CAMECO RESOURCES
CROW BUTTE OPERATION

86 Crow Butte Road
P.O. Box 169
Crawford, NE 69339-0169

(308) 665-2215
(308) 665-2341 - FAX

May 9, 2013

Mr. Michael Linder, Director
Nebraska Department of Environmental Quality
PO Box 98922
Lincoln, Nebraska 68509-8922

Crow Butte Resources, Inc.
Class III Underground Injection Control (UIC) Permit Number NE0122611
Mine Unit 3 Restoration Status

Dear Mr. Linder:

In accordance with the approved Crow Butte Resources, Inc., d/b/a Cameco Resources – Crow Butte Operation (CBO), Groundwater Restoration Plan, CBO is submitting analytical data concerning the restoration of Mine Unit 3 at the Crow Butte Uranium Project. Split samples from all restoration wells were obtained with the Nebraska Department of Environmental Quality (NDEQ) on March 1, 2013. This data provides supporting documentation that restoration efforts have been successful in returning Mine Unit 3 to the approved restoration goals. Upon NDEQ approval, CBO plans to place Mine Unit 3 into the initial phase of stabilization restoration.

Commercial operation of Mine Unit 3 began in November 1992. The restoration plan for this mine unit was submitted to NDEQ on March 24, 1999 and was amended and approved by NDEQ in a letter dated February 13, 2008. Injection of lixiviant into this mine unit was ceased on July 22, 1999. Since that time period, the mine unit has been in IX and RO treatment with the following exceptions:

On August 9, 2007 the entire restoration circuit was shut down so that changes could be made to increase the flow through IX and RO treatment. During this time period the mine unit was in recirculation to maintain a hydrologic bleed until April 1, 2009, when IX treatment resumed in this mine unit. On May 26, 2009, the RO circuit was restarted and this mine unit was placed back into RO treatment.

In February 2009, Crow Butte contracted with a third party hydrogeologist to develop a restoration flow model for Mine Units 2 through 5. The groundwater flows at the facility were simulated using MODFLOW2000, a three-dimensional groundwater flow model developed by the United States Geological Survey. The groundwater flow model was calibrated to pre-mining conditions using water level data collected prior to the mining activities in January 1983. Initial estimates of aquifer properties and boundary water levels were adjusted slightly as part of the model calibration process in order to achieve the best possible match between observed and simulated water levels. The calibrated groundwater flow model was used to optimize restoration in Mine Unit 3 given certain practical limitations on treatment rates, disposal capacity, and existing well injection and extraction rates. Based on this model, eight additional restoration wells were installed to remediate the excursion of lixiviant along the perimeter monitor well IJ-13.

Restoration was performed as described in the Groundwater Restoration Plan, utilizing groundwater sweep, treatment and recirculation. The total gallons used in each phase through the end of March 2013 are as follows:

Restoration Phase	Total Gallons	Pore Volumes
Sweep	13,351,100	.70
Treatment (IX)	781,420,810	40.97
Treatment (RO)	473,010,400	24.80*
Recirculation	61,796,520	3.24

*See attached Aqui-Ver, Inc. report for a detailed analysis and history of RO treatment.

CBO is required by the NDEQ UIC Permit to determine the baseline groundwater quality for a list of 27 water quality parameters. The baseline average for each well is determined for each parameter. These well averages are then used to determine the overall mine unit average for each parameter. Baseline for Mine Unit 3 was determined prior to mining operations and submitted for approval by the regulatory agencies.

NDEQ restoration goals are based upon state groundwater standards. For those parameters that have a numerical groundwater standard established in Title 118 of the NDEQ Rules and Regulations[1] or in other established documents, restoration must successfully return the groundwater to that standard. If the baseline preoperational mean for the mine unit exceeds the standard for any parameter, the restoration goal for that parameter is set at the baseline mean plus two standard deviations. Where no standard is established (calcium, potassium, magnesium and sodium) the restoration value is set at one order of magnitude above baseline mean. The restoration value for total carbonate shall not exceed 50% of the total dissolved solids.

[1] Title 118 – Ground Water Quality Standards and Use Classification, NDEQ July 29, 1996.

All parameters in Mine Unit 3 have met the NDEQ restoration goals on a mine unit average. CBO obtained composite samples from the restoration wells on March 1, 2013. This sampling indicated that all parameters met the restoration goals.

The attached table provides analytical data for the Mine Unit 3 restoration wells. The results for all parameters are from the March 2013 composite sampling.

Based upon the analytical results, CBO believes that restoration efforts have been successful in restoring Mine Unit 3 to the approved restoration goals. Split sampling will be performed with the NDEQ upon approval from the department to begin stability monitoring. At that time, Mine Unit 3 will be shut in for the stabilization phase of restoration.

If you have any questions or require further information, please do not hesitate to contact me at (307) 316-7601.

Sincerely,
CAMECO RESOURCES
CROW BUTTE OPERATION

William Goranson /TAC

William Goranson, President
Crow Butte Resources, Inc.

Attachment: As Stated

cc: Shar Sapp – NDEQ Chadron Office
Nancy Harris – NDEQ Lincoln Office
Ron Burrows - NRC
CBO - File
cc: CR - Cheyenne

CAMECO RESOURCES
CROW BUTTE OPERATION

Mine Unit 3 Restoration Results

Parameter	Title 118 Groundwater Standard [2]	MU-3 Baseline Mean	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value [3]	MU-3 Average Water Quality March 2013
Ammonium (mg/L)	10.0	<0.329	N/A	10.0	0.09
Arsenic (mg/L)	0.05	<0.001	N/A	0.05	0.046
Barium (mg/L)	1.0	<0.1	N/A	1.0	<0.1
Cadmium (mg/L)[1]	0.005	<0.01	N/A	0.005	<0.005
Chloride (mg/L)	250.0	197.6	16.7	250.0	40.0
Copper (mg/L)	1.0	<0.0108	N/A	1.0	<0.01
Fluoride (mg/L)	4.0	0.719	0.05	4.0	0.70
Iron (mg/L)	0.3	<0.05	N/A	0.3	0.07
Mercury (mg/L)	0.002	<0.001	N/A	0.002	<0.001
Manganese (mg/L)	0.05	<0.01	N/A	0.05	0.01
Molybdenum (mg/L)	1.0	<0.1	N/A	1.0	<0.1
Nickel (mg/L)	0.15	<0.05	N/A	0.15	<0.05
Nitrate (mg/L)	10.0	<0.0728	N/A	10.0	<0.1
Lead (mg/L)	0.05	<0.05	N/A	0.05	0.001
Radium (pCi/L)	5.0	165	222.5	611.0	64.0
Selenium (mg/L)	0.05	<0.00115	N/A	0.05	<0.005
Sodium (mg/L)	N/A	428	27.6	4280	138.0
Sulfate (mg/L)	250.0	377.0	13.4	404.0	75.0
Uranium (mg/L)	5.0	0.115	0.158	5.0	0.6020
Vanadium (mg/L)	0.2	<0.1	N/A	0.2	0.2
Zinc (mg/L)	5.0	<0.0131	N/A	5.0	<0.01
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5	8.04
Calcium (mg/L)	N/A	13.3	3.1	133.0	7.0
Total Carbonate (mg/L)	N/A	358.7	24.8	592.0	208.0
Potassium (mg/L)	N/A	13.9	4.0	139	5.0
Magnesium (mg/L)	N/A	3.5	0.9	35.0	1.0
TDS (mg/L)	N/A	1183.0	47.4	1183.0	420.0

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

[2] Title 118 numerical standards in effect at the time the Notice of Intent was filed with the NDEQ.

[3] Restoration values based on Title 118 numerical standards and well field averages at the time the Notice of Intent was submitted to the NDEQ.

N/A = Not Applicable

AQUI-VER, INC.

Cameco

Pore Volume Restoration Analysis

Cameco Resources
Crow Butte Operations
Dawes County, Nebraska

April 4, 2013

Prepared By:

AQUI-VER, INC.

4800 Wadsworth Boulevard
Suite 400
Wheat Ridge, CO 80033 USA

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

1. EXECUTIVE SUMMARY

Cameco Resources (Cameco) has conducted an analysis to determine the number of pore volumes necessary to restore the production aquifer at the Crow Butte uranium in-situ recovery (ISR) facility near Crawford, Nebraska. Prior to May 2009, groundwater restoration at the site was relatively inefficient, resulting in an excessive number of pore volumes being treated to achieve restoration goals. In order to improve the efficiency of groundwater restoration, Cameco Resources completed a study in 2009 which included the preparation of a comprehensive, model-based restoration plan (MBRP) for mine units MU-2 through MU-5. The MBRP was implemented beginning in May 2009 with full-scale restoration of MU-2, followed by full-scale restoration of MU-3 in December 2009. The efficiency of groundwater restoration has improved significantly since implementation of the MBRP.

Pore volume restoration requirements were calculated by applying the general approach of Zheng et al. (1991, 1992) using the concept of the mixed linear reservoir (MLR) or batch mixing model of Gelhar and Wilson (1974). This methodology has been previously employed to compute pore volume restoration requirements at Cameco's Smith Ranch-Highland facility in Converse County, Wyoming. This analysis was focused on recent groundwater restoration activities completed in MU-2 and MU-3 as part of the MBRP.

Results of the pore volume restoration analysis demonstrate that restoration of MU-2 and MU-3 was accomplished (with the exception of local elevated arsenic concentrations in MU-3) in approximately 6 to 9 months following the implementation of the MBRP. Restoration was achieved after 2.11 pore volumes of groundwater treatment in MU-2, and 0.74 pore volumes of groundwater treatment in MU-3, as computed by the MLR model. The total number of pore volumes treated in MU-2 and MU-3 as part of the MBRP was 2.25 and 1.72, respectively.

Spot treatment in MU-2 and MU-3 continued following full-scale restoration to address localized elevated arsenic and/or vanadium concentrations and to prepare for stability. Recent geochemical evaluations of arsenic and vanadium trends in MU-2 and MU-3 suggest localized elevated concentrations of arsenic and vanadium likely occur due to local over-treatment by injection of RO permeate, resulting in loss of aquifer buffering capacity and increased pH as inorganic carbon is removed (arsenic and vanadium mobility increases with increasing pH in this system). Care will be taken in the future to prevent over-treatment of restored areas to prevent the mobilization of arsenic and vanadium.

Results of the pore volume restoration analysis in MU-2 and MU-3 were expanded to evaluate the number of pore volumes required for future restoration of other mine units at the site. Results of this analysis indicate the theoretical number of pore volumes required to restore a mine unit from the post-mining condition to a fully restored condition at the site is 1.54 (MU-3 analogy) to 3.00 (MU-2 analogy).

The theoretical affected pore volume (APV) calculated from the MLR model is larger than Cameo's calculated APV by a factor of approximately 1.21 (MU-2) to 3.87 (MU-3). The difference between the theoretical and calculated APV represents a combination of uncertainties inherent in Cameco's APV calculations (e.g. estimated flare factor, porosity, pattern area, sand thickness), restoration inefficiencies (although much less than historical inefficiencies), deviation from the theoretical model assumption of complete mixing, and variation in the computed average water quality versus the actual average water quality. If Cameco's calculated APV for MU-2 and MU-3 is used instead of the theoretical APV computed by the MLR model, the total number of pore volumes required to restore groundwater from a post-mining condition to a fully restored condition is 3.63 (more efficient) to 5.96 (less efficient).

The results of this study can be used to compare the relative effectiveness of restoration before and after the implementation of the MBRP. Prior to May 2009 and the implementation of the MBRP in MU-2, more than 35 pore volumes of groundwater were treated as part of restoration activities (using Cameco's calculated APV). Likewise, prior to December 2009 and the implementation of the MBRP in MU-3, more than 59 pore volumes of groundwater were treated as part of restoration activities. Despite the relatively large number of pore volumes treated prior to implementation of the MBRP, MU-2 and MU-3 were only 30 to 50 percent restored, respectively, at the time the MBRP was implemented in May 2009. By comparison, results of this study indicate complete restoration of the production aquifer can be achieved in approximately 3.6 to 6.0 pore volumes using the MBRP and Cameco's calculated APV, a significant improvement in restoration efficiency.

2. INTRODUCTION

Cameco Resources (Cameco) has conducted an analysis to determine the number of pore volumes necessary to restore the production aquifer at the Crow Butte uranium in-situ recovery (ISR) facility (the site). The Crow Butte facility is located near Crawford, Nebraska in Dawes County. This analysis was focused on recent groundwater restoration activities completed in Mine Units 2 and 3 (MU-2 and MU-3) at the site.

2.1 Background

Prior to May 2009, groundwater restoration at the site was relatively inefficient, resulting in an excessive number of pore volumes being treated to achieve restoration goals. The primary reasons for the relative inefficiency of past restoration efforts include:

- location of restoration wells and pumping rates were not optimal, resulting in reduced effectiveness and prolonged duration of restoration,
- limited scale of restoration and use of a relatively small number of restoration wells given limited reverse osmosis (RO) treatment and disposal well capacity,
- lack of effective infrastructure to deliver RO permeate to wellfields,
- groundwater treatment using less than efficient methods including excessive groundwater sweep and water transfer,
- incursions of poor quality water into previously restored areas resulting from inefficient management of well pumping and injection rates (e.g. restoration bleed), and
- less management focus on restoration, with associated lack of formal restoration plan and optimization tools (e.g. computer model).

In order to improve the efficiency of groundwater restoration, Cameco Resources completed a study which included the preparation of a comprehensive, model-based restoration plan (MBRP) for mine units MU-2 through MU-5 at the site (WorleyParsons, 2009). The MBRP included the development and application of a three-dimensional groundwater flow and transport model for the purpose of optimizing restoration well locations, injection and extraction rates, and the overall restoration sequence for each mine unit. RO treatment capacity was also expanded to allow full-scale restoration of multiple wellhouses and/or mine units. The MBRP was implemented beginning in May 2009 with full-scale restoration of MU-2, followed by full-scale restoration of MU-3 in December 2009. The efficiency of groundwater restoration has improved significantly since implementation of the MBRP, as demonstrated in the following sections.

2.2 Purpose and Scope

The purpose of this analysis was to determine the number of pore volumes required to restore the production aquifer at the site based on results of the recent restoration of MU-2 and MU-3 as an example. The analysis included performance of the following tasks, described in detail in **Sections 3 and 4** of this report:

- develop a theoretical pore volume restoration curve for a conservative chemical constituent (e.g. chloride) in MU-2 and MU-3,
- compare the theoretical pore volume restoration curve to observed chloride concentrations during restoration,

- calculate the theoretical Affected Pore Volume (APV),
- calculate retardation factors for non-conservative constituents of concern,
- develop theoretical pore volume restoration curves for remaining constituents of concern,
- compare theoretical restoration curves to observed concentration decline during restoration, and
- calculate the number of pore volumes required to restore a typical ISR wellfield.

3. MINE UNIT 2 AND 3 RESTORATION AND WATER QUALITY

This analysis was focused on recent groundwater restoration activities completed as part of the MBRP in MU-2 and MU-3 (**Figure 3-1**). Historical groundwater sampling results (Guideline 8 analyses) from MU-2 and MU-3 were obtained from Cameco for this study. Water quality data were available for 12 wells in MU-2 and 13 wells in MU-3 for this analysis. Average concentrations were calculated using groundwater analytical data reported for individual wells completed in the production aquifer in each mine unit, and are assumed to be representative of the average groundwater quality in each mine unit. This assumption is supported by the close agreement between calculated average concentrations and results of composite samples analyzed periodically during the restoration period. **Tables 3-1 and 3-2** summarize the average concentration calculated for constituents of concern in MU-2 and MU-3, respectively .

3.1 Mine Unit 2 Restoration

Full-scale groundwater restoration in MU-2 was conducted between May 2009 and March 2010 (11 months) in general accordance with the MBRP (WorleyParsons, 2009). Restoration during this period was conducted by groundwater extraction, treatment by Reverse Osmosis (RO), and injection of treated groundwater back into the production aquifer. The groundwater extraction/RO treatment rate in MU-2 is illustrated in **Figure 3-2**.

As shown in **Table 3-1**, groundwater in MU-2 was fully restored (e.g. had meet applicable NDEQ restoration standards) in January 2010 after nine months of full-scale restoration. Full-scale restoration continued for several months following January 2010, with concentrations of most chemical constituents continuing to decline for the duration of full-scale restoration. Restoration activities in MU-2 continued after March 2010, but restoration was not full-scale and was limited to spot treatment of specific areas having somewhat elevated concentrations of arsenic and/or vanadium, as shown by the reduced groundwater extraction rate in **Figure 3-2**. **Table 3-3** summarizes the volume of groundwater extracted and treated by RO in MU-2 during restoration.

3.2 Mine Unit 3 Restoration

Full-scale groundwater restoration in MU-3 was conducted between December 2009 and October 2011 (22 months) in general accordance with the MBRP (WorleyParsons, 2009). Restoration during this period was conducted by groundwater extraction, treatment by Reverse Osmosis (RO), and injection of treated groundwater back into the production aquifer. The groundwater extraction/RO treatment rate in MU-3 is illustrated in **Figure 3-3**. A significant decrease in flow occurred in October 2010, although restoration was still considered full-scale given the large number and wide distribution of wells being operated from October 2010 through October 2011.

As shown in **Table 3-2**, groundwater in MU-3 was fully restored with the exception of elevated average arsenic concentrations in May 2010 after six months of full-scale restoration. Full-scale restoration activities continued for approximately 16 months after May 2010, with concentrations of most constituents continuing to decline for the duration of full-scale restoration. Restoration activities in MU-3 continued after October 2011, but restoration was not full-scale and limited to spot treatment of specific areas having somewhat elevated concentrations of arsenic and/or vanadium, as shown by the reduced groundwater extraction rate in **Figure 3-3**. **Table 3-4** summarizes the volume of groundwater extracted and treated by RO in MU-3 during restoration.

