APPENDIX 10-C
2012 TO 2013 GEOCHEMISTRY BASELINE UPDATES

Seabridge Gold Inc.

KSM PROJECT
2012 to 2013 Geochemistry Baseline Updates

SEABRIDGE GOLD

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KSM Project 2012 to 2013 Geochemistry Baseline Updates

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1 Introduction and Scope of Work

This report provides subsequent geochemical characterization of waste rock for the proposed KSM Project completed after the deadline for the 2012 Metal Leaching/Acid Rock Drainage Baseline Report (Appendix 10-A). The objectives of this report are to:

- Define and outline the neutralization potential (NP) characterization methodology;
- Present geochemical characterization of deposit materials including:
    - A geochemical comparison of ore and waste materials; and
    - A geochemical characterization of the Kerr and Iron Cap deposits based on a more detailed Acid-Base Accounting (ABA) block model; and
- Present data for new humidity cells from the Sulphurets and Mitchell deposits not currently presented in Appendix 10-A.

2 Neutralization Potential Characterization

There are several methods for estimating NP; however, no one method is considered the best for estimating effective or available NP (Price 2009). Rather, a comparison with carbonate NP and "bulk NP" can estimate the percentage of carbonate NP contributing to the bulk NP (Price 2009).

Geochemical baseline static testing at the proposed Project site was initiated in 2003. Bulk NP was analyzed using the EPA 600 – Sobek NP analytical methodology with the Price correction factor (Price 2009) for 268 samples. In subsequent years leading up to the issuing of the AIR (January 2011), an additional 1,635 ABA analyses were completed using the same EPA 600 - Sobek NP methodology. The AIR for the proposed Project was received in 2011 and states that "the geochemical prediction program…will include static testing using both Sobek NP and Modified Sobek NP". Typically, it is not appropriate to change the ABA analytical methods midstream of a geochemical characterization program in order to ensure that the program produces data that are internally consistent. Therefore a target of 10 to 15% of samples collected after receipt of the AIR was established to be analysed for both Sobek NP and modified Sobek NP. After the approval of the AIR in 2011, 17% of the samples collected were analyzed for both Sobek NP and modified Sobek NP (results discussed below).

The geochemical characterization program and analytical methods used at the proposed Project site was discussed at working group meetings in 2011 and 2012. The geochemical characterization program continued to use the EPA 600 - Sobek NP method with the Price correction factor (Price 2009) for the baseline geochemical characterization studies of the proposed project site.

In 2012, 109 samples from the proposed Project site were resubmitted for static testing that included both Sobek NP and modified Sobek NP methodologies (Price 2009). The results are presented in Table 2-1 and Figure 2-1. The unavailable NP for the modified Sobek NP was determined to be 6 kg $CaCO_3$/t and an adjusted modified Sobek NP was determined for each sample. The adjusted Sobek NP for the 109 samples ranged from -14 kg $CaCO_3$/t to 605 kg $CaCO_3$/t, with a median of 90 kg $CaCO_3$/t for and ranged from -7 kg $CaCO_3$/t to 571 kg $CaCO_3$/t with a median of 55 kg $CaCO_3$/t for adjusted modified Sobek NP.

2.1 Waste Rock Segregation

Segregation of waste rock on the basis of ARD potential will only be applied to the Sulphurets Deposit, and only during the construction phase. Additional geochemical characterization of the NP from Sulphurets waste rock was undertaken to provide increased certainty for the ARD classification criteria to be used during segregation. The ML/ARD Management Plan (Chapter 26) outlines that only material with an adjusted sulphide net potential ratio (SNPR) of greater than 3.0 will be characterized as suitable for construction outside the water storage dam (WSD) catchment.

Table 2-1. Modified Sobek Neutralization Potential and Bulk Sobek Neutralization Potential

Sample ID	Mod. ABA Neutralization Potential (kg CaCO$_3$/t)	Std Sobek Neutralization Potential (kg CaCO$_3$/t)	Sample ID	Mod. ABA Neutralization Potential (kg CaCO$_3$/t)	Std Sobek Neutralization Potential (kg CaCO$_3$/t)	Sample ID	Mod. ABA Neutralization Potential (kg CaCO$_3$/t)	Std Sobek Neutralization Potential (kg CaCO$_3$/t)
S156852	-1.0	1.0	X67107	63.2	74.3	X66012	84.9	147.0
S156638	0.0	1.8	X66250	109.3	160.0	X66066	49.7	94.8
S156717	10.3	14.3	S154961	75.0	110.0	H42420	108.3	202.5
S154644	21.5	30.0	X66086	375.0	462.5	H42407	109.3	246.3
S156835	2.8	4.0	H45086	36.3	58.8	H42445	87.0	195.0
S156847	9.5	15.0	H45103	37.3	47.5	H47708	51.5	85.0
S154884	40.0	53.8	X64724	90.0	121.3	X16344	77.5	87.5
H47962	53.9	60.8	X64719	98.8	118.8	H47674	28.5	52.5
S157122	17.5	50.5	X64718	124.3	148.8	X16345	72.5	96.3
S156810	25.3	35.0	H45081	203.5	287.5	X16346	79.5	93.8
S155119	71.0	105.0	H45078	63.5	101.3	X16342	53.3	72.5
S156644	1.0	5.5	H45080	204.5	275.0	H42920	142.4	231.8
X67303	14.4	18.9	S157569	83.5	167.5	H42933	166.4	224.9
X67359	57.7	67.6	X63850	101.6	163.9	H42946	60.8	169.2
S154788	18.8	23.0	X63901	70.8	122.5	H49567	213.4	286.3
S157239	25.3	43.8	X65684	52.3	77.0	H49580	171.2	259.4
S155017	56.8	88.8	X63893	90.0	165.0	X66386	252.3	324.5
S157082	29.3	108.8	X65761	78.7	125.0	X66440	47.4	65.0
X67354	100.0	213.8	E192870	96.0	161.3	X66524	103.1	166.7
S156922	1.8	3.3	H44452	50.5	77.5	X19892	105.6	172.9
X67132	6.0	11.5	H44495	60.0	82.5	H49598	154.0	229.9
X67133	9.3	13.0	H44501	45.0	83.8	H49996	234.8	312.0
X67142	29.8	74.9	X63597	248.4	387.6	H49934	2.5	7.0
X67195	50.4	69.9	X63646	117.8	160.8	H49954	24.7	43.9

(continued)

Table 2-1. Modified Sobek Neutralization Potential and Bulk Sobek Neutralization Potential (completed)

Sample ID	Mod. ABA Neutralization Potential (kg $CaCO_3$/t)	Std Sobek Neutralization Potential (kg $CaCO_3$/t)	Sample ID	Mod. ABA Neutralization Potential (kg $CaCO_3$/t)	Std Sobek Neutralization Potential (kg $CaCO_3$/t)	Sample ID	Mod. ABA Neutralization Potential (kg $CaCO_3$/t)	Std Sobek Neutralization Potential (kg $CaCO_3$/t)
X67143	18.3	28.5	X63712	47.2	72.9	H49982	7.7	12.0
X67174	99.0	170.0	H44497	60.3	101.3	KSMMNRX005	85.1	139.1
S155509	28.3	58.8	H44480	60.0	65.0	KSMMNRX010	2.6	3.8
S154697	11.3	12.5	H44491	59.5	92.5	KSMMSRX002	0.4	2.4
S154899	23.8	25.0	H44494	76.3	108.8	KSMMSRX007	48.9	65.2
X66249	46.3	163.8	H42421	75.8	200.0	KSMMSRX012	215.8	295.1
X66100	106.2	133.5	H42450	61.3	150.0	KSMMSRX017	79.2	131.6
X66155	139.4	230.6	H42446	80.8	148.8	KSMSURX004	26.5	62.7
X66208	162.0	214.3	X63793	60.5	114.9	KSMSURX009	73.0	134.1
X66245	90.9	174.4	X65831	75.9	126.3	H47984	576.6	619.7
X66302	88.1	181.4	X65870	126.0	146.4	KSMSURX014	31.5	106.5
X66355	116.0	188.9	X65924	44.9	90.5	M41758	42.1	50.8
						X67051	75.1	112.1

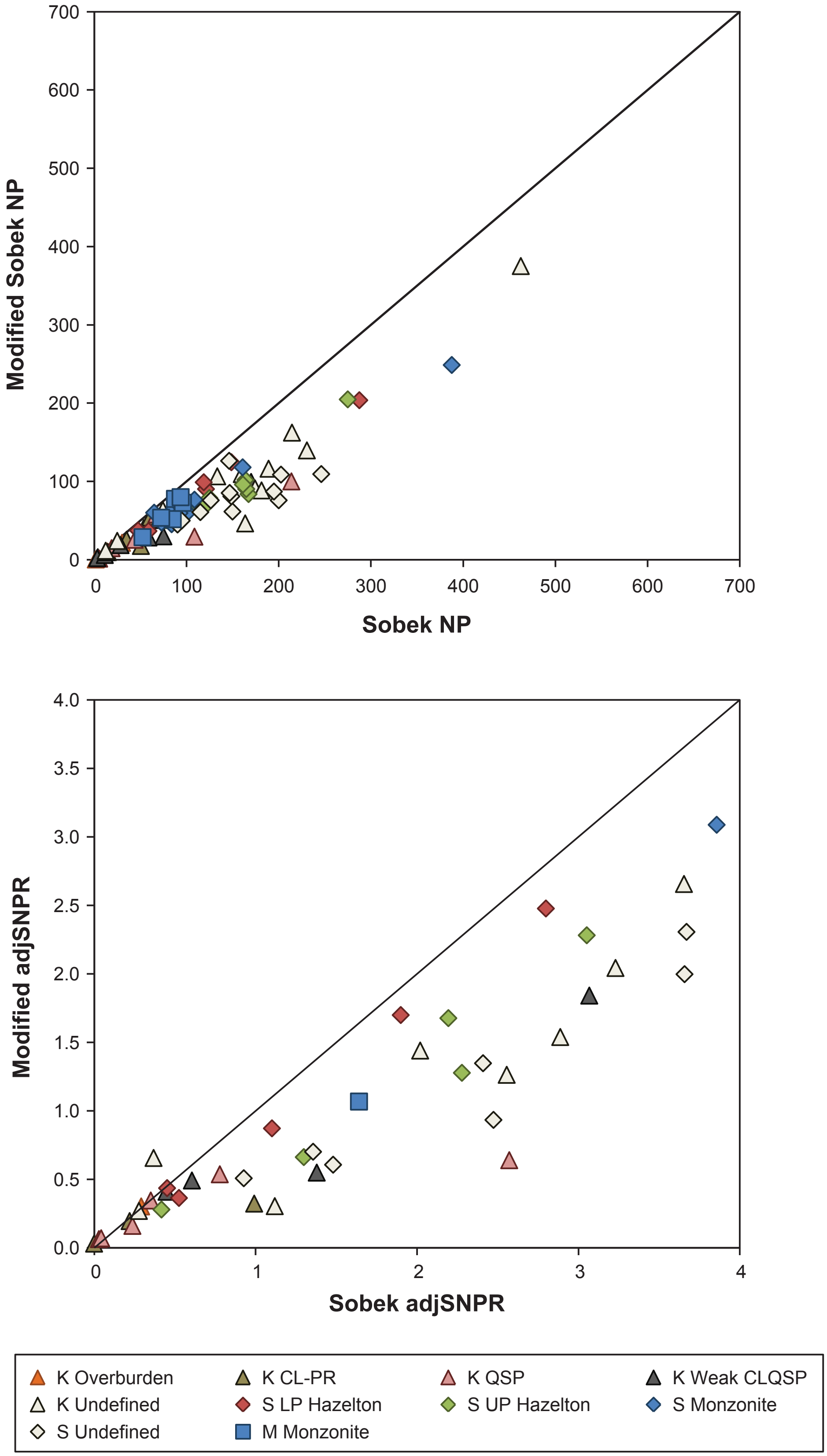


Figure 2-1

Modified Sobek NP versus Sobek NP and Modified adjSNPR versus Sobek adjSNPR

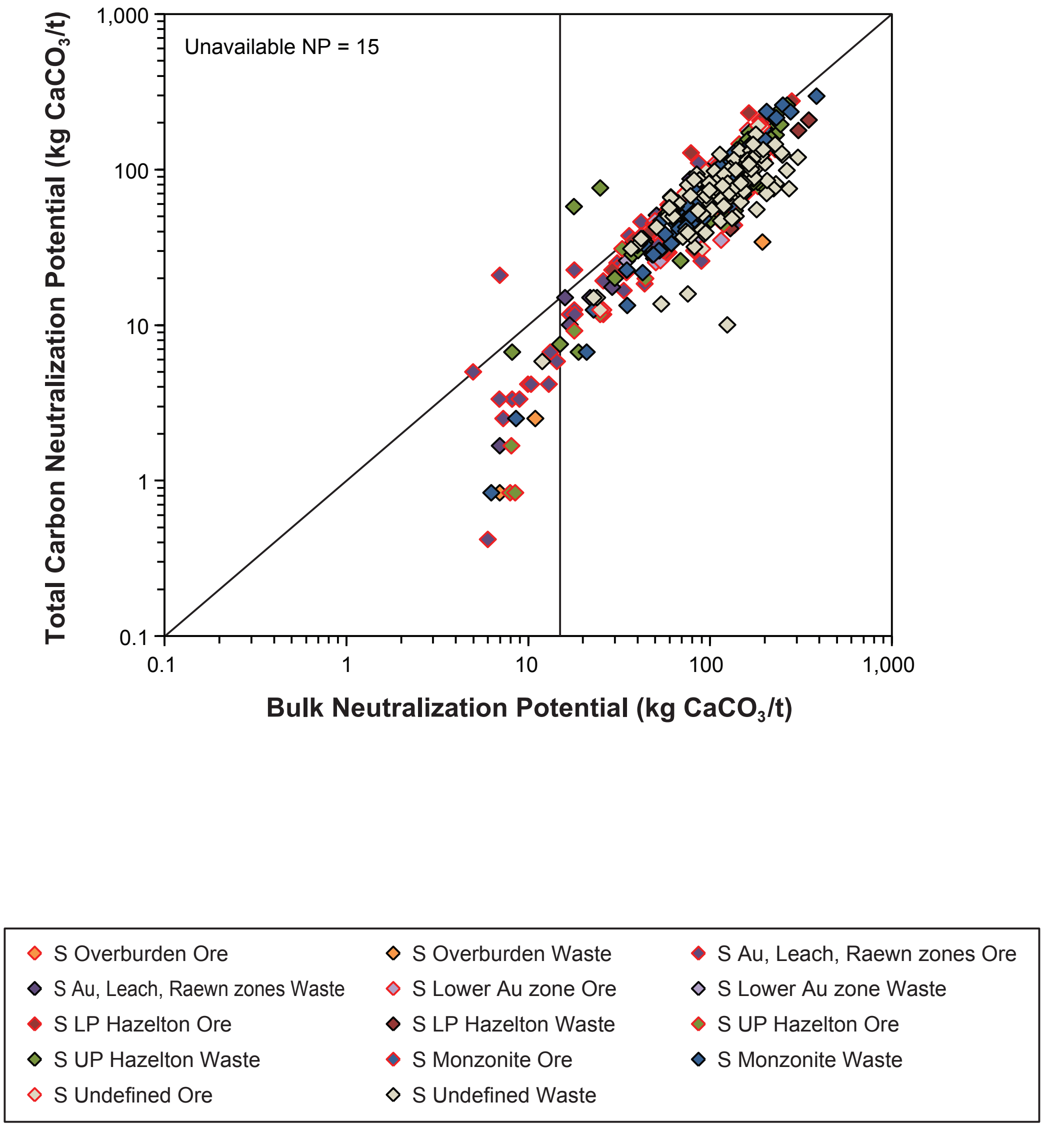
The NP of waste rock at the proposed Project site is discussed in Chapter 10 and Appendix 10-A. Based on samples with a paste pH<6, the maximum unavailable NP for the different deposits was 13, 6, 13, and 9 kg $CaCO_3$/t for Kerr, Sulphurets, Mitchell, and Iron Cap samples, respectively. As a conservative measure, a correction factor of 15 kg $CaCO_3$/t unavailable NP was applied to all deposit materials (including Sulphurets).

Bulk Sobek NP and total carbon NP are strongly correlated above 13 kg $CaCO_3$/t. This result indicates that the NP above 13 kg $CaCO_3$/t is likely from carbonate mineral assemblages available to neutralize acid generated from sulphide mineral oxidation (Figure 2.1-1). The total carbon NP and adjusted Sobek NP were, on average, within 10%.

The carbonate NP was calculated as an additional method used to provide an estimate of the available NP. The carbonate NP is strongly correlated to the bulk Sobek NP above the estimated unavailable NP (Figure 2.1-2), indicating the NP above 15 kg $CaCO_3$/t is likely from available carbonate mineral assemblages.

Typically, materials with an SNPR greater than 2.0 are considered to be NPAG (Price 2009). The geochemistry baseline program was completed using this criterion as a preliminary assessment of the ARD potential of site materials. The average molar ratio of (Ca+Mg)/SO_4 over time can indicate the relative rate of carbonate NP consumption. Therefore, the site specific SNPR criterion can be estimated from the average (Ca+Mg)/SO_4 ratio overtime from humidity cell results (Price 2009). The Sulphurets deposit humidity cell data indicates that material with an SNPR greater than 2.3 is NPAG and material with an SNPR less than 2.3 is PAG (Figure 2.1-3).

Based on the static and kinetic test results the segregation criterion for the ML/ARD management plan used a conservative adjusted SNPR criterion of 3.0 to ensure that PAG geologic materials are stored within the WSD catchment. The segregation method will only be applied to the Sulphurets Deposit during the construction phase.



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Sulphurets Deposit Total Carbon Neutralization Potential versus Sobek Neutralization Potential by Ore/Waste Designation

Figure 2.1-1

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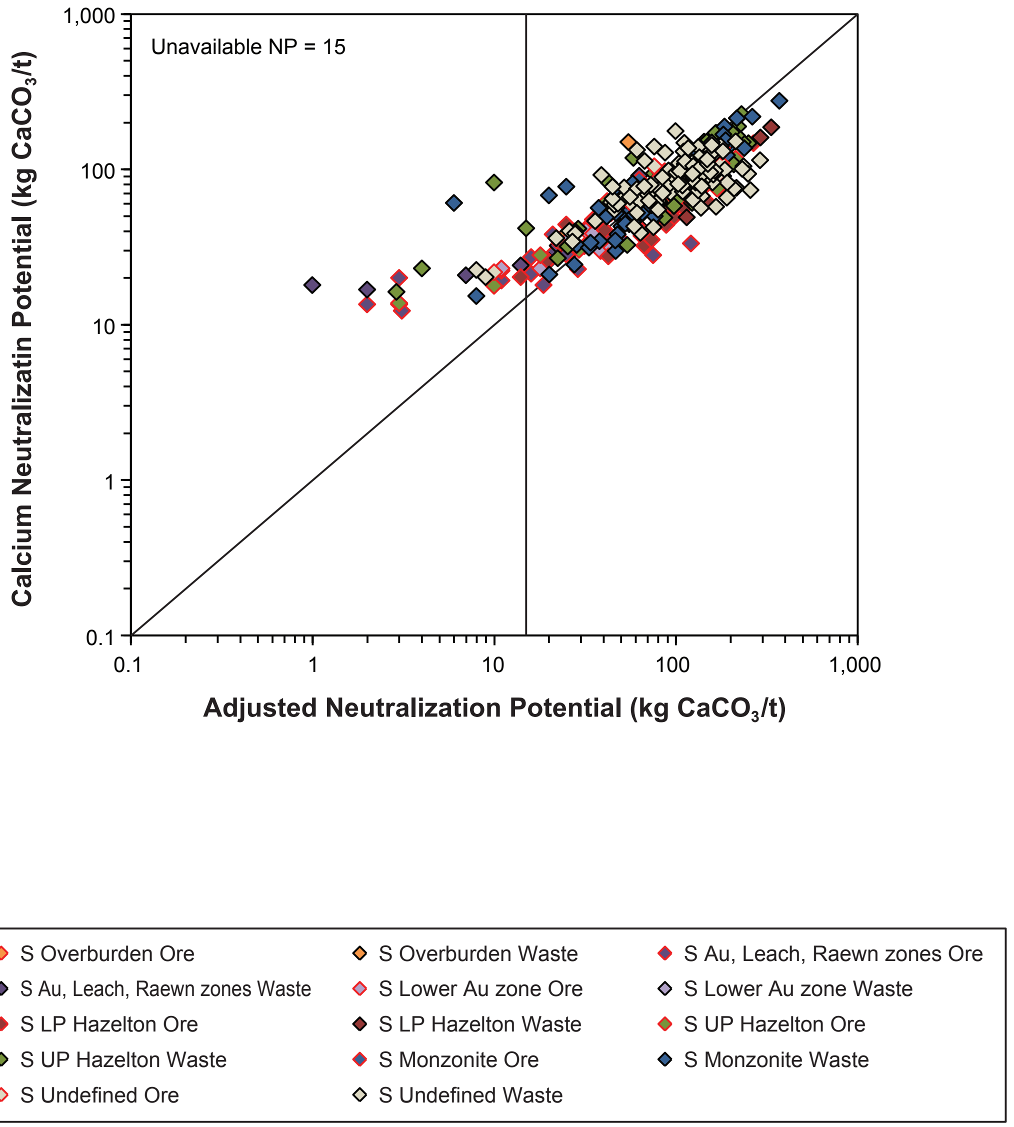

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Sulphurets Deposit Calcium Neutralization Potential versus Adjusted Sobek Neutralization Potential by Ore/Waste Designation

Figure 2.1-2

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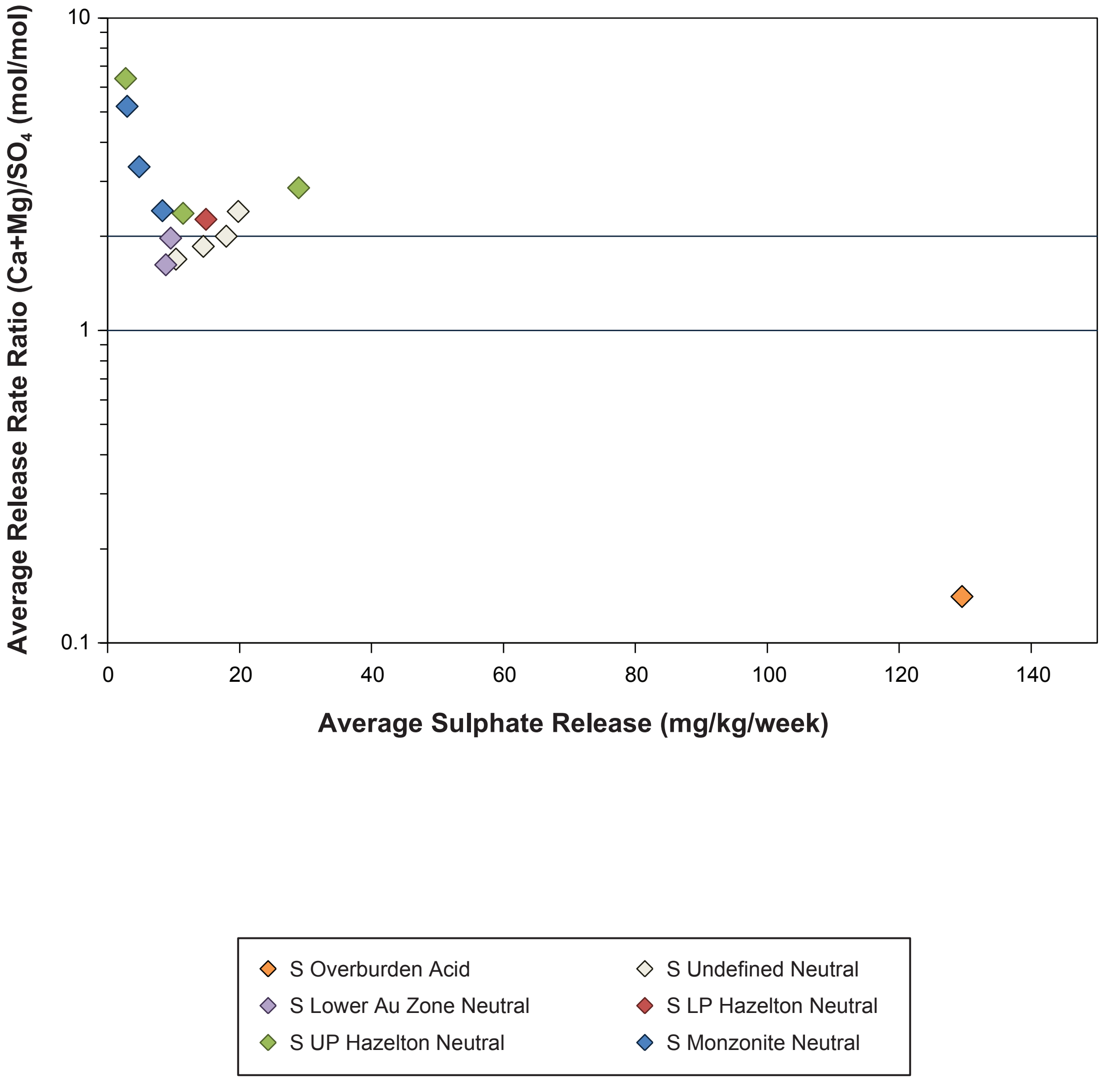

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Average Release rate Ratio of (Ca+Mg)/SO_4 versus Average Sulphate release rate (mg/kg/wk)

Figure 2.1-3

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3 Deposit Rock Characterization

Deposit rock samples were collected at the proposed Project site between 2003 and 2012, and included both proposed ore grade and waste rock materials. During baseline geochemical characterization of the proposed Project, the distinction between ore and waste rock samples was uncertain and therefore, all deposit samples were classified based on model code regardless of being ore or waste rock. Subsequently, deposit samples were segregated based on the ore versus waste criterion as defined by Moose Mountain Technical Services (MMTS).

