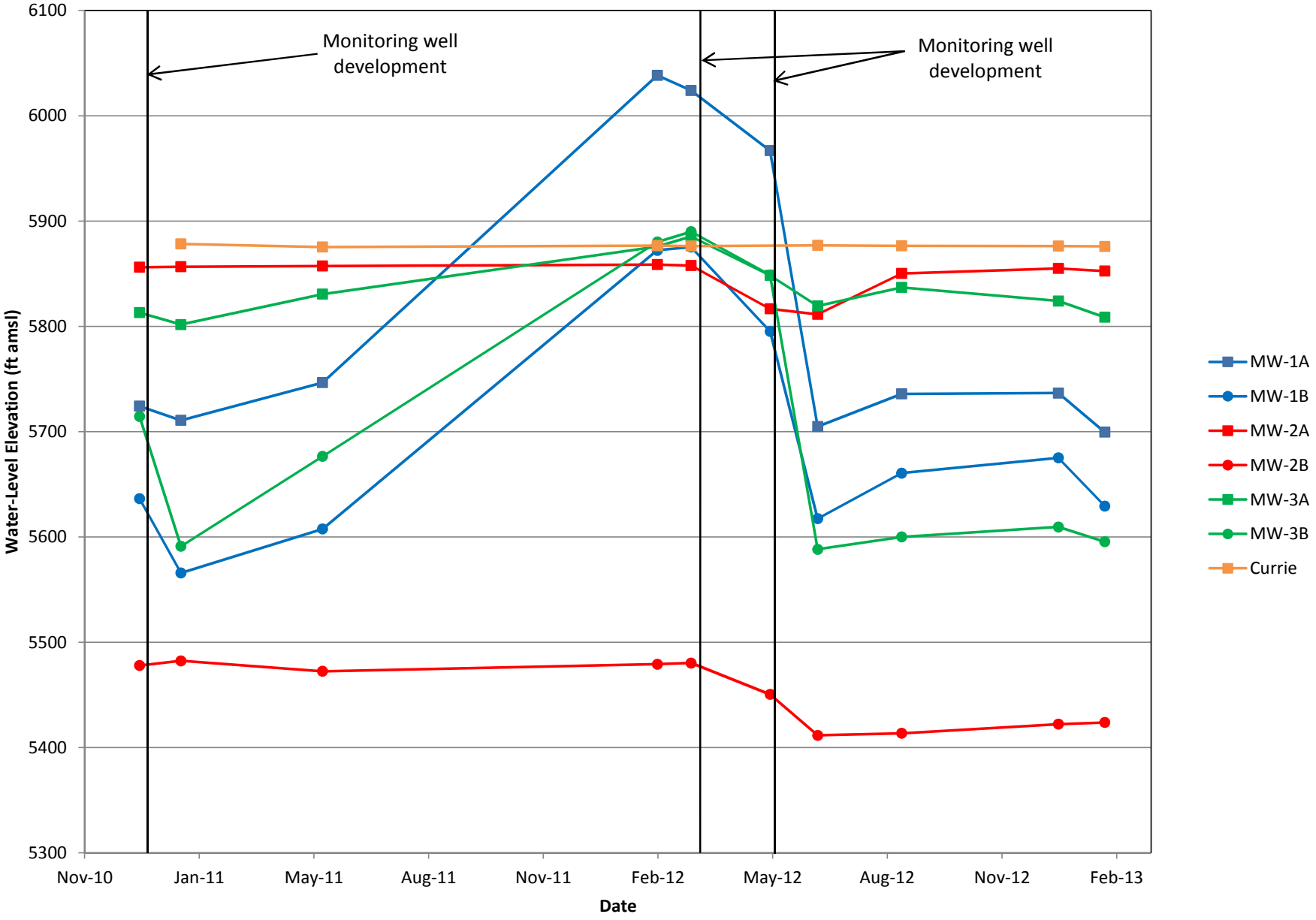
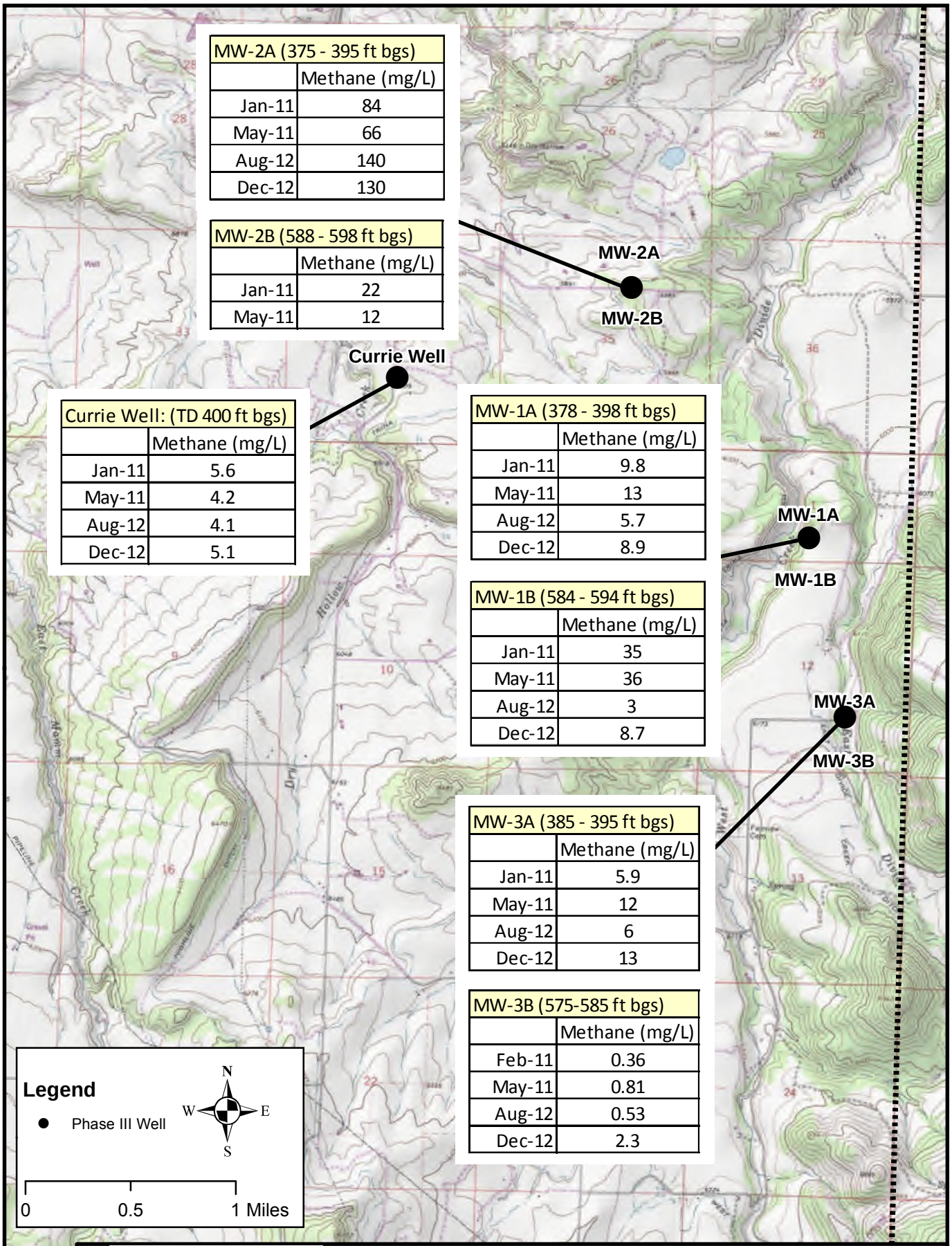
Figure 7. Water-Level Elevation Time Series Plot for Phase III Wells





