Appendix C

Nitrate, Sulfate, and Uranium Plume Maps

(See text for an explanation of contouring methods and well-selection criteria)

This page intentionally left blank

Contents

Figures

Figure C–1. Nitrate (mg/L as NO_3) Plume Map: February 2010 ..... C–1
Figure C–2. Sulfate (mg/L) Plume Map: February 2010 ..... C–2
Figure C–3. Uranium (μg/L) Plume Map: February 2010 ..... C–3

This page intentionally left blank

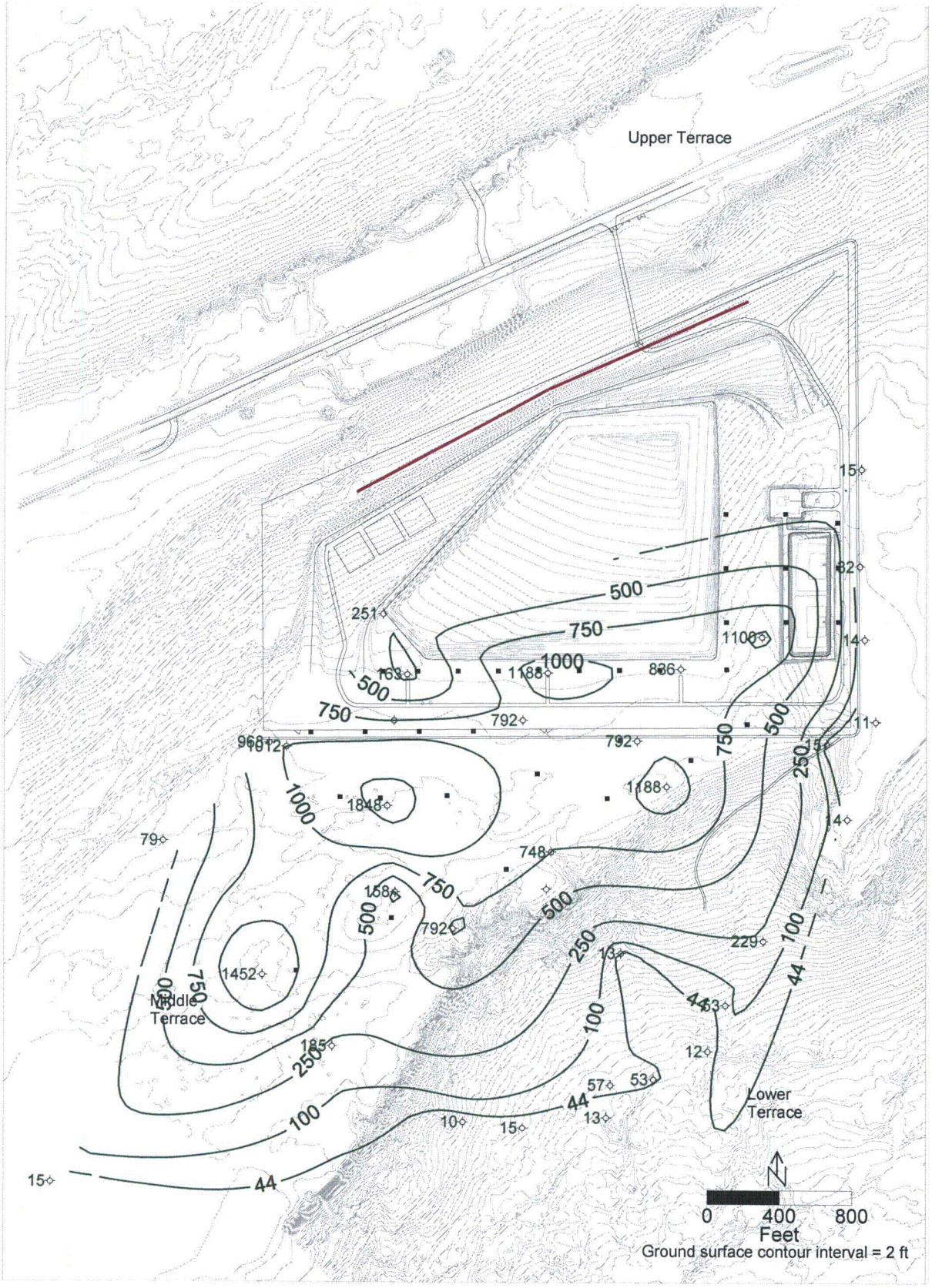


Figure C−1. Nitrate (mg/L as NO_3) Plume Map: February 2010

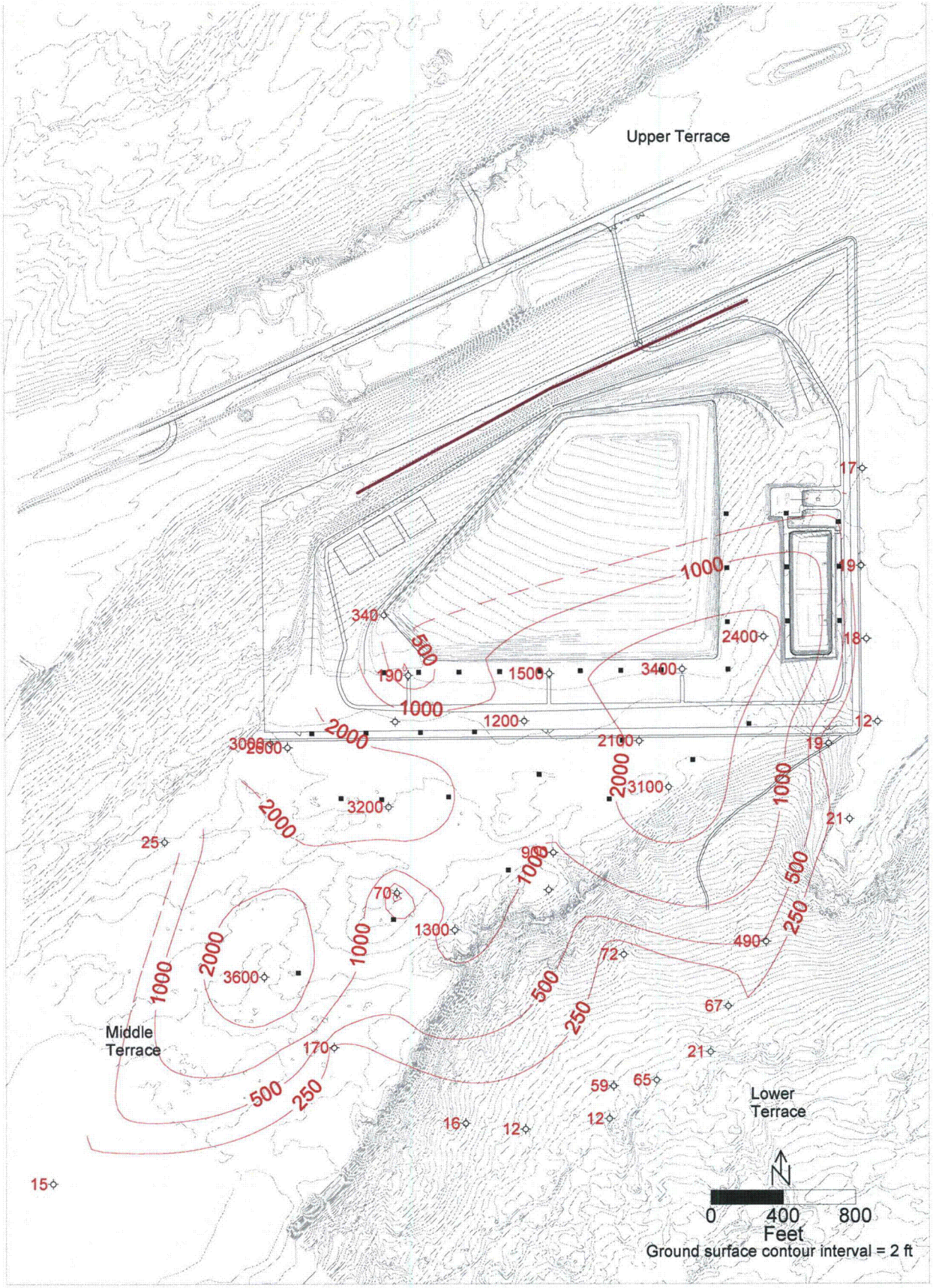


Figure C–2. Sulfate (mg/L) Plume Map: February 2010

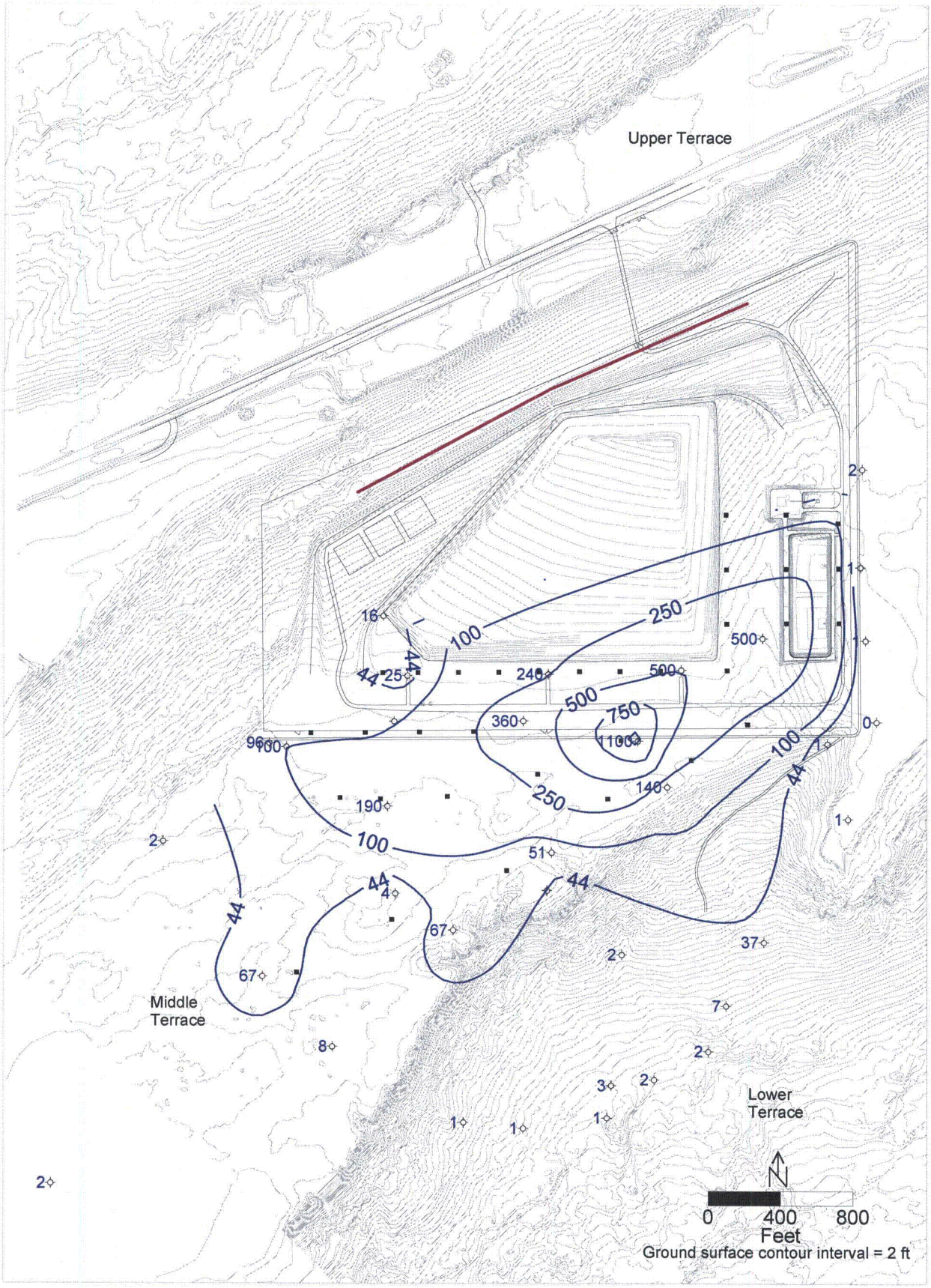


Figure C–3. Uranium (µg/L) Plume Map: February 2010

This page intentionally left blank

Appendix D

Monitoring Well Water Level Hydrographs

This page intentionally left blank

Contents

Figures

Figure D–1. Monitoring Wells at Infiltration Trench: 0686–0688, 0943, 0945, 0946 ..... D–1
Figure D–2. Horizon A and B Monitoring Wells 286, 934–936, 940 ..... D–2
Figure D–3. Horizon A and B Monitoring Wells 262, 287, 906, 938, 941, 942 ..... D–3
Figure D–4. Middle Terrace Well Pair 263 and 264 ..... D–4
Figure D–5. Middle Terrace Well Pair 265 and 266 ..... D–5
Figure D–6. Middle Terrace Well Pair 909 and 932 ..... D–6
Figure D–7. Middle Terrace Well Cluster 908, 912, and 913 ..... D–7
Figure D–8. Middle Terrace Well Cluster 268, 256, and 257 ..... D–8
Figure D–9. Middle Terrace Well Cluster 251, 252, and 1116 ..... D–9
Figure D–10. Middle Terrace Well Cluster 254, 255, 273, 287, and 941 ..... D–10
Figure D–11. Middle Terrace Well Cluster 914, 915, and 916 ..... D–11
Figure D–12. Lower Terrace Well Cluster 277, 903, 920, and 921 ..... D–12

