INT-050

CROW BUTTE RESOURCES, INC.

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August 24, 2001

United States Nuclear Regulatory Commission Official Hearing Exhibit		
In the Matter of:	CROW BUTTE RESOURCES, INC. (License Renewal for the In Situ Leach Facility, Crawford, Nebraska)	
	ASLBP #: 08-867-02-OLA-BD01	
	Docket #: 04008943	
	Exhibit #: INT-050-00-BD01	Identified: 8/18/2015
	Admitted: 8/18/2015	Withdrawn:
	Rejected:	Stricken:
	Other:	

Mr. Melvyn Leach, Chief
Fuel Cycle Licensing Branch, FCSS
c/o Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Re: Source Materials License SUA-1534
Docket No. 40-8943
Mine Unit 1 Restoration; Response to Request For Additional Information

Dear Mr. Leach:

By letter dated June 26, 2001, the US Nuclear Regulatory Commission (NRC) requested that Crow Butte Resources, Inc. (CBR) provide additional information to support the requested approval of groundwater restoration in Mine Unit 1. NRC requested a response within 60 days. Enclosure 1 contains CBR's response to the request for additional information. We believe that the information originally provided in the Mine Unit 1 Restoration Report (Crow Butte Resources, Inc., 2000) supplemented by the information contained in Enclosure 1 will provide NRC with the necessary assurances that the water quality in the Mine Unit 1 mining zone aquifer meets or exceeds the appropriate NRC regulatory and license requirements.

CBR requests that NRC approve the Mine Unit 1 groundwater restoration in an expeditious manner. The Mine Unit 1 Restoration report was originally submitted to NRC in January 2000. The NRC reviewed this original submittal for eighteen (18) months before submitting its request to CBR for additional information.

The NRC's timely approval of groundwater restoration is critical to allow well abandonment and surface reclamation activities to proceed at Mine Unit 1. We are prepared to provide any further information required to assist NRC in reaching a decision on Mine Unit 1 restoration, although we believe that we have already provided more than enough information in order for the NRC to make its decision.

NMSS01 Public
Rec'd from NMSS on 09/25/01

If you have any questions or require further information, please contact Mike Griffin at (308) 665-2215.

Sincerely,
CROW BUTTE RESOURCES, INC.

Stephen P. Collings

Stephen P. Collings
Senior Vice President of Operations

Enclosures: As Stated

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CROW BUTTE RESOURCES, INC.

Crow Butte Resources, Inc.
Response to U.S. Nuclear Regulatory Commission
Request For Additional Information

Mine Unit 1 Groundwater Restoration Completion

Crow Butte Uranium Project

August 24, 2001

United States Nuclear Regulatory Commission
Source Materials License SUA-1534

Submitted To: US Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
11545 Rockville Pike
Rockville, Maryland 20850

Prepared By: Crow Butte Resources, Inc.
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Crawford, Nebraska 69339

Table of Contents

1 INTRODUCTION

Crow Butte Resources, Inc. (CBR) operates a uranium solution mine in Dawes County, Nebraska. The permitted area includes approximately 2,800 acres in all or portions of Sections 11, 12, and 13 of Township 31N, Range 52W and Sections 18, 19, 20, 29 and 30 of Township 31N, Range 51W. The process plant is located in Section 19, Township 31 North, Range 51 West. The wellfields for current mining operations are located in Sections 18 and 19. Mining operations are conducted under a Class III Underground Injection Control (UIC) permit issued by the Nebraska Department of Environmental Quality (NDEQ) and source materials license SUA-1534 issued by the U. S. Nuclear Regulatory Commission (NRC).

On September 3, 1999, CBR submitted the Mine Unit 1 Restoration Report to the NDEQ. NDEQ determined that the groundwater restoration met the requirements of Nebraska statute and regulations and the conditions of the Class III UIC permit. On November 18, 1999, the NDEQ accepted the groundwater restoration of Mine Unit 1.

On January 10, 2000, CBR submitted the Mine Unit 1 Restoration Report[1] to the NRC. The report reviewed the mining history in Mine Unit 1, groundwater restoration efforts including the post-restoration stabilization monitoring, and provided an analysis of the effectiveness of the restoration. CBR requested that NRC amend portions of the source materials license governing groundwater restoration and approve the restoration of groundwater in Mine Unit 1.

On June 26, 2001, NRC responded to CBR's request to approve the Mine Unit 1 restoration with a Request for Additional Information. The Request for Additional Information addressed three areas where NRC requires additional information in order to approve the Mine Unit 1 restoration. This document provides the additional information requested by NRC.

2 EFFORTS TO ACHIEVE PRIMARY RESTORATION GOALS

NRC requested additional information concerning CBR's efforts to restore the groundwater in Mine Unit 1 to the primary restoration goal, which is "... to return groundwater affected by mining operations to baseline values on a mine unit average." NRC requested the following information to support CBR's position that adequate efforts were made to reach the primary restoration goal.

[1] Crow Butte Resources, Inc., *Mine Unit 1 Restoration Report, Crow Butte Uranium Project*, January 10, 2000.

2.1 NRC Request

The licensee must provide a written description of the attempts and effort it put forward to attain the primary restoration goals for Unit 1 contained in the approved license application. The description should include a listing of those parameters that meet the primary restoration goal and those that are above the primary restoration goal, as well as those at or below the secondary restoration goal. The description should also include the technical or economic reasons why it was not possible to achieve the primary restoration goals.

2.2 CBR Response

2.2.1 Restoration Description

CBR provided a full description of the restoration efforts in the Mine Unit 1 Restoration Report. The descriptions contained in Sections 3 and 4 of the Restoration Report discussed each phase of restoration and included specific data for the groundwater sweep, groundwater transfer, groundwater treatment (with ion exchange and reverse osmosis), reductant addition, groundwater recirculation, and stabilization phases of restoration. The Restoration Report summarized pertinent data such as dates of treatment, total gallons and pore volumes processed for each step, the mining patterns affected, and the results of groundwater monitoring.

The Mine Unit 1 restoration efforts were summarized in Section 5 of the Restoration Report. Table 1 is provided (and was included as Table 9 in the Restoration Report) to summarize the Mine Unit 1 restoration efforts. Restoration began in May 1994 and was completed in slightly over five years with the final stabilization sample taken in August 1999. A total of 626,208,629 gallons (36.47 pore volumes) of affected groundwater was processed in the combined restoration steps.

Table 1: Restoration Summary

Restoration Step	Date Begun	Date Completed	Total Gallons	Total Pore Volumes
Groundwater Transfer	May 1994	July 1997[1]	15,193,704	0.89
Groundwater Sweep	April 1994	July 1994	1,708,949	0.09
Groundwater Ion Exchange Treatment	September 1994	February 1999	456,946,618	26.62
Groundwater Reverse Osmosis Treatment	October 1995	July 1998	103,413,312	6.02
Wellfield Recirculation	August 1998	February 1999	48,946,046	2.85
Stabilization	February 1999	August 1999	N/A	N/A
Summary	*May 1994*	*August 1999*	*626,208,629*	*36.47*

Notes:
1 Groundwater Transfer was accomplished in five discreet steps during this time period.

2.2.2 Parameter-by-Parameter Comparison with Restoration Standards

NRC requested a listing of parameters that were returned to baseline and those that were at or below the secondary restoration goal. The post-restoration data was originally included in Table 7 of the Restoration Report, with separate listings for those parameters restored to concentrations below baseline and those that met the secondary restoration goals. Table 10 provided the post-restoration and stabilization period data for each parameter. CBR is providing an updated version of these Tables with this response. The following changes were made from the Tables originally presented in the Restoration Report.

- The data presented for each monitored constituent is the average concentration for all restoration wells for the stabilization period. This data was originally presented in Table 10, but was not directly compared with the restoration standards.
- The data has been organized into two separate tables. Table 2 lists the parameters that were returned to a water quality meeting the primary restoration goal (i.e., below the baseline average concentration). Table 3 lists parameters that exceeded the baseline

average but were returned to the UIC permit standards, which are the NRC secondary restoration goals. No monitored parameters were above the UIC permit standards.

- The tables were revised to include only those parameters contained in Amendment 11 of SUA-1534. Amendment 11 modified the parameter list in License Condition 10.3B to duplicate the parameters contained in the Restoration Table in CBR's Class III UIC permit issued by the NDEQ. Because of Amendment 11, several parameters that were originally discussed in the Restoration Report are no longer considered restoration parameters by NRC.

- The UIC permit standards for cadmium and selenium were modified by NDEQ on March 9, 2001. The cadmium standard was reduced from 0.01 mg/l to 0.005 mg/l. The selenium standard was increased from 0.01 mg/l to 0.05 mg/l. These changes were necessary to update the permit requirements to meet changes in the State groundwater standards contained in Title 118, Groundwater Quality Standards and Use Classifications. The new permit standards for these parameters are included in Table 2. The changes in these permit standards had no affect on the restoration status for these two parameters in Mine Unit 1.

Table 2 lists seventeen restoration parameters that were successfully returned to a water quality below the premining baseline average. Table 3 lists the remaining ten parameters that met the UIC permit standards but were above the baseline average for that parameter.

Table 2: Parameters Returned to Baseline

Parameter	Baseline Average (Primary Goal)	UIC Permit Standard (Secondary Goal)	Stabilization Average Water Quality
Ammonium (mg/l)	0.37	10	0.12
Barium (mg/l)	0.1	1.00	<0.1
Cadmium (mg/l)	0.006	0.005	<0.005
Chloride (mg/l)	204	250	139
Copper (mg/l)	0.017	1.00	<0.01
Fluoride (mg/l)	0.69	4.00	0.54
Lead (mg/l)	0.031	0.05	<0.01
Manganese (mg/l)	0.11	0.05	0.02
Mercury (mg/l)	0.001	0.002	<0.001
Nickel (mg/l)	0.034	0.15	<0.01
Nitrate (mg/l)	0.05	10.0	<0.11
pH (Std. Units)	8.5	6.5 – 8.5	8.18
Selenium (mg/l)	0.003	0.05	<0.002
Sodium (mg/l)	412.2	4122	352
Sulfate (mg/l)	356.2	375	331
TDS (mg/l)	1170.2	1218	1094
Zinc (mg/l)	0.036	5.00	<0.02

Table 3: Parameters Below UIC Permit Standards

Parameter	Baseline Average (Primary Goal)	UIC Permit Standard	Stabilization Average Water Quality
Arsenic (mg/l)	<0.002	0.05	0.017
Calcium (mg/l)	12.5	125	19.9
Total Carbonate (mg/l)	351	609	421
Iron (mg/l)	<0.044	0.30	<0.09
Potassium (mg/l)	12.5	125	13.2
Magnesium (mg/l)	3.2	32	5.3
Molybdenum (mg/l)	<0.069	1.00	0.10
Vanadium (mg/l)	<0.066	0.2	0.11
Radium-226 (pCi/l)	229.7	584	303
Uranium (mg/l)	0.092	5.0	1.73

It should be noted that, of the ten parameters that meet the UIC permit standards but were not returned to baseline concentrations, when standard statistical methods are applied to the baseline data, the concentrations of five of these parameters are statistically the same as baseline. The NRC states in NUREG-1569[2] that "...the baseline average plus three standard deviations is another method for establishing primary restoration targets that has been found acceptable by the NRC." CBR recognizes that this method of determining baseline concentrations is not the method approved in CBR's License. CBR is required to restore the affected groundwater on a mine unit average to the average baseline concentration with no statistical analysis of the data. However, CBR believes that NRC should consider statistical methods when determining whether acceptable efforts have been made to return Mine Unit 1 to baseline condition. Using NRC-accepted methods, five of the ten parameters are statistically at baseline concentration on a mine unit average.

[2] USNRC, NUREG-1569, *DRAFT STANDARD REVIEW PLAN for In Situ Leach Uranium Extraction License Applications*, October 1997.

The following comparison uses the baseline data originally presented in Table 3 of the Restoration Report and the results of stabilization sampling that were presented in Table 8 of the Restoration Report.

Table 4: Statistical Comparison of Selected Parameters

Parameter	Baseline Average	Baseline Standard Deviation	Average plus 3 Standard Deviations	Stabilization Average Water Quality
Calcium (mg/l)	12.5	3.2	22.1	19.9
Total Carbonate (mg/l)	351	29.9	441	421
Potassium (mg/l)	12.5	1.5	17	13.2
Magnesium (mg/l)	3.2	0.8	5.6	5.3
Radium-226 (pCi/l)	229.7	177.1	761	303

2.2.3 Technical and Economic Reasons for Completion of Restoration

As discussed in the previous sections, CBR spent five years on the Mine Unit 1 restoration effort. Sampling results at the end of the wellfield recirculation phase in late 1999 indicated that all parameters met the NDEQ Permit standards (NRC secondary goals). The majority of the restoration parameters met the primary goal of average baseline concentration. Based on these results, CBR determined that continued restoration efforts in Mine Unit 1 were not justified. This determination was based upon several considerations:

2.2.3.1 Diminishing Effectiveness

The groundwater treatment phase consists of ion exchange treatment for removal of soluble uranium and reverse osmosis treatment for removal of virtually all other contaminants. However, ion exchange and reverse osmosis treatment processes are not 100 percent efficient for removal of the species of interest. The efficiency of ion exchange is dependent on several factors, including flow rate, retention time, and ionic concentration in the solution. Reverse osmosis has removal efficiencies for the constituents of concern ranging from 88 to 99+

percent. Reference is made to Table 5 of the Restoration Report, which listed typical rejection rates for reverse osmosis.

Recognizing that the treatment processes employed are not 100 percent effective, a point will be reached during treatment when additional efforts will result in minimal improvement in the water quality. Restoration efforts in Mine Unit 1 proceeded beyond the point where significant improvement was possible with continuing treatment. To illustrate this, Figures 1 and 2 contain summary data for the restoration patterns that compares the percentage of reduction of uranium and conductivity from the initial, post-mining concentration with the total number of pore volumes processed during groundwater treatment. From these graphs, it is apparent that further processing quickly loses effectiveness after the initial pore volumes.

Figure 1
Reduction of Uranium per Pore Volume Treated

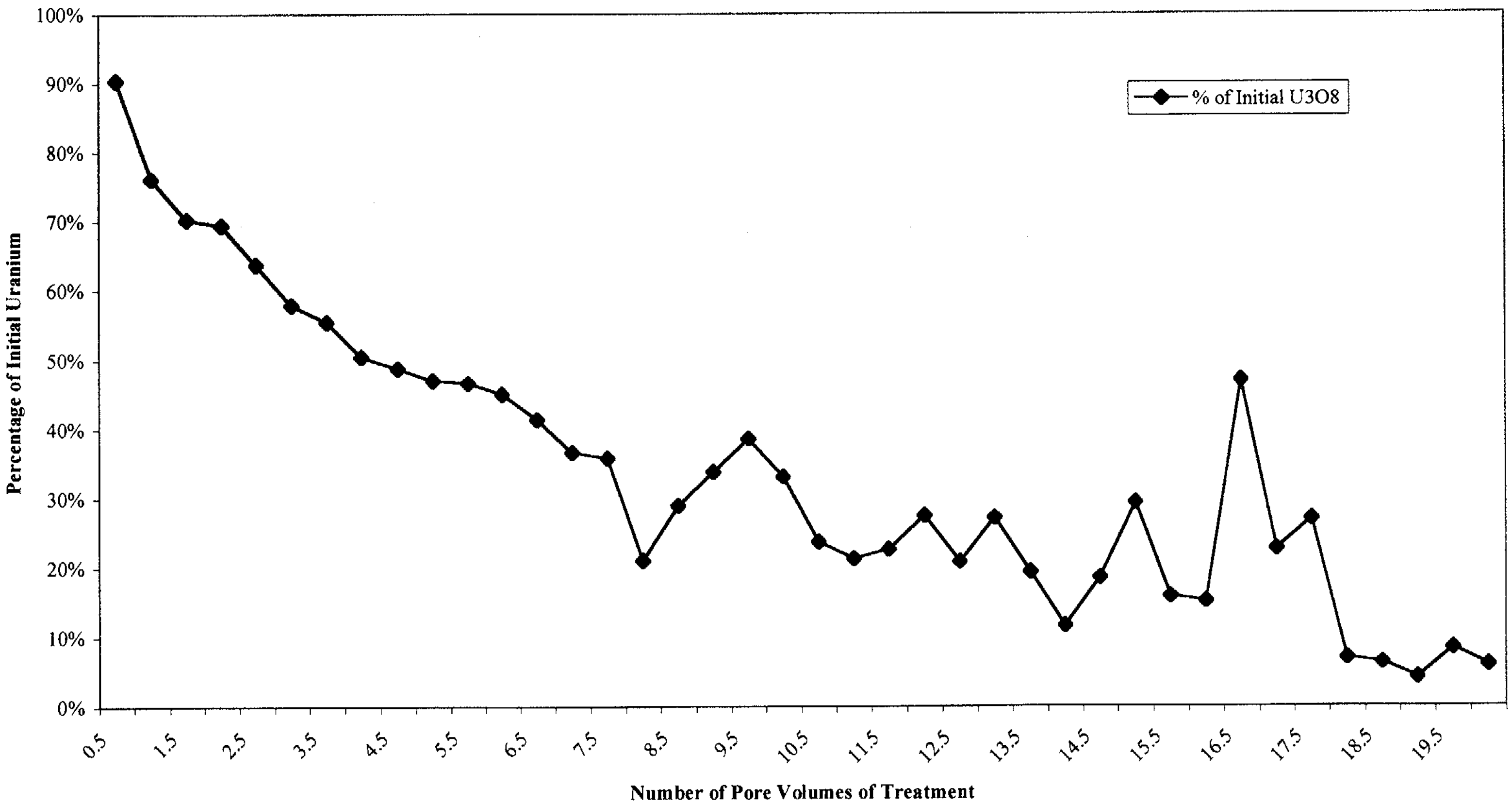
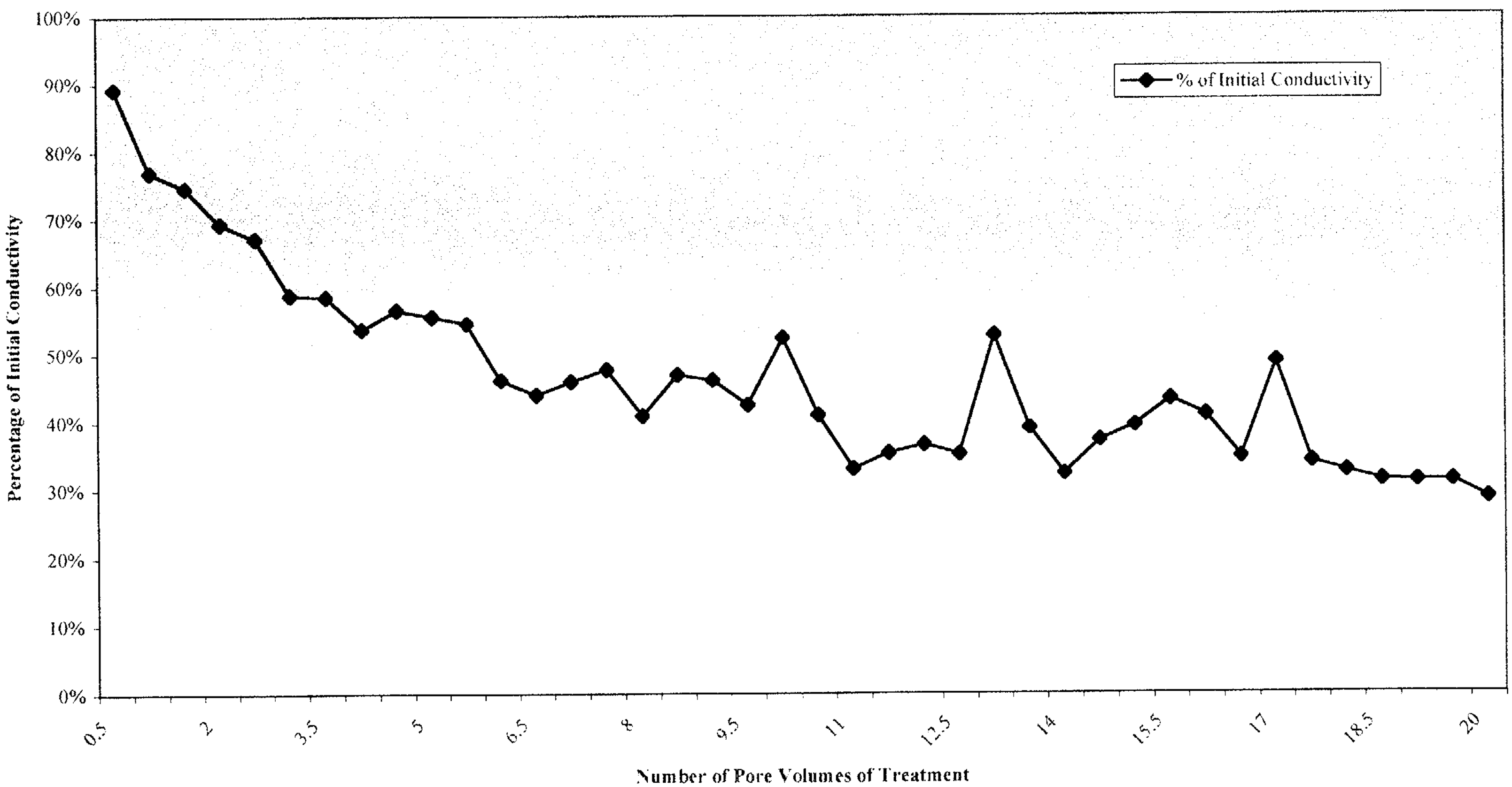


