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Moab UMTRA Project
2022 Groundwater Program Report

Revision 0

July 2023

Office of Environmental Management

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Moab UMTRA Project 2022 Groundwater Program Report

Revision 0

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Revision History

Revision	Date	Description
0	July 2023	Initial issue.

Contents

Figures

Figures (*continued*)

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 or 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 2022 and evaluates the effectiveness of the remediation systems to remove contaminant mass from the groundwater system and protect endangered fish habitats that may develop in the Colorado River adjacent to the site.

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 is designed to limit ecological risk from contaminated groundwater discharging to potential endangered fish habitat areas along the Colorado River. This protection is accomplished by removing contaminant mass with groundwater extraction wells. In addition, freshwater injection between the river and the tailings pile creates a hydraulic barrier that reduces discharge of contaminated water to suitable habitat areas. 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.

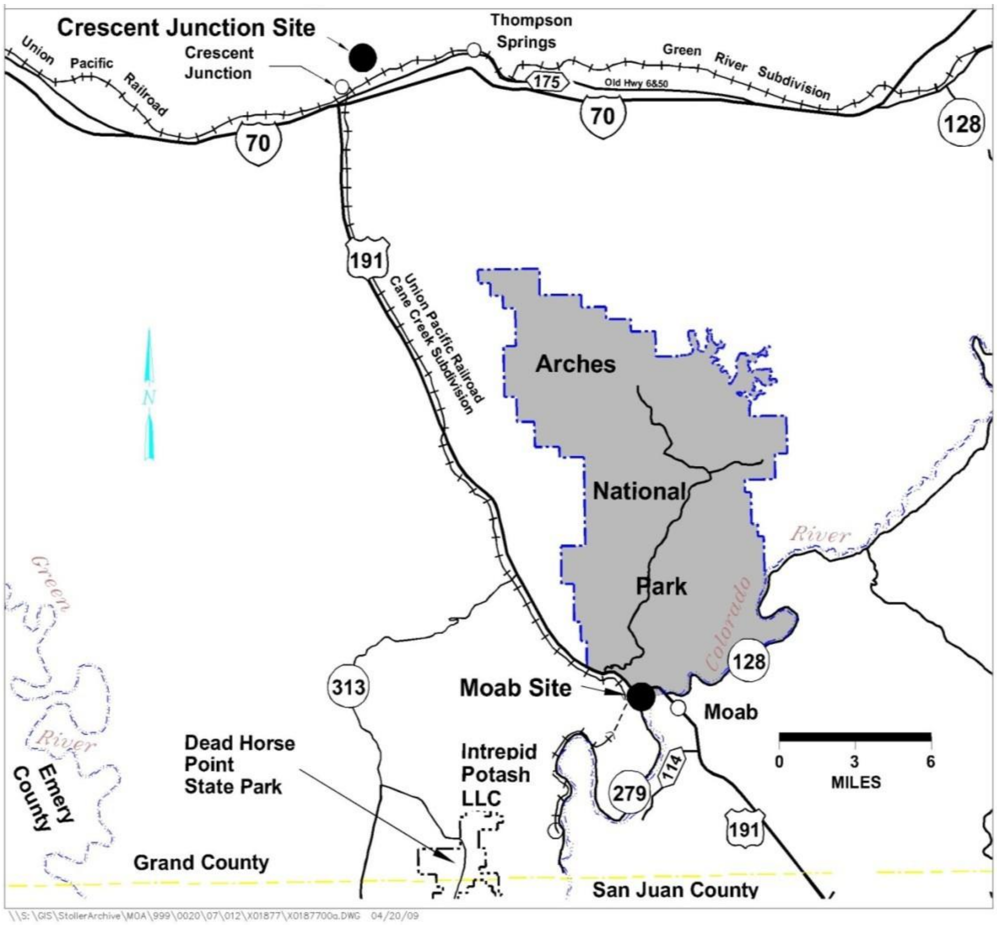

Figure 1. Location of the Moab Project Site

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 U.S. Environmental Protection Agency (EPA). Monitoring wells are also part of the IA system for evaluation purposes. In 2022, 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 is made of overbank deposits from the Colorado River.

The lower part of the basin-fill alluvium mostly consists of a 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 to the southwest toward the river more than 450 ft near the deepest part of the basin. The upper silty-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 February through March 2022, when the Colorado River flows ranged from 2,040 to 2,630 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). 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 the course of each year in response to changes in river stage.

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. The ammonia beneath the interface represents a potential long-term source of contamination to the upper alluvial groundwater system.

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).

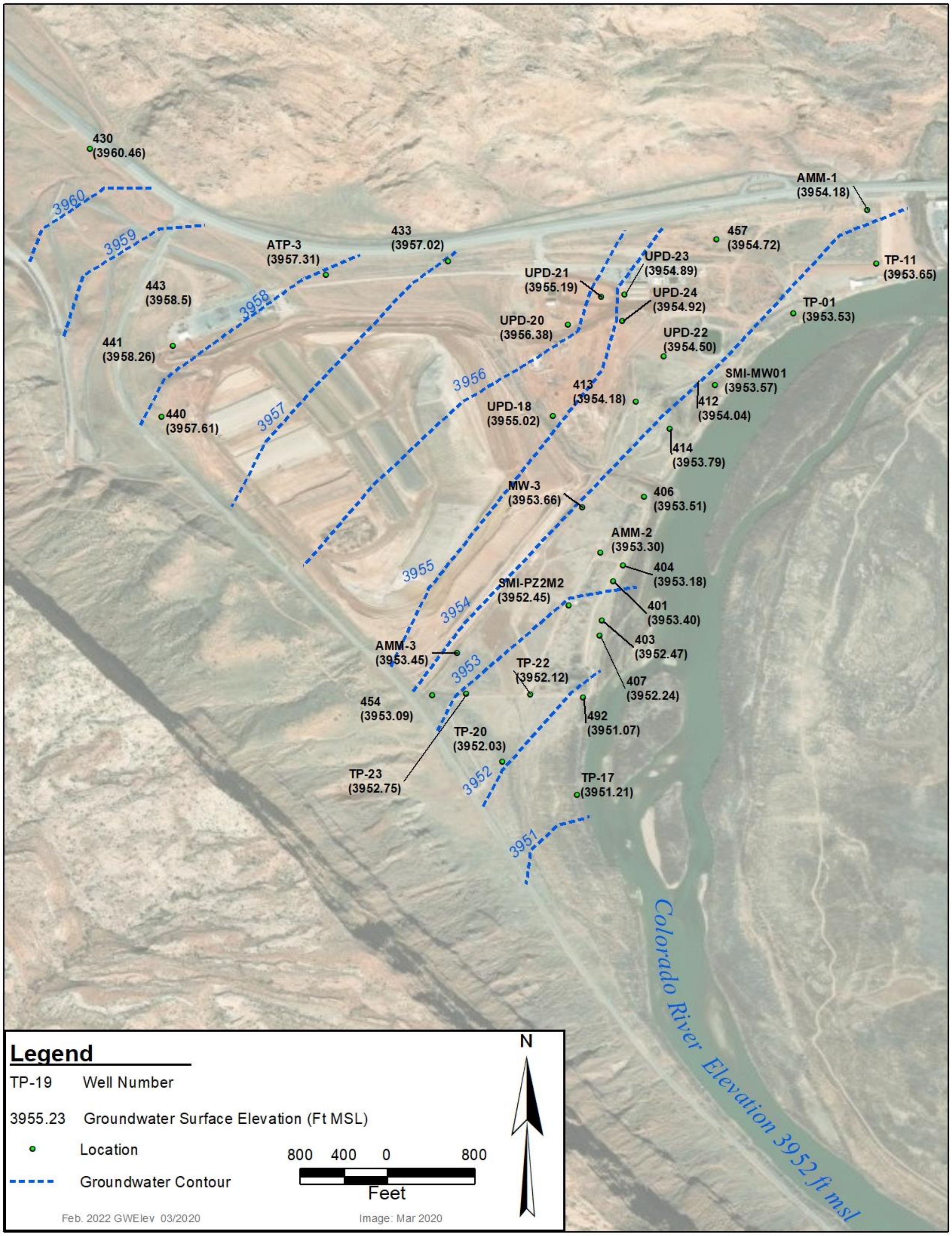

Figure 3. Site-wide Groundwater Elevations February/March 2022

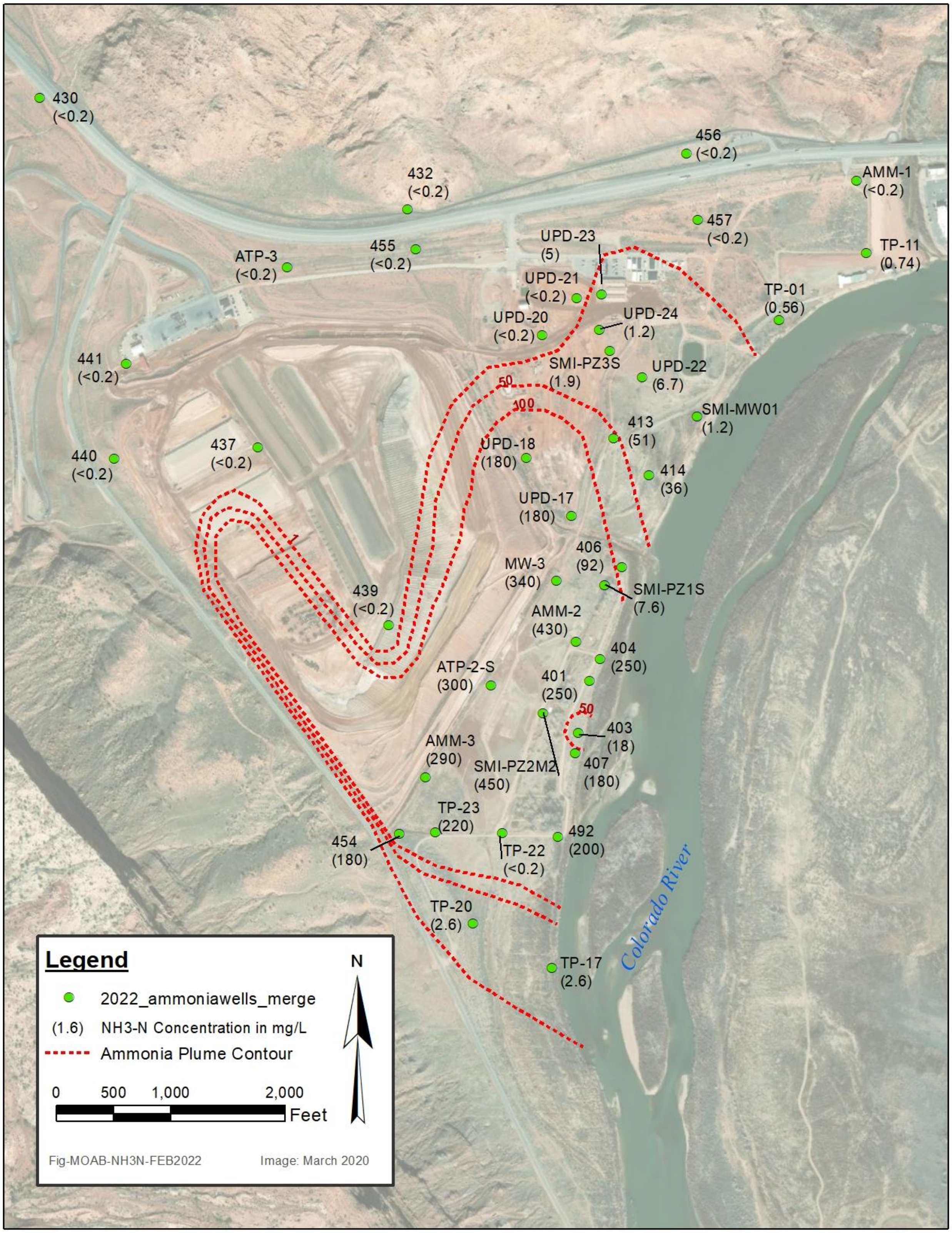

Figure 4. Ammonia Plume in Shallow Groundwater February/March 2022

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 February/March 2022.

Figure 5 shows the distribution of dissolved uranium in shallow groundwater in 2022.
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.”

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 the majority of the year, when the river is experiencing baseflow (less than 4,000 cfs), groundwater discharges into the river (river gaining conditions). As the river flow increases in response to the spring runoff, the river changes from gaining to losing conditions and a freshwater lens develops in the aquifer underlying the well field.

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).

Figure 6 displays the groundwater elevation versus the elevation of the Colorado River in 2022. 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/GJTAC1640). In 2022, The Colorado River Basin had a lower than average snowpack, which combined with dry soil conditions from the previous year, led to a below average water year.

Between January and April 2022, the Colorado River was under gaining conditions (when the groundwater elevation was higher than the river surface elevation). The river switched to losing conditions (groundwater elevation lower than the river surface elevation) in early April through December. Monsoonal moisture impacted the river flow through the fall, leading to a prolonged period of river losing conditions.

