DOE–EM/GJTAC2005

Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA

UMTRA Project

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2010 Ground Water Program Report

August 2011

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-AC30-07CC60012 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Revision 0

Review and Approval

8/23/11

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Revision History

Revision No.	Date	Reason/Basis for Revision
0	August 2011	Initial issue.

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Acronyms and Abbreviations

AWQC	ambient water quality criteria
bgs	below ground surface
btoc	below top of casing
CF	configuration
cfs	cubic feet per second
DOE	U.S. Department of Energy
DTW	depth to water
ft	feet
ft btoc	feet below top of casing
gal	gallons
gpm	gallons per minute
IA	interim action
kg	kilogram
µmhos/cm	micromhos per centimeter
µs/cm	microsieverts per centimeter
mg/L	milligrams per liter
msl	mean sea level
NH3-N	ammonia nitrogen
RAC	Remedial Action Contractor
TD	total depth
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Introduction

1.1 Purpose and Scope

The purpose of this Ground Water Program Report is to assess the performance of 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 in Utah and to protect endangered fish habitat in the Colorado River near the site during 2010.

This report describes the ground water program activities for the Moab Project during 2010 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 tons of uranium mill tailings, material that ranges from dry sand to wet “slime” clay that remained after the ore is processed, 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. Beginning in April 2009, tailings have been relocated by rail to a disposal cell being constructed 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 and some of the more mobile constituents have migrated downgradient and are discharging to the Colorado River adjacent to the site.

In 2005, DOE issued a Record of Decision that 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. Clean surface water also is injected to protect fish habitat in riparian areas along the Colorado River. The IA system is discussed in further detail in Section 2.0.

2.0 Ground Water Program Description

The ground water program at the Moab site is designed to limit ecological risk from contaminated groundwater discharging to potential endangered fish species habitat areas (critical habitats) along the Colorado River. This protection is accomplished through removal of contaminant mass with ground water extraction wells before it reaches the river. Freshwater is injected between the river and the tailings pile to create a hydraulic barrier that prevents discharge of contaminated water to critical habitat areas. When critical habitat exists, upstream surface water, unaffected surface water is diverted to the area to reduce contaminant levels. The program consists of the ground water IA and the initial action program. Ground water and surface water monitoring are performed with both of these actions. Each of these aspects will be discussed in separate sections in this report.

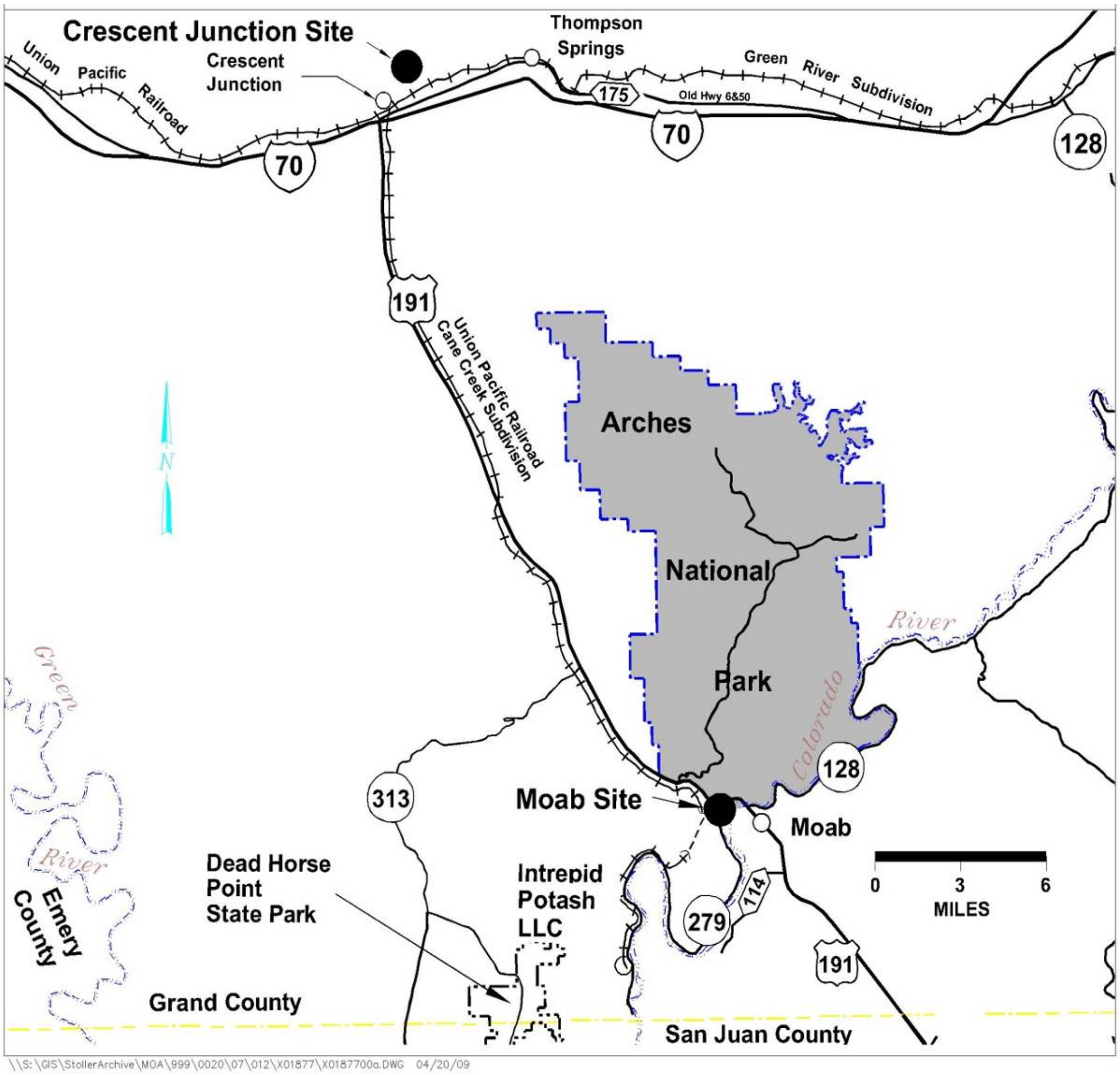


Figure 1. Site Location

2.1 IA Ground Water System

DOE installed and began operating the first of several configurations of extraction/injection wells that compose 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 reduce the discharge of ammonia-contaminated ground water to backwater areas that may potentially be suitable habitat for threatened and endangered aquatic species and to provide performance data for use in selecting and designing a final ground water remedy.

Figure 2. Location of IA Wells

Contaminated ground water from the shallow plume above the brine zone is extracted through series of wells and pumped to an evaporation pond on top of the tailings pile. The IA system also includes injection of diverted river water into the saturated soil through the wells and an infiltration trench installed near the western bank of the river. Monitoring wells are also part of the IA system for evaluation purposes.

2.2 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site consists of unconsolidated alluvium (Figure 3). Underlying the alluvium are salt beds of the Paradox Formation. The alluvium at the Moab site is mostly comprised of either the Moab Wash alluvium or 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 composed of two distinct types of material. The upper unit consists mostly of fine sand, silt, and clay, and ranges in thickness from 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 silty and clay. This deeper coarse alluvium pinches out to the northwest along the subsurface bedrock contact and thickens to the southeast toward the river to more than 450 ft near the deepest part of the basin. The upper silty-sand unit typically has a hydraulic conductivity of less than 2 ft/day, whereas the underlying gravelly sand unit 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 April 2010, and exhibits that ground water underlying both the site and the Matheson Wetlands flows towards and discharges into the Colorado River. Figure 4 is a water table map generated using October 2010 data collected across the entire site, and illustrates how nearly all the ground water underlying the site flows southeast toward the river, and discharges along the river’s western bank.

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 saline interface occurs naturally beneath the Moab site that is delineated at a TDS concentration of 35,000 mg/L. The interface moves laterally and vertically during the course of each year in response to such stresses as seasonal transpiration and changes in river stage.

The tailings pile fluids contain TDS exceeding 35,000 mg/L, allowing this fluid has sufficient density to migrate vertically 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 brackish water/brine interface. The ammonia beneath the interface represents a potential long-term source of contamination to the upper alluvial ground water system.

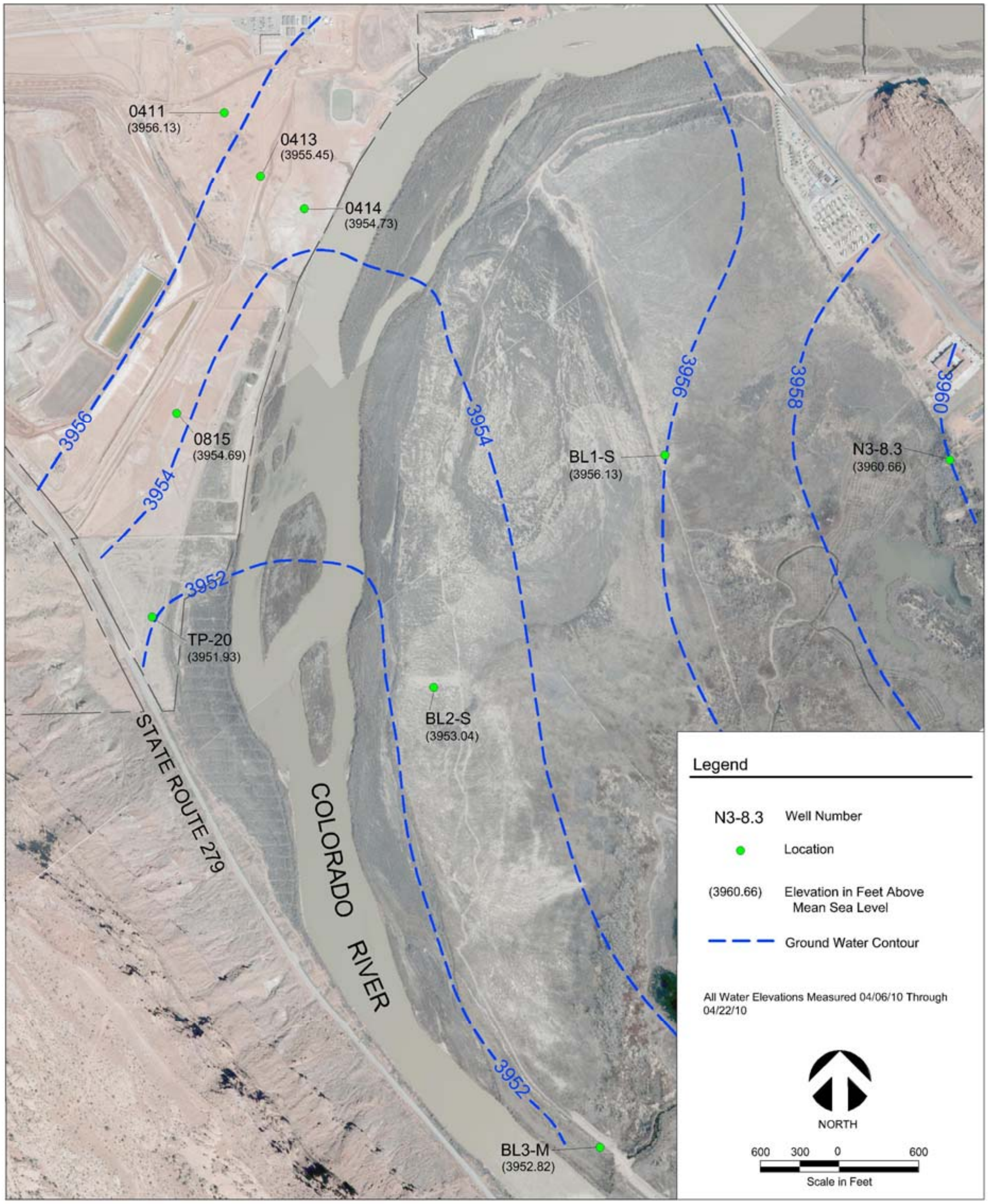


Figure 3. April 2010 Ground Water Surface Elevation Contours

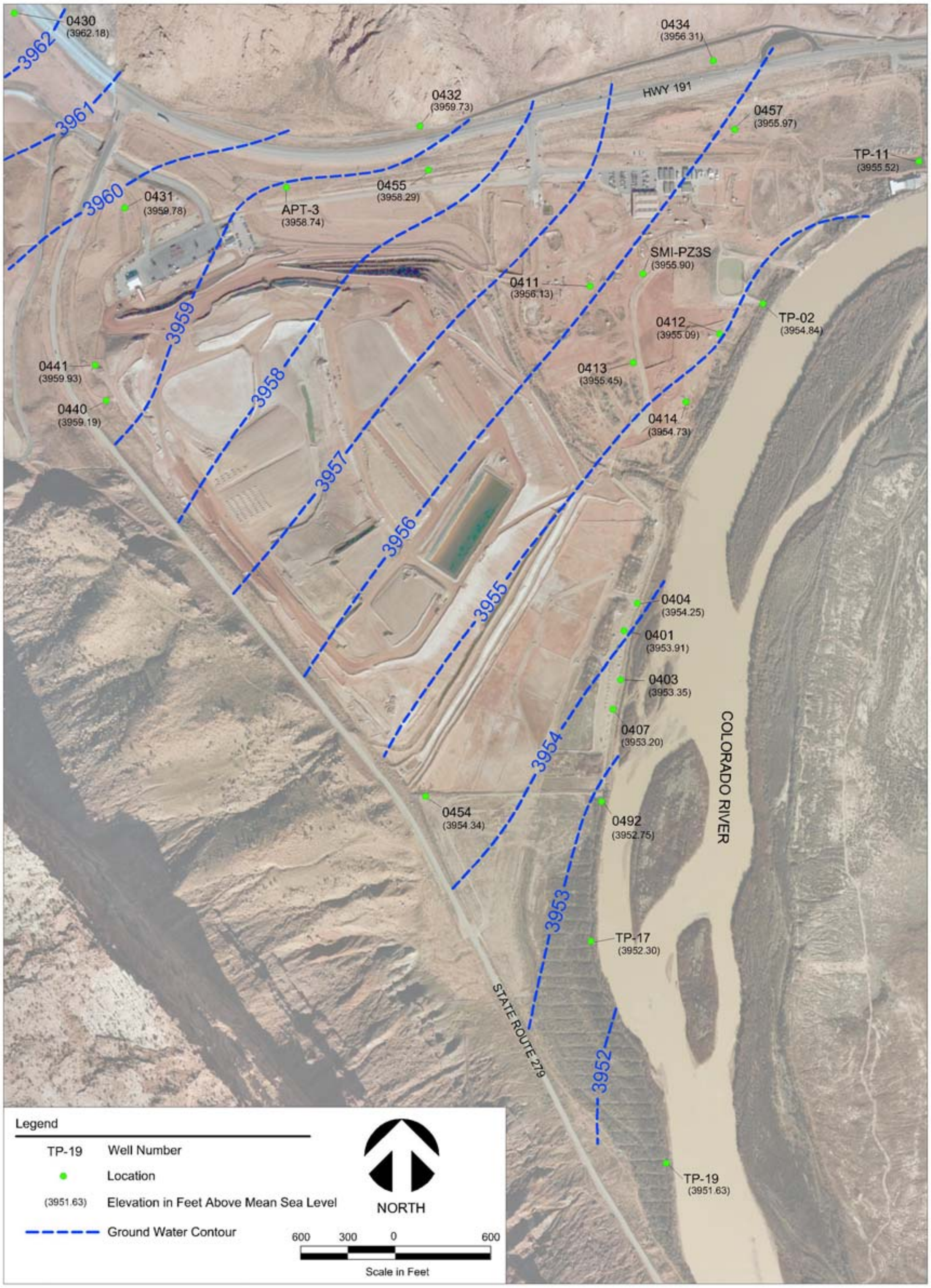


Figure 4. October 2010 Ground Water Surface Elevation Contours

Since the cessation of milling operations at the site, the flux of relatively freshwater entering the site upgradient of the tailings pile may have diluted the ammonia levels in the shallow ground water (Figure 5). 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 no flushing of the legacy plume by advective flow of freshwater due to density stratification of the brine zone.

In addition to ammonia, the other primary constituent of concern in ground water is uranium. Figure 6 shows the distribution of dissolved uranium in shallow ground water. Wells to monitor water quality have been installed on the site over a series of 10 different investigations. The first monitoring wells associated with site characterization were installed in 1970.

2.3 Surface Water/Ground Water Interaction

Previous investigations have shown that the surface water flow in the Colorado River can strongly affect ground water elevations and contaminant concentrations in the well field. As the Colorado River reaches peak spring runoff flows, it changes from gaining to losing conditions, and a lens of freshwater migrates into the well field ground water system.

The freshwater lens is more prominent on the southern end of the well field, where a prominent backwater channel flows adjacent to the river bank.

A geochemical investigation conducted in 2008 indicated that in the southern half of the well field, where Colorado River side channels are located adjacent to the well field, a freshwater lens begins to form beneath the well field when the river flow is above 10,000 cubic feet per second (cfs). A smaller scale of this study took place in 2010. Ground water parameters were recorded at nine Configuration (CF) 1 observation wells five times during various river flows from April through August. Figures 7 through 10 illustrate how the freshwater lens migrated into the well field in May when the river flow was 12,100 cfs. The lens began to increase vertically and horizontally in June when the river flow was 29,500 cfs and then began to migrate back towards the river in August, when the flow had decreased to 4,710 cfs.

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and sampling remediation and monitoring wells. In 2010, the IA well field ran on both extraction and injection mode.

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 as “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 estimate the contaminant mass removal from each well.

