APPENDIX C

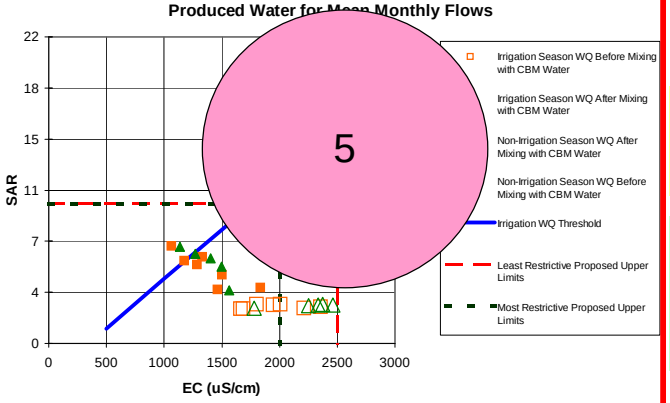
SPREADSHEET MODEL RESULTS

APPENDIX C-1

NORMAL YEAR CONDITIONS

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin



5

		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	CBNG Discharge Quality EC (uS/cm) 95% Lower	EC (uS/cm) Mean	EC (uS/cm) 95% upper	SAR (--) 95% Lower	SAR (--) Mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)	
				909	929	950	6.80	7.62	8.43			
Non-Irrigation Season	Nov	0.9	0.40	1386				6.12	6.68	2460	2.74	Non-Irrigation Season
	Dec	0.9	0.15	1118				6.93	7.62	2372	2.79	
	Jan	0.9	0.29	1256				6.43	7.04	2335	2.74	
	Feb	0.9	0.68	1486				5.50	5.97	2251	2.71	
	Mar	0.9	2.60	1557				3.83	4.04	1782	2.52	
Irrigation Season	Apr	0.9	1.15	1492	150			4.90	5.25	1949	2.77	Irrigation Season
	May	0.9	0.63	1276	1288		16	5.64	6.12	1800	2.82	
	Jun	0.9	0.13	1047	1065		6.30	7.01	7.72	2005	2.8	
	Jul	0.9	2.47	1460	1466	1471	3.63	3.85	4.07	1661	2.48	
	Aug	0.9	0.44	1163	1177	1191	5.38	5.93	6.47	1684	2.47	
	Sep	0.9	2.17	1831	1837	1844	3.78	4.01	4.25	2214	2.52	
	Oct	0.9	0.35	1313	1328	1343	5.62	6.21	6.80	2354	2.6	

4

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and W

Drainage	Stream Gauge Location	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teck	0.7	0.9	0.9

3

Mean Monthly Discharge			
		Days	cfs
O		31	0.35
		30	0.40
		31	0.15
		31	0.29
		28	0.68
		31	2.60
		30	1.15
		31	0.63
		30	0.13
Ju		31	2.47
Aug		31	0.44
Sep	130	30	2.17

2

Plotting Position: Most and Least Restrictive Limits			
	EC	SAR	
	0		
Least Restrictiv	2500		
	2500		
	0		
Most Restrictiv	2000		
	2000		

Irrigation WQ Threshold Line	
500	1.07
1000	4.62
1500	8.17
2990	18.75

1

See following page for descriptions of chart sections

Descriptions of Chart Sections

1

Section 1: The values in this section are used to plot lines within the graph delineating themost restrictive, least restrictive, and the irrigation water quality threshold. The most restrictive and least restrictve limits data were obtained from the pertinent regulatory agency. They are tabulated in the spreadsheet table named "CBNG Discharge Parameters" and referenced herein.

2

Section 2: This section tabulates the mean monthly stream flow for each site. These data are referenced from the table located in Section 4 and used in the mixing calculations.

3

Section 3: This section computes the amount of CBM water which ultimately reaches the receiving waters following conveyance losses. The table is initially populated by reference to worksheet CBNG Discharge Parameters. Output from this table is then referenced by Section 4 where it is used in mixing computations

4

Section 4: This section is where the mixing calculations occur. CBM water with a given water quality is mixed with a background water with its own water quality. Using simple mixing computations described in the table, downstream water quality is estimated. Irrigation season is displayed in the area shaded green; non-irrigation season is shaded yellow.

5

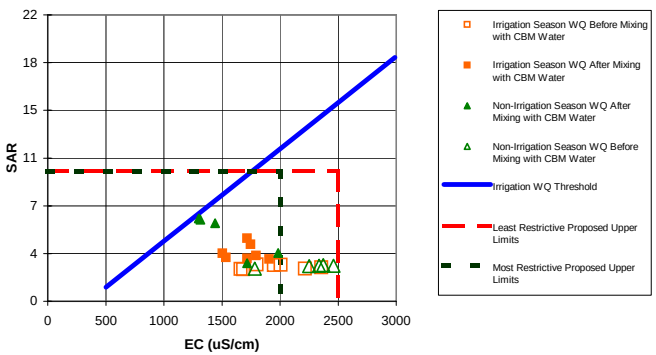
Section 5: This section presents the summary graph illustrating irrigation suitability and the water quality data relative to the "limits". The graph references "Limits" data from Section 1 and pertinent water quality data from section 4.

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality [1]						Background Water Quality	
		CBM Flow	StreamFlow	EC			SAR			EC	SAR
		(cfs)	(cfs)	(uS/cm)			(--)			(uS/cm)	(--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	0.9	0.45	1426	1440	1454	5.45	5.99	6.53	2460	2.74
	Dec	0.9	0.31	1283	1299	1315	5.77	6.38	6.98	2372	2.79
	Jan	0.9	0.34	1300	1315	1330	5.69	6.28	6.87	2335	2.74
	Feb	0.9	3.55	1979	1984	1988	3.54	3.70	3.87	2251	2.71
	Mar	0.9	10.61	1714	1715	1717	2.85	2.92	2.98	1782	2.52
Irrigation Season	Apr	0.9	5.03	1791	1794	1797	3.38	3.51	3.63	1949	2.77
	May	0.9	8.37	1713	1715	1718	3.21	3.29	3.36	1800	2.82
	Jun	0.9	8.85	1904	1906	1908	3.17	3.24	3.32	2005	2.8
	Jul	0.9	4.32	1531	1535	1538	3.23	3.37	3.51	1661	2.48
	Aug	0.9	2.89	1500	1505	1510	3.50	3.69	3.89	1684	2.47
	Sep	0.9	1.57	1738	1746	1754	4.08	4.38	4.67	2214	2.52
	Oct	0.9	1.11	1707	1716	1725	4.48	4.85	5.21	2354	2.6

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	3.0	0.7	0.9	0.9

Flow In Antelope Creek

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	69	31	1.11
Nov	27	30	0.45
Dec	19	31	0.31
Jan	21	31	0.34
Feb	199	28	3.55
Mar	658	31	10.61
Apr	302	30	5.03
May	519	31	8.37
Jun	531	30	8.85
Jul	268	31	4.32
Aug	179	31	2.89
Sep	94	30	1.57

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
	0	10
Most Restrictive	2000	10
	2000	0

Irrigation WQ Threshold Line

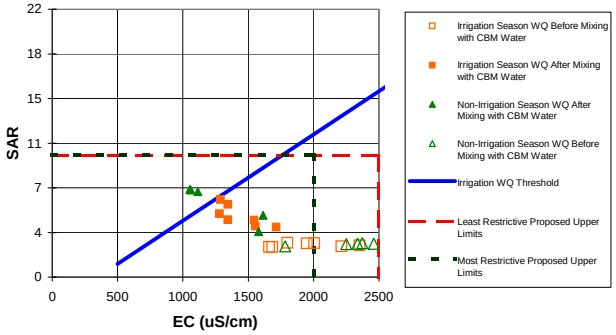
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% Lower	Mixed Water Quality EC (uS/cm) Mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% Lower	Mixed Water Quality SAR (--) Mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	3.3	0.45	1095	1113	1132	6.31	7.03	7.75	2460	2.74
	Dec	3.3	0.31	1034	1053	1072	6.46	7.20	7.95	2372	2.79
	Jan	3.3	0.34	1042	1061	1080	6.42	7.16	7.90	2335	2.74
	Feb	3.3	3.55	1604	1614	1624	4.68	5.07	5.47	2251	2.71
	Mar	3.3	10.61	1575	1580	1585	3.54	3.73	3.92	1782	2.52
Irrigation Season	Apr	3.3	5.03	1537	1545	1553	4.37	4.69	5.01	1949	2.77
	May	3.3	8.37	1548	1554	1560	3.95	4.18	4.41	1800	2.82
	Jun	3.3	8.85	1707	1713	1719	3.89	4.11	4.33	2005	2.8
	Jul	3.3	4.32	1335	1344	1353	4.35	4.70	5.06	1661	2.48
	Aug	3.3	2.89	1271	1282	1293	4.78	5.21	5.65	1684	2.47
	Sep	3.3	1.57	1329	1344	1358	5.42	5.97	6.52	2214	2.52
	Oct	3.3	1.11	1272	1288	1304	5.74	6.35	6.96	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	10.9	0.7	3.3	3.3

Flow In Antelope Creek

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	69	31	1.11
Nov	27	30	0.45
Dec	19	31	0.31
Jan	21	31	0.34
Feb	199	28	3.55
Mar	658	31	10.61
Apr	302	30	5.03
May	519	31	8.37
Jun	531	30	8.85
Jul	268	31	4.32
Aug	179	31	2.89
Sep	94	30	1.57

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

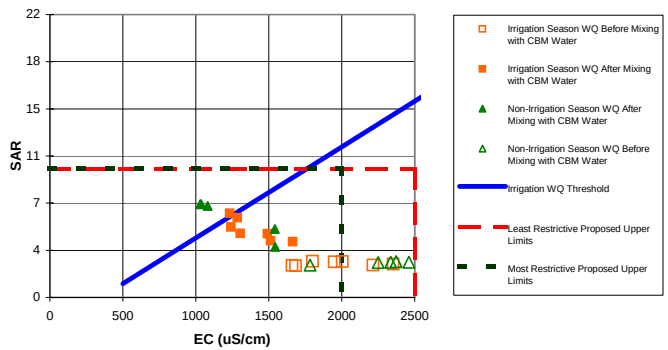
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	4.1	0.45	1062	1081	1100	6.40	7.13	7.87	2460	2.74
	Dec	4.1	0.31	1011	1031	1050	6.52	7.28	8.03	2372	2.79
	Jan	4.1	0.34	1018	1037	1056	6.49	7.24	7.99	2335	2.74
	Feb	4.1	3.55	1532	1543	1554	4.90	5.34	5.78	2251	2.71
	Mar	4.1	10.61	1539	1544	1550	3.71	3.94	4.17	1782	2.52
Irrigation Season	Apr	4.1	5.03	1482	1491	1501	4.58	4.95	5.31	1949	2.77
	May	4.1	8.37	1507	1514	1521	4.13	4.40	4.66	1800	2.82
	Jun	4.1	8.85	1658	1664	1671	4.07	4.32	4.58	2005	2.8
	Jul	4.1	4.32	1295	1305	1315	4.58	4.98	5.38	1661	2.48
	Aug	4.1	2.89	1229	1241	1254	5.01	5.49	5.97	1684	2.47
	Sep	4.1	1.57	1270	1285	1300	5.62	6.20	6.79	2214	2.52
	Oct	4.1	1.11	1217	1233	1249	5.91	6.55	7.19	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	13.5	0.7	4.1	4.1

Flow In Antelope Creek

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	69	31	1.11
Nov	27	30	0.45
Dec	19	31	0.31
Jan	21	31	0.34
Feb	199	28	3.55
Mar	658	31	10.61
Apr	302	30	5.03
May	519	31	8.37
Jun	531	30	8.85
Jul	268	31	4.32
Aug	179	31	2.89
Sep	94	30	1.57

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

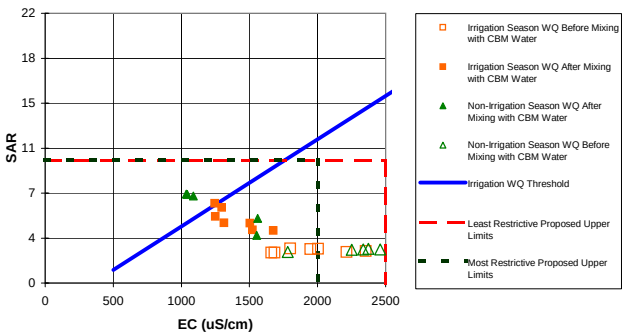
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% Lower	Mixed Water Quality EC (uS/cm) Mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% Lower	Mixed Water Quality SAR (--) Mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	3.9	0.45	1069	1088	1107	6.38	7.11	7.84	2460	2.74
	Dec	3.9	0.31	1016	1036	1055	6.51	7.26	8.01	2372	2.79
	Jan	3.9	0.34	1023	1042	1061	6.48	7.22	7.97	2335	2.74
	Feb	3.9	3.55	1548	1559	1570	4.85	5.28	5.70	2251	2.71
	Mar	3.9	10.61	1547	1553	1558	3.67	3.89	4.11	1782	2.52
Irrigation Season	Apr	3.9	5.03	1495	1504	1513	4.53	4.89	5.24	1949	2.77
	May	3.9	8.37	1517	1523	1530	4.09	4.34	4.60	1800	2.82
	Jun	3.9	8.85	1670	1676	1682	4.02	4.27	4.52	2005	2.8
	Jul	3.9	4.32	1304	1314	1324	4.53	4.92	5.30	1661	2.48
	Aug	3.9	2.89	1239	1251	1263	4.96	5.43	5.89	1684	2.47
	Sep	3.9	1.57	1283	1298	1313	5.57	6.15	6.73	2214	2.52
	Oct	3.9	1.11	1229	1245	1261	5.87	6.50	7.14	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	12.9	0.7	3.9	3.9

Flow In Antelope Creek

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	69	31	1.11
Nov	27	30	0.45
Dec	19	31	0.31
Jan	21	31	0.34
Feb	199	28	3.55
Mar	658	31	10.61
Apr	302	30	5.03
May	519	31	8.37
Jun	531	30	8.85
Jul	268	31	4.32
Aug	179	31	2.89
Sep	94	30	1.57

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

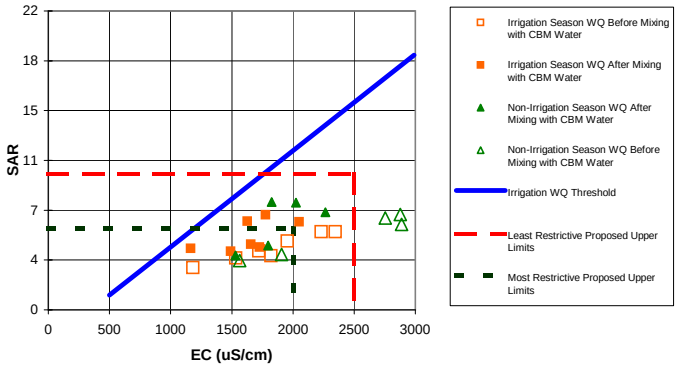
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
	EC (uS/cm)			SAR (--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	4.3	4.60	2019	2023	2027	7.71	7.90	8.09	2877	7.02
	Dec	4.3	3.31	1821	1825	1830	7.72	7.94	8.16	2755	6.77
	Jan	4.3	7.97	2262	2264	2267	7.04	7.18	7.32	2887	6.29
	Feb	4.3	27.02	1797	1798	1799	4.68	4.73	4.79	1907	4.08
	Mar	4.3	54.94	1530	1531	1532	3.99	4.02	4.05	1564	3.64
Irrigation Season	Apr	4.3	35.47	1655	1656	1657	4.78	4.83	4.87	1722	4.34
	May	4.3	39.03	1489	1490	1491	4.27	4.31	4.35	1532	3.81
	Jun	4.3	27.92	1725	1726	1727	4.58	4.63	4.68	1821	3.98
	Jul	4.3	12.97	1162	1164	1166	4.43	4.53	4.63	1182	3.1
	Aug	4.3	6.74	1623	1626	1629	6.38	6.53	6.68	1955	5.06
	Sep	4.3	6.27	1772	1775	1778	6.85	7.01	7.17	2231	5.76
	Oct	4.3	13.65	2048	2050	2052	6.40	6.49	6.58	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	14.4	0.7	4.3	4.3

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	846	31	13.65
Nov	276	30	4.60
Dec	205	31	3.31
Jan	494	31	7.97
Feb	1513	28	27.02
Mar	3406	31	54.94
Apr	2128	30	35.47
May	2420	31	39.03
Jun	1675	30	27.92
Jul	804	31	12.97
Aug	418	31	6.74
Sep	376	30	6.27

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

Irrigation WQ Threshold Line

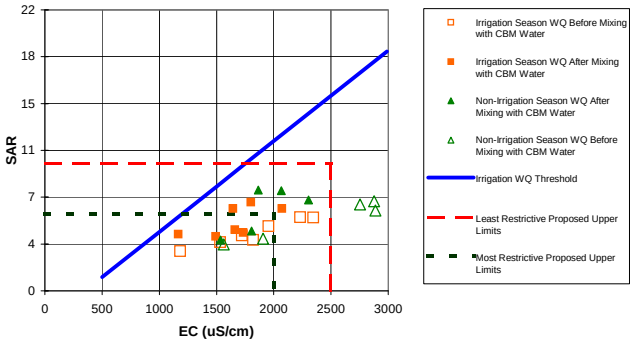
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
	EC (uS/cm)			SAR (--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	3.9	4.60	2063	2066	2070	7.67	7.85	8.03	2877	7.02
	Dec	3.9	3.31	1861	1865	1869	7.67	7.89	8.10	2755	6.77
	Jan	3.9	7.97	2301	2303	2306	7.00	7.13	7.25	2887	6.29
	Feb	3.9	27.02	1805	1806	1807	4.63	4.68	4.73	1907	4.08
	Mar	3.9	54.94	1533	1534	1534	3.96	3.98	4.01	1564	3.64
Irrigation Season	Apr	3.9	35.47	1661	1661	1662	4.75	4.79	4.82	1722	4.34
	May	3.9	39.03	1493	1494	1494	4.23	4.27	4.30	1532	3.81
	Jun	3.9	27.92	1733	1734	1735	4.53	4.57	4.62	1821	3.98
	Jul	3.9	12.97	1164	1165	1167	4.34	4.43	4.52	1182	3.1
	Aug	3.9	6.74	1642	1645	1648	6.30	6.44	6.59	1955	5.06
	Sep	3.9	6.27	1798	1801	1804	6.79	6.94	7.09	2231	5.76
	Oct	3.9	13.65	2070	2071	2073	6.35	6.44	6.52	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	13.1	0.7	3.9	3.9

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	846	31	13.65
Nov	276	30	4.60
Dec	205	31	3.31
Jan	494	31	7.97
Feb	1513	28	27.02
Mar	3406	31	54.94
Apr	2128	30	35.47
May	2420	31	39.03
Jun	1675	30	27.92
Jul	804	31	12.97
Aug	418	31	6.74
Sep	376	30	6.27

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

Irrigation WQ Threshold Line

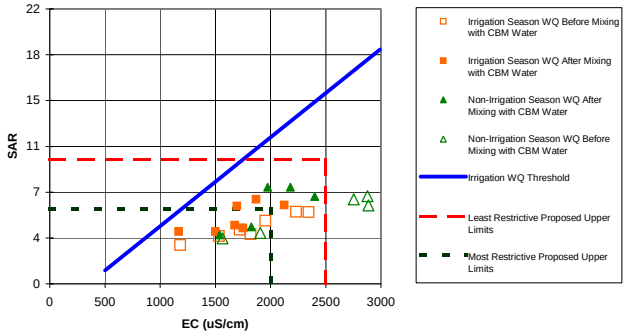
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
	EC (uS/cm)			SAR (--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% Lower	Mixed Water Quality EC (uS/cm) Mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% Lower	Mixed Water Quality SAR (--) Mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	3.0	4.60	2176	2179	2182	7.58	7.74	7.89	2877	7.02
	Dec	3.0	3.31	1969	1973	1976	7.57	7.75	7.94	2755	6.77
	Jan	3.0	7.97	2399	2401	2403	6.88	6.99	7.09	2887	6.29
	Feb	3.0	27.02	1827	1827	1828	4.52	4.56	4.59	1907	4.08
	Mar	3.0	54.94	1540	1540	1541	3.89	3.91	3.93	1564	3.64
Irrigation Season	Apr	3.0	35.47	1674	1674	1675	4.66	4.69	4.72	1722	4.34
	May	3.0	39.03	1501	1502	1502	4.14	4.17	4.20	1532	3.81
	Jun	3.0	27.92	1751	1752	1753	4.41	4.45	4.49	1821	3.98
	Jul	3.0	12.97	1167	1168	1170	4.10	4.18	4.25	1182	3.1
	Aug	3.0	6.74	1692	1695	1697	6.10	6.22	6.34	1955	5.06
	Sep	3.0	6.27	1866	1868	1871	6.63	6.75	6.88	2231	5.76
	Oct	3.0	13.65	2122	2123	2125	6.24	6.31	6.38	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	9.9	0.7	3.0	3.0

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	846	31	13.65
Nov	276	30	4.60
Dec	205	31	3.31
Jan	494	31	7.97
Feb	1513	28	27.02
Mar	3406	31	54.94
Apr	2128	30	35.47
May	2420	31	39.03
Jun	1675	30	27.92
Jul	804	31	12.97
Aug	418	31	6.74
Sep	376	30	6.27

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
	0	6
Most Restrictive	2000	6
	2000	0

Irrigation WQ Threshold Line

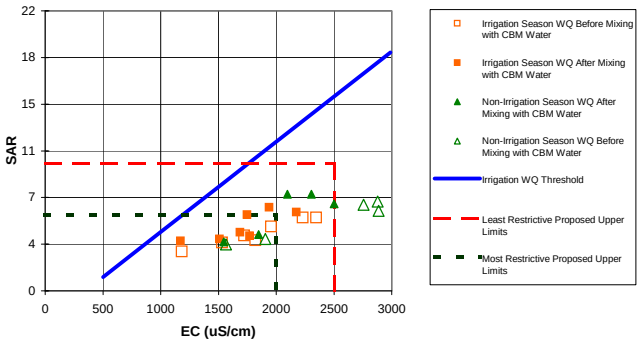
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
	EC (uS/cm)			SAR (--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	2.2	4.60	2303	2305	2308	7.48	7.61	7.73	2877	7.02
	Dec	2.2	3.31	2095	2098	2101	7.44	7.59	7.75	2755	6.77
	Jan	2.2	7.97	2501	2503	2504	6.76	6.84	6.93	2887	6.29
	Feb	2.2	27.02	1846	1847	1848	4.41	4.44	4.47	1907	4.08
	Mar	2.2	54.94	1546	1547	1547	3.82	3.84	3.86	1564	3.64
Irrigation Season	Apr	2.2	35.47	1686	1686	1687	4.58	4.60	4.63	1722	4.34
	May	2.2	39.03	1509	1509	1510	4.06	4.08	4.10	1532	3.81
	Jun	2.2	27.92	1768	1769	1770	4.31	4.33	4.36	1821	3.98
	Jul	2.2	12.97	1170	1172	1173	3.87	3.93	3.99	1182	3.1
	Aug	2.2	6.74	1745	1747	1749	5.89	5.99	6.09	1955	5.06
	Sep	2.2	6.27	1938	1940	1942	6.46	6.56	6.66	2231	5.76
	Oct	2.2	13.65	2173	2174	2175	6.12	6.18	6.23	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	7.3	0.7	2.2	2.2

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	846	31	13.65
Nov	276	30	4.60
Dec	205	31	3.31
Jan	494	31	7.97
Feb	1513	28	27.02
Mar	3406	31	54.94
Apr	2128	30	35.47
May	2420	31	39.03
Jun	1675	30	27.92
Jul	804	31	12.97
Aug	418	31	6.74
Sep	376	30	6.27

