TABLES

TABLE 1
Geologic Unit Descriptions within the Pinedale Anticline Project Area[b]
PAPA Numerical Groundwater Model

Unit Label[a]	Description of Map Units
a	Alluvium
ao	Alluvium and glacial outwash
as	Alluvium and slopewash with minor components of residuum and terrace deposits
asf	Alluvium, slopewash, and alluvial fan deposits
asr	Alluvium, slopewash, and residuum with minor components of bedrock outcrops and colluvium
b	Bench deposits
bd	Dissected bench deposits
bo	Bench deposits and glacial outwash
f	Alluvial fan deposits
M	Mined out/disrupted area
oa	Glacial outwash and alluvium
Qac	Holocene and Pleistocene alluvium and colluvium
Qal	Holocene and Pleistocene alluvial deposits
Qc	Holocene and Pleistocene colluvium
Qt	Holocene and Pleistocene terrace deposits
rR	Residuum and bedrock outcrops with minor components of slopewash and colluvium
rRs	Residuum, bedrock outcrops, and slopewash
rs	Residuum and slopewash with minor components of colluviums and bedrock outcrops
rsR	Residuum, slopewash, and minor components of bedrock outcrops and colluvium
sa	Slopewash and alluvium with minor components of bedrock outcrops, residuum, and colluvium
sar	Slopewash, alluvium, and residuum
sf	Slopewash and alluvial fan deposits
sfa	Slopewash, alluvial fans, and alluvium
sra	Slopewash, residuum, and alluvium
sRf	Slopewash, bedrock, and alluvial fan deposits
srR	Slopewash, bedrock outcrops, and residuum with minor components of slopewash and colluvium
t	Terrace deposits
Tgfo	Fontenelle Tongue of the Green River Formation
Tgl	Laney Shale Member of the Green River Formation
Tgw	Wilkins Peak Member of the Green River Formation
to	Terrace deposits mixed and glacial outwash
Twcb	Cathedral Bluffs tongue of the Wasatch Formation
Twnf	New Fork Tongue of the Wasatch Formation

[a] Geologic units shown on **Figures 4** and **5**.

[b] Hydraulic properties for the geologic units are discussed in **Sections 2.0** through **4.0**.

Source: Wyoming State Geological Society, Open File Report 09-05 (2009a).

Table 2

Calculated Vertical Gradient at Study Well Locations[a,b]

PAPA Numerical Groundwater Model

Location	Vertical Gradient			
	Alluvial Deposits		Wasatch Formation	
	2010	2011	2010	2011
X-1	-0.003	0.016	-0.003	0.016
X-2	-0.001	0.012	-0.001	0.012
X-3	0.001	-0.015	0.001	-0.015
X-4	0.075		0.227	
X-5	0.140		0.140	
T-1			-0.187	-0.163
T-3			-0.097	-0.020
T-4			-0.368	-0.366
T-6			0.066	0.070
T-7			-0.253	-0.367
T-8	0.064		0.064	

[a] All values are in feet/foot. Negative values = downward gradient; positive values = upward gradient.

[b] Blank cells = one or more missing water level.

TABLE 3

Summary of Aquifer Test Analysis Results

PAPA Numerical Groundwater Model

Pumping Well[b]	Saturated Thickness (feet)	Screened Interval (feet)	Recovery Analysis[a]			Drawdown Analysis[a]		
			T (feet^2/day)	*K* (feet/day)	Method[c]	*T* (feet^2/day)	*K* (feet/day)	Method
X-2-A	25	5-30	1.11E+04	4.46E+02	Theis	1.98E+03	7.90E+01	Neuman (1975)
X-2-SW	40	110 - 150	2.62E+02	6.56E+00	Theis	5.15E+01	1.29E+00	Hantush (1956)
X-4-SW	30	190 - 220	5.60E+01	1.88E+00	Theis	4.80E+00	1.60E-01	Hantush (1956)
X-4-RW	40	390 - 430	1.60E+00	4.00E-02	Theis	7.00E-01	2.00E-02	Hantush (1956)
T-1-SW	20	127 - 147	4.30E+01	2.15E+00	Theis	4.65E+01	2.33E+00	Theis (1935)
T-1-RW	23	625 - 648	1.90E+01	8.30E-01	Theis	1.28E+01	5.57E-01	Theis (1935)
T-3-RW	55	700 - 755	2.64E+02	4.81E+00	Theis	4.60E+01	8.40E-01	Hantush (1956)
T-4-SW	18	172 - 190	2.10E+01	1.18E+00	Theis	3.10E+01	1.74E+00	Hantush (1956)
T-4-RW-b [c]	19	637 - 656	9.20E+01	4.83E+00	Theis	4.00E+01	2.09E+00	Theis (1935)
			1.80E+02	9.47E+00	Theis	1.50E+02	7.89E+00	Hantush (1956)
T-5-RW	225	390 - 615	4.20E+00	2.00E-02	Theis	5.70E+00	2.50E-02	Theis (1935)
T-8-SW	18	208 - 226	7.50E+00	4.20E-01	Theis	1.00E+00	5.60E-02	Hantush (1956)
T-9-RW	55	740 - 795	1.90E+00	4.00E-02	Theis	2.50E+00	4.50E-02	Hantush (1956)