MMTS classified each deposit sample within the 3D resource block model based on net smelter return (NSR) cut-off values generated in November 2012 (Table 3-1). The NSR values were assigned to samples located within the block model classifying all deposit samples as either ore or waste (Table 3-2).

Table 3-1. Net Smelter Returns used to Designate Ore Versus Waste

Deposit	Net Smelter Return Criteria
Kerr	
Waste	0-9.60
Ore	>=9.61
Sulphurets	
Waste	0-10.16
Ore	>=10.17
Mitchell Open Pit	
Waste	0-9.56
Ore	>=9.56
Mitchell Underground	
Waste	0-15.56
Ore	>=15.57
Iron Cap Underground	
Waste	0-15.56
Ore	>=15.57

Static and kinetic test results indicate the majority of Kerr and Iron Cap deposit samples show variations in characteristics; however, these deposits are considered to be PAG for mine planning and management. Designating static samples as ore versus waste based on NSR results in fewer than half of the samples being classified as ore (Table 3-2). This percentage fluctuates with the NSR cut-off values and the abundance of drill holes that are within the deposit ore body. Earlier stages of an exploration program are typically used to classify a resource or reserve for the ore body, reducing the likelihood of a drill hole sample representing waste rock or pit wall.

Table 3-2. Deposit Samples Classified as Ore versus Waste by ABA Block Model Code

ABA Block Model Code*	Ore	Waste	Total	Percent Waste Samples
Kerr				
Overburden	0	7	7	100%
CL-PR	51	7	58	12%
QSP	57	85	142	60%
Weak CLQSP	7	43	50	86%
Premier dike	3	3	6	50%
Undefined	9	33	42	79%
Total	127	178	305	58%
Sulphurets				
Overburden	1	8	9	89%
Au, leach, Raewyn	43	8	51	16%
Lower Au zone	26	5	31	16%
LP Hazelton	34	6	40	15%
UP Hazelton	45	69	114	61%
Monzonite	4	81	85	95%
Undefined	9	93	102	91%
Total	162	270	432	63%
Mitchell				
Overburden	0	7	7	100%
UP Hazelton	26	247	273	90%
LP Hazelton	422	131	553	24%
Monzonite	3	77	80	96%
Leach breccia/bornite breccia	12	11	23	48%
Total	463	473	936	51%
Iron Cap				
Overburden	0	3	3	100%
Hazelton	16	3	19	16%
Diorite	37	52	89	58%
Monzonite	3	23	26	88%
Undefined	103	115	213	53%
Total	159	196	355	55%
Total	**911**	**1,117**	**2,028**	**55%**

***See Table 4-1 for details on block model codes**

The reclassification of static samples by ore versus waste rock showed no apparent variance from the original interpretation of the static data. As observed in Figures 3-1, 3-2, and 3-3, there is substantial overlap between ore and waste materials.

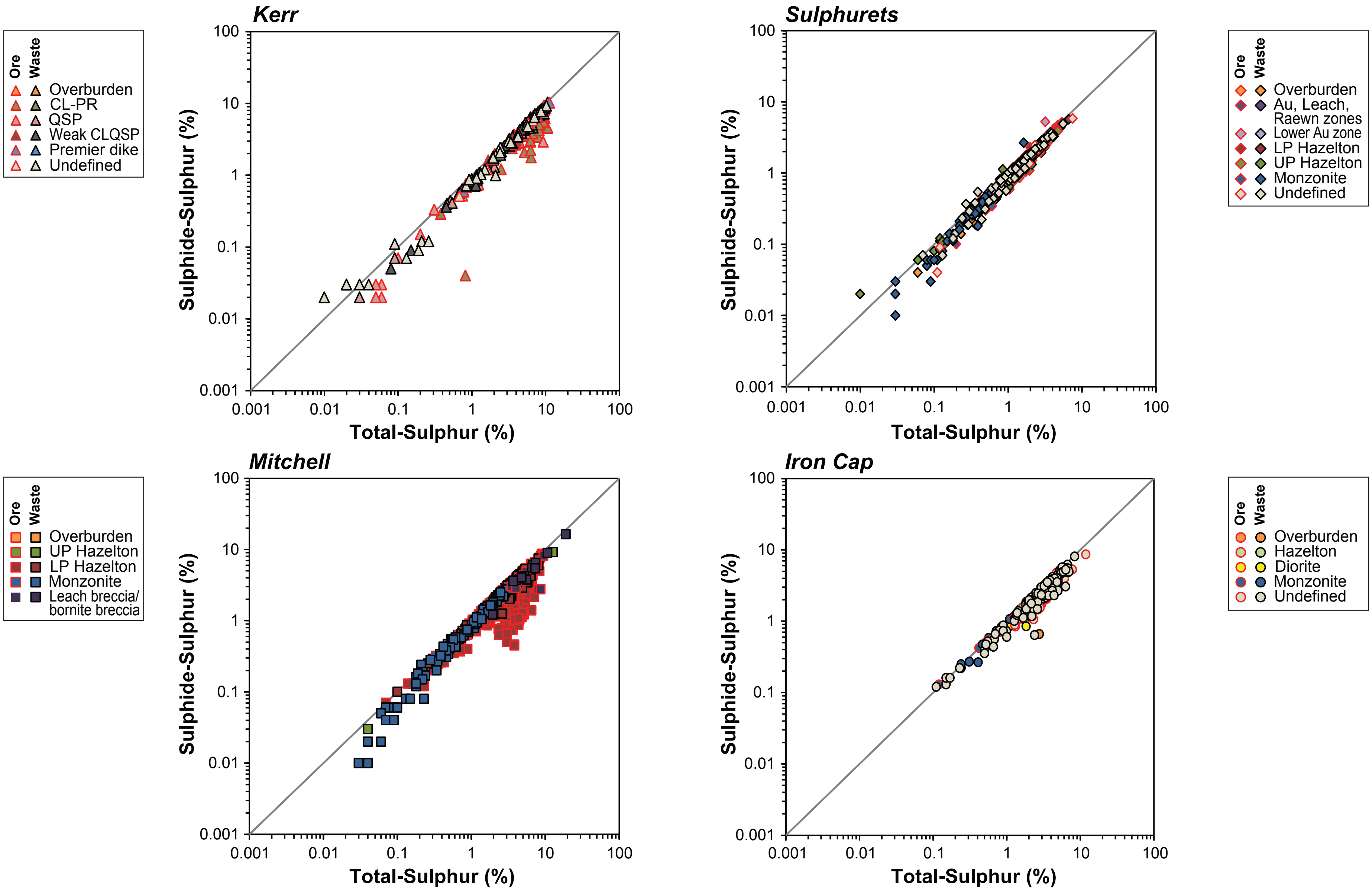

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Figure 3-1

Sulphide-Sulphur versus Total Sulphur by Deposit, Model Code, and Ore/Waste Designation

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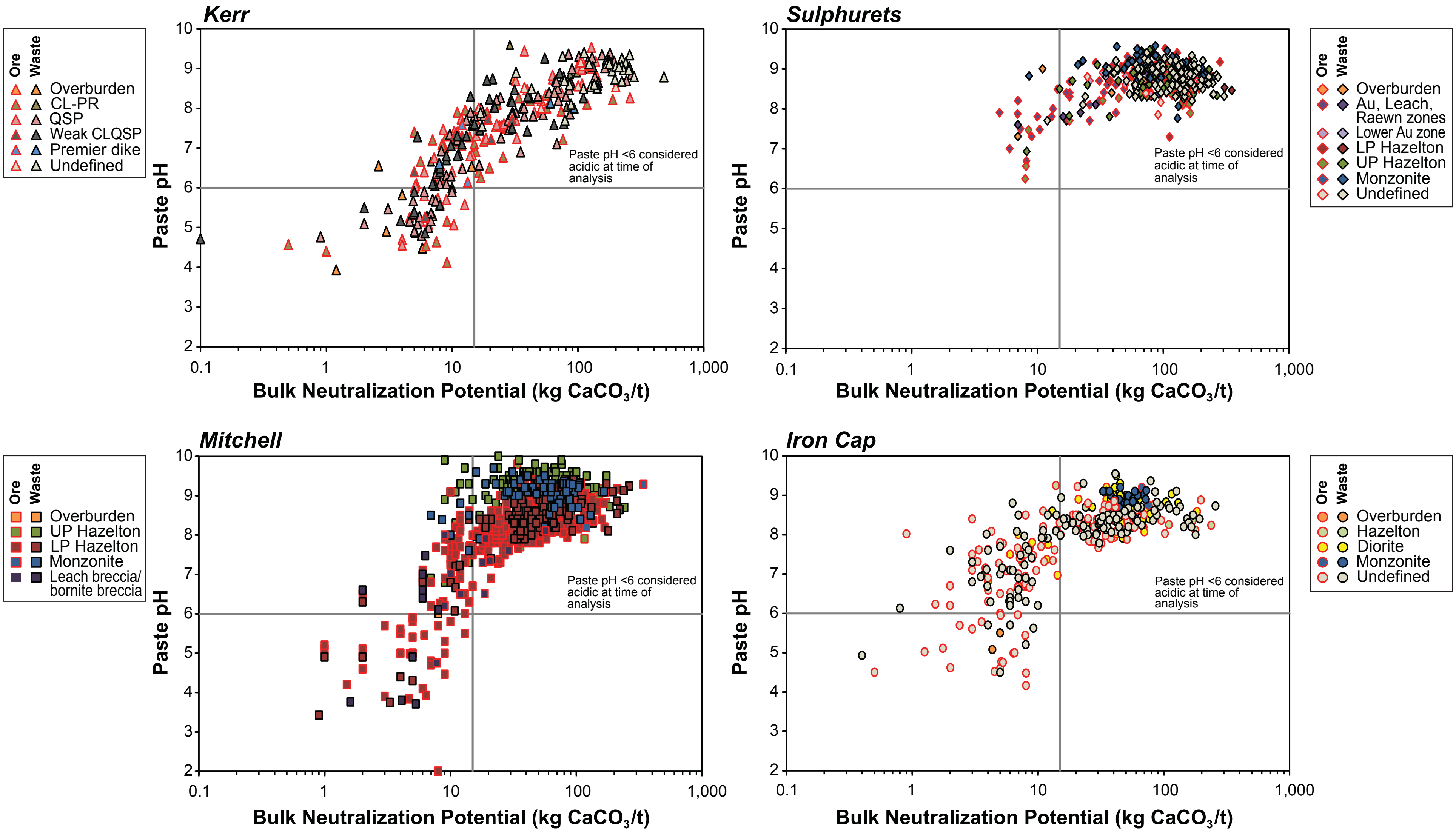


Figure 3-2

Paste pH versus Sobek Neutralization Potential by Deposit, Model Code, and Ore/Waste Designation

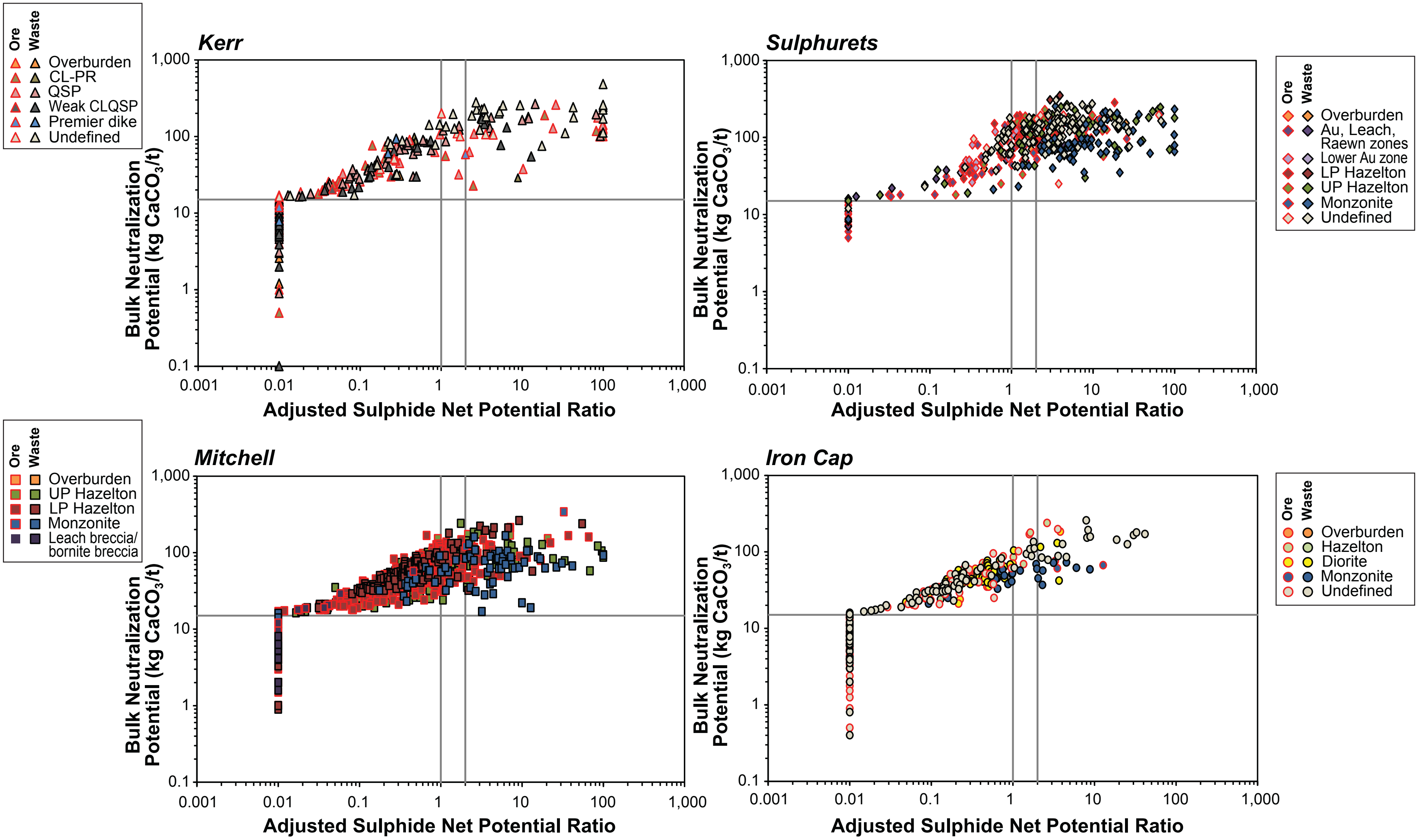


Figure 3-3

Sobek Neutralization Potential versus Adjusted Sulphide Net Potential Ratio by Deposit, Model Code, and Ore/Waste Designation

There are four instances where reclassifying the deposit material static samples by deposit, ABA model code, and ore versus waste has the potential to affect the proposed geochemical characterization in Chapter 10 of the Application/EIS:

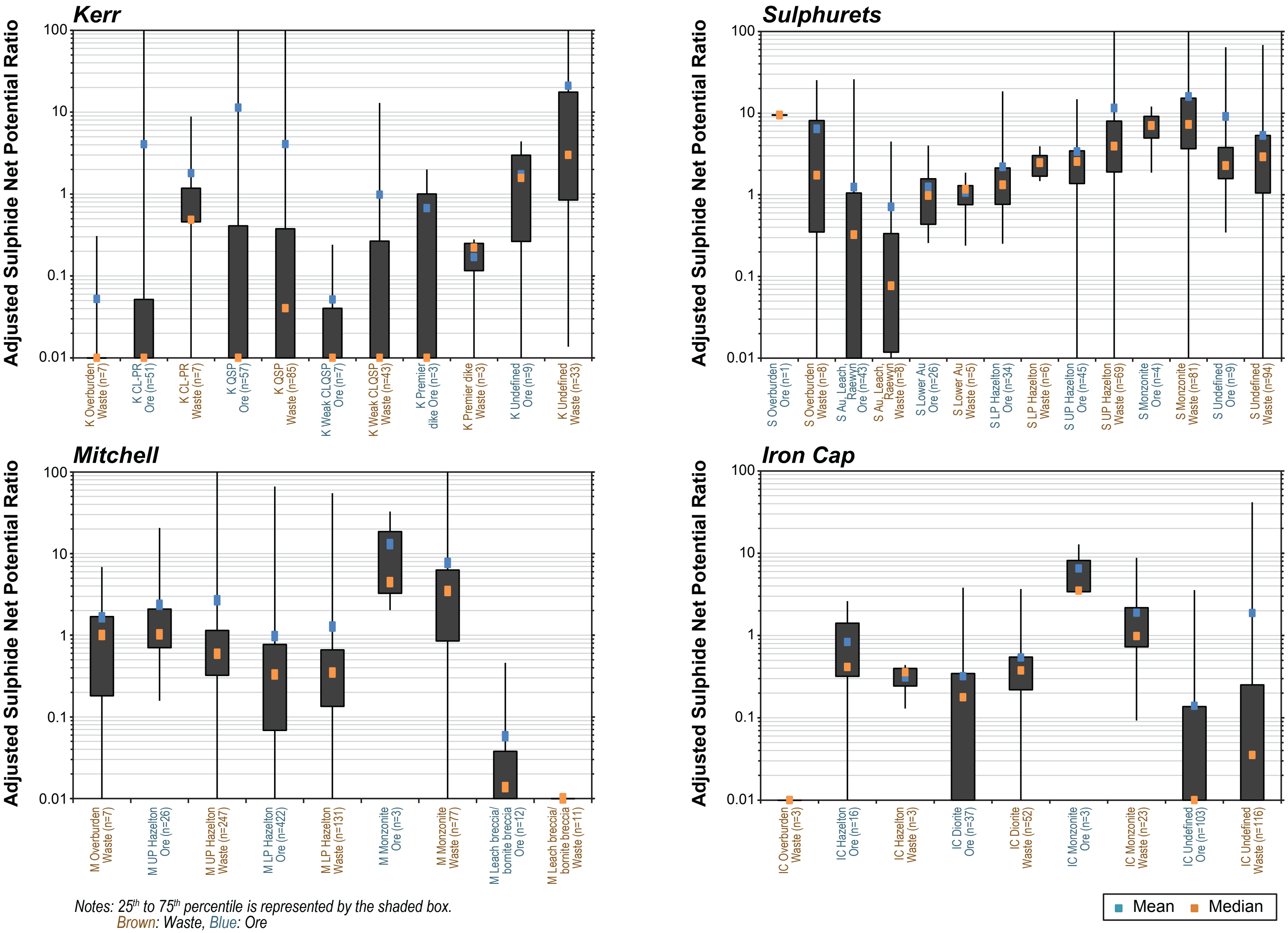
1. Kerr CL-PR,
2. Kerr Undefined,
3. Sulphurets LP Hazelton, and
4. Sulphurets UP Hazelton.

In these instances there are differences that can be observed when comparing statistical summaries for adjSNPR (Figure 3-4) and NP (Figure 3-5). Kerr CL-PR waste samples have higher adjSNPR values than ore samples, as a result of high NP in the waste rock, with median adjSNPR values of 0.48 and 0.01 measured for waste (n=7) and ore (n=51) samples respectively. Both ore and waste are still classified as PAG, however. Additionally, Kerr CL-PR makes up only 3.1% of Kerr deposit material reporting to RSFs, or less than 1% of total waste rock reporting to RSFs. Therefore there is no change to the overall interpretation.

Kerr Undefined samples can be separated by adjSNPR, with median adjSNPR values of 1.58 and 3.00 measured for ore (n=9) and waste (n=33) samples respectively. The difference in adjusted SNPR is a result of higher NP values in the waste samples, as the sulphide acid potential (SAP) values are similar between the two sets of samples, as presented in Figure 3-6. Approximately 99% of Kerr Undefined waste samples are classified as PAG, therefore it is unlikely that not potentially acid generating (NPAG) material could be segregated.

The median adjSNPR values for Sulphurets Lower Panel (LP) Hazelton ore (n=34) versus waste (n=6) samples were 1.32 and 2.46 respectively. The higher adjSNPR in the waste rock is caused by higher NP values compared with the ore. However, with more than 25% of Sulphurets LP Hazelton waste samples classified as PAG the potential to segregate appropriate construction material is limited, especially as only approximately 5% of Sulphurets deposit waste material is classified as LP Hazelton.

Upper Panel (UP) Hazelton samples in the Sulphurets deposit have differences in adjSNPR values, when comparing ore and waste. Median adjSNPR values of 2.55 and 3.95 were measured for ore (n=45) and waste (n=69) samples (Figure 3-4). In the UP Hazelton samples, NP values are similar between sub-sets (Figure 3-5), and the lower median adjSNPR in the ore is the result of higher median SAP values (Figure 3-6). The overall interpretation of UP Hazelton does not change as the median value of samples is greater than 2.0, as are the median values of the reclassified sample sub-sets.



