uraniumone™
investing in our energy

August 8, 2014

Kathy Shreve
Environmental Program Principal
Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building 4W
122 W. 25th Street
Cheyenne, WY 82002

Subject: Submittal of information requested in the WDEQ-WQD letter dated June 24, 2014, Deep Disposal Well CR 18-3: Christensen Ranch Class I UIC Disposal Wells Permit No. UIC 10-219

Dear Ms. Shreve:

Please find attached Uranium One's *Supplemental Report on Christensen Ranch Well CR 18-3 Status and Plan of Action*. This report is submitted to comply with the WDEQ request for additional information identified in the June 24, 2014 letter to Donna Wichers from Kathy Shreve and the July 10, 2014 email from John Passehl to Jon Winter. Uranium One would be available to meet at your earliest convenience to discuss this submittal and the plan to bring well CR 18-3 back into operation. If you have any questions please do not hesitate to contact me at 307-233-6331 or via email at jon.winter@uranium1.com.

Sincerely,

Jon Winter
Director of Health, Safety and Environment
Uranium One Americas

Cc: Ron Linton – U.S. NRC – Willow Creek Project Manager
Hal Demuth - Petrotek Engineering
Luke McMahan – WDEQ- LQD District III

Uranium One USA, Inc.
A Member of the Uranium One Inc. Group of Companies
tel +1 307-234-8235 • **fax** +1 307-237-8235
907 N. Poplar Street, Suite 260
Casper, Wyoming 82601
www.uranium1.com

Supplemental Report on Christensen Ranch Well 18-3 Status and Plan of Action

This report supplements and, as appropriate, revises the reports, information and statements previously communicated to the Water Quality Division (WQD) of the Wyoming Department of Environmental Quality (DEQ) regarding the movement of fluid from Christensen Ranch 18-3 (CR 18-3) well into an interval above the perforations and below the primary confining layer. Results of the investigations and analyses that have been conducted to date are presented along with a plan of action.

This plan has been developed and is submitted in fulfillment of the duties of Uranium One under UIC permit 10-219, Condition O, including the duty to take all reasonable steps to minimize or correct any adverse impact on the environment resulting from this incident, the duty to provide information for permit modification, and the duty to amend the permit.

I. Background

Uranium One contracted Petrotek Engineering Corporation (Petrotek) to perform the 5-year mechanical integrity tests (MITs) for deep disposal wells DW No. 1 and CR 18-3 at the Willow Creek ISR uranium project as per Condition M ("Mechanical Integrity") of the UIC Permit 10-219. On June 19, 2014 Petrotek arrived on site at well CR 18-3 to supervise the Part I and II MIT operations. At the time testing began, the wells had been shut in for more than 24 hours. Petrotek conducted Part I MIT testing on the CR 18-3 well and the tubing/casing annulus passed Part I MIT requirements without issue. The subcontractor Superior Production Logging was rigged up on the CR 18-3 well and Part II MIT testing was initiated (temperature and gamma logs along with the collar locator).

The initial June 19, 2014 temperature log from the Part II MIT raised some concern as it suggested possible fluid storage behind the casing in an interval above the top perforations (4,022' KB) and below the packer (3,735' KB) (Figure 1). Further testing using velocity shots in conjunction with radioactive tracer logging indicated that approximately 23% of the injected flow was exiting casing in the vicinity of 3,820'-3,830' KB under test conditions (i.e., 2% KCl pumped at 0.46 bpm at approximately 800 psi wellhead pressure). Based on these initial results, CR 18-3 was shut-in pending a more detailed review of the logs and test data.

In response to these developments, a workover rig was mobilized on June 27, 2014; the tubing and packer were removed and a casing inspection log was run. The Baker Micro Vertilog run to inspect the casing indicated a hole (100% penetration) in the casing at a depth of 3,828' KB. After consultation and agreement from DEQ, the 5 ½" casing was displaced with approximately 100 barrels (bbl) heavy brine (10% KCl) along with corrosion inhibitor/O2 scavenger/antiscalant/biocide. These activities were conducted to secure the well from potential fluid movement up the open cased hole and protect the tubulars from corrosion and bacterial degradation during shut in. The workover rig was rigged down on July 1, 2014 and the well remains shut in.

