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# Portable X-Ray Fluorescence (pXRF) Measurements of Uranium and Thorium in Madison, Wisconsin, Water Utility Wells 4 and 27

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# Portable X-Ray Fluorescence (pXRF) Measurements of Uranium and Thorium in Madison, Wisconsin, Water Utility Wells 4 and 27

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## Introduction:

Radium is a radioactive element that is linked to a possible cause of cancer. It behaves like calcium and can easily become incorporated into the body when ingested. The concentration of radium dissolved in the groundwater is a pertinent and ongoing concern for well water quality, particularly for areas of eastern Wisconsin where wells draw water from the Cambrian- and Ordovician-aged sandstone and limestone aquifers (Luczaj and Masarik, 2015, and sources therein). Specific municipalities such as the village of Sussex and the city of Waukesha have been publicized recently due to this issue. Municipal wells in Madison and south-central Wisconsin also draw their water from the same aquifer system, and recently in 2016 radium concentrations in Madison Water Utility well 27 have reached levels that are above or close to the health standard of 5 pC/L[1]; the Madison Water Utility subsequently asked the Wisconsin Geological and Natural History for assistance in better understanding the source of radium.

Radium forms after radioactive decay of isotopes of uranium-238, 235 and thorium-232 that occur naturally within rocks as isotopes radium-226, 223, and 224, respectively. The concentration of which is dependent on the lithology. Granites host particularly large concentrations of uranium and thorium due to their igneous origin. Siltstones or shales can also be sources of uranium and thorium as these elements can easily become incorporated into clay minerals that comprise these types of rocks. In this study, we analyzed the lithology and the elemental composition of ground rock samples, also known as cuttings, that were collected during the installation of well 27. This information will allow us to identify the Cambrian-aged rock units with higher concentration of uranium and thorium that might act as potential sources of the radium in Madison's groundwater. We included cuttings from a second well, Madison Water Utility well 4, which was abandoned and located about 250 ft. (76 m) southeast from well 27, to test the reproducibility our study results. By inferring potential natural sources of radium in these wells, we hope to develop hypotheses that can explain the formation, transport, and observed concentrations of radium in Madison's well water.

## Materials and Methods:

Elemental data was collected using portable x-ray fluorescence (pXRF) on well cuttings from well 4 (WGNHS number: 13000051) and well 27 (13001328). These wells are about 200 ft. (61m) apart and their locations are shown in figure 1. The depths and thickness of the Cambrian-aged rock formations open to these two wells are similar and expected, given their close proximity to each other. Graphic geologic logs for the two wells are shown in figure 2 and were interpreted based on lithologic description of each well's cuttings samples. In both wells, unlithified glacial sediment (till) overlies bedrock. The bedrock formations are from top to

[1] Picocurie (pC) = $10^{-12}$ Curie ≈ $10^{-12}$ gram(g); 1pC/Liter(L) ≈ $10^{-12}$g/L ≈ $10^{-15}$g/g = 1 ppq (parts per quadrillion) = $10^{-9}$ ppm (parts per million) = 0.000000001 ppm (Assuming Radium-226)

bottom: the Tunnel City Group (sandstone aquifer), the Wonewoc Formation (sandstone aquifer), the Eau Claire Formation (siltstone aquitard), and the Mount Simon Formation (sandstone aquifer). These four units comprise the major bedrock units of the Cambrian-Ordovician sandstone aquifer in southern, eastern, and western Wisconsin and adjacent States to the south, east, and west. Reddish gray siltstone was recovered in the drill cuttings collected from the bottom of both wells. This lithology might be part of the Mount Simon Formation or it could be weathered crystalline basement. Previous interpretations of cuttings from well 4 made the interpretation of weathered basement. However, the absence of Precambrian igneous or metamorphic clasts in the cuttings lead us to conclude that the rock encountered at the bottom of both wells is the part of the Mount Simon often referred to as the shaly/silty “red beds” and are commonly present at the bottom of this formation in Wisconsin. Furthermore, the geophysical log from nearby Madison Water Utility test well 31 (13001495) indicates that the depth at which basement occurs is deeper than the two wells examined (see below).

We used the methods outlined in Zambito and others (2016) for collecting pXRF data from well cuttings. Analysis using pXRF was performed initially on each sample selected at a 90 second total filter duration-time (main filter = 30s, light filter = 30s, and low filter = 30s). Samples that had detections of thorium and uranium were reanalyzed using a 240 second total filter duration-time (main filter = 180s, light filter = 30s, and low filter = 30s) to ensure reproducibility and increased instrument precision (see appendix 1). Each cuttings sample typically represents a 5-foot interval of drilled rock. Therefore, when plotting the elemental concentration values in figures 3a and 3b for each cuttings sample, we picked the mid-point of the sample-depth interval; for example, cuttings representing depths of 250-255’ were plotted as 252.5’. For the purposes of our study, we assume that a given cuttings sample is representative of the entire sample interval and was not collected at a specific depth within that interval. The elemental data presented herein can be found in appendix 2.

**Results:**

The pXRF results are presented in figures 3a and 3b. The pXRF recognizes low concentrations, below 11 ppm, of uranium and thorium in 34 out of 298 cutting samples from wells 4 and 27. The limits of detection for these elements by the pXRF device is ~1 ppm for thorium and ~2 ppm for uranium (see appendix 1 for determining limit of detection and the accuracy of determining these elements). The data when plotted suggests two types of trends for these two elements, as shown for both wells in figures 3a and b, respectively: 1) uranium and thorium trends are complimentary and continuous throughout a specific interval, particularly in the Eau Claire Formation or 2) as isolated occurrences within a geologic unit, in the till and Mount Simon Formation. Both trends are present and correlative between the two wells.

A few samples from the surficial till in both wells 4 and 27 have detectable concentrations of thorium, but not uranium. These samples were not reanalyzed based on our assumption that most till throughout Wisconsin contains ground-up Precambrian igneous rocks that naturally have relatively high abundances of uranium and thorium, as mentioned briefly in the introduction. Furthermore, according to Wisconsin Geological and Natural History Survey (WGNHS) records, the steel well casing extends below the glacial sediment into the underlying bedrock: well 4 is cased to ~154’ depth into the Wonewoc Formation, and well 27 is cased to a depth of 246’ into the top of the Mount Simon Formation so the wells are not open to the rock intervals above those depths.

In both wells, the till lies uncomfortably over Tunnel City Group strata. The pXRF did not detect thorium or uranium in the Tunnel City Group. The Tunnel City Group present at these wells is quartz-rich sandstone with trace carbonate cement (Mazomanie Formation); not glauconitic or dolomitic as it is usually characterized elsewhere in the region (Lone Rock Formation). Similar to the Tunnel City Group, cuttings from the Wonewoc Formation in samples from both wells are also predominantly quartz sand and neither thorium nor uranium was detected by pXRF. In addition to the quartz sand, the Wonewoc Formation commonly hosts iron oxides with minor iron sulfides.

The Eau Claire Formation was unique in that the pXRF identified the most consistent and the highest concentrations of thorium and uranium in cutting sets from both wells. Within a 15- to 20-foot interval identified as a silty and dolomitic facie of the Eau Claire formation, 60-70% of the samples contained both thorium and uranium above the level of detection. This interval was re-analyzed with the longer 240-second total filter duration time to minimize increase the precision of the pXRF instrument. Thorium was present in cuttings samples at concentrations ranging from 1.51 to 5.57 ppm in well 4, and from 3.32 to 10.95 ppm in well 27. Uranium was present in cuttings samples at concentrations between 1.8 to 6.34 ppm, and 4.1 to 6.96 ppm in well 4 and well 27, respectively.

The Mount Simon Formation from both cuttings sets is a quartz sand unit, similar to both the Tunnel City Group and the Wonewoc Formation. However, it differs from the two by an increase in abundance of iron oxide and iron sulfide grains, the presence of semi- to well-developed intermittent carbonate cement, and rare greenish gray or red shale clasts. The pXRF revealed an interval in both wells within the lower part of the Mount Simon where thorium and uranium were detected as isolated occurrences, not continuous like observed in the Eau Claire Formation. These samples were also re-analyzed with the longer 240-second total filter duration time. The results of which showed inconsistent thorium and uranium values between the shortened and extended total filter duration analyses of the same sample. This inconsistency could be attributed to the way the sample settled in the sample container when analyzed with the pXRF between different analysis sessions due to lithologic heterogeneity of the cuttings sample.

The lowest unit identified in both wells is enigmatic, characterized as a reddish-maroon shaly siltstone with rare quartz grains. It is unclear if this is weathered Precambrian crystalline rock or fluvial red bed deposits characteristic of the lower Mount Simon, though we prefer the latter interpretation because the geophysical log from nearby test well 31 indicates that the depth at which basement occurs is deeper than the two wells examined. This unit was reanalyzed with the pXRF using the longer filter time, and infrequent detects of uranium and thorium were identified. This is similar to what was observed for the till interval. Since the drillers for both wells stopped drilling once they reached this interval, there are a limited number of samples collected of this lithology.

**Discussion/Conclusions:**

Using pXRF analysis, uranium and thorium were detected in the Eau Claire Formation, lower Mount Simon Formation, and in the deepest cuttings samples from these wells which are either weathered crystalline basement and/or shaly siltstones in the basal Mount Simon; only thorium was detected in the tills. Of these intervals, save for the till, we observed that concentrations of uranium and thorium are coincident, and concentrations of uranium and thorium in both wells are highest in the Eau Claire Formation. In this interval, thorium and uranium trends follow potassium, aluminum, and calcium as well as the gamma log from a nearby test well 31 (see figures 3a. and b.). This suggests that uranium and thorium could be associated with the clay minerals that comprise the dolomitic shale and siltstone of the Eau Claire Formation. In the Mount Simon Formation, the presence of thorium and uranium in well

27 appears to be associated with aluminum and potassium peaks suggesting that they might also be related to clay mineral content which, in this unit, appears to be present as matrix between the sand grains. However, this trend is not as obvious in well 4 which may be due to the way the sample settled before it was analyzed with the pXRF or differences in drilling processes.

In comparison, the Tunnel City Group in a nearby whole-rock continuous core (Arcadis MW-5; 13005716) drilled just 2.5 miles northeast of the wells 4 and 27 is a tan, sandy dolomite and that becomes increasingly sandier with diluted or rare glauconite with increasing depth below surface. Unpublished pXRF elemental data previously collected on this core reveals no thorium or uranium in this unit. Unpublished data from another core collected 10 miles east of the wells study area (Cottage Grove Hydrite 18; 13001216) shows a more prominent dolomite-cemented and glauconitic lithology in the upper Tunnel City that abruptly transitions into a cleaner quartz arenite with lesser amounts of glauconite with increasing depth. The pXRF elemental data from that core showed irregular detections of thorium and uranium in the dolomitic and glauconitic portions but not in the quartz sandstone interval. Although the lithology of the Tunnel City Group can be different across the state (Mazomanie versus Lone Rock Formations), the facies preserved at the Madison wells study site is sandstone with no detects of uranium or thorium.

It should be noted that although the pXRF does not detect uranium and thorium in the Tunnel City and Wonowoc sandstones in either well, previous study in west- and south-central Wisconsin found both uranium and thorium in both the Wonewoc Formation and Tunnel City Group sandstones, albeit at low concentrations, as indicated by ICP-MS analysis (appendix 1).

Based on the data from wells 4 and 27, we recommend further analyses by collecting ICP-MS data for the cuttings samples with uranium and thorium detects by pXRF, as well as some samples with no detects that would form a baseline, in order to accurately characterize the uranium and thorium concentration in the rocks in the sandstone units open to these wells. Suggested cuttings samples to be analyzed are provided in table 1.

## Acknowledgments

This Open-File Report was greatly enhanced by the critical reviews of Bill Batten and Ken Bradbury, both of the Wisconsin Geological and Natural History Survey, UW-Extension. Funding for the research presented in this report was provided by the Wisconsin Geological and Natural History Survey and the Madison Water Utility.

## References

Luczaj, J and Masarik K., 2015, Groundwater quantity and quality issues in a water-rich region: Examples from Wisconsin, USA: resources, 4 vol., 2 i., 323-357 pp., doi:10.3390/resources4020323

Zambito, J.J., IV, McLaughlin, P.I., Haas, L.D., Stewart, E.K., Bremmer, S.E., and Hurth, M.J., 2016, Sampling methodologies and data analysis techniques for geologic materials using portable x-ray fluorescence (pXRF) elemental analysis: Wisconsin Geological and Natural History Survey Open-File Report 2016-02, 12 p., 5 appendices.

| | WATER UTILITY WELL | FOOTAGE | GEOLOGIC UNIT | U or Th DETECTION |
|---|---|---|---|---|
| 1 | 4 | 102.5 (100-105') | Tunnel City | No |
| 2 | 4 | 177.5 (175-180') | Wonewoc | No |
| 3 | 4 | 222.5 (220-225') | Eau Claire | Yes |
| 4 | 4 | 227.5 (225-230') | Eau Claire | Yes |
| 5 | 4 | 237.5 (235-240') | Eau Claire/Mount Simon | Yes |
| 6 | 4 | 437.5 (435-440') | Mount Simon | No |
| 7 | 4 | 637.5 (635-640') | Mount Simon | Yes |
| 8 | 4 | 662.5 (660-665') | Mount Simon | Yes |
| 9 | 4 | 717.5 (715-720') | Mount Simon? | Yes |
| 10 | 4 | 727.5 (725-730') | Mount Simon? | Yes |
| 11 | 27 | 102.5 (100-105') | Tunnel City | No |
| 12 | 27 | 177.5 (175-180') | Wonewoc | No |
| 13 | 27 | 227.5 (225-230') | Eau Claire | Yes |
| 14 | 27 | 232.5 (230-235') | Eau Claire | Yes |
| 15 | 27 | 237.5 (235-240') | Eau Claire | Yes |
| 16 | 27 | 617.5 (615-620') | Mount Simon | Yes |
| 17 | 27 | 642.5 (640-645') | Mount Simon | Yes |
| 18 | 27 | 657.5 (655-660') | Mount Simon | Yes |
| 19 | 27 | 740.0 (739-741') | Mount Simon? | Yes |

Table 1. Suggested cuttings intervals for analysis using ICP-MS.

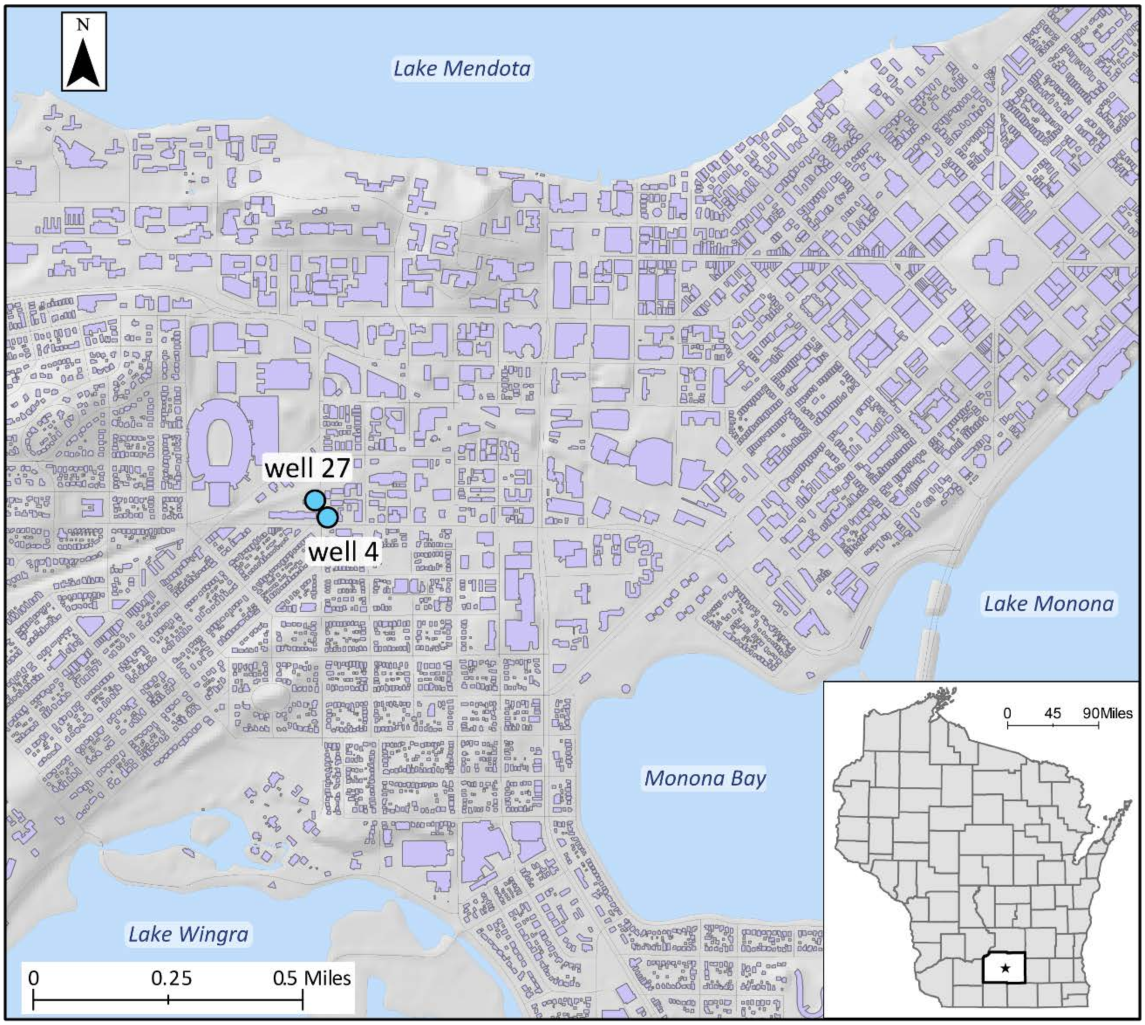



Figure 1. Locality map of Madison Water Utility wells 4 and 27. Inset map shows location of Madison (star).

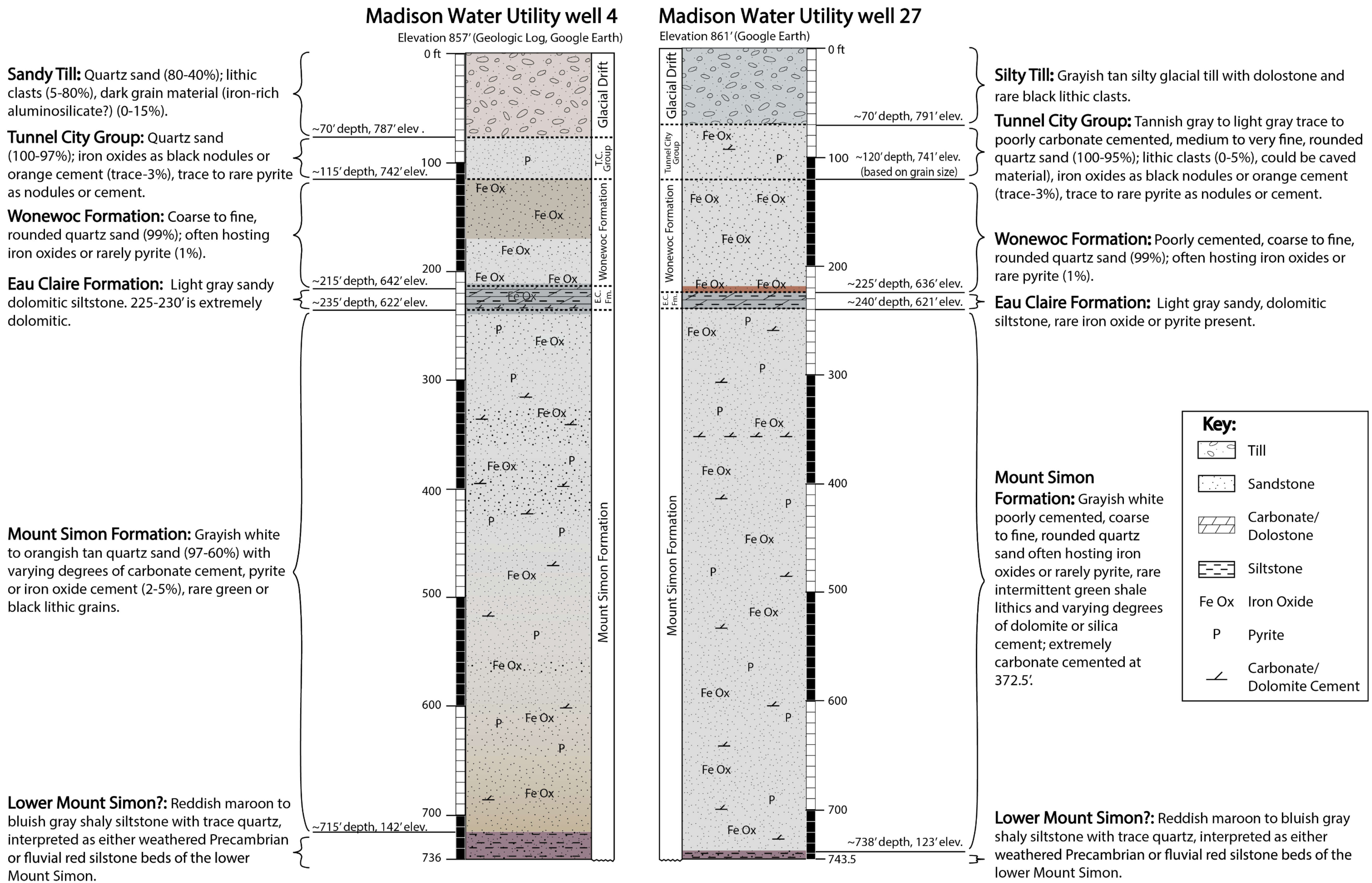



Figure 2. Geologic interpretation of cuttings from wells 4 and 27.

Figure 3a. pXRF data for well 4 and figure 3b. pXRF data for well 27.
Results of the pXRF analysis with the wells compiled geologic log, sample images of cuttings (inset A-E), and a gamma log from a nearby well, test well 31 located about 1.5 mi (2.6 km) to the southwest.

Each dot represents a pXRF data point for a given cuttings sample; asterisk indicates the value is off (higher than) the scale shown. The horizontal axis is a measure of elemental weight abundance in that sample, displayed as either parts per million (ppm) or as percent weight (%), where 1% = 10000 ppm. The vertical axis is the cuttings sample-depth. Light gray horizontal bars associated with each data point represents the two-sigma analytical uncertainty of the pXRF instrument for interpreting the abundance of that element in the sample. The error bar lengths can vary and are dependent on either the complexity of the sample (presence of several different uncommon minerals with a complex range of elements) or the ability for the instrument to read the element (the pXRF has difficulty identifying specific elements due to their atomic weights); see Zambito and others (2016) for further explanation. More abundant elements such as calcium, aluminum, silicon, and potassium, appear to have a smaller error bars or are often not visible due to the scale the data is presented (percent versus ppm). The gamma log from a nearby well is provided for comparison with the pXRF data. Elements plotted are aluminum (Al), potassium (K), calcium (Ca), silicon (Si), thorium (Th), and uranium (U). Al, Ca, Si and K are presented as a percent weight whereas uranium and thorium are displayed in ppm. K (displayed in purple) and Al (displayed in gray) are plotted together and can be used as a proxy for clay mineral content, and show similarities to the gamma log from the nearby well. Ca (blue) and Si (yellow) are plotted together and can be used as proxies for carbonates and sandstones, respectively. Note that Ca and Si trends are generally opposite. Ca can also be present in clays but only as a minor component. Iron (Fe) and sulfur (S) are displayed together as a proxy for the phase of Fe, i.e., reduced or oxidized. Fe in the presence of oxygen forms iron oxides which are light orange or rust colored and are often present as coating sand grains, as seen in the sand rich sample images. Fe in the absence of oxygen forms iron sulfide minerals with the most common being pyrite. Note in Figure 2 the relative difference in the presence of pyrite in the Wonewoc Formation compared to the Mount Simon Formation. This is likely attributed to the aquitard properties of the Eau Claire Formation preventing oxygen from the surface being incorporated into the Mount Simon. Plots of uranium and thorium are displayed with two different analyzation times: 90 and 240 seconds. Note the shorter gray error bars in the longer run times, representing greater precision in the pXRF analysis. A select number of samples were re-analyzed for the 240 second duration. Letters correspond to images of the cuttings samples.