MW-2A (375 - 395 ft bgs)	
	Methane (mg/L)
Jan-11	84
May-11	66
Aug-12	140
Dec-12	130

MW-2B (588 - 598 ft bgs)	
	Methane (mg/L)
Jan-11	22
May-11	12

Currie Well: (TD 400 ft bgs)	
	Methane (mg/L)
Jan-11	5.6
May-11	4.2
Aug-12	4.1
Dec-12	5.1

MW-1A (378 - 398 ft bgs)	
	Methane (mg/L)
Jan-11	9.8
May-11	13
Aug-12	5.7
Dec-12	8.9

MW-1B (584 - 594 ft bgs)	
	Methane (mg/L)
Jan-11	35
May-11	36
Aug-12	3
Dec-12	8.7

MW-3A (385 - 395 ft bgs)	
	Methane (mg/L)
Jan-11	5.9
May-11	12
Aug-12	6
Dec-12	13

MW-3B (575-585 ft bgs)	
	Methane (mg/L)
Feb-11	0.36
May-11	0.81
Aug-12	0.53
Dec-12	2.3

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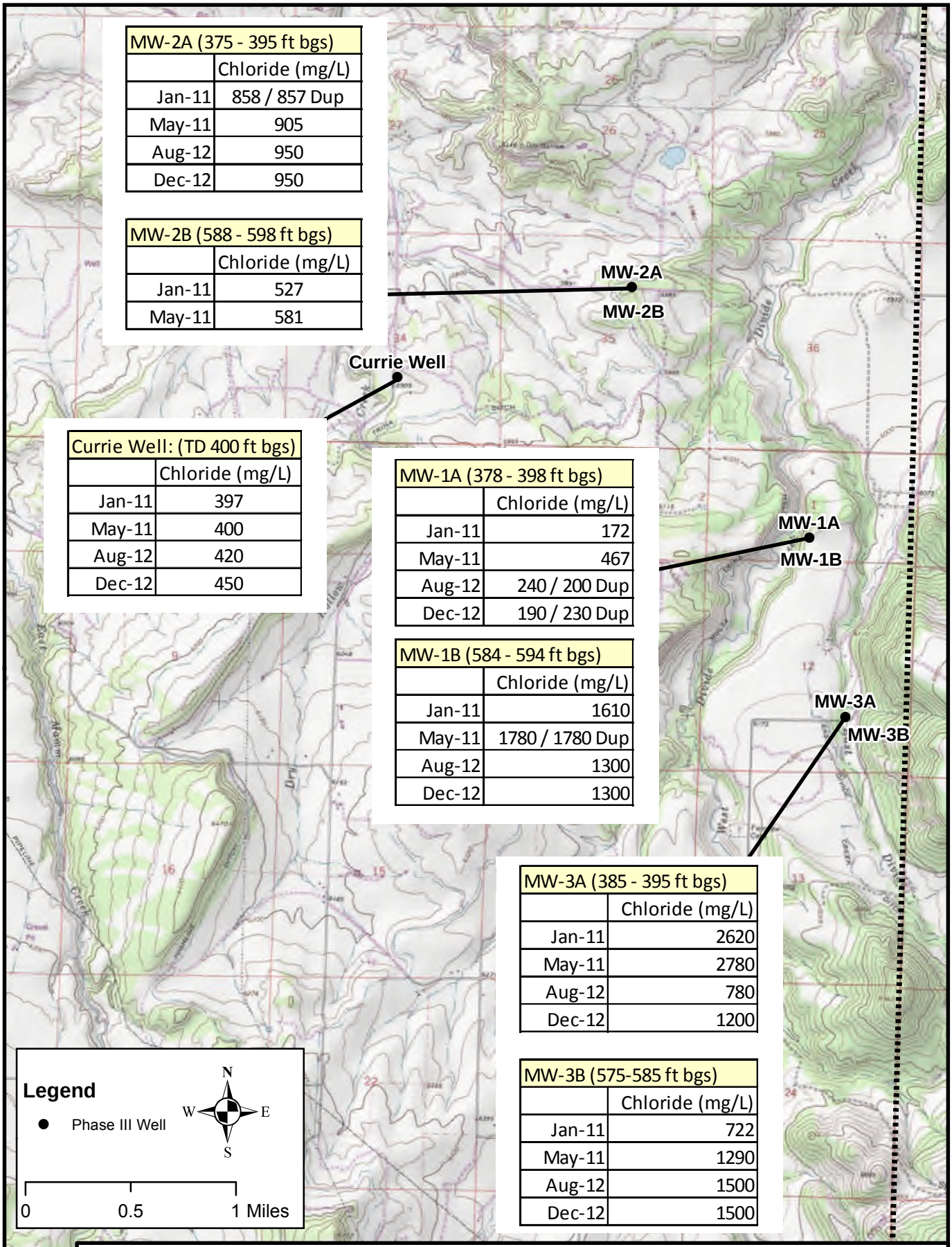
Figure 8. Methane in Phase III Monitoring Wells Map



MW-2A (375 - 395 ft bgs)	
	Chloride (mg/L)
Jan-11	858 / 857 Dup
May-11	905
Aug-12	950
Dec-12	950

MW-2B (588 - 598 ft bgs)	
	Chloride (mg/L)
Jan-11	527
May-11	581

Currie Well: (TD 400 ft bgs)	
	Chloride (mg/L)
Jan-11	397
May-11	400
Aug-12	420
Dec-12	450

MW-1A (378 - 398 ft bgs)	
	Chloride (mg/L)
Jan-11	172
May-11	467
Aug-12	240 / 200 Dup
Dec-12	190 / 230 Dup

MW-1B (584 - 594 ft bgs)	
	Chloride (mg/L)
Jan-11	1610
May-11	1780 / 1780 Dup
Aug-12	1300
Dec-12	1300

MW-3A (385 - 395 ft bgs)	
	Chloride (mg/L)
Jan-11	2620
May-11	2780
Aug-12	780
Dec-12	1200

