Appendix M
Recharge Areas, Recharge Wells and Augmentation Wells

1.0 Purpose

The purpose of this appendix is to present the process use to develop the inputs for recharge areas, recharge wells and augmentation wells for inclusion in the South Platte Decision Support System (SPDSS) Alluvial Groundwater Model. This data collection effort was undertaken by the Colorado Division of Water Resources and provided to be incorporated into the model. Four separate tasks were conducted to identify, collect and summarize available hydrogeologic data associated with recharge areas, recharge wells and augmentation wells for the SPDSS Alluvial Groundwater Model.

The development of each of these data sets was documented in the following four technical memoranda, labeled as Appendices R, S, T and V. Please note that these "appendices" were developed prior to the drafting of this report and consequently their appendix naming convention does not follow the naming convention for the other appendices to this modeling report.

- Appendix R – Lower South Platte Surface Water Model Recharge Area Diversion Records
- Appendix S – Lower South Platte Surface Water Model Augmentation Wells
- Appendix T – Lower South Platte Surface Water Model Recharge Wells
- Appendix V – Lower South Platte Surface Water Model Recharge Areas

The hydrogeologic data collected through these efforts were used to develop inputs and for calibration of the SPDSS Alluvial Groundwater Model. The information and data presented in these technical memoranda were used to:

1. *Define the locations and amount of recharge at recharge areas within the SPDSS Study Area*
2. *Define the locations and amount of pumping at recharge wells within the SPDSS Study Area*
3. *Define the locations and amount of pumping at augmentation wells within the SPDSS Study Area*

Copies of these technical memoranda are included in this Appendix M.

Appendix R – Lower South Platte Surface Water Model Recharge Area Diversion Records

Appendix R
Lower South Platte Surface Water Model
Recharge Area Diversion Records

To: File
From: Ray R. Bennett
Date: March 23, 2009
Regarding: Recharge Area Diversion Records

Introduction

The objective of this Task is as follows:

> *Evaluate available diversion to recharge data. Work with Division 1 to determine how this data may be used in the SPDSS consumptive use, ground water and surface water modeling.*

Diversions to recharge are available from HydroBase. In general recharge data may occur as part of the diversion record for a Recharge Area ID or a Carrier ID (e.g. a structure that carries water from the South Platte to the recharge facility). Also, the Carrier diversion coding may or may not result in the water diverted to recharge as being reported under the diversion total (**see Attachment 1**). Finally the Recharge Area diversion coding often uses the From Code to indicate a carrier structure but this is practice is inconsistent.

For various reasons including the above, a new structure type called Recharge Area (RA) was requested by Division 1 and adopted for HydroBase. In general by searching HydroBase for all Recharge Area structures the total amount diverted to recharge can be obtained. Unfortunately, the Carrier associated with that diversion is not, consistently coded.

Approach

Diversions to recharge were obtained from HydroBase dated July 1, 2008. Because of current limitations with TsTool and because each diversion to recharge might have a different class (e.g. Source, From, Use, and Type) over time the following approach was used to extract the data from HydroBase and sum the amount carried to recharge.

1. A list of all Recharge Area structures located in Division 1 was obtained from the Structure Table in HydroBase (fn=RechargeAreas_All.csv).
2. The program **TsTool_Rch** was used with the option that assigns a carrier using the from code, not a Recharge to Structure file. The result was a TsTool command file named TsTool_RechargeAreaX.TsTool that does the following for every recharge area identified in Step 1:
    - Extracts Infrequent diversions, if any from HydroBase.
    - Extracts diversions by water class (e.g. every Source, From, Use and Type code) from HydroBase.

- Generates an *.stm file that contains diversions to recharge for every infrequent and diversion class named RechargeArea_All.dat
- Generates one *.stm file for every recharge area in a directory named ./Diversion_RA.

3. The program **TsTool_Sum** was executed to extract data from the file RechargeArea_All.dat generated in Step 2, sum data by Carrier, and print to a file named RechargeArea_All_20090311.stm and RechargeWells_20090311.stm where the Carrier is determined using the From code in the diversion data. Following are comments related to how TsTool_Sum operates:
   - One Recharge Area might be served by more than one Carrier structure.
   - If a Recharge Area has a From Code that is the same as the Recharge Area ID or its associated Recharge Plan its From Code is estimated to not occur since a Recharge Area or a Recharge Plan is not a Carrier.
   - If a Recharge Area has 1. Some diversion records with a From Code and 2. Other records with no From Code those without data are set to the From Code that occurs most often in the diversion records.
   - If a Recharge Area has 1. No From Code in any diversion data the From Code is estimated to be the Ditch ID contained in the HydroBase Association Table.
   - If a Recharge Area has 1. No From Code in any diversion data and 2. No Ditch ID in the HydroBase Association Table then the From Code is estimated to be the ditch associated with the augmentation plan that is associated with the Recharge Area.
   - If a Recharge Area has a From Code that is a well ID, its from code is the well id and all the diversions associated with that recharge well are printed to an output file (e.g. *RechargeWells_20090311.stm*).
   - If a Recharge Area has 1. No From Code in any diversion data and 2. No Ditch ID in the HydroBase Association Table and 3. No ditch associated with the augmentation plan, it is set to a recharge well associated with that augmentation plan. When more than one recharge well is associated with an augmentation plan, the amount associated with each well is distributed evenly (e.g. if the diversion is 100 af/mo and two wells are identified, each is estimated to pump 50 af/mo) and printed to an output file (e.g. *RechargeWells_20090311.stm*).
   - If a recharge Area has a From Code that is part of an Aggregated ID, it is set to the Aggregated ID. Note an Aggregated ID is used in the SPDSS modeling when more than one ditch is used to irrigate the same land (e.g. the Bijou Ditch System (0100507_D) serves lands that may get water from Ids 1000507, 0100504 and 0100710).
4. The program **SmPlanT** was executed to sum all recharge data associated with an augmentation plan and print to a file named Sp2008L.rre. Following are comments related to how SmPlanT operates:

- It totals all diversions to recharge associated with an augmentation plan contained in a user specified list (SmPlan.plr). This list, that is typically generated by the program SmPlan is often a subset of available augmentation plans. When the list is a subset, some diversion to recharge data is no included in the output file.

