HOMESTAKE
Grants Project

Homestake Mining Company of California

Jesse R. Toepfer
Closure Manager

21 November 2013

Mr. David Mayerson
Ground Water Quality Bureau
New Mexico Environment Department
1190 S. Saint Francis Drive
Santa Fe, NM 87505-4173

RE: Update on Treatment Activities at Homestake

Mr. Mayerson:

As a follow-up to our 7 November meeting with you and the NMED staff, I would like to provide you with an update on the status of the alternate treatment technologies that we are pursuing at the Grants Reclamation Project.

Enclosed with this letter, you will find several documents that should provide you with the information you requested. Additionally, you had also requested a copy of the rebound study that was completed in 2012. That study is also enclosed.

Lastly, per our discussions, please know that we intend to provide regular updates to your department such as the ones enclosed with this letter. We trust that these periodic communications will give NMED confidence with regard to the progress that Homestake is making toward remediating the site.

Should you have any questions, please feel free to call me directly at 505.290.3067.

Sincerely yours,

Jesse R. Toepfer
Closure Manager
HOMESTAKE MINING COMPANY OF CALIFORNIA

Enclosures (4)

xc: Mr. J. Giraudo, Barrick – SLC, UT; w/enclosures
Mr. B. Ferdinand, Barrick – SLC, UT; w/enclosures
Mr. P. Malone, Barrick – SLC, UT; w/enclosures
Mr. J. Indall, Comeau, Maldegen, Templeman & Indall – Santa Fe, NM; w/enclosures
Mr. G. Hoffman, Hydro-Engineering – Casper, WY; w/enclsoures
Mr. J. Buckley, Nuclear Regulatory Commission – Rockville, MD; w/enclosures
Mr. S. Appaji, US Environmental Protection Agency – Dallas, TX; w/enclosures

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HOMESTAKE MINING COMPANY OF CALIFORNIA

Grants Reclamation Project

Progress Summary: Microfiltration, LTP Tracer Testing, TPP Injections Research, CAP, DRP, Site-Wide Water Balance Tool, and Rebound Evaluation

Submitted On:
21 November 2013

Submitted To:
New Mexico Environment Department
United States Nuclear Regulatory Commission, Region IV
United States Environmental Protection Agency, Region 6

Submitted By:
Homestake Mining Company of California

ENCLOSURE 1

PROGRESS SUMMARY: MICROFILTRATION, LTP TRACER TESTING, TPP INJECTIONS RESEARCH, CAP, DRP, SITE-WIDE WATER BALANCE TOOL, AND REBOUND EVALUATION

HOMESTAKE MINING COMPANY OF CALIFORNIA

Grants Reclamation Project

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Introduction

Homestake has prepared this summary as a means to keep the key regulatory agencies apprised of the remediation progress that has occurred and continues to occur at the Grants Reclamation Project.

Microfiltration Pilot

Homestake retained the services of ARCADIS to conduct an evaluation of the capacity of the reverse osmosis (RO) water treatment plant (WTP) from 2011 to 2012.

The results indicated that the solids contact clarifier (SCC) and RO were capable of treating a nominal throughput capacity of 600 gallons per minute (gpm), and the limiting process in the plant was the sand filters which have a capacity of approximately 450 gpm. This, however, limited the RO treatment capacity to 300 gpm, because at that flow rate, only one RO skid can be operated (Figure 1 below).

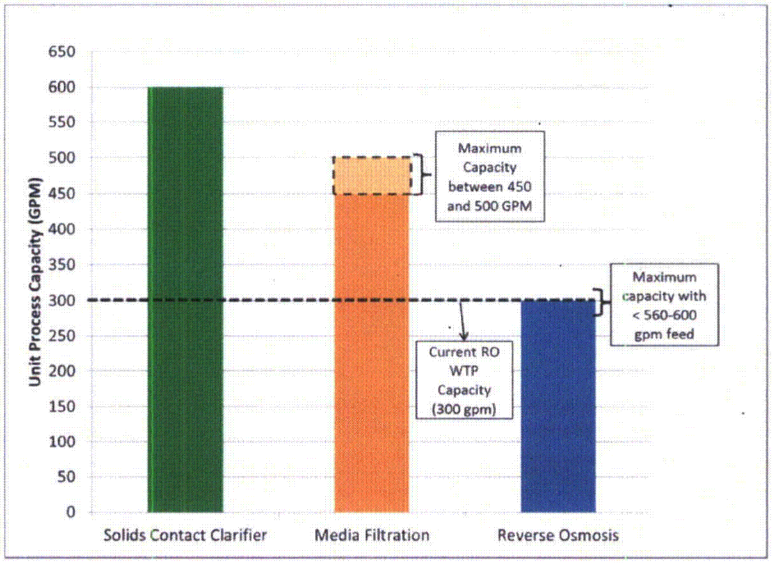

Figure 1. Unit Process Capacity.

Recommendations from the evaluation of low pressure membrane filtration were focused on accomplishing the following goals:

- Restore the RO plant to its design rated treatment capacity of 600 gpm
- Protect RO elements and reduce operation and maintenance costs
- Provide the ability to treat lower quality water.

ARCADIS initiated low pressure membrane pilot testing in August of 2013. While still ongoing and still being evaluated, the preliminary results following eight weeks of testing indicate the low pressure membrane technology can successfully accomplish the three goals listed above.

Pilot testing is scheduled to be completed in December. The "basis of design" report for implementation of the membranes into the existing RO WTP, which encompasses design through approximately 30%, is also scheduled for completion in December.

LTP Tracer Testing

Multiple applied tracer tests have been implemented in the large tailings pile (LTP) to refine the conceptual site model (CSM), evaluate the properties of tailings pore-water flow, and use the results to evaluate and optimize the LTP injection and recovery program.

These activities have been conducted to address comments from the US Army Corps of Engineers (ACOE) made during the EPA Remedial System Evaluation (RSE) Addendum in 2010. Tracer testing was also performed to collect hydraulic information necessary for the design of LTP tripolyphosphate (TPP) pilot testing (TPP, a soluble, injectable form of phosphate, is being evaluated for its application for in-situ treatment of uranium).

A total of four applied tracer tests have been implemented:

1. TPP Pilot 1 (Q4 2010)
2. TPP Pilot 2 (Q4 2010)
3. Sulfur hexafluoride (SF_6) Tracer (Q1 2011)
4. LTP Tracer 2 (Q2 2013)

TPP Pilot 1 area is primarily fine-grained material (slimes) located in the NW quadrant of the LTP; TPP Pilot 2 area is located in the SE quadrant of the LTP (in the sand berm) and consists primarily of medium-to coarse-grained material (sands). Bromide and a fluorescent tracer (fluorescein) were used for both tests which consisted of injecting 20,000 and 5,000 gallons of tracer solution, followed by tracer monitoring at wells immediately adjacent to the injection point for six months. Test results confirmed the hydraulic connection of injection and monitoring points, determined the injected volume and radius of influence relationship, and estimated reagent dilution and transport. The results were also applied to understanding the LTP flow regime and updating the LTP CSM.

A third tracer test using dissolved gas (SF_6) was implemented in the NW quadrant of the LTP where the injection and recovery program has been successful at reducing uranium concentrations in pore water. (This test was performed in support of the rebound evaluation, discussed below.) Tracer breakthrough was rapid (approximately 2 weeks) and the calculated transport velocities estimated from breakthrough were 3 to 5 feet per day (ft/d), which is significantly higher than previous estimates.

The CSM was updated with the understanding that the majority of injected water travels through a relatively small fraction of the tailings (approximately 5%) at reasonably fast velocities.

The fourth tracer test (LTP Tracer 2) was implemented in the NE quadrant of the LTP where injection and recovery performance, as measured by uranium concentration decreases in pore water, has been relatively slow. LTP Tracer 2 was implemented using fluorescein followed by tracer monitoring at wells immediately adjacent to the injection point for five months; monitoring is currently ongoing. Tracer breakthrough was observed at three monitoring wells during injections and three additional monitoring wells after injections.

Preliminary results indicate that transport velocities are still relatively high (0.5 to 3 ft/day) and comparable to the SF_6 results. However the difference in injection and recovery performance is likely attributable to the magnitude and rate of mass transfer from the slimes to the sands where injection and recovery occurs.

Rebound Evaluation

This work focused on the evaluation of the constituent concentrations in the LTP that are expected to be realized upon completion of the injection and recovery program. The objective of the injection/recovery program in the LTP is to reduce constituent concentrations to a level that will prevent the LTP from being a long-term source to groundwater during gravity drain-down of the pile. Once the concentration of uranium reaches an average of 2 mg/L within the pile, the injection and recovery program is expected to cease.

A rebound evaluation was performed between December 2010 and May 2012 to evaluate constituent concentrations after injection/recovery operations cease. These activities have been conducted to address comments from the ACOE made during the 2010 RSE Addendum.

First, a tracer test was conducted, followed by cessation of injection and recovery in a prescribed area, and 1-year of constituent monitoring. Nine wells were monitored for uranium, molybdenum, selenium, calcium, alkalinity, pH, sulfate, and total dissolved solids. Tailings solids were also evaluated in the lab for the ease at which uranium could be leached.

The key takeaways from the rebound study are as follows:

- The tracer test indicated that diffusive mass transfer rates into and out of the lower permeability zones are low, and therefore, post-injection/recovery rebound caused by back diffusion is expected to be minimal.
- This result, combined with laboratory test results that showed the majority of uranium in the tailing solids is not easily leached, indicates that the uranium remaining in the pile is hydraulically and chemically bound.
- Water levels were monitored in the rebound evaluation area and a decrease of up to 16 feet was observed; this provides validation that the conditions established were representative of post-injection/recovery.
- Concentrations over time indicate widespread rebound of key water quality parameters did not occur.

These data show that significant rebound of the constituents is not expected after the LTP water injection and recovery program ends and that constituent reductions achieved will be sustained long-term.

Tripolyphosphate Pilot Testing

The objective of the TPP alluvial pilot test is to evaluate the suitability of injection of soluble phosphate (TPP) into groundwater for *in-situ* treatment of uranium. This treatment approach results in rapid immobilization of uranium in the ground and does not create secondary waste materials that require disposal. This alternative groundwater treatment technology is described in the CAP as undergoing evaluation. As described above, TPP test work was completed first in the LTP, and then in the alluvial groundwater system within the hydraulic barrier.

Approval to conduct TPP pilot-testing in the alluvium was received by NMED in February 2013. Two areas were targeted for alluvial TPP pilot testing: the "S-area," which is located west of the large tailings pile (LTP), has a relatively high groundwater velocity, and large saturated zone; and the "X-area," which is located east of the LTP, has a relatively low groundwater velocity, and small saturated zone.

Well installation activities occurred in April 2013, targeting 35 to 45 feet below ground surface [ft bgs] in the X-area and 55 to 75 ft bgs and 75 to 95 ft bgs in the S-area. Tracer testing using a fluorescent dye tracer was completed in July 2013 to estimate mobile porosity and confirm the general groundwater flow direction in each pilot area. A second round of well installations occurred in July 2013 to complete the monitoring network in both pilot areas.

TPP injections began in August 2013 and are summarized as follows:

- S-area: 16,000 gallons of reagent chemicals were injected, including 13,000 gallons of sodium tripolyphosphate and 3,000 gallons of calcium chloride.
- X-area: 5,500 gallons of reagent chemicals were injected, including 4,000 gallons of sodium tripolyphosphate and 1,500 gallons of calcium chloride.

Baseline monitoring was conducted prior to initiating injections. Performance monitoring is currently ongoing. To date, up to 96% of the uranium was removed from the dissolved phase in the S-area; the uranium concentration dropped from 1.44 milligrams per liter (mg/L) to 0.047 mg/L (at 15 days post injection). In the X-area, 58% of the uranium was removed from the dissolved phase; the uranium concentration dropped from 5.25 mg/L to 2.30 mg/L (at 15 days post injection).

Performance monitoring will continue through 120 days post-injection (January 2014) to evaluate residual treatment capacity as well as to evaluate whether the precipitated uranium can re-dissolve. Arsenic and phosphorus concentrations increased slightly above baseline as expected, but they did not exceed specific concentration limits required by NMED and the concentration increase remained highly localized near the injection well.

NMED's approval required completion of two tasks: evaluate the stability of the treated uranium through a "push-pull" test, and perform soil coring to further evaluate the insoluble uranium phosphate minerals. Both of these activities will be completed in the 2nd Quarter 2014. A final report detailing performance and results will be submitted in June 2014.

Sitewide Water Balance Tool

Work on a site-wide water balance tool began in 2011, and is currently ongoing. The impetus behind the site-wide water balance tool stems from a comment made by the ACOE during the 2010 RSE addendum. The purpose of the tool is to help illustrate how water and brine is managed at the site. It can also be used as a decision making tool to help evaluate and effectively manage water/waste streams.

The tool has been updated so it contains flow and water quality information, site-wide flow and uranium loading, LTP flow and uranium loading, and RO WTP flow and uranium loading.

The tool is currently undergoing testing and validation using site data prior to finalizing.

Corrective Action Program

On March 15, 2012, HMC submitted a 2012 revised Updated Corrective Action Plan (2012 Updated CAP), to the US Nuclear Regulatory Commission (NRC). This new CAP is a second revision of the HMC 2006 CAP.

On June 7, 2012, the NRC held a public meeting in Grants, New Mexico for the purpose of receiving comments on the revised 2012 Updated CAP. As a result of this meeting and in response to requests from the public, EPA, and NMED, the comment period was extended from 60 days to eight months. The review of the 2012 Updated CAP has been extended due to substantial revisions and to incorporate EPA and NMED requirements, as well as to address public comments.

Decommissioning and Reclamation Plan

HMC submitted an updated Decommissioning and Reclamation Plan (DRP Update 2013) to the NRC on April 4, 2013. The purpose of the 2013 DRP is to update and revised the previous reclamation plan dated October 1993, which summarize the site reclamation and decommissioning activities that occurred between 1993 and the date of submittal of the updated plan. The updated DRP describes the remaining site decommissioning and reclamation tasks necessary to terminate HMC's license. The 2013 DRP also provides supporting basis for the groundwater reclamation schedule provided in the HMC 2012 Updated CAP, which is currently under review by the NRC.

Due to requests for additional review time by public entities, the NRC (as of October 24, 2013) reported the agency would be extending the public comment period by an additional 90 days to ensure that the public has sufficient opportunity to participate in the DRP Update 2013 review process. The public review process is currently ongoing.

ENCLOSURE 2

ZEOLITE PILOT STUDY TEST AND RESULTS

RESOURCE INVESTIGATION AND
MANAGEMENT CONSULTANTS, LLC

RIMCON, LLC
INDUSTRIAL MINERAL TECHNOLOGIES

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300 GPM ZEOLITE-BASED WATER TREATMENT SYSTEM PILOT TEST RESULTS

Prepared For:

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Prepared By:

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November 19, 2013

RIMCON ZEOLITE-BASED 300 GPM WATER TREATMENT SYSTEM 2013 PILOT TEST RESULTS

Executive Summary

RIMCON developed a proprietary natural zeolite-based water treatment process to be used to remove uranium from the Grants Reclamation project waters. Natural zeolites are altered volcanic hydrated aluminosilicate minerals that are negatively charged. As such, they are capable of adsorbing large concentrations of cations from water streams. The goal of the testing was to remove uranium from site feed waters to levels below the uranium site standard of 0.16 mg/L in the alluvial aquicfer. The successful removal of uranium from site waters will assist Homestake (HMC) with the remediation of the Grants site.

The treatment design consists of three zeolite filled cells that can be operated in sequence. Influent waters are passed through a primary treatment zeolite cell and routed into a secondary cell for uranium polishing. After treatment in the secondary cell, the water was discharged for use in rinsing of the site large tailings pile. Uranium concentrations and pH were routinely measured in the field and at a laboratory to monitor the efficiency if the system and to make field operational adjustments.

Pilot testing was conducted for approximately 5 weeks in September and October, 2013. The site water that was treated was comprised of the Upper Chinle Aquifer well water (CE wells) and the South collection wells that had a combined uranium concentration averaging 1.85 mg/L. After one week of testing, the CE well water was diverted for other uses and the testing continued with the South Collection well water. The average uranium concentration of this water was 0.40 mg/L. Test water flow rates ranged from 140 gpm to 275 gpm.

For approximately the first four weeks of testing, the discharge from the secondary zeolite treatment cell (Cell #2) averaged **0.065 mg/L**, well below the site standard of 0.16 mg/L. At no time during this period did the treated uranium concentration exceed the site standard. For the first four weeks of pilot testing, the process successfully treated 66,475,000 gallons of water for uranium removal.

The treated water was also analyzed for the site alluvial aquifer standards to determine if the treatment process had any effect on the water quality going to discharge. The table below summarizes the results of the site standard testing.

Alluvial Aquifer Site Standards: Before and After Zeolite Treatment

Constituent	Unit	Alluvial Aquifer Site Standard	South Collection Well Average	Zeolite Cell #2 Discharge Avg.	Comment
Selenium	mg/L	0.32	0.041	0.042	No change after treatment
Uranium	mg/L	0.16	0.40	0.058	Reduced after treatment
Molybdenum	mg/L	0.10	0.022	0.030	No change after treatment
Sulfate	mg/L	1500	737	1115	Slight increase but well below std.
Chloride	mg/L	250	188	181	No change after treatment
TDS	mg/L	2734	1720	1895	Slight increase but well below std.
Nitrate	mg/L	12	2.50	2.43	No change after treatment
Vanadium	mg/L	0.02	Non-detect	Non-detect	No change after treatment
Thorium 230	piC/L	0.3	Non-detect	Non-detect	No change after treatment
Ra 226 + Ra 228	piC/L	5	Non-detect	Non-detect	No change after treatment

Note: The sample averages reported above are from 2 sample periods: 09/26/2013 and 10/10/2013.

Results of the testing show that the zeolite process does not have any effect on the concentration of selenium, molybdenum, chloride, nitrate, radium, vanadium, and thorium. The process is successful in consistently reducing uranium levels below site standards. Sulfate concentrations increase as a result of the process due to the addition of sulfuric acid, but are well below site standards. The TDS also increases slightly after treatment, again due to the addition of sulfuric acid.

This process will allow HMC to successfully treat large quantities of slightly contaminated water, and reduce Homestake's reliance on San Andres fresh water for remediation purposes. Since the process does not affect the concentration of site standard constituents, the treated water has multiple uses. These uses include the continued injection into the large tailing pile for rinsing or for injection back into the alluvial aquifer. Results of this test, as well as previous tests, provide reliable justification that the process is ready to go to full-scale operation.

1.0 BACKGROUND

RIMCON, LLC has been developing a new 300 gpm (capacity up to 400 gpm) zeolite-based water treatment system at the Homestake Mining Company (HMC) Uranium Mill Site near Grants, New Mexico. The zeolite process is designed to remove uranium from slightly contaminated water originating from several site water sources. Natural zeolites are a microporous, negatively-charged, hydrated aluminosilicate volcanic mineral with unique sieving and cation exchange properties. They consist of open, three-dimensional cage-like structures with a vast network of open channels extending throughout the structure. Positively charged cations can adsorb to the negatively charged aluminosilicate lattice structure. The zeolite species used in this testing is Clinoptilolitem, and has a chemical formula as follows:

$$\mathbf{(Ca, K_2)(Al_6SiO)24H_2O}$$

Previous testing and development of the zeolite process included laboratory bench column testing, field column testing, operation of a 5-gallon per minute (gpm) onsite pilot test system, and operation of a 50 gpm pilot system located on top of the site large tailing pile. Water from this previous testing came largely from the Upper Chinle aquifer. The results of this testing were previously submitted to HMC, upon the review of which, caused sufficient interest in the technology to warrant further pilot testing. HMC then built a larger 300 gpm pilot system, in close proximity to the 50 gpm system, also on top of the large tailings pile.

Construction of the new zeolite system for uranium removal began in 2012, in the approximate center of the large tailings pile (LTP), and was completed in early fall, 2013. The system was designed to treat an average of 300 gpm. While the previously tested 50 gpm system was designed and built with two treatment cells, the new larger system was designed with 3 treatment cells to add operational flexibility. In addition, a water pump back system was added to allow flexibility in the system's service operations.

Attached Figure 1.0 depicts the configuration of the typical process facility, including, general piping and water flow features, process control building, and support features.

2.0 PILOT TEST PROCEDURES

Water from both the Upper Chinle aquifer CE wells and from the South Collection wells, previously used to supply the site irrigation systems, were piped to the new system for treatment. While the system is designed to meet the site alluvial aquifer standards for uranium (0.16 mg/L), laboratory analyses for other site standards were also obtained. Those parameters include selenium, molybdenum, sulfate, chloride, total dissolved solids, nitrate, vanadium, thorium-230, and radium 226 + radium 228. Discussion on the results of these other site standards is presented in Section 4.0.

Initial system testing utilized a combination of the Upper Chinle CE wells used in previous testing and the addition of the South Collection wells comprised of both Upper Chinle aquifer and alluvial aquifer waters. The average uranium concentration of the CE Well water ranged from 2.7 to 3.5 mg/L. The average uranium concentration of the South Collection wells ranged from 0.35 to 0.50 mg/l.

Zeolite was prepared for pilot testing by conducting an initial weak acid regeneration to remove dominant natural cations from the zeolite exchange complex. Regeneration and rinse volumes were piped to Evaporation Pond #2 for storage and evaporation. Initial raw regeneration laboratory data for uranium, pH, and bicarbonate is provided in attached Table 1.0.

Initial system startup and primary treatment began in Cell #1 on September 9, 2013 and secondary treatment through Cell #2 began on September 11, 2013. Raw water was supplied to the system from both the CE well field and the South Collection well field. Test parameters were monitored on site by HMC personnel and remotely by RIMCON. Monitored parameters included raw water pH, acid modified feed water pH, Cell #1 pH, Cell #2 pH, feed flow rate, and acid consumption usage.

3.0 URANIUM ADSORPTION TEST RESULTS

Laboratory test results for uranium adsorption are presented in attached Table 1.0. Initial water flows tested through the system were from the combined CE wells and the South Collection wells and the tested flow rate was averaged 275 gpm. The combined uranium concentration was 1.85 mg/L. The testing of the mixed water supply lasted only a few days due to the CE well water being transferred for use elsewhere. During this short test period, the average uranium concentration from Cell #2 going to discharge and injection was 0.067 mg/L. Based on totalizer flow rates, approximately 1,386,000 gallons of water were treated for injection into the large tailings pile.

Once the CE well water was diverted away from the system, South Collection water was used for testing. Initially, the feed water flow rate to the system was 140 gpm, pending startup of additional wells. The system operated at this flow rate for approximately 2 weeks and the average uranium concentration of the untreated water for this period was 0.45 mg/L. For this approximate 2 week period, the average uranium concentration going to discharge from Cell #2 was 0.065 mg/L with a range of 0.044 to 0.097 mg/L. Approximately 26,208,000 gallons of South Collection water was treated during this period. Attached Figure 2.0 shows the plotted uranium treatment data for this period.

At approximately 4 weeks of testing, additional wells from the South Collection field were added to the feed flow rate, increasing to an average flow rate of just over 270 gpm. Again, the average concentration of uranium in the feed was around 0.40 mg/L. The system was operated at this flow rate for approximately 10 days, treating about 38,880,000 gallons. For the first week of this operation, the average uranium concentration of the Cell #2 discharge water was 0.058 mg/l. Again, attached Figure 2.0 shows the plotted uranium concentrations for the first approximately 4 weeks of successful operation.

After the conclusion of the above test period, the treating efficiency decreased significantly with the Cell #2 uranium discharge increasing to 0.229 mg/l, about two-thirds the inflow concentration.

The explanation for this is as follows:

Referring to attached Figure 2.0, the upward trend in uranium can be observed. A black bar on the graph shows where the successful treatment ends and the upward trend begins. While the upward trend may be the result of loading of the zeolite, issues with operational flows and offgassing were the likely cause of the upward trend. During this later test period, a leak in the bottom of the acid metering pump was diverting acid from the system. The result is that the feed pH was higher than desired and consequently the feed bicarbonate levels were also higher than necessary for efficient adsorption of uranium. As discussed in previous reports, in order for efficient adsorption to occur, the bicarbonate levels must be very low to non-detect. The pH of the system allows for control over the bicarbonate levels with a desired pH level being less than 5.5. Referring to attached Figure 3.0, the pH levels can be observed and shows that as the uranium adsorption decrease, the pH was at levels in excess of desired. Again, a black bar on the graph shows when this tend begins.

Attached Figure 4.0 depicts the laboratory bicarbonate levels for the testing timeframe. Note that with the decreasing uranium adsorption and the increasing pH, the bicarbonate levels for this last few days of testing also increased to unacceptable levels. A black bar on the graph shows this time frame. The preferred bicarbonate level is at or near 0.0 mg/L.

For the first 4 weeks of operation the system successfully treated approximately 66,475,000 gallons of water to a weighted average discharge concentration of 0.065 mg/L, well below the site standard of 0.16 mg/L. Additional improvements in operation treatment efficiencies can be achieved. The following sections discuss procedures necessary for improvement of the operating efficiencies and additional testing recommendations.

4.0 ALLUVIAL AQUIFER SITE STANDARDS

As part of the pilot test procedures, laboratory samples were taken to ascertain the effect of the treatment process on the constituents of the alluvial aquifer site standards. Those constituents are selenium, uranium, molybdenum, sulfate, chloride, total dissolved solids, nitrate, vanadium, thorium 230 and radium 226 Plus radium 228. The pilot test results for uranium adsorption are described in the previous section.

The table below summaries the results of the site standard testing.

Alluvial Aquifer Site Standards: Before and After Zeolite Treatment

Constituent	Unit	Alluvial Aquifer Site Standard	South Collection Well Average	Zeolite Cell #2 Discharge Avg.	Comment
Selenium	mg/L	0.32	0.041	0.042	No change after treatment
Uranium	mg/L	0.16	0.40	0.058	Reduced after treatment
Molybdenum	mg/L	0.10	0.022	0.030	No change after treatment
Sulfate	mg/L	1500	737	1115	Slight increase but well below std.
Chloride	mg/L	250	188	181	No change after treatment
TDS	mg/L	2734	1720	1895	Slight increase but well below std.
Nitrate	mg/L	12	2.50	2.43	No change after treatment
Vanadium	mg/L	0.02	Non-detect	Non-detect	No change after treatment
Thorium 230	piC/L	0.3	Non-detect	Non-detect	No change after treatment
Ra 226 + Ra 228	piC/L	5	Non-detect	Non-detect	No change after treatment

Note: The sample averages reported above are from 2 sample periods: 09/26/2013 and 10/10/2013.

Samples were taken from the raw South Collection well feed water and from the discharge line from the secondary treatment zeolite cell at discharge. Review of the data above shows that the zeolite treatment process did not have any effect on selenium, molybdenum, chloride, nitrate, radium, vanadium, and thorium-230. As described in the previous section, the process was successful in reducing the uranium concentrations significantly below the alluvial aquifer site standard of 0.16 mg/L.

Sulfate concentrations increased approximately 50% over the south collection well average after zeolite treatment, but are well below the site standard. Sulfuric acid is used in the process and results in an increase of sulfate concentration. The TDS concentration increased slightly over the south collection well concentration, again due to the use of sulfuric acid during operation.

5.0 DISCUSSION

While the first approximate 4 weeks of testing were very successful, improvement in treatment efficiencies and lowering of the discharge uranium concentrations can be achieved. Referring to Figure 2.0, the uranium adsorption in Cell #1 was not efficient as compared to Cell #2. Better adsorption in Cell #1 would have resulted in increased adsorption efficiencies in Cell #2. The initial regeneration of Cell #1 was not as effective as that in Cell #2.

When the acid was added to the regeneration tanks for the first Cell #1 regeneration, measurement of the acid was based on increases in the tank level noted on the regeneration tank manifold, because the electronic tank volume readout was not yet operational. Insufficient acid was added to the tanks to insure proper regeneration. Following the Cell #1 regeneration, the acid tank level indicator was installed and operational, and the exact volume of acid added was correctly metered.

While the testing bicarbonate levels were sufficiently low to achieve good operating results for the first 4 weeks of testing, the bicarbonate levels in the feed water was often above 60 mg/L at times. It is important to the process efficiency to ensure that bicarbonate levels are at, or near, non-detect levels. Ensuring the bicarbonate levels are at or near 0.0 mg/L increases the adsorption efficiencies, particularly in Cell #2.

6.0 SUMMARY

The RIMCON zeolite-based water treatment technology for the removal of uranium was tested for approximately 5 weeks in September and October, 2013. Natural zeolites originate from altered volcanic rocks and are comprised of hydrated aluminosilicates that are capable of adsorbing cations, in this case uranium, from site waters. The goal of the testing was to remove uranium from site feed waters to levels below the uranium site standard of 0.16 mg/L.

The pilot study was successful, and provides reliable justification to proceed with a full-scale operation.

The site water that was treated was comprised of the Upper Chinle Aquifer well water (CE wells) and the South collection wells that had a combined uranium concentration averaging 1.85 mg/L. After one week of testing, the CE well water was diverted for other uses and the testing continued with the South Collection well water. The average uranium concentration of this water was 0.40 mg/L. Test water flow rates ranged from 140 gpm to 275 gpm. For approximately the first 4 weeks of testing the discharge from the secondary zeolite treatment cell (Cell #2) average 0.065 mg/L, well below the site standard of 0.16 mg/L. At no time during this period did the treated uranium concentration exceed the site standard. For the first 4 weeks of pilot testing, the process successfully treated 66,475,000 gallons of water for uranium removal.

The treated water was also analyzed for the site alluvial aquifer standards to determine if the treatment process had any effect on the water quality going to discharge. The constituents analyzed were selenium, uranium, molybdenum, sulfate, chloride, total dissolve solids, nitrate, vanadium, thorium 230, and radium 226 plus 228. Results of the testing show that the zeolite process does not have any effect on the concentration of selenium, molybdenum, chloride, nitrate, radium, vanadium, and thorium. As described above, the process is successful in consistently reducing uranium levels below site standards. Sulfate concentrations increase as a result of the process due to the addition of sulfuric acid but are well below site standards. The TDS also increases slightly after treatment, again due to the addition of sulfuric acid.

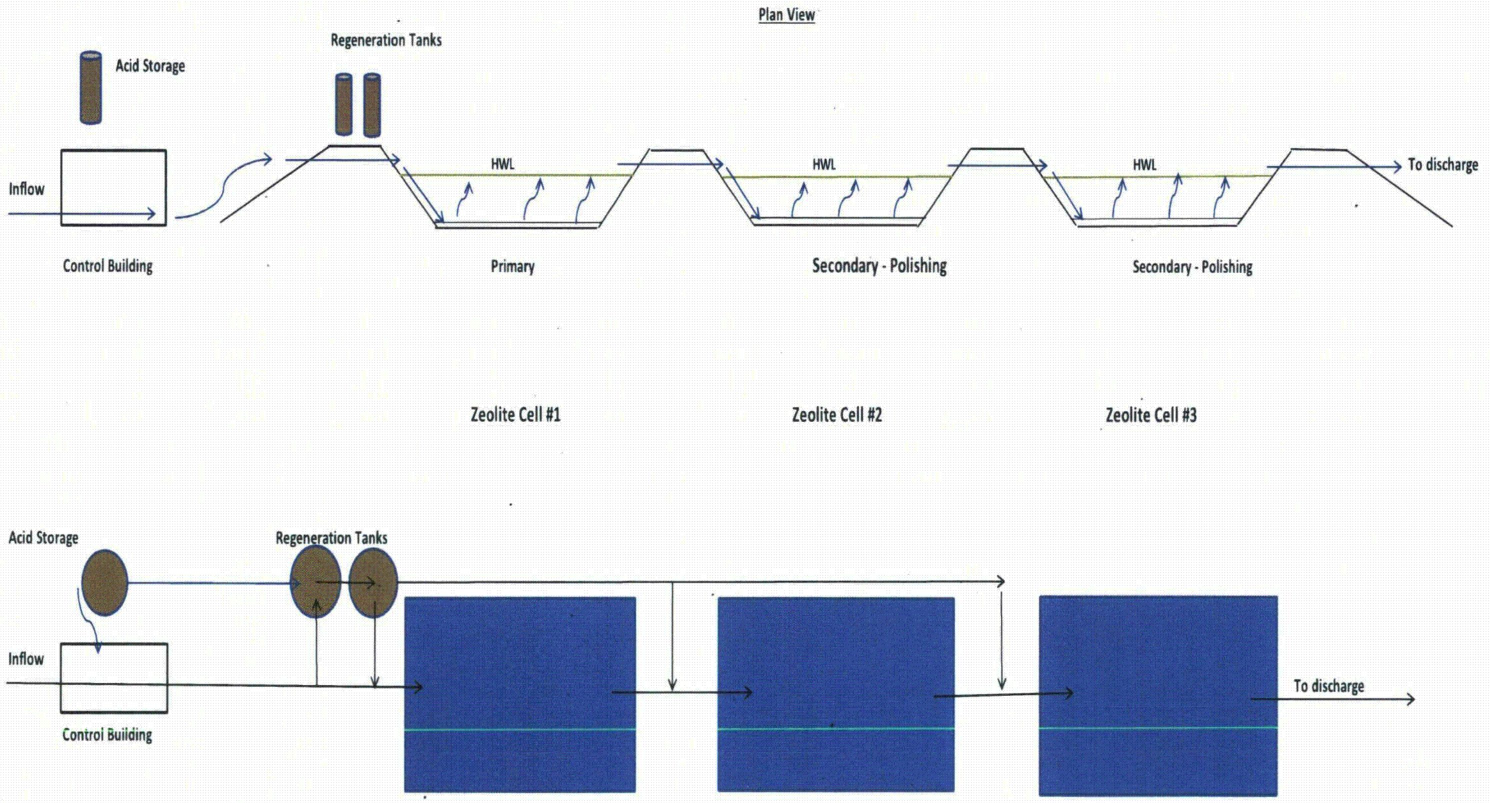
The concentration of uranium, while significantly below site standards, can be reduced further with additional modification of the operating procedures. Further reduction, or elimination, of bicarbonate levels will occur when the acid metering process is refined. The reduction of the bicarbonate will free up additional uranium for adsorption on the zeolite exchange complex.

This process will allow HMC to successfully treat large quantities of slightly contaminated water, and reduce Homestake's reliance on San Andres fresh water for remediation purposes. Since the process does not affect the concentration of site standard constituents, the treated water has multiple uses. These uses include the continued injection into the large tailing pile for rinsing or for injection back into the alluvial aquifer.