MW-3B (575-585 ft bgs)	
	Chloride (mg/L)
Jan-11	722
May-11	1290
Aug-12	1500
Dec-12	1500

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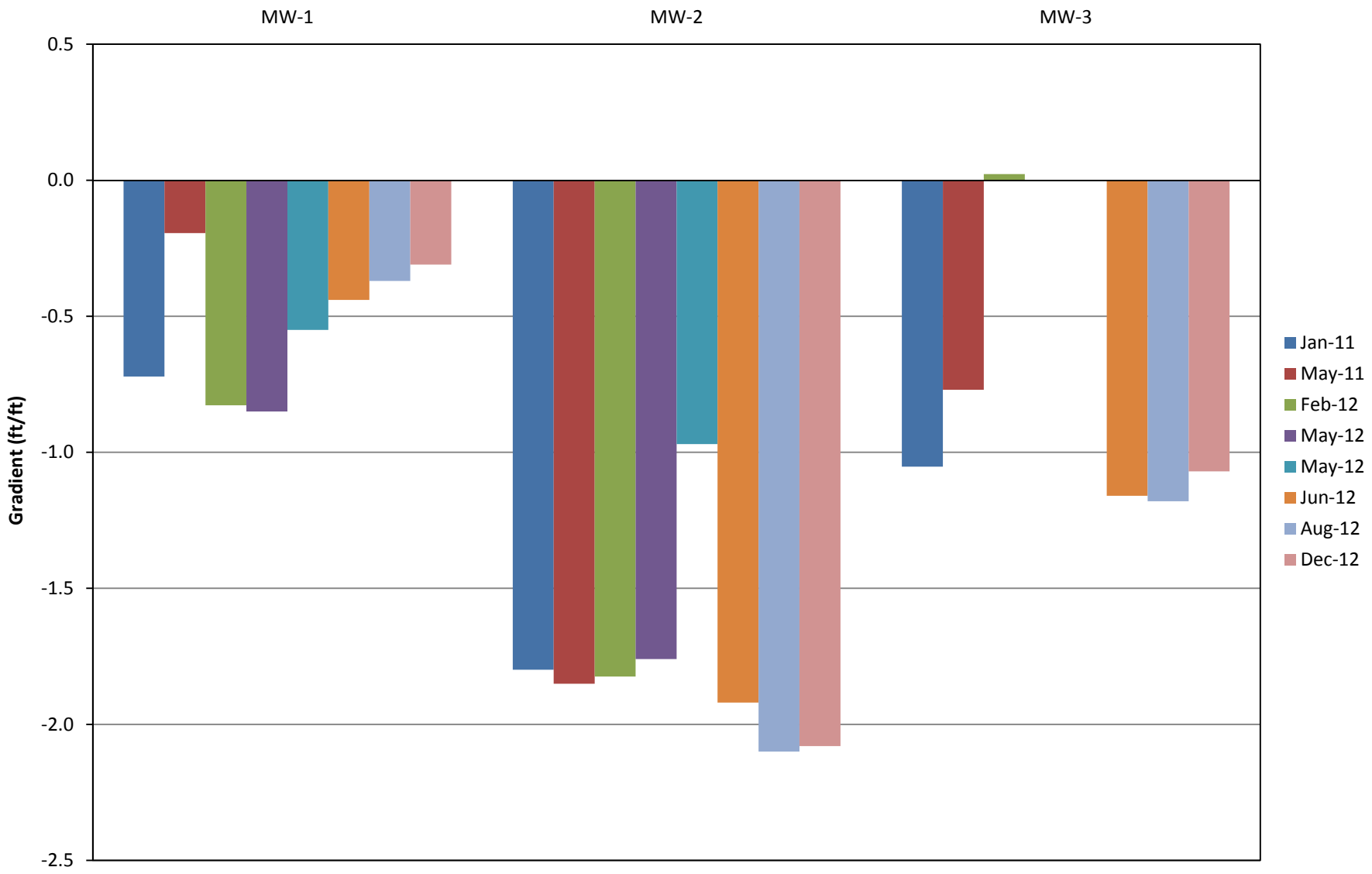
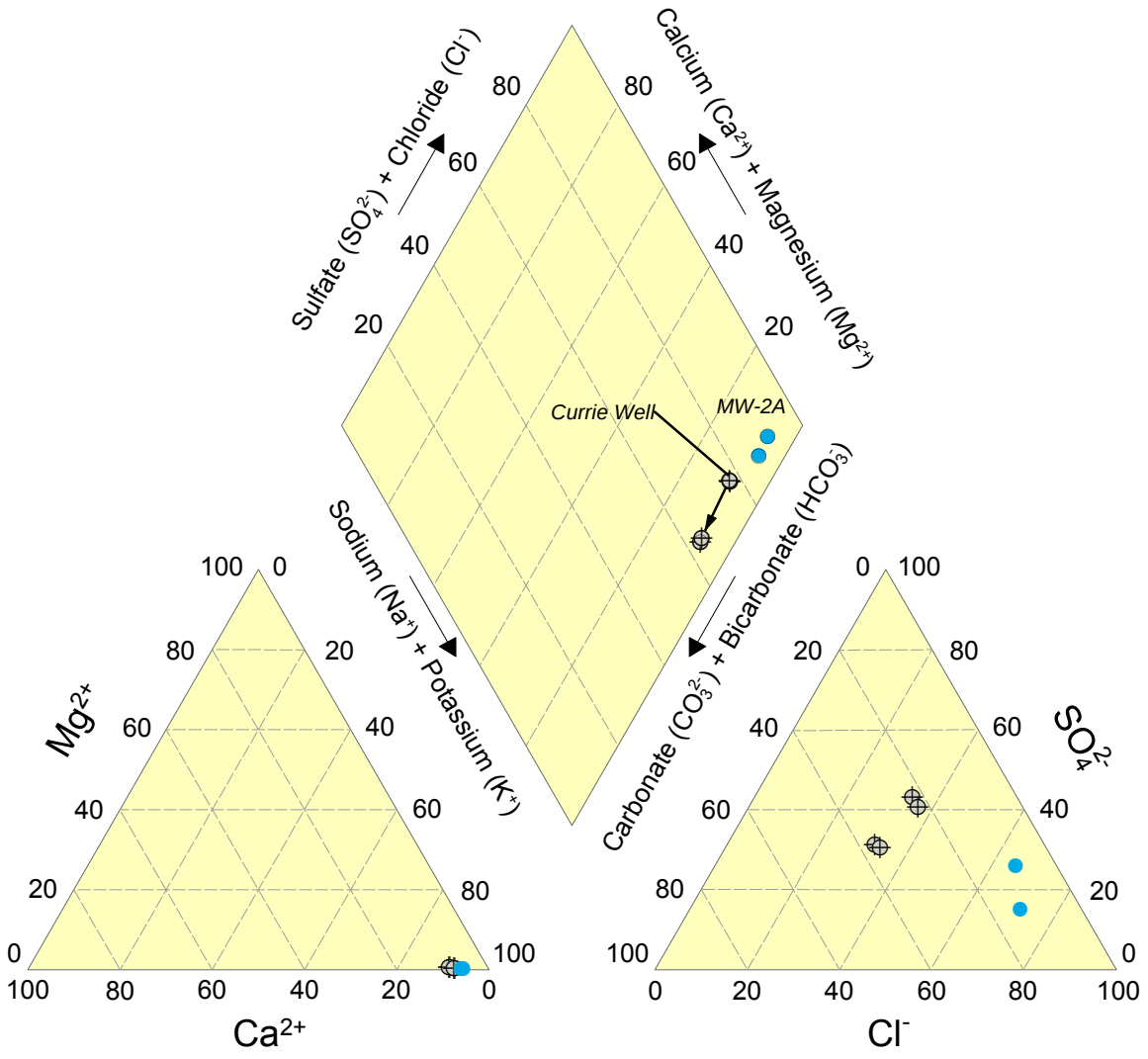
Figure 9. Chloride Concentration Map, Phase III Wells 2011 and 2012



