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April 30, 2014

Certified Mail #70123050000053967497
Return Receipt Requested

Ms. Erika Schwender, Director
New Mexico Environment Department
Resource Protection Division
P.O. Box 5469
Santa Fe, New Mexico 87502

Dear Ms. Schwender:

Re: Revised Year 4 pH Monitoring Report
Smelter Tailing Soils Investigation Unit- Chino AOC

Freeport-McMoRan Chino Mines Company (Chino) submits under separate cover the *Year 4 pH Monitoring Report* for the Smelter Tailing Soils Investigation Unit under the Chino Administrative Order on Consent (AOC). This report is the fourth annual report as required under the Soil pH Monitoring Plan submitted to New Mexico Environment Department (NMED) on July 7, 2010. The report was submitted via email today to Mr. Matt Schultz.

Please contact Mr. Ned Hall at (520) 393-2292 if you have any questions regarding this report.

Sincerely,

A handwritten signature in black ink that reads 'Sherry Burt-Kested'.

Sherry Burt-Kested, Manager
Environment Services

SBK:pp
20140425-001

c: Matt Schultz, NMED (via email)
Joseph Fox, NMED (via email)
Petra Sanchez, EPA (via email)
Ned Hall, FCX (via email)

**Freeport-McMoRan Chino Mines
Company**

**Administrative Order on Consent
Year 4 pH Monitoring Report
Smelter/Tailing Soils
Investigation Unit**

Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

April 2014



**Administrative Order on
Consent Year 4 pH
Monitoring Report
Smelter/Tailing Soils
Investigation Unit**

Freeport-McMoRan Chino Mines
Company
Vanadium, New Mexico

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Date:
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1. Introduction

In 2010, Freeport-McMoRan Chino Mines Company (Chino) initiated a 5-year monitoring program to determine the permanence of the effect of the January 7, 2008 white rain event that fell on the Chino Smelter Tailings Soils Investigation Unit (STSIU) located in Vanadium, New Mexico (site; ARCADIS U.S., Inc. [ARCADIS] 2010a). The source of the residues in the white rain was found to be evaporates in playas to the southeast of Chino, as evidenced by the finding that 75 percent (%) of the residues in the white rain matched the chemical signatures of the evaporites in the Willcox playa in southeastern Arizona and the Lordsburg playa in western New Mexico (ARCADIS 2008). During the event, this milky alkaline rain containing calcium oxides and hydroxides was deposited across southwestern New Mexico, including the Chino Administrative Order on Consent Investigative Area and STSIU. The white rain water had a pH of 7.2 as reported at a weather station located 40 miles north of Chino at Gila Cliffs Dwellings National Monument, higher than had been observed in rainfall in 21 years (average pH was 4.7 to 5.3). Similarly, the calcium concentration in this rain was higher than had been observed for 15 years (ARCADIS 2008).

1.1 Background

A comparison of surface soil sample results from 0 to 6 inches at Chino before and after (2009) the white rain event indicated an upward shift in soil pH in large areas of the STSIU (ARCADIS 2008). This is illustrated by contour maps with estimated pH “zones” suggesting the white rain reduced the footprint of the low pH zone (pH < 5) (ARCADIS 2010a). However, the pre-white rain and 2009 data were not co-located. To further evaluate the magnitude of the effect of the white rain, samples collected in 1999 from the upland ecological risk assessment (ERA) sample locations (as part of the site-wide ERA, Newfields 2005) were compared to samples collected at the same locations in 2010 as part of an insect copper uptake study (ARCADIS 2010b). The site-wide ERA results were supplemented with results from 2006 (pre-white rain) and 2008 (post-white rain) for the amendment study areas. The amendment study dataset was added because these locations also had co-located samples from before and after the white rain event.

The comparison of co-located data showed that pH increased in soils where pH was initially less than a threshold of 5.4 to 5.5 (pre-white rain), but did not increase when initial soil pH was equal to or greater than this threshold (**Figure 1**). Total copper concentration in soils remained largely unchanged regardless of pH (**Figure 2**), which is consistent with the anticipated behavior of copper. The calculated cupric ion activity

(referred to herein as $pCu = -\log\{Cu\}$), a potential measure of bioavailability of copper to plants (defined in ARCADIS 2012a), showed a decrease in soils with increased pH, as indicated by increased pCu (**Figure 3, Table 1**).

A concurrent reduction in copper concentrations in insect tissue was measured at most sites that showed such pH improvement (**Figure 4, Table 2**), as detailed in ARCADIS (2010b).

Based on laboratory phytotoxicity studies and plant community surveys conducted in the field in 1999, the site-wide ERA stated that elevated concentrations of copper and other metals, combined with depressed soil pH, have led to a risk of phytotoxicity for some areas at Chino. Because the field and vegetative effects were best correlated with pCu, Newfields (2005) proposed that risk criteria for remedies be based on pCu. Consequently, the New Mexico Environment Department (NMED) included a Preliminary Feasibility Study Remedial Action Criteria for pCu at less than or equal to 5 in areas where soil copper content was greater than 327 milligrams per kilogram (mg/kg) (NMED 2011). Therefore, pCu was calculated for all sample sites in the STSIU in 2009 based on this NMED emphasis on pCu.

Similar to pH, the contour maps of pCu zones before and after the white rain event suggested a reduction in the area of the pCu less than 5 zone after the white rain event (ARCADIS 2010a). However, the permanence of the reduction in areas with low pH and pCu, as observed in 2009, was uncertain at that time and, thus, the 5-year monitoring program was initiated.

1.2 Monitoring Objectives

The objective of the pH monitoring program is to determine if the changes in pH and pCu in upland soils that resulted from the white rain event are temporary or permanent (ARCADIS 2010a). In 2008, the white rain appeared to effectively buffer soils with calcium oxide or calcium hydroxide, removing the active acidity and increasing the pH to 5 or greater in many areas (ARCADIS 2008; **Figure 1**). Soils with a pH greater than or equal to 5 in 2009 appeared to be acid-neutralizing based on acid-base accounting (ABA) results. Soil samples that still had pH less than 5 were acid-generating (ARCADIS 2010a), likely because they were classified as very strongly acidic soils (pH 4.5 to 5.0) and extremely acidic soils (pH 3.5 to 4.4), as defined by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS 1998). Mineralogical analysis (ARCADIS 2010a) of the soil suggests that most of the copper sulfide minerals are not strongly acid-generating. Specifically, copper sulfides



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from the smelter or tailings (cubanite, bornite, chalcopyrite, covellite) have low oxidation and weathering rates relative to pyrite (ARCADIS 2010a, Kalinnikov et al. 2001, Moncur et al. 2009). In addition, iron sulfide minerals (e.g., pyrite) in the soil have the potential to be acid generating. The long-term potential for pH to decrease due to any sulfide mineral oxidization must be considered. Therefore, a pH monitoring program over a 5-year period was initiated in 2010 to determine if the pH shift from the white rain is a temporary or permanent effect. In addition, the acid generating potential of soils with pCu less than 5 was evaluated. This is the fourth annual report on the results of pH monitoring, which will be subjected to more extensive interpretation in the fifth annual monitoring report.

2. Sampling Design and Methods

The 5-year pH monitoring program was designed to evaluate whether the decreased acidity in post-white rain will remain unchanged and whether it will continue to decrease the availability of the cupric ion to the plants and invertebrates. Parameters monitored in the soil to track such changes include pH, total copper, and ABA, each monitored during the fall season. Total copper and pH are used to calculate pCu using the upland equation in the site-wide ERA (Newfields 2005). ABA includes acid neutralization potential (ANP) by the modified Sobek method and acid generation potential (AGP) calculated from sulfide sulfur determination (referred to as pyritic/sulfide sulfur by the analytical laboratory). Other sulfur forms (total, sulfate, and organic/insoluble) were also determined to help interpret the ABA results, which are particularly important if soils have a high percentage of sulfate mineral phases that are not acid-generating (ARCADIS 2012a).

In the original monitoring plan (ARCADIS 2010a), areas within three estimated pH zones (pH 4 to 5, 5 to 6, and 6 to 7) post-white rain were targeted for monitoring. All zones had a lower pH prior to the white rain event. Sample locations were randomly placed within each zone and captured a range of topographic units on the site. Originally, a minimum of six locations in each of the three pH zones were targeted for monitoring, which totaled 18 locations selected for long-term monitoring over a 5-year period. Four additional locations already monitored in the amendment study reference plots were added to increase the total number of locations to 22 (ARCADIS 2011). During the 2013 sampling event, only 17 of these 22 monitoring locations were sampled. This was because the excavation of surficial soil (0 to 6 inches) at four of the original sample locations in summer 2011 and one additional location (FID 17) in 2013 removed five of the monitoring locations (Figure 1 in ARCADIS 2012a shows their former locations). The primary excavation activities were conducted in support of reclamation of the older tailing impoundments.

Locations sampled in 1999 (ERA locations) and reported in the site-wide ERA (Newfields 2005) were not originally included in the design of the monitoring plan because these locations were not randomly located, represent only flat areas, under-represent locations that had very low pH (2 to 3) pre-white rain, and, therefore, under-represent locations of post-white rain in the targeted pH zones of 4 to 5 and 5 to 6 (most ERA locations have a pH greater than 6 post-white rain). Nonetheless, an additional five ERA locations (ERA-2, ERA-3, ERA-4, ERA-10, and ERA-13) were added to the program in 2012 and 2013 because of the loss of the monitoring locations detailed above. These additional ERA locations were established and sampled in 1999



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for the site-wide ERA, and resampled for the insect study in 2010 (ARCADIS 2010b). These additional sampling locations allow interpretation of long-term changes due to the white rain by evaluating trends from 1999 to the present. A disadvantage is that they cannot be included with the other 17 pH monitoring locations when statistically evaluating annual changes across the target pH zones from 2010 to 2013 because they were not sampled in 2011. Moreover, the area of the sampling locations used to composite soil was much larger in the 2010 insect study (31,416 square meter [m²]; ARCADIS 2010b) than the area sampled from 2010 to 2013 for the pH monitoring program (2,500 m²; ARCADIS 2010b). The five additional sampling locations added to the pH monitoring program in 2012 are a subset of the original 15 upland ERA locations reported in the site-wide ERA (Newfields 2005) and met selection criteria of low pH pre-white rain (less the 5.4-5.5 threshold) and a large improvement post-white rain when sampled in 2010 for the insect study (ARCADIS 2010b). With the inclusion of these new locations, the pH monitoring program currently (in 2013) includes 22 locations.

Each of the soil locations sampled to meet the purposes of the pH monitoring program has been a composite of five grab samples within a 50-meter (m) by 50-m square area. The five grab samples were collected at the center and the four corners of the 50-m by 50-m square, as described in the work plan (ARCADIS 2010a).

3. Analytical Methods

All composite soil samples were analyzed for pH, total copper, and ABA, including sulfur forms from 2010 to 2013, by ACZ Laboratories, Inc. (ACZ), located in Steamboat Springs, Colorado. The long-term monitoring protocol outlined in the pH monitoring plan states that samples analyzed for copper and pH will be sieved to less than 2 millimeters and analyzed according to the approved work plan. This protocol has been followed, except in 2010 when the amendment study reference plot soil samples were not sieved prior to analysis, which was conducted by SVL Analytical, Inc., in Coeur d'Alene, Idaho. These samples were adjusted to represent copper and pH of sieved samples using the regression equations in ARCADIS (2012b).

The analytical methods used for the pH monitoring program include:

- Soil pH analysis using deionized water (U.S. Environmental Protection Agency [EPA] 9045C or saturated paste).
- Total copper analysis by acid digestion using EPA 3050B followed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) (EPA 6010B) with a method detection limit of 1 mg/kg.
- Samples were air-dried at 34 degrees Celsius before analysis and all estimates were based on dry weight. Soils subjected to ABA analysis were sieved to less than 250 micrometers (μm) following standard procedures.
- The ABA analysis included measurement of neutralization potential and sulfur forms (total sulfur, pyritic/sulfide sulfur, sulfate sulfur, and organic/insoluble sulfur) using the Modified Sobek procedure (EPA M600/2-78-054), specifically:
 - Neutralization potential in % as calcium carbonate (CaCO_3) was determined using EPA M600/2-78-054 3.2.3, with a 0.1% method detection limit. The laboratory calculated ANP in tons CaCO_3 per kiloton ($\text{t CaCO}_3/\text{kt}$) by multiplying the neutralization potential by 10.
 - Sulfur forms (total, pyritic/sulfide sulfur, sulfate sulfur, and organic/insoluble sulfur) were determined using EPA M600/2-78-054 3.2.4 with a 0.01% detection limit. Total sulfur content was determined by combustion via Leco furnace. The analysis of sulfur forms was conducted on separate sample aliquots, with a subsampling being digested in 4.8 Normal (N) hydrochloric

acid (HCl) and another being digested in 2 N nitric acid (HNO₃). ACZ uses the terms pyritic/sulfide sulfur; however, this methodology does not distinguish between pyritic (FeS₂) and non-pyritic sulfide minerals (e.g., CuS).