TABLE 3-1

MU-2 Average Concentrations of Constituents of Concern in Groundwater

Sample Date	Units	Carbonate	Calcium	Chloride	Fluoride	Magnesium	Nitrogen Ammonia	Potassium	Sodium	Sulfate	pH	TDS	Arsenic	Barium	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Uranium	Vanadium	Zinc	Radium 226
NDEQ Restoration Value		*585*	*134*	*250*	*4*	*35*	*10*	*126*	*4108*	*369*	*6.5-8.5*	*1170.4*	*0.05*	*1*	*0.005*	*1*	*0.3*	*0.050*	*0.05*	*0.002*	*1*	*0.15*	*0.050*	*5*	*0.2*	*5*	*1058*
Apr-07	mg/l	--	35.67	259.78	0.38	8.11	--	14.23	478.83	458.33	7.92	1521.56	0.018	--	--	--	0.10	--	0.10	--	0.18	--	0.002	3.81	0.70	0.01	335.43
Nov-09	mg/l	5.00	8.60	62.87	0.72	3.00	--	5.83	176.83	110.83	8.33	478.33	0.032	--	--	--	0.11	0.003	0.02	--	0.15	--	0.002	1.81	0.21	--	216.50
Jan-10	mg/l	9.00	5.00	43.60	0.70	2.00	--	4.80	112.40	59.80	8.10	308.80	0.040	--	--	--	0.10	0.007	0.03	--	--	--	0.001	0.29	0.20	0.02	271.80
Mar-10	mg/l	9.00	3.17	27.29	0.77	1.00	0.06	3.57	108.00	51.43	8.01	314.29	0.033	--	--	--	0.37	0.004	0.02	--	--	--	--	0.46	0.23	--	91.71
Jun-10	mg/l	7.00	13.11	28.78	0.68	4.33	0.06	4.67	93.89	49.11	7.85	300.89	0.031	0.060	--	0.01	0.33	0.005	0.02	--	0.10	--	0.002	0.35	0.30	0.03	116.22
Jul-10	mg/l	--	2.63	33.25	0.67	1.00	--	3.75	110.75	57.50	7.39	286.75	0.037	--	--	--	0.40	0.003	0.02	--	--	--	0.001	0.23	0.25	0.01	98.13
Oct-10	mg/l	7.00	3.00	38.25	1.54	1.00	--	3.63	113.63	84.75	8.13	319.88	0.038	--	--	--	0.25	0.002	0.02	--	0.10	--	--	0.24	0.20	0.01	66.00
Apr-11	mg/l	6.20	4.90	54.00	1.21	1.60	--	5.40	154.90	99.30	8.04	428.30	0.026	--	--	--	0.18	0.002	0.02	--	0.13	--	--	0.50	0.20	0.02	119.10
Jun-11	mg/l	8.25	6.33	59.78	0.51	1.75	0.06	5.44	162.56	106.44	8.11	482.11	0.026	--	--	--	0.15	0.001	0.02	--	0.15	--	0.002	0.79	0.20	--	130.56
Jul-11	mg/l	5.50	6.44	59.33	0.51	2.00	--	5.89	181.22	112.44	8.06	489.67	0.026	--	--	--	0.19	--	0.03	--	0.15	--	0.002	0.63	0.20	0.05	102.57
Aug-11	mg/l	4.71	7.00	63.78	0.48	1.67	--	5.89	171.67	121.33	8.01	535.78	0.026	--	--	--	0.15	--	0.02	--	0.15	--	--	0.77	0.20	0.01	134.98
Sep-11	mg/l	4.67	7.22	68.22	0.47	1.67	--	6.67	183.11	129.44	7.88	560.78	0.024	--	--	--	0.13	--	0.02	--	0.13	--	0.002	0.92	0.10	--	133.79
Oct-11	mg/l	5.50	8.00	70.89	0.48	1.86	0.05	6.67	209.22	134.56	7.81	577.33	0.021	--	--	--	0.25	--	0.02	--	0.13	--	0.002	0.97	0.10	0.02	121.29
Nov-11	mg/l	5.40	6.67	66.22	0.54	2.00	0.05	7.00	194.67	127.44	7.78	573.89	0.024	--	--	--	0.22	--	0.02	--	0.14	--	0.002	0.79	0.10	--	115.03
Dec-11	mg/l	5.00	6.67	70.00	0.44	2.00	--	6.33	183.11	134.67	7.84	531.22	0.021	--	--	--	0.16	0.002	0.02	--	0.12	--	0.006	0.72	--	--	116.91
Jan-12	mg/l	4.00	5.56	55.33	0.56	1.75	0.05	5.78	162.67	109.89	8.01	460.44	0.022	--	--	0.01	0.15	0.005	0.03	0.001	0.14	--	0.002	0.53	0.10	0.03	93.72
Feb-12	mg/l	4.00	6.22	59.78	0.56	2.25	--	6.22	174.56	118.00	7.95	493.44	0.024	--	--	0.01	0.19	0.004	0.02	--	0.14	--	0.002	0.44	0.20	0.02	133.49
Mar-12	mg/l	5.00	6.88	55.22	0.61	2.00	0.06	6.00	165.67	108.11	8.02	491.56	0.023	--	--	0.02	0.15	0.006	0.03	--	0.15	--	0.003	0.42	0.20	0.01	155.59
Apr-12	mg/l	7.00	8.50	49.89	0.60	2.33	--	5.56	152.00	98.11	8.01	447.78	0.025	--	--	0.02	0.16	0.006	0.03	--	0.17	--	0.004	0.42	0.20	--	228.66
May-12	mg/l	63.75	12.38	41.64	0.60	1.50	--	6.00	152.78	95.89	8.01	433.11	0.091	--	--	0.02	0.17	0.014	0.05	--	0.20	--	0.090	1.47	0.18	--	193.96
Jun-12	mg/l	4.50	5.75	43.33	0.67	1.50	0.13	5.33	149.89	90.00	8.03	413.67	0.023	--	--	0.03	0.22	0.006	0.03	--	0.20	--	--	0.40	0.15	--	122.61
Jul-12	mg/l	6.00	5.50	46.78	0.69	1.75	--	5.44	142.33	90.22	8.01	399.67	0.024	--	--	0.02	0.17	0.005	0.04	--	0.20	--	0.001	0.44	0.20	0.01	223.33
Aug-12	mg/l	7.00	5.57	42.11	0.73	1.67	0.05	4.56	131.89	84.22	8.09	385.22	0.028	--	--	0.02	0.18	0.004	0.03	--	0.20	--	0.002	0.41	0.30	--	136.27
Sep-12	mg/l	5.33	5.57	39.67	0.69	1.33	--	4.78	127.11	80.00	8.09	366.33	0.028	--	--	0.02	0.21	0.004	0.04	--	0.20	--	0.002	0.39	0.30	--	133.26

(shaded) Full-Scale Restoration Period

Notes:

1. Excluded 8/4/2010 and 11/2/2010 sampling events (only one well sampled).
2. Excluded wells I180P, P113 and P97 after March 2010 (wells impacted by incursion after complete restoration).
3. Red Font = exceeded NDEQ Restoration Value
4. -- = not analyzed

TABLE 3-2
MU-3 Average Concentrations of Constituents of Concern in Groundwater

Sample Date	Units	Carbonate	Calcium	Chloride	Fluoride	Magnesium	Nitrogen Ammonia	Potassium	Sodium	Sulfate	pH	TDS	Arsenic	Barium	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Uranium	Vanadium	Zinc	Radium 226
NDEQ Restoration Value		*592*	*133*	*250*	*4*	*35*	*10*	*139*	*4280*	*404*	*6.5-8.5*	*1183*	*0.05*	*1*	*0.005*	*1*	*0.3*	*0.050*	*0.05*	*0.002*	*1*	*0.15*	*0.050*	*5*	*0.2*	*5*	*611*
Nov-09	mg/l	6.50	38.25	296.25	0.58	9.50	0.08	19.75	594.00	469.25	8.19	1800.00	0.05	–	–	–	0.08	0.002	0.08	–	0.25	–	0.004	8.78	0.37	–	477.50
Dec-09	mg/l	–	41.67	304.67	0.50	10.67	0.06	20.67	642.00	468.33	8.01	1778.00	0.02	–	–	–	0.04		0.06	0.002	0.23	–	0.002	8.01	0.40	0.01	327.67
May-10	mg/l	–	14.50	130.50	0.85	3.50	0.07	10.50	357.50	230.50	7.81	878.50	0.15	–	–	–	0.03		0.03	–	0.40	–	0.001	2.07	0.20	0.04	283.00
Sep-10	mg/l	11.33	13.78	106.33	0.97	3.83	0.13	10.33	285.44	174.44	7.89	828.87	0.06	–	–	–	0.12	0.003	0.03	0.001	0.20	–	0.002	1.40	0.36		209.33
Apr-11	mg/l	7.25	9.25	72.38	0.88	8.00	0.15	8.00	226.38	120.88	8.04	596.88	0.07	–	–	0.01	0.09	0.002	0.02	–	0.13	–	0.001	1.28	0.38	0.07	102.30
Jun-11	mg/l	5.83	8.40	82.82	0.85	2.40	0.09	8.09	168.09	113.73	8.25	538.09	0.07	–	–	–	0.07	0.001	0.02	–	0.13	–	0.003	0.69	0.47		44.62
Jul-11	mg/l	6.40	6.80	57.00	0.83	2.50	0.12	8.09	167.09	101.91	8.06	501.09	0.05	–	–	–	0.07		0.03	–	0.12	–	0.005	0.79	0.48	0.07	74.01
Aug-11	mg/l	8.00	5.30	54.09	0.82	2.33	0.12	6.00	172.55	96.09	8.07	479.38	0.06	–	–	–	0.07	0.001	0.03	–	0.13	–	0.012	0.73	0.40		50.04
Sep-11	mg/l	7.00	5.80	58.55	0.78	3.00	0.14	8.00	170.45	102.09	8.04	503.09	0.06	–	–	–	0.06		0.03	–	0.13	–	0.003	0.70	0.41		41.39
Oct-11	mg/l	7.67	8.50	54.64	0.75	2.75	0.12	6.60	172.73	95.09	8.11	484.45	0.05	–	–	–	0.10	0.003	0.02	0.001	0.14	–	0.004	0.67	0.40	0.02	44.22
Nov-11	mg/l	7.33	6.50	54.09	0.77	3.00	0.11	6.70	172.09	95.64	8.04	500.00	0.05	–	–	–	0.17	0.003	0.03	–	0.14	–	0.002	0.65	0.40	–	56.38
Dec-11	mg/l	6.00	6.80	55.73	0.74	3.00	0.11	6.40	163.45	99.91	7.96	476.09	0.05	–	–	–	0.06	0.002	0.03	–	0.14	–	0.002	0.58	0.33	–	63.17
Jan-12	mg/l	7.33	7.30	55.64	0.85	3.75	0.10	6.30	168.64	100.45	8.10	477.91	0.05	–	–	–	0.08	0.002	0.03	–	0.18	–	0.003	0.67	0.40	0.02	56.03
Feb-12	mg/l	7.00	7.30	53.18	0.87	3.25	0.12	6.80	166.18	95.36	8.10	472.27	0.05	–	–	–	0.07	0.002	0.03	–	0.16	–	0.003	0.61	0.40	0.01	46.05
Mar-12	mg/l	8.50	8.50	58.00	0.86	5.33	0.11	7.00	177.18	104.27	8.12	526.45	0.05	–	–	0.01	0.07	0.002	0.03	–	0.20	–	0.003	0.80	0.37	0.01	88.05
Apr-12	mg/l	10.00	7.20	51.73	0.84	5.00	0.12	6.78	155.91	92.91	8.12	475.45	0.05	–	–	–	0.06	0.002	0.02	–	0.15	–	0.003	0.62	0.37	–	83.69
May-12	mg/l	9.33	7.60	50.45	0.88	4.00	0.17	6.60	162.55	91.55	8.08	461.73	0.11	–	–	–	0.07	0.003	0.02	0.002	0.17	–	0.145	0.86	0.36	–	51.71
Jun-12	mg/l	6.00	7.40	49.18	0.92	3.50	0.16	6.89	167.09	90.27	8.21	469.00	0.05	–	–	–	0.08	0.002	0.03	–	0.20	–	0.006	0.53	0.43	–	63.75
Jul-12	mg/l	9.00	7.64	53.42	0.90	4.00	0.14	6.18	165.92	91.33	8.12	457.25	0.05	–	–	0.01	0.08	0.004	0.03	0.002	0.20	–	0.004	0.54	0.41	0.01	100.48
Aug-12	mg/l	5.00	7.55	53.08	0.89	4.00	0.12	6.18	162.87	96.50	8.14	471.08	0.05	–	–	0.01	0.09	0.005	0.03	–	0.20	–	0.004	0.62	0.41	–	197.93
Sep-12	mg/l	9.67	8.09	54.75	0.84	4.25	0.24	5.67	166.42	100.08	8.13	480.75	0.05	–	–	0.01	0.07	0.005	0.03	–	0.18	–	0.006	0.68	0.37	–	117.91

Full-Scale Restoration Period

Notes:

1. Excluded wells P246 and P217 in average calculations (initial concentrations at or near baseline chloride concentration at onset of full-scale restoration (<50 mg/L).
2. Excluded Feburary 2010 and June 2010 sampling events (only 2 wells sampled) from average calculations.
3. Red Font = exceeded NDEQ Restoration Value
4. – = not analyzed

TABLE 3-3
MU-2 Volume of Groundwater Treated During Restoration

Date	MU-2 RO (gallons)
May-09	[redacted]
Jun-09	[redacted]
Jul-09	[redacted]
Aug-09	[redacted]
Sep-09	[redacted]
Oct-09	[redacted]
Nov-09	[redacted]
Dec-09	[redacted]
Jan-10	[redacted]
Feb-10	[redacted]
Mar-10	[redacted]
Apr-10	1,259,559
May-10	1,272,850
Jun-10	1,286,686

Full-Scale Restoration Period

Notes:

1. RO = Reverse Osmosis

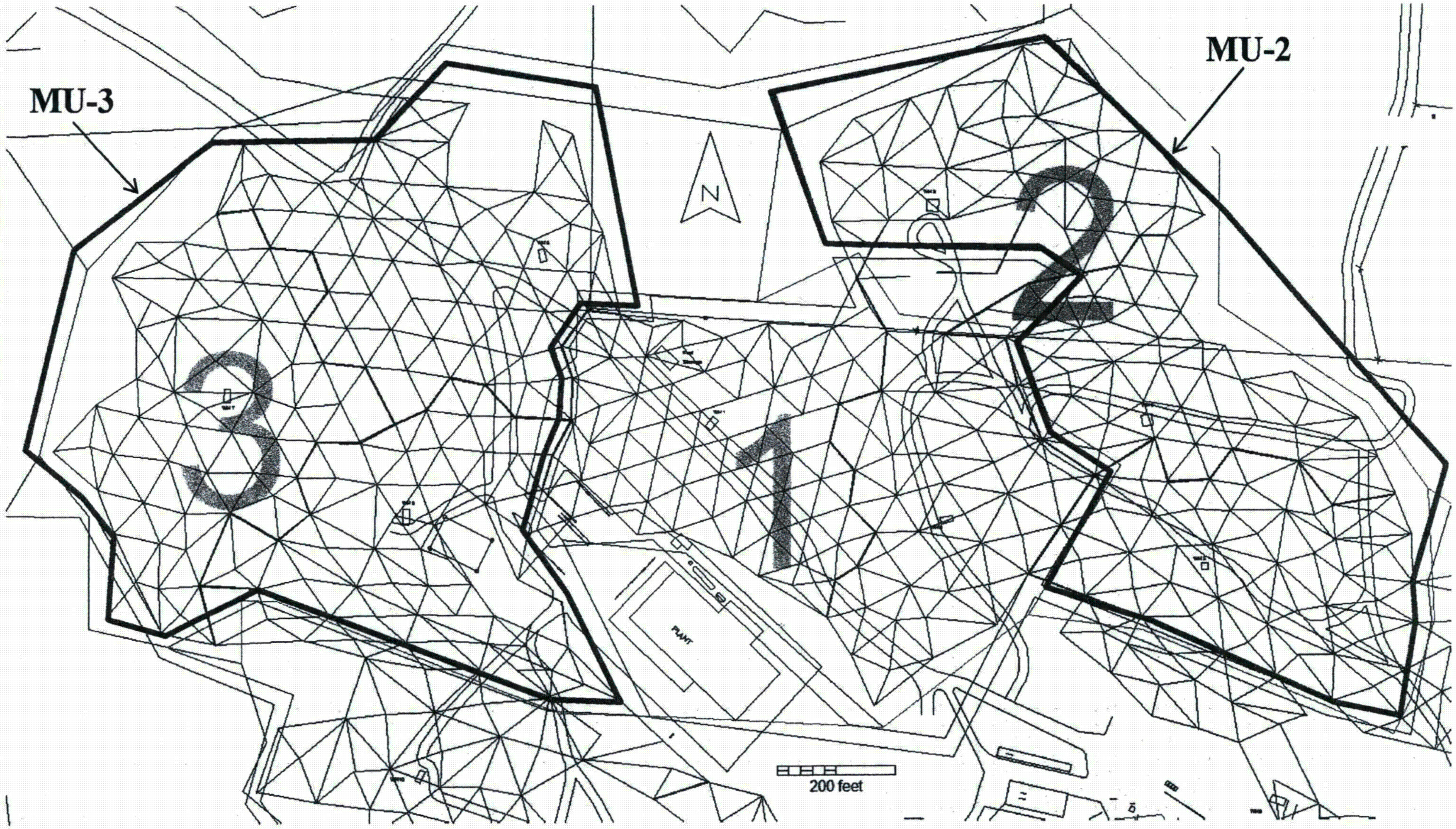
TABLE 3-4
MU-3 Volume of Groundwater Treated During Restoration

Date	MU-3 RO (gallons)
Dec-09	9,241,922
Jan-10	8,486,645
Feb-10	7,709,118
Mar-10	8,710,379
Apr-10	10,108,820
May-10	10,179,871
Jun-10	8,492,464
Jul-10	8,686,298
Aug-10	9,193,635
Sep-10	5,649,331
Oct-10	7,257,347
Nov-10	1,571,039
Dec-10	1,932,584
Jan-11	2,942,281
Feb-11	3,540,161
Mar-11	3,871,855
Apr-11	3,382,771
May-11	1,764,783
Jun-11	3,211,305
Jul-11	3,224,826
Aug-11	3,236,451
Sep-11	3,463,516
Oct-11	3,347,188
Nov-11	1,830,082
Dec-11	1,723,149
Jan-12	1,332,812

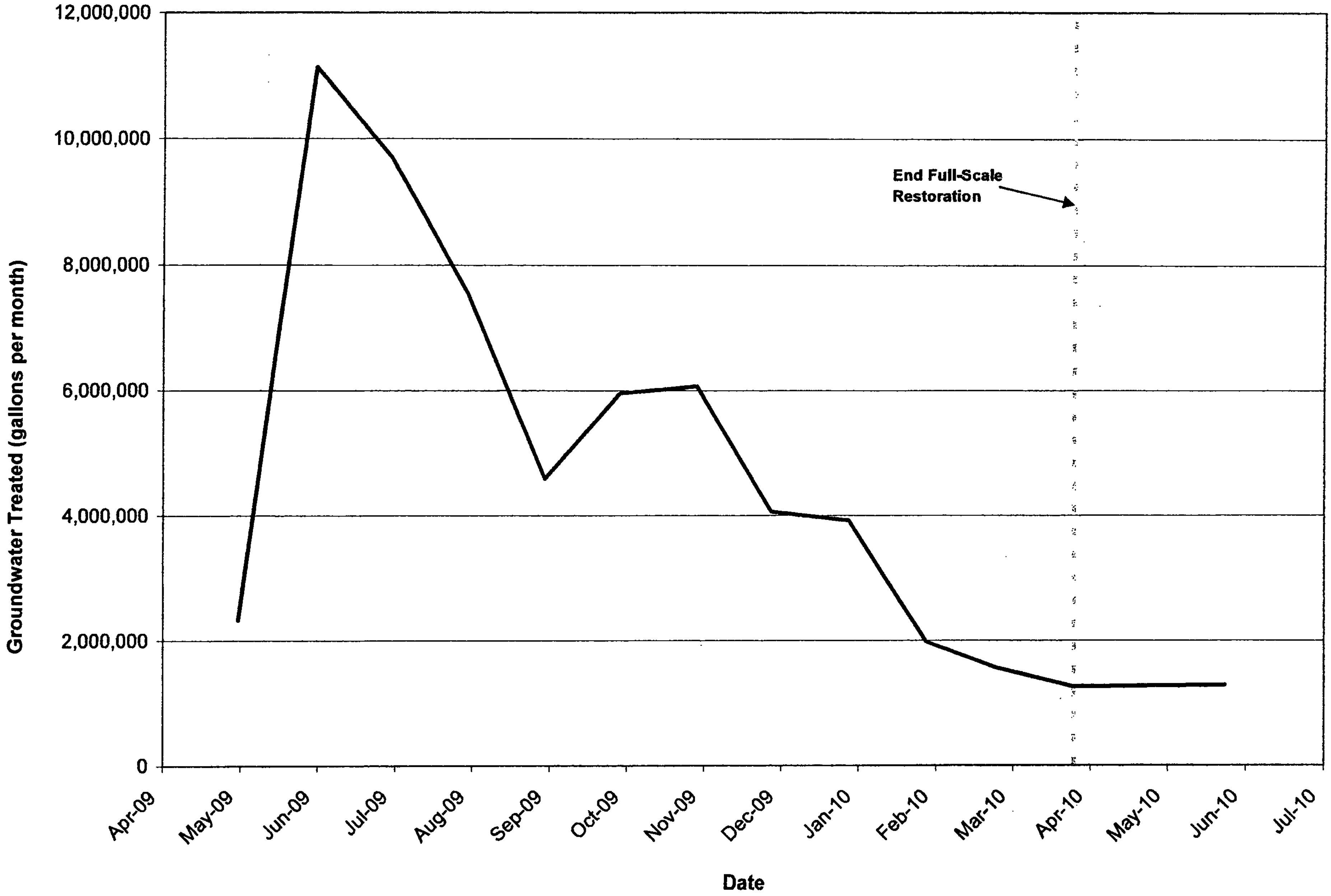
Full-Scale Restoration Period (shaded)

Notes:

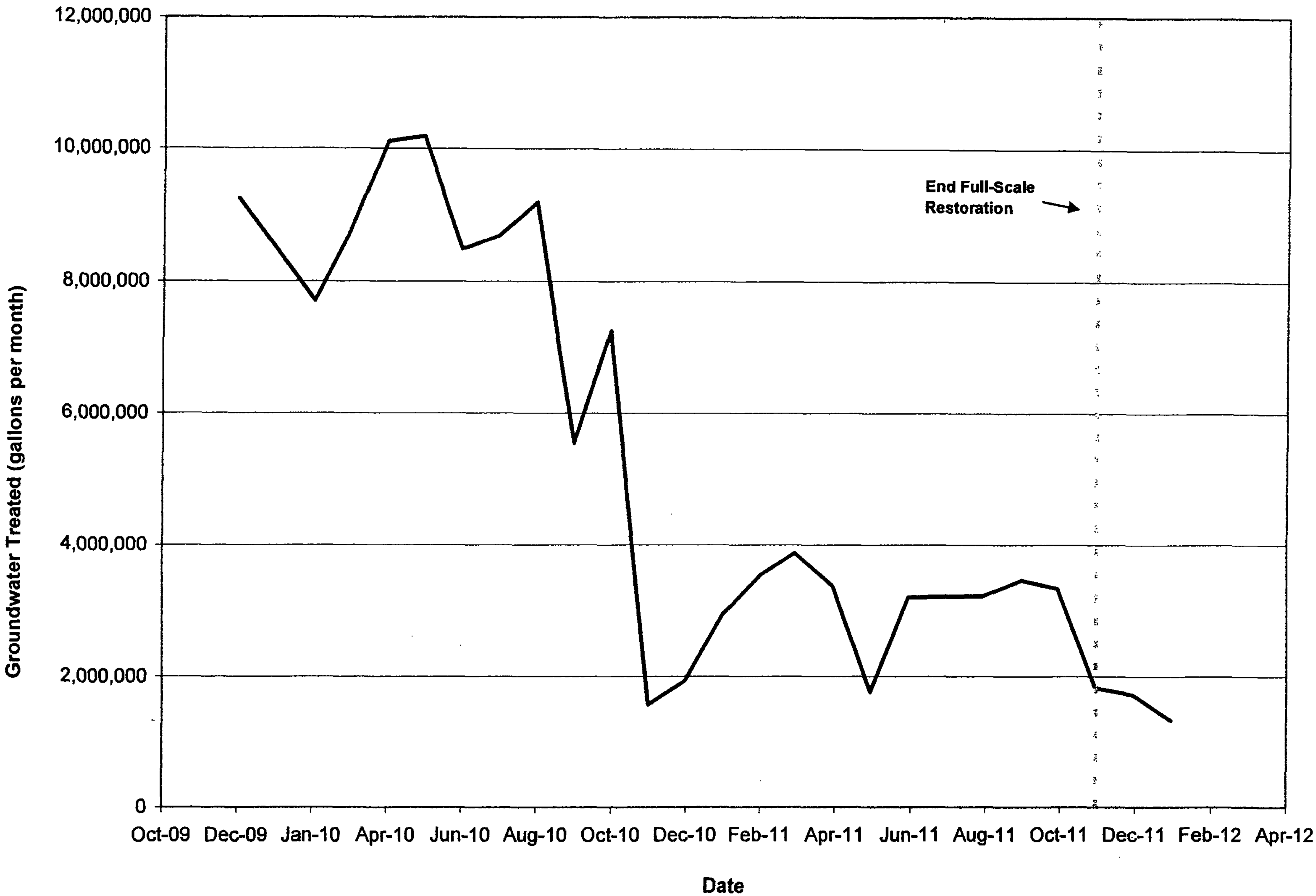
1. RO = Reverse Osmosis



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	Mine Units MU-2 and MU-3	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: 3-1



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MU-2 Groundwater Extraction and RO Treatment Rate**	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: **3-2**



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MU-3 Groundwater Extraction and RO Treatment Rate**	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: **3-3**

4. PORE VOLUME RESTORATION MODELING

Pore volume restoration requirements were calculated by applying the general approach of Zheng et al. (1991, 1992) using the concept of the mixed linear reservoir (MLR) or batch mixing model of Gelhar and Wilson (1974). This methodology has been previously employed to compute pore volume restoration requirements at Cameco's Smith Ranch-Highland facility in Converse County, Wyoming (Lewis Water Consultants, 1999). The MLR model is based on the simple principle that an affected aquifer can be represented as a fully mixed solution at some average concentration. The concentration of this solute then changes instantaneously in response to changes in inflow, outflow, and solute mass.