Figure 2
Reduction of Conductivity per Pore Volume



2.2.3.2 Consumptive Water Usage

The in situ leach mining process uses very little water during mining operations. A minimal "process bleed" (approximately 1 percent, or 40 gpm at Crow Butte) is sent to the waste system to provide excursion control. However, the restoration process requires significantly increased water consumption. CBR is sensitive to the issue of consumptive water usage due to the semi-arid environment and limited water resources in the area where mining operations occur. Efforts are made wherever possible to minimize consumptive water usage. For instance, CBR prefers to employ groundwater transfer, where affected groundwater from a spent mining area is transferred to a new mining area, to groundwater sweep. Groundwater transfer allows CBR to conserve mining chemicals and the groundwater resource, while groundwater sweep results in the consumptive use of 100 percent of the groundwater that is pumped.

For Mine Unit 1, Table 5 estimates the volume of water that was sent to the waste disposal system during restoration. As previously noted, CBR processed 626,208,629 gallons during restoration of Mine Unit 1. Of this total, an estimated 27,562,277 gallons, or approximately 4.4 percent of the total restoration volume, was sent to the waste disposal system. While this is a relatively low waste production rate as a percentage of total flow and indicates optimization of the restoration processes, the fact remains that over 27 million gallons of groundwater was sent to the evaporation ponds or the deep disposal well in order to complete restoration of Mine Unit 1.

It should be noted that the consumptive use of resources is a concern of the NDEQ. The Class III UIC permit specifically provides that, in the case where the permit restoration standards are not achievable, the NDEQ may adopt alternate values if it is determined, in part, that "...further restoration efforts would consume energy, water, or other natural resources of the State without providing a corresponding benefit..." Since CBR successfully achieved the NDEQ restoration standards, it is arguable that any further use of "energy, water or other natural resources" to further treat the affected groundwater could not provide a "corresponding benefit."

Table 5: Water Usage During Restoration

Restoration Step	Total Gallons	Estimated Waste Stream (%)	Estimated Gallons to Waste
Groundwater Transfer	15,193,704	0	0
Groundwater Sweep	1,708,949	100	1,708,949
Groundwater Ion Exchange Treatment	456,946,618	0	0
Groundwater Reverse Osmosis Treatment	103,413,312	25	25,853,328
Wellfield Recirculation	48,946,046	0	0
Total:	**626,208,629**		**27,562,277**

2.2.3.3 Cost

Considering the diminished effectiveness of further treatment and the consumptive usage of groundwater if restoration continued, there was no justification for the further expenditure of resources on restoration of Mine Unit 1. Based on the information provided in Table 1 and the cost estimates used for the 2000 Crow Butte surety update, it is estimated that CBR expended over $365,000 for the restoration of Mine Unit 1. The following table provides an estimate for each phase of the restoration process. These estimated costs include operating labor and energy costs. The cost of supervision, sampling, and analytical costs in the CBR laboratory are not included in this estimate.

Table 6: Restoration Cost Summary

Restoration Step	Total Gallons	Cost Basis[1]	Total Estimated Cost
Groundwater Transfer	15,193,704	$0.69/Kgal	$10,483
Groundwater Sweep	1,708,949	$0.517/Kgal	$884
Groundwater Ion Exchange Treatment	456,946,618	$0.05/Kgal	$22,997
Groundwater Reverse Osmosis Treatment	103,413,312	$1.96/Kgal	$202,690
Wellfield Recirculation	48,946,046	$0.69/Kgal	$33,773
Consumables	5 years	$16,797/year	$83,985
Stabilization	6 months	$1,800/month	$10,800
Total:			**$365,612**

Notes: [1] Source: 2000 Crow Butte Surety Update

2.2.4 Summary

In summary, CBR successfully returned twenty-two of twenty-seven restoration parameters to concentrations that were, on a mine unit average and considering statistical variation, at *or below* the baseline concentrations. The other five parameters were restored to concentrations that are well below the NDEQ Permit standards, which are based on the drinking water standards established by the State of Nebraska and are the NRC-approved secondary restoration goals. After five years of effort, consumption of over 27 million gallons of groundwater during treatment activities, and the expenditure of over $365,000, CBR believes that the diminished returns expected from further restoration efforts justify the conclusion that reasonable efforts have been made during the restoration of Mine Unit 1. Any further efforts would result in minimal, if any, improvement in the overall groundwater quality in Mine Unit 1. The State of Nebraska concurred with this decision with their November 1999 approval of the Mine Unit 1 restoration.

3 STABILITY OF GROUNDWATER RESTORATION

The NRC noted "strongly increasing" trends in a number of restoration parameters during the six month stabilization period. Specifically, NRC noted increasing trends in uranium, carbonate, potassium, radium-226, calcium, ammonium, chloride, iron, magnesium, manganese, molybdenum, sodium, sulfate, and total dissolved solids. In NRC's opinion, these trends could indicate that Mine Unit 1 was not stable during the stabilization monitoring period. NRC requested the following information to support CBR's position that Mine Unit 1 is stable.

3.1 NRC Request

The licensee must submit additional monitoring data to show that all measured constituents have reached the restoration goals in License Condition 10.3 and that the restored concentrations are stable, as demonstrated by no strongly increasing concentration trends through time. These data should be presented in time versus concentration graphs of each constituent, with the restoration standard indicated on the graph. Tables of numerical values used to compile the graphs, and laboratory measurements should also be included. These data should include the time period just prior to and during the stabilization period, and measurements taken since the end of the 6-month stabilization period. The licensee must also submit iso-concentration maps of uranium, radium-226, total carbonate, and total dissolved solids in the Unit 1 restoration wells and perimeter monitor wells, once the restoration has stabilized, to illustrate well field water-quality conditions at the end of stabilization.

3.2 CBR Response

3.2.1 Attainment of Restoration Goals

CBR has submitted data in the Restoration Report to show that the measured constituents have reached the restoration goals in License Condition 10.3. Amendment 11 of SUA-1534 recognized the UIC Permit standards as promulgated by the NDEQ as the NRC secondary restoration goals. As described in Section 2.2.2 and contained in Table 2 and Table 3, all measured restoration parameters meet the primary or secondary NRC restoration goals.

3.2.2 Stability of Restoration

In the Request for Additional Information, NRC does not provide a definition for a "strongly increasing" trend. CBR agrees that, in general, the monitoring data for Mine Unit 1 during the six month stability monitoring period showed increasing trends. These trends were evident during the first five months of monitoring. However, the final stability sample showed a significant decrease, on a mine unit average, for virtually all parameters. Reference is made to Figure 11 of the Restoration Report, which plotted stability trends for all measured constituents during the stabilization period as a percentage of the UIC permit restoration standards. Reference is also made to Table 8 of the Restoration Report, which contains the results of the stabilization monitoring.

A review of the constituents of concern listed in the Request for Additional Information indicates that many of these parameters were restored to a quality that was *better* than the baseline concentration for that parameter. In the study of groundwater geochemistry, generally the formation that contains the groundwater determines the groundwater quality. In undisturbed aquifers, the groundwater chemistry is in equilibrium with the formation. Therefore, when decreasing a particular parameter alters the groundwater quality, the formation groundwater system will tend towards equilibrium. In this circumstance, it is not unexpected that an increase in the concentration for parameters below the equilibrium concentration will occur over time until the groundwater again equilibrates with the sandstone formation. Of the fourteen parameters noted as indicating a strong increasing trend, five constituents (total dissolved solids, sulfate, sodium, chloride, and ammonium) were restored to a concentration well below the baseline average. Two others (potassium and radium-226) had at least one stabilization sample that was below the baseline concentration, indicating that restoration had successfully returned these constituents to a quality approaching if not as good as baseline.

Appendix A contains trend graphs from the stabilization period for all fourteen parameters identified by NRC. The graphs include a reference line for the average baseline concentration of the parameter. A review of these graphs indicates that most parameters do not exhibit a significant increasing trend, particularly when the final sample results are considered. Of the fourteen parameters listed by NRC, eleven showed no change or a significant decrease in the final stabilization sample. Only three parameters (ammonia, iron and magnesium) exhibited an increasing trend throughout the stabilization period.

- Ammonia was restored to concentrations below baseline. The final sample was 0.18 mg/l, or approximately 50 percent of the baseline concentration of 0.37 mg/l. It should be expected that ammonia concentrations would increase until natural background concentrations are restored.

- Iron exhibits a strong trend throughout the stabilization period, increasing from 0.049 to 0.127 mg/l. However, restoration successfully reduced iron to concentrations well below the secondary restoration goal. The final sample was 0.127 mg/l, or 42 percent of the restoration standard of 0.30 mg/l, which is based on the EPA Secondary Drinking Water Regulations (SDWR).
- Magnesium increased from 4.3 to 6.1 mg/l during the stabilization period. However, restoration successfully reduced magnesium to concentrations well below the secondary restoration goal. The final sample was 6.1 mg/l, or 19 percent of the restoration standard of 32 mg/l. Note that there are no EPA or NDEQ numerical standards for magnesium. The restoration standard is based upon one order of magnitude above baseline concentrations due to the ability of some major ions to vary with pH.

To provide additional data supporting the assertion that Mine Unit 1 is relatively stable, CBR has summarized monitoring data for three Mine Unit 1 baseline restoration wells that have been sampled routinely since the stabilization period. These wells were designated as perimeter monitor wells in December 1999 following the approval of the Mine Unit 1 restoration by the NDEQ. The three wells (PR-8, PR-15 and IJ-13) were selected to serve as perimeter monitor wells for Mine Units 2 and 3 and are evenly distributed in Mine Unit 1. Figure 3 shows the location of these three wells within Mine Unit 1.

Biweekly monitoring for PR-8, PR-15, and IJ-13 began on December 30, 1999 and has continued to the present. Monitoring is performed for the five excursion parameters (sodium, chloride, sulfate, conductivity, and alkalinity). CBR believes that the excursion monitoring data from these wells is useful because NRC lists three of the parameters (chloride, sodium and sulfate) as constituents of concern due to the trends noted during stabilization. Another parameter, conductivity, is a general indicator of the ionic concentration of water and will address NRC concerns over the total dissolved solids parameter. These four parameters were restored to concentrations at or below the baseline concentrations, so some increase over time would be expected. The final excursion parameter, alkalinity, may be used to address NRC concerns over the trend for total carbonate.

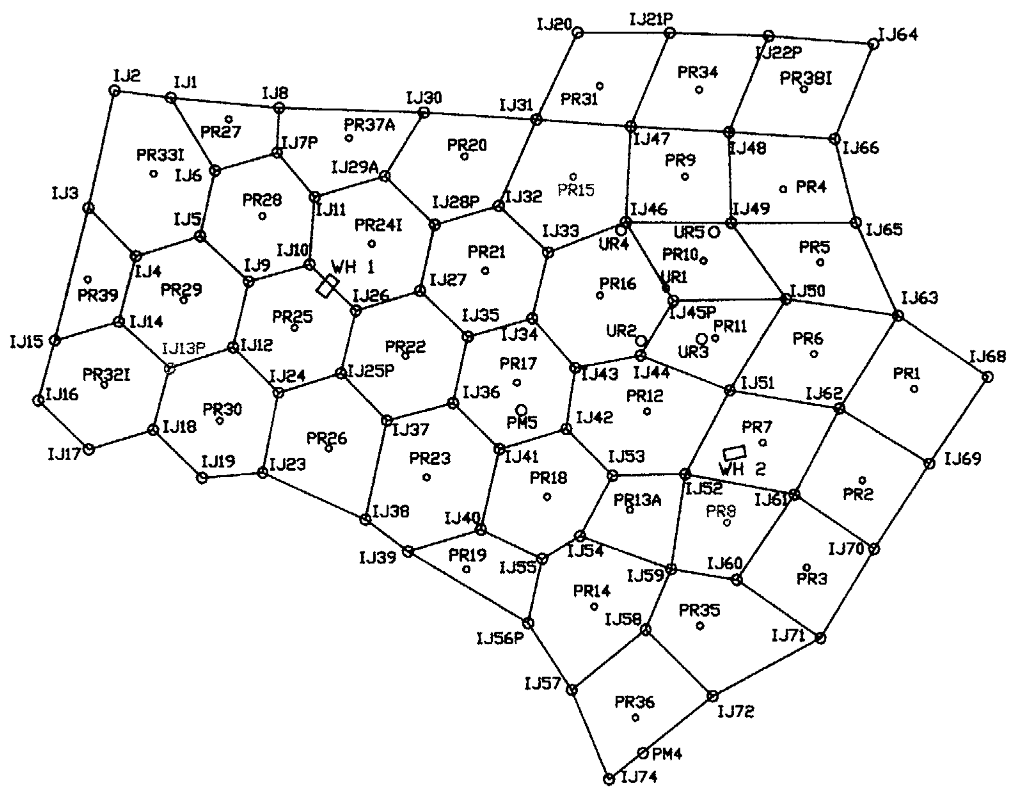
Figure 4 provides the results of the stabilization monitoring from February through July 1999 and the biweekly excursion monitoring from December 30, 1999 through July 12, 2001 for PR-8, PR-15, and IJ-13, showing trends during this period for all five excursion parameters. The individual data for each monitored constituent was averaged for the three wells in accordance with the restoration goals (i.e., mine unit average). Note that there were no samples obtained during the period between the end of the stabilization period in July 1999 and the initial excursion monitoring following NDEQ approval of Mine Unit 1 restoration in December 1999.

The data for the 29-month period indicates no increasing trend for any of the monitored constituents. The complete monitoring data and individual trend graphs for each parameter are included in Appendix B. Note that the individual trend graphs also show the baseline concentration for reference purposes. With the exception of alkalinity, all parameters are below the baseline average for the parameter of interest. Average alkalinity concentrations have been approximately 13 percent above baseline during the period, but no strong trends are exhibited.

Based upon the analysis of the stabilization data for the constituents listed by NRC and the representative stabilization and monitoring data obtained since December 1999, CBR believes that Mine Unit 1 has exhibited stability during and since the stabilization phase of restoration.

