DOE–EM/GJTAC2174

Office of Environmental Management – Grand Junction

MOAB UMTRA UTAH

UMTRA Project

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2014 Ground Water Program Report

Revision 0

May 2015

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-EM0002067
for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Revision 0

Review and Approval

05/12/15

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Revision History

Revision Number	Date	Reason for Revision
0	May 2015	Initial issue.

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Acronyms and Abbreviations

ALS	ALS Global
bgs	below ground surface
CA	Contamination Area
CF	configuration
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
IA	interim action
in.	inch
kg	kilograms
lb	pounds
µmhos/cm	micromhos per centimeter
µs/cm	microsiemens per centimeter
mg/L	milligrams per liter
mil	million or millions
RAC	Remedial Action Contractor
TDS	total dissolved solids
UDWR	Utah Division of Wildlife Resources
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Introduction

1.1 Purpose and Scope

The purpose of the Ground Water Program Report is to assess the performance measures the U.S. Department of Energy (DOE) has taken to remediate the ground water 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 Ground Water Program activities for the Moab Project during 2014 and evaluates how the ground water 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 ground water. 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 ground water at the Moab site. As an interim action (IA), DOE began limited ground water remediation that involves extraction of contaminated ground water 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 Ground Water Program Description

The Ground Water Program at the Moab site is designed to limit ecological risk from contaminated ground water discharging to potential endangered fish species habitat areas along the Colorado River. This protection is accomplished through removal of contaminant mass with ground water 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. In addition, 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. Ground water and surface water monitoring is performed in conjunction with injection and extraction operations and through water levels and analytical data. Surface water diversion performance is measured by analytical data.

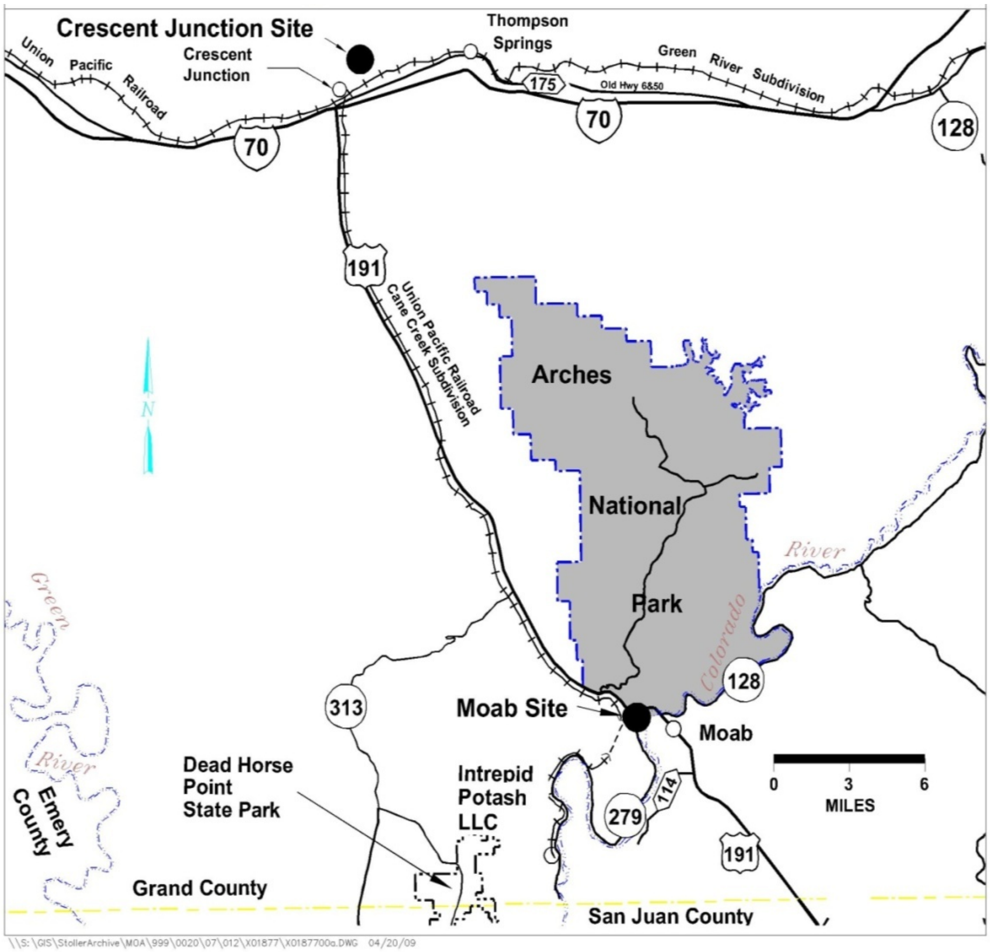


Figure 1. Location of the Moab Project Site

2.1 IA Ground Water System

DOE installed and began operating the first of several configurations (CFs) of extraction/injection wells that comprise the IA ground water system in 2003 (Figure 2). The well field consists of five configurations of wells, an infiltration trench, and a baseline area. The objectives of the IA system are to: 1) reduce the discharge of ammonia-contaminated ground water to side channels that may be suitable habitat for endangered aquatic species; 2) remove contaminant mass through ground water extraction; and 3) to provide performance data for use in selecting and designing a final ground water remedy.

Contaminated ground water from the shallow plume above the brine zone is extracted through a series of eight extraction wells (CF5) and pumped to an evaporation pond or through evaporation units on top of the tailings pile. The IA system also includes injection of diverted river water into the underlying alluvium through remediation wells (CFs 1 through 4) and an infiltration trench installed near the western bank of the river. A surface water diversion system adjacent to the IA well field delivers freshwater 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. Monitoring wells are also part of the IA system for evaluation purposes.

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. The Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and interfingers near the northwestern boundary of the site into the basin-fill alluvium deposited by the Colorado River.

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 a hydraulic conductivity that ranges from 100 to 200 ft/day.

Water table contour maps indicate the ground water in this area discharges into the Colorado River. Figure 3 was generated using data collected in June 2014 and exhibits how ground water underlying the site discharges into the Colorado River. The river flow ranged from 24,000 to 37,400 cubic feet per second (cfs) when the ground water elevation was measured. Figure 4 shows the ground water contours in November/December 2014 when the river flow ranged from 3,550 to 4,140 cfs. The ground water elevation in May was higher due to the bank storage during the above-average peak river flow on the Colorado River.

Most ground water 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, allowing this fluid to have sufficient density to vertically migrate downward in ground water 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 ground water 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 ground water (Figures 5 and 6).

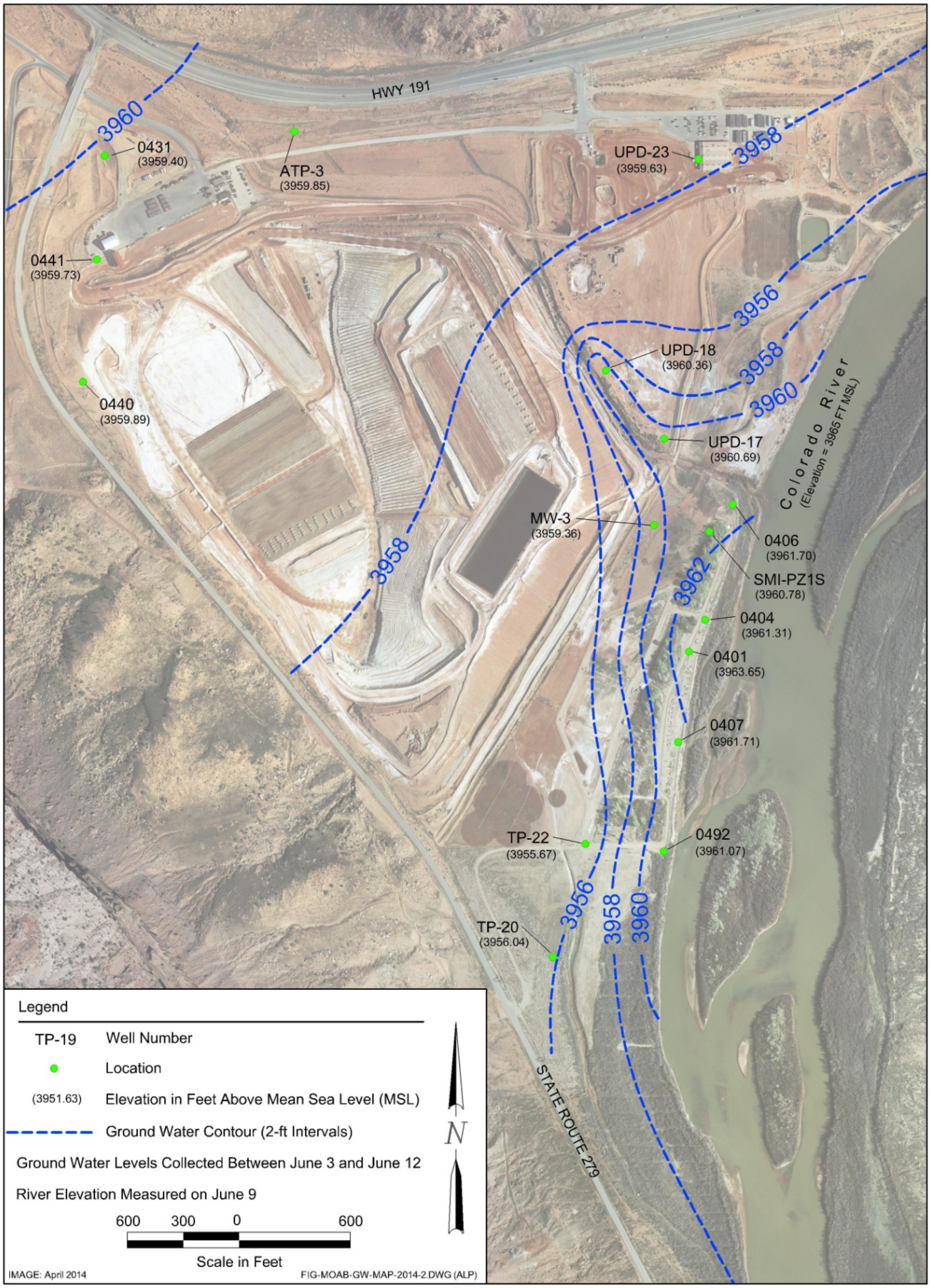


Figure 3. Site-wide Water Contour Map June 2014

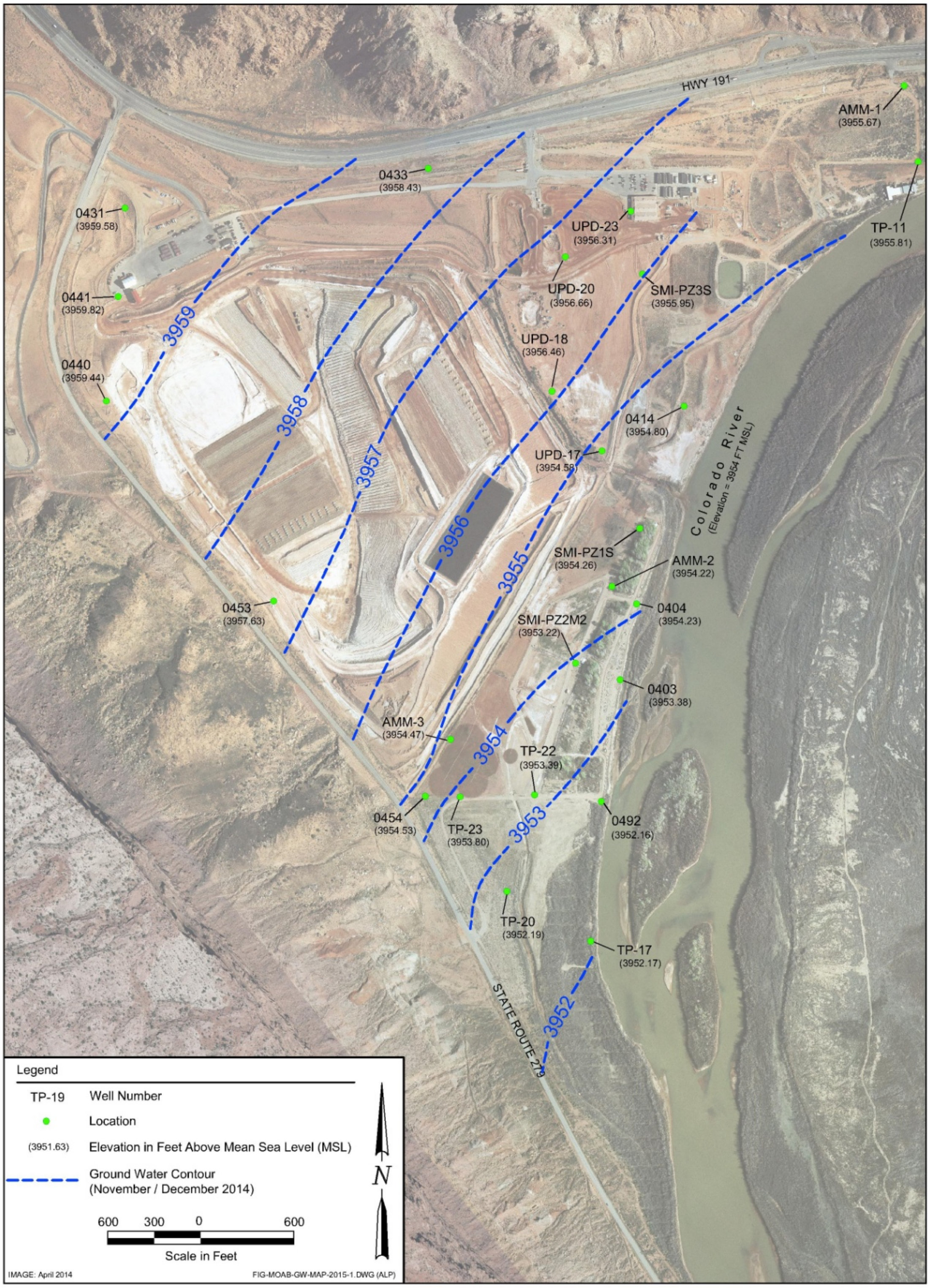


Figure 4. Site-wide Water Contour Map November/December 2014

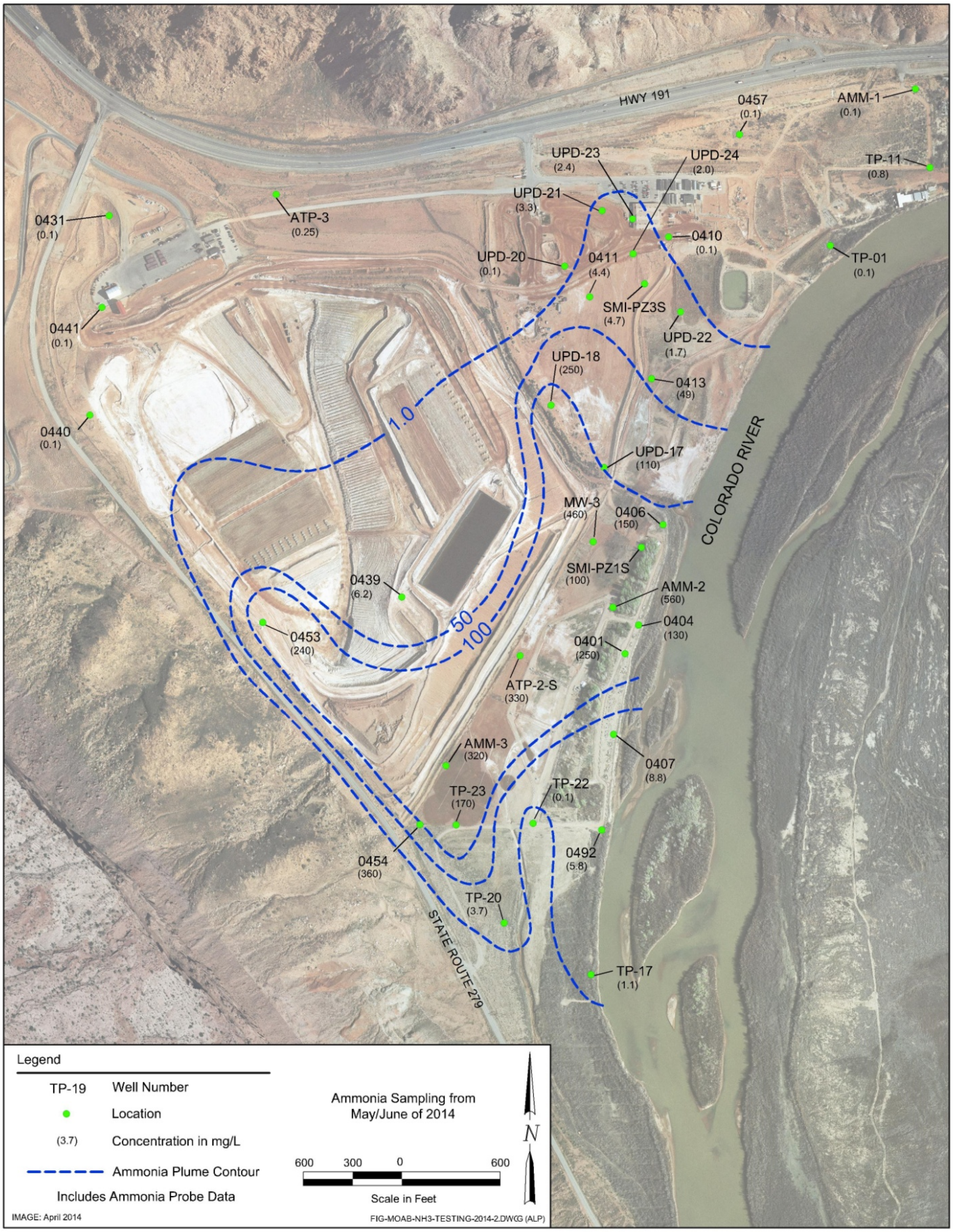


Figure 5. Ammonia Plume in Shallow Ground Water, May/June 2014

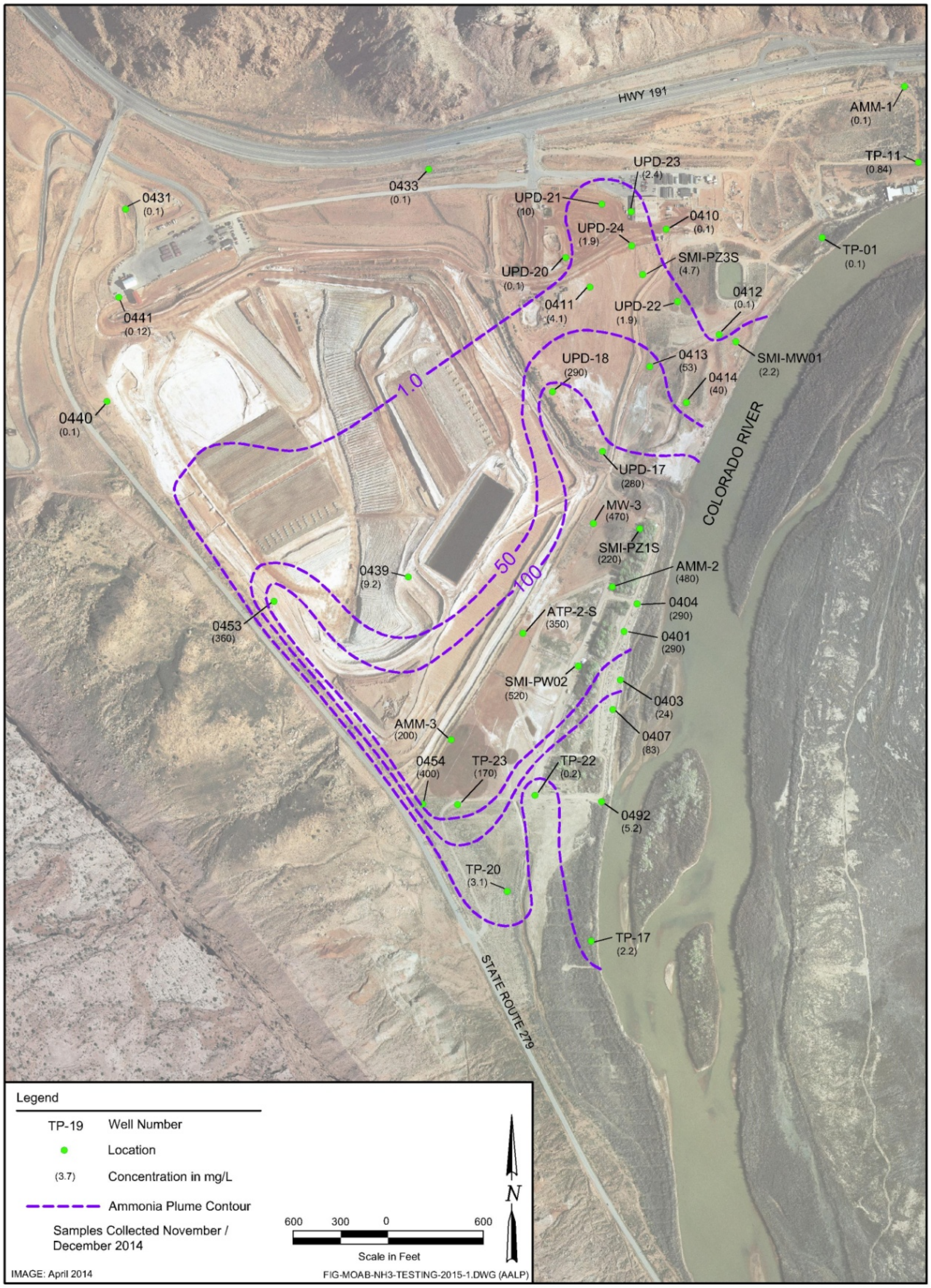


Figure 6. Ammonia Plume in Shallow Ground Water, November/December 2014

Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow ground water beneath the tailings pile, where aerobic conditions are more likely; however, there is now flushing of the legacy plume by advective flow of freshwater due to density stratification of the brine zone.

Figure 5 shows the ammonia plume in June 2014, and Figure 6 shows the ammonia plume in November/December 2014. The two plume maps are comparable.

In addition to ammonia, the other primary constituent of concern in ground water is uranium. Figures 7 and 8 show the distribution of dissolved uranium in shallow ground water in 2014. The uranium plume is similar in the spring and winter with one exception: The concentration in the sample collected from well UPD-24, which increased from 7 to 10 mg/L between June and November/December.

2.3 Surface Water/Ground Water Interaction

Previous investigations have shown that Colorado River flows impact the ground water elevations and contaminant concentrations in the well field. For the majority of the year, when the river is experiencing base flows (less than 5,000 cfs), ground water discharges into the river (gaining conditions). As the river flows increase in response to the spring runoff the river changes from gaining to losing conditions, and a fresh water lens starts to develop in the subsurface underlying the well field. At this time the ground water gradient direction reverses in the vicinity of the river bank, and the ground water contaminant concentrations are diluted. Once the river flows subside, the river switches back from losing to gaining, the ground water gradient direction becomes re-established towards the river (to the southeast), and the fresh water lens recedes.

