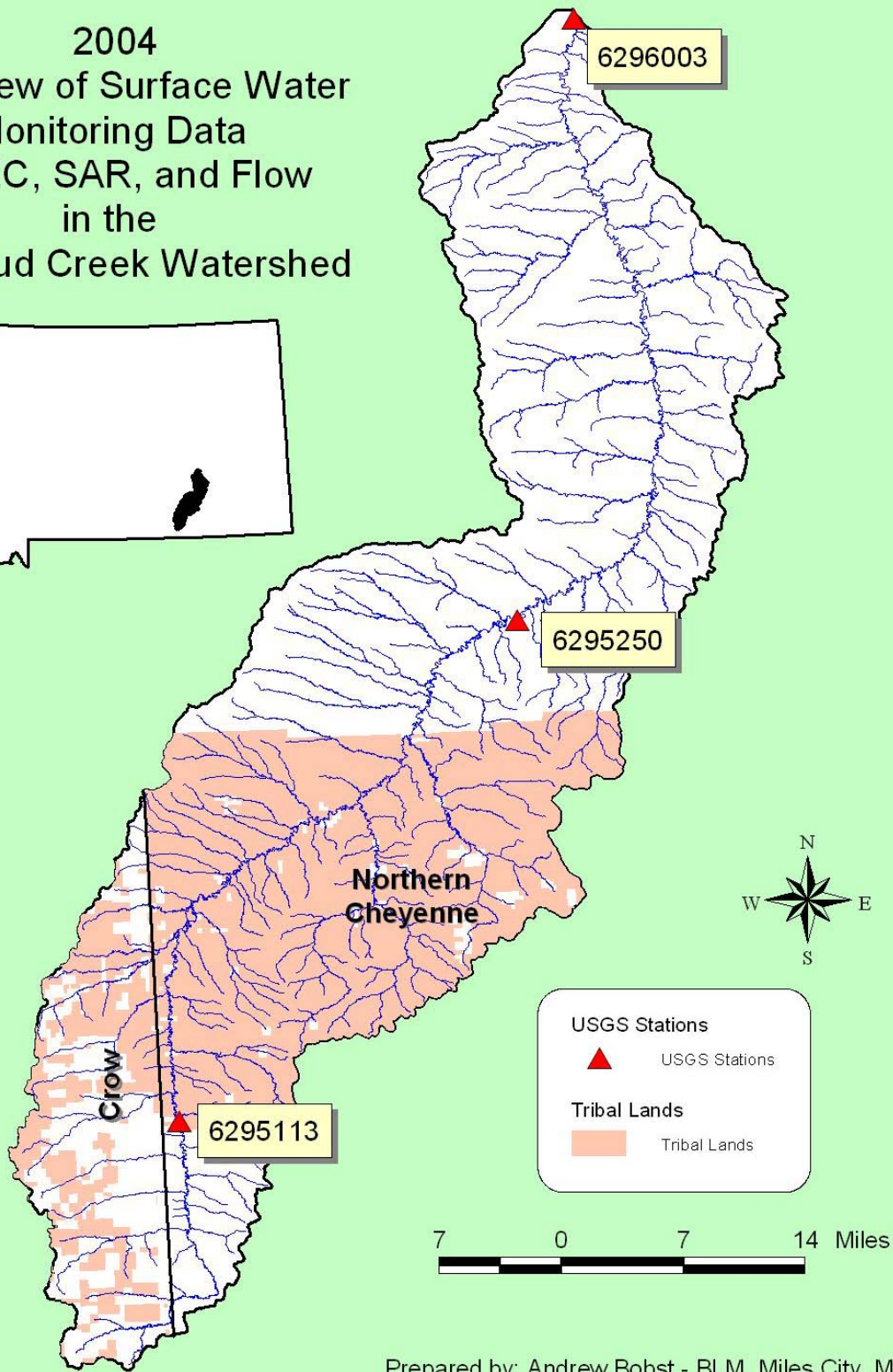
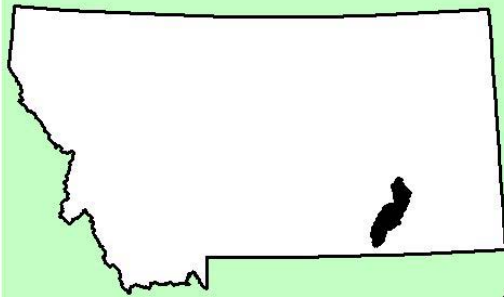


2004  
Overview of Surface Water  
Monitoring Data  
for EC, SAR, and Flow  
in the  
Rosebud Creek Watershed



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*This cover map shows the Rosebud Creek Watershed. Also shown are streams, and tribal lands. The locations of the 3 surface water monitoring sites which are the subject of this report are also included.*

**Introduction:**

The Rosebud Creek watershed has been identified as a watershed that may experience Coal Bed Natural Gas (CBNG) development (BLM, 2003). CBNG is typically produced by pumping groundwater from the coal bed aquifer. This reduces the hydrostatic pressure within the coal seam (allowing the methane to desorb from the coal surface) and creates a pressure gradient within the aquifer that allows the methane to flow towards the pumping wells. The waters contained within the coal seams have high sodium adsorption ratios (SAR (a complex ratio of Na to Ca+Mg) typically between 30 and 60), very little sulfate, and are moderately saline (electrical conductivity (EC) values on the order of 2,000 microseamens per centimeters (uS/cm)) (VanVoast, 2003).

One method which has been employed to manage this co-produced water is to discharge it, either treated or untreated, into surface waters under a National Pollutant Discharge Elimination System (NPDES) permit. In Montana, discharge permitting is conducted by the Montana Department of Environmental Quality (MDEQ) under its Montana Pollutant Discharge Elimination System (MPDES) permit program. On the Northern Cheyenne Reservation, the NPDES program is administered by the EPA. CBNG discharges could have noticeable effects on the quality and quantity (flow) of water in Rosebud Creek. The parameters most likely to be affected by CBNG discharges are EC and SAR (MDEQ, 2003), and so this report will focus on these. The MDEQ has adopted standards for EC and SAR which apply to Rosebud Creek. These standards are summarized on Table 1. MDEQ has defined the irrigation season as extending from March 1<sup>st</sup> to October 31<sup>st</sup>.

There is currently no CBNG activity in the Rosebud Creek watershed. The purpose of this report is to establish baseline condition based upon historical data, and data collected during water year 2004, and preliminary data from water year 2005, as available (water years run from October 1<sup>st</sup> to September 30<sup>th</sup>).

There are three active surface water monitoring stations within the Rosebud Creek watershed (see cover map). These stations are located near Kirby (upstream of the Northern Cheyenne Reservation; 6295113), near Colstrip (downstream of the Northern Cheyenne Reservation; 6295250) and near Rosebud (at the mouth; 6296003). The monitoring of these stations is funded by the Northern Cheyenne Tribe, the USGS, and the BLM. The Northern Cheyenne Tribe and USGS are currently splitting the cost of measuring flows at all 3 stations, and collecting realtime EC measurements at the station near Kirby (upstream of the reservation). The BLM is currently funding collection of analytical samples at the Kirby, and Rosebud stations. During water year 2004, realtime EC measurements were not collected at the Kirby station, and analytical samples were not collected at the Rosebud station.

**Data Review:**

Realtime data refers to that data collected by an in situ data collection device, with readouts sent to a central data base on a short time interval. Mean daily values are used to evaluate realtime data in this report. Analytical samples are grab samples collected at the station and sent for laboratory analysis. Analytical samples are of higher quality since instrument drift may be an issue with realtime data, while analytical analysis includes regular recalibration of the equipment.

Rosebud Creek near Kirby, MT: Only flow was measured in real time at this site. Twelve analytical samples were collected in water year 2004, and the preliminary results for 8 analytical samples from water year 2005 are available.