Notes:

[a] *T* = transmissivity; *K* = hydraulic conductivity.

[b] Wells T-8-RW, X-4-SW, and X-4-RW are artesian.

[c] *Bottom* row of aquifer parameter estimates are from observation well response in well AN11-10D, located 170 ft from pumping well.

See **Figures 6** and **7** for well locations.

= Alluvium HSU

= Wasatch HSU

HSU = Hydrostratigraphic Unit

TABLE 4

Steady-State Groundwater Balance

PAPA Numerical Groundwater Model

Inflow	**Minimum (acre-feet/year)**	**Maximum (acre-feet/year)**	**Average (acre-feet/year)**
Natural Recharge (R_N)	7,588	12,562	10,075
Irrigation Recharge (R_I)	5,862	7,328	6,595
Ditch Loss (R_D)	1,239	43,744	16,128
Underflow In (U_{in})	95,086	345,690	220,388
Total Inflow	**109,775**	**409,324**	**253,186**
Outflow	**Minimum (acre-feet/year)**	**Maximum (acre-feet/year)**	**Average (acre-feet/year)**
Evapotranspiration (ET)	41,361	59,042	50,201
Pumped Groundwater [a] (G_{pump})	1,036	1,553	1,294
Underflow Out (U_{out})	4,354	34,411	19,383
Discharge to Rivers[a] (BF)	160,981	241,472	201,227
Total Outflow	**207,732**	**336,478**	**272,105**

[a] Minimum and maximum estimates calculated as ±20 percent of average estimate.

TABLE 5
Seepage Rates and Estimated Total Ditch Loss
PAPA Numerical Groundwater Model

Study[a]	PBS&J (2008)	Leigh & Fipps (2002)	Quinn et al. (1989)	Nofziger et al. (1979)	Nelson Engineering (2004)	MT DNRC (2003)	Iqbal et al. (2002)
State/Province	Montana	Texas	California	Oklahoma	Wyoming	Montana	Alberta
Seepage Rate Loss Type	acre-feet/year per mile of ditch				percent of low per mile of ditch		$feet^3$ per $feet^2$ of ditch area per day
Seepage Rate	344	144	11	250	2.8%	3.8%	0.07
Total Ditch Loss Domain (acre-feet/year)	59,363	24,863	1,909	43,141	11,383	14,168	1,303

[a] Complete references given in text.

TABLE 6
Estimated Base Flow Reporting to Streams/Rivers
PAPA Numerical Groundwater Model

Stream	Base Flow ($feet^3$/second)
Pine Creek	3.3
Pole Creek	8.0
Boulder Creek	-6.1
New Fork River	136.0
Green River	52.0
East Fork River	33.2
Big Sandy River	0.2
Total Base Flow	**278.0**

Table 7
Simulated Width of Streams/Rivers
PAPA Numerical Groundwater Model

River	Modeled Width (feet) (based on 2006 aerial photo)	Initial Depth (feet)	Initial Hydraulic Conductivity (feet/day)
Green River[a]	50-100	5	10.0
New Fork River	20-160	5	10.0
Pine Creek	20	2	1.0
Pole Creek	20	2	10.0
Boulder Creek	40-50	2	0.5
East Fork River	60	2	0.5
Muddy Creek	20	2	0.5
Big Sandy River[a]	20	5	0.5
Alkali Creek	1	1	0.5
Duck Creek	10	2	0.5
Fall Creek	20	2	0.5

[a] River is located on the edge of the model domain therefore only half of the total