4.1 Mixed Linear Reservoir (MLR) Model

The number of pore volumes (Npv) required to reduce the initial concentration (Ci) of a dissolved chemical constituent to a lesser or final concentration (Cs) based on the MLR model is given by:

$$Npv = - R \ln (Cs/Ci) \quad (1)$$

Where R is the retardation factor, which is a measure of chemical attenuation within the aquifer. For a conservative or non-reactive chemical constituent such as chloride, R equals 1.0.

Figures 4-1 and 4-2 compare the modeled and observed chloride pore volume restoration curves for MU-2 and MU-3, respectively. In general, modeled and observed pore volume restoration curves compare favorably for the duration of full-scale restoration. Given an initial chloride concentration of 259.78 mg/L, a final chloride concentration of 27.29 mg/L in March 2010, the total number of pore volumes treated in MU-2 as part of the MBRP was 2.25. Likewise, given an initial chloride concentration of 304.67 mg/L, a final chloride concentration of 54.64 mg/L in October 2011, the total number of pore volumes treated in MU-3 as part of the MBRP was 1.72.

Given the total number of pore volumes treated, retardation factors for other non-conservative chemical constituents can be calculated by rearranging equation (1) and solving for R. **Tables 4-1 and 4-2** summarize calculated R values for constituents of concern for MU-2 and MU-3, respectively. R values less than one are calculated for some dissolved metals, which is interpreted to represent accelerated restoration due to the injection of sodium sulfide and associated metal reduction, or other geochemical reactions. Figures **4-3 through 4-12** compare the resulting modeled and observed pore volume restoration curves in MU- 2 for 10 constituents of concern. Similarly, **Figures 4-13 through 4-22** compare the resulting modeled and observed pore volume restoration curves in MU-3 for 10 constituents of concern. It is not possible to compute pore volume restoration curves for constituents with initial and final concentrations that were increasing or near the detection limit during the restoration period.

4.2 Affected Pore Volume Calculations

A benefit of the MLR model is the ability to calculate the affected pore volume (APV) as:

$$APV = TV/Npv \quad (2)$$

where TV is the total volume of groundwater extracted as part of the MBRP. For example, given a total volume of groundwater extracted as part of the MBRP of 58,870,540 gallons and 2.25 pore volumes treated from equation (1), the theoretical APV for MU-2 from equation (2) is 26,164,684 gallons. By comparison, Cameco's calculated APV for MU-2 is 21,622,000 gallons. Similarly, given a total volume of groundwater extracted as part of the MBRP of 126,861,972 gallons and 1.72 pore volumes treated, the theoretical APV for MU-3 is 73,756,960 gallons. Cameco's calculated APV for MU-3 is 19,073,000. The difference between the theoretical and calculated APV's represents a combination of uncertainties including:

- uncertainty in Cameco's APV calculations (e.g. estimated flare factor, porosity, pattern area, sand thickness),
- restoration inefficiency (although much less than historical inefficiencies described in 2.1), including over-treatment of restored areas and areas bordering MU-2 and MU-3 (e.g. injection fence along boundary with MU-4, restored areas bordering MU-1),
- deviation from the theoretical model assumption of complete mixing (e.g. variability in water quality across the mine unit), and
- uncertainty in the computed average water quality (e.g. sampling a large number of wells will better approximate the average water quality than sampling a small number of wells).

4.3 Summary of Pore Volume Restoration Analysis in MU-2 and MU-3

Results of the pore volume analysis in MU-2 and MU-3 demonstrate that restoration of these mine units was accomplished (with the exception of local elevated arsenic concentrations in MU-3) in approximately 6 to 9 months following the implementation of the MBRP. Restoration was achieved after 2.11 pore volumes of groundwater treatment in MU-2, and 0.74 pore volumes of groundwater treatment in MU-3. The total number of pore volumes treated in MU-2 and MU-3 as part of the MBRP was 2.25 and 1.72, respectively.

Spot treatment in MU-2 and MU-3 continued following full-scale restoration to address localized elevated arsenic and/or vanadium concentrations and to prepare for stability. Recent geochemical evaluations of arsenic and vanadium trends in MU-2 and MU-3 suggest localized elevated concentrations of arsenic and vanadium likely occur due to local over-treatment by injection of RO permeate, resulting in loss of aquifer buffering capacity and increased pH as inorganic carbon is removed (arsenic and vanadium mobility increases with increasing pH in this system). Care will be taken in the future to prevent over-treatment of restored areas to prevent the mobilization of arsenic and vanadium.

TABLE 4-1
Calculated Retardation Factors (R Values) in MU-2

Constituent	Ci (mg/l)	Cs (mg/l)	Cs/Ci	LN (Cs/Ci)	Npv	R
Ammonia	NA	NA	NA	NA	2.25	NA
Arsenic	0.018	0.033	1.857	0.62	2.25	NC
Barium	NA	NA	NA	NA	2.25	NA
Cadmium	NA	NA	NA	NA	2.25	NA
Chloride	259.78	27.29	0.105	-2.25	2.25	1.00
Copper	NA	NA	NA	NA	2.25	NA
Fluorine	0.36	0.77	2.156	0.77	2.25	NC
Iron	0.10	0.37	3.761	1.32	2.25	NC
Mercury	NA	NA	NA	NA	2.25	NA
Manganese	0.10	0.02	0.208	-1.57	2.25	1.43
Molybdenum	NA	NA	NA	NA	2.25	NA
Nickel	NA	NA	NA	NA	2.25	NA
Nitrate as N	NA	NA	NA	NA	2.25	NA
Lead	NA	NA	NA	NA	2.25	NA
Radium 226	335.43	91.71	0.273	-1.30	2.25	1.74
Selenium	0.002	0.001	0.625	-0.47	2.25	NC
Sodium	478.63	108.00	0.226	-1.49	2.25	1.51
Sulfate	458.33	51.43	0.112	-2.19	2.25	1.03
Uranium	3.81	0.46	0.120	-2.12	2.25	1.06
Vanadium	0.70	0.23	0.333	-1.10	2.25	2.05
Zinc	NA	NA	NA	NA	2.25	NA
Calcium	35.67	3.17	0.089	-2.42	2.25	0.93
Carbonate	NA	NA	NA	NA	2.25	NA
Potassium	14.23	3.57	0.251	-1.38	2.25	1.63
Magnesium	8.11	1.00	0.123	-2.09	2.25	1.07
Total Dissolved Solids	1521.56	314.29	0.207	-1.58	2.25	1.43

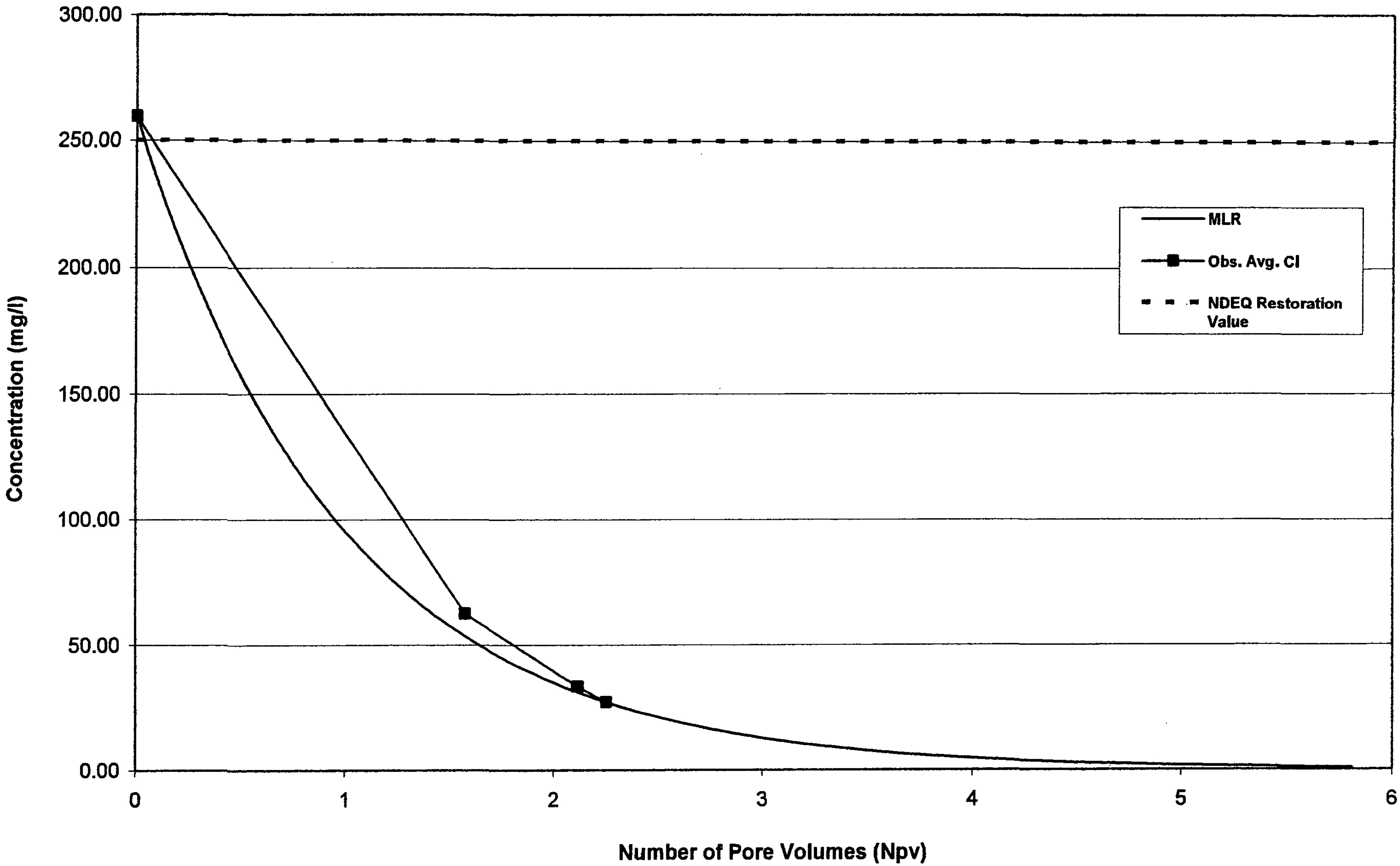
Notes:
1. NC = not calculated due to steady or increasing concentrations, or concentrations near or below the detection limit.
2. NA = not applicable due to no available or limited groundwater sample data.
3. Ci = average initial concentration at the beginning of full-scale restoration.
4. Cs = average concentration at the end of full scale restoration.
5. Npv = number of pore volumes.
6. R (retardation factor) = - Npv / LN (Cs/Ci).
7. mg/l = milligrams per liter.

TABLE 4-2
Calculated Retardation Factors (R Values) in MU-3

Constituent	Ci (mg/l)	Cs (mg/l)	Cs/Ci	LN (Cs/Ci)	Npv	R
Ammonia	0.06	0.11	2.000	0.69	1.72	NC
Arsenic	0.02	0.05	2.143	0.76	1.72	NC
Barium	NA	NA	NA	NA	1.72	NA
Cadmium	NA	NA	NA	NA	1.72	NA
Chloride	304.67	54.64	0.179	-1.72	1.72	1.00
Copper	NA	NA	NA	NA	1.72	NA
Fluorine	0.50	0.75	1.491	0.40	1.72	NC
Iron	0.04	0.10	2.673	0.98	1.72	NC
Mercury	NA	NA	NA	NA	1.72	NA
Manganese	0.06	0.02	0.353	-1.04	1.72	1.65
Molybdenum	0.23	0.14	0.600	-0.51	1.72	3.37
Nickel	NA	NA	NA	NA	1.72	NA
Nitrate as N	NA	NA	NA	NA	1.72	NA
Lead	NA	NA	NA	NA	1.72	NA
Radium 226	327.67	44.22	0.135	-2.00	1.72	0.86
Selenium	0.002	0.004	2.667	0.98	1.72	NC
Sodium	642.00	172.73	0.269	-1.31	1.72	1.31
Sulfate	468.33	95.09	0.203	-1.59	1.72	1.08
Uranium	6.01	0.67	0.111	-2.20	1.72	0.78
Vanadium	0.40	0.40	1.000	0.00	1.72	NC
Zinc	NA	NA	NA	NA	1.72	NA
Calcium	41.67	6.50	0.156	-1.86	1.72	0.93
Carbonate	NA	NA	NA	NA	1.72	NA
Potassium	20.67	6.60	0.319	-1.14	1.72	1.51
Magnesium	10.67	2.75	0.258	-1.36	1.72	1.27
Total Dissolved Solids	1,770.00	484.45	0.274	-1.30	1.72	1.33

Notes:

1. NC = not calculated due to steady or increasing concentrations, or concentrations near or below the detection limit.
2. NA = not applicable due to no available or limited groundwater sample data.
3. Ci = average initial concentration at the beginning of full-scale restoration.
4. Cs = average concentration at the end of full-scale restoration.
5. Npv = number of pore volumes.
6. R (retardation factor) = - Npv / LN (Cs/Ci).
7. mg/l = milligrams per liter.



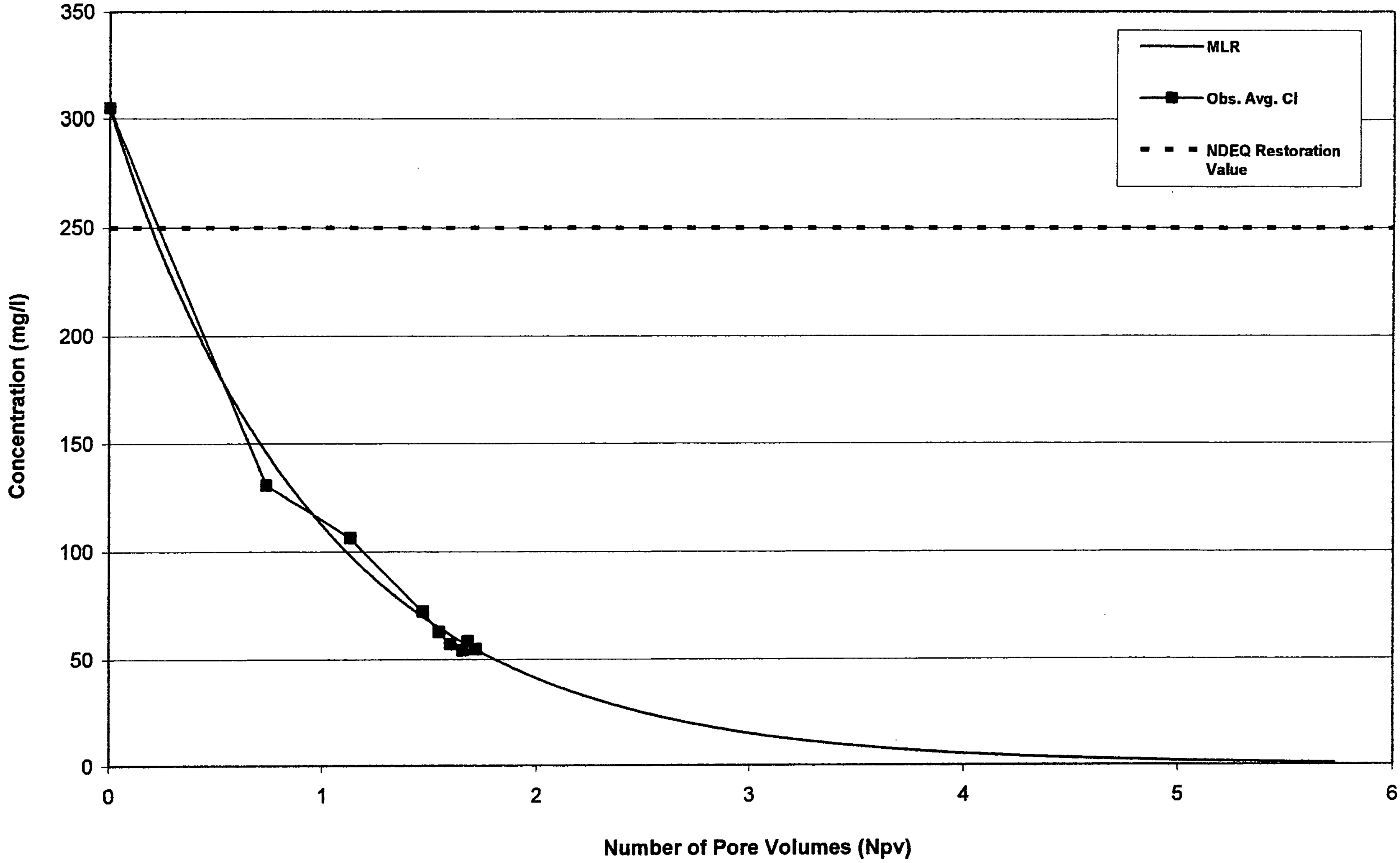
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated Chloride Pore-Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-1



AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

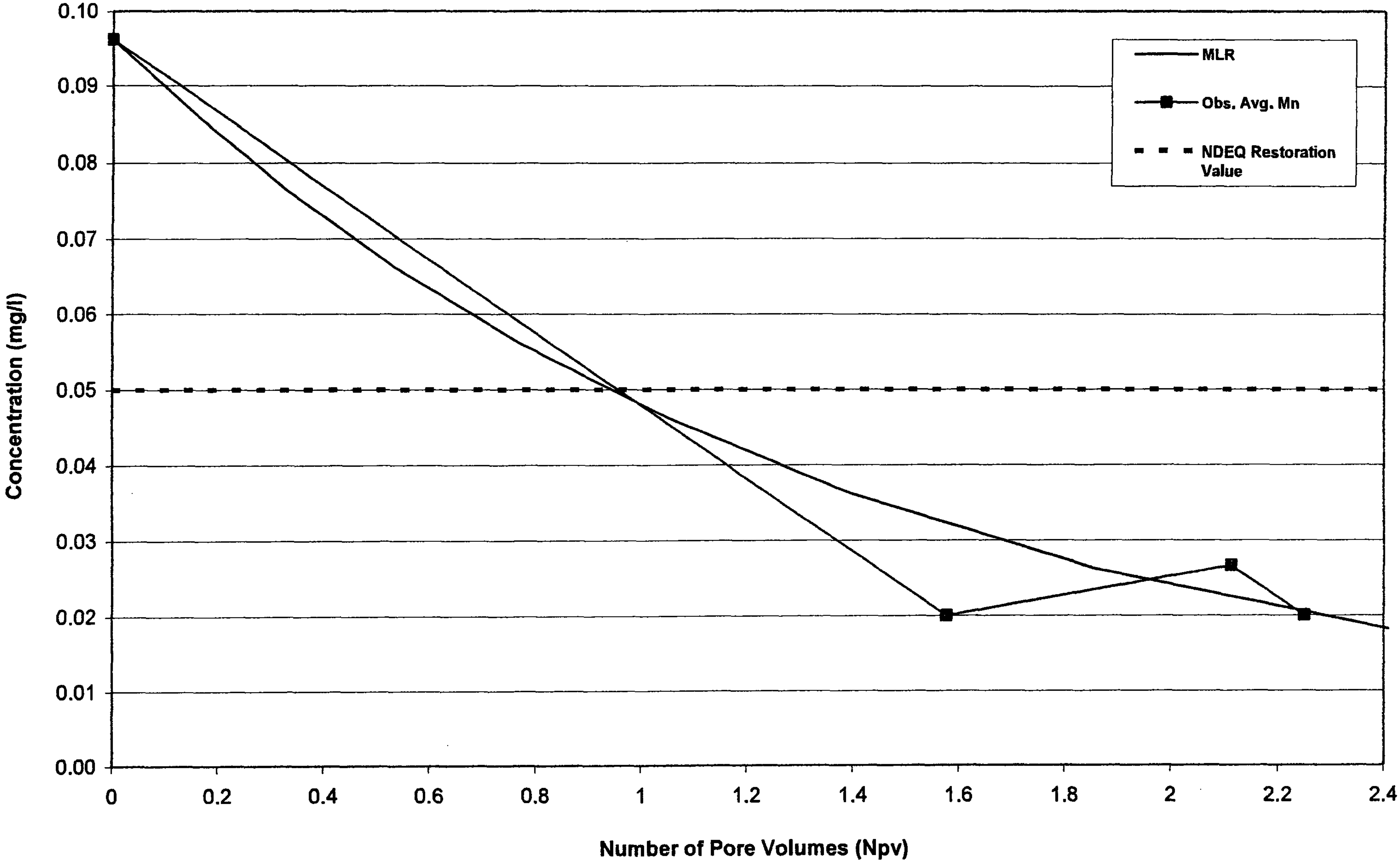
MU-3 Observed vs. Simulated Chloride Pore-Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:

4-2



AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

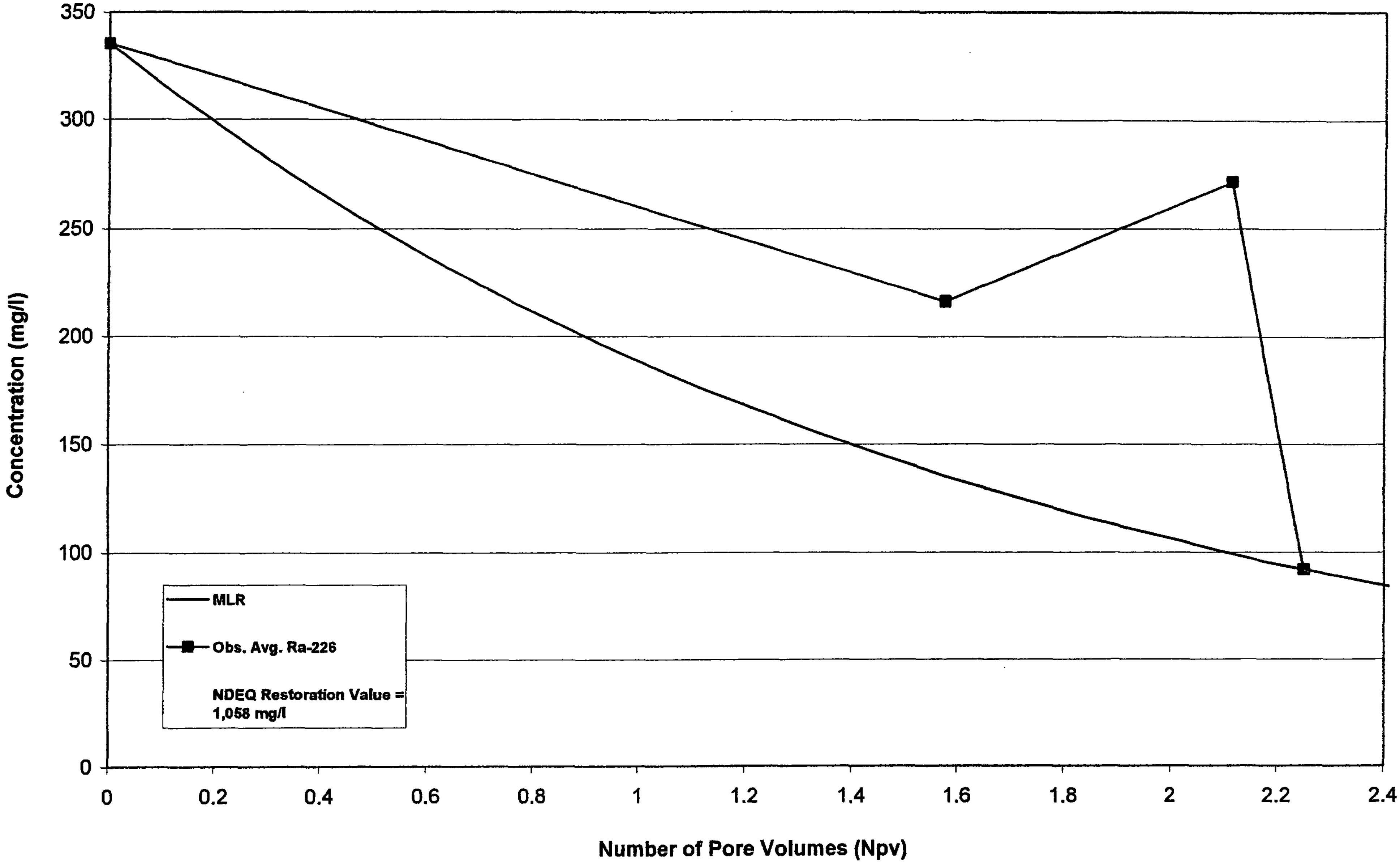
MU-2 Observed vs. Simulated Mn Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:

4-3



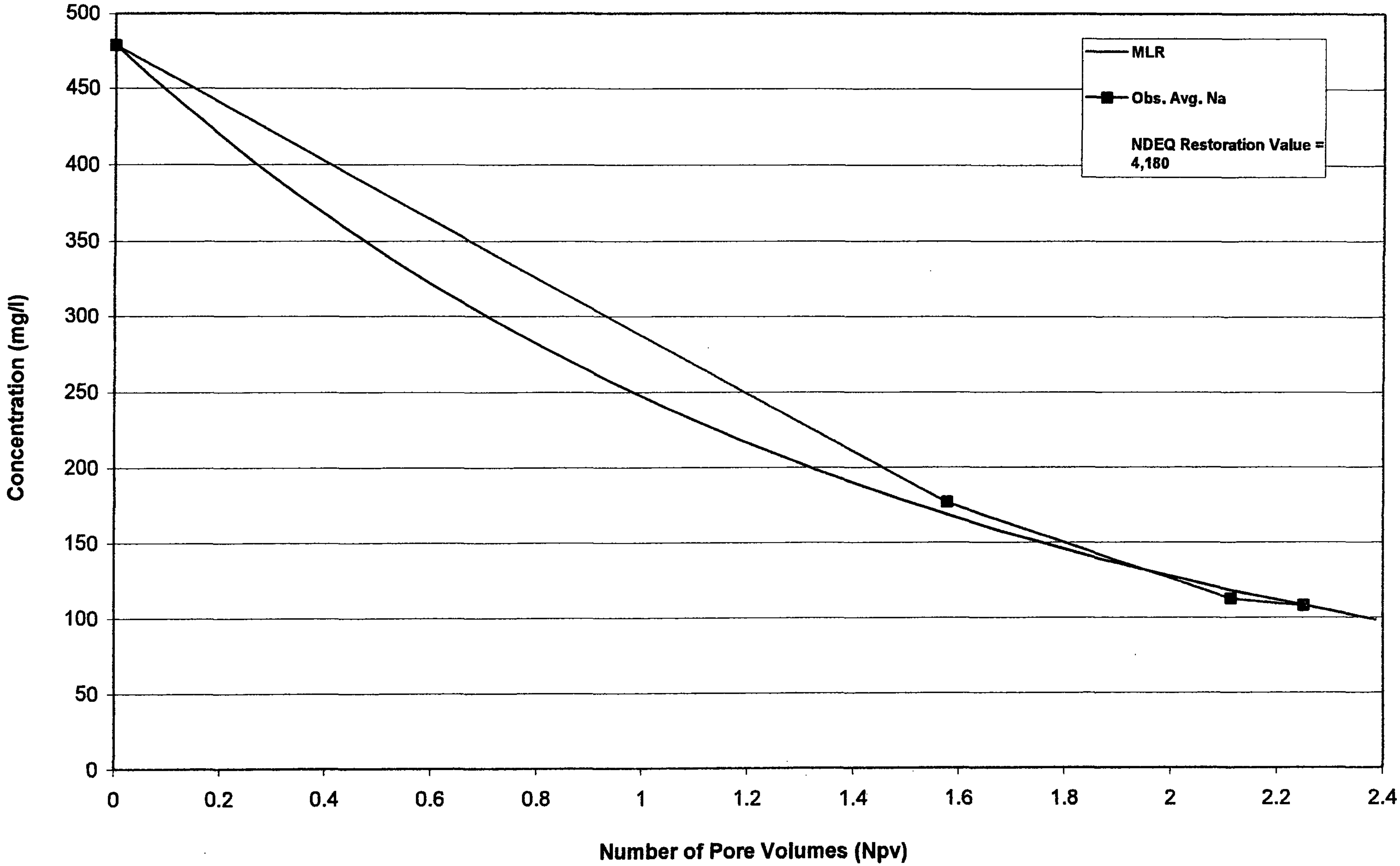
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated Ra-226 Pore Volume Restoration Curve

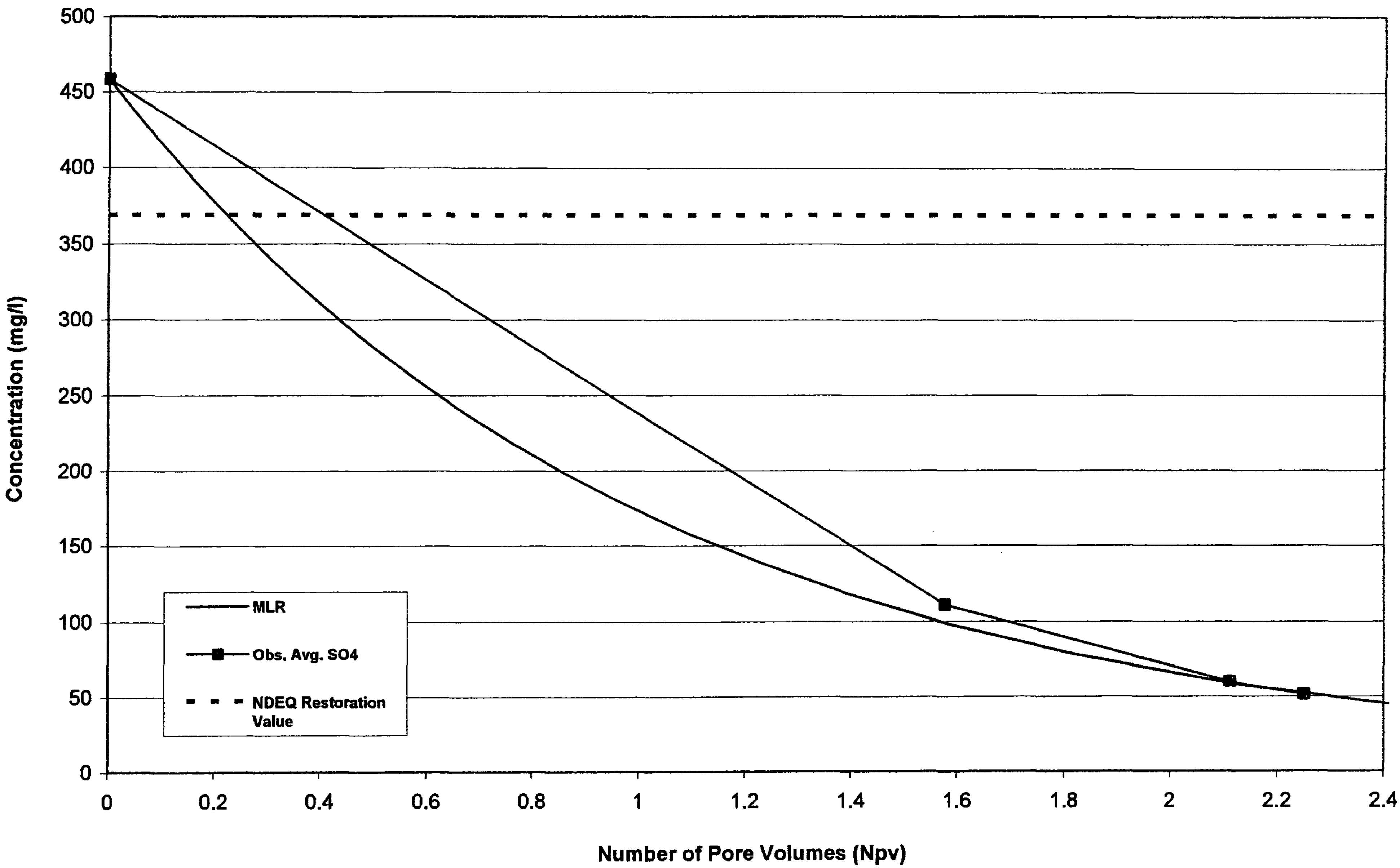
Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-4



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MU-2 Observed vs. Simulated Na Pore Volume Restoration Curve**	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: **4-5**



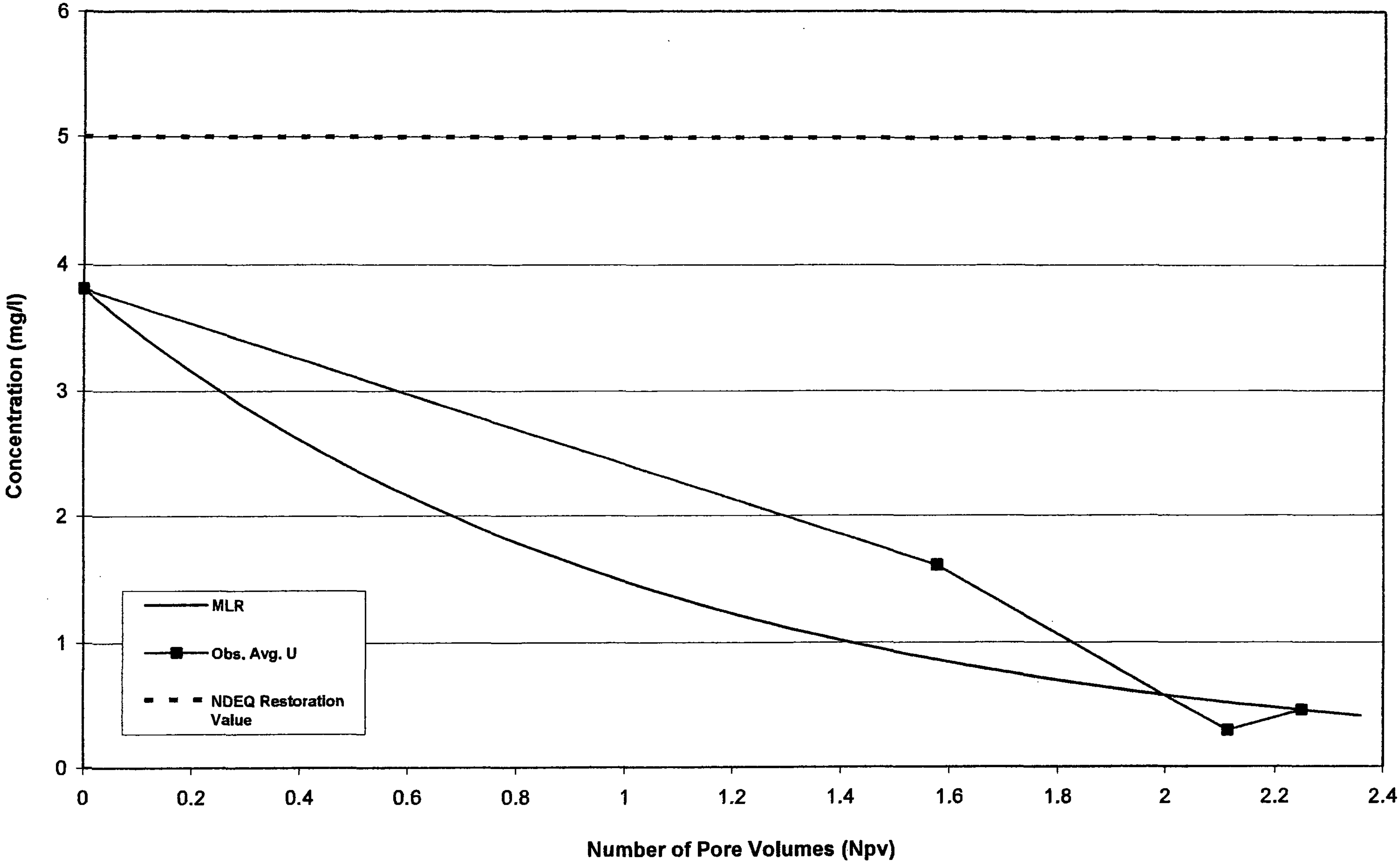
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated SO_4 Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-6



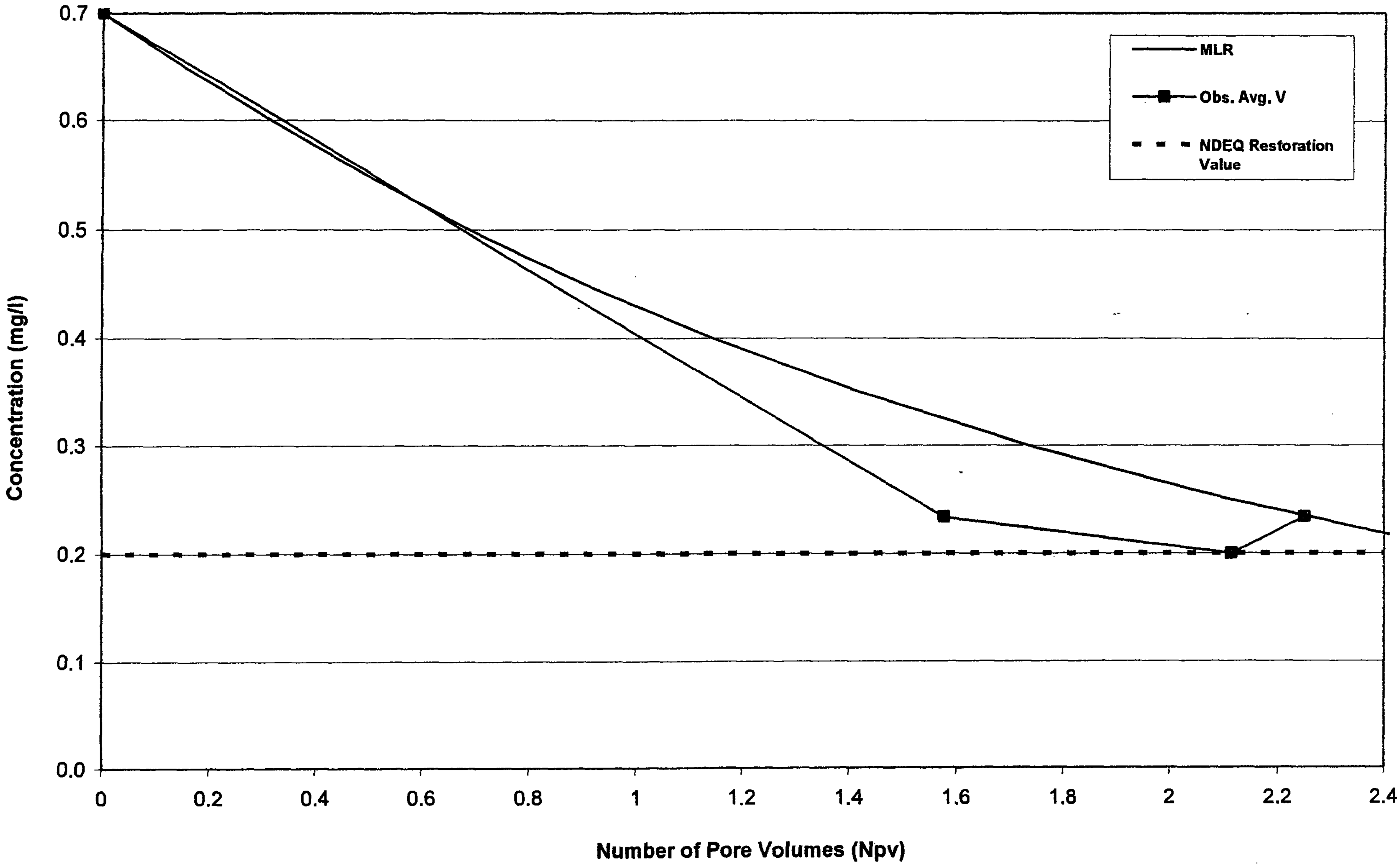
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated U Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-7