Further investigations and analyses have been conducted to determine whether there has been any adverse impact on the environment resulting from the unintended fluid movement into the casing penetration at 3,828' KB. This supplemental report presents the results of those

investigations and analyses along with Uranium One's proposed plan of action in response to the failure of Part II of the 2014 MIT in the CR 18-3 well.

II. Analysis of the Unintended Flow Above the Perforations

In an attempt to determine the time when the unintended flow started, Uranium One evaluated (1) when the last previous Part II MIT was conducted, and (2) historical injection and operational data since that time. The last Part II MIT approved by DEQ was conducted on August 25, 2009; the log results indicated flow entering the original perforation zone starting at 4,022' KB and perforations below that depth. Prior to and after the 2009 testing, the CR 18-3 well was shut in because the CR facility was temporarily shut down due to low uranium prices. The CR 18-3 well remained shut in until February 2, 2011 when Uranium One re-started production operations.

Uranium One has evaluated the injection data since the 2011 re-start in an attempt to identify when the unintended flow started. The long-term injection data (injection pressure and injection rate) were evaluated to assess whether there was a significant change in injection capacity that would be indicative of additional porosity-thickness receiving fluid.

The results of this analysis are presented in Figure 2 (Average Daily Injection Pressure and Average Daily Injection Rate versus Time) and Figure 3 (Injectivity versus Time). Data from both figures are somewhat scattered during the period from February 2011 to August 2012 when new operational limits were applied as part of the Class I permit renewal approved by DEQ on August 7, 2012. After this period, the well operation (pressure and rate) is relatively consistent over time, and review of those data does not yield any conclusive results. In this regard, there is no verifiable indication of when the unintended flow began.

IIa. Hypothetical Flow Evaluation

While not conclusive, it could be conjectured that the unintended flow started January 1, 2014 and continued to June 19, 2014. This hypothesis is based on the injectivity plot trend showing slightly increased injectivity from January 1 to January 25, 2014, and another similar slightly increasing injectivity trend from February 5 to February 14, 2014. Note that significant uncertainty exists in this assumed hypothesis, as many variables can influence the calculation of well injectivity using surface pressure data. However, to meet the requirements of Condition O of UIC permit 10-219, Uranium One presents the following analysis:

If the unintended flow did start January 1, 2014, the volume of the flow can be estimated as follows:

Flow duration (January 1 – June 19, 2014)	190 days	(Assumed)
Assumed well injection rate	47 gpm	(U1 injection data)
Total volume injected into well in 190 days	12,859,200 gal	(calculated)
Approx. flow percentage of total volume	23 percent	(RAT-Temp log)
Assumed flow rate	10.8 gpm	(calculated)
Assumed flow volume (190 days)	2,957,616 gal	(calculated)

Assumed thickness of flow zone	10 feet	(RAT-Temp log)
Assumed effective porosity	17 percent	(OH logs)
Calc. radius of fluid displacement (ULEW)	272 feet	(per DEQ WQRR CH 13.)

Based on these assumptions, it is possible, if the flow occurred for a hypothetical 190-day period, that the radius of piston-like fluid displacement (Ultimate Limit of Emplaced Waste [ULEW]) could be a radial distance approximately 272 feet from the well. This calculation assumes full conservation of mass; no geochemical retardation or precipitation is included. Hence, this calculation would be representative, with the underlying assumptions, of conservative species such as chloride. However, the transport of primary constituents of concern (uranium and radium 226) is overestimated in this calculation because dispersion and retardation are ignored. As dispersion will be less significant than retardation, it is not considered further.

To assess potential travel distance including retardation, a simple advective flow analytical calculation is used as discussed below. As the Uranium One sampling results attest, the injected fluid contains low concentrations of dissolved uranium and radium that are transported by the injected water. Chemical processes can affect the rate at which the solutes (uranium and radium) are transported by the solvent (the injected water). The most common chemical process encountered is ion exchange involving clay minerals (e.g., montmorillinite and vermiculite) or zeolites. A measure of the amount of ion exchange which occurs is referred to as the "distribution coefficient" which is a determination of the amount of solute left on matrix after it has been mixed with the injected water, and allowed to reach equilibrium. The distribution coefficient (K_d) is defined by the following equation: $K_d = C/C_o$

where C = concentration sorbed per gram of soil/matrix

C_o = equilibrium concentration in the injected water

The K_d values found in the literature are 10 ml/g for radium[1], and 1 ml/g for uranium[2].

