DOE F 4600.2
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U.S. Department of Energy
FEDERAL ASSISTANCE REPORTING CHECKLIST AND INSTRUCTIONS FOR RD&D PROJECTS

1. Identification Number: **DE-FE0006821**	2. Program/Project Title: **Small Scale Field Test Demonstration CO2 Sequestration**	
3. Recipient: **University of Kansas Center for Research, Inc.**		
4. Reporting Requirements:	Frequency	Addressees
A. MANAGEMENT REPORTING		
☒ Research Performance Progress Report (RPPR)	Q	FITS@NETL.DOE.GOV
☒ Special Status Report	A	FITS@NETL.DOE.GOV
B. SCIENTIFIC/TECHNICAL REPORTING		
(Reports/Products must be submitted with appropriate DOE F 241. The 241 forms are available at www.osti.gov/elink)		
Report/Product — Form		
☒ Final Scientific/Technical Report — DOE F 241.3	FG	http://www.osti.gov/elink-2413
☒ Conference papers/proceedings* — DOE F 241.3	A	http://www.osti.gov/elink-2413
☐ Software/Manual — DOE F 241.4		
☐ Other (see special instructions) — DOE F 241.3		
** Scientific and technical conferences only*		
C. FINANCIAL REPORTING		
☒ SF-425 Federal Financial Report	Q, FG	FITS@NETL.DOE.GOV
D. CLOSEOUT REPORTING		
☒ Patent Certification	FC	FITS@NETL.DOE.GOV
☒ SF-428 & 428B Final Property Report	FC	FITS@NETL.DOE.GOV
☐ Other		
E. OTHER REPORTING		
☒ Annual Indirect Cost Proposal	O	See block 5 below for instructions.
☐ Audit of For-Profit Recipients		
☒ SF-428 Tangible Personal Property Report Forms Family	A	FITS@NETL.DOE.GOV
☒ Other – see block 5 below	A	FITS@NETL.DOE.GOV

FREQUENCY CODES AND DUE DATES:

A - Within 5 calendar days after events or as specified.
FG- Final; 90 calendar days after the project period ends.
FC- Final; End of Effort.
Y - Yearly; 90 calendar days after the end of the reporting period.
S - Semiannually; within 30 calendar days after end of project year and project half-year.
Q - Quarterly; within 30 days after end of the reporting period.
Y180 – Yearly; 180 days after the end of the recipient's fiscal year
O - Other; See instructions for further details.

5. Special Instructions:

Annual Indirect Cost Proposal – If DOE is the Cognizant Federal Agency, then the proposal should be sent to FITS@NETL.DOE.GOV . Otherwise, it should be sent to the Cognizant Federal Agency.

Other – The Recipient shall provide all deliverables as contained in Section D of Attachment 2 Statement of Project Objectives.

QUARTERLY PROGRESS REPORT
To
DOE-NETL
Brian Dressel, Program Manager
Award Number: DE-FE0006821

SMALL SCALE FIELD TEST DEMONSTRATING CO_2 SEQUESTRATION IN ARBUCKLE SALINE AQUIFER AND BY CO_2-EOR AT WELLINGTON FIELD, SUMNER COUNTY, KANSAS

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Joint Principal Investigator:
Jason Rush

Prepared by Lynn Watney
Date of Report: May 11, 2015
DUNS Number: 076248616

Recipient: University of Kansas Center for Research &
Kansas Geological Survey
1930 Constant Avenue
Lawrence, KS 66047

Project/Grant Period: 10/1/2011 through 9/30/2016

Fourteenth Quarterly Report

Period Covered by the Report: January 1, 2015 through March 31, 2015

Signature of Submitting Official:

Willard Lynn Watney

EXECUTIVE SUMMARY

Project Objectives

The objectives of this project are to understand the processes that occur when a maximum of 70,000 metric tonnes of CO_2 are injected into two different formations to evaluate the response in different lithofacies and depositional environments. The evaluation will be accomplished through the use of both *in situ* and indirect MVA (monitoring, verification, and accounting) technologies. The project will optimize for carbon storage accounting for 99% of the CO_2 using lab and field testing and comprehensive characterization and modeling techniques.

CO_2 will be injected under supercritical conditions to demonstrate state-of-the-art MVA tools and techniques to monitor and visualize the injected CO_2 plume and to refine geomodels developed using nearly continuous core, exhaustive wireline logs, and well tests and a multi-component 3D seismic survey. Reservoir simulation studies will map the injected CO_2 plume and estimate tonnage of CO_2 stored in solution, as residual gas, and by mineralization and integrate MVA results and reservoir models shall be used to evaluate CO_2 leakage. A rapid-response mitigation plan will be developed to minimize CO_2 leakage and provide comprehensive risk management strategy. A documentation of best practice methodologies for MVA and application for closure of the carbon storage test will complete the project. The CO_2 shall be supplied from a reliable facility and have an adequate delivery and quality of CO_2.

Scope of Work

Budget Period 1 includes updating reservoirs models at Wellington Field and filing Class II and Class VI injection permit application. Static 3D geocellular models of the Mississippian and Arbuckle shall integrate petrophysical information from core, wireline logs, and well tests with spatial and attribute information from their respective 3D seismic volumes. Dynamic models (composition simulations) of these reservoirs shall incorporate this information with laboratory data obtained from rock and fluid analyses to predict the properties of the CO_2 plume through time. The results will be used as the basis to establish the MVA and as a basis to compare with actual CO_2 injection. The small scale field test shall evaluate the accuracy of the models as a means to refine them in order to improve the predictions of the behavior and fate of CO_2 and optimizing carbon storage.

Budget Period 2 includes completing a Class II underground injection control permit; drilling and equipping a new borehole into the Mississippian reservoir for use in the first phase of CO_2 injection; establishing MVA infrastructure and acquiring baseline data; establishing source of CO_2 and transportation to the injection site; building injection facilities in the oil field; and injecting CO_2 into the Mississippian-age spiculitic cherty dolomitic open marine carbonate reservoir as part of the small scale carbon storage project.

In Budget Period 3, contingent on securing a Class VI injection permit, the drilling and completion of an observation well will be done to monitor injection of CO_2 under supercritical conditions into the Lower Ordovician Arbuckle shallow (peritidal) marine dolomitic reservoir. Monitoring during pre-injection, during injection, and post injection will be accomplished with MVA tools and techniques to visualize CO_2 plume movement and will be used to reconcile simulation results. Necessary documentation will be submitted for closure of the small scale carbon storage project.

Project Goals

The proposed small scale injection will advance the science and practice of carbon sequestration in the Midcontinent by refining characterization and modeling, evaluating best practices for MVA tailored to the geologic setting, optimize methods for remediation and risk management, and provide technical information and training to enable additional projects and facilitate discussions on issues of liability and risk management for operators, regulators, and policy makers.

The data gathered as part of this research effort and pilot study will be shared with the Southwest Sequestration Partnership (SWP) and integrated into the National Carbon Sequestration Database and Geographic Information System (NATCARB) and the 6th Edition of the Carbon Sequestration Atlas of the United States and Canada.

Project Deliverables by Task

1.5 Well Drilling and Installation Plan (Can be Appendix to PMP or Quarterly Report)
1.6 MVA Plan (Can be Appendix to PMP or Quarterly Report)
1.7 Public Outreach Plan (Can be Appendix to PMP)
1.8 Arbuckle Injection Permit Application Review go/no go Memo
1.9 Mississippian Injection Permit Application Review go/no go Memo
1.10 Site Development, Operations, and Closure Plan (Can be Appendix to PMP)
2.0 Suitable geology for Injection Arbuckle go/no go Memo
3.0 Suitable geology for Injection Mississippian go/no go Memo
11.2 Capture and Compression Design and Cost Evaluation go/no go Memo
19 Updated Site Characterization/Conceptual Models (Can be Appendix to Quarterly Report)
21 Commercialization Plan (Can be Appendix to Quarterly Report).
30 Best Practices Plan (Can be Appendix to Quarterly or Final Report)

ACCOMPLISHMENTS

1. **Participated in DOE peer review in Pittsburgh on March 5.**
2. **Class II application was filed with Kansas Corporation Commission in January and approved in February 2015.**
3. **Continued conference calls and written communications with EPA regarding review of Class VI application. Submitted responses to requests from EPA for additional information (RAI) in regards to the application. Responded to inquiries regarding**

evaluation of surface water with drilling, completion, testing, and analyses fit for purpose to evaluate the presence of a USDW.

4. **Drilled and completed three shallow water wells and conducted extensive sampling, pumping, and lab work to evaluate surface waters in AOR. Findings to date is that the shallow bedrock in the AOR is primarily a low yield, brine saturated aquiclude that overlies and is in equilibrium with diffusive dissolution from the underlying shallow Hutchinson salt. Surface water in AOR and immediately vicinity is limited to thin surficial colluvium and alluvial lenses.**
5. **Drilled Berexco Wellington KGS #2-32 in March 2015. Surface sampling and wireline logging above surface casing enhanced understanding of the presence of surface aquifer and aquitard system. The Mississippian oil reservoir was cored, evaluated with modern wireline logs, and is undergoing testing. The reservoir at #2-32 consists of an evenly porous (20-25% porosity) interval that is ~60 ft thick. The upper 40 ft is at residual oil saturation indicating that location has been effectively waterflooded and is in communication with one or more injection wells.**
6. **KGS #2-28 will be further tested, cores will be analyzed, and models will be adjusted to determine how the reservoir is re-pressured and what the anticipated CO2 plume will be.**

Milestone Status Report

Task	Budget Period	Number	Milestone Description
Task 2.	1	1	Site Characterization of Arbuckle Saline Aquifer System - Wellington Field
Task 3.	1	2	Site characterization of Mississippian Reservoir for CO2 EOR - Wellington Field
Task 10.	2	3	Pre-injection MVA - establish background (baseline) readings
Task 13.	2	4	Retrofit Arbuckle Injection Well (#1-28) for MVA Tool Installation
Task 18.	3-yr1	5	Compare Simulation Results with MVA Data and Analysis and Submit Update of Site Characterization, Modeling, and Monitoring Plan
Task 22.	3-yr1	6	Recondition Mississippian Boreholes Around Mississippian CO2-EOR injector
Task 27.	3-yr2	7	Evaluate CO2 Sequestration Potential of CO2-EOR Pilot
Task 28.	3-yr2	8	Evaluate Potential of Incremental Oil Recovery and CO2 Sequestration by CO2-EOR - Wellington field

Task 2 – Site Characterization of Arbuckle Saline Aquifer System - Wellington Field

Focus of efforts in January to early March were directed to complete responses to questions from EPA on the Class VI application submitted to us on December 24, 2014. All responses submitted to EPA on March 4, 2015, including:

- Table 1. AoR and Corrective Action
- Table 2. Testing and Monitoring (Ground Water/Plume/Pressure-Front Monitoring)
- Table 3. Testing and Monitoring (Other Monitoring)
- Table 4. Testing and Monitoring (PISC and Site Closure)

On March 3rd, provided updated Gantt chart to DOE with best and worst case scenarios for approval of Class VI application (**Figure 1**):

Scenario #1: Most probable - Complete review of Class VI in May. Begin fabrication of U-tube & CASSM in May and complete in October. Install and test CASSM U-tube in Nov-Dec. Inject CO2 in Arbuckle in January 2017 through August. Close September 2017 with carryover funds.

Scenario #2: Worst case -- Complete EPA review for public comment in July. Begin fabrication of CASSM & U-tube in July and complete in December. Install and test CASSM & U-tube in Jan.-Feb. 2016. Inject CO2 in March 2016 and complete Oct. 30, 2016. PISC through Nov.2017 with carryover funds.

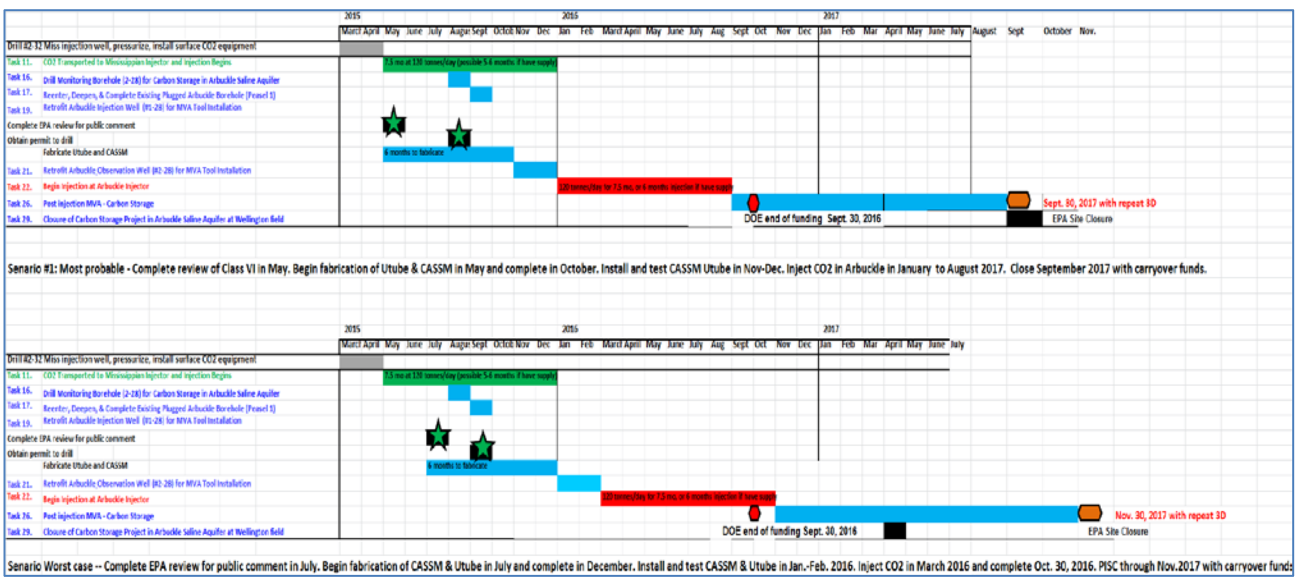


Figure 1. Suggested Class VI and injection schedules for best and worst case.

Updates to the Arbuckle model showed lower pressures (~60%) and much smaller free phase CO2 than previous versions. This decrease in pressure and free phase was noted in the model after introducing capillary pressure (**Figure 2**). It is expected that the notable plume will be a near wellbore event with dilute CO_2 in solution beyond with a similar AoR. This has been presented to EPA to support ongoing requests to reduce EPA requirements for financial assurance and PISC.

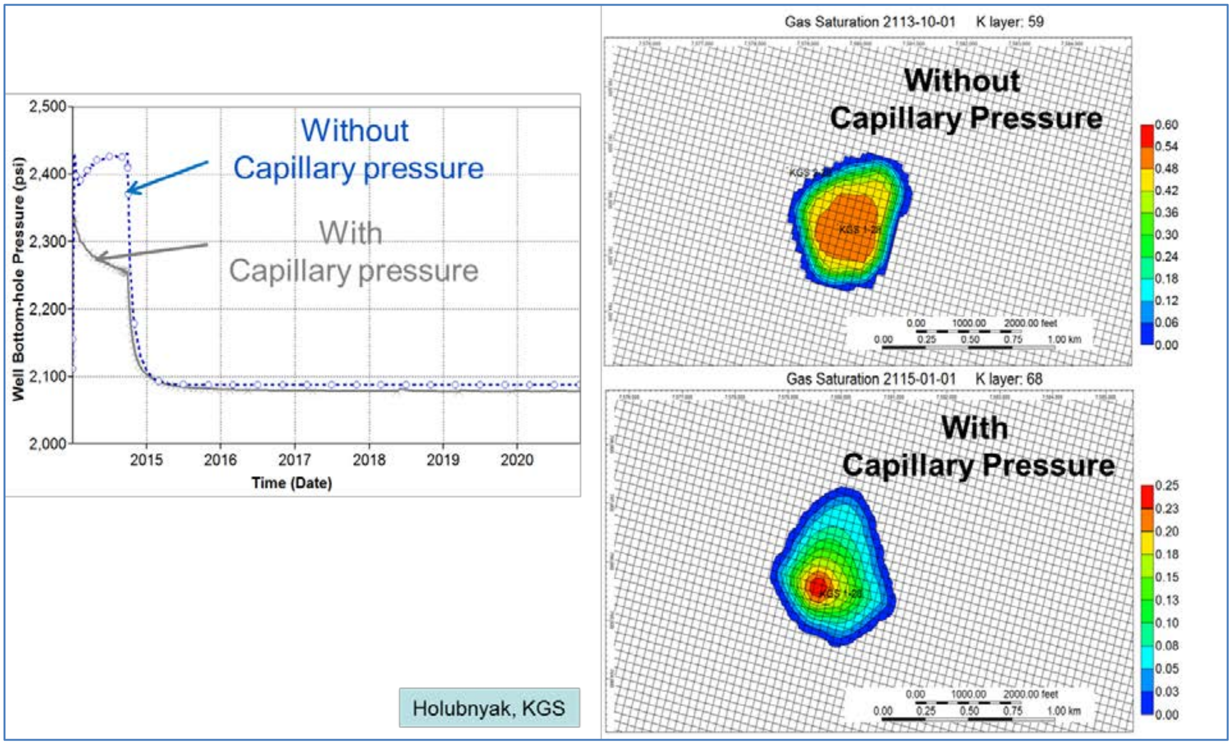


Figure 2. Simulation of Arbuckle CO2 Injection bottom hole pressure and free-phase CO_2 maximum plume.

Task 3 – Site characterization of Mississippian Reservoir - Wellington Field

Class II application to obtain a permit to inject CO2 into the Mississippian oil reservoir was filed with Kansas Corporation Commission in January and the permit was received in February. An "Intent to drill" application was then filed to drill the Mississippian injection well during March. See more discussion below.

The pilot CO_2-EOR injection at Wellington Field will serve as a calibration site and field demonstration to engage petroleum industry on merits of CO_2-EOR in Kansas and

- Convey requirements for using and storing anthropogenic sources of CO_2
- Test best practices
- Cost-effective characterization, modeling, and monitoring to aid in applying next-generation CO_2-EOR methods
- Refine model realizations to optimize for commercial scale CO_2 sequestration
- Managing operation, reduce economic and environmental risks, compliance with regulations
- Couple the oil field and the underlying saline aquifer to increase the CO_2 sequestration capacity

- Relay experience with Class VI geosequestration with EPA so as to understand requirements for using CCUS in carbon storage.

Task 6. Establish MVA Infrastructure

Subtask 6.2. Install CGPS and seismometers near injection borehole

Obtained initial data from CGPS and SAR – Data has been collected from the cGPS since August 2014 and a steady baseline is being recorded (**Figure 3**).

Figure 4 is the first scene of the side looking satellite-based radar for Wellington. Subsequent scenes are being taken on a monthly interval to capture any changes during re-pressuring the Mississippian and the CO2 injection. The cGPS appears to be showing the stability we need to refine the estimates of any ground deformation.

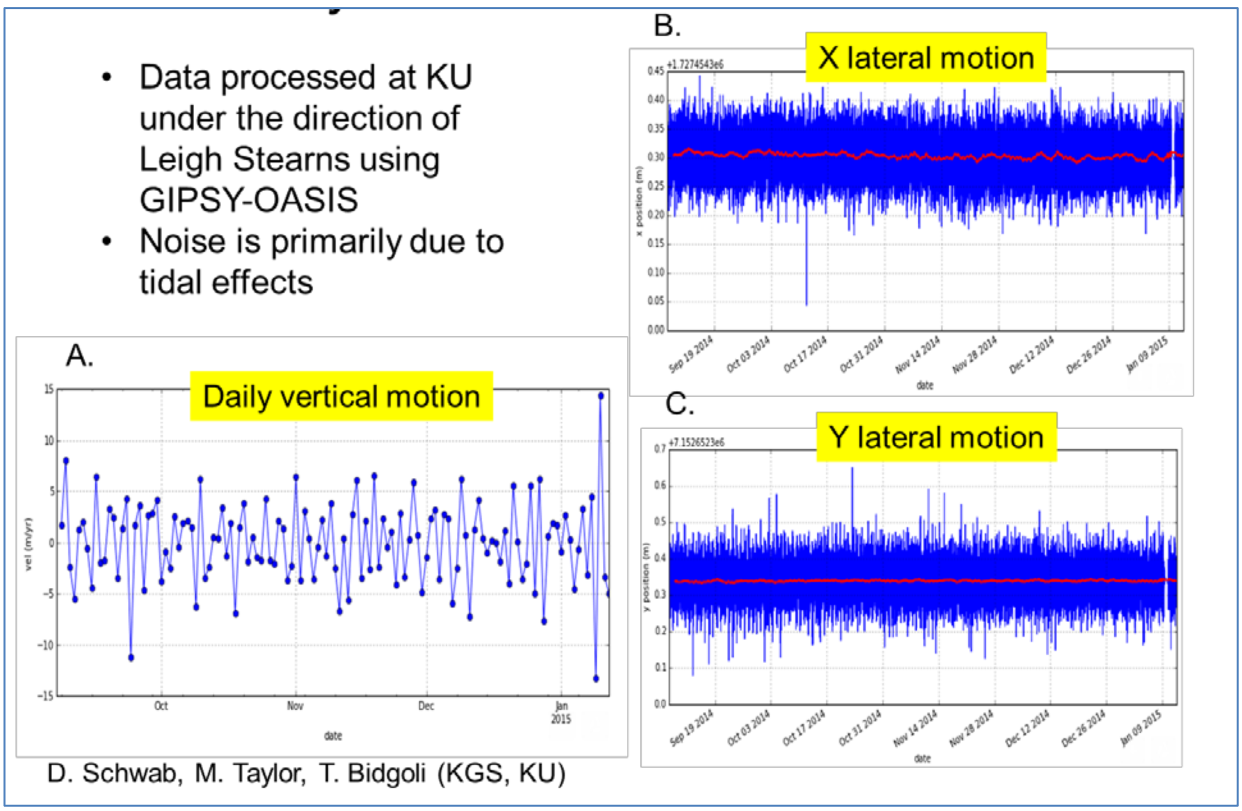


Figure 3. Data from August 2014 to February 2015 being obtained from continuous GPS instrument installed at Wellington Field.

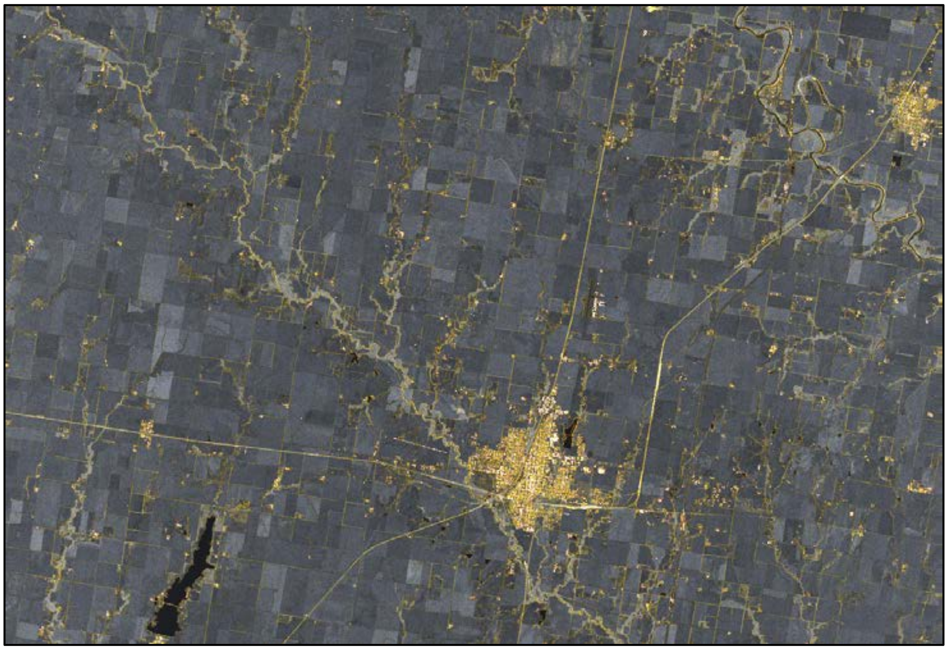


Figure 4. This is the first SAR acquisition from Terrasar-X illustrated in low resolution.

Wellington townsite is the bright area is located below the middle of the image. Future scenes will be used to create the interferometry used to deduce the changes in surface elevation.

Concurrent with this monitoring we are examining microseismic events and sampling the Mississippian wells for baseline and changes in brine chemistry as well as oil and CO_2 that are recovered.

For the past quarter, efforts have been made by J. Victorine to calibrate the velocity field at Wellington to obtain more precise location of hypocenters of microseismic events beneath Wellington (**Figure 5**). "Davies" sample logs and the sonic logs provide a useful means to obtain a good average Vp and Vs velocities. It is further necessary to compute accurate time differences for small events under the sensors.

A first step was create a Java program to find the microseismic events and compute the time difference from the data stream. The problem is finding the event first, identifying when the event started and then computing the time difference of the shear (s) and compression (p) waves (**Figure 5**). Effort was initially focused on finding an event determining the primary and secondary frequencies and building a Gaussian Sine filter to pass through the raw data. The objective was to create two "pulses" for the s and p waves. Then, the time difference could be computed from the center of the pulses.

When the time differences are obtained and he will use average Vp and Vs velocities to predict the distances to the seismic events to be conveyed as 3D plots of the events over time. John also plans to incorporate the petrophysical data into this display along with faults other discontinuities as they are delimited by the microseismicity so we can get a geologic reference. Importantly, for DOE and the team, he will create summary web pages of the microseismic events with the location, depth, and distance from faults. Resolution of the event signals that are obtained will help in the study of the mechanisms.

We plan to use the time and location of the shot points from the high resolution 2D seismic surveys to further establish the velocities along the reflection ray paths.

Characterizing microseismic events is a nontrivial exercise due to the low signal to noise and velocity variation along oblique ray paths at these shallow depths of the Mississippian.

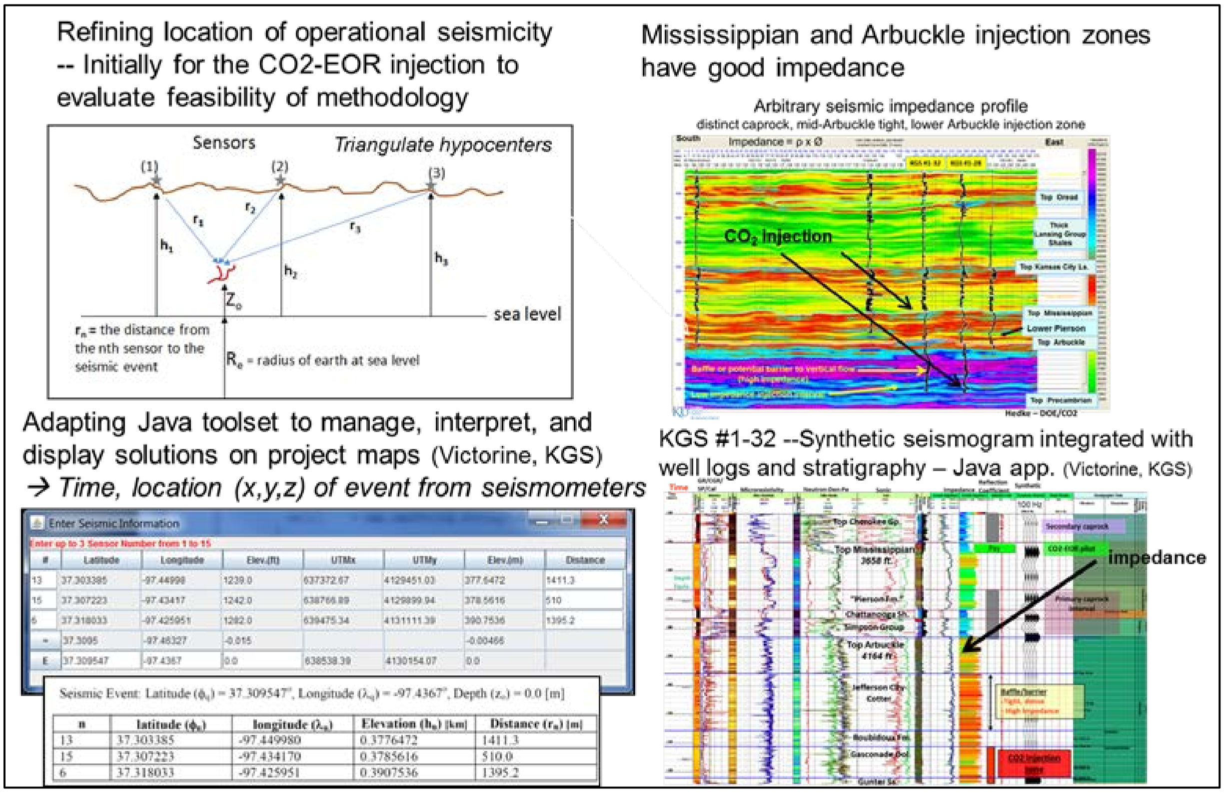


Figure 5. Resolution of Hypocenters from IRIS Seismometer Array at Wellington. Seismic information is abundant including velocity of the interval being examined to resolve operational microseismicity.

