The Use of Groundwater Models for Water Administration In Colorado

Association of Western State Engineers
Spring Workshop
June, 2018
Oklahoma City, Oklahoma

Mary R. Halstead, M.S., P.E.
mary.halstead@state.co.us
Chief of Modeling and Decision Support Systems Team

COLORADO
Division of Water Resources
Department of Natural Resources

Presentation Scope

1. Discussion of Groundwater Models Used In Water Administration in Colorado
2. Brief Introduction to the Colorado Decision Support Systems (CDSS)
   (Colorado's central repository for administrative, hydrogeologic and modeling data, planning models and tools)
3. Lessons Learned

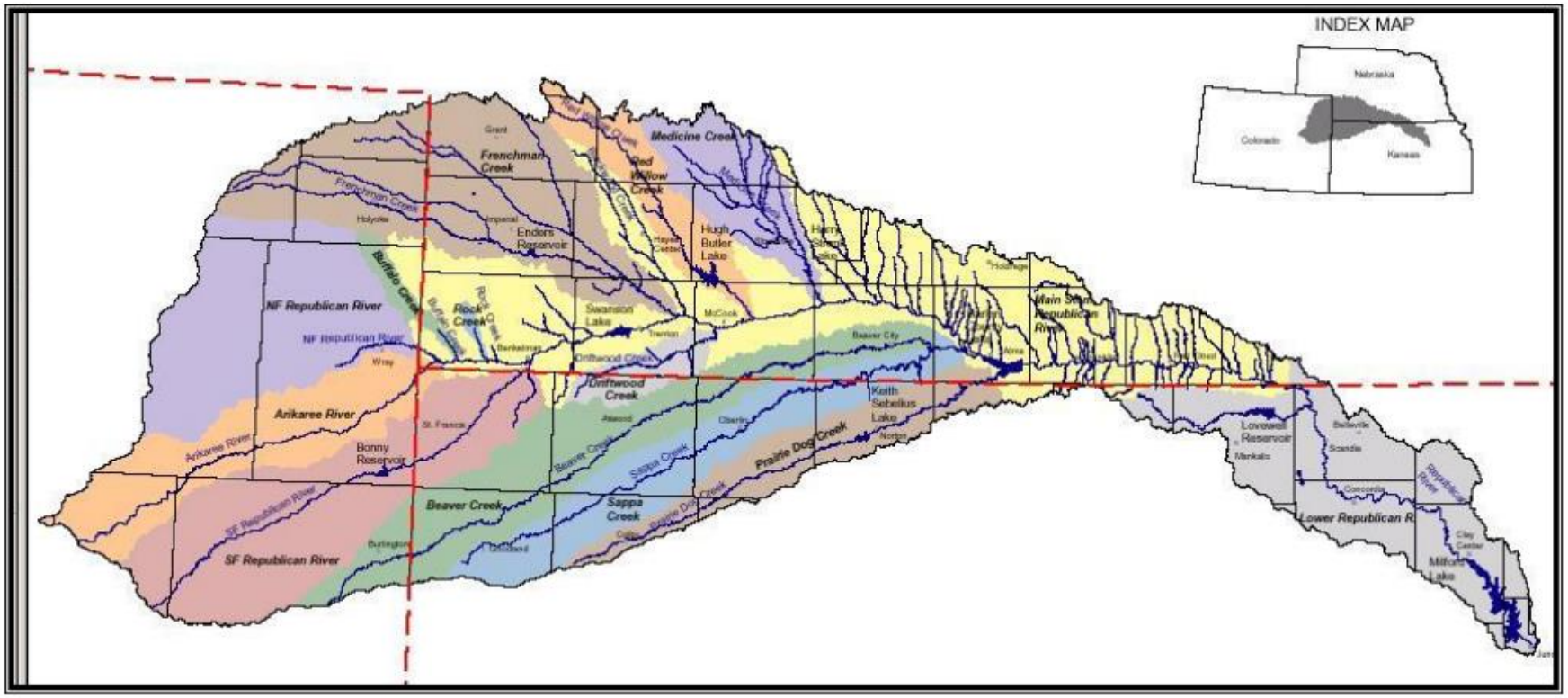
Three Categories of Groundwater Model Use for Administration in Colorado

1. Interstate compact compliance models
2. CDWR groundwater models for internal Colorado water rights administration
3. Water user models reviewed by CDWR - these models are used in new or changed water right adjudications. (i.e water court cases and non-tributary petitions)

