Umetco Minerals Corporation

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June 17, 2005

Mr. Richard Weller, Project Manager
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards
Mail Stop T-8-A-33
Two White Flint North, 11545 Rockville Pike
Rockville, Maryland 20852-2738

CERTIFIED MAIL/RETURN RECEIPT

Reference: Materials License SUA-648, Docket No. 40-0299

Re: License Amendment Request

Dear Mr. Weller:

Umetco Minerals Corporation (Umetco) is requesting a license amendment to License Condition 35, U.S. Nuclear Regulatory Commission (NRC) Materials License Number SUA-648, for Umetco's Gas Hills Uranium Mill Site. The purpose of this amendment request is the proposed revision to the Alternate Concentration Limit (ACL) for Lead-210 (Pb-210) for the Southwestern Flow Regime (SWFR).

As indicated in Umetco's submittal dated February 14, 2005, *Umetco Gas Hills – Evaluation of Pb-210 in Ground Water Well GW7*, and subsequent discussions with NRC staff, monitoring of Point of Compliance (POC) Well GW7 indicate increased concentrations of Pb-210 exceeding the ACL of 46.7 Pico curies per liter (pCi/L).

The enclosed report – *Determination of Lead-210 ACL for the Southwestern Flow Regime*, contains an evaluation of increased Pb-210 concentration in GW7, methodology used for selection of the proposed Pb-210 ACL value and geochemical modeling used to evaluate the predicted Pb-210 concentration at the Point of Exposure (POE).

Also included with this submittal please find the revised groundwater monitoring plan (Appendix M of Umetco's ACL Application) which has been modified to reflect the proposed changes to License Condition 35.

Umetco proposes the following modifications (underlined/strike through) to License Condition 35:

35. The Alternate Concentration Limits (ACL) for ground water contained in Umetco's application dated May 11 and May 18, 2001 as revised by submittals of July 30, 2001, December 3, 2001 and March 4 and October 2, 2002, **and June 9, 2005** have been approved for this site. The licensee shall implement a ground water compliance monitoring program that includes the following.

    A. Conduct monitoring as described in the Ground water Monitoring Plan (ACL application, Appendix M) in the ~~January 5, 2004~~ **June 9, 2005** submittal. The validation of ACL exceedance will be in accordance with Section 4 of Appendix M. The licensee shall submit this monitoring data to the NRC by September 30th of each year and include ground water contour maps, contamination iso-concentration maps and trend graphs.

    B. Comply with the following ACL in the western flow regime at Point of Compliance (POC) wells MW1 and MW21A: arsenic = 1.8 mg/l, beryllium = 1.64mg/l, lead-210 = 35.4 pCi/l, nickel =13.0 mg/l, combined radium-226 and 228 = 250 pCi/l, selenium = 0.161 mg/l, thorium-230 = 57.4 pCi/l, and uranium-natural = 11.9 mg/l.

    C. Comply with the following ACL in the southwestern flow regime at POC wells GW7 and GW8: arsenic = 1.36 mg/l, beryllium =1.70 mg/l, **lead-210 = 189 pCi/l**, nickel = 9.34 mg/l, combined radium-226 and 228 = 353 pCi/l, selenium = 0.53 mg/l, thorium-230 = 44.8, and uranium-natural = 34.1.

D. The licensee shall use, at a minimum, the following lower limits of detection for water quality analysis in mg/l, unless otherwise noted: arsenic=0.01, beryllium =0.01, nickel = 0.01 selenium = 0.005, total dissolved solids = 10, sulfate = 1.0, chloride =1.0, iron = 0.1, pH = 0.1 (standard units), natural uranium = 0.0015, combined radium-226 and 228 = 1.0 pCi/l, thorium-230 = 1.0 pCi/l, lead-210 = 1.0 pCi/l, and gross alpha = 5.0 pCi/l.

E. The ACL for gross alpha for both flow regimes is based on the sum of its major contributors and not on a measured number. The ACL for gross alpha is considered to be met if the major contributing radionuclides (Th-230, Ra-226 = Ra-228, Pb-210) are all below their ACL.

Please contact me at 970-256-8889 or by e-mail at gieckte@dow.com if you have any questions or comments.

Sincerely,

Thomas E. Gieck

Thomas E. Gieck
Remediation Leader

TEG/jfc

Enclosures: As stated
cc: Mr. Mark Moxley WDEQ w/enclosure

Umetco Minerals Corporation
Determination of Lead-210 ACL
For the
Southwestern Flow Regime

Umetco Minerals Corporation
Gas Hills, Wyoming

June 2005

Attachments

Umetco Minerals Corporation
Determination of Lead-210 ACL
For The
Southwestern Flow Regime

Umetco Minerals
Determination of Lead-210 ACL for the Southwestern Flow Regime

1.0 INTRODUCTION

Groundwater monitoring results from Point of Compliance (POC) Well GW7 indicate increasing trends in lead-210 (Pb-210), with several values for Pb-210 exceeding the Alternate Concentration Limit (ACL) of 46.7 picocuries per liter (pCi/L). An evaluation of the increased Pb-210 concentration in monitor well GW-7 was submitted to the U.S. Nuclear Regulatory Commission (NRC) by letter dated February 14, 2005.

Based on the NRC review and subsequent discussions of the February 14, 2005 submittal, Umetco Minerals Corporation (Umetco) is proposing a revised lead-210 (Pb-210) Alternate Concentration Limit (ACL) for groundwater in the East Gas Hills Southwestern Flow Regime (SWFR). A revised ACL for Pb-210 is desired to avoid future exceedences of the current SWFR Pb-210 ACL (46.7 pCi/L) which have recently occurred in Monitoring Well GW7.

2.0 BACKGROUND

Umetco's proposal to amend License SUA-648, authorizing the use of ACLs at the East Gas Hills Site, was approved by the NRC on March 29, 2002 (Umetco, 2001). The authorized ACL values for nine constituents in POC wells were developed using a statistical evaluation of historical data collected after 1992. The proposed ACL for a particular constituent was equivalent to the 95 percent Upper Confidence Limit of the Upper 95_{th} Quantile of the representative data set (Section 4.0; Umetco, 2001). The only exception was for thorium-230, which was set equal to the highest observed value at POC Well GW7 because it exceeded the statistical threshold used for the remaining constituents. Predicted constituent concentrations at the Point of Exposure (POE) were then evaluated using the geochemical reactive transport model PHREEQC (Parkhurst, 1995). The results of geochemical modeling indicated that constituent concentrations would be attenuated to levels within the range of background and protective of human health and the environment.

3.0 EVALUATION of Pb-210 in POC WELL GW-7

Evaluation of groundwater elevation and water quality trends show that fluctuation of ground water levels in mineralized zones can produce naturally-elevated concentrations of Pb-210 which exceed the current ACL for Pb-210 as discussed in Umetco's February 14, 2005 submittal to NRC (Telesto Solutions, Inc., 2005).

3.1 Geologic Setting

Well GW7 is completed in the shallow groundwater of the Upper Wind River Formation, which comprises the Southwestern Flow Regime (SWFR). The Wind River Formation was geochemically-altered during a post-depositional period of uranium concentration, which occurred primarily as roll-front deposits. In the southern portion of the A-9 Repository Area, discontinuous occurrences of mineralized roll front deposits are still present in the underlying Wind River Aquifer. Figure 1.9 from the Umetco ACL Application (Umetco 2001) shows the distribution of uranium roll front deposits in the southern portion of the A-9 Area. The POC Well GW7 is located along cross-section D-D', southwest of the A-9 Repository as shown (Figure 1.9; Umetco, 2001). Gamma survey results from 1983 have shown that the occurrence of subsurface uranium mineralization below GW7 is coincident with the water table (Figure 1.13 from Umetco, 2001). Based upon these observations, the historically-elevated concentrations of radionuclides in GW7 are attributed to the presence of natural mineralization (Umetco, 2001). Fluctuations in the elevation of the water table within the borehole alternately expose and submerge the mineralized zone. When groundwater levels are low, the mineralized zone is exposed to atmospheric oxygen, promoting oxidation of sulfide minerals in the ore zone. When water levels rise and re-saturate the mineralized zone, oxidation products such as acidity, sulfate, and metals are released to groundwater. As a result, Well GW7 has historically contained elevated concentrations of several licensed constituents (Umetco 2001).

3.2 Water Quality Evaluation

The ACL for Pb-210 in SWFR groundwater is 46.7 pCi/L (Umetco, 2001). In May of 2003 the ACL was exceeded, with a Pb-210 concentration of 48.4 pCi/L (Figure 1). Well GW-7 was re-sampled in July of 2003, and the Pb-210 concentration decreased below the ACL to 28.8 pCi/L. Subsequent analysis for Pb-210 in June 2004 yielded inconclusive results. However, the most recent result for Pb-210 in GW-7 was in exceedance of the ACL at 54 pCi/L in October of 2004. None of the remaining eight licensed constituents (arsenic, beryllium, natural uranium, nickel, radium-226+228, selenium, and thorium-230) have exceeded the designated ACLs in GW7.

Groundwater pumping in the vicinity of the A-9 Repository resulted in depression of the water table between 1998 and 2002. Since pumping has ceased, groundwater elevations have begun to recover as a result of backfilling of the adjacent C-18 Pit. Although Pb-210 concentrations in GW7 have fluctuated widely over the years, recent increases in Pb-210 concentrations are correlated with the recovery of groundwater elevations. Similar effects were noted for natural uranium in GW7, where faster responses of uranium concentrations to groundwater elevation changes were noted. As discussed in Section 3.1, these trends result from the oxidation of reduced minerals in the mineralized zone when groundwater elevations are lowered. Trends in the pH and sulfate concentrations at GW7 are also consistent with oxidation of sulfide minerals (e.g., pyrite) in the ore deposits, which produce increased acidity (low pH) and sulfate concentrations upon oxidations:

$$FeS_2\,(\text{pyrite}) + 7/2\ O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{\ 2-} + 2H^+$$

For these reasons it is concluded that the recent exceedences for Pb-210 in GW-7 are very localized and the result of natural mineralization at the site. Additional data to support this conclusion are the historic Pb-210 concentrations that have been measured in the SWFR at the East Gas Hills Site. For example, Table E-1 from the Umetco ACL application (Umetco, 2001) shows that only three measurements ever exceeded the ACL value of 46.7 pCi/L in the SWFR, and one of the measurements (48.9 pCi/L) was from GW7. Therefore, it is unlikely that the recent Pb-210 exceedences observed in GW7 are the result of migration of a Pb-210 contaminant plume.

4.0 PROPOSED ACL REVISION FOR LEAD-210

The method described below, which was used to propose a revised ACL for Pb-210 in the SWFR, is similar to the approach outlined in the original Gas Hills ACL Application (Umetco, 2001). One important difference is that the proposed ACL value presented herein was determined by considering all available ground water quality data (1985 through 2004), whereas the original ACL application only considered post-1992 data.

All Pb-210 data from the Umetco database were first ranked to determine which monitoring wells consistently recorded the highest concentrations for each constituent. The ranking of Pb-210 data in Table 1 shows that Monitoring Wells GW3, GW7, and MW7 most commonly contained the highest concentrations of Pb-210. The highest observed Pb-210 concentrations were measured in GW3 between 1986 and 1987. The data from GW3 were not previously considered in the original Gas Hills ACL Application (Umetco, 2001), where the calculated ACL values were derived using data from Wells GW-7 and MW-7 after 1992.

The 95 percent Upper Confidence Limit of the Upper 95_{th} Quantile calculated using all Pb-210 data from Monitoring Wells GW3, GW7, and MW7 is 57.9 pCi/L (Attachment 1). However, the most recent result for Pb-210 in POC Well GW7 was in exceedence of the existing ACL (46.7 pCi/L) at 54 pCi/L. To provide improved assurance that a revised ACL will not be exceeded in the future, the highest observed Pb-210 concentration of 189 pCi/L from Well GW3 (Figure 1) is proposed as the Pb-210 ACL for the SWFR.

5.0 GEOCHEMICAL ASSESSMENT

The geochemical transport model PHREEQC (Parkhurst, 1995) was used to evaluate the predicted Pb-210 concentrations at the SWFR POE for a 1,000-year model simulation. Similar to the authorized ACL, model simulations were run using two flow rates: 0.167 feet/day and 0.280 feet/day (Umetco, 2001). The PHREEQC model input files which were submitted with the original ACL Application (Umetco, 2001) were modified to produce a revised decreasing source term for Pb-210 based on the proposed revised ACL of 189 pCi/L (2.44×10^{-11} mg/L). Hard copies of the modified PHREEQC input files where constituent concentrations are expressed in mg/L are included in Attachment 2.

6.0 CONCLUSION

Based upon the results of geochemical modeling, the proposed revised Pb-210 ACL of 189 pCi/L for the SWFR is shown to be protective of human health and the environment. In summary, the model results show that:

- The predicted Pb-210 concentrations at the POE at 1,000-years (Figure 2) are 0.115 pCi/L (0.167 feet/day) and 0.113 pCi/L (0.280 feet/day) and are within the range of natural background for the SWFR (Table 2).
- The maximum predicted Pb-210 concentrations at the POE during the 1000-year simulation (Figure 3) are 0.23 pCi/L (0.167 feet/day) and 0.24 pCi/L (0.280 feet/day) (Table 2). The maximum predicted Pb-210 concentrations at the POE are within the range of natural background for the SWFR and remain unchanged from the original ACL Application (Umetco, 2001).

6.0 REFERENCES

Parkhurst, 1995. User's Guide to PHREEQC: A Computer Program for Speciation, Reaction-Path, Advective Transport, and Inverse Geochemical Calculations. U.S. Geological Survey, Water Resources Investigations Report 95-4227. Lakewood, Colorado. 143 pp.

Telesto Solutions, Inc. 2005. Gas Hills ACL Action Plan for Point of Compliance Well GW-7. Technical Memorandum to Umetco Minerals Corporation, January 28.

Telesto Solutions, Inc, 2005. Proposed Revised ACL for Pb-210 in the Southwestern Flow Regime. Technical Memorandum to Umetco Minerals Corporation, April 1, 2005.

Umetco Minerals Corporation. 2001. Final Application for Alternate Concentration Limits for Gas Hills, Wyoming. November.

Table 1 Ranking of Pb-210 Values in SWFR Monitoring Wells from 1985 through 2004[1]

Rank	Location	Date	Pb-210 (pCi/L)		Rank	Location	Date	Pb-210 (pCi/L)
1	GW3	24-Mar-87	189		22	EPW2	09-Sep-87	39.3
2	GW3	17-Sep-86	124.1		23	GW7	20-Apr-88	37.3
3	GW3	10-Dec-86	120.3		24	MW7	15-Mar-88	37.1
4	MW10	24-May-89	87.5		25	MW7	15-May-96	37
5	GW7	23-Sep-87	85.4		26	MW7	30-Aug-94	35.6
6	MW7	16-Dec-86	84		27	MW67	13-Dec-95	35
7	PW1	08-Dec-98	65		28	MW7	01-Dec-87	34.1
8	GW7	21-Jun-04	59.8		29	GW7	15-Oct-85	33
9	GW7	07-May-86	54		30	GW7	20-Jul-85	33
10	GW8	21-Jun-04	53.4		31	MCW61	16-Aug-94	32.9
11	MW7	16-May-88	50.8		32	MW7	11-Jun-97	32
12	MWC61	07-May-96	49		33	MW7	12-Dec-95	32
13	GW7	16-Mar-94	48.9		34	MW7	07-Mar-95	31.5
14	GW7	07-May-03	48.4		35	EPW2	01-Nov-88	31.3
15	MW7	11-Sep-96	45		36	GW7	02-Jun-97	31
16	MW7	07-Dec-89	44.6		37	MW7	03-Mar-87	30.7
17	MW7	19-Nov-96	44		38	GW8	16-Mar-94	30.3
18	GW7	28-Apr-87	43		39	GHGW7	06-Oct-04	29.9
19	MW10	16-Dec-86	42		40	MW7	17-May-95	29
20	GW7	15-Aug-94	40.3		41	GW7	14-Jul-03	28.8
21	GW7	18-Aug-97	40					

1) Excluding data from Monitoring Well HW4 as discussed in the text of ACL Application (Umetco 2001). Shading indicates monitoring wells which consistently recorded the highest concentrations for Pb-210.