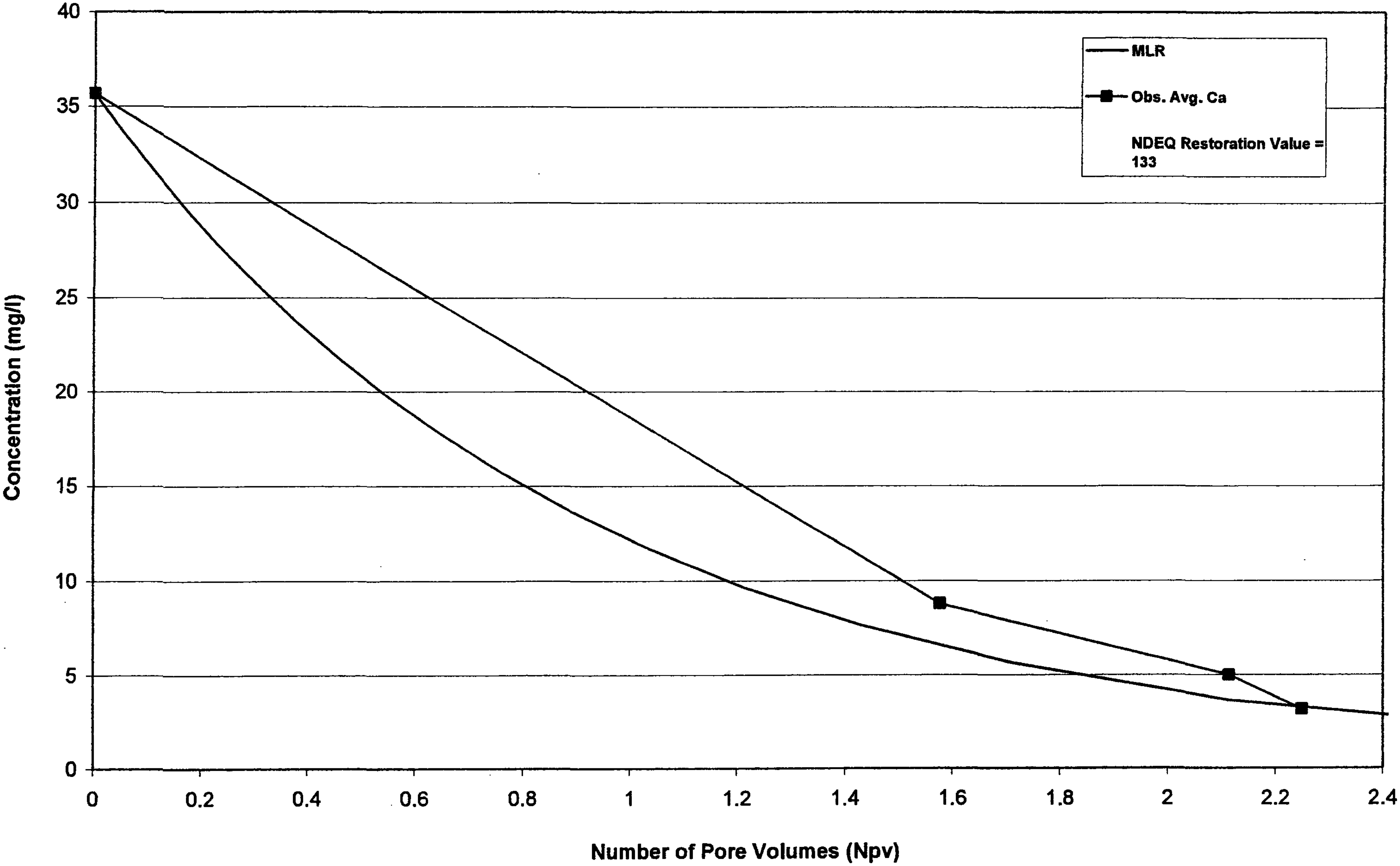
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated V Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-8



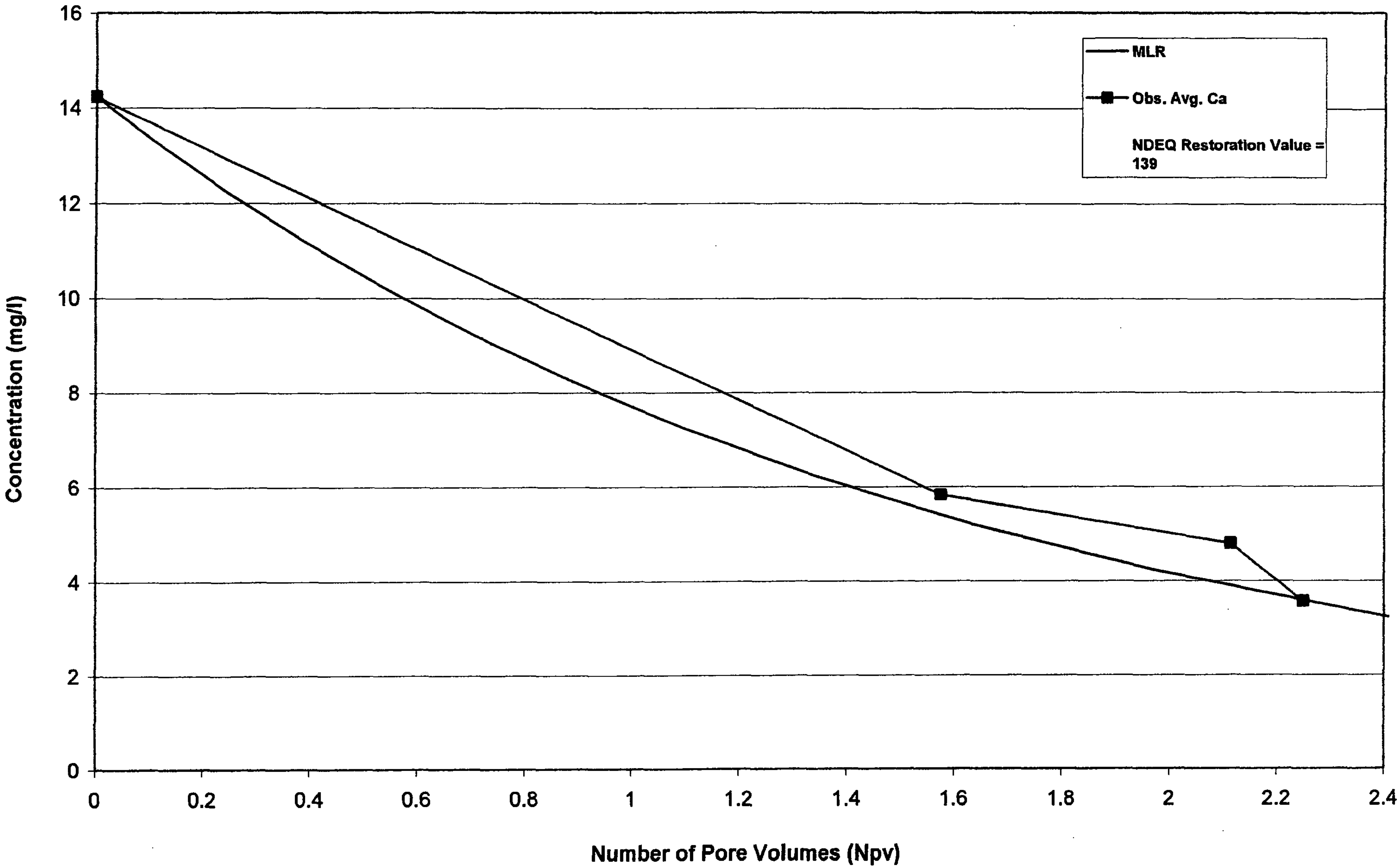
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated Ca Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-9



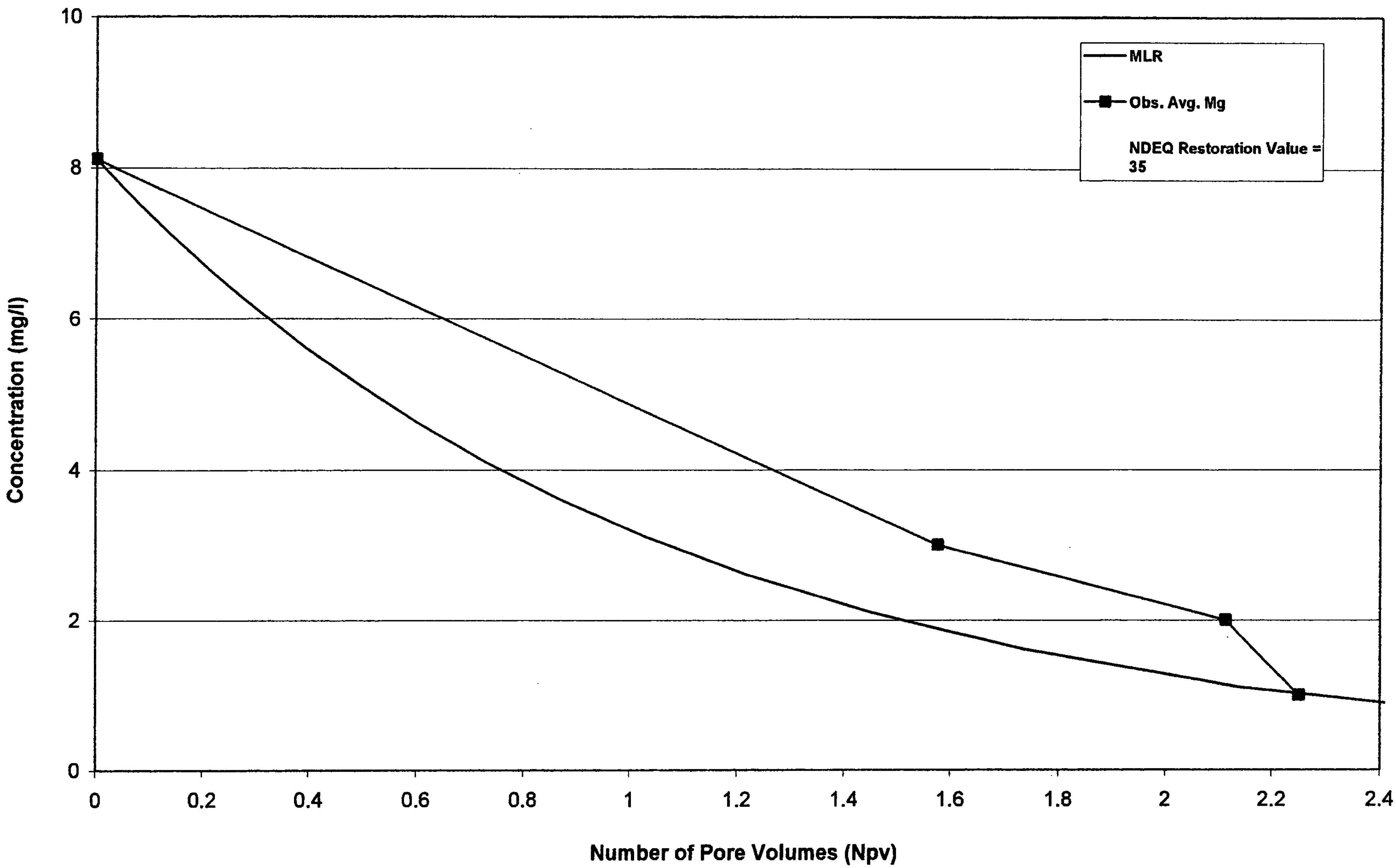
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated K Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-10



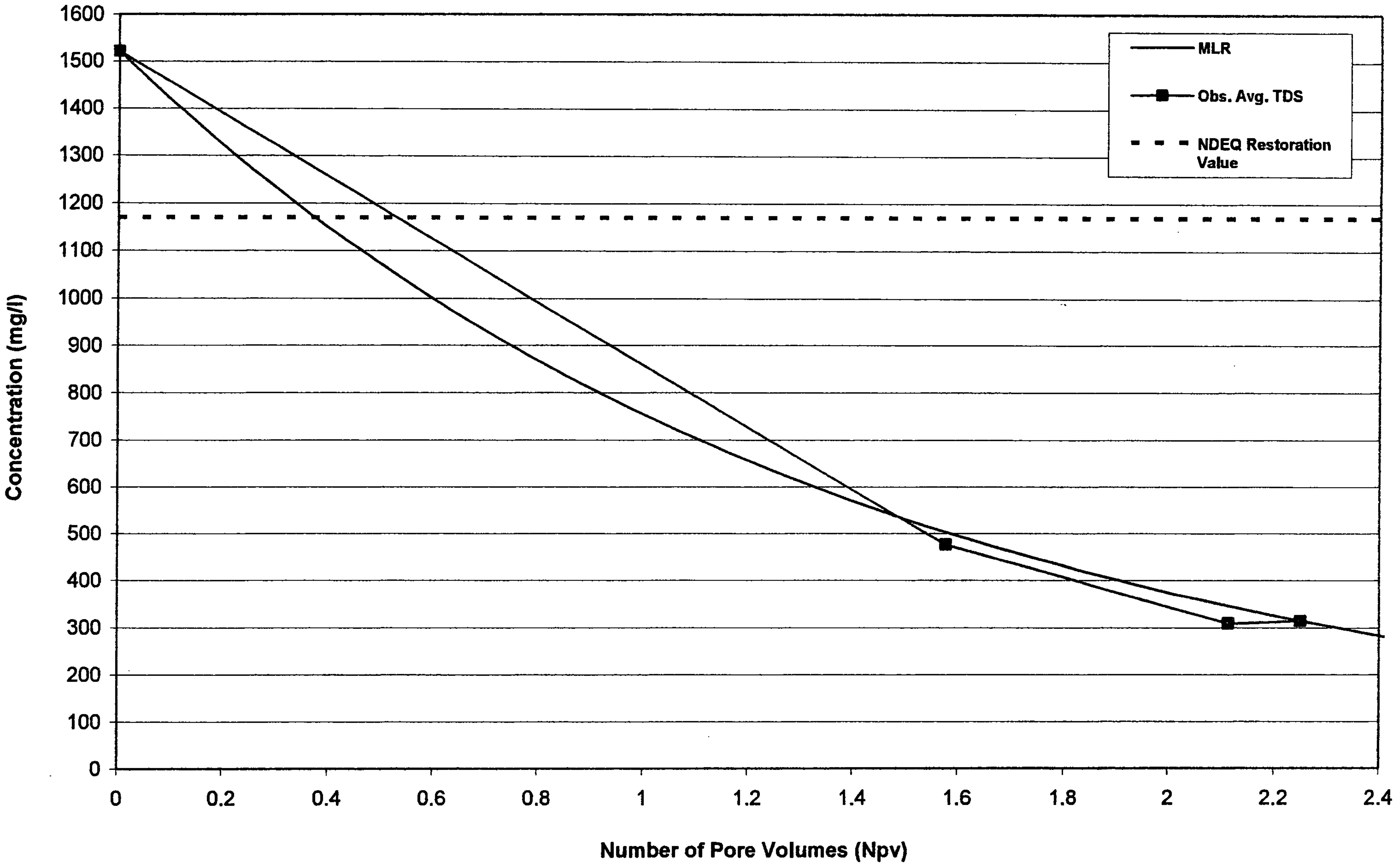
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated Mg Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-11



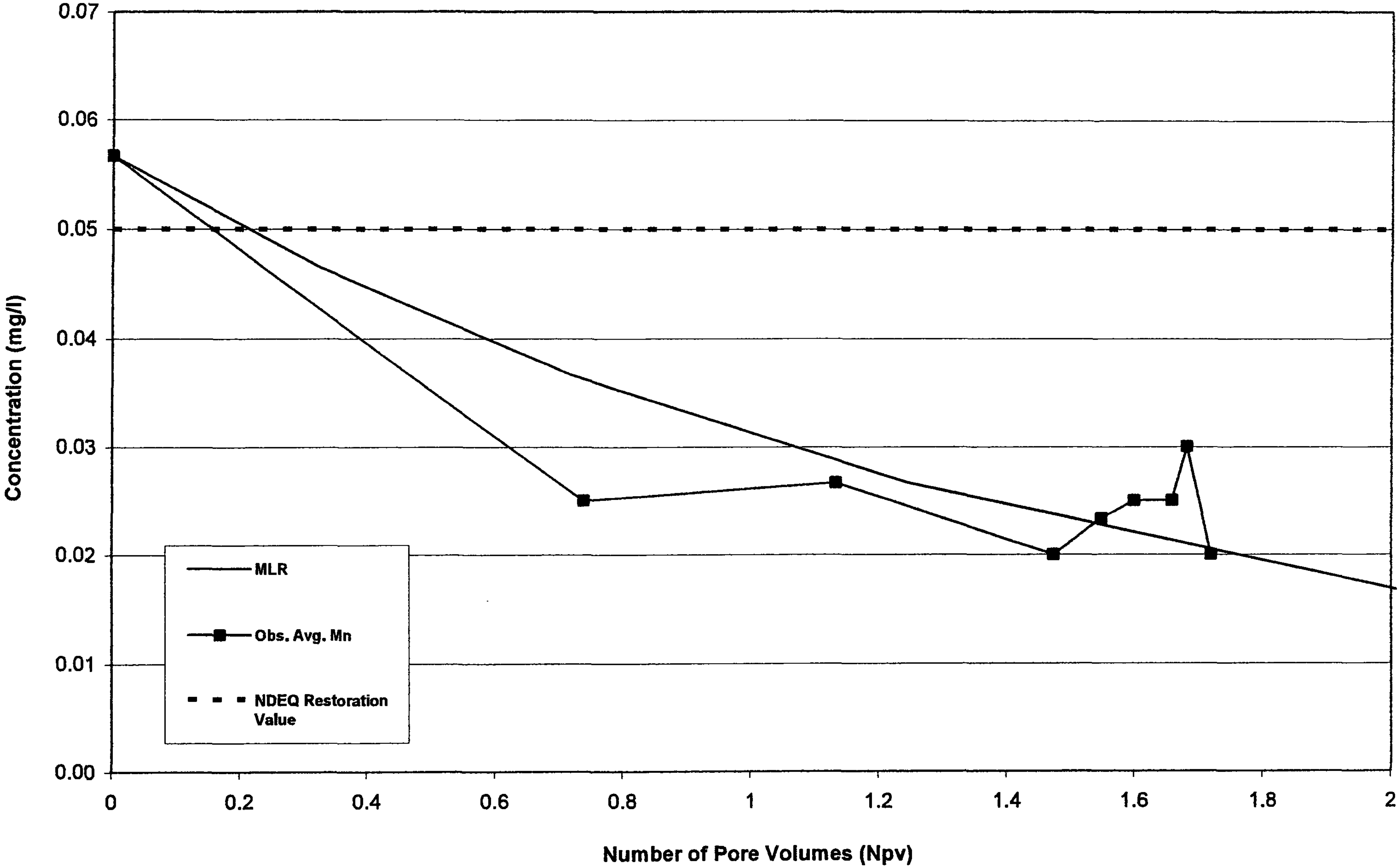
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-2 Observed vs. Simulated TDS Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-12



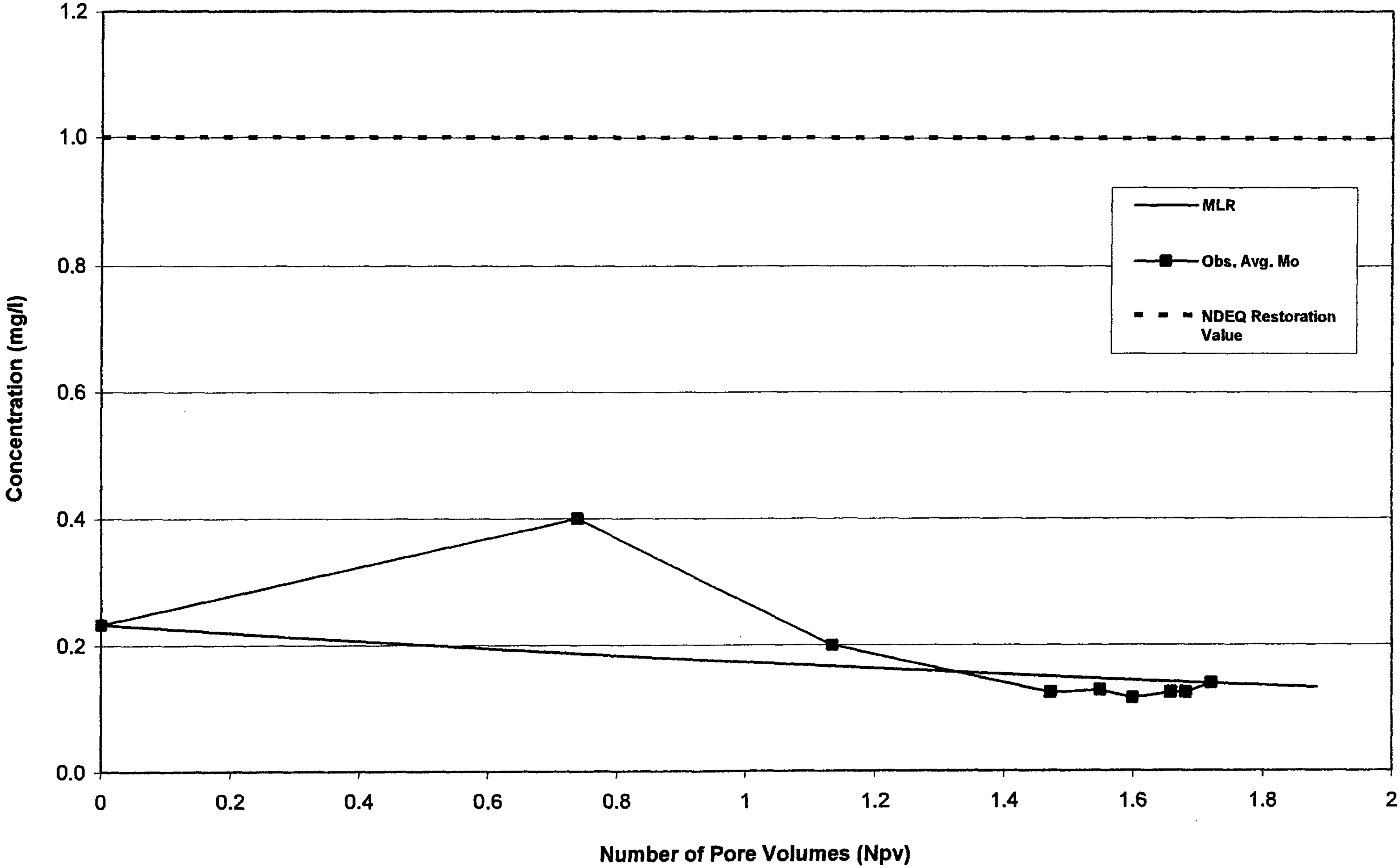
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated Mn Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-13