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

Irrigation WQ Threshold Line

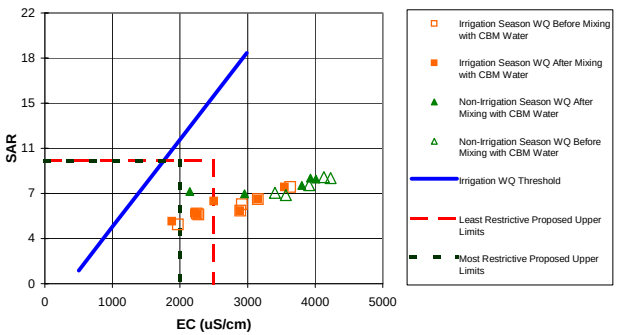
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.8	2.65	2949	2954	2959	7.12	7.31	7.50	3565	7.22
	Dec	0.8	0.77	2133	2144	2154	7.09	7.50	7.92	3405	7.39
	Jan	0.8	11.21	4008	4009	4011	8.46	8.52	8.57	4229	8.58
	Feb	0.8	21.36	3803	3803	3804	7.97	8.00	8.03	3911	8.01
	Mar	0.8	12.06	3927	3928	3929	8.54	8.60	8.65	4127	8.66
Irrigation Season	Apr	0.8	25.57	3547	3548	3549	7.84	7.86	7.89	3630	7.87
	May	0.8	238.60	3147	3148	3148	6.88	6.88	6.89	3155	6.88
	Jun	0.8	114.82	2881	2881	2882	5.94	5.94	5.95	2895	5.93
	Jul	0.8	31.26	2217	2217	2218	5.72	5.74	5.76	2250	5.69
	Aug	0.8	8.24	1878	1880	1882	5.00	5.07	5.14	1972	4.82
	Sep	0.8	55.42	2252	2252	2252	5.65	5.66	5.67	2271	5.63
	Oct	0.8	3.00	2493	2498	2502	6.53	6.70	6.87	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.5	0.7	0.8	0.8

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	186	31	3.00
Nov	159	30	2.65
Dec	48	31	0.77
Jan	695	31	11.21
Feb	1196	28	21.36
Mar	748	31	12.06
Apr	1534	30	25.57
May	14793	31	238.60
Jun	6889	30	114.82
Jul	1938	31	31.26
Aug	511	31	8.24
Sep	3325	30	55.42

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

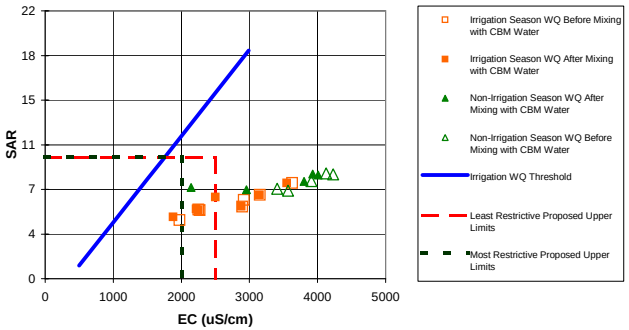
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.8	2.65	2949	2954	2959	7.12	7.31	7.50	3565	7.22
	Dec	0.8	0.77	2133	2144	2154	7.09	7.50	7.92	3405	7.39
	Jan	0.8	11.21	4008	4009	4011	8.46	8.52	8.57	4229	8.58
	Feb	0.8	21.36	3803	3803	3804	7.97	8.00	8.03	3911	8.01
	Mar	0.8	12.06	3927	3928	3929	8.54	8.60	8.65	4127	8.66
Irrigation Season	Apr	0.8	25.57	3547	3548	3549	7.84	7.86	7.89	3630	7.87
	May	0.8	238.60	3147	3148	3148	6.88	6.88	6.89	3155	6.88
	Jun	0.8	114.82	2881	2881	2882	5.94	5.94	5.95	2895	5.93
	Jul	0.8	31.26	2217	2217	2218	5.72	5.74	5.76	2250	5.69
	Aug	0.8	8.24	1878	1880	1882	5.00	5.07	5.14	1972	4.82
	Sep	0.8	55.42	2252	2252	2252	5.65	5.66	5.67	2271	5.63
	Oct	0.8	3.00	2493	2498	2502	6.53	6.70	6.87	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.8	0.7	0.8	0.8

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	186	31	3.00
Nov	159	30	2.65
Dec	48	31	0.77
Jan	695	31	11.21
Feb	1196	28	21.36
Mar	748	31	12.06
Apr	1534	30	25.57
May	14793	31	238.60
Jun	6889	30	114.82
Jul	1938	31	31.26
Aug	511	31	8.24
Sep	3325	30	55.42

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

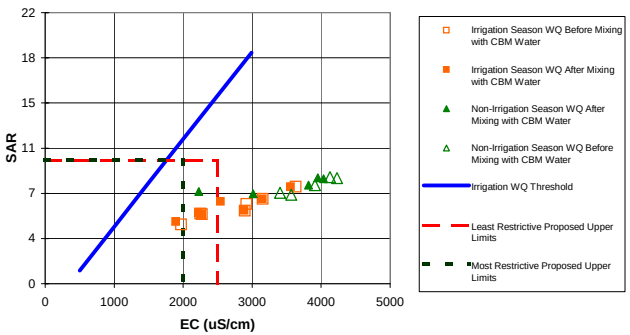
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.7	2.65	3010	3014	3019	7.13	7.30	7.47	3565	7.22
	Dec	0.7	0.77	2216	2226	2236	7.11	7.50	7.89	3405	7.39
	Jan	0.7	11.21	4034	4035	4036	8.48	8.52	8.57	4229	8.58
	Feb	0.7	21.36	3816	3816	3817	7.97	8.00	8.02	3911	8.01
	Mar	0.7	12.06	3950	3952	3953	8.56	8.60	8.65	4127	8.66
Irrigation Season	Apr	0.7	25.57	3557	3558	3559	7.84	7.86	7.88	3630	7.87
	May	0.7	238.60	3148	3148	3149	6.88	6.88	6.88	3155	6.88
	Jun	0.7	114.82	2883	2883	2883	5.94	5.94	5.95	2895	5.93
	Jul	0.7	31.26	2221	2221	2222	5.71	5.73	5.75	2250	5.69
	Aug	0.7	8.24	1889	1890	1892	4.98	5.04	5.10	1972	4.82
	Sep	0.7	55.42	2254	2254	2255	5.64	5.65	5.66	2271	5.63
	Oct	0.7	3.00	2536	2540	2544	6.52	6.68	6.83	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.4	0.7	0.7	0.7

Flow In Belle Fourche River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	186	31	3.00
Nov	159	30	2.65
Dec	48	31	0.77
Jan	695	31	11.21
Feb	1196	28	21.36
Mar	748	31	12.06
Apr	1534	30	25.57
May	14793	31	238.60
Jun	6889	30	114.82
Jul	1938	31	31.26
Aug	511	31	8.24
Sep	3325	30	55.42

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

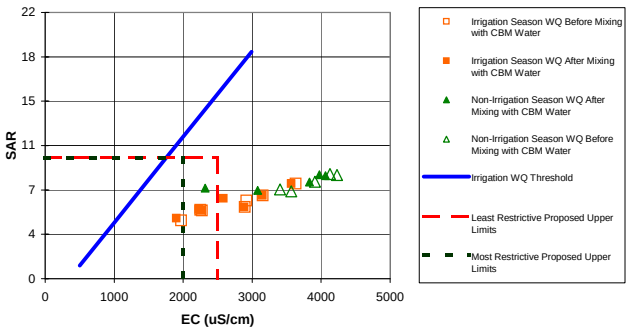
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.6	2.65	3075	3078	3082	7.14	7.29	7.44	3565	7.22
	Dec	0.6	0.77	2312	2321	2330	7.13	7.49	7.85	3405	7.39
	Jan	0.6	11.21	4060	4061	4062	8.49	8.53	8.57	4229	8.58
	Feb	0.6	21.36	3829	3830	3830	7.98	8.00	8.02	3911	8.01
	Mar	0.6	12.06	3974	3975	3976	8.57	8.61	8.65	4127	8.66
Irrigation Season	Apr	0.6	25.57	3568	3568	3569	7.85	7.86	7.88	3630	7.87
	May	0.6	238.60	3149	3149	3149	6.88	6.88	6.88	3155	6.88
	Jun	0.6	114.82	2885	2885	2885	5.93	5.94	5.94	2895	5.93
	Jul	0.6	31.26	2225	2225	2226	5.71	5.73	5.74	2250	5.69
	Aug	0.6	8.24	1900	1901	1903	4.95	5.01	5.07	1972	4.82
	Sep	0.6	55.42	2256	2257	2257	5.64	5.65	5.66	2271	5.63
	Oct	0.6	3.00	2581	2585	2588	6.52	6.65	6.79	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	1.9	0.7	0.6	0.6

Flow In Upper Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	186	31	3.00
Nov	159	30	2.65
Dec	48	31	0.77
Jan	695	31	11.21
Feb	1196	28	21.36
Mar	748	31	12.06
Apr	1534	30	25.57
May	14793	31	238.60
Jun	6889	30	114.82
Jul	1938	31	31.26
Aug	511	31	8.24
Sep	3325	30	55.42

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

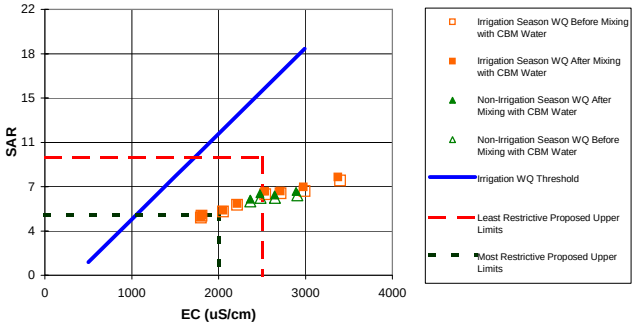
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	2.3	155.72	2643	2643	2643	6.64	6.66	6.67	2650	6.42
	Dec	2.3	111.65	2891	2891	2892	6.91	6.93	6.95	2906	6.61
	Jan	2.3	103.61	2475	2475	2476	6.73	6.75	6.77	2482	6.4
	Feb	2.3	216.80	2364	2364	2364	6.28	6.29	6.30	2366	6.12
Irrigation Season	Mar	2.3	388.05	2052	2052	2052	5.38	5.38	5.39	2051	5.28
	Apr	2.3	388.48	2213	2213	2213	5.93	5.94	5.94	2213	5.84
	May	2.3	718.77	1804	1804	1804	4.97	4.98	4.98	1803	4.92
	Jun	2.3	633.57	1798	1798	1798	4.82	4.82	4.83	1797	4.76
	Jul	2.3	215.00	2710	2710	2711	6.95	6.96	6.97	2716	6.79
	Aug	2.3	106.58	2974	2975	2975	7.28	7.30	7.32	2992	6.97
	Sep	2.3	109.05	3374	3375	3375	8.11	8.13	8.15	3400	7.83
	Oct	2.3	159.26	2532	2532	2532	6.92	6.94	6.95	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	7.8	0.7	2.3	2.3

Flow In Upper Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	9874	31	159.26
Nov	9343	30	155.72
Dec	6922	31	111.65
Jan	6424	31	103.61
Feb	12141	28	216.80
Mar	24059	31	388.05
Apr	23309	30	388.48
May	44564	31	718.77
Jun	38014	30	633.57
Jul	13330	31	215.00
Aug	6608	31	106.58
Sep	6543	30	109.05

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

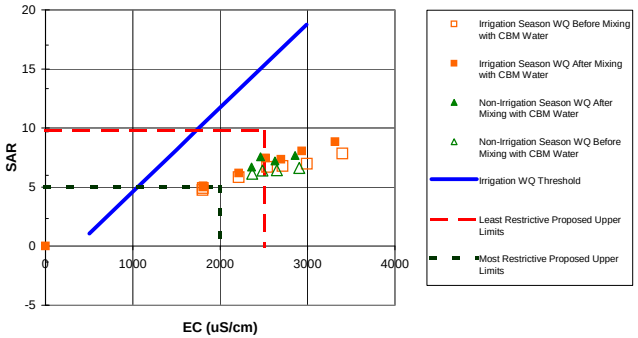
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	8.0	155.72	2626	2627	2628	7.16	7.21	7.26	2650	6.42
	Dec	8.0	111.65	2856	2857	2859	7.61	7.68	7.74	2906	6.61
	Jan	8.0	103.61	2459	2460	2462	7.49	7.56	7.63	2482	6.4
	Feb	8.0	216.80	2359	2359	2360	6.67	6.71	6.74	2366	6.12
Irrigation Season	Mar	0.0	-0.43	0	0	0	0.00	0.00	0.00	-162	-0.56
	Apr	8.0	388.48	2212	2212	2213	6.16	6.18	6.20	2213	5.84
	May	8.0	718.77	1807	1807	1807	5.10	5.11	5.12	1803	4.92
	Jun	8.0	633.57	1802	1802	1802	4.97	4.98	4.99	1797	4.76
	Jul	8.0	215.00	2696	2697	2697	7.32	7.36	7.39	2716	6.79
	Aug	8.0	106.58	2934	2935	2937	7.99	8.06	8.13	2992	6.97
	Sep	8.0	109.05	3315	3317	3318	8.77	8.84	8.90	3400	7.83
	Oct	8.0	159.26	2519	2520	2521	7.42	7.47	7.51	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	26.6	0.7	8.0	8.0

Flow In Upper Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	9874	31	159.26
Nov	9343	30	155.72
Dec	6922	31	111.65
Jan	6424	31	103.61
Feb	12141	28	216.80
Mar	24059	31	388.05
Apr	23309	30	388.48
May	44564	31	718.77
Jun	38014	30	633.57
Jul	13330	31	215.00
Aug	6608	31	106.58
Sep	6543	30	109.05

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

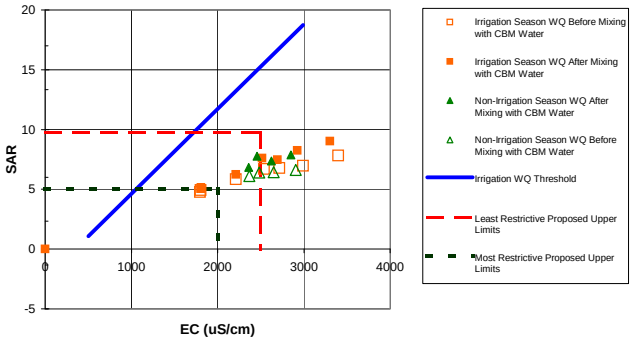
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	9.6	155.72	2622	2623	2624	7.30	7.36	7.41	2650	6.42
	Dec	9.6	111.65	2847	2849	2850	7.80	7.87	7.95	2906	6.61
	Jan	9.6	103.61	2455	2456	2458	7.69	7.77	7.85	2482	6.4
	Feb	9.6	216.80	2357	2358	2359	6.78	6.82	6.86	2366	6.12
Irrigation Season	Mar	0.0	-0.43	0	0	0	0.00	0.00	0.00	-162	-0.56
	Apr	9.6	388.48	2212	2212	2213	6.22	6.24	6.27	2213	5.84
	May	9.6	718.77	1808	1808	1808	5.14	5.15	5.17	1803	4.92
	Jun	9.6	633.57	1802	1803	1803	5.01	5.03	5.04	1797	4.76
	Jul	9.6	215.00	2692	2693	2694	7.42	7.46	7.51	2716	6.79
	Aug	9.6	106.58	2923	2925	2927	8.18	8.26	8.34	2992	6.97
	Sep	9.6	109.05	3300	3301	3303	8.95	9.02	9.10	3400	7.83
	Oct	9.6	159.26	2516	2517	2518	7.56	7.61	7.67	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	31.9	0.7	9.6	9.6

Flow In Upper Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	9874	31	159.26
Nov	9343	30	155.72
Dec	6922	31	111.65
Jan	6424	31	103.61
Feb	12141	28	216.80
Mar	24059	31	388.05
Apr	23309	30	388.48
May	44564	31	718.77
Jun	38014	30	633.57
Jul	13330	31	215.00
Aug	6608	31	106.58
Sep	6543	30	109.05

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

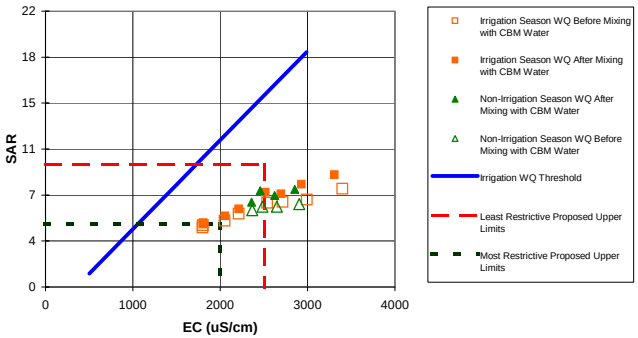
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC (uS/cm) mean	EC (uS/cm) 95% upper	SAR (--) 95% lower	SAR (--) mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	9.0	155.72	2623	2624	2625	7.25	7.30	7.36	2650	6.42
	Dec	9.0	111.65	2850	2852	2853	7.73	7.80	7.87	2906	6.61
	Jan	9.0	103.61	2456	2458	2459	7.62	7.69	7.77	2482	6.4
	Feb	9.0	216.80	2358	2359	2359	6.74	6.78	6.81	2366	6.12
Irrigation Season	Mar	9.0	388.05	2053	2054	2054	5.65	5.67	5.69	2051	5.28
	Apr	9.0	388.48	2212	2212	2213	6.20	6.22	6.24	2213	5.84
	May	9.0	718.77	1807	1808	1808	5.13	5.14	5.15	1803	4.92
	Jun	9.0	633.57	1802	1802	1803	5.00	5.01	5.02	1797	4.76
	Jul	9.0	215.00	2694	2694	2695	7.39	7.42	7.46	2716	6.79
	Aug	9.0	106.58	2927	2929	2930	8.11	8.19	8.26	2992	6.97
	Sep	9.0	109.05	3306	3307	3308	8.88	8.95	9.03	3400	7.83
	Oct	9.0	159.26	2517	2518	2519	7.51	7.56	7.61	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	30.0	0.7	9.0	9.0

Flow In Upper Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	9874	31	159.26
Nov	9343	30	155.72
Dec	6922	31	111.65
Jan	6424	31	103.61
Feb	12141	28	216.80
Mar	24059	31	388.05
Apr	23309	30	388.48
May	44564	31	718.77
Jun	38014	30	633.57
Jul	13330	31	215.00
Aug	6608	31	106.58
Sep	6543	30	109.05

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

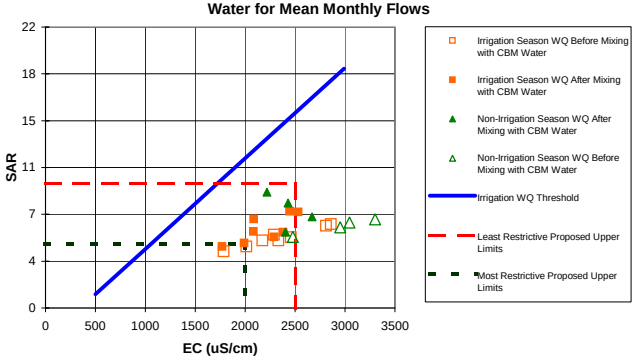
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC (uS/cm) mean	EC (uS/cm) 95% upper	SAR (--) 95% lower	SAR (--) mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	1.6	2.40	2424	2430	2436	8.00	8.22	8.43	3044	6.7
	Dec	1.6	1.05	2209	2219	2228	8.76	9.08	9.41	3300	6.94
	Jan	1.6	6.53	2666	2669	2672	7.04	7.15	7.26	2953	6.33
	Feb	1.6	19.80	2403	2405	2406	5.90	5.94	5.98	2477	5.57
Irrigation Season	Mar	1.6	25.05	1767	1768	1769	4.77	4.80	4.84	1785	4.44
	Apr	1.6	18.65	2381	2382	2383	5.90	5.94	5.98	2457	5.55
	May	1.6	31.77	1988	1989	1990	5.06	5.08	5.11	2013	4.81
	Jun	1.6	28.05	2288	2289	2289	5.54	5.57	5.60	2333	5.29
	Jul	1.6	10.08	2081	2083	2085	5.93	6.00	6.08	2174	5.29
	Aug	1.6	4.98	2528	2531	2535	7.39	7.52	7.65	2860	6.57
	Sep	1.6	4.10	2440	2445	2449	7.43	7.58	7.73	2810	6.44
	Oct	1.6	4.56	2082	2086	2090	6.83	6.97	7.11	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	5.3	0.7	1.6	1.6

Flow In Little Powder River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	283	31	4.56
Nov	144	30	2.40
Dec	65	31	1.05
Jan	405	31	6.53
Feb	1109	28	19.80
Mar	1553	31	25.05
Apr	1119	30	18.65
May	1970	31	31.77
Jun	1683	30	28.05
Jul	625	31	10.08
Aug	309	31	4.98
Sep	246	30	4.10

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

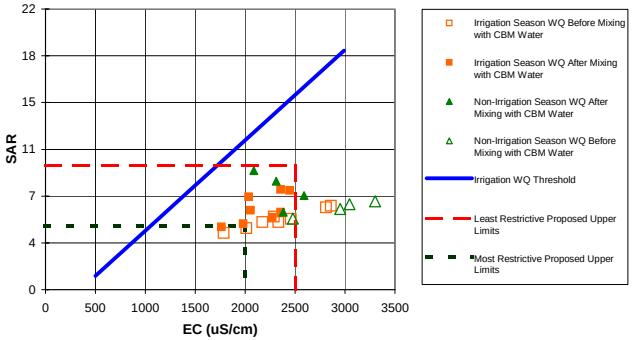
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	2.2	2.40	2302	2310	2317	8.26	8.51	8.77	3044	6.7
	Dec	2.2	1.05	2077	2088	2098	8.98	9.34	9.71	3300	6.94
	Jan	2.2	6.53	2585	2589	2593	7.24	7.38	7.51	2953	6.33
	Feb	2.2	19.80	2379	2380	2382	6.01	6.06	6.12	2477	5.57
Irrigation Season	Mar	2.2	25.05	1761	1763	1764	4.88	4.93	4.97	1785	4.44
	Apr	2.2	18.65	2355	2357	2359	6.01	6.07	6.13	2457	5.55
	May	2.2	31.77	1979	1980	1981	5.14	5.18	5.21	2013	4.81
	Jun	2.2	28.05	2272	2273	2274	5.63	5.67	5.71	2333	5.29
	Jul	2.2	10.08	2052	2055	2058	6.13	6.22	6.32	2174	5.29
	Aug	2.2	4.98	2441	2446	2451	7.61	7.77	7.94	2860	6.57
	Sep	2.2	4.10	2350	2356	2361	7.67	7.85	8.04	2810	6.44
	Oct	2.2	4.56	2030	2035	2040	7.10	7.28	7.46	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	7.3	0.7	2.2	2.2

Flow In Little Powder River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	283	31	4.56
Nov	144	30	2.40
Dec	65	31	1.05
Jan	405	31	6.53
Feb	1109	28	19.80
Mar	1553	31	25.05
Apr	1119	30	18.65
May	1970	31	31.77
Jun	1683	30	28.05
Jul	625	31	10.08
Aug	309	31	4.98
Sep	246	30	4.10

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

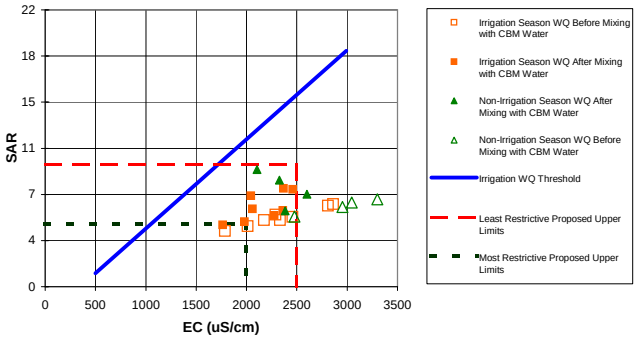
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	2.1	2.40	2320	2328	2335	8.22	8.47	8.72	3044	6.7
	Dec	2.1	1.05	2096	2106	2116	8.95	9.31	9.67	3300	6.94
	Jan	2.1	6.53	2598	2602	2605	7.21	7.34	7.47	2953	6.33
	Feb	2.1	19.80	2383	2384	2386	5.99	6.04	6.09	2477	5.57
Irrigation Season	Mar	2.1	25.05	1762	1764	1765	4.87	4.91	4.95	1785	4.44
	Apr	2.1	18.65	2359	2361	2363	6.00	6.05	6.10	2457	5.55
	May	2.1	31.77	1981	1982	1983	5.13	5.16	5.20	2013	4.81
	Jun	2.1	28.05	2275	2276	2277	5.61	5.65	5.69	2333	5.29
	Jul	2.1	10.08	2057	2059	2062	6.09	6.19	6.28	2174	5.29
	Aug	2.1	4.98	2455	2459	2464	7.57	7.73	7.89	2860	6.57
	Sep	2.1	4.10	2364	2369	2375	7.63	7.81	7.99	2810	6.44
	Oct	2.1	4.56	2038	2043	2048	7.06	7.23	7.40	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	7.0	0.7	2.1	2.1

Flow In Little Powder River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	283	31	4.56
Nov	144	30	2.40
Dec	65	31	1.05
Jan	405	31	6.53
Feb	1109	28	19.80
Mar	1553	31	25.05
Apr	1119	30	18.65
May	1970	31	31.77
Jun	1683	30	28.05
Jul	625	31	10.08
Aug	309	31	4.98
Sep	246	30	4.10

