DOE–EM/GJTAC2270

Office of Environmental Management – Grand Junction

UMTRA Project

Moab UMTRA Project
2017 Groundwater Program Report

October 2018

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-EM0005014 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Revision 0

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Revision 0

Review and Approval

FOR 10/25/18

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10/25/18

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10/25/18

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Revision History

Revision	Date	Reason for Revision
0	October 2018	Initial issue.

Contents

Figures

Figures (*continued*)

Tables

Appendices

Acronyms and Abbreviations

ALS	ALS Global
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
gal	gallon or gallons
gpm	gallons per minute
HMI	human machine interface
IA	interim action
kg	kilograms
lb	pounds
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 performance measures the U.S. Department of Energy (DOE) has taken to remediate groundwater at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site and to protect endangered fish habitat in the Colorado River adjacent to the site. This report describes the Groundwater Program activities for the Moab Project during 2017 and evaluates how the groundwater system at the Moab site responds to various pumping regimes and fluctuating river flow.

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 in 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, including 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 to 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, as necessary, its ongoing active remediation of contaminated groundwater at the Moab site. As an interim action (IA), DOE began limited groundwater remediation that involves extraction of contaminated groundwater from on-site remediation wells and evaporation of the extracted water in a lined pond. Diverted river water is also injected into remediation wells to protect fish habitat in riparian areas along the Colorado River.

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 species habitat areas along the Colorado River. This protection is accomplished by removing contaminant mass with groundwater extraction wells and by freshwater injection between the river and the tailings pile to create a hydraulic barrier that reduces discharge of contaminated water to suitable habitat areas. When necessary, surface water diversion takes place in the side channel adjacent to the IA well field when the area is considered a suitable habitat for endangered young-of-year fish species.

Groundwater and surface water monitoring is performed in conjunction with injection and extraction operations and through water level and analytical data. Surface water diversion performance is measured by analytical data.

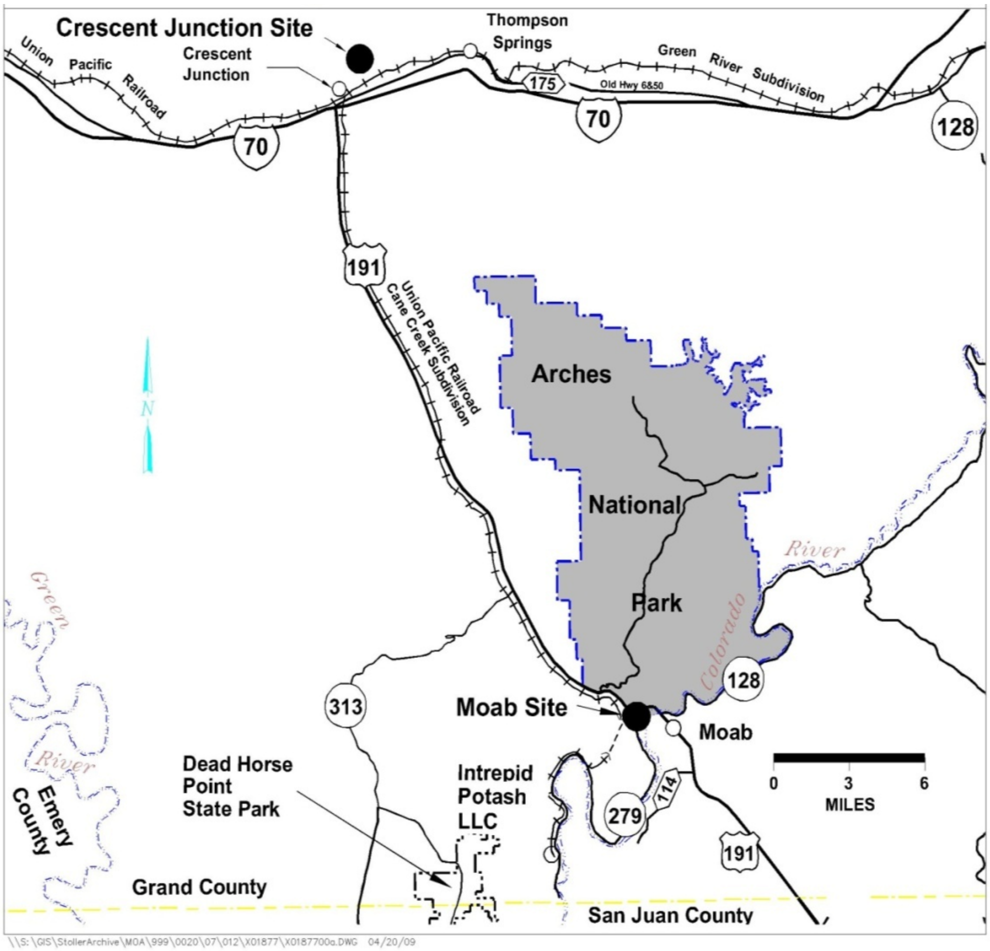

Figure 1. Location of the Moab Project Site

2.1 IA Groundwater System

DOE 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) reduce the discharge of ammonia-contaminated groundwater to side channels that may be suitable habitat for endangered aquatic species, 2) remove contaminant mass through groundwater extraction, 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 diverted river water into the underlying alluvium through remediation wells (CF4) and an infiltration trench installed near the western bank of the river. A surface water diversion system adjacent to the IA well field delivers fresh water to the side channel adjacent to the IA well field.

This diversion occurs when the channel is considered a suitable habitat for endangered young-of-year fish species and the ammonia concentrations exceed either the acute or chronic established U.S. Environmental Protection Agency (EPA) criteria. Monitoring wells are also part of the IA system for evaluation purposes. In 2017, CF4 was used for freshwater injection and extraction operations occurred at CF5.

Figure 2. Location of IA Wells

2.2 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site consists of unconsolidated alluvium and salt beds of the Paradox Formation. The alluvium at the Moab site 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 northwestern 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 consists mostly 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 an hydraulic conductivity that ranges from 100 to 200 ft/day.

Water table contour maps indicate the groundwater in this area discharges into the Colorado River. Figure 3 was generated using data collected in May/June 2017 and exhibits how groundwater underlying the site discharges into the Colorado River. The river flow ranged from 15,800 to 26,200 cubic feet per second (cfs) when the groundwater elevations were measured. Figure 4 shows the groundwater contours in December/January 2017/2018, when the river flow ranged from 3,250 to 4,050 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 occurs naturally 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 stresses such as 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, the flux of relatively fresh water entering the site upgradient of the tailings pile may have diluted the ammonia levels in the shallow groundwater (Figures 5 and 6).