Notes: 25th to 75th percentile is represented by the shaded box.
Brown: Waste, Blue: Ore

Figure 3-4

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Statistical Summary of Deposit Material Adjusted Sulphide Net Potential Ratio by Deposit, Model Code, and Ore/Waste Designation

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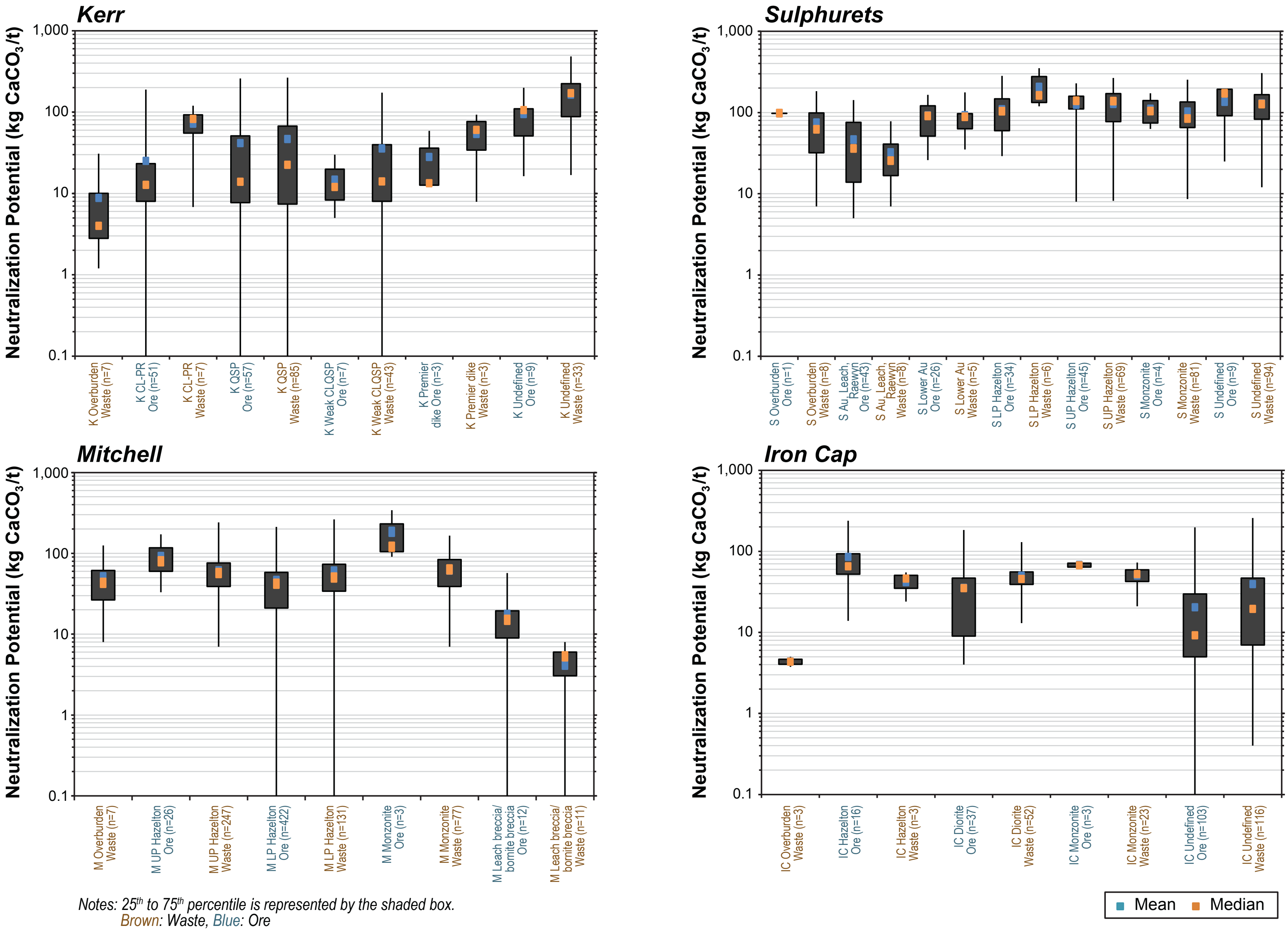

Notes: 25th to 75th percentile is represented by the shaded box.
Brown: Waste, Blue: Ore

Figure 3-5

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Statistical Summary of Deposit Material Sobek Neutralization Potential by Deposit, Model Code, and Ore/Waste Designation

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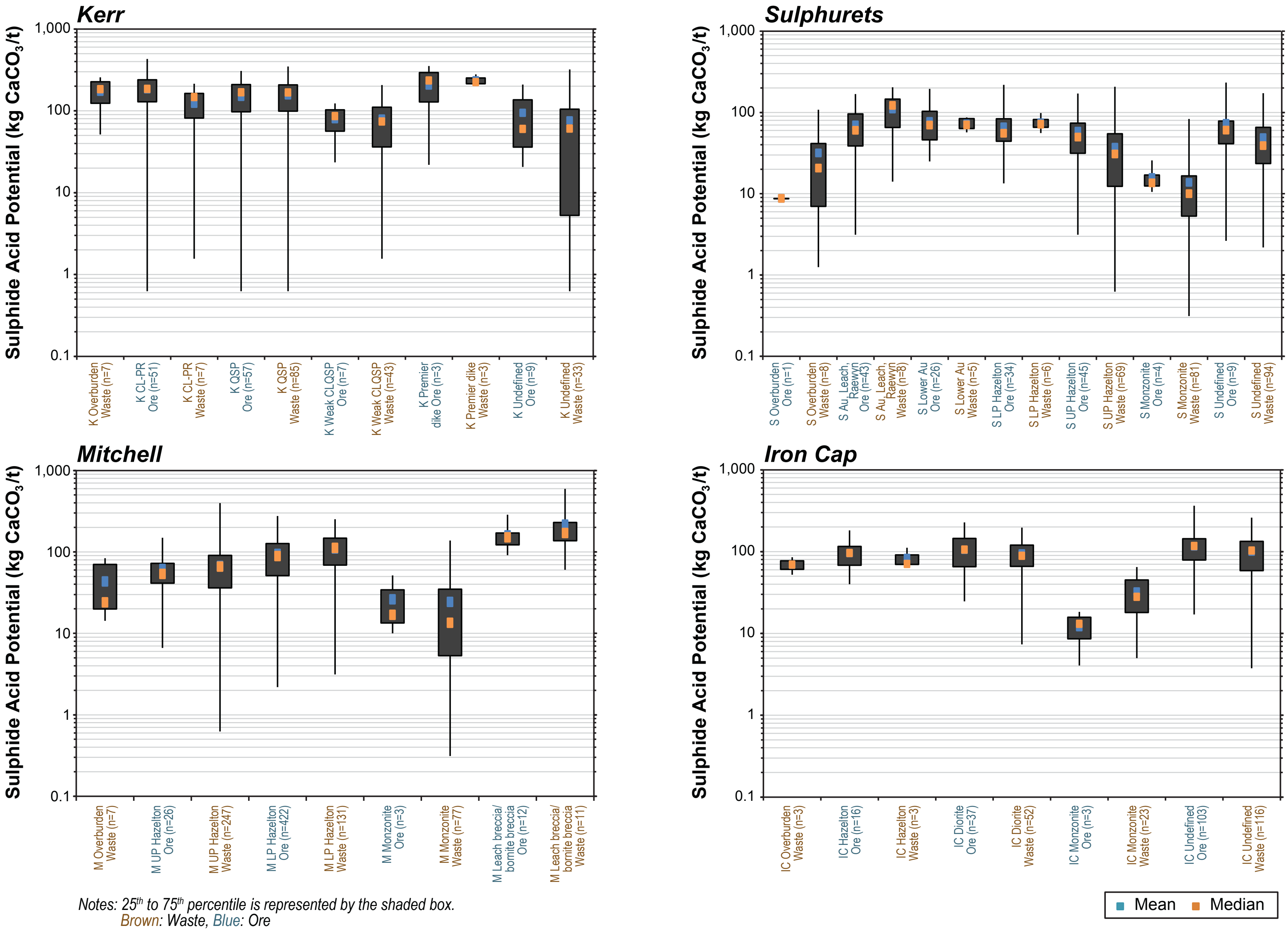
Figure 3-5



Notes: 25th to 75th percentile is represented by the shaded box.
Brown: Waste, Blue: Ore

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Statistical Summary of Deposit Material Sulphide Acid Potential by Deposit, Model Code, and Ore/Waste Designation

Figure 3-6

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4 Kerr and Iron Cap Characterization

The ABA block model codes are discussed in Appendix 10-A Section 4.6. The Sulphurets and Mitchell deposits have a proportion of PAG and NPAG materials, whereas the more than 90% of Kerr and Iron Cap deposits are classified as PAG. Although the ABA block model had multiple categories for Kerr and Iron Cap (Table 4-1) samples from these deposits were compiled into only one code for geochemical characterization and the development of source terms for predictive water quality modelling.

Table 4-1. Block Model Codes and Associated Descriptions

Block Model Codes	Description
Kerr	
Overburden	> 50% soil or glaciofluvial material
CL-PR	Chlorite-propylitic alteration
QSP	Quartz-sericite-pyrite alteration
Weak CLQSP	Weak chlorite-quartz-sericite-pyrite alteration
Premier dike	Premier and hornblende dikes
Undefined	Default for material outside the ore zone
Iron Cap	
Overburden	> 50% soil or glaciofluvial material
Glacial ice	Glacial ice
Hazelton	Default sedimentary unit
Diorite	Diorite intrusion
Monzonite	Monzonite intrusion
Undefined	Default for edge effects or minor units

The percentage of deposit waste rock scheduled to be placed in the RSFs includes both Kerr deposit waste rock and Iron Cap development waste rock. The majority of Kerr and Iron Cap (99% and 100%, respectively) waste rock is classified as PAG using both the combined and individual block model classifications. Because of the high proportion of PAG material, no segregation of PAG and NPAG is planned for these units.

4.1 Detailed Kerr and Iron Cap Model Codes

The reclassification of Kerr and Iron Cap deposit material was assessed to determine if there are variances in the geochemical characteristics between mine wastes. The reclassified ABA block model codes of Kerr and Iron Cap results in a lower proportion of representativeness of the kinetic characterization program as illustrated in Table 4.1-1. New humidity cells were initiated in 2012 and 2013 to geochemically characterize these block model codes in addition to Sulphurets and Mitchell block model codes.

Table 4.1-1. KSM Deposit Material Representivity with Additional Humidity Cells

	Percent of Total Deposit Material		Number of Humidity Cells		% Represented	
	PAG	NPAG	PAG	NPAG	PAG	NPAG
Kerr						
Overburden	3.0%	0.0%	0	0	0.0%	0.0%
CL-PR	3.1%	0.0%	2	0	3.1%	0.0%
QSP	31.2%	0.2%	1	0	31.2%	0.0%
Weak CLQSP	16.6%	0.0%	1	0	16.6%	0.0%
Premier dike	2.1%	0.0%	0	0	0.0%	0.0%
Undefined	43.1%	0.6%	1	1	43.1%	0.6%
Total					94.0%	0.6%
Sulphurets						
Overburden	0.1%	2.1%	1	0	0.1%	0.0%
Au, Leach, Raewyn zones	4.6%	0.1%	0	0	0.0%	0.0%
Lower Au zone	9.5%	0.0%	2	0	9.5%	0.0%
LP Hazelton	5.2%	0.3%	1	0	5.2%	0.0%
UP Hazelton	5.5%	14.0%	1	3	5.5%	14.0%
Monzonite	1.5%	18.1%	0	3	0.0%	18.1%
Undefined	6.6%	32.4%	2	2	6.6%	32.4%
Total					26.9%	64.5%
Mitchell						
Overburden	1.5%	0.0%	0	0	0.0%	0.0%
UP Hazelton	58.9%	1.2%	8	0	58.9%	0.0%
LP Hazelton	15.8%	0.4%	12	0	15.8%	0.0%
Monzonite	2.4%	19.1%	0	2	0.0%	19.1%
Leach breccia/bornite breccia	0.4%	0.0%	1	0	0.4%	0.0%
Undefined	0.0%	0.0%	0	0	0.0%	0.0%
Total					75.1%	19.1%
Iron Cap						
Overburden	0.0%	0.0%	0	0	0.0%	0.0%
Hazelton	68.2%	0.0%	1	0	68.2%	0.0%
Diorite	0.0%	0.0%	2	0	0.0%	0.0%
Monzonite	29.1%	0.0%	1	0	29.1%	0.0%
Undefined	2.6%	0.0%	4	0	2.6%	0.0%
Total					99.9%	0.0%

The majority of Kerr waste rock has been reclassified to undefined. As part of the reclassification, new humidity cells were initiated with Kerr PAG and NPAG waste rock classified as undefined. The reclassification of the Iron Cap deposit has resulted in a high proportion of Hazelton and Monzonite waste rock. New humidity cells were also initiated with waste rock classified as PAG for both Hazelton and Monzonite block model codes. The addition of these humidity cells increases the proportion of Kerr and Iron Cap waste rock represented by humidity cells to 94.6% and 99.9%, respectively (Table 4.1-1).

The increased representativeness of the kinetic program provides data to establish and understand the geochemical variability of waste rock and to establish the representativeness and appropriateness of the samples used in kinetic testing and water quality predictions. Kerr Pit is not scheduled to begin operations until Year 27 of the mine life. The current Kerr waste rock data set will be expanded upon prior to mining. There will be sufficient time for additional geochemical characterization of Kerr waste rock to establish and understand the geochemical variability of the waste rock.

Furthermore, the volume of Iron Cap deposit material is significantly smaller than the other deposits; less than 20 Mt of Iron Cap rock will be added to the RSF, compared to 3,000 Mt of total waste rock. Any changes to the estimated input values as a result of reclassifying Iron Cap deposit by model code and ML/ARD criteria would therefore be unlikely to have a measurable effect on the modelled downstream water quality.

Overall, reclassifying the Kerr and Iron Cap deposits by model code and ML/ARD criteria does not indicate an underestimation by the water quality model of the downstream watercourses.

5 Additional Deposit Material Kinetic Tests

New humidity cells were initiated to increase the representivity of deposit materials at the proposed Project site that were not included in the 2012 ML/ARD Baseline report (Appendix 10-A). Because the new humidity cells were not stable at the cut-off date for the baseline report they were not included in the assessment.

Nine new deposit material humidity cells were initiated in August 2012 (8 Sulphurets and 1 Mitchell deposit) and four new deposit material humidity cells were initiated in May 2013 (2 Kerr and 2 Iron Cap deposit). Table 5-1 outlines the operational status of the new deposit material humidity cells as of May 10, 2013. Analytical results are not yet available from the new Kerr and Iron Cap humidity cells.

Table 5-1. Additional KSM Humidity Cells

Humidity Cell Identification	Waste/Ore	Weeks Operated	Status
Kerr			
K-HC-05 Undefined	Waste	0*	Ongoing weekly sampling
K-HC-06 Undefined	Waste	0*	Ongoing weekly sampling
Sulphurets			
S-HC-08 LP Hazelton	Ore	33	Ongoing monthly sampling
S-HC-09 UP Hazelton	Ore	33	Ongoing monthly sampling
S-HC-10 UP Hazelton	Waste	33	Ongoing monthly sampling
S-HC-11 Monzonite	Waste	33	Ongoing monthly sampling
S-HC-12 Monzonite	Waste	33	Ongoing monthly sampling
S-HC-13 Monzonite	Waste	33	Ongoing monthly sampling
S-HC-14 Undefined	Waste	33	Ongoing monthly sampling
S-HC-15 Undefined	Waste	33	Ongoing monthly sampling
Mitchell			
M-HC-24 Monzonite	Waste	33	Ongoing monthly sampling
Iron Cap			
IC-HC-08 Hazelton	Ore	0*	Ongoing weekly sampling
IC-HC-09 Monzonite	Waste	0*	Ongoing weekly sampling

UP = Upper Panel
LP = Lower Panel
*** = zero weeks because humidity cells initiated after May 10, 2013**

5.1 Pre-test Static Test Results

Subsamples of new humidity cell material were obtained to determine pre-humidity cell solid-phase static test properties. Analyses included ABA and solid-phase elemental concentration analysis.

5.1.1 Paste pH

Figure 5.1-1 presents the statistical distribution of the paste pH for the model codes represented by the additional humidity cells. The paste pH values of the additional humidity cell samples are also represented. The results show that the majority of humidity cell values are within the paste pH interquartile range for their respective model codes. The exception is humidity cell S-HC-08 LP Hazelton, which has a lower measured paste pH than the majority of samples for that model code.

5.1.1.1 Sulphur Species

Figure 5.1-2 presents the statistical distribution of total-sulphur concentrations for the model codes represented by the additional humidity cells, in relation to the total-sulphur concentrations of the additional humidity cell samples. The results show that the majority of the humidity cell values are within the total-sulphur interquartile range for their respective model codes. Humidity cell samples from S LP Hazelton and S Monzonite exhibited total-sulphur concentrations variability towards the higher range of waste rock samples.

Figure 5.1-3 presents the statistical distribution of sulphide-sulphur concentrations for the model codes represented by the additional humidity cells, in relation to the sulphide-sulphur concentrations of the additional humidity cell samples. The results show that the majority of the humidity cell values are within the sulphide-sulphur interquartile range for their respective model codes. The humidity cell sample from S LP Hazelton exhibited sulphide-sulphur concentration variability towards the higher range of waste rock samples. Humidity cell samples from S Monzonite exhibited sulphide-sulphur concentrations variability towards both the higher and lower range of waste rock samples.

5.1.2 Neutralization Potential

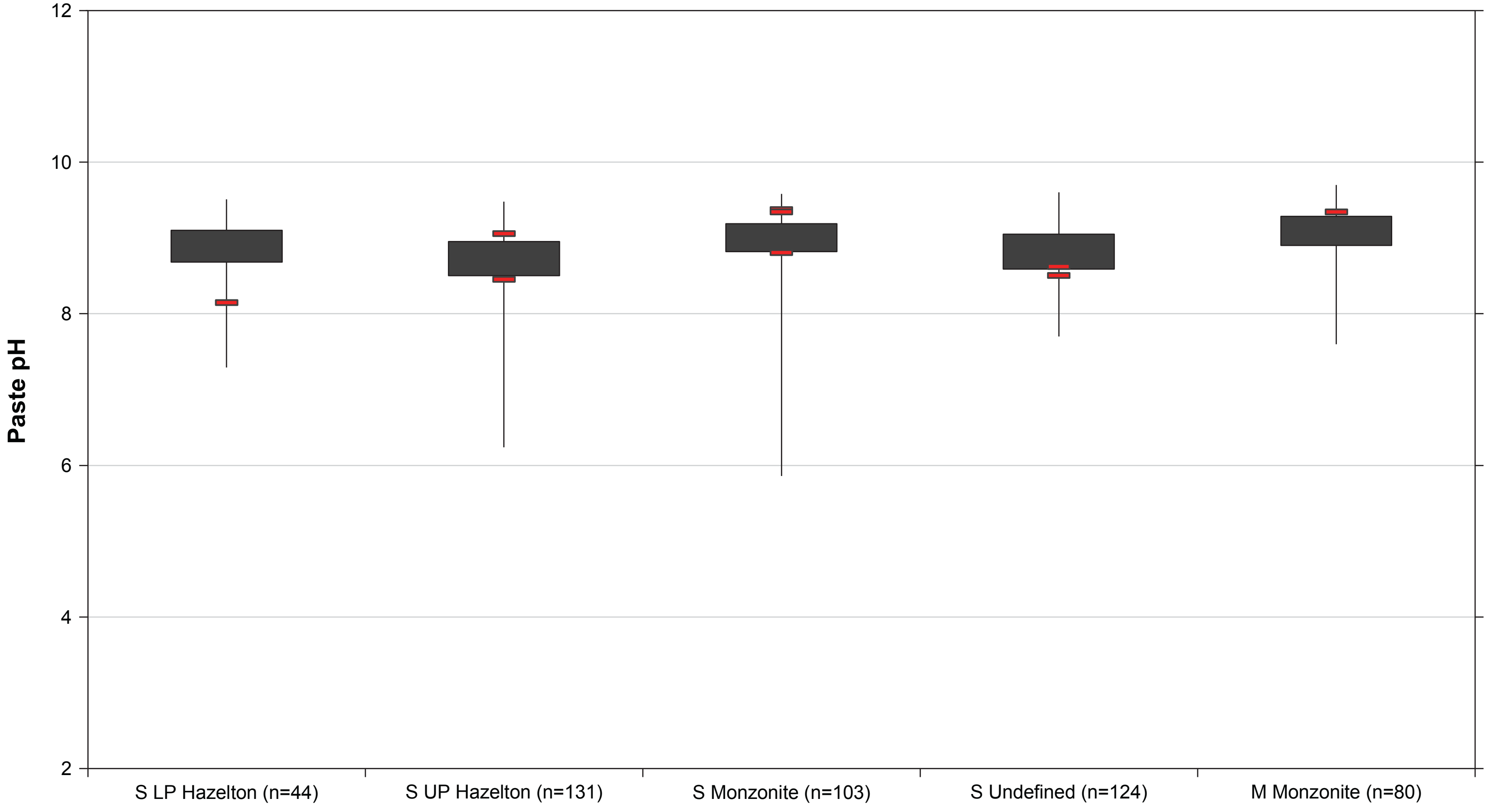
Figure 5.1-4 presents the statistical distribution of NP values for the model codes represented by the additional humidity cells, in relation to the NP values of the additional humidity cell samples. The results show that the majority of the humidity cell values are within the NP interquartile range for their respective model codes. Humidity cell samples from S UP Hazelton, S Undefined, and M Monzonite exhibited NP values variability towards the higher range of waste rock samples.

5.1.3 Adjusted Sulphide Net Potential Ratio

Figure 5.1-5 presents the statistical distribution of adjusted SNPR values for the model codes represented by the additional humidity cells, in relation to the SNPR values of the additional humidity cell samples. The results show that the majority of the humidity cell values are within the SNPR interquartile range for their respective model codes. Humidity cell samples from S Monzonite exhibited SNPR values variability towards both the higher and lower range of waste rock samples.

5.1.4 Whole Rock and Solid-phase Elemental Analysis

The multi-element concentrations in the additional humidity cell samples were measured by ICP-MS analysis after strong four-acid digestion and by XRF whole-rock analysis.



Note: 25th to 75th percentile is represented by the shaded box.

Figure 5.1-1

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Statistical Summary of Paste pH by Model Code

Figure 5.1-1

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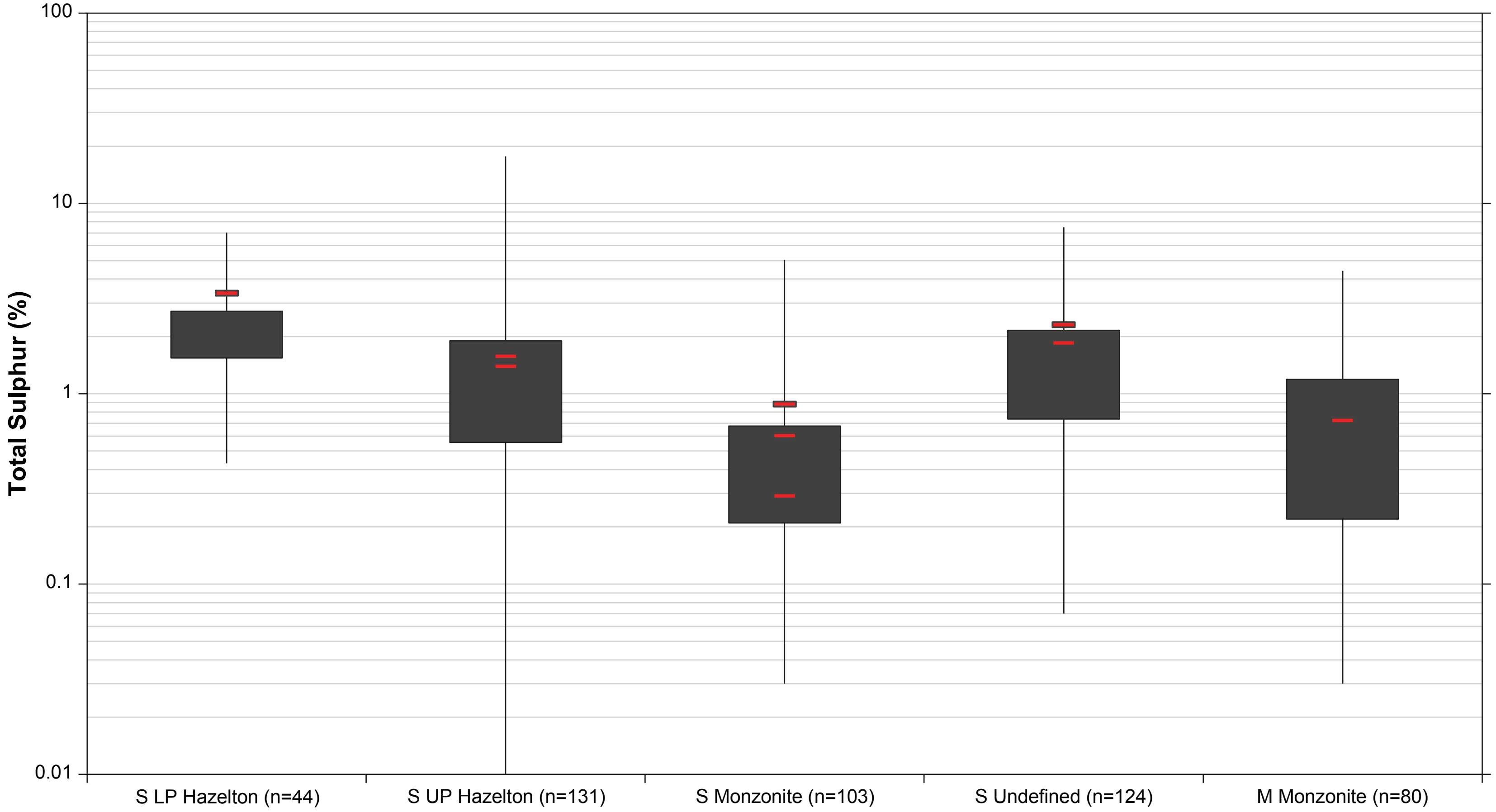

Note: 25th to 75th percentile is represented by the shaded box.