Table 2 Geochemical Modeling Results for the SWFR Using the Proposed Revised Pb-210 ACL of 189 pCi/L

Parameter	POE Concentration	Maximum POE Concentration for the 1000-Year Simulation
Model Result using Low Flow Rate (0.167 ft/day)	0.115 pCi/L	0.23 pCi/L
Model Result using High Flow Rate (0.280 ft/day)	0.113 pCi/L	0.24 pCi/L
Background Range (Umetco, 2001)	-0.80 to 3.5 pCi/L	

ATTACHMENT 1
STATISTICAL ANALYSIS OF DATA FROM MONITOR WELLS
GW3, GW7 AND MW7

LocCode	Date	Result		LocCode	Date	Result		LocCode	Date	Result		LocCode	Date	Result
GW3	Sep-86	124.1		GW3	Feb-99	10		GW7	06-Dec-94	4.6		MW7	24-Jan-89	26.1
GW3	Dec-86	120.3		GW3	Aug-99	11		GW7	27-Jun-95	5.4		MW7	24-May-89	28
GW3	Mar-87	189		GW3	Feb-00	13		GW7	16-Aug-95	7.5		MW7	07-Dec-89	44.6
GW3	Sep-87	85.4		GW3	Jul-00	6.3		GW7	05-Dec-95	9.6		MW7	25-Apr-90	26.4
GW3	Dec-87	23.4		GW3	Mar-01	16		GW7	21-Mar-96	7		MW7	06-Nov-90	15.6
GW3	Mar-88	22.7		GW3	Aug-01	15.3		GW7	19-Jun-96	7.6		MW7	31-May-91	19.6
GW3	May-88	21		GW7	20-Jul-85	33		GW7	22-Aug-96	10		MW7	20-Nov-91	2.2
GW3	Sep-88	15.9		GW7	15-Oct-85	33		GW7	11-Nov-96	23		MW7	01-Jan-92	3.6
GW3	Dec-88	24.4		GW7	15-Jan-86	27		GW7	26-Feb-97	17		MW7	09-Dec-92	0.5
GW3	Mar-89	14.2		GW7	7-May-86	54		GW7	02-Jun-97	31		MW7	08-Jun-93	6.6
GW3	May-89	21.5		GW7	15-Jul-86	14.2		GW7	18-Aug-97	40		MW7	07-Dec-93	20.6
GW3	Dec-89	17.9		GW7	4-Nov-86	21.3		GW7	28-Oct-97	28		MW7	23-Mar-94	12.1
GW3	May-90	5.8		GW7	9-Feb-87	27		GW7	24-Apr-98	24		MW7	08-Jun-94	23.1
GW3	Dec-90	19.4		GW7	28-Apr-87	43		GW7	09-Jun-98	24		MW7	30-Aug-94	35.6
GW3	Jun-91	13		GW7	28-Jul-87	20.9		GW7	31-Aug-98	14		MW7	13-Dec-94	17.9
GW3	Dec-91	21.8		GW7	08-Oct-87	27.1		GW7	27-Oct-98	15		MW7	07-Mar-95	31.5
GW3	Dec-92	22.2		GW7	09-Feb-88	19.5		GW7	17-Feb-99	20		MW7	17-May-95	29
GW3	Dec-93	9.7		GW7	20-Apr-88	37.3		GW7	18-Aug-99	20		MW7	26-Jul-95	24
GW3	Mar-94	7.4		GW7	13-Jul-88	18.4		GW7	01-Mar-00	28		MW7	12-Dec-95	32
GW3	Jun-94	2.6		GW7	25-Oct-88	9.9		GW7	27-Jul-00	20		MW7	19-Mar-96	27
GW3	Dec-94	8.7		GW7	03-Jan-89	8.5		GW7	24-Jan-01	20		MW7	15-May-96	37
GW3	Mar-95	9.7		GW7	17-Apr-89	8.3		GW7	20-Jul-01	26.8		MW7	11-Sep-96	45
GW3	May-95	4.9		GW7	24-Jul-89	4.3		GW7	11-Jun-02	18.1		MW7	19-Nov-96	44
GW3	Jul-95	4		GW7	27-Nov-89	13.3		GW7	07-May-03	48.4		MW7	19-Feb-97	23
GW3	Dec-95	9.1		GW7	18-Apr-90	7.2		GW7	14-Jul-03	28.8		MW7	11-Jun-97	32
GW3	Mar-96	11		GW7	30-Oct-90	24.7		GW7	21-Jun-04	59.8		MW7	07-Aug-97	27
GW3	Dec-96	11		GW7	21-May-91	1.8		MW7	15-Sep-86	16		MW7	27-Oct-97	28
GW3	Sep-96	8.4		GW7	09-Oct-91	10.2		MW7	16-Dec-86	84		MW7	02-Mar-98	26
GW3	Nov-96	12		GW7	10-Oct-91	10.2		MW7	03-Mar-87	30.7		MW7	19-May-98	22
GW3	May-97	10		GW7	12-May-92	7		MW7	20-May-87	20.9		MW7	26-Aug-98	21
GW3	Aug-97	7.6		GW7	20-Oct-92	5.8		MW7	21-Sep-87	17.5		MW7	30-Nov-98	20
GW3	Oct-97	10		GW7	15-Jun-93	7.9		MW7	01-Dec-87	34.1		MW7	03-Feb-99	17
GW3	Feb-98	7.8		GW7	13-Dec-93	6		MW7	15-Mar-88	37.1				
GW3	Jun-98	8.4		GW7	16-Mar-94	48.9		MW7	16-May-88	50.8				
GW3	Sep-98	9.1		GW7	02-Jun-94	10.5		MW7	03-Aug-88	9.4				
GW3	Nov-98	9.8		GW7	15-Aug-94	40.3		MW7	22-Nov-88	25.1				

STATISTICAL ANALYSIS OF DATA FROM MONITOR WELLS GW3, GW7 AND MW7

Descriptive Statistics:

Mean	23.2
Standard Error	2.0
Median	19.6
Mode	20
Standard Deviation	23.4
Sample Variance	549.4
Kurtosis	21.5
Skewness	3.9
Range	188.5
Minimum	0.5
Maximum	189
Sum	3246.5
Count	140
Confidence Level (95%)	3.9

95th percentile	51.3
Calculated ACL [1)]	55.2
Highest observed	189

1) 95% Upper Confidence Limit of the Upper of the 95th Quantile

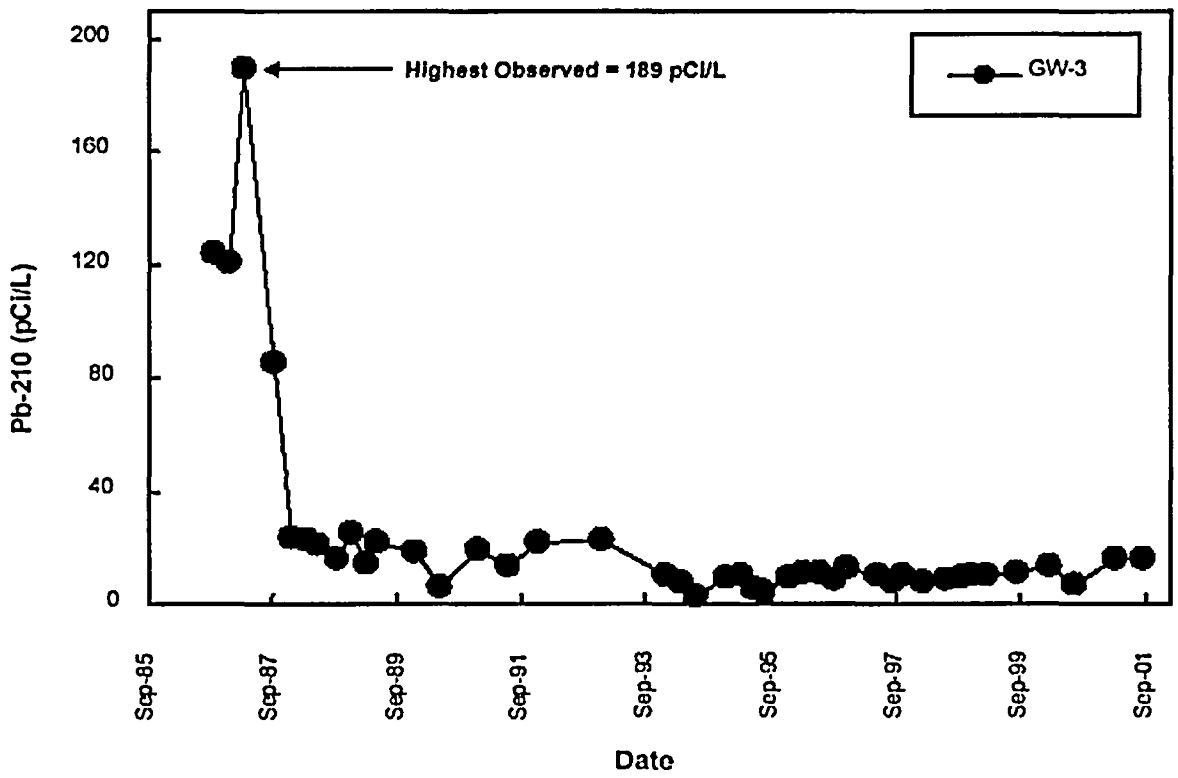

FIGURE 1
HISTORIC LEAD-210 CONCENTRATIONS IN MONITORING WELL GW-3
EAST GAS HILLS

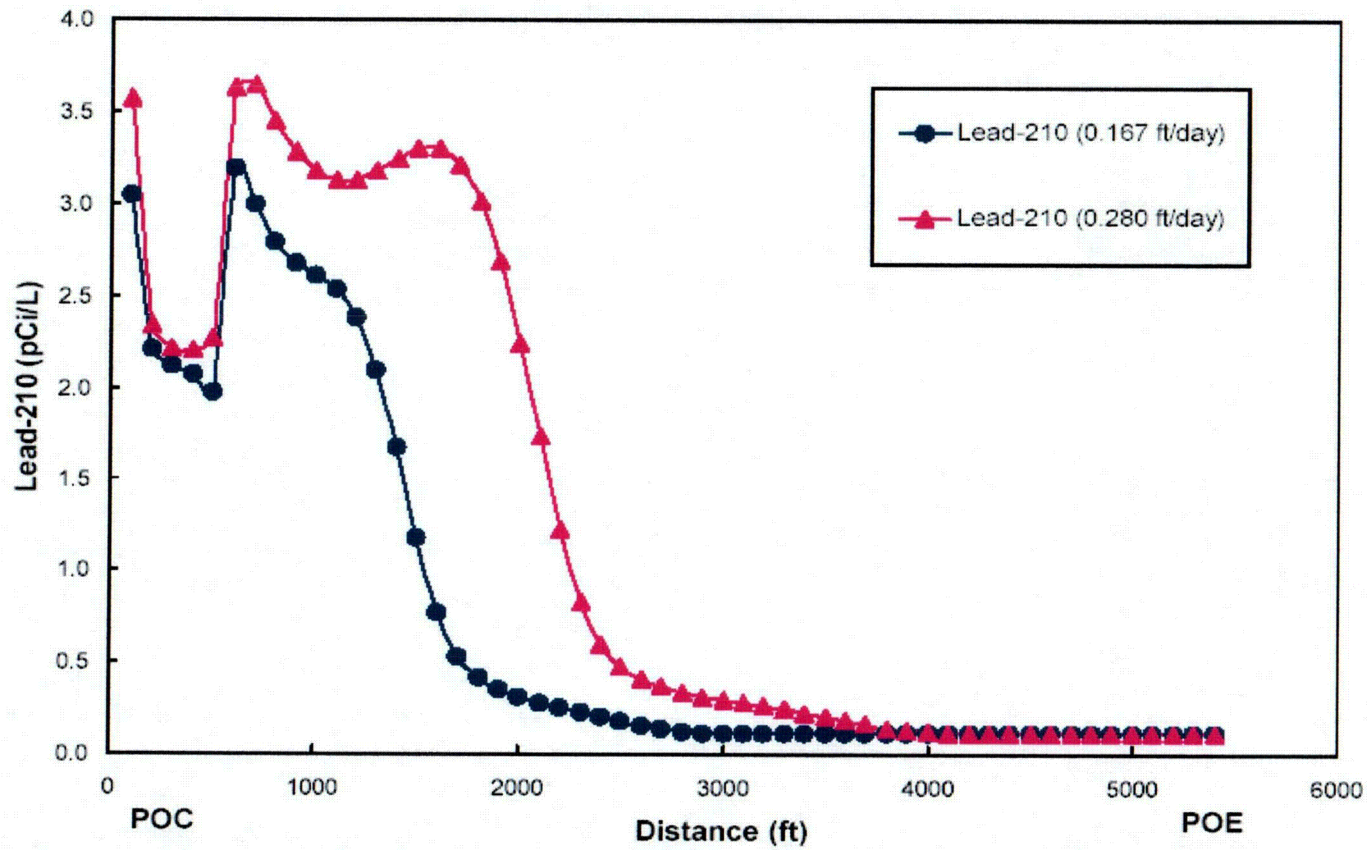

FIGURE 2
PREDICTED 1000-YEAR LEAD-210 CONCENTRATIONS BETWEEN THE SOUTHWESTERN FLOW REGIME POC AND POE USING THE PROPOSED REVISED ACL OF 189 pCi/l

C01

ATTACHMENT 2
REVISED PHREEQC INPUT FILES

SWFR1d.in

```
TITLE A-9 area (SW flow regime). FILE: SWFR1d.in
#Concentration vs Distance between POE and POE
#Using flow rate of 0.167 ft/d - DECREASING SOURCE TERM TO 90%
REDUCTION
#Dispersivity = 50
#SOLID PHASES ALLOWED
#Revised in 2005 for Pb-210

KNOBS
      -iterations 100
      -tolerance 1.00E-13
      -step_size 100
      -pe_step_size 10
      -diagonal_scale TRUE
      -debug_prep FALSE
      -debug_set FALSE
      -debug_model FALSE
      -debug_inverse FALSE
      -logfile FALSE

SOLUTION 0 # Initial Source Term

      units       ppm
      pe          8
      pH          4.33
      Th          2.22e-6
      Pb          2.44e-9     #Revised ACL 2005
      Be          1.7
      Ca          660
      Mg          144
      Na          61
      K           15
      Fe(2)       89
      Cl          161
      As          1.36
      Ni          9.34
      Se          0.53
      Si          56.4
      U           34.1
      Alkalinity  2.44 as HCO3
      S(6)        2650
      Ra          3.57e-7

SOLUTION 1-5 GW8 January 2001

      units       ppm
      pe          7
      pH          4.73
      S(6)        1540
      Cl          97
      Alkalinity  2.0 as HCO3
      Ca          418
      Na          30.6
      Mg          70.8
      K           17.6
      Fe(2)       127
      As          0.007
      Be          0.076
      Th          7.97e-8
      Pb          2.58e-10
      Ra          6.25e-8
      Ni          1.31
      Se          0.001
```

```
        U              10.3
SOLUTION 6-54 MW-74 January 2001

        Units          ppm
        pe             6
        pH             6.69
        S(6)           24.1
        Cl             9.1
        Alkalinity     35 as HCO3
        Ca             17.7
        Na             6.3
        Mg             2.9
        K              4.2
        Fe(2)          0.1
        As             0.0019
        Be             0.001 # 1/2 DL
        Th             3.77e-8
        Pb             1.68e-11
        Ra             4.55e-10
        Ni             0.005 # 1/2 DL
        Se             0.012
        U              0.0139
        S(-2)          0.033

EQUILIBRIUM_PHASES 1-54
        Calcite                      0.0          0.0
        Gypsum                       0.0          0.0
        Uraninite          0.0          0.0
        USiO4(c)           0.0          0.0
        Ferroselite        0.0          0.0
        Se(A)              0.0          0.0
        RaSO4              0.0          0.0
        NiSe               0.0          0.0
        Anglesite          0.0          0.0

SURFACE 1-5
        -equilibrate 1
        Hfo_wOH        0.086         600          45.9
        Hfo_sOH        0.0021

SURFACE 6-54
        -equilibrate 6
        Hfo_wOH        0.086         600          45.9
        Hfo_sOH        0.0021

EXCHANGE 1-5
        -equilibrate 1
        X              1.2

EXCHANGE 6-54
        -equilibrate 6
        X              1.2

TRANSPORT
        -lengths                     54*30.5
        -dispersivities    54*50
        -cells             54
        -shifts            4

PRINT
        -reset false
END
```

```
SWFR1d.in
SOLUTION 0 #33% REDUCTION
        units          ppm
        pe             5.6
        pH             4.47
        Th             1.47e-6
        Pb             1.63e-9      #Revised ACL 2005
        Ra             2.41E-07
        U              22.62
        Be             1.13
        Ca             536.7
        Mg             116.7
        Na             57
        K              16.2
        Fe(2)          61.8
        Cl             114.6
        As             0.90
        Ni             6.20
        Se             0.35
        Si             37.4
        Alkalinity 4.0 as HCO3
        S(6)           1980.5

TRANSPORT
        -lengths                    54*30.5
        -dispersivities     54*50
        -cells              54
        -shifts             2

END

SOLUTION 0 #50% Reduction

        units          ppm
        pe             5.5
        pH             4.57
        Th             1.12e-6
        Pb             1.22e-9      #Revised ACL 2005
        Ra             1.86E-07
        U              17.16
        Be             0.85
        Ca             477.5
        Mg             103.6
        Na             55
        K              16.8
        Fe(2)          48.9
        Cl             92.5
        As             0.68
        Ni             4.7
        Se             0.27
        Si             28.31
        Alkalinity 4.73 as HCO3
        S(6)           1661

TRANSPORT
        -lengths                    54*30.5
        -dispersivities     54*50
        -cells              54
        -shifts             4

END

SOLUTION 0 #75% Reduction
```

```
        units       ppm
        pe          5.1
        pH          4.85
        Th          5.65e-07
        Pb          6.1E-10      #Revised ACL 2005
        Ra          1.0E-07
        U           8.62
        Be          0.43
        Ca          384.9
        Mg          83.1
        Na          51.9
        K           17.7
        Fe(2)       28.7
        Cl          58
        As          0.34
        Ni          2.36
        Se          0.13
        Si          14.2
        Alkalinity 5.88 as HCO3
        S(6)        1161

TRANSPORT
        -lengths                   54*30.5
        -dispersivities     54*50
        -cells              54
        -shifts             12
END

SOLUTION 0 #90% Reduction

        units       ppm
        pe          4.4
        pH          5.27
        Th          2.33E-07
        Pb          2.45e-10     #Revised ACL 2005
        Ra          4.84e-8
        U           3.5
        Be          0.17
        Ca          329.4
        Mg          70.8
        Na          50
        K           18.2
        Fe(2)       16.5
        Cl          37.3
        As          0.14
        Ni          0.96
        Se          0.05
        Si          5.66
        Alkalinity 6.56 as HCO3
        S(6)        860.7

TRANSPORT
        -lengths                   54*30.5
        -dispersivities     54*50
        -cells              54
        -shifts             588
        -punch_frequency           588

SELECTED_OUTPUT

        -file C:\SWFR1d.dat
```

