DOE-EM/GJRAC3123

Moab UMTRA Project 2023 Groundwater Program Report

Revision 0

July 2024

Office of Environmental Management

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Revision 0

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Revision History

Revision	Date	Description
0	July 2024	Initial issue.

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Tables

Appendices

Acronyms and Abbreviations

ALS	ALS Environmental
bgs	below ground surface
CA	Contamination Area
CF	configuration
CFR	Code of Federal Regulations
cfs	cubic feet per second
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet/foot
ft bgs	feet below ground surface
gal	gallon or gallons
gpm	gallons per minute
IA	interim action
kg	kilograms
lb	pound
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
mil	million or millions
msl	mean sea level
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Introduction

1.1 Purpose and Scope

The purpose of the annual Groundwater Program Report is to assess the groundwater interim action performance measures the U.S. Department of Energy (DOE) has taken at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site. This report describes the Groundwater Program activities for the Moab Project during calendar year 2023 and evaluates the effectiveness of the remediation systems to remove contaminant mass from the groundwater system and protect suitable habitats for endangered fish that may develop in Colorado River side channels.

1.2 Site History and Background

The Moab Project site is a former uranium ore-processing facility located approximately 3 miles northwest of the city of Moab in Grand County, Utah (Figure 1). The Moab mill operated from 1956 to 1984. When the processing operations ceased, an estimated 16 million (mil) tons of uranium mill tailings accumulated in an unlined impoundment. A portion of the impoundment is within the 100-year floodplain of the Colorado River. In 2001, ownership of the site was transferred to DOE. Since April 2009, tailings have been relocated by rail to a disposal cell 30 miles north, near Crescent Junction, Utah.

Site-related contaminants, primarily ammonia and uranium, have leached from the tailings pile into the shallow groundwater. Some of the more mobile constituents have migrated downgradient and are discharging into the Colorado River adjacent to the site.

In 2005, DOE issued the *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P), which includes the cleanup alternative to continue and expand its ongoing active remediation of contaminated groundwater at the Moab site, as necessary. As an interim action (IA), DOE began limited groundwater remediation that involves extraction of contaminated groundwater from on-site remediation wells that is used for dust suppression inside the Contamination Area (CA). In addition, remediation activities also include the utilization of freshwater injection and surface water diversion systems.

2.0 Groundwater Program Description

The Groundwater Program at the Moab site was established to limit ecological risk from contaminated groundwater discharging to potential suitable habitat areas along the Colorado River. This protection is accomplished by removing contaminant mass utilizing groundwater extraction wells. In addition, freshwater injection between the river and the tailings pile creates a hydraulic barrier that reduces the discharge of contaminated water to the Colorado River. When necessary, surface water diversion takes place in areas of the Colorado River adjacent to the IA well field when suitable habitats develop for endangered young-of-year fish.

Groundwater and surface water monitoring is performed in conjunction with injection and extraction operations and through groundwater elevation and analytical data.

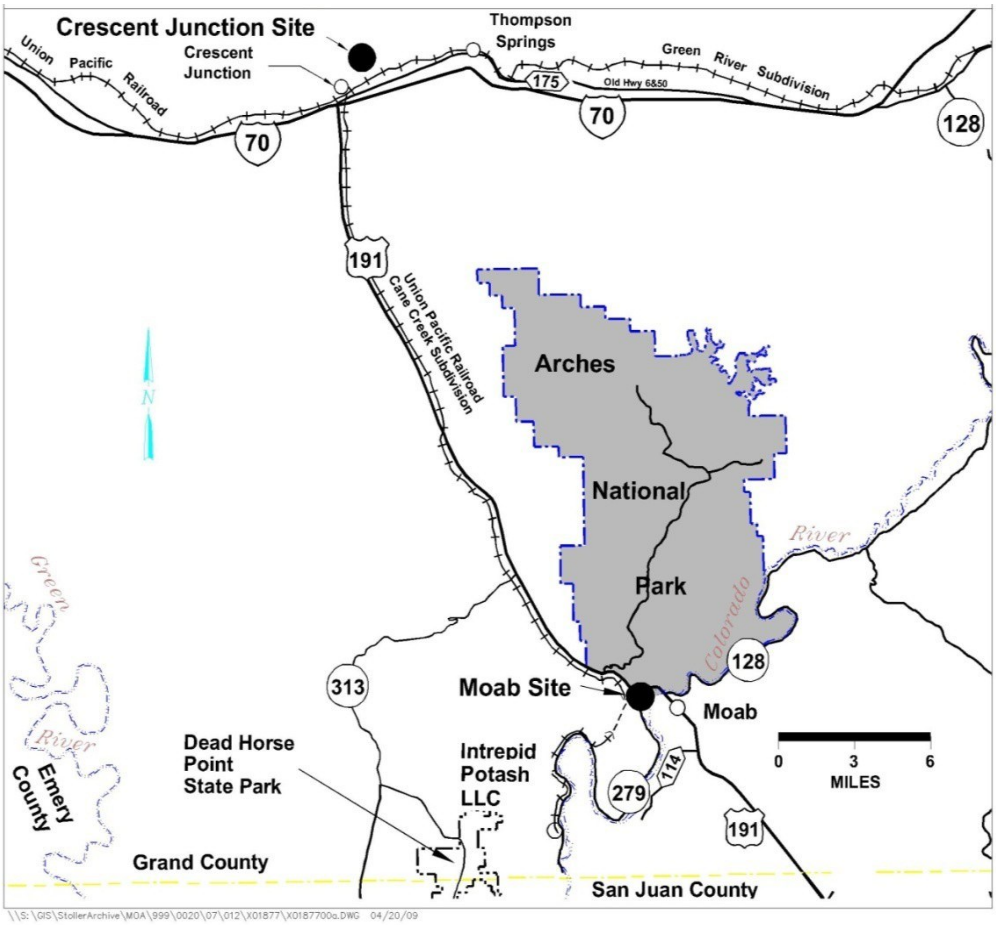

Figure 1. Location of the Moab Project Site

2.1 Interim Action Groundwater System

The Interim Action Groundwater System was installed and began operating the first of several configurations (CFs) of extraction/injection wells that comprise the IA groundwater system in 2003 (Figure 2).

The objectives of the IA system are to: 1) remove contaminant mass through groundwater extraction, 2) reduce the discharge of ammonia-contaminated groundwater to side channels that may be suitable habitat for endangered aquatic species, and 3) to provide performance data to select and design a final groundwater remedy. Contaminated groundwater from the shallow plume is extracted through a series of eight extraction wells (CF5). The IA system also includes injection of filtered river water into the underlying alluvium through remediation wells (CF4) located near the western bank of the river.

A surface water diversion system is designed to deliver fresh water to any area (primarily side channels) adjacent to the IA well field. This system is utilized when an area develops into a suitable habitat for endangered young-of-year fish species and is designed to reduce ammonia concentrations below either the acute or chronic criteria established by the U.S. Environmental Protection Agency (EPA). Observation wells located adjacent to the IA system are monitored for evaluation purposes. In 2023 CF4 wells were used for freshwater injection, and extraction operations occurred through the CF5 extraction wells.

Figure 2. Location of IA Wells

2.2 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site consists of alluvial valley fill deposits. The alluvium is mostly comprised of either the Moab Wash alluvium or the Colorado River basin-fill alluvium. Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and is deposited along the southeastern boundary of the site with the Colorado River basin-fill alluvium.

The basin-fill alluvium is comprised of two distinct types of material. The upper unit consists mostly of fine sand, silt, and clay and ranges in thickness up to 15 feet (ft) near the saturated zone in some areas. This shallow unit consists of overbank deposits from the Colorado River with a hydraulic conductivity that ranges from 20 to 50 ft/day.

The lower part of the basin-fill alluvium mostly consists of gravelly sand and sandy gravel, with minor amounts of silt and clay. This deeper, coarse alluvium pinches out to the northwest along the subsurface bedrock contact and thickens (more than 450 ft thick in the deepest part of the basin) to the southwest. The lower gravelly sand unit typically has a hydraulic conductivity that ranges from 100 to 200 ft/day.

Because of the conductive nature of the sands and gravels in the subsurface, any fluctuations in the Colorado River flows impact the groundwater surface elevations. Water table contour maps indicate the groundwater in this area discharges into the Colorado River under base flow conditions. Figure 3 is the groundwater surface contour map generated using data collected from January through March 2023, when the Colorado River flows ranged from 2,090 to 4,430 cubic feet per second (cfs).

Most groundwater beneath the site contains total dissolved solids (TDS) concentrations greater than 10,000 milligrams per liter (mg/L) (brackish water and brine) at depth. A brine interface naturally occurs beneath the Moab site that is delineated at a TDS concentration of 35,000 mg/L, which is equivalent to a specific conductance of approximately 50,000 micromhos per centimeter (µmhos/cm). The interface moves laterally and vertically during each year in response to river stage fluctuations.

The tailings pile fluids contain TDS exceeding 35,000 mg/L, which allows this fluid sufficient density to vertically migrate downward in groundwater under previous operating conditions at the site. This former density-driven flow has created a legacy plume of dissolved ammonia that now resides below the brackish water/brine interface.

Since the cessation of milling operations at the site in 1984, the flux of relatively fresh water entering the site upgradient of the tailings pile may have diluted the ammonia concentrations in the shallow groundwater (Figure 4).

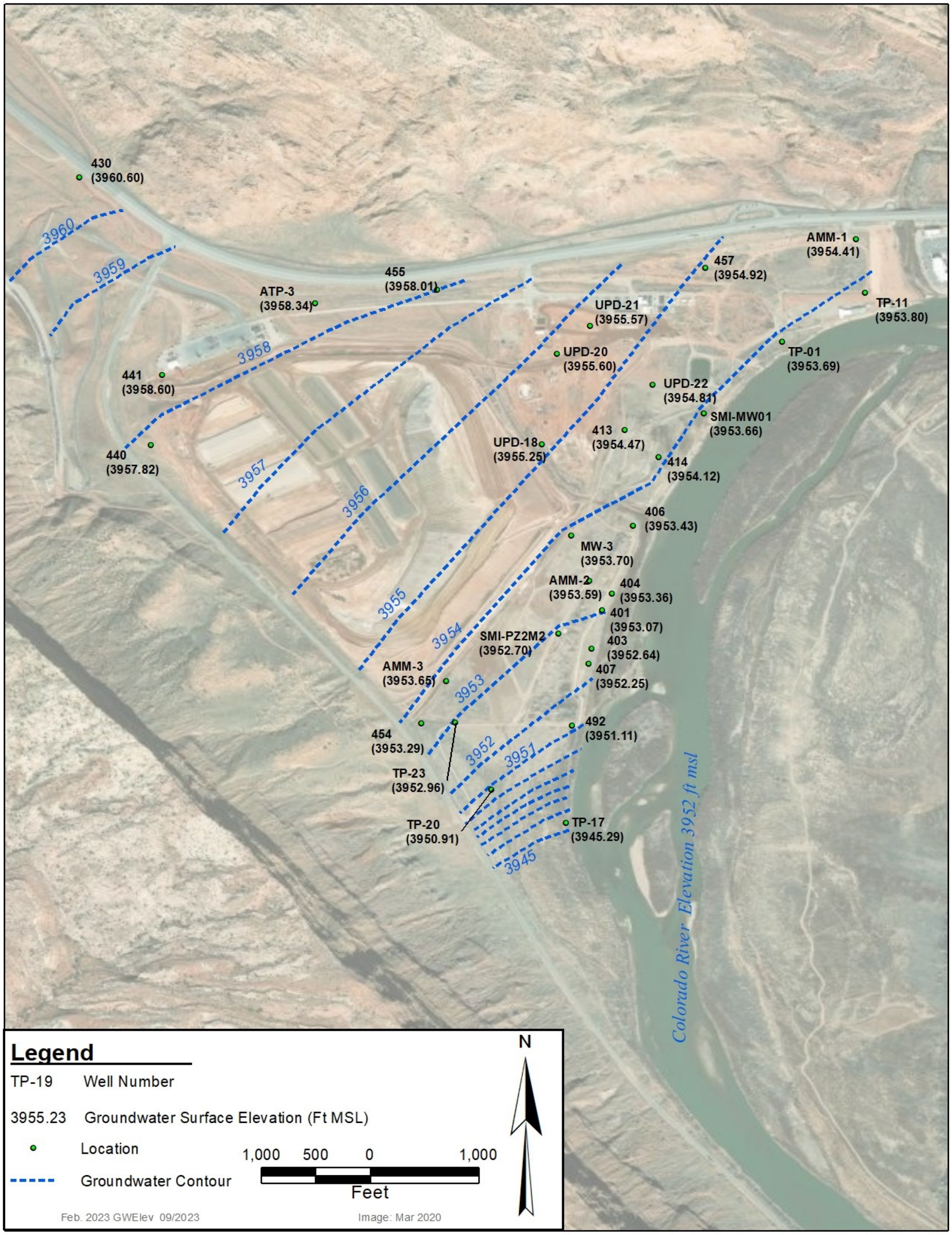

Figure 3. Site-wide Groundwater Elevations January-March 2023

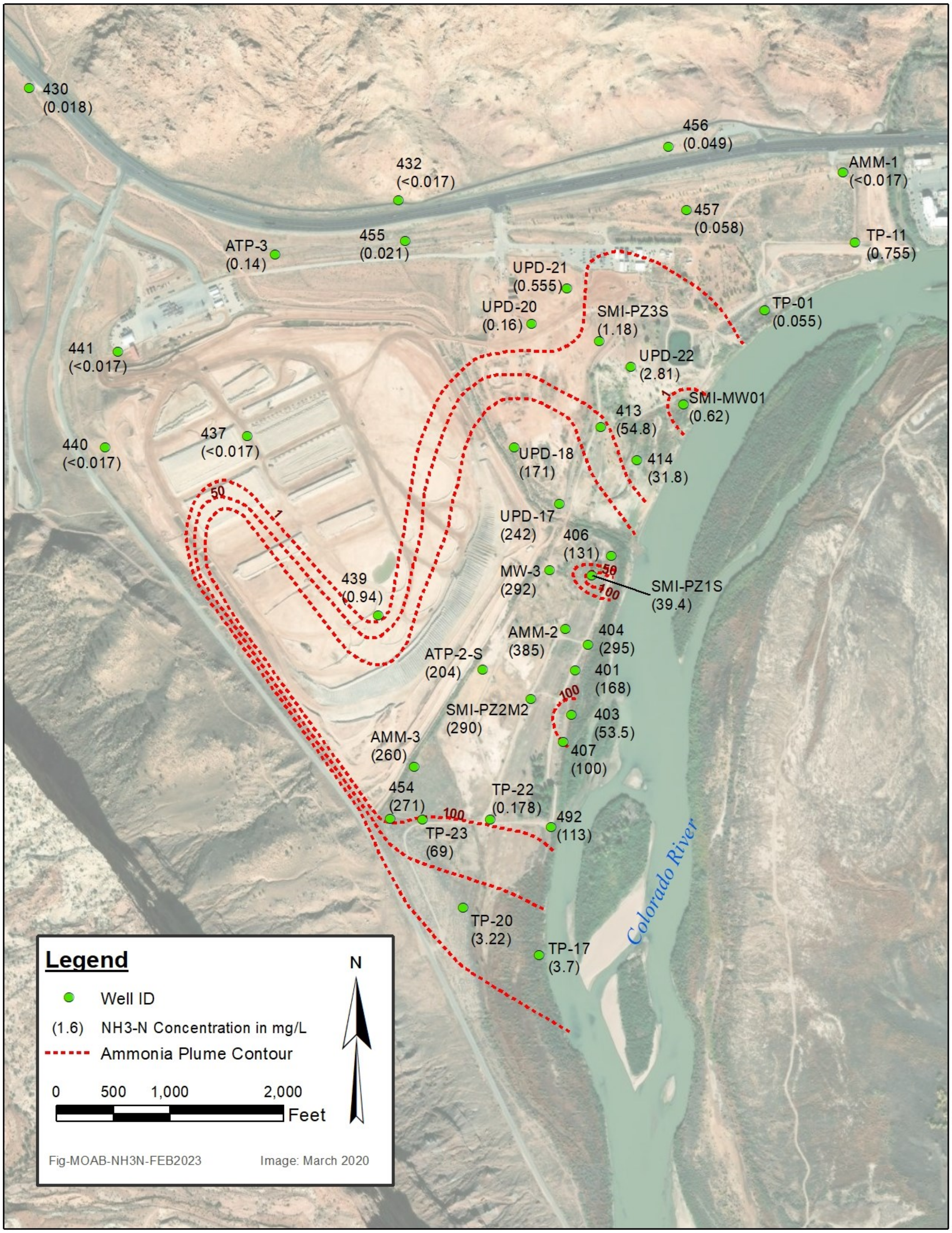

Figure 4. Ammonia Plume in Shallow Groundwater January-March 2023

Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow groundwater beneath the tailings pile, where aerobic conditions are more likely. However, there is no flushing of the legacy plume by an advective flow of fresh water due to density stratification of the brine zone. Figure 4 shows the ammonia plume in January-March 2023.

Figure 5 shows the distribution of dissolved uranium in shallow groundwater in 2023. The uranium groundwater standard of 0.044 mg/L is based on Table 1 in Title 40 Code of Federal Regulations Part 192, Subpart A (40 CFR 192A), "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites," assuming uranium-234 and uranium-238 activities are in equilibrium.

2.3 Surface Water/Groundwater Interaction

Previous investigations have shown that Colorado River flows impact the groundwater elevations and contaminant concentrations in the well field. For most of the year, when the river is experiencing baseflow (less than 4,000 cfs), groundwater discharges into the river (river gaining conditions, when the groundwater elevation was higher than the river surface elevation).