Figure 9 displays the ground water elevation and the elevation of the Colorado River in 2014. 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 2014 peak flow was 37,500 cfs (on June 3) which corresponds to an elevation of 3964.9 ft msl.

The Colorado River in 2014 was under losing conditions between January and mid-April (when the ground water elevation is greater than the river surface elevation), at which time the river started fluctuating between gaining and losing conditions through mid-May. The river was under losing conditions mid-May through mid-June (the river surface elevation was greater than the ground water surface elevation), until it switched back to gaining conditions.

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and sampling surface water locations, extraction wells, and monitoring wells. In 2014, the IA well field operations included extraction at CF5 and injection at CF4.

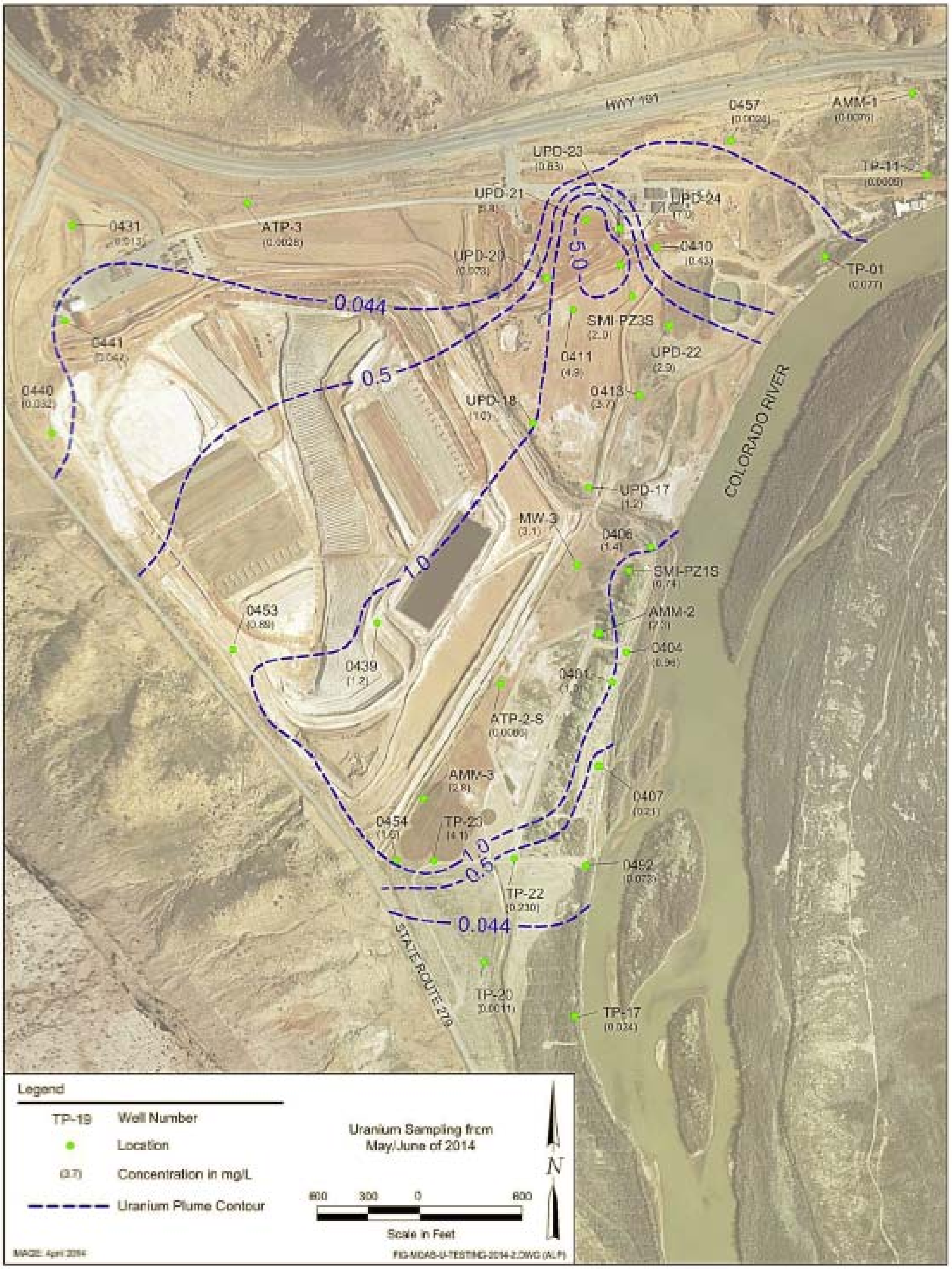


Figure 7. Uranium Plume in Shallow Ground Water, May/June 2014

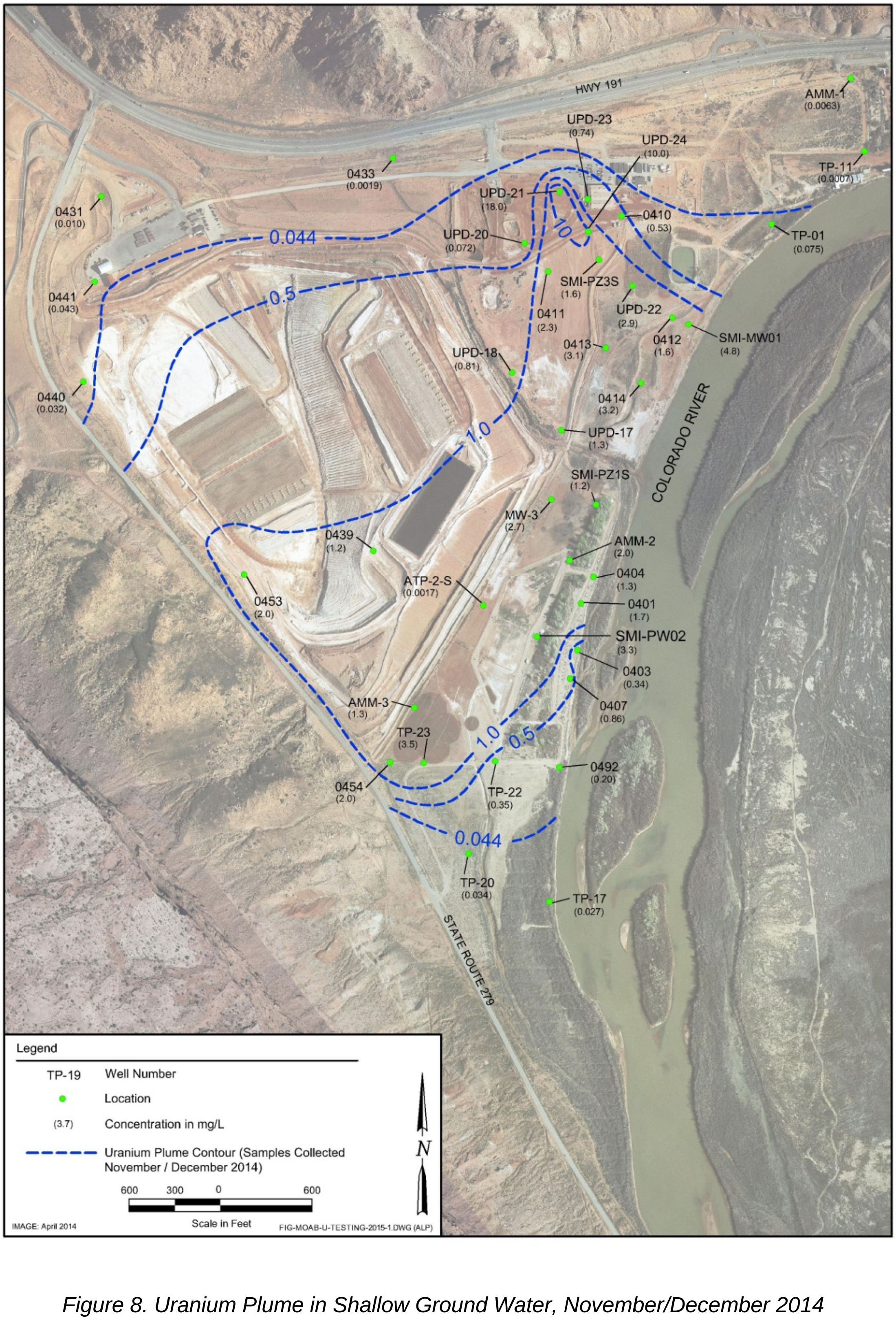


Figure 8. Uranium Plume in Shallow Ground Water, November/December 2014

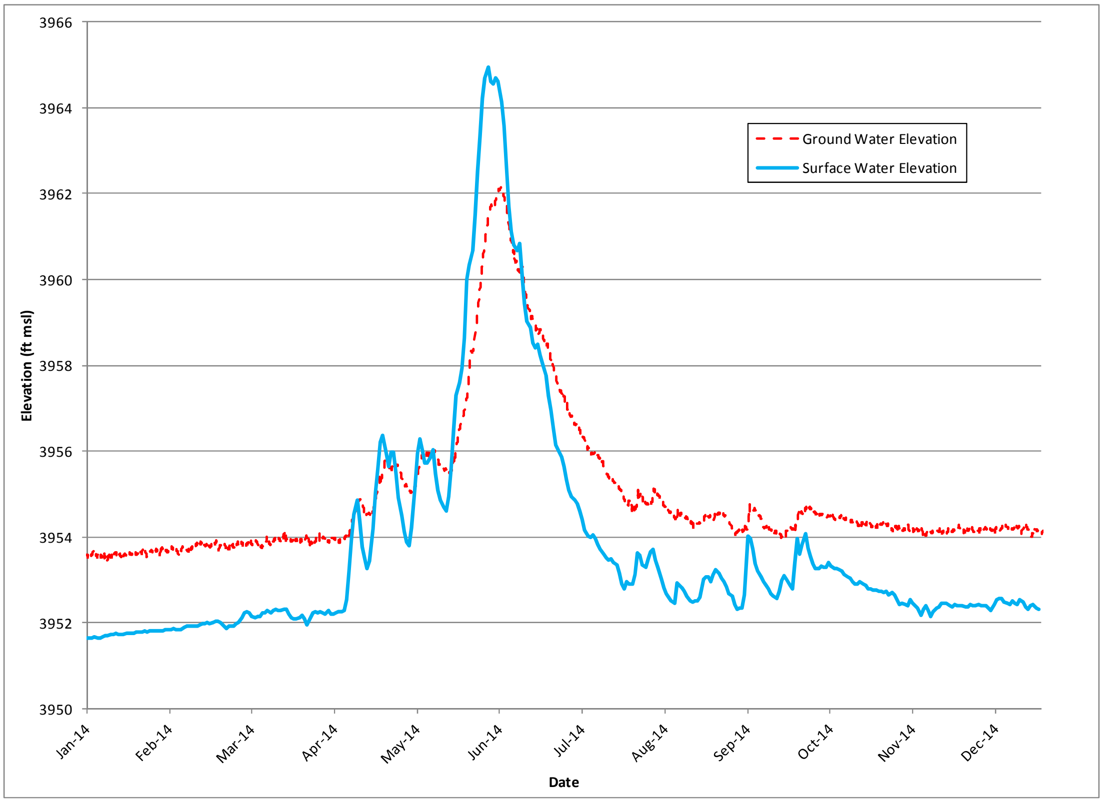


Figure 9. Ground Water Surface Elevation Compared to the Colorado River Surface Elevation, 2014

3.1 Remediation Well Extraction

Each extraction well also 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 ground water is discharged to the evaporation pond on top of the tailings pile, where it naturally evaporates, is sprayed through the evaporators, or used for dust suppression inside the Contamination Area (CA). Any contaminants that are 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

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

3.4 Water Quality

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, oxidation reduction potential, conductivity, and turbidity, 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/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830). Samples are shipped overnight to ALS Global (ALS) in Fort Collins, Colorado, for analysis.

A field ammonia probe is used on site to obtain ammonia concentrations. The probe is used at surface water locations, observation wells during injection, and at extraction wells during operation. Periodically, the ammonia probe data are verified with a laboratory sample analysis. Ammonia analytical data that were recorded with the ammonia probe are presented in this report are stated as such. All other ammonia analyses were provided by ALS.

4.0 Ground Water Extraction Operations and Performance

4.1 IA Operations

This section provides information regarding the IA well field extraction performance during the 2014 pumping season. Also included in this section is a discussion regarding the total ground water 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), mass removal (Tables A-4 and A-5), and drawdown data (Figures A-1 through A-6).

In 2014, the extraction system operated most of the year. The evaporator units were used between April and September, as dictated by the weather conditions. The extraction schedule was focused on optimizing ammonia and uranium mass removal and on rotating through each of the CF5 remediation wells.

Extraction operations began in January, with well PW02 at a rate of approximately 25 gpm, and well 0815 was utilized in February. Beginning in April, all eight extraction wells ran on a rotational basis at an average combined rate of approximately 37 gpm. Extraction was temporarily shut down in June due to on-site flooding during the peak river flow.

Throughout the summer, ground water extraction occurred by cycling through seven of the eight CF5 wells. The extraction rate peaked at 161 gpm on July 30. Extraction was suspended on September 24 to control the evaporation pond level. In the fall and winter, the extraction rate reached up to 30 gpm. The system was temporarily winterized on December 23 due to below-average air temperatures.

The associated volume of ground water 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 ground water extracted from CF5 in 2014. A total of 13.6 mil gal of water were extracted from CF5 during 2014.

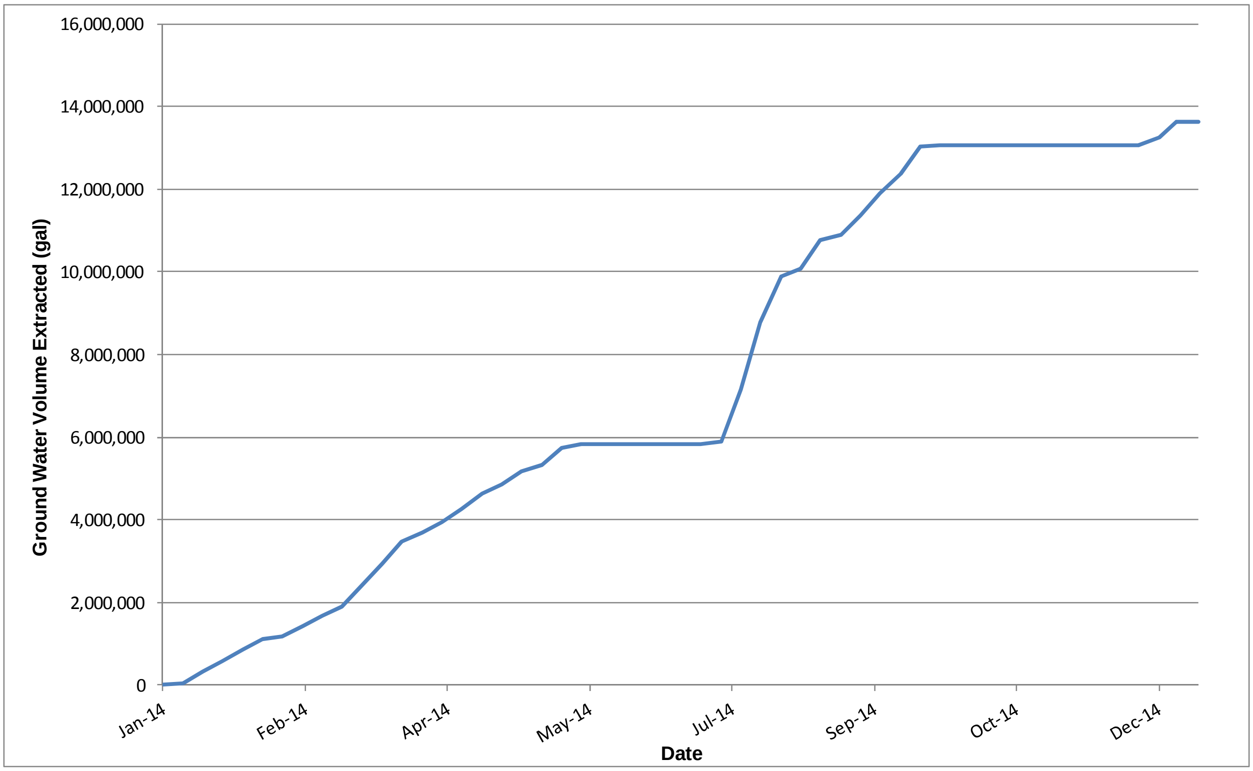


Figure 10. Cumulative Volume of Extracted Ground Water during 2014

4.1.1 CF5 Pumping Rate and Ground Water Extracted Volume

As previously mentioned, CF5 extraction wells 0810 through 0816 and PW02 were used to extract ground water in 2014. The well screens are placed at varying depths (Appendix A, Table A-1) due to varying depths to the brine interface in the CF5 area.

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3 (Appendix A). The majority of the 2014 extracted water was removed from well PW02 (2.8 mil gal). The remaining CF5 wells extracted between 1.2 and 2.0 mil gal in 2014. Extraction operations were maximized from July through September, when the evaporation potential was at its highest. The evaporator units and water trucks were used to dispose of the extracted water.

4.2 IA Extraction Performance

4.2.1 Ground Water Levels and Hydraulic Control

Figure 11 shows the average pumping rates and associated drawdown data for each of the CF5 wells. The wells with the highest drawdown (0810, 0811, and 0814) are located on the southern portion of CF5, while the wells on the northern end of CF5 (0813 and 0816) are more productive. This difference is likely due to variation in underlying sediments. The results are similar to those measured in previous years.

Hydrographs were prepared to compare background ground water elevations (from observation well 0405 located in the northern end of the well field) and ground water elevations of the CF5 extraction wells during the pumping season (see Figures 12 and 13 and A-1 to A-6 in Appendix A). Applicable extraction rates for each well were plotted against the ground water elevations.

Well 0405 water elevation data were adjusted so that both wells were assigned the same non-pumping water level; however, with well 0812, there was not a non-pumping water level to calibrate to well 0405, so data from the adjacent well (0813) was used. The difference between the two wells gives a qualitative estimate of drawdown in response to pumping.

Figures 12 and 13 show drawdown during extraction operations for wells PW02 and 0810 compared to the background ground water surface fluctuation. Both wells had maximum drawdown during higher rates of extraction, and the water levels rebounded quickly after the extraction operations were shut down.

4.2.2 Extraction Well Specific Capacity

Specific capacity is the measure of a well's performance relative to formation hydraulic characteristics. Individual extraction well drawdown data were used to compute the specific capacity during the 2014 pumping season. While this is not a rigorous method of calculating specific capacity because it does not account for well interference, it provides a qualitative evaluation of the relative performance of each extraction well (Table 1).

The specific capacity varies greatly in the CF5 wells. Remediation wells 0813 and 0816 have the highest specific capacities; up to 68.5 gpm/ft was measured in well 0813. More drawdown is observed in the wells with the lower specific capacity values (0811, 0812, PW02). The data shown in Table 1 is comparable to what was historically observed.

4.3 Contaminant Mass Removal

The ammonia and uranium mass removed by CF5 extraction wells in 2014 is presented in Tables A-4 and A-5 of Appendix A. These values are based on ground water extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from ground water 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 D (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.