# Madison Water Utility well 4

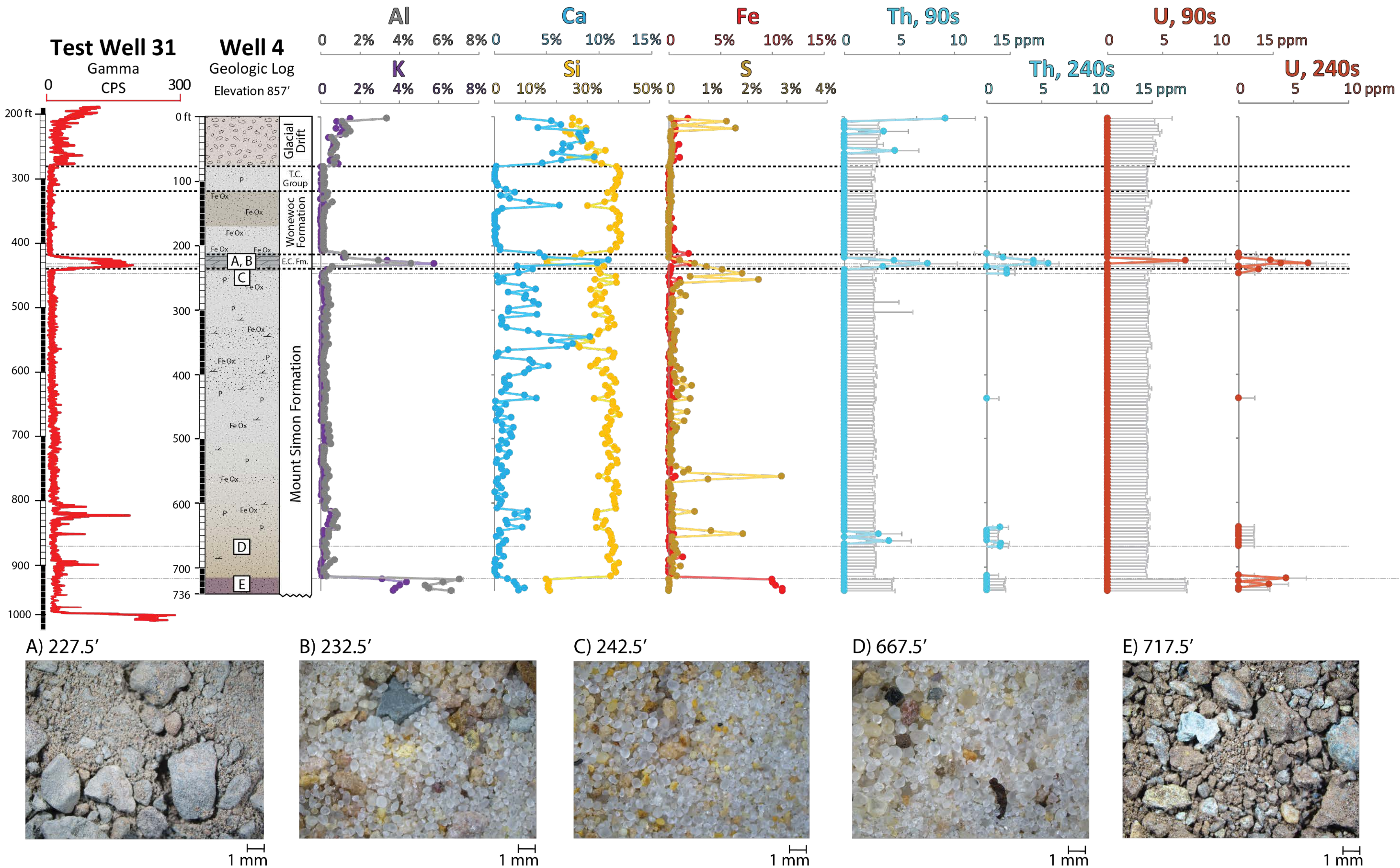



Figure 3a. pXRF data for well 4 and selected photographs of cuttings.

# Madison Water Utility well 27

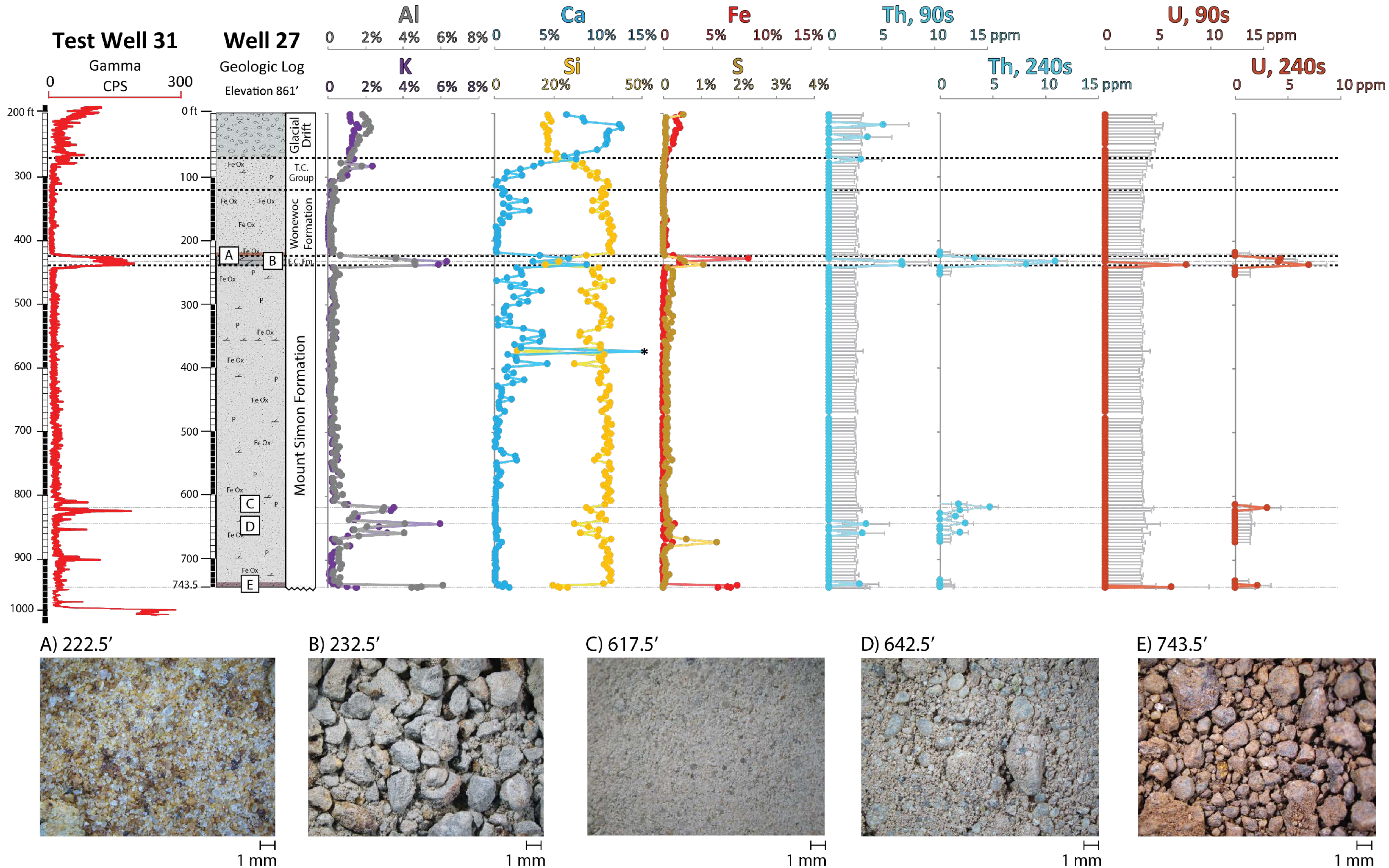



Figure 3b. pXRF data for well 27 and selected photographs.

Appendix 1: WGNHS pXRF accuracy for uranium and thorium

**Introduction:**

This appendix describes a series of tests that the WGNHS performed to investigate the accuracy of their portable x-ray fluorescence (pXRF) analyzer for determining the concentration of uranium and thorium in sandstone from two units in western and south-central Wisconsin: Tunnel City Group and Wonewoc Formation.

**Methods and Materials:**

We collected pXRF elemental data from the surfaces of various cores, hand samples, and well cuttings from south-central and western Wisconsin (Zambito et al. 2016). From these, we identified a suite of 26 samples representing a range of uranium (0.19 – 3.34ppm) and thorium (1.24 – 11.15 ppm) concentrations that span the Tunnel City Group – Wonewoc Formation boundary. This boundary was chosen because these units are dominated by two different lithologies common in Wisconsin, and presumably have different matrix properties. The Wonewoc is a quartz-dominated sandstone with iron-oxide and sulfide cements, and the Tunnel City is a shaly, dolomite-cemented glauconitic sandstone with iron-oxide and sulfide cements. These 26 samples were then powdered for additional pXRF and ICP-MS analysis.

The selected samples were collected from cores (WGNHS Belisle Quarry (56000829), WGNHS Arcadia Quarry (62000166), WGNHS Triemstra (11005900)), well cuttings (Arbor Hills (32000107)), and hand samples (Granddad Bluff, La Crosse, WI). Samples powders were drilled and powdered using a tungsten carbide bit on a drill press. For pXRF, powders were then analyzed in vials fitted with a 4 µm (0.16 mil) polypropylene thin film (see sample preparation methods in Zambito et al. 2016). Initial pXRF analyses of the rock powders were run for a total of 75 seconds (15 seconds Main filter, 30 seconds Light filter, 15 seconds Low filter, and 15 seconds High filter). Subsequent analyses were run for 75 seconds (15 seconds Main filter, 30 seconds Light filter, 15 seconds Low filter, and 15 seconds High filter), 90 seconds (30 seconds Main filter, 30 seconds Light filter, and 30 seconds Low filter), and 240 seconds (180 seconds Main filter, 30 seconds Light filter, and 30 seconds Low filter). The subsequent filter durations were chosen to investigate the accuracy of uranium and thorium on the pXRF, which is analyzed using the Main filter. ICP-MS analysis was performed by ALS Global (ME-MS61L Super Trace Lowest DL 4A package) at their Reno, NV laboratory in June 2016.

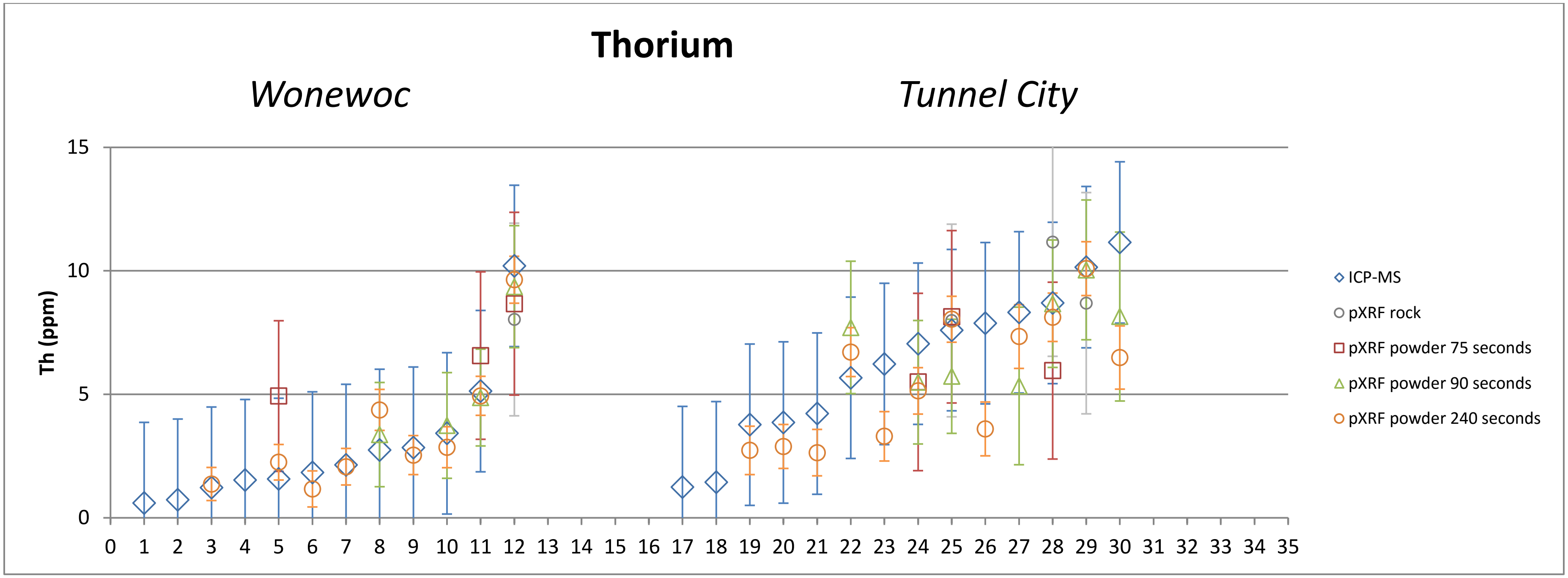
Error bars for pXRF data are a measure of analytical uncertainty of the instrument (two-sigma). Accuracy as described herein was determined visually by how well the pXRF data matched the ICP-MS data at varying elemental concentrations. It should be noted that the rock surface pXRF data was collected during a preliminary study, and therefore may not have been performed in the same spot that was sampled for powder and subsequently analyzed by ICP-MS.

## Appendix 1: WGNHS pXRF accuracy for uranium and thorium

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **FILTERS** | | | **FILTERS** | | | **FILTERS** | | | **FILTERS** | | |
| | | | | | | | Main = 15s | | | Main = 30s | | | Main = 180s | | | Main = 15s | | |
| | | | | | | | Light = 30s | | | Light = 30s | | | Light = 30s | | | Light = 30s | | |
| | | | | | | | Low = 15s | | | Low = 30s | | | Low = 30s | | | Low = 15s | | |
| | | | | | | | High = 15s | | | High = 0s | | | High = 0s | | | High = 15s | | |
| | | **SAMPLE*** | | | **Th** | **Th** | | **Th** | **Th** | | **Th** | **Th** | | **Th** | **Th** | | **Th** | **Th** |
| **Unit** | **Location** | **Horizon** | **Plotting #** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** |
| Wonewoc | Arbor Hills | 402.50 | 1 | ICP-MS | 0.59800 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 398.00 | 2 | ICP-MS | 0.73300 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Triemstra | 171.00 | 3 | ICP-MS | 1.22000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 1.37 | 0.67 | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 442.50 | 4 | ICP-MS | 1.52500 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Belisle Quarry | 199.00 | 5 | ICP-MS | 1.57500 | 3.26683 | XRF powder | 4.93 | 3.05 | XRF powder | | **< LOD** | XRF powder | 2.25 | 0.72 | XRF rock | | **< LOD** |
| Wonewoc | Triemstra | 202.90 | 6 | ICP-MS | 1.83500 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 1.17 | 0.73 | XRF rock | | **< LOD** |
| Wonewoc | Belisle | 182.00 | 7 | ICP-MS | 2.14000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.07 | 0.74 | XRF rock | | **< LOD** |
| Wonewoc | GDB | -0.65 | 8 | ICP-MS | 2.75000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 3.37 | 2.11 | XRF powder | 4.37 | 0.83 | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 430.50 | 9 | ICP-MS | 2.84000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.54 | 0.79 | XRF rock | | **< LOD** |
| Wonewoc | Triemstra | 176.00 | 10 | ICP-MS | 3.42000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 3.74 | 2.14 | XRF powder | 2.86 | 0.83 | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 375.70 | 11 | ICP-MS | 5.13000 | 3.26683 | XRF powder | 6.57 | 3.39 | XRF powder | 4.87 | 1.96 | XRF powder | 4.94 | 0.79 | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 376.50 | 12 | ICP-MS | 10.20000 | 3.26683 | XRF powder | 8.67 | 3.7 | XRF powder | 9.36 | 2.47 | XRF powder | 9.64 | 0.95 | XRF rock | 8.03 | 3.9 |
| | | **SAMPLE** | | | **Th** | **Th** | | **Th** | **Th** | | | | | | | | **Th** | **Th** |
| **Unit** | **Location** | **Horizon** | **Plotting #** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | | | **Analysis** | | | **Analysis** | **ppm** | **2σ** |
| Tunnel City | Arcadia Quarry | 313.90 | 17 | ICP-MS | 1.24500 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 347.70 | 18 | ICP-MS | 1.44000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.25a | 19 | ICP-MS | 3.77000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.73 | 0.98 | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.95a | 20 | ICP-MS | 3.86000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.89 | 0.89 | XRF rock | | **< LOD** |
| Tunnel City | Belisle Quarry | 146.00 | 21 | ICP-MS | 4.22000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.64 | 0.94 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 339.70 | 22 | ICP-MS | 5.67000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 7.71 | 2.68 | XRF powder | 6.71 | 0.99 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 296.60 | 23 | ICP-MS | 6.23000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 3.3 | 1 | XRF rock | | **< LOD** |
| Tunnel City | Belisle Quarry | 132.00 | 24 | ICP-MS | 7.05000 | 3.26683 | XRF powder | 5.5 | 3.59 | XRF powder | 5.49 | 2.5 | XRF powder | 5.14 | 0.94 | XRF rock | | **< LOD** |
| Tunnel City | Triemstra | 165.00 | 25 | ICP-MS | 7.60000 | 3.26683 | XRF powder | 8.14 | 3.49 | XRF powder | 5.73 | 2.31 | XRF powder | 8.04 | 0.93 | XRF rock | 7.99 | 3.9 |
| Tunnel City | Arcadia Quarry | 290.00 | 26 | ICP-MS | 7.88000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 3.6 | 1.09 | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.95c | 27 | ICP-MS | 8.32000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 5.34 | 3.19 | XRF powder | 7.34 | 1.29 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 309.50 | 28 | ICP-MS | 8.70000 | 3.26683 | XRF powder | 5.96 | 3.58 | XRF powder | 8.67 | 2.58 | XRF powder | 8.12 | 0.98 | XRF rock | 11.16 | 4.62 |
| Tunnel City | Arcadia Quarry | 350.90 | 29 | ICP-MS | 10.15000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 10.04 | 2.83 | XRF powder | 10.09 | 1.09 | XRF rock | 8.69 | 4.48 |
| Tunnel City | GDB | 3.95b | 30 | ICP-MS | 11.15000 | 3.26683 | XRF powder | | **< LOD** | XRF powder | 8.15 | 3.42 | XRF powder | 6.49 | 1.28 | XRF rock | | **< LOD** |

* Samples are named by the horizon of which they were collected from. Horizon depths corresponding to cores (Arcadia Quarry, Belisle Quarry, and Triemstra) or cuttings sets (Arbor Hills) are in feet below land surface. Horizon depths corresponding to hands samples (Granddad Bluff - GDB) are in meters from datum, which is the Tunnel City Group - Wonewoc Formation boundary contact.

Appendix 1: WGNHS pXRF accuracy for uranium and thorium

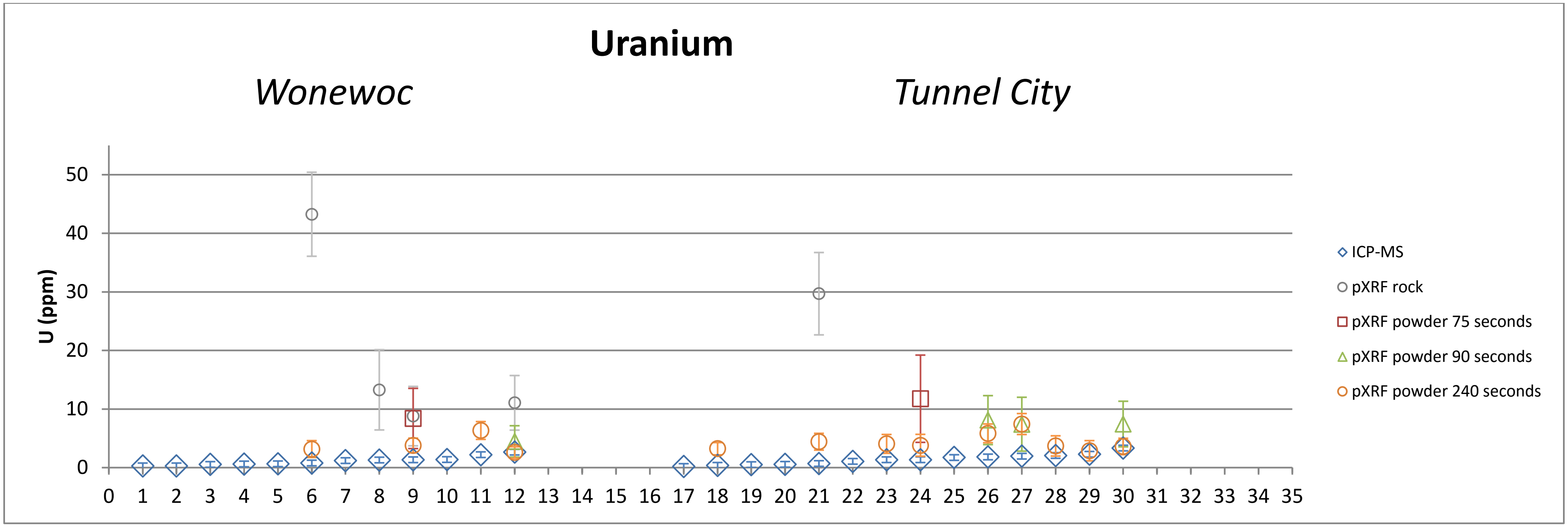


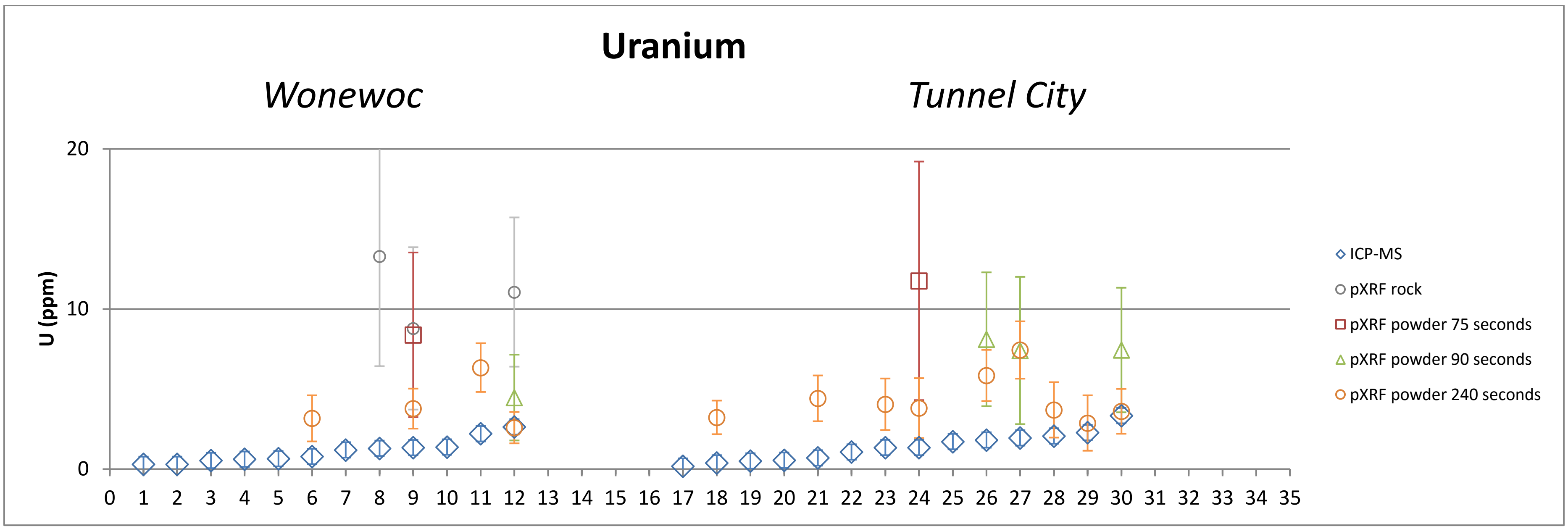
## Appendix 1: WGNHS pXRF accuracy for uranium and thorium