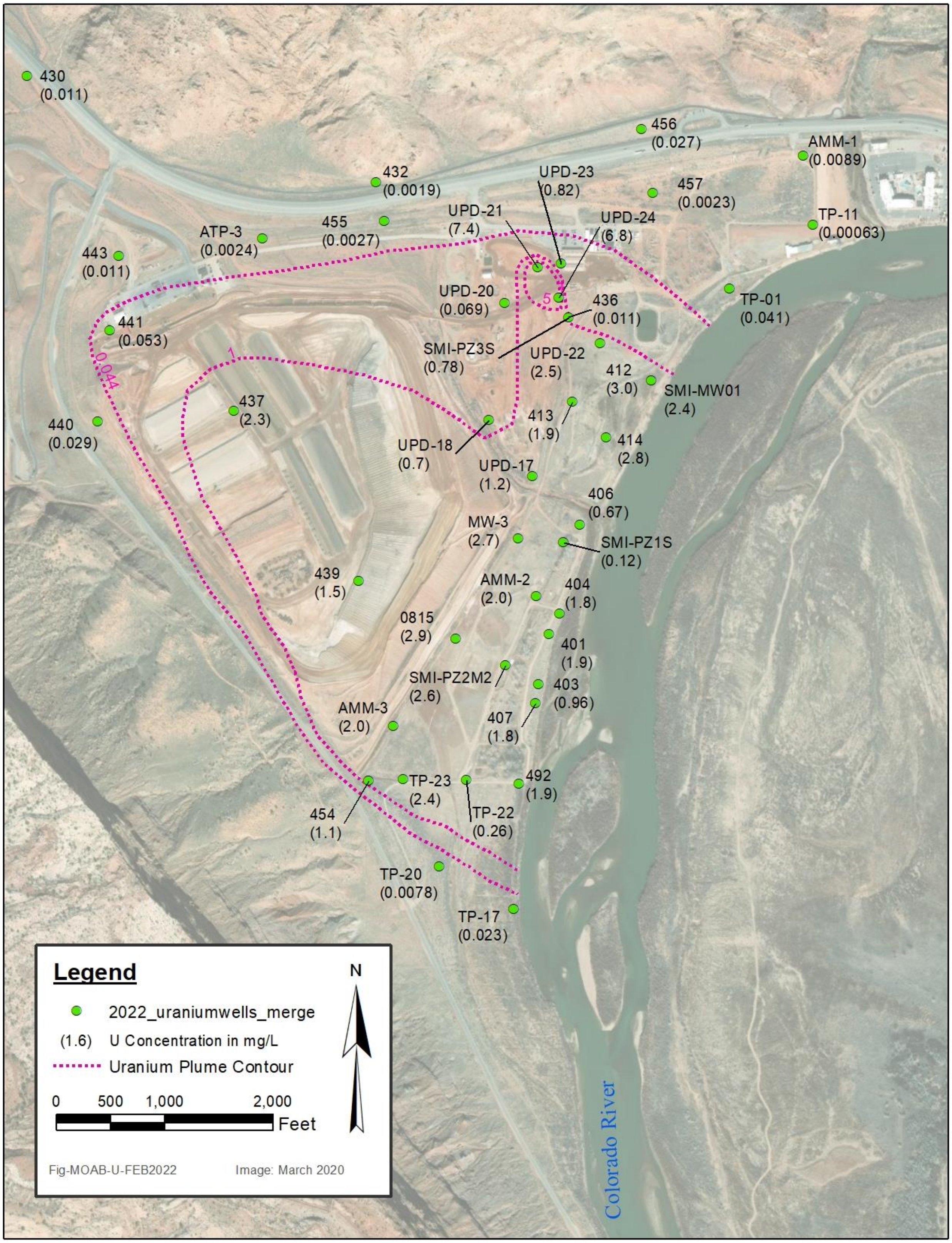

Figure 5. Uranium Plume in Shallow Groundwater February/March 2022

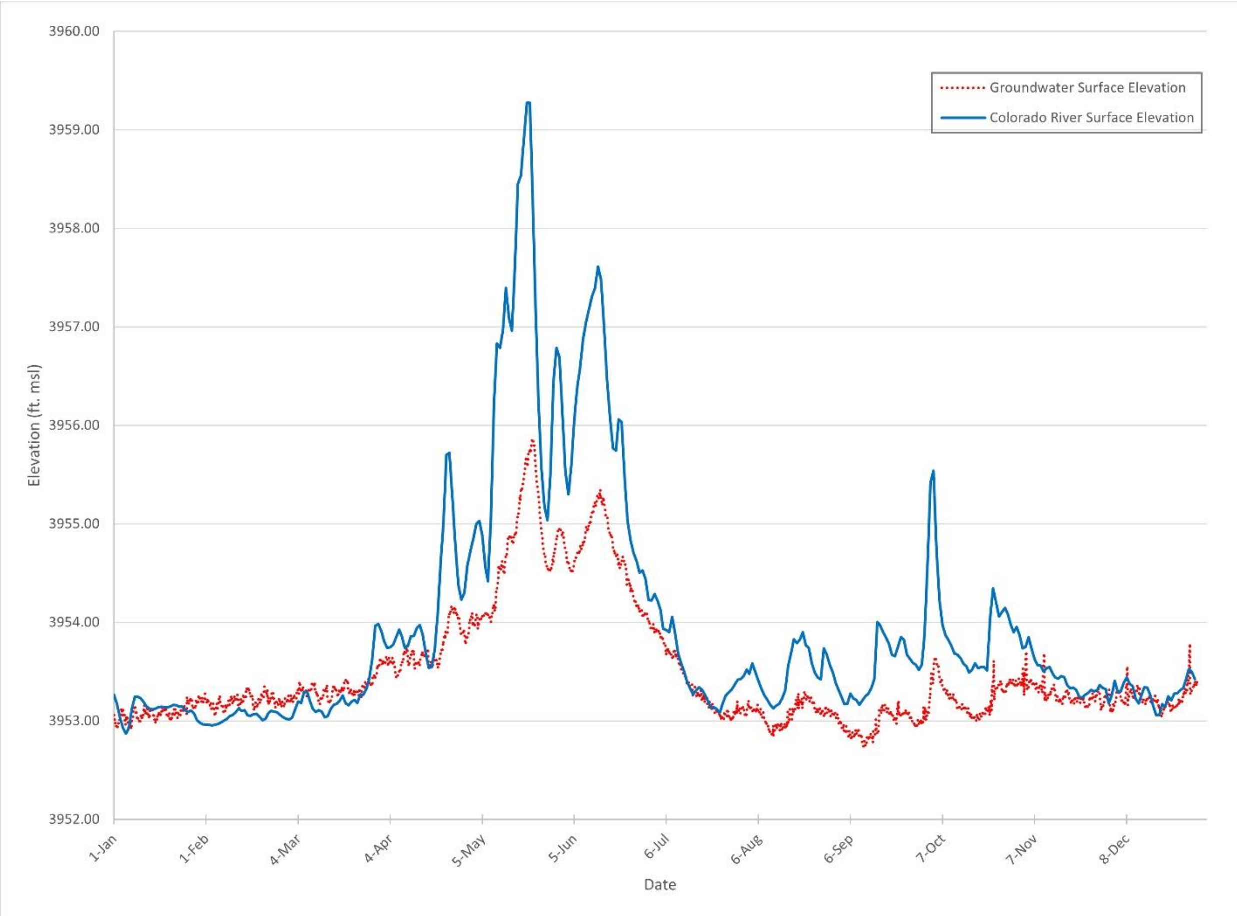

Figure 6. Groundwater Surface Elevation Compared to the Colorado River Surface Elevation 2022

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 (gal) 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 groundwater drawdown and 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 more frequently.

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.

Water 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/GJTAC1830). Samples were shipped overnight to ALS Environmental (ALS) in Fort Collins, Colorado and 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 2022 pumping season. This section also includes a discussion of the total groundwater extraction rate, hydraulic control, mass removal, and water quality. Appendix A contains tables of well construction information (Table A-1), a chronology of 2022 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 utilize extraction wells that supply groundwater directly to two 21,000-gal holding tanks. The water is then pumped into a 12,000-gal Klein tank, where it 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 primary water truck used to disperse extraction water over the tailings was inoperable during July and monsoonal rains in August and September lead to limited extraction volumes through these warmer months and an overall decrease annually compared to 2021.

The 2022 extraction schedule was focused on optimizing ammonia and uranium mass removal and rotating through each of the eight CF5 remediation wells. In 2022, the extraction system was re-started in mid-March and operated consistently until the system was winterized in mid-November. Extraction well 0814 required a submersible pump replacement and was not utilized during 2022. Figure 7 provides a graphic summary of when the 4.4 mil gal of groundwater was extracted from CF5 in 2022. The figure also identifies the period the primary water truck was inoperable.

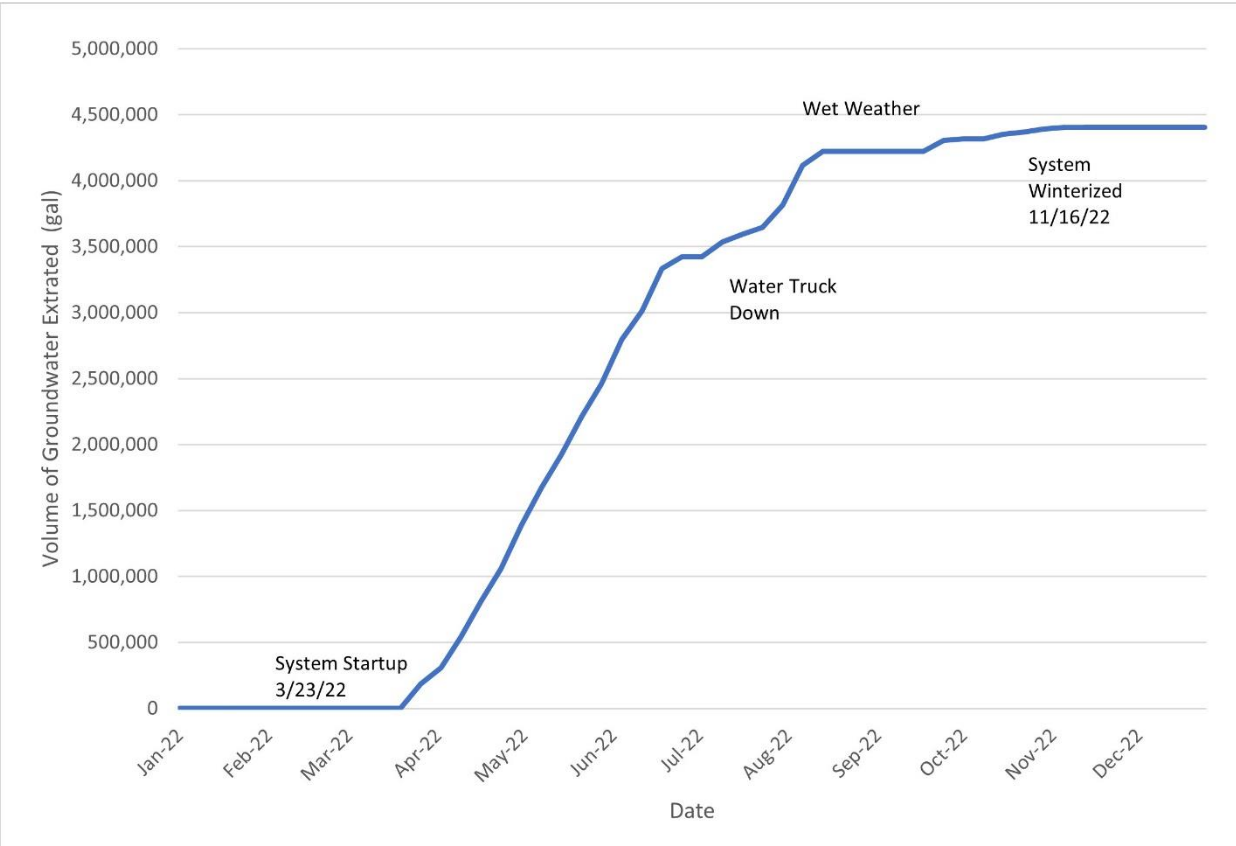

Figure 7. Cumulative Volume of Extracted Groundwater during 2022

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 2022 extracted water was removed from wells 0813 (0.96 mil gal) and 0816 (1.07 mil gal). The remaining CF5 wells extracted between approximately 233,210 and 679,490 gal in 2022. Extraction operations were maximized in June, when 1.21 mil gal of groundwater was extracted.

The 2022 ammonia and uranium mass removal is presented in Tables A-4 and A-5. These values are based on groundwater extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from groundwater by the extraction wells 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 analytical data presented in Table 1. In 2022, a total of 8,960 pounds (lb.) (4,064 kilograms [kg]) of ammonia and 89.7 lb. (40.7 kg) of uranium were extracted from the groundwater system.

Table A-4 shows that extraction wells 0813 and SMI-PW02 removed the most ammonia mass at 2,441 lb (1,107 kg) and 2,049 lb (929 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 0816 (23.18 lb, or 10.51 kg).

Table 1. CF5 Ammonia, Uranium, and Specific Conductance Results 2022

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	7/12/22	250	2.8	28,529
0811	7/12/22	310	2.4	21,662
0812	7/12/22	340	2.1	18,344
0813	7/12/22	260	1.8	13,752
0814	N/A	N/A	N/A	N/A
0815	7/12/22	100	2.9	18,260
0816	7/12/22	110	2.6	21,330
SMI-PW02	7/12/22	330	2.9	29,234

4.3 Groundwater Chemistry

Groundwater samples were collected from the CF5 extraction wells in July 2022 (Table 1). Ammonia concentrations ranged from 100 mg/L (well 0815) to 340 mg/L (wells 0812), and the uranium concentration ranged from 1.8 mg/L (well 0813) to 2.9 mg/L (wells SMI-PW02 and 0815). Specific conductance ranged from approximately 13,752 µmhos/cm at well 0813 (northern end of CF5) to 29,234 µmhos/cm at well SMI-PW02 (located centrally in CF5).

Figures 8 through 11 are time-versus-concentration trend plots that display trends of the CF5 extraction wells from 2010 through 2022, which represents the majority of the CF5 well field lifespan (extraction was started in April 2010). 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.

Taking into account all eight extraction wells, 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 have been gradually decreasing (well 0813 shows a slight increase). Uranium concentration trends show little change over time. Most wells show a slight decrease in concentrations, whereas the northern most wells (well 0813 and 0816) show a slight upward trend.

The data 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 these locations 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. The trend line associated with well SMI-PZ2M2 exhibits a larger decrease in the concentrations, likely in response to this monitoring well's proximity to an extraction well compared to AMM-2.

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.