Figure 3

Mine Unit 1
Monitor Well Locations



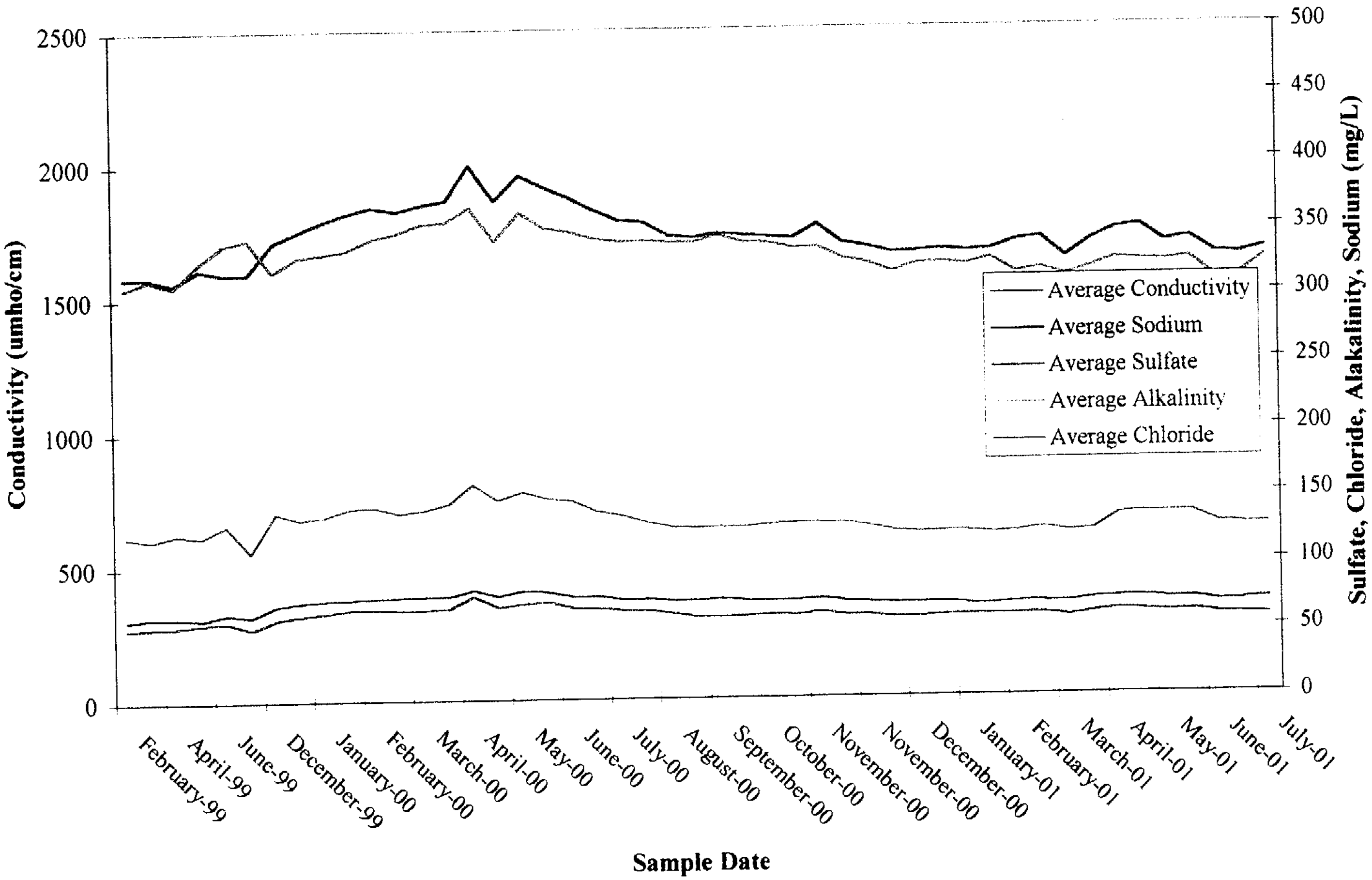
CROW BUTTE PROJECT
Mine Unit 1
Monitor Well Locations
Sec 19 T31N R51W

0 50 meters

0 50 100 150 200 feet

N

Figure 4
Mine Unit 1 Average Monitor Well Trends



3.2.3 Iso Concentration Maps

NRC requested that CBR submit iso-concentration maps for radium-226, natural uranium, total dissolved solids, and total carbonate in the Mine Unit 1 restoration and perimeter monitor wells, once the restoration is stable. As discussed in Section 3.2.2, CBR believes that the data indicates that the restoration was stable during the stabilization phase. Therefore, iso-concentration maps have been prepared from the stabilization period monitoring data.

Appendix C contains the iso-concentration maps for the parameters requested. The maps were developed from the final data set collected on July 15, 1999 from the Mine Unit 1 Baseline Restoration Wells. Data from the Mine Unit 1 perimeter monitor wells (CM1-Wells) was not used to prepare these maps as requested in the Request for Additional Information. As explained in Section 3.2 of the restoration report, these wells were no longer in service as monitor wells on that date. During the expansion of mining operations, the CM1–Wells were incorporated into neighboring mine units. Therefore, data collected from these wells would not be relative to the groundwater quality in Mine Unit 1 following restoration. The successive removal of these wells as active perimeter monitor wells was approved by NRC in the Notices of Intent to Operate for Mine Units 2, 3 and 4.

When reviewing these maps, it is important to keep in mind the limitations of the gridding programs, and the nature of the parameters being modeled. These iso-concentration maps were generated using a linear Kriging gridding method within the contouring program, Surfer (published by Golden Software, Golden, Colorado). This method produces a regularly spaced, rectangular array of concentration values collected from the Baseline Restoration Wells. These wells are not evenly spaced over the wellfield area, which leads to missing data in the grid pattern. The gridding method interpolates concentration values where no data exists. Therefore, the contours extending beyond the boundaries of the wellfield represent an interpretation by the gridding program where there is no data.

As mentioned above, the gridding program can only produce a grid map from the data provided. The gridding program does not recognize the geochemical reactions that take place between the groundwater and the host formation. This is another limitation associated with the gridding program. As an example, the iso-concentration map produced for radium-226 generates high concentration contours some distance beyond the southwest boundary of Mine Unit 1. However, due to the strong sorption affinity of radium-226, it is unlikely that these extrapolated concentration levels present an accurate representation of the radium-226 concentrations in that area. It has been documented at numerous uranium mine and tailings disposal sites that radium-226 does not migrate a significant distance from its source.

4 RESTORATION OF WELL FIELD FLARE

NRC has requested additional information related to wellfield flare, which is the presence of affected groundwater between the wellfield and the perimeter monitor wells. NRC is concerned that the Restoration Report does not describe how wellfield flare was restored. Specifically, NRC has requested the following information:

4.1 NRC Request

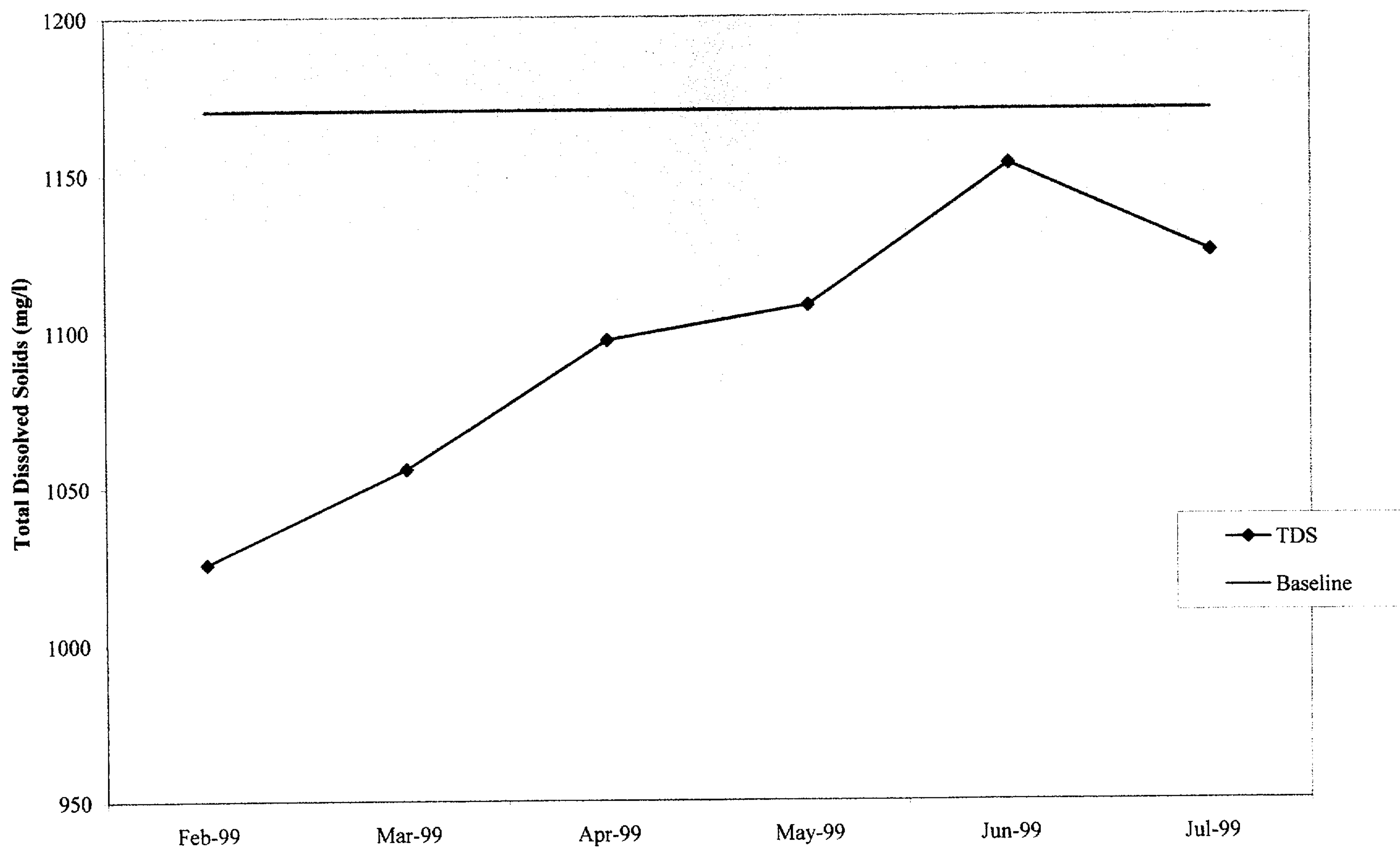
Describe how the well field contamination flares, between the wellfield and the perimeter monitoring wells on the north and south sides of Unit 1, have been restored. Provide any monitoring data, analyses, or calculations that show restoration has occurred in these areas.

4.2 CBR Response

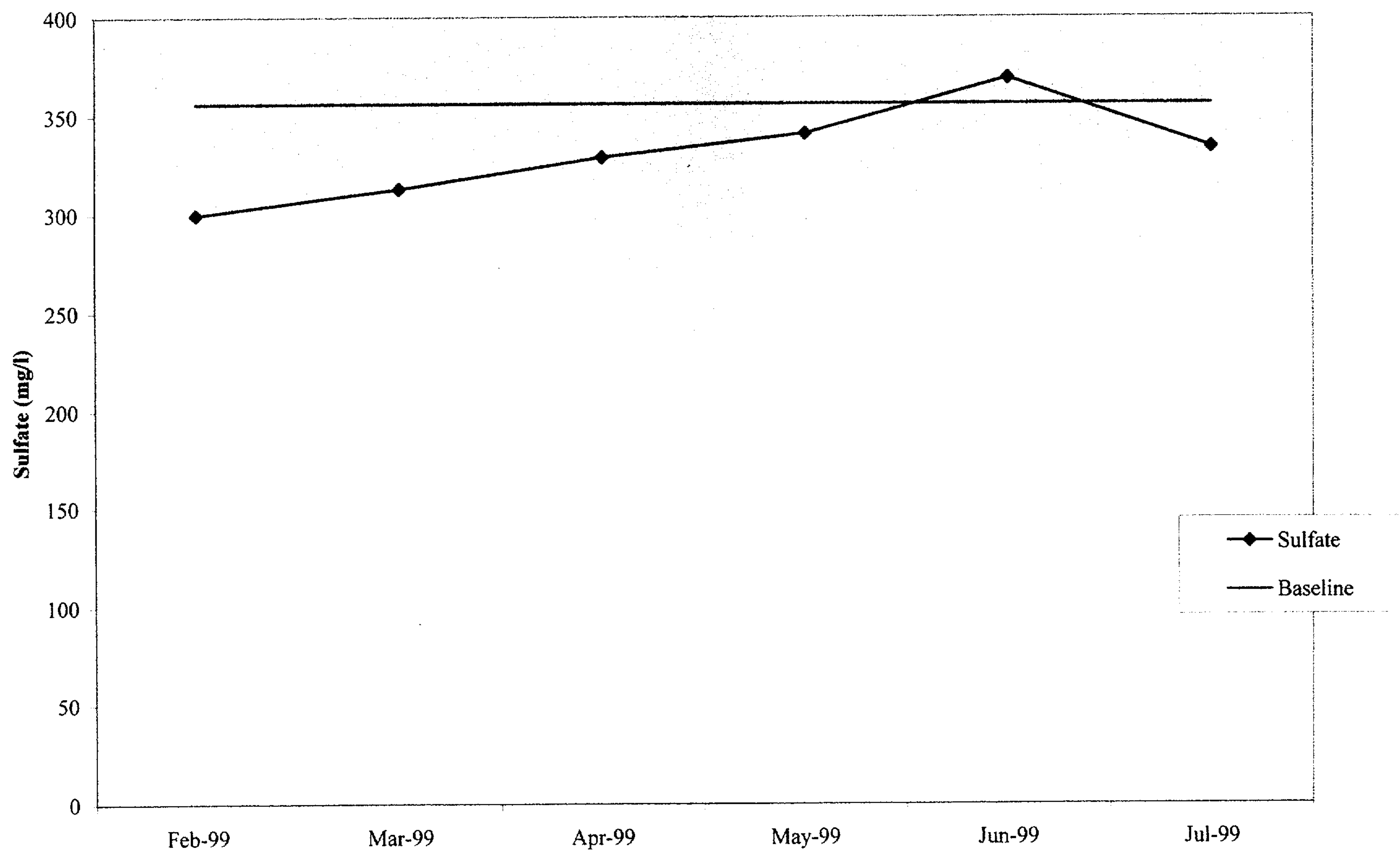
In Section 3.2 of the Mine Unit 1 Restoration Report, CBR describes the limited use of groundwater sweep during restoration due to the configuration of the surrounding mine units. In place of ground water sweep, CBR used a series of ground water transfers to replace high TDS mining solutions with baseline TDS groundwater within Mine Unit 1. The transfers produced similar results, as would an extended groundwater sweep program, with the exception of recovering mining solutions that had flared beyond the mine unit boundaries. Although some mining solution was recovered during the groundwater sweep phase of restoration, the solution was primarily recovered during reverse osmosis treatment of the edge patterns adjacent to these areas. This fact is demonstrated when comparing the number of pore volumes of reverse osmosis treatment needed to return the edge patterns to baseline conductivity, as compared to the interior patterns. An average of 8.4 pore volumes of reverse osmosis treatment was required to return the groundwater in the north and south edge patterns of Mine Unit 1 to baseline conductivity, versus 6.0 pore volumes for the rest of the Mine Unit 1 patterns. This would indicate that flared mining solutions were drawn into these edge patterns during reverse osmosis treatment. Since baseline groundwater conductivity was achieved in these edge patterns during reverse osmosis treatment, it would mean that the groundwater outside of these patterns was also returned to baseline conductivity, indicating that the flared mining solution was recovered from the areas north and south of Mine Unit 1 during restoration.

