

## 1.0 INTRODUCTION

This appendix discusses the specifics related to Disa Technologies, Inc. (Disa) process laboratory activities ancillary to the primary and secondary objectives of the high-pressure slurry ablation treatability study. These details include an assessment of the tasks performed and any potential impact on the results of the study. For a broader discussion of the tasks and how the resultant data were used to answer primary objectives, refer to Section 2.6 of the main report.

## 2.0 WET SIEVING

As detailed in Section 2.6.1 of the main report, a vibratory sieve shaker was used to separate the size fractions of materials for particle size distribution (PSD). Before wet sieving fractionation, process water for the slurry residence time sample was separated from the solids to be fractionated using a pressure filter over 5-micron filter paper. The substrate and components for this apparatus are shown on [Figure G-1](#). This method is a deviation from the sampling and analysis plan and quality assurance project plan, which had proposed separating the water from the solids via decanting (Tetra Tech, Inc. [Tetra Tech] 2022). The method for filtration of the water was chosen because it more accurately represents the process at full scale with Disa filter press operations separating at 5 microns and allows for better understanding of the true PSD with the inclusion of total suspended solids data (particles between 5 microns and 0.45 micron) and suspended versus dissolved (passing 0.45-micron filtration) concentrations in the water analyses. With this addition, the filtered water more accurately represents the process water filtered through a filter press that Disa plans to use at continuous scale. Process water samples selected for analysis were the 30-minute samples across all sites and concentrations and the 4- and 8-minute samples for the medium-concentration samples collected at the Old Church Rock Mine (OCRM).

Any solids retained on the 5-micron filter paper in the process of separating solids using wet sieving versus water for analysis were noted in Disa process laboratory logbooks (Appendix B-7 of the main report). These solids were then rinsed off the filter paper and recombined with the solids from wet sieving to capture all mass. As the slurry samples were split into multiple PSDs to avoid overloading screens, the PSD splits that the filtered solids were combined with were noted in the Disa process laboratory logbooks. For the two Quivira Church Rock 1 Mine (CR-1) samples (QV-L-4-WT and QV-M-4-WT filtered solids) with mass retained on the filter paper after solids and water separation, masses of the dried filter paper were recorded to assess what mass, if any, could be assumed to have been lost in this process. The mass retained on the filter paper was less than 0.02 percent of the total PSD mass, indicating the solids-water separation step was not a major contributor to any mass lost while processing at the Disa laboratory.



**Figure G-1. Pressure Filter Apparatus at the Disa Process Laboratory Used for Removing Water from the Passing 270-Mesh Fraction after Wet Sieving with All Components Laid Out on the Table**

Material retained on each of the sieve sizes of +25, +50, +100, +140, +200, and +270 mesh were transferred from the sieves to labeled plastic cups and dried at 50 degrees Celsius (°C) overnight. Per Disa's RO-TAP material processing standard operating procedure (SOP) (Appendix B-1C of the main report) for wet sieving at the Disa process laboratory, if soil or slurry samples were expected to be greater than 500 grams in total mass, the samples were split as evenly as possible into portions of sieve sets less than 500 grams. Samples split were denoted as their integer value over the total fractions splits. The Disa process laboratory logbooks (Appendix B-7 of the main report) detail the selection of the total number of PSDs based on the recorded masses of the wet samples after solids and water separation. Appendix B-3 of the main report contains the laboratory forms detailing wet sieving of all samples at the Disa process laboratory.

### 3.0 WATER FILTERING, FILTRATE DRYING, AND COMBINING WITH FINE FRACTIONS

As described in the work plan (Tetra Tech 2022), material washed through the 270-mesh screen during the wet sieving process was collected underneath the RO-TAP device and pressure filtered through the pressure filter apparatus at 60 pounds per square inch over a 5-micron filter paper. If the water was still murky after the fractionation water had passed through the pressure filter, the water was recycled back over the filter paper with the solids still on it. This recycling of water allowed for the built-up filter cake to retain any mass that otherwise might have been lost to the stored pressure filtered water. This recycling was important for samples such as the feed material that did not undergo initial separation from water before wet sieving. Slurry samples that had already undergone pressure filtration of fine solids during the solids-water separation step as described in [Section 2.6.2](#) of the main report rarely required this recycling.

For OCRM sample CR-M-0-SL-01, the fractionation water passing the 5-micron filter paper through the first filtration was sampled and filtered through a 0.45-micron filter for a sample that was then sent to Pace Analytical Services, LLC (Pace) for dissolved metals analysis. After this water was recycled back through the pressure filter and the built-up cake, it was again sampled and filtered through a 0.45-micron filter. As recorded on the PSD document for OCRM sample CR-M-0-SL-01 and in the Disa process laboratory logbooks (Appendix B-7 of the main report), the 0.45-micron filters used for this process were dried in the oven overnight at 50 °C with the tare masses recorded. After recording the net masses retained on these filters from the process, 0.23 percent of the mass of the entire PSD was observed to still be suspended in the water after the first pass of water through the pressure filter apparatus and no mass was observed suspended in the water after it had been recycled.