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **FILTERS** | | | **FILTERS** | | | **FILTERS** | | | **FILTERS** | | |
| | | | | | | | Main = 15s | | | Main = 30s | | | Main = 180s | | | Main = 15s | | |
| | | | | | | | Light = 30s | | | Light = 30s | | | Light = 30s | | | Light = 30s | | |
| | | | | | | | Low = 15s | | | Low = 30s | | | Low = 30s | | | Low = 15s | | |
| | | | | | | | High = 15s | | | High = 0s | | | High = 0s | | | High = 15s | | |
| | | **SAMPLE*** | | | **U** | **U** | | **U** | **U** | | **U** | **U** | | **U** | **U** | | **U** | **U** |
| **Unit** | **Location** | **Horizon** | **Plotting #** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** |
| Wonewoc | Triemstra | 171.00 | 1 | ICP-MS | 0.30000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 398.00 | 2 | ICP-MS | 0.30000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 442.50 | 3 | ICP-MS | 0.54000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arbor Hills | 402.50 | 4 | ICP-MS | 0.62000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Belisle Quarry | 182.00 | 5 | ICP-MS | 0.65000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Triemstra | 176.00 | 6 | ICP-MS | 0.79000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 3.17 | 1.44 | XRF rock | 43.25 | 7.17 |
| Wonewoc | Arcadia Quarry | 430.50 | 7 | ICP-MS | 1.20000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 375.70 | 8 | ICP-MS | 1.30000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | 13.28 | 6.85 |
| Wonewoc | GDB | -0.65 | 9 | ICP-MS | 1.34000 | 0.48083 | XRF powder | 8.39 | 5.14 | XRF powder | | **< LOD** | XRF powder | 3.78 | 1.25 | XRF rock | 8.79 | 5.07 |
| Wonewoc | Triemstra | 202.90 | 10 | ICP-MS | 1.38000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Wonewoc | Arcadia Quarry | 376.50 | 11 | ICP-MS | 2.21000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 6.34 | 1.52 | XRF rock | | **< LOD** |
| Wonewoc | Belisle Quarry | 199.00 | 12 | ICP-MS | 2.64000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | 4.47 | 2.68 | XRF powder | 2.59 | 0.98 | XRF rock | 11.06 | 4.66 |
| | | **SAMPLE** | | | **U** | **U** | | **U** | **U** | | **U** | **U** | | **U** | **U** | | **U** | **U** |
| **Unit** | **Location** | **Horizon** | **Plotting #** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** | **Analysis** | **ppm** | **2σ** |
| Tunnel City | Arcadia Quarry | 313.90 | 17 | ICP-MS | 0.19000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 347.70 | 18 | ICP-MS | 0.39000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 3.23 | 1.05 | XRF rock | | **< LOD** |
| Tunnel City | Belisle Quarry | 146.00 | 19 | ICP-MS | 0.51000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.95a | 20 | ICP-MS | 0.56000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.25a | 21 | ICP-MS | 0.70000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 4.42 | 1.43 | XRF rock | 29.69 | 7.03 |
| Tunnel City | GDB | 3.95c | 22 | ICP-MS | 1.07000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | Belisle Quarry | 132.00 | 23 | ICP-MS | 1.35000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 4.05 | 1.61 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 290.00 | 24 | ICP-MS | 1.35000 | 0.48083 | XRF powder | 11.76 | 7.45 | XRF powder | | **< LOD** | XRF powder | 3.81 | 1.87 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 296.60 | 25 | ICP-MS | 1.72000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF rock | | **< LOD** |
| Tunnel City | Triemstra | 165.00 | 26 | ICP-MS | 1.82000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | 8.11 | 4.18 | XRF powder | 5.85 | 1.6 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 309.50 | 27 | ICP-MS | 1.95000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | 7.41 | 4.6 | XRF powder | 7.44 | 1.79 | XRF rock | | **< LOD** |
| Tunnel City | GDB | 3.95b | 28 | ICP-MS | 2.07000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 3.7 | 1.73 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 350.90 | 29 | ICP-MS | 2.28000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | | **< LOD** | XRF powder | 2.88 | 1.73 | XRF rock | | **< LOD** |
| Tunnel City | Arcadia Quarry | 339.70 | 30 | ICP-MS | 3.34000 | 0.48083 | XRF powder | | **< LOD** | XRF powder | 7.44 | 3.89 | XRF powder | 3.61 | 1.4 | XRF rock | | **< LOD** |

* Samples are named by the horizon of which they were collected from. Horizon depths corresponding to cores (Arcadia Quarry, Belisle Quarry, and Triemstra) or cuttings sets (Arbor Hills) are in feet below land surface. Horizon depths corresponding to hands samples (Granddad Bluff - GDB) are in meters from datum, which is the Tunnel City Group - Wonewoc Formation boundary contact.

Appendix 1: WGNHS pXRF accuracy for uranium and thorium



**Results:**

Results of the pXRF and ICP-MS analyses are presented above. It should be noted that this comparison of pXRF and ICP-MS data is based on the specific duration of the pXRF filter times; longer duration times may increase pXRF accuracy and/or precision at certain concentrations and decrease the need for, or improve, calibration factors.

Thorium values determined by pXRF were nearly all within the accepted measurement determined by ICP-MS, regardless of the pXRF filter duration times. The accepted range of values for each measurement is denoted by vertical error bars above and below with each data point. The pXRF limit of detection for thorium is ~1 ppm at a total run time of 240 seconds, ~2.75 ppm at 90 seconds in the quartz-dominated sandstone matrix of the Wonewoc Formation, and ~5 ppm at 90 seconds run time in the more complex lithology of the Tunnel City Group. Uranium values were only accurate at accepted values of ~2 ppm and greater. At lower concentrations, pXRF analysis at 240 seconds either overestimated uranium concentrations or it was below the limit of detection for the instrument.

**Discussion:**

Comparison of rock surface (core and hand sample) pXRF values to both powdered rock pXRF and ICP-MS data should be done with the caveat that the rock powders were sampled from both the surface, and below it, and therefore may contain material not analyzed on the rock surface using pXRF. The rocks, due to small-scale features like burrows and non-uniform cements, as well as spatially-variable oxidation, are heterolithic within the scale of the pXRF analysis window. Additionally, the rock surface analyses were undertaken in some cases months before the powders were drilled; while we drilled powder from the same core depth, the sample would not have been the exact same spot on the core surface that was initially analyzed.

It should also be noted that grain size and mineralogy may cause differences in the concentrations measured by ICP-MS and pXRF on the rock powders analyzed. Rock powders collected using a drill bit can be relatively coarse depending on lithology and degree of cementation. In ICP-MS, the sample is fully digested which would minimize the effects of grain size and mineralogy relative to the pXRF analysis of loosely packed rock powders in a vial. Future studies of sandstones could incorporate comparison of pXRF to energy-dispersive XRF analysis of pressed pellets to further test the effects of grain size (see Rowe et al. 2012 for a study of mudstone).

The results presented suggest that the pXRF can accurately determine thorium values in the range of 1.24 – 11.15 ppm for the lithologies tested. However, the pXRF has difficulty accurately determining low concentrations of uranium (less than ~2 ppm) at both 90 and 240 second run times in both lithologies. The plots above also indicate that pXRF accuracy for uranium differs between the Wonewoc and Tunnel City samples between ~2 and 2.6 ppm, suggesting that there is a matrix (lithology) dependent effect on the pXRF instrument’s ability to accurately interpret the resulting fluorescence.

These results determined by analyzing the Wonewoc Formation and the Tunnel City Group may be applicable to other sandstone-dominated and other siliciclastic units in Wisconsin. The lithology of the quartz-dominated Wonewoc is similar to the Mount Simon Formation, Jordan Formation, and the Tonti Member of the St. Peter Formation. The dolomite cemented and glauconitic sandstone of the Tunnel City Group lithology is similar to that of the Eau Claire Formation in many parts of Wisconsin. Although, one should keep in mind the regional variation of lithologies within each unit across Wisconsin.

**References:**

Rowe, H., Hughes, N., and Robinson, K. (2012) The quantification and application of handheld energy-dispersive x-ray fluorescence (ED-XRF) in mudrock chemostratigraphy and geochemistry, Chemical Geology 324-325:122-131.

Zambito, J.J., IV, McLaughlin, P.I., Haas, L.D., Stewart, E.K., Bremmer, S.E., and Hurth, M.J., 2016, Sampling methodologies and data analysis techniques for geologic materials using portable x-ray fluorescence (pXRF) elemental analysis: Wisconsin Geological and Natural History Survey Open-File Report 2016-02, 12 p., 5 appendices.

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Description:**

PXRF elemental data from Madison Well, No. 4, Madison Well, No. 27, and the standards for the 90 second and 240 second total filter duration-time analyses are displayed in this appendix. Note that elemental values of zero are analyzes below the limit of detection of the pXRF instrument. All values are displayed in parts per million (ppm).

## Madison Well, No. 4 (90 s)

| Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 33606.22 | 938.82 | 2.5 | 1545.88 | 359.87 | 187.5 | 1759.24 | 342.87 | 372.5 | 4522.19 | 442.76 | 557.5 |
| 11120.77 | 664.8 | 7.5 | 1675.35 | 353.65 | 192.5 | 1375.62 | 379.44 | 377.5 | 3021.46 | 389.04 | 562.5 |
| 12400.62 | 704 | 12.5 | 1540.49 | 333.81 | 197.5 | 1723.04 | 391.98 | 382.5 | 2183.81 | 368.49 | 567.5 |
| 13979.26 | 698.99 | 17.5 | 1506.05 | 368.98 | 202.5 | 3204.06 | 469.93 | 387.5 | 2142.37 | 356.59 | 572.5 |
| 14929.43 | 813.4 | 22.5 | 2349.4 | 374.38 | 207.5 | 1641 | 425.25 | 392.5 | 2927.49 | 388.04 | 577.5 |
| 12753.9 | 724.05 | 27.5 | 12264.74 | 648.16 | 212.5 | 2268.47 | 390.93 | 397.5 | 1940.46 | 373.88 | 582.5 |
| 5816.06 | 586.21 | 32.5 | 12747.26 | 636.26 | 217.5 | 1573.06 | 377.23 | 402.5 | 2453.98 | 379.87 | 587.5 |
| 7114.3 | 637.57 | 37.5 | 29290.98 | 1200.46 | 222.5 | 2011.25 | 386.18 | 407.5 | 3916.53 | 403.94 | 592.5 |
| 8458.37 | 651.5 | 42.5 | 45846.64 | 1522.22 | 227.5 | 2918.51 | 410.27 | 412.5 | 2922.56 | 396.08 | 597.5 |
| 7899.21 | 646.45 | 47.5 | 5948.3 | 479.72 | 232.5 | 3194.93 | 391.57 | 417.5 | 2140.84 | 367.35 | 602.5 |
| 6496.19 | 641.73 | 52.5 | 4515.64 | 508.86 | 237.5 | 3540.53 | 407.72 | 422.5 | 2795.66 | 367.35 | 607.5 |
| 5278.52 | 554.7 | 57.5 | 2383.71 | 430.47 | 242.5 | 1939.91 | 370.51 | 427.5 | 7591.03 | 544.85 | 612.5 |
| 8367.7 | 696.9 | 62.5 | 2106.34 | 363.94 | 247.5 | 2677.15 | 456.18 | 432.5 | 8638.09 | 487.89 | 617.5 |
| 6739.31 | 603.1 | 67.5 | 2592.36 | 400.79 | 252.5 | 2730.79 | 422.52 | 437.5 | 7434.46 | 508.91 | 622.5 |
| 7131.53 | 572.86 | 72.5 | 1771.36 | 366.49 | 257.5 | 2545.79 | 351.92 | 442.5 | 6885.35 | 450.22 | 627.5 |
| 1408.9 | 356.43 | 77.5 | 3959.85 | 432.74 | 262.5 | 1677.43 | 369.89 | 447.5 | 5919.52 | 425.87 | 632.5 |
| 1984.8 | 366.27 | 82.5 | 3991.08 | 438.51 | 267.5 | 2254.75 | 362.82 | 452.5 | 8652.25 | 500.19 | 637.5 |
| 1592.44 | 356.47 | 87.5 | 3334.88 | 390.07 | 272.5 | 2014.27 | 377.37 | 457.5 | 4256.81 | 399.88 | 642.5 |
| 2361.51 | 370.29 | 92.5 | 3469.84 | 420.13 | 277.5 | 2080.41 | 377.71 | 462.5 | 4144.31 | 471.96 | 647.5 |
| 1564.14 | 323.02 | 97.5 | 4035.01 | 449.16 | 282.5 | 2198.41 | 389.39 | 467.5 | 4383.73 | 397.25 | 652.5 |
| 2455.53 | 344.4 | 102.5 | 3900.87 | 451.47 | 287.5 | 1398.68 | 339.37 | 472.5 | 2322.03 | 376.12 | 657.5 |
| 1766.28 | 345.78 | 107.5 | 5172.14 | 505.17 | 292.5 | 4191.22 | 402.82 | 477.5 | 3150.32 | 380.52 | 662.5 |
| 1714.97 | 359.39 | 112.5 | 3638.26 | 391.89 | 297.5 | 3978.93 | 416.22 | 482.5 | 2018.03 | 347.78 | 667.5 |
| 3864.67 | 420.03 | 117.5 | 2625.33 | 376.52 | 302.5 | 4734.17 | 407.15 | 487.5 | 2855.26 | 390.8 | 672.5 |
| 3372.49 | 394.93 | 122.5 | 3767.23 | 462.11 | 307.5 | 3976.97 | 408.66 | 492.5 | 3325.32 | 400.72 | 677.5 |
| 1489.99 | 374.65 | 127.5 | 2088.94 | 352.19 | 312.5 | 5026.58 | 439.71 | 497.5 | 2916.02 | 389.67 | 682.5 |
| 6221.32 | 516.71 | 132.5 | 3652.24 | 407.71 | 317.5 | 4496.92 | 403.54 | 502.5 | 7119.54 | 440.76 | 687.5 |
| 3792.92 | 488.36 | 137.5 | 2436.17 | 366.22 | 322.5 | 5358.71 | 421.64 | 507.5 | 5026.78 | 427.13 | 692.5 |
| 2186.36 | 371.95 | 142.5 | 2613.49 | 366.95 | 327.5 | 1928.4 | 352 | 512.5 | 3357.69 | 383.07 | 697.5 |
| 2202.51 | 352.25 | 147.5 | 2278.54 | 404.58 | 332.5 | 2502.7 | 376.55 | 517.5 | 1867.21 | 356.5 | 702.5 |
| 1604.4 | 364.63 | 152.5 | 3156.3 | 465.02 | 337.5 | 2134.67 | 369.58 | 522.5 | 2126.95 | 360.09 | 707.5 |
| 1428.18 | 343.2 | 157.5 | 3376.31 | 518.04 | 342.5 | 1510.74 | 375.2 | 527.5 | 3125.06 | 364.55 | 712.5 |
| 1041.2 | 346.61 | 162.5 | 2219.88 | 443.4 | 347.5 | 1627.47 | 346.7 | 532.5 | 70495.74 | 1698.89 | 717.5 |
| 1432.75 | 359.74 | 167.5 | 4334.11 | 524.59 | 352.5 | 1434.66 | 330.95 | 537.5 | 61916.61 | 1661.46 | 722.5 |
| 1849.46 | 349.12 | 172.5 | 2596.48 | 466.1 | 357.5 | 2618.19 | 392.23 | 542.5 | 52975.47 | 1478.86 | 727.5 |
| 1759.39 | 345.33 | 177.5 | 2244.68 | 391.89 | 362.5 | 3928.47 | 393.84 | 547.5 | 54807.62 | 1561.48 | 732.5 |
| 1674.51 | 356.49 | 182.5 | 2121.77 | 362.07 | 367.5 | 3448.35 | 400.16 | 552.5 | 66099.56 | 1712.98 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Madison Well, No. 4 (90 s)

| K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15018.32 | 262.13 | 2.5 | 342.45 | 39.53 | 187.5 | 405.24 | 42.14 | 372.5 | 2026.83 | 77.84 | 557.5 |
| 8528.54 | 168.81 | 7.5 | 412.89 | 41.1 | 192.5 | 460.41 | 56.05 | 377.5 | 1351.82 | 60.77 | 562.5 |
| 11281.65 | 200.51 | 12.5 | 442.54 | 43.73 | 197.5 | 590.58 | 64.48 | 382.5 | 781.91 | 48.75 | 567.5 |
| 7889.09 | 150.19 | 17.5 | 549.87 | 46.54 | 202.5 | 2071.11 | 90 | 387.5 | 962.33 | 52.24 | 572.5 |
| 11361.7 | 212.56 | 22.5 | 816.61 | 54.79 | 207.5 | 788.56 | 65.57 | 392.5 | 634.86 | 49.38 | 577.5 |
| 10075.21 | 195.97 | 27.5 | 12246.65 | 192 | 212.5 | 1099.55 | 69.03 | 397.5 | 781.12 | 47.28 | 582.5 |
| 4085.43 | 135.56 | 32.5 | 11813.75 | 184.21 | 217.5 | 528.17 | 48.33 | 402.5 | 588.6 | 51.18 | 587.5 |
| 6888.27 | 150.27 | 37.5 | 33890.22 | 378.77 | 222.5 | 672.2 | 51.54 | 407.5 | 3084.16 | 83.18 | 592.5 |
| 6722.48 | 154.03 | 42.5 | 57422.66 | 547.66 | 227.5 | 807.04 | 53.7 | 412.5 | 1191.18 | 62.68 | 597.5 |
| 6549.72 | 154.77 | 47.5 | 5989.13 | 113.64 | 232.5 | 984.92 | 58.84 | 417.5 | 1802.33 | 66.6 | 602.5 |
| 5678.19 | 137.5 | 52.5 | 3426.57 | 101.2 | 237.5 | 1264.76 | 62.37 | 422.5 | 2345.03 | 73.09 | 607.5 |
| 5221.44 | 130.67 | 57.5 | 1202.33 | 68.36 | 242.5 | 723.43 | 50.17 | 427.5 | 5409.98 | 119.71 | 612.5 |
| 6008.99 | 165.81 | 62.5 | 706.57 | 48.77 | 247.5 | 995.02 | 65.67 | 432.5 | 7974.49 | 131.32 | 617.5 |
| 4840.39 | 131.05 | 67.5 | 2014.01 | 80.46 | 252.5 | 879.98 | 73.76 | 437.5 | 4949.01 | 109.52 | 622.5 |
| 9088.52 | 157.36 | 72.5 | 440.68 | 44.23 | 257.5 | 1341.43 | 60.03 | 442.5 | 4755.12 | 105.51 | 627.5 |
| 424.06 | 43.26 | 77.5 | 1362.37 | 69.88 | 262.5 | 547.26 | 48.3 | 447.5 | 3959.47 | 94.38 | 632.5 |
| 1639.57 | 62.15 | 82.5 | 1223.98 | 78.15 | 267.5 | 1139.55 | 54.07 | 452.5 | 6957.04 | 133.23 | 637.5 |
| 390.75 | 40.86 | 87.5 | 1065.27 | 60.64 | 272.5 | 947.19 | 52.22 | 457.5 | 1400.04 | 61.89 | 642.5 |
| 1054.41 | 55.33 | 92.5 | 1582.88 | 75.23 | 277.5 | 461.49 | 44.21 | 462.5 | 1465.02 | 67.87 | 647.5 |
| 504.12 | 42.79 | 97.5 | 2015.62 | 78.63 | 282.5 | 1019.11 | 61.25 | 467.5 | 2486.52 | 75.47 | 652.5 |
| 460.13 | 43.98 | 102.5 | 2278.59 | 86.37 | 287.5 | 611.31 | 46 | 472.5 | 1365.12 | 62.51 | 657.5 |
| 775.75 | 50.49 | 107.5 | 3213.87 | 97.52 | 292.5 | 2082.88 | 72.25 | 477.5 | 1385.01 | 62.14 | 662.5 |
| 582.95 | 50.57 | 112.5 | 1299.6 | 63.75 | 297.5 | 1818.11 | 68.5 | 482.5 | 1088.92 | 55.13 | 667.5 |
| 1420.89 | 67.29 | 117.5 | 1412.15 | 63.04 | 302.5 | 2385.99 | 75.6 | 487.5 | 1571.88 | 66.51 | 672.5 |
| 1262.04 | 57.6 | 122.5 | 1997.35 | 87.43 | 307.5 | 1974.52 | 76.01 | 492.5 | 1877.86 | 71.84 | 677.5 |
| 191.53 | 41.63 | 127.5 | 725.63 | 50.83 | 312.5 | 2110.14 | 72.49 | 497.5 | 2234.64 | 82.05 | 682.5 |
| 1558 | 78.9 | 132.5 | 1513.27 | 65.82 | 317.5 | 2415.83 | 76.15 | 502.5 | 1256.18 | 56.79 | 687.5 |
| 691.07 | 77.54 | 137.5 | 636.71 | 48.99 | 322.5 | 2807.44 | 78.86 | 507.5 | 537.75 | 44.19 | 692.5 |
| 358.1 | 44.06 | 142.5 | 798.86 | 52.45 | 327.5 | 783.98 | 49.8 | 512.5 | 463.44 | 44.84 | 697.5 |
| 466.52 | 44.47 | 147.5 | 898.52 | 66.75 | 332.5 | 649.16 | 47.15 | 517.5 | 225.09 | 34.78 | 702.5 |
| 304.42 | 37.91 | 152.5 | 1083.18 | 69.06 | 337.5 | 1138.72 | 58.9 | 522.5 | 339.64 | 38.01 | 707.5 |
| 229.24 | 36.97 | 157.5 | 1365.89 | 101.66 | 342.5 | 905.39 | 56.67 | 527.5 | 708.14 | 46.87 | 712.5 |
| 222.13 | 36.28 | 162.5 | 685.33 | 73.08 | 347.5 | 486.87 | 45.47 | 532.5 | 31359.59 | 516.43 | 717.5 |
| 393.89 | 41.22 | 167.5 | 1179.62 | 97.41 | 352.5 | 543.87 | 45.52 | 537.5 | 43672.05 | 618.48 | 722.5 |
| 947.88 | 55.67 | 172.5 | 1283.89 | 90.5 | 357.5 | 1134.42 | 57.74 | 542.5 | 40317.1 | 575.15 | 727.5 |
| 270.17 | 39.93 | 177.5 | 973.78 | 59.4 | 362.5 | 1674.75 | 63.6 | 547.5 | 38105.11 | 566.71 | 732.5 |
| 286.44 | 37.47 | 182.5 | 705.54 | 51.34 | 367.5 | 1402.57 | 63.38 | 552.5 | 36775.92 | 562.79 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Madison Well, No. 4 (90 s)**

| Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23436.4 | 472.33 | 2.5 | 485.58 | 23.82 | 187.5 | 2296.05 | 47.51 | 372.5 | 8481.73 | 99.49 | 557.5 |
| 54763.31 | 618.45 | 7.5 | 1251.93 | 35.36 | 192.5 | 34405.45 | 414.28 | 377.5 | 3363.77 | 58.86 | 562.5 |
| 64007.3 | 689.06 | 12.5 | 2596.95 | 51.08 | 197.5 | 37048.46 | 455.5 | 382.5 | 2187.13 | 45.89 | 567.5 |
| 42047.43 | 541 | 17.5 | 5778.82 | 73.47 | 202.5 | 52063.8 | 557 | 387.5 | 4335.95 | 62.92 | 572.5 |
| 88158.09 | 829.22 | 22.5 | 5672.37 | 78.15 | 207.5 | 33202.37 | 430.46 | 392.5 | 7504.81 | 85.06 | 577.5 |
| 80952.49 | 776.17 | 27.5 | 43098.09 | 534.94 | 212.5 | 28802.61 | 400.65 | 397.5 | 902.99 | 30.43 | 582.5 |
| 82677.72 | 780.43 | 32.5 | 48083.67 | 529.4 | 217.5 | 13939.33 | 257.91 | 402.5 | 11087.2 | 233.29 | 587.5 |
| 84644.68 | 753.55 | 37.5 | 108791.74 | 964.5 | 222.5 | 10317.17 | 223.1 | 407.5 | 3440.15 | 60.1 | 592.5 |
| 65657.25 | 697.27 | 42.5 | 98450.52 | 1025.91 | 227.5 | 10047.81 | 220.95 | 412.5 | 7377.31 | 89.76 | 597.5 |
| 72735.91 | 722.81 | 47.5 | 21925.88 | 338.81 | 232.5 | 15018.69 | 273.85 | 417.5 | 5538.86 | 73.1 | 602.5 |
| 64971.96 | 673.99 | 52.5 | 36699.43 | 456.53 | 237.5 | 11479.43 | 242.46 | 422.5 | 3101.57 | 55.99 | 607.5 |
| 55996.01 | 602.68 | 57.5 | 23687.38 | 354.12 | 242.5 | 6935.3 | 80.93 | 427.5 | 32111.05 | 418.16 | 612.5 |
| 95574.02 | 859.73 | 62.5 | 2919.53 | 53.53 | 247.5 | 29489.39 | 400.81 | 432.5 | 19616.59 | 314.83 | 617.5 |
| 64224.82 | 672.65 | 67.5 | 9508.26 | 108.22 | 252.5 | 40367.01 | 480.87 | 437.5 | 31848.63 | 404.64 | 622.5 |
| 45815.89 | 531.86 | 72.5 | 4426.84 | 65.45 | 257.5 | 1877.48 | 44.93 | 442.5 | 11759.67 | 246.43 | 627.5 |
| 2365.36 | 48.72 | 77.5 | 27935.31 | 377.73 | 262.5 | 11422.7 | 229.11 | 447.5 | 12718.36 | 244.84 | 632.5 |
| 1615.2 | 40.45 | 82.5 | 40098.66 | 487.92 | 267.5 | 1432.2 | 37.8 | 452.5 | 27047.21 | 388.97 | 637.5 |
| 625.83 | 26.44 | 87.5 | 13674.86 | 265.46 | 272.5 | 6740.68 | 77.42 | 457.5 | 4840.09 | 69.73 | 642.5 |
| 1147.29 | 35.91 | 92.5 | 30500.81 | 398.64 | 277.5 | 4030.24 | 62.26 | 462.5 | 6721.03 | 87.48 | 647.5 |
| 629.35 | 26.52 | 97.5 | 29409.98 | 392.7 | 282.5 | 16536.68 | 293.97 | 467.5 | 2392.44 | 50.44 | 652.5 |
| 2168.39 | 46.82 | 102.5 | 37314.52 | 441.19 | 287.5 | 2246.47 | 46.86 | 472.5 | 11555.88 | 236.51 | 657.5 |
| 3682.89 | 60.15 | 107.5 | 42775.05 | 476.74 | 292.5 | 7806.98 | 87.88 | 477.5 | 8397.54 | 90.13 | 662.5 |
| 11659.44 | 235.42 | 112.5 | 14113.62 | 266.84 | 297.5 | 18361.97 | 289.77 | 482.5 | 5069.23 | 68.83 | 667.5 |
| 19765.42 | 312.54 | 117.5 | 13584.81 | 253.97 | 302.5 | 8179.14 | 89.33 | 487.5 | 4750.43 | 71.48 | 672.5 |
| 6321.7 | 75.61 | 122.5 | 40848.19 | 480.34 | 307.5 | 15832.64 | 282.62 | 492.5 | 5351.09 | 76.66 | 677.5 |
| 15218.59 | 262.08 | 127.5 | 7405.68 | 84.46 | 312.5 | 17251.25 | 279.03 | 497.5 | 9235.59 | 104.76 | 682.5 |
| 34269.04 | 458.58 | 132.5 | 8163.53 | 91.37 | 317.5 | 7318.23 | 85.03 | 502.5 | 1688.29 | 41.45 | 687.5 |
| 62298.15 | 627.96 | 137.5 | 7231.87 | 83.2 | 322.5 | 12129.6 | 234.76 | 507.5 | 862.54 | 30.85 | 692.5 |
| 7929.4 | 87.5 | 142.5 | 12126.96 | 234.27 | 327.5 | 4463.28 | 64.75 | 512.5 | 5794.15 | 74.51 | 697.5 |
| 3649.68 | 59.6 | 147.5 | 32949.93 | 433.52 | 332.5 | 4926.93 | 67.46 | 517.5 | 518.63 | 23.38 | 702.5 |
| 1050.94 | 32.13 | 152.5 | 42579.83 | 476.59 | 337.5 | 14779.78 | 257.5 | 522.5 | 1099.5 | 32.43 | 707.5 |
| 507.82 | 24.24 | 157.5 | 91711.41 | 789.96 | 342.5 | 11884.39 | 240.46 | 527.5 | 3300.52 | 54.67 | 712.5 |
| 609.62 | 25.49 | 162.5 | 54423.78 | 579.6 | 347.5 | 3072.63 | 56.12 | 532.5 | 12953.67 | 554.76 | 717.5 |
| 831.23 | 30.04 | 167.5 | 75509.45 | 708.2 | 352.5 | 2470.9 | 49.49 | 537.5 | 19284.57 | 684.63 | 722.5 |
| 2805 | 55.46 | 172.5 | 69325.99 | 661.95 | 357.5 | 7398.63 | 84.49 | 542.5 | 21673.98 | 679.96 | 727.5 |
| 562.83 | 26.35 | 177.5 | 13310.68 | 259.91 | 362.5 | 7303.85 | 81.35 | 547.5 | 29157.13 | 767.81 | 732.5 |
| 1497.49 | 37.08 | 182.5 | 4672.23 | 70.1 | 367.5 | 12441.11 | 239.74 | 552.5 | 23620.74 | 716.58 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Madison Well, No. 4 (90 s)

| Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 253461.42 | 1539.26 | 2.5 | 403844.06 | 1895.56 | 187.5 | 382348.47 | 1845.49 | 372.5 | 336925.84 | 1682.69 | 557.5 |
| 274445.31 | 1583.91 | 7.5 | 406142.25 | 1900.1 | 192.5 | 333804.63 | 1705.1 | 377.5 | 366682.47 | 1776.04 | 562.5 |
| 251081.03 | 1562.05 | 12.5 | 391315.44 | 1838.33 | 197.5 | 327444.16 | 1692.18 | 382.5 | 393158 | 1893.6 | 567.5 |
| 296366.56 | 1628.97 | 17.5 | 393965.88 | 1857.68 | 202.5 | 310236 | 1668.6 | 387.5 | 397293.69 | 1876.23 | 572.5 |
| 229392.83 | 1518.45 | 22.5 | 375698.09 | 1819.05 | 207.5 | 360707.94 | 1786.23 | 392.5 | 387892.25 | 1856.13 | 577.5 |
| 246820.48 | 1528.33 | 27.5 | 282482.63 | 1579.22 | 212.5 | 349204.09 | 1736.93 | 397.5 | 401999.16 | 1912.17 | 582.5 |
| 274138 | 1617.77 | 32.5 | 261171.25 | 1541.9 | 217.5 | 374862.66 | 1831.67 | 402.5 | 382741.81 | 1824.54 | 587.5 |
| 278712.22 | 1618.08 | 37.5 | 170171.41 | 1366.75 | 222.5 | 388292.81 | 1847.57 | 407.5 | 387310.03 | 1856.12 | 592.5 |
| 313013.13 | 1705.93 | 42.5 | 172180.41 | 1379.65 | 227.5 | 392830.5 | 1871.11 | 412.5 | 386158.09 | 1848.21 | 597.5 |
| 300862.16 | 1657.93 | 47.5 | 354490.09 | 1739.51 | 232.5 | 359452.97 | 1780.93 | 417.5 | 390528.88 | 1849.89 | 602.5 |
| 358448.22 | 1775.17 | 52.5 | 335398.47 | 1724.47 | 237.5 | 371513.41 | 1808.9 | 422.5 | 392878.31 | 1859.87 | 607.5 |
| 327925.5 | 1719.01 | 57.5 | 342690 | 1728.84 | 242.5 | 379141.16 | 1824.87 | 427.5 | 332497.69 | 1723.92 | 612.5 |
| 244826.84 | 1568.86 | 62.5 | 391812.47 | 1848.39 | 247.5 | 365828.75 | 1828.55 | 432.5 | 330825.28 | 1692.2 | 617.5 |
| 323021.53 | 1705.64 | 67.5 | 324697.53 | 1669.1 | 252.5 | 322794.41 | 1653.07 | 437.5 | 327555 | 1722.77 | 622.5 |
| 347249.31 | 1754.19 | 72.5 | 393419.88 | 1872.2 | 257.5 | 383396.06 | 1858.88 | 442.5 | 358865.34 | 1771.75 | 627.5 |
| 394607.75 | 1873.98 | 77.5 | 341103.09 | 1712.68 | 262.5 | 382756.84 | 1844.45 | 447.5 | 351519.88 | 1746.45 | 632.5 |
| 401517.25 | 1893.44 | 82.5 | 311533.03 | 1655.72 | 267.5 | 394766.72 | 1869.7 | 452.5 | 329789.5 | 1702.33 | 637.5 |
| 405463.84 | 1901.35 | 87.5 | 355432.25 | 1744.68 | 272.5 | 378454.66 | 1818.82 | 457.5 | 367488.06 | 1775.93 | 642.5 |
| 403906.06 | 1899.62 | 92.5 | 327586.81 | 1687.79 | 277.5 | 404013.28 | 1901.56 | 462.5 | 374141.5 | 1809.95 | 647.5 |
| 392327.91 | 1874.6 | 97.5 | 346104.31 | 1752.56 | 282.5 | 364949.19 | 1800.2 | 467.5 | 377228.53 | 1808.96 | 652.5 |
| 399797.09 | 1854.82 | 102.5 | 328675.88 | 1676.45 | 287.5 | 378157.63 | 1828.72 | 472.5 | 381197.84 | 1851.62 | 657.5 |
| 391907.03 | 1847.91 | 107.5 | 313946.81 | 1677.31 | 292.5 | 372332.63 | 1810.44 | 477.5 | 375538.97 | 1812.42 | 662.5 |
| 382417.72 | 1832.55 | 112.5 | 360888.78 | 1782.05 | 297.5 | 357692.66 | 1770.93 | 482.5 | 389550.5 | 1832.96 | 667.5 |
| 364656 | 1775.44 | 117.5 | 367415.34 | 1779.77 | 302.5 | 366650.38 | 1799.23 | 487.5 | 385225.28 | 1862.86 | 672.5 |
| 390783.16 | 1891.11 | 122.5 | 325244.03 | 1694.12 | 307.5 | 350057.94 | 1743.48 | 492.5 | 380062.06 | 1841.65 | 677.5 |
| 388358.63 | 1846.91 | 127.5 | 378719.69 | 1816.54 | 312.5 | 366269.03 | 1778.68 | 497.5 | 365128.81 | 1756.84 | 682.5 |
| 357056.53 | 1790.26 | 132.5 | 365878.25 | 1813.67 | 317.5 | 373471.31 | 1813.12 | 502.5 | 373850.56 | 1828.25 | 687.5 |
| 300470.06 | 1653.32 | 137.5 | 386627.28 | 1851.47 | 322.5 | 358138.94 | 1766.76 | 507.5 | 401521.22 | 1910.57 | 692.5 |
| 382914.19 | 1839.37 | 142.5 | 368220.91 | 1781.27 | 327.5 | 386360.97 | 1865.06 | 512.5 | 387814.88 | 1850.1 | 697.5 |
| 395593.94 | 1872.4 | 147.5 | 338471.88 | 1726.91 | 332.5 | 397032.63 | 1882.96 | 517.5 | 386740.66 | 1884.32 | 702.5 |
| 404212.75 | 1908.89 | 152.5 | 334342.19 | 1745.89 | 337.5 | 368547.94 | 1791.36 | 522.5 | 393103.38 | 1891.7 | 707.5 |
| 402003.75 | 1895.05 | 157.5 | 248282.47 | 1526.6 | 342.5 | 375651.03 | 1826.3 | 527.5 | 375530.84 | 1789.69 | 712.5 |
| 404069.34 | 1915.77 | 162.5 | 316230.19 | 1687.54 | 347.5 | 393591.09 | 1848.15 | 532.5 | 166907.72 | 1305.97 | 717.5 |
| 392854.22 | 1881.17 | 167.5 | 261964.89 | 1567.8 | 352.5 | 396723.13 | 1866.74 | 537.5 | 177938.16 | 1386.69 | 722.5 |
| 373405.91 | 1795.35 | 172.5 | 274924.53 | 1582.69 | 357.5 | 378346.22 | 1840.62 | 542.5 | 174639.48 | 1351.54 | 727.5 |
| 396560.63 | 1869.11 | 177.5 | 371411.44 | 1813.62 | 362.5 | 367163.25 | 1786.79 | 547.5 | 175016.92 | 1360.51 | 732.5 |
| 409921.06 | 1909.42 | 182.5 | 387687.06 | 1848.01 | 367.5 | 366517.34 | 1780.61 | 552.5 | 178868.86 | 1372.98 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Madison Well, No. 4 (90 s)**

| Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18951.61 | 231.83 | 2.5 | 940.38 | 42.35 | 187.5 | 422.19 | 32.44 | 372.5 | 6232.6 | 102.07 | 557.5 |
| 5373.56 | 95.81 | 7.5 | 666.42 | 37.52 | 192.5 | 1289.15 | 49.91 | 377.5 | 2744.31 | 67.54 | 562.5 |
| 5514.14 | 97.53 | 12.5 | 678.64 | 37.44 | 197.5 | 1367.32 | 50.93 | 382.5 | 229.09 | 27.39 | 567.5 |
| 6246.55 | 104.3 | 17.5 | 3503.21 | 75.91 | 202.5 | 2517.44 | 67.64 | 387.5 | 317.08 | 30 | 572.5 |
| 6438.02 | 108.49 | 22.5 | 6057.75 | 101.89 | 207.5 | 749.71 | 39.74 | 392.5 | 325.07 | 30.16 | 577.5 |
| 5100.44 | 94.88 | 27.5 | 19767.14 | 232.22 | 212.5 | 2526.8 | 67.37 | 397.5 | 281.31 | 28.76 | 582.5 |
| 3144.43 | 77.19 | 32.5 | 1282.52 | 49.31 | 217.5 | 1040.34 | 45.23 | 402.5 | 390.04 | 31.62 | 587.5 |
| 2576.35 | 68.7 | 37.5 | 6113.32 | 104.85 | 222.5 | 1707.95 | 55.37 | 407.5 | 456.02 | 33.14 | 592.5 |
| 10347.73 | 174.06 | 42.5 | 20699.67 | 250.59 | 227.5 | 814.66 | 40.91 | 412.5 | 3916.23 | 81.59 | 597.5 |
| 5907.96 | 100.83 | 47.5 | 2042.22 | 60.6 | 232.5 | 1171.02 | 48.15 | 417.5 | 488.39 | 33.83 | 602.5 |
| 4817.82 | 90.87 | 52.5 | 2120.44 | 62.14 | 237.5 | 3142.7 | 74.17 | 422.5 | 214.91 | 27.05 | 607.5 |
| 2805.78 | 70.56 | 57.5 | 1276.83 | 49.22 | 242.5 | 766.29 | 39.75 | 427.5 | 1696.58 | 55.64 | 612.5 |
| 11195.36 | 176.97 | 62.5 | 430.59 | 32.21 | 247.5 | 1922.69 | 59.12 | 432.5 | 706.41 | 38.64 | 617.5 |
| 4900 | 93.19 | 67.5 | 10528.62 | 167.41 | 252.5 | 6113.97 | 102.04 | 437.5 | 690.83 | 39.36 | 622.5 |
| 1518.31 | 54.2 | 72.5 | 656.86 | 37.38 | 257.5 | 837.59 | 41.63 | 442.5 | 755.95 | 40.06 | 627.5 |
| 573.42 | 35.26 | 77.5 | 1415.55 | 50.9 | 262.5 | 460.49 | 33.37 | 447.5 | 505.46 | 34.37 | 632.5 |
| 638.43 | 37 | 82.5 | 2766.09 | 69.45 | 267.5 | 235.06 | 27.37 | 452.5 | 1252.42 | 49.41 | 637.5 |
| 439.98 | 32.55 | 87.5 | 2868.11 | 69.55 | 272.5 | 677.82 | 37.55 | 457.5 | 1888.27 | 57.8 | 642.5 |
| 528.78 | 34.72 | 92.5 | 1107.01 | 46.03 | 277.5 | 268.04 | 28.58 | 462.5 | 4964.24 | 90.85 | 647.5 |
| 496.44 | 34.43 | 97.5 | 735.02 | 39.91 | 282.5 | 1231.08 | 48.64 | 467.5 | 773.78 | 39.31 | 652.5 |
| 236.84 | 27.27 | 102.5 | 1034.9 | 44.66 | 287.5 | 695.72 | 38.58 | 472.5 | 427.86 | 33.18 | 657.5 |
| 326.56 | 29.77 | 107.5 | 1039.3 | 44.97 | 292.5 | 362.17 | 31.06 | 477.5 | 761.4 | 40.04 | 662.5 |
| 425.44 | 32.65 | 112.5 | 463.03 | 33.66 | 297.5 | 1451.92 | 52.16 | 482.5 | 721.2 | 38.52 | 667.5 |
| 1071.02 | 45.75 | 117.5 | 680.45 | 39.17 | 302.5 | 503.83 | 34.62 | 487.5 | 1655.01 | 54.74 | 672.5 |
| 787.77 | 40.98 | 122.5 | 2517.11 | 66.23 | 307.5 | 1336.45 | 49.14 | 492.5 | 3073.3 | 72.36 | 677.5 |
| 423.92 | 32.61 | 127.5 | 261.78 | 28.43 | 312.5 | 591.07 | 36.21 | 497.5 | 13891.05 | 191.04 | 682.5 |
| 1106.69 | 47.25 | 132.5 | 2062.28 | 60.4 | 317.5 | 609.35 | 36.74 | 502.5 | 471.66 | 33.32 | 687.5 |
| 1837.32 | 59.17 | 137.5 | 347.14 | 30.84 | 322.5 | 993.28 | 44.04 | 507.5 | 645.86 | 37.42 | 692.5 |
| 539.08 | 35.01 | 142.5 | 374.57 | 31.2 | 327.5 | 331.55 | 30.48 | 512.5 | 330.14 | 30.26 | 697.5 |
| 541.68 | 35.17 | 147.5 | 1204.16 | 48.16 | 332.5 | 349.35 | 30.93 | 517.5 | 364.6 | 31.05 | 702.5 |
| 401.86 | 31.74 | 152.5 | 1483.56 | 53.84 | 337.5 | 774.12 | 40.3 | 522.5 | 193.93 | 26.55 | 707.5 |
| 2698.8 | 68.54 | 157.5 | 2683.56 | 70.78 | 342.5 | 1859.32 | 57.17 | 527.5 | 1273.18 | 47.88 | 712.5 |
| 359.92 | 30.98 | 162.5 | 2044.62 | 62.34 | 347.5 | 396.02 | 31.45 | 532.5 | 99351.95 | 679.08 | 717.5 |
| 1735.24 | 54.87 | 167.5 | 4625.84 | 89.54 | 352.5 | 172.48 | 25.98 | 537.5 | 100370.45 | 702.13 | 722.5 |
| 5310.06 | 93.37 | 172.5 | 4117.33 | 84.93 | 357.5 | 1114.9 | 45.99 | 542.5 | 102991.87 | 715.58 | 727.5 |
| 2036.99 | 59.29 | 177.5 | 1959.23 | 59.09 | 362.5 | 1655.47 | 54.91 | 547.5 | 110014.13 | 757.62 | 732.5 |
| 313.71 | 29.57 | 182.5 | 926.73 | 42.39 | 367.5 | 893.28 | 42.12 | 552.5 | 109785.32 | 760.22 | 736 |

**Madison Well, No. 4 (90 s)**

| S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 529.93 | 56.76 | 2.5 | 0 | 106.03 | 187.5 | 603.95 | 46.51 | 372.5 | 28544.89 | 277.12 | 557.5 |
| 14658.83 | 203.48 | 7.5 | 0 | 97.85 | 192.5 | 1392.47 | 65.09 | 377.5 | 10068.39 | 146.48 | 562.5 |
| 1342.06 | 77.3 | 12.5 | 0 | 103.86 | 197.5 | 528.67 | 51.45 | 382.5 | 0 | 104.09 | 567.5 |
| 16864.55 | 215.76 | 17.5 | 0 | 107.42 | 202.5 | 2138.21 | 81.57 | 387.5 | 416.95 | 43.28 | 572.5 |
| 652.24 | 68.81 | 22.5 | 0 | 124.35 | 207.5 | 3016.14 | 91.48 | 392.5 | 540.53 | 47.6 | 577.5 |
| 536.1 | 62.97 | 27.5 | 227.74 | 51.14 | 212.5 | 1340.37 | 62.13 | 397.5 | 0 | 99.53 | 582.5 |
| 472.15 | 62.13 | 32.5 | 0 | 165.16 | 217.5 | 1551.13 | 66.6 | 402.5 | 1387.83 | 61.09 | 587.5 |
| 660.44 | 68.07 | 37.5 | 2826.38 | 111.38 | 222.5 | 3759.01 | 91.42 | 407.5 | 892.59 | 53.59 | 592.5 |
| 1001.28 | 71.83 | 42.5 | 6659.59 | 158.12 | 227.5 | 1891.5 | 70.3 | 412.5 | 769.5 | 52.13 | 597.5 |
| 889.15 | 70.56 | 47.5 | 9613.94 | 148.85 | 232.5 | 5926.55 | 111.1 | 417.5 | 949.87 | 54.14 | 602.5 |
| 832.33 | 72.14 | 52.5 | 13618.62 | 191.57 | 237.5 | 3371.09 | 86.65 | 422.5 | 703.3 | 48.86 | 607.5 |
| 799.88 | 65.67 | 57.5 | 18645.38 | 221.25 | 242.5 | 2118.48 | 71.75 | 427.5 | 6544.82 | 129.72 | 612.5 |
| 784.64 | 73.03 | 62.5 | 5488.66 | 104.6 | 247.5 | 2564.1 | 88.01 | 432.5 | 1113.73 | 58.94 | 617.5 |
| 664.24 | 64.6 | 67.5 | 22794.46 | 240.08 | 252.5 | 5525.63 | 112.61 | 437.5 | 826.35 | 58.84 | 622.5 |
| 414.79 | 56.15 | 72.5 | 3059.72 | 82.11 | 257.5 | 424.17 | 43.36 | 442.5 | 950.72 | 54.16 | 627.5 |
| 0 | 107.76 | 77.5 | 2022.27 | 73.28 | 262.5 | 493.63 | 48.11 | 447.5 | 869.34 | 52.66 | 632.5 |
| 386.42 | 43.46 | 82.5 | 1133.63 | 62.55 | 267.5 | 513 | 46.42 | 452.5 | 1253.3 | 61.9 | 637.5 |
| 532.99 | 45.82 | 87.5 | 3054.36 | 81.05 | 272.5 | 4653.08 | 100.85 | 457.5 | 10829.33 | 149.16 | 642.5 |
| 750.28 | 49.13 | 92.5 | 4294.57 | 100.57 | 277.5 | 667.37 | 50.3 | 462.5 | 18814.23 | 222.53 | 647.5 |
| 425.31 | 40.99 | 97.5 | 1065.24 | 61.69 | 282.5 | 579.55 | 51.17 | 467.5 | 1029.69 | 55.01 | 652.5 |
| 455.43 | 41.02 | 102.5 | 1199.73 | 64.21 | 287.5 | 3944.32 | 88.64 | 472.5 | 1035.57 | 56.2 | 657.5 |
| 460.45 | 43.95 | 107.5 | 1221.05 | 68.35 | 292.5 | 1254.16 | 58.86 | 477.5 | 1814.44 | 66.13 | 662.5 |
| 362.08 | 42.91 | 112.5 | 614.19 | 48.99 | 297.5 | 2058.98 | 72.44 | 482.5 | 1114.61 | 54.17 | 667.5 |
| 497.44 | 48.02 | 117.5 | 3116.34 | 81.59 | 302.5 | 1766.69 | 65.54 | 487.5 | 1947.66 | 69.88 | 672.5 |
| 747.69 | 51.3 | 122.5 | 764.15 | 58.74 | 307.5 | 785.65 | 53.29 | 492.5 | 2308.05 | 74.61 | 677.5 |
| 0 | 110.99 | 127.5 | 1310.36 | 57.93 | 312.5 | 481.58 | 48.91 | 497.5 | 1381.64 | 60.38 | 682.5 |
| 796.83 | 59.84 | 132.5 | 700.91 | 52.39 | 317.5 | 637 | 48.9 | 502.5 | 465.39 | 46.15 | 687.5 |
| 501.04 | 57.22 | 137.5 | 781.82 | 50.62 | 322.5 | 644.71 | 49.82 | 507.5 | 939.95 | 55.03 | 692.5 |
| 434.53 | 44.91 | 142.5 | 646.03 | 48.41 | 327.5 | 0 | 105.21 | 512.5 | 3081.37 | 79.99 | 697.5 |
| 0 | 108.25 | 147.5 | 2087.18 | 76.45 | 332.5 | 939.18 | 53.65 | 517.5 | 1212.59 | 58 | 702.5 |
| 0 | 99.52 | 152.5 | 1456.32 | 71.76 | 337.5 | 503.75 | 47.13 | 522.5 | 911.28 | 52.6 | 707.5 |
| 0 | 111.02 | 157.5 | 1389.86 | 76.9 | 342.5 | 416.3 | 47.75 | 527.5 | 2035.35 | 66.55 | 712.5 |
| 0 | 99.45 | 162.5 | 1567.17 | 73.44 | 347.5 | 842.56 | 50.33 | 532.5 | 0 | 422.21 | 717.5 |
| 447.59 | 45.91 | 167.5 | 873.54 | 66.83 | 352.5 | 358.13 | 40.79 | 537.5 | 222.35 | 63.26 | 722.5 |
| 0 | 122.92 | 172.5 | 936.04 | 66.28 | 357.5 | 1829.82 | 69.93 | 542.5 | 165.68 | 61.38 | 727.5 |
| 0 | 109.8 | 177.5 | 1505.08 | 64.58 | 362.5 | 5043.55 | 100.59 | 547.5 | 0 | 90.33 | 732.5 |
| 0 | 103.79 | 182.5 | 481.39 | 45.74 | 367.5 | 3777.29 | 90.18 | 552.5 | 0 | 85.75 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Madison Well, No. 4 (90 s)

| Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.19 | 2.68 | 2.5 | 0 | 2.56 | 187.5 | 0 | 2.79 | 372.5 | 0 | 2.98 | 557.5 |
| 0 | 3.12 | 7.5 | 0 | 2.73 | 192.5 | 0 | 2.8 | 377.5 | 0 | 2.68 | 562.5 |
| 0 | 3.05 | 12.5 | 0 | 2.64 | 197.5 | 0 | 2.78 | 382.5 | 0 | 2.8 | 567.5 |
| 0 | 3.17 | 17.5 | 0 | 2.7 | 202.5 | 0 | 2.94 | 387.5 | 0 | 2.75 | 572.5 |
| 3.57 | 2.26 | 22.5 | 0 | 2.96 | 207.5 | 0 | 2.63 | 392.5 | 0 | 2.56 | 577.5 |
| 0 | 3.25 | 27.5 | 0 | 3.18 | 212.5 | 0 | 2.84 | 397.5 | 0 | 2.73 | 582.5 |
| 0 | 3.08 | 32.5 | 0 | 2.8 | 217.5 | 0 | 2.96 | 402.5 | 0 | 2.74 | 587.5 |
| 0 | 2.99 | 37.5 | 4.55 | 2.29 | 222.5 | 0 | 2.64 | 407.5 | 0 | 2.74 | 592.5 |
| 0 | 3.52 | 42.5 | 7.56 | 2.66 | 227.5 | 0 | 2.71 | 412.5 | 0 | 2.76 | 597.5 |
| 0 | 2.96 | 47.5 | 3.54 | 2.05 | 232.5 | 0 | 2.84 | 417.5 | 0 | 2.64 | 602.5 |
| 4.6 | 2.15 | 52.5 | 0 | 2.88 | 237.5 | 0 | 2.73 | 422.5 | 0 | 2.64 | 607.5 |
| 0 | 2.92 | 57.5 | 0 | 2.7 | 242.5 | 0 | 2.71 | 427.5 | 0 | 2.75 | 612.5 |
| 0 | 3.08 | 62.5 | 0 | 2.57 | 247.5 | 0 | 2.73 | 432.5 | 0 | 2.79 | 617.5 |
| 0 | 3.16 | 67.5 | 0 | 2.81 | 252.5 | 0 | 2.81 | 437.5 | 0 | 2.73 | 622.5 |
| 0 | 2.98 | 72.5 | 0 | 2.67 | 257.5 | 0 | 2.77 | 442.5 | 0 | 2.78 | 627.5 |
| 0 | 2.56 | 77.5 | 0 | 2.68 | 262.5 | 0 | 2.66 | 447.5 | 0 | 2.63 | 632.5 |
| 0 | 2.77 | 82.5 | 0 | 2.76 | 267.5 | 0 | 2.7 | 452.5 | 0 | 2.78 | 637.5 |
| 0 | 2.44 | 87.5 | 0 | 2.67 | 272.5 | 0 | 2.57 | 457.5 | 0 | 2.73 | 642.5 |
| 0 | 2.68 | 92.5 | 0 | 2.68 | 277.5 | 0 | 2.62 | 462.5 | 3.14 | 2.02 | 647.5 |
| 0 | 2.74 | 97.5 | 0 | 2.69 | 282.5 | 0 | 2.7 | 467.5 | 0 | 2.75 | 652.5 |
| 0 | 2.44 | 102.5 | 0 | 4.94 | 287.5 | 0 | 2.61 | 472.5 | 4.03 | 2.04 | 657.5 |
| 0 | 2.55 | 107.5 | 0 | 2.61 | 292.5 | 0 | 2.73 | 477.5 | 0 | 2.83 | 662.5 |
| 0 | 2.57 | 112.5 | 0 | 2.61 | 297.5 | 0 | 2.59 | 482.5 | 0 | 2.7 | 667.5 |
| 0 | 2.78 | 117.5 | 0 | 6.21 | 302.5 | 0 | 2.73 | 487.5 | 0 | 2.72 | 672.5 |
| 0 | 2.8 | 122.5 | 0 | 2.68 | 307.5 | 0 | 2.62 | 492.5 | 0 | 2.84 | 677.5 |
| 0 | 2.58 | 127.5 | 0 | 2.76 | 312.5 | 0 | 2.68 | 497.5 | 0 | 2.82 | 682.5 |
| 0 | 2.84 | 132.5 | 0 | 2.61 | 317.5 | 0 | 2.83 | 502.5 | 0 | 2.81 | 687.5 |
| 0 | 2.85 | 137.5 | 0 | 2.69 | 322.5 | 0 | 2.75 | 507.5 | 0 | 2.83 | 692.5 |
| 0 | 2.77 | 142.5 | 0 | 2.68 | 327.5 | 0 | 2.7 | 512.5 | 0 | 2.81 | 697.5 |
| 0 | 2.72 | 147.5 | 0 | 2.65 | 332.5 | 0 | 2.83 | 517.5 | 0 | 2.69 | 702.5 |
| 0 | 2.73 | 152.5 | 0 | 2.72 | 337.5 | 0 | 2.65 | 522.5 | 0 | 2.67 | 707.5 |
| 0 | 2.86 | 157.5 | 0 | 2.98 | 342.5 | 0 | 2.81 | 527.5 | 0 | 2.77 | 712.5 |
| 0 | 2.61 | 162.5 | 0 | 2.7 | 347.5 | 0 | 2.56 | 532.5 | 0 | 4.44 | 717.5 |
| 0 | 2.67 | 167.5 | 0 | 2.82 | 352.5 | 0 | 2.61 | 537.5 | 0 | 4.35 | 722.5 |
| 0 | 2.68 | 172.5 | 0 | 2.81 | 357.5 | 0 | 2.78 | 542.5 | 0 | 4.29 | 727.5 |
| 0 | 2.64 | 177.5 | 0 | 2.71 | 362.5 | 0 | 2.61 | 547.5 | 0 | 4.3 | 732.5 |
| 0 | 2.69 | 182.5 | 0 | 2.73 | 367.5 | 0 | 2.56 | 552.5 | 0 | 4.62 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Madison Well, No. 4 (90 s)**

| U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5.84 | 2.5 | 0 | 3.42 | 187.5 | 0 | 3.54 | 372.5 | 0 | 3.71 | 557.5 |
| 0 | 4.23 | 7.5 | 0 | 3.76 | 192.5 | 0 | 3.66 | 377.5 | 0 | 3.58 | 562.5 |
| 0 | 4.56 | 12.5 | 0 | 3.42 | 197.5 | 0 | 3.65 | 382.5 | 0 | 3.59 | 567.5 |
| 0 | 4.62 | 17.5 | 0 | 3.65 | 202.5 | 0 | 3.85 | 387.5 | 0 | 3.56 | 572.5 |
| 0 | 4.94 | 22.5 | 0 | 3.68 | 207.5 | 0 | 3.69 | 392.5 | 0 | 3.6 | 577.5 |
| 0 | 4.73 | 27.5 | 0 | 4.08 | 212.5 | 0 | 3.72 | 397.5 | 0 | 3.6 | 582.5 |
| 0 | 4.13 | 32.5 | 0 | 4.04 | 217.5 | 0 | 3.66 | 402.5 | 0 | 3.46 | 587.5 |
| 0 | 4.34 | 37.5 | 7.11 | 3.59 | 222.5 | 0 | 3.6 | 407.5 | 0 | 3.82 | 592.5 |
| 0 | 4.36 | 42.5 | 0 | 6.38 | 227.5 | 0 | 3.64 | 412.5 | 0 | 3.64 | 597.5 |
| 0 | 4.21 | 47.5 | 0 | 4.2 | 232.5 | 0 | 3.8 | 417.5 | 0 | 3.54 | 602.5 |
| 0 | 4.5 | 52.5 | 0 | 3.9 | 237.5 | 0 | 3.95 | 422.5 | 0 | 3.59 | 607.5 |
| 0 | 4.11 | 57.5 | 0 | 3.64 | 242.5 | 0 | 3.72 | 427.5 | 0 | 3.72 | 612.5 |
| 0 | 4.41 | 62.5 | 0 | 3.39 | 247.5 | 0 | 3.82 | 432.5 | 0 | 3.87 | 617.5 |
| 0 | 4.27 | 67.5 | 0 | 3.76 | 252.5 | 0 | 3.79 | 437.5 | 0 | 3.82 | 622.5 |
| 0 | 4.29 | 72.5 | 0 | 3.63 | 257.5 | 0 | 3.57 | 442.5 | 0 | 3.73 | 627.5 |
| 0 | 3.51 | 77.5 | 0 | 3.53 | 262.5 | 0 | 3.58 | 447.5 | 0 | 3.61 | 632.5 |
| 0 | 3.64 | 82.5 | 0 | 3.62 | 267.5 | 0 | 3.62 | 452.5 | 0 | 3.88 | 637.5 |
| 0 | 3.58 | 87.5 | 0 | 3.62 | 272.5 | 0 | 3.62 | 457.5 | 0 | 3.56 | 642.5 |
| 0 | 3.54 | 92.5 | 0 | 3.6 | 277.5 | 0 | 3.48 | 462.5 | 0 | 3.69 | 647.5 |
| 0 | 3.66 | 97.5 | 0 | 3.77 | 282.5 | 0 | 3.66 | 467.5 | 0 | 3.72 | 652.5 |
| 0 | 3.53 | 102.5 | 0 | 3.79 | 287.5 | 0 | 3.61 | 472.5 | 0 | 3.74 | 657.5 |
| 0 | 3.57 | 107.5 | 0 | 3.64 | 292.5 | 0 | 3.48 | 477.5 | 0 | 3.81 | 662.5 |
| 0 | 3.55 | 112.5 | 0 | 3.64 | 297.5 | 0 | 3.59 | 482.5 | 0 | 3.6 | 667.5 |
| 0 | 3.66 | 117.5 | 0 | 3.75 | 302.5 | 0 | 3.7 | 487.5 | 0 | 3.67 | 672.5 |
| 0 | 3.72 | 122.5 | 0 | 3.7 | 307.5 | 0 | 3.54 | 492.5 | 0 | 3.52 | 677.5 |
| 0 | 3.46 | 127.5 | 0 | 3.69 | 312.5 | 0 | 3.6 | 497.5 | 0 | 3.68 | 682.5 |
| 0 | 4 | 132.5 | 0 | 3.72 | 317.5 | 0 | 3.61 | 502.5 | 0 | 3.63 | 687.5 |
| 0 | 3.87 | 137.5 | 0 | 3.54 | 322.5 | 0 | 3.62 | 507.5 | 0 | 3.54 | 692.5 |
| 0 | 3.39 | 142.5 | 0 | 3.68 | 327.5 | 0 | 3.73 | 512.5 | 0 | 3.58 | 697.5 |
| 0 | 3.73 | 147.5 | 0 | 3.73 | 332.5 | 0 | 3.62 | 517.5 | 0 | 3.47 | 702.5 |
| 0 | 3.57 | 152.5 | 0 | 3.77 | 337.5 | 0 | 3.55 | 522.5 | 0 | 3.53 | 707.5 |
| 0 | 3.71 | 157.5 | 0 | 3.88 | 342.5 | 0 | 3.55 | 527.5 | 0 | 3.57 | 712.5 |
| 0 | 3.55 | 162.5 | 0 | 3.87 | 347.5 | 0 | 3.66 | 532.5 | 0 | 7.04 | 717.5 |
| 0 | 3.54 | 167.5 | 0 | 3.95 | 352.5 | 0 | 3.64 | 537.5 | 0 | 7.3 | 722.5 |
| 0 | 3.77 | 172.5 | 0 | 3.95 | 357.5 | 0 | 3.65 | 542.5 | 0 | 7.14 | 727.5 |
| 0 | 3.68 | 177.5 | 0 | 3.66 | 362.5 | 0 | 3.57 | 547.5 | 0 | 7.03 | 732.5 |
| 0 | 3.56 | 182.5 | 0 | 3.5 | 367.5 | 0 | 3.66 | 552.5 | 0 | 7.19 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Madison Well, No. 4 (240 s)

| Th (ppm) | Th Error (ppm) | Sample (ft. below surface) |
|---|---|---|
| 0 | 1.1 | 212.5 |
| 1.51 | 0.77 | 217.5 |
| 4.28 | 0.88 | 222.5 |
| 5.57 | 0.99 | 227.5 |
| 4.26 | 0.94 | 227.5 |
| 0 | 1.07 | 232.5 |
| 1.8 | 0.75 | 237.5 |
| 1.8 | 0.76 | 242.5 |
| 0 | 1.12 | 437.5 |
| 1.25 | 0.72 | 637.5 |
| 0 | 1.07 | 642.5 |
| 0 | 1.05 | 647.5 |
| 0 | 1.05 | 652.5 |
| 0 | 1.04 | 657.5 |
| 1.3 | 0.71 | 662.5 |
| 1.22 | 0.73 | 667.5 |
| 0 | 1.04 | 712.5 |
| 0 | 1.68 | 717.5 |
| 0 | 1.64 | 722.5 |
| 0 | 1.59 | 727.5 |
| 0 | 1.6 | 732.5 |
| 0 | 1.68 | 736 |

| U (ppm) | U Error (ppm) | Sample (ft. below surface) |
|---|---|---|
| 0 | 1.56 | 212.5 |
| 0 | 1.73 | 217.5 |
| 2.92 | 1.3 | 222.5 |
| 6.34 | 1.62 | 227.5 |
| 3.88 | 1.47 | 227.5 |
| 0 | 1.45 | 232.5 |
| 1.84 | 1.04 | 237.5 |
| 0 | 1.46 | 242.5 |
| 0 | 1.5 | 437.5 |
| 0 | 1.42 | 637.5 |
| 0 | 1.43 | 642.5 |
| 0 | 1.38 | 647.5 |
| 0 | 1.39 | 652.5 |
| 0 | 1.43 | 657.5 |
| 0 | 1.42 | 662.5 |
| 0 | 1.44 | 667.5 |
| 0 | 1.41 | 712.5 |
| 4.31 | 1.84 | 717.5 |
| 0 | 2.72 | 722.5 |
| 2.76 | 1.78 | 727.5 |
| 0 | 2.65 | 732.5 |
| 0 | 2.82 | 736 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Madison Well, No. 27 (90 s)**

| Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) | Al (ppm) | Al Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18407.91 | 824.36 | 2.5 | 1861.69 | 367.42 | 197.5 | 1947.17 | 401.76 | 387.5 | 6535.63 | 450.57 | 582.5 |
| 19997.02 | 905.09 | 7.5 | 2147.44 | 385.49 | 202.5 | 3328.18 | 460.85 | 392.5 | 3151.84 | 369.99 | 587.5 |
| 21842.64 | 953.09 | 12.5 | 2140.16 | 361.81 | 207.5 | 3321.81 | 404.75 | 397.5 | 3876.77 | 399.47 | 592.5 |
| 19695.95 | 1079.79 | 17.5 | 3128.09 | 370.44 | 212.5 | 2112.25 | 372.52 | 402.5 | 8114.88 | 488.62 | 597.5 |
| 22746.98 | 1238.22 | 22.5 | 2865.98 | 362.46 | 217.5 | 2505.76 | 401.65 | 407.5 | 4914.97 | 402.68 | 602.5 |
| 22043.8 | 1079.31 | 27.5 | 6843.49 | 545.22 | 222.5 | 2469.46 | 379.48 | 412.5 | 3616.83 | 397.15 | 607.5 |
| 20354.51 | 1016.75 | 32.5 | 36499.91 | 1402.19 | 227.5 | 3950.62 | 467.16 | 417.5 | 9057.69 | 489.74 | 612.5 |
| 16714.62 | 913.69 | 37.5 | 46016.43 | 1325.13 | 232.5 | 2500.36 | 393.61 | 422.5 | 30131.68 | 840.68 | 617.5 |
| 17012.98 | 914.71 | 42.5 | 46410.88 | 1513.96 | 237.5 | 2133.13 | 372.67 | 427.5 | 29423.38 | 856.26 | 622.5 |
| 15979.99 | 902.71 | 47.5 | 3431.22 | 421.76 | 242.5 | 1999.97 | 388.04 | 432.5 | 14221.17 | 613.33 | 627.5 |
| 14363.87 | 803.38 | 57.5 | 4318.64 | 452.58 | 247.5 | 1584.63 | 366.1 | 437.5 | 13282.66 | 563.94 | 632.5 |
| 13192.88 | 772.39 | 62.5 | 6146.11 | 506.26 | 252.5 | 1798.79 | 365.75 | 442.5 | 11656.49 | 549.63 | 637.5 |
| 12118.48 | 685.22 | 67.5 | 4042.87 | 401.59 | 257.5 | 3775.25 | 437.53 | 447.5 | 41084.27 | 1094.59 | 642.5 |
| 12039.71 | 694.8 | 72.5 | 2322.4 | 380.13 | 262.5 | 2275.44 | 373.33 | 452.5 | 21062.04 | 690.23 | 647.5 |
| 7219.61 | 535.03 | 77.5 | 3162.58 | 425.35 | 267.5 | 1966.56 | 376.62 | 457.5 | 14327.01 | 566.24 | 652.5 |
| 18072.7 | 752.7 | 82.5 | 2757.2 | 418.11 | 272.5 | 3195.59 | 385.7 | 462.5 | 40565.73 | 969.53 | 657.5 |
| 10040.34 | 561.65 | 87.5 | 2398.09 | 444.38 | 277.5 | 3630.36 | 387.63 | 467.5 | 16538.53 | 591.95 | 662.5 |
| 7746 | 471.68 | 92.5 | 3165 | 426.28 | 282.5 | 3592.71 | 378.54 | 477.5 | 3862.57 | 432.16 | 667.5 |
| 6783.39 | 501.46 | 97.5 | 3756.3 | 411.47 | 287.5 | 2576.08 | 387.11 | 482.5 | 6306.82 | 460.9 | 672.5 |
| 8022.97 | 472.64 | 102.5 | 4806.25 | 474.2 | 292.5 | 2555.42 | 385.7 | 487.5 | 10200.16 | 509.63 | 677.5 |
| 3298.77 | 384.94 | 107.5 | 2865.85 | 417.85 | 297.5 | 5593.86 | 423.18 | 492.5 | 6229.93 | 448.61 | 682.5 |
| 2043.65 | 357.68 | 112.5 | 4190.7 | 421.78 | 302.5 | 2332.7 | 369.15 | 497.5 | 5892.12 | 433.31 | 687.5 |
| 3871.98 | 401.64 | 117.5 | 3853.09 | 416.13 | 307.5 | 2600.26 | 385.63 | 502.5 | 6081.14 | 433.36 | 692.5 |
| 4104.44 | 414.06 | 122.5 | 3073.91 | 393.88 | 312.5 | 4932.71 | 418.45 | 507.5 | 5766.48 | 418.77 | 697.5 |
| 2731.23 | 378.6 | 127.5 | 2398.46 | 391.42 | 317.5 | 4115.26 | 419.95 | 512.5 | 5771.93 | 430.48 | 702.5 |
| 3310.99 | 405.46 | 132.5 | 1572.53 | 337.27 | 322.5 | 3712.32 | 388.23 | 517.5 | 7349.19 | 444.74 | 707.5 |
| 4764.92 | 485.86 | 137.5 | 4795.92 | 448.38 | 327.5 | 6466.09 | 475.76 | 522.5 | 6648.48 | 456.09 | 712.5 |
| 2628 | 397.24 | 142.5 | 2423.85 | 358.86 | 332.5 | 5240.55 | 439.82 | 527.5 | 3079.87 | 370.33 | 717.5 |
| 2570.69 | 388.64 | 147.5 | 2373.28 | 427.9 | 337.5 | 3020.04 | 390.86 | 532.5 | 2591.04 | 363.53 | 722.5 |
| 1802.52 | 417.18 | 152.5 | 4372.84 | 488.68 | 342.5 | 4953.48 | 463.21 | 537.5 | 6781.6 | 452.42 | 727.5 |
| 1630.02 | 367.63 | 157.5 | 3119.79 | 467.84 | 347.5 | 4255.14 | 433.9 | 542.5 | 3621.72 | 389.63 | 732.5 |
| 1651.7 | 363.3 | 162.5 | 4002.53 | 437.31 | 352.5 | 2657.1 | 382.11 | 547.5 | 6287.26 | 454.3 | 737 |
| 1511.55 | 381.53 | 167.5 | 2307.26 | 418.44 | 357.5 | 3494.03 | 384.17 | 552.5 | 61149.52 | 1317.55 | 740 |
| 1270.37 | 385.82 | 172.5 | 2416.56 | 401.5 | 362.5 | 3992.71 | 408.89 | 557.5 | 49934.88 | 1148.69 | 742 |
| 1416.89 | 340.93 | 177.5 | 3152.93 | 466.28 | 367.5 | 6347.07 | 454.02 | 562.5 | 44752.72 | 1189.11 | 743 |
| 3089.49 | 404.39 | 182.5 | 1488.82 | 774.39 | 372.5 | 7411.79 | 485.93 | 567.5 | 47960.63 | 1159.03 | 743.5 |
| 1427.32 | 350.54 | 187.5 | 1887.48 | 381.78 | 377.5 | 2763.61 | 366.95 | 572.5 | | | |
| 1936.43 | 375.77 | 192.5 | 2225.42 | 405.79 | 382.5 | 3331.15 | 381.21 | 577.5 | | | |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Madison Well, No. 27 (90 s)