SWFR1d.in

```
USER_PUNCH
    -headings As Be Cl Pb U Ni Se SO4 Th Ra sOPb+
    -headings wOPb+ PbX2 Anglesite sOHUO2+2
    -headings wOUO2+ USiO4(C) Uraninite sONi+ wONi+
    -headings NiSe sOHRa+2 wORa+ RaX2 RaSO4 wSeO4-
    -headings wOHSeO4-2 wSeO3- wOHSeO3-2 Se(A)
    -headings FeSe2 sSO4- wSO4- sOHSO4-2 wOHSO4-2
    -headings gypsum wOTh+3 wOTh(OH)+2 wOTh(OH)2+
    -headings wOTh(OH)3 wOTh(OH)4- sH2AsO3 wH2AsO3
    -headings sH2AsO4 wH2AsO4 sHAsO4- wHAsO4- sAsO4-2
    -headings wAsO4-2 sOHAsO4-3 wOHAsO4-3 sOBe+ wOBe+
    -headings Calcite Ca Mg Na K HCO3 SO4 Cl TDS
    -start
    10 REM Convert to ppm and show molalities
    20 PUNCH TOT("As")*74.9216*1000
    30 PUNCH TOT("Be")*9.0122*1000
    40 PUNCH TOT("Cl")*35.453*1000
    50 PUNCH TOT("Pb")*207.19*1000/1.29e-11
    60 PUNCH TOT("U")*238.029*1000
    70 PUNCH TOT("Ni")*58.71*1000
    80 PUNCH TOT("Se")*78.96*1000
    90 PUNCH TOT("S(6)")*96.0616*1000
    100 PUNCH TOT("Th")*232.038*1000/4.96e-8
    110 PUNCH TOT("Ra")*226*1000/1.01e-9
    120 PUNCH MOL("Hfo_sOPb+")
    130 PUNCH MOL("Hfo_wOPb+")
    140 PUNCH MOL("PbX2")
    150 PUNCH EQUI("Anglesite")
    160 PUNCH MOL("Hfo_sOHUO2+2")
    170 PUNCH MOL("Hfo_wOUO2+")
    180 PUNCH EQUI("USiO4(C)")
    190 PUNCH EQUI("Uraninite")
    200 PUNCH MOL("Hfo_sONi+")
    210 PUNCH MOL("Hfo_wONi+")
    220 PUNCH EQUI("NiSe")
    230 PUNCH MOL("Hfo_sOHRa+2")
    240 PUNCH MOL("Hfo_wORa+")
    250 PUNCH MOL("RaX2")
    260 PUNCH EQUI("RaSO4")
    270 PUNCH MOL("Hfo_wSeO4-")
    280 PUNCH MOL("Hfo_wOHSeO4-2")
    290 PUNCH MOL("Hfo_wSeO3-")
    300 PUNCH MOL("Hfo_wOHSeO3-2")
    310 PUNCH EQUI("Se(A)")
    320 PUNCH EQUI("Ferroselite")
    330 PUNCH MOL("Hfo_sSO4-")
    340 PUNCH MOL("Hfo_wSO4-")
    350 PUNCH MOL("Hfo_sOHSO4-2")
    360 PUNCH MOL("Hfo_wOHSO4-2")
    370 PUNCH EQUI("gypsum")
    380 PUNCH MOL("Hfo_wOTh+3")
    390 PUNCH MOL("Hfo_wOTh(OH)+2")
    400 PUNCH MOL("Hfo_wOTh(OH)2+")
    410 PUNCH MOL("Hfo_wOTh(OH)3")
    420 PUNCH MOL("Hfo_wOTh(OH)4-")
    430 PUNCH MOL("Hfo_sH2AsO3")
    440 PUNCH MOL("Hfo_wH2AsO3")
    450 PUNCH MOL("Hfo_sH2AsO4")
    460 PUNCH MOL("Hfo_wH2AsO4")
    470 PUNCH MOL("Hfo_sHAsO4-")
    480 PUNCH MOL("Hfo_wHAsO4-")
```

```
        490 PUNCH MOL("Hfo_sAsO4-2")
        500 PUNCH MOL("Hfo_wAsO4-2")
        510 PUNCH MOL("Hfo_sOHAsO4-3")
        520 PUNCH MOL("Hfo_wOHAsO4-3")
        530 PUNCH MOL("Hfo_sOBe+")
        540 PUNCH MOL("Hfo_wOBe+")
        550 PUNCH EQUI("Calcite")
        560 PUNCH TOT("Ca")*40.08*1000
        570 PUNCH TOT("Mg")*24.312*1000
        580 PUNCH TOT("Na")*22.9898*1000
        590 PUNCH TOT("K")*39.102*1000
        600 PUNCH TOT("C(4)")*61.018*1000
        610 PUNCH TOT("S(6)")*96.0616*1000
        620 PUNCH TOT("Cl")*35.453*1000
        630 A = (TOT("Ca")*40.08*1000)+(TOT("Mg")*24.312*1000)
        640 B = (TOT("Na")*22.9898*1000)+(TOT("K")*39.102*1000)
        650 C = TOT("C(4)")*61.018*1000
        660 D = TOT("S(6)")*96.0616*1000
        670 E = TOT("Cl")*35.453*1000
        680 PUNCH A+B+C+D+E
        -end
END
```

Appendix M

Groundwater Monitoring Plan
Gas Hills, Wyoming

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506

March 2002
Revised June 2005

Appendix M

Groundwater Monitoring Plan
Gas Hills, Wyoming

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506

March 2002
Revised June 2005

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** Sulfate and chloride target levels for non-POC model validation wells are provided in Attachment M-1, Tables 2 through 5.*

Figures

M-1 Monitoring Locations

Also see Attachment M-1 Figures 1.a through 8.b.

Attachments

Attachment M-1 Target Level Derivation and Model Validation Approach for Chloride and Sulfate

1.0 INTRODUCTION

This groundwater monitoring plan was developed in support of (revised) License Condition (LC) 35, which stipulates that Umetco implement a groundwater compliance monitoring program and identify appropriate actions to be taken if the Alternate Concentration Limits (ACLs) for groundwater are exceeded. In accordance with LC 35, this appendix identifies the groundwater monitoring locations for each flow regime, presents the associated monitoring plan, and describes how Umetco will define and address potential exceedances of ACLs and/or target levels established for non-licensed indicator constituents.

2.0 MONITORING APPROACH

Three types of monitoring wells are included in the Gas Hills site groundwater compliance monitoring program:

(1) the existing point of compliance (POC) wells;

(2) non-POC wells for the purposes of tracking any future (unexpected) downgradient and/or vertical contaminant migration; and

(3) a subset of the downgradient non-POC wells defined above, for the purposes of validating the site geochemical and groundwater flow model and to ensure that sulfate and chloride—non-licensed constituents regulated by the Wyoming Department of Environmental Quality (WDEQ)—do not exceed model predictions and/or WDEQ standards.

Table M-1 defines the POC and non-POC monitoring wells and summarizes the corresponding monitoring approach, including the sampling frequency and the specific analytes to be monitored. Groundwater monitoring locations are shown on Figure M-1 for both the Western and Southwestern flow regimes.

2.1 Point of Compliance Wells

The four existing POC wells—Western Flow Regime (WFR) wells MW1 and MW21A and Southwestern Flow Regime (SWFR) wells GW7 and GW8—will be sampled annually with analysis for ACL constituents. In addition, MW21A and GW7—located at or near the leading edge of the plume in their respective flow regimes—will be sampled semi-annually with analysis for sulfate, chloride, and natural uranium. GW7 has consistently had the highest observed concentrations of several licensed constituents, and is considered a "hot spot" within the SWFR contaminant plume.

2.2 Non-POC Wells

Non-POC monitoring wells were selected to provide early detection of any future downgradient or vertical contaminant migration, and/or to verify the groundwater flow and geochemical modeling results presented in the ACL application. These wells are identified in Table M-1 and shown on Figure M-1. Rationales supporting their selection are documented in Table M-2.

Table M-1 Gas Hills Site Groundwater Compliance Monitoring Wells

Well Type	Western Flow Regime Wells[1]	Southwestern Flow Regime Wells[2]	Monitoring Approach[3]
Point of Compliance (POC) Wells	MW1 **MW21A***	**GW7*** GW8	Wells to be sampled annually for ACL constituents. Sampling to be conducted every June until license termination, with results to be submitted to the NRC by September 30 of the same year. ______ *Asterisked wells—MW21A and GW7—to be sampled semi-annually for natural uranium (U-nat), sulfate, and chloride.
Non-POC Wells	MWI64 MW70A MW25 **MW71B**** **MW28**** MW77 Iron Spring	PW4 **MW72**** **MW82****	Sampling of these non-POC wells will be conducted semi-annually with analyses for sulfate, chloride, and U-nat. Except for chloride and sulfate monitoring at the four model validation wells (explained below), *this sampling will be conducted for information and tracking purposes only*—i.e., results will not be assessed for exceedances. ______ **Results for asterisked wells—MW71B, MW28, MW72, and MW82—will be used to verify model results (see below).
Model Validation Wells (*subset of above non-POC wells*)	MW71B MW28	MW72 MW82	Semi-annual sampling for chloride and sulfate as described above. Results will be compared with the target levels derived for the applicable timeframe. See Section 3.0 and **Attachment M-1 Tables 2 through 5.**

[1] Alternate Concentration Limits (ACLs) established for the Western Flow Regime POC wells MW1 and MW21A are as follows: Arsenic = 1.8 mg/l; Beryllium = 1.64 mg/l; Lead-210 = 35.4 pCi/l; Nickel = 13.0 mg/l; combined Radium-226 and -228 = 250 pCi/l; Selenium = 0.161 mg/l; Thorium-230 = 57.4 pCi/l; and Uranium-natural (U-Nat) = 11.9 mg/l. Action levels for chloride and sulfate are listed in Table M-3.

[2] ACLs established for the Southwestern Flow Regime POC wells GW7 and GW8 are: Arsenic = 1.36 mg/l; Beryllium = 1.70 mg/l; Lead-210 = 189 pCi/l; Nickel = 9.34 mg/l; combined Radium-226 and -228 = 353 pCi/l; Selenium = 0.53 mg/l; Thorium-230 = 44.8 pCi/l; and Uranium-natural = 34.1 mg/l. Action levels for chloride and sulfate are listed in Table M-3.

[3] Results of monitoring will be provided in the Groundwater Monitoring Review as required by License SUA-648.

Table M-2 Rationales Supporting Selection of Non-POC Monitoring Wells

WESTERN FLOW REGIME	
Monitoring Well	**Basis for Selection**
MWI64	This well is located at the downgradient edge of the Above-Grade Tailings Impoundment (AGTI) and exhibits some of the highest observed values for beryllium, nickel, lead-210, radium 226+228, natural uranium, gross alpha, chloride and sulfate. This well is within the "hot spot" area of the plume.
MW70A	This location is approximately 1,700 feet to the northwest of the restricted area. This well is screened in the upper portion of the Western Flow Regime and will monitor radial flow from the AGTI.
MW25	Water quality data and isoconcentration plots indicate this well, located approximately 1,500 feet hydraulically downgradient of the AGTI, would be appropriately located to monitor the leading edge of the plume.
MW71B**	This well is approximately 2,500 feet downgradient of the AGTI. It is screened in the lower portion of the Western Flow Regime and will indicate potential vertical migration.
MW28**	This well is located 2,500 feet hydraulically downgradient of the AGTI. Water quality data and isoconcentration plots indicate that there has been no impact from site-derived constituents. This location is a few hundred feet in advance of the groundwater plume and will provide the earliest indication of migration.
MW77	This location is near the proposed land transfer boundary, 4000 feet hydraulically downgradient of the AGTI, and is representative of water quality at the Point of Exposure (POE). Modeling indicates that site-derived constituents will reach this location in 70 to 80 years but will not degrade water quality to less than its current Class III status.
Iron Spring	This spring, approximately 10,000 feet from the AGTI, is the closest discharge point for groundwater migrating from the site. Groundwater modeling indicates no significant impacts to water quality resulting from site-derived constituents.
SOUTHWESTERN FLOW REGIME	
Monitoring Well	**Basis for Selection**
PW4	PW4 – This well is located 200 feet south of POCs GW7 and GW8. Once extraction is terminated, groundwater will migrate from GW7 toward PW4. Water quality data and isoconcentration plots indicate this well has been marginally impacted from site-derived constituents and is near the downgradient edge of the plume. This location will provide early monitoring within the Southwestern Flow regime plume.
MW72**	MW72 – Water quality data and isoconcentration plots indicate this well, located 1,000 feet southwest of the A-9 Repository, may be impacted from site derived constituents and is located near the downgradient edge of the groundwater plumes migrating from the site.
MW82**	MW82 – This proposed well is the furthest downgradient location from the A-9 repository (approximately 1,200 feet). The well location was selected based on its position along the modeled axis of the plume and also because it is upgradient of PRI's proposed Mine Unit 5.

Note: All wells listed above will be sampled semi-annually for analysis of sulfate, chloride, and U-nat. Sulfate and chloride results for asterisked (**) wells—MW71B, MW28, MW72, and MW82—will also be used to verify model results.

The non-POC monitoring locations listed in Table M-2 were selected on the basis of one or more of the following criteria, with input from the U.S. Nuclear Regulatory Commission:

- location within the plume and in "hot spot" locations;
- location proximal to extraction wells;
- location at downgradient edge of the plume;
- downgradient of site impacts; and/or
- a discharge point for groundwater (e.g., springs).

Sampling of non-POC wells will be conducted semi-annually with analyses for sulfate, chloride, and natural uranium as indicated in Table M-1.

3.0 MODEL VALIDATION COMPONENT OF COMPLIANCE MONITORING: CHLORIDE AND SULFATE

A subset of the non-POC wells defined above—WFR wells MW71B and MW28 and SWFR wells MW72 and MW82 (proposed new well; see below)—will be compared with target levels established for chloride and sulfate (see Attachment M-1). Although chloride and sulfate are not licensed constituents, they do have groundwater protection standards set by the Wyoming Department of Environmental Quality (WDEQ). More importantly, these constituents are minimally attenuated and therefore should provide the earliest indication of site-derived contaminant migration along groundwater flowpaths. As such, target levels were derived for the purposes of validating the sulfate and chloride model simulations. The monitoring approach is summarized in Table M-1, and detailed supporting information is provided in Attachment M-1. Target levels established for individual model validation wells are documented in Attachment M-1, Tables 2 through 5.

Proposed New Monitoring Well MW82

MW82, the proposed new well, will be located along the axis of the modeled chloride and sulfate plumes migrating from the A-9 Repository. No existing wells are suitably located for this purpose. The well will be incorporated into the groundwater monitoring plan, designed to support License Condition 35.