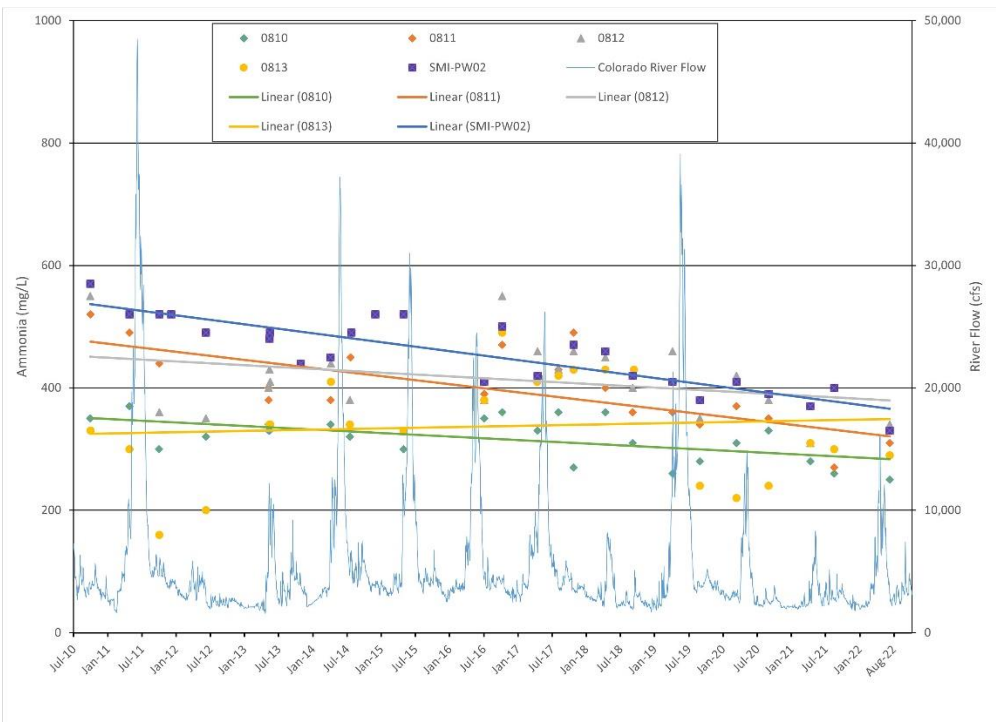

Figure 8. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Ammonia Concentration Plot

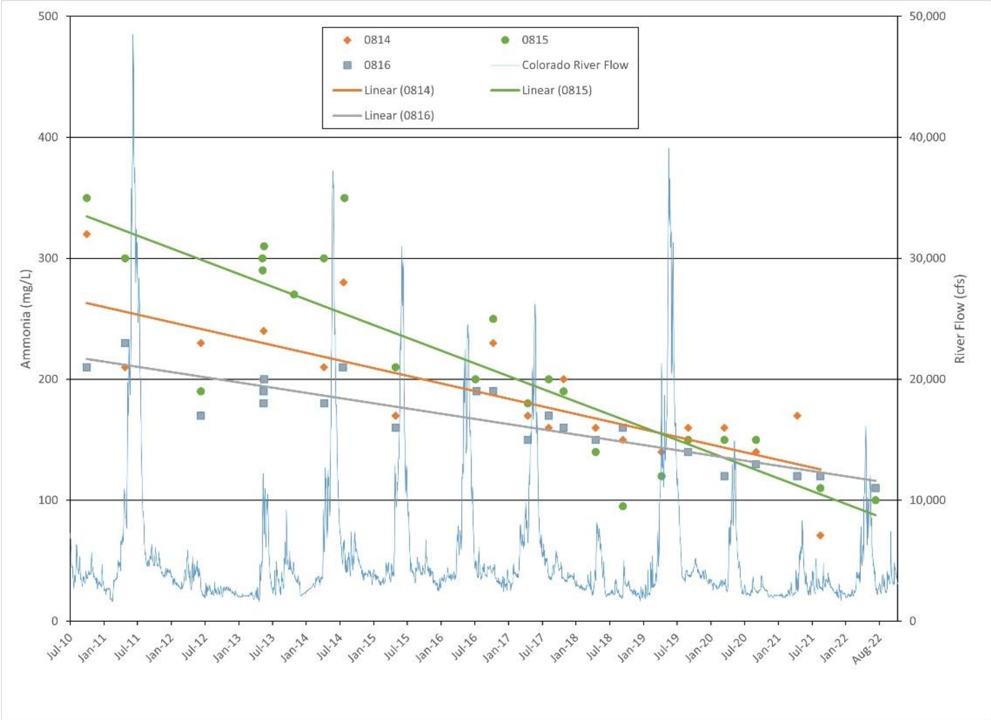

Figure 9. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Ammonia Concentration Plot

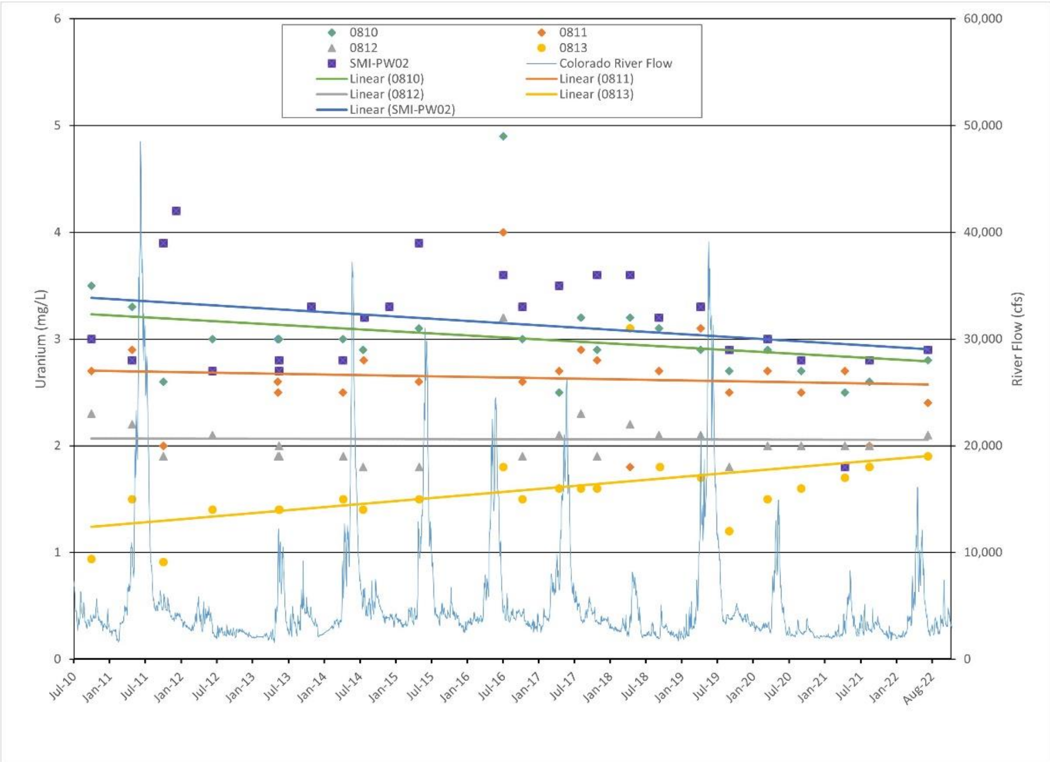

Figure 10. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Uranium Concentration Plot

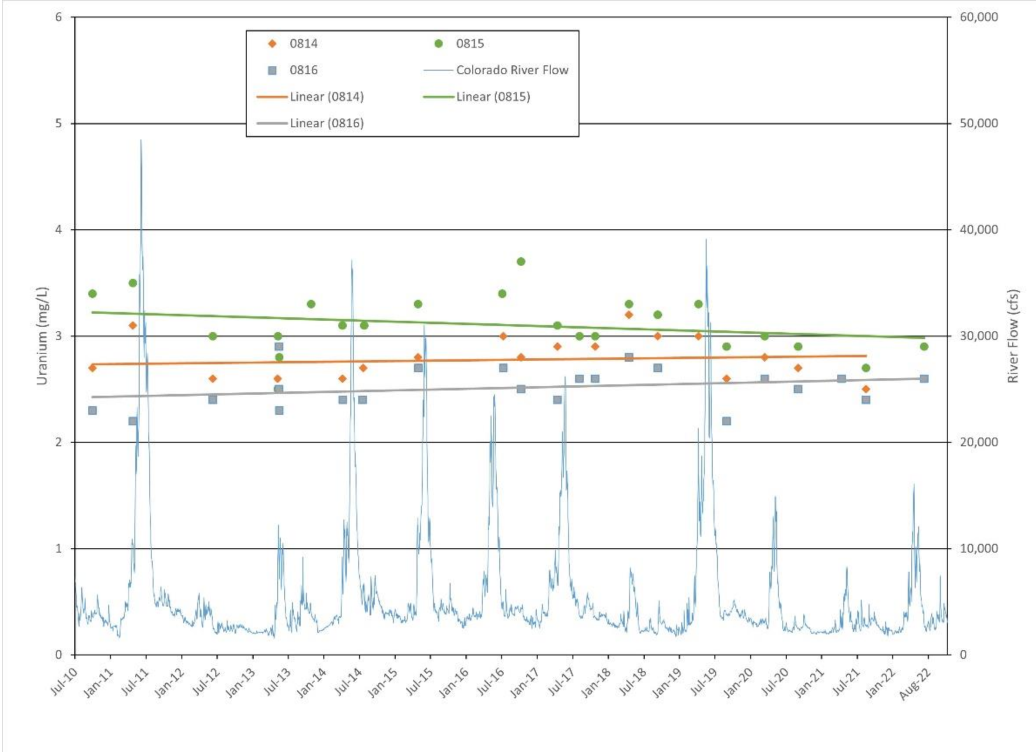

Figure 11. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Uranium Concentration Plot

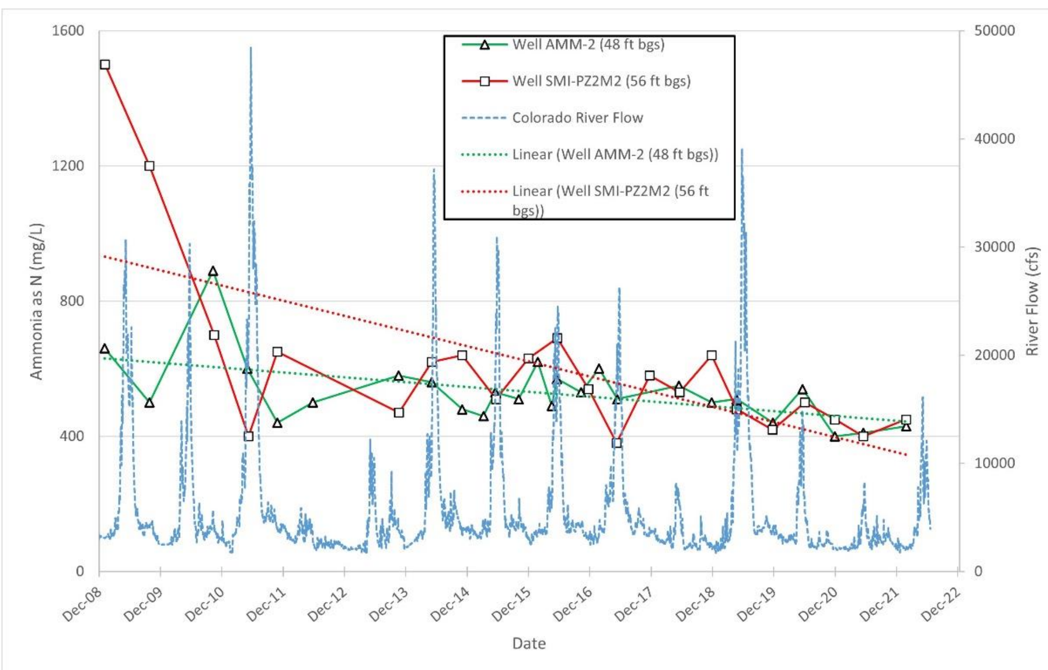

Figure 12. Monitoring Wells AMM-2 and SMI-PZ2M2 Time versus Ammonia Concentration Plot and Trend Lines

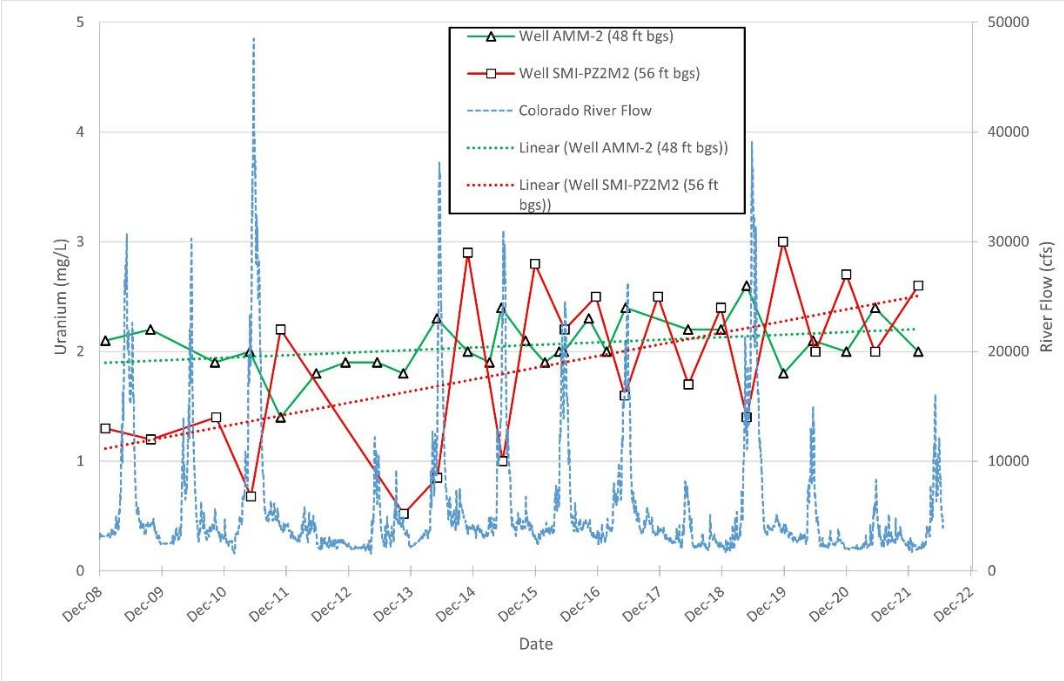

Figure 13. Monitoring Wells AMM-2 and SMI-PZ2M2 Time versus Uranium Concentration Plot and Trend Lines

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 Colorado River water that is diverted to the freshwater pond. This water is pumped through a sand and gravel media, and then through 1 - 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 of Appendix B. Table B-2 also contains a chronology of CF4 activities.

Configuration 4 is located 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 2022, a suitable habitat did not form due to low flow conditions and increased deposition.

5.1 Injection Performance

Freshwater injection into the CF4 wells occurred consistently January through December. In 2022, approximately 9.8 mil gal of freshwater were injected in CF4. Figure 14 provides a graphic summary of the cumulative volume of freshwater injected into CF4. The injection wells are typically developed annually to maintain efficiency and were developed during mid-July.

Injection was turned off for maintenance, repairs and high river flow (above 11,000 cfs).

