

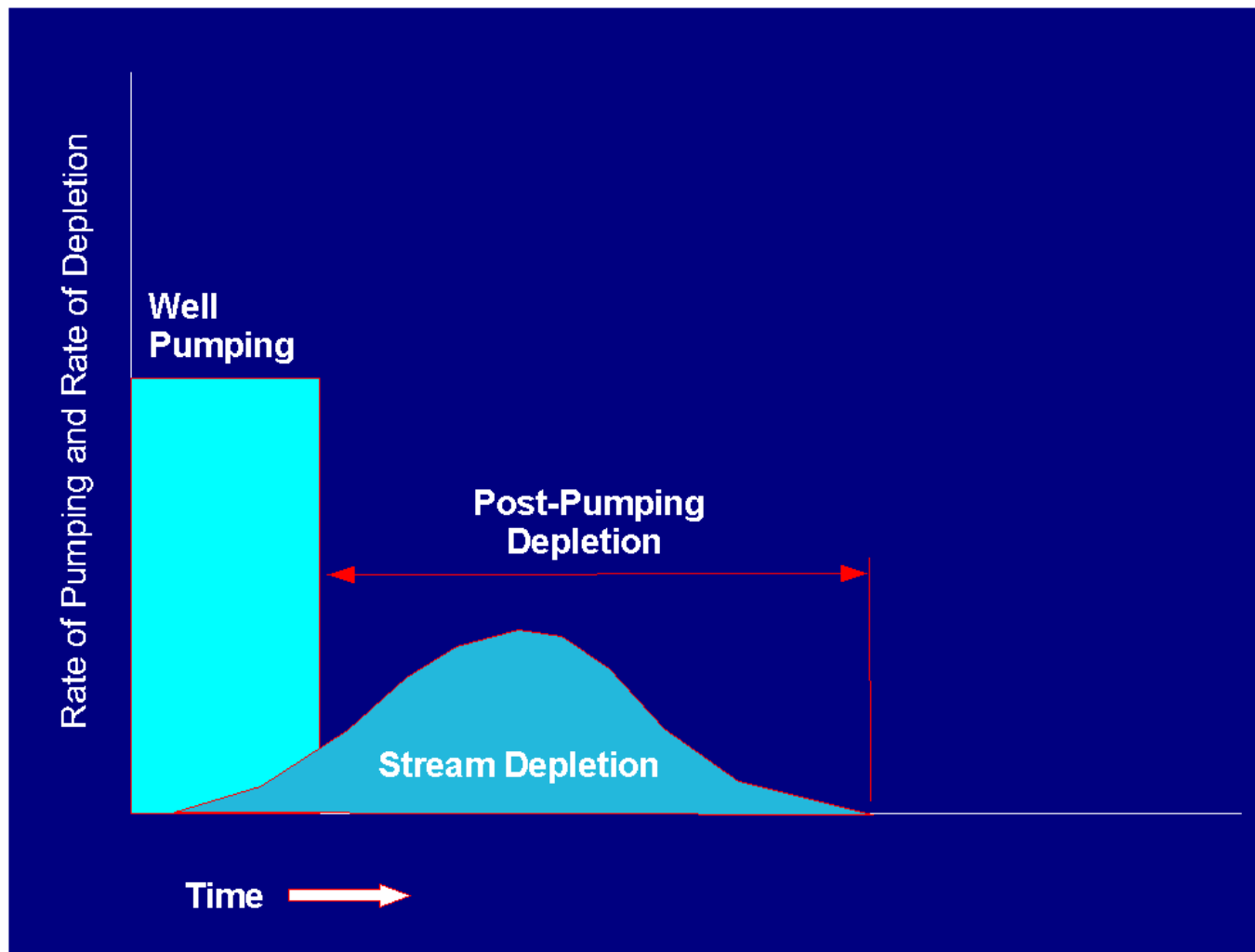
Use of Response Functions to Administer Water Rights

AWSE Spring Meeting
Salt Lake City, Utah
June 2015
Michael Sullivan

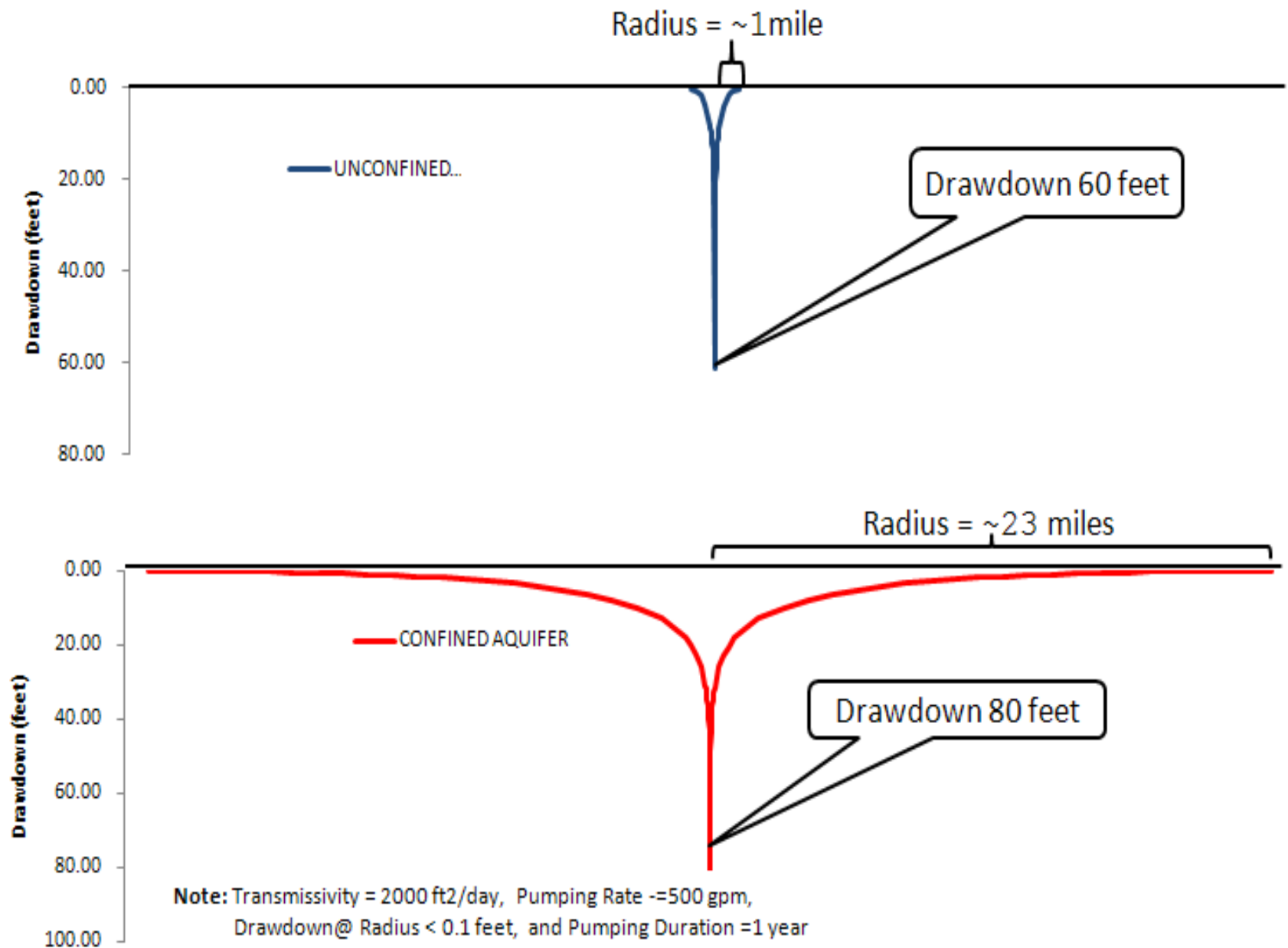
Integrating Groundwater and Surface Water Administration