Ignoring dispersion, one-dimensional theoretical sorption from laboratory studies can be extrapolated to predict the amount of sorption likely to occur in the field. The velocity of the ion transport in the field can then be predicted from Freeze & Cherry (*Groundwater*, Prentice-Hall International, 1979; Eq. 9.14) and Domineco & Schwartz (*Physical and Chemical Hydrogeology*, John Wiley & Sons, 1998, Eq. 18.7) and from NRC using the following formula[1]:

$$V_1 = v/(1 + (K_d B_d/\theta))$$

where V_1 = ion velocity

---

[1] USNRC NUREG-0706, Vol. II; Final Generic Environmental Impact Statement on Uranium Milling, September 1980, Appendix E-3.

[2] Department of Energy, DOE/LLW-238; Selected Radionuclides Important to Low Level Radioactive Waste Management, Section 15, November, 1996.

v = solution velocity

K_d = distribution coefficient

B_d = bulk density

θ = volumetric moisture content or effective porosity

The ion velocity for radium and uranium can then be calculated using the following values:

K_d = 10 ml/g (radium) or 1 ml/g (uranium)

B_d = 2.20 g/cm^3

θ = 0.17

v = 272 feet in 190 days (1.43 ft/d) (based on ULEW calculation)

Based on the above values, the horizontal ion velocities for radium and uranium are calculated to be:

V_1 (radium) = 2.1 feet in 190 days

V_1 (uranium) = 19.5 feet in 190 days

It is noted that the solution velocity used here is a conservative estimate based on the injection solution moving 272 feet in 190 days (i.e., a ULEW of 272 feet with an assumed flow rate of 10.8 gpm into only 10 feet of thickness). It is recognized that, due to slower velocities at distance due to radial flow, the velocity is higher in the early months and lower in the later time as the displacement radius grows.

To assess possible worst-case scenarios, travel distance was also calculated for the entire range of well operation (e.g., assuming the flow occurred in August 2012, and February 2011). The ULEW calculated for each of these hypothetical periods is 557 and 699 feet, respectively. In the worst-case scenario (flow starting in February 2011), assuming the retardation discussed above, the travel distance for Uranium is calculated to be 128.8 feet from the well; the Ra-226 travel distance is calculated as 13.8 feet. It is noted that the same retardation mechanism that limits transport distance during injection would also apply for production (fluid recovery).

III. Evidence for Containment within Injection Zone

The flow in the casing penetration at the approximate depth of 3,828' KB occurred within a relatively clean sand that is contained below by 180 feet of shale and above by 368 feet of shale/sand sequences. Hence, the dominant flow direction will be horizontal and the fluid will be contained in the sand from 3,820'-3,842' KB. There is little to no potential for upward fluid migration above this sand.

Further, the fluid which entered the casing penetration certainly is not likely to approach the regional overlying confinement (Lebo Shale at approximately 3,460' KB in the CR 18-3 well).

IV. No Impact to ULEW

It is noted that, even with the unintended flow that has occurred in the CR 18-3 well, the radius of fluid displacement (ULEW) and Cone of Influence (COI) calculations from the Permit 10-219 application remain valid because an additional effective reservoir thickness (from the 3,820-3,842' KB sand) is projected to reduce the (1) radial extent of the injection fluid plume front, and (2) the pressure rise at distance from the wellbore. After limited duration, any additional flow will not yield an increased ULEW or COI compared to the values used as the basis for the permit application. Further, the flow rates assumed for the 10-year permit duration (75 gpm) significantly exceed the actual rates that have been achieved during operations (approximately 45-50 gpm from August 2012 to date).