5. The program **TsTool** was executed with the command file named TsTool_RechargeArea_Check_2.TsTool to sum all recharge data associated with a recharge site and print to a file named RecharrgeAreas.stm. Following are comments related to how SmPlanT operates:
    - It reads each if the individual *.stm files created by the program TsTool and the command file named TsTool_RechargeAreaX.TsTool (see step 2) from a directory named ./Diversion_RA.
    - It then combines this data into a single file named RechargeAreas.stm

Results

The Recharge Area Structure Processing by **TsTool_Rch** resulted in 682 structures and 686 unique diversion classes (e.g a unique Source, From, Use and Type). The average diversion to recharge from 1979-2007 was approximately 77,000 ac-ft/yr.

Figure 1 presents the annual amount of water diverted to recharge from 1979-2007 while **Attachment 2** lists the data itself. As presented in **Figure 1**, the first recorded diversion to recharge occurred in 1979. Also the maximum amount diverted to recharge was approximately 197,000 ac-ft in 2007.

Figure 1

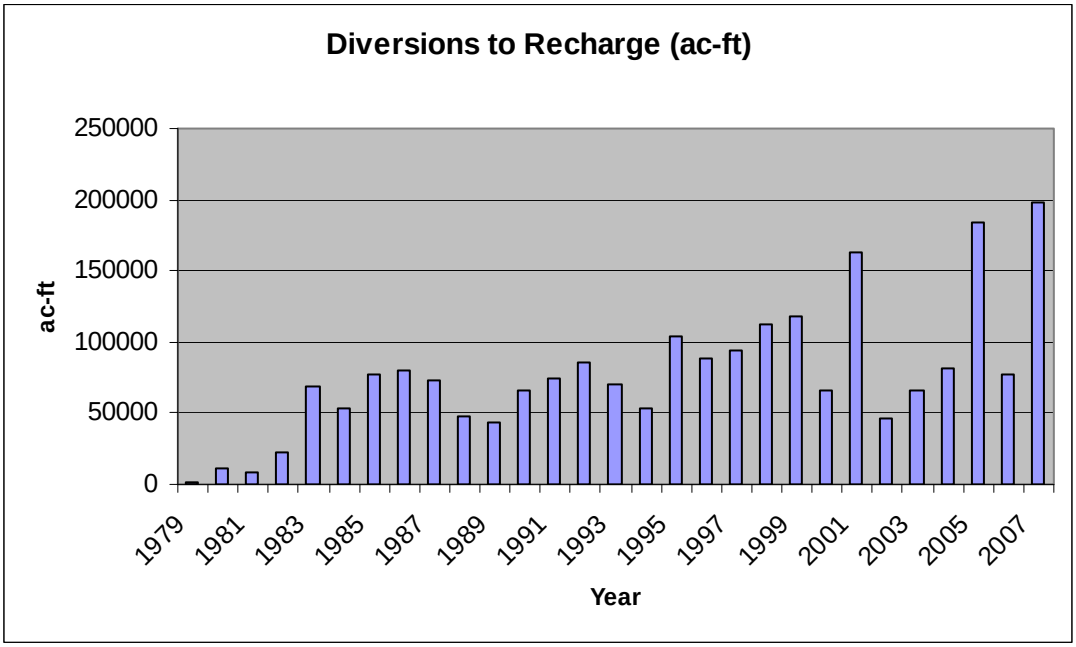
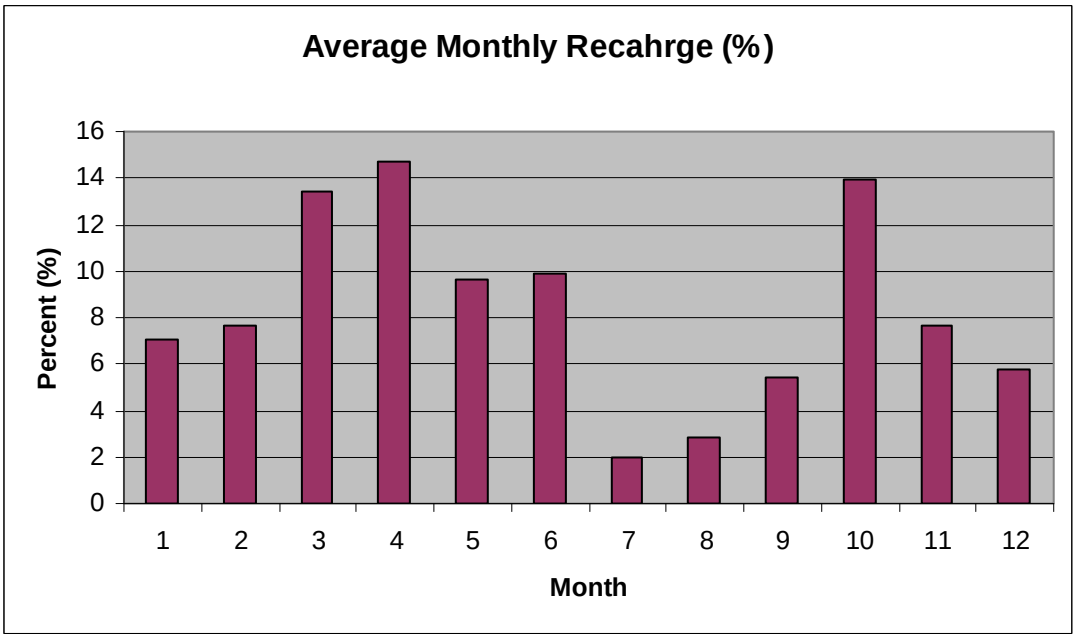


Figure 2 shows the average diversion to recharge by month. As presented, diversions to recharge may occur year round. Also, the largest diversions occur in October and March through June.

Figure 2



The Recharge Area Structure Processing by **TsTool_Sum** assigned each of the diversion classes to a carrier or well. As presented in **Table 1** the majority of the carrier structures (and recharge areas) are located in Water Districts 1 and 64. Also the total diversion by recharge wells averaged about 5,274 from 1979-2007.