| K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) | K (ppm) | K Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11716.72 | 217.63 | 2.5 | 391.67 | 40.47 | 197.5 | 729.8 | 54.86 | 387.5 | 6148.62 | 113.36 | 582.5 |
| 11777.07 | 222.36 | 7.5 | 802.05 | 52.38 | 202.5 | 2469.05 | 99.16 | 392.5 | 2650.08 | 75.4 | 587.5 |
| 12223.21 | 230.95 | 12.5 | 910.5 | 54.18 | 207.5 | 1970.07 | 72.14 | 397.5 | 2959.38 | 81.04 | 592.5 |
| 15596.93 | 272.86 | 17.5 | 1510.41 | 62.06 | 212.5 | 973.77 | 57.26 | 402.5 | 7833.31 | 119.17 | 597.5 |
| 16734.27 | 290.43 | 22.5 | 1865.74 | 67.71 | 217.5 | 1749.08 | 71.66 | 407.5 | 3904.09 | 86.1 | 602.5 |
| 13667.14 | 245.63 | 27.5 | 6875.96 | 150.95 | 222.5 | 1830.01 | 72.31 | 412.5 | 2867.98 | 77.77 | 607.5 |
| 14055.5 | 256 | 32.5 | 35975.1 | 488.17 | 227.5 | 2506.86 | 88.2 | 417.5 | 10873.97 | 146.83 | 612.5 |
| 13029.68 | 234.65 | 37.5 | 63196.8 | 555.7 | 232.5 | 1849.98 | 73.08 | 422.5 | 35338.85 | 344.93 | 617.5 |
| 13207.17 | 243.72 | 42.5 | 58760.95 | 564.64 | 237.5 | 1070.88 | 52.36 | 427.5 | 33635.76 | 342.83 | 622.5 |
| 13048.13 | 236.5 | 47.5 | 2783.03 | 90 | 242.5 | 752.97 | 49.21 | 432.5 | 14637.33 | 202.51 | 627.5 |
| 11554.26 | 213.08 | 57.5 | 4517.16 | 106.51 | 247.5 | 741.18 | 50.74 | 437.5 | 15909.59 | 201.5 | 632.5 |
| 11605.94 | 207.54 | 62.5 | 5351.64 | 119.35 | 252.5 | 1197.88 | 58.59 | 442.5 | 14342.96 | 193.91 | 637.5 |
| 12019.24 | 203.94 | 67.5 | 3465.12 | 86.3 | 257.5 | 3125.38 | 87.31 | 447.5 | 59623.84 | 534.38 | 642.5 |
| 13915.93 | 221.38 | 72.5 | 1547.49 | 64.6 | 262.5 | 1428.98 | 58.97 | 452.5 | 27149.02 | 298.37 | 647.5 |
| 11505.67 | 172.57 | 77.5 | 2056.31 | 83.63 | 267.5 | 1658.4 | 64.81 | 457.5 | 13285.16 | 189.93 | 652.5 |
| 23617.47 | 280.98 | 82.5 | 2002.98 | 71.19 | 272.5 | 2260.14 | 71.52 | 462.5 | 31597.22 | 326.49 | 657.5 |
| 11148.91 | 178.86 | 87.5 | 2163.13 | 90.83 | 277.5 | 2765.32 | 80.49 | 467.5 | 10548.63 | 167.48 | 662.5 |
| 8668.24 | 135.64 | 92.5 | 2680.29 | 89.42 | 282.5 | 2158.27 | 67.54 | 477.5 | 2506.94 | 74.21 | 667.5 |
| 10189.63 | 158.51 | 97.5 | 2777.33 | 87.78 | 287.5 | 1722.9 | 62.85 | 482.5 | 3684.69 | 95.93 | 672.5 |
| 6609.84 | 125.39 | 102.5 | 4461.79 | 110.1 | 302.5 | 1887.17 | 66.79 | 487.5 | 11930.79 | 162.03 | 677.5 |
| 2143.87 | 69.48 | 107.5 | 1925.25 | 75.78 | 307.5 | 4353.83 | 90.89 | 492.5 | 5953.96 | 110.91 | 682.5 |
| 1116.42 | 52.31 | 112.5 | 3029.69 | 84.78 | 302.5 | 1584.46 | 59.98 | 497.5 | 3512.69 | 82.48 | 687.5 |
| 2863.18 | 82.4 | 117.5 | 2757.69 | 79.33 | 307.5 | 2073.54 | 69.83 | 502.5 | 2100.38 | 68.6 | 692.5 |
| 2802.84 | 82.17 | 122.5 | 2157.05 | 74.34 | 312.5 | 4140.35 | 91.94 | 507.5 | 2007.29 | 69.06 | 697.5 |
| 1346.45 | 58.86 | 127.5 | 1282.33 | 63.78 | 317.5 | 2815.59 | 77.11 | 512.5 | 1645.58 | 61.04 | 702.5 |
| 2624 | 81.19 | 132.5 | 735.49 | 48.73 | 322.5 | 2447.62 | 73.55 | 517.5 | 2595.43 | 74.66 | 707.5 |
| 4417.14 | 111.16 | 137.5 | 3574.17 | 92.64 | 327.5 | 4700.74 | 96.66 | 522.5 | 2309.41 | 68.71 | 712.5 |
| 1368.55 | 64.13 | 142.5 | 1358.23 | 60.09 | 332.5 | 4305.77 | 97.54 | 527.5 | 1153.04 | 54.43 | 717.5 |
| 1258.94 | 62.26 | 147.5 | 1788.2 | 77.58 | 337.5 | 2492.88 | 77.31 | 532.5 | 964.43 | 51 | 722.5 |
| 1027.26 | 67.11 | 152.5 | 4489.03 | 118.37 | 342.5 | 5009.64 | 109.1 | 537.5 | 2356.68 | 73.45 | 727.5 |
| 631.1 | 48.04 | 157.5 | 2849.92 | 101.42 | 347.5 | 5061.74 | 118.26 | 542.5 | 1256.57 | 57.01 | 732.5 |
| 453.62 | 47.33 | 162.5 | 4228.68 | 107.05 | 352.5 | 2146.17 | 66.9 | 547.5 | 2731.02 | 81.77 | 737 |
| 580.4 | 48.48 | 167.5 | 1806.98 | 88.08 | 357.5 | 2477.18 | 74.16 | 552.5 | 5498.1 | 221.81 | 740 |
| 527.91 | 45.19 | 172.5 | 1519.8 | 70.78 | 362.5 | 2667.3 | 74.07 | 557.5 | 10285 | 256.35 | 742 |
| 397 | 41.58 | 177.5 | 2209.88 | 86.78 | 367.5 | 5623.04 | 110.09 | 562.5 | 15147.68 | 332.77 | 743 |
| 466.11 | 45.23 | 182.5 | 962.67 | 104.43 | 372.5 | 7055.73 | 120.22 | 567.5 | 15568.47 | 321.46 | 743.5 |
| 373.17 | 41.21 | 187.5 | 1222.74 | 63.41 | 377.5 | 2213.93 | 71.37 | 572.5 | | | |
| 509.47 | 42.86 | 192.5 | 1696.82 | 74.16 | 382.5 | 2264.37 | 67.97 | 577.5 | | | |

## Madison Well, No. 27 (90 s)

| Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) | Ca (ppm) | Ca Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 71883.66 | 760.41 | 2.5 | 1205.79 | 34.86 | 197.5 | 22694.58 | 325.39 | 387.5 | 5742.75 | 77.91 | 582.5 |
| 88279.18 | 820.98 | 7.5 | 3588.35 | 61.15 | 202.5 | 52463.81 | 552.75 | 392.5 | 1332.49 | 38.58 | 587.5 |
| 90263.54 | 840.88 | 12.5 | 3099.85 | 57.1 | 207.5 | 13170.6 | 253.07 | 397.5 | 1806.72 | 45.11 | 592.5 |
| 125074.07 | 1050.66 | 17.5 | 1218.77 | 37.11 | 212.5 | 10510.93 | 230.21 | 402.5 | 1747.74 | 46.14 | 597.5 |
| 127445.17 | 1080.67 | 22.5 | 2642.55 | 52.59 | 217.5 | 19352.5 | 311.66 | 407.5 | 1358.56 | 38.75 | 602.5 |
| 114772.79 | 955.84 | 27.5 | 45342.16 | 556.38 | 222.5 | 12762.28 | 255.06 | 412.5 | 897.75 | 33.33 | 607.5 |
| 111965.86 | 978.89 | 32.5 | 74748.13 | 986.9 | 227.5 | 29890.88 | 400.45 | 417.5 | 1048.55 | 44.06 | 612.5 |
| 111936.77 | 947.19 | 37.5 | 38676.85 | 643.75 | 232.5 | 18588.17 | 305.01 | 422.5 | 1424.04 | 71.72 | 617.5 |
| 112919.18 | 964.24 | 42.5 | 91905.8 | 1003.62 | 237.5 | 3294.89 | 54.21 | 427.5 | 1640.94 | 75.3 | 622.5 |
| 111832.91 | 945.87 | 47.5 | 22688.82 | 359.2 | 242.5 | 7452.78 | 81.29 | 432.5 | 997.06 | 50.94 | 627.5 |
| 102578.41 | 880.43 | 57.5 | 26727.77 | 369.39 | 247.5 | 7473.9 | 84.39 | 437.5 | 1021.58 | 48.61 | 632.5 |
| 82818.97 | 770.23 | 62.5 | 27677.02 | 392.38 | 252.5 | 7098.5 | 82.68 | 442.5 | 958.42 | 47.1 | 637.5 |
| 70025.24 | 687.26 | 67.5 | 12447.28 | 238.48 | 257.5 | 17261.2 | 296.88 | 447.5 | 972.41 | 104.5 | 642.5 |
| 81611.23 | 746.03 | 72.5 | 2579.62 | 53.08 | 262.5 | 4250.76 | 62.29 | 452.5 | 1358.7 | 68.14 | 647.5 |
| 47072.74 | 523.3 | 77.5 | 30753.81 | 415.36 | 267.5 | 4733 | 68.15 | 457.5 | 3416.27 | 68.33 | 652.5 |
| 39405.36 | 509.74 | 82.5 | 16531.75 | 275.48 | 272.5 | 4879.26 | 68.23 | 462.5 | 1535.96 | 72.06 | 657.5 |
| 26192.54 | 383.22 | 87.5 | 46556.75 | 508.01 | 277.5 | 10109.17 | 223.06 | 467.5 | 2581.1 | 59.39 | 662.5 |
| 12764.89 | 257.84 | 92.5 | 33427.45 | 414.82 | 282.5 | 1445.45 | 38.39 | 477.5 | 2275.88 | 48.72 | 667.5 |
| 27362.12 | 391.97 | 97.5 | 19441.74 | 321.92 | 287.5 | 5507.73 | 69.98 | 482.5 | 7580.66 | 92.57 | 672.5 |
| 10521.79 | 245.46 | 102.5 | 33153.84 | 423.31 | 292.5 | 2763.43 | 52.71 | 487.5 | 4374.13 | 75.91 | 677.5 |
| 2860.52 | 53.16 | 107.5 | 25397.37 | 357.37 | 297.5 | 1618.28 | 42.07 | 492.5 | 1878.1 | 48.57 | 682.5 |
| 1889.48 | 41.6 | 112.5 | 11845.62 | 240.06 | 302.5 | 4253.03 | 61.25 | 497.5 | 934.35 | 33.58 | 687.5 |
| 7740.41 | 88.55 | 117.5 | 10040.03 | 216.62 | 307.5 | 2404.5 | 50.02 | 502.5 | 880.36 | 32.36 | 692.5 |
| 10775.19 | 232.14 | 122.5 | 10062.25 | 223.41 | 312.5 | 3267.88 | 57.91 | 507.5 | 862.35 | 32.79 | 697.5 |
| 7901.66 | 83.89 | 127.5 | 15778.43 | 277.14 | 317.5 | 1151.01 | 36.51 | 512.5 | 1600.33 | 39.79 | 702.5 |
| 15061.21 | 273.17 | 132.5 | 2662.74 | 51.12 | 322.5 | 1233.4 | 37.53 | 517.5 | 999.16 | 34.53 | 707.5 |
| 31412.47 | 414.94 | 137.5 | 15494.91 | 279.48 | 327.5 | 1045.46 | 37.18 | 522.5 | 2151.06 | 45.18 | 712.5 |
| 9222.72 | 97.51 | 142.5 | 3873.41 | 61.98 | 332.5 | 6593.76 | 82.71 | 527.5 | 1099.94 | 34.01 | 717.5 |
| 14892.71 | 268.77 | 147.5 | 29226.44 | 399.12 | 337.5 | 8702.11 | 92.44 | 532.5 | 686.69 | 27.88 | 722.5 |
| 34746.14 | 416.92 | 152.5 | 47881.27 | 521.95 | 342.5 | 21222.06 | 329.83 | 537.5 | 1054.61 | 35.75 | 727.5 |
| 9059.04 | 90.07 | 157.5 | 48451.2 | 524.93 | 347.5 | 22599.73 | 360.39 | 542.5 | 990.26 | 33.19 | 732.5 |
| 15101.08 | 266.26 | 162.5 | 28122.4 | 386.43 | 352.5 | 2284.58 | 46.33 | 547.5 | 10093.29 | 224.54 | 737 |
| 6006.52 | 77.72 | 167.5 | 45232.08 | 510.7 | 357.5 | 2171.48 | 47.6 | 552.5 | 3526.35 | 131.85 | 740 |
| 7921.44 | 83.38 | 172.5 | 20201.82 | 329.12 | 362.5 | 2790.46 | 51.65 | 557.5 | 7988.56 | 165.5 | 742 |
| 1735.85 | 41.79 | 177.5 | 27110.52 | 393.44 | 367.5 | 6934.01 | 85.5 | 562.5 | 14707.67 | 487.86 | 743 |
| 3547.32 | 60.93 | 182.5 | 221713.38 | 1425.61 | 372.5 | 5589.54 | 77.14 | 567.5 | 14973.54 | 471.9 | 743.5 |
| 3137.98 | 54.25 | 187.5 | 13318.28 | 262.45 | 377.5 | 2565.25 | 51.37 | 572.5 | | | |
| 3821.7 | 58.42 | 192.5 | 21269.46 | 334.8 | 382.5 | 2192.2 | 45.32 | 577.5 | | | |

## Madison Well, No. 27 (90 s)

| Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) | Si (ppm) | Si Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 181385.42 | 1353.65 | 2.5 | 400859.34 | 1863.08 | 197.5 | 364284.72 | 1754.54 | 387.5 | 369386.78 | 1772.68 | 582.5 |
| 186568.58 | 1375.84 | 7.5 | 391823.28 | 1820.68 | 202.5 | 272050.16 | 1552.38 | 392.5 | 383850.97 | 1827.14 | 587.5 |
| 192565.75 | 1386.26 | 12.5 | 387346.47 | 1817.63 | 207.5 | 370821.47 | 1771.34 | 397.5 | 395312.13 | 1845.93 | 592.5 |
| 165543.05 | 1403.24 | 17.5 | 388551.22 | 1794.24 | 212.5 | 379234.66 | 1751.54 | 402.5 | 383306 | 1796.97 | 597.5 |
| 173062.92 | 1505.49 | 22.5 | 395460.47 | 1846.8 | 217.5 | 358788.78 | 1755.67 | 407.5 | 376938.91 | 1811.38 | 602.5 |
| 186664.25 | 1449.69 | 27.5 | 310375.53 | 1637.85 | 222.5 | 360782.44 | 1744.99 | 412.5 | 394710.72 | 1857.47 | 607.5 |
| 179221.97 | 1407.49 | 32.5 | 227542.48 | 1513.2 | 227.5 | 351463.41 | 1762.68 | 417.5 | 373844.5 | 1779.89 | 612.5 |
| 181914 | 1413.26 | 37.5 | 217792.11 | 1471.84 | 232.5 | 355700.47 | 1722.96 | 422.5 | 311791.06 | 1648.91 | 617.5 |
| 183447.52 | 1388.55 | 42.5 | 173281.8 | 1369.36 | 237.5 | 389217.41 | 1824.94 | 427.5 | 326974.34 | 1711.92 | 622.5 |
| 180833.69 | 1404.47 | 47.5 | 354011.47 | 1729.91 | 242.5 | 389052.28 | 1808.27 | 432.5 | 363631.75 | 1771.79 | 627.5 |
| 181114.42 | 1372.74 | 57.5 | 331306.81 | 1669.48 | 247.5 | 378310.28 | 1793.94 | 437.5 | 353174.44 | 1741.66 | 632.5 |
| 210752.23 | 1478.83 | 62.5 | 337455.69 | 1690.41 | 252.5 | 376142.25 | 1795.71 | 442.5 | 375825.91 | 1784.17 | 637.5 |
| 237076.66 | 1497.24 | 67.5 | 357590.97 | 1736.03 | 257.5 | 360040.5 | 1760.51 | 447.5 | 272100.66 | 1587.01 | 642.5 |
| 208842.91 | 1402.39 | 72.5 | 398173.94 | 1804.55 | 262.5 | 392351.25 | 1832.49 | 452.5 | 318067.91 | 1671.99 | 647.5 |
| 297773.72 | 1614.22 | 77.5 | 341286.66 | 1725.1 | 267.5 | 388403.5 | 1819.23 | 457.5 | 353239.53 | 1706.74 | 652.5 |
| 270798.69 | 1561.08 | 82.5 | 371189.63 | 1762.95 | 272.5 | 377606.97 | 1807.29 | 462.5 | 290875.91 | 1594.94 | 657.5 |
| 311950.31 | 1644.97 | 87.5 | 294215.19 | 1601.49 | 277.5 | 362806.44 | 1749.11 | 467.5 | 349655.91 | 1721.67 | 662.5 |
| 349185.94 | 1708.77 | 92.5 | 312210.31 | 1662.99 | 282.5 | 384128.22 | 1825.04 | 477.5 | 394040.16 | 1837.44 | 667.5 |
| 323868.16 | 1671.61 | 97.5 | 343387.19 | 1726.25 | 287.5 | 380444.41 | 1828.85 | 482.5 | 371911.47 | 1745.58 | 672.5 |
| 347385.72 | 1707.11 | 102.5 | 315452.84 | 1663.82 | 292.5 | 396581.5 | 1834.57 | 487.5 | 363149.84 | 1756.6 | 677.5 |
| 382680 | 1765.88 | 107.5 | 347444.22 | 1719.53 | 297.5 | 376631.81 | 1781.07 | 492.5 | 381615.38 | 1826.34 | 682.5 |
| 386423.03 | 1813.69 | 112.5 | 358350.91 | 1768.61 | 302.5 | 381443.78 | 1813.62 | 497.5 | 384830.06 | 1849.88 | 687.5 |
| 369931.56 | 1785.25 | 117.5 | 368503.5 | 1763.96 | 307.5 | 392997.94 | 1823.77 | 502.5 | 390476.03 | 1813.26 | 692.5 |
| 360682.97 | 1781.98 | 122.5 | 370410.69 | 1781.67 | 312.5 | 373704.22 | 1777.28 | 507.5 | 379309.47 | 1827.02 | 697.5 |
| 375855.91 | 1787.48 | 127.5 | 366475.19 | 1744.24 | 317.5 | 388751 | 1848.31 | 512.5 | 391257.84 | 1849.87 | 702.5 |
| 360513.97 | 1774.47 | 132.5 | 393975.5 | 1822.45 | 322.5 | 381903.03 | 1797.54 | 517.5 | 370464.56 | 1760.89 | 707.5 |
| 332995.03 | 1708.89 | 137.5 | 361078.59 | 1747.73 | 327.5 | 393136.69 | 1858.03 | 522.5 | 383781.84 | 1805.56 | 712.5 |
| 377583.31 | 1814.19 | 142.5 | 391995.78 | 1834.82 | 332.5 | 372278.06 | 1752.68 | 527.5 | 394190.19 | 1827.76 | 717.5 |
| 363922 | 1758.09 | 147.5 | 351526.19 | 1745.2 | 337.5 | 383118.66 | 1804.22 | 532.5 | 394648.56 | 1861.16 | 722.5 |
| 330839.5 | 1713.36 | 152.5 | 290659.47 | 1604.17 | 342.5 | 350240.63 | 1730.88 | 537.5 | 388406.19 | 1829.4 | 727.5 |
| 380717.53 | 1787.67 | 157.5 | 287842.72 | 1621.62 | 347.5 | 339863.75 | 1685.63 | 542.5 | 394416.72 | 1837.2 | 732.5 |
| 362878.47 | 1754.2 | 162.5 | 322340.47 | 1677.06 | 352.5 | 388539.81 | 1815.29 | 547.5 | 369512.94 | 1786.34 | 737 |
| 391585.5 | 1799.48 | 167.5 | 312144 | 1605.19 | 357.5 | 389924.66 | 1837.85 | 552.5 | 197528.63 | 1340.37 | 740 |
| 386530.59 | 1774.22 | 172.5 | 359842.84 | 1740.63 | 362.5 | 394339.56 | 1842.24 | 557.5 | 215696.09 | 1402.62 | 742 |
| 399378.84 | 1811.87 | 177.5 | 359279.06 | 1755.16 | 367.5 | 373363.69 | 1786.31 | 562.5 | 247966.27 | 1533.33 | 743 |
| 389389.81 | 1841.33 | 182.5 | 77731.82 | 1083.54 | 372.5 | 377065.47 | 1799.14 | 567.5 | 220914.69 | 1398.36 | 743.5 |
| 390600.69 | 1814.98 | 187.5 | 372690.97 | 1788.34 | 377.5 | 388163.31 | 1817.35 | 572.5 | | | |
| 404518.41 | 1867.36 | 192.5 | 353470.47 | 1734.91 | 382.5 | 387475.91 | 1839.01 | 577.5 | | | |