V. Impact to Injection Zone

The interval in which the casing penetration occurred has been described in several different ways over the life of well CR 18-3. Initially the porous intervals approved by DEQ for injection were referred to as the Lance Formation. However, the upper portion of the approved depth interval has more recently been described by DEQ as the Tullock Member of the Fort Union Formation. Notwithstanding this nomenclature change, neither the stratigraphy or depths have changed and the injection zone lies beneath a regional confining layer, which is the Lebo Shale Member of the Fort Union Formation, an approximate 500 to 1,000-foot thick unit consisting of shale or mudstone with minor interbedded lenticular sandstones. The interval into which unintended flow occurred is within the unit that has been classified by DEQ as Class VI groundwater under WQRR Chapter VIII because of the presence of contaminants and because "[t]his formation naturally contains traces of oil and gas and cannot reasonably be expected to provide a source of drinking water at this location" (DEQ Permit No. UIC 97-407, Condition C.1). Following that classification, the aquifer containing that same interval was designated by the United States Environmental Protection Agency (EPA) as an exempted aquifer.[3/] Although the injection intervals identified for the CR 18-3 well in the DEQ permit begin at 4,009' KB, the aquifer designated for exemption extends to shallower depths than those included in the DEQ permit and includes the interval into which the unintended flow from the casing penetration occurred. The aquifer exemption was based on the information submitted by DEQ concerning the appropriate groundwater classification of that interval. Accordingly, the unintended flow did not cause fluid migration into a fresh or potable groundwater.

When considering potential for adverse environmental impact, the most significant factor is that the interval into which flow occurred is beneath a substantial confining layer, and containment protection is provided by the thick Lebo Shale. As described previously, the available evidence provides no basis for concern that there has been any movement beyond this massive confining

---

3/ 64 Fed. Reg. 14800 (March 26, 1999). The exempted aquifer designation is codified at 40 CFR §147.2555. 64 Fed. Reg. at 14804.

layer, and no movement into fresh or potable groundwater that might result in any adverse environmental impact. Therefore, from an environmental protection standpoint, there is no benefit to recover the fluid that moved into the interval above the current injection zone. That fluid will remain contained just as the fluid injected into the current injection intervals will remain contained. More important, efforts to recover that fluid could cause adverse environmental impacts and would, at a minimum, increase significantly the volumes of wastewater to be re-injected into the current injection intervals following recovery. This would amount to attempting to move these fluids from one unit that provides safe and effective containment to another virtually identical unit that provides essentially identical safe and effective containment (for example, injecting recovery fluids from CR 18-3 into DW-1, or a new well drilled under Permit 10-219 that would be completed in the same geologic unit). It would not be reasonable to incur such costs and increased risks absent evidence of any need to do so to prevent adverse environmental impacts. Accordingly, the appropriate conclusion is that there would no environmental benefit from attempting to recover the fluid that flowed into the Class VI exempted aquifer.