MW82 will be completed within the Upper Wind River aquifer (above the mudstone unit that separates the Upper and Lower Wind River aquifers), near existing well MW30 (a Lower Wind River aquifer completion). Approximate coordinates of MW82 are N 788300 and E 835800. This location was selected because it is downgradient of the A-9 Repository and along the flowpath of groundwater migrating from that impoundment. The location is also hydraulically upgradient of the Power Resources, Inc. (PRI) proposed Mine Unit No. 5 and the underground Thunderbird and ROX mines. The elevation of the water table beneath the proposed well location is projected to be at 6790. Ground surface elevation is approximately 6840. Depth to water will be approximately 50 feet. The well will be constructed similar to previous monitoring wells MW72 and MW74 and will be screened across the upper 15-20 feet of the Upper Wind River aquifer. MW30 already provides sufficient monitoring at that location for the deeper hydrologic flow system within the Lower Wind River.

4.0 EXCEEDANCE IDENTIFICATION AND VERIFICATION RESAMPLING

The monitoring approach described above and in Table M-1 was developed to ensure that the groundwater ACLs are met, as well as to provide early detection of downgradient or vertical migration of site contaminants. As such, a mechanism for identifying exceedances and implementing appropriate responses to those exceedances, must be identified.

4.1 General Approach to Identifying Exceedances

In identifying exceedances, the overall intent is to allow early detection of potential ACL or target level exceedances, while minimizing the probability of false positive results—e.g., exceedances attributable to laboratory error or transient anomalous increases. Prediction limits are already built into both the ACLs and the target levels established for non-ACL (indicator) constituents. Therefore, comparison of the single values (e.g., ACL vs. monitoring result) should suffice. However, several factors must be accounted for when evaluating results and identifying exceedances. These factors are discussed below.

Significant Figures

Significant figures must be accounted for when comparing predicted values with measured values. The following general approach should be employed. For results less than 1000 mg/l, comparisons between measured values and predicted values should be based on 2 significant figures. For results exceeding 1000 mg/l, comparisons should be made on the basis of 3 significant figures. [Refer to Attachment M-1, Table 2 for a useful example.]

Verification Resampling

Verification resampling is an integral component of exceedance identification. To avoid "false positives" due to laboratory error and/or transient increases, a statistically significant exceedance will not be declared or reported until the results of verification resampling are known. Umetco's proposed approach to verification sampling is discussed below and in Table M-3.

4.2 ACL Constituents at Point of Compliance Wells

If any POC sample exceeds the ACL for one or more constituents, another sample will be analyzed within 3 months of obtaining the results, for the constituent(s), to rule out laboratory error or transient increase. If the first verification (re)sample also results in an exceedance of the same ACL, Umetco will notify the NRC within 30 days of receiving the second results. Contingent upon NRC approval, an additional verification sample may be collected before corrective action measures are considered (within 3 months of obtaining the second result).

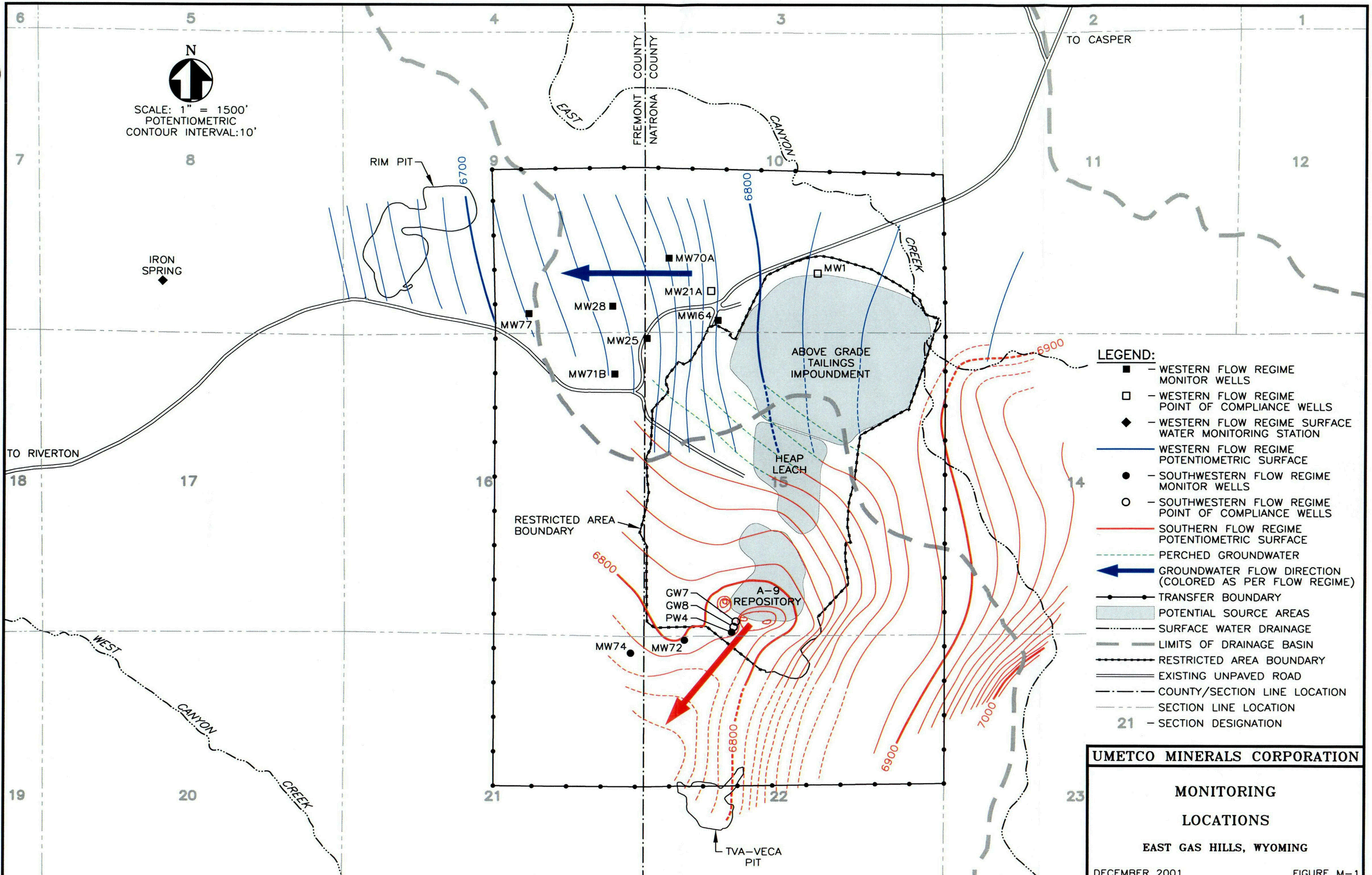
If the second verification (re)sample also results in an exceedance, Umetco will provide an "action plan" to the NRC within 60 days of receiving the second verification sample results. This action plan will describe appropriate corrective action(s), if necessary, and/or further analysis to ensure that no risk will be incurred at point of exposure (POE) locations. Such an analysis may require reassessment of model simulations and assumptions. This approach is detailed in Table M-3.

4.3 Chloride and Sulfate at Model Validation Wells

As discussed above, chloride and sulfate are included in the monitoring plan for a subset of the non-POC wells to evaluate the predictions made by modeling and/or to track the downgradient migration of site-related constituents. As described in Table M-3, exceedance of the chloride and/or sulfate target levels will trigger additional response, including, but not limited to, confirmation sampling and/or reassessment of the model simulations and assumptions. Consideration will be given to the degree of the exceedance and the potential impacts to water quality at the POE. . The potential for non-site related factors (e.g., mining impacts) must also be considered when identifying potential exceedances for these indicator parameters, in particular for sulfate. Response actions for exceedance of these parameters will be less rigorous than those discussed above for ACL constituents due to the conservatism already built into the model and the low probability that target level exceedances would adversely impact potential risks at POE locations.

Table M-3 Exceedance Identification and Action Approaches

Monitoring Endpoint	Exceedance Identification and Verification Resampling Approach	Actions to be Implemented if Exceedances are Verified
ACL Constituents at POC Wells	If any POC sample exceeds the ACL for one or more constituents (accounting for significant figures), another sample will be analyzed within 3 months of obtaining the results for the constituent(s). [*Re-analysis is only necessary for the constituent(s) exceeding the ACLs.*]	If the first verification (re)sample also results in an exceedance of the same ACL, Umetco will notify the NRC within 30 days of receiving the second results. Contingent upon NRC approval, an additional verification sample may be collected before corrective action measures are considered (within 3 months of obtaining the second result). If the second verification (re)sample also results in an exceedance, Umetco will provide an "action plan" to the NRC within 60 days of receiving the second verification sample results. This action plan will describe appropriate corrective action(s), *if necessary*, and/or further analysis to ensure that no risk will be incurred at point of exposure (POE) locations. Such an analysis may require reassessment of model simulations and assumptions.
Chloride and Sulfate in Model Validation Wells MW71B, MW28, MW72, and MW82	If any sample exceeds the corresponding target level for chloride or sulfate (see Attachment M-1 tables), another sample will be analyzed within 3 months of obtaining the results. If the first verification sample also exceeds the target level(s), another verification sample will be collected (within 3 months of the first).	Exceedance of three consecutive samples—the semi-annual sample, followed by two verification samples—is required before an exceedance of sulfate and chloride target levels is declared. NRC reporting requirements are the same as those identified above. Exceedances of chloride and/or sulfate target levels will trigger additional response, including but not limited to reassessment of the model simulations and assumptions. Corrective actions are not anticipated for these parameters, however, as exceedance of the target levels is expected to have a negligible impact on potential risks at the POE.
Chloride, Sulfate, and U-Nat at Remaining Non-POC Wells	None required. As indicated in Table M-2, *this sampling will be conducted for information and tracking purposes only*—i.e., results will not be assessed for exceedances.	Not Applicable.



FIGM-1.DWG

C02

Attachment M-1

Target Level Derivation and Model Validation Approach for Chloride and Sulfate

Gas Hills, Wyoming

Umetco Minerals Corporation
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Grand Junction, Colorado 81506

March 2002
Revised January 2004

Attachment M-1

Target Level Derivation and Model Validation Approach for Chloride and Sulfate

Gas Hills, Wyoming

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506

March 2002
Revised January 2004

Tables

Table 1	Calculation of Standard Deviation for Sulfate and Chloride Data Sets for MW28, MW71B, and MW72: 1997 through 2001
Table 2	Target Levels Derived for Western Flow Regime Well MW71B
Table 3	Target Levels Derived for Western Flow Regime Well MW28
Table 4	Target Levels Derived for Southwestern Flow Regime Well MW72
Table 5	Target Levels Derived for Southwestern Flow Regime Well MW82

Figures

Figure 1a.	Simulated Chloride Trends at MW71B (10 Years) – Western Flow Regime
Figure 1b.	Simulated Chloride Trends at MW71B (50 Years) – Western Flow Regime
Figure 2a.	Simulated Chloride Trends at MW28 (10 Years) – Western Flow Regime
Figure 2b.	Simulated Chloride Trends at MW28 (50 Years) – Western Flow Regime
Figure 3a.	Simulated Chloride Trends at MW72 (10 Years) – Southwestern Flow Regime
Figure 3b.	Simulated Chloride Trends at MW72 (50 Years) – Southwestern Flow Regime
Figure 4a.	Simulated Chloride Trends at MW82 (10 Years) – Southwestern Flow Regime
Figure 4b.	Simulated Chloride Trends at MW82 (50 Years) – Southwestern Flow Regime
Figure 5a.	Simulated Sulfate Trends at MW71B (10 Years) – Western Flow Regime
Figure 5b.	Simulated Sulfate Trends at MW71B (50 Years) – Western Flow Regime
Figure 6a.	Simulated Sulfate Trends at MW28 (10 Years) – Western Flow Regime
Figure 6b.	Simulated Sulfate Trends at MW28 (50 Years) – Western Flow Regime
Figure 7a.	Simulated Sulfate Trends at MW82 (10 Years) – Southwestern Flow Regime
Figure 7b.	Simulated Sulfate Trends at MW82 (50 Years) – Southwestern Flow Regime
Figure 8a.	Simulated Sulfate Trends at MW72 (10 Years) – Southwestern Flow Regime
Figure 8b.	Simulated Sulfate Trends at MW72 (50 Years) – Southwestern Flow Regime

Target Level Derivation and Model Validation Approach for Chloride and Sulfate

Introduction

A methodology is presented for validation of the Gas Hills groundwater flow and contaminant transport simulations of sulfate and chloride. These constituents are minimally attenuated and should provide the earliest indication of site-derived contaminant migration along groundwater flowpaths. Model results for selected wells that are included in the long-term groundwater monitoring are provided as graphs to allow for comparison with analytical measurements. A 95% UCL is included in the graphs that accounts for the variability in the analytical data. Future analytical measurements at observation wells MW28, MW71B, MW72, and proposed well MW82 should remain less than the 95% UCLs, herein referred to as target levels, for corresponding simulation times.

This attachment describes the selection and development of the concentration targets to be used for validating the sulfate and chloride model simulations. As indicated in the preceding appendix text, exceedance of the target levels will trigger additional response, including, but not limited to, confirmation sampling and/or reassessment of the model simulations and assumptions.

Methodology

Peak concentrations of sulfate and chloride at the Points of Exposure (POE) for the Western Flow Regime (WFR) and Southwestern Flow Regime (SWFR) are anticipated to occur in approximately 80 and 100 years, respectively. To provide a shorter frame of reference to compare model results to measured concentrations, intermediate observation points were selected. The monitor wells selected for short-term model validation results are listed below:.

Model Validation Well	Flow Regime	Nearest Impoundment	Distance from Impoundments (ft)
MW28	WFR	AGTI	2000
MW71B	WFR	AGTI	2000
MW72	SWFR	A-9 Repository	1000
MW82	SWFR	A-9 Repository	1200

*MW82 is proposed monitoring well location (see preceding Appendix M text).

The model results for chloride and sulfate are plotted for each of the observation wells. Initial conditions in the model represent the chloride and sulfate plume configuration at the beginning of the year 2000. Plots were constructed to show simulation results for 10 years and 50 years. The 10-year plots represent changes in concentration at the specified well from the year 2000 to 2010 and provide sufficient detail to allow comparison of measured (actual) data with the simulated results. Measured analytical data for 2000 and 2001 are also included on the 10-year plots. The 50-year plots provide a view of the long-term trends in concentration and compare the simulated data to WDEQ water quality standards.

Uncertainty or variability in analytical data is addressed through the use of upper confidence limits (UCLs). The 95% UCL is presented on each of the 10-year plots and was derived as follows. A standard deviation was calculated for the analytical data reported for each well from 1997 through 2001 for sulfate and chloride (Table 1). The standard deviation was multiplied by 1.96. The product of the standard deviation and 1.96 for each well was then added to the simulated results for that well to represent the 95% UCL. A standard deviation could not be calculated for MW82 because that well has not been drilled. Therefore, the standard deviation calculations for MW72 for chloride and sulfate were applied to MW82.

The 95% UCL plotted on the 10-year simulation figures should be used as the target for comparing analytical measurements to the model results. For example, as shown in Figure 1a, analytical measurements of chloride collected in January 2000 and January 2001 for observation well MW71B fall beneath the 95% UCL for the corresponding simulation times. This indicates that the model has over-predicted chloride values at that location, further evidence of the conservatism of the model. In the event that analytical measurements exceed the 95% UCL for corresponding simulation times, a confirmatory sampling event will be conducted as described in Table M-3 (see previous). Consideration will be given to the degree of the exceedance and the potential impacts to water quality at the POE.

For example, the 95% UCL for chloride at MW28 in 2005 is 14.3 mg/L. If an analytical measurement in 2005 for chloride at MW28 was 16.0 mg/L, then that would be an exceedance. However, the maximum simulated chloride value at MW28 occurs in 2036 at 73 mg/L and the maximum simulated value at the POE is 76 mg/L in 2055. Both values are significantly below the WDEQ Class I standard of 250 mg/L. Therefore, a slight exceedance of the 95% UCL for chloride at MW28 is not likely to pose a threat to human health or the environment.

Model Results

Results of the model simulations for chloride transport for each of the observation points are provided in Figures 1a through 4b. Graphs of chloride concentration versus time are shown for simulation periods of 10 years and 50 years. The figures show generally increasing trends in chloride concentration during early years, with concentrations peaking at about 30 to 35 years in the WFR wells (Figures 1a, 1b, 2a and 2b). Chloride concentration reaches a maximum within 3 to 4 years at MW72 (Figures 3a and 3b), and in about 45 years at MW82 (Figures 4a and 4b). All simulated values remain below the WDEQ Class I chloride standard of 250 mg/L as shown on the 50-year graphs. Also note that the 2000 and 2001 analytical chloride measurements (plotted on the 10-year graphs) fall below the plot of the 95% UCL.