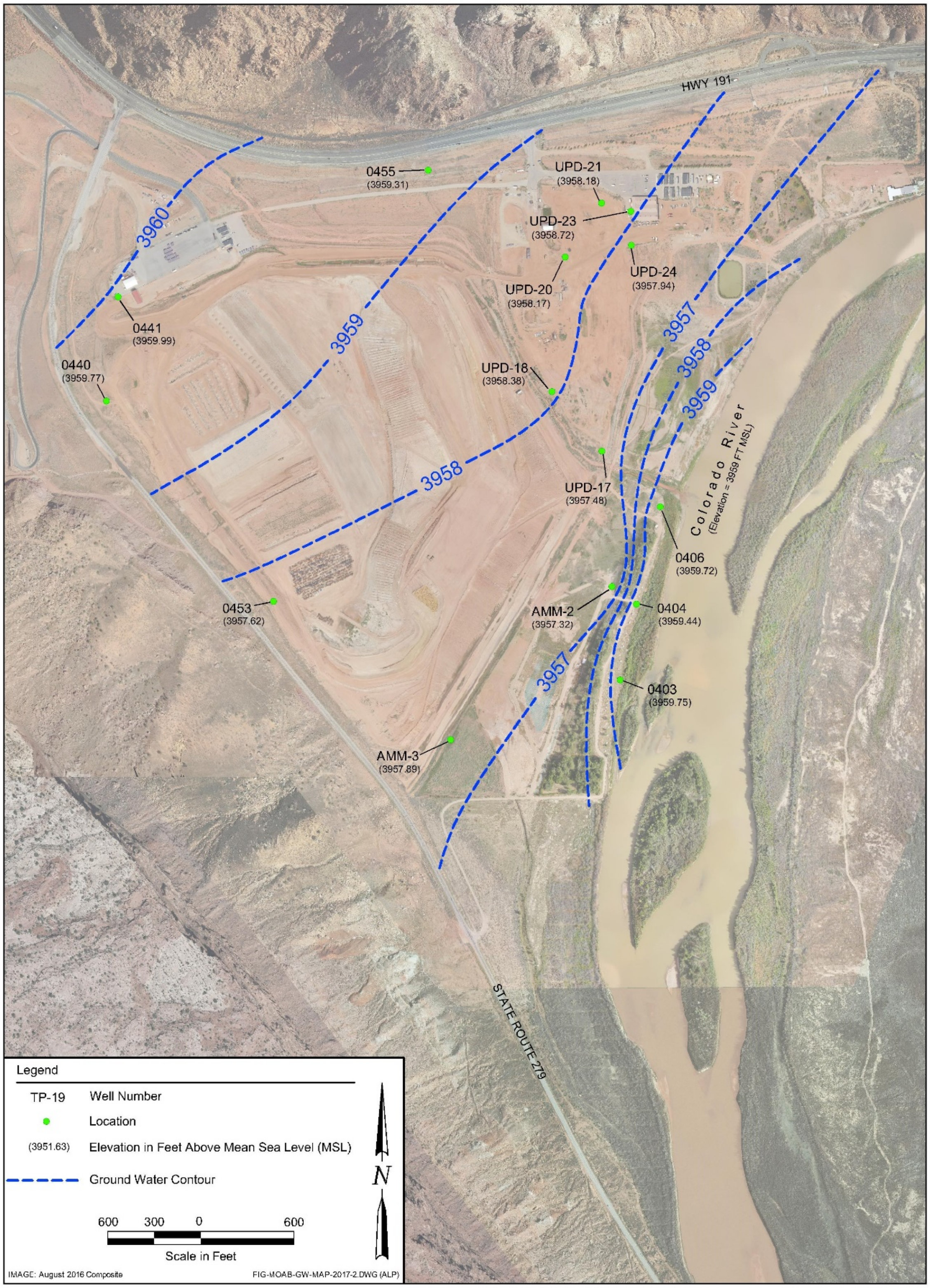

Figure 3. Site-wide Groundwater Surface Contour Map May 23 through June 14, 2017

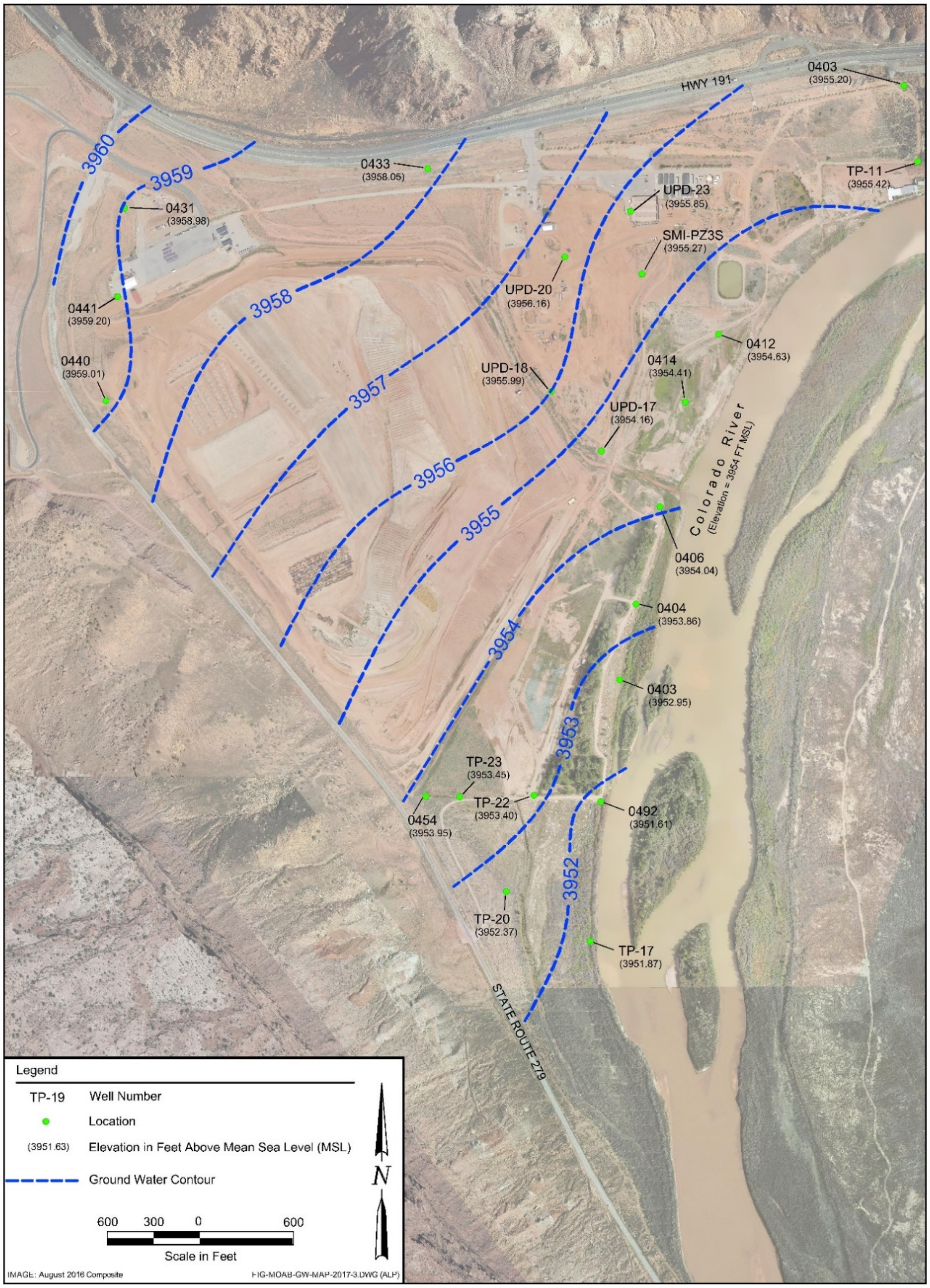

Figure 4. Site-wide Groundwater Surface Contour Map December/January 2017/2018

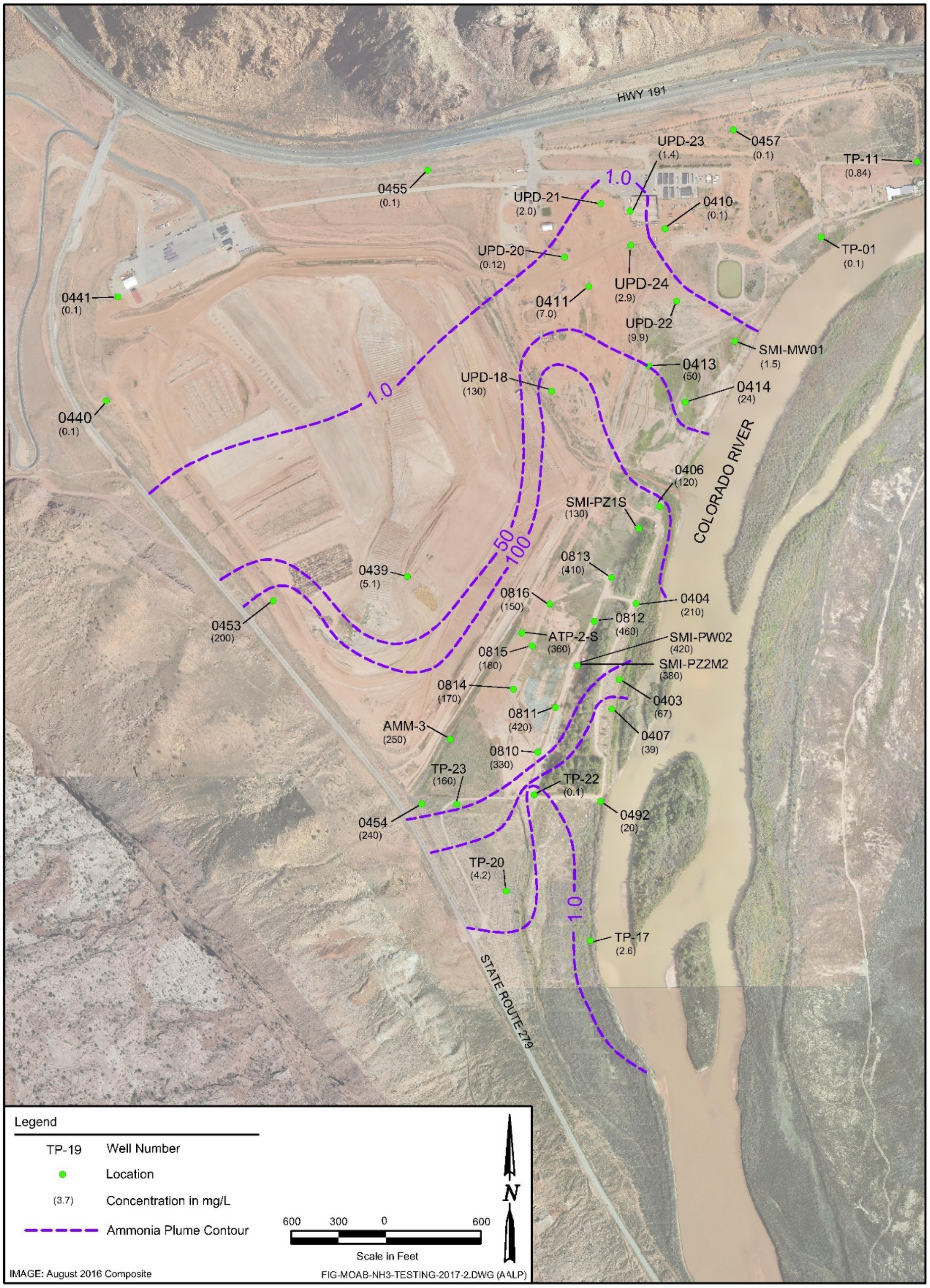

Figure 5. Ammonia Plume in Shallow Groundwater May/June 2017

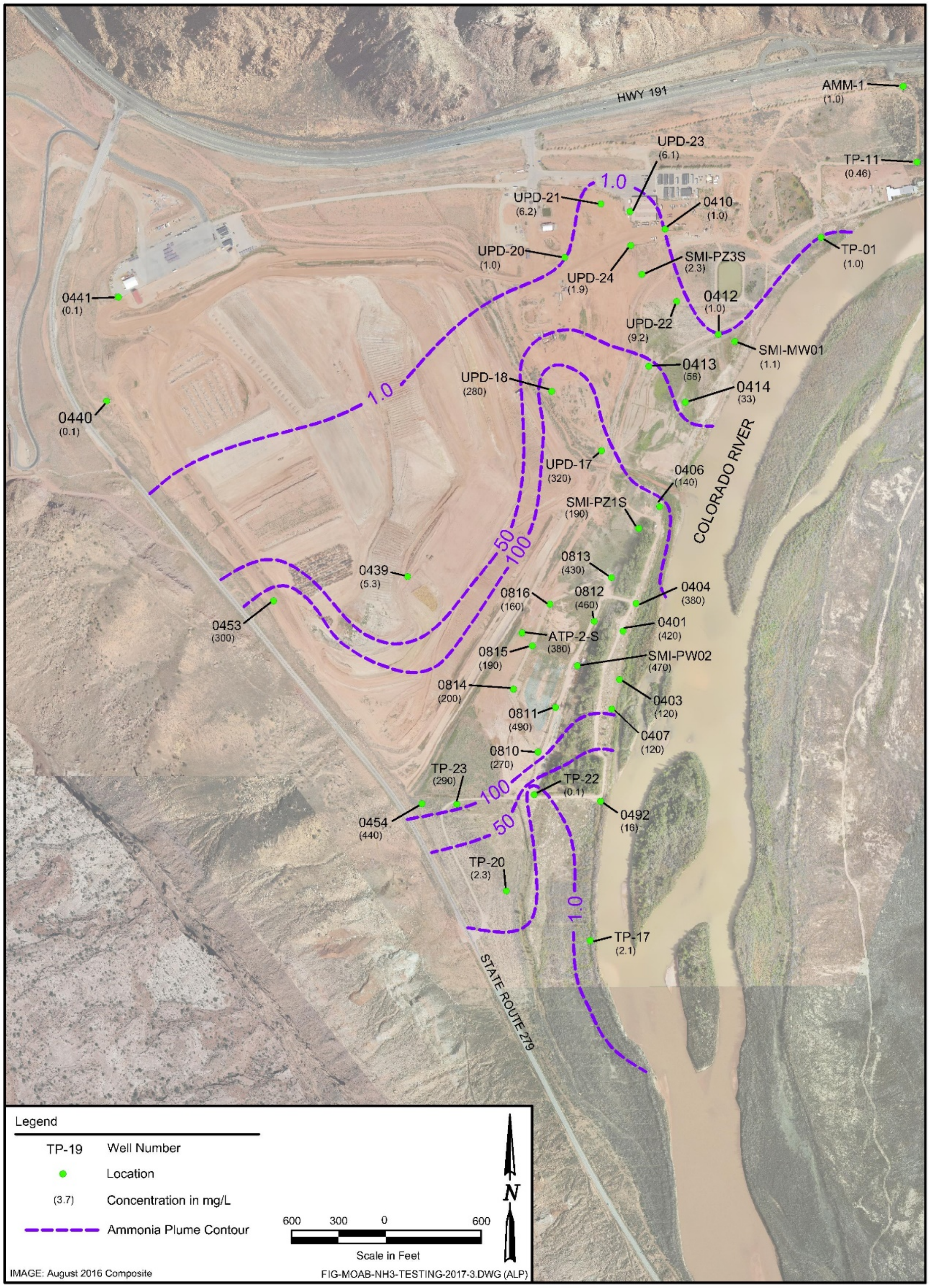

Figure 6. Ammonia Plume in Shallow Groundwater December/January 2017/2018

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 now flushing of the legacy plume by advective flow of fresh water due to density stratification of the brine zone. Figure 5 shows the ammonia plume in May/June 2017, and Figure 6 shows the ammonia plume in December/January 2017/2018. The two plume maps are comparable.

There is no standard associated with ammonia, while 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." In addition to ammonia, the other primary constituent of concern in groundwater is uranium. Figures 7 and 8 show the distribution of dissolved uranium in shallow groundwater in 2017. The uranium plume is similar in the early summer and winter.

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 5,000 cfs), groundwater discharges into the 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 starts to develop in the alluvium underlying the well field.

At this time, the groundwater gradient direction reverses in the vicinity of the riverbank, and the groundwater contaminant concentrations are diluted. Once the river flows subside, the river switches back from losing to gaining, the groundwater gradient direction is re-established towards the river (to the southeast), and the freshwater lens recedes.

Figure 9 displays the groundwater elevation and the elevation of the Colorado River in 2017. The elevation of the Colorado River was calculated using the river flows from the USGS Cisco gaging station and converting them to an elevation using the site rating curve included in the *Moab UMTRA Project Flood Mitigation Plan* (DOE-EM/GJTAC1640). The 2017 mean daily peak flow was 26,200 cfs (on June 10), which corresponds to an elevation of 3963.0 ft mean sea level (msl).

Between January and mid-March of 2017, the Colorado River was under gaining conditions (when the groundwater elevation was higher than the river surface elevation). Because of this elevation difference, the groundwater discharges into the river (Figure 9). In mid-March as the river stage increased due to the spring runoff, the river switched to losing conditions (with the river surface elevation higher than the groundwater elevation) through June 2017. Starting in July 2017, the river switched back primarily to gaining conditions.

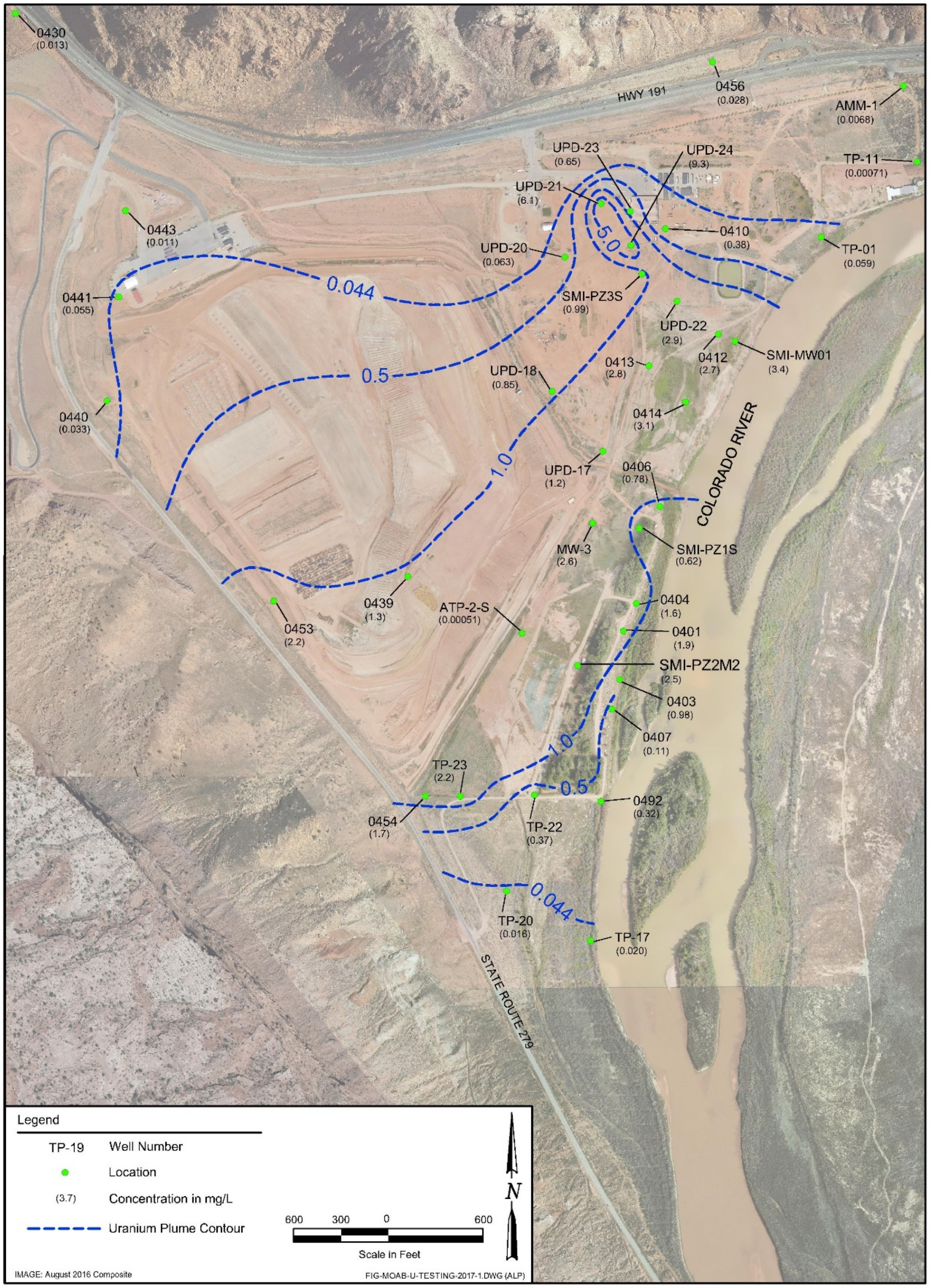

Figure 7. Uranium Plume in Shallow Groundwater May/June 2017

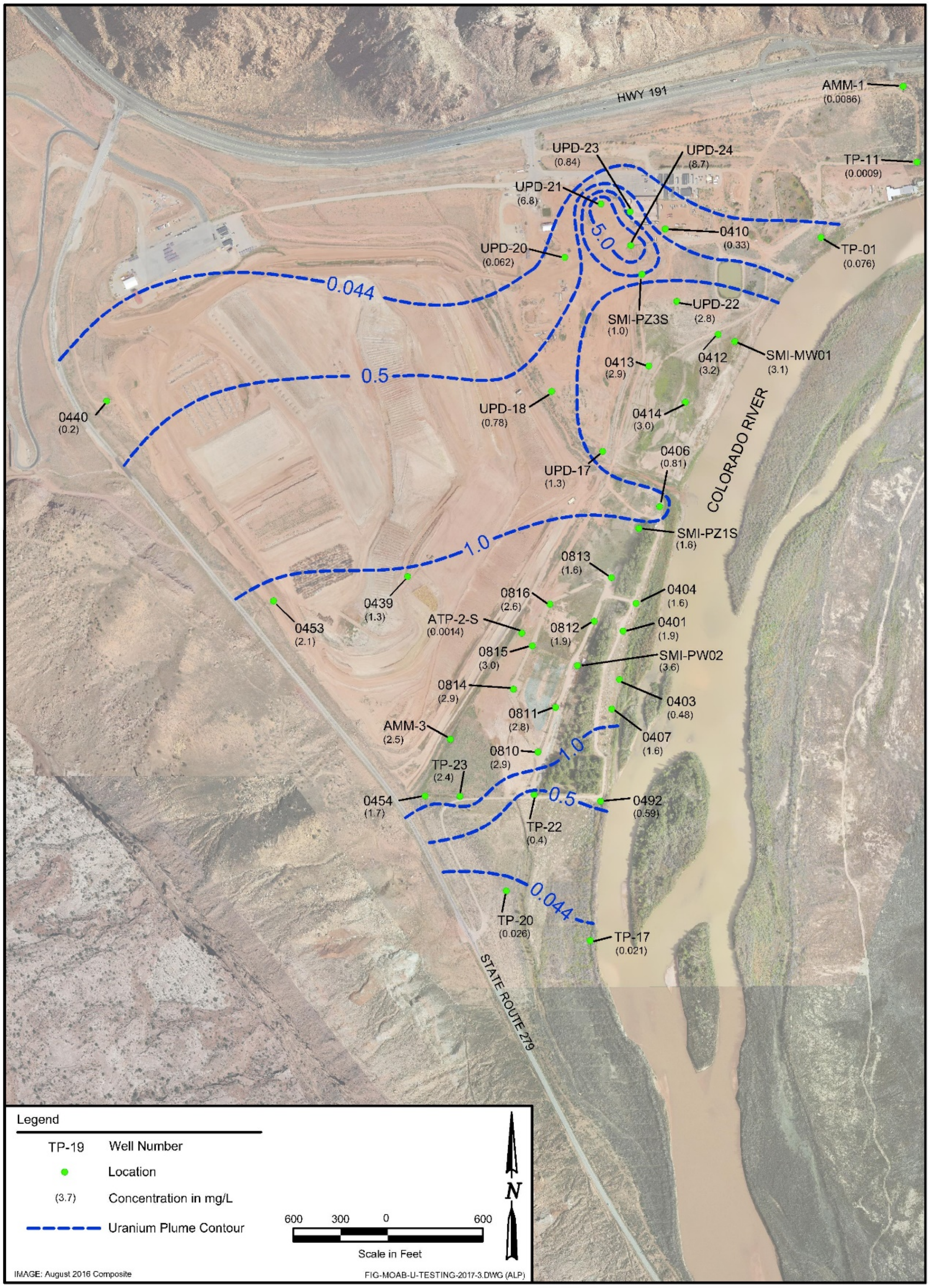

Figure 8. Uranium Plume in Shallow Groundwater December/January 2017/2018

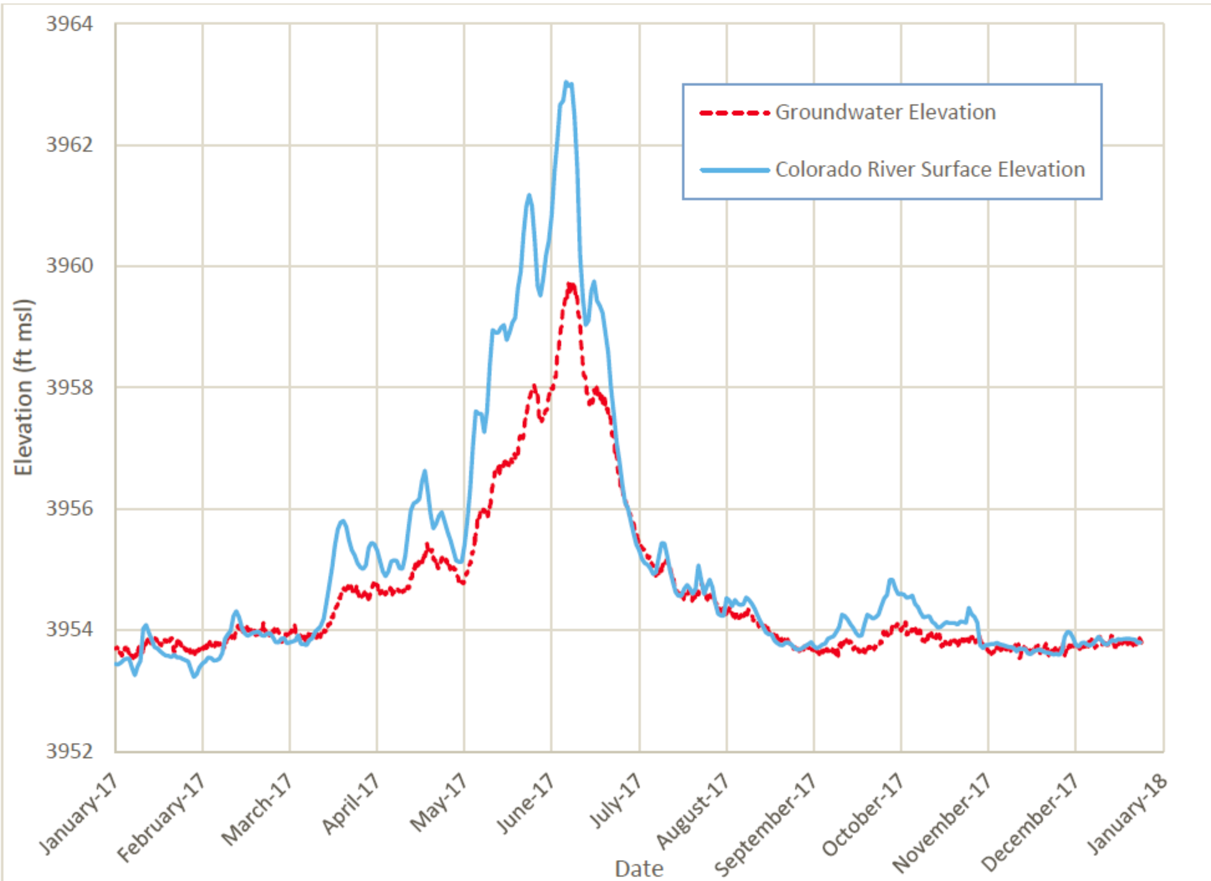

Figure 9. Groundwater Surface Elevation Compared to the Colorado River Surface Elevation 2017

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. In 2017, the IA well field operations included extraction at CF5 and injection at CF4.