Table 1
Diversions to Recharge (1979-2007)

From District	Number of Div Classes	Ave 50-07 Ac-Ft	Ave 79-07 Ac-Ft
1	306	26551	53102
2	36	2429	4858
3	6	194	388
4	6	83	166
23	3	1	2
64	262	6044	12088
Well	51	2637	5274
???	13	564	1128
Total	**683**	**38503**	**77006**

Table 2 summarizes the amount estimated to be diverted by Carrier using the program **TsTool_Sum**. As presented, there are 70 Carriers estimated to be associated with the 686 Recharge Area diversion classes. Note that it is common for one Carrier to be associated with many Recharge Areas. Also, the information listed under Carrier ID = Well_xxx is a summary, individual diversions by recharge wells are provided in the file named RechargeWells_20090311.stm. Finally, as described in the **Approach** (above), some Recharge Areas required the Carrier Ditch (e.g. the From Code) to be estimated or adjusted.

Table 2 Diversion to Recharge by Carrier

#	Carrier ID	Number of Div Classes	Total Number of Div Classes	Ave 50-07 Ac-ft	Ave 79-07 Ac-ft
1	????	13	13	564	1128
2	0100501	2	15	309	618
3	0100503_D	38	53	7800	15600
4	0100503_I	24	77	1473	2946
5	0100507_D	77	154	5238	10476
6	0100511	8	162	105	210
7	0100513	40	202	620	1240
8	0100514	44	246	4835	9670
9	0100515	16	262	1671	3342
10	0100517	7	269	69	138
11	0100518	18	287	1334	2668
12	0100519_D	15	302	2328	4656
13	0100526	3	305	27	54
14	0100687	12	317	537	1074
15	0100688	1	318	117	234
16	0100714	1	319	88	176
17	0200805	6	325	1018	2036
18	0200808	2	327	12	24
19	0200812	2	329	68	136
20	0200813	5	334	60	120
21	0200817	1	335	3	6
22	0200824	6	341	254	508
23	0200825	3	344	196	392
24	0200828	1	345	7	14
25	0200834	1	346	3	6
26	0200915	9	355	808	1616
27	0300911	1	356	28	56
28	0300926	2	358	35	70
29	0300929	2	360	124	248
30	0301029	1	361	7	14
31	0400523	6	367	83	166
32	23_ADP002	3	370	1	2
33	6400502	4	374	136	272
34	6400504	50	424	1057	2114
35	6400508	8	432	57	114
36	6400511_D	59	491	251	502
37	6400514	2	493	8	16
38	6400520	6	499	95	190
39	6400522_D	21	520	776	1552
40	6400524	10	530	131	262
41	6400525	3	533	33	66
42	6400528	5	538	143	286
43	6400530	12	550	307	614
44	6400531	4	554	65	130
45	6400532	3	557	254	508

46	6400533	45	602	1091	2182
47	6400535	21	623	1568	3136
48	6400559	5	628	9	18
49	6400587	2	630	62	124
50	6400829	2	632	1	2
51	Well_0109882	1	633	4	8
52	Well_0110090	1	634	7	14
53	Well_0110291	1	635	4	8
54	Well_6400801	2	637	8	16
55	Well_6405032	2	639	7	14
56	Well_6405064	2	641	24	48
57	Well_6405629	1	642	5	10
58	Well_6405887	3	645	10	20
59	Well_6406709	3	648	50	100
60	Well_6406710	1	649	6	12
61	Well_6406711	1	650	7	14
62	Well_6406712	1	651	3	6
63	Well_6406713	2	653	87	174
64	Well_Group_A	1	654	18	36
65	Well_Group_B	10	664	349	698
66	Well_Group_C	6	670	361	722
67	Well_Group_E	3	673	231	462
68	Well_Group_F	1	674	43	86
69	Well_Group_H	4	678	1390	2780
70	Well_Group_I	5	683	23	46
70	**Total**	**683**	**683**	**38503**	**77006**

Table 3 summarizes the amount estimated to be recharged by Augmentation Plan using the program **SumPlanT** As presented, there are19 Augmentation Plans included in the Lower South Platte River Water Resource Model. These plans recharge approximately 48,000 af/yr from 1979-2007. Note that it is common for one Augmentation Plan to be associated with many Recharge Areas. Also, as described in the **Approach** (above), these results only include those Augmentation Plans currently being simulated in the Lower South Platte Water Resource Model.

Table 3
Diversions to Recharge by Augmentation Plan
In the Lower South Platte Model Area

#	Augmentation Plan ID	Average 1950-2007	Average 19'79-2007
1	0102528	7218	14436
2	0103339	3038	6076
3	0102624	722	1444
4	0102522	65	130
5	0102513	3578	7156
6	0102529	1535	3070
7	0102535	1095	2190
8	0102518	2331	4662
9	6403392	599	1198
10	6402546	621	1242
11	6402539	140	280
12	6402552	100	200
13	6402540	131	262
14	6402536	571	1142
15	6402518	191	382
16	6402525	1390	2780
17	6402519	231	462
18	6402517	352	704
19	6402542	184	368
Total		**24092**	**48184**

Comments and Concerns:

Based on the amount of water diverted to recharge it is recommended this data be used to refine the SPDSS consumptive use (**StateCU**) and ground water (**Modflow**) models as soon as possible. In addition, it should be included in the SPDSS water supply model (**StateMod**). Following are comments and concerns associated with the Recharge Data Review:

- Diversions to Recharge were first recorded in 1979. They have averaged approximately 77,000 af/yr from 1979-2007. The maximum amount diverted to recharge was approximately 197,000 ac-ft in 2007.
- In general, it is reasonable to estimate total diversions include diversions to recharge since 3 of the 4 spot checks indicated the Total Carrier Diversion did include diversions to recharge (**Attachment 1**). Diversions to recharge by a Carrier are, in general, included in the total headgate diversion with a Use = Recharge (R) or Use = Other (Q).
- Diversions associated with a Recharge Area are generally at the recharge site itself; not the river (**Attachment 3** Correspondence with Division 1 Personnel). Therefore an initial reaction might be to increase diversions to recharge from the South Platte by a carrier loss. However based on discussions with Division 1 recharge water recorded at the recharge site is typically removed from the total diversion at the headgate when other uses are being diverted (e.g. 100% of all carrier loss is attributed to the other uses). Also if there are no other uses being diverted carrier losses are typically accrued to a recharge site (e.g. the carrier losses are treated like any other recharge site). Therefore there is no need to adjust recharge data by a carrier loss.
- Estimating the amount diverted to recharge by a Carrier was performed using the From Code associated with a Recharge Area Structure. This approach, instead of using data contained in the HydroBase association table was selected in cooperation with Division 1. Also as described in the **Approach** (above) some Recharge Areas required the Carrier Ditch (e.g. the From Code) to be estimated when none was provided.
- Estimating the amount diverted to recharge by a well was performed using the From Code associated with a Recharge Area Structure. When more than one recharge well was associated with an augmentation plan pumping was distributed to each well evenly (e.g. if the diversion to recharge is 100 af/mo and two wells were identified, each is estimated to pump 50 af/mo).
- Diversions to Recharge generated herein were compared to a spreadsheet compiled by Division 1 (Div1RchGMR07.xls) by water district. As presented in **Table 3** the comparison is generally good. Many differences are estimated to be attributed to the fact that the Division 1 data includes annual infrequent data (e.g. only an annual diversion is reported, not the month of diversion) while the results of this analysis (SPDSS) does not.
- A GIS file containing the location of Recharge Areas was developed from HydroBase as described in the memoranda titled Appendix V, Lower South Platte Surface Water Model, Recharge Areas.
- A GIS file containing the location of Recharge Wells was developed from HydroBase as described in the memoranda titled Appendix T, Lower South Platte Surface Water Model, Recharge Wells.

Table 3
Comparison to Division 1 Spreadsheet

Water District	Division 1	SPDSS	Delta
DIST 1	52,832	52,956	-124
DIST 2	5,897	4,259	1,638
DIST 64	18,941	19,392	-451
Other	546	497	48
Total	**78,215**	**77,105**	**1,111**

- For SPDSS modeling purposes the most cost effective approach to include diversions to Recharge Areas is to:

  (1) Total the amount diverted to recharge at each carrier (Table 2 [(1)]).
  (2) Adjust total headgate diversions by the amount diverted to recharge and provide this estimate to StateCU, Modflow and StateMod. Because some ditches may not include water diverted to recharge this estimate should never be allowed to be less than zero). This will result in the best estimate of irrigation pumping and recharge from irrigation.
  (3) Add Recharge Areas to the Ground Water Model.

  [(1)]Not all the structures listed in Table 2 should be used to adjust diversions to irrigate in the consumptive use model. Specifically the ID labeled Well represents pumping to recharge that has no irrigation associated with its use. Similarly ID's 0100714, 6400829, 6400587 and 6400559 represent small ditches or seeps that have no irrigated lands in HydroBase.

- The following table lists the key data files related to Recharge Data that were generated for SPDSS modeling purposes. Note that the first file is used by the SPDSS Consumptive Use Contractor to separate diversions from the river into those used for recharge and those used for irrigation and storage. The second and third files are use by the Ground Water Contractor in order to estimate pumping by Recharge Wells and the amount of diversion delivered to a recharge site.

#	File Name	# of structures with data	Description
1	RechargeArea_All_20090311.stm	70	Diversions to Recharge by a Carrier Structure or Well
2	RechargeWells_20090311.stm	42	Pumping by a Recharge Well to Recharge
3	RechargeAreas.stm	682	Diversions to Recharge by Recharge Site

Attachment 1
HydroBase Spot Checks on Recharge Data

In order to determine how the data is coded several spot checks were performed. In each case data was queried from HydroBase by diversion class. For the Recharge site every water class was evaluated. For the carrier only those with a use of Recharge (R) or Other (Q) were extracted. Following are the results:

Spot Check 1
Recharge Pond Bijou Recharge Pond 1 (0102000)
Carrier: Bijou Canal (0100507)
Associated TsTool Command Recharge_0102000.TsTool
Result:
Recharge Site has relatively complete records from 1982-2005.
The carrier data **does not include** diversions to recharge from approximately 1982 to 1987.
The **carrier data does include** diversions to recharge from 1988 to present.

Spot Check 2
Recharge Pond Lower P & B Daily Rechrg A (0102009)
Carrier: Lower Platte Beaver D (0100518)
Associated TsTool Command Recharge_0102009.TsTool
Result:
Recharge Site has relatively complete records from 1989-2005.
The **carrier data does include** diversions to recharge from 1988 to present.

Spot Check 3
Recharge Pond Liddle Ditch Recharge Area (6402007)
Carrier: Little Ditch (6400502)
Associated TsTool Command Recharge_6402007.TsTool
Associated Excel Sheet NA
Result:
Recharge Site has relatively complete records from 1982-2005.
The carrier data **does include** diversions to recharge from approximately 1985 to present.

Spot Check 4
Recharge Pond Liddle Thrasher Rchrg A (6402008)
Carrier: Little Ditch (6400502)
Associated TsTool Command Recharge_6402008.TsTool
Associated Excel Sheet NA
Result:
Recharge Site has relatively complete records from 1995-2005.
The carrier data **does include** diversions to recharge from approximately 1995 to present.

Comments and Concerns:

Following are comments and concerns associated with the Recharge Data Review:

- Diversions to recharge at the carrier are, typically, coded as Use = Recharge (R) or Use = Other (Q) and appear to be relatively complete from 1985 forward.

- In general, it is reasonable to estimate total diversions include diversions to recharge since 3 of the 4 spot checks indicated the carrier total diversion total did include diversions to recharge.

- In addition to diversions to recharge diversions to an off channel reservoir are often coded as Use = Other (Q). Therefore it is possible a search using Use = Other (Q) will result in diversions to an off channel reservoir, not diversions to recharge.