Results of the model simulations for sulfate transport for each of the observation points are provided in Figures 5a through 8b. Again, graphs are shown for simulation periods of 10 years and 50 years. The figures are similar to the chloride results, showing generally increasing trends in sulfate concentrations during early years, with concentrations peaking at about 30 to 35 years in the WFR wells (Figures 5a, 5b, 6a and 6b). Sulfate concentration reaches a maximum at 10 years at MW72 (Figures 7a and 7b). At MW82, the sulfate concentration levels off at approximately 750-800 mg/L after 45 years (Figure 7b). Note that all simulated values remain below the WDEQ Class III sulfate standard of 3,000 mg/L, and that the 2000 and 2001 analytical sulfate measurements fall below the plots of the 95% UCL. **Corresponding target levels derived for the 10-year simulation period (2000-2010) are provided in Tables 2 through 5.**

TABLES

Table 1. Calculation of Standard Deviation for Sulfate and Chloride Data Sets for MW28, MW71B, and MW72: 1997 through 2001. Gas Hills, Wyoming.

MW28	Measurement Date	Chloride	Sulfate
	2/3/1997	4	359
	4/30/1997	6	388
	7/25/1997	5	374
	10/8/1997	6	407
	1/28/1998	6	435
	4/28/1998	6	432
	7/29/1998	6	445
	10/20/1998	5	435
	1/19/1999	6	479
	1/20/2000	5.8	500
	1/15/2001	7.5	540
	Standard Deviation	0.87	54.57
	1.96 x Std Dev	1.71	106.96

MW71B	Measurement Date	Chloride	Sulfate
	8/12/1997	8	379
	11/17/1997	8	361
	1/27/1998	8	377
	5/5/1998	9	384
	8/12/1998	9	395
	11/3/1998	9	367
	1/26/1999	9	413
	1/20/2000	11	410
	1/16/2001	14	430
	Standard Deviation	1.94	23.04
	1.96 x Std Dev	3.81	45.15

MW72	Measurement Date	Chloride	Sulfate
	8/14/1997	108	569
	8/27/1997	101	599
	11/18/1997	99	492
	3/17/1998	109	607
	5/21/1998	105	641
	8/20/1998	121	668
	11/11/1998	106	664
	1/11/1999	110	835
	2/29/2000	120	1000
	1/16/2001	110	1100
	Standard Deviation	7.13	197.27
	1.96 x Std Dev	13.97	386.65

Table 2. Target Values Derived for Western Flow Regime Well MW71B

Year	Chloride (mg/l) Annual Target Range	June Target	Sulfate (mg/l) Annual Target Range	June Target
2000	14 – 19 (actual = 11)	--	470 – 533 (actual = 410)	--
2001	20 – 25 (actual = 14)	--	535 – 625 (actual = 430)	--
2002	25 – 31	28	633 – 738	683
2003	31 – 37	34	740 – 837	792
2004	38 – 45	41	846 – 945	889
2005	45 – 51	48	947 – 1,036	994
2006	52 – 58	54	1,042 – 1,130	1,081
2007	58 – 64	61	1,132 – 1,208	1,173
2008	64 – 70	67	1,214 – 1,289	1,247
2009	70 – 76	73	1,291 – 1,361	1,326
2010	76 (January 2010)	--	1,361 (Jan-10)	--

Note:

Significant figures must be accounted for when comparing predicted values with measured values. A general rule is as follows: For results less than 1000 mg/l, comparisons between measured values and predicted values should be based on 2 significant figures. For results exceeding 1000 mg/l, comparisons should be made on the basis of 3 significant figures. For example, a June 2009 sulfate result of 1,334 mg/l at MW71B would not be considered an exceedance of the corresponding 1,326 mg/l target level. Also note that the target levels shown above reflect the 95% upper confidence limits (UCLs) about the actual predicted values, a factor that must be accounted for when reviewing the synopses of predicted trends provided below.

MW71B, Predicted Chloride Trends:*

Increasing through approximately 2025, with 10-yr plateau of about 100-110 mg/l, followed by subsequent slight gradual attenuation (Figures 1.a and 1.b). All predicted values are well below the WDEQ Class I groundwater standard of 250 mg/l.

MW71B, Predicted Sulfate Trends;

Increasing through approx. 2025, with 10-yr plateau of approx. 2000 mg/l, followed by subsequent attenuation (Figures 5.a and 5.b). All predicted values are well below the WDEQ Class III groundwater standard of 3,000 mg/l.

Table 3. Target Values Derived for Western Flow Regime Well MW28

Year	Chloride (mg/l) Annual Target Range	June Target	Sulfate (mg/l) Annual Target Range	June Target
2000	25 – 26 (actual = 5.8)	–	830 – 856 (actual = 500)	–
2001	26 – 35 (actual = 7.7)	–	856 – 1001 (actual = 540)	–
2002	35 – 51 (actual = 14)	–	1001 – 1239 (actual = 610)	757
2003	51 – 69 (actual = 35)	–	1239 – 1484 (actual = 1010)	816
2004	69 – 83	75	1484 – 1695	1590
2005	83 – 94	88	1695 – 1846	1771
2006	94 – 100	97	1847 – 1947	1897
2007	100 – 104	102	1947 – 2006	19774
2008	104 – 106	105	2006 – 2036	2021
2009	106 – 106	106	2036 – 2049	2043
2010	106 – 106	106	2049 – 2053	2051

See notes following Table 2.

MW28, Predicted Chloride Trends:

Increasing through approx. 2030, with plateau at approx. 75 mg/l, followed by subsequent gradual attenuation (Figures 2.a and 2.b). All predicted values are well below the WDEQ Class I groundwater standard of 250 mg/l.

MW28, Predicted Sulfate Trends:

Increasing through approx. 2030, peaking at approx. 1500 mg/l, followed by subsequent attenuation (Figures 6.a and 6.b). All predicted values are well below the WDEQ Class III groundwater standard of 3,000 mg/l.

Table 5. Target Values Derived for Southwestern Flow Regime Well MW82

Year	Chloride (mg/l) Annual Target Range	Chloride (mg/l) June Target	Sulfate (mg/l) Annual Target Range	Sulfate (mg/l) June Target
2000	39.0 – 59.7	--	887 – 908	--
2001	59.7 – 77.2	--	908 – 972	--
2002	77.2 – 90.9	84	972 – 1055	1014
2003	90.9 – 98.7	95	1055 – 1130	1093
2004	98.7 – 100.8	100	1130 – 1186	1158
2005	100.8 – 99.5	100	1186 – 1223	1205
2006	99.5 – 97.4	99	1223 – 1252	1239
2007	97.4 – 96.4	97	1252 – 1284	1268
2008	96.4 – 97.2	97	1284 – 1323	1304
2009	97.2 – 99.3	98	1323 – 1367	1345
2010	99.3	99	1367	1367

MW82 installed in Spring 2002; see notes following Table 2. **These estimates are based on model predictions, and assume no impacts from surrounding PRI activities and/or naturally occurring mineralization.**

MW82, Predicted Chloride Trends:

Sharply increasing until approximately 2005 (with assumed baseline at 25 mg/l), then gradually increasing to a maximum of 130 mg/l by 2033 followed by a steady decline. All predicted values are well below the WDEQ Class I groundwater standard of 250 mg/l.

MW82, Predicted Sulfate Trends:

Steadily increasing until 2023, reaching a maximum value of 1850 mg/l (with assumed baseline of 500 mg/l), then gradually decreasing. All predicted values are well below the WDEQ Class III groundwater standard of 3000 mg/l.

FIGURES

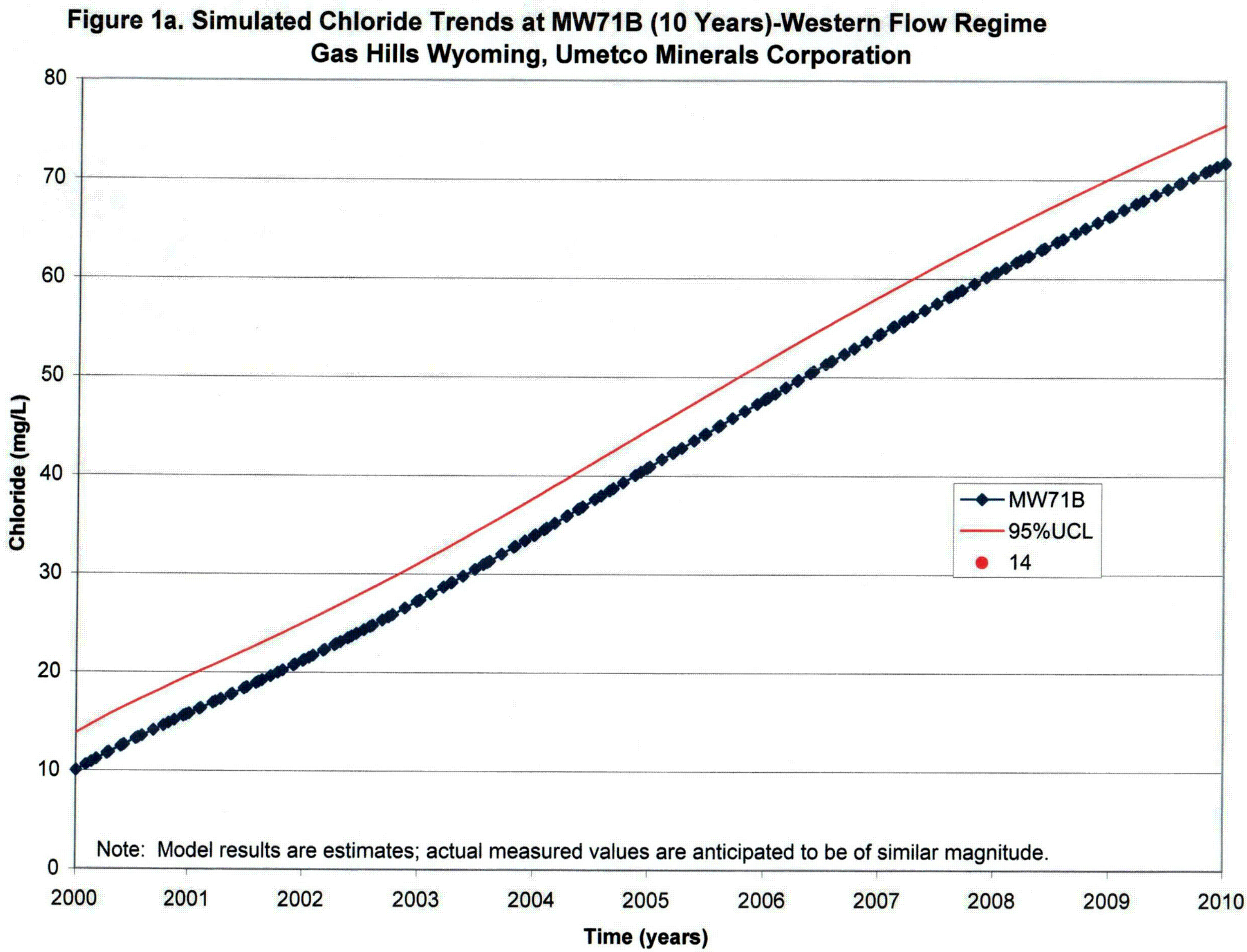
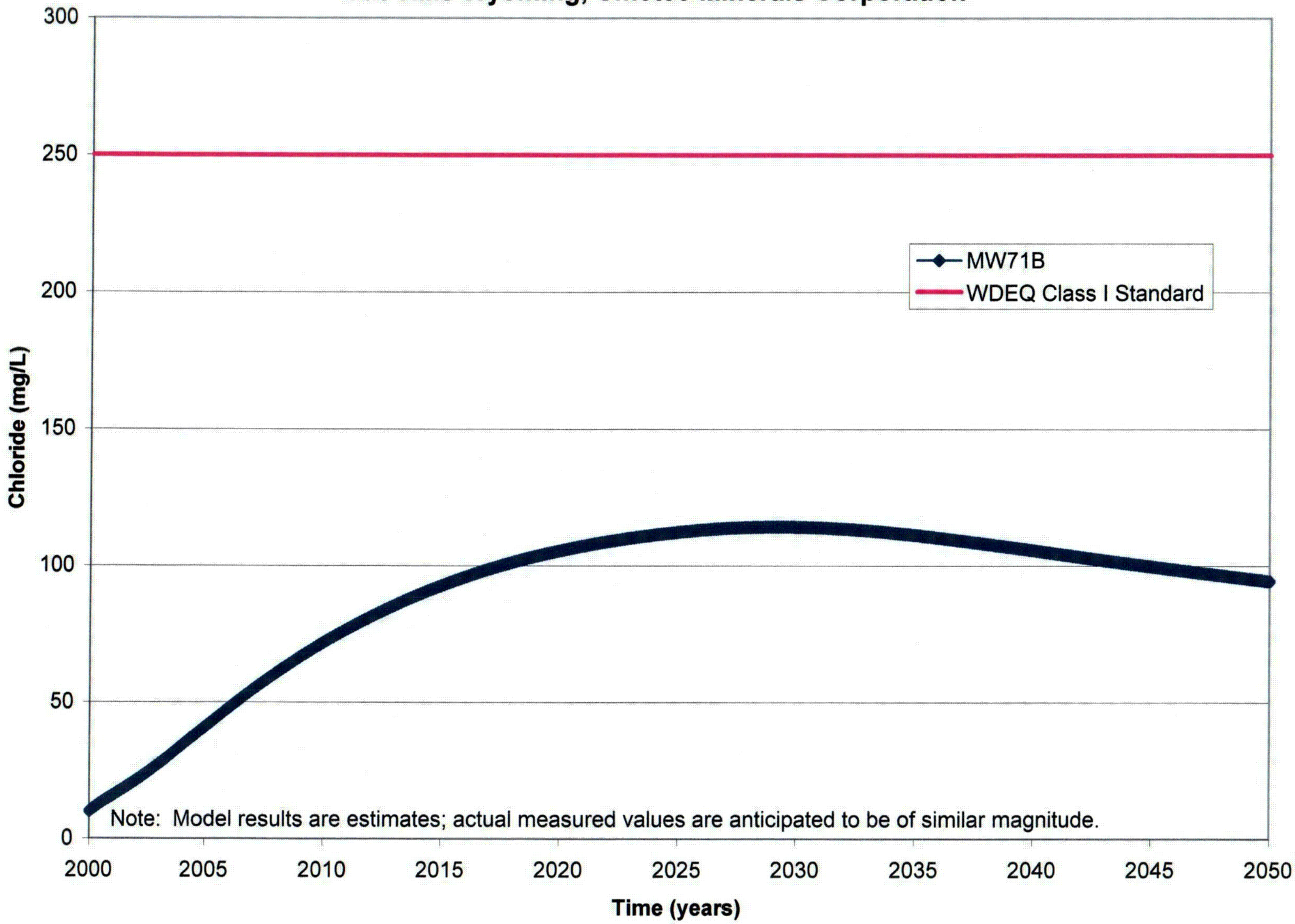


Figure 1a. Simulated Chloride Trends at MW71B (10 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation
Chloride (mg/L)
80
70
60
50
40
30
20
10
0
MW71B
95%UCL
14
Note: Model results are estimates; actual measured values are anticipated to be of similar magnitude.
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Time (years)