- ARCADIS calculated AGP in t CaCO₃/kt by multiplying the sulfide sulfur content (reported as pyritic/sulfide sulfur by ACZ) in % by a conversion factor of 31.25, based on acidity generated by pyrite oxidation (i.e., assuming all sulfide sulfur oxidation is represented by pyrite oxidation).

ABA results were used to determine the neutralization potential ratio (NPR = ANP/AGP) and net neutralization potential (NNP), where NNP is the difference between the ANP and AGP (i.e., NNP = ANP - AGP). These criteria are commonly used to categorize material into potentially acid-generating (PAG) or non-potentially acid-generating (non-PAG). Numerous interpretation schemes have been developed to assess the potential for acid generation using either criterion. For example, a sample with an NPR less than 1.0 will typically be characterized as PAG whereas an NPR greater than 2.0 represents a non-PAG sample (i.e., at least twice as much ANP as AGP). A sample with NPR values between these designations is considered to have uncertain acid-generating characteristics. The New Mexico Mining and Minerals Division (MMD) soil and overburden suitability guidelines, which are directly applicable, rate soil material as good based on an NNP of -5 t CaCO₃/kt or greater and unacceptable based on an NNP of less than -5 t CaCO₃/kt (MMD 1996).

Non-parametric hypothesis testing of repeated measurements on co-located samples (Friedman test with alpha = 0.05) was used to test for significant changes in time for each parameter from 2010 to 2013. Statistical analysis and calculations used the detection limits when values were below the detection limits.

4. Results

Results from the geochemical characterization are discussed below. Tables and figures are included to provide supporting information. The laboratory analytical results for pH, total copper, and pCu for soil samples collected from 2010 to 2013 are presented in **Table 3**. ABA results are summarized in **Table 4**.

Excluding ERA sites and sites with an asterisk in **Table 3** (removed by excavation), pH for the 17 locations changed significantly from 2010 to 2013, mainly between 2010 and 2011 ($P = 0.028$, Friedman repeated measures test and post-hoc test). In locations with $\text{pH} \geq 5$, pH tended to decrease from 2010 to 2012 and then increased again by 2013 (**Figure 5**). Sites with $\text{pH} < 5$ did not change or trended upward. No significant difference in pH existed at locations between 2010 and 2013 ($P = 0.464$, Friedman multiple comparisons test). Overall, the data do not support a consistent trend downward, suggesting the higher pH from the white rain is persisting. The mean pH values for the 17 sites are similar at 5.46, 5.24, 5.27, and 5.47 in 2010, 2011, 2012, and 2013, respectively. The combined mean pH over the 4-year monitoring period is 5.36.

Total copper concentrations at sample locations were significantly lower in 2011, 2012, and 2013 than in 2010 ($P < 0.01$, Friedman multiple comparisons test) (**Figure 6**). The mean total copper concentration was 1,304 mg/kg in 2010 vs. 873 mg/kg, 851 mg/kg, and 682 mg/kg in 2011, 2012, and 2013, respectively. Results indicate that, after 2010, total copper concentration decreased in most sites and remained at a consistently lower level. The sampling points removed due to excavation had no impact on the observed change, as the mean total copper concentration at the sampling points removed in 2011 was lower and not significantly different from the mean copper concentration at the remaining points ($P = 0.11$, Kruskal Wallis test). The decrease in total copper concentration between 2010 and 2011 will be investigated as part of the year 5 monitoring report.

Although there was a decrease in copper, pCu values were not quite significantly higher at each site from 2010 to 2013 ($P = 0.055$, Friedman multiple comparisons test; **Figure 7**). Specifically, mean pCu values for the 17 sites were 4.49, 4.78, 4.83, and 4.95 in 2010, 2011, 2012, and 2013, respectively. It is notable that the pCu values have consistently increased to higher values, almost significantly after four years of monitoring.

Figure 8 and **Figure 9** show the spatial distribution of soil pH and pCu results, respectively, for the 22 monitoring locations sampled in 2013.

White rain occurred in 2008 and did not appear to have changed copper in a consistent direction by 2010 (**Figure 2**), but, after 2010, copper decreased on average and has remained at a lower concentration. Overall, comparison of the ERA sites and amendment study areas sampled before and for all years sampled post-white rain (**Table 1**) shows that the initial improvement in pH ($P=0.03$) and pCu ($P=0.02$) from the white rain has persisted.

Variability in pH and total copper, as measured in field duplicate samples, is shown in **Table 5**. Relative percent difference in total copper compared to the mean of the primary and duplicate samples over 4 years of sampling varied between 0% and 32%, and pH varied between 0% and 15%. The variability was within the acceptable limits set forth in the Administrative Order on Consent Quality Assurance Plan (SRK 1997). This variability is consistent with inherent soil heterogeneity in the composite samples. Data collected at the monitoring locations over the next year will help further define the amount of variability at those sample locations and estimate if trends are evident after accounting for this variability.

Total sulfur content in 2013 soil samples ranged from less than 0.01% to 0.48%, with a mean of 0.14%, where the detection limit for non-detect samples was used when calculating the mean. These concentrations are low and fall within the range of background concentrations for sulfur in soil in the western United States (from less than 0.08% to 4.8%, with a mean of 0.19%; Shacklette and Boerngen 1984). Pyritic/sulfide sulfur content was also low, with levels low enough to be difficult for the laboratory to accurately quantify. Specifically, 12 of 22 soil samples were below the practical quantitation limit of 0.1% and, therefore, were flagged as estimates due to the low sulfur content. An average of 64% of the total sulfur content in samples collected in 2013 consisted of pyritic/sulfide sulfur.

NNP and NPR were highly variable and thus the means for these measures did not significantly differ over the 4 years; specifically (**Table 4**):

- Mean NNP = 23.3, 8.7, 10.8, and 15.6 t CaCO₃/kt for 2010, 2011, 2012, and 2013, respectively ($P=0.896$, Friedman test).
- Mean NPR = 51.8, 10.5, 10.9, and 18.3 for 2010, 2011, 2012, and 2013, respectively ($P=0.898$, Friedman test).

Duplicate results support that variability in ANP and AGP in some years (**Table 5**) was relatively high resulting in high calculated NNP and NPR variability, and, therefore, power to detect differences is low. Variability in ANP and sulfur forms (used to determine AGP) was likely due to inherent soil heterogeneity and measured values of pyritic/sulfide sulfur being very close to the detection and practical quantification limits (0.01% and 0.1%, respectively) as mentioned previously.

In 2013, 11 of the 22 samples had NPR less than 2.0 and were therefore identified as uncertain or PAG, which is consistent with the 2010 through 2012 results (**Figure 10 a-d**). However, the soils with NPR values below 2.0 also often had low pyritic/sulfide sulfur content and low ANP; therefore, it is also important to consider NNP guidelines. In 2013, all 22 samples met the MMD soil and overburden suitability guidelines based on NNP of -5 t CaCO₃/kt or greater (**Figure 11 a-d**). From 2010, 2011, 2012, and 2013, 5, 2, 1, and 0 samples, respectively, were below -5 t CaCO₃/kt criteria suggesting possible improvement over time (2010 through 2013). These findings are further supported by NNP as a function of pH (**Figure 12 a-d**), which shows that pH above approximately 5.0 has NNP values greater than -5 t CaCO₃/kt (with one outlier exception in 2010, FID 8). Thus, results support that soil with pH > 5 is not likely to be acid generating.

Regression analysis of the 2012 results provided in the third year pH monitoring report (ARCADIS 2013) suggested that soil samples with a pyritic/sulfide sulfur content of less than 0.1% had a low probability of generating acid using the NPR criterion (NPR ≥ 2.0). However, this threshold may be too low. The 0.1% pyritic/sulfide sulfur threshold may be overly conservative as illustrated by samples with higher pyritic/sulfide sulfur content meeting the MMD suitability guidelines (**Figure 11 a-d** and **Figure 12 a-d**).

The monitoring described above will be repeated in 2014 to provide additional data to evaluate the hypothesis that soils with this chemistry will not revert to lower pH.

5. Summary

Twenty-two locations were monitored in 2013 to determine if the changes in pH and pCu in upland soils that resulted from the 2008 white rain event are temporary or permanent. This report provides data for the fourth year of the 5-year monitoring program and compares results over all 4 years (2010 through 2013). Overall, the pH and pCu did not significantly change between the first (2010) and last year (2013) of monitoring conducted to date. A comparison of historical data to 2013 monitoring data also supports the conclusion that pH is not quickly reverting to low values post-white rain. ABA demonstrates that the soils are generally low in sulfur and have low ANP, with a wide range of NPR values (falling into all classes of non-acid generating, uncertain, and PAG). However, NNP is stable and all soils now meet the MMD soil and overburden suitability guidelines. These findings provide support that the 2008 white rain effect on pH and pCu may persist into the future. The significant decrease in total copper after 2010 will be investigated as part of the year 5 monitoring report.

These results provide a preliminary assessment of the stability of changes in soil chemistry observed after the white rain event. Data from future monitoring will be used to conduct trend analyses to determine if soil pH or pCu is significantly changing in one direction through time or if changes observed are within the range of sampling variability.

6. References

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Tables

Table 1
Historical ERA and Amendment Location Soil Results Compared to Post-White Rain Results

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Soil Sample Location	Soil pH (0 to 6 inches) S.U.				Soil Cu (0 to 6 inches) mg/kg				Soil pCu (0 to 6 inches) calculated			
	Pre-White Rain ¹	Post-White Rain ²	2012	2013	1999	2010 ³	2012	2013	1999	2010 ³	2012	2013
ERA 2	4.80	6.20	6.40	7.00	811	915	960	420	4.10	5.26	5.40	6.90
ERA 3	5.00	6.50	6.40	6.00	709	664	624	807	4.41	5.91	5.89	5.22
ERA 4	4.80	6.30	5.80	6.40	541	525	514	215	4.60	6.00	5.56	7.12
ERA 5	6.60	6.40	--	--	399	247	--	--	6.54	6.95	--	--
ERA 6	6.70	6.30	--	--	499	650	--	--	6.40	5.75	--	--
ERA 7	5.50	6.70	--	--	789	803	--	--	4.69	5.88	--	--
ERA 8	7.00	7.00	--	--	710	661	--	--	6.27	6.38	--	--
ERA 9	4.30	4.60	--	--	562	314	--	--	4.10	5.01	--	--
ERA 10	4.50	5.40	5.70	5.20	485	209	299	232	4.45	6.22	6.09	5.91
ERA 11	7.70	7.00	--	--	276	290	--	--	8.07	7.33	--	--
ERA 12	7.80	7.80	--	--	204	224	--	--	8.44	8.37	--	--
ERA 13	4.80	6.30	6.60	5.60	126	193	292	91	6.22	7.15	6.95	7.36
ERA 14	7.70	7.50	--	--	109	138	--	--	9.14	8.65	--	--
ERA 15	7.70	7.80	--	--	712	554	--	--	6.98	7.33	--	--
Amendment Plot or Reference #1 (West)*	6.49	8.20	7.60	7.50	--	2153	1120	605	--	5.81	6.33	6.95
Amendment Plot or Reference #2 (North)*	3.69	6.03	5.80	6.00	--	928	1170	578	--	5.49	4.61	5.61
Amendment Plot or Reference #3 (Northeast)*	5.41	5.68	5.10	6.70	--	2773	2250	1090	--	3.14	3.21	5.53
Amendment Plot or Reference #4 (East)*	4.76	5.75	4.80	6.00	--	1699	1210	923	--	3.68	3.64	5.07

Notes:

¹ERA samples were collected in 1999 (Newfields 2005) while Amendment Study Plot locations were sampled in 2006 before they were amended (ARCADIS 2013). Sampling protocols (average of three samples on 50-meter transects or one to two samples within 100-foot by 100-foot amendment plots) differed from pH monitoring plan protocols.

²ERA samples were collected post-white rain in 2010 (ARCADIS 2010b), while amendment reference plot locations were sampled in May 2008 just after the January 2008 white rain (ARCADIS 2013) event. Samples were collected using a different protocol than pH monitoring program, with 15 samples composited over a 100-meter radius area for ERA locations and two samples in a 100-foot by 100-foot plot for amendment plots (before treated).

