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Comments on the Colstrip Stage I and II Evaporation Ponds Report

July 24, 2013

Geo-Hydro, Inc (GHI) has reviewed the Stage I and II Evaporation Ponds Report that was prepared for PPL Montana, LLC by Hydrometrics, Inc., dated May 2013. Our specific comments and observations are referenced to sections of that report although many of the comments are in fact applicable to multiple sections.

General Comment

Section 3.6 of this report includes the general statement, "Overall, groundwater quality in remedial areas of the SOEP and STEP has shown improvement". There are several reasons why this assessment appears to be premature and overly optimistic, including:

- The apparent size of the groundwater plumes continues to expand. Monitoring and modeling results continue to drive expanded characterization and remediation activities in area not previously known to be impacted by process water (See section 5.0 and 6.0).

- The location of the leading edge and concentration gradients within the plumes are not identified. The concentration of contaminants in pumping wells says nothing about the location or movement of the leading edge or changes in plume footprint area. Annual iso-concentration maps showing the distribution of the various process water indicator parameters are needed to evaluate how the plume is responding to attempted remediation.

- The assessment of calculated improvements in groundwater quality may not reflect general groundwater quality. The assessment is performed only on pumping wells, many of which are subject to severe scaling problems. The chemical and biological processes that cause the observed scaling may remove contaminants from solution in the immediate vicinity of the pumping wells. The chemical composition of groundwater in areas distant from pumping wells is likely not changed.

- The assessment of calculated improvements in groundwater quality is based only on measured specific conductance in pumping wells. Monitoring data provides several examples where concentrations of other process water indicator parameters have increased while measured specific conductance has decreased. Basing the assessment of improvements on only one parameter that may or may not reflect groundwater quality at a particular location is highly suspect.

- A mass balance for process water constituents has apparently not been done. Calculation of the total mass of various contaminants remaining in groundwater, mass removed in treatment systems, and mass added through new seepage is a useful exercise that is commonly utilized at large plume remediation sites. The mass balance exercise would result in a more useful and potentially believable evaluation of remedial success.

Specific Comments

1. **Page 2-2, Section 2.2.6, Pond Seepage Estimates** – This section of the report provides estimates of seepage from each of the lined units in the area. The discussion of lithology and hydraulic conductivity indicates that the calculations assume the presence of 10-feet of low permeability clay beneath pond liners and above the alluvium. The limiting permeability in the calculated seepage estimates is that of the clay. Greater seepage could occur if liner defects are in contact with sediments with higher hydraulic conductivity and the presented seepage estimates should be viewed as minimum seepage estimates.

   The permeability of the clays that are assumed to be present beneath each of the liners may not be as low as assumed. Highly mineralized leachate from the ponds through clay minerals may have altered the mineralogy of clay materials such that the hydraulic conductivity may be significantly higher now when originally tested. Seepage estimates based on the original conductivity values may therefore underestimate current seepage rates.

2. **Page 3-33, Section 3.4.1, Site Hydrogeology** – Cross-sections referenced in this section (Figures 3-1, 3-2 and 3-3) each show units that are not identified on the legend. Each of the drawings show a green-dashed unit that needs to be identified.

3. **Page 3-40, Section 3.4.2, Distribution of Indicator Parameters** – This section of the report makes the claim that concentrations of bromide in wells 922A, 924A, and 2019D below 5 mg/l indicate that water is not currently seeping from the ponds. This conclusion is not supported by the available data. The highest concentration of bromide detected in any SOEP and STEP area wells (including those known to be severely impacted by process water) in 2012 was only 4 mg/l. Many of the 2012 groundwater analyses reported no detectable bromide even though other process water indicator parameters are often very high. Dilution of leachate released from impoundments results in concentrations of bromide and all other indicator parameters well below the concentrations observed in the source. Any detection of bromide in area monitoring wells is a potential indication of process water impacts.

   However, bromide concentration is not a singular indicator of process water impacts. The entire data set, including multiple indicator parameters, must be evaluated to identify impacted locations. Analytical results for bromide, boron, specific conductance, and sulfate reported for each of these wells in 2012 are listed below.

Well No.	Sample Date	Bromide (mg/l)	Boron (mg/l)	Specific Conductance (umhos/cm)	Sulfate (mg/l)
922A	3/23/2012	2	27	9,360	10,700
922A	9/6/2012	2	25.8	9,350	11,100
924A	3/23/2012	2	14.6	10,170	8,210
924A	9/6/2012	2	15.2	10,420	8,320
2019D	7/12/2012	1	10.5	5,600	4,330
2019D	9/6/2012	1	11.2	5,620	4,010

Note: Data taken from MDEQ 2012 Monitoring Data files.