VI. Plan of Action

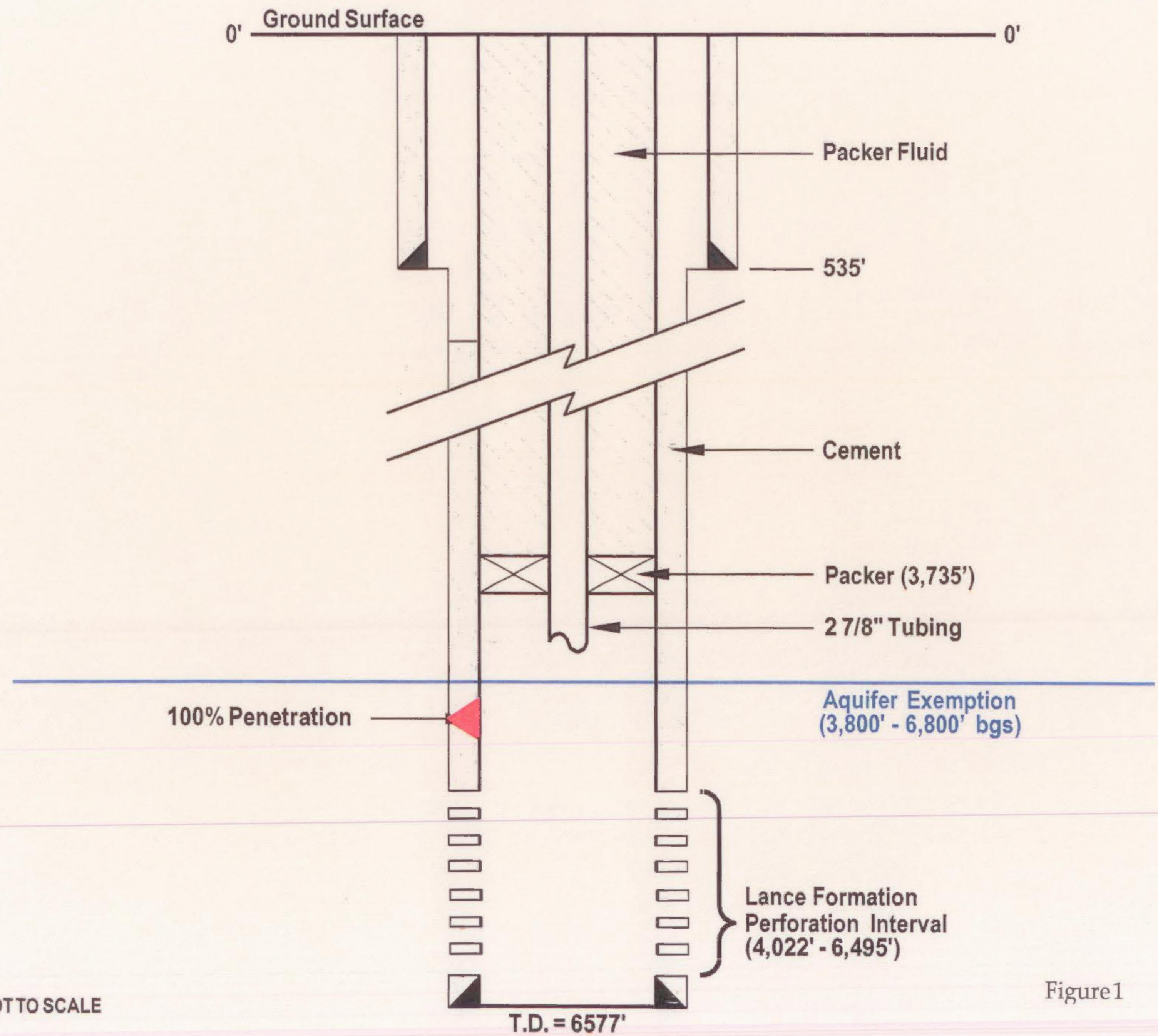
Based on the investigations, analyses, and assessments conducted in response to the unintended flow into the casing penetration above the Christensen Ranch 18-3 original perforations, the most appropriate and reasonable response steps include modifying UIC permit 10-219 to include the interval of 3,800 to 4,009 feet as an injection interval for the well (WQRR, Chapter 13, Sections 9(d)(v) and 9(d)(xi), UIC permit 10-219, Condition O). Previous DEQ actions recognize that modification of a permit is an appropriate response to this type of incident. A permit modification to expand the injection interval is particularly appropriate when the unintended fluid flow is into an interval DEQ has appropriately classified as a Class VI groundwater and into an aquifer EPA has exempted (WQRR, Chapter 13, Sections 8(f), 9(d)(i)).

Uranium One understands it has a duty to provide DEQ information to support its request for a permit modification to include the interval of 3,800 to 4,009 feet as a permitted injection interval and is providing the information in this report to support the requested modification. We will promptly submit an application for UIC permit modification as one of the action steps.

As another action step, Uranium One will provide a field operations plan that outlines procedures to run new injection tubing and a new packer, run required mechanical integrity tests and return the well to injection status.

The use of CR 18-3 is a critical component of the Christensen Ranch ISR operation, and provides over 50% of the existing operational wastewater disposal capacity. Water management through the use of reverse osmosis and good evaporation at this time of year are currently helping this situation. However, as the winter months approach, more concerted efforts will be necessary to continue operations without CR-18-3 such as shutting down portions of the operating wellfields. Accordingly, we respectfully request that DEQ expedite the review and approval of the requested permit modification.