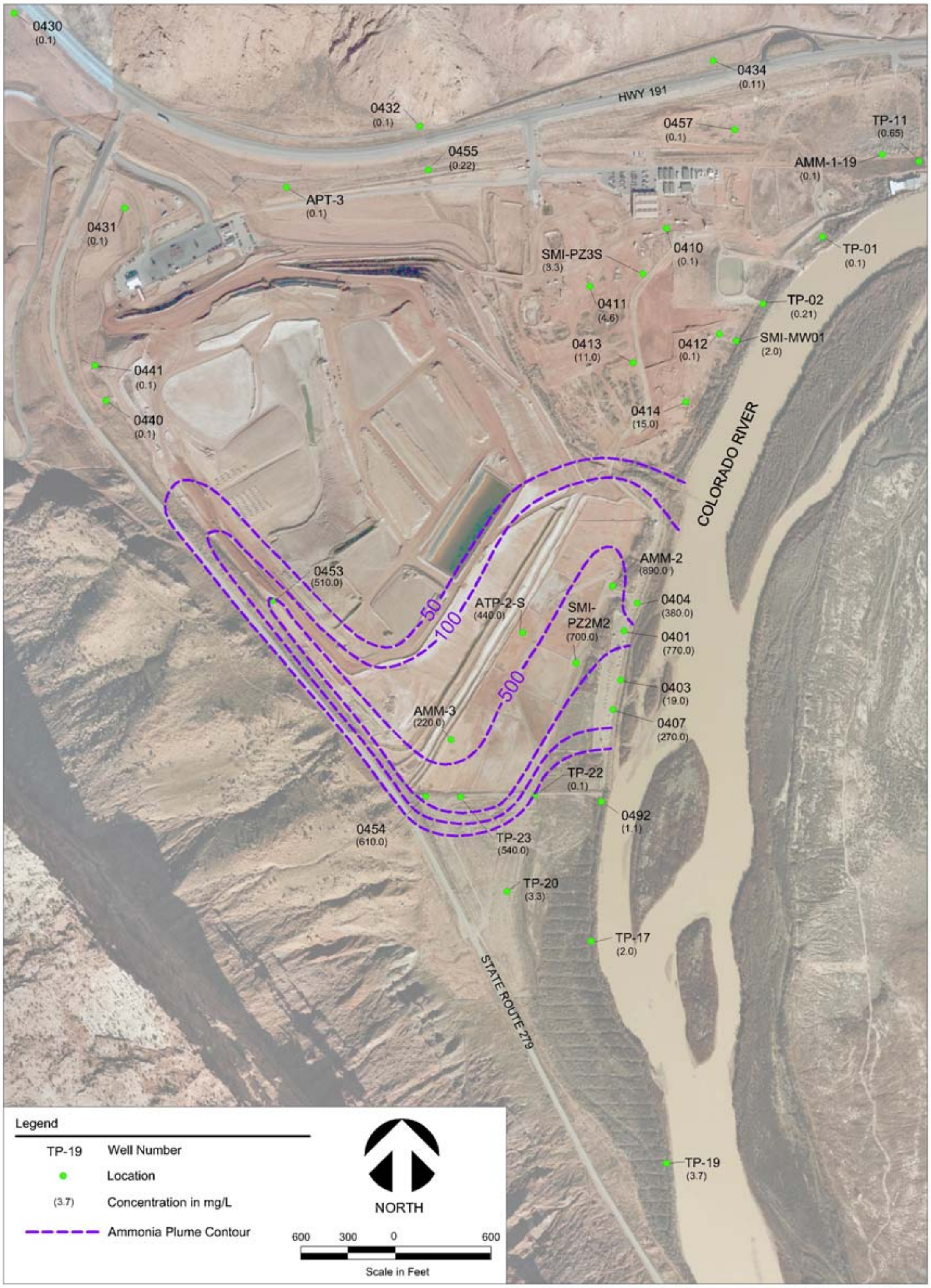


Figure 5. October 2010 Location of Ammonia Plume in Shallow Ground Water

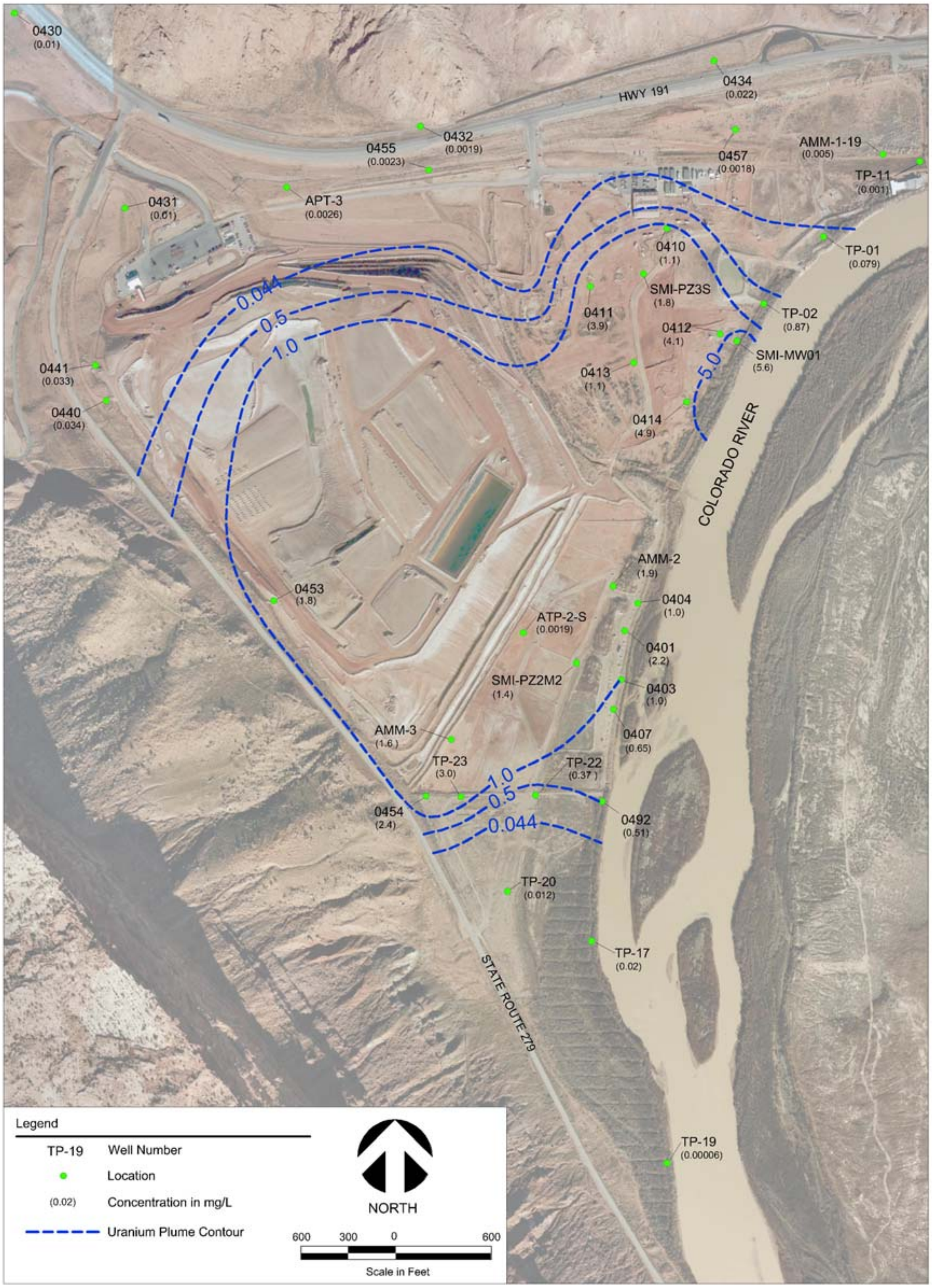


Figure 6. October 2010 Location of Uranium Plume in Shallow Ground Water

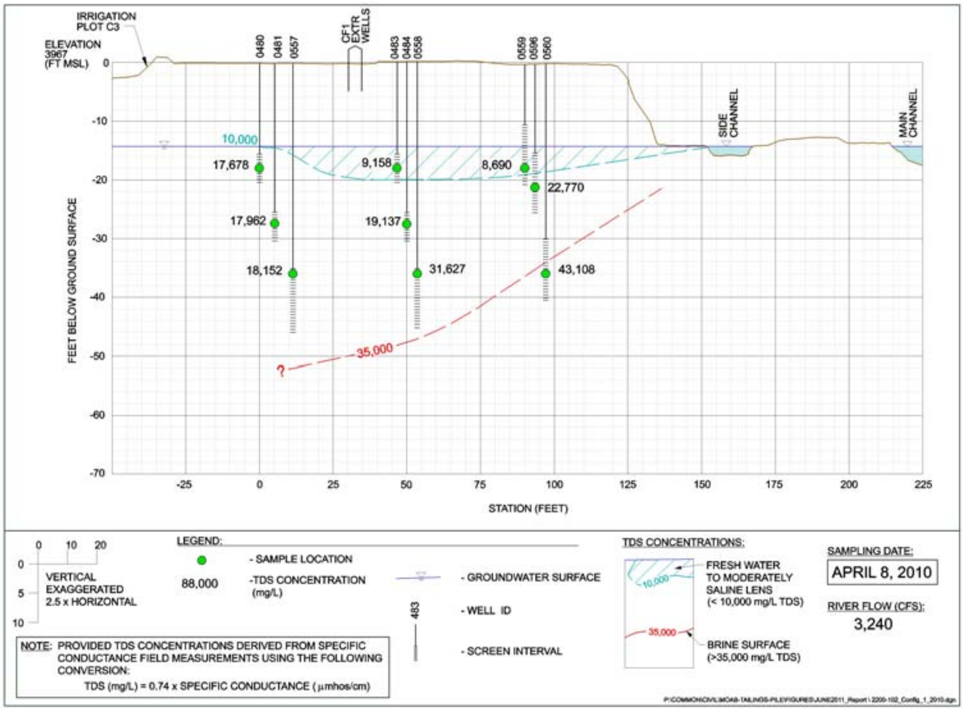


Figure 7. Cross-section of CF1 During Base-flow Conditions

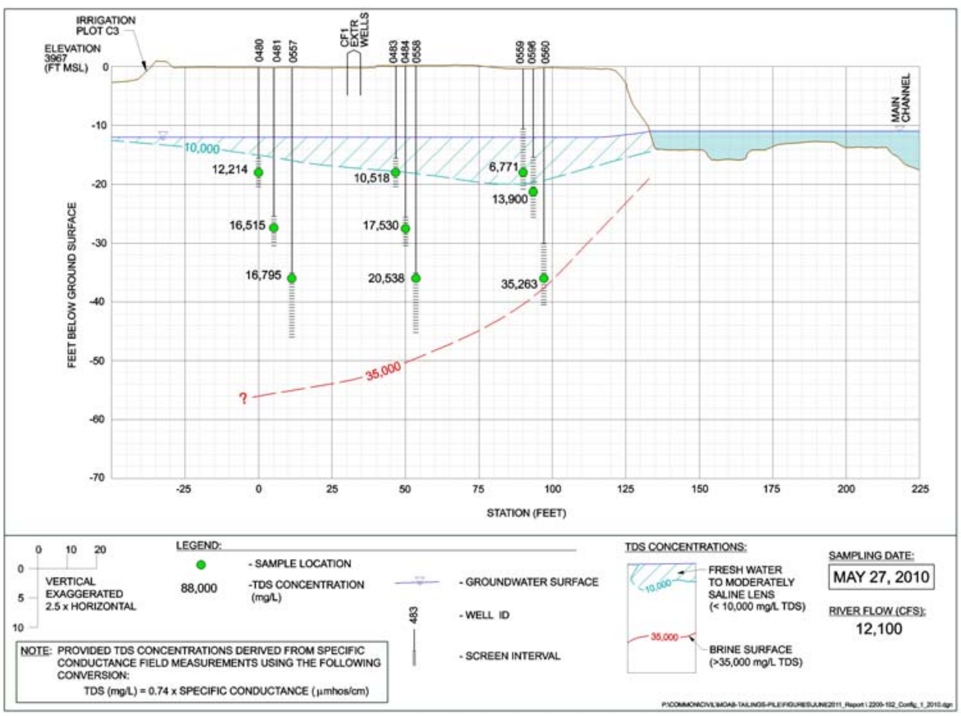


Figure 8. Cross-section of CF1 at 12,100 cfs

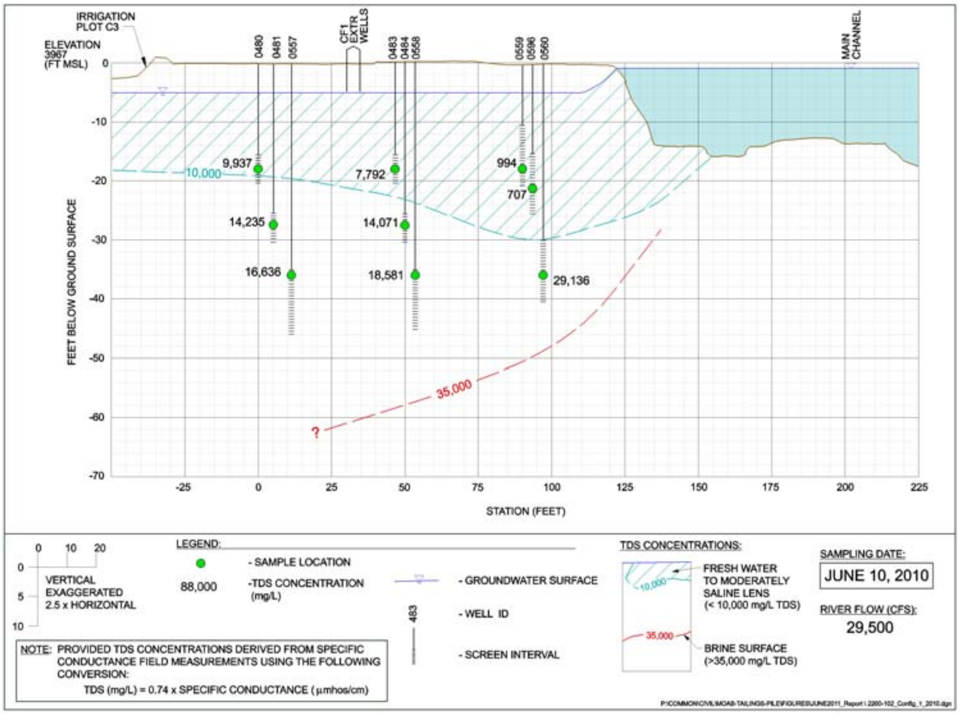


Figure 9. Cross-section through CF1 at 29,500 cfs

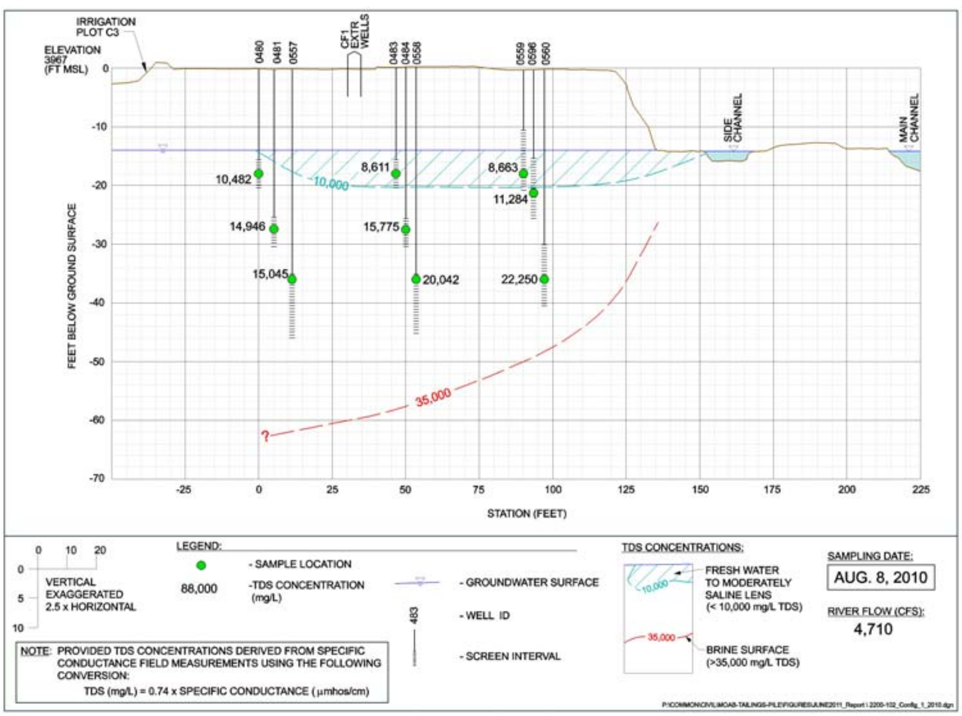


Figure 10. Cross-section through CF1 at 4,710 cfs

When the remediation wells are sampled, the resulting ammonia and uranium concentrations are used to calculate the contaminant mass removal. The ammonia and uranium mass removal concentrations are used in conjunction with the ground water extraction rate to calculate the mass removal. The contaminant mass that is removed is discharged to the evaporation pond on top of the tailings pile or sprayed through the evaporators. The evaporated contaminants are deposited as salt and will be removed for disposal with tailings and transported to the Crescent Junction disposal cell.

3.2 Remediation Well Injection

Each injection well also contains a flow meter that displays the instantaneous injection rate in gpm and the totals are read the same as during extraction operations. 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 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 [btoc]) in most wells. 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. Prior to sampling, field parameters including temperature, pH, oxidation reduction potential, conductivity, dissolved oxygen, 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), uranium, and TDS. 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 the ALS Laboratory Group in Fort Collins, Colorado.

An ammonia probe is occasionally used on site to obtain real-time ammonia concentrations. The probe is used mostly at surface water locations and in observation wells during injection. Frequently, the ammonia probe data is verified with a laboratory sample analysis. All of the ammonia data stated in this report that was recorded with the ammonia probe is stated as such. All other ammonia data is from the ALS Laboratory Group.

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 2010 pumping season when CFs 4 and 5 were actively extracting ground water. Also included in this section is a discussion regarding the total ground water extraction rate, hydraulic control, mass removal, and water quality for 2010.

Seven new extraction wells were added to the IA well field in late 2009 and early 2010. These CF5 extraction wells are located between the toe of the tailings pile and CFs 1 through 4, with the purpose of extracting contaminated ground water closer to the tailings pile. Due to its close proximity to the new wells, extraction well PW02 has been grouped together with CF5 (in the past, it has been grouped with CF1).

Observation wells were installed adjacent to each of the eight CF5 extraction wells (including PW02). The completion data for these wells can be found in the *Moab UMTRA Project Drilling Completion Report* (DOE-EM/GJTAC1890).

In 2010, IA operations were greatly impacted by the available storage in the evaporation pond (refer to Section 4.0 for more information on the evaporation pond). The extraction schedule was altered to focus on extraction from CF5 to increase ammonia and uranium removal. Each of the CF5 extraction wells has the ability to extract at a higher rate than the other configurations. The pumping rate is limited by available treatment capacity.

Extraction from CF5 began in April 2010 with wells 0815 and PW02. The rest of the CF5 wells were operational in August and continued extracting until late November. CF4 ran on extraction mode during the month of April, but was switched over to injection in September 2010 (refer to Section 5.0 for more information on well field injection operations). Well construction information and a chronology of events for CFs 4 and 5 can be found in Appendix A (Tables A-1 and A-2) and Appendix B (Tables B-1 and B-2).

Table 1 presents the average ground water extraction rates and the total volume removed from CFs 4 and 5 during 2010. As shown, the average extraction rate from the entire well field was 65.21 gpm, and more than 10 million gal of ground water was removed.

Table 1. Average Ground Water Extraction Rate and Total Volume During 2010

Well Field Configuration	Average Extraction Rate (gpm)	Total Volume Extraction (gal)
4	14.4	578,638
5	51.17	9,633,960
Total	**65.21**	**10,212,598**

The individual pumping rates and the associated volume of ground water extracted by each well within CFs 4 and 5 are presented in Appendices A and B, respectively. Appendix E contains all analytical and water level data.The data listed are generally based on flow rates recorded at meters installed at each extraction well head. These flow meters occasionally malfunctioned, which means that some pumping rates had to be assumed using rates that were accurately captured prior to and after periods of malfunction. Figure 11 provides a graphic summary of the cumulative volume of ground water extracted from each configuration in 2010.

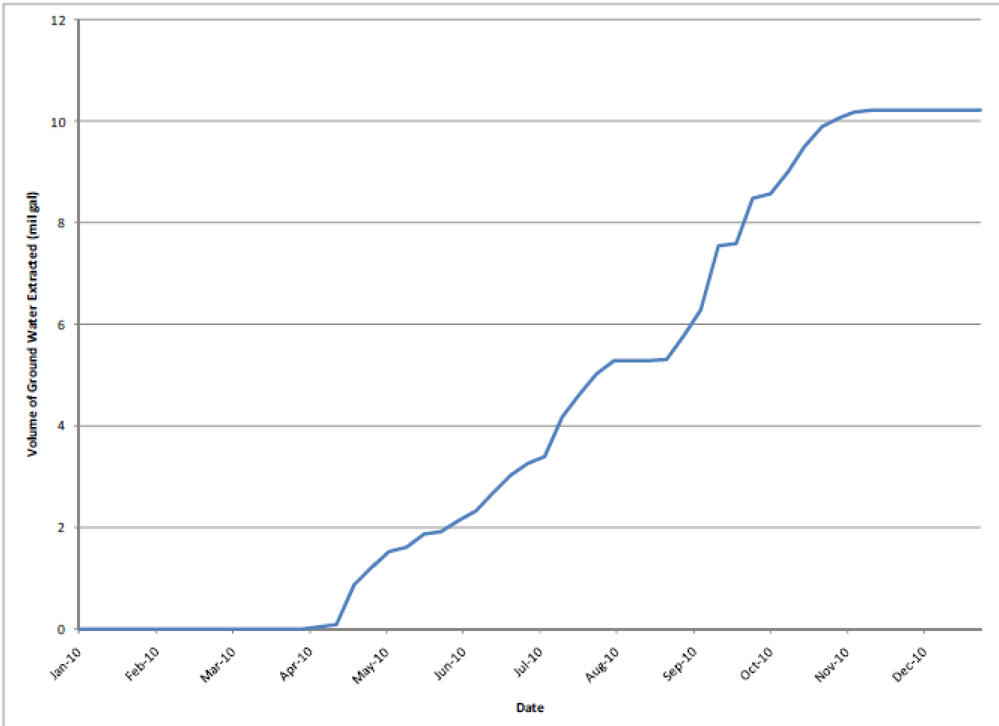


Figure 11. Cumulative Volume of Extracted Ground Water During 2010

4.1.1 CF4 Pumping Rate and Ground Water Extracted Volume

Nine of the CF4 remediation wells (0770, 0772, 0773, 0774, 0775, 0776, 0777, 0778, and 0779) ran on extraction mode beginning April 8 and were shut down on April 22 to control the evaporation pond level. Additional data tables are presented in Appendix A. Remediation wells 0770 through 0779 are screened from approximately 15 to 35 ft below ground surface (bgs) (3,951 to 3,930 ft mean sea level [msl]). These wells were switched over from extraction to injection mode on September 2 to protect an adjacent backwater channel (refer to Section 5 for more information on freshwater injection operations).

Monthly extraction volumes for April are listed in Appendix A, Table A-3. CF4 wells individually extracted between approximately 678 gal and 144,558 gal. A total of approximately 578,638 gal of ground water was extracted from the CF4 wells during the 2010 pumping season.

4.1.2 CF5 Pumping Rate and Ground Water Extracted Volume

CF5 extraction wells 0810 through 0816 and PW02 (Figure 13) were used to extract ground water in 2010. The well screens are placed at varying depths (Appendix B-1, Table B-1) due to varying depths to the brine interface in the CF5 area. Extraction wells PW02 and 0815 began extracting ground water on April 15. Wells 0810 through 0816 were started on August 26 and ran intermittently to supply water for the enhanced evaporation unit operations until November 23.

Monthly extraction volumes between August and November 2010 for each of the eight wells comprising the CF5 system are listed in Appendix B, Table B-3. CF5 wells individually extracted between approximately 61,464 and 5,010,493 gal. A total of approximately 9,634,000 gal of ground water was extracted from the CF5 wells during the 2010 pumping season.

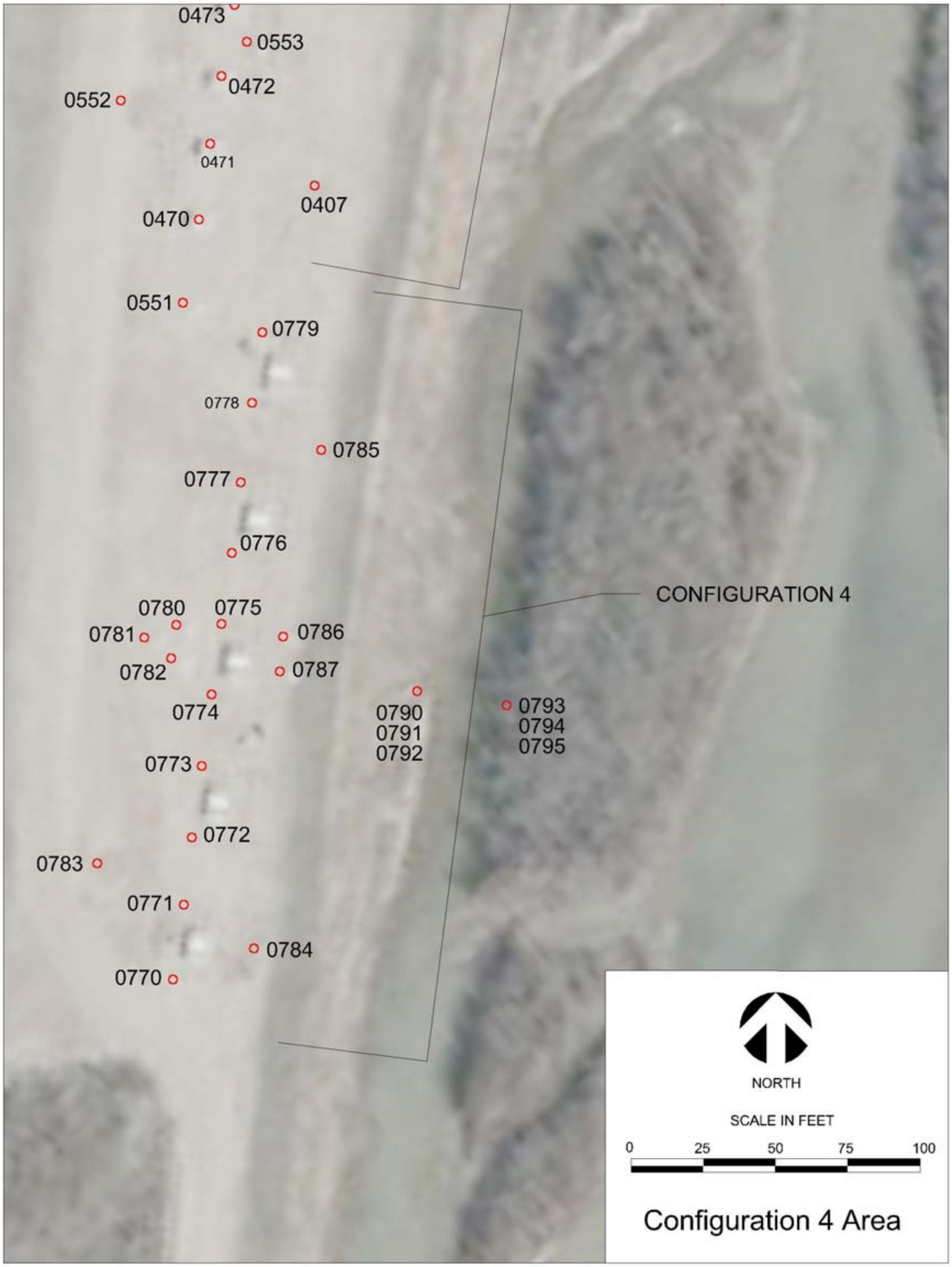


Figure 12. Location of Wells in CF4

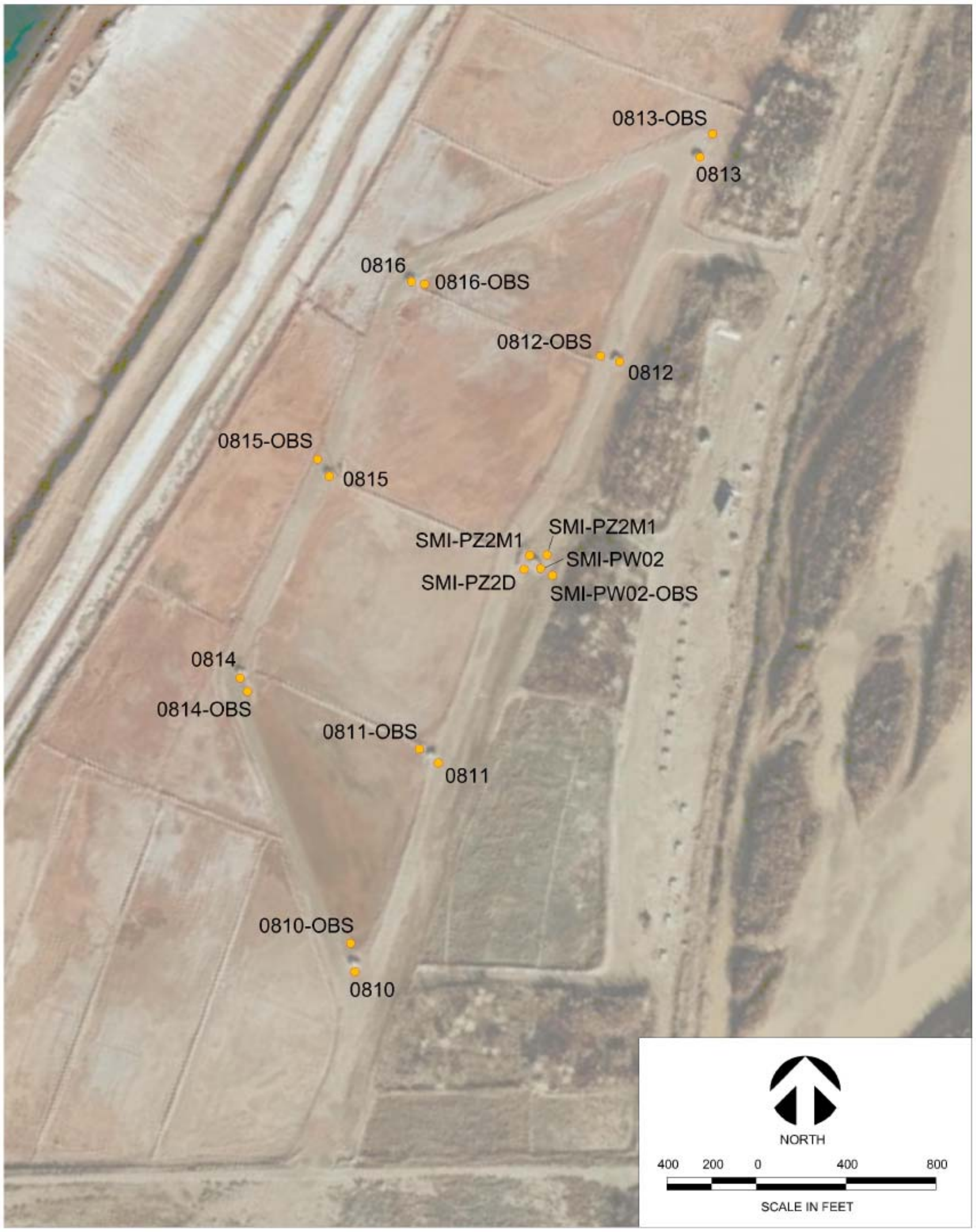
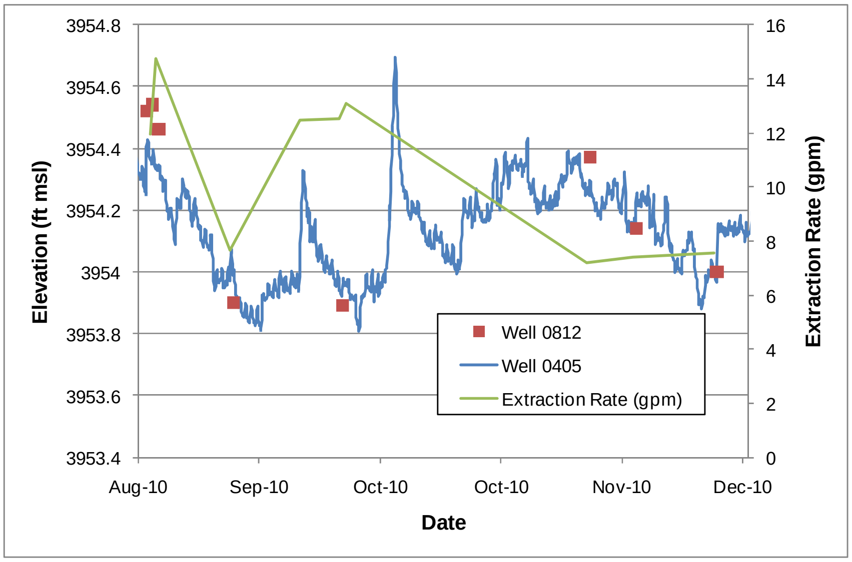


Figure 13. Location of Wells in CF5

4.2 IA Extraction Performance

4.2.1 Ground Water Levels and Hydraulic Control

Hydrographs were created by comparing ground water elevations from observation well 0405 located in the baseline area and ground water elevations of the CF5 extraction wells during the pumping season. Applicable extraction rates for each well were plotted against the ground water elevations to determine drawdown during operations. Baseline area water elevation data was adjusted so that both wells were assigned the same non-pumping water level. The difference between the two wells gives a qualitative estimate of drawdown in response to pumping. Figure 14 shows the drawdown during extraction on wells 0812 and 0815 in 2010 (Appendix B, Figures B-1 through B-6 has drawdown plots for the rest of the CF5 wells). Table 2 lists the highest drawdown value noted for each of the CF5 extraction wells.



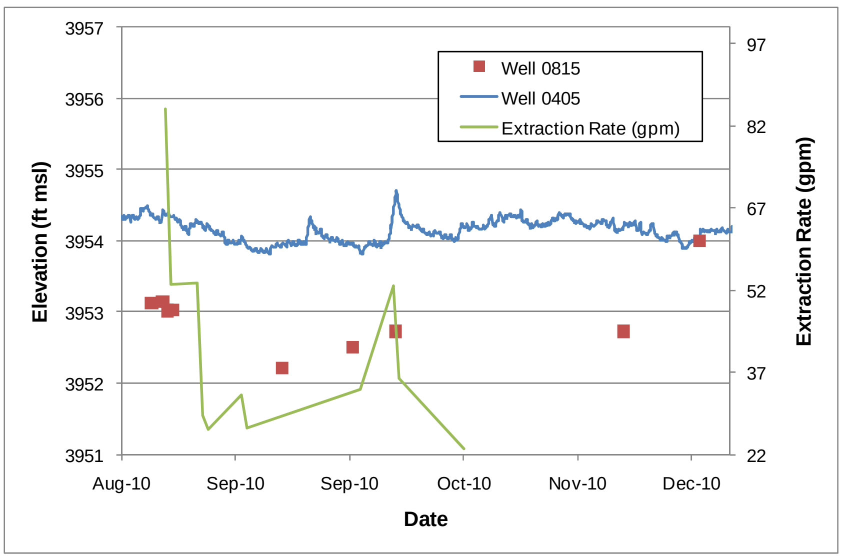


Figure 14. Water Level Data from CF5 Extraction Wells 0812 and 0815 in 2010

Table 2. Drawdown Measured in CF5 Wells in 2010

Location	Date	Drawdown (ft)	Extraction Rate (gpm)
0810	N/A	N/A	N/A
0811	9/2/10	0.13	73.2
0812	9/29/10	5.54	13.11
0813	10/28/10	0.76	61.6
0814	9/21/10	2.71	~93.7
0815	9/9/10	17.87	32.9
0816	9/27/10	11.22	~80
PW02	10/8/10	9.93	47.8

4.2.2 Remediation Well Specific Capacity

Specific capacity is a measure of a well's performance relative to formation hydraulic characteristics. Well drawdown data were used to compute the specific capacity during the 2010 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 3).

The specific capacity data listed in Table 3 was collected on August 27, 2010 during short-term aquifer test operations at each extraction well. All of the tests were short-term and, therefore, are not indicative of long-term pumping.

Table 3. Computed Specific Capacities at CF5 Extraction Wells During 2010

Well	Static DTW (ft btoc)	Measured DTW (ft btoc)	Drawdown (ft)	Pumping Rate (gpm)	Specific Capacity (gpm/ft)
0810	8.47	13.51	5.04	47.4	9.4
0811	9.01	17.69	8.68	46.1	5.3
0812	7.08	14.72	7.64	50.8	6.7
0813*	8.91	9.71	0.8	65.1	>50
0814	6.51	10.8	4.29	55.3	12.9
0815	8.6	13.88	5.28	48.8	9.2
0816	7.15	10.29	3.14	83.1	26.5
PW02	12.93	16.94	4.01	29.5	7.4

DTW = depth to water; ft btoc = feet below top of casing

Notes: *Well 0813 specific capacity was estimated to be >50 gpm/ft based on the field data. Additional testing is required.

4.3 Contaminant Mass Removal

The estimated ammonia and uranium mass removed by CFs 4 and 5 extraction wells in 2010 is presented in Table 4. These estimates are based on ground water extraction rate and volumes recorded by flow meters located along the well head discharge pump lines. The mass of ammonia and uranium removed from ground water by the extraction wells was estimated by multiplying the monthly extraction volumes by corresponding concentration of ammonia and uranium in each well.

The concentrations used in these calculations were drawn from analytical data presented in Appendices A and B for CFs 4 and 5, respectively. To estimate the contaminant mass removed when analytical data was not available for a specific month, concentrations were derived from previous and subsequent months to provide an approximate concentration.

As shown in Table 4, during the 2010 pumping season, a total of approximately 16,515 kilograms (kg) of ammonia and 107 kg of uranium were extracted from the ground water.

Table 4. Contaminant Mass Removal in 2010

Well Field Configuration	Total Ammonia Mass Removed (kg)	Total Uranium Mass Removed (kg)
4	1,397	5.7
5	15,118	101.3
Total	**16,515**	**107**

4.3.1 CF4 Contaminant Mass Removal

Table 4 indicates that an estimated total of 1,397 kg of ammonia was extracted from the ground water at CF4 wells during the 2010 pumping season. Table A-4 in Appendix A shows that the largest mass removal quantities were associated with wells 0773 and 0775, with 349 and 230 kg, respectively. These are also the two wells that had the highest extraction rate (Appendix A, Table A-3).

Estimated mass of uranium removed from ground water during 2010 extraction at CF4 was developed using the same techniques applied to ammonia. Table 4 indicates that an estimated 5.7 kg of uranium was extracted from the ground water at the CF4 wells during the 2010 pumping season. The monthly estimate of uranium mass removed by CF4 wells is listed in Table A-4 in Appendix A. Wells 0775 and 0773 removed the most uranium mass at 0.9 and 1.2 kg, respectively.

4.3.2 CF5 Contaminant Mass Removal

Table 4 indicates that an estimated total of 15,118 kg of ammonia was extracted from the ground water at CF5 wells during the 2010 pumping season. Table B-4 in Appendix B shows that extraction wells PW02 and 0816 extracted the most ammonia mass in CF5 in 2010.

Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Appendix B (Table B-5), which shows that a total of approximately 101.3 kg of uranium was removed from the ground water between April and November. The greatest mass of uranium was extracted from wells PW02 and 0815 at 51.9 and 23.4 kg, respectively. These are the two CF5 wells that extracted the most volume of ground water in 2010.

4.4 Ground Water Chemistry

Ground water samples were collected from the well field from January through November 2010, during various river stages and pumping regimes. The following section describes the ground water chemistry from CF5 in the IA well field. Additional ground water samples were collected, and the data can be found in Appendix E. The sample schedule for 2010 was streamlined to focus on locations with active pumping operations.

Ground water samples are collected from the IA well field and shipped to ALS Laboratory Group. In 2010, most of the ground water samples were analyzed for uranium, ammonia (as N), and TDS. All analyses performed by an off-site laboratory are validated and documented in a data validation package. Because CF4 ran in extraction mode for a short time, the ground water chemistry of wells from this area of the IA well field is summarized in Section 6.0.

4.4.1 CF5

CF5 wells were sampled up to four different times in 2010. Results are summarized in Appendix B (Figures B-7 through B-14). Since these wells were installed in late 2009/2010, the first sampling event consisted of three samples from varying elevations within the screened interval to determine where the dedicated submersible pumps should be placed (for wells 0810-0816). This sampling event took place in February (and was repeated in March), and the sample depths varied for each well, but ranged between 8.6 to 49 ft bgs. Samples were also collected in June with a peristaltic pump and then once again in September after the dedicated submersible pumps were installed.