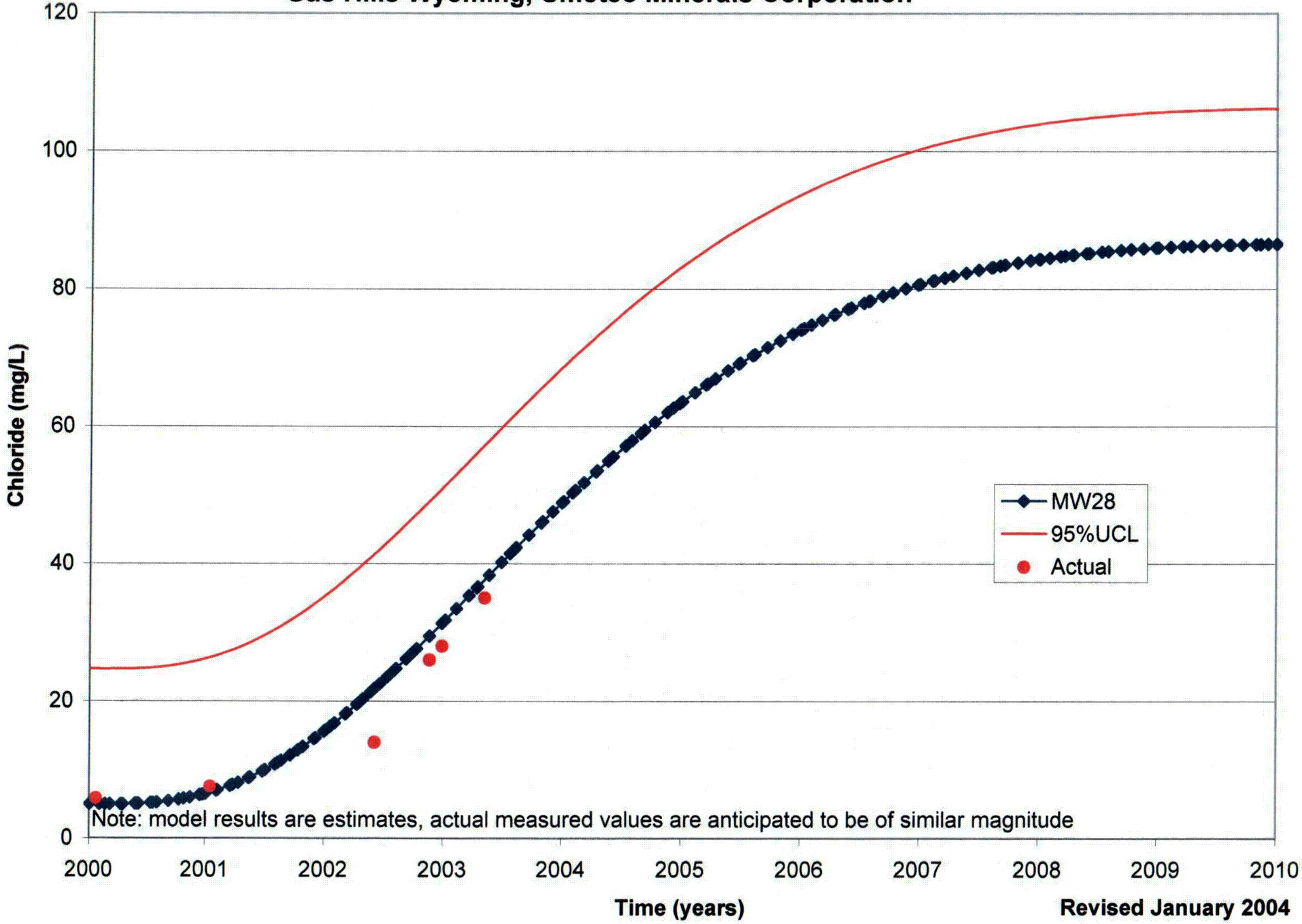
C03

Figure 1b. Simulated Chloride Trends at MW71B (50 Years)- Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



C04

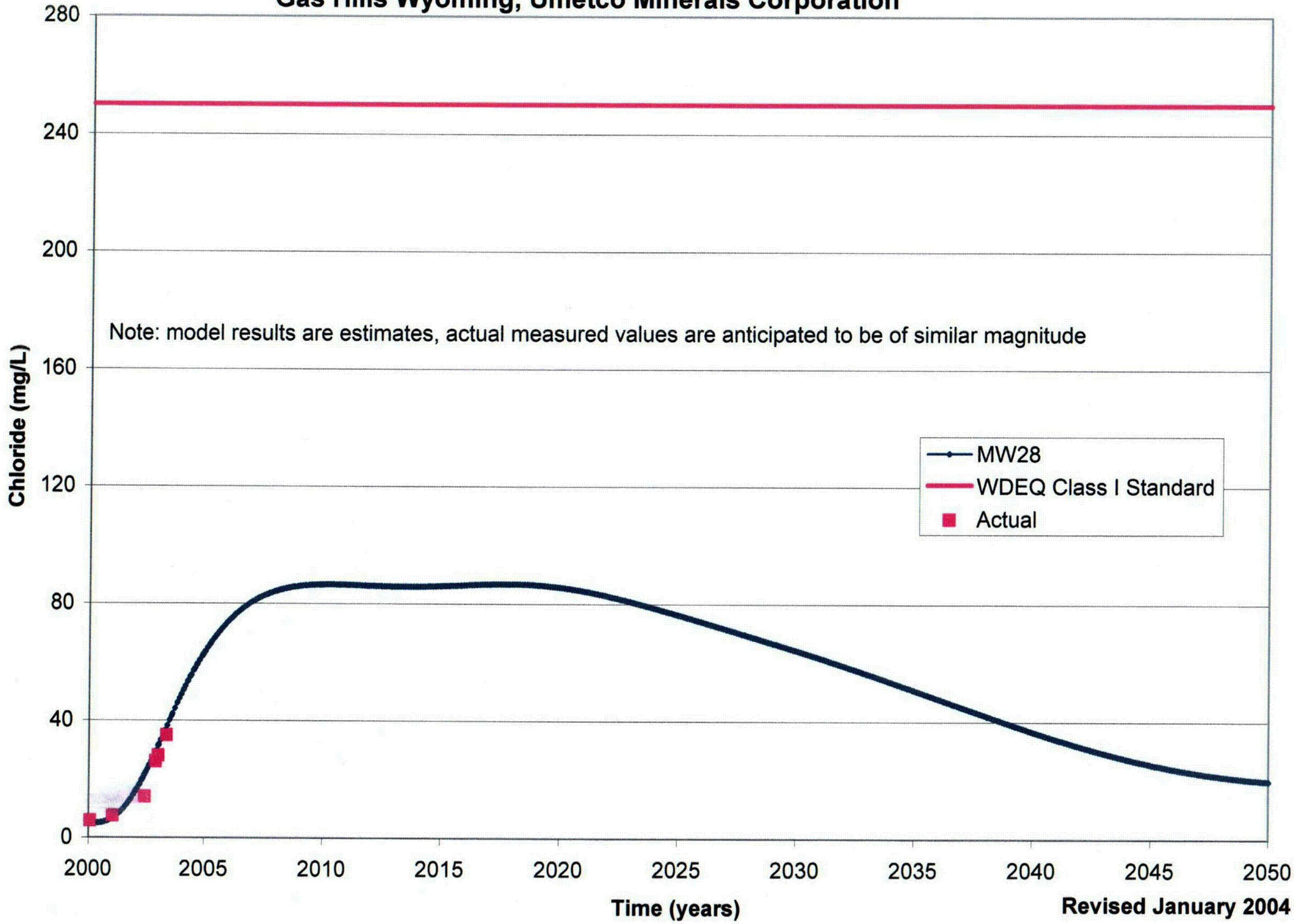
Figure 2a. Simulated Chloride Trends at MW28 (10 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



Revised January 2004

C05

Figure 2b. Simulated Chloride Trends at MW28 (50 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



COC

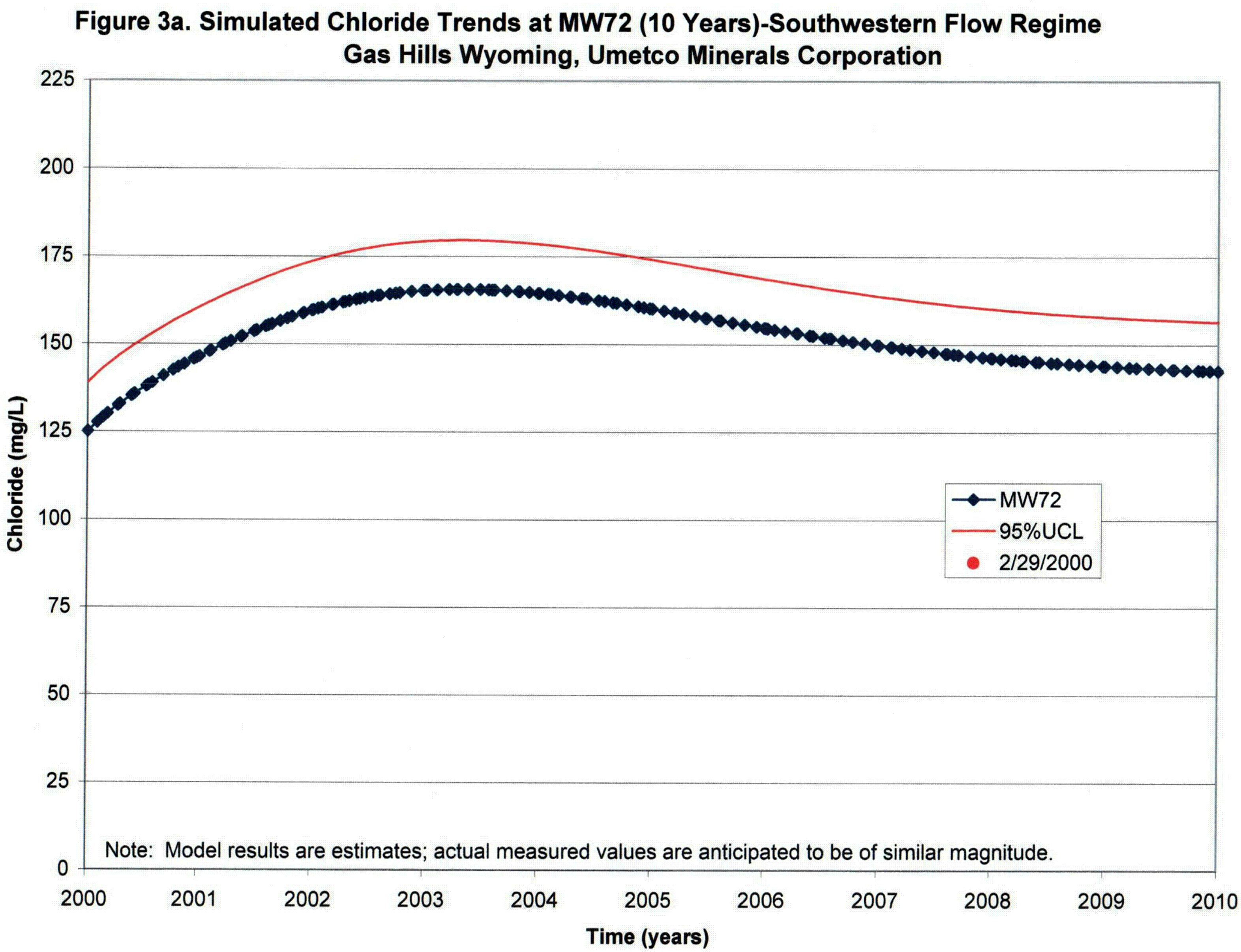
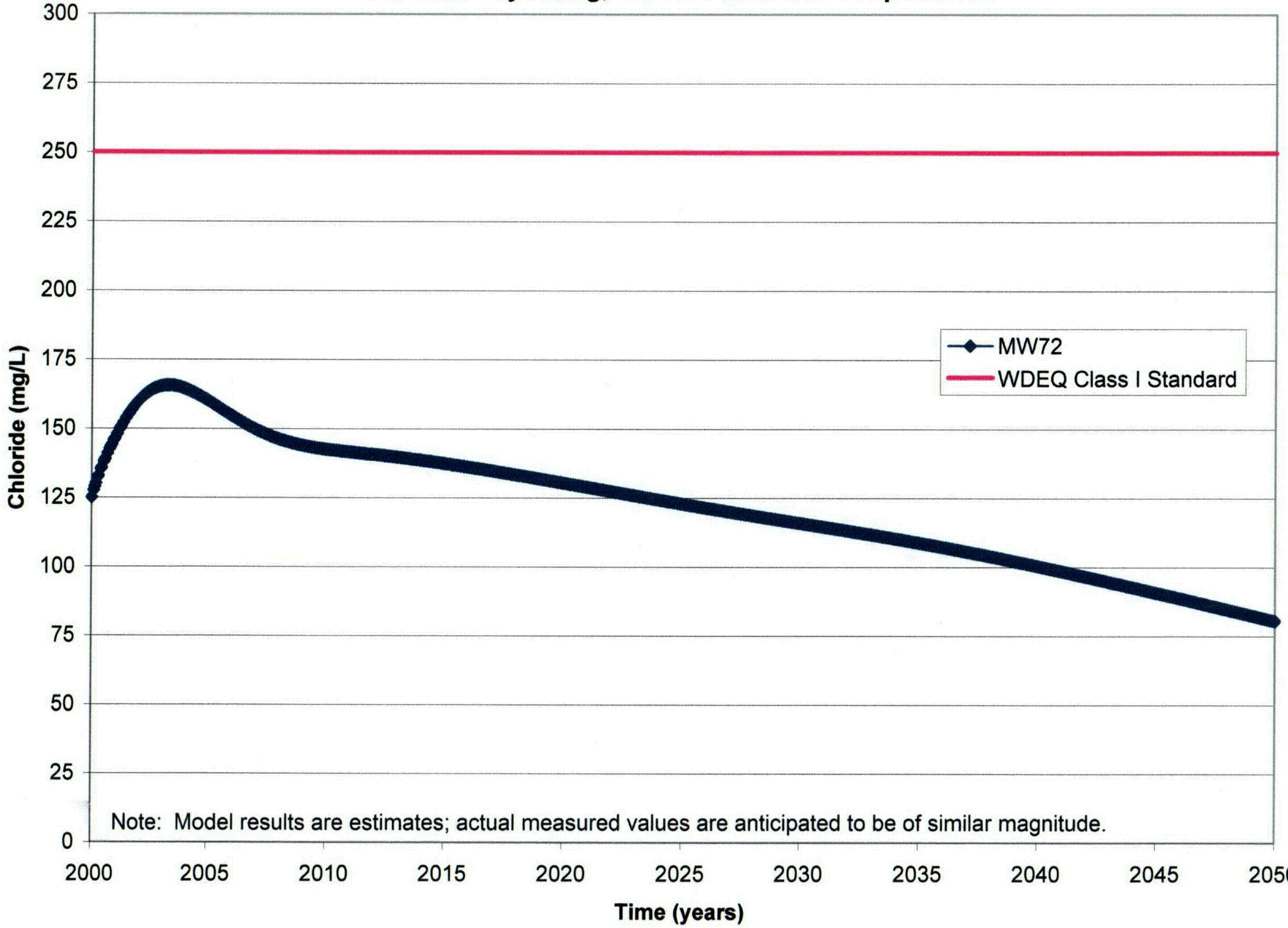


Figure 3a. Simulated Chloride Trends at MW72 (10 Years)-Southwestern Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation
Chloride (mg/L)
225
200
175
150
125
100
75
50
25
0
MW72
95%UCL
2/29/2000
Note: Model results are estimates; actual measured values are anticipated to be of similar magnitude.
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Time (years)

C07

Figure 3b. Simulated Chloride Trends at MW72 (50 Years)-Southwestern Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



C08

Figure 4a(r). Simulated Chloride Trends at MW82 (10 Years)-Southwestern Flow Regime Gas Hills Wyoming, Umetco Minerals Corporation