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 (displayed at "Total 1" on the flow meter), and the net volume since the last reset of the internal memory (displayed as "Total 2" on the flow meter). Flow meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water quality data to evaluate the performance of the system.

When the extraction wells are sampled, the resulting ammonia and uranium concentrations are used to calculate the contaminant mass removal. The contaminated water is then used as dust suppression in the Contamination Area (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 and are used in conjunction with water level data to estimate the amount of freshwater mounding in each well.

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 is installed at various locations to measure water levels more frequently.

3.4 Water Quality

Selected well and surface water locations are sampled at various times, depending on the purpose of the sampling event. Before sampling, the field parameters, which include temperature, pH, and conductivity, are measured and recorded. Observation wells are sampled with dedicated down-hole tubing and a peristaltic pump, while remediation wells are sampled with dedicated submersible pumps.

Water samples are collected at various depths and locations to monitor the primary contaminants of concern, ammonia (as N) and uranium. All water sampling was performed in accordance with the *Moab UMTRA Project Surface Water/Groundwater Sampling and Analysis Plan* (DOE-EM/GJTAC1830). Samples are shipped overnight to ALS Global (ALS) in Fort Collins, Colorado, for analysis.

4.0 Groundwater Extraction Operations and Performance

4.1 IA Operations

This section provides information regarding the IA well field extraction performance during the 2017 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), chronology (Table A-2), pumping volumes (Table A-3), and mass removal (Tables A-4 and A-5).

The evaporation pond was decommissioned in 2015 as excavation of the tailings continued. An updated extraction system was installed and first utilized in May 2016 and fully operational in June. The extraction operations are controlled by an automated system. Groundwater from extraction wells is pumped directly into two 21,000-gal frac tanks that serve as holding tanks. The water is then pumped directly into a 12,000-gal Klein tank. The water from the Klein tank is transferred to water trucks and used for dust suppression in the CA.

The system is controlled from an HMI (Human Machine Interface) system which is located in the Project 2 office trailer. Extraction operations are limited by how much water is needed for dust suppression in the CA and weather conditions (wet weather leads to less extraction, and warm, windy weather leads to more extraction). In 2017, the extraction system was started in March and operated in the spring, summer, and fall months.

The extraction schedule was focused on optimizing ammonia and uranium mass removal and rotating through each of the eight CF5 remediation wells. Operations continued until November, when the system was winterized.

The associated volume of groundwater extracted by each well in CF5 is shown in Appendix A, Table A-3. Figure 10 provides a graphic summary of the cumulative volume of groundwater extracted from CF5 in 2017. A total of approximately 8.4 mil gal of water was extracted from CF5 during 2017.

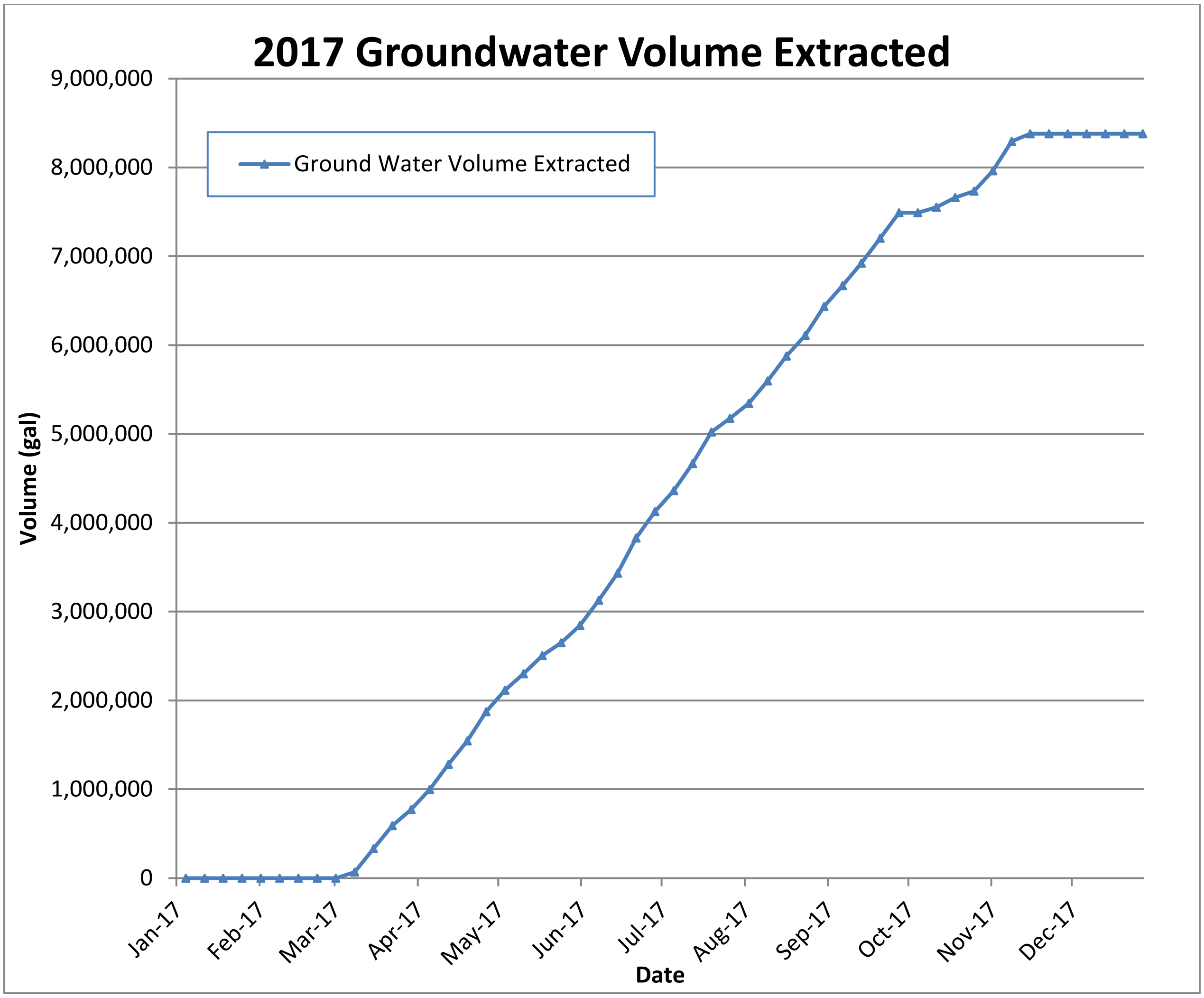

Figure 10. Cumulative Volume of Extracted Groundwater during 2017

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 (Appendix A). The majority of the 2017 extracted water was removed from well 0815 (1.5 mil gal) and 0816 (1.4 mil gal). The remaining CF5 wells extracted between 514,210 and 1.4 mil gal in 2017. Extraction operations were maximized in June, when 1.3 million gal were removed from the groundwater system.

The ammonia and uranium mass removed by CF5 extraction wells in 2017 is presented in Tables A-4 and A-5 of Appendix A. 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 Appendix C (available on the Project's SharePoint website). To estimate the contaminant mass removed when analytical data were not available for the specific month, concentrations were derived from previous and subsequent months to provide a representative concentration. In 2017, a total of 23,574 pounds (lb) (10,715 kilograms [kg]) of ammonia and 180.2 lb (81.9 kg) of uranium were extracted from the groundwater.

Table A-4 in Appendix A shows that extraction wells 0813 and PW02 removed the most ammonia mass at 5,300 lb (2,409 kg) and 3,228 lb (1,467 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Table A-5 in Appendix A, which shows the greatest mass of uranium was extracted from wells 0815 and 0816 at 42.2 lb (19.2 kg) and 29.4 lb (13.4 kg), respectively.

4.3 Groundwater Chemistry

Groundwater samples were collected from the CF5 extraction wells in May, October, and November (Table 1). Ammonia concentrations varied from 160 mg/L (Wells 0814 and 0816) to 490 mg/L (0811), and the uranium concentration ranged from 1.6 mg/L (0813) to 3.6 mg/L (PW02). Specific conductance ranged from 14,840 µmhos/cm at well 0813 (northern end of CF5) to 30,112 µmhos/cm at well 0810 (southern end).

5.0 Injection Operation and Performance

The main objective of freshwater injection is to form a hydrologic barrier between the tailings pile and the backwater channel that flows adjacent to the well field and to dilute contaminants before groundwater discharges into the backwater channel. Freshwater injection into the CF4 wells in 2017 occurred from January 11 to March 1, April 5 to May 17, July 11 to September 27, and November 1 to December 21.

The injection system uses Colorado River water that is diverted to a freshwater pond and is then pumped through sand and 1 to 5 micron bag filters and injected into the remediation wells. Construction information for the CF4 wells can be found in Table B-1 of Appendix B, and Table B-2 contains a chronology of CF4 activities.

Table 1. CF5 Ammonia and Uranium Concentrations, 2017

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	05/02/17	330	2.5	29,314
	08/23/17	360	3.2	28,904
	11/13/17	270	2.9	30,112
0811	05/02/17	420	2.7	21,525
	08/23/17	430	2.9	22,126
	11/13/17	490	2.8	21,850
0812	05/02/17	460	2.1	18,234
	08/23/17	430	2.3	16,111
	11/13/17	460	1.9	18,094
0813	05/01/17	410	1.6	14,840
	08/23/17	420	1.6	15,601
	11/13/17	430	1.6	15,464
0814	05/02/17	170	2.9	19,926
	08/23/17	160	3.0	23,248
	11/13/17	200	2.9	23,792
0815	05/02/17	180	3.1	23,012
	08/23/17	200	3.0	19,423
	11/13/17	190	3.0	25,078
0816	05/01/17	150	2.4	21,042
	08/23/17	170	2.6	22,238
	11/13/17	160	2.6	21,845
PW02	05/02/17	420	3.5	28,733
	11/13/17	470	3.6	27,310

CF4 is located in the southern portion of the IA well field, adjacent to a prominent side channel that typically remains open to the main channel until the river flow drops below 3,000 cfs. The brine/freshwater interface is higher in elevation in this portion of the well field, and sample results have indicated that groundwater discharges to the adjacent backwater channel. Approximately 5.8 mil gal of fresh water were injected into CF4 in 2017.

5.1 Injection Performance

Injection into all 10 CF4 wells began on January 11 (Table B-2, Appendix B). The system ran until mid-May when it was temporarily shut down during the peak river flow, following the *Flood Mitigation Plan*. CF4 operations resumed on July 11 when the river flow dropped below 15,000 cfs. CF4 injection was suspended while the wells were re-developed by Beeman Drilling from August 28 to September 14, 2017. All of the CF4 injection wells were winterized for the year on December 21.

5.2 Observation Well Chemical Data Summary

In 2017, groundwater samples were collected from the CF4 observation wells during injection operations in February, May, August, and November to assess the effectiveness of the system (Appendix B, Table B-3). It is important to note that the CF4 injection wells are screened from 15 to 35 ft below ground surface (ft bgs) and the CF1 injection wells are screened from 10 to 20 ft bgs.

All samples were submitted to ALS for ammonia and uranium analysis, and field parameters (temperature, pH, and specific conductance) are measured during the sample collection. Of primary concern regarding the sampling associated with the injection system performance are the ammonia concentrations due to its toxicity to aquatic life.

As expected because of the CF4 well screen intervals, the analytical results indicate ammonia concentrations downgradient of the injection wells were below 1 mg/L in the samples collected from 18 and 28 ft bgs. The highest concentrations were associated with the samples collected from a depth of 46 ft bgs (ranging from 1,600 to 2,100 mg/L at upgradient well 0781), which is more than 10 ft below the depth at which the fresh water is injected into the subsurface.

In November 2017 the specific conductance at the upgradient wells at a depth of 33 ft bgs had a specific conductance greater than 16,000 µmhos/cm, while at a depth of 46 ft bgs, the specific conductance exceeded 75,000 µmhos/cm. This implies the brine interface was located at a depth of approximately 45 ft bgs during injection during this time.

5.3 Freshwater Mounding

Water levels were collected on a near daily basis during injection operations. To determine the amount of freshwater mounding in each well, the water level data were plotted against the water levels measured in 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 in Appendix B for the injection wells. Mounding data was collected when the injection system was operating and not undergoing maintenance. Well development occurred from August 28 through September 14, those data were not included in mounding calculations. Figures B-11 through B-18 in Appendix B illustrate the mounding data in CF4 observation wells.

Figures 11 and 12 are contour maps showing the CF4 freshwater mounding in August and November 2017, respectively. The highest mounding occurs within 30 ft of the injection system. Maximum mounding occurred in each injection well at varying dates in the spring and fall. The amount of mounding was dependent on the individual well efficiency and the injection rate.

Table 2 presents the maximum mounding measured in each of the injection wells and the corresponding injection rate. The maximum mounding in the CF4 observation wells varied from 0.7 to 1.4 ft in the upgradient wells and from 0.9 to 1.4 ft in the downgradient wells. Maximum mounding occurred on May 8 for all CF4 observation wells.