Table 8
Simulated Width of Ditches
PAPA Numerical Groundwater Model

Ditch Name	**Modeled Width** (feet) (based on aerial photo, site photos, or discharge estimate)	**Ditch Name**	**Modeled Width** (feet) (based on aerial photo, site photos, or discharge estimate)
Ada	5	Jaycox No 1	3
Ball	3	Last Chance	3
Bertram	10	Lee L1	3
Boulder Canal	10	Lee Main	3
Burkhalter	3	Lovatt	3
Butler	3	Luman	5
Fayette L1	3	Metz	3
Fayette L2	3	Naylor	3
Fayette Main	3	Oliver	3
Griffin No 2	3	Paradise	10
Hanna	10	Pole Creek No 2	10
Hanna No 2	3	Sill	3
Harman	5	Taylor	3
Highland L1	3	Unnamed 1,3,4,5,6,7,8,9	2
Highland L2	10	Unnamed 10	3
Highland Main	10	Unnamed 11,12,13,14,15,16	2
Hill	10	Unnamed 17,18,19,20,21	2
Howard Routh L1	3	Wardell	3
Howard Routh Main	3	White	3

Table 9

Industrial Water Supply Well Location, Elevation, and 2010 Pumping Rate for Modeled Wells

PAPA Numerical Groundwater Model

#	Name	Coordinates[a]		Average Pumping Rate (feet^3/day)[b]	Model Layer		Bottom elevation (feet amsl)	Top elevation (feet asml)
		X	Y		Bottom	Top		
1	Riverside 8-3	1,959,768	15,508,144	-953	57	47	6,489	6,664
2	Riverside 2-14W	1,963,694	15,499,041	-6	69	66	6,113	6,288
3	Antelope 1-5	2,012,774	15,445,679	-1,051	59	49	6,461	6,636
4	Warbonnet 11-10	1,988,462	15,470,044	-502	61	49	6,426	6,601
5	Warbonnet 13-14	1,992,244	15,463,128	-1,281	53	46	6,558	6,733
6	Riverside 2-24	1,968,580	15,493,400	-431	68	63	6,186	6,361
7	Mesa 12-28	1,950,403	15,518,182	-819	48	39	6,650	6,825
8	Mesa 12-33	1,950,170	15,512,795	-527	61	51	6,421	6,596
9	Mesa 5-33	1,950,448	15,514,323	-1,979	58	47	6,468	6,643
10	North Pinedale 14-8	1,937,210	15,562,900	-647	57	47	6,483	6,658
11	Boulder 1-32	1,944,868	15,528,454	-626	46	37	6,679	6,854
12	Warbonnet 1-9	1,953,862	15,516,114	-12	60	49	6,449	6,624
13	Boulder 14-32	1,949,823	15,519,797	-278	49	41	6,641	6,816
14	Mesa 11-34	1,962,315	15,506,282	-3	68	63	6,188	6,363
15	Mesa 11-35	1,945,394	15,556,982	-713	64	56	6,342	6,517
16	Warbonnet 7-5	1,937,750	15,552,200	-122	57	41	6,471	6,771
17	Rainbow 8-31	1,980,089	15,482,888	-1	66	57	6,304	6,479
18	Riverside 12-3	1,985,312	15,472,052	-586	65	55	6,346	6,521
19	Mesa 5-26	1,977,944	15,479,112	-1	67	59	6,259	6,434
20	Jensen 11-11R	1,955,732	15,511,862	-1	62	54	6,375	6,550
21	Boulder 12A-33	1,960,995	15,510,282	-260	67	62	6,228	6,403
22	Mesa 1-29	1,979,104	15,476,261	-1,048	67	59	6,280	6,455
23	Mesa 12-16	1,962,363	15,501,009	-1	69	66	6,100	6,275
24	Mesa 12-17	1,982,225	15,480,040	-15	51	43	6,610	6,730
25	Mesa 13-5	1,949,921	15,529,055	-43	59	43	6,463	6,763
26	Mesa 14-16	1,951,116	15,522,949	-502	53	45	6,543	6,718
27	Mesa 14-21	1,952,724	15,526,940	-1,519	59	43	6,452	6,752
28	Mesa 15-16	1,954,140	15,527,413	-1,428	55	43	6,525	6,765
29	Mesa 15-20	1,995,036	15,452,084	-10	54	46	6,538	6,698
30	Mesa 15-20D	1,980,453	15,473,617	-21	46	40	6,692	6,812
31	Mesa 15-8	1,989,612	15,476,055	-7	67	61	6,288	6,408
32	Mesa 16-16	1,990,773	15,466,432	-13	53	44	6,601	6,761
33	Mesa Unit Well #2	1,984,307	15,475,879	-8,606	65	57	6,328	6,503
34	Mesa 3-17	1,947,110	15,529,100	-189	45	35	6,709	6,889
35	Mesa 3-20	1,944,706	15,538,048	-28	52	44	6,570	6,720

