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DRC-2016-010010

MEMORANDUM

TO: File

THROUGH: Phil Goble, Manager PRG 9/13/16

FROM: Tom Rushing, P.G. JR 9/13/16

DATE: September 8, 2016

SUBJECT: Review of the June 24, 2016 Energy Fuels Resources (USA) Inc. Source Assessment Report for MW-18 and MW-24, White Mesa Uranium Mill Ground Water Permit No. UGW370004

I. Review Summary:

A June 24, 2016 Source Assessment Report ("SAR") for sulfate in Monitoring Well MW-18 and fluoride, field pH, cadmium and thallium in Monitoring Well MW-24 was submitted to the Director by Energy Fuels Resources (USA) Inc. ("EFR"), received by the Utah Division of Waste Management and Radiation Control ("DWMRC") on June 24, 2016. The SAR was submitted for review and approval of proposed revised Ground Water Compliance Limits ("GWCL's") in the White Mesa Uranium Mill Groundwater Discharge Permit, Permit No. UGW370004.

The SAR provides an analysis of potential sources of the contamination for determination as to whether the uranium mill activities are the source of the ground water permit compliance limit exceedances, and a statistical evaluation and calculations of proposed modified GWCL's. EFR states generally in the SAR that *"This SAR addresses the constituents that were identified as exceeding the previously revised GWCLs in the fourth quarter of 2015 as described in the DWMRC-approved Q4 2015 Plan and Time Schedule. As noted above this SAR also addresses cadmium and thallium in MW-24 which EFR has added voluntarily."*

EFR uses the following categories for assessment for monitoring wells MW-18 and MW-24:

- MW-18 -- 1. Indicator Parameter Analysis, and, 2. Constituents in Wells with Previously Identified Increasing Trends
- MW-24 -- 1. Indicator Parameter Analysis, 2. Constituents in Wells with Previously Identified Increasing Trends, and, 3. Other Constituents and Wells (University of Utah Study)

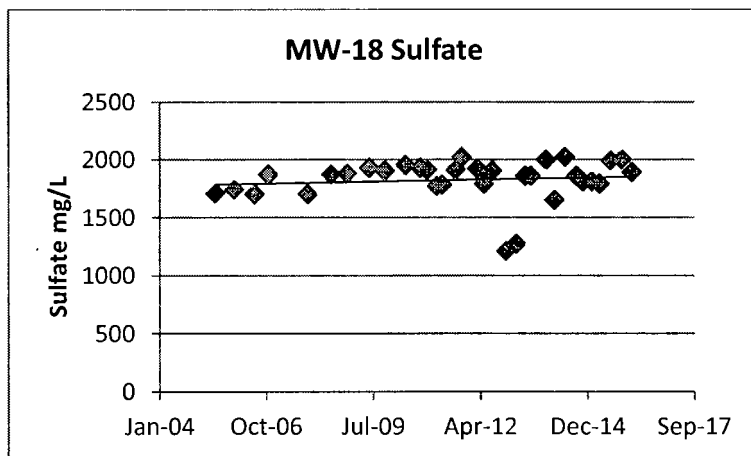
The SAR additionally discusses changes in groundwater chemistry with reference to, 1. Well Redevelopment Activities, 2. Geochemical Influences (Potential Pyrite Dissolution), 3. Hydrologic Influences (Infiltration from the wildlife ponds), and, 4. Analytical Influences (Change of laboratory).

Specific discussion of the SAR assessments for sulfate in monitoring well MW-18 and cadmium, fluoride, pH and thallium in monitoring well MW-24 is below.

II. DWMRC Findings Regarding the SAR Assessments

Monitoring Well MW-18

Sulfate exceeded the GWCL in monitoring well MW-18 (1,938.9 mg/L) two consecutive times during the 3rd and 4th Quarters of 2015. A plot of the historic sulfate concentrations in monitoring well MW-18 is below:



EFR uses two categories of assessment to determine whether the mill is the source of the GWCL Exceedances; Indicator Parameter Analysis and Pre Identified Rising Trend. It is also noted that monitoring well MW-18 is located hydraulically upgradient from the mill site. Discussion of these is below:

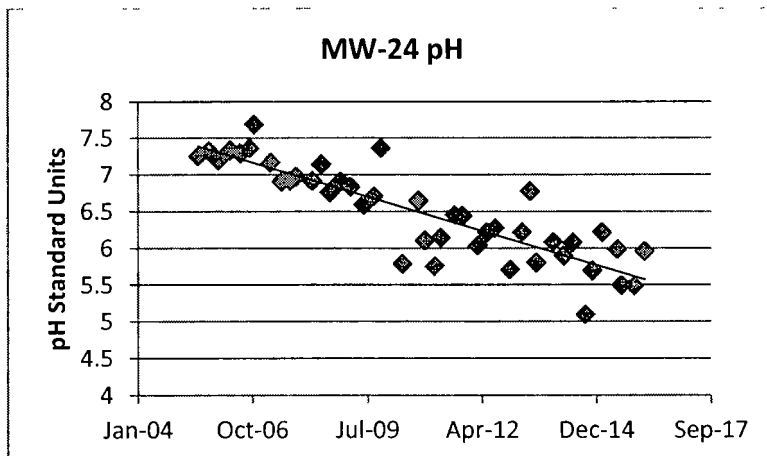
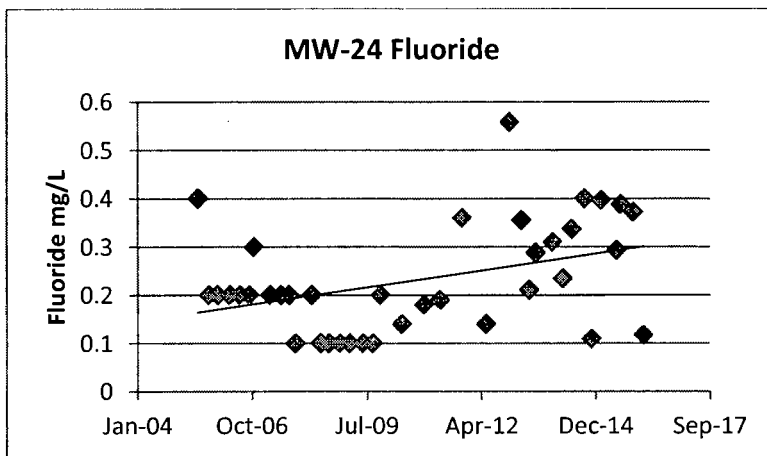
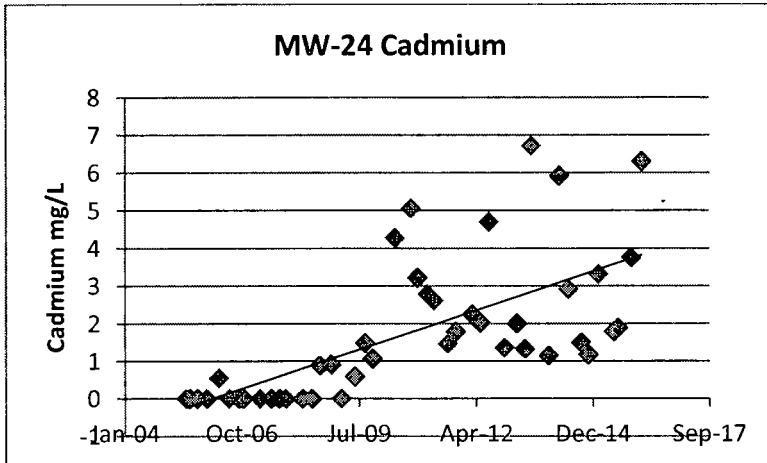
Indicator Parameters – Per DWMRC review of indicator parameter (Cl, Fl, SO₄ and U) trends using all data it is noted that chloride is showing a slight increasing trend, fluoride is showing a decreasing trend, uranium is showing a decreasing trend and sulfate is showing a slight increasing trend. The trends do not indicate seepage of tailings solution.