After filtration of the passing 270-mesh material was completed and the fractionation water was clear, all wet sieving fractionation was transferred from the 5-gallon bucket containment for each PSD and saved in clean 300-gallon totes throughout the course of processing at the Disa process laboratory. This process water was analyzed at the end of the study with results compared to the standards for Casper, Wyoming, municipal discharge and Nuclear Regulatory Commission (NRC) regulations on discharge of radionuclides to sewers as presented in [Table G-1](#) and [Table G-2](#), respectively. With 92 pounds of total mass of samples processed by wet sieving throughout, 0.21 pound of mass was assumed to be captured after recycling the water through a second time to capture suspended solids on the filter paper. If recycling had not been included in the pressure filtering step, this mass would have been lost to the wet sieving water contained in



the totes and not analyzed. After the filtration of the passing 270-mesh water onto the 5-micron filter paper had been completed, the moist material retained on the paper was dried in the oven at 50 °C for at least 12 hours. As with the size fractions above it, if the material needed to be dried for longer, it was left in the oven for longer. Because the dried filter cake of the passing 270-mesh material was flaky before shipment for analysis, the material was placed into a ring and puck pulverizer to break down the flakes and homogenize the material further to support unbiased sampling and analysis of the concentrate fractions. An average of no greater than 0.7 percent of the concentrate mass was recorded to have been lost during the pulverizing process. Pulverizing tracking forms are provided in Appendix B-8 of the main report.

The water removed from the pre-cut fines buckets was combined with the fractionation water totes. The field forms and laboratory logbooks (Appendix B-7 of the main report) note the masses of both dried fines and collected slurry to show how much the mass in the water of the collected fines buckets influenced the concentrations of analyzed constituents in the fractionation water totes.

#### 4.0 SOIL DRYING, HOMOGENIZING, AND SAMPLE SPLITTING

In Disa's original sampling after RO-TAP processing SOP (Appendix B-1D of the main report), sample splitting was to involve the use of a riffle splitter, which allows for unbiased splitting of a sample because of the design of its chutes. However, with the low concentrations of uranium and the cleanup goals for uranium and radium-226, any potential cross-contamination through use of a riffle splitter needed to be avoided. For instance, if a riffle splitter were used to split out a subsample of the passing 270-mesh concentrate fraction and not cleaned properly, it could contribute to cross-contamination of the next fractionation sample +25-mesh material and yield inaccurate uranium concentrations, as well as inaccurate conclusions about the effectiveness of the high-pressure slurry ablation treatment.

Because cross-contamination of the material to be split into subsamples needed to be avoided for synthetic precipitation leaching procedure extraction metals and radium-226, the Automated Mineralogy Identification and Characterization System, metals, and radium-226 analyses, Tetra Tech and Disa concluded that homogenization inside the original sample bag and then pouring into the subsample bag to achieve the correct mass was the best course of action. Plastic spoons were used to scoop material out of the fractionation sample bags and into the analytical sample bags when precision was required. These plastic spoons were cleaned with isopropyl alcohol before reuse. An example of how samples were split is shown on [Figure G-2](#). The sample mass logging and splitting forms are presented in Appendices B-4 and B-5 of the main report.

**Table G-1. Comparison of Saved Fractionation Water from Disa Process Laboratory Wet Sieving to Casper, Wyoming, Municipal Discharge Limits**

Metal	Casper Municipal Local Limit* (mg/L)	Fractionation Water Results		
		Old Church Rock Mine Fractionation Water (mg/L)	Quivira Church Rock 1 Mine Fractionation Water (mg/L)	Cove Transfer Station 2 Fractionation Water (mg/L)
Arsenic	6.42	0.0016	0.00211	0.00242
Cadmium	3.48	< 0.0000474	< 0.0000474	< 0.0000474
Chromium	39.44	< 0.0011	0.00119	0.00126
Copper	27.66	0.14	0.16	0.08
Lead	6.84	0.000458	0.000246	0.000607
Molybdenum	4.11	0.00265	0.00615	0.00349
Nickel	20.49	0.00293	< 0.00252	< 0.00252
Selenium	3.08	0.013	0.014	0.008
Silver	18.08	< 0.000206	< 0.000206	< 0.000206
Zinc	43.6	0.06	0.06	0.03
Mercury	0.49	NA	NA	NA

## Notes:

A "<" symbol indicates a nondetect result less than the corresponding method detection limit.

\* Limits per the Casper, Wyoming, municipal code at Title 13, Chapter 13.32.