This page intentionally left blank

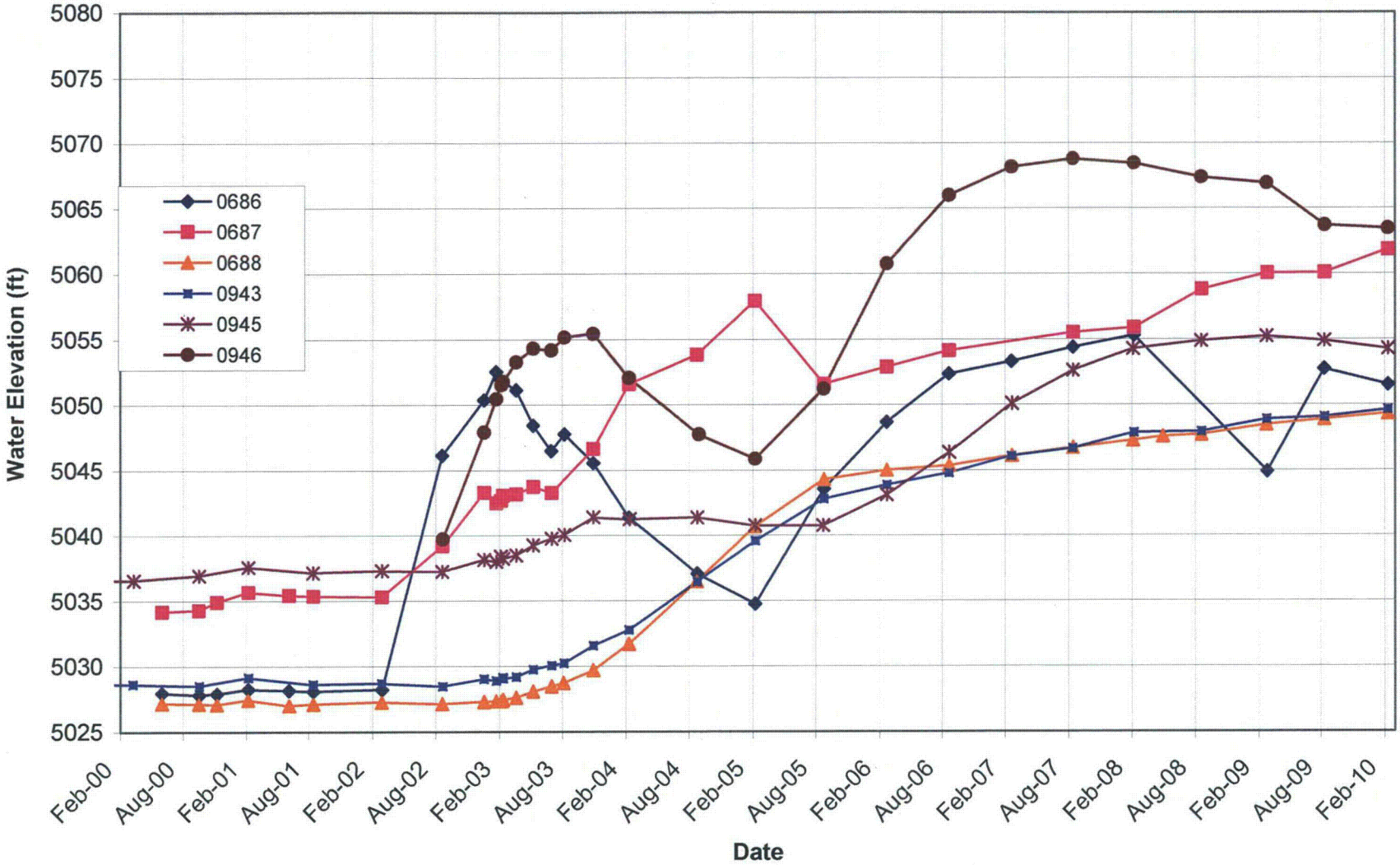


Figure D–1. Monitoring Wells at Infiltration Trench: 0686–0688, 0943, 0945, 0946

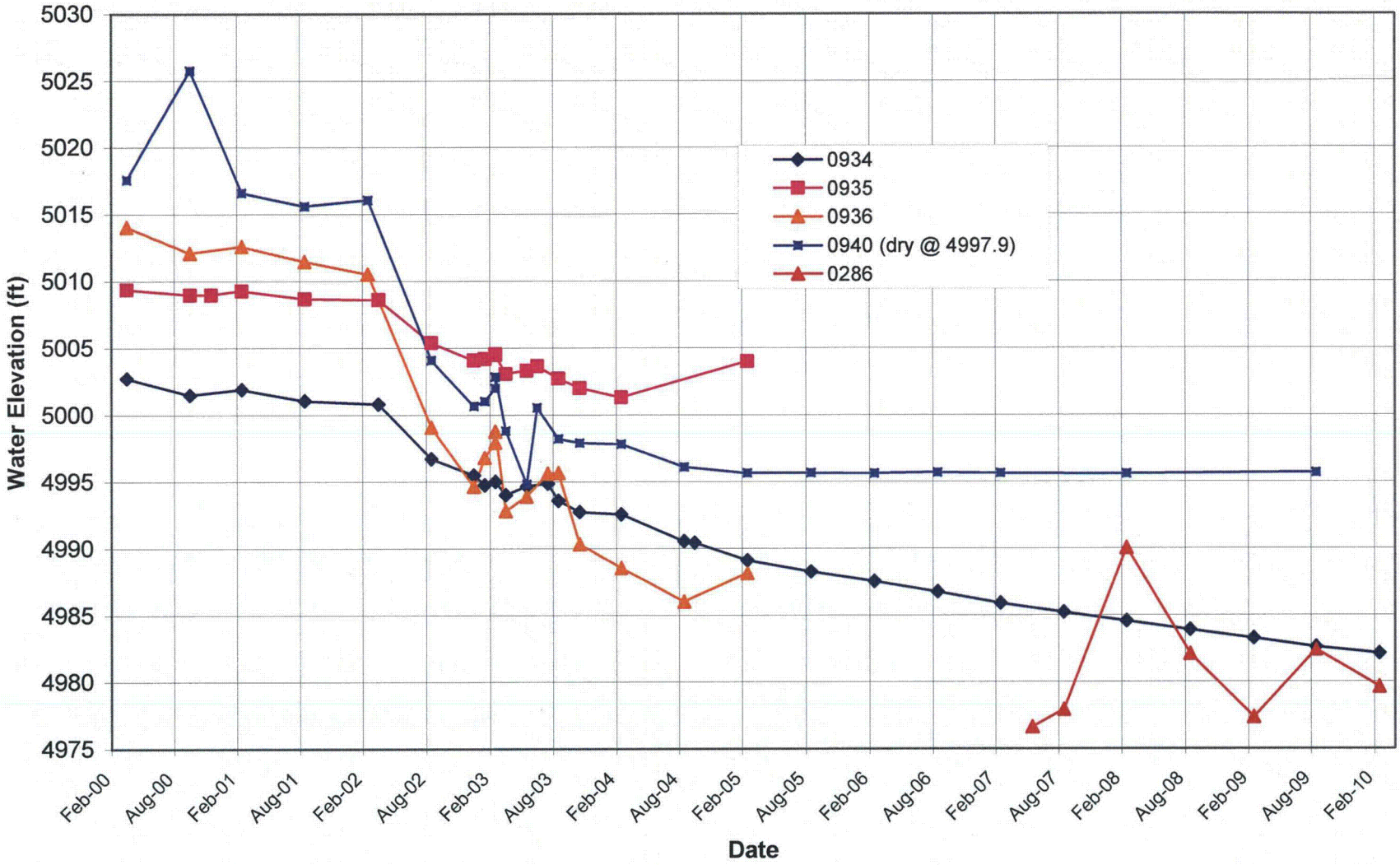


Figure D–2. Horizon A and B Monitoring Wells 286, 934–936, 940

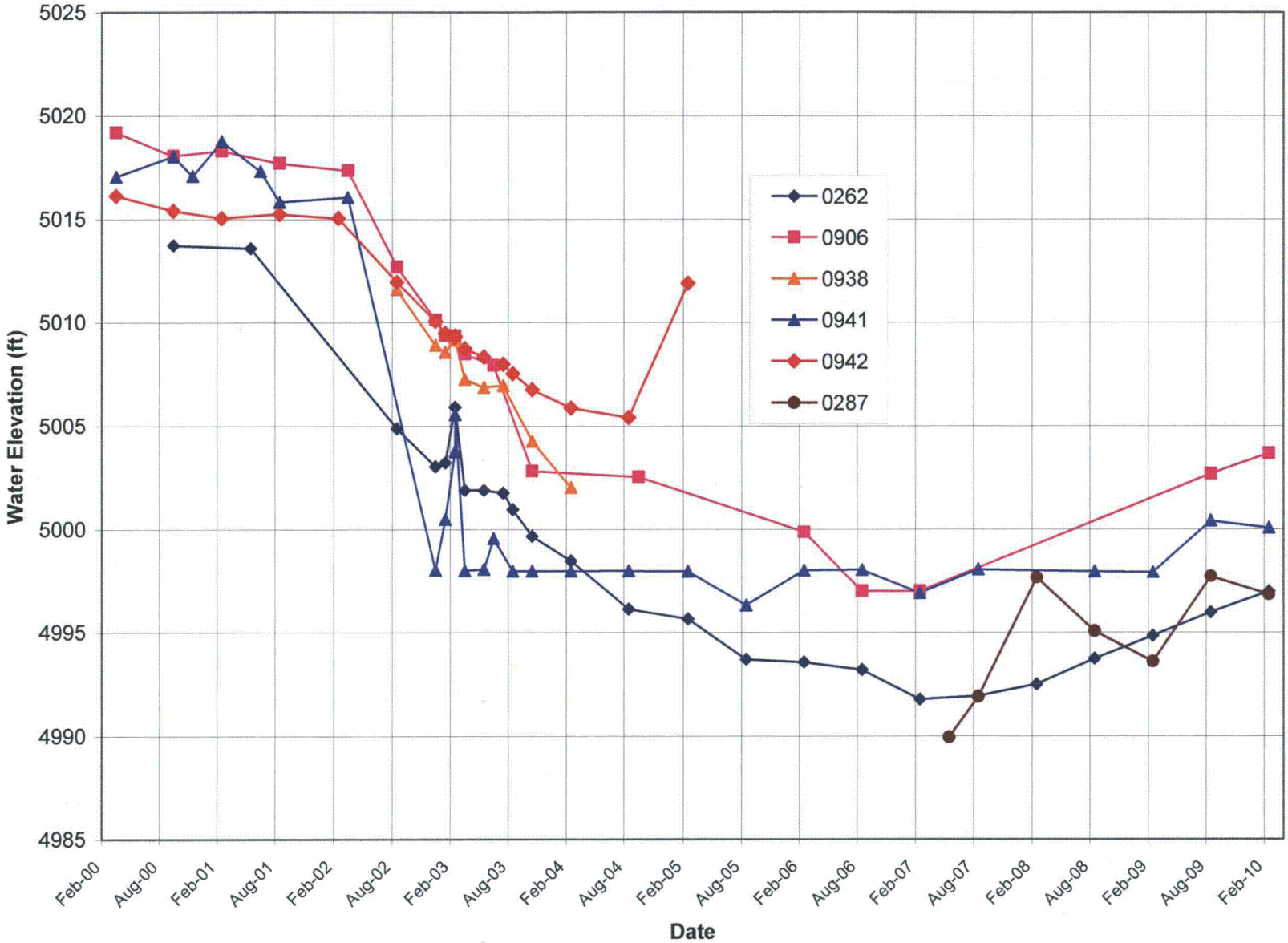


Figure D−3. Horizon A and B Monitoring Wells 262, 287, 906, 938, 941, 942

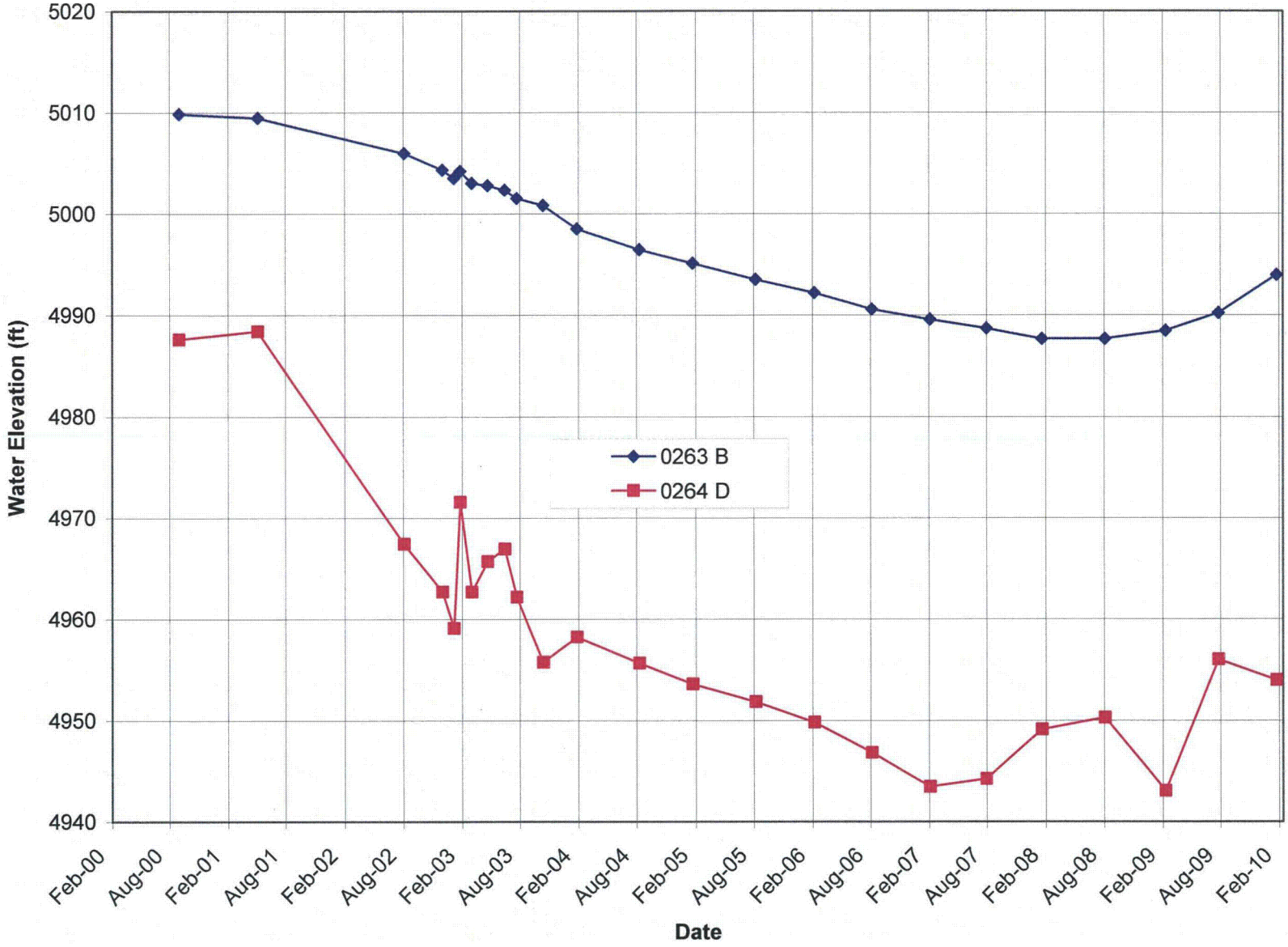


Figure D-4. Middle Terrace Well Pair 263 and 264

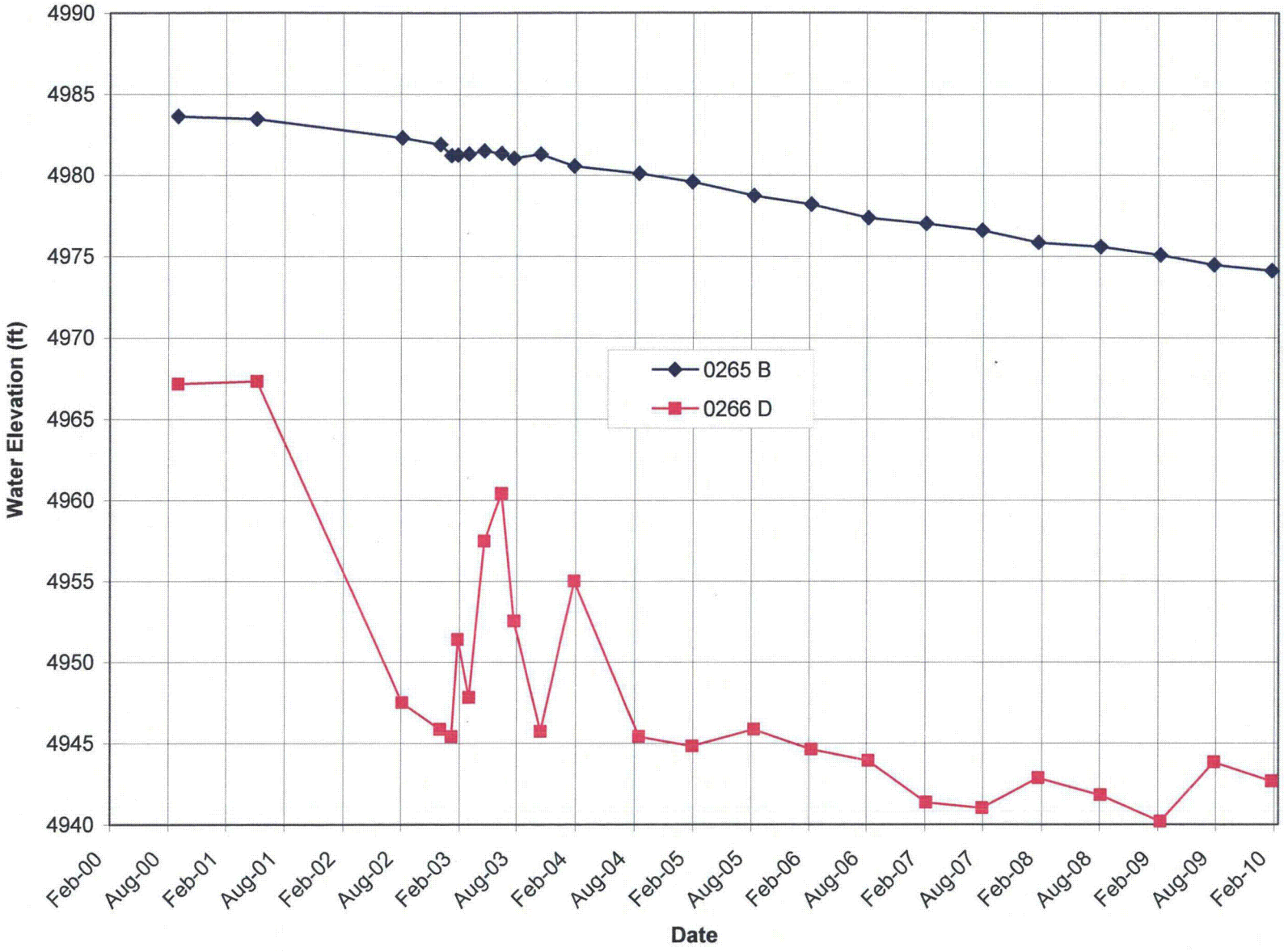


Figure D-5. Middle Terrace Well Pair 265 and 266

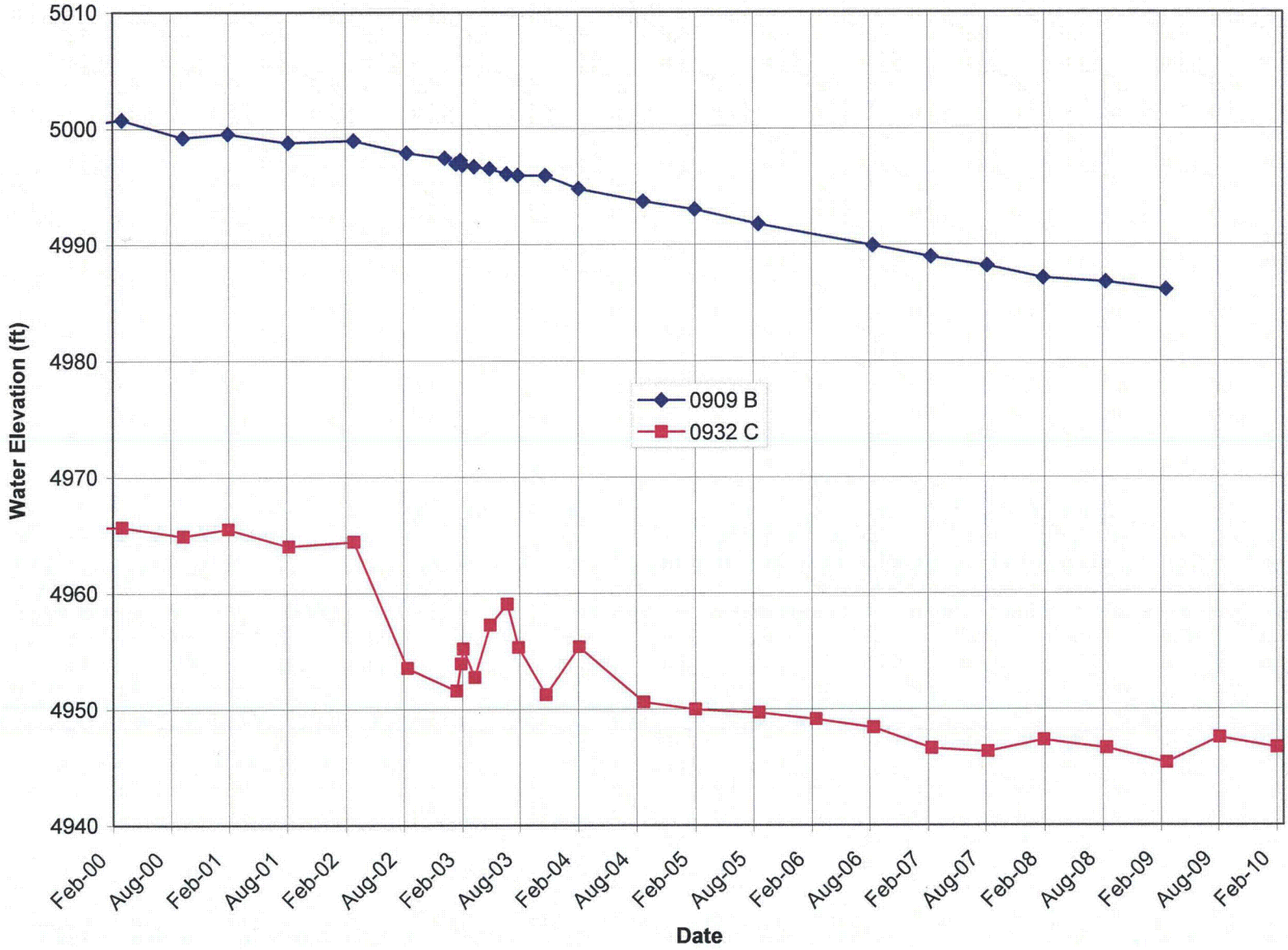


Figure D-6. Middle Terrace Well Pair 909 and 932

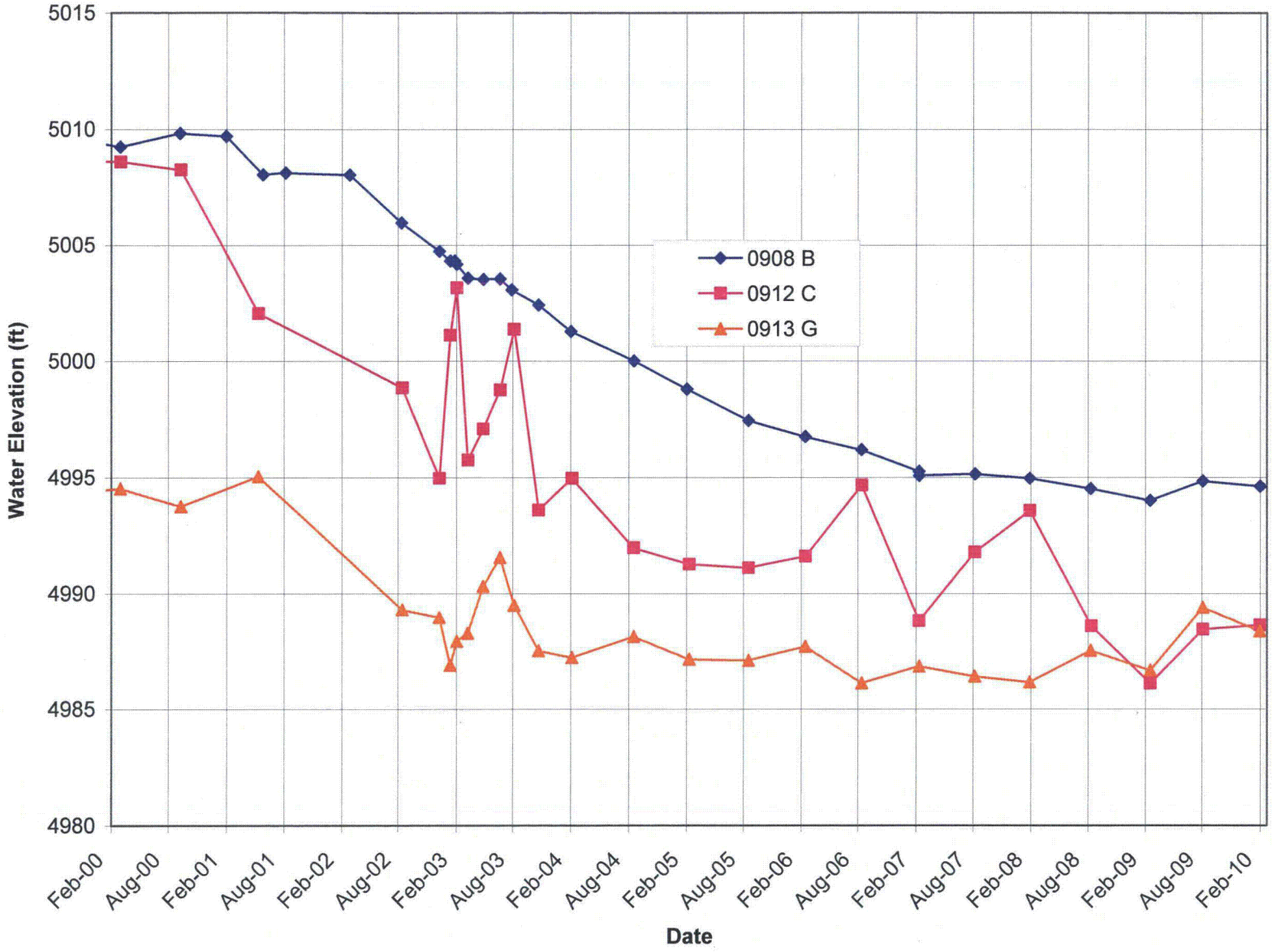


Figure D−7. Middle Terrace Well Cluster 908, 912, and 913

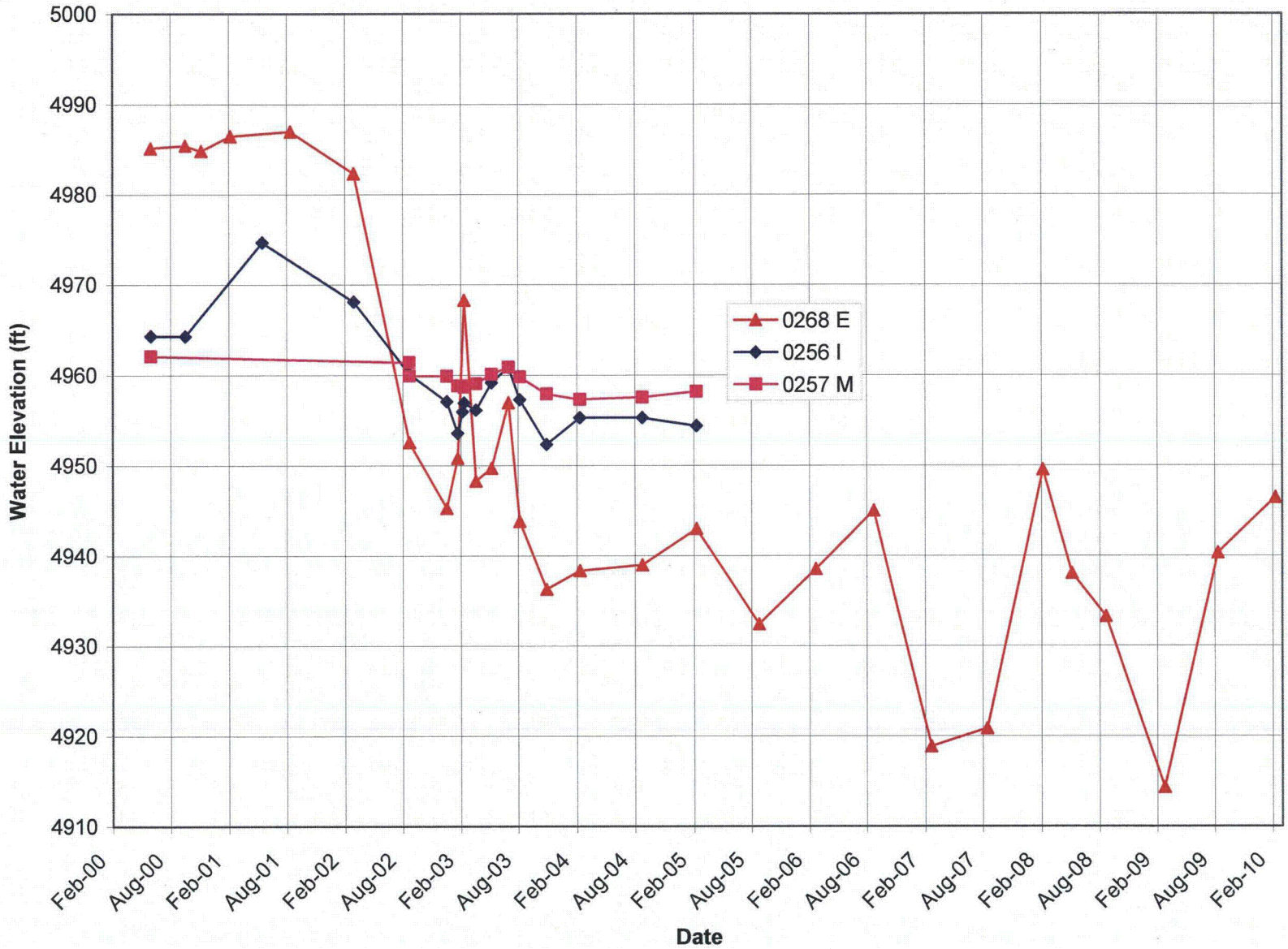


Figure D–8. Middle Terrace Well Cluster 268, 256, and 257

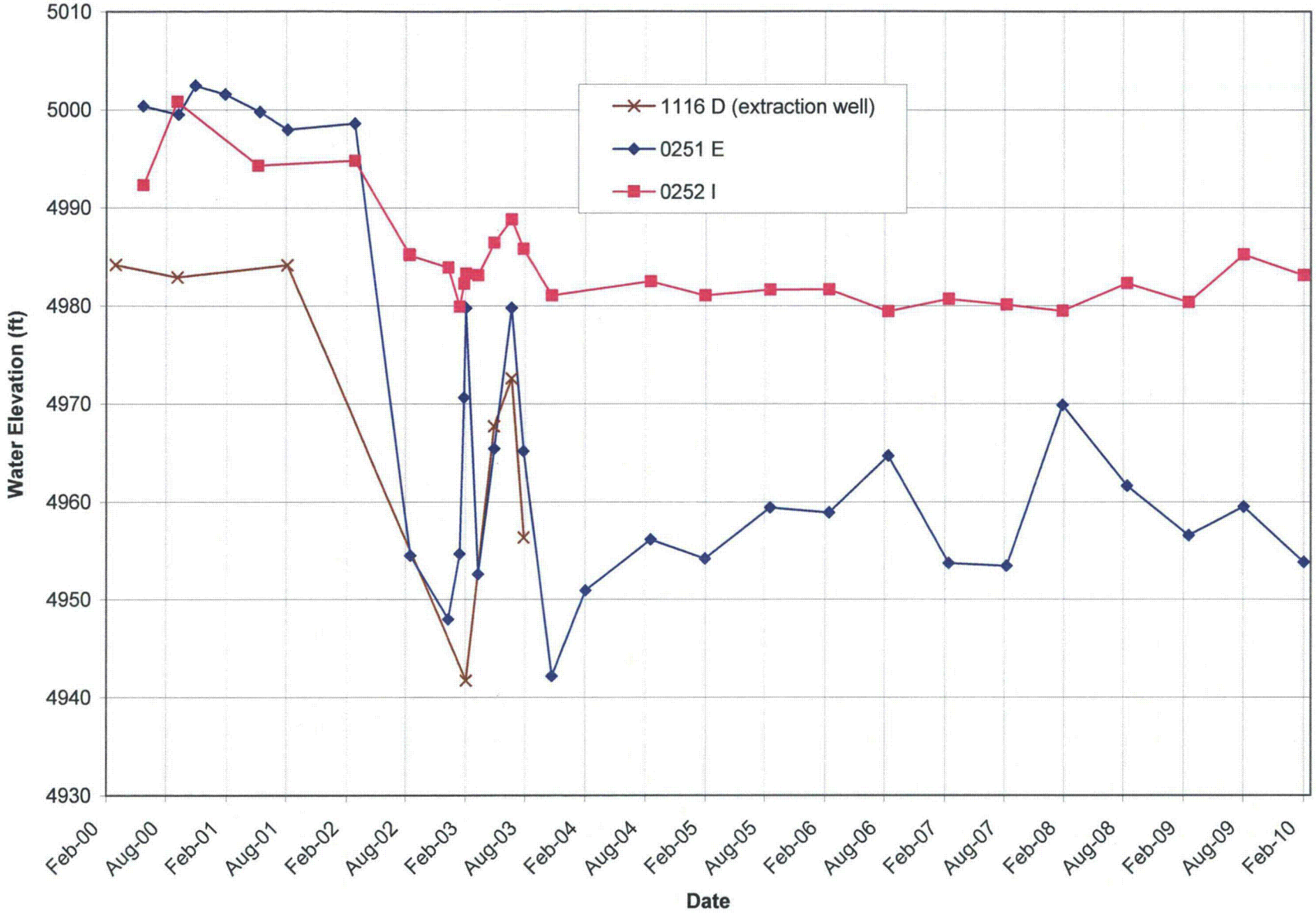


Figure D−9. Middle Terrace Well Cluster 251, 252, and 1116

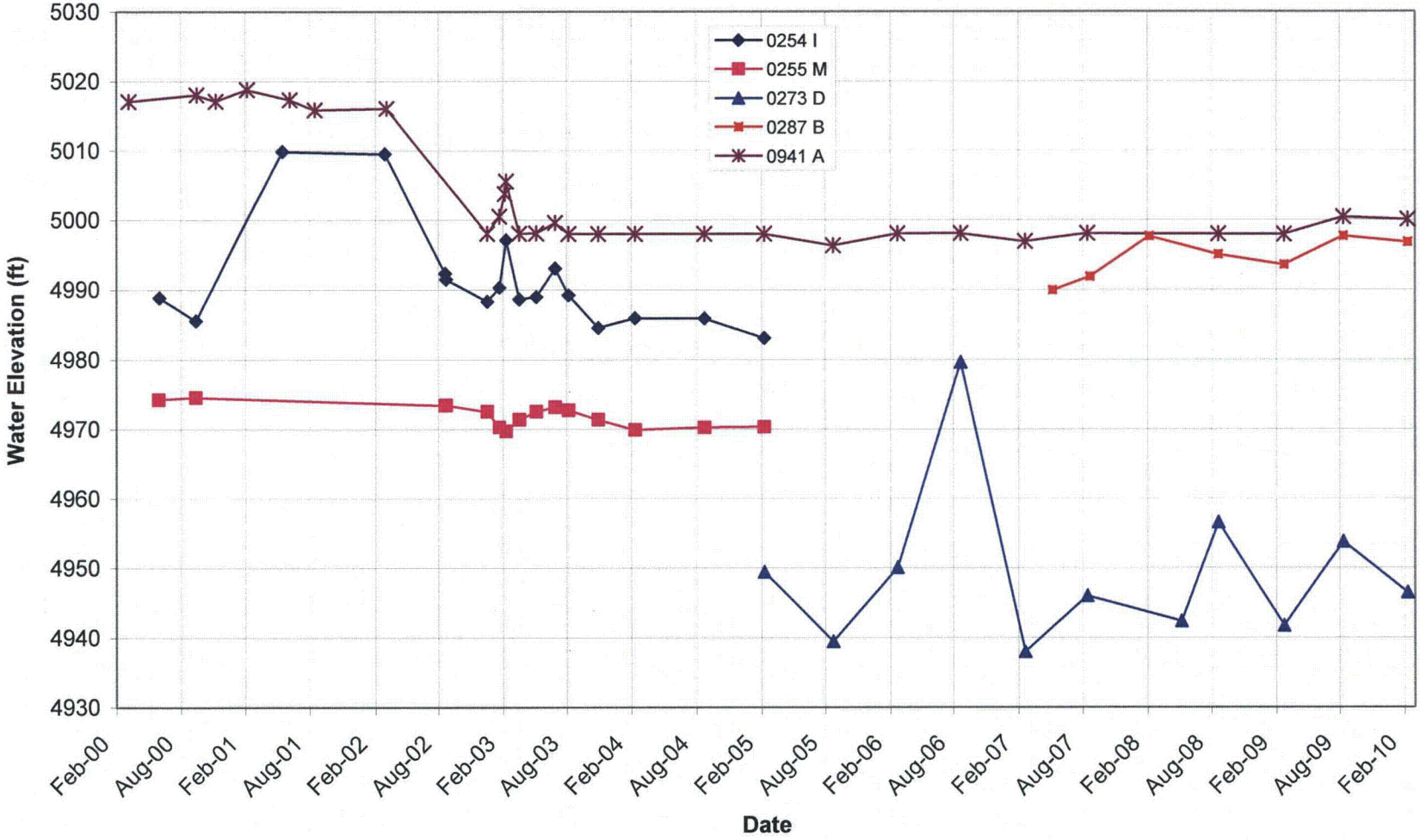


Figure D–10. Middle Terrace Well Cluster 254, 255, 273, 287, and 941

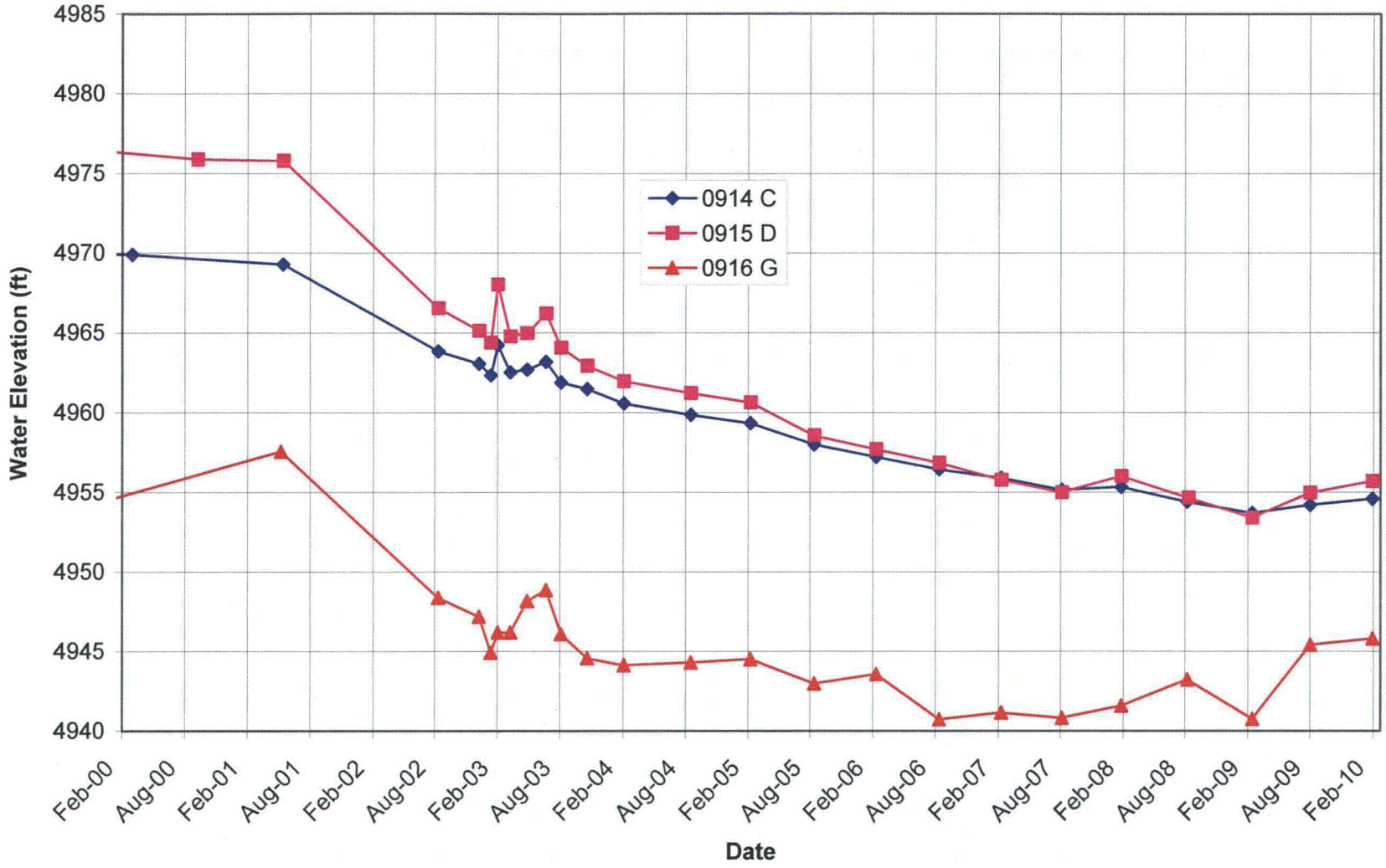


Figure D−11. Middle Terrace Well Cluster 914, 915, and 916

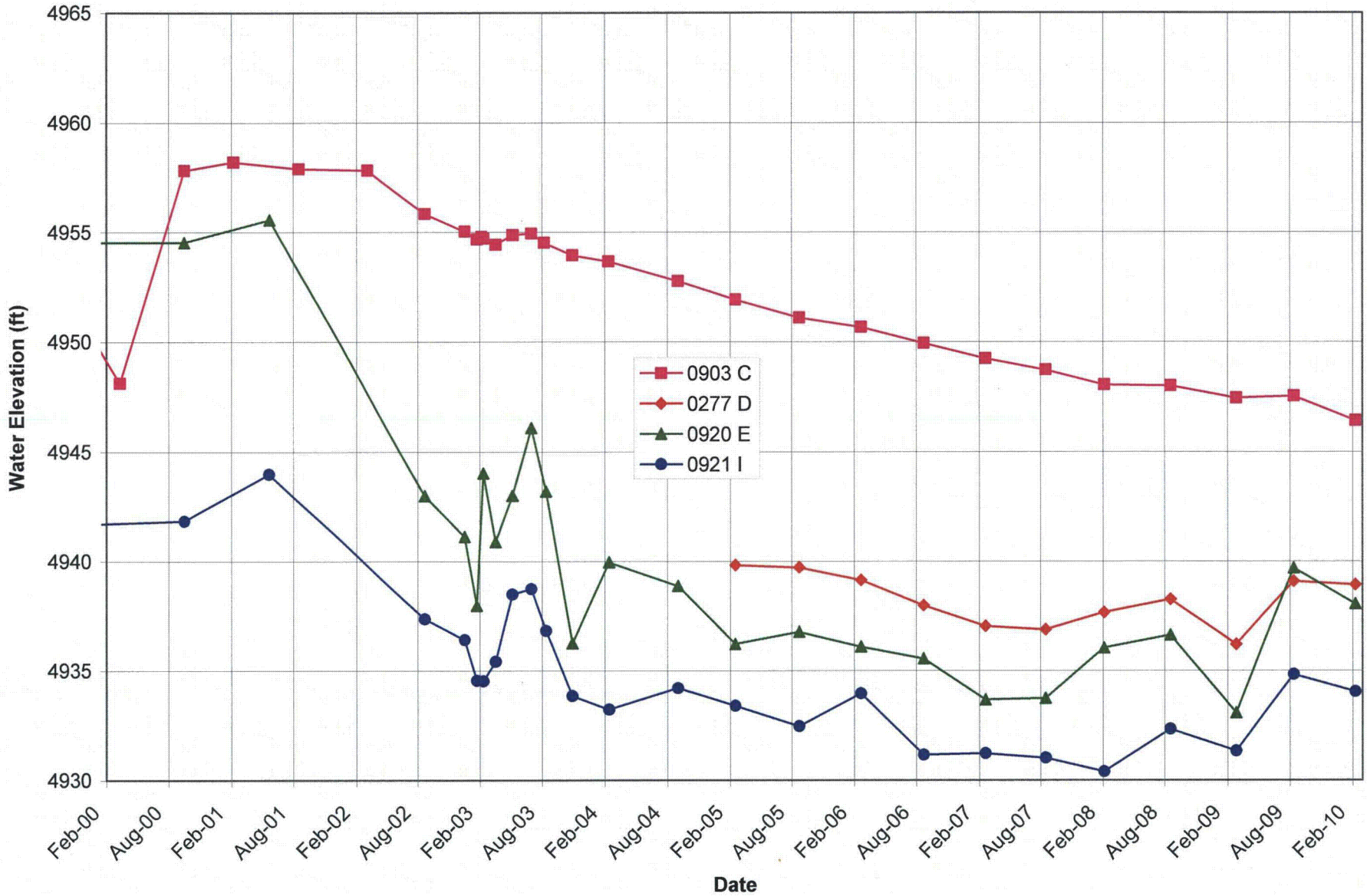


