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DIVISION OF WASTE MANAGEMENT
AND RADIATION CONTROL
Ty L. Howard
Director

DRC-2020-013464

MEMORANDUM

TO: File

THROUGH: Phil Goble, Manager 8/6/2020

FROM: Tom Rushing, P.G. TR 8/6/2020

DATE: August 5, 2020

SUBJECT: Review of the Energy Fuels Resources (USA) Inc. (EFR), White Mesa Uranium Mill, Blanding, Utah June 24, 2020 Source Assessment Report for Sulfate and TDS in Monitoring Well MW-31
Ground Water Discharge Permit No. UGW370004 (Permit)

Summary

A June 24, 2020 Source Assessment Report ("SAR") for Sulfate and Total Dissolved Solids (TDS) in Monitoring Well MW-31 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 June 26, 2020. The SAR was submitted for review and approval of source assessment investigation findings and proposed revised Ground Water Compliance Limits (GWCLs) for sulfate and TDS.

Monitoring well MW-31 is located on the southern berm of the Mill Tailings Cell 2 and is hydraulically downgradient from portions of Cell 2 and from the Mill processing and storage areas. MW-31 is within the defined nitrate/chloride plume, and non-compliance for nitrate and chloride are regulated through a separate consent order (UGW12-04) issued by the Director.

Monitoring well MW-31 has been subject to three previous SAR's (After submission of the comprehensive sitewide 2012 SAR) for various constituents as summarized on the table below:

Monitoring Well	SAR Date	Monitoring Constituents
MW-31	8/30/2013	Se
MW-31	12/19/2015	Se, SO4, TDS, pH
MW-31	8/20/2017	Se, SO4, TDS, U

Therefore, Sulfate and TDS were most recently reviewed per the 8/20/17 SAR which constituted a very rigorous review of a potential release of tailings wastewater from cell 2. Per that review DWMRC determined that tailings wastewater was not the source of the exceedances based on multiple lines of evidence. Per DWMRC review of previous SAR's it was recognized that increasing concentration trends were present for sulfate and TDS in monitoring well MW-31. Specifically, it was noted that increasing

concentrations of sulfate and TDS could be attributed to the location of monitoring well MW-31 within the nitrate/chloride contaminant plume. Per discussions between DWMRC and EFR at that time it was recognized that GWCL's for those parameters would likely exceed any modified GWCL's and that the parameters would need be reanalyzed to reflect continuing monitoring concentrations (statistics would need to reflect continuing concentrations) in order to cross check recent data. The basis of the DWMRC review of potential tailings solution release to the groundwater is the same, however, it was agreed that continuing review was necessary to ensure that none of the criteria had changed and that no additional information was generated to potentially refute the original findings. Review of the June 24, 2020 SAR is therefore a continuation of investigation of previously identified increasing trends for sulfate and uranium.

The June 24, 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-31, indicator parameter analysis, pH 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 sulfate and TDS in monitoring well MW-31:

Sulfate Data Plot of Historical Data at MW-31

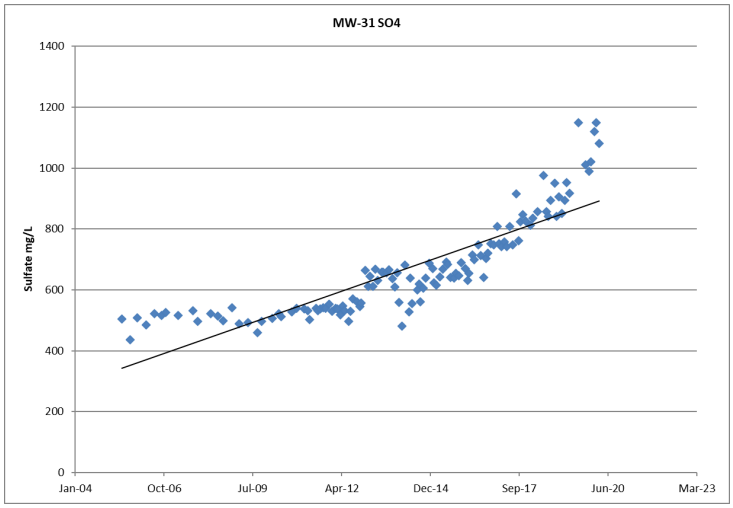
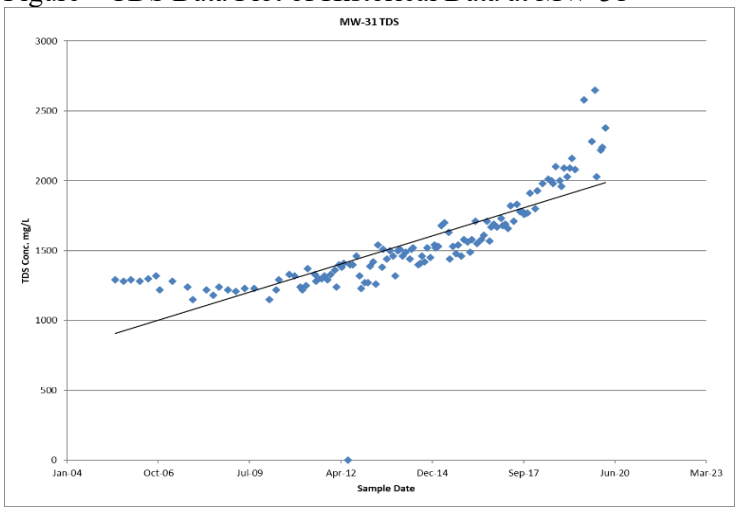


Figure – TDS Data Plot of Historical Data at MW-31



The SAR findings state that the GWCL exceedances and data trends are not caused by Mill activities (leakage from the tailings impoundments), and based on the increasing trends, EFR is proposing that a modified approach (background x 1.5) be used as a basis for revised sulfate and TDS GWCL's. This proposal is consistent with the Director approved statistical flow chart which allows consideration of a modified approach if a significant trend is evident. DWMRC review findings regarding the SAR and proposed revised GWCL's is discussed below.

DWMRC Review of Compliance Data and Trends

Sulfate – DWMRC notes that the Permit GWCL was modified/raised to 993 mg/L (from 697.6 mg/L) in the 2019 Permit modification. Sulfate concentrations in MW-31 are very low in comparison with other wells at the site. The highest historic value of sulfate is 1,150 mg/L (February 2020). This concentration is compared with highest historical values of other site monitoring wells (nearby MW-31) on the table below:

Monitoring Well No.	Location Relative to Tailings Cells	Highest Historic Measured Sulfate Value (mg/L)	Average Sulfate Concentration (Complete Data Set) (mg/L)
MW-31	Downgradient Cell 2	1,150	667
MW-1	Upgradient	1,990	837
MW-18	Upgradient	2,020	1,828
MW-19	Upgradient	1,320	669
MW-20	Far Downgradient	4,090	3,526
MW-03A	Far Downgradient	5,940	3,568
MW-29	Downgradient Cells 1 and 2	2,980	2704
MW-11	Downgradient Cells 2 and 3	1,360	1,105

Per DWMRC review, the sulfate concentrations in MW-31 are low by comparison site wide. Sulfate concentrations are rising at several of the monitoring wells at the mill including upgradient and far downgradient monitoring wells.

Total Dissolved Solids – DWMRC notes that the Permit GWCL was modified/raised to 2,132 mg/L (from 1,700 mg/L) in the 2019 Permit modification. TDS concentrations in MW-31 are low in comparison to site wide monitoring wells, including upgradient wells. TDS is largely affected by the nitrate/chloride plume, and, since the original concentrations are low, a systematic increase due to migration fluctuations in the plume create a relatively larger inflection (appears more considerable) than at other wells with higher existing background concentrations (less noticeable inflection) within the plume boundaries. MW-31 is also in proximity of the leading edge of the nitrate/chloride plume which results in a higher relative concentration curve than other wells which were central to the plume and show more stabilized concentrations or decreasing concentrations.