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mg/L Milligram per liter

NA Not analyzed

**Table G-2. Comparison of Saved Fractionation Water from Disa Process Laboratory Wet Sieving to NRC Regulations**

Constituent	Radionuclide Limits*			Fractionation Water Results		
	Monthly Average Release to Sewers (μCi/mL)	Monthly Average Release to Sewers (pCi/L)	Monthly Average Release to Sewers (mg/L)	Old Church Rock Mine Fractionation Water (mg/L or pCi/L)	Quivira Church Rock 1 Mine Fractionation Water (mg/L or pCi/L)	Cove Transfer Station 2 Fractionation Water (mg/L or pCi/L)
Radium-226	6.00E-07	600	Not applicable	23.9	20.2	8.2
Thorium-230	1.00E-06	1,000	Not applicable	1.6	0.8	1.6
Uranium	3.00E-06	3,000	4.23**	0.456	0.726	0.039

Notes:

\* Limits under NRC regulation at 10 *Code of Federal Regulations* Part 20, Appendix B, Table 3.

\*\* Calculated limit based on specific activity of 7.10e-7 pCi/g for natural uranium.

μCi/mL Microcurie per milliliter

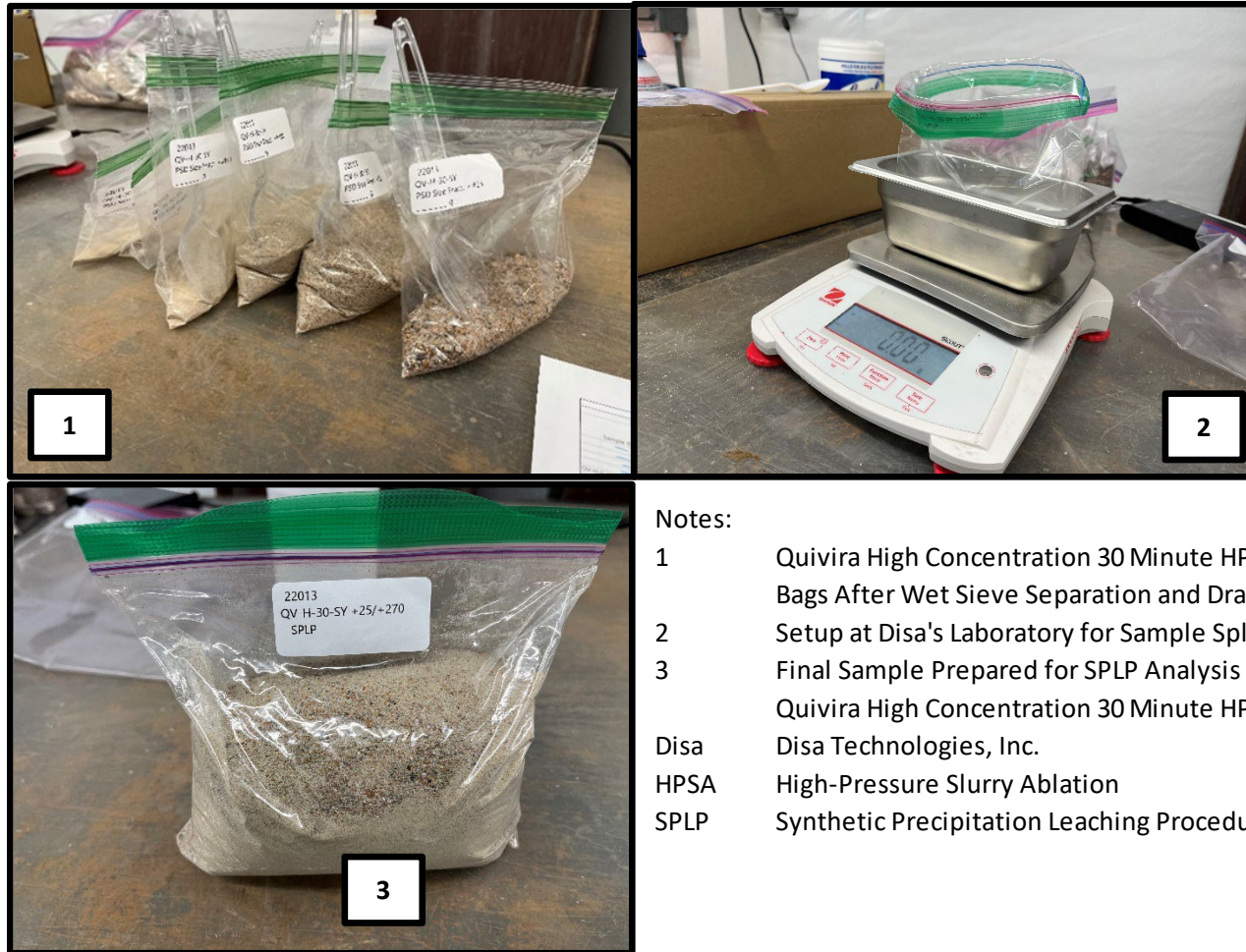
Disa Disa Technologies, Inc.

mg/L Milligram per liter

NRC Nuclear Regulatory Commission

pCi/g Picocurie per gram

pCi/L Picocurie per liter



Notes:

- 1 Quivira High Concentration 30 Minute HPSA Processing Sample Bags After Wet Sieve Separation and Drawing
- 2 Setup at Disa's Laboratory for Sample Splitting Into Subsamples
- 3 Final Sample Prepared for SPLP Analysis at Disa's Laboratory for Quivira High Concentration 30 Minute HPSA Processing

Disa Disa Technologies, Inc.