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

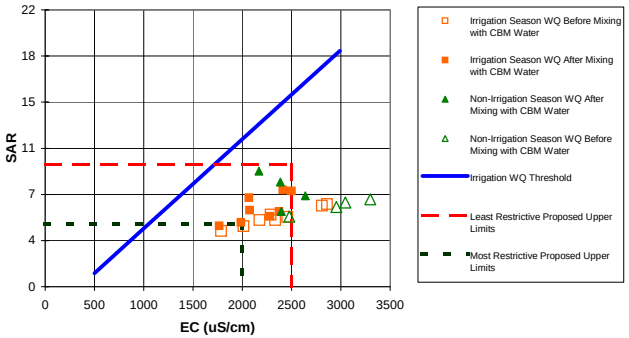
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	1.8	2.40	2379	2386	2393	8.09	8.32	8.56	3044	6.7
	Dec	1.8	1.05	2159	2169	2179	8.84	9.18	9.52	3300	6.94
	Jan	1.8	6.53	2638	2641	2644	7.11	7.23	7.35	2953	6.33
	Feb	1.8	19.80	2395	2396	2398	5.94	5.98	6.03	2477	5.57
Irrigation Season	Mar	1.8	25.05	1765	1766	1768	4.81	4.85	4.88	1785	4.44
	Apr	1.8	18.65	2372	2374	2375	5.94	5.98	6.03	2457	5.55
	May	1.8	31.77	1985	1986	1987	5.09	5.11	5.14	2013	4.81
	Jun	1.8	28.05	2282	2283	2284	5.57	5.60	5.64	2333	5.29
	Jul	1.8	10.08	2071	2073	2076	6.00	6.08	6.16	2174	5.29
	Aug	1.8	4.98	2497	2501	2505	7.47	7.61	7.75	2860	6.57
	Sep	1.8	4.10	2408	2413	2418	7.51	7.68	7.84	2810	6.44
	Oct	1.8	4.56	2064	2068	2073	6.92	7.08	7.23	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	6.0	0.7	1.8	1.8

Flow In Little Powder River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	283	31	4.56
Nov	144	30	2.40
Dec	65	31	1.05
Jan	405	31	6.53
Feb	1109	28	19.80
Mar	1553	31	25.05
Apr	1119	30	18.65
May	1970	31	31.77
Jun	1683	30	28.05
Jul	625	31	10.08
Aug	309	31	4.98
Sep	246	30	4.10

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line

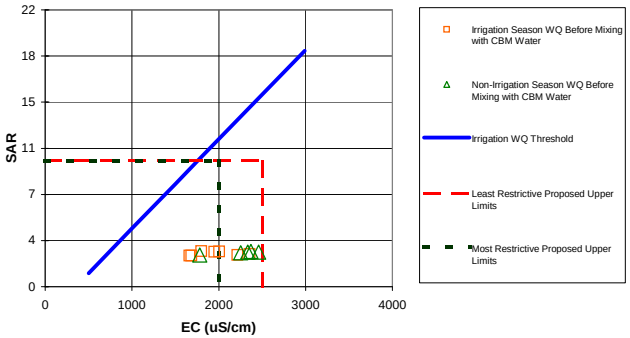
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2003
Stream Water Quality Before Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.00	0.08	2460	2460	2460	2.74	2.74	2.74	2460	2.74
	Dec	0.00	0.08	2372	2372	2372	2.79	2.79	2.79	2372	2.79
	Jan	0.00	0.03	2335	2335	2335	2.74	2.74	2.74	2335	2.74
	Feb	0.00	0.25	2251	2251	2251	2.71	2.71	2.71	2251	2.71
	Mar	0.00	0.48	1782	1782	1782	2.52	2.52	2.52	1782	2.52
Irrigation Season	Apr	0.00	0.27	1949	1949	1949	2.77	2.77	2.77	1949	2.77
	May	0.00	1.50	1800	1800	1800	2.82	2.82	2.82	1800	2.82
	Jun	0.00	0.33	2005	2005	2005	2.80	2.80	2.80	2005	2.8
	Jul	0.00	0.23	1661	1661	1661	2.48	2.48	2.48	1661	2.48
	Aug	0.00	0.13	1684	1684	1684	2.47	2.47	2.47	1684	2.47
	Sep	0.00	0.00							2214	2.52
	Oct	0.00	0.03	2354	2354	2354	2.60	2.60	2.60	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.0	0.7	0.0	0.0

Flow In Dry Fork Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	2	31	0.03
Nov	5	30	0.08
Dec	5	31	0.08
Jan	2	31	0.03
Feb	14	28	0.25
Mar	30	31	0.48
Apr	16	30	0.27
May	93	31	1.50
Jun	20	30	0.33
Jul	14	31	0.23
Aug	8	31	0.13
Sep	0	30	0.00

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

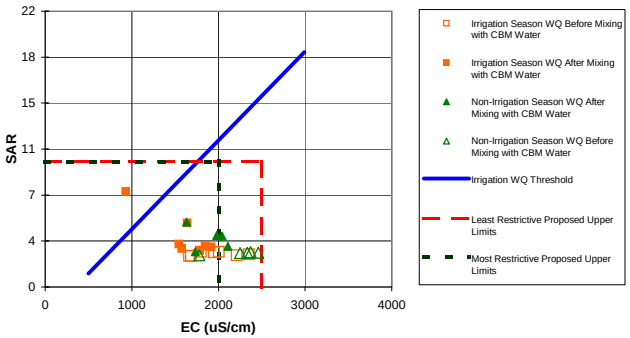
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.03	0.08	2037	2043	2048	3.85	4.07	4.29	2460	2.74
	Dec	0.03	0.08	1973	1979	1984	3.88	4.11	4.33	2372	2.79
	Jan	0.03	0.03	1622	1632	1643	4.77	5.18	5.58	2335	2.74
	Feb	0.03	0.25	2107	2109	2112	3.15	3.24	3.32	2251	2.71
	Mar	0.03	0.48	1731	1732	1733	2.77	2.82	2.87	1782	2.52
Irrigation Season	Apr	0.03	0.27	1845	1847	1849	3.17	3.25	3.34	1949	2.77
	May	0.03	1.50	1783	1783	1783	2.90	2.91	2.93	1800	2.82
	Jun	0.03	0.33	1914	1915	1917	3.13	3.20	3.27	2005	2.8
	Jul	0.03	0.23	1574	1577	1579	2.98	3.07	3.17	1661	2.48
	Aug	0.03	0.13	1539	1543	1546	3.28	3.43	3.59	1684	2.47
	Sep	0.03	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.03	0.03	1631	1642	1652	4.70	5.11	5.51	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.0	0.0

Flow In Dry Fork Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	2	31	0.03
Nov	5	30	0.08
Dec	5	31	0.08
Jan	2	31	0.03
Feb	14	28	0.25
Mar	30	31	0.48
Apr	16	30	0.27
May	93	31	1.50
Jun	20	30	0.33
Jul	14	31	0.23
Aug	8	31	0.13
Sep	0	30	0.00

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

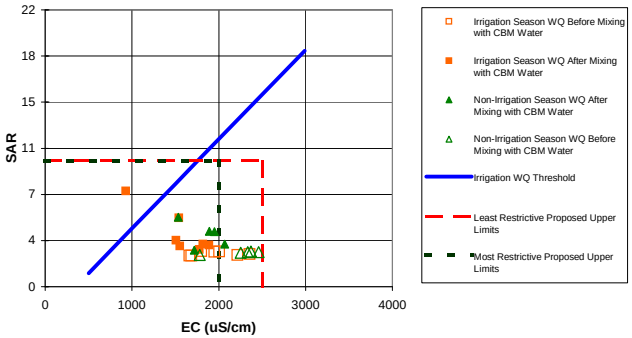
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.04	0.08	1943	1950	1957	4.09	4.37	4.64	2460	2.74
	Dec	0.04	0.08	1884	1891	1898	4.13	4.40	4.67	2372	2.79
	Jan	0.04	0.03	1520	1532	1544	5.06	5.53	5.99	2335	2.74
	Feb	0.04	0.25	2066	2069	2072	3.27	3.39	3.50	2251	2.71
	Mar	0.04	0.48	1715	1716	1718	2.85	2.91	2.97	1782	2.52
Irrigation Season	Apr	0.04	0.27	1815	1817	1820	3.29	3.40	3.50	1949	2.77
	May	0.04	1.50	1777	1777	1778	2.92	2.94	2.97	1800	2.82
	Jun	0.04	0.33	1886	1889	1891	3.23	3.32	3.41	2005	2.8
	Jul	0.04	0.23	1550	1553	1556	3.12	3.24	3.36	1661	2.48
	Aug	0.04	0.13	1502	1506	1511	3.49	3.68	3.87	1684	2.47
	Sep	0.04	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.04	0.03	1528	1540	1552	5.00	5.47	5.93	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.04	0.0

Flow In Dry Fork Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	2	31	0.03
Nov	5	30	0.08
Dec	5	31	0.08
Jan	2	31	0.03
Feb	14	28	0.25
Mar	30	31	0.48
Apr	16	30	0.27
May	93	31	1.50
Jun	20	30	0.33
Jul	14	31	0.23
Aug	8	31	0.13
Sep	0	30	0.00

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

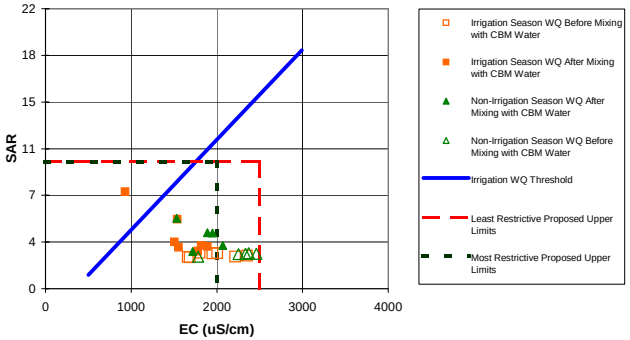
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Normal Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

Normal Year Conditions					
CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.04	0.08	1943	1950	1957	4.09	4.37	4.64	2460	2.74
	Dec	0.04	0.08	1884	1891	1898	4.13	4.40	4.67	2372	2.79
	Jan	0.04	0.03	1520	1532	1544	5.06	5.53	5.99	2335	2.74
	Feb	0.04	0.25	2066	2069	2072	3.27	3.39	3.50	2251	2.71
	Mar	0.04	0.48	1715	1716	1718	2.85	2.91	2.97	1782	2.52
Irrigation Season	Apr	0.04	0.27	1815	1817	1820	3.29	3.40	3.50	1949	2.77
	May	0.04	1.50	1777	1777	1778	2.92	2.94	2.97	1800	2.82
	Jun	0.04	0.33	1886	1889	1891	3.23	3.32	3.41	2005	2.8
	Jul	0.04	0.23	1550	1553	1556	3.12	3.24	3.36	1661	2.48
	Aug	0.04	0.13	1502	1506	1511	3.49	3.68	3.87	1684	2.47
	Sep	0.04	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.04	0.03	1528	1540	1552	5.00	5.47	5.93	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.04	0.0

Flow In Dry Fork Cheyenne River

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	2	31	0.03
Nov	5	30	0.08
Dec	5	31	0.08
Jan	2	31	0.03
Feb	14	28	0.25
Mar	30	31	0.48
Apr	16	30	0.27
May	93	31	1.50
Jun	20	30	0.33
Jul	14	31	0.23
Aug	8	31	0.13
Sep	0	30	0.00

Plotting Position: Most and Least Restrictive Limits

	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line

EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Fork Cheyenne Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC	SAR	EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Dry Fork Cheyenne River	Nov	2460	2.7	909	929	950	6.8	7.6	8.4	2460	2460	2460	2.7	2.7	2.7	2037	2043	2048	3.8	4.1	4.3	1943	1950	1957	4.1	4.4	4.6	1943	1950	1957	4.1	4.4	4.6
	Dec	2372	2.8	909	929	950	6.8	7.6	8.4	2372	2372	2372	2.8	2.8	2.8	1973	1979	1984	3.9	4.1	4.3	1884	1891	1898	4.1	4.4	4.7	1884	1891	1898	4.1	4.4	4.7
	Jan	2335	2.7	909	929	950	6.8	7.6	8.4	2335	2335	2335	2.7	2.7	2.7	1622	1632	1643	4.8	5.2	5.6	1520	1532	1544	5.1	5.5	6.0	1520	1532	1544	5.1	5.5	6.0
	Feb	2251	2.7	909	929	950	6.8	7.6	8.4	2251	2251	2251	2.7	2.7	2.7	2107	2109	2112	3.1	3.2	3.3	2066	2069	2072	3.3	3.4	3.5	2066	2069	2072	3.3	3.4	3.5
	Mar	1782	2.5	909	929	950	6.8	7.6	8.4	1782	1782	1782	2.5	2.5	2.5	1731	1732	1733	2.8	2.8	2.9	1715	1716	1718	2.8	2.9	3.0	1715	1716	1718	2.8	2.9	3.0
	Apr	1949	2.8	909	929	950	6.8	7.6	8.4	1949	1949	1949	2.8	2.8	2.8	1845	1847	1849	3.2	3.3	3.3	1815	1817	1820	3.3	3.4	3.5	1815	1817	1820	3.3	3.4	3.5
	May	1800	2.8	909	929	950	6.8	7.6	8.4	1800	1800	1800	2.8	2.8	2.8	1783	1783	1783	2.9	2.9	2.9	1777	1777	1778	2.9	2.9	3.0	1777	1777	1778	2.9	2.9	3.0
	Jun	2005	2.8	909	929	950	6.8	7.6	8.4	2005	2005	2005	2.8	2.8	2.8	1914	1915	1917	3.1	3.2	3.3	1886	1889	1891	3.2	3.3	3.4	1886	1889	1891	3.2	3.3	3.4
	Jul	1661	2.5	909	929	950	6.8	7.6	8.4	1661	1661	1661	2.5	2.5	2.5	1574	1577	1579	3.0	3.1	3.2	1550	1553	1556	3.1	3.2	3.4	1550	1553	1556	3.1	3.2	3.4
	Aug	1684	2.5	909	929	950	6.8	7.6	8.4	1684	1684	1684	2.5	2.5	2.5	1539	1543	1546	3.3	3.4	3.6	1502	1506	1511	3.5	3.7	3.9	1502	1506	1511	3.5	3.7	3.9
	Sep	2214	2.5	909	929	950	6.8	7.6	8.4	Not Applicable						Not Applicable						Not Applicable						Not Applicable					
	Oct	2354	2.6	909	929	950	6.8	7.6	8.4	2354	2354	2354	2.6	2.6	2.6	1631	1642	1652	4.7	5.1	5.5	1528	1540	1552	5.0	5.5	5.9	1528	1540	1552	5.0	5.5	5.9

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Dry Fork Cheyenne River	0.00%	0.0%		0.00%	0.0%		0.28%	-17.0%		5.46%	48.5%		0.36%	-20.7%		6.22%	59.3%		0.36%	-20.7%		6.22%	59.3%	
Dec		0.00%	0.0%		0.00%	0.0%		0.29%	-16.6%		5.41%	47.2%		0.37%	-20.3%		6.17%	57.7%		0.37%	-20.3%		6.17%	57.7%	
Jan		0.00%	0.0%		0.00%	0.0%		0.64%	-30.1%		7.86%	89.0%		0.78%	-34.4%		8.42%	101.7%		0.78%	-34.4%		8.42%	101.7%	
Feb		0.00%	0.0%		0.00%	0.0%		0.11%	-6.3%		2.70%	19.4%		0.14%	-8.1%		3.32%	25.0%		0.14%	-8.1%		3.32%	25.0%	
Mar		0.00%	0.0%		0.00%	0.0%		0.07%	-2.8%		1.70%	11.9%		0.09%	-3.7%		2.15%	15.6%		0.09%	-3.7%		2.15%	15.6%	
Apr		0.00%	0.0%		0.00%	0.0%		0.11%	-5.2%		2.50%	17.5%		0.15%	-6.7%		3.09%	22.6%		0.15%	-6.7%		3.09%	22.6%	
May		0.00%	0.0%		0.00%	0.0%		0.02%	-0.9%		0.55%	3.3%		0.03%	-1.3%		0.72%	4.4%		0.03%	-1.3%		0.72%	4.4%	
Jun		0.00%	0.0%		0.00%	0.0%		0.09%	-4.5%		2.12%	14.3%		0.12%	-5.8%		2.65%	18.6%		0.12%	-5.8%		2.65%	18.6%	
Jul		0.00%	0.0%		0.00%	0.0%		0.15%	-5.1%		3.06%	23.9%		0.20%	-6.5%		3.72%	30.7%		0.20%	-6.5%		3.72%	30.7%	
Aug		0.00%	0.0%		0.00%	0.0%		0.25%	-8.4%		4.45%	39.1%		0.33%	-10.5%		5.21%	49.0%		0.33%	-10.5%		5.21%	49.0%	
Sep		Not Applicable						Not Applicable						Not Applicable						Not Applicable					
Oct		0.00%	0.0%		0.00%	0.0%		0.64%	-30.3%		7.97%	96.5%		0.78%	-34.6%		8.51%	110.2%		0.78%	-34.6%		8.51%	110.2%	
	Max	0.00%	0.00%		0.00%	0.00%		0.64%	-30.26%		7.97%	96.45%		0.78%	-34.58%		8.51%	110.23%		0.78%	-34.58%		8.51%	110.23%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Little Powder River Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC			SAR			EC			SAR			EC			SAR			EC			SAR			EC			SAR		
				(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)		
		EC	SAR	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Little Powder River	Nov	3044	6.7	1493	1509	1524	10.0	10.5	11.0	2424	2430	2436	8.0	8.2	8.4	2302	2310	2317	8.3	8.5	8.8	2320	2328	2335	8.2	8.5	8.7	2379	2386	2393	8.1	8.3	8.6
	Dec	3300	6.9	1493	1509	1524	10.0	10.5	11.0	2209	2219	2228	8.8	9.1	9.4	2077	2088	2098	9.0	9.3	9.7	2096	2106	2116	8.9	9.3	9.7	2159	2169	2179	8.8	9.2	9.5
	Jan	2953	6.3	1493	1509	1524	10.0	10.5	11.0	2666	2669	2672	7.0	7.1	7.3	2585	2589	2593	7.2	7.4	7.5	2598	2602	2605	7.2	7.3	7.5	2638	2641	2644	7.1	7.2	7.3
	Feb	2477	5.6	1493	1509	1524	10.0	10.5	11.0	2403	2405	2406	5.9	5.9	6.0	2379	2380	2382	6.0	6.1	6.1	2383	2384	2386	6.0	6.0	6.1	2395	2396	2398	5.9	6.0	6.0
	Mar	1785	4.4	1493	1509	1524	10.0	10.5	11.0	1767	1768	1769	4.8	4.8	4.8	1761	1763	1764	4.9	4.9	5.0	1762	1764	1765	4.9	4.9	4.9	1765	1766	1768	4.8	4.8	4.9
	Apr	2457	5.6	1493	1509	1524	10.0	10.5	11.0	2381	2382	2383	5.9	5.9	6.0	2355	2357	2359	6.0	6.1	6.1	2359	2361	2363	6.0	6.1	6.1	2372	2374	2375	5.9	6.0	6.0
	May	2013	4.8	1493	1509	1524	10.0	10.5	11.0	1988	1989	1990	5.1	5.1	5.1	1979	1980	1981	5.1	5.2	5.2	1981	1982	1983	5.1	5.2	5.2	1985	1986	1987	5.1	5.1	5.1
	Jun	2333	5.3	1493	1509	1524	10.0	10.5	11.0	2288	2289	2289	5.5	5.6	5.6	2272	2273	2274	5.6	5.7	5.7	2275	2276	2277	5.6	5.7	5.7	2282	2283	2284	5.6	5.6	5.6
	Jul	2174	5.3	1493	1509	1524	10.0	10.5	11.0	2081	2083	2085	5.9	6.0	6.1	2052	2055	2058	6.1	6.2	6.3	2057	2059	2062	6.1	6.2	6.3	2071	2073	2076	6.0	6.1	6.2
	Aug	2860	6.6	1493	1509	1524	10.0	10.5	11.0	2528	2531	2535	7.4	7.5	7.7	2441	2446	2451	7.6	7.8	7.9	2455	2459	2464	7.6	7.7	7.9	2497	2501	2505	7.5	7.6	7.8
	Sep	2810	6.4	1493	1509	1524	10.0	10.5	11.0	2440	2445	2449	7.4	7.6	7.7	2350	2356	2361	7.7	7.9	8.0	2364	2369	2375	7.6	7.8	8.0	2408	2413	2418	7.5	7.7	7.8
	Oct	2289	5.7	1493	1509	1524	10.0	10.5	11.0	2082	2086	2090	6.8	7.0	7.1	2030	2035	2040	7.1	7.3	7.5	2038	2043	2048	7.1	7.2	7.4	2064	2068	2073	6.9	7.1	7.2

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Little Powder River	0.26%	-20.2%		2.63%	22.6%		0.32%	-24.1%		3.03%	27.1%		0.31%	-23.5%		2.97%	26.4%		0.28%	-21.6%		2.78%	24.3%	
Dec		0.42%	-32.8%		3.59%	30.9%		0.50%	-36.7%		3.91%	34.6%		0.49%	-36.2%		3.87%	34.1%		0.45%	-34.3%		3.71%	32.3%	
Jan		0.11%	-9.6%		1.49%	12.9%		0.15%	-12.3%		1.84%	16.6%		0.15%	-11.9%		1.79%	16.0%		0.13%	-10.6%		1.61%	14.2%	
Feb		0.05%	-2.9%		0.68%	6.6%		0.07%	-3.9%		0.89%	8.8%		0.06%	-3.7%		0.86%	8.5%		0.05%	-3.3%		0.75%	7.4%	
Mar		0.05%	-0.9%		0.67%	8.2%		0.07%	-1.2%		0.88%	11.0%		0.07%	-1.2%		0.85%	10.5%		0.06%	-1.0%		0.75%	9.1%	
Apr		0.05%	-3.0%		0.72%	7.0%		0.07%	-4.1%		0.94%	9.4%		0.07%	-3.9%		0.90%	9.0%		0.06%	-3.4%		0.79%	7.8%	
May		0.04%	-1.2%		0.51%	5.7%		0.05%	-1.6%		0.68%	7.6%		0.05%	-1.6%		0.65%	7.3%		0.04%	-1.3%		0.57%	6.3%	
Jun		0.04%	-1.9%		0.52%	5.3%		0.05%	-2.6%		0.69%	7.2%		0.05%	-2.5%		0.67%	6.8%		0.04%	-2.1%		0.58%	5.9%	
Jul		0.10%	-4.2%		1.23%	13.5%		0.14%	-5.5%		1.55%	17.6%		0.13%	-5.3%		1.50%	17.0%		0.11%	-4.6%		1.35%	14.9%	
Aug		0.15%	-11.5%		1.74%	14.5%		0.19%	-14.5%		2.13%	18.3%		0.19%	-14.0%		2.07%	17.7%		0.17%	-12.5%		1.88%	15.8%	
Sep		0.18%	-13.0%		2.00%	17.7%		0.23%	-16.2%		2.40%	22.0%		0.22%	-15.7%		2.34%	21.3%		0.20%	-14.1%		2.15%	19.2%	
Oct		0.19%	-8.9%		2.01%	21.6%		0.25%	-11.1%		2.41%	27.0%		0.24%	-10.7%		2.35%	26.2%		0.21%	-9.6%		2.16%	23.5%	
	Max	0.42%	-32.77%		3.59%	30.89%		0.50%	-36.74%		3.91%	34.64%		0.49%	-36.18%		3.87%	34.11%		0.45%	-34.28%		3.71%	32.32%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Upper Powder River Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC	SAR	EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Upper Powder River	Nov	2650	6.4	2161	2180	2200	21.6	22.6	23.5	2643	2643	2643	6.6	6.7	6.7	2626	2627	2628	7.2	7.2	7.3	2622	2623	2624	7.3	7.4	7.4	2623	2624	2625	7.3	7.3	7.4
	Dec	2906	6.6	2161	2180	2200	21.6	22.6	23.5	2891	2891	2892	6.9	6.9	7.0	2856	2857	2859	7.6	7.7	7.7	2847	2849	2850	7.8	7.9	8.0	2850	2852	2853	7.7	7.8	7.9
	Jan	2482	6.4	2161	2180	2200	21.6	22.6	23.5	2475	2475	2476	6.7	6.8	6.8	2459	2460	2462	7.5	7.6	7.6	2455	2456	2458	7.7	7.8	7.9	2456	2458	2459	7.6	7.7	7.8
	Feb	2366	6.1	2161	2180	2200	21.6	22.6	23.5	2364	2364	2364	6.3	6.3	6.3	2359	2359	2360	6.7	6.7	6.7	2357	2358	2359	6.8	6.8	6.9	2358	2359	2359	6.7	6.8	6.8
	Mar	2051	5.3	2161	2180	2200	21.6	22.6	23.5	2052	2052	2052	5.4	5.4	5.4	0	0	0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	2053	2054	2054	5.7	5.7	5.7
	Apr	2213	5.8	2161	2180	2200	21.6	22.6	23.5	2213	2213	2213	5.9	5.9	5.9	2212	2212	2213	6.2	6.2	6.2	2212	2212	2213	6.2	6.2	6.3	2212	2212	2213	6.2	6.2	6.2
	May	1803	4.9	2161	2180	2200	21.6	22.6	23.5	1804	1804	1804	5.0	5.0	5.0	1807	1807	1807	5.1	5.1	5.1	1808	1808	1808	5.1	5.2	5.2	1807	1808	1808	5.1	5.1	5.2
	Jun	1797	4.8	2161	2180	2200	21.6	22.6	23.5	1798	1798	1798	4.8	4.8	4.8	1802	1802	1802	5.0	5.0	5.0	1802	1803	1803	5.0	5.0	5.0	1802	1802	1803	5.0	5.0	5.0
	Jul	2716	6.8	2161	2180	2200	21.6	22.6	23.5	2710	2710	2711	6.9	7.0	7.0	2696	2697	2697	7.3	7.4	7.4	2692	2693	2694	7.4	7.5	7.5	2694	2694	2695	7.4	7.4	7.5
	Aug	2992	7.0	2161	2180	2200	21.6	22.6	23.5	2974	2975	2975	7.3	7.3	7.3	2934	2935	2937	8.0	8.1	8.1	2923	2925	2927	8.2	8.3	8.3	2927	2929	2930	8.1	8.2	8.3
	Sep	3400	7.8	2161	2180	2200	21.6	22.6	23.5	3374	3375	3375	8.1	8.1	8.2	3315	3317	3318	8.8	8.8	8.9	3300	3301	3303	8.9	9.0	9.1	3306	3307	3308	8.9	9.0	9.0
	Oct	2537	6.7	2161	2180	2200	21.6	22.6	23.5	2532	2532	2532	6.9	6.9	6.9	2519	2520	2521	7.4	7.5	7.5	2516	2517	2518	7.6	7.6	7.7	2517	2518	2519	7.5	7.6	7.6