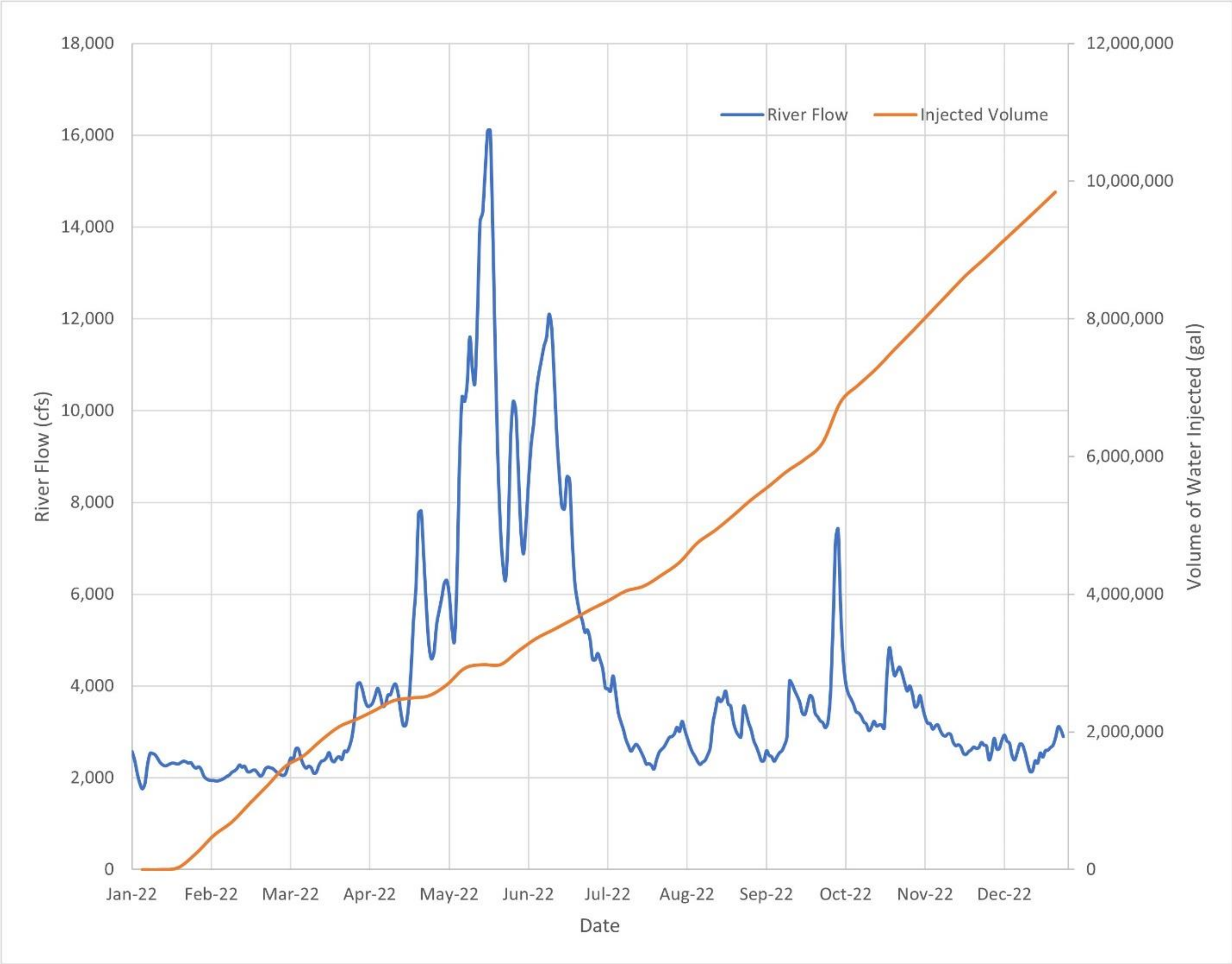

Figure 14. Cumulative Volume of Injected Freshwater during 2022

5.2 Observation Well Chemical Data Summary

Groundwater samples were collected from the CF4 observation wells during July 2022 to assess the effectiveness of the system (Table B-3).

Table 2. CF4 Observation Well Ammonia Concentrations, January, May, and September 2021

Location	Sample Depth (ft bgs)	Relative Location to Injection Wells	July 2022 Concentration (mg/L)
0780	28	Upgradient	0.2#
0781	46	Upgradient	1000
0782	33	Upgradient	8.2
0783	18	Upgradient	0.2#
0784	18	Downgradient	0.2#
0785	18	Downgradient	0.2#
0786	28	Downgradient	0.2#
0787	36	Downgradient	470

ft bgs = feet below ground surface, # = the result was below the detection limit

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 active for 6 months. Excluding the deepest wells, samples collected from less than 30 ft bgs indicate ammonia concentrations below the detection limit. 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 the background well 0405.

The water levels in each well were adjusted to match well 0405 during non-pumping baseflow conditions. Tables 3 and 4 summarize the mounding data that are shown in Figures B-1 to B-10 (Appendix B) for the injection wells. Mounding 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 August 2022 during injection operations. The highest freshwater mounding occurs within 30 ft of the injection system. The amount of mounding was dependent on the individual well’s efficiency and the corresponding injection rate.

Table 3 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 4 and varied from 2.53 to 2.62 ft in the upgradient wells and from 2.69 to 3.18 ft in the down gradient wells.

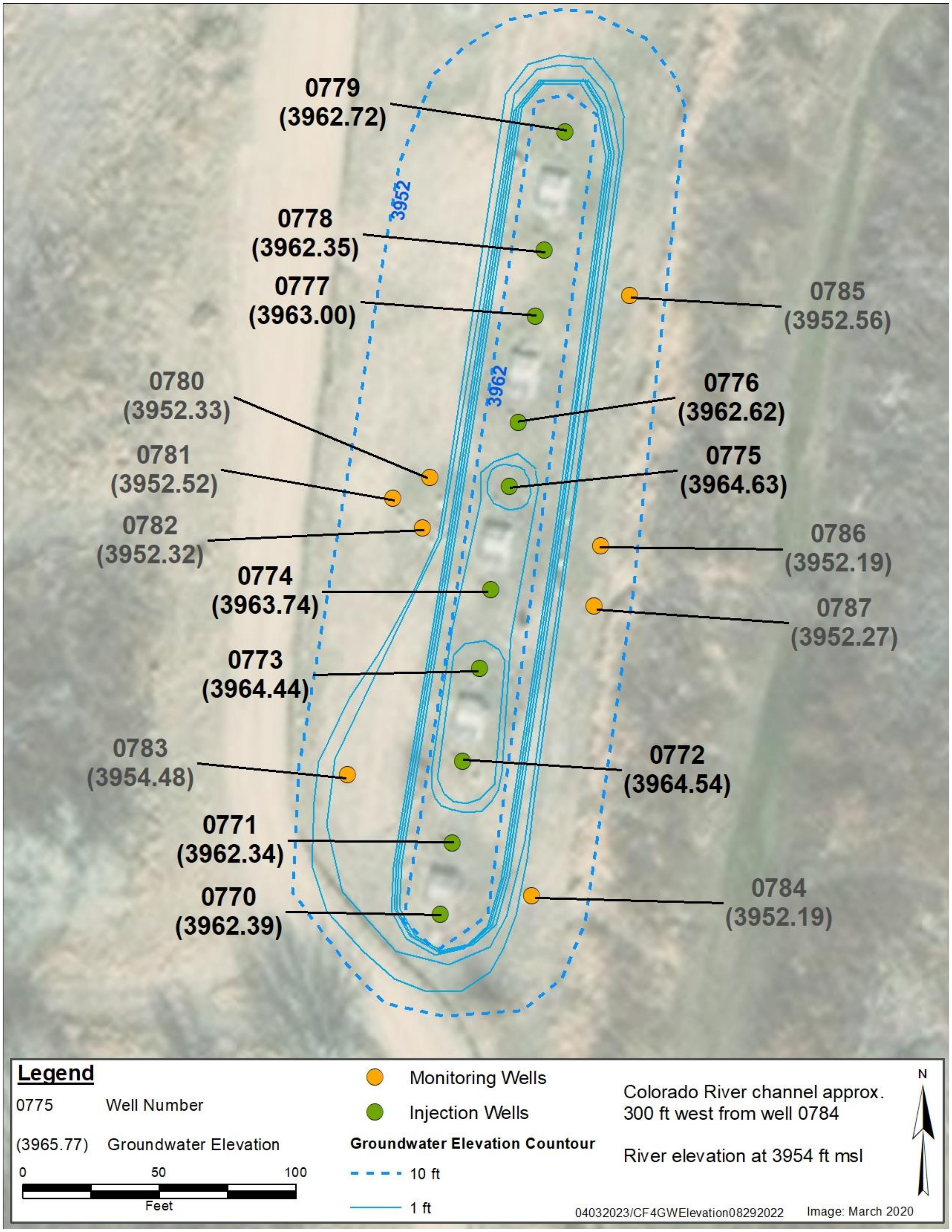

Figure 15. Freshwater Mounding at CF4 during Injection Operations August 2022

Table 3. Maximum Mounding Observed in CF4 Injection Well, 2022

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	8/31/22	Injection Well	12.87	3.56
0771	12/14/22	Injection Well	12.36	4.27
0772	8/31/22	Injection Well	14.21	2.72
0773	8/31/22	Injection Well	14.21	1.28
0774	8/31/22	Injection Well	13.79	2.56
0775	8/29/22	Injection Well	12.16	7.06
0776	8/31/22	Injection Well	13.80	2.84
0777	8/31022	Injection Well	13.03	3.37
0778	8/31/22	Injection Well	14.07	2.52
0779	8/31/22	Injection Well	14.88	1.2

Table 4. Freshwater Mounding Observed in CF4 Observation Wells, 2022

Well	Date	Location	Distance from Injection Source (ft)	Screened Interval (ft bgs)	Maximum Mounding (ft)
0780	6/16/22	Upgradient	25	20.3 – 30.1	0.46
0781	6/16/22	Upgradient	30	44.8 – 54.5	0.20
0782	6/16/22	Upgradient	25	31.0 – 40.8	0.44
0783	6/16/22	Upgradient	30	8.6 – 18.6	0.78
0784	6/16/22	Downgradient	30	9.4 – 19.4	0.35
0785	6/16/22	Downgradient	25	9.6 – 19.6	0.35
0786	6/16/22	Downgradient	30	20.5 – 30.3	0.13
0787	6/16/22	Downgradient	30	35.4 – 45.2	0.26

6.0 Surface Water Monitoring

Surface water monitoring occurs during the site-wide sampling event, when samples are collected upgradient of the site, on site, and downgradient of the site. The backwater channel adjacent to CF4 is monitored from June to September to determine if and when it becomes a suitable habitat for young-of-year fish. No suitable habitat for endangered species formed this year.

6.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in March 2022 (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 2022* (DOE-EM/GJTAC3084) and the results are presented in Table 5.

With the exception of one location, ammonia concentrations measured during this event were below the detection limit. Location CR3 had an ammonia concentration of 1.2 mg/L, which is above the Environmental Protection Agency (EPA) chronic criteria. This location was not considered a habitat at the time.

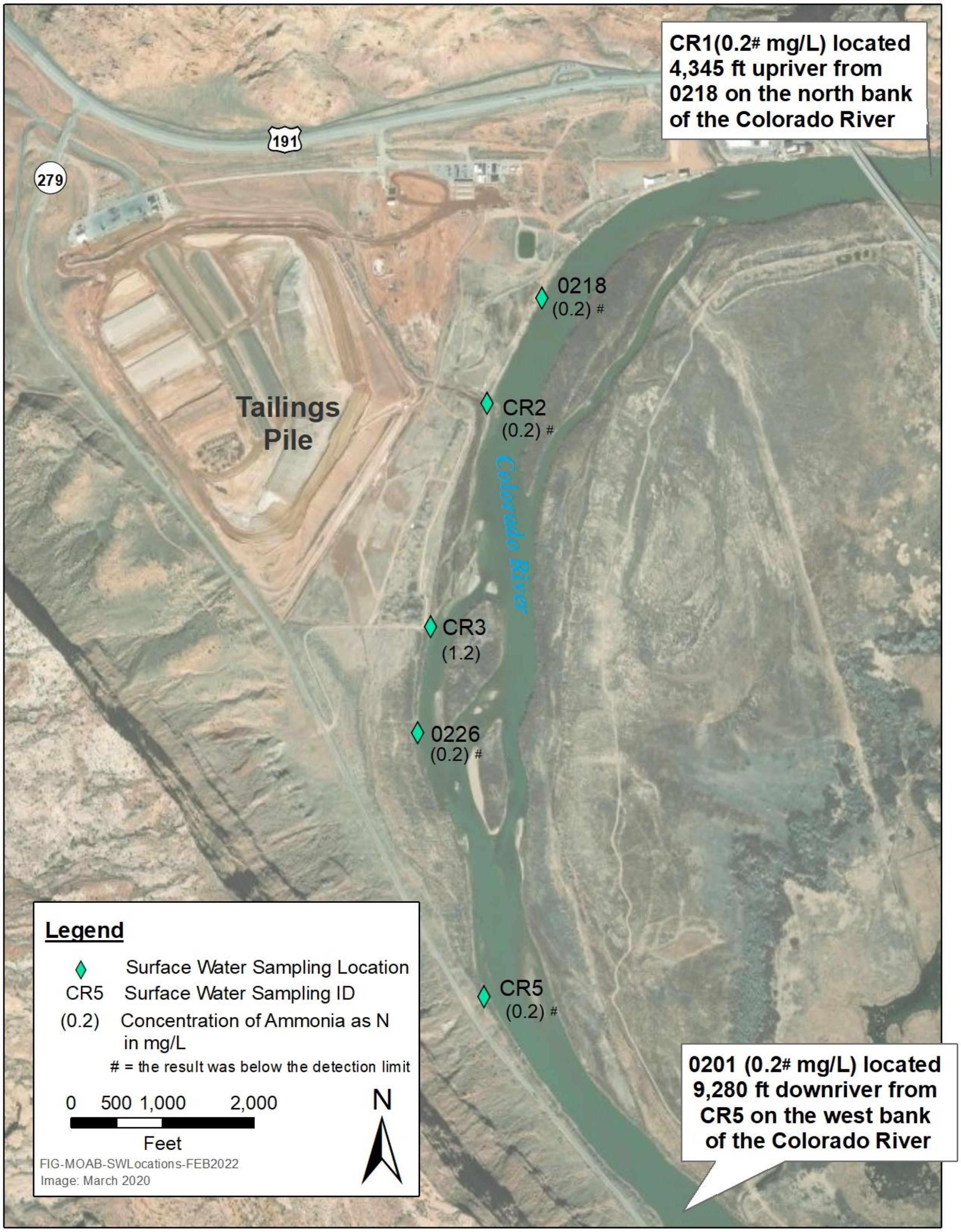

Figure 16. 2022 Site-wide Surface Water Sampling Locations

Table 5. May Through July 2022 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	3/8/22	6.27	7.38	0.2#	15	3.5
0218	3/7/22	7.02	8.01	0.2#	5.6	1.8
0226	3/8/22	7.15	8.65	0.2#	1.5	0.57
CR1	3/7/22	7.29	7.35	0.2#	15	3.5
CR2	3/7/22	8.33	8.08	0.2#	5.6	1.7
CR3	3/7/22	12.62	8.43	1.2	2.6	0.65
CR5	3/8/22	6.91	7.73	0.2#	8.1	2.6

*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)
*** A laboratory error prevented accurate analysis from location 0274
# = the result was 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 2022, the side channel was monitored through the summer after the peak flow, but the channel did not develop into a backwater habitat.