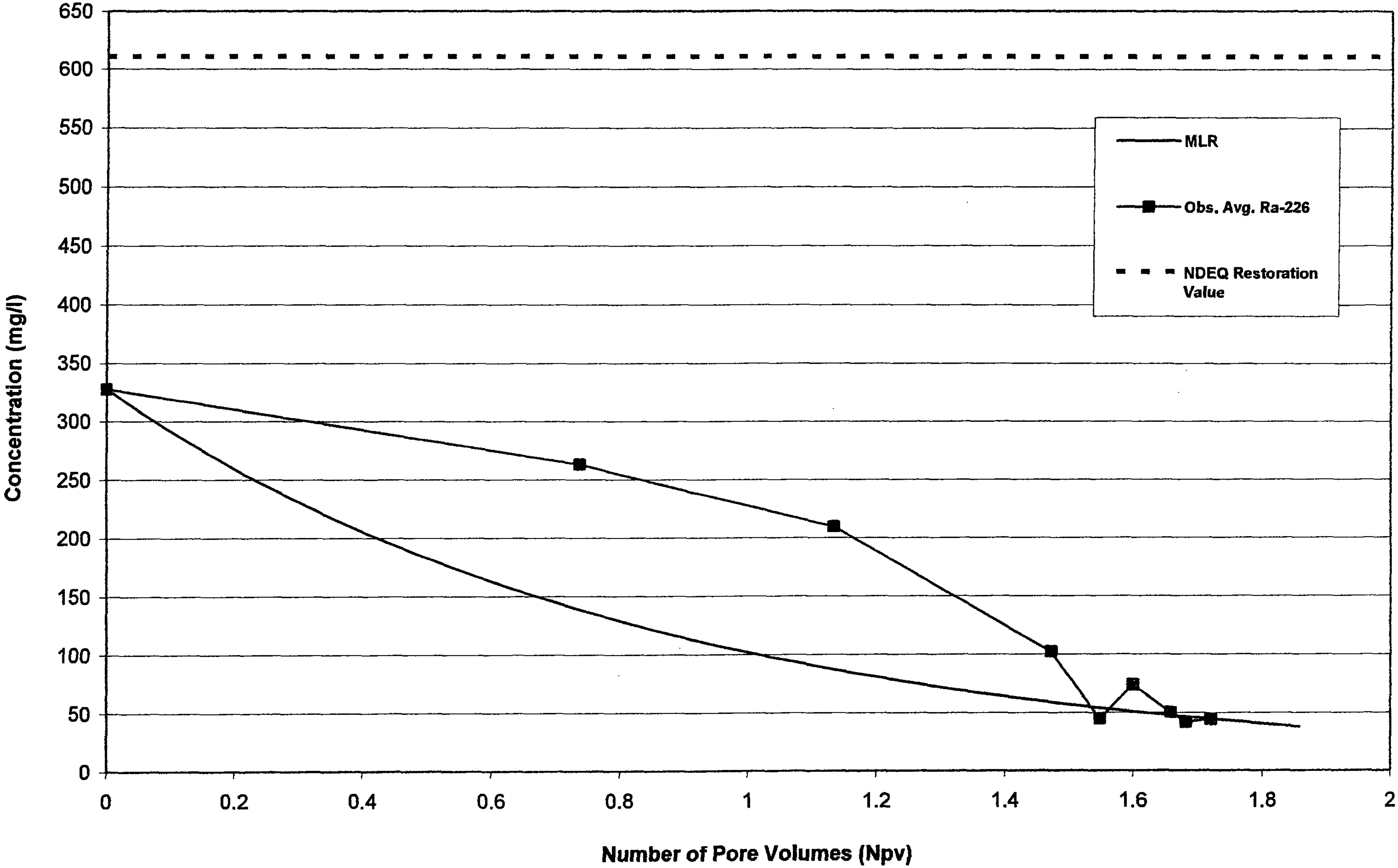
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated Mo Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-14



AQUI-VER, INC.

Hydrogeology, Water Resources & Data Services

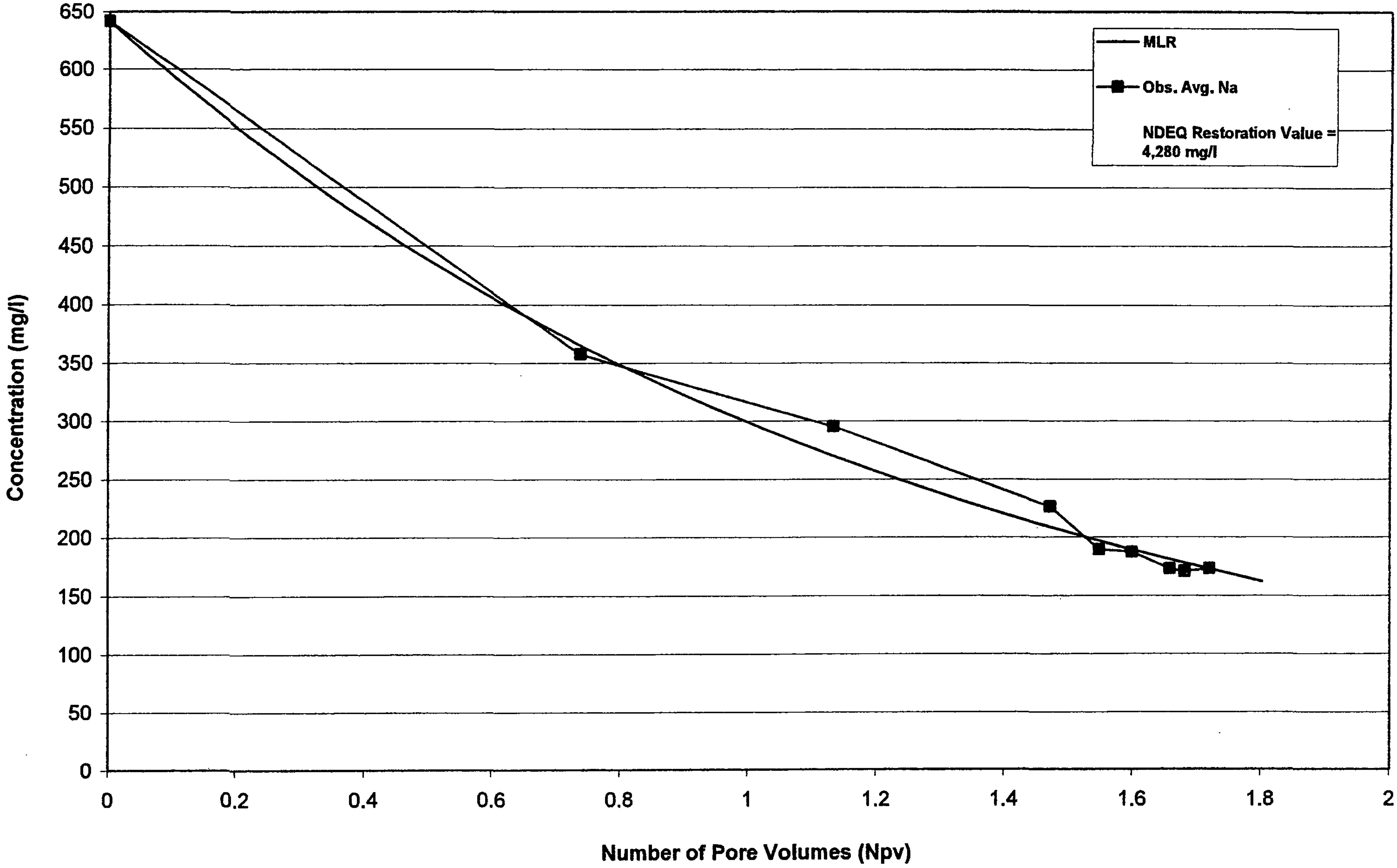
MU-3 Observed vs. Simulated Ra-226 Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:

4-15



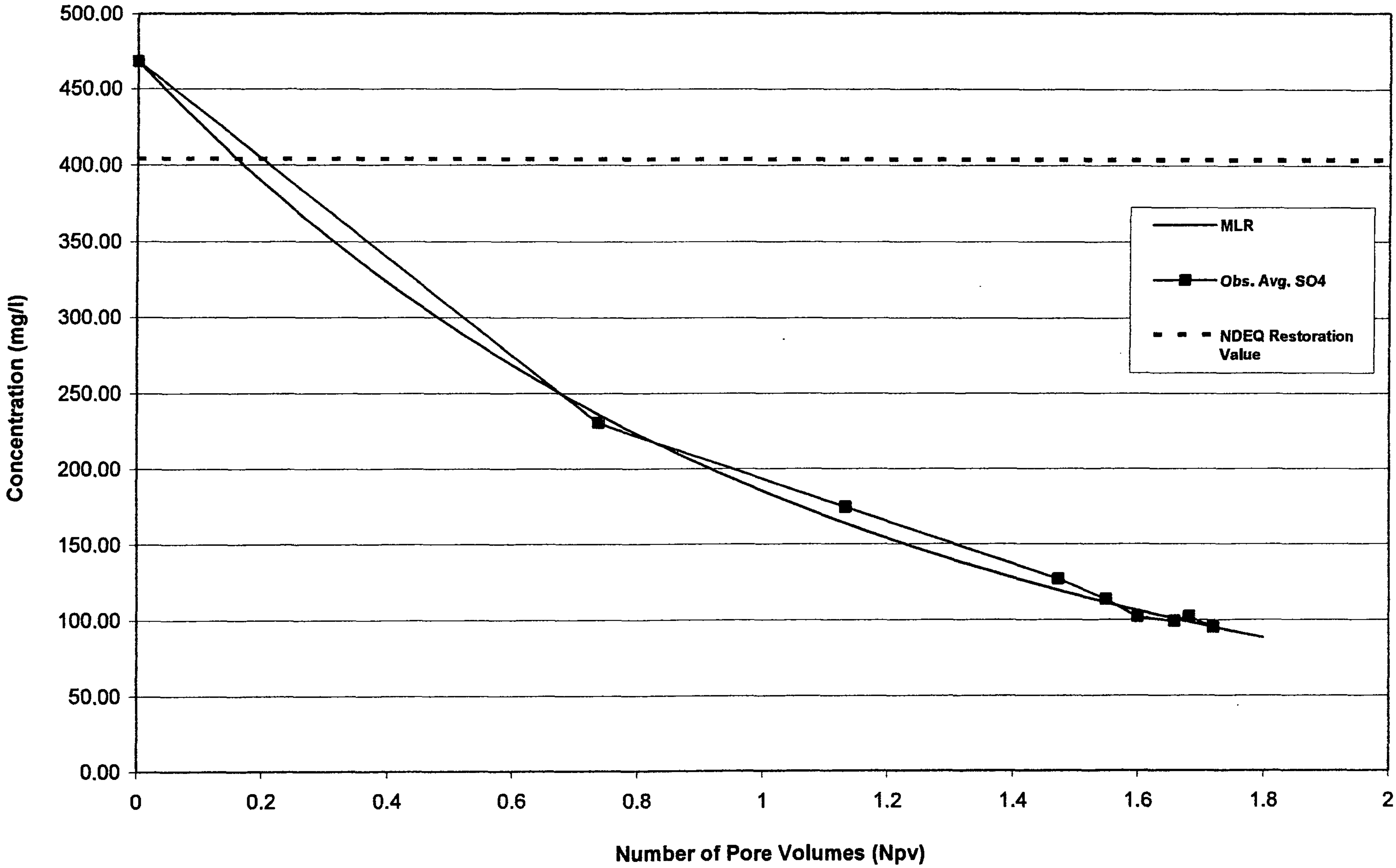
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated Na Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-16



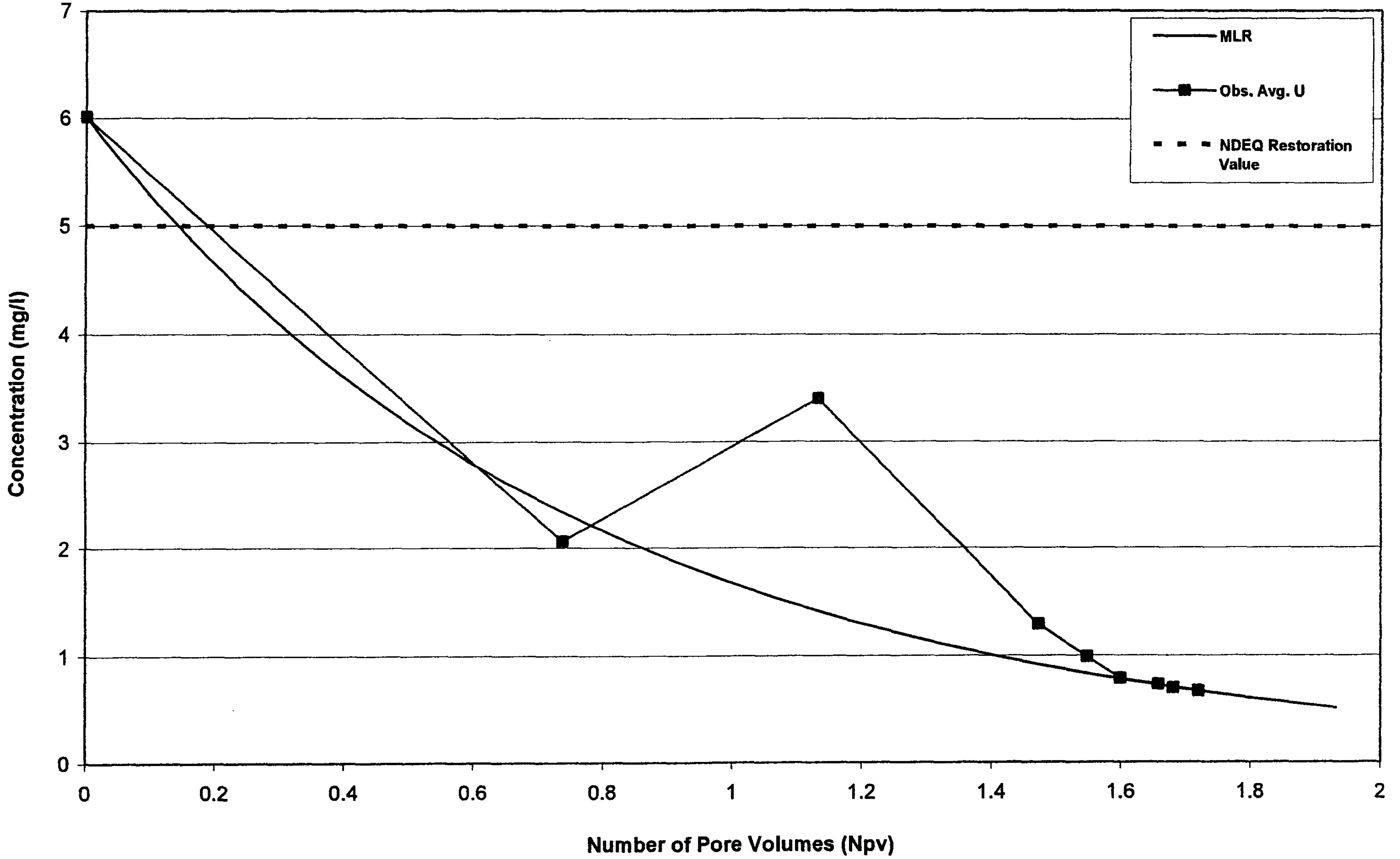
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated SO_4 Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-17



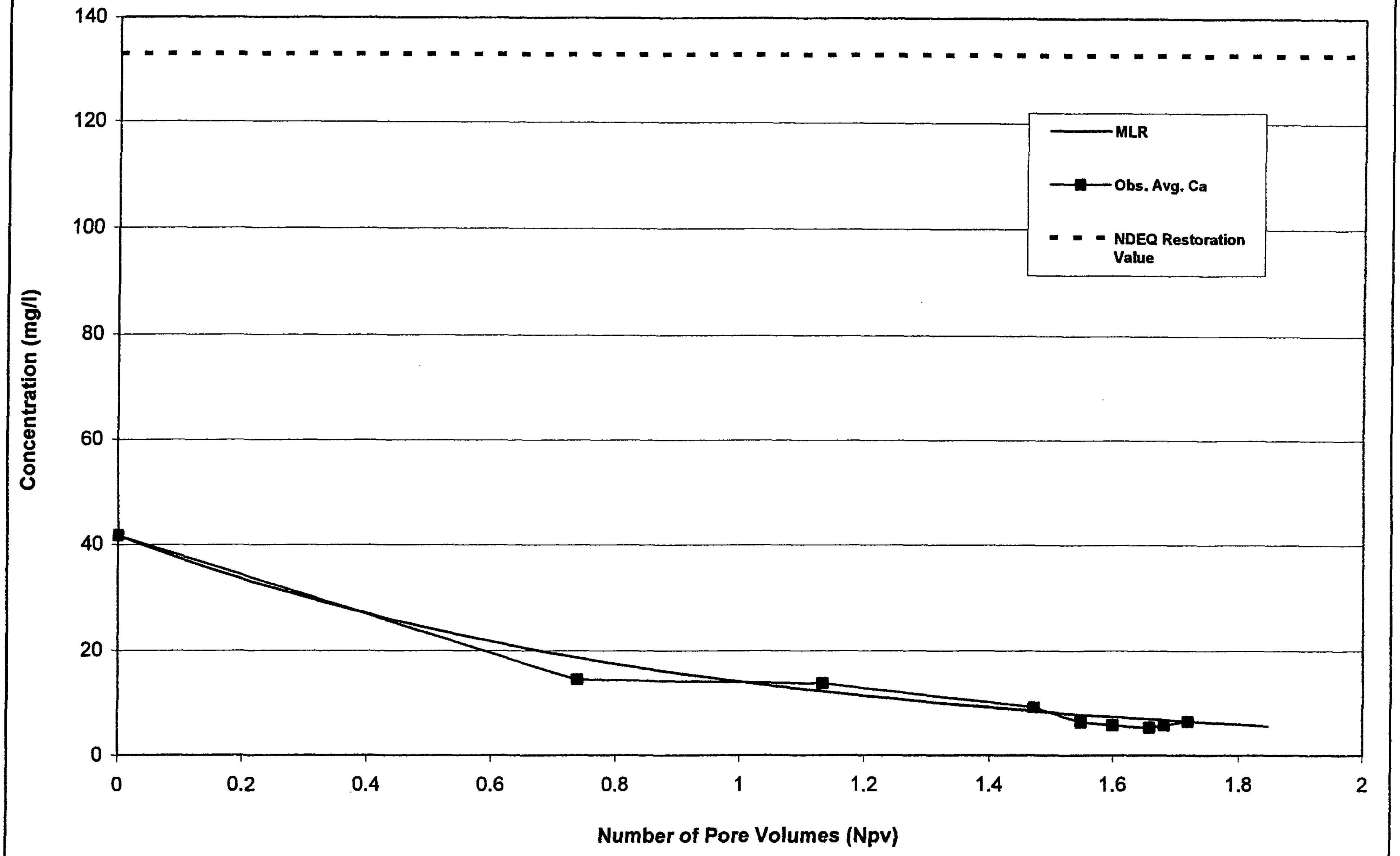
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated U Pore Volume Restoration Curve