The microseismicity has the potential to help resolve the heterogeneities in this Mississippian carbonate oil reservoir. Success can then be carried to the Arbuckle injection. Potential benefits include:

– **Microseismicity**

- Expanded and refined seismometer array augmented by KGS investment to record field operational seismic events down to -0.5 M,
- – 1+M events sufficient to observe barriers or conduits of flow,
- – fracture orientation,
- – understand earthquake focal mechanisms and stress regime,

– improve geomechanical model

– Information from microseismicity could enhance understanding of factors impacting CO_2 storage

- Capillary entrapment – defined using reservoir quality index
- CO_2 miscibility
- Fracture and parting pressure
- Permeability – kv & kh, relative permeability
- Geochemical reactions – employ reactive transport models

Crosswell seismic survey to calibrate CASSM -- The recording of the crosswell seismic was revisited in March with the intent of involving the acquisition of the original 3D seismic volume and the logging company who has done the work at Wellington. Contacts were make and the original objectives were conveyed including –

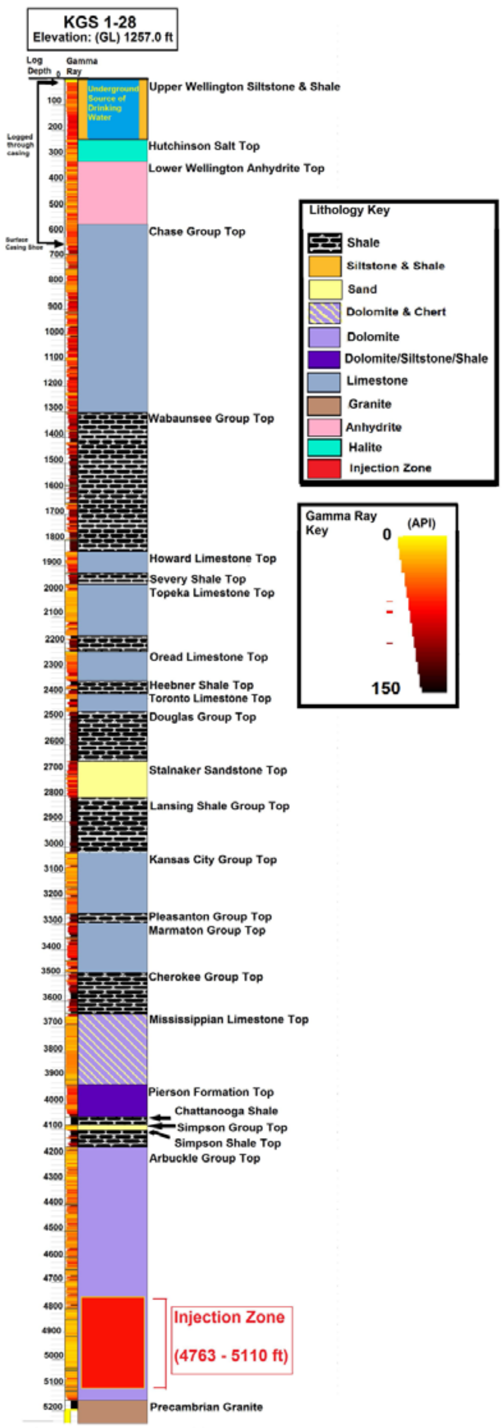
The following are additional answers to your initial questions --

A. Objectives of the survey

1. The crosswell tomography technology shall be used to monitor and visualize the movement of the CO_2 plume generated by injecting ~26,000 metric tons of CO2 in supercritical state into the lower Arbuckle saline aquifer in Berexco Wellington KGS #1-28 and observing the CO_2 plume in the Berexco Wellington KGS #2-28, yet to be drilled. The vertical and lateral extent of the CO_2 plume is shown below.
2. Two crosswell tomography surveys will provide 'bookends' to compare results with continuous active seismic (CASSM) survey overseen by Tom Daley at LBNL. CASSM geophones will be installed in Wellington KSG #2-28. The CASSM and cross well surveys will provide a detailed spatial description of the CO_2 distribution and the seismic wave field. The relatively sparse spatial sampling of the CASSM leaves uncertainty in some aspects of the interpretation of the seismic waveform (*CASSM focuses on the first arrival only, while crosswell allows understanding of later arriving phases*).
3. In addition, Wellington will likely be a designated site for DE-FEOO12700, "Distributed Fiber Optic Arrays: Integrated Temperature and Seismic Sensing for Detection of CO_2 Flow, Leakage and Subsurface Distribution." Rob Trautz, EPRI, is PI. The KGS minivibe will be used to acquire multiple VSP with a continuous fiber installed in well #2-28 and a fiber installed in a surface trench. Crosswell tomography will be used to evaluate the fiber project in an analogous manner to CASSM.
4. We also wish to use the crosswell tomography to refine our acquisition parameters for the repeat 3D that will be acquired by Paragon at the end of the injection to verify the location of the CO_2 plume.

The CASSM receivers shall be installed on production tubing in the monitoring borehole, along with other monitoring instrumentation (P/T gauge, U-tube, etc.) (**Figures 6 and 7**). The CASSM receivers are expected to be an array of hydrophones, with spatial distribution such that the expected vertical extent of the plume is monitored.

Different MVA tools shall be used to attempt to monitor, verify, and account for 99% of injected CO_2. The **crosswell tomography**, U-tube, and CASSM technology shall be used to monitor and visualize the movement of the CO_2 plume. Sampling and analysis of produced water and casing head gas from existing Mississippian wells and boreholes around the Arbuckle injector will be used to note patterns and trends in sample concentrations.



CASSM Monitoring: System performance shall be assessed by confirming a temporal resolution on the order of 10-30 minutes, allowing estimation of plume growth in real time, and potentially guiding other experiments depending on plume growth rates.

Figure 6 includes key formation tops for Wellington KGS #1-28, expected to the very similar since surface elevations of #2-28 is essentially the same as #1-28

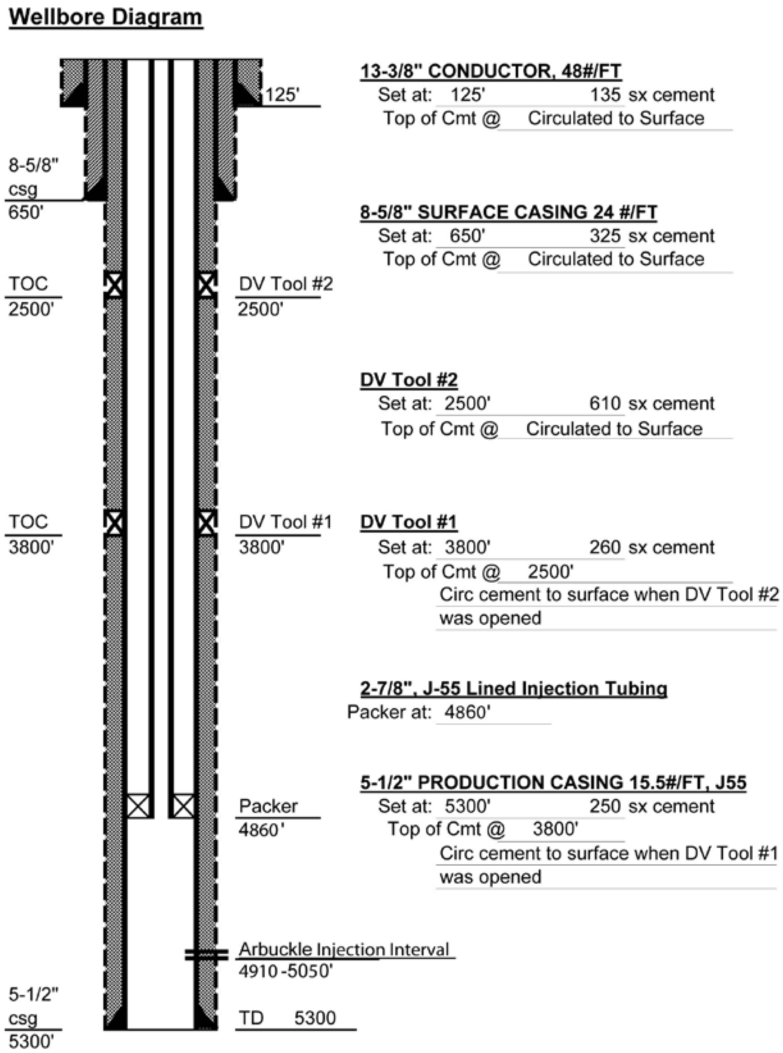


Figure 7. Current mechanical design of the Arbuckle monitoring well #2-28.

Task 7. Pre-injection MVA - Establish Background (Baseline) Readings

Subtask 7.2. Shallow Groundwater Sampling and Analysis

During the quarter the KGS/KSU team continued to evaluate the shallow groundwater in the AOR of the proposed Arbuckle injection well, KGS #1-28. EPA has been kept current activities of other relevant activities including --

- Peer-review of project underway, presenting on March 5th in Pittsburgh

    - Class VI permit needed in March timeframe to allow 7 mo. minimum to fabricate and test downhole MVA equipment in Arbuckle well before October 2015 injection
    - discussion of risks in obtaining permit and alternatives
- Drill, log, and test Mississippian injection well in March, following by pressurizing of reservoir followed by CO_2 injection
    - equivalent amounts and rates of CO_2 to be injected into the Mississippian as the Arbuckle
    - higher differential pressures in the Mississippian injection in addition to elevating reservoir pressure around the injection to initial reservoir pressure.
- Class II permit application approved by KCC
- Similar monitoring to be accomplished for Mississippian CO_2-EOR pilot
    - validate models (same methodology as used for the Arbuckle)
    - seismometer coverage same in both pilot areas, research – evaluate use to resolve operational seismicity
    - 2D high resolution seismic survey by KGS between #1-28 and Mississippian injector, #2-32
    - cGPS-InSAR coverage throughout Wellington Field area to establish baseline
    - sampling and analysis of Mississippian monitoring wells for fluids, gas, and tracer analogous to Arbuckle test, verify predicted CO_2 plume movement and compositional changes

Wellington Field is in a location of margin bedrock aquifers east of the High Plains and Dakota and west of the large alluvial aquifers associated with the Arkansas River Valley (**Figure 8**). Thus, is has been necessary to undertake origin work to delineate the extent and quality of the aquifer present in the AOR.

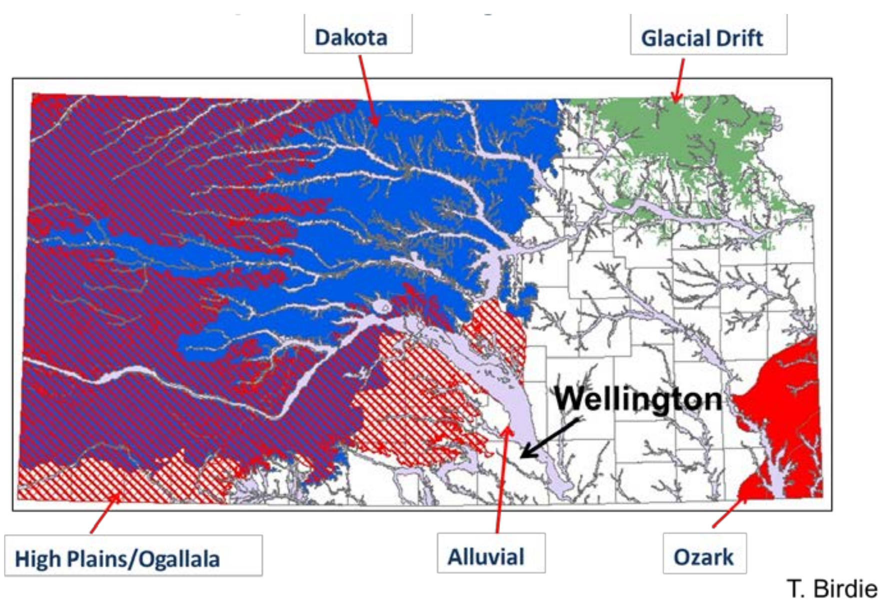


Figure 8. Wellington Field has minor surface bedrock aquifers that have required evaluation of the specific development in the AOR.

Three shallow water wells have been drilled within the Arbuckle AOR (**Figure 9**). SW-1 and SW-2 were drilled in late 2014 and completed and samples in early 2015 **(Figure 10).**

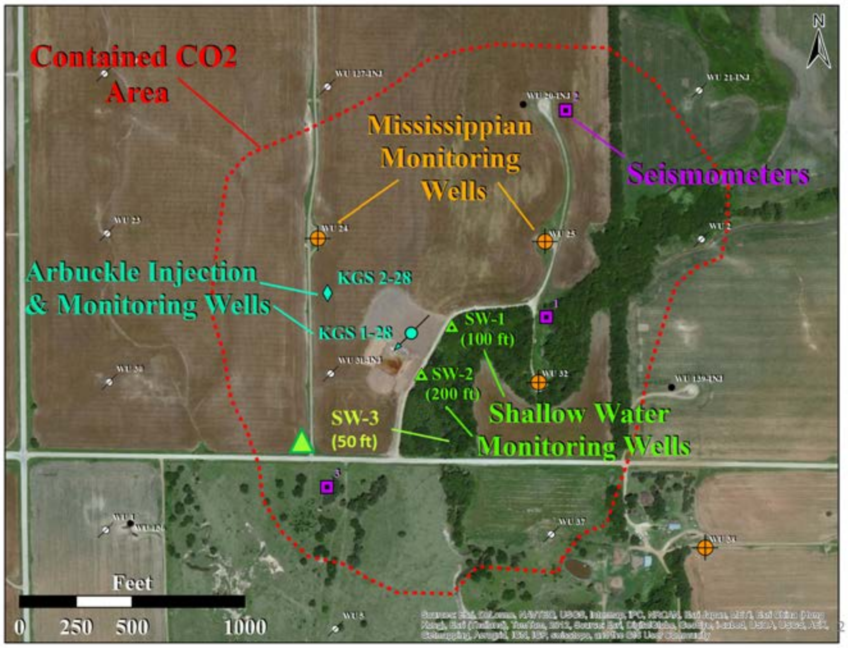


Figure 9. Test/monitoring wells for shallow water in CO2 AOR.

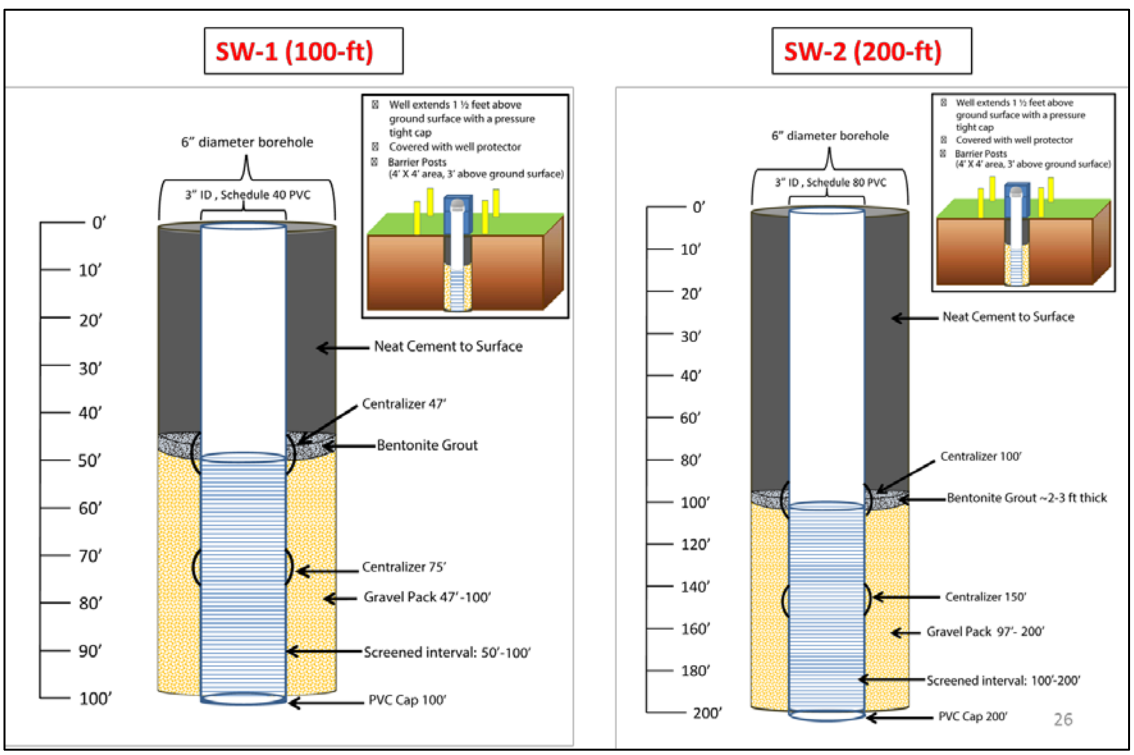


Figure 10. Well design for SW-1 and SW-2.

Initial results of first two shallow water wells, SW-1 and SW-2 were conveyed to EPA in January --

1. Negligible yield from 100-ft and 200-ft wells (SW1 yield ~.75 gal/day, low perm ~0 .01 md).
2. Highly saline water (TDS of water from 100 ft, 200 ft well was much greater than 10,000 TDS.
3. Due to low well yield and water quality conditions, the shallow formation at Wellington appears at this point to not qualify as a USDW (top of shale is ~13ft in SW1; ~10-20 ft in SW2)**.**
4. Wellington Shale in the AOR is an effective aquiclude that has prevented freshwater from directly contacting and dissolving the Hutchinson Salt (continuity of this interval in the Wellington Field).
5. Large scale mitigation strategies for Wellington Shale are unwarranted due to effects that pumping would likely have on the aquiclude (particle track monitoring).
6. Recommend EPA modify or replace the mitigation requirements due to local conditions of subsurface strata within AOR.
7. Financial assurance requirements to plug and mitigate the Wellington Shale aquiclude need to reflect lack of USDW contamination risks, reducing the need for extensive pollution mitigation.
8. Suggest modified approach to applying financial requirements for plugging and mitigation -
   A) Separate bonding for plugging and;
   B) Use of operator insurance for pollution mitigation, following the approach used by EPA to permit a Berexco Class II well in Montana.
9. Consider exempting the Wellington Shale as an aquifer in the AOR – implications of reduced permitting requirements.

SW-2 is the deepest of the shallow water wells at 200 ft (**Figure 11**). The uppermost 15 ft contains silt, sand, and clay. Shale below 15 ft contains increasing amounts of gypsum whose abundance remains steady with depth. Total depth of well is ~35 ft above the top of the Lower Permian Hutchison Salt member.

Photos of the cutting samples from SW-2 are shown in **Figures 12-31**. The samples illustrate the shallow sandy and silty interval that is then underlain by predominantly fine grained gray to dark gray shale with interbeds of limestone and ochre colored shale near the base of the well. Gypsum is abundant throughout the entire well except in the silty, sandy interval above 40 ft.

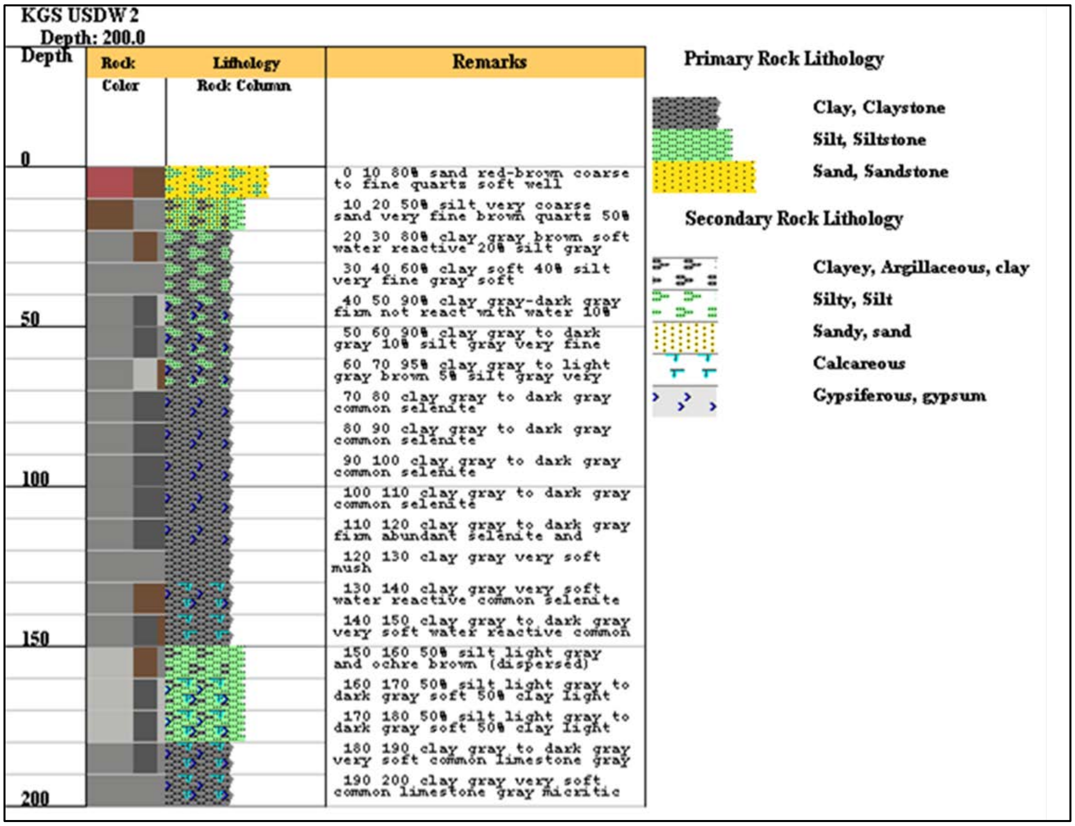


Figure 11. Sample description of deepest USDW monitoring well, SW-2.

Figure 12. SW-2 Well Cuttings (0-10 feet). 0;10; 80% sand, red-brown, coarse to fine; quartz, soft, well rounded; 20% silt, brown, clayey, dispersed.

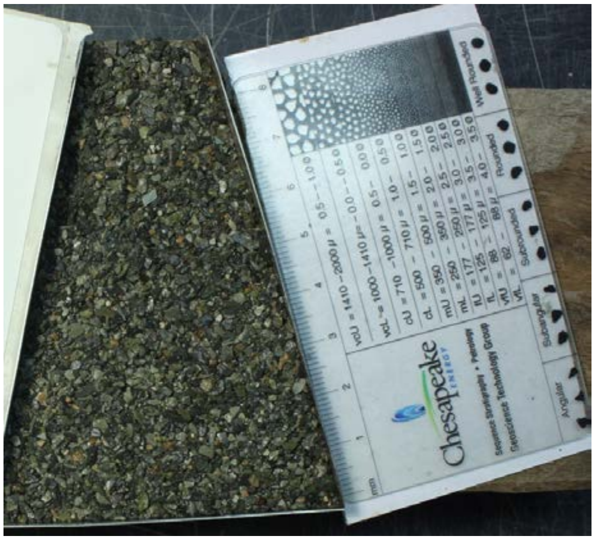


Figure 13. SW-2 Well Cuttings (10-20 feet). 10;20; 50% silt, very coarse, sand, very fine, brown, quartz, 50% clay, gray, soft.

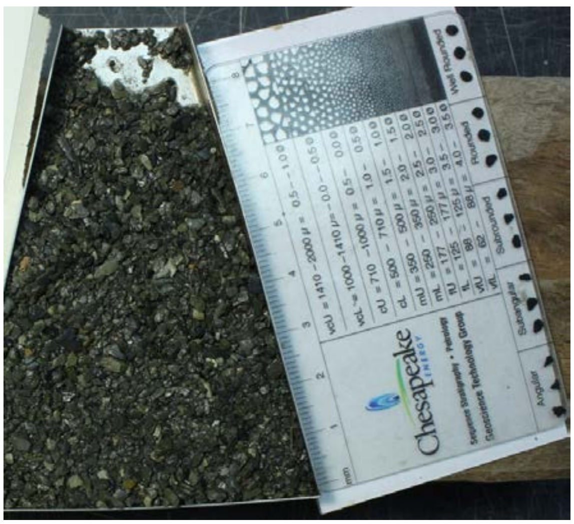


Figure 14. SW-2 Well Cuttings (20-30 feet). 20;30; 80% clay, gray brown, soft, water reactive, 20% silt, gray, more firm.

Figure 15. SW-2 Well Cuttings (30-40 feet). 30;40; 60% clay, soft, 40% silt, very fine, gray, soft.

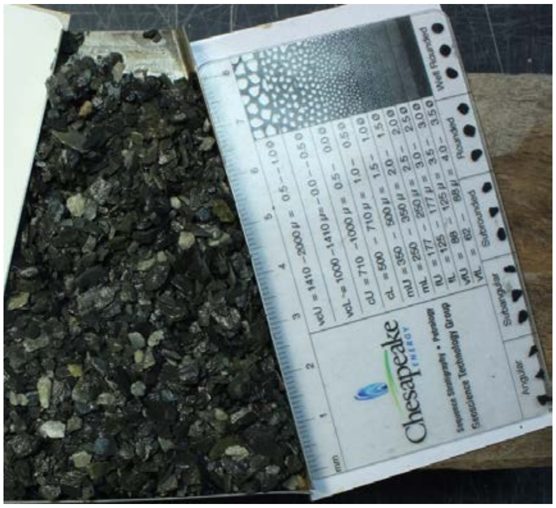


Figure 16. SW-2 Well Cuttings (40-50 feet). 40;50; 90% clay, gray-dark gray; firm, not react with water, 10% silt, light gray, very fine, quartz, rare selenite crystals.

Figure 17. SW-2 Well Cuttings (50-60 feet). 50;60; 90% clay, gray to dark gray, 10% silt, gray, very fine, firm, rate selenite crystals.

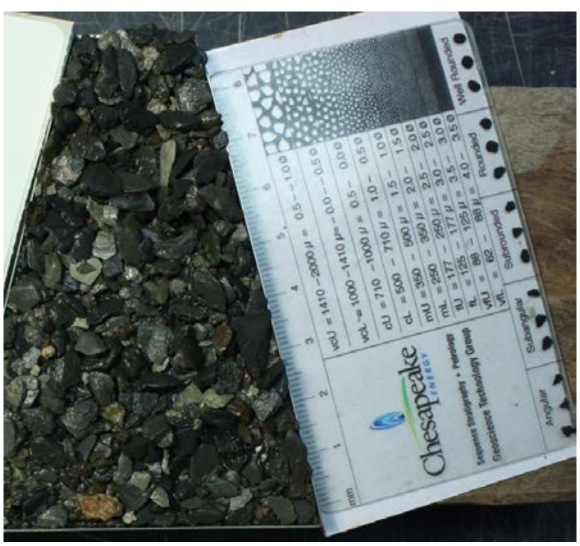


Figure 18. SW-2 Well Cuttings (60-70 feet). 60;70; 95% clay, gray to light gray, brown, 5% silt, gray, very fine, firm, frequent selenite.

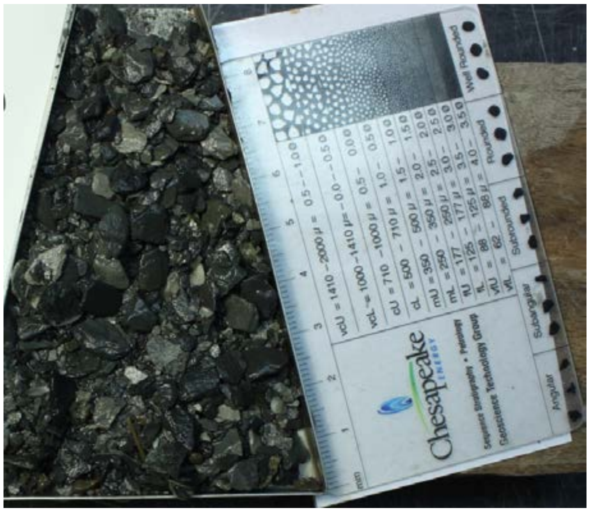


Figure 19. SW-2 Well Cuttings (70-80 feet). 70;80; clay, gray to dark gray; common selenite.

Figure 20. SW-2 Well Cuttings (80-90 feet). 80;90; clay, gray to dark gray; common selenite.

Figure 21. Satin spar crystals in sample cutting from 80-90 ft.

Figure 22. SW-2 Well Cuttings (90-100 feet). 90;100; clay, gray to dark gray; common selenite.

Figure 23. SW-2 Well Cuttings (100-110 feet). 100;110; clay, gray to dark gray; common selenite.

Figure 24. SW-2 Well Cuttings (110-120 feet). 110;120; clay, gray to dark gray, firm, abundant selenite and alabaster.

Figure 25. SW-2 Well Cuttings (120-130 feet). 120;130; clay, gray, very soft, mush (water reactive).

Figure 26. SW-2 Well Cuttings (130-140 feet). 130;140; clay, gray, very soft, water reactive, common selenite, rare limestone, brown, micrite.

Figure 27. SW-2 Well Cuttings (140-150 feet). 140;150; clay, gray to dark gray, very soft, water reactive, common limestone, brown, micrite.

Figure 28. SW-2 Well Cuttings (150-160 feet). 150;160; 50% silt, light gray and ochre brown (dispersed), very fine, 50% clay, light gray, possible water source.

Figure 29. SW-2 Well Cuttings (160-170 feet). 160;170; 50% silt, light gray to ochre, soft, 50% clay, light gray to dark gray, very soft, common limestone, gray, micritic, common selenite.

Figure 30. SW-2 Well Cuttings (170-180 feet). 170;180; 50% silt, light gray to dark gray, soft, 50% clay, light gray to dark gray, very soft, common limestone, gray, micritic, common selenite.