During water year 2004 recorded real-time flow values ranged from 0.0 to 8.0 cfs, with the mean being 1.73 cfs. Peak flows occurred in February. The historical mean flow record for this site (1980-2004) indicates flows at this station in an "average" year range from 1.07 to 19.6 cfs with the mean being 5.85 cfs. Thus flows during 2004 were overall lower than the historical record, with a substantially reduced spring peak (see Figure 1). This reduction vs. the historical record is believed to be mainly attributable to the lack of snow pack during the winter of 2003-2004, and the continued drought throughout this region (see Appendix A). Other factors such as new or changed irrigation, municipal, stock, or industrial use could also be affecting streamflow; however no changes in these activities are known to have occurred.

During water year 2004 analytical EC values at this site ranged from 880 to 1190 uS/cm, with the mean being 1076 uS/cm. Analytical SAR values at this site ranged from 0.7 to 1.1 with the mean being 0.9. Recorded instantaneous EC values were in excess of the MDEQ's mean monthly irrigation season standard (1000 uS/cm) much of the time. The MDEQ's NTE standards for EC were not exceeded. Recorded SAR values did not exceed the MDEQ's standards (see Table 2 and Figure 2). The preliminary data 8 EC samples and 6 SAR samples in water year 2005 were in line with 2004 data (see Figure 2).

Historical EC and SAR values at this site vary with flow. Historical EC values were routinely above the MDEQ's irrigation season mean monthly standard (EC<1000 uS/cm), but did not exceed the "Not to Exceed" (NTE) standard (EC<1500 uS/cm) (see Figure 3). Historical SAR values did not exceed MDEQ's mean monthly standard irrigation season standard (SAR<3.0), and did not exceed the NTE standard (SAR<4.5) (see Figure 4). Based upon this historical information, the mean monthly EC standard may not be attainable in Rosebud Creek during low flow years. This may be due to the quality of groundwater inflows, irrigation, or geology/soils (i.e. availability of soluble salts).

Recorded EC and SAR values were in line with historical values during comparable flows (see Figures 3 and 4).

Rosebud Creek near Colstrip, MT: Only flow was measured in real time at this site. No analytical samples were collected.

During water year 2004 recorded real-time flow values ranged from 0.0 to 80 cfs, with the mean being 3.6 cfs. Peak flows occurred in February. The historical mean flow record for this site (1975-2004) indicates flows at this station in an "average" year range from 5.14 to 63.7 cfs with the mean being 22.7 cfs. Thus flows during 2004 were overall lower than the historical record (see Table 3 and Figure 5). This reduction vs. the historical record is believed to be mainly attributable to the lack of snow pack during the winter of 2003-2004, and the continued drought throughout this region (see Appendix A). Other factors such as new or changed irrigation, municipal, stock, or industrial use could also be affecting streamflow; however no changes in these activities are known to have occurred.

Historical EC and SAR values at this site vary with flow. Historical EC values were often above the MDEQ's irrigation season mean monthly standard (EC<1000 uS/cm) and routinely above the NTE standard (EC<1500 uS/cm) (see Figure 6). Historical SAR values rarely exceeded the MDEQ's mean monthly standard irrigation season standard (SAR<3.0), and did not exceed the NTE standard (SAR<4.5) (see Figure 7). Based upon this historical information, the mean monthly EC standard may not be attainable in Rosebud Creek during low flow years. This may be due to the quality of groundwater inflows, irrigation, or geology/soils (i.e. availability of soluble salts).

Rosebud Creek near Rosebud, MT: Flow was measured in real time at this site. No analytical samples were collected in water year 2004; however some preliminary results are available for 2005.

During water year 2004 recorded real-time flow values ranged from 0.0 to 250 cfs, with the mean being 4.1 cfs. Peak flows occurred in February. The historical mean flow record for this site (1975-2004) indicates that flows at this station in an "average" year ranges from 3.6 to 128 cfs with the mean being 26.8 cfs. Thus flows during 2004 were overall lower than the historical record (see Figure 8). This reduction vs. the historical record is believed to be mainly attributable to the lack of snow pack during the winter of 2003-2004, and the continued drought throughout this region (see Appendix A). Other factors such as new or changed irrigation, municipal, stock, or industrial use could also be affecting streamflow; however no changes in these activities are known to have occurred.

The preliminary results of 5 EC samples and 2 SAR samples for water year 2005 indicate that this station is often in excess of the EC standards, but is well below the SAR standards (see Figure 9).

Historical EC and SAR values at this site vary with flow. Historical EC values were often above the MDEQ's irrigation season mean monthly standard (EC<1000 uS/cm) and routinely above the NTE standard (EC<1500 uS/cm) (see Figure 10). Historical SAR values were often above the MDEQ's mean monthly standard irrigation season standard (SAR<3.0), and routinely above the NTE limit (SAR<4.5) (see Figure 11). Based upon this historical information, the EC and SAR standards may not be attainable in Rosebud

Creek during low flow years. This may be due to the quality of groundwater inflows, irrigation, or geology/soils (i.e. availability of soluble salts).

The preliminary EC values for water year 2005 were in line with historical values during comparable flows (see Figure 10). The preliminary SAR values for water year 2005 were somewhat less than historical values during comparable flows (see Figure 11).

**Conclusions:**

During water year 2004 flows within the Rosebud Creek watershed were substantially less than historical values. Since EC and SAR are both closely correlated with flow, EC and SAR values were also elevated in water year 2004. Recorded values for EC and SAR were in line with that expected based upon historical relationships between EC and SAR vs. Flow.

At the station at Rosebud the MDEQ surface water standards for EC were exceeded in water year 2005, and they have historically been exceeded. SAR values at the Rosebud station have also historically exceeded the MDEQ standards. EC and SAR values appear to be in line with historical trends, and no CBNG development is currently occurring in this watershed. As such these standards may be unattainable during low flow years.

**References:**

BLM, 2003, Record of Decision and Final Statewide Oil and Gas EIS and Proposed Amendment of the Powder River and Billings RMPs.

MDEQ, 2003, Record of Decision for Montana Statewide Oil and Gas Environmental Impact Statement August 7, 2003, 14 pgs.

VanVoast, W.A., 2003, Geochemical signature of formation waters associated with coalbed methane, AAPG Bulletin, v. 87, no. 4 (April 2003), pp. 667–676.

**Reviewed by:**

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Hydrology, Wetland, Riparian, and Air Program Lead

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# Tables

**Table 1**

<b>MDEQ's Standards for EC and SAR in Rosebud Creek</b>				
	Mean Monthly EC	NTE EC	Mean Monthly SAR	NTE SAR
Irrigation Season	1000	1500	3.0	4.5
Non-Irrigation Season	1500	2500	5.0	7.5
NTE = "Not to Exceed"				

**Table 2**

06295113 ROSEBUD CREEK AT RESERVATION BOUNDARY, NEAR KIRBY, MT						
Summary Statistics - Water Years 2004 and Pre-1999						
Sample Statistics	Instant. Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
n	41	12	41	12	41	12
Min	0.65	0.03	688	880	0.4	0.69
Max	43	5.0	1080	1190	0.9	1.1
Mean	6.78	1.49	955	1076	0.7	0.89
Median	4.4	1.25	960	1092	0.7	0.89
Daily Value Statistics	Mean Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
Min	0.00	0.00	None	None	None	None
Max	170	8.0	None	None	None	None
Mean	6.73	1.73	None	None	None	None
Median	3.7	1.30	None	None	None	None
Min Monthly Mean	0.09	0.43	None	None	None	None
Max Monthly Mean	41.8	5.16	None	None	None	None