Figure D–12. Lower Terrace Well Cluster 277, 903, 920, and 921

Appendix E

Contaminant Concentration Trends at Monitoring Wells

This page intentionally left blank

Contents

Figures

Figure E–1. Horizons A and B Monitoring Wells, Nitrate as NO_3 Concentration E–1
Figure E–2. Horizons A and B Monitoring Wells, Sulfate Concentration E–2
Figure E–3. Horizons A and B Monitoring Wells, Uranium Concentration E–3
Figure E–4. Horizons A and B Sentinel Wells, Nitrate as NO_3 Concentration E–4
Figure E–5. Horizons A and B Sentinel Wells, Sulfate Concentration E–5
Figure E–6. Horizons A and B Sentinel Wells, Uranium Concentration E–6
Figure E–7. Horizons C and D Monitoring Wells, Nitrate as NO_3 Concentration E–7
Figure E–8. Horizons C and D Monitoring Wells, Sulfate Concentration E–8
Figure E–9. Horizons C and D Monitoring Wells, Uranium Concentration E–9
Figure E–10. Lower Terrace Monitoring Wells, Nitrate as NO_3 Concentration E–10
Figure E–11. Lower Terrace Monitoring Wells, Sulfate Concentration E–11
Figure E–12. Lower Terrace Monitoring Wells, Uranium Concentration E–12
Figure E–13. Deep Monitoring Wells, Nitrate as NO_3 Concentration E–13
Figure E–14. Deep Monitoring Wells, Sulfate Concentration E–14
Figure E–15. Deep Monitoring Wells, Uranium Concentration E–15