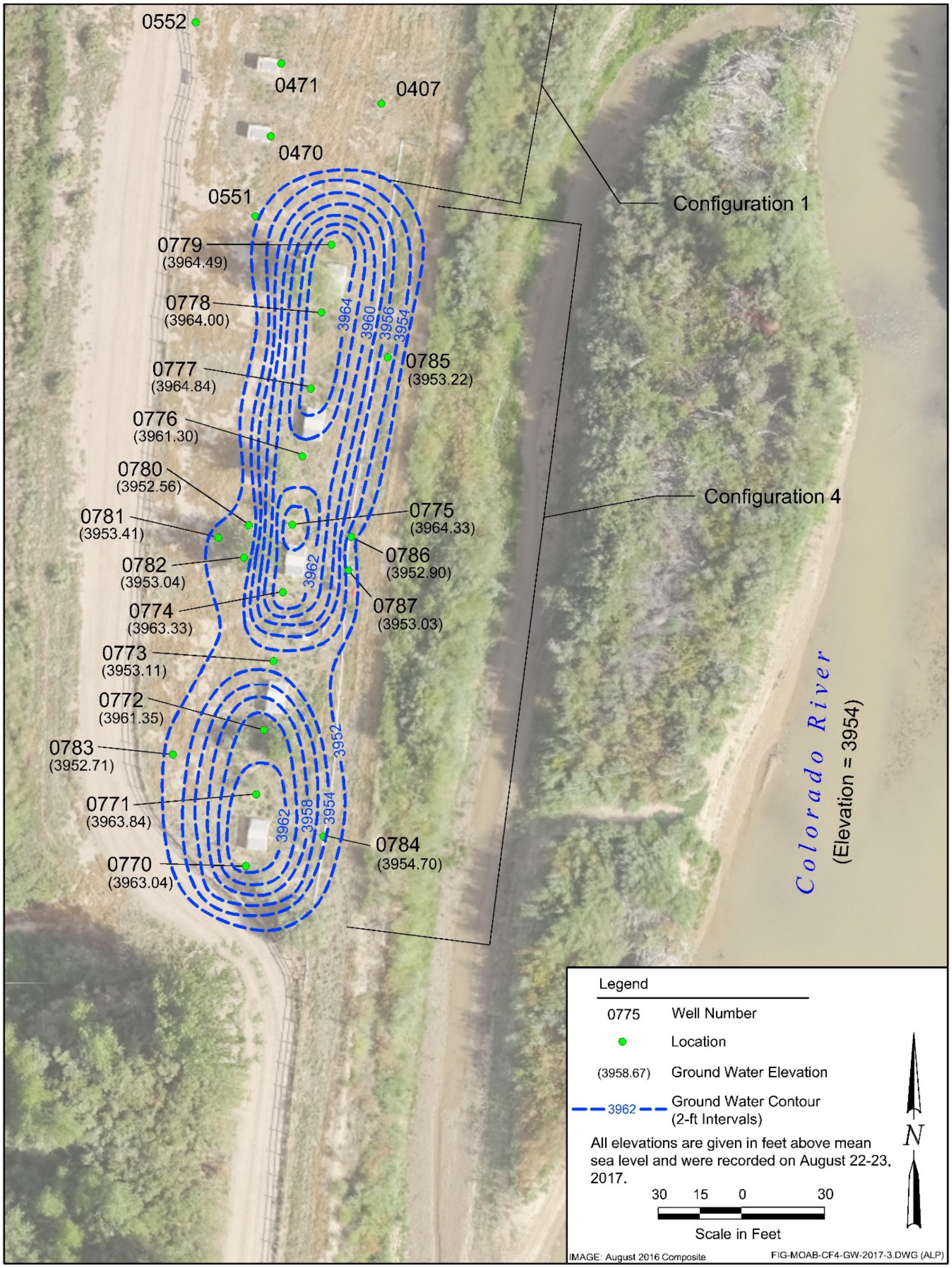

Figure 11. Freshwater Mounding at CF4 during Injection Operations August 2017

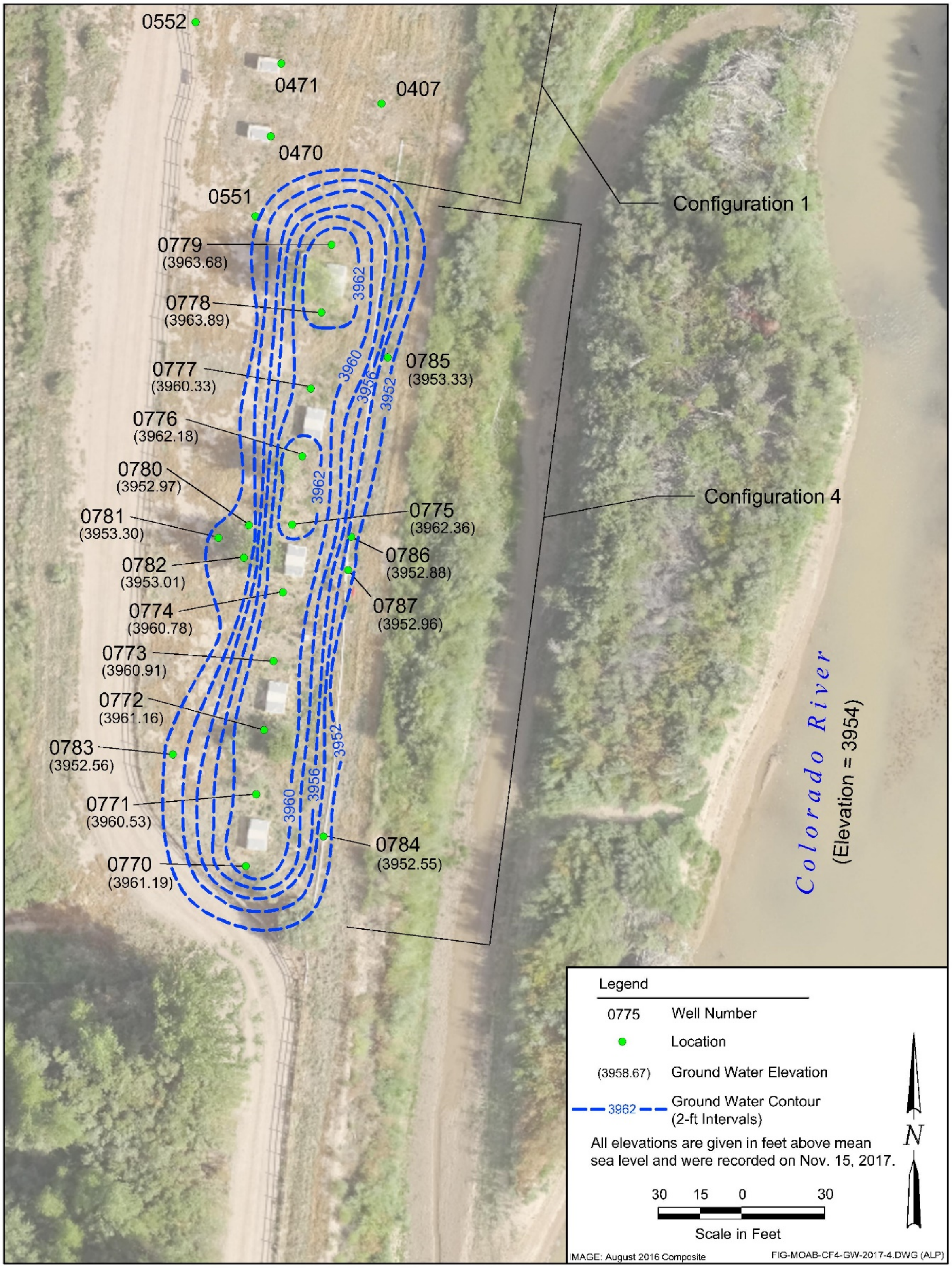

Figure 12. Freshwater Mounding at CF4 during Injection Operations November 2017

Table 2. Maximum Mounding Observed in Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
Configuration 4				
0770	04/18/17	Injection Well	10.7	3.3
0771	05/01/17	Injection Well	10.8	4.5
0772	04/19/17	Injection Well	11.5	2.7
0773	04/19/17	Injection Well	11.8	2.2
0774	08/21/17	Injection Well	12.7	2.6
0775	04/24/17	Injection Well	11.5	3.5
0776	04/24/17	Injection Well	11.3	2.6
0777	08/21/17	Injection Well	12.2	1.9
0778	04/26/17	Injection Well	11.2	1.4
0779	09/20/17	Injection Well	11.9	1.9

Table 3. Freshwater Mounding Observed in Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
Configuration 4				
0780	05/08/17	Upgradient	1.1	25
0781	05/08/17	Upgradient	1.4	30
0782	05/08/17	Upgradient	1.1	25
0783	05/08/17	Upgradient	0.7	30
0784	05/08/17	Downgradient	0.9	30
0785	05/08/17	Downgradient	1.4	25
0786	05/08/17	Downgradient	1.1	30
0787	05/08/17	Downgradient	1.1	30

6.0 Surface Water Monitoring

In 2017, the mean daily Colorado River flow ranged from 2,500 to 26,200 cfs from January through December. The channel that flows adjacent to CF4 was not considered a suitable habitat for young-of-year fish during the monitoring season (June through September) because it has remained silted in since 2013, and the depth of water within the channel was never sufficient to meet the definition of a suitable habitat. Surface water monitoring is completed through site-wide surface water sampling. The site-wide sampling event occurs twice a year, and surface water samples are collected upgradient of the site, on site, and downgradient of the site.

6.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in May/June 2017. Locations were sampled in preparation for the post-spring runoff peak flows, when the side channel could potentially develop into a suitable habitat. The results of this sampling event can be found in the *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2017* (DOE-EM/GJTAC2240). The ammonia concentrations measured during this event were all below than 0.1 mg/L detection limit, with the exception of the sample collected from location 0226.

The sample collected from this location was analyzed using a higher detection limit (1.0 compared to 0.1 mg/L), with the concentration below the detection limit. As a result, it is assumed that all surface water ammonia concentrations were below the applicable EPA criteria (for a suitable habitat) for both acute and chronic concentrations. Surface water samples were also collected in December/January when the river was at baseflow conditions.

These results can be found in the *Moab UMTRA Project Groundwater and Surface Water Monitoring July through December 2017* (DOE-EM/GJTAC2251). The ammonia concentrations measured during this event, all of which were below the 0.1 mg/L detection limit, with the exception of the samples collected from locations CR-1 (1.0 mg/L) and CR-3 (0.24 mg/L).

The sample collected from location CR-1 was analyzed using a higher detection limit (1.0 compared to 0.1 mg/L), with the concentration below the detection limit. All surface water ammonia concentrations are below the applicable EPA criteria (for a suitable habitat) for both acute and chronic concentrations.

6.2 Surface Water/Habitat Monitoring

Surface water monitoring adjacent to CF4 is typically conducted after the spring peak river flow begins to recede. The purpose is to monitor the ammonia concentrations in the side channel adjacent to the site, because the channel is a potential habitat for young-of-year endangered fish species (e.g., Colorado pikeminnow, razorback sucker). In 2017, the back water channel adjacent to CF4 did not meet the definition of a habitat during the months of June through September (closed off upriver, open downriver, sufficient depth). Figure 13 shows the condition of the CF4 side channel, it remained nearly dry for most of the season.

Figure 13. CF4 Side Channel August 30, 2017

6.3 Surface Water Monitoring Summary

All of the surface water ammonia samples collected in 2017 were below EPA acute and chronic criteria. The CF4 side channel remained silted in, and the water was too shallow to be considered a suitable habitat.

7.0 Investigations

7.1 Moab Sampling Events

Sampling events occurred throughout the year in 2017. CF4 observation wells and observation wells adjacent to the tree plots were sampled in January 2017. CF4 observation wells and CF5 extraction wells were sampled in May and August 2017. Site-wide sampling events took place in May/June 2017 during the peak river flow and in December/January 2017/2018 during baseflow conditions.

Maps of sample locations and the sample results can be found in the *Groundwater Surface Water Monitoring Report January through June 2017* and the *Groundwater Surface Water Monitoring Report July through December 2017*.

7.2 Crescent Junction Well 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, the majority of 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 that time. Observations show that after a significant event or multiple precipitation events, the runoff collects into the retention ditch at the toe of the pile. As this water infiltrates into the subsurface, it likely intercepts a fracture system that is at least in part connected to the fracture observed inside well 0205 and eventually seeps into the well.

The results of water samples (Table 4) collected in February and June 2017, and the two short-term recovery tests (completed in March and June) results were utilized to determine the source of the water. The manner in which the water elevation responds to the site precipitation (Figure 14) and the fluctuation of the recharge rate (Figure 15) suggest a connection between the water present in well 0205 and the surface runoff.

Analytical results indicate a clear distinction between the two isotopic signatures of groundwater encountered in well 0205 and Moab site groundwater that has been impacted by site operations, suggesting the water present in well 0205 is not associated with the tailings placed in the disposal cell.

Table 4. Well 0205 Analytical Data

Analyte	Sample Date and Analyte Concentration (mg/L)	
	7/27/16	**12/5/16**
Ammonia as N	15	13
Arsenic	0.039#	0.0039#
Barium	0.014	0.012
Bicarbonate as $CaCO_3$	1,000	950
Boron	1.3	1.2
Bromide	8#	10#
Cadmium	0.0033#	0.00033#
Calcium	370	260
Carbonate as $CaCO_3$	50#	100#
Chloride	3,600	3,700
Chromium	0.044	0.00051#
Copper	0.0097#	0.0016
Fluoride	4#	5#
Iron	0.3	7
Lead	0.013#	0.0013#
Magnesium	920	820
Manganese	0.53	0.3
Molybdenum	0.055	0.0022
Nitrate/ Nitrite as N	780	830
Potassium	53	58
Selenium	4.3	4.4
Sodium	10,000	9,700
Sulfate	22,000	24,000
Total Alkalinity as $CaCO_3$	1,000	950
Total Dissolved Solids	25,000	40,000
Uranium $_{234}$	32.5 +/- 5.5 pCi/L	27.1 +/- 4.6 pCi/L
Uranium $_{235}$	0.49 +/- 0.1 pCi/L	0.34 +/- 0.2 pCi/L
Uranium $_{238}$	11.2 +/- 2 pCi/L	9.2 +/- 1.7 pCi/L
Uranium	0.031	0.026

= Concentration at or below the detection limit

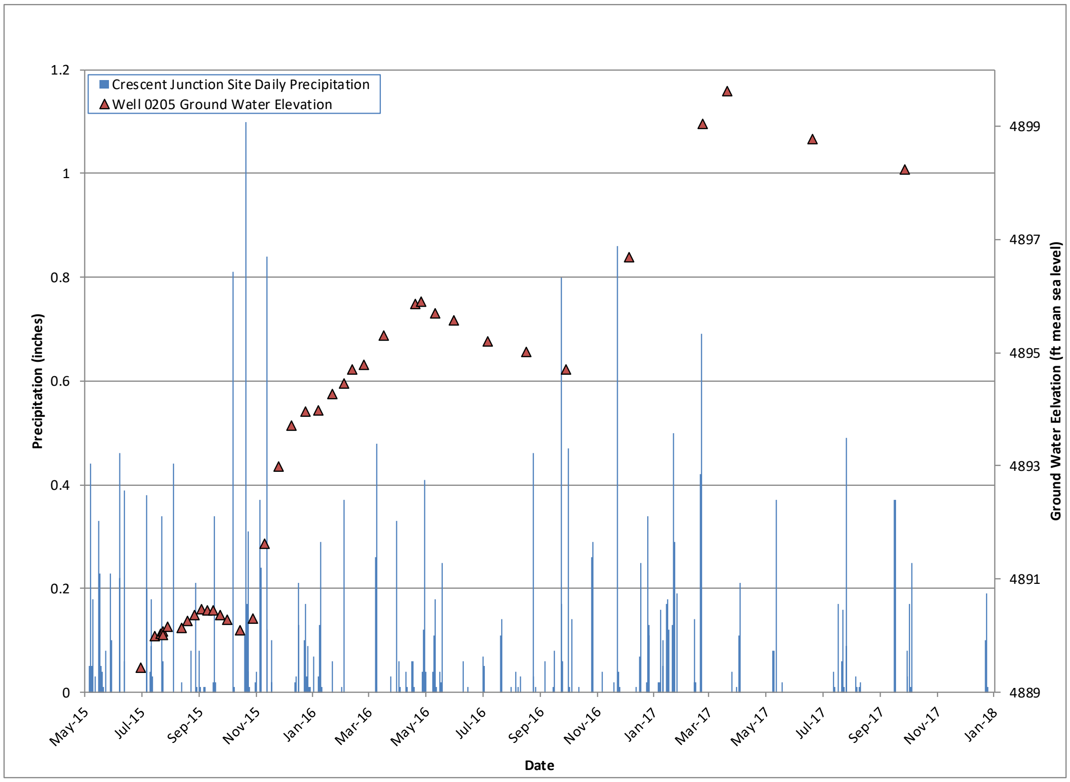

Figure 14. CJ Well 0205 Water Level Changes in Response to Precipitation through 2017

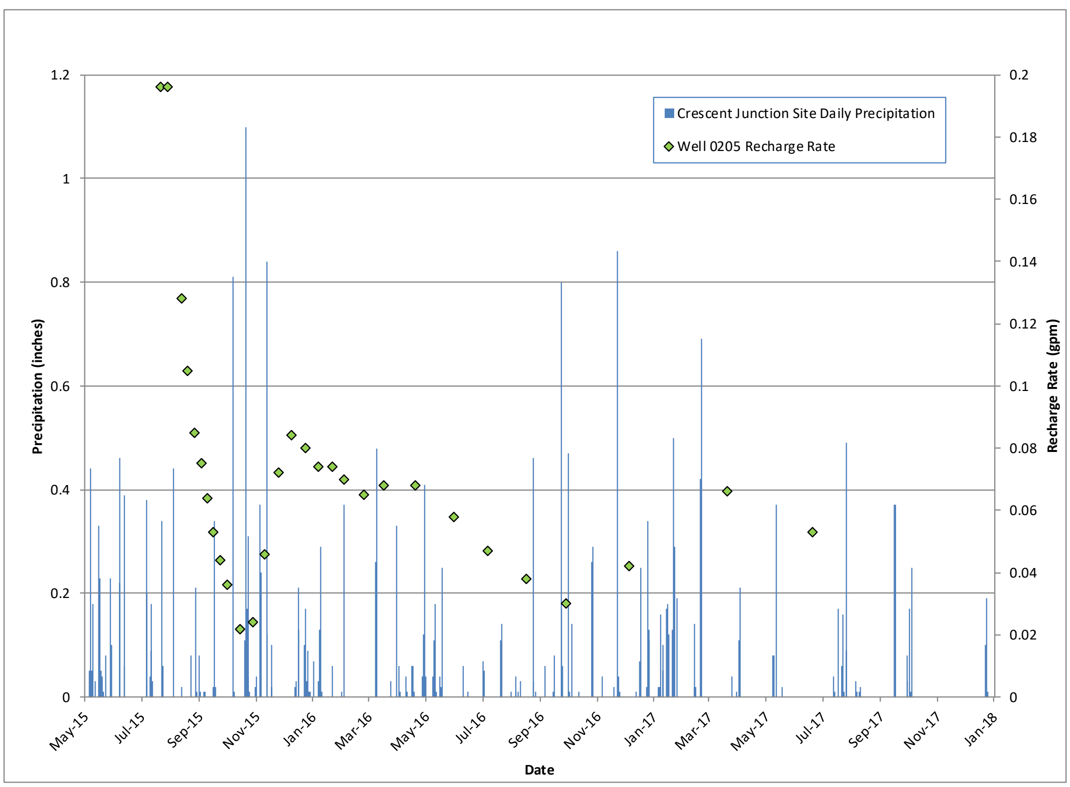

Figure 15. CJ Well 0205 Recharge Rate Changes in Response to Precipitation through 2017

8.0 Summary and Conclusions

In 2017, the IA operations focused on groundwater extraction (from CF5) and freshwater injection (CF4); the surface water diversion system operation was not required during the year, because a suitable habitat did not develop in the side channel.

A total of 8.4 mil gal of water were extracted from CF5 in 2017. The extraction rate peaked in July through September, and operations continued through the fall. Each of the eight extraction wells were utilized in 2017. Figure 16 shows the ammonia and uranium mass removed and the volume of groundwater extracted from the CF5 extraction wells from 2003 through 2017.