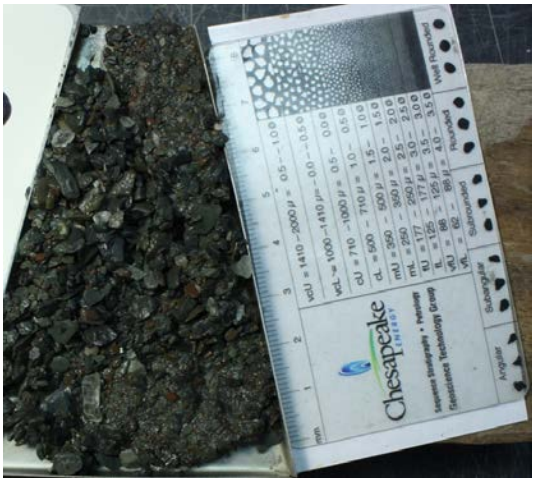


Figure 31. SW-2 Well Cuttings (180-190 feet). 180;190; clay, gray to dark gray, very soft, common limestone, gray, micritic, common selenite.

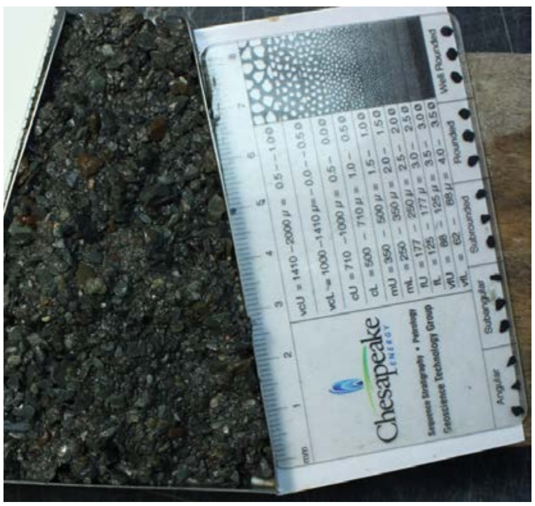


Figure 32. SW-2 Well Cuttings (190-200 feet). 190;200; clay, gray, very soft, common limestone, gray, micritic, common selenite.

A cross section of the Wellington shale is shown in **Figure 34** with an index map in **Figure 33**. The cross section illustrates its lateral continuity and vertical consistency explaining the preservation of the Hutchinson salt that is at depth of ~250 ft below the land surface.

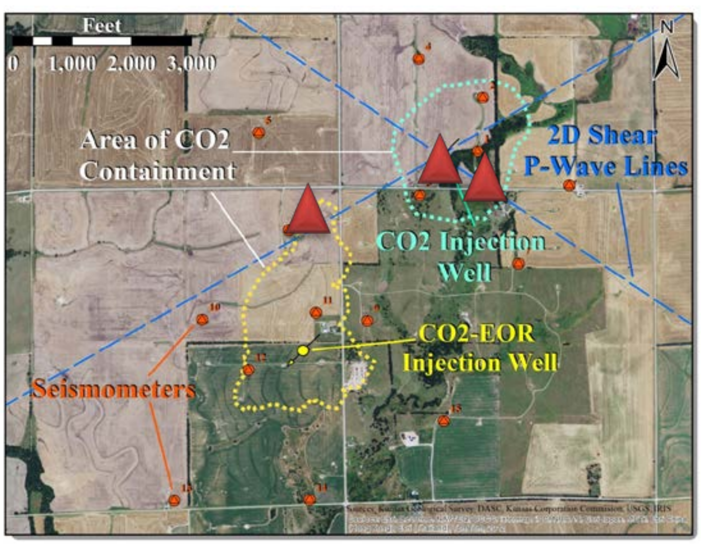


Figure 33. Adjoining small-scale pilot CO2 injection into Mississippian. Map serves as index for following cross section. Cross section in next figure runs from KGS #1-32 (left triangle) to KGS #1-28 (center) to SW-triangle on the right) located within 200 ft SE of #1-28.

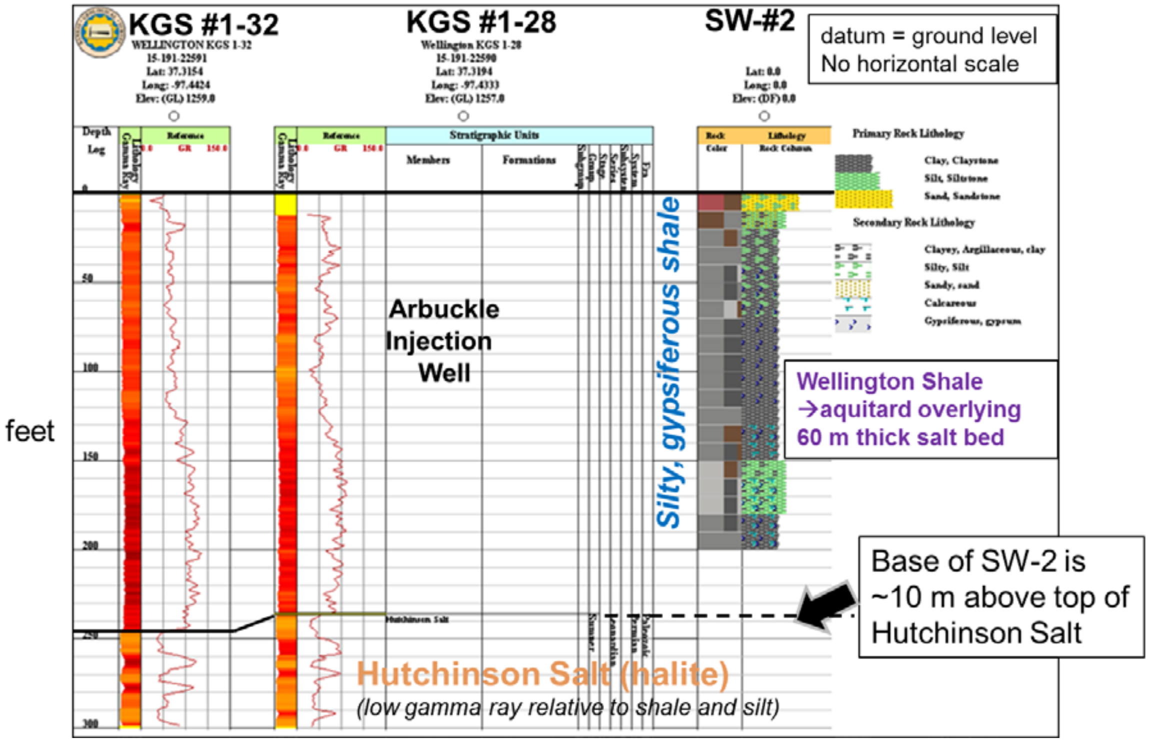


Figure 34. Gamma ray and sample log cross section between KGS #1-32, KGS #1-28, and SW-2. The datum of the cross section is ground level.

The strata near the top of the Hutchinson salt are preserved in core near Hutchinson Kansas and suggest a mixture of gypsum, halite, and shale forming chaotic and brecciated interval attesting that at least locally that dissolution along the top of the salt bed occurred after it was deposited (**Figure 35 and 36**). By closer examination, it can be inferred that the dissolution occurred early shortly after deposition since the strata overlying this contact are not significantly deformed.

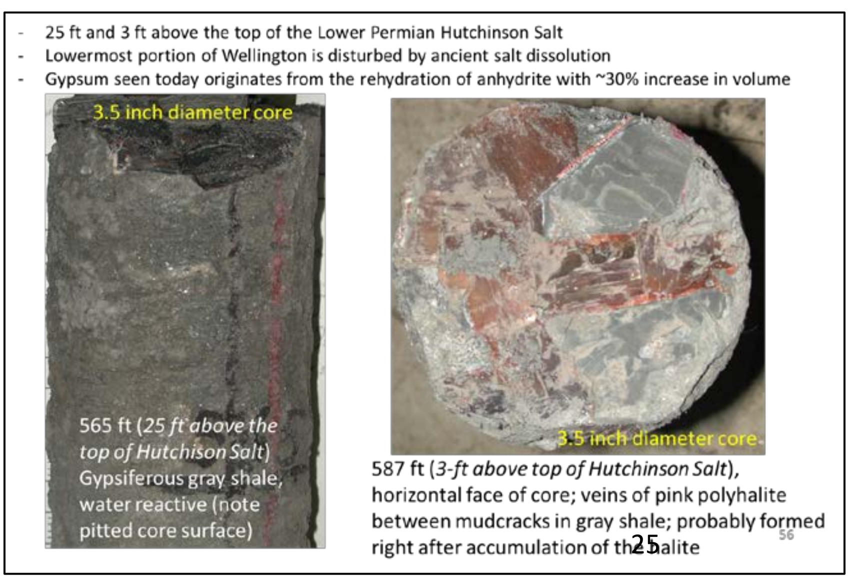


Figure 35. Example of Wellington Shale immediately above the Hutchinson Salt from Yaggy Q-5 corehole Hutchinson, Kansas.

Figure 36. Paleodissolution on top of Hutchinson Salt Member. Mixture of halite, gypsum, and shale from Yaggy Q-5 corehole Hutchinson, Kansas. Contorted bedding in gypsum (A), sharp irregular contacts between gypsum and halite (B), and mixed lithology (gypsum, halite, and shale) breccia (C), and veins of red halite (D) indicative of zones of paleodissolution that developed near the top of the Hutchinson Salt Member shortly after deposition.

A core of the Hutchinson Salt itself reveals relatively clean halite beds with varying amounts of dark gray shale laminations (**Figure 37**). The shale and halite beds can be traced considerable distances attesting to the evaporitic basin in which the halite was precipitated.

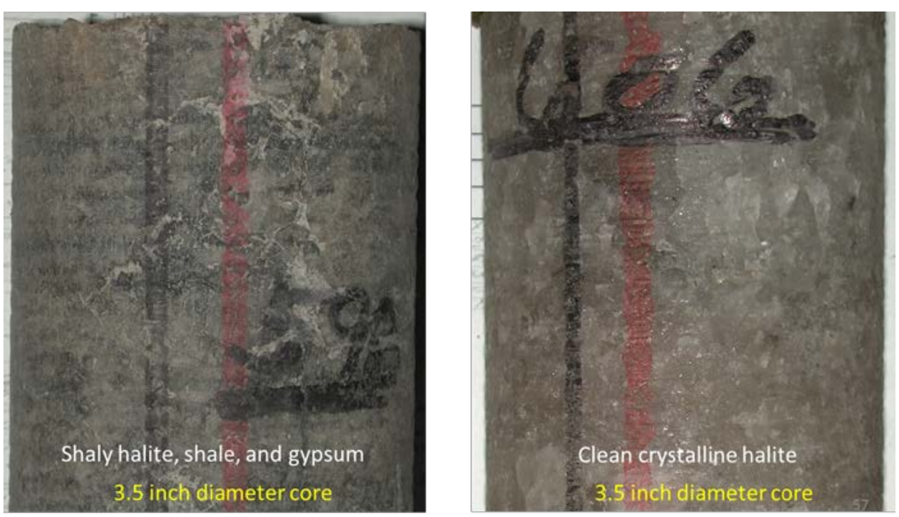


Figure 37. Examples of halite in the upper Hutchison Salt from Yaggy Q-5 corehole Hutchinson, Kansas.

Water samples were taken and analyzed according to the specifications of EPA. This resulted in the standardization of the methodologies and the manner in which the data were recorded, starting from the field **(Figure 38).**

DATE
LOCATION
TIME
CONTRIBUTORS
WELL ID:
WEATHER
COMMENTS

	Before Going to Field:
	Make DIC Vials
	Charge PDA
	Charge UV Spectrophotometer
	Calibrate Hydrolab
	Calibrate multimeter
	Calibrate conductivity meter
	Field Sampling and Testing Checklist
	Plastic Bags
	Rubber Bands
	Electric Tape
	Duct Tape
	Masking Tape
	Sharpies
	Gloves
	Kim Wipes
	Paper Towels
	Field Notebook
	Notebook with testing instructions & manuals
	Pens, Pencils
	Labels
	DI Water Sprayer Bottles
	Cooler
	Tape measure
	Beakers (50, 125, 250 ml)
	Extra batteries (AA, AAA)
	Safety Glasses
	GPS
	Whatman 45 Papers
	Pippette
	Pippette Tips
	Small volume syringe (<10mL)
	Syringes
	Syringe Filters
	Rubber Stoppers DIC
	Metal Caps DIC
	Crimper Tool DIC
	HNO3 Acid
	pH buffer solution 4, 7, 10
	conductivity solution (1.412 ms/cm) to calibrate conductivity meter (Cat. 013620HY)
	ORP standard solution to calibrate multimeter (Zobell's 013860HY)
	DI water + container
	Tap water + container
	Bailers
	Bailer Striing
	5-gallon buckets
	Water meter
	Tarp

59

	All bottles
	Extra DIC Hg-charged vials
	All kits
	Spectrophotometer
	Multimeter
	Conductivity meter
	Hydro Lab
	HACH PDA (for hydrolab)
	Bottles (1 sampling)
	(1) 500 mL amber plastic HDPE bottle (UA, UF)
	(1) 250 mL amber plastic bottle (A, F)
	(1) 250 mL transparent glass bottle (UA, UF)
	(1) 125 mL amber glass bottle (UA, F) – **Sr Isotope**
	(1) 125 mL amber plastic bottle (UA, F)
	(1) 60 mL transparent glass bottle (UA, F) – **Stable Isotope**
	(1) 60 mL transparent glass bottle (A, F) - **DOC**
	(2) 50 mL centrifuge tubes (UA, UF)
	(1) 20 mL HgCl2 charged transparent glass vial with crimp and seal (UA, UF) - **DIC**
	(1) 15 mL centrifuge tube (UA, UF)
	2 x 500mL amber plast HDPE bottles (for monitoring wells, above & below interval)
	All Spectrophotometer
	TNT 865 Sulfate
	TNT 864 Sulfate
	TNT 843 Phosphorous
	TNT 844 Phosphorous
	TNT 835 Nitrate
	TNT 870 Total Alkalinity
	TNT 830 Ammonia
	TNT 831 Ammonia
	TNT 832 Ammonia
	TNT 858 Iron
	TNT 839 Nitrite
	TNT 840 Nitrite
	Extra vials and rubber caps, rectangular and conical vials
	Sulfide Reagents 1 and 2
	SulfaVer 4 AccuVac Sulfate
	FerroVer AccuVac Iron

	Kits
	HACH
	Alkalinity (small)
	As Test Kit
	As E2 Test Kit
	Chloride (2 small kits)
	Dissolved Oxygen (small)
	Dissolved Oxygen (large)
	Ferrous Iron (Fe 2+)
	Mn
	PO4
	SO4
	SO4 Colorimeter
	LaMotte
	Chloride
	CHEMetrics
	Dissolved Oxygen

Figure 38. Water sampling forms shared by Austin Krehel (KSU).

Initial water analyses from SW-1 and SW-2 indicate elevated chlorides (**Figures 39 and 40**) with salinity increasing with depth. This gradient toward higher salinity is interpreted as diffusion of dissolved NaCl from the indigenous halite, but mainly from the Hutchinson Salt Bed itself.

Moreover, this diffusion is expected from long term exposure of the salt steadily reducing concentrations of brine by meteoric waters as erosion has brought the bed of halite in closer proximity to the land surface.

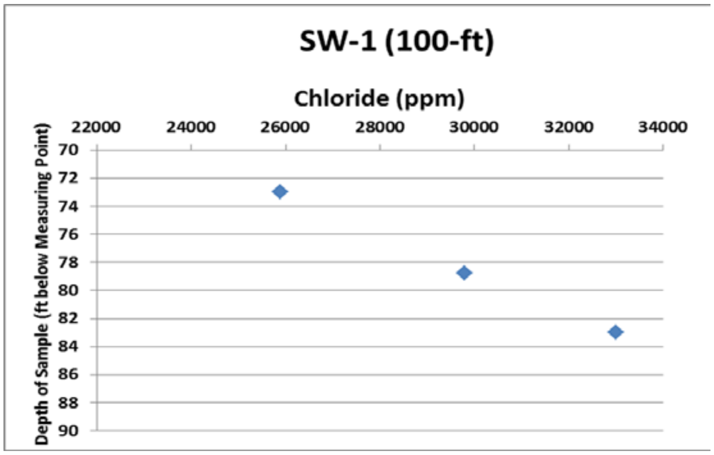


Figure 39. Groundwater Salinity in SW-1 (100-ft Well, Dec 14). Well Screened 50-100 ft. TDS > 10,000 ppm increasing with depth. Time series changes in salinity will be evaluating after continued monitoring.

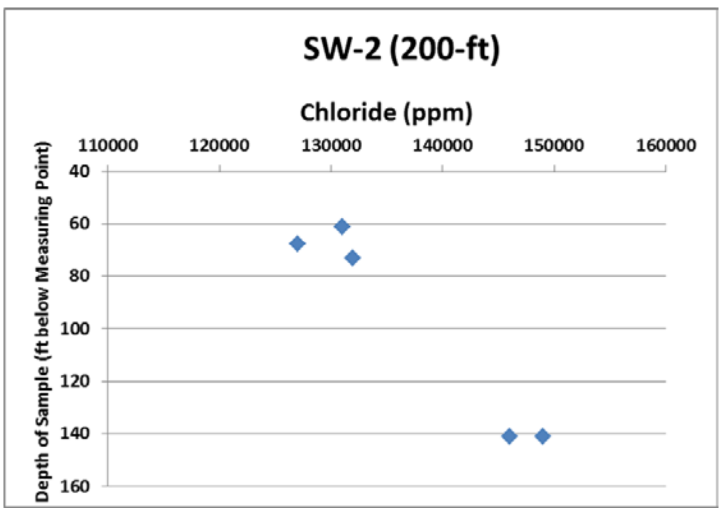


Figure 40. Groundwater Salinity in SW-2 (200-ft Well on Dec. 14, 2014). Well Screened 100-200 ft. TDS > 10,000 ppm with increasing salinity with depth.

The SW-1 well as bailed over a span of time from early November to mid December (**Figure 41 and 42**). The recovery rates of this well were analyzed using a standard hydrologic software indicating an estimated permeability of ~0.1 millidarcies (**Figure 43**). The analysis confirmed that the interval screened in this well (50 to 100 ft) is tight and is an aquiclude that has contributed to limiting the infiltration of meteoric water from the surface. The yield from this well was estimated at 0.75 gal/day using another hydrologic model (**Figure 44**). Pumping such as well would result in drawing in poor quality water into the borehole from depth and could lead to salt water intrusion during extended pumping. Besides salt water intrusion, the concern is extended to the possible dissolution of the salt bed below. Thus, mitigation of CO2 from this interval is not deemed feasible. A particle track model shows preliminary simulation of the pumping (**Figure 45**).

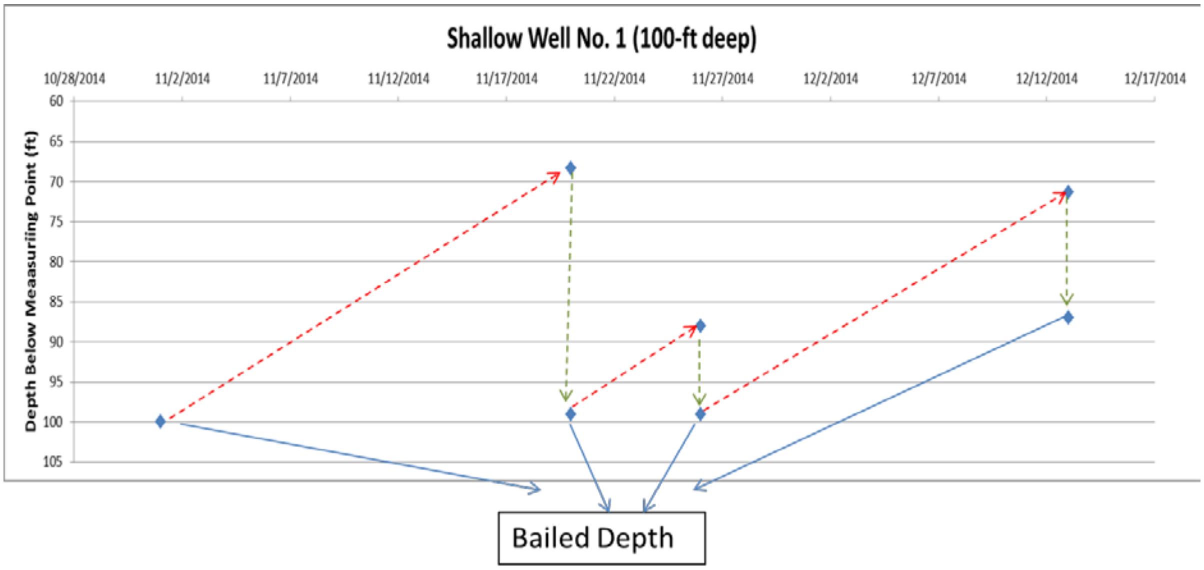


Figure 41. Well Bailing Summary (100-ft Well). Average Daily Recovery Rate = 1 .7 ft/day; similar recovery slopes. Expect recovery to continue gradually, ultimately to reach a static fluid level. Continue purging and monitoring to obtain 3 well volumes of fluid.

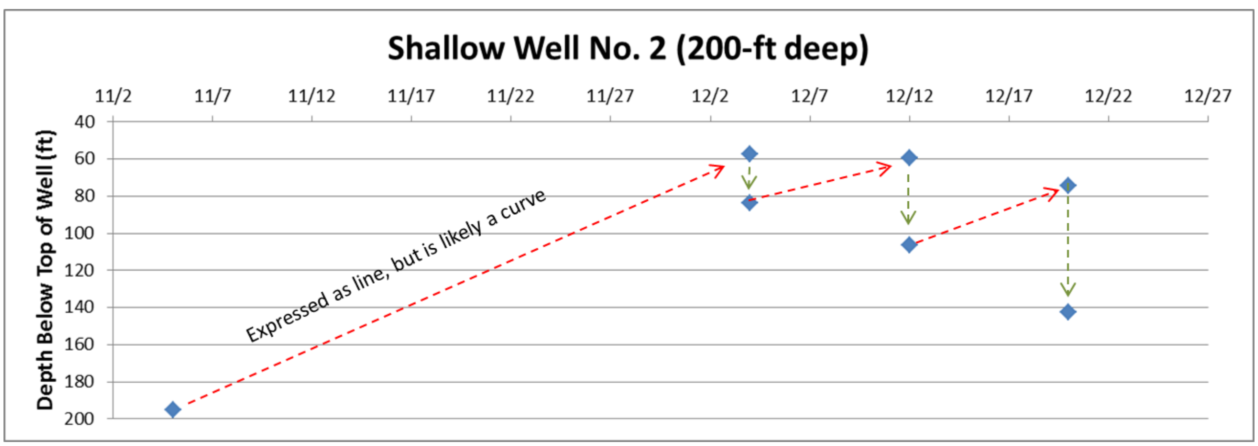


Figure 42. Well Bailing Summary SW-2 (200-ft Well). Average Daily Recovery Rate= 3.9 ft/day. Have had difficulty in bailing well below 140 ft. Continue to purge and monitor water levels to obtain 3 well volumes of fluid (consider pumping to lower fluid level to base of well).

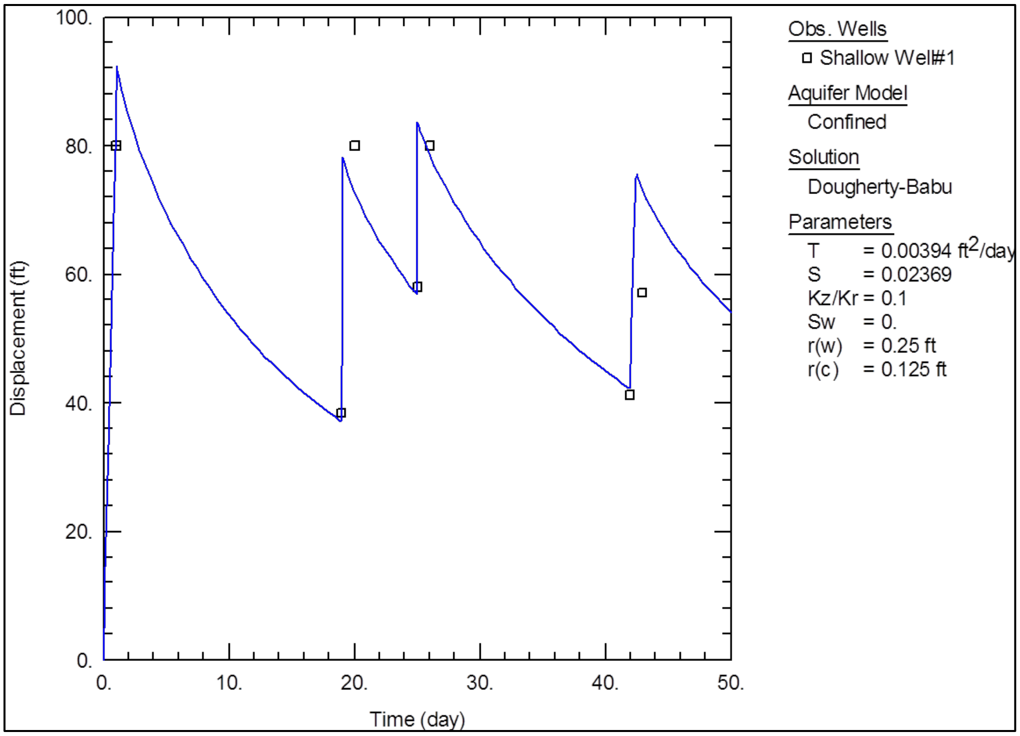


Figure 43. Permeability Estimation in USDW well #1 → Wellington Shale is an aquitard. Low Permeability of 0.00005 ft/day ~0.01 md an aquitard with properties equivalent to our caprock.

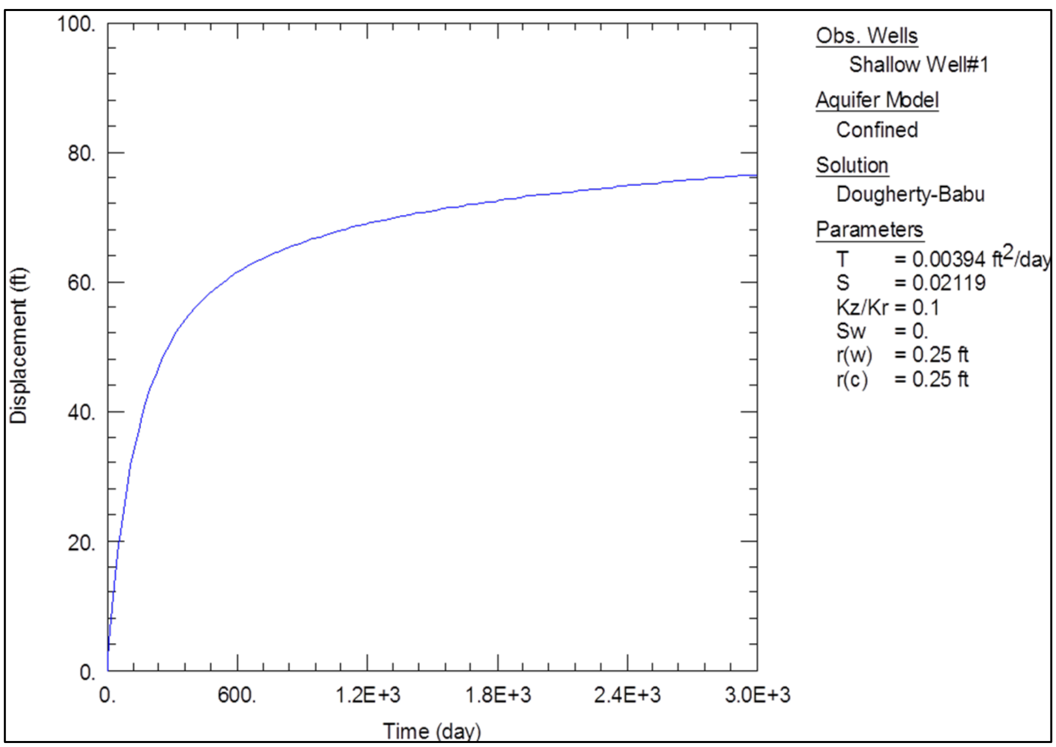


Figure 44. Well Yield Estimate. for 6-inch wellbore producing from screened interval in SW-1 with an 80 ft drawdown (Forward Modeling). Low Yield of 0.75 gal/day.

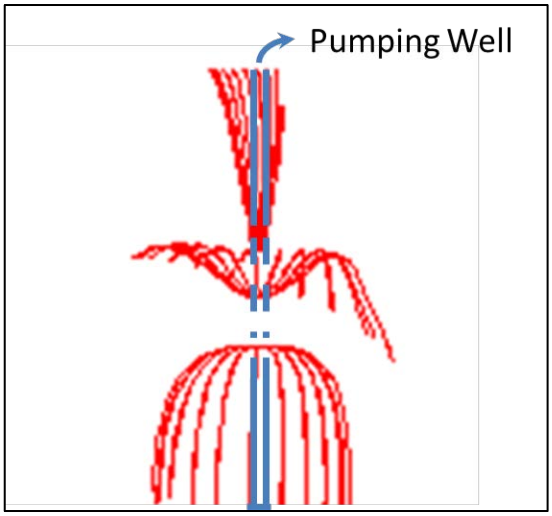


Figure 45. Particle Track Modeling. Preliminary simulations of pumping are expressed by particle tracking.

