Upper Platte Single Planning Group

Overview of the WWUM Modeling and Analyses

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Principal Hydrogeologist
Adaptive Resources Inc.

NORTH PLATTE Natural Resources District

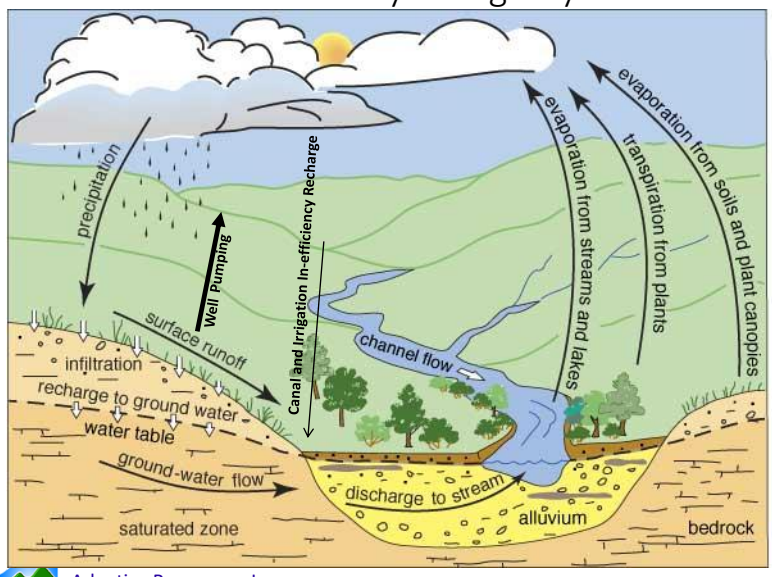
SOUTH PLATTE NATURAL RESOURCES DISTRICT

History of Modeling for SPNRD

- The COHYST Western Model Unit was the first generation of modeling – Completed in 2006
  - First cut at modeling the area.
- WWUM Modeling 1953 – 2010 was the second generation of modeling – Completed 2013
  - A complete rework of the COHYST model with numerous new and improved datasets
- WWUM Modeling 1953 -2013 is the third generation – Completed 2016
  - Extension of 2011 through 2013 and additional calibration to several components.

What are we trying to model?

A Schematic Similar to the North Platte and South Platte River's Hydrologic System



What is the Western Water Use Management Modeling?

- **Purpose:** Data centered modeling package to aid the North Platte NRD and South Platte NRD in water management decisions.

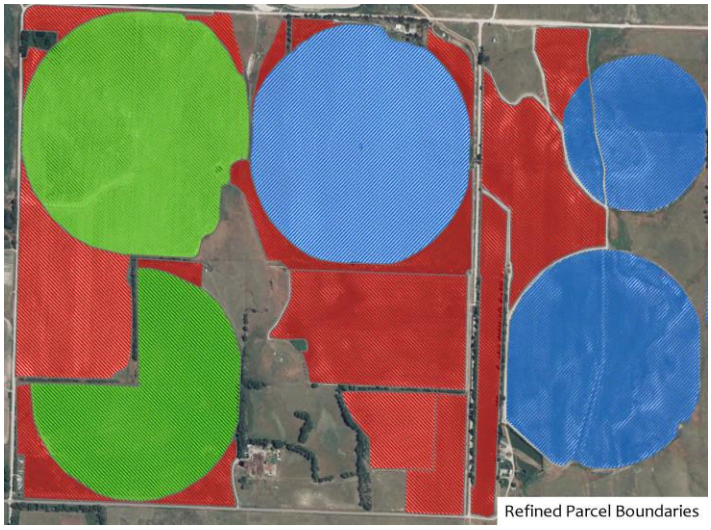
- Uses Three Models:
  - Surface Water Operations Model (NPNRD Only)
    - Simulates the prior appropriations system
    - Provides commingled ground water pumping and canal recharge
  - Regionalized Soil Water Balance Model
    - Uses climate and soil characteristics
    - Provides crop water use, irrigation water requirement, and ground only water pumping
  - Ground Water Model (MODFLOW)
    - Timing and movement of water through the aquifer

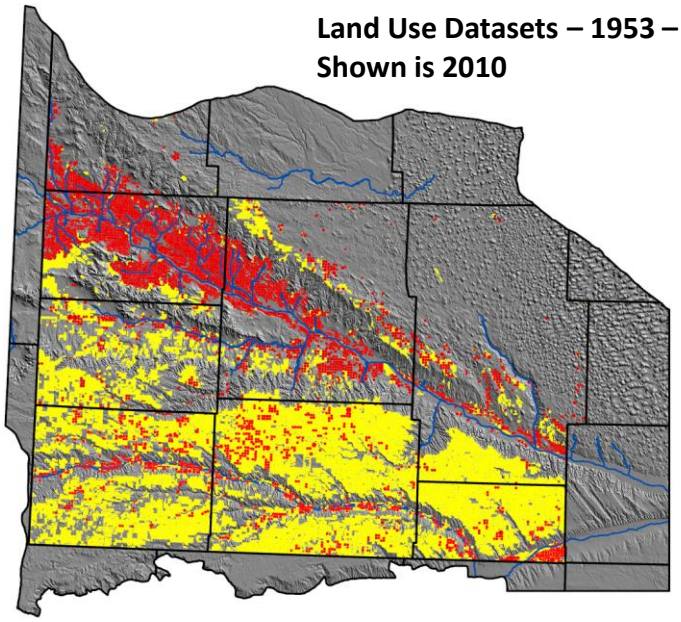
Modeling Dataset Review

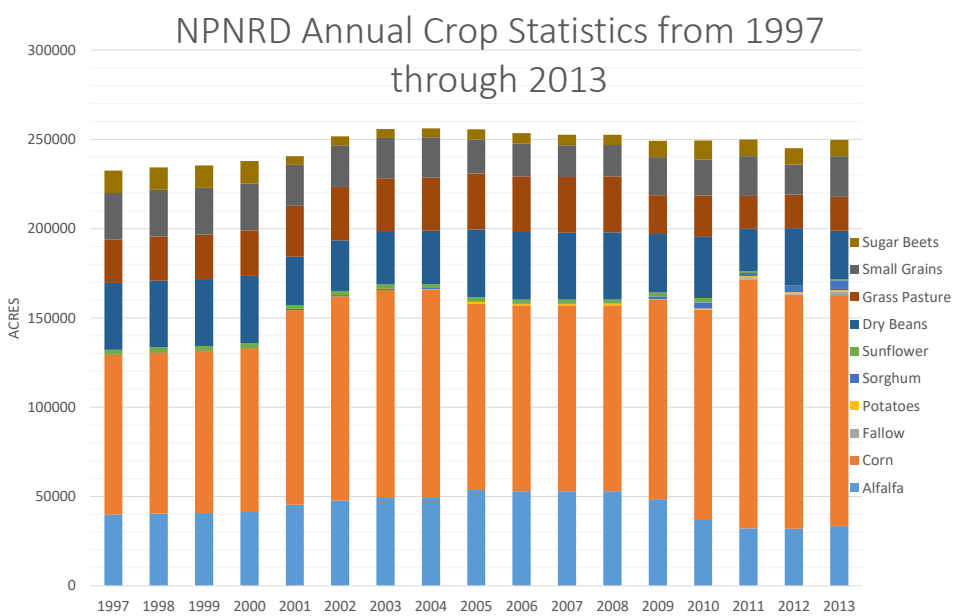
Modeling through 2013

- Land Use within NRDs – Annual 1953 - 2013
  - Aerial Photo Snap Shot Years
    - 1950s, 1970s, 1980s, 1993, 1997, 2001, 2003, 2005, 2009, 2010, 2012
    - Drew Circles and Squares Around Each Parcel for Each Snapshot
  - Attributed With:
    - Crop Type Information
    - Irrigation Water Source from NPNRD and SPNRD
    - Flood or Sprinkler Irrigation Method
    - Metered Pumping Information from Each NRD

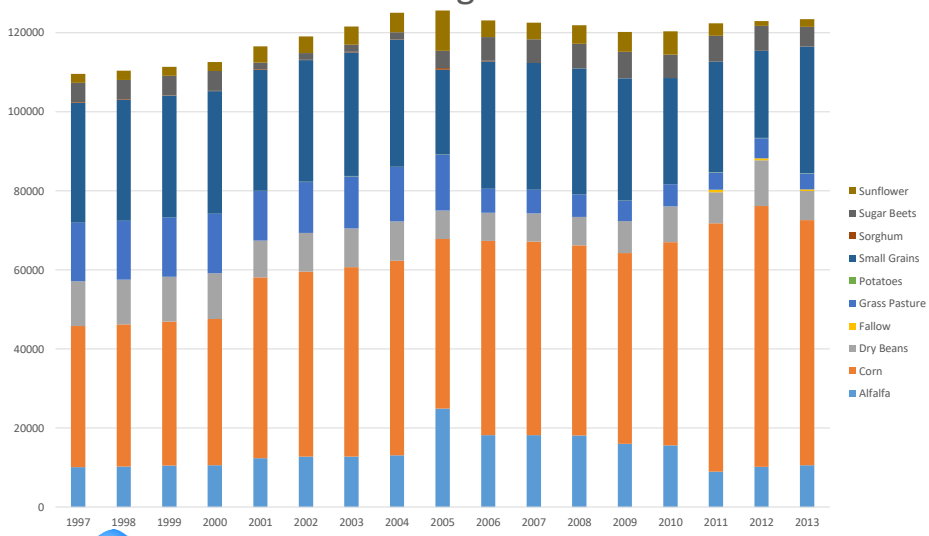
Land Use Datasets – 1953 - 2013



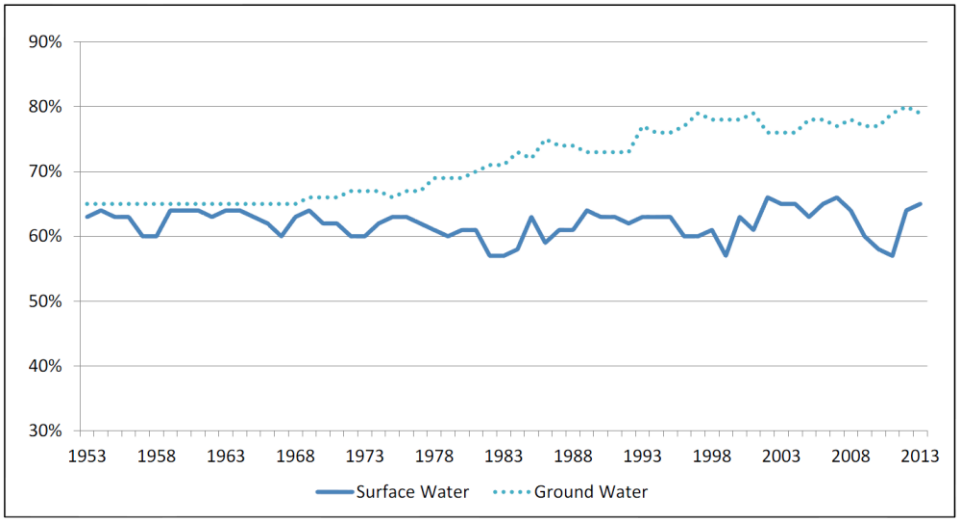

Land Use Datasets – 1953 – 2013
Shown is 2010


NPNRD Annual Crop Statistics from 1997 through 2013
ACRES
300000
250000
200000
150000
100000
50000
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Sugar Beets
Small Grains
Grass Pasture
Dry Beans
Sunflower
Sorghum
Potatoes
Fallow
Corn
Alfalfa