7.0 Investigations

In addition to the operation of the groundwater extraction, freshwater injection, and surface water diversion systems, Crescent Junction wells 0202 and 0205 were also monitored during 2022.

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 of the vicinity of well 0205. Before the installation of the cell cover, most of the precipitation would evaporate with larger storm events producing surface runoff, with a very small portion slowly infiltrating over a much larger area. With the cover material in place, there is often less evaporation and more surface runoff that tends to accumulate in discrete areas of the site and provides a longer-term source of infiltration.

Water was first encountered in well 0205 in late June 2015 and has been present in the well since. Observations show that after a significant event or multiple precipitation events, the runoff collects into the retention ditch at the toe of the cell. 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 and eventually flows into the well. A sample was collected from well 0205 in December 2022, with the results presented in Table 6.

Between the March and late June 2019 quarterly monitoring events, water was first encountered in well 0202, located to the west of the completed portion of the disposal cell (Figure 17). Samples of this water were also collected in December 2022 and were submitted to the analytical lab (GEL) for the same analyte suite as that of samples collected from well 0205. The results of the analysis of the water sample collected from well 0202 are also presented in Table 6.

A short-term recovery test was completed in December 2022 on well 0205, and the recharge rate measured at 0.027 gpm. This is similar to the last completed recovery test in December 2020. Well 0202 recharged too slowly to conduct a recovery test.

The manner in which the well 0205 water elevation responds to the site precipitation since 2015 is graphically displayed on Figure 18, and the fluctuation of the recharge rate in response to precipitation is shown on Figure 19.

Table 6. 2022 Crescent Junction Wells 0202 and 0205 Analyte Concentrations

Analyte	Analyte Concentration	
	Well 0202	Well 0205
	12/5/22	12/5/22
Ammonia as N	10.3	13.9
Arsenic	0.0207	0.025
Barium	0.0165	0.0123
Bicarbonate as $CaCO_3$	1060	942
Bromide	59.1	9.6[J]
Cadmium	0.001[#]	0.001[#]
Calcium	432	357
Carbonate as $CaCO_3$	1.45[#]	2.42
Chloride	6570	3050
Chromium	0.00389	0.0038
Cobalt	0.00375	0.00221
Copper	0.0128	0.00907
Fluoride	0.66[#]	1.65
Iron	0.03[#]	0.03[#]
Lead	0.0105	0.00382
Magnesium	1670	748
Manganese	0.6	0.325
Molybdenum	0.002[#]	0.002[#]
Nitrate/Nitrite as N	456	550
Selenium	0.0847	2.83
Sodium	23500	9450

Table 6. 2022 Crescent Junction Wells 0202 and 0205 Analyte Concentrations (continued)

Sulfate	16800	16500
Total Alkalinity as $CaCO_3$	1,060	942
Total Dissolved Solids	45100	34500
Uranium $_{234}$	36.9 +/- 5.65 pCi/L	36.7 +/- 3.55 pCi/L
Uranium $_{235}$	1.32# +/- 1.09 pCi/L	0.438 +/- 0.483 pCi/L
Uranium $_{238}$	10.8 +/- 3.09 pCi/L	13.4 +/- 2.15 pCi/L
Uranium	0.0218	0.0339

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

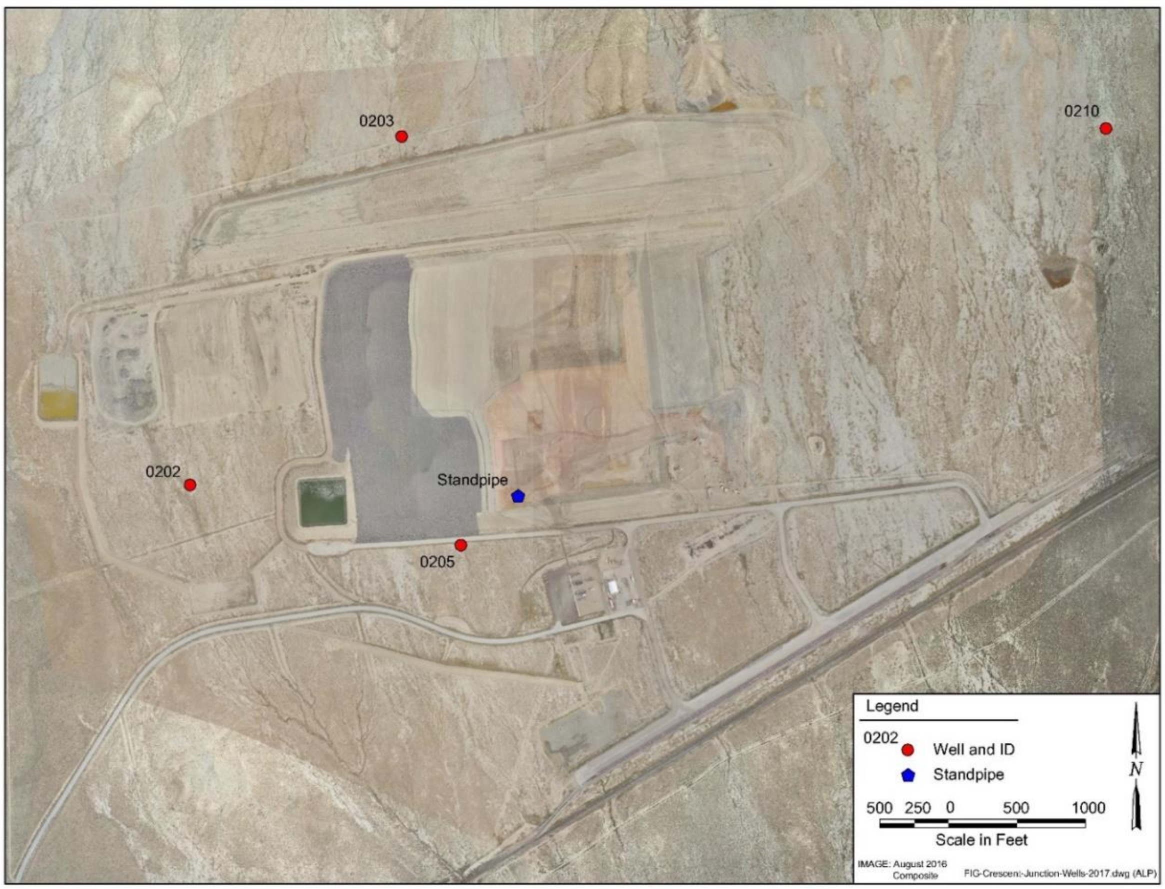

Figure 17. Crescent Junction Well Location Map

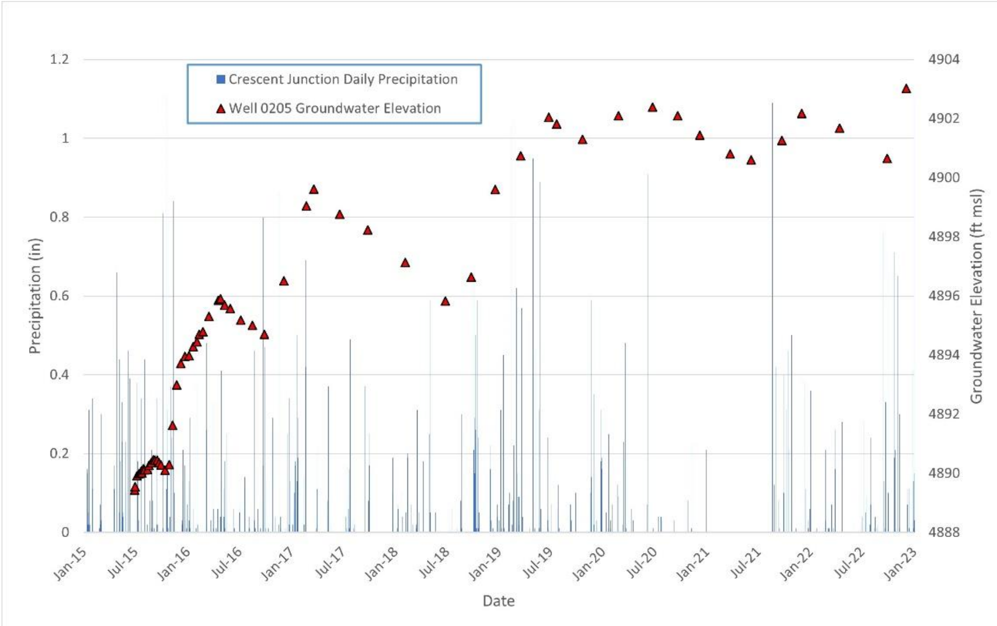

Figure 18. Crescent Junction Well 0205 Water Level Changes in Response to Precipitation through 2022

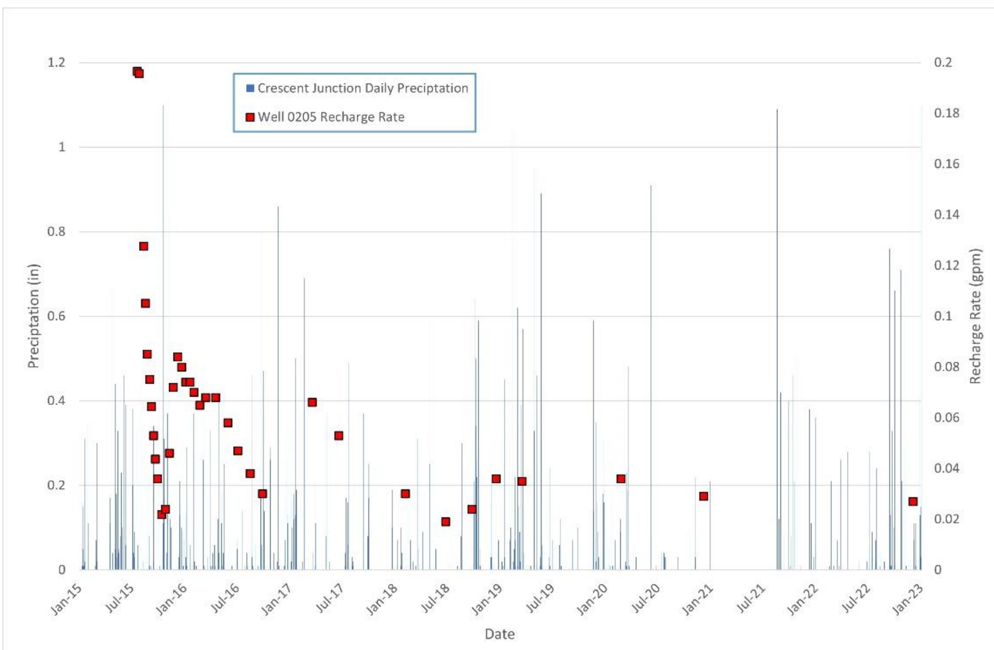

Figure 19. Crescent Junction Well 0205 Recharge Rate Changes In Response to Precipitation through 2022

8.0 Summary and Conclusions

In 2022, the IA operations focused on groundwater extraction (CF5) and freshwater injection (CF4). No critical habitat formed adjacent to the site, so no freshwater diversion occurred.

A total of 4.4 mil gal of water was extracted from CF5 in 2022. The extraction rate peaked in June, and operations continued through the fall. Seven of the eight extraction wells were utilized in 2022. Figure 20 shows the ammonia and uranium mass removed along with the volume of groundwater extracted from the CF5 extraction wells from 2003 through 2022.

The volume of extracted groundwater and removed contaminant mass were lower in 2022 compared to 2021. This was a result of the primary water truck maintenance issues during summer and early fall, when the extraction rate is typically highest. There were also several storm events in the fall that reduced the need for extraction water as dust suppression. A total of 8,960 lbs of ammonia and 89.7 lbs of uranium, was removed from the groundwater system in 2022.

Approximately 9.8 mil gal of freshwater was injected into CF4 in 2022. A below average river flow meant the injection system was used continuously, resulting in a higher volume of freshwater injected in 2022 compared to 2021. 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.

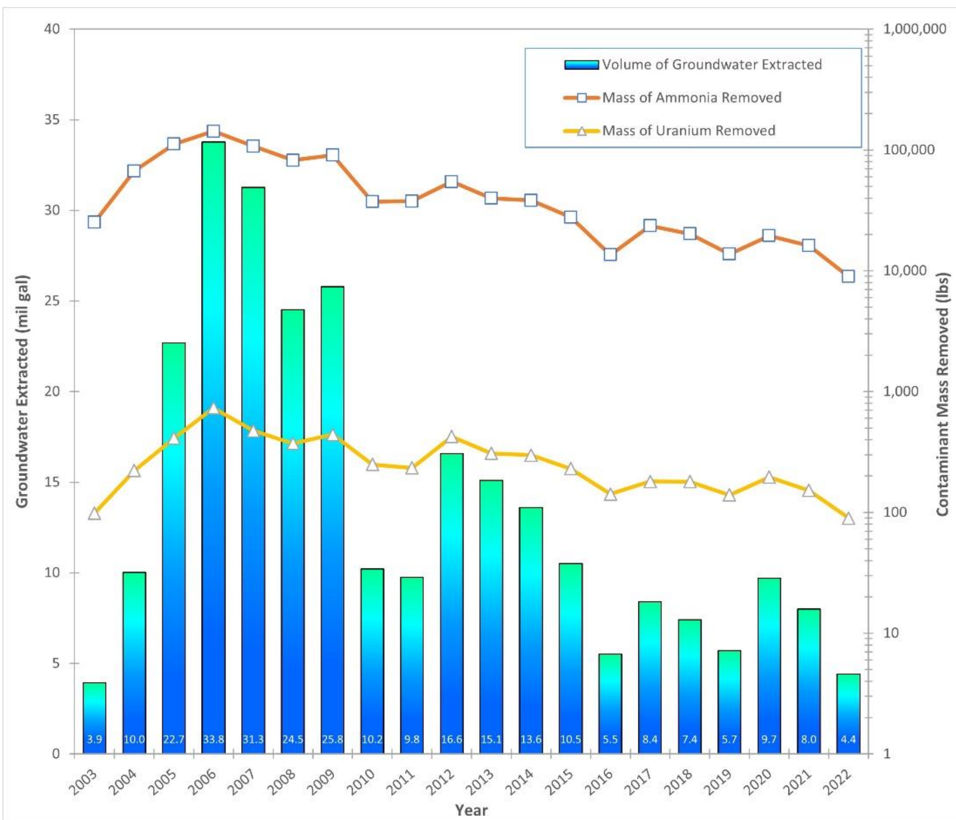

Figure 20. Groundwater Extracted Volume and Contaminant Mass Removal, 2003 through 2022

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/GJTAC1640).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2022* (DOE-EM/GJRAC3084).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring July through December 2022* (DOE-EM/GJRAC3098).