Notes:
Gradients are calculated relative to vertical distance between center of screened intervals.

Negative vertical gradients indicate downward flow from the shallow well to the deeper well, and positive vertical gradients indicate upward flow from the deeper well to the shallow well.

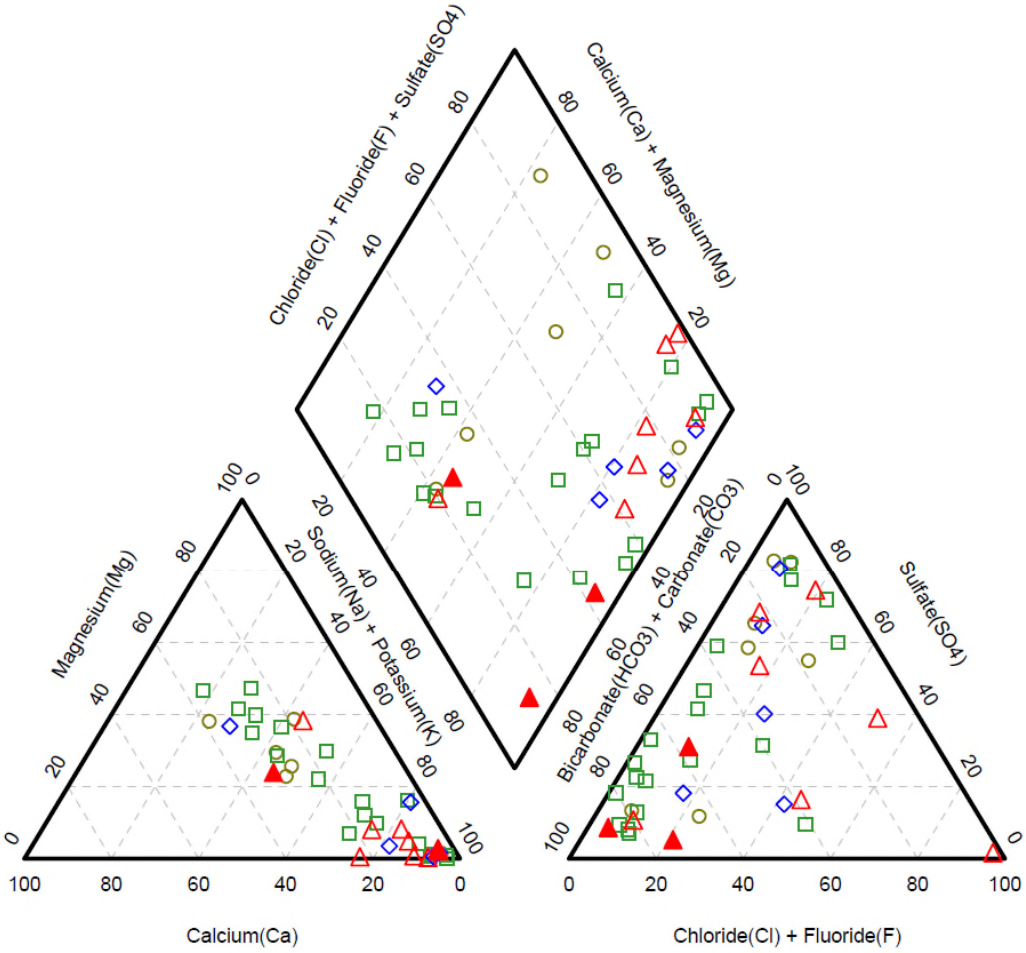
Vertical Hydraulic Gradient in Nested Wells	DATE:	5/6/2013
	DESIGNED:	DJB
	CHECKED:	DJB
	APPROVED:	DJB
	DRAWN:	DJB
	PROJECT: 117-7050003	
TETRA TECH	FIGURE:	10



Circle sizes on Piper diamond are proportional to TDS concentrations.
Arrows indicate evolution between sampling events.

TITLE: **Piper Diagram for Phase III Groundwater Samples**			
LOCATION: **Garfield County, Colorado**			
TETRA TECH	CHECKED	CG	FIGURE
	DRAFTED	ES	**11**
	PROJECT	7050003	
	DATE	5/16/2013	

