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DRC-2021-004704

MEMORANDUM

TO: File

THROUGH: Phil Goble, Manager PRG 1/19/2021

FROM: Tom Rushing, P.G. JR 1/19/2021

DATE: January 19, 2021

SUBJECT: Review of the Energy Fuels Resources (USA) Inc. (EFR), White Mesa Uranium Mill, Blanding, Utah October 19, 2020 Source Assessment Report for Selenium and Uranium in Monitoring Well MW-28
Ground Water Discharge Permit No. UGW370004 (Permit)

Summary

An October 19, 2020 Source Assessment Report ("SAR") for Selenium and Uranium in Monitoring Well MW-28 at the White Mesa Uranium Mill (Mill) was submitted to the Director by Energy Fuels Resources (USA) Inc. ("EFR") and received by the Utah Division of Waste Management and Radiation Control (DWMRC) on October 20, 2020. The SAR was submitted for review and approval of source assessment investigation findings and proposed revised Ground Water Compliance Limits (GWCLs) for selenium and uranium.

Monitoring well MW-28 is located on the southern berm of the Mill Cell 1 and is hydraulically downgradient from portions of Cell 1 and from the Mill processing and storage areas and historical upper wildlife ponds. MW-28 is within the area where migration of the nitrate/chloride plume would occur according to regional groundwater elevation data and flow lines. The nitrate/chloride plume at the Mill is regulated through a separate consent order (UGW12-04) issued by the Director. Per findings of the SAR, as discussed in detail below, "*the increasing trends in uranium and selenium in MW-28 are the result of implications from the nitrate/chloride plume.*" Based on DWMRC review of the SAR, historical data for MW-28, and previous conversations with EFR, it is likely that the current exceedances are due to the migration of the nitrate/chloride plume. Although the increasing parameter trends may eventually be regulated by the nitrate consent order, at this time further data and characterization of the plume migration is warranted and it is appropriate to modify GWCL's in the interim (GWCL's will not be raised above Groundwater Quality Standards in this case).

It was noted that monitoring well MW-28 was damaged by a mill vehicle during 2014. Damage occurred to the outer and inner casings and resulted in compliance issues with several monitoring parameters (uranium, vanadium, and cadmium). The well damage was repaired, and the well was over-pumped during the second quarter of 2014. Per review of the SAR and all historical groundwater monitoring data, the current OOC status for selenium and uranium are not associated with the previous well damage. It was

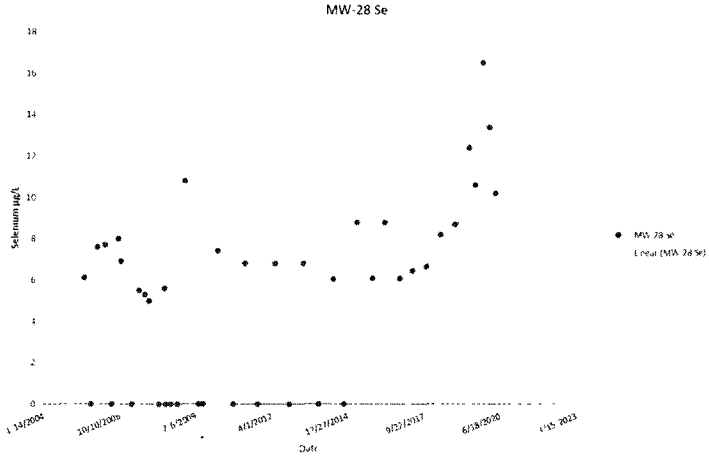
noted that the monitoring parameter results corrected and were reliable after completion of the EFRI corrective actions.