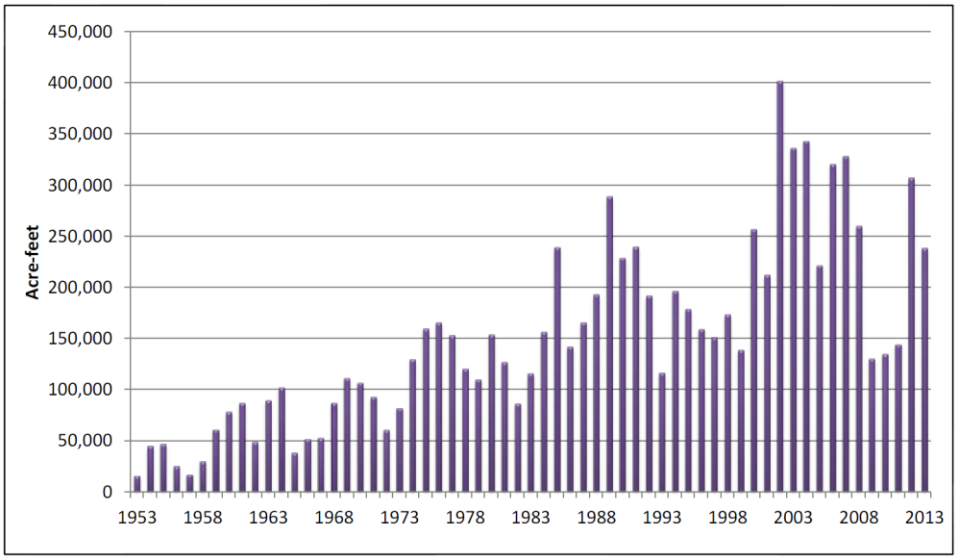
SPNRD Annual Crop Statistics from 1997 through 2013



NPNRD Irrigation Efficiency – 1953 - 2013



NPNRD Ground Water Pumping– 1953 - 2013



Modeling through 2013

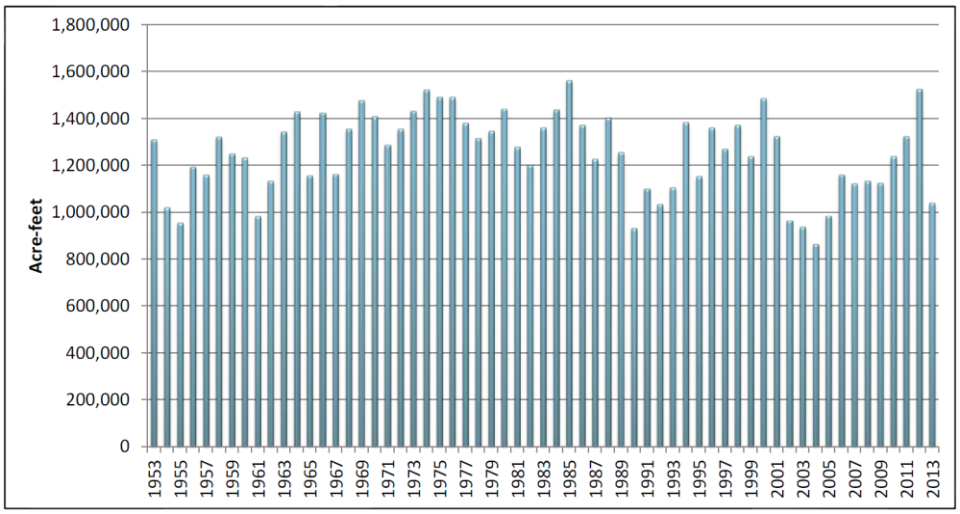
- Land Use outside NPNRD and SPNRD
  - Wyoming - Used existing land use dataset
    - 2005 Image
  - Colorado – Used information from the SPDSS modeling
  - UNWNRD – Used data from UNW Ground Water Model
  - COHYST – Used land use information from their modeling

Modeling Datasets

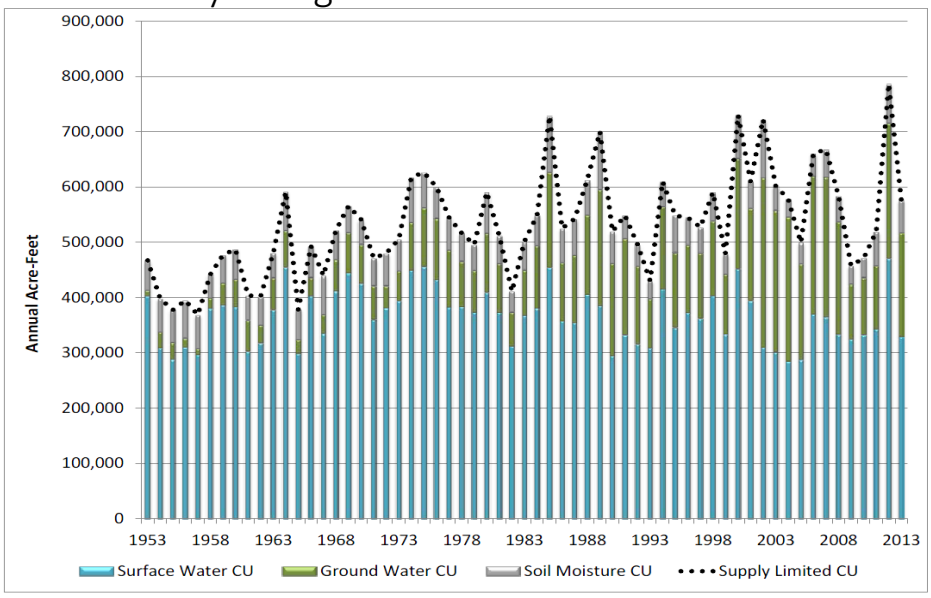
- Hydrology – Data Range from 1953 - 2013
  - Diversion, Stream Gage, and Monitor Well Information
    - NE DNR and US Bureau of Reclamation
      - Storage and Natural Flow Diversion Information
    - NE DNR and WY State Engineers Office
      - Stream Gage Information
    - NP and SP NRDs
      - Monitor Well Information
      - 874 Head Observation Points Were Used in the GW Model

Hydrologic Datasets – 1953 - 2013

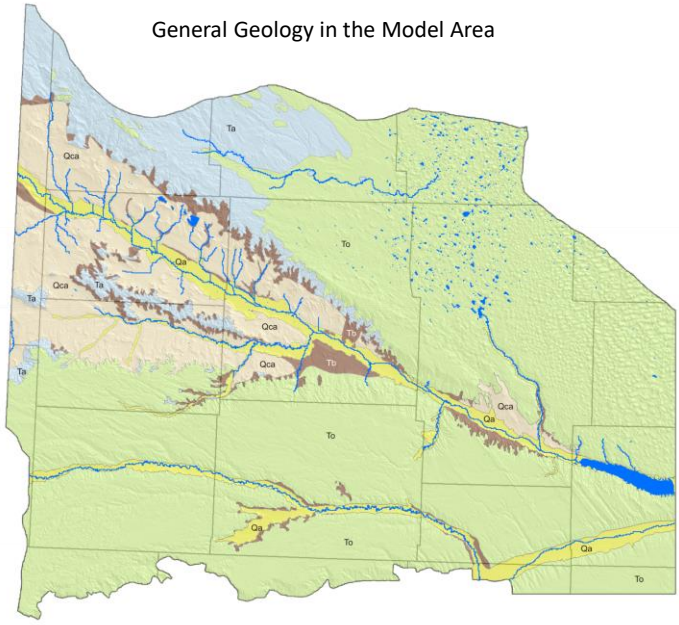
Total Annual Diversions (AF) within NPNRD



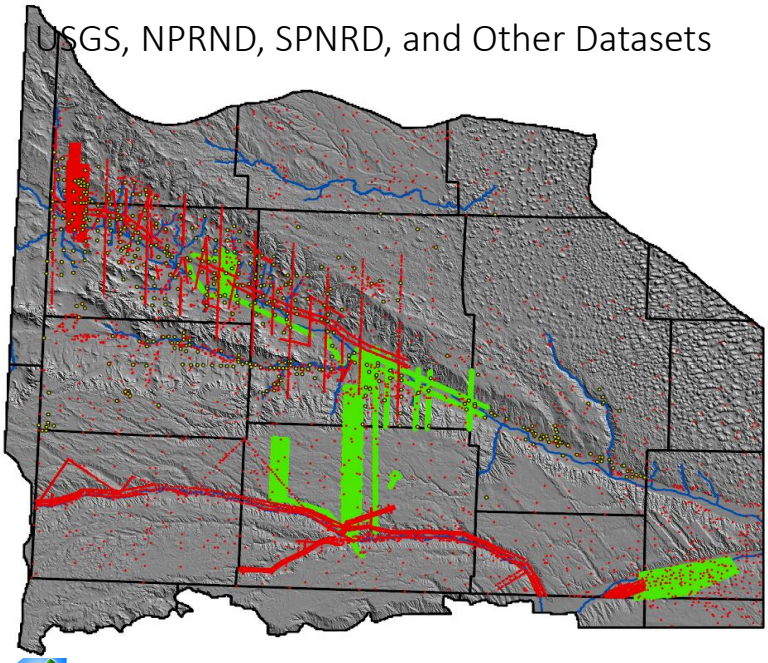
NPNRD Hydrologic Dataset – 1953 - 2013



General Geology in the Model Area



USGS, NPRND, SPNRD, and Other Datasets



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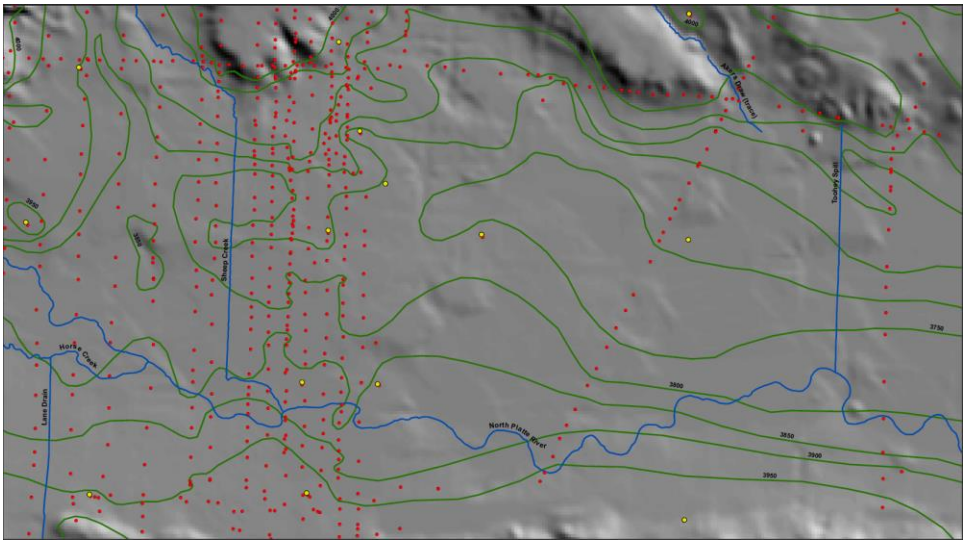

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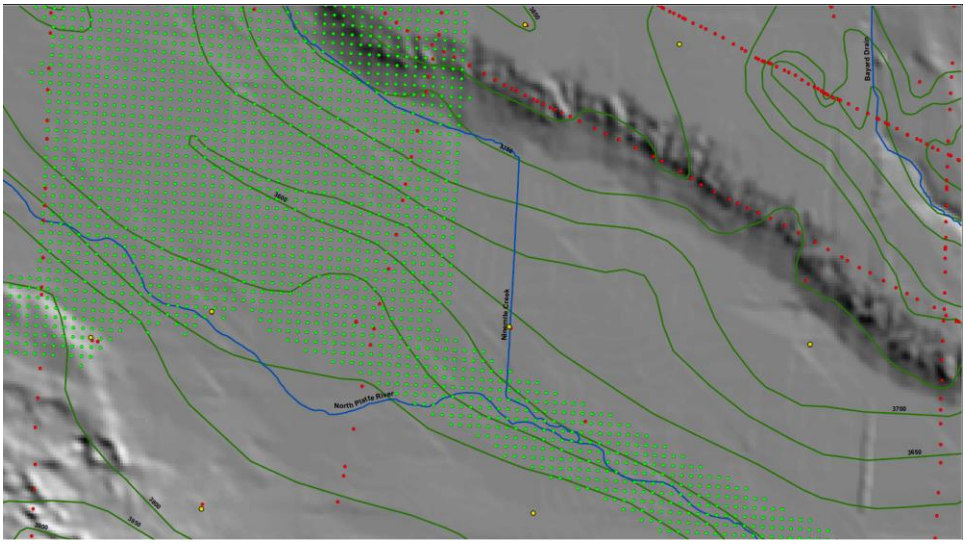