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Upper Powder River	0.01%	-0.3%		0.21%	3.7%		0.04%	-0.9%		0.65%	12.3%		0.04%	-1.0%		0.76%	14.6%		0.04%	-1.0%		0.72%	13.7%	
Dec		0.01%	-0.5%		0.28%	4.9%		0.05%	-1.7%		0.84%	16.2%		0.05%	-2.0%		0.97%	19.1%		0.05%	-1.9%		0.92%	18.0%	
Jan		0.02%	-0.3%		0.31%	5.5%		0.06%	-0.9%		0.91%	18.1%		0.07%	-1.0%		1.05%	21.4%		0.06%	-1.0%		1.00%	20.2%	
Feb		0.01%	-0.1%		0.16%	2.8%		0.03%	-0.3%		0.51%	9.6%		0.04%	-0.3%		0.60%	11.4%		0.03%	-0.3%		0.57%	10.7%	
Mar		0.01%	0.0%		0.11%	1.9%		#DIV/0!	-100.0%		#DIV/0!	-100.0%		#DIV/0!	-100.0%		#DIV/0!	-100.0%		0.02%	0.1%		0.38%	7.4%	
Apr		0.01%	0.0%		0.10%	1.7%		0.02%	0.0%		0.31%	5.8%		0.02%	0.0%		0.37%	6.9%		0.02%	0.0%		0.35%	6.5%	
May		0.00%	0.1%		0.06%	1.1%		0.01%	0.2%		0.21%	4.0%		0.01%	0.3%		0.25%	4.7%		0.01%	0.3%		0.23%	4.4%	
Jun		0.00%	0.1%		0.07%	1.4%		0.01%	0.3%		0.24%	4.7%		0.02%	0.3%		0.29%	5.6%		0.02%	0.3%		0.27%	5.2%	
Jul		0.01%	-0.2%		0.15%	2.5%		0.03%	-0.7%		0.47%	8.3%		0.03%	-0.8%		0.55%	9.9%		0.03%	-0.8%		0.52%	9.3%	
Aug		0.01%	-0.6%		0.28%	4.7%		0.05%	-1.9%		0.83%	15.6%		0.06%	-2.2%		0.96%	18.5%		0.05%	-2.1%		0.91%	17.4%	
Sep		0.01%	-0.7%		0.24%	3.9%		0.04%	-2.5%		0.74%	12.9%		0.05%	-2.9%		0.86%	15.2%		0.05%	-2.7%		0.82%	14.4%	
Oct		0.01%	-0.2%		0.20%	3.4%		0.04%	-0.7%		0.62%	11.3%		0.04%	-0.8%		0.72%	13.4%		0.04%	-0.8%		0.68%	12.6%	
	Max	0.02%	-0.74%		0.31%	5.49%		#DIV/0!	-100.00%		#DIV/0!	18.12%		#DIV/0!	-100.00%		#DIV/0!	21.43%		0.06%	-2.74%		1.00%	20.20%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Upper Cheyenne Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC	SAR	EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Upper cheyenne River	Nov	3565	7.2	909	929	950	6.8	7.6	0.0	2949	2954	2959	7.1	7.3	7.5	2949	2954	2959	7.1	7.3	7.5	3010	3014	3019	7.1	7.3	7.5	3075	3078	3082	7.1	7.3	7.4
	Dec	3405	7.4	909	929	950	6.8	7.6	0.0	2133	2144	2154	7.1	7.5	7.9	2133	2144	2154	7.1	7.5	7.9	2216	2226	2236	7.1	7.5	7.9	2312	2321	2330	7.1	7.5	7.8
	Jan	4229	8.6	909	929	950	6.8	7.6	0.0	4008	4009	4011	8.5	8.5	8.6	4008	4009	4011	8.5	8.5	8.6	4034	4035	4036	8.5	8.5	8.6	4060	4061	4062	8.5	8.5	8.6
	Feb	3911	8.0	909	929	950	6.8	7.6	0.0	3803	3803	3804	8.0	8.0	8.0	3803	3803	3804	8.0	8.0	8.0	3816	3816	3817	8.0	8.0	8.0	3829	3830	3830	8.0	8.0	8.0
	Mar	4127	8.7	909	929	950	6.8	7.6	0.0	3927	3928	3929	8.5	8.6	8.6	3927	3928	3929	8.5	8.6	8.6	3950	3952	3953	8.6	8.6	8.6	3974	3975	3976	8.6	8.6	8.6
	Apr	3630	7.9	909	929	950	6.8	7.6	0.0	3547	3548	3549	7.8	7.9	7.9	3547	3548	3549	7.8	7.9	7.9	3557	3558	3559	7.8	7.9	7.9	3568	3568	3569	7.8	7.9	7.9
	May	3155	6.9	909	929	950	6.8	7.6	0.0	3147	3148	3148	6.9	6.9	6.9	3147	3148	3148	6.9	6.9	6.9	3148	3148	3149	6.9	6.9	6.9	3149	3149	3149	6.9	6.9	6.9
	Jun	2895	5.9	909	929	950	6.8	7.6	0.0	2881	2881	2882	5.9	5.9	5.9	2881	2881	2882	5.9	5.9	5.9	2883	2883	2883	5.9	5.9	5.9	2885	2885	2885	5.9	5.9	5.9
	Jul	2250	5.7	909	929	950	6.8	7.6	0.0	2217	2217	2218	5.7	5.7	5.8	2217	2217	2218	5.7	5.7	5.8	2221	2221	2222	5.7	5.7	5.8	2225	2225	2226	5.7	5.7	5.7
	Aug	1972	4.8	909	929	950	6.8	7.6	0.0	1878	1880	1882	5.0	5.1	5.1	1878	1880	1882	5.0	5.1	5.1	1889	1890	1892	5.0	5.0	5.1	1900	1901	1903	5.0	5.0	5.1
	Sep	2271	5.6	909	929	950	6.8	7.6	0.0	2252	2252	2252	5.6	5.7	5.7	2252	2252	2252	5.6	5.7	5.7	2254	2254	2255	5.6	5.7	5.7	2256	2257	2257	5.6	5.7	5.7
	Oct	2916	6.5	909	929	950	6.8	7.6	0.0	2493	2498	2502	6.5	6.7	6.9	2493	2498	2502	6.5	6.7	6.9	2536	2540	2544	6.5	6.7	6.8	2581	2585	2588	6.5	6.7	6.8

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Upper cheyenne River	0.16%	-17.1%		2.58%	1.3%		0.16%	-17.1%		2.58%	1.3%		0.14%	-15.4%		2.33%	1.1%		0.13%	-13.6%		2.06%	1.0%	
Dec		0.50%	-37.0%		5.53%	1.6%		0.50%	-37.0%		5.53%	1.6%		0.45%	-34.6%		5.17%	1.5%		0.39%	-31.8%		4.76%	1.3%	
Jan		0.03%	-5.2%		0.64%	-0.7%		0.03%	-5.2%		0.64%	-0.7%		0.03%	-4.6%		0.56%	-0.7%		0.03%	-4.0%		0.48%	-0.6%	
Feb		0.02%	-2.8%		0.37%	-0.2%		0.02%	-2.8%		0.37%	-0.2%		0.02%	-2.4%		0.32%	-0.2%		0.01%	-2.1%		0.28%	-0.1%	
Mar		0.03%	-4.8%		0.59%	-0.8%		0.03%	-4.8%		0.59%	-0.8%		0.03%	-4.3%		0.52%	-0.7%		0.02%	-3.7%		0.45%	-0.6%	
Apr		0.02%	-2.3%		0.31%	-0.1%		0.02%	-2.3%		0.31%	-0.1%		0.02%	-2.0%		0.28%	-0.1%		0.01%	-1.7%		0.24%	-0.1%	
May		0.00%	-0.2%		0.04%	0.0%		0.00%	-0.2%		0.04%	0.0%		0.00%	-0.2%		0.03%	0.0%		0.00%	-0.2%		0.03%	0.0%	
Jun		0.01%	-0.5%		0.09%	0.2%		0.01%	-0.5%		0.09%	0.2%		0.00%	-0.4%		0.08%	0.2%		0.00%	-0.4%		0.07%	0.1%	
Jul		0.02%	-1.5%		0.35%	0.8%		0.02%	-1.5%		0.35%	0.8%		0.02%	-1.3%		0.31%	0.7%		0.02%	-1.1%		0.27%	0.6%	
Aug		0.10%	-4.7%		1.42%	5.1%		0.10%	-4.7%		1.42%	5.1%		0.09%	-4.1%		1.27%	4.5%		0.07%	-3.6%		1.10%	3.9%	
Sep		0.01%	-0.8%		0.20%	0.5%		0.01%	-0.8%		0.20%	0.5%		0.01%	-0.7%		0.18%	0.4%		0.01%	-0.6%		0.15%	0.4%	
Oct		0.18%	-14.3%		2.56%	3.8%		0.18%	-14.3%		2.56%	3.8%		0.16%	-12.9%		2.31%	3.4%		0.13%	-11.4%		2.04%	3.0%	
	Max	0.50%	-37.05%		5.53%	5.13%		0.50%	-37.05%		5.53%	5.13%		0.45%	-34.62%		5.17%	4.54%		0.39%	-31.84%		4.76%	3.94%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Belle Fourche Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC	SAR	EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Belle Fourche River	Nov	2877	7.0	1102	1110	1117	8.4	8.8	9.2	2019	2023	2027	7.7	7.9	8.1	2063	2066	2070	7.7	7.9	8.0	2176	2179	2182	7.6	7.7	7.9	2303	2305	2308	7.5	7.6	7.7
	Dec	2755	6.8	1102	1110	1117	8.4	8.8	9.2	1821	1825	1830	7.7	7.9	8.2	1861	1865	1869	7.7	7.9	8.1	1969	1973	1976	7.6	7.8	7.9	2095	2098	2101	7.4	7.6	7.8
	Jan	2887	6.3	1102	1110	1117	8.4	8.8	9.2	2262	2264	2267	7.0	7.2	7.3	2301	2303	2306	7.0	7.1	7.3	2399	2401	2403	6.9	7.0	7.1	2501	2503	2504	6.8	6.8	6.9
	Feb	1907	4.1	1102	1110	1117	8.4	8.8	9.2	1797	1798	1799	4.7	4.7	4.8	1805	1806	1807	4.6	4.7	4.7	1827	1827	1828	4.5	4.6	4.6	1846	1847	1848	4.4	4.4	4.5
	Mar	1564	3.6	1102	1110	1117	8.4	8.8	9.2	1530	1531	1532	4.0	4.0	4.0	1533	1534	1534	4.0	4.0	4.0	1540	1540	1541	3.9	3.9	3.9	1546	1547	1547	3.8	3.8	3.9
	Apr	1722	4.3	1102	1110	1117	8.4	8.8	9.2	1655	1656	1657	4.8	4.8	4.9	1661	1661	1662	4.7	4.8	4.8	1674	1674	1675	4.7	4.7	4.7	1686	1686	1687	4.6	4.6	4.6
	May	1532	3.8	1102	1110	1117	8.4	8.8	9.2	1489	1490	1491	4.3	4.3	4.3	1493	1494	1494	4.2	4.3	4.3	1501	1502	1502	4.1	4.2	4.2	1509	1509	1510	4.1	4.1	4.1
	Jun	1821	4.0	1102	1110	1117	8.4	8.8	9.2	1725	1726	1727	4.6	4.6	4.7	1733	1734	1735	4.5	4.6	4.6	1751	1752	1753	4.4	4.5	4.5	1768	1769	1770	4.3	4.3	4.4
	Jul	1182	3.1	1102	1110	1117	8.4	8.8	9.2	1162	1164	1166	4.4	4.5	4.6	1164	1165	1167	4.3	4.4	4.5	1167	1168	1170	4.1	4.2	4.3	1170	1172	1173	3.9	3.9	4.0
	Aug	1955	5.1	1102	1110	1117	8.4	8.8	9.2	1623	1626	1629	6.4	6.5	6.7	1642	1645	1648	6.3	6.4	6.6	1692	1695	1697	6.1	6.2	6.3	1745	1747	1749	5.9	6.0	6.1
	Sep	2231	5.8	1102	1110	1117	8.4	8.8	9.2	1772	1775	1778	6.9	7.0	7.2	1798	1801	1804	6.8	6.9	7.1	1866	1868	1871	6.6	6.8	6.9	1938	1940	1942	6.5	6.6	6.7
	Oct	2346	5.8	1102	1110	1117	8.4	8.8	9.2	2048	2050	2052	6.4	6.5	6.6	2070	2071	2073	6.3	6.4	6.5	2122	2123	2125	6.2	6.3	6.4	2173	2174	2175	6.1	6.2	6.2

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Belle Fourche River	0.18%	-29.7%		2.40%	12.5%		0.17%	-28.2%		2.29%	11.9%		0.14%	-24.2%		2.00%	10.2%		0.11%	-19.9%		1.66%	8.4%	
Dec		0.24%	-33.7%		2.79%	17.2%		0.22%	-32.3%		2.68%	16.5%		0.18%	-28.4%		2.40%	14.5%		0.14%	-23.8%		2.06%	12.2%	
Jan		0.12%	-21.6%		1.91%	14.2%		0.11%	-20.2%		1.80%	13.3%		0.09%	-16.8%		1.53%	11.1%		0.07%	-13.3%		1.24%	8.7%	
Feb		0.06%	-5.7%		1.14%	16.0%		0.05%	-5.3%		1.06%	14.7%		0.04%	-4.2%		0.86%	11.6%		0.03%	-3.1%		0.66%	8.8%	
Mar		0.04%	-2.1%		0.71%	10.4%		0.03%	-1.9%		0.65%	9.5%		0.03%	-1.5%		0.52%	7.4%		0.02%	-1.1%		0.39%	5.5%	
Apr		0.05%	-3.8%		0.88%	11.2%		0.05%	-3.5%		0.81%	10.3%		0.04%	-2.8%		0.65%	8.1%		0.03%	-2.1%		0.50%	6.0%	
May		0.05%	-2.7%		0.90%	13.1%		0.05%	-2.5%		0.83%	12.0%		0.04%	-2.0%		0.67%	9.4%		0.03%	-1.5%		0.51%	7.0%	
Jun		0.06%	-5.2%		1.13%	16.3%		0.05%	-4.8%		1.05%	14.9%		0.04%	-3.8%		0.85%	11.8%		0.03%	-2.9%		0.66%	8.9%	
Jul		0.16%	-1.5%		2.15%	46.1%		0.15%	-1.4%		2.04%	42.8%		0.12%	-1.1%		1.76%	34.7%		0.09%	-0.9%		1.44%	26.8%	
Aug		0.18%	-16.8%		2.33%	29.1%		0.17%	-15.8%		2.23%	27.3%		0.14%	-13.3%		1.94%	23.0%		0.11%	-10.6%		1.61%	18.4%	
Sep		0.17%	-20.4%		2.27%	21.7%		0.16%	-19.3%		2.16%	20.5%		0.13%	-16.3%		1.88%	17.3%		0.10%	-13.1%		1.55%	13.9%	
Oct		0.09%	-12.6%		1.45%	12.8%		0.08%	-11.7%		1.35%	11.9%		0.06%	-9.5%		1.12%	9.7%		0.05%	-7.3%		0.88%	7.4%	
	Max	0.24%	-33.74%		2.79%	46.06%		0.22%	-32.30%		2.68%	42.76%		0.18%	-28.39%		2.40%	34.75%		0.14%	-23.84%		2.06%	26.83%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Antelope Creek Sensitivity Analysis
Normal Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC			SAR			EC			SAR			EC			SAR			EC			SAR			EC			SAR		
				(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)		
		EC	SAR	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Antelope Creek	Nov	2460	2.7	909	929	950	6.8	7.6	8.4	1426	1440	1454	5.4	6.0	6.5	1095	1113	1132	6.3	7.0	7.7	1062	1081	1100	6.4	7.1	7.9	1069	1088	1107	6.4	7.1	7.8
	Dec	2372	2.8	909	929	950	6.8	7.6	8.4	1283	1299	1315	5.8	6.4	7.0	1034	1053	1072	6.5	7.2	7.9	1011	1031	1050	6.5	7.3	8.0	1016	1036	1055	6.5	7.3	8.0
	Jan	2335	2.7	909	929	950	6.8	7.6	8.4	1300	1315	1330	5.7	6.3	6.9	1042	1061	1080	6.4	7.2	7.9	1018	1037	1056	6.5	7.2	8.0	1023	1042	1061	6.5	7.2	8.0
	Feb	2251	2.7	909	929	950	6.8	7.6	8.4	1979	1984	1988	3.5	3.7	3.9	1604	1614	1624	4.7	5.1	5.5	1532	1543	1554	4.9	5.3	5.8	1548	1559	1570	4.9	5.3	5.7
	Mar	1782	2.5	909	929	950	6.8	7.6	8.4	1714	1715	1717	2.9	2.9	3.0	1575	1580	1585	3.5	3.7	3.9	1539	1544	1550	3.7	3.9	4.2	1547	1553	1558	3.7	3.9	4.1
	Apr	1949	2.8	909	929	950	6.8	7.6	8.4	1791	1794	1797	3.4	3.5	3.6	1537	1545	1553	4.4	4.7	5.0	1482	1491	1501	4.6	4.9	5.3	1495	1504	1513	4.5	4.9	5.2
	May	1800	2.8	909	929	950	6.8	7.6	8.4	1713	1715	1718	3.2	3.3	3.4	1548	1554	1560	3.9	4.2	4.4	1507	1514	1521	4.1	4.4	4.7	1517	1523	1530	4.1	4.3	4.6
	Jun	2005	2.8	909	929	950	6.8	7.6	8.4	1904	1906	1908	3.2	3.2	3.3	1707	1713	1719	3.9	4.1	4.3	1658	1664	1671	4.1	4.3	4.6	1670	1676	1682	4.0	4.3	4.5
	Jul	1661	2.5	909	929	950	6.8	7.6	8.4	1531	1535	1538	3.2	3.4	3.5	1335	1344	1353	4.4	4.7	5.1	1295	1305	1315	4.6	5.0	5.4	1304	1314	1324	4.5	4.9	5.3
	Aug	1684	2.5	909	929	950	6.8	7.6	8.4	1500	1505	1510	3.5	3.7	3.9	1271	1282	1293	4.8	5.2	5.6	1229	1241	1254	5.0	5.5	6.0	1239	1251	1263	5.0	5.4	5.9
	Sep	2214	2.5	909	929	950	6.8	7.6	8.4	1738	1746	1754	4.1	4.4	4.7	1329	1344	1358	5.4	6.0	6.5	1270	1285	1300	5.6	6.2	6.8	1283	1298	1313	5.6	6.2	6.7
	Oct	2354	2.6	909	929	950	6.8	7.6	8.4	1707	1716	1725	4.5	4.8	5.2	1272	1288	1304	5.7	6.4	7.0	1217	1233	1249	5.9	6.5	7.2	1229	1245	1261	5.9	6.5	7.1

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Antelope Creek	0.97%	-41.5%		9.06%	118.6%		1.65%	-54.8%		10.19%	156.6%		1.74%	-56.1%		10.29%	160.3%		1.72%	-55.8%		10.27%	159.5%	
Dec		1.20%	-45.2%		9.50%	128.6%		1.81%	-55.6%		10.34%	158.1%		1.88%	-56.5%		10.40%	160.8%		1.87%	-56.3%		10.39%	160.2%	
Jan		1.15%	-43.7%		9.41%	129.2%		1.79%	-54.6%		10.31%	161.3%		1.86%	-55.6%		10.38%	164.3%		1.84%	-55.4%		10.37%	163.7%	
Feb		0.21%	-11.9%		4.45%	36.6%		0.62%	-28.3%		7.73%	87.2%		0.73%	-31.5%		8.17%	97.0%		0.70%	-30.7%		8.08%	94.8%	
Mar		0.10%	-3.7%		2.18%	15.8%		0.31%	-11.3%		5.18%	48.0%		0.38%	-13.3%		5.76%	56.4%		0.36%	-12.9%		5.63%	54.3%	
Apr		0.18%	-7.9%		3.53%	26.5%		0.54%	-20.7%		6.88%	69.3%		0.63%	-23.5%		7.39%	78.6%		0.61%	-22.8%		7.28%	76.4%	
May		0.12%	-4.7%		2.41%	16.5%		0.38%	-13.7%		5.51%	48.1%		0.45%	-15.9%		6.09%	55.9%		0.44%	-15.4%		5.96%	54.1%	
Jun		0.10%	-5.0%		2.32%	15.9%		0.33%	-14.6%		5.38%	46.7%		0.40%	-17.0%		5.96%	54.5%		0.38%	-16.4%		5.83%	52.6%	
Jul		0.23%	-7.6%		4.17%	35.7%		0.67%	-19.1%		7.50%	89.7%		0.78%	-21.4%		7.96%	100.8%		0.75%	-20.9%		7.86%	98.2%	
Aug		0.33%	-10.6%		5.24%	49.5%		0.87%	-23.9%		8.33%	111.1%		0.99%	-26.3%		8.70%	122.2%		0.96%	-25.7%		8.62%	119.7%	
Sep		0.44%	-21.1%		6.78%	73.7%		1.05%	-39.3%		9.24%	137.0%		1.18%	-42.0%		9.49%	146.2%		1.15%	-41.4%		9.44%	144.2%	
Oct		0.54%	-27.1%		7.52%	86.4%		1.21%	-45.3%		9.59%	144.4%		1.33%	-47.6%		9.79%	151.8%		1.31%	-47.1%		9.75%	150.2%	
	Max	1.20%	-3.74%		9.50%	129.15%		1.81%	-11.35%		10.34%	161.32%		1.88%	-13.33%		10.40%	164.31%		1.87%	-12.86%		10.39%	163.67%	

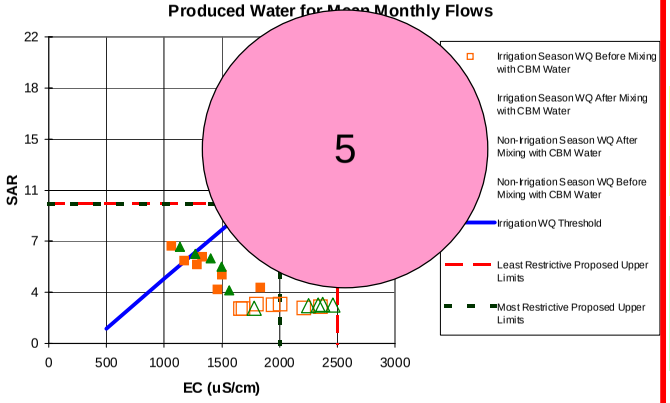
(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

APPENDIX C-2

DRY YEAR CONDITIONS

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin



5

		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	CBNG Discharge Quality EC (uS/cm) 95% Lower	EC (uS/cm) Mean	EC (uS/cm) 95% upper	SAR (--) 95% Lower	SAR (--) Mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)	
				909	929	950	6.80	7.62	8.43			
Non-Irrigation Season	Nov	0.9	0.40	1386				6.12	6.68	2460	2.74	Non-Irrigation Season
	Dec	0.9	0.15	1118				6.93	7.62	2372	2.79	
	Jan	0.9	0.29	1256				6.43	7.04	2335	2.74	
	Feb	0.9	0.68	1486				5.50	5.97	2251	2.71	
	Mar	0.9	2.60	1557				3.83	4.04	1782	2.52	
Irrigation Season	Apr	0.9	1.15	1492	150			4.90	5.25	1949	2.77	Irrigation Season
	May	0.9	0.63	1276	1288		16	5.64	6.12	1800	2.82	
	Jun	0.9	0.13	1047	1065		6.30	7.01	7.72	2005	2.8	
	Jul	0.9	2.47	1460	1466	1471	3.63	3.85	4.07	1661	2.48	
	Aug	0.9	0.44	1163	1177	1191	5.38	5.93	6.47	1684	2.47	
	Sep	0.9	2.17	1831	1837	1844	3.78	4.01	4.25	2214	2.52	
	Oct	0.9	0.35	1313	1328	1343	5.62	6.21	6.80	2354	2.6	

4

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and W

Drainage	Stream Gauge Location	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teck	0.7	0.9	0.9

3

Mean Monthly Discharge			
		Days	cfs
O		31	0.35
		30	0.40
		31	0.15
		31	0.29
		28	0.68
		31	2.60
		30	1.15
		31	0.63
		30	0.13
Ju		31	2.47
Aug		31	0.44
Sep	130	30	2.17

2

Plotting Position: Most and Least Restrictive Limits			
	EC	SAR	
	0		
Least Restrictiv	2500		
	2500		
	0		
Most Restrictiv	2000		
	2000		

Irrigation WQ Threshold Line	
500	1.07
1000	4.62
1500	8.17
2990	18.75

1

See following page for descriptions of chart sections

Descriptions of Chart Sections

1

Section 1: The values in this section are used to plot lines within the graph delineating themost restrictive, least restrictive, and the irrigation water quality threshold. The most restrictive and least restrictve limits data were obtained from the pertinent regulatory agency. They are tabulated in the spreadsheet table named "CBNG Discharge Parameters" and referenced herein.