³ERA samples were collected post-white rain in 2010 (ARCADIS 2010b) and amendment reference plot locations were sampled in Fall 2010 (ARCADIS 2013). Samples were collected using a different protocol than pH monitoring program with 15 samples composited over a 100-meter radius area for ERA locations and two samples in 100-foot by 100-foot amendment reference plots.

*Only pH was collected at the amendment study plot locations in 2006. In 2006 and 2008, soil samples on amendment reference plots did not exist and only amendment plots (before amending) were sampled (ARCADIS 2013). In 2012, the adjacent reference plots were available and sampled (since untreated) as part of the pH monitoring program. The comparison of amendment plot/reference locations assumes similar conditions on amendment plot and reference plots before amendments were applied. When differences in pH estimates derived from the pH monitoring program versus amendment study (ARCADIS 2013) on the same reference plot were greater than 7% in 2012 (true for Northeast and East Plots), the average of the two estimates was used.

All samples were sieved or adjusted to being sieved to less than 2 mm (see ARCADIS 2013 for adjustment regressions).

-- = not applicable

ERA = ecological risk assessment

mg/kg = milligrams per kilogram

mm = millimeters

pCu = -log (cupric ion activity)

S.U. = standard units

Table 2
Historic Copper Concentrations in Insect Tissue Compared to Post-White Rain Results

Year 4 pH Monitoring Report
Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

Location	1999 Insect Tissue Cu (mg/kg dry wt washed)¹	2010 Insect Tissue Cu (mg/kg dry wt washed)
ERA 2	198	176
ERA 3	252	111
ERA 4	193	92
ERA 5	163	74
ERA 6	232	163
ERA 7	338	68
ERA 8	461	162
ERA 9	175	155
ERA 10	37	100
ERA 11	88	95
ERA 12	66	127
ERA 13	164	116
ERA 14	167	87
ERA 15	304	318

Notes:

¹Assumes 1% is soil that was removed when washed (see ARCADIS 2010b).
Tissue samples include soil in gut or still adhered to insect after washing.

ERA = ecological risk assessment

mg/kg = milligrams per kilogram

wt = weight

Table 3
2010 to 2013 Long-Term Sample Location Results – pH, Total Copper, and pCu

Year 4 pH Monitoring Report
Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

Soil Sample Location	Soil pH (0 to 6 inches) (S.U.)				Soil Cu (0 to 6 inches) (mg/kg)				Soil pCu (0 to 6 inches) (calculated)			
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
FID 7	5.40	4.80	4.70	5.40	550	494	514	375	5.11	4.67	4.53	5.55
FID 8	6.50	6.40	5.50	6.50	545	332	252	358	6.14	6.62	6.10	6.62
FID 10	4.80	4.80	5.00	5.00	2060	2140	2210	1780	3.03	2.99	3.13	3.38
FID 15	4.90	4.80	4.60	5.20	2520	2260	1030	1950	2.89	2.92	3.64	3.46
FID 16	4.80	4.50	4.30	4.70	3550	2020	1450	1290	2.40	2.77	2.97	3.47
FID 17*	5.10	6.00	4.90	--	4550	4220	5150	--	2.40	3.32	2.07	--
FID 18	3.90	4.30	4.40	4.30	559	254	192	141	3.69	4.97	5.39	5.65
FID 22	6.50	6.20	6.40	6.30	488	430	308	296	6.27	6.13	6.70	6.66
FID 23*	4.40	--	--	--	202	--	--	--	5.33	--	--	--
FID 28	7.70	6.90	6.70	6.80	527	400	271	318	7.29	6.87	7.13	7.04
FID 37	4.80	4.60	4.50	5.30	1210	654	765	432	3.64	4.16	3.89	5.29
FID 43*	6.50	--	--	--	636	--	--	--	5.96	--	--	--
FID 101	4.20	3.80	4.20	4.20	405	272	290	221	4.34	4.43	4.73	5.04
FID 102	3.80	3.60	3.70	3.70	358	303	230	171	4.11	4.12	4.53	4.87
FID 103*	4.00	--	--	--	443	--	--	--	4.05	--	--	--
FID 104*	3.80	--	--	--	459	--	--	--	3.83	--	--	--
FID 105	5.60	4.90	6.60	4.70	1390	668	799	816	4.23	4.42	5.79	4.00
FID 106	5.00	5.00	5.70	4.60	454	254	408	247	4.95	5.62	5.73	5.28
ERA 2	--	--	6.40	7.00	--	--	960	420	--	--	5.40	6.90
ERA 3	--	--	6.40	6.00	--	--	624	807	--	--	5.89	5.22
ERA 4	--	--	5.80	6.40	--	--	514	215	--	--	5.56	7.12
ERA 10	--	--	5.70	5.20	--	--	299	232	--	--	6.09	5.91
ERA 13	--	--	6.60	5.60	--	--	292	91	--	--	6.95	7.36
Reference #1 (West) ¹	7.85	7.50	7.60	7.50	2153	597	1120	605	5.81	6.96	6.33	6.33
Reference #2 (North) ¹	6.46	6.00	5.80	6.00	928	687	1170	578	5.49	5.41	4.61	4.61
Reference #3 (Northeast) ¹	5.29	5.60	5.10	6.70	2773	1950	2250	1090	3.14	3.84	3.21	3.21
Reference #4 (East) ¹	5.26	5.40	4.80	6.00	1699	1130	1210	923	3.68	4.28	3.64	3.64

Notes:

¹ 2010 reference samples were tested using unsieved soil; therefore, a conversion factor has been applied to account for this discrepancy.

*Locations FID 23, FID 43, FID 103, FID 104, and FID 17 were excavated and not sampled.

MDL = method detection limit

mg/kg = milligrams per kilogram

pCu = -log (cupric ion activity)

S.U. = standard units

-- = not applicable

Table 4
2010 to 2013 Long-Term Sample Location Results – Acid-base Accounting

Year 4 pH Monitoring Report
Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

Soil Sample Location	Total Sulfur (%)				Pyritic/Sulfide Sulfur (%)				Sulfate Sulfur (%)				Non-Sulfate Sulfur (%)				Organic Sulfur (%)			
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
FID 7	0.05	0.07	0.02	0.05	0.04	0.03	0.02	0.03	0.01	0.01	<0.01	0.01	0.04	0.06	0.02	0.04	<0.01	0.03	<0.01	0.01
FID 8	0.68	0.59	0.11	0.34	0.31	0.26	0.04	0.20	0.31	0.27	0.07	0.11	0.37	0.32	0.04	0.23	0.06	0.06	<0.01	0.03
FID 10	0.04	0.11	0.05	0.13	0.03	0.07	0.05	0.11	0.01	0.02	<0.01	<0.01	0.03	0.09	0.05	0.13	<0.01	0.02	<0.01	0.02
FID 15	0.11	0.21	0.03	0.28	0.12	0.17	0.02	0.21	<0.01	0.02	0.01	0.04	0.11	0.19	0.02	0.24	0.01	0.02	<0.01	0.03
FID 16	0.27	0.26	0.06	0.22	0.15	<0.01	0.04	0.13	0.05	0.13	0.02	0.06	0.22	0.13	0.04	0.16	0.07	0.14	<0.01	0.03
FID 17*	0.57	0.48	0.68	--	0.37	0.38	0.56	--	0.12	0.05	0.07	--	0.45	0.43	0.61	--	0.08	0.05	0.05	--
FID 18	0.30	0.16	0.15	0.08	0.14	0.11	0.09	0.05	0.14	0.03	0.06	0.02	0.16	0.13	0.09	0.06	0.02	0.02	<0.01	0.01
FID 22	0.20	0.28	0.10	0.19	0.13	0.20	0.07	0.11	0.05	0.05	0.03	0.06	0.15	0.23	0.07	0.13	0.02	0.03	<0.01	0.02
FID 23*	0.11	--	--	--	0.07	--	--	--	0.04	--	--	--	0.07	--	--	--	<0.01	--	--	--
FID 28	0.18	0.19	<0.01	0.18	0.17	0.08	0.05	0.17	<0.01	0.07	<0.01	<0.01	0.18	0.12	<0.01	0.18	0.01	0.04	<0.01	0.02
FID 37	0.07	0.05	0.02	0.02	0.02	0.03	0.01	0.02	0.04	<0.01	0.01	<0.01	0.03	0.05	0.01	0.02	0.01	0.02	<0.01	<0.01
FID 43*	0.59	--	--	--	0.22	--	--	--	0.37	--	--	--	0.22	--	--	--	<0.01	--	--	--
FID 101	0.28	0.21	0.15	0.30	0.19	0.13	0.06	0.14	0.06	0.06	0.09	0.12	0.22	0.15	0.06	0.18	0.03	0.02	<0.01	0.04
FID 102	0.62	0.92	0.47	0.48	0.43	0.50	0.16	0.20	0.14	0.36	0.29	0.25	0.48	0.56	0.18	0.23	0.05	0.06	0.02	0.03
FID 103*	0.06	--	--	--	0.03	--	--	--	0.03	--	--	--	0.03	--	--	--	<0.01	--	--	--
FID 104*	0.98	--	--	--	0.31	--	--	--	0.61	--	--	--	0.37	--	--	--	0.06	--	--	--
FID 105	0.17	0.10	0.10	0.16	0.11	0.05	0.04	0.08	0.03	0.01	0.05	0.04	0.14	0.09	0.05	0.12	0.03	0.04	0.01	0.04
FID 106	0.04	0.05	0.03	0.02	0.03	0.02	0.02	0.03	0.01	0.01	0.01	<0.01	0.03	0.04	0.02	0.02	<0.01	0.02	<0.01	<0.01
ERA 2	--	--	0.15	<0.01	--	--	0.07	0.05	--	--	0.06	<0.01	--	--	0.09	<0.01	--	--	0.02	0.02
ERA 3	--	--	0.19	0.28	--	--	0.05	0.12	--	--	0.11	0.10	--	--	0.08	0.18	--	--	0.03	0.06
ERA 4	--	--	0.05	<0.01	--	--	0.03	0.02	--	--	0.02	<0.01	--	--	0.03	<0.01	--	--	<0.01	0.02
ERA 10	--	--	0.01	0.04	--	--	0.01	0.05	--	--	<0.01	<0.01	--	--	0.01	0.04	--	--	<0.01	0.01
ERA 13	--	--	<0.01	0.02	--	--	0.02	0.03	--	--	<0.01	<0.01	--	--	<0.01	0.02	--	--	<0.01	<0.01
Reference #1 (West)	0.03	0.09	<0.01	<0.01	<0.01	0.03	0.03	0.02	0.03	0.04	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.02	<0.01	0.02
Reference #2 (North)	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.05	<0.01	<0.01
Reference #3 (Northeast)	0.07	0.16	0.06	0.12	0.02	0.07	0.03	0.08	0.05	0.07	0.03	0.02	0.02	0.09	0.03	0.10	<0.01	0.02	<0.01	0.02
Reference #4 (East)	0.14	0.23	0.10	0.23	0.03	0.14	0.06	0.15	0.11	0.05	0.04	0.05	0.03	0.18	0.06	0.18	<0.01	0.04	<0.01	0.03

Notes:

¹AGP is calculated from Pyritic Sulfide Sulfur where S(%)*31.25 = AGP. AGP was calculated using the detection limit when Pyritic Sulfide Sulfur was less than 0.1%.

*Locations FID 23, 43, 103, 104, and 17 were excavated and not sampled in subsequent years.