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Statistical Summary of Total Sulphur by Model Code

Figure 5.1-2

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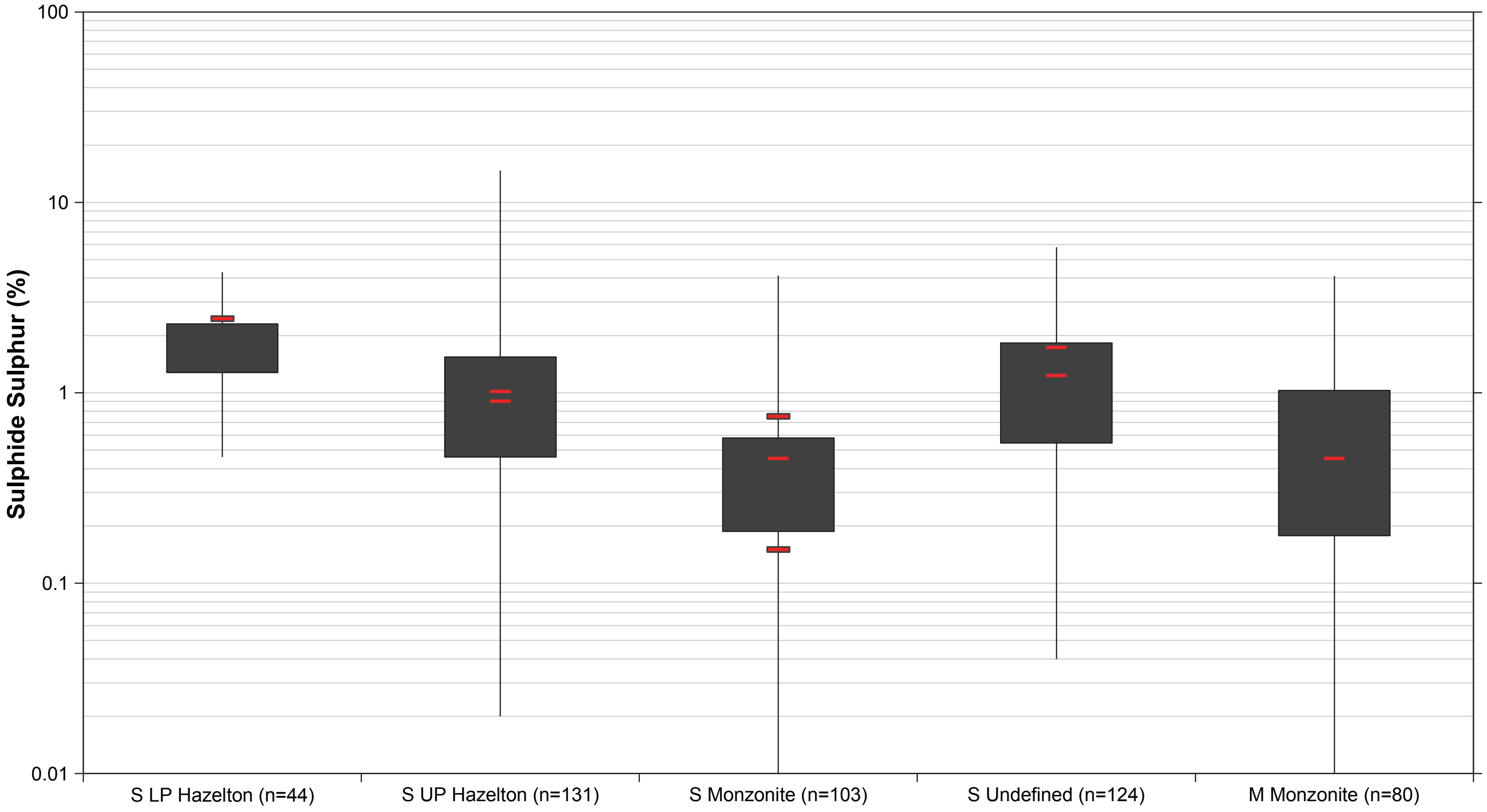

Note: 25th to 75th percentile is represented by the shaded box.

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Statistical Summary of Sulphide-Sulphur by Model Code

Figure 5.1-3

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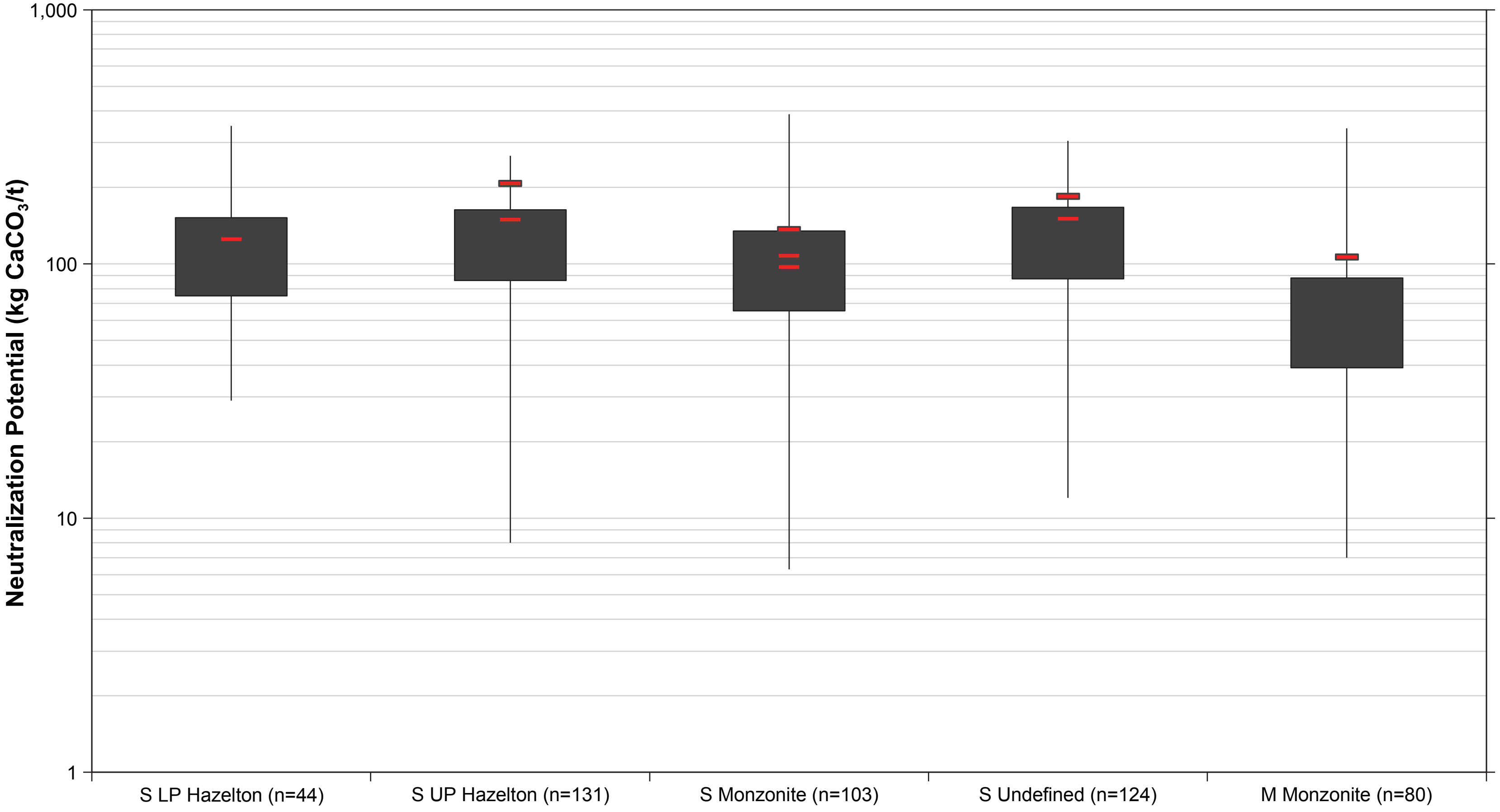
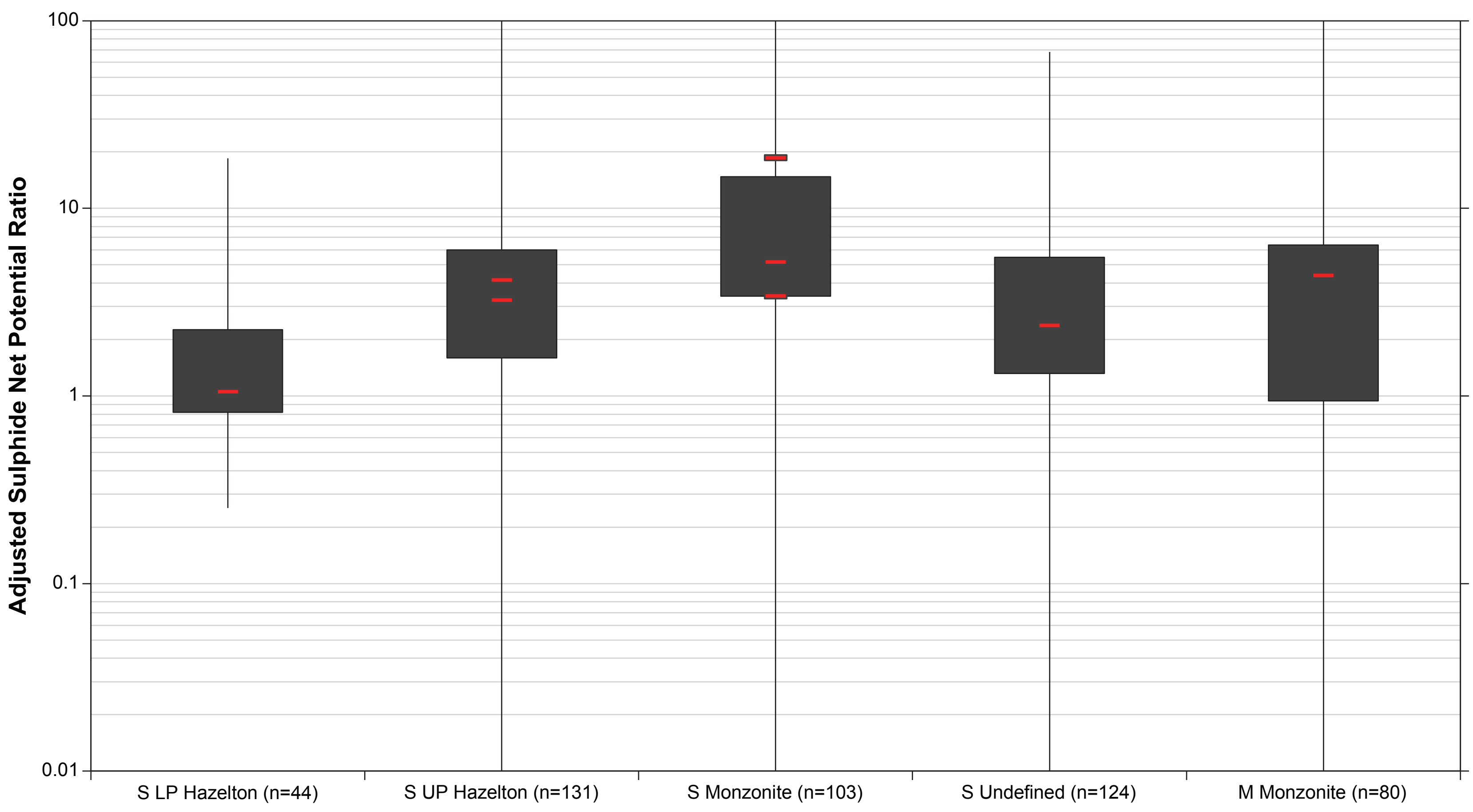


Note: 25th to 75th percentile is represented by the shaded box.

Statistical Summary of Neutralization Potential by Model Code

Figure 5.1-4



Note: 25th to 75th percentile is represented by the shaded box.

Figure 5.1-5

Statistical Summary of Adjusted Sulphide Net Potential ratio by Model Code

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Most of the humidity cell samples were comprised of oxide-equivalents of SiO_2 and Al_2O_3, which is consistent with the dominant presence of quartz, feldspar minerals, and other aluminosilicate minerals in the KSM rocks, and is consistent with the results from other humidity cell samples. Also consistent with the general mineralogy, there were lesser but still significant amounts of CaO, Fe_2O_3, K_2O, MgO and Na_2O.

5.1.5 Mineralogy

Mineralogy of the humidity cell material corresponds with the monzonite designation of most of the samples. The dominant minerals in the samples are feldspars (16 to 72%) with lesser amounts of quartz and muscovite (13 to 64%). Calcite and ankerite/dolomite (5 to 12%) were more abundant than siderite (less than one percent). Pyrite (less than one percent to 6%) was the only sulphide detected and was less abundant than carbonate in eight of the nine samples. S-HC-08 was logged as a strongly altered volcanic rock. The higher quartz and sulphide content and lower adjusted SNPR value (1.10) are consistent with the logged alteration and rock type. Elevated carbonate compared to sulphide mineral contents in the other eight humidity cells indicates that these humidity cells are unlikely to become acid generating. This is consistent with adjusted SNPR values as discussed in Section 3.2.1.4.

5.2 Kinetic Test Results

5.2.1 Sulphurets Deposit

Eight new humidity cells were initiated for four ABA block model codes (one humidity cell for LP Hazelton, two for UP Hazelton, 3 for Monzonite, and two for Undefined). All eight cells had been operating for 33 weeks at the cut-off time for this addendum.

5.2.1.1 pH, Sulphate, Acidity, and Alkalinity

The eight new humidity cells from the Sulphurets deposit had initial near-neutral pH, and pH values remained stable and above pH 7 for the first 33 weeks (Figure 5.2-1).

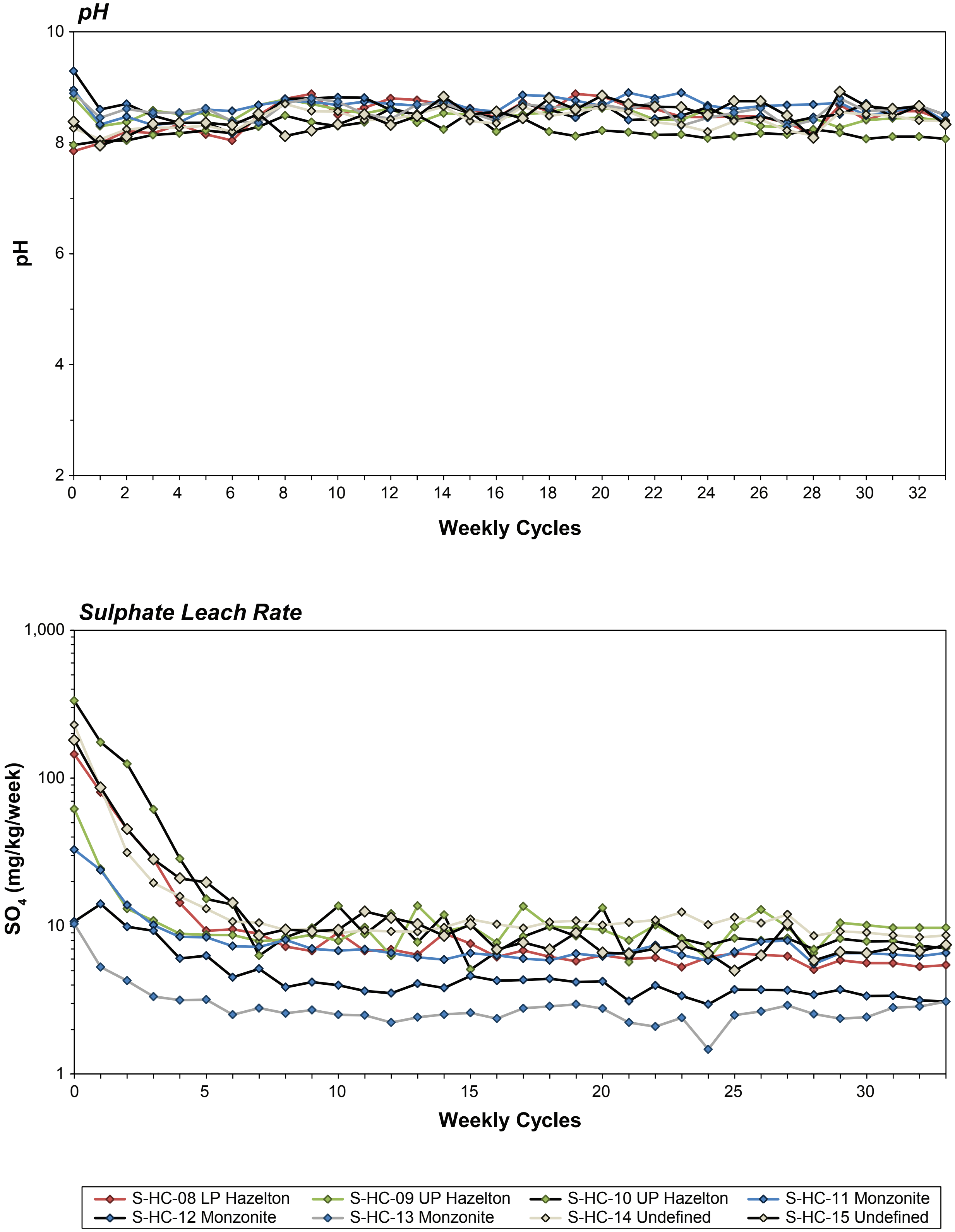
Sulphate production rates decreased rapidly for the first ten to 20 cycles, representing the flushing of surface precipitates. After this they stabilized between about 2.1 and 12.4 mg/kg/wk in most humidity cells, while remaining variable in S-HC-09 and S-HC-15 (Figure 5.2-1).

Acidity was highly variable and frequently below detection limits. Alkalinity production was stable in all humidity cells between approximately 10 to 20 mg/kg/wk (Figure 5.2-2).

5.2.1.2 Elements that Contribute to Acidity

Aluminum leach rates were stable in most of the humidity cells, levelling out or decreasing slightly over the last five to ten cycles. The exception is humidity cell S-HC-14 Undefined, in which aluminum leach rates increased over the last six weekly cycles (Figure 5.2-3). Iron leach rates were highly variable (Figure 5.2-3).

Manganese leach rates levelled out after being variable for the first five to ten cycles, stabilizing at between 0.01 to 0.03 mg/kg/wk (Figure 5.2-4).



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Weekly pH and Sulphate Production Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-1

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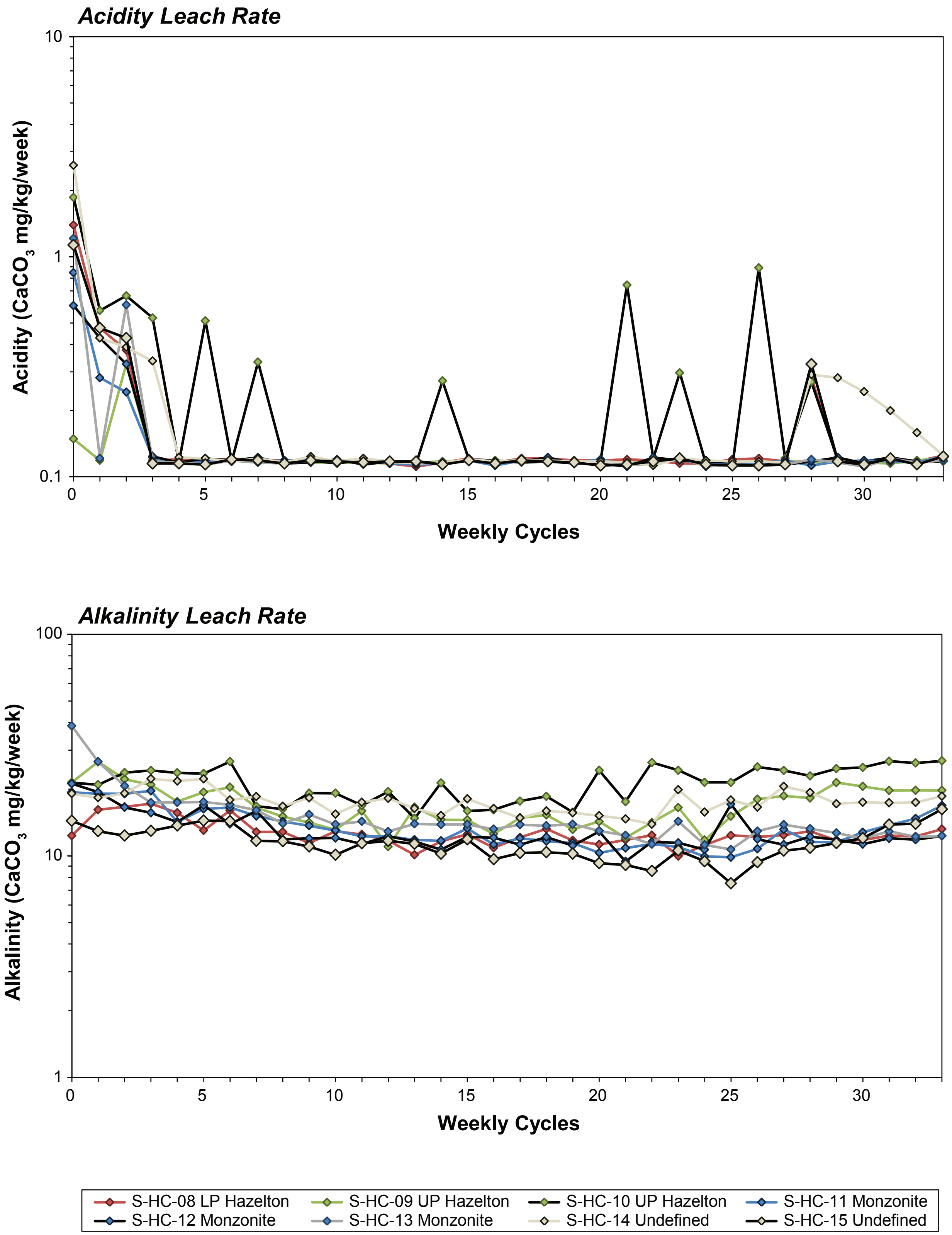

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Weekly Acidity and Alkalinity Production Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-2

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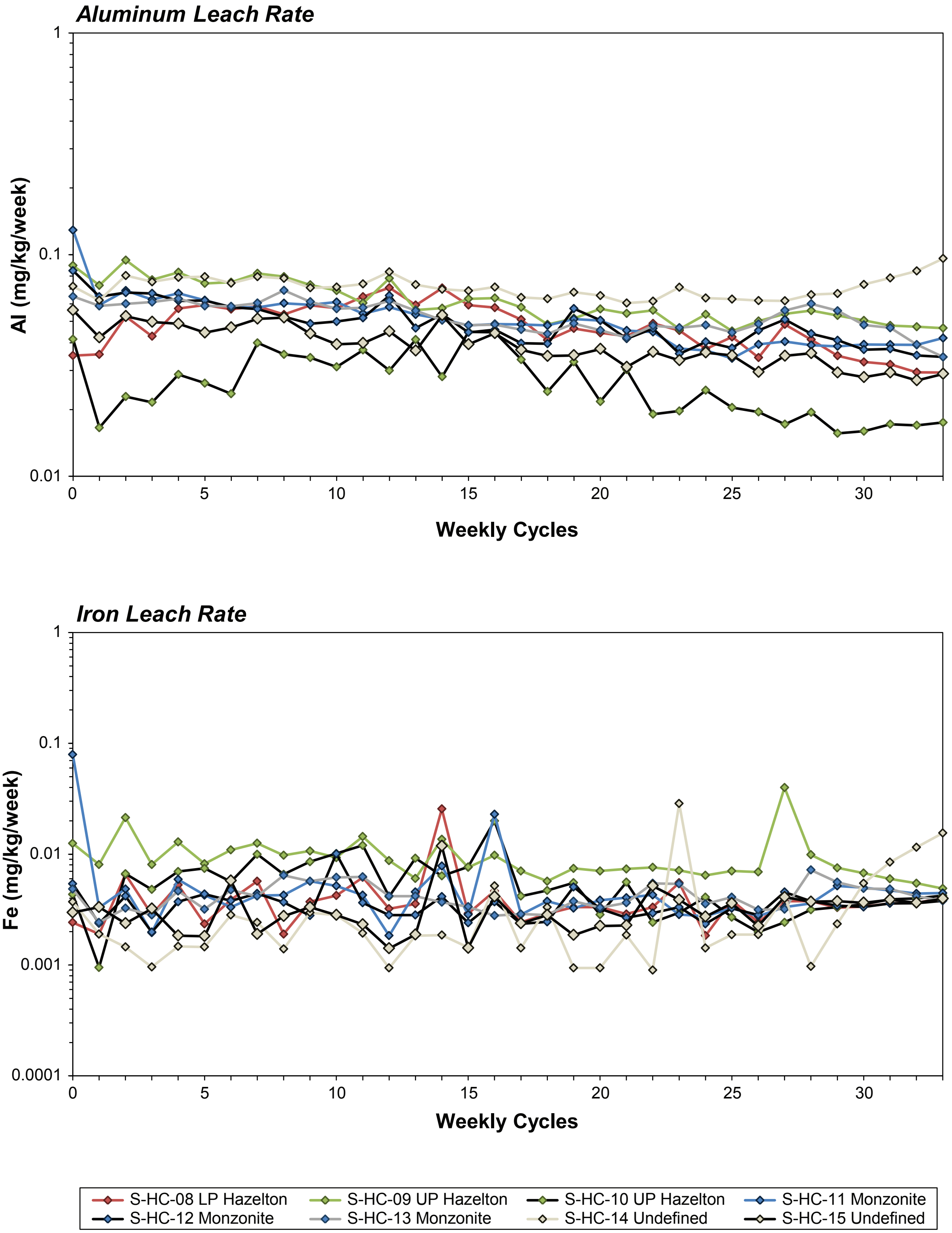

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Weekly Aluminum and Iron Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-3

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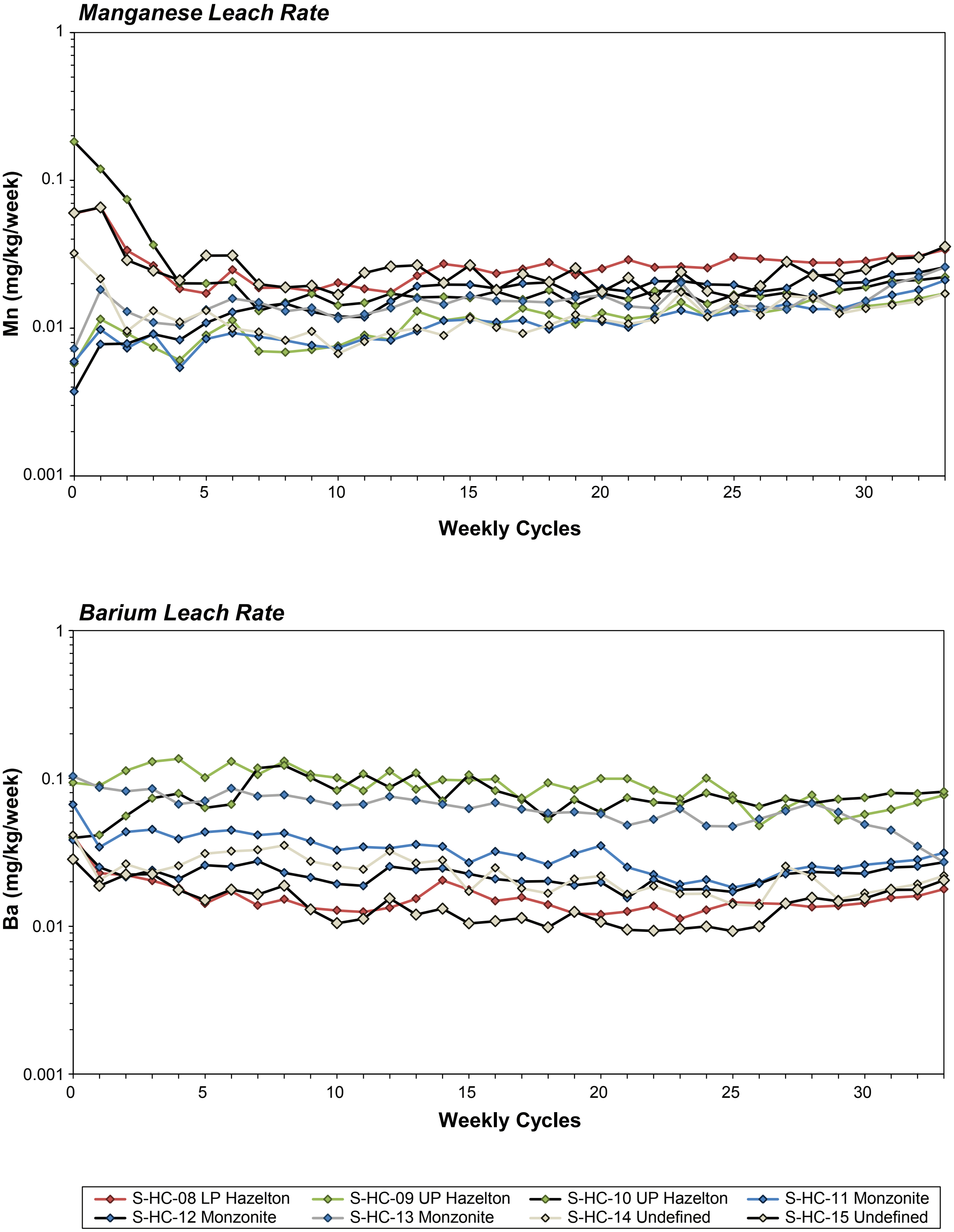

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Weekly Manganese and Barium Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-4

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5.2.1.3 Barium

Barium leach rates stabilized between 0.009 to 0.10 mg/kg/wk. The exception was humidity cell S-HC-13 Monzonite, in which barium leach rates steadily dropped for the last five weekly cycles (Figure 5.2-4).