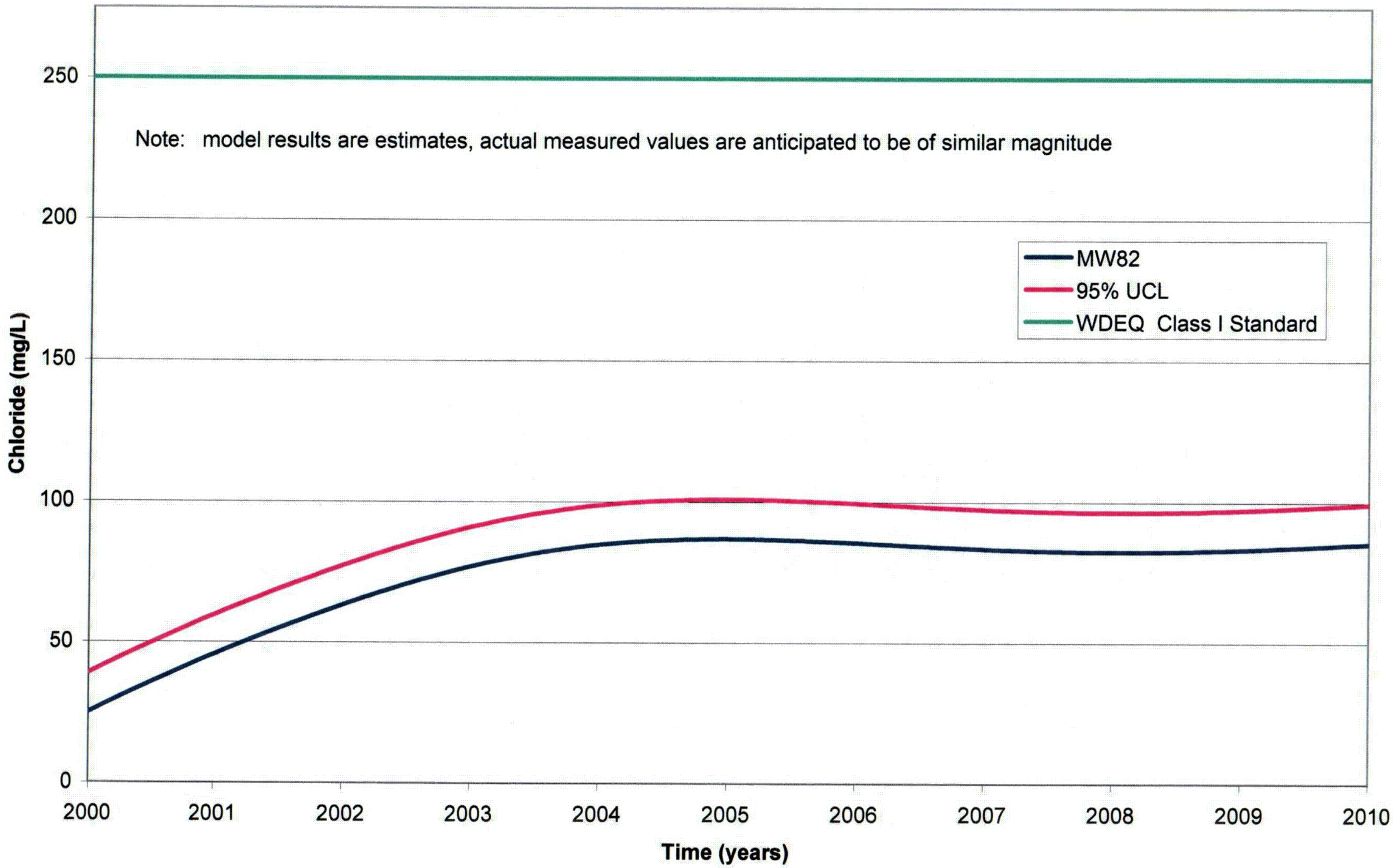
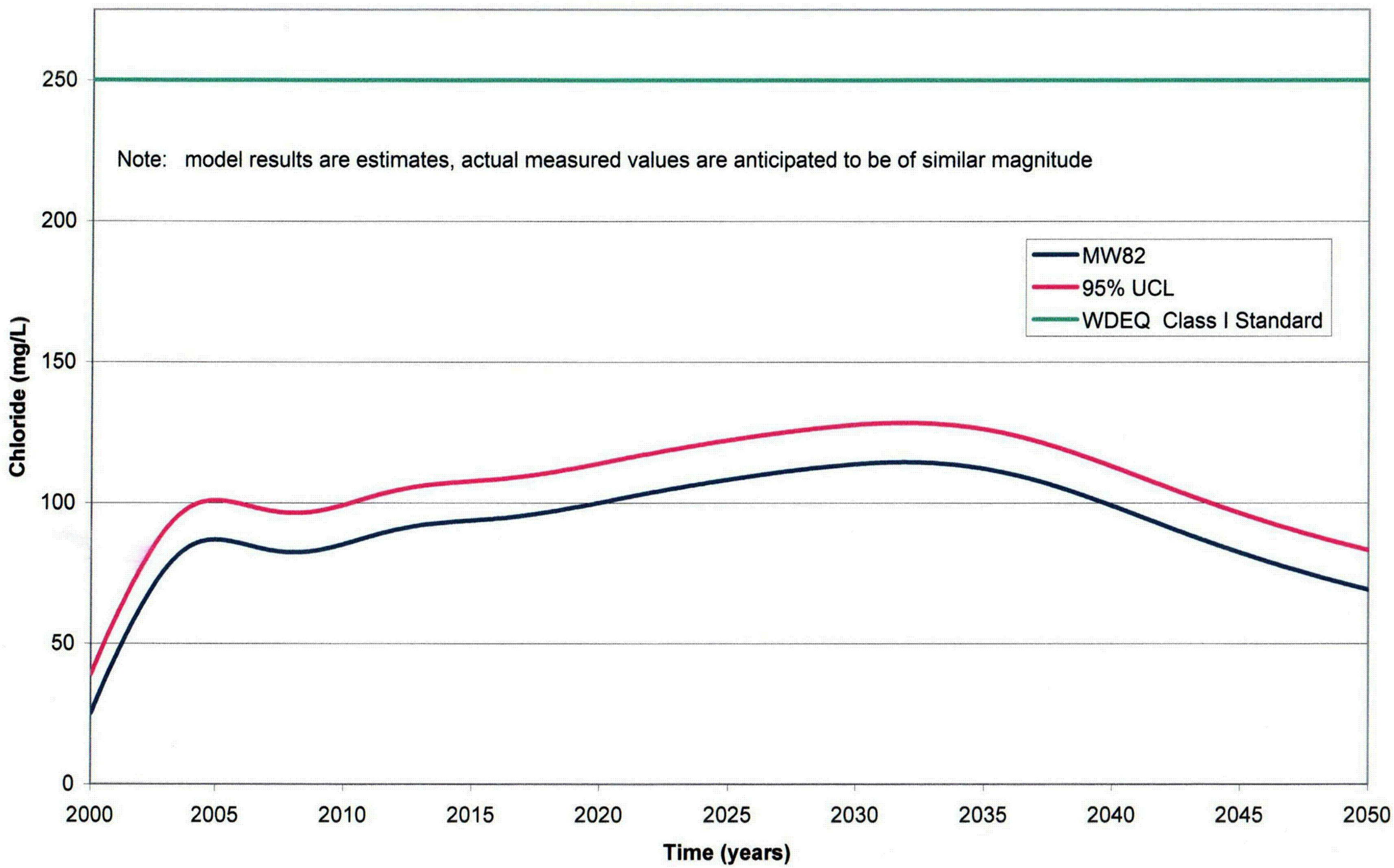
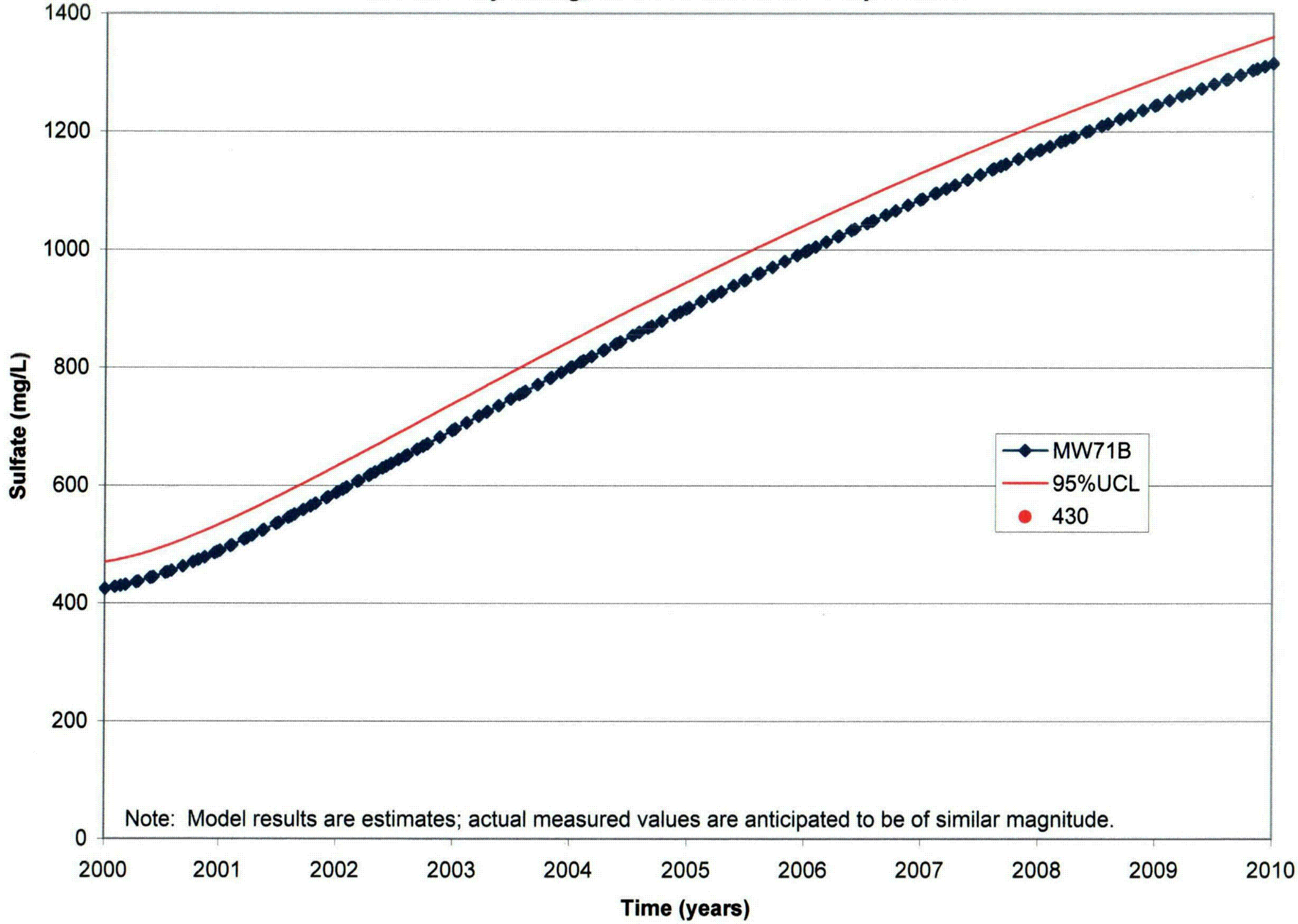


Figure 4b(r). Simulated Chloride Trends at MW82 (50 Years)-Southwestern Flow Regime Gas Hills Wyoming, Umetco Minerals Corporation



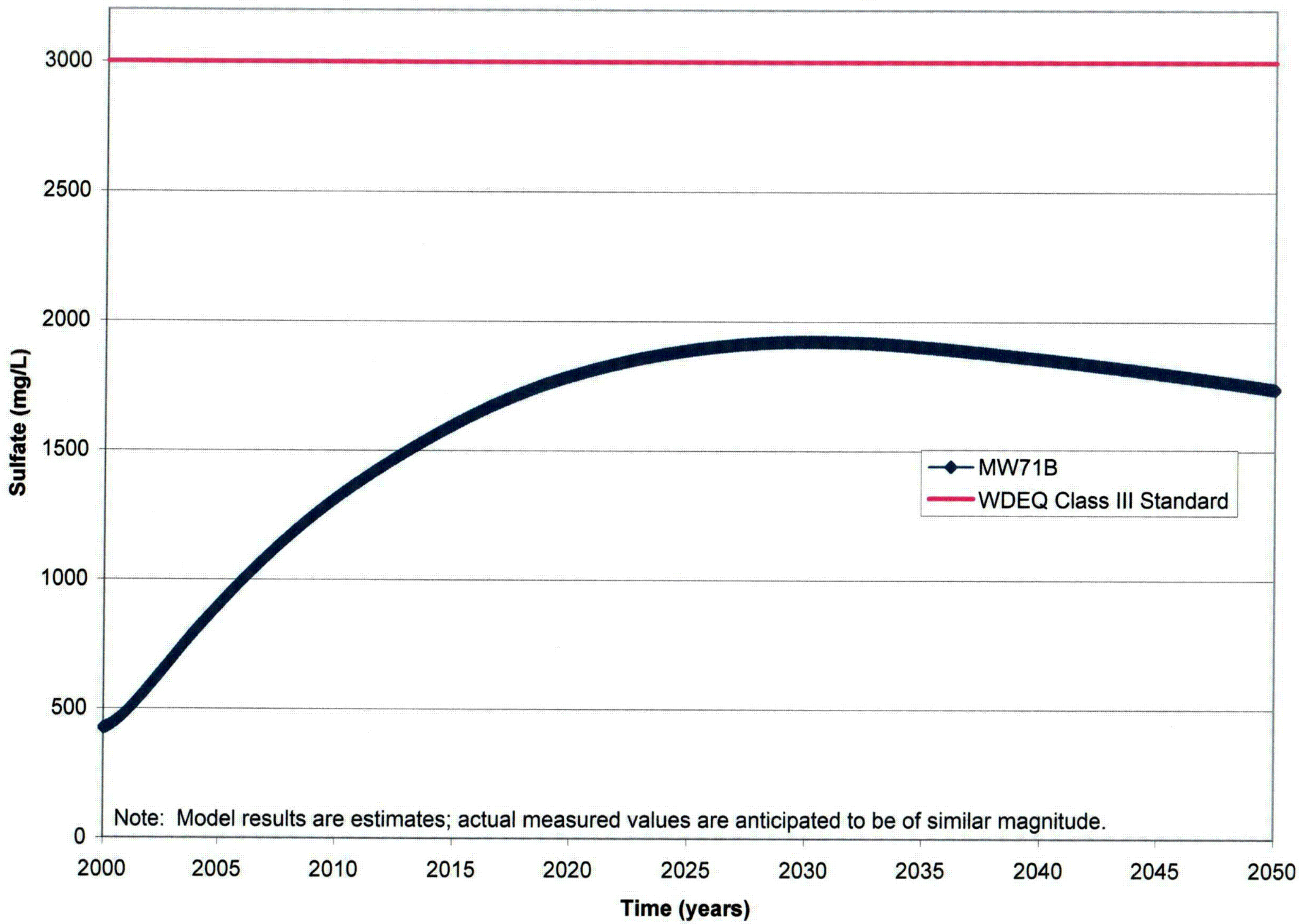
C10

Figure 5a. Simulated Sulfate Trends at MW71B (10 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



C11

Figure 5b. Simulated Sulfate Trends at MW71B (50 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