AGP = acid generation potential

ANP = acid neutralization potential

NNP = Net Neutralization Potential

NPR = Neutralization Potential Ratio

-- = not applicable

Table 4
2010 to 2013 Long-Term Sample Location Results – Acid-base Accounting

Year 4 pH Monitoring Report
Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

Soil Sample Location	AGP (tCaCO ₃ /kt) ¹ (calculated)				ANP (tCaCO ₃ /kt)				NNP (tCaCO ₃ /kt) ¹ (calculated)				NPR (ANP/AGP) ¹ (calculated)			
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
FID 7	1.25	0.94	0.63	0.94	33	0	8	1	31.8	-0.9	7.4	0.1	26.4	0.0	12.8	1.1
FID 8	9.69	8.13	1.25	6.25	0	16	3	17	-9.7	7.9	1.8	10.8	0.0	2.0	2.4	2.7
FID 10	0.94	2.19	1.56	3.44	2	5	1	2	1.1	2.8	-0.6	-1.4	2.1	2.3	0.6	0.6
FID 15	3.75	5.31	0.63	6.56	1	0	2	5	-2.8	-5.3	1.4	-1.6	0.3	0.0	3.2	0.8
FID 16	4.69	0.30	1.25	4.06	4	0	0	0	-0.7	-0.3	-1.3	-4.1	0.9	0.0	0.0	0.0
FID 17*	11.6	11.9	17.5	--	0	8	5	--	-11.6	-3.9	-12.5	--	0.0	0.7	0.3	--
FID 18	4.38	3.44	2.81	1.56	19	0	1	0	14.6	-3.4	-1.8	-1.6	4.3	0.0	0.4	0.0
FID 22	4.06	6.25	2.19	3.44	10	16	5	12	5.9	9.8	2.8	8.6	2.5	2.6	2.3	3.5
FID 23*	2.19	--	--	--	0	--	--	--	-2.2	--	--	--	0.0	--	--	--
FID 28	5.31	2.50	1.56	5.31	137	35	64	90	132	32.5	62.4	84.7	25.8	14.0	41.0	16.9
FID 37	0.63	0.94	0.31	0.63	0	1	0	2	-0.6	0.06	-0.3	1.4	0.0	1.1	0.0	3.2
FID 43*	6.88	--	--	--	25	--	--	--	18.1	--	--	--	3.6	--	--	--
FID 101	5.94	4.06	1.88	4.38	0	2	0	0	-5.9	-2.1	-1.9	-4.4	0.0	0.5	0.0	0.0
FID 102	13.4	15.6	5.00	6.25	0	0	28	2	-13.4	-15.6	23.0	-4.3	0.0	0.0	5.6	0.3
FID 103*	0.94	--	--	--	2	--	--	--	1.1	--	--	--	2.1	--	--	--
FID 104*	9.69	--	--	--	0	--	--	--	-9.7	--	--	--	0.0	--	--	--
FID 105	3.44	1.56	1.25	2.50	0	8	5	2	-3.4	6.4	3.8	-0.5	0.0	5.1	4.0	0.8
FID 106	0.94	0.63	0.63	0.94	0	0	13	2	-0.9	-0.6	12.4	1.1	0.0	0.0	20.8	2.1
ERA 2	--	--	2.19	1.56	--	--	0	18	--	--	-2.2	16.4	--	--	0.0	11.5
ERA 3	--	--	1.56	3.75	--	--	13	3	--	--	11.4	-0.8	--	--	8.3	0.8
ERA 4	--	--	0.94	0.63	--	--	8	5	--	--	7.1	4.4	--	--	8.5	8.0
ERA 10	--	--	0.31	1.56	--	--	0	3	--	--	-0.3	1.4	--	--	0.0	1.9
ERA 13	--	--	0.63	0.94	--	--	19	6	--	--	18.4	5.1	--	--	30.4	6.4
Reference #1 (West)	0.30	0.94	0.94	0.63	238	101	61	166	238	100	60.1	165	793	108	65	266
Reference #2 (North)	0.30	0.30	<0.3	0.63	4	11	6	5	3.3	10.7	5.7	4.4	12.0	36.7	20.0	8.0
Reference #3 (Northeast)	0.63	2.19	0.94	2.50	8	13	3	11	7.0	10.8	2.1	8.5	12.2	5.9	3.2	4.4
Reference #4 (East)	0.94	4.38	1.88	4.69	<0.3	0	8	3	-0.6	-4.4	6.1	-1.7	0.3	0.0	4.3	0.6

Notes:

¹AGP is calculated from Pyritic Sulfide Sulfur where S(%)*31.25 = AGP.

*Locations FID 23, 43, 103, 104, and 17 were excavated and not sampled in subsequent years.

AGP - Acid generation potential

ANP - Acid neutralization potential

NNP - Net Neutralization Potential

NPR - Neutralization Potential Ratio

-- = not applicable

Table 5
Duplicate Analysis of Samples Collected from 2010 to 2013

Year 4 pH Monitoring Report
Freeport-McMoRan Chino Mines Company
Vanadium, New Mexico

Soil Sample Location	Year	Soil pH (0 to 6 inches) (S.U.)	Soil Cu (0 to 6 inches) (mg/kg)	Total Sulfur (%)	Non-Sulfate Sulfur (%)	Pyritic Sulfide Sulfur (%)	Sulfate Sulfur (%)	ANP (tCaCO ₃ /kt)
FID 17	2010	5.1	4550	0.57	0.45	0.37	0.12	0
FID 17 DUP		5.3	3900	0.65	0.58	0.51	0.07	3
Relative percent difference		4%	15%	13%	25%	32%	53%	200%
FID 23	2010	4.4	202	0.11	0.07	0.07	0.04	0
FID 23 DUP		4.4	182	0.13	0.08	0.07	0.05	0
Relative percent difference		0%	10%	17%	13%	0%	22%	0%
FID 22	2011	6.2	430	0.19	0.15	0.04	0.04	16
FID 22 DUP		6.3	467	0.19	0.15	0.03	0.04	26
Relative percent difference		2%	8%	0%	0%	29%	0%	48%
FID 101	2011	3.8	272	0.19	0.13	0.02	0.06	2
FID 101 DUP		3.9	341	0.19	0.13	<0.01	0.06	0
Relative percent difference		3%	23%	0%	0%	67%	0%	200%
ERA 2	2012	6.4	960	0.15	0.09	0.07	0.06	0
ERA 2 DUP		6.4	953	<0.01	<0.01	0.05	<0.01	15
Relative percent difference		0%	1%	175%	160%	33%	143%	200%
ERA 13	2012	6.6	292	<0.01	<0.01	0.02	<0.01	19
ERA 13 DUP		5.7	257	<0.01	<0.01	0.01	<0.01	13
Relative percent difference		15%	13%	0%	0%	67%	0%	38%
FID 37	2013	5.3	432	0.02	0.02	0.02	<0.01	2
FID 37 DUP		5.2	365	0.01	0.01	0.02	<0.01	3
Relative percent difference		2%	17%	67%	67%	0%	0%	40%
FID 28	2013	6.8	318	0.18	0.18	0.17	<0.01	90
FID 28 DUP		6.8	230	0.19	0.19	0.19	<0.01	81
Relative percent difference		0%	32%	5%	5%	11%	0%	11%

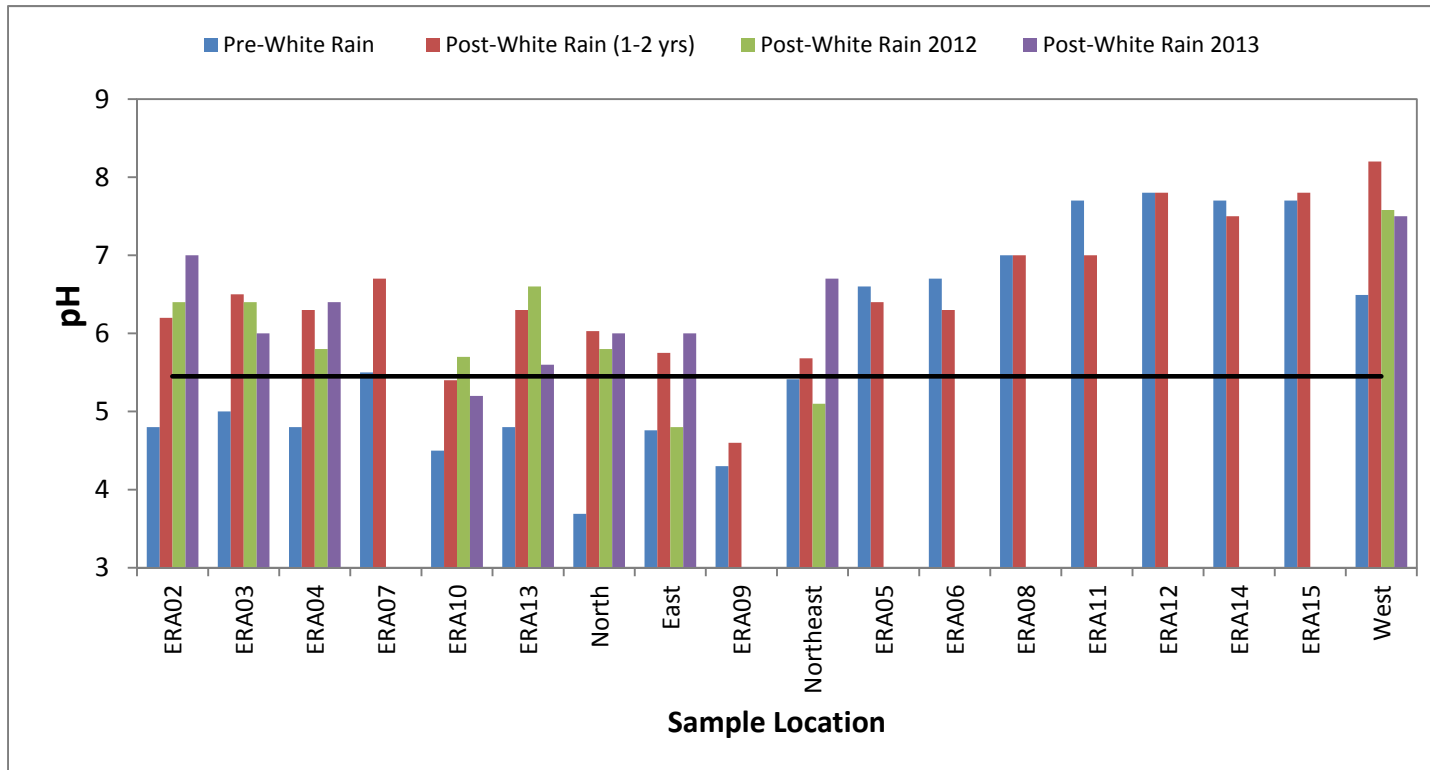
Notes:

ANP = acid neutralization potential

mg/kg = milligram per kilogram

S.U. - Standard units

Figures



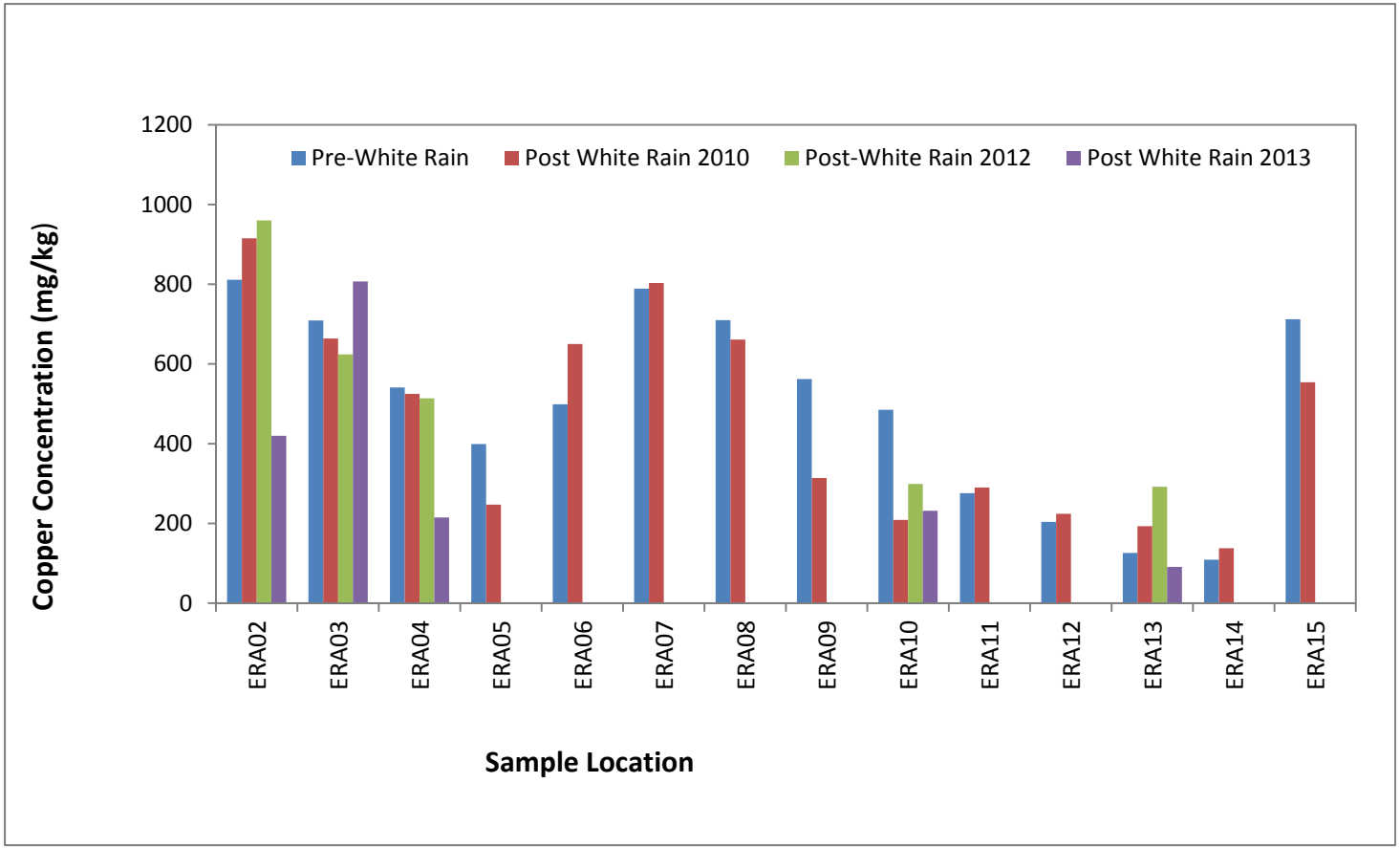
Note: pH increased in soils with low pH (~<5.4 to 5.5, line in graph) after the white rain, maintaining the higher pH to 2013. Pre-white rain = 1999 for ERA sites and 2006 for other areas (amendment study areas).

Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

pH before (1999 and 2006) and after (2008-2013)
 the White Rain



FIGURE
1



Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

Copper Concentration before (1999) and after (2010-2013) the White Rain


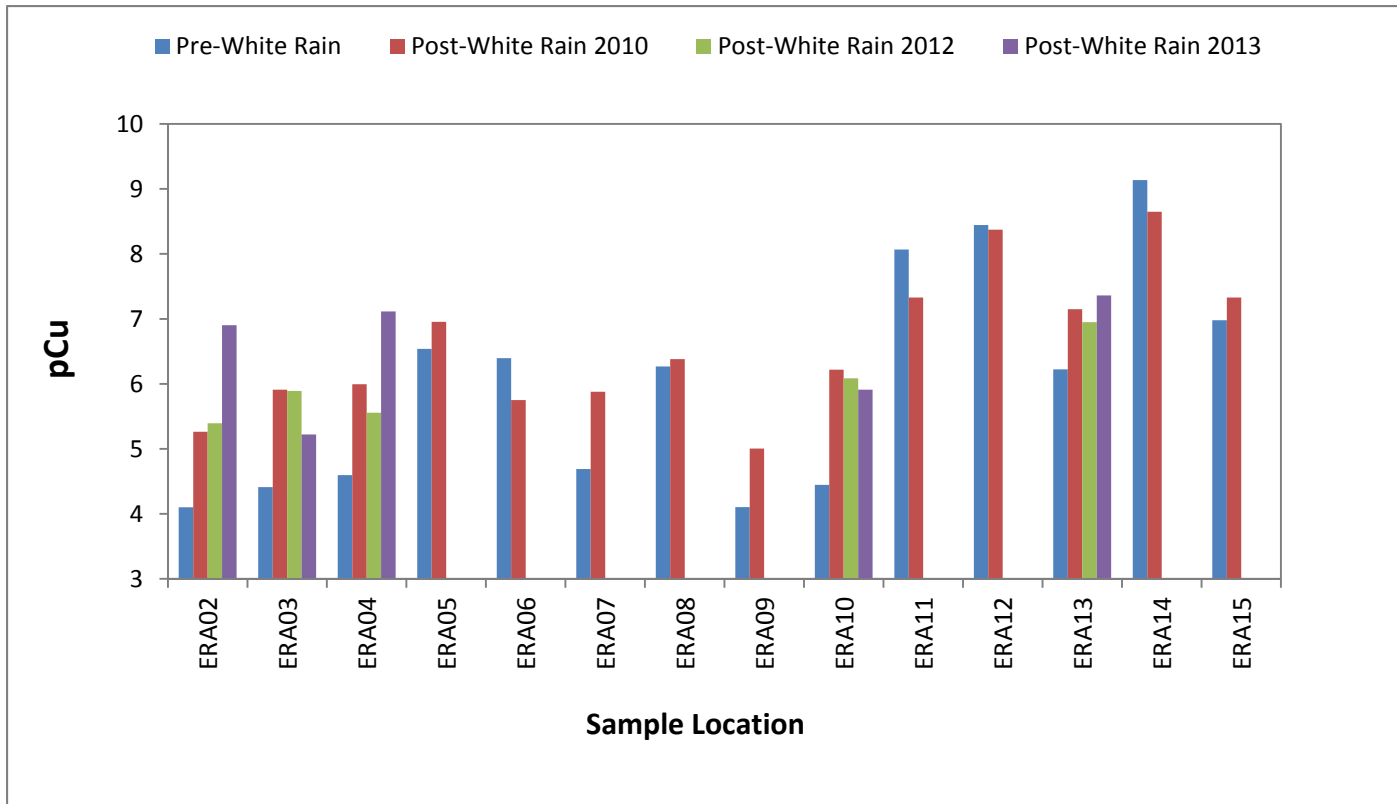


FIGURE
2



Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

pCu before (1999) and after (2010-2013) the White Rain


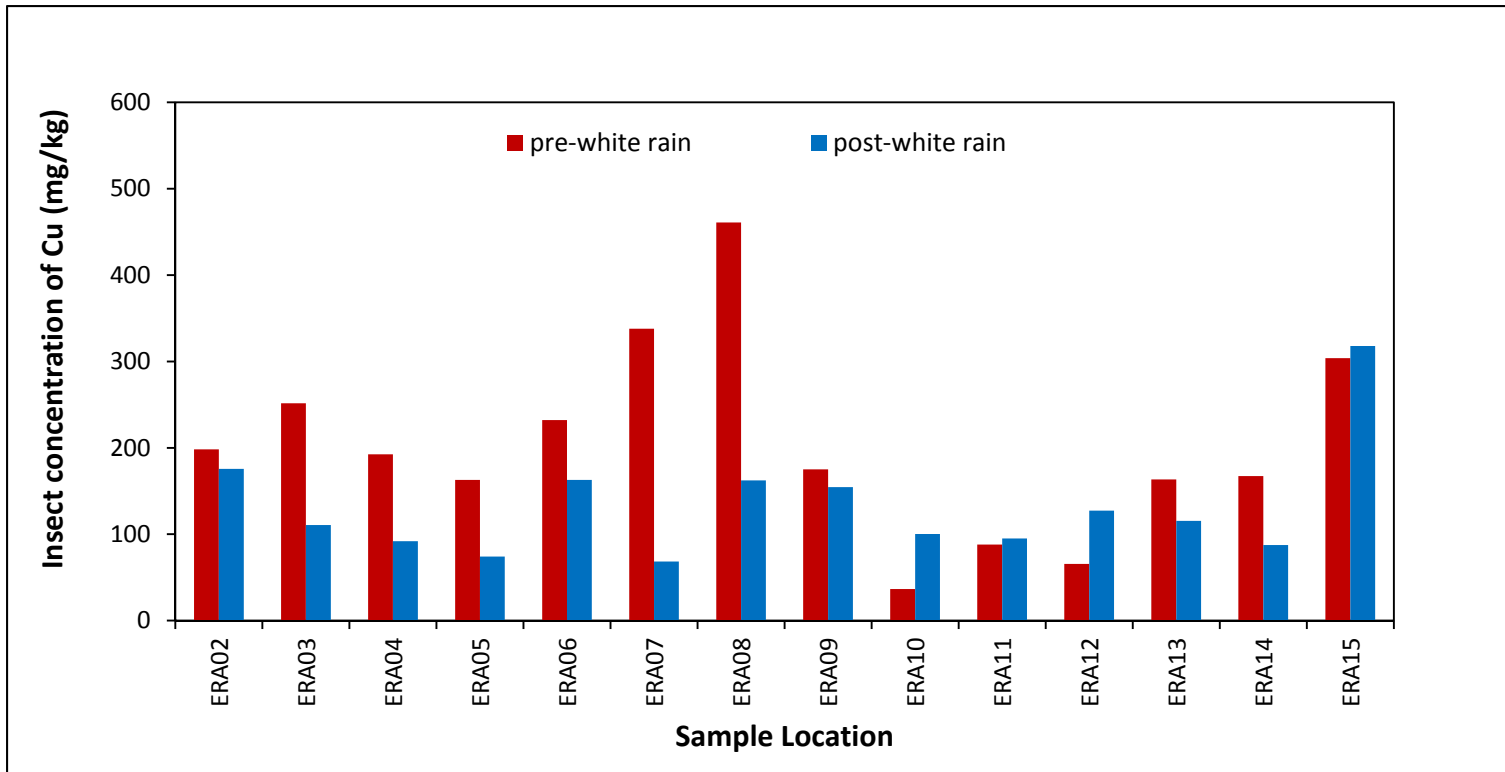


FIGURE
3



Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

Comparison of Copper Concentration in Insect Tissue before (1999) and after (2010) the White Rain