The data show that along with bromide; boron, specific conductance and sulfate are all very high. All of these wells are clearly impacted by process water with wells 922A and 924A showing higher impacts than well 2019D. Current seepage from the ponds is therefore likely.

4. **Page 3-56, Section 3.5.2, Groundwater Mitigation Activities** – Scaling problems have made it necessary to operate "the majority of systems without flow meters." Flow is being measured as sampling ports without back pressure causing overestimation of flow and calculated capture volumes that can reportedly "be 100 percent or more". These overestimated pumping rates are used as input values for the groundwater model. The groundwater model and estimates of groundwater capture derived from that model may be flawed by input of pumping rates known to be seriously overestimated in some cases.

5. **Page 3-59, Section 3.5.4, Planned SOEP and STEP Site Activities** – The 5th bullet in this section claims that Cell A, Cell E and the Old Clearwell seem to be containing water based on low levels of bromide detected in wells 922A, 924A, and 2019D. See comment on page 3-40 for further discussion.

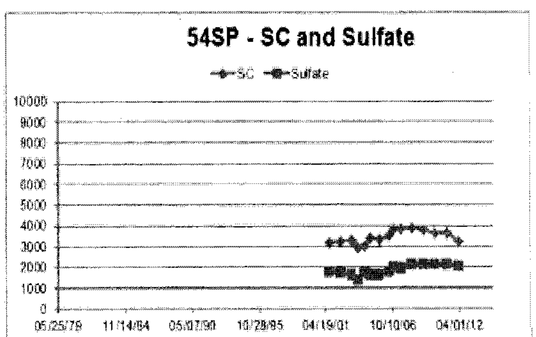
6. **Page 3-60, Section 3.6, Effectiveness Assessment of Remedial Action** – Lowering the head around a well by pumping can induce precipitation of dissolved minerals in and around the well, thus lowering concentrations in samples collected from the well. This is a common occurrence that is documented in several portions of the report that describe scaling of wells, pumps, and piping associated with the remediation system. The apparent decrease in concentration in pumping wells may be caused by chemical and/or biological processes in and immediately around the pumping well and not necessarily reflective of the chemical composition of groundwater measured in non-pumping monitoring wells.

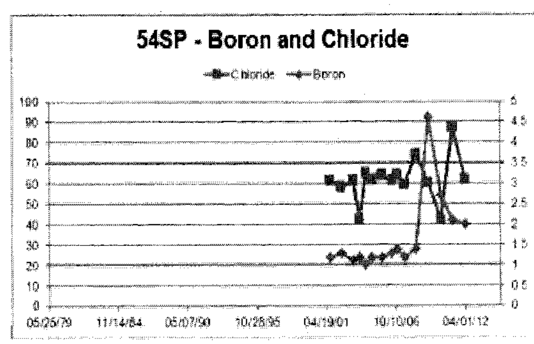
7. **Page 3-60, Section 3.6, Effectiveness Assessment of Remedial Action** –The effectiveness of remedial actions should evaluate changes in water chemistry across the entire site rather than evaluating only capture wells. Basing the assessment of remedial action effectiveness solely on

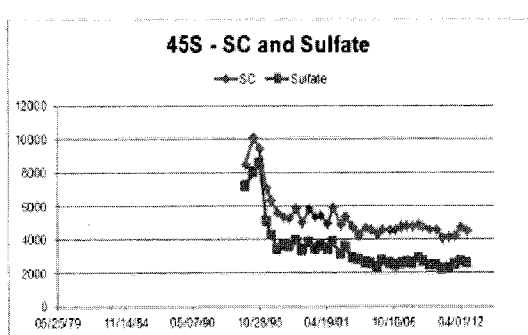
extraction wells without considering water quality in monitoring wells between extraction points provides an incomplete and skewed description of remediation effectiveness. Construction of isoconcentration maps based on both monitoring and capture well water chemistry data are needed.

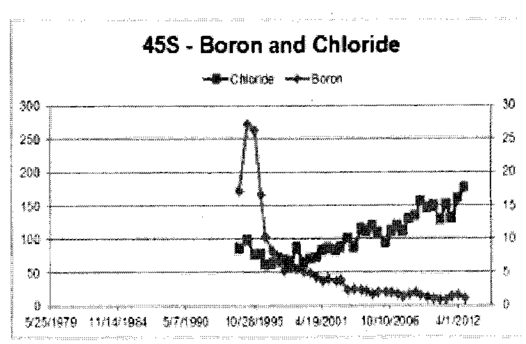
8. **Page 3-60, Section 3.6, Effectiveness Assessment of Remedial Action** – Changes in indicator parameter concentration in capture wells provide no insight into the size of the footprint of the contaminant plume. The location of the leading edge of contaminant plumes migrating away from the ponds should be identified. The size of the contaminant plume should diminish over time if remedial measures are effective. Continuing identification of process water impacts in areas not previously known to be impacted such as well 2024D and groundwater model report recommendations for further investigation of areas north of the SOEP and STEP appear to indicate that the footprint of the known groundwater plumes continue to grow in size.