The depth of the greatest ammonia concentrations observed in the extraction wells varied for each location. The highest concentration of 900 mg/L was observed in well 0814 at 15 ft bgs. Most of the highest ammonia concentrations were observed between 15 and 42 ft bgs; however, the concentration in well 0811 was nearly the same for all of the sample depths.

The TDS concentrations varied greatly between wells and increased with depth throughout the CF5 extraction wells. Well 0810 had the highest concentration of 36,000 mg/L at 38 ft bgs, indicating the bottom of the well was close to the brine interface. Locations 0816, 0813, and 0812 had the lowest measured concentration of 13,000 mg/L at 36 ft bgs, 42 ft bgs, and 42 ft bgs, respectively. It should be noted that the difference in TDS concentration at varying depths in wells 0811, 0812, 0813, and 0814 was very low.

The uranium concentrations did not vary as much as the ammonia and TDS concentrations in the CF5 extraction wells. Well 0815 had the highest measured concentration, 4.6 mg/L at 49 ft bgs. Well 0813 had the lowest uranium concentration of 2.1 mg/L at 16 ft bgs. In each of the new extraction wells, the lowest uranium concentrations were measured at the shallowest depth.

5.0 Evaporation Pond Operations

The sprinkler system that discharged ground water from the evaporation pond was dismantled in late 2009 as tailings were excavated. Three alternative systems developed to remove water from the evaporation pond include spraying by contaminated area water trucks (used for dust suppression), operation of two evaporation enhancement units, and discharge to an evaporation berm. Because tailings pore water was pumped into the evaporation pond from pot holes and wick drains on the top of the pile, the CF5 well field discharge line was fitted with a bypass valve so that extraction well water could be pumped directly to the evaporation enhancement units.

A chronology of the evaporation pond operations can be found in Appendix C, Table C-1 and is summarized here. Appendix E contains the analytical data.

Beginning in early March, the Remedial Action Contractor (RAC) began to use the evaporation pond water for dust suppression in the contaminated area. The weekly removal continued through December. On March 4, the RAC began to pump water from the wick pond into the evaporation pond in preparation for removal of the wick pond.

The two evaporation enhancement units that were added in November 2009 were used to spray the evaporation pond water beginning March 18 2010. By May 6, the RAC encountered pore fluids in the tailings excavation and pumped the excess fluids into the wick pond. The wick pond was removed on June 28 to make room for tailings drying bed space. After the wick pond was removed, the pore fluids were pumped directly into the evaporation pond. Since the pore fluids contain a high concentration of salts and other chemical constituents, the evaporation enhancement units were not used to spray the excavation pore water/ground water mixture stored in the evaporation pond.

On September 17, a portable 1,200-gal tank for well field ground water was added to the top of the pile and the 6-inch extraction line from the well field was re-routed to discharge directly to the tank. The evaporation enhancement units were re-directed over the southeastern edge of the tailings pile and were used to discharge CF5 ground water.

In September, an evaporation berm was constructed off of the southern end of the tailings pile, on a contaminated berm. Water from the evaporation pond was pumped onto this berm to a shallow depth and was then allowed to evaporate. Gypsum blocks were installed beneath the berm to ensure the water did not enter back into the underlying saturated soil.

The pH of the evaporation pond varied during 2010 due to the introduction of the wick pond fluids and pore fluids that were encountered during the tailings excavation. Figure 15 illustrates the fluctuations of the pH along with the evaporation pond level.

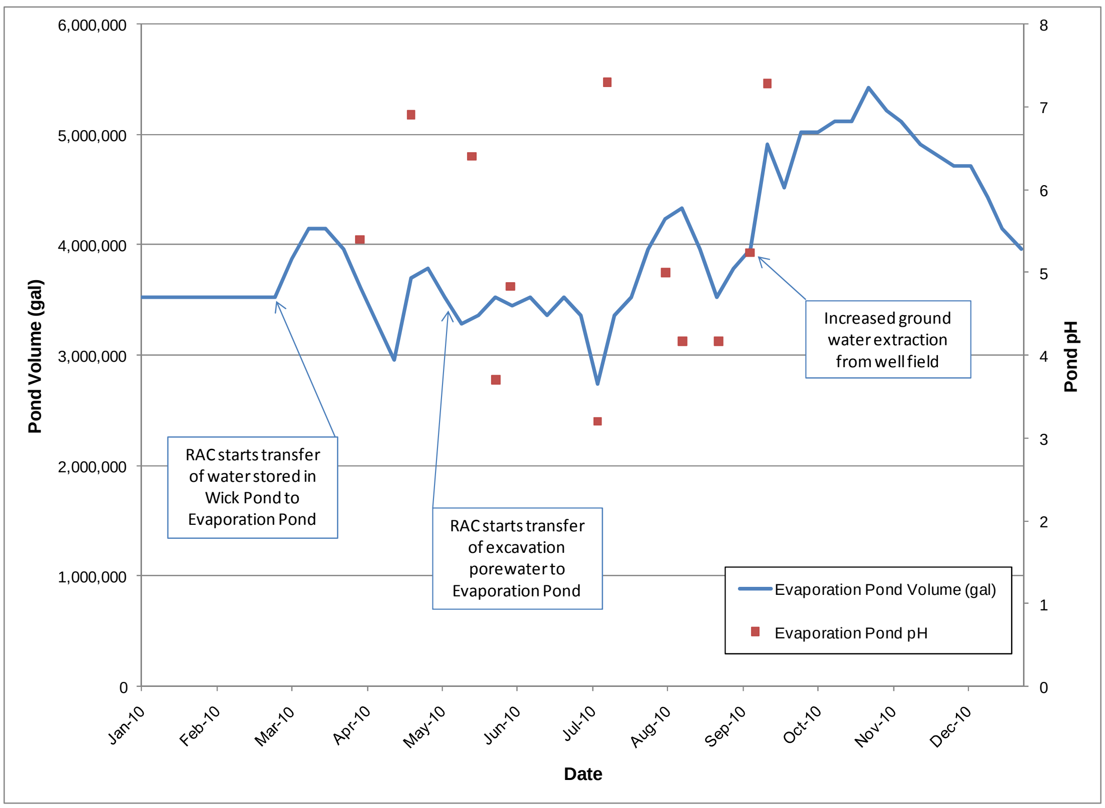


Figure 15. Evaporation Pond Level versus Pond pH

5.1 Water Delivery to Evaporation Pond

Water delivery and outflow to and from the evaporation pond is illustrated in Figure 16. Outflow began in March, when the enhanced evaporation units were used to discharge pond water into the air to increase the evaporation potential. Table C-3 in Appendix C summarizes the enhanced evaporation unit operations from September to November. Other sources of outflow to the evaporation pond include water truck removal and pumping to the adjacent evaporation berm. As Figure 16 illustrates, the outflow increased during the summer months when more water was used for dust suppression in the contaminated area and when the evaporation potential was the highest for the evaporation enhancement units. Table C-2 in Appendix C contains evaporation pond levels and the volume of water in the pond during 2010.

Inflow to the evaporation pond began in April, when extraction began at CF4 and wells 0815 and PW02 in CF5. An increase in flow was observed beginning in July when the rest of the CF5 wells were brought on extraction mode. The volume of water in the evaporation pond increased greatly in September and October, when the inflow to the pond exceeded the outflow. When the wells were winterized and shut down in December, the volume of water in the pond started to decline rapidly.

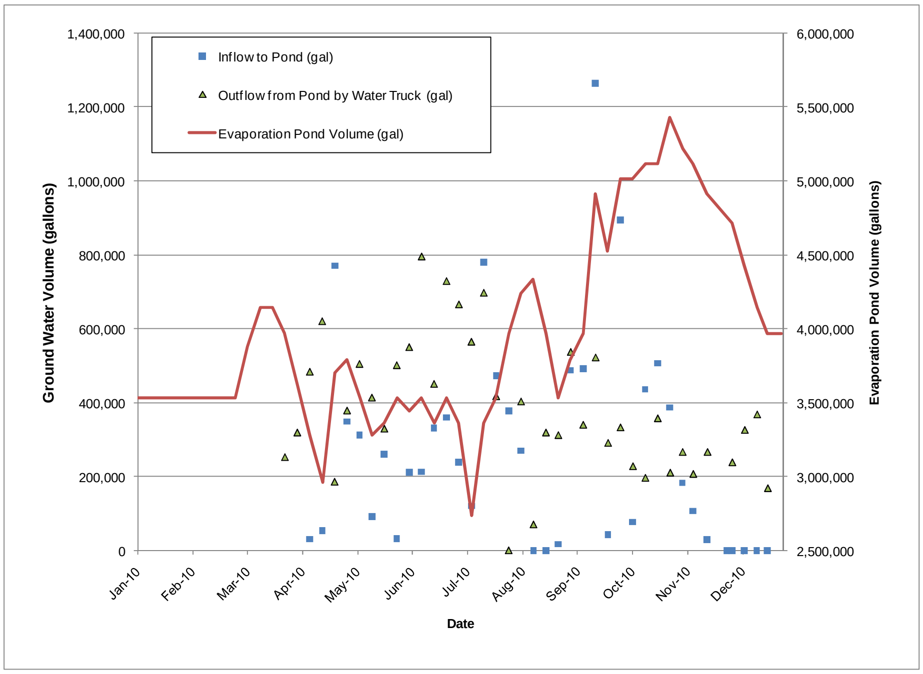


Figure 16. Rates of Water Delivery and Outflow to and from the Evaporation Pond and Pond Depths During 2010

5.2 Evaporation Pond Water Quality

Samples from the evaporation pond were collected when the IA well field was actively extracting ground water. Samples were collected from the inlet when the well field was extracting (0547) and grab samples using dedicated tubing and a peristaltic pump were collected from the pond surface (0548).

Time versus ammonia, TDS, and uranium concentration plots generated from data collected during 2010 is presented in Figure 17. Each was plotted with the evaporation pond level data collected during the same time frame.

Water chemistry data indicate that the ammonia concentration in the pond (location 0548) greatly increased from 1,900 mg/L in April to 3,600 mg/L in June with the introduction of the tailings pore fluids. The concentration dropped to 2,000 mg/L after additional ground water was added to the evaporation pond (Figure 17).

The TDS and uranium concentrations followed the same trend as ammonia. Both constituents greatly increased with the addition of pore fluids and then decreased as more ground water was added to the evaporation pond (Figure 17).

The ammonia and TDS concentrations in the pond inlet (0547) decreased in mid-June, possibly due to dilution from the river water or from flood irrigation of nearby revegetation plot contributions in the extracted well water. The uranium concentration increased in mid-June (Figure 17). A possible explanation for the rise in uranium is the introduction (possibly in the vicinity of CF5) of oxygenated river or irrigation water into the ground water that mobilizes the uranium.

6.0 Injection Operation and Performance

CF4 ran on injection mode from September to November. The main objective of freshwater injection is to: (1) form a hydrologic barrier between the tailings pile and the backwater channel that flows adjacent to the well field; and (2) to dilute contaminants prior to ground water discharge into the backwater channel.

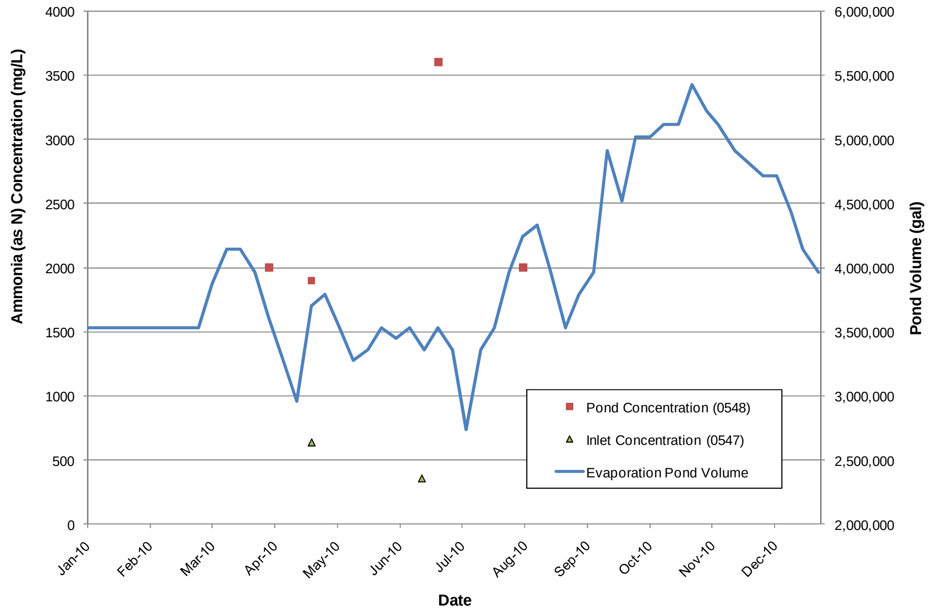
CF4 is located in the southern end of the Moab UMTRA well field, adjacent to a prominent backwater channel that is open to the river until flows decrease below 3,000 cfs. The brine/freshwater interface (defined at 35,000 mg/L TDS) is higher in elevation in this portion of the well field, and sample results have indicated that the ground water discharges to the adjacent backwater channel. During base flow conditions, the volume of water flowing into the channel is not always enough to dilute ammonia concentration that is introduced from the ground water.

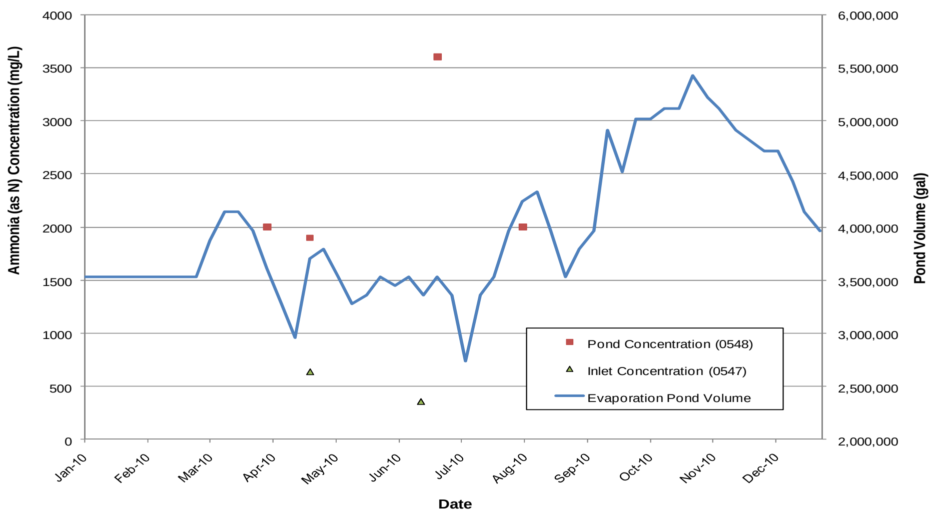
The injection system receives diverted river water that is piped to the well field, filtered through a sand filter, and pumped through the well field injection line. Four new injection wells were installed in CF2 in early 2010. The construction details of the four new injection wells can be found in Table 5. The purpose of these wells is to protect the adjacent backwater channel during critical habitat flows. CFs 1 and 3 were re-plumbed in 2010 for injection; however, these wells (and the four new CF2 injection wells) only ran on injection mode as a trial in late September. Injection was not performed in CFs 1, 2 and 3 and the injection trench as there was no critical habitat in adjacent channels.CF4 well construction information and a chronology of CF4 events can be found in Tables A-1 and A-2 in Appendix A.

6.1 Injection Performance

September
The injection system started at CF4 on September 8, when the Colorado River flow was 2,900 cfs, and the backwater channel began to close off from the river. The even-numbered remediation wells (0770, 0772, 0774, and 0776) began to inject approximately 3 to 12 gpm. Figure 18 is a cross-section showing the specific conductance and ammonia concentrations prior to the start of injection.

From September 22 to September 23, all of the CF2 and CF1 remediation wells were actively injecting freshwater into the well field along with the even-numbered CF4 wells. During this time, the total injection rate ranged from 24 to 80 gpm. The injection system was shut down on September 23 due to the high turbidity of the river water (as a result of a storm event).





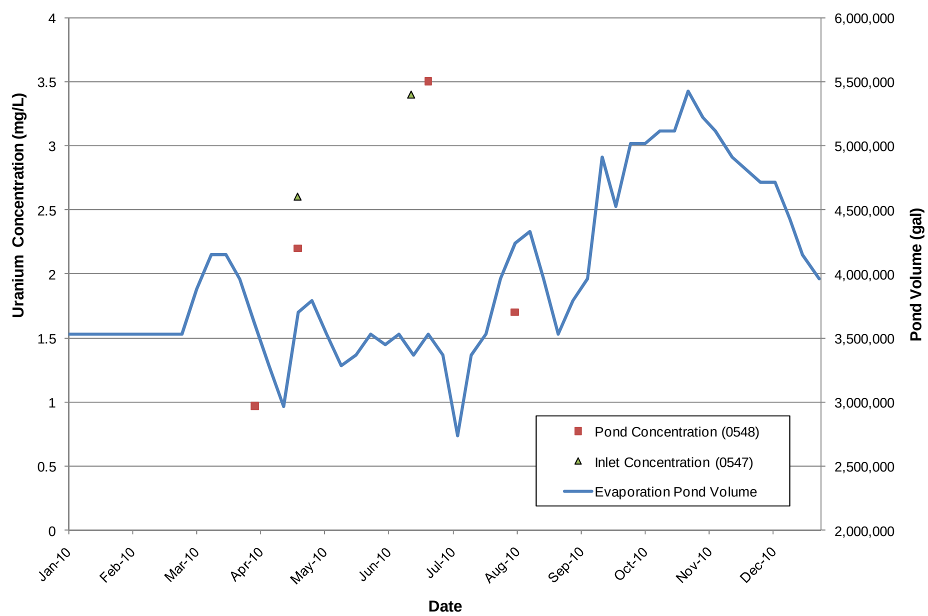
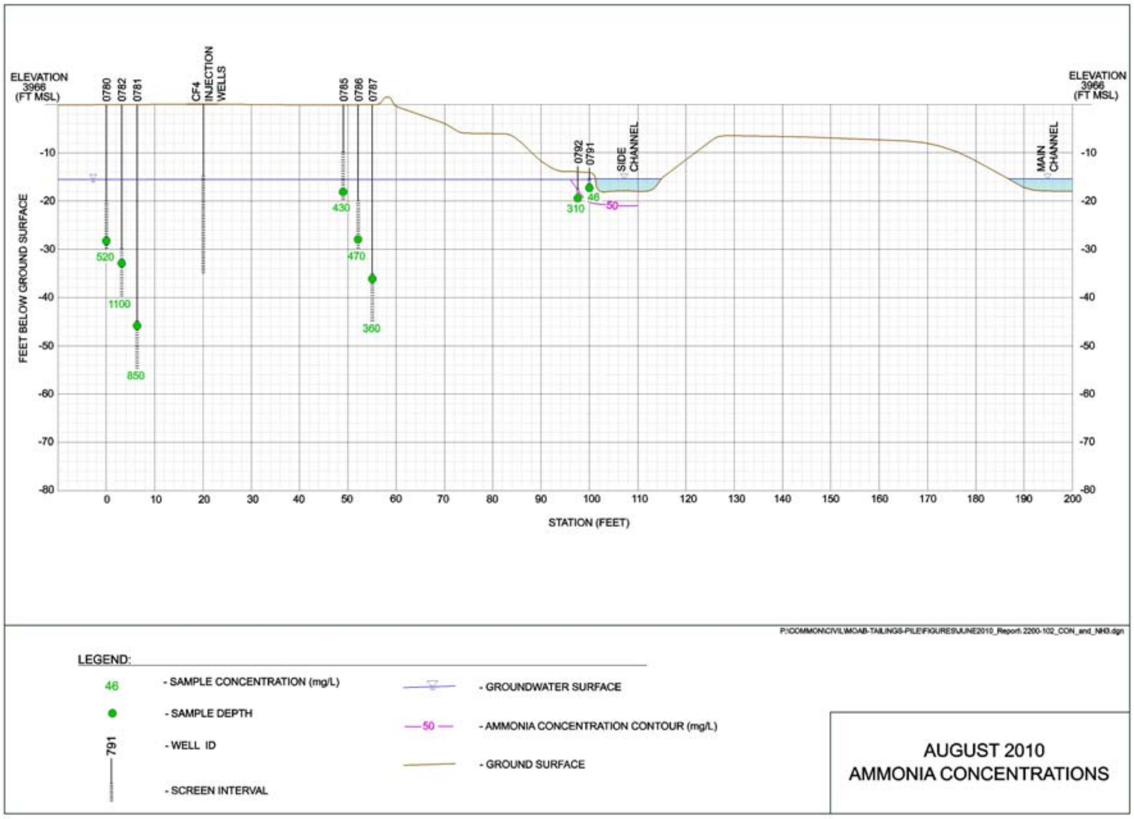


Figure 17. Measured Concentrations of Ammonia, TDS, and Uranium at 0547 (Pond Inlet) and 0548 (Pond Storage) During 2010



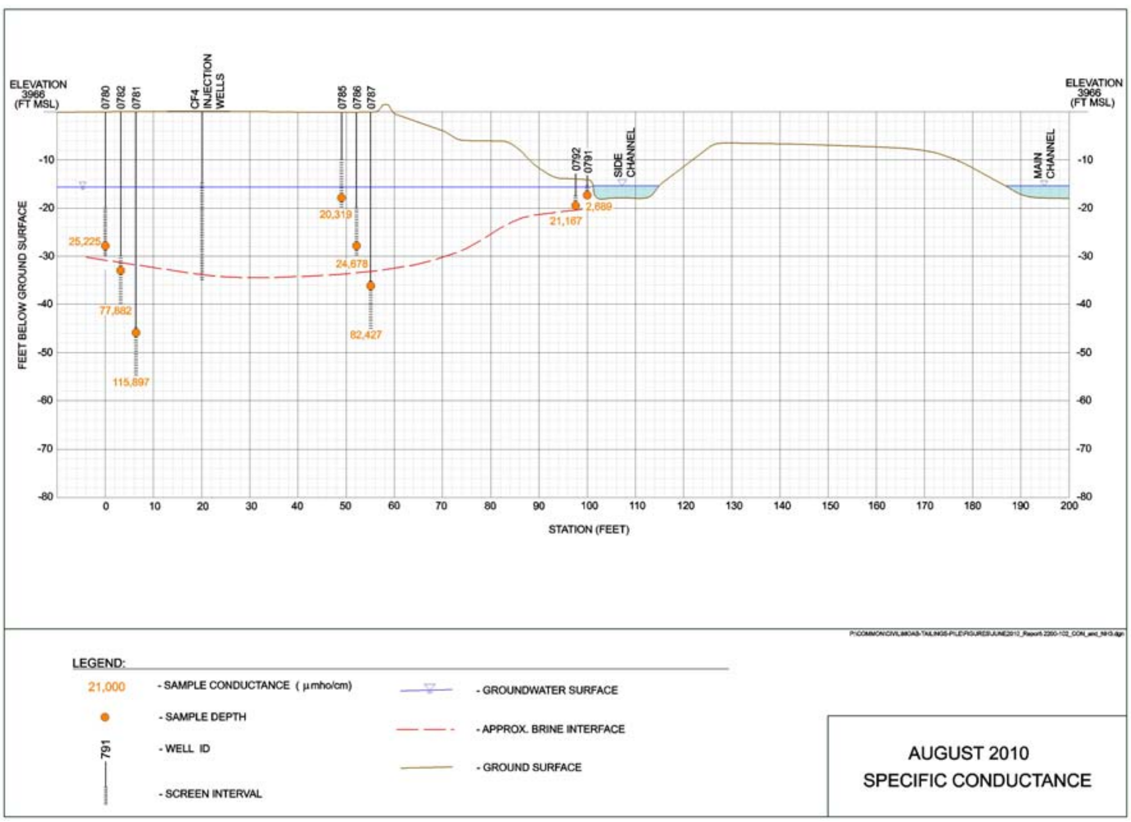


Figure 18. CF4 Cross-section Showing August Ammonia (top) and Specific Conductance (bottom)

Table 5. Well Construction Details for the New CF2 Injection Wells

Well No.	Well Dia. (inches)	TD (ft bgs)	Screen Interval (ft bgs)	Date Installed
0650	6	44.5	14.5 to 44.5	Dec 18, 2009
0651	6	43.2	13.2 to 43.2	Dec 17, 2009
0652	6	43.1	13.1 to 43.1	Dec 15, 2009
0653	6	43.1	13.1 to 43.1	Dec 8, 2009

Dia = diameter; TD = total depth

October

Injection continued at CF4 throughout most of October at rates of 27 to 50 gpm. On October 27, the sand filter became clogged with river water sediments and the injection system was shut down until November 1, while the filter was cleaned and backwashed. On October 28, field parameters and ammonia probe measurements were collected from the upgradient and downgradient observation wells, well points, and surface water at CF4. The results indicated that the specific conductance decreased significantly in all locations, both upgradient and downgradient. In upgradient observation well 0781, the specific conductance decreased by over 58,000 microsiemens per centimeter (µs/cm). Ammonia concentrations decreased in all locations but 0781, where the ammonia concentration went from 850 mg/L in August to 869 mg/L in October.

November

Injection was re-started on November 1 after the sand filter was clear enough to use. A new control panel that automatically flushes the sand filter was installed on November 4. The total injection rate at CF4 varied from 31 to 50 gpm throughout November. Parameters and ammonia probe samples were collected November 17. The specific conductance had decreased greatly from what was observed in October. Specific conductance in well 0787 decreased from 43,641 µs/cm in October to 6,500 µs/cm in November. Ammonia concentrations also decreased at all locations.

The injection system was shut down November 18 and was winterized on November 22. Figure 19 exhibits the ammonia and specific conductance concentrations measured during active CF4 injection, while the data shown in Figure 20 was collected more than 1 month after the system was shut down.

6.2 CF4 Well Point and Surface Water Results During Injection

During the months of September through November, the Colorado River flow varied from 2,500 to 5,670 cfs. Ammonia probe measurements were collected from the surface water and the adjacent well points in CF4 (analyzed on site with the ammonia probe).

During freshwater injection, a few seeps, extending from the river bank, were noted in the CF4 channel. The water in the seeps was tested with the ammonia probe, and the concentration was recorded at 46.8 mg/L in November, after the system was consistently injecting fresh water for approximately two weeks. A seep was also measured earlier in March, before system operation, when the river was near base-flow conditions and the ammonia probe result was 238 mg/L, indicating that injection had substantially reduced the concentration in the fall (refer to Table 6 for sample results).

Table 6. Ammonia Probe Data from the Seep Near Surface Water Location 0274

Date	Location	River Flow (cfs)	NH3-N (mg/L)
3/23/10	0274-Seep	2,840	238
11/17/10*	0274-Seep	3,430	46.8
11/23/10*	0274-Seep	3,430	42.4

NH3-N = ammonia nitrogen
*Sample collected while injection was running or soon after injection was shut down.

The well points have been sampled a few times in 2010. Recent data has suggested that the well point ammonia concentration can vary greatly from month to month. The lowest ammonia concentrations in 2010 were collected when the injection system was running (see Table 6). Ammonia concentrations in well point 0792 decreased from 310 mg/L in August to 40.9 mg/L in November during injection (Table 7).

Table 7. Ammonia Data from CF4 Well Points

Date	Location	NH3-N (mg/L)	Analysis
3/3/10	0791	570	Laboratory Data
8/4/10	0791	46	Laboratory Data
11/17/10*	0791	39.9	Ammonia Probe
3/3/10	0792	280	Laboratory Data
8/4/10	0792	310	Laboratory Data
11/17/10*	0792	40.9	Ammonia Probe

NH3-N = ammonia nitrogen
*Sample collected while injection was running.

6.3 Summary of Chemical and Analytical Data from Observation Wells

Ammonia probe measurements were collected in CF4 observation wells prior to and during freshwater injection into CF4. The sample results are shown in Figures 21 and 22. Figure 21 shows how the ammonia concentration decreased in the observation wells upgradient of the injection system. Prior to injection (August), the ammonia varied from 190 to 1,100 mg/L, with the highest concentration measured at 33 ft bgs. It is likely that the concentrations remained high until the start of injection in August.

After the injection system had been running for over a month, the ammonia concentrations began to decrease, and by mid-November, the concentrations had decreased to a range of 3.96 to 670 mg/L. The highest ammonia concentration that was measured in November was from well 0781 at 46 ft bgs.

Freshwater injection had a more significant impact on the ammonia concentration in the downgradient wells (Figure 22). Prior to injection, the ammonia concentration varied from 190 to 470 mg/L, with the highest concentration measured at location 0782 at 33 ft bgs (Figure 22). After the injection system had been running for over a month, the ammonia concentrations began to decrease, and by mid-November and the concentrations had decreased to a range of 1.89 to 45 mg/L. This indicates that the freshwater injection impacted the ground water ammonia concentration to a depth of 36 ft bgs. Figure 21 shows that the ammonia concentration also rapidly declined during injection operations in the up-gradient wells, especially at depths to 33 ft bgs.

