Wellington KS CO2 EOR Project

- August 23, 2016

- Dana G. Wreath
- Vice President Engineering
- Berexco LLC – a private oil and gas company based in Wichita KS
- Operator of Wellington Field in southern KS

DOE Funded CO2 Research

QUARTERLY PROGRESS REPORT

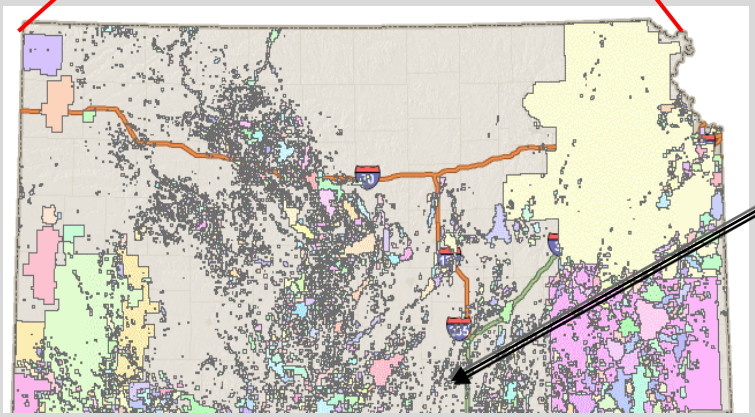
To
DOE-NETL
Brian Dressel, Program Manager
Award Number: DE-FE0006821

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

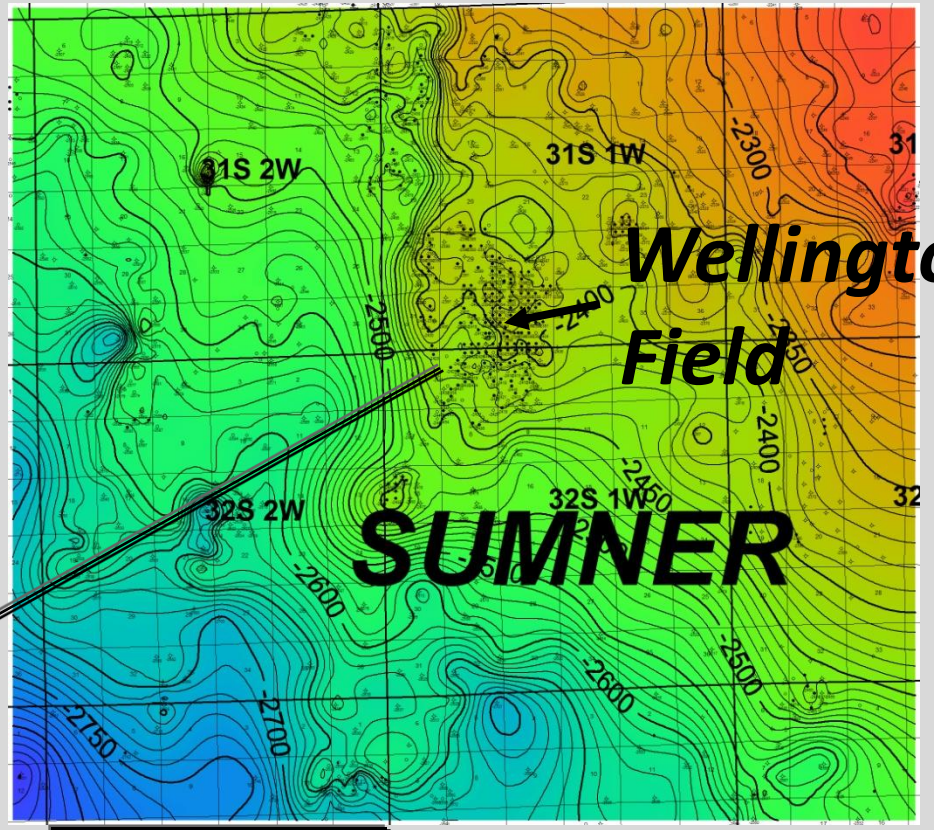
Project Director/Principal Investigator:
W. Lynn Watney
Senior Scientific Fellow
Kansas Geological Survey

Ph: 785-864-2184, Fax: 785-864-5317
lwatney@kgs.ku.edu

Wellington Field
Site of Small Scale Field Test



Top Mississippian Structure, 10 ft C.I.



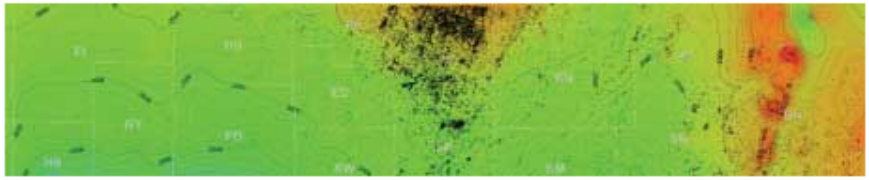
20 Million Barrel Oil Field above Arbuckle Group

KANSAS GEOLOGICAL SURVEY
The University of Kansas

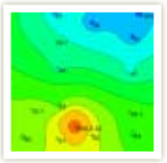
Kansas Geological Survey Website
http://www.kgs.ku.edu/PRS/Ozark/index.html

South-central Kansas CO_2 Project

Kansas Geological Survey

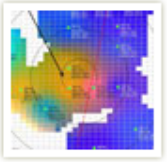


Updates June 2016



New presentations from Carbon Capture, Utilization & Storage Conference, June 2016.

Updates May 2016



Eighteenth Quarterly Report for Small Scale Field Test.

Updates April 2016

New photos from a recent tour of the CO_2 injection site.

New presentations from Nov. 2015 conferences.

New presentation from Kansas NextStep Conference in Hays, April 2016.

About...

South-central Kansas CO_2 Project is a DOE-funded project of the Kansas Geological Survey. More ...

Topics...

Home

Small Scale Field Test

Presentations

Reports

Well Data

Well 1-32

Well 2-32

Well 1-28

Interactive Map

CO_2-EOR Technology & Carbon Management Research in Kansas

- Utilize oil and gas field Infrastructure
- Utilize comparable approaches to characterization and simulation of oil and reservoirs
- Evaluated sites for commercial scale carbon storage sites in aquifers beneath existing oil fields
- Conduct small scale CO2-EOR injection at Wellington Field, Sumner County Kansas
- KU & partners have performed extensive research on:
  - -monitoring
  - -verification
  - -accounting of the CO_2 over the long term

Wellington Project Current Status

- CO2 EOR Project is the first phase at 3600’ depth, then deep saline injection to follow (USEPA Class 6) at 5100’ depth.
- CO2 EOR injection began Jan 2016 and was completed June 22, 2016.
- EOR recovery, monitoring and CO2 mass balance measurement currently ongoing.
- USEPA Class 6 Injection Permit pending for saline injection phase. Timing?

Injection Well Permitting

- EOR requires Class 2 UIC Permit
- Regulator is Kansas Corporation Commission
- KCC has primacy for Class 2 wells
- Permit application is 10 page document
- USEPA has oversight function over KCC

- CO2 Disposal (not EOR) requires Class 6 Permit
- USEPA has primacy for Class 6. Class 6 program modeled from Class 1 Hazardous Waste Disposal
- Comparison of Class 2 vs Class 6

KANSAS CORPORATION COMMISSION
OIL & GAS CONSERVATION DIVISION

Form U-1
July 2014
Form must be Typed
Form must be Signed
All blanks must be Filled

APPLICATION FOR INJECTION WELL

DESIGN APPROVAL

Disposal ☐

Enhanced Recovery: ☐ Repressuring ☐ Waterflood ☑ Tertiary

Date: JANUARY 22, 2015

Operator License Number: 34318

Operator: BEREXCO LLC

Address: 2020 N. BRAMBLEWOOD
WICHITA, KS 67206

Contact Person: BRETT BLAZER

Phone: 316-265-3311

Email: blazerb@berexco.com

Permit Number:

API Number:

Well Location

NE - NW - NE - SE Sec. 32 Twp. 31 S. R. 1 ☐ E ☑ W

2700 feet from ☐ N / ☑ S Line of Section

750 feet from ☑ E / ☐ W Line of Section

GPS Location: Lat: 37.3105085 (e.g. xx.xxxxx) Long: -97.4422507 (e.g. -xxx.xxxxx)

Datum: ☑ NAD27 ☐ NAD83 ☐ WGS84

Lease Description: SEE ATTACHMENT A

Lease Name: WELLINGTON Well Number: KGS #2-32

Field Name: WELLINGTON

County: SUMNER

Deepest Usable Water

Formation: Sumner Group

Depth to Bottom of Formation: 230'

Check One: ☐ Old Well Being Converted ☐ Newly Drilled Well ☑ Well to be Drilled

Surface Elevation: 1262 feet Well Total Depth: 3815 feet Plug Back Depth: 3770 feet

Datum of top of injection formation: 3662(-2400) feet *(reference mean sea level)*

Injection Formation Description:

Name	top / bottom		perf / open hole		depth		
MISSISSIPPI	3662	3687	PERF	at	3662	to 3687	feet
	/			at		to	feet

List of Wells/Facilities Supplying Produced Saltwater or Other Fluids Approved by the Conservation Division:
(attach additional sheets if necessary)

	Lease Operator	Lease/Facility Name	Lease/Facility Description	Well ID & Spot Location
1.	BEREXCO LLC	WELLINGTON UNIT	SEE ATTACHMENT A	
2.				
3.				