The result of the conversation with EPA on January 15th is that information gathered to that point suggests no USDW. EPA requested that we drill another shallow water well (UDSW Well #3) on the opposite (west) side of the AOR (**Figure 46**). The SW-3 was drilled in early February to a depth of 50 ft. The well was screened from 25 ft to bottom. The well was pumped over a 2 week interval to check if saltwater (> 10,000 ppm) is induced in the well.

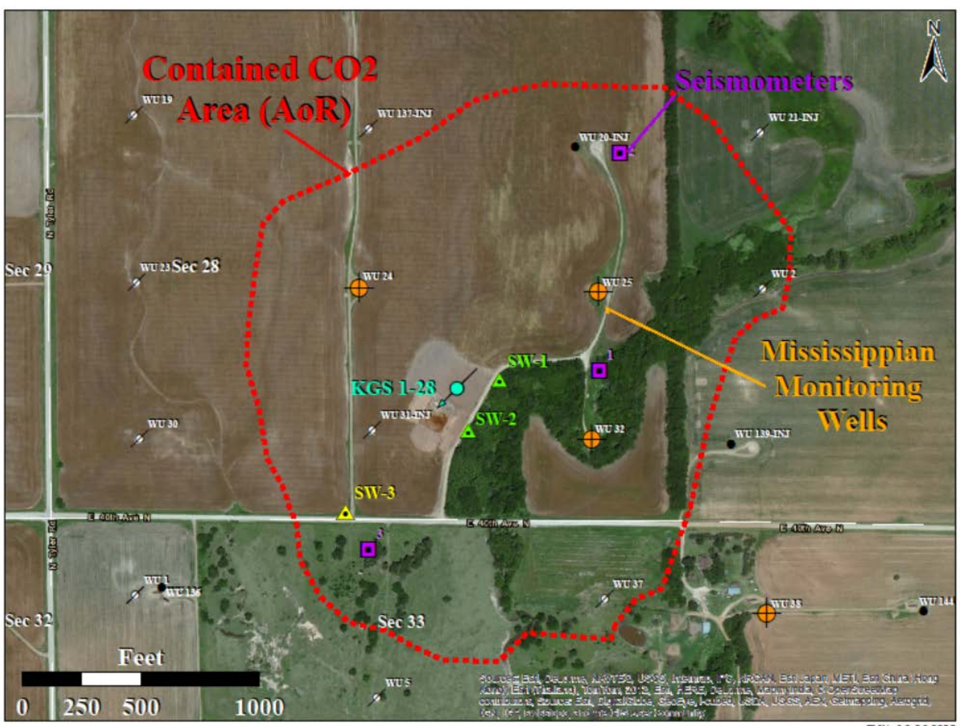


Figure 46. Location of SW-3 in the southwestern AOR.

Well Construction Objective of SW-3 as modified from that conveyed to EPA

The objective of constructing monitoring well SW-3 was to determine groundwater quality in the Upper Wellington Formation overlying the Hutchinson Salt beds. A related goal was to determine if there is an Underground Source of Drinking Water (USDW) with the Area of Review of the Wellington CO_2 storage site. The USDW is defined by the EPA as:

> "Underground source of drinking water (USDW) means an aquifer or its portion:
> Which supplies any public water system; or Which contains a sufficient quantity of ground water to supply a public water system; and
> Currently supplies drinking water for human consumption; or
> Contains fewer than 10,000 mg/l total dissolved solids; and
> Which is not an exempted aquifer."

The well can be used to monitor water quality in the Upper Wellington Formation during CO_2 storage activities in order to ensure that CO_2 remains confined in the injection zone within the Arbuckle Group and does not escape into any shallower formations or the atmosphere. A generalized stratigraphic column of the Wellington formations is presented in **Figure 47**. The thickness of the Upper Wellington, Hutchinson Salt Beds, and the Lower Wellington formations is variable in the area, but is consistent through Wellington Field area. At some locations, the Upper Wellington member may be thin or absent, but only the upper shale member is present at Wellington. The Upper Wellington shale overlies the Hutchinson Salt Beds, which suggests the likelihood of inducing highly saline water from production wells in the Upper Wellington Formation.

Site Description and Location

The monitoring well is located in the midst of cropland approximately 750 feet southwest of the proposed CO_2 injection well KGS 1-28. The monitoring well location and depth information is presented in Table 1.

Table 1 Location, well depth, and ground elevation at monitoring well SW-3.

Completion Date	Latitude	Longitude	Section	Ground Elevation (ft, msl)	Well depth (ft)	Height of Measuring Point Above Ground (ft)
2/8/2015	37.318081	-97.435420	T31S R1W S29 SE SW SW	xx	50	1.5

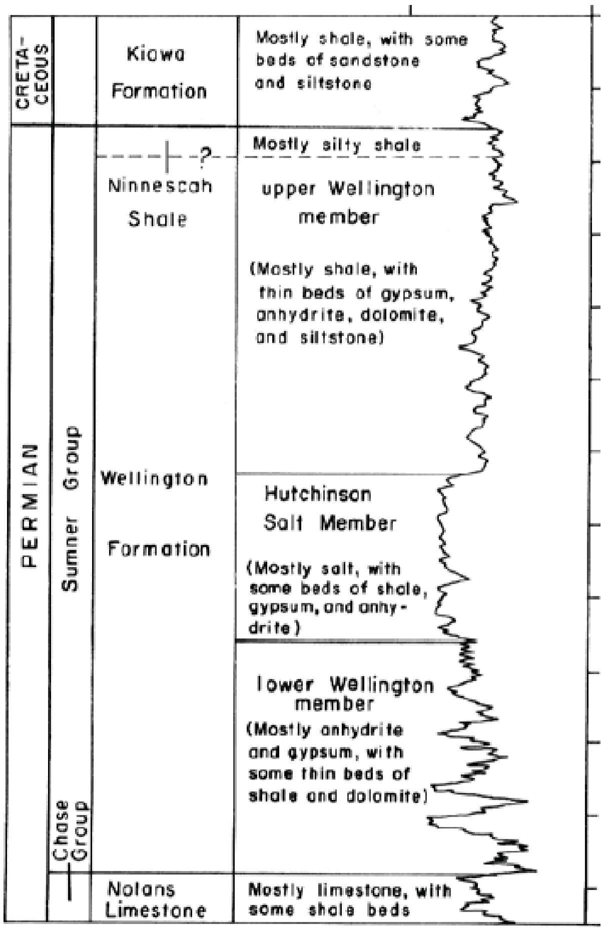


Figure 47. Stratigraphic relationship of bedrock in central Kansas (from Gogel, 1981)

Well Construction

The well design specifications are provided in **Figure 48**. Construction at the site started on February 8, 2015 using a rotary drill bit and completed on February 9, 2015. The 6.5- inch borehole was drilled to a depth of 50 feet. The well was completed using a 4-inch Schedule 40 PVC pipe with a 10 slot (0.010) screen from 25-50 feet. Approximately three feet of bentonite was used between the gravel pack and the cement grout to prevent cement grout from coming in contact with the gravel pack, which can impact the pH of water samples.

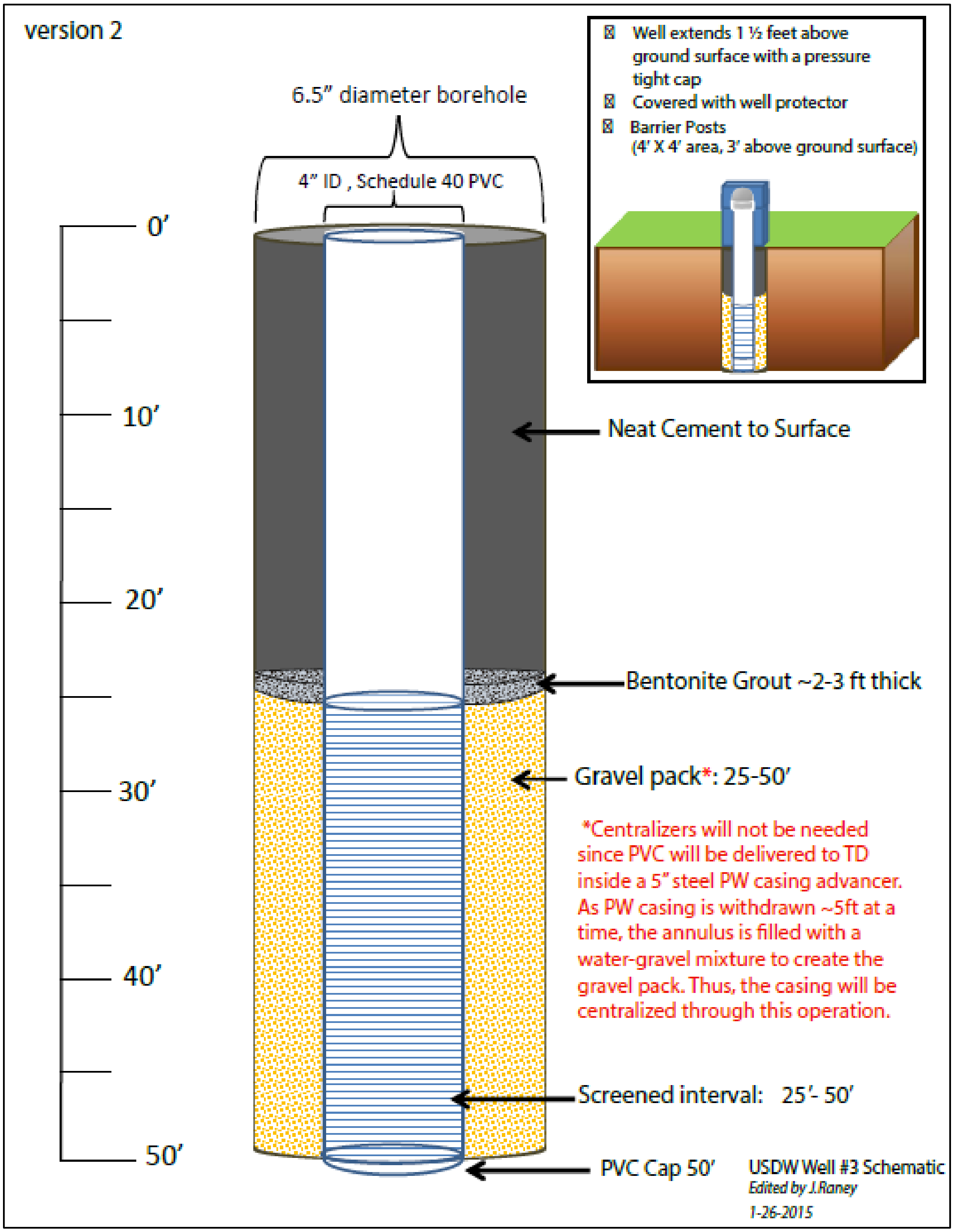
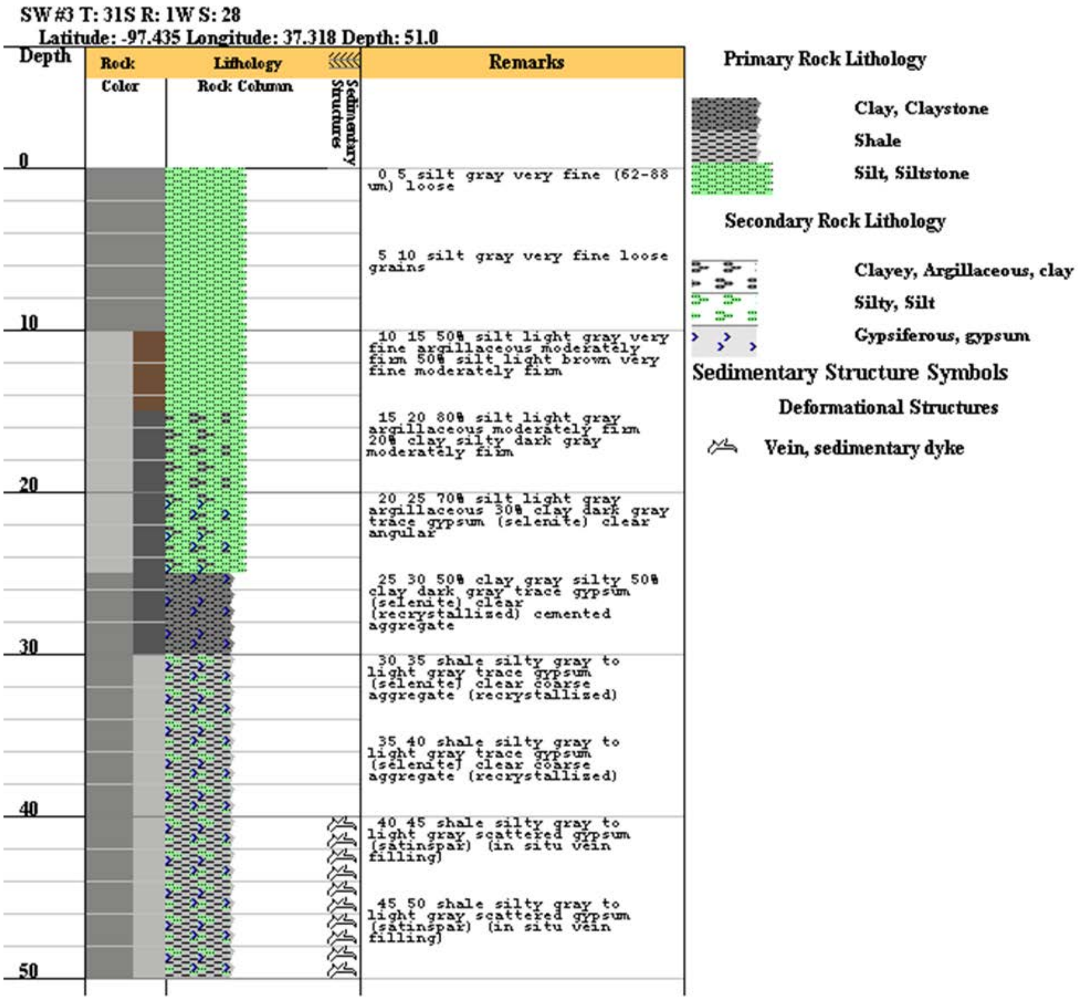


Figure 48. The UDSW Well #3 was to be drilled to 50 ft and screened from 25 ft to bottom.



CUTTINGS DESCRIPTION

KGS SW #3 well (50 ft TD)

Longitude: -97.435, Latitude: 37.318
Located 690 ft south-southwest of Wellington KGS #1-28
County: Sumner County
Screen interval: 25-50 ft
Total Depth: 50 ft; Elevation: 1255 Ground level
0;5; silt, gray, very fine (62-88 um), loose
5;10; silt, gray, very fine, loose grains
10;15; 50% silt, light gray, very fine, argillaceous, moderately firm, 50% silt, light brown, very fine, moderately firm
15;20; 80% silt, light gray, argillaceous, moderately firm, 20% clay, silty, dark gray, moderately firm
20;25; 70% silt, light gray, argillaceous, 30% clay, dark gray, trace gypsum (selenite), clear, angular
25;30; 50% clay, gray, silty, 50% clay, dark gray; trace gypsum (selenite), clear (recrystallized) cemented aggregate
30;35; shale, silty, gray to light gray, trace gypsum (selenite), clear, coarse aggregate (recrystallized)
35;40; shale, silty, gray to light gray, trace gypsum (selenite), clear, coarse aggregate (recrystallized)
40;45; shale, silty, gray to light gray, scattered gypsum (satinspar) (in situ vein filling)
45;50; shale, silty, gray to light gray, scattered gypsum (satinspar) (in situ vein filling)

Figure 49. Graphic section of SW-3 shallow water well.

The drilled cuttings were described and are reported in the graphic column and depth listing in **Figure 49**. The results of the drilling are summarized as follows:

1. Silt to 25 ft
2. Silty shale 25-50 ft
3. First gypsum @ 20-25 ft
   - Recrystallized
4. Satin spar @40-50 ft
   (interpreted as precipitated by early burial diagenesis, unrecrystallized by surface processes as see in wells #1 and #2).

The first gypsum is in the 20-25 ft sample described as recrystallized that consists of loose clusters of corroded selenite crystals in a framework of alabaster that make up individual cuttings pieces. The recrystallization indicates that the gypsum has likely undergone frequent partial dissolution and recrystallization. This is attributed to changing saturation conditions of the brine that resides at these shallow depths. The salinity of the brine likely changes seasonally as wet and dry conditions alternate. In contrast, at 40 ft, satin spar is present indicating vein filling gypsum that is common in cores of the Upper Wellington shale that have not been affected by recent meteoric water. This indicates that gypsum is stable at 40 ft below the surface.

SW-3 has a similar lithologic profile as SW-2, but SW-3 has slightly more and thicker silt to around 25 ft, but SW-3 contains less sand-sized particles (**Figure 50**).

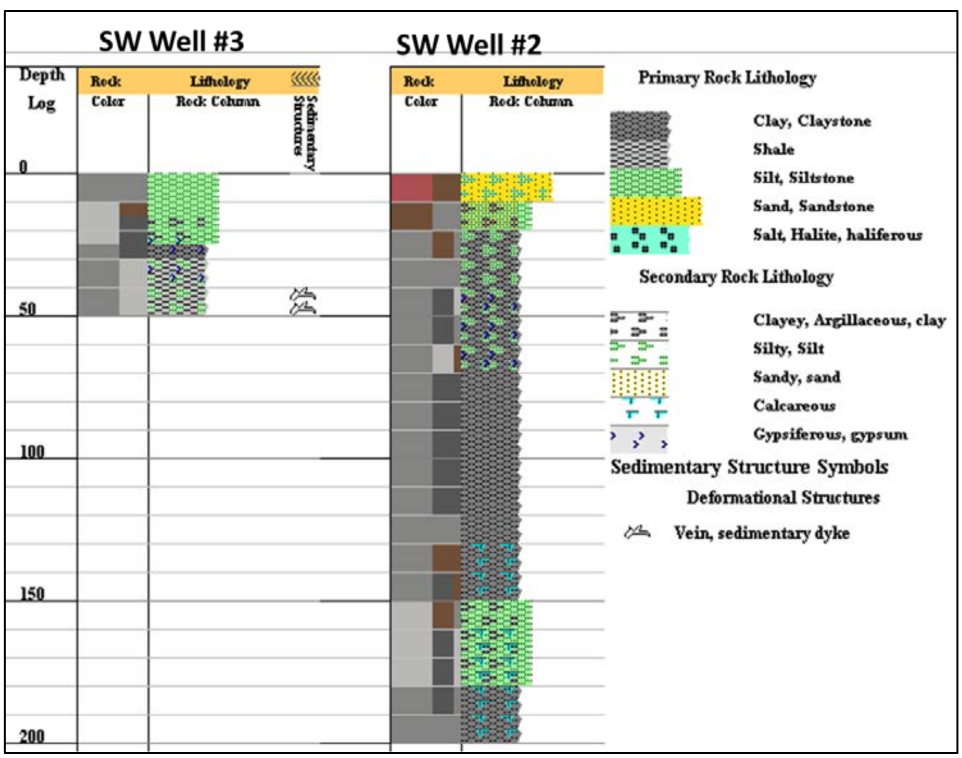


Figure 50. Graphic profile of SW Well #3.

Well Development, SW-3

<u>February 8 and 9, 2015</u>

Following construction of the well, approximately 150 gallons of was removed on February 8, 2015 using an air bailer. This was followed by withdrawal of an additional 300 gallons on February 8, 2015. One well volume consists of approximately 26 gallons. Therefore, a total of 11.5 well volumes of groundwater was extracted from well immediately after construction of the well.

<u>February 19, 2015</u>

The site was visited on February 19, 2015 to obtain water quality samples using a hand bailer. Approximately 0.37 gallons was extracted during each bailing operation. A total of 50 bails (18.5 gallons) was removed prior to obtaining the water quality samples; the results of which are discussed below.

<u>March 12, 2015</u>

Based on the recommendation of EPA, a separate visit was made to the site on March 12, 2015 in order to purge the well with a surge-block. Surging was initiated at 7:30 am with the block at a depth of 25 ft (i.e., top of screen) and applying 25 vigorous up and down strokes. This process was repeated four additional times by lowering the surging start depth by 5-feet each time.

Accordingly, the final (surging) start depth was 45 feet below ground. After the final surging operation, the well was allowed to settle for approximately one hour.

Initial water quality measurements were taken after an hour using a bailer to extract approximately 3 gallons of water before starting pumpage. The water was extremely *dirty* and dark grey in color. Pumping began at 9:15am at an average rate of 25 gallons every 9 minutes. Water quality measurements were then taken at the 25, 50, 100, and 150 gallon marks. The following parameters were measured at each of these gallon marks: turbidity, specific conductance, temperature, pH, salinity, dissolved oxygen, and redox potential. The turbidity trends are presented in **Figure 51**. The salinity parameters are presented and discussed below in the Water Quality section. The entire suite of water quality data for the sample collected on March 12, 2015 is presented in Appendix G. As can be noted from **Figure 51**, the water stayed fairly turbid until the 150 gallon mark, when it cleared up significantly. At 175 gallons the pump unexpectedly shut off, and the water collection tank was emptied into a large truck. An additional 25 gallons was pumped with another pump. Due to the higher horse-power of this pump, it increased the sediment intake significantly and caused the turbidity to increase. This is reflected in the sudden spike in turbidity (**Figure 51**).

The original pump was successfully run again at the 200 gallon mark. The water appeared turbid until the 225 and 250 gallon mark. Additional measurements were taken at 300, 325, 350, 375, 400, and 425 gallons marks. The water in these last 6 measurements was very clear and seemed to remain constantly clear as pumping continued (**Figure 7**).

Figure 51. Turbidity in SW-3 following surging operations on March 12, 2015.

Well Water Levels and Well Yield

Water levels were measured during several trips to the site as documented in **Table 2**. The water levels are consistently in the 11-12 feet (below measuring point) range. The measuring point is approximately 18 inches above ground.

The well has not been operated continuously for an extended period in order to derive a sustainable yield. However, during the well development and sampling operations conducted on March 19 and March 27, a yield of greater than 3 GPM was estimated.

Table 2. Water level measurements at SW-3

Date	**Water Level (ft below Measuring Point*)**	**Notes**
2/9/2015	~ 10’	Estimated by driller
2/19/2015 12 noon	11’-0.25”	Prior to bailing
2/19/2015 ~ 5 pm	11’-0.75”	After 20 bailing cycles
3/12/2015 (7:30am)	11’-5”	Prior to commencing pumpage
3/17/2015 (8:10 am)	11’-4”	Prior to commencing pumpage

3/17/2015 (10:00 am)	12'-5"	After pumping 200 gallons

* Measuring point approximately 18 inches above ground.

Water Quality Sampling

The water quality in SW-3 was determined during four separate trips to the site. The purpose of the first three trips was to obtain an initial estimate of the TDS at the site. Therefore a strict sampling protocol was not followed during these visits. During the last two trips, the sampling, handling, and transportation procedure forwarded to the EPA in the proposed QASP (KGS, 2015) were followed. The water quality results derived during each site visit are documented below. A TDS of greater than 10,000 mg/l was measured during each visit. Further explanation of field activities and observations are documented below.

Table 3. TDS estimated during site visits and from laboratory sample

Date	TDS (mg/l)	Depth (ft below MP)	Notes
2/11/15	24,027	~ 11-12	Bailing operation. Sample analyzed in lab by Baker-Hughes
2/19/15	25,195	~ 12	Bailing operation. TDS estimated from specific conductivity
3/12/15	24,924		After pumping 425 gallons. TDS estimated from specific conductivity
3/17/15	31,500		After pumping 100 gallons of groundwater. TDS derived from lab based concentration of cations and anions
3/17/15	28,200		After pumping 200 gallons of groundwater. TDS derived from lab based concentration of cations and anions

<u>Feb 11, 2015</u>

In order to obtain a preliminary estimate of water quality, a sample was collected at the water table (~ 11 ft) and forwarded to Baker Hughes for laboratory analysis.. A TDS value of 24,027 mg/l was estimated for the sample.

<u>Feb 19, 2015</u>

After bailing 18.5 gallons (~ 0.7 well volumes), a sample was collected and a specific conductance of 37,600 micro-siemens/cm and salinity=18,800 mg/l was measured using a portable meter. Based on a TDS/conductivity ratio of 0.67, a TDS value of 25,195 mg/l was derived.

March 12th 2015

During the site visit on March 12, 2015, up to 425 gallons was pumped from SW-3. The TDS estimated from specific conductance (TDS = 0.67 conductance) is presented in **Table 4** and also displayed in **Figure 52** along with the specific conductance and salinity data. The TDS appears to stabilize at approximately 25,000 mg/l.

Table 4. TDS estimated from specific conductance during site visit on March 12, 2015

Estimated TDS (in mg/L) based on conductance		
	0 gallons	30,552
	25 gallons	29,480
	50 gallons	27,604
	100 gallons	28,140
	150 gallons	27,001
	225 gallons	27,068
	250 gallons	26,063
	300 gallons	25,259
	325 gallons	24,924
	350 gallons	25,125
	375 gallons	24,857
	400 gallons	25,125
	425 gallons	24,924

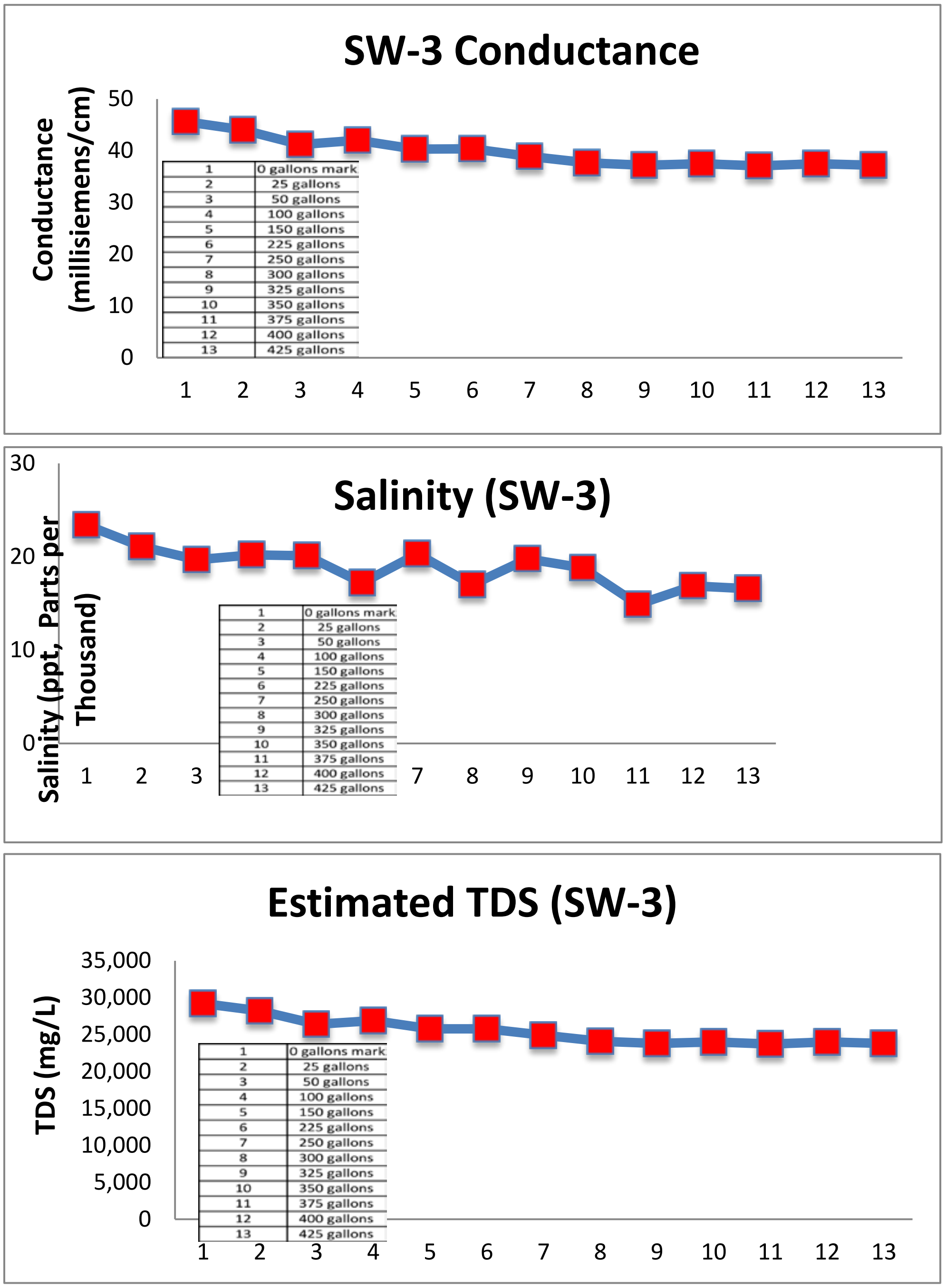


Figure 52. Temporal trends for various salinity parameters in SW-3 following surging operations on March 12, 2015.

March 19th 2015

During the site visit on March 17, 2015, up to 200 gallons was pumped from SW-3. The TDS estimated from specific conductance (TDS = 0.67 conductance) is presented in **Table 4** and also displayed in **Figure 53** along with the specific conductance and salinity data. The TDS appears to fluctuate in the 29,000-30,000 mg/l range.

