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NEW MEXICO
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February 20, 2014

Ms. Sherry Burt-Kested, Manager
Environment Services
Freeport-McMoRan Chino Mines Company
P.O. Box 10
Bayard, New Mexico 88023

RE: Comments on Phytotoxicity and Vegetation Community Study Workplan
Smelter/Tailing Soils Investigation Unit (STSIU)
Chino Administrative Order on Consent (AOC)

Dear Ms. Burt-Kested:

The Ground Water Quality Bureau of the New Mexico Environment Department (NMED) received the Phytotoxicity and Vegetation Community Study Workplan on February 3rd, 2014. NMED has completed a review of the Workplan and lists comments under separate cover that must be addressed before NMED can approve the Workplan.

If you have any questions regarding this report, please contact me at (575)-956-1550.

Sincerely,

Matt Schultz, Chino AOC Project Manager
Mining Environmental Compliance Section
Ground Water Quality Bureau
New Mexico Environment Department
Silver City Field Office

cc: Petra Sanchez, USEPA (via email)
Kurt Vollbrecht, NMED (via email)
Joseph Fox, NMED (via email)

Mark Lewis, Formation Environmental (via email)
Joe Allen, Formation Environmental (via email)
Ned Hall, Freeport-McMoRan Copper & Gold (via email)
Pam Pinson, Freeport-McMoRan Chino Mines Company (via email)

This document presents the New Mexico Environment Department's (NMED's) comments on Freeport-McMoRan Chino Mines Company's (Chino's) Response to comments and formally submitted Work Plan: Smelter/Tailing Soils Investigation Unit (STSIU)-Phytotoxicity and Vegetation Community Study received February 3, 2014. This document is organized to present a response to active comments between NMED and Chino. Original comments by NMED from December 19, 2013 are reproduced below in bold, followed by Chino's response to each comment in italics from January 13, 2014, followed by NMED's followup response on January 23, 2014, followed by Chino's followup response in italics from February 3, 2014, and finally followed by NMED's followup response in this document dated February 20, 2014.

NMED Comment 1. Section 1.0 Introduction, page 1: The portions at the end of the first paragraph are not relevant to the purpose of the workplan introduction. Suggest limiting the discussion to a summary of the findings of the Paschke and Redente (2002) paper. Delete the last two sentences of paragraph 1 and rephrase the first two sentences of paragraph 2.

Chino Response: The phytotoxicity and community studies are designed to inform decisions for remedial technologies and remedial goals, and this point was clarified in the first paragraph. Though Chino agrees the statement by Dr. Redente is not directly pertinent to the phytotoxicity study design, the statement does provide insight on how an expert views the vegetation community in the STSIU and a basis for the applicable remedial technologies. The last but not the second to last sentence of paragraph 1 was deleted. The first sentence of paragraph 2 was also deleted.

NMED Followup Response:
The introductory text in the second paragraph of the updated workplan remains unacceptable. Some of the text is not directly related to the rationale, objectives or methodology for this study, and appears to be related to identification of remedial technologies and alternatives in the FS based on the level of disturbance generated in a cleanup. NMED agrees that these could be important points to address in the FS, but are not directly related to the specific rationale for this study.

Regarding the 'challenges' listed for the 1999 study, Chino should identify which of these are being addressed as part of this study. Based on response to a later comment, identifying differences in ecological significance, while important, will not be a specific objective of this study. Chino should also specify how locations on "bedrock and tops of ridges" will be accounted for in this study. Are there reference (or de minimus) locations selected specifically to address these types? If not, the plan for analysis of community data should explicitly recognize that bedrock area or rocky ridge tops are likely to have natural lower cover, diversity, etc. compared to areas with more fully developed soil cover. If it does not, these are clearly confounding factors on which to base conclusions about PEL for communities.

Chino Followup Response: Chino has removed all discussion of remedial technologies and alternatives from this workplan. Chino has also removed the bullet discussing the ecological significance between the different endpoints.