Table 9

Industrial Water Supply Well Location, Elevation, and 2010 Pumping Rate for Modeled Wells

PAPA Numerical Groundwater Model

#	Name	Coordinates[a]		Average Pumping Rate (feet^3/day)[b]	Model Layer		Bottom elevation (feet amsl)	Top elevation (feet asml)
		X	Y		Bottom	Top		
36	Mesa 7-21	1,951,657	15,527,638	-636	54	43	6,542	6,742
37	Mesa 9-17	1,947,624	15,522,557	-315	46	41	6,659	6,799
38	Mesa 16-28	1,947,850	15,521,290	-2,759	47	39	6,649	6,824
39	Riverside 1-4	1,947,630	15,532,527	-215	46	41	6,696	6,816
40	Riverside 11-14	1,951,584	15,529,930	-655	45	36	6,706	6,881
41	Riverside 11-2	1,946,282	15,531,222	-1,067	45	36	6,703	6,878
42	Riverside 12-12	1,946,080	15,526,279	-1,232	55	43	6,535	6,735
43	Riverside 15-12	1,952,970	15,524,449	-1,211	60	49	6,453	6,613
44	Riverside 5-1	1,960,555	15,518,220	-545	65	55	6,356	6,531
45	Riverside 5-2	2,006,081	15,449,517	-10,132	51	43	6,569	6,744
46	Stud Horse Butte 11-23	1,955,750	15,506,623	-4,626	67	59	6,264	6,439
47	Stewart Point 11-21	1,962,263	15,496,564	-10	69	66	6,146	6,321
48	Stewart Point 11-33	1,966,323	15,499,435	-2	69	66	6,123	6,298
49	Stewart Point 14-20	1,953,938	15,510,226	-47	57	50	6,516	6,596
50	Stewart Point 16-18D	1,968,795	15,500,156	-11	69	65	6,139	6,314
51	Stewart Point 16-6 R	1,966,553	15,506,568	-140	69	66	6,146	6,321
52	Stewart Point 1A 3-18	1,961,245	15,507,689	-29	67	62	6,215	6,390
53	Stewart Point 1B 3-18	1,994,624	15,426,971	-13	63	53	6,385	6,560
54	Stewart Point 8-32D	1,942,839	15,553,847	-344	67	49	6,222	6,632
55	Warbonnet 15-26	1,942,752	15,542,709	-349	53	39	6,553	6,828
56	Warbonnet 16-5	1,933,585	15,558,841	-154	65	57	6,326	6,486
57	Warbonnet 2D-3D	1,933,823	15,558,268	-83	57	46	6,503	6,678
58	Warbonnet 7-15D	1,933,696	15,558,137	-89	55	45	6,523	6,698
59	Warbonnet 7-4	1,940,330	15,543,900	-281	43	33	6,736	6,911
60	Warbonnet 8-25	2,001,889	15,455,310	-18	48	43	6,649	6,769
61	Warbonnet 9-23	1,996,471	15,459,085	-289	47	32	6,674	6,919

[a] UTM Zone 12 Feet; North American Datum of 1983.

[b] Pumping rate shown as negative number in model to indicate water withdrawn from aquifer.

Table 10
Initial Hydraulic Conductivity Estimates
PAPA Numerical Groundwater Model

Lithology	Initial K_h (feet/day)	Source of value	Initial K_z (feet/day)	Range (feet/day)
Wasatch Sandstone	7	Pumping test results	0.7	0.5-50
Wasatch Shale/Siltstone	0.8	Literature (Domenico and Schwartz, 1990)	0.08	0.0001-10
Glacial Outwash	40	Literature (Fetter, 2001)	10	3-300
Alluvium	400	Pumping Test Result	40	1-1000
Mesa Terrace Gravel Deposits	100	Literature (Fetter, 2001)	10	2-2,000
Deep Wasatch	0.9	Low end pumping test results	0.09	0.0001-5

Note: K_h = Horizontal Hydraulic Conductivity; K_z = Vertical Hydraulic Conductivity.