SAR Studies and Findings

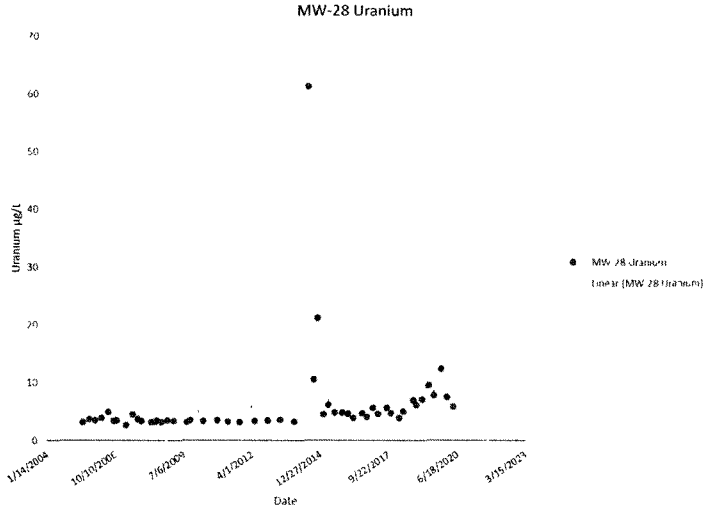
The October 19, 2020 SAR is broken up into four primary sections: 1. Approach for analysis of potential sources of the contamination; 2. Results of the analysis (e.g., sitewide pH, changes in groundwater in MW-28, indicator parameter analysis, and mass balance analysis); 3. Statistical evaluation and calculation of revised GWCL's for trending parameters, and 4. Conclusions and recommendations.

Figures below depict the time/concentration plots for selenium and uranium in monitoring well MW-28:

Selenium Data Plot of Historical Data at MW-28



Uranium Data Plot of Historical Data at MW-28



Both data sets show an inflection (rising trend) beginning post 2017.

Selenium – The SAR notes that selenium concentrations in MW-28 are relatively low for the site. The time series plots show variability in selenium concentrations prior to 2012 and an increase in concentrations following the 2014 damage and repair. A point of inflection is apparent showing an increasing trend post 2017. The SAR discusses that this trend is likely associated with the mobilization of naturally occurring selenium in the formation by nitrate from the nitrate/chloride plume, oxidation of selenium-bearing pyrite by nitrate, and generally elevated selenium concentrations within the nitrate/chloride plume.

Uranium – The SAR notes that uranium concentrations in MW-28 are relatively low for the site. A spike in concentrations is noted in 2014 associated with the well damage and repair. There is a point of inflection apparent in the post 2017 data where an increasing trend is evident. The SAR discusses that this trend is likely due to mobilization of naturally occurring uranium in the formation by nitrate in the nitrate/chloride plume, increased mobility of naturally occurring uranium resulting from increased bicarbonate.

EFR Results of Analysis

1. Site-Wide pH Changes

Section 3.1 of the SAR includes a discussion of sitewide pH changes, discussion includes past findings regarding pyrite oxidation by reaction with nitrate which has been discussed in EFR documents regarding geochemical reactions associated with the nitrate/chloride plume. The SAR specifically lists an oxygen/pyrite specific reaction and two nitrate/pyrite reactions, and notes that one of the nitrate/pyrite reactions can oxidize pyrite without decreases in pH, as appears to be occurring per the MW-28 data, and has been discussed at other monitoring wells within the nitrate/chloride plume (MW-30 and MW-31). The SAR specifically hypothesizes that the geochemical process at MW-28 is a nitrate/pyrite reaction which produces sulfate but consumes acid (SAR p. 8).

Section 3.1 also notes that although the overall trend in pH is flat, there is a slight increasing trend in pH since 2016. The rising pH is attributed to higher concentrations of bicarbonate at MW-28 and at other well locations where land surface has been graded flat and promotes additional surface water infiltration. Increased bicarbonate and increased nitrate in groundwater has been documented as associated with increased uranium in groundwater.

Per DWMRC review in the case of seepage of tailings wastewater there would be a decrease in pH associated with increasing concentration of indicator parameters. The data does not support a tailings source.

In this case, pH is rising, and parameter increases are apparently being caused by chemical reactions associated with the nitrate/chloride plume and not affected by acidic tailings wastewater.