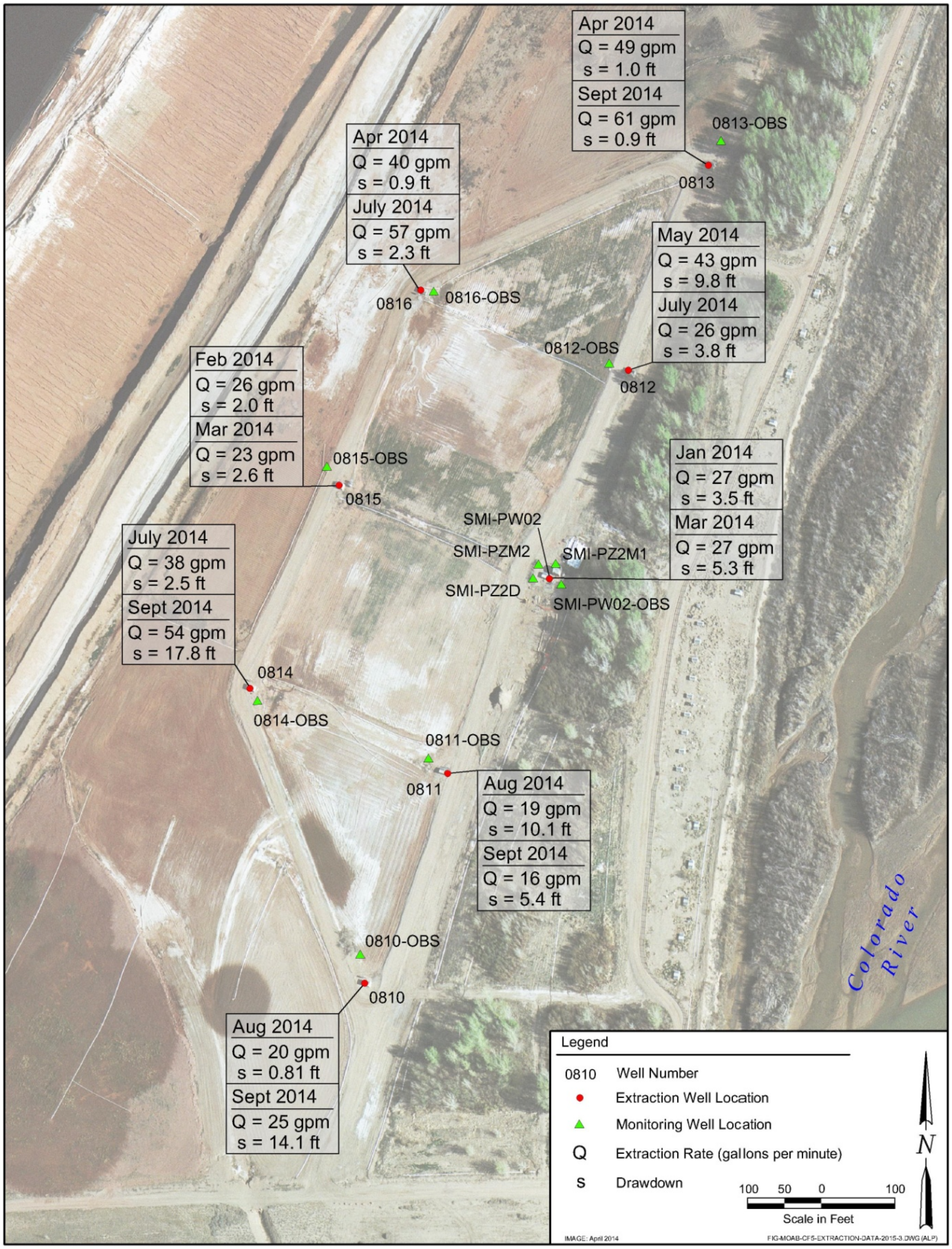


Figure 11. Flow Rates and Drawdowns in CF5 in 2014

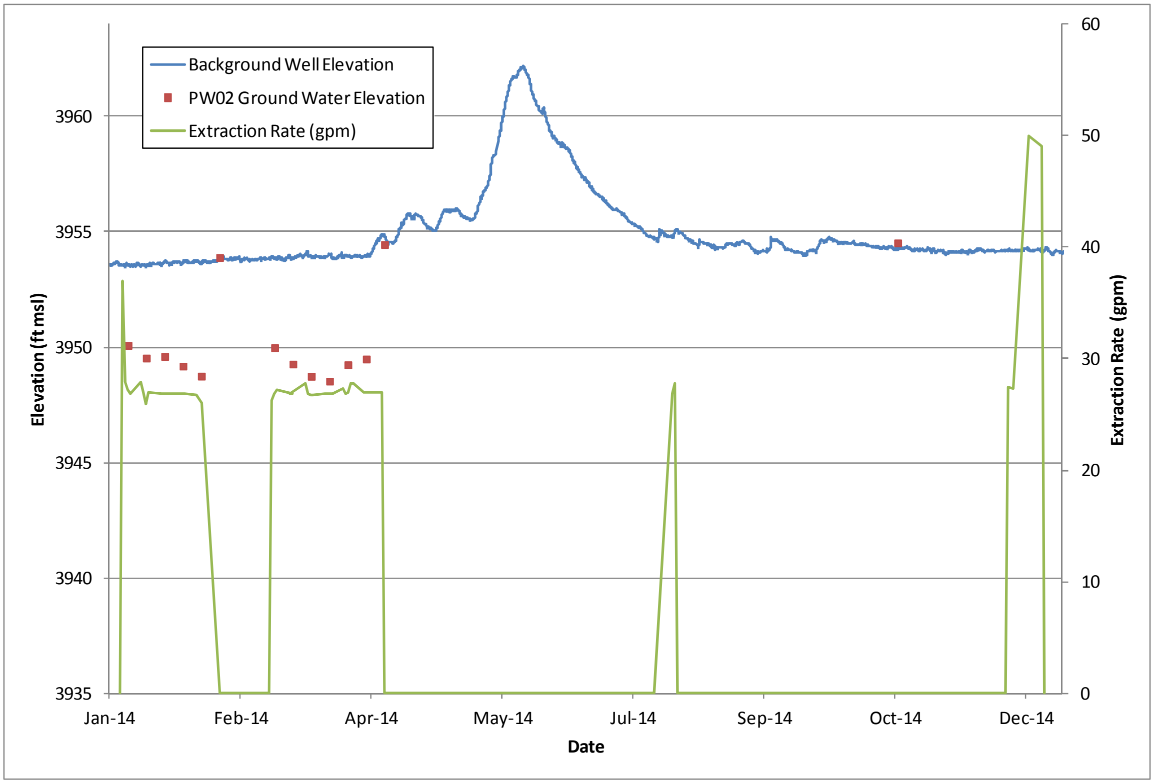


Figure 12. Drawdown Data for Extraction Well PW02

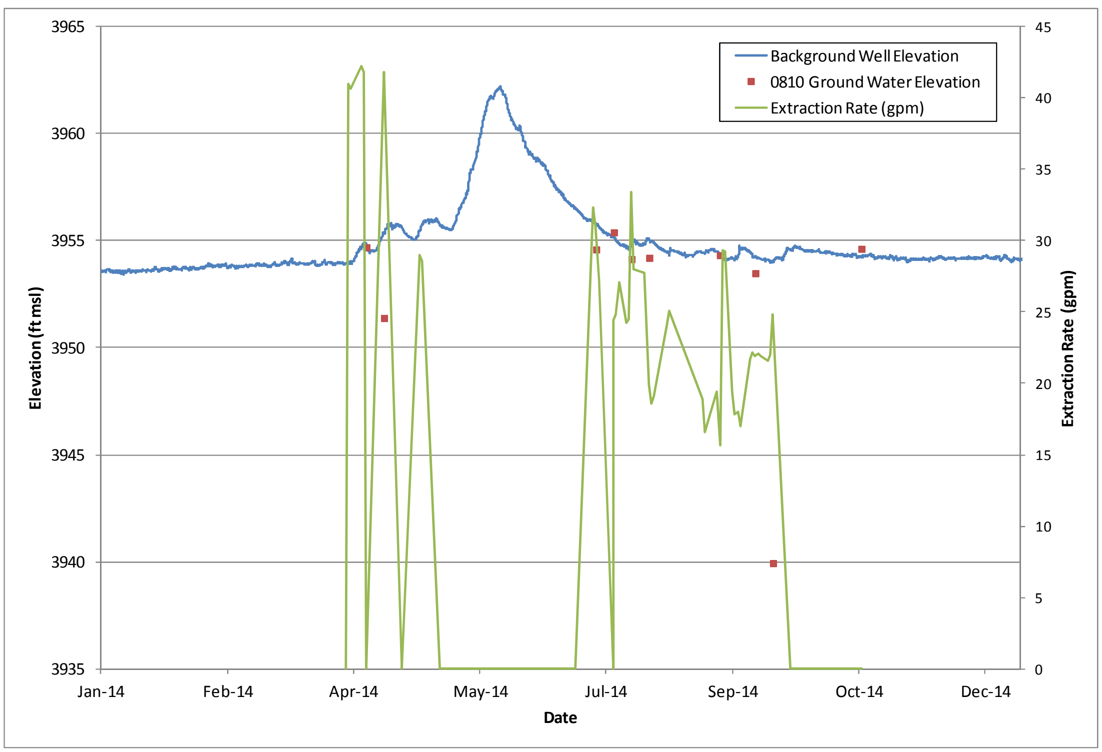


Figure 13. Drawdown Data for Extraction Well 0810

Table 1. Drawdown during Extraction Operations

Location	Date	Drawdown (ft)	Extraction Rate (gpm)	Specific Capacity (gpm/ft)
0810	08/06/14	0.8	20	25.0
	09/24/14	14.1	25	1.8
0811	08/27/14	10.1	19	1.9
	09/17/14	5.4	16	3.0
0812	05/14/14	9.8	43	4.4
	07/22/14	3.8	26	6.8
0813	04/16/14	1.0	49	49.0
	09/17/14	0.9	61	67.8
0814	07/16/14	2.5	38	15.2
	09/17/14	17.8	54	3.0
0815	02/12/14	2.0	26	13.0
	03/12/14	2.6	23	8.8
0816	04/30/14	0.9	40	44.4
	07/23/14	2.3	57	24.8
PW02	01/08/14	3.5	27	7.7
	03/26/14	5.4	27	5.1

In 2014, a total of 38,309 pounds (lb) (17,376 kilograms (kg)) of ammonia and 297 lb (134 kg) of uranium were extracted from the ground water. Table A-4 in Appendix A shows that extraction wells PW02 and 0813 removed the most ammonia mass, at 10,660 lb (4,835 kg) and 5,718 lb (2,593 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Appendix A, Table A-5, which shows the greatest mass of uranium was extracted from wells 0815 and PW02 at 77 lb (35 kg) and 46 lb (21 kg), respectively.

4.4 Ground Water Chemistry

Ground water samples were collected from the CF5 extraction wells in April and July/August 2014 (Table 2), and samples were collected from PW02 again in December 2014. Ammonia concentrations varied from 180 mg/L (0816) to 520 mg/L (PW02), and the uranium concentration ranged from 1.4 mg/L (0813) to 3.3 mg/L (PW02). Specific conductance ranged from 12,354 µmhos/cm at well 0813 (northern end of CF5) to 35,268 µmhos/cm at well PW02. The specific conductance was higher at PW02 because the pump is set at a lower elevation.

Table 2. CF5 Ammonia and Uranium Concentrations, 2014

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	04/15/14	340	3.0	31,635
	07/28/14	320	2.9	29,742
0811	04/15/14	380	2.5	22,176
	07/31/14	450	2.8	26,044
0812	04/17/14	440	1.9	19,533
	07/28/14	380	1.8	20,940
0813	04/17/14	410	1.5	15,616
	07/28/14	340	1.4	12,354
0814	04/15/14	210	2.6	24,571
	07/31/14	280	2.7	27,535

Table 2. CF5 Ammonia and Uranium Concentrations, 2014 (continued)

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0815	04/15/14	300	3.1	28,623
	08/05/14	350	3.1	25,074
0816	04/15/14	180	2.4	22,617
	07/28/14	210	2.4	24,387
PW02	04/15/14	450	2.8	35,268
	08/05/14	490	3.2	21,987
	12/12/14	520	3.3	26,115

5.0 Evaporation Pond Operations

The evaporation pond, located on the southeastern portion of the tailings pile, stores the ground water that was extracted from the CF5 wells. Water stored in the pond is removed by evaporation, by water trucks for dust suppression on top of the tailings pile, or through the use of evaporator units located on the edge of the pond.

A chronology of the evaporation pond operations can be found in Table B-1 in Appendix B and is summarized here. Table B-2 contains the 2014 evaporation pond level and volume for 2014, and Table B-3 contains the evaporator operations.

The Remedial Action Contractor (RAC) removed water from the pond for dust suppression from February until late November.

5.1 Evaporation Pond Water Balance

Water inflows and outflows, along with the pond level, are illustrated in Figure 14. As shown, the outflow varied from month to month, but was highest from March through September.

Approximately 13.7 mil gal of extraction water were removed from the evaporation pond by water trucks in the Contamination Area. Most of the water was removed during the spring and summer months (April through June) when the evaporation potential is highest (Figure 14). This water is used for dust suppression inside the CA.

Approximately 1.6 mil gal of extracted water were pumped through the evaporators between April and October, when the weather conditions are more conducive to evaporation. On occasion, during favorable weather, the evaporators ran overnight. The total gallons represent what was pumped through the evaporators as opposed to what actually evaporated, which was not possible to calculate.

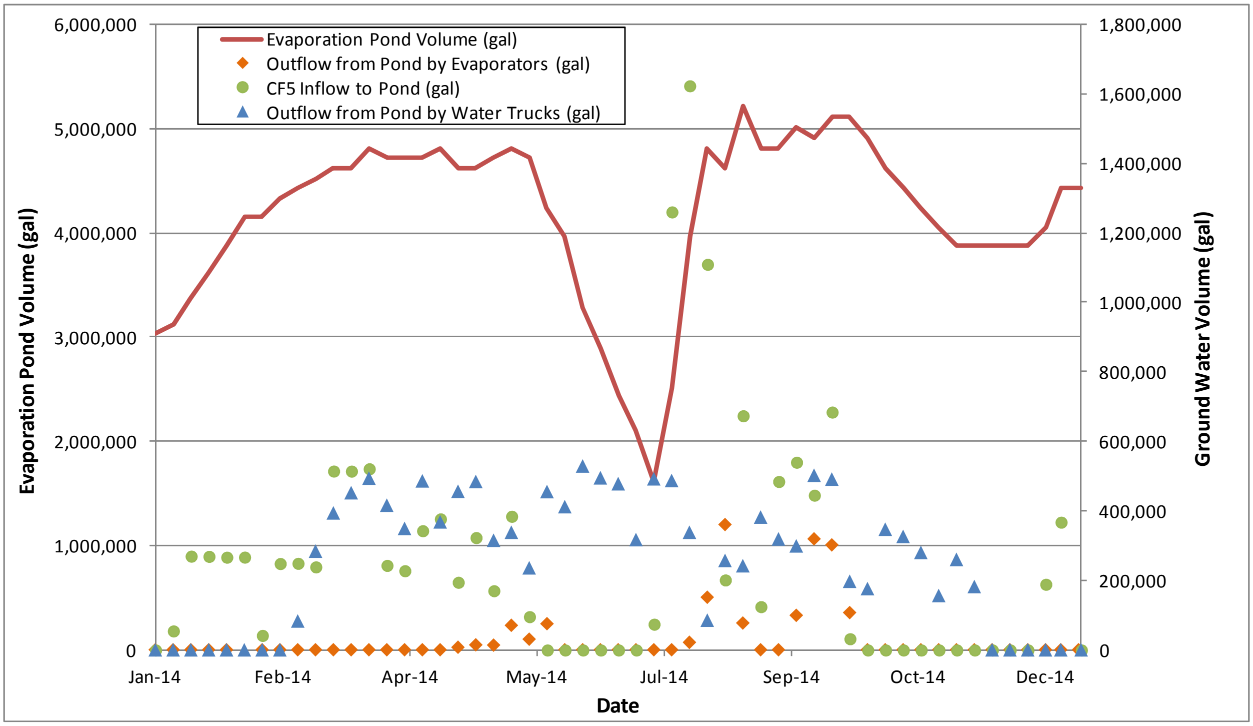


Figure 14. Rates of Water Delivery and Outflow to and from the Evaporation Pond and Pond Volume during 2014

6.0 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 ground water discharges into the backwater channel. Freshwater injection into the CF4 wells occurred from January to May and again from July to December.

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

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 ground water discharges to the adjacent backwater channel.

Approximately 8.5 mil gal of freshwater were injected into CF4 in 2014.

6.1 Injection Performance

A chronology of injection events in 2014 can be found in Table C-2 of Appendix C. Before starting injection operations, ammonia probe samples were collected and analyzed in the CF4 observation wells, and water levels were recorded.

Injection into all 10 wells began on January 15. The system ran into mid-May when it was shut down during the peak river flow following the Flood Mitigation Plan. Operations resumed in mid-July, and it was necessary to suspend operations from mid-August through late October due to a break in the injection line at Moab Wash. During this time the injection wells were developed. Injection continued from late October through December 23, when it was winterized.

6.2 Summary of Chemical Data from Observation Wells

Throughout 2014, ammonia probe samples were collected from the CF4 observation wells and well points before and during injection operations to access the effectiveness of the system (Appendix C, Table C-3). Ammonia samples that were collected were analyzed with the ammonia probe on site, and splits were sent to ALS. Chemical data plots of ammonia and specific conductance can be found in Appendix C, Figures C-1 to C-6.

Ammonia samples were collected before injection startup in January (ammonia probe), during operations in April (ammonia probe and ALS), in July (ammonia probe and ALS) and October (ammonia probe) when the system was shut down (Appendix C, Table C-3). The results of these samples indicate ammonia concentrations were lowest at 18 ft below ground surface (bgs) (less than 1 mg/L at downgradient wells 0784, 0785) and highest between 36 and 46 ft bgs (up to 1,578 mg/L at upgradient well 0781). Ammonia probe samples collected during injection operations show that the downgradient concentrations are drastically lower at 36 ft bgs (Appendix C, Figures C-1, C-3, and C-5). For example, the ammonia concentration in well 0787 (36 ft bgs) dropped from 1,566 mg/L before injection operations to 26.1 mg/L in April. When injection was temporarily shut down, the ammonia increased to 541 mg/L.

The specific conductance decreased at all of the downgradient observation wells during injection operations. Before injection operations, the specific conductance varied from 2,230 microsiemens per centimeter (µs/cm) (18 ft bgs) to 69,213 µs/cm (36 ft bgs). During operations, the specific conductance dropped to between 1,103 µs/cm (18 ft bgs) and 1,400 µs/cm (36 ft bgs). The drop in conductivity is due to the suppression of the brine interface during operations. Conductivity increased again when the injection was temporarily suspended in the fall.

Ammonia concentrations in the upgradient wells also decreased during injection operations. For example, the ammonia concentration in well 0781 (46 ft bgs) went from 1,578 mg/L before injection to 461 mg/L during operations.

The specific conductance at the upgradient observation wells followed the same trend as the ammonia concentrations (Appendix C, Figures C-2, C-4, and C-6). Conductivity dropped at all upgradient wells. The conductivity in well 0781 dropped from 83,170 µs/cm to 17,970 µs/cm when the system was operational. It is likely that the brine interface was located near 46 ft bgs and was impacted by the injection rate.

6.3 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 collected water levels were plotted against the pressure transducer water levels 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 is shown in Appendix C, Figures C-7 to C-16 for the injection wells. Figures C-17 through C-24 in Appendix C illustrate the mounding data in CF4 observation wells.

Figures 15 and 16 are contour maps showing the CF4 freshwater mounding in April and July 2014, 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 summer. The amount of mounding was dependent on the individual well efficiency and the injection rate. Table 3 presents the maximum mounding measured in each of the ten injection wells and the corresponding injection rate.

The mounding in the observation wells varied from 0.07 to 0.48 ft in the upgradient wells and 0.35 ft in the upgradient wells (Table 4). The amount of mounding observed in 2014 was lower than than what was observed in 2013. Nearly all of the observation wells had the highest mounding in mid-May. It is likely that the wells were also impacted by the spring runoff on the Colorado River.

Table 3. Maximum Mounding Observed in CF4 Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	05/12/14	Injection Well	9.46	2.9
0771	07/23/14	Injection Well	10.95	5.1
0772	03/20/14	Injection Well	12.82	1.4
0773	07/21/14	Injection Well	11.16	0.9
0774	07/23/14	Injection Well	11.57	1.2
0775	03/25/14	Injection Well	8.34	10.5
0776	04/15/14	Injection Well	11.77	3.5
0777	07/23/14	Injection Well	11.54	2.6
0778	04/08/14	Injection Well	15.24	0.90
0779	04/15/14	Injection Well	11.10	1.5

Table 4. Freshwater Mounding Observed in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0783	05/12/14	Upgradient	0.35	30
0784	05/12/14	Downgradient	0.48	30
0785	05/12/14	Downgradient	0.32	25
0786	05/13/14	Downgradient	0.07	30

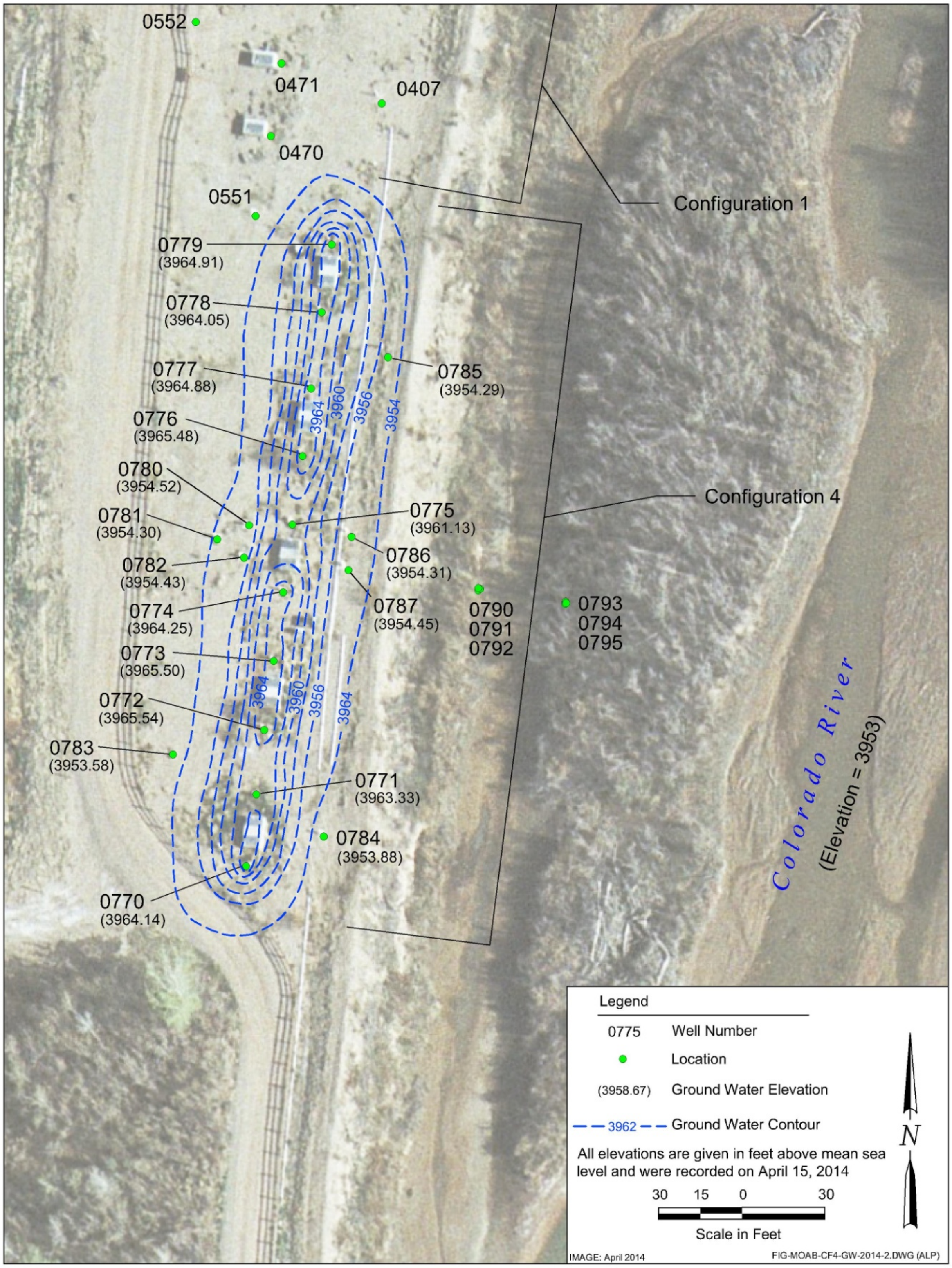


Figure 15. Freshwater Mounding at CF4 during Injection Operations April 2014

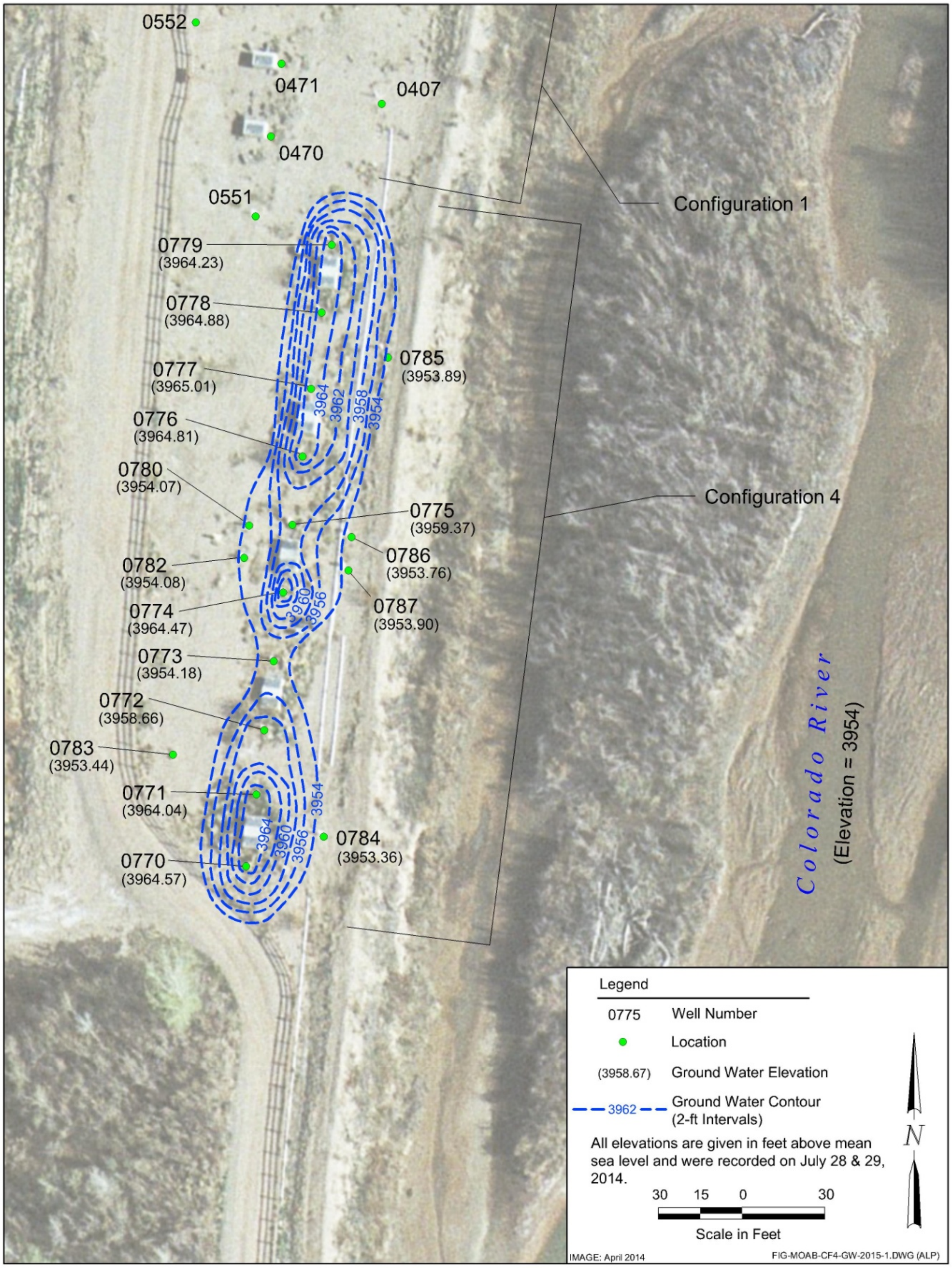


Figure 16. Freshwater Mounding at CF4 during Injection Operations July 2014

7.0 Surface Water Monitoring

In 2014, the river flow ranged from 2,380 to 37,500 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). During those three months, the river flow at the Cisco Gage varied from 3,490 to 37,500 cfs.