EFR Investigations of Potential Sources of Report Increasing Trends at Monitoring Well MW-31

1. ***Changes in Mill Groundwater Operations***

Per section 3.2 of the SAR and review of previous SAR's for MW-31, there are several Mill operational and environmental changes that have occurred and that appear to be consistent with data inflections seen on the time series plots. Specifically these changes are; 1. The initiation of monthly groundwater sampling

in 2010; 2. A well redevelopment project in 2011; 3. A change in environmental laboratory used in 2012; 4. A peak groundwater elevation at MW-31 in 2013; and, 5. Five new chloroform wells brought online on the east side of Cell 2 in 2014. Per DWMRC review of the time series plot it is observable that the trends in MW-31 and at other sitewide monitoring wells appear to begin in late 2010 and 2011, during the time of initiation of increased frequency (monthly monitoring) and the well redevelopment project, which included over pumping all monitoring wells at the Mill. These actions may have introduced/allowed oxygen to enter pores within the sandstone and shales of formations in the well screened intervals and caused geochemical reactions within the minerals of those zones. Also, an inflection in certain monitoring analytes and wider scattering of data is clearly seen in 2012 when the analytical laboratory was changed, although the increasing trend is more pronounced in recent time and is likely influenced by migration of the nitrate/choloride plume.

Per DWMRC findings regarding time series plots of data, the data inflection seen late 2012, for certain parameters indicates a shift in background concentrations due to the laboratory change. For parameters where this is observed in MW-31, and consistent with the EPA 2009 Unified Statistical Guidance, it is appropriate to use the data after this inflection to evaluate the background data. The Director approved statistical flow chart also allows for the use of a modified approach if an upward trend is apparent, providing that the cause of the trends is not from Mill activities (or addressed through separate compliance action such as the corrective action plan for the nitrate/chloride plume).

2. Discussion of Tailings Solution Groundwater Indicator Parameters at Monitoring Well MW-31

The SAR Section 3.3 discusses four usual 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 descriptive statistics for indicator parameters.

Per DWMRC review of the SAR Piper diagrams evaluating chemical relationships of Cell 1 wastewater and observed groundwater concentrations; fluoride, sulfate and uranium concentrations in MW-31 are within the same background range of monitoring wells upgradient and far downgradient from the Mill. The evaluation confirmed that chloride concentrations in MW-31 are well above background range, as expected, based on the MW-31 location within the nitrate/chloride plume.

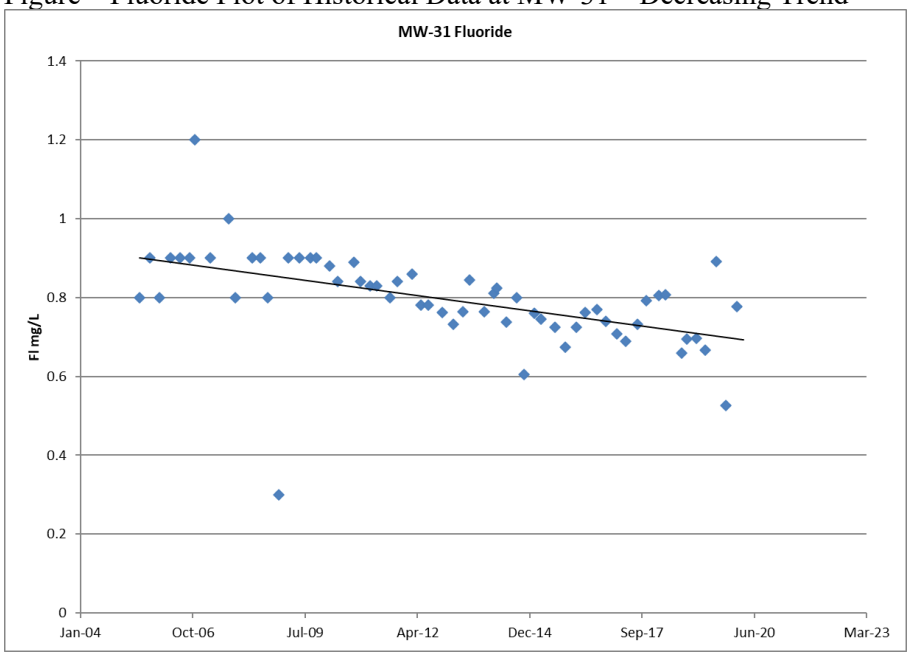
Chloride

The use of chloride as an indicator parameter in the case of monitoring well MW-31is complicated by the fact that MW-31 is screened within a nitrate/chloride plume, and chloride is therefore above background and is not a reliable primary indicator of cell leakage for MW-31. Chloride at monitoring well MW-31 is showing a significant increasing trend. Findings related to comparisons of MW-31 chloride and background wells outside of the nitrate/chloride plume show chloride well outside of background range. The chloride plume has been delineated based on concentrations and plots clearly show that the plume leading edge is hydraulically upgradient from the mill tailings cells and is not attributed to tailings cell leakage based on groundwater flow data and mass balance calculations.