Table 11
Target Flux Estimates
PAPA Numerical Groundwater Model

River	Target Flux (feet^3/second) (groundwater reporting to surface water)
Green River above Alkali Stream	52.0
New Fork River	136.0
Pine Creek	3.3
Pole Creek	8.0
Boulder Creek	-6.1
East Fork River	33.2

Table 12
Calibration Statistics
PAPA Numerical Groundwater Model

Statistic	Statistics for Single-Layer Targets[a]	Statistics for Multi-Layer Targets (FWL4 Package)[b]
Residual Mean	0.16	-0.13
Absolute Residual Mean	3.77	3.93
Residual Standard Deviation	4.53	4.77
Sum of Squares	1,976	2,186
Root Mean Square Error	4.47	4.7
Minimum Residual	-8.6	-11.4
Maximum Residual	9.4	10.5
Number of Observations	97	97
Range in Observations	371.7	371.7
Scaled Standard Deviation	0.012	0.013
Scaled Absolute Mean	0.01	0.011
Scaled Root Mean Square	0.012	0.013

[a] Calibration statistics calculated using single layer representing the middle of the screened interval.

[b] Calibration statistics representing wells screened across multiple layers.

Table 13
Calibration Statistics Based on 2009 Groundwater Elevation Targets
PAPA Numerical Groundwater Model

Statistic	Statistics Based on all Targets	Statistics based on 2009 Target Values Only
Residual Mean	0.16	-0.33
Absolute Residual Mean	3.77	3.92
Residual Standard Deviation	4.53	4.81
Sum of Squares	1,976	605
Root Mean Square Error	4.47	4.73
Minimum Residual	-8.6	-8.6
Maximum Residual	9.4	8.6
Number of Observations	97	27
Range in Observations	371.7	275.0
Scaled Standard Deviation	0.012	0.017
Scaled Absolute Mean	0.010	0.014
Scaled RMS	0.012	0.017

Table 14

Vertical Gradient Targets and Residuals[a]

PAPA Numerical Groundwater Model

Name	Observed Value	Simulated Value	Residual
T-3 Well Pair	0.023	0.004	0.019
T-4 Well Pair	0.016	0.016	0.000
T-6 Well Pair	-0.066	-0.037	-0.029
X-1 Well Pair	-0.003	0.004	-0.007
X-2 Well Pair	-0.014	0.001	-0.015
X-3 Well Pair	0.023	0.014	0.009

[a] All values are in feet/foot.

Table 15
Estimated and Simulated Groundwater Balance[a, b]
PAPA Numerical Groundwater Model

In	Estimated			Model Simulated
	Minimum	Maximum	Average	
Natural Recharge	7,588	12,562	10,075	20,102
Irrigation Recharge	5,862	7,328	6,595	
In Flow	95,086	345,690	220,388	181,622
Ditch Loss	1,239	43,744	16,128	20,917
Total	**109,775**	**409,324**	**253,186**	**222,641**
Out	**Estimated**			**Model Simulated**
	Minimum	**Maximum**	**Average**	
Evapotranspiration	41,361	59,042	50,200	37,602
Industrial Water Supply Wells	415	415	415	415
Out Flow	4,354	34,411	19,383	13,699
Discharge to Rivers	160,981	241,472	201,227	170,909
Total	**207,732**	**336,478**	**272,105**	**222,624**

[a] All values listed in table are in acre-feet/year.

[b] Differences between total inflow and outflow are discussed in **Section 2.5**.

Table 16
Estimated and Simulated Base Flow Reporting to Streams/Rivers
PAPA Numerical Groundwater Model

River	Target Flux[a]	Simulated Flux[a]	Residual[a]	Percent Variance
Green River above Alkali Stream	52.0	19.0	33.0	63.5
New Fork River	136.0	101.0	35.0	25.7
Pine Creek	3.3	2.9	0.4	12.1
Pole Creek	8.0	10.5	-2.5	-31.3
Boulder Creek	-6.1	23.9	-30.0	491.8
East Fork River	33.2	38.0	-4.8	-14.5
Big Sandy River	0.2	2.6	-2.4	-1,200.0

[a] Reported in $feet^3$/second.