2

Section 2: This section tabulates the mean monthly stream flow for each site. These data are referenced from the table located in Section 4 and used in the mixing calculations.

3

Section 3: This section computes the amount of CBM water which ultimately reaches the receiving waters following conveyance losses. The table is initially populated by reference to worksheet CBNG Discharge Parameters. Output from this table is then referenced by Section 4 where it is used in mixing computations

4

Section 4: This section is where the mixing calculations occur. CBM water with a given water quality is mixed with a background water with its own water quality. Using simple mixing computations described in the table, downstream water quality is estimated. Irrigation season is displayed in the area shaded green; non-irrigation season is shaded yellow.

5

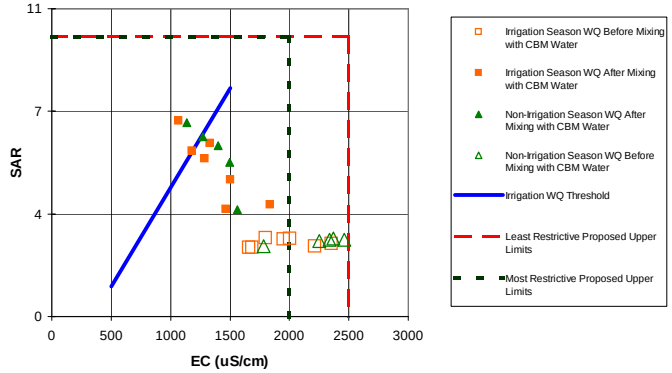
Section 5: This section presents the summary graph illustrating irrigation suitability and the water quality data relative to the "limits". The graph references "Limits" data from Section 1 and pertinent water quality data from section 4.

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality [1] EC (uS/cm) 95% Lower	EC Mean	EC 95% upper	SAR (--) 95% Lower	SAR Mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.9	0.40	1386	1400	1415	5.55	6.12	6.68	2460	2.74
	Dec	0.9	0.15	1118	1136	1153	6.23	6.93	7.62	2372	2.79
	Jan	0.9	0.29	1256	1272	1288	5.81	6.43	7.04	2335	2.74
	Feb	0.9	0.68	1486	1498	1510	5.04	5.50	5.97	2251	2.71
	Mar	0.9	2.60	1557	1563	1568	3.62	3.83	4.04	1782	2.52
Irrigation Season	Apr	0.9	1.15	1492	1501	1511	4.54	4.90	5.25	1949	2.77
	May	0.9	0.63	1276	1288	1300	5.16	5.64	6.12	1800	2.82
	Jun	0.9	0.13	1047	1065	1083	6.30	7.01	7.72	2005	2.8
	Jul	0.9	2.47	1460	1466	1471	3.63	3.85	4.07	1661	2.48
	Aug	0.9	0.44	1163	1177	1191	5.38	5.93	6.47	1684	2.47
	Sep	0.9	2.17	1831	1837	1844	3.78	4.01	4.25	2214	2.52
	Oct	0.9	0.35	1313	1328	1343	5.62	6.21	6.80	2354	2.6

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	3.0	0.7	0.9	0.9

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	22	31	0.35
Nov	24	30	0.40
Dec	9	31	0.15
Jan	18	31	0.29
Feb	38	28	0.68
Mar	161	31	2.60
Apr	69	30	1.15
May	39	31	0.63
Jun	8	30	0.13
Jul	153	31	2.47
Aug	27	31	0.44
Sep	130	30	2.17

Plotting Position: Most and Least Restrictive Limits			
	EC	SAR	
	0	10	
Least Restrictiv	2500	10	
	2500	0	
	0	10	
Most Restrictiv	2000	10	
	2000	0	

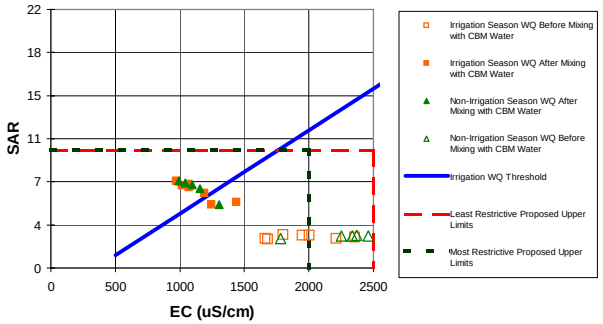
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	3.3	0.40	1076	1095	1114	6.36	7.09	7.81	2460	2.74
	Dec	3.3	0.15	972	992	1012	6.63	7.41	8.18	2372	2.79
	Jan	3.3	0.29	1024	1043	1062	6.47	7.22	7.97	2335	2.74
	Feb	3.3	0.68	1138	1155	1173	6.10	6.78	7.45	2251	2.71
	Mar	3.3	2.60	1293	1305	1317	4.91	5.37	5.83	1782	2.52
Irrigation Season	Apr	3.3	1.15	1177	1193	1208	5.76	6.36	6.97	1949	2.77
	May	3.3	0.63	1051	1069	1087	6.16	6.85	7.53	1800	2.82
	Jun	3.3	0.13	950	970	990	6.65	7.43	8.22	2005	2.8
	Jul	3.3	2.47	1231	1243	1255	4.95	5.42	5.88	1661	2.48
	Aug	3.3	0.44	1000	1018	1037	6.29	7.01	7.73	1684	2.47
	Sep	3.3	2.17	1426	1439	1452	5.10	5.59	6.09	2214	2.52
	Oct	3.3	0.35	1047	1066	1085	6.40	7.13	7.87	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	10.9	0.7	3.3	3.3

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	22	31	0.35
Nov	24	30	0.40
Dec	9	31	0.15
Jan	18	31	0.29
Feb	38	28	0.68
Mar	161	31	2.60
Apr	69	30	1.15
May	39	31	0.63
Jun	8	30	0.13
Jul	153	31	2.47
Aug	27	31	0.44
Sep	130	30	2.17

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

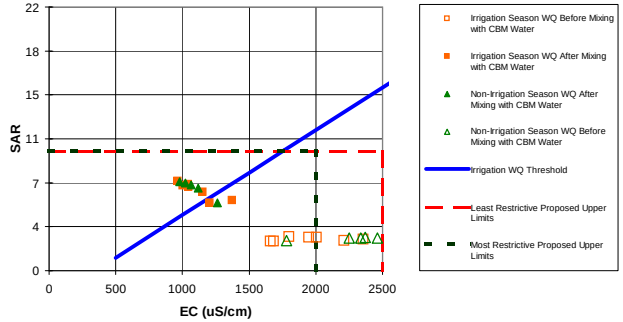
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% Lower	Mixed Water Quality EC (uS/cm) Mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% Lower	Mixed Water Quality SAR (--) Mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	4.1	0.40	1046	1066	1085	6.44	7.18	7.92	2460	2.74
	Dec	4.1	0.15	960	980	1001	6.66	7.45	8.23	2372	2.79
	Jan	4.1	0.29	1003	1022	1042	6.53	7.29	8.05	2335	2.74
	Feb	4.1	0.68	1100	1117	1135	6.22	6.92	7.62	2251	2.71
	Mar	4.1	2.60	1248	1260	1273	5.14	5.64	6.14	1782	2.52
Irrigation Season	Apr	4.1	1.15	1136	1153	1169	5.92	6.55	7.19	1949	2.77
	May	4.1	0.63	1027	1045	1064	6.27	6.98	7.68	1800	2.82
	Jun	4.1	0.13	942	963	983	6.68	7.47	8.26	2005	2.8
	Jul	4.1	2.47	1191	1204	1218	5.18	5.68	6.19	1661	2.48
	Aug	4.1	0.44	984	1003	1021	6.38	7.12	7.85	1684	2.47
	Sep	4.1	2.17	1360	1374	1388	5.32	5.85	6.38	2214	2.52
	Oct	4.1	0.35	1022	1042	1061	6.47	7.22	7.97	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	13.5	0.7	4.1	4.1

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	22	31	0.35
Nov	24	30	0.40
Dec	9	31	0.15
Jan	18	31	0.29
Feb	38	28	0.68
Mar	161	31	2.60
Apr	69	30	1.15
May	39	31	0.63
Jun	8	30	0.13
Jul	153	31	2.47
Aug	27	31	0.44
Sep	130	30	2.17

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

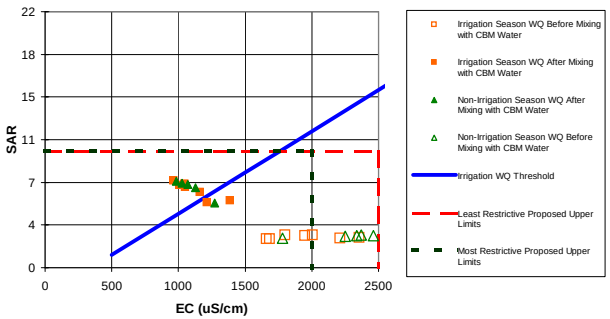
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Antelope Creek: 2020
Stream Water Quality Before and After Mixing with CBM
Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% Lower	Mixed Water Quality EC (uS/cm) Mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% Lower	Mixed Water Quality SAR (--) Mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	3.9	0.40	1053	1072	1091	6.42	7.16	7.90	2460	2.74
	Dec	3.9	0.15	963	983	1003	6.65	7.44	8.22	2372	2.79
	Jan	3.9	0.29	1007	1027	1046	6.52	7.28	8.04	2335	2.74
	Feb	3.9	0.68	1108	1126	1143	6.19	6.89	7.58	2251	2.71
	Mar	3.9	2.60	1258	1270	1283	5.09	5.58	6.07	1782	2.52
Irrigation Season	Apr	3.9	1.15	1146	1162	1178	5.88	6.51	7.14	1949	2.77
	May	3.9	0.63	1033	1051	1069	6.25	6.95	7.65	1800	2.82
	Jun	3.9	0.13	944	964	984	6.67	7.46	8.25	2005	2.8
	Jul	3.9	2.47	1200	1213	1226	5.13	5.62	6.12	1661	2.48
	Aug	3.9	0.44	987	1006	1025	6.36	7.09	7.83	1684	2.47
	Sep	3.9	2.17	1375	1389	1402	5.27	5.79	6.32	2214	2.52
	Oct	3.9	0.35	1028	1047	1066	6.46	7.20	7.95	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Antelope	Antelope Creek near Teckla, WY	12.9	0.7	3.9	3.9

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	22	31	0.35
Nov	24	30	0.40
Dec	9	31	0.15
Jan	18	31	0.29
Feb	38	28	0.68
Mar	161	31	2.60
Apr	69	30	1.15
May	39	31	0.63
Jun	8	30	0.13
Jul	153	31	2.47
Aug	27	31	0.44
Sep	130	30	2.17

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restric	2500	10
	2500	0
Most Restric	0	10
	2000	10
	2000	0

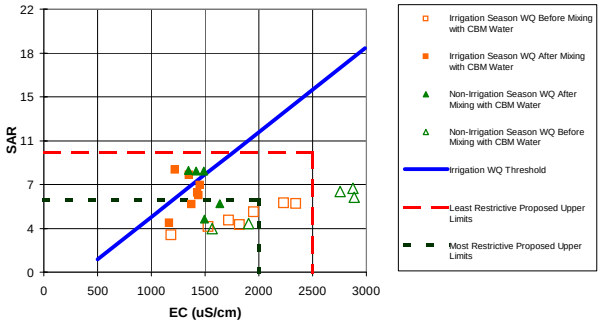
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
	EC			SAR	
	(uS/cm)			(--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow	StreamFlow	EC			SAR			EC	SAR
		(cfs)	(cfs)	(uS/cm)			(--)			(uS/cm)	(--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	4.3	1.16	1479	1485	1491	8.14	8.45	8.76	2877	7.02
	Dec	4.3	0.98	1409	1415	1421	8.13	8.45	8.77	2755	6.77
	Jan	4.3	0.65	1337	1343	1350	8.16	8.50	8.84	2887	6.29
	Feb	4.3	8.28	1632	1634	1637	5.57	5.71	5.84	1907	4.08
	Mar	4.3	23.54	1493	1494	1495	4.38	4.44	4.50	1564	3.64
Irrigation Season	Apr	4.3	4.98	1435	1438	1442	6.24	6.42	6.60	1722	4.34
	May	4.3	7.15	1371	1373	1376	5.55	5.70	5.84	1532	3.81
	Jun	4.3	3.53	1426	1430	1435	6.43	6.65	6.86	1821	3.98
	Jul	4.3	19.18	1167	1169	1170	4.08	4.15	4.22	1182	3.1
	Aug	4.3	2.94	1448	1453	1458	7.07	7.30	7.53	1955	5.06
	Sep	4.3	1.19	1347	1353	1359	7.86	8.17	8.47	2231	5.76
	Oct	4.3	0.42	1213	1220	1227	8.20	8.56	8.92	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	14.4	0.7	4.3	4.3

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	25.78333333	31	0.42
Nov	69.75937	30	1.16
Dec	60.83333333	31	0.98
Jan	40.5	31	0.65
Feb	463.7034167	28	8.28
Mar	1459.54671	31	23.54
Apr	298.7534767	30	4.98
May	443.4144467	31	7.15
Jun	211.5	30	3.53
Jul	1189.381403	31	19.18
Aug	182.5	31	2.94
Sep	71.17809667	30	1.19

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

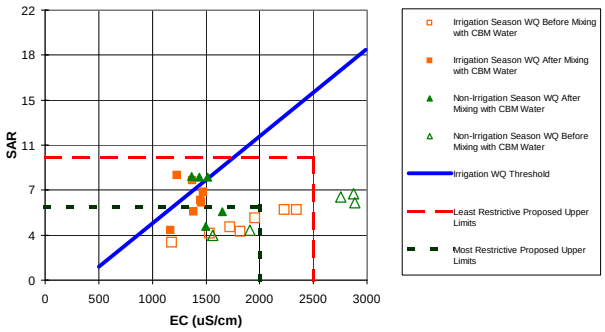
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
	EC			SAR	
	(uS/cm)			(--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow	StreamFlow	EC			SAR			EC	SAR
		(cfs)	(cfs)	(uS/cm)			(--)			(uS/cm)	(--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	3.9	1.16	1509	1515	1521	8.12	8.42	8.72	2877	7.02
	Dec	3.9	0.98	1434	1440	1446	8.11	8.42	8.73	2755	6.77
	Jan	3.9	0.65	1357	1364	1370	8.14	8.47	8.81	2887	6.29
	Feb	3.9	8.28	1649	1652	1654	5.48	5.60	5.73	1907	4.08
	Mar	3.9	23.54	1498	1499	1501	4.32	4.38	4.43	1564	3.64
Irrigation Season	Apr	3.9	4.98	1450	1453	1456	6.14	6.31	6.49	1722	4.34
	May	3.9	7.15	1380	1383	1386	5.45	5.58	5.72	1532	3.81
	Jun	3.9	3.53	1444	1448	1452	6.32	6.53	6.73	1821	3.98
	Jul	3.9	19.18	1169	1170	1171	4.00	4.07	4.14	1182	3.1
	Aug	3.9	2.94	1469	1473	1477	6.99	7.21	7.44	1955	5.06
	Sep	3.9	1.19	1366	1372	1378	7.82	8.12	8.42	2231	5.76
	Oct	3.9	0.42	1223	1230	1237	8.18	8.53	8.89	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	13.1	0.7	3.9	3.9

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	25.78333333	31	0.42
Nov	69.75937	30	1.16
Dec	60.83333333	31	0.98
Jan	40.5	31	0.65
Feb	463.7034167	28	8.28
Mar	1459.54671	31	23.54
Apr	298.7534767	30	4.98
May	443.4144467	31	7.15
Jun	211.5	30	3.53
Jul	1189.381403	31	19.18
Aug	182.5	31	2.94
Sep	71.17809667	30	1.19

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

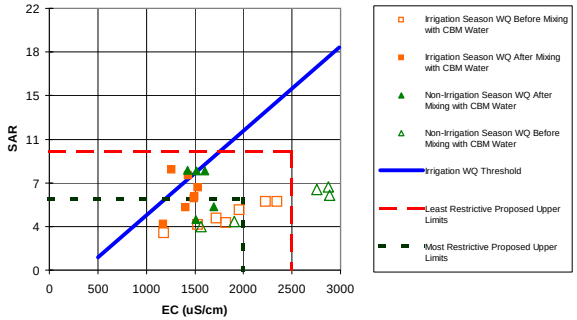
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
	EC			SAR	
	(uS/cm)			(--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow	StreamFlow	EC			SAR			EC	SAR
		(cfs)	(cfs)	(uS/cm)			(--)			(uS/cm)	(--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	3.0	1.16	1597	1603	1608	8.05	8.33	8.61	2877	7.02
	Dec	3.0	0.98	1509	1515	1521	8.03	8.33	8.62	2755	6.77
	Jan	3.0	0.65	1420	1426	1433	8.06	8.38	8.70	2887	6.29
	Feb	3.0	8.28	1693	1695	1697	5.24	5.34	5.45	1907	4.08
	Mar	3.0	23.54	1512	1513	1514	4.18	4.23	4.27	1564	3.64
Irrigation Season	Apr	3.0	4.98	1489	1492	1495	5.88	6.03	6.18	1722	4.34
	May	3.0	7.15	1405	1407	1409	5.18	5.29	5.41	1532	3.81
	Jun	3.0	3.53	1491	1494	1498	6.03	6.21	6.39	1821	3.98
	Jul	3.0	19.18	1171	1172	1173	3.82	3.88	3.93	1182	3.1
	Aug	3.0	2.94	1524	1528	1532	6.77	6.97	7.16	1955	5.06
	Sep	3.0	1.19	1423	1428	1434	7.68	7.96	8.24	2231	5.76
	Oct	3.0	0.42	1255	1262	1268	8.11	8.46	8.80	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	9.9	0.7	3.0	3.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	25.78333333	31	0.42
Nov	69.75937	30	1.16
Dec	60.83333333	31	0.98
Jan	40.5	31	0.65
Feb	463.7034167	28	8.28
Mar	1459.54671	31	23.54
Apr	298.7534767	30	4.98
May	443.4144467	31	7.15
Jun	211.5	30	3.53
Jul	1189.381403	31	19.18
Aug	182.5	31	2.94
Sep	71.17809667	30	1.19

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
	0	6
Most Restrictive	2000	6
	2000	0

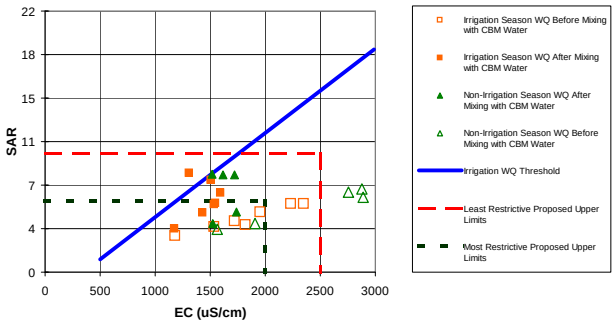
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
	EC			SAR	
	(uS/cm)			(--)	
1102	1110	1117	8.4	8.8	9.2

Upper Belle Fourche River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow	StreamFlow	EC			SAR			EC	SAR
		(cfs)	(cfs)	(uS/cm)			(--)			(uS/cm)	(--)
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper		
Non-Irrigation Season	Nov	2.2	1.16	1715	1720	1725	7.95	8.21	8.46	2877	7.02
	Dec	2.2	0.98	1612	1617	1622	7.93	8.20	8.47	2755	6.77
	Jan	2.2	0.65	1509	1515	1521	7.95	8.25	8.56	2887	6.29
	Feb	2.2	8.28	1738	1740	1741	5.00	5.08	5.16	1907	4.08
	Mar	2.2	23.54	1525	1525	1526	4.05	4.08	4.12	1564	3.64
Irrigation Season	Apr	2.2	4.98	1532	1534	1537	5.60	5.72	5.84	1722	4.34
	May	2.2	7.15	1431	1433	1434	4.90	4.99	5.08	1532	3.81
	Jun	2.2	3.53	1545	1548	1551	5.69	5.84	5.99	1821	3.98
	Jul	2.2	19.18	1174	1175	1175	3.65	3.69	3.73	1182	3.1
	Aug	2.2	2.94	1590	1593	1596	6.51	6.68	6.84	1955	5.06
	Sep	2.2	1.19	1498	1503	1508	7.50	7.76	8.01	2231	5.76
	Oct	2.2	0.42	1302	1308	1314	8.01	8.34	8.67	2346	5.75

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Belle Fourche	Upper Belle Fourche River	7.3	0.7	2.2	2.2

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	25.78333333	31	0.42
Nov	69.75937	30	1.16
Dec	60.83333333	31	0.98
Jan	40.5	31	0.65
Feb	463.7034167	28	8.28
Mar	1459.54671	31	23.54
Apr	298.7534767	30	4.98
May	443.4144467	31	7.15
Jun	211.5	30	3.53
Jul	1189.381403	31	19.18
Aug	182.5	31	2.94
Sep	71.17809667	30	1.19

Table of Plotting Positions for graph

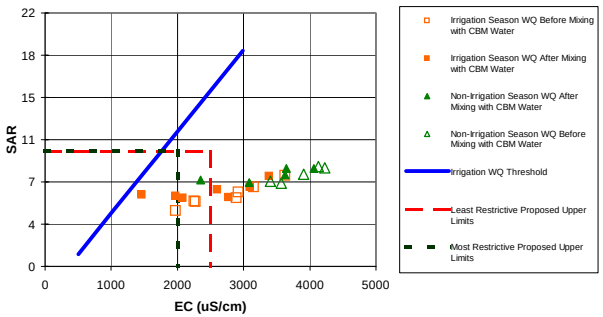
Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	6
	2000	6
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC (uS/cm) mean	EC (uS/cm) 95% upper	SAR (--) 95% lower	SAR (--) mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.8	3.60	3082	3086	3090	7.14	7.29	7.44	3565	7.22
	Dec	0.8	1.08	2343	2352	2360	7.14	7.49	7.83	3405	7.39
	Jan	0.8	15.37	4065	4066	4067	8.49	8.53	8.57	4229	8.58
	Feb	0.8	7.68	3628	3630	3632	7.90	7.97	8.05	3911	8.01
	Mar	0.8	4.56	3647	3650	3653	8.38	8.50	8.63	4127	8.66
Irrigation Season	Apr	0.8	7.88	3379	3381	3383	7.77	7.85	7.92	3630	7.87
	May	0.8	27.97	3093	3093	3094	6.88	6.90	6.92	3155	6.88
	Jun	0.8	12.70	2777	2779	2780	5.98	6.03	6.08	2895	5.93
	Jul	0.8	3.02	1969	1973	1978	5.92	6.09	6.26	2250	5.69
	Aug	0.8	0.82	1447	1457	1467	5.80	6.20	6.60	1972	4.82
	Sep	0.8	4.67	2072	2075	2078	5.80	5.92	6.04	2271	5.63
	Oct	0.8	4.18	2594	2597	2600	6.51	6.65	6.78	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.5	0.7	0.8	0.8