Surface water monitoring is completed through site-wide surface water sampling and biota monitoring. 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 (Figure 17).

7.1 Site-wide Surface Water Monitoring

Surface water sampling was conducted adjacent to the well field in April 2014. Locations were sampled in preparation for the post-spring runoff peak flows, when the side channel could potentially develop into a suitable habitat. The data would be used to determine where the highest ammonia concentrations were present in the side channel before peak spring runoff. The results of this sampling event can be found in the *Ground Water and Surface Water Monitoring January through June 2014*. The ammonia concentrations were the highest just off of the bank of CF4.

Four surface water samples were collected off of CF4 in September. At the time, the channel was very shallow and was not considered a habitat. The results can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2014* (DOE-EM/GJTAC2149). All of the ammonia concentrations were below the U.S. Environmental Protection Agency (EPA) acute criteria.

Site-wide surface water monitoring took place in May and in November/December. Ammonia and uranium sample results were analyzed by ALS Environmental, Inc. The results of the May 2014 sampling event can be found in the *Ground Water and Surface Water Monitoring January through June 2014*. In May, all of the ammonia concentrations were below the detection limit of 0.1 mg/L. The results of the November/December 2014 sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2014* (DOE-EM/GJTAC2168). All of the ammonia concentrations were below the EPA acute and chronic criteria.

7.2 Surface Water Monitoring

Surface water monitoring is conducted yearly 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 2013, a combination of the higher than average peak flow and an active late summer monsoonal season deposited an abundance of silt in the side channel. In 2014, due to the deposition in the side channel, it did not meet the suitable young-of-year habitat criteria (closed off upriver, open downriver).

The impact of the deposition of sediment is evident in the photos displayed in Figure 18. The top photo was taken in 2012, prior to the 2013 late summer storm events. The bottom photo was taken in April 2014, showing the change in the side channel configuration. Both photos were taken at approximately the same river flow (3,500 cfs).

Channel B, which was identified as a habitat last year, flowed through to the river during the entire year and did not meet the suitable habitat criteria.

A meeting was held on August 20 with Paul Abate and Chris Cline of the U.S. Fish and Wildlife Services and Paul Bedame of Utah Division of Wildlife Resources (UDWR). A presentation was made describing recent ground water and surface water related site activities and the group was then taken on a tour of the well field. The UDWR representative confirmed that it was not necessary to divert water into the side channel off CF4 under its current configuration.

Observations

In June, the river flow ranged from 11,400 to 37,400 cfs, which is above the daily average flow of 15,500 to 23,200 cfs. The side channel adjacent to the well field flowed through to the river the entire month.

In July, the river flow ranged from 4,530 to 12,000, which is slightly below the daily average flow of 5,410 to 14,900 cfs. On July 14, a representative from the Utah Division of Natural Resources was on site to seine areas that had been flooded for endangered fish. None were noted.

By July 25, the river flow had decreased to 4,600 cfs, and the side channel adjacent to CF4 was still flowing through to the river. A monsoonal storm increased the river flow to 7,640 cfs on July 30, allowing more water to flow through the side channel.

In August, the river flow ranged from 3,910 to 8,110 cfs, which is above the average of 3,620 to 5,360 cfs. On August 11, the river flow had decreased to 4,330 cfs, and abundant sediment was noted within the bed of the side channel as the result of recent storms.

The channel was barely open to the river on the both the northern and southern ends, so it was not considered a habitat. By August 14, the river flow had dropped to 4,830 cfs, and the channel was no longer connected to the river. The middle portion of the channel still contained approximately 3 inches (in.) of water with a soft, muddy substrate.

In September, the river flow ranged from 3,610 to 7,660 cfs, which is above the average of 3,510 to 4,100 cfs. On September 5, the side channel was nearly dry, and some of the newly deposited sediment had started to lithify. The river flow increased rapidly to 9,270 cfs on September 10 as a result of a storm system, and the side channel flowed through once again.

For the remainder of the year, the channel remained dry and closed off to the river. This is the first year these conditions have been observed.

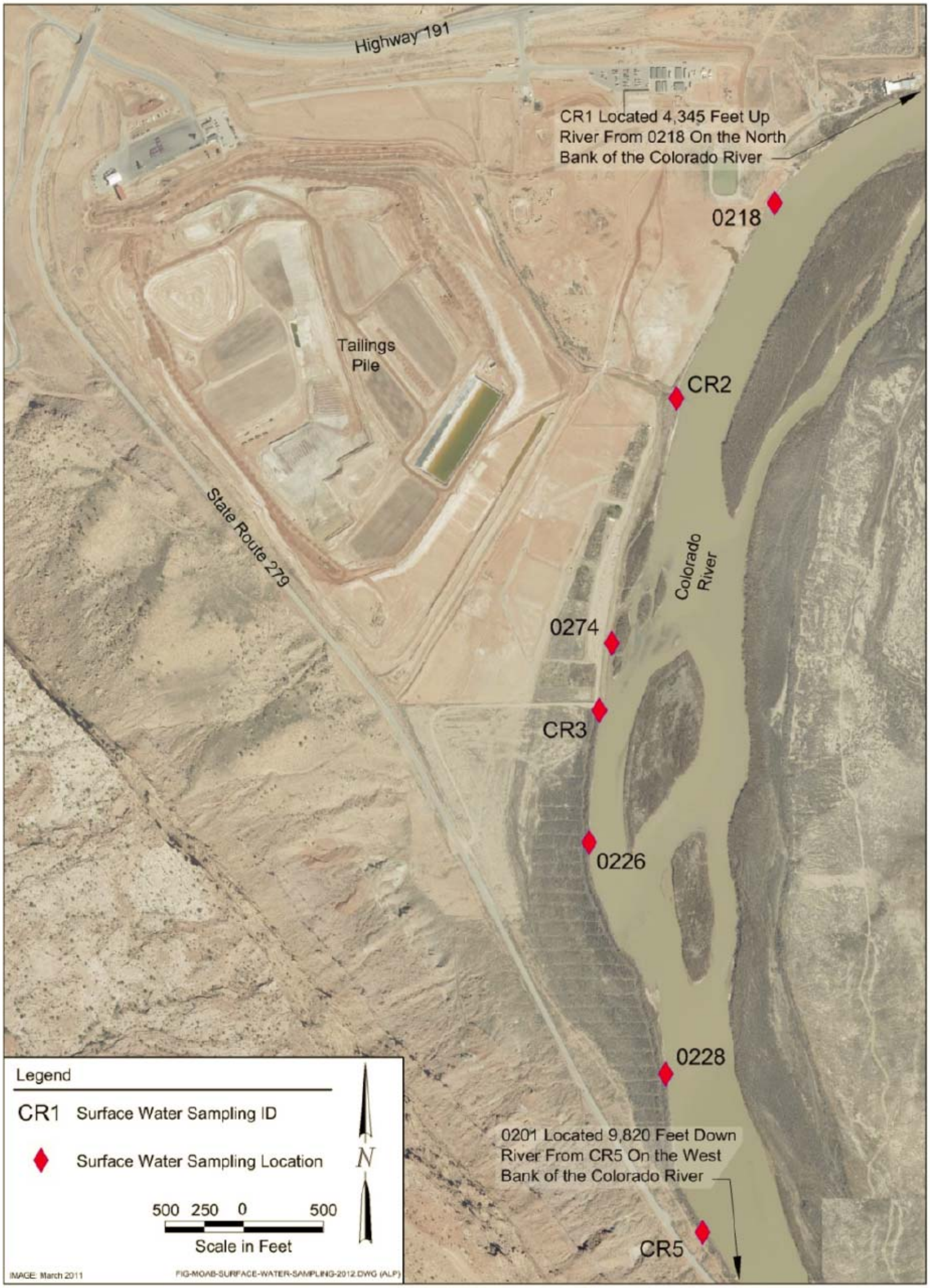


Figure 17. Site-wide Surface Water Sample Locations

Figure 18. Side Channel Comparison between April 2012 (top) and April 2014 (bottom)

7.3 Summary of Surface Water Monitoring

The low river flow combined with the frequent storm events resulted in the accumulation of silt in the CF4 side channel. After the habitat monitoring season, the southern end of the channel (where it connects to the main river channel) was dry for most of the winter months. Channel B (adjacent to the CF4 side channel) flowed through to the river during the year. No dead or distressed fish were found within the channel during the 2014 biota monitoring season. Figure 19 shows the river flow and the number of habitat days from 2006 through 2014. Note that the years with the highest river flow tend to have the least amount of suitable habitat days; however, in 2014, there were zero days of suitable habitat due to late summer sedimentation within the channel bed.

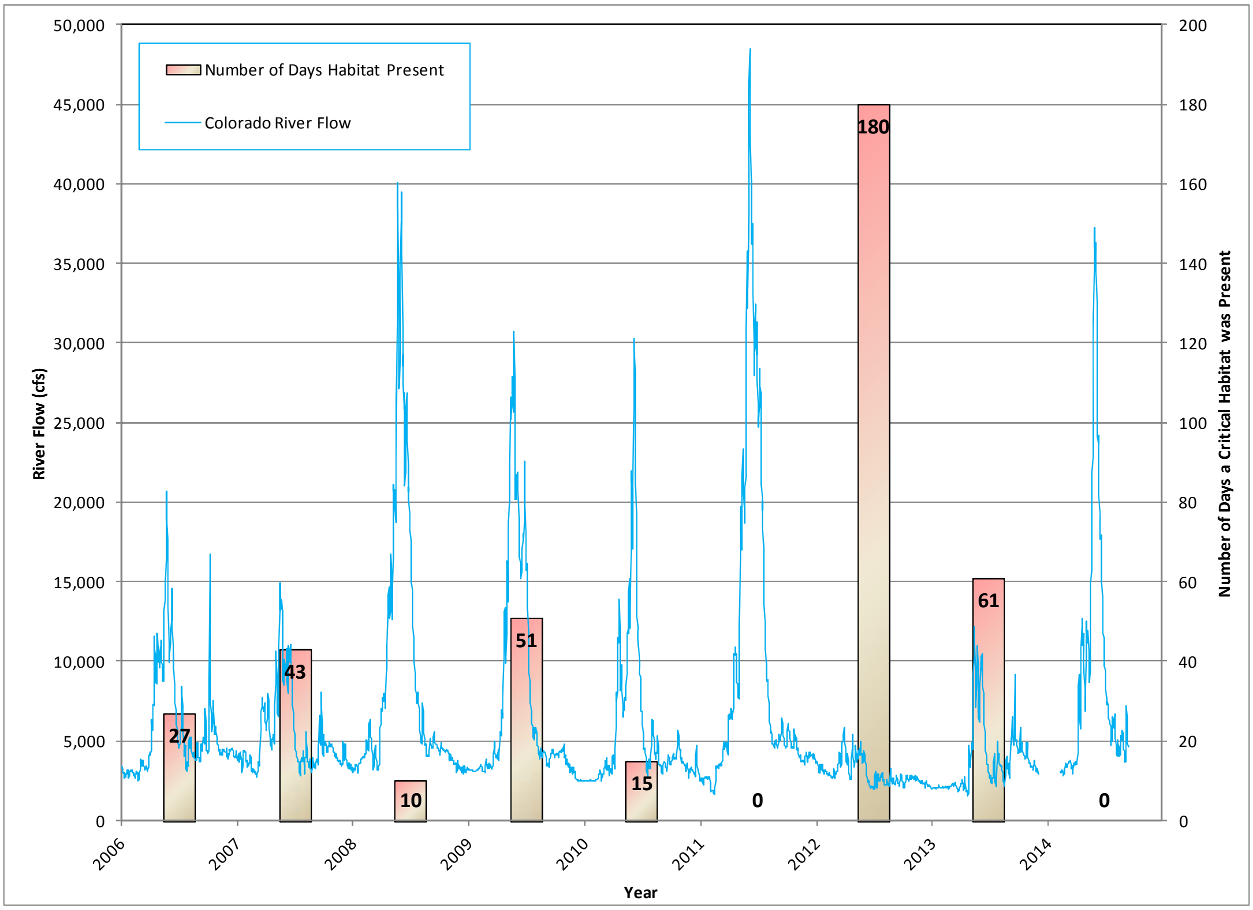


Figure 19. Number of Habitat Days vs. River Flow, 2006 through 2014

8.0 Investigations

8.1 Tree Plot Area Ground Water Investigation

In an attempt to determine if phytoremediation reduces the ammonia concentrations in ground water, samples have been collected from wells located in the vicinity of the northernmost tree plot in the IA well field near the infiltration trench (see Figure 20).

The influence of phytoremediation on the ground water system is difficult to determine because of other hydrogeologic impacts to this area. Flood irrigation has taken place inside the tree plot since 2005/2006 and upgradient to the tree plot since 2010. Ground water extraction from CF5 also plays a role. In addition, this area is in close proximity to the riverbank. Previous investigations have shown that ground water underlying this area is impacted by a freshwater lens that develops when the spring runoff river stage is above average, further reducing the ammonia concentrations.

Figure 21 shows the ammonia concentration of two monitoring wells upgradient of the revegetation plots (SMI-PW01 (20 ft bgs) and SMI-PZ1S [18 ft bgs]) and two monitoring wells downgradient of the plots (0683 (27 ft bgs) and 0684 [18 ft bgs]). These wells were sampled more frequently between 2005 to 2010; however, there is a general downward trend in the ammonia at downgradient locations 0683 and 0684 and also at upgradient location SMI-PZ1S. Since there are many factors that can impact the ammonia concentration in the ground water, it is unclear whether this decrease is due to the tree plots utilizing the ammonia in the ground water. Further and more frequent sampling of these wells is scheduled.

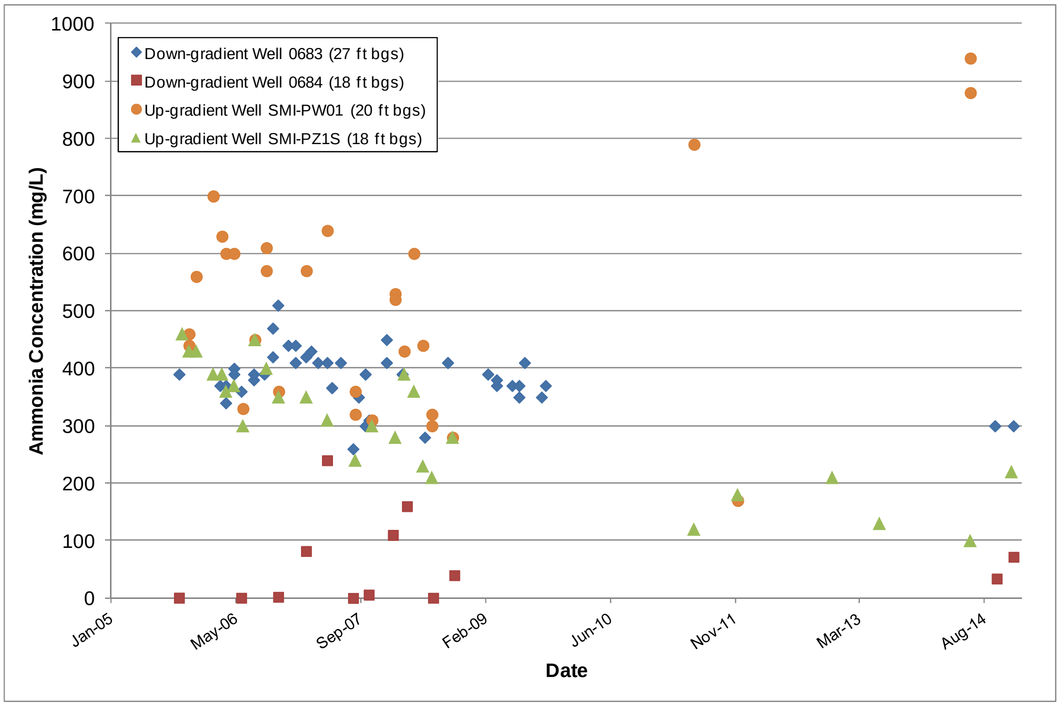


Figure 20. Ground Water Ammonia Concentrations in the Vicinity of the Tree Plot Area

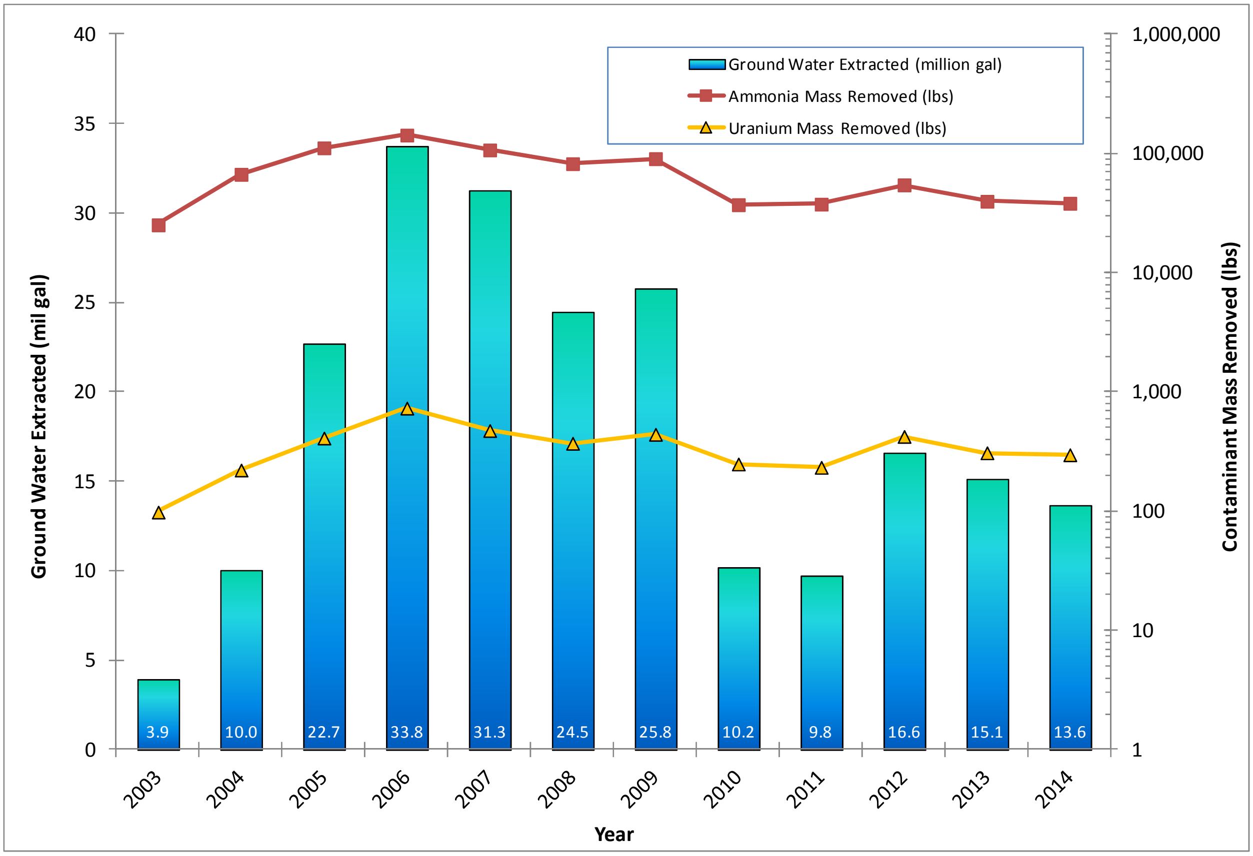


Figure 21. Volume of Ground Water Extracted and Ammonia Mass Removal, 2003 through 2014

9.0 Summary and Conclusions

In 2014, the IA operations focused on year-round ground water 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 at any side channel.

A total of 13.6 mil gal of water were extracted from CF5 in 2014. The extraction rate peaked at 161 gpm in July, and operations continued year-round. Each of the eight extraction wells were utilized in 2014. Figure 18 shows the ammonia and uranium mass removed and the volume of ground water extracted from the CF5 extraction wells in 2014. The volume and mass removed is similar to the past few years. More than 297 lb of uranium and more than 38,309 lb of ammonia were removed from the ground water in 2014.

Approximately 1.6 mil gal of extracted water were pumped through the evaporators, and 13.7 mil gal of extracted water were used by water trucks for dust suppression in the contaminated area. The evaporators were run overnight when conditions were favorable. Less water was pumped through the evaporators in 2014 compared to 2013 due to on-site flooding, which led to a shutdown of extraction operations, and electrical and equipment issues.

Approximately 8.5 mil gal of freshwater were injected into CF4 in 2014. Ammonia probe 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 2014 since the side channel adjacent to CF4 did not meet the definition of a suitable habitat for young-of-year endangered fish species. This is the first season the channel has remained dry. Channel B, which was identified as a habitat in 2013, remained flowing through to the river throughout the year.

10.0 References

DOE (U. S. Department of Energy), *Moab UMTRA Project Flood Mitigation Plan* (DOE-EM/GJTAC1640).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2014* (DOE-EM/GJTAC2149).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2014* (DOE-EM/GJTAC2168).

DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Ground Water 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 2014 Ground Water Extraction

Appendix A. Tables and Data for 2014 Ground Water 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

msl = mean sea level

Table A-2. Chronology of CF5 Activities in 2014

Date	River Flow (cfs)	Activity
January	Ice	Extraction from PW02 (total 37 gpm) on January 6 and through the rest of the month.
February	2,820 to 3,270	Extraction from PW02 from February 1 to February 12 (27 gpm). Extraction from well 0815 from February 12 to February 19 (25 gpm). Drain valve repair made to 4-in. line on February 6.
March	2,380 to 3,730	Extraction from PW02 (27 gpm), 0813 (25-50 gpm), and 0815 (23 gpm).
April	3,290 to 13,000	Extraction from 0810 (40 gpm), 0811 (15 gpm), 0813 (26-50 gpm), 0814 (30 gpm), 0815 (25 gpm), 0816 (40 gpm), and PW02 (27 gpm). Started pumping from 6-in. line wells only on April 9. Extraction wells were sampled April 15-17. Evaporators were started and the 4-in. extraction line was replaced on April 29.
May	6,710 to 33,700	Extraction from 0810 (30 gpm), 0811 (20 gpm), 0812 (40 gpm), 0813 (26 gpm), 0814 (34 gpm), and 0816 (24-40 gpm). Shut down extraction on May 22 for river flood preparations.
June	11,400 to 37,500	No extraction. Evaporators were shut down for Health and Safety concerns on June 4.
July	4,900 to 12,000	Extraction from 0810 (25 gpm), 0811 (13-25 gpm), 0812 (25-43 gpm), 0813 (35 gpm), 0814 (40 gpm), and 0816 (38-57 gpm). Re-started evaporators on July 29.
August	3,980 to 8,060	Extraction from 0810 (16-27 gpm), 0811 (20 gpm), 0812 (18 gpm), 0813 (29-59 gpm), 0814 (22-55 gpm), 0815 (28 gpm), 0816 (44 gpm), and PW02 (27 gpm). Evaporators were shut down on August 14 due to generator issues.
September	3,490 to 7,810	Extraction from 0810 (15-29 gpm), 0811 (14 gpm), 0812 (24 gpm), 0813 (46-62 gpm), and 0814 (24-54 gpm). Evaporators were restarted on September 24. Extraction shut down to control pond level on September 24.
October	4,500 to 7,790	Extraction from 0812 (7 gpm), 0813 (9 gpm), 0815 (8 gpm), and 0816 (7 gpm). Evaporators and extraction winterized October 29.
November	3,750 to 4,760	No extraction.
December	3,510 to 4,380	Re-started extraction from PW02 (27-50 gpm) until it was winterized on December 23.

Table A-3. CF5 Extraction Volumes 2014

Well	Volume Extracted (gal)												
	Jan-14	**Feb-14**	**Mar-14**	**Apr-14**	**May-14**	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**	**Dec-14**	**Totals**
810	0	0	0	316,464	44,107	0	371,642	255,775	327,281	12,293	0	0	1,327,562
811	0	0	0	127,542	160,092	0	197,991	253,302	286,962	7,031	0	0	1,032,920
812	0	0	0	791	397,914	0	306,508	249,499	304,832	13,056	0	0	1,272,600
813	0	0	0	87,728	149,421	0	607,336	278,886	692,206	32	0	0	1,815,609
814	0	0	0	256,734	49,229	0	536,041	218,078	544,059	59	0	0	1,604,200
815	0	501,581	944,490	232,149	0	0	0	11,117	0	0	0	0	1,689,337
816	0	0	0	110,404	174,026	0	939,056	823,409	0	0	0	0	2,046,895
PW02	861,498	305,848	845,950	255,155	0	0	0	20,247	0	0	0	557,067	2,845,765
MONTHLY	861,498	807,429	1,790,440	2,773,934	1,949,578	0	5,917,148	4,220,626	4,310,680	64,942	0	557,067	13,149,936
TOTAL (gal)	13,149,936												

Table A-4. CF5 Ammonia Mass Removal 2014

Well	Ammonia Mass Removed (lbs)												
	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Totals
810	0	0	0	881	125	0	1,052	714	872	33	0	0	3,677
811	0	0	0	412	507	0	626	931	1,075	26	0	0	3,577
812	0	0	0	3	1,458	0	1,123	889	965	41	0	0	4,478
813	0	0	0	263	510	0	2,073	911	1,960	0	0	0	5,718
814	0	0	0	454	86	0	937	464	1,269	0	0	0	3,210
815	0	1,128	2,123	522	0	0	0	28	0	0	0	0	3,801
816	0	0	0	172	261	0	1,408	1,348	0	0	0	0	3,188
PW02	3,156	1,121	3,099	935	0	0	0	76	0	0	0	2,273	10,660
MONTHLY	3,156	2,248	5,223	3,641	2,946	0	7,220	5,361	6,140	101	0	2,273	38,309
TOTAL (gal)	**38,309**												

Appendix A. Tables and Data for 2014 Ground Water Extraction (*continued*)

Table A-5. CF5 Uranium Mass Removal 2014

Well	Uranium Mass Removed (lbs)												
	Jan-14	**Feb-14**	**Mar-14**	**Apr-14**	**May-14**	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**	**Dec-14**	**Totals**
810	0	0	0	7.9	1.1	0	9.3	6.3	7.9	0.3	0	0	32.8
811	0	0	0	2.7	3.3	0	4.1	5.8	6.7	0.2	0	0	22.8
812	0	0	0	0	6.3	0	4.8	3.9	4.6	0.2	0	0	19.8
813	0	0	0	1.0	1.9	0	7.6	3.4	8.1	0	0	0	22.0
814	0	0	0	5.4	1.1	0	11.6	4.8	12.2	0	0	0	35.1
815	0	13.8	26.0	6.4	0	0	0	0.3	0	0	0	0	46.4
816	0	0	0	2.3	3.5	0	8.2	16.5	0	0	0	0	41.0
PW02	23.7	8.4	23.2	7.0	0	0	0	0.5	0	0	0	14.8	77.7
MONTHLY	23.7	22.2	49.2	32.7	17.1	0	56.2	41.6	39.5	0.7	0	14.8	**297.6**
TOTAL (lb)							**297.6**						

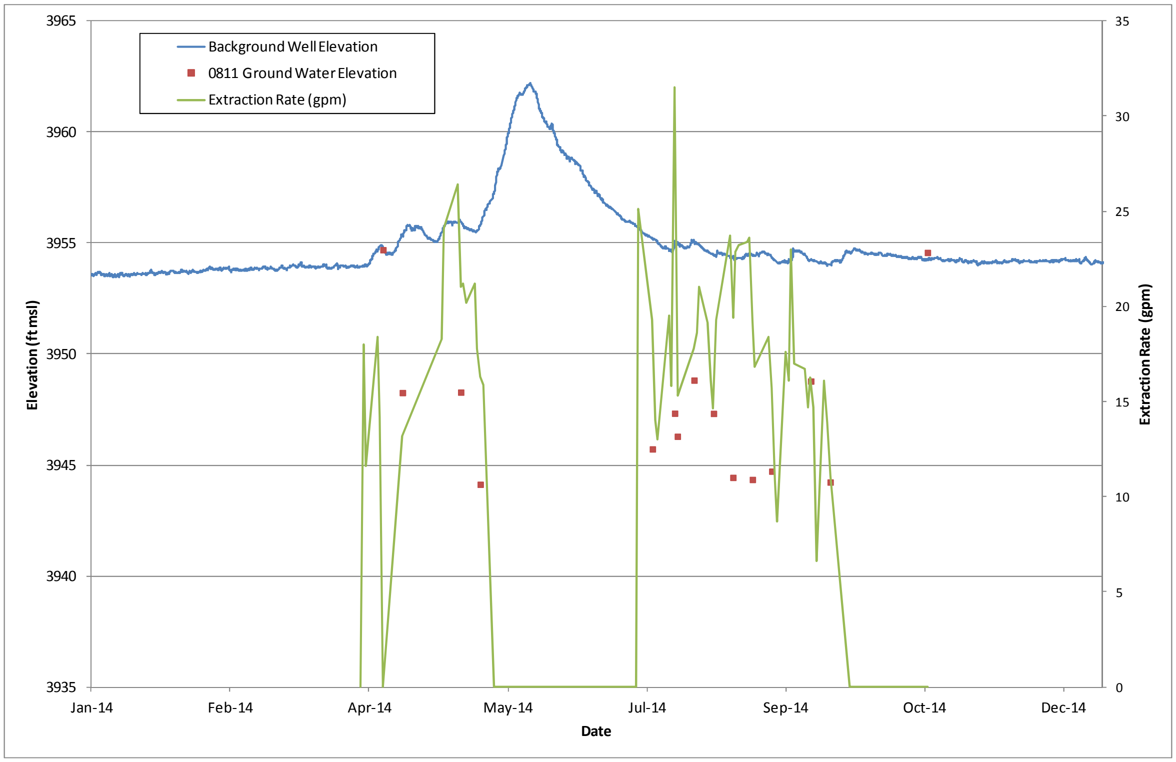


Figure A-1. Drawdown Plot for Well 0811

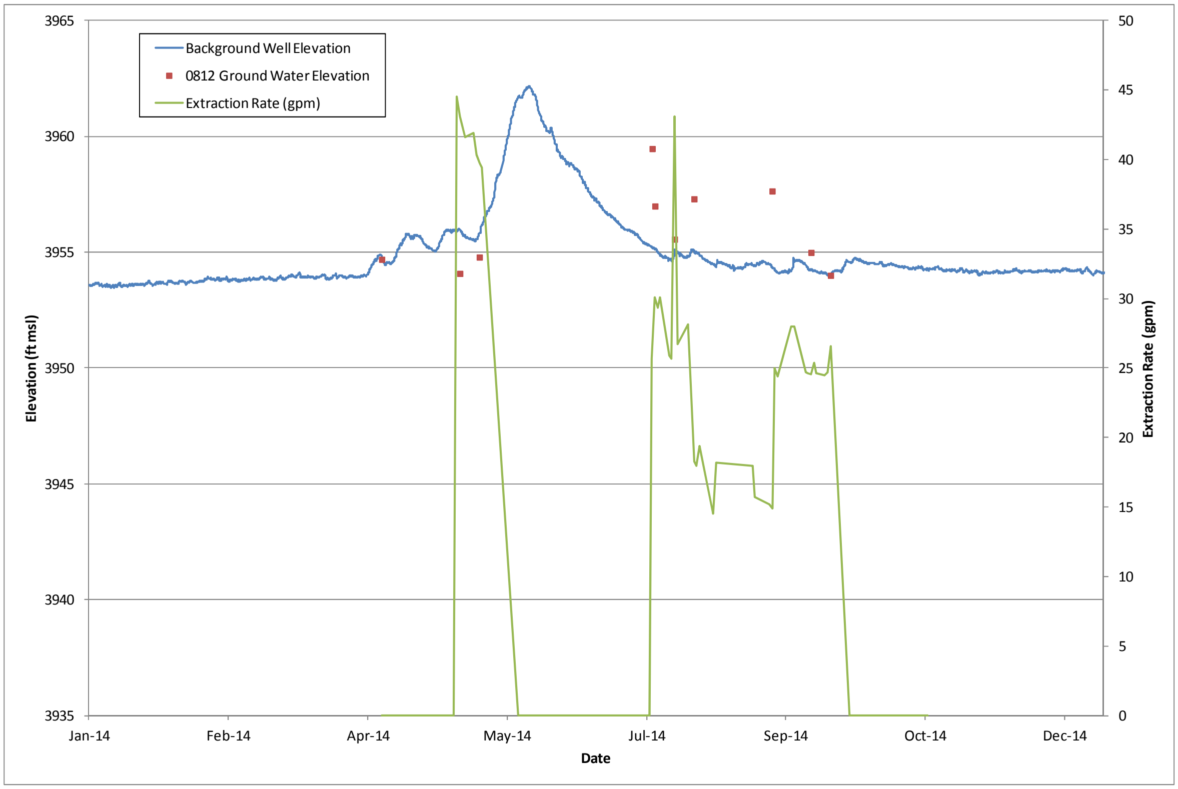


Figure A-2. Drawdown Plot for Well 0812

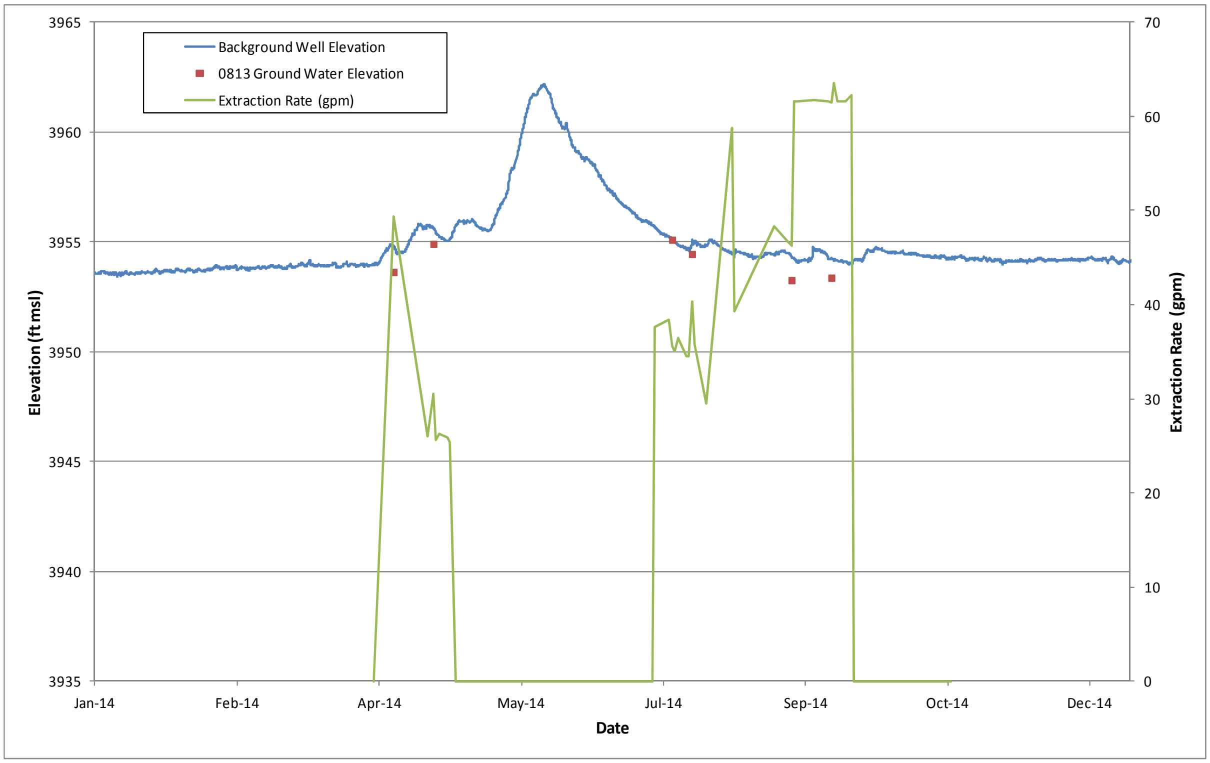


Figure A-3. Drawdown Plot for Well 0813

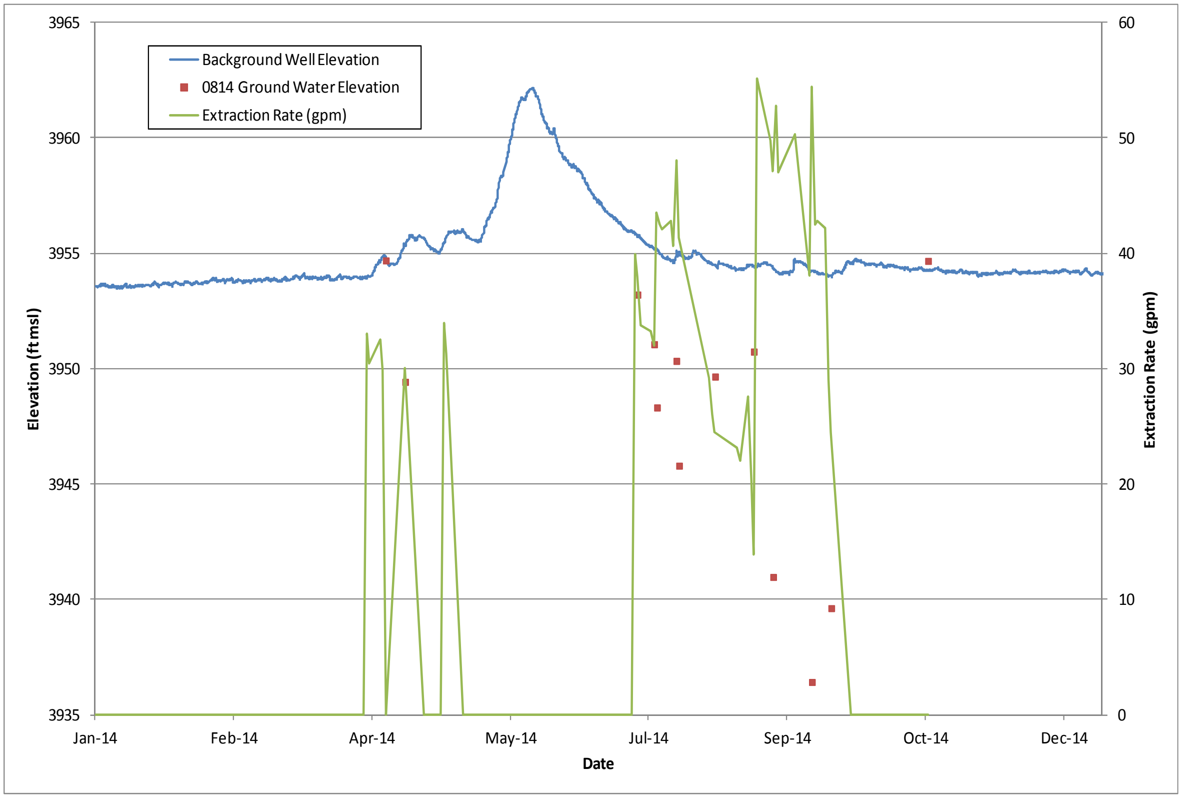


Figure A-4. Drawdown Plot for Well 0814

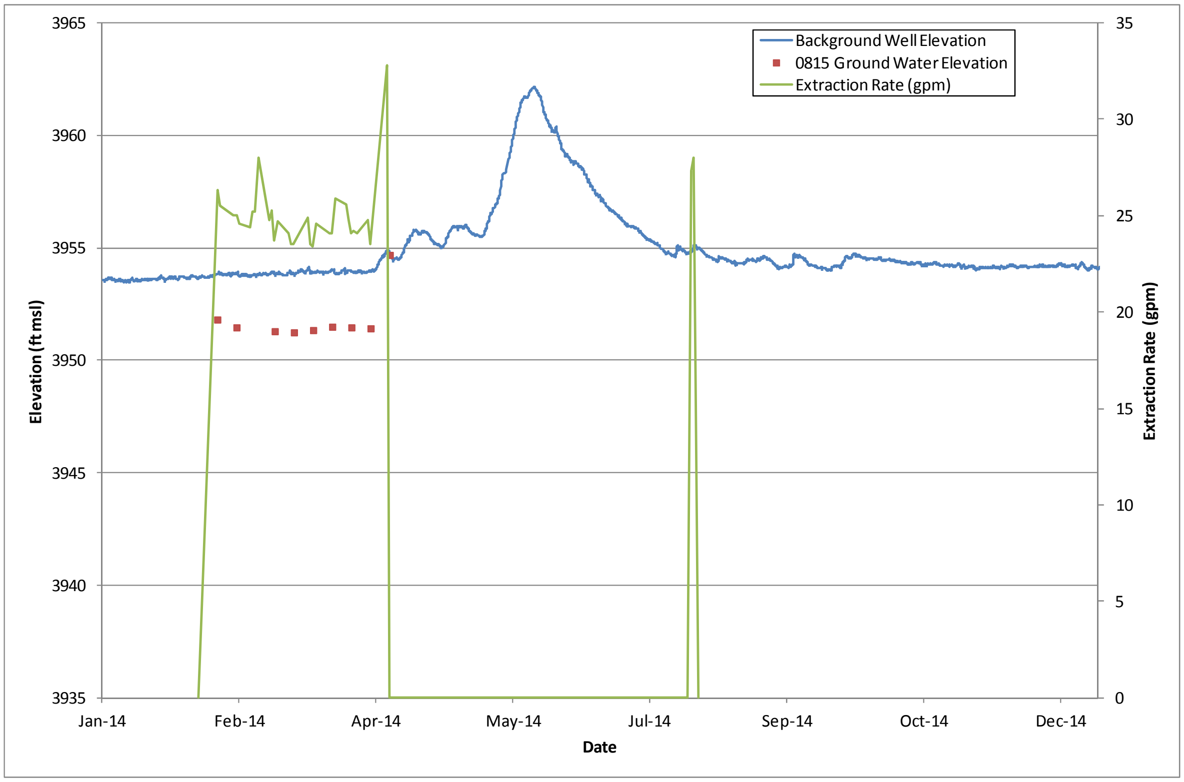


Figure A-5. Drawdown Plot for Well 0815

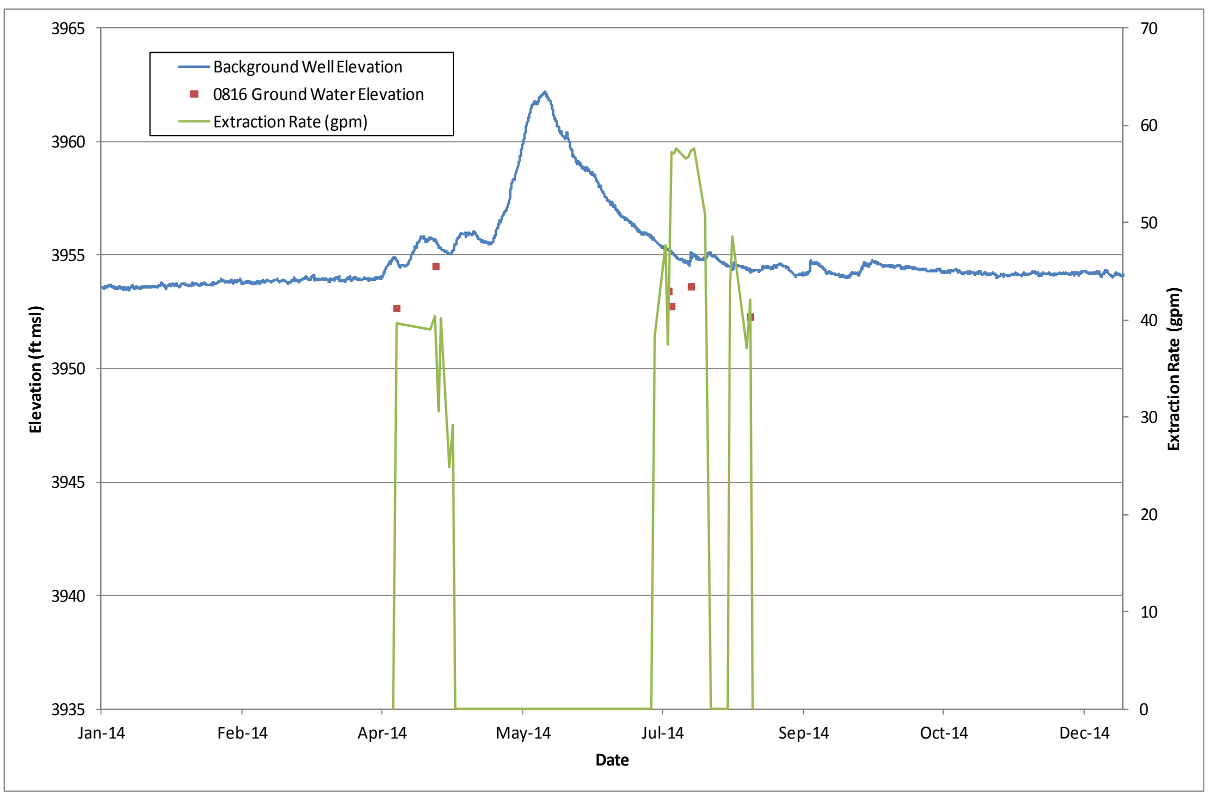


Figure A-6. Drawdown Plot for Well 0816

Appendix B.
2014 Evaporation Pond Data

Appendix B. 2014 Evaporation Pond Data

Table B-1. Evaporation Pond Chronology for 2014

Date	Pond Level (ft)	Activity
01/06/14	7.5	Extraction began from PW02.
02/12/14	8.7	Extraction from 0815.
02/26/14	9.0	RAC starts to remove water from pond for dust suppression.
04/16/14	9.3	Started extraction from 6-in. line.
04/29/14	9.2	Evaporators started.
05/22/14	9.4	Shut down extraction for flood preparation.
06/04/15	8.8	Evaporators shut down for Health and Safety concerns.
07/15/14	5.3	Started extraction operations.
07/29/14	8.5	Started evaporator operations.
08/14/14	9.2	Evaporators shut down due to generator issues.
09/03/14	9.4	Re-started evaporators.
09/24/14	9.7	Evaporators down for generator issue and extraction shut down to control pond level.
10/28/14	8.8	Extraction winterized.
10/29/14	8.8	Evaporators winterized.
12/10/14	8.4	Extraction from PW02.
12/23/14	9.0	Extraction winterized.