## Madison Well, No. 27 (90 s)

| Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) | Fe (ppm) | Fe Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19079.19 | 224.63 | 2.5 | 1235.23 | 46.59 | 197.5 | 394.63 | 31.18 | 387.5 | 412.37 | 31.14 | 582.5 |
| 12726.85 | 176.8 | 7.5 | 2507 | 62.56 | 202.5 | 1046.79 | 43.34 | 392.5 | 183.24 | 25.84 | 587.5 |
| 14556.41 | 188.52 | 12.5 | 3678.96 | 77.15 | 207.5 | 333.51 | 29.35 | 397.5 | 153.2 | 24.34 | 592.5 |
| 16921.49 | 219.11 | 17.5 | 573.97 | 33.85 | 212.5 | 267.79 | 26.86 | 402.5 | 319.34 | 28.41 | 597.5 |
| 17322.87 | 220.08 | 22.5 | 627.59 | 36.56 | 217.5 | 696.72 | 37.96 | 407.5 | 276.99 | 28.27 | 602.5 |
| 12710.4 | 177.2 | 27.5 | 10604.09 | 164.29 | 222.5 | 278 | 27.62 | 412.5 | 264.74 | 27.75 | 607.5 |
| 12690.94 | 186.1 | 32.5 | 86902.64 | 607.25 | 227.5 | 790.31 | 40.29 | 417.5 | 352.44 | 29.82 | 612.5 |
| 11524.45 | 179.86 | 37.5 | 16243.08 | 214.17 | 232.5 | 470.53 | 32.17 | 422.5 | 2010.35 | 59.18 | 617.5 |
| 10351.53 | 164.16 | 42.5 | 19442.58 | 244.54 | 237.5 | 461.49 | 32.16 | 427.5 | 1611.9 | 54.48 | 622.5 |
| 10476.45 | 166.62 | 47.5 | 2365.51 | 62.94 | 242.5 | 367.53 | 29.43 | 432.5 | 435.95 | 31.38 | 627.5 |
| 5984.26 | 101.33 | 57.5 | 1653.15 | 52.13 | 247.5 | 359.62 | 29.69 | 437.5 | 641.84 | 36.55 | 632.5 |
| 3740.67 | 80.68 | 62.5 | 1526.02 | 50.3 | 252.5 | 282.55 | 28.12 | 442.5 | 794.54 | 39.27 | 637.5 |
| 2244.87 | 62.89 | 67.5 | 567.03 | 34.82 | 257.5 | 564.98 | 34.6 | 447.5 | 11823.76 | 180.51 | 642.5 |
| 2686.04 | 66.35 | 72.5 | 1552.56 | 50.09 | 262.5 | 416.98 | 31.37 | 452.5 | 1804.33 | 56.22 | 647.5 |
| 1261.7 | 48.72 | 77.5 | 832.73 | 41.43 | 267.5 | 378.88 | 30.14 | 457.5 | 1070.6 | 43.78 | 652.5 |
| 2637.79 | 66.77 | 82.5 | 442.44 | 31.4 | 272.5 | 293.28 | 28.43 | 462.5 | 1359.37 | 49.85 | 657.5 |
| 1124.97 | 44.82 | 87.5 | 1407.29 | 49.34 | 277.5 | 473.87 | 32.83 | 467.5 | 829.52 | 39.82 | 662.5 |
| 748.42 | 38.08 | 92.5 | 1254.16 | 48.53 | 282.5 | 348.29 | 29.88 | 477.5 | 2883.31 | 68.34 | 667.5 |
| 1427.22 | 50.24 | 97.5 | 562.74 | 35.47 | 287.5 | 471.55 | 33.01 | 482.5 | 10022.11 | 162.33 | 672.5 |
| 812.55 | 39.17 | 102.5 | 856.43 | 40.65 | 292.5 | 350.74 | 29.33 | 487.5 | 1454.35 | 50.69 | 677.5 |
| 390.8 | 29.54 | 107.5 | 577.76 | 35.04 | 297.5 | 385.35 | 30.25 | 492.5 | 846.77 | 40.54 | 682.5 |
| 298.13 | 27.99 | 112.5 | 512.58 | 33.72 | 302.5 | 271.69 | 27.89 | 497.5 | 517.81 | 34.12 | 687.5 |
| 720.48 | 38.07 | 117.5 | 416.7 | 30.93 | 307.5 | 263.2 | 26.88 | 502.5 | 168.03 | 24.34 | 692.5 |
| 1392.85 | 50.18 | 122.5 | 506.93 | 33.42 | 312.5 | 400.8 | 30.55 | 507.5 | 204.65 | 26.27 | 697.5 |
| 500.96 | 33.26 | 127.5 | 703.33 | 37.33 | 317.5 | 358.62 | 29.78 | 512.5 | 232.27 | 26.91 | 702.5 |
| 710.1 | 38.23 | 132.5 | 147.48 | 24.23 | 322.5 | 264.55 | 27.31 | 517.5 | 1286.96 | 46.69 | 707.5 |
| 1173.21 | 46 | 137.5 | 618.33 | 35.65 | 327.5 | 332.36 | 29.09 | 522.5 | 367.48 | 29.39 | 712.5 |
| 843.32 | 40.32 | 142.5 | 226.18 | 26.96 | 332.5 | 829.34 | 38.73 | 527.5 | 223.84 | 26.32 | 717.5 |
| 1152.69 | 45.53 | 147.5 | 702.09 | 38.29 | 337.5 | 560.75 | 34.63 | 532.5 | 539.19 | 34.7 | 722.5 |
| 718.93 | 38.38 | 152.5 | 1336.94 | 49.64 | 342.5 | 897.06 | 41.26 | 537.5 | 524.07 | 33.46 | 727.5 |
| 663.85 | 36.04 | 157.5 | 869.63 | 41.72 | 347.5 | 1091.85 | 44.12 | 542.5 | 427.98 | 31.16 | 732.5 |
| 2392.32 | 63.44 | 162.5 | 769.27 | 39.36 | 352.5 | 265.62 | 27.11 | 547.5 | 1196.13 | 46.33 | 737 |
| 3842.87 | 75.75 | 167.5 | 3054.07 | 69.62 | 357.5 | 241.34 | 27.2 | 552.5 | 75633.3 | 527.79 | 740 |
| 718.63 | 35.47 | 172.5 | 1164.72 | 45.38 | 362.5 | 844.61 | 40.18 | 557.5 | 65533.3 | 484.88 | 742 |
| 957.05 | 41.14 | 177.5 | 1012.29 | 42.28 | 367.5 | 1045.71 | 44.21 | 562.5 | 68772.59 | 512.76 | 743 |
| 2832.94 | 67.6 | 182.5 | 3863.65 | 87.68 | 372.5 | 591.56 | 34.94 | 567.5 | 55677.99 | 419.27 | 743.5 |
| 2129.27 | 58.8 | 187.5 | 412.97 | 31.51 | 377.5 | 241.69 | 26.89 | 572.5 | | | |
| 2003.77 | 58.26 | 192.5 | 484.58 | 32.62 | 382.5 | 194.31 | 25.95 | 577.5 | | | |

## Madison Well, No. 27 (90 s)

| S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) | S (ppm) | S Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5427.38 | 131.09 | 2.5 | 0 | 100.12 | 197.5 | 526.38 | 51.46 | 387.5 | 484.55 | 48.42 | 582.5 |
| 759.26 | 72.07 | 7.5 | 0 | 116.32 | 202.5 | 1191.82 | 69.27 | 392.5 | 0 | 110.99 | 587.5 |
| 689.93 | 70.71 | 12.5 | 0 | 115.59 | 207.5 | 651.41 | 51.66 | 397.5 | 0 | 108.66 | 592.5 |
| 628.49 | 78.74 | 17.5 | 0 | 98.48 | 212.5 | 517.7 | 47.83 | 402.5 | 306.71 | 45.99 | 597.5 |
| 767.53 | 88.83 | 22.5 | 0 | 113.99 | 217.5 | 1228.08 | 61.96 | 407.5 | 509.56 | 46.71 | 602.5 |
| 693.89 | 79.32 | 27.5 | 420.01 | 56.11 | 222.5 | 512.65 | 48.56 | 412.5 | 601.21 | 49.17 | 607.5 |
| 689.13 | 75.56 | 32.5 | 4637.56 | 134.11 | 227.5 | 850.29 | 60.32 | 417.5 | 513.29 | 48.65 | 612.5 |
| 735.59 | 76.23 | 37.5 | 5735.67 | 140.13 | 232.5 | 812.7 | 55.23 | 422.5 | 691.9 | 58.6 | 617.5 |
| 737.72 | 75.16 | 42.5 | 10730.3 | 193.82 | 237.5 | 1197.22 | 58.75 | 427.5 | 987.97 | 64.73 | 622.5 |
| 682.42 | 75.33 | 47.5 | 1195.98 | 62.71 | 242.5 | 707.1 | 53.25 | 432.5 | 841 | 58.7 | 627.5 |
| 682.75 | 71.18 | 57.5 | 2621.88 | 84.1 | 247.5 | 1151.5 | 59.38 | 437.5 | 971.97 | 57.66 | 632.5 |
| 506.08 | 67.54 | 62.5 | 2488.32 | 84.61 | 252.5 | 642.5 | 51.12 | 442.5 | 1617.93 | 67.72 | 637.5 |
| 409.58 | 60.46 | 67.5 | 2584.17 | 77.04 | 257.5 | 962.09 | 60.36 | 447.5 | 726.44 | 66.65 | 642.5 |
| 226.63 | 57.27 | 72.5 | 2257.22 | 72.16 | 262.5 | 1274.93 | 59.64 | 452.5 | 2312.22 | 78.98 | 647.5 |
| 298.98 | 52.3 | 77.5 | 1977.03 | 74.51 | 267.5 | 1109.96 | 58.03 | 457.5 | 1854.69 | 67.96 | 652.5 |
| 145.64 | 52.38 | 82.5 | 2156.73 | 76.45 | 272.5 | 464.98 | 47.16 | 462.5 | 1123.33 | 62.68 | 657.5 |
| 0 | 143.95 | 87.5 | 2239.71 | 82.45 | 277.5 | 1027.06 | 55.89 | 467.5 | 1762.49 | 66.77 | 662.5 |
| 0 | 126.2 | 92.5 | 2617.19 | 83.15 | 282.5 | 1227.57 | 56.55 | 477.5 | 6186.07 | 116.98 | 667.5 |
| 342.6 | 50.37 | 97.5 | 1413.81 | 63.59 | 287.5 | 891.75 | 55.25 | 482.5 | 14174.98 | 175.64 | 672.5 |
| 253.06 | 44.31 | 102.5 | 1367.64 | 69.1 | 292.5 | 1040.88 | 56.82 | 487.5 | 2053.11 | 71.45 | 677.5 |
| 0 | 104.13 | 107.5 | 1008.68 | 60.69 | 297.5 | 1204.04 | 58.5 | 492.5 | 877.52 | 54.6 | 682.5 |
| 0 | 93.95 | 112.5 | 1506.84 | 65.24 | 302.5 | 655.28 | 50.1 | 497.5 | 456.27 | 46.73 | 687.5 |
| 0 | 117.02 | 117.5 | 1094.86 | 59.14 | 307.5 | 1070.67 | 57.75 | 502.5 | 0 | 104.79 | 692.5 |
| 257.27 | 44.94 | 122.5 | 1643.78 | 66.03 | 312.5 | 720.7 | 51.91 | 507.5 | 329.4 | 43.29 | 697.5 |
| 0 | 106.53 | 127.5 | 2559.46 | 77.62 | 317.5 | 942.51 | 57.05 | 512.5 | 551.95 | 47.99 | 702.5 |
| 0 | 120.48 | 132.5 | 499.45 | 44.12 | 322.5 | 574.69 | 48.56 | 517.5 | 736.25 | 50.77 | 707.5 |
| 0 | 138.85 | 137.5 | 2225.25 | 75.89 | 327.5 | 721.13 | 54.7 | 522.5 | 609.24 | 50.19 | 712.5 |
| 0 | 113.91 | 142.5 | 790.19 | 49.36 | 332.5 | 1500.32 | 65.56 | 527.5 | 461.13 | 44.64 | 717.5 |
| 0 | 119.02 | 147.5 | 1109.79 | 63.83 | 337.5 | 803.33 | 53.29 | 532.5 | 1650.28 | 62.15 | 722.5 |
| 464.92 | 53.87 | 152.5 | 2534.62 | 85.98 | 342.5 | 1312.73 | 65.61 | 537.5 | 889 | 54 | 727.5 |
| 0 | 106.27 | 157.5 | 1607.74 | 75.44 | 347.5 | 2398.22 | 78.27 | 542.5 | 624.51 | 48.64 | 732.5 |
| 636.99 | 50.45 | 162.5 | 2082.66 | 75.94 | 352.5 | 879.71 | 54.75 | 547.5 | 428.74 | 47.77 | 737 |
| 316.23 | 46.53 | 167.5 | 420.96 | 51.55 | 357.5 | 501.76 | 46.17 | 552.5 | 0 | 394.54 | 740 |
| 369.16 | 49.95 | 172.5 | 863.95 | 56.94 | 362.5 | 1660.28 | 65.48 | 557.5 | 0 | 313.32 | 742 |
| 0 | 98.48 | 177.5 | 1433.22 | 71.97 | 367.5 | 1678.48 | 66.66 | 562.5 | 0 | 297.44 | 743 |
| 0 | 108.05 | 182.5 | 726.89 | 87.87 | 372.5 | 1193.91 | 61.96 | 567.5 | 0 | 306.6 | 743.5 |
| 0 | 104.58 | 187.5 | 711.16 | 52.93 | 377.5 | 697.43 | 49.03 | 572.5 | | | |
| 0 | 99.12 | 192.5 | 790.75 | 56.65 | 382.5 | 0 | 102.41 | 577.5 | | | |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

**Madison Well, No. 27 (90 s)**

| Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) | Th (ppm) | Th Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3.23 | 2.5 | 0 | 2.71 | 197.5 | 0 | 2.7 | 387.5 | 0 | 2.64 | 582.5 |
| 0 | 3 | 7.5 | 0 | 2.52 | 202.5 | 0 | 2.51 | 392.5 | 0 | 2.59 | 587.5 |
| 0 | 2.96 | 12.5 | 0 | 2.79 | 207.5 | 0 | 2.62 | 397.5 | 0 | 2.51 | 592.5 |
| 5.16 | 2.42 | 17.5 | 0 | 2.5 | 212.5 | 0 | 2.38 | 402.5 | 0 | 2.54 | 597.5 |
| 0 | 3.41 | 22.5 | 0 | 2.66 | 217.5 | 0 | 2.61 | 407.5 | 0 | 2.64 | 602.5 |
| 0 | 3.04 | 27.5 | 0 | 3.07 | 222.5 | 0 | 2.3 | 412.5 | 0 | 2.64 | 607.5 |
| 0 | 3.09 | 32.5 | 0 | 4.18 | 227.5 | 0 | 2.78 | 417.5 | 0 | 2.72 | 612.5 |
| 3.67 | 2.23 | 37.5 | 6.88 | 2.56 | 232.5 | 0 | 2.58 | 422.5 | 0 | 2.95 | 617.5 |
| 0 | 3.06 | 42.5 | 6.99 | 2.67 | 237.5 | 0 | 2.64 | 427.5 | 0 | 3.08 | 622.5 |
| 0 | 3.1 | 47.5 | 0 | 2.59 | 242.5 | 0 | 2.52 | 432.5 | 0 | 2.58 | 627.5 |
| 0 | 2.95 | 57.5 | 0 | 2.42 | 247.5 | 0 | 2.5 | 437.5 | 0 | 2.65 | 632.5 |
| 0 | 3.03 | 62.5 | 0 | 2.51 | 252.5 | 0 | 2.53 | 442.5 | 0 | 2.66 | 637.5 |
| 0 | 2.83 | 67.5 | 0 | 2.54 | 257.5 | 0 | 2.55 | 447.5 | 3.53 | 2.19 | 642.5 |
| 3.05 | 1.97 | 72.5 | 0 | 2.42 | 262.5 | 0 | 2.43 | 452.5 | 0 | 2.73 | 647.5 |
| 0 | 2.73 | 77.5 | 0 | 2.65 | 267.5 | 0 | 2.53 | 457.5 | 0 | 2.61 | 652.5 |
| 0 | 2.79 | 82.5 | 0 | 2.53 | 272.5 | 0 | 2.54 | 462.5 | 3.18 | 2.01 | 657.5 |
| 0 | 2.55 | 87.5 | 0 | 2.59 | 277.5 | 0 | 2.68 | 467.5 | 0 | 2.72 | 662.5 |
| 0 | 2.43 | 92.5 | 0 | 2.66 | 282.5 | 0 | 2.47 | 477.5 | 0 | 2.64 | 667.5 |
| 0 | 2.63 | 97.5 | 0 | 2.64 | 287.5 | 0 | 2.54 | 482.5 | 0 | 2.59 | 672.5 |
| 0 | 2.7 | 102.5 | 0 | 2.49 | 292.5 | 0 | 2.59 | 487.5 | 0 | 2.75 | 677.5 |
| 0 | 2.37 | 107.5 | 0 | 2.56 | 297.5 | 0 | 2.55 | 492.5 | 0 | 2.53 | 682.5 |
| 0 | 2.59 | 112.5 | 0 | 2.58 | 302.5 | 0 | 2.41 | 497.5 | 0 | 2.63 | 687.5 |
| 0 | 2.62 | 117.5 | 0 | 2.52 | 307.5 | 0 | 2.47 | 502.5 | 0 | 2.6 | 692.5 |
| 0 | 2.81 | 122.5 | 0 | 2.49 | 312.5 | 0 | 2.57 | 507.5 | 0 | 2.49 | 697.5 |
| 0 | 2.43 | 127.5 | 0 | 2.55 | 317.5 | 0 | 2.54 | 512.5 | 0 | 2.67 | 702.5 |
| 0 | 2.64 | 132.5 | 0 | 2.51 | 322.5 | 0 | 2.6 | 517.5 | 0 | 2.63 | 707.5 |
| 0 | 2.61 | 137.5 | 0 | 2.65 | 327.5 | 0 | 2.6 | 522.5 | 0 | 2.58 | 712.5 |
| 0 | 2.58 | 142.5 | 0 | 2.72 | 332.5 | 0 | 2.33 | 527.5 | 0 | 2.48 | 717.5 |
| 0 | 2.65 | 147.5 | 0 | 2.69 | 337.5 | 0 | 2.59 | 532.5 | 0 | 2.79 | 722.5 |
| 0 | 2.62 | 152.5 | 0 | 2.6 | 342.5 | 0 | 2.62 | 537.5 | 0 | 2.46 | 727.5 |
| 0 | 2.45 | 157.5 | 0 | 2.6 | 347.5 | 0 | 2.47 | 542.5 | 0 | 2.57 | 732.5 |
| 0 | 2.78 | 162.5 | 0 | 2.59 | 352.5 | 0 | 2.58 | 547.5 | 2.87 | 1.89 | 737 |
| 0 | 2.64 | 167.5 | 0 | 2.48 | 357.5 | 0 | 2.58 | 552.5 | 0 | 3.6 | 740 |
| 0 | 2.55 | 172.5 | 0 | 2.64 | 362.5 | 0 | 2.55 | 557.5 | 0 | 3.43 | 742 |
| 0 | 2.58 | 177.5 | 0 | 2.55 | 367.5 | 0 | 2.73 | 562.5 | 0 | 3.9 | 743 |
| 0 | 2.75 | 182.5 | 0 | 3.23 | 372.5 | 0 | 2.5 | 567.5 | 0 | 3.38 | 743.5 |
| 0 | 2.59 | 187.5 | 0 | 2.52 | 377.5 | 0 | 2.54 | 572.5 | | | |
| 0 | 2.71 | 192.5 | 0 | 2.61 | 382.5 | 0 | 2.61 | 577.5 | | | |

## Madison Well, No. 27 (90 s)

| U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) | U (ppm) | U Error (ppm) | Sample (ft. below surface) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 4.88 | 2.5 | 0 | 3.58 | 197.5 | 0 | 3.66 | 387.5 | 0 | 3.49 | 582.5 |
| 0 | 4.48 | 7.5 | 0 | 3.44 | 202.5 | 0 | 3.6 | 392.5 | 0 | 3.46 | 587.5 |
| 0 | 4.64 | 12.5 | 0 | 3.61 | 207.5 | 0 | 3.54 | 397.5 | 0 | 3.57 | 592.5 |
| 0 | 5.47 | 17.5 | 0 | 3.4 | 212.5 | 0 | 3.19 | 402.5 | 0 | 3.56 | 597.5 |
| 0 | 5.46 | 22.5 | 0 | 3.5 | 217.5 | 0 | 3.44 | 407.5 | 0 | 3.59 | 602.5 |
| 0 | 4.71 | 27.5 | 0 | 3.89 | 222.5 | 0 | 3.3 | 412.5 | 0 | 3.66 | 607.5 |
| 0 | 5.17 | 32.5 | 0 | 5.98 | 227.5 | 0 | 3.58 | 417.5 | 0 | 3.56 | 612.5 |
| 0 | 5.02 | 37.5 | 0 | 6.43 | 232.5 | 0 | 3.41 | 422.5 | 0 | 4.59 | 617.5 |
| 0 | 4.63 | 42.5 | 7.71 | 4.44 | 237.5 | 0 | 3.52 | 427.5 | 0 | 4.37 | 622.5 |
| 0 | 4.83 | 47.5 | 0 | 3.58 | 242.5 | 0 | 3.34 | 432.5 | 0 | 3.68 | 627.5 |
| 0 | 4.73 | 57.5 | 0 | 3.5 | 247.5 | 0 | 3.4 | 437.5 | 0 | 3.69 | 632.5 |
| 0 | 4.29 | 62.5 | 0 | 3.52 | 252.5 | 0 | 3.4 | 442.5 | 0 | 3.79 | 637.5 |
| 0 | 4.18 | 67.5 | 0 | 3.49 | 257.5 | 0 | 3.49 | 447.5 | 0 | 5.22 | 642.5 |
| 0 | 4.23 | 72.5 | 0 | 3.39 | 262.5 | 0 | 3.59 | 452.5 | 0 | 3.94 | 647.5 |
| 0 | 3.92 | 77.5 | 0 | 3.67 | 267.5 | 0 | 3.48 | 457.5 | 0 | 3.49 | 652.5 |
| 0 | 4.48 | 82.5 | 0 | 3.36 | 272.5 | 0 | 3.48 | 462.5 | 0 | 4.24 | 657.5 |
| 0 | 3.9 | 87.5 | 0 | 3.43 | 277.5 | 0 | 3.47 | 467.5 | 0 | 3.58 | 662.5 |
| 0 | 3.55 | 92.5 | 0 | 3.58 | 282.5 | 0 | 3.58 | 477.5 | 0 | 3.43 | 667.5 |
| 0 | 3.8 | 97.5 | 0 | 3.62 | 287.5 | 0 | 3.45 | 482.5 | 0 | 3.78 | 672.5 |
| 0 | 3.51 | 102.5 | 0 | 3.54 | 292.5 | 0 | 3.39 | 487.5 | 0 | 3.56 | 677.5 |
| 0 | 3.33 | 107.5 | 0 | 3.62 | 297.5 | 0 | 3.3 | 492.5 | 0 | 3.64 | 682.5 |
| 0 | 3.56 | 112.5 | 0 | 3.54 | 302.5 | 0 | 3.49 | 497.5 | 0 | 3.62 | 687.5 |
| 0 | 3.48 | 117.5 | 0 | 3.41 | 307.5 | 0 | 3.39 | 502.5 | 0 | 3.39 | 692.5 |
| 0 | 3.57 | 122.5 | 0 | 3.45 | 312.5 | 0 | 3.54 | 507.5 | 0 | 3.4 | 697.5 |
| 0 | 3.41 | 127.5 | 0 | 3.57 | 317.5 | 0 | 3.47 | 512.5 | 0 | 3.55 | 702.5 |
| 0 | 3.66 | 132.5 | 0 | 3.42 | 322.5 | 0 | 3.51 | 517.5 | 0 | 3.44 | 707.5 |
| 0 | 3.66 | 137.5 | 0 | 3.42 | 327.5 | 0 | 3.5 | 522.5 | 0 | 3.41 | 712.5 |
| 0 | 3.52 | 142.5 | 0 | 3.58 | 332.5 | 0 | 3.43 | 527.5 | 0 | 3.35 | 717.5 |
| 0 | 3.62 | 147.5 | 0 | 3.53 | 337.5 | 0 | 3.66 | 532.5 | 0 | 3.58 | 722.5 |
| 0 | 3.56 | 152.5 | 0 | 3.75 | 342.5 | 0 | 3.53 | 537.5 | 0 | 3.45 | 727.5 |
| 0 | 3.41 | 157.5 | 0 | 3.54 | 347.5 | 0 | 3.5 | 542.5 | 0 | 3.42 | 732.5 |
| 0 | 3.52 | 162.5 | 0 | 3.55 | 352.5 | 0 | 3.42 | 547.5 | 0 | 3.46 | 737 |
| 0 | 3.39 | 167.5 | 0 | 3.52 | 357.5 | 0 | 3.54 | 552.5 | 0 | 4.82 | 740 |
| 0 | 3.32 | 172.5 | 0 | 3.37 | 362.5 | 0 | 3.46 | 557.5 | 6.25 | 3.53 | 742 |
| 0 | 3.29 | 177.5 | 0 | 3.48 | 367.5 | 0 | 3.59 | 562.5 | 0 | 5.93 | 743 |
| 0 | 3.7 | 182.5 | 0 | 4.23 | 372.5 | 0 | 3.55 | 567.5 | 0 | 4.78 | 743.5 |
| 0 | 3.42 | 187.5 | 0 | 3.51 | 377.5 | 0 | 3.51 | 572.5 | | | |
| 0 | 3.57 | 192.5 | 0 | 3.48 | 382.5 | 0 | 3.47 | 577.5 | | | |