**Table 3**

06295250 ROSEBUD CREEK NEAR COLSTRIP, MT						
Summary Statistics - Water Years 2004 and Pre-1999						
Sample Statistics	Instant. Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
n	97	None	97	None	97	None
Min	0.29	None	310	None	0.5	None
Max	310	None	2480	None	3.3	None
Mean	47	None	1327	None	1.5	None
Median	27	None	1310	None	1.3	None
Daily Value Statistics	Mean Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
Min	0.00	0.00	None	None	None	None
Max	668	80	None	None	None	None
Mean	26	3.6	None	None	None	None
Median	13	0.9	None	None	None	None
Min Monthly Mean	0.00	0.00	None	None	None	None
Max Monthly Mean	306	16.0	None	None	None	None



**Table 4**

06296003 ROSEBUD CREEK AT MOUTH, NEAR ROSEBUD, MT						
Summary Statistics - Water Years 2004 and Pre-1999						
Sample Statistics	Instant. Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
n	127	None	127	None	127	None
Min	0.05	None	198	None	0.9	None
Max	916	None	3210	None	9.0	None
Mean	58.1	None	1585	None	3.1	None
Median	21.0	None	1520	None	2.0	None
Daily Value Statistics	Mean Streamflow		Specific Conductance		SAR	
	pre-99	2004	pre-99	2004	pre-99	2004
Min	0.00	0.00	None	None	None	None
Max	2800	250	None	None	None	None
Mean	31.0	4.1	None	None	None	None
Median	9.8	0.06	None	None	None	None
Min Monthly Mean	0.00	0.10	None	None	None	None
Max Monthly Mean	478	35.10	None	None	None	None

# Figures

**Figure 1: Rosebud Creek near Kirby (6295113)**

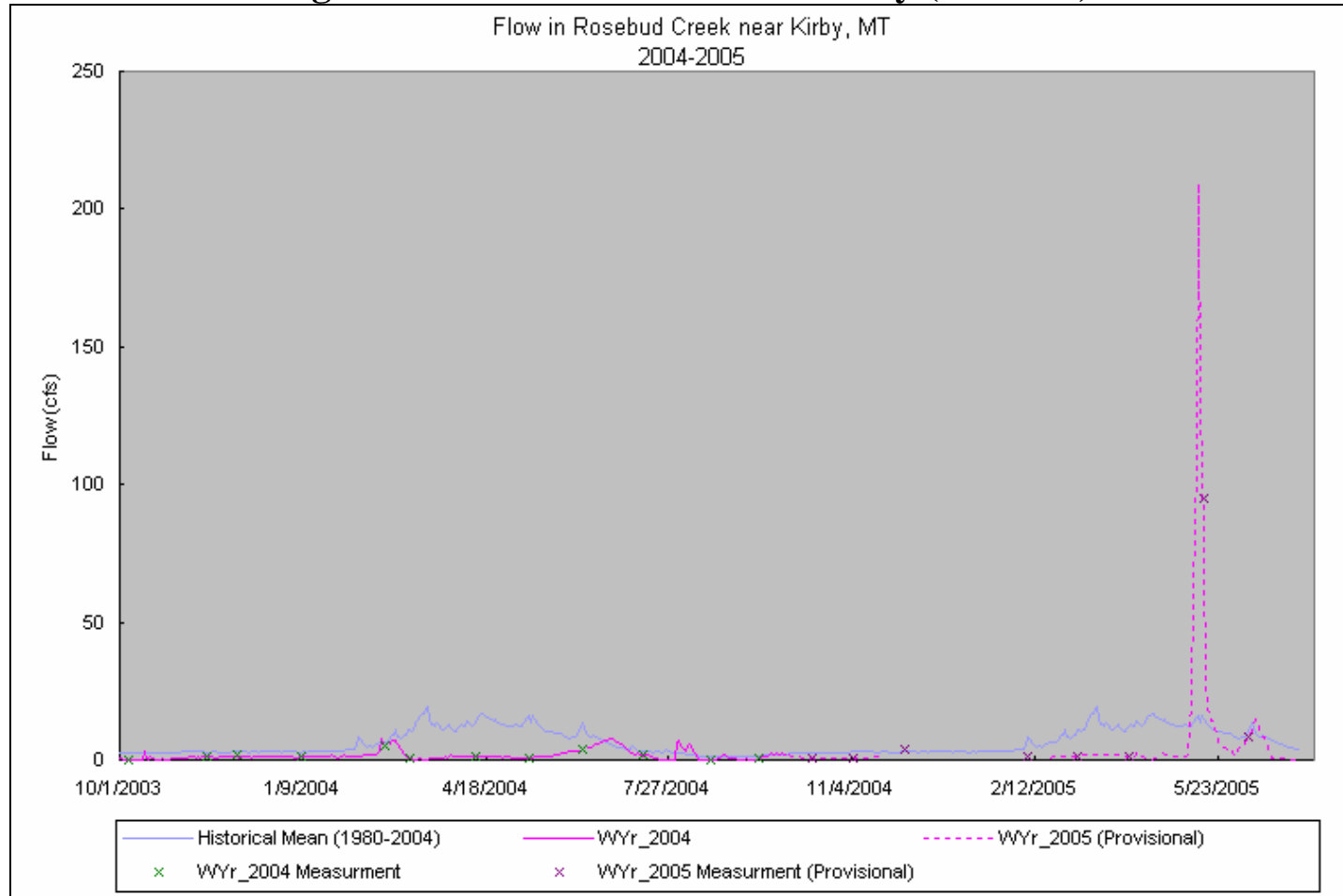


Figure 1 shows realtime flow values in a time series plot for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Kirby, MT. Historical daily mean flow values are also shown. Recorded flow values during water year 2004 ranged from 0 to 8 cfs. During water year 2004 the spring flow was substantially less than historical values and flows were less than historical daily mean values for most of the year.