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	259	31	4.18
Nov	216	30	3.60
Dec	67	31	1.08
Jan	953	31	15.37
Feb	430	28	7.68
Mar	283	31	4.56
Apr	473	30	7.88
May	1734	31	27.97
Jun	762	30	12.70
Jul	187	31	3.02
Aug	51	31	0.82
Sep	280	30	4.67

Table of Plotting Positions for graph

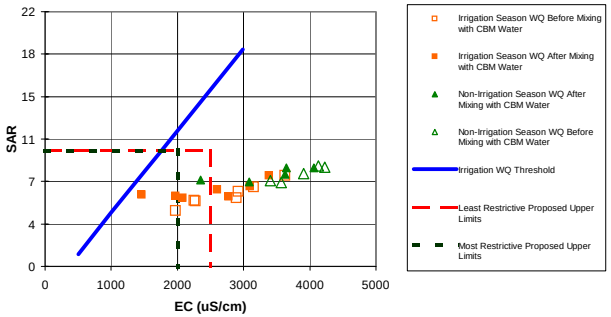
Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.8	3.60	3082	3086	3090	7.14	7.29	7.44	3565	7.22
	Dec	0.8	1.08	2343	2352	2360	7.14	7.49	7.83	3405	7.39
	Jan	0.8	15.37	4065	4066	4067	8.49	8.53	8.57	4229	8.58
	Feb	0.8	7.68	3628	3630	3632	7.90	7.97	8.05	3911	8.01
	Mar	0.8	4.56	3647	3650	3653	8.38	8.50	8.63	4127	8.66
Irrigation Season	Apr	0.8	7.88	3379	3381	3383	7.77	7.85	7.92	3630	7.87
	May	0.8	27.97	3093	3093	3094	6.88	6.90	6.92	3155	6.88
	Jun	0.8	12.70	2777	2779	2780	5.98	6.03	6.08	2895	5.93
	Jul	0.8	3.02	1969	1973	1978	5.92	6.09	6.26	2250	5.69
	Aug	0.8	0.82	1447	1457	1467	5.80	6.20	6.60	1972	4.82
	Sep	0.8	4.67	2072	2075	2078	5.80	5.92	6.04	2271	5.63
	Oct	0.8	4.18	2594	2597	2600	6.51	6.65	6.78	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.8	0.7	0.8	0.8

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	259	31	4.18
Nov	216	30	3.60
Dec	67	31	1.08
Jan	953	31	15.37
Feb	430	28	7.68
Mar	283	31	4.56
Apr	473	30	7.88
May	1734	31	27.97
Jun	762	30	12.70
Jul	187	31	3.02
Aug	51	31	0.82
Sep	280	30	4.67

Table of Plotting Positions for graph

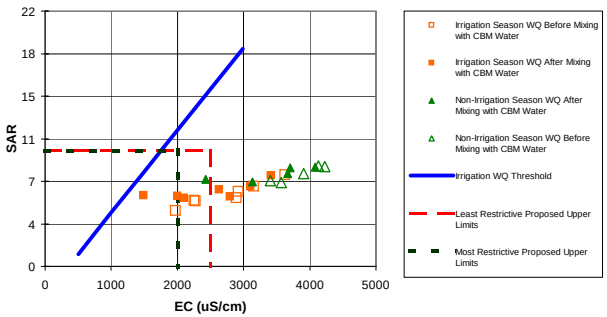
Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.7	3.60	3133	3136	3139	7.15	7.28	7.42	3565	7.22
	Dec	0.7	1.08	2423	2431	2440	7.16	7.48	7.80	3405	7.39
	Jan	0.7	15.37	4084	4085	4086	8.50	8.54	8.57	4229	8.58
	Feb	0.7	7.68	3660	3662	3664	7.91	7.98	8.05	3911	8.01
	Mar	0.7	4.56	3699	3701	3704	8.41	8.52	8.63	4127	8.66
Irrigation Season	Apr	0.7	7.88	3408	3410	3411	7.78	7.85	7.92	3630	7.87
	May	0.7	27.97	3100	3101	3101	6.88	6.90	6.92	3155	6.88
	Jun	0.7	12.70	2791	2792	2793	5.98	6.02	6.06	2895	5.93
	Jul	0.7	3.02	1998	2002	2005	5.90	6.05	6.21	2250	5.69
	Aug	0.7	0.82	1482	1492	1502	5.73	6.11	6.48	1972	4.82
	Sep	0.7	4.67	2093	2096	2099	5.78	5.89	5.99	2271	5.63
	Oct	0.7	4.18	2628	2631	2634	6.51	6.63	6.74	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	2.4	0.7	0.7	0.7

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	259	31	4.18
Nov	216	30	3.60
Dec	67	31	1.08
Jan	953	31	15.37
Feb	430	28	7.68
Mar	283	31	4.56
Apr	473	30	7.88
May	1734	31	27.97
Jun	762	30	12.70
Jul	187	31	3.02
Aug	51	31	0.82
Sep	280	30	4.67

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

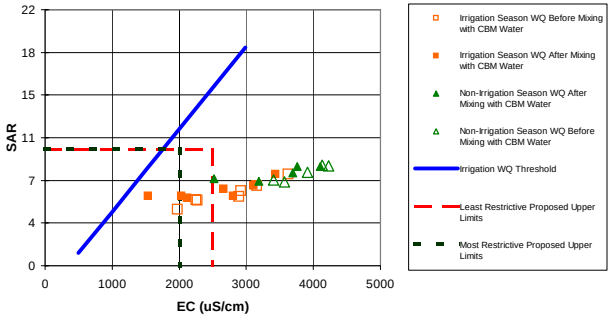
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Upper Cheyenne River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed EC mean	Mixed EC 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed SAR mean	Mixed SAR 95% upper	Background Water Quality EC (uS/cm)	Background SAR (--)
Non-Irrigation Season	Nov	0.6	3.60	3186	3188	3191	7.16	7.28	7.39	3565	7.22
	Dec	0.6	1.08	2513	2521	2528	7.18	7.47	7.76	3405	7.39
	Jan	0.6	15.37	4104	4105	4106	8.51	8.54	8.57	4229	8.58
	Feb	0.6	7.68	3693	3695	3696	7.92	7.98	8.04	3911	8.01
	Mar	0.6	4.56	3753	3755	3758	8.44	8.54	8.63	4127	8.66
Irrigation Season	Apr	0.6	7.88	3437	3439	3440	7.79	7.85	7.91	3630	7.87
	May	0.6	27.97	3108	3108	3109	6.88	6.90	6.91	3155	6.88
	Jun	0.6	12.70	2805	2806	2807	5.97	6.01	6.04	2895	5.93
	Jul	0.6	3.02	2028	2031	2035	5.87	6.01	6.14	2250	5.69
	Aug	0.6	0.82	1523	1531	1540	5.66	6.00	6.35	1972	4.82
	Sep	0.6	4.67	2116	2118	2121	5.76	5.86	5.95	2271	5.63
	Oct	0.6	4.18	2664	2667	2669	6.50	6.61	6.71	2916	6.46

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Cheyenne	Upper Cheyenne River	1.9	0.7	0.6	0.6

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	259	31	4.18
Nov	216	30	3.60
Dec	67	31	1.08
Jan	953	31	15.37
Feb	430	28	7.68
Mar	283	31	4.56
Apr	473	30	7.88
May	1734	31	27.97
Jun	762	30	12.70
Jul	187	31	3.02
Aug	51	31	0.82
Sep	280	30	4.67

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

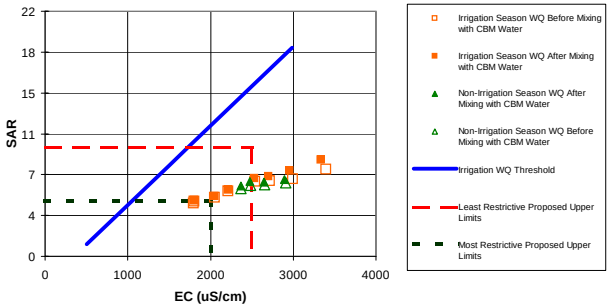
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	2.3	143.70	2642	2643	2643	6.66	6.67	6.69	2650	6.42
	Dec	2.3	114.27	2891	2892	2892	6.91	6.93	6.94	2906	6.61
	Jan	2.3	113.95	2476	2476	2476	6.70	6.72	6.74	2482	6.4
	Feb	2.3	180.39	2363	2364	2364	6.32	6.33	6.34	2366	6.12
	Mar	2.3	301.02	2052	2052	2052	5.40	5.41	5.42	2051	5.28
Irrigation Season	Apr	2.3	232.78	2212	2213	2213	5.99	6.00	6.01	2213	5.84
	May	2.3	341.65	1805	1806	1806	5.03	5.04	5.04	1803	4.92
	Jun	2.3	157.00	1802	1803	1803	5.00	5.02	5.03	1797	4.76
	Jul	2.3	93.02	2703	2703	2704	7.15	7.17	7.19	2716	6.79
	Aug	2.3	45.32	2952	2953	2954	7.68	7.72	7.77	2992	6.97
	Sep	2.3	38.57	3330	3331	3332	8.61	8.66	8.71	3400	7.83
	Oct	2.3	123.27	2530	2530	2531	6.98	7.00	7.02	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	7.8	0.7	2.3	2.3

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	7643	31	123.27
Nov	8622	30	143.70
Dec	7085	31	114.27
Jan	7065	31	113.95
Feb	10102	28	180.39
Mar	18663	31	301.02
Apr	13967	30	232.78
May	21182	31	341.65
Jun	9420	30	157.00
Jul	5767	31	93.02
Aug	2810	31	45.32
Sep	2314	30	38.57

Table of Plotting Positions for graph

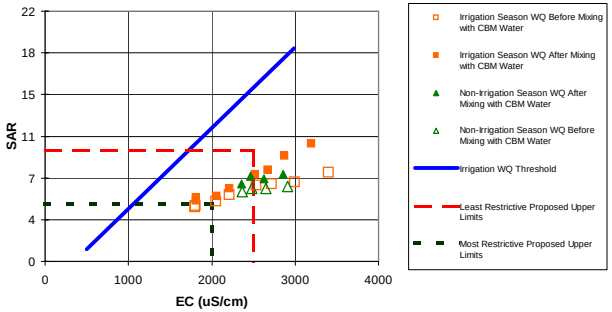
Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	9.75
Least Restrictiv	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line	
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	8.0	143.70	2624	2625	2626	7.22	7.27	7.32	2650	6.42
	Dec	8.0	114.27	2857	2859	2860	7.59	7.65	7.72	2906	6.61
	Jan	8.0	113.95	2461	2462	2463	7.40	7.46	7.52	2482	6.4
	Feb	8.0	180.39	2357	2358	2359	6.78	6.82	6.86	2366	6.12
	Mar	8.0	301.02	2054	2054	2055	5.70	5.73	5.75	2051	5.28
Irrigation Season	Apr	8.0	232.78	2211	2212	2213	6.36	6.40	6.43	2213	5.84
	May	8.0	341.65	1811	1812	1812	5.30	5.32	5.35	1803	4.92
	Jun	8.0	157.00	1815	1816	1817	5.58	5.62	5.67	1797	4.76
	Jul	8.0	93.02	2672	2674	2675	7.96	8.04	8.12	2716	6.79
	Aug	8.0	45.32	2867	2870	2873	9.17	9.31	9.46	2992	6.97
	Sep	8.0	38.57	3187	3190	3194	10.20	10.36	10.53	3400	7.83
	Oct	8.0	123.27	2514	2515	2516	7.62	7.68	7.74	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	26.6	0.7	8.0	8.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	7643	31	123.27
Nov	8622	30	143.70
Dec	7085	31	114.27
Jan	7065	31	113.95
Feb	10102	28	180.39
Mar	18663	31	301.02
Apr	13967	30	232.78
May	21182	31	341.65
Jun	9420	30	157.00
Jul	5767	31	93.02
Aug	2810	31	45.32
Sep	2314	30	38.57

Table of Plotting Positions for graph

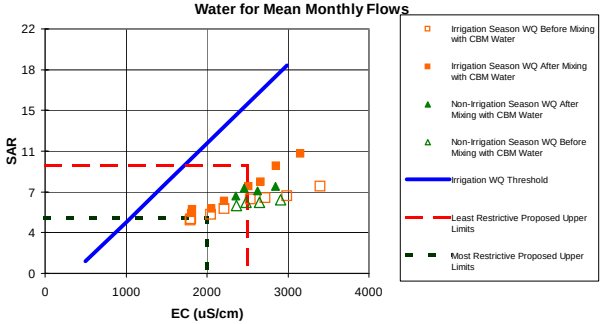
Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictiv	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	9.6	143.70	2619	2621	2622	7.37	7.43	7.49	2650	6.42
	Dec	9.6	114.27	2848	2850	2851	7.77	7.85	7.92	2906	6.61
	Jan	9.6	113.95	2457	2459	2460	7.58	7.66	7.73	2482	6.4
	Feb	9.6	180.39	2356	2357	2358	6.90	6.95	7.00	2366	6.12
	Mar	9.6	301.02	2054	2055	2056	5.78	5.81	5.84	2051	5.28
Irrigation Season	Apr	9.6	232.78	2211	2212	2212	6.46	6.50	6.54	2213	5.84
	May	9.6	341.65	1813	1813	1814	5.38	5.40	5.43	1803	4.92
	Jun	9.6	157.00	1818	1819	1820	5.73	5.79	5.84	1797	4.76
	Jul	9.6	93.02	2664	2666	2668	8.18	8.27	8.36	2716	6.79
	Aug	9.6	45.32	2847	2850	2854	9.53	9.70	9.87	2992	6.97
	Sep	9.6	38.57	3153	3157	3161	10.58	10.77	10.96	3400	7.83
	Oct	9.6	123.27	2510	2511	2513	7.79	7.86	7.93	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	31.9	0.7	9.6	9.6

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	7643	31	123.27
Nov	8622	30	143.70
Dec	7085	31	114.27
Jan	7065	31	113.95
Feb	10102	28	180.39
Mar	18663	31	301.02
Apr	13967	30	232.78
May	21182	31	341.65
Jun	9420	30	157.00
Jul	5767	31	93.02
Aug	2810	31	45.32
Sep	2314	30	38.57

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictiv	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

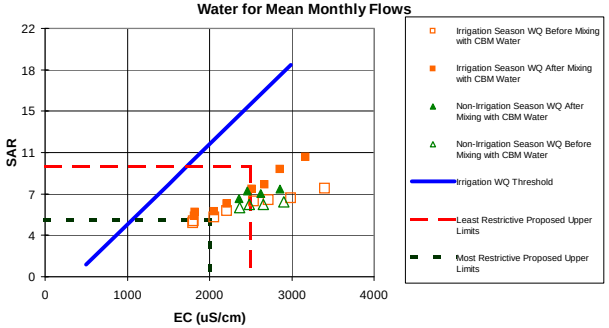
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
2161	2180	2200	21.62	22.58	23.54

Upper Powder River 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	9.0	143.70	2621	2622	2623	7.32	7.37	7.43	2650	6.42
	Dec	9.0	114.27	2852	2853	2854	7.71	7.78	7.85	2906	6.61
	Jan	9.0	113.95	2458	2460	2461	7.51	7.58	7.65	2482	6.4
	Feb	9.0	180.39	2356	2357	2358	6.86	6.90	6.95	2366	6.12
	Mar	9.0	301.02	2054	2055	2055	5.75	5.78	5.81	2051	5.28
Irrigation Season	Apr	9.0	232.78	2211	2212	2213	6.43	6.46	6.50	2213	5.84
	May	9.0	341.65	1812	1813	1813	5.35	5.37	5.40	1803	4.92
	Jun	9.0	157.00	1817	1818	1819	5.67	5.73	5.78	1797	4.76
	Jul	9.0	93.02	2667	2669	2670	8.10	8.18	8.27	2716	6.79
	Aug	9.0	45.32	2854	2857	2861	9.40	9.56	9.71	2992	6.97
	Sep	9.0	38.57	3166	3169	3173	10.44	10.62	10.80	3400	7.83
	Oct	9.0	123.27	2511	2513	2514	7.72	7.79	7.85	2537	6.71

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Upper Powder	Upper Powder River	30.0	0.7	9.0	9.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	7643	31	123.27
Nov	8622	30	143.70
Dec	7085	31	114.27
Jan	7065	31	113.95
Feb	10102	28	180.39
Mar	18663	31	301.02
Apr	13967	30	232.78
May	21182	31	341.65
Jun	9420	30	157.00
Jul	5767	31	93.02
Aug	2810	31	45.32
Sep	2314	30	38.57

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictiv	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

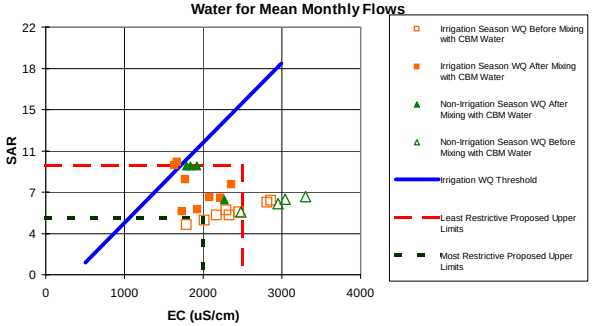
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2003
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC (uS/cm) mean	EC (uS/cm) 95% upper	SAR (--) 95% lower	SAR (--) mean	SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	1.6	0.43	1822	1834	1846	9.26	9.69	10.11	3044	6.7
	Dec	1.6	0.48	1910	1922	1934	9.26	9.67	10.09	3300	6.94
	Jan	1.6	0.39	1779	1792	1804	9.24	9.68	10.11	2953	6.33
	Feb	1.6	5.70	2261	2265	2268	6.53	6.65	6.77	2477	5.57
	Mar	1.6	6.44	1727	1730	1733	5.54	5.64	5.75	1785	4.44
Irrigation Season	Apr	1.6	4.73	2213	2217	2221	6.66	6.80	6.94	2457	5.55
	May	1.6	7.65	1923	1926	1928	5.70	5.79	5.89	2013	4.81
	Jun	1.6	3.67	2078	2083	2088	6.71	6.87	7.03	2333	5.29
	Jul	1.6	1.03	1760	1769	1779	8.13	8.45	8.78	2174	5.29
	Aug	1.6	2.73	2355	2361	2366	7.82	8.02	8.22	2860	6.57
	Sep	1.6	0.22	1653	1666	1680	9.53	10.00	10.48	2810	6.44
	Oct	1.6	0.31	1622	1636	1649	9.27	9.72	10.17	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	5.3	0.7	1.6	1.6

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	19	31	0.31
Nov	26	30	0.43
Dec	30	31	0.48
Jan	24	31	0.39
Feb	319	28	5.70
Mar	399	31	6.44
Apr	284	30	4.73
May	474	31	7.65
Jun	220	30	3.67
Jul	64	31	1.03
Aug	169	31	2.73
Sep	13	30	0.22

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

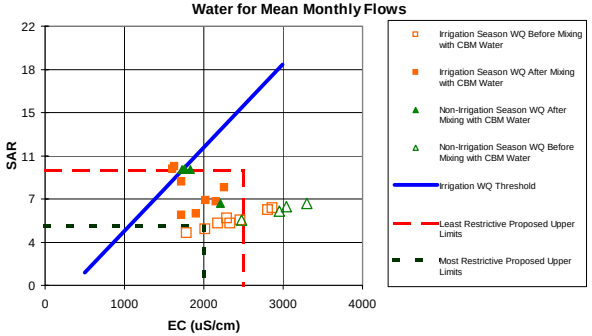
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	2.2	0.43	1747	1760	1773	9.42	9.87	10.32	3044	6.7
	Dec	2.2	0.48	1817	1830	1842	9.41	9.86	10.30	3300	6.94
	Jan	2.2	0.39	1713	1726	1740	9.41	9.86	10.32	2953	6.33
	Feb	2.2	5.70	2203	2207	2212	6.79	6.94	7.09	2477	5.57
	Mar	2.2	6.44	1711	1715	1719	5.84	5.98	6.12	1785	4.44
Irrigation Season	Apr	2.2	4.73	2151	2156	2161	6.95	7.12	7.29	2457	5.55
	May	2.2	7.65	1897	1900	1904	5.96	6.08	6.20	2013	4.81
	Jun	2.2	3.67	2018	2024	2030	7.04	7.24	7.44	2333	5.29
	Jul	2.2	1.03	1710	1721	1732	8.46	8.83	9.20	2174	5.29
	Aug	2.2	2.73	2250	2257	2264	8.08	8.32	8.56	2860	6.57
	Sep	2.2	0.22	1613	1627	1641	9.63	10.12	10.61	2810	6.44
	Oct	2.2	0.31	1592	1605	1619	9.43	9.90	10.38	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	7.3	0.7	2.2	2.2

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	19	31	0.31
Nov	26	30	0.43
Dec	30	31	0.48
Jan	24	31	0.39
Feb	319	28	5.70
Mar	399	31	6.44
Apr	284	30	4.73
May	474	31	7.65
Jun	220	30	3.67
Jul	64	31	1.03
Aug	169	31	2.73
Sep	13	30	0.22

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

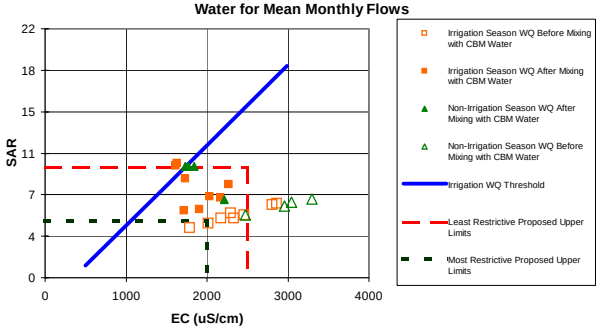
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	2.1	0.43	1757	1770	1783	9.40	9.85	10.29	3044	6.7
	Dec	2.1	0.48	1829	1842	1855	9.39	9.83	10.27	3300	6.94
	Jan	2.1	0.39	1722	1735	1748	9.38	9.84	10.29	2953	6.33
	Feb	2.1	5.70	2212	2216	2221	6.75	6.89	7.04	2477	5.57
	Mar	2.1	6.44	1713	1717	1721	5.80	5.93	6.06	1785	4.44
Irrigation Season	Apr	2.1	4.73	2161	2165	2170	6.90	7.07	7.24	2457	5.55
	May	2.1	7.65	1901	1904	1908	5.92	6.03	6.15	2013	4.81
	Jun	2.1	3.67	2027	2033	2039	6.99	7.18	7.38	2333	5.29
	Jul	2.1	1.03	1717	1728	1738	8.42	8.78	9.14	2174	5.29
	Aug	2.1	2.73	2266	2273	2279	8.04	8.27	8.51	2860	6.57
	Sep	2.1	0.22	1618	1632	1646	9.62	10.11	10.60	2810	6.44
	Oct	2.1	0.31	1596	1609	1623	9.41	9.88	10.35	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	7.0	0.7	2.1	2.1

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	19	31	0.31
Nov	26	30	0.43
Dec	30	31	0.48
Jan	24	31	0.39
Feb	319	28	5.70
Mar	399	31	6.44
Apr	284	30	4.73
May	474	31	7.65
Jun	220	30	3.67
Jul	64	31	1.03
Aug	169	31	2.73
Sep	13	30	0.22

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictiv	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

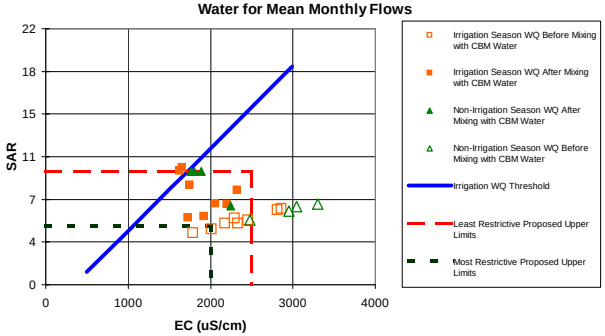
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
1493	1509	1524	9.95	10.49	11.03