Table 1.0 Pilot Test Laboratory Data

Sample Name	Date Sampled	Time Sampled	pH	TDS mg/L	HCO3 mg/L	Cl mg/L	NO3 mg/L	SO4 mg/L	Mo mg/L	Se mg/L	Diss. U mg/L	V mg/L	Ra 226 pCi/g	Ra 228 pCi/g	Th 230 pCi/g
South Coll.	9/26/2013	8:00 AM	7.36		497						0.377				
300 Feed - 200	9/26/2013	8:10 AM	5.84		62.8						0.359				
300 Z1 - 200	9/26/2013	8:10 AM	5.48		14.6						0.123				
300 Z2 - 200	9/26/2013	8:15 AM	5.98		20.2						0.044				
300 Z2 - SS	9/27/2013	11:00 AM	5.77	1950	21.3	178	2.34	1160	0.023	0.041	0.058	< 0.005	ND	ND	-0.045
South Coll. - SS	9/27/2013	11:00 AM	5.72	1740	21.2	185	2.46	695	0.022	0.039	0.058	< 0.005	ND	ND	-0.011
300 Z2 - 270	9/27/2013	11:00 AM	5.7		30.8						0.098				
300 Z1 - 270	9/27/2013	11:00 AM	5.28		28.1						0.26				
300 Feed - 270	9/27/2013	11:00 AM	5.94		67.4						0.305				
South Coll.	10/1/2013	10:18 AM	7.21		489						0.399				
300 Feed	10/1/2013	10:21 AM	6.36		142						0.394				
300 Z-1	10/1/2013	10:24 AM	6.17		104						0.34				
300 Z-2	10/1/2013	10:27 AM	6.36		97.5						0.229				
South Coll.	10/3/2013	1:26 PM	7.47		501						0.395				
300 Feed	10/3/2013	1:28 PM	6.38		144						0.328				
300 Z-1	10/3/2013	1:31 PM	6.31		131						0.385				
300 Z-2	10/3/2013	1:33 PM	6.56		136						0.489				
South Coll. - SS - Ra	10/10/2013	10:00 AM													
300 Z2 - SS - Ra	10/10/2013	10:03 AM													
South Coll. - Th	10/10/2013	10:08 AM													
300 Z2 - SS - Th	10/10/2013	10:15 AM													
South Coll. - SS - U	10/10/2013	10:10 AM													
300 Z2 - SS - U	10/10/2013	10:18 AM													
300 Feed	10/10/2013	10:21 AM	5.98		71.7						0.296				
300 Z-1	10/10/2013	10:23 AM	6.69		136						0.286				
South Coll. - SS	10/10/2013	10:05 AM	7.53	1700	459	190	2.53	778	0.022	0.043	0.327	0.005	ND	ND	ND
300 Z2 - SS	10/10/2013	10:13 AM	7.64	1840	149	183	2.52	1070	0.037	0.044	0.425	< 0.005	ND	ND	0.012
300 Z-1 Regen 1	10/22/2013	10:20 AM	1.66												
300 Z-1 Regen 2	10/23/2013	9:20 AM	1.69												
300 Z-1 Regen 3	10/23/2013	11:20 AM	1.68												

Figure 1.0 - Natural Zeolite Based Uranium Treatment System



Schematic View

Normal Operating Sequence

Cell #1 to Cell #2 to Discharge
Cell #2 to Cell #3 to Discharge
Cell #1 to Cell #3 to Discharge

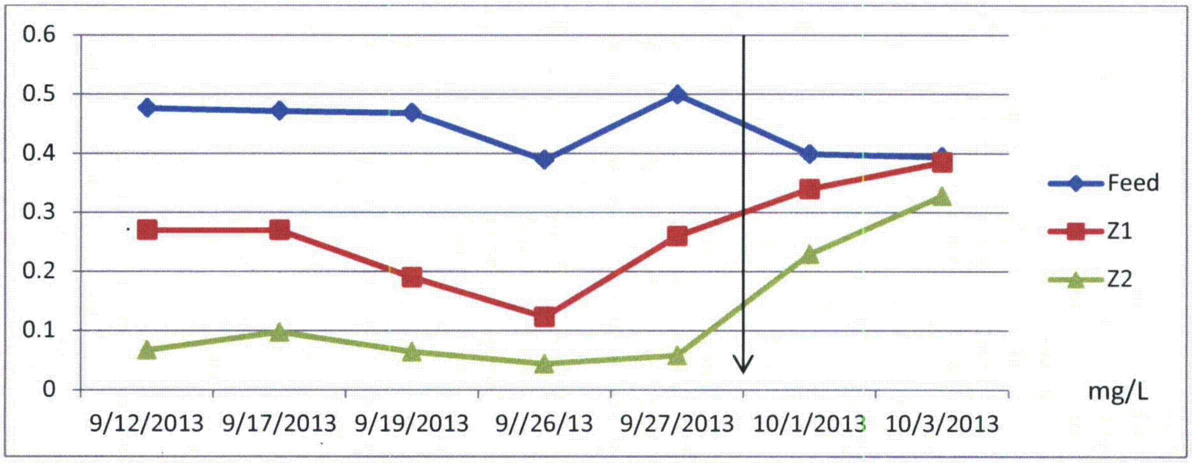


Figure 2.0 – Uranium Adsorption Test Data

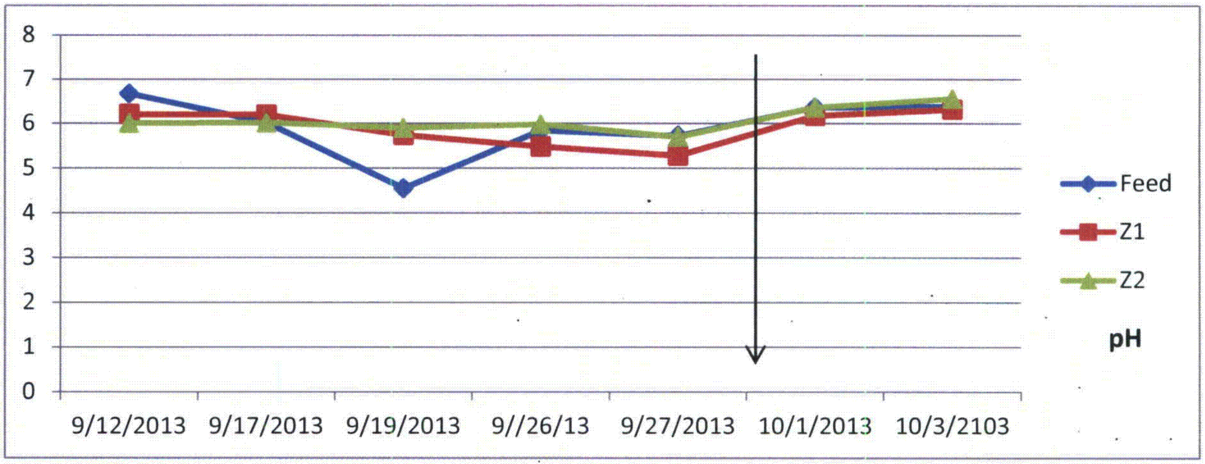


Figure 3.0 – pH Test Data

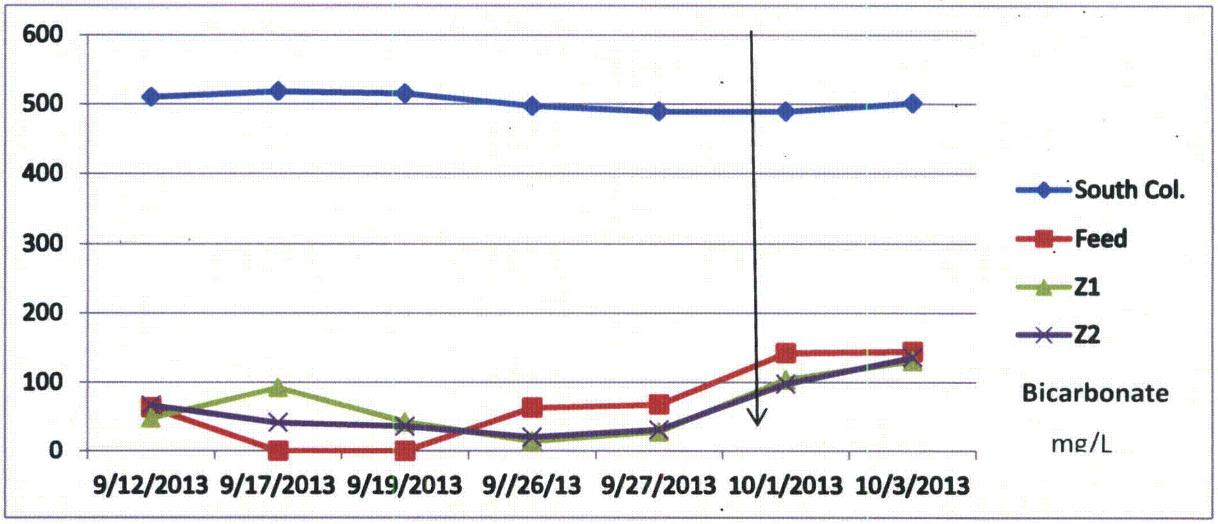


Figure 4.0 – Bicarbonate Test Data

ENCLOSURE 3

ELECTRIC-COAGULATION PILOT STUDY TEST AND RESULTS

CleanWave®
Water Treatment Solutions

Electrocoagulation Treatment of Uranium Impaired Ground Water: Homestake Mining Company of California

Charles R. Landis and Denney Eames

November 1, 2013

Executive Summary

Baroid IDP implemented an electrocoagulation (EC) process to treat contaminated ground water at the Homestake mill site near Milan, New Mexico. The goals of the project were to

- Use EC to remove relatively low concentrations of uranium (U-238) and other chemical components from a dewatering well field
- Estimate the operational parameters for full scale, steady-state water treatment operations
- Demonstrate a complex treatment solution

This project was completed within Homestake's safety targets, cost requirements, and treatment targets. Operations were performed in a safe work environment: no lost time or reportable incidents and compliance with ALARA (as low as reasonably achievable). The EC treatment process repeated its capability to remove critical contaminants from the mill site waters.

On September 16, 2013, the project began with a five day set-up schedule, followed by 20 day operational schedule — four 5-day weeks of continuous operation with the option of working on Saturdays if required. We projected 960,000 gallons of water for treatment during the steady-state phase of the project. During week three, one ion exchange resin chamber was regenerated (restored for reuse) over 1 day. During the project (about halfway), we spent one day evaluating molybdenum flocculation (how sufficiently these particles clumped together for easier removal). However, the treatment schedule was continuous— no mechanical failure of CleanWave®. After the demonstration, all the EC equipment was decontaminated and certified for free release.

Executive Summary Table 1 illustrates the overall performance of the EC system with regard to the constituents of concern in the Alluvial aquifer.

Executive Summary Table 1. Comparison of various water chemistries for the major analytes of interest.

Parameter	Project Influent Average	Project Effluent Average	Alluvial Aquifer Standard	Effluent Compliance
Uranium **(mg/l)**	3.02	0.026	0.16	YES
Molybdenum **(mg/l)**	2.20	0.864	0.10	NO
Selenium **(mg/l)**	0.14	0.172	0.32	YES
Sulfate **(mg/l)**	978	1008	1500	YES
Chloride **(mg/l)**	198	515	250	NO
TDS **(mg/l)**	2,279	2647	2734	YES

* Note: The increase in chlorides is due to the addition of hydrochloric acid (HCl), which was added to address molybdenum concentrations; were this unit to have been operated in circumstances where molybdenum was not a concern, the chloride levels would have remained approximately constant.

CleanWave® set-up time was on target. Although the steady-state phase (treatment) required two additional days, we gained time during the demobilization phase which was completed a day early. The total volume of processed water

from installation to demobilization was 1,002,666 gallons: 25,000 gallons for decontamination; 12,000 gallons to charge the pumps, weir tanks and ultrafiltration; and 965,000 gallons treated with the proposed solution.
The EC process successfully removed uranium to below the alluvial standard (0.16 mg/L) and significantly reduced molybdenum, while yielding greater than 95% recovery. Thus, a full scale production system with the CleanWave® equipment will be capable of meeting discharge targets while maintaining 95% recovery.

The results show that treating these waters will be challenging for common treatment technologies. These waters require a sophisticated two-phase treatment system: flocculation and solids separation (ultrafiltration). Uranium and molybdenum require separate removal steps after the EC process —selective flocculation and then separation— to assure optimal flocculent development. Also, the low suspended solids and iron content require customized CleanWave® EC equipment.

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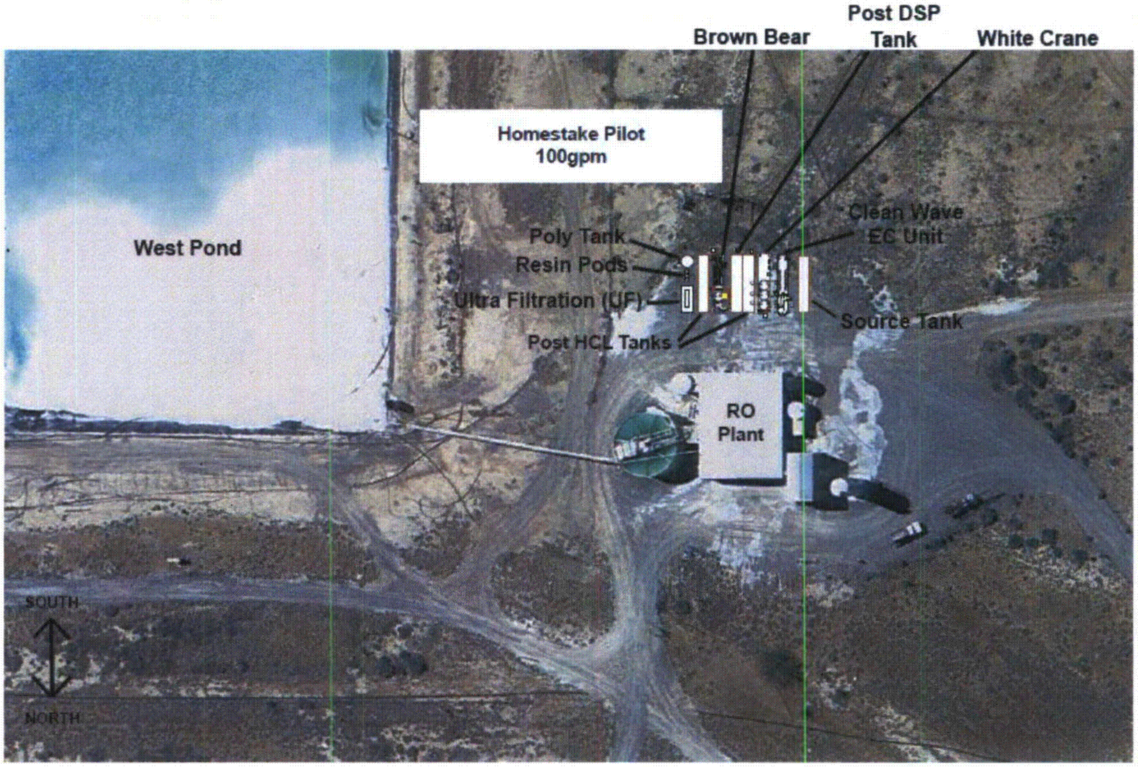
Project Introduction

CleanWave® electrocoagulation (EC) was first introduced to Homestake in September 2012 at a Baroid IDP field demonstration. Following that demonstration, 30 gallons of water from the Homestake Mill Site were evaluated with the EC-based technology at a laboratory scale. In the December 21, 2012 treatability report, Baroid IDP recommended a two-step (EC-Ultra Filtration (UF)) treatment process to meet treatment targets based on aquifers local to the Homestake Mill Site (Table 1). Highlights of the report include the following:

1. Dissolved and total uranium could be successfully removed to meet aquifer targets with controlled EC treatments
2. Total molybdenum (Mo) could also be addressed either outright with EC-UF treatment or as a pre-treatment to ion exchange resins or reverse osmosis (RO) filtration technologies.
3. Given the complexity of various aquifer targets (alluvial; sulfate and chloride mainly), additional polishing with RO may be advised.
4. A field scale demonstration of the CleanWave® solution would be required to more accurately estimate the operational costs (e.g., labor requirements, EC cell usage, and power consumption).
5. Source water for the demonstration would be aggregated from the CE dewatering well field. Although no water sample was available prior to the installation of the equipment, Baroid IDP agreed to install the solution based upon its previous success.

Project Process Flow Description

The Homestake CleanWave® solution is based on a sequence of three core pieces of equipment (EC, UF and Ion Exchange Resin (IXR)) and optimizing four processes (oxidation-reduction reactions, passive settling, membrane filtration, and surface adsorption) to meet the aqueous chemical targets. The site was located on the south side of the existing water treatment facility with a footprint of approximately 3600 ft^2 (Figure 1).



* Note: Brown Bear is a trailer mounted filtration media unit, large sand filtration vessels. Brown Bear is the name for that unit in a CleanWave rig. White Crane is the pH adjustment unit.

Figure 1. Aerial view of CleanWave® location on Homestake Mill Site adjacent to existing water treatment facility Source: Google Earth

The treatment capacity for this project was quoted at 100 gpm. The source water was an aggregation of several wells located in the CE well field. This water was aerated prior to being fed to the CleanWave® EC unit to initiate the coagulation reaction. The EC step was followed by passive solids separation and ultra-fine (UF) media filtration (see Process 5: Ultra-filtration and Figure 2). The Mo settling was achieved by a pH adjustment with hydrochloric acid (HCl) in an 18,000 gallon "over-and-under" weir tank. After the supernatant passed from the first weir tank, disodium phosphate was injected into the water stream prior to the second weir tank to flocculate and settle uranium. The final supernatant was then filtered with 0.03um UF to capture the fine particles from the process. Permeate from the UF then passed to three IXR chambers with media specifically selected for molybdate adsorption. The following discussion describes these steps in greater detail.

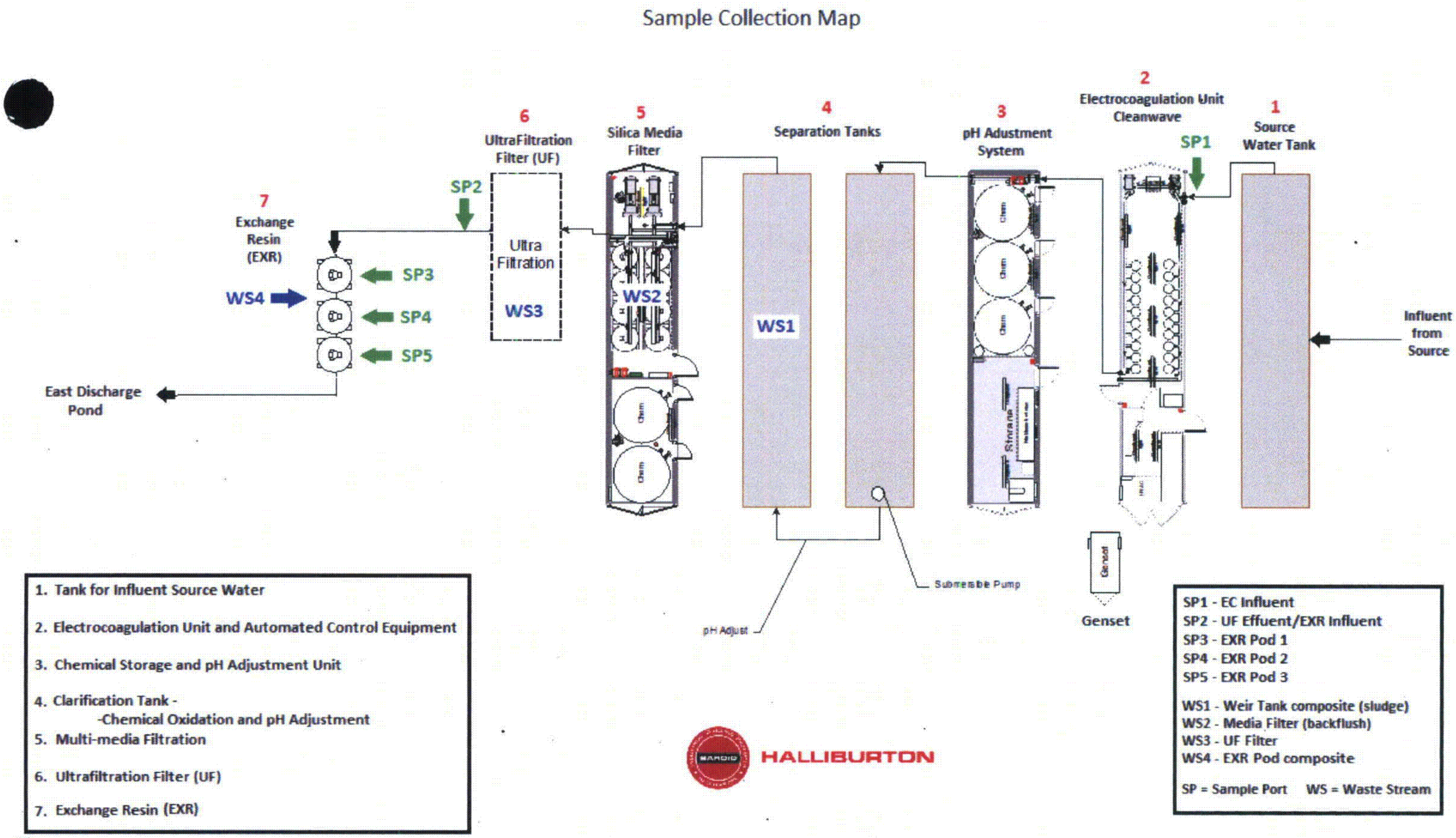


Figure 2. Schematic of CleanWave® solution. Treatment flow is from right to left. Green SP# designates water sampling points and WS# indicates solids sampling.

Process Step 1: Aeration (Redox Optimization)

Aeration was the first step in the treatment process to ensure that the dissolved oxygen was close to saturation. The additional oxygen ensured that redox conditions were optimized for uranium and molybdenum removal during EC. The source water from the CE well field was aggregated and pumped to a source tank where it was aerated (> 5 mg/L dissolved oxygen) with two aerators located at the entry point and near the discharge point in the tank. Molybdenum coagulation with iron ($Fe(OH)^{2-}$) favors the Mo^{6+} valence state achieved by oxidizing the Mo^{4+} state. The aerator ran continuously throughout the project. The source tank also served as a visual inspection point for any changes in turbidity from the CE water.

Process 2: Electrocoagulation

EC, the second step, introduces an electrical current in the water which electronically destabilizes suspended particles (TSS), multivalent metals, and many organic compounds (most hydrocarbons). The Homestake waters are relatively low turbidity water with very low TSS and dissolved organic matter phases; so in this project, destabilizing and removing the metals was the objective. Once destabilized, positively charged ions react with relatively more negatively charged particles in the water column resulting in stable particles.

The CleanWave® EC unit for this project was selected for the Homestake job due to the potential of scaling it hydraulically from the demonstration directly to full-scale production. Iron is the target coagulant and is liberated from the EC plates at a rate correlated directly to the current applied and the flow rate through each cell. To achieve the desired flocculent production and metals removal, the current per cell was set at 200 amps from a target voltage of 80 volts.

Process 3: pH Adjustment

Following the EC cell, pH was adjusted to ensure efficient nucleation of the tiny particles, coagulation of the contaminants and subsequent passive settling in the weir tanks. The theory of the flocculation process is that it is a separately occurring reaction between the charged contaminant and the newly sacrificed iron in suspension. Thus, each contaminant is in reality its own family of reactions. Each reaction can then be expected to generate flocs with their own attributes reflecting the specific redox chemistry and its particle size in suspension. In the case of molybdenum, the sparse literature describing this chemistry indicates that molybdenum tends to co-precipitate as mixed metal phases (Aube and Stroaizzo, 2000). Further, these co-precipitates are highly pH dependent meaning that excursions above pH 4 would lead to their dissolution and return to the supernatant. Thus throughout the settling process in the weir tanks, pH must be monitored closely especially if the molybdenum flocs are small.

Process 4: Solids Separation Tank and/or Clarification Tank

The fourth step was passive separation of the coagulated solids. Particle settling or solids separation in weir tanks is often classified as "passive" settling due to the absence of high energy flow regimes of centrifugation or induced air-flow separation equipment. There are many proven forms of solids separation in the water treatment industry. Many of the techniques are based on the exploitation of Stoke's Law (Appendix I) describing the settling of particles in a given flow regime. Given the operational reality of this project, passive settling in readily available settling weir tanks was selected. The flow rate through the 18,000 gallon weir tanks was approximately 180 minutes; i.e., 6,000 gallons per 60 minutes at 100gpm. However, if the flow rate is too high, the flocs are relatively small or the pH is poorly controlled, solids separation may be inefficient in a given process. Suspended floc volumes that pass through the discharge point of a settling tank are called "carry-over" and add to the load of any downstream removal technology. This added contaminant load adversely impacts the efficiency of any filtration or adsorption process and increases membrane replacement and resin regeneration costs. Changing the solids separation step in the full-scale operation solves this problem.

The solids separation step consisted of first removing the molybdenum and then the uranium. All other associated metals were observed in the treatability study to fall-out with these metals in this process. The molybdenum removal was a pH controlled co-precipitation separation achieved in tank one (as above). The discharge from tank one was dosed with disodium phosphate to flocculate uranium (U) in a second weir tank prior to UF.

Process 5: Ultra-Filtration (UF)

Ultra-filtration (UF) is a pressure-driven purification process in which water and low molecular weight substances permeate a membrane while particles, colloids, and macromolecules do not. In this project, the UF was installed into the process flow to remove micro-flocs or "pin-flocs" that were not separated in the weir tanks. The relatively high proportion of dissolved U compared to the total uranium in the M-9 waters warranted the use of a UF for this solution. The pore size of the membranes is between 0.01 and 0.04 micrometers. For this work, membranes with an average pore diameter of 0.03 were selected. Water used in back flushing the UF unit is returned to the solid separation unit to remove solids from the water stream and maintain the high recovery for the entire system.

Project Performance Parameters and Successes

Health and Safety

Baroid IDP and its licensed partner, Water Tectonics Inc., met all its goals during this demonstration. The CleanWave® solution was completely staged from our warehouse and vendors around North America by September 12, 2013. Baroid IDP informed Homestake staff of every delivery. Baroid IDP staff coordinated staff for all electrical and plumbing requirements for the installation in the week of September 9, 2013. Baroid IDP staff completed all equipment-specific training required at the site.

The project was executed without a lost time or reportable incident. The work was completed with appropriate PPE, minimized direct contact with the waters, and exposure monitoring programs. All appropriate PPE was worn each day; i.e., eyewear, steel-toed boots and hard hats. Primary CleanWave® unit operators wore polypropylene gloves for their sampling and cell exchange work. All chemicals were accompanied with their MSDS (SDS). The DSP and HCl mixing totes were installed with secondary containment units. All equipment not requiring direct contact with the impaired water was stored more than 30 feet from the site.

Before any work at the site began, all staff was trained according to Homestake's ALARA program. All staff wore radiation monitoring badges, submitted urine samples at the start and finish of the project, and signed the Homestake logbook each day upon arrival and departure. All short-term visitors were accompanied by ALARA certified visiting workers. No food was consumed on site near the equipment or their housings.

EC is a longstanding undercapitalized technology. It has the remained largely in the domain of academic research for decades outside of the mainstream of water treatment solutions (Holt et.al, 2004). Its first principles are founded on the electrochemistry of generating common metals (iron and aluminum) used otherwise as coagulants in chloride and sulfate salts to treat polluted waters (Mollaha et. al., 2004; Holt et.al. 2004). Holt et.al, (2004) attributes the poor adoption of EC in distributed industrial applications to a lack EC reactor (cell) design and operation. Its ability to coagulate many metals, suspended solids and certain polar organics has really never been in dispute. However, Baroid IDP and Water Tectonics have continued to prove the technology for widespread use across multiple industries.

Bidding Process Summary

Based on the results of the 2012 treatability study, Baroid IDP was asked to quote a field scale demonstration in the spring of 2013. The CleanWave® solution was quoted on a pro-forma basis in late spring (April and May, 2013) for a 100gpm field demonstration and a 400gpm full-scale production facility to be commissioned at some point in 2014.

In May 2013, Baroid IDP hosted a visit by Mr. Jesse Toepfer at the Halliburton Midland-Odessa, TX office to inspect a functioning CleanWave® unit, and the cell design itself. Baroid IDP and agreed at the time to the concept that the potential opportunity at the Milan site (Homestake's Grants Reclamation Project) would involve a CleanWave® unit for the demonstration that could be scaled at higher flow rates.

In August 2013, Baroid IDP staff was summoned to Milan for a kick-off meeting where they were invited to bid on the project by August 16. Baroid IDP was informed that an exchange resin polishing step would be required although it was not recommended from the treatability work on the M-9 well waters. The meeting also included a visit locating the CleanWave® site with operational connectivity to electricity and plumbing required for the job. Baroid IDP informed Homestake that complete mobilization would take thirty calendar days. September 16, 2013 was identified as the drop-dead start date in order to meet the firm deadline.

Baroid IDP was awarded the project on August 19 and agreed to install a solution based on the previous treatability report. On or around August 22, Homestake received itemized quotes, one each for the delivery, equipment and services associated with the EC-based CleanWave® process and one for the delivery and equipment for the exchange resin station.

The Baroid IDP was informed that the work must be completed and reported by November 1.

CleanWave® Mobility

All of the unique operational and technical features of custom CleanWave® solutions were on display at the Homestake Mill Site. Each treatment phase is mobile and highly placeable. The CleanWave® EC unit for example was mounted on a truck trailer as a self-contained unit with twenty EC cells, digital controls and power supply all protected from extremes in weather. Forty foot long settling tanks were easily arranged in the process for a specific flocculation and optimized to minimize footprint. Aesthetically, there was also an absence of white powdered polymer and coagulant around the site. All equipment performed without failure from the installation to completion (September 19 to October 18, 2013)

Influent/Effluent Evaluation

The first phase of the demonstration compared the source waters from the treatability study to those for the demonstration (Table 1). The selenium, sulfate, chloride and total dissolved solids (TDS) concentrations were all comparable to the previously studied influent waters used in the treatability study. However, the uranium and molybdenum concentrations were significantly higher. The average uranium influent concentration was 3.02 mg/L while the molybdenum influent concentration average was 2.20 mg/L.

Table 1. Comparison of various water chemistries for the major analytes of interest.

Parameter	Project Influent Average	Project Effluent Average	Alluvial Aquifer Standard	Effluent Compliance
Uranium **(mg/l)**	3.02	0.026	0.16	YES
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TDS **(mg/l)**	2,279	2647	2734	YES

* Note: The increase in chlorides is due to the addition of hydrochloric acid (HCl), which was added to address molybdenum concentrations; were this unit to have been operated in circumstances where molybdenum was not a concern, the chloride levels would have remained approximately constant.

The dosages for iron and DSP used in the pilot were derived from the treatability study (Figure 3 & 4). The targeted iron dosage from the EC process based on the treatability study was 35 mg/L. The targeted DSP dosage was 250 mg/L. The iron dose is important for the desired co-precipitation with molybdenum. Its concentration and the pH of the reaction determine the effectiveness of the removal.

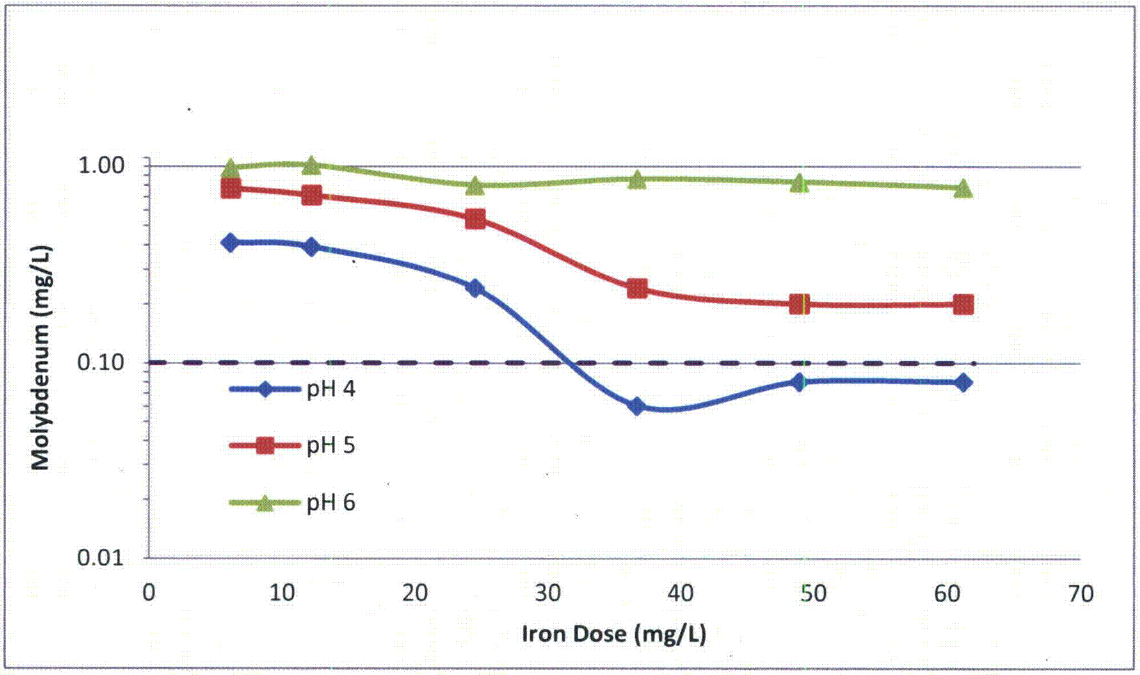

Figure 3. Molybdenum removal at pH 4 (blue line), pH 5 (red line), and pH 6 (green line) at various iron doses contributed in EC treatment. [The discharge limit in the aquifers for Molybdenum is 0.10 mg/L (dashed purple line).]

Our pilot work confirmed the treatability study where at pH below 4.0 and in the presence of iron molybdenum will precipitate. In addition, this mechanism for building these solids for settling is nearly a stoichiometric relationship. Thus for any given Mo content, a given Fe co-precipitate concentration can be determined.

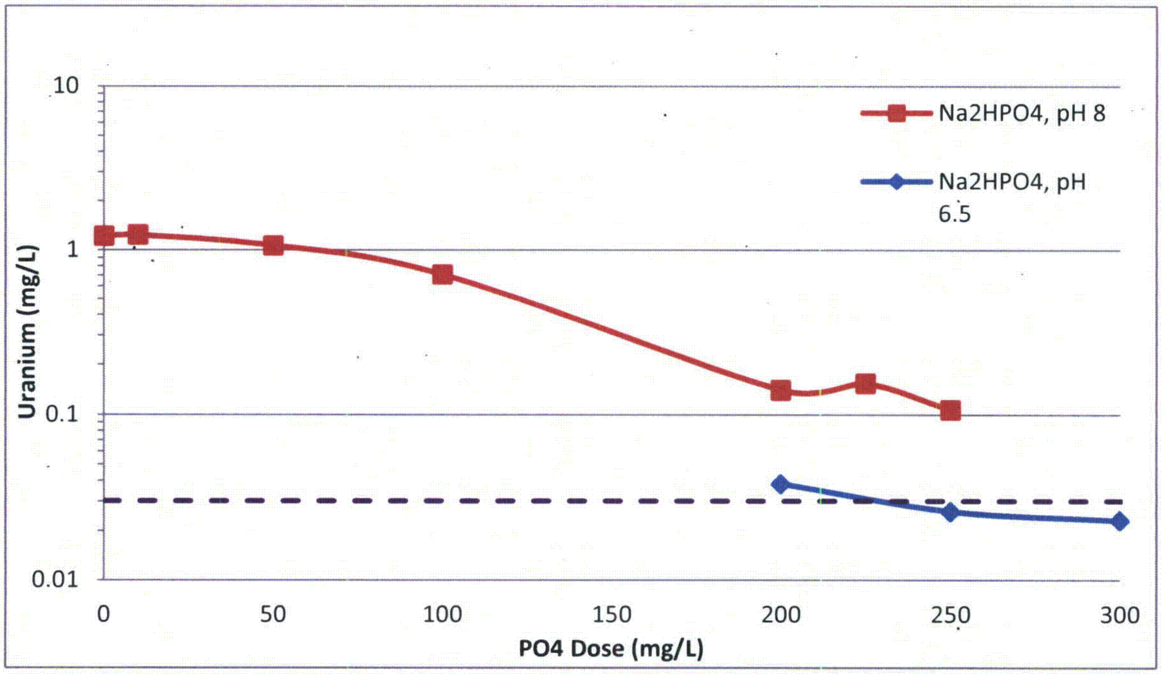

Figure 4. Uranium removal at various phosphate doses using disodium phosphate at pH 8 (red line), disodium phosphate at pH 6.5 (blue line), and potassium phosphate (solid purple line). [The most stringent discharge limit in the local aquifers for Uranium is 0.03 mg/L (dashed purple line).]

The results from the field solution effluent confirm that a well-designed EC-UF based system is a strong candidate alternative to a membrane-only based solution. Selenium, sulfate and chloride in the effluent are below the limits and stay below the limit thru the process system up to UF filtration at SP-2.

The two main treatment steps in the process target the uranium and molybdenum contaminants. The U average effluent at SP-2 for the project is 0.0267 mg/L. This value represents a 99.1% reduction in U from the average influent value of 3.02 mg/L. This achievement included successfully addressing two challenges likely to arise at Homestake (see Identified Challenges section below).

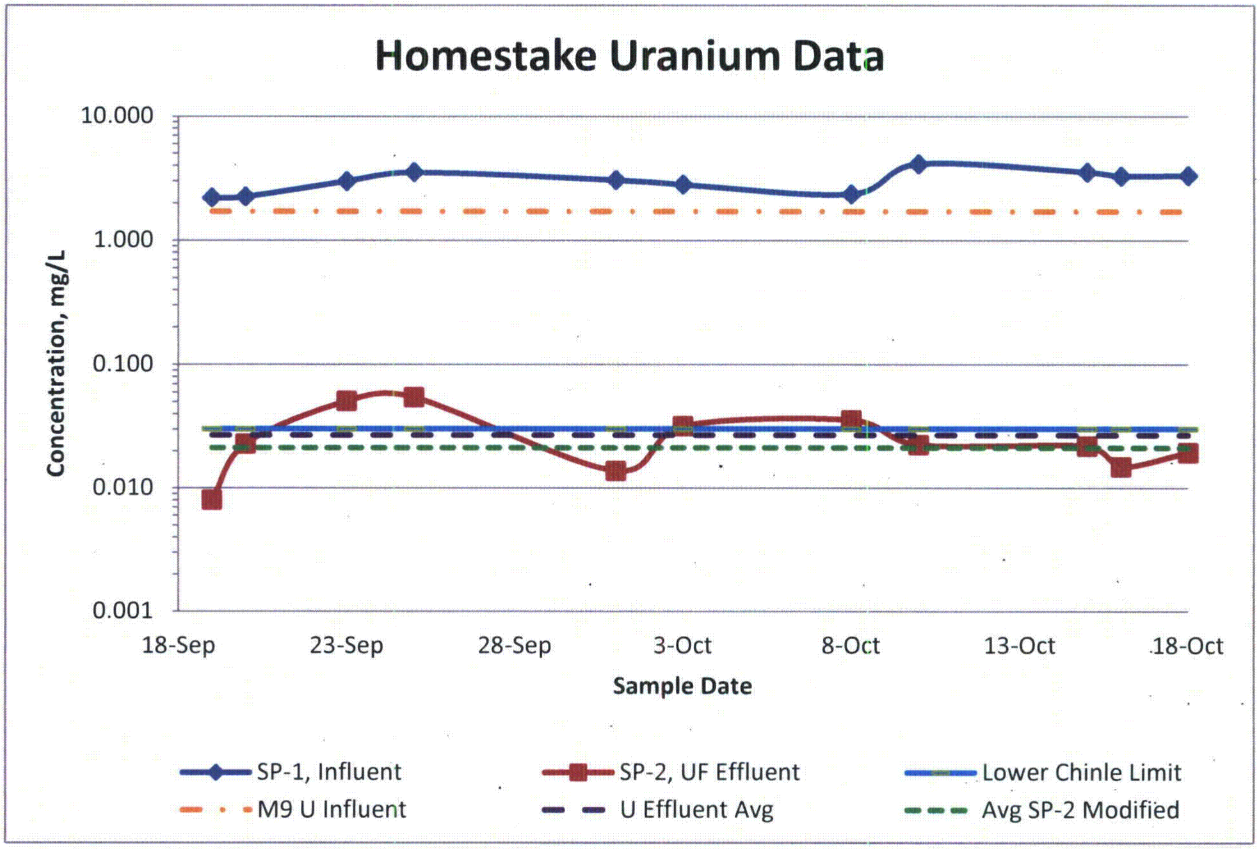

Figure 5. Graph of Uranium data during the Homestake demonstration showing compliance on an average monthly basis (U= 0.0267 mg/L) despite mixing temperature fluctuations and source water changes, both from the CE well field and mixing waters.