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 2022 Groundwater Extraction

Appendix A. Tables and Data for 2022 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. 2022 Chronology of CF5 Activities

Date	Activity
January	System winterized.
February	System winterized.
March	Restarted extraction system on March 23.
April	Extraction system operation in automatic mode.
May	Extraction system operation in automatic mode.
June	Extraction system operation in automatic mode. Largest water truck under repair last week of June.
July	Extraction system operation in automatic mode. Smaller water trucks through July. Largest water truck repaired last week of July
August	Extraction system operation in automatic mode. Water truck under repair.
September	Extraction system not used for majority of the month due to wet weather.
October	Extraction system operation in automatic mode. Smaller water trucks used to pull water. New battery installed at Klein tank system October 12.
November	System winterized November 16.
December	System winterized.

Table A-3. CF5 Extraction Volumes 2022

Well	Extraction Volumes Removed (gal)												
	26-Jan	23-Feb	30-Mar	27-Apr	25-May	29-Jun	27-Jul	30-Aug	28-Sep	26-Oct	30-Nov	28-Dec	Well Total
810	0	0	9,354	100,159	160,997	157,789	21,541	74,766	12,202	9,166	5,603	0	**551,577**
811	0	0	1,794	49,671	63,903	68,895	10,447	30,471	1,996	3,141	2,300	0	**232,618**
812	0	0	19,295	66,225	94,388	95,538	9,783	42,166	3,942	1,976	3,234	0	**336,547**
813	0	0	51,995	173,071	187,299	296,674	64,116	138,694	21,874	16,265	9,856	0	**959,844**
814	0	0	0	0	0	0	0	0	0	0	0	0	**0**
815	0	0	27,236	127,682	157,964	152,034	31,756	57,509	12,142	9,243	0	0	**575,566**
816	0	0	48,644	213,543	308,664	258,258	53,294	140,845	20,441	15,210	9,356	0	**1,068,255**
SMI-PW02	0	0	28,390	140,675	181,381	184,638	30,577	88,928	12,169	7,024	5,495	0	**679,277**
Monthly Total	**0**	**0**	**186,708**	**871,026**	**1,154,596**	**1,213,826**	**221,514**	**573,379**	**84,766**	**62,025**	**35,844**	**0**	
Annual Total													**4,403,684**

Table A-4. CF5 Ammonia Mass Removal 2022

Well	Ammonia Mass Removed (lbs)												
	26-Jan	23-Feb	30-Mar	27-Apr	25-May	29-Jun	27-Jul	30-Aug	28-Sep	26-Oct	30-Nov	28-Dec	Well Total
810	0	0	22	234	376	369	45	156	25	19	12	0	**1258**
811	0	0	5	128	165	178	27	79	5	8	6	0	**602**
812	0	0	50	171	244	247	28	120	11	6	9	0	**886**
813	0	0	135	448	485	767	155	336	53	39	24	0	**2441**
814	0	0	0	0	0	0	0	0	0	0	0	0	**0**
815	0	0	34	160	198	190	26	48	10	8	0	0	**674**
816	0	0	49	214	309	259	49	129	19	14	9	0	**1050**
SMI-PW02	0	0	88	434	560	570	84	245	34	19	15	0	**2049**
Monthly Total	**0**	**0**	**381**	**1789**	**2337**	**2580**	**414**	**1112**	**157**	**113**	**74**	**0**	
Annual Total													**8,960**

Table A-5. CF5 Uranium Mass Removal 2022

Well	Uranium Mass Removed (lbs)												
	26-Jan	23-Feb	30-Mar	27-Apr	25-May	29-Jun	27-Jul	30-Aug	28-Sep	26-Oct	30-Nov	28-Dec	Well Total
810	0.0	0.0	0.2	2.1	3.4	3.3	0.5	1.7	0.3	0.2	0.1	0.0	**11.8**
811	0.0	0.0	0.0	1.1	1.4	1.6	0.2	0.6	0.0	0.1	0.0	0.0	**5.1**
812	0.0	0.0	0.3	1.1	1.6	1.6	0.2	0.7	0.1	0.0	0.1	0.0	**5.7**
813	0.0	0.0	0.7	2.5	2.7	4.2	1.0	2.2	0.3	0.3	0.2	0.0	**14.0**
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	0.7	3.1	3.8	3.7	0.8	1.4	0.3	0.2	0.0	0.0	**13.9**
816	0.0	0.0	1.1	4.6	6.7	5.6	1.2	3.1	0.4	0.3	0.2	0.0	**23.2**
SMI-PW02	0.0	0.0	0.7	3.3	4.2	4.3	0.7	2.2	0.3	0.2	0.1	0.0	**16.0**
Monthly Total	**0.0**	**0.0**	**3.7**	**17.8**	**23.8**	**24.2**	**4.6**	**11.9**	**1.8**	**1.3**	**0.7**	**0.0**	
Annual Total													**89.7**

Appendix B.

Tables and Data for 2022 Freshwater Injection

Appendix B. Tables and Data for 2022 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

Appendix B. Tables and Data for 2022 Freshwater Injection (*continued*)

Table B-2. 2022 Chronology of CF4 Activities

Month	Activity
January	Replaced pressure sensor at 15 hp injection pump. Restarted injection on 1/18.
February	Injection operated normally.
March	Injection operated normally.
April	Injection periodically down for potential storms and power outages. VFD parameters modified, and maintenance performed.
May	Injection shut down from 5/13 to 5/25 as river discharge was over 11,000 cfs and the spin filter needed maintenance.
June	Injection operated normally.
July	Well development was performed on injection wells by HRL Drilling from 7/26 to 7/28. Wells were generally surged three times and water evacuated. Well 0779 had low recharge and could not be developed.
August	Injection operated normally.
September	Injection operated normally.
October	Injection operated normally.
November	Injection operated normally.
December	Injection continued through winter.

Table B-3. CF4 Observation Well Analytical Sample Results 2022

Location	Location from Injection	Sample Depth (ft bgs)	Date	Ammonia as N (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0780	Upgradient	28	7/6/22	0.2	0.0074	655
0781	Upgradient	46	7/6/22	1000	3.2	62,508
0782	Upgradient	33	7/6/22	8.2	0.051	1,298
0783	Upgradient	18	7/6/22	0.2	0.03	1,314
0784	Downgradient	18	7/11/22	0.2	0.0041	743
0785	Downgradient	18	7/11/22	0.2	0.012	747
0786	Downgradient	28	7/11/22	0.2	0.0076	715
0787	Downgradient	36	7/11/22	470	1.7	31,969

Note: µmhos/cm = micromhos per centimeter

Appendix B. Tables and Data for 2022 Freshwater Injection (*continued*)