Interstate Compact Compliance Models

- Developed to estimate groundwater use impacts to the stream for compact administration
- Currently used models
  - Republican River Basin (Colorado, Nebraska, Kansas)
  - Arkansas River Basin (Colorado, Kansas)

Republican River Basin

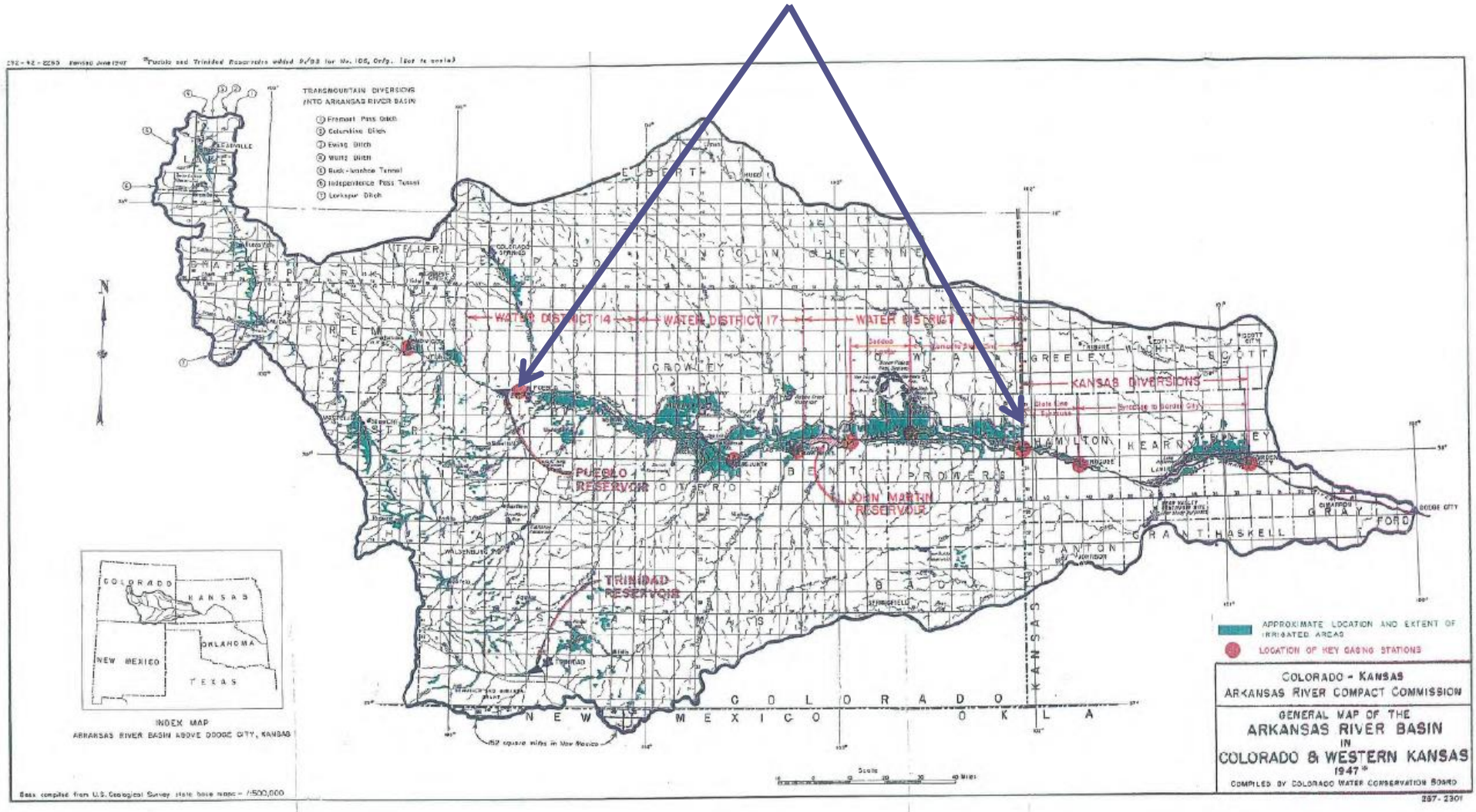


Republican River Compact Administration (RRCA) Model

- Model developed in accordance with the 2002 Final Settlement Stipulation in Kansas v. Nebraska and Colorado
- Purpose: determine amount, location and timing of streamflow depletions to the Republican River caused by well pumping and to determine stream flow accretion from recharge of water imported from the Platte River Basin into the Republican River Basin
- The MODFLOW 2000 model considers only the impact of ground water pumping and surface water imports to the baseflow for the major streams in the Republican River Basin. It is not a surface water model and total streamflows are not incorporated in its design or calculations.