	Producing Formation	Strata Depth			Total Dissolved Solids *(if available)*	
1.	MISSISSIPPI	3500	to 3800	feet		mg/l
2.			to	feet		mg/l
3.			to	feet		mg/l

Maximum Requested Liquid Injection Rate: 2000 bbls / day; or

Maximum Requested Gas Injection Rate: 4,000,000 scf / day. Type of Gas: CARBON DIOXIDE

Maximum Requested Injection Pressure: 1200w 1500g psig

Mail to: KCC - Conservation Division, 266 N Main St, Ste 220, Wichita, Kansas 67202-1513

Well Completion

Type: ☑ Tubing & Packer ☐ Packerless ☐ Tubingless

	Conductor	Surface	Intermediate	Production	Tubing
Size	13-3/8" 43#	8-5/8" 24#		5-1/2" 15.5#	2-7/8" LINED
Setting Depth	120'	600'		3815'	+/- 3612'
Amount of Cement	135 sx	300 sx		235 sx	NONE
Top of Cement	0'	0'		2450'	N/A
Bottom of Cement	120'	600'		3815'	N/A

If Alternate II cementing, complete the following:

Perforations / D.V. Tool at +/-2450' feet, cemented to 0' feet with 400 sx.

Tubing: Type 2-7/8" PLASTIC LINED Grade J-55

Packer: Type TENSION Depth +/-3162'

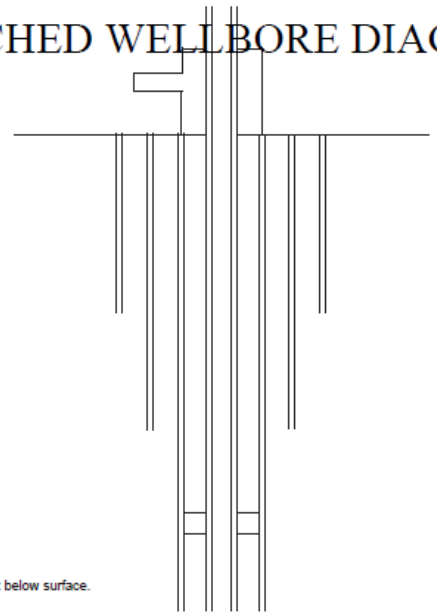
Annulus Corrosion Inhibitor: Type TREATED FRESH WATER Concentration 0.5%

List Logs Enclosed: CEMENT BOND LOG

Well Sketch

(To sketch installation, darken the appropriate lines, indicate cement, and show depths.)

SEE ATTACHED WELLBORE DIAGRAM



Static fluid level is N/A feet below surface.

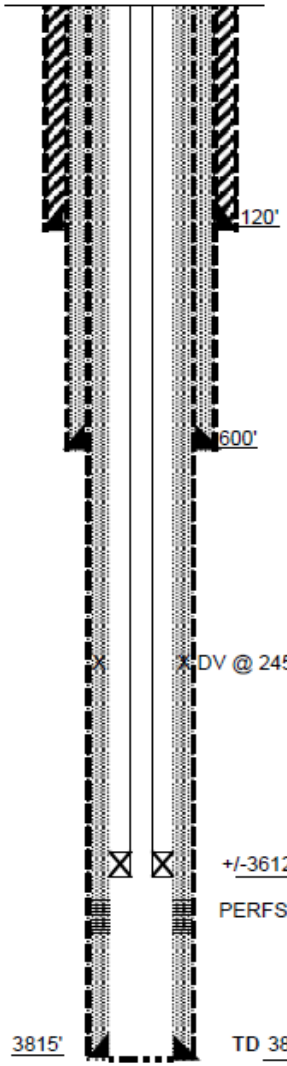
APPLICATION FOR INJECTION WELL

Form U-1
Page 2

WELLBORE DIAGRAM

LEASE Wellington KGS #2-32 **API: 15-** 191-
NE NW NE SE Sec 32 31S - 1W Sumner COUNTY KANSAS

INJECTION ZONE:
Mississippi 3662'-3687'

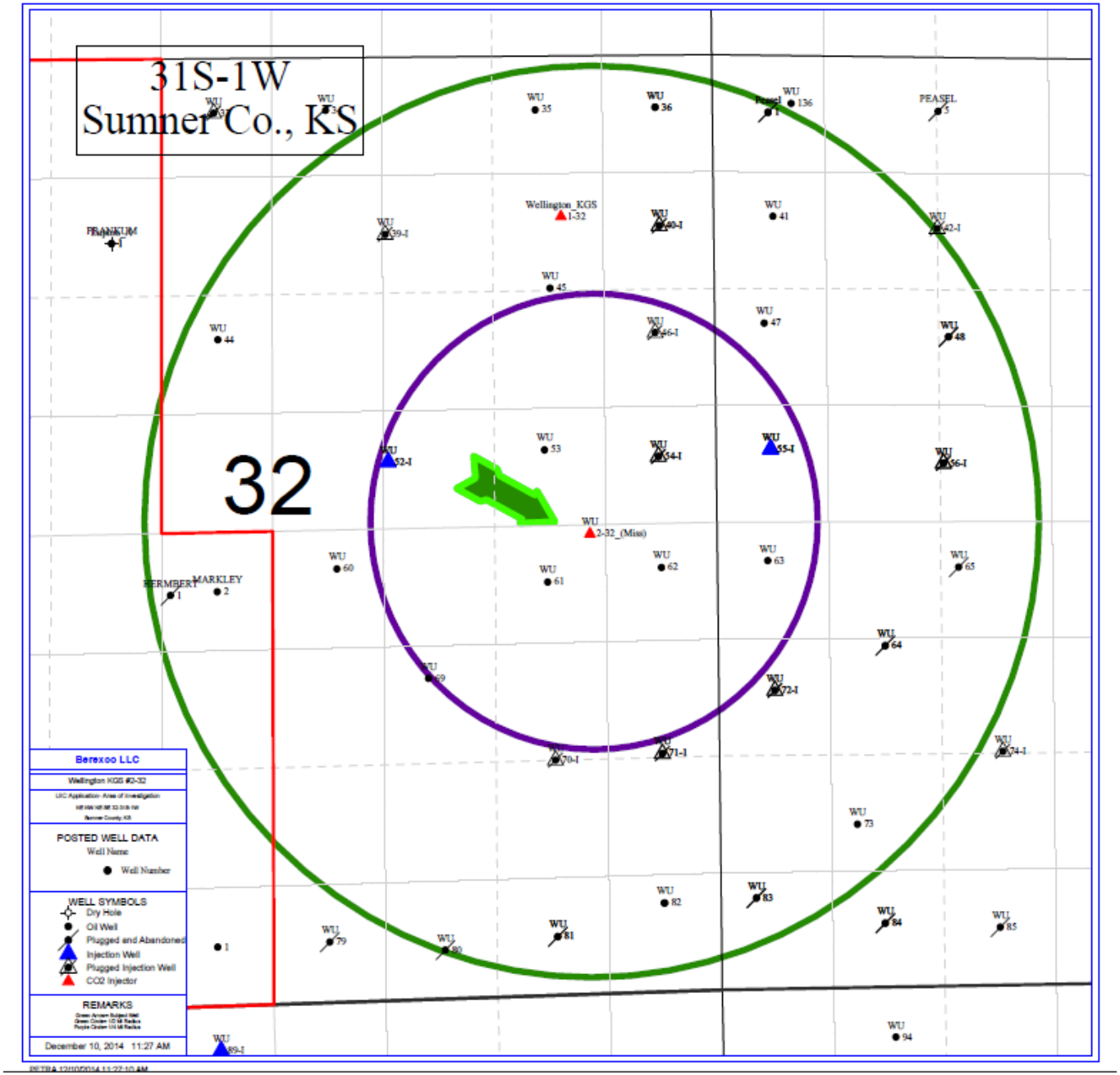


13-3/8" CONDUCTOR CASING
43.0 #/Ft Set at 120' w/ 135 sx cement
Top of Cmt @ 0'

8-5/8" SURFACE CASING
24.0 #/Ft Set at: 600' w/ 300 sx cement
Top of Cmt @ 0'

5-1/2" PRODUCTION CASING
15.5 #/Ft Set at: 3815' w/ 235 sx cement
Top of Cmt @ 0'

INJECTION STRING
TUBING: 2-7/8" PLASTIC LINED
PACKER: TENSION- STRADDLE PACKERS
Set at: +/-3612


31S-1W
Sumner Co., KS
32
Wellington_KGS 1-32
2-32_(Miss)
FRANKUM 1
FERMBERT 1
MARKLEY 2
PEASEL 5
Berexco LLC
Wellington KGS #2-32
POSTED WELL DATA
Well Name
Well Number
WELL SYMBOLS
Dry Hole
Oil Well
Plugged and Abandoned
Injection Well
Plugged Injection Well
CO2 Injector
REMARKS
December 10, 2014 11:27 AM