5.2.1.4 Trace Elements

Trace element concentrations were generally highest in the Upper Panel Hazelton and Undefined humidity cells. S-HC-15 Undefined had the consistently highest leach rates of the new humidity cells for arsenic, cadmium, cobalt, lead, and zinc. Humidity cells classified under the Monzonite model code had predominantly the lowest trace element concentrations. Leach rates for most trace elements were stable after the first five to ten weeks. Of note are leach rates in humidity cell S-HC-14 Undefined, which increased steadily from week 29 to 33 for cadmium, chromium, copper, lead, nickel, vanadium, and zinc.

Arsenic leach rates were stable for the first 33 weeks. The lowest leach rates were observed from S-HC-11 Monzonite, and the highest from S-HC-15 Undefined (Figure 5.2-5).

Cadmium concentrations were highly variable and often below detection limits for most humidity cells. S-HC-15 Undefined, S-HC-10 UP Hazelton, and S-HC-08 LP Hazelton had cadmium concentrations that were consistently above detection limits, and had stable leach rates (Figure 5.2-5).

Chromium concentrations were highly variable and frequently below detection limits. The two Undefined humidity cells had significantly increasing leach rates after cycle 29 (Figure 5.2-6).

Cobalt leach rates were stable for the first 33 weeks (Figure 5.2-6). Copper leach rates also stabilized after the first ten weeks, having peaked at the seventh to eight weeks and then decreased rapidly. As noted above, the exception was the Undefined humidity cell S-HC-14 Undefined (Figure 5.2-7).

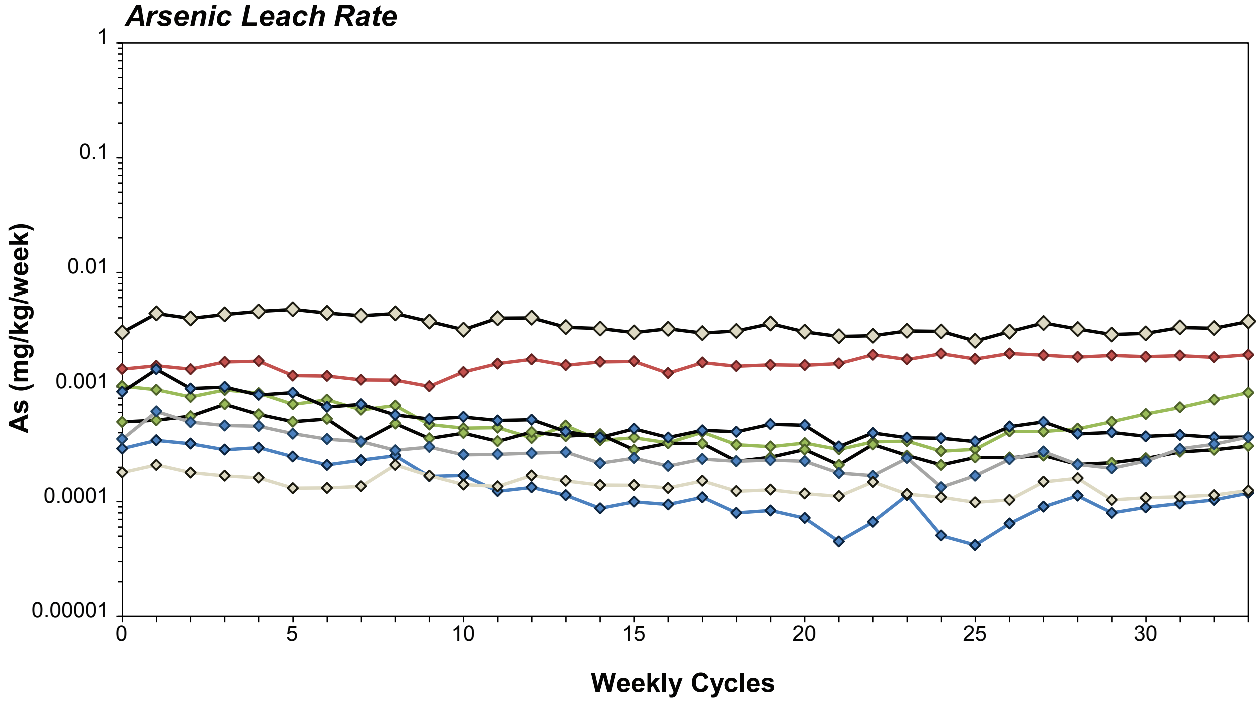
Fluoride concentrations decreased steadily in all new humidity cells, and dropped below detection limits within the first 30 weeks for most humidity cells (Figure 5.2-7).

Lead concentrations were highly variable and close to detection limits for most humidity cells. Exceptions were S-HC-08 LP Hazelton, S-HC-15 Undefined, and S-HC-10 UP Hazelton, all of which stabilized in the first few weeks with leach rates of more than an order of magnitude greater than the rest of the humidity cells (Figure 5.2-8).

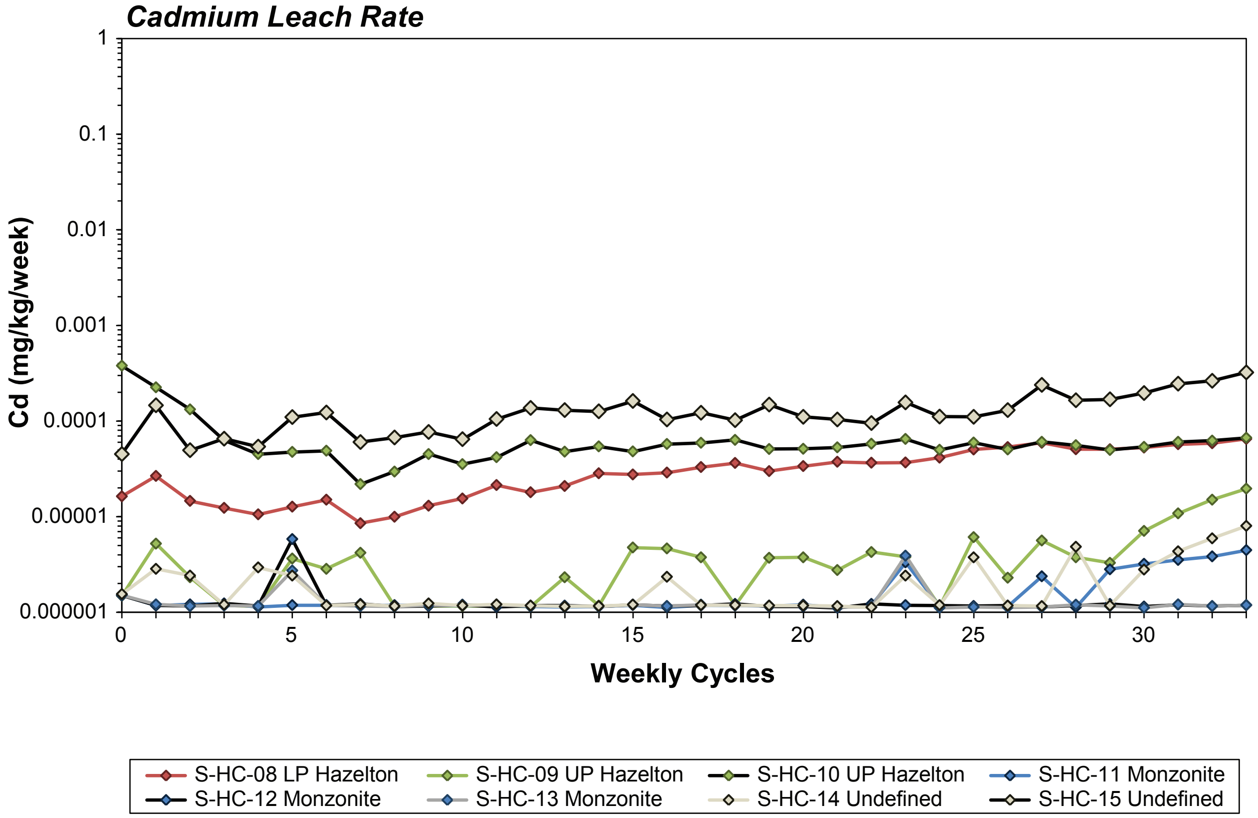
Molybdenum leach rates stabilized after approximately eight to ten weeks. Elevated leach rates were observed in the two humidity cells assigned to the UP Hazelton model code S-HC-09 and S-HC-10 (Figure 5.2-8).

Nickel concentrations were highly variable and had not stabilized by the cut-off time for this addendum (Figure 5.2-9).

Selenium leach rates decreased steadily for the first 33 weeks of analysis (Figure 5.2-9).



Arsenic Leach Rate



Cadmium Leach Rate

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Weekly Arsenic and Cadmium Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-5

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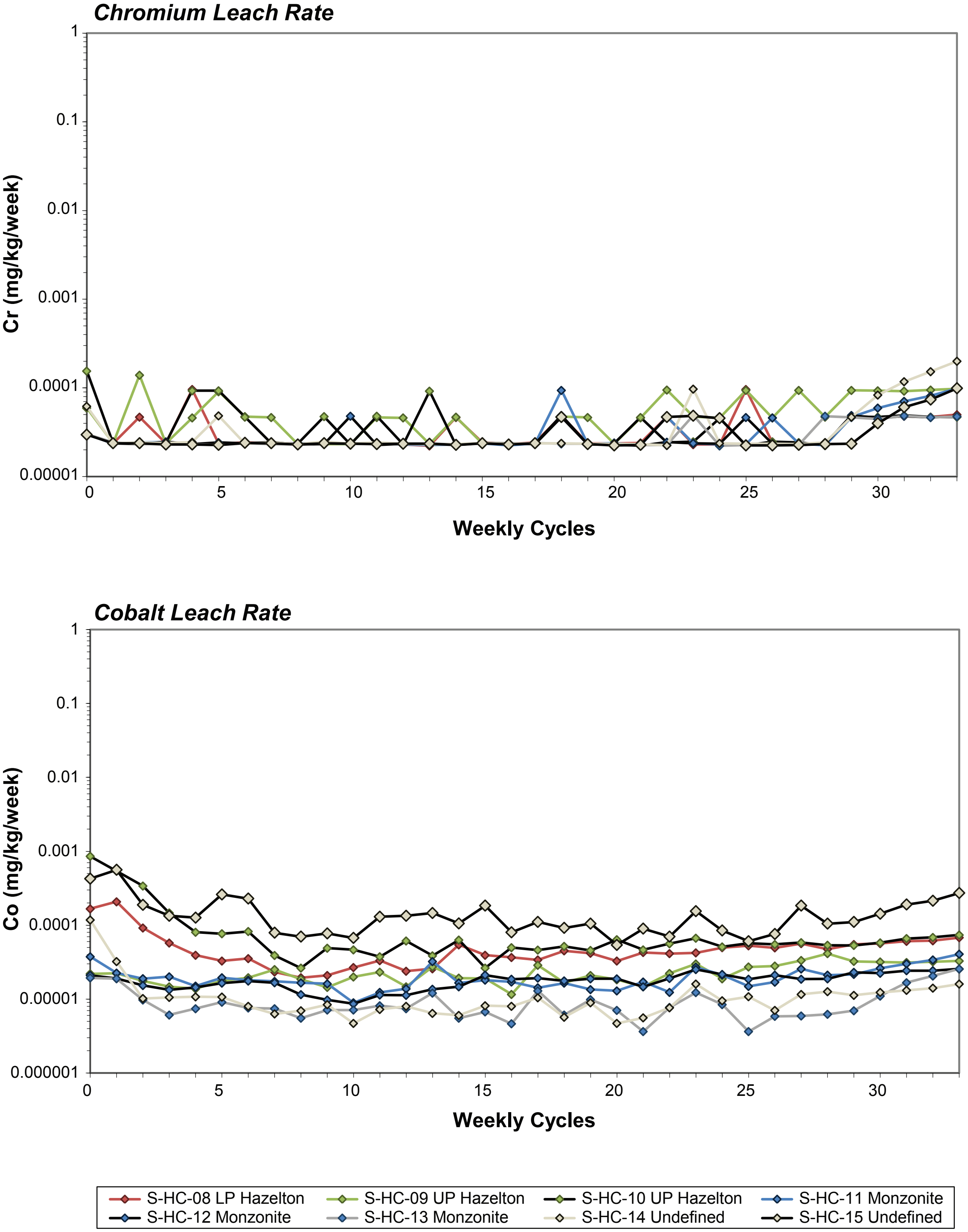
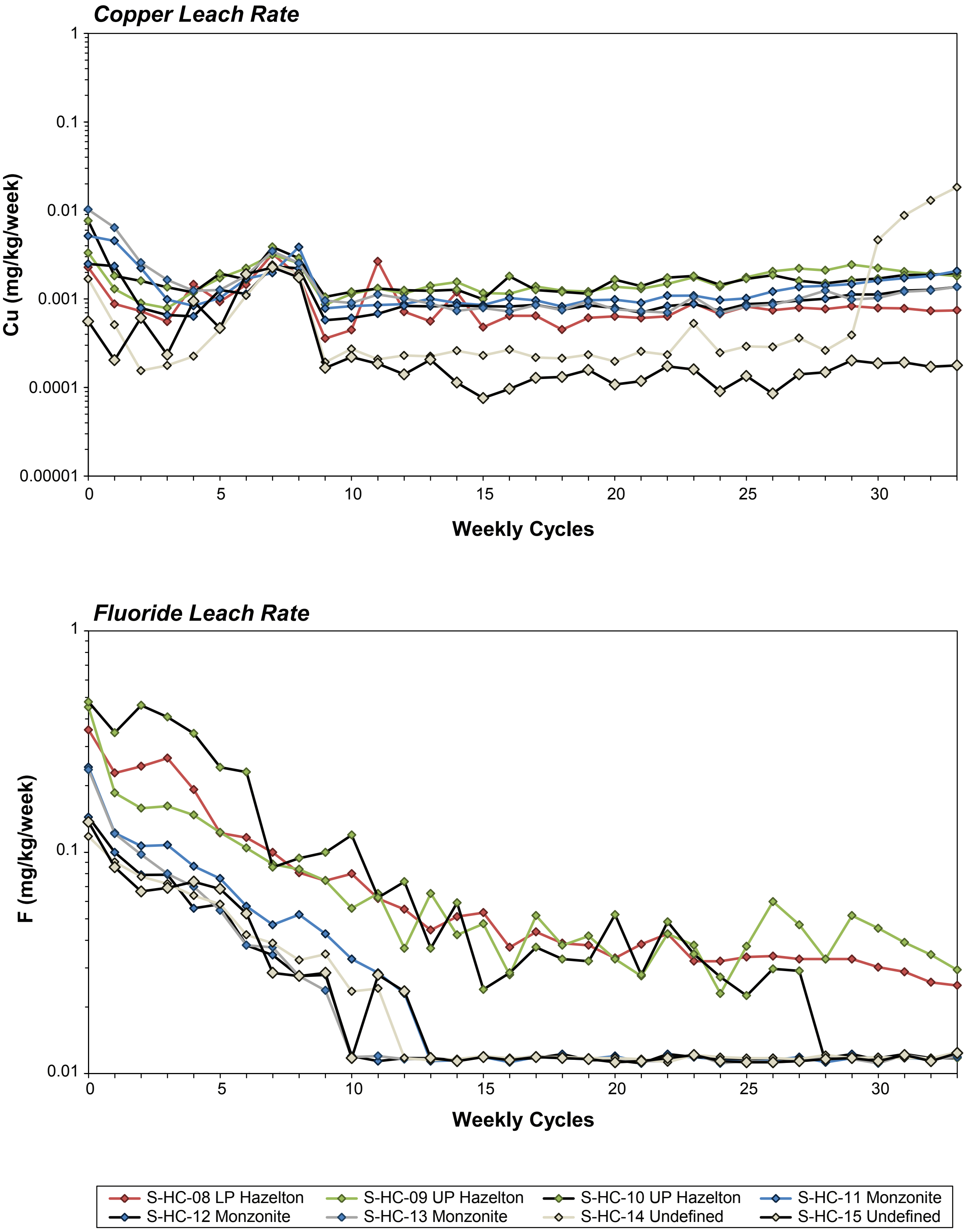


Weekly Chromium and Cobalt Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells



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Weekly Copper and Fluoride Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-7

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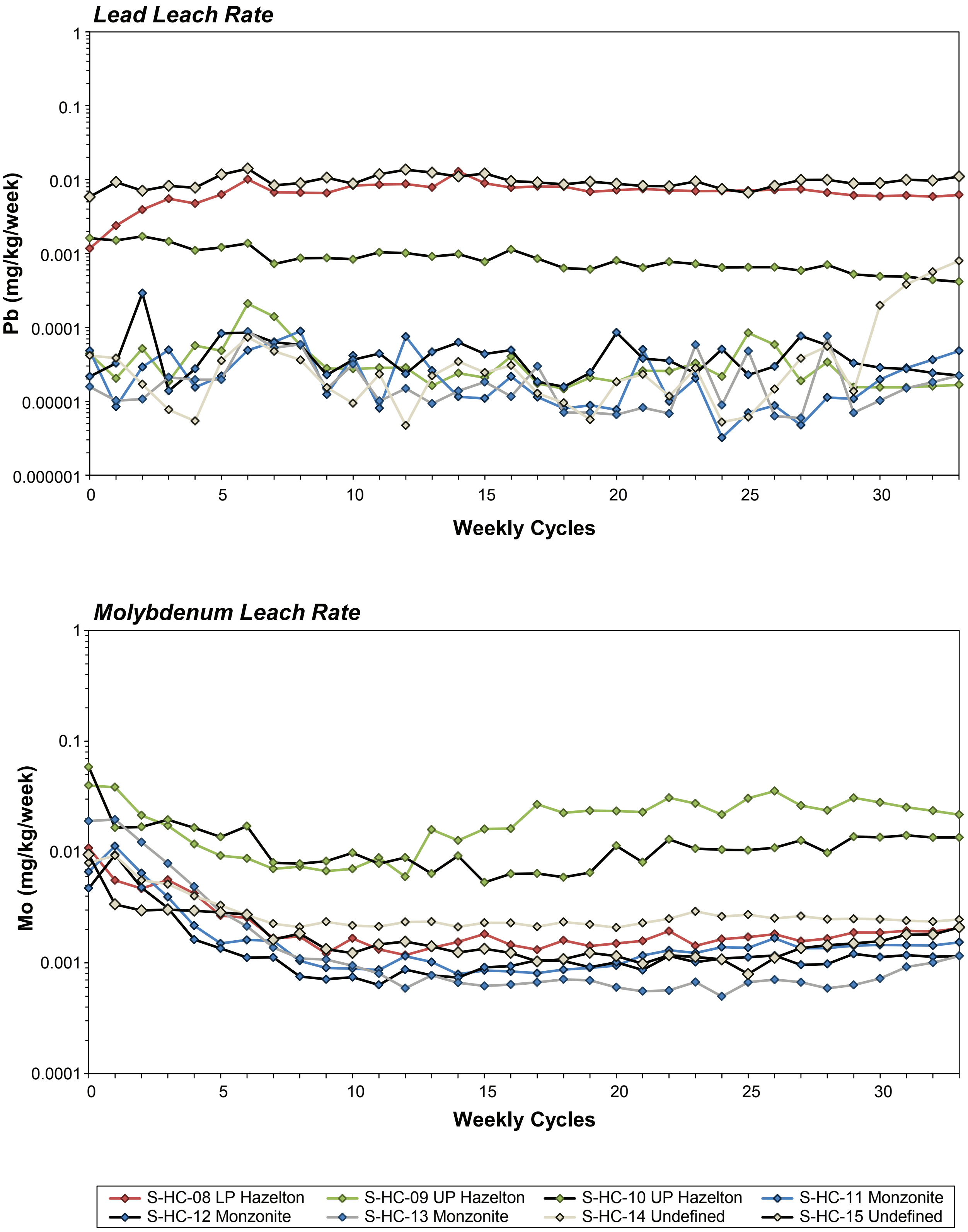

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Weekly Lead and Molybdenum Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-8

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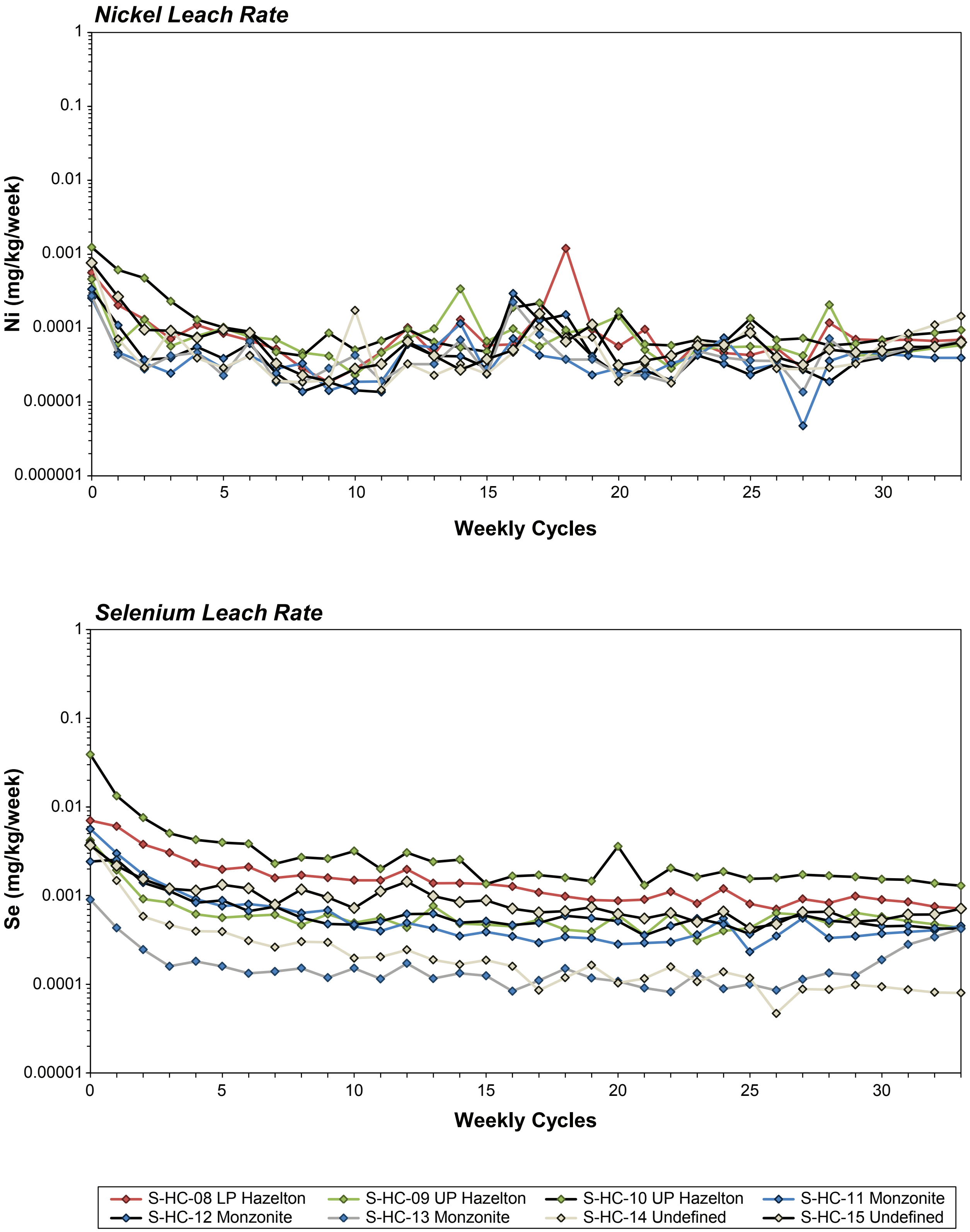

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Weekly Nickel and Selenium Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-9

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Silver concentrations were variable and frequently below detection limits (Figure 5.2-10).