Original Completion Schematic
Christensen 18-3



NOT TO SCALE

Figure 1

Uranium One Americas
Willow Creek Project - Johnson County, WY

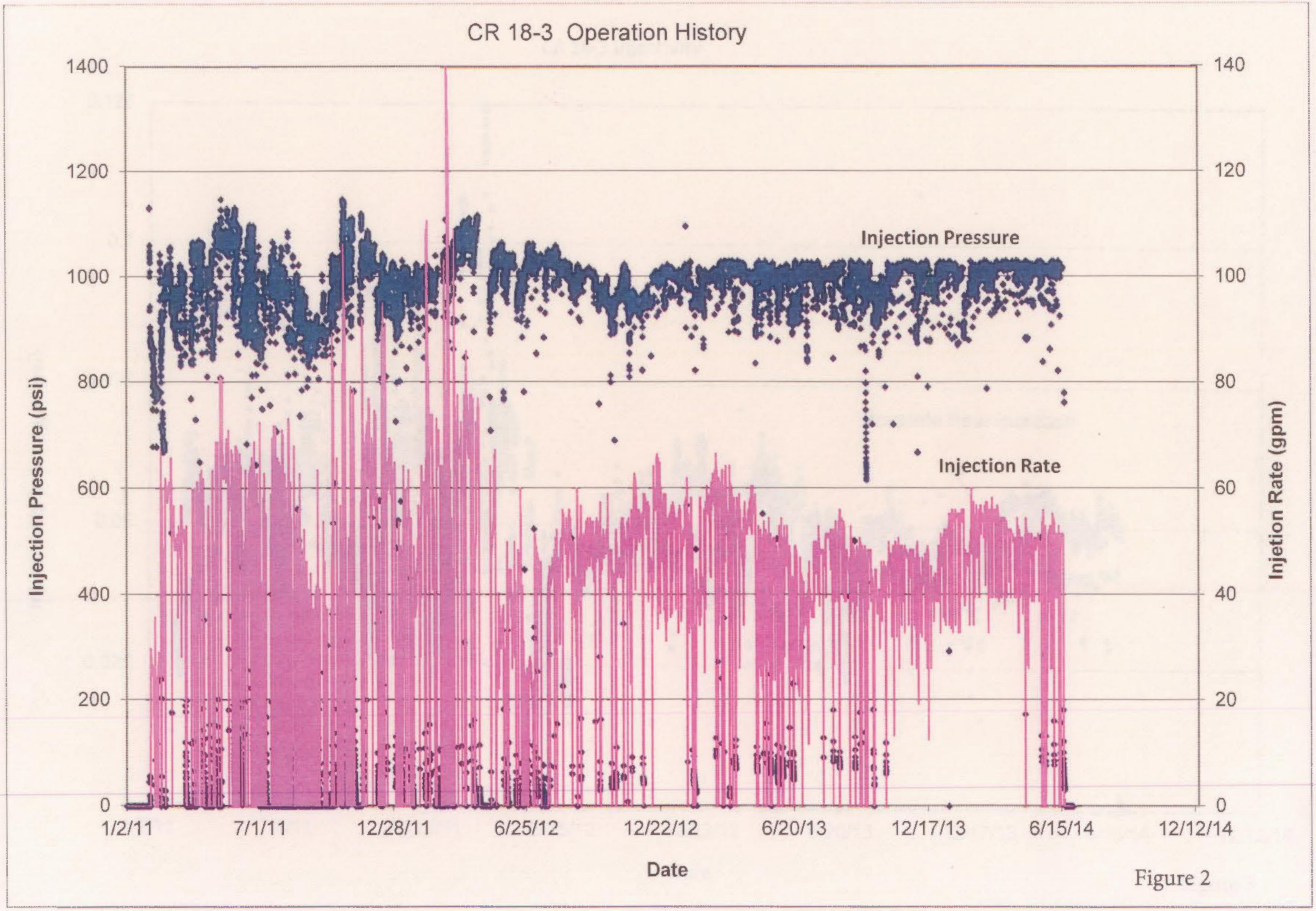


Figure 2