Table B-2. Pond Level vs. Pond Volume 2014

Date	Pond Level (ft)	Pond Volume (gal)
01/01/14	7.4	3,040,877
01/08/14	7.5	3,119,888
01/15/14	7.8	3,363,036
01/22/14	8.1	3,615,357
01/29/14	8.4	3,876,852
02/05/14	8.7	4,147,521
02/12/14	8.7	4,147,521
02/19/14	8.9	4,333,063
02/26/14	9.0	4,427,363
03/05/14	9.1	4,522,682
03/12/14	9.2	4,619,021

Appendix B. 2014 Evaporation Pond Data (*continued*)

Table B-2. Pond Level vs. Pond Volume 2014 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
03/26/14	9.4	4,814,756
04/02/14	9.3	4,716,379
04/09/14	9.3	4,716,379
04/16/14	9.3	4,716,379
04/23/14	9.4	4,814,756
04/30/14	9.2	4,619,021
05/07/14	9.2	4,619,021
05/14/14	9.3	4,716,379
05/21/14	9.4	4,814,756
05/28/14	9.3	4,716,379
06/04/14	8.8	4,239,782
06/11/14	8.5	3,966,056
06/18/14	7.7	3,280,967
06/25/14	7.2	2,885,914
07/02/14	6.6	2,445,485
07/09/14	6.1	2,106,492
07/16/14	5.3	1,617,105
07/23/14	6.7	2,516,342
07/30/14	8.5	3,966,056
08/06/14	9.4	4,814,756
08/13/14	9.2	4,619,021
08/20/14	9.8	5,218,457
08/27/14	9.4	4,814,756
09/03/14	9.4	4,814,756
09/10/14	9.6	5,014,568
09/17/14	9.5	4,914,152

Table B-2. Pond Level vs. Pond Volume 2014 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
09/24/14	9.7	5,116,003
10/01/14	9.7	5,116,003
10/08/14	9.5	4,914,152
10/15/14	9.2	4,619,021
10/22/14	9.0	4,427,363
10/29/14	8.8	4,239,782
11/05/14	8.6	4,056,279
11/12/14	8.4	3,876,852
11/19/14	8.4	3,876,852
11/26/14	8.4	3,876,852
12/03/14	8.4	3,876,852
12/10/14	8.4	3,876,852
12/17/14	8.6	4,056,279
12/23/14	9.0	4,427,363

Table B-3. Evaporator Operations 2014

Date	Total Gallons
04/30/14	41,759
05/07/14	41,766
05/14/14	41,773
05/21/14	41,780
05/28/14	41,787
06/04/14	41,794
06/11/14	41,801
06/18/14	41,808
06/25/14	41,815
07/02/14	41,822
07/09/14	41,829
07/16/14	41,836
07/23/14	41,843
07/30/14	41,850
08/06/14	41,857
08/13/14	41,864
08/20/14	41,871
08/27/14	41,878
09/03/14	41,885
09/10/14	41,892
09/17/14	41,899
09/24/14	41,906
10/01/14	41,913
04/30/14	41,759
05/07/14	41,766
05/14/14	41,773
05/21/14	41,780
05/28/14	41,787
06/04/14	41,794
06/01/14	41,801

Appendix C.
Tables and Data for 2014 Freshwater Injection

Appendix C. Tables and Data for 2014 Freshwater Injection

Table C-1. CF4 Well Construction

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
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

msl = mean sea level

Table C-2. Chronology of CF4 Activities in 2014

Month	River Flow (cfs)	Activity
January	Ice	Injection system was started on January 15.
February	2,820 to 3,270	Injection system operated all month.
March	2,380 to 3,730	Injection system operated most of the month. It was shut down from March 19-21 to replace a valve in CF4. The system was shut down on March 27, and the filter was cleaned. The system was restarted on March 31.
April	3,290 to 13,000	Injection system operated most of the month. It was shut down from April 4-6 for maintenance.
May	6,710 to 33,700	Injection system was shut down May 13 because of the increasing river flow.
June	11,400 to 37,500	No injection operations due to high river flow.
July	4,900 to 12,000	Injection system was re-started July 10. It was shut down on July 29 due to high turbidity in the river water.
August	3,980 to 8,060	Injection system was re-started on August 12. It was shut down on August 18 due to a break in the line at Moab Wash.
September	3,490 to 7,810	No injection operations. The injection wells were redeveloped by Zimmerman Well Services.
October	4,500 to 7,790	Injection operations resumed on October 23.
November	3,750 to 4,760	Injection system operated all month.
December	3,510 to 4,380	Injection system was shut down and winterized on December 23.

Table C-3. Ammonia Probe Sample Results 2014

					780 (Up-18' bgs)		781 (Up-46' bgs)		782 (Up-33' bgs)		783 (Up-18' bgs)		784 (D-18' bgs)		785 (D-18' bgs)		786 (D-28' bgs)		787 (D-36' bgs)		790 (tallest)		791 (short)		792 (mid)	
Date	**River Flow (cfs)**	**Inj?**	**Length of time?**	**Total gpm**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**
01/14/14	ICE	NO	Not since 12/18/13	0	9,930	159	83,170	1,578	15,749	372	4,760	1.5	2256	1	2,230	1	14,809	261	69,213	1,566	N/A	N/A	N/A	N/A	N/A	N/A
04/14/14	3,490	YES	Since 04/06/14	22.4	1,068	1.47	17,970	461	1228	9.86	1,412	1	1,103	1	1,146	1	1,097	1	1,400	26.1	N/A	N/A	N/A	N/A	N/A	N/A
07/09/14	8,260	NO	Not since 05/13/14	0	3,843	1.07	75,542	1,578	18,349	356	2,762	1	3,110	1	1,745	1	2,136	9.14	26,832	541	N/A	N/A	N/A	N/A	N/A	N/A
07/30/14	6,310	NO	Not since 07/28/14	0	1,739	1	114,158	1,906	1,126	3.33	4,144	1	1,906	1	1,613	1	1,854	1	34,790	432	5,233	1	2,425	1.8	2,838	102.8
10/22/14	4,940	NO	Not since 08/14/14	0	2,194	3.46	27,521	572	2,503	34.9	3,674	2.36	3,114	1	5,162	1	11,675	73.3	11,478	143.2	N/A	N/A	N/A	N/A	N/A	N/A

Numbers in red indicate sample had to be diluted before analysis.