T:\Mamm Creek\GIS\mxd\Fig15_Piper_new calcs_rev052313.mxd

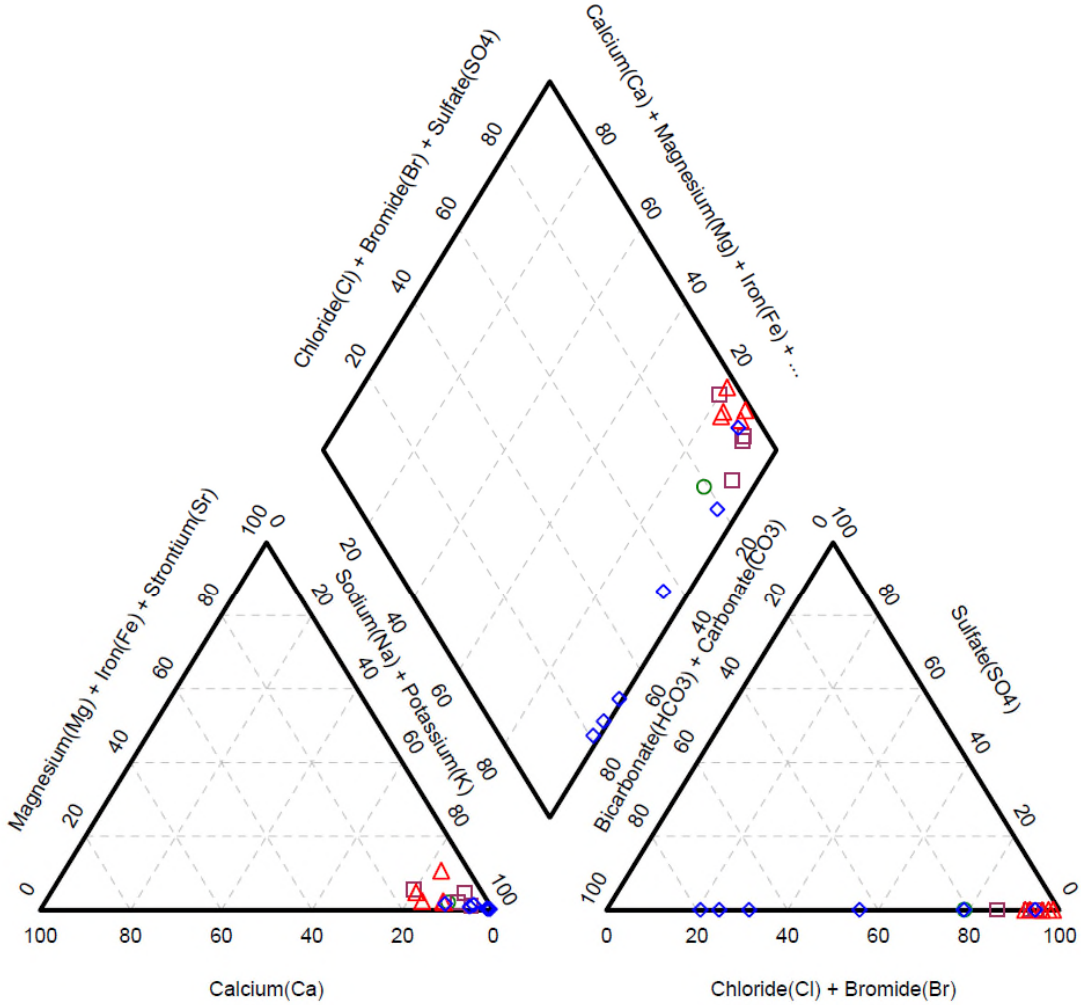


Divisions according to well Depth

0-100 ft
101-200 ft
201-300 ft
301-400 ft
401-495 ft

Reproduced from Figure 4.11 of:
Phase II Hydrogeologic Characterization of the
Mamm Creek Field Area, Garfield County, Colorado
S.S. Papadopulos & Assoc., September 2008

Piper Diagram for Phase II Domestic Well Groundwater Samples	DATE:	Sep2011
	DESIGNED:	
	CHECKED:	
	APPROVED:	
	DRAWN:	
	PROJECT: 117-7050002	
TETRA TECH	FIGURE: 12	



Produced Water Samples - Grouped by TDS ranges
Less than 1,000 mg/L
5,000 - 10,000 mg/L
10,000 - 15,000 mg/L
Greater than 15,000 mg/L

Reproduced from Figure 4.15 of:
Phase II Hydrogeologic Characterization of the
Mamm Creek Field Area, Garfield County, Colorado
S.S. Papadopulos & Assoc., September 2008

Piper Diagram for Phase II Produced Water Samples	DATE:	Sep2011
	DESIGNED:	
	CHECKED:	
	APPROVED:	
	DRAWN:	
	PROJECT: 117-7050002	
TETRA TECH	FIGURE: 13	

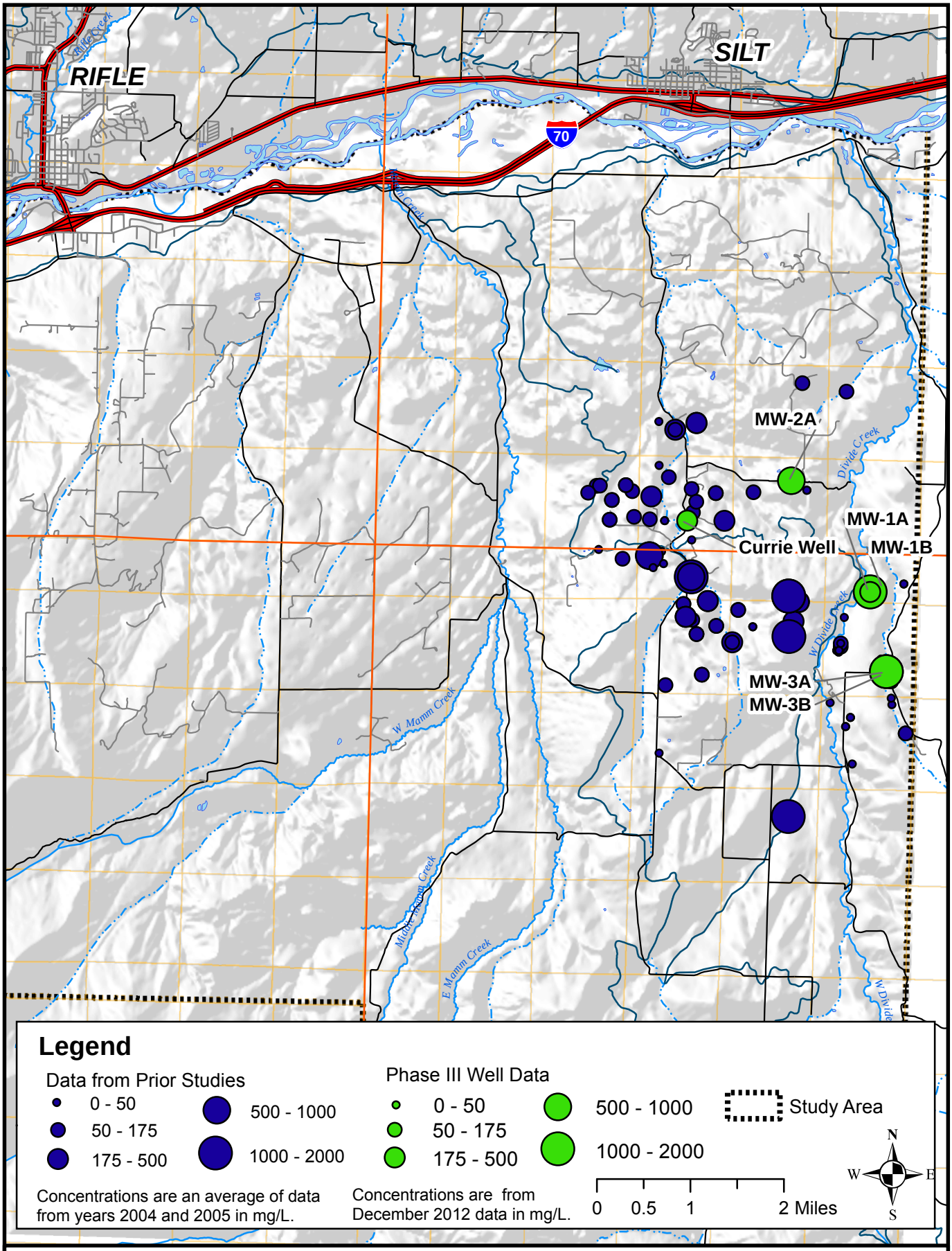


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Figure 14. Chloride Concentration Map, Groundwater for Phase III Study Area 2004 - 2012