This page intentionally left blank

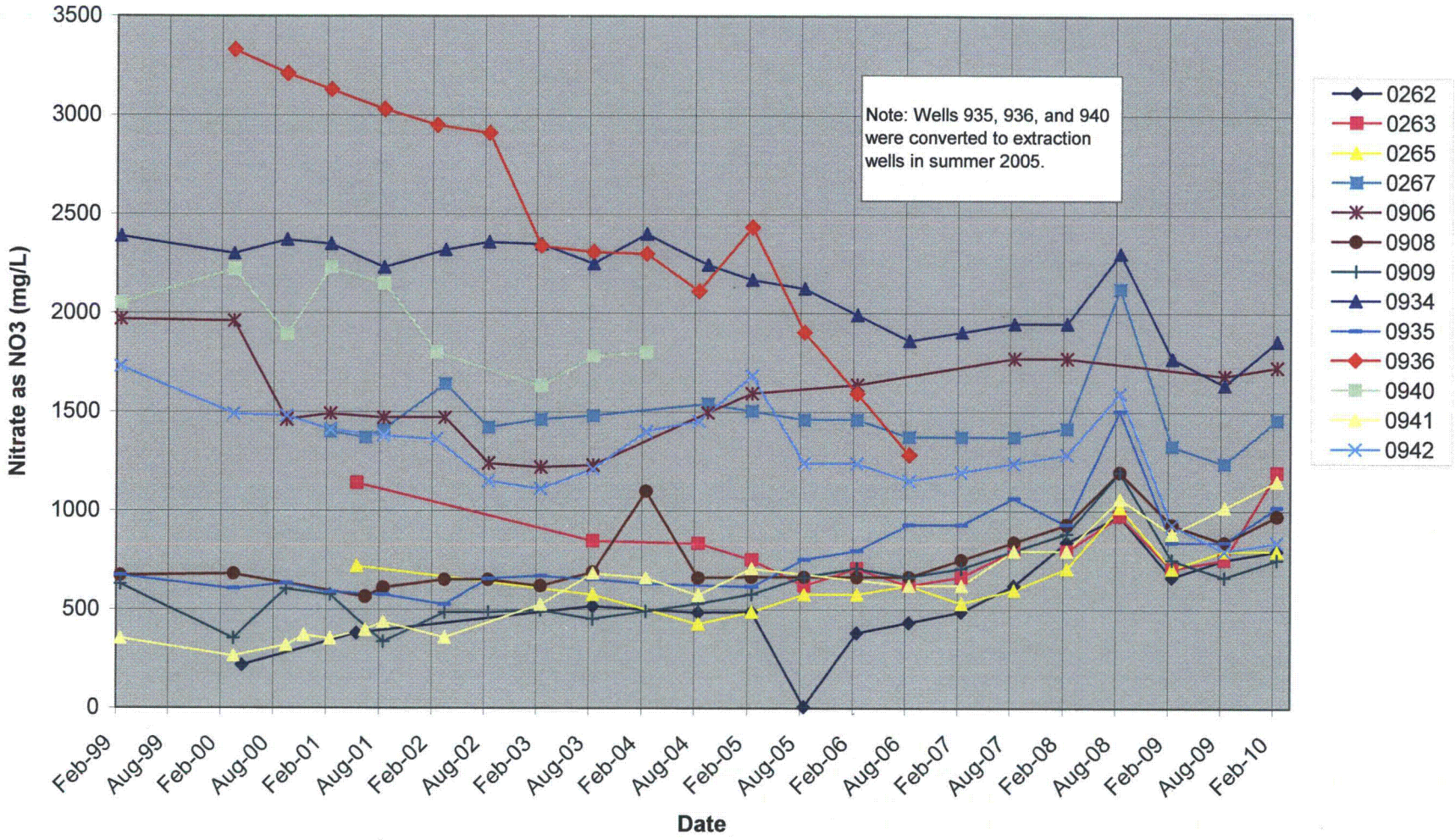


Figure E−1. Horizons A and B Monitoring Wells, Nitrate as NO_3 Concentration

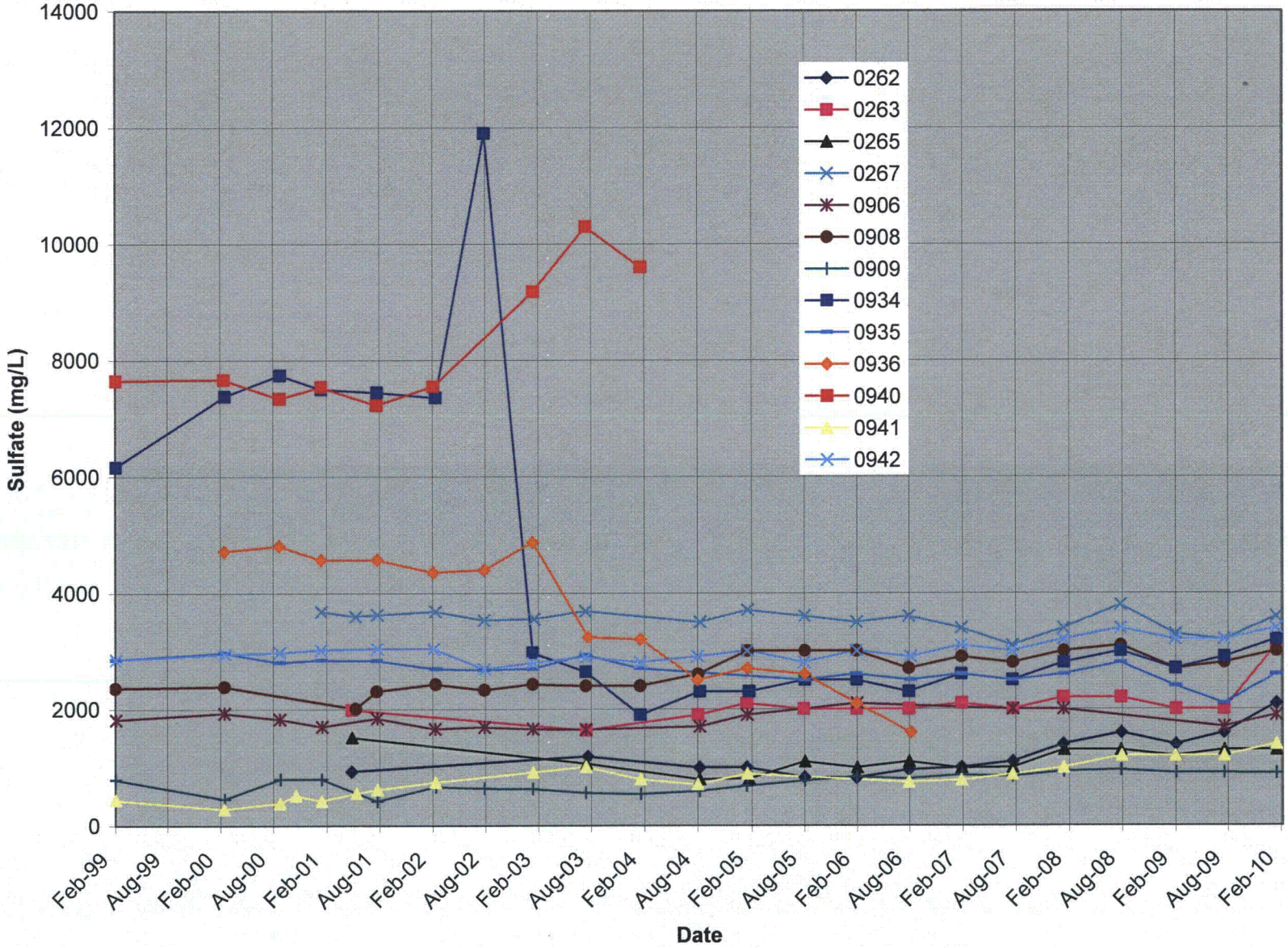


Figure E−2. Horizons A and B Monitoring Wells, Sulfate Concentration

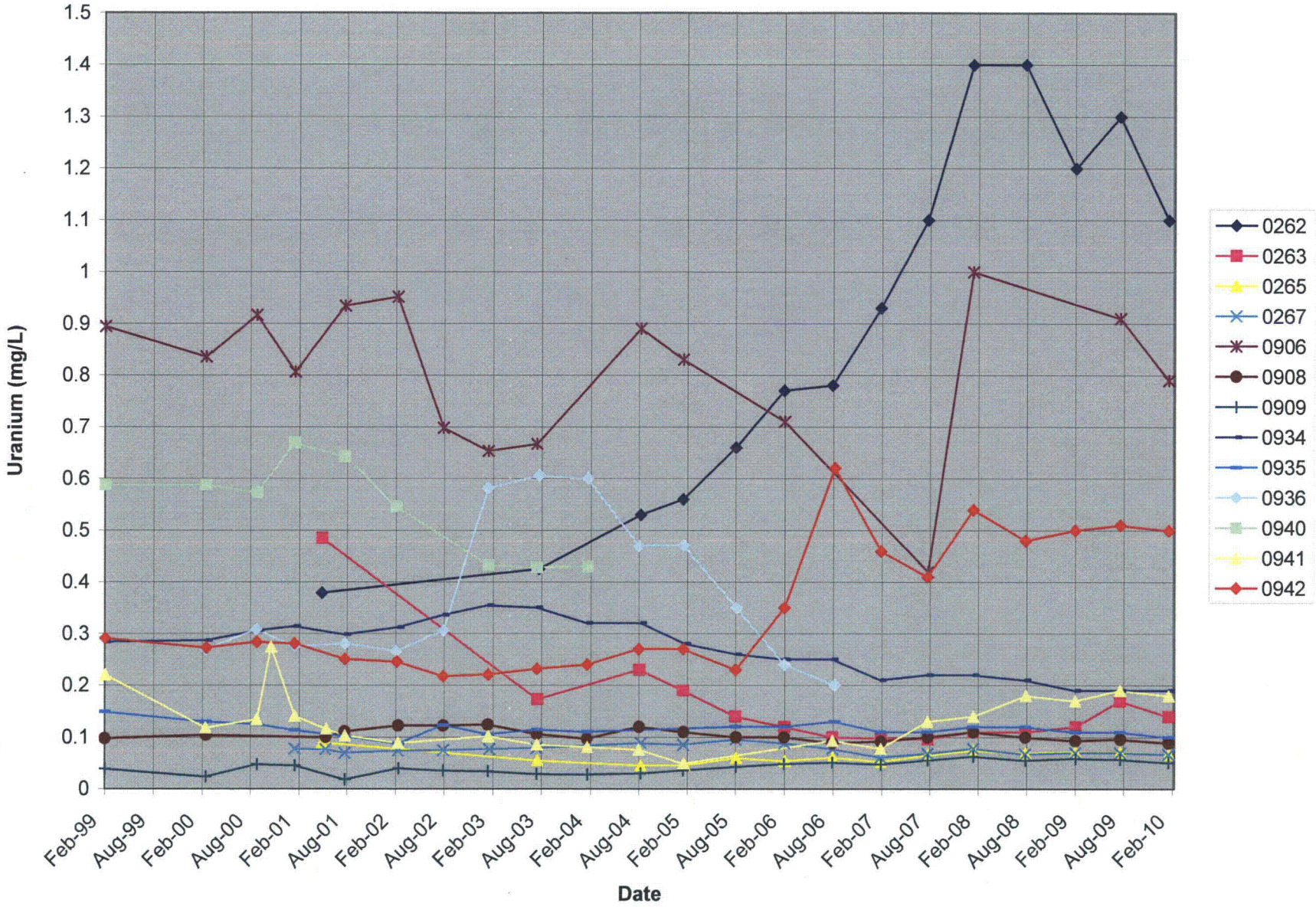


Figure E−3. Horizons A and B Monitoring Wells, Uranium Concentration

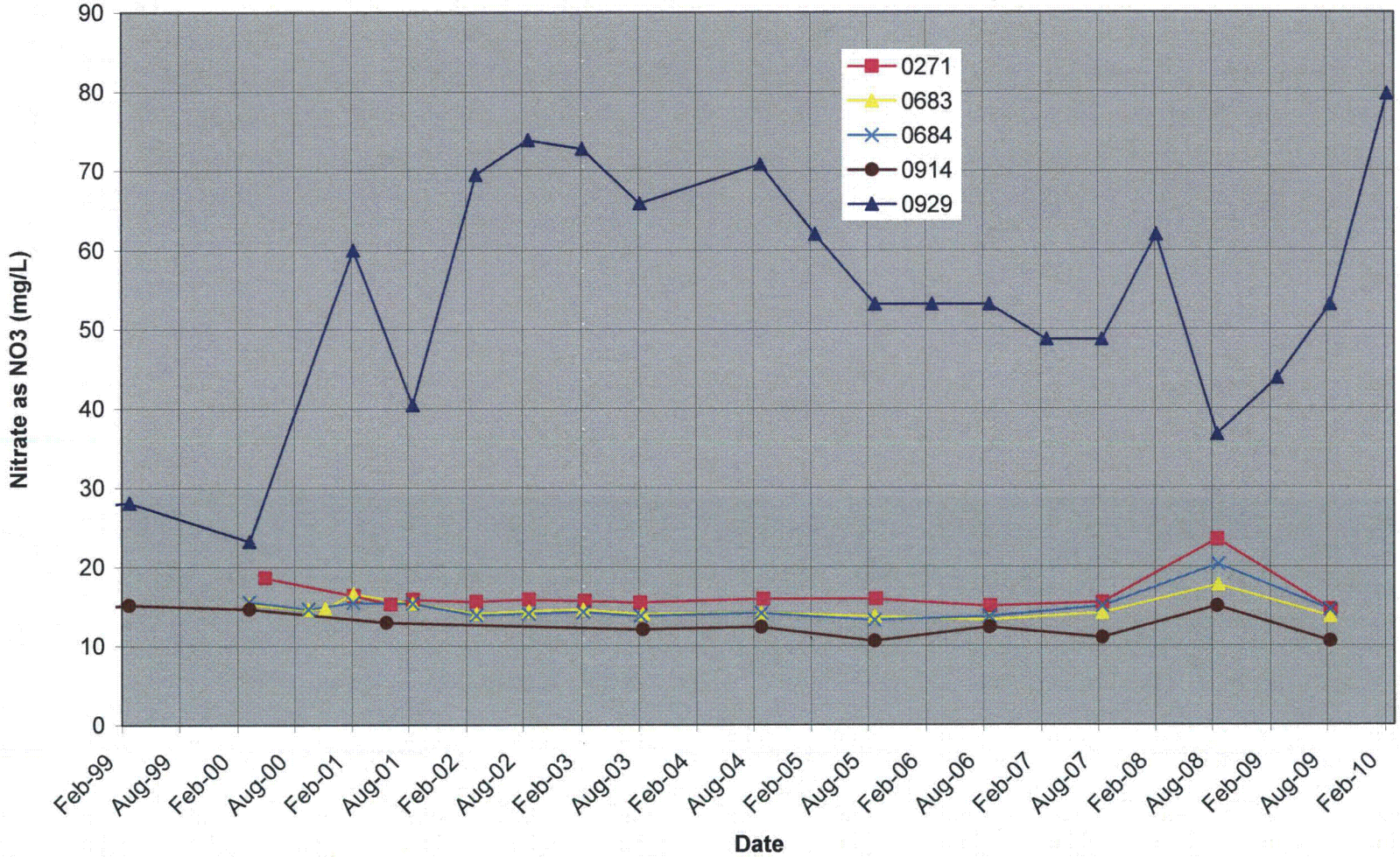


Figure E-4. Horizons A and B Sentinel Wells, Nitrate as NO_3 Concentration

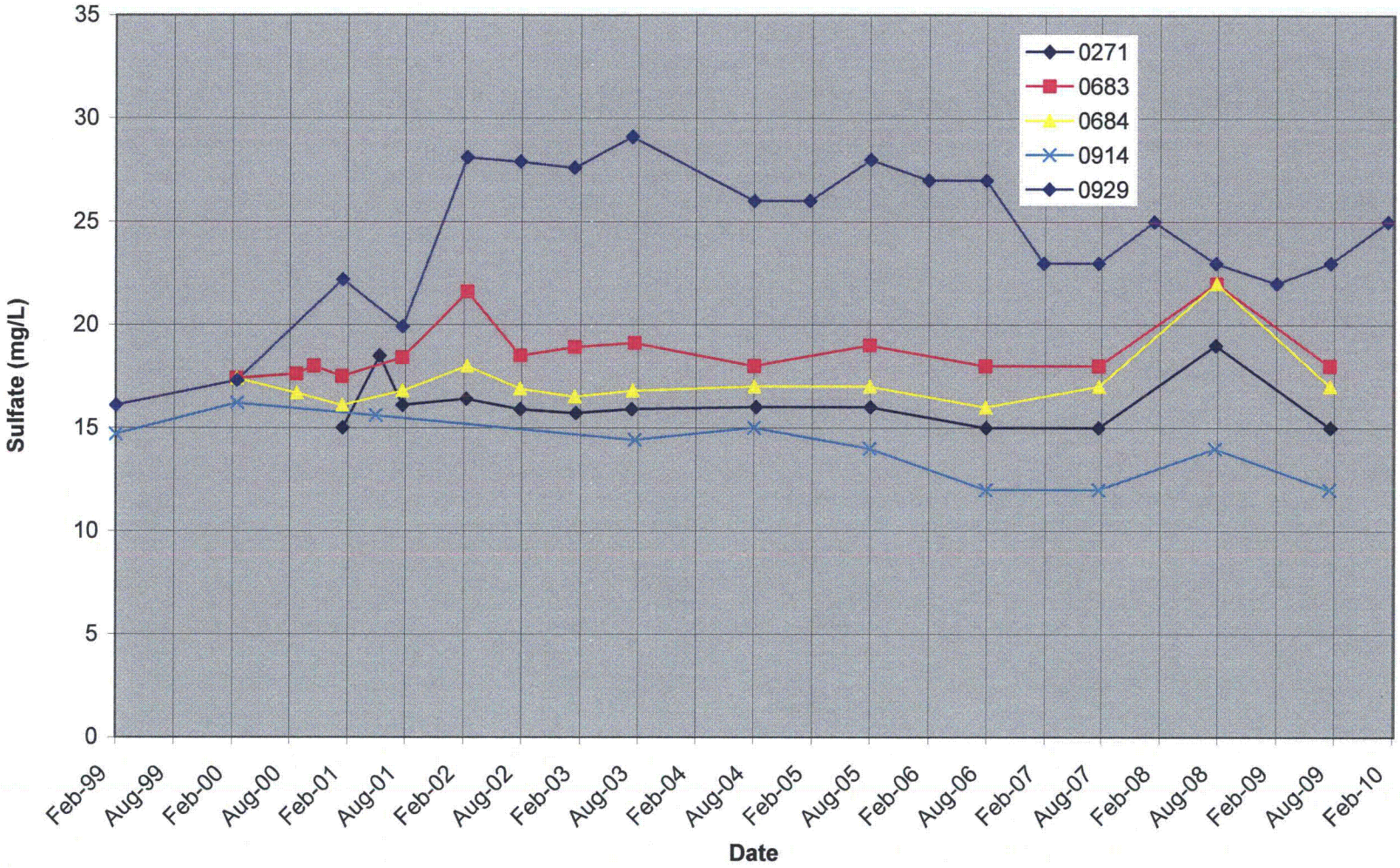


Figure E−5. Horizons A and B Sentinel Wells, Sulfate Concentration

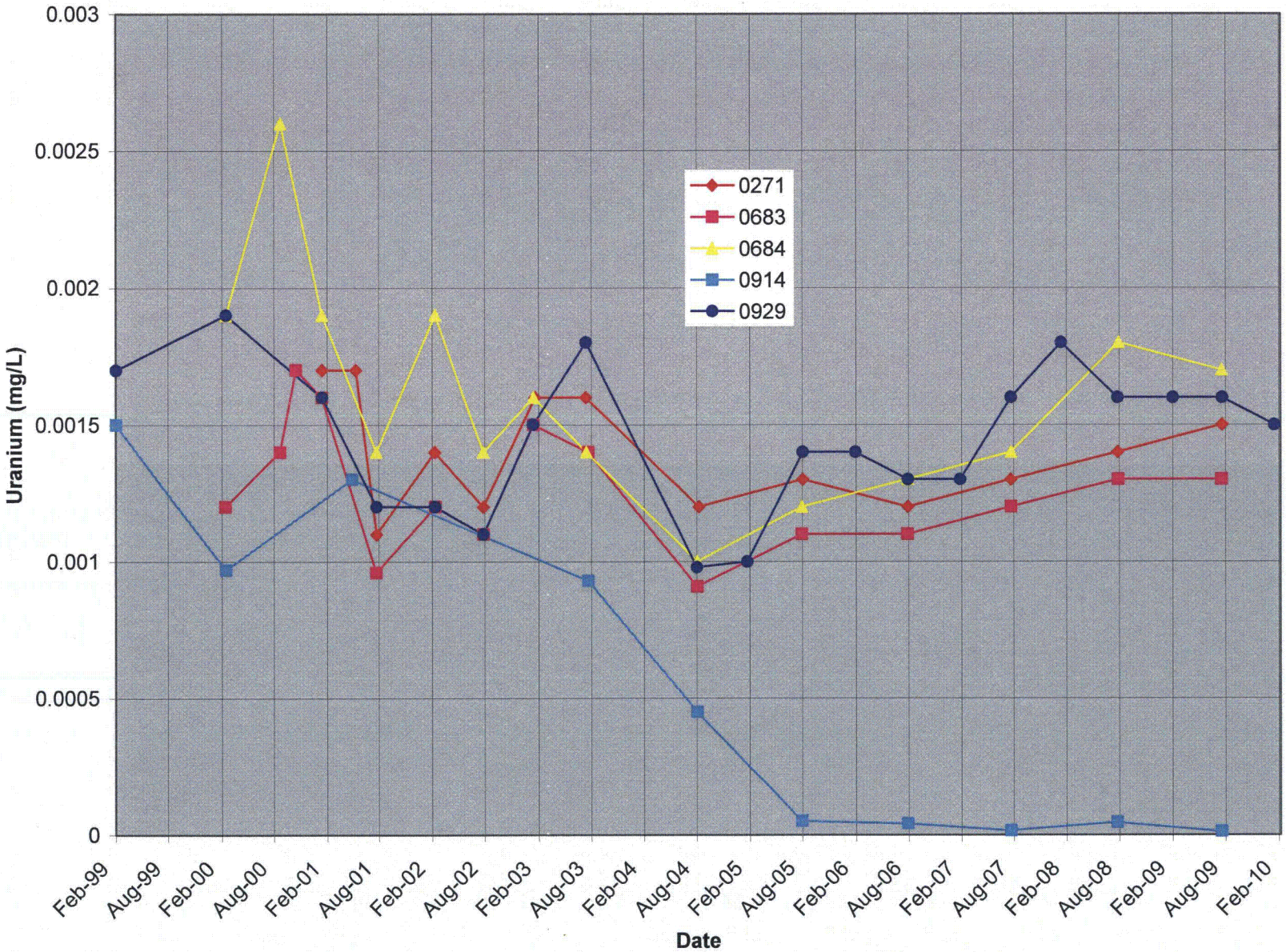


Figure E-6. Horizons A and B Sentinel Wells, Uranium Concentration

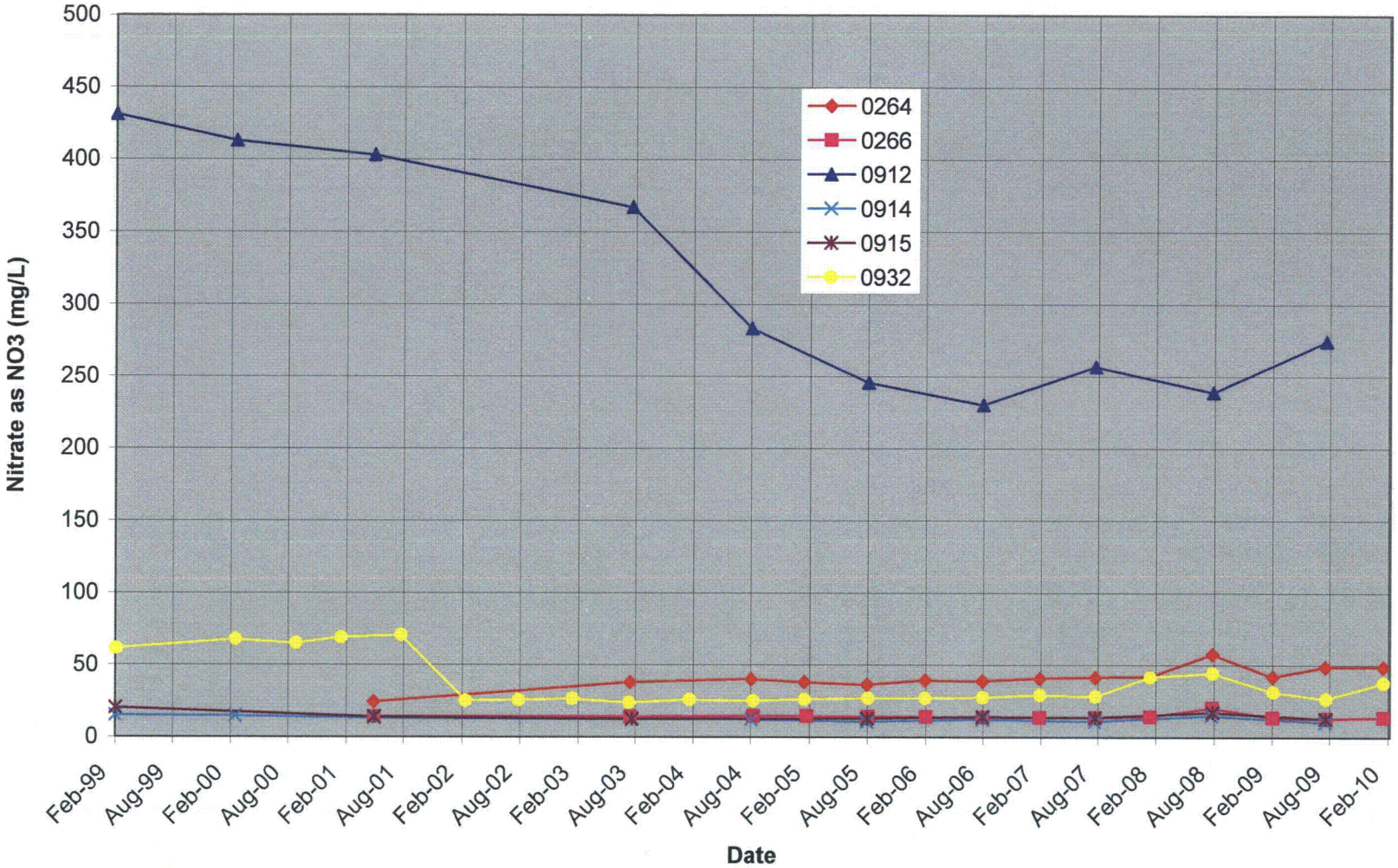


Figure E−7. Horizons C and D Monitoring Wells, Nitrate as NO_3 Concentration

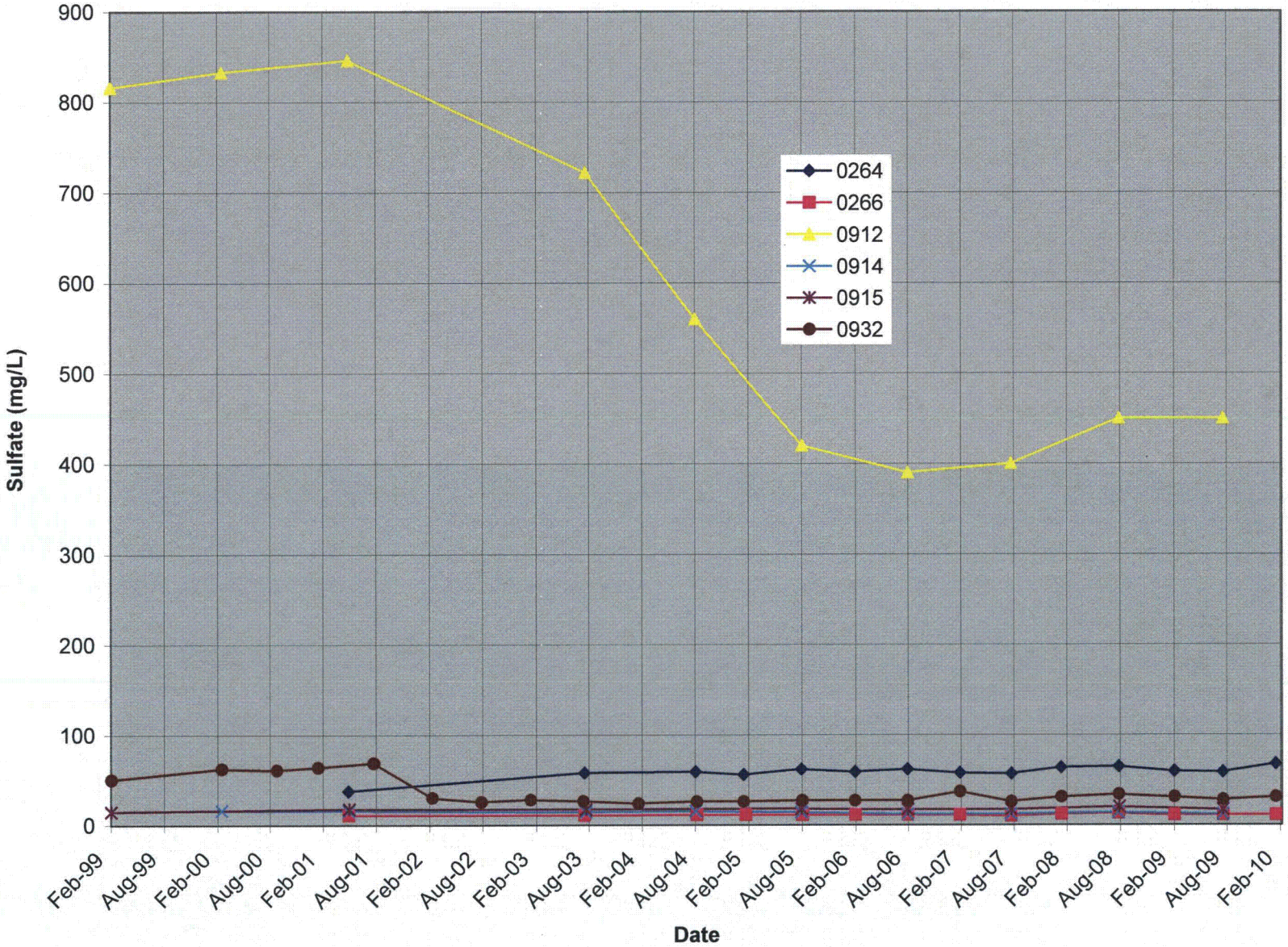


Figure E–8. Horizons C and D Monitoring Wells, Sulfate Concentration

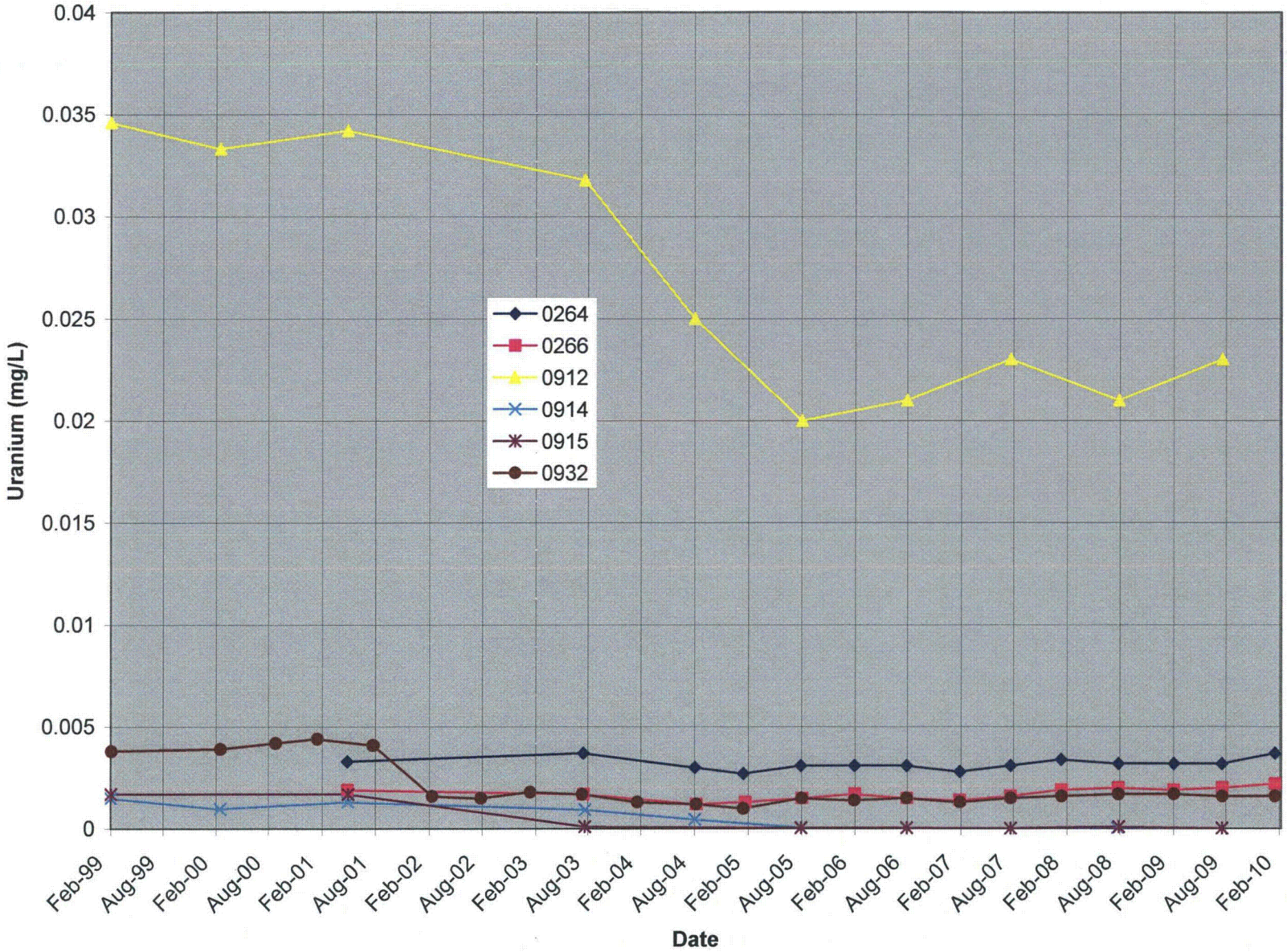


Figure E−9. Horizons C and D Monitoring Wells, Uranium Concentration

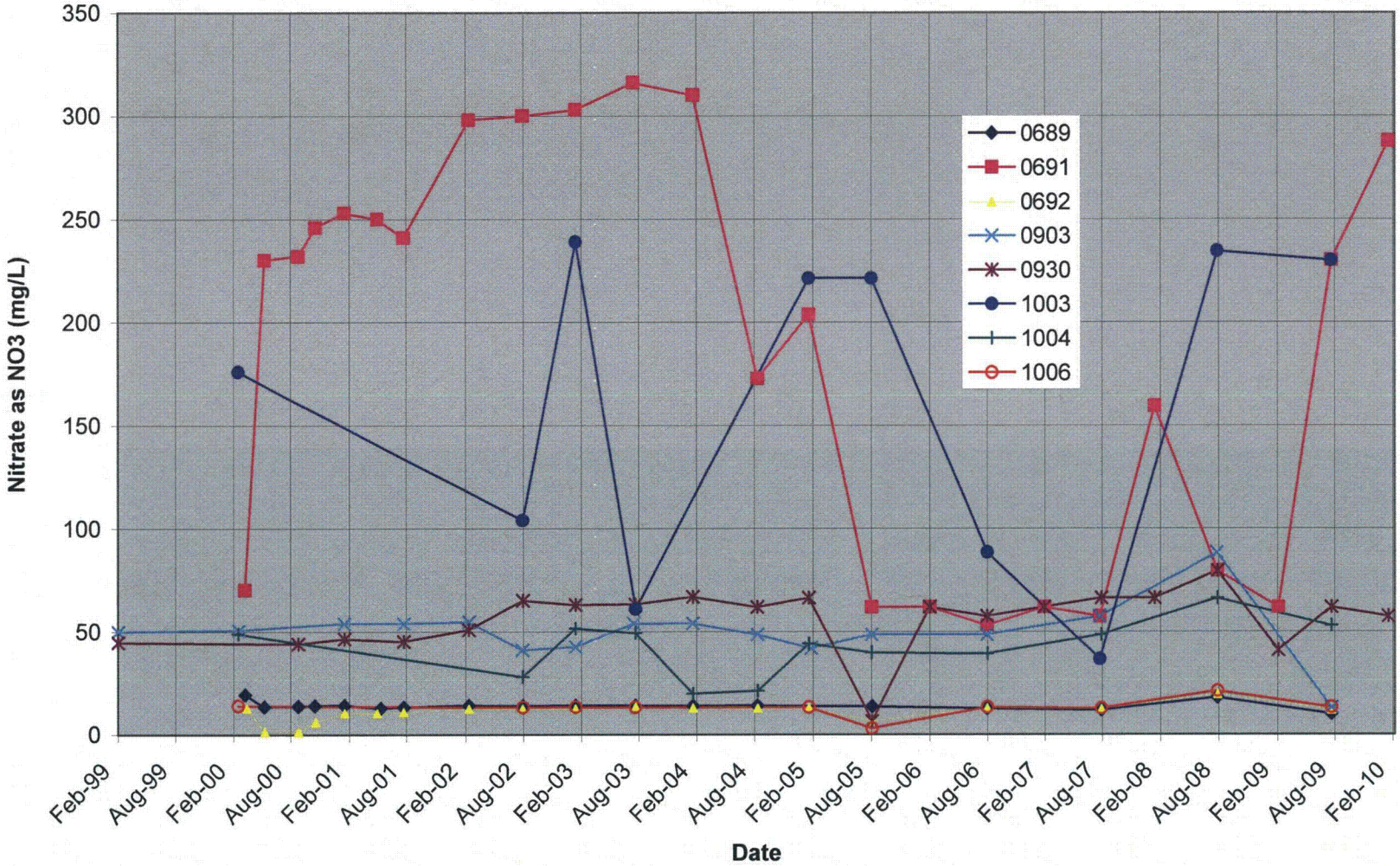


Figure E–10. Lower Terrace Monitoring Wells, Nitrate as NO_3 Concentration