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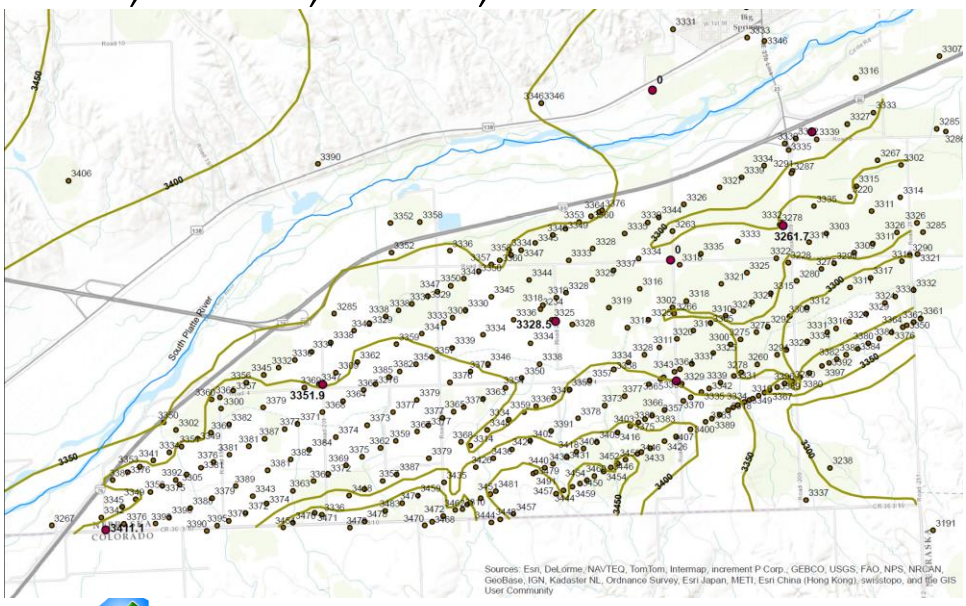
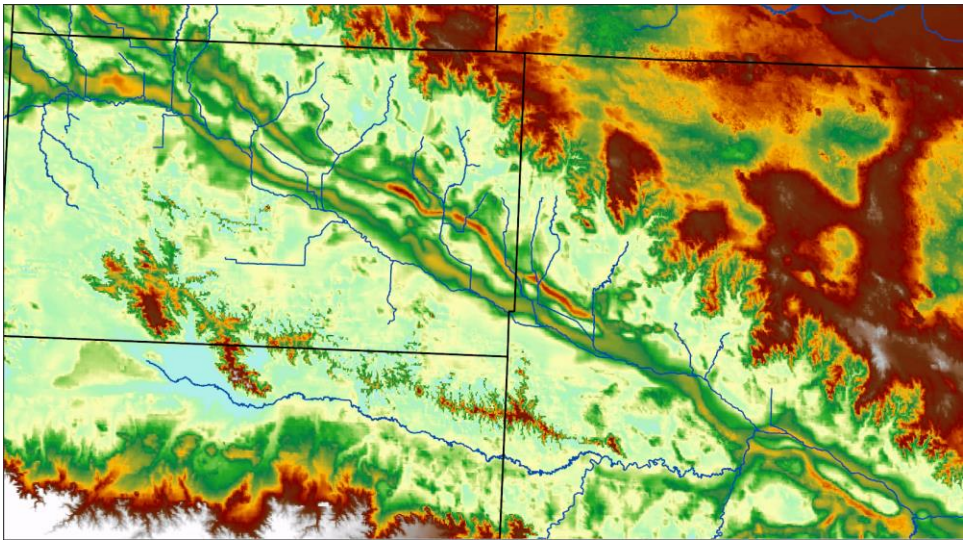
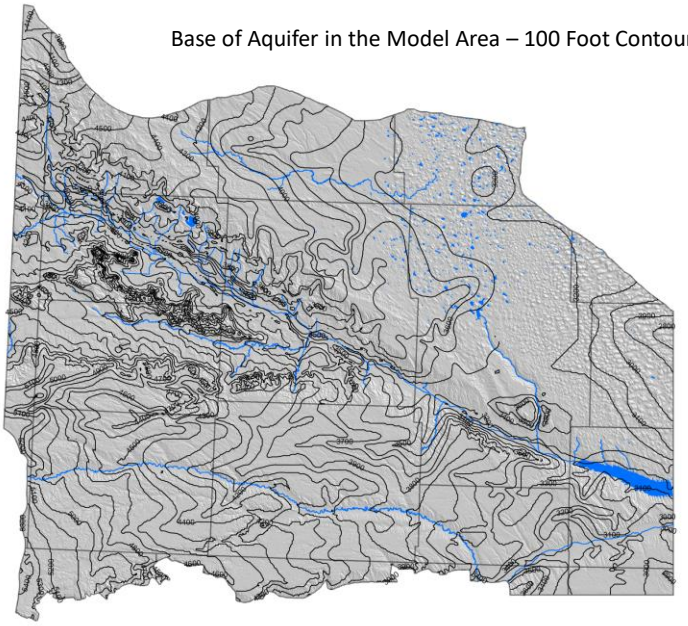


Saturated Thickness Map NPNRD



Base of Aquifer in the Model Area – 100 Foot Contours

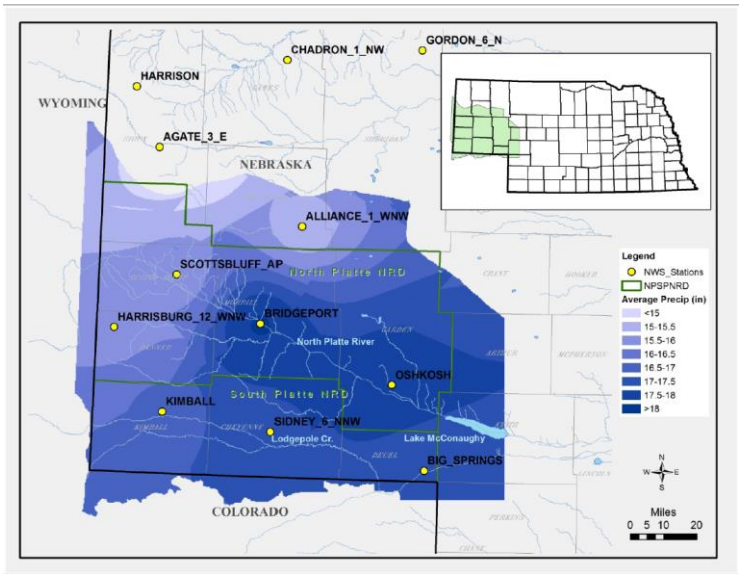


Regionalized Soil Water Balance Model

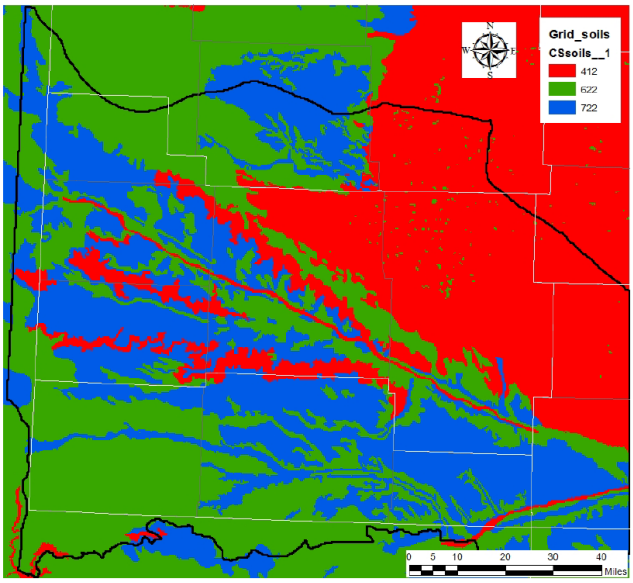
Current Modeling

- Regionalized Soil Water Balance Model
  - Crop Consumptive Use (CROPSIM)
    - Soil Water Balance
    - Determines Net Irrigation Requirement (Water Needed by Crops)
    - Provides Ground Water Only Land Pumping (Pre-Metered)
    - Provides Recharge from Irrigation Inefficiency and Precipitation

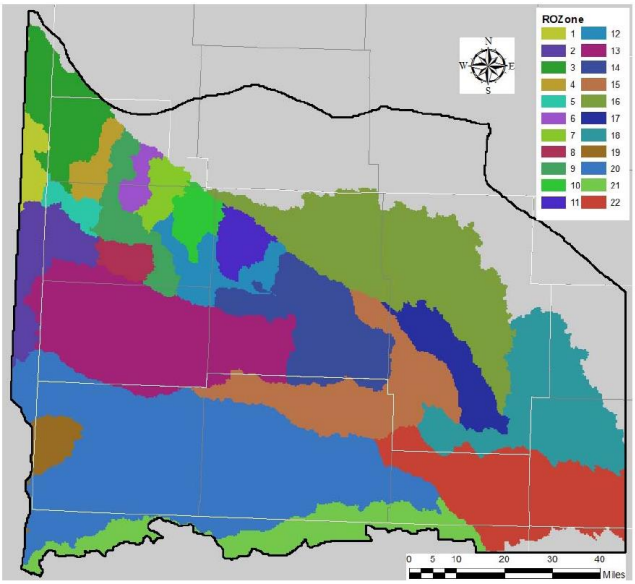
Weather Stations



Soil Classifications for CROPSIM



Runoff Zones

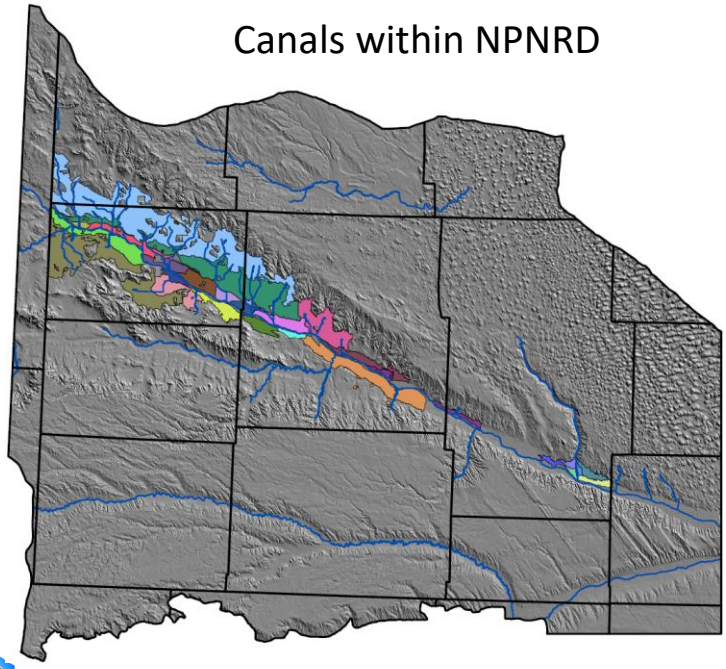


Surface Water Operations Model

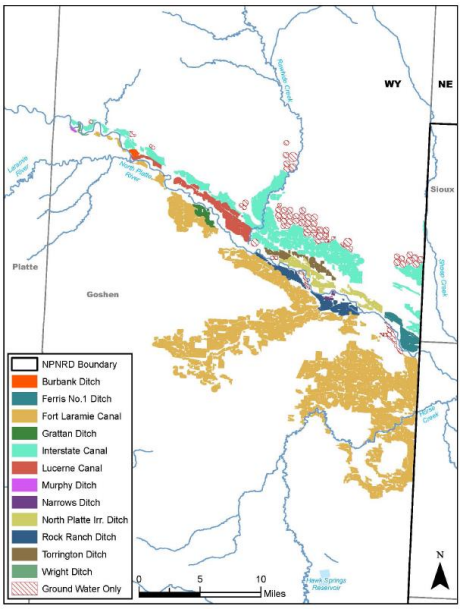
Surface Water Operations Model

- Model's Surface Water Deliveries Based on:
  - Prior Appropriation System
  - Crop Water Demands
  - System Operations
- Model is from Whalen Diversion Dam in WY to Lewellen North Platte River Gage
- Provides Ground Water Model with:
  - Commingled Pumping Estimates Prior to Meters
  - Canal Recharge