Attachment 2 Recharge Data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	404.3	380.8	785.1
1980	1364.6	813.2	901.3	1993.9	2530.8	1434.5	495.6	626.1	600.6	383.9	529.6	210.3	11884.5
1981	936.6	650.9	2592.2	853.1	1214.3	141.2	0.0	0.0	0.0	68.6	553.8	837.8	7848.5
1982	402.8	412.3	898.1	643.6	413.0	950.8	868.7	1061.6	2548.0	3978.2	7210.6	2765.4	22153.0
1983	2194.8	5926.9	7403.9	7945.4	9693.0	6880.1	2851.4	3692.8	2727.0	7594.0	7682.8	3903.2	68495.3
1984	2919.7	2943.8	3621.7	5194.9	8957.8	4630.1	1594.2	3275.5	3606.8	7109.9	6436.0	3278.9	53569.4
1985	2015.0	1652.3	5931.8	8031.7	10628.1	5147.2	2915.9	3084.5	6650.5	15128.1	9751.1	6714.6	77650.8
1986	5147.5	4027.1	11787.1	7218.7	7010.4	9807.1	1434.1	1574.8	3641.4	10022.3	10347.9	7570.0	79588.3
1987	5424.0	8374.0	9842.5	9136.9	5865.7	5554.4	838.9	1297.2	3600.2	6701.5	11180.0	5649.7	73465.1
1988	753.6	1758.9	10788.9	9267.3	6974.9	7397.2	1179.5	1141.2	1601.4	898.2	2198.2	4325.8	48285.2
1989	2920.5	3887.6	8176.6	3215.5	1014.2	2337.7	735.7	380.4	6427.3	11748.6	2084.5	673.7	43602.4
1990	5698.8	6359.9	15207.0	8856.0	1408.0	4662.4	957.2	1394.4	3182.6	12407.0	4585.7	892.1	65611.0
1991	4086.8	8149.4	15876.6	3723.1	653.4	8531.6	619.5	1238.5	8468.6	15077.7	1288.9	7101.6	74815.8
1992	5267.1	7628.9	14465.9	12794.9	406.2	1915.8	1217.0	5485.8	7115.9	13732.4	11146.0	4235.4	85411.4
1993	3688.1	4686.6	8146.2	14585.3	566.7	4934.7	534.4	941.0	8970.8	12491.6	7047.2	3371.3	69963.9
1994	6136.4	4621.6	10414.5	6670.2	818.5	640.0	566.9	341.4	989.2	19008.9	2757.6	700.0	53665.3
1995	800.4	779.6	2499.4	14877.3	20883.5	14635.7	8198.4	1932.8	7792.2	13606.9	10119.3	7723.3	103848.8
1996	5927.3	5035.2	10505.5	6973.8	4345.2	13888.6	1516.8	1615.0	9435.7	13317.3	9801.7	6779.5	89141.6
1997	3940.7	8575.7	13680.4	11863.6	2349.9	16021.7	2386.2	6573.4	5694.7	9038.8	7385.9	6974.7	94485.7
1998	3617.9	6359.7	12467.8	18455.8	9481.4	7079.2	3422.5	4117.7	6151.5	16754.0	16531.3	7589.2	112028.1
1999	5554.7	4344.9	13746.6	14966.5	15315.4	9426.1	3259.2	10026.2	8128.3	15549.6	11071.5	6178.5	117567.5
2000	9378.6	4929.2	19735.7	18700.8	4416.2	928.7	769.3	699.2	362.4	1383.6	1692.9	2967.6	65964.0
2001	12252.4	12977.0	18155.7	37229.1	17951.8	10662.5	1883.4	1270.0	10290.8	20398.7	13791.9	5996.2	162859.5
2002	6081.6	6256.1	6522.4	14819.2	1086.8	581.1	211.7	164.0	172.1	1367.6	3001.9	6523.7	46788.1
2003	8361.7	7667.5	11204.3	2323.7	3987.4	5485.2	312.7	712.0	391.2	16269.9	3606.7	6079.2	66401.4
2004	14354.8	16169.9	10319.3	1583.8	1111.2	1137.0	960.3	3452.9	3356.5	16418.5	5091.8	6916.9	80872.8
2005	12116.0	17075.1	12257.5	34474.1	14058.9	50967.7	1224.1	2259.2	2679.8	28827.1	1985.6	6352.0	184277.2
2006	15123.9	6473.2	20172.9	14788.2	1480.3	1034.3	1156.0	1340.9	1948.7	5948.0	2349.9	5567.6	77383.8
2007	11951.8	13185.9	23393.2	38347.1	59958.3	25258.4	2273.8	3969.7	3750.3	15470.4	0.0	0.0	197559.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	785.1
Max	15123.9	17075.1	23393.2	38347.1	59958.3	50967.7	8198.4	10026.2	10290.8	28827.1	16531.3	7723.3	197559.0
Mean	5462.7	5921.5	10369.5	11363.2	7399.4	7657.6	1530.5	2195.5	4147.7	10713.8	5918.4	4422.7	77102.5

Attachment 3 Division 1 Correspondence

From: Schantz, Brent
Sent: Tuesday, May 20, 2008 11:23 AM
To: Bennett, Ray
Subject: Recharge Data

It is measured inflow at the recharge site.

Brent Schantz
District 1 & 64 Water Commissioner
Colorado Division of Water Resources
Greeley Office 970.352.8712x1217
Sterling Office 970.522.5390
Cellular 970.381.8159
Brent.Schantz@state.co.us

From: Bennett, Ray
Sent: Tuesday, May 20, 2008 11:23 AM
To: Schantz, Brent
Subject: Recharge Data

Brent,
I am looking at the recharge data in HydroBase. In general is this data recorded at the recharge site (after canal losses) or at the river?
Thanks,
Rrb

Attachment 3 Recharge Data Locations

The following approach was used to generated GIS coverage for Recharge Data:

Recharge Area Locations

1. Using the Access design query named Div1_Structure_RecharegArea all structures in Division 1 with a use type = RA (Recharge Area) were queried and saved to a *.dbf file (RechargeAreas.dbf).
2. An existing project was opened in ArcMap
3. “File, Add Data” was used to add the *.dbf data to ArcMap
4. Right clicking on the newly added data and Selected “Disply xy data”.
5. Selected the events data layer and selected “Data, Export Data”
6. Selected appropriate options to display x and y coordinates.
7. Selected Export Data and entered the shape file name (Div1_RechargeAreas_20080908).

Comment: The above approach resulted in 680 recharge area locations. A review of the Recharge Area locations indicated some did not have UTM coordinates. Division 1 was provided a list for those that have diversion data in order to complete the location information.