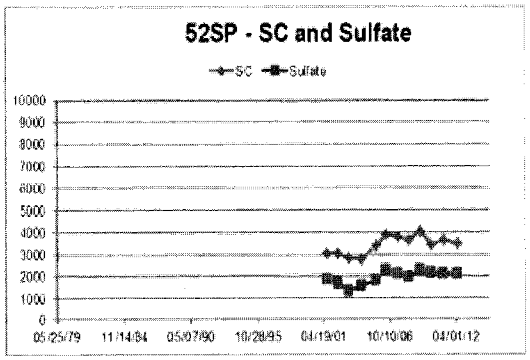
9. **Page 3-60, Section 3.6, Effectiveness Assessment of Remedial Action** – The evaluation of remediation effectiveness is based on evaluation of specific conductance rather than evaluating the full suite of indicator parameters. Review of analytical data plots from other plant areas (examples shown below) show many instances where other parameters such as boron, sulfate, or chloride have increased concurrent with steady or declining specific conductance. The specific conductance measured at an extraction well is therefore not necessarily reflective of overall groundwater quality, even at a specific well.

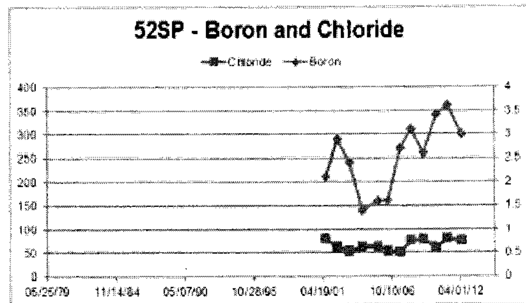






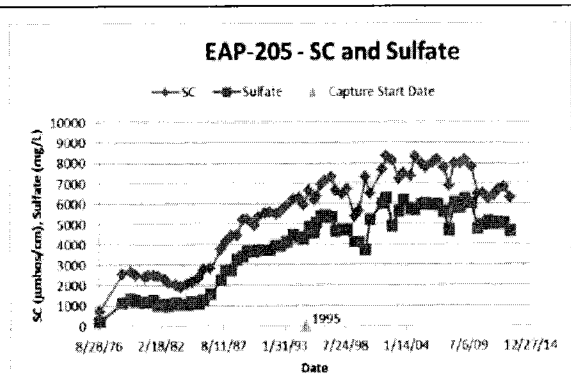


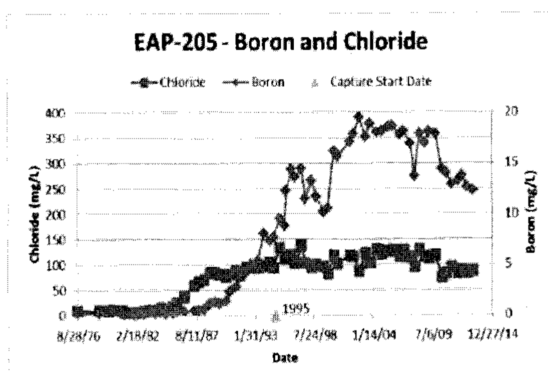


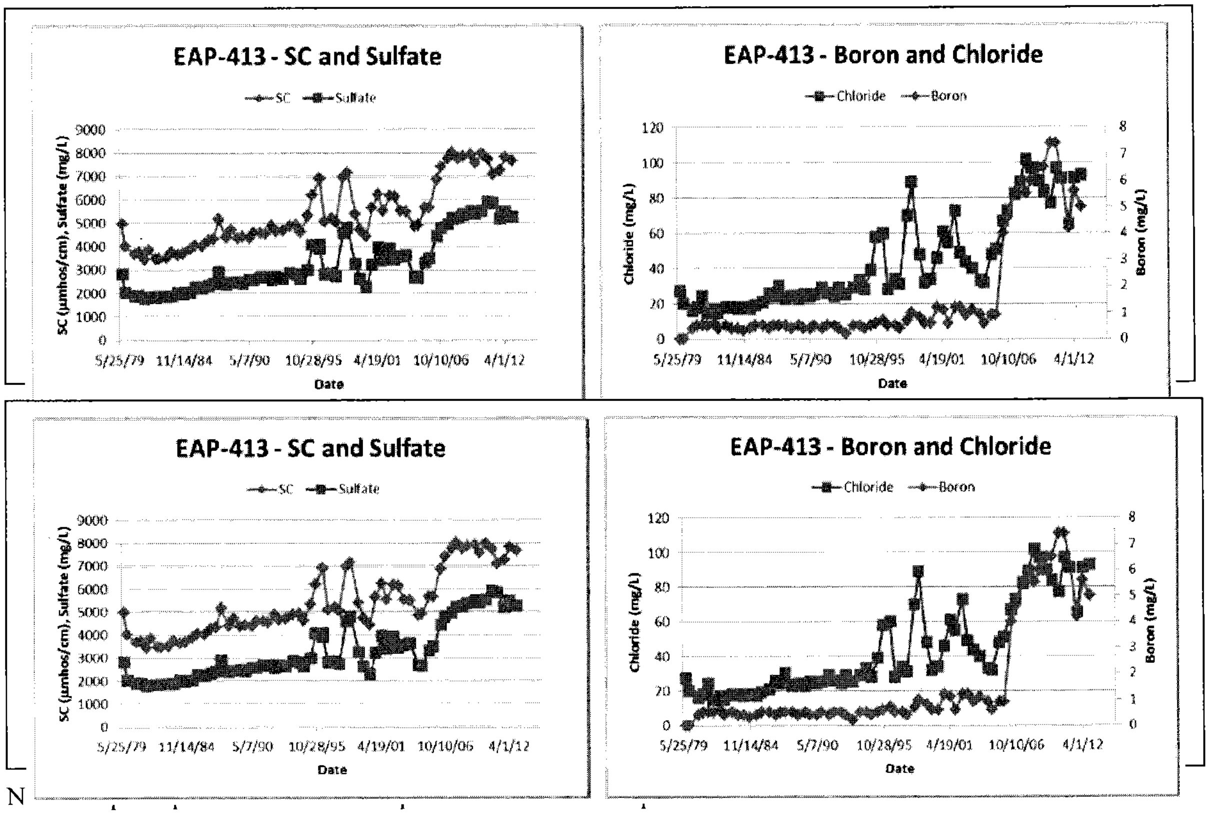


Note: Graphs reproduced from Colstrip 2012 Plant Site Report

10. **Page 3-60, Section 3.6, Effectiveness Assessment of Remedial Action** – The apparent effectiveness of remedial measures is calculated by comparing recent measurements of specific conductance in SOEP and STEP capture wells to the highest specific conductance ever measured in those wells. Calculated improvements in groundwater quality, based only on specific conductance, are reported to range from 2 to 63 percent. This evaluation can be put in context by examining some of the long-term graphs of indicator parameter data included in the report. The data graphs for EAP-119 (Fig 3-14), EAP-205 (Fig 2-15), and EAP-413 (Fig 3-17A) each show plots of indicator parameter concentrations extending back into the 1970's (below). Each of these long-term data records show that even though the most recent analyses are below the highest concentrations ever recorded at these locations, concentrations of all process water indicator parameters remain very high and in most cases are several times the concentrations measured before operation of the ponds was initiated.