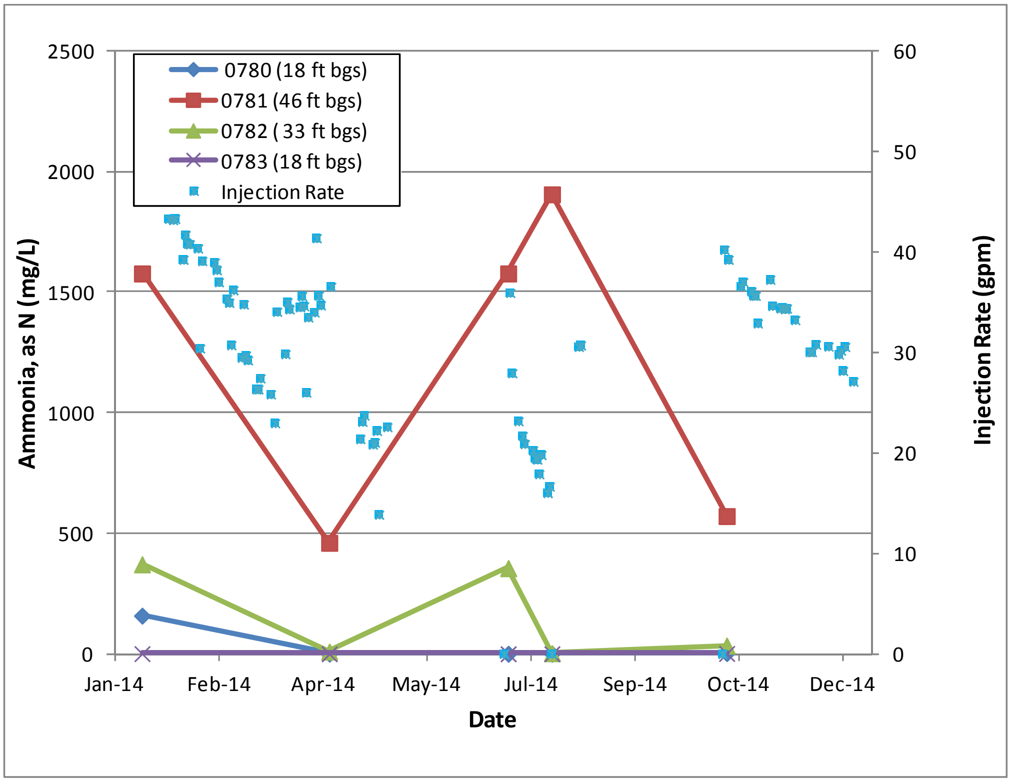


Figure C-1. Ammonia Concentration of Upgradient CF4 Observation Wells in 2014

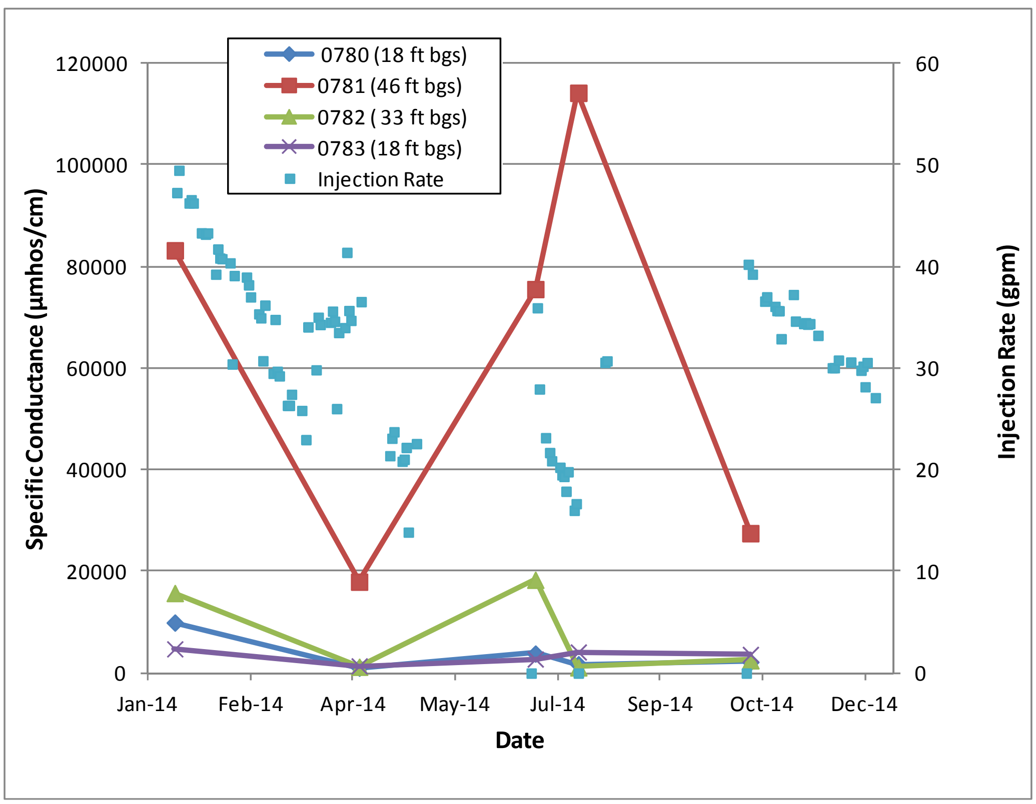


Figure C-2. Specific Conductance of Upgradient CF4 Observation Wells in 2014

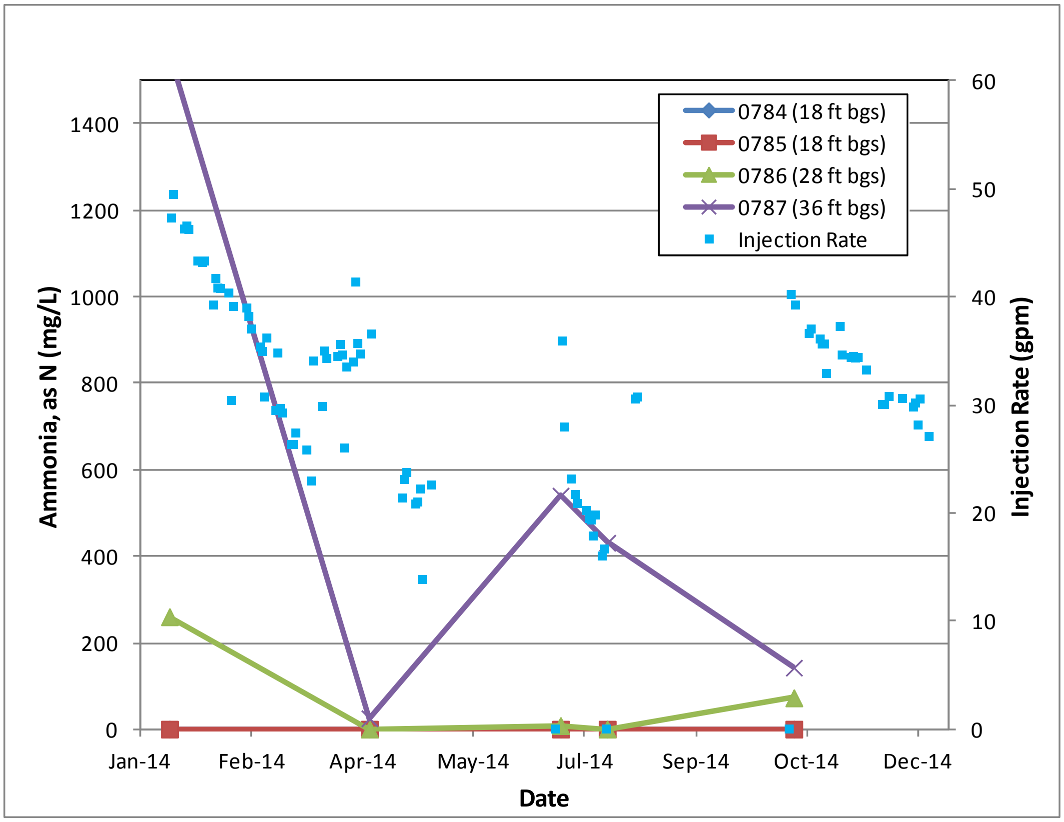


Figure C-3. Ammonia Concentration in Downgradient CF4 Observation Wells in 2014

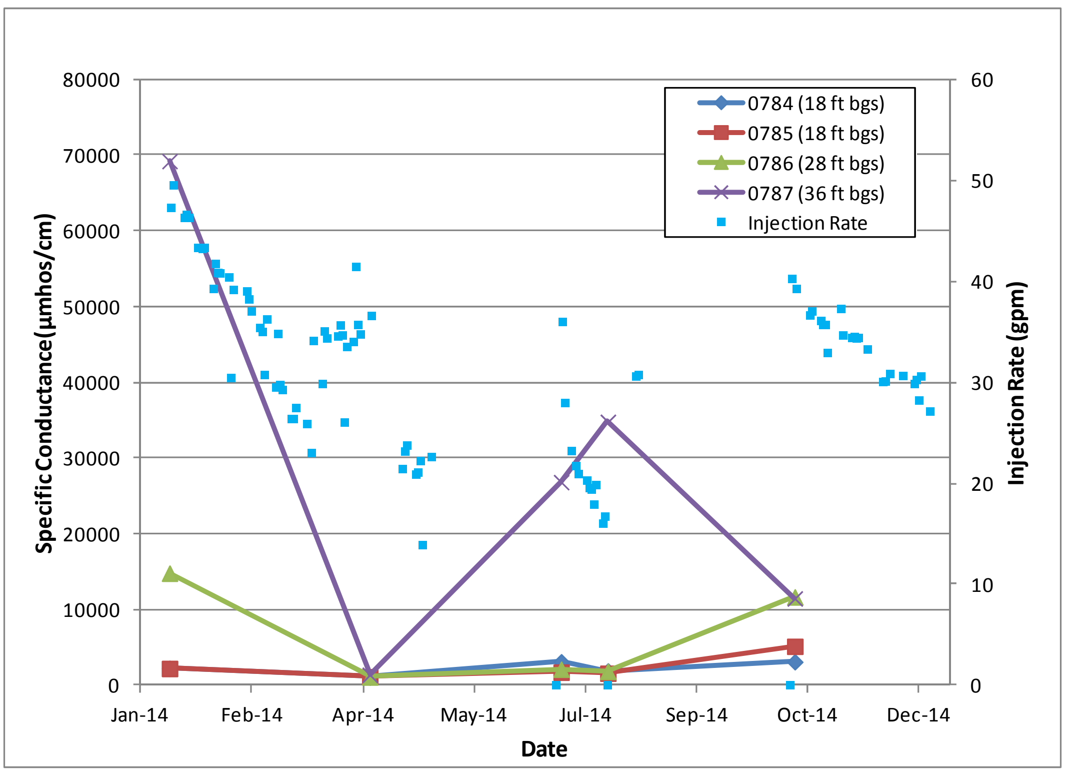


Figure C-4. Specific Conductance in Downgradient CF4 Observation Wells in 2014

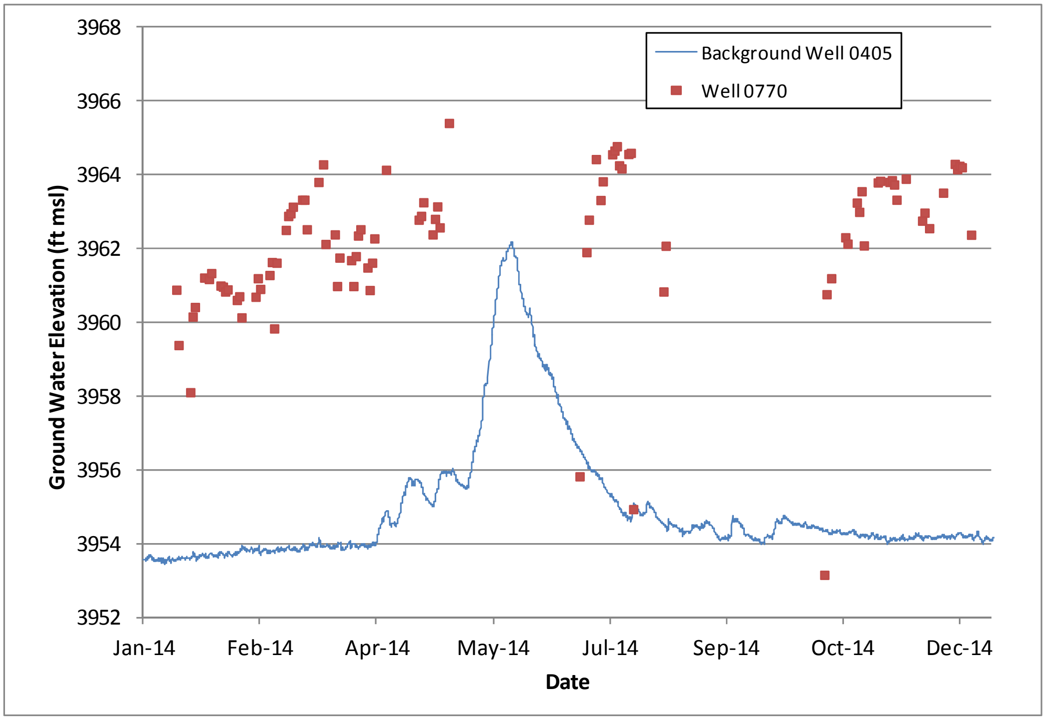


Figure C-5. Freshwater Mounding in Remediation Well 0770 during Injection

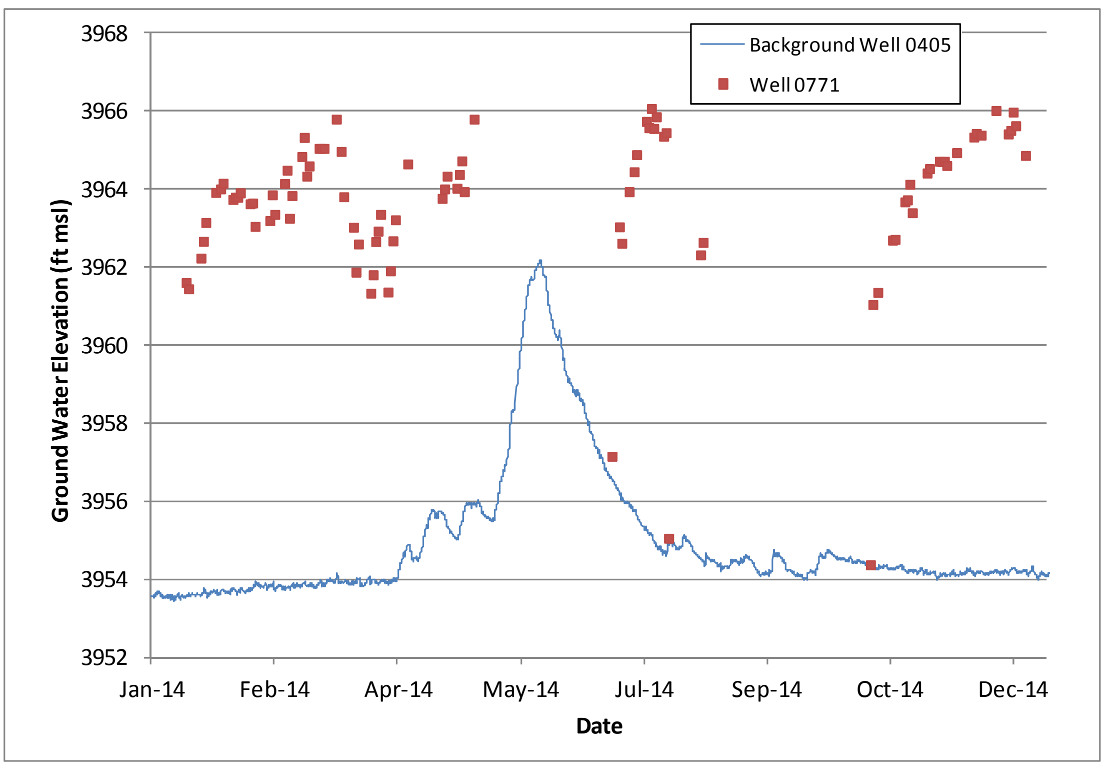


Figure C-6. Freshwater Mounding in Remediation Well 0771 during Injection

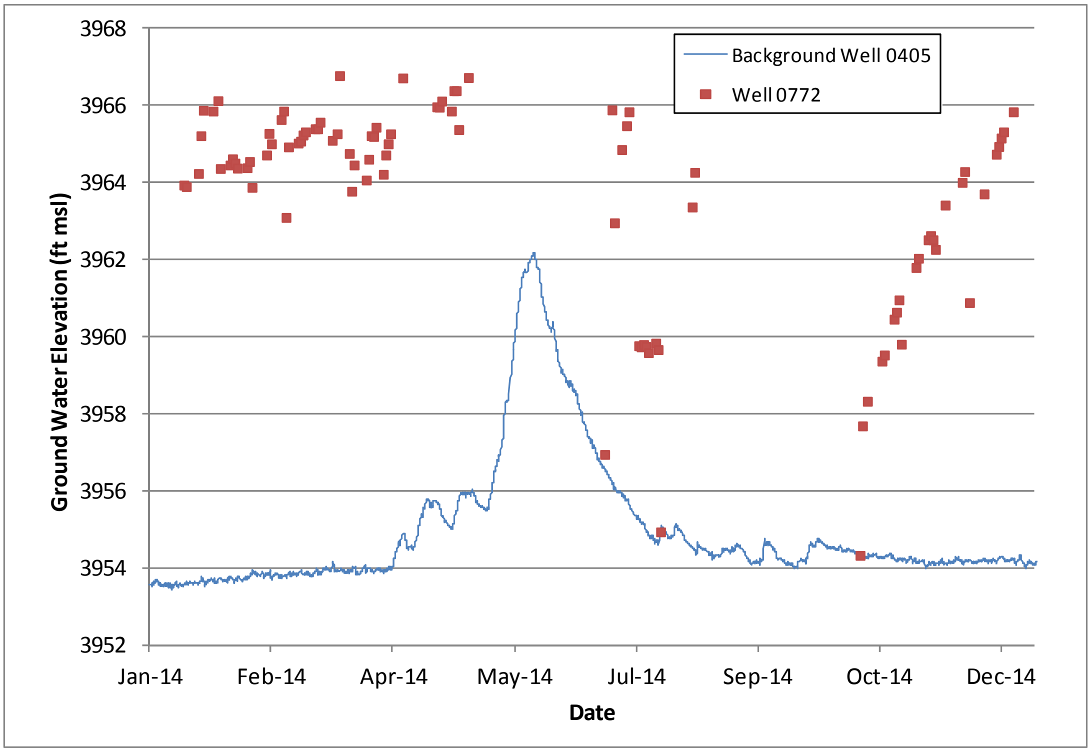


Figure C-7. Freshwater Mounding in Remediation Well 0772 during Injection

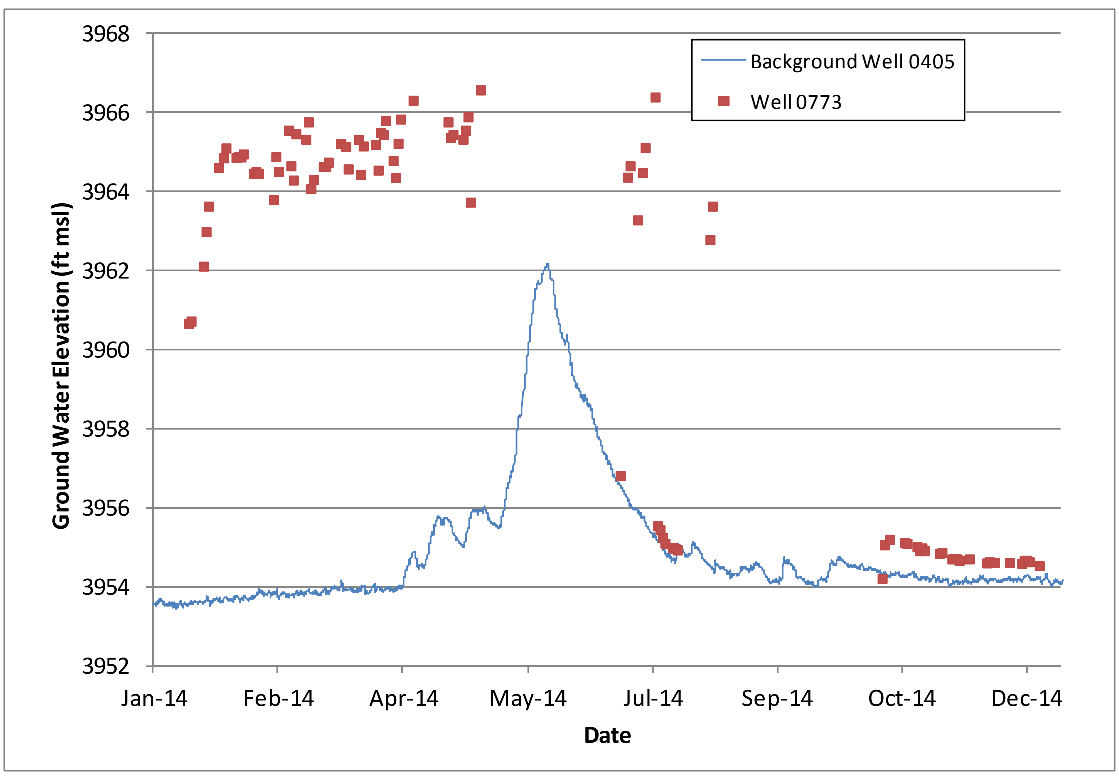


Figure C-8. Freshwater Mounding in Remediation Well 0773 during Injection

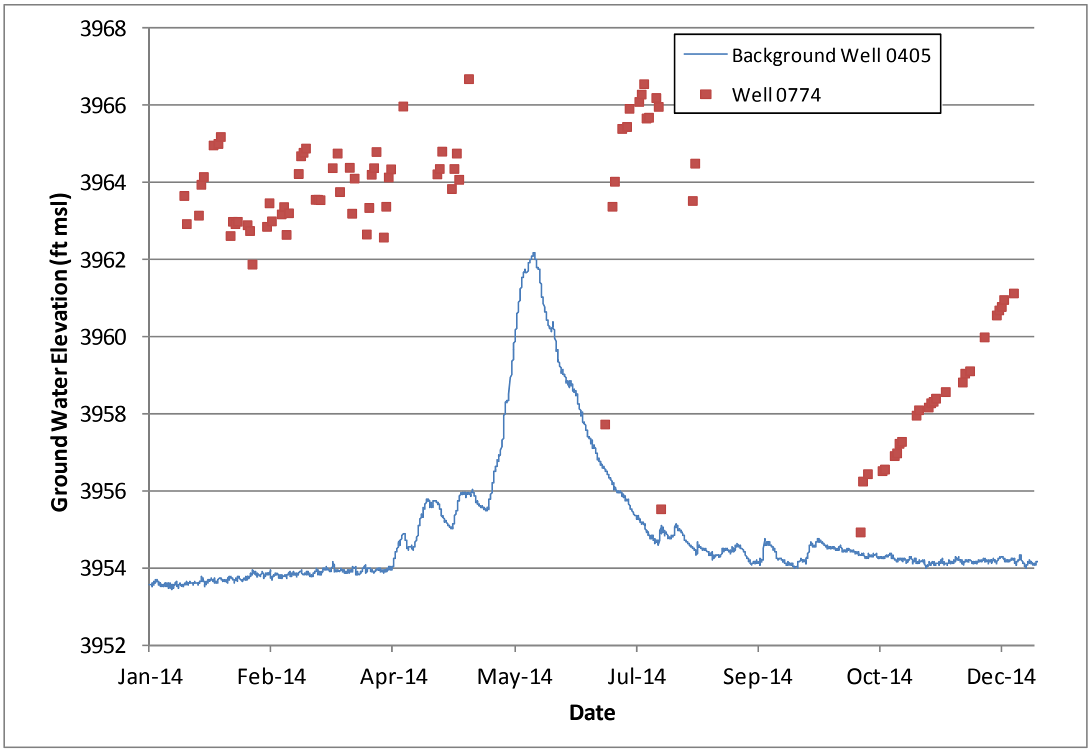


Figure C-9. Freshwater Mounding in Remediation Well 0774 during Injection

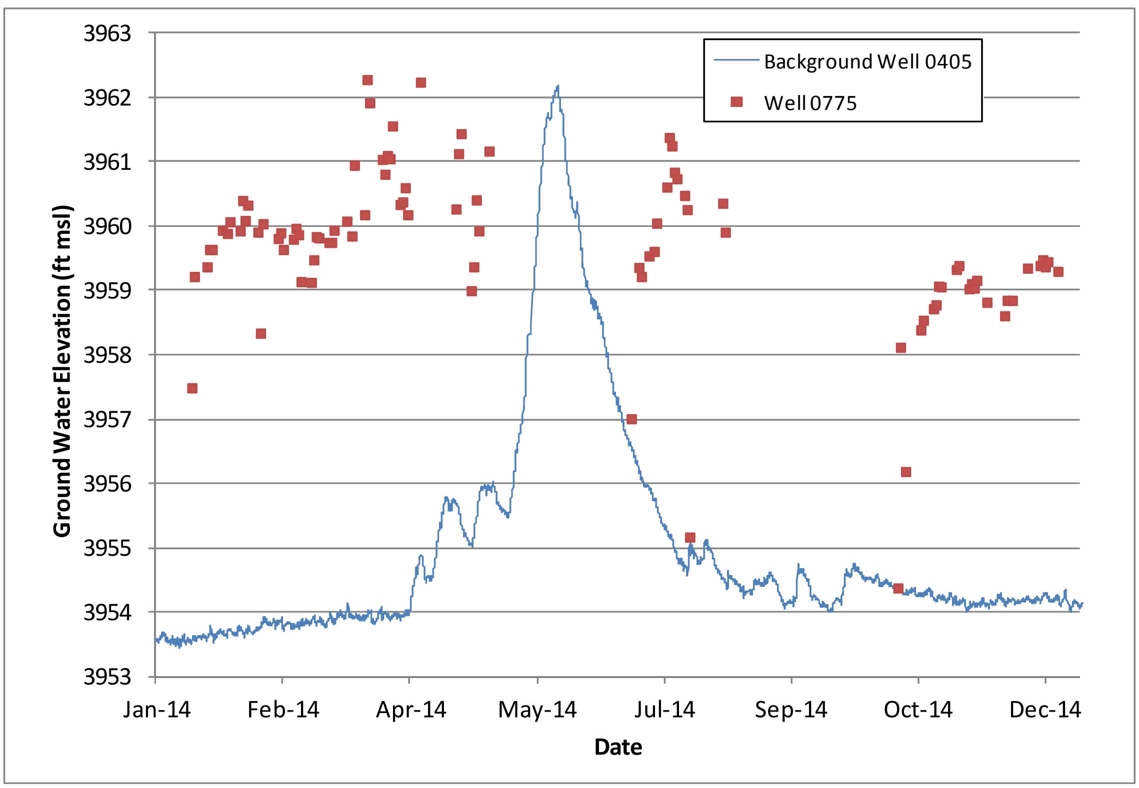


Figure C-10. Freshwater Mounding in Remediation Well 0775 during Injection