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

KGS 2-32 Drilling Phase

3/20/15	Spud well 7:00 am, 3/20/2015. TD 17-1/2" conductor hole @ 140' KB, 3/20/2015. Survey 1° @ 140'. Ran 3 jts 13-3/8" 48# conductor casing- set @ 137' KB. Cemented with 145 sx Class A cement with 1/4# flakes and 3% CC. Finished cementing 1:15 pm, 3/20/2015. Cement circulated to surface.
3/21/15	Drilling @ 465'. TD 12-1/4" surface hole @ 650' KB, 3/21/15. Survey 1° @ 650'. Ran open hole logs in surface hole- LTD @ 653' KB. Log showed base of conductor @ 142' KB. Ran 15 jts 8-5/8" 24# surface casing. Set @ 647' KB. Cemented with 175 sx 60/40 POZ 6% gel 1/4# flakes 3% CC tailed with 150 sx Class A with 1/4# flakes and 3% CC. Plug landed 8:15 pm, 3/21/15. Cement circulated to surface.
3/22/15	Drilling out of surface casing.
3/23/15	Drilling @ 1470'. Survey 3/4° @ 1164'.
3/24/15	Drilling @ 2325'. Surveys 1/2° @ 1670, 3/4° @ 2179'.
3/25/15	Drilling @ 3135'. Surveys 3/4° @ 2624', 1/4° @ 3134'. Displaced mud system at 2815'.
3/26/15	Conditioning hole for coring. Reached core point @ 3654' KB 6:15 am, 3/26/2015. Survey 1/2° @ 3654'. TIH w/ coring tools. Cored from 3654' to 3669' and core barrel jammed. TOH w/ Core #1. Recovered 15' of core. TIH and resumed coring- core barrel jammed @ 3691'. TOH w/ Core #2. Recovered 22' of core.
3/27/15	Coring @ 3691'. Cored to 3751'. Recovered 60' of core. Ran DST #1: DST #1, 3671'-3751', Mississippi Times: 30-60-60-120 IFP: 51-235# FFP: 231-392# ISIP: 955# FSIP: 959# Recovery: 300' VSOSMW (Tr O, 95% W), 120' VSOSWM (Tr O, 35% W), 120' M; Chlorides 95,000 ppm
3/28/15	Drilling @ 3765'. TD well @ 3860' 2:00 pm, 3/28/15. Survey 1/4° @ 3860'.
3/29/15	Running open hole logs- LTD @ 3860' KB. Lay down drill pipe and drill collars. Ran 95 jts 5-1/2" 15.5# casing. Tag TD @ 3860' KB and set casing @ 3858' KB. Circulated halfway into hole and on bottom. DV @ 2515' KB. Baskets @ 3732', 3608', on jt below DV tool and at 1000'. Ran centralizers every other collar up to 3000' and on joints above and below DV tool.
3/30/15	Cemented bottom stage with 95 sx A-Con w/ 1/4# flakes and 2% CC mixed at 2.01 cu ft/sx tailed with 195 sx AA-2 thixotropic cement with 5% Calseal, 1% C-44 Gas Blok CO_2 resistant additive, 10% salt, 1/4# defoamer, 1/4# flakes 1/2% fluid loss, 0.3% CFR-2, and 6# gilsonite. Plug landed 2:10 am, 3/30/15. Opened DV tool and circulated 4 hours. Saw cement from bottom stage circulate to surface. Cemented top stage with 465 sx A-Con w/ 1/4# flakes 2% CC at 2.01 cu ft/sx and 50 sx AA-2. Plug landed 7:20 am, 3/30/15. Cement circulated to surface. Plugged mouse and rat holes with 50 sx A-Con. Rig released 3/30/15
3/31/15	Waiting on completion.

KGS 2-32 Completion

4/22/15	MIRU BX Rig #13. TIH w/ 4-7/8" bit, 3- 3-1/8" drill collars and 2-7/8" workstring. Tag DV @ 2515' KB. Drill out DV tool. Tag PBTD @ 3820' KB. Circulated hole clean with fresh water. SOH w/ tubing, drill collars and bit. Shut down.
4/23/15	FOH w/ tubing and bit. Ran CBL- PBTD @ 3815' KB. Good bond from TD to surface. Pressured casing to 2500#- held. TIH w/ 4-7/8" bit, 5-1/2" casing scraper and 2-7/8" workstring to 3780' KB. Shut down.
4/24/15	Swab casing fluid level down to 3150' from surface. TOH w/ bit, scraper and tubing. Perforate Mississippi Chert from 3664'-3706' KB, 4 SPF. Shut down.
4/25-26/15	Shut down.
4/27/15	Ran 5-1/2" X 2-7/8" Arrowset PKR. Set @ 3638' KB. Ran swab- fluid level 1800' from surface, 100' free oil on top. Recovered 10.8 BW on swab down. Had 700' fill up after 1 hour. Acidized Mississippi perfs with 2500 gallons 10% NEFE-HCl and 250 ball sealers. Treated 3 BPM @ 1300# initially, increased to 5.7 BPM @ 700# towards end. ISIP 50#, 30 seconds to vacuum. TLTR 90 BTF. Ran swab- fluid level 1100' from surface. Recovered 44.7 BW on swab down. Next hour recovered 20.8 BTF with trace oil. Shut down.
4/28/15	Ran swab- fluid level 2000' from surface, 50' oil on top. Swabbed 26.7 BTF. Release PKR and run across perfs to remove any remaining ball sealers. Reset PKR @ 3638' KB. Ran swab. Recovered 16.8 BTF on swab down. 1st Hour — 19.1 BTF, fluid level 2800' from surface 2nd Hour — 23.4 BTF 3rd Hour — 16.7 BTF 4th Hour — 13.4 BTF 5th Hour — 13.4 BTF 6th Hour — 20 BTF. Fluid level stayed 2800' from surface. Caught fluid samples. Shut down.
4/29/15	Ran swab- fluid level 2000' from surface, 75' free oil on top. Injected 2 BPM for 10 minutes- took fluid on vacuum. Injected 4 BPM for 10 minutes- stabilized pressure 150#. TOH w/ tubing and PKR. RDMO BX Rig #13.
4/30/15	Waiting for pulse test scheduled for the week of May 10.
5/12/15	Ran pulse test in well.
5/27/15	Too muddy to move in rig/injection tubing.
6/8/15	MIRU Contract WS Rig. TIH w/ nickel coated Arrowset-1X PKR with Viton rubber and 1.875" stainless steel profile nipple for X-style blanking plugs, nickel coated on-off tool and 110 jts TK-70XT coated tubing. Pump packer fluid and set PKR @ 3636' KB. Annulus held 150#. RDMO Contract WS Rig. Will MIT well 6/10/15.
6/10/15	MIT well to 350#- held. Witnessed by Jonathan Hill of KCC District #2 office.
6/23/15	Permit for carbon dioxide injection now approved by KCC.

THE STATE CORPORATION COMMISSION OF THE STATE OF KANSAS
CONSERVATION DIVISION

INJECTION PERMIT FOR ENHANCED RECOVERY

Oper. License #: 34318	Permit #: E-32,147
Operator: Berexco LLC	Pilot Well Name & No.: Wellington KGS #2-32
Address: 2020 N. Bramblewood	Location: 2700'FSL 750'FEL
City: Wichita	Sec. 32 Twp 31S Rge 1 ☐ (E) ☒ (W)
State: KS	County: Sumner
Zip Code: 67206	Field Name: Wellington

Project Acreage: NE NW NE SE Section 32-31S-1W

After reviewing the operator's application for an Enhanced Recovery Injection Well Permit dated January 23rd ,2015, the Conservation Division grants a permit for the injection of produced saltwater or other fluids approved by the Conservation Division. Each additional permitted well is subject to the specifications and requirements of this permit including any attachments or any attached amendments.

- **The injection formation is known as the Mississippi.**
- **The depth of the permitted injection interval is from 3662' to 3687', ☒(PF), ☐(OH)**
- **The maximum authorized injection rate is 2000 barrels of fluid per day.**
- **The maximum authorized injection pressure is 1200 PSIG.**
- **The maximum authorized injection rate for CO2 is 4,000,000 scf per day.**
- **The maximum authorized injection pressure for CO2 is 1500 PSIG.**
- **Authorized rates and pressures are subject to temporary or permanent modification during or as the result of any investigation conducted by Commission Staff.**
- **Attachment ☒ YES, ☐ NO.**

Complete casing information for the Pilot well is as follows:

	SIZE	SEAT DEPTH	INTERVAL CEMENTED	SACKS CEMENT USED
Conductor	**13.375"**	**120'**	**0' to 120'**	**135**
Surface	**8.625"**	**600'**	**0' to 600'**	**300**
Production	**5.5"**	**3815'**	**2450' to 3815'**	**235**
Tubing	**2.875"**	**3636'**	**' to '**	

Additional Cementing: DV tool set at 2450 and cemented to surface with 400 sacks.
Packer type and setting depth: Arrowset set @ 3636'

In addition to the specific permit conditions and requirements set out above or on the attachment hereto, this permit is subject to all of the provisions of K.A.R. 83-3-400 et seq. Injection authority cannot be transferred without approval of the Conservation Division.

See attached for leases supplying fluid for disposal.