11. **Page 3-72, Section 3.7, On-Going Investigations/Activities -** Further investigation/mitigation work is planned or on-going in the vicinity of wells 2024D, 2025D, and PW-704. The groundwater model report recommended additional investigation north of SOEP between 355D and 903D, and additional well installations between 902D and 903D, and downgradient of wells 970D and 971D. These facts all indicate that that the lateral and vertical extent of process water impacts has yet to be fully identified. Iso-concentration maps showing the concentration of process water indicator parameters should produced annually to provide for annual comparison of the extent of the impacted area. The total mass of each process water indicator above natural background concentration should be calculated on an annual basis in order to document remedial progress.

12. **Page 4-1, Section 4.0, Groundwater Model Results and Interpretation** - The capture zone analysis conducted during the model update used pumping rate information that has been acknowledged to overstate pumping by 100% or more in some wells. Inclusion of erroneous pumping rates into the model would result in inaccurate capture zone identification. The groundwater model and capture zone simulations created from the model are therefore of questionable validity.

13. **Page 5-1, Section 5.0, Identification of Data Gaps** – The data gaps identified in this section (like the on-going investigations discussed in comment #12) highlight several areas of investigation that need to be completed to fully characterize the site. It is likely that the footprint of the area of impacted groundwater will expand further as additional characterization is completed. Iso-concentration maps showing the concentration of process water indicator parameters should produced annually to provide for annual comparison of the extent of the impacted area. The total mass of each process water indicator above natural background concentration should be calculated on an annual basis in order to document remedial progress.