- Water Admin: Daily on/off of water rights
- Well depletions impact streams
- Can't directly measure depletions so use model to determine impact:
 - Glover/AWAS/Finite Difference Model
- Simple system = simple model
- Complex system = complex model
 - More complex makes prediction difficult.
 - Use RF to distill historic results to predict future

Delayed Depletions

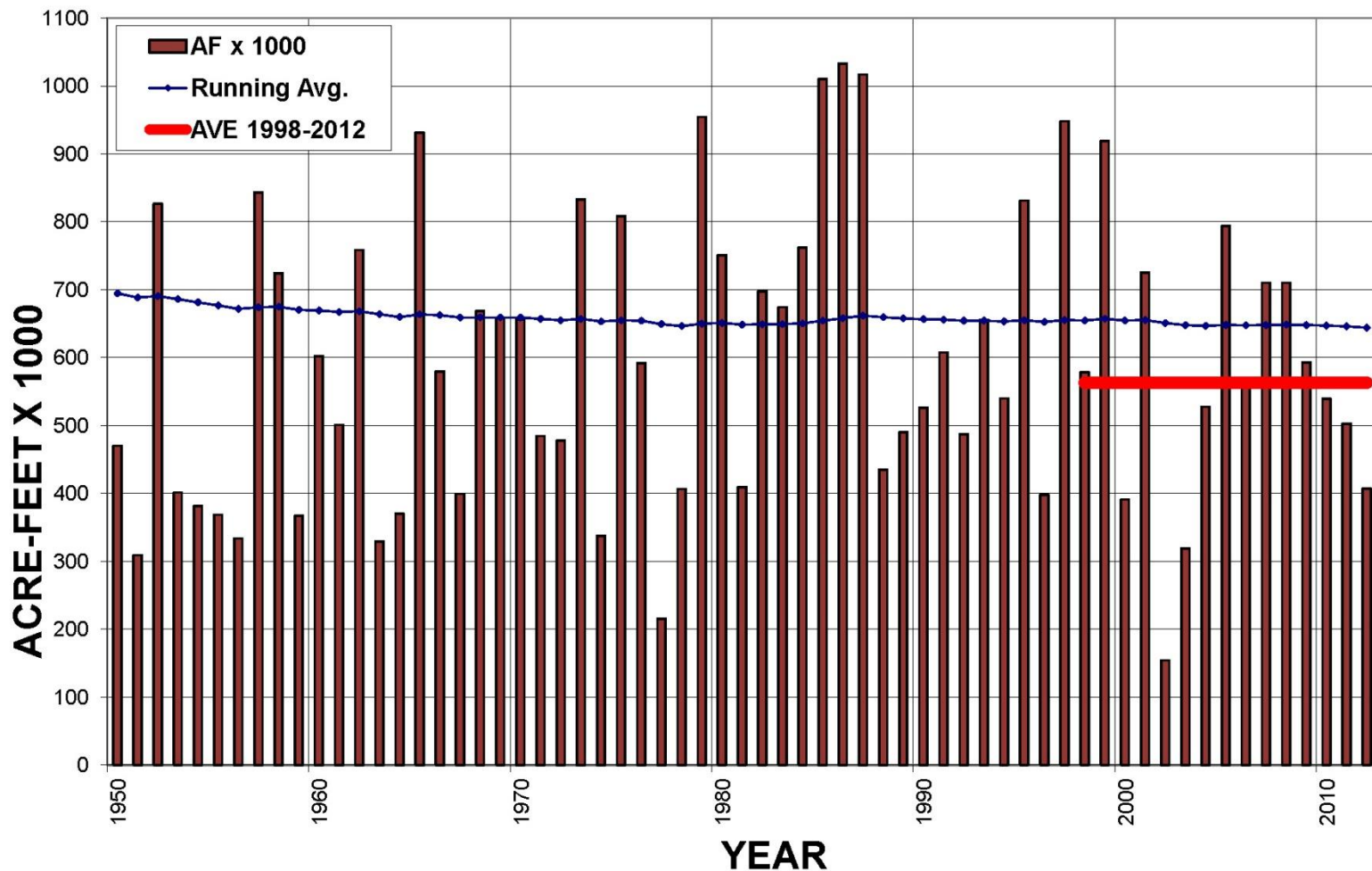


Confined Versus Unconfined Aquifers - Schematic Cones of Depression

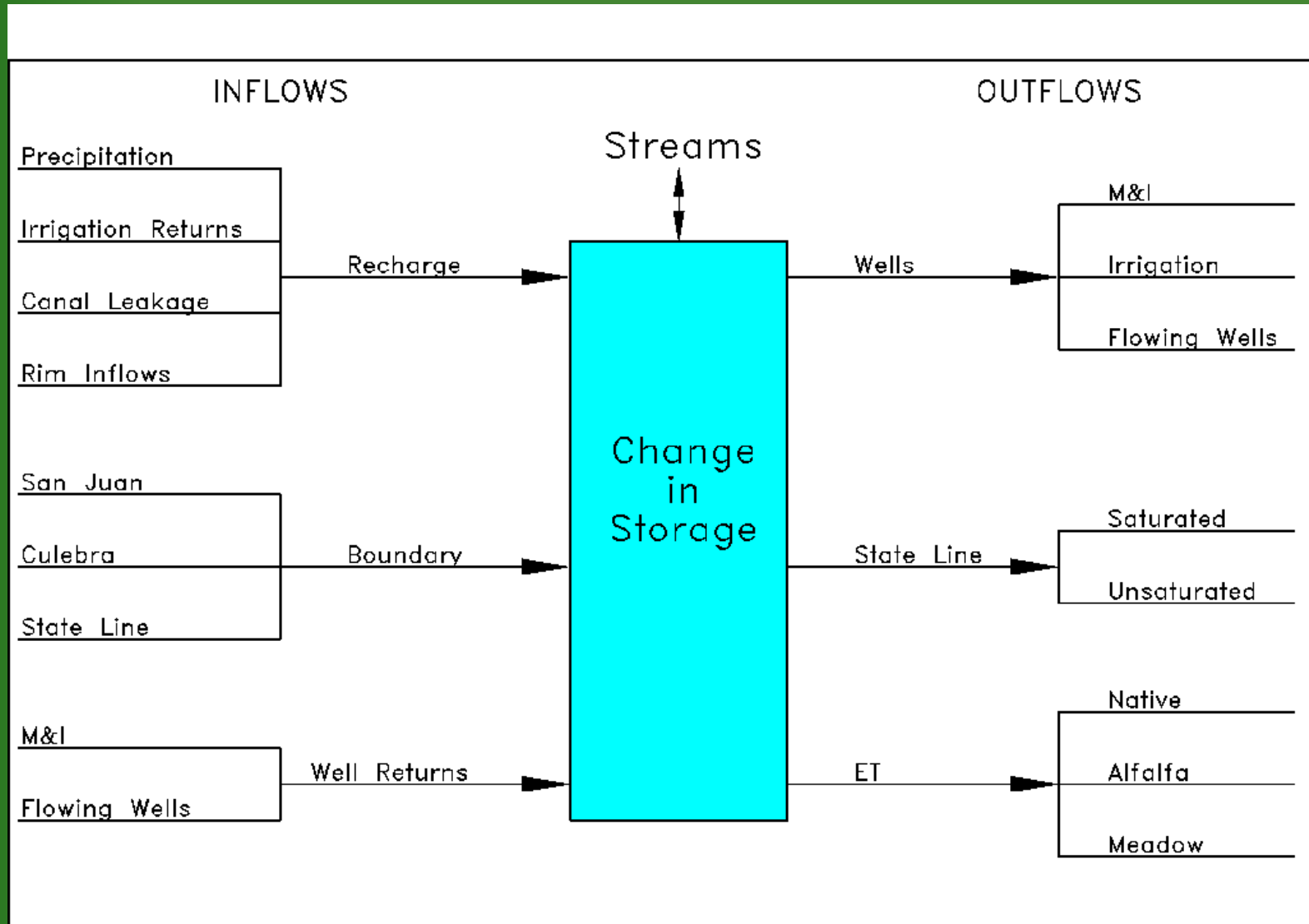


Drought

RIO GRANDE NEAR DEL NORTE, CO
ANNUAL CALENDAR YEAR FLOWS



Modeling



HydroBase

GIS Data (Spatial Data)