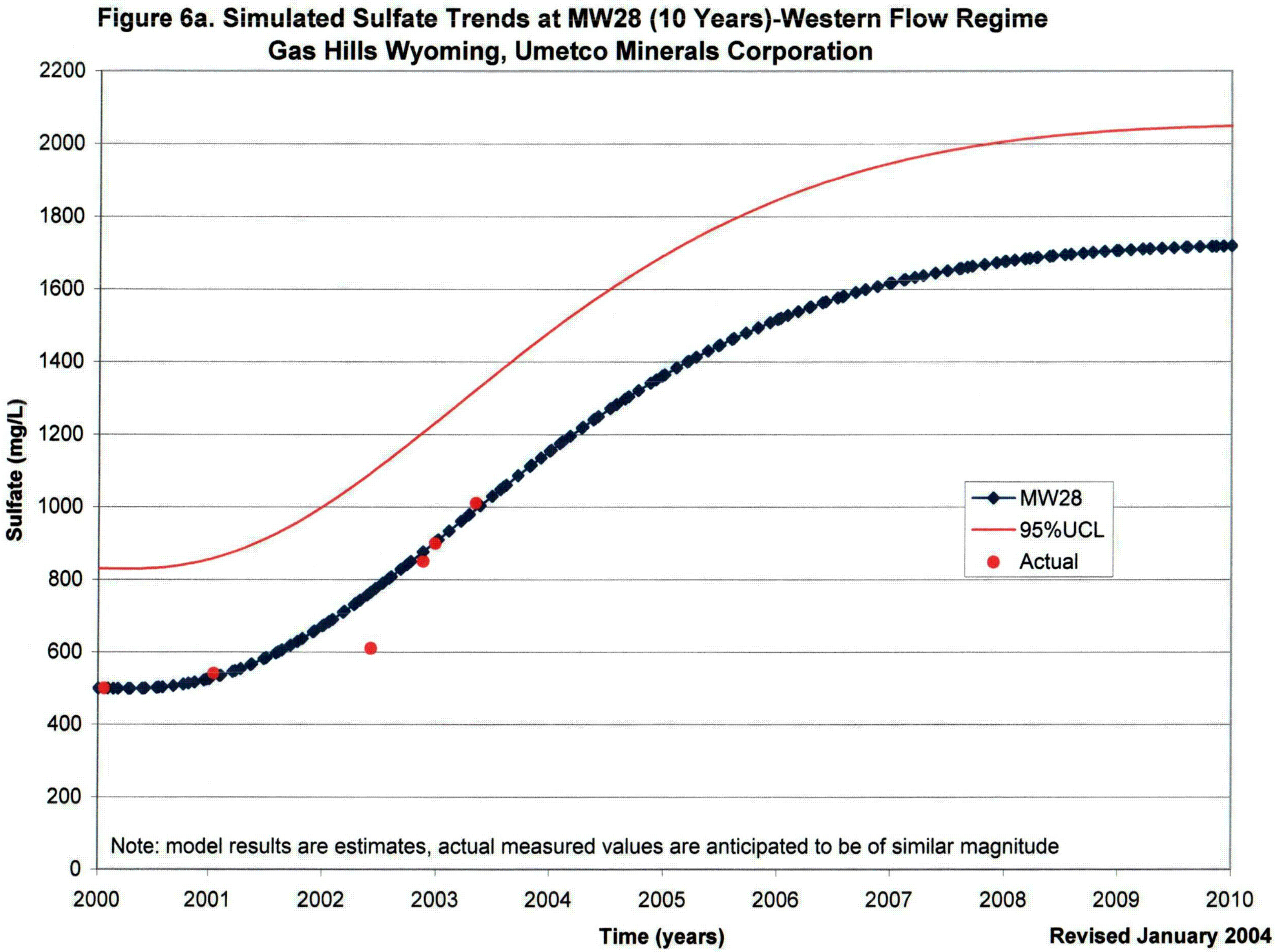
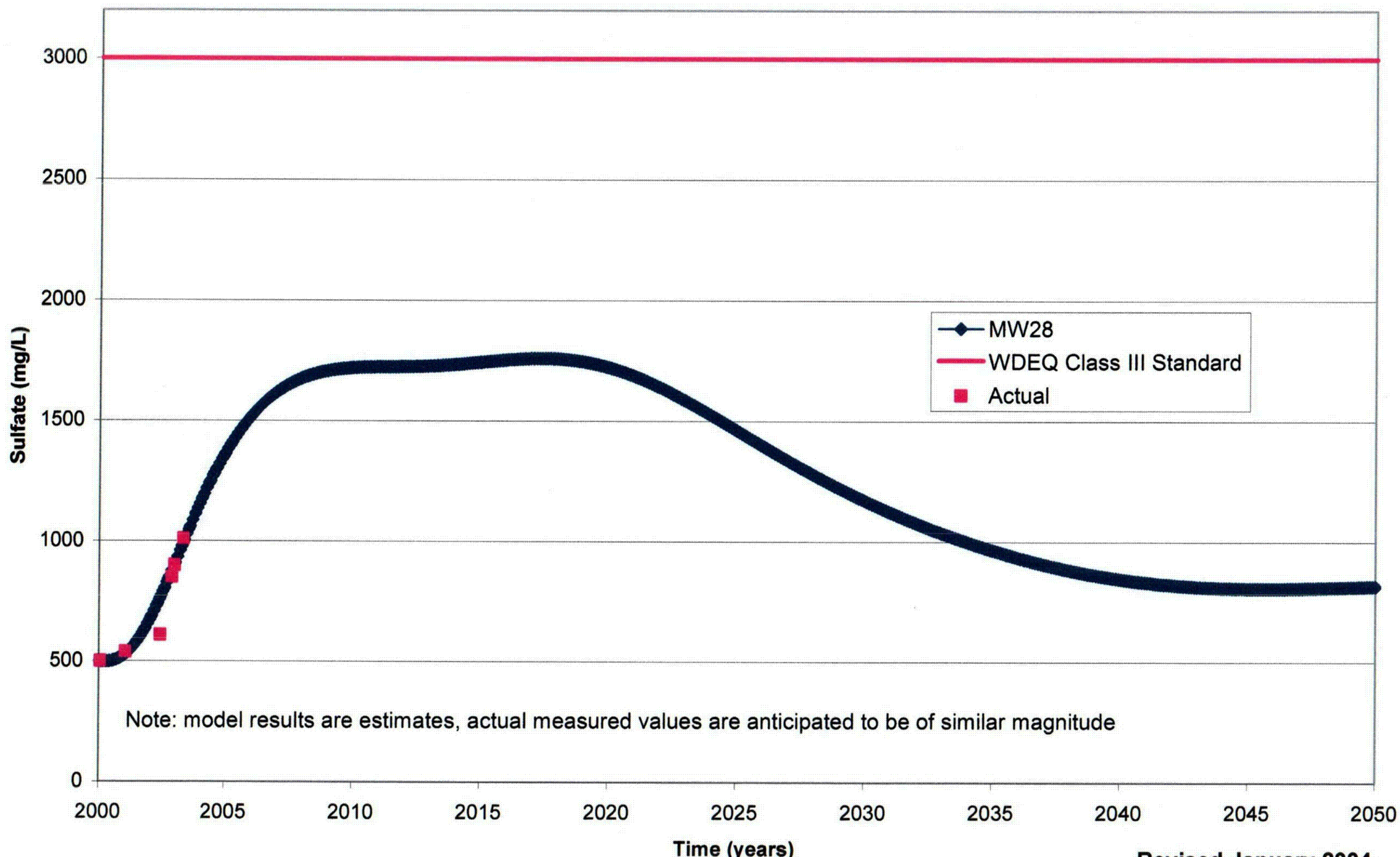


Figure 6a. Simulated Sulfate Trends at MW28 (10 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation
Sulfate (mg/L)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MW28
95%UCL
Actual
Note: model results are estimates, actual measured values are anticipated to be of similar magnitude
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Time (years)
Revised January 2004

C13

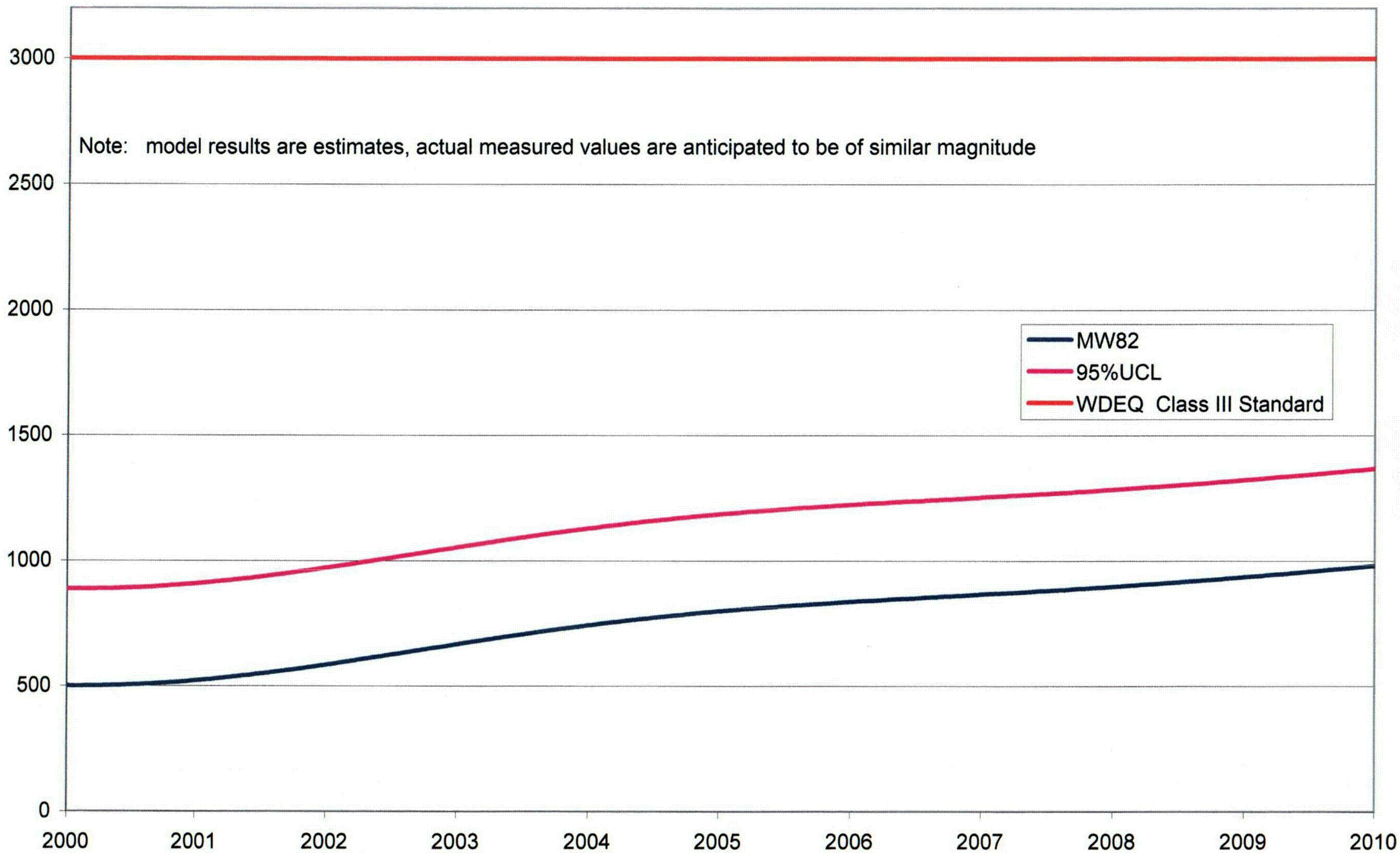
Figure 6b. Simulated Sulfate Trends at MW28 (50 Years)-Western Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



Revised January 2004

C14

Figure 7a(r). Simulated Sulfate Trends at MW82 (10 Years)-Southwestern Flow Regime Gas Hills Wyoming, Umetco Minerals Corporation



C15

Figure 7b(r). Simulated Sulfate Trends at MW82 (50 Years)-Southwestern Flow Regime Gas Hills Wyoming, Umetco Minerals Corporation

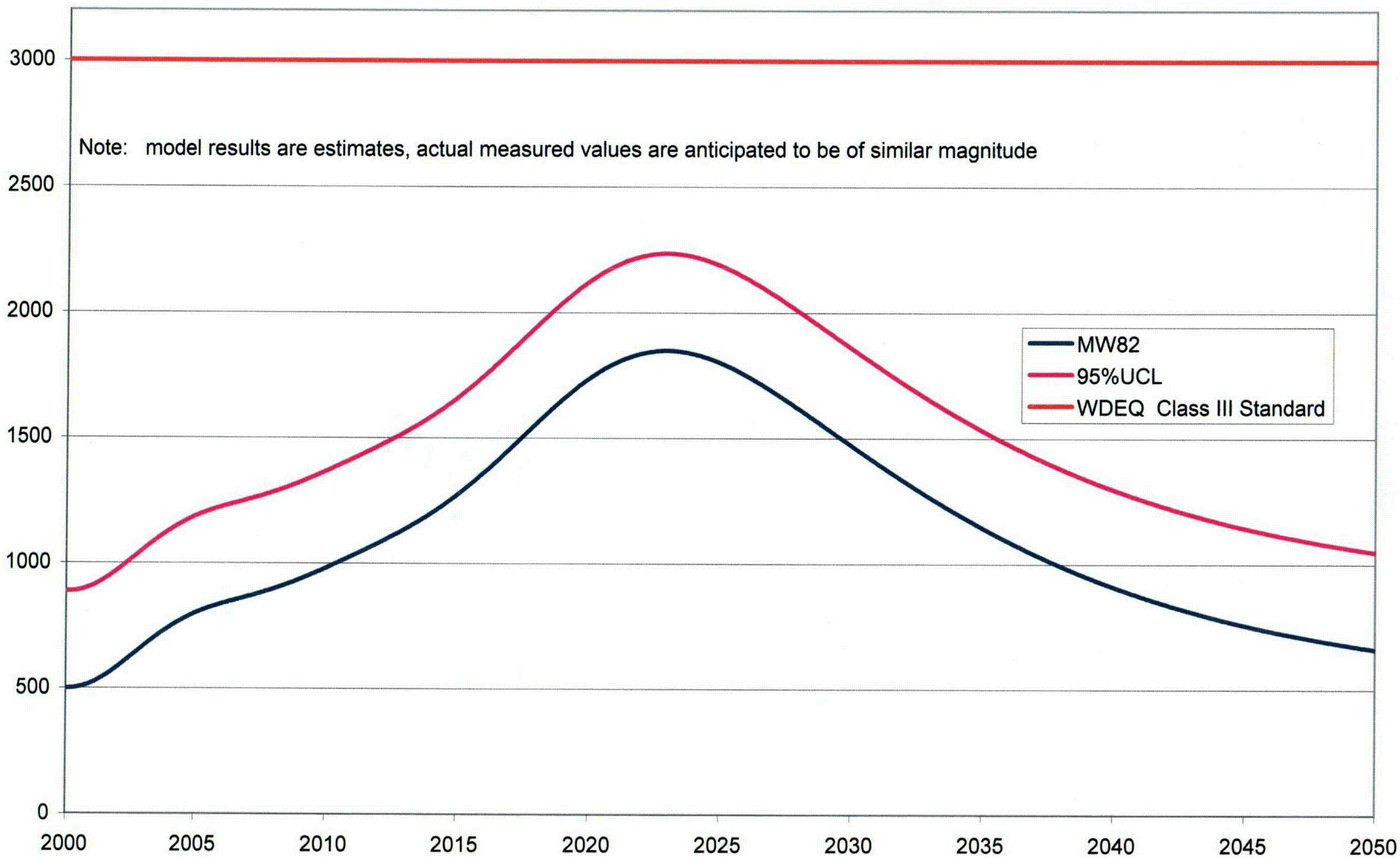
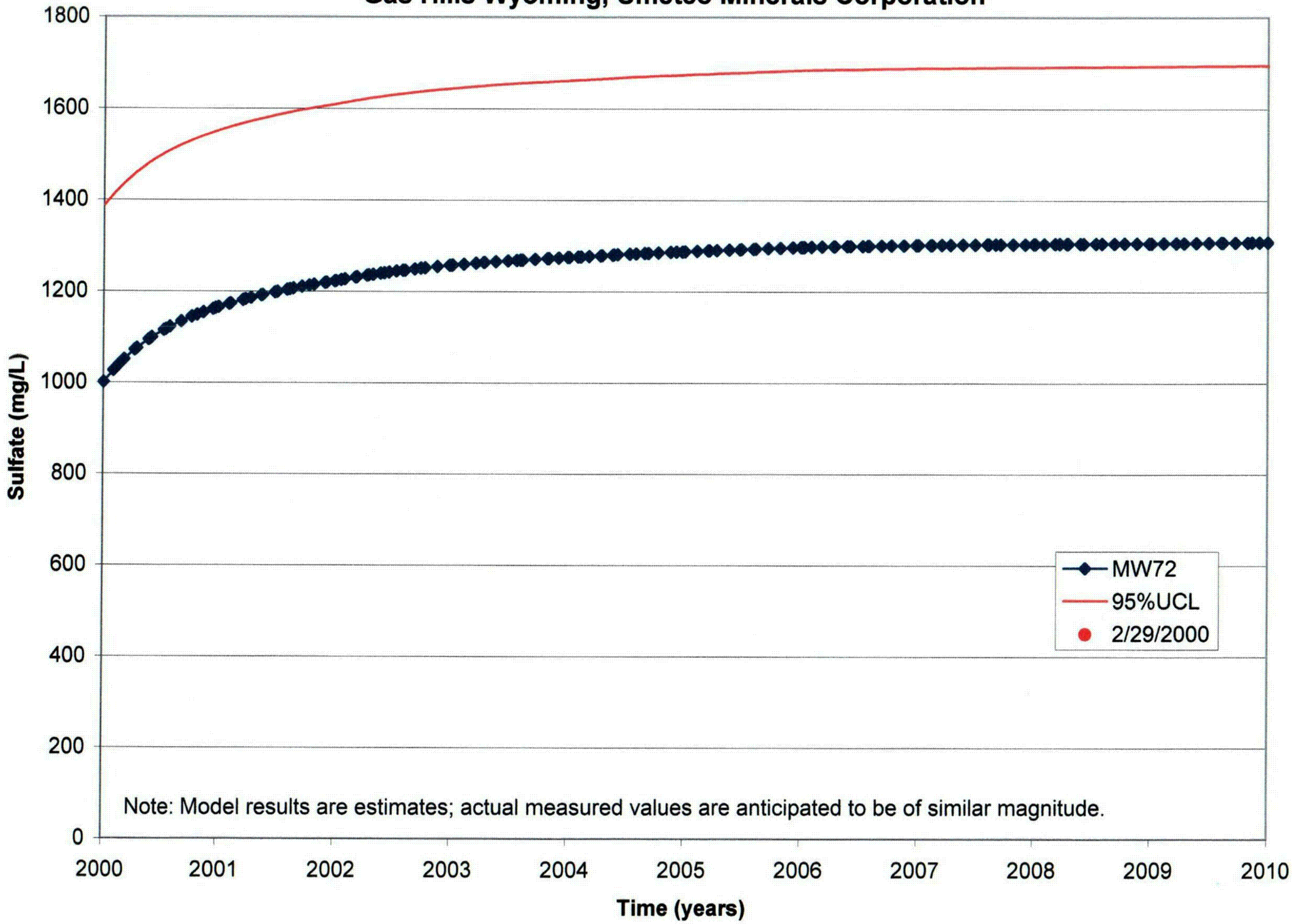


Figure 8a. Simulated Sulfate Trends at MW72 (10 Years)-Southwestern Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation



C17

Figure 8b. Simulated Sulfate Trends at MW72 (50 Years)-Southwestern Flow Regime
Gas Hills Wyoming, Umetco Minerals Corporation