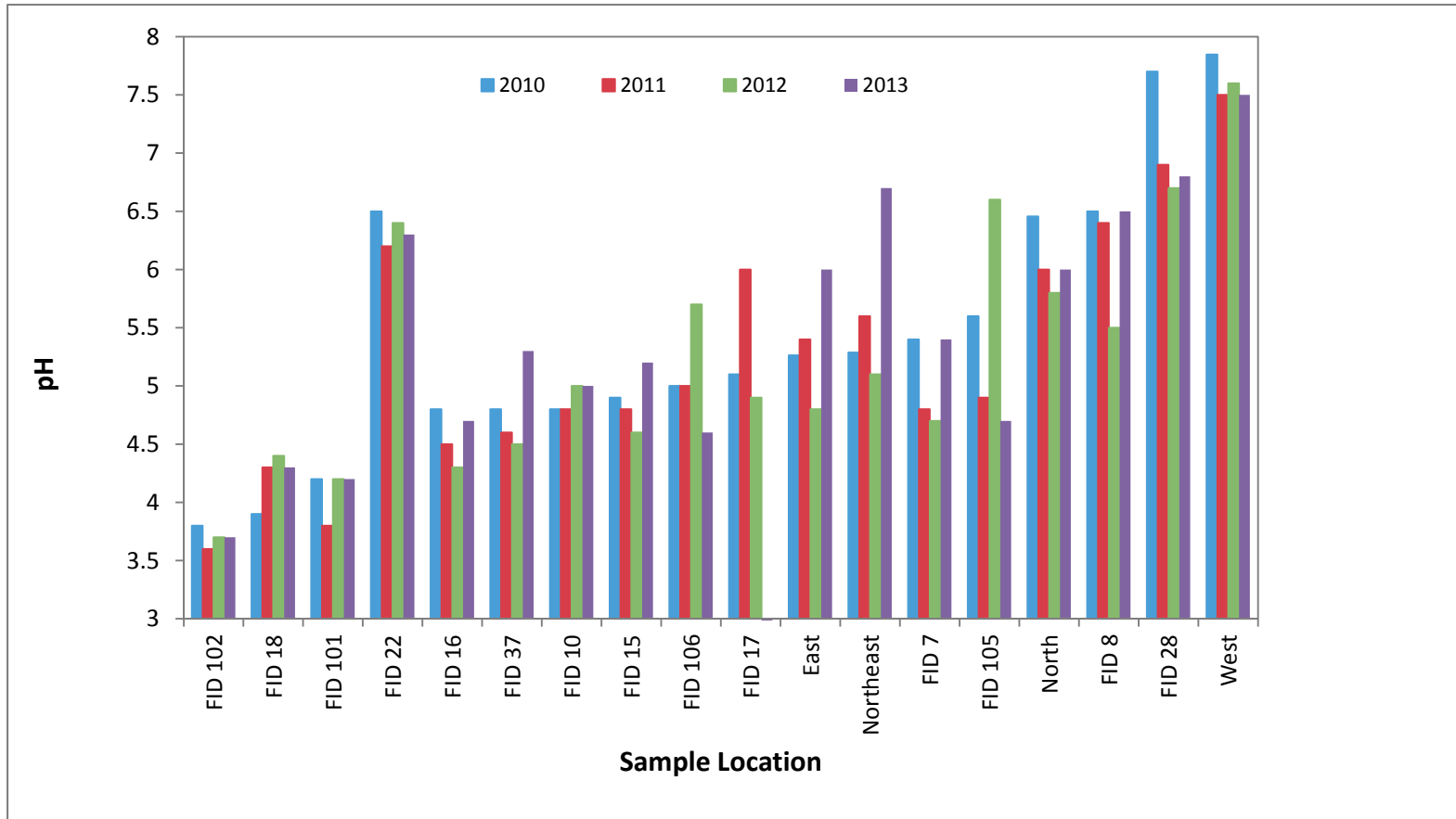
 **ARCADIS**

FIGURE **4**



Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

**pH of Soils (0 to 6 inches) on Monitoring Sites
 from 2010 to 2013**


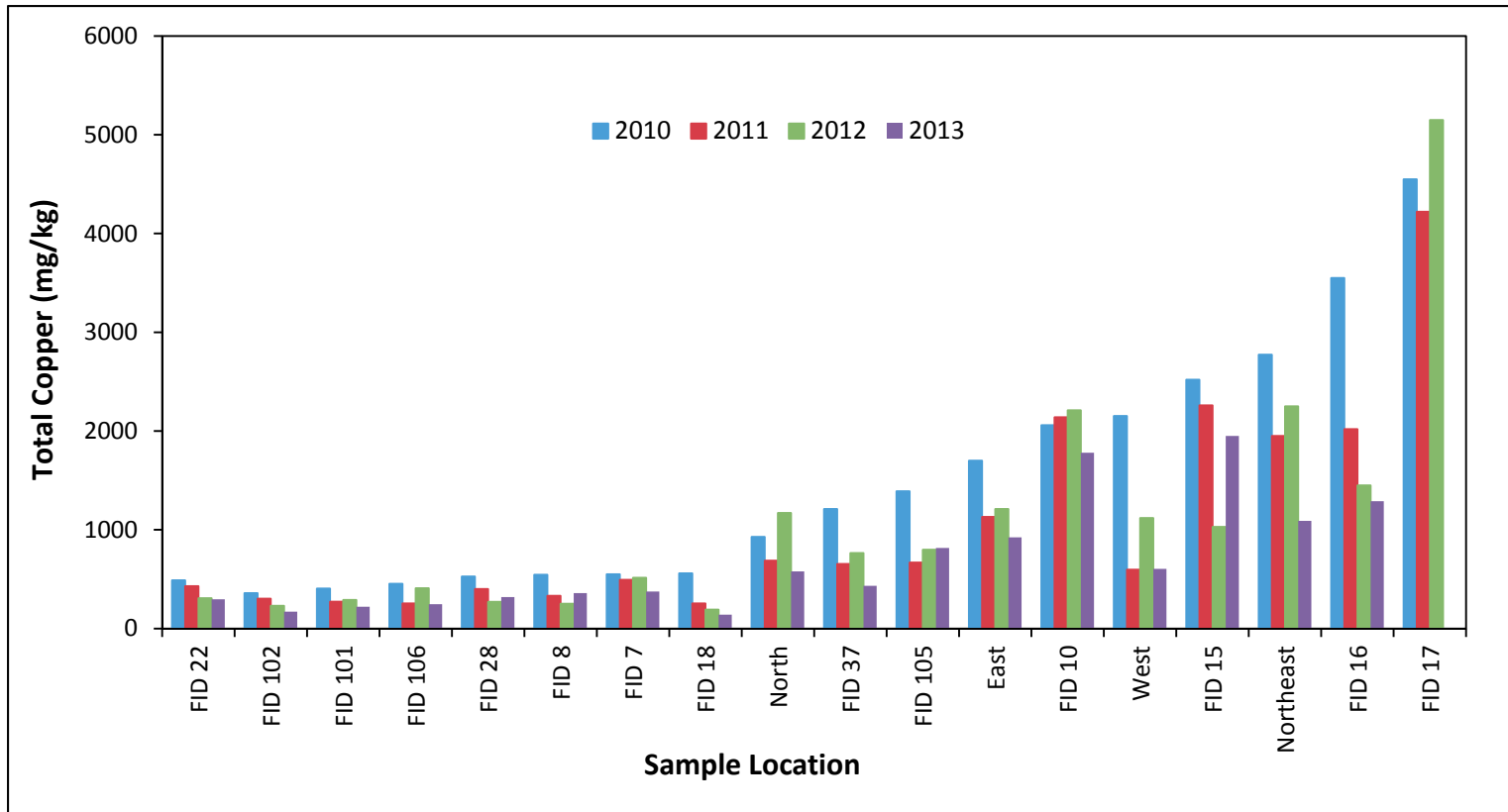
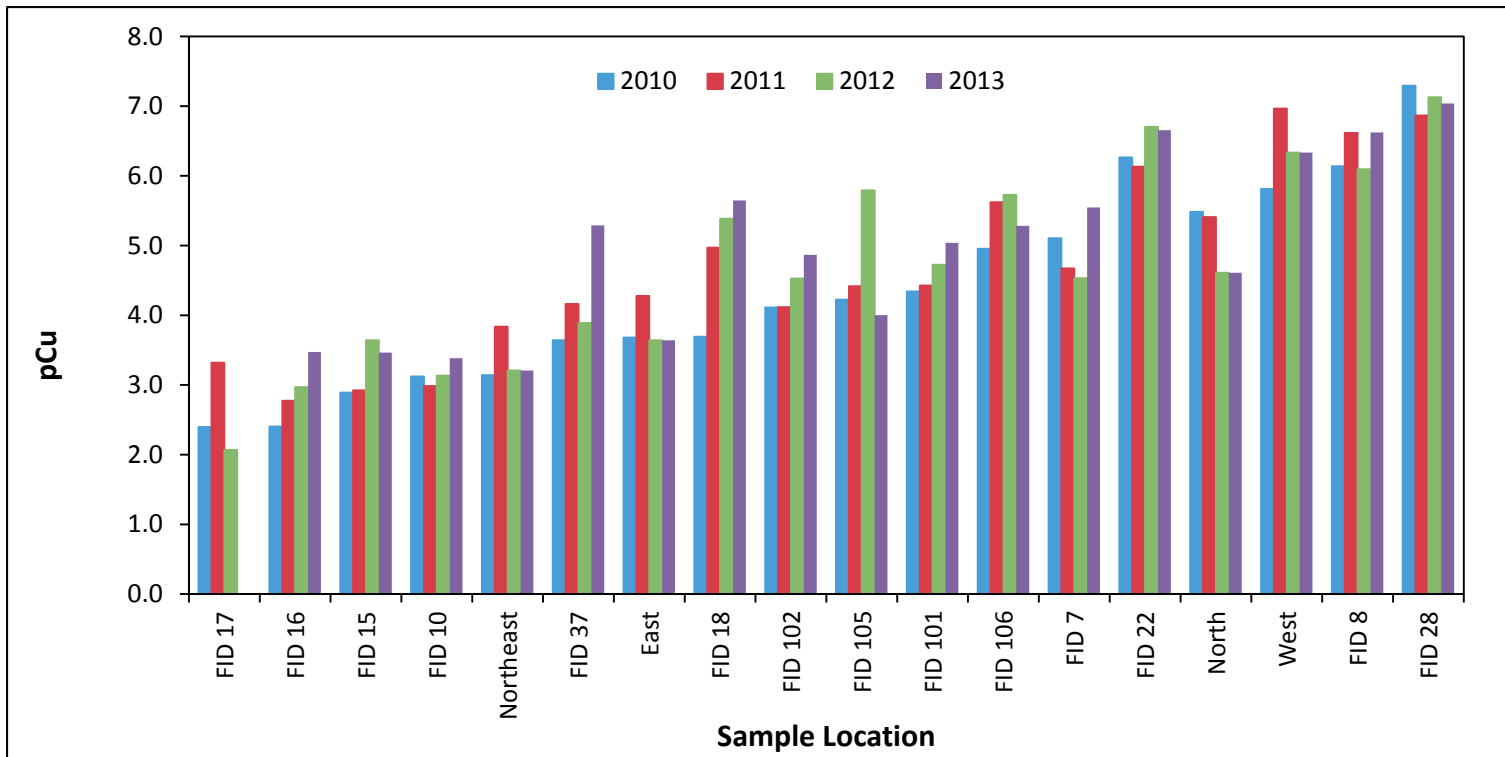
 **ARCADIS**

FIGURE **5**



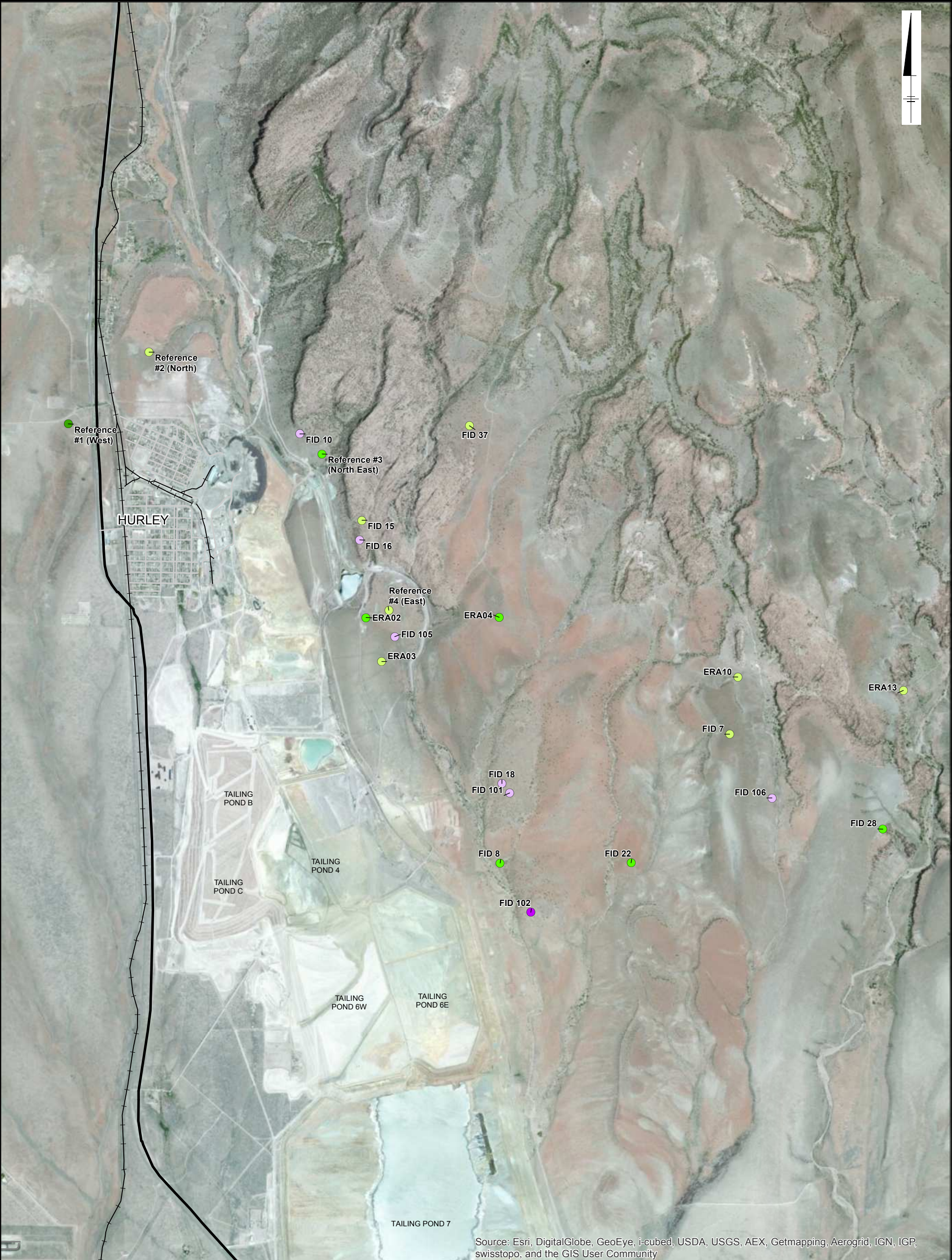


Freeport-McMoRan Chino Mines Company
 Vanadium, New Mexico
 Year 4 pH Monitoring Report