The average molybdenum effluent for SP-2 for the project was 0.864 mg/L (Figure 6). This value represents a 57.6% reduction in molybdenum from the average influent value of 2.20 mg/L. The average reduction in concentration for molybdenum was 1.27 mg/L. This reduction exceeded the indications from the treatability study waters. Those waters had a molybdenum concentration of 1.17 mg/L. The study showed that a dosage of 35 mg/L of iron with EC was required to remove molybdenum concentration to below the specified limit (See Figure 3). The demonstration was able to replicate the treatability study removing >1.2 mg/L of molybdenum. The molybdenum reduction is the difference between the influent (SP-1) and the effluent (SP-2) molybdenum concentrations.

Although the molybdenum treatment target was not met on a monthly average basis, the removal rates are consistent with the treatability study iron dosage and the equipment selected based for the treatability study.

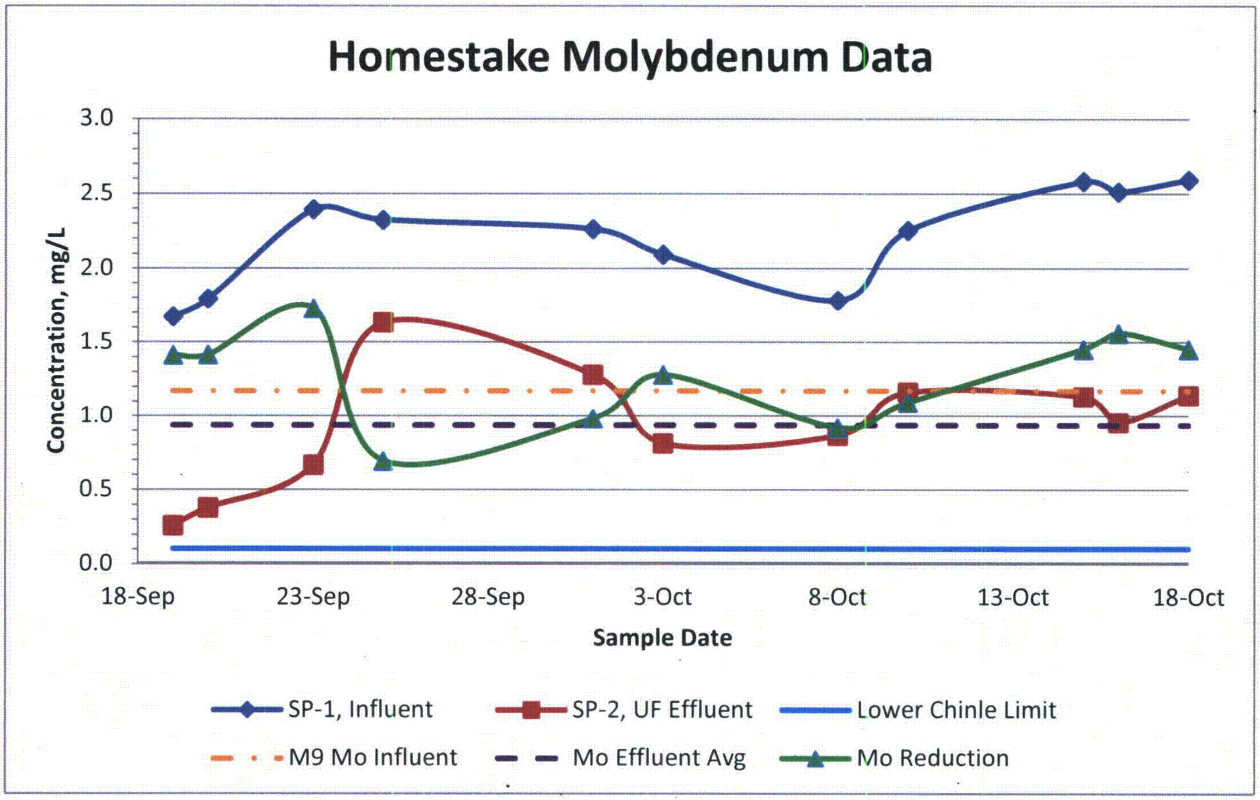

Figure 6. Various trends in molybdenum variation during the demonstration including SP-1, SP-2, and the difference between the two samples. (0.864 mg/L average)

These variation and trends in the molybdenum data point to a solution to meet the treatment targets. The flocs observed in the HCl tank were considerably smaller than the typical Fe-cored flocs produced by CleanWave®. In fact we classified them as "pin" flocs. Just as their name suggests, these smaller particles settle more slowly and in a low-energy weir tank have a higher probability to remain in suspension. If the floc passes as "carry-over" to the DSP dosed tank, the molybdenum could easily re-enter the solution prior to UF treatment due to reactions with the DSP or slight changes in pH. The treatability study and literature indicated that uranium and molybdenum could not be co-precipitated or coagulated at the same time; thus requiring two separate settling tanks. Due to the small floc size, we suspected that the increase in SP-2 molybdenum was due to carry-over. Water filtered from the sludge/high-solids slurry in the DSP tank collected on October 8 yielded a concentration of 16.3 mg/L. This result indicated that a significant amount of molybdenum was carrying over to the to the DSP process.

On October 9, the team added an additional settling weir tank to double the settling time prior the DSP tank to help reduce the carry-over. As a result, the SP-2 molybdenum remained under 1.2 mg/L while the SP-1 molybdenum climbed significantly to its highest levels during the demonstration. The last four samples show molybdenum increasing from 2.25 mg/L and ending at over 2.50 mg/L.

Addressing the Molybdenum Challenge

On October 8, a water sample was collected following the first settling tank and prior to the DSP injection. We filtered the sample with the UF to assess the removal capability of the UF on waters not experiencing the reaction with the DSP. The molybdenum concentration after traversing the length of only one weir tank was 0.398 mg/L. This value was less than half of the value at SP-2 on October 8 and October 10, indicating also indicating that the carry-over could be significantly filtered with a UF. In addition, using the average for molybdenum for the project (2.20 mg/L), the EC-HCl settling step reduced approximately 82% of the feed molybdenum concentration.

Judging these data in light of their trends and the literature, solids separation is the key to optimizing the EC reaction. The increase in molybdenum content from the first sample 9/19 to its plateau speaks to the development of a poorly separated, relatively thick if not diffuse floc layer in the tanks that must be removed in order to prevent carry-over and any subsequent reaction later in the treatment process. Clearly passive settling in weir tanks must give way to established mechanical clarification techniques.
We believe that the following changes will help to improve this result:

1. Increasing the Iron dosage from the EC system for stoichiometric balance with the molybdenum.
2. Changing from a rectangular clarifier to a circular clarifier to reduce the horizontal velocity of the fluid significantly before going over the weir.
3. Using sludge recycling and floc mixing in these clarifiers to enhance collisions and increase the floc size. This will help to co-precipitate the molybdenum and improve the separation.
4. Two step UF to optimize the molybdenum removal prior to the DSP uranium coagulation step.

From a treatment perspective, this project represented the first attempt to duplicate recent successful treatment of molybdenum in mine wastewater with iron as a coagulant but without the use of ferric chloride. Molybdenum has been removed from waste waters at astounding costs and lower efficiencies using pH adjusted ferric chloride treatments (Aube and Stroiazzo, 2000; Patterson, 2003). The circa 2000 costs for this process flow was estimated to be over $10MM in construction and $1.5 MM in annual operating costs (Aube and Stroiazzo, 2000). These studies also report the important water properties required for molybdenum treatment, namely the need to dose with Fe for maximum molybdenum concentrations.

Ion Exchange Resin Performance

As requested by Homestake, IXR was added to the process flow. A chloride based anion resin was selected based on lab tests conducted by Water Tectonics as the best option for molybdenum polishing. The resin was used to polish the UF permeate using three resin chambers in series. Samples (SP-3, SP-4 and SP-5) were collected after each chamber to measure performance and loading rates.

The results show that this resin primarily prefers uranium over molybdenum. The SP4 sample yielded anomalous results throughout the demonstration for unknown reason. The data show each bed was loaded by adsorbed sulfate, uranium, molybdenum and selenium and released chloride (Figures 7, 8, 9, 10 and 11). As the beds became fully loaded, molybdenum was released due to preferential sulfate adsorption. However, uranium continued to be adsorbed due to its higher affinity to the resin than the sulfate.

The overall adsorption trend among these ions for this resin is as follows:

uranium > sulfate > molybdenum > selenium >> chloride

Given the observed loading rates during the project, we regenerated the first bed in the system using a 1% sodium chloride brine solution (Appendix II). The regeneration process is very similar to a water softener and can be automated in a full scale system easily. The resin in the first chamber was manually regenerated during a shutdown of the equipment. Automated regeneration equipment is widely used in the water treatment industry. The process used 3 bed volumes of brine to regenerate a bed. The data shows that the regeneration was successful. Specifically, the U data from SP5 return to compliance in early October after the regeneration process

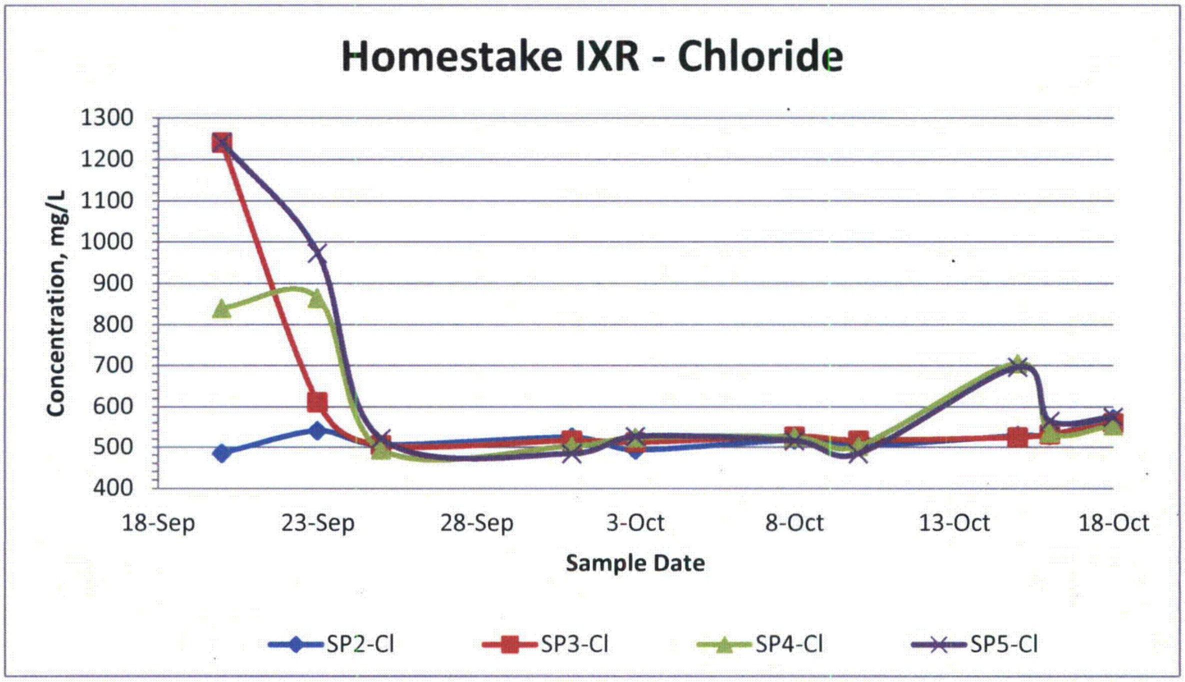

Figure 7. Chloride concentrations thru the ion exchange resin showing the release of chlorides at the outset which increases the chloride level over the discharge limit of 634 mg/L. Once the beds are exhausted, they stop releasing chloride. The spike after October 10, 2013 was due to the regeneration of vessel #1.

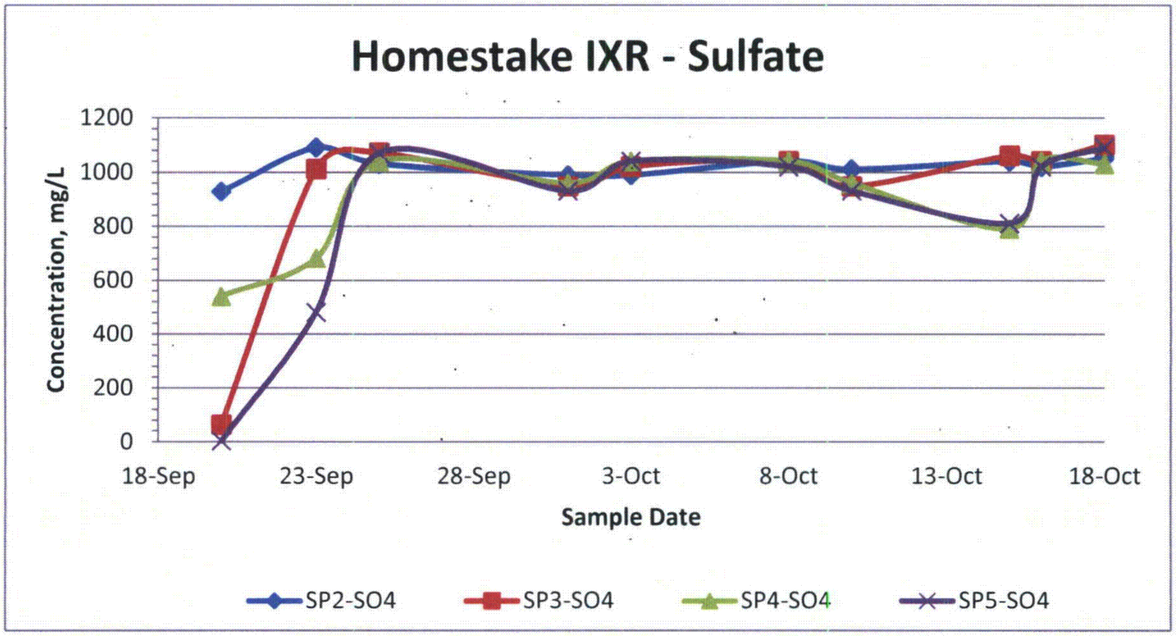

Figure 8. Sulfate concentrations through the ion exchange resin illustrating the adsorption of sulfate at the outset of the project. Once the beds are exhausted, they stop removing the sulfate. The dip after October 10, 2013 was due to the regeneration of vessel #1.

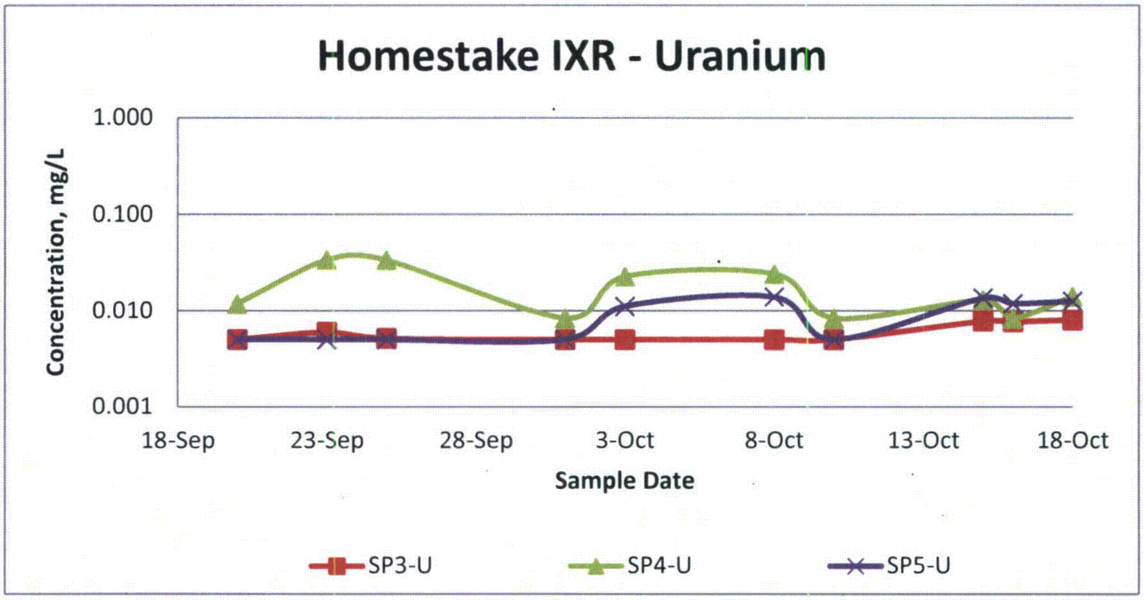

Figure 9. Uranium concentrations through the ion exchange resin illustrating the continuous reduction throughout the pilot project.

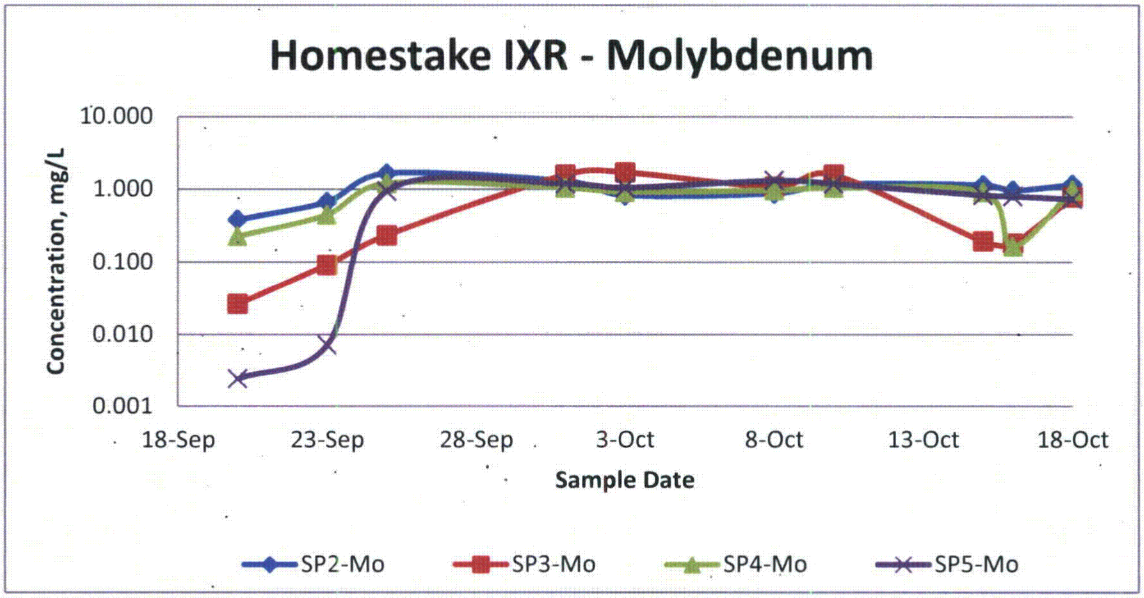

Figure 10. Molybdenum concentrations through the ion exchange resin. Once the beds are exhausted, they stop removing the molybdenum. The reduction in sulfate after October 10, 2013 was due to the regeneration of vessel #1.

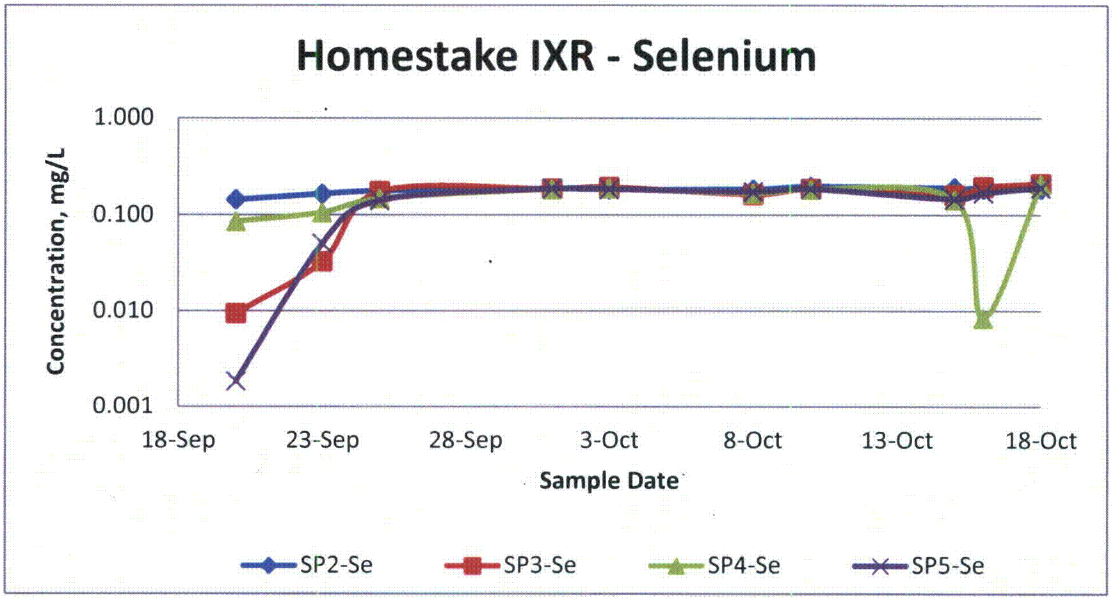

Figure 11. Selenium concentrations through the ion exchange resin. You can see how the adsorption of Selenium in the beginning of the project lowers the concentration. Once the beds are exhausted, they stop removing the selenium. The reduction in sulfate after October 10, 2013 was due to the regeneration of vessel #1.

In conclusion, the results from the in-line sampling show that

- The EC produces remarkable removal rates for U, easily meeting the treatment targets for the Alluvial Aquifer
- The amount of waste sludge/solids to achieve this result is less than 5% of the source water volume
- The current (as-tested) configuration of the EC system is not effective at removing molybdenum to the 0.100 mg/L target.

The results of the demonstration suggest the Homestake Mill Site CE waters require a sophisticated system of flocculation and solids separation. Uranium and molybdenum require separate removal steps from the EC initiated coagulation reaction.

Identified Challenges

Due to the scale of this project, many challenges were quickly identified, solved and documented by direct, hands-on efforts by the operators. The challenges overcome are DSP dosing, solids separation and resin regeneration.

Molybdenum develops flocs from a co-precipitation reaction with Fe that is pH sensitive. This requires a separate flocculation and separation step in order to assure optimal floc development. Secondly, the suspended solids and iron are low in the CE waters. In many mine waters, Fe occurs at sufficiently high levels to precipitate intrinsically with the EC initiated reaction. This is not the case for the CE waters. As a result, CleanWave® EC must be modified to achieve the desired sacrificial iron to achieve molybdenum removal.

Another challenge encountered during this demonstration was the response from the water quality testing lab with data to ensure quality and evaluate solutions to the trouble shooting required to succeed.

Dibasic Sodium Phosphate Dosing

A critical step to complete the uranium flocculation is the addition of the DSP to the EC effluent. Only four (4) of the eleven (11) sample values exceeded the discharge limit of 0.03 mg/L (Figure 5). Two of these samples occurred on the 9/23 and 9/25. These values were 0.050 and 0.054 mg/L respectively and still represent a removal rate of over 98%. However if this excursion was left unaddressed, the monthly average would certainly failed to meet the target.

The solubility of DSP is very dependent on the temperature of the water. The solubility of DSP at 20C is about 7.2%. At 15C, the solubility of DSP drops to less than 3.5%. During the first week of the project, the high and low temperature ranged from 16-21C and -5–2C, respectively. This phenomenon is evident in the uranium data (September 23 and 25, 2013) where the highest excursions for post-UF waters were observed (Figure 6). The DSP was dosed by dissolving anhydrous DSP in a solution of RO permeate water and although we mixed the solution continuously, granular DSP was observed in the bottom of the tank. We concluded that the dip in temperature at night during the week of 23rd slowed the warming of the water during the day for our afternoon sampling thereby limiting the DSP solubility.

We solved this mixing issue with a heater and warming the chemical tank at night. By elevating the temperature to 25 – 30C we were able to easily dissolve the DSP and calculate the correct dosing. We then developed a calibration based on the conductivity of the chemical tote with the correct dosage setting on the chemical pump. This technique will be directly transferable to any full production system. Using this method we were able control the DSP dosage and remove the uranium to the treatment target.

The other two samples above the limit of 0.03 mg/L occurred on October 3 and October 8 at values of 0.032 and 0.035 respectively. These values narrowly exceed the target value. The most likely factor for this excursion is the change in mixing water for the DSP. The RO unit was stopped for maintenance. At that time, "tower water" was used to mix the DSP solution. The tower water contained calcium, had a higher conductivity and very likely precipitated some of the DSP. The clarity of the solution was reduced yielding a slightly milky color. We adjusted the calibration used to dose the DSP and successfully met the uranium target by staying below the limit of 0.03 mg/L for the remainder of the project.

Cell Life Summary

The cell lifetime was calculated to be 350,000 gallons per cell, lower than cell life averages in other EC applications (e.g., storm water, oilfield flow back, etc.) These applications tend to achieve greater than 500,000 gallon up to a million gallons of cell life. In this demonstration, the need to generate enough iron to co-precipitate molybdenum decreased the lifetime significantly. Also, the actual flow capacity for CleanWave® is 500 gpm, or 59.5% of the designed flow capacity of the unit. This difference reflects the need to increase the interaction time between the iron in the EC cells and the molybdenum and uranium in the ground water.

Table 2. Performance results for CleanWave solution at Homestake mill site.

Performance Parameter	Result
Designed Flow Capacity (gpm)	840
Actual Flow Capacity (gpm)	500
Treated Volume (gals)	965,000
Cell Life (gals)	350,000

Conclusion

The Homestake Mill Site CE waters require sophisticated treatment systems. Any solution capable of treating all the constituents of concern will require advanced technology and skilled operation. This work indicates that the CleanWave solution can very successfully flocculate uranium and meet stringent discharge targets, even competing with membrane technologies such as reverse osmosis (RO). Compared to CleanWave, RO yields much lower recoveries that meet local aquifer targets. In this demonstration, the water yield was more than 95% by volume, meeting the targets. For a process targeting only uranium, CleanWave could likely achieve >98% yield (<2% waste). For waters requiring the removal uranium and molybdenum, separate removal steps will be required to meet the treatment targets and recoveries volumes at greater than 95%.

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APPENDIX I ABBREVIATIONS & EQUATIONS

ALARA:	As Low As Reasonably Achievable
CAPEX:	Capital Expense
EC:	Electro-coagulation
IXR:	Ion Exchange Resin
DSP:	Disodium hydrogen phosphate ($Na2HPO4$) or sodium salt of phosphoric acid
HCl:	Hydrochloric Acid
MSDS:	Material Data Safety Sheet
OPEX:	Operation Expense
SDS:	Safety Data Sheet
UF:	Ultra-Filtration
WTP:	Water Treatment Plant

Stokes Law: Terminal velocity (or settling velocity) is given by:

$$v_s = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g\, R^2$$

Where:

υ_s is the particle's settling velocity (m/s) (vertically downwards if $\rho_p > \rho_f$, upwards if $\rho_p < \rho_f$), g is the gravitational acceleration (m/s2), ρ_p is the mass density of the particles (kg/m3), and ρ_f is the mass density of the fluid (kg/m3).

APPENDIX II Resin Regeneration Procedure

1. Prepare brine solution. Mix 420lb (924 kg) NaCl in 500 gal (1893 L) water to make a 10% NaCl brine
2. Configure hydraulics to ensure reverse flow is possible. Normal flow is from bottom of bed up to top
3. Circulate 500 gal brine at 5 gpm* for a contact time of 60 minutes. Low flow rate is required to avoid excessive bed expansion. Actual contact time was 104 minutes to avoid loss of resin.
4. Reconfigure hydraulic for normal bottom up flow. Flush resin with water for one hour prior to sampling Clarification Details.

ENCLOSURE 4

REBOUND EVALUATION SUMMARY REPORT
(COMPLETED BY ARCADIS, 2012)

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Rebound Evaluation Summary Report

Grants Reclamation Project
Grants, New Mexico

December 2012

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Rebound Evaluation Summary Report

Grants Reclamation Project
Grants, New Mexico

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Date:
December 17 2012

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Figure 2 Dissolved Gas Tracer Test Photographs

Figure 3 Extended Shutdown Area

Figure 4 Uranium Forms in LTP

Figure 5 SF_6 Breakthrough Curves – Primary Monitoring Wells

Figure 6 SF$_6$ Breakthrough Curves – Secondary Monitoring Wells

Figure 7 Local Potentiometric Contours (June 2011)

Figure 8 Local Potentiometric Contours (January 2012)

Figure 9 Local Potentiometric Contours (May 2012)

Figure 10 Uranium Concentration Trends – Primary Monitoring Wells

Figure 11 Selenium Concentration Trends – Primary Monitoring Wells

Figure 12 Molybdenum Concentration Trends – Primary Monitoring Wells

Attachment

A Rebound Evaluation Results

1. Executive Summary

On behalf of Homestake Mining Company of California (HMC), ARCADIS has prepared this Summary Report for the Rebound Evaluation that was conducted from December 2010 to May 2012 at the Grants Reclamation Project (site). The Rebound Evaluation was conducted to evaluate the potential for increases in concentration ("rebound") of constituents of concern (COCs) in the Large Tailings Pile (LTP) when the source control program ends.

The source control program began at the site in 2000 and was designed to promote decreases in the concentration of uranium and other COCs in LTP pore water. The program involves the flushing of the LTP with slightly impacted groundwater to hydraulically force contaminated tailings pore water to toe drains and extraction wells to expedite natural draindown of the LTP.

As part of the Rebound Evaluation, a tracer test was performed to determine pore water transport direction and velocity and the degree of diffusive mass transfer between pore water residing in coarser- and finer-grained tailings material (sands and slimes, respectively). The tracer test indicated that diffusive mass transfer rates into and out of the lower permeability zones are low and therefore post-flushing rebound caused by back diffusion is expected to be minimal. Over a 6-acre area of the LTP where flushing was shut down, nine wells were used to collect data for the key water quality parameters, including uranium, molybdenum, selenium, calcium, alkalinity, pH, sulfate, and total dissolved solids (TDS). Water levels were also monitored in this area and a decrease of up to 16 feet was observed.

An evaluation of concentrations over time demonstrates that widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown. These data indicate that significant rebound of the COCs should not be expected after the source control program ends for the LTP. Consequently, COC reductions achieved during flushing are likely to be sustained for the long-term.

2. Introduction

HMC owns and operates the site, which is a former uranium mill located in Cibola County, New Mexico. Currently, the primary activity at the site is the containment and treatment of contaminated groundwater through a groundwater restoration program.

The objective of this program is to restore concentrations of the COCs to levels that meet site standards established for each of the aquifers present at the site.

The updated Corrective Action Program (CAP) describes the current site restoration strategy and was submitted to the regulatory agencies and to stakeholders in March 2012 (HMC 2012). This CAP update includes detailed information about current site conditions, recent modifications to the groundwater restoration program, and key aspects of the proposed future implementation of the CAP. The CAP should be consulted for detailed information about the site.

ARCADIS has assisted HMC with source evaluation and control activities since 2010. These activities were specifically designed to address issues raised in the Army Corps of Engineers (ACOE) Remedial System Evaluation (RSE) that was finalized on December 23, 2010 for the Environmental Protection Agency (EPA). In the RSE (ACOE 2010), the ACOE identified the long-term leaching behavior of the COCs under post-flushing conditions in the LTP as a data gap.

The Rebound Evaluation was designed to simulate post-flushing conditions in the LTP and produce data to directly respond to the ACOE's comments. The Rebound Evaluation included a dissolved gas tracer test to evaluate the hydraulics of the rebound evaluation well network, a year of post-flushing monitoring, and a laboratory testing program to evaluate forms of uranium in the LTP.

ARCADIS conducted these activities with the support of HMC staff and Hydro-Engineering, LLC (Hydro-Engineering).

3. Rebound Evaluation

The primary objective of the Rebound Evaluation was to provide further analysis of the source control program and to predict future leaching and hydraulic behavior of uranium in the LTP after completion of the flushing in the LTP. The three phases and associated objectives of the Rebound Evaluation are:

- *Phase 1 – Tracer Testing:* Collect site-specific data about local hydraulic and solute transport properties of the LTP by implementing a tracer test.
- *Phase 2 – Rebound Monitoring:* Evaluate trends in pore water chemistry once flushing of the LTP is discontinued.

- *Phase 3 – Bench Testing*: Evaluate the leaching behavior of uranium, molybdenum, and selenium from the tailings solids.

The field activities for the Rebound Evaluation were conducted in the west-central part of the LTP (**Figure 1**). The primary criterion for selecting this area was the performance of the source control program, which successfully reduced the concentration of uranium and other COC's in the area. Therefore, discontinuing active flushing in the area mimicked the LTP draindown at the end of the source control program.

The tracer system was installed in December 2010 and tracer injections occurred in January 2011 and from March to May 2011. Tracer injections and flushing in the Rebound Area ended on May 9, 2011 and monthly tracer and aqueous monitoring was conducted until October 2011. The monitoring frequency was reduced to bimonthly after October 2011 and continued through May 2012.

3.1 Tracer Test

The objectives of the tracer test were to evaluate the hydraulic connectivity of the Rebound Evaluation well network and to characterize the flow regime and transport velocities of the LTP in the area. For this test, a dissolved gas was used as the applied tracer. The advantage of using dissolved gas as a tracer (instead of isotopes, salts, or dyes) is that it can be injected continuously for an extended period of time with little field oversight; consequently, a much larger volume of water can be dosed. Additionally, dissolved gas tracers have very low detection limits and are therefore measureable in groundwater at low concentrations. The dissolved gas tracer used in the Rebound Evaluation test was sulfur hexafluoride (SF_6), a non-toxic, inert gas and has been used for more than 20 years in applied studies (e.g., Wilson and Mackay 1993).

The well network for the tracer test and subsequent rebound monitoring is depicted in **Figure 1**. Four extraction wells (WE9, WF2, WF9, and WF11) were converted to the primary monitoring wells by pulling pumps and associated tubing and equipment in December 2010. This conversion allowed these wells to serve as representative monitoring wells for the LTP during rebound evaluation activities. Wells WL1, WL2, WM1, WM2, WM3, and WT14 were used for active injections of water and tracer. Well construction details for all wells in the network are included in **Table 1**.

Dissolved Gas Tracer Delivery

The tracer SF_6 was introduced into the six injection wells at a target flow rate of 0.9 standard cubic feet of air per hour (SCFH-air). The gas was conveyed through copper tubing from compressed gas cylinders to approximately five feet from the bottom of each injection well. At the end of the piping, a microporous (6 micron pore size) diffusion stone maximized transfer of SF_6 from the gas to the aqueous (dissolved) phase. Pictures of the dissolved gas tracer diffusion stone are included in **Figure 2**.

The target gas pressure (at the header) was approximately 18 pounds per square inch (psi) for each injection well to overcome hydrostatic pressure on the diffusion stone and any head losses in the conveyance piping. For injection wells where the water column was near the top of the well casing, bubbles at the surface confirmed the gas flow rate was sufficient to overcome hydrostatic pressure and that the aqueous phase transfer rate was not limited by the gas flow rate.

A total of seven 115-pound cylinders of SF_6 were used from January 21 to 31 and from March 24 to May 9, 2011. Due to operational challenges with the injection system during the January injection period, the system was temporarily shut down and modifications were made in February and March to improve system delivery efficiency; injections resumed on March 24.