Fluoride

Fluoride is highly concentrated in tailings wastewater and per literature and mill groundwater transport modeling has been shown to be highly mobile in the vadose zone and groundwater beneath the tailings impoundments. Per the figure below, fluoride is showing a decreasing concentration trend in MW-31.

Figure – Fluoride Plot of Historical Data at MW-31 – Decreasing Trend



Mass balance calculations for fluoride have been reviewed by DWMRC. Per findings the concentration of fluoride in groundwater when compared with less mobile constituents in tailings wastewater are much lower; additionally as per the figure above overall concentrations are declining but would be increasing due to input of tailings wastewater which is high in fluoride concentration. Previous SAR's used a comparison of selenium and fluoride in Cell 1 tailings wastewater and MW-31 groundwater and concluded that selenium is found at much higher percentages in groundwater than fluoride. Fluoride concentrations should be over 20 times higher to indicate a relationship with tailings wastewater.

Sulfate

Sulfate concentrations in MW-31 are very low in comparison with other monitoring wells at the site, including upgradient and far downgradient monitoring wells. The highest historic value of sulfate in MW-31 is 1,150 mg/L (Feb. 2020). This concentration is compared with highest historical values of other site monitoring wells (nearby MW-31) on the table below which shows a lower maximum concentration and average concentration of sulfate at MW-31:

Monitoring Well No.	Location Relative to Tailings Cells	Highest Historic Measured Sulfate Value (mg/L)	Average Sulfate Concentration (Complete Data Set) (mg/L)
MW-31	Downgradient Cell 2	1,150	667
MW-1	Upgradient	1,990	837
MW-18	Upgradient	2,020	1,828
MW-19	Upgradient	1,320	669
MW-20	Far Downgradient	4,130	3,526
MW-03A	Far Downgradient	5,940	3,568
MW-29	Downgradient Cells 1 and 2	2,980	2704
MW-11	Downgradient Cells 2 and 3	1,410	1,105

The SAR additionally includes box plots comparing groundwater chemistry and concentration of ugradient and downgradient monitoring wells with MW-31. Per DWMRC review of box plot comparisons, the sulfate concentrations in MW-31 are low by comparison site wide.

The relatively low concentration of sulfate in MW-31 indicates a source other than tailings solution.

Uranium

Uranium concentrations in monitoring well MW-31, like sulfate concentrations, are low site-wide. Uranium concentrations in MW-31 are within background concentration range and are low for the mill site. Rising uranium concentrations are likely associated with lower pH in the groundwater.

Indicator parameters, other than chloride, are seen to have low site wide concentrations regardless of trends. Chloride concentrations are higher than background due to impacts from the chloride/nitrate plume. Per SAR evaluations of ratios of the mobile contaminants in groundwater with the tailings wastewater concentrations, it appears that the source of the mobile contaminants is due to causes other than tailings wastewater.

3. pH Analysis

Section 3.1 of the SAR includes a discussion of "Site-Wide Decreasing pH," and, Section 3.4 and Appendix D of the SAR include an evaluation of pH in MW-31. The analysis includes statistical evaluation (identification of outliers and trend analysis) which confirms a significantly decreasing trend in pH in MW-31. The SAR discusses that the decreasing pH trend may be caused by pyrite dissolution from various reactions with oxygen and/or nitrate and bacteria which could cause rises in sulfate and TDS geochemically due to acid (dissolving metals) and sulfate production. DWMRC has agreed that pyrite dissolution is a possible cause of decreasing pH and potential reactions. This is supported by similar reactions and constituent increases at other monitoring wells site wide.

4. Mass Balance

The SAR includes a mass balance evaluation (Section 3.5 and Appendix E) of current concentrations of fluoride, uranium, chloride, sulfate in MW-31, and mean concentrations of the same parameters in cell 1 wastewater (mean of data 2013 through 2019). 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.