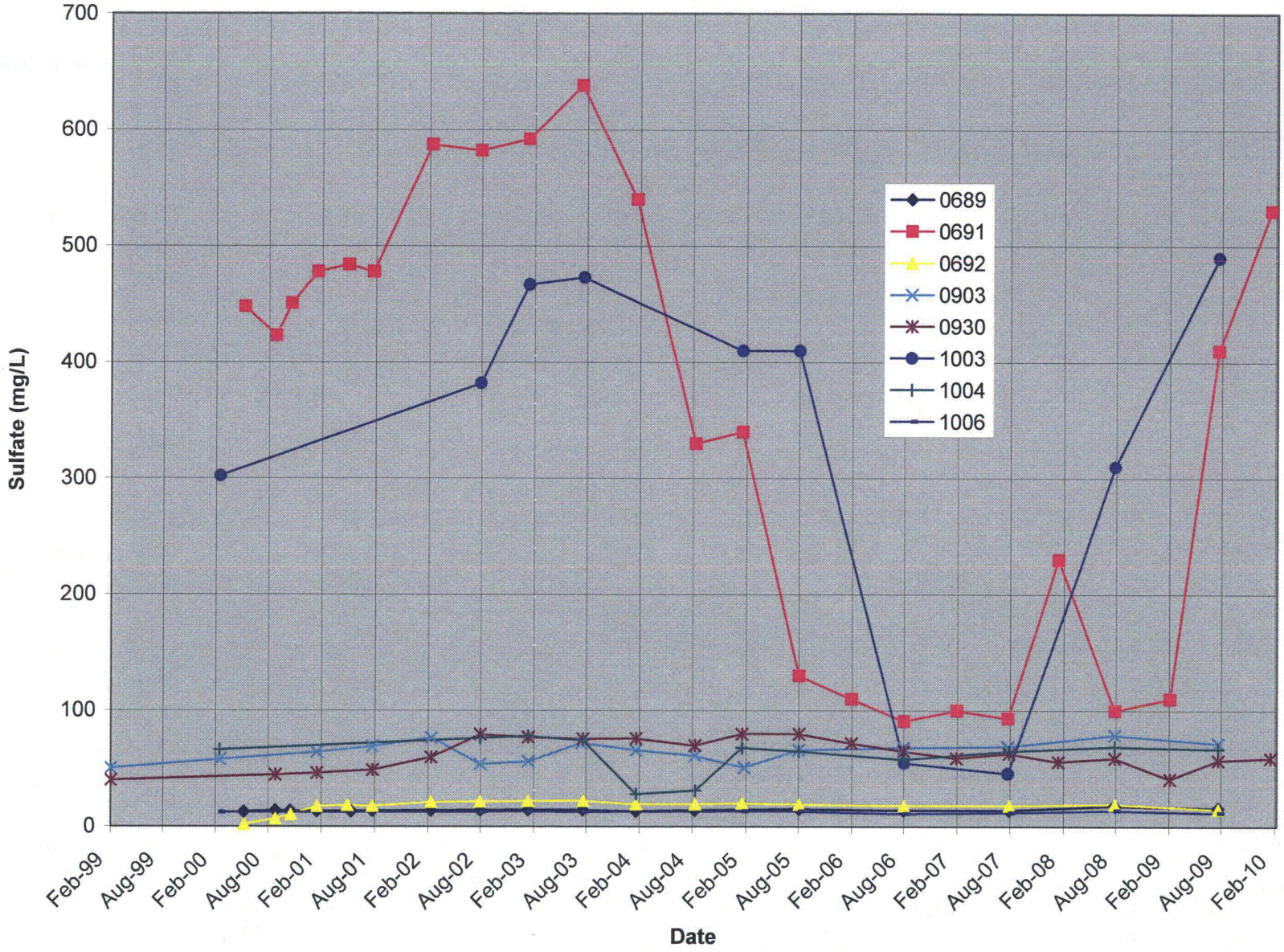


Figure E−11. Lower Terrace Monitoring Wells, Sulfate Concentration

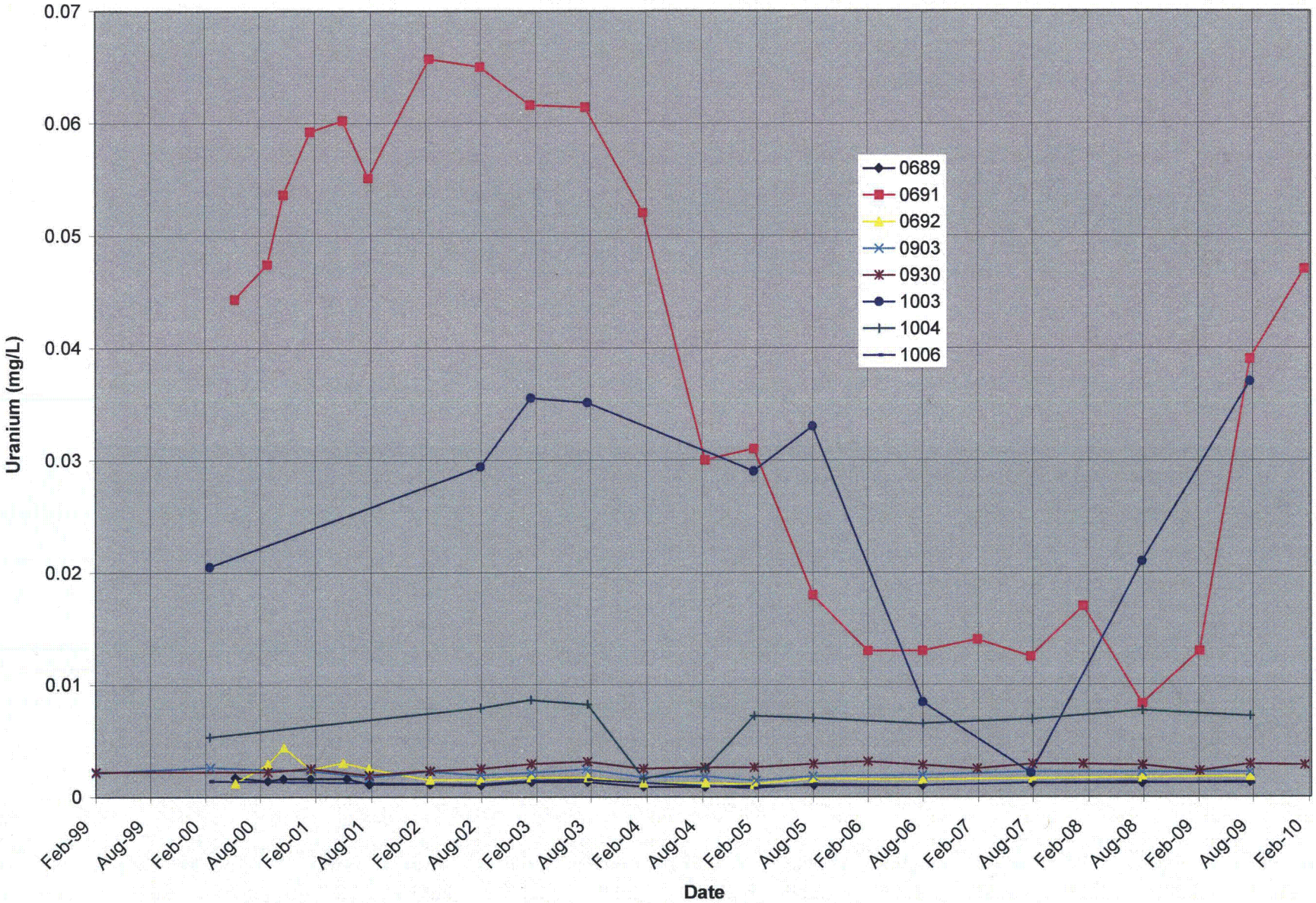


Figure E−12. Lower Terrace Monitoring Wells, Uranium Concentration

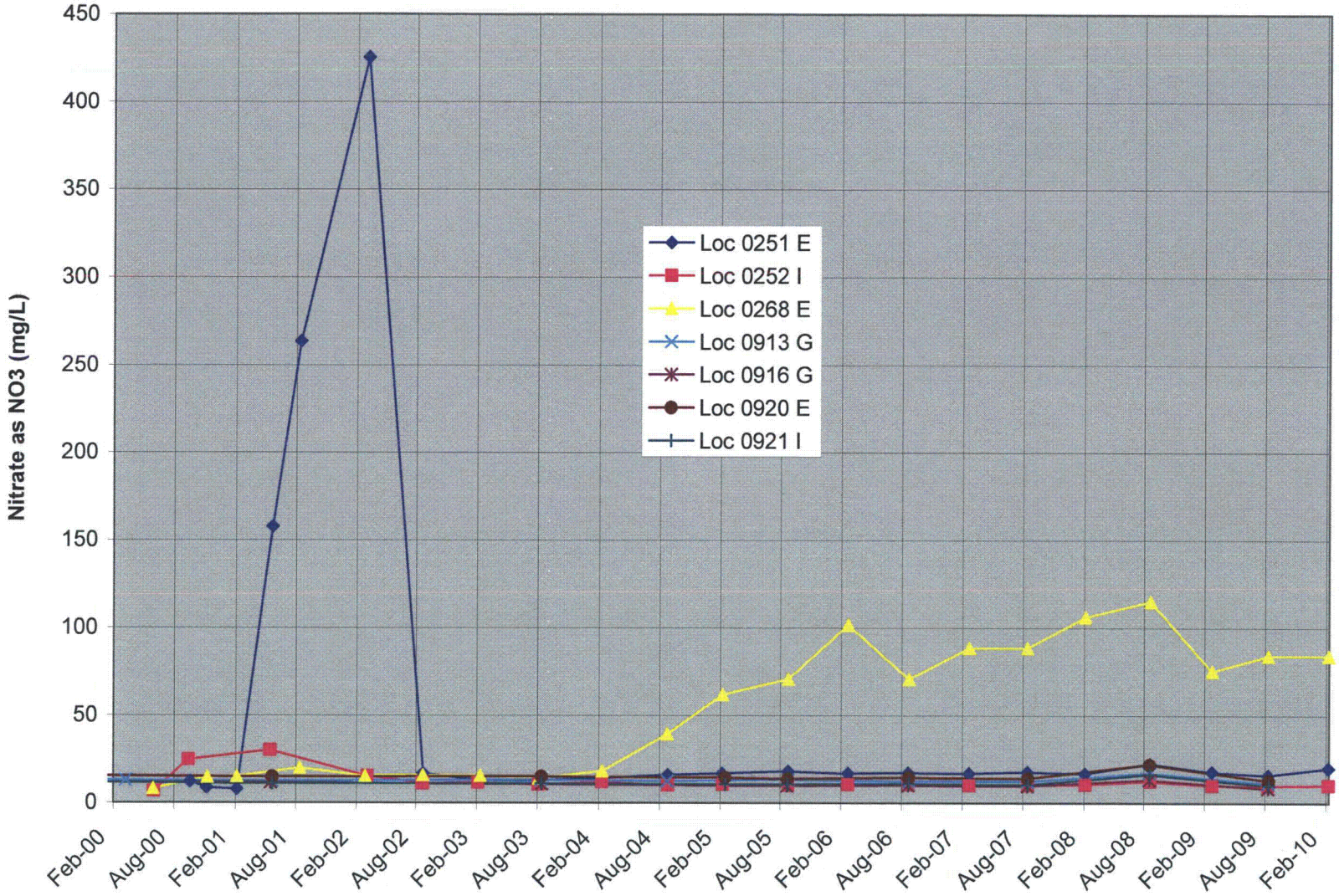


Figure E−13. Deep Monitoring Wells, Nitrate as NO_3 Concentration

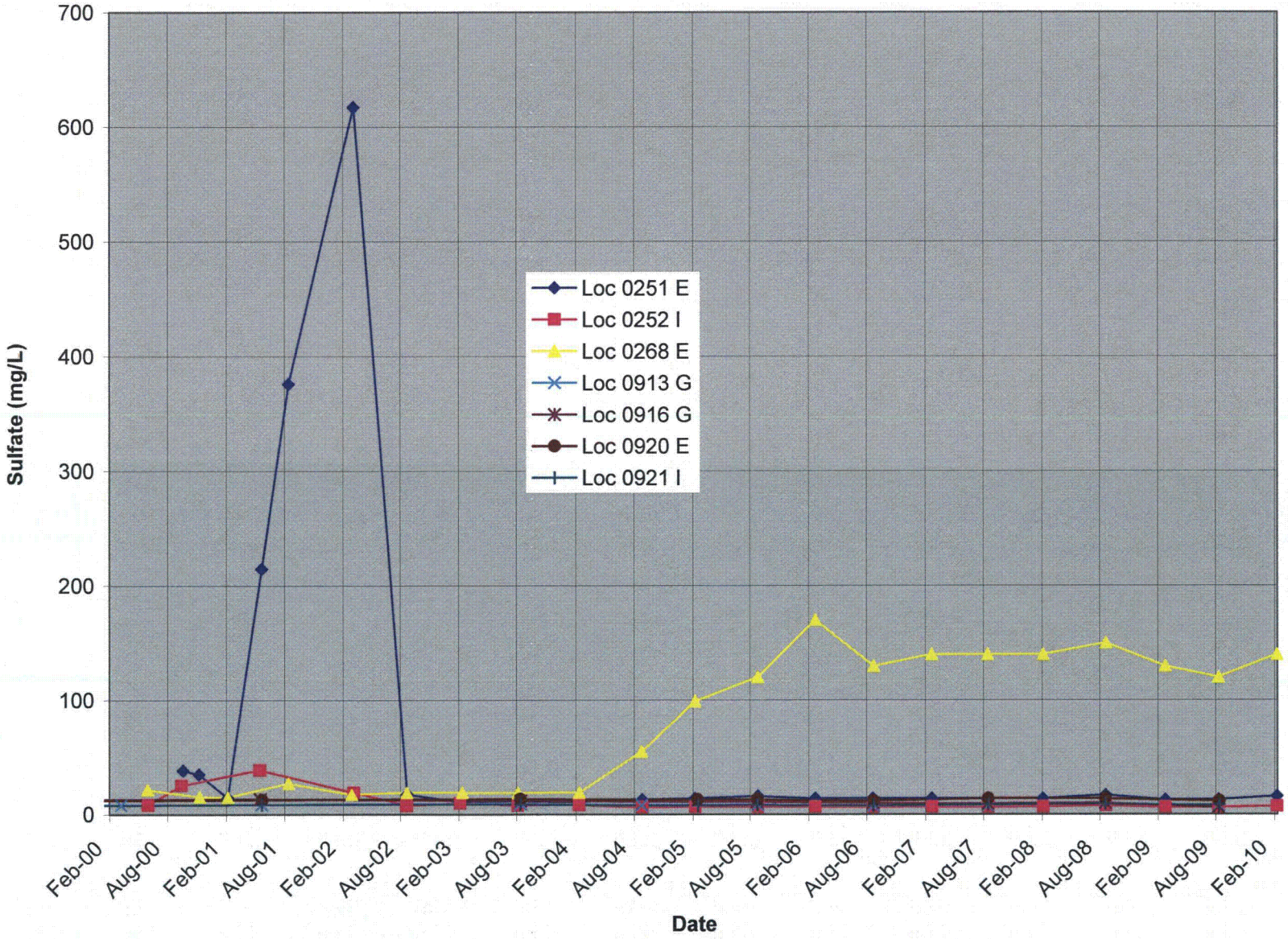


Figure E−14. Deep Monitoring Wells, Sulfate Concentration

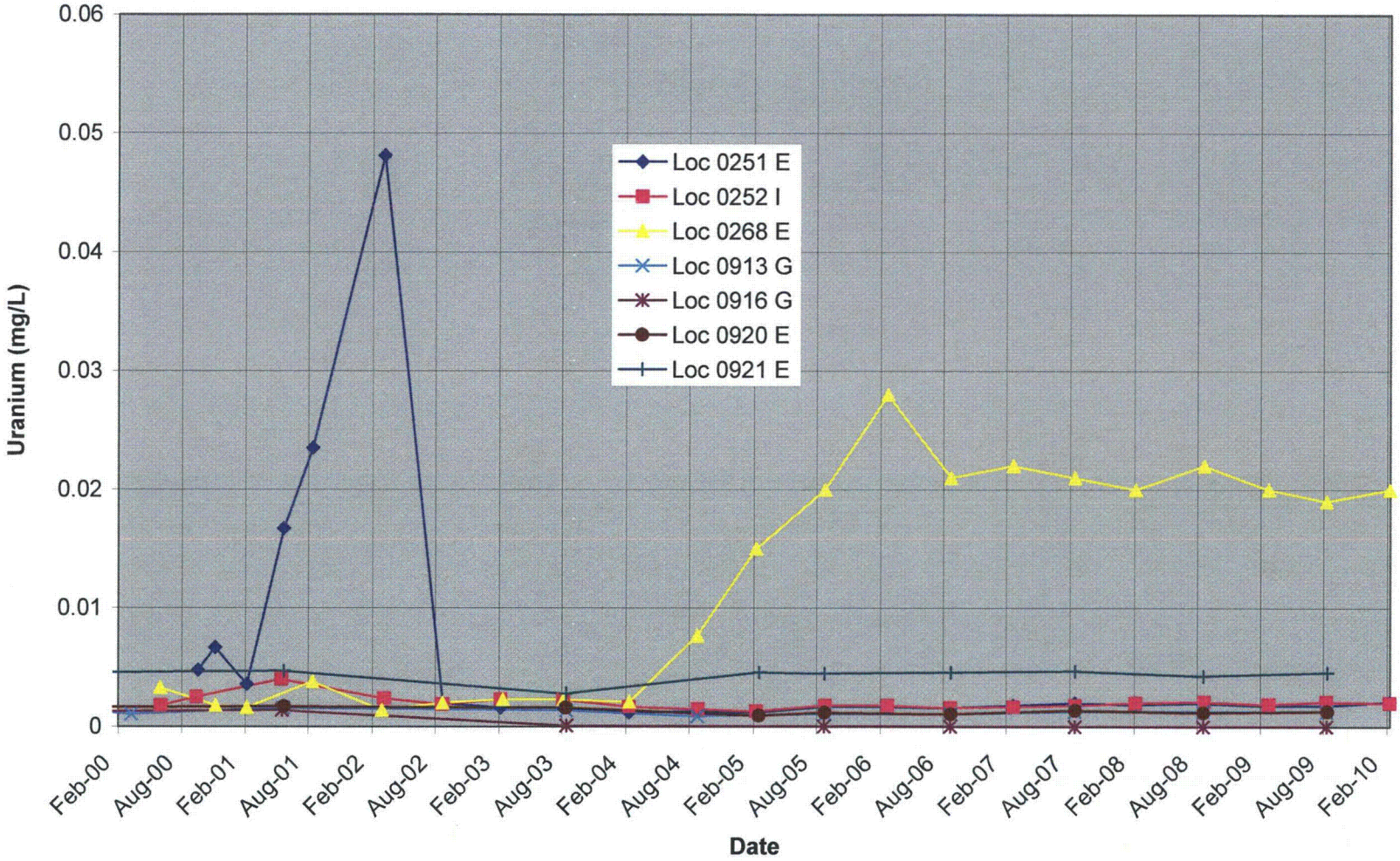


Figure E−15. Deep Monitoring Wells, Uranium Concentration

This page intentionally left blank

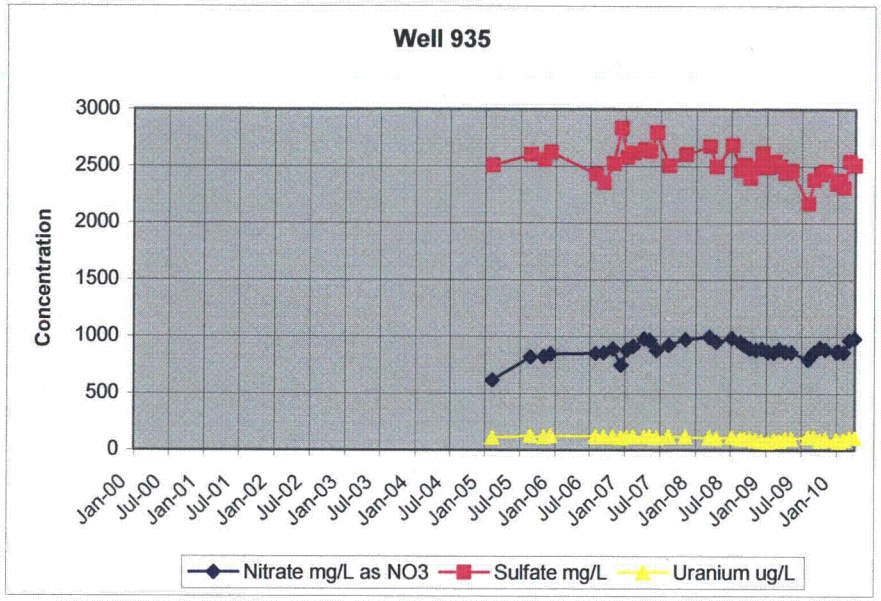
Appendix F

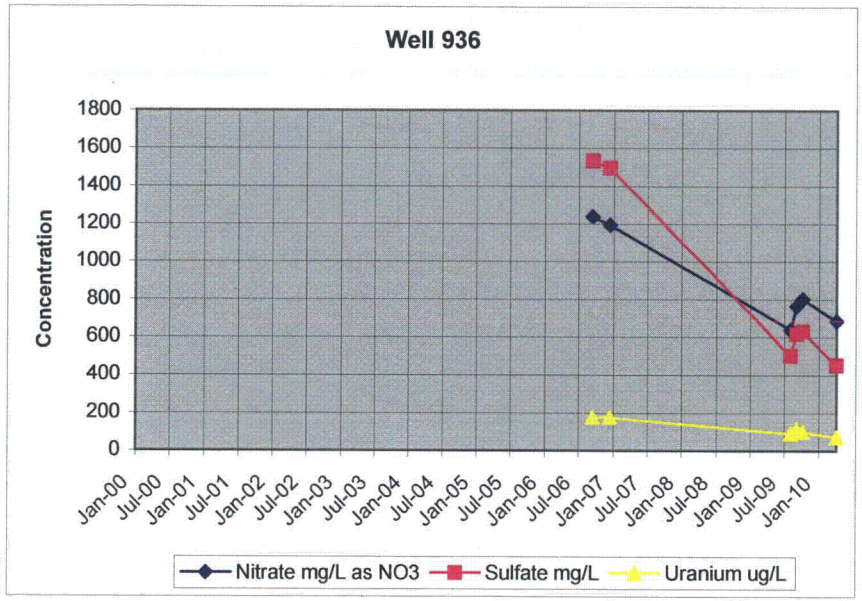
Contaminant Concentration Trends at Extraction Wells

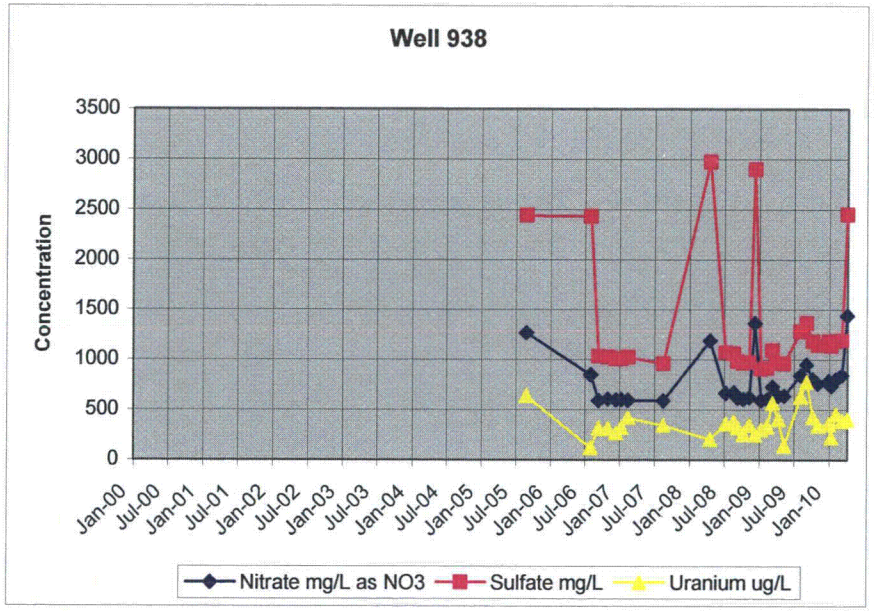
This page intentionally left blank

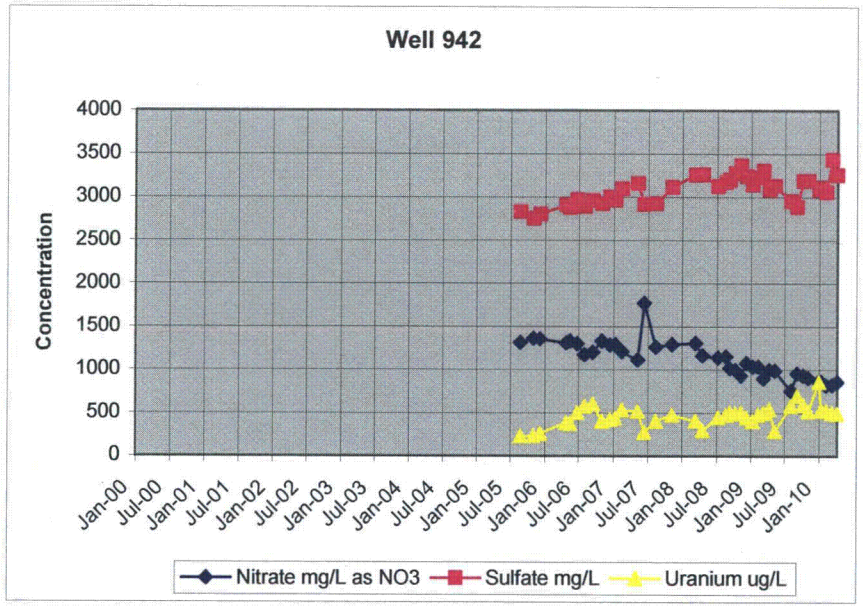
Note: Time-concentration graphs for wells 1107, 1110, 1112, 1115, 1117, 1118, 1123, 1124, 126, 1127, and 1128 are each plotted twice, once at a higher scale on the *y* axis to show constituents present at higher concentrations, and again at a lower scale to show the trend of a constituent with concentrations too low to be depicted at the higher scale.