**Figure 2: Rosebud Creek near Kirby (6295113)**

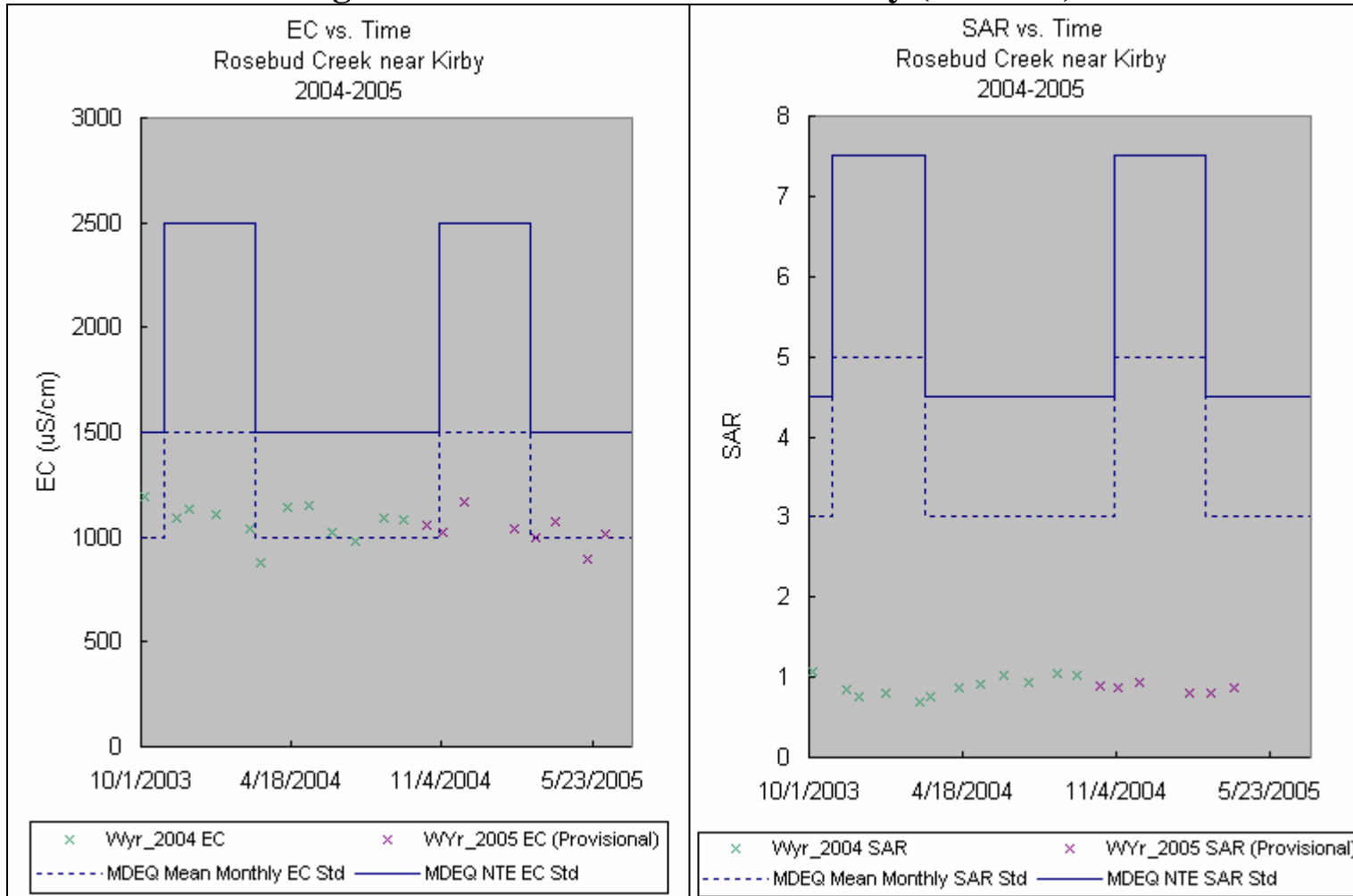
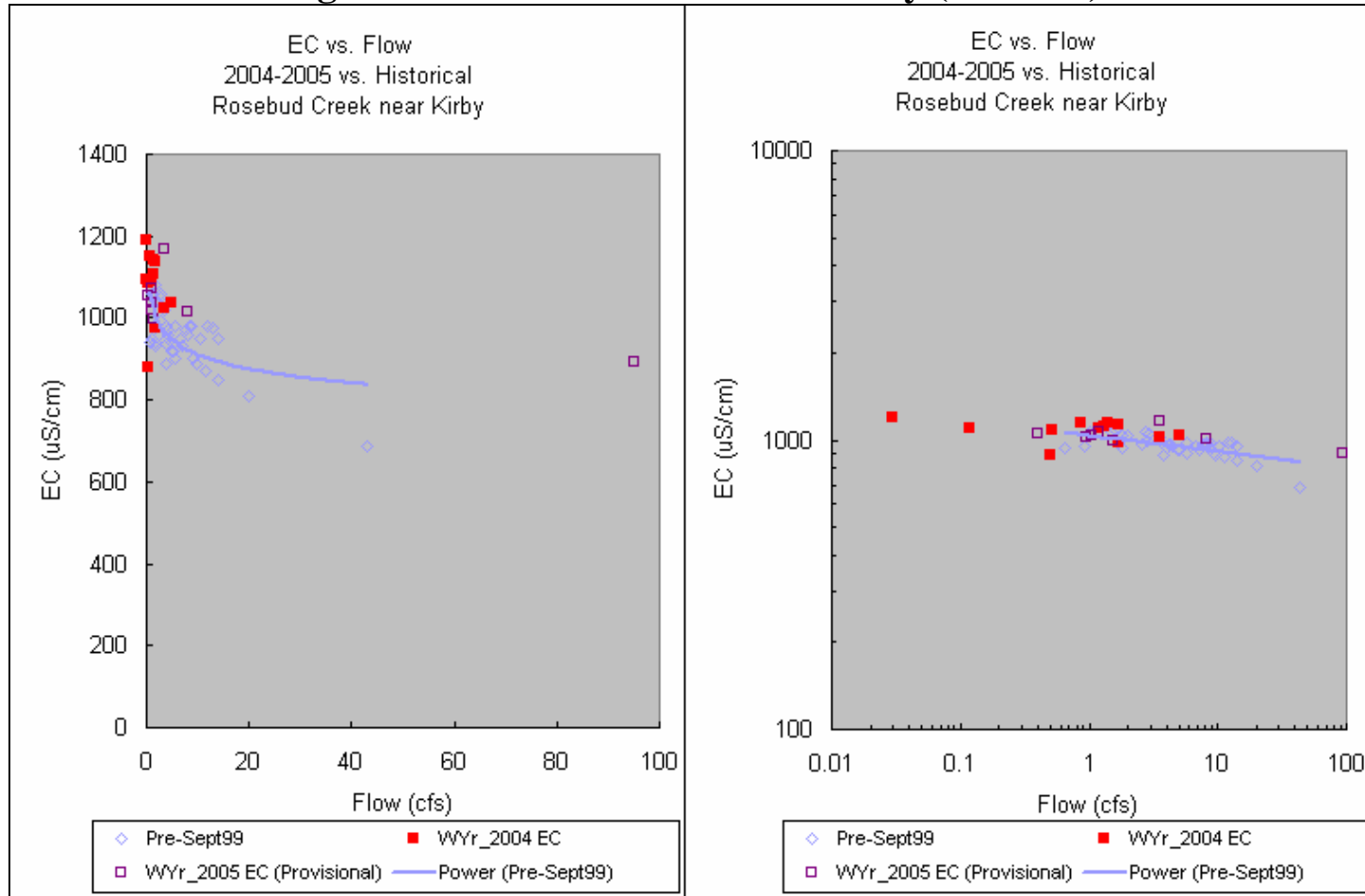


Figure 2 shows analytical EC and SAR values in a time series plots for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Kirby, MT. Analytical EC values during 2004 ranged from 880 to 1190 uS/cm. Analytical SAR values ranged from 0.7 to 1.1. Recorded EC values consistently exceeded MDEQ's mean monthly standard; however they stayed below the "Not to Exceed" (NTE) standards. SAR values were well below MDEQ's standards.