Arkansas River Basin

Model Area: Pueblo Reservoir – State Line



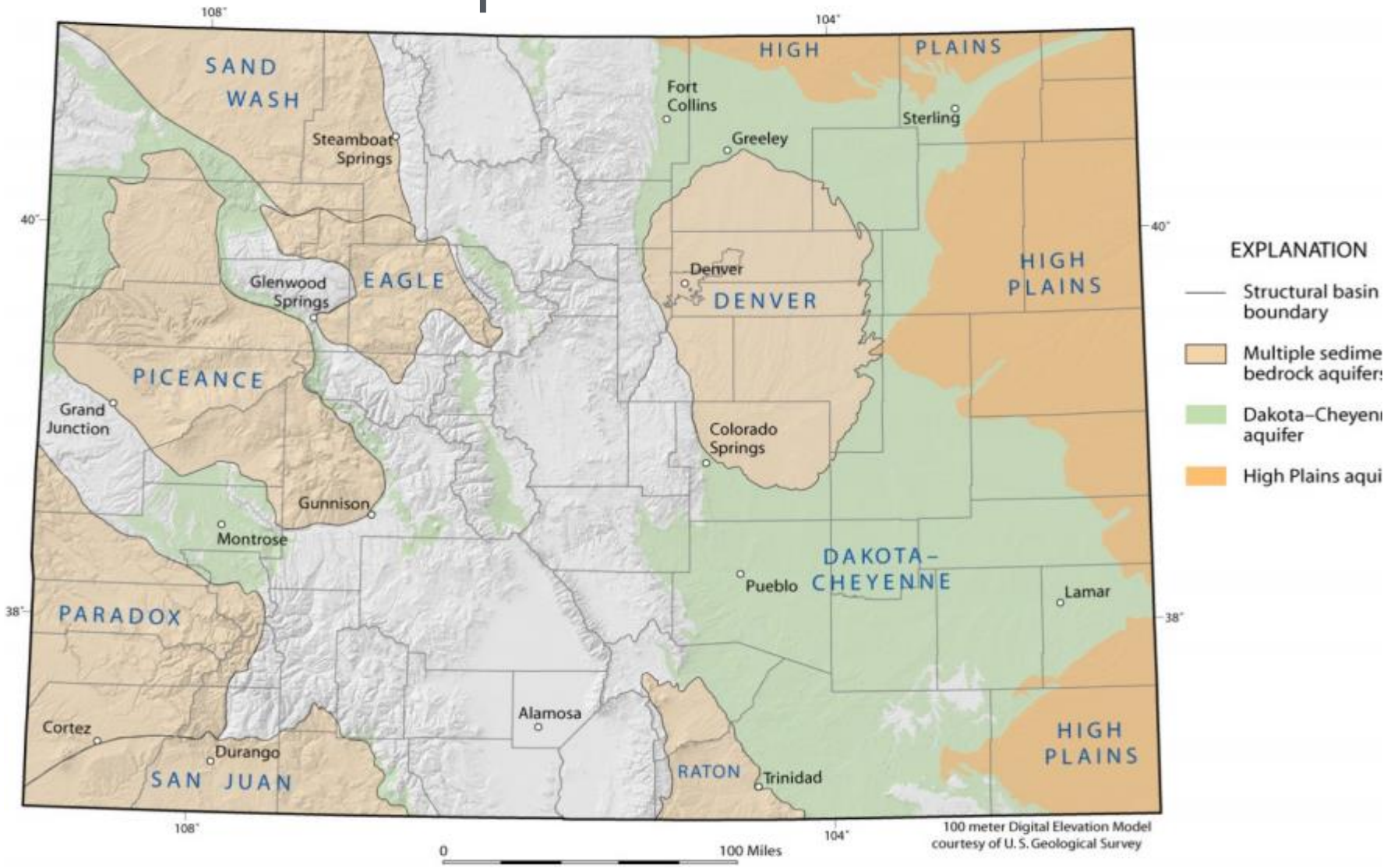
Arkansas River Basin Hydrologic-Institutional (H-I) Model:

- Model specified in Final Opinion Kansas v. Colorado (Supreme Court #105) Proposed Judgment and Decree (Jan 2008)
- Surface water and consumptive use model which includes groundwater response functions
- The H-I model is used to determine depletions and accretions to usable Stateline flow caused by groundwater pumping and replacement.
- Provides 10-year accounting of compact compliance

CDWR Groundwater Models for Internal Colorado Water Rights Administration

- Typically needed to address regional issues where individual water user models are not workable
- Generally requires Colorado legislative approval for spending and for authority
- Examples:
  - Denver Basin Aquifer Models (Senate Bill 85-5)
  - Rio Grande Decision Support System (RGDSS) Groundwater Model (HB 98-1011 and SB 04 – 222)

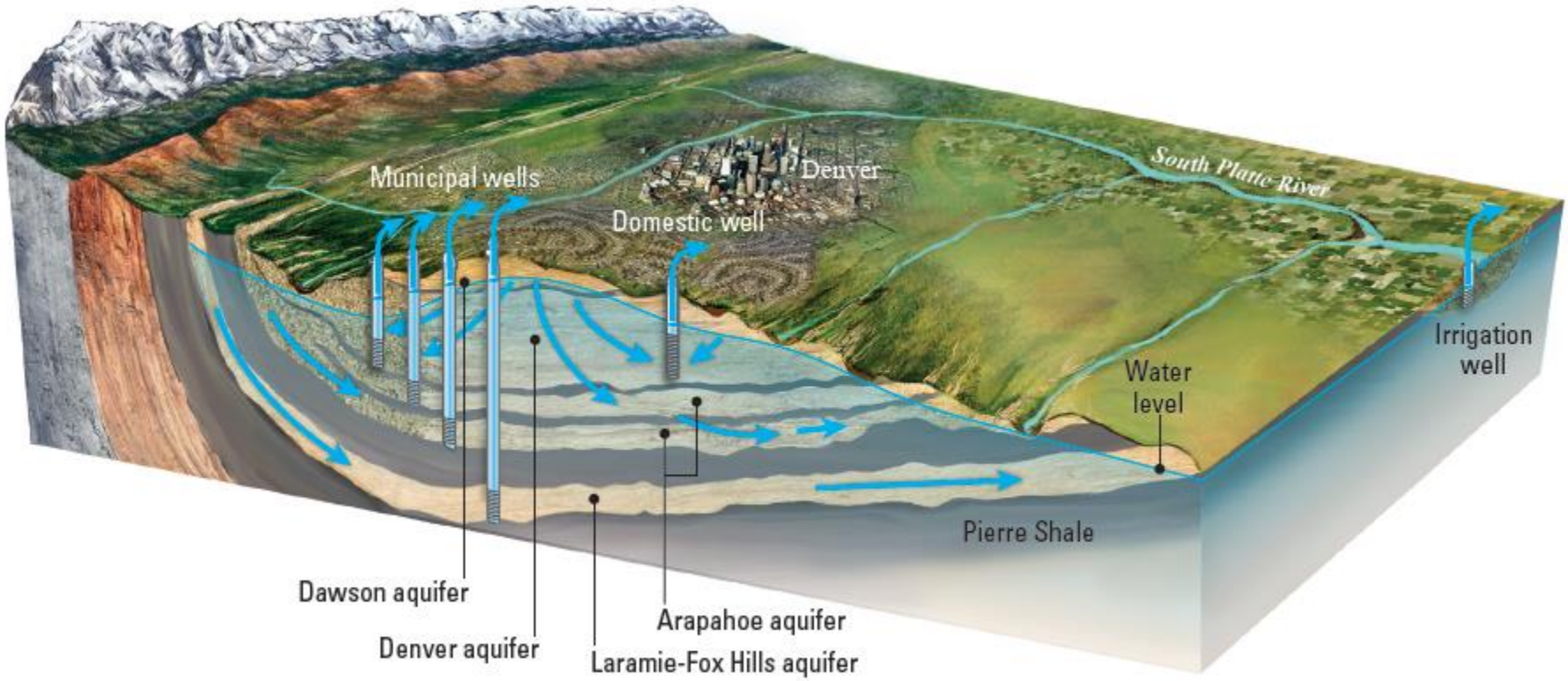
Denver Basin Aquifers



COLORADO
Division of Water Resources
Department of Natural Resources

Source: Ground Water Atlas of Colorado, Colorado Geological Survey, Special Publication 53

Denver Basin: Conceptual Block Diagram



Source: Paschke, S.S. ed., 2011, Groundwater availability of the Denver Basin aquifer system, Colorado: U.S. Geological Survey Professional Paper 1770, 274 p.