Recharge Well Locations

1. Using the Access design query named Div1_Structure_RecharegWells all structures in Division 1 with a structure type = 2 (Well) and a Structure name that contains Rchrg (e.g. Like(“*Rchrg*”) were queried and saved to a *.dbf file (RechargeWells.dbf).
2. Using the Access design query named Div1_Structure_DiversionWells four diversions that currently use wells as alternate points (6400513, 6400518, 6400631 & 6400801) were queried and saved to a *.dbf file (RechargeWells.dbf).
3. An existing project was opened in ArcMap
4. “File, Add Data” was used to add the *.dbf data to ArcMap
5. Right clicking on the newly added data and Selected “Disply xy data”.
6. Selected the events data layer and selected “Data, Export Data”
7. Selected appropriate options to display x and y coordinates.
8. Selected Export Data and entered the shape file name (Div1_RechargeWells_20080908).

Comment: The above resulted in 38 recharge well locations. These locations contains every well identified as having recharge data.

Augmentation Well Locations

1. Using the Access design query named Div1_Structure_AugmentationWells all structures in Division 1 with a structure type = 2 (Well) and a Structure name that contains Aug W (e.g. Like("*Aug W*") were queried and saved to a *.dbf file (AugmentationWells.dbf).
2. An existing project was opened in ArcMap
3. "File, Add Data" was used to add the *.dbf data to ArcMap
4. Right clicking on the newly added data and Selected "Disply xy data".
5. Selected the events data layer and selected "Data, Export Data"
6. Selected appropriate options to display x and y coordinates.
7. Selected Export Data and entered the shape file name (Div1_AugmentationWells_20080908).

Comment: The above resulted in 29 augmentation well locations. This list may expand based on additional analysis by Division 1.

Appendix S – Lower South Platte Surface Water Model Augmentation Wells

Appendix S
Lower South Platte Surface Water Model
Augmentation Wells

To: File
From: Ray R. Bennett
Date: March 11, 2009
Regarding: Augmentation Wells

Introduction

An Augmentation Well, as used herein, is a well that pumps water for release to the stream. They are commonly used to offset well depletions and/or meet the terms and conditions associated with a water transfer. In general, augmentation well pumping began around 2002 in order to assist in meeting augmentation requirements during a sever drought.

The objective of this Task is as follows:

> *Evaluate available augmentation well data. Recommend how this data may be used in the SPDSS consumptive use, ground water and surface water modeling.*

Results

Augmentation Well Structures

Augmentation Wells were obtained from HydroBase using the query titled:

> Div1_Well_Rights_Augmentation

This query returns all water right where the Division = 1, Structure Type = 2 (well), and the Use = Aug (augmentation). As presented in **Table 1** the above returned 5,531 wells in Division 1. Unfortunately many of the structures decreed for augmentation are also decreed for many other uses (e.g. irrigation, municipal, recreation, fishery, domestic, power, etc.). This assignment to multiple uses has, in general, become common in order to provide flexibility for potential future uses.

Based on discussions with the Division 1 office many of these wells have not, to date, been used for augmentation. Therefore the Division 1 office was requested to identify augmentation wells which have operated as an augmentation supply. This request resulted in three spreadsheets provided by Email on January 27, 2009 (D64_AugWellRecords.xls, D1_AguWellRecords.xls, & D2_AugWellRecords.xls). Based on this data 26 operational augmentation wells were identified (**Table 2**).

Table 1
Well Rights Decreed for Augmentation

Water District	Count
1	574
2	465
3	6
4	3
5	7
6	13
7	37
8	4066
9	70
23	18
64	242
80	30
Total	**5531**

Table 2
Operational Augmentation Well Structures (source Division 1)

Count	WDID	UTM_X	UTM_Y	Name
1	105478	623130.1	4463521	AMEN WELL 8415
2	108435	593853.3	4455748	JENSEN TEAGUE AUG W 2-60616F
3	109877	586874.2	4464551	DT EAST AUG WELL 59357
4	109883	581106	4463488	ROTHE AUG WELL 59915
5	109885	593784.4	4455381	JENSEN TEAGUE AUG W 3-60617F
6	110157	577896.1	4458031	ORPHAN WLS OF WIGGINS AUG W
7	110285	534765	4431890	FOILES LAR WELL 60671F
8	205837	517892.3	4430544	MOLER WELL 1-47086
9	206105	520922.7	4463230	EWING WELL 1-8946
10	207165	522559.2	4464035	MC CARTHY WELL 13587
11	209427	514858.5	4429123	BAURER/EIBERGER W 49171
12	6406008	719460.1	4542288	PARKER WELL 1-14157
13	6406276	697521.6	4526077	SONNENBERG WELL 10-9579F
14	6406279	696938.8	4525545	SONNENBERG WELL 11-10789
15	6406494	716549.8	4538949	WALTER WELL 7093
16	6406639	729624	4542500	KONTNY AUG WELL 56046
17	6406704	697341	4525672	DINSDALE BROS AUG WL 5
18	6406705	676924.1	4518364	SVOBODA AUG WELL 59883F
19	6406707	705078	4530212	TOYNE AUG WELL

20	109855	4431512	534679.3	FOILES LAR WL FLD
21	108435	4455748	593853.3	JENSEN TEAGUE AUG W 2-60616F
22	6405000	0	0	NA
23	6405001	0	0	NA
24	6405005	0	0	NA
25	6405007	0	0	NA
26	6405008	0	0	NA

Augmentation Well Pumping

Historic augmentation well pumping is difficult to query from HydroBase because of inconsistent coding assignments over time. Therefore the spreadsheets provided by Division 1 (D64_AugWellRecords.xls, D1_AguWellRecords.xls, & D2_AugWellRecords.xls) were used to develop the following TsTool command files in order to extract the data from HydroBase:

AugWells_WD_01.TsTool
AugWells_WD_02.TsTool
AugWells_WD_64.TsTool
AugWells_All.TsTool

The first three files extract data by water district with specific Source, From, Use & Type coding. The last file simply combines results into one basin wide file that was provided to CDM for use by the SPDSS Ground Water Model under the name:

AugmentationWells_20090213.stm

Augmentation Well Operating Rules

StateMod estimates the amount pumped by an Augmentation Well using an operating rule. The data preprocessor **SmOpr** was used to generate operating rules for each augmentation well listed in **Table 2**.