**TSTool &
StateDMI**

**CDSS Tool Box &
StateDGI**

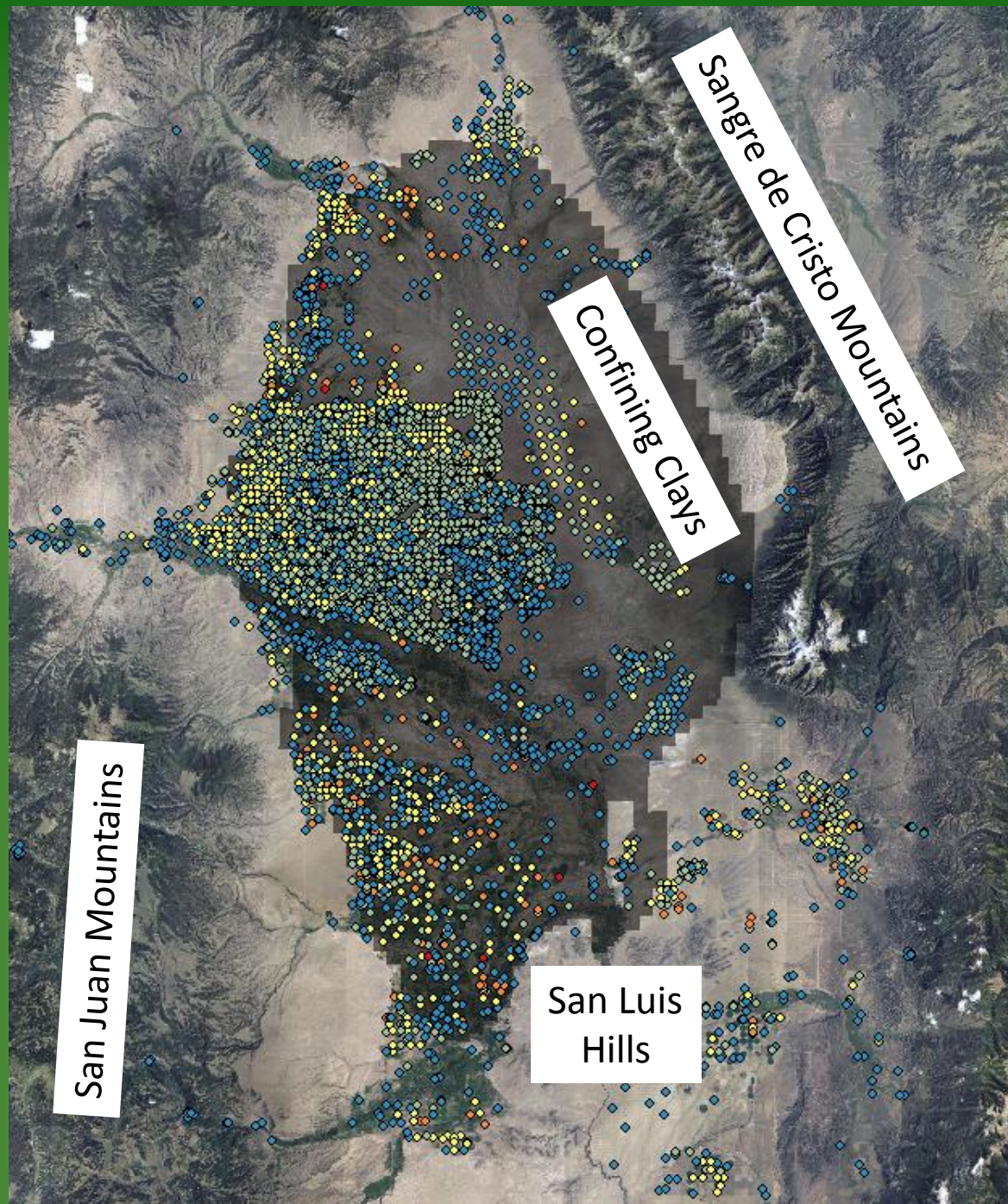
StateCU

MODFLOW

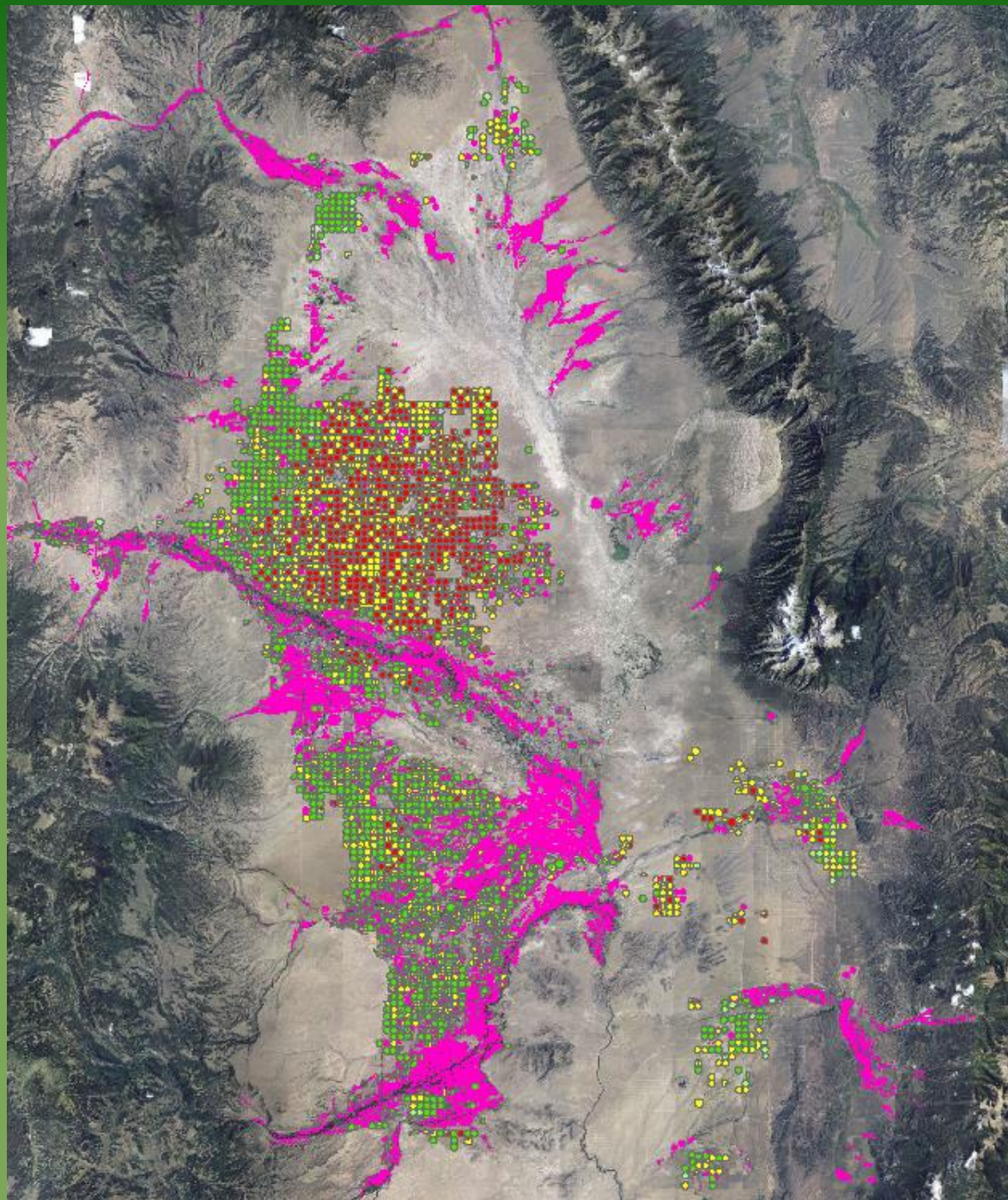


Why RF's

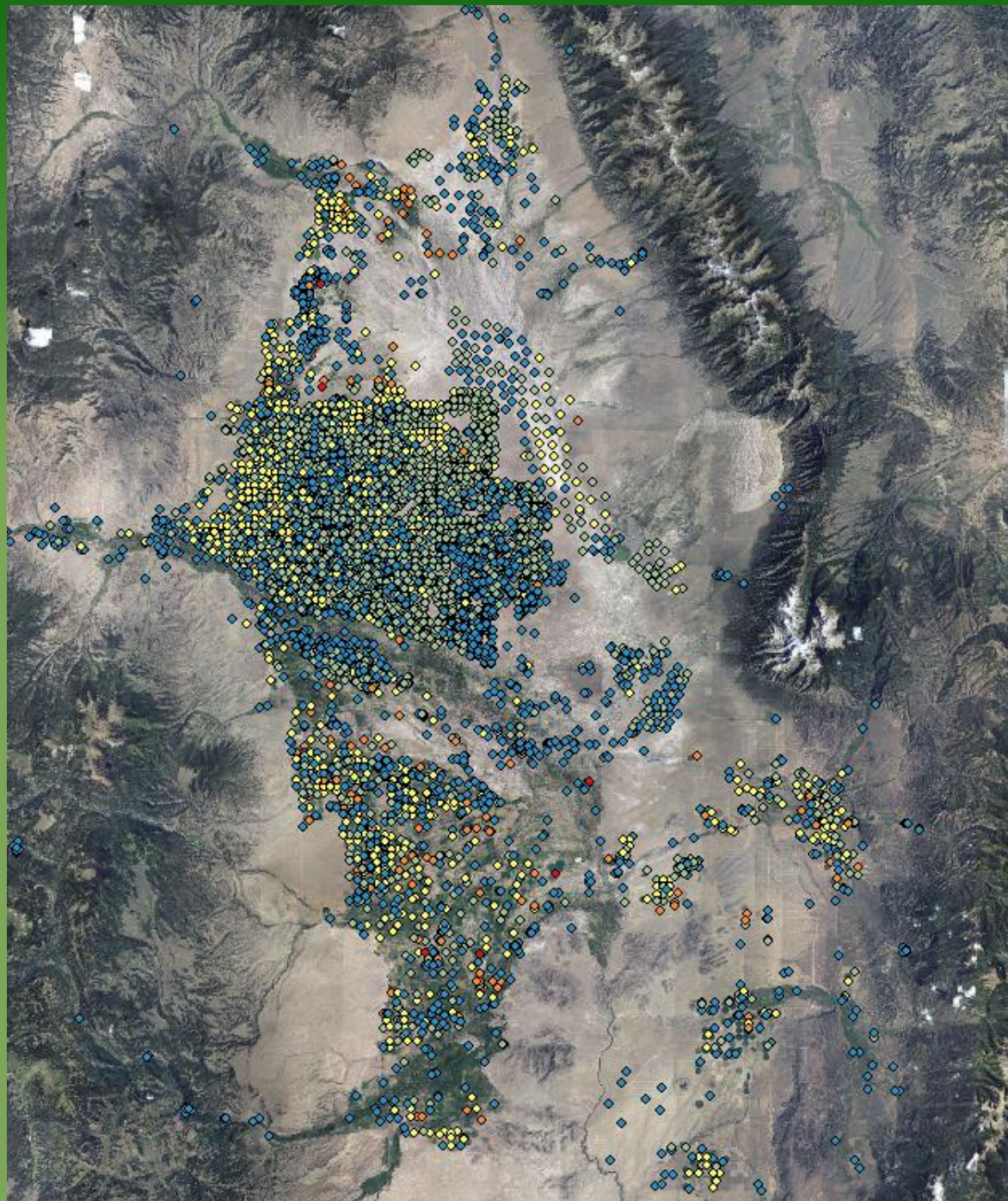
- Complexity of systems, quick analysis of impacts
 - Example: South Platte vs. Rio Grande Basin
- Results model vs. Prediction model
- Ease of use for users
 - Scenarios to build funding case for GWMP
 - Short time frame for ARP