Evaluation of the dissolved gas tracer injections focuses on the second injection period from March 24 to May 9, 2011. Based on totalizer readings from the active injection wells approximately 854,000 gallons of water were dosed with SF_6, tracer during both injection periods.

Dissolved Gas Tracer Monitoring

The monitoring wells were used to evaluate the distribution and transport of SF_6 in the Rebound Evaluation area. Passive diffusion (PD) samplers (Divine and McCray 2004) were employed to collect representative samples from monitoring wells (a photograph of a PD sampler being deployed down a monitoring well is included in **Figure 2)**.

Three PD samplers were deployed at different depths in the monitoring wells for a minimum of one week; SF_6 diffused through the membrane into the PD sampler to achieve equilibrium. The PD samplers were sent to DHL Analytical (Round Rock, TX) for analysis of SF_6 concentration in air, which was converted to the equilibrium dissolved concentration in water using the ideal gas law and the dimensionless Henry's

Law constant, which is 122 at 10°C for SF_6 (Wilson and Mackay 1993). The dissolved concentration in water is reported as parts per billion on a volumetric basis (ppbV), such that 1 ppbV is one volume of SF_6 in one billion volumes of water.

During the period of active injections (January through May 2011), the PD samplers were collected weekly for analysis; after collection, new PD samplers were deployed for the next monitoring event. After SF_6 injections were discontinued on May 9, 2011, the PD samplers were collected for analysis approximately every other week until August 16, 2011. Additional monitoring events were conducted from November 17, 2011 to May 9, 2012 in a limited number of wells to characterize long-term tracer washout. Throughout the tracer test, the maximum concentration of SF_6 recorded among the three PD samplers deployed in each well was used in the data evaluation. The SF_6 analytical data are included in the Rebound Evaluation At-A-Glance (AAG) charts (**Appendix A**).

3.2 Post-Flushing Monitoring

On May 9, 2011, all active flushing in the Rebound Evaluation area (**Figure 1**) was discontinued. Based on the results of the dissolved gas tracer monitoring (showing an extended area of influence of injected water across the area selected for rebound monitoring), additional injection wells to the southwest of the Rebound Evaluation area (**Figure 3**) were also shut down on May 19, 2011 to increase the extent of the Rebound Evaluation area and produce conditions more representative of post-flushing conditions.

Additionally, five wells to the northeast of the injection wells (WF10, WF12, WT6, WU3, and WU6) were included in continued SF_6 monitoring and the post-flushing rebound monitoring program (**Table 1**). This area remained shut down since May 19, 2011 for the duration of the Rebound Evaluation.

In total, the Rebound Evaluation area is approximately 6 acres, or 3% of the total LTP acreage (215 acres). The injection wells that were shut down had contributed approximately 20 gallons per minute (gpm) to the flushing program, or approximately 7% of the total LTP flushing rate (270 gpm in 2011).

The post-flushing (rebound) water quality monitoring phase of the Rebound Evaluation lasted one year, from May 2011 to May 2012. The rebound monitoring network consisted of nine monitoring wells, as depicted on **Figure 1**. The wells were sampled using a submersible pump and purged for 30 minutes prior to collecting a sample; samples are submitted to Energy Laboratories in Casper, Wyoming for analysis.

In addition to collecting samples for water quality analysis, water levels in the monitoring wells were measured prior to purging at each monitoring event. This hydraulic monitoring tracked decreasing water levels in the local area of the LTP, indicating local draindown.

The monitoring wells were sampled in December 2010 and in January, February, and April 2011 to provide baseline concentrations representative of flushing conditions. Monitoring wells were sampled monthly from May 2011 (after flushing was discontinued on May 9) to October 2011 and were sampled bimonthly from December 2011 to May 2012. All rebound monitoring data is included in the AAG charts in **Appendix A**. Results of the post-flushing monitoring, and an evaluation of this data, are discussed in **Section 4**.

4. Laboratory Testing

Laboratory testing was designed to provide additional technical support to the Rebound Evaluation. The laboratory test program included pore water and solid-phase uranium analyses to determine the form of uranium present in the LTP.

During cone penetrating testing (CPT) conducted in March 2012, two intact cores were collected from borehole EP19 within the Rebound Evaluation area of the LTP. The cores were collected from the saturated zone of the LTP, starting approximately 5 feet below the local potentiometric surface. Coring was targeted for a zone with relatively low permeability based on CPT results from an adjacent boring.

Cores were collected in 21-inch long plastic core sleeves, then were brought to the surface, capped, and shipped on ice to Chemac Environmental Services (Chemac, Centennial, Colorado) for analysis. The two cores were obtained from the same borehole, one directly beneath the other.

4.1 Testing Methods

Pore water from the cores was analyzed for a subset of dissolved water quality parameters relevant to the Rebound Evaluation. Pore water was extruded from the core material through a Whatman-1 filter paper using a filter press. The pore water was then filtered through a 0.45-micron (µm) filter for determination of dissolved metals concentrations.

Tailing solids from the cores were also analyzed for grain size and solid phase parameters relevant to the Rebound Evaluation. After filtering the pore water from the cores, the remaining tailing solids were then dried and homogenized. A comparison of saturated and dry weights of the solids was used to determine the porosity of the sample. The dried and homogenized tailings solids underwent selective extraction testing to determine the relative abundance of different chemical forms of uranium present in the LTP.

Specifically, the following extractions in the selective extraction testing targeted specific forms of uranium:

- *Extraction 1 – NaCl Solution:* The first extraction used a 0.1 molar (M) sodium chloride (NaCl) solution with a solid to solution ratio of 20 grams (g) solids to 160 milliliters (mL) of solution. The target uranium form removed during Extraction 1 was uranium dissolved in pore water and uranium that was weakly adsorbed to solids.

- *Extraction 2 – Carbonate/Bicarbonate Solution:* The second extraction used a 20 millimolar (mM) sodium carbonate/bicarbonate solution with a solid to solution ratio of 20 g solids to 400 mL solution. The solution was at a pH of 9.5. The target uranium form removed during Extraction 2 was all adsorbed uranium.

- *Extraction 3 – EPA Method 3050B:* The third extraction followed EPA Method 3050B (nitric acid total digestion). The target uranium form removed during Extraction 3 was uranium associated (adsorbed and co-precipitated) with all crystalline solids except for silicate minerals.

- *Extraction 4 – EPA Method 3052:* The fourth and final extraction followed EPA Method 2052 (microwave-assisted hydrofluoric acid total digestion). The target uranium form removed during Extraction 4 was uranium contained in all solid phase material (including silicate minerals).

To minimize sample losses, extractions and digestions were not performed sequentially on the same sample of material. Instead, separate solid subsamples from each core were collected after homogenization for each analysis.

The analyses above are listed in order of their ability to extract uranium that is progressively more strongly associated with the solids. Accordingly, each numbered extraction is capable of dissolving the uranium released by preceding extractions. An effective sequential selective extraction can therefore be obtained by subtraction (e.g., Extraction 2 uranium minus Extraction 1 uranium is the strongly adsorbed fraction of uranium).

4.2 Laboratory Analysis Results

The porosity of the tailings solids in the cores was calculated by comparing the saturated and dried masses of the material. The calculated total porosity is approximately 0.43 to 0.46. The drainable fraction of the total porosity was determined to be relatively low based on the small volume of pore water that was extruded from the material by the filter press: approximately 3.5 mL was collected from Core #1 and no pore water was collected from Core #2. This assessment is consistent with the grain size analysis that was performed on the samples, which revealed that 67% of the solids had a grain size less than 180 µm (**Table 2**). The high proportion of fine-grained particles results in relatively low drainable porosity.

The limited amount of pore water extruded from Core #1 was analyzed for dissolved uranium, molybdenum, selenium, vanadium, calcium, and iron (**Table 3**), which are some of the key parameters of the Rebound Evaluation and other LTP evaluations.

The dried and homogenized tailings solids were analyzed for the same solid phase parameters as the pore water, with the addition of total manganese. This parameter list was also used throughout the sequential extraction testing (**Table 4**).

The results from the pore water analysis were compared to the solid phase analysis using a mass of solids basis using a solid to solution ratio of 3.4 kilograms per liter (kg/L), which was calculated from the saturated and dried masses of the solids. Comparing these mass basis pore water concentrations with the results of the first extraction step (NaCl solution) indicates that most of the uranium, selenium, and vanadium that were extracted by this solution were originally in the adsorbed, rather than aqueous, phase before sample drying. In contrast, approximately 70% of the molybdenum present in the adsorbed and nitric acid extractable fractions is present in the pore water (**Table 4**), indicating a much lower sorption affinity for molybdenum.

The extractable uranium uniquely associated with each extraction step was calculated by subtraction, as described in **Section 3.1**. These results, depicted in **Figure 4**, mimic the concentrations that would be observed if the extractions were performed sequentially on the same solids sample. Small differences between Cores #1 and #2 in the relative abundances of different uranium forms are indicative of heterogeneities on a relatively small scale in the LTP.

The results of the sequential extraction tests on Core #1 indicate that a very small fraction of the uranium in the LTP exists in the aqueous phase. Because no pore water could be extruded from Core #2, the aqueous fraction could not be determined. Although the uranium dissolved in pore water from Core #1 represents only 1.5% of the total uranium present in the sample, it represents approximately 7% of the available uranium (assuming that only the uranium dissolved in pore water and adsorbed uranium forms are leachable from the tailings solids).

The selective extraction tests on Core #1 (**Table 4**, **Figure 4**) also indicate that a significant proportion of the metals, including uranium, are extractable by hydrofluoric acid (Extraction 4), but not nitric acid (Extraction 3). These results indicate that this fraction may be associated with silicate minerals, clays, and amorphous silica. However, this phenomenon was not observed in Core #2 (**Table 4**, **Figure 4**). This discrepancy may be attributable to differences between the samples. While the distribution of uranium in the LTP may exhibit significant variability with location, depth, and grain size and should not be assumed to be consistent, the majority of uranium in the LTP is not geochemically available and will not leach from solids under ambient conditions.

5. Results

The sampling results for the Rebound Evaluation are presented in charts in **Appendix A**. These charts include the following information: well network maps; graphs of SF_6 concentrations and depths to water; concentrations of dissolved uranium, molybdenum, selenium, and calcium; and pH, sulfate, TDS, and alkalinity data.

Tracer Monitoring

The four primary monitoring wells in the Rebound Evaluation were WE9, WF2, WF9, and WF11 (**Figure 1**). Tracer was rapidly detected at very high concentrations (generally within an order of magnitude of the average injection concentrations) in all four of these wells. After SF_6 injections ended on May 9, 2011, rapid washout of the tracer was observed in wells WE9, WF2, and WF11. Tracer concentrations remained elevated in well WF9, the well furthest east in the monitoring network. Based on the observed washout and review of water level data, the local direction of groundwater flow was estimated to be to the northeast. Therefore, the monitoring network was expanded to include five additional wells to the northeast of the original network: WT6, WF12, WU6, WU3, and WF10. High concentrations of SF_6 (up to 1,100,000 ppbV), have been observed in well WU3, which is the most distal well in the monitoring network, indicating that this well is in a primary path of pore water flow and that water appears to be moving towards the perimeter sand dikes and central sand dike during the "shutdown" conditions. SF_6 breakthrough curves for the four primary monitoring wells are depicted in **Figure 5** and curves for the five secondary monitoring wells are depicted in **Figure 6**.

The results of the dissolved gas tracer test indicate that flow is focused in zones of coarser material with higher permeability. Based on analysis of the tracer breakthrough data under injection conditions, the flow velocity in this area of the LTP ranges from approximately 3 to 5 feet per day (ft/day). Based on the average bulk permeability of the LTP materials and hydraulic gradient, the mobile porosity (the volume where the majority of advective flow occurs) is estimated to be less than 3%. Additionally, the high peak tracer concentrations and rapid and nearly complete washout observed indicates that that diffusive mass transfer between the higher permeability sands and lower permeability slimes material is relatively slow.

Potentiometric Surface

While the monitoring of the Rebound Evaluation focuses primarily on the changes in geochemical conditions, water level measurements are an indication of the hydraulic effects of shutdown. Since the shutdown, decreases in water levels at monitoring wells in the Rebound Area have ranged from 3.45 to 16.25 feet from approximately March 2011 (during flushing) to May 2012 (the final post-flushing monitoring event). The significant area-wide decrease in water levels confirms that the shutdown has a significant hydraulic footprint. More importantly, this decrease demonstrates that local draindown is occurring and that the rebound monitoring data provide useful insight and a representative model of LTP-wide draindown after the source control program ends.

Water levels in the nine primary and secondary monitoring wells and in other wells in the Rebound Evaluation area were used to generate contours of the local potentiometric surface to monitor changes in the flow direction and hydraulic gradient of local pore water. The local potentiometric surface for June 2011, January 2012, and May 2012 is depicted in **Figures 7**, **8**, and **9**, respectively. These figures demonstrate that the northeasterly pore water flow direction was consistent over time, but the hydraulic gradient decreased.

Water Quality Monitoring

The complete results of the water quality monitoring are included in **Appendix A**. The uranium, selenium, and molybdenum trends in the primary monitoring wells are depicted in **Figures 10**, **11**, and **12**, respectively.

Molybdenum concentrations (**Figure 12**) are relatively variable compared to the uranium and selenium concentrations (**Figures 10** and **11**, respectively). The results of the selective extraction tests (**Section 3.2**) indicated that the tailings solids exhibit a much lower sorption affinity for molybdenum than other metals. Unlike the other metals, most of the molybdenum in the LTP is dissolved in water, rather than adsorbed to or associated with solids. This lower sorption affinity and the variability in post-flushing molybdenum concentrations suggest that molybdenum is significantly more labile in the LTP than other COCs.

Data collected at all nine wells for uranium, molybdenum, selenium, calcium, alkalinity, pH, sulfate, and total dissolved solids (TDS), which are summarized in **Attachment A**, demonstrate that widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown. These data indicate that significant rebound of the COCs should not be expected after the source control program ends for the LTP.

6. Conclusions and Recommendations

Overall, the Rebound Evaluation confirmed that flushing most effectively addresses the higher-permeability preferential flow paths in the LTP, as demonstrated by the very high tracer transport rates. Lower permeability materials in the LTP are flushed much more slowly (if at all), and therefore treatment efficiency and effectiveness is lower for these zones. However, the tracer test results also demonstrate that diffusive mass transfer rates into and out of the low permeability zones are low and therefore post-flushing rebound caused by back diffusion is expected to be low. Consequently, COC reductions achieved during flushing are likely to be sustained for the long-term.

The objectives of the source control program can be considered achieved once the higher permeability flow paths are flushed and the average concentrations of the wells that monitor permeable zones reach target concentrations. Therefore, it is recommended that the operation of the flushing program be optimized and focused exclusively on injection wells with high uranium concentrations that accept relatively high flow rates (i.e., greater than about 1 gpm), as these wells are connected to more permeable materials. Active flushing should be terminated and post-flushing monitoring should be initiated in areas where injection wells have achieved the target uranium concentration of 2 mg/L and/or have low (<1 gpm) injection rates.

7. References

Divine, C.E. J.E. and McCray. 2004. Estimation of diffusion coefficients and equilibration times of VOC and dissolved gas solutes for LDPE passive diffusion samplers. *Environmental Science and Technology*, 38(6): 1849-1857.

HMC. 2012. Grants Reclamation Project Updated Corrective Action Program (CAP). Prepared for the Nuclear Regulatory Commission. March.

Wilson, R.D. and Mackay, D.M. (1993). SF6 as a conservative tracer is saturated media with high intragranular porosity or high organic carbon content. Ground Water, 34, 241 – 249.

U.S. Army Corps of Engineers (ACOE). 2010. Focused View of Specific Remediation Issues, An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico. Final Report. December 23.

Table 1 **Well Network and Construction**

	Well ID	Total Depth (*ft BTOC*)	Screened Interval (*ft BTOC*)	Diffusion Stone Deployment Depth (*ft BTOC*)	Passive Diffusion Sampler Depths (*ft BTOC*)
Primary Monitoring Wells	WF2	110	28 - 108	N/A	45, 60, 70
	WF9	116	36 - 116	N/A	45, 60, 70
	WF11	116	36 - 116	N/A	45, 60, 70
	WE9	116	36 - 116	N/A	45, 60, 70
Additional Monitoring Wells	WF10	116	36 - 116	N/A	45, 60, 70
	WF12	116	36 - 116	N/A	45, 60, 70
	WT6	90	40 - 90	N/A	45, 60, 70
	WU3	90	40 - 90	N/A	45, 60, 70
	WU6	90	40 - 90	N/A	45, 60, 70
Injection Wells	WL1	62	N/A	57	N/A
	WL2	43	N/A	38	N/A
	WM1	85	N/A	80	N/A
	WM2	80	N/A	75	N/A
	WM3	85	N/A	80	N/A
	WT14	91	N/A	86	N/A

Key
ft BTOC = feet below top of casing
N/A = Not Applicable

Table 2 LTP Core – Grain Size Analysis

Sieve Size	Percent Passing
18 mesh (1000 µm)	95.3
35 mesh (500 µm)	93.1
80 mesh (180 µm)	67.3
200 mesh (74 µm)	30.7

Key

µm = micron

Table 3 LTP Core – Pore Water Results

Parameter	Result (mg/L)
Calcium	11.11
Iron	0.28
Molybdenum	57.22
Selenium	0.28
Uranium	12.35
Vanadium	1.65

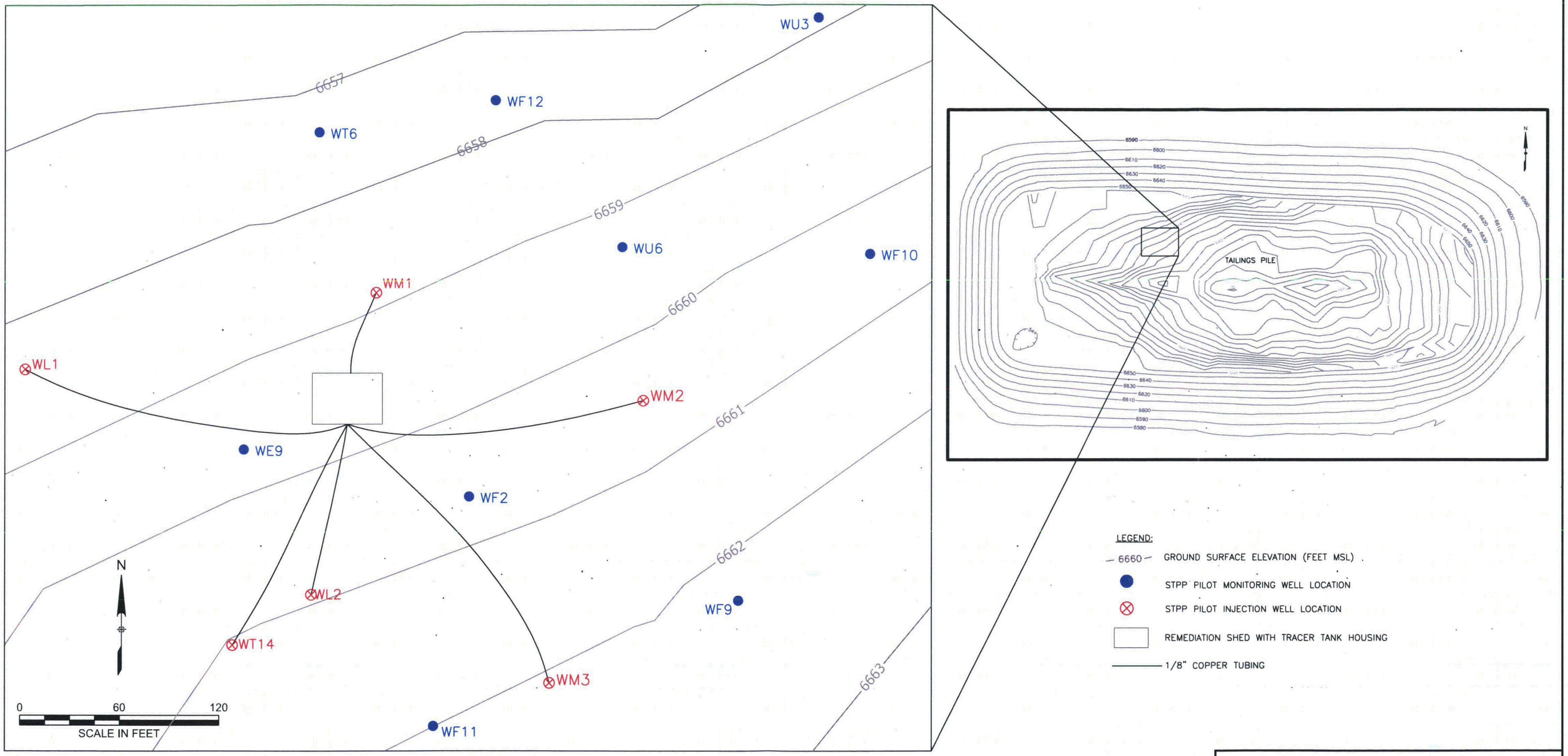
Table 4 **LTP Core – Solid Phase Extraction Results**

Parameter	Pore Water*	Extraction 1	Extraction 2	Extraction 3	Extraction 4
Core #1					
pH (s.u.)	N/A	9.76	9.47	N/A	N/A
Calcium (mg/kg)	3.27	23.2	24	32,600	75,000
Iron (mg/kg)	0.08	< 0.16	4	10,000	26,900
Manganese (mg/kg)	N/A	N/A	N/A	350	860
Molybdenum (mg/kg)	16.83	23.6	24.2	23	50
Selenium (mg/kg)	0.08	50	48.8	96	<300
Uranium (mg/kg)	3.63	40.96	50.8	160	235
Vanadium (mg/kg)	0.49	15.2	17.62	446	1210
Core #2					
pH (s.u.)	N/A	9.97	9.46	N/A	N/A
Calcium (mg/kg)	N/A	20	30	35,200	40,000
Iron (mg/kg)	N/A	< 0.16	1.8	14,100	16,000
Manganese (mg/kg)	N/A	N/A	N/A	352	410
Molybdenum (mg/kg)	N/A	29.6	28	29	60
Selenium (mg/kg)	N/A	62.32	55.2	116	<300
Uranium (mg/kg)	N/A	71.52	81.4	192	200
Vanadium (mg/kg)	N/A	15.68	16.78	596	730

Key

mg/kg = milligrams per kilogram
N/A = not analyzed
s.u. = standard units

* Pore water analyses were converted to a solids mass basis using a solid:solution ratio of 3.4 kg/L, based on saturated vs. air dried masses.



REBOUND EVALUATION
WELL NETWORK

HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

REBOUND EVALUATION
WELL NETWORK

ARCADIS

FIGURE
1

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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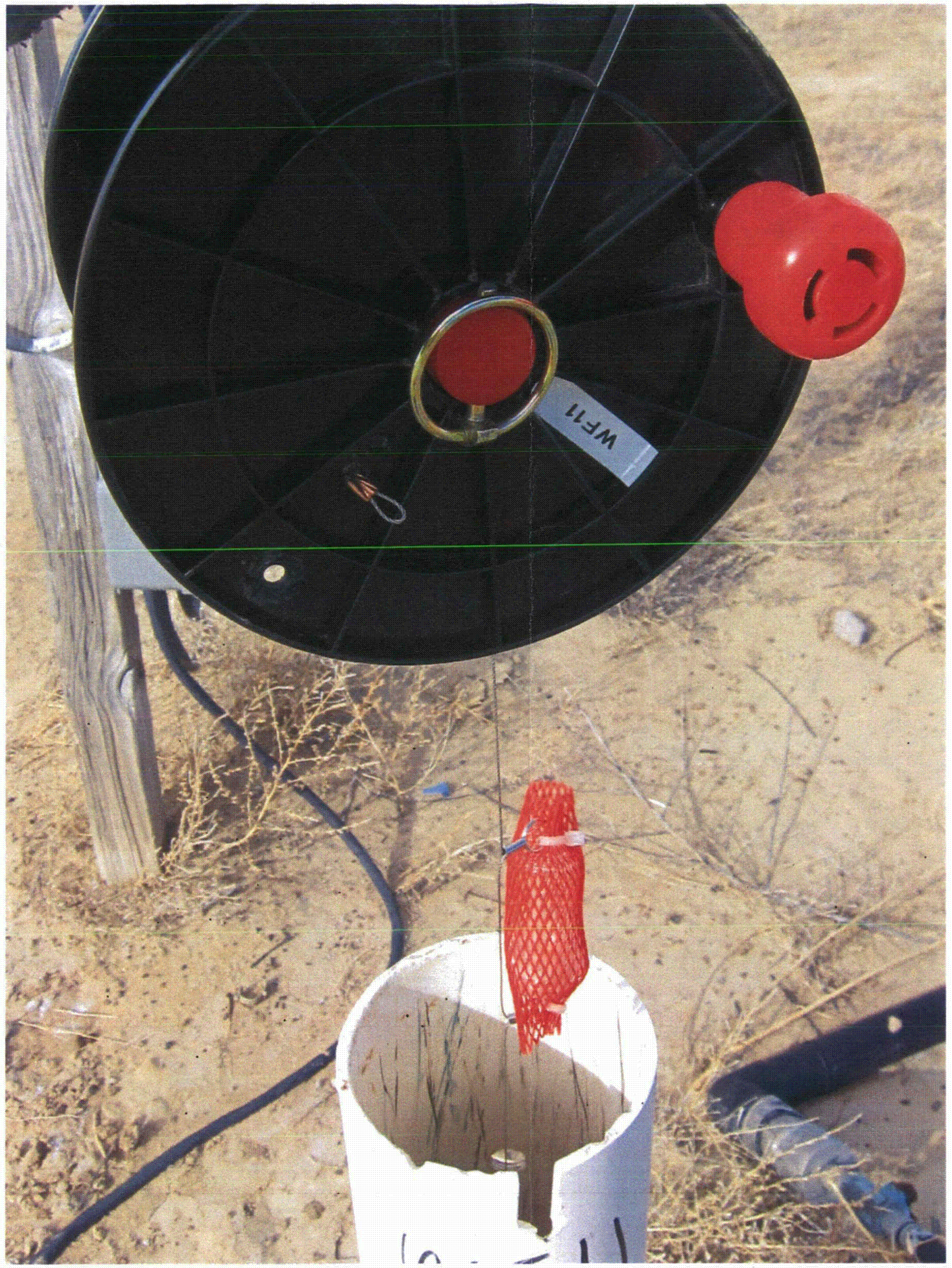

PHOTO A

PHOTO B

PHOTO A: SULFUR HEXAFLUORIDE (SF_6) GAS BUBBLING FROM DIFFUSION STONE PRIOR TO DEPLOYMENT DOWN A TRACER INJECTION WELL.

PHOTO B: REEL SYSTEM FOR DEPLOYMENT OF PASSIVE DIFFUSION SAMPLERS DOWN A TRACER MONITORING WELL.

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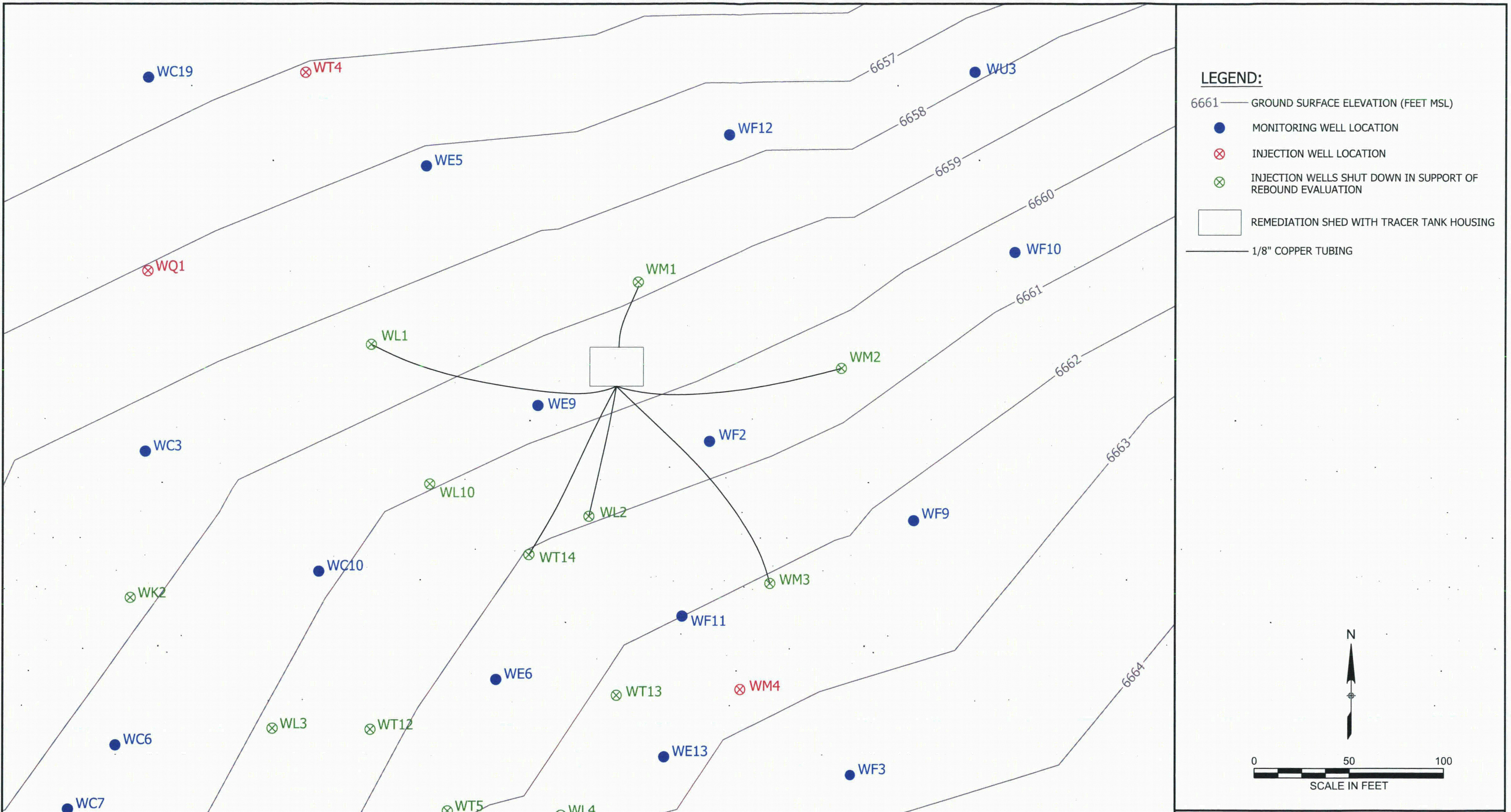
DISSOLVED GAS TRACER TEST PHOTOGRAPHS

ARCADIS

FIGURE
2

K:\A000120-Grants\Illustrators\2012 Figure Renumber\Figure 2 Dissolved Gas Tracer Test Photographs.ai @ 12/11/2012 PREPARED BY: JC



LEGEND:

6661 —— GROUND SURFACE ELEVATION (FEET MSL)

● MONITORING WELL LOCATION

⊗ INJECTION WELL LOCATION

⊗ INJECTION WELLS SHUT DOWN IN SUPPORT OF REBOUND EVALUATION

☐ REMEDIATION SHED WITH TRACER TANK HOUSING

—— 1/8" COPPER TUBING

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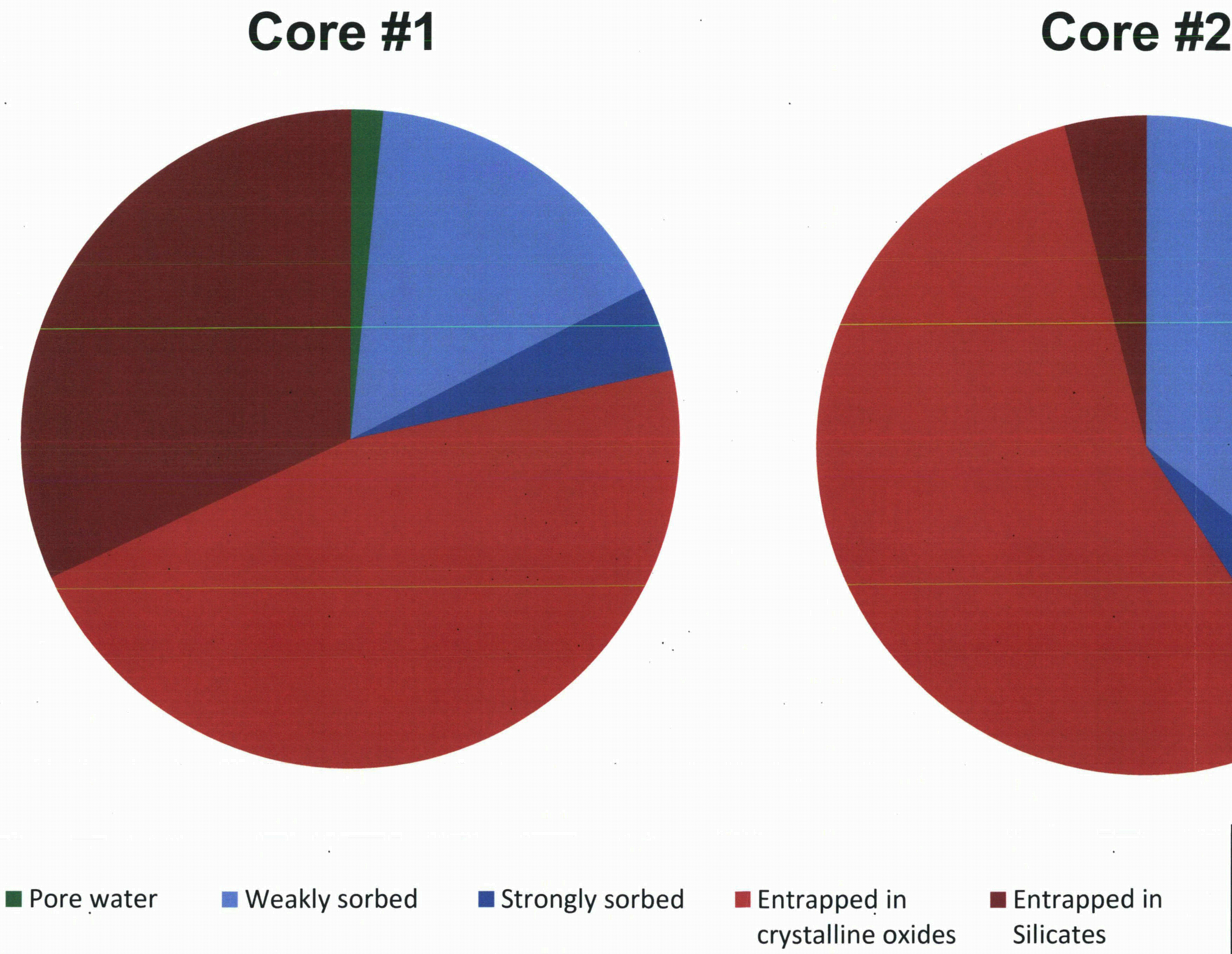
GRANTS RECLAMATION PROJECT