Table 4. Estimated TDS at SW-3 on March 17, 2015

Estimated TDS (mg/l) based on conductance	
0 gallons mark	18,157
25 gallons	30,820
50 gallons	31,892
100 gallons	30,820
150 gallons	28,877
200 gallons	28,140

Groundwater samples were also collected on March 17, 2015 at the 100 and 200 gallon mark and forwarded to Continental Analytical Services (CAS) in Salina, KS for laboratory based concentration measurements of key parameters. A TDS value of 31,500 mg/l and 28,200 mg/l was estimated at the 100 and 200 gallon mark from key parameters as indicated in **Tables 5 and 6**.

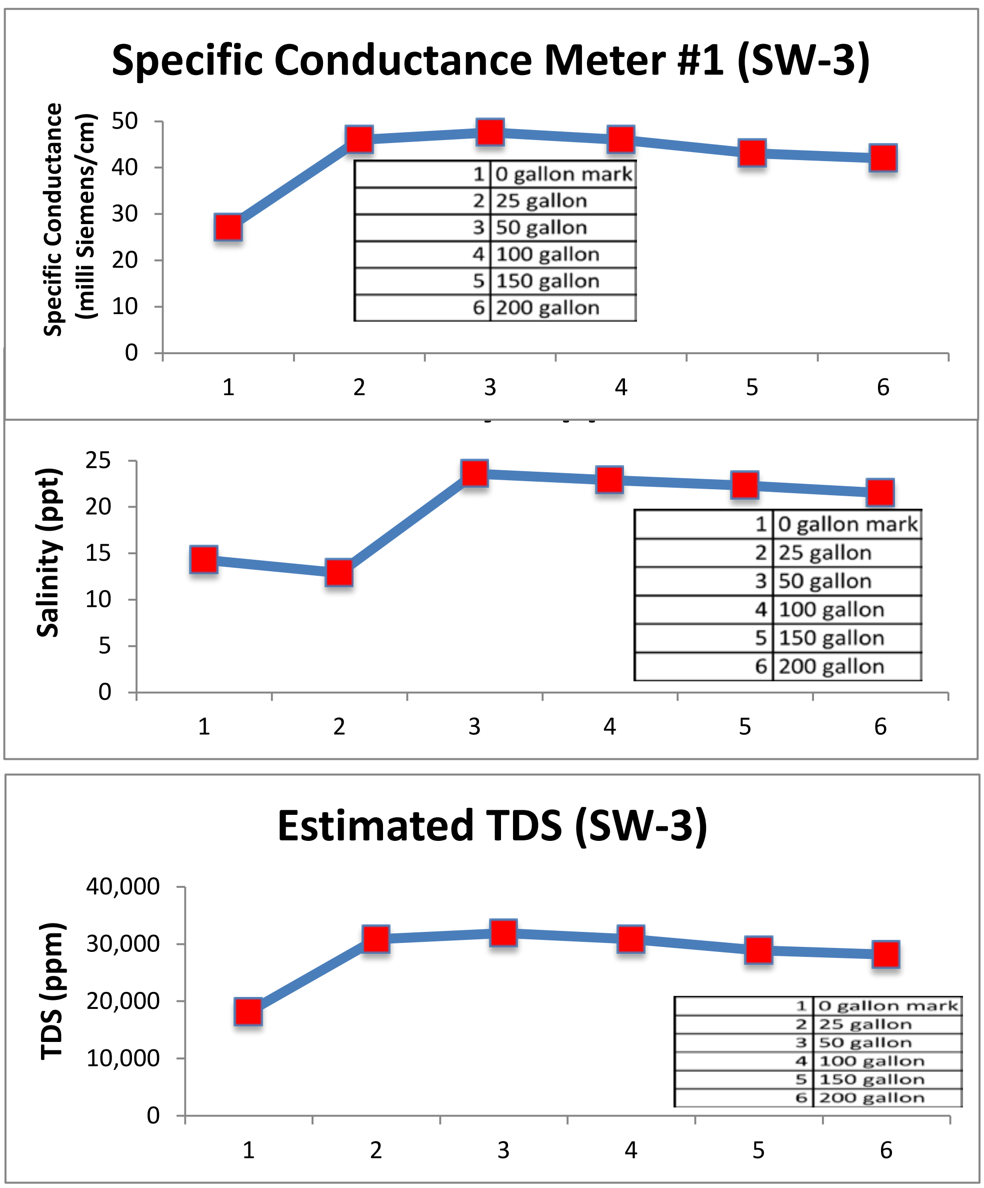


Figure 53. Temporal trends for various salinity parameters in SW-3 during pumping on March 19, 2015.

Table 5. Estimation of TDS (mg/l) using major cations and anions concentration at the 100 gallon mark.

Cation (mg/l)		**Anion (mg/l)**	
Ca	4270	**Cl**	18400
Mg	1510	**SO_4**	1330
K	23.6	**PO_4**	ND(0.050)
Na	4720	**Alkalinity**	88
Dissolved Silica	19.1	**Br**	56
Fe	1.6		
Mn	126 ug/L		
Al	ND(500)M (ug/L)		
	Total Dissolved Solids	**31500 mg/L**	
	ND=non detected		

Table 6. Estimation of TDS (mg/l) using major cations and anions at the 100 gallon mark.

Cation (mg/l)		**Anion (mg/L)**	
Ca	3820	**Cl**	17200
Mg	1380	**SO_4**	1260
K	21.3	**PO_4**	ND(0.050)
Na	3860	**Alkalinity**	101
Dissolved Silica	19.3	**Br**	52
Fe	1.54		
Mn	107 ug/L		
Al	ND(500)M (ug/L)		
	Total Dissolved Solids	**28200 mg/L**	
	ND= non detected		

An (ion) charge balance analysis was conducted in order to ensure that the major constituents in the groundwater samples used to estimate TDS were accounted for in the determination of TDS. The charge balance for the samples at 100 and 200 gallon mark are presented in **Tables 7** and **8.**

Table 7. Charge balance for sample at 100 gallon mark at SW-3 collected on March 17, 2015

Cation				Anion			
	mg/L		meq/L	mg/L			meq/L
Ca^{++}	*4270*	as Ca	213.5	Alk	88	as $CaCO_3$	1.8
Mg^{++}	*1510.0*	as Mg	125.8	Cl^-	*18400*	as Cl	518.3
Na^+	*4720*	as Na	205.2	$SO4^=$	*1330*	as SO_4	27.7
K^+	*23.6*	as K	0.6	$NO3^-$	*0.5*	as NO_3	0.0
NH_4^+	*0.0*	as NH_4	0.0	F^-	*0.7*	as F	0.0
		□cations	**545.16**			□anions	**547.82**

Financial Assurance Talking Points

- Lack of a significant USDW
  - Lack thickness (possibly limited to uppermost 13 ft)
  - Limited long-term yield of any freshwater in the AOR for domestic use due to limitations in storage and drawdown limitations of the shallow zone without encroachment of brine.
- Concerns about technical feasibility of mitigation
  - Salt water intrusion from pumping aquiclude with shallow halite.
  - Integrity of the shale-halite unit in the area indicates sealing nature of this caprock that can be disturbed by pumping
  - No significant salt dissolution in the immediate area due to natural processes or otherwise
    - Previous work indicates lack of strength of the thin (200 ft) shale to support a cavern if the halite is dissolving
    - Infer that no fractures or faults or leaking wells have allowed the bed of halite to dissolve in the immediate vicinity of Wellington Field
    - Thus recommend minimal invasive action such as drilling into the shale bed

Alternatives for financial assurance

1. Large scale mitigation strategies for upper Wellington Shale are unwarranted due to effects that pumping would likely have on the aquiclude.
2. Recommend that it is appropriate in the AOR to modify or replace the migration model used by EPA.
3. Financial assurance requirements to plug and mitigate the Wellington aquiclude needs to reflect the reduced risk of USDW contamination.
   - Bonding for plugging

- Operator insurance for pollution mitigation, in this case, no more risk than a Class II disposal/EOR

Data Table and Java Program for Archiving and Display of Water Chemistry

A Brine Summary Web Page was created by J. Victorine that will allow the user to create Sample Concentration Plots and Piper Diagram for individual water samples. The Java-based software later provide the means to compare analyses spatially (with well location) and through time to detect differences important for monitoring. This would be useful for any water that is being analyzed and will be made accessible to the team to permit rapid comparison with other monitoring methods.

A series of Oracle database tables were created to store the brine information that will be input from a comma delimited format. The Comma Separated Values (CSV) ASCII File are in 3 sections:

(1) The Header Section is the Basic Sample information, Well name, lab, sample dates, etc.
(2) The Data Section with each cations and anions on a separate line, the row order of the anions and cations are not important.
(3) The Other Data Section with data like Resistivity, conductivity, temperature, pressure, etc. The row order of the other data is not important.

An example analyses from Continental Analytical Services was input and reported as follows:

--HEADER SECTION:
Well name, Sampled_Date, Lab Name, Lab_Number, Amount_Fluid, Amount_Fluid_Units, Recieved_Date, Reported_Date, File_Number, Order_Number, Description
KGS SW #3, 03/17/2015 10:00,Continental Analytical Services Inc., 15031047,100, gallons, 03/18/2015, 03/27/2015, 6692,124904, 100 gallon pumped

-- DATA SECTION
Mnemonic, Analysis, Value, Units, Dilation_Factor, LoQ, Book_Page,   QC_Batch, INST_Batch, Prepared_Date, Analyzed_Date, Analyst, Method
Al, Aluminum Dissolved ICP,ND(500) M,ug/L, 5.0,500,7443/218,03/23/15 07:45, 03/24/15 14:35, 150323-3,2IP4083,KMW,6010B
Ca, Calcium Dissolved ICP,4270,mg/L, 10.0,5,7443/221,03/23/15 07:45,03/26/15 18:03, 150323-3,3IP4085,KMW,6010B
Fe, Iron, Dissolved ICP,1.60,mg/L, 1.0,0.10,7443/217,03/23/15 07:45,03/23/15 15:59, 150323-3,3IP4082,KMW,6010B
Mg, Magnesium Dissolved ICP,1510,mg/L,5.0,0.5,7443/218,03/23/15 07:45, 03/24/15 14:35, 150323-3,2IP4083,KMW,6010B
K,Potassium Dissolved ICP,23.6,mg/L,1.0,0.3,7443/217,03/23/15 07:45, 03/23/15 15:59, 150323-3,3IP4082,KMW,6010B
Cl, Chloride,18400,mg/L, 1000,1000,7277/696, N/A,03/23/15 17:13,1IC2082, 2IC2082,MLL,300 0/9056A

PO4,Orthophosphate as P D-React,ND(0.050), mg/L,1.0,0.050,7182/384,N/A,03/18/15 14:04,150318-3, 150318-3,JND,4500-P(E)-1999
SO4,Sulfate,1330,mg/L,100,100,7277/697,N/A,03/24/15 18:32,1IC2083,2IC2083,MLL,300 0/9056A
Br,Bromide,56,mg/L,10,5,7277/697,N/A,03/24/15 16:38,1IC2083,2IC2083,MLL,300 0/9056A

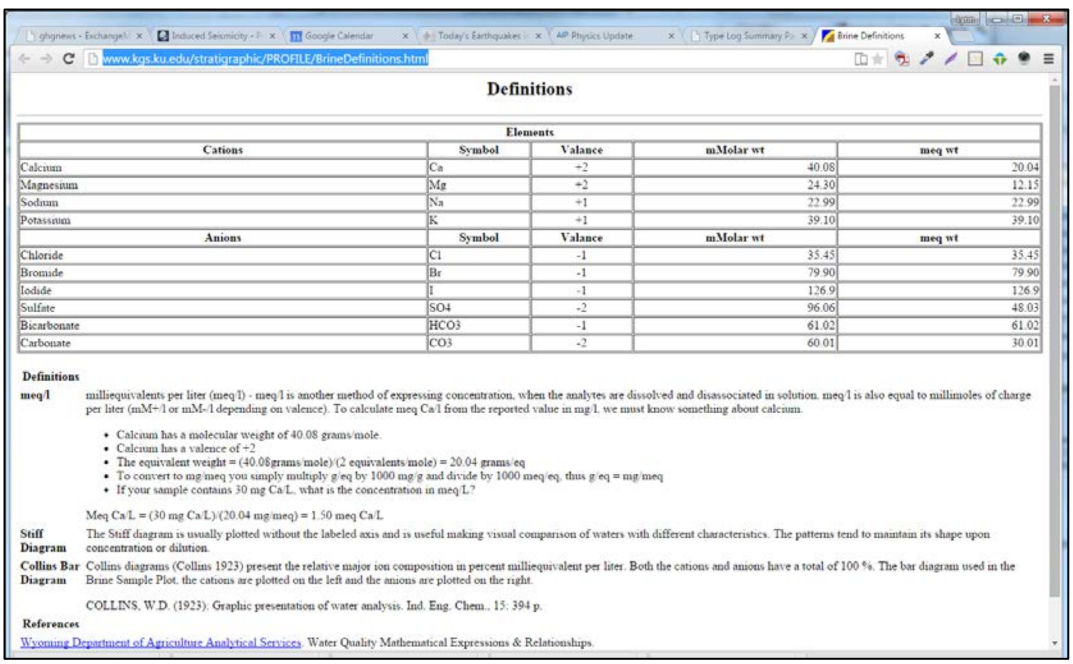
-- OTHER DATA SECTION
Analysis, Value, Units
Specific conductance meter 1, 46, mS/cm
Avg Temp, 16.7, degrees C
Specific conductance meter #2,45.8, mS/cm
pH, 7.23,
Est TDS based on conductance,30820, mg/L

. . .

The units for the anions and cations are mg/L or ug/L, 'u' is not the Greek mu. In other words no Greek symbols are use since they can not be parsed without knowing the actual character, which for Greek mu is not always the same between editors.

The ASCII lab results can be parsed into this format and a series of scripts will be created to push into the database. XML files will be built to plot the data.

Examples from the new Brine Summary Web Page are shown in **Figures 53 through 50**. Plots provide a means to rapidly review and compare water data “on the fly” from an active database. Tools are available to plot and export the data as well for reporting.



Definitions

Elements				
Cations	**Symbol**	**Valance**	**mMolar wt**	**meq wt**
Calcium	Ca	+2	40.08	20.04
Magnesium	Mg	+2	24.30	12.15
Sodium	Na	+1	22.99	22.99
Potassium	K	+1	39.10	39.10
Anions	**Symbol**	**Valance**	**mMolar wt**	**meq wt**
Chloride	Cl	-1	35.45	35.45
Bromide	Br	-1	79.90	79.90
Iodide	I	-1	126.9	126.9
Sulfate	SO4	-2	96.06	48.03
Bicarbonate	HCO3	-1	61.02	61.02
Carbonate	CO3	-2	60.01	30.01

Definitions

meq/l milliequivalents per liter (meq/l) - meq/l is another method of expressing concentration, when the analytes are dissolved and disassociated in solution. meq/l is also equal to millimoles of charge per liter (mM+/l or mM-/l depending on valence). To calculate meq Ca/l from the reported value in mg/l, we must know something about calcium.

- Calcium has a molecular weight of 40.08 grams/mole.
- Calcium has a valence of +2
- The equivalent weight = (40.08grams/mole)/(2 equivalents/mole) = 20.04 grams/eq
- To convert to mg/meq you simply multiply g/eq by 1000 mg/g and divide by 1000 meq/eq, thus g/eq = mg/meq
- If your sample contains 30 mg Ca/L, what is the concentration in meq/L?

Meq Ca/L = (30 mg Ca/L)/(20.04 mg/meq) = 1.50 meq Ca/L

Stiff Diagram The Stiff diagram is usually plotted without the labeled axis and is useful making visual comparison of waters with different characteristics. The patterns tend to maintain its shape upon concentration or dilution.

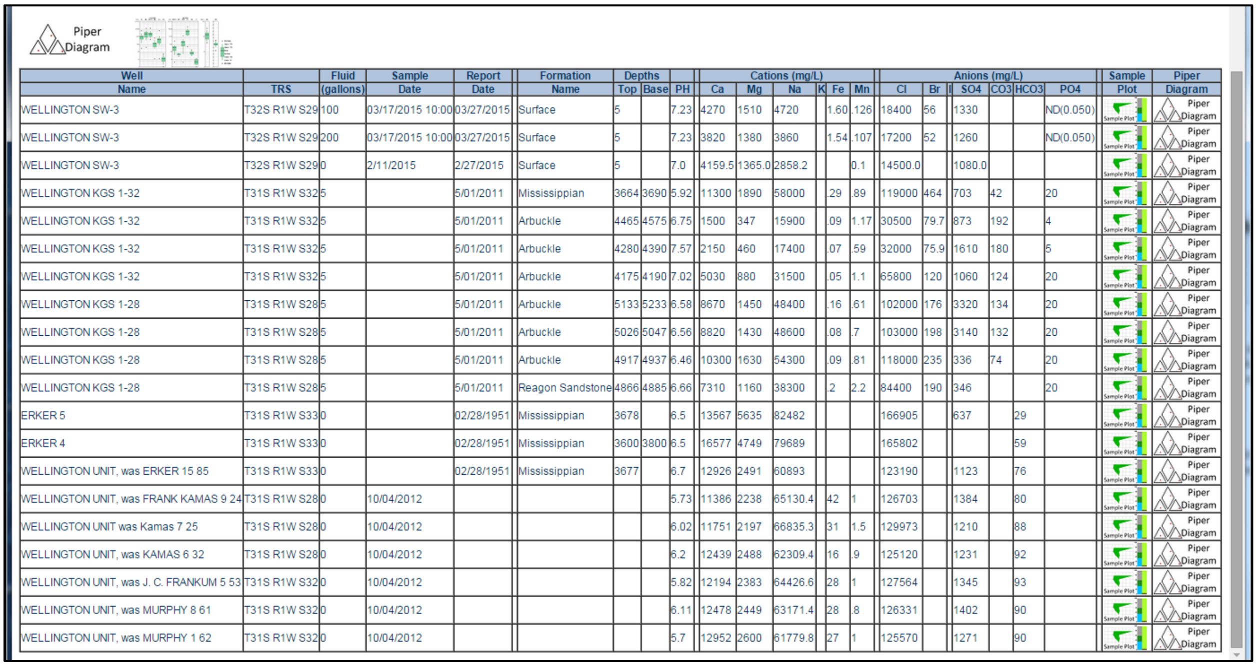
Collins Bar Diagram Collins diagrams (Collins 1923) present the relative major ion composition in percent milliequivalent per liter. Both the cations and anions have a total of 100 %. The bar diagram used in the Brine Sample Plot, the cations are plotted on the left and the anions are plotted on the right.

COLLINS, W.D. (1923): Graphic presentation of water analysis. Ind. Eng. Chem., 15: 394 p.

References

Wyoming Department of Agriculture Analytical Services. Water Quality Mathematical Expressions & Relationships.

Figure 53. Definitions page from the Brine Summary Web Page.



Well Name	TRS	Fluid (gallons)	Sample Date	Report Date	Formation Name	Depths Top	Depths Base	PH	Ca	Mg	Na	K	Fe	Mn	Cl	Br	I	SO4	CO3	HCO3	PO4	Sample Plot	Piper Diagram
WELLINGTON SW-3	T32S R1W S29	100	03/17/2015 10:00	03/27/2015	Surface	5		7.23	4270	1510	4720		1.60	.126	18400	56		1330			ND(0.050)	Sample Plot	Piper Diagram
WELLINGTON SW-3	T32S R1W S29	200	03/17/2015 10:00	03/27/2015	Surface	5		7.23	3820	1380	3860		1.54	.107	17200	52		1260			ND(0.050)	Sample Plot	Piper Diagram
WELLINGTON SW-3	T32S R1W S29	0	2/11/2015	2/27/2015	Surface	5		7.0	4159.5	1365.0	2858.2			0.1	14500.0			1080.0				Sample Plot	Piper Diagram
WELLINGTON KGS 1-32	T31S R1W S32	5		5/01/2011	Mississippian	3664	3690	5.92	11300	1890	58000		.29	.89	119000	464		703	42		20	Sample Plot	Piper Diagram
WELLINGTON KGS 1-32	T31S R1W S32	5		5/01/2011	Arbuckle	4465	4575	6.75	1500	347	15900		.09	1.17	30500	79.7		873	192		4	Sample Plot	Piper Diagram
WELLINGTON KGS 1-32	T31S R1W S32	5		5/01/2011	Arbuckle	4280	4390	7.57	2150	460	17400		.07	.59	32000	75.9		1610	180		5	Sample Plot	Piper Diagram
WELLINGTON KGS 1-32	T31S R1W S32	5		5/01/2011	Arbuckle	4175	4190	7.02	5030	880	31500		.05	1.1	65800	120		1060	124		20	Sample Plot	Piper Diagram
WELLINGTON KGS 1-28	T31S R1W S28	5		5/01/2011	Arbuckle	5133	5233	6.58	8670	1450	48400		.16	.61	102000	176		3320	134		20	Sample Plot	Piper Diagram
WELLINGTON KGS 1-28	T31S R1W S28	5		5/01/2011	Arbuckle	5026	5047	6.56	8820	1430	48600		.08	.7	103000	198		3140	132		20	Sample Plot	Piper Diagram
WELLINGTON KGS 1-28	T31S R1W S28	5		5/01/2011	Arbuckle	4917	4937	6.46	10300	1630	54300		.09	.81	118000	235		336	74		20	Sample Plot	Piper Diagram
WELLINGTON KGS 1-28	T31S R1W S28	5		5/01/2011	Reagon Sandstone	4866	4885	6.66	7310	1160	38300		.2	2.2	84400	190		346			20	Sample Plot	Piper Diagram
ERKER 5	T31S R1W S33	0		02/28/1951	Mississippian	3678		6.5	13567	5635	82482				166905			637		29		Sample Plot	Piper Diagram
ERKER 4	T31S R1W S33	0		02/28/1951	Mississippian	3600	3800	6.5	16577	4749	79689				165802					59		Sample Plot	Piper Diagram
WELLINGTON UNIT, was ERKER 15 85	T31S R1W S33	0		02/28/1951	Mississippian	3677		6.7	12926	2491	60893				123190			1123		76		Sample Plot	Piper Diagram
WELLINGTON UNIT, was FRANK KAMAS 9 24	T31S R1W S28	0	10/04/2012					5.73	11386	2238	65130.4		42	1	126703			1384		80		Sample Plot	Piper Diagram
WELLINGTON UNIT was Kamas 7 25	T31S R1W S28	0	10/04/2012					6.02	11751	2197	66835.3		31	1.5	129973			1210		88		Sample Plot	Piper Diagram
WELLINGTON UNIT, was KAMAS 6 32	T31S R1W S28	0	10/04/2012					6.2	12439	2488	62309.4		16	.9	125120			1231		92		Sample Plot	Piper Diagram
WELLINGTON UNIT, was J. C. FRANKUM 5 53	T31S R1W S32	0	10/04/2012					5.82	12194	2383	64426.6		28	1	127564			1345		93		Sample Plot	Piper Diagram
WELLINGTON UNIT, was MURPHY 8 61	T31S R1W S32	0	10/04/2012					6.11	12478	2449	63171.4		28	.8	126331			1402		90		Sample Plot	Piper Diagram
WELLINGTON UNIT, was MURPHY 1 62	T31S R1W S32	0	10/04/2012					5.7	12952	2600	61779.8		27	1	125570			1271		90		Sample Plot	Piper Diagram

Figure 54. List of water well samples obtained to date for Wellington Field as displayed from the Brine Summary Web Page.

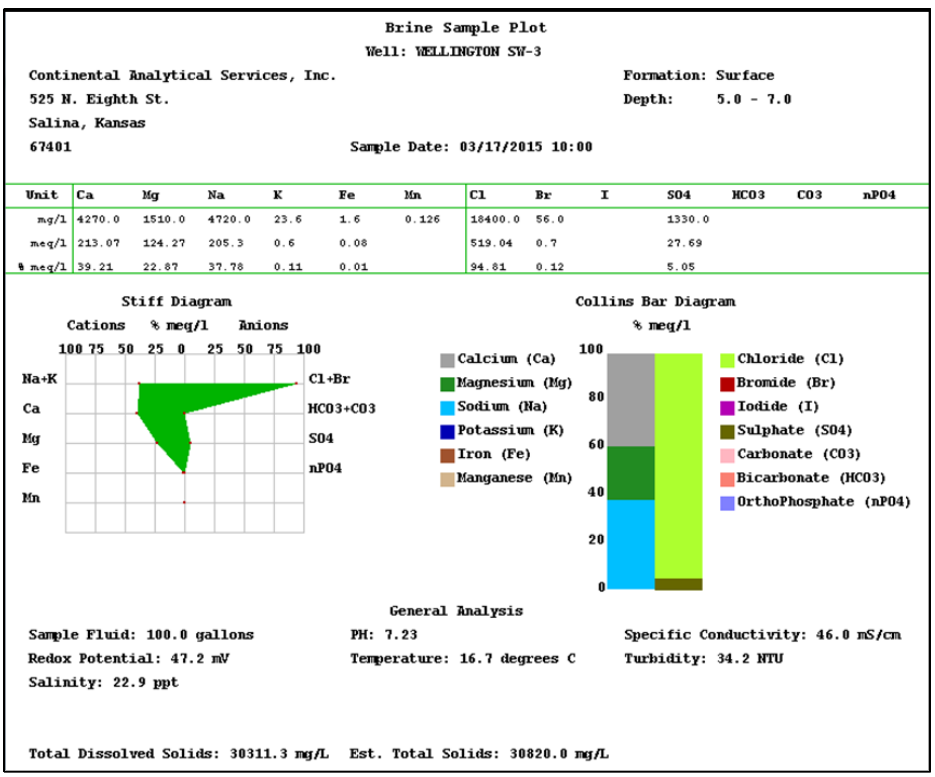


Figure 55. Default brine sample plot generated for SW-3 using Java software accessed from the Brine Summary Web Page (right two columns of table shown in Figure 54). Compare patterns to Mississippian water shown in Figure 57.

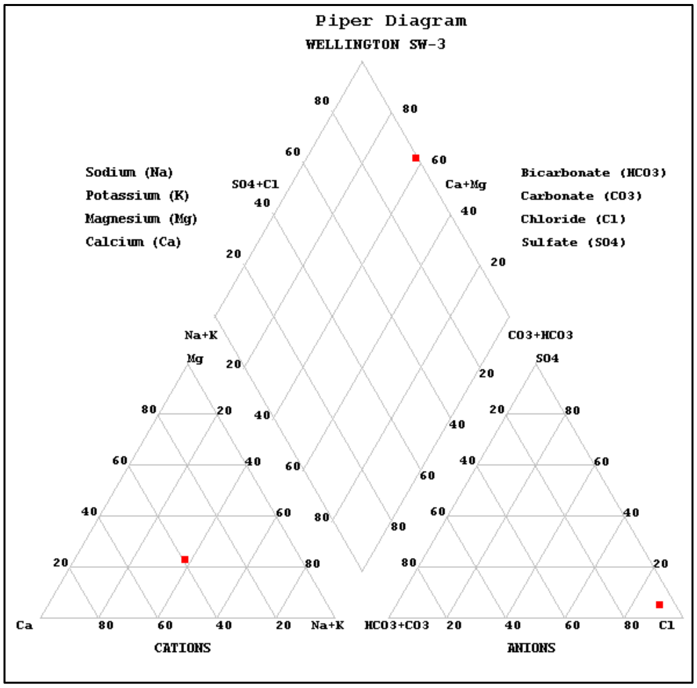
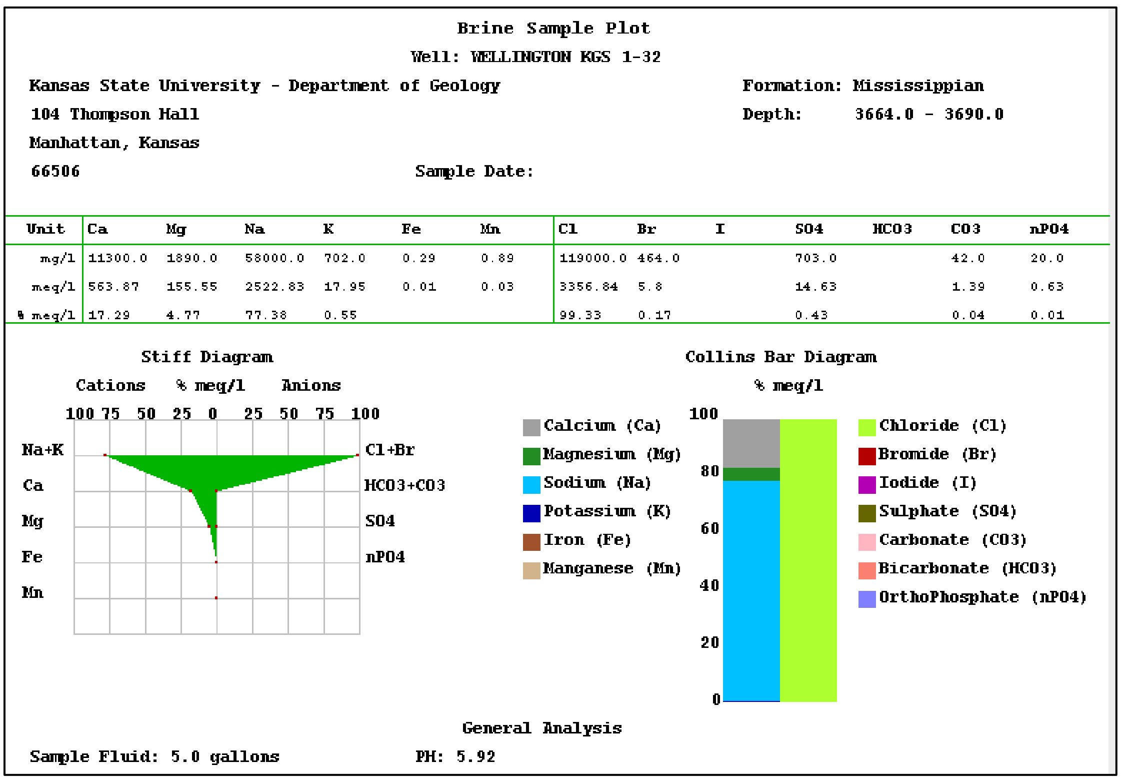


Figure 56. Piper diagram for SW-3 brine sample.