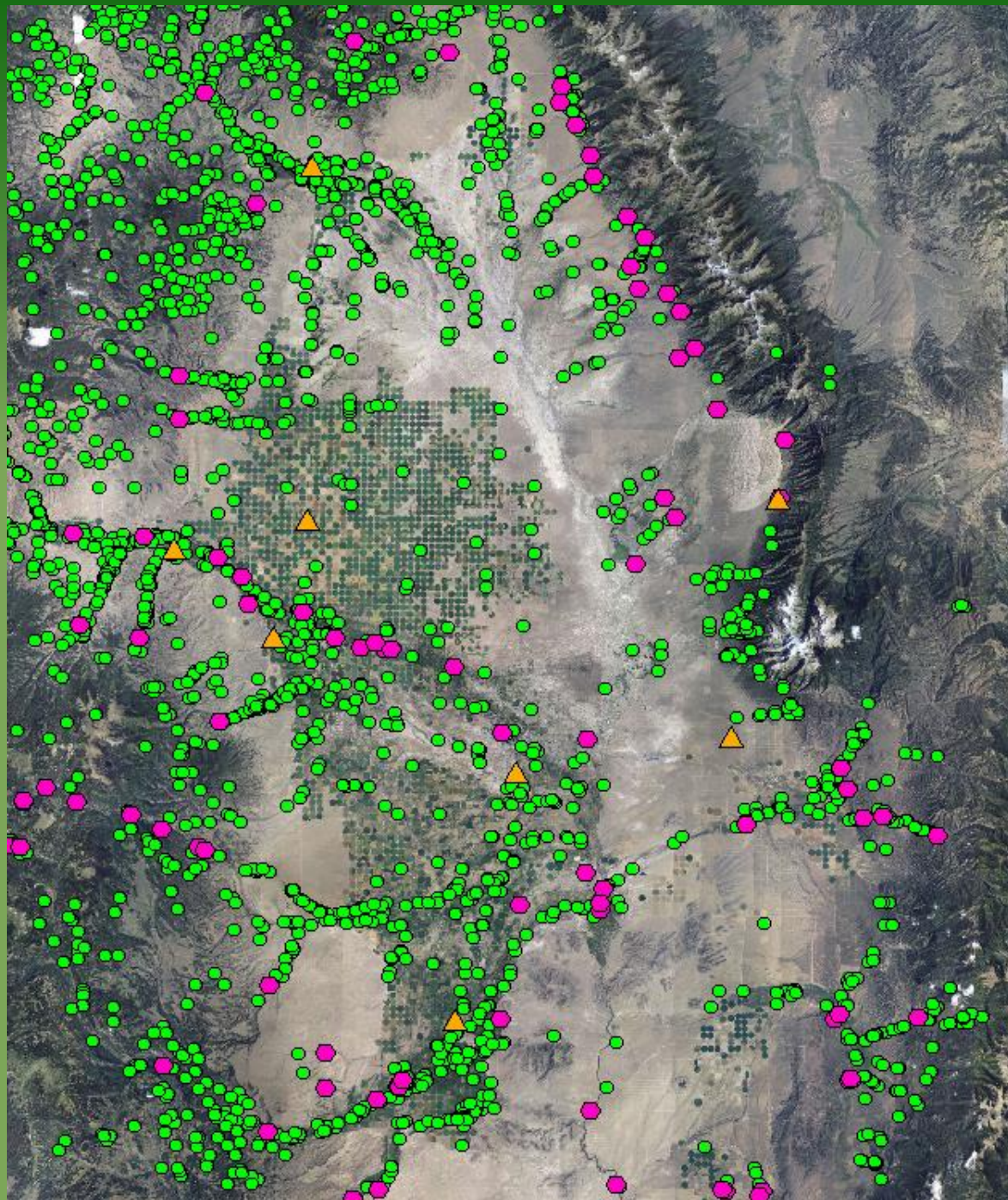
- Irrigated acreage

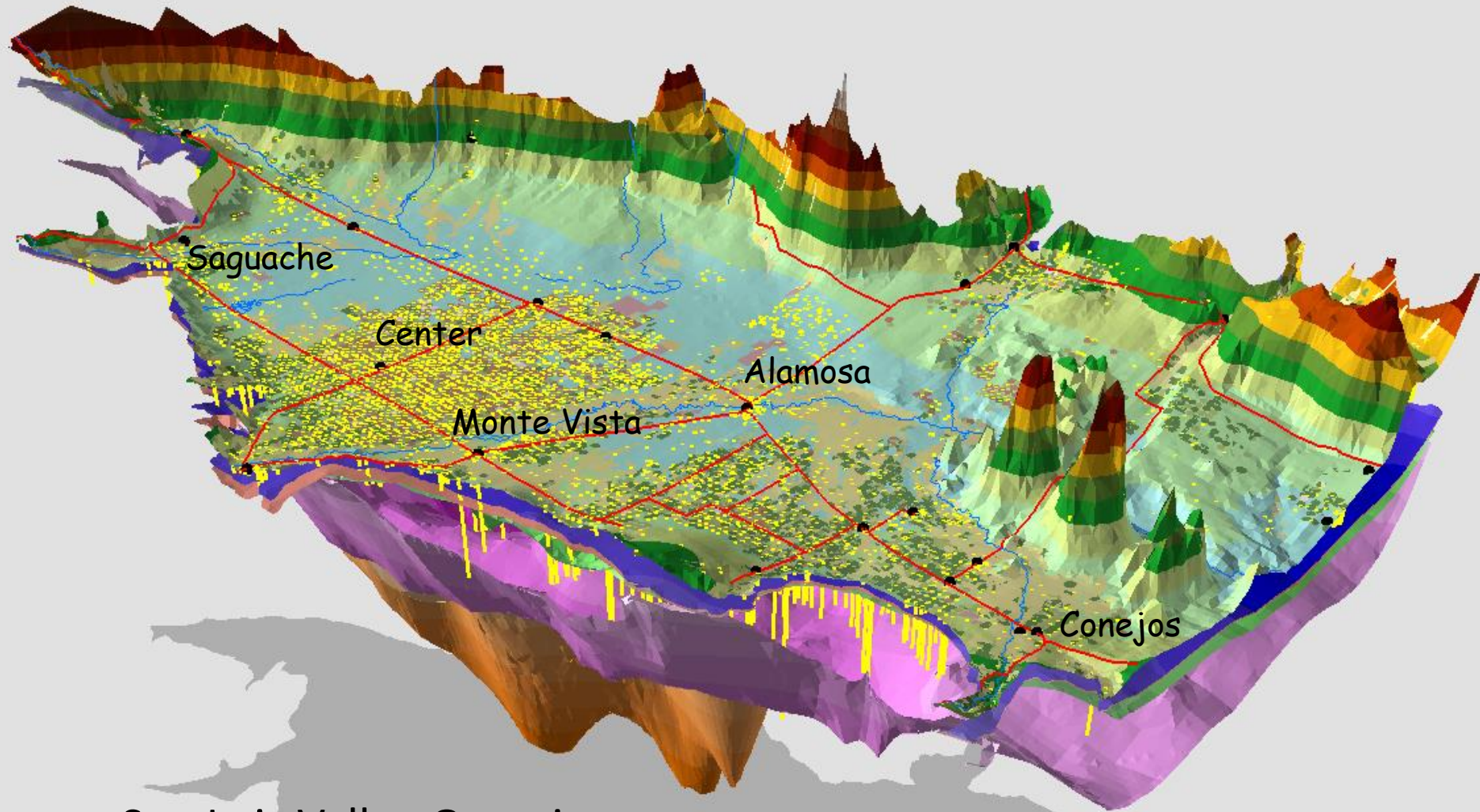


- Location of wells with metered diversion records



- Diversion structures
- Streamflow gages
- Climate stations