Canals within NPNRD



Wyoming Land Use by Water Source



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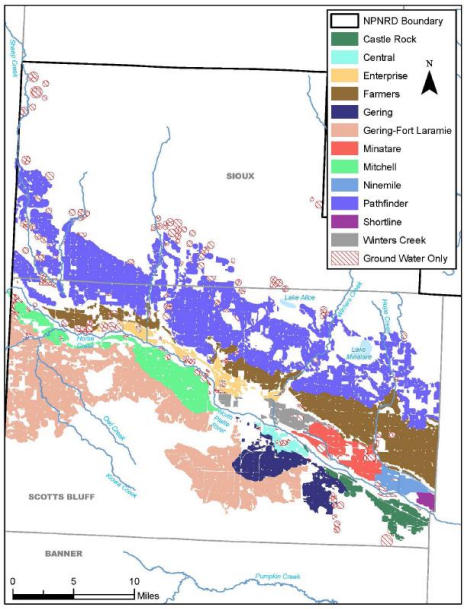
Scotts Bluff and Sioux Counties Land Use by Water Source



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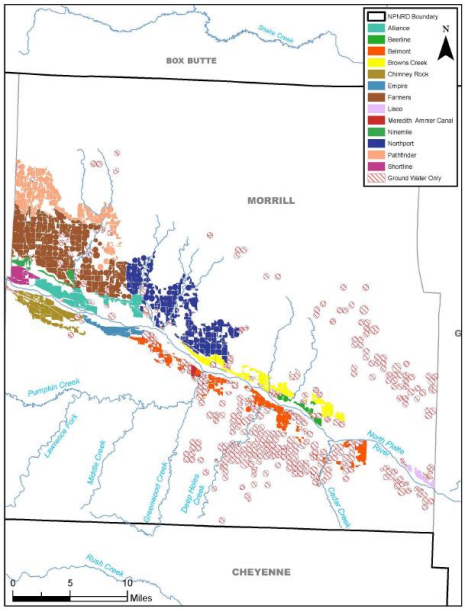
Morrill County Land Use by Water Source



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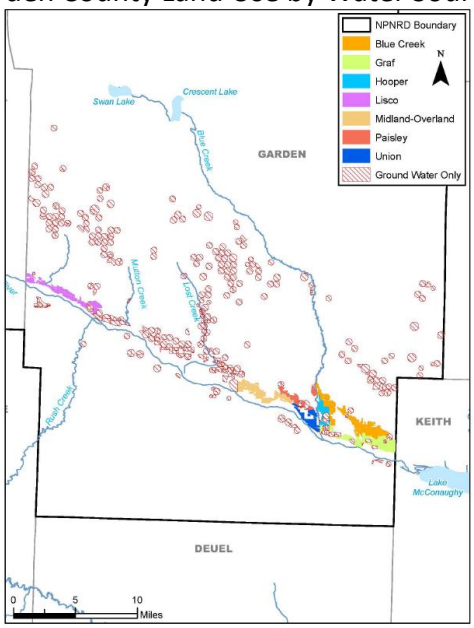
Garden County Land Use by Water Source



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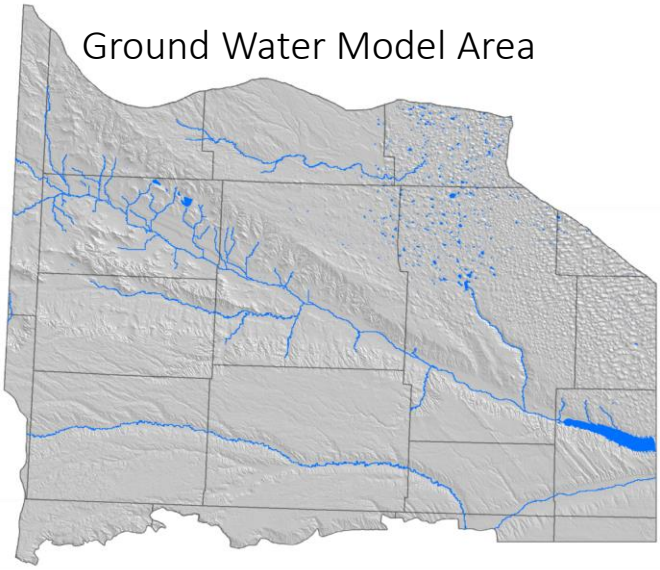
Ground Water Model

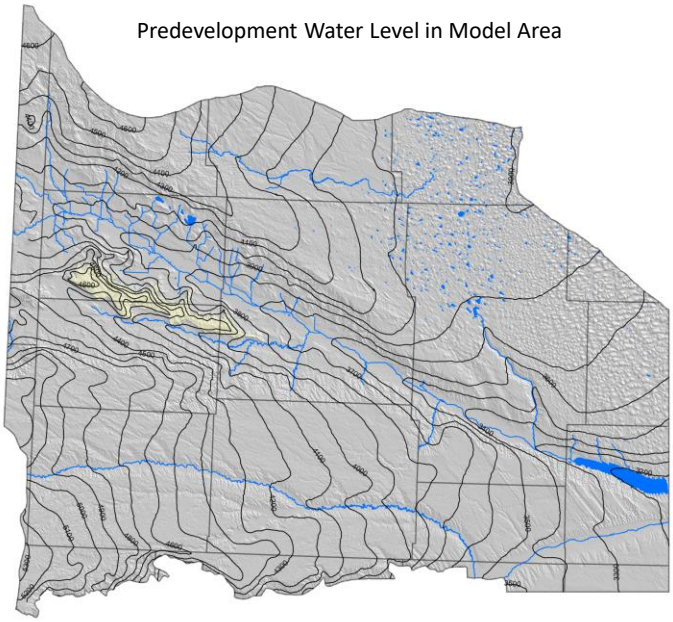
Ground Water Model Area



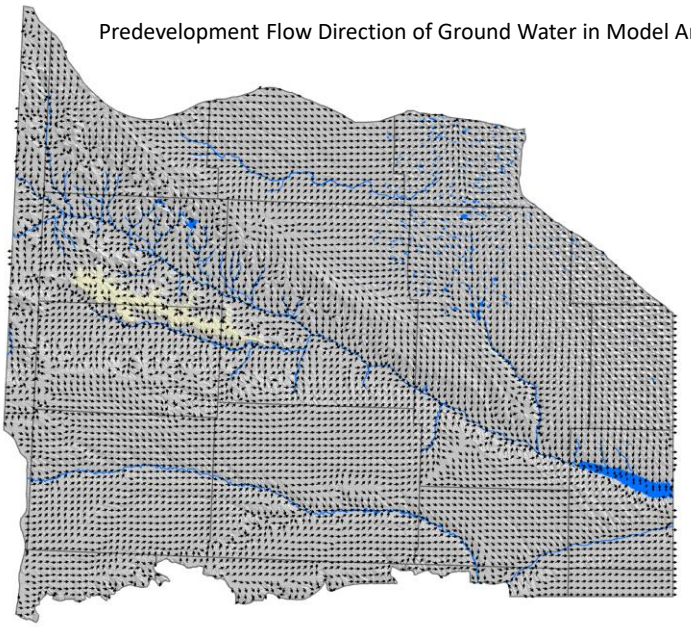
Current Modeling

- Ground Water Modeling
  - 40 Acre Cell Size
  - 177,780 Active Model Cells
  - 874 Head Calibration Targets
    - Mostly within NPNRD and SPNRD

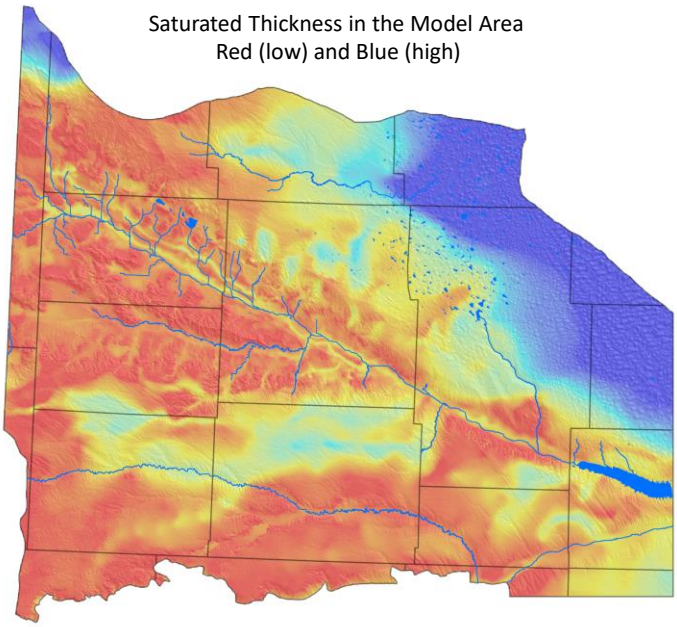
Predevelopment Water Level in Model Area

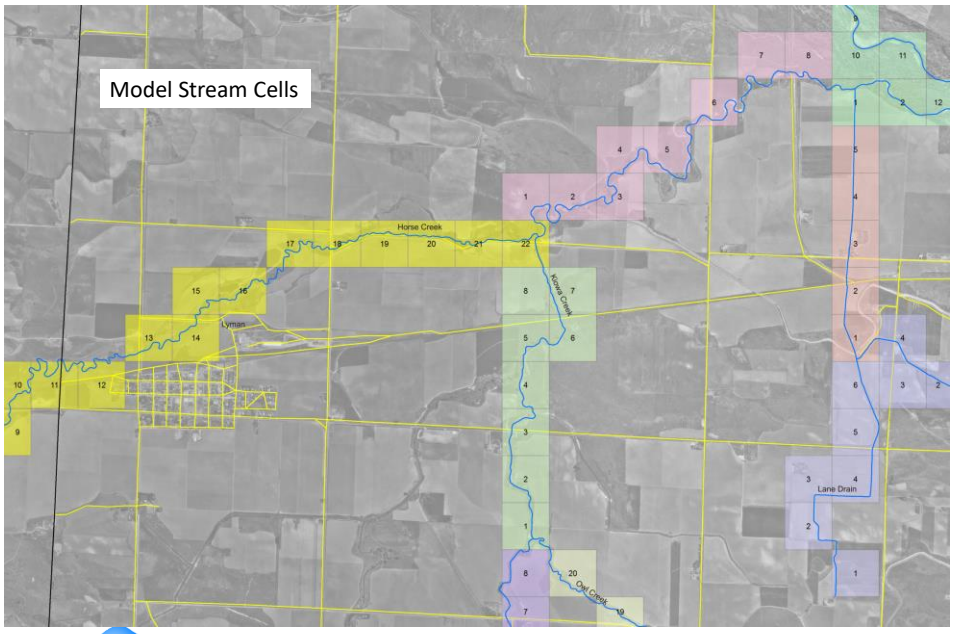


Predevelopment Flow Direction of Ground Water in Model Area



Saturated Thickness in the Model Area
Red (low) and Blue (high)