During higher flows, the groundwater gradient direction reverses adjacent to the river, and the groundwater contaminant concentrations are diluted. Once these flows subside, the river switches back from losing to gaining, and the groundwater gradient direction is re-established towards the river (to the southeast). Between January and April 2023, the Colorado River was under gaining conditions and switched to losing conditions in early April through August.

Figure 6 displays the groundwater elevation versus the elevation of the Colorado River in 2023. The elevation of the Colorado River was calculated using the river flows from the USGS Cisco gaging station and converting the flow to an elevation using the site rating curve included in the *Moab UMTRA Project Flood and Drought Mitigation Plan* (DOE-EM/GJ1640). In 2023, The Colorado River Basin had a higher-than-average snowpack, which led to an above average Colorado River flow.

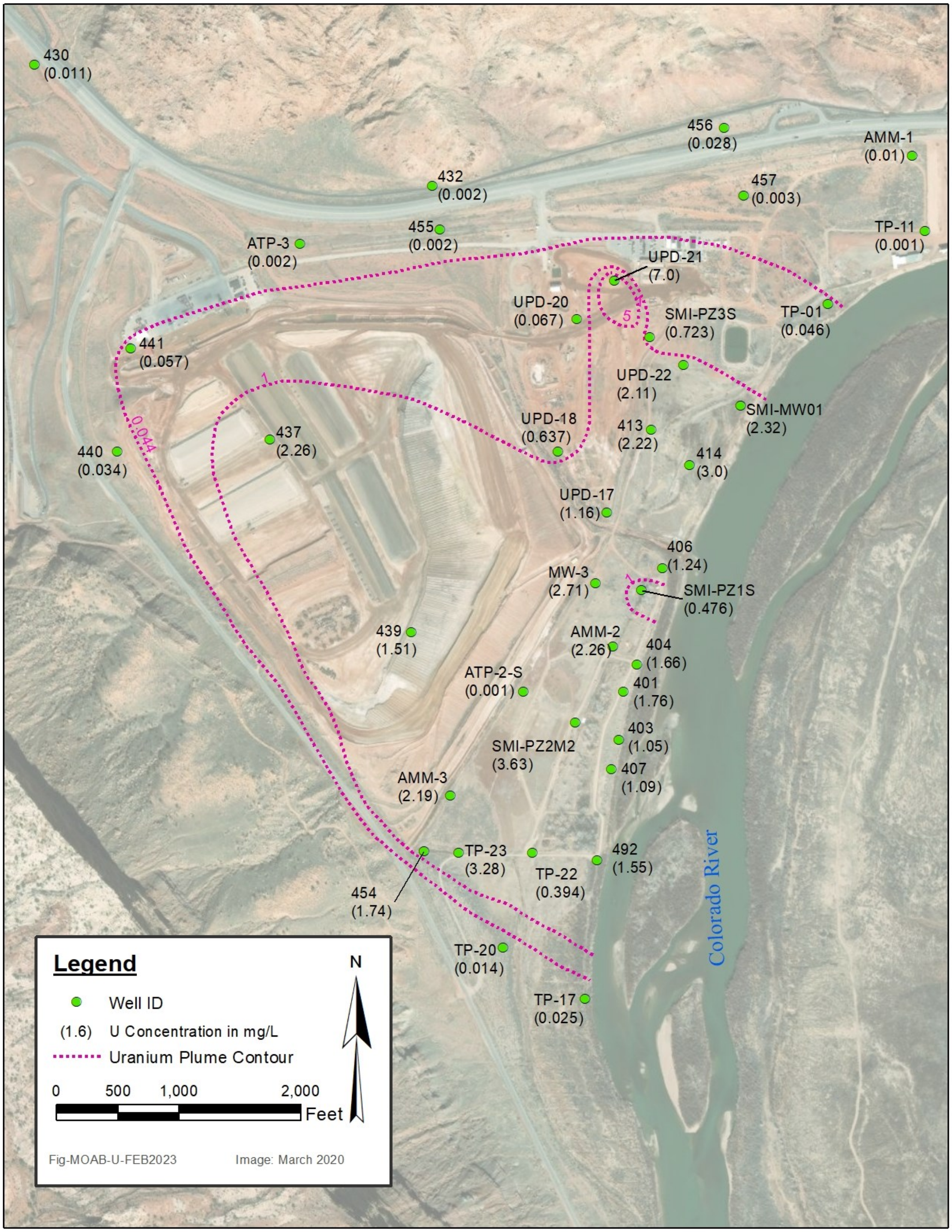

Figure 5. Uranium Plume in Shallow Groundwater January-March 2023

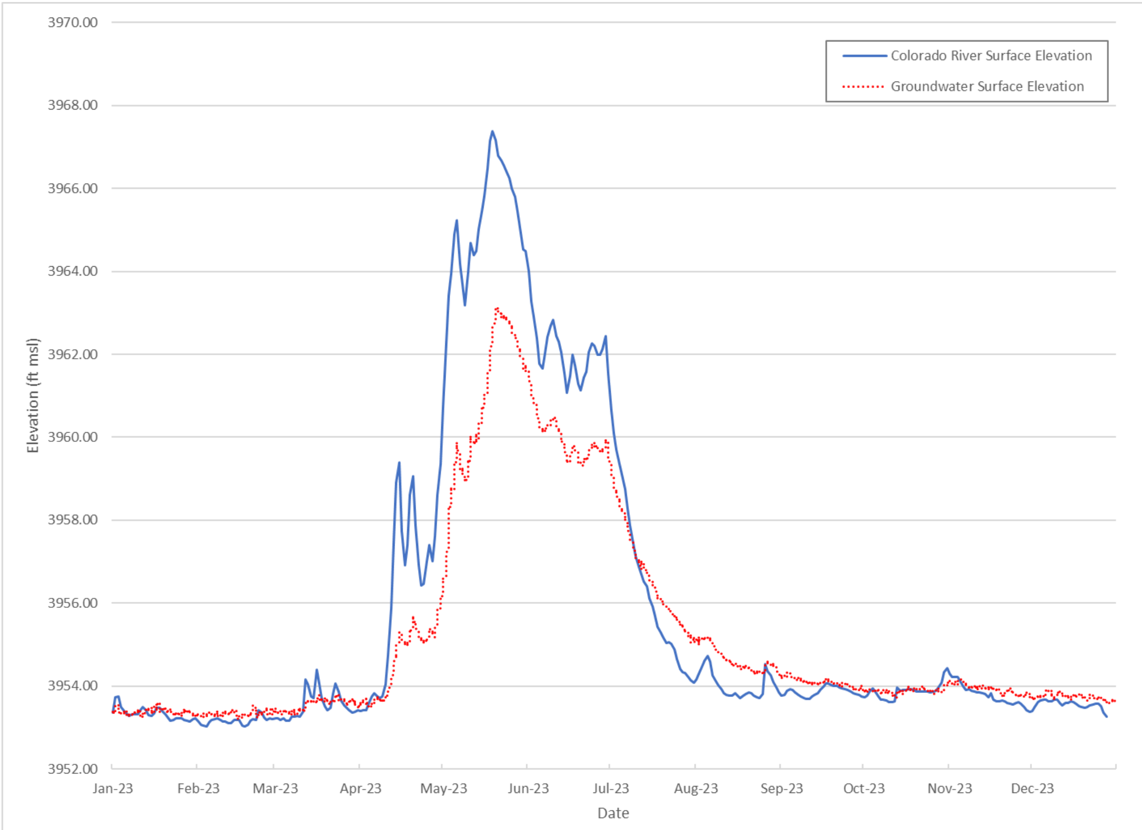

Figure 6. Groundwater Surface Elevation Compared to the Colorado River Surface Elevation 2023

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and the collection of samples from surface water locations, extraction wells, and monitoring wells for analytical analysis.

3.1 Remediation Well Extraction

Each extraction well contains a flow meter that displays the instantaneous flow rate in gallons per minute (gpm), the cumulative total volume extracted, and the net volume since the last reset of the internal memory. Flow meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water quality data to calculate the contaminant mass removal and evaluate the performance of the system.

This extracted groundwater is used as dust suppression in the CA. Any contaminants deposited as salts in the CA will eventually be removed for disposal with tailings and transported to the Crescent Junction disposal site.

3.2 Remediation Well Injection

Each injection well contains a flow meter that displays the instantaneous injection rate (in gpm) and the total volume. Flow meter readings are recorded manually on a weekly basis during injection operations. Water level data are used to calculate the elevation of freshwater mounding in response to the injection activities.

3.3 Water Levels

Groundwater levels are recorded in the IA well field on a weekly basis during injection operations to monitor freshwater mounding. A water-level indicator is used to measure the depth to groundwater (below top of casing). Data logging equipment with pressure transducers are installed at various locations to measure water levels on a more frequent basis.

3.4 Water Quality

Select well and surface water locations are sampled at various times, depending on the purpose of the sampling event. Prior to collecting a sample, the field parameters (which include temperature, pH, and conductivity) are measured and recorded. Observation wells are primarily sampled with dedicated down-hole tubing and a peristaltic pump, while extraction wells are sampled with dedicated submersible pumps.

Groundwater samples are collected from observation wells at various depths and locations to monitor the primary contaminants of concern, ammonia (as NH_3-N) and uranium. All sampling was performed in accordance with the *Moab UMTRA Project Surface Water/Groundwater Sampling and Analysis Plan* (DOE- EM/GJRAC1830). Samples were shipped overnight to Gel Laboratories (GEL) in Charleston, South Carolina, for analysis.

4.0 Groundwater Extraction System Operations and Performance

4.1 Interim Action Operations

This section provides information regarding the IA well field extraction performance during the 2023 pumping season. This section also includes a discussion of the total groundwater extraction volume, hydraulic control, mass removal, and water quality. Appendix A contains tables of well construction information (Table A-1), a chronology of 2023 activities (Table A-2), pumping volumes (Table A-3), and mass removal (Tables A-4 and A-5).

Groundwater extraction operations are controlled by an automated system, which utilizes extraction wells that supply groundwater directly to two 21,000-gal holding tanks. The water is then pumped into a 12,000-gallon (gal) Klein tank, where it is transferred to water trucks and used for dust suppression in the CA.

Extraction operations are limited by how much water is needed for dust suppression in the CA and by weather conditions (wet weather leads to less extraction, and warm, windy weather leads to more extraction). The 2023 extraction schedule was focused on optimizing ammonia and uranium mass removal through the operational CF5 remediation wells. The system was restarted in mid-April 2023, but above-average river flows resulted in the flooding of the well field and prevented the use of the extraction system from late April through early August. The system was operational from August until winterization in November.

Extraction well 0814 experienced a communications system error that was difficult to diagnose and was not utilized during 2023. In addition, the well 0816 submersible pump failed in September and was not utilized after that time. Figure 7 provides a graphic summary of when the 2.2 mil gal of groundwater was extracted from CF5 in 2023. The figure also identifies the time period the system was not in operation due to flooding.

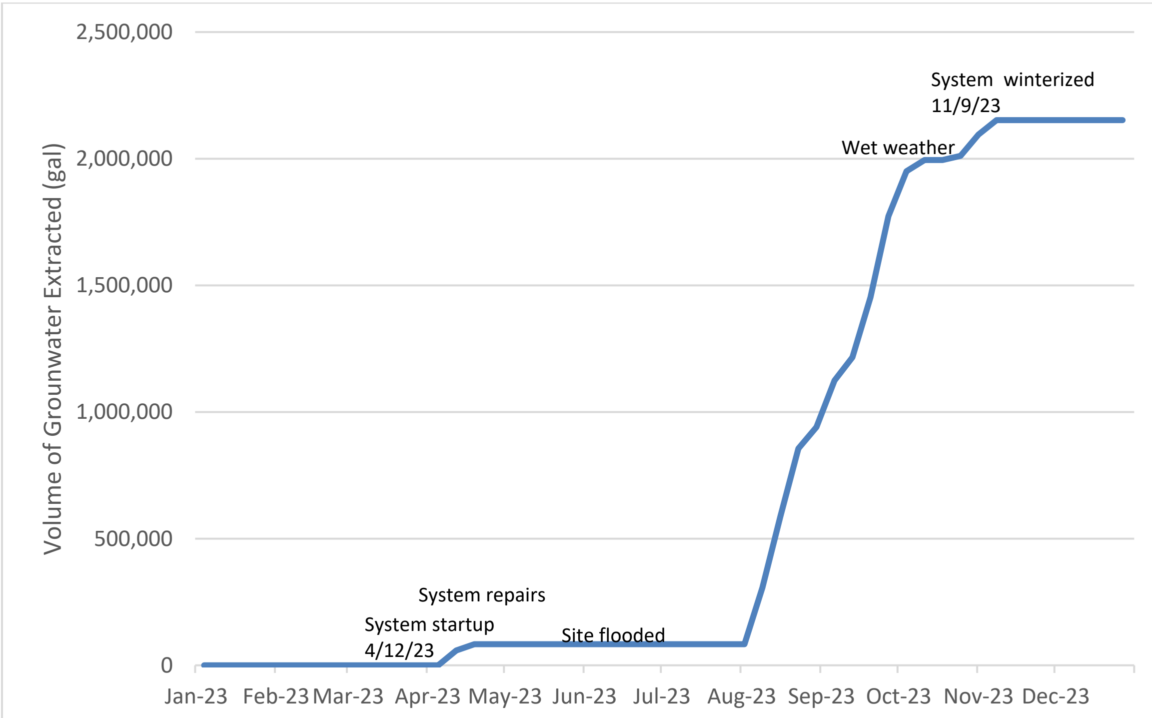

Figure 7. Cumulative Volume of Extracted Groundwater during 2023

4.2 CF5 Groundwater Volume Extracted and Contaminant Mass Removal

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3. The majority of the 2023 extracted water was removed from wells 0813 (approximately 385,500 gal) and 0815 (357,000 gal). The remaining CF5 wells extracted between approximately 170,500 and 353,600 gal in 2023. Extraction operations were maximized in August, when 858,000 gal of groundwater was extracted.

The 2023 ammonia and uranium mass removal are presented in Tables A-4 and A-5, respectively. These values are based on groundwater extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from the groundwater system was calculated by multiplying the extracted volume by the corresponding contaminant mass concentration measured in each well's discharge.

The concentrations used in these calculations were drawn from 2023 analytical data (Table 1). A total of 4,200 pounds (lb) (1,909 kilograms [kg]) of ammonia and 45.6 lb (20.7 kg) of uranium were extracted from the groundwater system in 2023. Table A-4 shows that extraction wells 0813 and SMI-PW02 removed the most ammonia mass at 931 lb (423 kg) and 933 lb (424 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Table A-5, which shows the greatest mass of uranium was extracted from well 0815 (8.6 lb, or 3.9 kg).

4.3 Groundwater Chemistry

Groundwater samples were collected from the CF5 extraction wells in November 2023 (Table 1). Ammonia concentrations ranged from 92 mg/L (well 0815) to 286 mg/L (well 0812), and the uranium concentration ranged from 1.33 mg/L (well 0813) to 3.35 mg/L (well 0815). Specific conductance ranged from approximately 10,250 µmhos/cm at well 0813 (northern end of CF5) to 26,860 µmhos/cm at well 0810 (southern end of CF5).

Table 1. CF5 Ammonia, Uranium, and Specific Conductance Results 2023

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	11/02/23	239	2.97	26,860
0811	11/02/23	271	2.73	18,470
0812	11/02/23	286	2.10	15,940
0813	11/02/23	195	1.33	10,250
0814	N/A	N/A	N/A	N/A
0815	11/02/23	92	3.35	19,855
0816	N/A	N/A	N/A	N/A
SMI-PW02	11/02/23	284	3.24	22,780

Notes: NA = Not Applicable, location not sampled due to submersible pump malfunction.

Table 2 provides the geometric mean, standard deviation, 95% confidence interval, and the change in ammonia concentration based on the linear trend line for the CF5 extraction wells since 2010. The trend lines applied to data collected since June 2010 from CF5 extraction wells indicate that on average the ammonia concentrations are decreasing at a rate ranging from 1.2 to 20.2 mg/L/yr. As of 2023, the CF5 extraction well geometric mean ammonia concentrations ranged from 149 to 447 mg/L and the concentrations have decreased an average of 10.8 mg/L/yr.

Table 2. Statistical Data for CF5 Extraction Well Ammonia Data, 2010 through 2023

Ammonia Concentrations (2010 – 2023)	CF5 Extraction Well							
	0810	0811	0812	0813	0814	0815	0816	PW02
Geometric Mean (mg/L)	319.9	386.7	419.8	342.8	229.6	194.6	148.7	446.9
Standard Deviation (mg/L)	49.2	70.7	74.2	85.6	191.1	83.4	59.5	70.3
95% Confidence Interval (mg/L)	17.0	24.9	25.3	27.6	65.2	28.9	20.6	24.7
Change in Concentration (mg/L/yr)	-6.5	-13.8	-7.8	-1.2	-12.6	-20.2	-8.5	-15.8

Statistical data for the uranium results since 2010 are presented in Table 3. Trend lines applied to the uranium results over the past 13 years for all CF5 wells indicate six wells on average are decreasing as much as 0.03 mg/L/yr, while the concentrations associated with well 0813 are increasing at up to 0.04 mg/L/yr. This increase in uranium is associated with the periodic influx of oxygenated water and its impact on the subsurface geochemical conditions.