2. Changes in Groundwater in MW-28

Section 3.2 of the SAR discusses changes in groundwater in MW-28 and notes that only 11 data points were available at the time of the background report. Significantly more data is now available. This section discusses changes in MW-28 groundwater which are consistent with impacts from the nitrate/chloride plume including:

1. Chloride has been generally increasing since the well was installed, however nitrate is lagging chloride due to likely degradation by pyrite.
2. Nitrate began increasing in late 2014.
3. Increases in selenium and uranium are directly related to increases in nitrate.
4. Selenium and uranium are observed to correlate directly with the nitrate/chloride plume in impacted monitoring wells. Reactions and literature sources are cited in the SAR.

Per DWMRC review this section describes an observed correlation between rising uranium and selenium concentrations with the nitrate/chloride plume and provides literature sources regarding possible geochemical reactions in the aquifer.

3. Mass Balance Analyses

The SAR includes a mass balance evaluation (Section 3.4 and Appendix D) for MW-28 and notes that the same method was recently used for another monitoring well located within the nitrate/chloride plume (MW-31). The mass balance model is based on current concentrations of fluoride, uranium, chloride, sulfate and selenium in MW-28, and mean concentrations of the same parameters in cell 1 wastewater (mean of data 2013 through current). This evaluation is the same method used to evaluate mass balance in the 2017 SAR for MW-31. The mass balance calculations evaluate the data for comparisons due to dilution and do not consider relative mobility of contaminants.

Based on large inconsistencies between the cell 1 tailings wastewater (TMS) concentrations and the expected diluted concentrations, the SAR concludes that "*TMS seepage is not a contributor to the groundwater chemistry at MW-28.*"

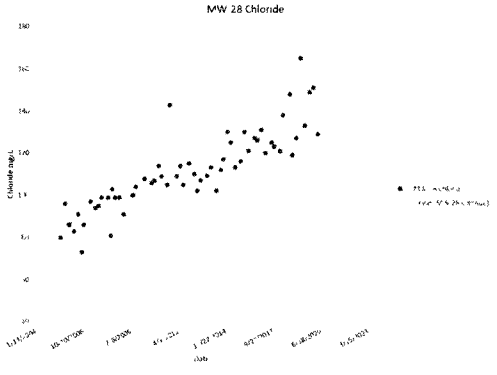
Per DWMRC review, the analysis indicates that the groundwater concentrations of these parameters in MW-28 are not consistent with a tailings source.

4. Discussion of Tailings Solution Groundwater Indicator Parameters at Monitoring Well MW-28

The SAR Section 3.3 discusses four primary indicator parameters (Chloride, Fluoride, Sulfate and Uranium) which would be detected in ground water in the event of discharge from the Mill tailings cells. Additionally, the SAR Appendix C-1 and C-2 present a summary of statistical analysis for indicator parameters.

Chloride

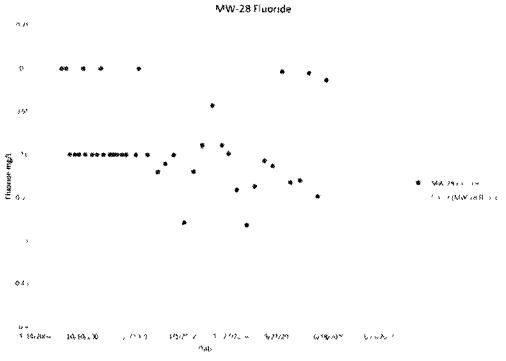
Figure – Chloride Plot of Historical Data at MW-28 – Increasing Trend



The use of chloride as an indicator parameter in the case of monitoring well MW-28 is complicated by the fact that MW-28 appears to be impacted by the nitrate/chloride plume, and chloride is therefore increasing and is not a reliable primary indicator of cell leakage for MW-28. Chloride at monitoring well MW-28 is now showing a significant increasing trend.