**Figure 3: Rosebud Creek near Kirby (6295113)**

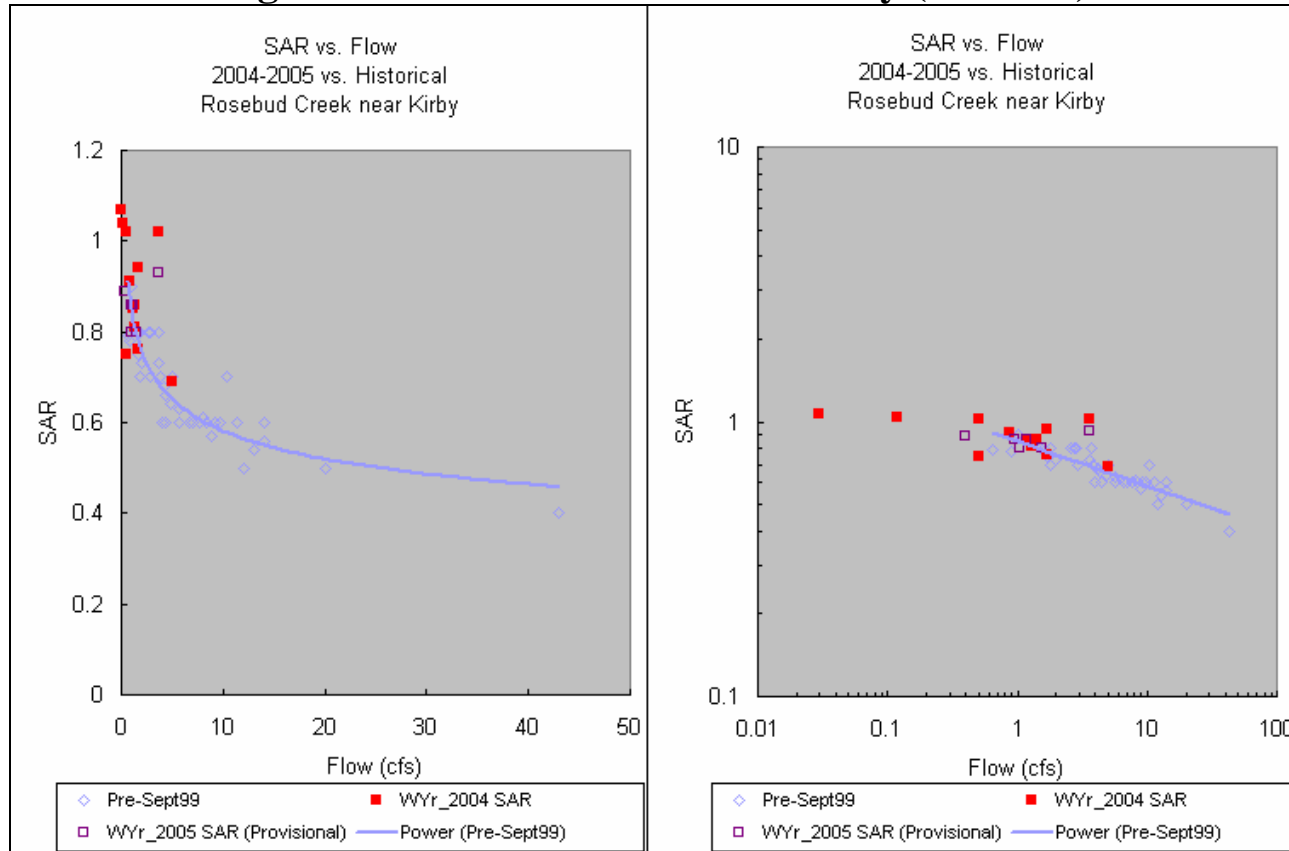


**A**

Figure 3 shows analytical EC values charted vs. flow for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Kirby, MT. These values are charted on both linear (A) and logarithmic (B) scales. Historical EC vs. Flow values are also shown. Recent EC values were in line with historical values during comparable flows.

**B**

**Figure 4: Rosebud Creek near Kirby (6295113)**



**A**

Figure 4 shows analytical SAR values charted vs. flow for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Kirby, MT. These values are charted on both linear (A) and logarithmic (B) scales. Historical SAR vs. Flow values are also shown. Recent SAR values were in line with historical values during comparable flows.

**B**

**Figure 5: Rosebud Creek near Colstrip (6295250)**

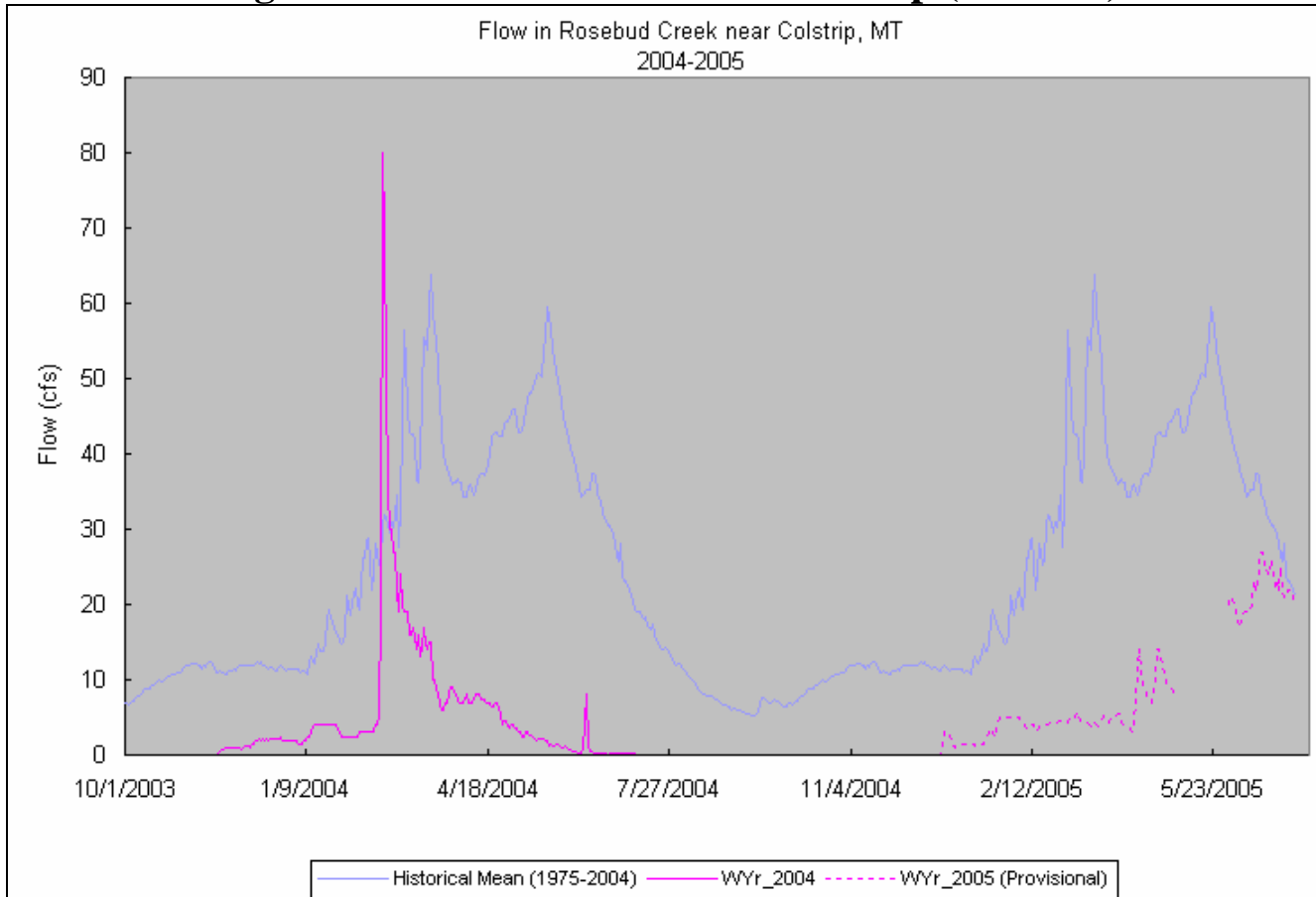
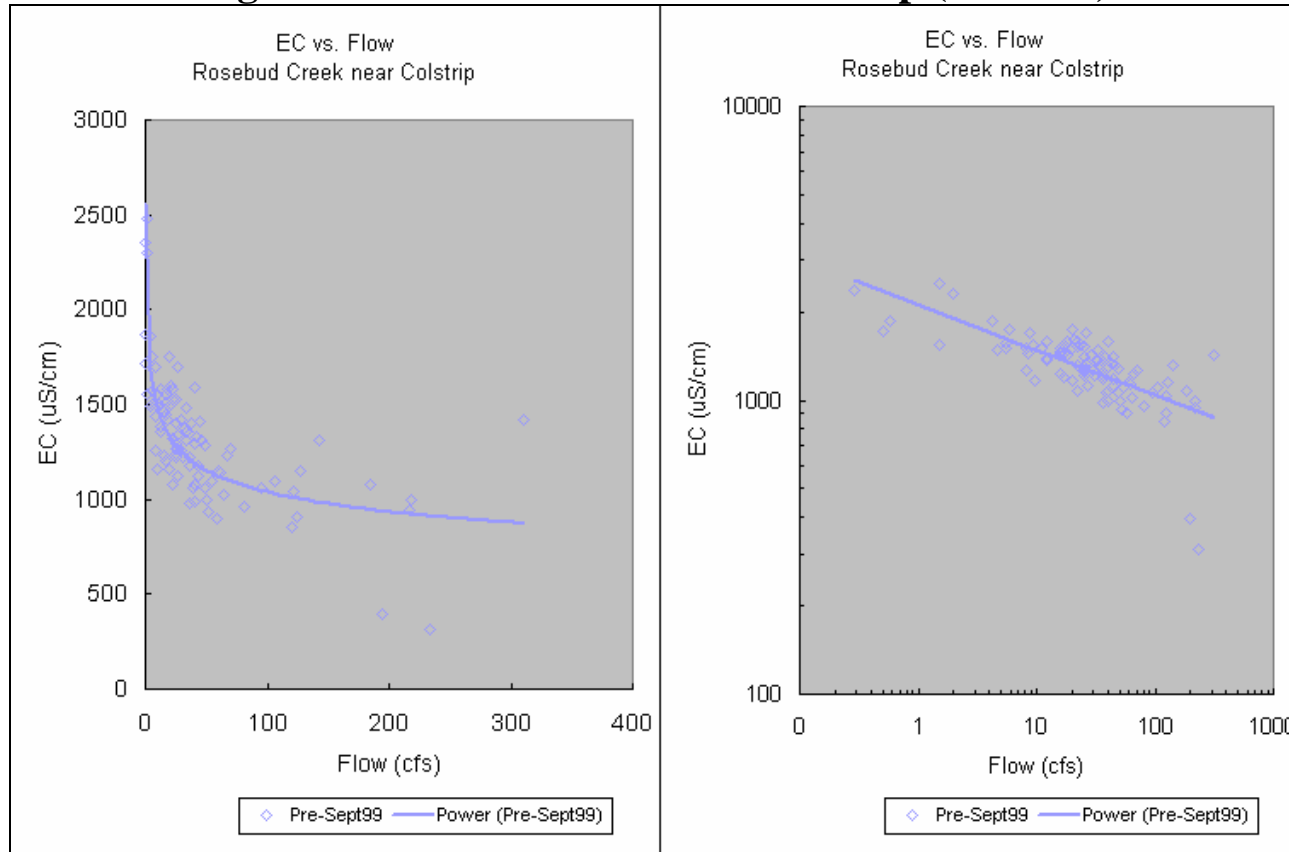