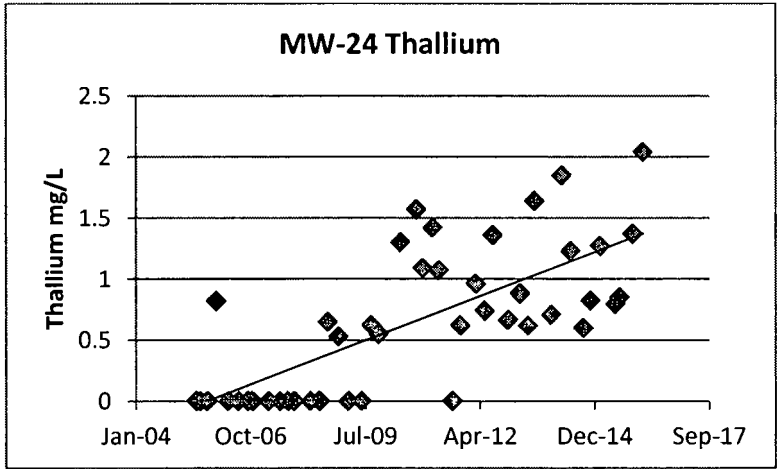
Pre Identified Rising Trend – The SAR (p. 10) notes that “Sulfate concentrations in upgradient well MW-18 have been significantly increasing since the time of the Existing Wells Background Report.”

Per a letter signed by the Director and dated April 25, 2013, Ground Water Compliance Limits (GWCLs) will be removed from the Permit based on the location of the well, hydraulically upgradient from Mill activities and waste storage. This was also noted by EFR in Section 3.4.1 (p. 11) of the SAR. Since all GWCLs will be removed from the Permit for MW-18, the statistical analysis and proposed modified GWCLs in the SAR were not reviewed. However, Per DWMRC review of the SAR and ground water monitoring data, it does not appear that Mill activities or tailings solution discharge are the source of the increasing sulfate concentrations in monitoring well MW-18.

Monitoring Well MW-24

Plots of data for the four monitoring well MW-24 parameters subject to the SAR are below. It was noted that cadmium, fluoride, and thallium plots all show an increasing trend, and that pH shows a decreasing trend.

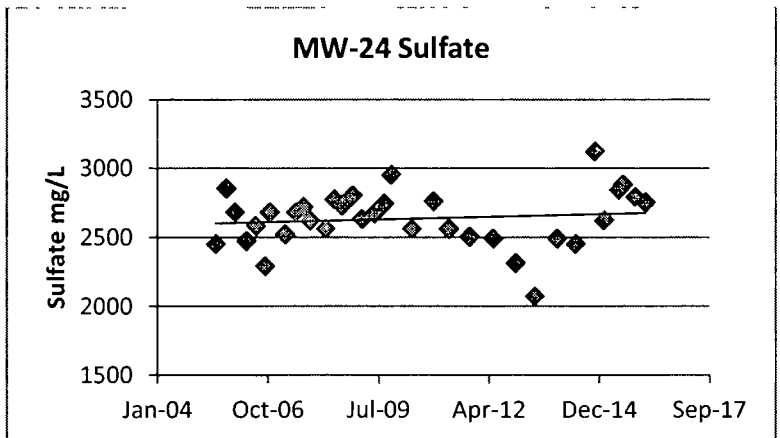
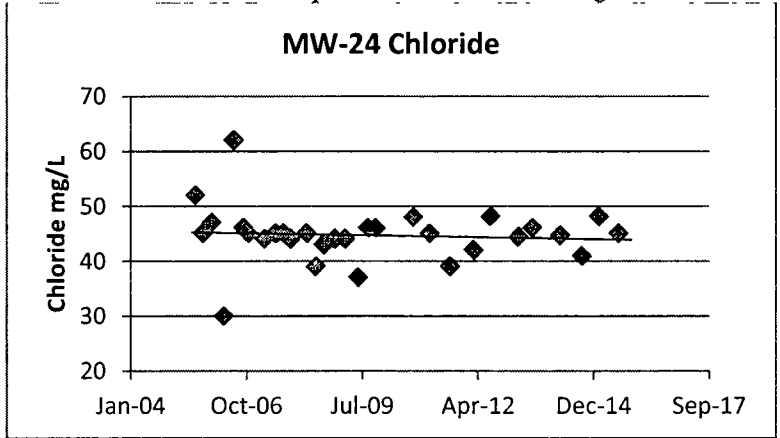