Figure 15a. Chloride Concentration Time Series in Groundwater in Phase III Study Area 2004 to 2005

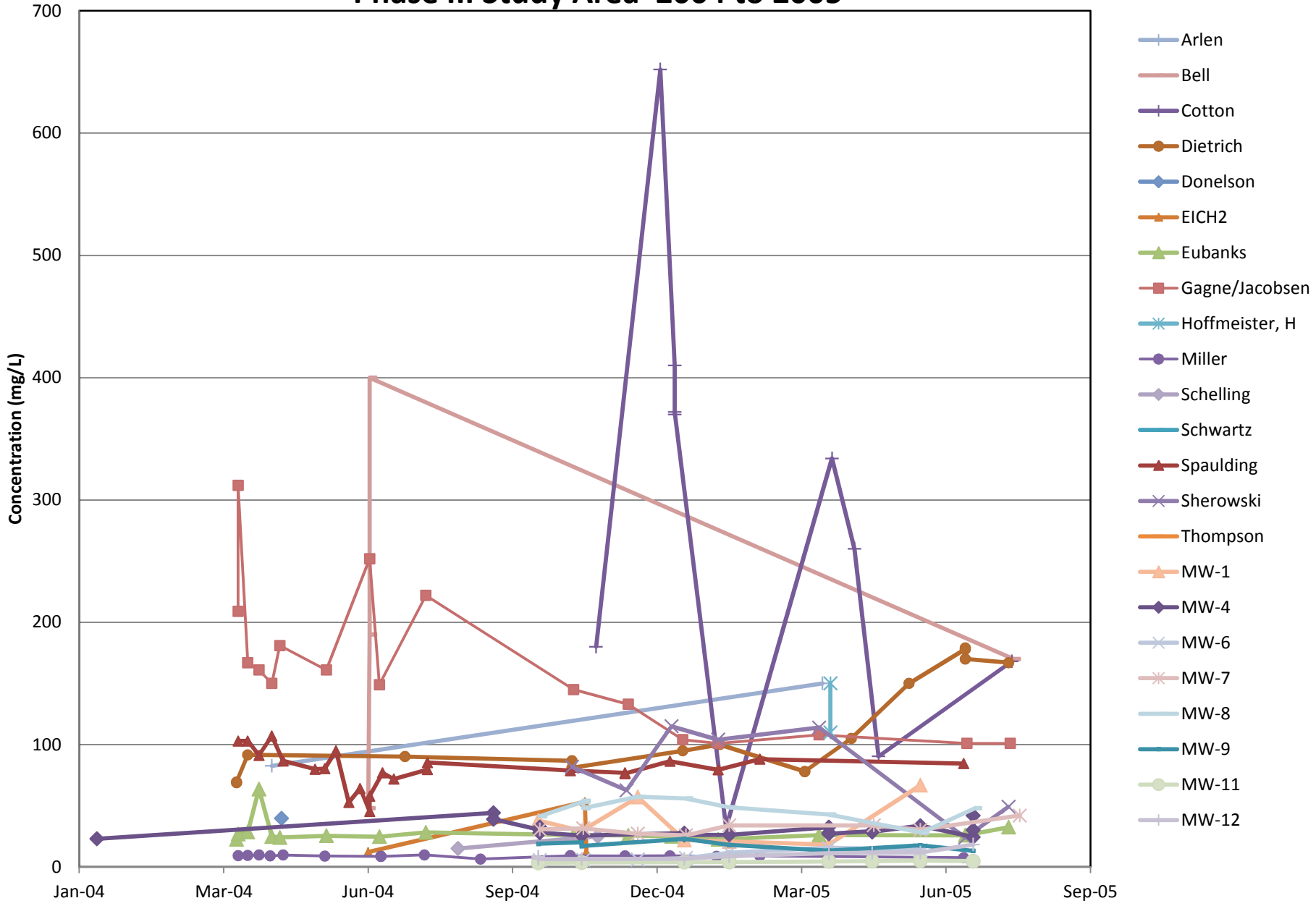
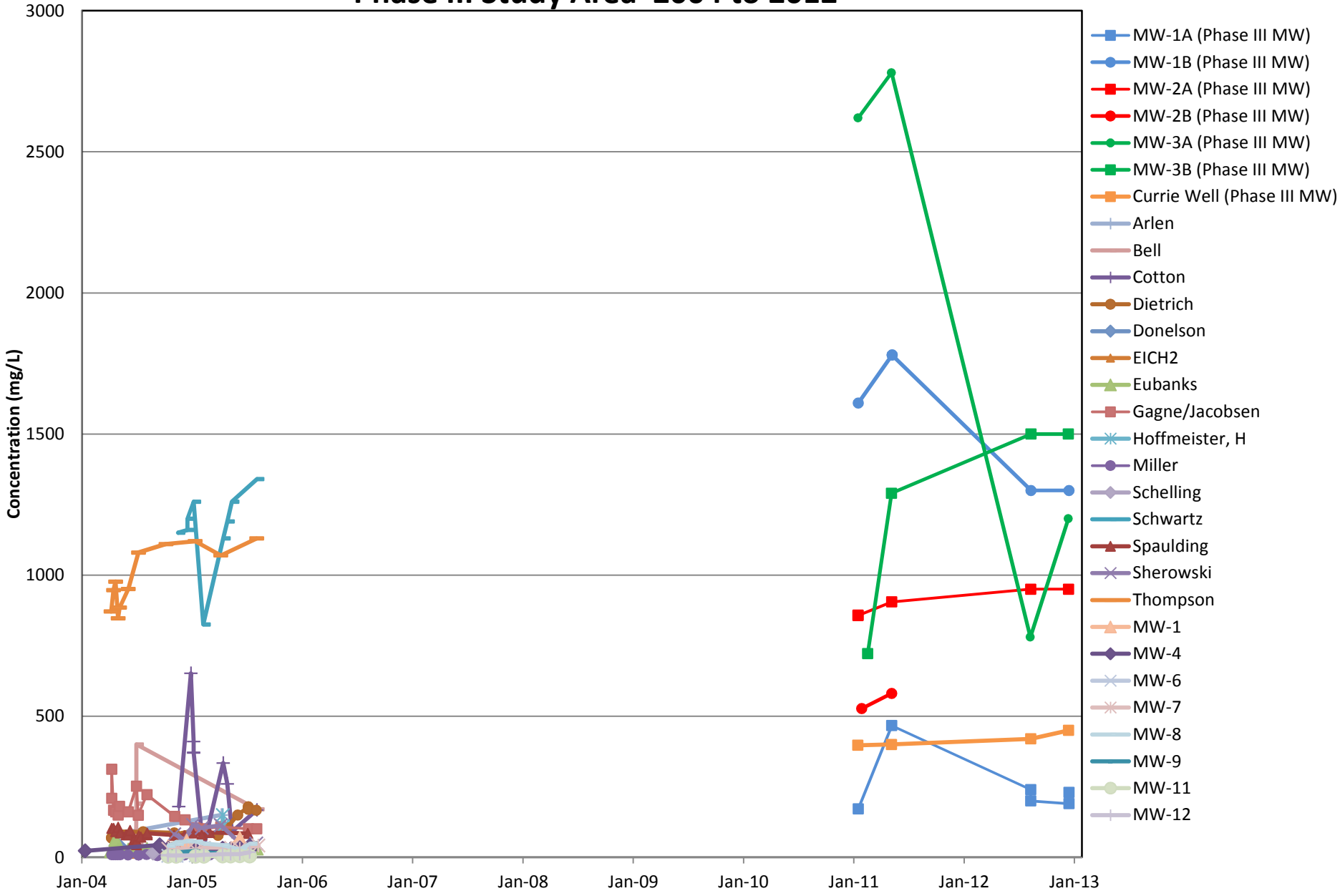