Chino agrees that presence or absence of bedrock has the potential to be a confounding factor. The physical covariates (bedrock, slope, aspect, and elevation) that Chino will evaluate during the analysis have been specifically called out in third paragraph of Section 2.2. Reference (de minimus) locations STS-PT-2013-21, STS-PT_2013-22, and STS-PT-2013-23 were selected by Chino and NMED in 2012 to use as bedrock reference for the evaluation of cover and richness and Chino anticipates using these locations as reference (de minimus) locations in the phytotoxicity study.

NMED Followup Response 2:
At the end of Section 1, Chino states that "The objectives of the community and phytotoxicity studies are to identify the De Minimus (i.e., negligible) effect level (DEL) and probable adverse effect level (PEL) of pCu." Section 2.2 discusses the specific approach for estimating the DEL,

but an approach for the PEL is not included. Please provide a description of the PEL calculation approach, and provide an explanation of how Chino envisions the use of each endpoint.

NMED Comment 2. Section 1.0 Introduction, page 2: It is unclear how the proposed phytotoxicity study results will be used to "evaluate the potential for natural recovery in areas with pCu <5."

Chino Response: The proposed phytotoxicity and community study results could be used to support a natural recovery remedial strategy, depending on the outcome of the PEL in the 2014 study. The updated PEL may turn out to be lower than the current proposed pre-FS RAC of 5 for pCu, and if so, would provide a line of evidence, along with Redente's comment about doing more harm than good when disturbing vegetation near the PEL, to justify the monitoring of areas with pCu in the range of the uncertainty of the updated PEL. Further explanation of this point was added to the text.

NMED Followup Response:
The text seems to imply that if the PEL is ≥5, monitoring natural recovery is not viable. Without further rationale for this implication, the statement does not make sense. A PEL for native species that is lower 5 might change the areas to be considered for risk management action (including MNR), but does not fundamentally change the remedial alternatives available.

Chino Followup Response: Chino has removed all discussion of monitoring and natural recovery from the workplan text.

NMED Followup Response 2:
NMED notes the changes.

NMED Comment 4. Section 2.0, page 3, first paragraph: The objectives stated here do not match the study data uses provided in the last paragraph of Section 1.0. Is the objective of the study to 'address the reliability of the cupric ion pre-FS RAC... and to evaluate the potential for natural recovery', or is it 'to identify thresholds for adverse effects of pCu on plant endpoints such as emergence, survival, and growth'? Please clarify.

Chino Response: The objectives of the community and phytototoxicity studies can be viewed as the first of two tiers of objectives required to complete the upland pCu evaluation in the Feasibility Study:
1) Identify the probable adverse effect threshold (PEL) from phytotoxicity and community studies; and,
2) Use the identified PEL in the evaluation of remedial technologies.
The text in Section 2 has been updated to clarify the study objectives.

NMED Followup Response:
The response indicates that an objective of the study is to "*Use the identified PEL in the evaluation of remedial technologies.*" We agree that this could be an eventual use of the phytotoxicity study results, but neither remedial technologies nor remedial alternatives are being evaluated as part of this study. How does Chino envision the PEL to be used in evaluating 'remedial technologies'? We can understand the context of evaluating remedial alternatives, but if Chino believes that the PEL value is critical to evaluating candidate technologies for the site, we would like to understand the rationale so that we can agree on the use of the results of this study.

Further, the revised text and the comment response do not seem to be related, or at least consistent.

Chino Followup Response: Chino has further revised the text to the following: "The objectives of the community and phytototoxicity studies are to identify the deminimus effect level (DEL) and probable adverse effect level (PEL) of pCu."

NMED Followup Response 2:
NMED notes the changes.

NMED Comment 6. Section 2.01, 2nd paragraph: The paragraph implies a cause/effect relationship between two disjunct concepts. The text implies that the difference in the relationships between pCu2+ and total Cu and pH observed in Sauve et al (1997) and the ERA site-specific analysis is evidence that pCu2+ tolerance in the plants could be different. The equations predicting pCu2+ could be totally different, but result in no difference in toxicity thresholds of plants. The site-specific geochemistry does not "produce a lower toxic threshold". Rather, the physiological acclamation processes or genetic adaptation of the plants have the potential to alter pCu2+ tolerance. Both the effect of geochemistry and the acclimation of plants are dependent on site-specific conditions. The previous site investigations did not attempt to apply the Sauve et al. pCu2+ prediction equations or the toxicity thresholds to the Chino site. The important aspects of the proposed study are to apply the methods in Sauve et al and the previous site investigations to (1) evaluate the potential change in the pCu prediction equations that could have resulted from the 'white rain events' and (2) evaluate the toxicity thresholds for plants grown from native species and from seeds from the site. These overall objectives are stated elsewhere, but this paragraph confuses the issue. This comment may seem picayune, but the distinctions cited are important to make sure all parties have a common understanding of what is being measured and why it could be important.