HPSA High-Pressure Slurry Ablation

SPLP Synthetic Precipitation Leaching Procedure

**Figure G-2. Illustration of Sample Splitting Process after Wet Sieve Separation**

## 5.0 X-RAY FLUORESCENCE ANALYZER SCREENING

Before performing any X-ray fluorescence (XRF) analysis, calibration was checked and a blank was run. Additionally, an XRF puck containing a standard sample with a known uranium concentration was run. With the samples separated into their respective fractions, 5 to 10 grams were removed from each of the bags after they had been manually and thoroughly homogenized for the most accurate aliquot's analysis. Each XRF puck was scooped out of the bag, and a mylar film was placed over the top of the puck. Then the puck was placed in the XRF station and read by the XRF analyzer for two beams, each with a 30-second duration. Fractionation samples analyzed by XRF were performed in sets of seven for the PSD of an individual sample corresponding to the size fractions of +25, +50, +100, +140, +200, +270, and -270 mesh. Between each PSD set, the blank and the uranium standard were measured with the XRF analyzer as detailed in Disa's sampling after RO-TAP material processing SOP (Appendix B-1D of the main report).

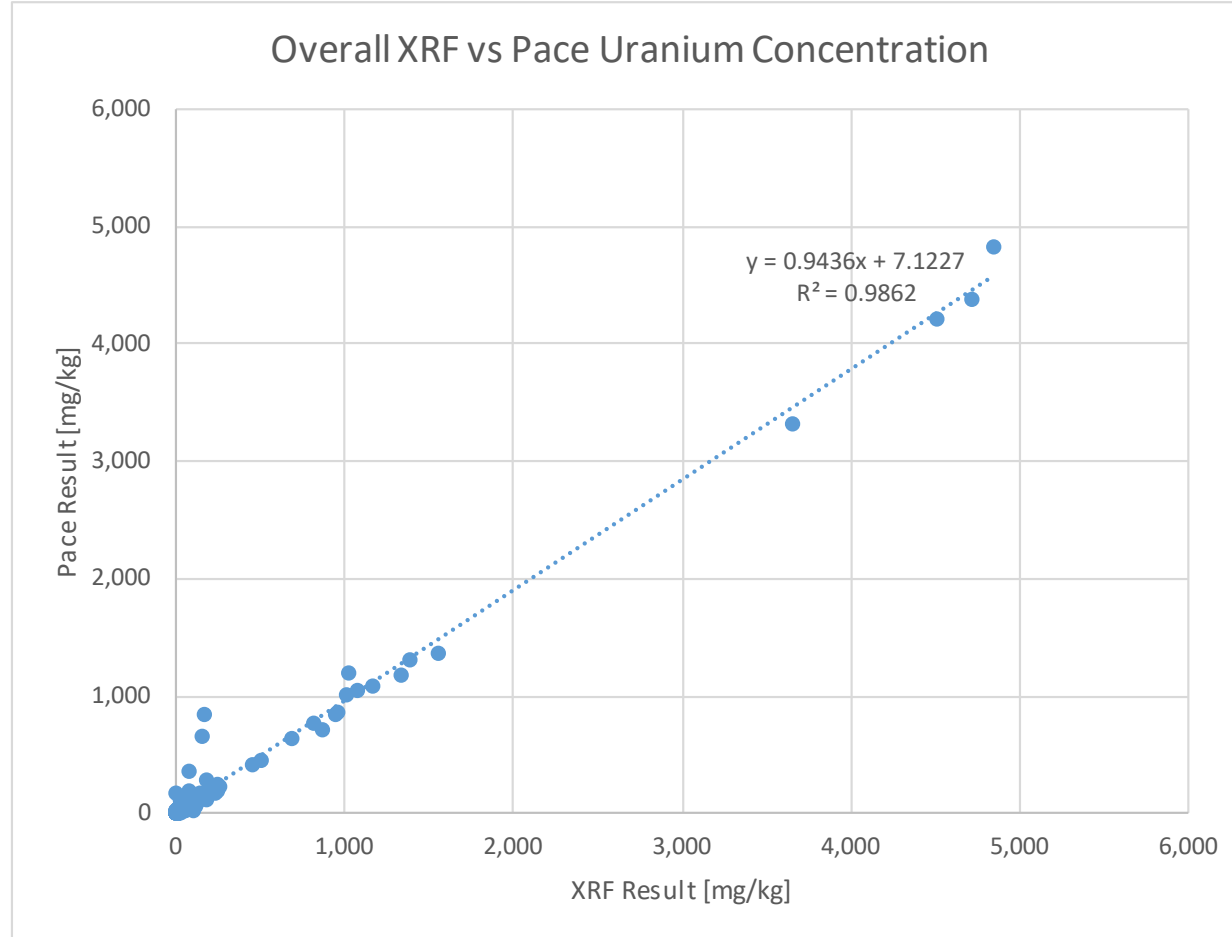
The raw and analyzed data from the XRF analyzer were exported and summarized by site (Appendix C of the main report). Although the data are qualitative, approximate indications as to the shift of concentrations throughout the treatment times and size fractions are presented. Comparisons between the recorded uranium concentrations of the XRF analyzer and the Pace data are shown on [Figure G-3](#) through [Figure G-7](#). When compared across all OCRM, Quivira CR-1, and Cove Transfer Station (CTS) 2 samples across all size ranges and concentrations, the XRF analyzer demonstrated slightly higher uranium concentration measurements than the Pace data with a trendline coefficient of determination ( $R^2$ ) of 0.9862 ([Figure G-3](#)). When only considering comparisons between XRF and Pace data for all Quivira CR-1 and OCRM sample size fractions, a similar correlation between the two datasets can also be drawn as shown on [Figure G-4](#). Since the samples were not pulverized before analysis by XRF, the analyzed coarser fractions likely exhibit greater variance from the Pace data. As pulverizing typically homogenizes the sample and reduces the particle size to between 100 and 400 mesh (Global Gilson 2023), uranium concentration results for the size fractions retained on the 25-, 50-, and 100-mesh screens are more likely to deviate from the Pace data. [Figure G-5](#) shows two charts broken down between OCRM samples retained on size fractions of 100 mesh or greater and OCRM samples of size fractions with particles passing 100-mesh plus pulverized concentrates. Unlike the OCRM and Quivira CR-1 samples, the CTS 2 samples analyzed by XRF did not exhibit a good correlation with a trendline  $R^2$  of 0.4573 ([Figure G-6](#)). When CTS 2 samples are separated into samples more and less likely to be affected by the high concentration piece of ore (nugget effect), the spread between XRF and Pace data for material becomes more noticeable for samples with particle sizes greater than 100 mesh ([Figure G-7](#)).