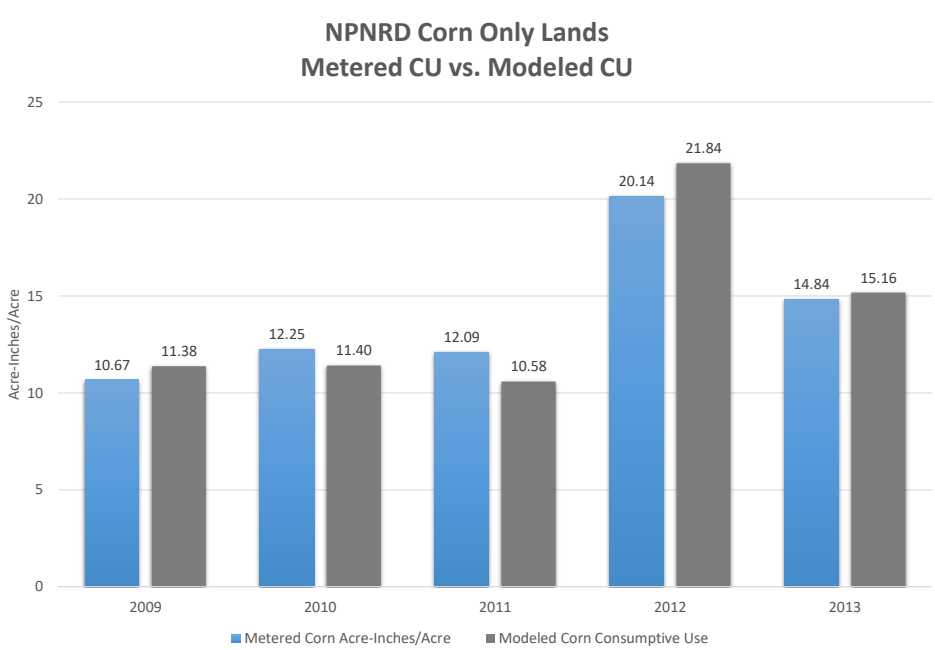




CROPSIM Calibration

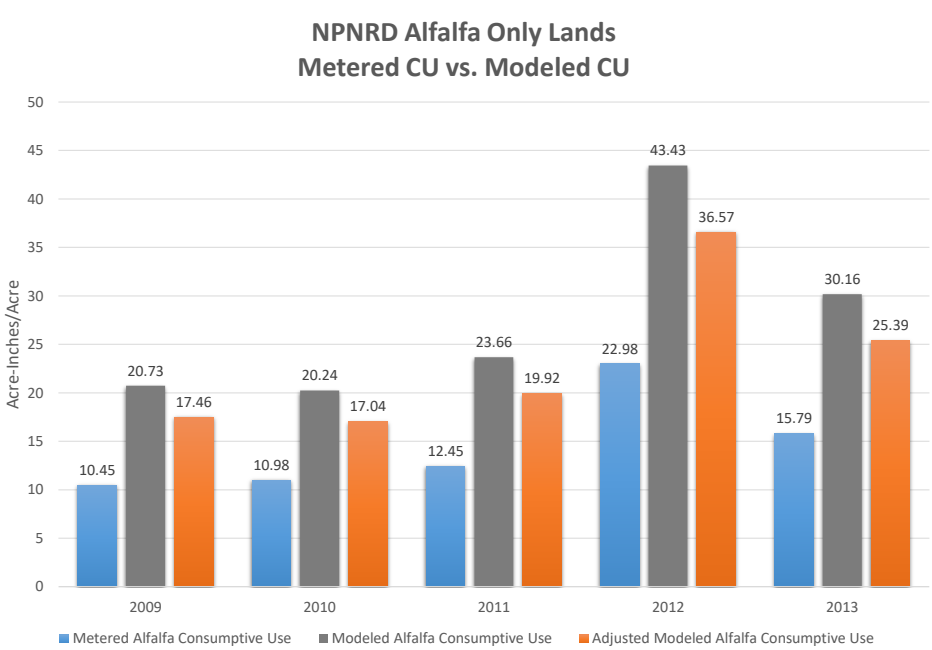
CROPSIM Calibration

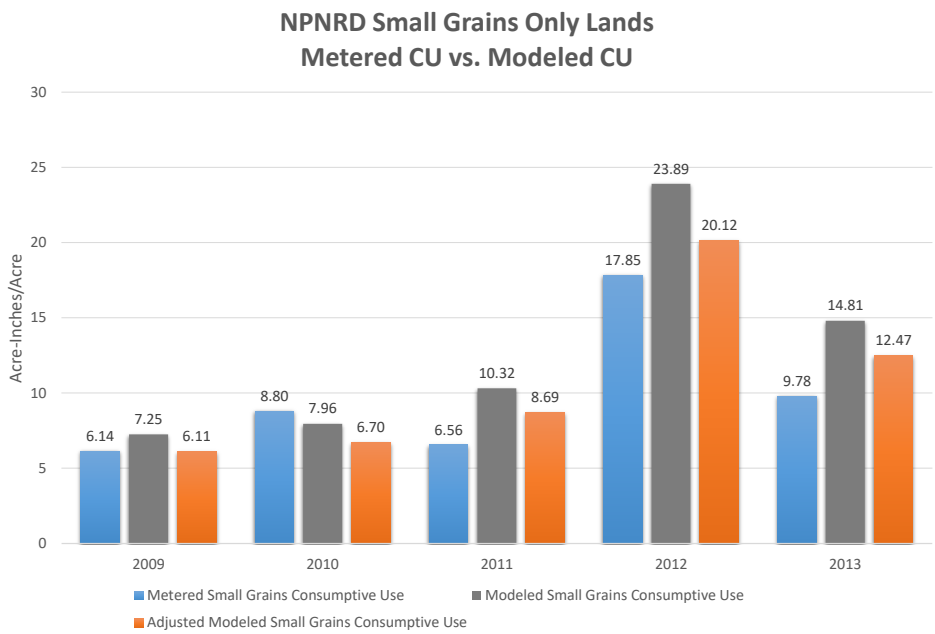
- Completed a QC check on the estimates of crop consumptive use predicted by CROPSIM using metered pumping data
  - Only on single crop only lands in each NRD



CROPSIM Calibration

- Adjusted irrigated alfalfa, small grains, and grass pasture to 80% of full NIR





Modeling Results

Ground Water Model vs. Ground Water Baseflow (1953 – 2010)

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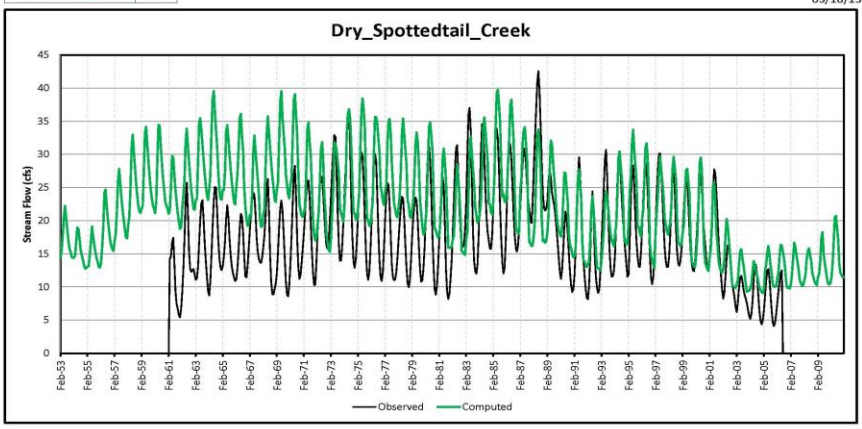

Ground Water Model vs. Ground Water Baseflow (1953 – 2010)

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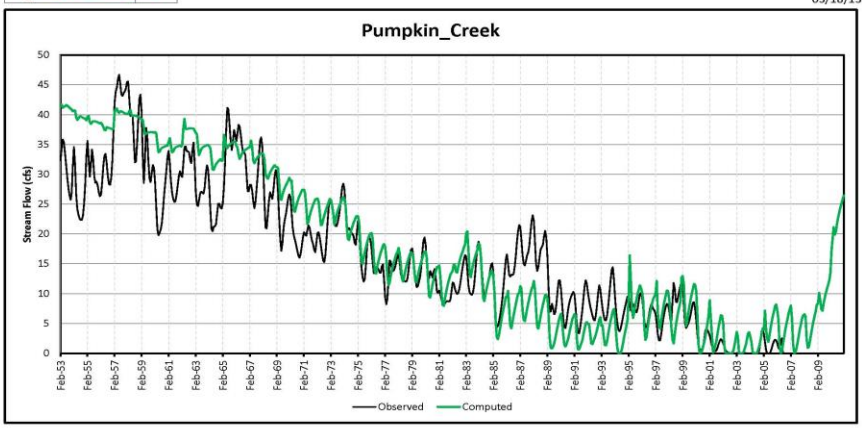
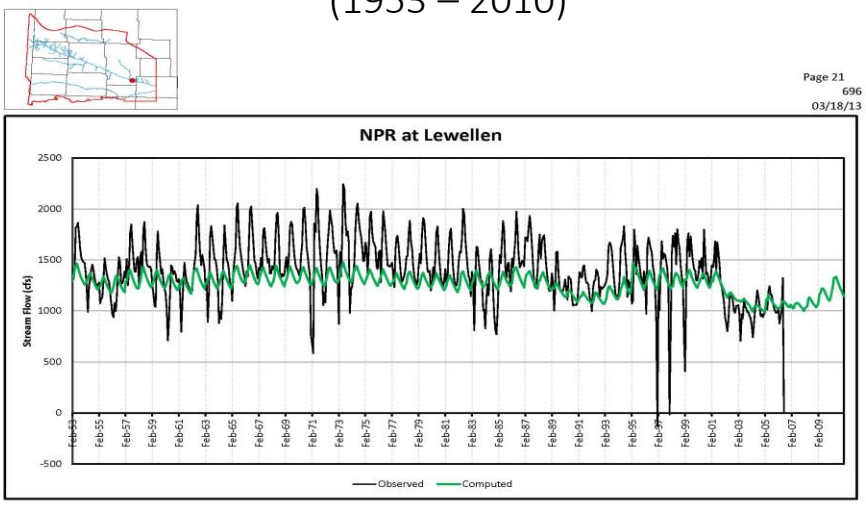
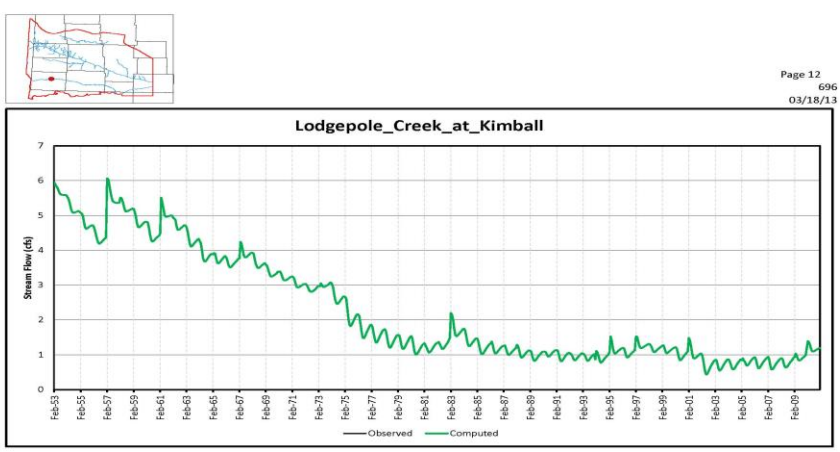


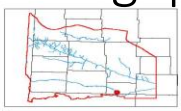
Ground Water Model vs. Ground Water Baseflow (1953 – 2010)



Modeled Lodgepole Creek Flow Hydrographs



Lodgepole Creek Flow Hydrographs



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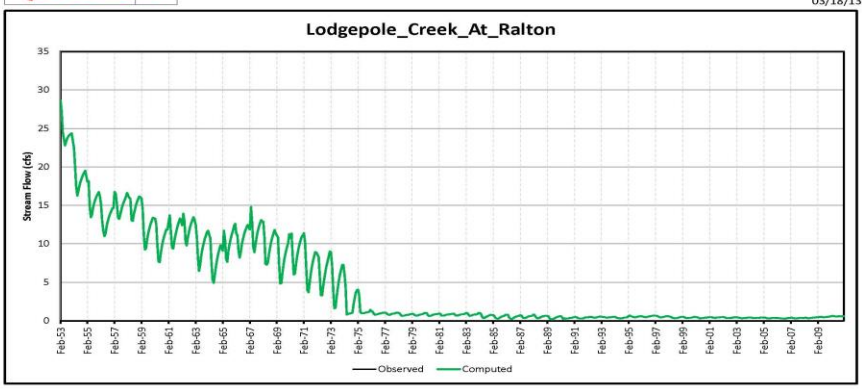
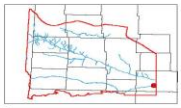