Appendix A. Stabilization Trends for Selected Parameters

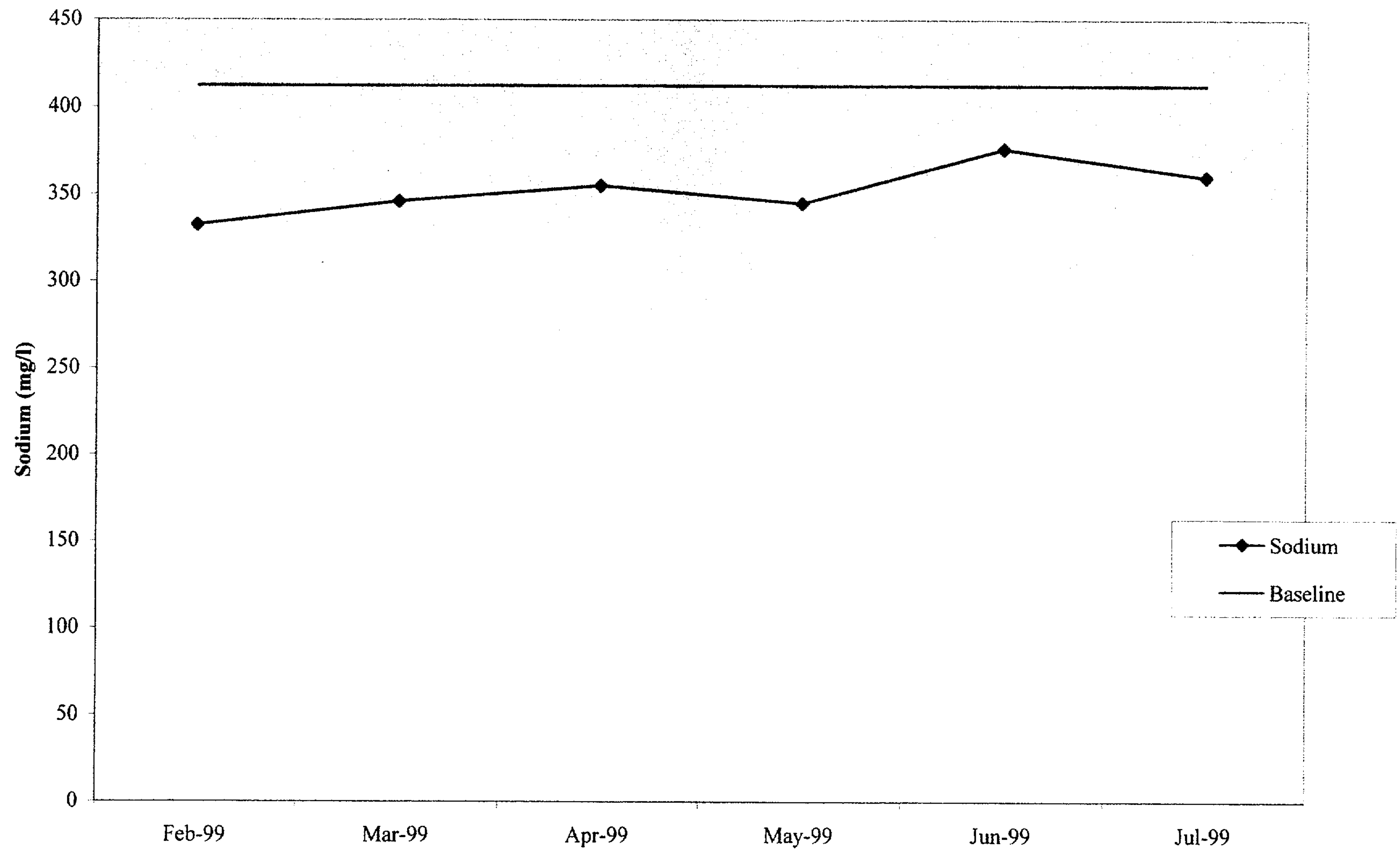
Mine Unit 1 Total Dissolved Solids Trend