Table 3. Statistical Data for CF5 Extraction Well Uranium Data, 2010 through 2023

Uranium Concentrations (2010 – 2023)	CF5 Extraction Well							
	0810	0811	0812	0813	0814*	0815	0816*	PW02
Geometric Mean (mg/L)	3.02	2.59	2.20	1.68	2.73	3.26	2.44	3.14
Standard Deviation (mg/L)	0.54	0.37	0.43	0.48	0.23	0.46	0.49	0.53
95% Confidence Interval (mg/L)	0.19	0.13	0.15	0.16	0.08	0.16	0.17	0.19
Change in Concentration (mg/L/yr)	-0.03	-0.01	0.00	+0.04	-0.01	-0.01	-0.01	-0.03

Figures 8 through 11 are time-versus-concentration trend plots that display trends of the CF5 extraction wells from 2010 through 2023, which represents the CF5 well field lifespan. Figure 8 is the time versus ammonia concentration trend plot for extraction wells 0810 through 0813 and SMI-PW02, all of which are located along the CF5 southeastern boundary. Figure 9 displays the ammonia concentration trend plots for CF5 wells 0814 through 0816, which are located closer to the base of the tailings pile. Figures 10 and 11 are the time-versus-uranium concentration trend plots for the same sets of wells.

Considering all 2023 analytical data, the ammonia concentrations continue to be significantly higher (in some cases twice as high) in the samples collected from wells located along the CF5 southeastern boundary compared to the wells located along the toe of the tailings pile. A similar trend is not apparent regarding the uranium concentrations, with both lines of wells having very similar results.

In general, ammonia contaminant concentrations associated with samples collected from all CF5 wells have been gradually decreasing. Uranium concentration trends show little change over time. Most wells show a slight decrease in concentrations, whereas the northern and western wells (well 0813, well 0814, and well 0816) show a slight upward trend.

The data collected from wells AMM-2 and SMI-PZ2M2 provide some insight on how the CF5 extraction wells are impacting the groundwater system. Well AMM-2 is located approximately 100 ft southeast of extraction well 0813, and well SMI-PZ2M2 is within the well SMI-PW02 cluster. Samples have been consistently collected from AMM-2 and SMI-PZ2M2 at depths of 48 and 56 ft bgs, respectively.

Figure 12 presents the ammonia concentrations measured from these locations along with linear trend lines for each data set. As shown in this plot, the trend lines for both data sets are displaying a decreasing ammonia concentration since 2009.

Figure 13 is a similar plot for the uranium concentrations. Both trend lines show the uranium concentrations are increasing. This may be indicative of uranium concentrations increasing due to changing geochemical conditions during high river stages.

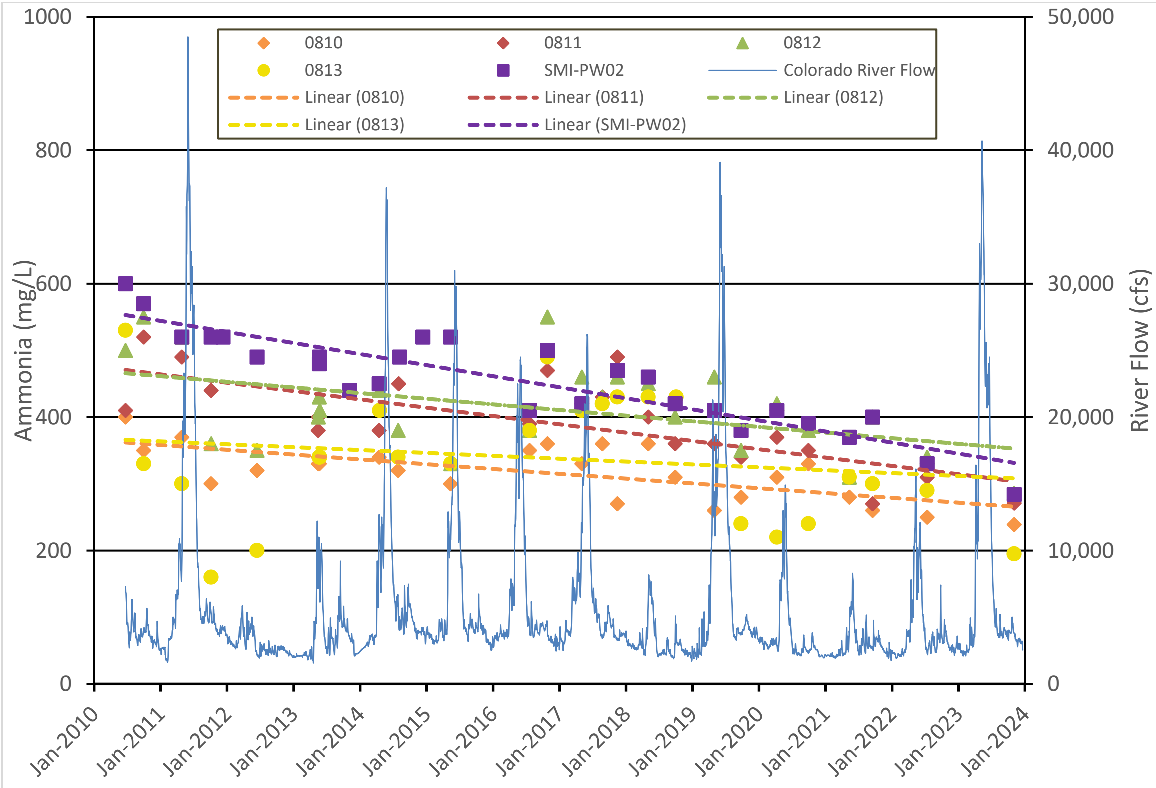

Figure 8. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Ammonia Concentration Plot

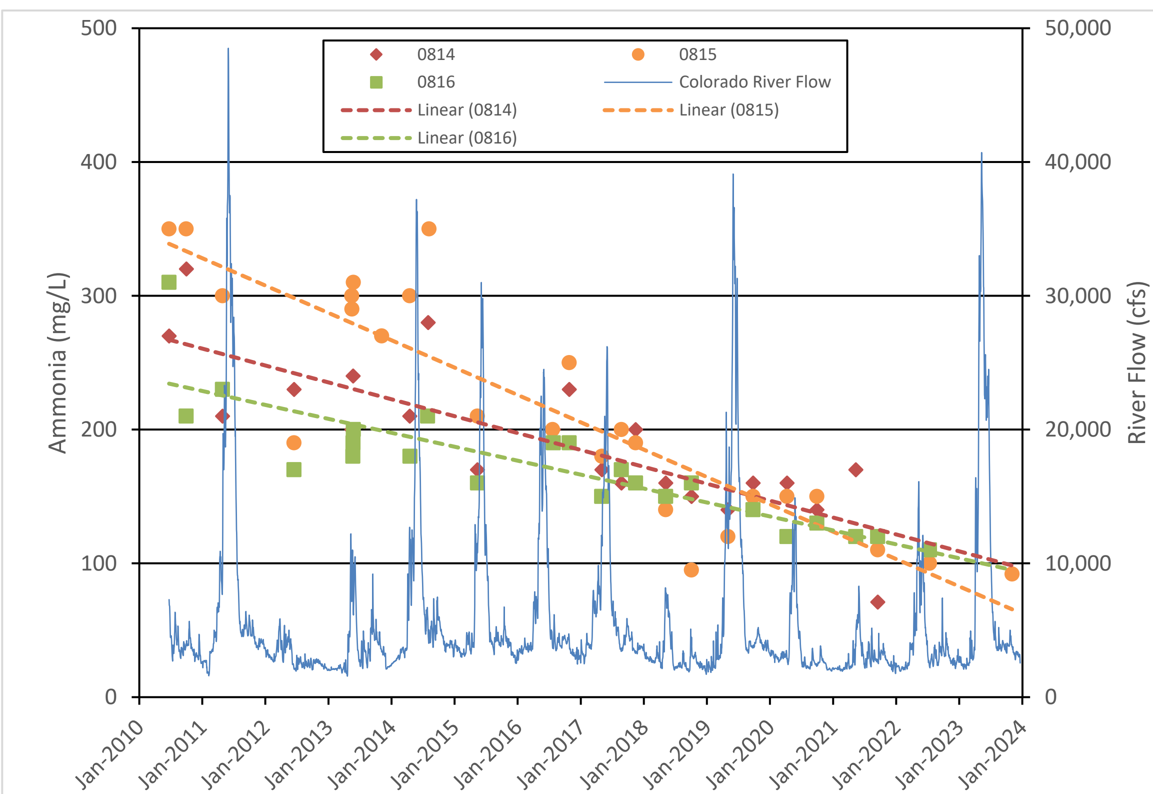

Figure 9. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Ammonia Concentration Plot

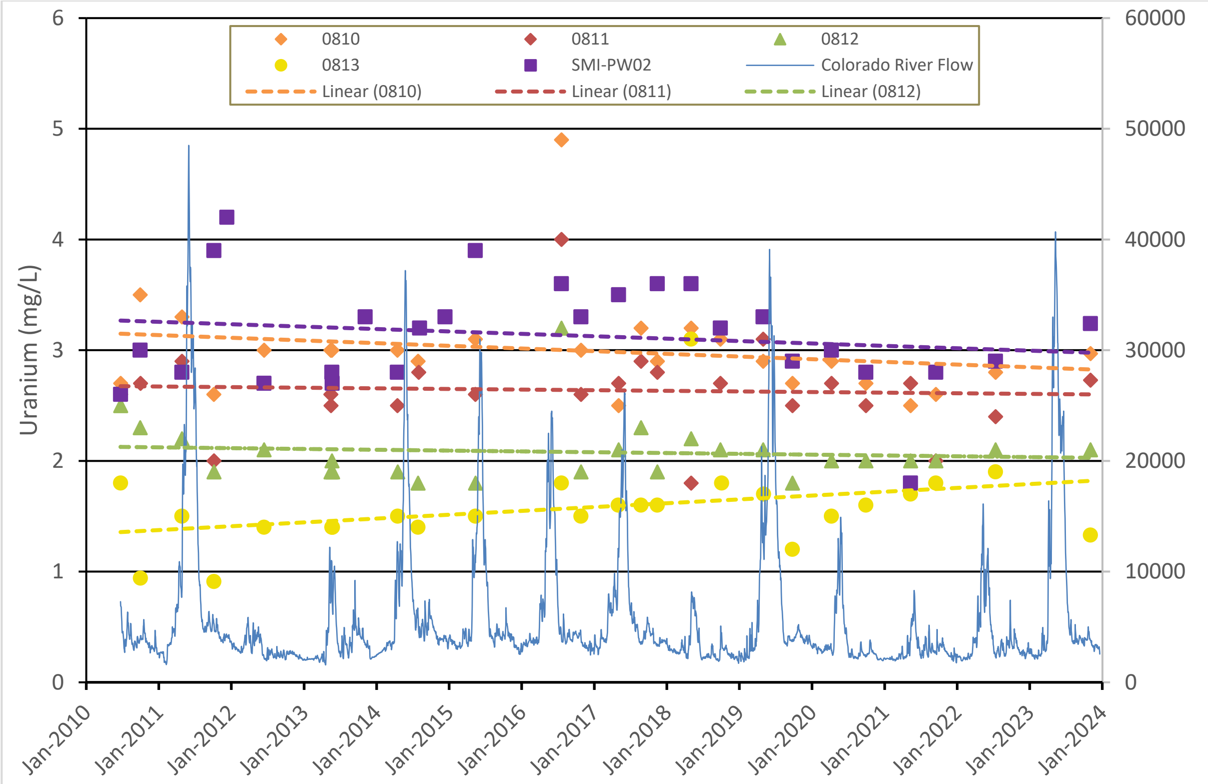

Figure 10. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Uranium Concentration Plot

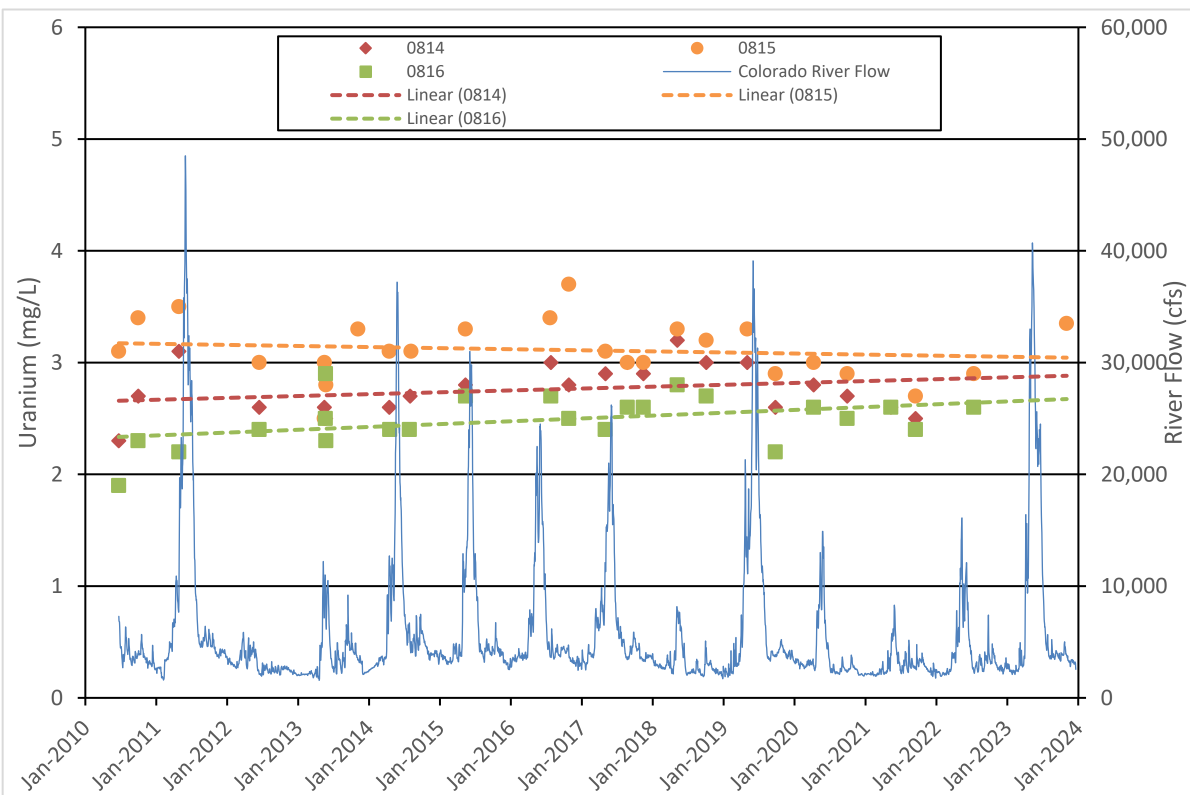

Figure 11. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Uranium Concentration Plot

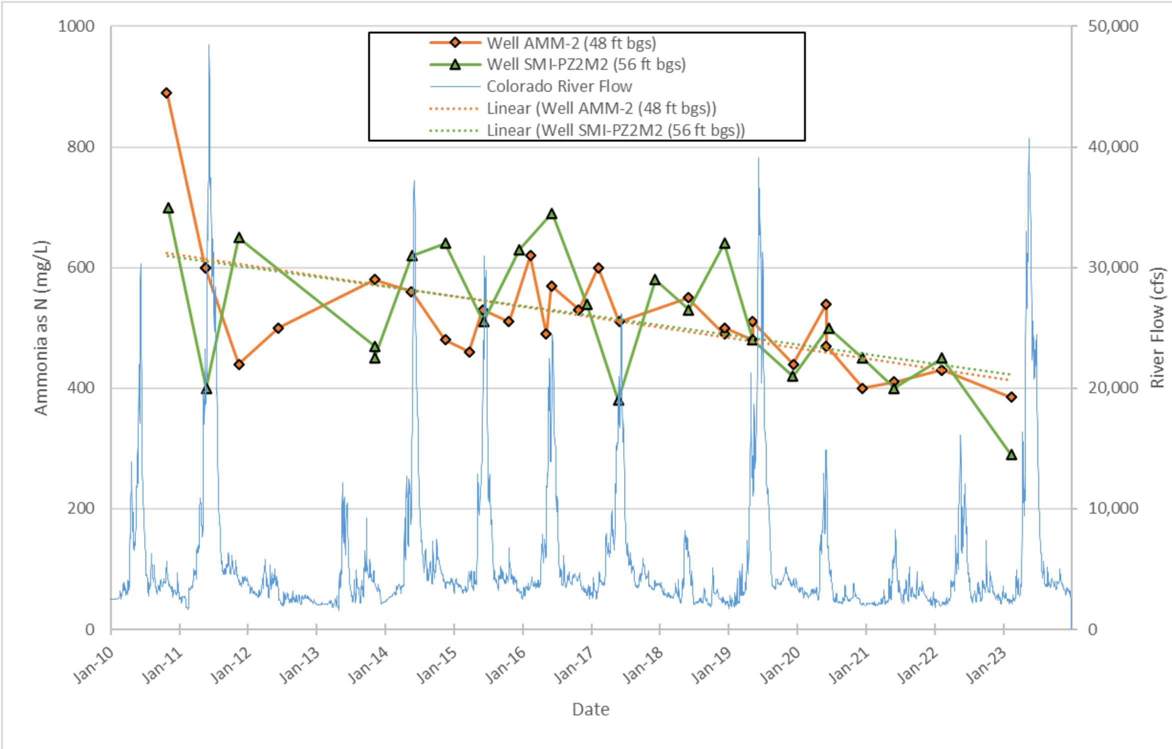

Figure 12. Monitoring Wells AMM-2 and SMI-PZ2M2 Time versus Ammonia Concentration Plot and Trend Lines