South Platte River Flow Hydrographs



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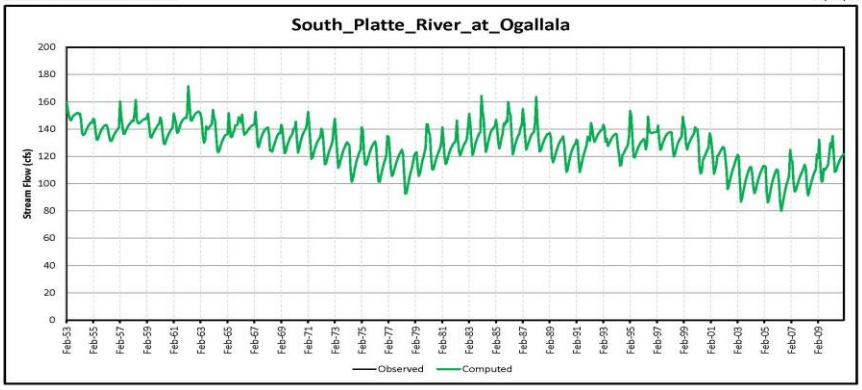

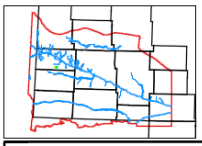

Head Observation Target

Monitor Well Hydrograph – South of Mitchell near NPR

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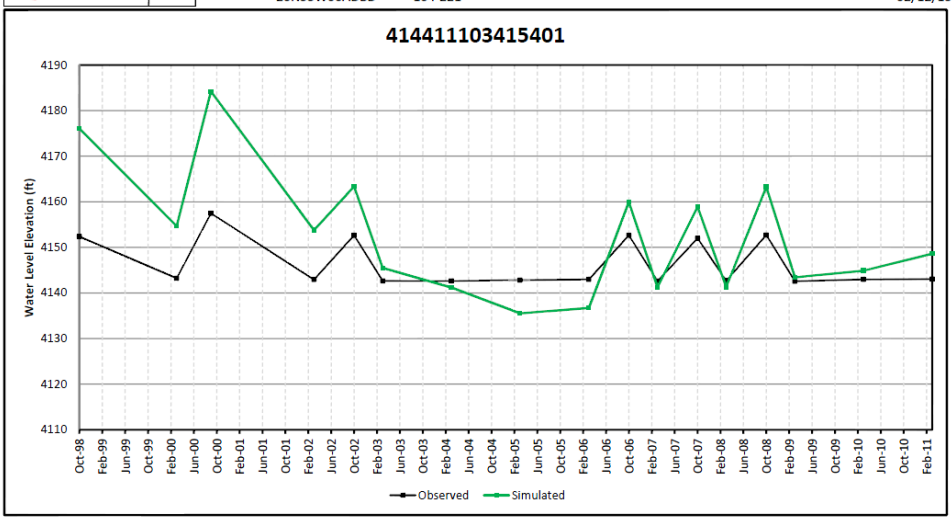
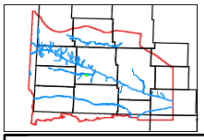
20N55W06ADBD 104-221





Head Observation Target

Monitor Well Hydrograph – Lower Pumpkin Creek Area

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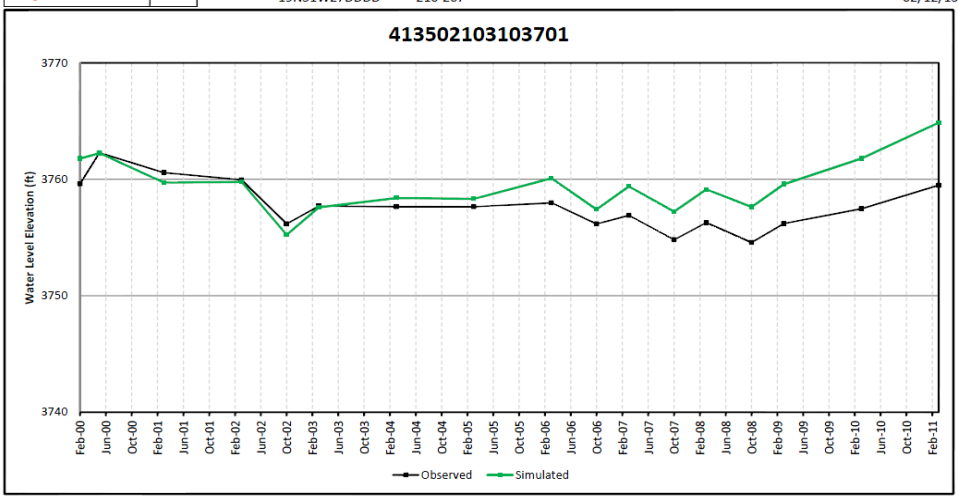
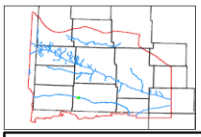
19N51W27DDDD 210-267



Head Observation Target



Monitor Well Hydrograph Near Dix

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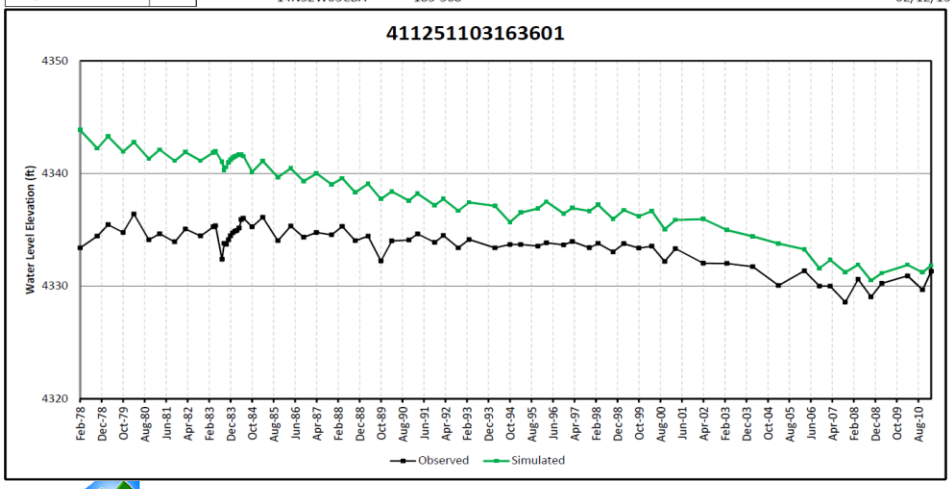
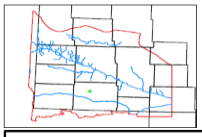
14N52W03CBA 185-368



Head Observation Target



Monitor Well Hydrograph - North Cheyenne County Tablelands

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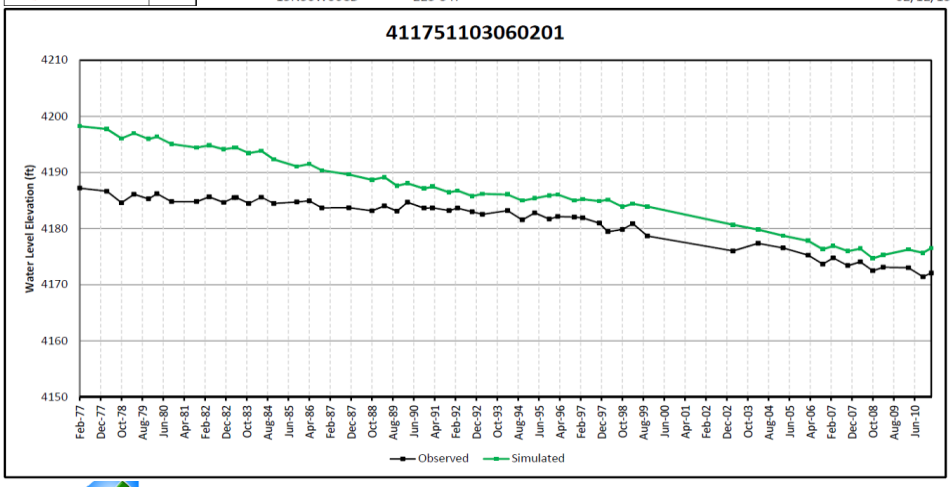
15N50W06CD 223-347



How do we use the models?

Change Modeling Discussion

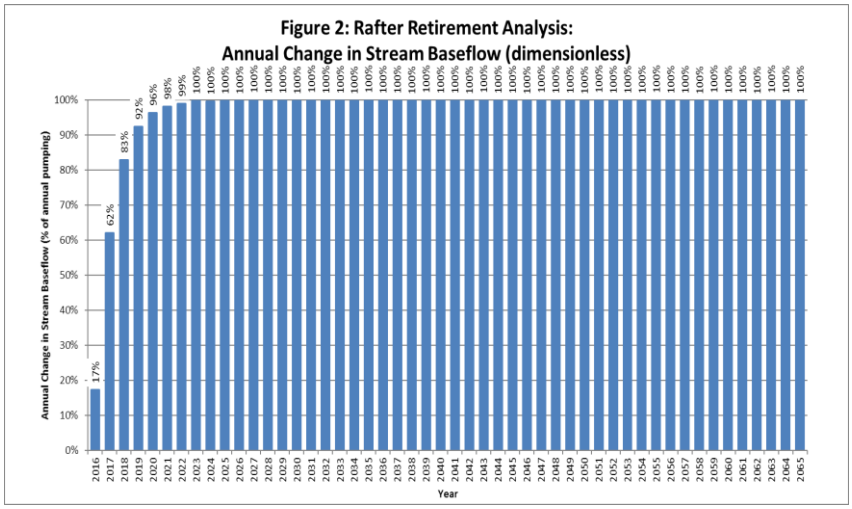
Change Modeling Discussion

- Modeling Design
  - Baseline Model
    - Typically the historic model with everything that actually happened
  - Modified Model
    - Modify one feature of the model
    - Example: Remove irrigated lands from the model to determine the depletive affects
  - Analysis
    - Baseline Model – Modified Model = Change
    - Change is typically streamflow or baseflow
  - Discussion about the analyses and the WWUM Modeling and COHYST Modeling overlap area

Ground Water Irrigated Acreage Retirement Analyses

Ground Water Irrigated Acreage Retirement Analyses

- Analyses
  - Determine accretive impacts from retiring ground water irrigated acres
    - Help NRDs determine if a property has sufficient impacts to a stream to purchase the ground water certified acres
    - Completed upwards of 40 to 50 analyses for NPNRD and SPNRD

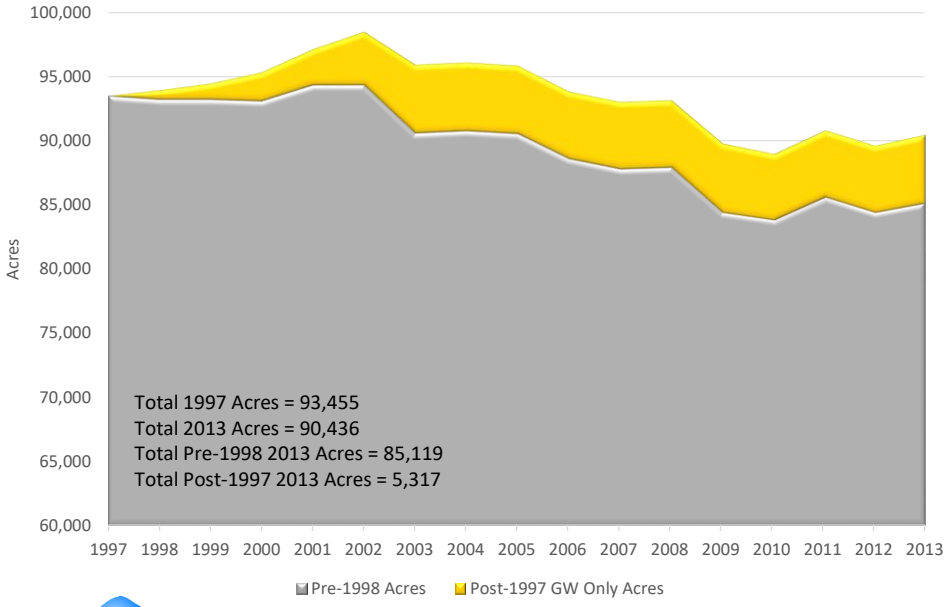


Post-1997 Depletions Analysis

Post-1997 Depletions Analysis

- Analysis
  - Determine Depletions Due to Irrigated Lands Developed after 1997
  - Analysis Repeated the 2009 – 2013 Model Time Period for 50 Years into the Future