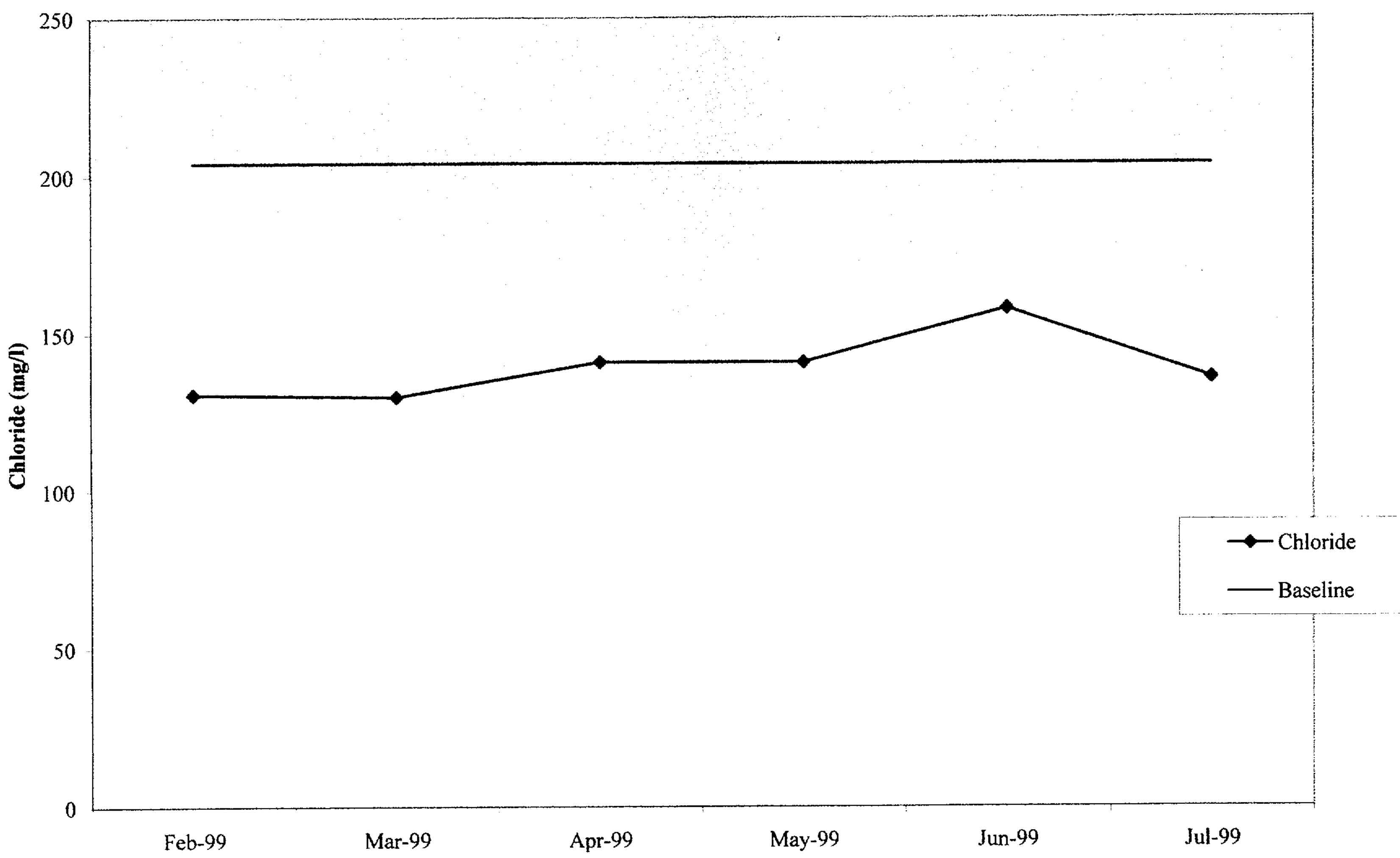
Mine Unit 1 Sulfate Trend



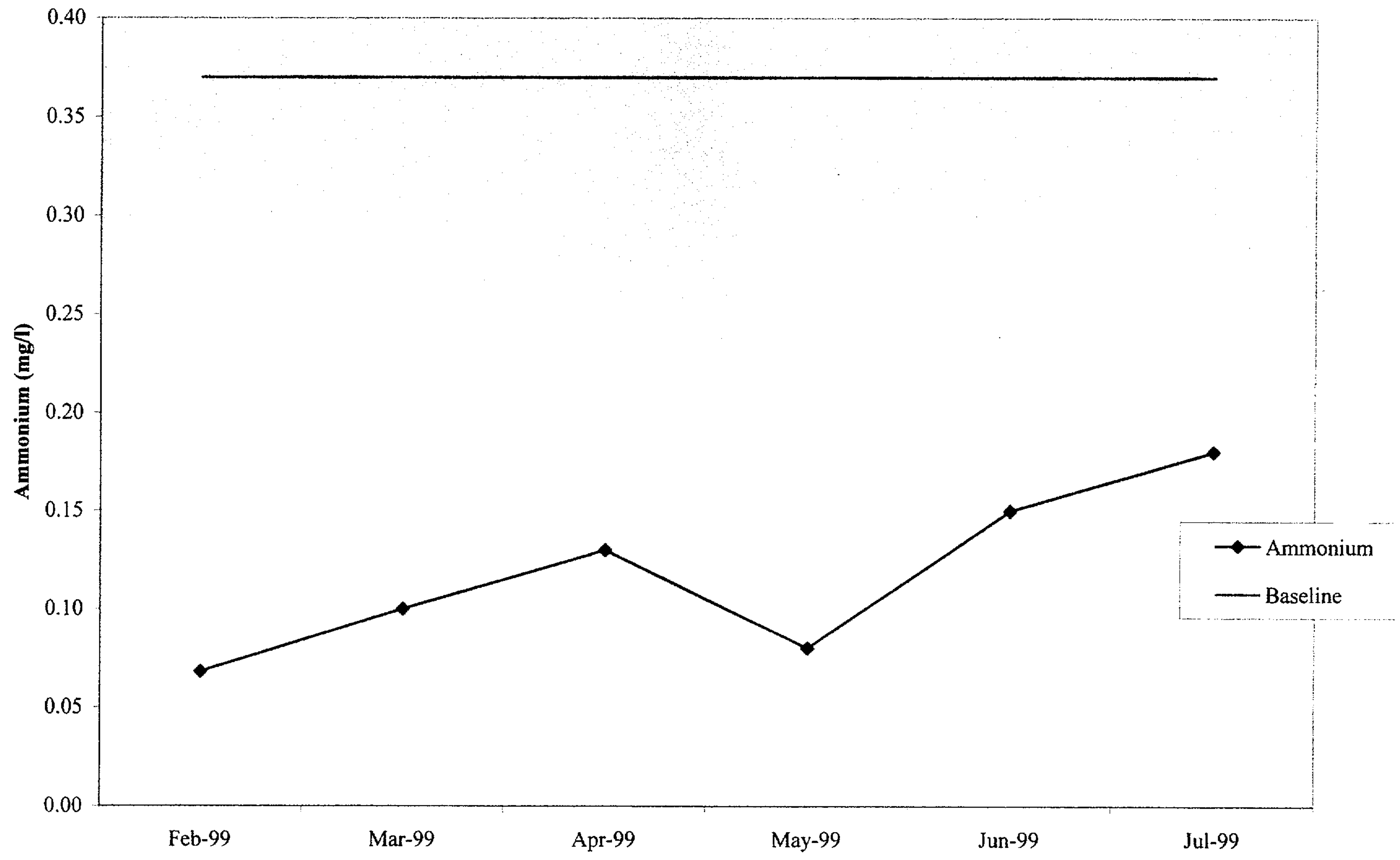
Mine Unit 1 Sodium Trend



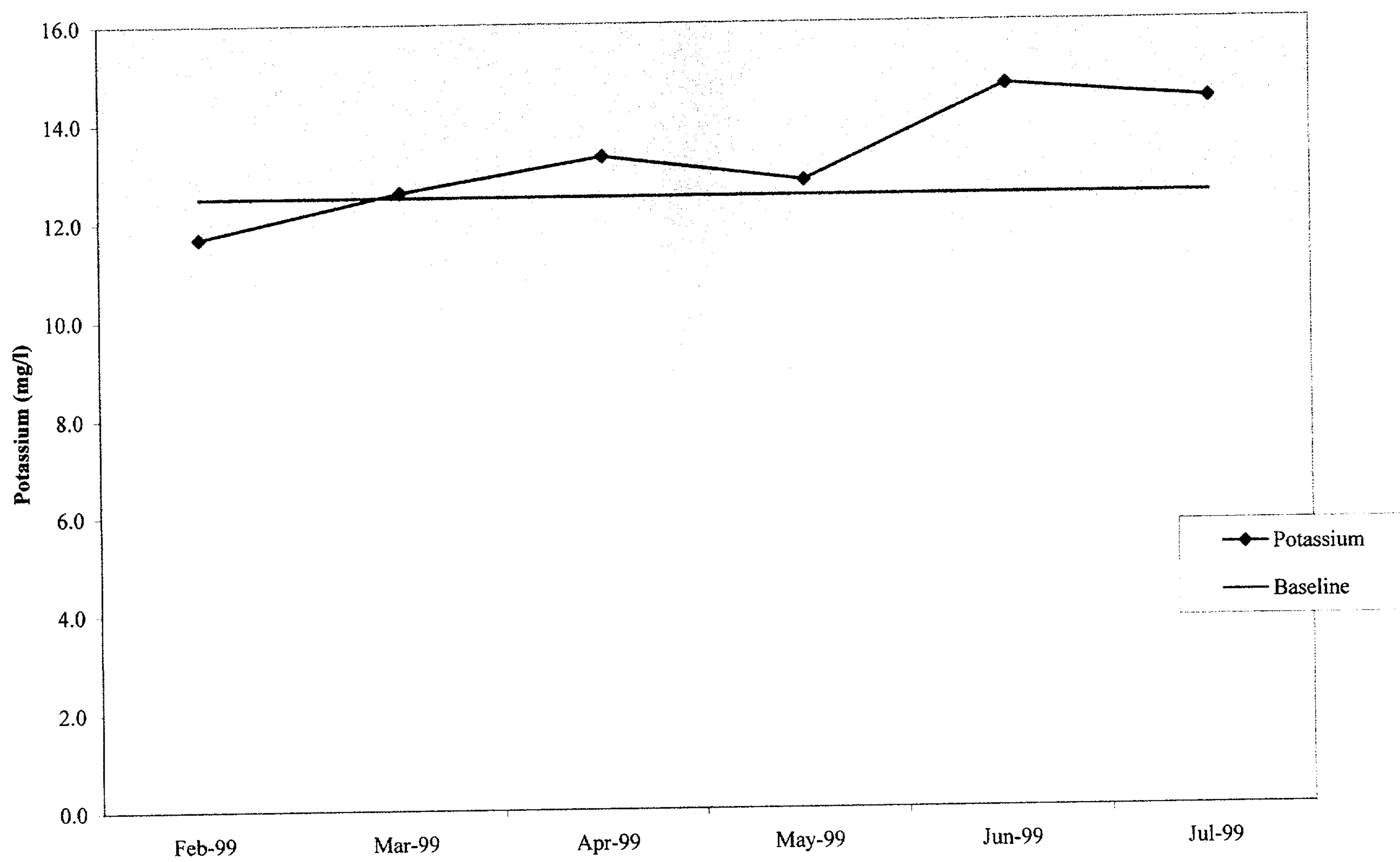
Mine Unit 1 Chloride Trend



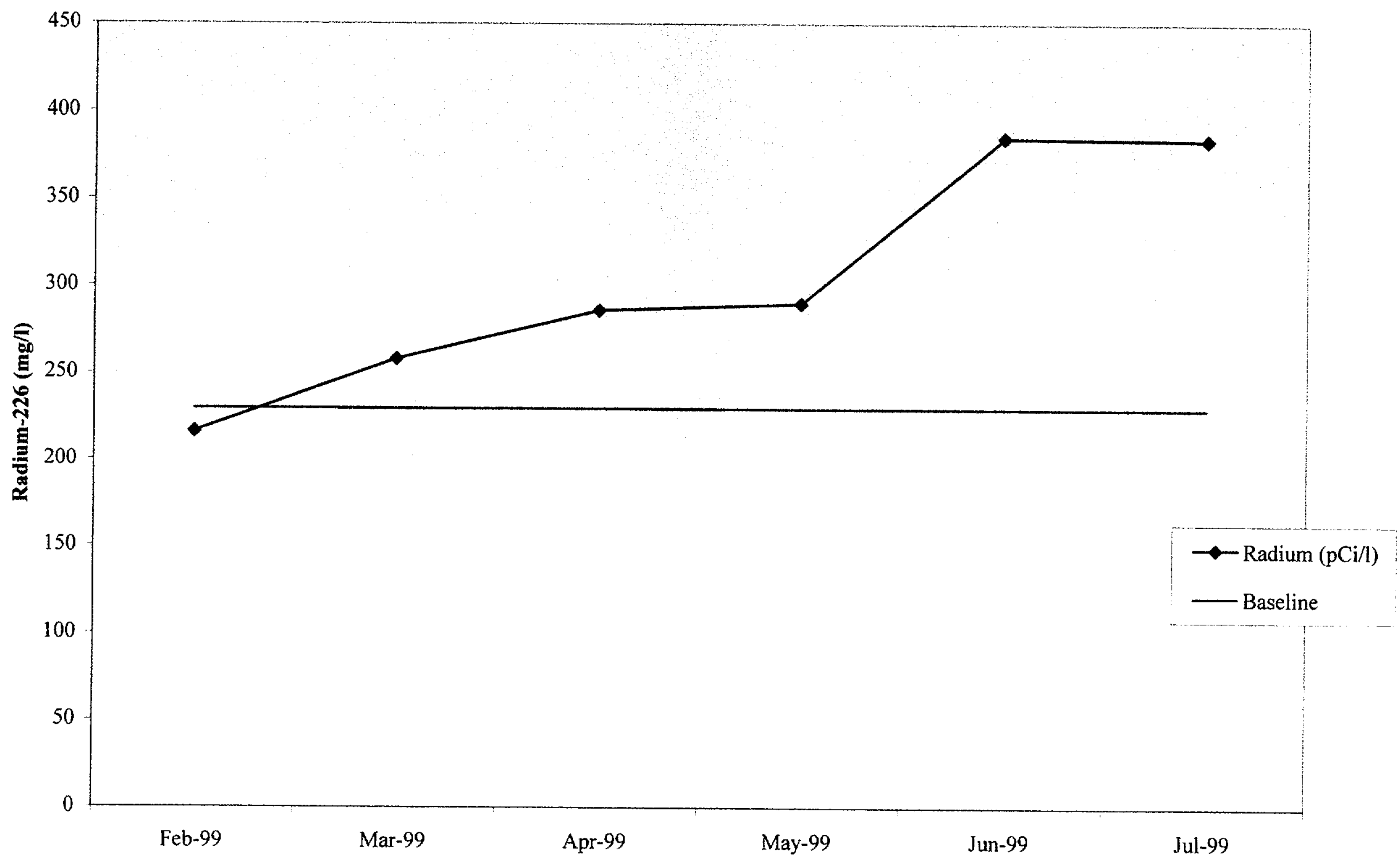
Mine Unit 1 Ammonium Trend



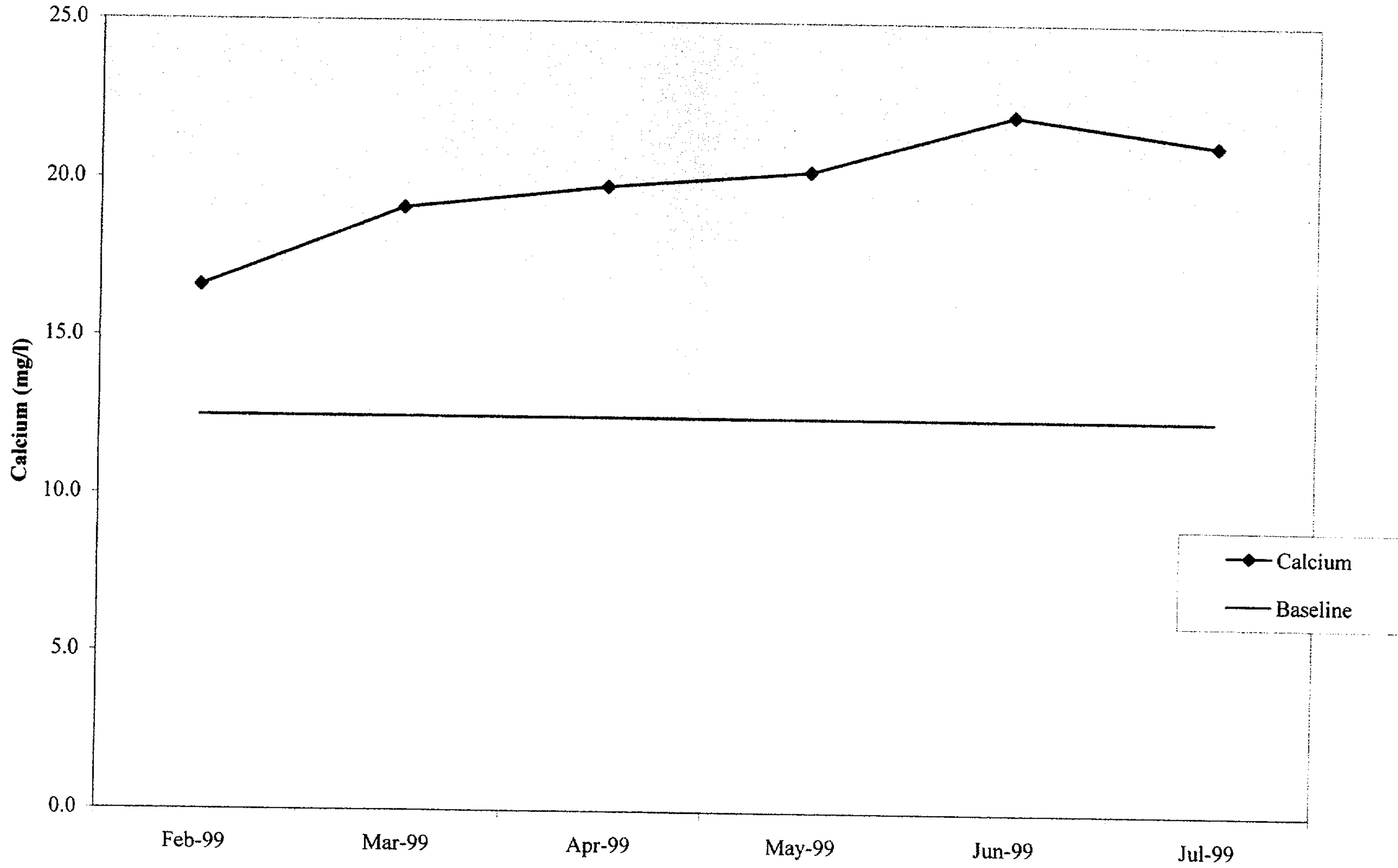
Mine Unit 1 Potassium Trend

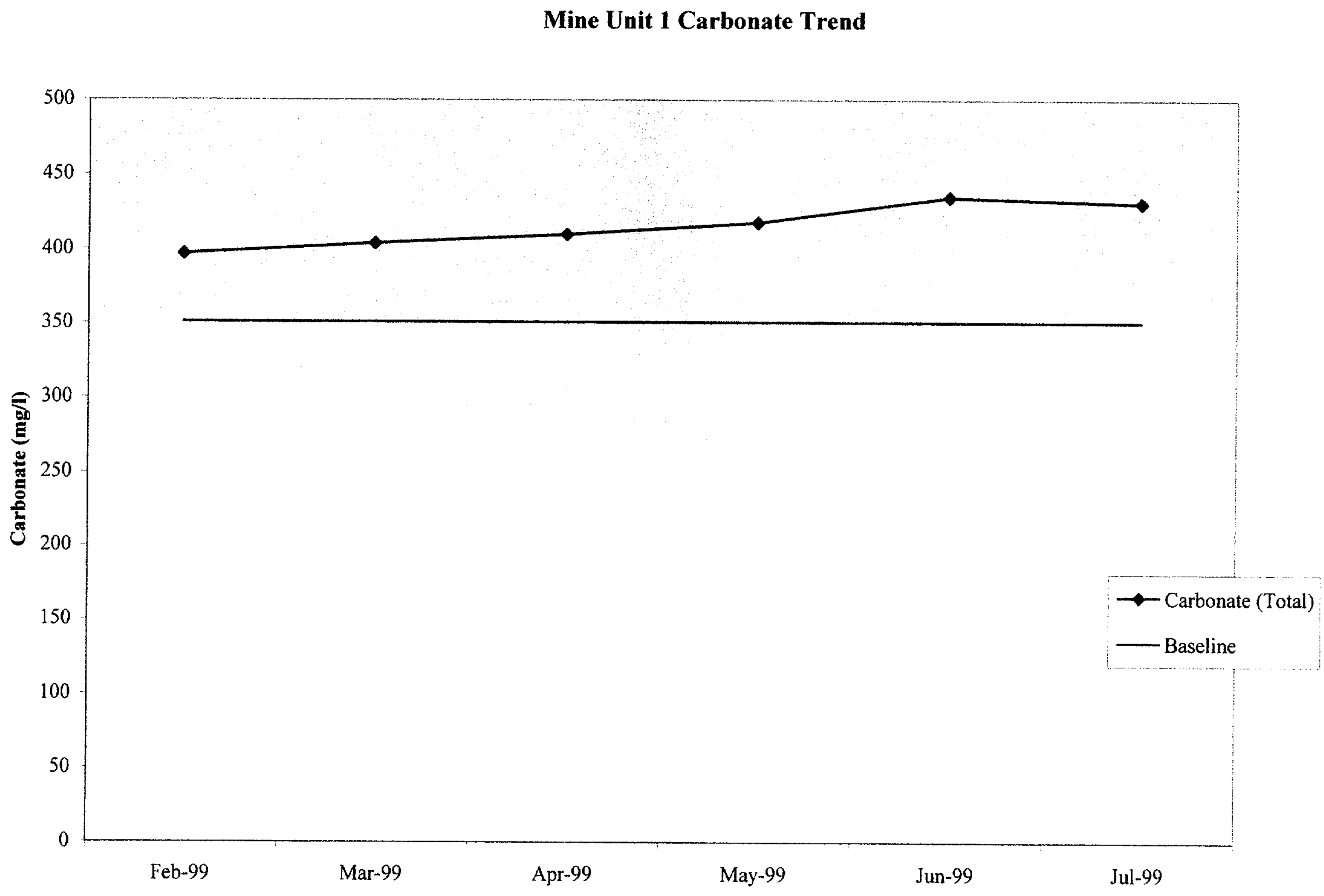


Mine Unit 1 Radium-226 Trend



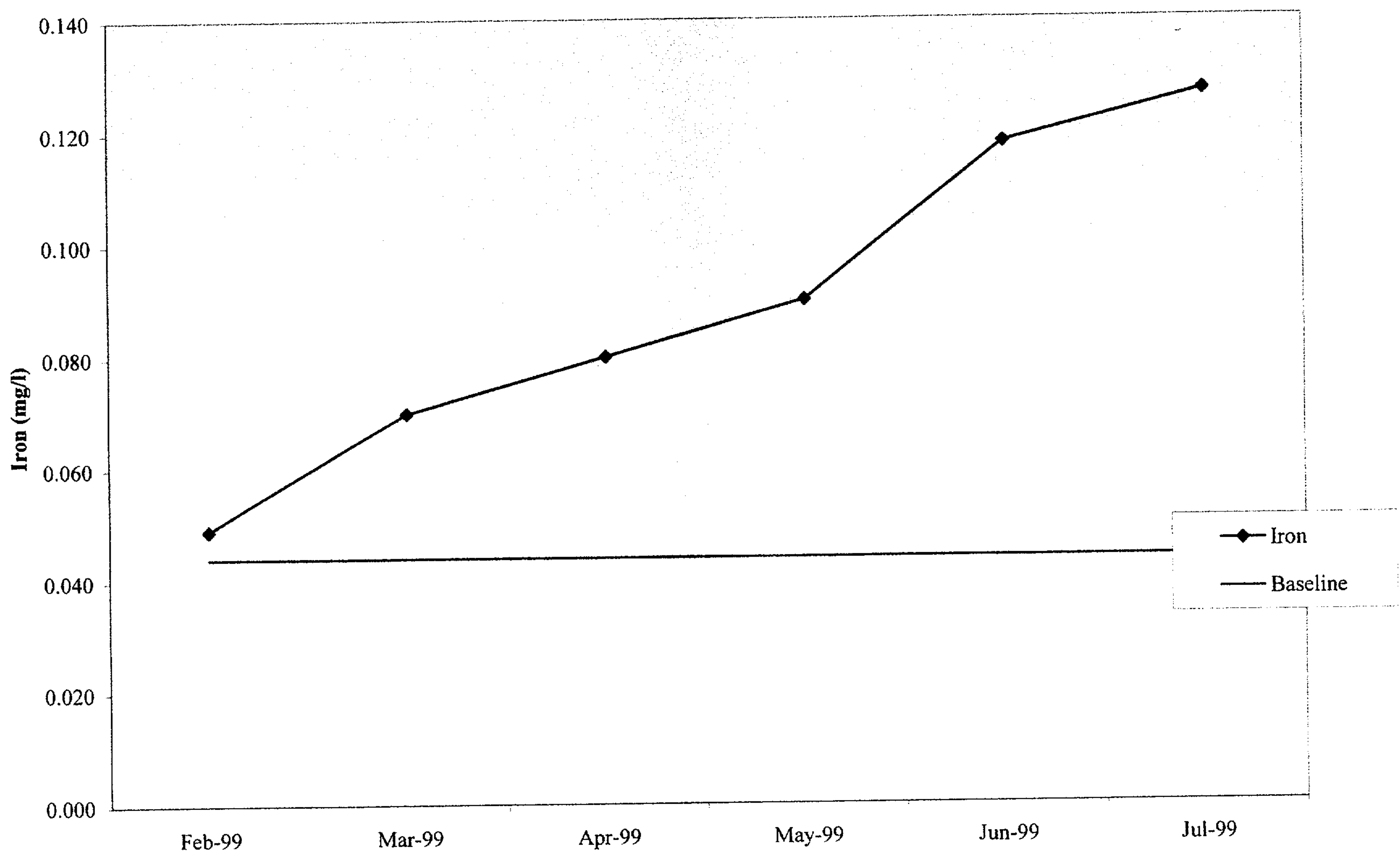
Mine Unit 1 Calcium Trend



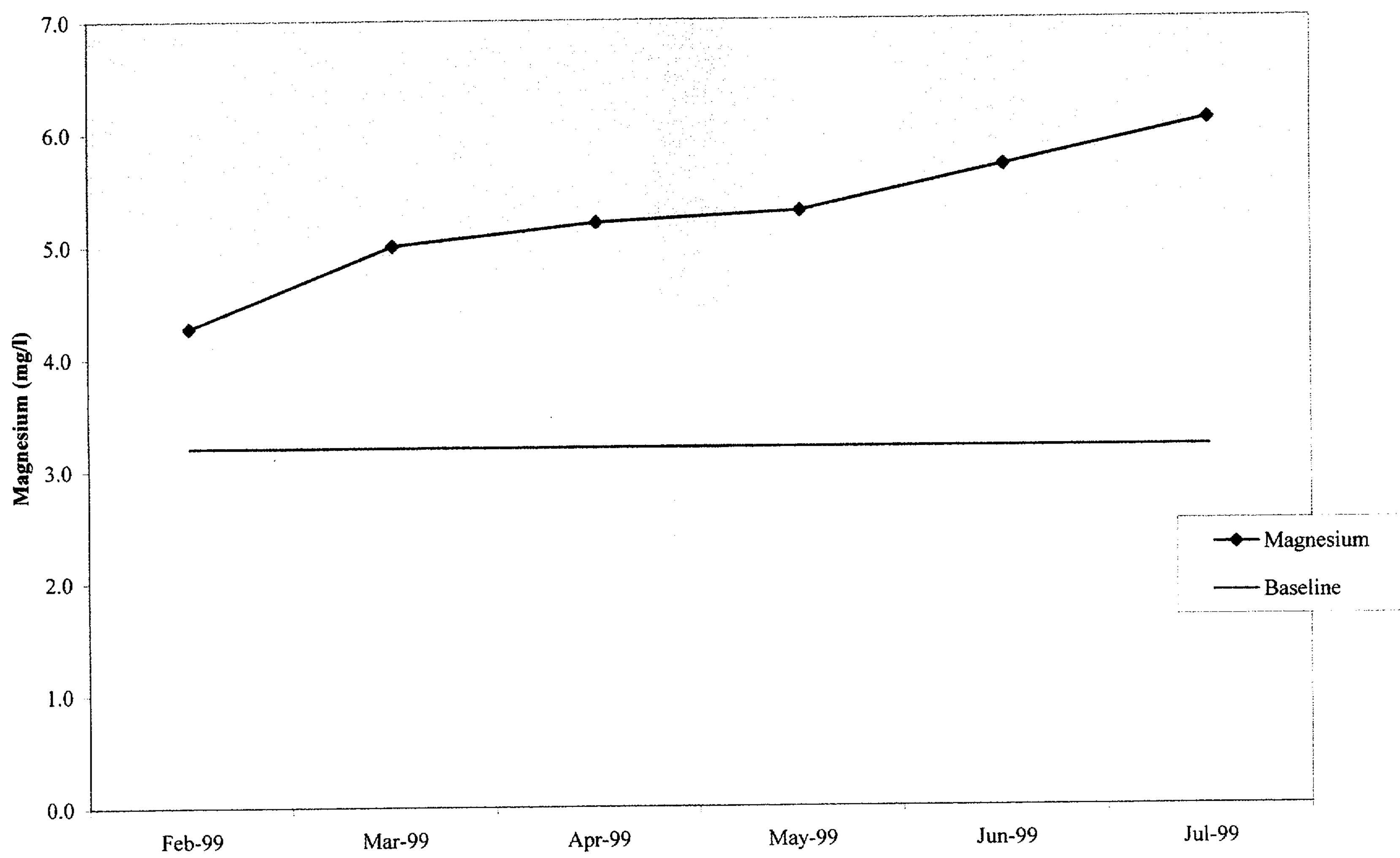


Mine Unit 1 Carbonate Trend
Carbonate (mg/l)
500
450
400
350
300
250
200
150
100
50
0
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Carbonate (Total)
Baseline