Date Approved: June 18, 2015

Director, Underground Injection Control
Conservation Division

Well(s), Leases(s) and Facilities supplying fluid for injection:

Lease Operator	Lease Name	Lease Description
Berexco LLC	Wellington Unit	S/2 Section 20; Section 29, W/2 & W/2 SE/4 Section 28; E/2 & E/2 E/2 NW/4 Section 32; Section 33, 31S-1W. SE/4 Section 6; W/2 & NE/4 & N/2 SE/4 Section 5; E/2 & NW/4 & E/2 SW/4 & NW/4 SW/4 Section 4; NE/4 Section 7; and NW/4 Section 8 and W/2 NE/4 Section 9-32S-1W

Class 2 Permit Features

- Protects Useable Drinking Water – surface casing covering USDW cemented to surface.
- Requires production casing be cemented well above injection perfs, but not necessarily to surface.
- Area of review completed by State regulators to confirm no improperly plugged wells or conduits
- MIT testing required
- Monitoring of annulus required and well can be inspected by state regulators at any time
- USEPA oversight of State's Class 2 program
- You can actually get a Class 2 permit

Wellington KS Class 6 Permit Application Timeline

- Berexco and KS Geological Survey Team started work on permit application Oct 2012
- First internal draft January 2013
- Internal simulation modeling completed February 2014
- Permit application submitted to USEPA May 2014. 1468 page document, including appendices

OMB No. 2040-0042 Approval Expires 11/30/2014

United States Environmental Protection Agency

EPA

Underground Injection Control Permit Application

(Collected under the authority of the Safe Drinking Water Act. Sections 1421, 1422, 40 CFR 144)

I. EPA ID Number			
		T/A	C
U			

Read Attached Instructions Before Starting

For Official Use Only

Application approved (mo day year)	Date received (mo day year)	Permit Number	Well ID	FINDS Number

II. Owner Name and Address

Owner Name: Berexco LLC

Street Address: 2020 North Bramblewood Dr.

Phone Number: (316) 265-3311

City: Wichita

State: KS

ZIP CODE: 67206

III. Operator Name and Address

Owner Name: Berexco LLC

Street Address: 2020 North Bramblewood Dr.

Phone Number: (316) 265-3311

City: Wichita

State: KS

ZIP CODE: 67206

IV. Commercial Facility

[x] Yes
[ ] No

V. Ownership

[x] Private
[ ] Federal
[ ] Other

VI. Legal Contact

[x] Owner
[ ] Operator

VII. SIC Codes

1311, 1321, 1381, 1382

VIII. Well Status *(Mark "x")*

[ ] A. Operating — Date Started (mo day year):

[ ] B. Modification/Conversion

[x] C. Proposed

IX. Type of Permit Requested *(Mark "x" and specify if required)*

[x] A. Individual [ ] B. Area

Number of Existing Wells	Number of Proposed Wells	Name(s) of field(s) or project(s)
0	1	Wellington Field

X. Class and Type of Well *(see reverse)*

A. Class(es) (enter code(s))	B. Type(s) (enter code(s))	C. If class is "other" or type is code 'x,' explain	D. Number of wells per type (if area permit)
Other (Class VI)	X	Geologic Sequestration	

XI. Location of Well(s) or Approximate Center of Field or Project

Latitude Deg	Min	Sec	Longitude Deg	Min	Sec	Township and Range Sec	Twp	Range	1/4 Sec	Feet From	Line	Feet From	Line
37	19	10.1	97	26	.451	28	31S	1W	SW	560	S	1700	W

XII. Indian Lands (Mark 'x')

[ ] Yes
[x] No

XIII. Attachments

(Complete the following questions on a separate sheet(s) and number accordingly; see instructions)

For Classes I, II, III, (and other classes) complete and submit on a separate sheet(s) Attachments A--U (pp 2-6) as appropriate. Attach maps where required. List attachments by letter which are applicable and are included with your application.

XIV. Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possiblity of fine and imprisonment. (Ref. 40 CFR 144.32)

A. Name and Title *(Type or Print)*: Dana Wreath, Vice President Berexco LLC

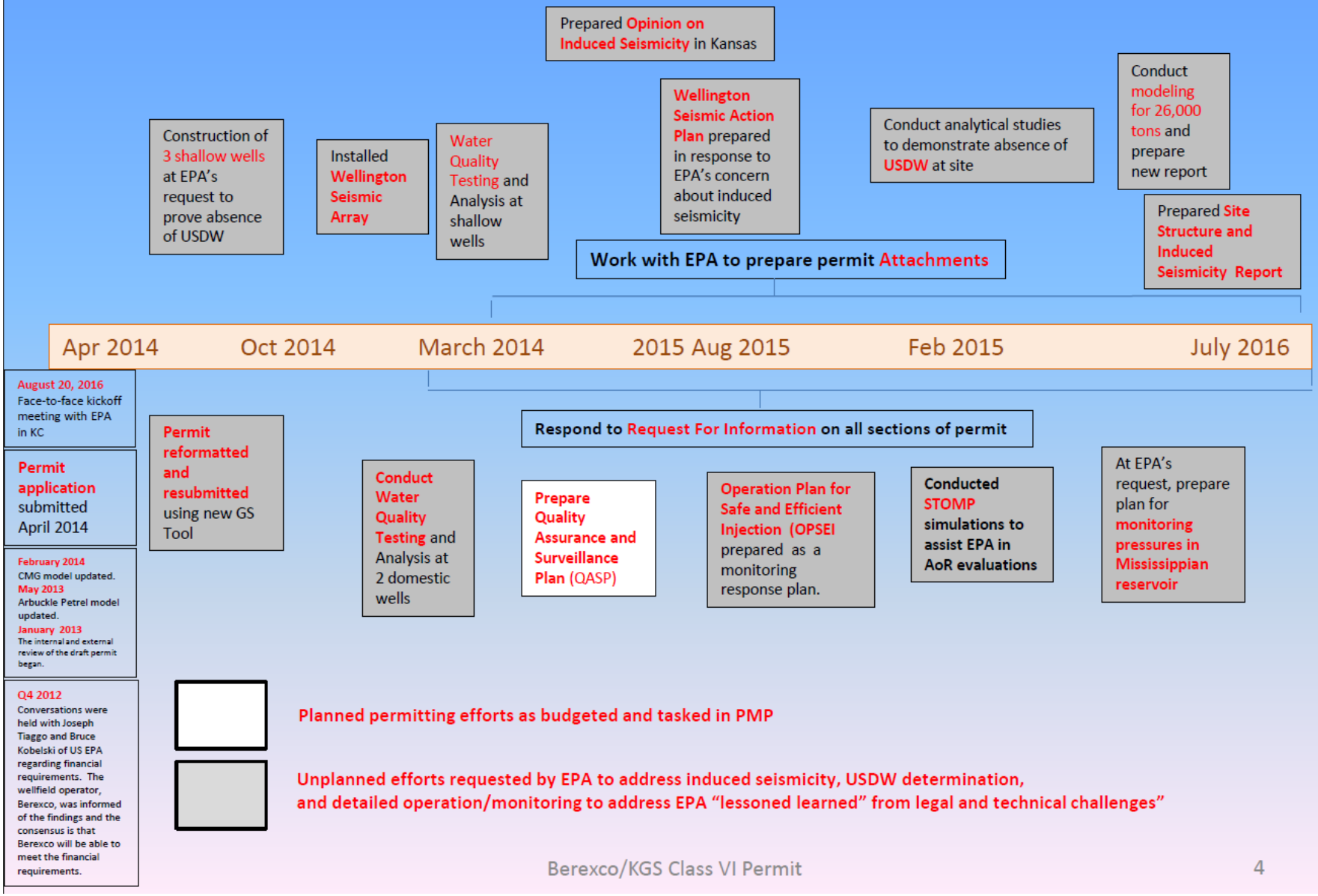
B. Phone No. *(Area Code and No.)*: (316) 337-8331

C. Signature: Dana Wreath

D. Date Signed: May 23, 2014

EPA Form 7520-6 (Rev. 12-11)

Permitting Timeline



Status of Attachments in the Wellington Permit

- Permit details are in the following 9 attachments
- 7 Attachments near completion

A. SUMMARY OF OPERATING REQUIREMENTS Draft Prepared

B. AREA OF REVIEW AND CORRECTIVE ACTION PLAN Awaiting confirmation of Area of Review by EPA modelers

C. TESTING AND MONITORING PLAN Draft Prepared

D. WELL PLUGGING PLAN Draft Prepared

E. POST-INJECTION SITE CARE AND SITE CLOSURE PLAN Awaiting confirmation of Area of Review by EPA modelers

F. EMERGENCY AND REMEDIAL RESPONSE PLAN Draft Prepared

G. CONSTRUCTION DETAILS Draft Prepared

H. FINANCIAL ASSURANCE DEMONSTRATION Costs for three out of four cost categories finalized. KGS preparing a response document to lower cost of one emergency scenario. Berexco needs to inform EPA of the preferred financial instrument to guarantee financial obligations.