**pCu Concentration of Soils (0 to 6 inches) on
 Monitoring Sites from 2010 to 2013**



FIGURE
7

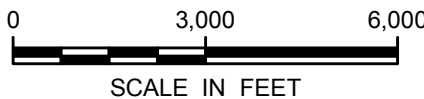


Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

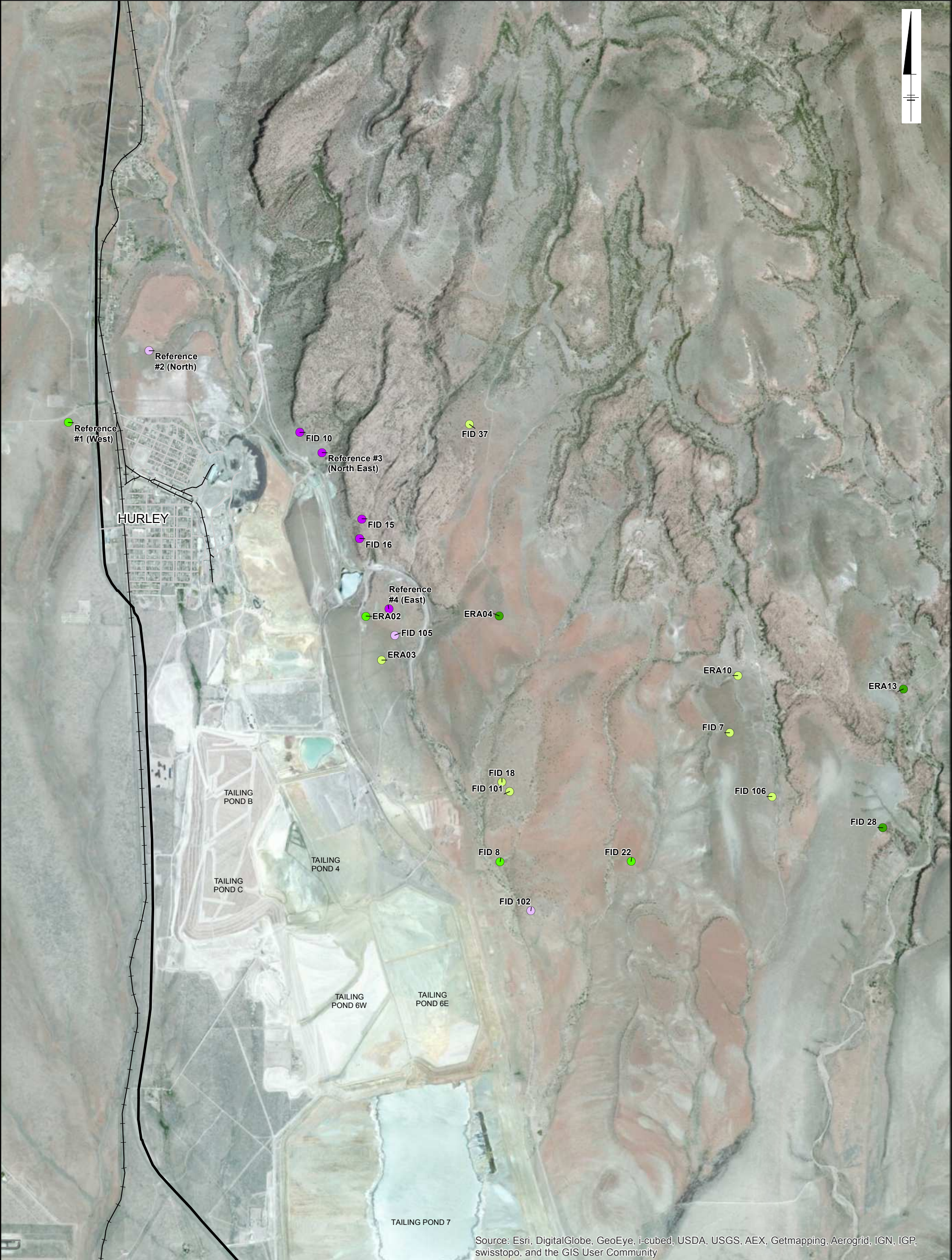
pH Range

- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8



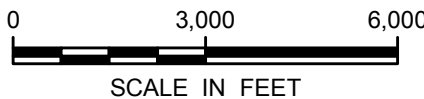
SCALE IN FEET

FREEPORT-MCMORAN CHINO MINES COMPANY VANADIUM, NEW MEXICO YEAR 4 pH MONITORING REPORT	
MONITORING LOCATIONS WITH pH RESULTS FOR 2013	
	FIGURE 8



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Legend**
- pCu Range**
- 3 - 4
 - 4 - 5
 - 5 - 6
 - 6 - 7
 - 7 - 8



FREEPORT-MCMORAN CHINO MINES COMPANY
 VANADIUM, NEW MEXICO

YEAR 4 pH MONITORING REPORT

**MONITORING LOCATIONS WITH
 pCu RESULTS FOR 2013**


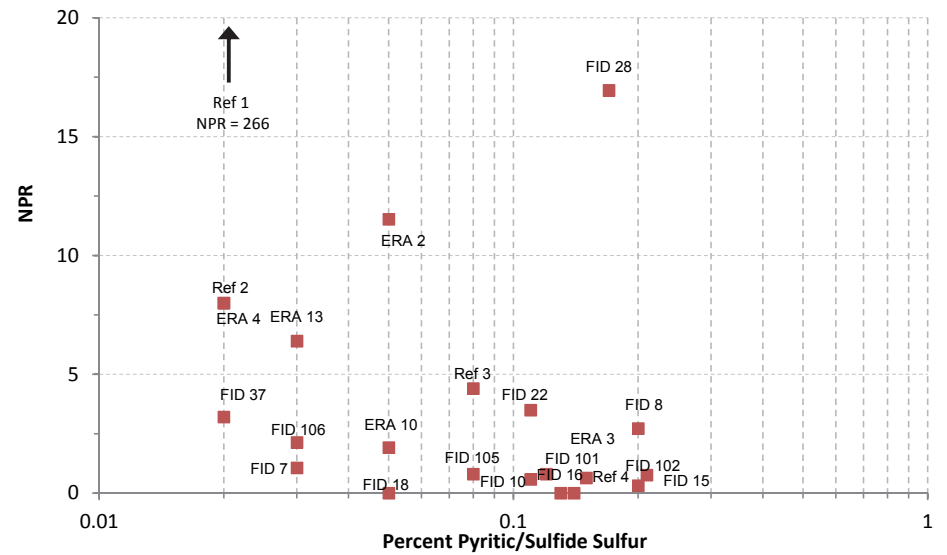
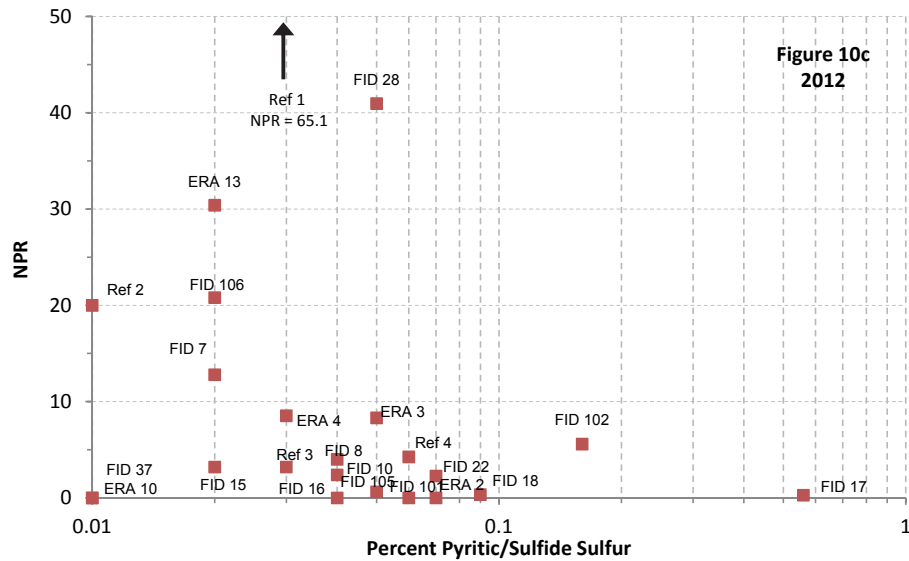
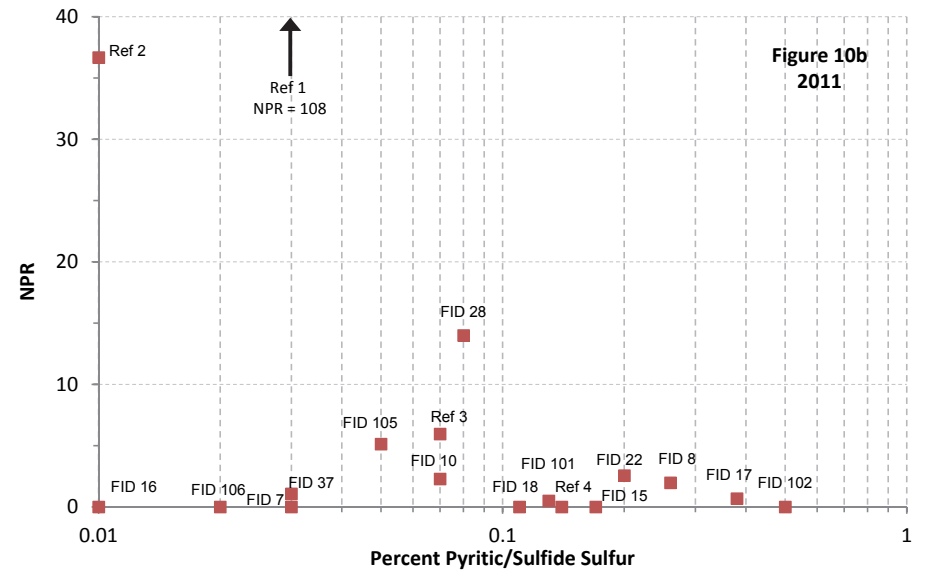
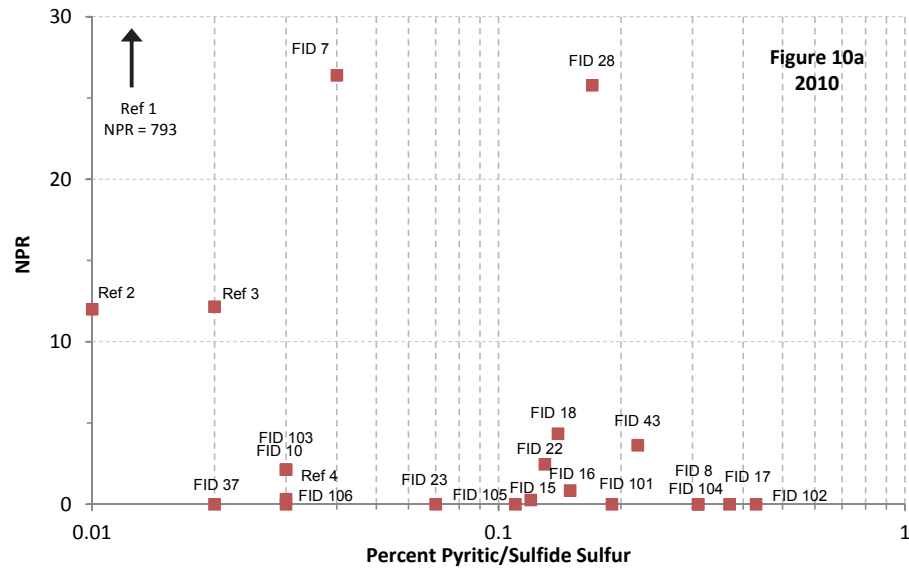