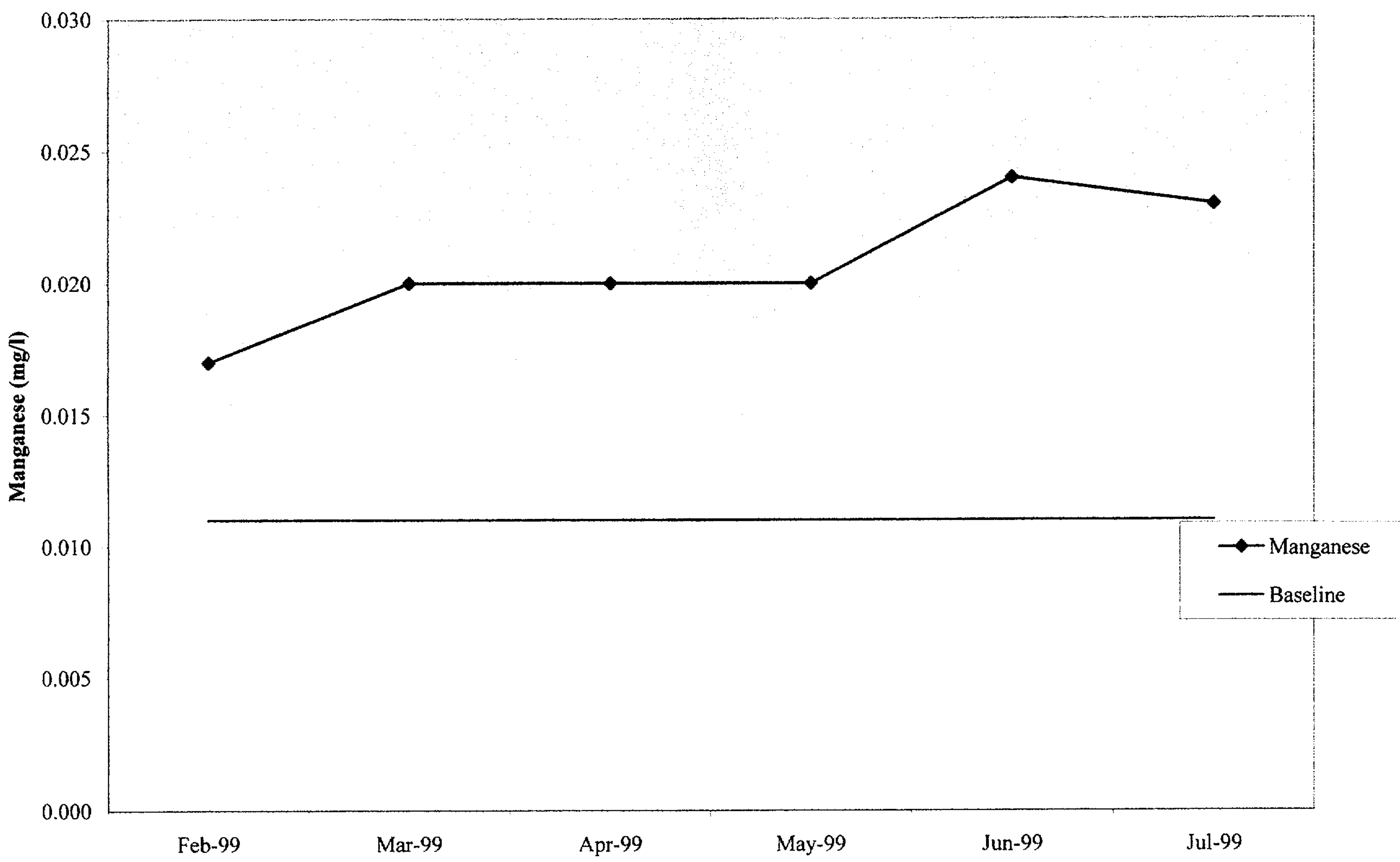
Mine Unit 1 Iron Trend

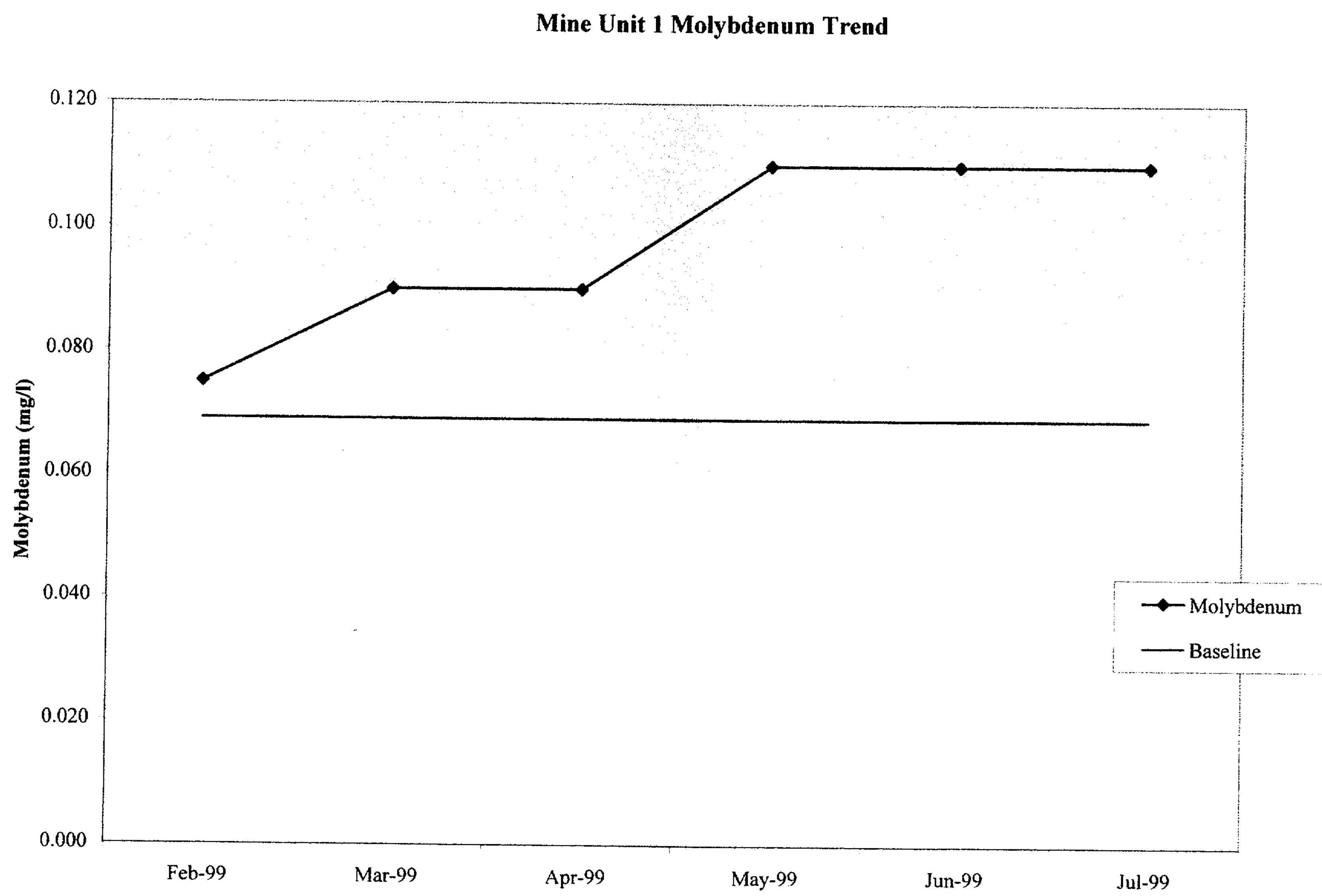


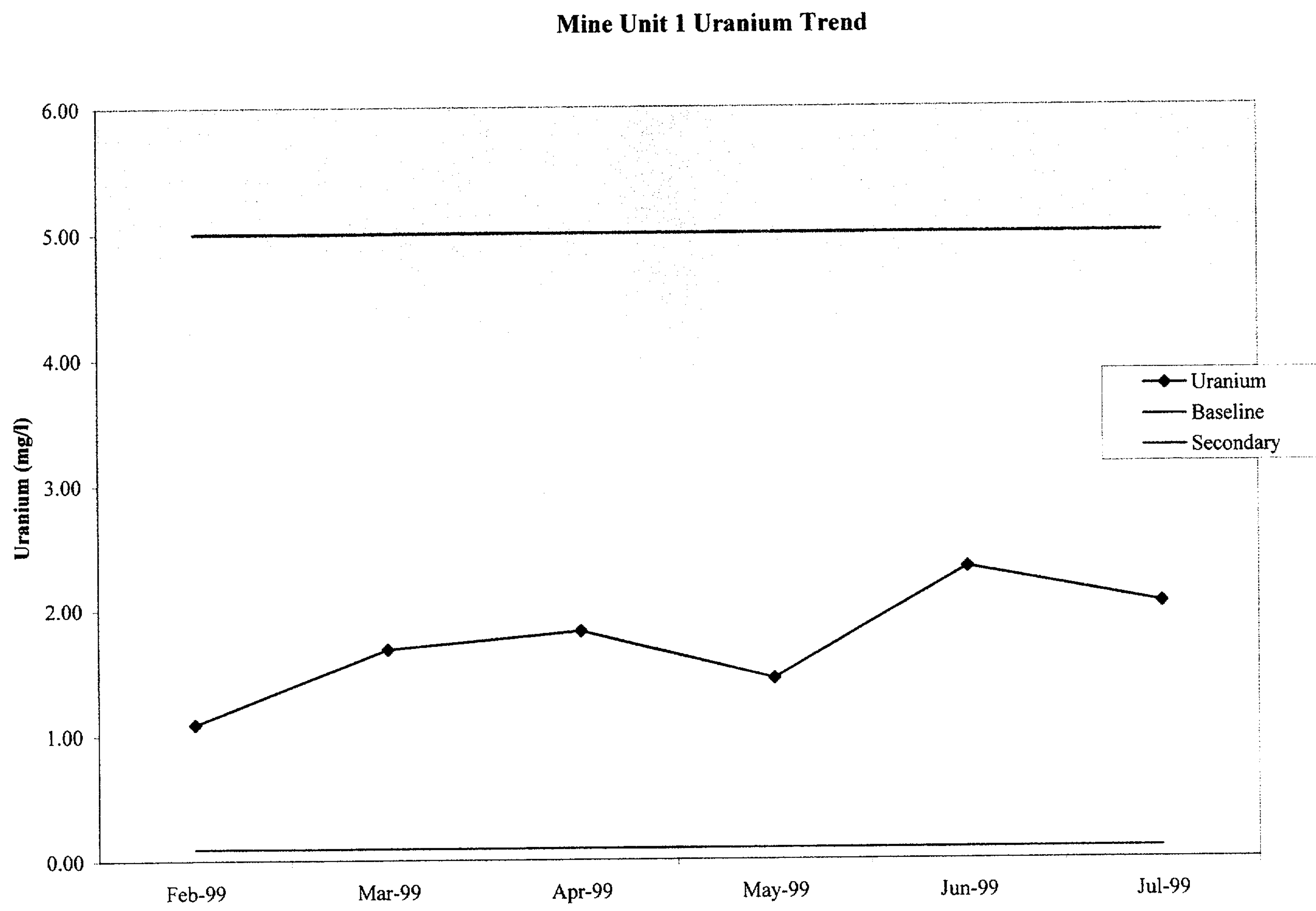
Mine Unit 1 Magnesium Trend



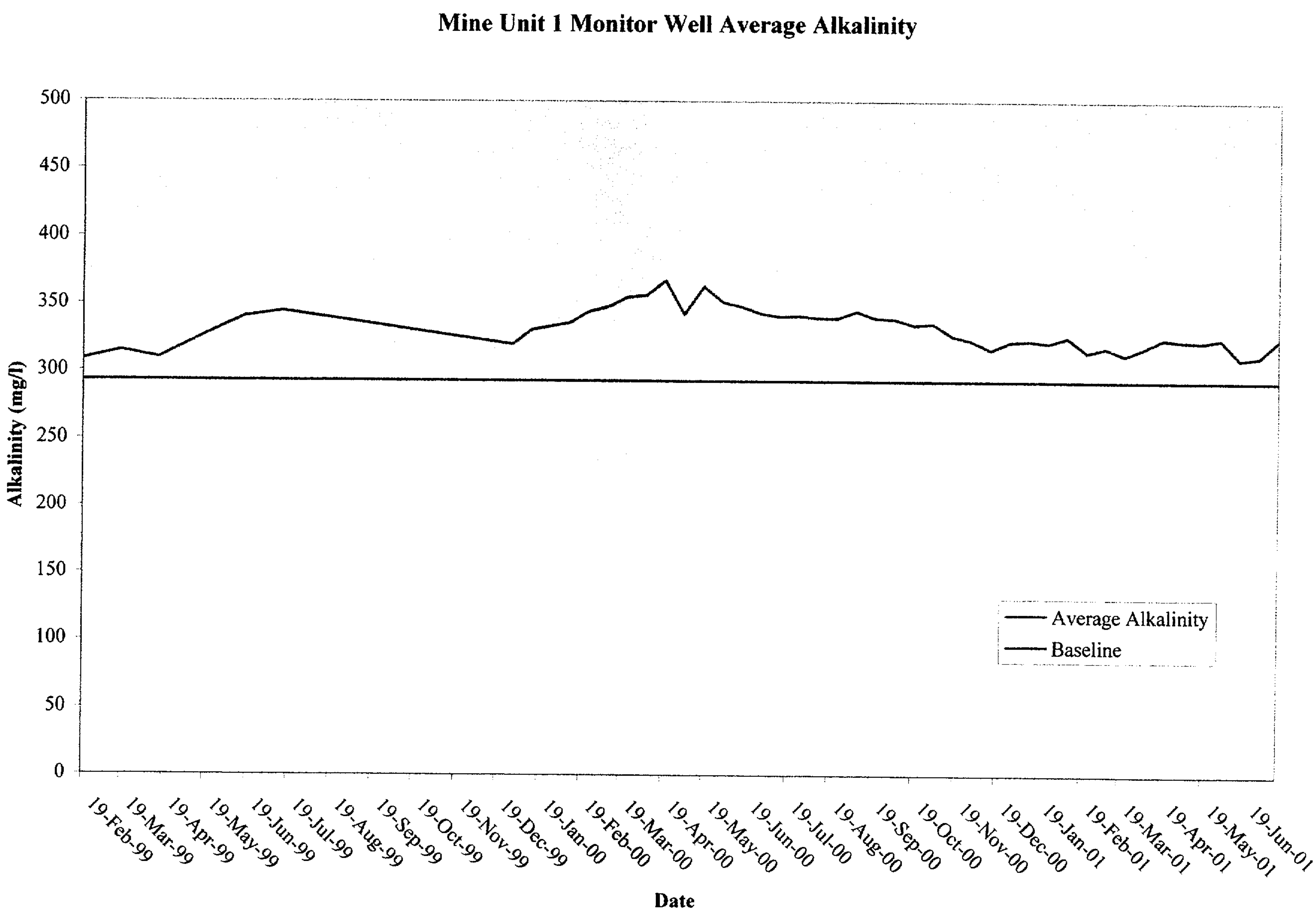
Mine Unit 1 Manganese Trend



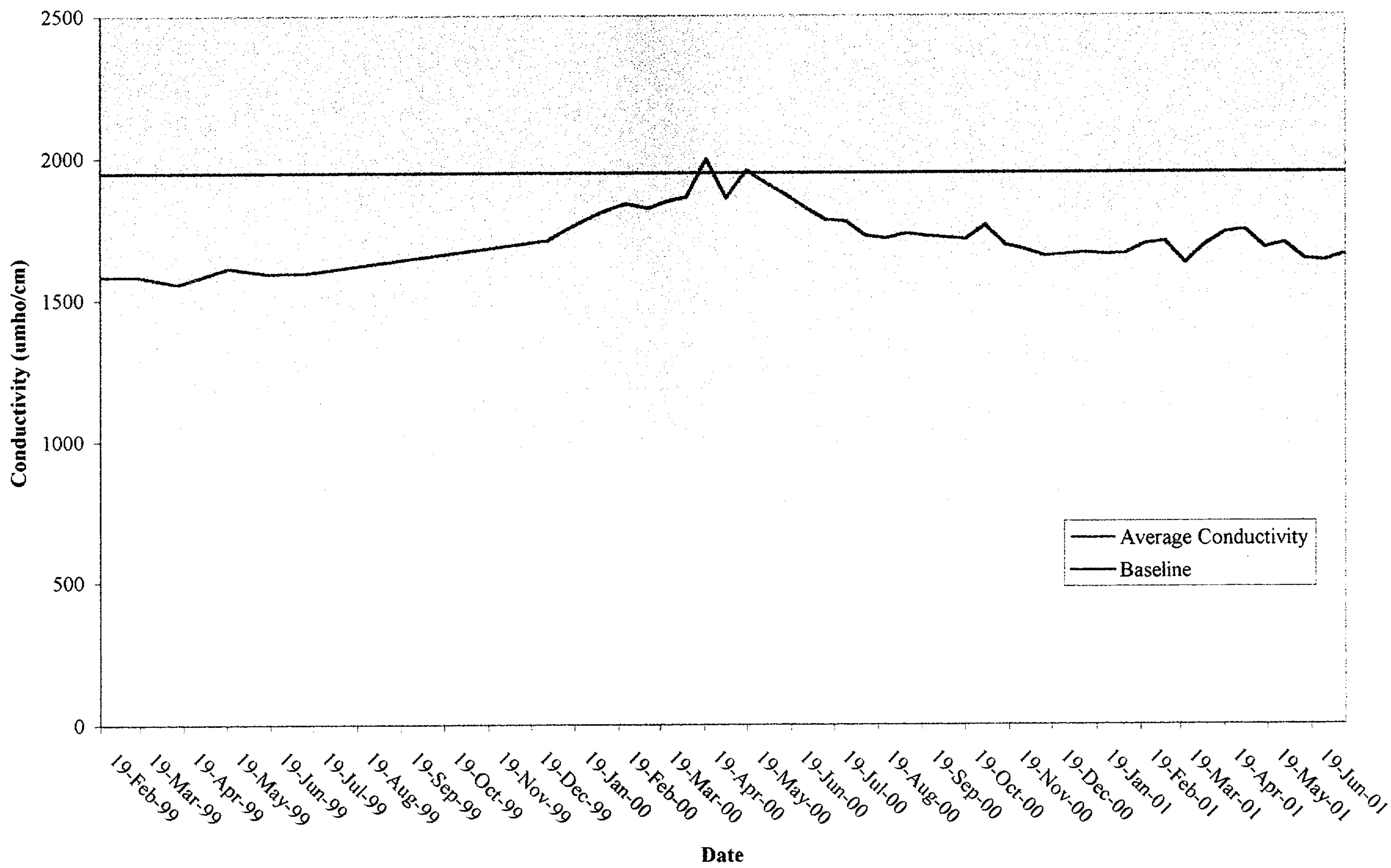

Mine Unit 1 Molybdenum Trend
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Molybdenum (mg/l)
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Molybdenum
Baseline


Mine Unit 1 Uranium Trend
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Uranium (mg/l)
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Uranium
Baseline
Secondary

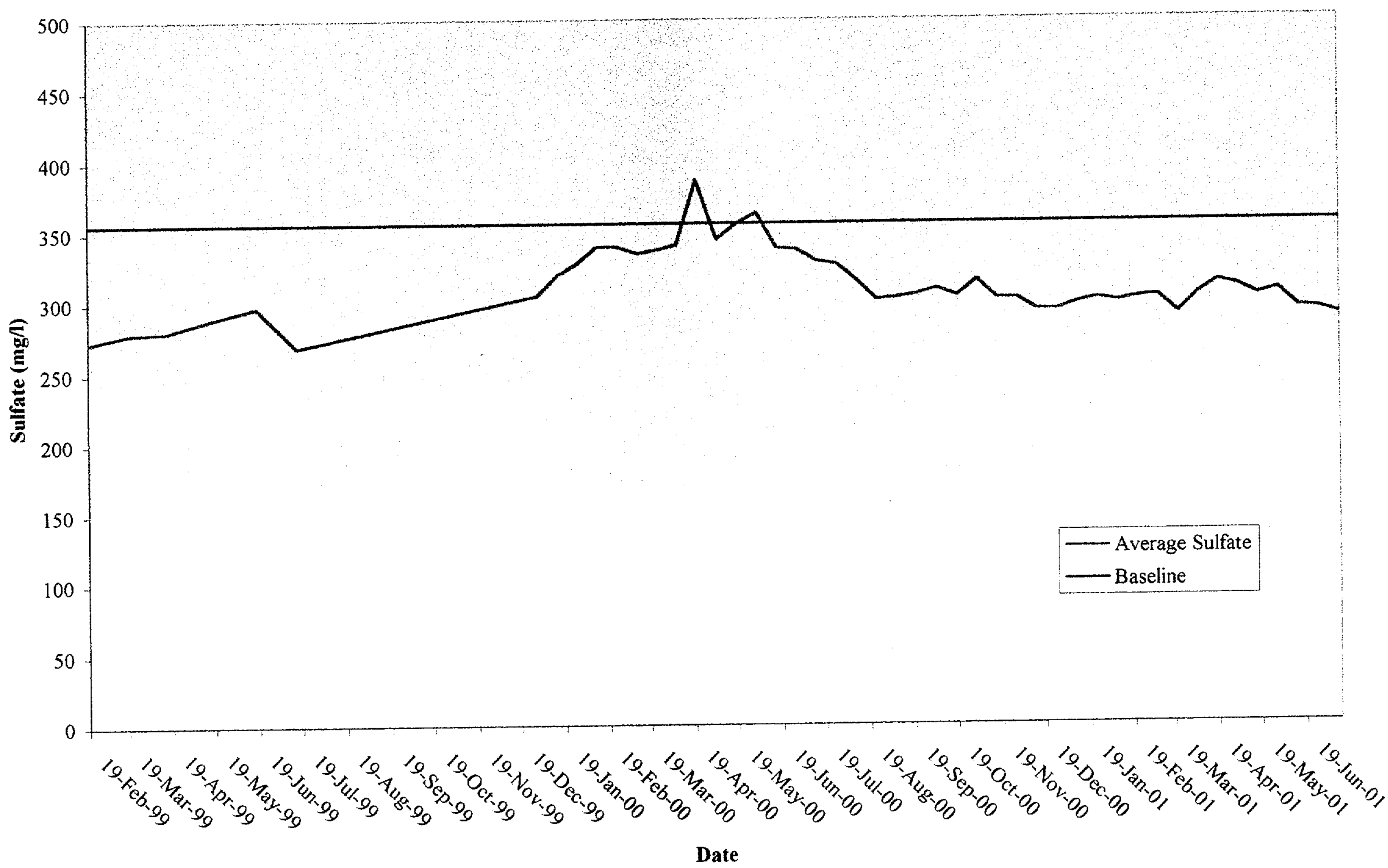
Appendix B. Trends for Selected Parameters Since Stabilization