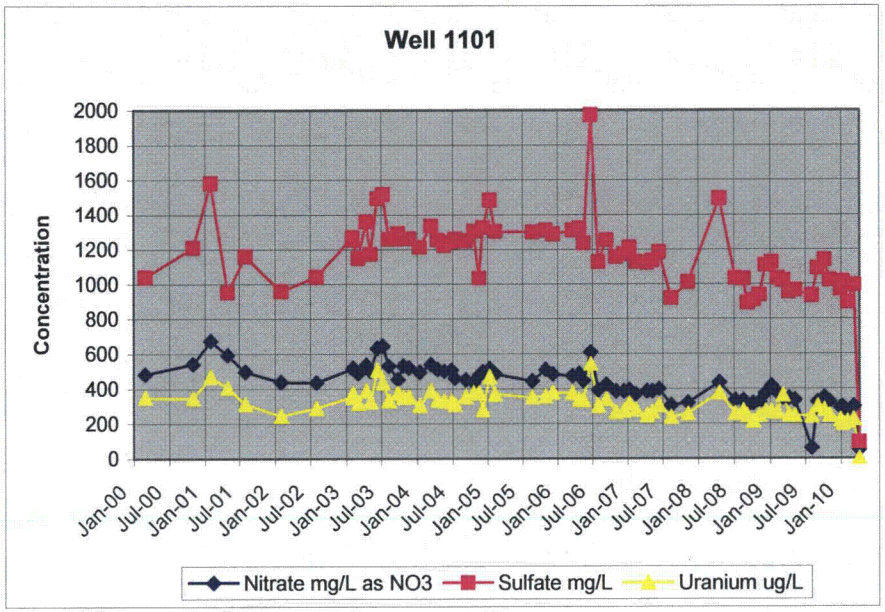
This page intentionally left blank

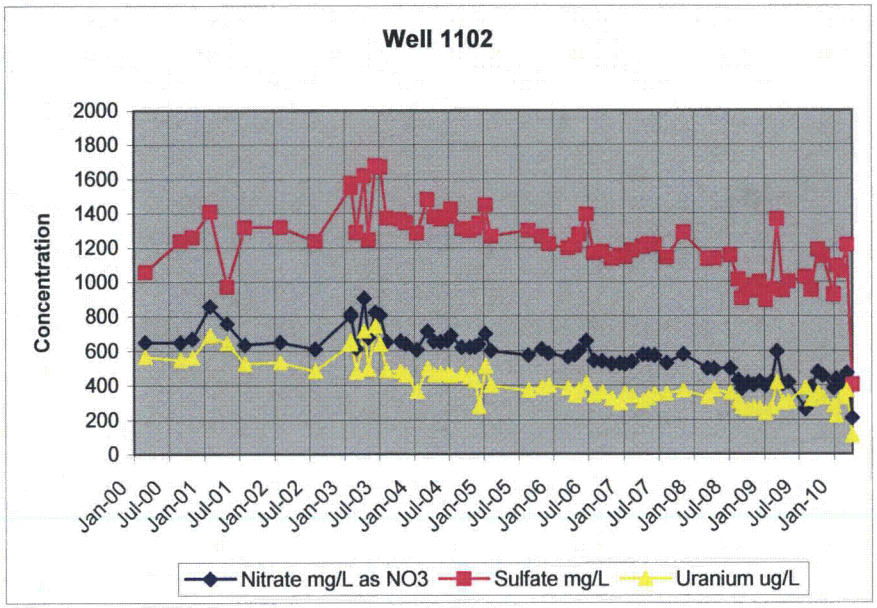

Well 935
Concentration
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

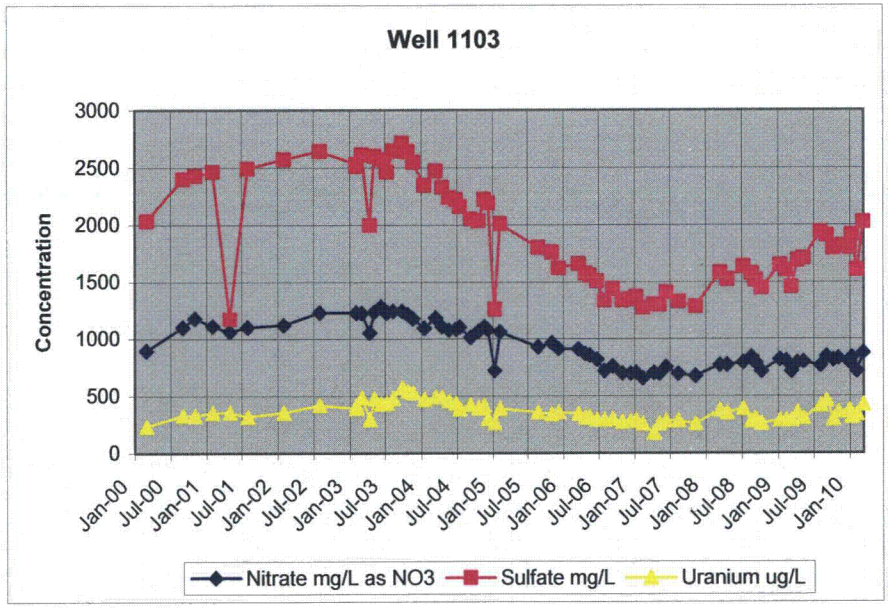

Well 936
Concentration
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

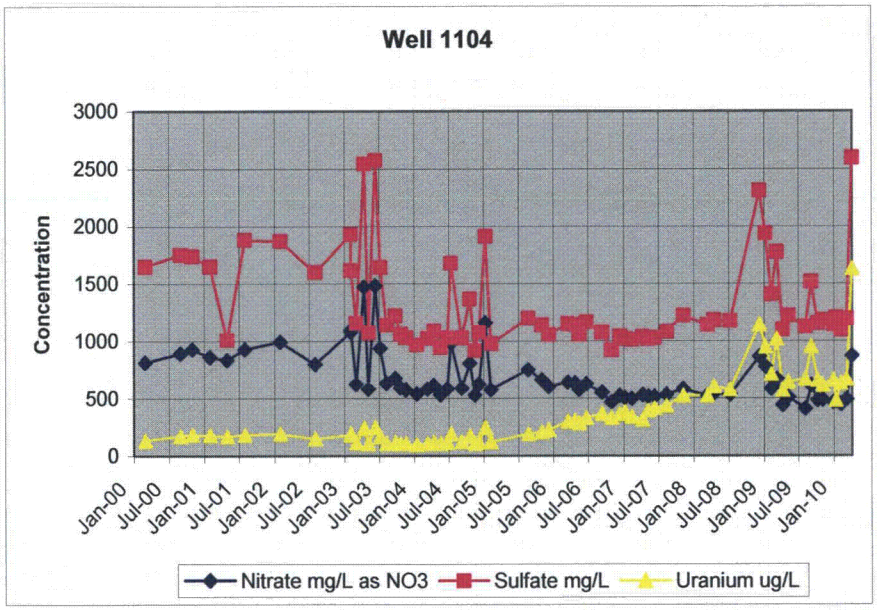

Well 938
Concentration
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

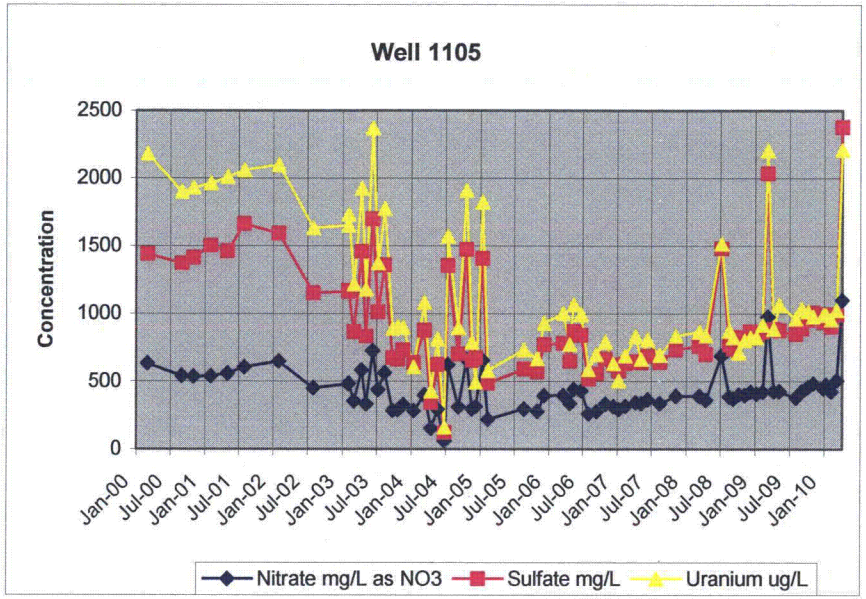

Well 942
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

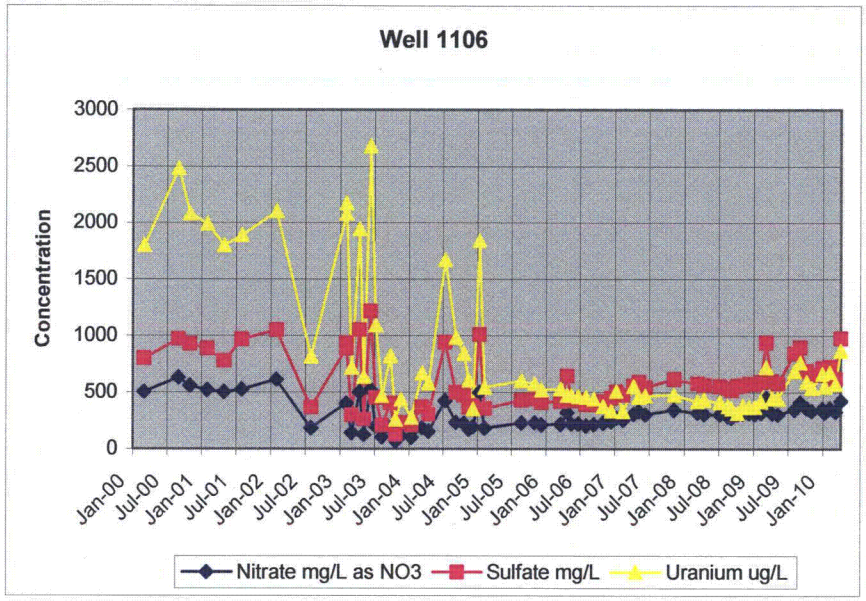

Well 1101
Concentration
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

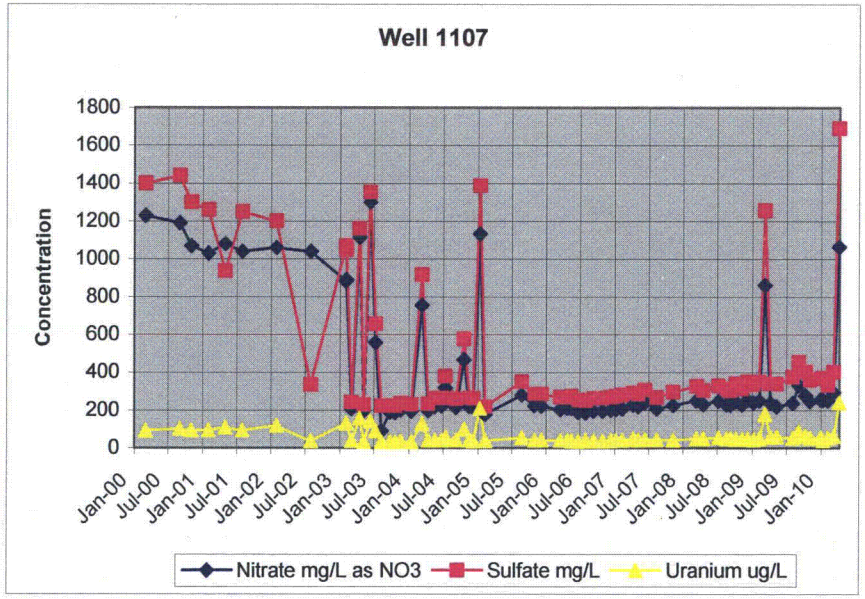

Well 1102
Concentration
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

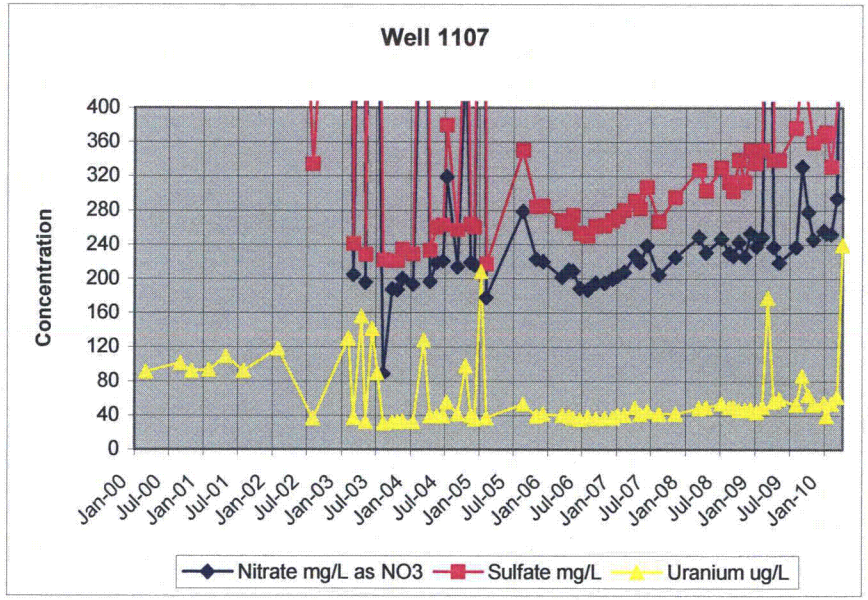

Well 1103
Concentration
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

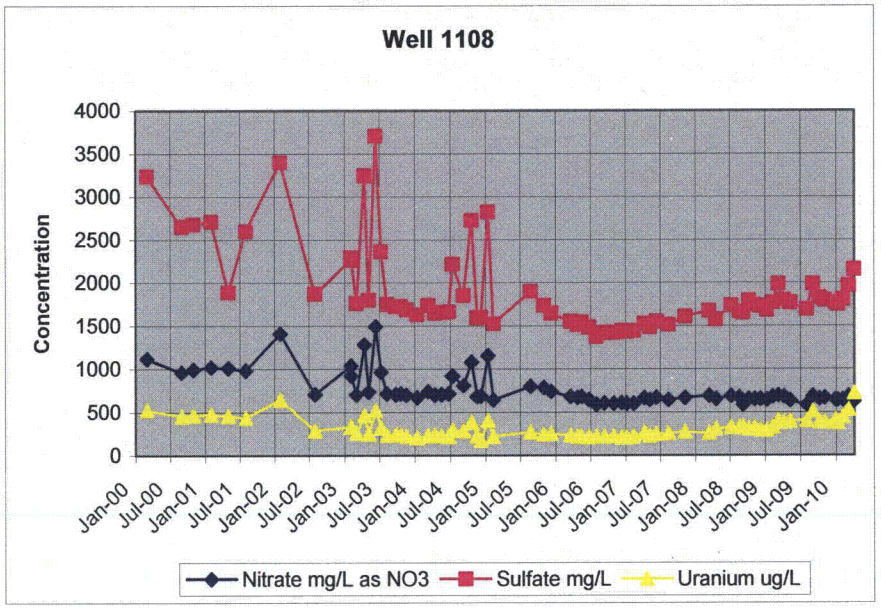

Well 1104
Concentration
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

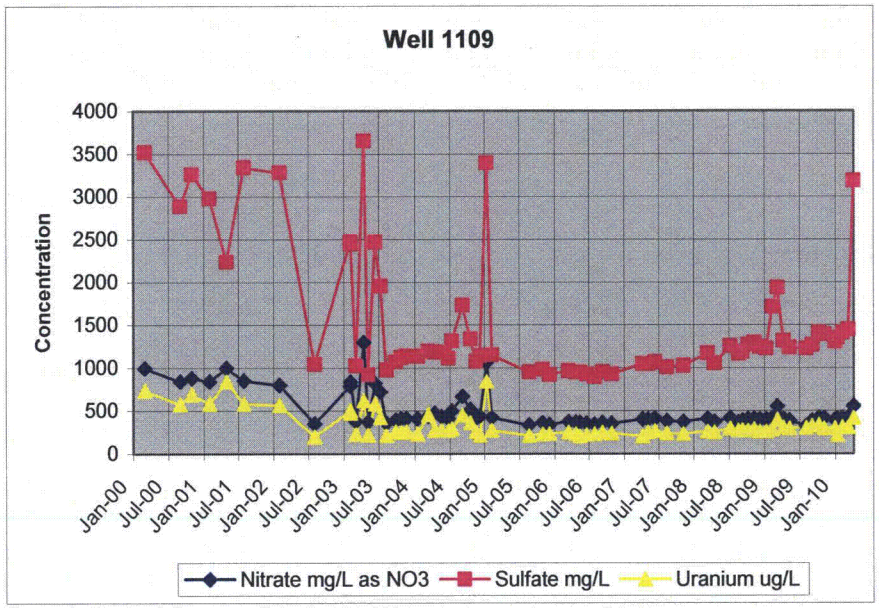

Well 1105
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

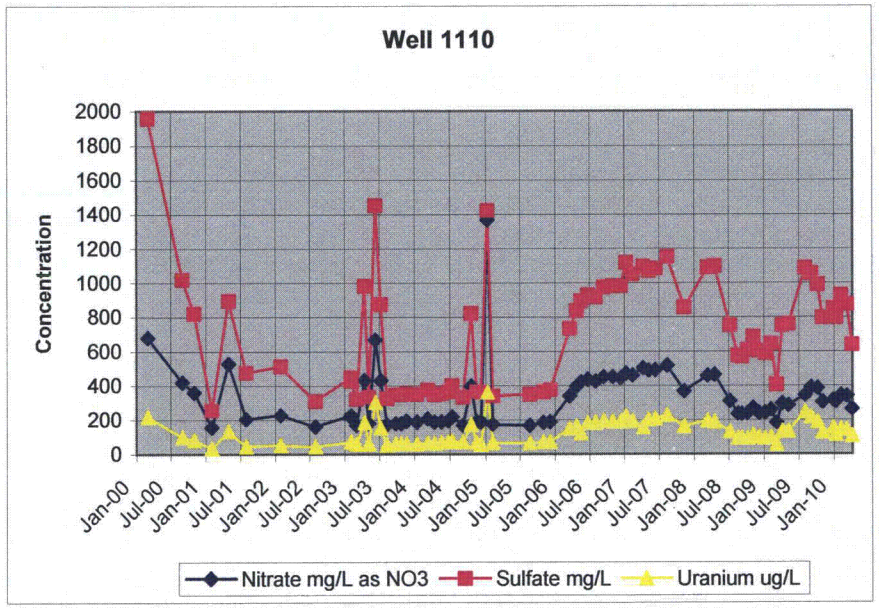

Well 1106
Concentration
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

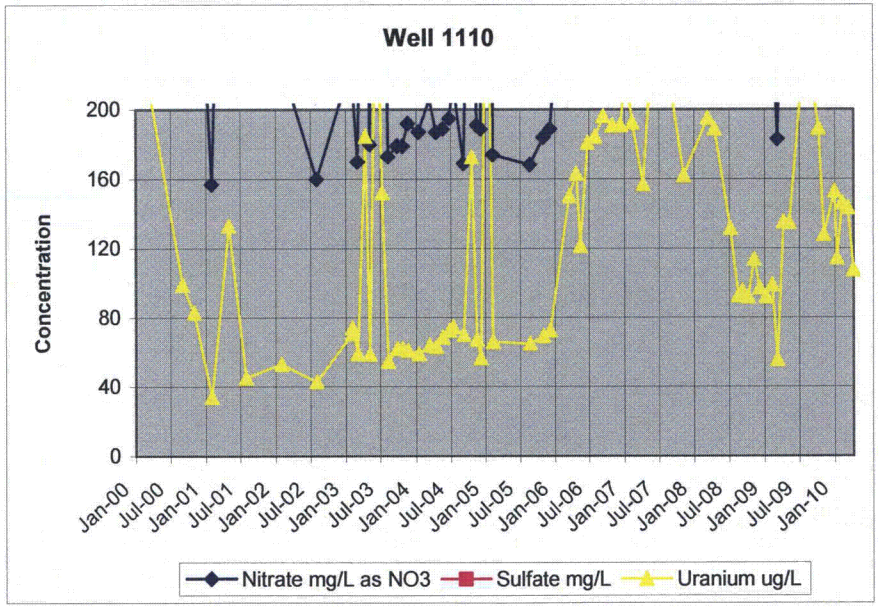

Well 1107
Concentration
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

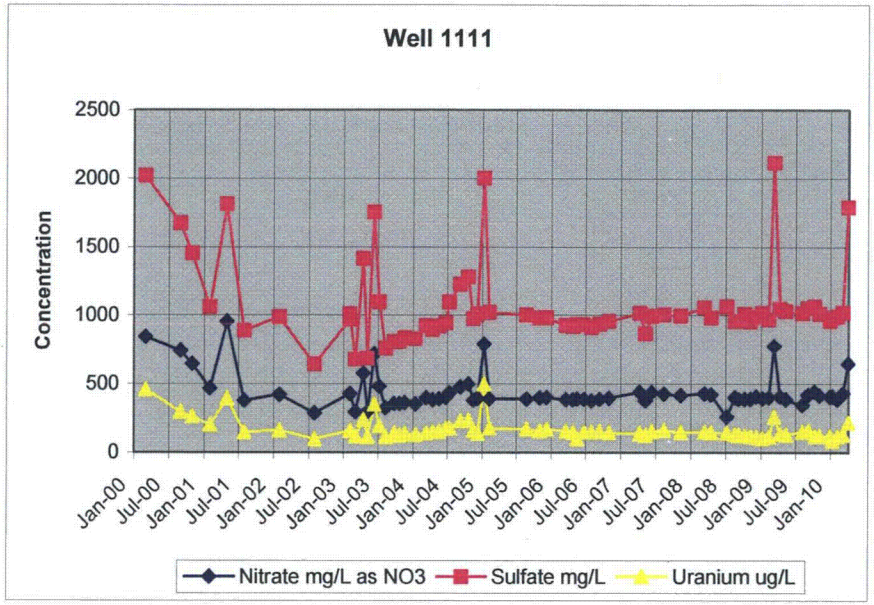

Well 1107
Concentration
400
360
320
280
240
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

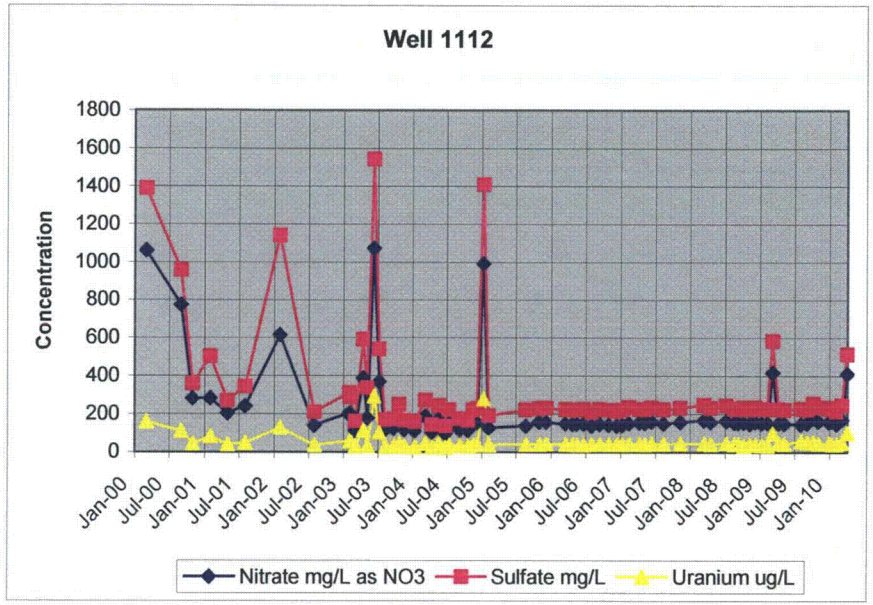

Well 1108
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

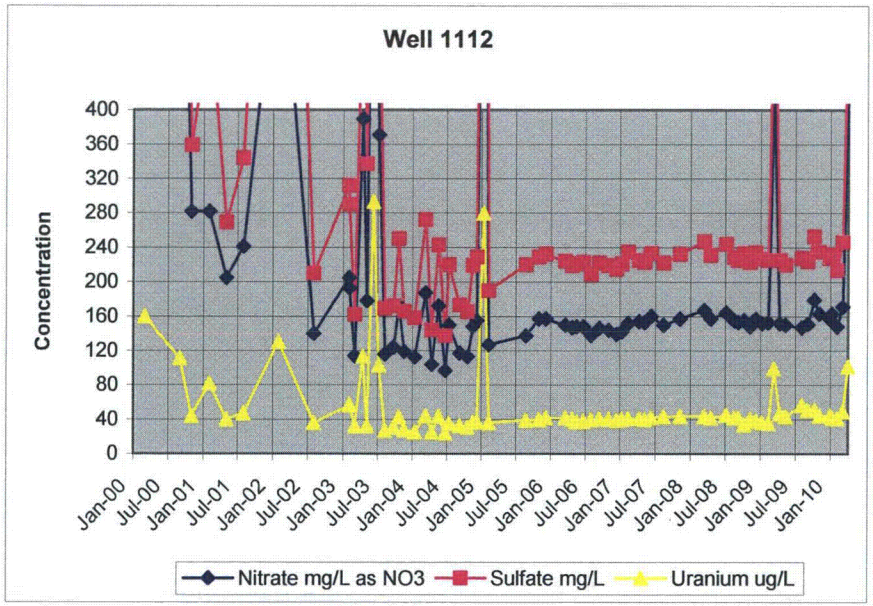

Well 1109
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

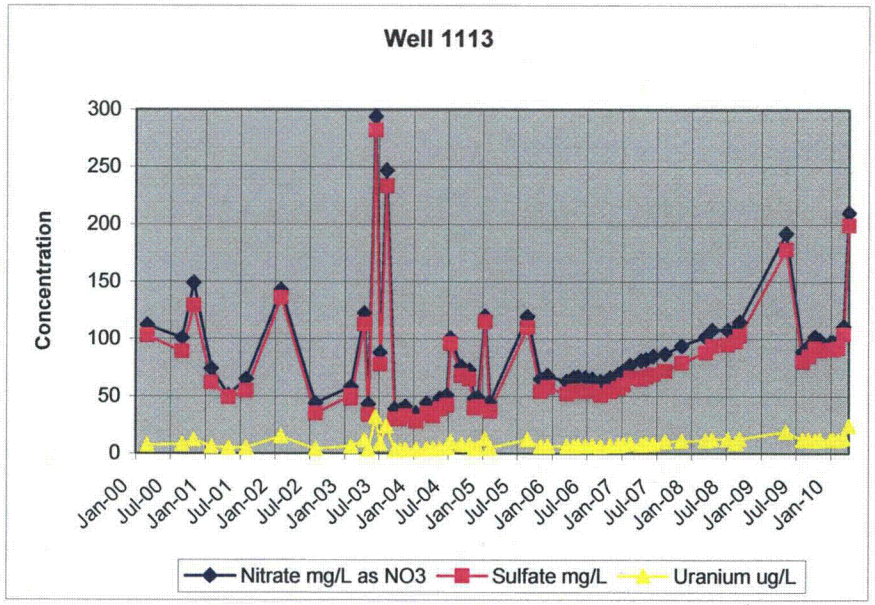

Well 1110
Concentration
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

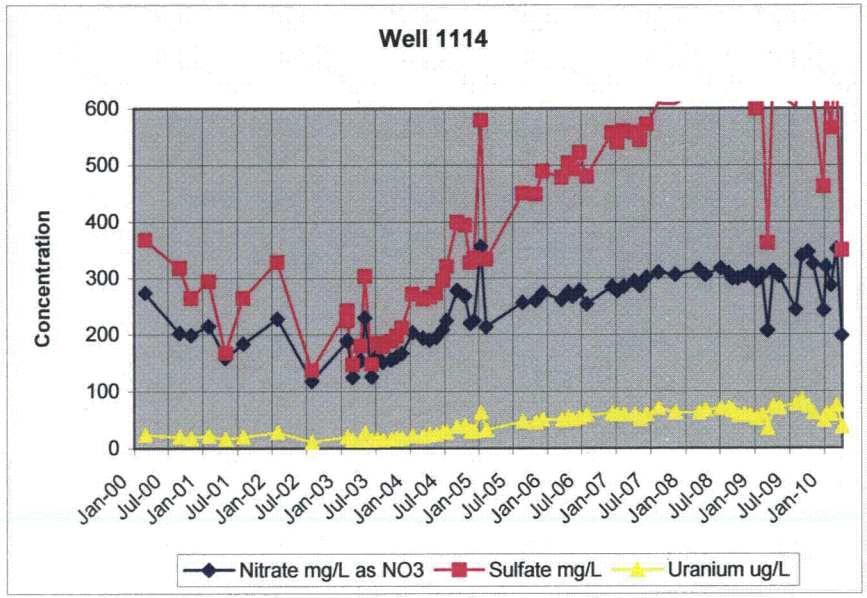

Well 1110
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

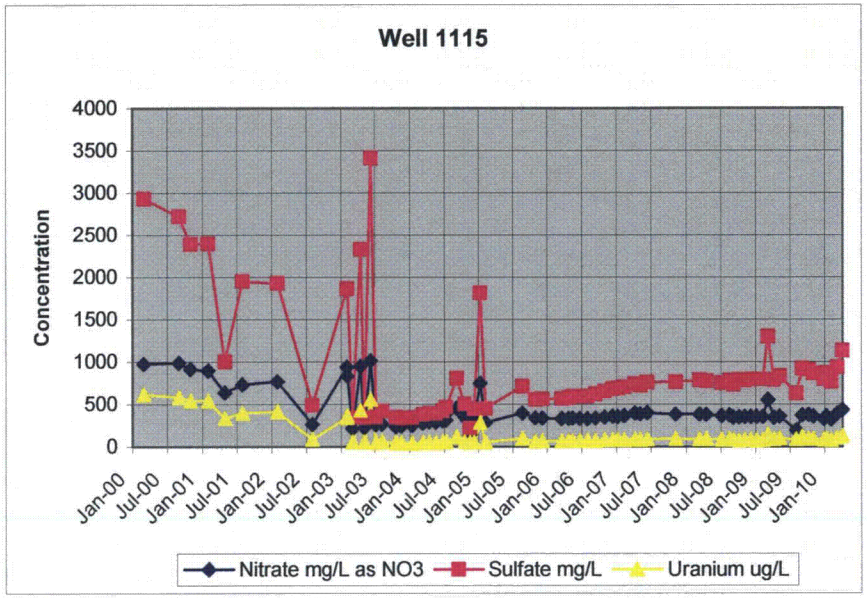

Well 1111
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

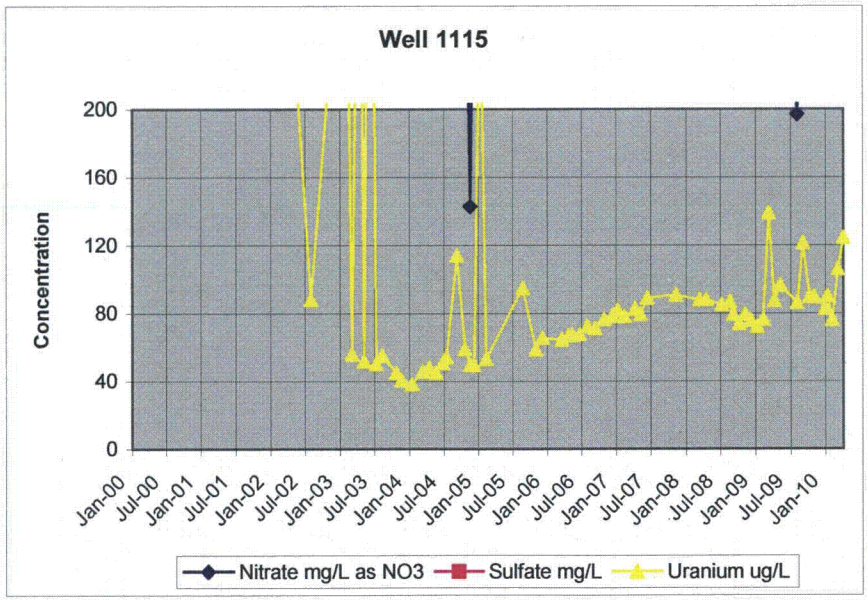

Well 1112
Concentration
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

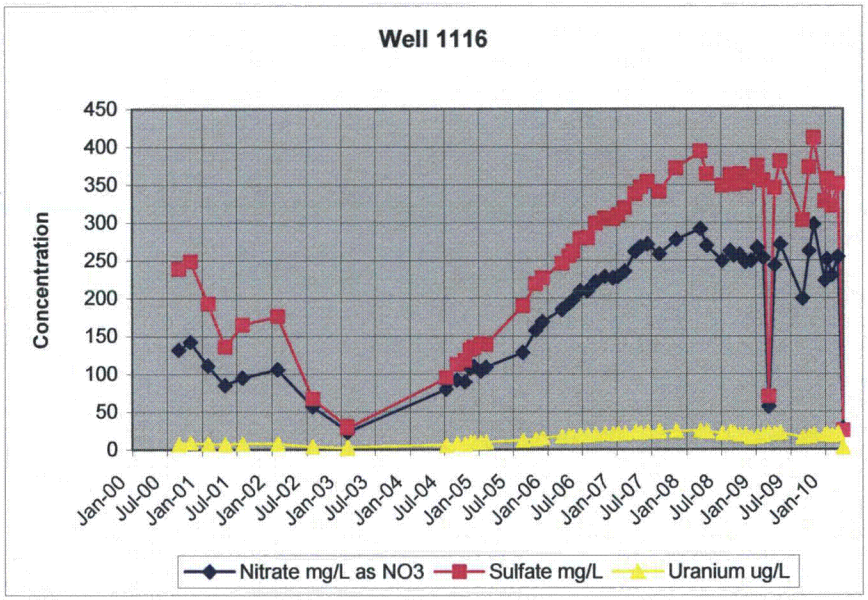

Well 1112
Concentration
400
360
320
280
240
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

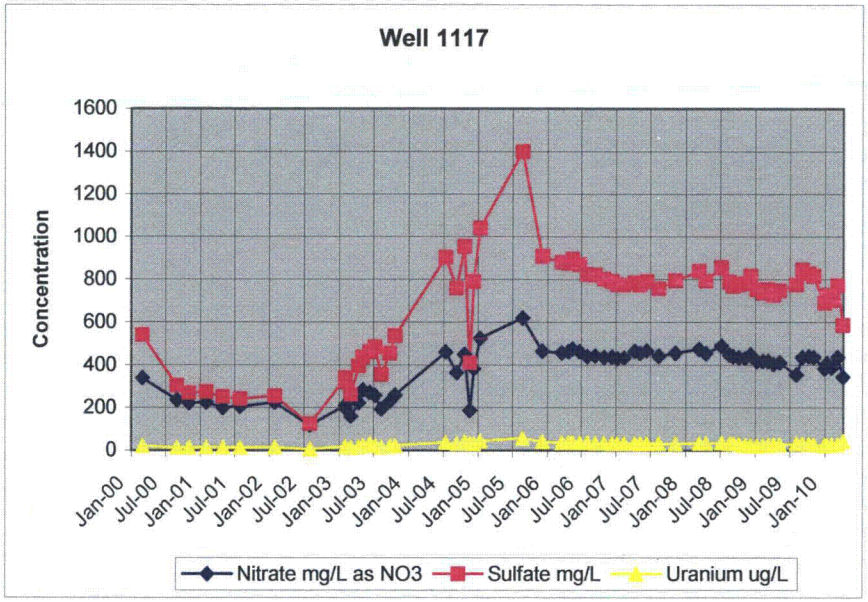

Well 1113
Concentration
300
250
200
150
100
50
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

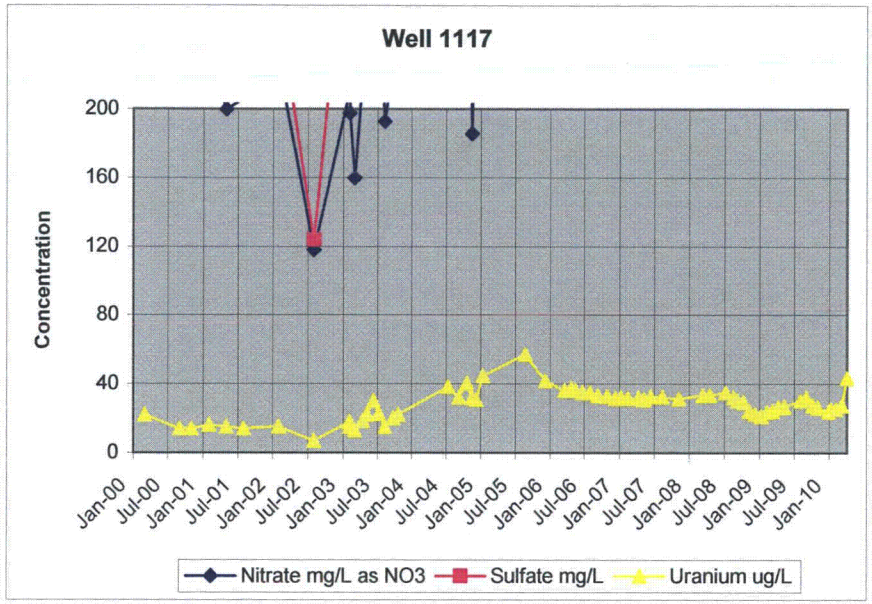

Well 1114
Concentration
600
500
400
300
200
100
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

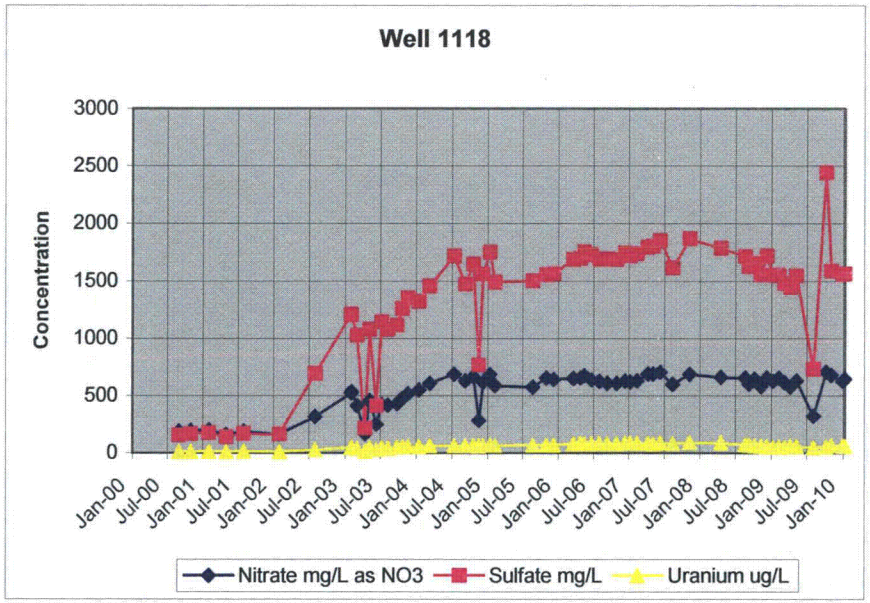

Well 1115
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

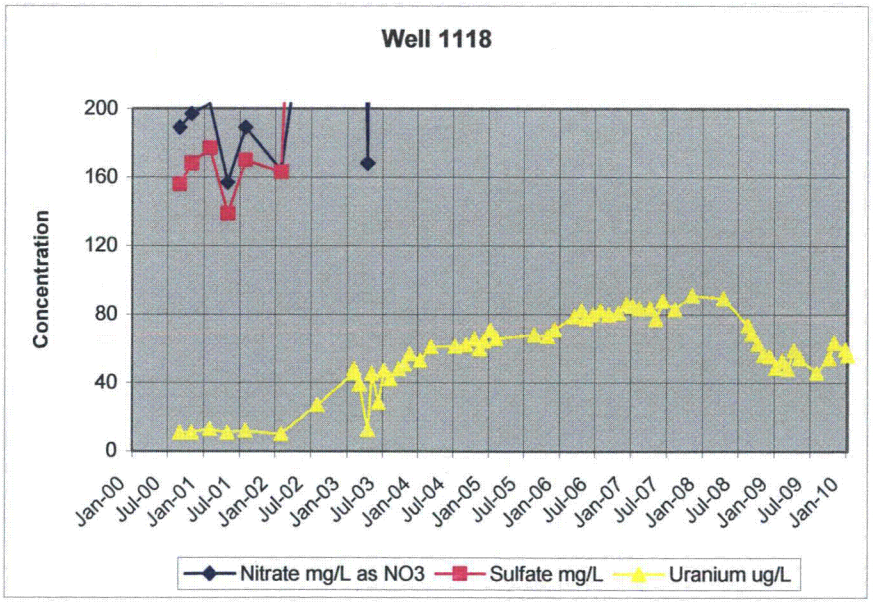

Well 1115
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

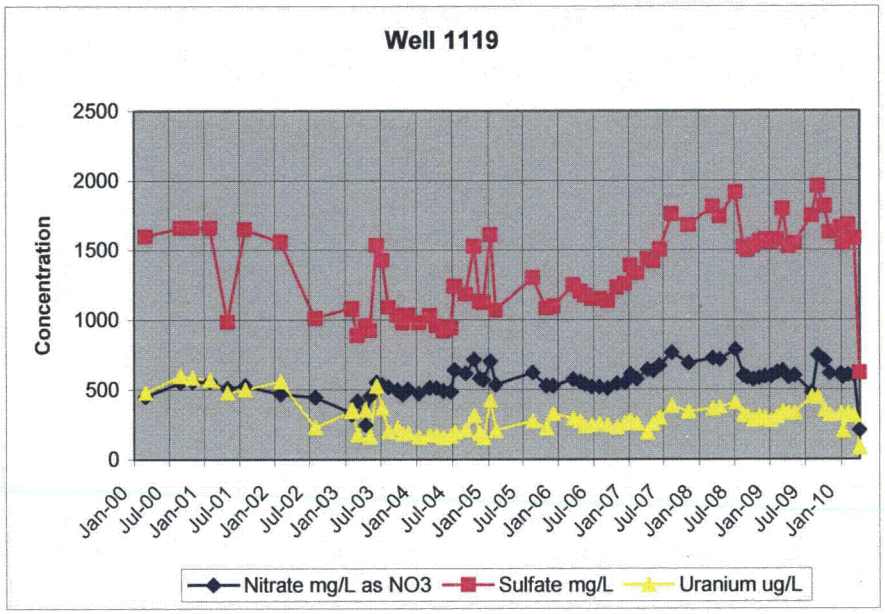

Well 1116
Concentration
450
400
350
300
250
200
150
100
50
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