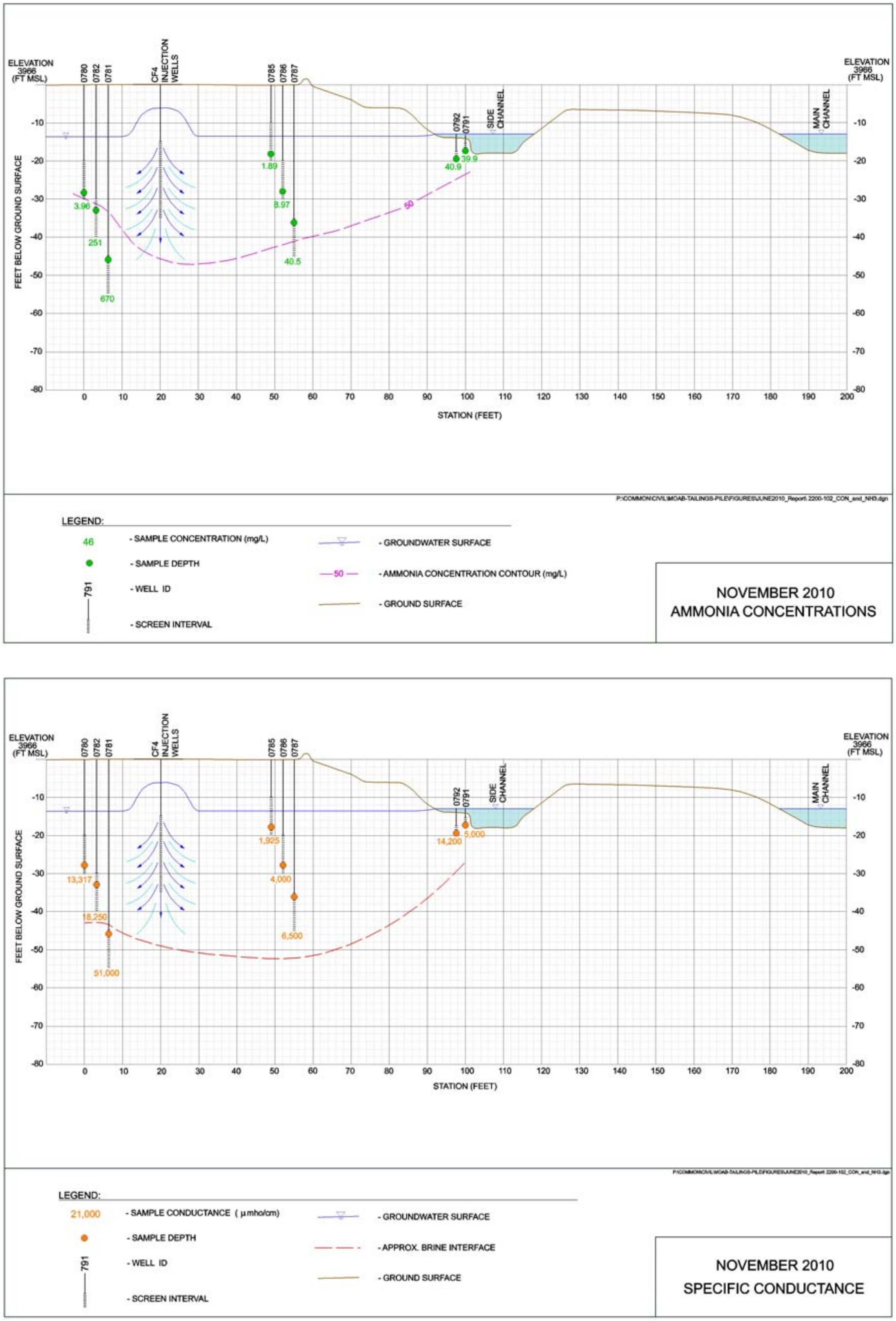


Figure 19. CF4 Cross-section Showing November Ammonia (top) and Specific Conductance (bottom)

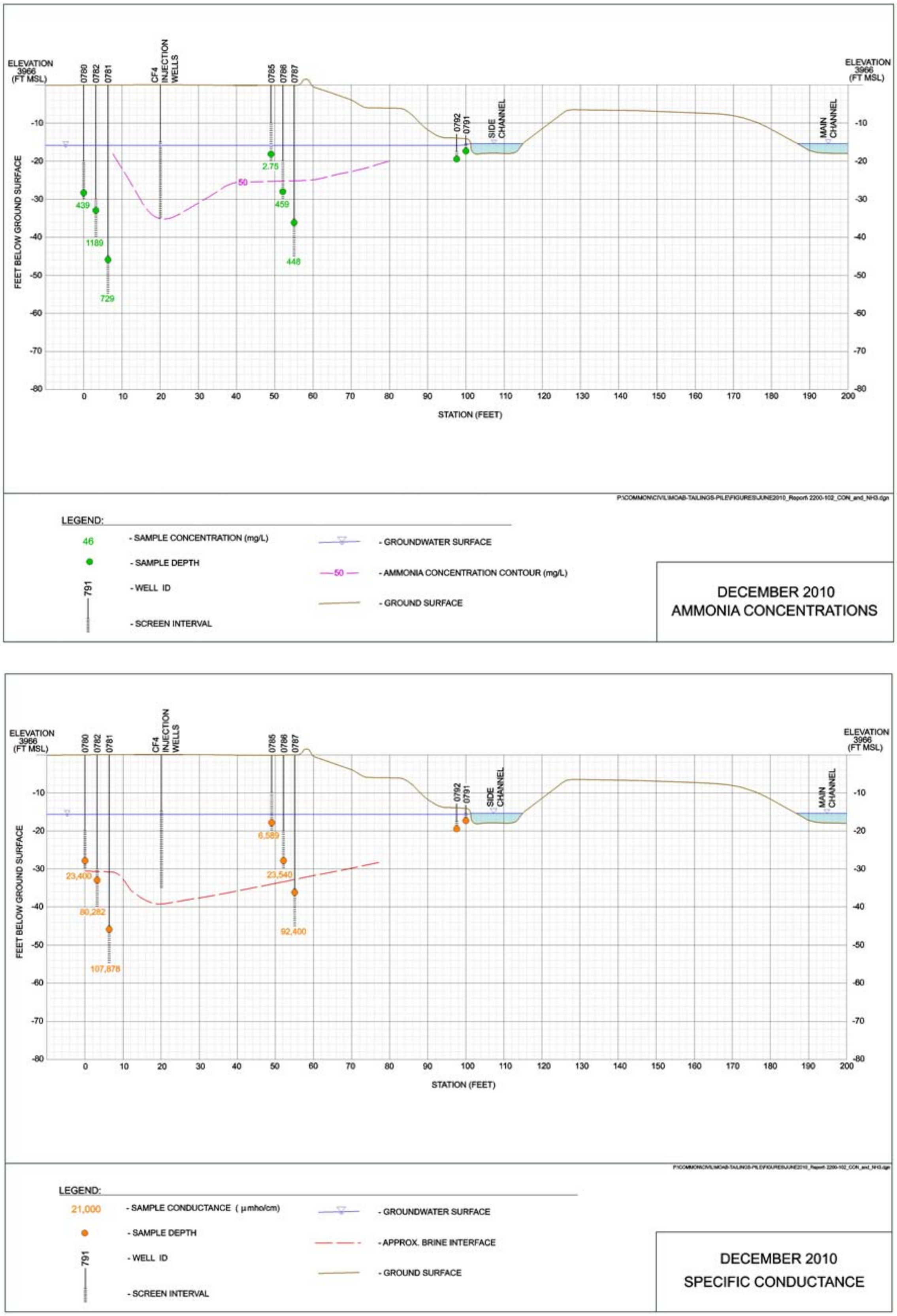


Figure 20. CF4 Cross-section Showing December Ammonia (top) and Specific Conductance (bottom)

Prior to injection, the brine interface was positioned near 33 ft bgs, and the specific conductance range in the upgradient wells varied from 25,000 to 115,897 µmhos/cm (Figure 23). After freshwater injection, the brine interface was suppressed to approximately 46 ft bgs, and the specific conductance range varied from 3,317 to 51,000 µmhos/cm. These results indicate that the freshwater injection has an impact on the ammonia concentration and depth to brine interface in the upgradient wells. Figure 24 shows the same trend for the up-gradient wells.

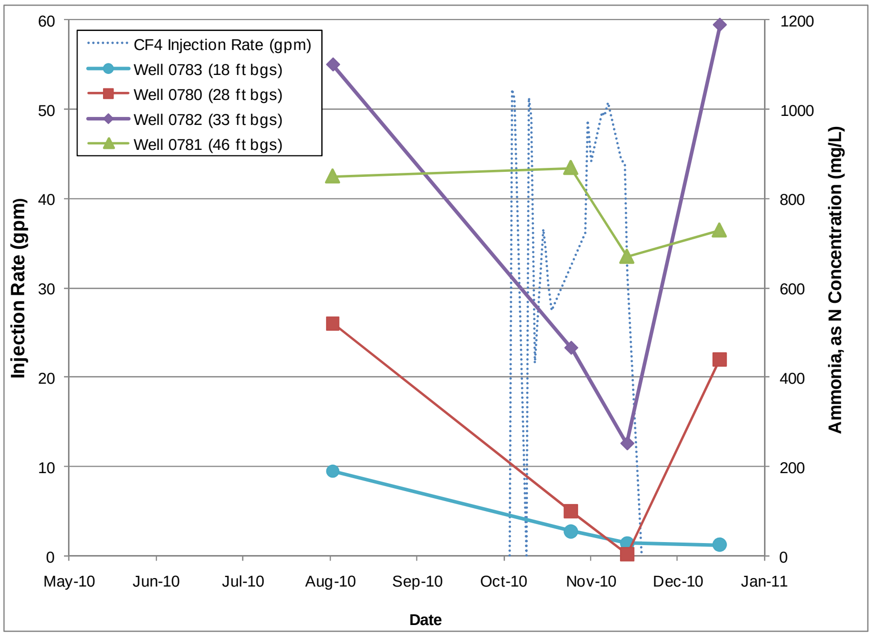


Figure 21. Ammonia Concentrations in Upgradient CF4 Observation Wells

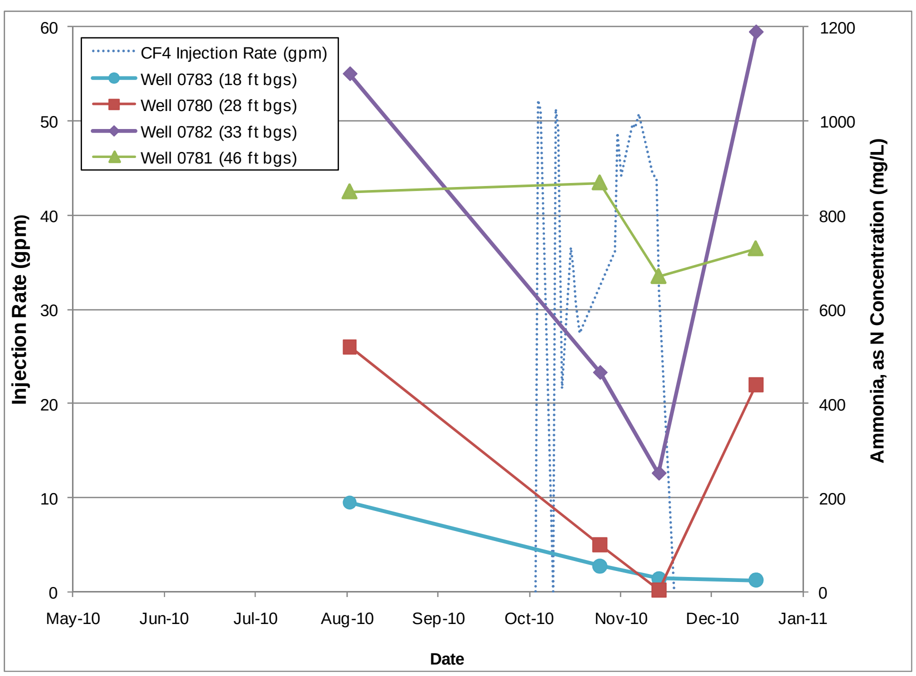


Figure 22. Ammonia Concentrations in Downgradient CF4 Observation Wells

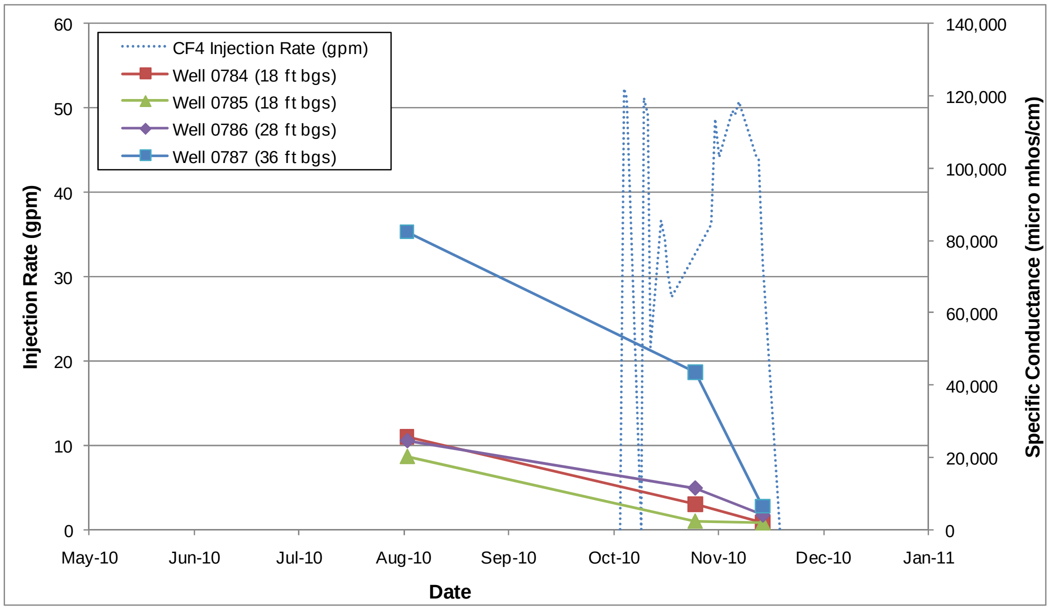


Figure 23. Specific Conductivity Concentration in the CF4 Upgradient Observation Wells

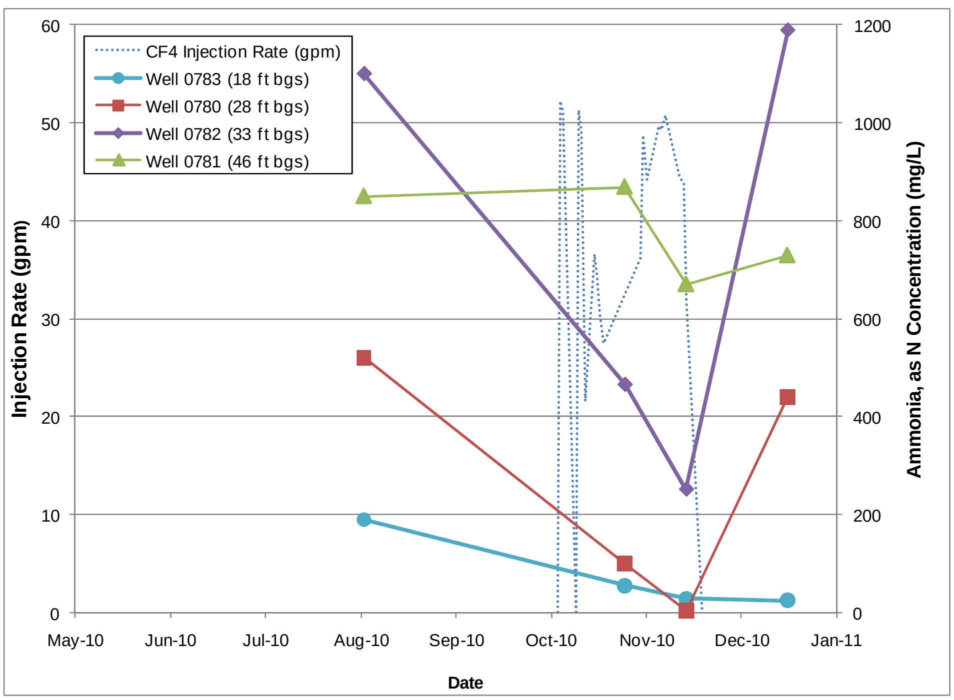


Figure 24. Specific Conductivity Concentration in the CF4 Downgradient Observation Wells

Prior to freshwater injection, the specific conductivity range varied from 20,310 to 82,427 µmhos/cm and the brine interface was between 28 and 36 ft bgs. After injection, the brine interface was suppressed to greater than 36 ft bgs and the conductivity ranged varied from 1,925 to 6,500 µmhos/cm (Figures 23 and 24).

6.4 Freshwater Mounding During Injection

Water levels were collected on a near-daily basis in the active remediation wells (0770, 0772, 0774, 0776, and 0778) and in the adjacent remediation wells that were not utilized (0771, 0773, 07775, 0777, and 0779). 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 0406. The water levels in each well were calibrated to match well 0406 during non-pumping, base-flow conditions. Table 8 summarizes the mounding data that is shown in Figures A-1 through A-10 in Appendix A.

Mounding in active injection wells peaked around November 16, when the cumulative CF4 injection rate was 43.9 gpm. The non-active injection wells showed fairly consistent mounding throughout the pumping, but the ground water elevation peaked slightly around October 15.

Table 8. Observed Freshwater Mounding in CF4 Remediation Wells

Well	Date	Type	Maximum Mounding (ft)
0770	11/16/10	Active Injection	5.41
0771	11/04/10	Non-Active Injection	2.06
0772	11/16/10	Active Injection	8.96
0773	10/15/10	Non-Active Injection	1.57
0774	11/10/10	Active Injection	10.93
0775	10/15/10	Non-Active Injection	1.65
0776	11/16/10	Active Injection	12.35
0777	10/15/10	Non-Active Injection	1.48
0778	11/10/10	Active Injection	11.63
0779	10/13/10	Non-Active Injection	1.46

The ratio of freshwater mounding versus the injection rate was calculated for each of the active remediation wells. The numbers listed in Table 9 represent baseline measurements that will be used to determine the injection performance of each well. For instance, if the rate of mounding in one of the remediation wells changes significantly, it may indicate that the well may need to be developed. The data in Table 9 also indicates that higher injection rates do not necessarily produce greater mounding. The lithology in CF4 varies from gravelly sand to sandy silt, so the hydraulic conductivity varies for remediation well.

Table 9. CF4 Freshwater Mounding and Injection Rates

Location	Mounding (ft)	Injection rate (gpm)
0770	0.54	0.67
0772	2.72	3.87
0774	0.44	0.61
0776	1.5	7.78
0778	0.58	0.78

CF4 observation well water-levels were calibrated to changes in water levels in baseline observation well 0406 so that the amount of freshwater mounding during injection could be calculated (Figures A-11 through A-15 in Appendix A). The shallow upgradient wells showed approximately 0.1 ft of mounding, while the downgradient shallow wells had at least 0.3 ft of mounding (Table 10). This indicates that freshwater injection impacts wells up to 50 ft upgradient and downgradient of the CF3 well field.

Table 10. Observed Freshwater Mounding in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0780	11/03/10	Upgradient	0.095	15
0783	11/02/10	Upgradient	0.198	30
0784	11/02/10	Downgradient	0.374	30
0785	11/03/10	Downgradient	0.303	25
0786	11/03/10	Downgradient	0.343	30

6.5 Injection Rate versus Water Elevation

As the injection rate increased in early November, the water level in the injection wells increased (Figures A-16 through A-20 in Appendix A). Some of the injection wells had a more dramatic increase than others. For instance, the water level in well 0770 remained fairly constant, while 4 to 8 gpm was injected. The water level in well 0772 changed in response to injection, although the injection rate in the well varied from 0 to 6.2 gpm. It is possible that the elevation change that occurred in this well is a result of the high injection rate in the adjacent well 0774 (up to 18 gpm).

7.0 Surface Water Operations and Performance

7.1 Surface Water Operations

Surface water operations include several activities that take place at the Moab site during critical habitat flow values on the Colorado River. These activities include surface water and biota monitoring in backwater channels that meet critical habitat criteria (closed off upstream; open to main channel downstream), surface water sampling, and running the Surface Water Action System. The Surface Water Action System consists of a pump and associated piping that divert fresh river water into the backwater channel to reduce ammonia concentrations in critical habitat areas formed after the peak runoff until late September. On occasion, the Surface Water Action System is used as a protective measure if a backwater channel is approaching critical habitat flows during the months when young-of-year endangered fish might be present (July through September).

During the late summer months, one main backwater channel flows parallel to the IA well field. As the river flow decreased, the channel gradually dried up from the north to the south. The southern area (adjacent to IA CFs 1 and 4) is typically considered a critical habitat for at least a couple of weeks a year, whereas the northern portion of the channel quickly becomes stagnant and shut off from the river. Critical habitat flows vary from year to year based on erosion and deposition in the backwater channels (Table 11).

Table 11. Critical Habitat Flow Ranges from 2006 to 2010

Well Field Configuration near the River Critical Habitat	2006 Critical Habitat Flow Range (cfs)	2007 Critical Habitat Flow Range (cfs)	2008 Critical Habitat Flow Range (cfs)	2009 Critical Habitat Flow Range (cfs)	2010 Critical Habitat Flow Range (cfs)
1	4,500	5,000-4,000	N/A	4,300-3,700	4,800
2	5,400-4,500	6,790-5,500	7,400-6,000	7,800-6,500	8,890-7,000
3	7,500-4,570	6,790-5,700	7,790-7,400	N/A	N/A
4	N/A	<3,400	N/A	<3,500	<3,000

Surface water monitoring occurs in the Colorado River at various times throughout the year, depending on the sampling objectives. In 2010, surface water locations were sampled in January, February, March, April, June, October, and November. Each location was sampled for ammonia (as N), TDS, and uranium. The objective of surface water monitoring is to observe the channel morphology and evaluate the impact of the site activities on river quality. Monitoring is conducted in accordance with the *Surface/Ground Water Sampling and Analysis Plan.*

Additional surface water monitoring, referred to as biota monitoring, occurs in the summer after the spring runoff has peaked and as the river flow rate diminishes to base flow (approximately 3,000 cfs). Biota monitoring occurs from July through September, when the endangered young-of-year Colorado pikeminnow may reside in the backwater channels adjacent to the site.

During the summer months, observations on the morphology of the backwater channels and the presence or absence of fish are noted in a log, and surface water samples are collected from locations that may be a potential critical habitat. Samples are analyzed for ammonia either by ALS Laboratory Group or by the real-time ammonia probe. The U.S. Environmental Protection Agency has a set of standards for acute and chronic criterion for freshwater aquatic habitats, which are dependent on pH and temperature. If a critical habitat area adjacent to the site contains an ammonia concentration above the acute/chronic criteria, the Surface Water Action System is started.

7.2 Surface Water Quality

Surface water quality is monitored throughout the year; however, the backwater channels are monitored more frequently during critical habitat flows during the descending limb of the hydrograph following the peak flow.

During base-flow conditions, surface water locations are monitored for informational purposes to determine if the ground water is impacting the backwater channels adjacent to the site (Appendix E).

7.2.1 Monitoring During Critical Habitat

The river flow gradually dropped in early July from 7,120 cfs on July 1 to 4,600 cfs (Photos D-1 to D-6 in Appendix D) on July 8 (Figure 25). During this time, the backwater channel adjacent to CF2 consisted of isolated, stagnant pockets of water.

The morphology of the channel adjacent to CF1 had changed from previous years. Approximately 6 inches of sediment had been deposited in this channel and the downriver end of the channel was slightly higher in elevation than the upriver end. When the river flow was 4,600 cfs, the channel was less than 1-inch deep, approximately 1-ft wide, and was barely flowing through to the river. When the Colorado River flow (at the Cisco gauge) dropped below approximately 4,500 cfs, the backwater channel adjacent to CF1 became dry (Figure 25).

It was noted in July that the backwater channel adjacent to CF4 becomes a critical habitat when the flows are less than 3,000 cfs (Figure 25), which occurred from July 20 to July 23 (Photos D-7 to D-8 in Appendix D). The Initial Action was initiated on July 20 and continued until July 26 (Figure 25). Water for the Surface Water Action System was diverted from the freshwater pond through two CF4 vaults. The water was directed towards the CF4 channel by two hoses that were placed on the bank of the channel. Due to a series of precipitation events, the Colorado River flow increased to over 3,000 cfs and the Surface Water Action System was turned off while the diversion water was used for revegetation irrigation. On July 28 (Photos D-9 to D-11 in Appendix D), the well field freshwater injection line was used to deliver approximately 200 gpm of freshwater to the CF4 backwater channel. Since the river was just slightly above critical habitat flows, the Surface Water Action System was used to protect the channel in the case the river flow should decrease to critical habitat conditions.

A storm event in early August led to increased turbidity and deposition in the CF4 backwater channel (Photos D-12 and D-13 in Appendix D). River flow increased over 6,000 cfs as a result of the stormy weather conditions, and the Surface Water Action System was shut down on August 5 (Figure 26, Photos D-14 and D-15).

The Surface Water Action System was started on August 31 (Photos D-16 and D-17 in Appendix D), when the river flow decreased to 3,500 cfs. To flush the entire channel, gated pipe was placed along the length of the channel, and diverted water was pumped from a few hundred feet downriver as a preventative measure.

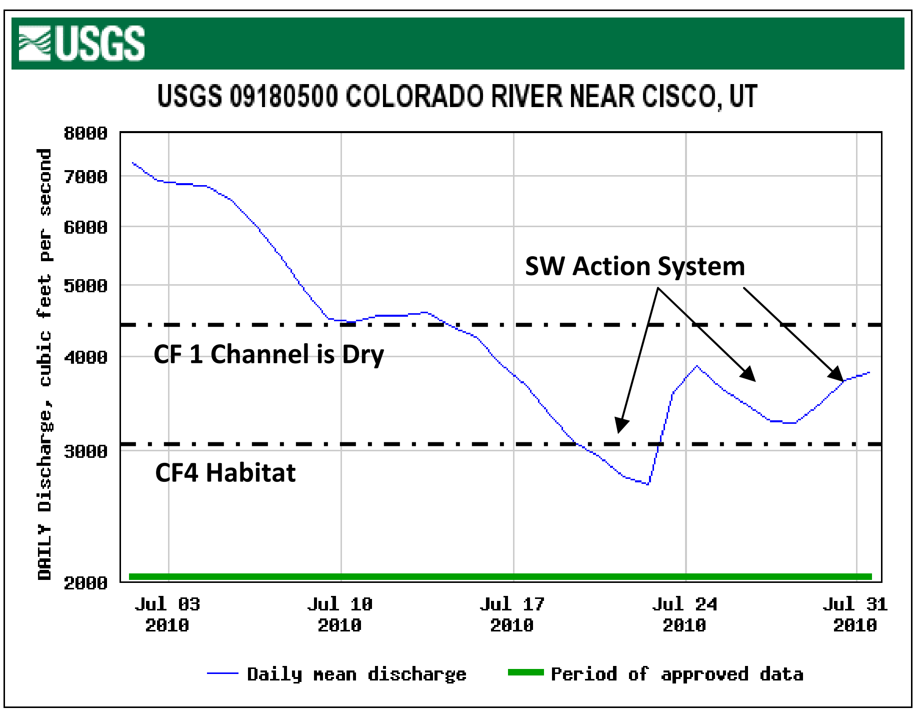


Figure 25. July 2010 Cisco Gauge Hydrograph

The river flow varied between 3,000 and 4,000 cfs in September, and the Surface Water Action System ran until October 1 (Figure 27, Photos D-18 to D-20 in Appendix D). During this time, the diverted water allowed the backwater channel to remain open to the river. No fish were observed in the channel during the month.