Mine Unit 1 Monitor Well Average Alkalinity
500
450
400
350
300
250
200
150
100
50
0
Alkalinity (mg/l)
Average Alkalinity
Baseline
19-Feb-99
19-Mar-99
19-Apr-99
19-May-99
19-Jun-99
19-Jul-99
19-Aug-99
19-Sep-99
19-Oct-99
19-Nov-99
19-Dec-99
19-Jan-00
19-Feb-00
19-Mar-00
19-Apr-00
19-May-00
19-Jun-00
19-Jul-00
19-Aug-00
19-Sep-00
19-Oct-00
19-Nov-00
19-Dec-00
19-Jan-01
19-Feb-01
19-Mar-01
19-Apr-01
19-May-01
19-Jun-01
Date

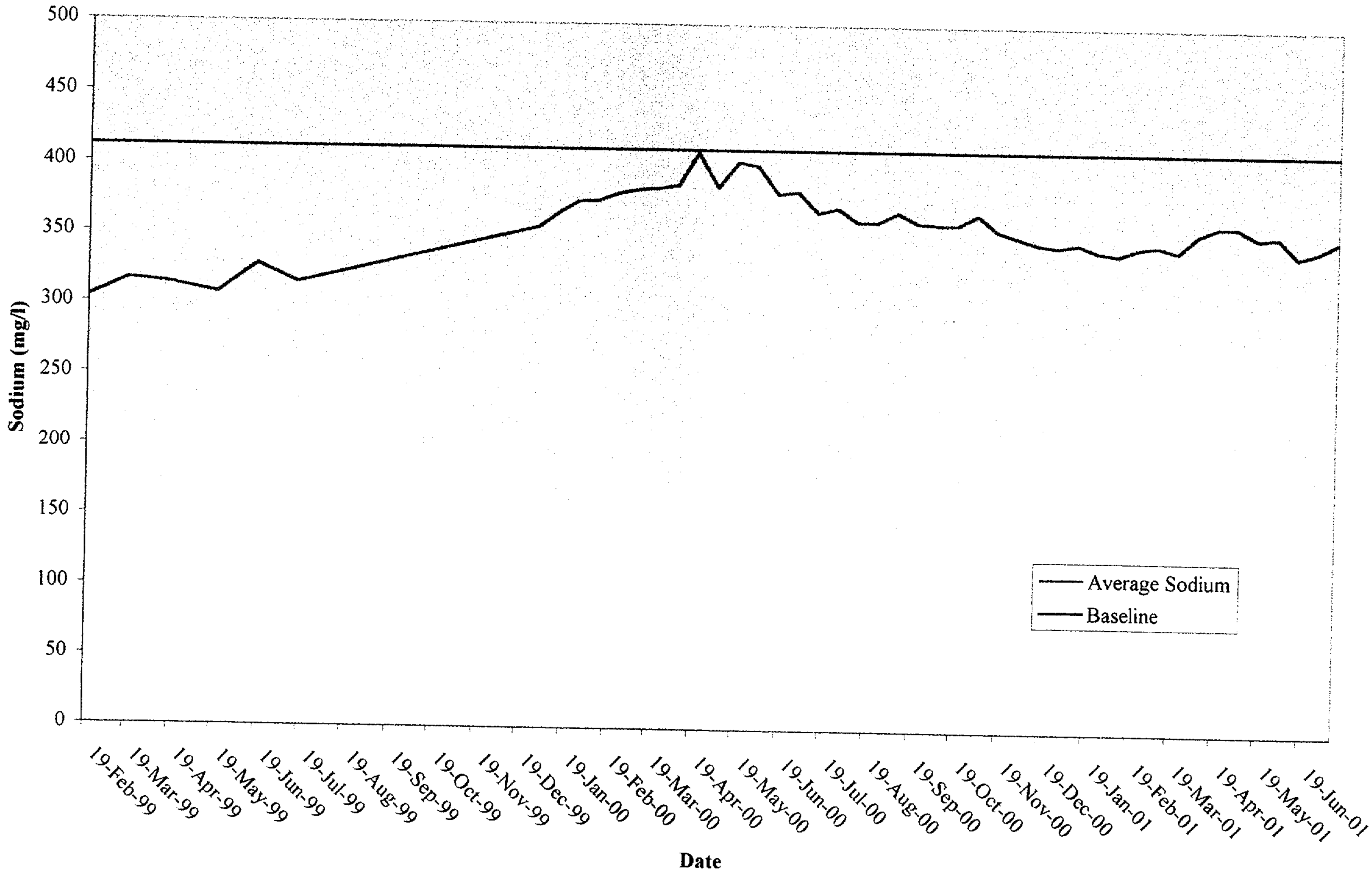
Mine Unit 1 Monitor Well Average Conductivity



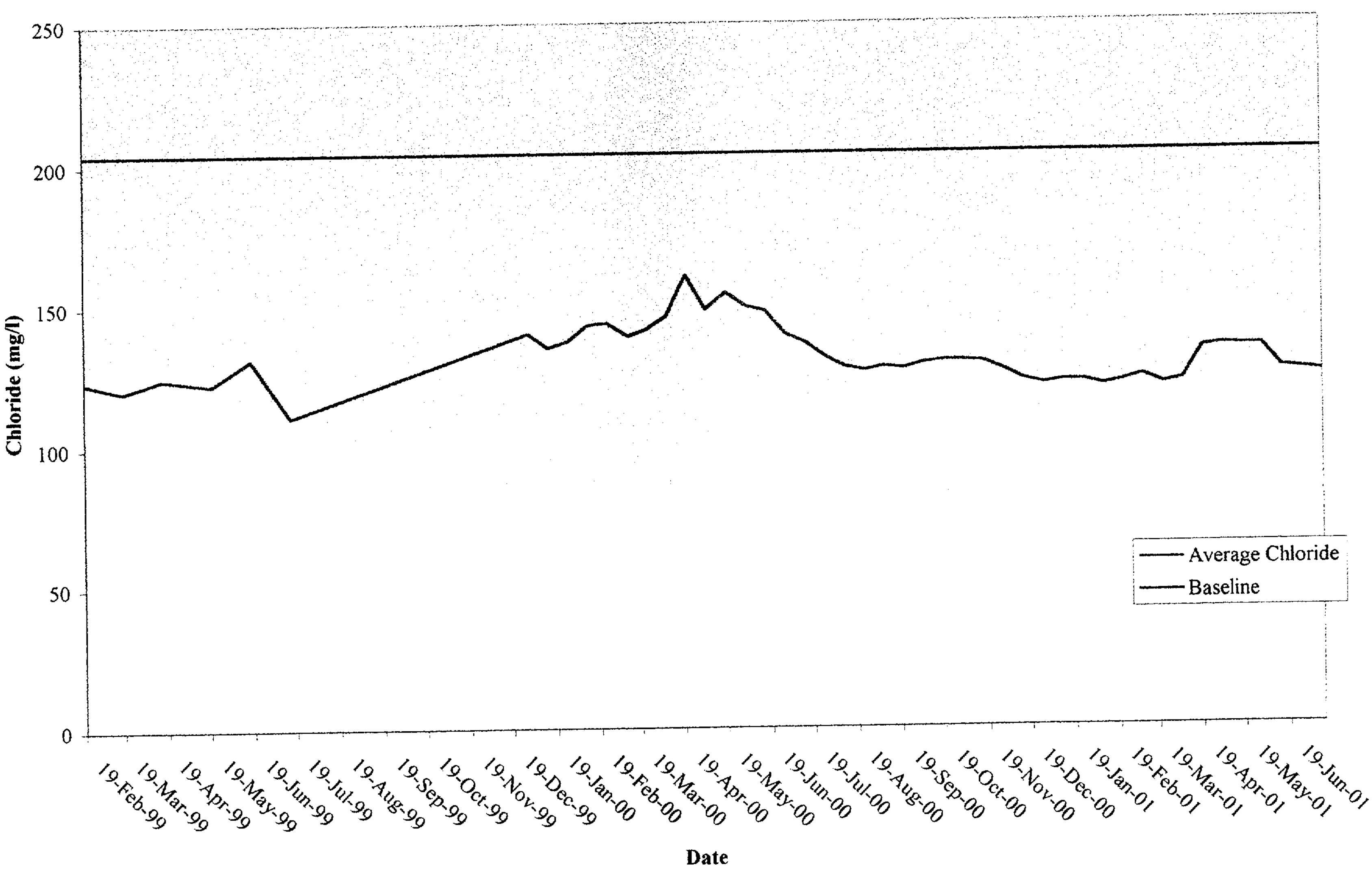
Mine Unit 1 Monitor Well Average Sulfate Concentration



Mine Unit 1 Monitor Well Average Sodium Concentration



Mine Unit 1 Monitor Well Average Choride Concentration



Mine Unit 1 Monitor Well Chloride Monitoring Data

Sample Date	PR-15	IJ-13	PR-8	Average Chloride
19-Feb-99	87.7	126	157	124
18-Mar-99	86.2	125	150	120
15-Apr-99	92.5	139	143	125
20-May-99	81	135	152	123
17-Jun-99	85.8	145	164	132
15-Jul-99	72	123	138	111
30-Dec-99	111	165	145	140
13-Jan-00	111	156	139	135
27-Jan-00	111	161	141	138
10-Feb-00	109	165	156	143
24-Feb-00	110	168	154	144
10-Mar-00	110	163	145	139
23-Mar-00	110	167	148	142
6-Apr-00	112	180	147	146
20-Apr-00	107	240	136	161
4-May-00	73	238	135	149
18-May-00	109	220	135	155
1-Jun-00	110	204	135	150
15-Jun-00	112	197	135	148
29-Jun-00	112	179	128	140
13-Jul-00	116	173	121	137
27-Jul-00	113	166	116	132
10-Aug-00	113	164	107	128
24-Aug-00	114	159	107	127
7-Sep-00	113	155	116	128
21-Sep-00	110	162	110	127
5-Oct-00	112	158	118	129
19-Oct-00	112	157	121	130
2-Nov-00	112	157	121	130
16-Nov-00	115	153	121	130
30-Nov-00	110	149	121	127
14-Dec-00	114	146	110	123
28-Dec-00	111	143	111	122
11-Jan-01	114	143	111	123
25-Jan-01	116	141	111	123
8-Feb-01	116	143	104	121
22-Feb-01	116	143	108	122
8-Mar-01	118	145	110	124
22-Mar-01	118	143	103	121
5-Apr-01	118	145	105	123
19-Apr-01	120	152	130	134
3-May-01	121	152	132	135
17-May-01	121	152	131	135
31-May-01	121	154	129	135
14-Jun-01	117	154	109	127
28-Jun-01	117	154	107	126
12-Jul-01	117	154	105	125

Mine Unit 1 Monitor Well Sodium Monitoring Data

Sample Date	PR-15	IJ-13	PR-8	Average Sodium
19-Feb-99	210	332	371	304
18-Mar-99	214	350	386	317
15-Apr-99	214	354	375	314
20-May-99	217	339	366	307
17-Jun-99	230	367	387	328
15-Jul-99	228	346	371	315
30-Dec-99	273	408	387	356
13-Jan-00	283	425	390	366
27-Jan-00	284	438	402	375
10-Feb-00	288	433	405	375
24-Feb-00	290	440	412	381
10-Mar-00	297	447	407	384
23-Mar-00	292	448	414	385
6-Apr-00	288	473	399	387
20-Apr-00	275	575	380	410
4-May-00	205	576	375	385
18-May-00	274	564	373	404
1-Jun-00	298	520	384	401
15-Jun-00	285	490	368	381
29-Jun-00	302	478	369	383
13-Jul-00	297	458	350	368
27-Jul-00	300	455	359	371
10-Aug-00	305	448	332	362
24-Aug-00	310	444	332	362
7-Sep-00	308	445	354	369
21-Sep-00	299	440	345	361
5-Oct-00	302	437	343	361
19-Oct-00	306	424	351	360
2-Nov-00	309	438	357	368
16-Nov-00	307	413	349	356
30-Nov-00	306	409	340	352
14-Dec-00	308	411	323	347
28-Dec-00	304	407	325	345
11-Jan-01	308	412	323	348
25-Jan-01	308	408	311	342
8-Feb-01	312	419	290	340
22-Feb-01	311	415	310	345
8-Mar-01	312	407	322	347
22-Mar-01	316	406	307	343
5-Apr-01	321	428	317	355
19-Apr-01	317	424	342	361
3-May-01	315	424	344	361
17-May-01	320	418	321	353
31-May-01	316	435	312	354
14-Jun-01	315	425	281	340
28-Jun-01	319	421	293	344
12-Jul-01	317	431	307	352

Mine Unit 1 Monitor Well Sulfate Monitoring Data

Sample Date	PR-15	IJ-13	PR-8	Average Sulfate
19-Feb-99	160	306	352	273
18-Mar-99	156	326	355	279
15-Apr-99	163	335	343	280
20-May-99	152	351	368	290
17-Jun-99	155	353	384	297
15-Jul-99	139	319	348	269
30-Dec-99	216	357	342	305
13-Jan-00	229	382	347	319
27-Jan-00	232	384	367	328
10-Feb-00	237	395	387	340
24-Feb-00	242	403	374	340
10-Mar-00	243	389	372	335
23-Mar-00	244	397	371	337
6-Apr-00	242	425	355	341
20-Apr-00	230	582	348	387
4-May-00	154	562	318	345
18-May-00	231	501	335	356
1-Jun-00	247	503	340	363
15-Jun-00	242	451	322	338
29-Jun-00	250	449	314	338
13-Jul-00	256	429	302	329
27-Jul-00	258	425	297	327
10-Aug-00	257	411	277	315
24-Aug-00	258	382	264	301
7-Sep-00	255	376	277	303
21-Sep-00	252	379	284	305
5-Oct-00	250	388	289	309
19-Oct-00	251	374	286	304
2-Nov-00	254	389	302	315
16-Nov-00	253	358	295	302
30-Nov-00	253	364	289	302
14-Dec-00	250	361	270	294
28-Dec-00	257	355	269	294
11-Jan-01	263	364	269	299
25-Jan-01	277	360	268	302
8-Feb-01	279	361	257	299
22-Feb-01	279	361	266	302
8-Mar-01	277	356	276	303
22-Mar-01	277	358	237	291
5-Apr-01	277	368	268	304
19-Apr-01	277	376	287	313
3-May-01	265	374	291	310
17-May-01	269	368	272	303
31-May-01	270	376	275	307
14-Jun-01	260	376	247	294
28-Jun-01	269	371	240	293
12-Jul-01	256	370	241	289

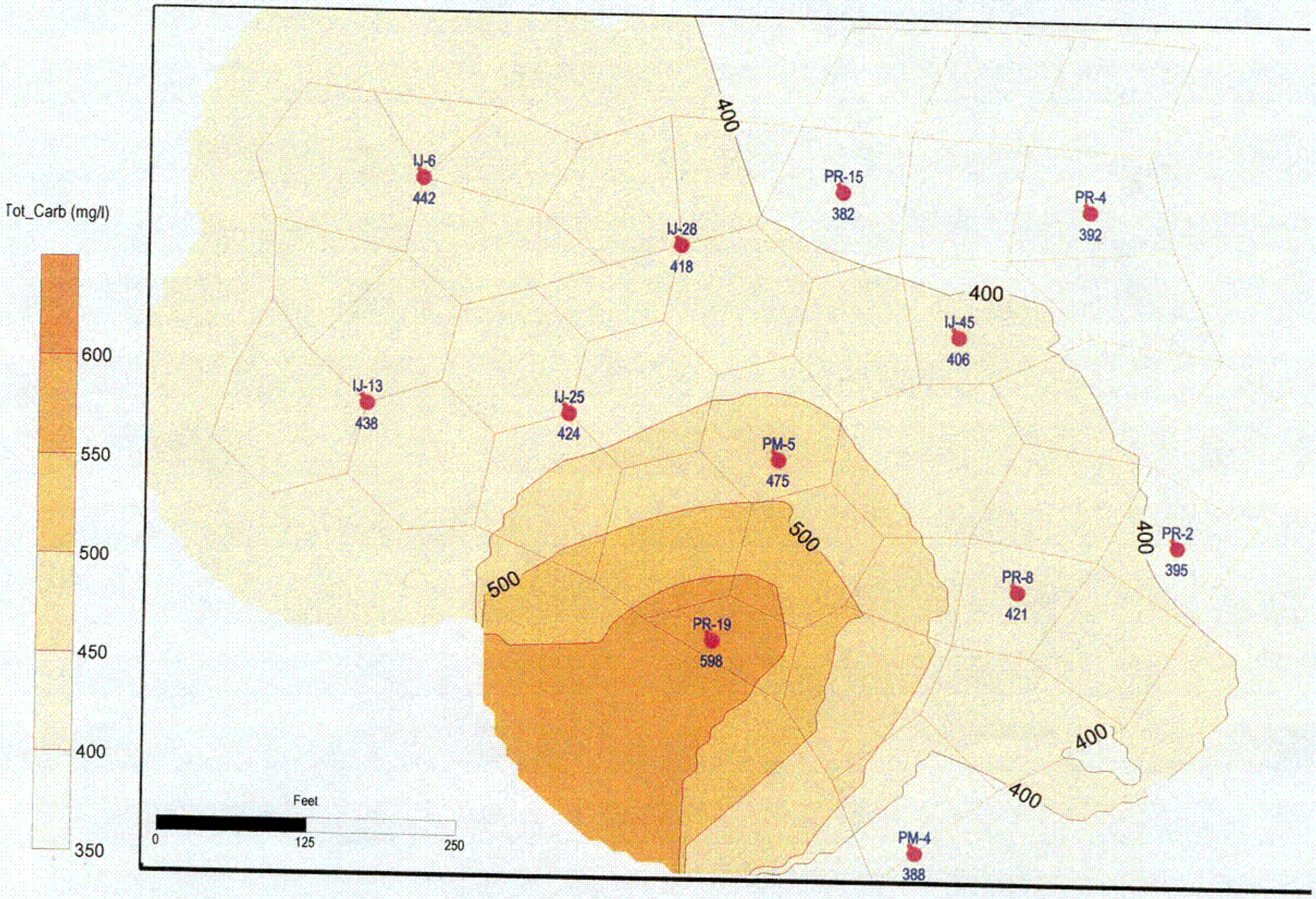
Mine Unit 1 Monitor Well Conductivity Monitoring Data