Chino Response: The overall objectives of this study have been clearly defined in Section 2.0 in this latest draft revision in the response to comment #4.

Chino's study plan is to collect the measured pCu because it is more accurate and a better replication of the 1999 study but only to be used to meet the objective of re-evaluating the DEL and PEL. For clarification of overall objectives, Chino has accepted the current equations predicting pCu in the sitewide ERA and has used them to calculate pCu and interpret data results on the site in many AOC reports for over the last 14 years. It is not Chino's intention to recalculate the pCu prediction equations from the 1999 ERA.

The geochemistry in the STSIU soils is different than that of the soils used in Sauve et al. This difference is why a field study, with site specific species, is warranted. Chino is not saying that the toxicity threshold will necessarily be different because the predictive pCu equation is different. However, given different geochemistry, Chino is also not assuming toxicity in Sauve will be similar to that of the STSIU.

Section 2.01 has been updated to add additional clarity regarding site specific geochemistry and the objectives of this study.

NMED Followup Response:
The revised text is still incorrect in stating that "They calculated pCu for each study using equations predicting pCu from a dataset reported in Sauvé et al. (1997)." The ERA developed site-specific equations based on the methods of Sauvé et al. (1997). This is an important distinction because the paragraph goes on to state that "...pCu thresholds from the literature may not be applicable to Chino." The relevance of this statement is not clear since no literature (i.e., non-Chino site) pCu thresholds have been applied at Chino.

Also, change the fifth sentence to "Similar to the 1999 phytotoxicity study reported in the BERA (NewFields 2005),..." since technically NewFields did not do the 1999 phytotoxicity study.

Chino Followup Response: The second paragraph in Section 2.01 has been revised to remove any discussion of cause/effect and discussion of literature pCu thresholds. NMED's above comment that Chino is still incorrectly stating that "They calculated pCu for each study using.....Sauve et al. (1997)" is incorrect. The "They" Chino is referencing is Sauve et al. not NewFields.

The fifth sentence has been updated per NMED's request.

NMED Followup Response 2:
The fifth sentence does not appear to be updated in the most recent workplan per NMED's request. Therefore, please change the now second sentence (formerly fifth sentence) of the second paragraph to:

> "The 1999 phytotoxicity study for the site wide BERA reported in Newfields (2005) included site-specific measurements of pCu, toxicity to standard test species, and field measures of plant community composition and structure. This study extends the analysis by evaluating the pCu toxicity to the native plant species both from nursery seeds and seeds collected from the STSIU, and the potential effects of precipitates from the 'white rain' event on soil pCu and toxicity."

NMED Comment 12. Section 2.1, page 6. Delete footnote #1 since extremely low pCu soils were eventually located and collected.

Chino Response: Footnote #1 has been removed as low pCu has been confirmed on collected soils. Note, the soil with copper concentrate (95,300 mg/kg) was eliminated as not representative of Chino soils and lowest pCu expected is in the 2 to 3 range.

Chino has also updated Figure 1 to only include the 33 sample locations that will be used in the phytotoxicity greenhouse study. There were 5 low pCu samples collected, but only two of those samples have been retained for inclusion in the greenhouse portion of the study.

NMED Followup Response:
NMED notes the changes. Please also delete the asterisk and explanation in Table 2 "* - if suitable soil cannot be found on site, Site soil will be modified to produce adequately low pCu," which is no longer necessary. Please include the final results of the laboratory testing for copper and pH as well as the calculated pCu for the 33 soil sample locations in the phytotoxicity experiment in a new table.