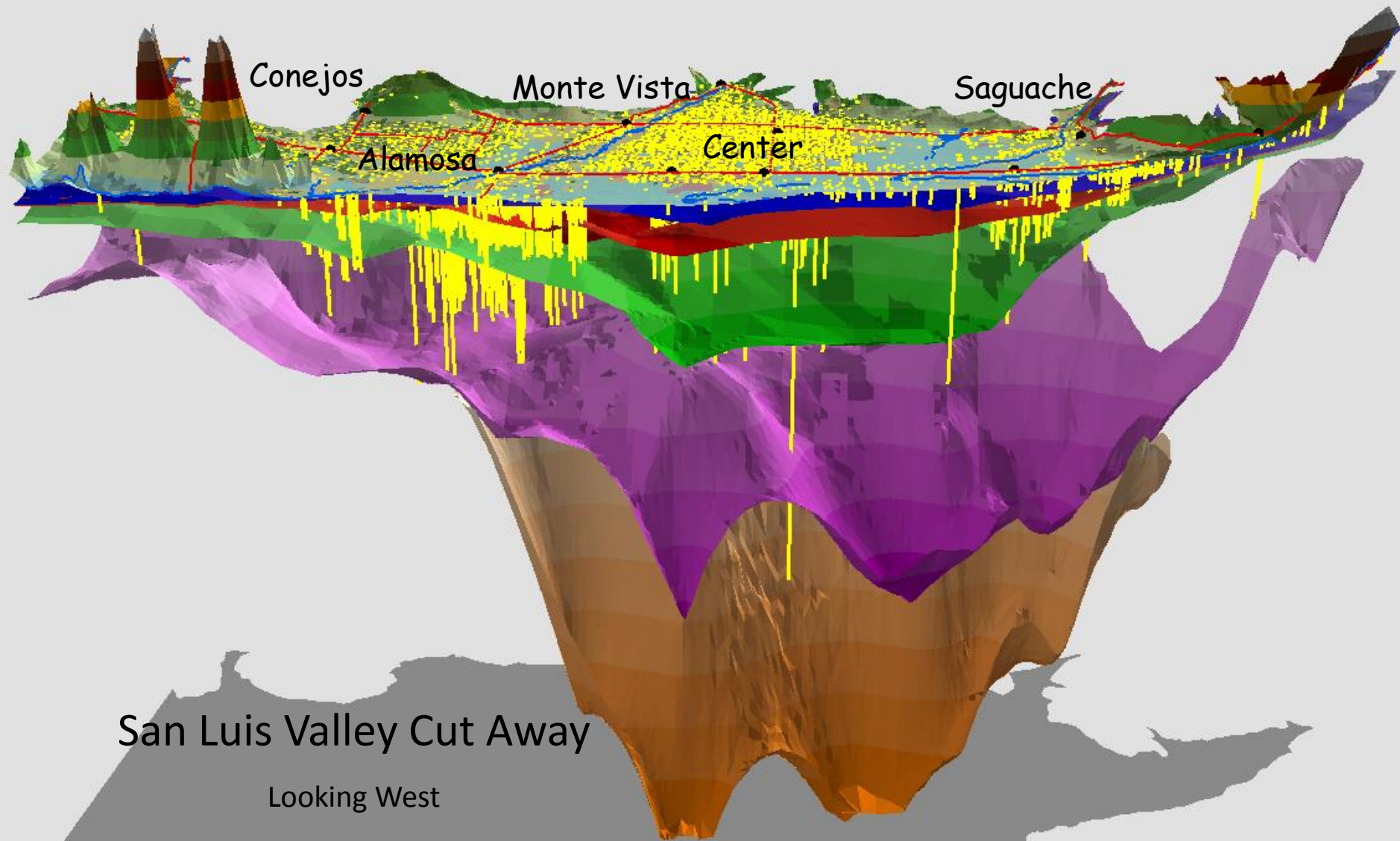




San Luis Valley Overview

Looking Northeast

Vertical Exaggeration = 10x



San Luis Valley Cut Away

Looking West

Vertical Exaggeration = 10x

HydroBase

GIS Data (Spatial Data)