EXTENDED SHUTDOWN AREA

ARCADIS

FIGURE
3



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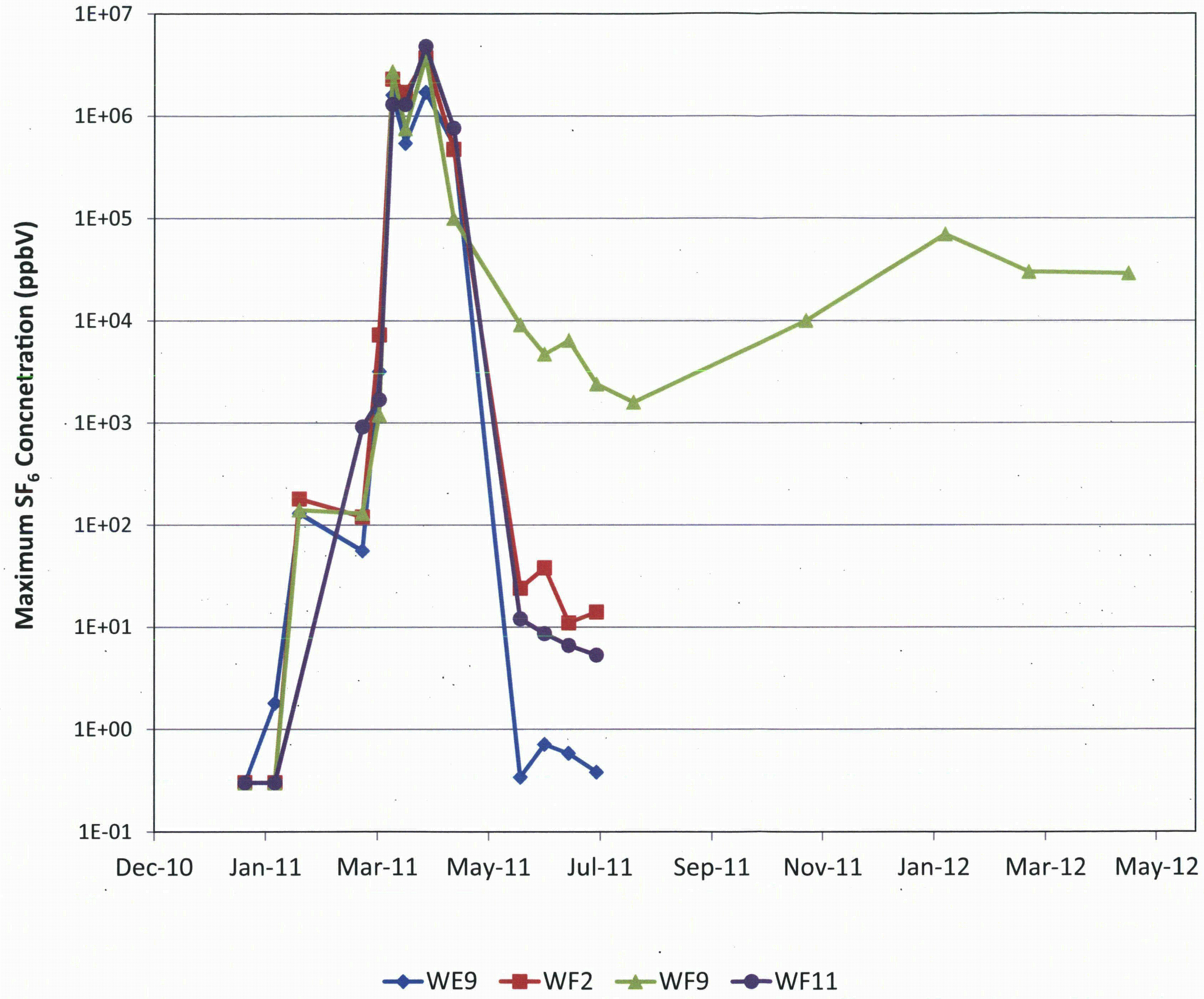
URANIUM FORMS IN LTP

ARCADIS

FIGURE
4

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 4 Uranium Forms in LTP.ai @ 12/11/2012 PREPARED BY: JC



K:\A000120-Grants\Illustrators\2012 Figure Renumber\Figure 5 SF6 Breakthrough Curves – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC

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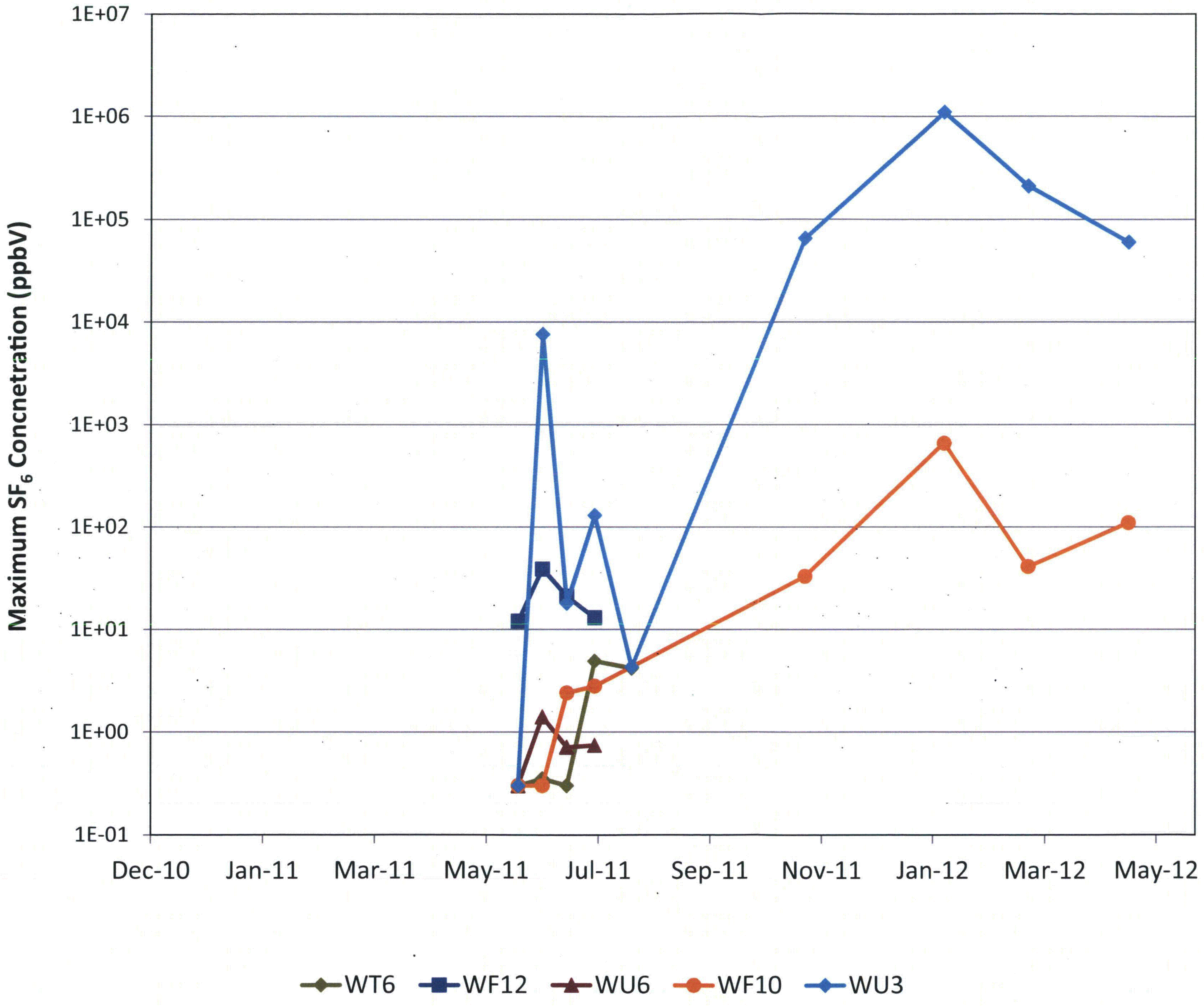
GRANTS RECLAMATION PROJECT

SF$_6$ BREAKTHROUGH CURVES
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
5



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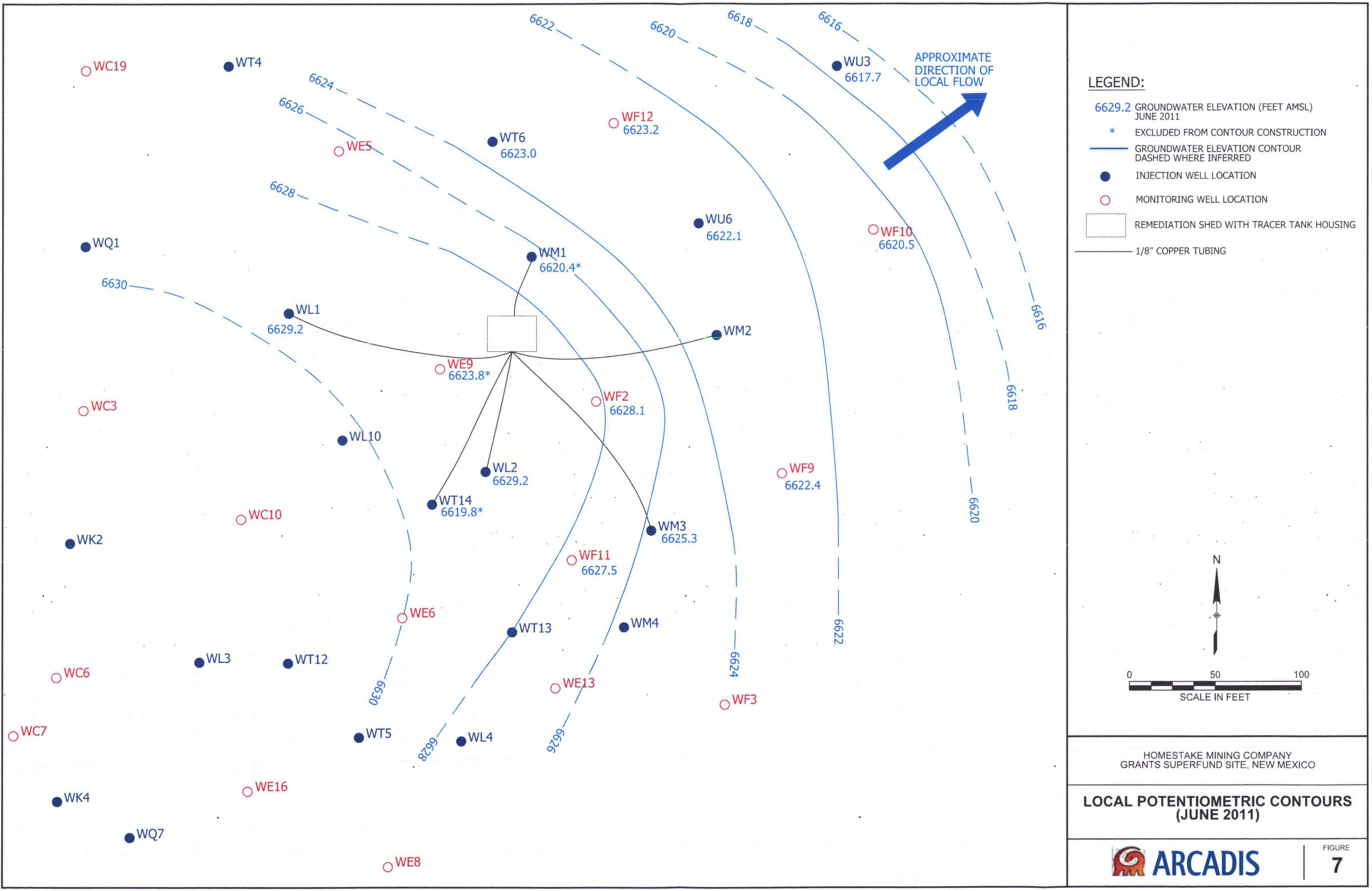
GRANTS RECLAMATION PROJECT

SF_6 BREAKTHROUGH CURVES SECONDARY MONITORING WELLS

ARCADIS

FIGURE
6

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 6 SF6 Breakthrough Curves – Secondary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC



HOMESTAKE MINING COMPANY
GRANTS SUPERFUND SITE, NEW MEXICO

LOCAL POTENTIOMETRIC CONTOURS (JUNE 2011)

ARCADIS

FIGURE
7

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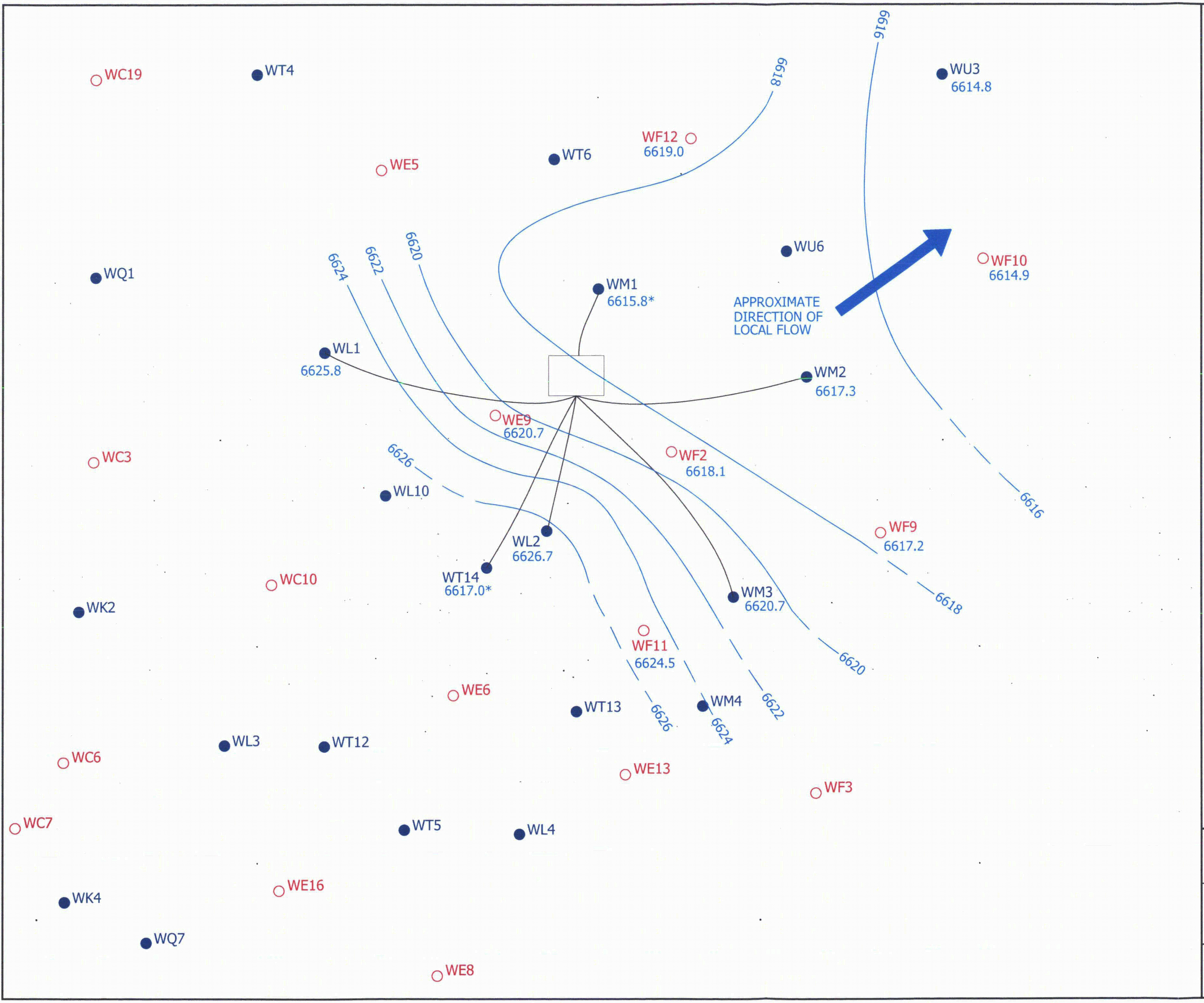

LEGEND:

6624.5 GROUNDWATER ELEVATION (FEET AMSL) JANUARY 2012

* EXCLUDED FROM CONTOUR CONSTRUCTION

— GROUNDWATER ELEVATION CONTOUR DASHED WHERE INFERRED

● INJECTION WELL LOCATION

○ MONITORING WELL LOCATION

☐ REMEDIATION SHED WITH TRACER TANK HOUSING

— 1/8" COPPER TUBING

N

0 50 100

SCALE IN FEET

HOMESTAKE MINING COMPANY
GRANTS SUPERFUND SITE, NEW MEXICO

LOCAL POTENTIOMETRIC CONTOURS (JANUARY 2012)

ARCADIS

FIGURE
8

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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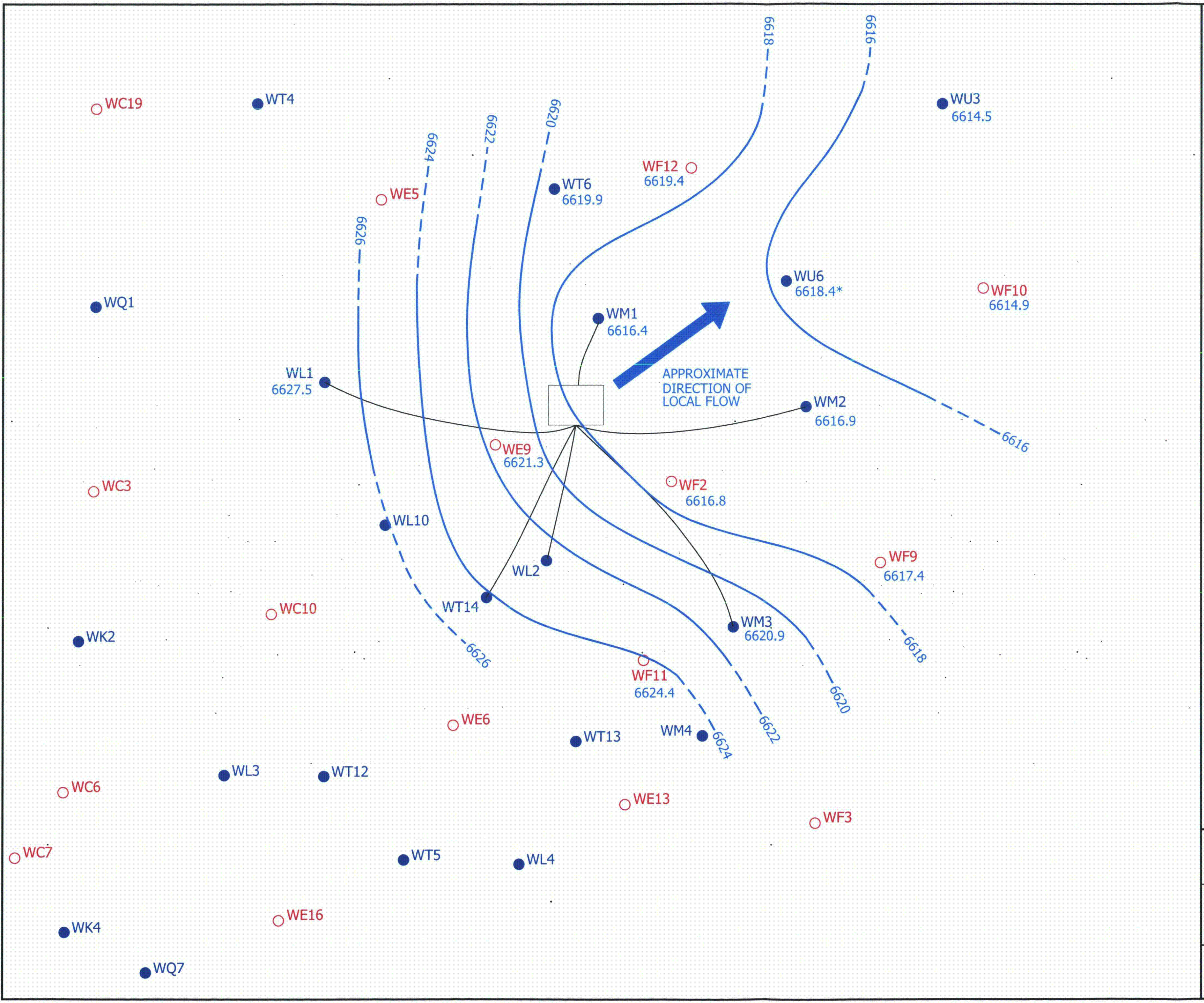
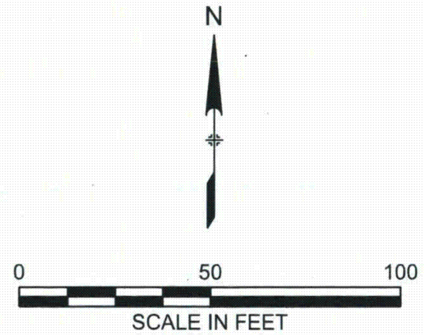


CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Lakewood-CO\ACT\AO000120\0001\00003\AO000120W04.dwg LAYOUT: MODEL SAVED: 6/19/2012 5:01 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ARCADIS-DEN.CTB PLOTTED: 6/20/2012 2:36 PM BY: HOEFER, MATTHEW

LEGEND:

6614.5	GROUNDWATER ELEVATION (FEET AMSL) JANUARY 2012
*	EXCLUDED FROM CONTOUR CONSTRUCTION
—	GROUNDWATER ELEVATION CONTOUR DASHED WHERE INFERRED
●	INJECTION WELL LOCATION
○	MONITORING WELL LOCATION
☐	REMEDIATION SHED WITH TRACER TANK HOUSING
—	1/8" COPPER TUBING

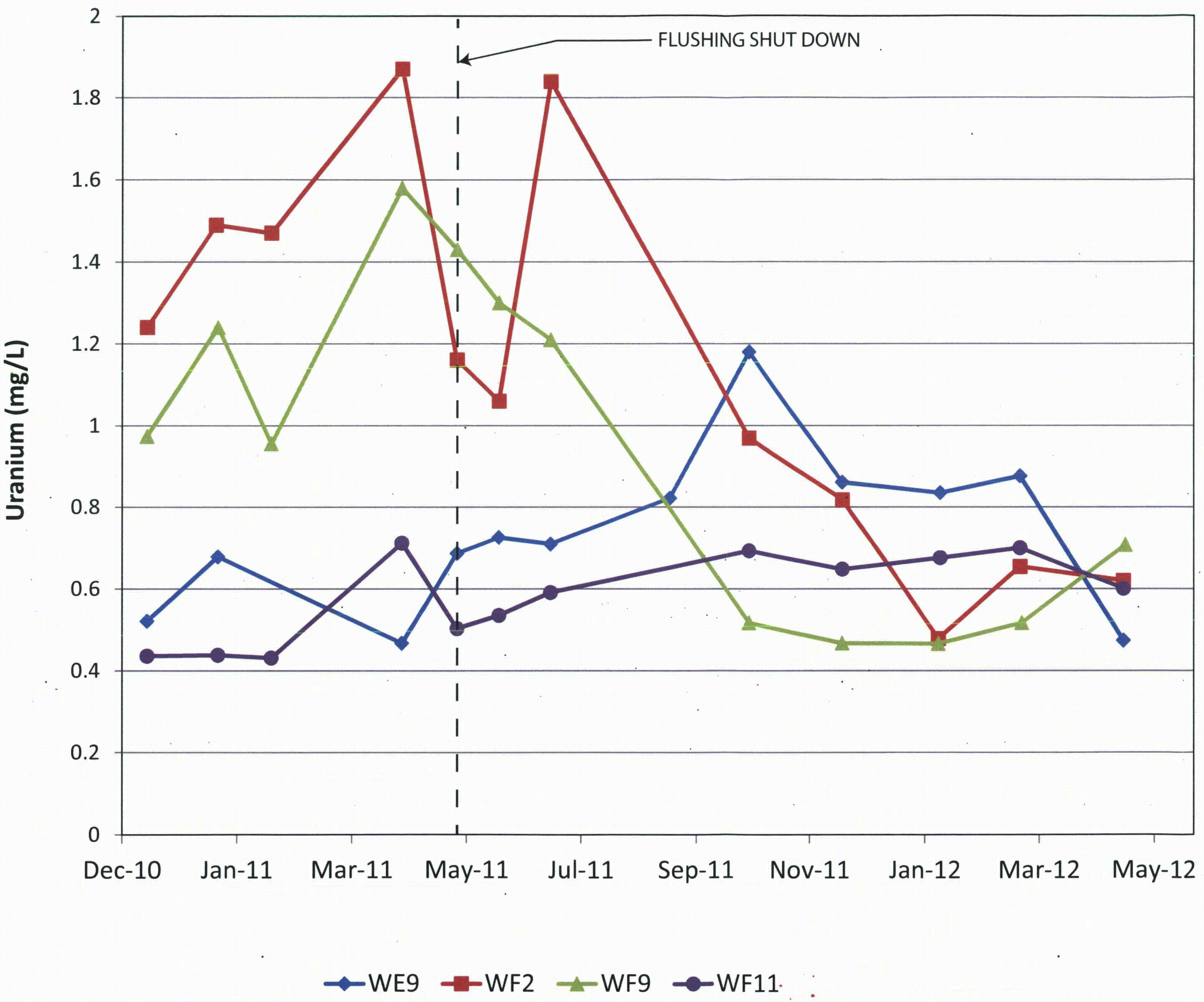


HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

LOCAL POTENTIOMETRIC CONTOURS (MAY 2012)

ARCADIS

FIGURE
9



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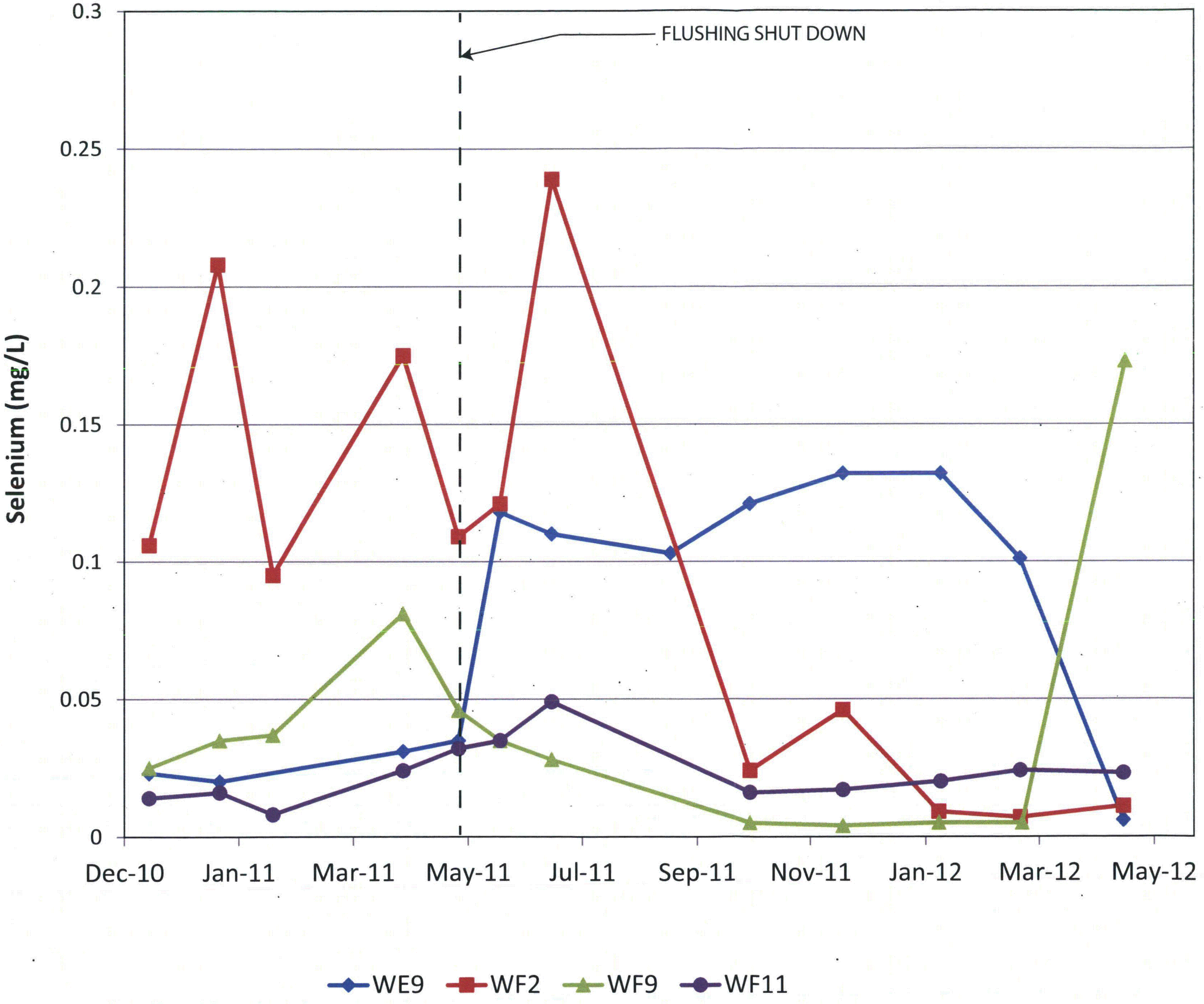
GRANTS RECLAMATION PROJECT

URANIUM CONCENTRATION TRENDS
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
10

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 10 Uranium Concentration Trends – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC



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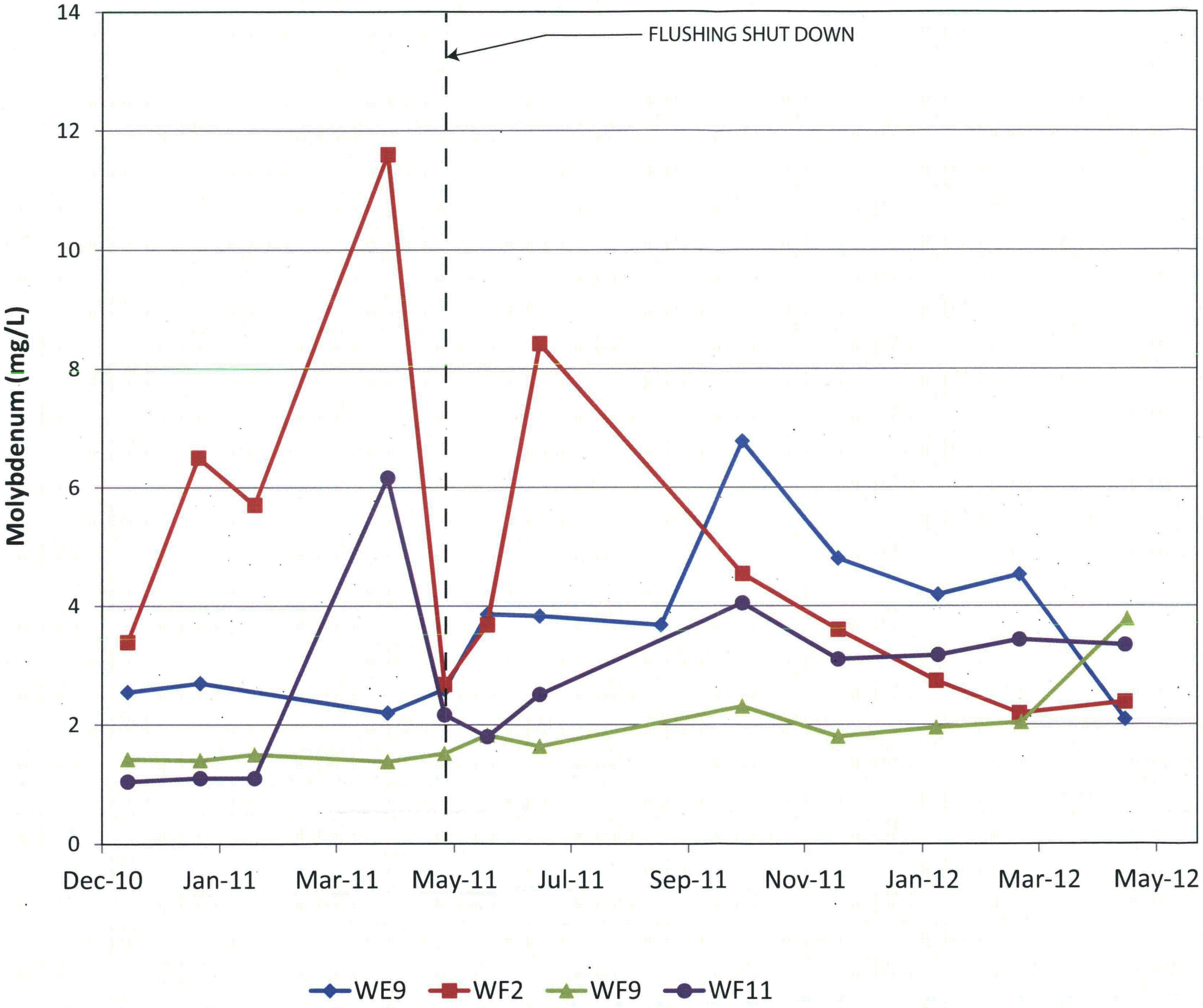
GRANTS RECLAMATION PROJECT

SELENIUM CONCENTRATION TRENDS
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
11

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 11 Selenium Concentration Trends – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC



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GRANTS RECLAMATION PROJECT

MOLYBDENUM CONCENTRATION TRENDS
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
12

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 12 Molybdenum Concentration Trends – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC

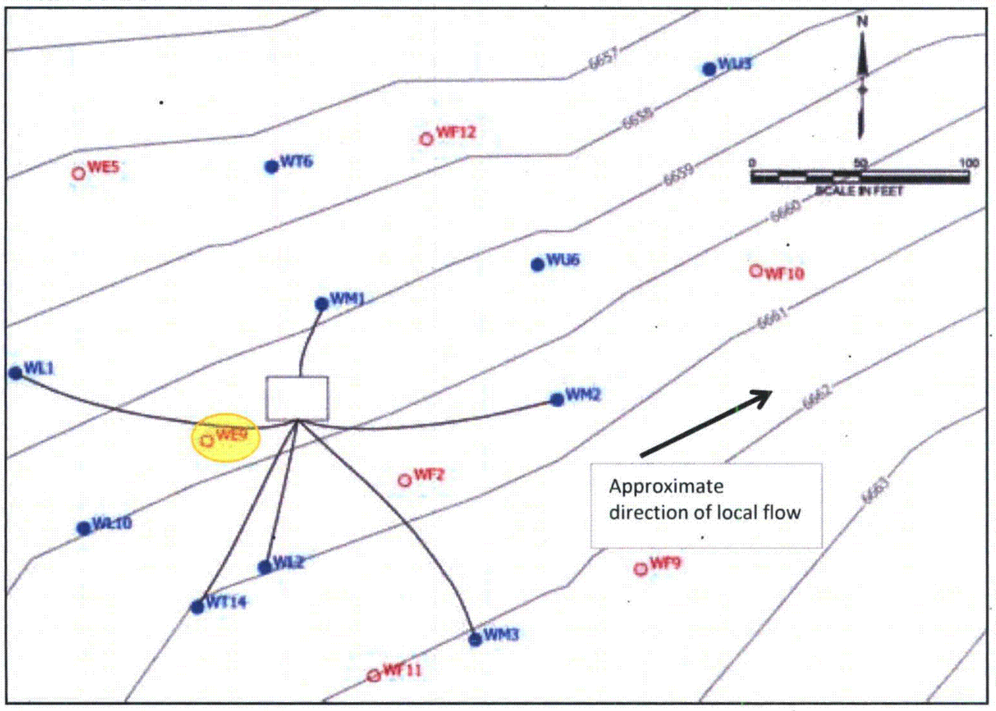
Attachment A

Rebound Evaluation Results

Rebound Evaluation At-A-Glance Charts
Well ID: WE9

Updated May 30, 2012
Most recent data: May 8, 201

Well Location:



LEGEND:

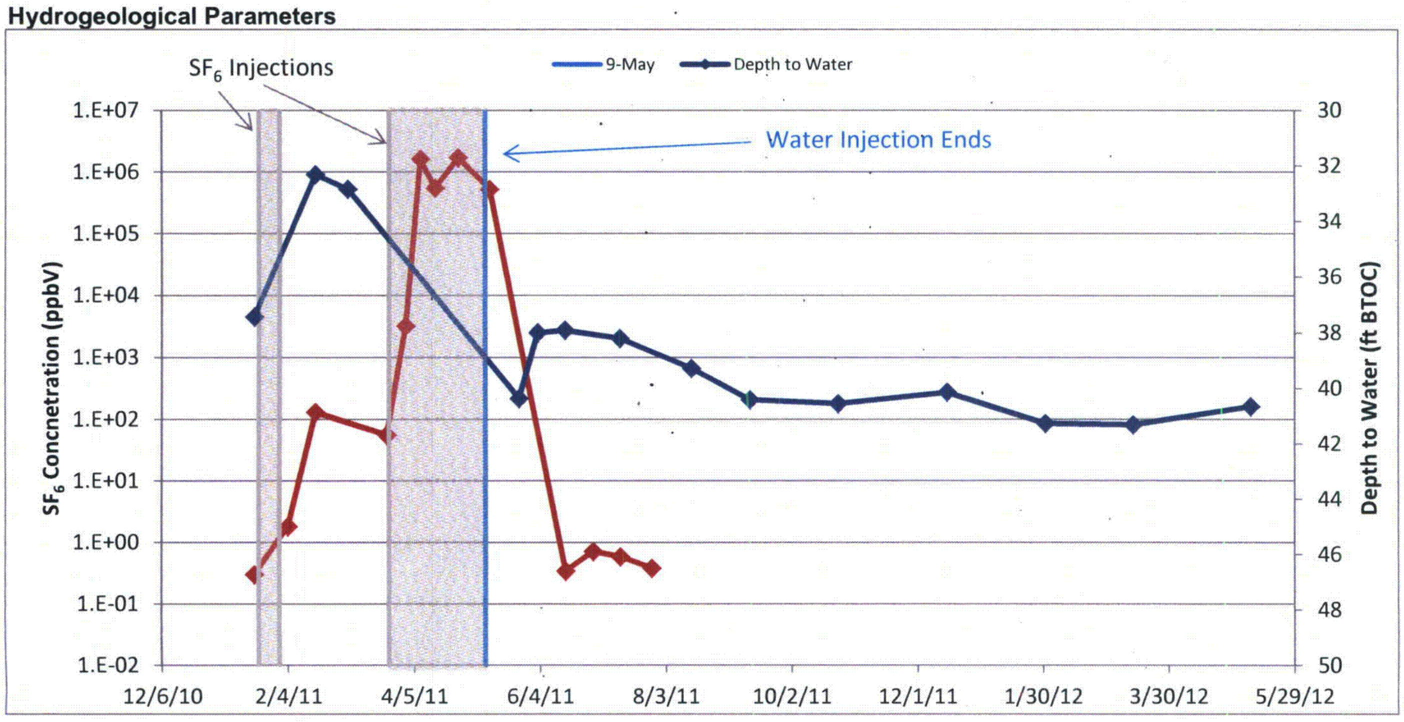
6661 —— GROUND SURFACE ELEVATION (FEET MSL)
● INJECTION WELL LOCATION
○ MONITORING WELL LOCATION
☐ REMEDIATION SHED WITH TRACER TANK HOUSING
—— 1/8" COPPER TUBING

Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6661.96 ft MSL	2.96 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

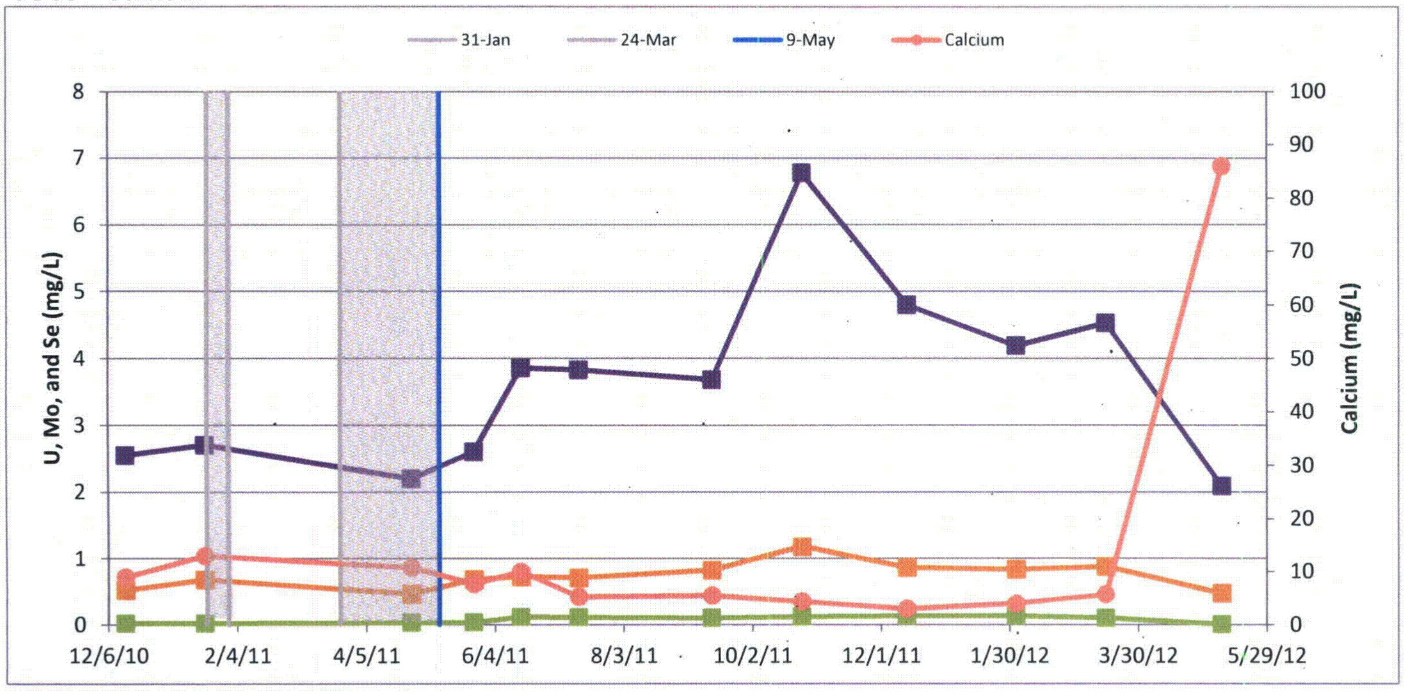


Historic Data

Date	DTW (ft BTOC)
7/7/09	47.15
9/2/09	41.59
10/21/09	42.1
1/7/10	36.75
2/5/10	36.68
6/11/10	45.59
8/9/10	42.82
3/4/11	32.85

No background concentration of SF_6.