Little Powder River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	1.8	0.43	1792	1805	1817	9.32	9.76	10.20	3044	6.7
	Dec	1.8	0.48	1874	1886	1898	9.32	9.74	10.17	3300	6.94
	Jan	1.8	0.39	1753	1766	1779	9.31	9.75	10.19	2953	6.33
	Feb	1.8	5.70	2241	2245	2248	6.62	6.75	6.88	2477	5.57
	Mar	1.8	6.44	1721	1725	1728	5.64	5.76	5.88	1785	4.44
Irrigation Season	Apr	1.8	4.73	2191	2196	2200	6.76	6.91	7.06	2457	5.55
	May	1.8	7.65	1914	1917	1920	5.79	5.89	5.99	2013	4.81
	Jun	1.8	3.67	2057	2062	2067	6.82	7.00	7.18	2333	5.29
	Jul	1.8	1.03	1741	1751	1761	8.25	8.60	8.94	2174	5.29
	Aug	1.8	2.73	2317	2323	2329	7.91	8.13	8.34	2860	6.57
	Sep	1.8	0.22	1637	1651	1664	9.57	10.05	10.53	2810	6.44
	Oct	1.8	0.31	1610	1624	1637	9.33	9.79	10.25	2289	5.73

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Little Powder	Little Powder River	6.0	0.7	1.8	1.8

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	19	31	0.31
Nov	26	30	0.43
Dec	30	31	0.48
Jan	24	31	0.39
Feb	319	28	5.70
Mar	399	31	6.44
Apr	284	30	4.73
May	474	31	7.65
Jun	220	30	3.67
Jul	64	31	1.03
Aug	169	31	2.73
Sep	13	30	0.22

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	9.75
Least Restrictive	2500	9.75
	2500	0
Most Restrictive	0	5
	2000	5
	2000	0

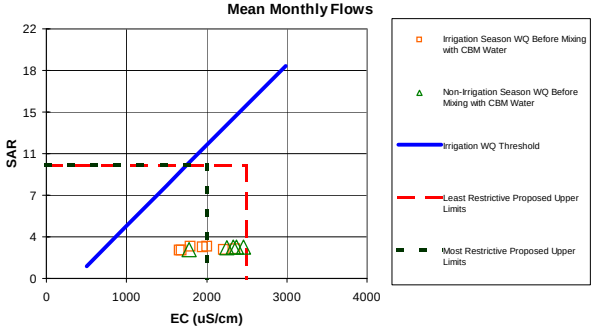
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2003
Stream Water Quality Before Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.00	0.02	2460	2460	2460	2.74	2.74	2.74	2460	2.74
	Dec	0.00	0.02	2372	2372	2372	2.79	2.79	2.79	2372	2.79
	Jan	0.00	0.00	Not Applicable			Not Applicable			2335	2.74
	Feb	0.00	0.04	2251	2251	2251	2.71	2.71	2.71	2251	2.71
	Mar	0.00	0.08	1782	1782	1782	2.52	2.52	2.52	1782	2.52
Irrigation Season	Apr	0.00	0.10	1949	1949	1949	2.77	2.77	2.77	1949	2.77
	May	0.00	0.06	1800	1800	1800	2.82	2.82	2.82	1800	2.82
	Jun	0.00	0.00	Not Applicable			Not Applicable			2005	2.8
	Jul	0.00	0.18	1661	1661	1661	2.48	2.48	2.48	1661	2.48
	Aug	0.00	0.00	Not Applicable			Not Applicable			1684	2.47
	Sep	0.00	0.00	Not Applicable			Not Applicable			2214	2.52
	Oct	0.00	0.00	Not Applicable			Not Applicable			2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.0	0.7	0.0	0.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	0	31	0.00
Nov	1	30	0.02
Dec	1	31	0.02
Jan	0	31	0.00
Feb	2	28	0.04
Mar	5	31	0.08
Apr	6	30	0.10
May	4	31	0.06
Jun	0	30	0.00
Jul	11	31	0.18
Aug	0	31	0.00
Sep	0	30	0.00

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

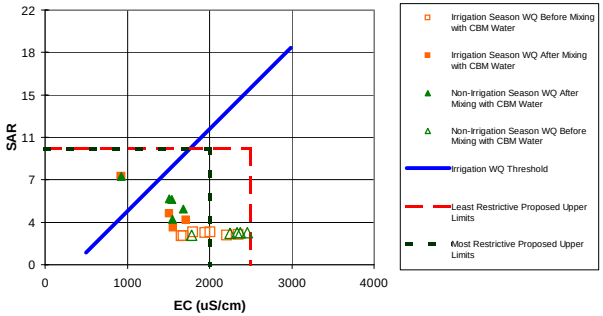
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2010
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	EC mean	EC 95% upper	SAR (--) 95% lower	SAR mean	SAR 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.03	0.02	1529	1542	1554	5.18	5.67	6.15	2460	2.74
	Dec	0.03	0.02	1494	1506	1519	5.20	5.69	6.17	2372	2.79
	Jan	0.03	0.00	909	929	950	6.80	7.62	8.43	2335	2.74
	Feb	0.03	0.04	1676	1685	1694	4.46	4.81	5.16	2251	2.71
	Mar	0.03	0.08	1544	1549	1555	3.69	3.91	4.13	1782	2.52
Irrigation Season	Apr	0.03	0.10	1709	1714	1719	3.70	3.89	4.08	1949	2.77
	May	0.03	0.06	1503	1510	1517	4.15	4.42	4.69	1800	2.82
	Jun	0.03	0.00	909	929	950	6.80	7.62	8.43	2005	2.8
	Jul	0.03	0.18	1554	1556	1559	3.10	3.21	3.33	1661	2.48
	Aug	0.03	0.00	909	929	950	6.80	7.62	8.43	1684	2.47
	Sep	0.03	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.03	0.00	909	929	950	6.80	7.62	8.43	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.0	0.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	0	31	0.00
Nov	1	30	0.02
Dec	1	31	0.02
Jan	0	31	0.00
Feb	2	28	0.04
Mar	5	31	0.08
Apr	6	30	0.10
May	4	31	0.06
Jun	0	30	0.00
Jul	11	31	0.18
Aug	0	31	0.00
Sep	0	30	0.00

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

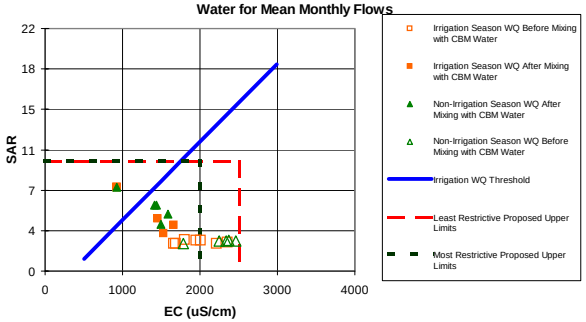
Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions

Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2015
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean CBM Flow (cfs)	Monthly Mean StreamFlow (cfs)	Mixed Water Quality EC (uS/cm) 95% lower	Mixed Water Quality EC (uS/cm) mean	Mixed Water Quality EC (uS/cm) 95% upper	Mixed Water Quality SAR (--) 95% lower	Mixed Water Quality SAR (--) mean	Mixed Water Quality SAR (--) 95% upper	Background Water Quality EC (uS/cm)	Background Water Quality SAR (--)
Non-Irrigation Season	Nov	0.04	0.02	1426	1440	1454	5.45	5.99	6.53	2460	2.74
	Dec	0.04	0.02	1396	1410	1424	5.46	6.01	6.55	2372	2.79
	Jan	0.04	0.00	909	929	950	6.80	7.62	8.43	2335	2.74
	Feb	0.04	0.04	1580	1590	1601	4.76	5.16	5.57	2251	2.71
	Mar	0.04	0.08	1491	1498	1505	3.95	4.22	4.49	1782	2.52
Irrigation Season	Apr	0.04	0.10	1652	1658	1664	3.92	4.15	4.39	1949	2.77
	May	0.04	0.06	1443	1452	1460	4.41	4.74	5.06	1800	2.82
	Jun	0.04	0.00	909	929	950	6.80	7.62	8.43	2005	2.8
	Jul	0.04	0.18	1524	1528	1532	3.27	3.41	3.56	1661	2.48
	Aug	0.04	0.00	909	929	950	6.80	7.62	8.43	1684	2.47
	Sep	0.04	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.04	0.00	909	929	950	6.80	7.62	8.43	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.04	0.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	0	31	0.00
Nov	1	30	0.02
Dec	1	31	0.02
Jan	0	31	0.00
Feb	2	28	0.04
Mar	5	31	0.08
Apr	6	30	0.10
May	4	31	0.06
Jun	0	30	0.00
Jul	11	31	0.18
Aug	0	31	0.00
Sep	0	30	0.00

Table of Plotting Positions for graph

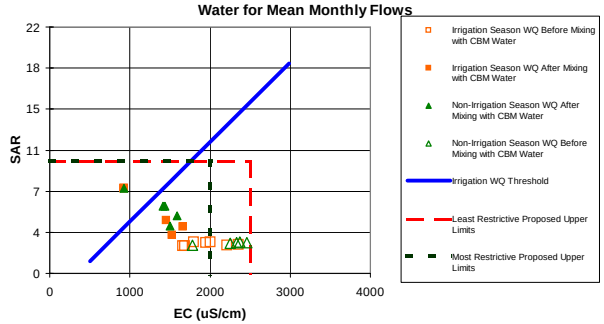
Plotting Position: Most and Least Restrictive Limits	EC	SAR
	0	10
Least Restrictive	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Year Conditions
Impact of CBM Development on Surface Water in Powder River Basin

CBNG Discharge Quality					
EC (uS/cm)			SAR (--)		
909	929	950	6.80	7.62	8.43

Dry Fork Cheyenne River: 2020
Stream Water Quality Before and After Mixing with CBM Produced Water for Mean Monthly Flows



		Monthly Mean		Mixed Water Quality						Background Water Quality	
		CBM Flow (cfs)	StreamFlow (cfs)	EC (uS/cm)			SAR (--)			EC (uS/cm)	SAR (--)
				95% lower	mean	95% upper	95% lower	mean	95% upper		
Non-Irrigation Season	Nov	0.04	0.02	1426	1440	1454	5.45	5.99	6.53	2460	2.74
	Dec	0.04	0.02	1396	1410	1424	5.46	6.01	6.55	2372	2.79
	Jan	0.04	0.00	909	929	950	6.80	7.62	8.43	2335	2.74
	Feb	0.04	0.04	1580	1590	1601	4.76	5.16	5.57	2251	2.71
	Mar	0.04	0.08	1491	1498	1505	3.95	4.22	4.49	1782	2.52
Irrigation Season	Apr	0.04	0.10	1652	1658	1664	3.92	4.15	4.39	1949	2.77
	May	0.04	0.06	1443	1452	1460	4.41	4.74	5.06	1800	2.82
	Jun	0.04	0.00	909	929	950	6.80	7.62	8.43	2005	2.8
	Jul	0.04	0.18	1524	1528	1532	3.27	3.41	3.56	1661	2.48
	Aug	0.04	0.00	909	929	950	6.80	7.62	8.43	1684	2.47
	Sep	0.04	0.00	909	929	950	6.80	7.62	8.43	2214	2.52
	Oct	0.04	0.00	909	929	950	6.80	7.62	8.43	2354	2.6

[1] Note:

Mixed water quality =
{(Q1 x C1) + (Q2 x C2)} / (Q1 + Q2)

Where:
Q1 = CBM Flow (cfs)
Q2 = Streamflow (cfs)
C1 = CBM EC or SAR
C2 = Background EC or SAR

Calculated Effective CBM Surface Discharge and Water Quality

Drainage	Stream Gauge Location	Estimated CBM Water Production (cfs)	Conveyance Losses (%)	Estimated CBM Discharge to River (cfs)	Cumulative Estimated CBM Discharge to River (cfs)
Dry Fork Cheyenne	Dry Fork Cheyenne River	0.1	0.7	0.04	0.0

Mean Monthly Discharge			
	Acre feet	Days	cfs
Oct	0	31	0.00
Nov	1	30	0.02
Dec	1	31	0.02
Jan	0	31	0.00
Feb	2	28	0.04
Mar	5	31	0.08
Apr	6	30	0.10
May	4	31	0.06
Jun	0	30	0.00
Jul	11	31	0.18
Aug	0	31	0.00
Sep	0	30	0.00

Table of Plotting Positions for graph

Plotting Position: Most and Least Restrictive Limits		
	EC	SAR
	0	10
Least Restrictiv	2500	10
	2500	0
Most Restrictive	0	10
	2000	10
	2000	0

Irrigation WQ Threshold Line	
EC	SAR
500	1.07
1000	4.62
1500	8.17
2990	18.75

Dry Fork Cheyenne Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC			SAR			EC			SAR			EC			SAR			EC			SAR			EC			SAR		
				(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)		
		EC	SAR	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork	95% Lower	Mean	95% Dry Fork
Dry Fork Cheyenne River	Nov	2460	2.7	909	929	950	6.8	7.6	8.4	2460	2460	2460	2.7	2.7	2.7	1529	1542	1554	5.2	5.7	6.2	1426	1440	1454	5.4	6.0	6.5	1426	1440	1454	5.4	6.0	6.5
	Dec	2372	2.8	909	929	950	6.8	7.6	8.4	2372	2372	2372	2.8	2.8	2.8	1494	1506	1519	5.2	5.7	6.2	1396	1410	1424	5.5	6.0	6.5	1396	1410	1424	5.5	6.0	6.5
	Jan	2335	2.7	909	929	950	6.8	7.6	8.4	Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
	Feb	2251	2.7	909	929	950	6.8	7.6	8.4	2251	2251	2251	2.7	2.7	2.7	1676	1685	1694	4.5	4.8	5.2	1580	1590	1601	4.8	5.2	5.6	1580	1590	1601	4.8	5.2	5.6
	Mar	1782	2.5	909	929	950	6.8	7.6	8.4	1782	1782	1782	2.5	2.5	2.5	1544	1549	1555	3.7	3.9	4.1	1491	1498	1505	3.9	4.2	4.5	1491	1498	1505	3.9	4.2	4.5
	Apr	1949	2.8	909	929	950	6.8	7.6	8.4	1949	1949	1949	2.8	2.8	2.8	1709	1714	1719	3.7	3.9	4.1	1652	1658	1664	3.9	4.2	4.4	1652	1658	1664	3.9	4.2	4.4
	May	1800	2.8	909	929	950	6.8	7.6	8.4	1800	1800	1800	2.8	2.8	2.8	1503	1510	1517	4.1	4.4	4.7	1443	1452	1460	4.4	4.7	5.1	1443	1452	1460	4.4	4.7	5.1
	Jun	2005	2.8	909	929	950	6.8	7.6	8.4	Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
	Jul	1661	2.5	909	929	950	6.8	7.6	8.4	1661	1661	1661	2.5	2.5	2.5	1554	1556	1559	3.1	3.2	3.3	1524	1528	1532	3.3	3.4	3.6	1524	1528	1532	3.3	3.4	3.6
	Aug	1684	2.5	909	929	950	6.8	7.6	8.4	Not Applicable			Not Applicable			909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4
	Sep	2214	2.5	909	929	950	6.8	7.6	8.4	Not Applicable						909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4
	Oct	2354	2.6	909	929	950	6.8	7.6	8.4	Not Applicable			Not Applicable			909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4	909	929	950	6.8	7.6	8.4

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC			SAR			EC			SAR			EC			SAR			EC			SAR		
		(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Dry Fork Cheyenne River	0.00%	0.0%		0.00%	0.0%		0.81%	-37.3%		8.62%	106.8%		0.97%	-41.5%		9.06%	118.6%		0.97%	-41.5%		9.06%	118.6%	
Dec		0.00%	0.0%		0.00%	0.0%		0.83%	-36.5%		8.59%	103.8%		0.99%	-40.5%		9.04%	115.3%		0.99%	-40.5%		9.04%	115.3%	
Jan		Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
Feb		0.00%	0.0%		0.00%	0.0%		0.53%	-25.2%		7.25%	77.6%		0.66%	-29.4%		7.89%	90.5%		0.66%	-29.4%		7.89%	90.5%	
Mar		0.00%	0.0%		0.00%	0.0%		0.37%	-13.0%		5.68%	55.1%		0.46%	-15.9%		6.43%	67.4%		0.46%	-15.9%		6.43%	67.4%	
Apr		0.00%	0.0%		0.00%	0.0%		0.28%	-12.1%		4.83%	40.4%		0.36%	-14.9%		5.60%	50.0%		0.36%	-14.9%		5.60%	50.0%	
May		0.00%	0.0%		0.00%	0.0%		0.46%	-16.1%		6.14%	56.7%		0.58%	-19.3%		6.87%	68.0%		0.58%	-19.3%		6.87%	68.0%	
Jun		Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
Jul		0.00%	0.0%		0.00%	0.0%		0.19%	-6.3%		3.62%	29.6%		0.25%	-8.0%		4.34%	37.7%		0.25%	-8.0%		4.34%	37.7%	
Aug		Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
Sep		Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
Oct		Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable			Not Applicable		
	Max	0.00%	0.00%		0.00%	0.00%		0.83%	-37.33%		8.62%	106.76%		0.99%	-41.48%		9.06%	118.63%		0.99%	-41.48%		9.06%	118.63%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Little Powder River Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC			SAR			EC			SAR			EC			SAR			EC			SAR			EC			SAR		
				(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)			(uS/cm)			(--)		
		EC	SAR	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little	95% Lower	Mean	95% Little
Little Powder River	Nov	3044	6.7	1493	1509	1524	10.0	10.5	11.0	1822	1834	1846	9.3	9.7	10.1	1747	1760	1773	9.4	9.9	10.3	1757	1770	1783	9.4	9.8	10.3	1792	1805	1817	9.3	9.8	10.2
	Dec	3300	6.9	1493	1509	1524	10.0	10.5	11.0	1910	1922	1934	9.3	9.7	10.1	1817	1830	1842	9.4	9.9	10.3	1829	1842	1855	9.4	9.8	10.3	1874	1886	1898	9.3	9.7	10.2
	Jan	2953	6.3	1493	1509	1524	10.0	10.5	11.0	1779	1792	1804	9.2	9.7	10.1	1713	1726	1740	9.4	9.9	10.3	1722	1735	1748	9.4	9.8	10.3	1753	1766	1779	9.3	9.8	10.2
	Feb	2477	5.6	1493	1509	1524	10.0	10.5	11.0	2261	2265	2268	6.5	6.6	6.8	2203	2207	2212	6.8	6.9	7.1	2212	2216	2221	6.7	6.9	7.0	2241	2245	2248	6.6	6.8	6.9
	Mar	1785	4.4	1493	1509	1524	10.0	10.5	11.0	1727	1730	1733	5.5	5.6	5.8	1711	1715	1719	5.8	6.0	6.1	1713	1717	1721	5.8	5.9	6.1	1721	1725	1728	5.6	5.8	5.9
	Apr	2457	5.6	1493	1509	1524	10.0	10.5	11.0	2213	2217	2221	6.7	6.8	6.9	2151	2156	2161	6.9	7.1	7.3	2161	2165	2170	6.9	7.1	7.2	2191	2196	2200	6.8	6.9	7.1
	May	2013	4.8	1493	1509	1524	10.0	10.5	11.0	1923	1926	1928	5.7	5.8	5.9	1897	1900	1904	6.0	6.1	6.2	1901	1904	1908	5.9	6.0	6.1	1914	1917	1920	5.8	5.9	6.0
	Jun	2333	5.3	1493	1509	1524	10.0	10.5	11.0	2078	2083	2088	6.7	6.9	7.0	2018	2024	2030	7.0	7.2	7.4	2027	2033	2039	7.0	7.2	7.4	2057	2062	2067	6.8	7.0	7.2
	Jul	2174	5.3	1493	1509	1524	10.0	10.5	11.0	1760	1769	1779	8.1	8.5	8.8	1710	1721	1732	8.5	8.8	9.2	1717	1728	1738	8.4	8.8	9.1	1741	1751	1761	8.3	8.6	8.9
	Aug	2860	6.6	1493	1509	1524	10.0	10.5	11.0	2355	2361	2366	7.8	8.0	8.2	2250	2257	2264	8.1	8.3	8.6	2266	2273	2279	8.0	8.3	8.5	2317	2323	2329	7.9	8.1	8.3
	Sep	2810	6.4	1493	1509	1524	10.0	10.5	11.0	1653	1666	1680	9.5	10.0	10.5	1613	1627	1641	9.6	10.1	10.6	1618	1632	1646	9.6	10.1	10.6	1637	1651	1664	9.6	10.0	10.5
	Oct	2289	5.7	1493	1509	1524	10.0	10.5	11.0	1622	1636	1649	9.3	9.7	10.2	1592	1605	1619	9.4	9.9	10.4	1596	1609	1623	9.4	9.9	10.3	1610	1624	1637	9.3	9.8	10.3

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Little Powder River	0.67%	-39.7%		4.39%	44.6%		0.74%	-42.2%		4.57%	47.3%		0.73%	-41.9%		4.55%	47.0%		0.70%	-40.7%		4.46%	45.7%	
Dec		0.62%	-41.8%		4.29%	39.4%		0.70%	-44.6%		4.50%	42.0%		0.69%	-44.2%		4.47%	41.6%		0.65%	-42.8%		4.37%	40.4%	
Jan		0.70%	-39.3%		4.48%	52.9%		0.76%	-41.5%		4.65%	55.8%		0.76%	-41.2%		4.63%	55.4%		0.72%	-40.2%		4.55%	54.0%	
Feb		0.15%	-8.6%		1.78%	19.4%		0.20%	-10.9%		2.17%	24.6%		0.19%	-10.5%		2.11%	23.8%		0.17%	-9.4%		1.92%	21.2%	
Mar		0.18%	-3.1%		1.90%	27.1%		0.23%	-3.9%		2.30%	34.7%		0.22%	-3.8%		2.24%	33.5%		0.20%	-3.4%		2.05%	29.8%	
Apr		0.18%	-9.8%		2.01%	22.5%		0.23%	-12.2%		2.41%	28.3%		0.22%	-11.9%		2.35%	27.4%		0.20%	-10.6%		2.15%	24.5%	
May		0.14%	-4.3%		1.61%	20.4%		0.18%	-5.6%		1.98%	26.4%		0.18%	-5.4%		1.93%	25.4%		0.15%	-4.8%		1.74%	22.5%	
Jun		0.23%	-10.7%		2.39%	29.9%		0.29%	-13.2%		2.79%	36.8%		0.28%	-12.9%		2.73%	35.8%		0.25%	-11.6%		2.54%	32.4%	
Jul		0.53%	-18.6%		3.88%	59.8%		0.62%	-20.8%		4.16%	67.0%		0.60%	-20.5%		4.12%	66.0%		0.56%	-19.5%		3.99%	62.5%	
Aug		0.24%	-17.5%		2.49%	22.1%		0.31%	-21.1%		2.89%	26.6%		0.30%	-20.5%		2.84%	25.9%		0.27%	-18.8%		2.64%	23.7%	
Sep		0.82%	-40.7%		4.74%	55.3%		0.87%	-42.1%		4.85%	57.2%		0.86%	-41.9%		4.83%	56.9%		0.84%	-41.3%		4.79%	56.1%	
Oct		0.80%	-28.5%		4.65%	69.6%		0.85%	-29.9%		4.78%	72.8%		0.84%	-29.7%		4.76%	72.4%		0.82%	-29.1%		4.70%	70.9%	
	Max	0.82%	-41.75%		4.74%	69.61%		0.87%	-44.55%		4.85%	72.83%		0.86%	-44.18%		4.83%	72.40%		0.84%	-42.85%		4.79%	70.88%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Upper Powder River Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		EC	SAR	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Upper Powder River	Nov	2650	6.4	2161	2180	2200	21.6	22.6	23.5	2642	2643	2643	6.7	6.7	6.7	2624	2625	2626	7.2	7.3	7.3	2619	2621	2622	7.4	7.4	7.5	2621	2622	2623	7.3	7.4	7.4
	Dec	2906	6.6	2161	2180	2200	21.6	22.6	23.5	2891	2892	2892	6.9	6.9	6.9	2857	2859	2860	7.6	7.7	7.7	2848	2850	2851	7.8	7.8	7.9	2852	2853	2854	7.7	7.8	7.8
	Jan	2482	6.4	2161	2180	2200	21.6	22.6	23.5	2476	2476	2476	6.7	6.7	6.7	2461	2462	2463	7.4	7.5	7.5	2457	2459	2460	7.6	7.7	7.7	2458	2460	2461	7.5	7.6	7.7
	Feb	2366	6.1	2161	2180	2200	21.6	22.6	23.5	2363	2364	2364	6.3	6.3	6.3	2357	2358	2359	6.8	6.8	6.9	2356	2357	2358	6.9	7.0	7.0	2356	2357	2358	6.9	6.9	6.9
	Mar	2051	5.3	2161	2180	2200	21.6	22.6	23.5	2052	2052	2052	5.4	5.4	5.4	2054	2054	2055	5.7	5.7	5.8	2054	2055	2056	5.8	5.8	5.8	2054	2055	2055	5.8	5.8	5.8
	Apr	2213	5.8	2161	2180	2200	21.6	22.6	23.5	2212	2213	2213	6.0	6.0	6.0	2211	2212	2213	6.4	6.4	6.4	2211	2212	2212	6.5	6.5	6.5	2211	2212	2213	6.4	6.5	6.5
	May	1803	4.9	2161	2180	2200	21.6	22.6	23.5	1805	1806	1806	5.0	5.0	5.0	1811	1812	1812	5.3	5.3	5.3	1813	1813	1814	5.4	5.4	5.4	1812	1813	1813	5.3	5.4	5.4
	Jun	1797	4.8	2161	2180	2200	21.6	22.6	23.5	1802	1803	1803	5.0	5.0	5.0	1815	1816	1817	5.6	5.6	5.7	1818	1819	1820	5.7	5.8	5.8	1817	1818	1819	5.7	5.7	5.8
	Jul	2716	6.8	2161	2180	2200	21.6	22.6	23.5	2703	2703	2704	7.1	7.2	7.2	2672	2674	2675	8.0	8.0	8.1	2664	2666	2668	8.2	8.3	8.4	2667	2669	2670	8.1	8.2	8.3
	Aug	2992	7.0	2161	2180	2200	21.6	22.6	23.5	2952	2953	2954	7.7	7.7	7.8	2867	2870	2873	9.2	9.3	9.5	2847	2850	2854	9.5	9.7	9.9	2854	2857	2861	9.4	9.6	9.7
	Sep	3400	7.8	2161	2180	2200	21.6	22.6	23.5	3330	3331	3332	8.6	8.7	8.7	3187	3190	3194	10.2	10.4	10.5	3153	3157	3161	10.6	10.8	11.0	3166	3169	3173	10.4	10.6	10.8
	Oct	2537	6.7	2161	2180	2200	21.6	22.6	23.5	2530	2530	2531	7.0	7.0	7.0	2514	2515	2516	7.6	7.7	7.7	2510	2511	2513	7.8	7.9	7.9	2511	2513	2514	7.7	7.8	7.9