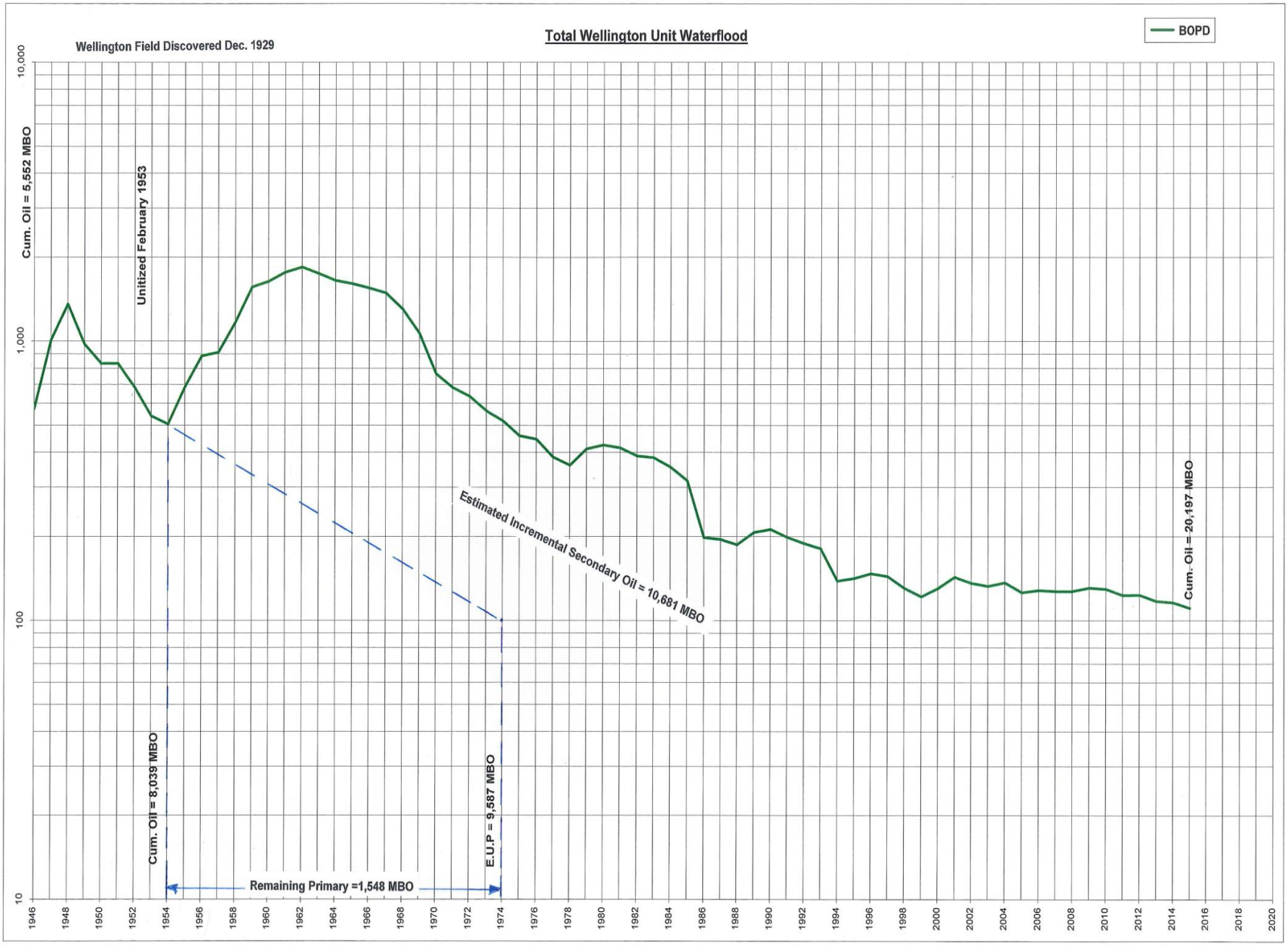
I. STIMULATION PROGRAM Draft Prepared

Class 6 – Where are we now?

- Some fundamental issues pending.
- USEPA modeling results and related area of review determination.
- Post Injection Site Closure duration and terms still pending. Relates to financial assurance requirements.
- May have a draft permit to be made public in 6-12 months, but are not sure.
- After that, still have public comment period and potential for litigation.

Wellington EOR Project

- Small scale CO2 injection in portion of large successful waterflood.
- Mississippian carbonate formation – dolomite and lime.
- Oil response and CO2 also arriving at producing wells.
- Measurement of CO2 injected and recovered, material balance calculation of CO2 stored.