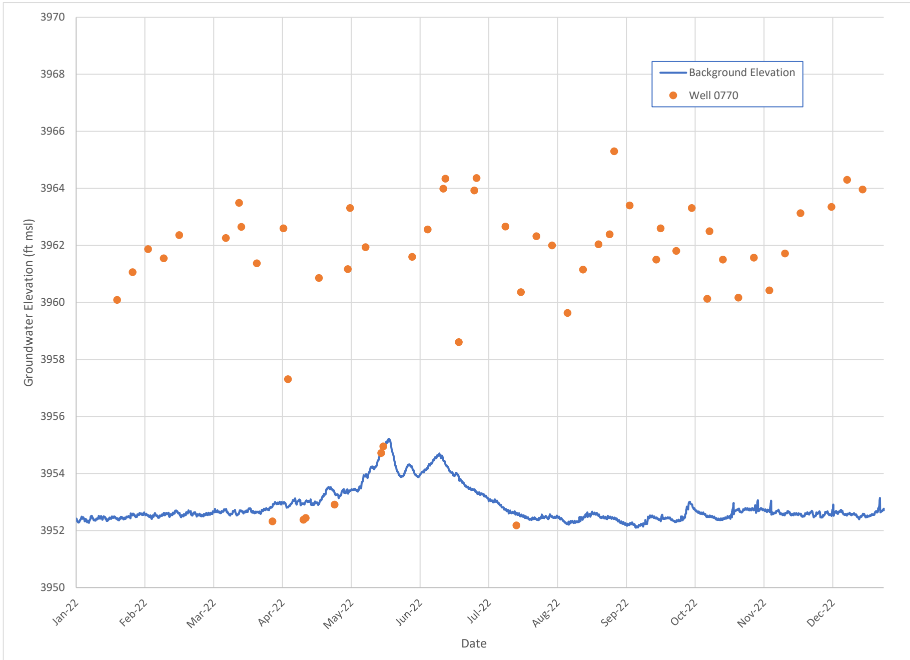

Figure B-1. Freshwater Mounding in Remediation Well 0770 during Injection

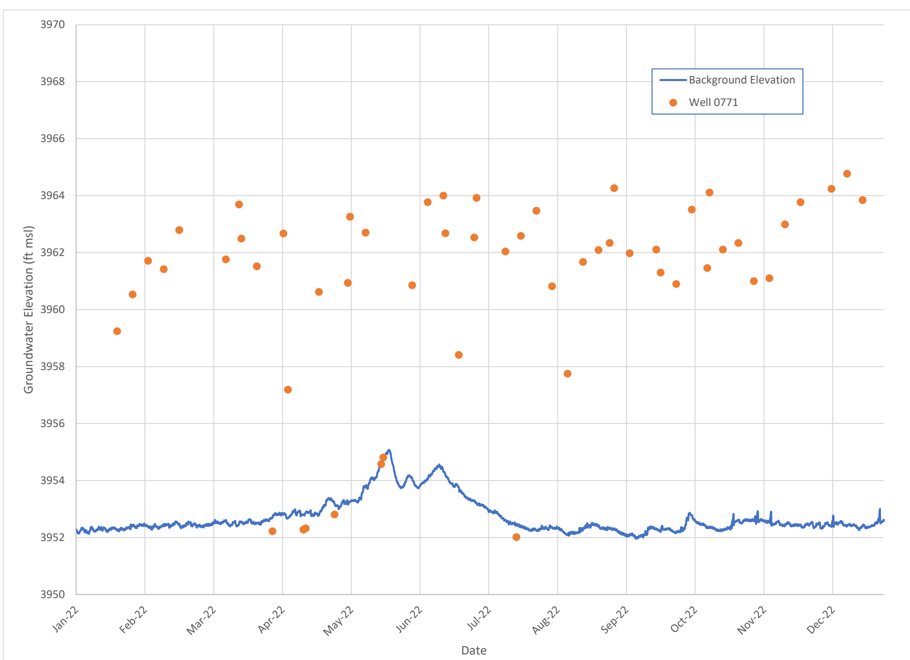

Figure B-2. Freshwater Mounding in Remediation Well 0771 during Injection

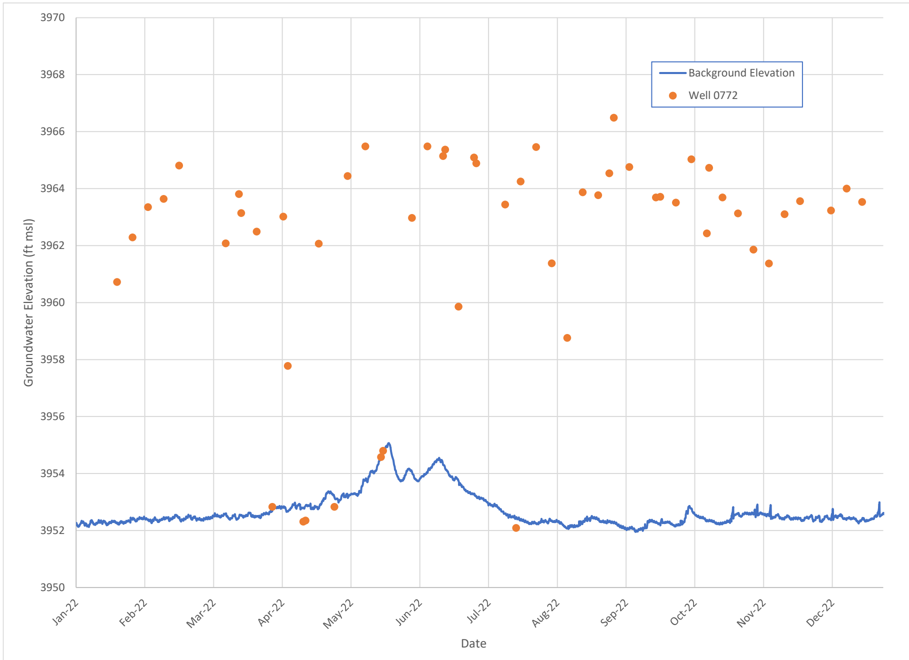

Figure B-3. Freshwater Mounding in Remediation Well 0772 during Injection

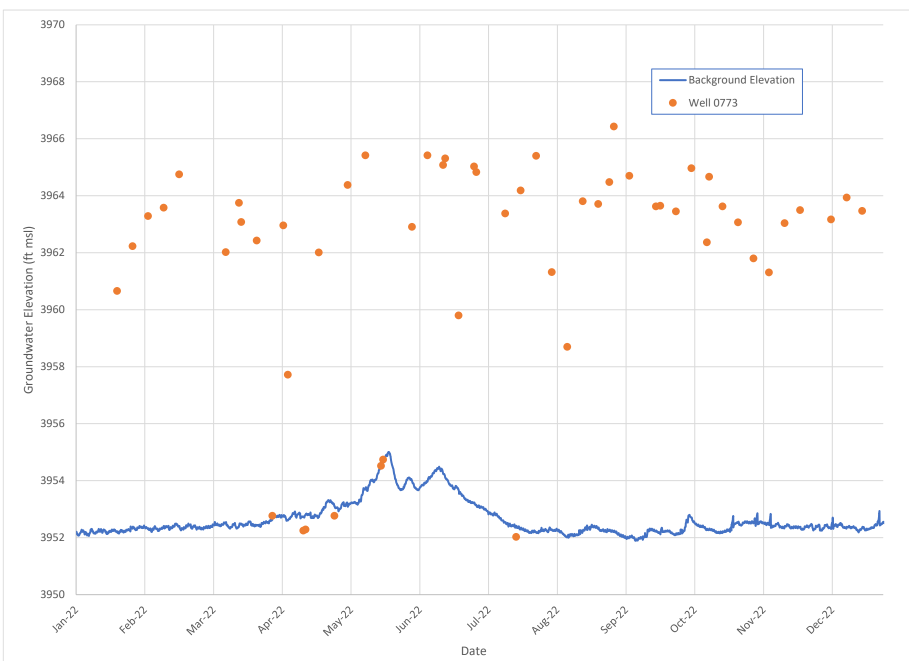

Figure B-4. Freshwater Mounding in Remediation Well 0773 during Injection

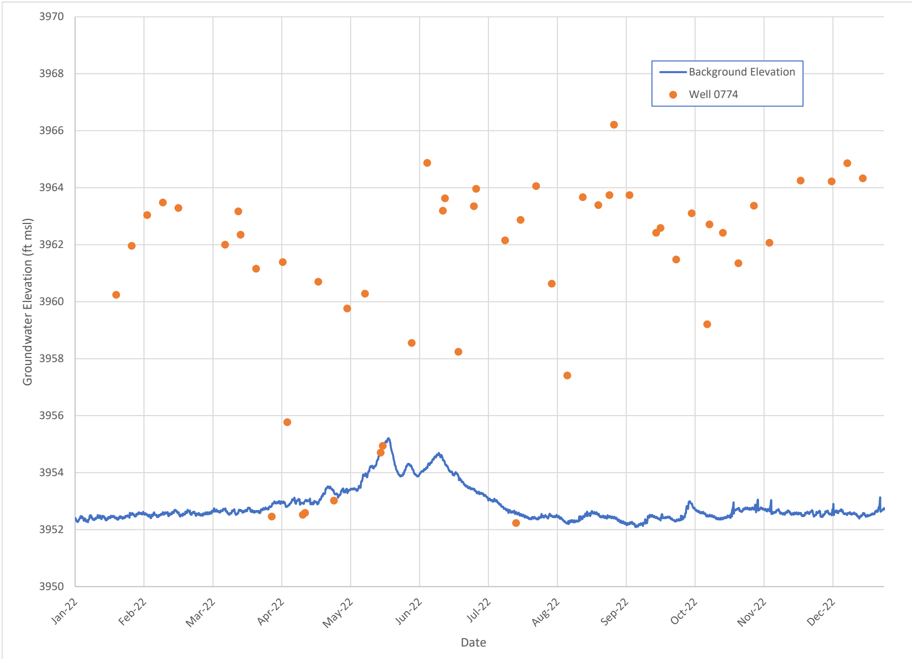

Figure B-5. Freshwater Mounding in Remediation Well 0774 during Injection

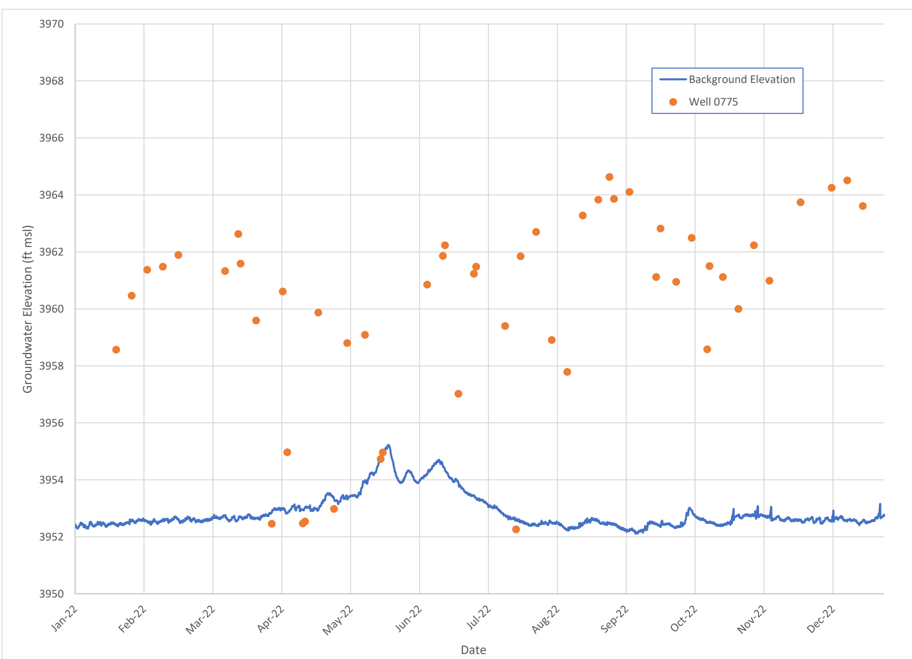

Figure B-6. Freshwater Mounding in Remediation Well 0775 during Injection

Appendix B. Tables and Data for 2022 Freshwater Injection (*continued*)

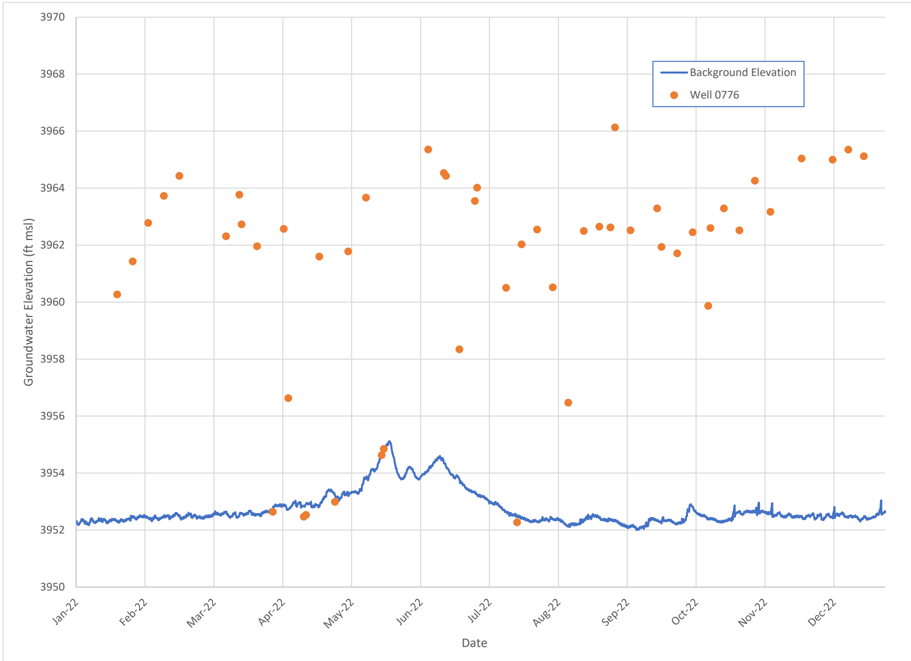

Figure B-7. Freshwater Mounding in Remediation Well 0776 during Injection

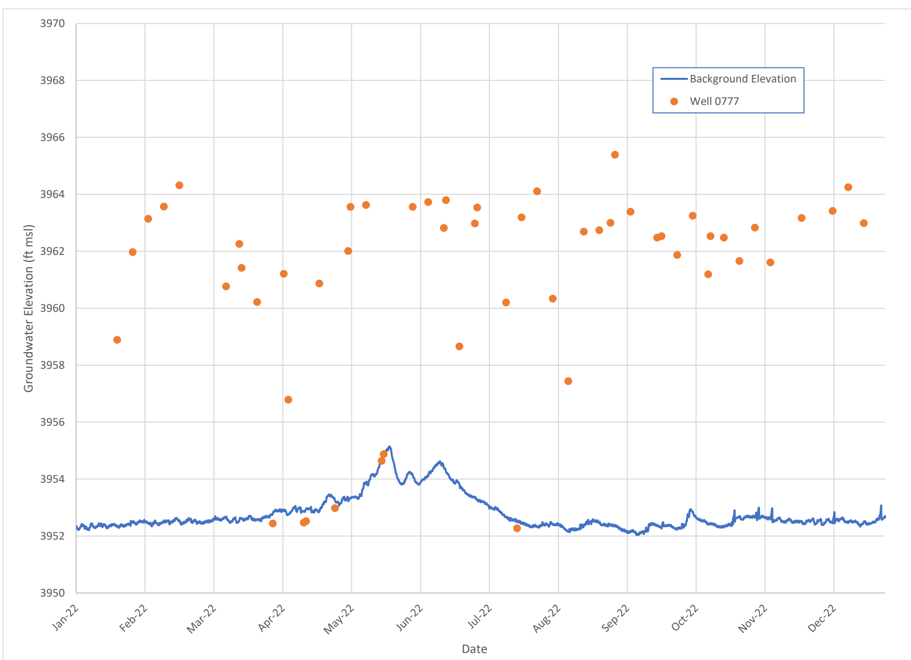

Figure B-8. Freshwater Mounding in Remediation Well 0777 during Injection

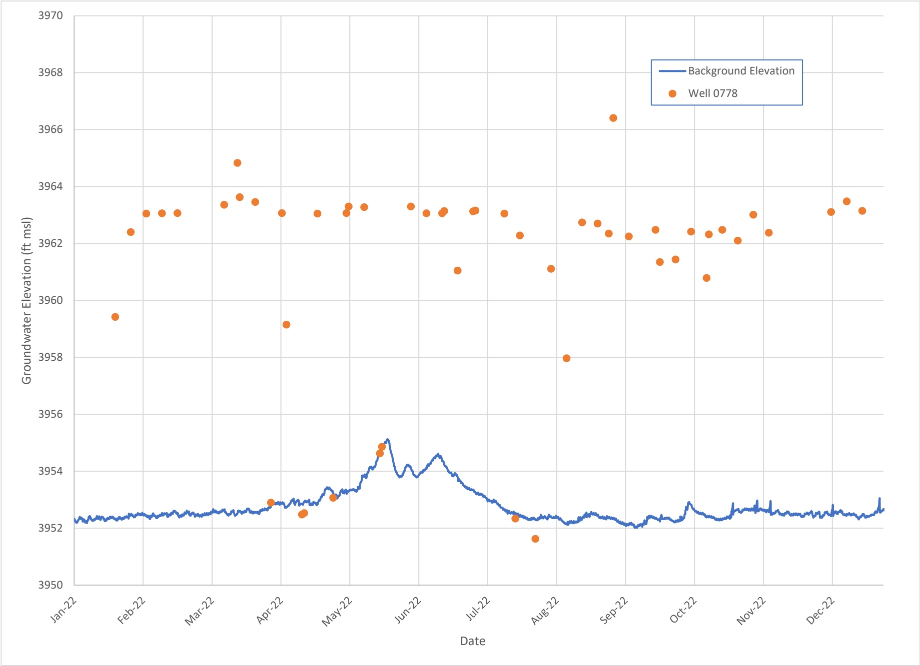

Figure B-9. Freshwater Mounding in Remediation Well 0778 during Injection

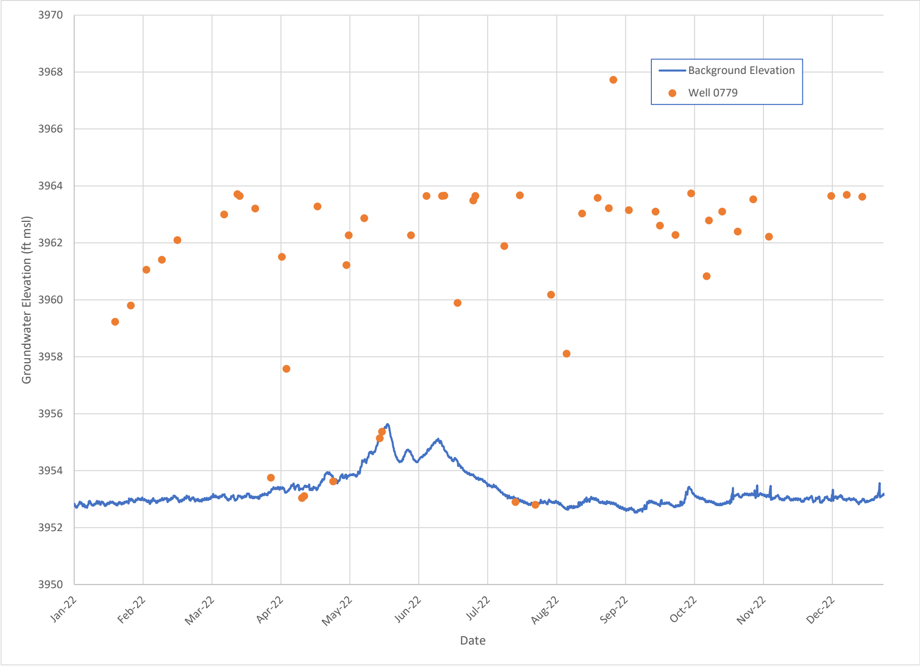

Figure B-10. Freshwater Mounding in Remediation Well 0779 during Injection

Appendix B. Tables and Data for 2022 Freshwater Injection (*continued*)