Vanadium concentrations were also highly variable and often below detection limits for three humidity cells – S-HC-08 LP Hazelton, S-HC-10 UP Hazelton, and S-HC-15 Undefined. Vanadium leach rates were stable for the remaining Sulphurets humidity cells. An increase in leach rate was observed for S-HC-14 Undefined, as described above (Figure 5.2-10).

Zinc concentrations were highly variable for humidity cells assigned to the Monzonite model code, in addition to S-HC-14 Undefined. Zinc leach rates increased steadily for all other humidity cells (Figure 5.2-11).

5.2.1.5 Elements Associated with the Neutralization Potential

Calcium and magnesium leach rates both decreased steadily for the first five to ten weeks, indicating neutralization potential was likely being consumed (Figure 5.2-12). After the first ten weeks, calcium leach rates stabilized, while magnesium leach rates continued to decrease slowly in the humidity cells not assigned to the UP Hazelton model code.

5.2.2 Mitchell Deposit

One new humidity cell was initiated for the Mitchell Deposit, for the Monzonite model code, and had been operating for 33 weeks at the time of this addendum.

5.2.2.1 pH, Sulphate, Acidity, and Alkalinity

M-HC-24 had an initial pH of 9.09, and maintained a high pH, between 8.14 and 9.16 (Figure 5.2-13). Sulphate production decreased rapidly for the first five weeks, indicating flushing of surface precipitates as in most other near-neutral humidity cells, and remained variable but low (Figure 5.2-13).

Acidity production was below detection limits for all except the initial concentration (Figure 5.2-14). Alkalinity leach rates were stable between 10 and 26 mg/kg/wk (Figure 5.2-14).

5.2.2.2 Elements that Contribute to Acidity

Aluminum leach rates stabilized after the first three weeks and were steady at 0.07 to 0.10 mg/kg/wk (Figure 5.2-15). Iron leach rates were highly variable for the first 12 weeks, after which they increased slowly (Figure 5.2-15). Manganese rates, while variable, also increased overall in the first 33 weeks (Figure 5.2-16).

5.2.2.3 Barium

Barium concentrations were highly variable and had not stabilized by the time of writing this addendum.

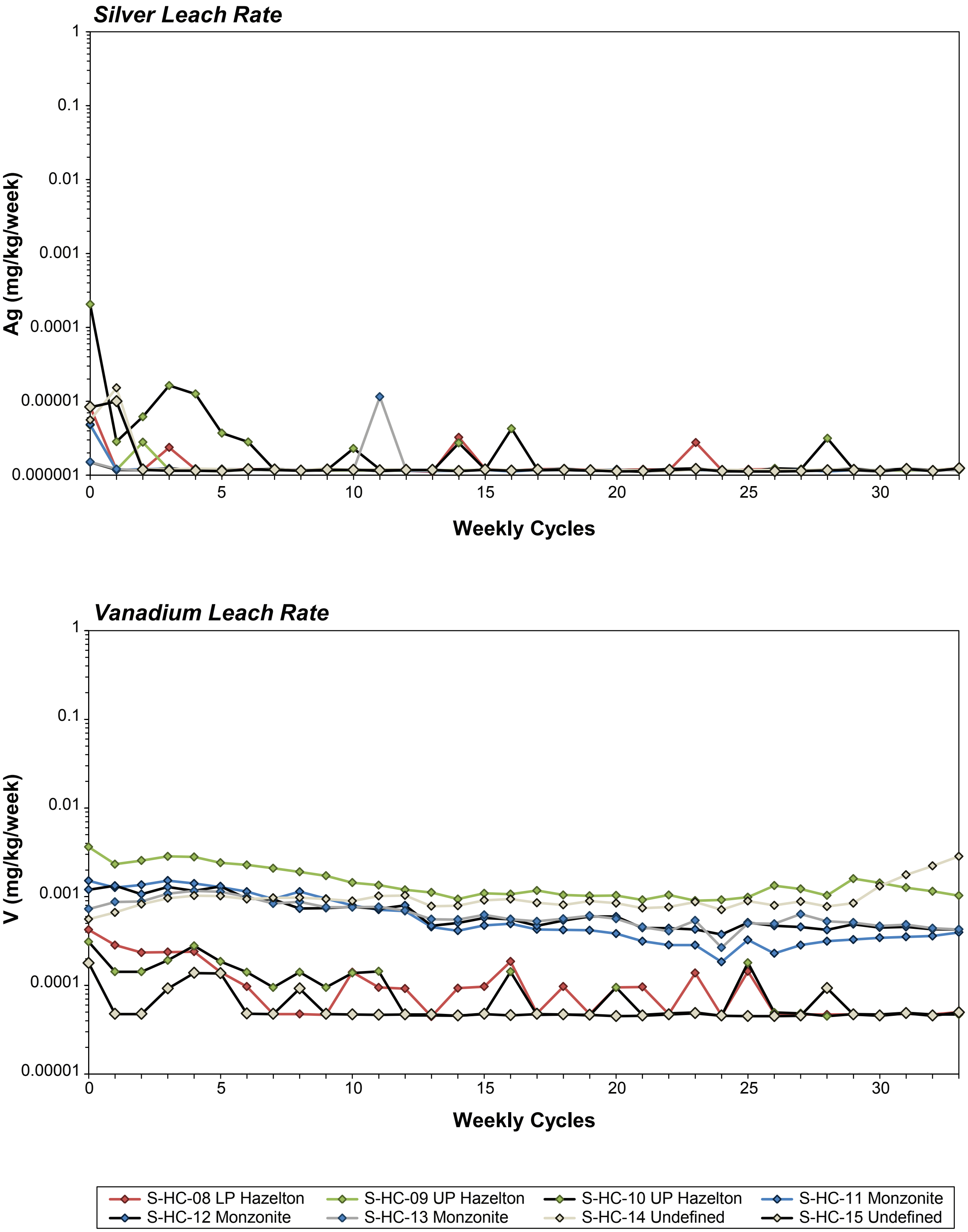

Figure 5.2-10

Weekly Silver and Vanadium Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

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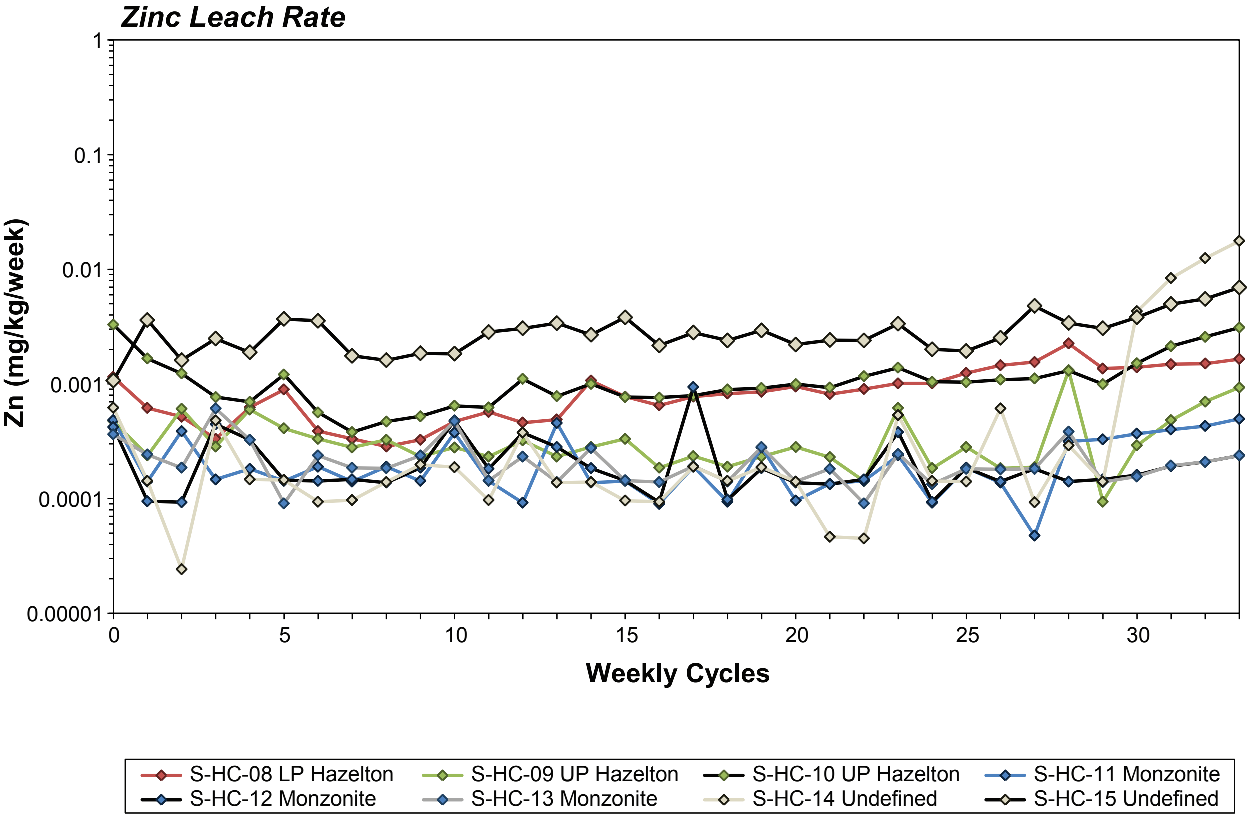

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Weekly Zinc Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-11

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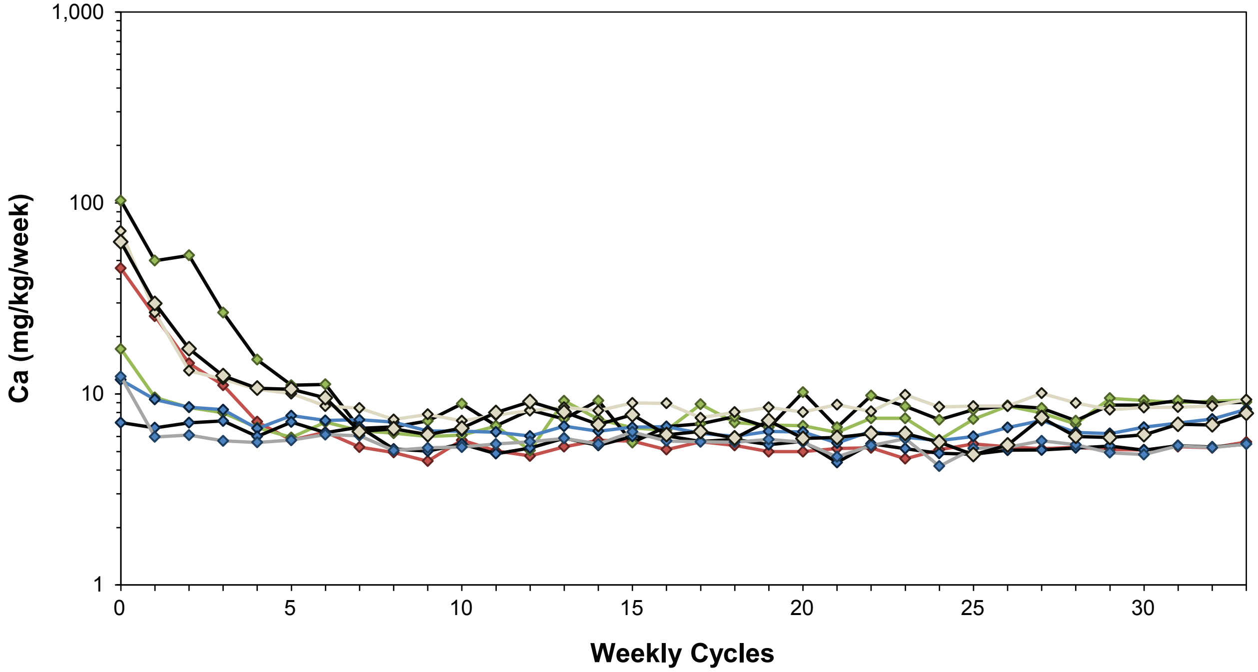
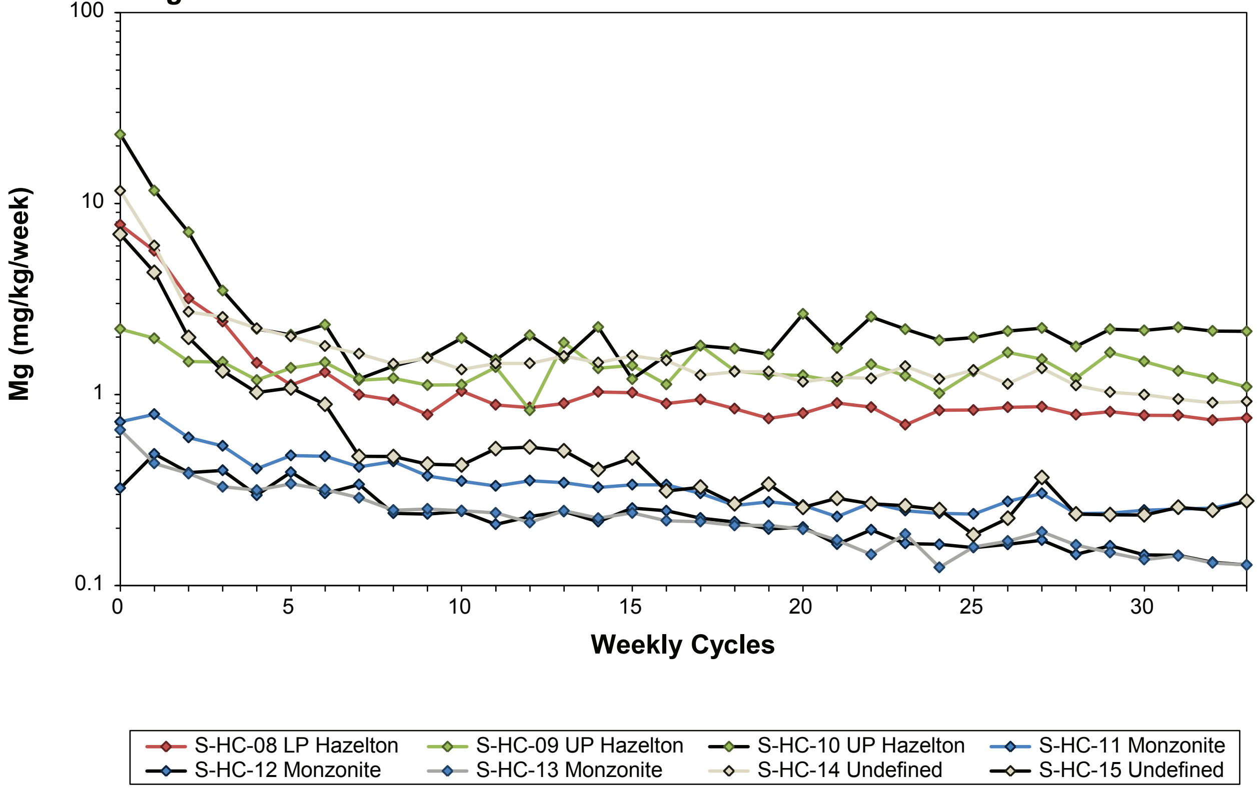
Calcium Leach Rate



Magnesium Leach Rate



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Weekly Calcium and Magnesium Leach Rates, Sulphurets Deposit Waste Rock Additional Humidity Cells

Figure 5.2-12

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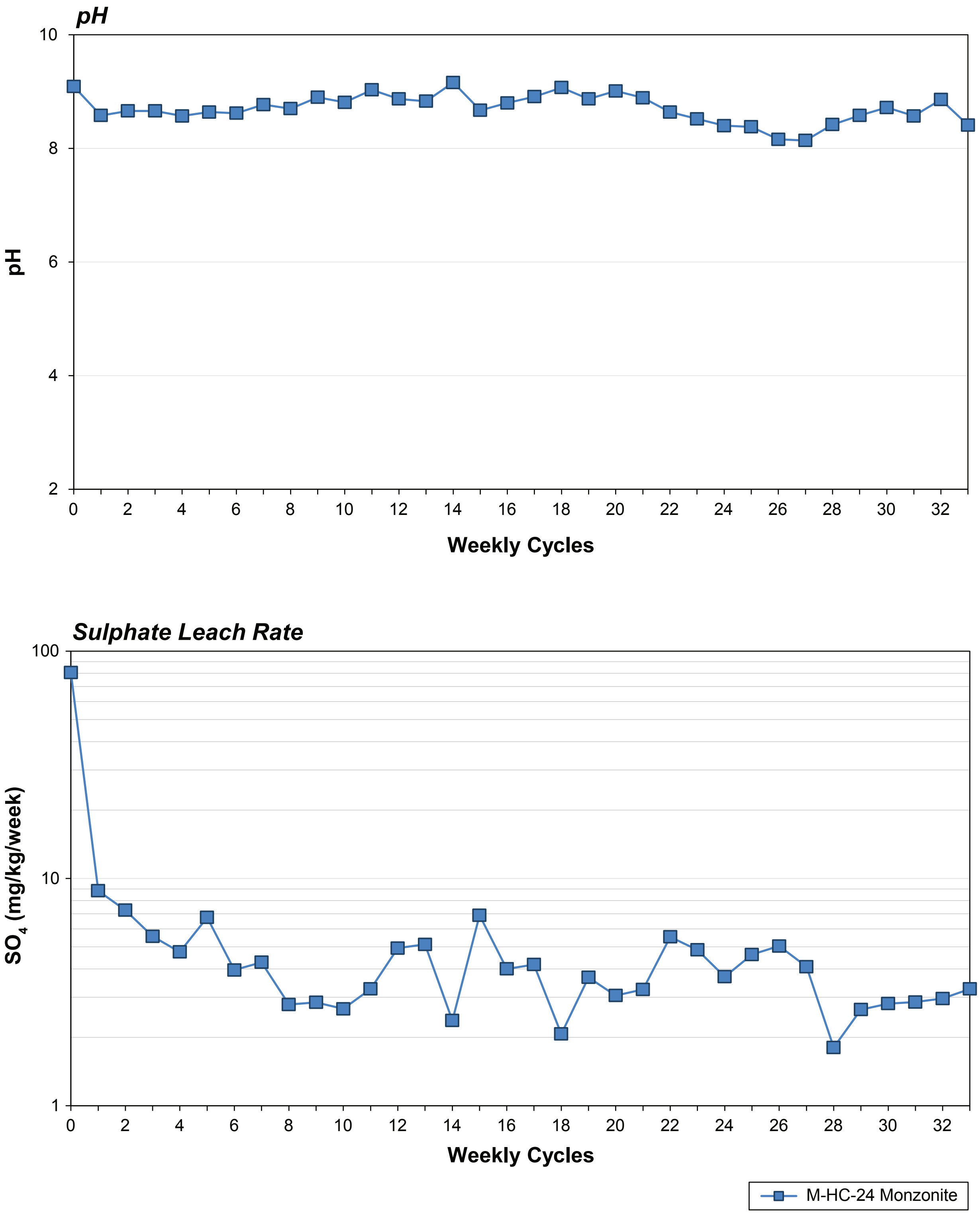

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Weekly pH and Sulphate Production Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-13

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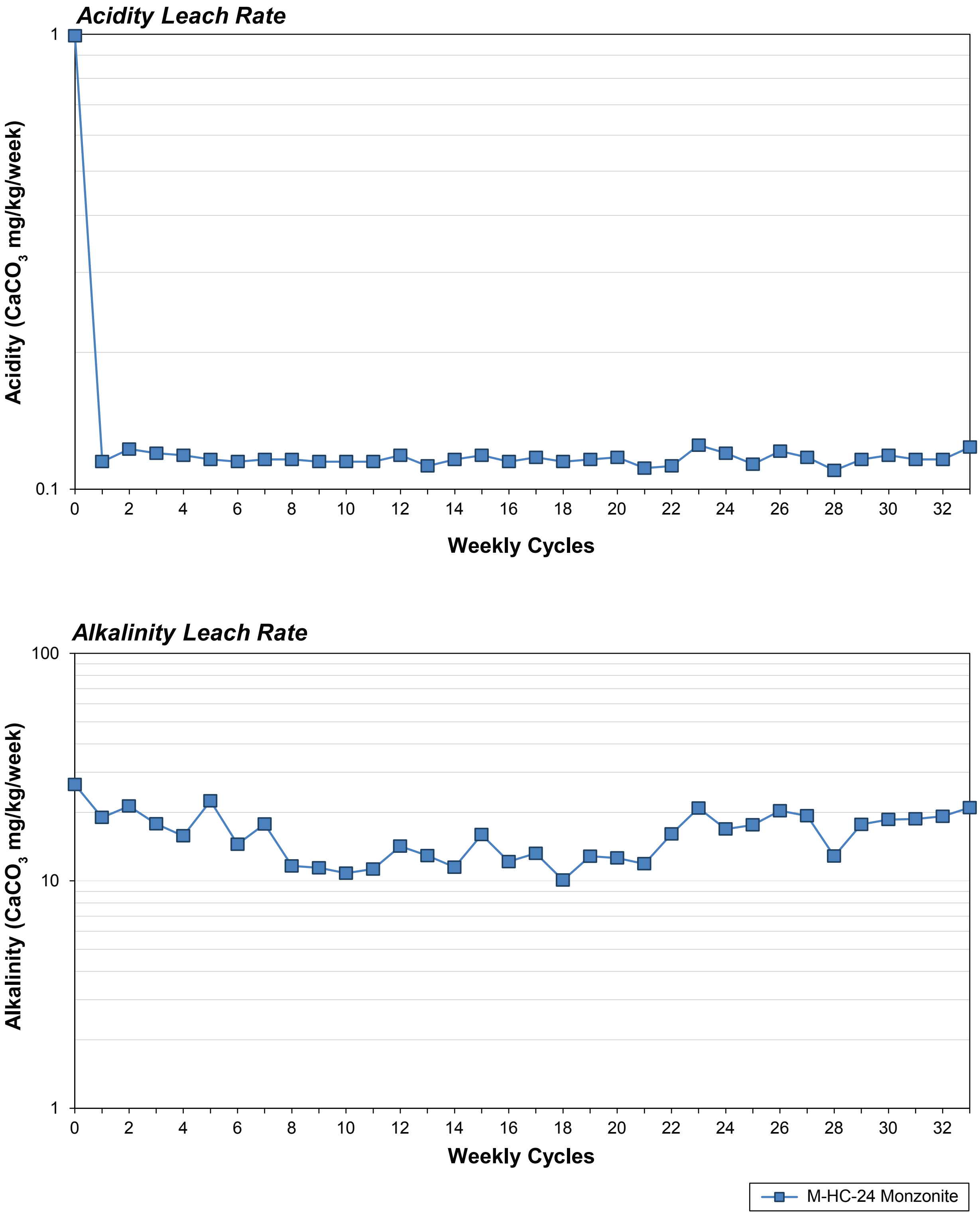