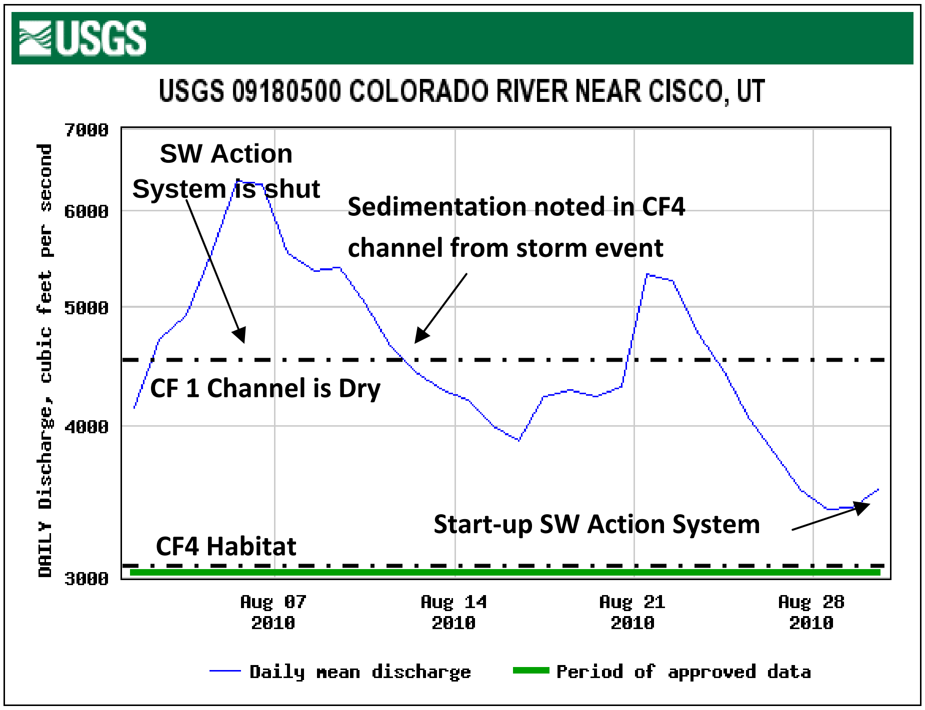


Figure 26. August 2010 Cisco Gauge Hydrograph

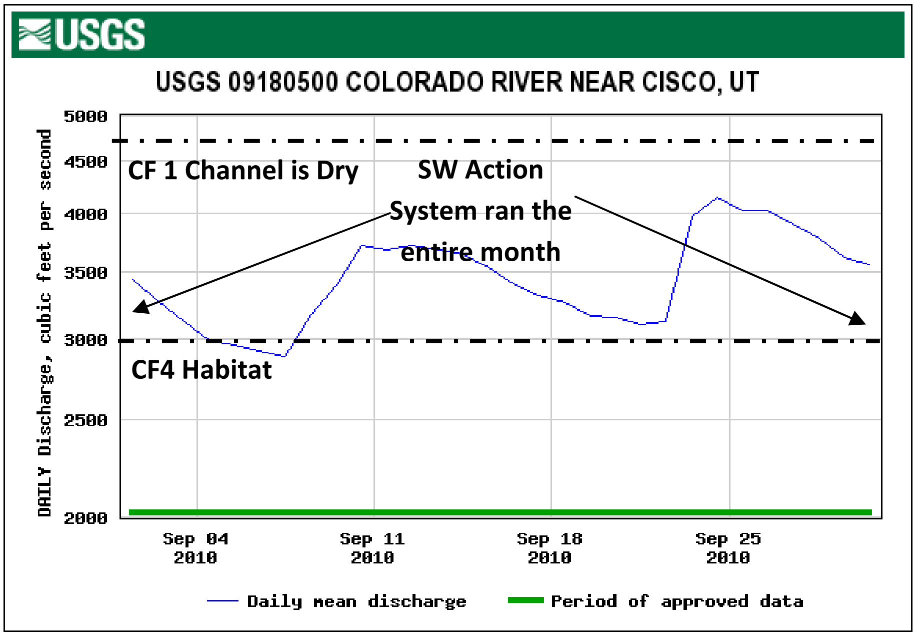


Figure 27. September 2010 Cisco Gauge Hydrograph

7.2.2 Monitoring Throughout the Year

Surface water locations associated with the well field were sampled intermittently in 2010 when water was present. Table 12 summarizes the ammonia concentration recorded for each surface water location and the corresponding state/federal ambient water quality criteria (AWQC) acute and chronic concentrations for fish in early life stages. The ammonia concentrations listed in the table are results from laboratory data.

Table 12. Surface Water Sample Ammonia (as N) Results Compared to Acute and Chronic Criteria

Location	Date	Ammonia Total as N (mg/L)	State/Federal AWQC-Acute Total as N (mg/L)	State/Federal AWQC-Chronic Total as N (mg/L)
0216	1/26/10	80	29.5	5.39
0239	3/2/10	7.2	6.95	1.52
0243	3/1/10	1.2	3.88	1.29
0259	3/1/10	4.6	3.88	1.29
0274	1/27/10	2.8	3.83	1.79
0274	2/25/10	540	36.1	4.72
0274	3/2/10	690	36.1	4.72
0274	10/1/10	4.4	17.0	3.61
0277	3/2/10	200	14.4	3.58
0278	3/2/10	240	26.2	5.80
0278	10/1/10	12	14.4	3.25
0279	3/2/10	71	14.4	2.86
0279	10/1/10	18	17.0	3.61

Some of the locations exceeded the acute and/or chronic criteria in 2010. Most of the samples were collected from CFs 1 and 4 during base-flow conditions for informational purposes. The March samples were collected in shallow bodies of surface water, which were stagnant (or nearly stagnant) and did not meet the definition of a habitat area. In particular, the samples collected off of CF4 (0274 and 0279) were collected for informational purposes only, as a ground water seep was exposed during the low river stage in this area.

8.0 Summary and Conclusions

In 2010, the IA operations were focused on extraction for maximum mass removal from CF5 and freshwater injection to protect the backwater channel in CF4. CF4 and CF5 extracted ground water in April, and CF5 continued extracting until the operation was suspended to replace piping and electrical service following soils remediation north of the Moab Wash. CF4 began freshwater injection operation in September.

Table 13 presents the ammonia and uranium mass removal rates from 2010 compared to those from previous years. To determine the mass removal rate, the total mass removed was divided by the total extracted volume for a given year. Both the ammonia and uranium mass removal were higher in 2010 than in most previous years.

Table 13. Ammonia Mass Removal and Uranium Mass Removal from 2006 to 2010

Year	Ammonia Mass Removal (kg/gal)	Uranium Mass Removal (kg/gal)
2006	4.23×10^{-3}	2.16×10^{-5}
2007	3.43×10^{-3}	1.52×10^{-5}
2008	3.35×10^{-3}	1.51×10^{-5}
2009	3.51×10^{-3}	1.71×10^{-5}
2010	3.64×10^{-3}	2.43×10^{-5}

With the elimination of the sprinkler system for tailings drying bed space, two forced-air evaporation units and an irrigation berm were added to the ground water system. In addition, the RAC removed evaporation pond water for dust suppression in the contaminated area. In 2010, pore fluids were encountered during the tailings excavation and the fluids were pumped to the evaporation pond. As a result of the changed chemical composition, the evaporation units were re-plumbed to be supplied by ground water from the IA well field.

Surface water monitoring was performed during the Colorado River base- and peak-flow conditions. The results indicate that as the river flow decreases, the ammonia concentration in the backwater channels adjacent to the site is likely to increase. After the peak flow recedes in the late spring and summer months, surface water diversion may be used to reduce any elevated ammonia concentrations in any critical fish habitat. The Surface Water Action System ran intermittently from July through September 2010.

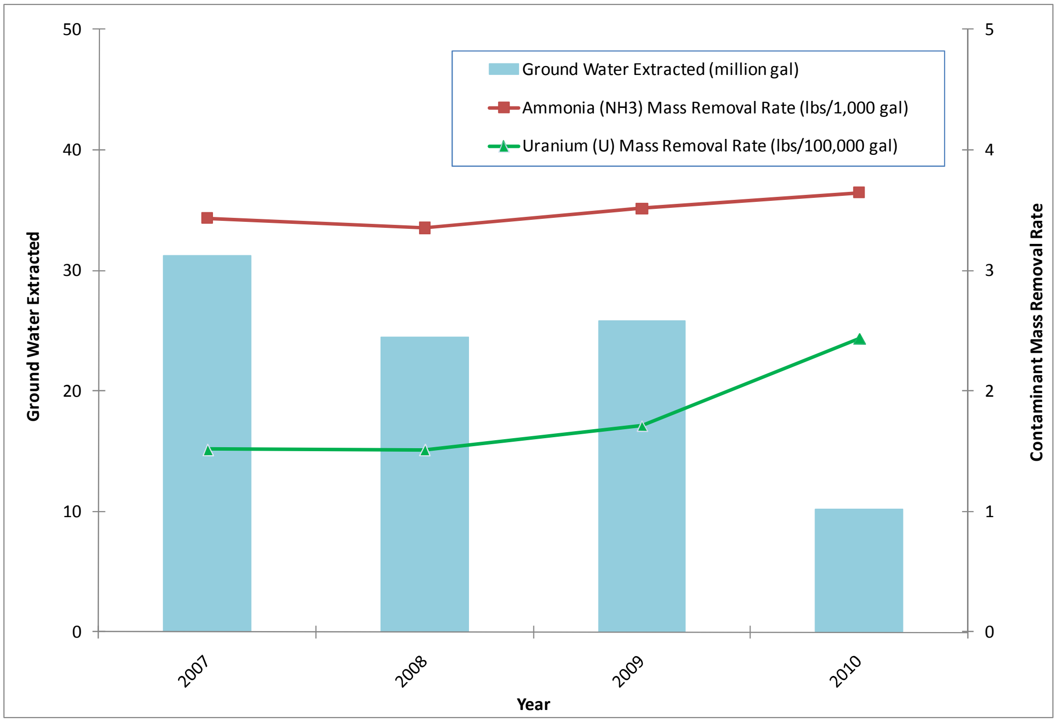


Figure 28. Ground Water Extraction versus Mass Removal for 2007 through 2010

9.0 References

DOE (U.S. Department of Energy) *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830), November 2009.

DOE (U.S. Department of Energy) *Moab UMTRA Project Drilling Completion Report* (DOE-EM/GJTAC1890), June 2010.

DOE (U.S. Department of Energy) *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah*, September 2005.

Appendix A.
CF4 Tables and Data for 2010

Table A-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

Table A-2. Chronology of CF4 Activities in 2010

Date	River Flow (daily mean cfs)	Activity	Samples Collected
Nov 10, 2009 to April 5, 2010	2,460 to 4,100	CF4 shut down for winter	N/A
Jan 20-27, 2010	Ice	Monthly Sampling	One surface location (0274)
Feb 25 2010 to March 4, 2010	2,460 to 2,950	Monthly Sampling	Three well points (0790, 0791, 0792), four surface location (0274, 0277, 0278, 0279)
Apr 15-27, 2009	7,490 to 13,900	Ran extraction	N/A
Aug 3-5, 2010	4,920 to 6,340	Monthly Sampling	Eight Observation Wells (0780, 0781, 0782, 0783, 0784, 0785, 0786, 0787), three well points (0791, 0792, 0793)
Sept 2, 2010	3,270	Tested fresh water injection	N/A
Sept 8, 2010	3,180	Started fresh water injection	N/A
Sept 29, 2010 to Oct 1, 2010	3,390 to 3,480	Monthly Sampling	Three surface locations (0274, 0278, 0279)
Nov 20, 2010	3,130	Shut down injection for winter	N/A

Table A-3. Monthly Average Pumping Rates and Extraction Volumes at CF4 Remediation Wells, April 2010

Month	Well 0770		Well 0772		Well 0773		Well 0774		Well 0775	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Apr-10	61,486	5.19	67,952	5.67	144,558	11.4	46,109	3.40	95,200	6.5

Month	Well 0776		Well 0777		Well 0778		Well 0779	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Apr-10	28,705	2.22	66,560	5.16	67,390	5.70	678	2.295

Table A-4. Estimated Ammonia Mass Withdrawals at CF4 Extraction Wells During 2010

Month	Well 0770		Well 0772		Well 0773		Well 0774	
	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)
Apr-10	640	148	640	164	640	349	640	111

Month	Well 0775		Well 0776		Well 0777		Well 0778		Well 0779	
	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)
Apr-10	640	230	640	69	640	161	640	163	640	1.64

Table A-5. Estimated Uranium Mass Withdrawals at CF4 Extraction Wells During 2010

Month	Well 0770		Well 0772		Well 0773		Well 0774	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Apr-10	2.60	0.60	2.60	0.66	2.60	1.42	2.60	0.45

Month	Well 0775		Well 0776		Well 0777		Well 0778		Well 0779	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Apr-10	2.60	0.93	2.60	0.28	2.60	0.65	2.60	0.66	2.60	0.006

Table A-6. Summary of CF1 Ammonia (as N), TDS, and Uranium Ground Water Concentrations (mg/L) During 2010 vs. Historical Range

Location	N	Type	2010 Ammonia Concentration Range (mg/L)	Historical Ammonia Concentration Range (mg/L)	TDS Concentration Range (mg/L)	Historical TDS Concentration Range (mg/L)	Uranium Concentration Range (mg/L)	Historical Uranium Concentration Range (mg/L)
0780	7	Observation	520 - 660	77 - 890	19,000 - 21,000	1,000 – 25,000	3.0	0.24 – 3.9
0781	7	Observation	850	25 - 630	83,000	59,000 – 91,000	0.61	0.03 – 1.3
0782	7	Observation	1,100 -1,400	63 – 1,000	5,100 - 79,000	10,000 – 90,000	0.72 - 1.20	0.29 – 2.9
0783	7	Observation	190	26 - 380	22,000	330 – 23,000	2.90	0.17 – 3.7
0784	7	Observation	190	3.6 - 410	22,000	260 – 23,000	2.9	0.48 – 3.7
0785	7	Observation	430	6.7 - 680	15,000	320 – 89,000	2.20	0.34 – 3.2
0786	7	Observation	470 - 760	27 - 820	19,000 - 33,000	490 – 56,000	2.20 - 2.60	0.072 – 3.2
0787	7	Observation	360 - 410	32 - 340	58,000 - 59,000	1,100 – 91,000	0.89 - 0.91	0.11 – 0.81
0790	3	Well Point	420	0.1 - 720	16,000	380 – 24,000	2.80	0.011 – 2.9
0791	3	Well Point	450 - 570	0.71 – 770	18,000 - 24,000	660 – 26,000	2.60 – 3.10	0.017 – 2.7
0792	3	Well Point	10 - 20	195 - 760	11,000 – 14,000	7,600 – 22,000	0.33 – 0.45	0.76 – 1.6
0793	3	Well Point	0.1	0.18 – 0.44	340 - 920	605 – 24,000	0.01 - 0.02	0.006 – 0.014