Table 17

Simulated Horizontal and Vertical Hydraulic Conductivity Ranges[a]

PAPA Numerical Groundwater Model

Hydrogeologic Zone[b]	Lithology	K_h	K_v
1	Wasatch Sandstone	2.0	1.6
2	Wasatch Shale/Siltstone	0.39	0.18
3	Glacial Outwash	60	60
4	Wasatch Shale/Siltstone	0.7	0.24
5	Alluvial Deposits	400	4.0
6	Mesa Terrace Gravel Deposits	100	100
7	Wasatch Sandstone	10	0.16
8	Wasatch Shale/Siltstone	0.04	0.01
9	Wasatch Sandstone	16.67	3.0
10	Wasatch Sandstone	5.0	0.5
11	Wasatch Sandstone	30	0.01
12	Wasatch Shale/Siltstone	0.005	0.001
13	Wasatch Shale/Siltstone	0.01	0.0005
14	Wasatch Sandstone	4.4	3.0
15	Wasatch Shale/Siltstone	0.1	0.1
16	Wasatch Sandstone	10	1.8
17	Wasatch Shale/Siltstone	0.1	0.1
18	Wasatch Sandstone	1.0	0.1
19	Wasatch Sandstone	8.0	0.8
20	Wasatch Sandstone	18	4.0
21	Wasatch Shale/Siltstone	6.0	0.004
22	Wasatch Sandstone	18	0.1
23	Alluvial Deposits	6.0	1.0

[a] All values are in feet/day.

[b] Refer to **Appendix G** for location.

Note: K_h = Horizontal Hydraulic Conductivity; K_v = Vertical Hydraulic Conductivity.

Table 18
Calibrated Stream/River Parameterization
PAPA Numerical Groundwater Model

River	Modeled Width (feet) (based on 2006 aerial photo)	Modeled Depth (feet)	Modeled Hydraulic Conductivity (feet/day)
Green River[a]	50-100	5	30.0
New Fork River	20-160	5	100.0
Pine Creek	20	2	0.1
Pole Creek	20	2	0.1
Boulder Creek	40-50	2	0.1
East Fork River	60	2	0.1
Muddy Creek	20	2	0.5
Big Sandy River[a]	20	5	0.1
Alkali Creek	1	1	0.5
Duck Creek	10	2	1.0
Fall Creek	20	2	0.5

[a] River is located on the edge of the model domain therefore only half of the total width was used.

Table 19

Hydraulic Conductivity Values Used during Sensitivity Analysis[a]

PAPA Numerical Groundwater Model

Zone	Calibrated K_h	Minimum K_h	Maximum K_h	Calibrated K_v	Minimum K_v	Maximum K_v
1	2.0	0.2	20	1.6	0.16	16
2	0.39	0.039	3.89	0.18	0.018	1.8
3	60	6.0	600	60	6.0	600
4	0.7	0.07	7.0	0.24	0.024	2.4
5	400	40	4,000	4.0	0.4	40
6	100	10	1,000	100	10	1,000
7	10	1.0	100	0.16	0.016	1.6
8	0.043	0.0043	0.4	0.01	0.001	0.1
9	16.67	1.67	166.71	3.0	0.3	30
10	5.0	0.5	50	0.5	0.05	5.0
11	30	3.0	300	0.01	0.001	0.1
12	0.005	0.0005	0.05	0.001	0.0001	0.01
13	0.01	0.001	0.1	0.0005	0.00005	0.005
14	4.44	0.44	44.43	3.0	0.3	30
15	0.1	0.01	1.0	0.1	0.01	1.0
16	10	1.0	100	1.8	0.18	18
17	0.1	0.01	1.0	0.1	0.01	1.0
18	1.0	0.1	10	0.1	0.01	1.0
19	8.0	0.8	80	0.8	0.08	8.0
20	18	1.8	180	4.0	0.4	40
21	6.0	0.6	60	0.004	0.0004	0.04
22	18	1.8	180	0.1	0.01	1.0
23	6.0	0.6	60	1.0	0.1	10

[a] All values in feet/day.

Note: K_h = Horizontal Hydraulic Conductivity; K_z = Vertical Hydraulic Conductivity.