## 6.0 REFERENCES

Global Gilson. 2023. "Ring and Puck Mill." Accessed February 5.  
<https://www.globalgilson.com/vibrating-cup-pulverizer>.

Tetra Tech, Inc. (Tetra Tech). 2022. "Ablation Treatability Study Work Plan." August.



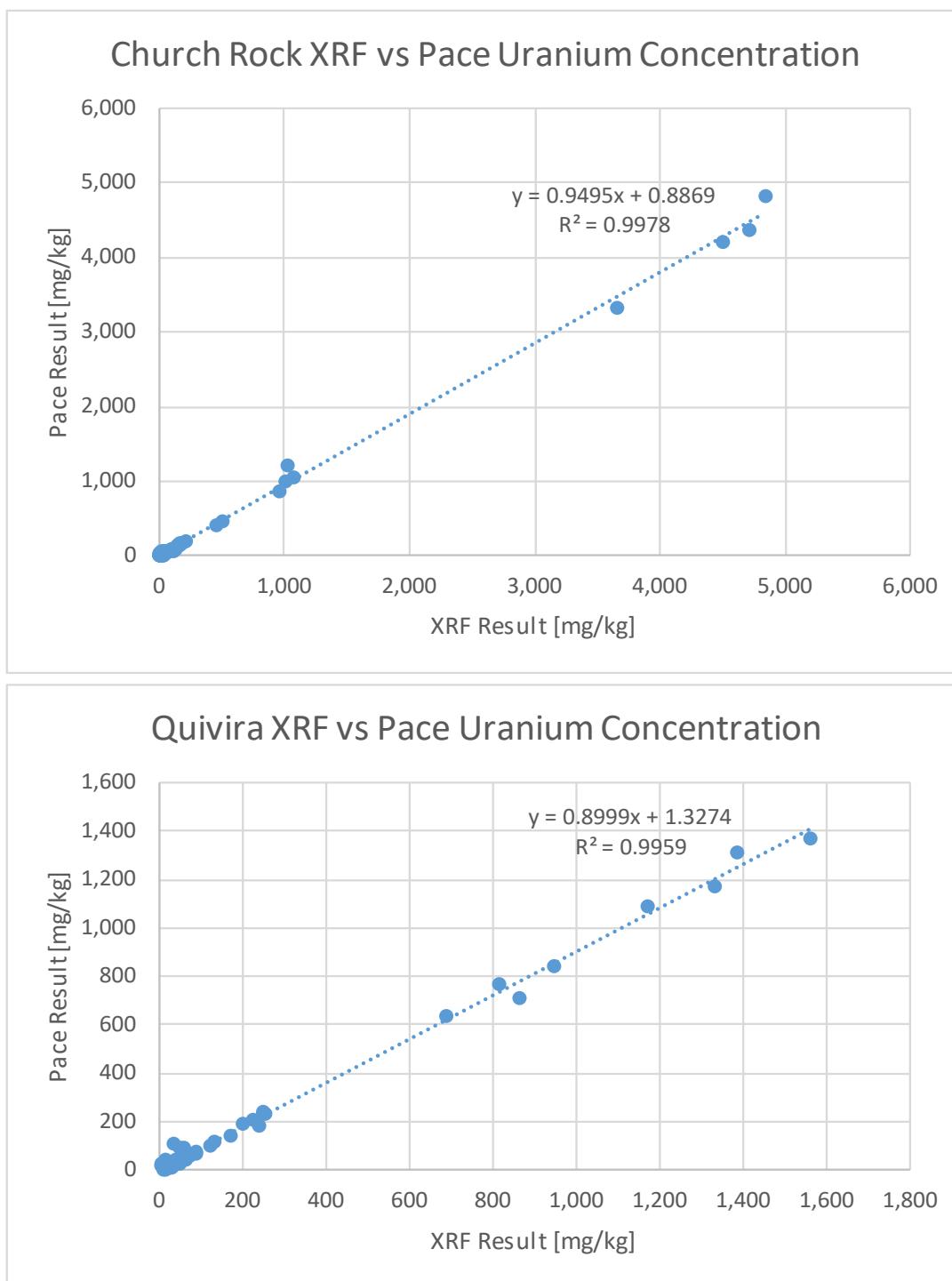