Total Wellington Unit Waterflood
BOPD
Wellington Field Discovered Dec. 1929
Unitized February 1953
Cum. Oil = 5,552 MBO
Cum. Oil = 8,039 MBO
Estimated Incremental Secondary Oil = 10,681 MBO
Remaining Primary =1,548 MBO
E.U.P = 9,587 MBO
Cum. Oil = 20,197 MBO
10,000
1,000
100
10
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
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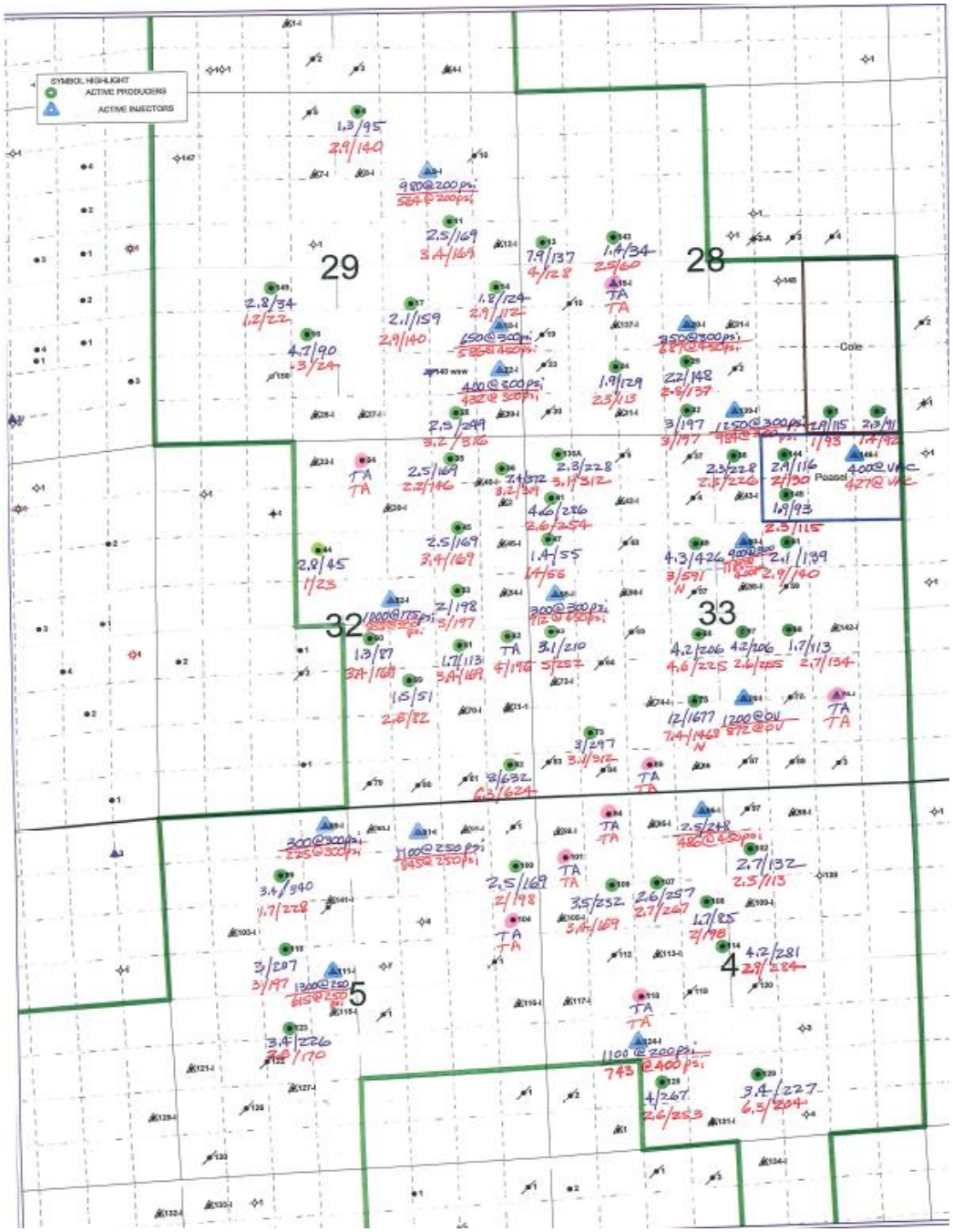
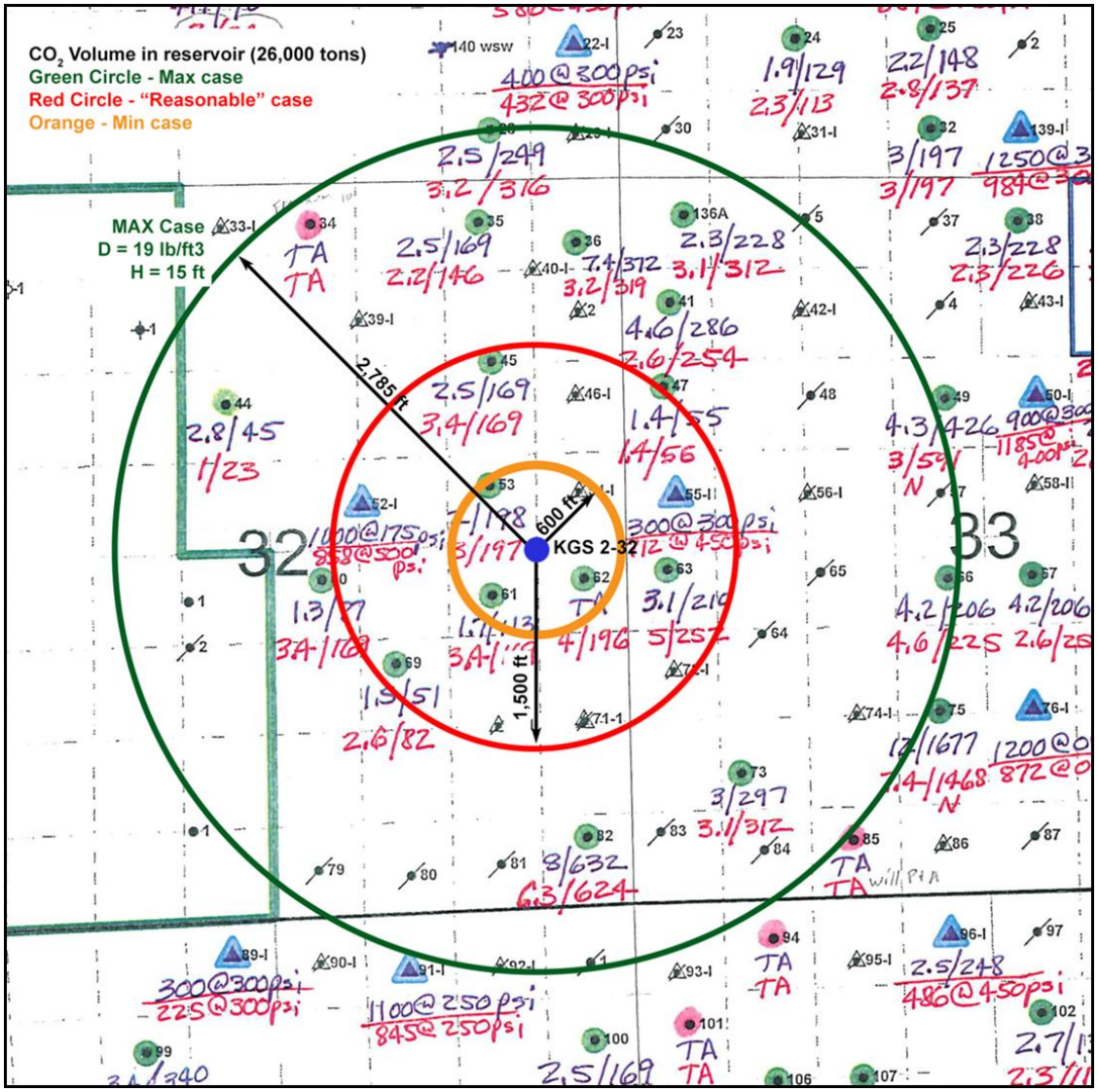
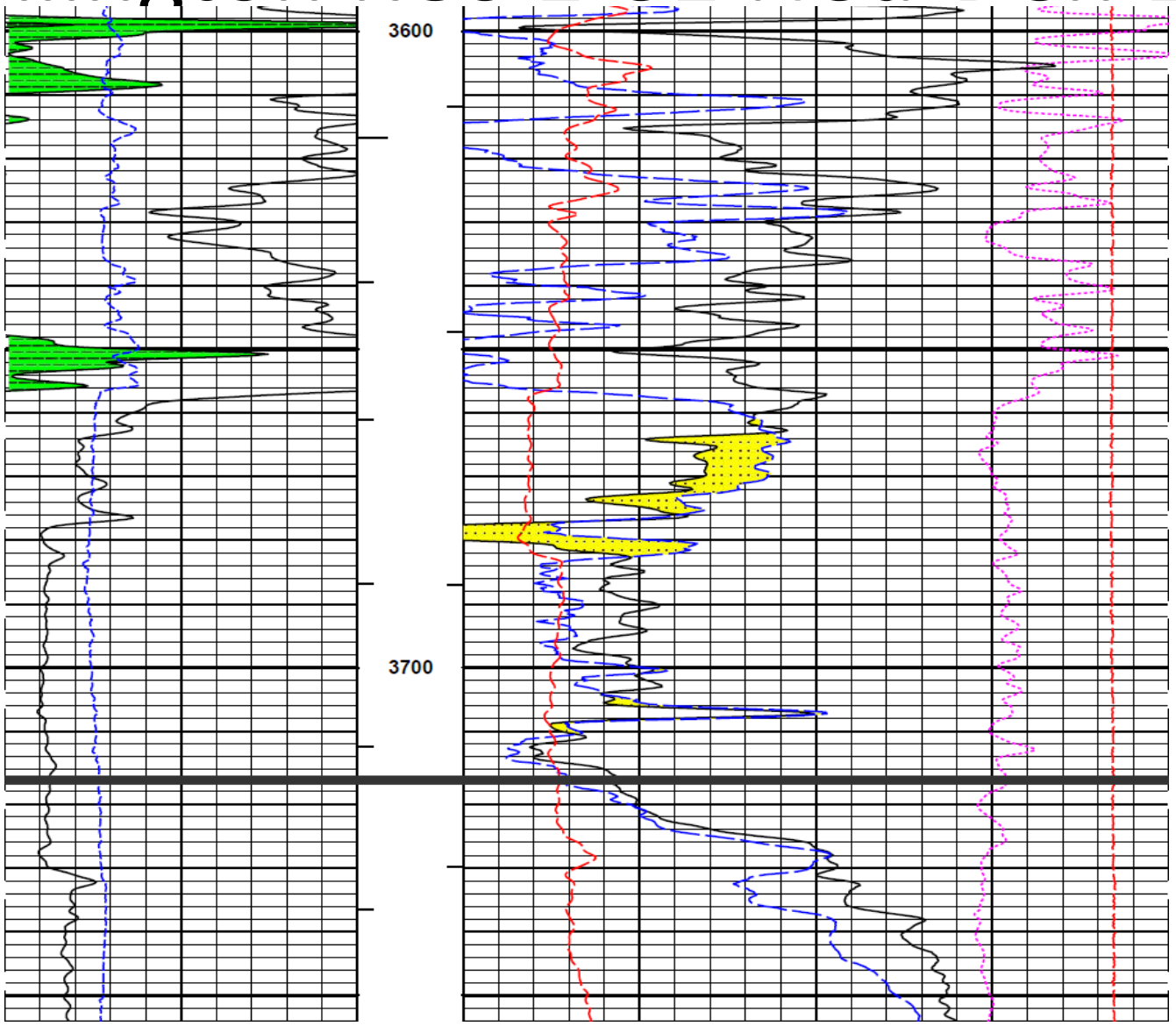
2010
2012
2014
2016
2018
2020