The volume of groundwater and amount of contaminant mass removed was higher in 2017 compared to the previous year. A total of 23,574 lb of ammonia and 180.2 lb of uranium were extracted from the groundwater system in 2017.

Approximately 5.8 mil gal of fresh water were injected into CF4 in 2017. Laboratory data from the CF4 observation wells during injection operations indicate the system is effective at diluting ammonia concentrations, especially from 28 to 36 ft bgs. Specific conductance also decreases at the downgradient observation wells during freshwater injection. Site-wide surface water samples indicated the contaminants do not extend past the site boundary. The surface water diversion system was not necessary in 2017 since the side channel adjacent to CF4 did not meet the definition of a suitable habitat for young-of-year endangered fish species.

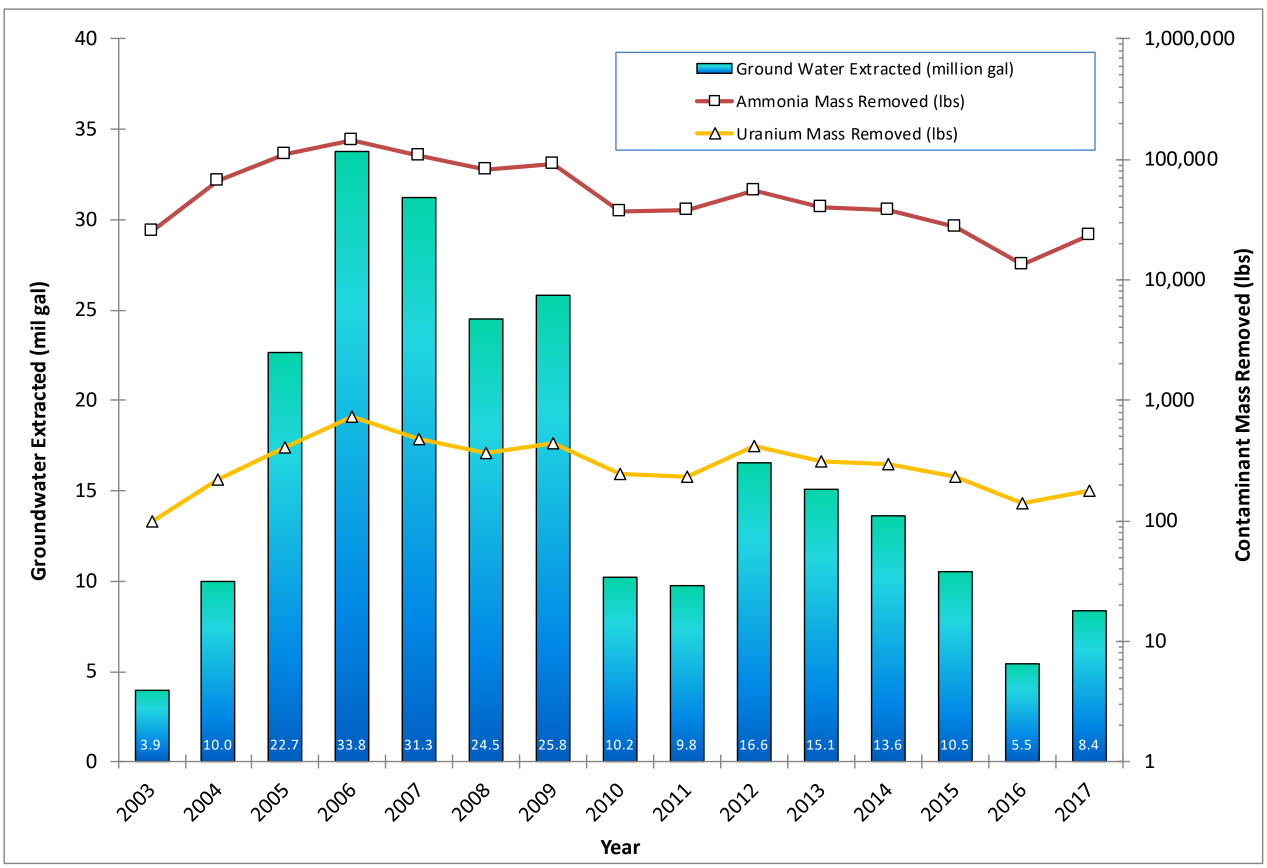

Figure 16. Groundwater Extracted Volume and Contaminant Mass Removal, 2003 through 2017

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 Mitigation Plan* (DOE-EM/GJTAC1640).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2017* (DOE-EM/GJTAC2240).

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring July through December 2017* (DOE-EM/GJTAC2251).

DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Groundwater Sampling and Analysis Plan* (DOE-EM/GJTAC1830).

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 2017 Groundwater Extraction

Appendix A. Tables and Data for 2017 Groundwater Extraction

Table A-1. Well Construction for CF5 Extraction Wells

Well	Well Type/Relative Depth	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. Chronology of CF5 Activities in 2017

Date	River Flow (cfs)	Activity
January	2,500 to 4,290	No extraction
February	3,020 to 4,770	No extraction
March	3,580 to 7,990	Restarted extraction system on March 7.
April	6,000 to 9,850	Extraction system operational in automatic mode
May	6,510 to 21,000	Extraction system operational in automatic mode
June	9,350 to 26,200	Extraction system operational in automatic mode
July	5,300 to 8,660	Extraction system operational in automatic mode
August	3,430 to 5,600	Extraction system operational in automatic mode
September	3,470 to 4,950	Extraction system operational in automatic mode
October	4,190 to 5,880	Extraction system was shut down on Oct 16 to repair a leak in a pump house hose. Extraction was resumed on Oct 25.
November	3,260 to 4,660	Winterization of the extraction system (well vaults, pump house, and storage tanks) occurred on Nov 14 and 15.
December	3,250 to 4,050	Winterized

Table A-3. CF5 Extraction Volumes 2017

Well	Extraction Volumes Removed (gal)												
	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Well Total
0810	0	0	131,142	138,103	155,601	174,028	130,129	197,881	185,340	46,034	119,910	0	1,278,168
0811	0	0	52,951	96,000	1,343	0	71,659	112,878	98,272	24,583	56,524	0	514,210
0812	0	0	34,067	173,154	31,863	150,825	126,247	119,387	135,131	33,780	82,297	0	886,751
0813	0	0	153,897	162,384	203,225	288,317	249,346	199,236	101,554	16,908	33,184	0	1,408,051
0814	0	0	69,143	51,714	8,936	0	0	72,128	165,116	43,701	113,909	0	524,647
0815	0	0	87,694	264,187	186,951	214,907	182,402	232,573	159,774	48,753	121,616	0	1,498,857
0816	0	0	164,512	41,714	252,380	291,607	197,957	325,981	123,498	0	45,632	0	1,443,281
SMI-PW02	0	0	77,706	174,237	132,598	159,777	91,917	0	85,913	29,529	74,480	0	826,157
MONTHLY TOTAL	0	0	771,112	1,101,493	972,897	1,279,461	1,049,657	1,260,064	1,054,598	243,288	647,552	0	
ANNUAL TOTAL													**8,380,122**

Table A-4. CF5 Ammonia Mass Removal 2017

Well	Ammonia Mass Removed (lbs)												
	Jan-17	**Feb-17**	**Mar-17**	**Apr-17**	**May-17**	**Jun-17**	**Jul-17**	**Aug-17**	**Sep-17**	**Oct-17**	**Nov-17**	**Dec-17**	**Total**
0810	0	0	393	414	466	512	358	544	509	126	330	0	3,652
0811	0	0	207	376	5	0	280	442	385	96	221	0	2,012
0812	0	0	156	793	146	665	484	457	518	129	315	0	3,663
0813	0	0	628	663	829	1131	851	680	347	58	113	0	5,300
0814	0	0	132	99	17	0	0	138	316	84	218	0	1,005
0815	0	0	183	550	389	418	273	349	239	73	182	0	2,657
0816	0	0	260	66	399	439	247	407	154	0	57	0	2,030
SMI-PW02	0	0	324	725	552	641	321	0	300	103	260	0	3,228
MONTHLY TOTAL:	0	0	2,283	3,686	2,805	3,806	2,815	3,017	2,769	670	1,697	0	
ANNUAL TOTAL:													**23,547**

Table A-5. CF5 Uranium Mass Removal 2017

Well	Uranium Mass Removed (lbs)												
	Jan-17	**Feb-17**	**Mar-17**	**Apr-17**	**May-17**	**Jun-17**	**Jul-17**	**Aug-17**	**Sep-17**	**Oct-17**	**Nov-17**	**Dec-17**	**Total**
0810	0.0	0.0	3.3	3.4	3.9	4.2	2.7	4.1	3.9	1.0	2.5	0.0	28.9
0811	0.0	0.0	1.1	2.1	0.0	0.0	1.6	2.4	2.1	0.5	1.2	0.0	11.1
0812	0.0	0.0	0.5	2.7	0.5	2.4	2.2	2.1	2.4	0.6	1.4	0.0	14.9
0813	0.0	0.0	1.9	2.0	2.5	3.7	3.3	2.7	1.4	0.2	0.4	0.0	18.1
0814	0.0	0.0	1.6	1.2	0.2	0.0	0.0	1.7	3.8	1.0	2.7	0.0	12.2
0815	0.0	0.0	2.7	8.1	5.8	6.4	4.7	6.0	4.1	1.3	3.1	0.0	42.2
0816	0.0	0.0	3.4	0.9	5.3	6.0	4.0	6.5	2.5	0.0	0.9	0.0	29.4
SMI-PW02	0.0	0.0	2.1	4.8	3.6	4.5	2.7	0.0	2.5	0.9	2.2	0.0	23.2
MONTHLY TOTAL:	0.0	0.0	16.8	25.3	21.8	27.1	21.1	25.5	22.6	5.4	14.5	0.0	
ANNUAL TOTAL:													**180.2**

Appendix B.
Tables and Data for 2017 Freshwater Injection

Appendix B. Tables and Data for 2017 Freshwater Injection

Table B-1. CF4/CF1 Well Construction

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
Configuration 4					
0770	Remediation/Deep	6	3,968.86	14.9 – 34.8	35.2
0771	Remediation/Deep	6	3,969.04	15.0 – 34.9	35.3
0772	Remediation/Deep	6	3,969.21	15.2 – 35.1	35.5
0773	Remediation/Deep	6	3,969.15	15.2 – 35.1	35.5
0774	Remediation/Deep	6	3,968.77	15.5 – 35.4	35.8
0775	Remediation/Deep	6	3,969.18	15.1 – 35.0	35.4
0776	Remediation/Deep	6	3,968.97	15.2 – 35.1	35.5
0777	Remediation/Deep	6	3,968.76	15.3 – 35.2	35.6
0778	Remediation/Deep	6	3,968.93	15.1 – 35.0	35.4
0779	Remediation/Deep	6	3,968.34	15.7 – 35.6	36.0
0780	Observation/Shallow	6	3,968.45	20.3 – 30.1	30.5
0781	Observation/Deep	6	3,968.56	44.8 – 54.5	55.0
0782	Observation/Deep	6	3,968.46	31.0 – 40.8	41.2
0783	Observation/Shallow	2	3,968.82	8.6 – 18.6	19.1
0784	Observation/Shallow	2	3,968.73	9.4 – 19.4	19.9
0785	Observation/Shallow	2	3,968.24	9.6 – 19.6	19.9
0786	Observation/Shallow	6	3,968.14	20.5 – 30.3	30.7
0787	Observation/Deep	6	3,968.43	35.4 – 45.2	45.7
0790	Well Point/Shallow	1	3,953.91	2.0 – 3.0	3.0
0791	Well Point/Intermediate	1	3,953.91	4.3 – 5.3	5.3
0792	Well Point/Deep	1	3,953.91	9.3 – 10.3	10.3
0793	Well Point/Shallow	1	3,952.69	2.0 – 3.0	3.0
0794	Well Point/Intermediate	1	3,952.69	4.3 – 5.3	5.3
0795	Well Point/Deep	1	3,952.69	9.3 – 10.3	10.3

Table B-1. CF4/CF1 Well Construction (continued)

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
Configuration 1					
0470	Remediation/Intermediate	4	3966.56	10.3 - 19.7	21.3
0471	Remediation/Intermediate	4	3966.59	10.3 - 19.7	21.3
0472	Remediation/Intermediate	4	3966.62	10.3 - 19.7	21.3
0473	Remediation/Intermediate	4	3966.67	10.3 - 19.7	21.3
0474	Remediation/Intermediate	4	3967.02	10.3 - 19.7	21.3
0475	Remediation/Intermediate	4	3967.13	10.3 - 19.7	21.3
0476	Remediation/Intermediate	4	3967.38	10.3 - 19.7	21.3
0480	Observation/Shallow	4	3966.94	15.5 - 19.8	20.3
0481	Observation/Intermediate	4	3967.01	25.4 - 29.7	31.3
0483	Observation/Shallow	4	3967.00	15.5 - 19.8	20.3
0484	Observation/Intermediate	4	3967.19	25.5 - 29.8	30.3
0558	Observation/Intermediate	6	3966.85	35.0 - 45.0	45.1
0559	Observation/Shallow	1	3967.84	10.5 - 20.5	20.7
0560	Observation/Intermediate	6	3966.95	30.0 - 40.0	40.4

Table B-2. Chronology of CF1/CF4 Activities in 2017

Month	River Flow (cfs)	Activity
January	2,500 to 4,290	Injection system was started at CF4 on January 10.
February	3,020 to 4,770	Injection system temporarily winterized on February 21 for freshwater pond clean out
March	3,580 to 7,990	Injection system down from February 21 through all of March
April	6,000 to 9,850	Injection system restarted into CF4 April 3.
May	6,510 to 21,000	Injection system was shut down on May 9 due to high river stage.
June	9,350 to 26,200	Injection system was shut down for the entire month of June.
July	5,300 to 8,660	Injection system was restarted on July 11.
August	3,430 to 5,600	CF 4 injection wells were re-developed by Beeman Drilling from August 28 – September 14.
September	3,470 to 4,950	CF 4 injection wells were re-developed by Beeman Drilling from August 28 – September 14. Injection system shut down September 21. Filter was not backflushing correctly.
October	4,190 to 5,880	Injection system shut down all month.
November	3,260 to 4,660	Injection system down November 17 due to power outage and winterization.
December	3,250 to 4,050	Injection system restarted December 6. Injection system was shut down December 9 due to broken fitting, restarted December 11. Injection system was winterized on December 21.

Table B-3. Analytical Sample Results 2017

Location	Location from Injection	Sample Depth (ft bgs)	Date	Ammonia, as N (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
780	Upgradient	28	2/2/2017	0.27	0.01	1,377
			5/8/2017	0.14	0.0076	649
			8/22/2017	0.27	0.011	1,100
			11/15/2017	0.86	0.068	1,859
781	Upgradient	46	2/2/2017	2,100	2.1	78,103
			5/8/2017	1,800	2.5	63,554
			8/22/2017	1,900	2.4	75,841
			11/15/2017	1,600	3.1	61,430
782	Upgradient	33	2/2/2017	14	0.048	1,527
			5/8/2017	230	1.6	13,605
			8/22/2017	320	1.8	16,308
			11/15/2017	360	2.2	17,968
783	Upgradient	18	1/31/2017	0.2	0.046	1,279
			5/8/2017	0.1	0.043	986
			8/22/2017	0.16	0.037	1,321
			11/15/2017	0.11	0.052	1,299
784	Downgradient	18	1/31/2017	0.1	0.0073	1,264
			5/8/2017	0.1	0.0038	598
			8/22/2017	0.13	0.0087	1243
			11/15/2017	0.1	0.012	1,229
785	Downgradient	18	2/2/2017	0.1	0.0094	1,355
			5/8/2017	0.1	0.012	829
			8/22/2017	0.1	0.0092	1218
			11/15/2017	1	0.011	1,294
786	Downgradient	28	1/31/2017	0.1	0.0086	1,347
			5/8/2017	1.1	0.028	831
			8/22/2017	28	0.053	2,000
			11/15/2017	46	0.39	4,530
787	Downgradient	36	1/31/2017	1500	1.9	55,958
			5/8/2017	1,000	2.1	45,477
			8/22/2017	1,600	2.1	59,439
			11/15/2017	930	2.8	35,783