Figure 5 shows realtime flow values in a time series plot for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Colstrip, MT. Historical daily mean flow values are also shown. Recorded flow values during water year 2004 ranged from 0 to 80 cfs. During water year 2004 the spring flow was substantially less than historical values and flows were less than historical daily mean values for most of the year.

**Figure 6: Rosebud Creek near Colstrip (6295250)**



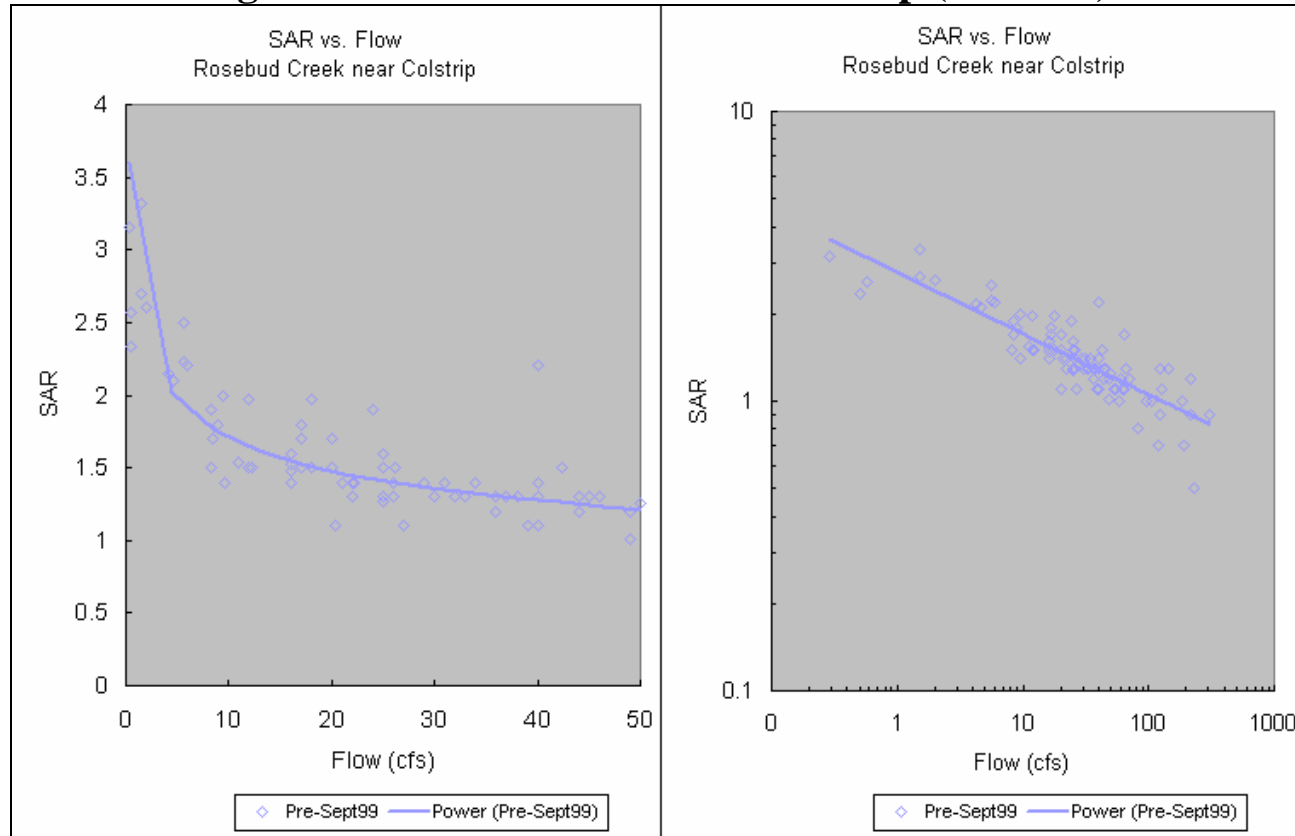
**A**

Figure 6 shows historical analytical EC values charted vs. flow for Rosebud Creek near Colstrip, MT. No EC values were collected at this station during water years 2004 or 2005. The historical values are charted on both linear (A) and logarithmic (B) scales. These historical values were often above the MDEQ's irrigation season mean monthly standard (1000 uS/cm) and routinely above the "Not to Exceed" standard (1500 uS/cm).

**B**



**Figure 7: Rosebud Creek near Colstrip (6295250)**



**A**

Figure 6 shows historical analytical SAR values charted vs. flow for Rosebud Creek near Colstrip, MT. No SAR values were collected at this station during water years 2004 or 2005. Historical values are charted on both linear (A) and logarithmic (B) scales. These historical values rarely exceeded the MDEQ's most stringent standard for SAR. (irrigation season mean monthly standard = 3.0).