Fluoride

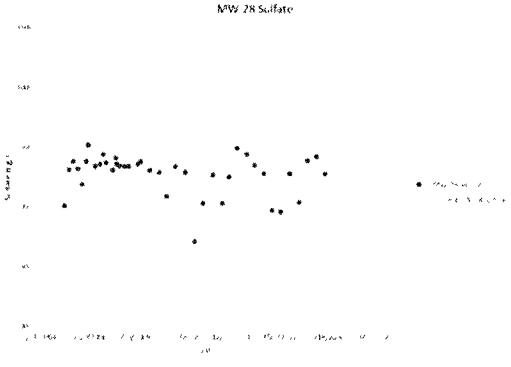
Figure – Fluoride Plot of Historical Data at MW-28 – Decreasing Trend



Fluoride concentrations were decreasing at the time of the Background Report and continue to show a decreasing trend.

Sulfate

Figure – Sulfate Plot of Historical Data at MW-28 – Decreasing Trend



Sulfate concentrations in MW-28 exhibit a slight decreasing trend.

Uranium

Uranium concentrations in monitoring well MW-28 were not showing a trend at the time of the background report and are very low compared to sitewide averages. Uranium is currently exhibiting a strong increasing trend associated with geochemical reactions associated with the nitrate/chloride plume.

Indicator Parameter Findings

Chloride is the best indicator of potential tailings wastewater seepage; however, chloride is not a good indicatory in MW-28 due to impacts from the nitrate/chloride plume. Analysis of fluoride and sulfate demonstrate that no trends are evident which is not indicative of a tailings wastewater source which would include steeply increasing trends in these parameters. Per analysis of the ratios of chloride to fluoride and of chloride to sulfate in the SAR, the ratios differ from average ratios of these constituents in cell 1 tailings wastewater. The increasing ratio of chloride to fluoride is consistent with impacts from the migration of the nitrate/chloride plume to MW-28.

5. University of Utah Study

Section 2.3 of the SAR summarizes the results of the 2007 University of Utah groundwater study at the mill which characterized the groundwater flow, chemical composition, noble gas composition and groundwater age to evaluate whether elevated trace metals concentrations noted in the background report were due to seepage from tailings wastewater. The study found no evidence of tailings cell 1 groundwater contamination at that time.

6. Source Assessment Conclusions

Section 3.5 of the SAR discusses the summary of results for evaluation of each of the SAR parameters at MW-28 (Selenium and Uranium).

Based on EFR evaluations and studies performed and discussed in the SAR, and DWMRC review as discussed above, it appears that the Out of Compliance status and rising trends for selenium and uranium are not due to the release of tailings wastewater but are due to impacts from migration of the nitrate/chloride plume.

EFR Proposed Modified GWCL Statistical Evaluation of Data:

Based on DWMRC review of the SAR statistical analysis it was noted that analysis was conducted for the complete historic data set for MW-28 and for a post 2017 data set. DWMRC notes that per the MW-28 selenium and uranium plots there is a shift in 2017 with rising concentrations. Per above the rising selenium and uranium concentrations are associated with the nitrate/chloride plume. The complete data set did not show normal or log normal distribution for selenium or uranium since the shift is an upward trend associated with the plume. The post 2017 data set did show normality for selenium and uranium.

EFR Statistical methods used in the SAR included: 1. Descriptive statistics for the complete and modified data sets; 2. Mean and Standard Deviation Calculation; 3. Shapiro-Wilk Test for normality; and 4. Mann-Kendall Trend Analysis (non-normally distributed data sets). Proposed GWCL's were calculated based on Mean + 2σ of the post 2017 data set, Highest Historical Value, and Fraction of the Groundwater Quality Standard. The calculations and findings are summarized on a table in the SAR (Appendix B-1 of the SAR).

Per the SAR Section 4.2, EFR proposed that GWCL's be adjusted according to 0.5 times the Groundwater Quality Standard, which is the highest calculation proposed in the SAR. The DWMRC approved statistical flow chart for the White Mesa Mill groundwater monitoring wells clarifies that if an upward trend is apparent for an analyte then a modified approach should be considered. The modified approach should allow for a GWCL which considers the increasing concentrations.