µmhos/cm = micromhos per centimeter

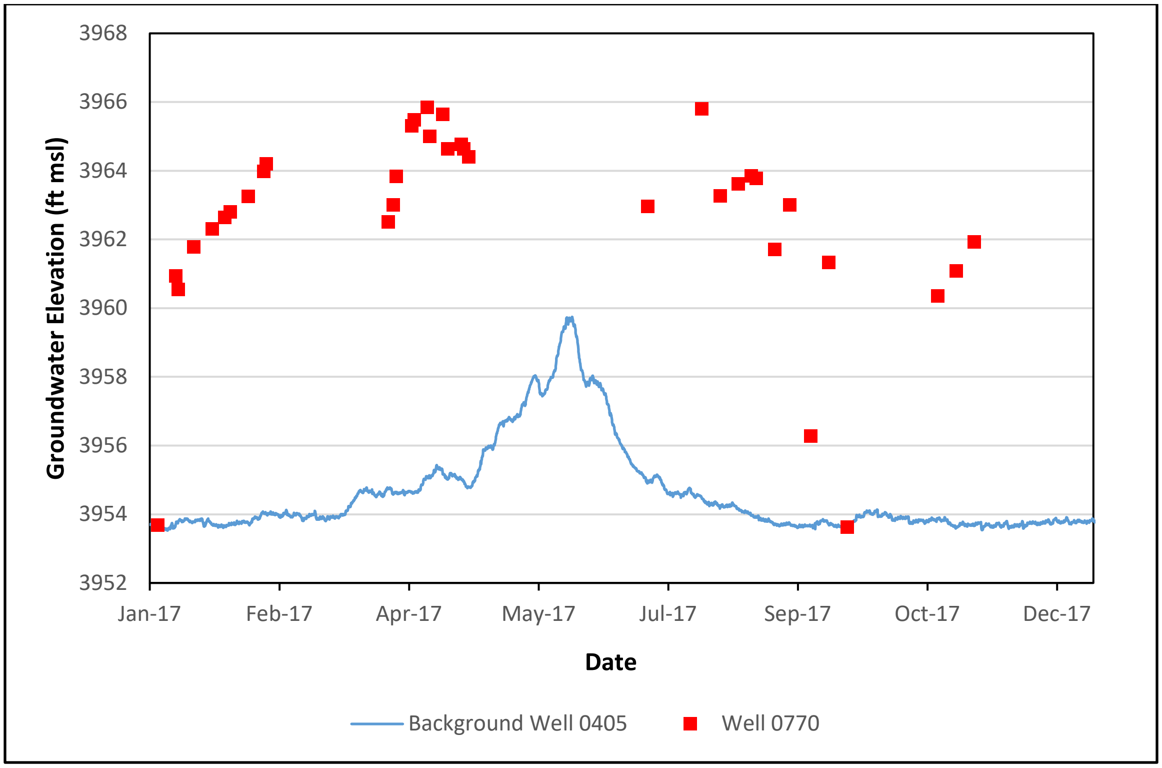

Figure B-1. Freshwater Mounding in Remediation Well 0770 during Injection

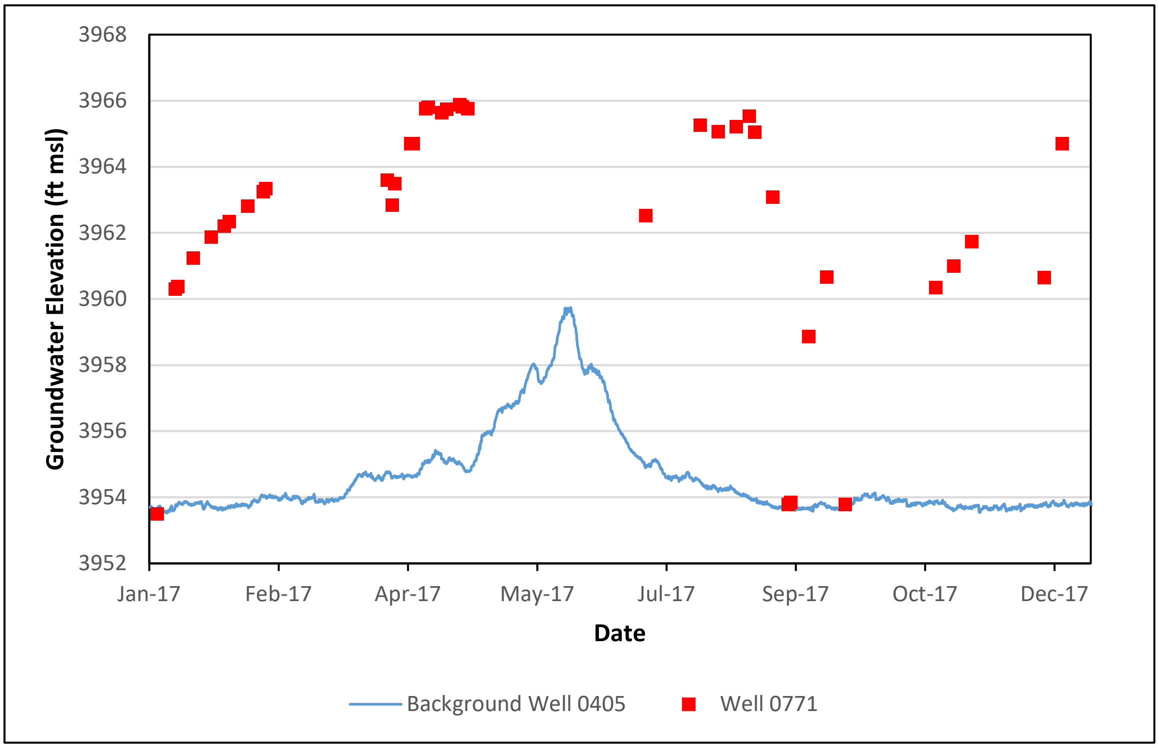

Figure B-2. Freshwater Mounding in Remediation Well 0771 during Injection

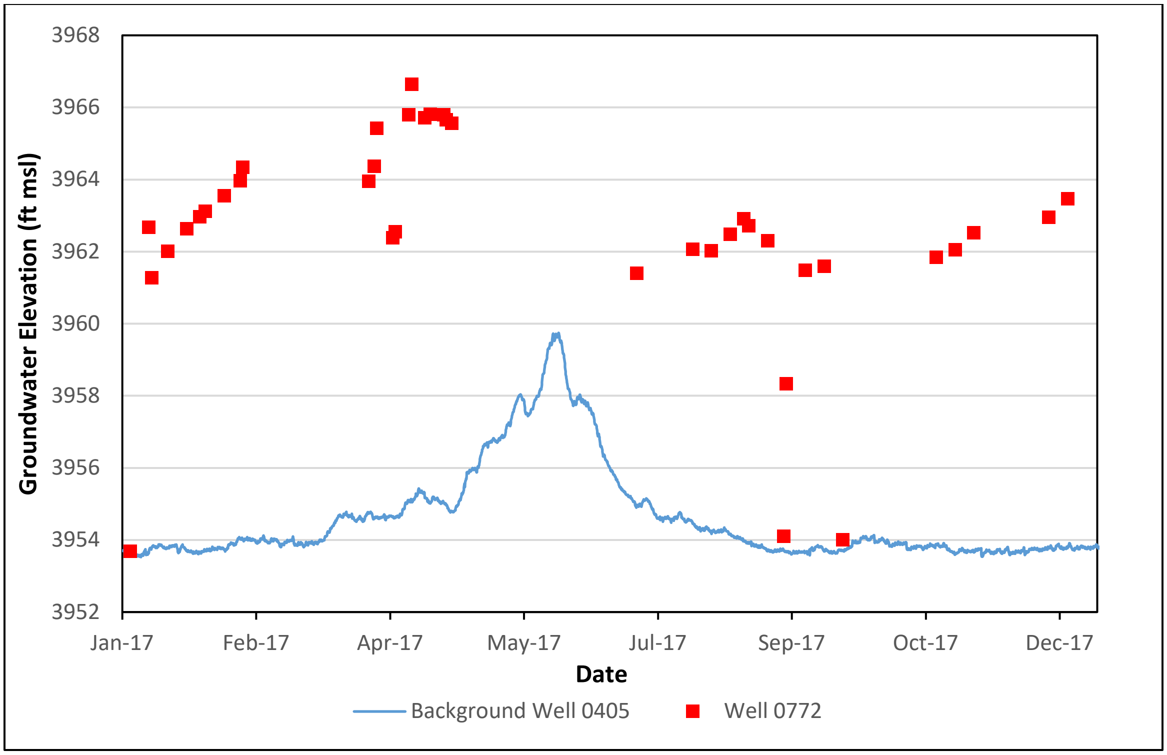

Figure B-3. Freshwater Mounding in Remediation Well 0772 during Injection

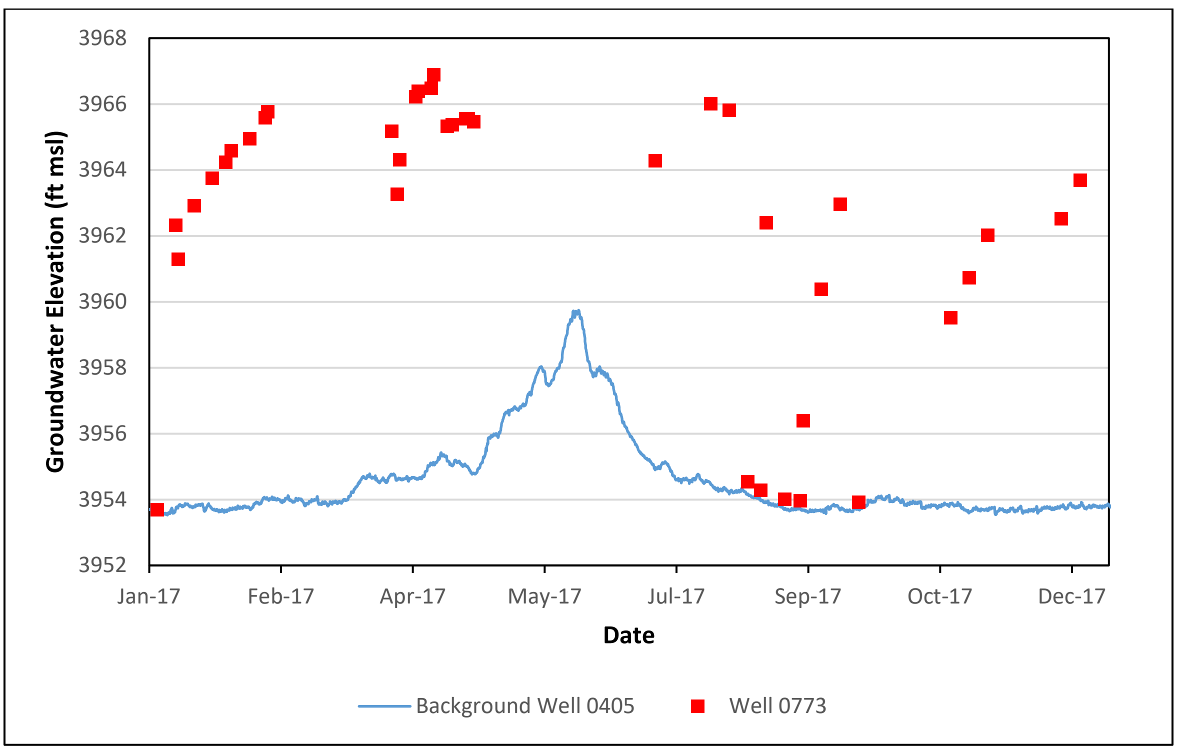

Figure B-4. Freshwater Mounding in Remediation Well 0773 during Injection

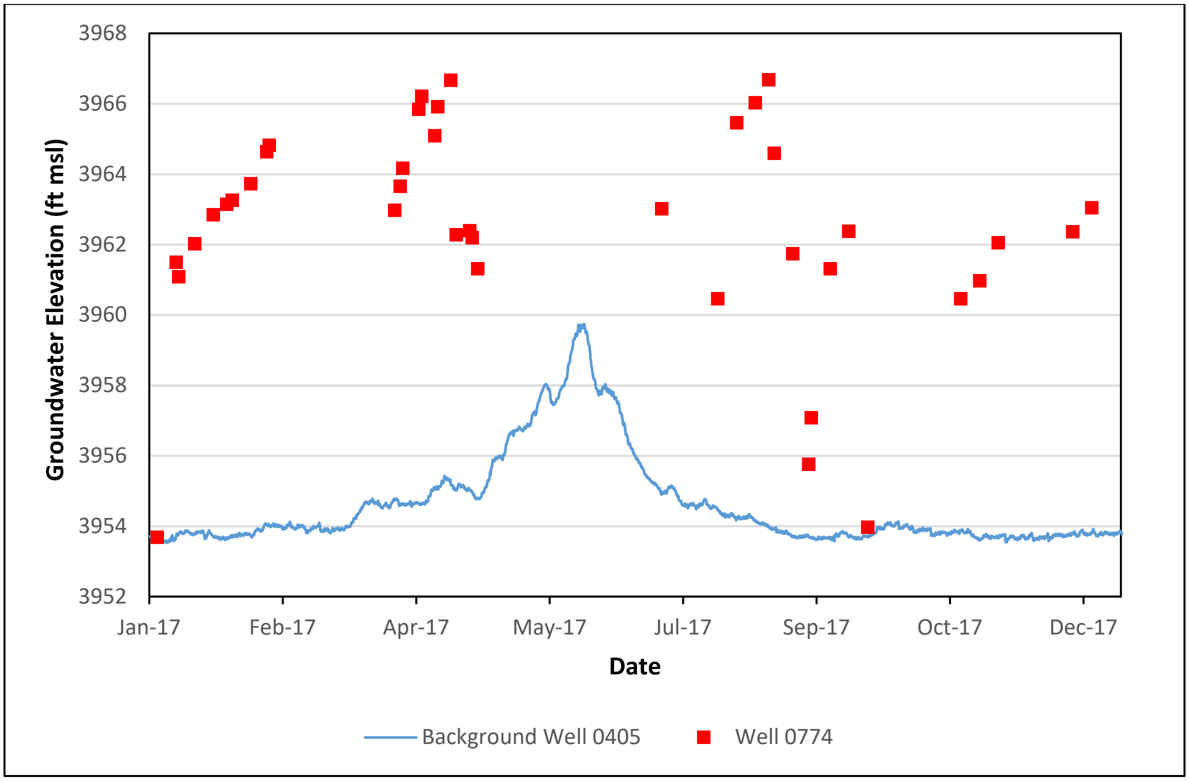

Figure B-5. Freshwater Mounding in Remediation Well 0774 during Injection

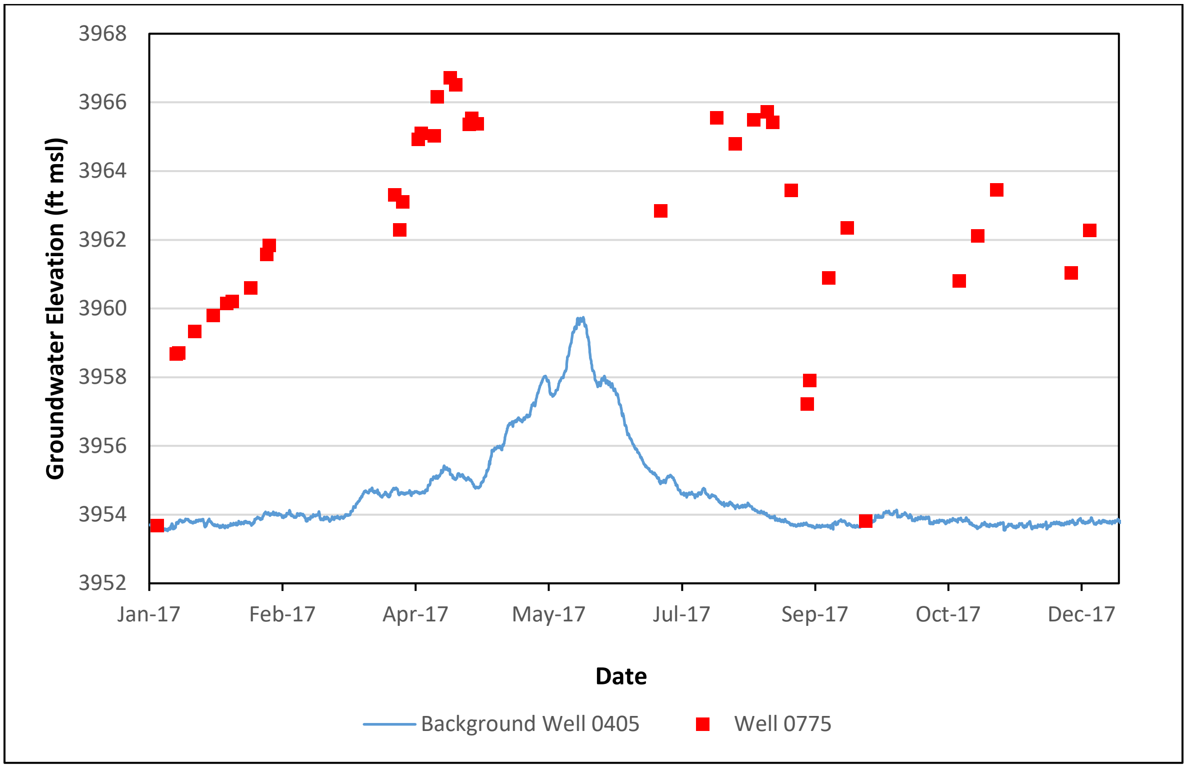