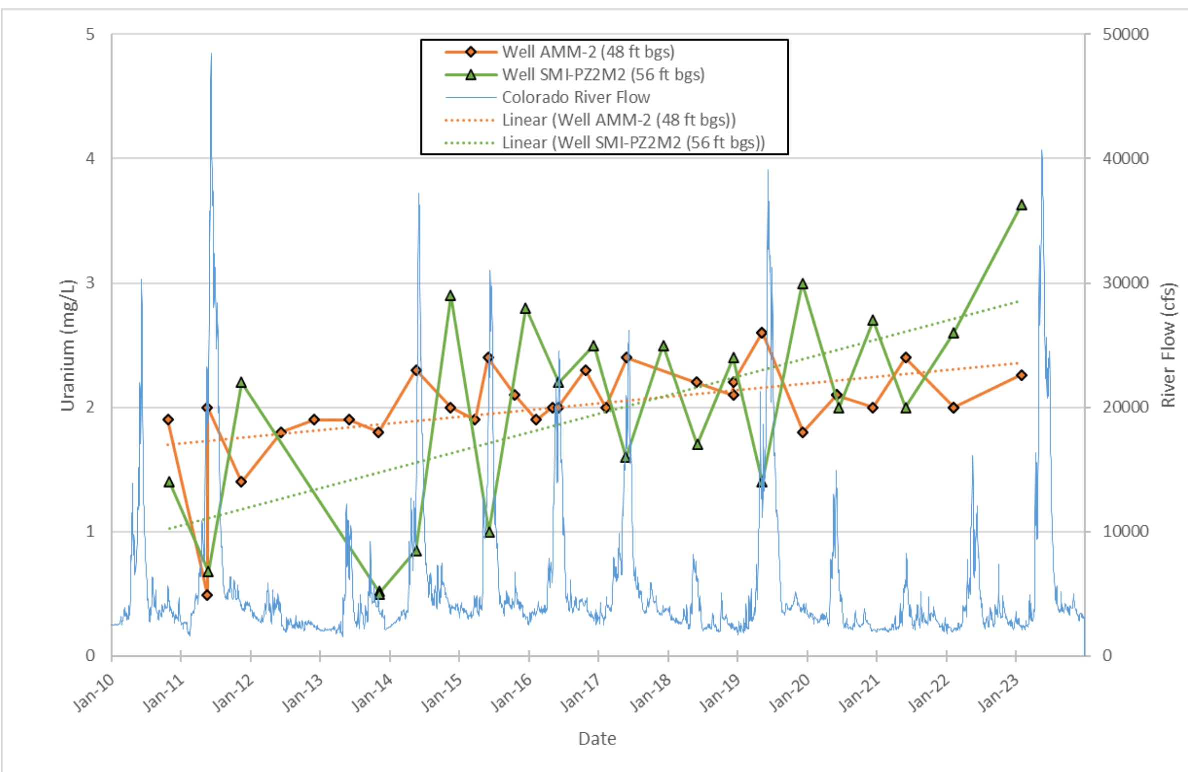

Figure 13. Monitoring Wells AMM-2 and SMI-PZ2M2 Time versus Uranium Concentration Plot and Trend Lines

5.0 Freshwater Injection System Operation and Performance

The main objective of freshwater injection is to form a hydrologic barrier between the tailings pile and the Colorado River side channel that potentially develops into a suitable young-of-year fish habitat. In addition, the contaminant concentrations are diluted prior to discharging into the river. The injection system uses filtered Colorado River water that is diverted to the freshwater pond. This water is pumped through a sand-and-gravel media, and then through 1or 5-micron bag filters prior to being injected into the CF4 remediation wells. Construction information for the CF4 wells can be found in Table B-1 (Appendix B). Table B-2 also contains a chronology of CF4 activities.

Configuration 4 is in the southern portion of the IA wellfield adjacent to a prominent side channel. The channel typically remains open to the main channel until the river flow drops below 3,000 cfs and a backwater (open at the bottom and closed off at the top) forms. During 2023 this channel did not develop into a suitable habitat.

5.1 Injection Performance

Freshwater injection into the CF4 wells occurred consistently in January and August through December. In 2023, approximately 3.2 mil gal of freshwater were injected in CF4. Figure 14 provides a graphic summary of the cumulative volume of freshwater injected into CF4.

Injection was turned off for maintenance, repairs, and high river flow (above 11,000 cfs) through most of the spring and summer months.

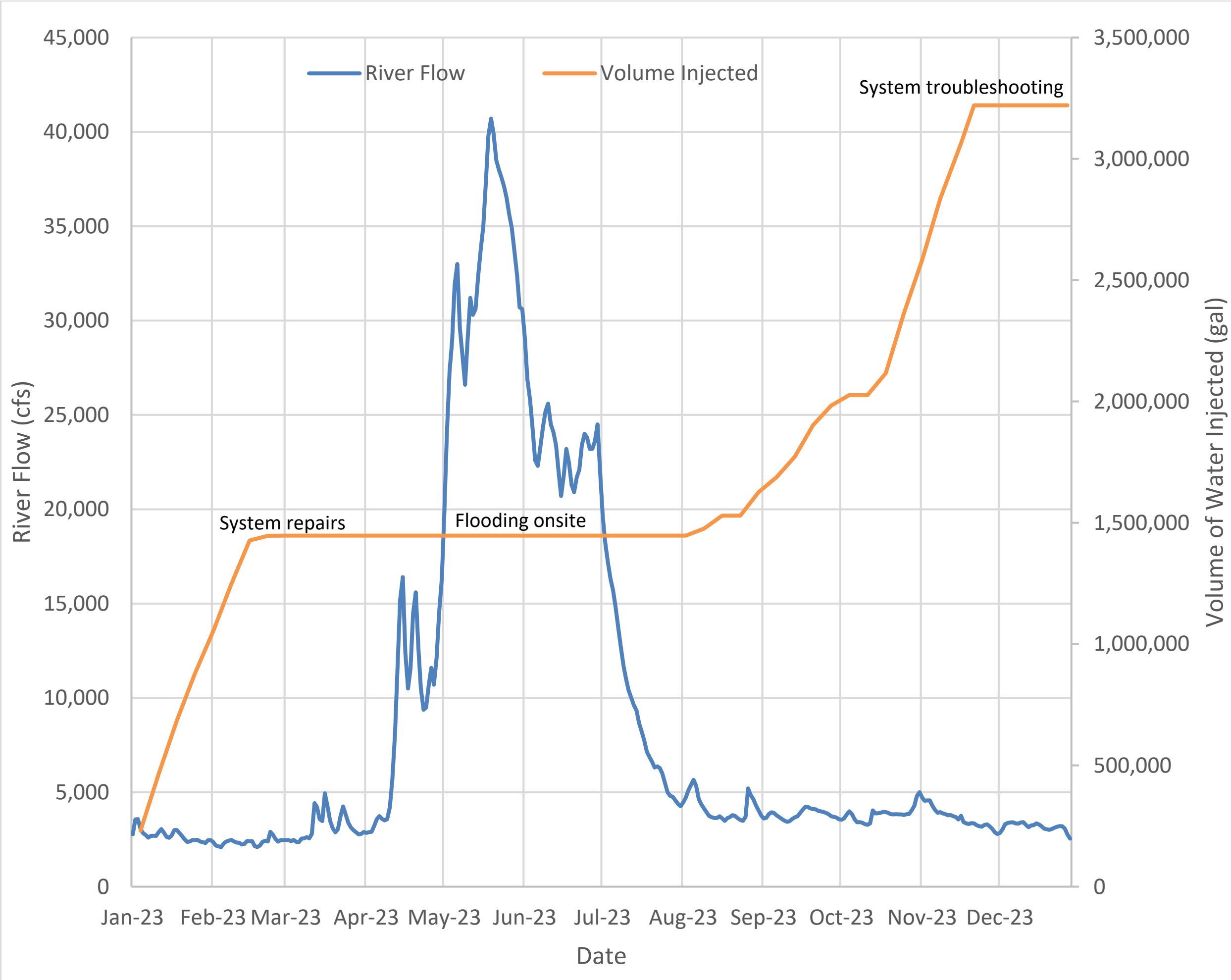

Figure 14. Cumulative Volume of Injected Freshwater during 2023

5.2 Observation Well Chemical Data Summary

Groundwater samples were collected from the CF4 observation wells during July and November 2023 to assess the effectiveness of the system (Table 4).

Table 4. CF4 Observation Well Ammonia Concentrations, July and November 2023

Location	Sample Depth (ft bgs)	Relative Location to Injection Wells	July 2023 Concentration (mg/L)	November 2023 Concentration (mg/L)
0780	28	Upgradient	37.1	2.83
0781	46	Upgradient	769	678
0782	33	Upgradient	459	275
0783	18	Upgradient	0.034	0.03
0784	18	Downgradient	0.024	0.03
0785	18	Downgradient	0.018	0.152
0786	28	Downgradient	17.2	23.8
0787	36	Downgradient	535	581

ft bgs = feet below ground surface

The CF4 wells are screened to deliver freshwater into the subsurface from 15 to 35 feet below ground surface (ft bgs). Samples collected from observation wells 0780, 0783, 0784, 0785, and 0786 are all screened within this shallow zone, and represent the ammonia concentrations directly impacted by the freshwater injection. Wells 0781, 0782, and 0787 represent the conditions near the bottom of the zone where the CF4 injection wells deliver freshwater into the subsurface when the system is active. Samples collected from these locations typically have the highest concentrations.

When the samples were collected in July, the system had been inactive for 5 months. Ammonia levels were generally higher than the baseline levels collected later in November. When the wells were sampled in November, the system had been active for 3 months. Excluding the deepest wells, samples collected from less than 30 ft bgs indicate ammonia concentrations decreased after the injection system was restarted. This suggests the system is effective in diluting contaminant concentrations in this shallow zone.

5.3 Freshwater Mounding

Water levels were collected on a regular basis during injection operations. To determine the amount of freshwater mounding in each well, the water level data were plotted against the levels measured in background well 0405.

The water levels in each well were adjusted to match well 0405 during non-pumping baseflow conditions. Tables 5 and 6 summarize the mounding data that are shown in Figures B-1 to B-10 (Appendix B) for the injection wells. Water elevation data were collected when the injection system was operating and not undergoing maintenance. Figures B-11 through B-18 illustrate the mounding data in CF4 observation wells.

Figure 15 displays the CF4 groundwater elevations in monitoring and injection wells in November 2023 during injection operations. The highest freshwater mounding occurs within 30 ft of the injection system, and the amount of mounding was dependent on the individual well's efficiency and the corresponding injection rate.

Table 5 presents the maximum mounding measured in each of the injection wells and the corresponding injection rate. The maximum mounding in the CF4 observation wells is presented in Table 6 and varied from 0.12 to 0.22 ft in the upgradient wells and from 0.20 to 1.04 ft in the down gradient wells.

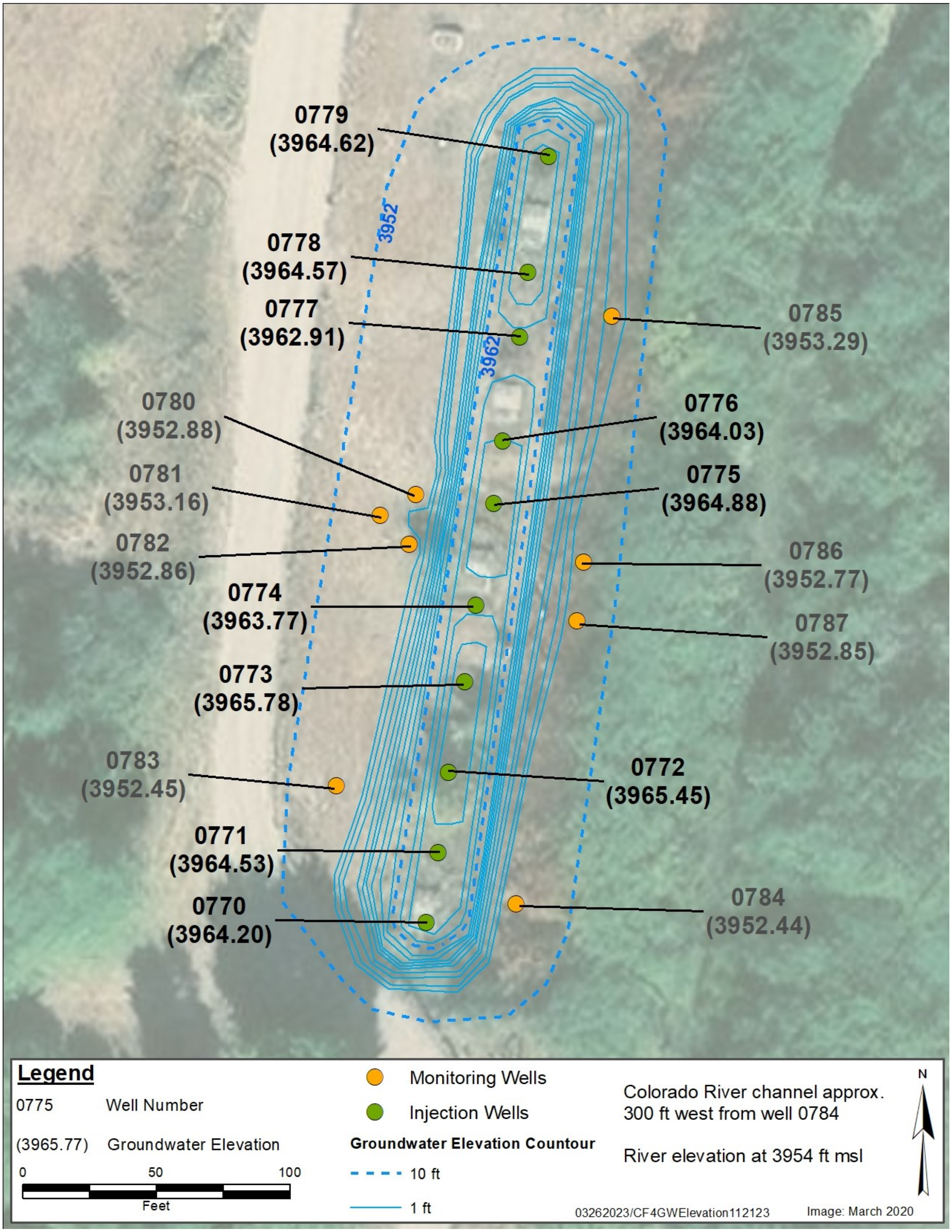

Figure 15. Freshwater Mounding at CF4 during Injection Operations, November 2023

Table 5. Maximum Mounding Observed in CF4 Injection Well, 2023

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	2/15/23	Injection Well	13.02	3.94
0771	1/10/23	Injection Well	13.95	2.25
0772	1/10/23	Injection Well	15.03	1.35
0773	11/21/23	Injection Well	12.32	1.27
0774	1/10/23	Injection Well	13.32	2.55
0775	2/15/23	Injection Well	13.00	5.73
0776	1/10/23	Injection Well	13.60	2.50
0777	1/10/23	Injection Well	12.67	3.26
0778	1/10/23	Injection Well	13.71	2.35
0779	1/10/23	Injection Well	14.35	1.16

Table 6. Freshwater Mounding Observed in CF4 Observation Wells, 2023

Well	Date	Location	Distance from Injection Source (ft)	Screened Interval (ft bgs)	Maximum Mounding (ft)
0780	6/13/23	Upgradient	25	20.3 – 30.1	0.22
0781	7/12/23	Upgradient	30	44.8 – 54.5	0.12
0782	6/13/23	Upgradient	25	31.0 – 40.8	0.22
0783	6/13/23	Upgradient	30	8.6 – 18.6	0.16
0784	5/11/23	Downgradient	30	9.4 – 19.4	0.74
0785	5/11/23	Downgradient	25	9.6 – 19.6	1.04
0786	5/11/23	Downgradient	30	20.5 – 30.3	0.51
0787	6/13/23	Downgradient	30	35.4 – 45.2	0.20

6.0 Surface Water Monitoring

Surface water monitoring occurs during the site-wide sampling event, when Colorado River samples are collected upgradient of the site, along the site boundary, and downgradient of the site. The backwater channel adjacent to CF4 is monitored from June to September to determine when it potentially becomes a suitable habitat for young-of-year fish.

6.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in February 2023 (locations and corresponding results are shown on Figure 16). The results of this sampling event can be found in the *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2023* (DOE-EM/GJ RAC3106) and the results are presented in Table 7.

All locations had ammonia levels below the EPA acute and chronic criteria based on temperature and pH.