Unit	Ca	Mg	Na	K	Fe	Mn	Cl	Br	I	SO4	HCO3	CO3	nPO4
mg/l	11300.0	1890.0	58000.0	702.0	0.29	0.89	119000.0	464.0		703.0		42.0	20.0
meq/l	563.87	155.55	2522.83	17.95	0.01	0.03	3356.84	5.8		14.63		1.39	0.63
% meq/l	17.29	4.77	77.38	0.55			99.33	0.17		0.43		0.04	0.01

Figure 57. Default brine sample plot generated for Wellington #1-32 Mississippian brine sample using Java software accessed from the Brine Summary Web Page (right two columns of table shown in Figure 54). Compare patterns to surface water shown in Figure 55.

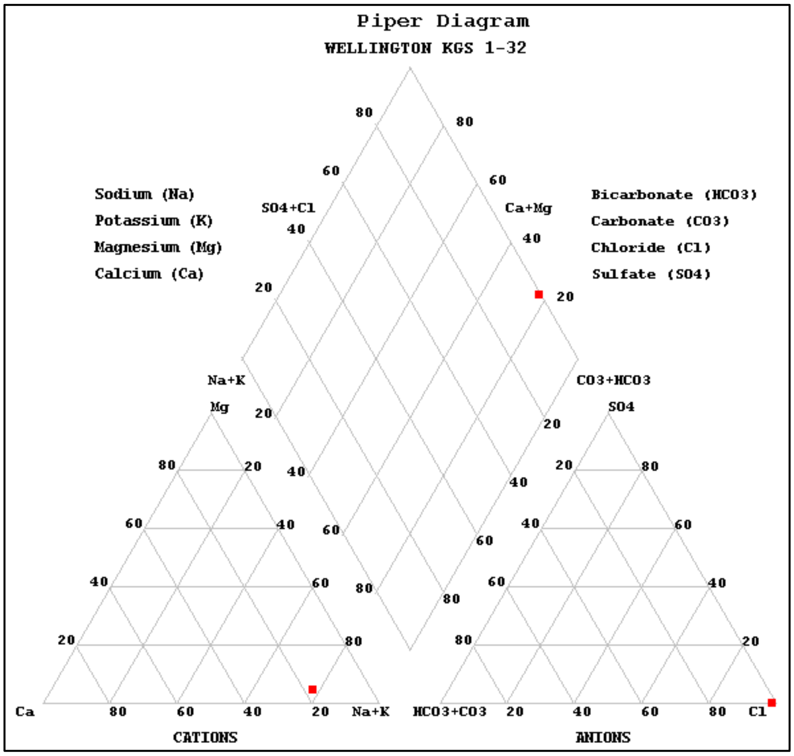


Figure 58. Piper diagram for Wellington Mississippian brine sample.

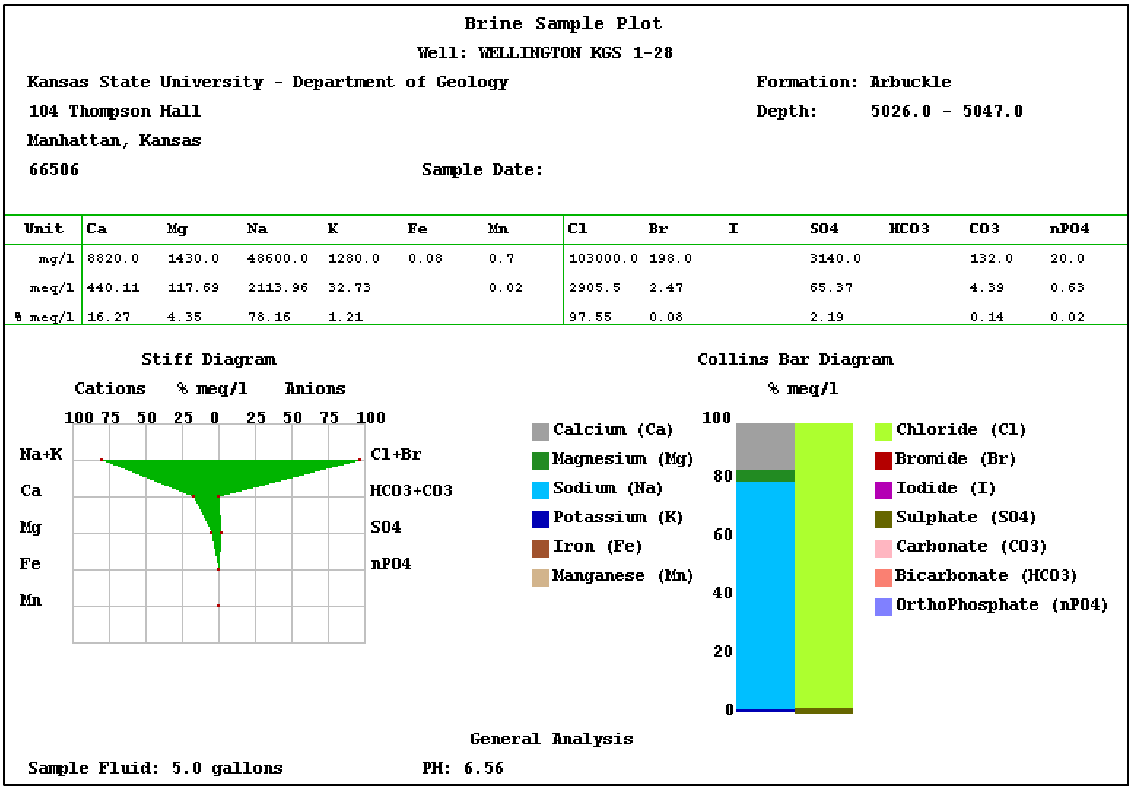


Figure 59. Default brine sample plot generated for Wellington #1-32 Arbuckle brine sample using Java software accessed from the Brine Summary Web Page (right two columns of table shown in Figure 54). Compare patterns to Mississippian water shown in Figure 57.

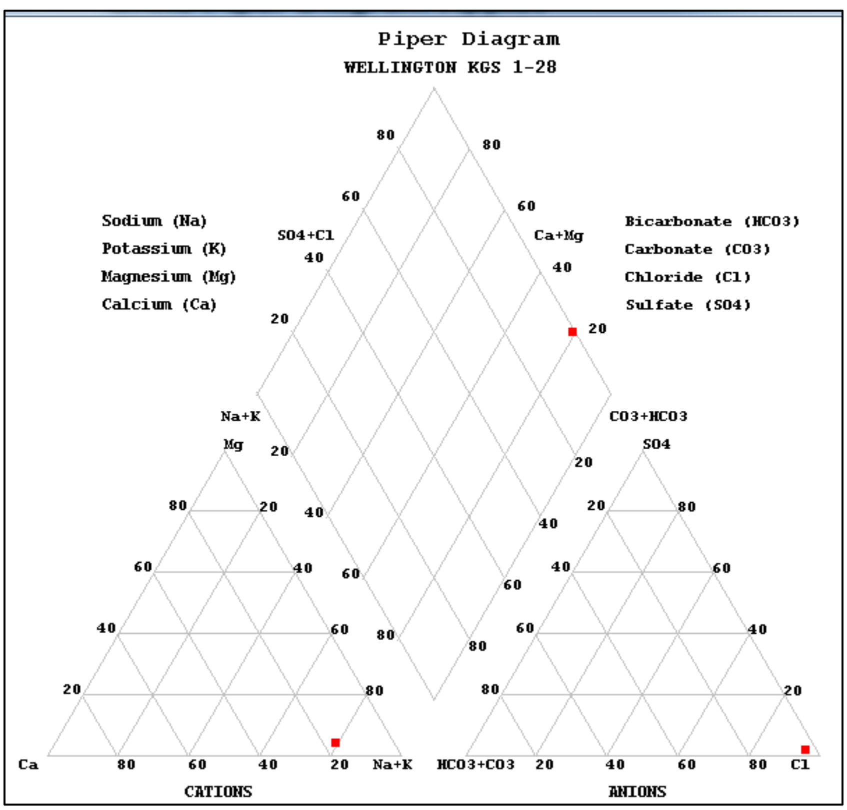


Figure 60. Piper diagram for Wellington Arbuckle brine sample.

Figure 61. Illustration of in the field sampling water from SW-3, Chance Reese, KSU.

Photos in **Figure 61** illustrate some of the equipment used by Chance Reese to sample SW-3. Initial readings of water quality indicate high salinity values. The third photo was taken after 10-11 bail volumes were disposed. The water clarity was fairly consistent throughout the bailing process, and became slightly murkier over time.

Future Communications with EPA - Seismicity in South-Central Kansas, Defining Safe Injection, Implications for Wellington Field Test

Recent earthquakes in south-central Kansas dramatically increased since 2013 from less than 2 to over 30 in one month during a time volumes of brine disposal increased nearly 10-fold in Harper County the focus of the seismic activity. Increased volumes resulted from a few wells with large rates of injection at elevated surface pressures. Kansas' induced seismicity committee comprised of state regulating agencies for Class I and II injection wells and the KGS reviewed the seismicity and on March 19, the Kansas Corporation Commission signed an order reducing saltwater injection rates in proximity to four seismically active zones in Harper and eastern Sumner County (**Figure 62**). The seismic zone in closest proximity to Wellington is located 15 miles to the west.

Since the injection rates were reduced in wells in proximity to the seismicity, the frequency and size of the earthquakes have diminished (**Figures 63-65**). The geologic maps generated from http://maps.kgs.ku.edu/co2/ indicate the focus of the western zone of continuing seismic activity corresponds to a subtle Mississippian structure ridge and a sharp linear change in the total magnetic field intensity that is confirmed from nearby wells to be the boundary between granite (magnetic high) and a deep rift valley sedimentary succession (magnetic low). The Proterozoic rift valley trends northeast extending through the central portion of Kansas. Wellington Field lies outside of the rift valley and its bounding faults and west of the Nemaha Uplift. While seismicity has occurred nearby, Wellington has not experienced the felt earthquakes that are over 2.5 magnitude.

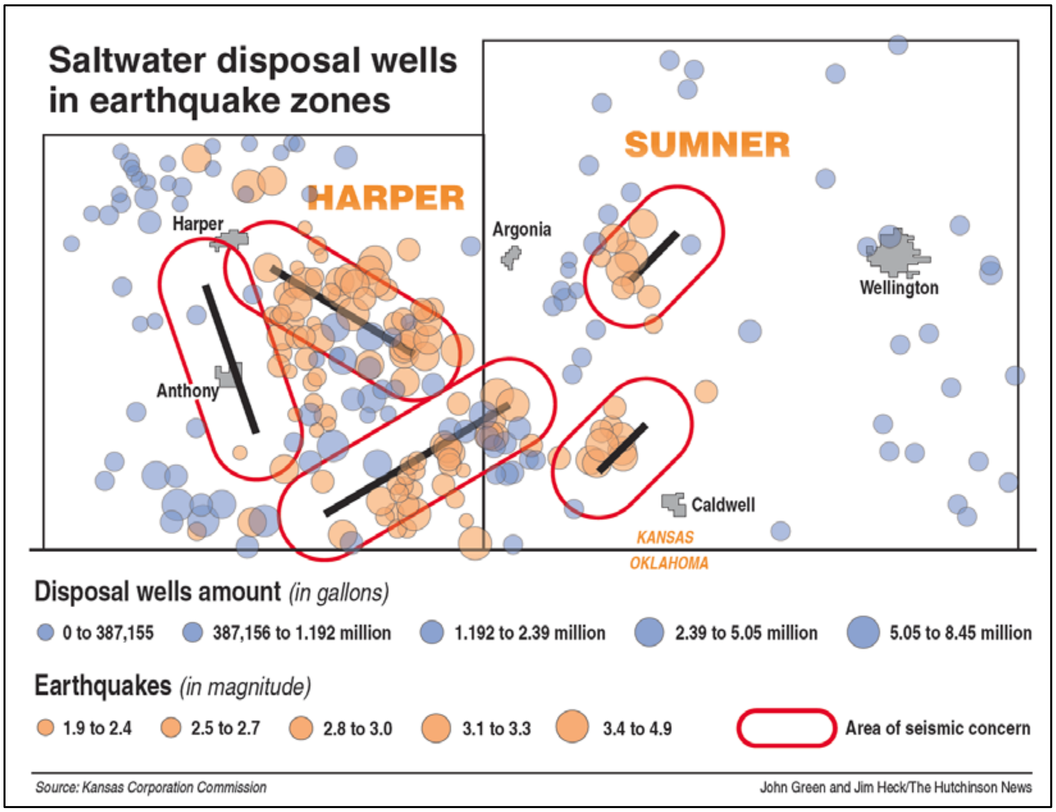


Figure 62. Map of disposal wells, earthquakes, and lineaments there brine injection was reduced in Harper and Sumner counties in south-central Kansas. Illustration is from the Hutchinson News. Wellington Field is located immediately NW of Wellington Field.

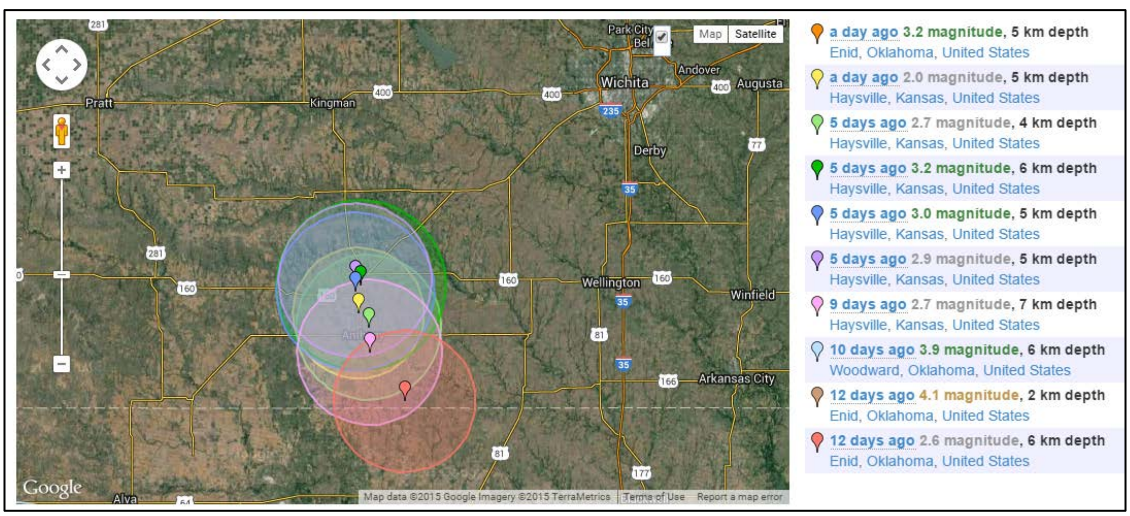


Figure 63. Recent earthquakes 5-11-15. http://earthquaketrack.com/us-ks-wichita/recent are limited to the western most NW-SE trending seismic lineament extending near Harper and Anthony Kansas in western Harper County.

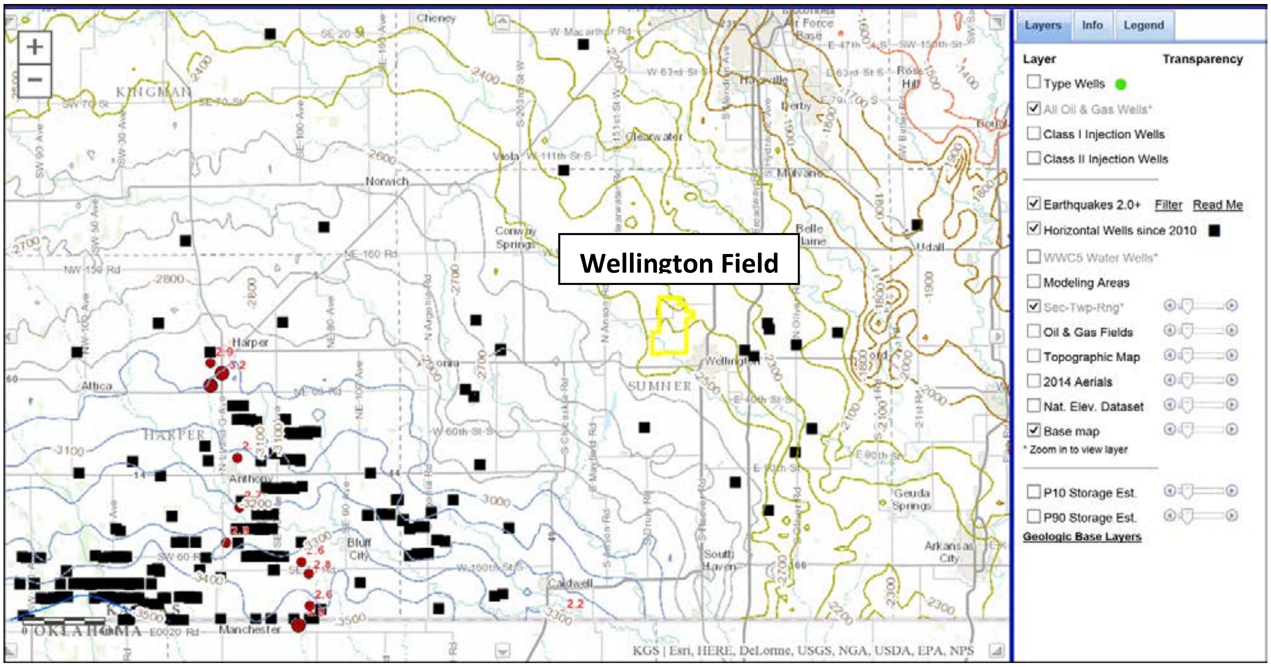


Figure 64. Mississippian structure, earthquakes in past month (4-10 to 5-10-15), Mississippian horizontal wells (black squares), yellow outline of Wellington Field.

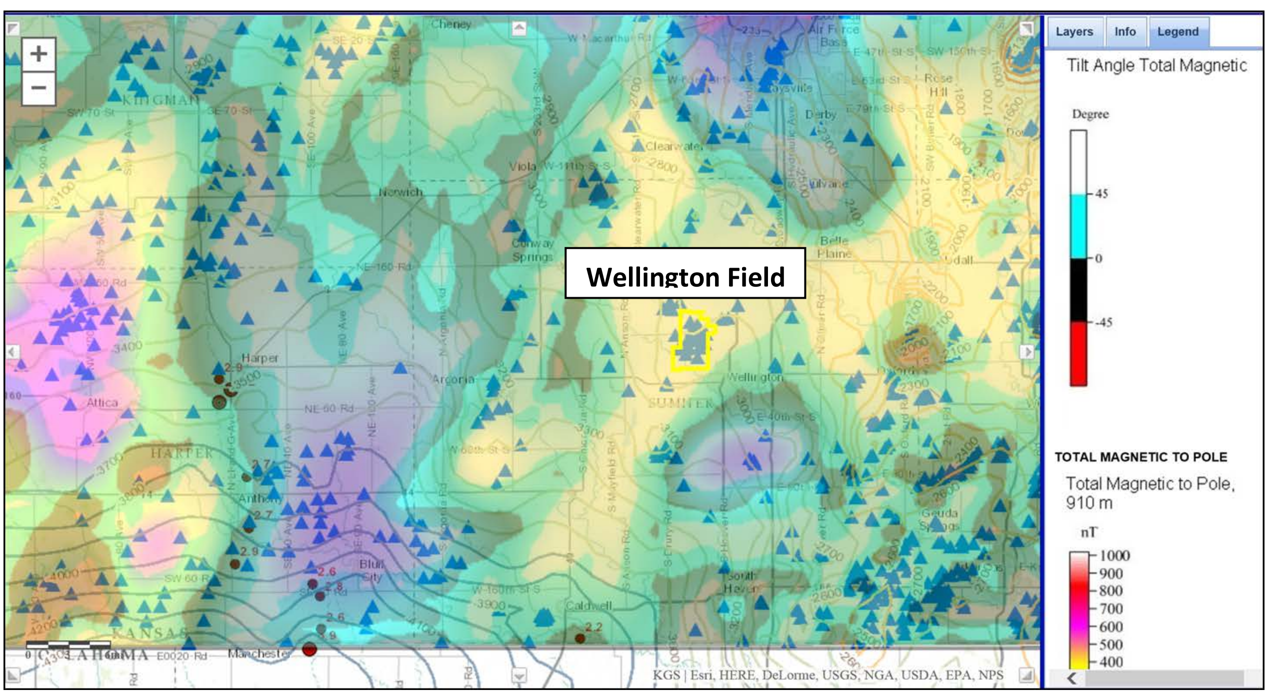


Figure 65. Arbuckle structure, Total magnetic and tilt angle of total magnetic, earthquakes in past month (4-10 to 5-10-15), Class II wells, yellow outline of Wellington Field

Project Schedule

BP2 activities continue on schedule:

1. Class VI Application:

- EPA received our responses to Tables 1, 3, and the QASP document and third round of discussions are
- We are updating our report of the evaluation of the surface waters as new information becomes available.
- Rick Miller/KGS will acquire baseline high-resolution seismic data
- Work continues on establishing baseline for Mississippian water use with both the Mississippian and Arbuckle injections.
    - Incorporating data obtained by Berexco related to previous well maintenance
    - Incorporating analyses of Mississippian brine from 2056 activities
    - New sampling starting soon to provide a longer term (6+ mo.) baseline for the Arbuckle injection.
- Preparation of a report updating the EPA in on the potential for seismicity at Wellington -- Updates of fault mapping and geomechanical analysis in relationship to creating felt seismicity during the Arbuckle injection.

2. Mississippian CO2 injection --

- Mississippian injection well, KGS #2-32, was successfully completed last week. Mississippian was perforated 3663-3706 ft. acidized and a brine injectivity test was conducted indicating #150 psi surface pressure and 4 barrels per minute (5760 bbls per day). This is roughly 10x that rate that CO2 would be injected so well has more than adequate injectivity.
- Mississippian at KGS #2-32 is at residual oil saturation, estimated by Mina to be between 23 and 30% based on NMR log.
- A 5-well interference test will be done to test communication between KGS #2-32 and surrounding wells and evaluate the effects of a small fault east of #2-32, provide important geomechanical parameters via leakoff test in steps E-G of the pulse test schedule. Pulse test is designed and will be analyzed by Mina Fazelalavi, Pressure sampling rate is 1 second and duration of the recording will extend until the next day.

- Pending review of the existing reservoir model with new results of the interference test and initial review of the seismic data, the methodology of the repressurization of reservoir will be done
- Discussions with Linde and Praxair CO2 supply continue
- Considerations being given regarding running a single well tracer to evaluate residual oil near the injector prior to CO2 injection
- A date for CO2 injection into the Mississippian has not been set, but nominally we are looking at up to 60 days due to well completion, receipt of core analysis, completing baseline data, and installation of surface equipment for injection.

Activities of Lawrence Berkeley National Lab

Discussions regarding costs of equipment and fabrication times in terms of project timing and budget.

ONGOING ACTIVITIES

Task 1. Project Management and Reporting

Completed activities include –

Subtask 1.7. Public Outreach Plan

Completed drafts of Public Information Circular, Fact Sheet, and KGS Press Release for upcoming work at Wellington. Press release (reviewed by key parties, project fact sheet, website-visibility, and meet with public at Wellington to discuss the project and answer questions.)

Subtask 1.8. Arbuckle Injection Permit Application Review go/no go Memo

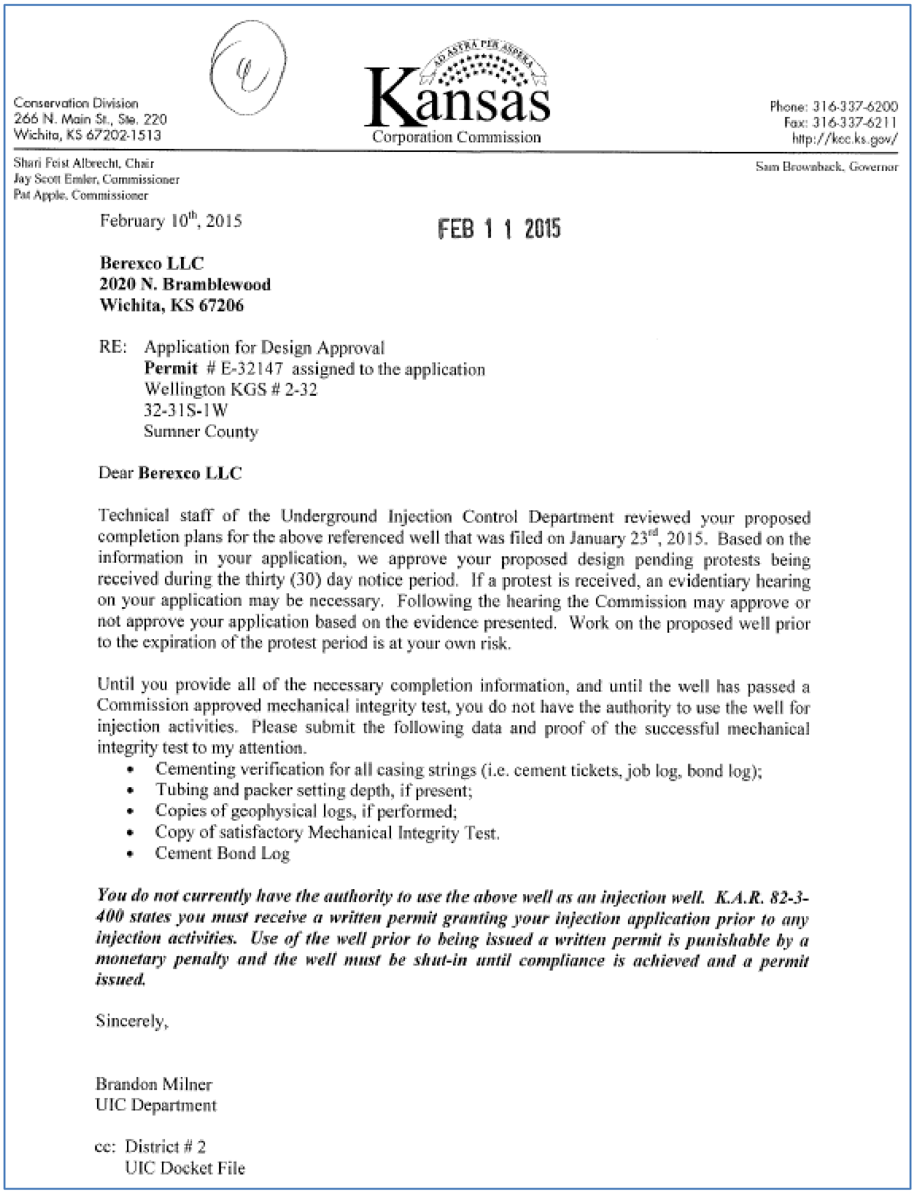
General Permit Application:

Seismicity

Task 3. Site characterization of Mississippian Reservoir - Wellington Field (Class II Application & GO/NO-GO DECISION #4)

Drilling and Completion of Berexco Wellington KGS #2-32

Class II permit to inject CO_2 in the Mississippian for the CO_2-EOR pilot and a permit to drill was received from the Kansas Corporation Commission (**Figures 65-67**).



Conservation Division
266 N. Main St., Ste. 220
Wichita, KS 67202-1513

Kansas
Corporation Commission

Phone: 316-337-6200
Fax: 316-337-6211
http://kcc.ks.gov/

Shari Feist Albrecht, Chair
Jay Scott Emler, Commissioner
Pat Apple, Commissioner

Sam Brownback, Governor

February 10th, 2015

FEB 1 1 2015

Berexco LLC
2020 N. Bramblewood
Wichita, KS 67206

RE: Application for Design Approval
Permit # E-32147 assigned to the application
Wellington KGS # 2-32
32-31S-1W
Sumner County

Dear **Berexco LLC**

Technical staff of the Underground Injection Control Department reviewed your proposed completion plans for the above referenced well that was filed on January 23rd, 2015. Based on the information in your application, we approve your proposed design pending protests being received during the thirty (30) day notice period. If a protest is received, an evidentiary hearing on your application may be necessary. Following the hearing the Commission may approve or not approve your application based on the evidence presented. Work on the proposed well prior to the expiration of the protest period is at your own risk.

Until you provide all of the necessary completion information, and until the well has passed a Commission approved mechanical integrity test, you do not have the authority to use the well for injection activities. Please submit the following data and proof of the successful mechanical integrity test to my attention.