## Madison Well, No. 27 (240 s)

| Th (ppm) | Th Error (ppm) | Sample (ft. below surface) |
|---|---|---|
| 0 | 0.97 | 217.5 |
| 0 | 1.18 | 222.5 |
| 3.32 | 0.98 | 227.5 |
| 10.95 | 1.11 | 232.5 |
| 8.17 | 1.06 | 237.5 |
| 0 | 1.03 | 242.5 |
| 0 | 1.03 | 247.5 |
| 0 | 1.01 | 252.5 |
| 1.8 | 0.72 | 612.5 |
| 4.7 | 0.83 | 617.5 |
| 1.9 | 0.74 | 622.5 |
| 0 | 1.03 | 627.5 |
| 1.46 | 0.72 | 632.5 |
| 0 | 1.06 | 637.5 |
| 2.38 | 0.81 | 642.5 |
| 0 | 1.02 | 647.5 |
| 0 | 1.04 | 652.5 |
| 1.92 | 0.73 | 657.5 |
| 0 | 1.02 | 662.5 |
| 0 | 1.05 | 667.5 |
| 0 | 1.02 | 672.5 |
| 0 | 0.96 | 732.5 |
| 0 | 1.04 | 737 |
| 0 | 1.38 | 740 |
| 0 | 1.35 | 742 |
| 0 | 1.29 | 743 |
| 0 | 1.24 | 743.5 |

| U (ppm) | U Error (ppm) | Sample (ft. below surface) |
|---|---|---|
| 0 | 1.36 | 217.5 |
| 0 | 1.51 | 222.5 |
| 4.31 | 1.41 | 227.5 |
| 4.1 | 1.77 | 232.5 |
| 6.96 | 1.72 | 237.5 |
| 0 | 1.4 | 242.5 |
| 0 | 1.38 | 247.5 |
| 0 | 1.38 | 252.5 |
| 0 | 1.51 | 612.5 |
| 3.05 | 1.28 | 617.5 |
| 0 | 1.66 | 622.5 |
| 0 | 1.42 | 627.5 |
| 0 | 1.49 | 632.5 |
| 0 | 1.54 | 637.5 |
| 0 | 1.87 | 642.5 |
| 0 | 1.49 | 647.5 |
| 0 | 1.47 | 652.5 |
| 0 | 1.49 | 657.5 |
| 0 | 1.38 | 662.5 |
| 0 | 1.39 | 667.5 |
| 0 | 1.4 | 672.5 |
| 0 | 1.29 | 732.5 |
| 0 | 1.37 | 737 |
| 2.15 | 1.26 | 740 |
| 0 | 1.91 | 742 |
| 0 | 1.88 | 743 |
| 0 | 1.81 | 743.5 |

pXRF elemental data of the standards used in the different analysis sessions. The extended filter time analysis of selected cuttings samples for Madison Well, No. 4 and 27 was completed in the same session. Certificate of analysis for each standard are available through the links below and Zambito and others (2016).

a) Thermo Scientific Blank 180-647 SiO2 : Part of Thermo Scientific Soil/Mining QC Reference Sample Set

b) USGS Carbonatite, COQ-1: http://crustal.usgs.gov/geochemical_reference_standards/pdfs/carbon.pdf

c) USGS Brush Creek Shale, SBC-1: http://crustal.usgs.gov/geochemical_reference_standards/pdfs/SBC-1.pdf

d) USGS Devonian Ohio Shale, SDO-1: http://crustal.usgs.gov/geochemical_reference_standards/pdfs/ohioshale.pdf

e) NIST Standard Reference Material 1d, Argillaceous Limestone, SRM-1d: https://nemo.nist.gov/m-srmors/certificates/1D.pdf

## Standards- Madison Well, No. 4 (90 s)

| Sample | Sample Type | Al (ppm) | Al Error (ppm) | K (ppm) | K Error (ppm) | Ca (ppm) | Ca Error (ppm) | Si (ppm) | Si Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-847 | standard | 0 | 640.59 | 81.12 | 31.87 | 888.84 | 29.3 | 308038.97 | 1564.23 |
| 180-647 | standard | 0 | 423.75 | 83.52 | 31.84 | 814.24 | 27.88 | 307048.13 | 1596.16 |
| 180-647 | standard | 0 | 711.43 | 107.73 | 32.76 | 859.26 | 29.08 | 302686.81 | 1580.91 |
| 180-647 | standard | 0 | 443.81 | 109.74 | 33.67 | 938.66 | 30.85 | 309295.44 | 1593.91 |
| COQ-1 | standard | 3123.93 | 1343.98 | 1506.89 | 172.28 | 442315.75 | 3203.05 | 20968.73 | 756.19 |
| COQ-1 | standard | 3177.85 | 1317.1 | 1216.9 | 164.92 | 450077.75 | 3218.44 | 19439.46 | 721.26 |
| COQ-1 | standard | 3432.63 | 1370.33 | 1715.73 | 175.13 | 440869.63 | 3159.1 | 21456.69 | 746.57 |
| COQ-1 | standard | 2286.42 | 1296.64 | 1436.48 | 171.34 | 447504.56 | 3212.8 | 20878.46 | 740.66 |
| SBC-1 | standard | 100175.86 | 2139.24 | 26515.59 | 464.34 | 22333.41 | 649.08 | 238481.03 | 1563.73 |
| SBC-1 | standard | 95652.59 | 2074 | 26706.2 | 470.1 | 22506.82 | 658.09 | 233656.78 | 1560.03 |
| SBC-1 | standard | 101093.58 | 2187.25 | 26537.48 | 464.16 | 22991.31 | 651.96 | 236968.41 | 1578.45 |
| SBC-1 | standard | 99374.45 | 2226.28 | 26806.77 | 470.01 | 22738.61 | 661.92 | 237887.75 | 1600.1 |
| SDO-1 | standard | 57806.91 | 1590.73 | 25475.74 | 440.28 | 7543.17 | 184.4 | 236859.27 | 1508.19 |
| SDO-1 | standard | 56798.46 | 1533.52 | 25204.38 | 441.12 | 7545.63 | 185.78 | 228640.95 | 1443.2 |
| SDO-1 | standard | 57323.3 | 1528.45 | 24998.36 | 440.24 | 7607.18 | 188.12 | 231916.98 | 1448.34 |
| SDO-1 | standard | 57414.87 | 1584.71 | 25584.6 | 451.93 | 7693.63 | 190.82 | 233894.17 | 1494.4 |
| SRM1d | standard | 3171.18 | 1297.02 | 1270.23 | 153.57 | 454438.97 | 2521.64 | 17384.75 | 687.5 |
| SRM1d | standard | 3564.29 | 1249.31 | 1304.91 | 149.95 | 456349.69 | 2498.72 | 17118.62 | 672.92 |
| SRM1d | standard | 2041.12 | 1193.89 | 1502 | 153.53 | 455815.81 | 2536.74 | 17528.13 | 676.91 |
| SRM1d | standard | 2876.6 | 1231.36 | 1339.9 | 151.94 | 453852.56 | 2495.33 | 18267.34 | 695.57 |

## Standards- Madison Well, No. 4 (90 s)

| Sample | Sample Type | Fe (ppm) | Fe Error (ppm) | S (ppm) | S Error (ppm) | U (ppm) | U Error (ppm) | Th (ppm) | Th Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-847 | standard | 0 | 25.65 | 0 | 89.56 | 0 | 3.11 | 0 | 2.31 |
| 180-647 | standard | 0 | 26.32 | 0 | 89.3 | 0 | 3.24 | 0 | 2.31 |
| 180-647 | standard | 0 | 26.35 | 0 | 90.71 | 0 | 3.12 | 0 | 2.3 |
| 180-647 | standard | 0 | 25.11 | 0 | 96.1 | 0 | 3.08 | 0 | 2.25 |
| COQ-1 | standard | 21005.26 | 400.41 | 1849.81 | 243.47 | 0 | 27.94 | 18.75 | 7.9 |
| COQ-1 | standard | 19976.26 | 388.35 | 1710.24 | 231.59 | 0 | 27.33 | 0 | 10.6 |
| COQ-1 | standard | 22553.57 | 412.81 | 1816.97 | 233.33 | 0 | 26.95 | 0 | 11.01 |
| COQ-1 | standard | 21837.46 | 409.78 | 1856.46 | 237.09 | 0 | 27.49 | 13.42 | 7.66 |
| SBC-1 | standard | 68181.84 | 521.26 | 6208.28 | 139.44 | 0 | 8.69 | 13.78 | 3.67 |
| SBC-1 | standard | 68655.62 | 530.12 | 6335.41 | 141.56 | 10.3 | 6.04 | 12.59 | 3.68 |
| SBC-1 | standard | 68396.96 | 525.12 | 6371.74 | 143.81 | 0 | 8.67 | 14.67 | 3.73 |
| SBC-1 | standard | 68684.52 | 514.61 | 6398.08 | 148.93 | 10.16 | 5.82 | 12.45 | 3.56 |
| SDO-1 | standard | 61807.68 | 487.09 | 71087.68 | 557.99 | 42.76 | 6.25 | 4.64 | 3.09 |
| SDO-1 | standard | 62313.7 | 480.44 | 68632.16 | 527.87 | 50.28 | 6.31 | 6.83 | 3.15 |
| SDO-1 | standard | 60692.36 | 472.58 | 68509.07 | 526.72 | 46.04 | 6.21 | 6.57 | 3.11 |
| SDO-1 | standard | 61806.45 | 489.95 | 69464.94 | 547.46 | 48.54 | 6.4 | 7.3 | 3.24 |
| SRM1d | standard | 1463.86 | 62.74 | 1007.96 | 120.45 | 0 | 5.43 | 4.33 | 2.52 |
| SRM1d | standard | 1514.94 | 63.67 | 1011.64 | 118.38 | 0 | 5.48 | 4.94 | 2.58 |
| SRM1d | standard | 1553.04 | 65.53 | 1076.25 | 119.78 | 0 | 5.55 | 4.2 | 2.57 |
| SRM1d | standard | 1522.26 | 63.67 | 1262.37 | 124.75 | 0 | 5.52 | 0 | 3.72 |

# Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Standards- Madison Well, No. 27 (90 s)

| Sample | Sample Type | Al (ppm) | Al Error (ppm) | K (ppm) | K Error (ppm) | Ca (ppm) | Ca Error (ppm) | Si (ppm) | Si Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-647 | standard | 0 | 625.49 | 63.57 | 32.03 | 1014.72 | 31.57 | 308012.78 | 1581.43 |
| 180-647 | standard | 0 | 647.3 | 95.71 | 32.7 | 974.91 | 30.81 | 306547.41 | 1612.45 |
| 180-647 | standard | 0 | 405.96 | 96.16 | 33.08 | 986.74 | 31.35 | 297347.22 | 1559.29 |
| 180-647 | standard | 0 | 411.52 | 76.34 | 31.72 | 1053.89 | 31.29 | 302417.97 | 1547.6 |
| 180-647 | standard | 0 | 640.13 | 99.05 | 32.75 | 1077.75 | 32.29 | 314443.97 | 1566.25 |
| COQ-1 | standard | 2242.66 | 1330.19 | 1787.58 | 174.54 | 449714.97 | 3188.06 | 21555.59 | 780.97 |
| COQ-1 | standard | 2604.14 | 1364.47 | 1912.94 | 177.52 | 449301.19 | 3216.13 | 22006.44 | 789.1 |
| COQ-1 | standard | 2834.16 | 1316.31 | 1660.62 | 174.29 | 451125.25 | 3230.56 | 21531.8 | 754.06 |
| COQ-1 | standard | 2098.08 | 1257.64 | 1676.63 | 174.34 | 443114.22 | 3162.01 | 21810.58 | 746.72 |
| COQ-1 | standard | 0 | 1890.94 | 1233.49 | 163.8 | 445127.28 | 3140.43 | 20472.1 | 735.47 |
| SBC-1 | standard | 100890.66 | 2206.08 | 26634.08 | 474.59 | 22723.24 | 660.6 | 237019.27 | 1588.08 |
| SBC-1 | standard | 99281.4 | 2141.92 | 26277.61 | 470.2 | 22981.73 | 667.87 | 235629.91 | 1548.89 |
| SBC-1 | standard | 97801.48 | 2164.63 | 26399.94 | 467.99 | 22872.16 | 659.08 | 237494.83 | 1591.23 |
| SBC-1 | standard | 99475.91 | 2180.81 | 26290.61 | 467.68 | 23317.05 | 669.62 | 236342.09 | 1566.71 |
| SBC-1 | standard | 98152.08 | 2131.75 | 26505.33 | 459.42 | 23063.58 | 647.05 | 237147.3 | 1560.79 |
| SDO-1 | standard | 56453.48 | 1518.39 | 25314.3 | 444.07 | 7620.51 | 187.09 | 234142.25 | 1482.59 |
| SDO-1 | standard | 56854.32 | 1522.86 | 25189.86 | 442.71 | 7748.49 | 188.3 | 231642.94 | 1457.39 |
| SDO-1 | standard | 55246.86 | 1603.95 | 25743.12 | 444.4 | 7733.47 | 186.76 | 227744.89 | 1522.48 |
| SDO-1 | standard | 57077.16 | 1501.61 | 24909.29 | 437.64 | 7962.08 | 191.95 | 231066.61 | 1437.77 |
| SDO-1 | standard | 58681.88 | 1558.95 | 25391.25 | 444.7 | 7975.16 | 190.91 | 233673.75 | 1457.6 |
| SRM1d | standard | 3298.74 | 1229.84 | 1392.07 | 152 | 464576.75 | 2570.47 | 17312.54 | 665.61 |
| SRM1d | standard | 3121.81 | 1242.98 | 1347.48 | 151.96 | 459036.78 | 2547.22 | 17651.74 | 673.14 |
| SRM1d | standard | 2988.04 | 1241.26 | 1290.6 | 148.09 | 460685.13 | 2540.65 | 17178.4 | 679.04 |
| SRM1d | standard | 2122.51 | 1182.82 | 1224.15 | 149.38 | 454240.47 | 2543.13 | 17998.61 | 681.39 |
| SRM1d | standard | 4532.8 | 1272.06 | 1301.45 | 151.97 | 456634.06 | 2524.74 | 18533.45 | 688.49 |

## Standards- Madison Well, No. 27 (90 s)

| Sample | Sample Type | Fe (ppm) | Fe Error (ppm) | S (ppm) | S Error (ppm) | U (ppm) | U Error (ppm) | Th (ppm) | Th Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-647 | standard | 0 | 25.42 | 0 | 97.81 | 0 | 2.36 | 0 | 3.24 |
| 180-647 | standard | 0 | 26.08 | 0 | 86.22 | 0 | 2.3 | 0 | 3.18 |
| 180-647 | standard | 0 | 26.22 | 0 | 94.29 | 0 | 2.33 | 0 | 3.27 |
| 180-647 | standard | 0 | 25.46 | 0 | 87.5 | 0 | 2.29 | 0 | 3.05 |
| 180-647 | standard | 0 | 24.23 | 0 | 96.8 | 0 | 2.22 | 0 | 3.04 |
| COQ-1 | standard | 21774.05 | 401.96 | 1970.72 | 242.13 | 0 | 10.81 | 0 | 26.05 |
| COQ-1 | standard | 21526.91 | 402.01 | 2053.68 | 246.44 | 0 | 10.98 | 0 | 26.86 |
| COQ-1 | standard | 20521.21 | 395.4 | 1980.42 | 239.74 | 0 | 11.21 | 0 | 27.12 |
| COQ-1 | standard | 19967.53 | 382.88 | 1941.05 | 229.3 | 0 | 10.72 | 0 | 27.22 |
| COQ-1 | standard | 17701.78 | 354.51 | 1968.33 | 232.66 | 0 | 10.81 | 0 | 26.31 |
| SBC-1 | standard | 68032.17 | 523.83 | 6221.64 | 143.12 | 12.15 | 3.6 | 0 | 8.63 |
| SBC-1 | standard | 68296.52 | 518.29 | 6317.51 | 139.81 | 11.37 | 3.55 | 8.91 | 5.83 |
| SBC-1 | standard | 68434.57 | 523.36 | 6488.84 | 146.99 | 13.46 | 3.66 | 10.25 | 5.91 |
| SBC-1 | standard | 68064.41 | 514.52 | 6170.49 | 141.19 | 12.46 | 3.57 | 0 | 8.58 |
| SBC-1 | standard | 68236.14 | 518.89 | 6316.42 | 141.26 | 12.63 | 3.61 | 11 | 5.91 |
| SDO-1 | standard | 61929.2 | 494.37 | 69592.4 | 544.6 | 0 | 4.72 | 48.16 | 6.49 |
| SDO-1 | standard | 61943.6 | 484.81 | 69372.45 | 535.81 | 6.43 | 3.17 | 44.42 | 6.25 |
| SDO-1 | standard | 61622.41 | 483.34 | 67711.26 | 547.98 | 8.23 | 3.23 | 47.2 | 6.34 |
| SDO-1 | standard | 60632.2 | 469.76 | 68594.07 | 523.73 | 6.9 | 3.09 | 41.3 | 6.04 |
| SDO-1 | standard | 62054.5 | 485.57 | 69564.75 | 535.2 | 0 | 4.57 | 48.42 | 6.32 |
| SRM1d | standard | 1506.34 | 64.58 | 1148.49 | 118.54 | 6.16 | 2.68 | 0 | 5.52 |
| SRM1d | standard | 1550.01 | 65.3 | 996.55 | 115.96 | 0 | 3.71 | 0 | 5.55 |
| SRM1d | standard | 1471.88 | 64.16 | 1133.19 | 121.5 | 4.05 | 2.57 | 0 | 5.58 |
| SRM1d | standard | 1460.19 | 63.22 | 1138.76 | 119.98 | 0 | 3.68 | 0 | 5.51 |
| SRM1d | standard | 1494.57 | 64.12 | 1054.81 | 118 | 5.69 | 2.64 | 0 | 5.71 |

Appendix 2: pXRF data for Madison City Well, No. 4 and No. 27 cuttings and standards

## Standards- Extended Filter Time Analysis of Selected Samples from Madison Well, No. 4 and 27 (240 s)

| Sample | Sample Type | Al (ppm) | Al Error (ppm) | K (ppm) | K Error (ppm) | Ca (ppm) | Ca Error (ppm) | Si (ppm) | Si Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-647 | standard | 0 | 555.43 | 56.67 | 31.74 | 1459.67 | 36.95 | 317674.28 | 1085.91 |
| 180-647 | standard | 0 | 447.19 | 0 | 48.63 | 1411.16 | 37.2 | 313455.47 | 1075.59 |
| 180-647 | standard | 0 | 448.12 | 102.95 | 34.42 | 1406.49 | 37.62 | 312765.63 | 1051.14 |
| 180-647 | standard | 0 | 626.78 | 75.8 | 32.44 | 1397.49 | 36.24 | 309557.22 | 1052.21 |
| COQ-1 | standard | 4310.72 | 1405.36 | 1831.19 | 178.01 | 461170.66 | 2029.72 | 22539.58 | 762.11 |
| COQ-1 | standard | 2734.4 | 1364.17 | 1877.63 | 183.11 | 464463.44 | 2026.53 | 22639.61 | 771.83 |
| COQ-1 | standard | 3959.86 | 1409.8 | 2004.07 | 180.17 | 456799.16 | 1989.54 | 22849.1 | 758.43 |
| COQ-1 | standard | 0 | 1960.35 | 1236.24 | 166.5 | 456430.06 | 1976.37 | 21741.05 | 752.74 |
| SBC-1 | standard | 108952.58 | 2292.87 | 27356.33 | 466.76 | 25289.37 | 692.39 | 249894.08 | 1348.07 |
| SBC-1 | standard | 108819.47 | 2169.74 | 27653.94 | 470.69 | 24103.47 | 678.28 | 250750.69 | 1292.74 |
| SBC-1 | standard | 106910.79 | 2157.12 | 27473.03 | 468.21 | 24358.58 | 685.27 | 252323.72 | 1316.88 |
| SBC-1 | standard | 108738.24 | 2206.66 | 27863.43 | 474.63 | 24336.61 | 686.35 | 249753.72 | 1308.97 |
| SDO-1 | standard | 61786.95 | 1605.88 | 27051.38 | 446.86 | 8542.58 | 196.51 | 241077.48 | 1241.17 |
| SDO-1 | standard | 61696.5 | 1614.88 | 26112.83 | 434.83 | 8153.54 | 191.1 | 244035.47 | 1229.87 |
| SDO-1 | standard | 61208.63 | 1575.14 | 26193.6 | 440.99 | 8363.3 | 195.26 | 243485.72 | 1223.52 |
| SDO-1 | standard | 61831.98 | 1642.65 | 26742.69 | 451.01 | 8154.87 | 196.12 | 246403.8 | 1274.87 |
| SRM1d | standard | 2285.67 | 1259.94 | 1272.29 | 151.74 | 470407.75 | 1720.74 | 19623.01 | 719.72 |
| SRM1d | standard | 3207.48 | 1281.41 | 1261.12 | 151.81 | 473009.34 | 1720.12 | 18954.65 | 703.31 |
| SRM1d | standard | 3723.12 | 1348.78 | 1385.6 | 155.22 | 471788.47 | 1743.79 | 19576.69 | 711.78 |
| SRM1d | standard | 3143.8 | 1270.04 | 1329.02 | 156.79 | 473399.16 | 1733.67 | 19780.83 | 709.89 |

## Standards- Extended Filter Time Analysis of Selected Samples from Madison Well, No. 4 and 27 (240 s)

| Sample | Sample Type | Fe (ppm) | Fe Error (ppm) | S (ppm) | S Error (ppm) | U (ppm) | U Error (ppm) | Th (ppm) | Th Error (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| 180-647 | standard | 0 | 9.92 | 0 | 95.57 | 0 | 0.89 | 0 | 1.21 |
| 180-647 | standard | 0 | 9.91 | 0 | 91.8 | 0 | 0.87 | 0 | 1.2 |
| 180-647 | standard | 0 | 9.9 | 0 | 98.94 | 0 | 0.89 | 0 | 1.21 |
| 180-647 | standard | 0 | 10.11 | 0 | 86.41 | 0 | 0.86 | 0 | 1.21 |
| COQ-1 | standard | 21316.61 | 156.2 | 1829.86 | 234.73 | 6.13 | 2.82 | 0 | 10.5 |
| COQ-1 | standard | 20801.62 | 153.49 | 1829.88 | 241.87 | 5.8 | 2.8 | 0 | 10.4 |
| COQ-1 | standard | 21719.58 | 157.88 | 2018.07 | 240.16 | 9.8 | 2.89 | 0 | 10.55 |
| COQ-1 | standard | 19879.46 | 148.97 | 1926.43 | 237.88 | 10.57 | 2.86 | 0 | 10.35 |
| SBC-1 | standard | 68397.02 | 206.04 | 6874.16 | 150.7 | 13.59 | 1.43 | 8.06 | 2.3 |
| SBC-1 | standard | 68124.84 | 204.29 | 6763.45 | 142.05 | 11.71 | 1.4 | 8.96 | 2.3 |
| SBC-1 | standard | 68781.15 | 207.81 | 6990.69 | 147.12 | 11.48 | 1.4 | 6.13 | 2.28 |
| SBC-1 | standard | 68203.84 | 204.69 | 6706.42 | 143.8 | 12.57 | 1.4 | 7.99 | 2.27 |
| SDO-1 | standard | 61739.83 | 188.09 | 72903.27 | 441.09 | 4.79 | 1.19 | 43.83 | 2.41 |
| SDO-1 | standard | 61385.23 | 187.3 | 72588.88 | 435.26 | 5.55 | 1.2 | 45.24 | 2.42 |
| SDO-1 | standard | 61139.33 | 185.95 | 72830.89 | 433.85 | 4.54 | 1.17 | 44.96 | 2.4 |
| SDO-1 | standard | 61716.87 | 188.23 | 73382.95 | 452.76 | 5.73 | 1.2 | 46.46 | 2.43 |
| SRM1d | standard | 1530.21 | 24.78 | 1212.66 | 125.16 | 3.84 | 0.97 | 0 | 2.11 |
| SRM1d | standard | 1504.37 | 24.56 | 1189.13 | 123.05 | 3.28 | 0.96 | 0 | 2.11 |
| SRM1d | standard | 1528.62 | 24.82 | 1165.07 | 122.55 | 4.02 | 0.98 | 0 | 2.14 |
| SRM1d | standard | 1524.22 | 24.95 | 1084.8 | 120.1 | 3.26 | 0.97 | 3.2 | 1.45 |