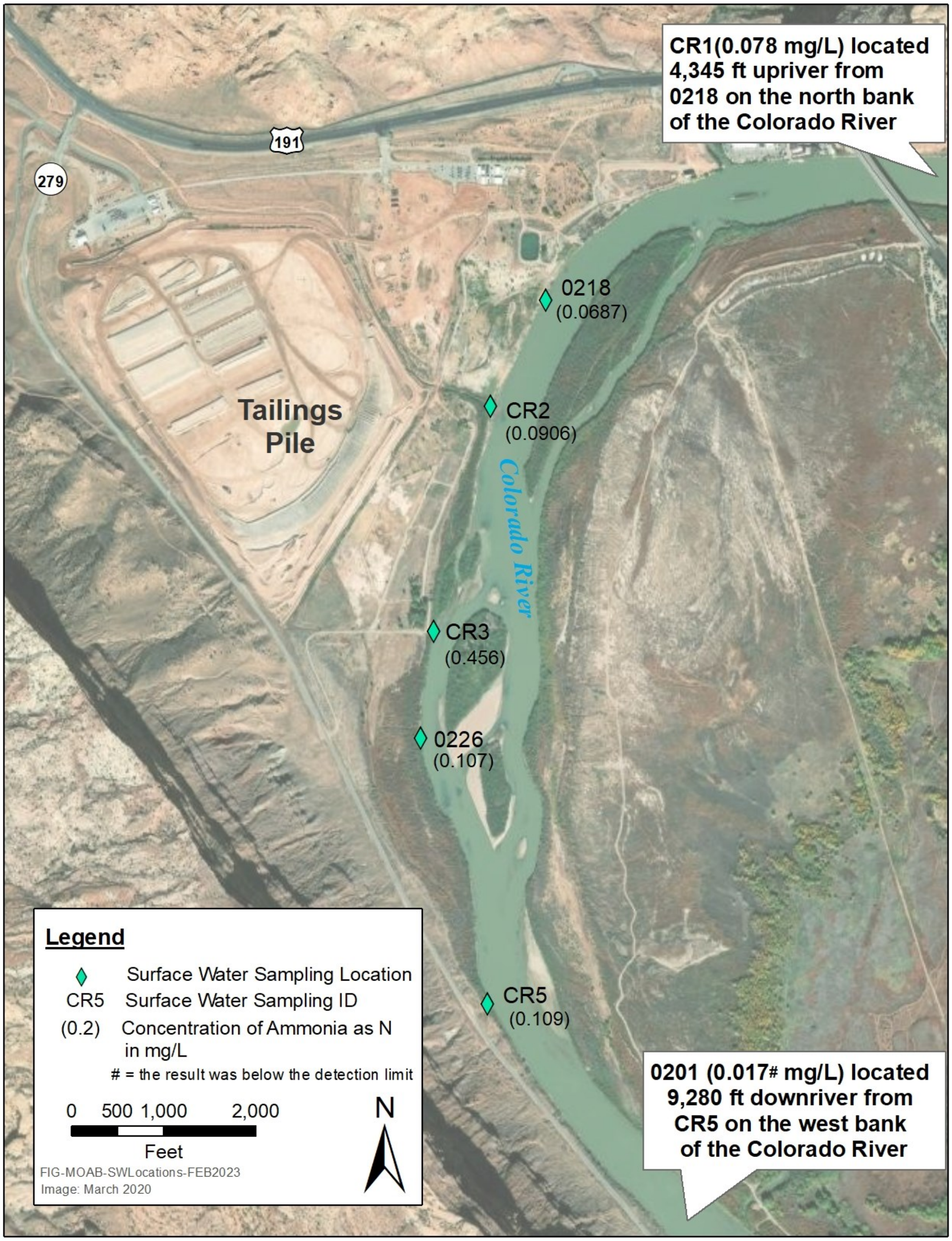

Figure 16. 2023 Site-wide Surface Water Sampling Locations

Table 7. January through March 2023 Site-wide Surface Water Ammonia Concentrations and Comparisons to EPA Acute and Chronic Criteria

Location	Date	Temp (°C)	pH	March 2022 Ammonia as N (mg/L)	EPA – Acute Total as N (mg/L)*	EPA – Chronic Total as N (mg/L)**
0201	2/6/23	4.10	8.53	0.017#	3.3	0.80
0218	2/3/23	4.20	8.50	0.0687	3.3	0.80
0226	2/6/23	4.30	8.86	0.107	1.6	0.42
CR1	2/6/23	3.50	8.44	0.0780	4.1	0.95
CR2	2/7/23	3.50	8.47	0.0906	3.3	0.80
CR3	2/6/23	6.80	8.65	0.456	2.3	0.57
CR5	2/6/23	3.80	8.59	0.109	2.8	0.68

*U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater State (Effective April 2013), Table N.4., Temperature and pH-Dependent Values, Acute Concentration of Total Ammonia as N (mg/L)
**U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater State (Effective April 2013), Table 6. Temperature and pH-Dependent Values, Chronic Concentration of Total Ammonia as N (mg/L)
= Concentration at or below the detection limit

6.2 Surface Water/Habitat Monitoring

Surface water monitoring adjacent to CF4 is typically conducted after the spring peak river flow begins to recede and a suitable habitat develops. The purpose is to monitor the water quality and protect young-of-year endangered fish species (e.g., Colorado pikeminnow, razorback sucker) from elevated ammonia concentrations. In 2023, the side channel was monitored through the summer after the peak flow, but the channel did not develop into a suitable habitat due to above average Colorado River flows.

7.0 Investigations

Water samples were also collected from Crescent Junction wells 0202 and 0205 (Figure 17) during 2023.

7.1 Crescent Junction Wells 0202 and 0205 Sampling and Recharge Monitoring

The placement of the cell cover has significantly altered the surface runoff/hydrology in the vicinity of well 0205, where water was first encountered in late June 2015. Field observations have shown that after significant precipitation events, the runoff collects into the retention ditch at the toe of the cell (and across the road from well 0205) as opposed to being allowed to slowly infiltrate into the ground over a large area. As this water infiltrates into the subsurface, it likely intercepts a fracture system that is in part connected to the fracture observed inside well 0205, eventually discharging into the well. A sample was collected from well 0205 in December 2023 and submitted to the analytical laboratory for metals, inorganics, and isotopic uranium analysis.

June 2019 represents the first time a sufficient volume of water was present in well 0202 to collect a sample and submit it for laboratory analysis. Samples of this water were again collected in December 2023 and submitted to the analytical lab (GEL) also for metals, inorganics, and isotopic uranium analysis. The 2023 results of the analysis of the water sample collected from wells 0202 and 205 are presented in Table 8.

Figure 17. Crescent Junction Well Location Map

Table 8. 2023 Crescent Junction Wells 0202 and 0205 Analyte Concentrations

Analyte	Analyte Concentration	
	Well 0202	Well 0205
	12/13/23	12/13/23
Ammonia as N	5.10	8.56
Arsenic	0.00862 J	0.00847J
Barium	0.0185	0.0130
Bicarbonate as $CaCO_3$	910	842
Bromide	18.6	4.59J
Cadmium	0.001#	0.001#
Calcium	415	388
Carbonate as $CaCO_3$	0.725#	0.725#
Chloride	5090	2110
Chromium	0.00907J	0.00817J
Cobalt	0.00100#	0.00100#
Copper	0.0132 J	0.00983J
Fluoride	1.65#	1.65#
Iron	0.03#	0.03#
Lead	0.00947 J	0.00405J
Magnesium	1480	1280
Manganese	0.470	0.411
Molybdenum	0.002#	0.002#
Nitrate/Nitrite as N	630	486
Selenium	0.802	3.010
Sodium	11300	9010
Sulfate	19900	22,700
Total Alkalinity as $CaCO_3$	910	842
Total Dissolved Solids	43400	40,400
$Uranium^{234}$	51.8 +/- 5.76 pCi/L	36.6.7 +/- 5.21 pCi/L
$Uranium^{235}$	1.37 +/- 1.13 pCi/L	1.12# +/- 0.81 pCi/L
$Uranium^{238}$	15.2 +/- 3.13 pCi/L	14.6 +/- 3.28 pCi/L
Uranium	0.0465	0.0391

# = Concentration at or below the detection limit, Note: All concentrations in mg/L, except where noted
J = Concentration is estimated.

Historic nitrate/nitrite and uranium concentrations for both wells 0202 and 0205 are presented as 18 and 19, respectively.

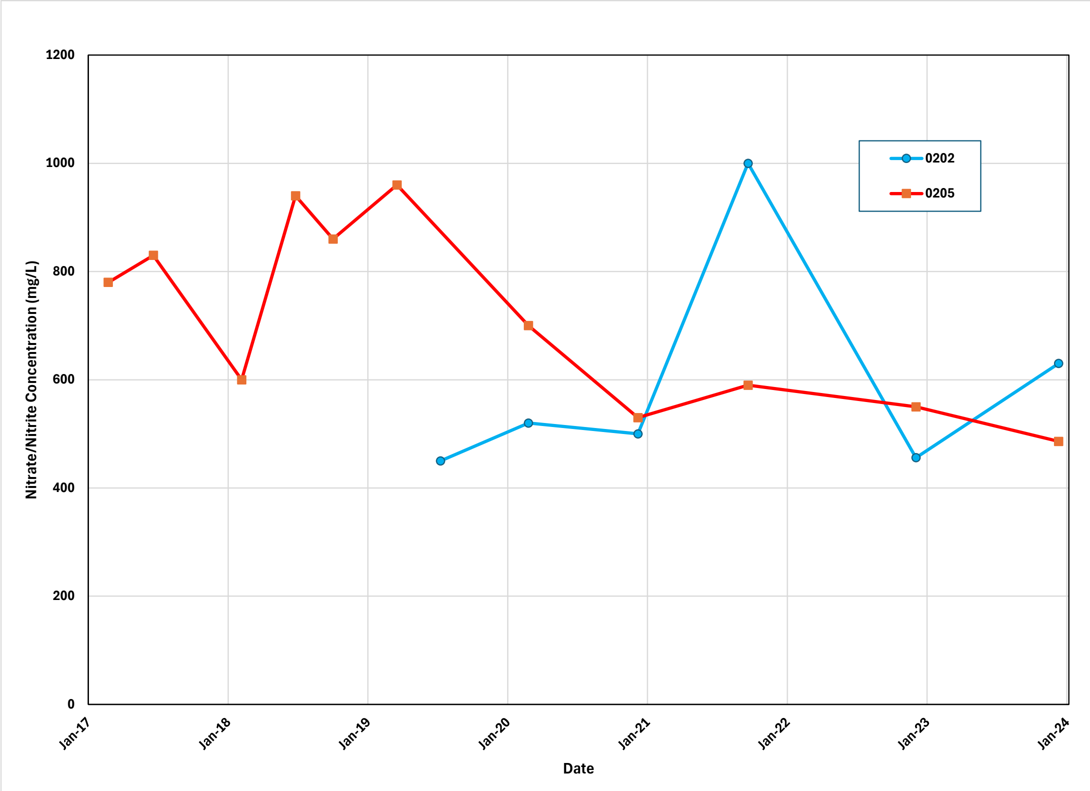

Figure 18. Nitrate/Nitrite Concentrations in Wells 0202 and 0205

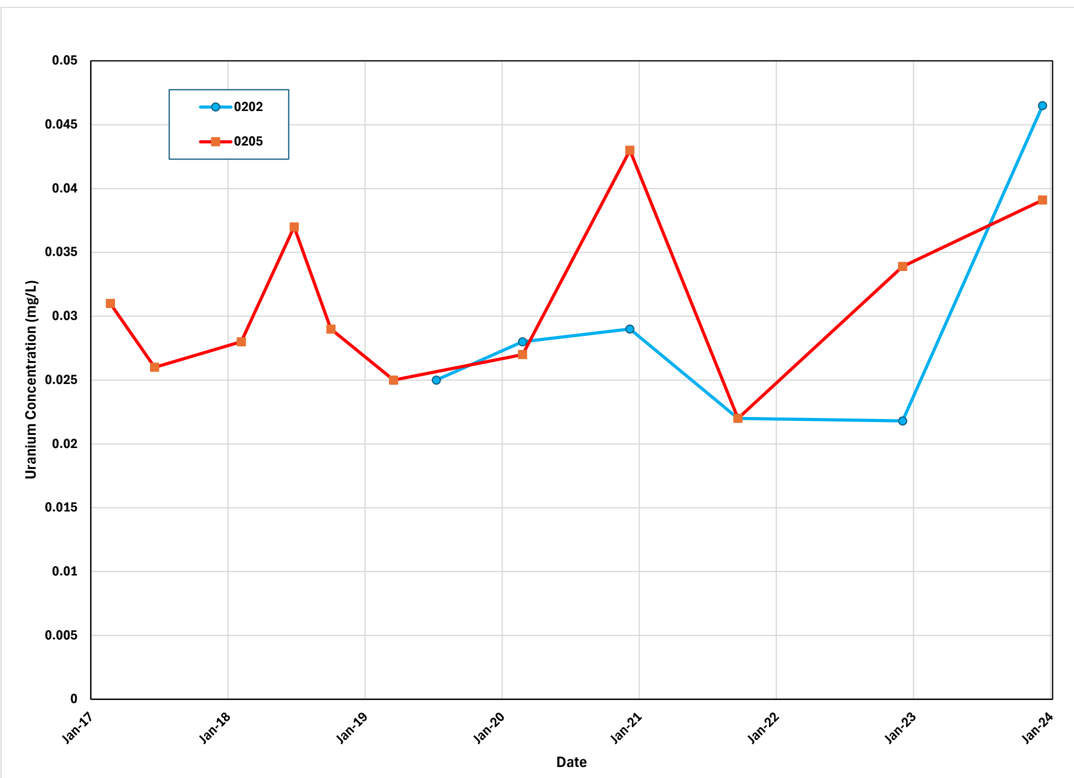

Figure 19. Uranium Concentrations in Wells 0202 and 0205

Figure 20 presents both well 0202 and 0205 water level elevations along with the measured daily precipitation from 2015 through 2023. As the plot displays, the water elevations in both wells have a similar response to the precipitation events.

A short-term recovery test was completed in December 2023 on well 0205, and the recharge rate measured was 0.022 gpm which is comparable to the last completed recovery test in December 2022 (0.027 gpm). The measured recharge rate in well 0205 in response to precipitation is shown on Figure 21. Well 0202 has recharged too slowly in the past to conduct a recovery test. Because of this, a recovery test was not performed on well 0202.

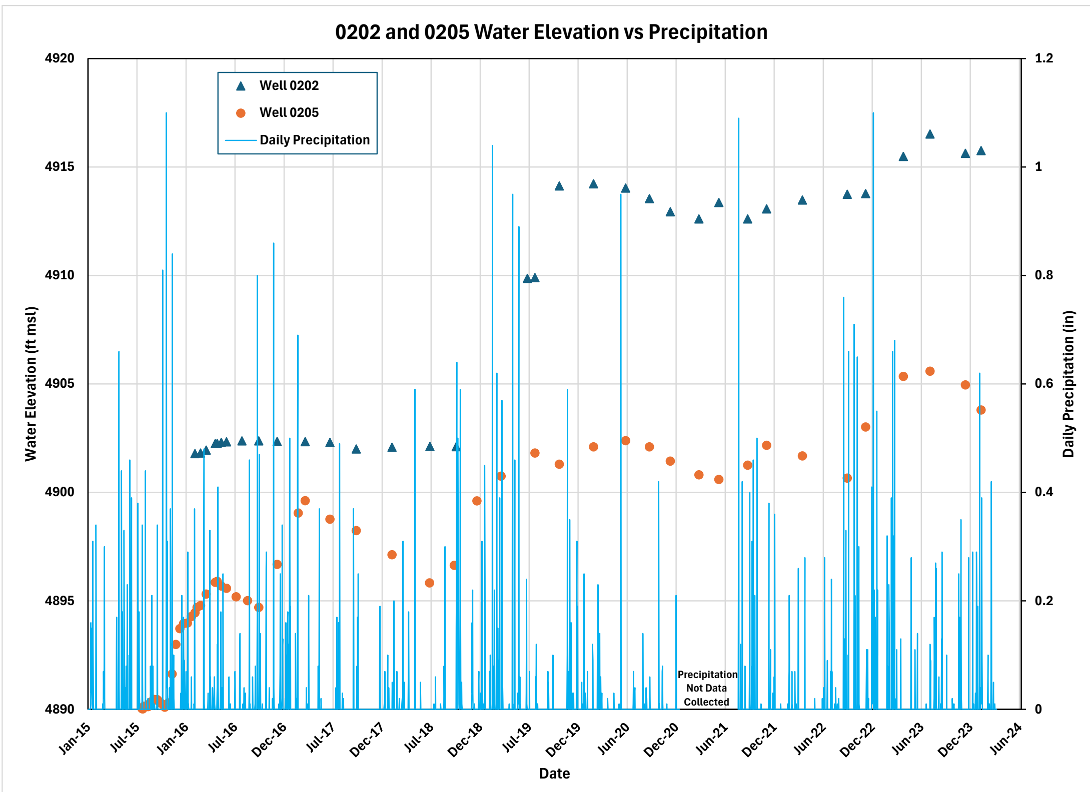

Figure 20. Crescent Junction Wells 0202 and 0205 Water Elevation Changes in Response to Precipitation through 2023

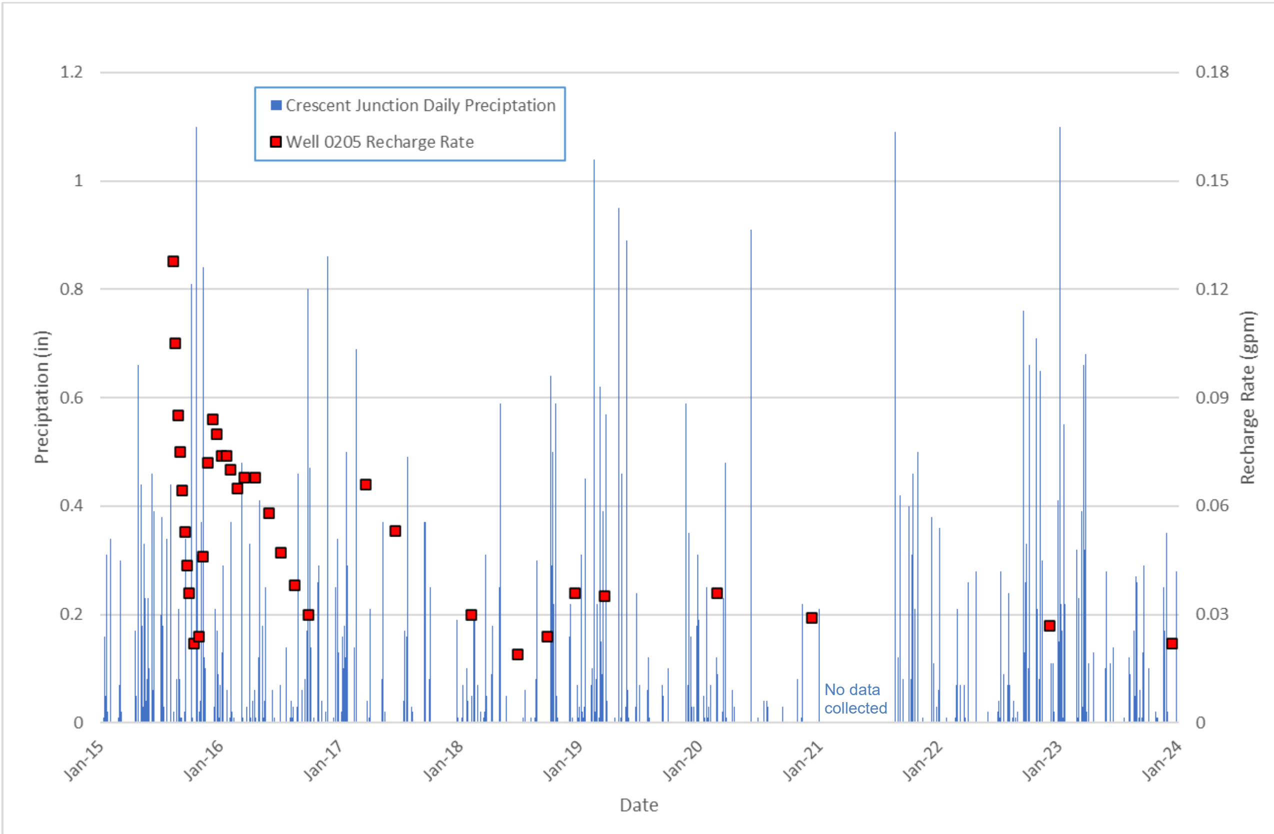

Figure 21. Crescent Junction Well 0205 Recharge Rate Changes In Response to Precipitation through 2023

8.0 Summary and Conclusions

In 2023 the IA operations focused on groundwater extraction (CF5) and freshwater injection (CF4). A suitable habitat did not develop adjacent to the site and the freshwater diversion system was not utilized.