NPNRD All Active Ground Water Only Land Use Development in OA Area



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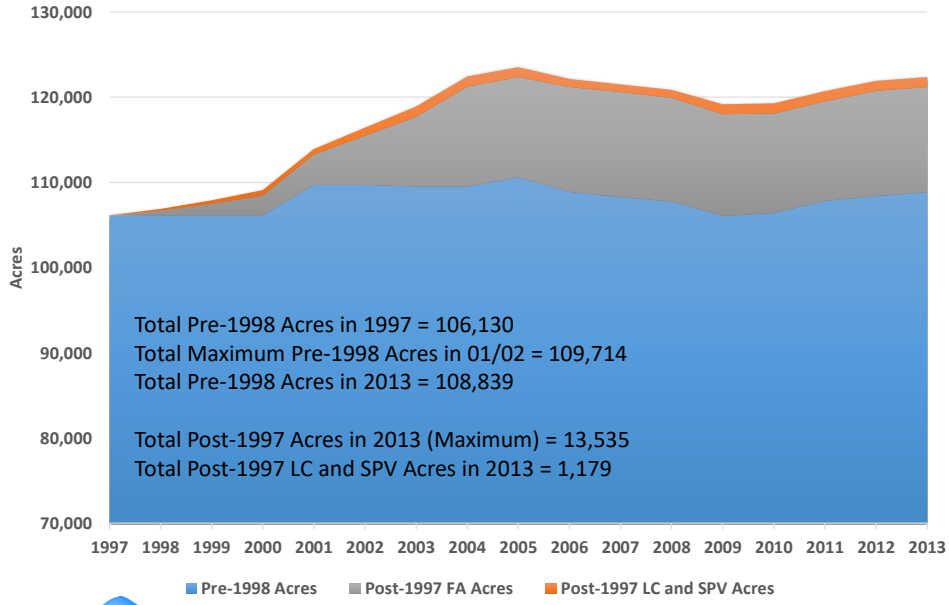
Preliminary SPNRD All Ground Water Only Land Use Development



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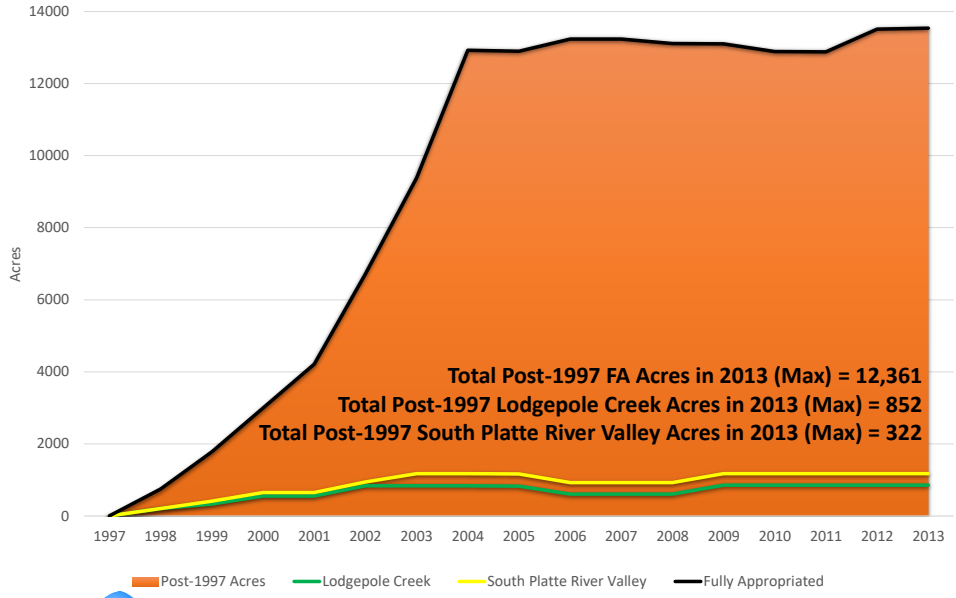
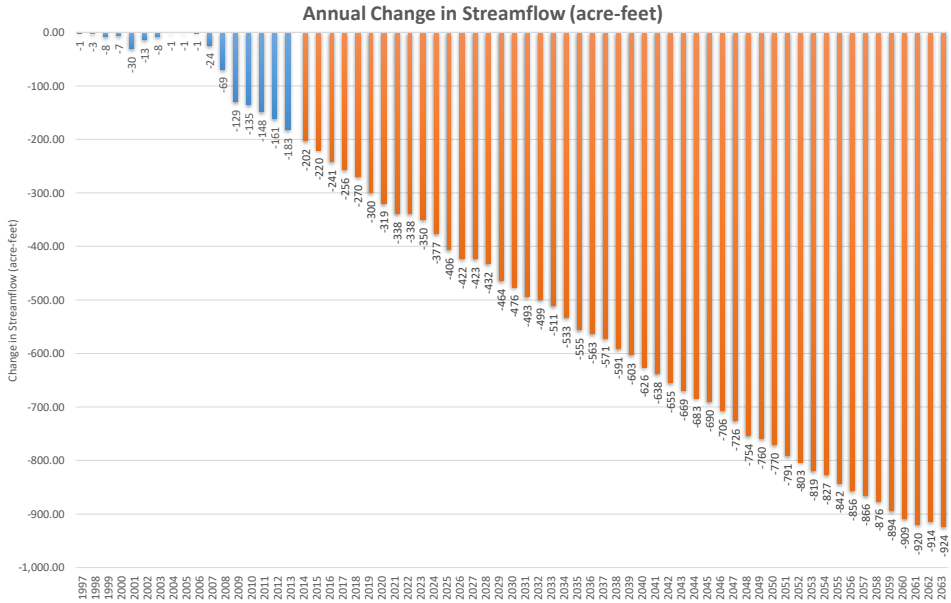
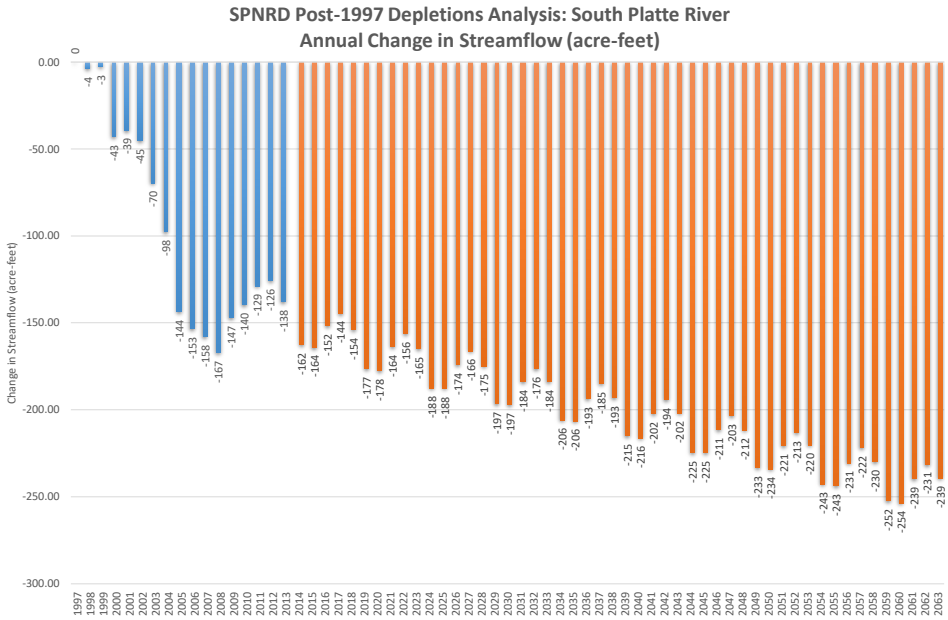
Preliminary SPNRD All Ground Water Only Land Use Development



SPNRD Post-1997 Depletion Analysis: All Lodgepole Creek
Annual Change in Streamflow (acre-feet)

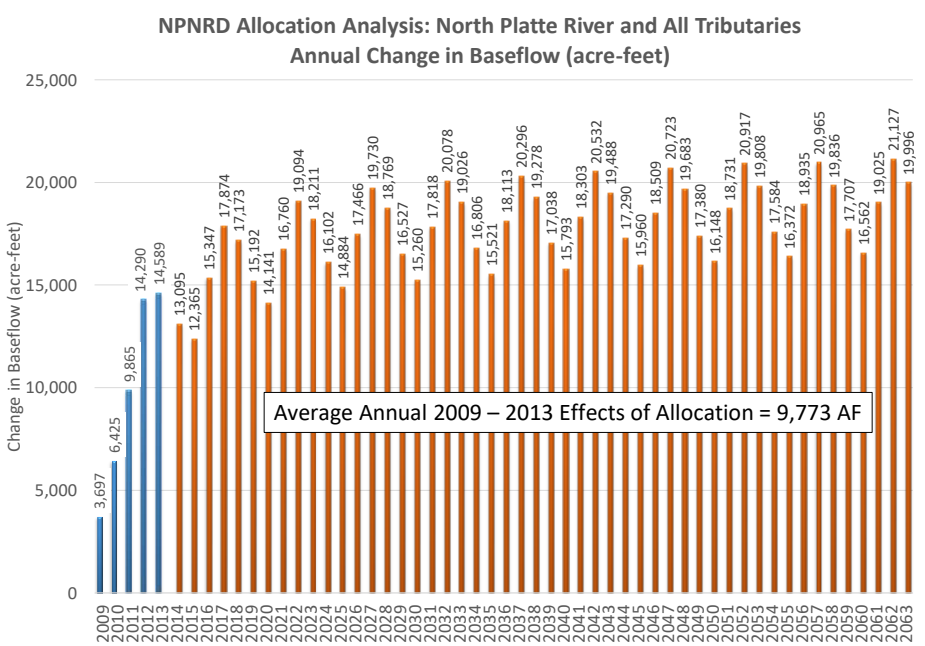


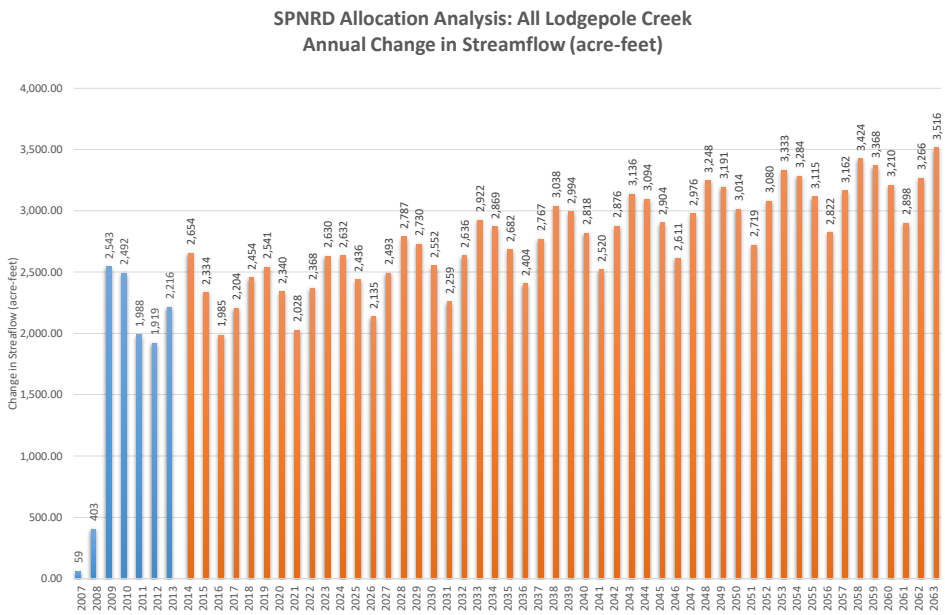


Allocation Analysis

Allocation Analysis

- Analysis
  - Difference between Modeled and Metered Pumping Information
  - Considered Savings on Consumptive Use through Allocations
  - Only On Pre-1998 Lands
  - Run with 2009 to 2013 Repeated through 2063