Sample Date	PR-15	IJ-13	PR-8	Average Conductivity
19-Feb-99	1070	1720	1960	1583
18-Mar-99	1110	1740	1900	1583
15-Apr-99	1090	1750	1830	1557
20-May-99	1140	1820	1880	1613
17-Jun-99	1100	1760	1920	1593
15-Jul-99	1140	1780	1870	1597
30-Dec-99	1340	1960	1830	1710
13-Jan-00	1390	2010	1850	1750
27-Jan-00	1400	2070	1890	1787
10-Feb-00	1410	2080	1960	1817
24-Feb-00	1430	2130	1960	1840
10-Mar-00	1450	2100	1920	1823
23-Mar-00	1450	2150	1940	1847
6-Apr-00	1440	2260	1890	1863
20-Apr-00	1400	2790	1800	1997
4-May-00	1040	2770	1770	1860
18-May-00	1420	2650	1800	1957
1-Jun-00	1460	2480	1790	1910
15-Jun-00	1460	2380	1770	1870
29-Jun-00	1480	2270	1720	1823
13-Jul-00	1510	2180	1660	1783
27-Jul-00	1530	2170	1630	1777
10-Aug-00	1520	2110	1550	1727
24-Aug-00	1530	2070	1550	1717
7-Sep-00	1510	2060	1630	1733
21-Sep-00	1490	2060	1630	1727
5-Oct-00	1490	2060	1610	1720
19-Oct-00	1500	2010	1630	1713
2-Nov-00	1500	2120	1670	1763
16-Nov-00	1510	1930	1640	1693
30-Nov-00	1510	1920	1600	1677
14-Dec-00	1510	1920	1530	1653
28-Dec-00	1520	1920	1540	1660
11-Jan-01	1530	1940	1530	1667
25-Jan-01	1540	1940	1500	1660
8-Feb-01	1590	1960	1440	1663
22-Feb-01	1590	1990	1510	1697
8-Mar-01	1590	1970	1560	1707
22-Mar-01	1590	1940	1360	1630
5-Apr-01	1570	2010	1500	1693
19-Apr-01	1580	2010	1620	1737
3-May-01	1570	2020	1650	1747
17-May-01	1570	1970	1510	1683
31-May-01	1570	2040	1490	1700
14-Jun-01	1560	2010	1360	1643
28-Jun-01	1570	1970	1370	1637
12-Jul-01	1560	2000	1420	1660

Mine Unit 1 Monitor Well Alkalinity Monitoring Data

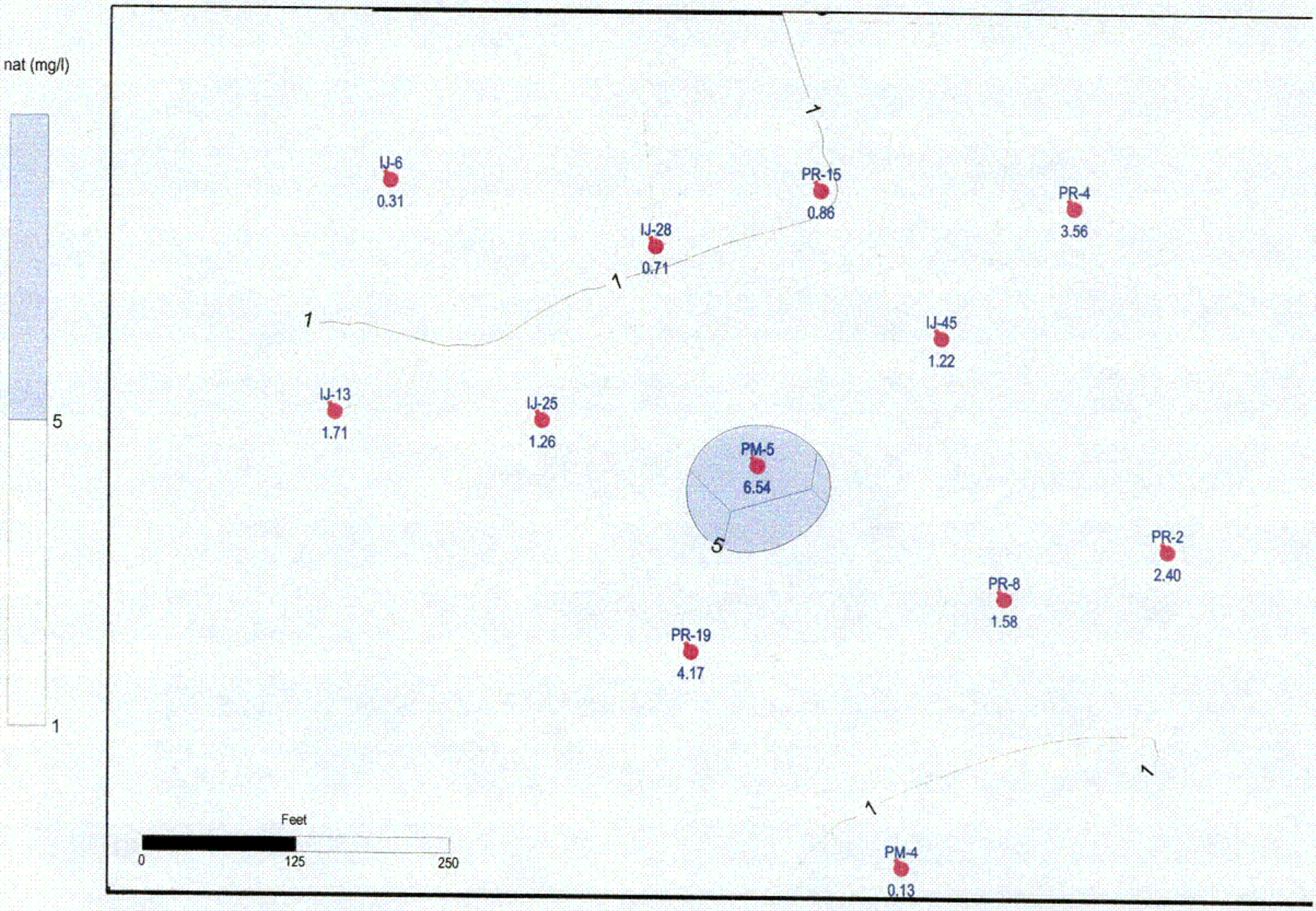
Sample Date	PR-15	IJ-13	PR-8	Average Alkalinity
19-Feb-99	243	330	353	309
18-Mar-99	242	351	352	315
15-Apr-99	244	354	331	310
20-May-99	281	355	346	327
17-Jun-99	298	369	355	341
15-Jul-99	318	365	351	345
30-Dec-99	270	360	330	320
13-Jan-00	275	378	340	331
27-Jan-00	275	385	340	333
10-Feb-00	278	390	340	336
24-Feb-00	285	395	353	344
10-Mar-00	295	395	355	348
23-Mar-00	300	405	360	355
6-Apr-00	295	415	360	357
20-Apr-00	290	468	345	368
4-May-00	233	470	325	343
18-May-00	300	460	330	363
1-Jun-00	300	420	335	352
15-Jun-00	300	415	330	348
29-Jun-00	305	400	325	343
13-Jul-00	303	395	325	341
27-Jul-00	305	395	325	342
10-Aug-00	310	390	320	340
24-Aug-00	315	385	320	340
7-Sep-00	310	395	330	345
21-Sep-00	305	385	330	340
5-Oct-00	310	378	330	339
19-Oct-00	310	370	325	335
2-Nov-00	310	378	320	336
16-Nov-00	308	358	315	327
30-Nov-00	305	355	310	323
14-Dec-00	300	350	300	317
28-Dec-00	308	360	300	323
11-Jan-01	310	360	300	323
25-Jan-01	300	365	300	322
8-Feb-01	313	365	300	326
22-Feb-01	305	360	280	315
8-Mar-01	305	360	290	318
22-Mar-01	310	360	268	313
5-Apr-01	305	370	280	318
19-Apr-01	310	375	290	325
3-May-01	310	370	290	323
17-May-01	313	370	285	323
31-May-01	315	370	290	325
14-Jun-01	305	375	250	310
28-Jun-01	305	370	260	312
12-Jul-01	315	359	300	325

Appendix C. Iso-Concentration Maps for Selected Parameters



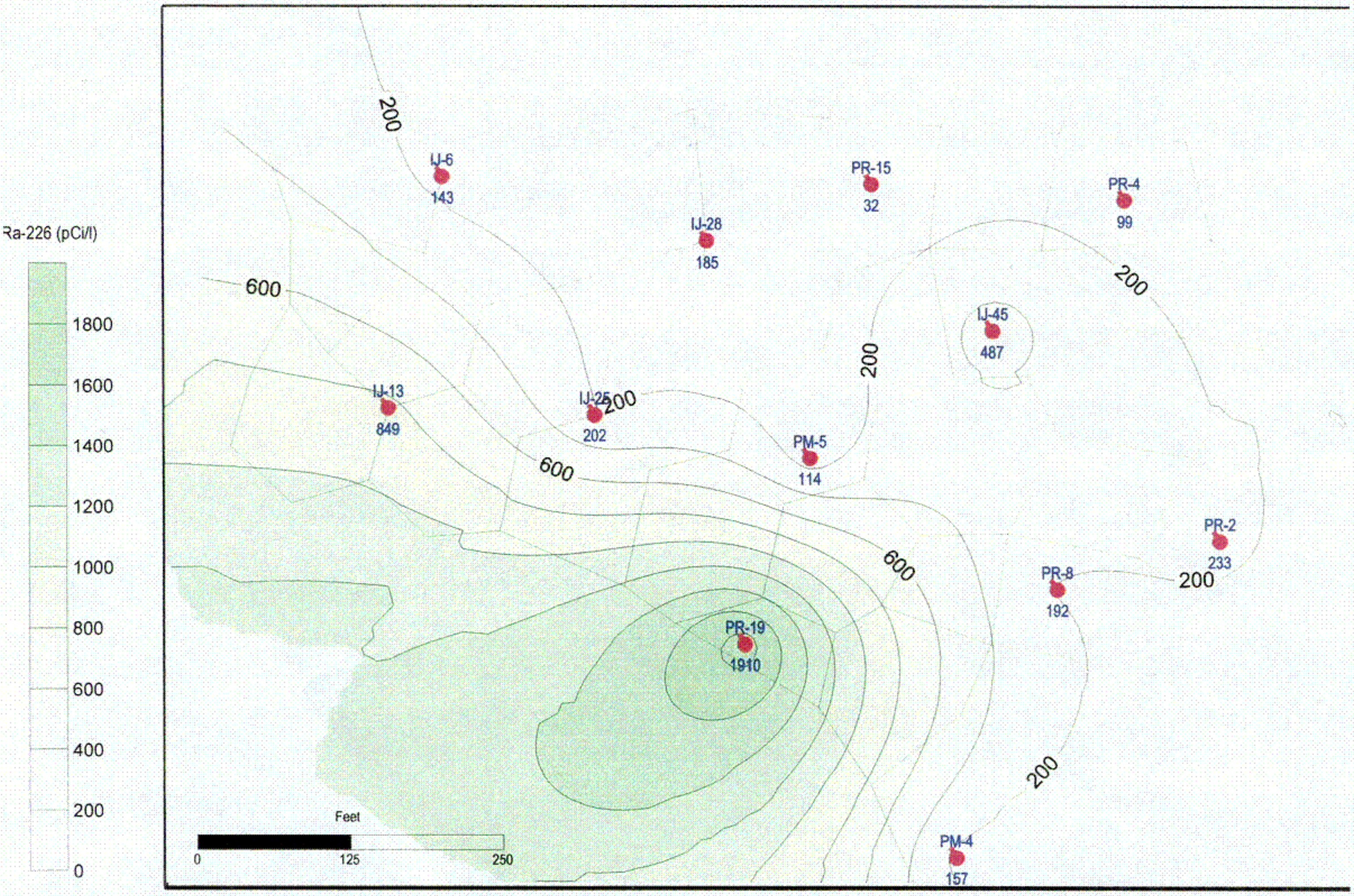
Mine Unit 1 Iso-concentration Map for Total Carbonate, July 1999

C1



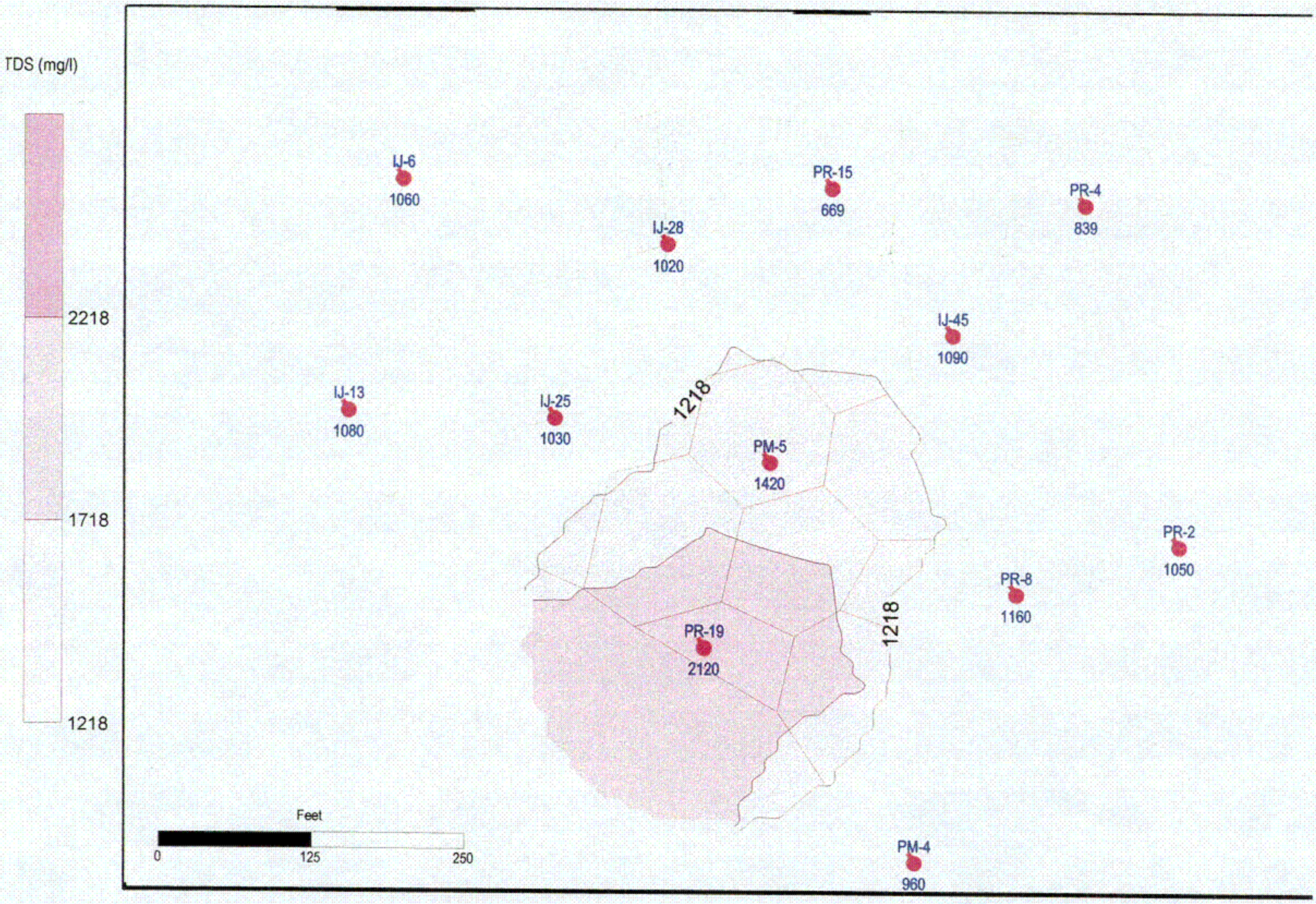
Mine Unit 1 Iso-concentration Map for Natural Uranium, July 1999

C2



Mine Unit 1 Iso-concentration Map for Radium 226, July 1999

C3



Mine Unit 1 Iso-concentration Map for TDS, July 1999

C4