**Notes:**

mg/kg      milligrams per kilogram

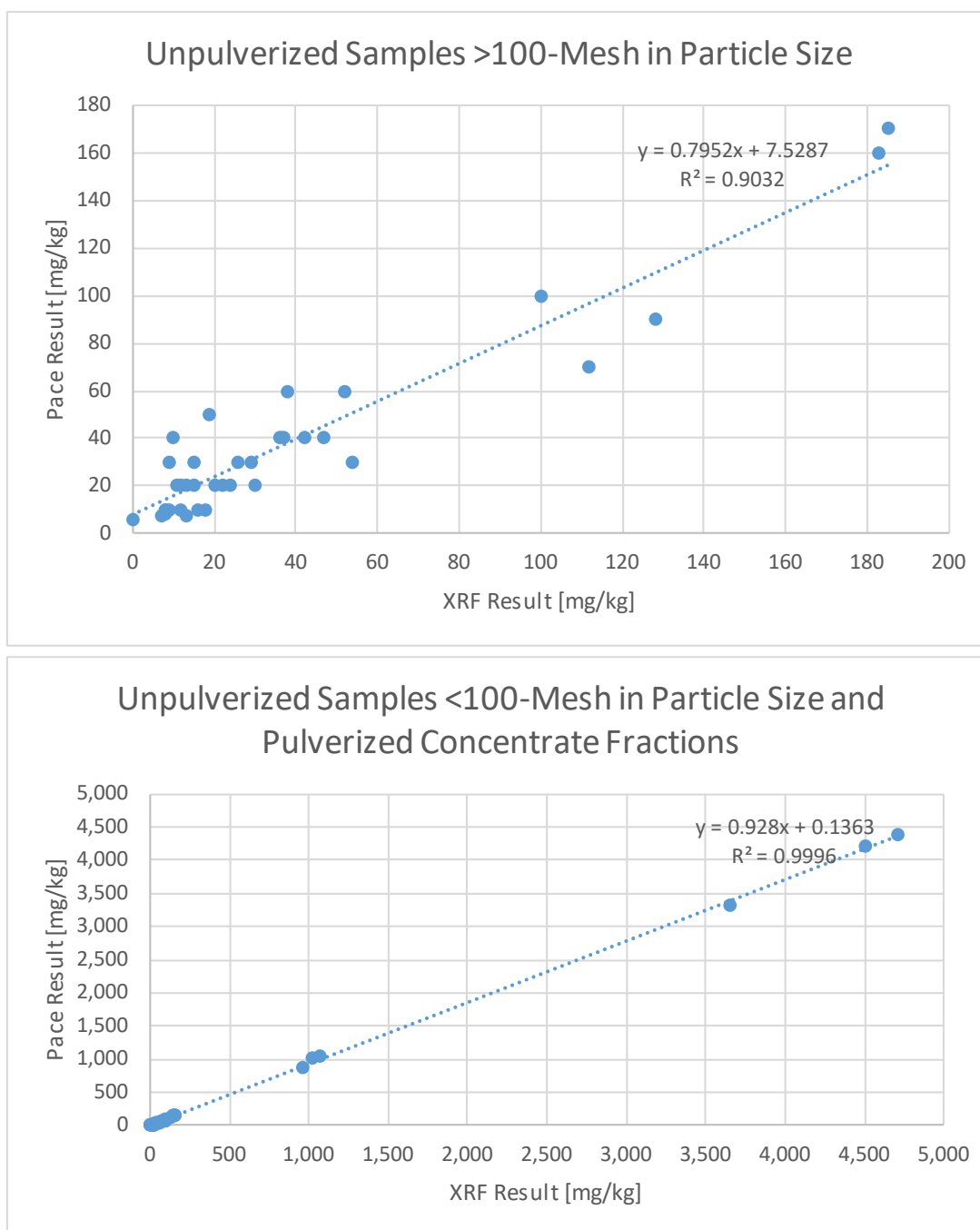
XRF        X-ray fluorescence

**Figure G-3. Uranium Results from Disa XRF Analysis Versus USEPA Method 6020 Analysis for All Fractionation Samples at All Three Test Sites**



Notes:  