A total of 2.2 mil gal of water was extracted from CF5 in 2023. The extraction rate peaked in August, and operations continued through the fall. Seven of the eight extraction wells were utilized in 2023. Figure 22 shows the ammonia and uranium mass removed along with the volume of groundwater extracted from the CF5 extraction wells from 2003 through 2023.

The volume of extracted groundwater and removed contaminant mass decreased in 2023 compared to 2022. This was a result of the system needing repairs and the system being shut down due to high river flow. A total of 4,200 lbs of ammonia and 47 lbs of uranium, was removed from the groundwater system in 2023.

Approximately 3.2 mil gal of freshwater was injected into CF4 in 2023. The above average river flow and system repairs meant the injection system was used for only part of the year, resulting in a lower volume of freshwater injected in 2023 compared to 2022. Laboratory data from the CF4 observation wells during injection operations indicate the system is effective at diluting ammonia concentrations, especially from the groundwater surface down to a depth of approximately 30 ft bgs. Site-wide surface water samples indicated the contaminants do not extend past the site boundary.

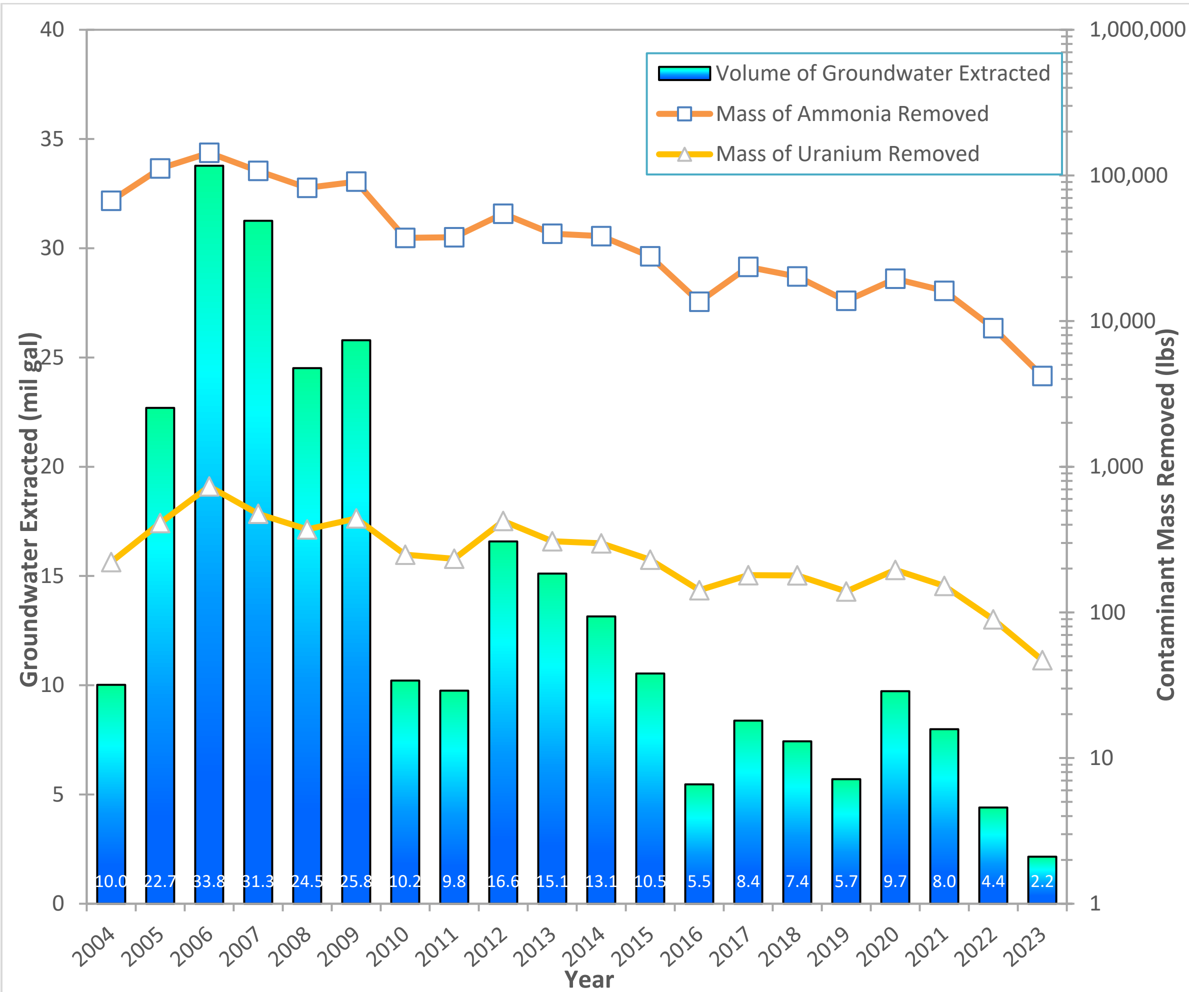

Figure 22. Groundwater Extracted Volume and Contaminant Mass Removal, 2003 through 2023

9.0 References

40 CFR 192A (U.S. Code of Federal Regulations), "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites."

DOE (U. S. Department of Energy), *Moab UMTRA Project Flood and Drought Mitigation Plan* (DOE-EM/GJ1640).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2023* (DOE-EM/GJRAC3106).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring July through December 2023* (DOE-EM/GJRAC3118).

DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Groundwater Sampling and Analysis Plan* (DOE-EM/GJRAC1830).

DOE (U.S. Department of Energy), *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P).

Appendix A.

Tables and Data for 2023 Groundwater Extraction

Appendix A. Tables and Data for 2023 Groundwater Extraction

Table A-1. Well Construction for CF5 Extraction Wells

Well	Well Type	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0810	Extraction	8	3,966.56	10.4 – 40.4	40.4
0811	Extraction	8	3,966.59	8.8 – 38.6	38.6
0812	Extraction	8	3,966.62	14.2 – 44.2	44.2
0813	Extraction	8	3,966.67	14.4 – 44.4	44.4
0814	Extraction	8	3,967.02	12.4 – 42.4	42.4
0815	Extraction	8	3,967.13	21.7 – 51.7	51.7
0816	Extraction	8	3,967.38	20.9 – 50.9	50.9
SMI-PW02	Extraction	4	3,965.60	20.0 – 60.0	60.3

In. = inch

Table A-2. 2023 Chronology of CF5 Activities

Date	Activity
January	System winterized.
February	System winterized.
March	System winterized.
April	Restarted extraction system on April 12. Leak identified at Klein tank identified following startup.
May	Removal of extraction infrastructure started on 5/1 in preparation for flooding.
June	No operations due to flooding conditions.
July	Began reinstalling electrical infrastructure on 7/3.
August	Klein tanks sensor restored and camlock fitting at Klein tank repaired on 8/3 and 8/4, respectively. Extraction restarted on 8/7.
September	The extraction system runs automatically. Well pump 0816 failed on 9/18. Electrician confirmed pump was bad on 9/25.
October	Extraction system operation in automatic mode.
November	System winterized the week of November 8.
December	System winterized.

Table A-3. CF5 Extraction Volumes 2023

Well	Extraction Volumes Removed (gal)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Well Total
810	0	0	0	13,267	0	0	0	139,213	141,436	11,610	10,167	0	**315,693**
811	0	0	0	5,438	0	0	0	77,089	55,978	27,144	4,851	0	**170,500**
812	0	0	0	8,115	0	0	0	75,517	63,369	31,485	5,666	0	**184,152**
813	0	0	0	22,353	0	0	0	22,000	223,808	99,878	17,464	0	**385,503**
814	0	0	0	42	0	0	0	0	0	0	109	0	**151**
815	0	0	0	12,684	0	0	0	151,975	131,369	52,070	8,794	0	**356,892**
816	0	0	0	21,249	0	0	0	248,839	83,529	0	0	0	**353,617**
SMI-PW02	0	0	0	0	0	0	0	142,466	132,993	54,268	9,645	0	**339,372**
Monthly Total	**0**	**0**	**0**	**83,148**	**0**	**0**	**0**	**857,099**	**832,482**	**276,455**	**56,696**	**0**	
Annual Total													**2,105,880**

Table A-4. CF5 Ammonia Mass Removal 2023

Well	Ammonia Mass Removed (lbs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Well Total
810	0	0	0	28	0	0	0	290	294	121	21	0	**754**
811	0	0	0	14	0	0	0	199	144	70	13	0	**440**
812	0	0	0	23	0	0	0	214	179	89	16	0	**521**
813	0	0	0	54	0	0	0	53	540	241	42	0	**931**
814	0	0	0	0	0	0	0	0	0	0	0	0	**0**
815	0	0	0	11	0	0	0	127	109	43	7	0	**297**
816	0	0	0	19	0	0	0	228	77	0	0	0	**324**
SMI-PW02	0	0	0	0	0	0	0	391	365	149	27	0	**933**
Monthly Total	**0**	**0**	**0**	**149**	**0**	**0**	**0**	**1502**	**1710**	**714**	**126**	**0**	
Annual Total													**4,200**

Table A-5. CF5 Uranium Mass Removal 2023

Well	Uranium Mass Removed (lbs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Well Total
810	0.0	0.0	0.0	0.3	0.0	0.0	0.0	3.2	3.3	1.4	0.2	0.0	**8.4**
811	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.5	1.1	0.5	0.1	0.0	**3.4**
812	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.3	1.1	0.6	0.1	0.0	**3.2**
813	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.3	3.5	1.6	0.3	0.0	**6.1**
814	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
815	0.0	0.0	0.0	0.3	0.0	0.0	0.0	3.7	3.2	1.3	0.2	0.0	**8.6**
816	0.0	0.0	0.0	0.5	0.0	0.0	0.0	5.4	1.8	0.0	0.0	0.0	**7.7**
SMI-PW02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.2	1.3	0.2	0.0	**8.2**
Monthly Total	**0.0**	**0.0**	**0.0**	**1.7**	**0.0**	**0.0**	**0.0**	**19.0**	**17.3**	**6.6**	**1.2**	**0.0**	
Annual Total													**45.6**

Appendix B.

Tables and Data for 2023 Freshwater Injection

Appendix B. Tables and Data for 2023 Freshwater Injection

Table B-1. CF4 Well Construction Details

Well	Well Type / Relative Depth	Diameter (in)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0770	Remediation/Deep	6	14.9 – 34.8	35.2
0771	Remediation/Deep	6	15.0 – 34.9	35.3
0772	Remediation/Deep	6	15.2 – 35.1	35.5
0773	Remediation/Deep	6	15.2 – 35.1	35.5
0774	Remediation/Deep	6	15.5 – 35.4	35.8
0775	Remediation/Deep	6	15.1 – 35.0	35.4
0776	Remediation/Deep	6	15.2 – 35.1	35.5
0777	Remediation/Deep	6	15.3 – 35.2	35.6
0778	Remediation/Deep	6	15.1 – 35.0	35.4
0779	Remediation/Deep	6	15.7 – 35.6	36.0
0780	Observation/Shallow	6	20.3 – 30.1	30.5
0781	Observation/Deep	6	44.8 – 54.5	55.0
0782	Observation/Deep	6	31.0 – 40.8	41.2
0783	Observation/Shallow	2	8.6 – 18.6	19.1
0784	Observation/Shallow	2	9.4 – 19.4	19.9
0785	Observation/Shallow	2	9.6 – 19.6	19.9
0786	Observation/Shallow	6	20.5 – 30.3	30.7
0787	Observation/Deep	6	35.4 – 45.2	45.7

Table B-2. 2023 Chronology of CF4 Activities

Month	Activity
January	Injection operated normally.
February	Injections operated normally for most of the month. System shut down due to bad solenoid/3-way valve.
March	No injection. Solenoid replaced.
April	No injection. Media removed from sand filter tanks.
May	No injection (flooding).
June	No injection (flooding).
July	No injection. New media placed in sand filter tanks.
August	3-way valve serviced. The system restarted at the beginning of the month. System shut down due to line break. System restarted near end of the month. Filters clogging too quickly.
September	Injection operated during the week (poor filtration). Repaired break in a manifold.
October	Injection operated during the week (poor filtration).
November	Injection operated normally and was winterized for holiday break.
December	No injection (pump troubleshooting).

Table B-3. CF4 Observation Well Analytical Sample Results 2023

Location	Location from Injection	Sample Depth (ft bgs)	Ammonia Total as N (mg/L)		Uranium (mg/L)		Specific Conductance (µmhos/cm)	
			7/20/23	11/14/23	7/20/23	11/14/23	7/20/23	11/14/23
0780	Upgradient	28	37.1	2.83	0.377	0.0514	4,966	1,491
0781	Upgradient	46	769	678	3.24	3.96	53,200	54,552
0782	Upgradient	33	459	289	2.22	2.69	30,235	18,395
0783	Upgradient	18	0.034	0.03	0.0427	0.0898	1,776	2,567
0784	Downgradient	18	0.024	0.03	0.0343	0.0182	1,403	1,251
0785	Downgradient	18	0.018	0.152	0.0473	0.019	1,156	1,369
0786	Downgradient	28	17.2	53.8	0.199	0.139	5,032	2,530
0787	Downgradient	36	535	581	1.63	2.61	38,071	42,082

Note: µmhos/cm = micromhos per centimeter

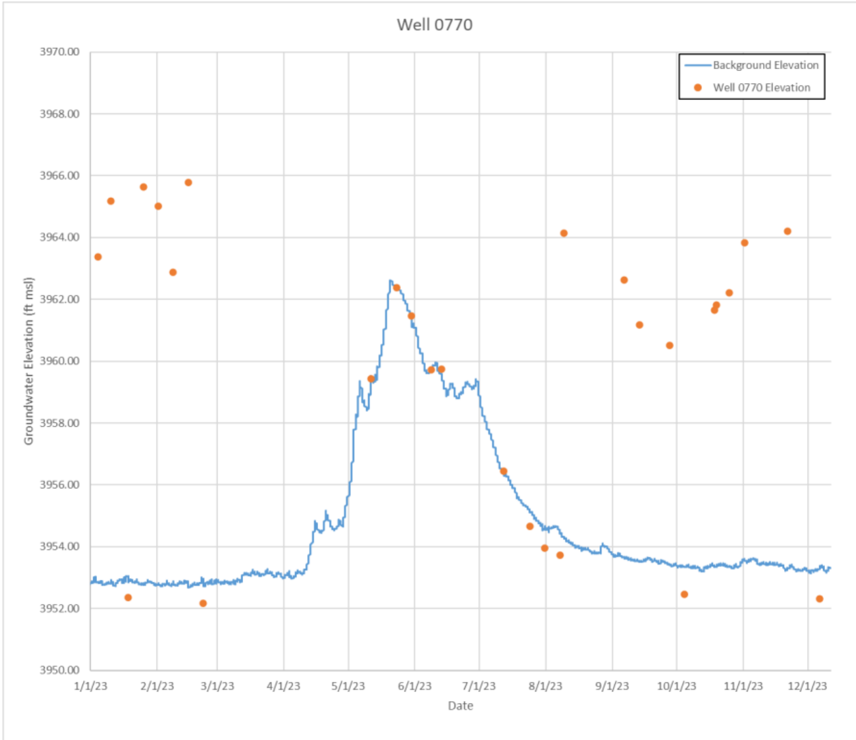

Figure B-1. Freshwater Mounding in Remediation Well 0770 During Injection

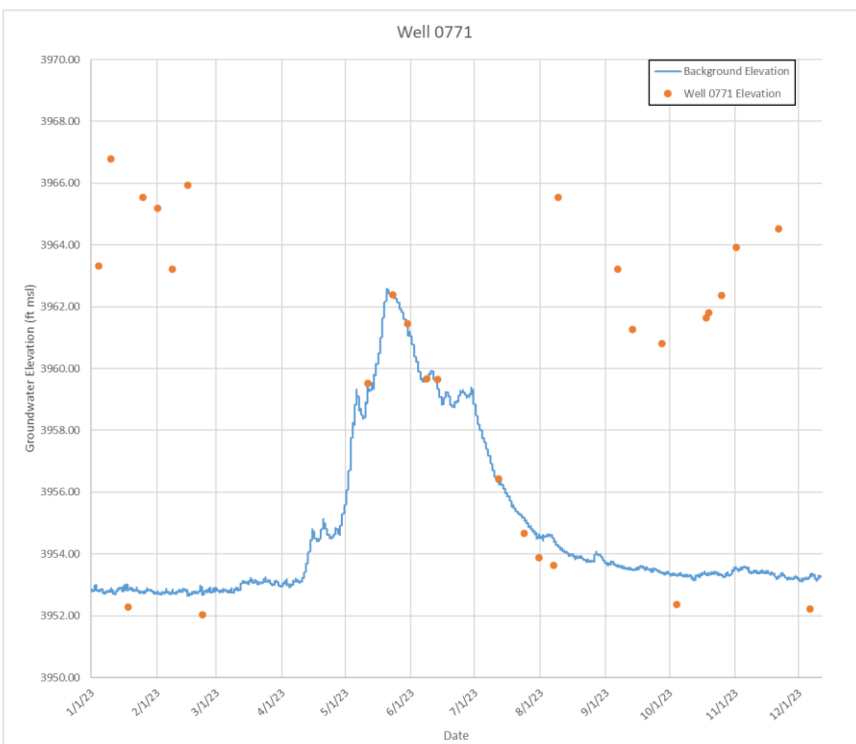

Figure B-2. Freshwater Mounding in Remediation Well 0771 During Injection

Appendix B. Tables and Data for 2023 Freshwater Injection (*continued*)