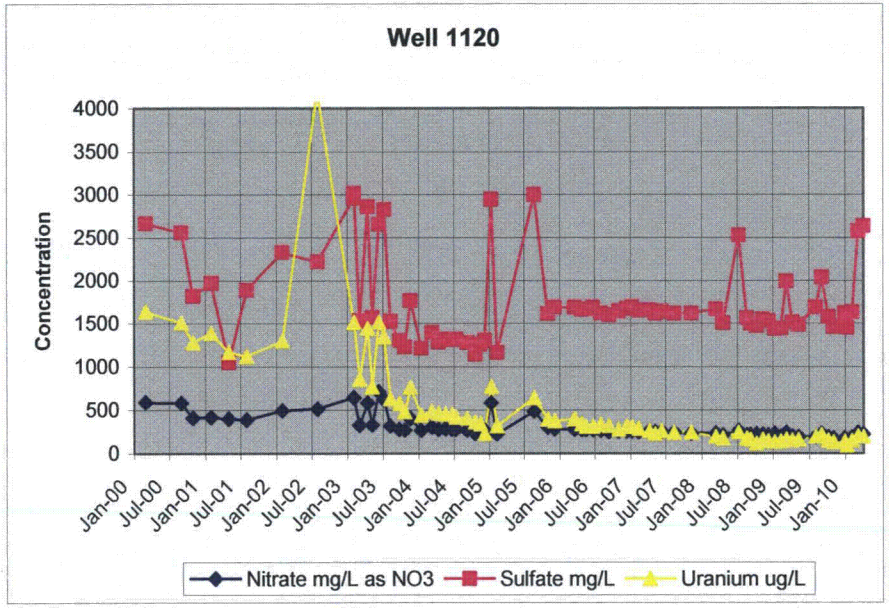

Well 1117
Concentration
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

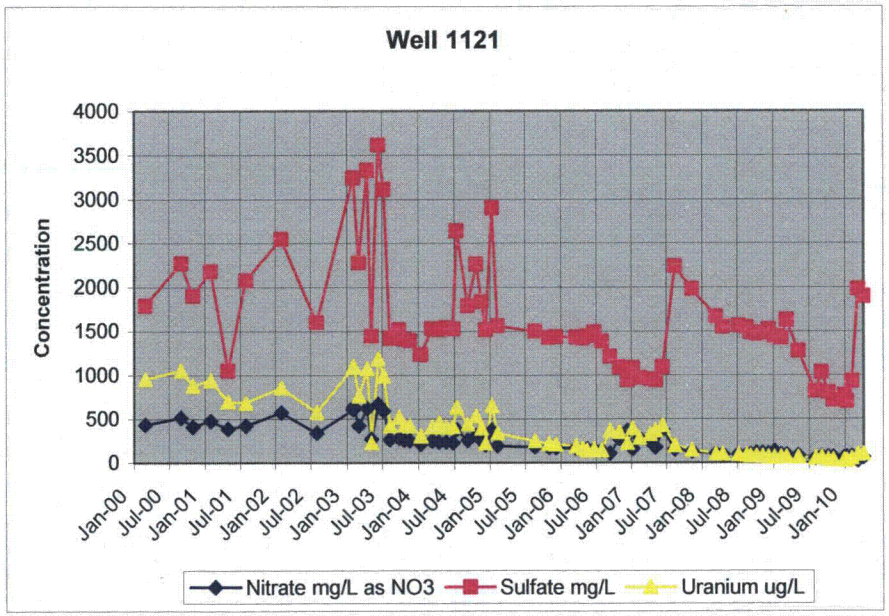

Well 1117
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

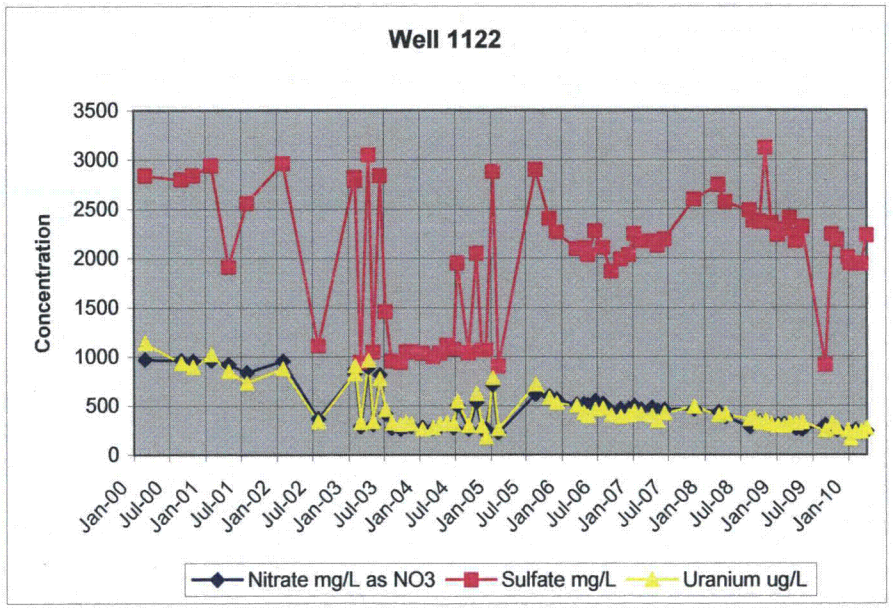

Well 1118
Concentration
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

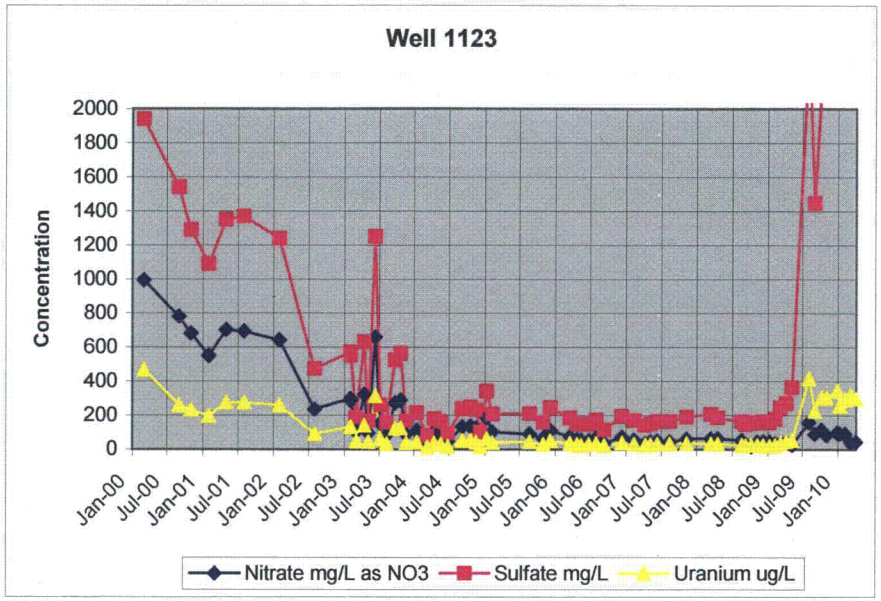

Well 1118
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

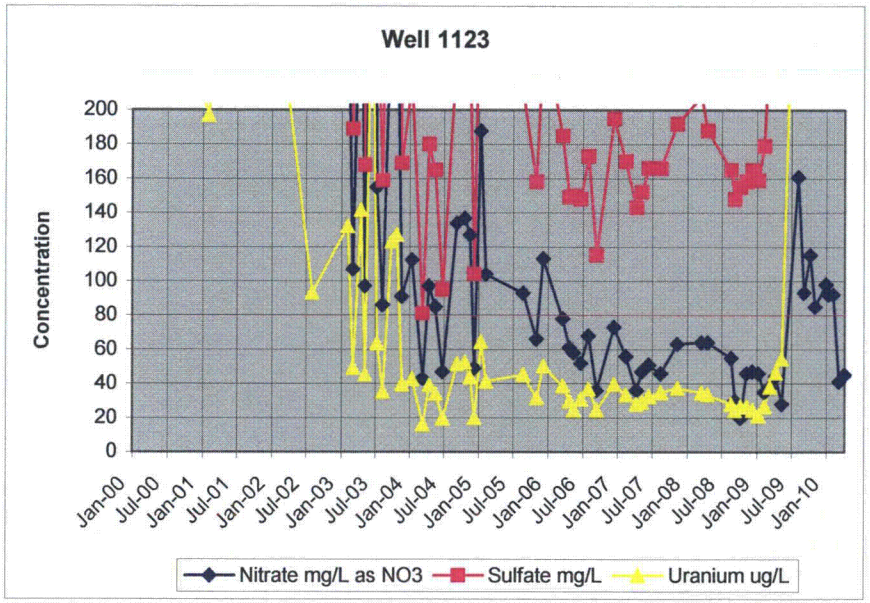

Well 1119
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

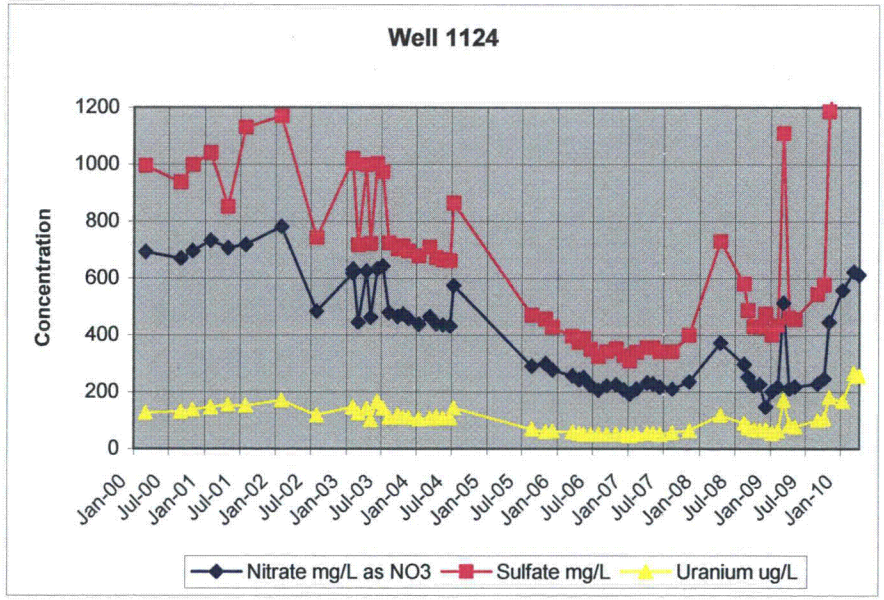

Well 1120
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

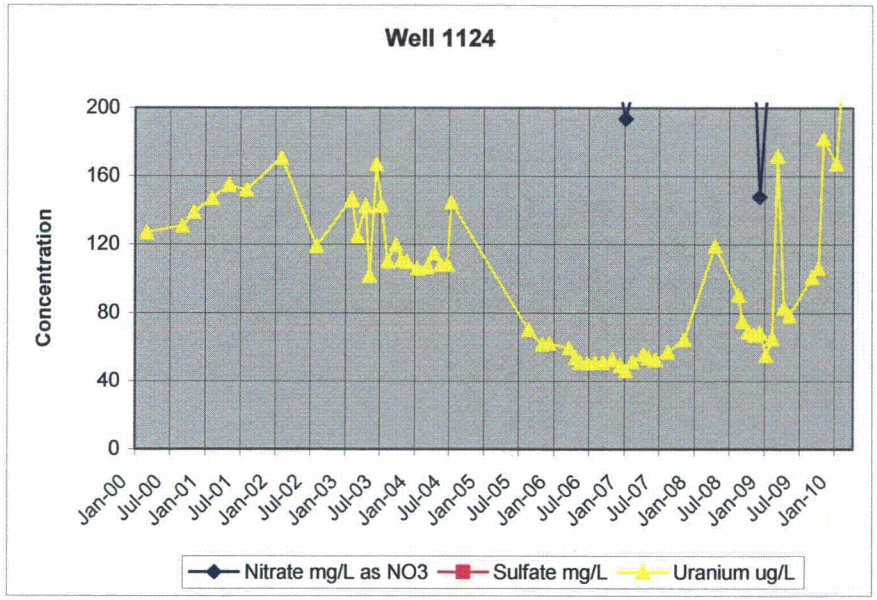

Well 1121
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

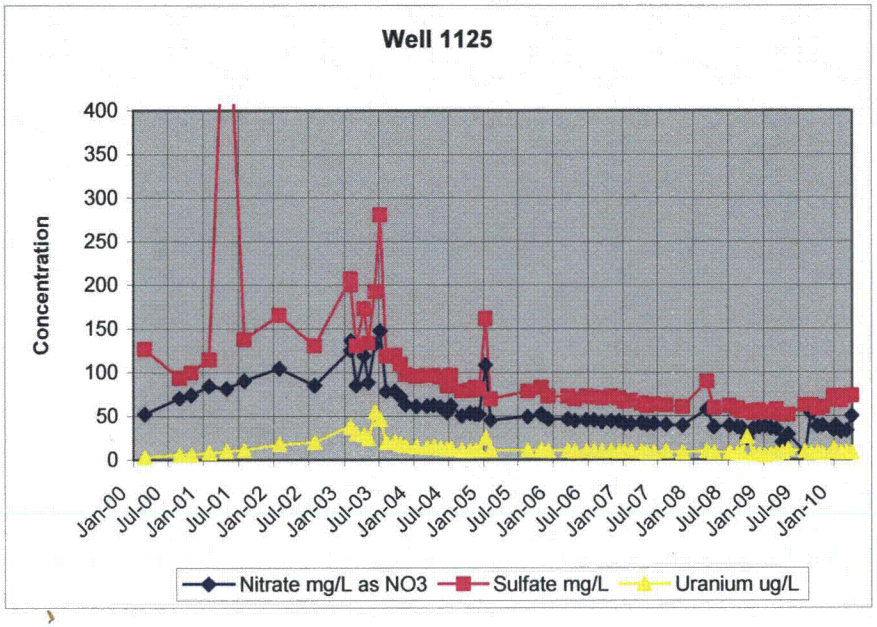

Well 1122
Concentration
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

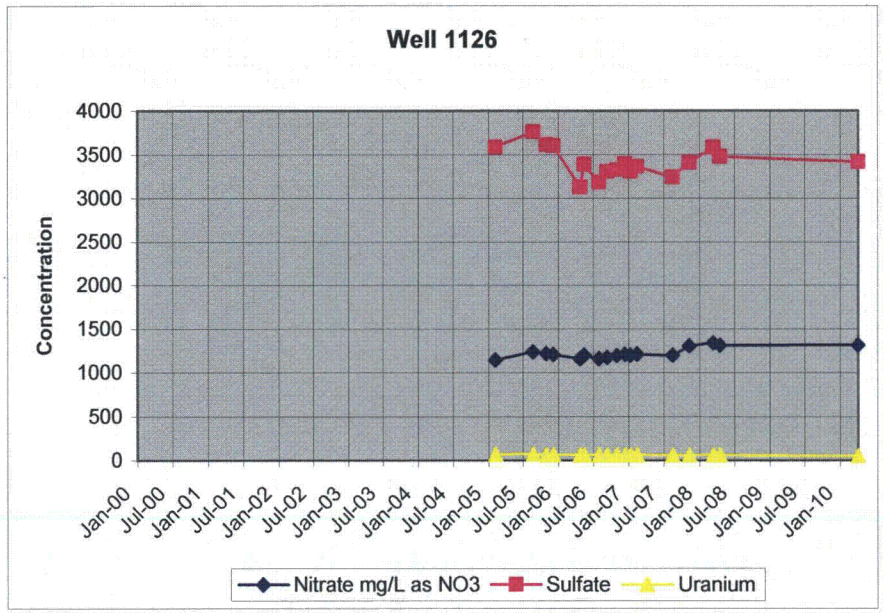

Well 1123
Concentration
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

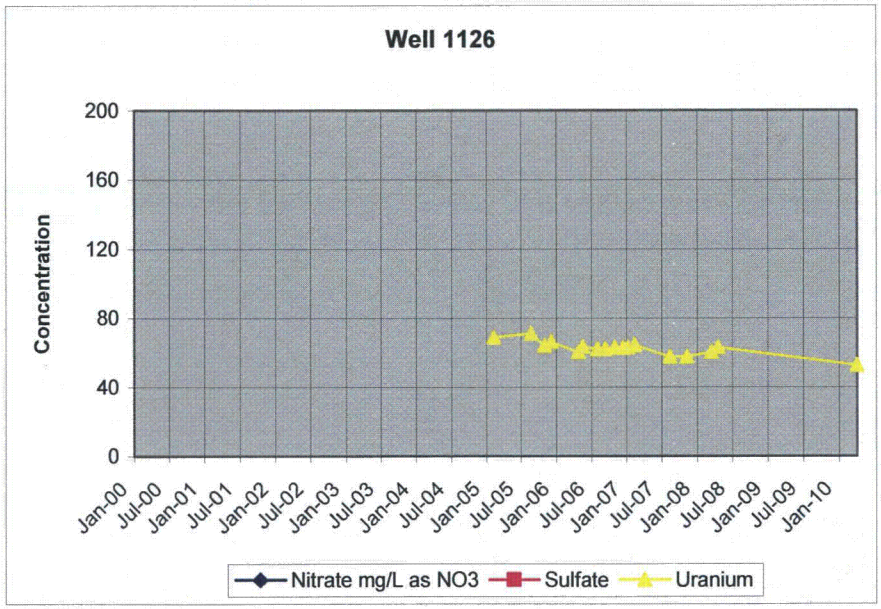

Well 1123
Concentration
200
180
160
140
120
100
80
60
40
20
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

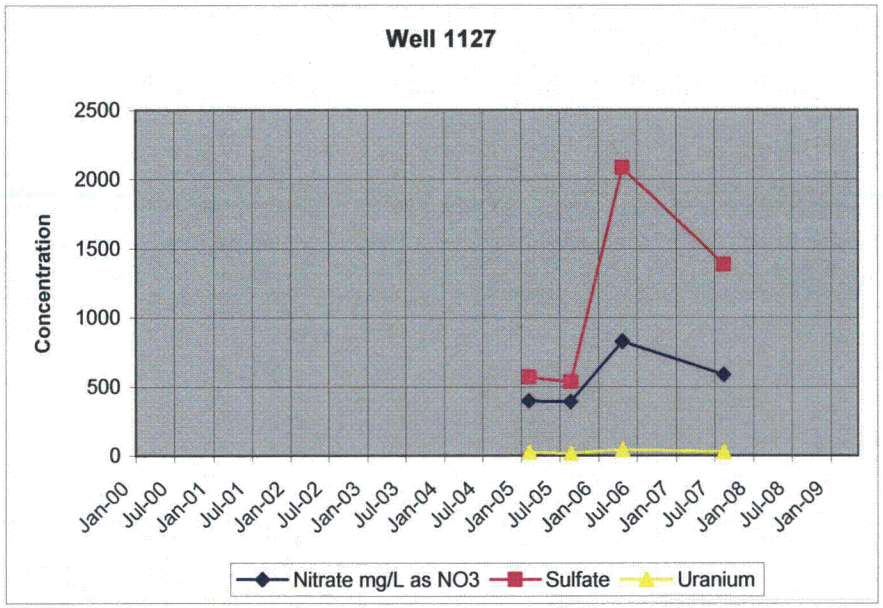

Well 1124
Concentration
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

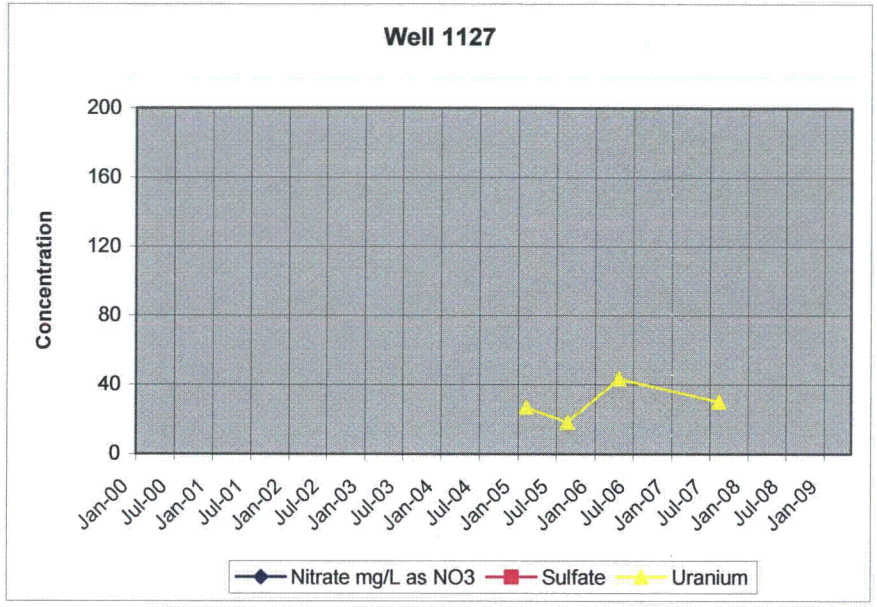

Well 1124
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

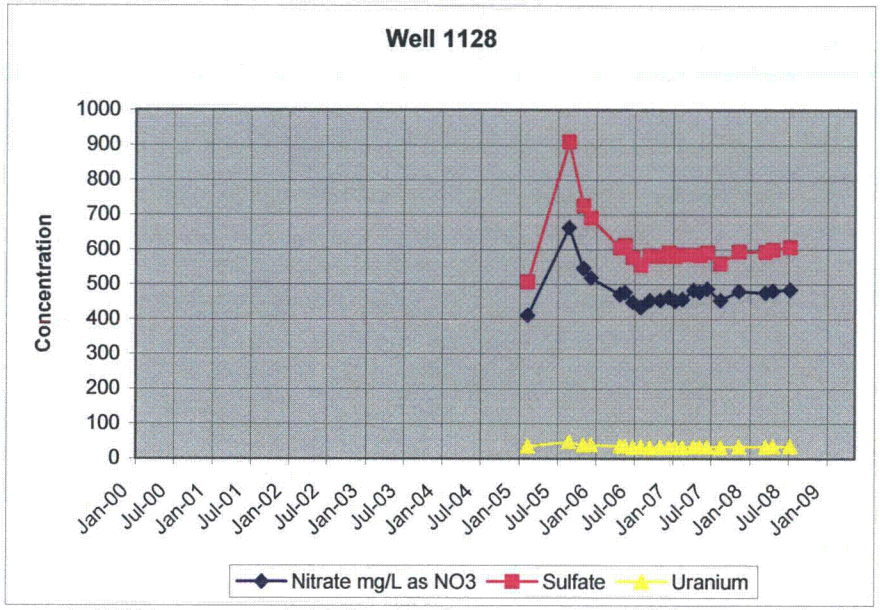

Well 1125
Concentration
400
350
300
250
200
150
100
50
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate mg/L
Uranium ug/L

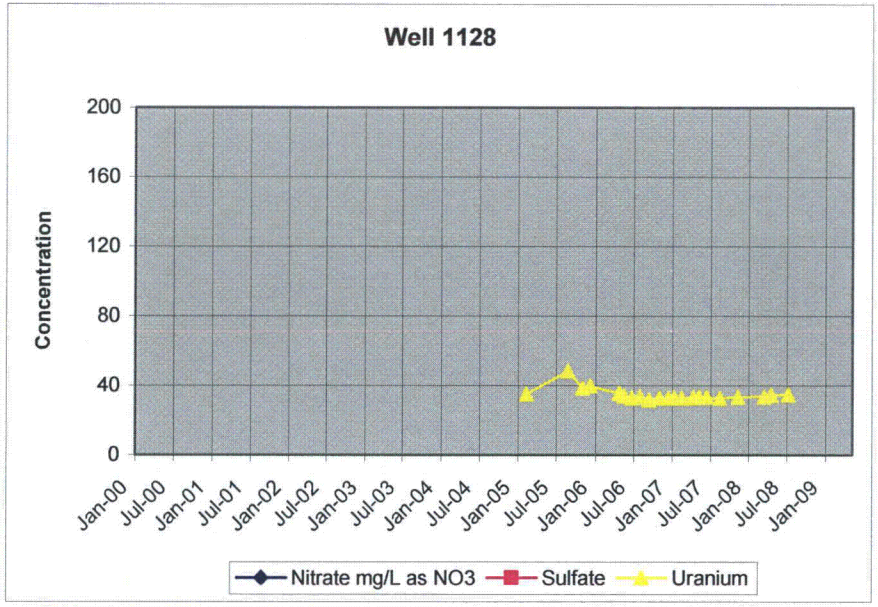

Well 1126
Concentration
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium

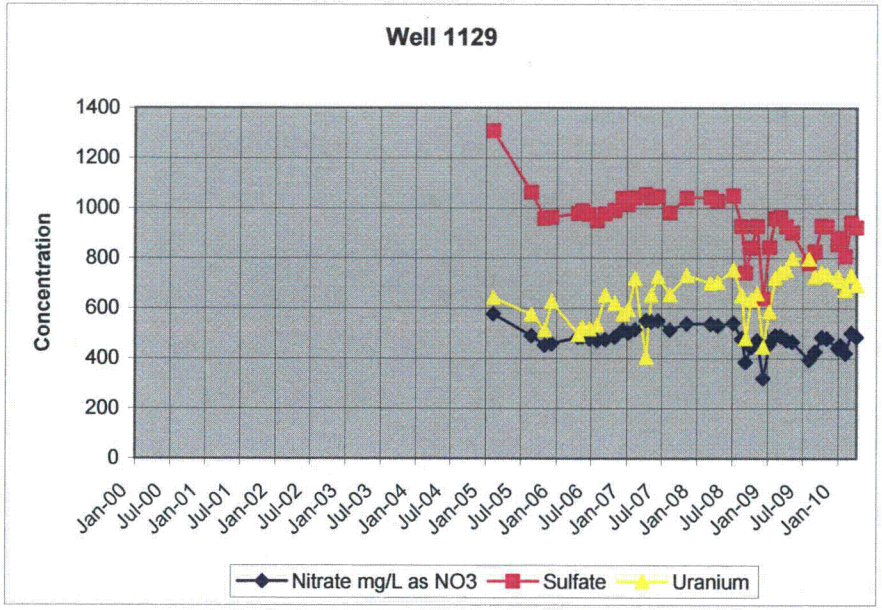

Well 1126
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium

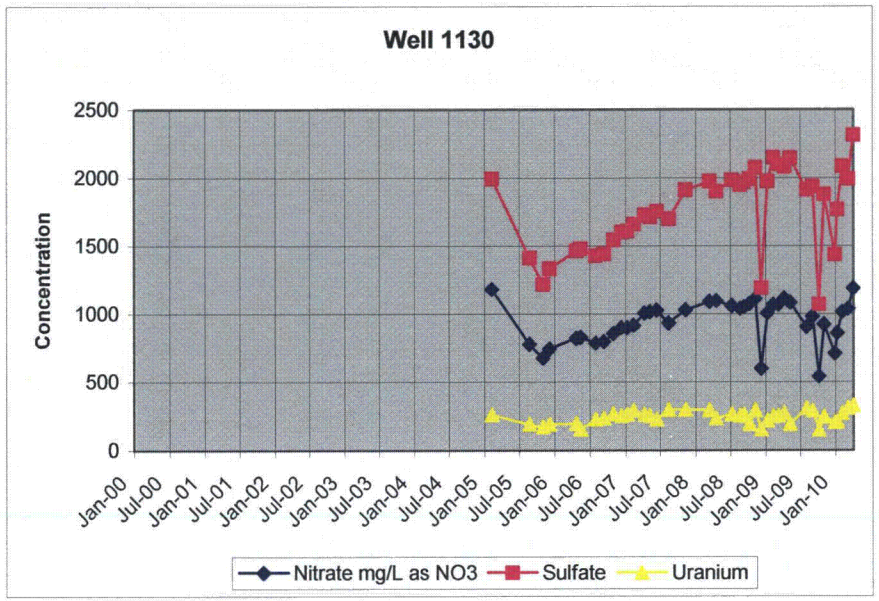

Well 1127
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
Nitrate mg/L as NO3
Sulfate
Uranium