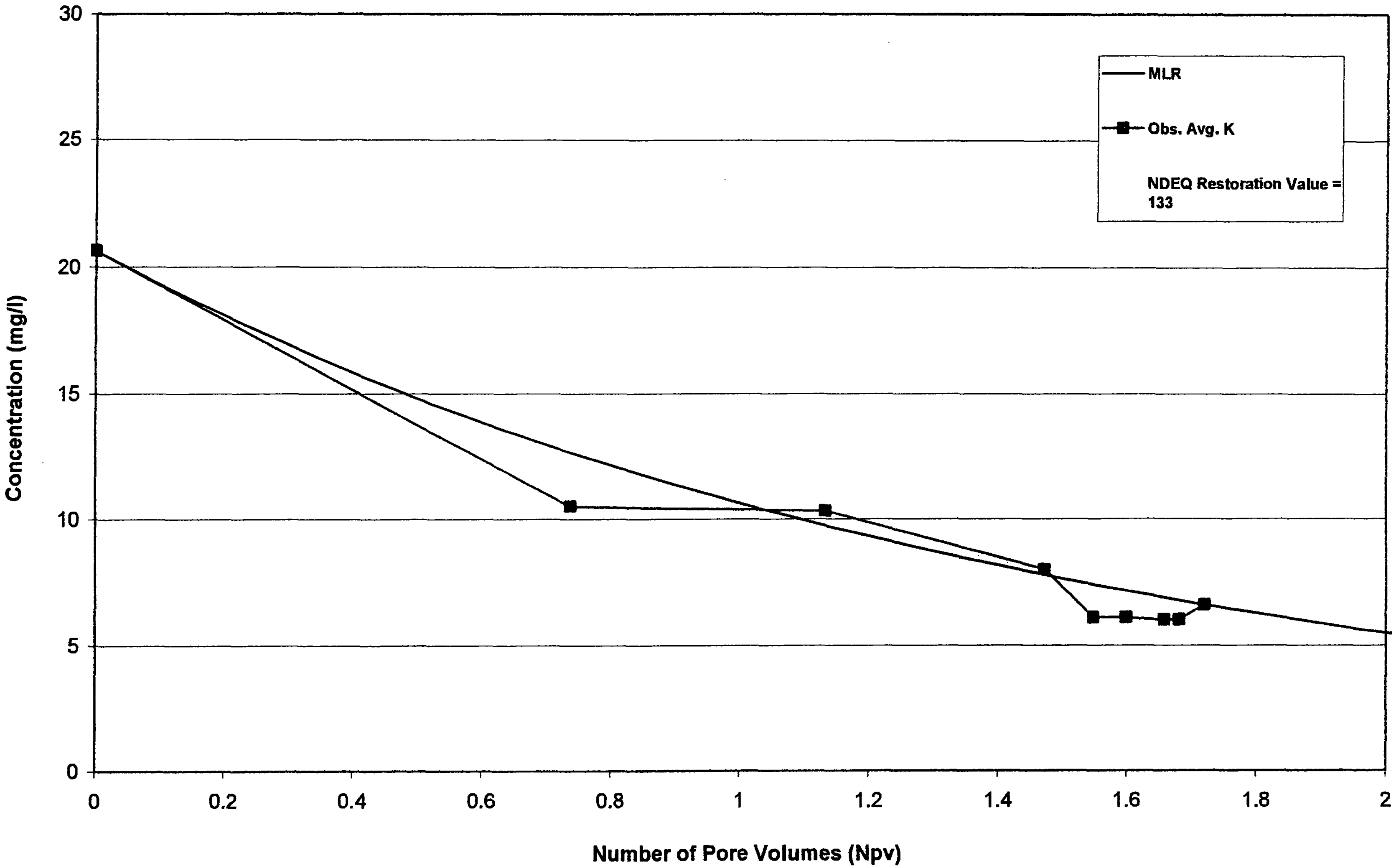
Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-18



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MU-3 Observed vs. Simulated Ca Restoration Curve**	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: **4-19**



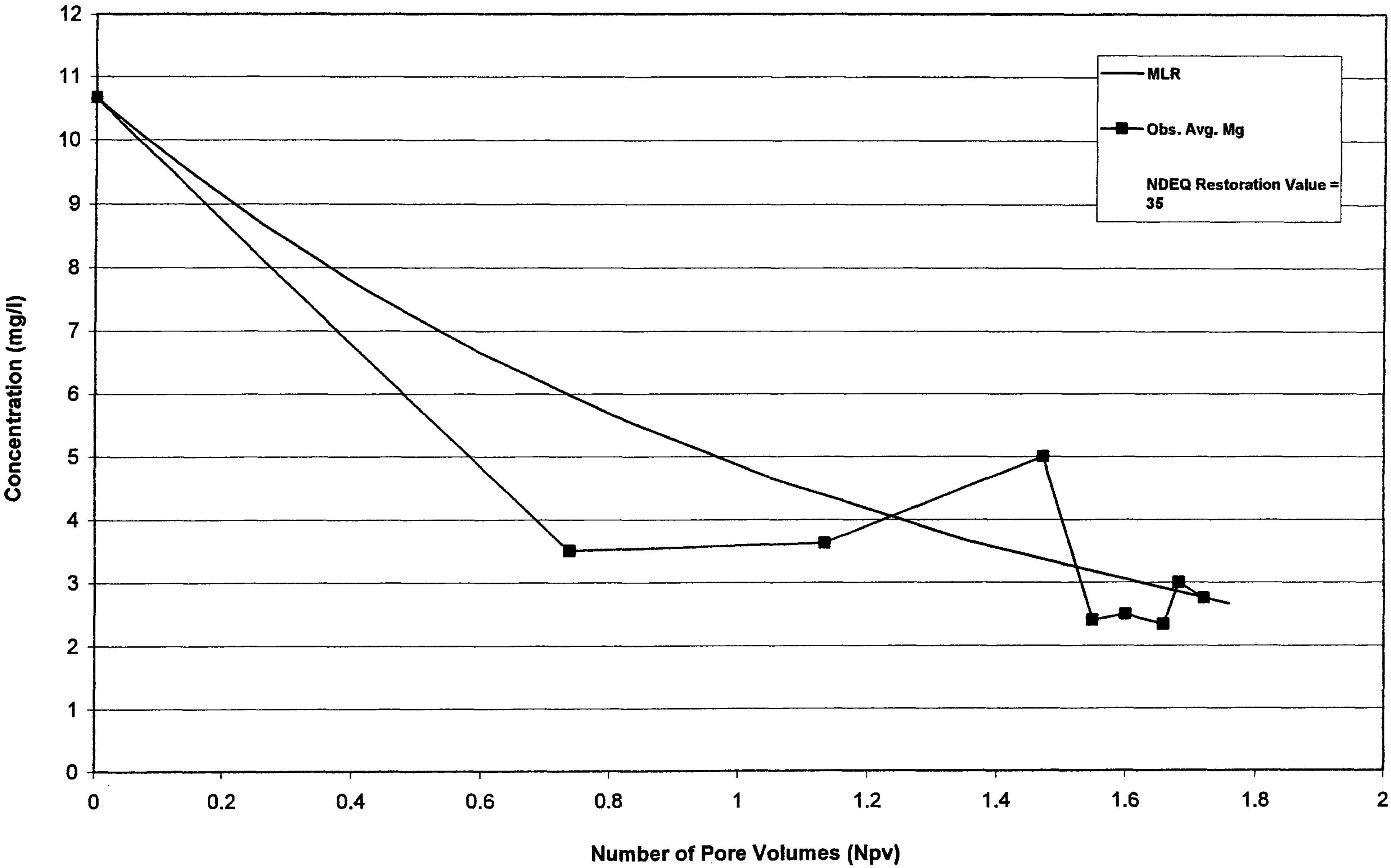
AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated K Pore Volume Restoration Curve

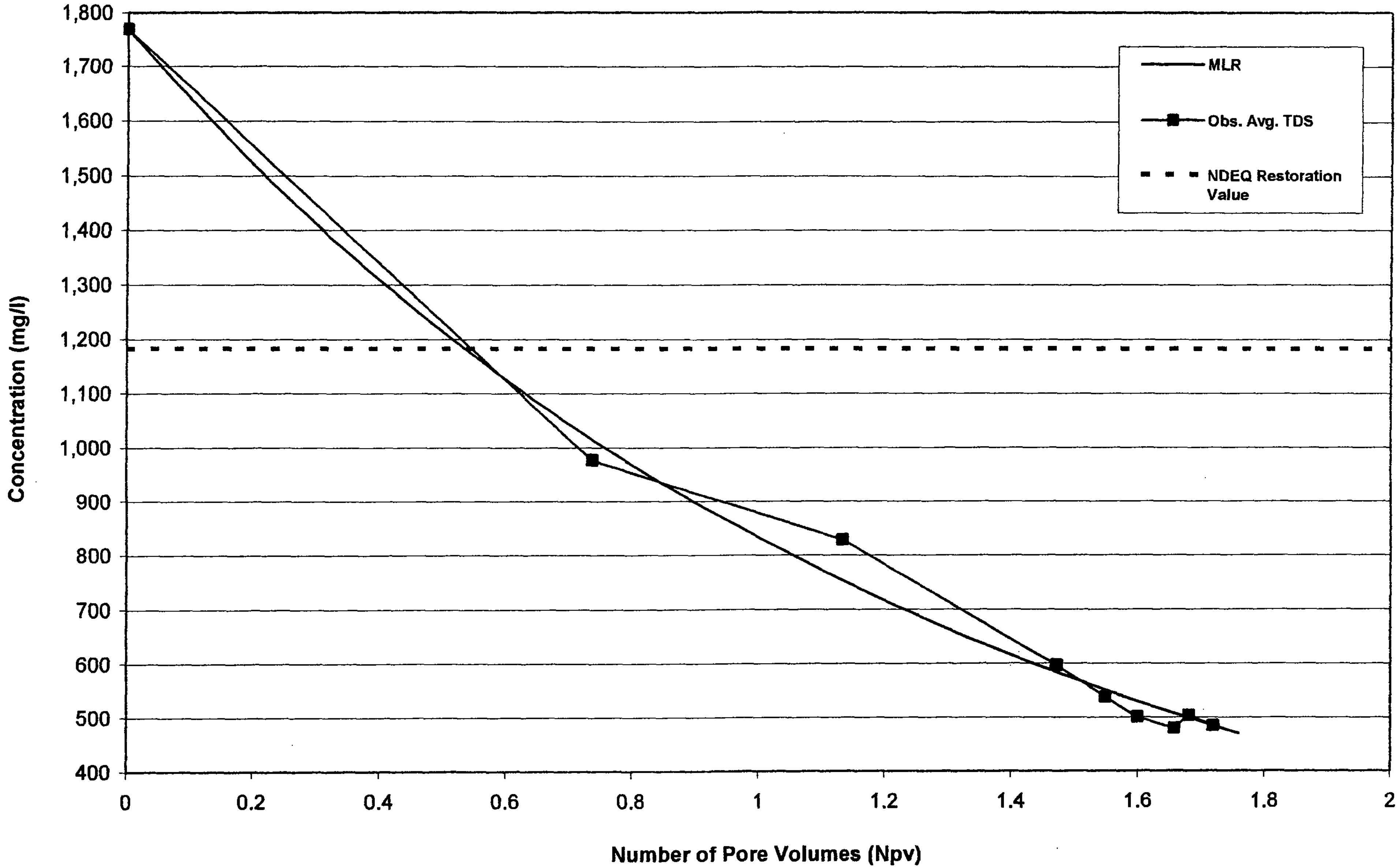
Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-20



AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**MU-3 Observed vs. Simulated Mg Pore Volume Restoration Curve**	Cameco Resources Crow Butte Facility Dawes County, Nebraska Cameco	FIGURE: **4-21**



AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

MU-3 Observed vs. Simulated TDS Pore Volume Restoration Curve

Cameco Resources
Crow Butte Facility
Dawes County, Nebraska

Cameco

FIGURE:
4-22

5. PORE VOLUME RESTORATION REQUIREMENTS FOR OTHER MINE UNITS

Results of the pore volume restoration analysis described in **Section 4** can be expanded to evaluate the pore volume restoration requirements for other mine units at the site. The pore volume restoration requirements for future mine units can be evaluated by using the MLR model to calculate the additional number of pore volumes needed to lower the chloride concentration from a post-mining condition to a fully restored condition. Groundwater quality data collected from MU-2 and MU-3 in 1996 and 1999 indicate average post-mining concentrations of chloride were approximately 633 and 681 mg/l, respectively (**Attachment A**). Given an initial average chloride concentration (Ci) of 633 mg/L for MU-2, the additional number of pore volumes needed to restore the production aquifer from a post-mining condition to a fully restored condition is 0.89. Given an initial chloride concentration (Ci) of 681 mg/L for MU-3, the additional number of pore volumes needed to restore the production aquifer from a post-mining condition to a fully restored condition is 0.80. By summing together these additional pore volume requirements and the full-scale pore volume restoration requirements for MU-2 and MU-3 (2.11 and 0.74 pore volumes, respectively), we can conclude the theoretical number of pore volumes required to restore a mine unit from the post-mining condition to a fully restored condition at the site is 1.54 (MU-3 analogy) to 3.00 (MU-2 analogy).

It was noted in **Section 4.2** that the theoretical affected pore volume (APV) computed from the MLR model differs somewhat from the historical APV calculated by Cameco. The theoretical APV calculated by the MLR model for MU-2 and MU-3 is larger than the historical APV calculated by Cameco by a factor of approximately 1.21 (MU-2) to 3.87 (MU-3). The difference between the theoretical and calculated APV represents a combination of uncertainties inherent in Cameco's APV calculations (e.g. estimated flare factor, porosity, pattern area, sand thickness), restoration inefficiencies (although much less than historical inefficiencies), deviation from the theoretical model assumption of complete mixing, and uncertainty in the computed average water quality. If Cameco's calculated APV for MU-2 and MU-3 is used instead of the theoretical APV computed by the MLR model, the total number of pore volumes required to restore groundwater from a post-mining condition to a fully restored condition is approximately 3.63 (more efficient) to 5.96 (less efficient).

6. SUMMARY AND CONCLUSIONS

Results of the pore volume analysis in MU-2 and MU-3 demonstrate that restoration of these mine units was accomplished (with the exception of local elevated arsenic concentrations in MU-3) in approximately 6 to 9 months following the implementation of the MBRP. Restoration was achieved after 2.11 pore volumes of groundwater treatment in MU-2, and 0.74 pore volumes of groundwater treatment in MU-3. The total number of pore volumes treated in MU-2 and MU-3 as part of the MBRP was 2.25 and 1.72, respectively.

Results of the pore volume restoration analysis in MU-2 and MU-3 were expanded to evaluate the number of pore volumes required for future restoration of other mine units at the site. Results of this analysis indicate the theoretical number of pore volumes required to restore a mine unit from the post-mining condition to a fully restored condition at the site is 1.54 (MU-3 analogy) to 3.00 (MU-2 analogy).

The theoretical APV calculated from the MLR model is larger than Cameo's calculated APV by a factor of approximately 1.21 (MU-2) to 3.87 (MU-3). The difference between the theoretical and calculated APV represents a combination of uncertainties inherent in Cameco's APV calculations (e.g. estimated flare factor, porosity, pattern area, sand thickness, restoration inefficiencies, deviation from the theoretical model assumption of complete mixing, and uncertainty in the computed average water quality. If Cameco's calculated APV for MU-2 and MU-3 is used instead of the theoretical APV computed by the MLR model, the total number of pore volumes required to restore groundwater from a post-mining condition to a fully restored condition is approximately 3.63 (more efficient) to 5.96 (less efficient).

The results of this study can be used to compare the relative effectiveness of restoration before and after the implementation of the MBRP. Prior to May 2009 and the implementation of the MBRP in MU-2, the total volume of groundwater treated as part of MU-2 restoration was approximately 767 million gallons, or approximately 35 pore volumes using Cameco's calculated APV. Likewise, prior to December 2009 and the implementation of the MBRP in MU-3, the total volume of groundwater treated as part of MU-3 restoration was 1.123 billion gallons, or approximately 59 pore volumes using Cameco's calculated APV. Despite the relatively large number of pore volumes treated prior to implementation of the MBRP, MU-2 and MU-3 were only 30 to 50 percent restored, respectively, at the time the MBRP was implemented in May 2009. By comparison, results of this study indicate complete restoration of the production aquifer can be achieved in approximately 3.6 to 6.0 pore volumes using the MBRP and Cameco's calculated APV.

7. REFERENCES

Gelhar, L.W. and Wilson, J.L.,1974. Ground-water quality modelling. *Ground Water*, 12, 399-408.

Lewis Water Consultants, 1999. Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility. Dated October 29.

WorleyParsons, 2009. Wellfield Restoration Modeling, Crow Butte Resources Mine Units 2-5, Cameco Resources, Crow Butte Operations, Crawford, Nebraska. Dated February 19.

Zheng, C., Bennett, G.D., and Andrews, C.B., 1991. Analysis of Ground-Water Remedial Alternatives at a Superfund Site, Groundwater, vol. 29, no. 6, pp. 838-848.

Zheng, C., Bennett, G.D., and Andrews, C.B., 1992. Reply to Discussion of "Analysis of Ground-Water Remedial Alternatives at a Superfund Site", Groundwater, vol. 30, no. 3, pp. 440-442.

ATTACHMENT A

Post-Mining Water Quality Analyses

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03–05–96
Sample I.D.:	BL–1 (I–171)
Sample Date:	02–15–96
Sample Number:	96–13442

Major Ions

Major Ions	Units	Results	Detection Limit
Calcium (Ca)	mg/l	111	1.0
Magnesium (Mg)	mg/l	30.9	1.0
Sodium (Na)	mg/l	1159	1.0
Potassium (K)	mg/l	41.4	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	1341	0.10
Sulfate (SO_4)	mg/l	1155	1.0
Chloride (Cl)	mg/l	643	1.0
Ammonium (NH_4) as N	mg/l	0.08	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	0.96	0.10
Fluoride (F)	mg/l	0.39	0.10
Silica (SiO_2)	mg/l	24.5	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	4043	1.0
Conductivity	µmho/cm	5993	1.0
Alkalinity; measured as $CaCO_3$	mg/l	1099	1.0
pH	std. units	7.67	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.032	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	1.03	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.01	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.36	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.45	0.10
Nickel (Ni)	mg/l	0.12	0.05
Selenium (Se)	mg/l	0.112	0.001
Vanadium (V)	mg/l	0.72	0.10
Zinc (Zn)	mg/l	0.12	0.01

Radiometric

Uranium (U^{Nat})	mg/l	4.519	0.0003
Radium 226 (Ra^{226})	pCi/l	1347	0.2
Radium Precision ±		12.1	

Quality Assurance Data

			Acceptance Range
Anion	meq	64.25	
Cation	meq	59.62	
WYDEQ A/C Balance	%	–3.74	–5 – +5
Calc TDS	mg/l	3841	
TDS A/C Balance	dec. %	1.05	0.90 – 1.10

Report Approved by: R.A. [signature]

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03–05–96
Sample I.D.:	BL–2 (P–94)
Sample Date:	02–15–96
Sample Number:	96–13446

Major Ions

Major Ions	Units	Results	Detection Limit
Calcium (Ca)	mg/l	142	1.0
Magnesium (Mg)	mg/l	37.1	1.0
Sodium (Na)	mg/l	1197	1.0
Potassium (K)	mg/l	43.8	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	1338	0.10
Sulfate (SO_4)	mg/l	1325	1.0
Chloride (Cl)	mg/l	685	1.0
Ammonium (NH_4) as N	mg/l	< 0.05	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	0.62	0.10
Fluoride (F)	mg/l	0.37	0.10
Silica (SiO_2)	mg/l	28.1	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	4310	1.0
Conductivity	µmho/cm	6220	1.0
Alkalinity; measured as $CaCO_3$	mg/l	1097	1.0
pH	std. units	7.51	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.018	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	1.15	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.01	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.22	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.41	0.10
Nickel (Ni)	mg/l	0.73	0.05
Selenium (Se)	mg/l	0.125	0.001
Vanadium (V)	mg/l	0.50	0.10
Zinc (Zn)	mg/l	0.13	0.01

Radiometric

Uranium (U^{Nat})	mg/l	9.847	0.0003
Radium 226 (Ra^{226})	pCi/l	510	0.2
Radium Precision ±		7.2	

Quality Assurance Data			Acceptance Range
Anion	meq	68.91	
Cation	meq	63.39	
WYDEQ A/C Balance	%	–4.17	–5 – +5
Calc TDS	mg/l	4131	
TDS A/C Balance	dec. %	1.04	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96
Sample I.D.: PM–2 (I–188)
Sample Date: 02–15–96
Sample Number: 96–13444

Major Ions

Major Ions	Units	Results	Detection Limit
Calcium (Ca)	mg/l	119	1.0
Magnesium (Mg)	mg/l	34.0	1.0
Sodium (Na)	mg/l	1183	1.0
Potassium (K)	mg/l	45.1	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	1248	0.10
Sulfate (SO_4)	mg/l	1240	1.0
Chloride (Cl)	mg/l	609	1.0
Ammonium (NH_4) as N	mg/l	0.19	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	0.79	0.10
Fluoride (F)	mg/l	0.32	0.10
Silica (SiO_2)	mg/l	26.8	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	4160	1.0
Conductivity	µmho/cm	6027	1.0
Alkalinity; measured as $CaCO_3$	mg/l	1023	1.0
pH	std. units	7.49	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.025	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	1.15	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.01	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.21	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.40	0.10
Nickel (Ni)	mg/l	< 0.05	0.05
Selenium (Se)	mg/l	0.178	0.001
Vanadium (V)	mg/l	0.34	0.10
Zinc (Zn)	mg/l	0.06	0.01