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Upper Powder River	0.01%	-0.3%		0.23%	4.0%		0.04%	-0.9%		0.70%	13.3%		0.05%	-1.1%		0.81%	15.8%		0.04%	-1.0%		0.77%	14.8%	
Dec		0.01%	-0.5%		0.27%	4.8%		0.04%	-1.6%		0.82%	15.8%		0.05%	-1.9%		0.95%	18.7%		0.05%	-1.8%		0.90%	17.6%	
Jan		0.02%	-0.2%		0.28%	5.0%		0.05%	-0.8%		0.84%	16.6%		0.06%	-0.9%		0.97%	19.6%		0.06%	-0.9%		0.93%	18.5%	
Feb		0.01%	-0.1%		0.19%	3.4%		0.04%	-0.3%		0.60%	11.4%		0.04%	-0.4%		0.70%	13.6%		0.04%	-0.4%		0.66%	12.8%	
Mar		0.01%	0.0%		0.13%	2.5%		0.02%	0.2%		0.43%	8.5%		0.03%	0.2%		0.51%	10.1%		0.03%	0.2%		0.48%	9.5%	
Apr		0.01%	0.0%		0.16%	2.8%		0.03%	0.0%		0.50%	9.5%		0.04%	-0.1%		0.59%	11.4%		0.03%	-0.1%		0.55%	10.7%	
May		0.01%	0.1%		0.13%	2.4%		0.02%	0.5%		0.41%	8.2%		0.03%	0.6%		0.49%	9.8%		0.03%	0.5%		0.46%	9.2%	
Jun		0.02%	0.3%		0.28%	5.4%		0.05%	1.0%		0.83%	18.1%		0.06%	1.2%		0.96%	21.6%		0.06%	1.2%		0.91%	20.3%	
Jul		0.02%	-0.5%		0.32%	5.6%		0.06%	-1.6%		0.95%	18.4%		0.07%	-1.8%		1.09%	21.7%		0.06%	-1.7%		1.04%	20.5%	
Aug		0.03%	-1.3%		0.60%	10.8%		0.10%	-4.1%		1.55%	33.6%		0.12%	-4.7%		1.73%	39.1%		0.11%	-4.5%		1.67%	37.1%	
Sep		0.03%	-2.0%		0.62%	10.6%		0.11%	-6.2%		1.59%	32.4%		0.12%	-7.2%		1.78%	37.5%		0.12%	-6.8%		1.71%	35.6%	
Oct		0.01%	-0.3%		0.25%	4.3%		0.05%	-0.9%		0.76%	14.4%		0.06%	-1.0%		0.88%	17.1%		0.05%	-1.0%		0.84%	16.1%	
	Max	0.03%	-2.02%		0.62%	10.81%		0.11%	-6.16%		1.59%	33.59%		0.12%	-7.15%		1.78%	39.14%		0.12%	-6.79%		1.71%	37.10%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Upper Cheyenne Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		EC	SAR	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Upper cheyenne River	Nov	3565	7.2	909	929	950	6.8	7.6	8.4	3082	3086	3090	7.1	7.3	7.4	3082	3086	3090	7.1	7.3	7.4	3133	3136	3139	7.2	7.3	7.4	3186	3188	3191	7.2	7.3	7.4
	Dec	3405	7.4	909	929	950	6.8	7.6	8.4	2343	2352	2360	7.1	7.5	7.8	2343	2352	2360	7.1	7.5	7.8	2423	2431	2440	7.2	7.5	7.8	2513	2521	2528	7.2	7.5	7.8
	Jan	4229	8.6	909	929	950	6.8	7.6	8.4	4065	4066	4067	8.5	8.5	8.6	4065	4066	4067	8.5	8.5	8.6	4084	4085	4086	8.5	8.5	8.6	4104	4105	4106	8.5	8.5	8.6
	Feb	3911	8.0	909	929	950	6.8	7.6	8.4	3628	3630	3632	7.9	8.0	8.0	3628	3630	3632	7.9	8.0	8.0	3660	3662	3664	7.9	8.0	8.0	3693	3695	3696	7.9	8.0	8.0
	Mar	4127	8.7	909	929	950	6.8	7.6	8.4	3647	3650	3653	8.4	8.5	8.6	3647	3650	3653	8.4	8.5	8.6	3699	3701	3704	8.4	8.5	8.6	3753	3755	3758	8.4	8.5	8.6
	Apr	3630	7.9	909	929	950	6.8	7.6	8.4	3379	3381	3383	7.8	7.8	7.9	3379	3381	3383	7.8	7.8	7.9	3408	3410	3411	7.8	7.8	7.9	3437	3439	3440	7.8	7.9	7.9
	May	3155	6.9	909	929	950	6.8	7.6	8.4	3093	3093	3094	6.9	6.9	6.9	3093	3093	3094	6.9	6.9	6.9	3100	3101	3101	6.9	6.9	6.9	3108	3108	3109	6.9	6.9	6.9
	Jun	2895	5.9	909	929	950	6.8	7.6	8.4	2777	2779	2780	6.0	6.0	6.1	2777	2779	2780	6.0	6.0	6.1	2791	2792	2793	6.0	6.0	6.1	2805	2806	2807	6.0	6.0	6.0
	Jul	2250	5.7	909	929	950	6.8	7.6	8.4	1969	1973	1978	5.9	6.1	6.3	1969	1973	1978	5.9	6.1	6.3	1998	2002	2005	5.9	6.1	6.2	2028	2031	2035	5.9	6.0	6.1
	Aug	1972	4.8	909	929	950	6.8	7.6	8.4	1447	1457	1467	5.8	6.2	6.6	1447	1457	1467	5.8	6.2	6.6	1482	1492	1502	5.7	6.1	6.5	1523	1531	1540	5.7	6.0	6.3
	Sep	2271	5.6	909	929	950	6.8	7.6	8.4	2072	2075	2078	5.8	5.9	6.0	2072	2075	2078	5.8	5.9	6.0	2093	2096	2099	5.8	5.9	6.0	2116	2118	2121	5.8	5.9	5.9
	Oct	2916	6.5	909	929	950	6.8	7.6	8.4	2594	2597	2600	6.5	6.6	6.8	2594	2597	2600	6.5	6.6	6.8	2628	2631	2634	6.5	6.6	6.7	2664	2667	2669	6.5	6.6	6.7

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Upper cheyenne River	0.12%	-13.4%		2.03%	1.0%		0.12%	-13.4%		2.03%	1.0%		0.11%	-12.0%		1.82%	0.9%		0.09%	-10.6%		1.60%	0.8%	
Dec		0.38%	-30.9%		4.63%	1.3%		0.38%	-30.9%		4.63%	1.3%		0.34%	-28.6%		4.28%	1.2%		0.30%	-26.0%		3.89%	1.1%	
Jan		0.03%	-3.9%		0.47%	-0.6%		0.03%	-3.9%		0.47%	-0.6%		0.02%	-3.4%		0.42%	-0.5%		0.02%	-2.9%		0.36%	-0.4%	
Feb		0.05%	-7.2%		0.96%	-0.5%		0.05%	-7.2%		0.96%	-0.5%		0.05%	-6.4%		0.85%	-0.4%		0.04%	-5.5%		0.74%	-0.4%	
Mar		0.09%	-11.6%		1.43%	-1.8%		0.09%	-11.6%		1.43%	-1.8%		0.08%	-10.3%		1.27%	-1.6%		0.06%	-9.0%		1.11%	-1.4%	
Apr		0.06%	-6.9%		0.96%	-0.3%		0.06%	-6.9%		0.96%	-0.3%		0.05%	-6.1%		0.85%	-0.3%		0.04%	-5.3%		0.73%	-0.2%	
May		0.02%	-2.0%		0.33%	0.3%		0.02%	-2.0%		0.33%	0.3%		0.02%	-1.7%		0.29%	0.3%		0.01%	-1.5%		0.25%	0.2%	
Jun		0.04%	-4.0%		0.80%	1.7%		0.04%	-4.0%		0.80%	1.7%		0.04%	-3.5%		0.71%	1.5%		0.03%	-3.1%		0.61%	1.3%	
Jul		0.22%	-12.3%		2.80%	7.1%		0.22%	-12.3%		2.80%	7.1%		0.20%	-11.0%		2.53%	6.4%		0.17%	-9.7%		2.25%	5.6%	
Aug		0.71%	-26.1%		6.49%	28.6%		0.71%	-26.1%		6.49%	28.6%		0.64%	-24.3%		6.14%	26.7%		0.58%	-22.3%		5.73%	24.5%	
Sep		0.15%	-8.6%		2.01%	5.2%		0.15%	-8.6%		2.01%	5.2%		0.13%	-7.7%		1.80%	4.6%		0.11%	-6.7%		1.58%	4.0%	
Oct		0.13%	-10.9%		1.97%	2.9%		0.13%	-10.9%		1.97%	2.9%		0.11%	-9.8%		1.76%	2.6%		0.10%	-8.6%		1.55%	2.2%	
	Max	0.71%	-30.94%		6.49%	28.64%		0.71%	-30.94%		6.49%	28.64%		0.64%	-28.59%		6.14%	26.71%		0.58%	-25.97%		5.73%	24.51%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Belle Fourche Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC	SAR	EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
				95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Belle Fourche River	Nov	2877	7.0	1102	1110	1117	8.4	8.8	9.2	1479	1485	1491	8.1	8.4	8.8	1509	1515	1521	8.1	8.4	8.7	1597	1603	1608	8.0	8.3	8.6	1715	1720	1725	8.0	8.2	8.5
	Dec	2755	6.8	1102	1110	1117	8.4	8.8	9.2	1409	1415	1421	8.1	8.5	8.8	1434	1440	1446	8.1	8.4	8.7	1509	1515	1521	8.0	8.3	8.6	1612	1617	1622	7.9	8.2	8.5
	Jan	2887	6.3	1102	1110	1117	8.4	8.8	9.2	1337	1343	1350	8.2	8.5	8.8	1357	1364	1370	8.1	8.5	8.8	1420	1426	1433	8.1	8.4	8.7	1509	1515	1521	8.0	8.3	8.6
	Feb	1907	4.1	1102	1110	1117	8.4	8.8	9.2	1632	1634	1637	5.6	5.7	5.8	1649	1652	1654	5.5	5.6	5.7	1693	1695	1697	5.2	5.3	5.4	1738	1740	1741	5.0	5.1	5.2
	Mar	1564	3.6	1102	1110	1117	8.4	8.8	9.2	1493	1494	1495	4.4	4.4	4.5	1498	1499	1501	4.3	4.4	4.4	1512	1513	1514	4.2	4.2	4.3	1525	1525	1526	4.1	4.1	4.1
	Apr	1722	4.3	1102	1110	1117	8.4	8.8	9.2	1435	1438	1442	6.2	6.4	6.6	1450	1453	1456	6.1	6.3	6.5	1489	1492	1495	5.9	6.0	6.2	1532	1534	1537	5.6	5.7	5.8
	May	1532	3.8	1102	1110	1117	8.4	8.8	9.2	1371	1373	1376	5.5	5.7	5.8	1380	1383	1386	5.4	5.6	5.7	1405	1407	1409	5.2	5.3	5.4	1431	1433	1434	4.9	5.0	5.1
	Jun	1821	4.0	1102	1110	1117	8.4	8.8	9.2	1426	1430	1435	6.4	6.6	6.9	1444	1448	1452	6.3	6.5	6.7	1491	1494	1498	6.0	6.2	6.4	1545	1548	1551	5.7	5.8	6.0
	Jul	1182	3.1	1102	1110	1117	8.4	8.8	9.2	1167	1169	1170	4.1	4.2	4.2	1169	1170	1171	4.0	4.1	4.1	1171	1172	1173	3.8	3.9	3.9	1174	1175	1175	3.6	3.7	3.7
	Aug	1955	5.1	1102	1110	1117	8.4	8.8	9.2	1448	1453	1458	7.1	7.3	7.5	1469	1473	1477	7.0	7.2	7.4	1524	1528	1532	6.8	7.0	7.2	1590	1593	1596	6.5	6.7	6.8
	Sep	2231	5.8	1102	1110	1117	8.4	8.8	9.2	1347	1353	1359	7.9	8.2	8.5	1366	1372	1378	7.8	8.1	8.4	1423	1428	1434	7.7	8.0	8.2	1498	1503	1508	7.5	7.8	8.0
	Oct	2346	5.8	1102	1110	1117	8.4	8.8	9.2	1213	1220	1227	8.2	8.6	8.9	1223	1230	1237	8.2	8.5	8.9	1255	1262	1268	8.1	8.5	8.8	1302	1308	1314	8.0	8.3	8.7

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Belle Fourche River	0.40%	-48.4%		3.65%	20.4%		0.39%	-47.3%		3.58%	19.9%		0.34%	-44.3%		3.39%	18.6%		0.29%	-40.2%		3.12%	16.9%	
Dec		0.44%	-48.6%		3.77%	24.8%		0.42%	-47.7%		3.72%	24.4%		0.38%	-45.0%		3.54%	23.0%		0.33%	-41.3%		3.30%	21.1%	
Jan		0.49%	-53.5%		4.00%	35.1%		0.48%	-52.8%		3.96%	34.7%		0.44%	-50.6%		3.84%	33.2%		0.39%	-47.5%		3.66%	31.2%	
Feb		0.16%	-14.3%		2.35%	39.8%		0.15%	-13.4%		2.24%	37.3%		0.12%	-11.1%		1.95%	31.0%		0.09%	-8.8%		1.62%	24.5%	
Mar		0.08%	-4.5%		1.36%	22.0%		0.07%	-4.1%		1.27%	20.3%		0.06%	-3.3%		1.05%	16.1%		0.04%	-2.5%		0.82%	12.2%	
Apr		0.25%	-16.5%		2.82%	48.0%		0.23%	-15.6%		2.72%	45.5%		0.19%	-13.4%		2.44%	38.9%		0.15%	-10.9%		2.10%	31.7%	
May		0.21%	-10.4%		2.58%	49.5%		0.19%	-9.7%		2.47%	46.5%		0.16%	-8.1%		2.19%	39.0%		0.12%	-6.5%		1.84%	31.0%	
Jun		0.29%	-21.4%		3.23%	67.0%		0.28%	-20.5%		3.15%	64.0%		0.23%	-17.9%		2.90%	56.0%		0.19%	-15.0%		2.57%	46.8%	
Jul		0.12%	-1.1%		1.73%	33.9%		0.11%	-1.0%		1.63%	31.3%		0.09%	-0.8%		1.37%	25.0%		0.07%	-0.6%		1.09%	19.0%	
Aug		0.31%	-25.7%		3.18%	44.3%		0.29%	-24.7%		3.09%	42.5%		0.25%	-21.8%		2.84%	37.7%		0.20%	-18.5%		2.51%	31.9%	
Sep		0.44%	-39.4%		3.75%	41.8%		0.42%	-38.5%		3.70%	40.9%		0.38%	-36.0%		3.52%	38.2%		0.33%	-32.6%		3.28%	34.6%	
Oct		0.57%	-48.0%		4.17%	48.9%		0.56%	-47.6%		4.14%	48.4%		0.53%	-46.2%		4.06%	47.0%		0.49%	-44.2%		3.94%	45.0%	
	Max	0.57%	-53.48%		4.17%	66.98%		0.56%	-52.77%		4.14%	64.02%		0.53%	-50.60%		4.06%	56.03%		0.49%	-47.52%		3.94%	46.83%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit

Antelope Creek Sensitivity Analysis
Dry Year Conditions

River	Month	Background		CBNG Discharge Quality						Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
				EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		EC	SAR	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper	95% Lower	Mean	95% upper
Antelope Creek	Nov	2460	2.7	909	929	950	6.8	7.6	8.4	1386	1400	1415	5.6	6.1	6.7	1076	1095	1114	6.4	7.1	7.8	1046	1066	1085	6.4	7.2	7.9	1053	1072	1091	6.4	7.2	7.9
	Dec	2372	2.8	909	929	950	6.8	7.6	8.4	1118	1136	1153	6.2	6.9	7.6	972	992	1012	6.6	7.4	8.2	960	980	1001	6.7	7.4	8.2	963	983	1003	6.7	7.4	8.2
	Jan	2335	2.7	909	929	950	6.8	7.6	8.4	1256	1272	1288	5.8	6.4	7.0	1024	1043	1062	6.5	7.2	8.0	1003	1022	1042	6.5	7.3	8.1	1007	1027	1046	6.5	7.3	8.0
	Feb	2251	2.7	909	929	950	6.8	7.6	8.4	1486	1498	1510	5.0	5.5	6.0	1138	1155	1173	6.1	6.8	7.5	1100	1117	1135	6.2	6.9	7.6	1108	1126	1143	6.2	6.9	7.6
	Mar	1782	2.5	909	929	950	6.8	7.6	8.4	1557	1563	1568	3.6	3.8	4.0	1293	1305	1317	4.9	5.4	5.8	1248	1260	1273	5.1	5.6	6.1	1258	1270	1283	5.1	5.6	6.1
	Apr	1949	2.8	909	929	950	6.8	7.6	8.4	1492	1501	1511	4.5	4.9	5.3	1177	1193	1208	5.8	6.4	7.0	1136	1153	1169	5.9	6.6	7.2	1146	1162	1178	5.9	6.5	7.1
	May	1800	2.8	909	929	950	6.8	7.6	8.4	1276	1288	1300	5.2	5.6	6.1	1051	1069	1087	6.2	6.8	7.5	1027	1045	1064	6.3	7.0	7.7	1033	1051	1069	6.2	6.9	7.6
	Jun	2005	2.8	909	929	950	6.8	7.6	8.4	1047	1065	1083	6.3	7.0	7.7	950	970	990	6.6	7.4	8.2	942	963	983	6.7	7.5	8.3	944	964	984	6.7	7.5	8.2
	Jul	1661	2.5	909	929	950	6.8	7.6	8.4	1460	1466	1471	3.6	3.9	4.1	1231	1243	1255	5.0	5.4	5.9	1191	1204	1218	5.2	5.7	6.2	1200	1213	1226	5.1	5.6	6.1
	Aug	1684	2.5	909	929	950	6.8	7.6	8.4	1163	1177	1191	5.4	5.9	6.5	1000	1018	1037	6.3	7.0	7.7	984	1003	1021	6.4	7.1	7.9	987	1006	1025	6.4	7.1	7.8
	Sep	2214	2.5	909	929	950	6.8	7.6	8.4	1831	1837	1844	3.8	4.0	4.3	1426	1439	1452	5.1	5.6	6.1	1360	1374	1388	5.3	5.9	6.4	1375	1389	1402	5.3	5.8	6.3
	Oct	2354	2.6	909	929	950	6.8	7.6	8.4	1313	1328	1343	5.6	6.2	6.8	1047	1066	1085	6.4	7.1	7.9	1022	1042	1061	6.5	7.2	8.0	1028	1047	1066	6.5	7.2	7.9

Upper portion of spreadsheet collects data from previous worksheets and summarizes here

Month	River	Mixed Water Quality 2003						Mixed Water Quality 2010						Mixed Water Quality - 2015						Mixed Water Quality - 2020					
		EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)			EC (uS/cm)			SAR (--)		
		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)		95% Confidence (plus or minus) (2)	Mean (1)	
Nov	Antelope Creek	1.03%	-43.1%		9.22%	123.2%		1.70%	-55.5%		10.25%	158.7%		1.79%	-56.7%		10.33%	162.1%		1.77%	-56.4%		10.31%	161.4%	
Dec		1.58%	-52.1%		10.08%	148.3%		2.01%	-58.2%		10.52%	165.4%		2.06%	-58.7%		10.55%	166.9%		2.05%	-58.6%		10.54%	166.6%	
Jan		1.24%	-45.5%		9.58%	134.6%		1.84%	-55.3%		10.37%	163.6%		1.91%	-56.2%		10.43%	166.2%		1.89%	-56.0%		10.41%	165.6%	
Feb		0.79%	-33.4%		8.43%	103.1%		1.50%	-48.7%		9.96%	150.1%		1.60%	-50.4%		10.10%	155.3%		1.58%	-50.0%		10.07%	154.1%	
Mar		0.34%	-12.3%		5.47%	52.0%		0.90%	-26.8%		8.48%	113.1%		1.01%	-29.3%		8.84%	123.7%		0.99%	-28.7%		8.76%	121.3%	
Apr		0.61%	-23.0%		7.30%	76.8%		1.30%	-38.8%		9.49%	129.7%		1.41%	-40.9%		9.70%	136.6%		1.39%	-40.4%		9.66%	135.1%	
May		0.95%	-28.4%		8.49%	100.0%		1.64%	-40.6%		9.99%	142.8%		1.73%	-41.9%		10.12%	147.4%		1.71%	-41.6%		10.09%	146.4%	
Jun		1.71%	-46.9%		10.15%	150.3%		2.07%	-51.6%		10.54%	165.5%		2.10%	-52.0%		10.57%	166.7%		2.10%	-51.9%		10.56%	166.4%	
Jul		0.38%	-11.8%		5.65%	55.3%		0.96%	-25.2%		8.60%	118.4%		1.08%	-27.5%		8.94%	129.2%		1.05%	-27.0%		8.86%	126.8%	
Aug		1.19%	-30.1%		9.23%	139.9%		1.81%	-39.5%		10.25%	183.8%		1.88%	-40.5%		10.33%	188.1%		1.87%	-40.3%		10.32%	187.2%	
Sep		0.33%	-17.0%		5.95%	59.3%		0.88%	-35.0%		8.78%	122.0%		0.99%	-37.9%		9.10%	132.2%		0.97%	-37.3%		9.03%	129.9%	
Oct		1.13%	-43.6%		9.44%	138.9%		1.77%	-54.7%		10.32%	174.4%		1.85%	-55.8%		10.39%	177.7%		1.83%	-55.5%		10.38%	177.0%	
	Max	1.71%	-52.13%		10.15%	150.28%		2.07%	-58.17%		10.54%	183.81%		2.10%	-58.67%		10.57%	188.13%		2.10%	-58.56%		10.56%	187.20%	

(1) Computed difference between mixed water and background water quality
(2) Computed difference (as a percentage) between mixed mean water quality and upper or lower 95% confidence limit