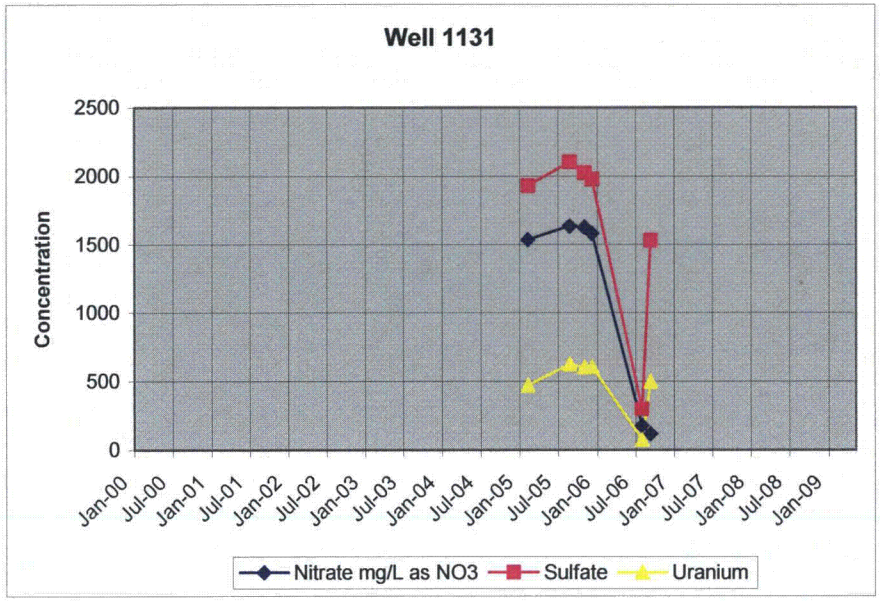

Well 1127
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
Nitrate mg/L as NO3
Sulfate
Uranium

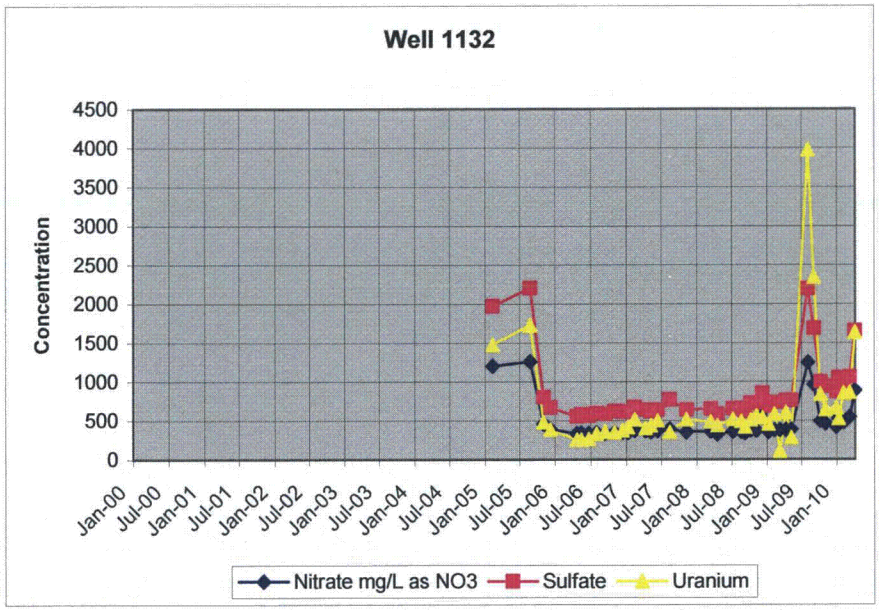

Well 1128
Concentration
1000
900
800
700
600
500
400
300
200
100
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
Nitrate mg/L as NO3
Sulfate
Uranium

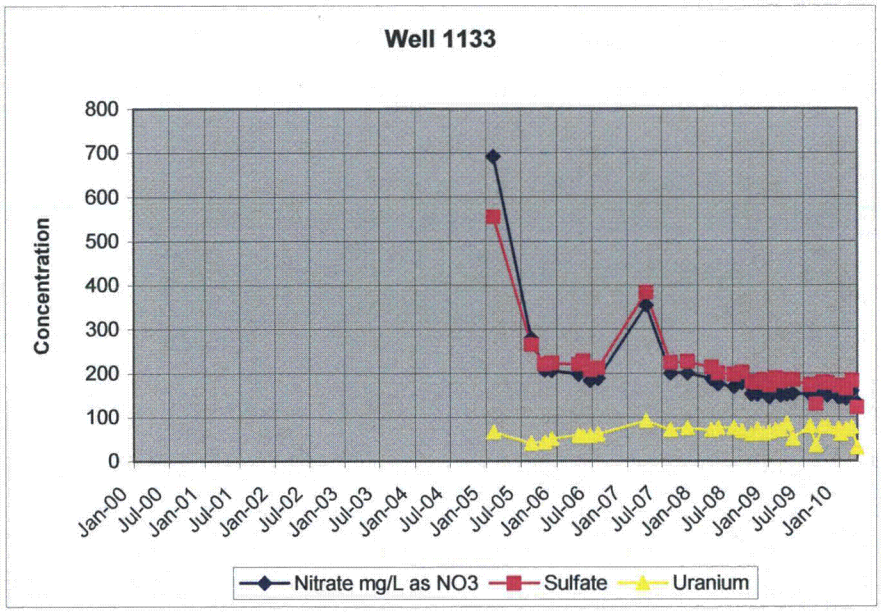

Well 1128
Concentration
200
160
120
80
40
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
Nitrate mg/L as NO3
Sulfate
Uranium


Well 1129
Concentration
1400
1200
1000
800
600
400
200
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium


Well 1130
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium


Well 1131
Concentration
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09
Nitrate mg/L as NO3
Sulfate
Uranium


Well 1132
Concentration
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium


Well 1133
Concentration
800
700
600
500
400
300
200
100
0
Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10
Nitrate mg/L as NO3
Sulfate
Uranium

Appendix G

Calculation Sets

This page intentionally left blank

Contents

Calculation 1 Estimated Volume and Mass of Groundwater Contamination for the Baseline Period G–1
Calculation 2 Estimated Aquifer Restoration Time Based on Mass and Volume Removal Rates G–5
Calculation 3 Calculate a Bulk Index of Aquifer Restoration for Sulfate G–9
Calculation 4 Calculate a Bulk Index of Aquifer Restoration for Uranium G–13

This page intentionally left blank

Calculation 1
Estimated Volume and Mass of Groundwater Contamination for the Baseline Period

This page intentionally left blank

Calculation Set #1: Estimated Mass and volume of ground water contamination for the baseline period (originally included in July 2005 annual report)

Tuba City, AZ, Disposal Site

Objective: estimate the baseline volume of contaminated groundwater of the Middle Terrace; estimate the baseline mass of dissolved nitrate,sulfate, and uranium in the groundwater

Method:
1) estimate the area of the plume from baseline contaminant maps separately for Horizons A and B combined and Horizons C and D combined
2) estimate the vertical thickness of contamination for Horizons A and B combined and Horizons C and D combined
3) assume 25% porosity and compute the separate plume volumes for Horizons A and B combined and Horizons C and D combined
4) compute separate concentration averages for sulfate and uranium for Horizons A and B combined and Horizons C and D combined from baseline contaminant maps
5) multiply concentration average by plume volume to determine contaminant mass for Horizons A and B combined and Horizons C and D combined
6) sum the volume and mass estimates

Calcualtion:

1) map area of contaminant plume

Horizons A and B	plume length (northeast to southwest)	4,000	ft
	plume width	1,800	ft
	area	7,200,000	ft^2
Horizons C and D	plume length (northeast to southwest)	2,500	ft
	plume width	1,800	ft
	area	4,500,000	ft^2

2) thickness of contamination

Horizons A and B			Horizons C and D		
thickness Horizon A	25	ft	thickness Horizon C	50	ft
thickness Horizon B	50	ft	thickness Horizon D	25	ft
A&B combined thickness	75	ft	C&D combined thickness	75	ft

assumptions

*approximately the upper half of Horizon A not saturated during baseline period

*Horizon B is fully saturated

*entire thickness of Horizon C contaminated

*Horizon D not contaminated at many locations, assume 50% contaminated thickness

3) plume volumes

Horizons A and B	volume of contaminated groundwater	135,000,000	ft^3	**135,000,000**	**ft^3**
		1,012,500,000	gal	**1,013,000,000**	**gal**
		3,832,312,500	L	**3,832,000,000**	**L**
Horizons C and D	volume of contaminated groundwater	28,125,000	ft^3	**28,000,000**	**ft^3**
		210,937,500	gal	**211,000,000**	**gal**
		798,398,438	L	**798,000,000**	**L**

4) baseline concentrations

Horizons A and B

well	Horizon	U mg/L	sulfate mg/L	nitrate mg/L as NO3
262	B	0.379	931	380
263	B	0.485	1990	1140
265	B	0.090	1520	720
267	B	0.073	3680	1640
906	A	0.951	1660	1470
908	B	0.122	2430	651
909	B	0.040	666	485
934	B	0.312	7360	2320
936	B	0.267	4360	2950
940	A	0.546	7550	1800
941	A	0.089	745	358
942	B	0.246	3030	1360
944	B	0.950	1590	1010
geometric mean mg/L		0.231	2174	1028

Horizons C and D

well	Horizon	U mg/L	sulfate mg/L	N mg/L as NO3
1101	D	0.245	960	438
1102	D	0.533	1320	650
1103	D	0.355	2570	1120
1104	D	0.194	1870	993
1105	D	2.100	1590	648
1106	D	2.100	1050	614
1107	D	0.118	1200	1060
1108	D	0.646	3400	1410
1109	D	0.565	3280	798
1110	D	0.053	512	227
1111	D	0.161	988	421
1112	D	0.130	1140	617
1113	D	0.053	**250**	143
1114	D	0.040	328	228
1115	D	0.410	1930	766
1116	D	0.040	250	106
1117	D	0.040	255	225
1118	D	0.040	250	164
1119	D	0.555	1560	468
1120	D	1.3	2330	493
1121	D	0.849	2590	535
1122	D	0.878	2960	954
1123	D	0.261	1240	643
1124	D	0.171	1170	781
1125	D	0.04	250	104
912	C	0.04	846	403
geometric mean mg/L		0.214	1020	464

5) mass calculation

Horizons A and B	mass uranium	884	kg
		1,949	lb
	mass sulfate	8,330,201	kg
		18,359,764	lb
	mass N as NO3	3,940,636	kg
		8,685,162	lb
Horizons C and D	mass uranium	171	kg
		377	lb
	mass sulfate	814,310	kg
		1,794,738	lb
	mass N as NO3	370,337	kg
		816,223	lb

6) total volume and masses

total volume contaminated groundwater	**163,000,000**	**ft^3**
	1,222,500,000	**gal**
	4,627,162,500	**L**
total mass uranium	**1,055**	**kg**
	2,326	**lb**
total mass sulfate	**9,144,511**	**kg**
	20,154,502	**lb**
total mass nitrate as NO3	**4,310,973**	**kg**
	9,501,384	**lb**

Figure G-1. Calculation Set, Estimated Mass and Volume of Ground Water Contamination, Tuba City, Arizona, Disposal Site

This page intentionally left blank

Calculation 2
Estimated Aquifer Restoration Time
Based on Mass and Volume Removal Rates

This page intentionally left blank

Calculation Set #2: Estimated aquifer restoration time based on mass and volume removal rates
Tuba City Site
Annual Performance Evaluation Report
Period of Review: April 2009 through March 2010

Objective: Estimate aquifer cleanup times

Method: Compare mass and volume removed as of **April 1, 2010** to estimates of initial contaminant inventory; predict cleanup time calculated removal rates to date.

Calculation: Estimate #1: Initial contaminant volume and mass estimates from DOE Baseline Performance Evaluation, May 2003.
Estimate #2: Initial contaminant volume and mass estimates recalculated for April 2005 - March 2006 Performance Evaluation Report - see Calculation Set #1

Estimate #1

	initial mass lb	cumulative removed lb	% removed			initial vol gal	cumulative removed gal	# pore vols removed	% plume vol removed	
Nitrate	12,400,000	1,135,649	9			3.40E+09	338,423,000	0.100	10	
Sulfate	17,900,000	2,862,526	16			2.70E+09	338,423,000	0.125	13	
Uranium	2,800	720.9	26			3.00E+09	338,423,000	0.113	11	

	mass removal rate % per yr	cleanup time, yrs	cleanup date	# yrs until cleanup			pore volume removal rate % / yr	1-pore volume cleanup time, yrs	1-pore volume cleanup date	# yrs until cleanup
Nitrate	1.2	85	2087	77			1.3	78	2080	71
Sulfate	2.1	49	2051	41			1.6	62	2064	54
Uranium	3.3	30	2032	22			1.4	69	2071	61
t1=	15-Jun-02									
t2=	01-Apr-10									
t2 - t1=	7.8	yrs								

Estimate #2

	initial mass lb	cumulative removed lb	% removed			initial vol gal	cumulative removed gal	# pore vols removed	% plume vol removed	
Nitrate	9,500,000	1,135,649	12			1.20E+09	338,423,000	0.282	28	
Sulfate	20,000,000	2,862,526	14			1.20E+09	338,423,000	0.282	28	
Uranium	2,300	720.9	31			1.20E+09	338,423,000	0.282	28	

Projection	mass removal rate % per yr	cleanup time, yrs	cleanup date	# yrs until cleanup			pore volume removal rate % / yr	1-pore volume cleanup time, yrs	1-pore volume cleanup date	# yrs until cleanup
Nitrate	1.5	65	2067	57			3.6	28	2030	20
Sulfate	1.8	54	2056	47			3.6	28	2030	20
Uranium	4.0	25	2027	17			3.6	28	2030	20
t1=	15-Jun-02									
t2=	1-Apr-10									
t2 - t1=	7.8	yrs								

Figure G−2. Calculation Set 2, Estimated Aquifer Restoration Time Based on Mass and Volume Removal Rates

This page intentionally left blank

Calculation 3
Calculate a Bulk Index of Aquifer Restoration for Sulfate

This page intentionally left blank

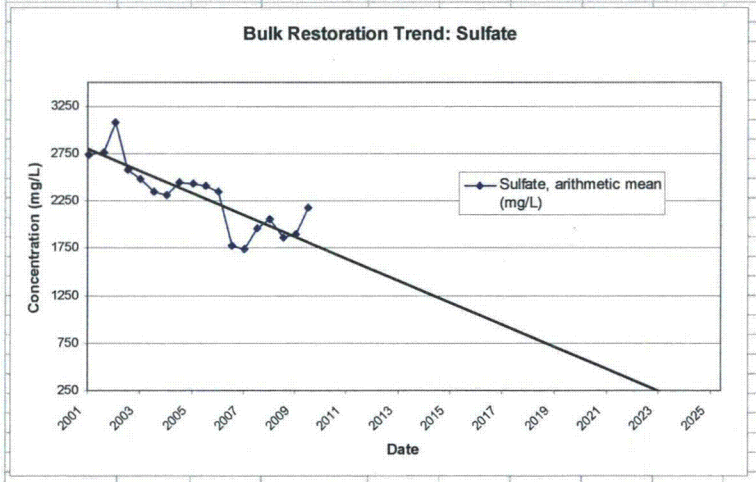
Calculation Set #3: Calculate a bulk index of aquifer restoration for sulfate
Tuba City, AZ, Disposal Site

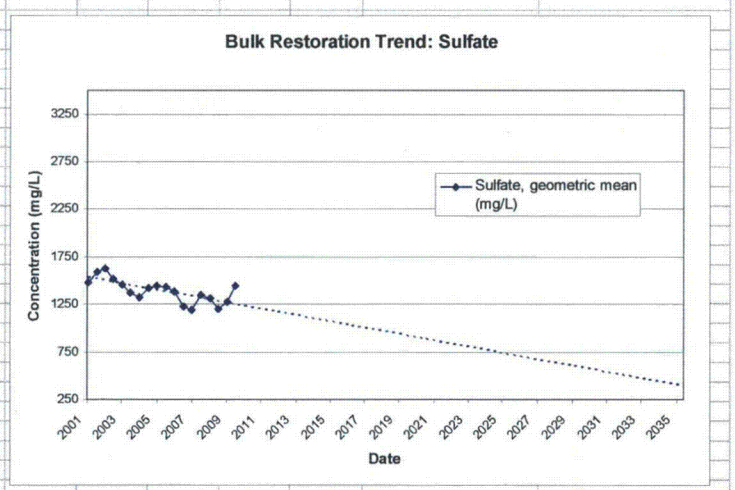
Objective: Develop a bulk concentration index for measuring restoration progress for sulfate.

Method: 1) Compute an average concentration of a contaminant for a given sampling date/event for a selected group of monitor wells within the contaminant plume.
2) Plot the computed averages over time.

Calculation: The selected monitor wells below have the most comprehensive data set and are located throughout the contaminant plume in Horizons A and B.
No historical data exist for Horizons C and D within the contaminant plume.
Note: Where data are absent in the table below, concentrations are carried forward from the previous date as shown in ***bold italic.***

	Sulfate (mg/L)															
Date	**0262**	**0263**	**0265**	**0267**	**0906**	**0908**	**0909**	**0929**	**0934**	**0936**	**0940**	**0941**	**0942**		**Sulfate, arithmetic mean (mg/L)**	**Sulfate, geometric mean (mg/L)**
08/16/2001	***931***	***1990***	***1520***	3620	1840	2310	419	19.9	7450	4570	7230	620	3030	baseline	2735	1482
03/06/2002	***931***	***1990***	***1520***	3680	1660	2430	666	28.1	7360	4360	7550	745	3030	baseline	2765	1594
08/20/2002	***931***	***1990***	***1520***	3530	1690	2330	637	27.9	11900	4400	***7550***	***745***	2680		3072	1625
02/06/2003	***931***	***1990***	***1520***	3550	1660	2430	629	27.6	2970	4880	9180	920	2790		2575	1524
08/06/2003	1190	1640	1070	3690	1650	2400	564	29.1	2640	3240	10300	1010	2890		2486	1453
02/12/2004	***1190***	***1640***	***1070***	***3690***	***1650***	2400	540	***29.1***	1900	3200	9600	800	2800		2347	1375
08/31/2004	1000	1900	800	3500	1700	2600	590	26	2300	2500	***9600***	710	2900		2317	1331
02/10/2005	1000	2100	810	3700	1900	3000	680	26	2300	2700	***9600***	890	3000		2439	1426
08/31/2005	830	2000	1100	3600	***1900***	3000	770	28	2500	2600	***9600***	***890***	2800		2432	1450
02/22/2006	820	2000	1000	3500	2100	3000	840	27	2400	2100	***9600***	***890***	3000		2406	1431
08/31/2006	960	2000	1100	3600	***2100***	2700	810	27	2300	1600	***9600***	750	2900		2342	1390
02/22/2007	1000	2100	990	3400	***2100***	2900	870	23	2600	***1600***	1701	780	3100		1782	1230
8/16/2007	1100	2000	1000	3100	2000	2800	850	23	2500		1701	880	3000		1746	1194
2/5/2008	1400	2200	1300	3400	2000	3000	930	25	2800		2200	1000	3200		1955	1352
8/20/2008	1600	2200	1300	3800		3100	960	23	3000			1200	3400		2058	1307
02/25/2009	1400	2000	1200	3300		2700	910	22	2700			1200	3200		1863	1200
08/13/2009	1600	2000	1300	3200	1700	2800	910	23	2900			1200	3200		1894	1277
02/09/2010	2100	3100	1300	3600	1900	3000	900	25	3200			1400	3400		2175	1450





t1=	Jun-02	
t2=	Feb-10	
t2 - t1=	7.6	yr
t3=	Jun-18	extrapolated
projected cleanup time from t1=	16	yr
projected cleanup time from t2=	8	yr

t1=	Jun-02	
t2=	Feb-10	
t2 - t1=	7.6	yr
t3=	Jun-30	extrapolated
projected cleanup time from t1=	28	yr
projected cleanup time from t2=	20	yr

Figure G-3. Calculation Set 3, Calculate a Bulk Index of Aquifer Restoration for Sulfate

This page intentionally left blank

Calculation 4
Calculate a Bulk Index of Aquifer Restoration for Uranium

This page intentionally left blank

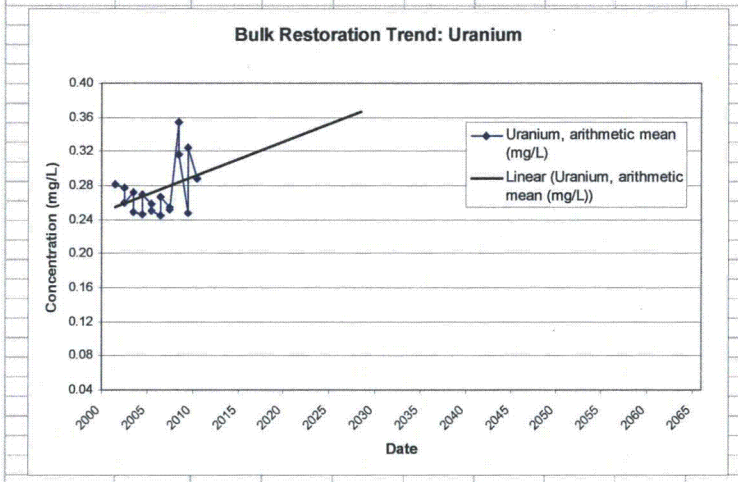
Calculation Set #4: Calculate a bulk index of aquifer restoration for uranium
Tuba City, AZ, Disposal Site

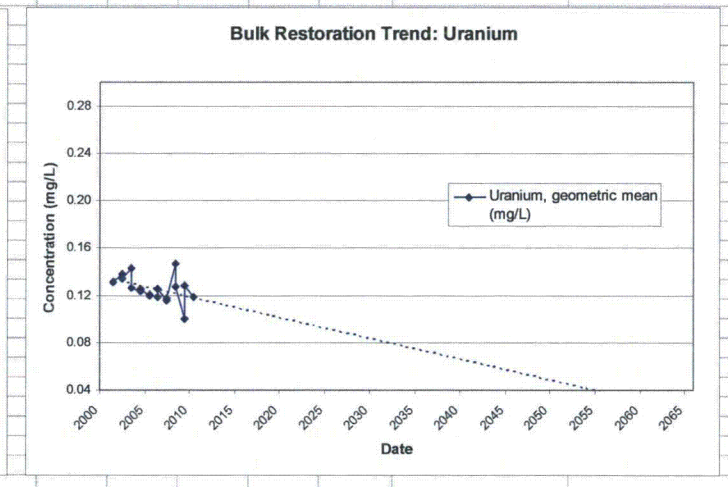
Objective: Develop a bulk concentration index for measuring restoration progress for uranium

Method: 1) Compute an average concentration of a contaminant for a given sampling date/event for a selected group of monitor wells within the contaminant plume
2) Compare the computed averages over time

Calculation: The selected monitor wells below have the most comprehensive data set and are located throughout the contaminant plume in Horizons A and B; no historical data exist for Horizons C and D within the contaminant plume.
Note: where data are absent in the table below, concentrations are carried forward from the previous date as shown in ***bold italic***

	Uranium mg/L														Uranium,	Uranium,
date_sampled	Loc 0262	Loc 0263	Loc 0265	Loc 0267	Loc 0906	Loc 0908	Loc 0909	Loc 0929	Loc 0934	Loc 0936	Loc 0940	Loc 0941	Loc 0942		arithmetic mean (mg/L)	geometric mean (mg/L)
08/16/01	***0.379***	***0.485***	***0.090***	0.070	0.934	0.111	0.018	0.001	0.298	0.281	0.643	0.103	0.251	baseline	0.2818	0.1316
03/06/02	***0.379***	***0.485***	***0.090***	0.073	0.951	0.122	0.039	0.001	0.312	0.267	0.546	0.089	0.246	baseline	0.2769	0.1378
08/20/02	***0.379***	***0.485***	***0.090***	0.074	0.698	0.122	0.035	0.001	0.336	0.306	***0.546***	***0.089***	0.218		0.2599	0.1336
02/06/03	***0.379***	***0.485***	***0.090***	0.077	0.653	0.124	0.033	0.002	0.355	0.582	0.432	0.102	0.221		0.2718	0.1428
08/06/03	0.425	0.173	0.055	0.078	0.667	0.106	0.028	0.002	0.350	0.606	0.428	0.086	0.232		0.2489	0.1261
02/12/04	***0.425***	***0.173***	***0.055***	***0.078***	***0.667***	0.097	0.027	***0.002***	0.320	0.600	0.430	0.081	0.240		0.2458	0.1238
08/31/04	0.530	0.230	0.045	0.088	0.890	0.120	0.029	0.001	0.320	0.470	***0.430***	0.076	0.270		0.2692	0.1256
02/10/05	0.560	0.190	0.045	0.085	0.830	0.110	0.035	0.001	0.280	0.470	***0.430***	0.049	0.270		0.2581	0.1191
08/31/05	0.660	0.140	0.060	0.095	***0.830***	0.100	0.042	0.001	0.260	0.350	***0.430***	***0.049***	0.230		0.2498	0.1205
02/22/06	0.770	0.120	0.054	0.088	0.710	0.100	0.048	0.001	0.250	0.240	***0.430***	***0.049***	0.330		0.2454	0.1181
08/31/06	0.780	0.100	0.061	0.077	***0.710***	0.089	0.051	0.001	0.250	0.200	***0.430***	0.093	0.620		0.2663	0.1254
02/22/07	0.930	0.098	0.053	0.061	***0.710***	0.092	0.047	0.001	0.210	***0.200***	0.365	0.078	0.460		0.2542	0.1154
08/16/07	1.100	0.096	0.063	0.068	0.420	0.100	0.055	0.002	0.220		0.365	0.130	0.410		0.2524	0.1178
02/05/08	1.400	0.110	0.074	0.078	1.000	0.110	0.063	0.002	0.220		0.520	0.140	0.540		0.3547	0.1463
8/20/2008	1.400	0.110	0.069	0.067		0.100	0.550	0.002	0.210			0.180	0.480		0.3168	0.1275
02/25/2009	1.200	0.120	0.072	0.070		0.093	0.059	0.002	0.190			0.170	0.500		0.2476	0.1003
08/13/2009	1.3	0.17	0.071	0.07	0.91	0.096	0.057	0.0016	0.19			0.19	0.51		0.3241	0.1287
02/09/2010	1.1	0.14	0.067	0.067	0.79	0.089	0.051	0.0015	0.19			0.18	0.5		0.2887	0.1183





t1=	15-Jun-02		t1=	15-Jun-02		
t2=	9-Feb-10		t2=	9-Feb-10		
t2 - t1=	7.7	yr	t2 - t1=	7.7	yr	
t3=	(+) slope	extrapolated	t3=	Jun-65	extrapolated	
projected cleanup time from t1=	N/A	yr	projected cleanup time from t1=	63	yr	
projected cleanup time from t2=	N/A	yr	projected cleanup time from t2=	55	yr	

Figure G−4. Calculation Set 4, Calculate a Bulk Index of Aquifer Restoration for Uranium

This page intentionally left blank