Augmentation Well Locations

In order to develop a GIS file of Augmentation Well locations a list of all wells was obtained from HydroBase using the query titled:

Div1_Structure_Wells

This query returns all structures in Division = 1 with a Structure Type = 2 (well) named Div1_Structure_Wells.xls. This file was then saved to a *.prn file and processed by the program named Get_Utm. The net result was a list of 26 augmentation wells saved as a GIS file with the name:

Div1_AugmentationWells_20090311.shp, etc.

As presented in **Table 2**, of the 26 augmentation wells with diversion records only the first 21 have location data. Based on discussions with Division 1 these sites will never have a location data.

Recommendation

Augmentation wells, wells that pump and discharge to the river are an important component of current and future South Platte River operations. Therefore it is recommended this data be added to the SPDSS ground water (Modflow) model as soon as possible. In addition, it should be included in the SPDSS water supply model (StateMod).

Comments and Concerns:

Following are comments and concerns associated with the Agricultural and Recharge Well data.

- Augmentation well pumping can be an important water supply to both Augmentation and Term and Condition plans, particularly in times of relatively low water supply.
- The ability to query augmentation well pumping from HydroBase is extremely difficult because historic coding methods have changed over time. Therefore the Division 1 office provided a list of augmentation wells and their associated diversions.
- As presented in **Table 2** only 21 of the 26 augmentation wells have location data. Based on discussions with Division 1 these sites will never have a location. Therefore they are not expected to be included in the SPDSS Ground Water Model.

Appendix T – Lower South Platte Surface Water Model Recharge Wells

Appendix T
Lower South Platte Surface Water Model
Recharge Wells
Preliminary Draft

To: File
From: Ray R. Bennett
Date: March 23, 2009
Regarding: Recharge Wells

Introduction

A Recharge Well, as used herein, is a well that pumps water for recharge. They are commonly used to deliver water to a recharge facility who's seepage will, ultimately, be used to offset well depletions and/or meet the terms and conditions associated with a water transfer. In general, recharge well pumping began around 1980 with the increased development of recharge sites.

The objective of this Task is as follows:

> *Evaluate available recharge well data. Recommend how this data may be used in the SPDSS consumptive use, ground water and surface water modeling.*

Results

Recharge Well Structures

Recharge Wells were obtained from the structure table in HydroBase using the query titled:

Div1_Structure_RechargeWells

This query returns all water right where the Division = 1, Structure Type = 2 (well), and the name contains the string "Rchrg". The above query returned 26 wells in Division 1. In addition all wells identified as having diversions to recharge by the recharge processing program TsTool_Sum were added by querying HydroBase for selected structure IDs (query = Div1_structure_RechargeWells_Add & Add2. As presented in **Table 1** the above process resulted in 51 recharge structures. Of that number 3 are located in Water District 1 and 48 are located in Water District 64. **Appendix A** presents a list of each recharge well.

Table 1
Recharge Well Structures

Water District	Count
1	3
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
23	0
64	48
80	0
Total	**51**

Recharge Well Pumping

The development of historic recharge well pumping is described in the memorandum titled Appendix R, Lower South Plate Surface Water Model Recharge Diversions. As presented in **Appendix A** of the 51 recharge wells identified 42 have any diversion records and 9 do not.

Recharge Well Operating Rules

StateMod estimates the amount pumped by a Recharge Well using an operating rule. The data preprocessor **SmOpr** was used to generate operating rules for each Recharge well structure listed in **Table 1**.

Recharge Well Locations

A GIS file of Recharge Well locations, titled Div1_RechargeWells_20081120 was developed for each of the 53 wells identified as having a use of Recharge. Note that every one of these wells have location data.

Recommendation

Recharge wells are an important component of current and future South Platte River operations. Therefore it is recommended this data be added to the SPDSS ground water (Modflow) model as soon as possible. In addition, it should be included in the SPDSS water supply model (StateMod).

Comments and Concerns:

Following are comments and concerns associated with Recharge Well data.

- Recharge well locations have been estimated for Division 1 Recharge well pumping can be an important water supply to both Recharge and Term and Condition plans, particularly in times of relatively low water supply.

- The above approach to estimate recharge wells, (searching HydroBase for the string “Rechrg” in the name and adding wells with diversion records) is considered appropriate because it results in a list of active recharge wells. When HydroBase is queried for water rights with a use of Rech approximately 126 entries are obtained. However, many of these are the same structure and many are decreed for multiple uses in addition to recharge.

- Historic Recharge well pumping identified in HydroBase is extremely limited. Therefore the Division 1 office has been requested to determine if more information is available and needs to be entered into HydroBase. This memorandum will be revised if and when that data is obtained.