SYMBOL HIGHLIGHT
ACTIVE PRODUCERS
ACTIVE INJECTORS
29
28
32
33
4
5
Cole
Passol

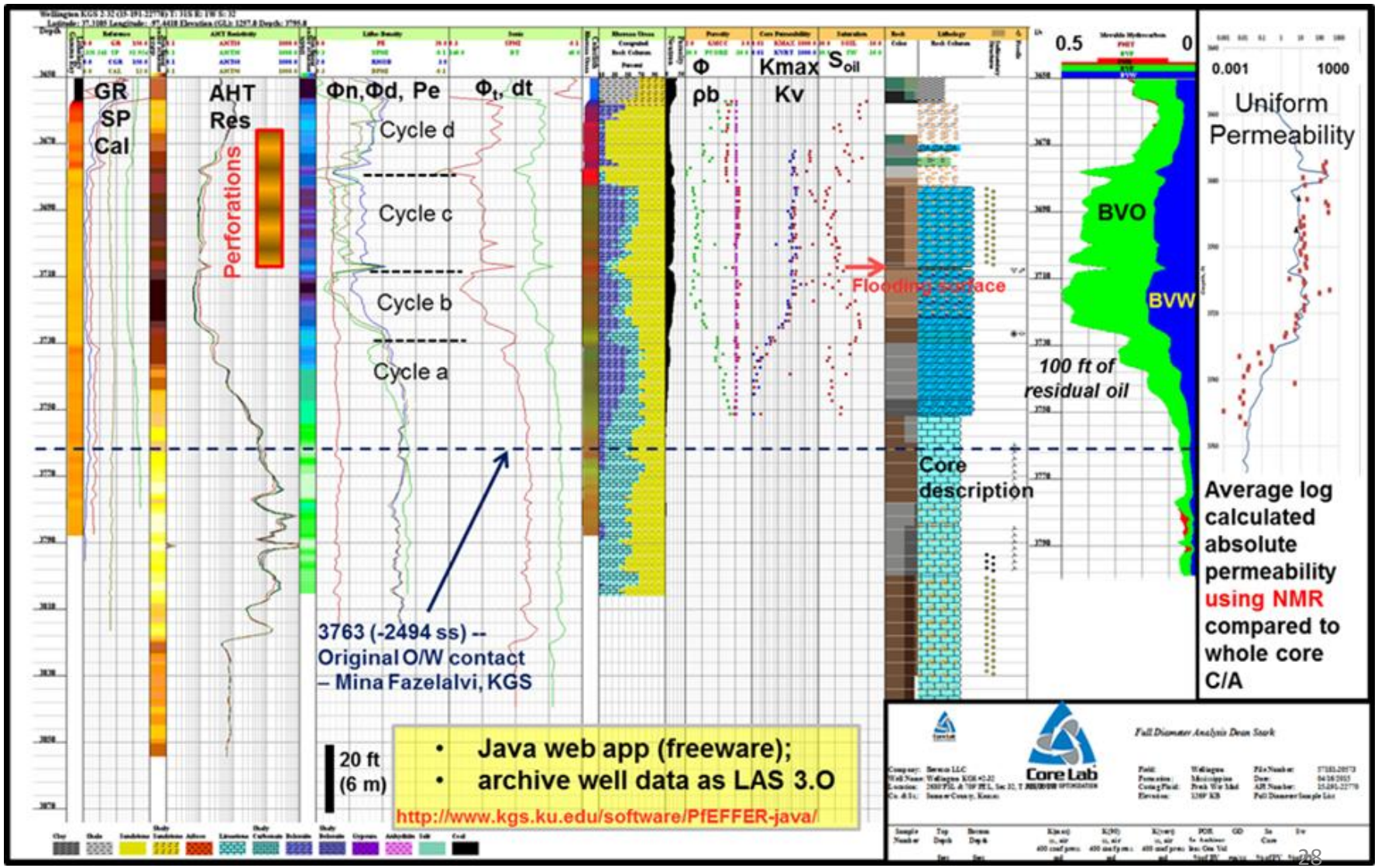
Wellington CO2 Project



Wellington KGS 2-32 Neu-Den Log

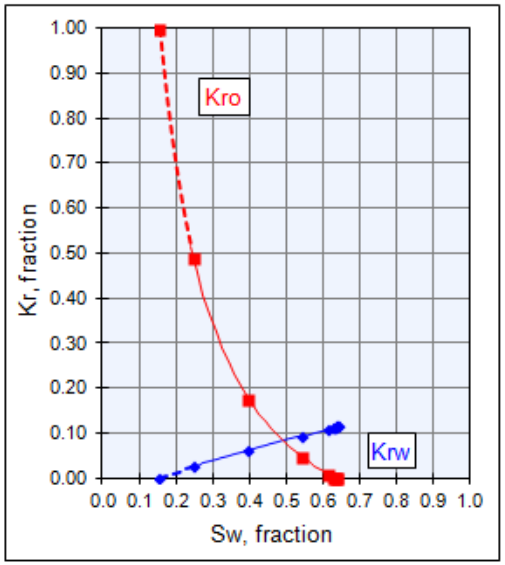


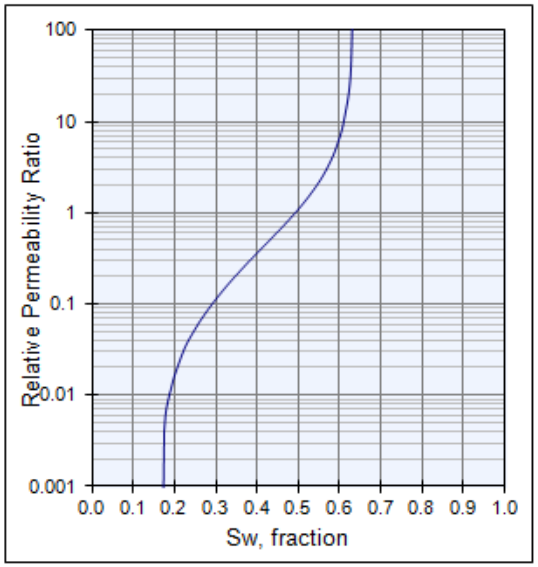
Mississippian Reservoir

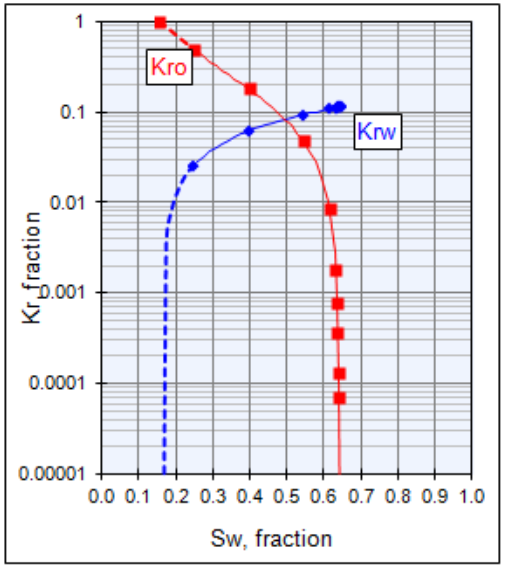


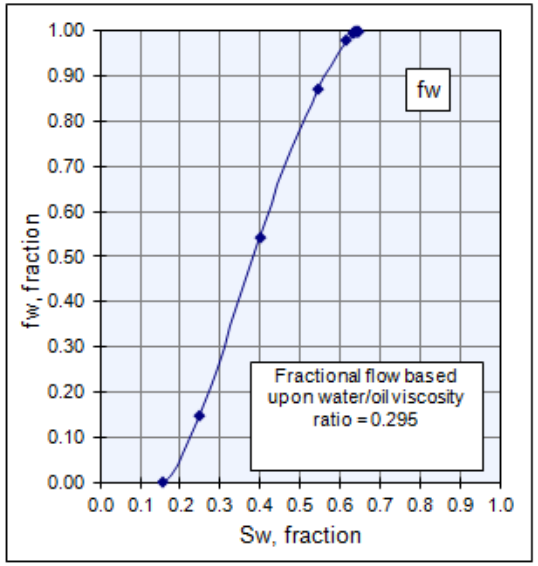
Company:	Berexco LLC
Well:	Wellington KGS #2-32
Field:	Wellington
Location:	Sumner County, Kansas
File:	HOU-150357

Sample Number:	1
Sample Depth, feet:	3685.20
Permeability to Air, md:	10.1
Klinkenberg Permeability,md:	8.08
Porosity, fraction:	0.252
Initial Water Saturation, fraction:	0.158
Effective Oil Permeability at Swi, md:	7.36









CO2 Injection

5/30/16	1502 BBL CO2 injected @ 166# TP. Current rate 1588 BPD. E. Nelson 27 BO.
5/31/16	1480 BBL CO2 injected @ 154# TP. Current rate 1428 BPD. E. Nelson 28 BO.
6/1/16	1472 BBL CO2 injected @ 180# TP. Current rate 1453 BPD. E. Nelson 28 BO.
6/2/16	1758 BBL CO2 injected @ 180# TP. Current rate 1543 BPD. E. Nelson 28 BO.
6/3/16	1186 BBL CO2 injected @ 160# TP. Current rate 1373 BPD. E. Nelson 4 BO- cleaned stock tank.
6/4/16	1236 BBL CO2 injected @ 171# TP. Current rate 1473 BPD. E. Nelson 33 BO.
6/5/16	1433 BBL CO2 injected @ 152# TP. Current rate 1322 BPD. E. Nelson 35 BO.
6/6/16	1727 BBL CO2 injected @ 184# TP. Current rate 1575 BPD. E. Nelson 32 BO.
6/7/16	1176 BBL CO2 injected @ 200# TP. Current rate 1405 BPD. E. Nelson 33 BO.
6/8/16	1514 BBL CO2 injected @ 177# TP. Current rate 1508 BPD. E. Nelson 45 BO.
6/9/16	1514 BBL CO2 injected @ 178# TP. Current rate 1453 BPD. E. Nelson 42 BO.
6/10/16	1298 BBL CO2 injected @ 180# TP. Current rate 1657 BPD. E. Nelson 42 BO.
6/11/16	1641 BBL CO2 injected @ 190# TP. Current rate 1496 BPD. E. Nelson 15 BO- issues with separator.
6/12/16	1417 BBL CO2 injected @ 174# TP. Current rate 1323 BPD. E. Nelson 42 BO.
6/13/16	1448 BBL CO2 injected @ 205# TP. Current rate 1433 BPD. E. Nelson 37 BO.
6/14/16	1499 BBL CO2 injected @ 207# TP. Current rate 1449 BPD. E. Nelson 33 BO.
6/15/16	1223 BBL CO2 injected @ 205# TP. Current rate 1420 BPD. E. Nelson 31 BO.
6/16/16	1578 BBL CO2 injected @ 250# TP. Current rate 1276 BPD. E. Nelson 33 BO.
6/17/16	1106 BBL CO2 injected @ 211# TP. Current rate 1502 BPD. E. Nelson 36 BO.
6/18/16	1889 BBL CO2 injected @ 210# TP. Current rate 1401 BPD. E. Nelson 35 BO.
6/19/16	879 BBL CO2 injected @ 231# TP. Current rate 1225 BPD. E. Nelson 40 BO.
6/20/16	1339 BBL CO2 injected @ 218# TP. Current rate 1414 BPD. E. Nelson 33 BO.
6/21/16	1495 BBL CO2 injected @ 237# TP. Current rate 1133 BPD. E. Nelson 44 BO.
6/22/16	1302 BBL CO2 injected @ 213# TP. Current rate 1226 BPD. E. Nelson 40 BO. CO2 pump shut down permanently 4:00 pm, 6/22/16. Killed well with 40 BW and left shut in.

Injection Well Downhole Equipment

- Lined tubing
- Packer equipped for CO2 service
- Profile nipple and on/off tool
- If needed, can set wireline plug in profile nipple and then sting out with tubing leaving plugged packer in bottom of the well.