- Cementing verification for all casing strings (i.e. cement tickets, job log, bond log);
- Tubing and packer setting depth, if present;
- Copies of geophysical logs, if performed;
- Copy of satisfactory Mechanical Integrity Test.
- Cement Bond Log

You do not currently have the authority to use the above well as an injection well. K.A.R. 82-3-400 states you must receive a written permit granting your injection application prior to any injection activities. Use of the well prior to being issued a written permit is punishable by a monetary penalty and the well must be shut-in until compliance is achieved and a permit issued.

Sincerely,

Brandon Milner
UIC Department

cc: District # 2
UIC Docket File

Figure 65. Letter from KCC approving design for Berexco Wellingtion KGS #2-32.

1245593

For KCC Use:
Effective Date: 03/23/2015
District # 2
SGA? ☒ Yes ☐ No

KANSAS CORPORATION COMMISSION
OIL & GAS CONSERVATION DIVISION

Form C-1
March 2010
Form must be Typed
Form must be Signed
All blanks must be Filled

NOTICE OF INTENT TO DRILL

Must be approved by KCC five (5) days prior to commencing well

Form KSONA-1, Certification of Compliance with the Kansas Surface Owner Notification Act, MUST be submitted with this form.

Expected Spud Date: 03/19/2015 (*month day year*)

OPERATOR: License# 34318
Name: BEREXCO LLC
Address 1: 2020 N. Bramblewood
Address 2:
City: Wichita State: KS Zip: 67206 + 1094
Contact Person: Dana Wreath
Phone: 316-265-3311

CONTRACTOR: License# 34484
Name: Fossil Drilling, Inc.

Well Drilled For: ☐ Oil ☐ Gas ☒ Enh Rec ☐ Storage ☐ Disposal ☐ Seismic ; ____ # of Holes ☐ Other:

Well Class: ☒ Infield ☐ Pool Ext. ☐ Wildcat ☐ Other

Type Equipment: ☒ Mud Rotary ☐ Air Rotary ☐ Cable

☐ If OWWO: old well information as follows:
Operator:
Well Name:
Original Completion Date: Original Total Depth:

Directional, Deviated or Horizontal wellbore? ☐ Yes ☒ No
If Yes, true vertical depth:
Bottom Hole Location:
KCC DKT #:

Top of salt at 225 feet. OK to run surface casing through salt section once conductor is set.

Spot Description:
NE - NW - NE - SE (Q/Q/Q/Q) Sec. 32 Twp. 31 S. R. 1 ☐ E ☒ W
2680 feet from ☐ N / ☒ S Line of Section
709 feet from ☒ E / ☐ W Line of Section
Is SECTION: ☐ Regular ☒ Irregular?

(Note: Locate well on the Section Plat on reverse side)

County: Sumner
Lease Name: Wellington KGS Well #: 2-32
Field Name: Wellington
Is this a Prorated / Spaced Field? ☐ Yes ☒ No
Target Formation(s): Mississippi
Nearest Lease or unit boundary line (in footage): 1931
Ground Surface Elevation: 1257 Surveyed feet MSL
Water well within one-quarter mile: ☐ Yes ☒ No
Public water supply well within one mile: ☐ Yes ☒ No
Depth to bottom of fresh water: 60
Depth to bottom of usable water: 230
Surface Pipe by Alternate: ☒ I ☐ II
Length of Surface Pipe Planned to be set: 600
Length of Conductor Pipe (if any): 120
Projected Total Depth: 3815
Formation at Total Depth: Mississippi
Water Source for Drilling Operations:
☐ Well ☐ Farm Pond ☒ Other: unknown - haul
DWR Permit #:
(Note: Apply for Permit with DWR ☐)
Will Cores be taken? ☒ Yes ☐ No
If Yes, proposed zone: Mississippi

AFFIDAVIT

The undersigned hereby affirms that the drilling, completion and eventual plugging of this well will comply with K.S.A. 55 et. seq.

It is agreed that the following minimum requirements will be met:

1. Notify the appropriate district office *prior* to spudding of well;
2. A copy of the approved notice of intent to drill *shall be* posted on each drilling rig;
3. The minimum amount of surface pipe as specified below *shall be set* by circulating cement to the top; in all cases surface pipe *shall be set* through all unconsolidated materials plus a minimum of 20 feet into the underlying formation.
4. If the well is dry hole, an agreement between the operator and the district office on plug length and placement is necessary *prior to plugging;*
5. The appropriate district office will be notified before well is either plugged or production casing is cemented in;
6. If an ALTERNATE II COMPLETION, production pipe shall be cemented from below any usable water to surface within *120 DAYS* of spud date. Or pursuant to Appendix "B" - Eastern Kansas surface casing order #133,891-C, which applies to the KCC District 3 area, alternate II cementing must be completed within 30 days of the spud date or the well shall be plugged. *In all cases, NOTIFY district office* prior to any cementing.

Submitted Electronically

For KCC Use ONLY
API # 15 - 15-191-22770-00-00
Conductor pipe required 80 feet
Minimum surface pipe required 220 feet per ALT. ☒ I ☐ II
Approved by: Rick Hestermann 03/18/2015
This authorization expires: 03/18/2016
(This authorization void if drilling not started within 12 months of approval date.)
Spud date: Agent:

Mail to: KCC - Conservation Division,
130 S. Market - Room 2078, Wichita, Kansas 67202

Remember to:
- File Certification of Compliance with the Kansas Surface Owner Notification Act (KSONA-1) with Intent to Drill;
- File Drill Pit Application (form CDP-1) with Intent to Drill;
- File Completion Form ACO-1 within 120 days of spud date;
- File acreage attribution plat according to field proration orders;
- Notify appropriate district office 48 hours prior to workover or re-entry;
- Submit plugging report (CP-4) after plugging is completed (within 60 days);
- Obtain written approval before disposing or injecting salt water.
- If well will not be drilled or permit has expired (See: authorized expiration date) please check the box below and return to the address below.

☐ **Well will not be drilled or Permit Expired** Date:
Signature of Operator or Agent:

32 31 1 ☐ E ☒ W

Figure 65. Approved intent to drill for the Berexco KGS #2-32.

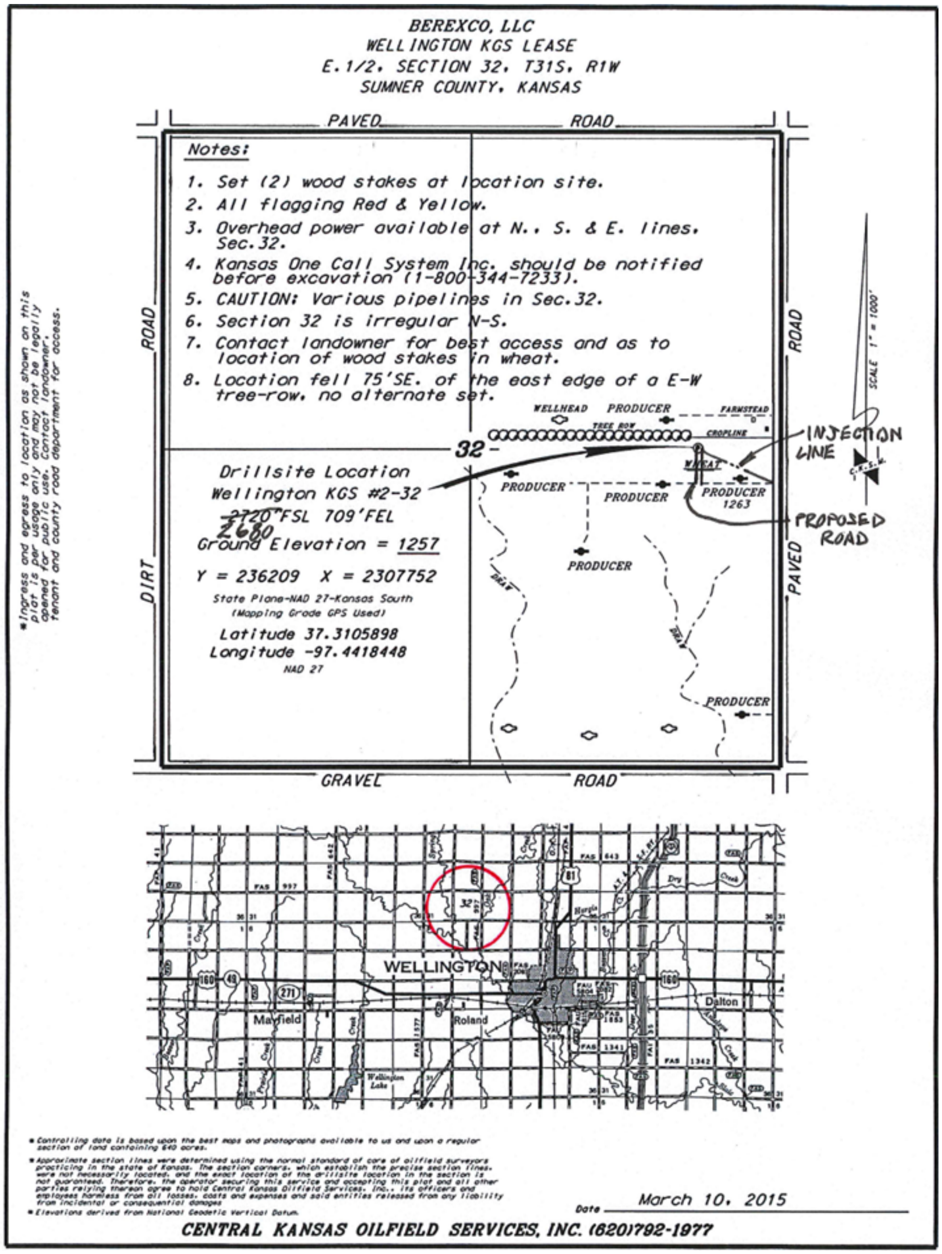


Figure 67. Plat map accompanying the Intent to Drill.

The Berexco Wellington KGS #2-32 spudded 3/20/15, logged on 3/29-15, and cased for completion on 3/30/15. Key contractors involved in the drilling and testing of the well are noted in **Figure 68**. Centralizers were run every other collar up to 3000 ft when the casing was cemented. CO_2 resistant cement was circulated to surface. A structure map on the top of the Mississippian shows relatively level surface with relief in the area of ~30 ft across a distance of 1000 ft. The slope a slope of <2 degrees (**Figure 69**). A trace of a pre-Pennsylvanian fault is shown by black dashed line that lies to the east of KGS #2-32.

Figure 68. Berexco Wellington KGS #2-32 was drilled and completed in March 2015.

The well was initially drilled to 140 ft and conductor pipe was set in the Wellington Shale. Cutting samples were collected every 10 ft from below the conductor pipe to total depth. Surface casing was set at 650 ft in the top of the Chase Group carbonates after Halliburton logged the interval from 650 ft to the base of the conductor pipe (**Figures 70 and 71**). Wireline logs include a modern log suite including GR, SP, caliper, Φneutron, Φdensity, p-wave sonic, microlog, and array resistivity capable of distinguishing lithology, porosity, and fluid content.

This shallow logging interval includes the lower portion of the upper Wellington shale that has been the focus of shallow water well drilling and water sampling to the northwest surrounding KGS #1-28 (**Figure 72**). The logged and sampled interval incldues 75 ft. of Hutchinson Salt and 250 ft of underlying lower Wellington anhydrite and shale interbeds that overlie the top of Chase Group carbonates at 560 ft. The evaporitic interval is the ultimate "caprock" that separate the surface aquifers from aquifers below. The evaporate interval covers broad regions of central Kansas including all of Wellington Field.

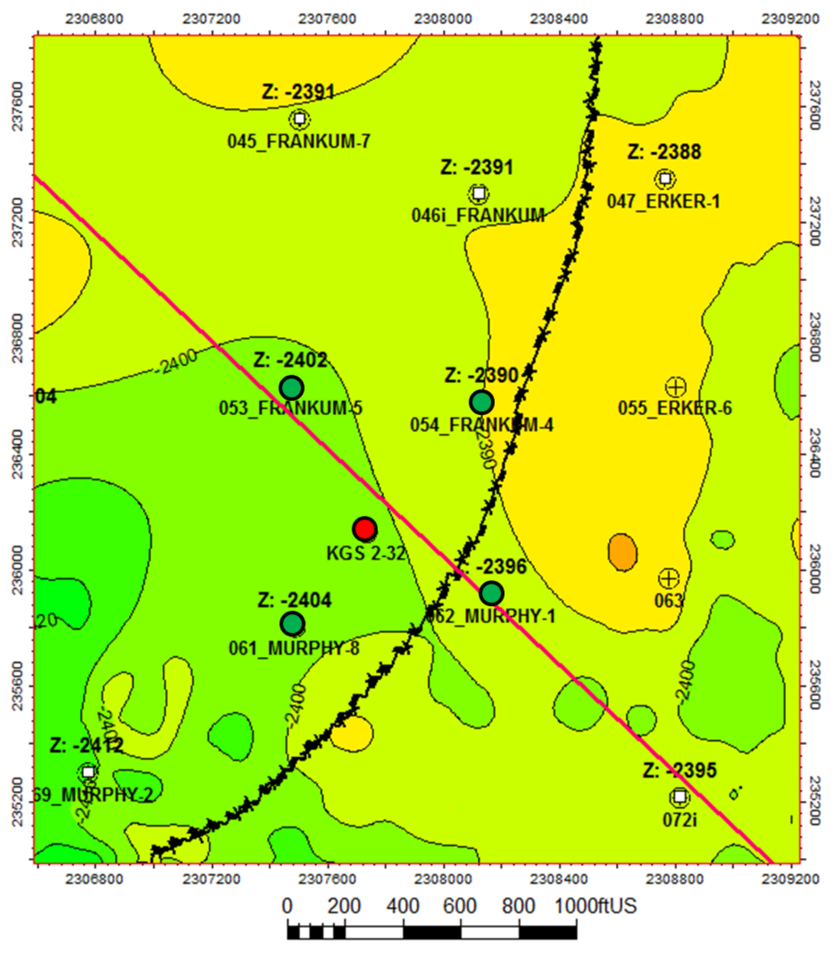


Figure 69. Structure map of CO2 EOR pilot area. Location of fault with small offset in the Mississippianis identified by black hachured line.

Figure 72 is a cross section between KGS #2-32 and the water wells SW #3 and SW #2 located near KGS #1-28 to the northeast. The lithologic description log (georeport) of KGS #2-32 is included as a graphic column along the right side of #2-32 to allow comparison of the full lithologic section to allow comparison to the shallower wells. The cross section puts the significance of the evaporate interval in perspective to the proximity to the surface water and while serving as an excellent barrier precluding communication of the surface water with the underlying fluids, the proximity of the halite bed to the surface and long term geologic dissolution of the salt has locally provided natural contamination of meteoric water as noted at Wellington Field.

The sample descriptions on a 10 ft basis for the shallow section is included in **Table 8**.

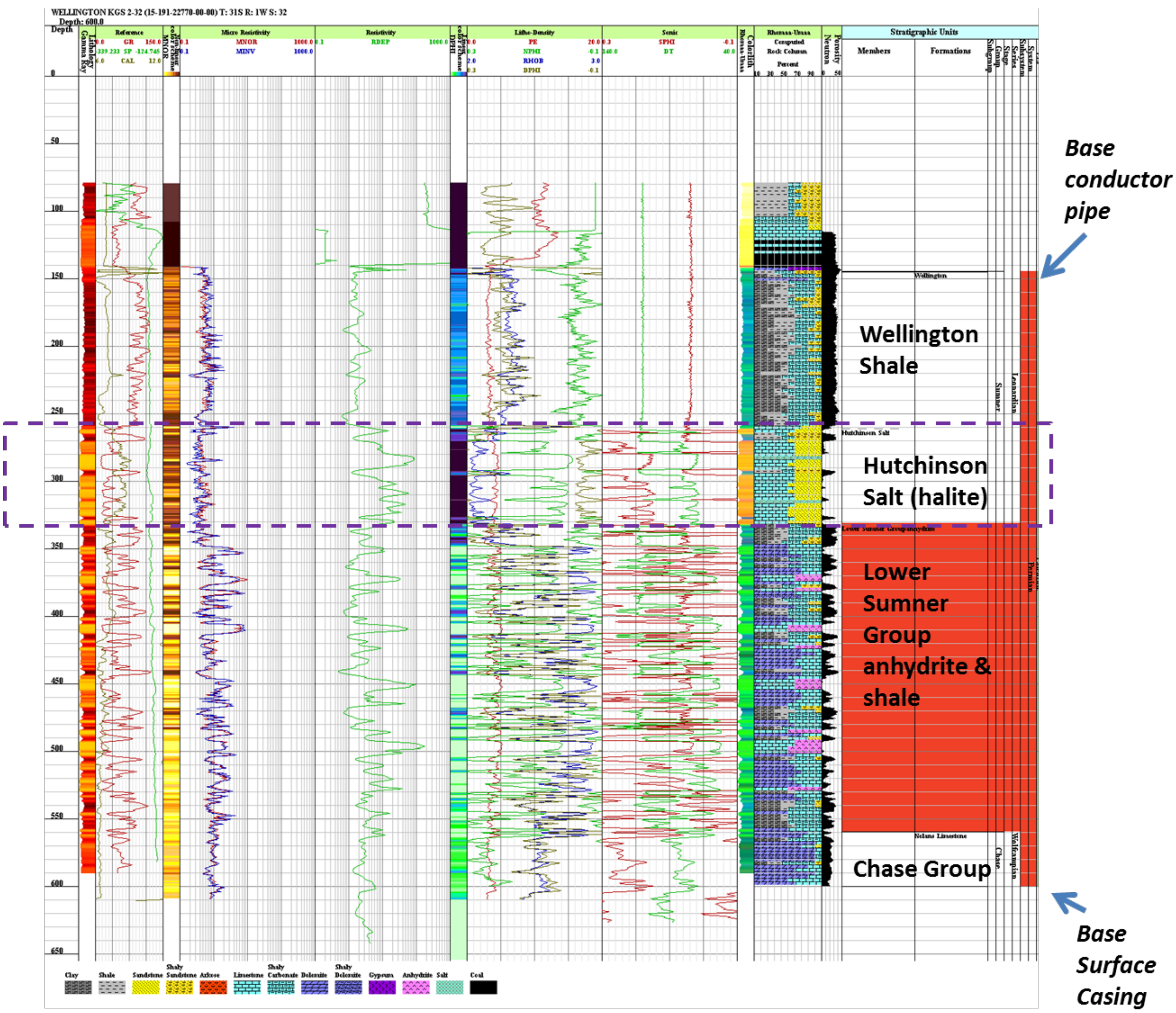


Figure 70. Array of well logs and lithologic interpretation of the upper logging interval in KGS #2-32.

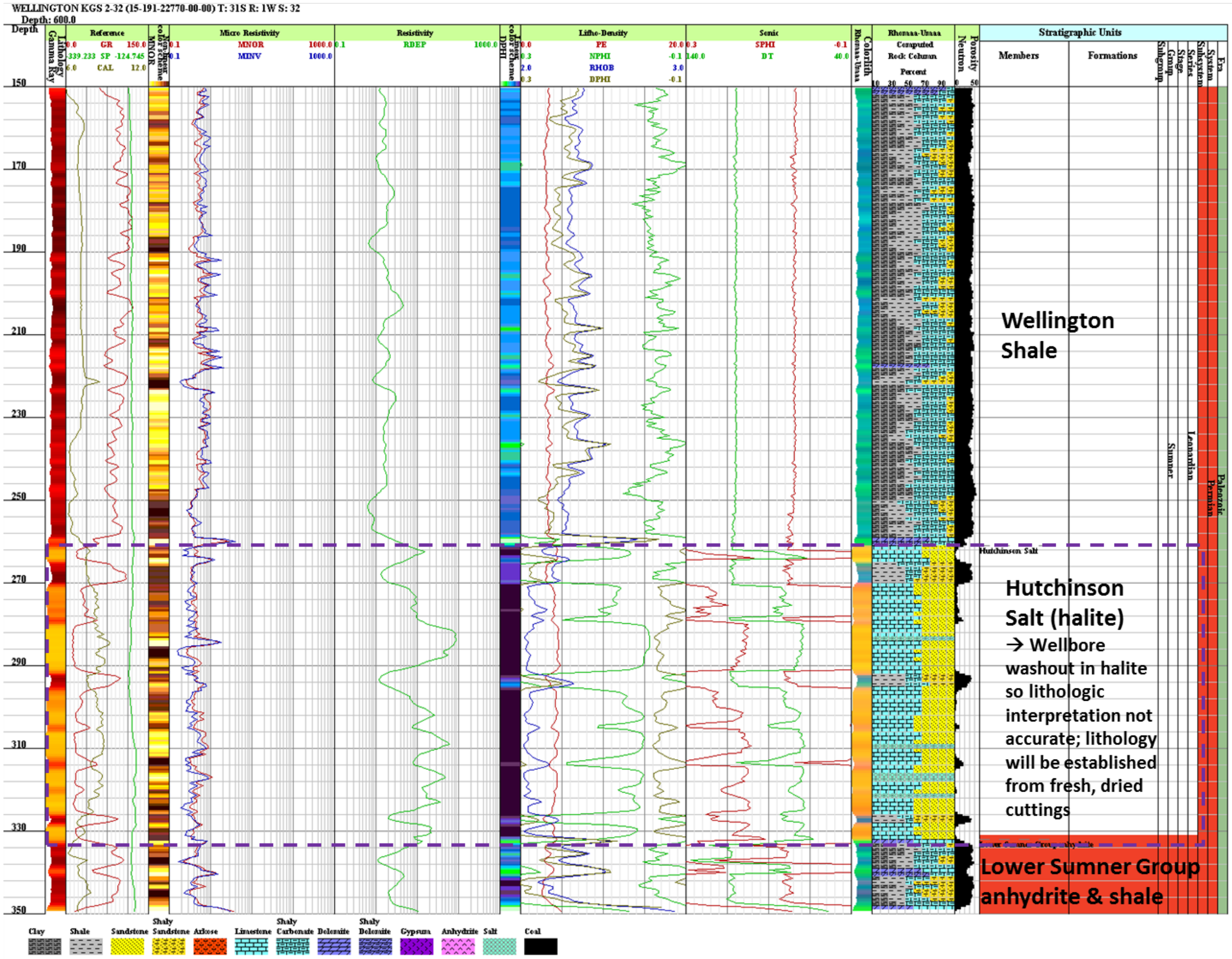


Figure 71. Close-up look at the upper Wellington shale and the Hutchinson Salt. The lithologic interpretation of the Hutchinson Salt interval is in error due to washout of the borehole at the depths of the halite intervals. The brown curve in the first track on the left illustrates the washout. This is a typical response in wells drilled with freshwater mud.

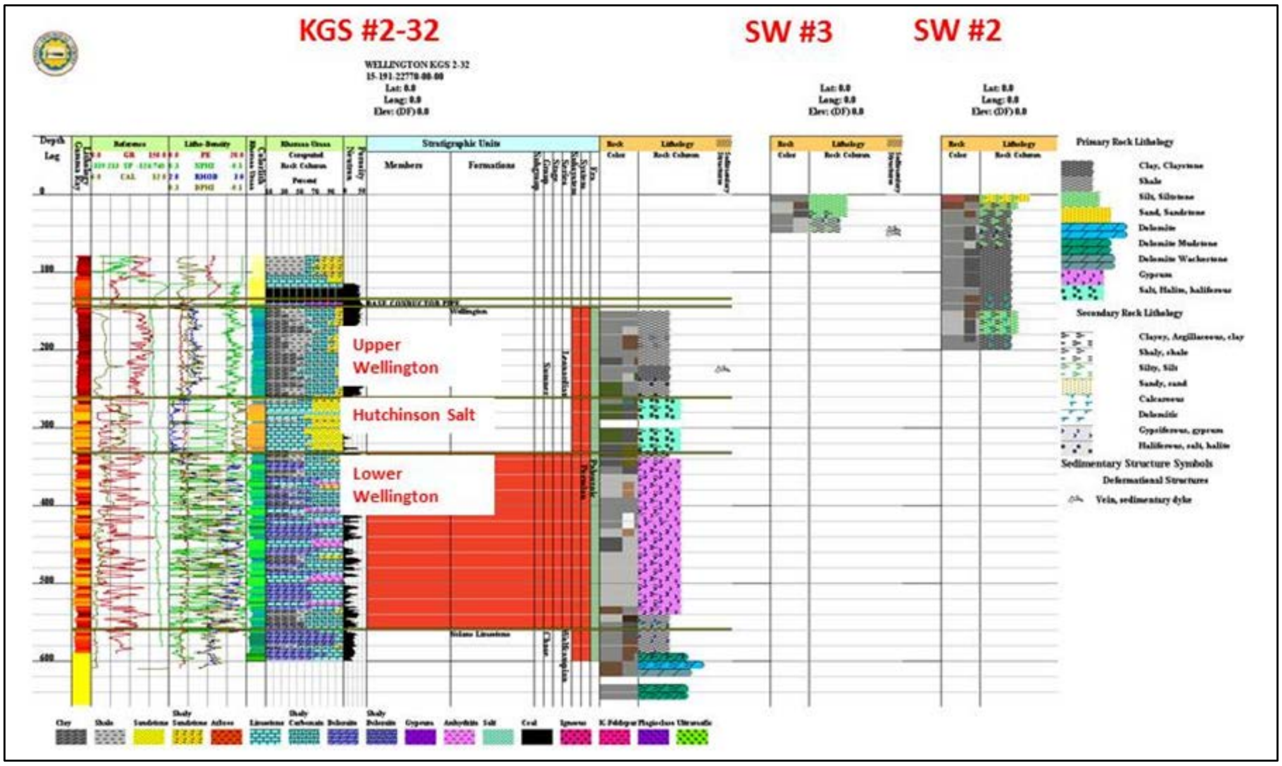


Figure 72. Cross section Wellington KGS #2-32 to SW-3 to SW-2. Comparison lithologies at recently constructed wells at Wellington (KGS 2-32, SW-2, and SW-3) emphasizing similar rock types within the Wellington formation.

Table 8. Cuttings description.

Cuttings description, Shallow interval
Berexco Wellington KGS #2-32
15-191-22770-00-00
1W-31S-Sec32
County: Sumner County
KB:1266
GL: 1257
Depth interval: 150-650 ft
CL: 42,000
RM: 0.527
150;160; Shale, gray, moderately firm (Wellington Shale)
160;170; Shale, gray, moderately firm, scattered satin spar (vein fill, not recrystallized)
170;180; Shale, gray to light gray, moderately firm, scattered satin spar
180;190; 70% shale, gray, 30% claystone, brown, common satin spar
190;200; 60% shale, gray, 40% claystone, brown
200;210; 90% shale, gray, 10% satin spar
210;220; 60% shale, dark gray, 20% gray shale, 10% brown shale, 10% satin spar
220;230; 90% claystone, gray, 5% alabaster (depositional type vs. vein fill), 5% satin spar
230;240; 90% claystone, gray-light gray, olive green, trace red claystone, scattered gypsum, trace halite (dissolved smoothed edges of clear crystals)
240;250; 80% shale, olive green, 10% shale, gray, scattered alabaster, trace halite
250;260; 80% shale, olive green, 10% shale, gray, scattered alabaster, trace halite

260;270; 90% shale, gray-green, 10% shale, brown, scattered alabaster and satin spar
270;280; 70% shale, olive green, 20% shale, dark gray, 10% shale, brown, trace gypsum
280;290; 70% shale, olive green, 20% shale, dark gray, 10% shale, brown, trace gypsum
290:300; 70% shale, olive green, 20% shale, dark gray, 10% shale, brown, scattered halite, clear, smooth, trace gypsum
300;310; 70% shale, olive green, 20% shale, dark gray, 10% shale, brown, scattered halite, clear, smooth, trace gypsum
310;320; 70% shale, olive green, 20% shale, dark gray, 10% shale, brown, scattered halite, clear, smooth, trace gypsum
320;330; 60% shale, dark gray; 30% shale, olive gay, 10% gypsum
330;340; 60% shale, dark gray; 30% shale, olive gay, 10% gypsum
340;350; 60% shale, dark gray; 30% shale, olive gay, 10% gypsum, trace halite
350;360; 70% shale, gray, 30% shale, dark gray, 10% alabaster
360;370; 70% shale, light gray, 20% gypsum, alabaster
370;380; 70% gypsum, alabaster, light gray, light brown, dense, 30% claystone, light gray
380;390; 70% gypsum, alabaster, light gray, light brown, dense, 30% claystone, light gray
390;400; 80% gypsum, alabaster, 20% claystone, gray
400;410; 80% gypsum, alabaster, 20% claystone, gray, scattered claystone, gray
410;420; 80% gypsum, alabaster, gray, white, scattered dolomite, microcrystalline, dense, gray
420;430; 80% gypsum, alabaster, gray, white, scattered dolomite, gray, light brown, microcrystalline, dense
430;440; 90% gypsum, alabaster, light gray, light brown, 10% shale, light gray
440;450; 70% gypsum, alabaster, 10% shale, dark gray, 10% shale, light gray
450;460; 70% gypsum, alabaster, 10% shale, dark gray, 10% shale, light gray, scattered alabaster, translucent
460;470; 95% gypsum, alabaster, 5% shale, light gray
470;480; 95% gypsum, alabaster, 5% shale, light gray
480;490; 95% gypsum, alabaster, 5% shale, light gray
490;500; 95% gypsum, alabaster, 5% shale, light gray
500;510; 95% gypsum, alabaster, 5% shale, light gray
510;520; 90% gypsum, alabaster, 10% shale, light gray
520;530; 80% gypsum, alabaster, 20% shale, light gray
530;540; 80% gypsum, alabaster, 10% dolomite, brown, microcrystalline, 10% shale, gray
540;550; 70% gypsum, alabaster, 25% shale, light to dark gray, 5% dolomite, brown, dark brown, peloid packstone
550;560; 70% shale, gray to dark gray, olive green, 30% gypsum, alabaster, trace dolomite, brown, mottled, microcystaline
560;570; 50% shale, gray to dark gray, 45% gypsum, alabaster, 5% dolomite, micrite
570;580; 60% gypsum, alabaster, 25% shale, gray, 15% dolomite, brown, micrite
580;590; 70% shale, gray, 25% gypsum, alabaster, 5% dolomite, brown, micrite
590;600; 60% dolomite, gray, brown, micrite and microcrystalline, 35% shale, gray, 5% gypsum, alabaster
600;610; 50% dolomite, brown, 50% shale, gray
610;620; 60% dolomite, brown, gray, wackestone-grainstone, peloid, bioclastic, porosity
620-630; 50% dolomite, micrite, 50% shale, gray
630;640; 50% dolomite, micrite, 50% shale, gray
640;650; 50% dolomite, micrite, 50% shale, gray

The second logging run was at total depth of the well in the upper portion of the Mississippian including the full section of the oil reservoir (**Figure 73**). Ninety feet of core were taken as shown the figure below from the top of the reservoir to the base of the porous zone.