Table 20
Recharge and Evapotranspiration Rate and Depth Values Used during Sensitivity Analysis
PAPA Numerical Groundwater Model

Multiplier[a]	Total Recharge (acre-feet/year)	Potential Evapotranspiration Rate (inch/year)	Extinction Depth (feet)
0.5	10,051	8.75	2.5
0.6	12,061	10.50	3.0
0.7	14,071	12.25	3.5
0.8	16,082	14.00	4.0
0.9	18,092	15.75	4.5
1	20,102	17.50	5.0
1.1	22,112	19.25	5.5
1.2	24,122	21.00	6.0
1.3	26,133	22.75	6.5
1.4	28,143	24.50	7.0
1.5	30,153	26.25	7.5

[a] A multiplier of 1 represents the calibrated value.

Table 21
Sources and Receptors Identified for Advective Transport Analysis
PAPA Numerical Groundwater Model

Receptors (Reverse Particle Tracking)	Potential Sources (Forward Particle Tracking)
Domestic Wells in River Corridors	Pre-1984 Gas Wells
New Fork River and Green River	Liquid Gathering Facilities
Stock Wells	Gas Pads
Irrigation Ditches	Gas Pipelines
	Roads
	Saltwater Disposal Facilities

Table 22
Industrial Water Supply Wells Used for Reverse and Forward Particle Tracking
PAPA Numerical Groundwater Model

SCCD ID	Well Name	Operator	Northing[a]	Easting[a]	Top of Casing Elevation (feet amsl)	Total Depth (feet btoc)	Screened Interval (feet btoc)[b]	Depth to Water Sept-2010 (feet btoc)[b]	Model Layer Corresponding to Groundwater Elevation	Model Layer Thickness (feet)	Development Area	Rationale
AMI007	Mesa 15-8	QEP Energy	4,734,324	593,639	7,477	813	660-780	508.9	29	57	DA1 - Stewart Point and Mesa	In DA1 in areas not previously simulated by stock wells in regional gw system.
AMI027	Mesa 3-20	QEP Energy	4,732,419	593,166	7,465	940	730-930	758.0[c]	45	22	DA1 - Stewart Point and Mesa	In DA1 in areas not previously simulated by stock wells in regional gw system.
AMI028	Stewart Point 11-33	QEP Energy	4,738,640	592,304	7,519	980	690-965	530.9	29	37	DA1 - Stewart Point and Mesa	In DA1 where some stock wells are completed above the regional gw system. North of SP 11-33, stock wells are completed in the regional gw system near existing IWSW and have already been simulated by particle tracking.
AMI132	Riverside 15-12	Ultra Resources	4,724,457	600,090	6,931	410	250-410	22.1	33	27	DA3 - Boulder and Riverside	In DA3 previously listed as VRP well.
AMI134	Rainbow 13-32W	Shell	4,708,453	612,147	7,315	750	Unknown	368.0	31	31	DA5 - Antelope and Rainbow	In DA5 in areas not previously simulated by stock wells in regional gw system. Has had detectable levels of PHC.
AMI140	North Mesa 4-7-32-109W	Shell	4,735,685	590,915	7,517	1,040	795-970	519.5	29	55	DA1 - Stewart Point and Mesa	In DA1 where some stock wells are completed above the regional gw system. North of SP 11-33, stock wells are completed in the regional gw system near existing IWSW and have already been simulated by particle tracking.
AMI146	Antelope 11-10D	Shell	4,705,667	615,650	7,171	680	470-660	219.6	30	9	DA5 - Antelope and Rainbow	In DA5 in areas not previously simulated by stock wells in regional gw system. Has had detectable levels of PHC.
AMI156	Riverside 2-24	Shell	4,722,408	600,025	6,977	700	448-658	35.9	32	16	DA3 - Boulder and Riverside	In DA3 in areas not previously simulated by stock wells in regional gw system.
AMI166	Mesa 10-33	Ultra Resources	4,728,214	595,330	7,256	790	670-790	318.4[d]	31	33	DA2 - New Fork	In DA2 previously listed as VRP well.
AMI182	Highway #7	Yates Petroleum Company	4,705,986	613,938	7,273	610	490-610	324.6	31	32	DA5 - Antelope and Rainbow	In DA5 in areas not previously simulated by stock wells in regional gw system. Has had detectable levels of PHC.
AMI190	Riverside 11-14	Ultra Resources	4,723,362	598,099	6,939	510	165-410	24.1	33	29	DA3 - Boulder and Riverside	In DA3 previously listed as VRP well.
AMI237	Warbonnet 7-15D	Ultra Resources	4,714,178	606,789	7,353	750	590-750	411.2	31	36	DA4 - Warbonnet	In DA4 well in VRP.
AMI249	Warbonnet 2D-3D	Ultra Resources	4,717,111	606,435	7,240	950	830-950	295.3	31	29	DA4 - Warbonnet	Spatial coverage in DA4.
AMI258	Riverside 11-25	Shell	4,720,069	599,659	7,000	800	350-760	64.8	31	30	DA3 - Boulder and Riverside	In DA3 pending VRP well.
AMI272	Mesa 7-34B	Ultra Resources	4,729,805	597,241	7,166	835	220-810	211.9[d]	31	19	DA2 - New Fork	In DA2 in areas not previously simulated by stock wells in regional gw system.