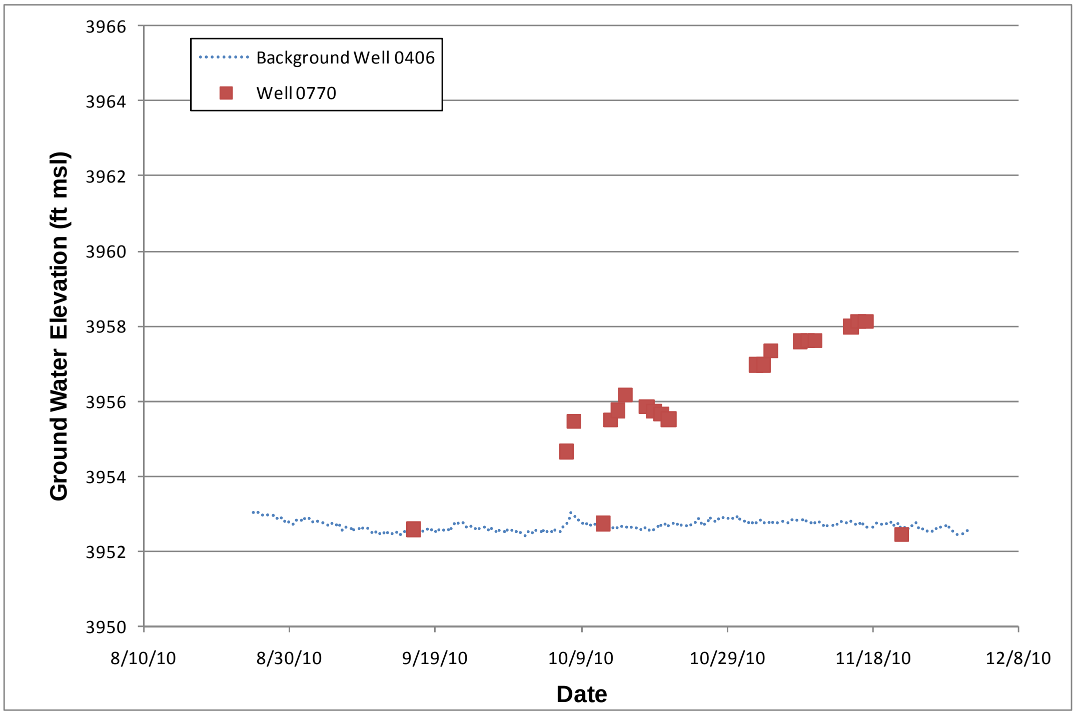


Figure A-1. Freshwater Mounding in Remediation Well 0770 during Injection

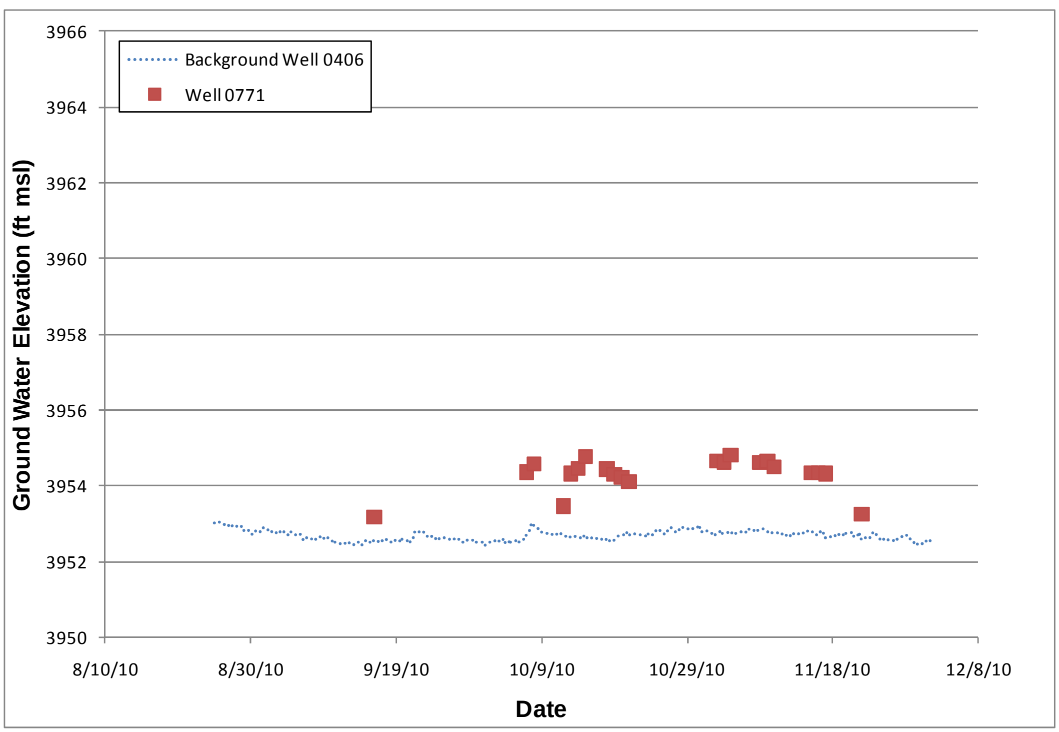


Figure A-2. Freshwater Mounding in Remediation Well 0771 during Injection

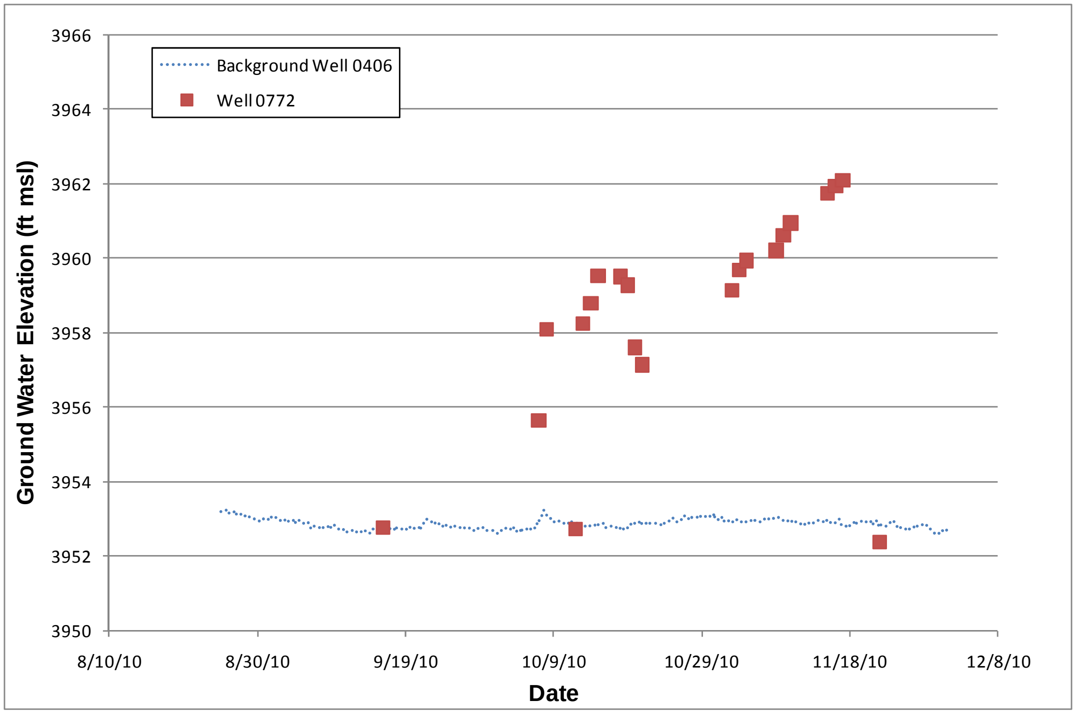


Figure A-3. Freshwater Mounding in Remediation Well 0772 during Injection

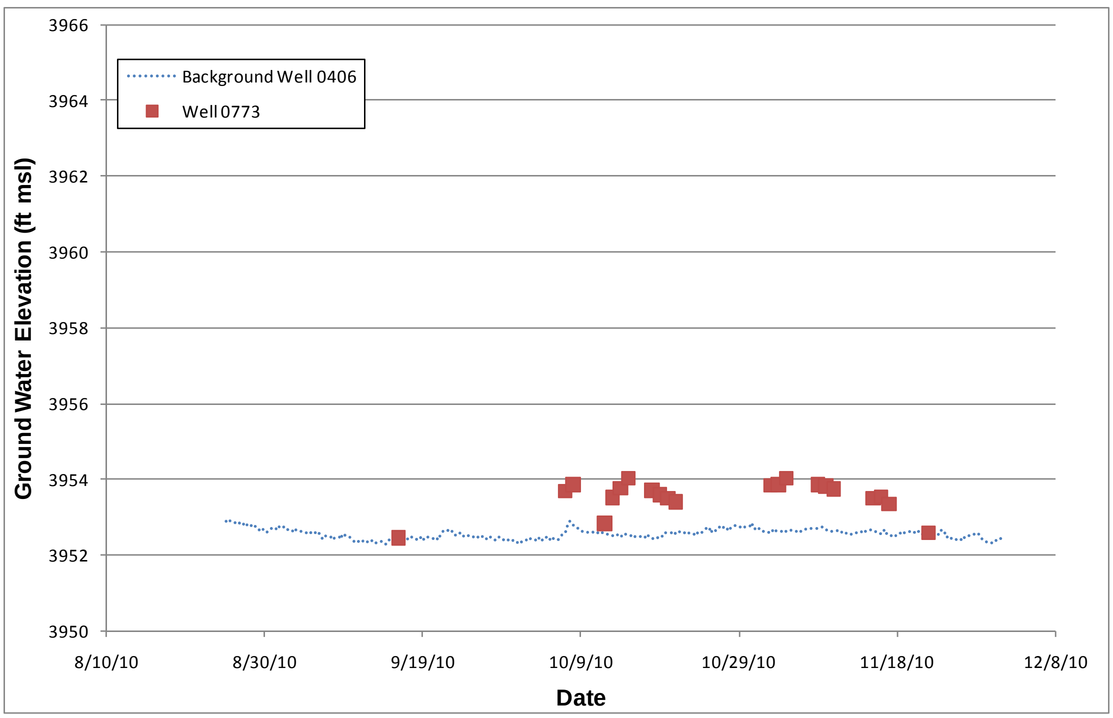


Figure A-4. Freshwater Mounding in Remediation Well 0773 during Injection

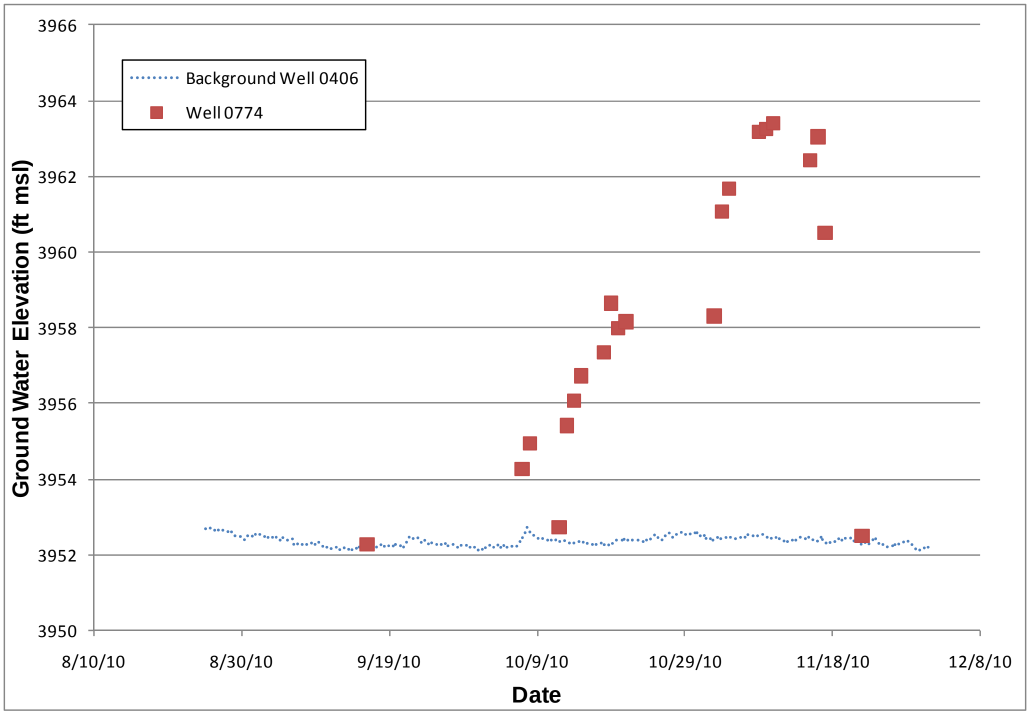


Figure A-5. Freshwater Mounding in Remediation Well 0774 during Injection

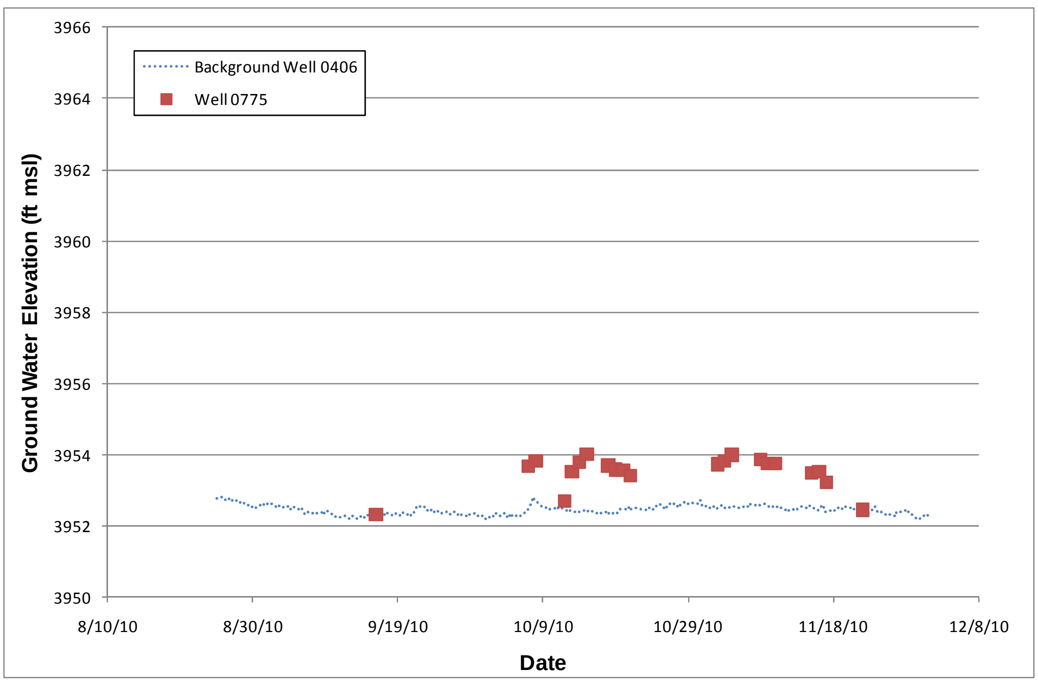


Figure A-6. Freshwater Mounding in Remediation Well 0775 during Injection

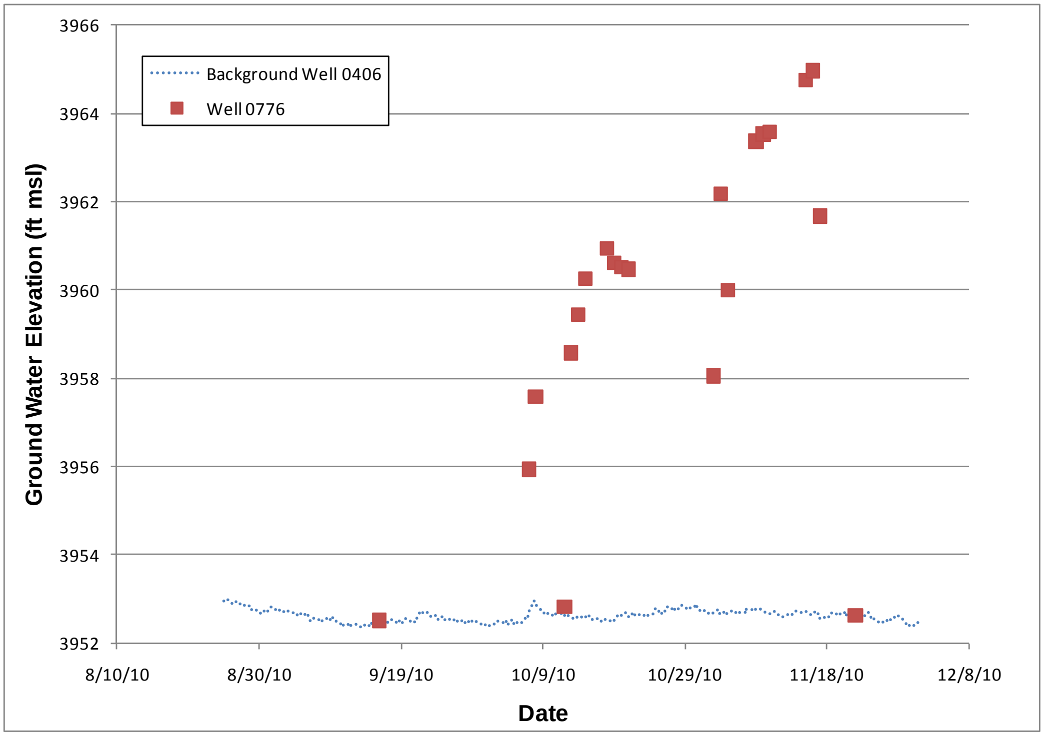


Figure A-7. Freshwater Mounding in Remediation Well 0776 during Injection

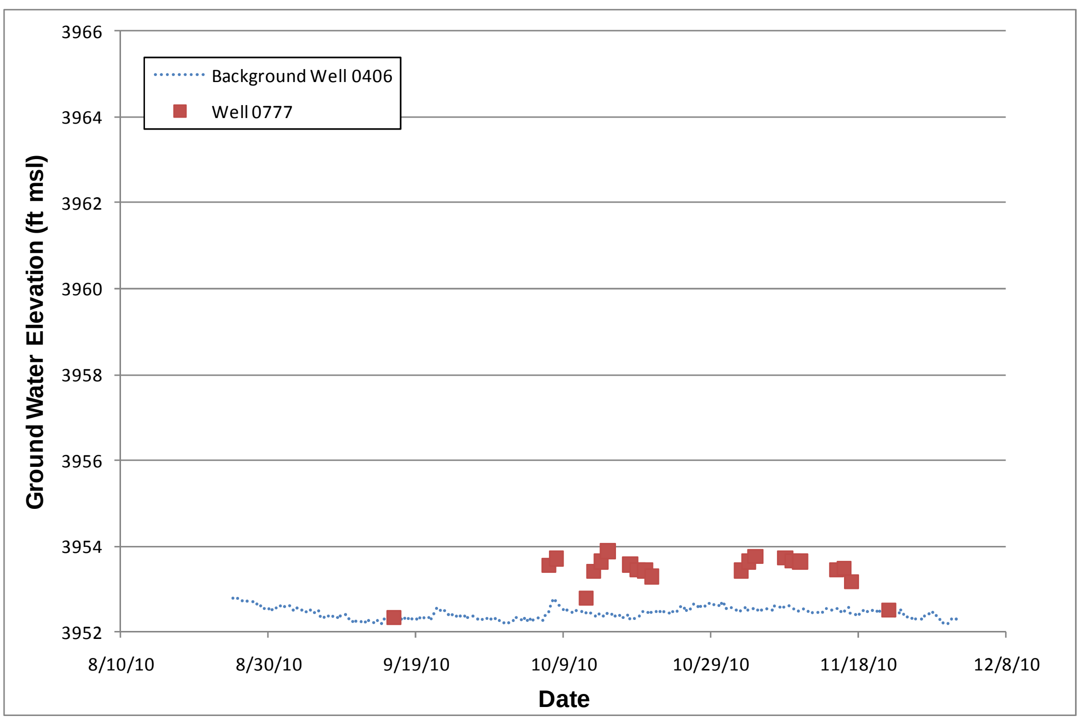


Figure A-8. Freshwater Mounding in Remediation Well 0777 during Injection

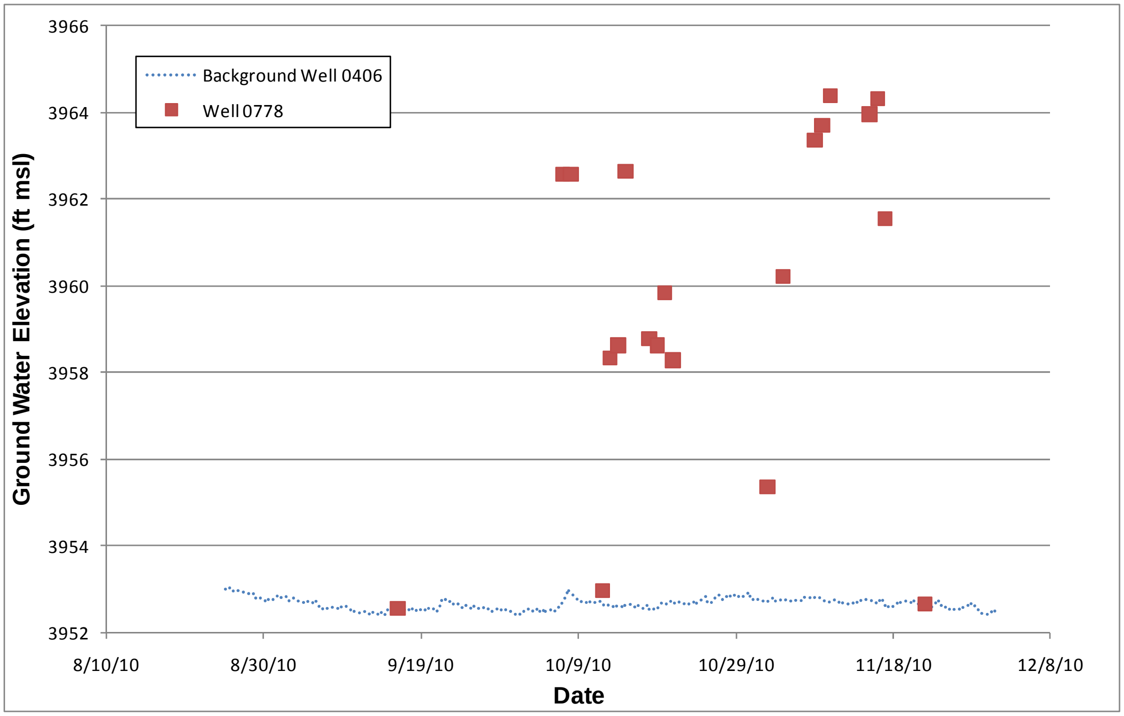


Figure A-9. Freshwater Mounding in Remediation Well 0778 during Injection

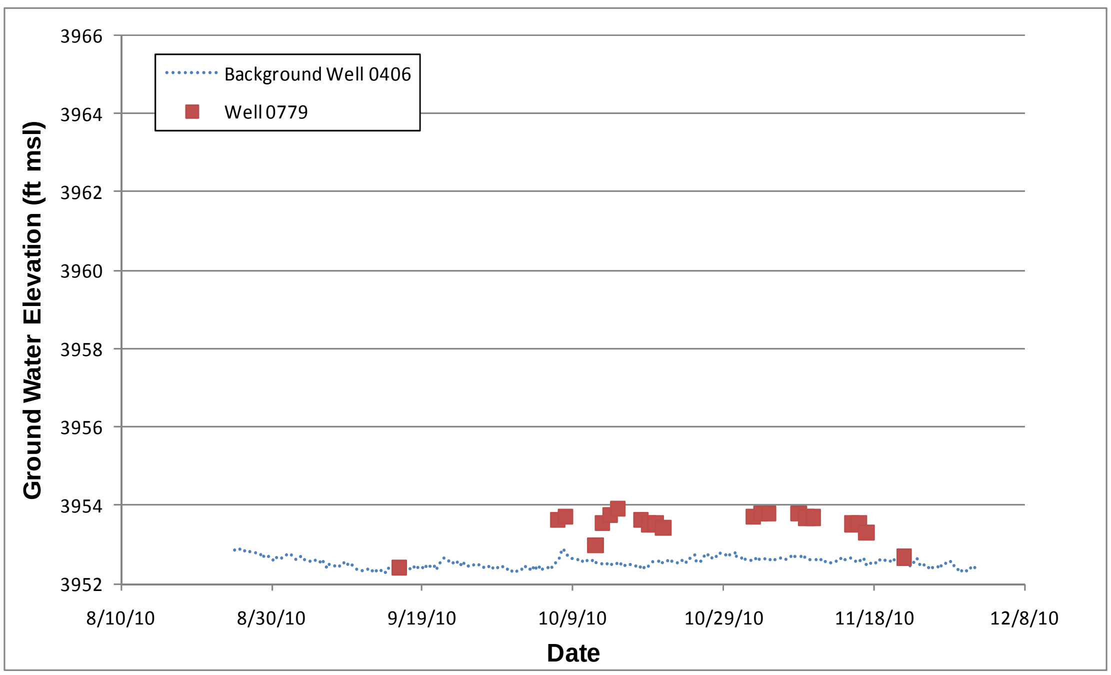


Figure A-10. Freshwater Mounding in Remediation Well 0779 during Injection

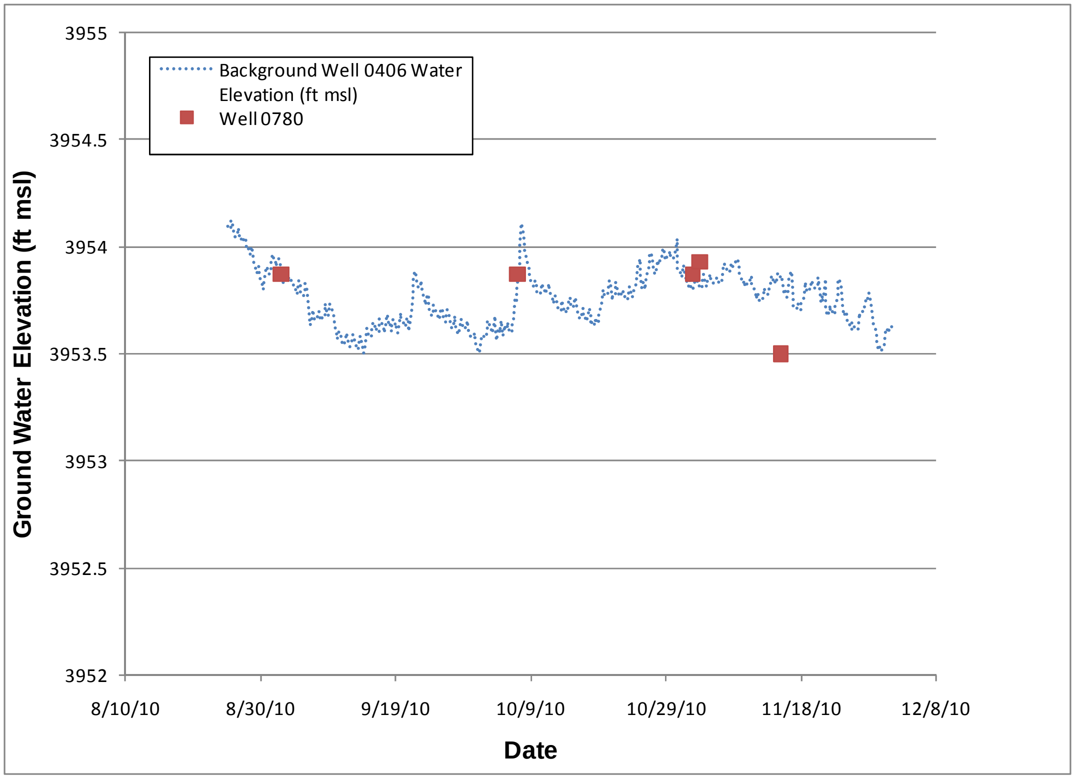


Figure A-11. Freshwater Mounding in Observation Well 0780

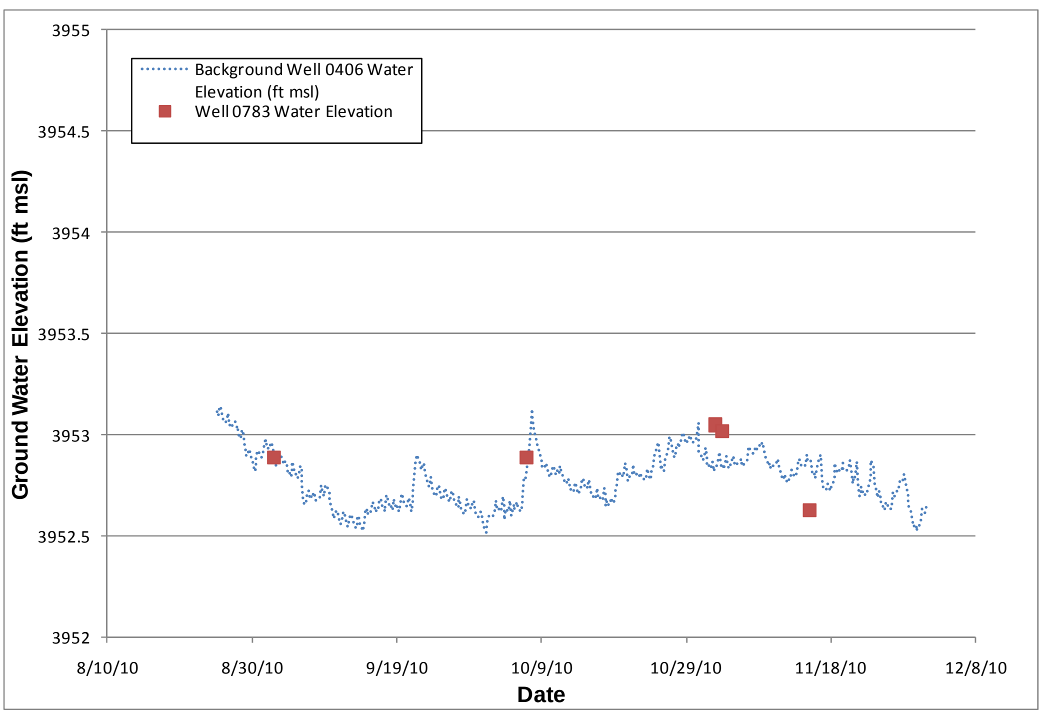


Figure A-12. Freshwater Mounding in Observation Well 0783

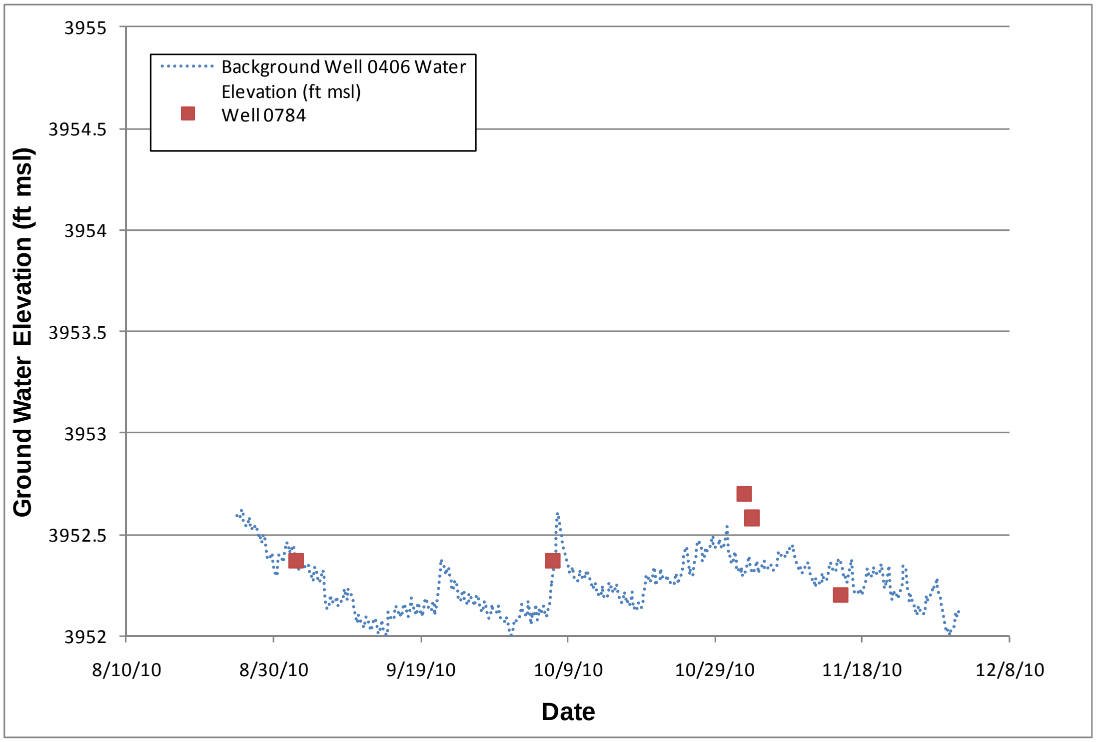


Figure A-13. Freshwater Mounding in Observation Well 0784

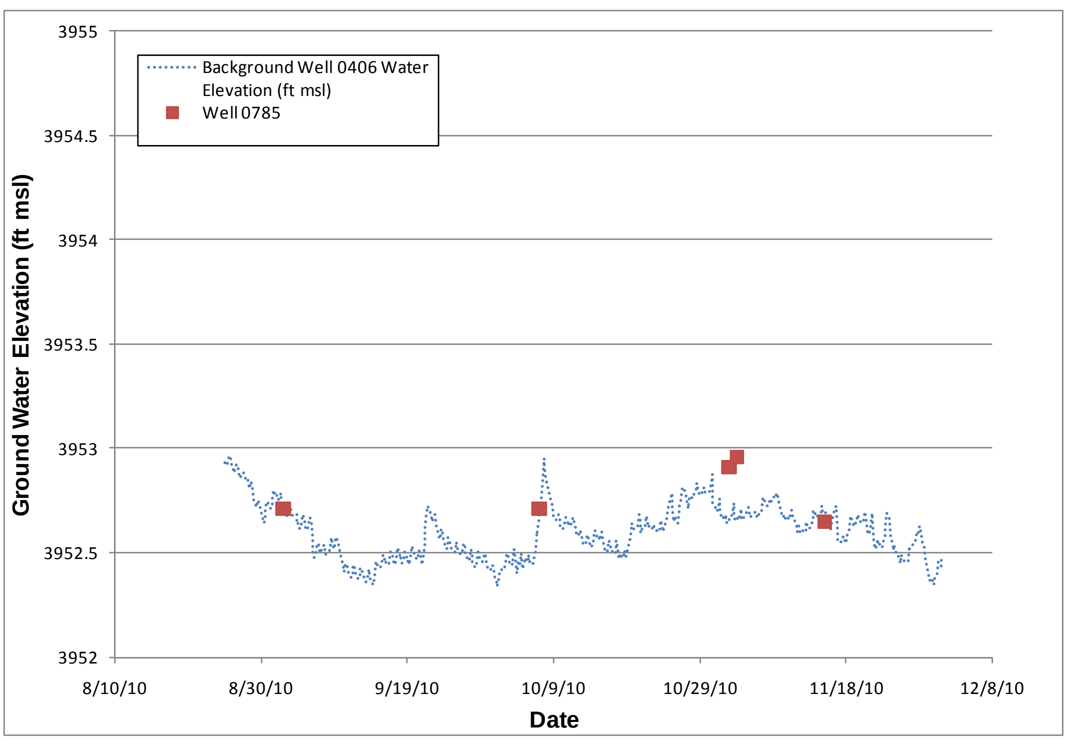


Figure A-14. Freshwater Mounding in Observation Well 0785

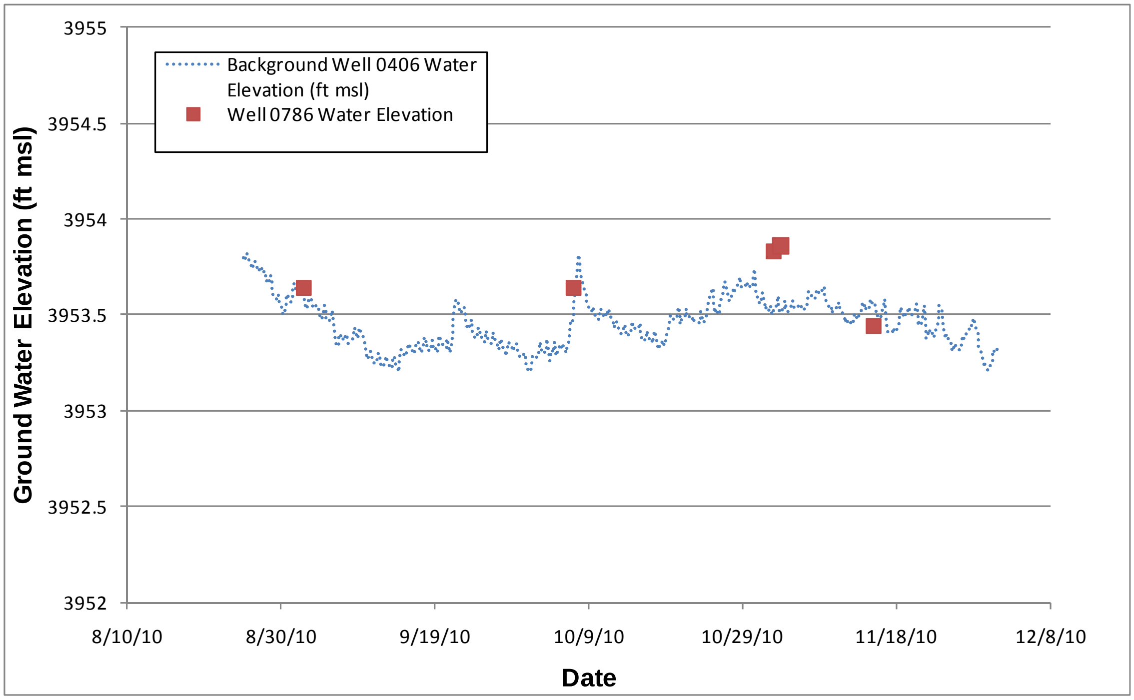


Figure A-15. Freshwater Mounding in Observation Well 0786

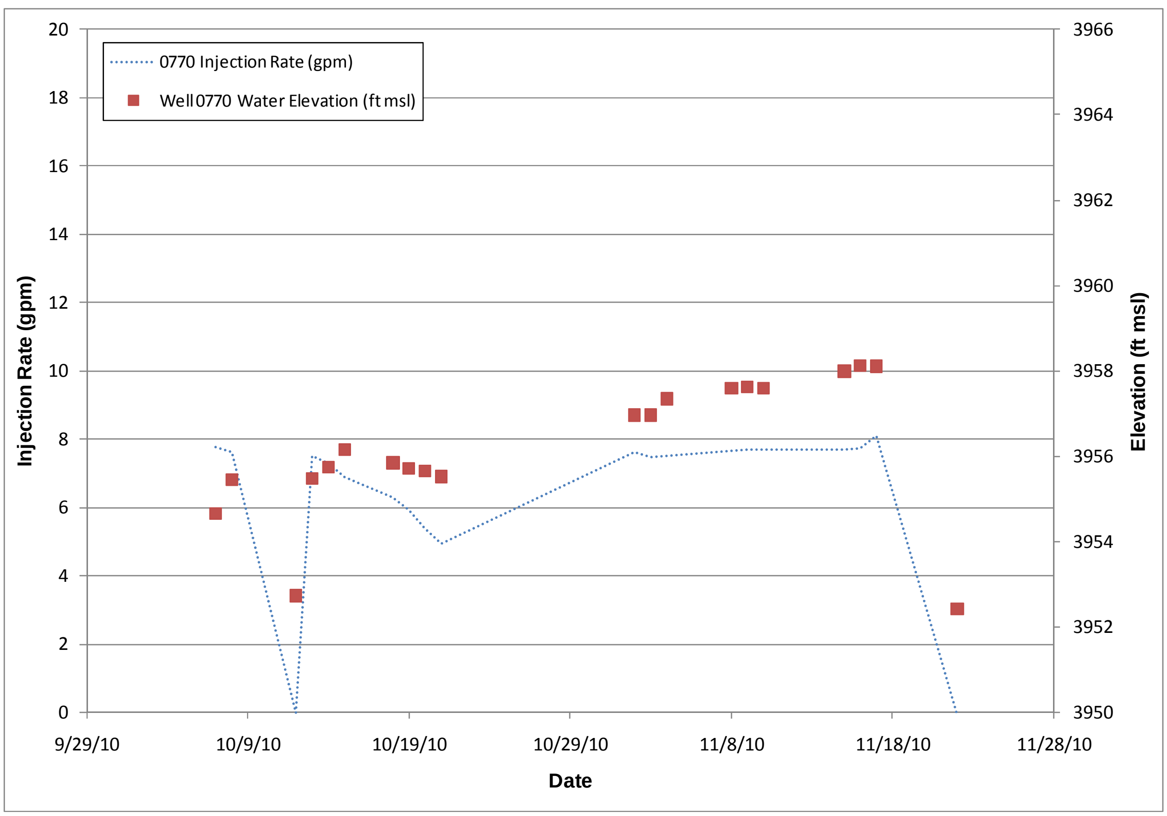


Figure A-16. Remediation Well 0770 Injection Rate vs. Water Elevation

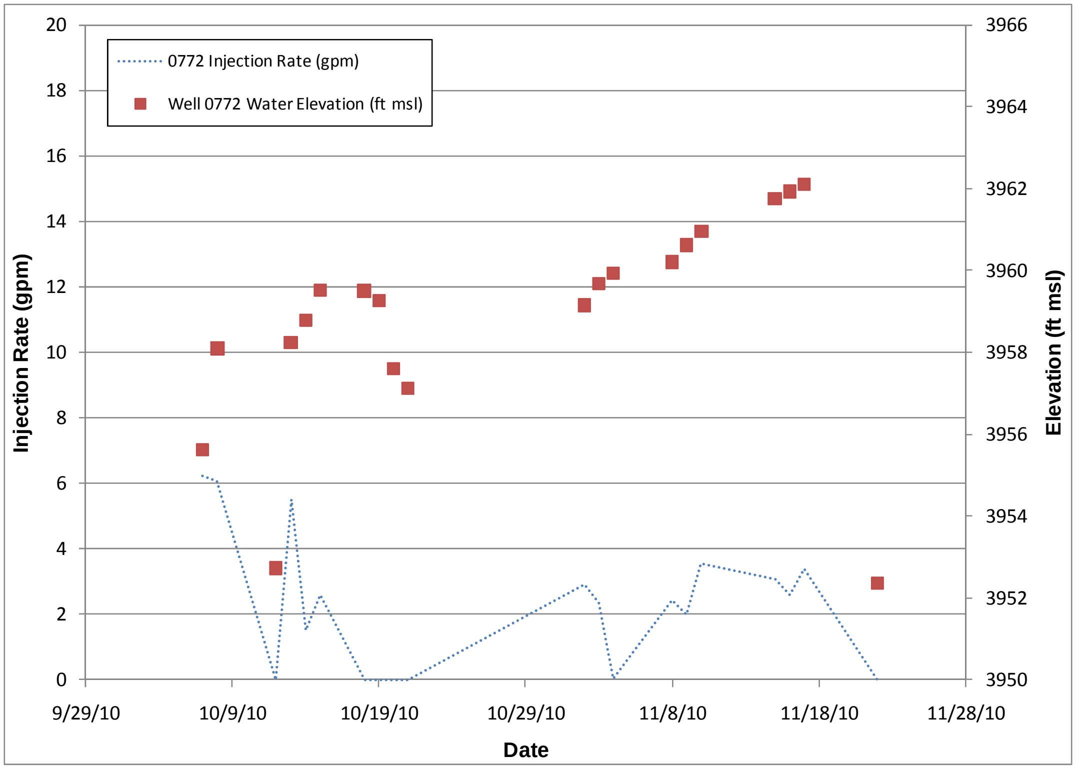


Figure A-17. Remediation Well 0772 Injection Rate vs. Water Elevation

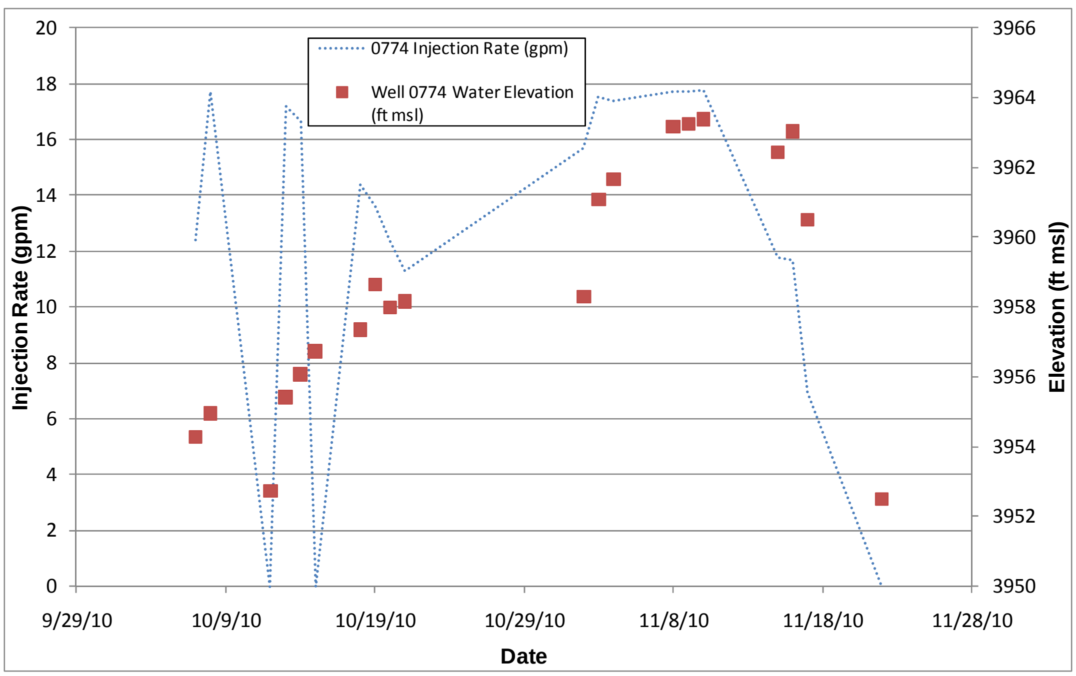


Figure A-18. Remediation Well 0774 Injection Rate vs. Water Elevation

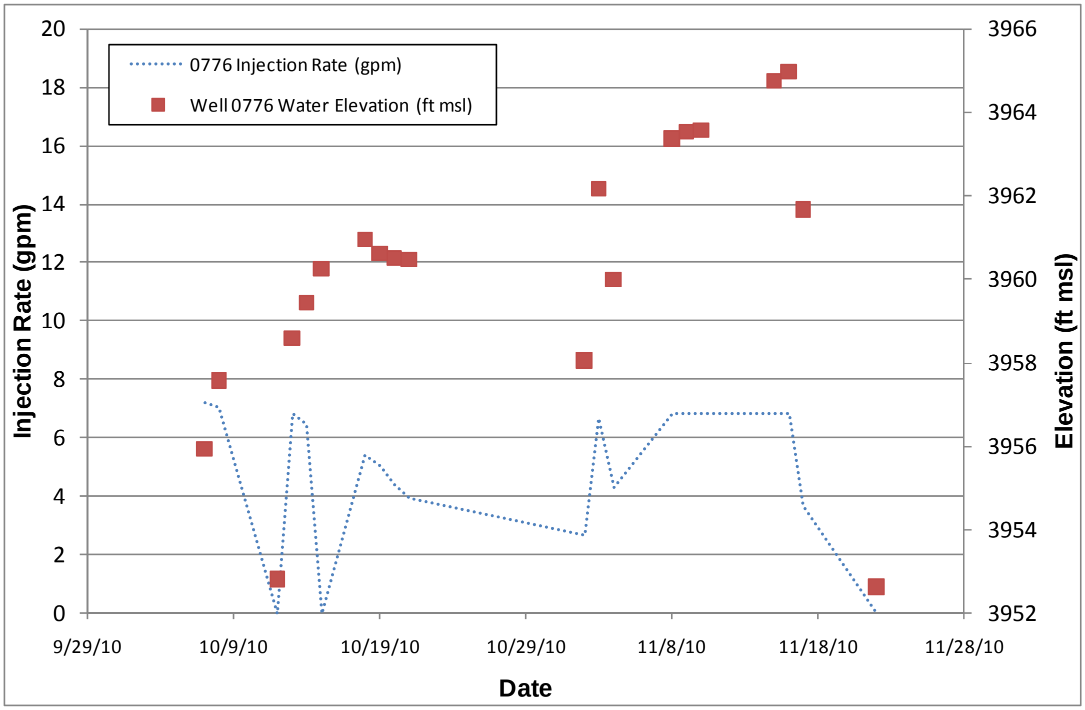


Figure A-19. Remediation Well 0776 Injection Rate vs. Water Elevation

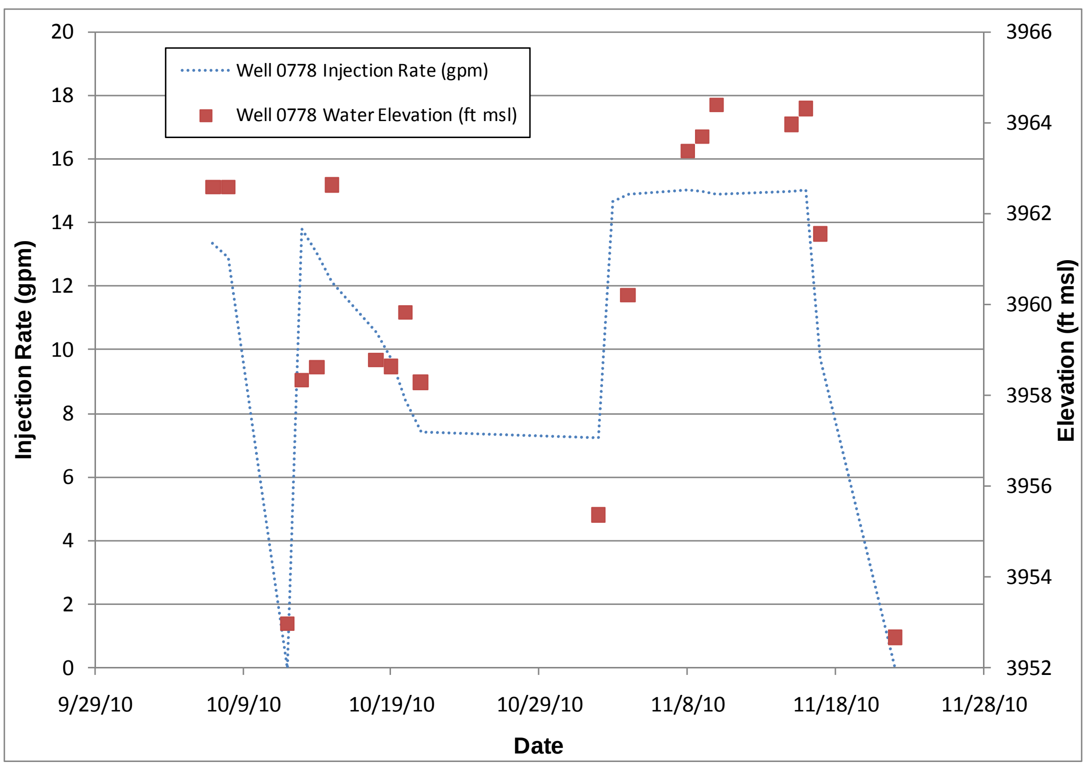


Figure A-20. Remediation Well 0778 Injection Rate vs. Water Elevation

Appendix B.
CF5 Tables and Data for 2010

Table B-1. Summary of Well Construction in CF5

Well	Well Type/Relative Depth	Diameter (inches)	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	8.6–38.6	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	20–60	60.3
0810-OBS	Observation/Shallow	1.5	3,966.90	4.4–14.4	14.4
0811-OBS	Observation/Shallow	1.5	3,967.20	4.4–14.4	14.4
0812-OBS	Observation/Shallow	1.5	3,966.94	3.5–13.5	13.5
0813-OBS	Observation/Shallow	1.5	3,967.01	4.4–14.4	14.4
0814-OBS	Observation/Shallow	1.5	3,967.03	3.4–13.4	13.4
0815-OBS	Observation/Shallow	1.5	3,967.00	3.4–13.4	13.4
0816-OBS	Observation/Shallow	1.5	3,967.19	3.3–13.3	13.3

Table B-2. Chronology for CF5 in 2010

Date	River Flow (daily mean cfs)	Activity	Samples Collected
December 20, 2009-January 8, 2010	2,470 to 2,550	Wells 0810-0816 installed/developed	
February 16, 2010	2,680	Profile sampling of all CF5 wells	0810-0816
March 30, 2010	2,940	Profile sampling of all CF5 wells	0810-0816
April 15, 2010	7,490	Start extracting from PW02 and 0815	
June 22, 2010	11,900	Samples collected from mid-screen	0810-0816, PW02
June 29, 2010	8,440	Pump installed in 0811	
July 27, 2010	3,280	Pump installed in 0812, 0813, 0814, 0815, 0816	
August 19, 2010	4,220	New pumps in 0810	
August 19-26, 2010	3,790 to 5,320	Vaults placed over wells and well plumbing installed, pump tests	
August 27, 2010	3,540	Start pumping from wells	
September 29-30, 2010	3,560 to 3,620	Sampling event with dedicated submersible pumps	0810-0816, PW02
September 30, 2010	3,560	Started using exclusively CF5 water for enhanced evaporation units	