COCs + Calcium

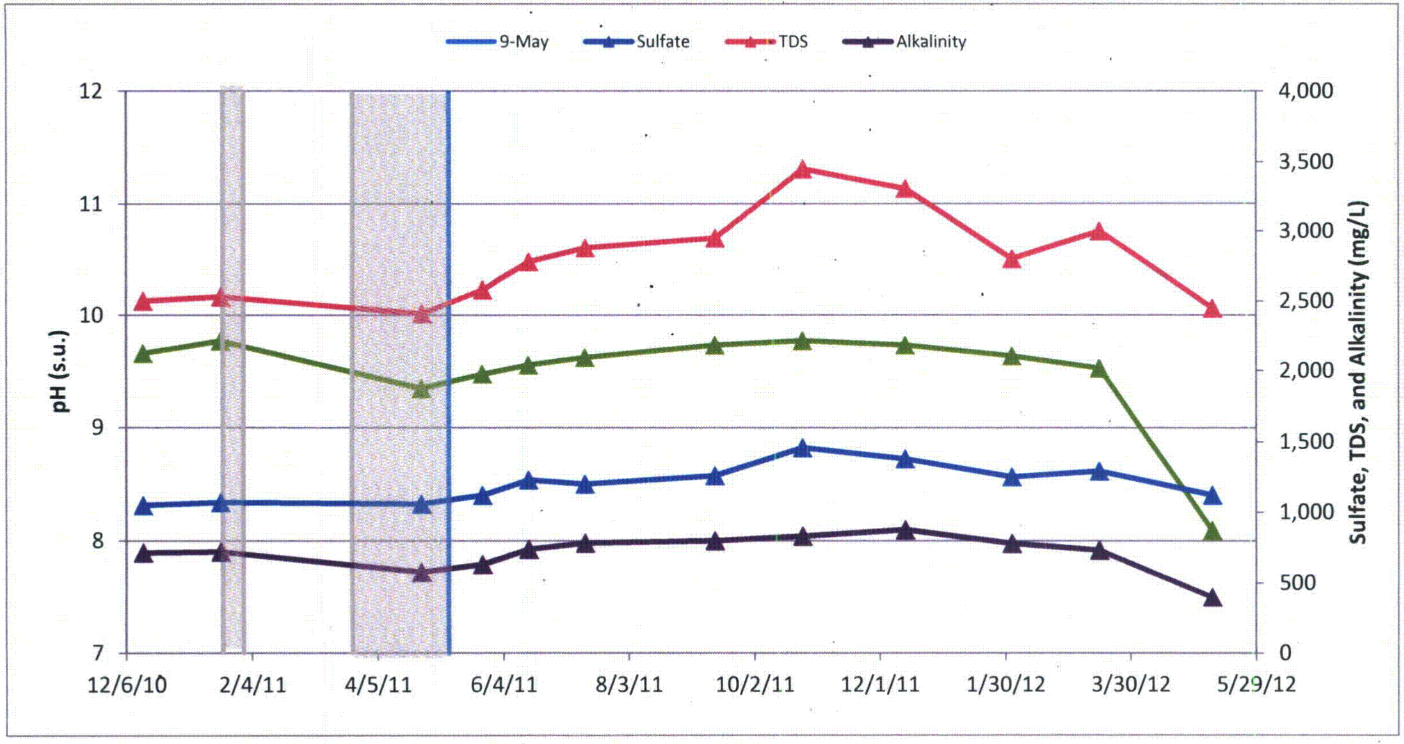


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
9/13/09	2.49	9.89	0.101
3/31/10	3.1	10.7	0.15
12/14/10	0.521	2.55	0.023
1/20/11	0.679	2.7	0.02
4/26/11	0.467	2.2	0.031

Date	Calcium (mg/L)
12/14/10	9
1/20/11	13
4/26/11	10.8

Geochemical Parameters



Historic Data

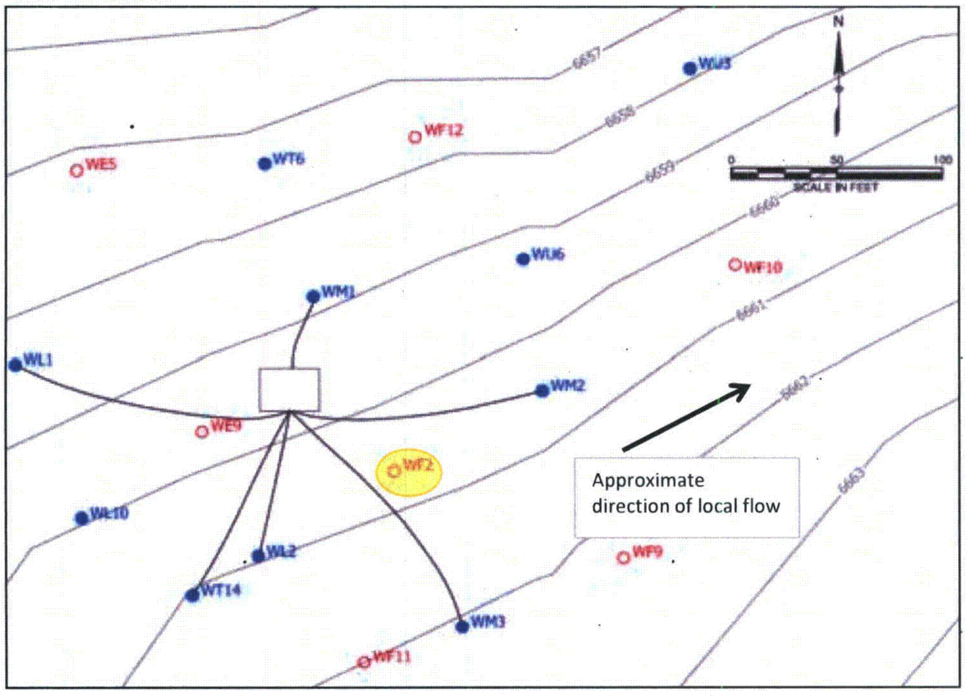
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	9.66	715
1/20/11	9.77	723
4/26/11	9.34	580

Date	Sulfate (mg/L)	TDS (mg/L)
9/13/09	1780	4570
3/31/10	1570	4310
12/14/10	1050	2500
1/20/11	1070	2530
4/26/11	1060	2410

Rebound Evaluation At-A-Glance Charts
Well ID: WF2

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



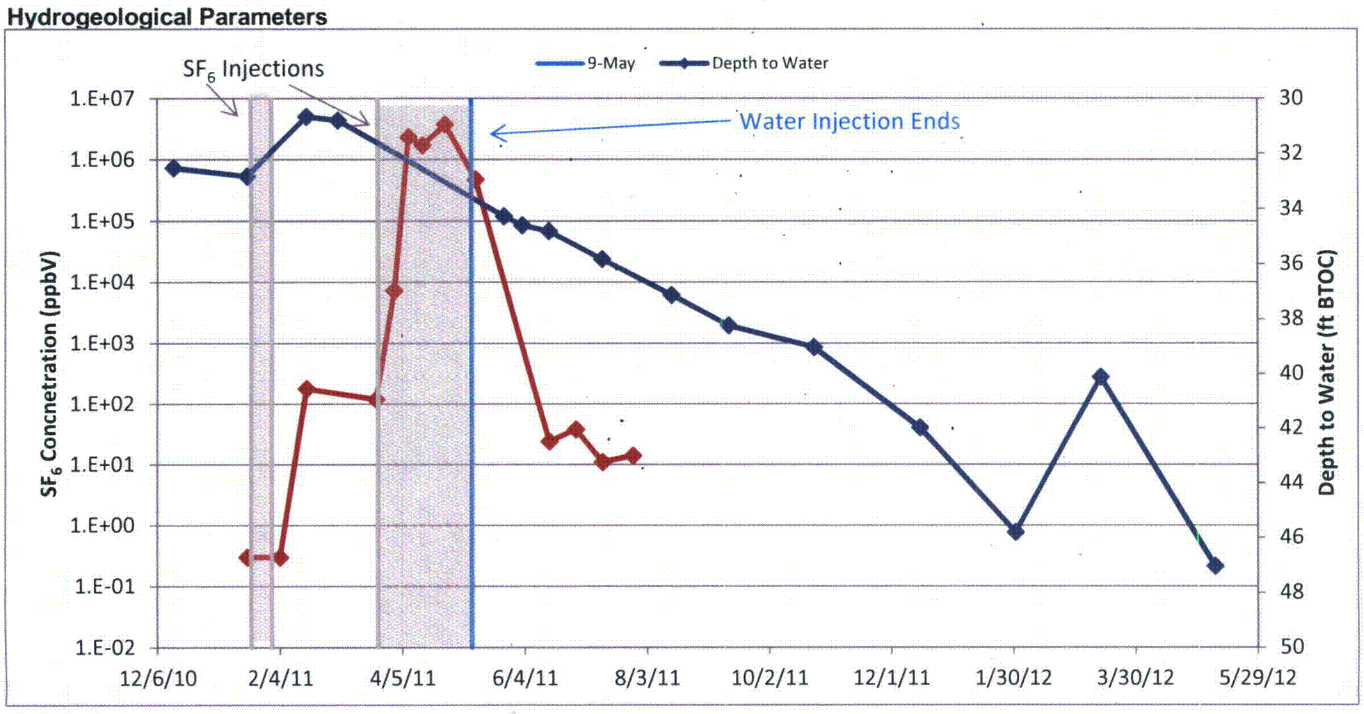
LEGEND:
6661 —— GROUND SURFACE ELEVATION (FEET MSL)
● INJECTION WELL LOCATION
○ MONITORING WELL LOCATION
☐ REMEDIATION SHED WITH TRACER TANK HOUSING
—— 1/8" COPPER TUBING

Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
111.8 ft	28 - 108 ft	5 in	6660.82 ft MSL	3.7 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

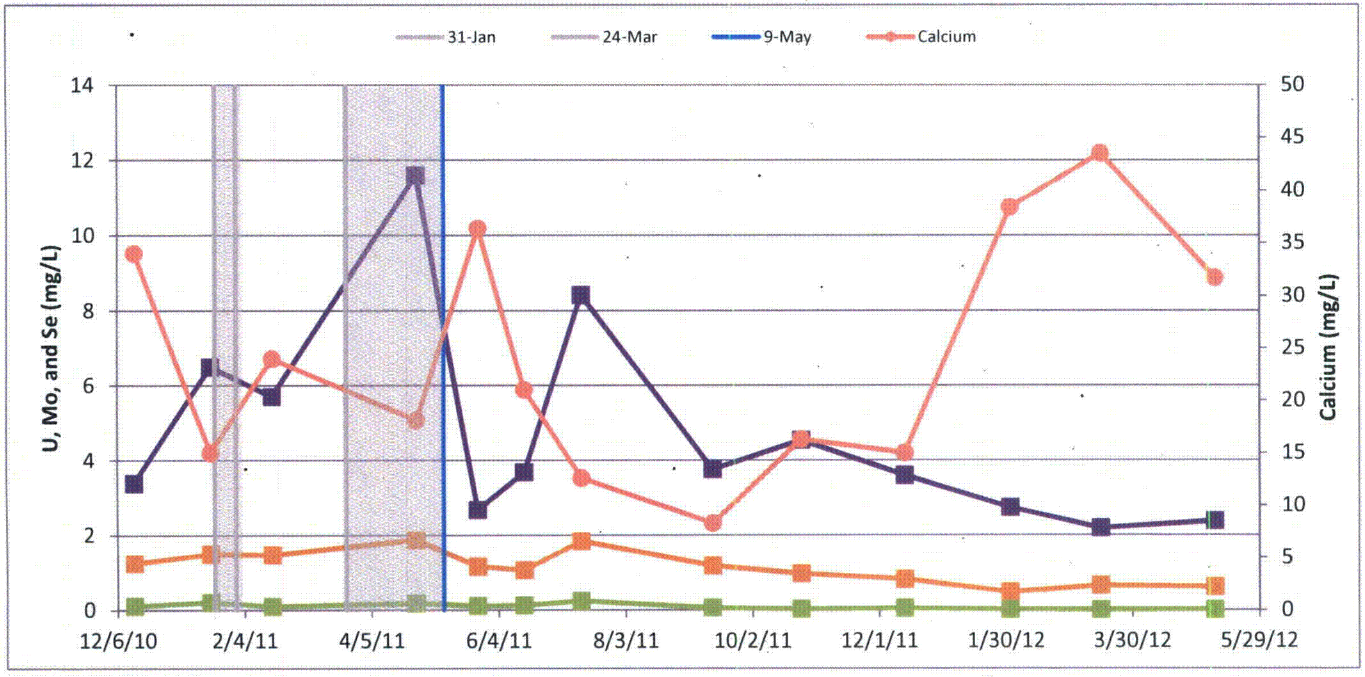


Historic Data

Date	DTW (ft BTOC)
7/16/08	35.3
2/22/09	35.8
7/8/09	32.06
8/6/09	32.64
10/21/09	34.96
1/7/10	30.15
2/5/10	35.25
6/11/10	34.86
8/9/10	31.95
3/4/11	30.8

No background concentration of SF$_6$.

COCs + Calcium

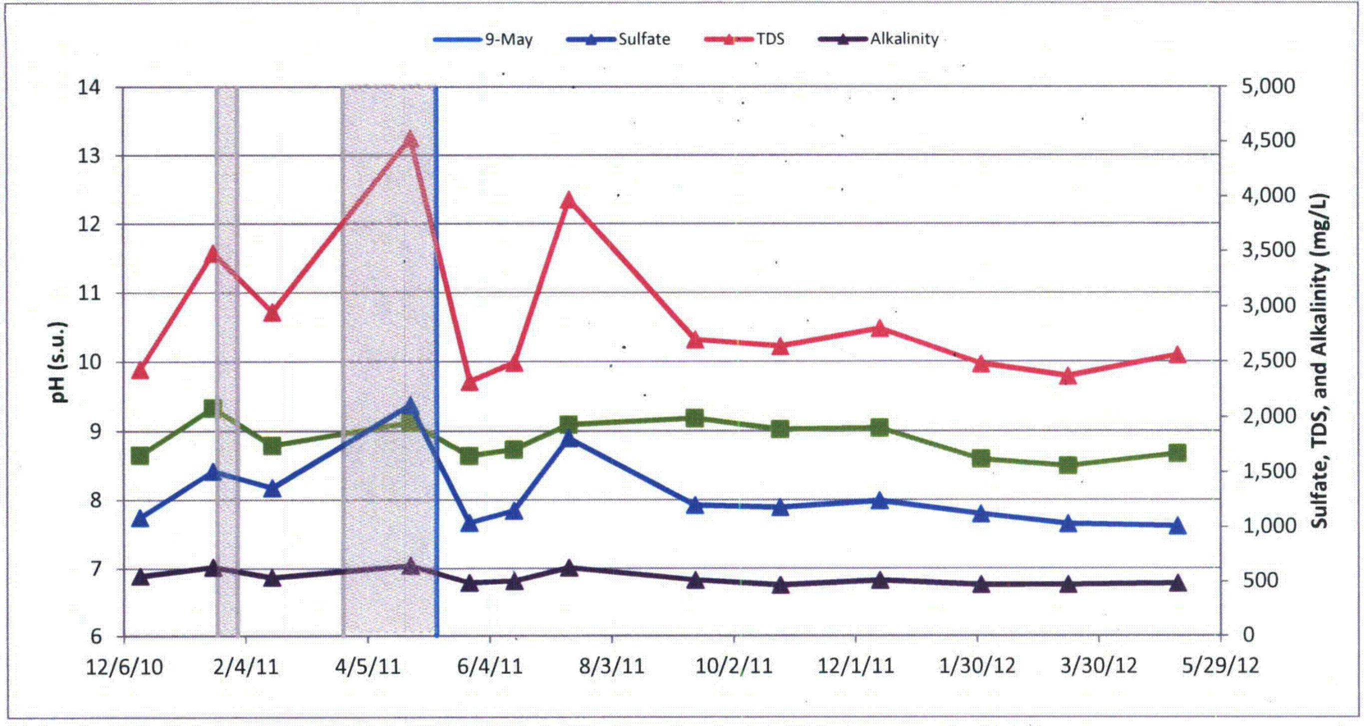


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
9/28/08	3.7	15.8	1.72
5/13/09	2.81	10.3	0.636
8/13/09	2.71	9.98	0.582
3/31/10	1.5	4.8	0.18
5/4/10	1.32	4.86	0.111
12/14/10	1.24	3.39	0.106
1/19/11	1.49	6.5	0.208
2/17/11	1.47	5.7	0.095
4/26/11	1.87	11.6	0.175

Date	Calcium (mg/L)
9/28/08	8
12/14/10	34
1/19/11	15
2/17/11	24
4/26/11	18.1

Geochemical Parameters



Historic Data

Date	pH (s.u.)	Alkalinity (mg/L)
9/28/08	9.04	719
12/14/10	8.65	555
1/19/11	9.33	638
2/17/11	8.79	541
4/26/11	9.12	652

Date	Sulfate (mg/L)	TDS (mg/L)
9/28/08	2260	4950
5/13/09	1820	4000
8/13/09	1730	3730
3/31/10	1220	2940
5/4/10	1180	2780
12/14/10	1090	2430
1/19/11	1510	3480
2/17/11	1360	2950
4/26/11	2110	4530

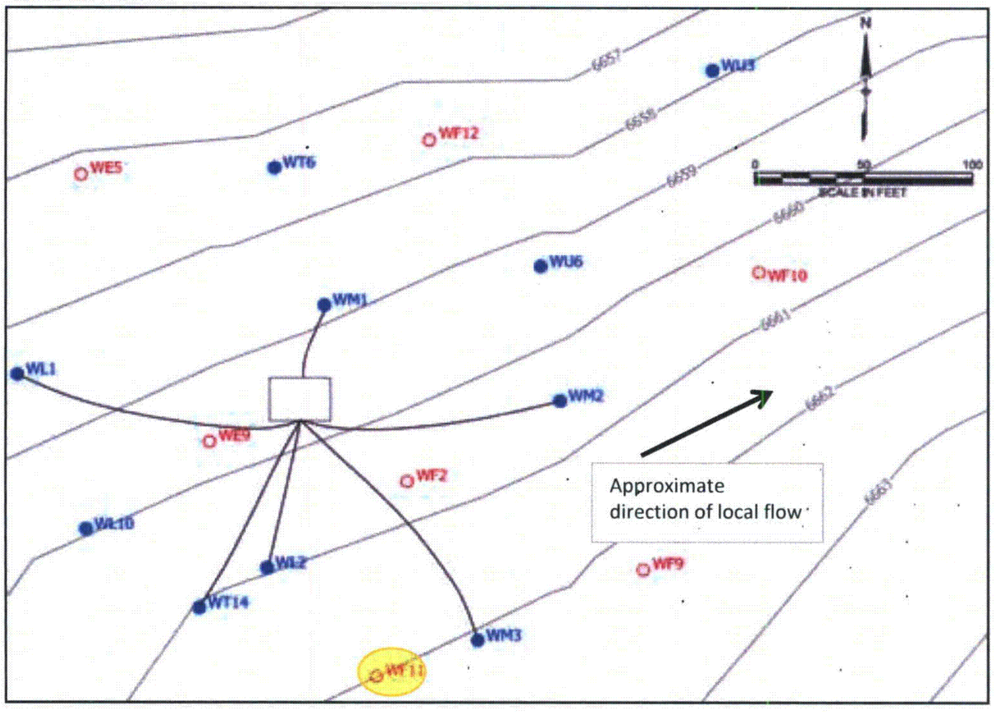
ebound Evaluation At-A-Glance Charts

Well ID: WF11

Updated May 30, 2012

Most recent data: May 8, 2012

Well Location:



LEGEND:

6661 —— GROUND SURFACE ELEVATION (FEET MSL)

● INJECTION WELL LOCATION

○ MONITORING WELL LOCATION

☐ REMEDIATION SHED WITH TRACER TANK HOUSING

—— 1/8" COPPER TUBING

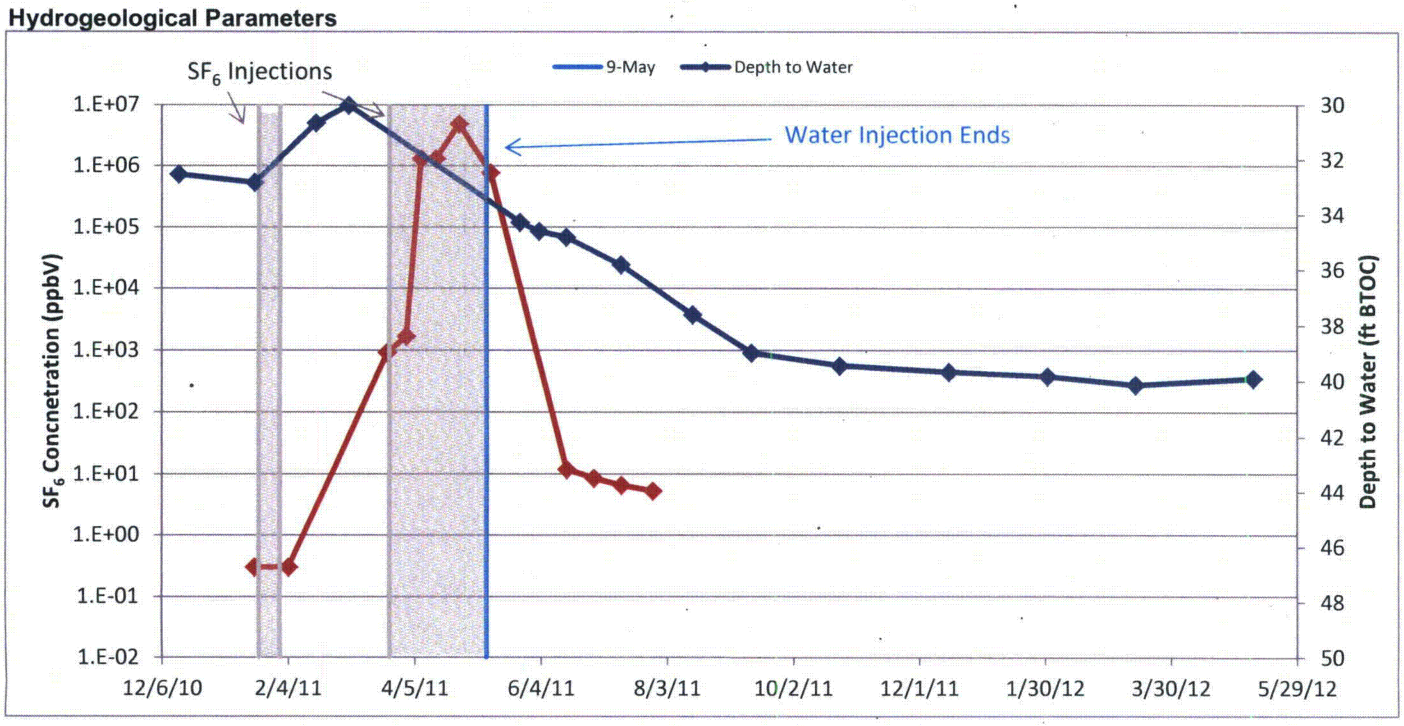
Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6664.84 ft MSL	2.93 ft

Notes:

PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

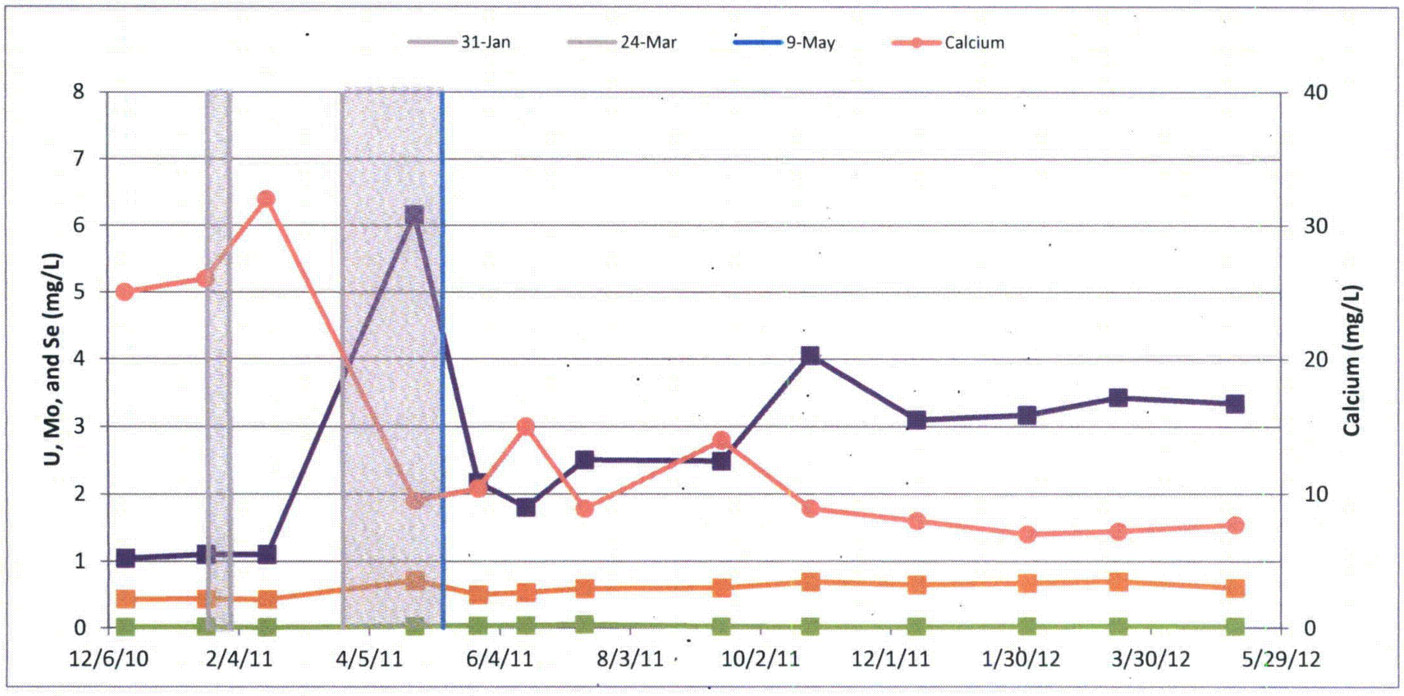


Historic Data

Date	DTW (ft BTOC)
7/16/08	37.5
5/13/09	29.42
7/8/09	56.33
6/11/10	34.19
8/9/10	31.25
3/4/11	30.02

No background concentration of SF$_6$.

COCs + Calcium

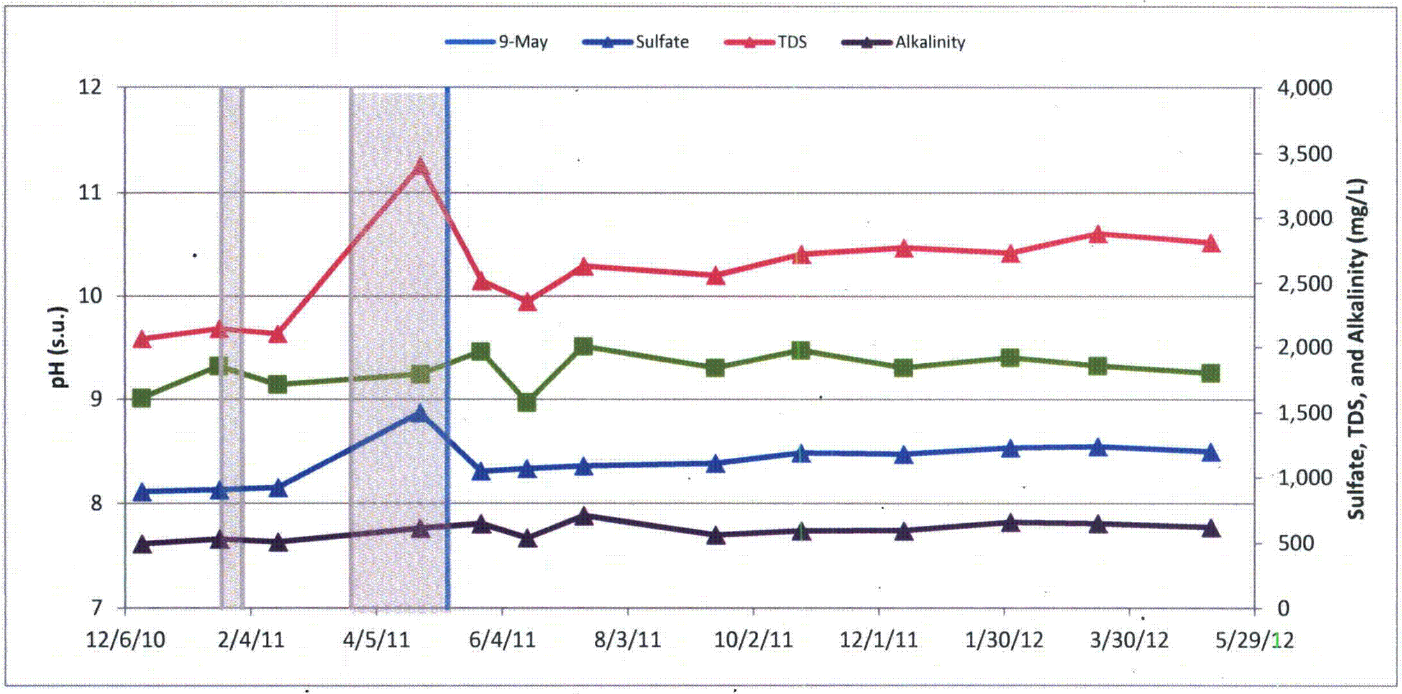


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
2/22/09	0.676	1.33	0.009
5/13/09	0.64	2.42	0.065
5/5/10	0.706	2.97	0.142
12/14/10	0.436	1.04	0.014
1/20/11	0.438	1.1	0.016
2/17/11	0.431	1.1	0.008
4/27/11	0.712	6.16	0.024

Date	Calcium (mg/L)
12/14/10	25
1/20/11	26
2/17/11	32
4/27/11	9.5

Geochemical Parameters



Historic Data

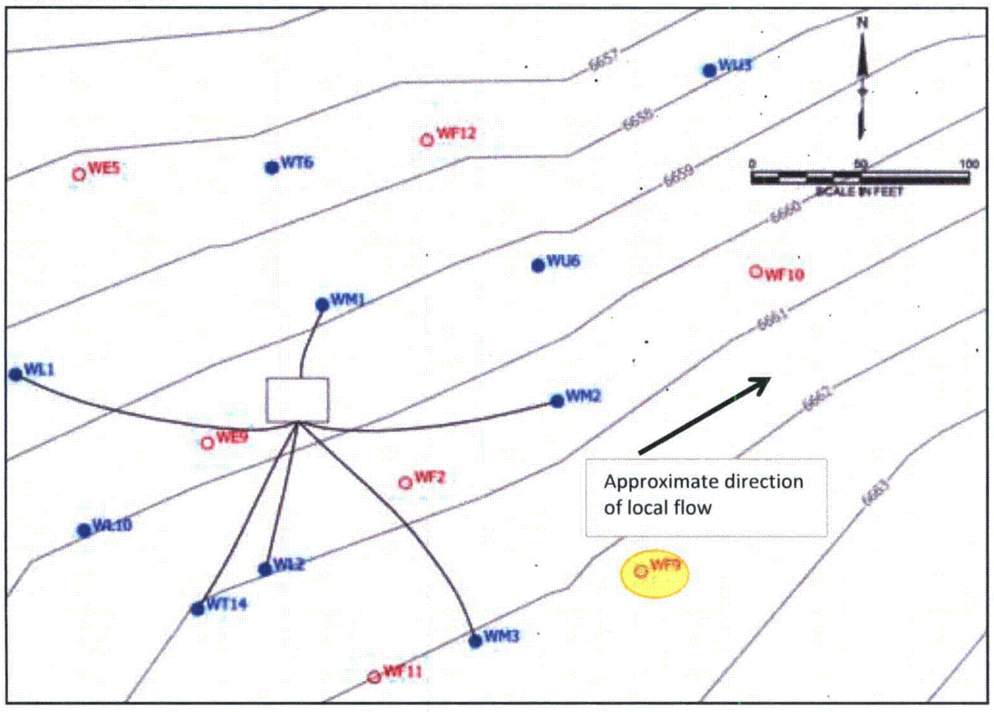
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	9.01	493
1/20/11	9.32	528
2/17/11	9.14	506
4/27/11	9.24	613

Date	Sulfate (mg/L)	TDS (mg/L)
2/22/09	893	2110
5/13/09	976	2460
5/5/10	987	2440
12/14/10	893	2070
1/20/11	907	2150
2/17/11	924	2110
4/27/11	1500	3410

Rebound E[illegible]uation At-A-Glance Charts
Well ID: WF9

Up[illegible]ed May 30, 2012
Most recent data: May 9, 2012

Well Location:



LEGEND:

6661 —— GROUND SURFACE ELEVATION (FEET MSL)