mg/kg      milligrams per kilogram  
XRF        X-ray fluorescence

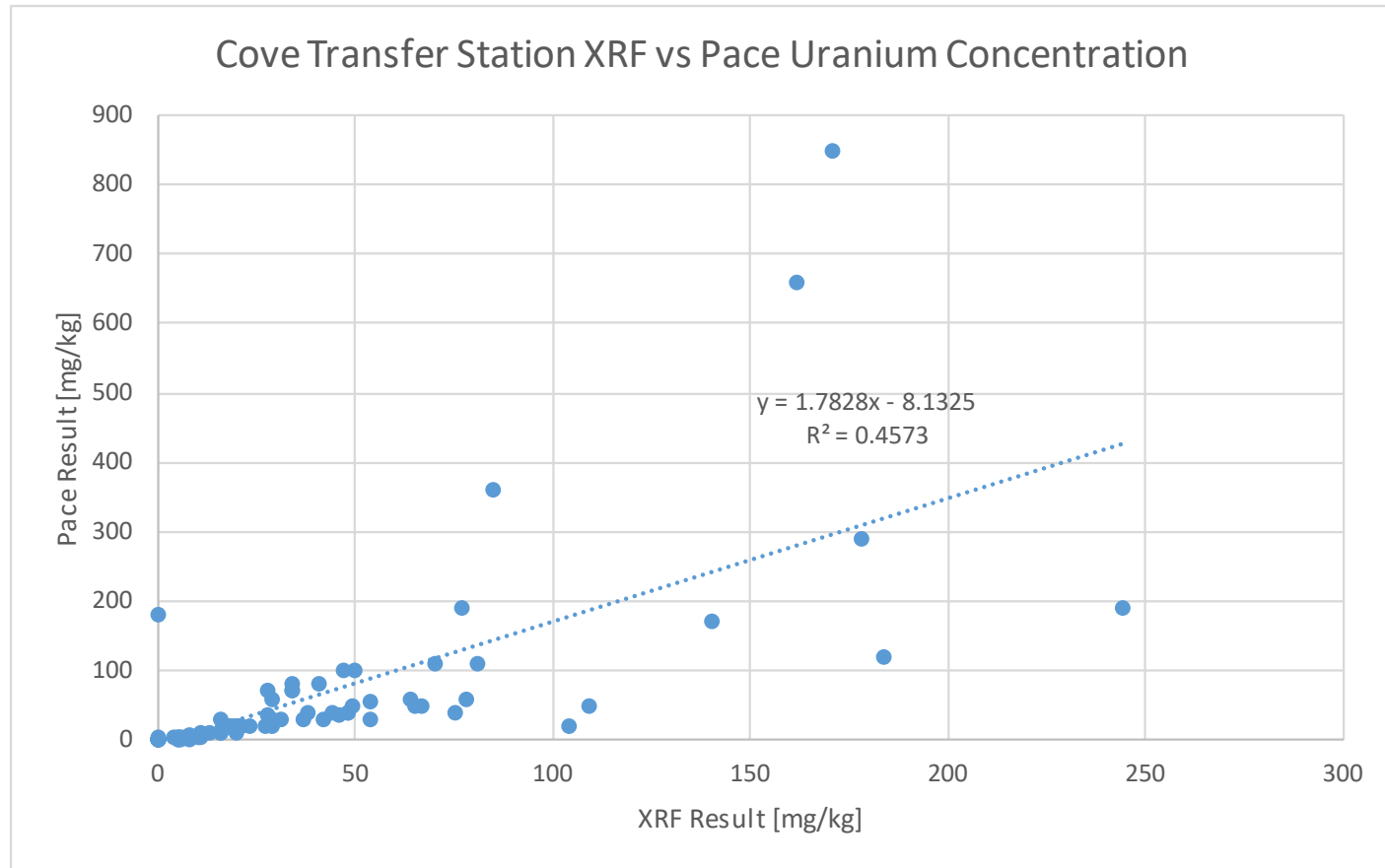
**Figure G-4. Uranium Results from Disa XRF Analysis Versus USEPA Method 6020 Analysis for Old Church Rock Mine and Quivira Church Rock 1 Mine Samples**