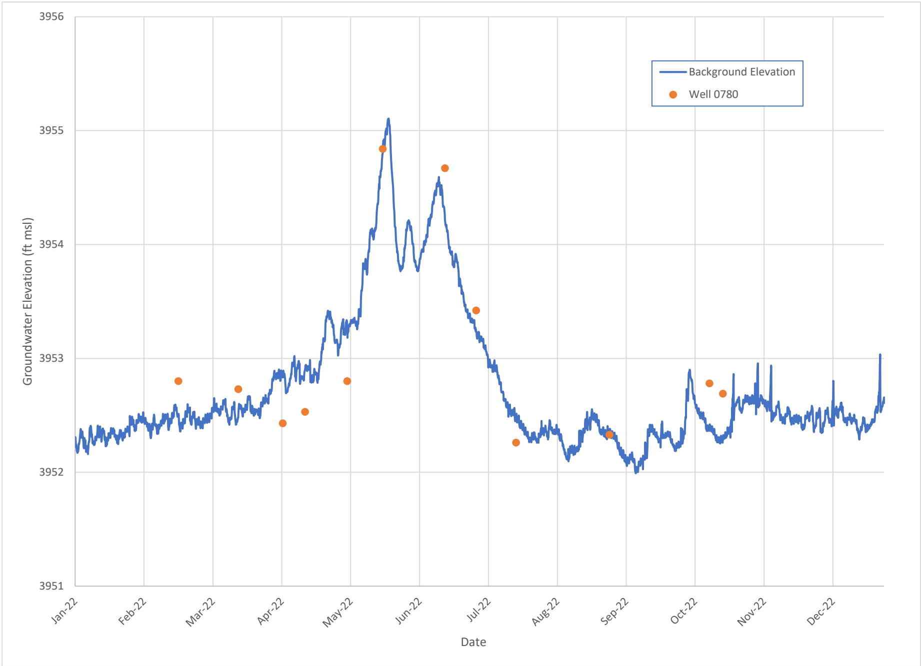

Figure B-11. Freshwater Mounding in Observation Well 0780

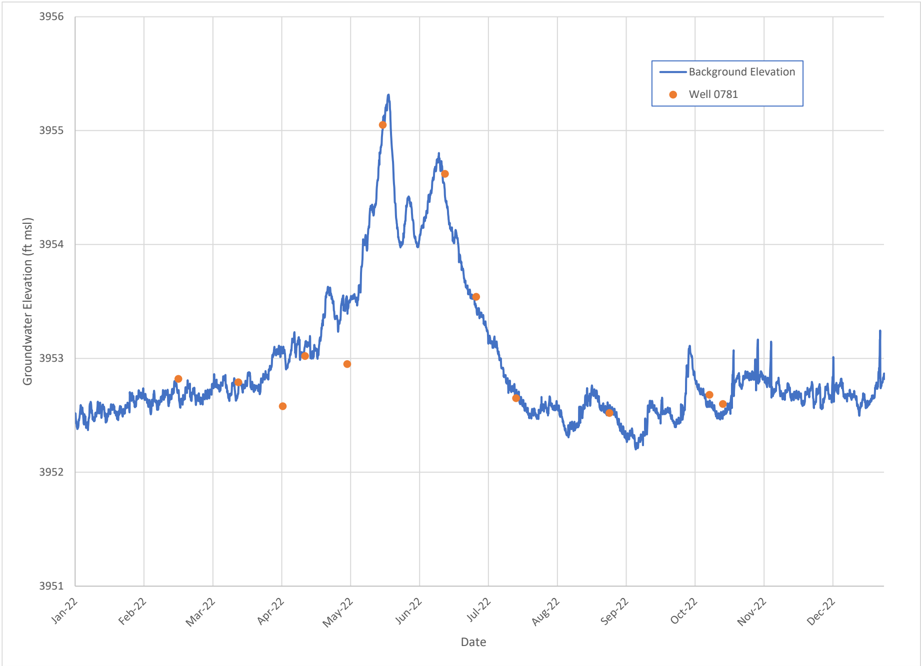

Figure B-12. Freshwater Mounding in Observation Well 0781

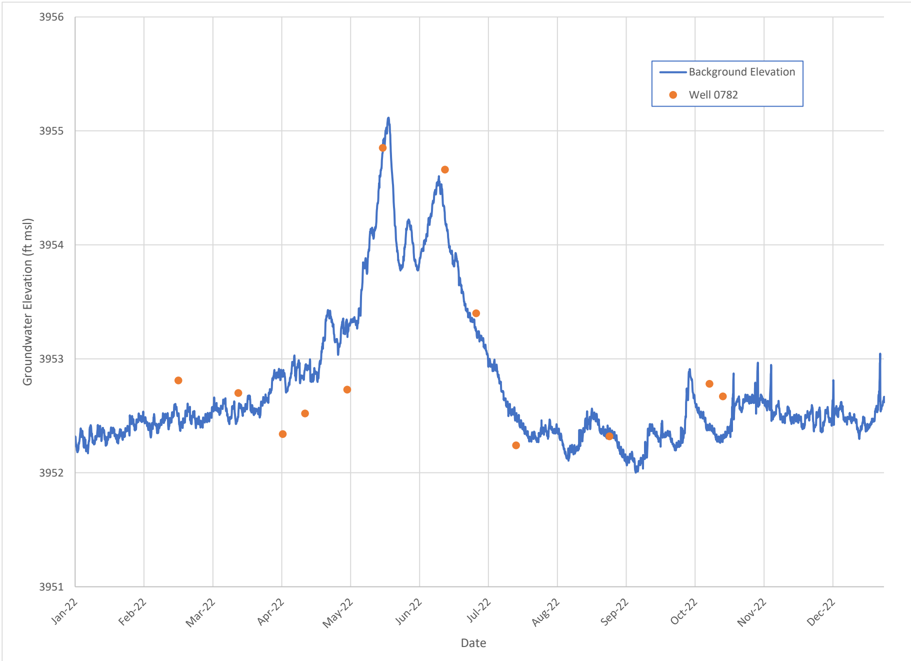

Figure B-13. Freshwater Mounding in Observation Well 0782

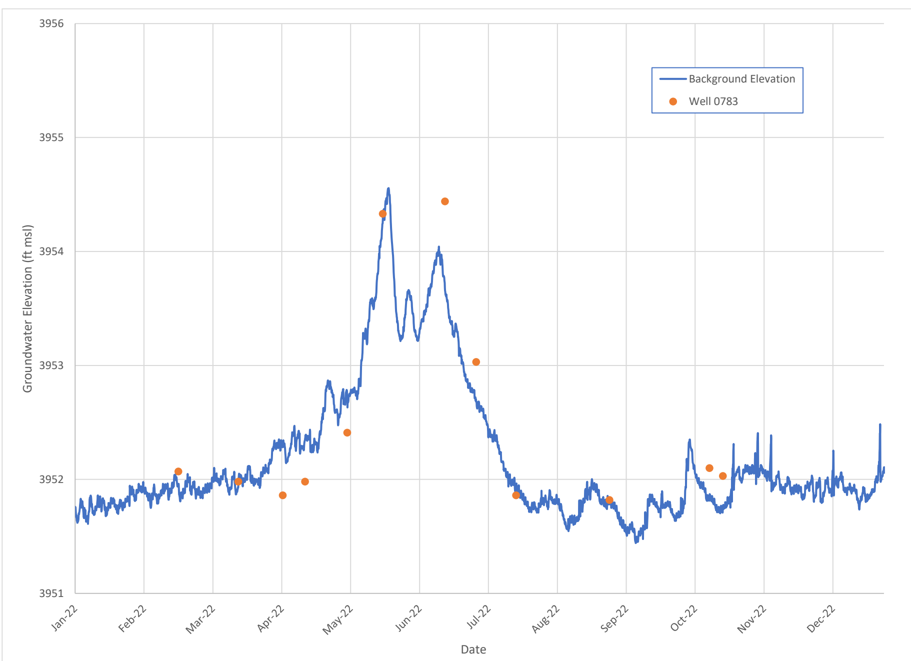

Figure B-14. Freshwater Mounding in Observation Well 0783

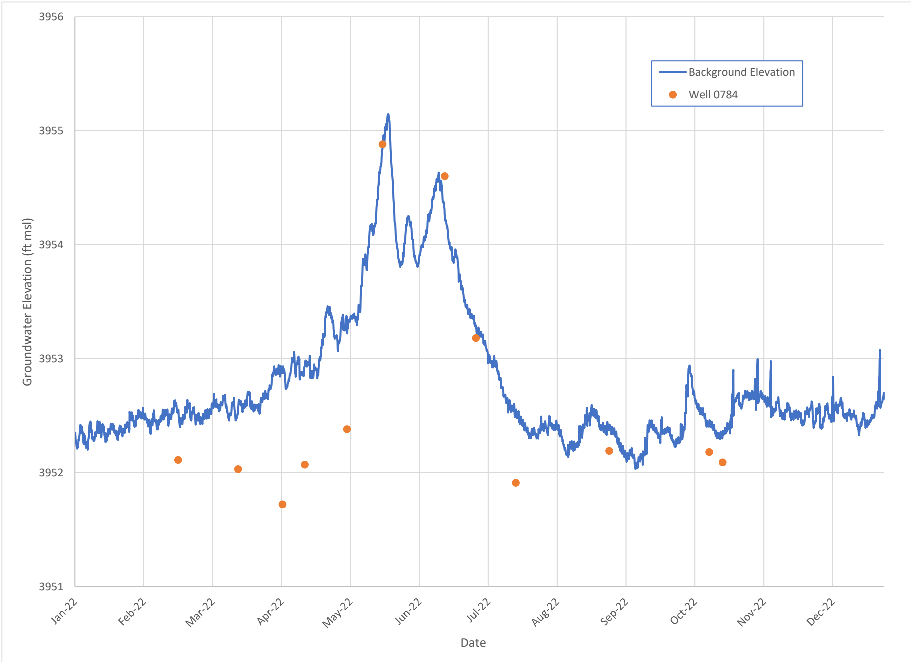

Figure B-15. Freshwater Mounding in Observation Well 0784

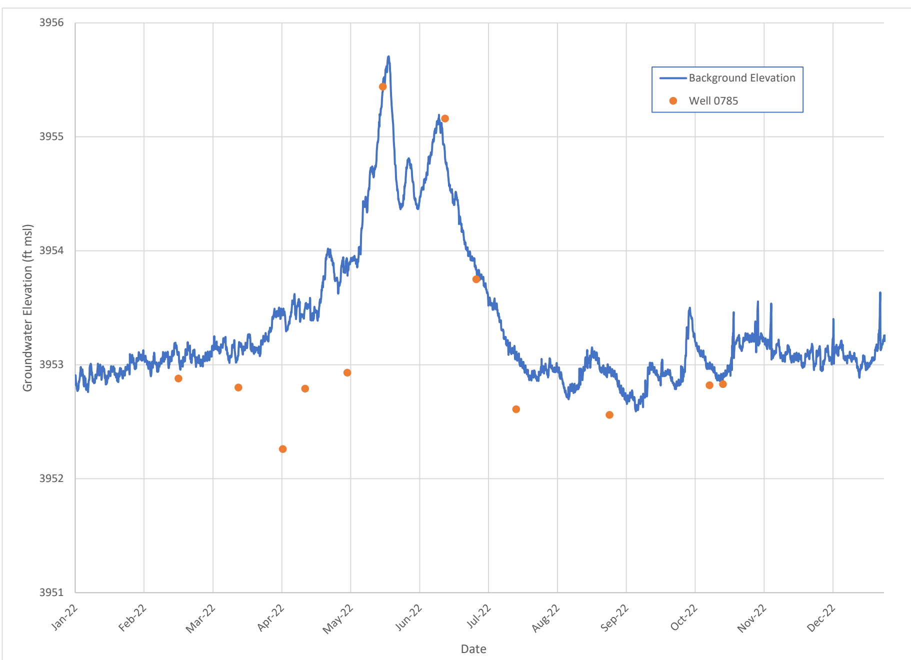

Figure B-16. Freshwater Mounding in Observation Well 0785

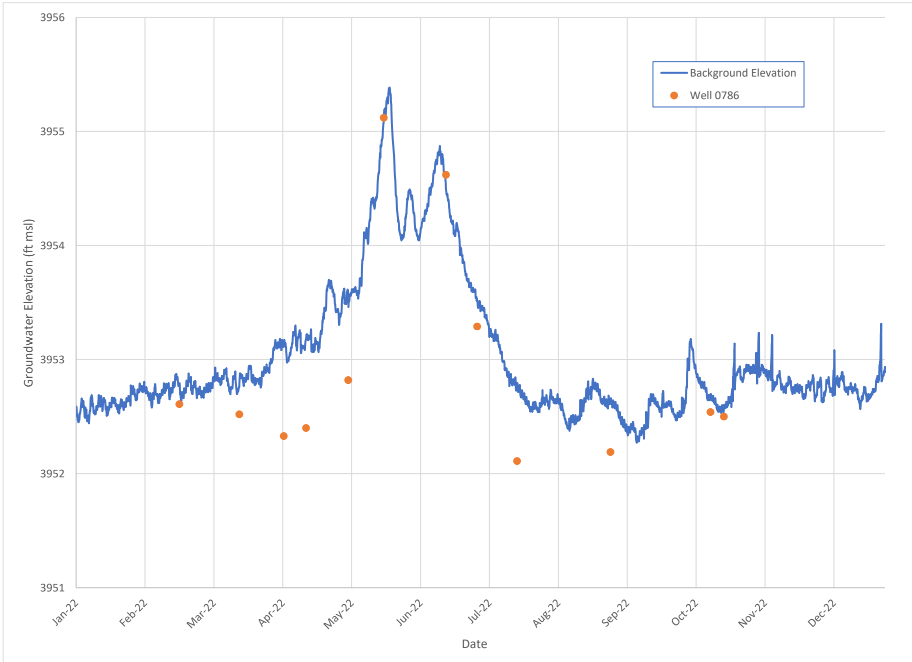

Figure B-17. Freshwater Mounding in Observation Well 0786

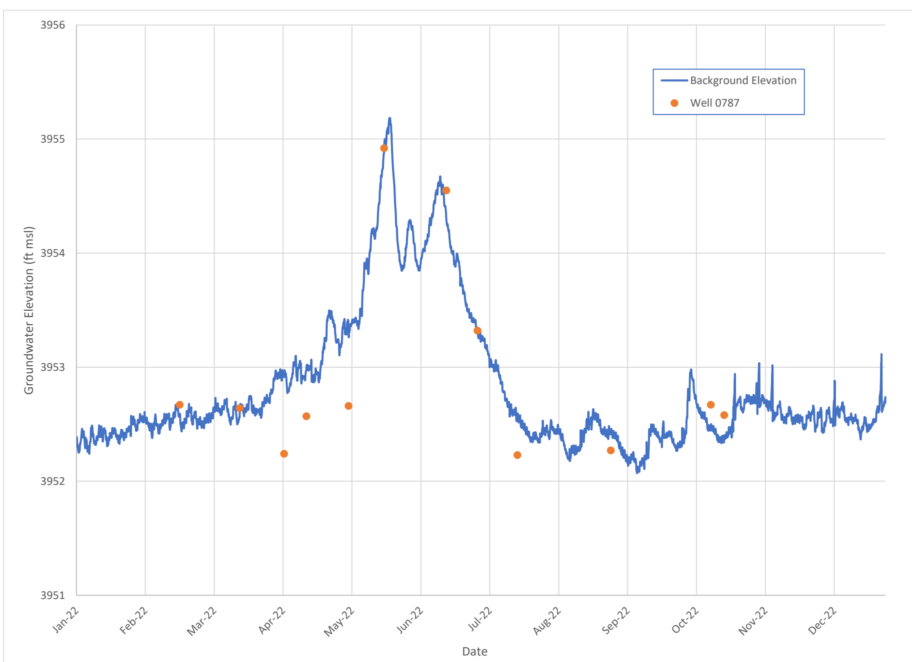

Figure B-18. Freshwater Mounding in Observation Well 0787