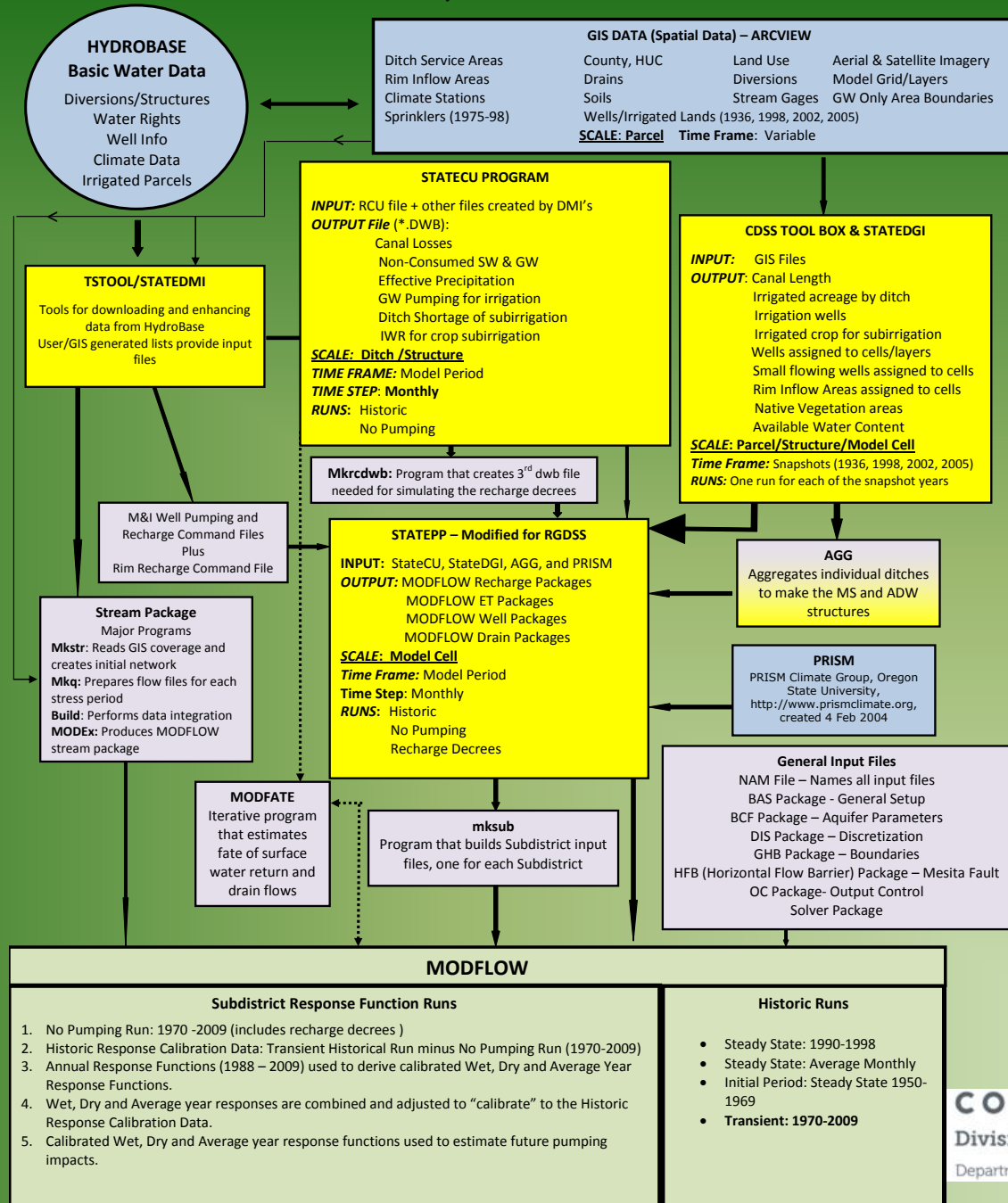
**TSTool &
StateDMI**

**CDSS Tool Box &
StateDGI**

StateCU

MODFLOW





Model output

Stream Impacts for Sub District 1 - 2012e.xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Add-Ins Acrobat

Cut Copy Paste Format Painter Clipboard

Arial 10 Font

Wrap Text Alignment

Number

Conditional Formatting as Table Cell Styles Styles

Insert Delete Format Cells

AutoSum Fill Clear Sort & Filter Find & Select Editing

D12 =Depl RG1!D12+Depl RG2!D12+Depl RG3!D12

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Total for All Streams - Estimated Stream Depletions (This is just the sum from the other "Depl" Sheets)																				
2	Response Functions specified in sheet "Lag" (20 years). The response factors are expressed as a given months depletion as a percentage of the ANNUAL net groundwater consumptive use																				
3	The Annual net GW Cons Use is specified in sheet Results																				
4	NO INPUT DATA IS SPECIFIED IN THIS SHEET																				
5	Results are summarized in sheet Results																				
6																					
7	Strm Depl as % of Net GW CL			-0.8%	4.0%	5.6%	-41.7%	9.5%	-852.5%	-3.6%	10.1%	6.0%	-372.0%	-5.9%	6.8%	-12.2%	-14.3%	-7.3%	689.9%	41.9%	4.4%
8	Total GW Con Use (ac-ft) ---->			56,060	95,312	122,440	12,418	182,482	1,125	45,149	210,870	132,848	2,517	38,936	158,093	28,341	25,900	35,849	-1,451	-38,214	100,33
9	Total Stream Depletion ---->			-429	3,846	6,801	-5,183	17,253	-9,591	-1,618	21,252	7,935	-9,364	-2,294	10,685	-3,449	-3,714	-2,631	-10,010	-15,999	4,39
10	Year ---->			1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
11	Input Year	Input Month	Total Return	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
145	1981	2	86	-1.53	14.22	26.00	-20.45	70.69	-43.66	-7.18	129.35	42.67	-99.07	-25.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
146	1981	3	104	-1.67	15.54	28.44	-22.44	79.05	-45.38	-7.99	145.30	47.46	-104.65	-29.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147	1981	4	96	-1.54	14.35	26.26	-20.67	71.56	-43.83	-7.23	131.07	42.68	-96.11	-23.86	3.16	0.00	0.00	0.00	0.00	0.00	0.00
148	1981	5	135	-1.63	15.01	27.29	-21.35	85.59	-52.33	-7.28	157.57	42.00	-113.07	-22.28	25.13	0.00	0.00	0.00	0.00	0.00	0.00
149	1981	6	166	-1.42	13.05	23.55	-18.23	83.05	-51.61	-5.95	149.49	32.77	-108.31	-22.46	71.70	0.00	0.00	0.00	0.00	0.00	0.00
150	1981	7	169	-1.36	12.41	22.22	-17.10	73.17	-49.97	-5.36	140.97	31.63	-103.26	-18.98	85.01	0.00	0.00	0.00	0.00	0.00	0.00
151	1981	8	212	-1.38	12.73	22.98	-17.92	68.30	-43.97	-5.95	120.47	33.03	-91.87	-16.55	132.38	0.00	0.00	0.00	0.00	0.00	0.00
152	1981	9	237	-1.28	11.76	21.28	-16.58	68.01	-43.47	-5.46	123.81	30.04	-90.09	-14.46	152.99	0.00	0.00	0.00	0.00	0.00	0.00
153	1981	10	276	-1.50	13.84	25.08	-19.51	73.52	-46.32	-6.51	134.89	35.92	-94.73	-16.06	177.24	0.00	0.00	0.00	0.00	0.00	0.00
154	1981	11	268	-1.53	14.10	25.73	-20.20	71.58	-44.05	-6.84	127.20	37.36	-90.42	-16.40	171.24	0.00	0.00	0.00	0.00	0.00	0.00
155	1981	12	271	-1.69	15.66	28.60	-22.47	77.49	-45.32	-7.72	134.08	42.66	-94.20	-18.29	162.20	0.00	0.00	0.00	0.00	0.00	0.00
156	1982	1	252	-1.65	15.27	27.92	-21.95	73.01	-42.02	-7.55	127.94	41.69	-86.72	-17.38	143.28	0.00	0.00	0.00	0.00	0.00	0.00
157	1982	2	213	-1.48	13.72	25.14	-19.81	63.32	-37.07	-6.84	111.75	37.87	-76.61	-15.39	118.41	0.00	0.00	0.00	0.00	0.00	0.00
158	1982	3	249	-1.61	14.98	27.48	-21.67	70.43	-38.33	-7.60	124.33	42.25	-80.73	-16.78	136.19	0.00	0.00	0.00	0.00	0.00	0.00
159	1982	4	209	-1.49	13.84	25.37	-20.01	64.31	-37.42	-6.91	112.98	37.96	-75.27	-14.78	111.10	-1.02	0.00	0.00	0.00	0.00	0.00
160	1982	5	208	-1.58	14.57	26.55	-20.80	76.55	-44.79	-7.03	135.61	37.70	-89.29	-14.66	103.77	-8.11	0.00	0.00	0.00	0.00	0.00
161	1982	6	185	-1.38	12.72	23.07	-17.95	74.04	-44.45	-5.85	130.36	30.24	-85.94	-11.43	104.60	-23.14	0.00	0.00	0.00	0.00	0.00
162	1982	7	154	-1.33	12.19	21.94	-16.93	68.20	-42.96	-5.30	122.50	28.45	-82.79	-10.91	88.38	-27.44	0.00	0.00	0.00	0.00	0.00
163	1982	8	120	-1.34	12.41	22.51	-17.51	62.09	-37.81	-5.80	105.20	30.44	-73.11	-11.12	77.06	-42.73	0.00	0.00	0.00	0.00	0.00
164	1982	9	104	-1.25	11.49	20.80	-16.22	61.20	-37.46	-5.34	106.76	27.75	-72.04	-10.01	67.33	-49.38	0.00	0.00	0.00	0.00	0.00