Chino Followup Response: Chino has removed the "" footnote in Table 2. The laboratory results for copper, pH, calculated pCu, and measured pCu are attached in Table 1. These results will be presented in the final report, thus Chino does not see the necessity in including them in the workplan.*

NMED Followup Response 2:
NMED notes the change. Providing the Table 1 information separately from the workplan now, and later in the final report is acceptable.

NMED Comment 16. Section 2.1, page 9: Describe how the pH of greenhouse well water will be decreased to approximately 6 to mimic the rainfall pH.

Chino Response: The greenhouse will use bottled water and will adjust the pH using dilute HCL.

NMED Followup Response:

NMED assumes that the bottled water will be analyzed and the starting chemistry of that water reported.

Chino Followup Response:
None given

NMED Followup Response 2:
The workplan on page 8 was updated to now use "filtered tap water" as discussed during a conference call, but the well water chemistry data in Appendix C appears to be missing:

> "Pots will be manually watered from above using filtered tap water with its pH decreased to approximately 6 to mimic rainfall pH on the STSIU prior to irrigation (ARCADIS 2008; see Appendix C for well water chemistry [emphasis added])." p.8

NMED Comment 18. Section 2.2, page 9, first paragraph. The ERA analysis of data used a one-variable linear analysis, but it was based on the pCu scale, and so is fundamentally logistic. Do you plan transform pCu data further? Do you plan to transform the phytotoxicity test data?

Chino Response: The pCu scale is not logistic (S-shaped) but logarithmic. Chino expects to use dose-response modeling, which is S-shaped, or whichever model best fits the data. An example is the following nonlinear equation:

$R = R_{max}/[1 + (EC50/10^{-pCu})^{slope}]$

where R is the control-normalized response endpoint. pCu is entered directly into this equation, which is exponentiated to transform it to cupric ion activity. The three other parameters in this equation would be estimated using non-linear regression and are the asymptotic maximum response (Rmax), median effects level of cupric ion activity (EC50), and slope. The EC50 of cupric ion activity can be back-transformed to an EC50 in pCu units.

Seed type can easily be added as a categorical covariate to this non-linear equation (allowing the parameters to differ for each seed type). If continuous variables must be added to account for confounding factors, the non-linear equation will be transformed to its logit form and re-arranged to allow estimation of the three non-linear parameters and coefficients for the covariates. Full and reduced (minus covariates) versions of the models will be compared with an F test to evaluate if the additional covariates are significant.

NMED Followup Response:
Does the use of the EC50 in the above equations represent a change from the ECxx values shown on page 9? If so, please explain.

Chino Followup Response: No, the above equation can be used with any of the ECxx values shown on 9. The derivation of the non-linear equation can be seen below (Meyer and Adams, 2010):

Derivation of Nonlinear Regression Equation to Estimate an ECx from Phtyotoxicty Data

A general logistic concentration-response curve for a survival, growth, or reproduction response (R) of an organism to a specified chemical activity of cupric ion ($\{Cu^{2+}\}$) can be written as:

$$R = \frac{R_{max}}{1 + \left(\frac{EC50}{\{Cu^{2+}\}}\right)^{slope}}$$

Eqn. 1)

Equation 1 is derived from a linear-log-logit function:

$$\log\left(\frac{R_{max} - R}{R}\right) = -slope \cdot [\log(\{Cu^{2+}\}) - \log(EC50)]$$

(Eqn. 2)

At x% effect, log({Cu2+}) = log(ECx). For example, at 20% effect, log({Cu2+}) = log(EC20). Therefore, Equation 2 can be rewritten as:

$$\log\left(\frac{x}{100 - x}\right) = -slope \cdot [\log(ECx) - \log(EC50)]$$

(Eqn. 3)

After rearrangement of Equation 3,

$$\log(EC50) = \log(ECx) + \frac{\log\left(\frac{x}{100 - x}\right)}{slope}$$

(Eqn. 4)

Now substitute Equation 4 into Equation 2, and replace log({Cu2+}) with -pCu to produce:

$$\log\left(\frac{R_{max} - R}{R}\right) = -slope \cdot \left[-pCu - \log(ECx) - \frac{\log\left(\frac{x}{100 - x}\right)}{slope}\right]$$