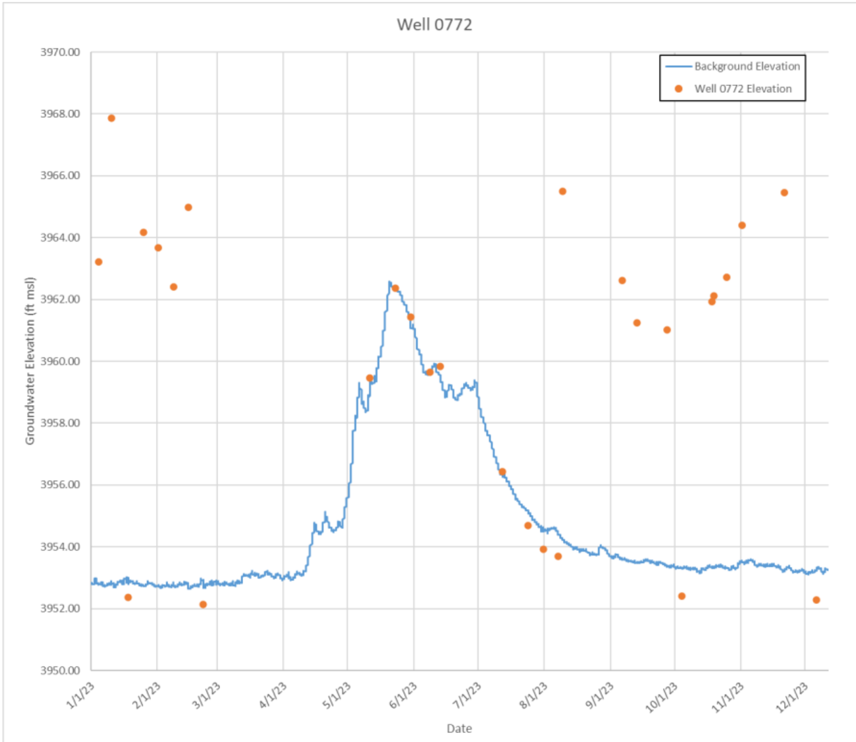

Figure B-3. Freshwater Mounding in Remediation Well 0772 During Injection

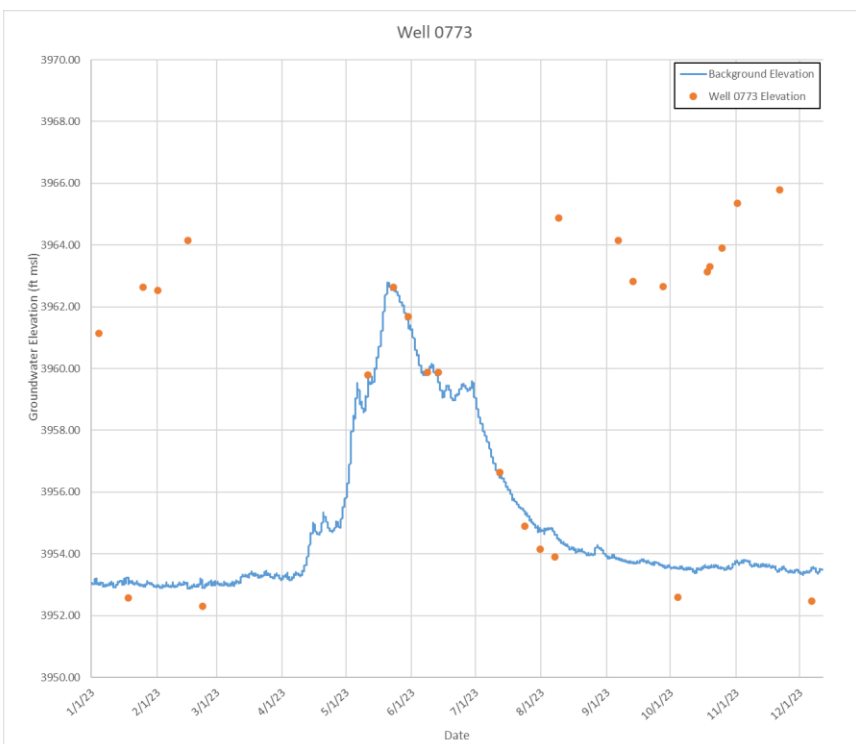

Figure B-4. Freshwater Mounding in Remediation Well 0773 During Injection

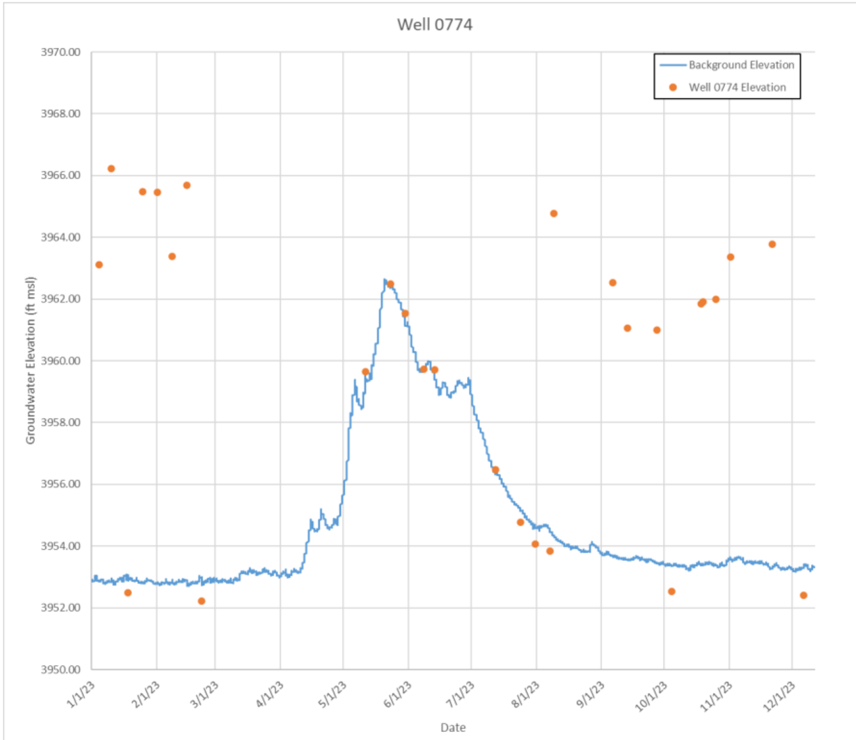

Figure B-5. Freshwater Mounding in Remediation Well 0774 During Injection

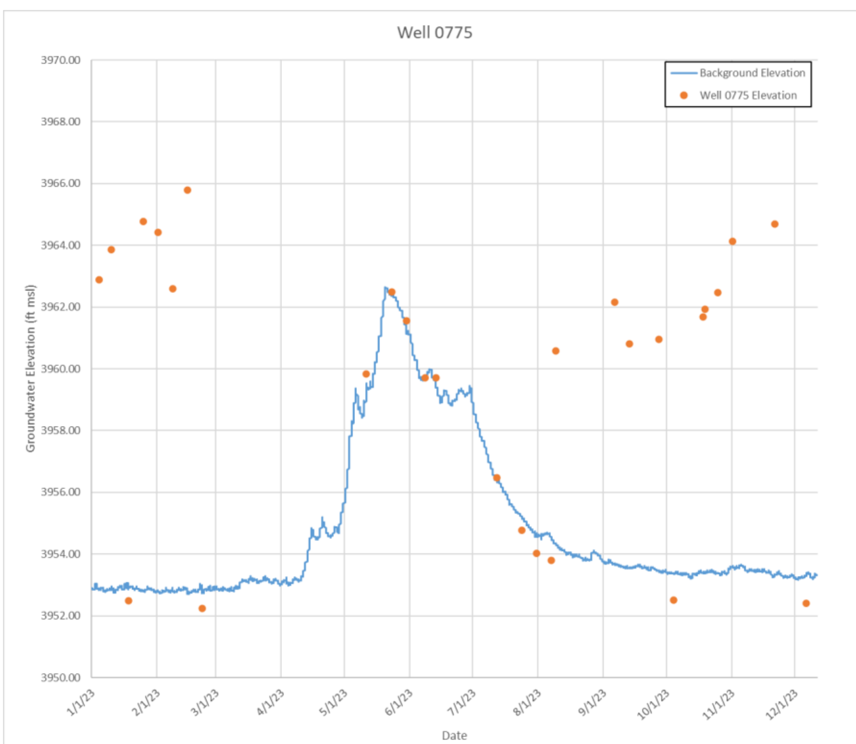

Figure B-6. Freshwater Mounding in Remediation Well 0775 During Injection

Appendix B. Tables and Data for 2023 Freshwater Injection (*continued*)