Radiometric

Uranium (U^{Nat})	mg/l	21.52	0.0003
Radium 226 (Ra^{226})	pCi/l	882	0.2
Radium Precision ±		9.6	

Quality Assurance Data

			Acceptance Range
Anion	meq	63.53	
Cation	meq	61.42	
WYDEQ A/C Balance	%	–1.69	–5 – +5
Calc TDS	mg/l	3886	
TDS A/C Balance	dec. %	1.07	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03-05-96
Sample I.D.:	PM-8 (I-196)
Sample Date:	02-16-96
Sample Number:	96-13453

Major Ions

	Units		Results	Detection Limit
Calcium (Ca)	mg/l		134	1.0
Magnesium (Mg)	mg/l		37.0	1.0
Sodium (Na)	mg/l		1135	1.0
Potassium (K)	mg/l		44.1	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1124	0.10
Sulfate (SO_4)	mg/l		1431	1.0
Chloride (Cl)	mg/l		622	1.0
Ammonium (NH_4) as N	mg/l		0.21	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		0.55	0.10
Fluoride (F)	mg/l		0.26	0.10
Silica (SiO_2)	mg/l		27.2	1.0

Non-Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		4268	1.0
Conductivity	µmho/cm		6061	1.0
Alkalinity; measured as $CaCO_3$	mg/l		921	1.0
pH	std. units		7.50	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.025	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.20	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l		0.02	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.10	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.30	0.10
Nickel (Ni)	mg/l	<	0.05	0.05
Selenium (Se)	mg/l		0.112	0.001
Vanadium (V)	mg/l		0.62	0.10
Zinc (Zn)	mg/l		0.14	0.01

Radiometric

Uranium (U^{Nat})	mg/l		17.52	0.0003
Radium 226 (Ra^{226})	pCi/l		1231	0.2
Radium Precision ±			16.2	

Quality Assurance Data — **Acceptance Range**

				Acceptance Range
Anion	meq		65.81	
Cation	meq		60.30	
WYDEQ A/C Balance	%		-4.37	-5 – +5
Calc TDS	mg/l		3996	
TDS A/C Balance	dec. %		1.07	0.90 – 1.10

Report Approved by: R. A. Garling /pst

PIM 13442cbr.wk3

COMPLETE ENVIRONMENTAL ANALYTICAL SERVICES

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03–05–96
Sample I.D.:	PM–9 (P–97)
Sample Date:	02–16–96
Sample Number:	96–13449

Major Ions	Units		Results	Detection Limit
Calcium (Ca)	mg/l		126	1.0
Magnesium (Mg)	mg/l		36.2	1.0
Sodium (Na)	mg/l		1156	1.0
Potassium (K)	mg/l		45.1	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1192	0.10
Sulfate (SO_4)	mg/l		1351	1.0
Chloride (Cl)	mg/l		654	1.0
Ammonium (NH_4) as N	mg/l	<	0.05	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		0.67	0.10
Fluoride (F)	mg/l		0.24	0.10
Silica (SiO_2)	mg/l		26.1	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		3791	1.0
Conductivity	µmho/cm		5585	1.0
Alkalinity; measured as $CaCO_3$	mg/l		977	1.0
pH	std. units		7.66	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.017	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.20	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l		0.02	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.05	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.35	0.10
Nickel (Ni)	mg/l	<	0.05	0.05
Selenium (Se)	mg/l		0.161	0.001
Vanadium (V)	mg/l		0.23	0.10
Zinc (Zn)	mg/l		0.10	0.01

Radiometric

Uranium (U^{Nat})	mg/l		14.51	0.0003
Radium 226 (Ra^{226})	pCi/l		709	0.2
Radium Precision ±			10.0	

Quality Assurance Data				Acceptance Range
Anion	meq		66.18	
Cation	meq		60.76	
WYDEQ A/C Balance	%		–4.27	–5 – +5
Calc TDS	mg/l		3994	
TDS A/C Balance	dec. %		0.95	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03–05–96
Sample I.D.:	CMI–4 (I–144)
Sample Date:	02–15–96
Sample Number:	96–13445

Major Ions

	Units	Results	Detection Limit
Calcium (Ca)	mg/l	123	1.0
Magnesium (Mg)	mg/l	33.3	1.0
Sodium (Na)	mg/l	1203	1.0
Potassium (K)	mg/l	42.9	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	1351	0.10
Sulfate (SO_4)	mg/l	1211	1.0
Chloride (Cl)	mg/l	655	1.0
Ammonium (NH_4) as N	mg/l	0.14	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	0.67	0.10
Fluoride (F)	mg/l	0.41	0.10
Silica (SiO_2)	mg/l	31.3	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	4142	1.0
Conductivity	µmho/cm	6061	1.0
Alkalinity; measured as $CaCO_3$	mg/l	1107	1.0
pH	std. units	7.58	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.031	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	1.09	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.01	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.15	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.40	0.10
Nickel (Ni)	mg/l	< 0.05	0.05
Selenium (Se)	mg/l	0.131	0.001
Vanadium (V)	mg/l	0.40	0.10
Zinc (Zn)	mg/l	0.12	0.01

Radiometric

Uranium (U^{Nat})	mg/l	8.188	0.0003
Radium 226 (Ra^{226})	pCi/l	1697	0.2
Radium Precision ±		13.3	

Quality Assurance Data — **Acceptance Range**

			Acceptance Range
Anion	meq	65.90	
Cation	meq	62.37	
WYDEQ A/C Balance	%	–2.75	–5 – +5
Calc TDS	mg/l	3979	
TDS A/C Balance	dec. %	1.04	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96
Sample I.D.: CMI–5 (I–175P)
Sample Date: 02–16–96
Sample Number: 96–13446

Major Ions	Units	Results	Detection Limit
Calcium (Ca)	mg/l	124	1.0
Magnesium (Mg)	mg/l	34.0	1.0
Sodium (Na)	mg/l	1105	1.0
Potassium (K)	mg/l	37.8	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	1312	0.10
Sulfate (SO_4)	mg/l	1163	1.0
Chloride (Cl)	mg/l	610	1.0
Ammonium (NH_4) as N	mg/l	0.38	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	< 0.10	0.10
Fluoride (F)	mg/l	0.37	0.10
Silica (SiO_2)	mg/l	23.6	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	3955	1.0
Conductivity	µmho/cm	5743	1.0
Alkalinity; measured as $CaCO_3$	mg/l	1075	1.0
pH	std. units	7.64	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.035	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	1.13	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.03	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.37	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.44	0.10
Nickel (Ni)	mg/l	< 0.05	0.05
Selenium (Se)	mg/l	0.022	0.001
Vanadium (V)	mg/l	0.63	0.10
Zinc (Zn)	mg/l	0.08	0.01

Radiometric

Uranium (U^{Nat})	mg/l	35.03	0.0003
Radium 226 (Ra^{226})	pCi/l	3038	0.2
Radium Precision ±		20.1	

Quality Assurance Data			Acceptance Range
Anion	meq	62.95	
Cation	meq	58.11	
WYDEQ A/C Balance	%	–4.00	–5 – +5
Calc TDS	mg/l	3755	
TDS A/C Balance	dec. %	1.05	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96

Sample I.D.:	I–142
Sample Date:	02–16–96
Sample Number:	96–13451

Major Ions

Major Ions	Units		Results	Detection Limit
Calcium (Ca)	mg/l		93.3	1.0
Magnesium (Mg)	mg/l		26.4	1.0
Sodium (Na)	mg/l		1028	1.0
Potassium (K)	mg/l		37.7	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1049	0.10
Sulfate (SO_4)	mg/l		1106	1.0
Chloride (Cl)	mg/l		601	1.0
Ammonium (NH_4) as N	mg/l	<	0.05	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		0.32	0.10
Fluoride (F)	mg/l	<	0.10	0.10
Silica (SiO_2)	mg/l		24.8	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		3601	1.0
Conductivity	µmho/cm		5346	1.0
Alkalinity; measured as $CaCO_3$	mg/l		860	1.0
pH	std. units		7.75	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.023	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.05	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l	<	0.01	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.18	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.48	0.10
Nickel (Ni)	mg/l	<	0.05	0.05
Selenium (Se)	mg/l		0.051	0.001
Vanadium (V)	mg/l		1.27	0.10
Zinc (Zn)	mg/l		0.05	0.01

Radiometric

Uranium (U^{Nat})	mg/l		7.380	0.0003
Radium 226 (Ra^{226})	pCi/l		1268	0.2
Radium Precision ±			13.0	

Quality Assurance Data — **Acceptance Range**

				Acceptance Range
Anion	meq		57.21	
Cation	meq		52.56	
WYDEQ A/C Balance	%		−4.24	−5 – +5
Calc TDS	mg/l		3444	
TDS A/C Balance	dec. %		1.05	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96

Sample I.D.:	I–180
Sample Date:	02–16–96
Sample Number:	96–13452

Major Ions

Major Ions	Units		Results	Detection Limit
Calcium (Ca)	mg/l		109	1.0
Magnesium (Mg)	mg/l		29.2	1.0
Sodium (Na)	mg/l		1081	1.0
Potassium (K)	mg/l		39.5	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1192	0.10
Sulfate (SO_4)	mg/l		1097	1.0
Chloride (Cl)	mg/l		640	1.0
Ammonium (NH_4) as N	mg/l	<	0.05	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		1.20	0.10
Fluoride (F)	mg/l		0.43	0.10
Silica (SiO_2)	mg/l		31.5	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		3757	1.0
Conductivity	µmho/cm		5550	1.0
Alkalinity; measured as $CaCO_3$	mg/l		977	1.0
pH	std. units		7.96	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.035	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.16	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l		0.03	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.11	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.49	0.10
Nickel (Ni)	mg/l	<	0.05	0.05
Selenium (Se)	mg/l		0.119	0.001
Vanadium (V)	mg/l		0.92	0.10
Zinc (Zn)	mg/l		0.08	0.01

Radiometric

Uranium (U^{Nat})	mg/l		3.320	0.0003
Radium 226 (Ra^{226})	pCi/l		1622	0.2
Radium Precision ±			14.4	

Quality Assurance Data | **Acceptance Range**

Anion	meq		60.54	
Cation	meq		55.92	
WYDEQ A/C Balance	%		–3.96	–5 – +5
Calc TDS	mg/l		3630	
TDS A/C Balance	dec. %		1.04	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96

Sample I.D.:	P–21 (I–137)
Sample Date:	02–16–96
Sample Number:	96–13450

Major Ions	Units		Results	Detection Limit
Calcium (Ca)	mg/l		140	1.0
Magnesium (Mg)	mg/l		38.0	1.0
Sodium (Na)	mg/l		1186	1.0
Potassium (K)	mg/l		46.0	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1232	0.10
Sulfate (SO_4)	mg/l		1406	1.0
Chloride (Cl)	mg/l		668	1.0
Ammonium (NH_4) as N	mg/l		0.09	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		0.61	0.10
Fluoride (F)	mg/l		0.94	0.10
Silica (SiO_2)	mg/l		31.0	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		4298	1.0
Conductivity	µmho/cm		6084	1.0
Alkalinity; measured as $CaCO_3$	mg/l		1010	1.0
pH	std. units		7.44	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.022	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.25	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l		0.04	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.12	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.34	0.10
Nickel (Ni)	mg/l	<	0.05	0.05
Selenium (Se)	mg/l		0.059	0.001
Vanadium (V)	mg/l		0.60	0.10
Zinc (Zn)	mg/l		0.10	0.01

Radiometric

Uranium (U^{Nat})	mg/l		36.88	0.0003
Radium 226 (Ra^{226})	pCi/l		2101	0.2
Radium Precision ±			21.4	

Quality Assurance Data				Acceptance Range
Anion	meq		68.41	
Cation	meq		62.94	
WYDEQ A/C Balance	%		−4.16	−5 – +5
Calc TDS	mg/l		4135	
TDS A/C Balance	dec. %		1.04	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date:	03–05–96
Sample I.D.:	P–113
Sample Date:	02–15–96
Sample Number:	96–13447

Major Ions

Major Ions	Units	Results	Detection Limit
Calcium (Ca)	mg/l	85.3	1.0
Magnesium (Mg)	mg/l	22.0	1.0
Sodium (Na)	mg/l	962	1.0
Potassium (K)	mg/l	35.7	1.0
Carbonate (CO_3)	mg/l	0	0.10
Bicarbonate (HCO_3)	mg/l	922	0.10
Sulfate (SO_4)	mg/l	1040	1.0
Chloride (Cl)	mg/l	581	1.0
Ammonium (NH_4) as N	mg/l	< 0.05	0.05
Nitrite (NO_2) as N	mg/l	< 0.10	0.10
Nitrate (NO_3) as N	mg/l	1.54	0.10
Fluoride (F)	mg/l	0.38	0.10
Silica (SiO_2)	mg/l	24.4	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l	3268	1.0
Conductivity	µmho/cm	5006	1.0
Alkalinity; measured as $CaCO_3$	mg/l	756	1.0
pH	std. units	7.69	0.10

Trace Metals

Aluminum (Al)	mg/l	< 0.10	0.10
Arsenic (As)	mg/l	0.025	0.001
Barium (Ba)	mg/l	< 0.10	0.10
Boron (B)	mg/l	0.91	0.10
Cadmium (Cd)	mg/l	< 0.01	0.01
Chromium (Cr)	mg/l	< 0.05	0.05
Copper (Cu)	mg/l	0.02	0.01
Iron (Fe)	mg/l	< 0.05	0.05
Lead (Pb)	mg/l	< 0.05	0.05
Manganese (Mn)	mg/l	0.21	0.01
Mercury (Hg)	mg/l	< 0.001	0.001
Molybdenum (Mo)	mg/l	0.43	0.10
Nickel (Ni)	mg/l	0.10	0.05
Selenium (Se)	mg/l	0.273	0.001
Vanadium (V)	mg/l	0.64	0.10
Zinc (Zn)	mg/l	0.05	0.01

Radiometric

Uranium (U^{Nat})	mg/l	9.826	0.0003
Radium 226 (Ra^{226})	pCi/l	1110	0.2
Radium Precision ±		10.9	

Quality Assurance Data — **Acceptance Range**

			Acceptance Range
Anion	meq	53.29	
Cation	meq	48.87	
WYDEQ A/C Balance	%	−4.33	−5 – +5
Calc TDS	mg/l	3219	
TDS A/C Balance	dec. %	1.02	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
P.O. BOX 3258 • CASPER, WY 82602 • PHONE (307) 235-0515
254 NORTH CENTER, SUITE 100 • CASPER, WY 82601 • FAX (307) 234-1639

WATER ANALYSIS REPORT – Crow Butte Resources

Report Date: 03–05–96

Sample I.D.:	BL–3 (I–136)
Sample Date:	02–15–96
Sample Number:	96–13443

Major Ions	Units		Results	Detection Limit
Calcium (Ca)	mg/l		118	1.0
Magnesium (Mg)	mg/l		32.1	1.0
Sodium (Na)	mg/l		1154	1.0
Potassium (K)	mg/l		40.0	1.0
Carbonate (CO_3)	mg/l		0	0.10
Bicarbonate (HCO_3)	mg/l		1364	0.10
Sulfate (SO_4)	mg/l		1138	1.0
Chloride (Cl)	mg/l		624	1.0
Ammonium (NH_4) as N	mg/l		0.41	0.05
Nitrite (NO_2) as N	mg/l	<	0.10	0.10
Nitrate (NO_3) as N	mg/l		0.89	0.10
Fluoride (F)	mg/l		0.42	0.10
Silica (SiO_2)	mg/l		29.9	1.0

Non–Metals

Total Dissolved Solids (TDS) @ 180°C	mg/l		4077	1.0
Conductivity	µmho/cm		5993	1.0
Alkalinity; measured as $CaCO_3$	mg/l		1118	1.0
pH	std. units		7.56	0.10

Trace Metals

Aluminum (Al)	mg/l	<	0.10	0.10
Arsenic (As)	mg/l		0.042	0.001
Barium (Ba)	mg/l	<	0.10	0.10
Boron (B)	mg/l		1.12	0.10
Cadmium (Cd)	mg/l	<	0.01	0.01
Chromium (Cr)	mg/l	<	0.05	0.05
Copper (Cu)	mg/l	<	0.01	0.01
Iron (Fe)	mg/l	<	0.05	0.05
Lead (Pb)	mg/l	<	0.05	0.05
Manganese (Mn)	mg/l		0.93	0.01
Mercury (Hg)	mg/l	<	0.001	0.001
Molybdenum (Mo)	mg/l		0.41	0.10
Nickel (Ni)	mg/l		0.05	0.05
Selenium (Se)	mg/l		0.124	0.001
Vanadium (V)	mg/l		0.72	0.10
Zinc (Zn)	mg/l		0.11	0.01

Radiometric

Uranium (U^{Nat})	mg/l		3.600	0.0003
Radium 226 (Ra^{226})	pCi/l		2108	0.2
Radium Precision ±			14.8	

Quality Assurance Data				Acceptance Range
Anion	meq		63.74	
Cation	meq		59.87	
WYDEQ A/C Balance	%		–3.13	–5 – +5
Calc TDS	mg/l		3824	
TDS A/C Balance	dec. %		1.07	0.90 – 1.10

PIM 13442cbr.wk3

ENERGY LABORATORIES, INC.
SHIPPING: 2393 SALT CREEK HIGHWAY • CASPER, WY 82601
MAILING: P.O. BOX 3258 • CASPER, WY 82602
E-mail: energy@trib.com • FAX: (307) 234-1639 • PHONE: (307) 235-0515 • TOLL FREE: (888) 235-0515
Billings • Casper • Gillette • Rapid City

LABORATORY ANALYSIS REPORT
CROW BUTTE RESOURCES

Sample ID:	Sample #1 MU#3 Inj.
Sample Date:	07-23-99
Sample Matrix:	Water
Laboratory ID:	99-36358
Report Date:	August 16, 1999

Major Ions		Method	Units	Reporting Limit	Results
Calcium	Ca	EPA 200.7	mg/L	1.0	95.0
Magnesium	Mg	EPA 200.7	mg/L	1.0	25.0
Sodium	Na	EPA 200.7	mg/L	1.0	1240
Potassium	K	EPA 200.7	mg/L	1.0	40.0
Carbonate	CO_3	SM 2320 B.	mg/L	1.0	< 1.0
Bicarbonate	HCO_3	SM 2320 B.	mg/L	1.0	1440
Sulfate	SO_4	SM 4500-SO_4 E.	mg/L	1.0	740
Chloride	Cl	SM 4500-Cl B.	mg/L	1.0	681
Ammonium as N	NH_4	EPA 350.1	mg/L	0.05	< 0.05
Nitrite as N	NO_2	SM 4500-NO_2 B.	mg/L	0.10	< 0.10
Nitrate + Nitrite as N	$NO_3 + NO_2$	EPA 353.2	mg/L	0.10	0.49
Fluoride	F	SM 4500-F C.	mg/L	0.10	0.47
Silica	SiO_2	EPA 200.7	mg/L	1.0	21.5

Non-Metals					
Total Dissolved Solids @ 180°C	TDS	SM 2540 C. Mod.	mg/L	2.0	3680
Conductivity		EPA 120.1	µmho/cm	1.0	6020
Alkalinity	$CaCO_3$	SM 2320 B.	mg/L	1.0	1180
pH		SM 4500-H B.	std. units	0.10	7.81

Trace Metals					
Aluminum	Al	EPA 200.7	mg/L	0.10	< 0.10
Arsenic	As	EPA 200.8	mg/L	0.001	0.062
Barium	Ba	EPA 200.7	mg/L	0.10	< 0.10
Boron	B	EPA 200.7	mg/L	0.10	1.0
Cadmium	Cd	EPA 200.8	mg/L	0.005	< 0.005
Chromium	Cr	EPA 200.7	mg/L	0.05	< 0.05
Copper	Cu	EPA 200.7	mg/L	0.01	0.06
Iron	Fe	EPA 200.7	mg/L	0.05	< 0.05
Lead	Pb	EPA 200.7	mg/L	0.05	< 0.05
Manganese	Mn	EPA 200.7	mg/L	0.01	0.07
Mercury	Hg	EPA 200.8	mg/L	0.001	< 0.001
Molybdenum	Mo	EPA 200.7	mg/L	0.10	0.40
Nickel	Ni	EPA 200.7	mg/L	0.05	< 0.05
Selenium	Se	EPA 200.8	mg/L	0.001	0.065
Vanadium	V	EPA 200.7	mg/L	0.10	1.10
Zinc	Zn	EPA 200.7	mg/L	0.01	0.10

Radiometrics					
Uranium	^{Nat}U	EPA 200.8	mg/L	0.0003	2.10
Radium 226	^{226}Ra	EPA 903.0	pCi/L	0.2	991
Radium Error Estimate ±					9.4

Quality Assurance Data			Target Range	
Anion		meq		58.26
Cation		meq		61.80
WYDEQ A/C Balance		%	-5 - +5	2.95
Calc TDS		mg/L		3565
TDS A/C Balance		dec. %	0.80 - 1.20	1.03

msj r:\reports\clients99\crow_butte\water\36358.xls

Log In No. 54710