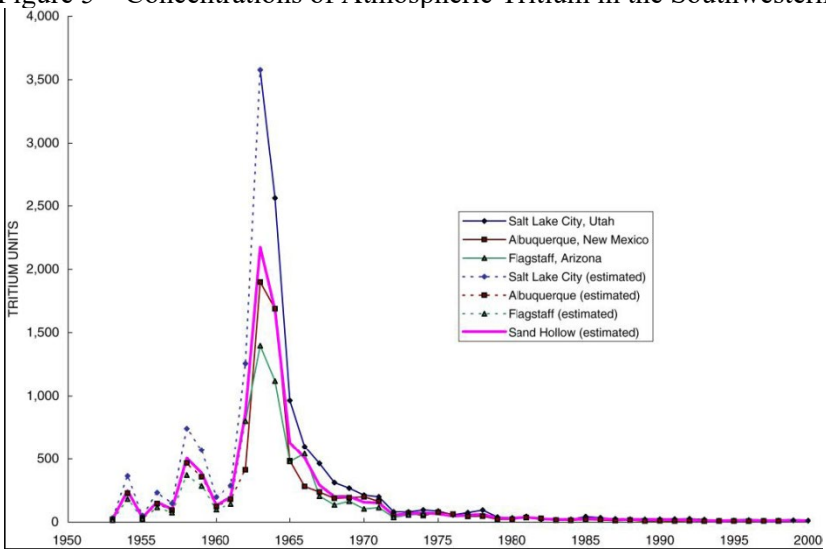
Based on large inconsistencies between the tailings wastewater concentrations and the expected diluted concentrations, the SAR concludes that "*the mass balance analysis indicates that potential tailings system seepage is an unlikely contributor to the groundwater chemistry at MW-31*." Per review, the analysis indicates that the groundwater concentrations of these parameters in MW-31 are not consistent with a tailings source. The current findings/conclusions are consistent with the review of the mass balance evaluation in the 2017 SAR for MW-31, which showed significant underestimation or overestimation of expected observed constituent concentrations in the event of tailings cell seepage and a determination that tailings wastewater was an unlikely cause of the observed concentrations in MW-31.

5. University of Utah Study

Monitoring well MW-31 was included in a University of Utah study conducted at the White Mesa Uranium Mill during 2007 (Final Report of Study Findings Dated May, 2008). Based on groundwater age dating at monitoring well MW-31 [chlorofluorocarbon ("CFC") analysis], the groundwater was found to exhibit CFC recharge dates which predate the construction of the Mill in 1980.

Additionally, tritium concentrations in monitoring well MW-31 were found to be non-detect. If ground water in monitoring well MW-31 had a surface infiltration source post 1950's (time period of atmospheric injection of tritium during above-ground thermonuclear weapons testing) then tritium concentrations would be expected in ground water samples in monitoring well MW-31. Figure 5 below is taken from the University of Utah ("U of U") Report (Hurst and Solomon 2008) and depicts atmospheric concentrations of tritium in the southwest by year.

Figure 5 – Concentrations of Atmospheric Tritium in the Southwestern United States



Based on review of the U of U Report and specific data results for monitoring well MW-31 age dating of groundwater at the well indicates that the MW-31 groundwater predates Mill construction.

6. Source Assessment Conclusions

Section 3.6 of the SAR discusses the summary of results for evaluation of each of the SAR parameters at MW-31 (SO4 and TDS).

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 sulfate and TDS are not due to wastewater release from the mill. Per discussion above, these parameters have previously been studied and reviewed for MW-31 and a long-term rising trend has been identified. It is not unexpected that future compliance issues will occur for the same parameters at MW-31 since the Permit uses intrawell background to calculate GWCL's.

Per discussion in the SAR, the sulfate and TDS exceedances are likely related to common geochemical influences in the Dakota/Burro Canyon Aquifer. The same influences are observed at other Mill monitoring wells site-wide. Investigations of conservative tracers and mass balance evaluations of the tailings wastewater does not support that rising sulfate and TDS concentrations at MW-31 are Mill caused. Additionally, the University of Utah Study confirmed that identified rising trends for constituents in MW-31 were not Mill caused but were present before construction and operation of the Mill.

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-31, for a post September 2012 data set, and for a post May 2014 data set. The complete data set and the post September 2012 data set did not show normal or log normal distribution for sulfate or TDS. The post May 2014 data showed log normality for sulfate but was not normal for TDS. Statistical methods used 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 + 2 Standard Deviation, Upper Tolerance Limit, Highest Historical Value and Background Mean Concentration times 1.5. The calculations and findings are summarized on a table in the SAR (Appendix B-1 of the SAR).