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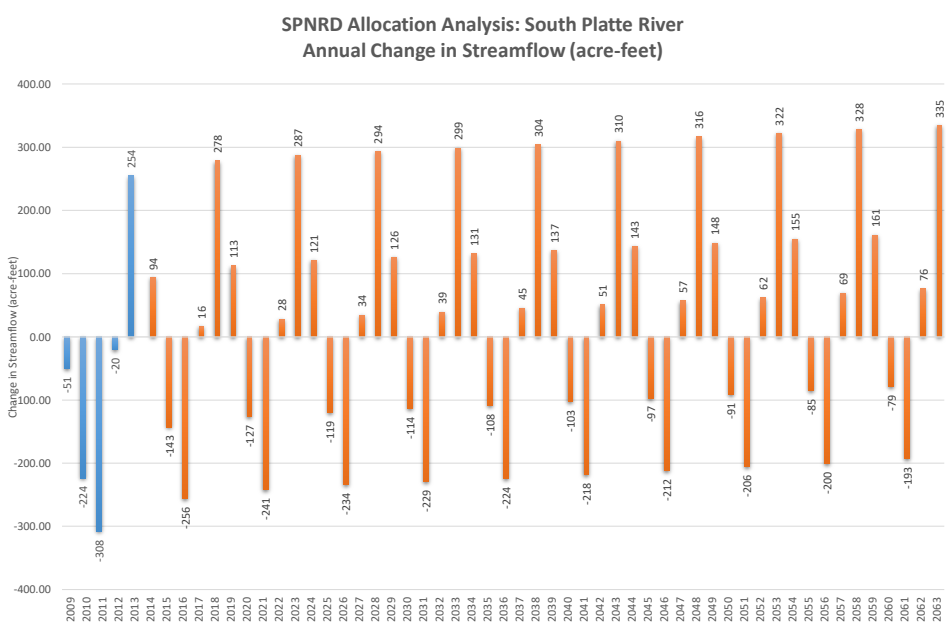

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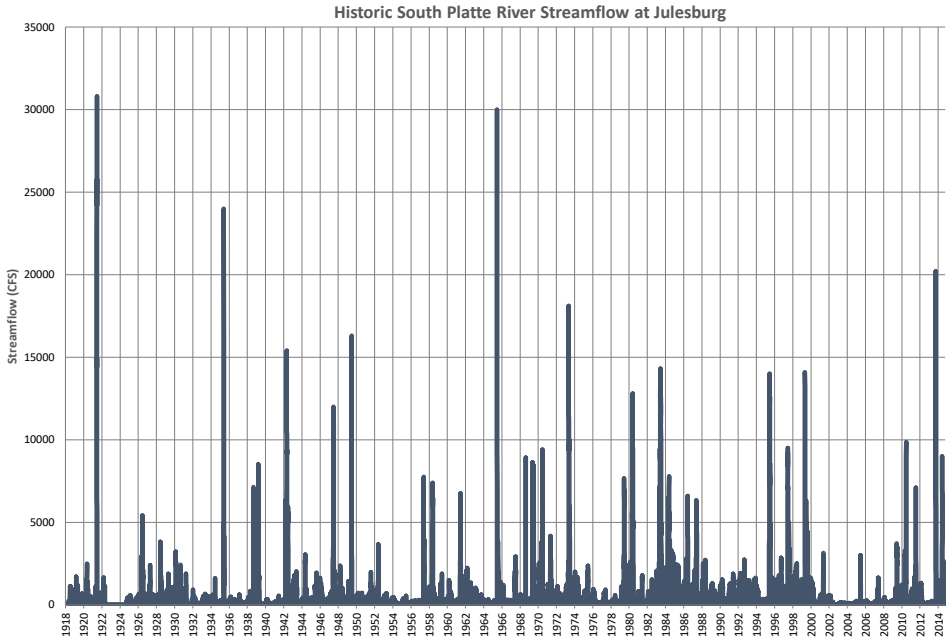
South Platte River Canal and Pit Recharge Analysis

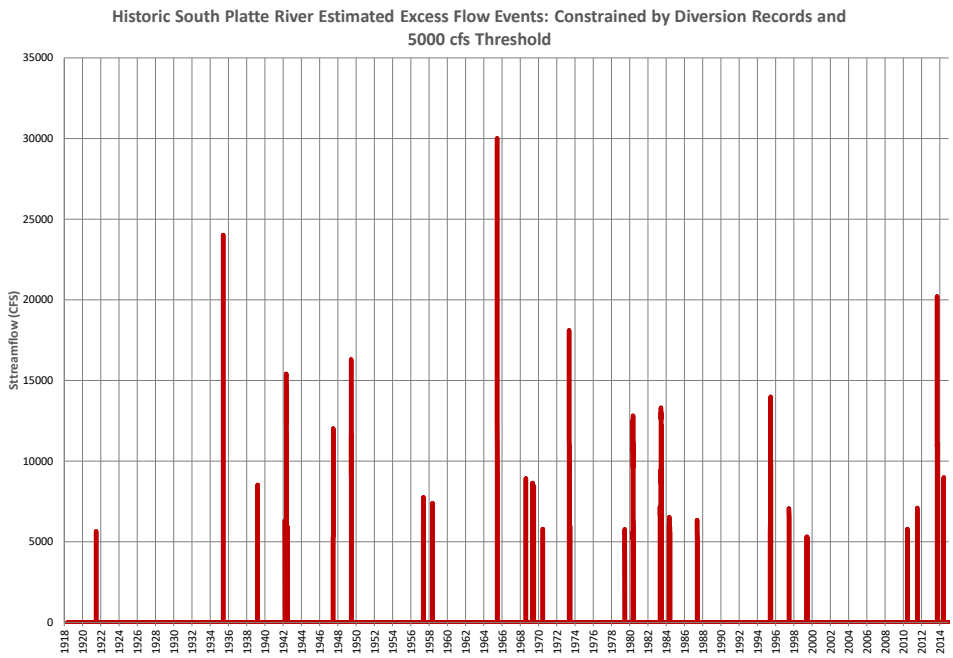
South Platte River Canal and Pit Recharge Analysis

- Analysis
  - Determine the Accretive Effects of the Canal and Pit Recharge Projects
  - Analysis on the South Platte River on Western Canal
- Projection of Events in Future
  - Use Historic Streamflow



South Platte River Canal and Pit Recharge Analysis

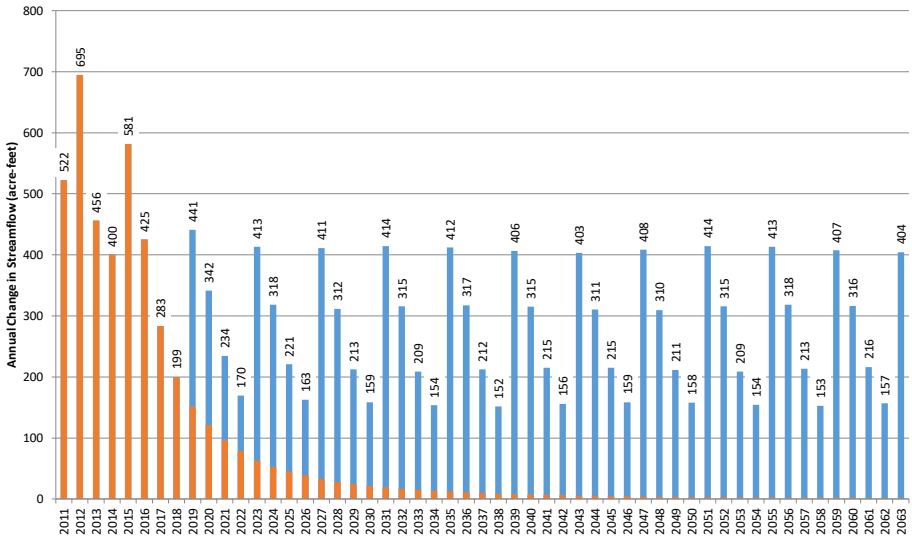
- Analysis Projection
  - Limit to 5000 CFS
  - Limit to Time Periods when Western Canal is <u>Not</u> Diverting for Irrigation
    - Use Diversion Records



South Platte River
Canal and Pit Recharge Analysis

- Analysis Projection
  - Found 25 Excess Flow Events from 1918 through 2014
  - Results
    - Average Excess Flow Event Every 4 Years

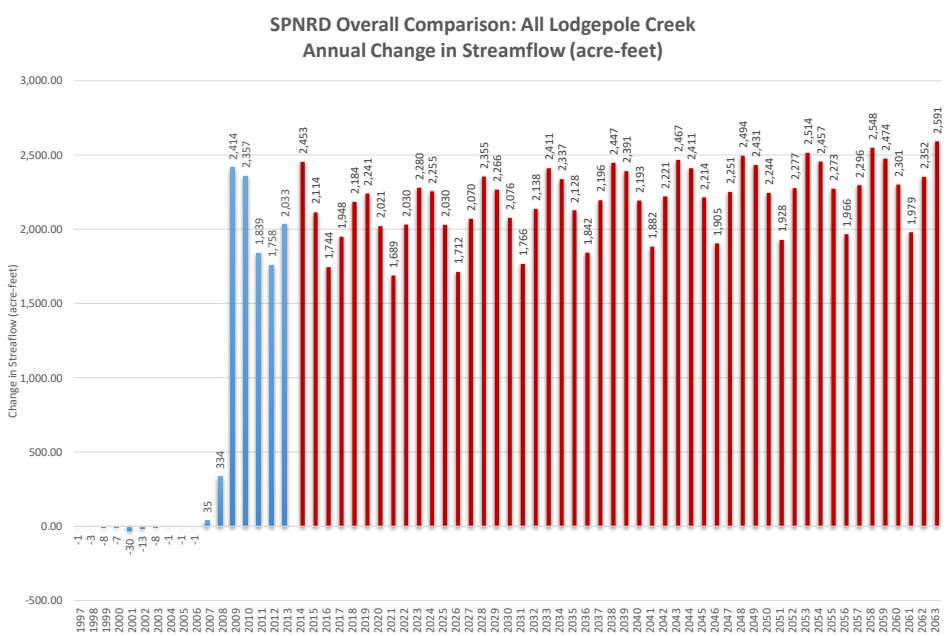
SP Natural Resources District Canal Recharge Analysis:
Annual Instantaneous Change in Stream Baseflow (acre-feet)

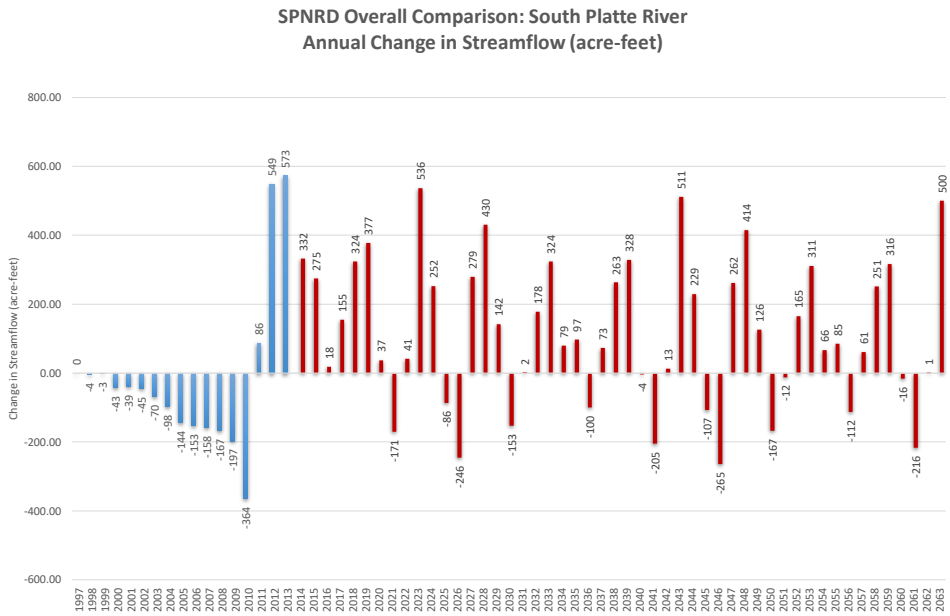


Overall SPNRD Management Activities Analysis

Overall Comparison

- Comparison
  - Post-1997 Depletions
  - Allocation Effects
  - Canal and Pit Recharge (South Platte River Only)





Thanks!

- Questions
- Comments