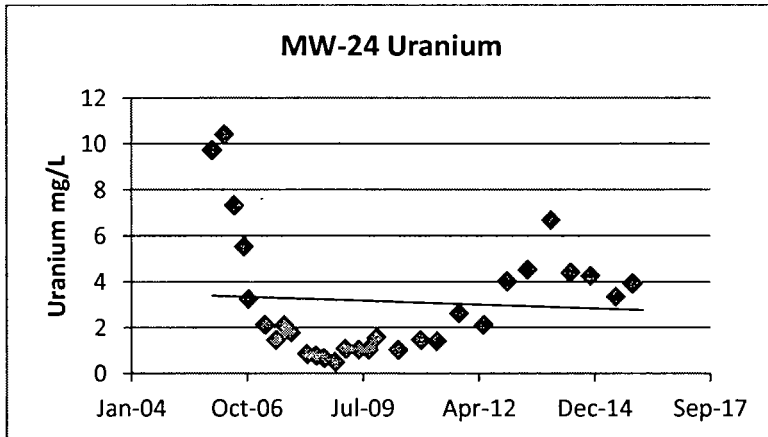


Indicator Parameter Analysis

Per review of the plots of indicator parameters it was noted that chloride, sulfate and uranium are not showing increasing or decreasing trends, per above fluoride is showing an increasing trend. Based on review of the indicator parameters trends and concentrations it does not appear that tailings solution is the cause of GWCL exceedances for cadmium, thallium and fluoride or for the decreasing pH.

Plots of data for indicator parameters in monitoring well MW-24:





University of Utah Study

The 2007/2008 University of Utah Study which included ground water age dating of the water in tailings cell 1, the wildlife ponds, and comparison with groundwater age and which included monitoring well MW-2 (near MW-24) found that “stable isotope fingerprints do not suggest contamination of groundwater by tailings cell leakage, evidence that is corroborated by trace metal concentrations similar to historically observed concentrations.” The University of Utah Study included sample collection for several constituents (trace metal and radiological samples) and evaluated isotopic ratios which indicated that at groundwater monitoring locations where “recent” recharge is evident, it most likely occurred due to seepage from the wildlife ponds.

Pre-Identified Increasing Trends

Per the SAR, decreasing trends were identified for pH in monitoring well MW-24 at the time of the new wells background report and the decreases were additionally studied in the EFR November 9, 2012 pH Report. Increasing trends were identified for cadmium and thallium in the 2012 EFR Source Assessment Report. EFR notes that cadmium and thallium are soluble at lower pH and discusses that decreasing pH appears to be causing increases in certain metals concentrations in the wells.

EFR has proposed that oxidation of pyrite may be causing pH decreases which have been noted at monitoring wells upgradient and far downgradient from the Mill tailings cells. Per the EFR November 9, 2012 pH Report, it is concluded that adequate pyrite exists in the mineral matrix in core below the water table to cause the observed decreasing pH trends. It is hypothesized that oxygen may have been introduced into groundwater around the monitoring well screens from infiltration from the wildlife ponds or may be due to activities to overpump and re-develop the well screens. The DWMRC has concluded that pyrite dissolution is a possible explanation for the decreasing pH trends.

Conclusions

Based on DWMRC review of the EFR SAR, there is no clear indication that tailings solution is causing the parameter exceedances and increasing concentration trends. This is based on review of the indicator parameters, review of site data, review of the University of Utah Report, and review of the EFR SAR.

III. EFR Proposed Modified Groundwater Compliance Limits

Sulfate in Monitoring Well MW-18

Per discussion above, EFR provided a proposed modified GWCL for sulfate in monitoring well MW-18, however, since this is an upgradient well, GWCL's will be removed for this monitoring location, the statistical review and proposed GWCL were not reviewed.

Cadmium, Thallium, Fluoride and pH in Monitoring Well MW-24

The following statistical methods were used by EFR to develop the proposed modified GWCLs:

- Standard Deviation Calculation
- Shapiro-Wilk Test for Normality
- Least Squares Regression Trend Analysis (Normal or Lognormal Distribution)
- Mann-Kendall Trend Analysis (Non Normal Distribution)

The table below summarizes the EFR calculations and background rationale for the proposed TDS GWCL.

Table of EFR Proposed Revised GWCL's for Monitoring Well MW-24:

Well Number	Parameter	Location	Current GWCL	Approved 2012 Modified GWCL	Highest Historic Value	Calculated Mean + 2 α	DRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?
MW-24	Cadmium	Down Gradient	2.5 ug/L	4.28 ug/L	6.72	5.59	Per the flow chart 15-50 Percent Non Detects, and non-normally distributed data, alternate statistics (non-parametric) are to be used. GWCLs may be set by Mean + 2 α , HHV, or Modified Approach. Additional analysis is warranted for compliance with the flow chart.
MW-24	Fluoride	Down Gradient	0.36 mg/L	NA	0.558	0.47	Per the flow chart, 0-15 Percent Non Detects Column, Mean + 2 α to be used unless an upward trend is identified in which case a modified approach may be considered. Per DWMRC review of the data, Mean + 2 α appears appropriate.
MW-24	pH	Down Gradient	6.5 - 8.5	5.55 - 8.5	4.83	5.03	Per the flow chart, 0-15 Percent Non Detects Column, Mean + 2 α to be used unless an upward trend is identified in which case a modified approach may be considered. Per DWMRC review of the data, Mean + 2 α appears appropriate.
MW-24	Thallium	Down Gradient	1 ug/L	1.57 ug/L	2.1	1.76	Per the flow chart 15-50

Well Number	Parameter	Location	Current GWCL	Approved 2012 Modified GWCL	Highest Historic Value	Calculated Mean + 2 α	DRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?
							Percent Non Detects, and non-normally distributed data, alternate statistics (non-parametric) are to be used. GWCLs may be set by Mean + 2 α , HHV, or Modified Approach. Additional analysis is warranted for compliance with the flow chart.

Conclusions

Based on review of the statistical calculations, telephone conference with EFR, and consistent with the Director approved flow chart for the White Mesa Uranium Mill, DWMRC staff recommends that the GWCL’s for monitoring well MW-31 be modified as summarized on the table below:

Recommended Changes to GWCL’s

Well Number	Parameter	Current GWCL	Modified GWCL	Method of Analysis
MW-24	Fluoride	0.36 mg/L	0.47 mg/L	Mean + 2 α
MW-24	pH	5.55-8.5 S.U.	5.03-8.5 S.U.	Mean + 2 α

Based on DWMRC review of the statistical analysis for cadmium and thallium in monitoring well MW-24 it was noted that the data sets used were not normally distributed and that trend analysis showed increasing trends for both parameters. EFR proposes using the highest historical value from all data points for each parameter to modify the GWCL.

Per DWMRC review of the cadmium and thallium data sets it was noted that a large number of non-detects are included in the early time data, and that after 2009, the concentrations begin increasing. EFR attributes these increases as associated with declining pH due to pyrite oxidation in groundwater. For comparison it would be helpful for EFR to provide a separate analysis of the data sets as was provided in the December 9, 2015 SAR (Monitoring Well MW-31) using a divided data set based on an identified point of inflection in the data. Specifically, a data inflection is noted at approximately 2009 for cadmium and thallium in monitoring well MW-24. This comparison test is useful in that it may provide a normalized data set and a comparable and representative determination of mean + 2 α .

Per the December 9, 2015 SAR, DWMRC used the divided data set test as a comparison tool against mean + 2 α and Highest Historical Value and determined that since all of the results were in the same range it was appropriate to use the highest value of the three methods. Cadmium and Thallium in monitoring well MW-24 would benefit from this same type of analysis and should be submitted for review.

I. References

¹ Energy Fuels Resources (USA) Inc., June 24, 2016, *Source Assessment Report for MW-18 and MW-24*, Prepared by Intera

² Energy Fuels Resources (USA) Inc., June 6, 2012, *White Mesa Uranium Mill Ground Water Monitoring Quality Assurance Plan (QAP), Revision 7.2.*

³ United States Environmental Protection Agency (USEPA), 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, EPA 530/R-09-007*

⁴ INTERA Incorporated, 2007, *Revised Background Groundwater Quality Report: Existing Wells for Denison Mines (USA) Corp.'s White Mesa Uranium Mill Site, San Juan County, Utah.*

⁵ INTERA Incorporated, 2007, *Background Groundwater Quality Report: New Wells for Denison Mines (USA) Corp.'s White Mesa Uranium Mill Site, San Juan County, Utah.*

⁶ INTERA Incorporated, 2012, *pH Report White Mesa Uranium Mill*

⁶ Hurst, T.G., and Solomon, D.K., 2008. *Summary of Work Completed, Data Results, Interpretations and Recommendations for the July 2007 Sampling Event at the Denison Mines, USA, White Mesa Uranium Mill located near Blanding Utah.* Prepared by University of Utah Department of Geology and Geophysics.

⁷ Utah Department of Environmental Quality, August 24, 2012, *Utah Ground Water Discharge Permit, Permit No. UGW370004 issued for the Energy Fuels Resources (USA) Inc. White Mesa Uranium Mill.*