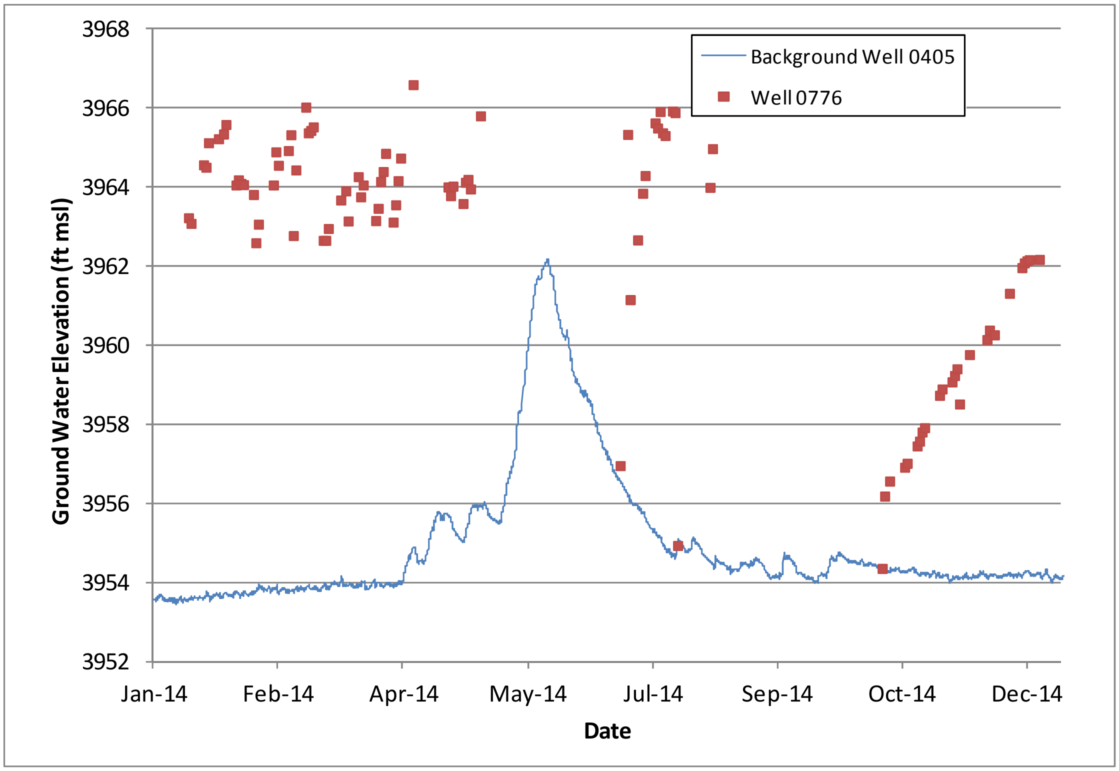


Figure C-11. Freshwater Mounding in Remediation Well 0776 during Injection

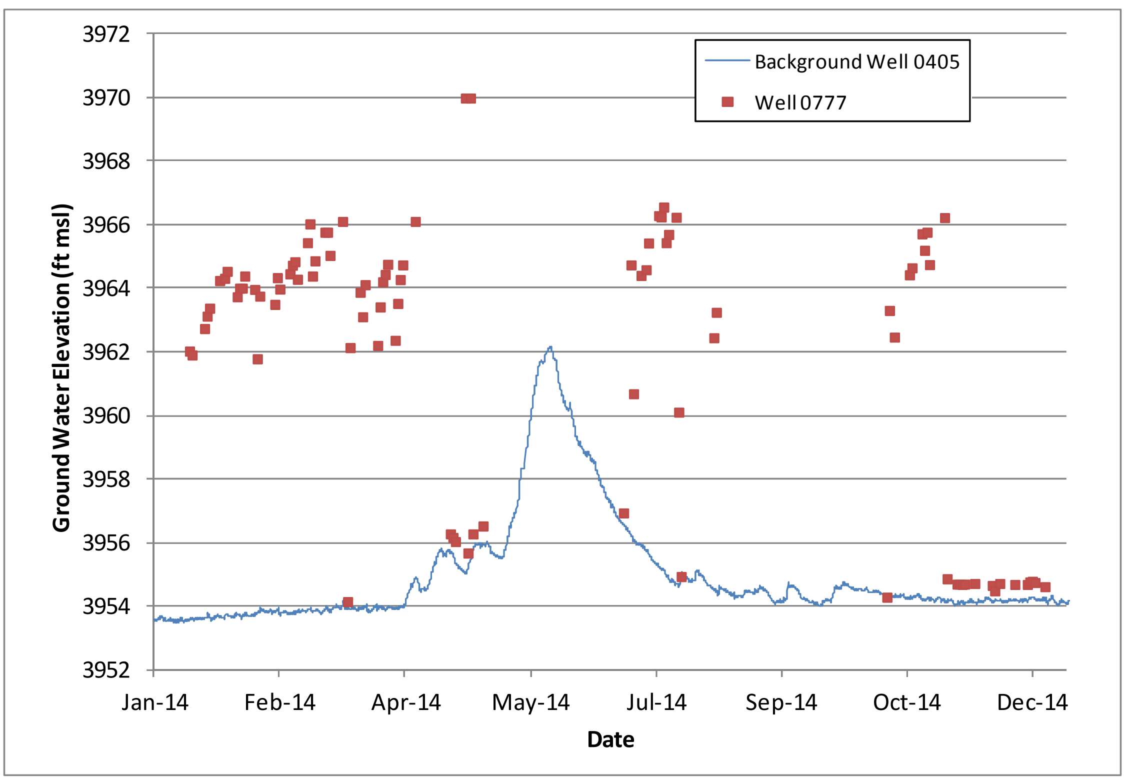


Figure C-12. Freshwater Mounding in Remediation Well 0777 during Injection

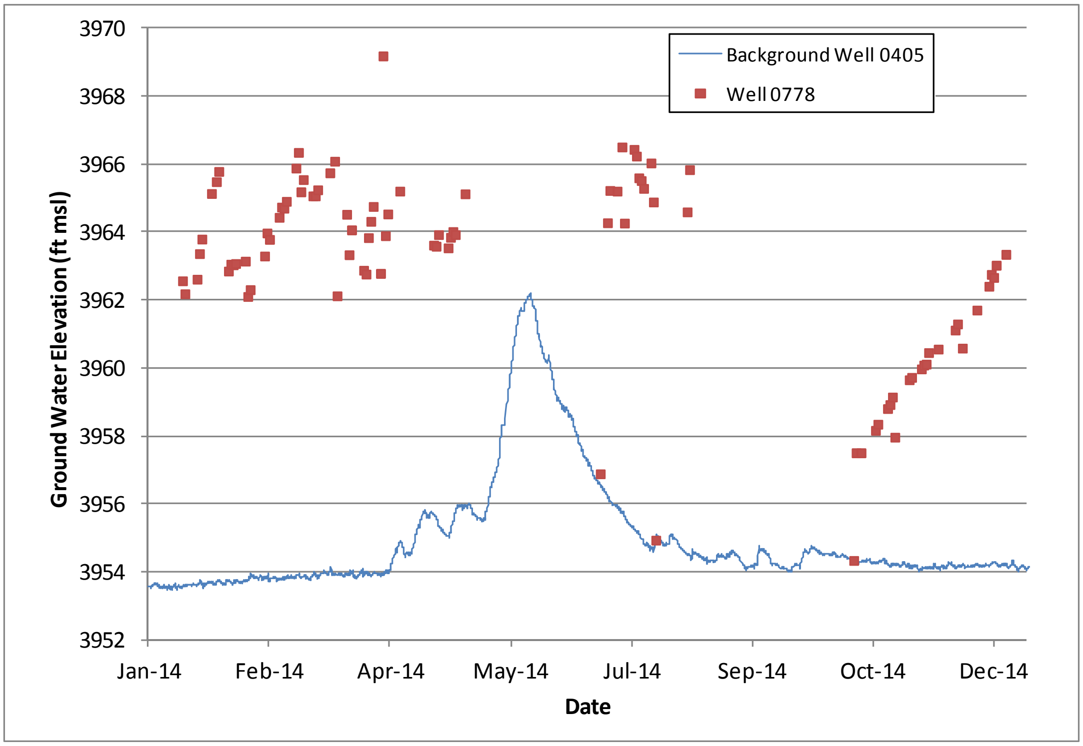


Figure C-13. Freshwater Mounding in Remediation Well 0778 during Injection

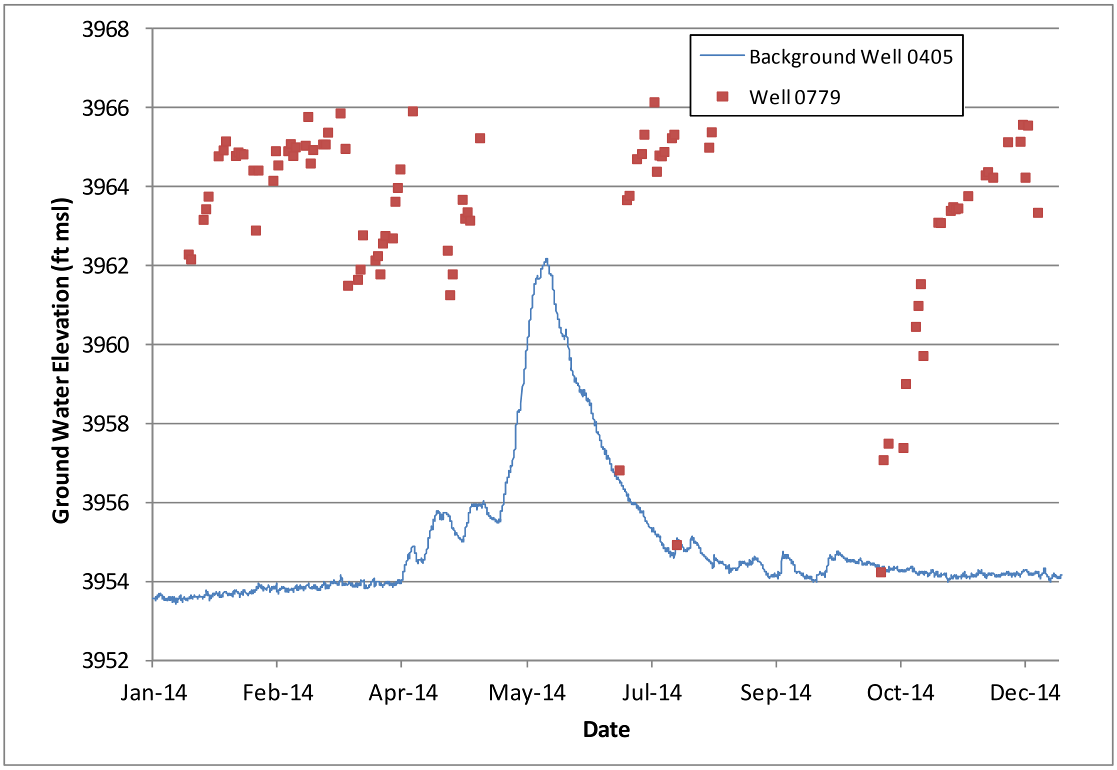
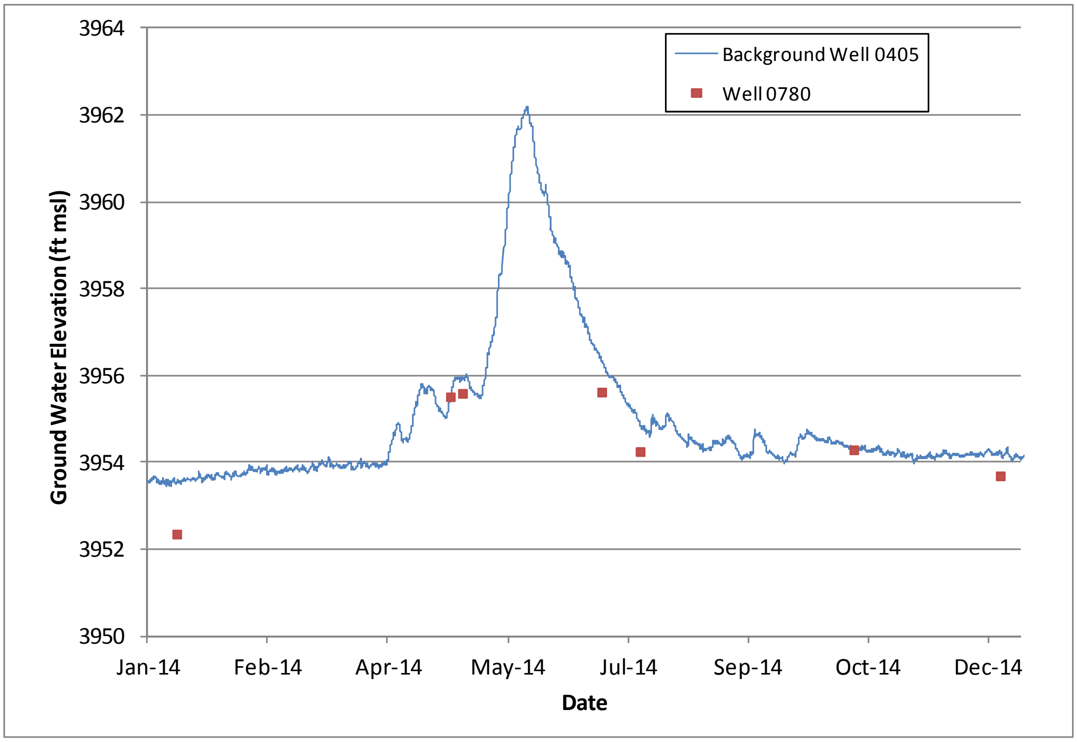
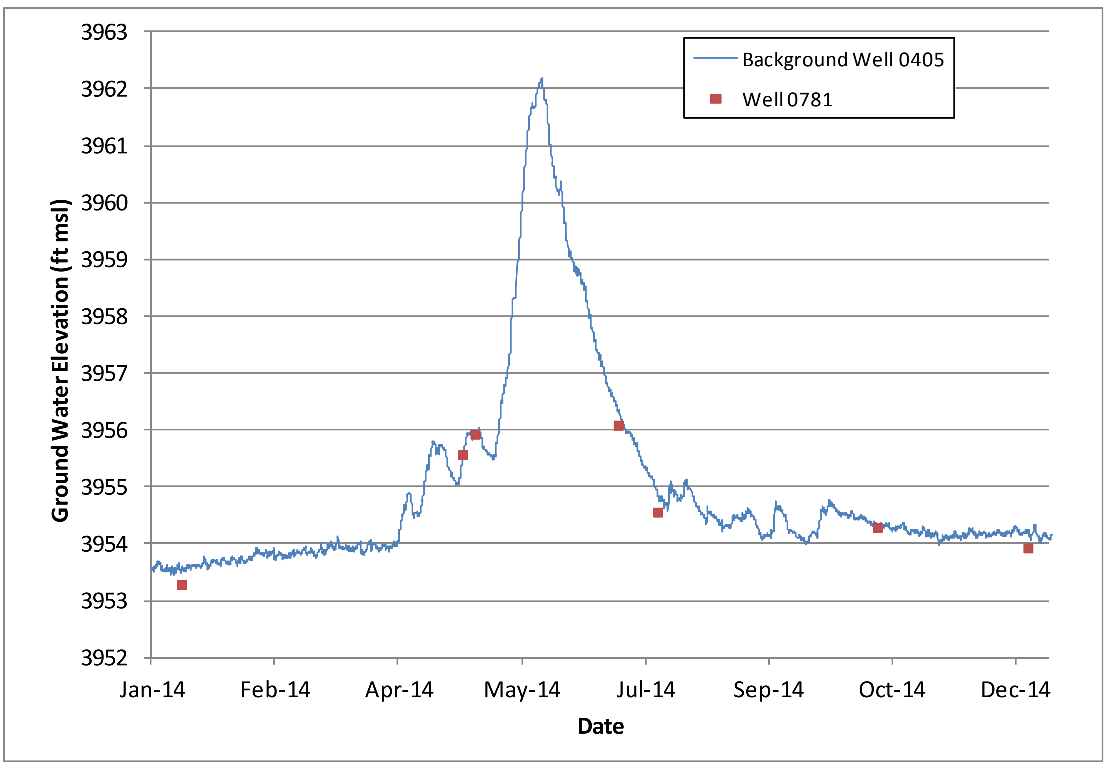


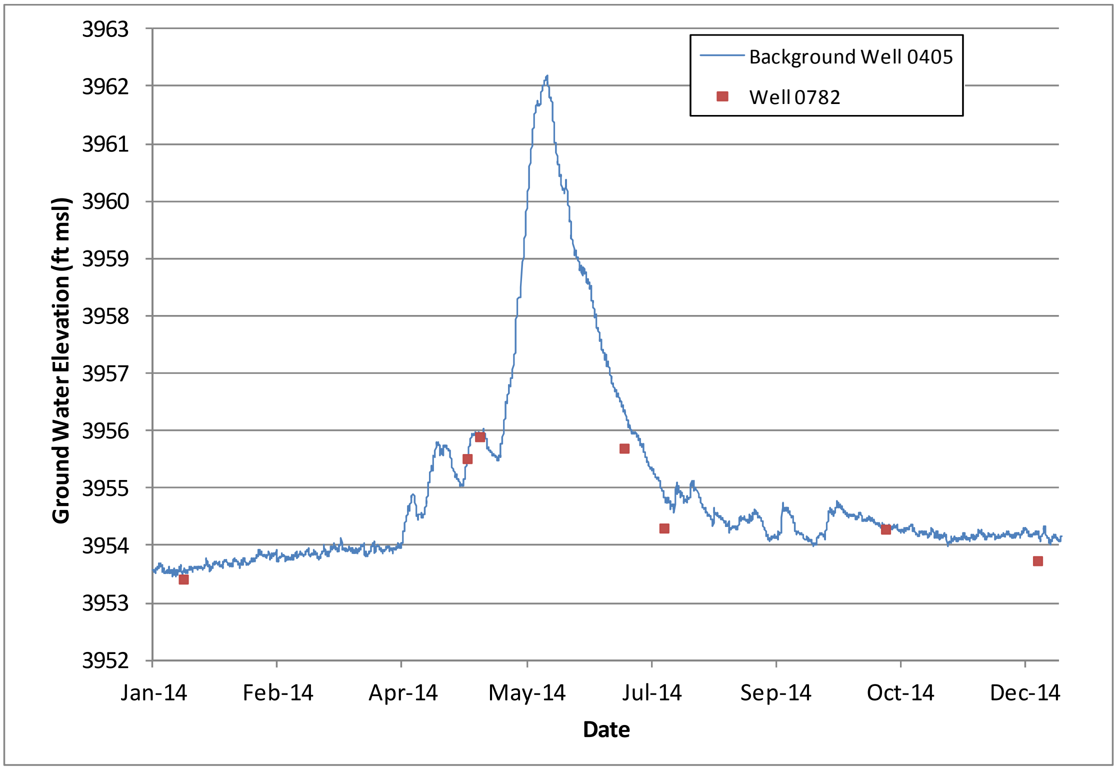
Figure C-14. Freshwater Mounding in Remediation Well 0779 during Injection



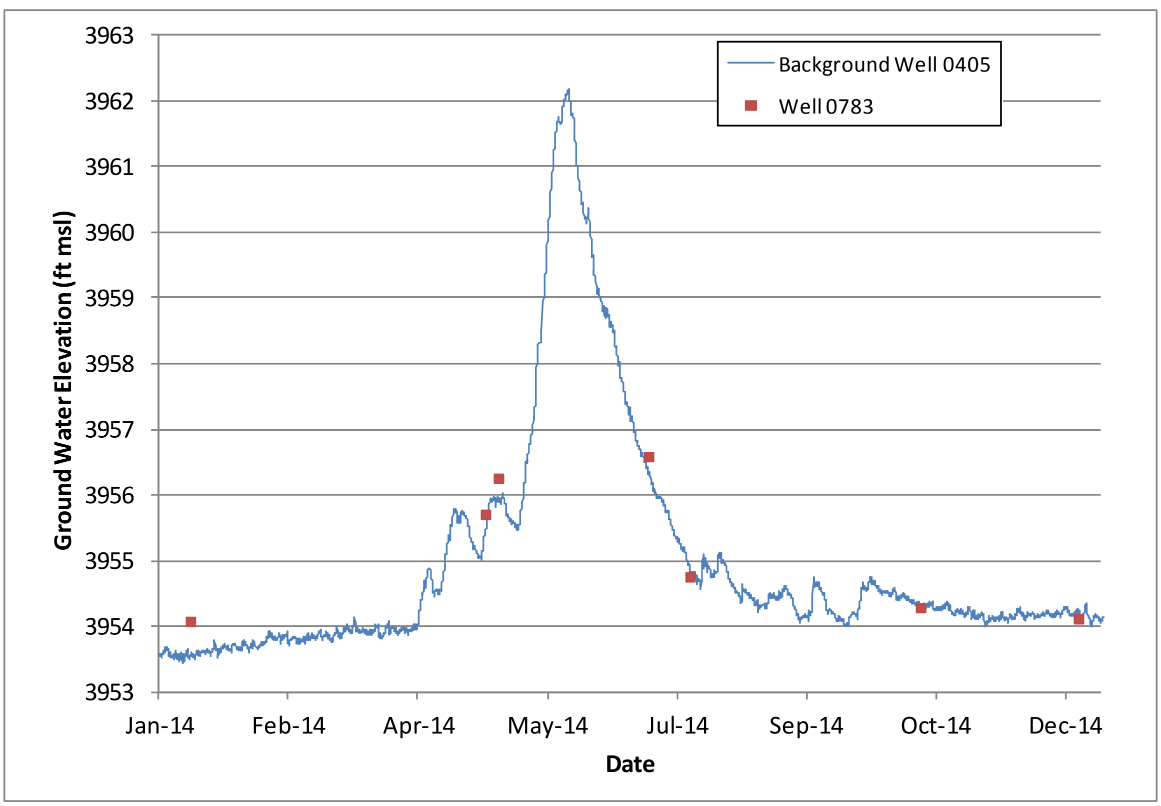
C-15. Freshwater Mounding in Observation Well 0780



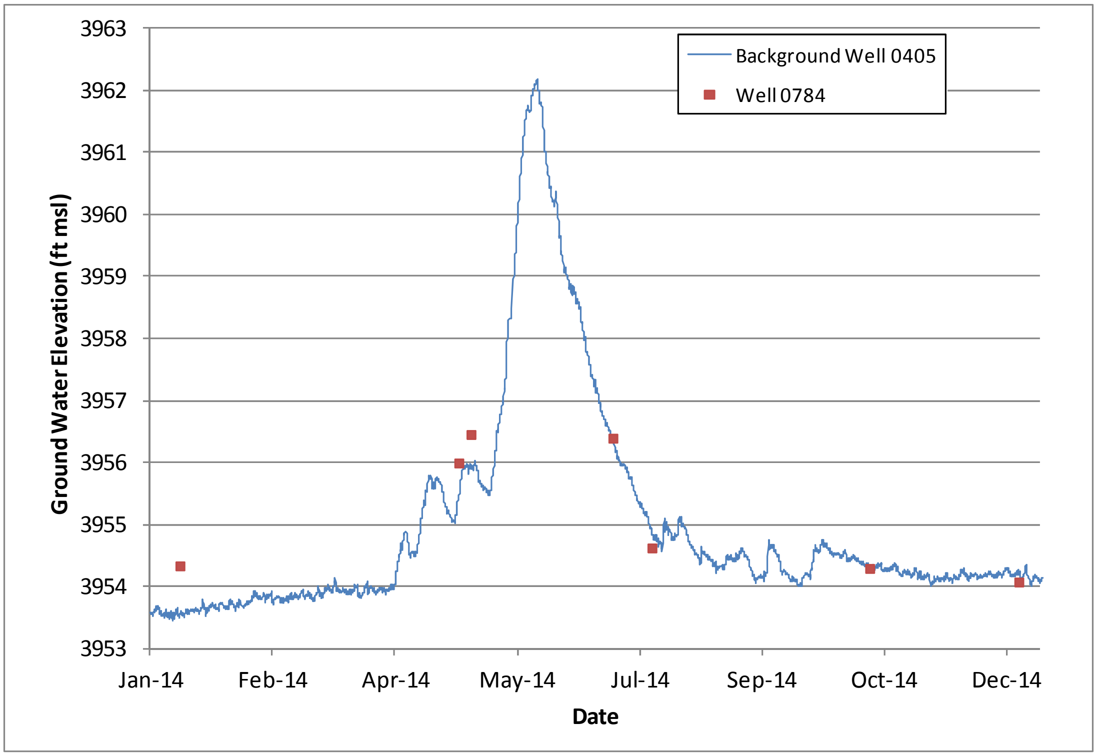
C-16. Freshwater Mounding in Observation Well 0781



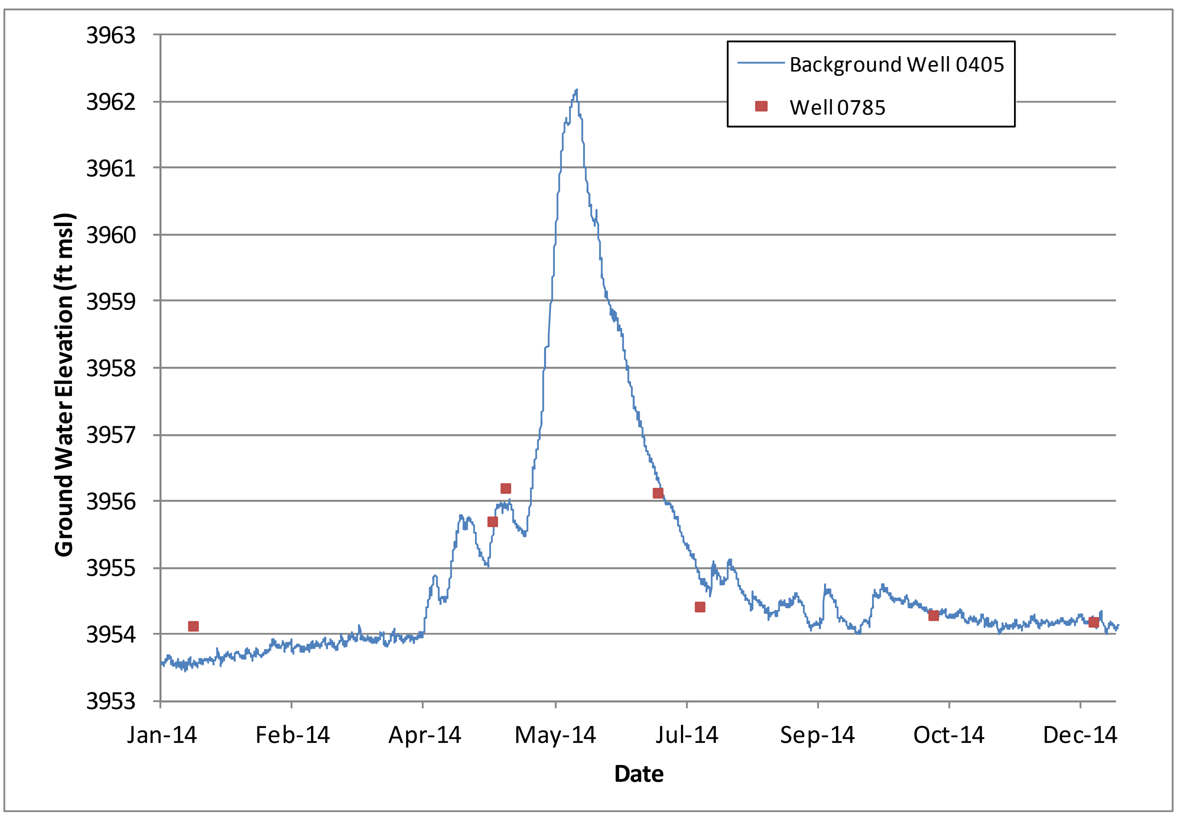
C-17. Freshwater Mounding in Observation Well 0782



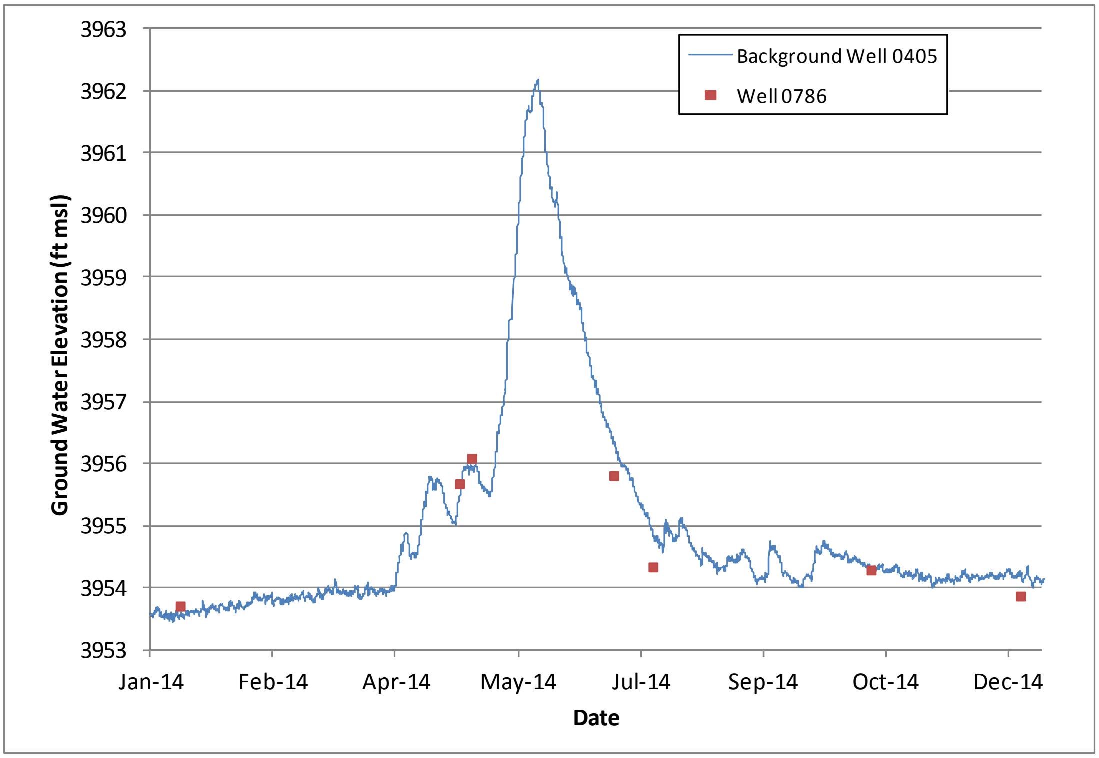
C-18. Freshwater Mounding in Observation Well 0783



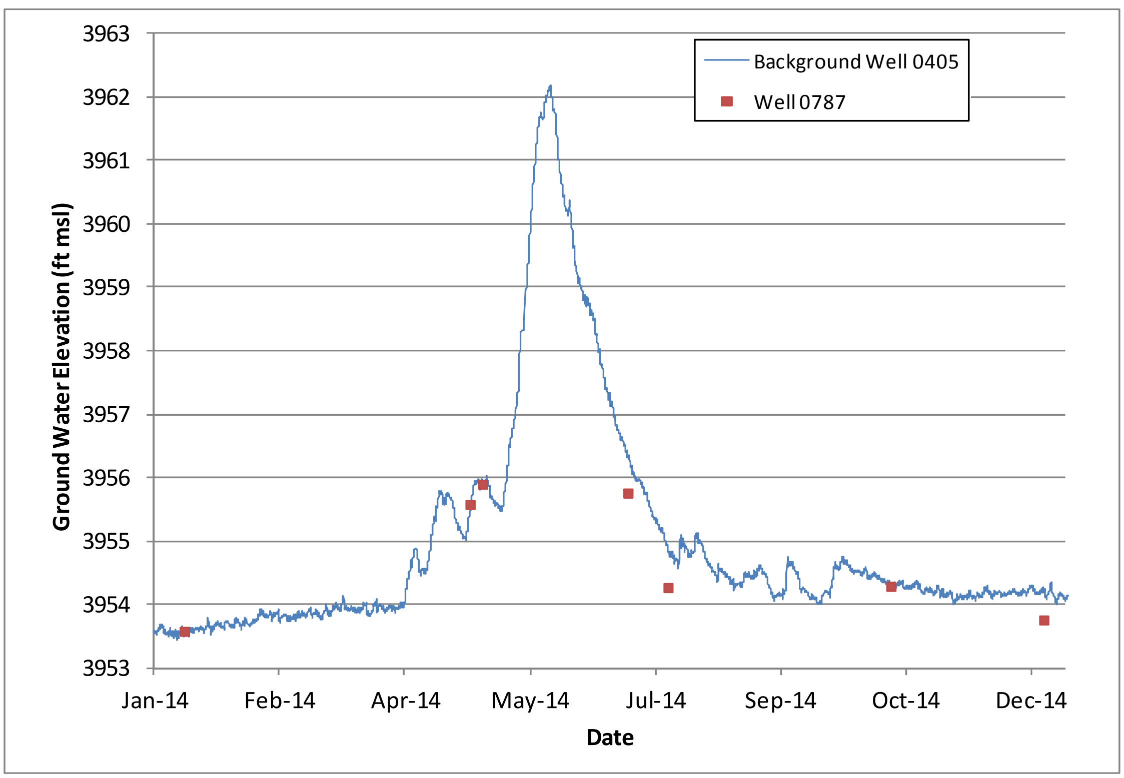
C-19. Freshwater Mounding in Observation Well 0784



C-20. Freshwater Mounding in Observation Well 0785



C-21. Freshwater Mounding in Observation Well 0786



C-22. Freshwater Mounding in Observation Well 0787