October 7-28, 2010	3,840 to 5,670	Started pumping for enhanced evaporation units, shut down	
November 17, 2010	3,540	Wells 0812 and 0816 started pumping for enhanced evaporation units, shut down, evaporation units down	
November 23, 2010	3,580	Winterized	

Table B-3. Monthly Average Pumping Rates and Extraction Volumes at CF5 Wells for 2010

Month	Well 0810		Well 0811		Well 0812		Well 0813	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Aug-10	1,613	42.51	1,612	50.81	1,728	48.56	1,951	60.88
Sept-10	365,251	44.5	166,245	42.27	37,015	37.07	30,658	61
Oct-10	15,160	--	15,160	--	1,198	--	92,618	61.6
Nov-10	--	--	--	--	21,523	--	106,024	--
Total	382,024	87.01	183,017	93.08	61,464	85.63	231,251	183.48

Month	Well 0814		Well 0815		Well 0816		Well PW02	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
April-10	--	--	22,238	2.1	--	--	605,738	20.1
May-10	--	--	90,913	3.0	--	--	608,547	14.9
June-10	--	--	299,975	6.0	--	--	1,055,548	21.5
Jul-10	--	--	732,454	18.1	--	--	1,019,710	24
Aug-10	3,153	62.75	3,267	50.27	3,371	60.02	270,471	38.53
Sept-10	41,656	68.12	490,058	33.43	1,448,095	81	602,635	44.08
Oct-10	34,000	--	334,037	44.4	69,147	88.9	847,834	51
Nov-10	--	--	--	--	193,357	--	--	--
Total	78,809	130.87	1,972,942	128.1	1,713,970	229.92	5,010,483	214.11

Table B-4. Estimated Ammonia Mass Withdrawals at CF5 Extraction Wells During 2010

Month	Well 0810		Well 0811		Well 0812		Well 0813	
	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)
Aug-10	350	2.1	520	3.2	550	3.6	350	2.6
Sept-10	350	483.2	520	326.8	550	77.0	350	40.6
Oct-10	350	20.1	520	29.8	550	2.5	350	122.5
Nov-10	--	--	--	--	550	44.7	350	140.3
Total		**505.4**		**359.7**		**127.8**		**305.95**

Month	Well 0814		Well 0815		Well 0816		Well PW02	
	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)	Am Conc (mg/L)	Mass Removed (kg)
Apr-10	--	--	240.0	20.2	--	--	600	1,373.8
May-10	--	--	240	82.5	--	--	600	1,380.2
June-10	--	--	350	396.9	--	--	600	2,394.0
Jul-10	--	--	350	969.0	--	--	600	2,312.7
Aug-10	320	3.8	350	4.3	210	2.7	570	582.8
Sept-10	320	50.4	350	648.3	210	1,149.5	570	1,298.4
Oct-10	320	41.1	350.0	441.9	210	54.9	570	1,826.7
Nov-10	--	--	--	--	210.0	153.5	--	--
Total		**95.33**		**1,094.60**		**1,360.55**		**11,168.62**

Table B-5. Estimated Uranium Mass Withdrawals at CF5 Extraction Wells During 2010

Month	Well 0810		Well 0811		Well 0812		Well 0813	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Aug-10	3.5	0.0	2.7	0.0	2.3	0.0	3.5	0.0
Sept-10	3.5	4.8	2.7	1.7	2.3	0.3	3.5	0.4
Oct-10	3.5	0.2	2.7	0.2	2.3	0.0	3.5	1.2
Nov-10	--	--	--	--	2.3	0.2	3.5	1.4
Total		**5**		**1.9**		**0.5**		**3**

Month	Well 0814		Well 0815		Well 0816		Well PW02	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Apr-10	--	--	4.1	0.3	--	--	2.6	6.0
May-10	--	--	4.1	1.4	--	--	2.6	6.0
June-10	--	--	3.1	3.5	--	--	2.6	10.4
Jul-10	--	--	3.1	8.6	--	--	2.6	10.0
Aug-10	2.7	0.0	3.1	0.0	2.3	0.0	3	3.1
Sept-10	2.7	0.4	3.1	5.7	2.3	12.6	3	6.8
Oct-10	2.7	0.3	3.1	3.9	2.3	0.6	3	9.6
Nov-10	--	--	--	--	2.3	1.7	--	--
Total		**0.7**		**23.4**		**14.9**		**51.9**

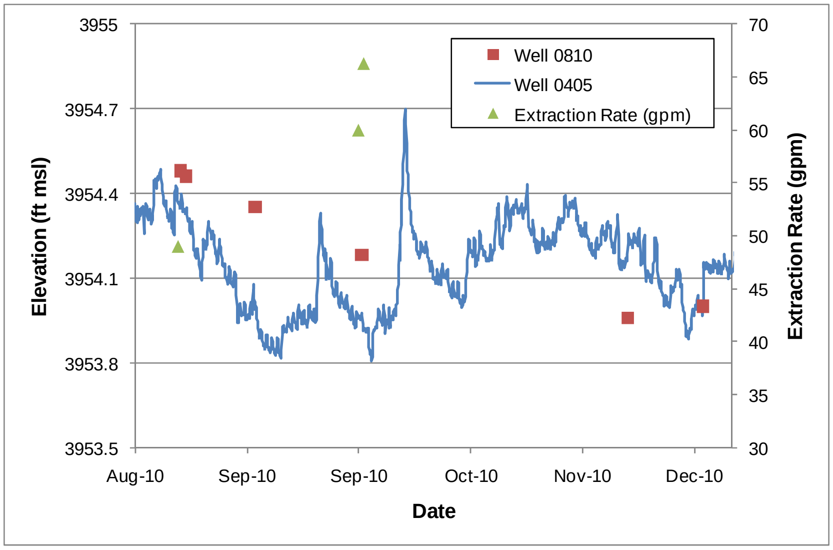


Figure B-1. Observed Drawdown at Well 0810

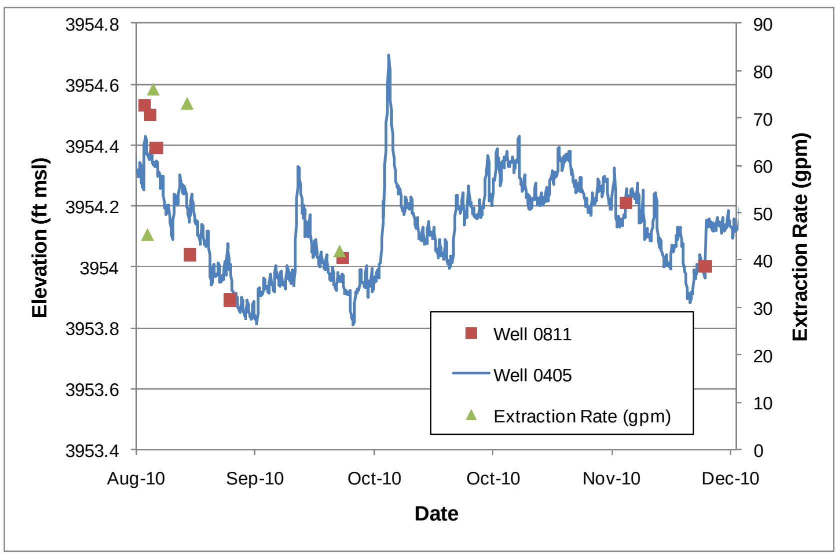


Figure B-2. Observed Drawdown at Well 0811

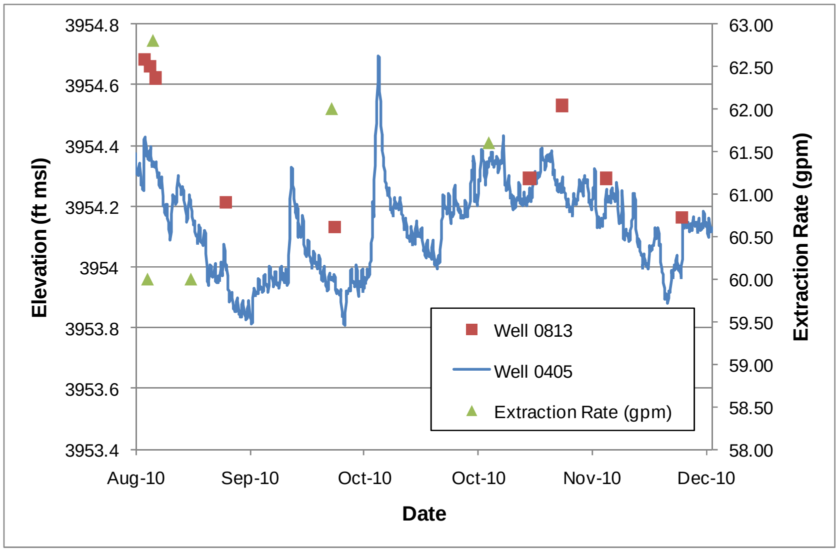


Figure B-3. Observed Drawdown at Well 0813

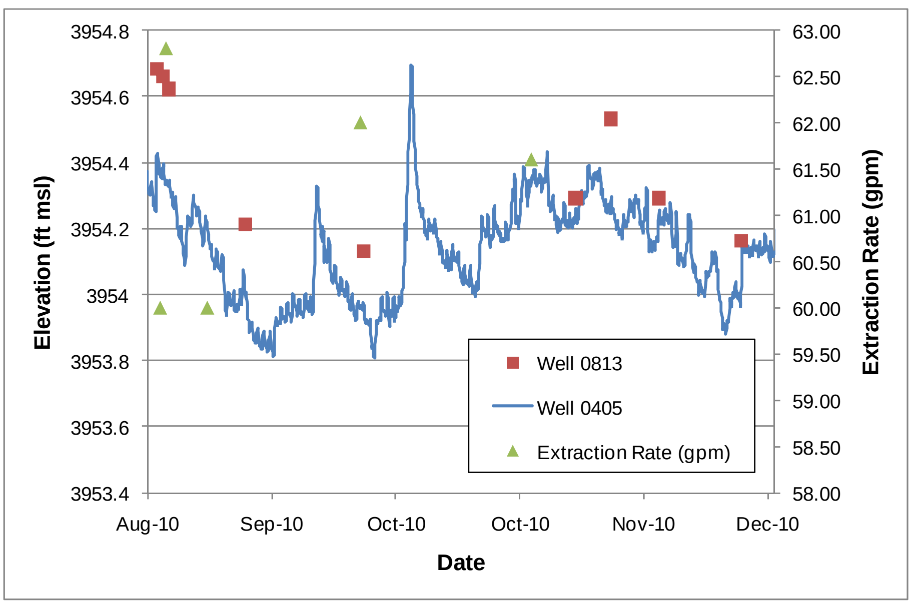


Figure B-4. Observed Drawdown at Well 0814

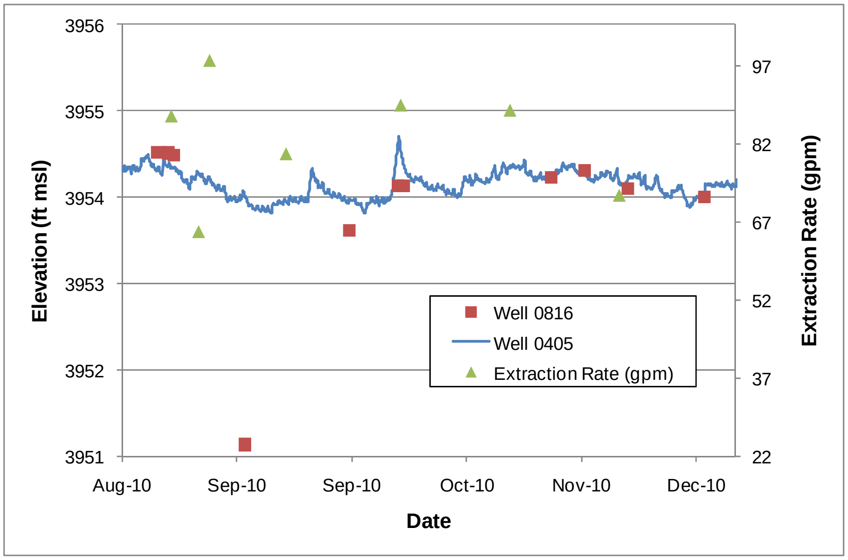


Figure B-5. Observed Drawdown at Well 0816

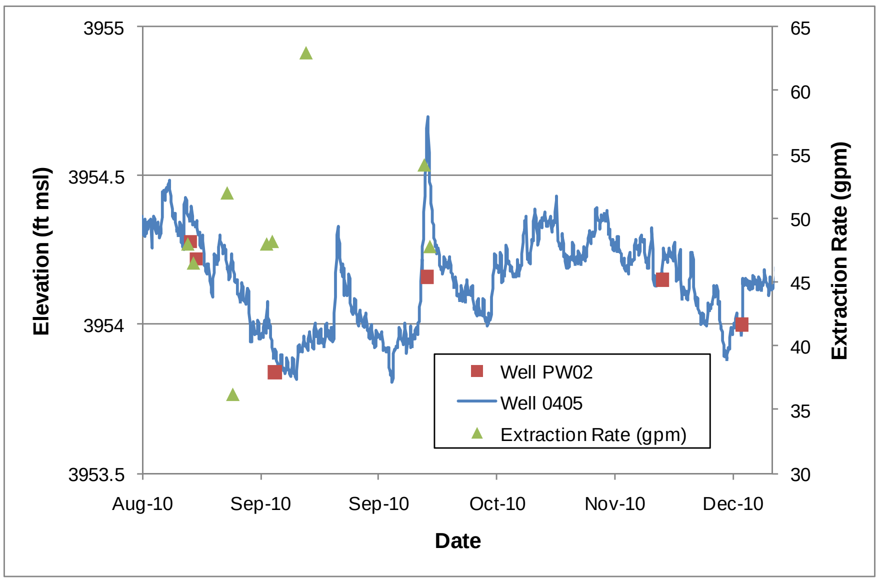


Figure B-6. Observed Drawdown at Well PW02

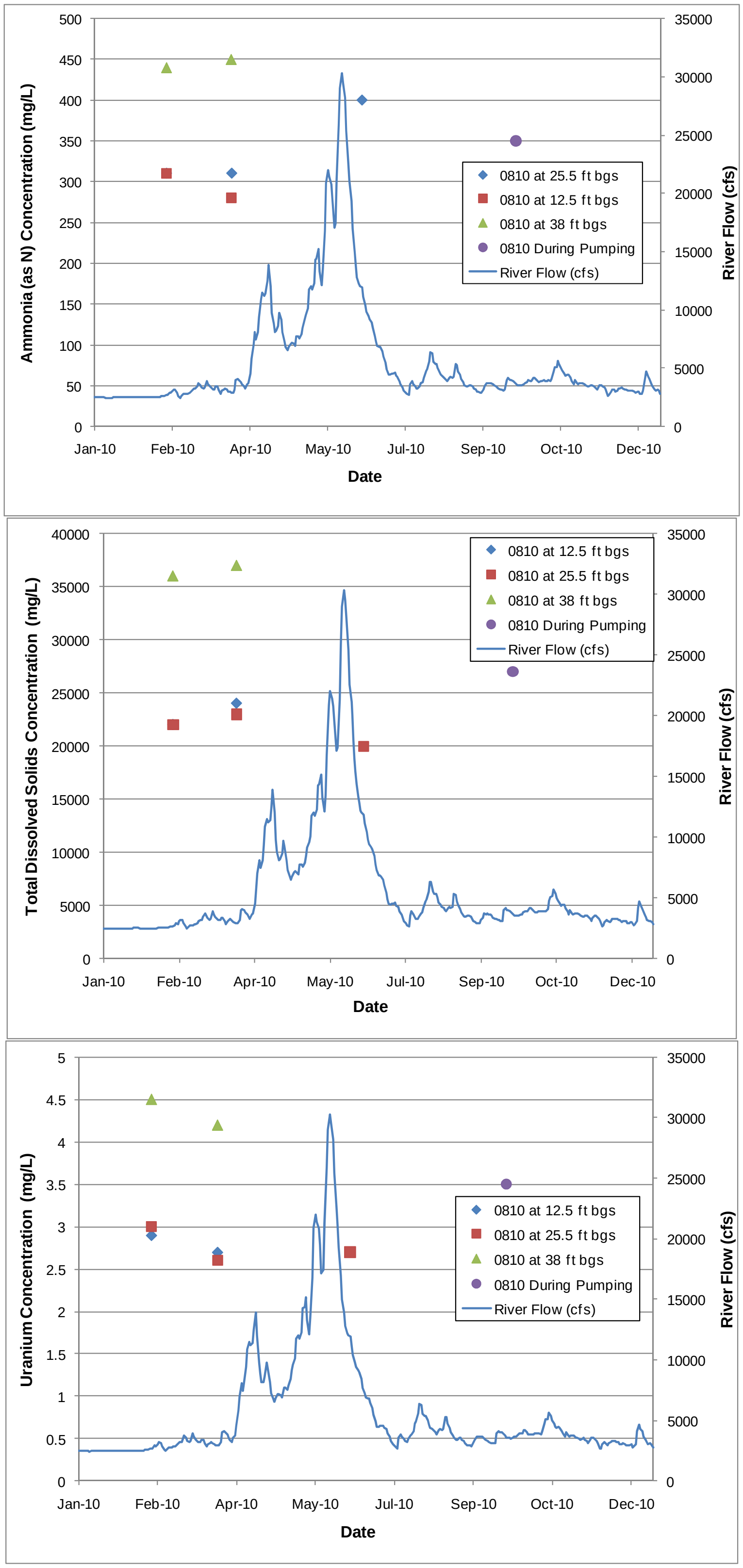


Figure B-7. Ammonia, TDS, and Uranium Concentrations Measured at Well 0810 in 2010

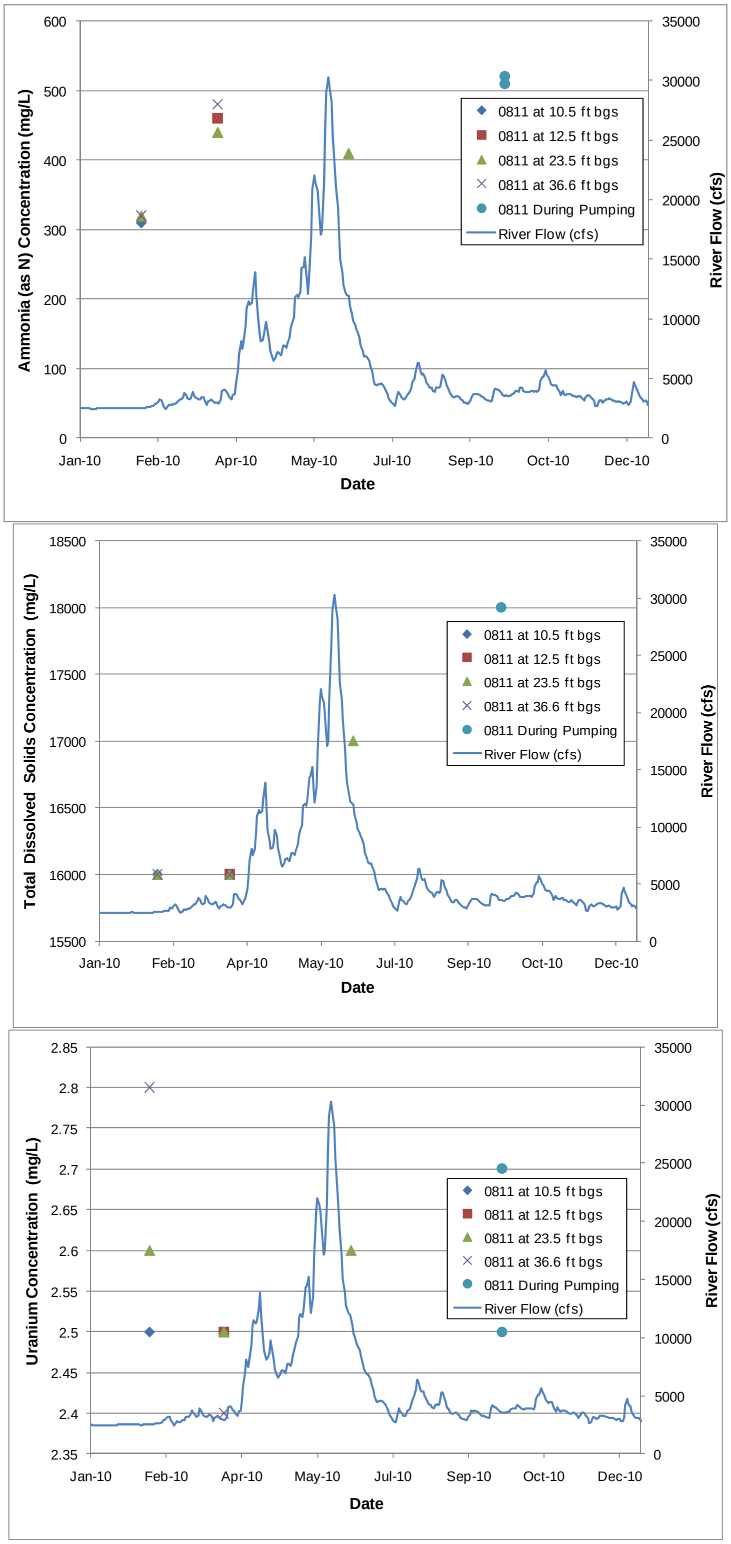


Figure B-8. Ammonia, TDS, and Uranium Concentrations Measured at Well 0811 in 2010