Denver Basin Aquifer Models

- In 1985, CDWR Staff developed individual models for each of the Denver Basin Aquifers: Dawson, Denver, Arapahoe and Laramie-Fox Hills
- These models were used to create maps identifying locations where the use of ground water from the Denver Basin would have a minimal effect on the surface water system (**nontributary**)
- The 1985 groundwater models are still used today to determine stream depletions for wells in the "not nontributary" areas
- These models are available on the CDWR website

Rio Grande Basin & San Luis Valley

Division 3

San Luis Valley

Denver Post, Front Page, June 24, 2018

Photo from Kelley Thompson, CDWR

San Luis People's Ditch (1852): Oldest irrigation system in continuous use in CO

Photo Source: JFLECK AT INKSTAIN
(http://www.inkstain.net/fleck/2018/05/old-water-the-san-luis-peoples-ditch/)

Rio Grande Basin Groundwater Use

A. ESPINOSA WELL, BORED IN 1888.

Photo from Siebenthal, C.E., 1910, Geology and Water Resources of the San Luis Valley, Colorado, USGS Water-Supply Paper 240

Need for RGDSS Groundwater Model

- Model is part of the *Rules Governing the Withdrawal of Groundwater in the Rio Grande Basin*.
- The State Engineer filed these Rules with Water Court in the Fall 2015 (15CW3024), Trial was held in January - February of this year - Waiting for decision
- Simplified summary of why we need a model:
  - Rules require groundwater users to replace their injurious depletions to the surface water streams and restore and maintain aquifer sustainability
  - Because of complex layered hydrogeology (i.e. confined aquifer) simple, inexpensive methods such as SDF, Glover, AWAS can't be used to calculate well impacts to streams in the SLV
  - Need basin-wide groundwater flow model to determine well impacts to streams

RGDSS Groundwater Model Selected Highlights

- Significant Water User Inputs: Technical Peer Review Team (PRT) open to all interested parties and were attended by staff, water users, engineers, geologists, modelers and other occasional observers - PRT met 47 times from 2011 to 2015

- Phase 6 Major Enhancements 6P98:
  - Determined stream impacts for 7 Response Areas
  - Added irrigated datasets for 2002, 2005, 2009 and 2010
  - Incorporated meter data for 2009 and 2010

Have a Model – Now What?

- Rules require each Subdistrict (~Response Area) to provide an ARP by April 15th of each year detailing the amount, location and timing of depletions and associated replacements and remedies for the upcoming irrigation season
- Current version of the model runs through 2010
- This year (2018) Subdistrict 1 submitted their ARP on time. How do they do it with a model that only goes through 2010?
- The answer is Response Functions

Response Function (RF)- Overview

- The RFs are based on results from the RGDSS Groundwater Model
- RFs are created & calibrated for each of the impacted streams in a Response Area (Total 27)
- RFs are used to estimate net stream depletions for the upcoming year
- Administration works using an tag-team type process:
  - The complex model is created and RFs are calibrated (Version A) - Version A RFs are used while working on updating the model.
  - Say # years later, the Model and RFs are updated to Version B – Version B RFs are used until the next update.
  - And so on….

RGDSS Groundwater Model

Go to website: www.water.state.co.us

On the front page click on:
Completed Rules: *Division 3 Rio Grande Rules*

One can Download:

- All the Division 3 Rules + Statement of Basis & Purpose
- SLV Rules Advisory Committee meeting minutes and briefing documents
- Model, data files, documentation
- Response function calibration/ application workbooks

