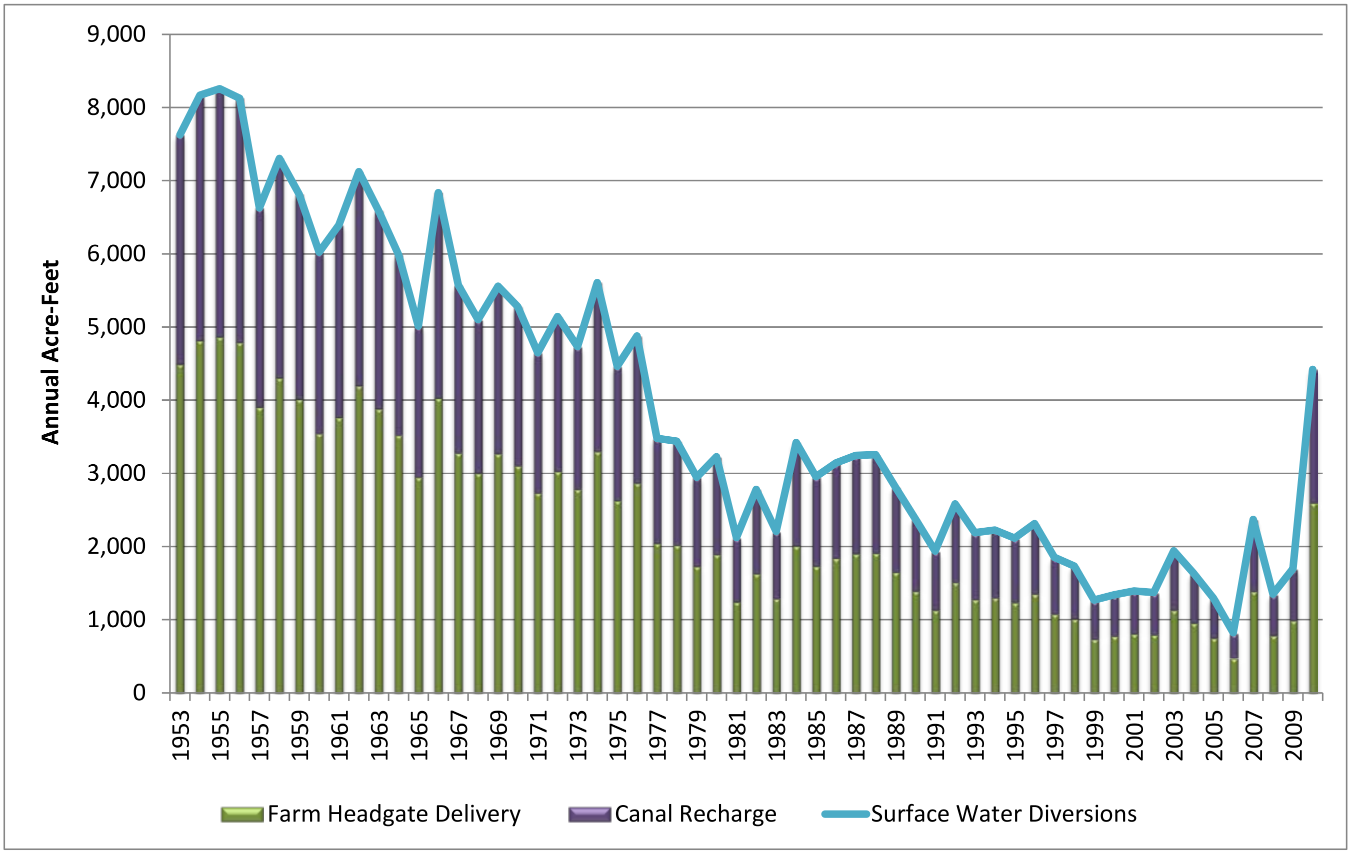


Figure 8 summarizes the annual canal recharge as a portion of the total surface water diversions and the remaining portion available at the farm headgate. As canal efficiency was modeled at 59% for all structures,

there is a constant portion of the surface water diversions that is modeled as canal recharge, 1,606 acre-feet on average over the 1953 to 2010 study period.

Figure 8: Pumpkin Creek & Greenwood Creek Canal Recharge



Integration: The monthly estimates of supplemental pumping and canal recharge are distributed to a spatial level for use in the ground water model. External to this analysis, supplemental pumping results from this StateCU analysis for the 1953 to 2002 period are limited by well capacity, and merged with metered pumping records generally available from 2003 through 2010. The merged monthly pumping information is then distributed spatially to well locations based on their assignment to 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. 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.