Based on the calculations of the post 2017 data set it was noted that a normal distribution was evident and that the proposed GWCL could be set according to mean + 2σ of the data. This is more reflective of current conditions in the monitoring well, is in conformance with the approved statistical flow chart, and considers the increasing trends. Additionally, the use of a modified post 2017 data set recognizes a data point of inflection and is consistent with the Environmental Protection Agency 2009 Unified Statistical Guidance.

The table below summarizes the EFR calculations and background rationale for the proposed modified GWCL's.

Table of EFR Proposed Revised GWCL's for Monitoring Well MW-28:

Well Number	Parameter	Current GWCL	EFR Proposed GWCL Revision	Method to Determine Proposed GWCL	DWMRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?	DWMRC Recommended Modified GWCL Based on SAR Review
MW-28	Selenium	11.1 µg/L	25 µg/L	Fraction of GWQS	Increasing Trend allows for modified approach on Flow Chart. Use of the post 2017 data set is appropriate and in conformance with EPA guidance since a data shift is noted corresponding to impacts from the nitrate/chloride plume.	17.9 µg/L*
MW-28	Uranium	4.9 µg/L	15 µg/L	Fraction of GWQS	Increasing Trend allows for modified approach on Flow Chart. Use of the post 2017 data set is appropriate and in conformance with EPA guidance since a data shift is noted corresponding to impacts from the nitrate/chloride plume.	12.29 µg/L*

*Based on Mean + 2σ of the background data mean of the post 2017 data set for MW-28

Conclusions:

Based on DWMRC review of the background statistics and confirmation that the proposed parameters for GWCL modifications are showing increasing trends are likely caused by geochemical impacts due to the nitrate/chloride plume. Per review of the SAR Section regarding proposed modifications to the GWCL's and statistical analysis of the data as discussed in the table above, the GWCL's will be modified in the White Mesa Uranium Mill Ground Water Permit for monitoring well MW-28 selenium and uranium as summarized on the table below:

Well Number	Parameter	Current GWCL	Modified GWCL	Method of Analysis
MW-28	Selenium	11.10 µg/L	17.9 µg/L	Mean + 2σ*
MW-28	Uranium	4.90 µg/L	12.29 µg/L	Mean + 2σ*

*Based on Mean + 2σ of the background data mean of the post 2017 data set for MW-28

Based on review a letter will be sent to EFR of initial approval of the modified GWCL's on the table above. The letter will include notification that the modifications are subject to public notice and public participation requirements, and that the modifications will not be effective until formal issuance of a modified Permit.

References

[1] Energy Fuels Resources (USA) Inc., October 19, 2020, *Transmittal of Source Assessment Report for MW-28 White Mesa Mill Groundwater Discharge Permit UGW370004*

[2] Energy Fuels Resources (USA) Inc., August 15, 2017, *White Mesa Uranium Mill Ground Water Monitoring Quality Assurance Plan (QAP), Revision 7.4*

[3] Energy Fuels Resources (USA) Inc., October 12, 2012, *Source Assessment Report*, Prepared by Intera

[4] Energy Fuels Resources (USA) Inc., November 9, 2012, *pH Report*, Prepared by Intera

[5] Hurst, T.G., and Solomon, D.K. University of Utah, 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 Near Blanding,* Utah, Prepared by Department of Geology and Geophysics

[6] Hydro Geo Chem, December 7, 2012, *Pyrite Investigation Report*

[7] Intera, 2007, *Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards, White Mesa Mill Site, San Juan County, Utah*

[8] United States Environmental Protection Agency, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance EPA530/R-09-007*

[9] Utah Department of Environmental Quality, January 19, 2018, Modified on March 19, 2019, *Utah Division of Radiation Control, Ground Water Discharge Permit, Permit No. UGW370004, Energy Fuels Resources (USA) Inc.*