Figure B-6. Freshwater Mounding in Remediation Well 0775 during Injection

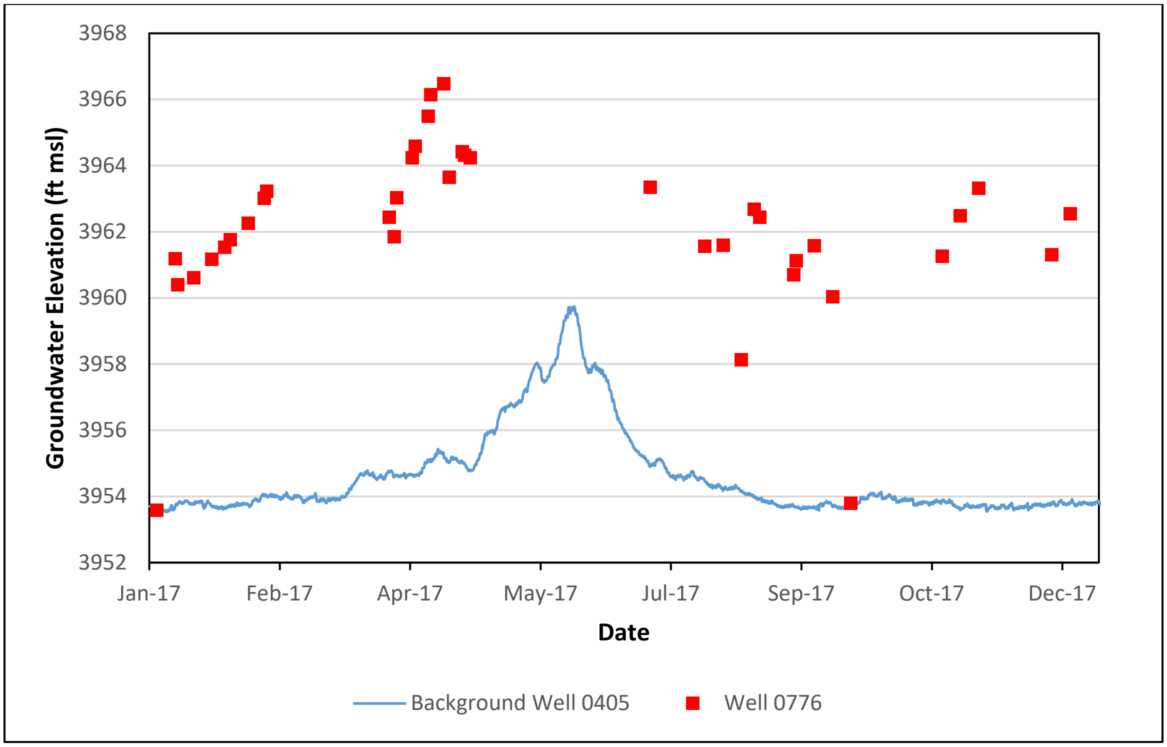

Figure B-7. Freshwater Mounding in Remediation Well 0776 during Injection

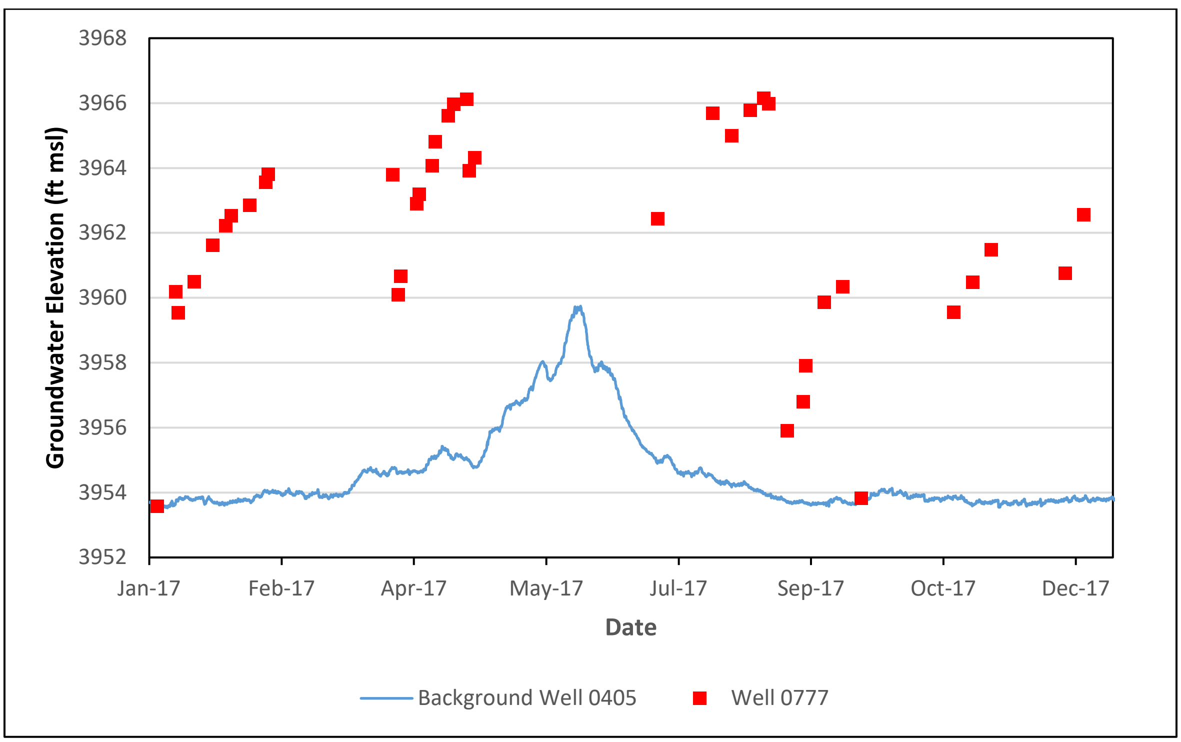

Figure B-8. Freshwater Mounding in Remediation Well 0777 during Injection

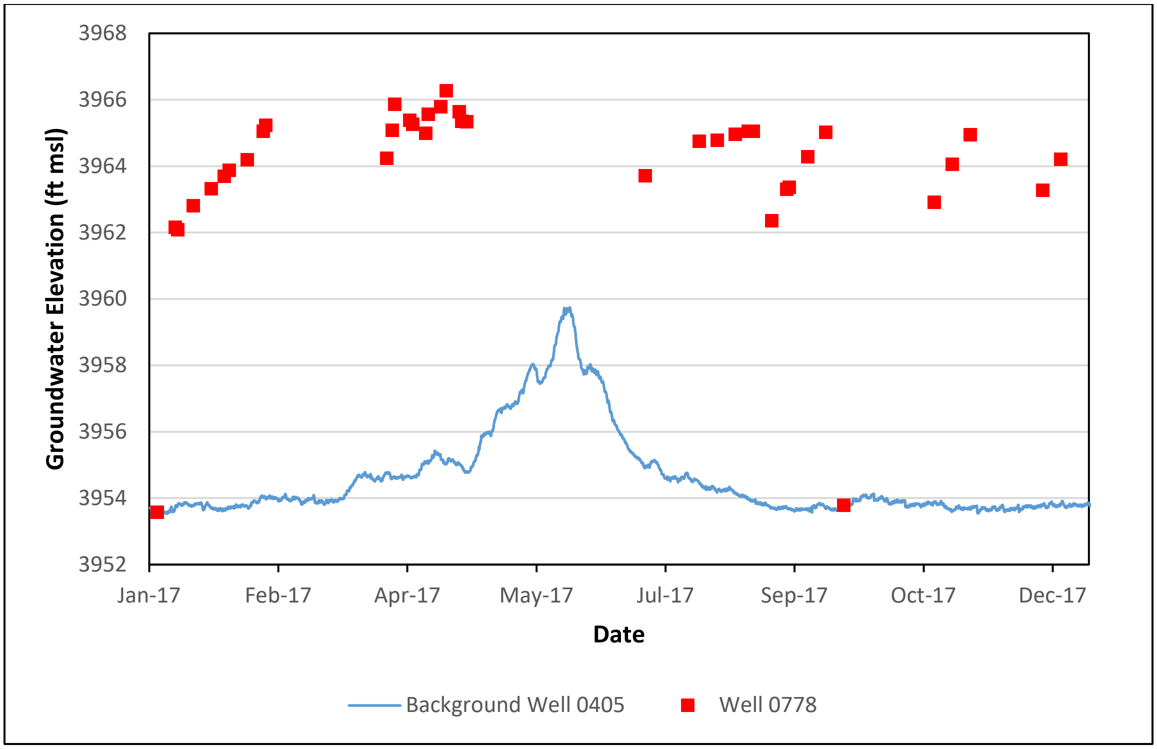

Figure B-9. Freshwater Mounding in Remediation Well 0778 during Injection

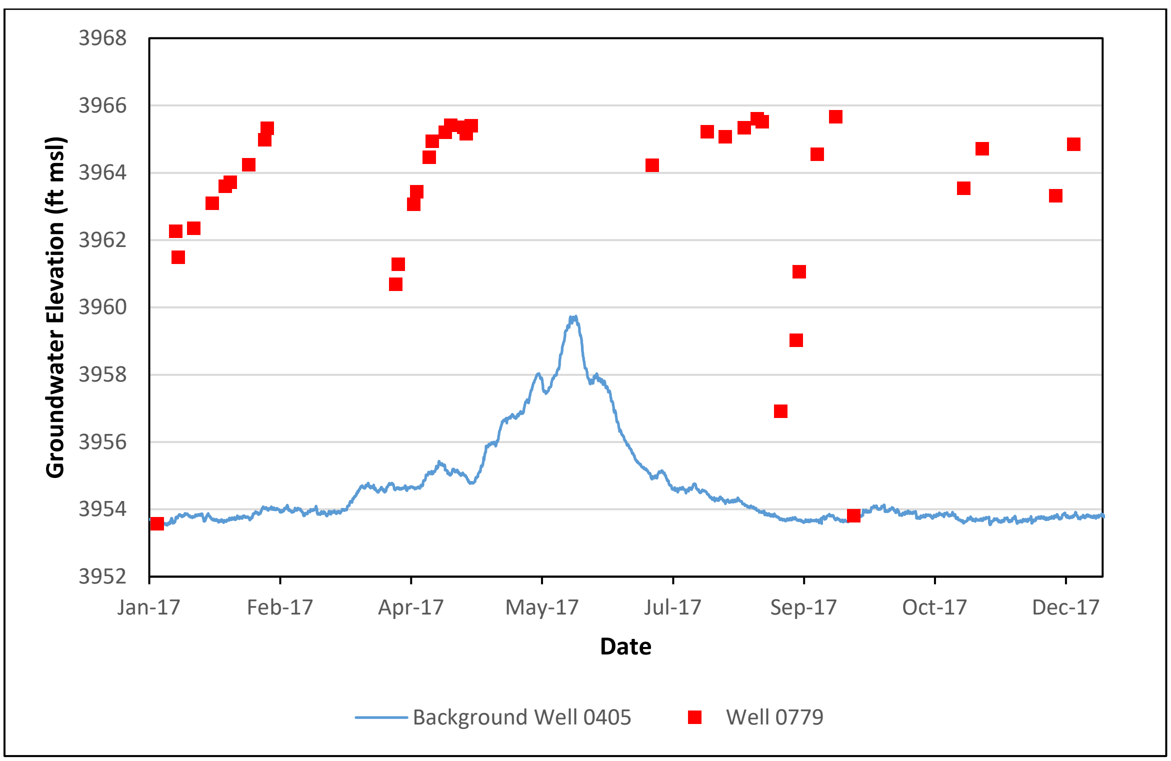

Figure B-10. Freshwater Mounding in Remediation Well 0779 during Injection

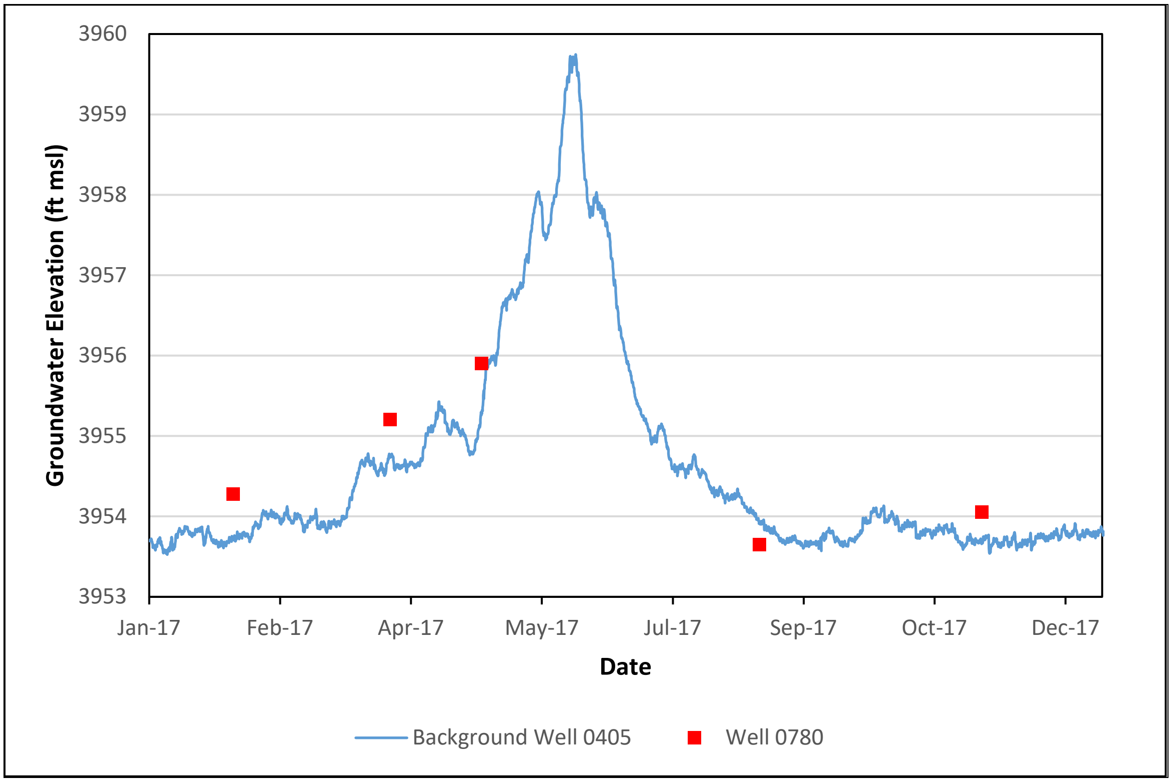

Figure B-11. Freshwater Mounding in Observation Well 0780

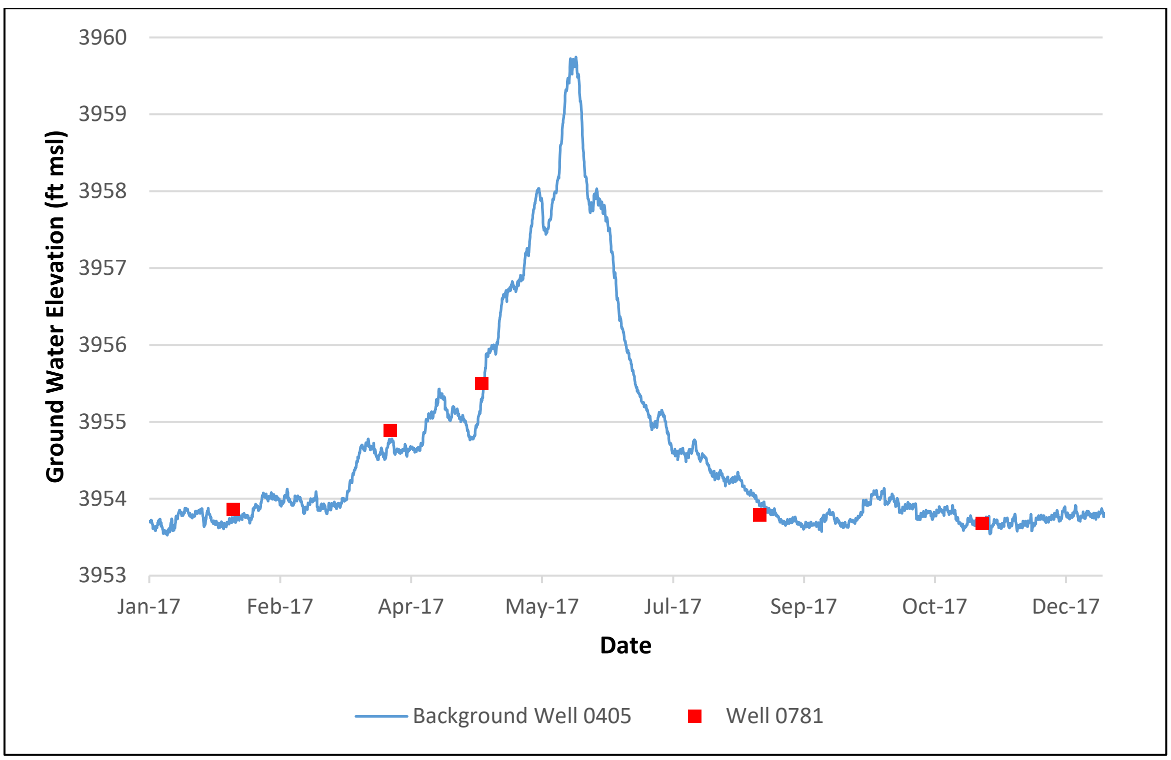