Per the DWMRC approved statistical flow chart for the White Mesa Mill groundwater monitoring wells, it was noted 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 this, EFR calculated GWCL's according to the Utah Groundwater Rules (Utah Administrative Code R317-6) which allow maximums to be set according to Mean + 2 Standard Deviations, 0.5 times the GWQS (Class III Water), or 1.5 times the background concentration. DWMRC findings note that setting the GWCL at a maximum value for these parameters is reasonable, given that the wells will likely exceed a more conservative GWCL in a short period of time when considering the increasing trends.

Therefore, when comparing the various calculated GWCL's it is found appropriate to set GWCL's for sulfate and TDS according to 1.5 times background for post May 2014 data sets (Se and SO4) since this method provides the highest concentrations approved by the statistical flow chart. These values are in conformance with the approved statistical flow chart, the Utah Groundwater Rules, EPA Statistical Guidance and consider the increasing data trends.

A cross review of EFR calculated mean concentrations for parameters using 1.5 X background was conducted as shown on the table below. Per evaluation, the EFR mean calculations are correct and are representative of the data set used for evaluation.

Table – Comparison of EFR Background Data Set Mean Values in SAR with DWMRC Calculated Mean for SO4 and TDS in MW-31

Parameter	EFR Calculated Mean	DWMRC Calculated Mean
MW-31 Sulfate (Post May 2014)	780.3 mg/L	767.7 mg/L
MW-31 TDS (Post May 2014)	1775.7 mg/L	1758.5 mg/L

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

Table of EFR Proposed Revised GWCL's for Monitoring Well MW-31:

Well Number	Parameter	Current GWCL	EFR Proposed GWCL Revision	Method to Determine GWCL	DWMRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?	DWMRC Recommended Modified GWCL Based on SAR Review
MW-31	Sulfate	993 mg/L	1170.5 mg/L	1.5 X Background of Recent (Post May 2014) Data Set	Increasing Trend allows for modified approach on Flow Chart. Per UAC 317-6, Class III water is allowed to be calculated by 1.5 X Background. Per DWMRC Review of the Sulfate Data the modified approach appears appropriate. Use of the post Oct. 2014 data set is appropriate and in conformance with EPA guidance since a data shift is noted corresponding to laboratory change. The 2014 data shift is more evident based on the collection of recent data since the 2017 MW-31 SAR.	1170.5 mg/L
MW-31	TDS	2132 mg/L	2664 mg/L	1.5 X Background of Recent (Post May 2014) Data Set	Increasing Trend allows for modified approach on Flow Chart. Per UAC 317-6, Class III water is allowed to be calculated by 1.5 X Background. Per DWMRC Review of the TDS Data the modified approach is appropriate. A 2014 data shift is noted, this shift was not evident per the 2017 SAR review, however more recent data has clarified the data shift.	2664 mg/L

Conclusions:

Based on DWMRC review of the background statistics and confirmation that the proposed parameters for GWCL modifications are showing increasing trends not associated with contamination from the Mill, it is appropriate to set GWCL's for these parameters at background x 1.5 per Utah Administrative Code (UAC) R317-6 for Class III groundwater. This review is consistent with the Director approved statistical flowchart which appreciates that a modified approach is appropriate for parameters showing statistically significant increasing trends.

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., August 20, 2017, *Transmittal of Source Assessment Report for Sulfate, Selenium, Total Dissolved Solids, and Uranium in MW-31 White Mesa Mill Groundwater Discharge Permit UGW370004*

[2] Energy Fuels Resources (USA) Inc., June 24, 2020, *Transmittal of Source assessment Report for MW-31 White Mesa Mill Groundwater Permit UGW370004*

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

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

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

[6] 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

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

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

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

[10] 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.*

[11]Utah Department of Environmental Quality, March 14, 2018, *Review of the Energy Fuels Resources (USA) Inc. (EFR), White Mesa Uranium Mill, Blanding, Utah August 21, 2017 Source Assessment Report for Selenium, Sulfate, Total Dissolved Solids (TDS) and Uranium in Monitoring Well MW-31*.