**B**

**Figure 8: Rosebud Creek near Rosebud (6296003)**

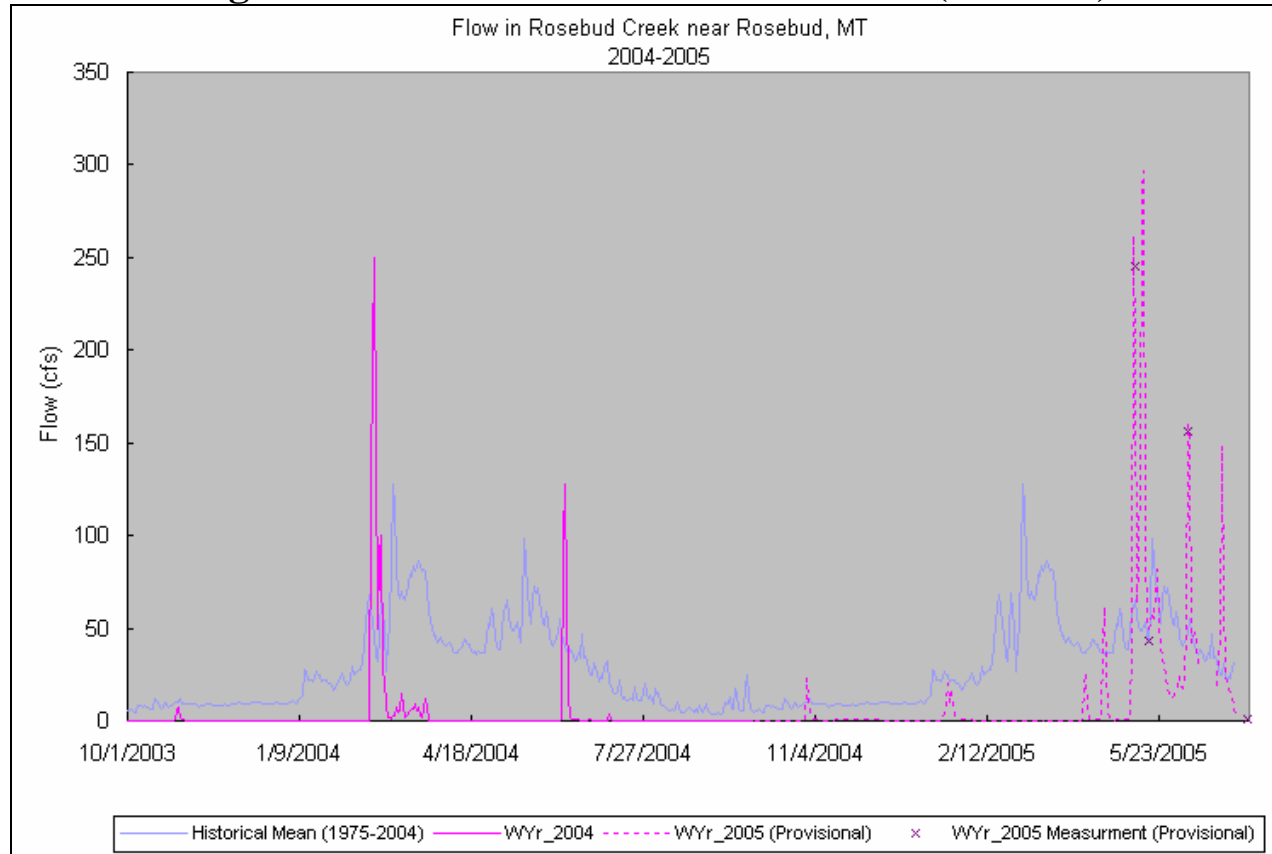


Figure 8 shows realtime flow values in a time series plot for water year 2004, and preliminary data for water year 2005, for Rosebud Creek near Rosebud, MT. Historical daily mean flow values are also shown. Recorded flow values during water year 2004 ranged from 0 to 250 cfs. During water year 2004 the spring flow was substantially less than historical values and flows were less than historical daily mean values for most of the year.

**Figure 9: Rosebud Creek near Rosebud (6296003)**

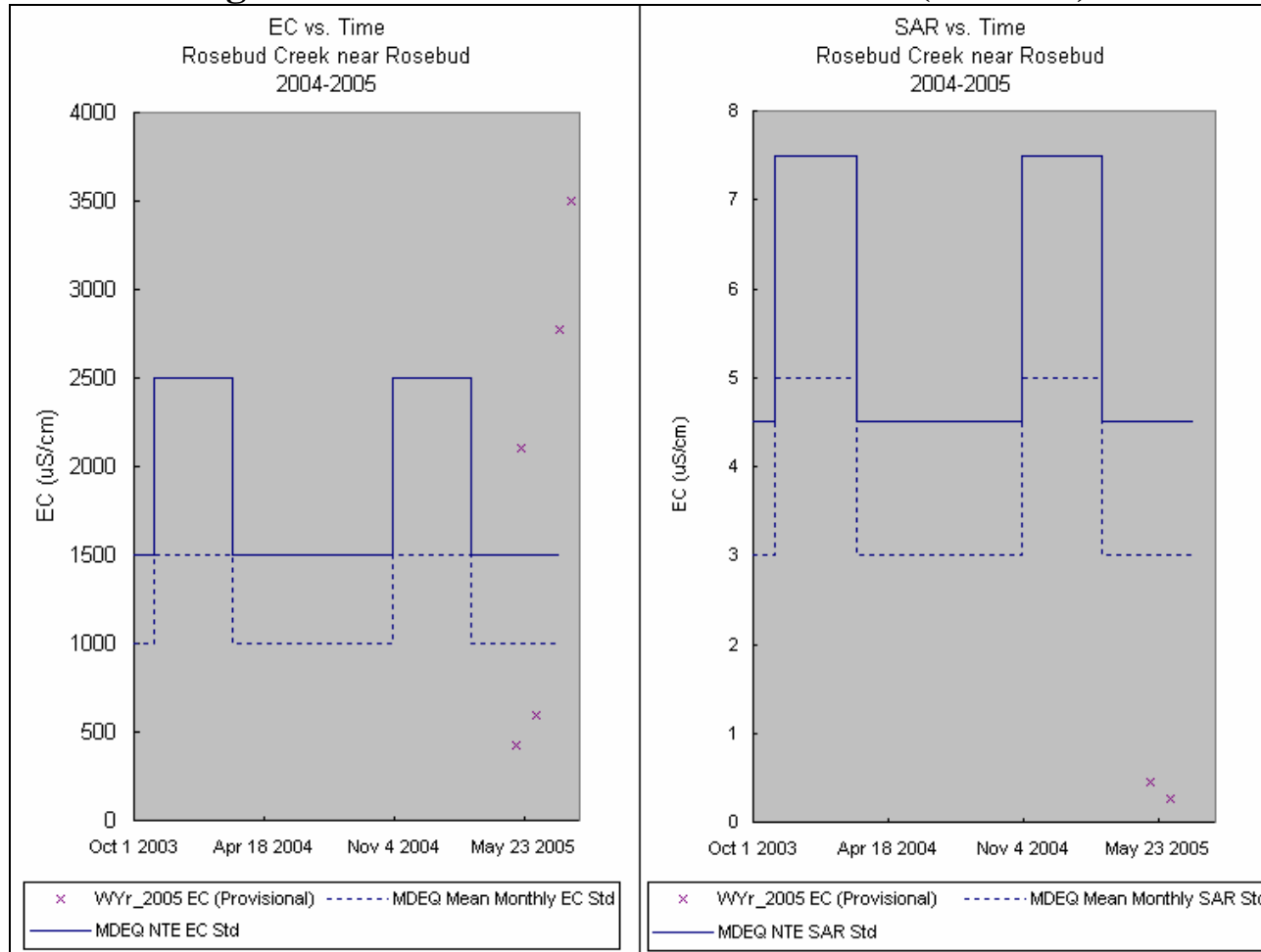
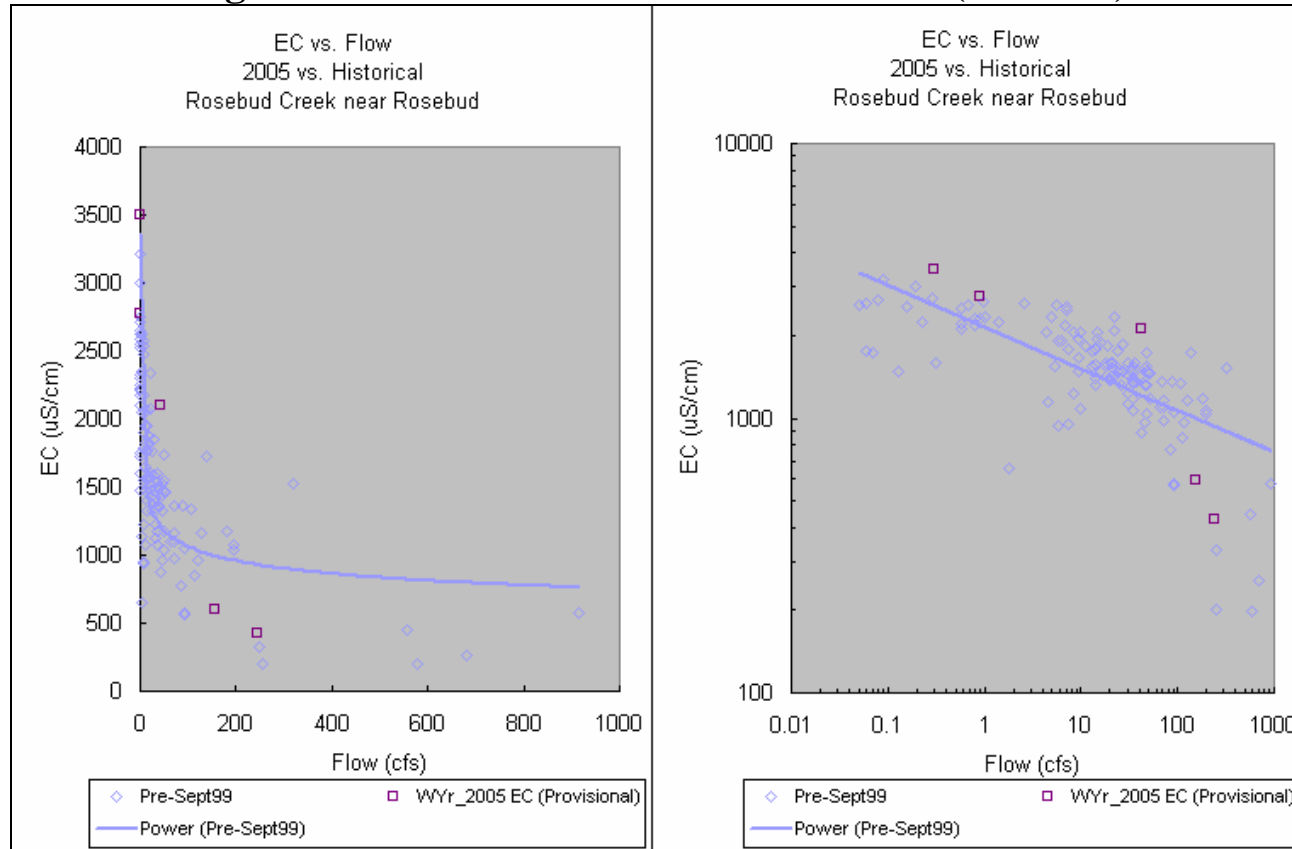