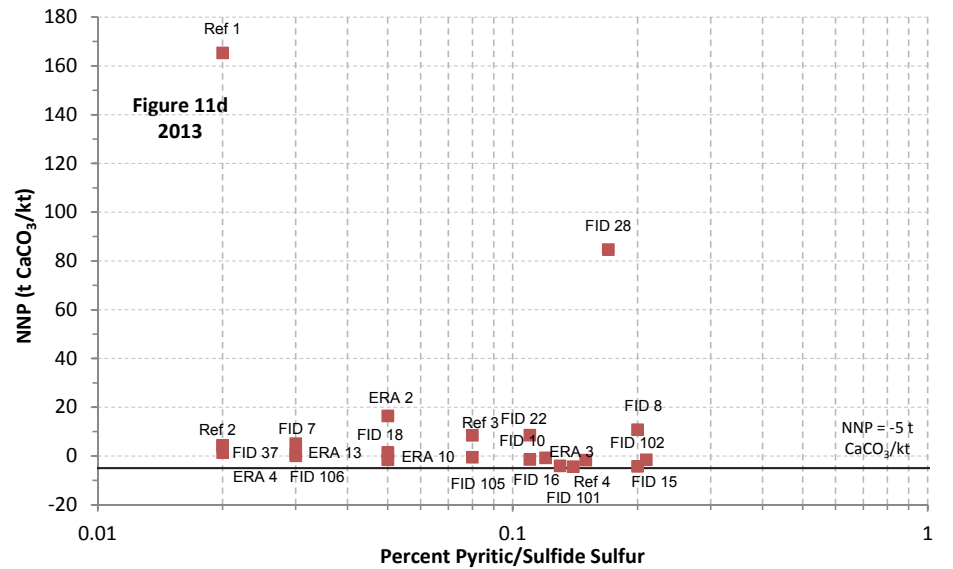
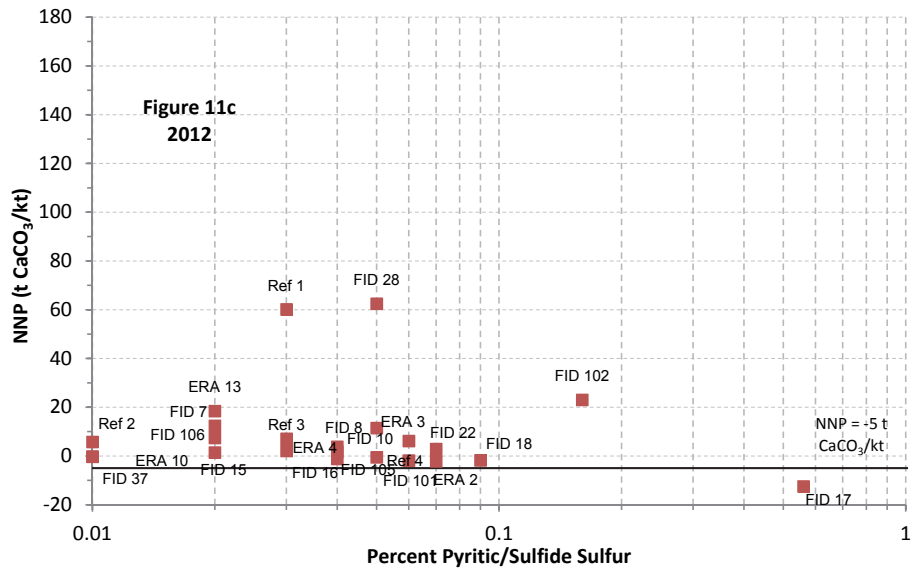
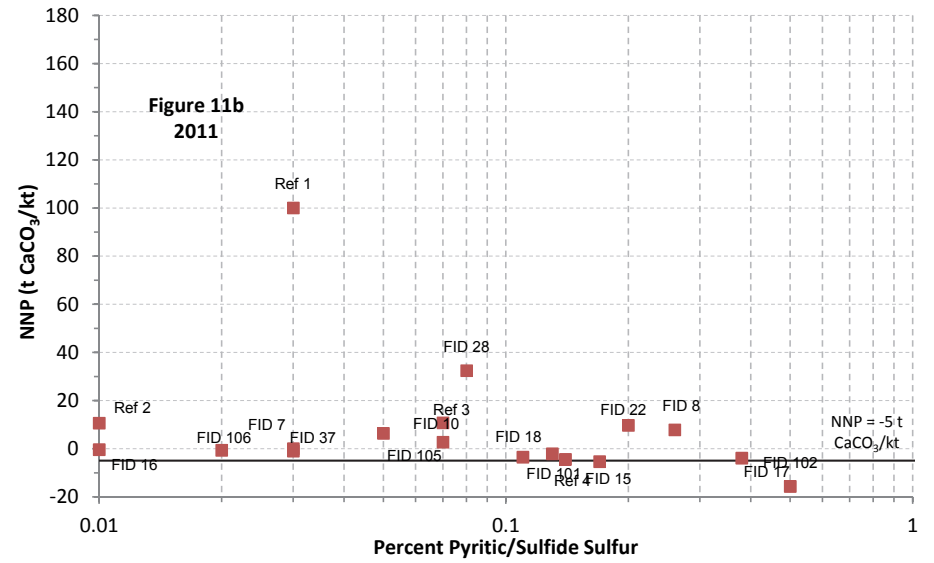
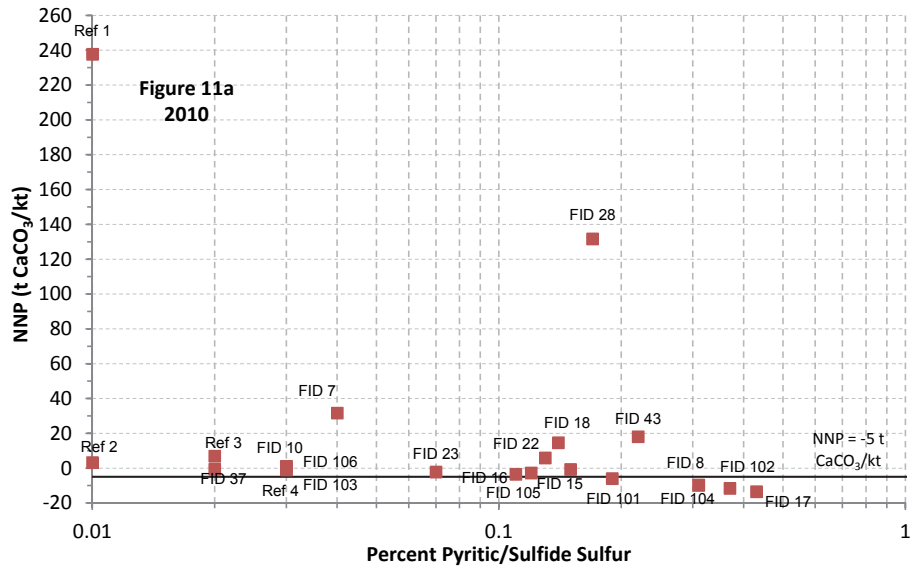
FIGURE
9



Note: Y-axes have different scales to best display data.

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YEAR 4 REPORT - PH MONITORING
Relationship of Percent Sulfide Sulfur and NPR

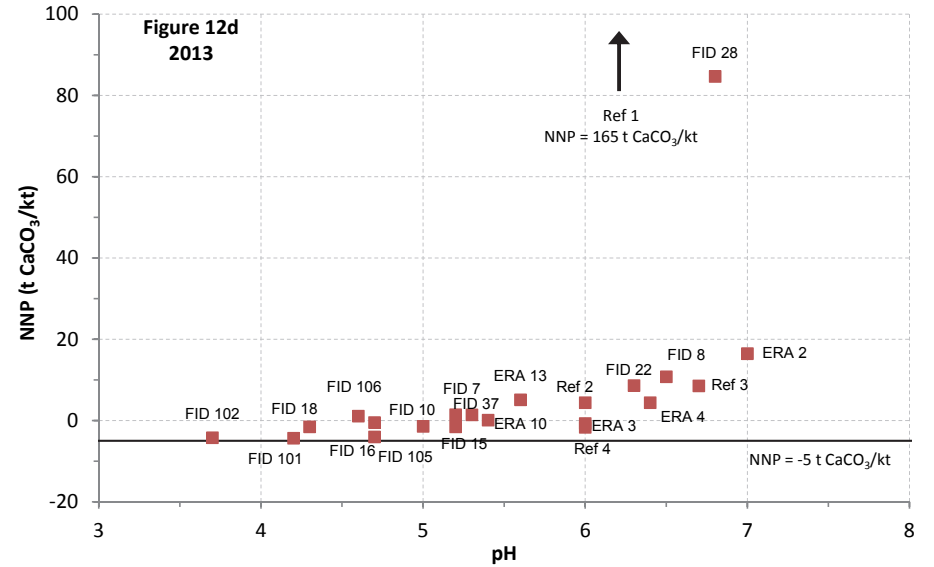
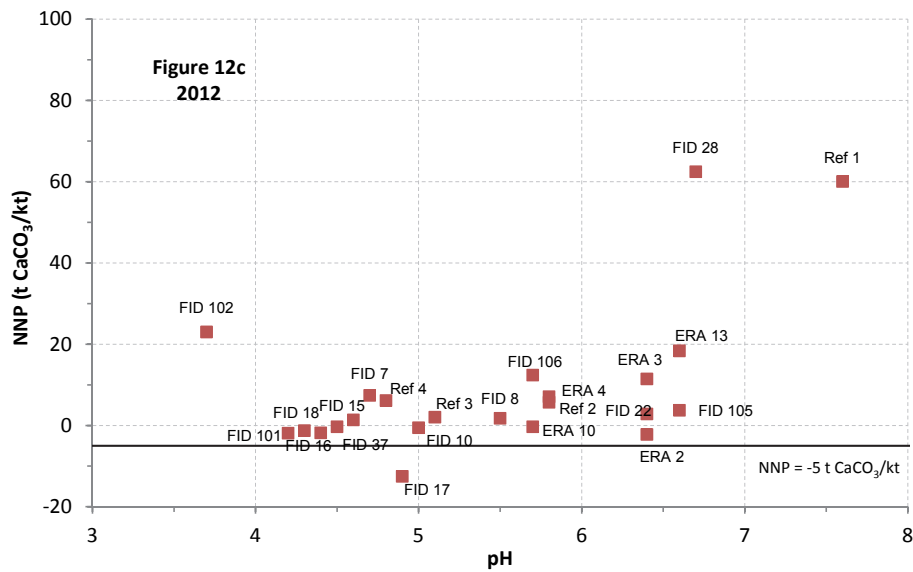
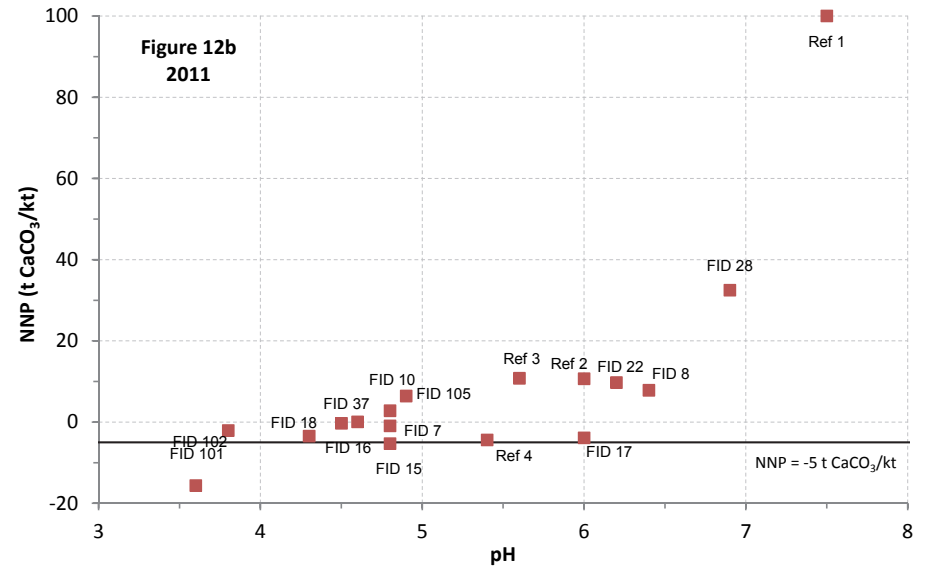
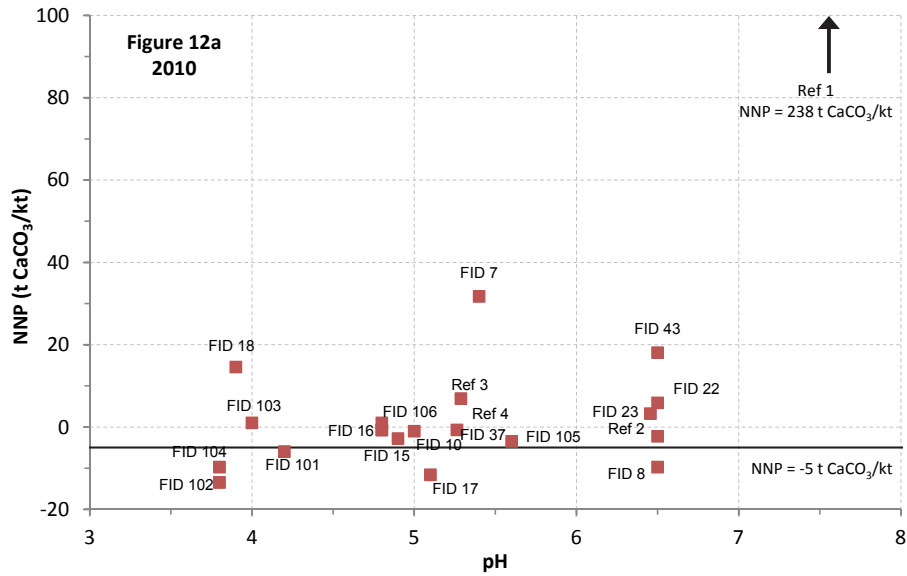




Note: Y-axes have different scales to best display data.

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Relationship of Percent Sulfide Sulfur and NNP





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Relationship of pH and NNP