Notes:

mg/kg      milligrams per kilogram  
XRF        X-ray fluorescence

**Figure G-5. Uranium Results from Disa XRF Analysis Versus USEPA Method 6020 Analysis for Old Church Rock Mine Samples Divided into Sieve Sizes Likely to Be Affected by the Nugget Effect**

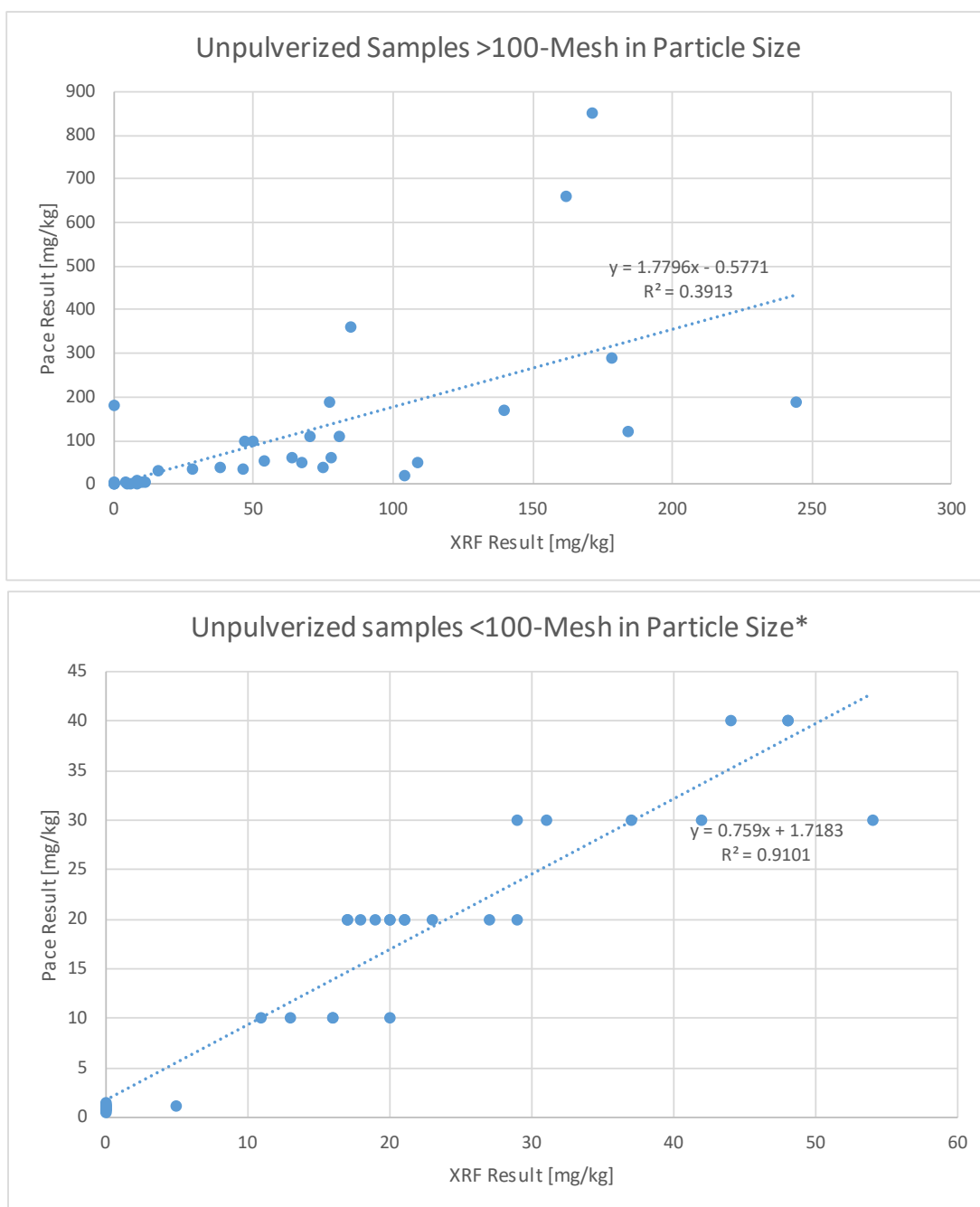
**Notes:**

mg/kg     milligrams per kilogram

XRF       X-ray fluorescence

**Figure G-6. Uranium Results from Disa XRF Analysis Versus USEPA Method 6020 Analysis for All Cove Transfer Station 2 Samples**





Notes:

- \* Passing 270-Mesh samples were excluded because samples were not pulverized prior to XRF analysis and may be affected by nugget effect
- mg/kg milligrams per kilogram
- XRF X-ray fluorescence

**Figure G-7. Uranium Results from Disa XRF Analysis Versus USEPA Method 6020 Analysis for Cove Transfer Station 2 Samples Divided into Sieve Sizes Likely to Be Affected by the Nugget Effect**