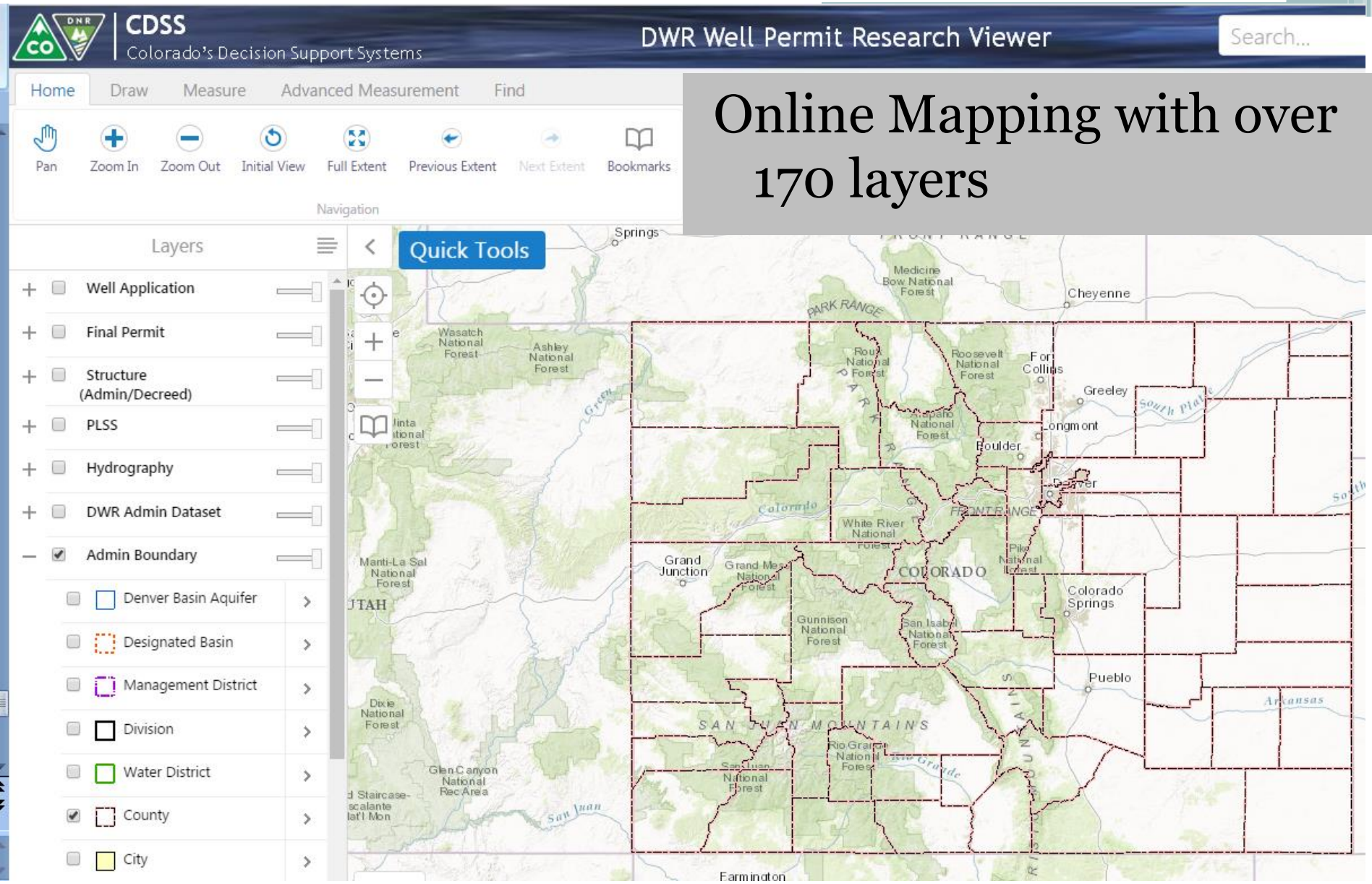
Water User Models

- CDWR reviews selected models in water court cases and non-tributary petitions
- Use of models includes:
  - Augmentation plan to replace stream depletions from over 6,000 coal bed methane wells
  - Water rights for recharge ponds to provide water to meet ESA stream flows
  - Multitude of augmentation plans for groundwater user groups
  - Non-tributary determinations

CDSS – Colorado Decision Support Systems

- Central repository for all hydrogeologic, administrative and modeling data and tools (http://cdss.state.co.us)

Online Mapping with over 170 layers



Lessons Learned

- Models are being used more and more and these models are becoming more complex
- Need model savvy staff that understands modeling & coding but who are also able to communicate this knowledge to the public
- Public involvement difficult but critical:
  - RGDSS Rules/model – 47 technical PRT meetings just for Phase 6 and 24 public meetings in the San Luis Valley from 2009 to 2015

Mary R. Halstead, M.S., P.E.
mary.halstead@state.co.us
(303) 866-3581 ext. 8263
Chief of the Modeling and Decision Support Systems Team