Figure 5.2-14

Weekly Acidity and Alkalinity Production Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

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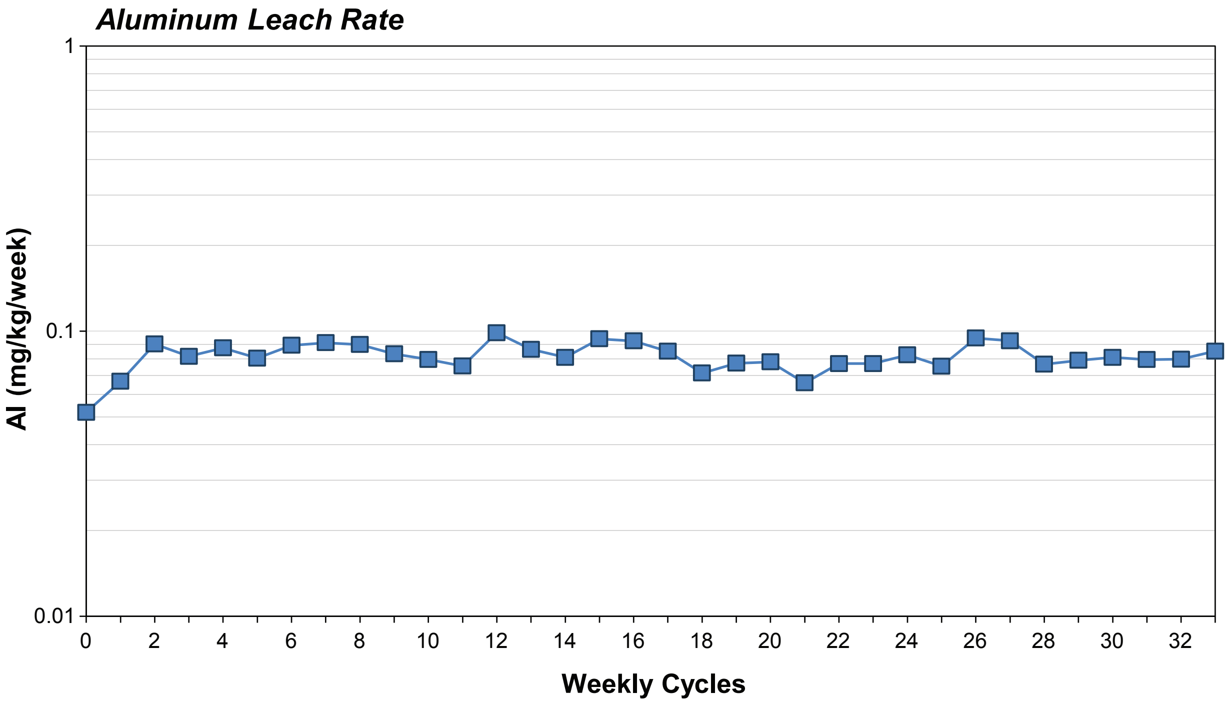

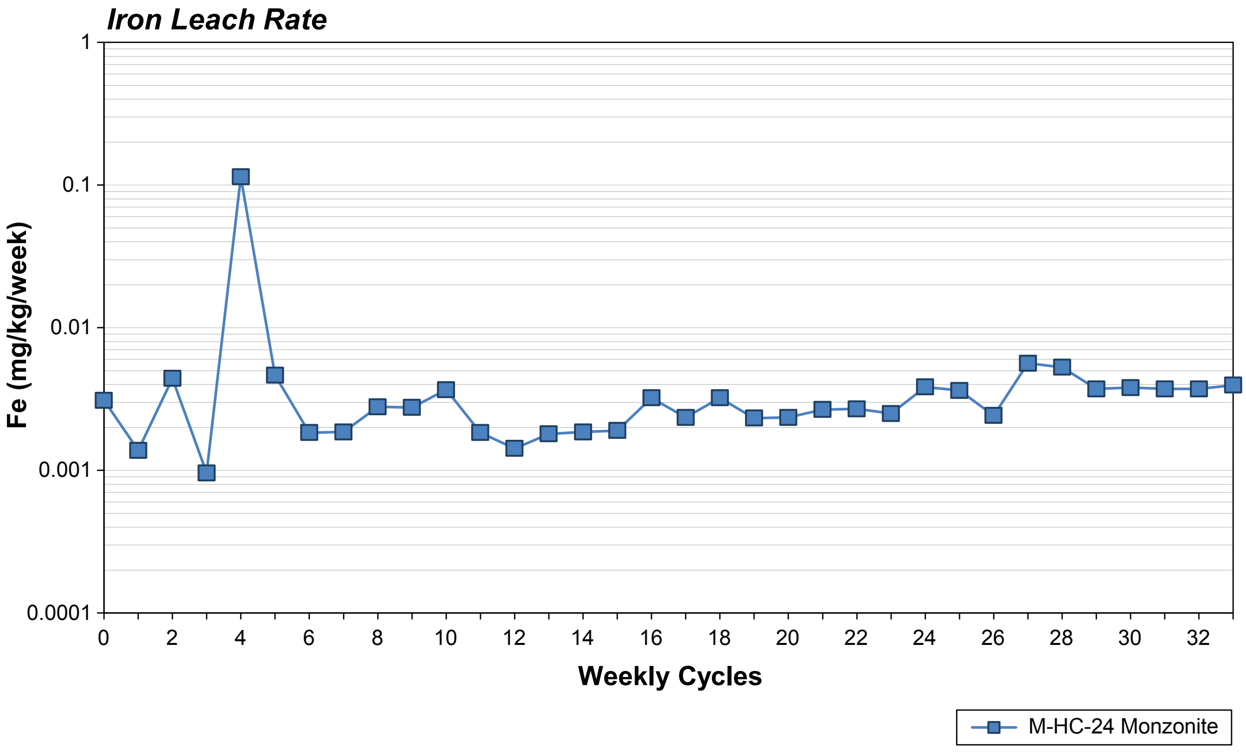

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Weekly Aluminum and Iron Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-15

Rescan
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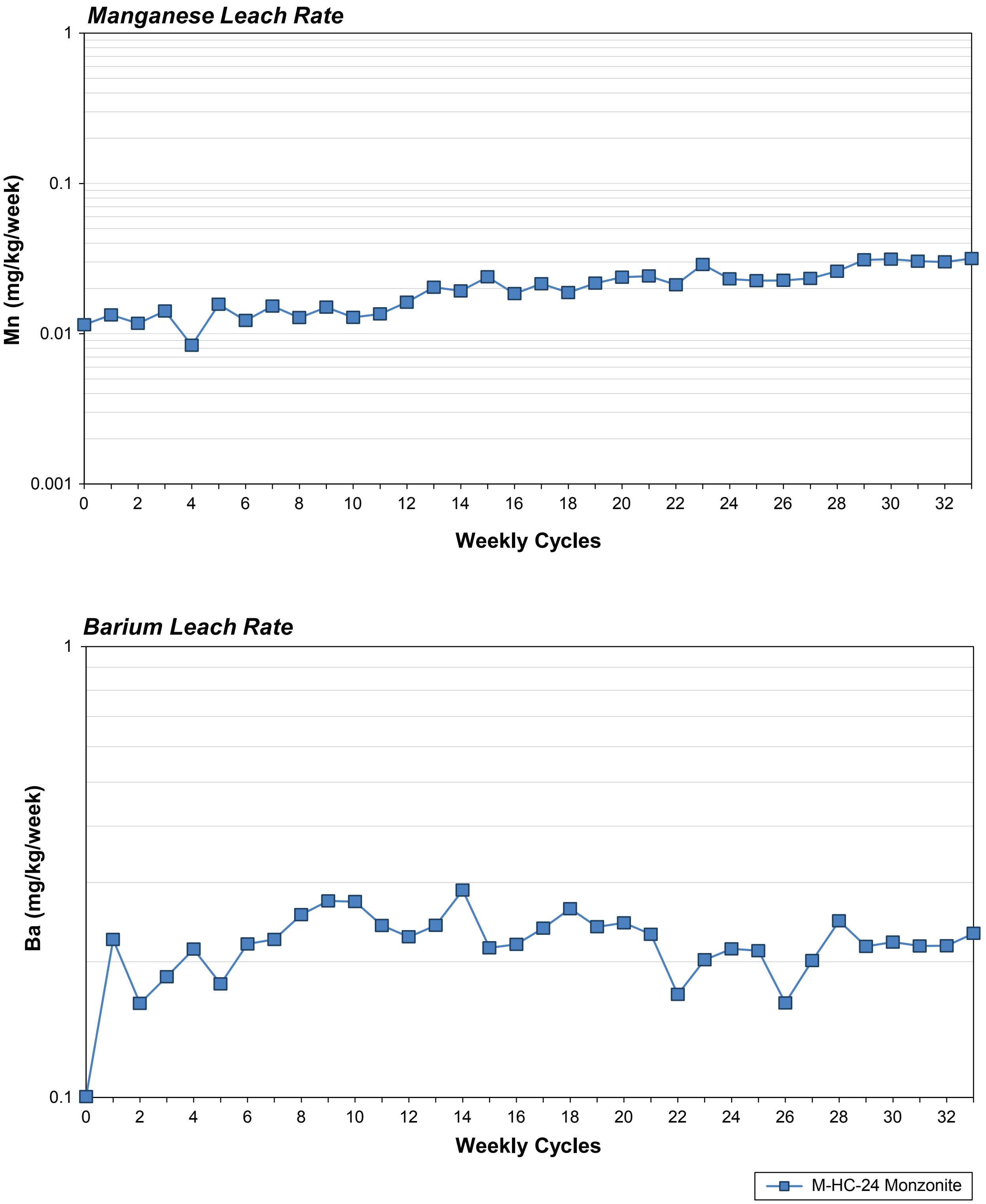

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Weekly Manganese and Barium Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-16

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5.2.2.4 Trace Elements

Trace element leach rates in humidity cell M-HC-24 Monzonite were frequently variable, not having stabilized by the time of writing this addendum. Leach rates for copper and fluoride (Figure 5.2-17), lead and molybdenum (Figure 5.2-18), and nickel and selenium (Figure 5.2-19) were all highly variable and have not stabilized.

Cadmium (Figure 5.2-20) and chromium (Figure 5.2-20) concentrations were highly variable, and below detection limits for the majority of weeks. Silver concentrations were below detection limits for almost all weeks (Figure 5.2-21).

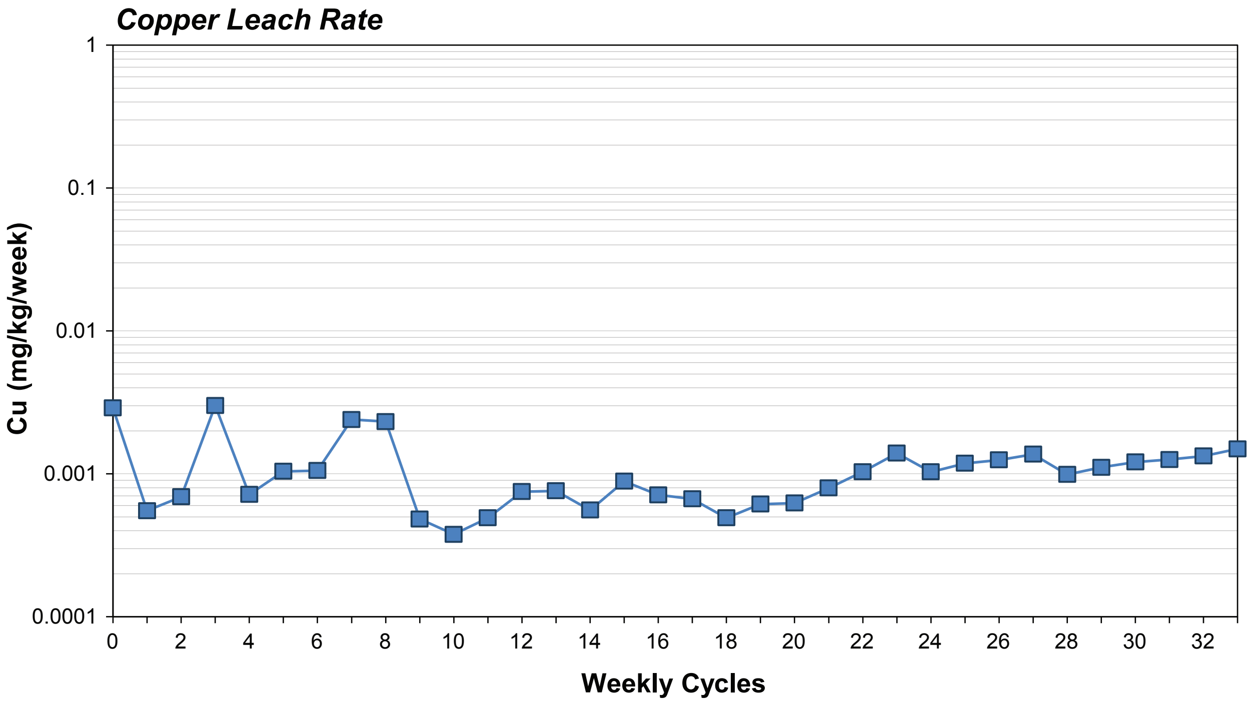
Arsenic leach rates were low and remained steady between 0.00002 and 0.00008 mg/kg/wk for most weekly cycles (Figure 5.2-21). Cobalt leach rates were relatively stable at 0.00001 to 0.00002 mg/kg/wk (Figure 5.2-22). Vanadium leach rates, while variable, fluctuated between 0.0001 and 0.0004 mg/kg/wk (Figure 5.2-22). Zinc leach rates after the first five weeks were relatively stable between 0.0002 and 0.0005 mg/kg/wk (Figure 5.2-23).

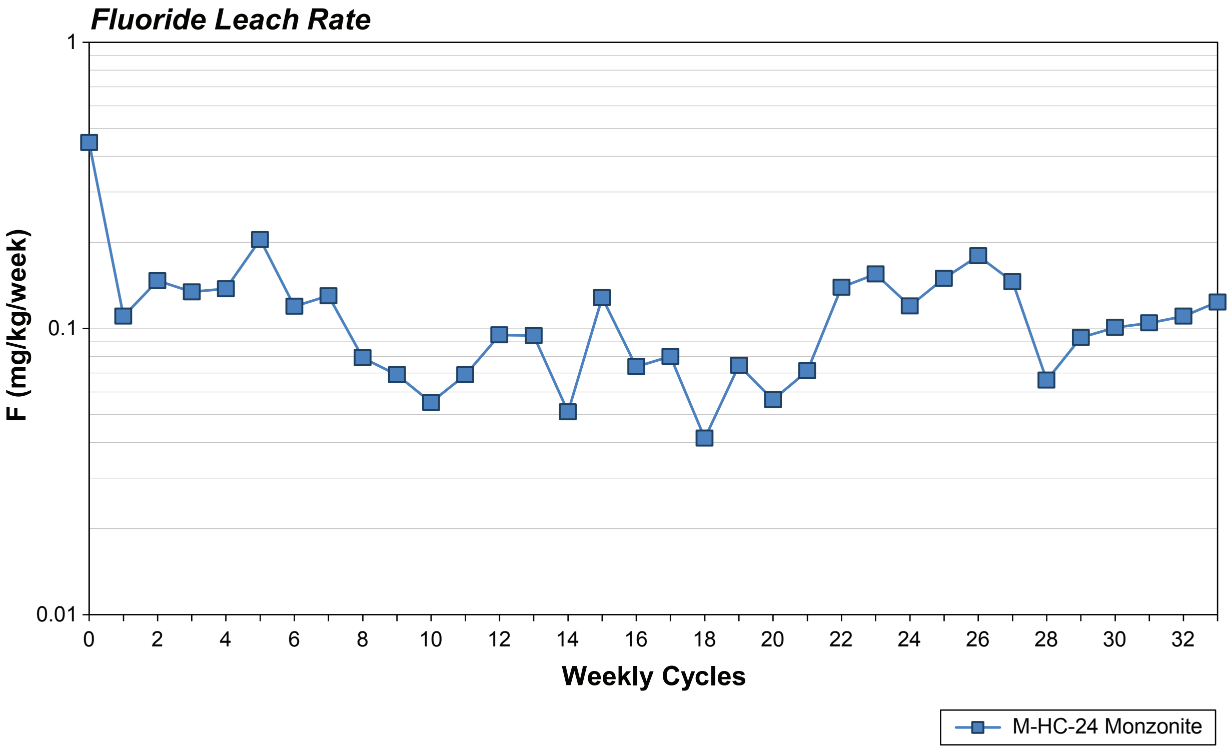
5.2.2.5 Elements Associated with the Neutralization Potential

Calcium and magnesium concentrations both decreased significantly in the first week, after which leach rates for both elements have been variable (Figure 5.2-24).

5.3 Effect on Water Quality Model Inputs

It is inappropriate to compare unstable leach rates from the new humidity cells to the dataset currently used as the water quality model inputs. Humidity cells typically take 40 weeks to stabilize and can sometimes take over 60 weeks or more (Price 2009). Ongoing validation of water quality model inputs and results is expected during mine planning and operation.





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Weekly Copper and Fluoride Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-17

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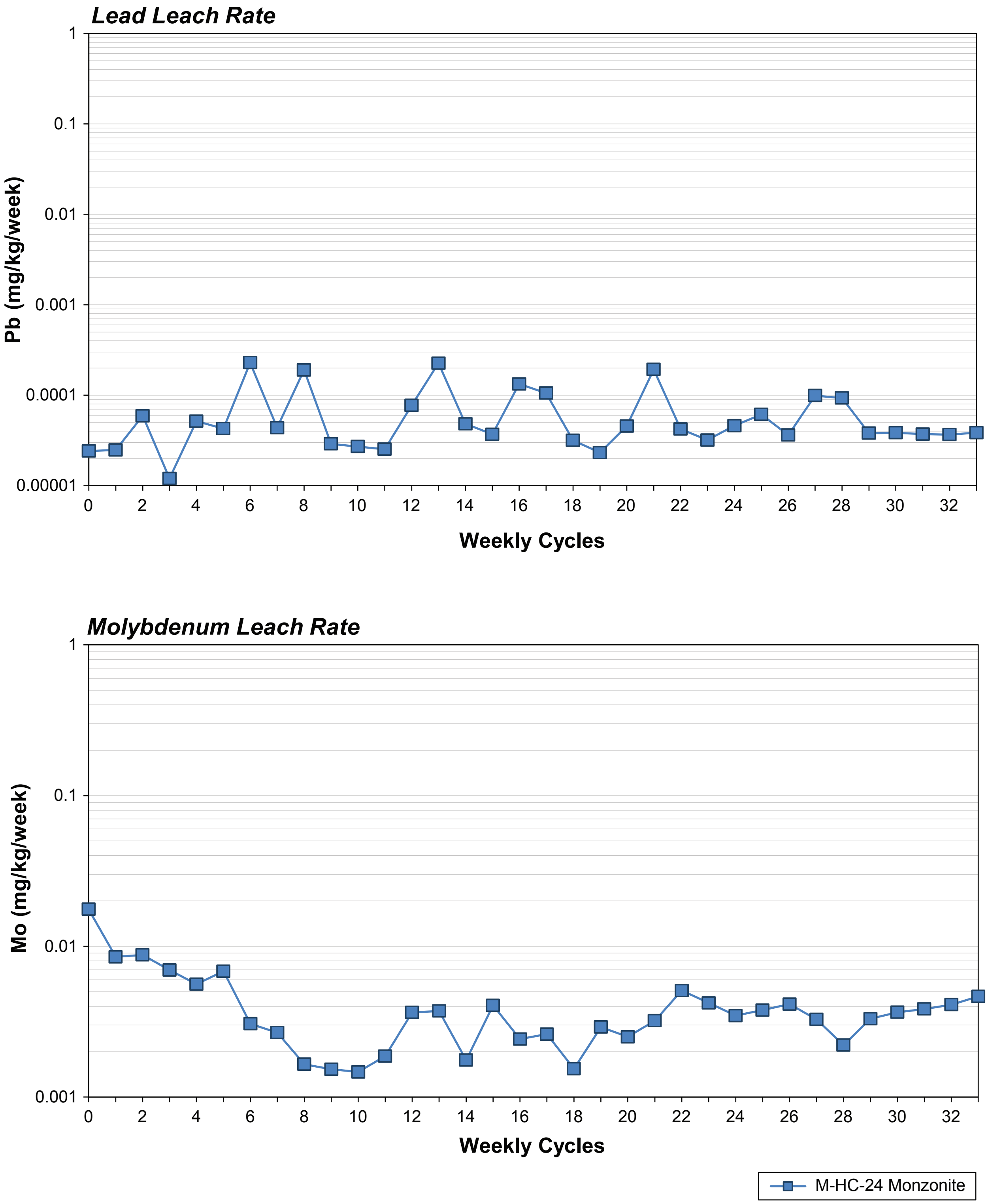

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Weekly Lead and Molybdenum Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-18