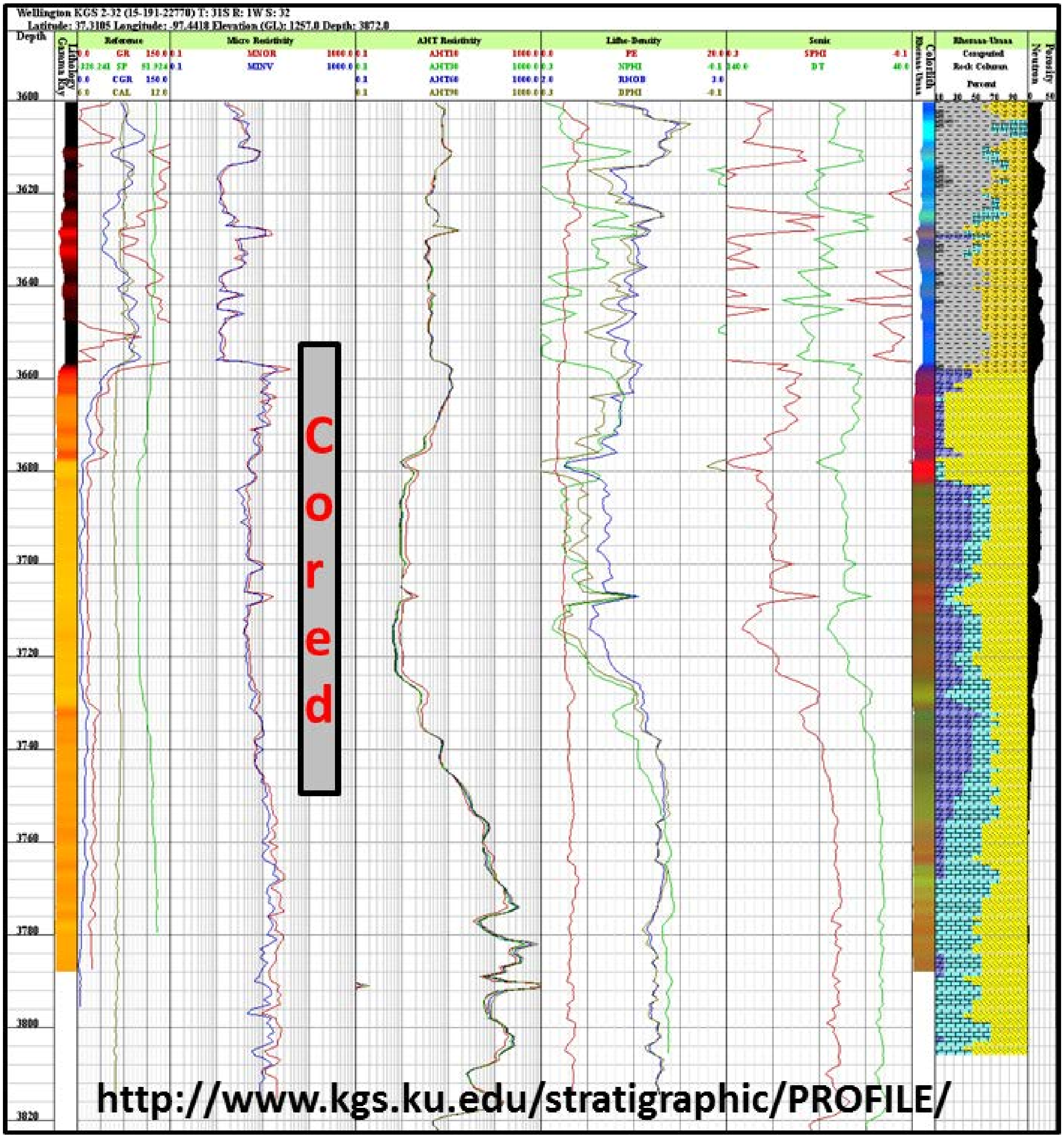


Figure 73. Ninety feet of core were acquired extending from the Middle Pennsylvanian Cherokee Shale through the main porous interval of the Mississippian oil reservoir.

The core is being analyzed by Core Lab in Midland including standard porosity and permeability measurements and fluid saturation (**Figure 74**).

Full Diameter Analysis Dean Stark

Company:	Berexco LLC	Field:	Wellington	File Number:	57181-20573
Well Name:	Wellington KGS #2-32	Formation:	Mississippian	Date:	04/16/2015
Location:	2680'FSL & 709'FEL, Sec 32, T 31S, R 1W	Coring Fluid:	Fresh Wtr Mud	API Number:	15-191-22770
Co. & St.:	Sumner County, Kansas	Elevation:	1269' KB	Full Diameter Sample List	

Sample Number	Top Depth feet	Bottom Depth feet	K(max) ss, air 400 conf press md	K(90) ss, air 400 conf press md	K(vert) ss, air 400 conf press md	POR Ie, Ambient ;eas Grn Vol % of BV	GD gm/cc	So Core % of PV	Sw % of PV

Figure 74. Core was delivered to Core Lab in Midland TX where whole core analysis was to be done on the Mississippian at 1-ft intervals. Two preserved 1 1/2 inch diameter plug samples were also taken for relative permeability measurements.

The standard log analysis using porosity and resistivity logs indicates oil saturation of 30% (**Figure 75**). This indicates that the reservoir at the site of this injection well has been swept the waterflood and is close to residual oil saturation. The analysis of the magnetic resonance imaging log (**Figure 76**) also indicates an oil saturation of the same and suggests the saturation is at residual.

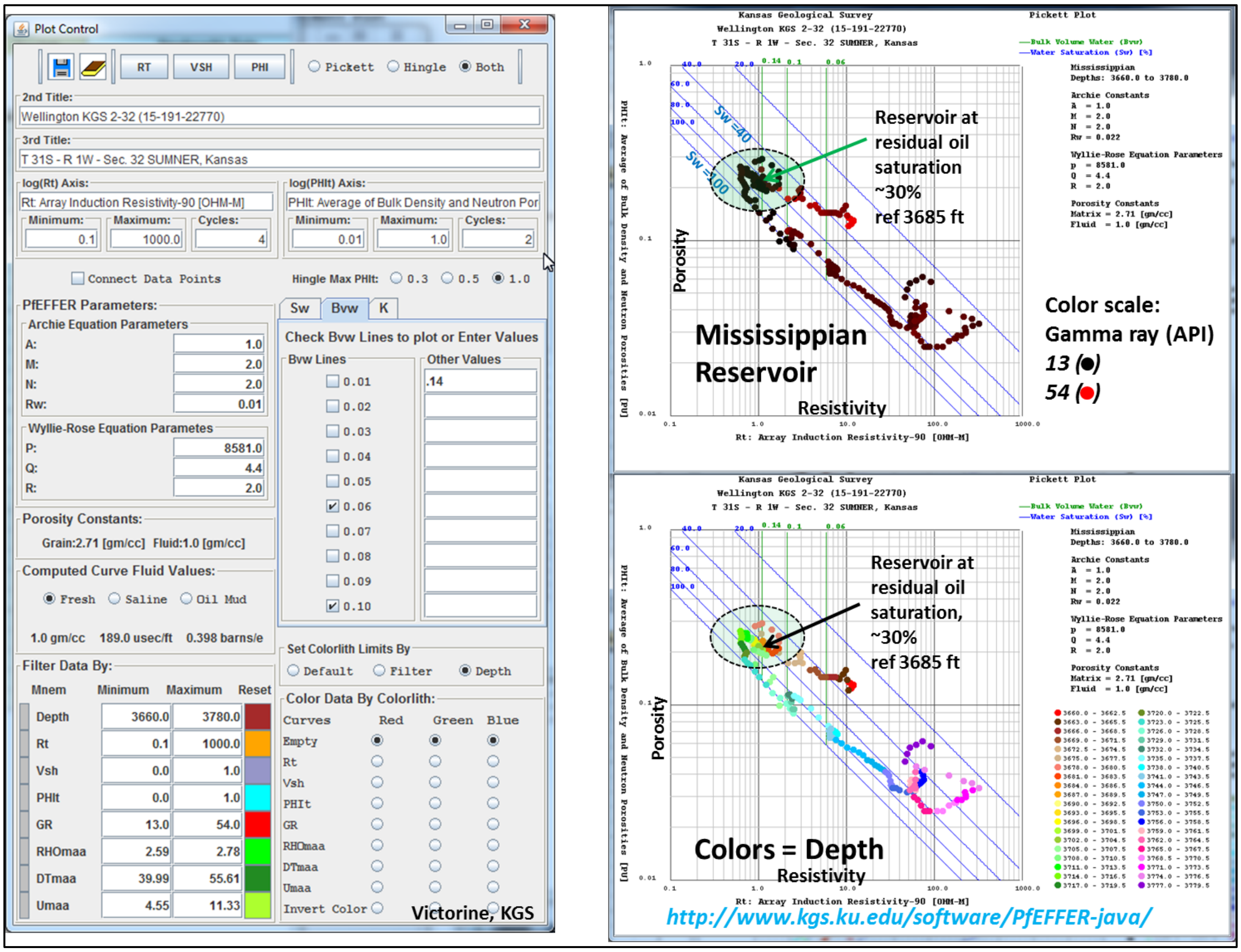


Figure 75. Log analysis with the KGS web-based Java applet was used to estimate the oil saturation that is believed to be at residual ~30% which is also consistent with the nuclear magnetic resonance log (MRIL) of Halliburton.

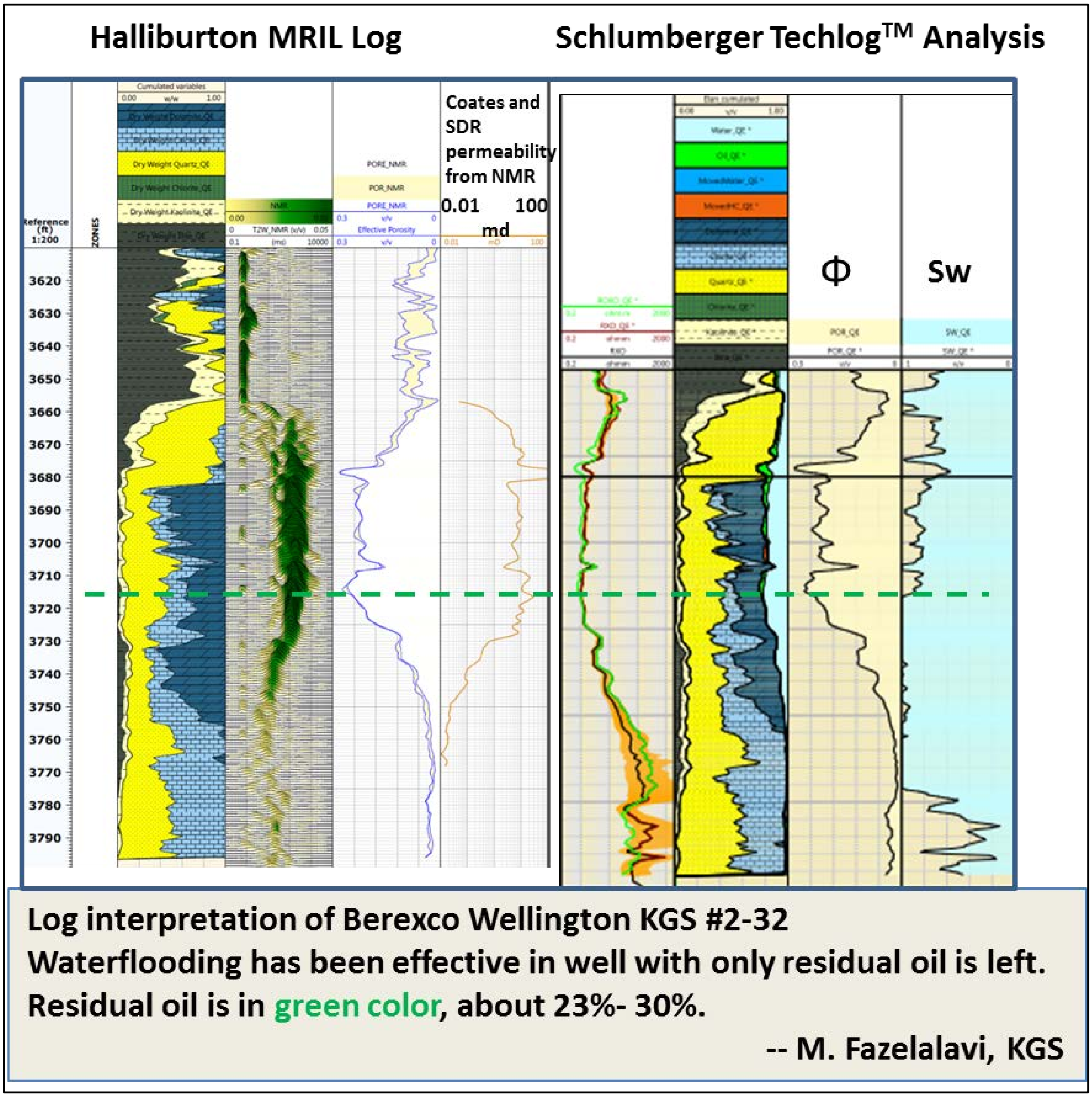


Figure 76. Residual oil determined from analysis if MRIL log. Base of residual oil is ~3715 ft.

The combination of MRIL and formation microresisitity log as shown in **Figure 77** confirms and helps to quantify the pore architecture of the Mississippian siliceous dolomitic reservoir and along with core analysis including capillary pressure measurements will help to refine the reservoir model.

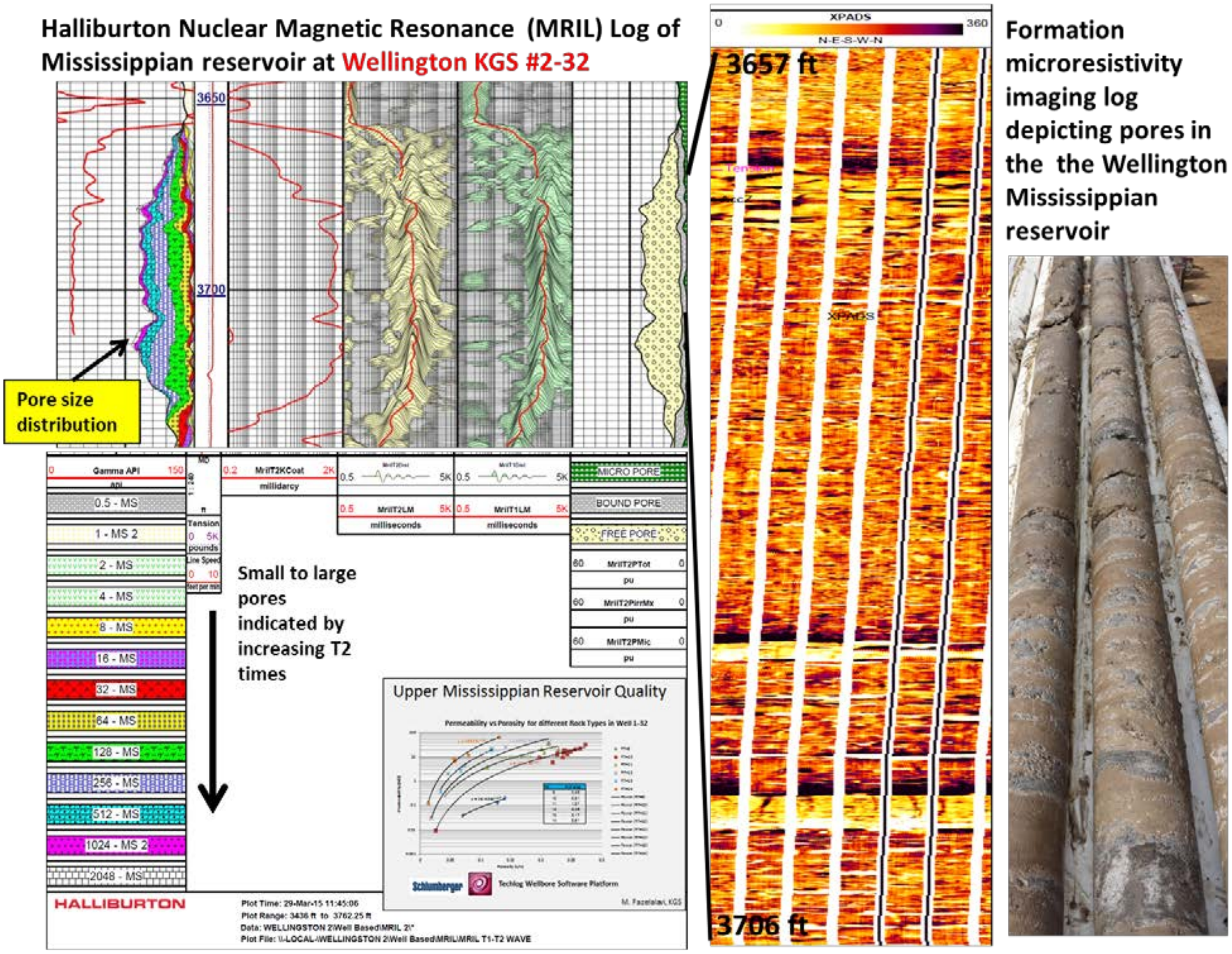


Figure 77. MRIL log output showing pore size distribution compared with the formation microresistivity imaging log and core of the Mississippian oil reservoir in KGS #2-32.

Subtask 6.3. Establish Protocols for InSAR data collection

See earlier.

Subtask 6.4. Drill Shallow Freshwater Monitoring Boreholes (Contingent on Go Decision pts 1&3)

See earlier discussion.

Subtask 6.7. Outfit Surrounding Mississippian Boreholes for MVA (Contingent on Go pts 1&3)

Sampling will be done at Mississippian wells before the Mississippian reservoir is pressurized before CO_2 is injected.

Subtask 7.5 High Res 2D Seismic Lines Targeting Mississippian Reservoir

To be carried out next quarter prior to injecting CO_2.

Task 8. Recondition Mississippian Boreholes Around Mississippian injector re-pressuring Mississippian and sampling producing wells

This activity has begun and baseline sampling of the Mississippian wells will be done in the next quarter.

Key Findings

1. Shallow water wells #1, #2, and #3 have yielded only saltwater in relatively small amounts.
2. EPA continues to review the Class VI application following a well defined schedule.
3. The CO2-EOR injection well was drilled, cored, and tested and is yielding considerable information about the Mississippian reservoir and further documentation of the shallow beds related to surface water and nearby evaporate beds.
4. Methodology to record, integrate, interpret, and display information obtained from the project
5. The seismic network at Wellington is vital to ensuring safe injection and information gained from the instrumentation will aid in the understanding of the seismicity in the region. Work done previously under DOE contract DE-FE0002056 is providing a regional framework to help understand the that mechanisms of regional seismicity, some of which has been attributed to injection of brine under large volumes, rates, and pressures.

Plans for Fifteenth Quarter 2015

1. Complete preparations for CO2 injection to the Mississippian.
2. Inject CO2 into the Mississippian.
3. Continue to respond to EPA's review of the Class VI permit application.

PRODUCTS

Publications, conference papers, and presentations

- Dennis Hedke and Lynn Watney, 2015, Deep-seated Karst at Cutter Field and Evidence Indicating Strike-Slip Movement in Basement Rocks in the Hugoton Embayment", January 7, 2015 Kansas Geological Society Technical Presentation.
- Yevhen Holubnyak, 2015, Storage Capacity Estimations for Arbuckle Saline Aquifer in South Central and South-Western Kansas, 14th Carbon Capture, Utilization, and Storage Conference, Pittsburgh, PA.
- Evaluating Risks of Induced Seismicity for CO2 Geological Storage in the Arbuckle Saline Aquifer, South-Central Kansas 14th Carbon Capture, Utilization, and Storage Conference, Pittsburgh, PA.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

A project organization chart follows (**Figure 19**). The work authorized in this budget period includes tasks discussed above.

Organizational Structure
Small Scale Field Test - Wellington Field (FE0006821)

University of Kansas Center For Research

Kansas Geological Survey

Name	Project Job Title	Primary Responsibility
W. Lynn Watney	Project Leader, Joint PI	*Geology, information synthesis, point of contact*
Jason Rush	Joint PI	*Geology, static modeling, data integration, synthesis*
Tiraz Birdie	Consulting Engineer	*Engineer, data synthesis, Class VI application*
Yevhen 'Eugene' Holubnyak	Petroleum Engineer	*Reservoir Engineer, dynamic modeling, synthesis*
John Doveton	Co-Principal Investigator	*Log petrophysics, geostatistics*
Kerry D. Newell	Co-Principal Investigator	*Fluid geochemistry*
Richard Miller	Geophysicist	*2D Seismic acquisition, interpretation, monitoring wells*
Fatemeh 'Mina' FazelAlavi	Engineering Assistant	*Log data analysis, modeling*
John Victorine	Software Programmer	*Database management, web tool design*
Jennifer Raney	Project Coordinator	*Project management, communications, data handling*

KU Department of Geology

Name	Project Job Title	Primary Responsibility
Mike Taylor	Co-Principal Investigator	CGPS, InSAR surveys, microseismic data integration
Drew Schwab	Graduate Research Student	InSAR surveys, seismic

Subcontracts

Kansas State University

Name	Project Job Title	Primary Responsibility
Saugata Datta	Co - Principal Investigator	*Aqueous Geochemistry, tracer analysis*
Austin Krehel	Graduate Research Assistant	*Sampling, aqueous geochemistry*

Lawrence Berkeley National Laboratory

Name	Project Job Title	Primary Responsibility
Tom Daley	Co - Principal Investigator	*Geophysicist, crosshole and CASSM data*
Barry Freifeld	Co - Principal Investigator	*Mechanical Engineer, U-Tube Sampler*

Berexco, Beredco Drilling -- *Wichita, KS*

Wellington Field access; drilling, completion and testing; monitoring and sampling, daily field operation

Name	Primary Responsibility
Dana Wreath - VP	*Manager, engineer*
Evan Mayhew	*Operations manager, well design*
Brett Blazer	*Engineer, field operations*
Jason Bruns	*Canaan Well Services - contact*
Beredco Drilling Team	*Drilling and completion activities*

CO_2 Suppliers

Praxair Services, Inc.

Pete Wilt	*Commercial Business Director*
Justin Anderson	*Oil & Gas Representative*
Mark Weise	*Oil & Gas Representative*

Linde, LLC

Earl Lawson	*Vice President*
Neeraj Saxena	*Clean Energy Services*
Chris White	*Business Development Engineer*
Kevin Watts	*EOR Director*

Figure 19. Organizational Chart.

IMPACT

See earlier discussion.

CHANGES/PROBLEMS

Please refer to earlier discussion.

BUDGETARY INFORMATION

Cost Status Report

See table below and on the following page for the cost status for quarters 1-13.

COST PLAN/STATUS	BP1 Starts: 10/1/11								
	10/1/11-12/31/11	1/1/12-3/31/12	4/1/12-6/30/12	7/1/12-9/30/12	10/1 /12- 12/31/12	1/1/13 - 3/31/13	4/1/13 - 6/30/13	7/1/13-9/30/13	10/1/13 - 12/31/13
Baseline Reporting Quarter	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Baseline Cost Plan (from SF-424A)	(from 424A, Sec. D)								
Federal Share	$326.84	$17,208.52	$17,282.92	$31,693.50	$23,000.00	$23,000.00	$23,000.00	$23,000.00	$1,997,070.75
Non-Federal Share	$365,421.00	$365,421.00	$365,421.00	$365,421.00	$0.00	$0.00	$0.00	$0.00	$258,982.75
Total Planned (Federal and Non-Federal)	$365,747.84	$382,629.52	$382,703.92	$397,114.50	$23,000.00	$23,000.00	$23,000.00	$23,000.00	$2,256,053.50
Cumulative Baseline Cost	$365,747.84	$748,377.36	$1,131,081.28	$1,528,195.78	$1,551,195.78	$1,574,195.78	$1,597,195.78	$1,620,195.78	$3,876,249.28
Actual Incurred Costs									
Federal Share	$326.84	$17,208.52	$17,282.92	$31,693.50	$31,572.56	$25,465.07	$13,078.68	$52,993.14	$23,181.46
Non-Federal Share	$0.00	$6,475.85	$43,028.94	$9,058.04	$15,226.34	$0.00	$0.00	$0.00	$0.00
Total Incurred Costs-Quarterly (Federal and Non-Federal)	$326.84	$17,208.52	$60,311.86	$40,751.54	$46,798.90	$25,465.07	$13,078.68	$52,993.14	$23,181.46
Cumulative Incurred Costs	$326.84	$17,535.36	$77,847.22	$118,598.76	$165,397.66	$190,862.73	$203,941.41	$256,934.55	$280,116.01
Variance									
Federal Share	$0.00	$0.00	$0.00	$0.00	-$8,572.56	-$2,465.07	$9,921.32	-$29,993.14	$1,973,889.29
Non-Federal Share	$365,421.00	$358,945.15	$322,392.06	$356,362.96	-$15,226.34	$0.00	$0.00	$0.00	$258,982.75
Total Variance-Quarterly Federal and Non-Federal)	$365,421.00	$358,945.15	$322,392.06	$356,362.96	-$23,798.90	-$2,465.07	$9,921.32	-$29,993.14	$2,232,872.04
Cumulative Variance	**$365,421.00**	**$724,366.15**	**$1,046,758.21**	**$1,403,121.17**	**$1,379,322.27**	**$1,376,857.20**	**$1,386,778.52**	**$1,356,785.38**	**$3,589,657.42**

BP1 Ends 8/31/14		BP2 Starts 9/1/14	Ends 8/31/15			BP3 Starts 9/1/15	Ends 9/30/16			
1/1/14 - 3/31/14 Q10	4/1/14 - 6/30/14 Q11	7/1/14 - 9/30/14 Q12	10/1/14 - 12/31/14 Q13	1/1/15 - 3/31/15 Q14	4/1/15 - 6/30/15 Q15	7/1/15 - 9/30/15 Q16	10/1/15 - 12/31/15 Q17	1/1/16 - 3/31/16 Q18	4/1/16 - 6/30/16 Q19	7/1/16 - 9/30/16 Q20
$1,997,070.75	$1,997,070.75	$1,997,070.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75
$258,982.75	$258,982.75	$258,982.75	$184,656.00	$184,656.00	$184,656.00	$184,656.00	$0.00	$0.00	$0.00	$0.00
$2,256,053.50	$2,256,053.50	$2,256,053.50	$509,743.75	$509,743.75	$509,743.75	$509,743.75	$325,087.75	$325,087.75	$325,087.75	$325,087.75
$6,132,302.78	$8,388,356.28	$10,644,409.78	$11,154,153.53	$11,663,897.28	$12,173,641.03	$12,683,384.78	$13,008,472.53	$13,333,560.28	$13,658,648.03	$13,983,735.78
$12,053.49	$9,400.96	$0.00	$50,936.04	$74,137.93	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$0.00	$90,624.59	$0.00	$33,953.80	$1,409,519.41	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$12,053.49	$100,025.55	$0.00	$84,889.84	$1,483,657.34	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$292,169.50	$392,195.05	$392,195.05	$477,084.89	$1,960,742.23	$1,960,742.23	$1,960,742.23	$1,960,742.23	$1,960,742.23	$1,960,742.23	$1,960,742.23
$1,985,017.26	$1,987,669.79	$1,997,070.75	$274,151.71	$250,949.82						
$258,982.75	$168,358.16	$258,982.75	$150,702.20	-$1,224,863.41						
$2,244,000.01	$2,156,027.95	$2,256,053.50	$424,853.91	-$973,913.59						
$5,833,657.43	**$7,989,685.38**	**$10,245,738.88**	**$10,670,592.79**	**$9,696,679.20**						

THIS NUMBER WAS REDUCED BY $594.94 FROM PREVIOUS SUBMISSION - NOT CLEAR WHY

KUCR PROCESSED KSU COST SHARE FEB 2015 BUT BACKDATED IT TO 11/30/2014.THUS THE CHANGE