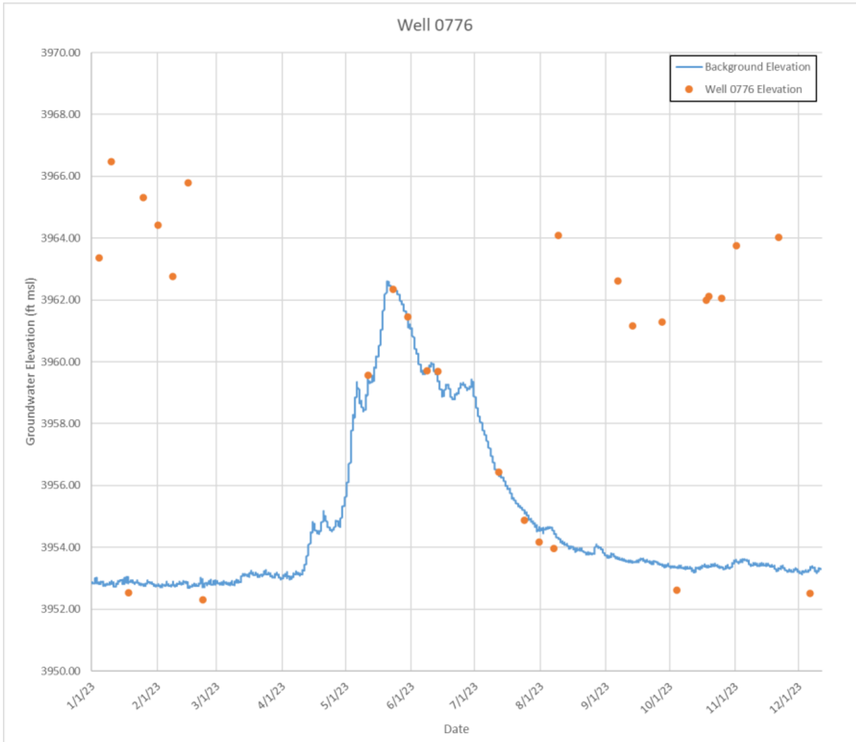

Figure B-7. Freshwater Mounding in Remediation Well 0776 During Injection

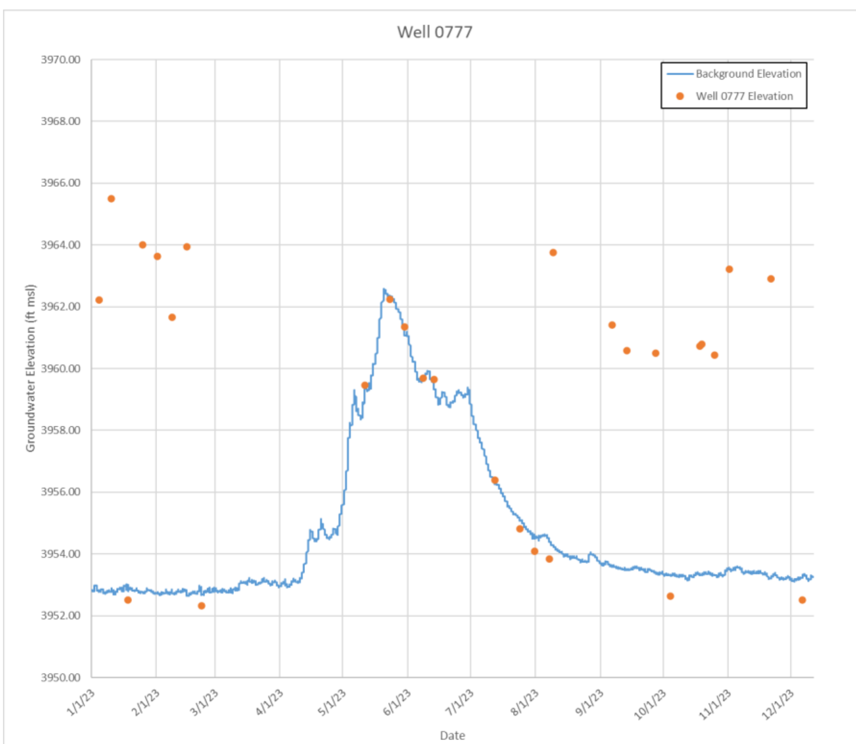

Figure B-8. Freshwater Mounding in Remediation Well 0777 During Injection

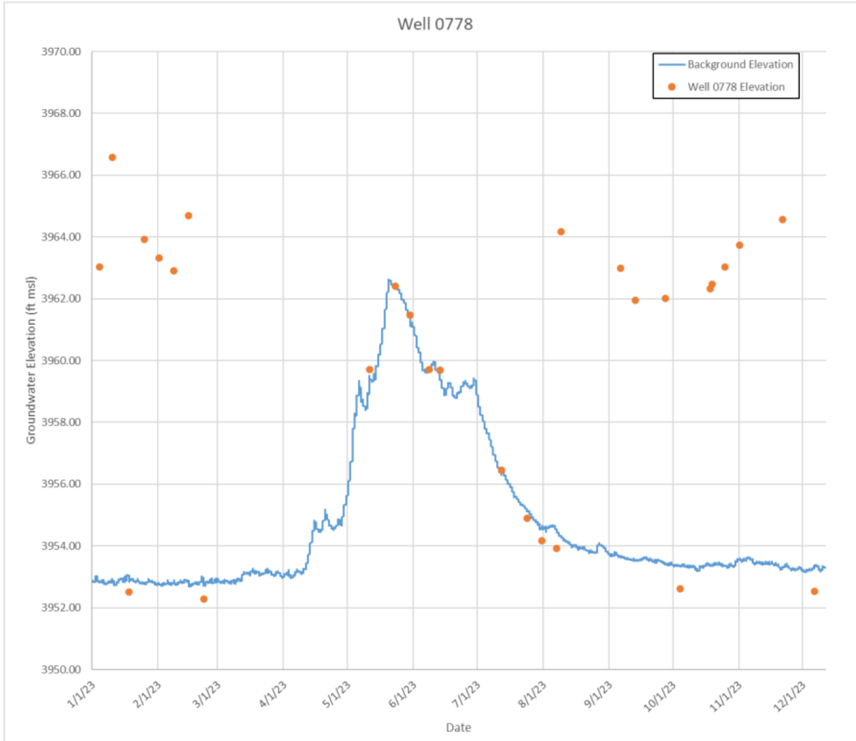

Figure B-9. Freshwater Mounding in Remediation Well 0778 During Injection

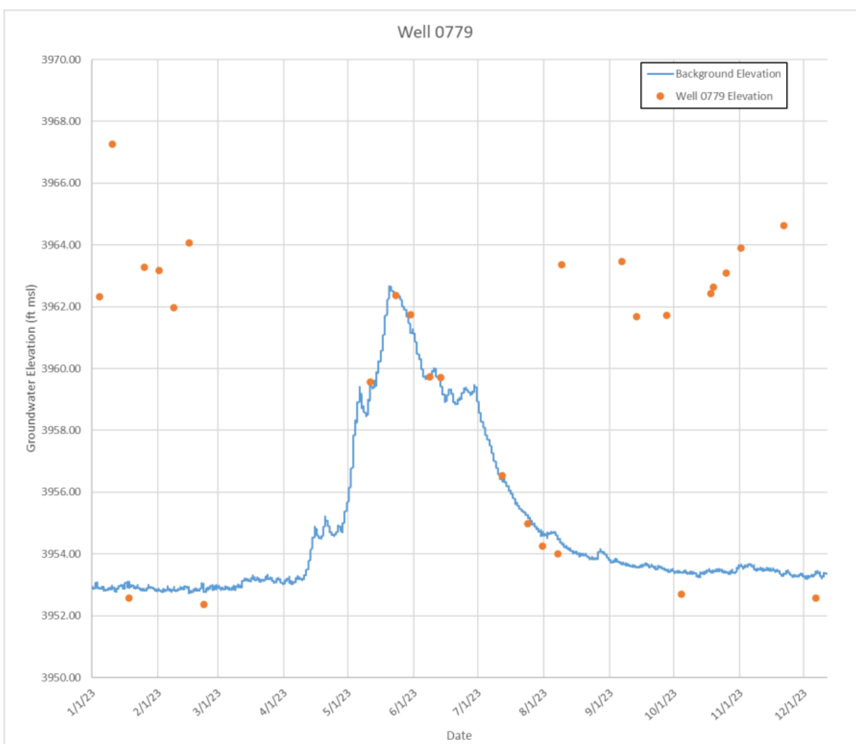

Figure B-10. Freshwater Mounding in Remediation Well 0779 During Injection

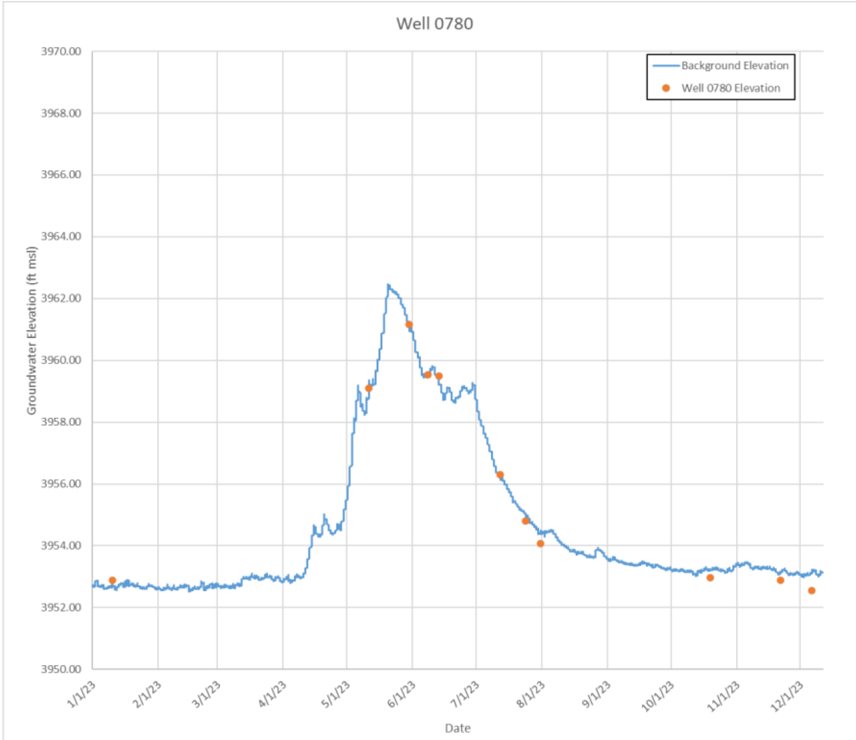

Figure B-11. Freshwater Mounding in Observation Well 0780

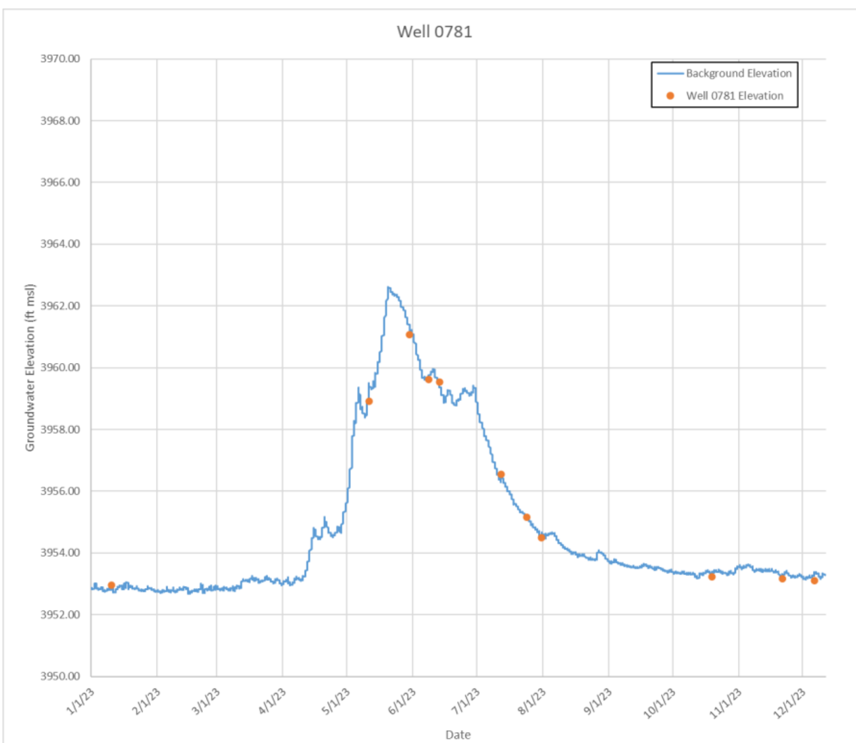

Figure B-12. Freshwater Mounding in Observation Well 0781

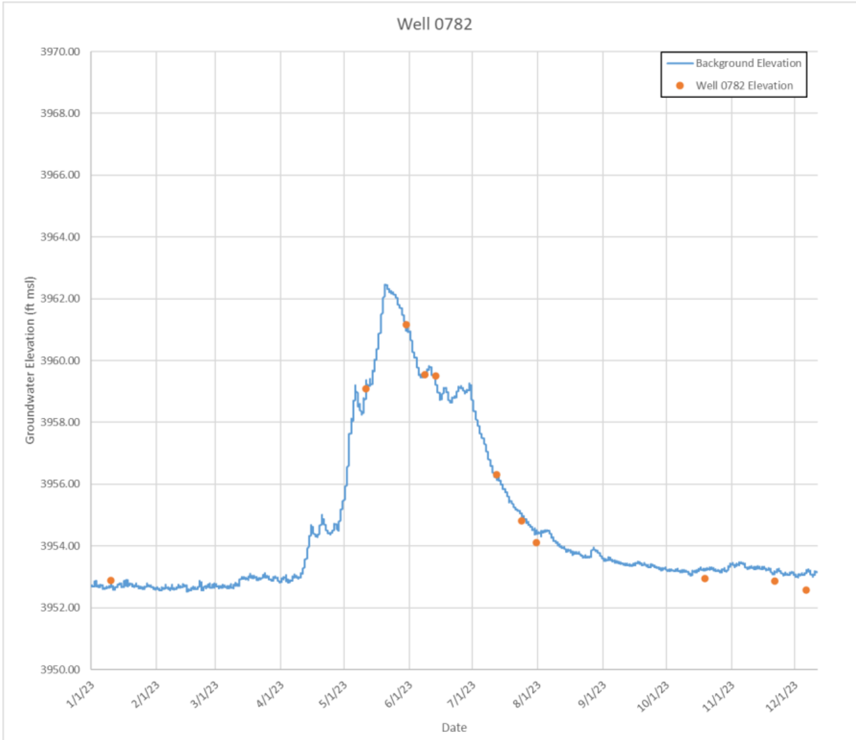

Figure B-13. Freshwater Mounding in Observation Well 0782

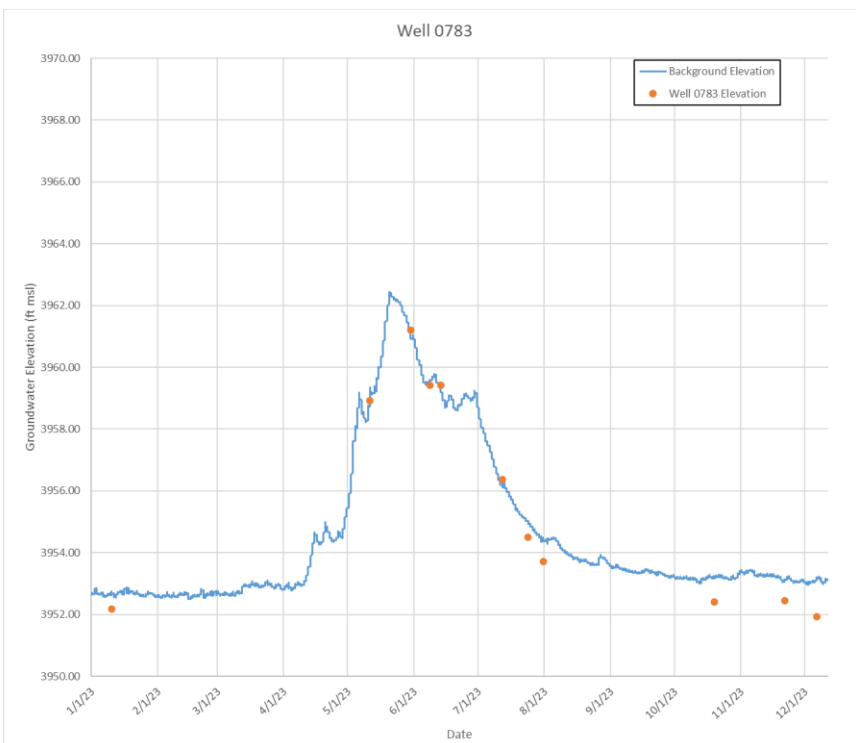

Figure B-14. Freshwater Mounding in Observation Well 0783

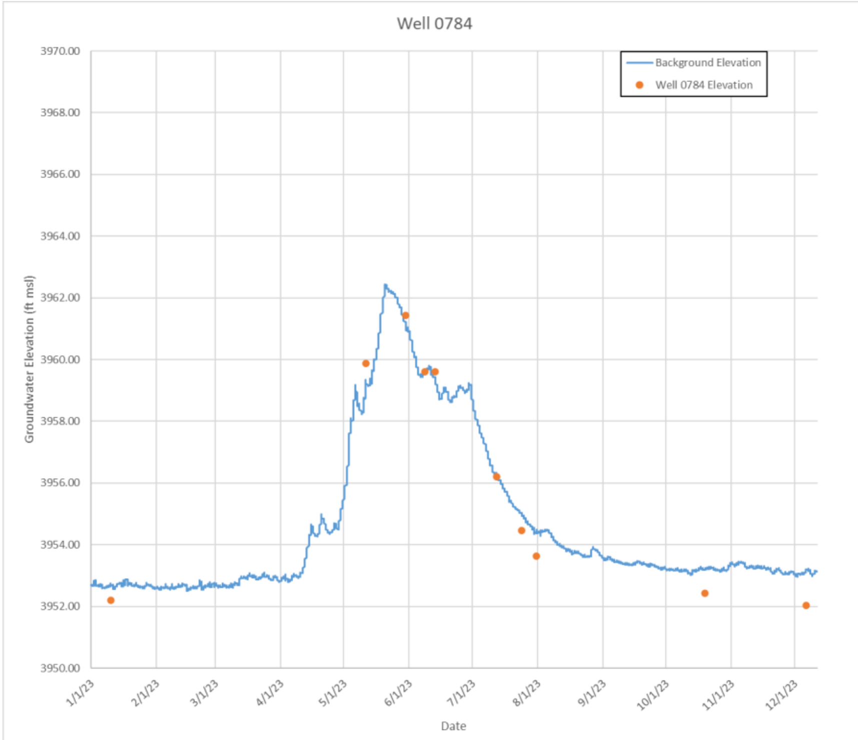

Figure B-15. Freshwater Mounding in Observation Well 0784

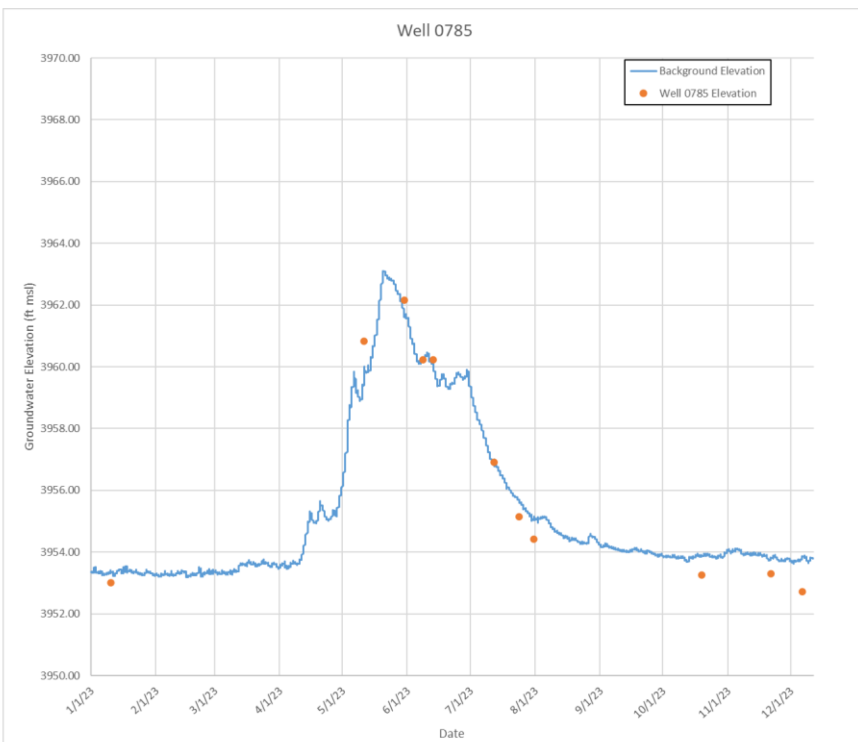

Figure B-16. Freshwater Mounding in Observation Well 0785

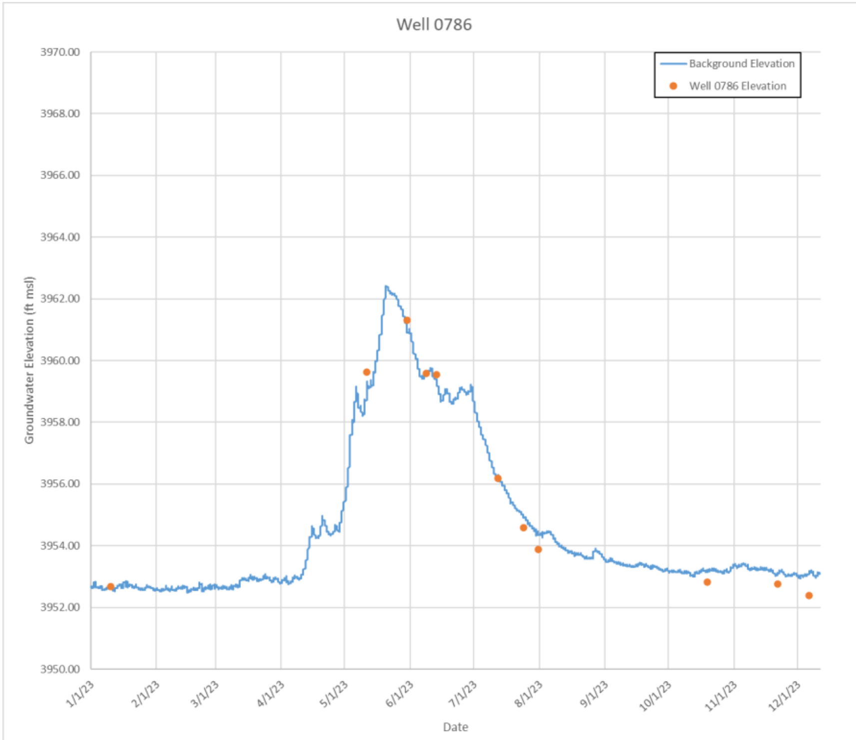

Figure B-17. Freshwater Mounding in Observation Well 0786

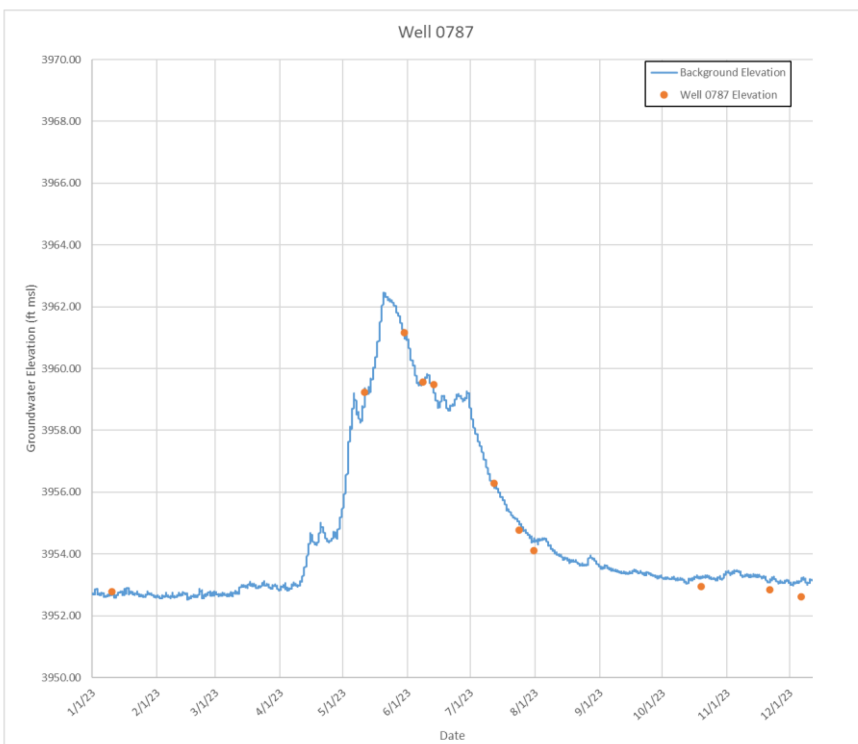

Figure B-18. Freshwater Mounding in Observation Well 0787