● INJECTION WELL LOCATION

○ MONITORING WELL LOCATION

☐ REMEDIATION SHED WITH TRACER TANK HOUSING

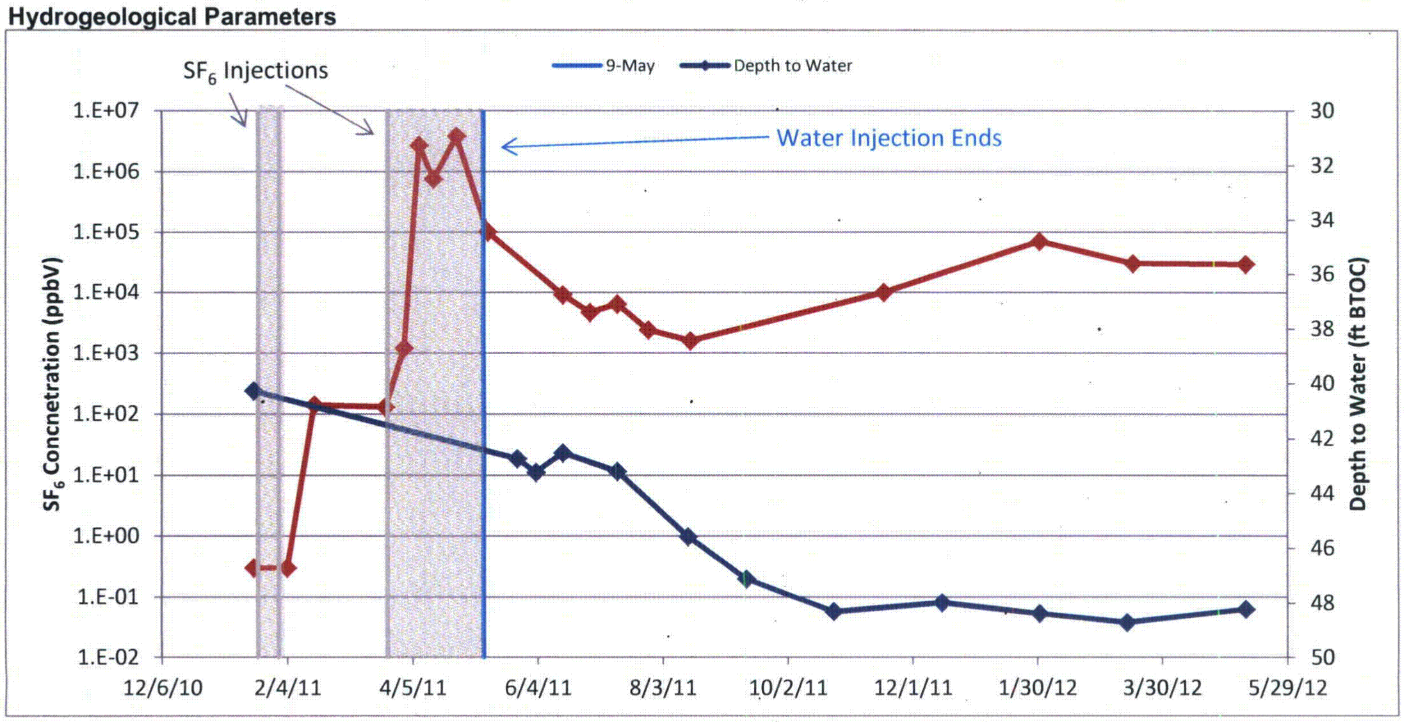
—— 1/8" COPPER TUBING

Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6665.7 ft MSL	3.17 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

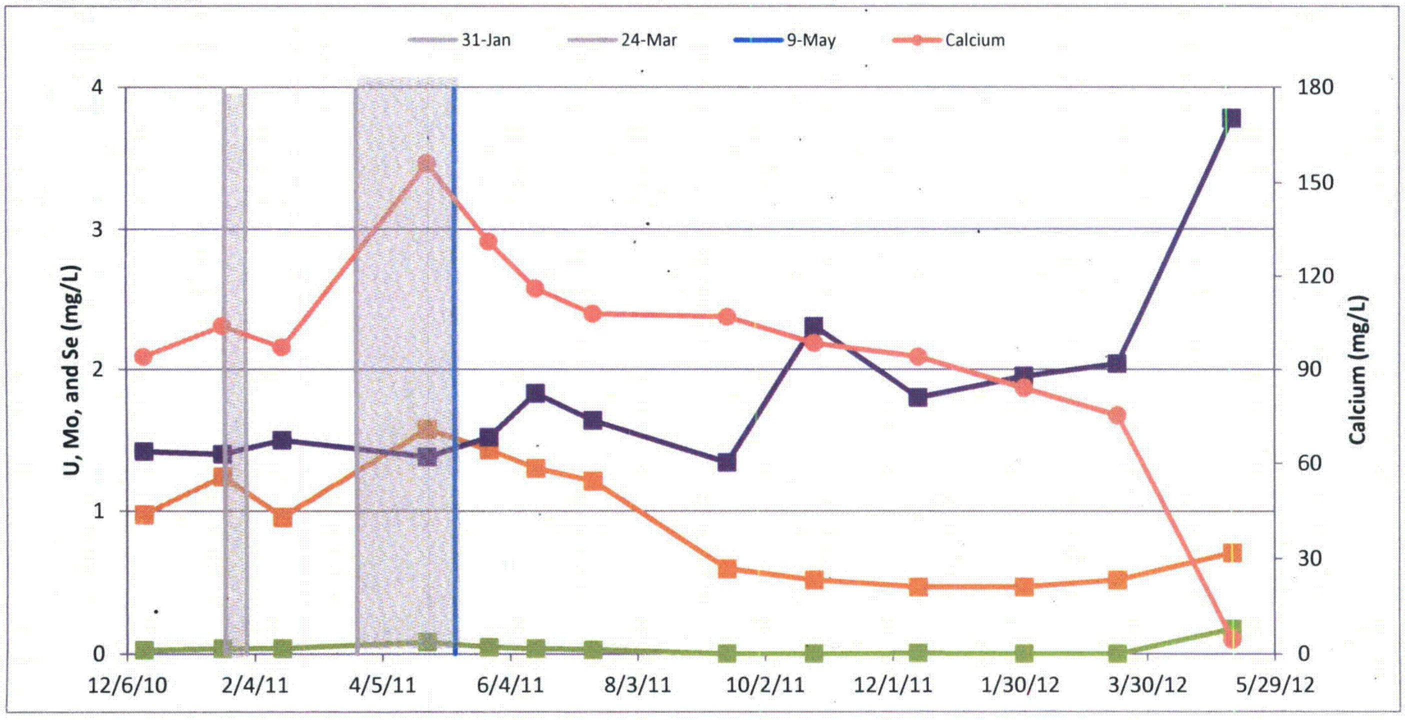


Historic Data

Date	DTW (ft BTOC)
10/21/09	41.24
6/11/10	41.45
8/9/10	40.41

No background concentration of SF$_6$.

COCs + Calcium

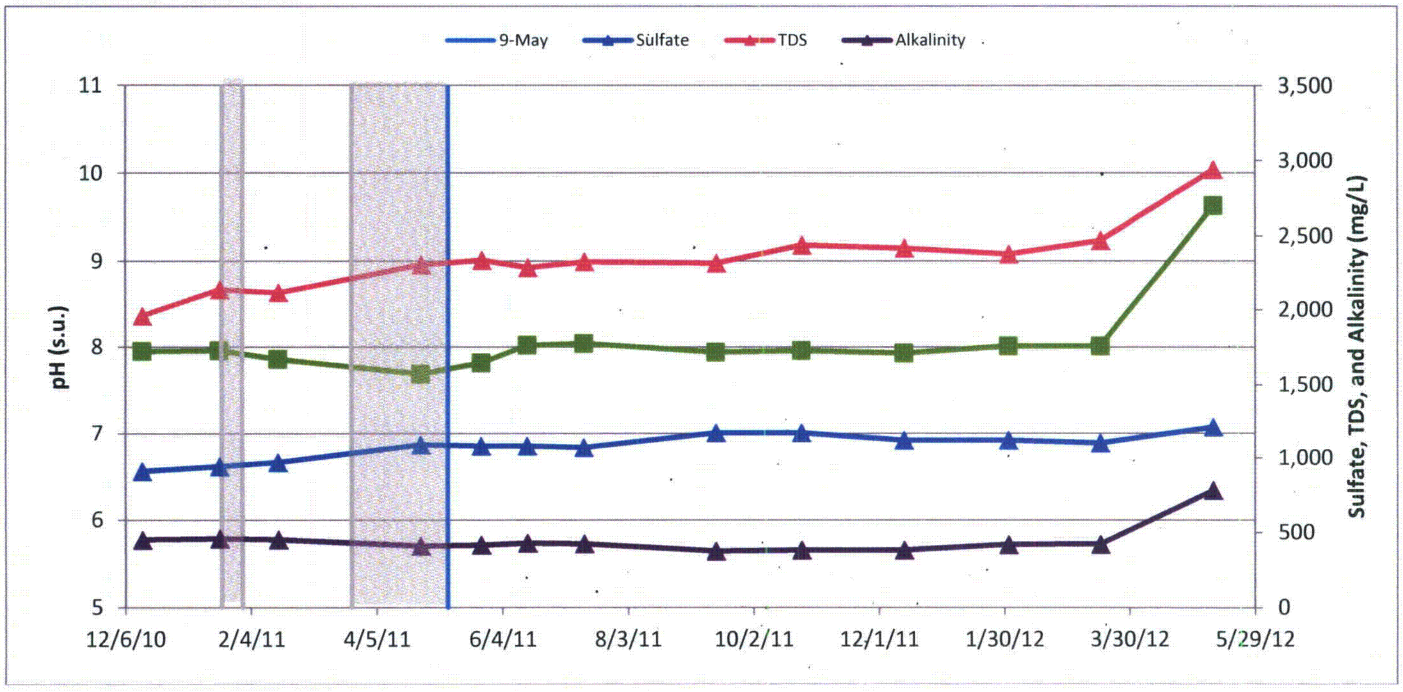


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
3/31/10	1.3	2.3	0.038
12/14/10	0.974	1.42	0.025
1/20/11	1.24	1.4	0.035
4/26/11	1.58	1.38	0.081

Date	Calcium (mg/L)
12/14/10	94
1/20/11	104
4/26/11	156

Geochemical Parameters



Historic Data

Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	7.95	451
1/20/11	7.96	459
4/26/11	7.69	410

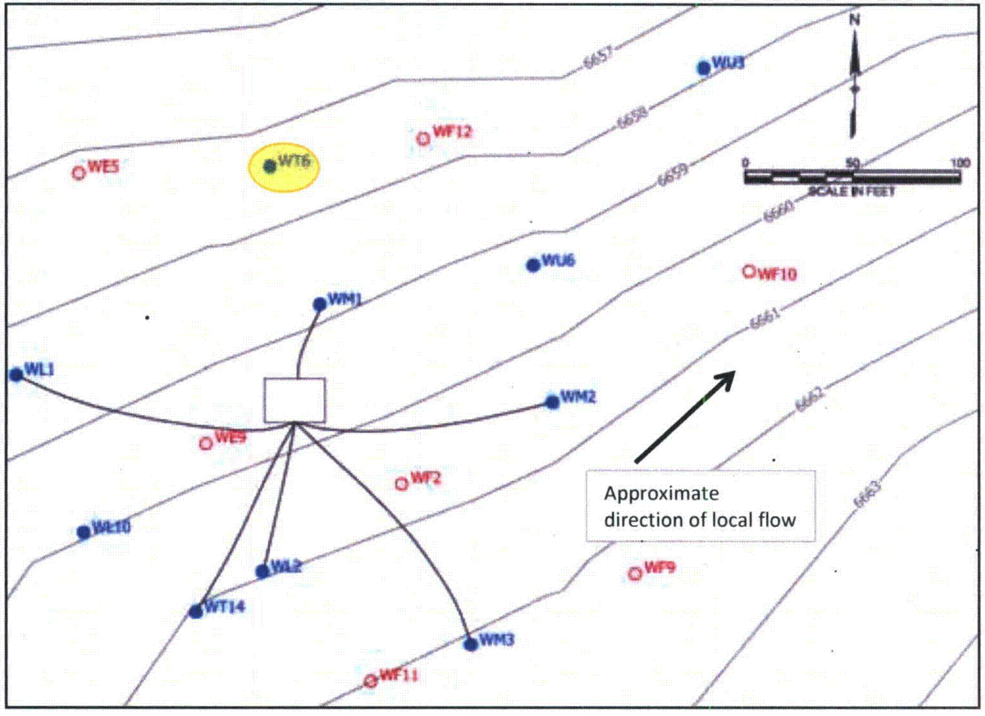
Date	Sulfate (mg/L)	TDS (mg/L)
3/31/10	1020	2270
12/14/10	910	1960
1/20/11	941	2140
4/26/11	1090	2310

Rebound E[illegible]uation At-A-Glance Charts
Well ID: WT6

Up[illegible]d May 30, 2012

Most recent data: May 8, 2012

Well Location:



LEGEND:

6661 — GROUND SURFACE ELEVATION (FEET MSL)

● INJECTION WELL LOCATION

○ MONITORING WELL LOCATION

☐ REMEDIATION SHED WITH TRACER TANK HOUSING

— 1/8" COPPER TUBING

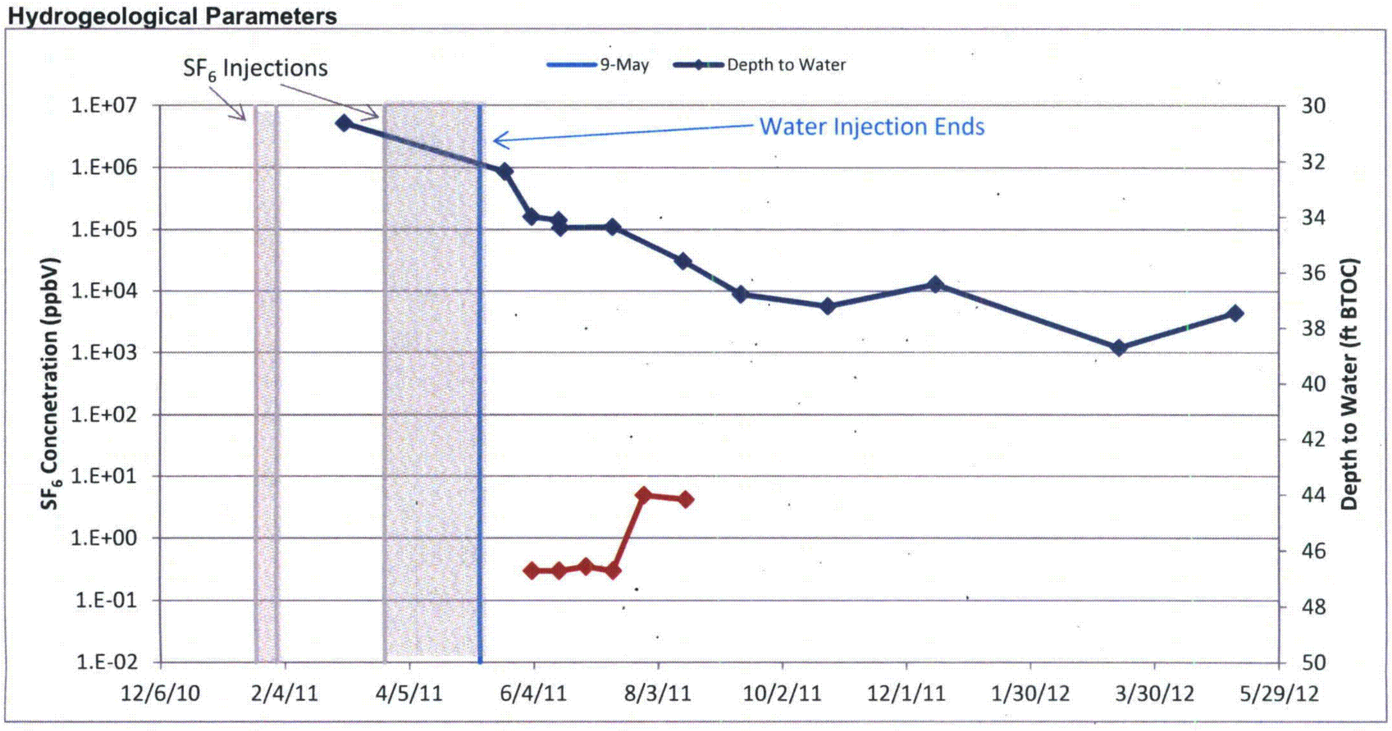
Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6657 ft MSL	2

Notes:

PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

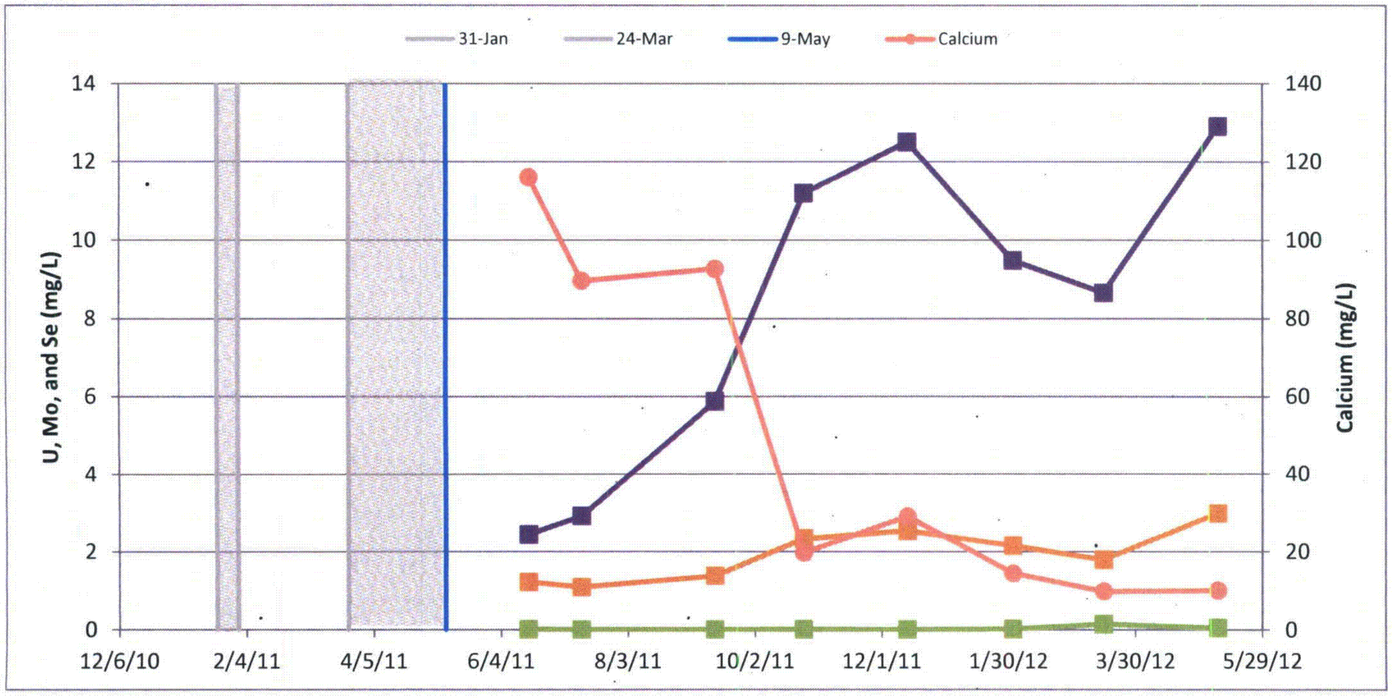


Historic Data

Date	DTW (ft BTOC)
5/16/08	38.55
5/17/08	38.55
2/22/09	32.79
2/22/09	32.79
4/10/10	32.98
10/8/10	35
3/4/11	30.65

No background concentration of SF_6.

COCs + Calcium

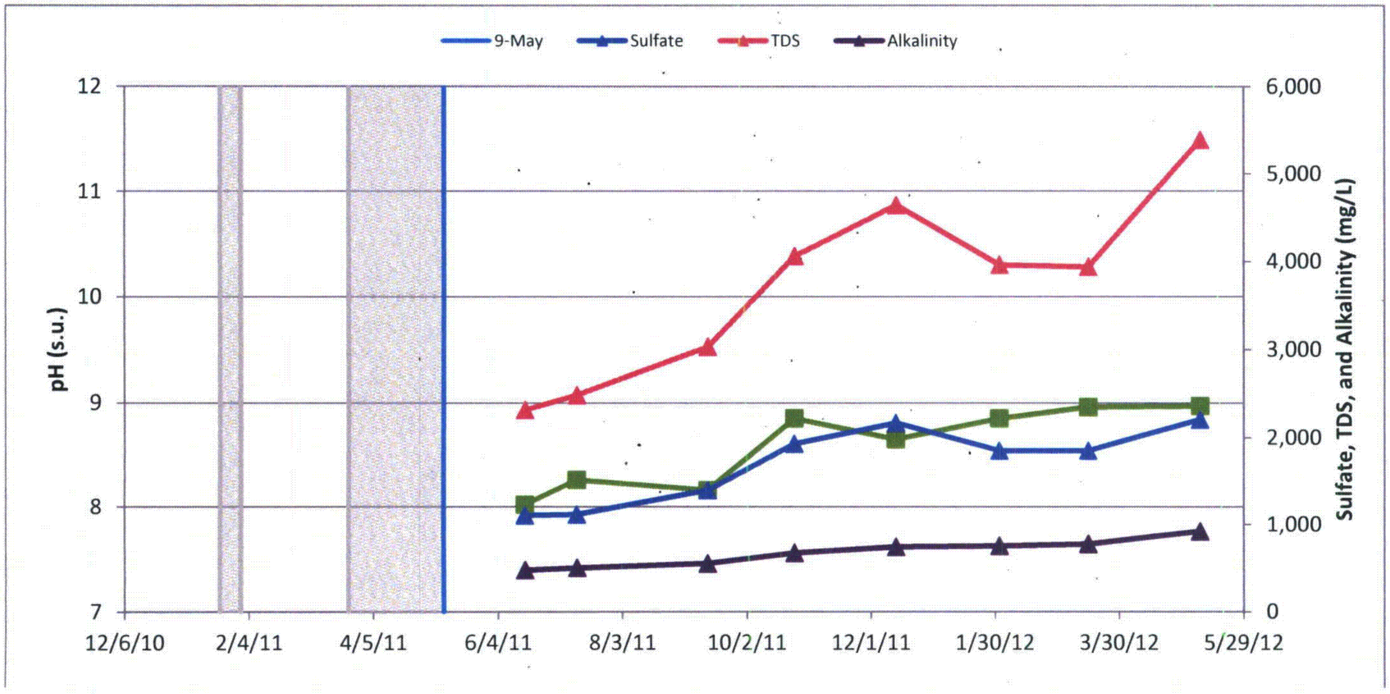


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
5/17/08	1.37	7.37	0.05
2/22/09	0.795	2.58	0.011
4/10/10	0.903	1.26	<0.005
10/8/10	0.844	0.97	<0.005

Date	Calcium (mg/L)
5/17/08	10.8

Geochemical Parameters



Historic Data

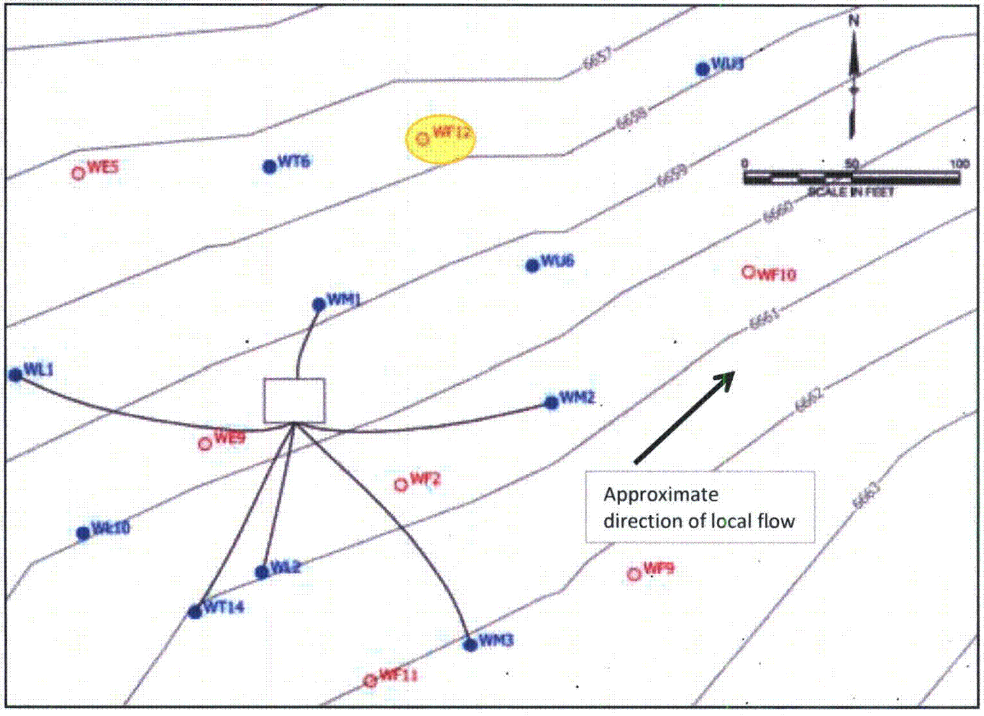
Date	pH (s.u.)	Alkalinity (mg/L)
5/17/08	9.21	623

Date	Sulfate (mg/L)	TDS (mg/L)
5/17/08	1620	3350
2/22/09	1000	2260
4/10/10	884	1890
10/8/10	826	2220

Rebound Evaluation At-A-Glance Charts
Well ID: WF12

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



LEGEND:

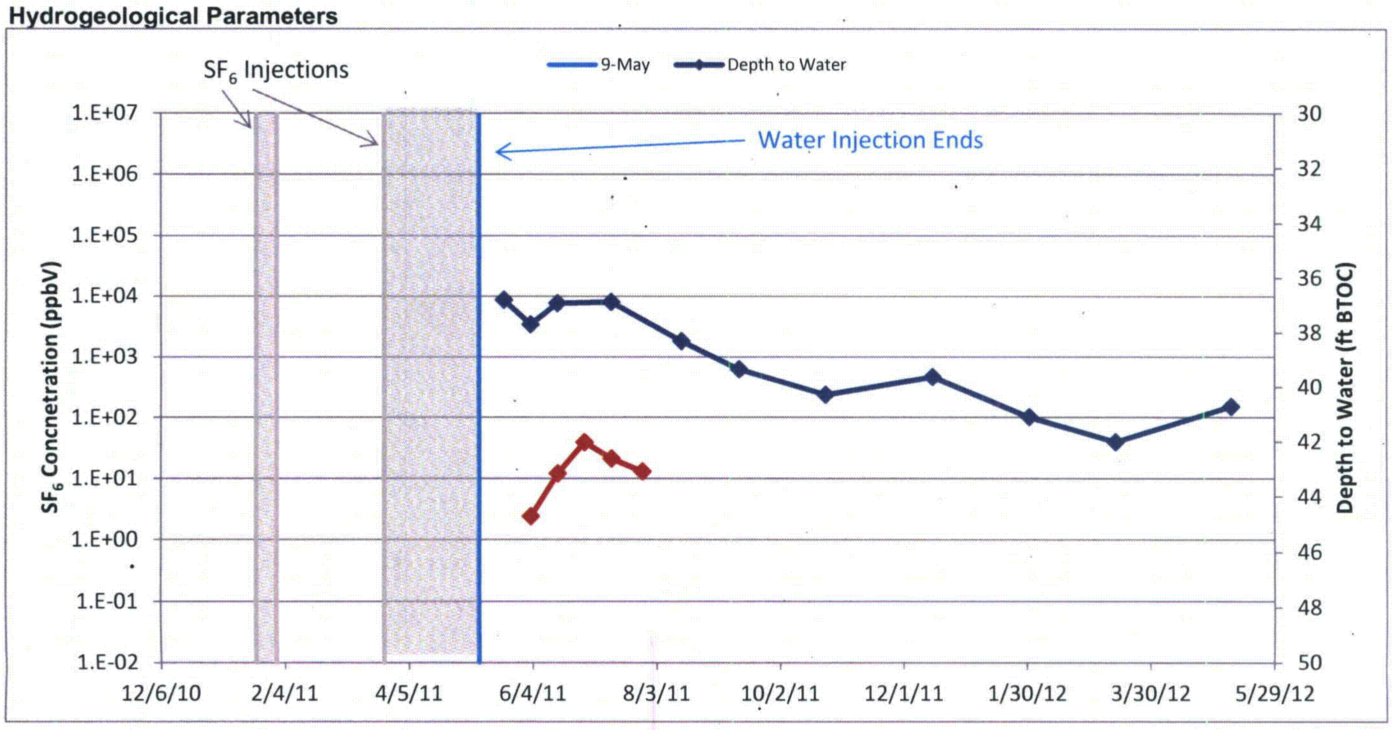
6661 —— GROUND SURFACE ELEVATION (FEET MSL)
● INJECTION WELL LOCATION
○ MONITORING WELL LOCATION
☐ REMEDIATION SHED WITH TRACER TANK HOUSING
—— 1/8" COPPER TUBING

Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6655.65 ft MSL	3.26 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

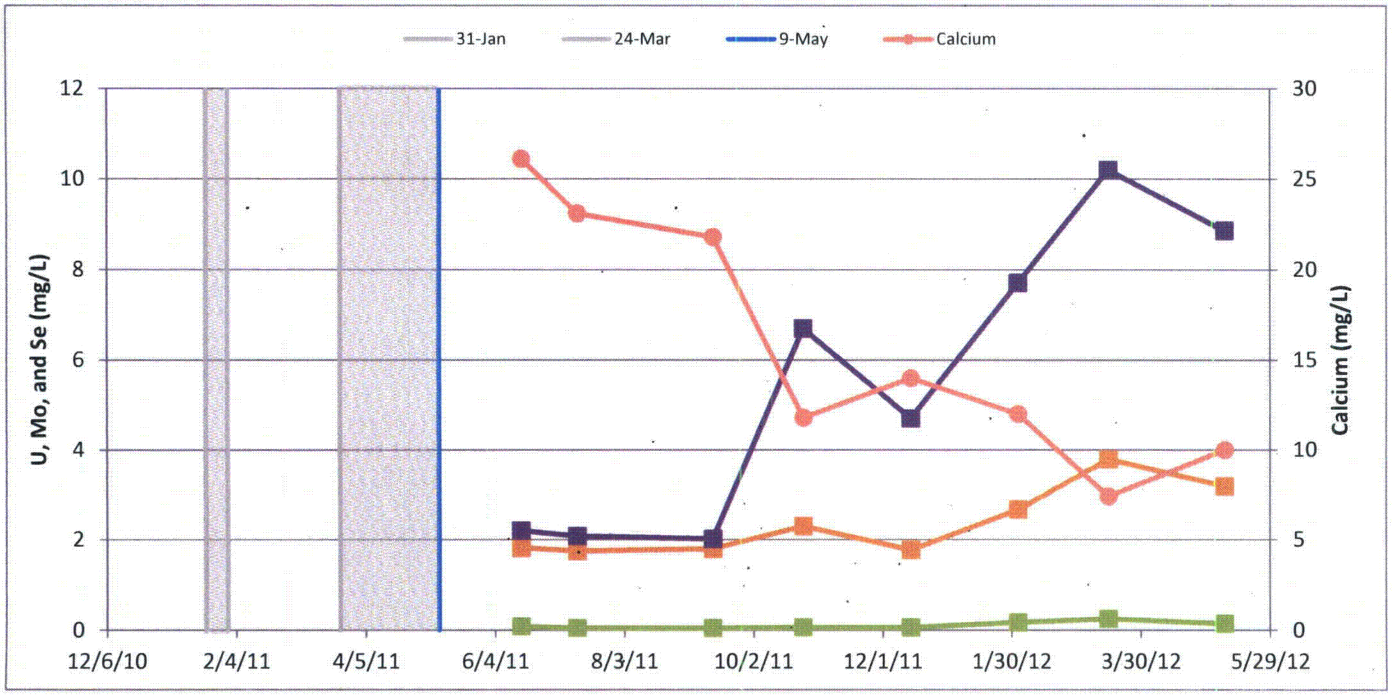


Historic Data

Date	DTW (ft BTOC)
7/16/08	45.4
7/8/09	51.94
8/6/09	42.6
9/2/09	38.23
6/11/10	38.48
8/9/10	37.8

No background concentration of SF$_6$.