Figure B-12. Freshwater Mounding in Observation Well 0781

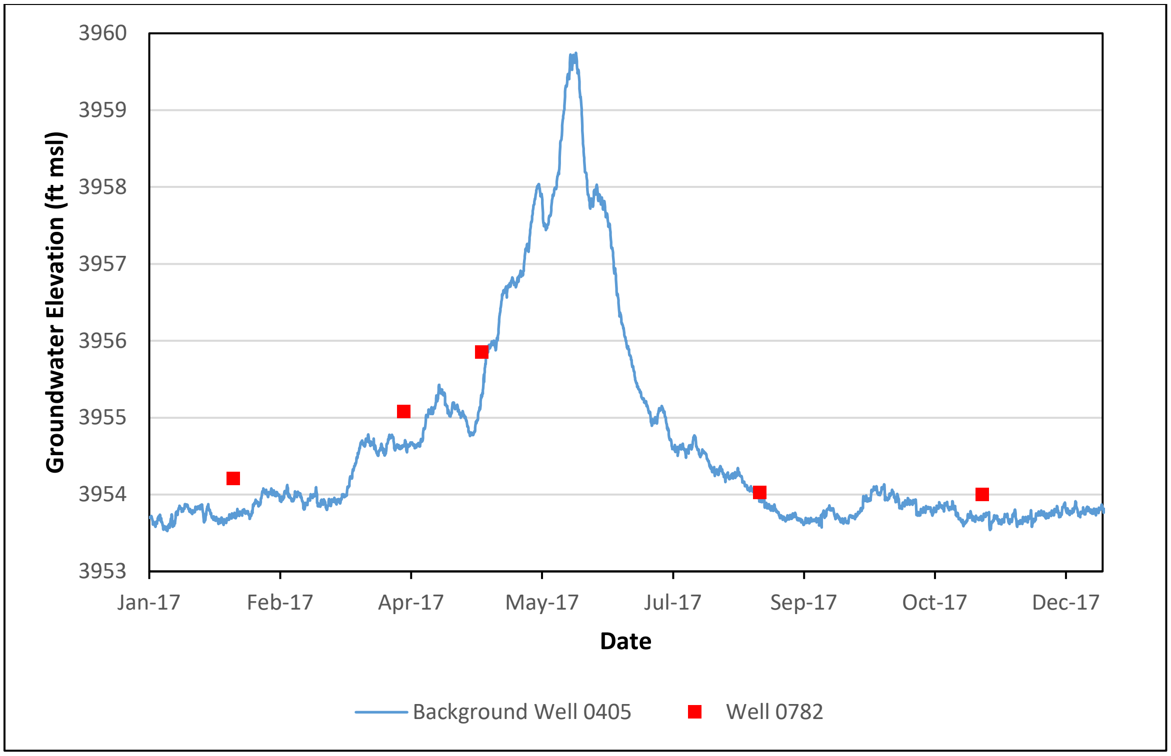

Figure B-13. Freshwater Mounding in Observation Well 0782

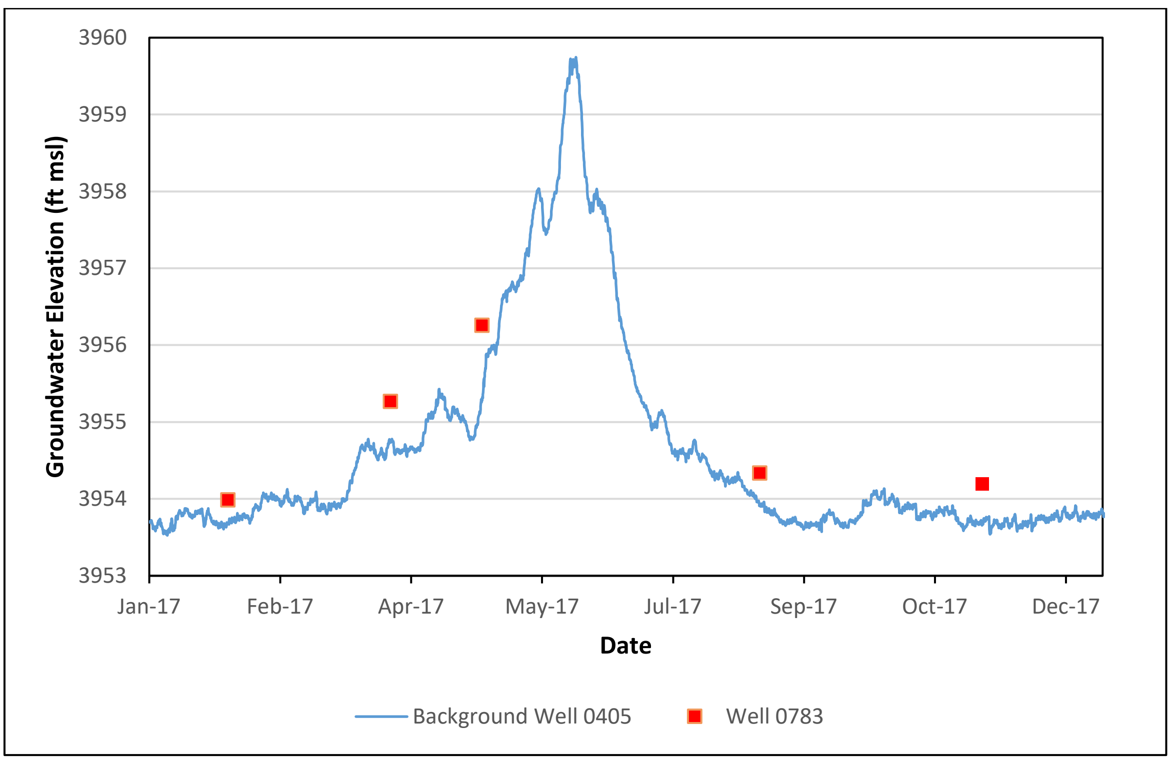

Figure B-14. Freshwater Mounding in Observation Well 0783

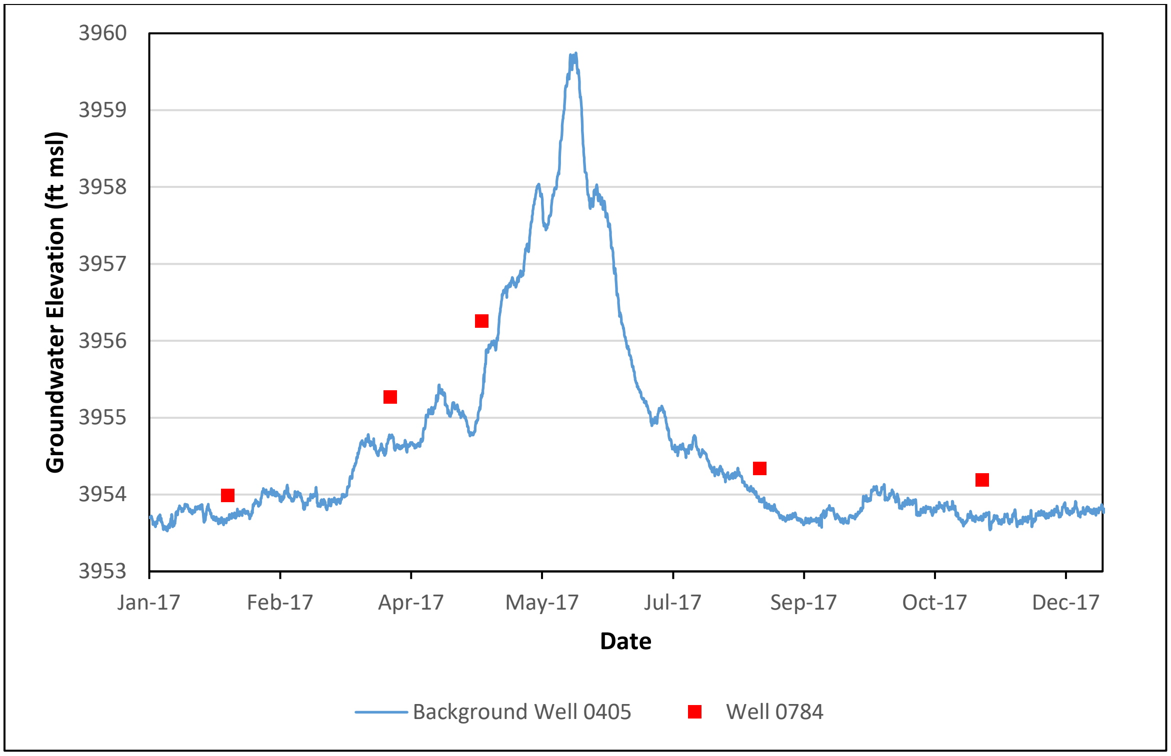

Figure B-15. Freshwater Mounding in Observation Well 0784

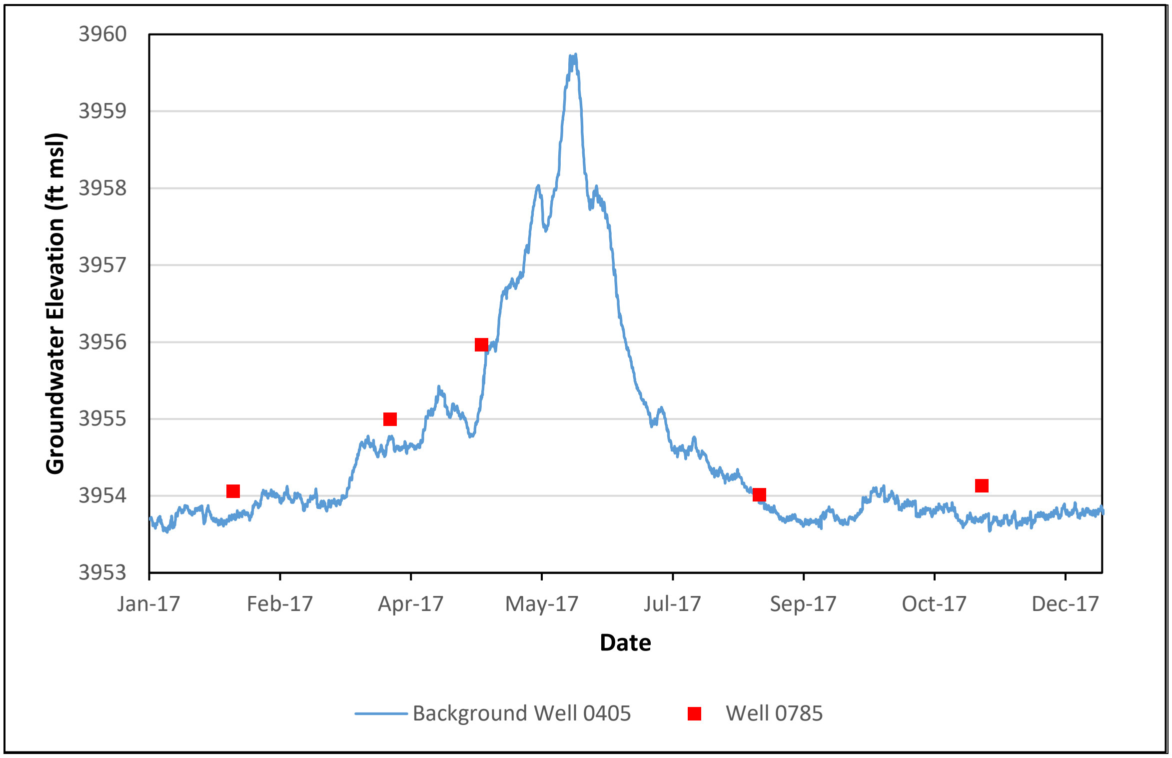

Figure B-16. Freshwater Mounding in Observation Well 0785

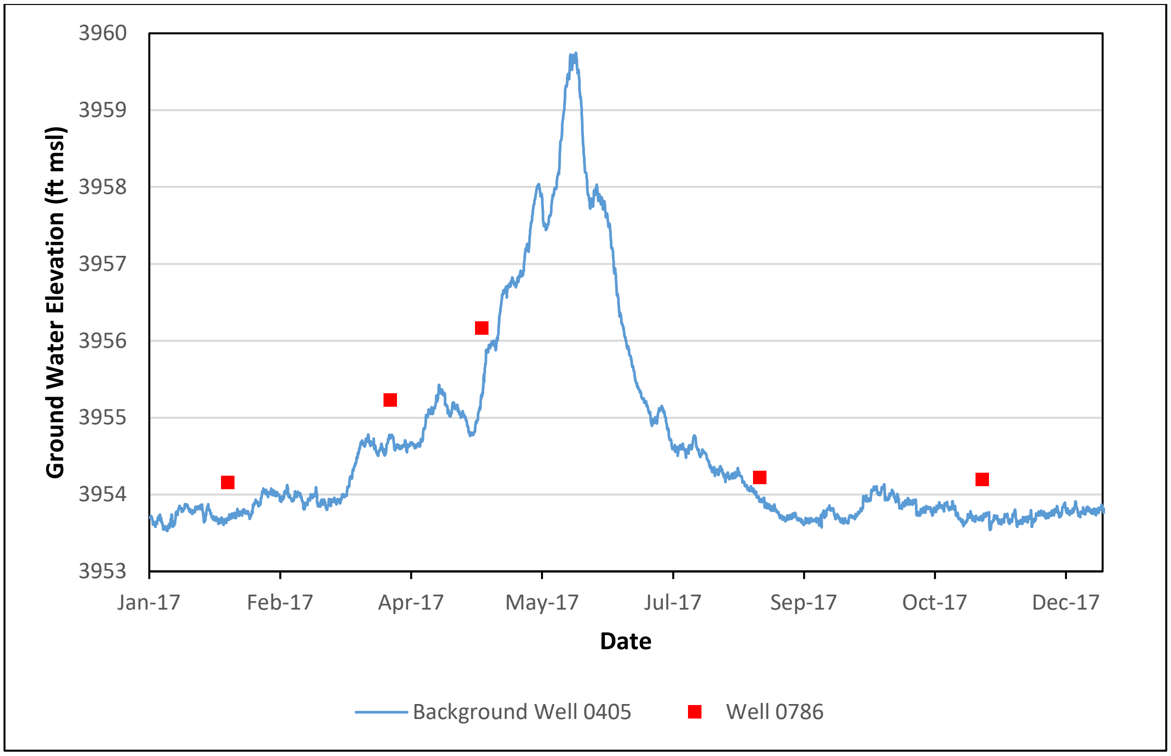

Figure B-17. Freshwater Mounding in Observation Well 0786

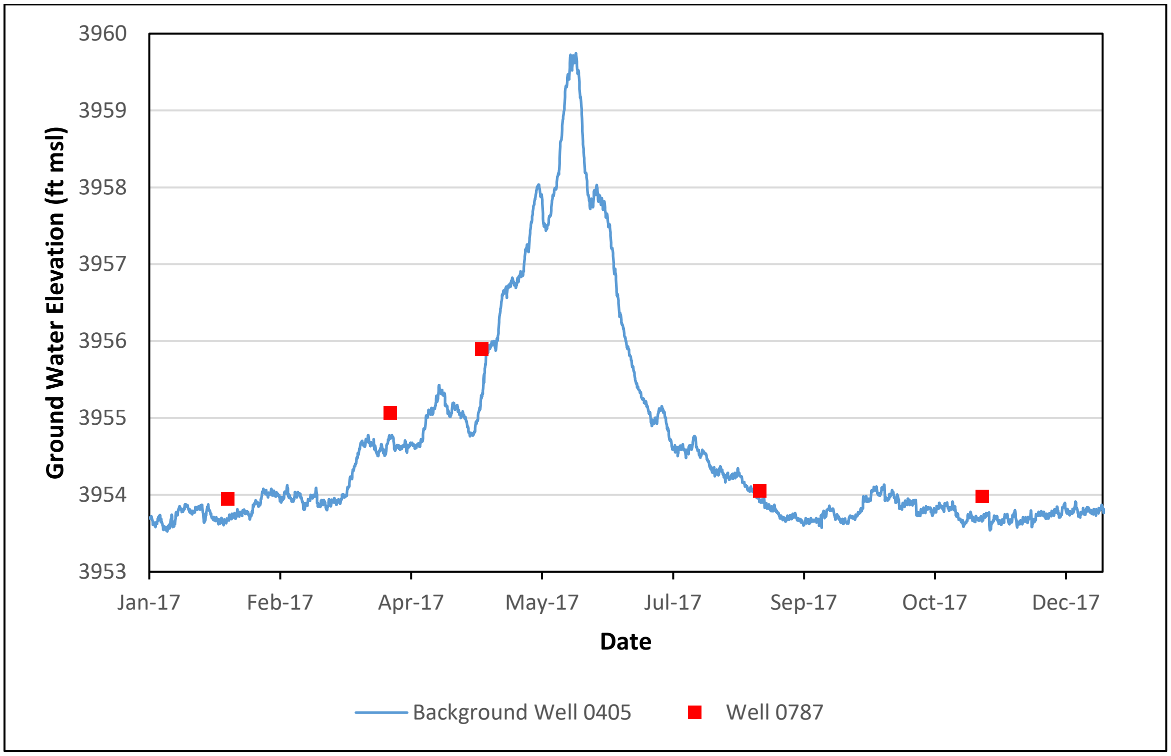

Figure B-18. Freshwater Mounding in Observation Well 0787