Figure 9 shows analytical EC values in a time series plot for Rosebud Creek near Rosebud, MT. No analytical data was collected in water year 2004. Preliminary samples for water year 2005 were often above the MDEQ's EC standards, and were below the SAR standard.

**Figure 10: Rosebud Creek near Rosebud (6296003)**

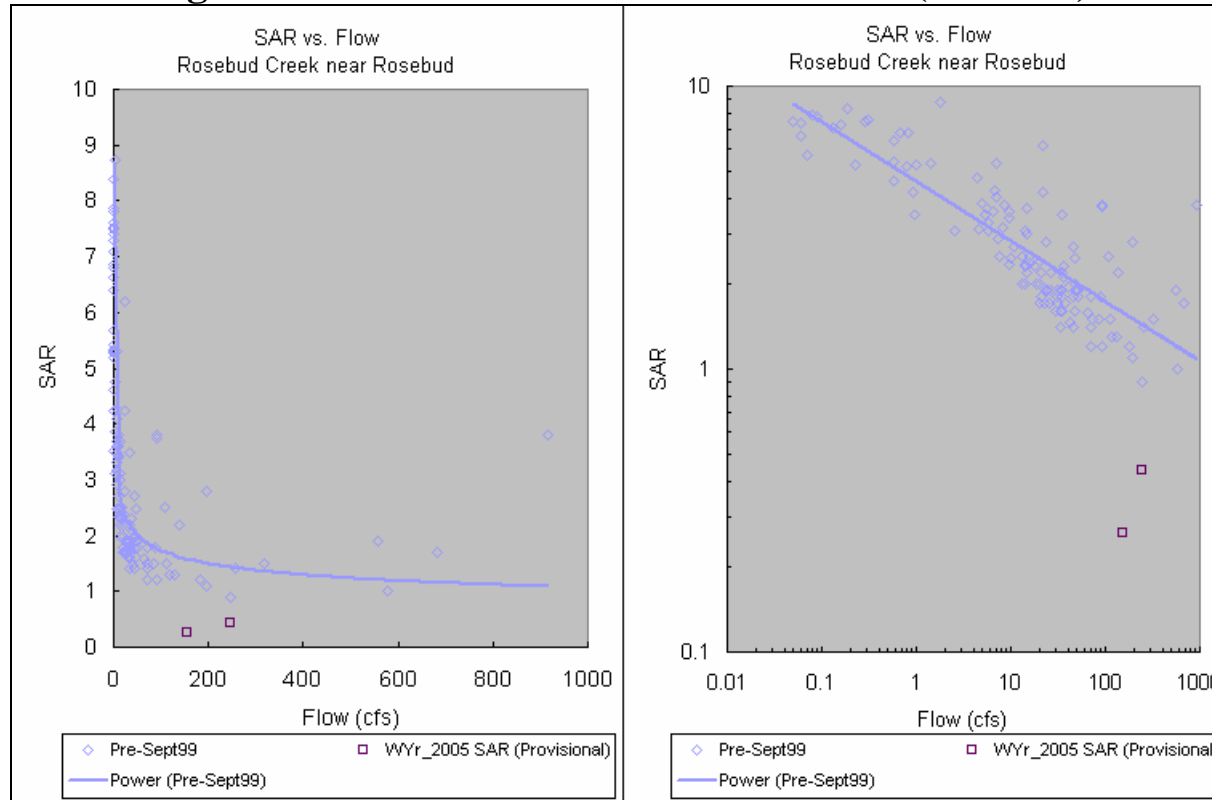


**A**

Figure 10 shows preliminary analytical EC values for water year 2005, for Rosebud Creek near Rosebud, MT. These values are charted on both linear (A) and logarithmic (B) scales. Historical EC vs. Flow values are also shown. Preliminary EC values appear to be within the range of historical values during comparable flows.

**B**

**Figure 11: Rosebud Creek near Rosebud (6296003)**



**A**

Figure 11 shows preliminary analytical SAR values for water year 2005, for Rosebud Creek near Rosebud, MT. These values are charted on both linear (A) and logarithmic (B) scales. Historical SAR vs. Flow values are also shown. Preliminary water year 2005 SAR values appear to be somewhat less than historical values at comparable flows.

**B**

**Appendix A – Precipitation Data in  
the Area of Rosebud Creek**