Appendix A
Recharge Well List

COUNT	STR_NAME	UTM_X	UTM_Y	DIVERSIONS
1	QUINT RECHARGE W 59271	629669	4473165	Yes
2	JENSEN TEAGUE AUG WELL 4	594180	4458145	Yes
3	LOWER PLATTE BEAVER RCHRG W 60156	629586	4473004	Yes
4	CHAMBERS DITCH	677587	4520005	**No**
5	LONE TREE DITCH	663748	4511996	**No**
6	CURLEE PUMP STATION 1	640281	4479429	Yes
7	QUINT PUMP STATION 2	640305	4478619	Yes
8	COTTONWOOD CR RCHRG PUMP	701157	4532925	Yes
9	FREEMAN WELL 2-7148	663721	4513192	Yes
10	SHERWIN WELL 2-20893	651775	4493910	Yes
11	CONDON PUMP 3-38720-F	683920	4523047	Yes
12	CONDON PUMP 1-24796-F	683203	4523100	Yes
13	CONDON PUMP 2-25169-F	683418	4523108	Yes
14	HETTINGER WELL 1-15698F	641013	4483328	Yes
15	MCCORMICK WELL 2-10289	709052	4533099	Yes
16	SONNENBERG WELL 36-30513	694951	4526919	**No**
17	LONE TREE ALT PT PUMP	668172	4515350	Yes
18	STROMBERGER E RCHRG W 1	670270	4516519	Yes
19	STROMBERGER E RCHRG W 2	670081	4516519	Yes
20	STROMBERGER E RCHRG W 3	669836	4516419	Yes
21	STROMBERGER E RCHRG W 4 58703	667467	4514812	Yes
22	STROMBERGER E RCHRG W 5 58704	667354	4514626	Yes
23	STROMBERGER E RCHRG W 6	667257	4514472	Yes
24	DINSDALE BROS RCHRG WL 3	696619	4527850	Yes
25	DINSDALE BROS RCHRG WL 4	696619	4527850	**No**
26	STROMBERGER RCHRG WL A	666870	4514492	Yes
27	STROMBERGER RCHRG WL B	666662	4514488	Yes
28	MILLER CHANCE RCHRG WL 1	647561	4489864	**No**
29	MILLER CHANCE RCHRG WL 2	647309	4489843	**No**
30	MILLER CHANCE RCHRG WL 3	647316	4489722	**No**
31	LOWLINE RCHRG W 60535	653979	4501588	**No**
32	LIBERAL COLO RCHRG W 61270	673355	4517559	Yes
33	LIBERAL COLO RCHRG W 61583	672852	4517121	Yes
34	PLATTEVIEW RANCH W 59193-F	704972	4532477	Yes
35	SVOBODA RECHARGE WL 1B-58552	676009	4519472	Yes
36	SVOBODA RECHARGE WL 1C-58553	676131	4519477	Yes
37	SVOBODA RECHARGE WL 2B-58691	675827	4519447	Yes
38	SVOBODA RECHARGE WL 2C-58692	675705	4519442	Yes
39	DINSDALE BROS RCHRG WL 2-50036	695086	4527176	Yes
40	BUFFALO FARMS RCHRG W 2	638450	4480389	**No**

41	PORTER FARMS RCHRG W 60893	735080	4542690	Yes
42	TAMARACK RECHARGE W 1-47191	687724	4523923	Yes
43	TAMARACK RECHARGE W 2-49222	687244	4523556	Yes
44	TAMARACK RECHARGE W 3-53168	688147	4524060	Yes
45	TAMARACK RECHARGE W 4-53169	694316	4526385	Yes
46	TAMARACK RECHARGE W 5-50444	687477	4523743	Yes
47	TAMARACK RECHARGE W 6-53336	687963	4523948	Yes
48	TAMARACK RECHARGE W 7-53441	688370	4524158	Yes
49	TAMARACK RECHARGE W 8-53538	688549	4524273	Yes
50	TAMARACK RECHARGE W 9-53539	694456	4526463	Yes
51	TAMARACK RECHARGE W 10-53540	694568	4526565	Yes

Appendix V – Lower South Platte Surface Water Model Recharge Areas

Appendix V
Lower South Platte Surface Water Model
Recharge Areas

To: File
From: Ray R. Bennett
Date: March 11, 2009
Regarding: Recharge Areas

Introduction

A Recharge Area, as used herein, is a pond, pit, reservoir or canal that is used to recharge water for augmentation purposes. They are commonly used to recharge water that will, ultimately, be used to offset well depletions and/or meet the terms and conditions associated with a water transfer. In general, recharge area use began around 1979 in Division 1.

The objective of this Task is as follows:

> *Evaluate available recharge area data. Recommend how this data may be used in the SPDSS consumptive use, ground water and surface water modeling.*

Results

Recharge Area Structures

Recharge Areas were obtained from a local copy of HydroBase using the custom Access query titled:

Div1_Structure_RechargeArea

This query returns all structures in Division = 1 with a Structure Type = RA (Recharge Area). As presented in **Table 1** the above returned 680 recharge areas in division 1. Of that number 229 are located Water District 1, 397 are located in Water District 64, and the balance are spread throughout the remaining Water Districts.

Table 1
Recharge Area Structures

Water District	Count
1	229
2	43
3	5
4	3
5	0
6	2
7	0
8	0
9	0
23	1
64	397
80	0
Total	**680**

Recharge Area Diversions

The development of historic recharge area diversions is described in the memorandum titled Appendix R, Lower South Plate Surface Water Model Recharge Data.

Recharge Area Operating Rules

StateMod estimates the amount carried to a Recharge Area using a Carrier with Loss (type 45) operating rule. The data preprocessor **SmOpr** was used to generate operating rules for each Augmentation Plan with one or more Recharge areas.

Recharge Area Locations

A GIS file of Recharge Area locations, titled Div1_RechargeAreas_20090311 was developed for each of the 680 structures identified as a Recharge Area. Of the 680 recharge areas nine (9) listed in **Table 2** do not and will never have location data based on correspondence with Division 1

Table 2
Recharge Areas with No Location Data

Count	wdid	strtype	str_name	UTM_x	UTM_y
1	0102002	RA	TORMOHLEN RECHARGE AREA	NA	NA
2	0102020	RA	DECHANT RCHRG AREA	NA	NA
3	0102027	RA	EMPIRE RES RECHARGE AREA	NA	NA
4	0102046	RA	MORGAN Q WD RECHRG A	NA	NA
5	0102088	RA	RIVERSIDE GROVES RCHRG A 2	NA	NA
6	0102089	RA	RIVERSIDE GROVES RCHRG A 3	NA	NA
7	0102226	RA	BIJOU OLSEN RCHRG A 4	NA	NA
8	0202024	RA	FARR RECHARGE AREA	NA	NA
9	6402062	RA	TAMARACK RCHG A E A	NA	NA

Recommendation

Recharge wells are an important component of current and future South Platte River operations. Therefore it is recommended this data be added to the SPDSS ground water (Modflow) model as soon as possible. In addition, it should be included in the SPDSS water supply model (StateMod).

Comments and Concerns:

Following are comments and concerns associated with Recharge Well data.

- Recharge Areas can be an important water supply to both Well Pumping and Term and Condition plans, particularly in times of relatively low water supply.

- Recharge Areas should, in general, be an area or a canal. However only point locations are available in HydroBase. Therefore, recharge areas should be assigned to the ground water model using the intersection of the point location with the Ground Water Model grid. Note this approach may result in some recharge being assigned to an incorrect ground water model cell if the point location is not indicative of where recharge actually occurs.