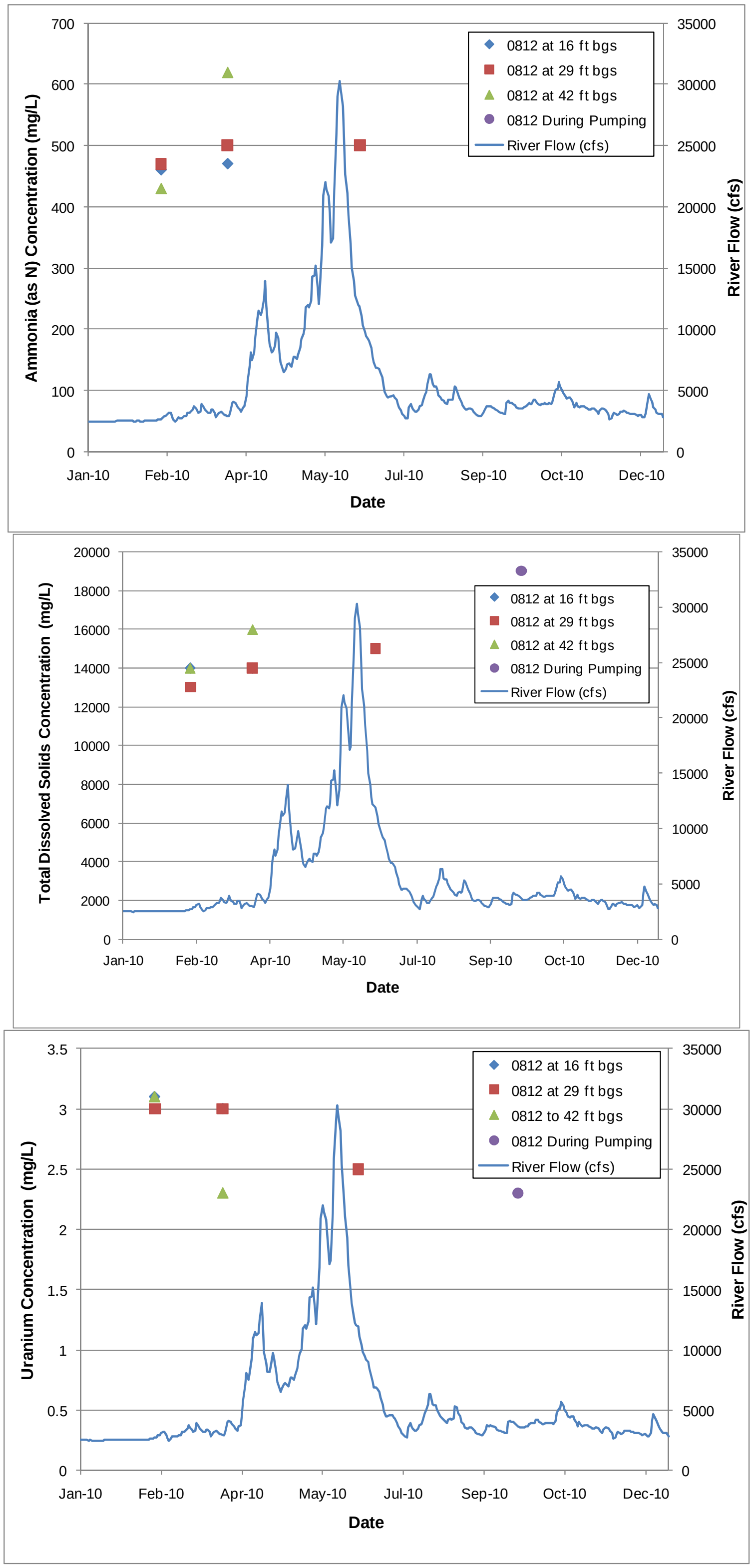


Figure B-9. Ammonia, TDS, and Uranium Concentrations Measured at Well 0812 in 2010

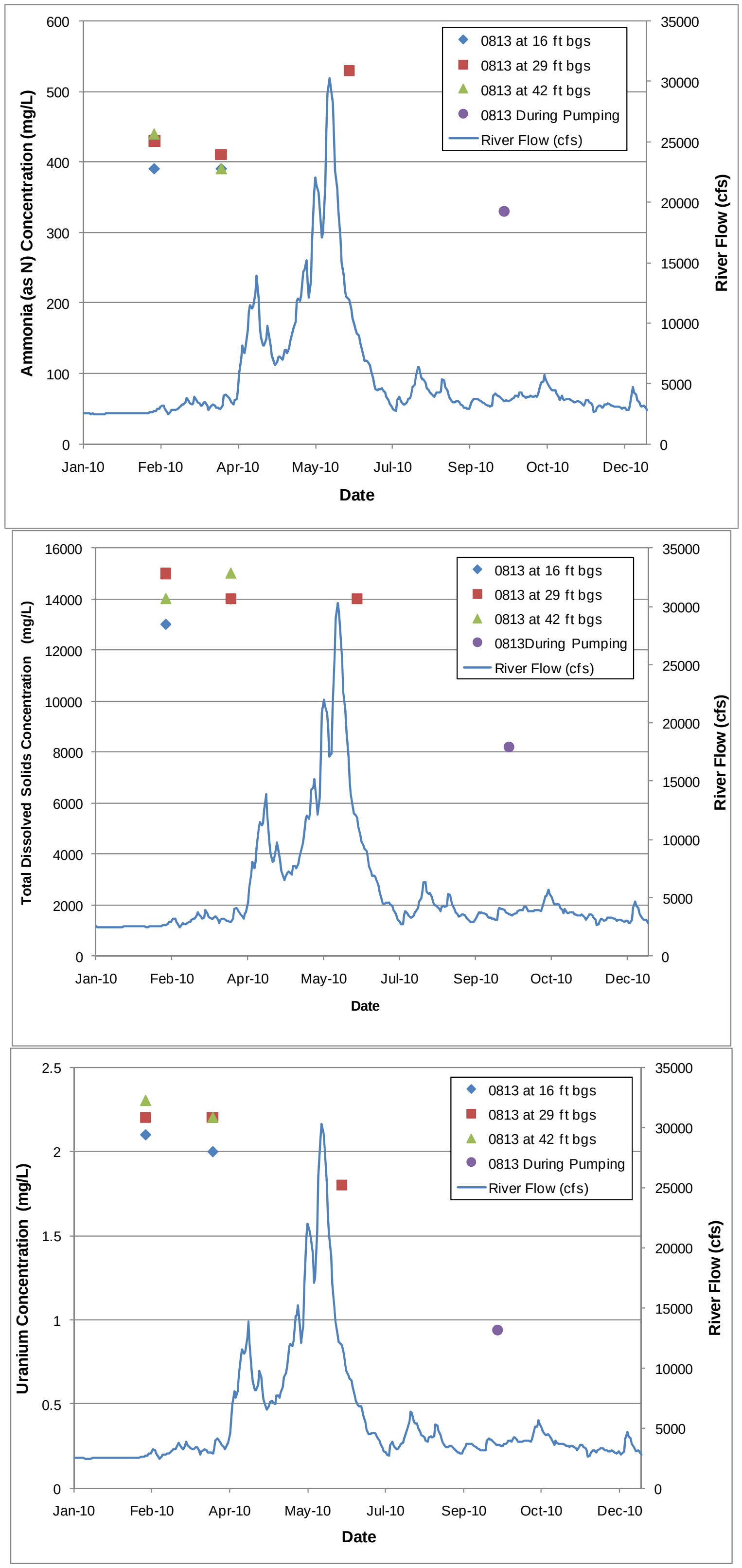


Figure B-10. Ammonia, TDS, and Uranium Concentrations Measured at Well 0813 in 2010

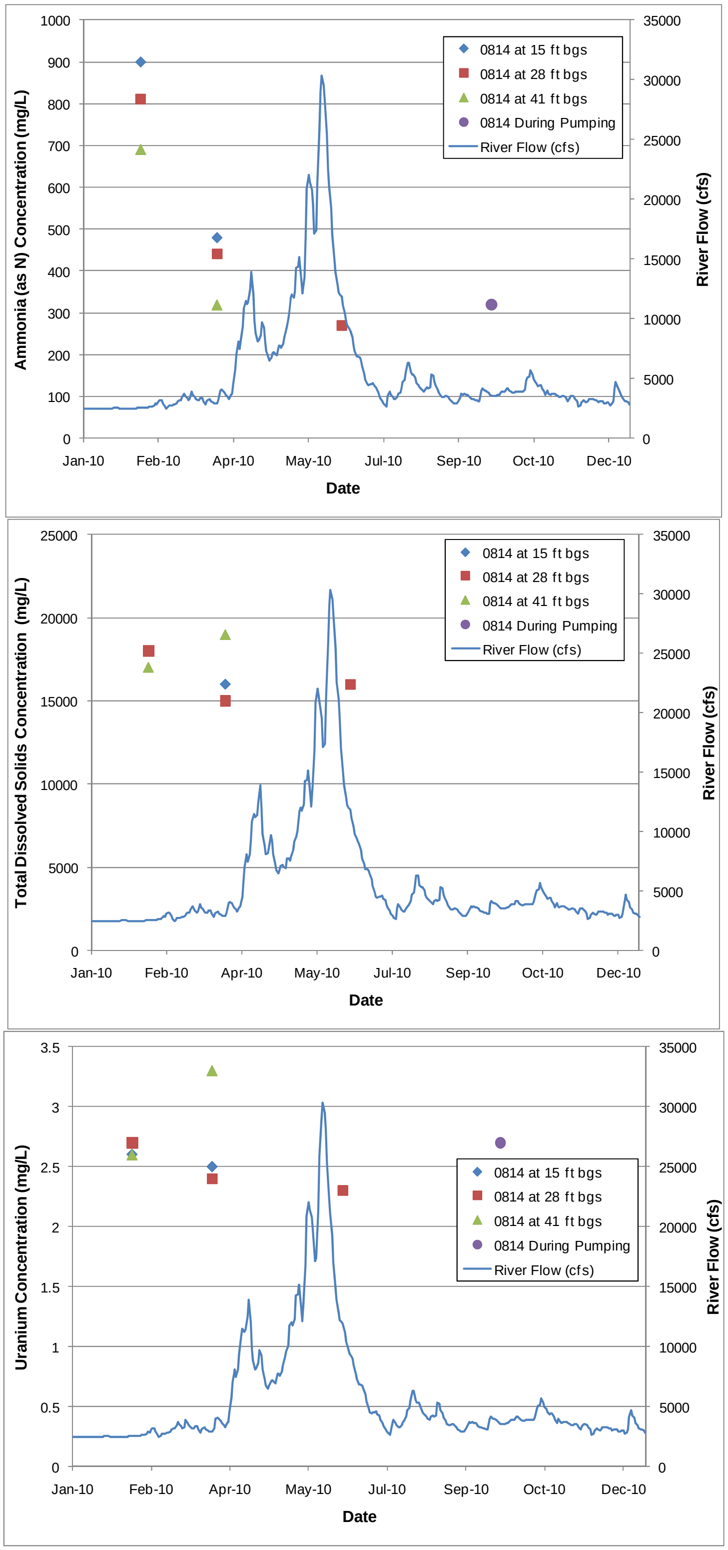
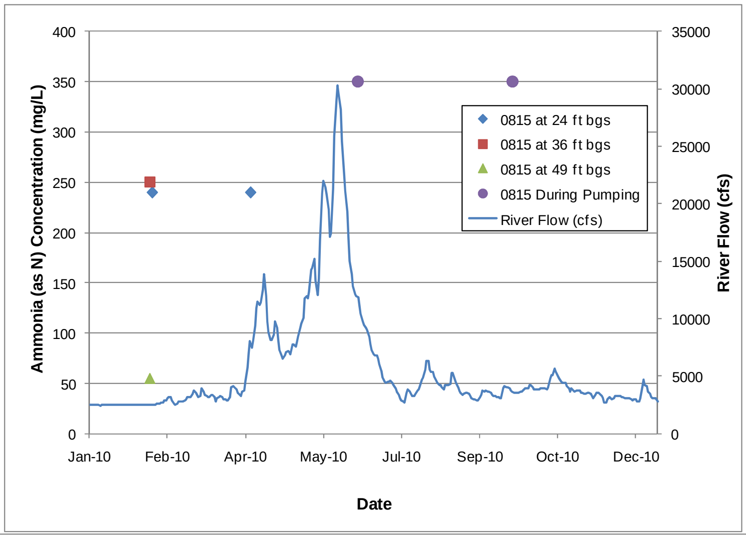
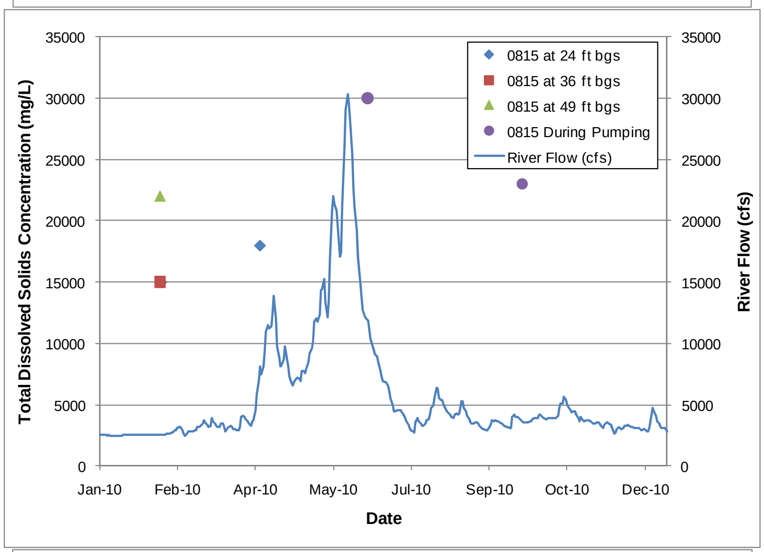


Figure B-11. Ammonia, TDS, and Uranium Concentrations Measured at Well 0814 in 2010





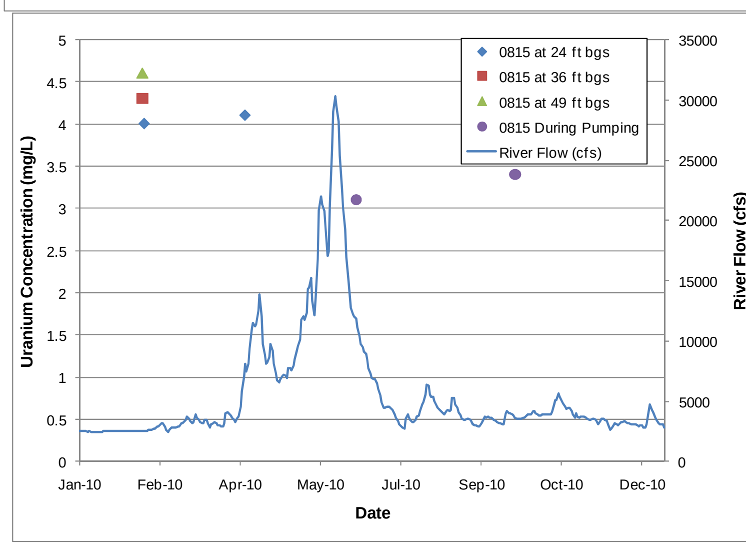


Figure B-12. Ammonia, TDS, and Uranium Concentrations Measured at Well 0815 in 2010

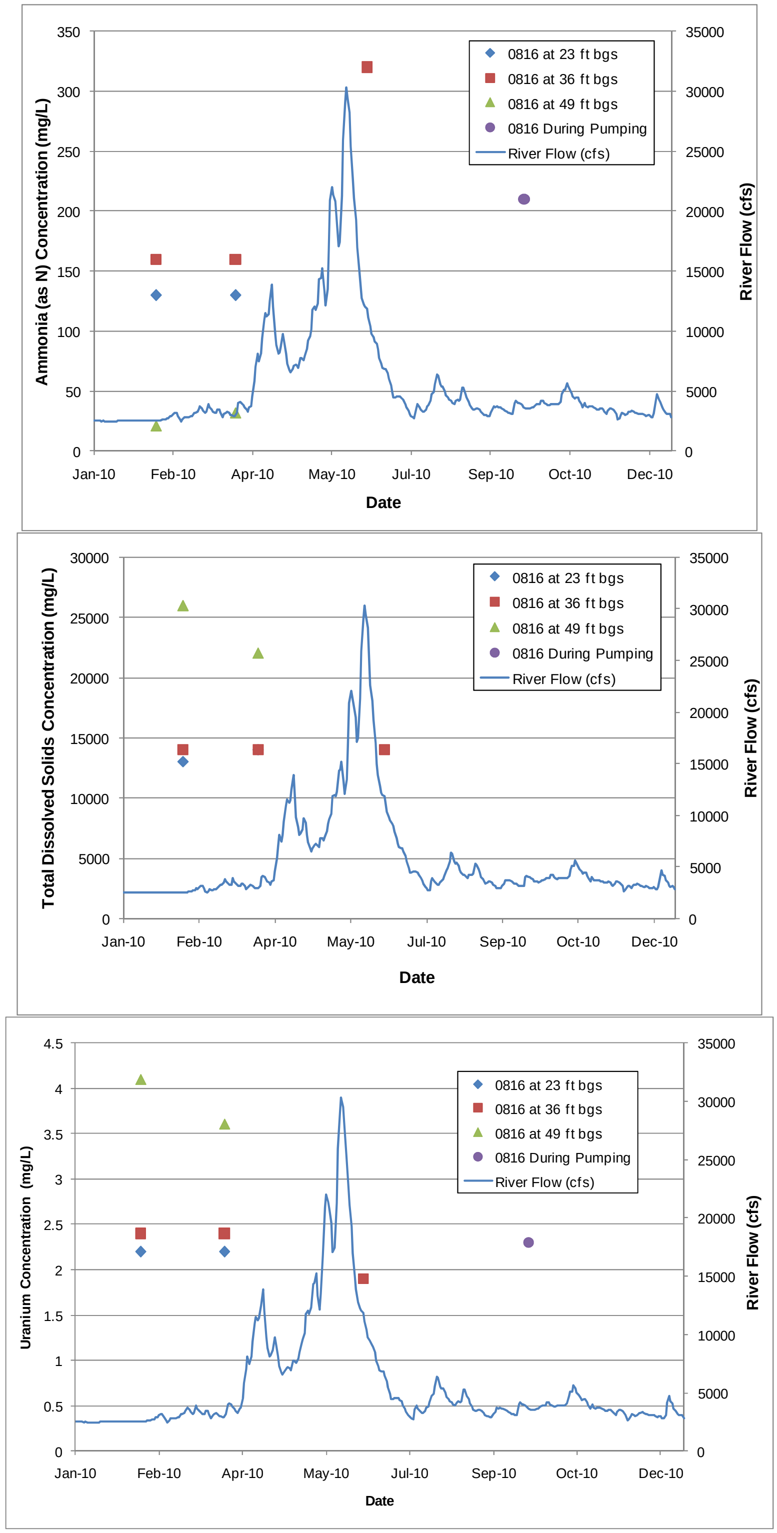


Figure B-13. Ammonia, TDS, and Uranium Concentrations Measured at Well 0816 in 2010

Date	Analyte	Concentration	River Flow (cfs)
6/22/2010	Ammonia, as N	600 mg/L	11,900
	Total Dissolved Solids	40,000 mg/L	
	Uranium	2.6 mg/L	
9/29/2010	Ammonia, as N	570 mg/L	3,620
	Total Dissolved Solids	29,000 mg/L	
	Uranium	3 mg/L	

Table B-6. Ammonia, TDS, and Uranium Concentrations Measured at Well PW02 in 2010

Appendix C.
2010 Evaporation Pond Data

Table C-1. Important Dates, Evaporation Pond Levels, and Activities Associated with the IA Treatment Systems During 2010

Date	Pond Level (ft)	pH	Activity
Feb 11, 2010	8.0	–	Sampled CF5 Extraction Wells on 2/8 - 2/16
Mar 4, 2010	8.4	–	RAC pumping water from potholes/sump to wick pond, water being transferred to evap pond
Mar 11, 2010	8.7	–	Started operating landsharks on limited schedule
Mar 18, 2010	8.7	–	RAC started removing water from evap pond on 3/18
Mar 25, 2010	8.5	–	Pump installed in well 0815 on 3/30, sampled CF5 extraction wells from 3/30 to 3/31
Apr 1, 2010	8.1	–	Extraction line re-connected
Apr 1, 2010	8.1	5.4	Sampled pond for NH3, TDS, and U
Apr 8, 2010	7.7	–	Started pumping from CF4 4/5/10 @ 14:30, ~45 gpm (lasted only ~20 hrs, power down)
Apr 15, 2010	7.3	–	Started pumping from CF5 (0815) @ 08:00, re-started CF4 & PW02, shut down 0815 after ~7 hrs (controller)
Apr 22, 2010	8.2	6.9	Shut down CF4 4/23 @ 11:45 to control pond level, sampled pond
May 6, 2010	8.0	–	Shut down PW02 on 5/7, crack in check valve. Started transferring water from excavation bottom to evap pond on 5/8
May 13, 2010	7.7		PW02 re-started 5/11, check valve replaced
May 17, 2010	–	6.4	
May 20, 2010	7.8	–	Re-started 0815 @ 60 gpm on 5/18 @ 09:15, shut down PW02. Shut down 815 on 5/19 @ 13:30 due to leak (55 gpm)
May 27, 2010	8.0	3.7*	Re-started PW02 @ 1600 on 5/26
Jun 2, 2010	–	4.83*	
Jun 17, 2010	7.8	–	Well 0815 re-started on 6/16 @ 14:00
Jun 24, 2010	8.0	–	Sampled CF5 Extraction Wells on 6/22, sampled pond water for IH&S analysis on 6/24
Jul 8, 2010	7.0	3.2	
Jul 12, 2010	–	7.3*	
Aug 5, 2010	8.8	5.0	Sampled pond for NH3, TDS, and U
Aug 12, 2010	8.9	4.17*	Shut down well field for CF5 work

Table C-1. Important Dates, Evaporation Pond Levels, and Activities Associated with the IA Treatment Systems During 2010 (continued)

Date	Pond Level (ft)	pH	Activity
Aug 26, 2010	8.0	–	Started pumping from all CF5 wells on 8/26
Aug 27, 2010	–	4.17*	
Sept 2, 2010	8.3	–	Break in 6 in line found on 8/30, repaired by 9/1
Sept 9, 2010	8.5	5.24*	
Sept 16, 2010	9.5	7.28*	
Sept 30, 2010	9.6	–	Sampled CF5 Extraction Wells 9/29 - 9/30
Nov 18, 2010	9.5	–	Injection pump shut down unexpectedly on 11/20
Nov 29, 2010	–	–	Injection system winterized on 11/22, CF5 winterized on 11/23
Dec 2, 2010	9.3	–	Power to well field shut off on 12/6 for surface remediation

*Average pH from multiple readings

Table C-2. Evaporation Pond Level and Volume for 2010

Date	Pond Level (ft)	pH	Volume of Water Stored In Pond (gal)
1/7/10	8.0	–	3,530,231
1/14/10	8.0	–	3,530,231
1/21/10	8.0	–	3,530,231
1/28/10	8.0	–	3,530,231
1/28/10	8.0	–	3,530,231
2/4/10	8.0	–	3,530,231
2/11/10	8.0	–	3,530,231
2/18/10	8.0	–	3,530,231
2/25/10	8.0	–	3,530,231
2/25/10	8.7	–	4,147,521
3/4/10	8.4	–	3,876,852
3/11/10	8.7	–	4,147,521
3/18/10	8.7	–	4,147,521
3/25/10	8.5	–	3,966,056
4/1/10	8.1	–	3,615,357
4/1/10	8.1	5.4	3,615,357
4/8/10	7.7	–	3,280,967
4/15/10	7.3	–	2,962,886
4/22/10	8.2	6.9	3,701,503
4/29/10	8.3	–	3,788,668
4/29/10	8.3	–	3,788,668
5/6/10	8.0	–	3,530,231
5/13/10	7.7	–	3,280,967
5/17/10	–	6.4	–
5/20/10	7.8	–	3,363,036
5/27/10	8.0	3.7*	3,530,231
5/27/10	8.0	–	3,530,231
6/2/10	–	4.83*	–
6/3/10	7.9	–	3,446,124
6/10/10	8.0	–	3,530,231
6/17/10	7.8	–	3,363,036
6/24/10	8.0	–	3,530,231
7/1/10	7.8	–	3,363,036
7/1/10	7.8	–	3,363,036
7/8/10	7.0	3.2	2,735,027
7/12/10	–	7.3*	–
7/15/10	7.8	–	3,363,036

Table C-2. Evaporation Pond Level and Volume for 2010 (continued)

Date	**Pond Level (ft)**	**pH**	**Volume of Water Stored In Pond (gal)**
7/22/10	8.0	–	3,530,231
7/29/10	8.5	–	3,966,056
7/29/10	8.5	–	3,966,056
8/5/10	8.8	5.0	4,239,782
8/12/10	8.9	4.17*	4,333,063
8/19/10	8.5	–	3,966,056
8/26/10	8.0	–	3,530,231
8/27/10	–	4.17*	–
9/2/10	8.3	–	3,788,668
9/2/10	8.3	–	3,788,668
9/9/10	8.5	5.24*	3,966,056
9/16/10	9.5	7.28*	4,914,152
9/23/10	9.1	–	4,522,682
9/30/10	9.6	–	5,014,567
9/30/10	9.6	–	5,014,567
10/7/10	9.6	–	5,014,567
10/14/10	9.7	–	5,116,003
10/21/10	9.7	–	5,116,003
10/28/10	10.0	–	5,426,423
10/28/10	10.0	–	5,426,423
11/4/10	9.8	–	5,218,457
11/10/10	9.7	–	5,116,003
11/18/10	9.5	–	4,914,152
12/2/10	9.3	–	–
12/2/10	9.3	–	–
12/9/10	9.0	–	–
12/16/10	8.7	–	–
12/22/10	8.5	–	–
12/30/10	8.5	–	–

Table C-3. Enhanced Evaporator Operations for September through November 2010

Date	Total Hours	Total GPM	Comments
9/23/10	1.0	125	
9/24/10	9.0	125	
9/27/10	5.5	125	
9/28/10	3.9	121	
9/29/10	5.7	122	
9/30/10	1.8	244	
10/15/10	4.2	100	
10/21/10	2.4	175	Operated both units
10/28/10	5.0	145	
10/29/10	6.0	145	
11/1/10	2.5	145	
11/2/10	4.2	145	
11/3/10	4.1	145	
11/4/10	4.5	145	
11/5/10	4.0	145	Operated both units
11/9/10	2.3	120	
11/17/10	5.5	120	Only one unit operable

Appendix D.
Surface Water Operations and Biota Monitoring

July 01, 2010
River Flow 7,290

Photo D-1. CF3 Intermediate Channel (view to south)

Photo D-2. Confluence of CF3 and CF 2 (view to northeast)

Photo D-3. CF2 Channel (view to south)

July 08, 2010
River Flow 4,890 cfs

Photo D-4. CF1 Channel (view to south)

Photo D-5. Confluence of CFs 1 and 4 (view to south)

Photo D-6. CF4 Channel (view to south)

July 22, 2010
River Flow 2,700 cfs

Photo D-7. CF4 Channel (view to north)

Photo D-8. CF4 Channel (view to south)

July 29, 2010
River Flow 3,470 cfs

Photo D-9. CF4 Channel; Initial Action Diverting Water Through Gravel Bar (view to north)

Photo D-10. CF4 Channel (view to south)

Photo D-11. CF4 Channel at CF1 Confluence (view to northeast)

August 03, 2010
River Flow 4,920 cfs

Photo D-12. CF4 Channel (view to north)

Photo D-13. CF4 Channel (view to south)

August 18, 2010
River Flow 4,280 cfs

Photo D-14. CF4 Channel (view to north)

Photo D-15. CF4 Channel (view to south)

August 31, 2010
River Flow 3,540 cfs

Photo D-16. CF4 Channel With Initial Action Piping (view to north)

Photo D-17. CF4 Channel With Initial Action Piping (view to south)

September 07, 2010
River Flow 2,890 cfs

Photo D-18. CF4 Channel With Initial Action Piping (view to north)

Photo D-19. CF4 Channel Towards Confluence With Initial Action Piping (view to north.

Photo D-20. CF4 Channel With Initial Action Piping (view to south)