Ready Table 4 Month1 Depl Total Depl RG1 Depl RG2 Depl RG3 Lag RG1 Lag RG2 Lag RG3 GWM Diff RG1 RG2 RG3 Chart1 Chart2



Response Function

- NGWCU, Forecast Streamflow, Year Type

Stream Impacts for Sub District 1 - 2012e.xlsx - Microsoft Excel

HomeInsertPage LayoutFormulasDataReviewViewAdd-InsAcrobat

CutCopyPasteFormat Painter

Clipboard

Arial18

Font

Alignment

Wrap Text

Merge & Center

Number

Conditional Formatting

Format as Table

Cell Styles

Styles

Insert

Delete

Format

Cells

AutoSum

Fill

Clear

Sort & Filter

Find & Select

Editing

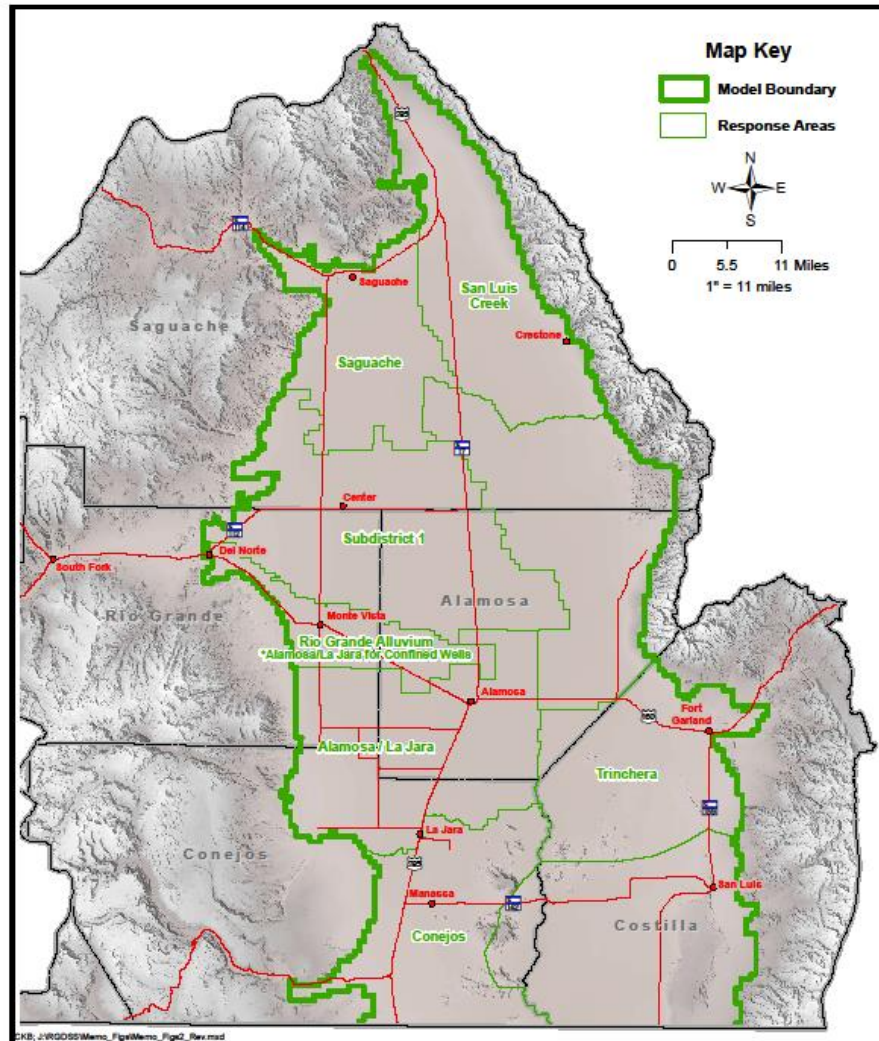
Table 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Table 3													
2	Subdistrict No. 1 Monthly Stream Replacement Obligation for 2012 Plan Year													
3	(units of ac-ft)													
4														
5		Sub-District No. 1 Total												
6		2012								2013				
7	Reach of Rio Grande	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
8	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
9	Rio Grande at Del Norte Gage to Excelsior Canal Headgate	275	305	349	376	353	345	302	323	328	286	316	295	3,852
10	Excelsior Headgate to Chicago Ditch Headgate	48	61	-5	-10	-1	29	61	57	49	42	63	46	440
11	Chicago Ditch Headgate to Stateline	29	2	2	4	17	49	57	68	59	47	47	32	413
12	Total	351	368	347	369	369	424	420	448	436	376	427	372	4,706
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														

Table 1Table 2Table 3Table 4Month1Depl TotalDepl RG1Depl RG2Depl RG3Lag RG1Lag RG2Lag RG3GWMDiffRG1

Ready

Response Areas



CRB: 2/8/2013 Memo_Fig2Memo_Fig2_Rev.mxd



State of Colorado – Division of Water Resources
RGDSS -- Response Areas

Date: 10/21/2013



COLORADO
Division of Water Resources
Department of Natural Resources

Annual Replacement Plan

- Projected NGWCU
- Projected year
- RF used
- Water Supply for replacement
- Agreements
- Long term coverage of extended depletions

Daily Administration

- Table 3 used to determine replacement daily
- Water users tell what source to use each day
- If conditions change (snowpack) may be able to respond with an amendment
- End of year review

Questions???