(Eqn. 5)

And a covariate (e.g., DOC concentration) could be added, as follows:

$$\log\left(\frac{R_{max} - R}{R}\right) = -slope \cdot \left[-pCu - \log(ECx) - \frac{\log\left(\frac{x}{100 - x}\right)}{slope} + a \cdot \log(DOC)\right]$$

(Eqn. 6)

Rearranging Equation 6 to isolate R on the left-hand side of the equation produces:

$$R = \frac{R_{max}}{1 + 10^{slope \cdot \left[-pCu - \log(ECx) - \frac{\log\left(\frac{x}{100 - x}\right)}{slope} + a \log(DOC)\right]}}$$

(Eqn. 7)

For example, for an EC20, log(x/(100 – x)) = log (20/(100 – 20)) = log(0.25) = -0.60206 . Note that instead of using base 10 logarithms, log could represent the natural logarithm (and the "10" in the denominator would then have to be changed to "e"). Use nonlinear regression to solve Equation 7 for Rmax, slope, ECx, and a (using pCu and DOC as the independent variables). The results from the non-liner ECx will provide the confidence limits around the value.

Meyer, J.S., and W.J. Adams. 2010. Relationship between biotic ligand model-based water quality criteria and avoidance and olfactory responses to copper by fish. Environmental Toxicology and Chemistry 29 (9): 2096–2103.

NMED Followup Response 2:
Thank you for the explanation. But we should have been clearer in the initial comment. The question is whether Chino intends use of the EC50 specifically for the PEL or DEL. We assume not, because of the discussion in Section 2.2, but as noted above, the PEL is left out of that discussion.

NMED Comment 22. Section 4.0: It is important that Chino and NMED agree on analysis and interpretation of results from this study before the FS draft is completed. For example, any remediation goals derived from this study will be important in the detailed analysis of the Remediation Alternatives. Discussion and a draft of the analysis report prior to the draft FS is appropriate and requested.

Chino Response: Comment noted and Chino agrees.

NMED Followup Response:
NMED notes the response, but would appreciate this change be included in Section 4.0.

Chino Followup Response:
None given

NMED Followup Response 2:
NMED notes and appreciates the change. For clarity purposes, please change the second to last sentence to "The results of the phytotoxicity study and vegetation community analysis will be provided, discussed with, and reviewed by NMED before the draft FS Report."

NMED Comment 23. Figure 2: Please explain why there are nine reference sites displayed when only five are mentioned in the text and tables?

Chino Response: This was an error; Figure 2 has been updated to include only the 5 locations where reference soil was sampled.

NMED Followup Response:
NMED notes the change, but requests that a new column be added to Table 7 with calculated pCu. Table 7 needs to be resorted by name for ease of comparing to Table 6.

Chino Followup Response: Chino has included the calculated pCu and resorted Table 7 as requested.

NMED Followup Response 2:
NMED notes the changes. However, there are now some inconsistencies in the table number references in Section 3.0 since there is no Table 8, and Table 7 doesn't contain OAT data.

Additional details to address:

- Cover page, spine, and footer still state "Draft"
- The date in the footer after page 1 needs to be updated.
- "Reference" needs to be changed to "De Minimus" in Footnote 3 (page 9), and the first sentence and second to last sentence of Section 3.0

References

Kopittke, P.M., Blamey, F.P.C., Sheldon, A.R., and N.W. Menzies. 2009. Tolerance of perennial grasses to high copper in sand culture. Environmental Chemistry 6: 253-259.

Kopittke, P.M., Blamey, F.P.C., Asher, C.J., and N.W. Menzies. 2010. Trace metal phytotoxicity in solution culture: a review. Journal of Experimental Botany 61(4): 945-954.

Nagajyoti, P.C., Lee, K.D., and T.V.M Sreekanth. 2010. Heavy metals, occurrence and toxicity for plants: a review. Environmental Chemistry Letters 8: 199-216.

Paschke, M.W., and E.F. Redente. 2002. Copper toxicity thresholds for important restoration grass species of the Western United States. Environmental Toxicology and Chemistry 21(12): 2692-2697.