Figure 15b. Chloride Concentration Time Series in Groundwater in Phase III Study Area 2004 to 2012



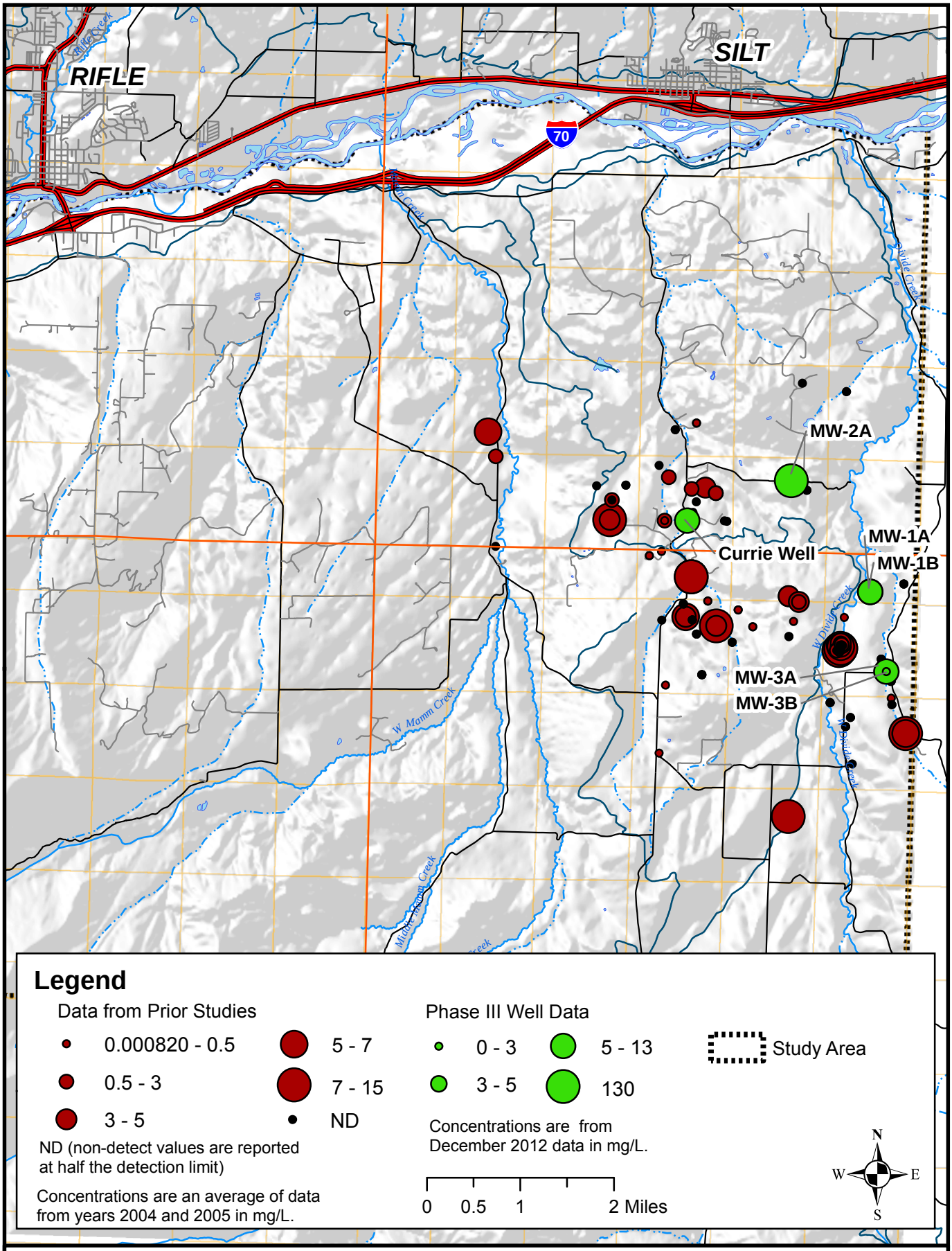


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Figure 16. Methane Concentration Map, Groundwater in and Around Phase III Study Area 2004 - 2012