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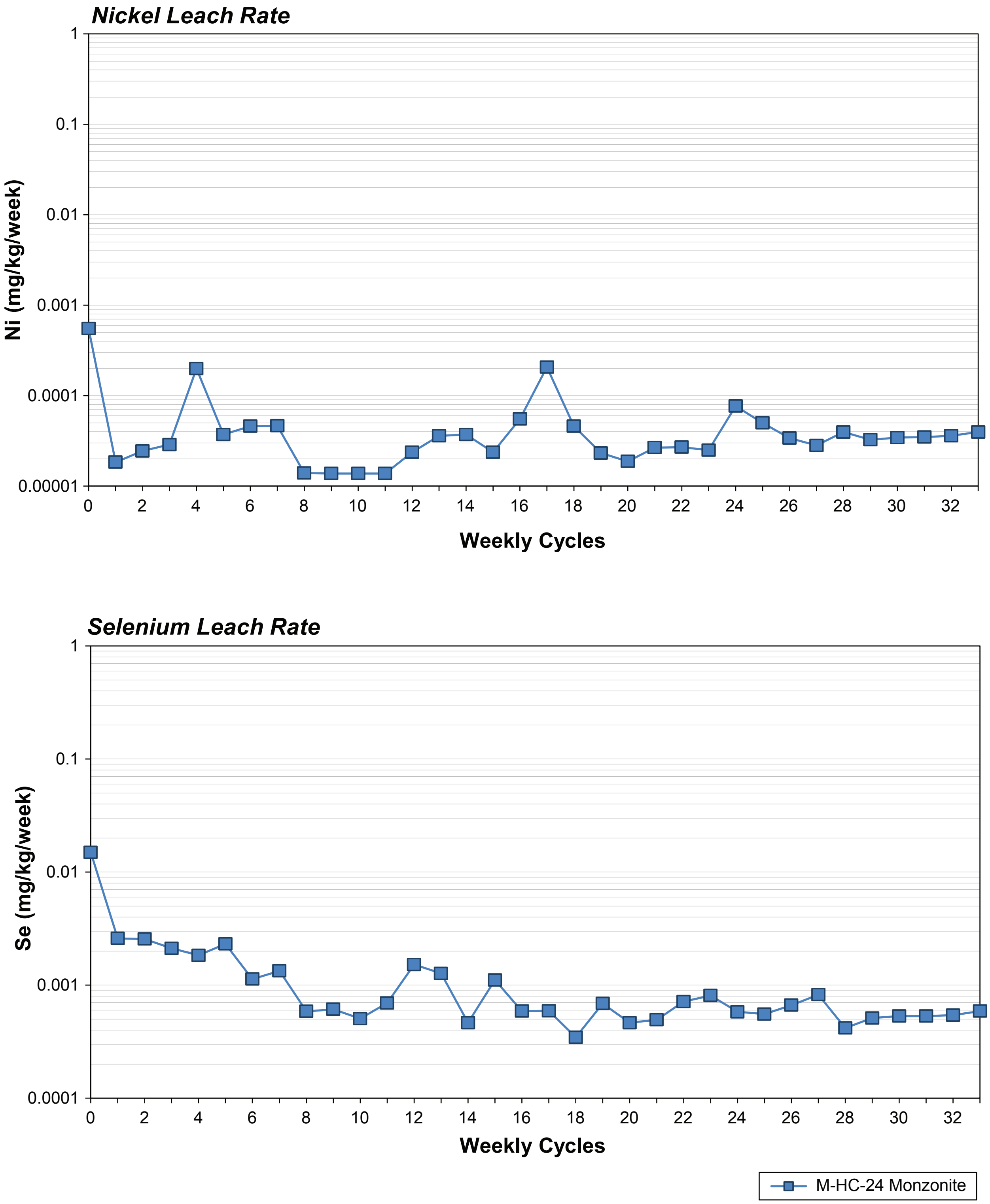
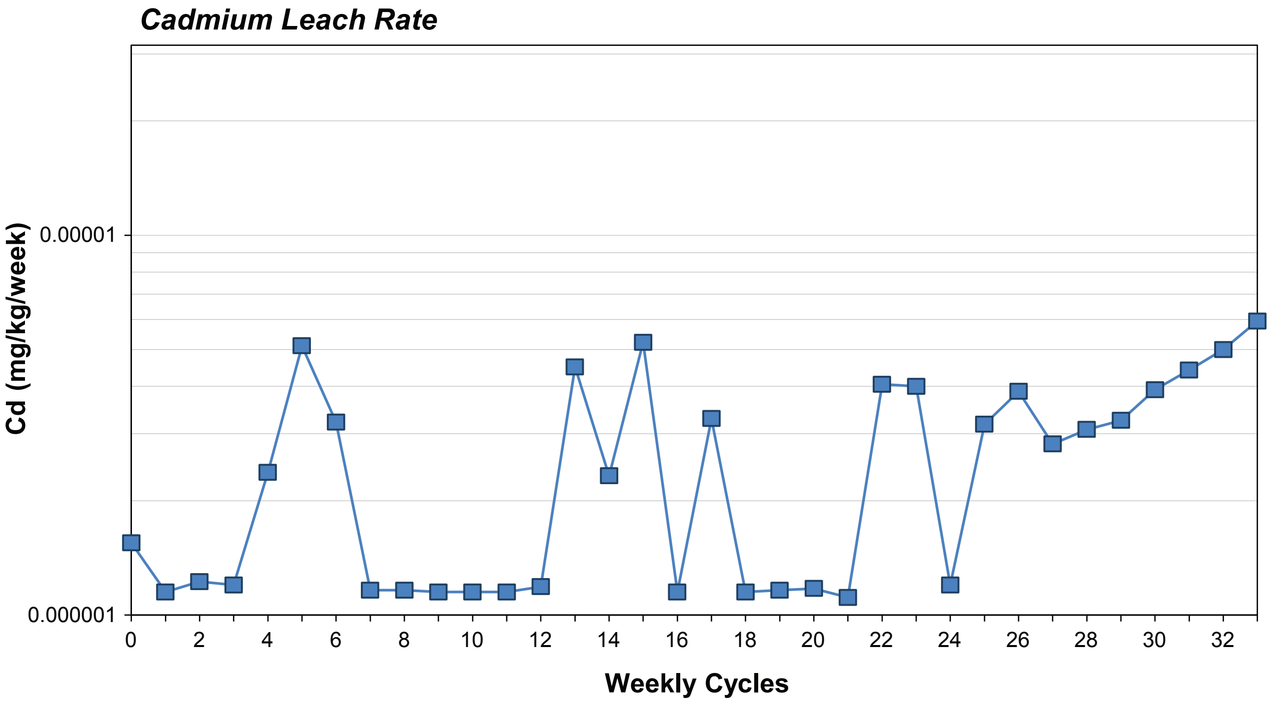
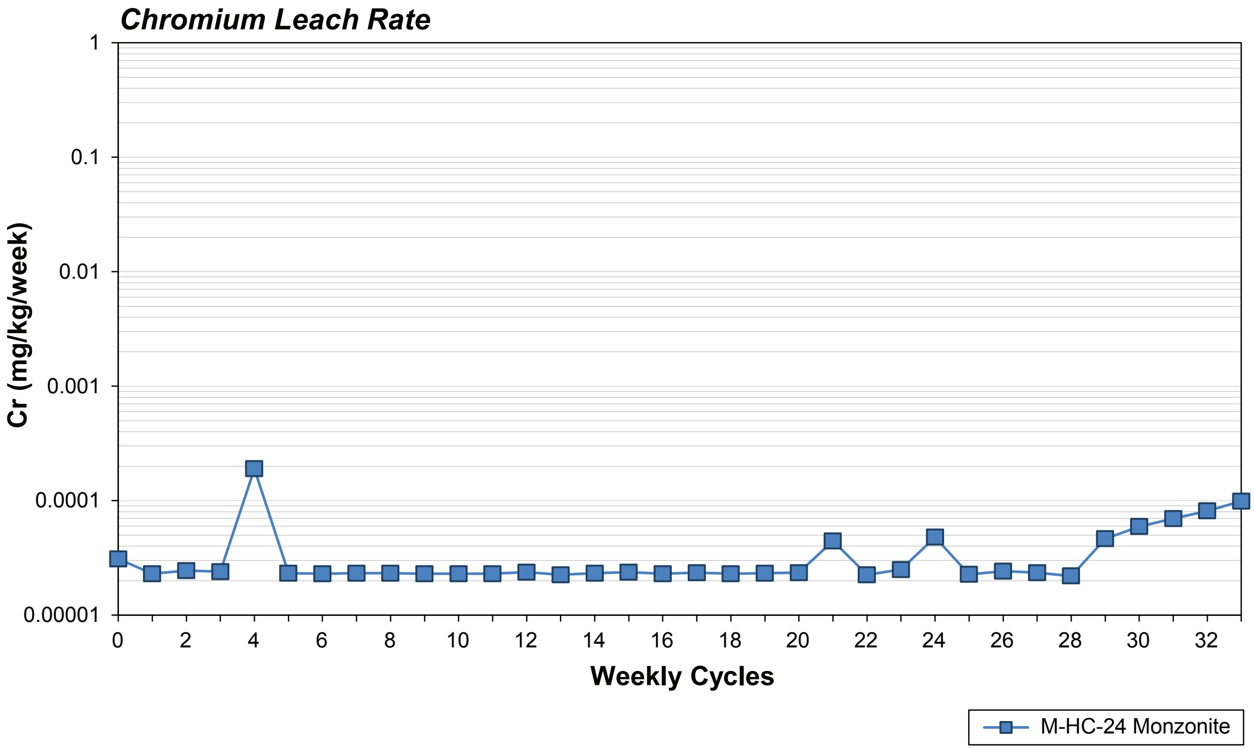


Weekly Nickel and Selenium Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-19





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Weekly Cadmium and Chromium Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-20

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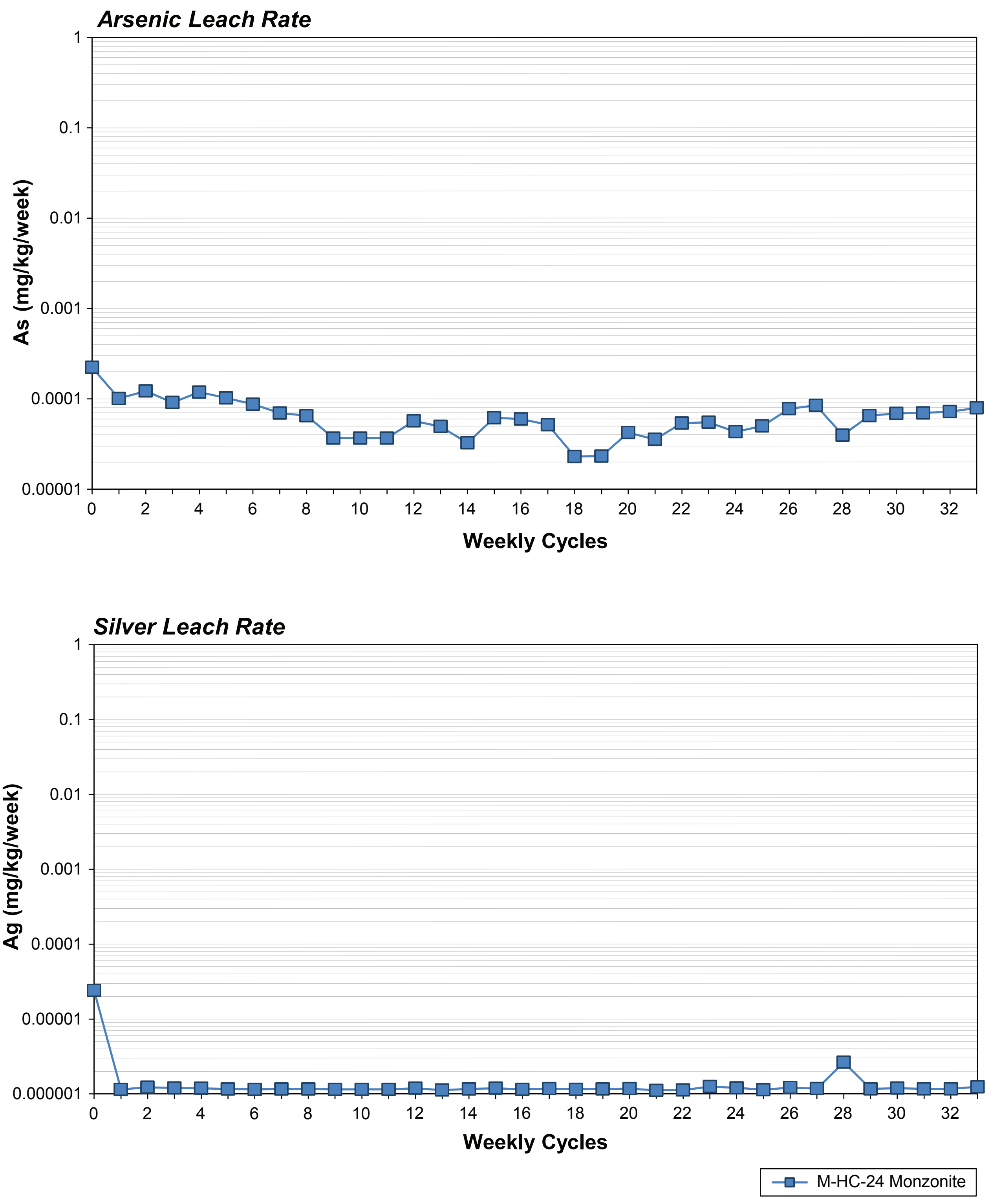

Weekly Arsenic and Silver Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-21

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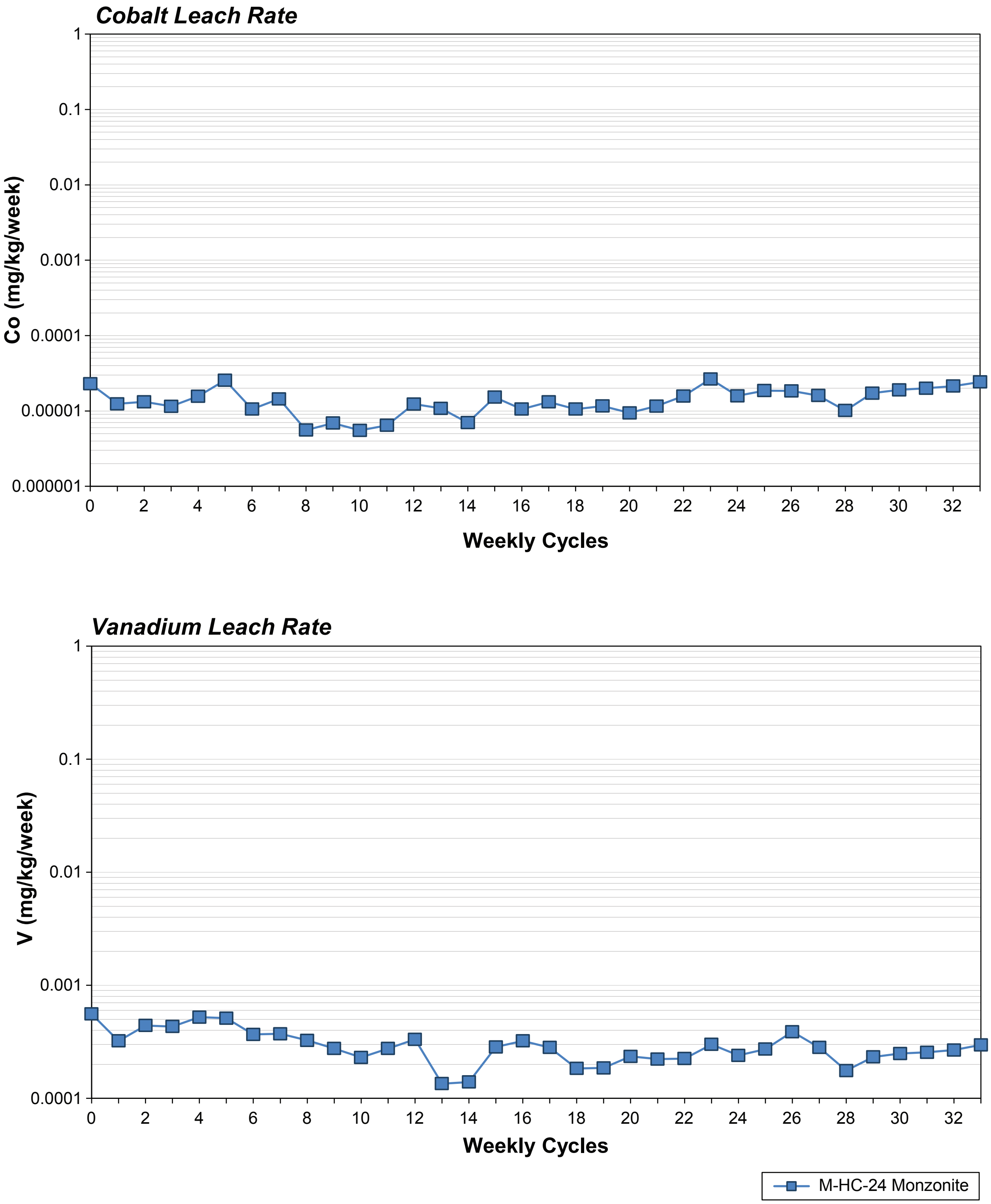

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KSM PROJECT

Weekly Cobalt and Vanadium Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-22

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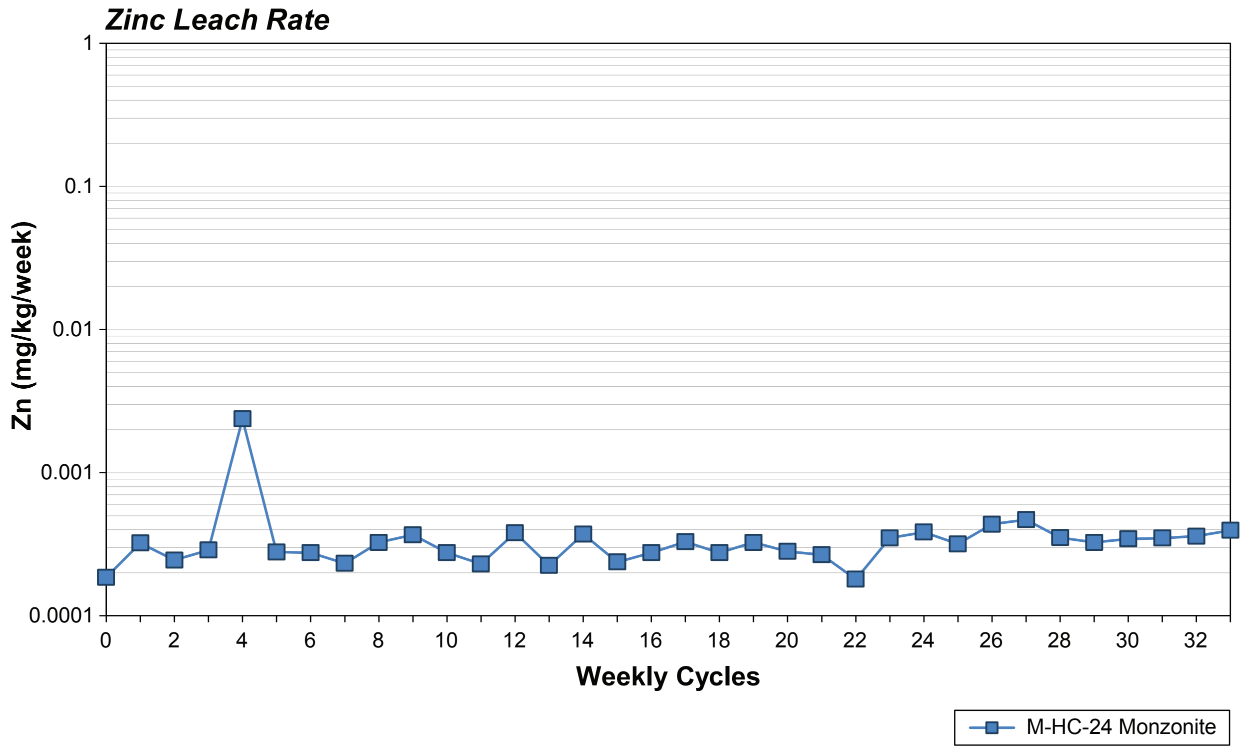

Figure 5.2-23

Weekly Zinc Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

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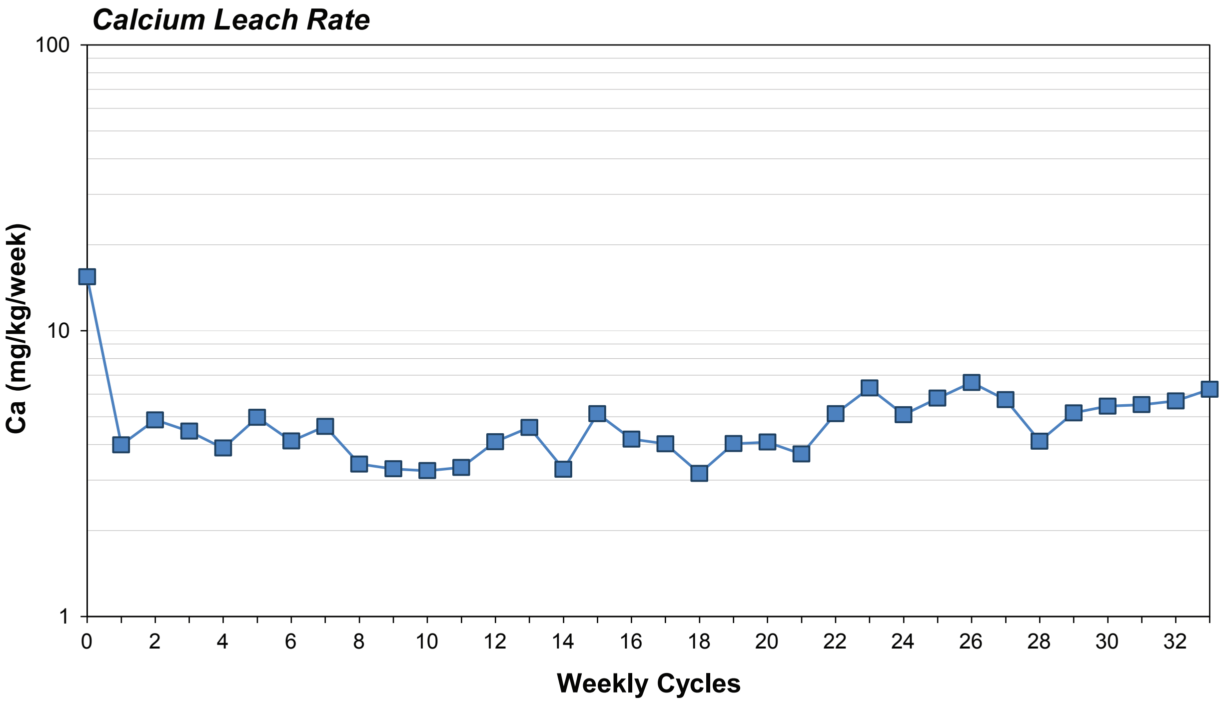

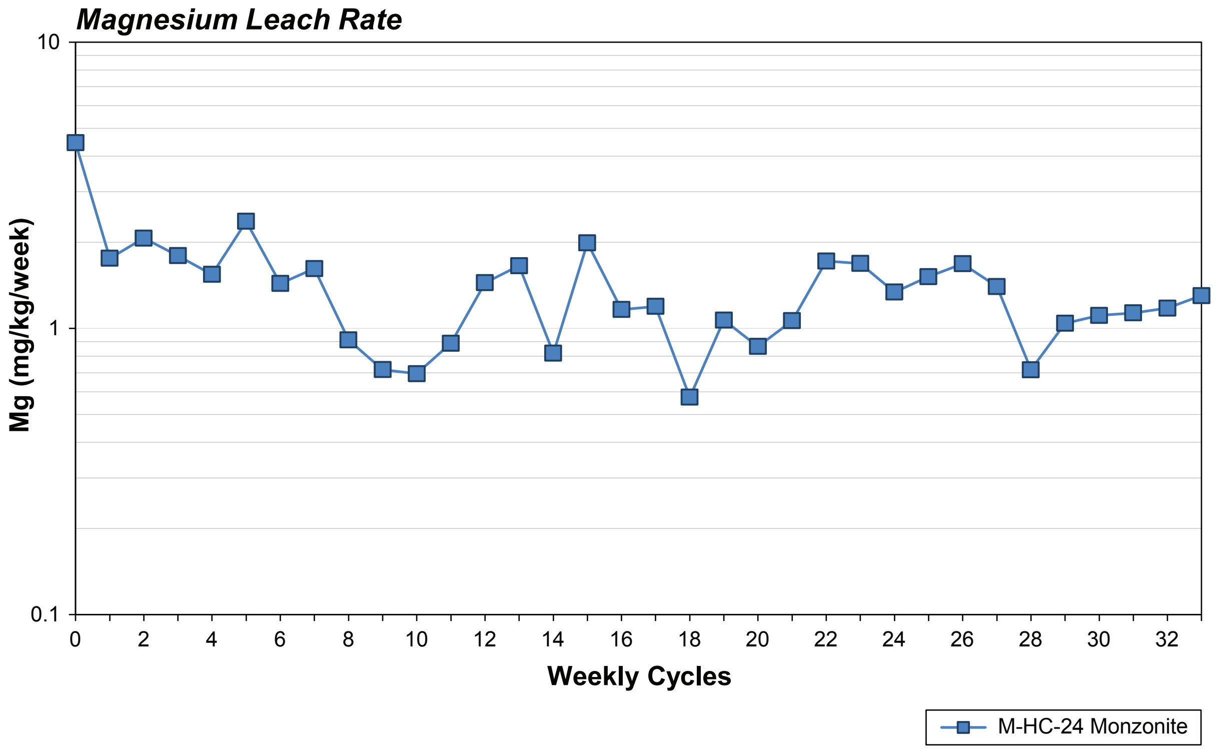

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Weekly Calcium and Magnesium Leach Rates, Mitchell Deposit Waste Rock Additional Humidity Cell M-HC-24

Figure 5.2-24

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6 Conclusions

The objective of this addendum to the 2012 ML/ARD Baseline Report (Appendix 10-A) is to update the geochemical inventory as described in Chapter 26 (Environmental Management Plans) and to address provincial screening comments relating to the geochemical characterization of deposit waste rock. This report contains a more detailed segregation of the static test results for deposit material provided in Appendix 10-A, and results from additional deposit waste rock humidity cells that were initiated in August 2012.

In this addendum the following screening comments were assessed:

1. The addition of modified Sobek methodology to characterize NP in addition to the standard Sobek method as part of the static testing program;
2. The reclassification of samples in the Kerr and Iron Cap deposit by their full ABA block model code in place of combining all Kerr samples under one code and all Iron Cap under another;
3. The reclassification of humidity cells into ore and waste categories based on a NSR criteria in place of assuming ore and waste samples are similar in ML/ARD geochemistry; and
4. Additional humidity cell testing of Sulphurets and Mitchell deposit material that is likely to be used in the construction of the WSD.

The Sobek NP method overestimates the bulk NP compared to the modified Sobek bulk NP method by approximately 30%; therefore, a conservative approach to waste rock management planning was used in the ML/ARD Management Plan (Section 26.14).

Reclassifying the Kerr and Iron Cap deposit material samples based on ABA block model code has had no impact on downstream water quality predictions because the volumes of material from these two deposits predicted to be NPAG are less than 1% of the total deposit material stored in the Mitchell and McTagg rock storage facilities.

The reclassification of static and kinetic samples by ore versus waste rock showed there is substantial overlap between ore and waste materials. The classification of materials as ore versus waste, based on NSR criteria, does not affected the conclusion in the baseline (Appendix 10-A) or the management plans (Chapter 26).

An additional nine humidity cells were initiated in August 2012. Their primary focus was to characterize the ML/ARD potential of NPAG material that might be used as construction material outside the WSD catchment. The humidity cells have been operating for 33 weeks as of May 10, 2013. The humidity cells have not stabilized.

The reclassification of Kerr and Iron Cap samples into block model codes and the addition of humidity cells further refines our understanding of the KSM geochemistry and does not significantly affect the conclusions discussed in Appendix 10-A or Chapters 10 and 26.

References

Price, W. A. 2009. *Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1*. Natural Resources Canada, Mine Environmental Neutral Drainage Program: Ottawa, ON.