COCs + Calcium

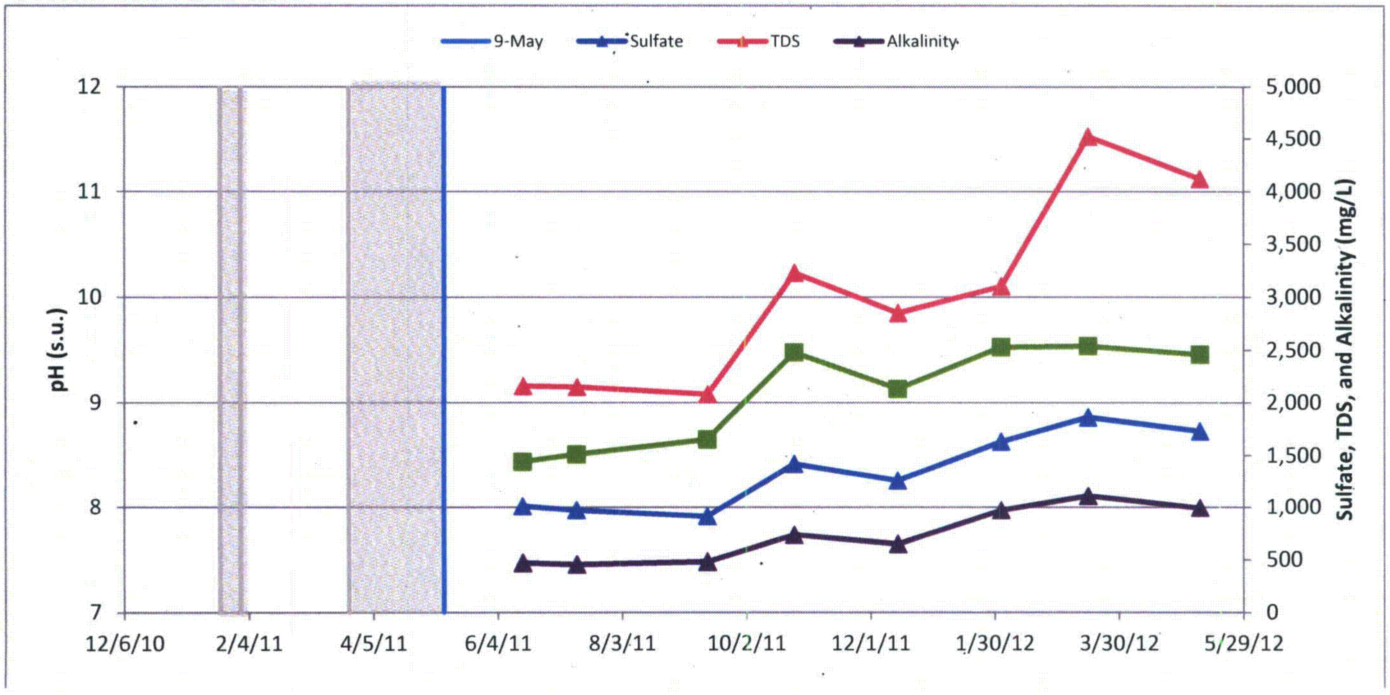


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
1/14/09	7.37	10.2	0.255
9/13/09	3.41	3.49	0.319
5/4/10	1.56	1.31	0.112

Date	Calcium (mg/L)
1/14/09	19.4

Geochemical Parameters



Historic Data

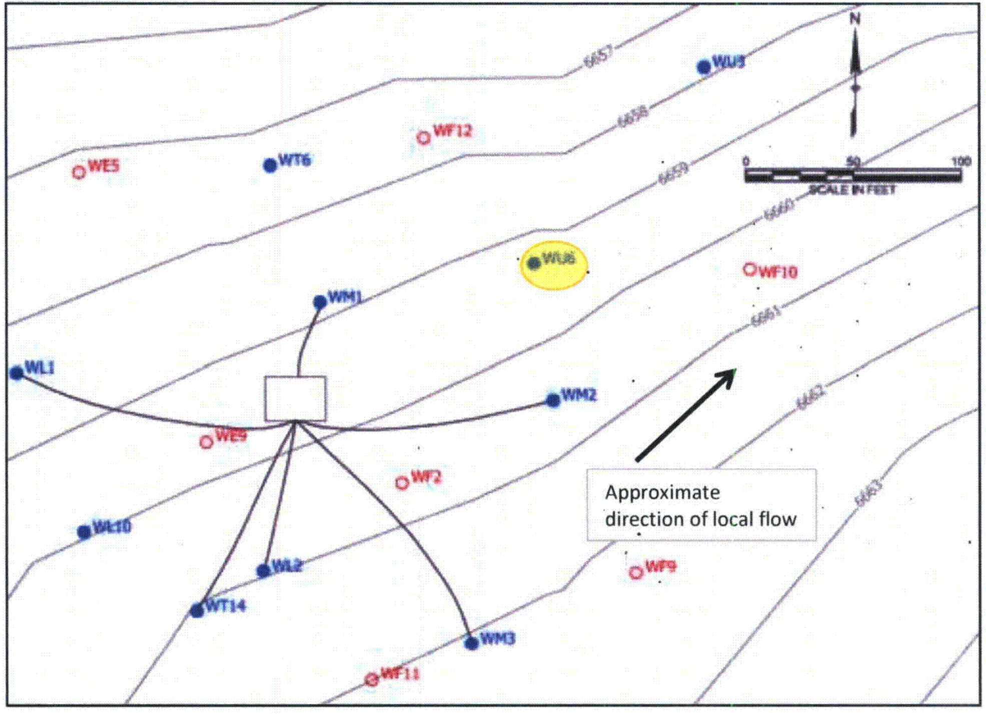
Date	pH (s.u.)	Alkalinity (mg/L)
1/14/09	8.9	681

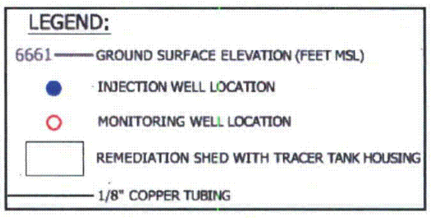
Date	Sulfate (mg/L)	TDS (mg/L)
1/14/09	1700	3730
9/13/09	1060	2290
5/4/10	862	1910

Rebound E[illegible]uation At-A-Glance Charts
Well ID: WU6

Up[illegible]d May 30, 2012
Most recent data: May 8, 2012

Well Location:



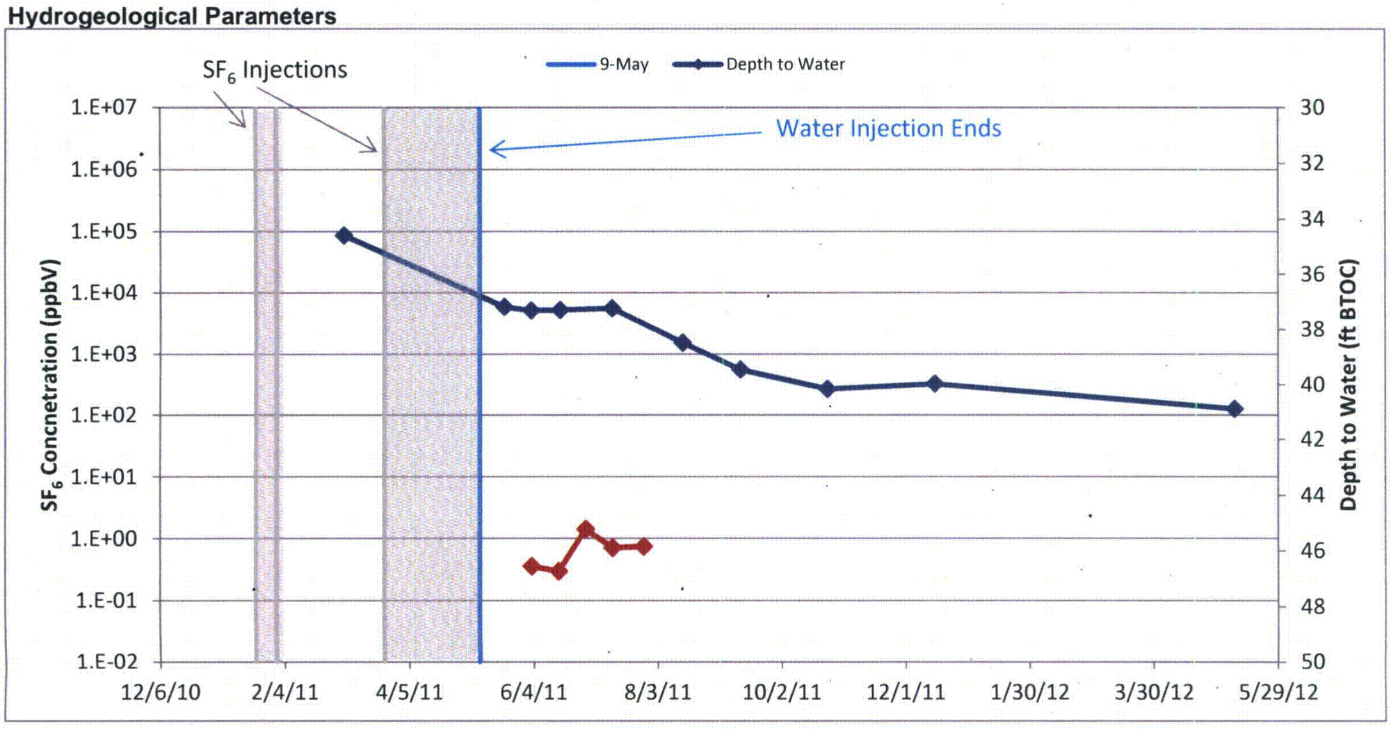


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6661 ft MSL	2

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

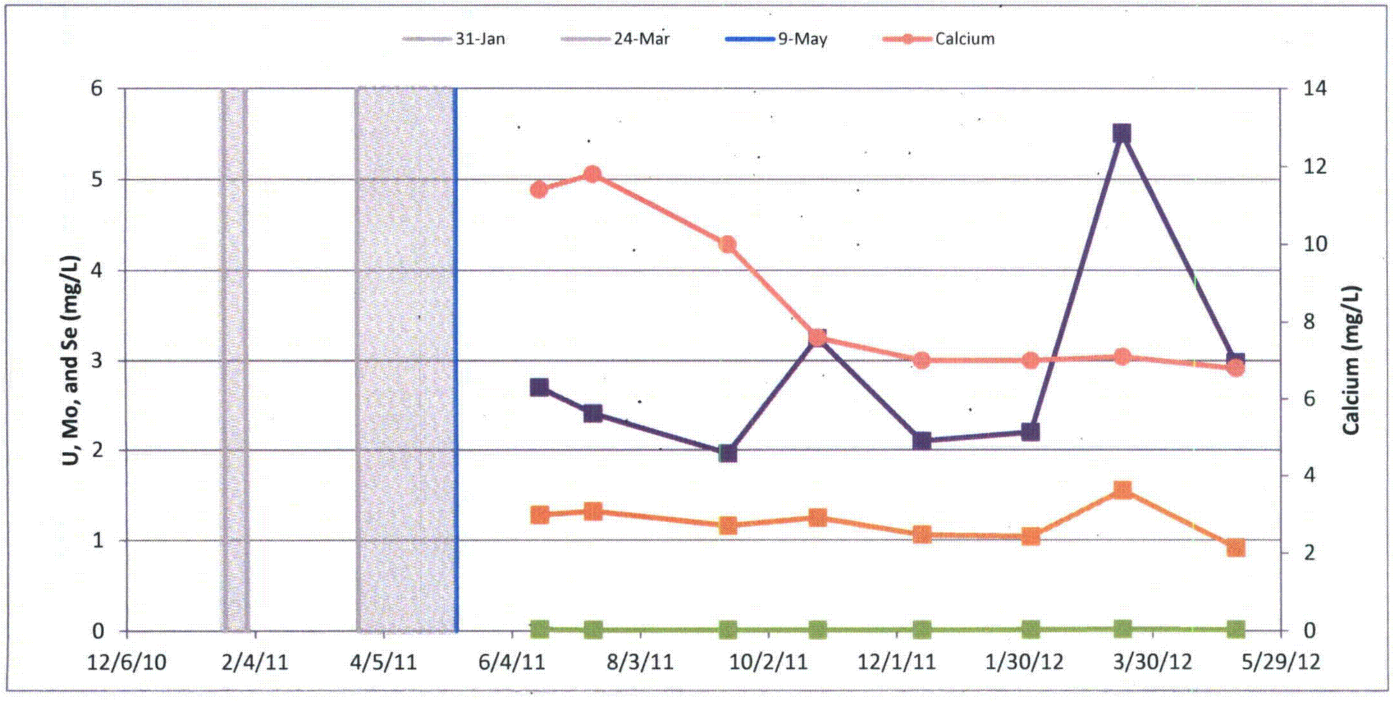


Historic Data

Date	DTW (ft BTOC)
5/16/08	40.8
5/16/08	40.8
2/22/09	37.47
4/10/10	37.33
10/7/10	38.4
3/4/11	34.59

No background concentration of SF_6.

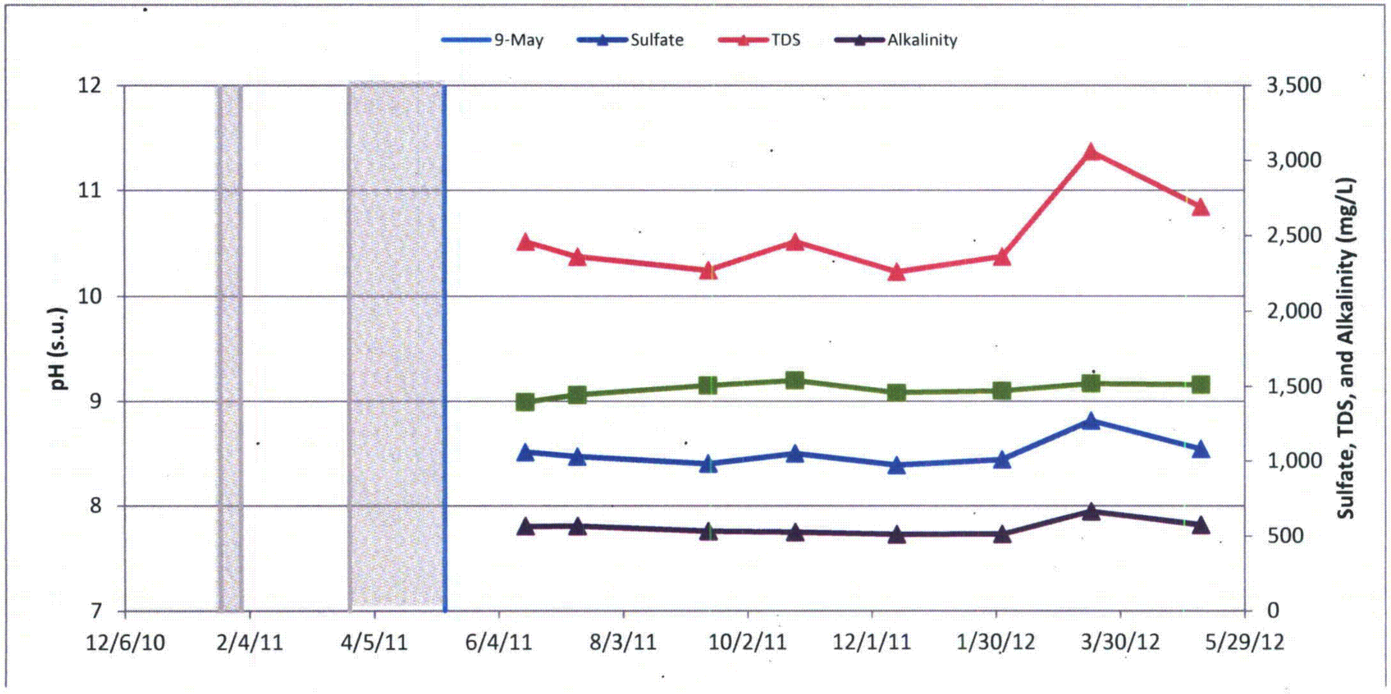
COCs + Calcium



Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
5/16/08	5.63	21.9	0.021
2/22/09	2.01	7.55	<0.005
4/10/10	1.5	5.04	0.007
10/7/10	1.54	3.88	0.009

Geochemical Parameters



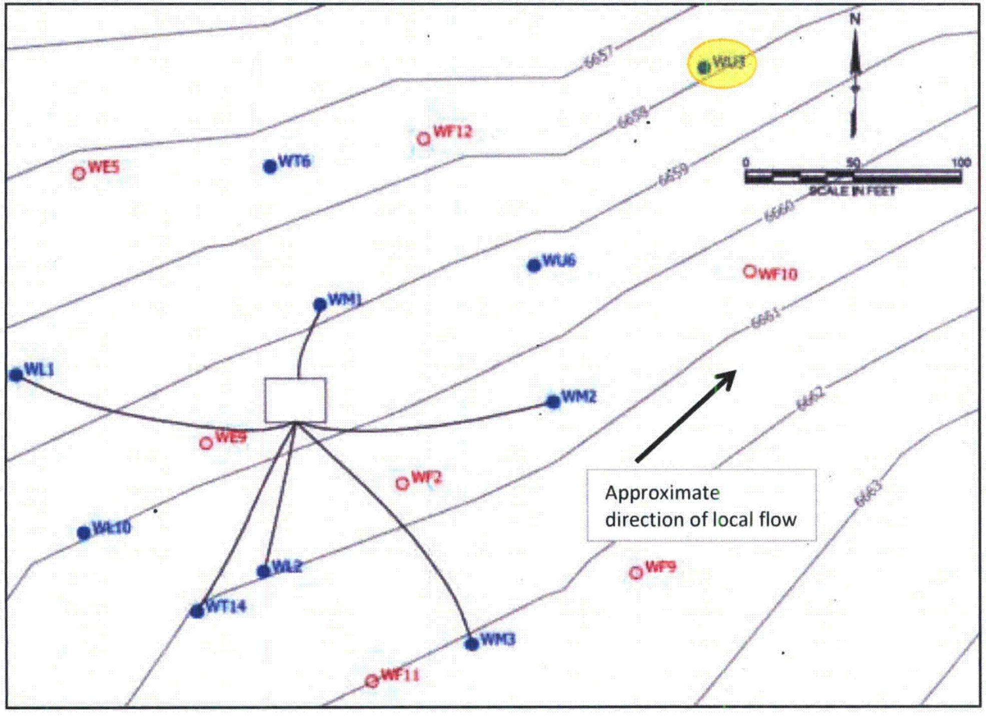
Historic Data

Date	Sulfate (mg/L)	TDS (mg/L)
5/16/08	3110	6260
2/22/09	1600	3560
4/10/10	1210	2810
10/7/10	1070	2570

Rebound E[illegible]uation At-A-Glance Charts
Well ID: WU3

Up[illegible]ed May 30, 2012
Most recent data: May 9, 2012

Well Location:



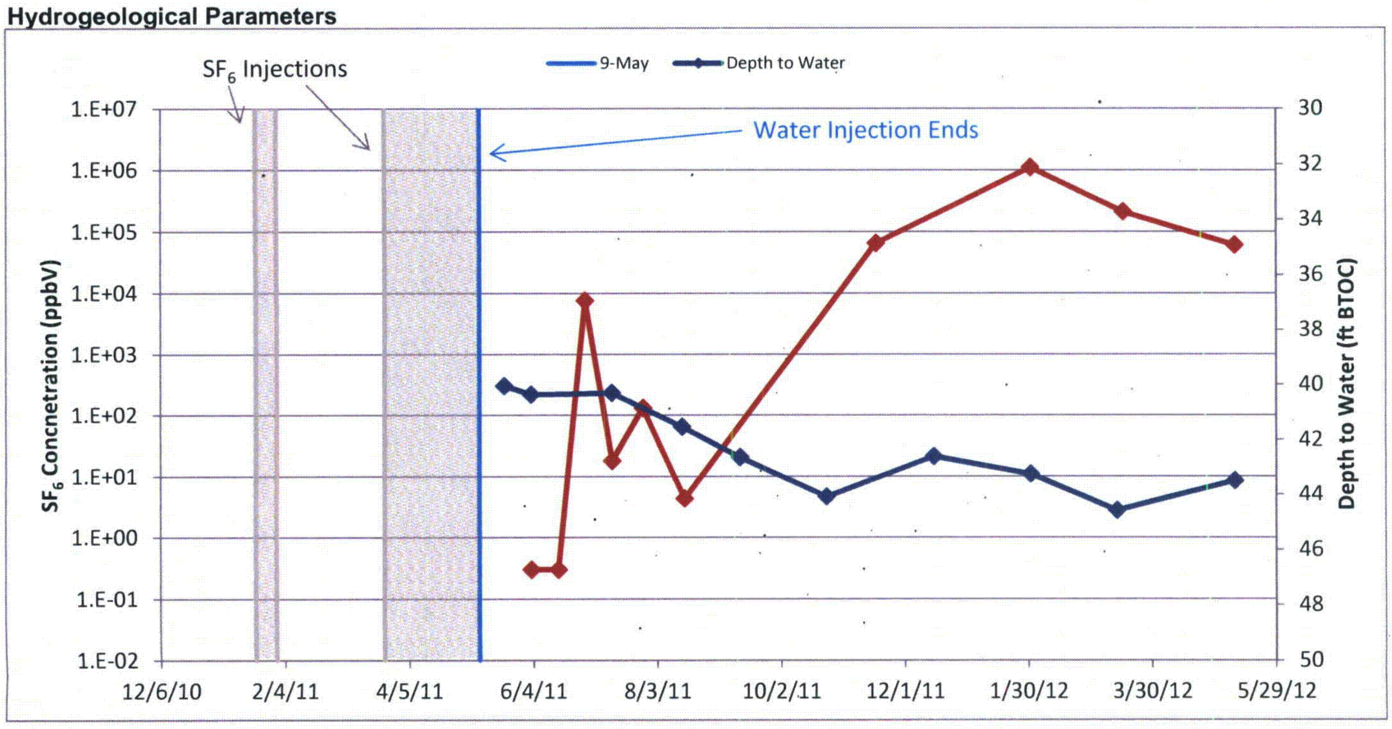
Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6661 ft MSL	(flush)

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

LEGEND:
6661 —— GROUND SURFACE ELEVATION (FEET MSL)
● INJECTION WELL LOCATION
○ MONITORING WELL LOCATION
☐ REMEDIATION SHED WITH TRACER TANK HOUSING
—— 1/8" COPPER TUBING

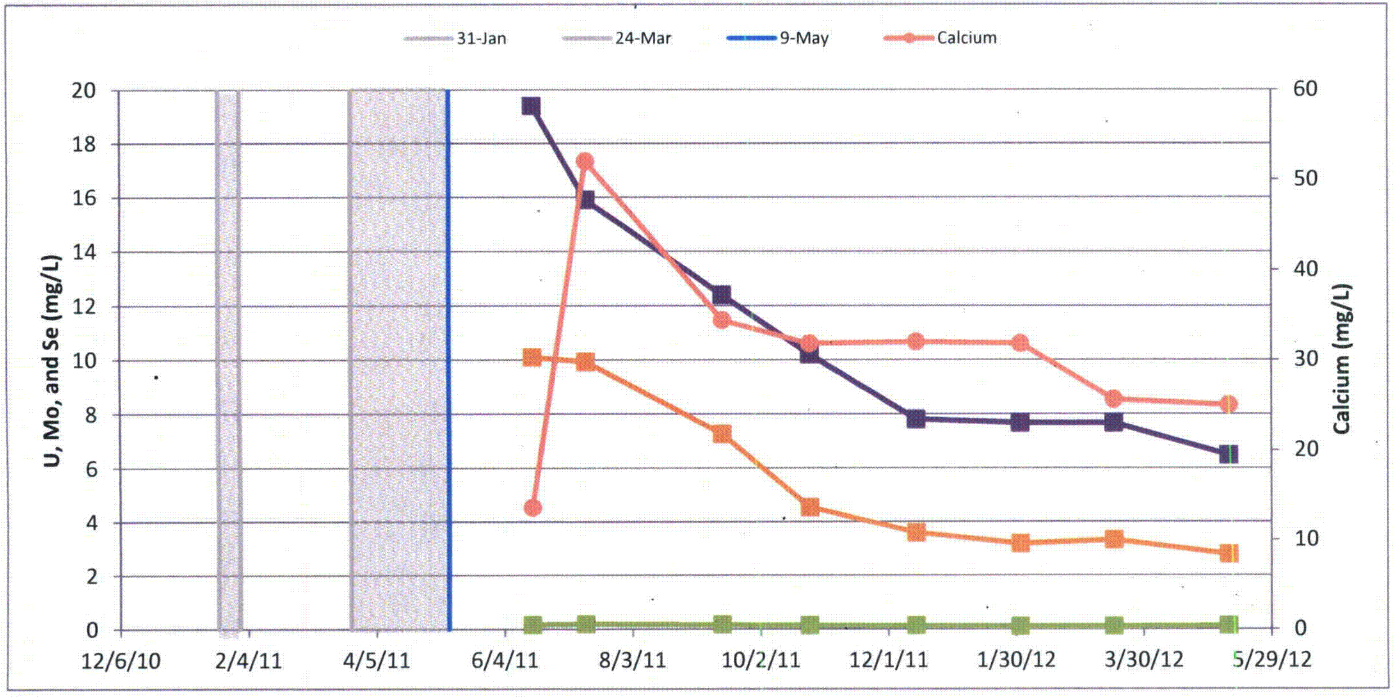
Hydrogeological Parameters



Historic Data - none

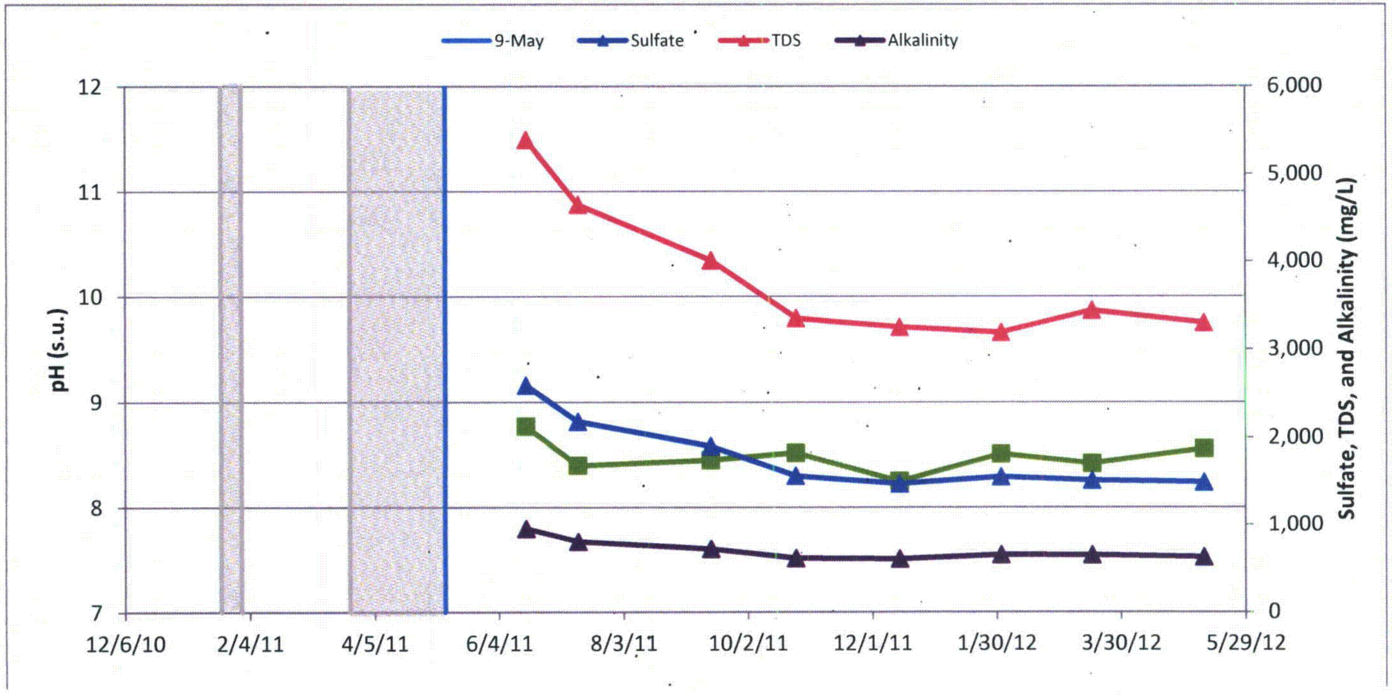
No background concentration of SF$_6$.

COCs + Calcium



Historic Data - none

Geochemical Parameters

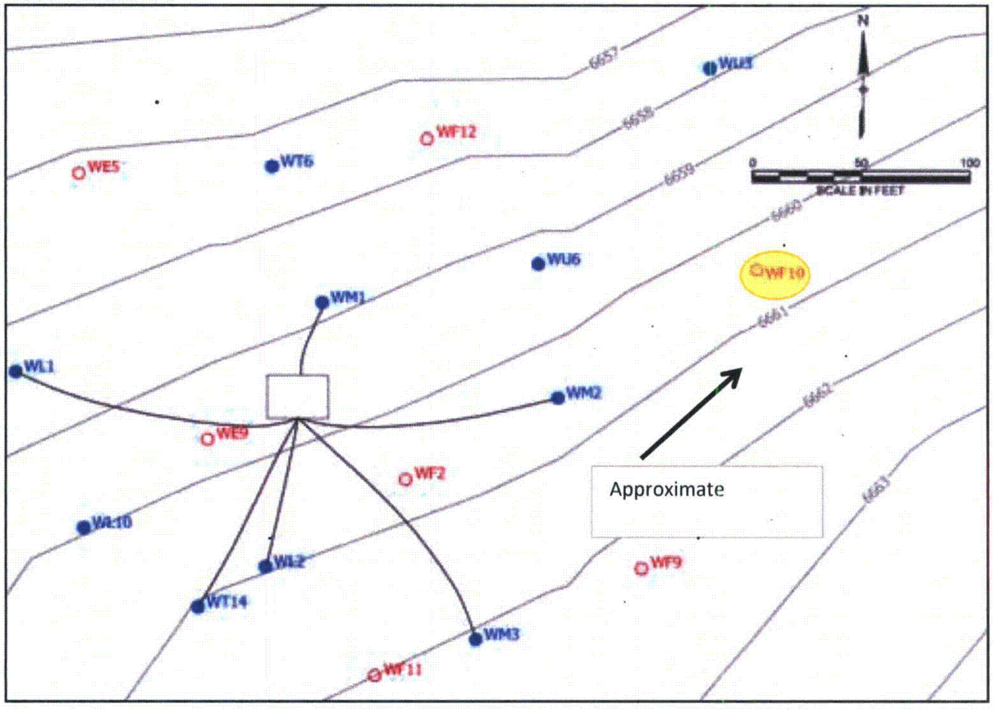


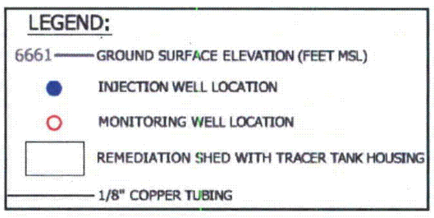
Historic Data - none

Rebound Ev[illegible]ation At-A-Glance Charts
Well ID: WF10

Up[illegible]ed May 30, 2012
Most recent data: May 9, 2012

Well Location:



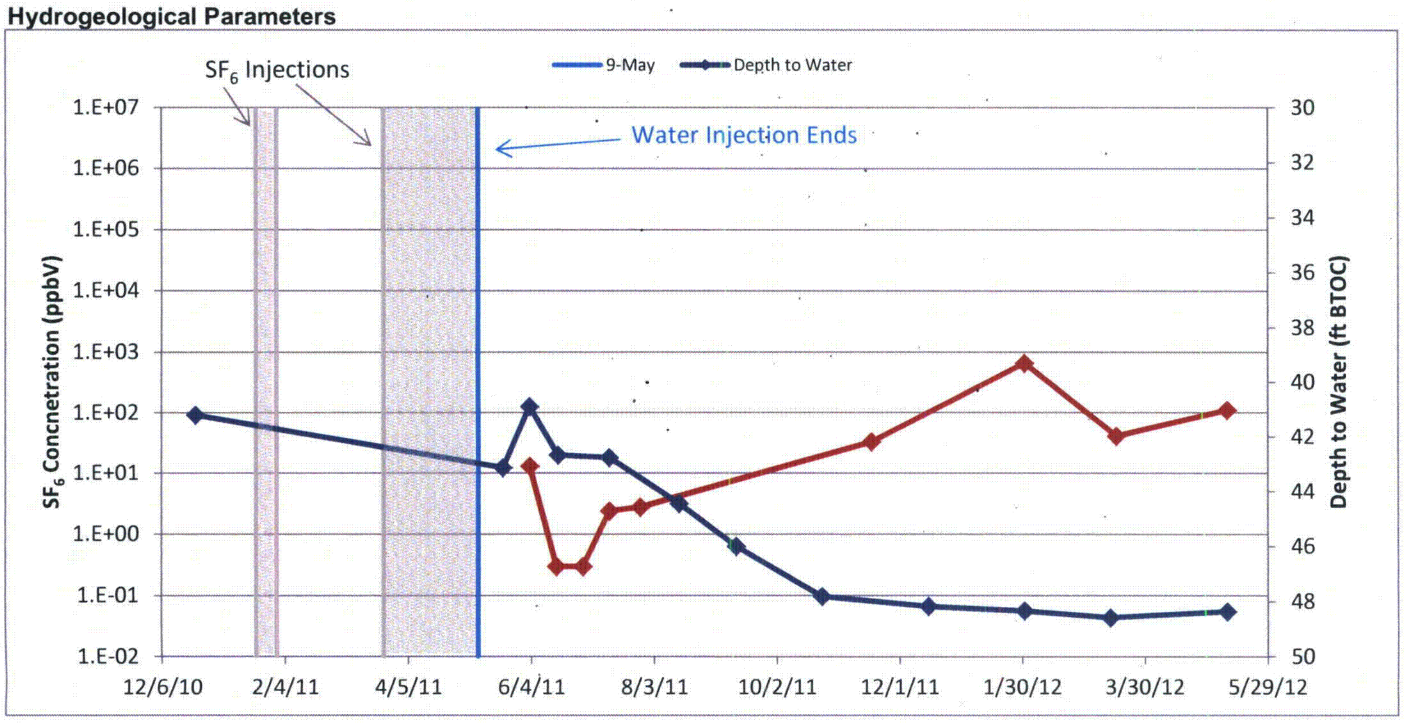


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6663.39 ft MSL	3.08 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

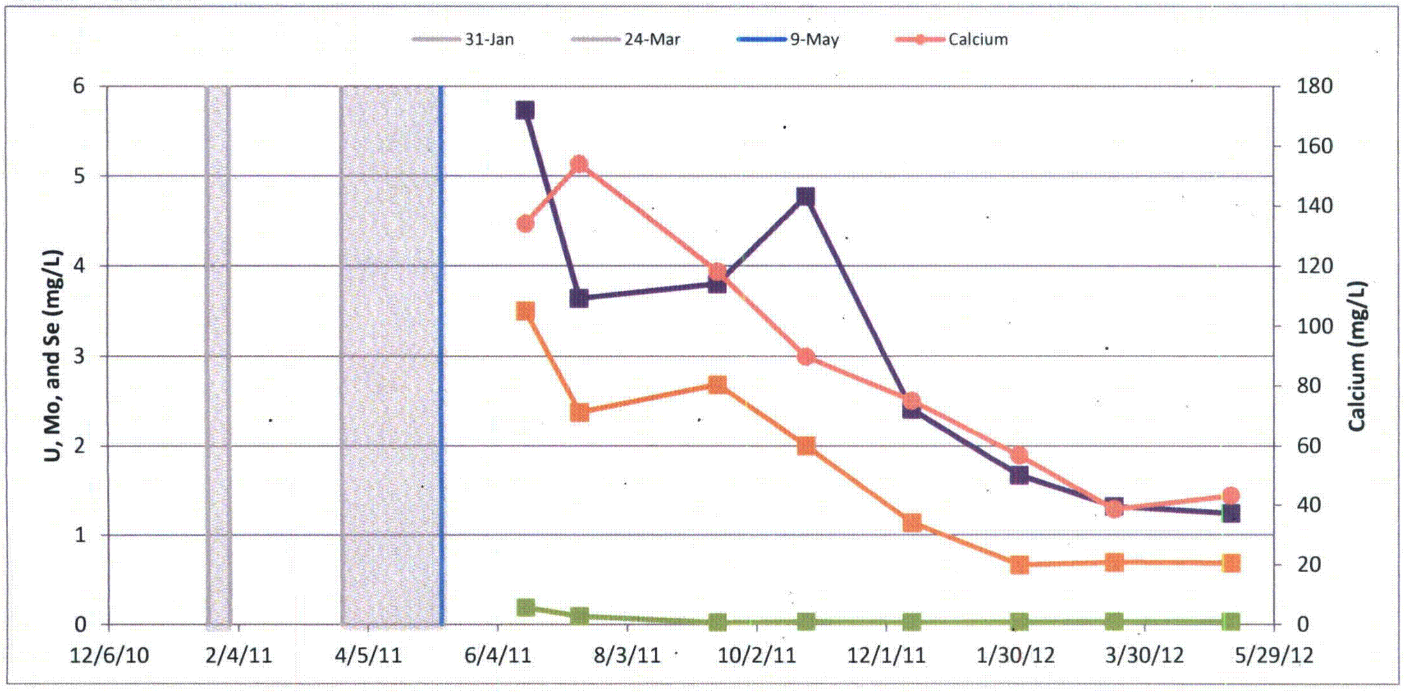


Historic Data

Date	DTW (ft BTOC)
7/16/08	46.7
8/23/08	47.11
2/22/09	44
2/24/09	44.2
7/8/09	50.79
8/6/09	47.46
10/29/09	42.8
4/10/10	43.5
6/11/10	42.4
8/9/10	43.03
12/22/10	41.2

No background concentration of SF_6.

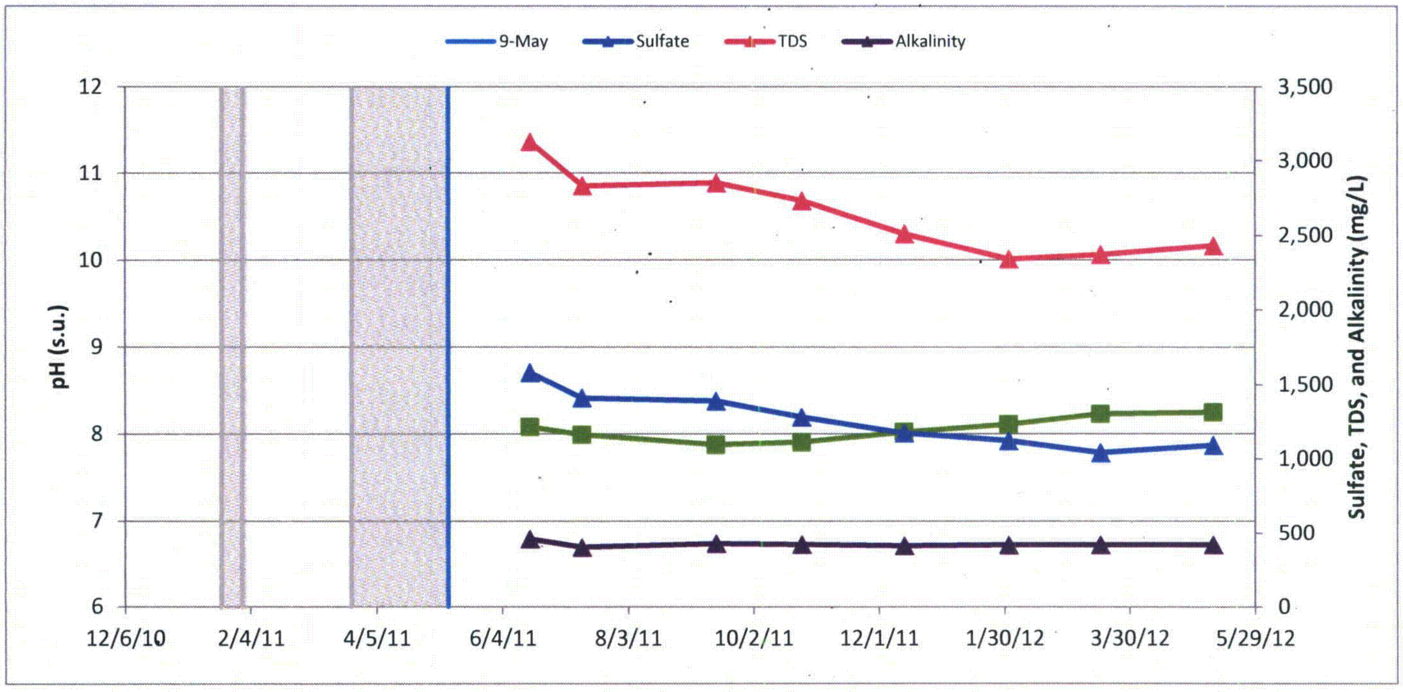
COCs + Calcium



Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
4/21/09	1.94	2.03	0.13
5/13/09	9	9.82	0.564
5/4/10	3.84	7.84	0.438

Geochemical Parameters



Historic Data

Date	Sulfate (mg/L)	TDS (mg/L
4/21/09	1950	4150
5/13/09	1840	4010
5/4/10	1440	3150