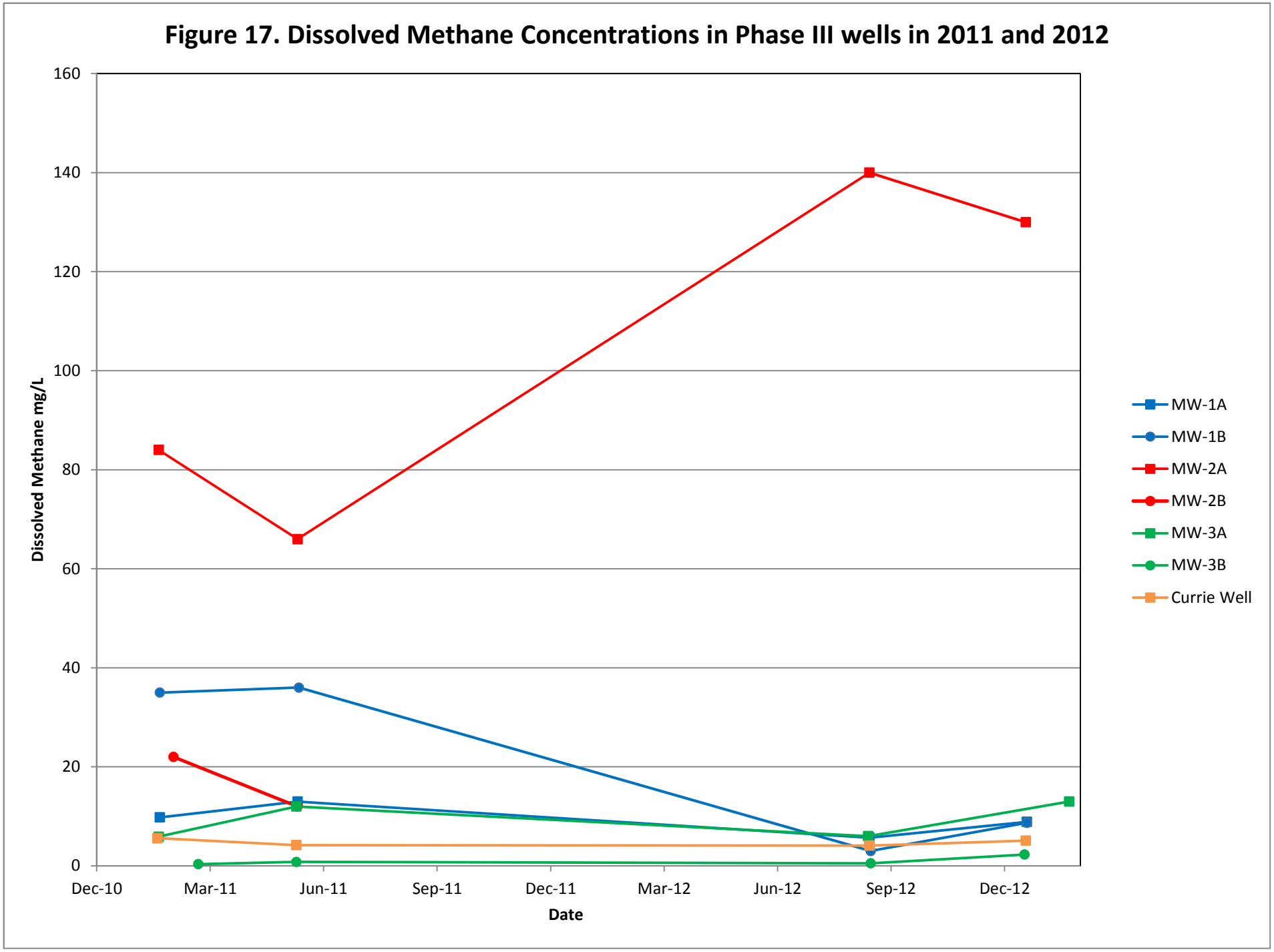
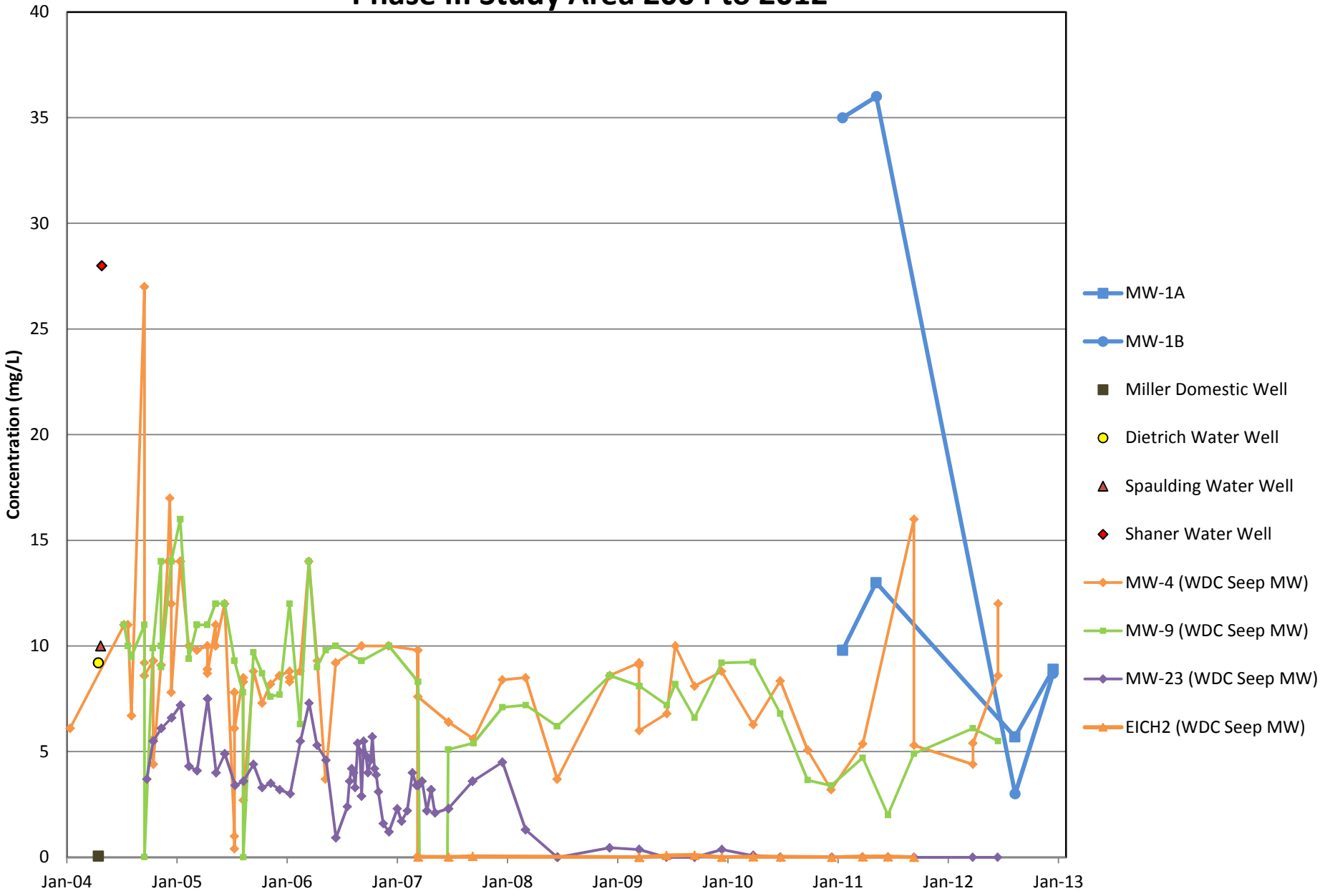


Figure 17. Dissolved Methane Concentrations in Phase III wells in 2011 and 2012
Dissolved Methane mg/L
160
140
120
100
80
60
40
20
0
Dec-10
Mar-11
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Date
MW-1A
MW-1B
MW-2A
MW-2B
MW-3A
MW-3B
Currie Well

Figure 18. Methane Concentration Time Series in Groundwater in Phase III Study Area 2004 to 2012



Note: Non-detect values are plotted at 1/2 the detection limit