[a] UTM Zone 12 Meters; North American Datum of 1983.

[b] Length of Water Column in Well = (Top of Casing Elevation - Depth to Water) - (Top of Casing Elevatoin - Depth to mid-point of screened interval).

[c] Measured 10/19/2006

[d] Measured April 2009

Note: SCCD = Sublette County Conservation District; amsl = above mean sea level; btoc = below top of casing; DA = Development Area; VRP = Voluntary Reme

PHC = petroleum hydrocarbon; IWSW = Imdustrial Water Supply Well; gw = groundwater.

Table 23
Representative Effective Porosity Values from Yu et al. (1993)
PAPA Numerical Groundwater Model

Lithologic Material	Geologic Unit in Model	Effective Porosity, η_e	
		Range	Arithmetic Mean (value in model)
Sandstone (medium)	Wasatch Sandstone	0.12 - 0.41	0.27
Siltstone	Wasatch Shale/Siltstone	0.01 - 0.33	0.12
Gravel (fine)	Alluvium	0.13 - 0.40	0.28

Table 24

Hydraulic Conductivity Values Used during Uncertainty Analysis[a]

PAPA Numerical Groundwater Model

Zone	Calibrated Value		0.5x Multiplier		5x Multiplier	
	K_h	K_z	K_h	K_z	K_h	K_z
1	2.0	1.6	1.0	0.8	10	8.0
2	0.39	0.18	0.19	0.09	1.94	0.9
3	60	60	30	30	300	300
4	0.7	0.24	0.35	0.12	3.5	1.2
5	400	4.0	200	2.0	2,000	20
6	100	100	50	50	500	500
7	10	0.16	5.0	0.08	50	0.8
8	0.04	0.01	0.02	0.005	0.21	0.05
9	16.67	3.0	8.34	1.5	83.35	15
10	5.0	0.5	2.5	0.25	25	2.5
11	30	0.01	15	0.005	150	0.05
12	0.005	0.001	0.0025	0.0005	0.025	0.005
13	0.01	0.0005	0.005	0.00025	0.05	0.0025
14	4.44	3.0	2.22	1.5	22.21	15
15	0.1	0.1	0.05	0.05	0.5	0.5
16	10	1.8	5.0	0.9	50	9.0
17	0.1	0.1	0.05	0.05	0.5	0.5
18	1.0	0.1	0.5	0.05	5.0	0.5
19	8.0	0.8	4.0	0.4	40	4.0
20	18	4.0	9.0	2.0	90	20
21	6.0	0.004	3.0	0.002	30	0.02
22	18	0.1	9.0	0.05	90	0.5
23	6.0	1.0	3.0	0.5	30	5.0

[a] All values in feet/day.

Note: K_h = Horizontal Hydraulic Conductivity; K_z = Vertical Hydraulic Conductivity.

Table 25

Input Volume and Initial Concentration for Solute Transport Scenarios

PAPA Numerical Groundwater Model

Scenario	Total Volume of Spill (feet^3)	Type of Liquid	Initial Concentration			MODFLOW Boundary Type
			Benzene (mg/L)	Toluene (mg/L)	Chloride (mg/L)	
Road	842	Condensate	53.2	62.2	NA	Constant Concentration
Pipeline	3,214	Produced Water	45.2	80.6	6,880	Constant Flux/Concentration
Liquid Gathering Facility	56,150	Condensate	53.2	62.2	NA	Constant Concentration
Natural Gas Pad	2,807	Flowback Fluid	0.003	0.02	7,520	Constant Flux/Concentration
Shut in Pre-1984 Natural Gas Well	15,146,918	Natural Gas/Condensate/Produced Water	422	500	6,880	Constant Flux/Concentration

Note: NA = Not Applicable; mg/L = milligram/liter.