Injection Tubing Lining - NOV

TK®-70XT

TK-70XT is a tough, flexible; thick-film coating that has been modified for enhanced abrasion resistance. Laboratory testing has shown it to be 11x more abrasion resistant than standard TK-70. This thermoset coating is suitable for CO_2 injection, oil and water service, including rod pumping applications where excellent mechanical performance is required. Hydrocarbons can cause problems with certain corrosion control solutions in water handling. TK-70XT is hydrocarbon resistant and provides outstanding protection during systematic acidizing. This coating can be applied to new or used pipe, holiday free, which results in a smooth surface that provides increased hydraulic efficiency and deposit mitigation.

Specifications

Type	Epoxy (Powder)
Color	Dark Red
Temperature	225°F (107°C)
Pressure	To yield strength of pipe.
Applied Thickness	10-20 mils (254-508 μm)
Primary Applications	New and used tubular goods
Primary Services	Subsurface CO_2 and water handling systems, salt solutions, crude oil production (rod pumping), and mild mineral acids
Limited Service	Should be limited to low concentrations of H_2S

TK®-70XT

Injection Packer

Wellington KGS 2-32. The pkr. is a 5 ½ x 2 7/8

Nickel coated AS1 with viton rubber kit (rubbers,

o-rings and seals), the on off tool is a DT-2

Nickel coated with viton seal kit and stainless steel stinger.

Packer sets last motion up, ¼ turn to the right

at the tool, stack out 15000# then pull 15000#

tension (do this 2-3 times) you can now leave tool

in tension compression or neutral.

Packer releases by stacking out weight on pkr. ¼

turn to the right and pickup tubing to release.

On off tool releases from pkr. by stacking out weight

on pkr. ¼ turn to the left and pick up tubing, on off tool

latches back to pkr. by setting weight on it.

The profile size is 1.875X

ASI-X PACKER

The **ASI-X Single String Double-Grip Production Packer** is the most versatile of the mechanically set retrievable packers and may be used in any production application. This packer is suited for treating, testing, or injection applications, in pumping or flowing wells, either deep or shallow. This packer can be left in tension or compression depending on well conditions and the required application.

A large internal by-pass reduces swabbing when running and retrieving. The by-pass closes when the packer is set and opens prior to releasing the upper slips when retrieving to allow pressure equalization. The J-slot design allows easy setting and releasing; 1/4 turn right-hand set, 1/4 turn right-hand release.

The standard ASI-X Packer is designed for differential pressures up to 7,000 PSI (unless noted otherwise). This packer is also available in an HT version which is designed for differential pressures up to 10,000 PSI (unless noted otherwise). The HT version allows this packer to be utilized in completions where high pressure treating operations are performed and it is desirable to leave the tool in the well for production.

Special Features

- By-pass below upper slips to wash debris when valve is opened
- By-pass is opened before upper slips are released
- Can be set with tension for shallow well applications
- Can be left in tension, compression or neutral
- 1/4 turn right-hand set, 1/4 turn right-hand release
- Additional J-Slot arrangements available

Product Specifications

Casing		Recommended Hole Size (inches)	Gage OD (inches)	Max OD (inches)	Tool ID (inches)	Thread Connections Box Up / Pin Down	Part Number	
Size (inches)	Weight (lbs/ft)						Std	HT
2-7/8	6.4 - 6.5	2.375 - 2.441	2.250	2.263[1]	0.63	1.050 EUE	60325-3E*	-
	8.6	2.259	2.125	2.152[1]	0.63	1.050 EUE	60324-3E*	-
3-1/2	7.5 - 7.7	3.068 - 3.250	2.938	-	1.25	1.900 NUE	60336*	-
	7.7 - 10.2	2.922 - 3.068	2.781	-	1.25	1.900 NUE	60335*	-
	12.95	2.750	2.562	-	1.00	1.315 EUE / 1.660 EUE	60337*	-
4	9.5 - 11.0	3.476 - 3.548	3.250	3.312[1]	1.50	1.900 EUE	60340*	-
	10.46 - 12.95	3.340 - 3.476	3.187	-	1.50	1.900 EUE	60341*	-
4-1/2	9.5 - 13.5	3.920 - 4.090	3.750	-	1.94	2-3/8 EUE	60345[2]	60345HT[2]
	13.5 - 15.1	3.826 - 3.920	3.650	-	1.94	2-3/8 EUE	60344[2]	60344HT[2]
	15.1	3.826	3.641	-	1.94	2-3/8 EUE	60346	-
	15.1 - 16.6	3.754 - 3.826	3.594	-	1.50	1.900 EUE	60343	-
	18.8	3.640	3.437	-	1.50	1.900 EUE	60342	-
5	11.5 - 15.0	4.408 - 4.560	4.125	4.220[1]	1.94	2-3/8 EUE	60350	60350HT
	15.0 - 18.0	4.276 - 4.408	4.063	-	1.94	2-3/8 EUE	60349	-
	18.0 - 20.8	4.156 - 4.276	4.000	4.010[1]	1.94	2-3/8 EUE	60352	60352HT
	21.4	4.126	3.938	-	1.94	2-3/8 EUE	60353	60353HT

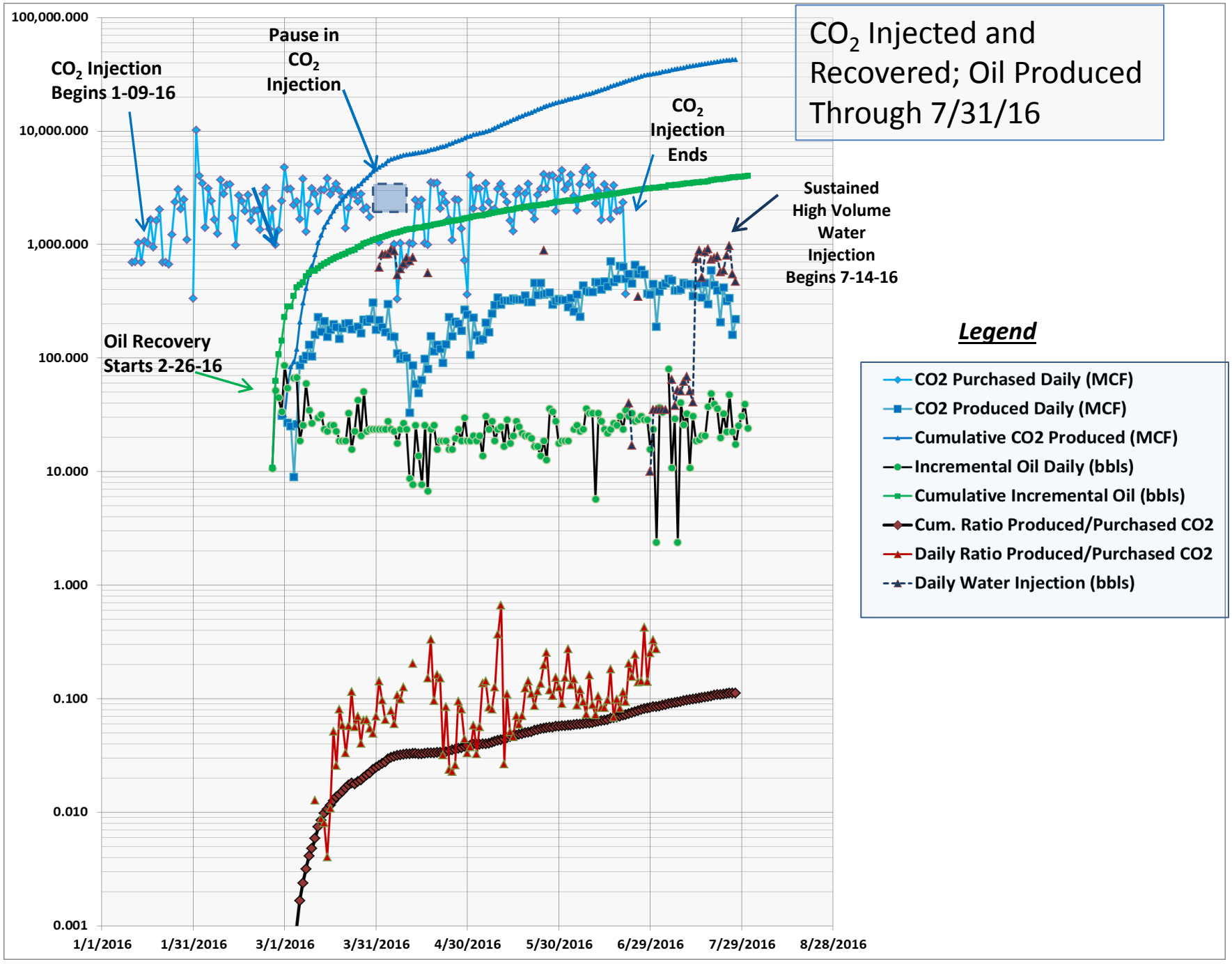
[1] Maximum OD is across retracted drag blocks.
[2] Drilled for wireline.
* Designed for differential pressures up to 10,000 PSI.
Rubber Trim Upgrade Options (additional cost, inquire with a D&L sales associate): HSN, Viton, ECNER/Aflas, ECNER/HSN, EPDM
NOTE: All pricing includes standard Nitrile trim. Other sizes, connections, and rubber options available upon request.

Wellington Results

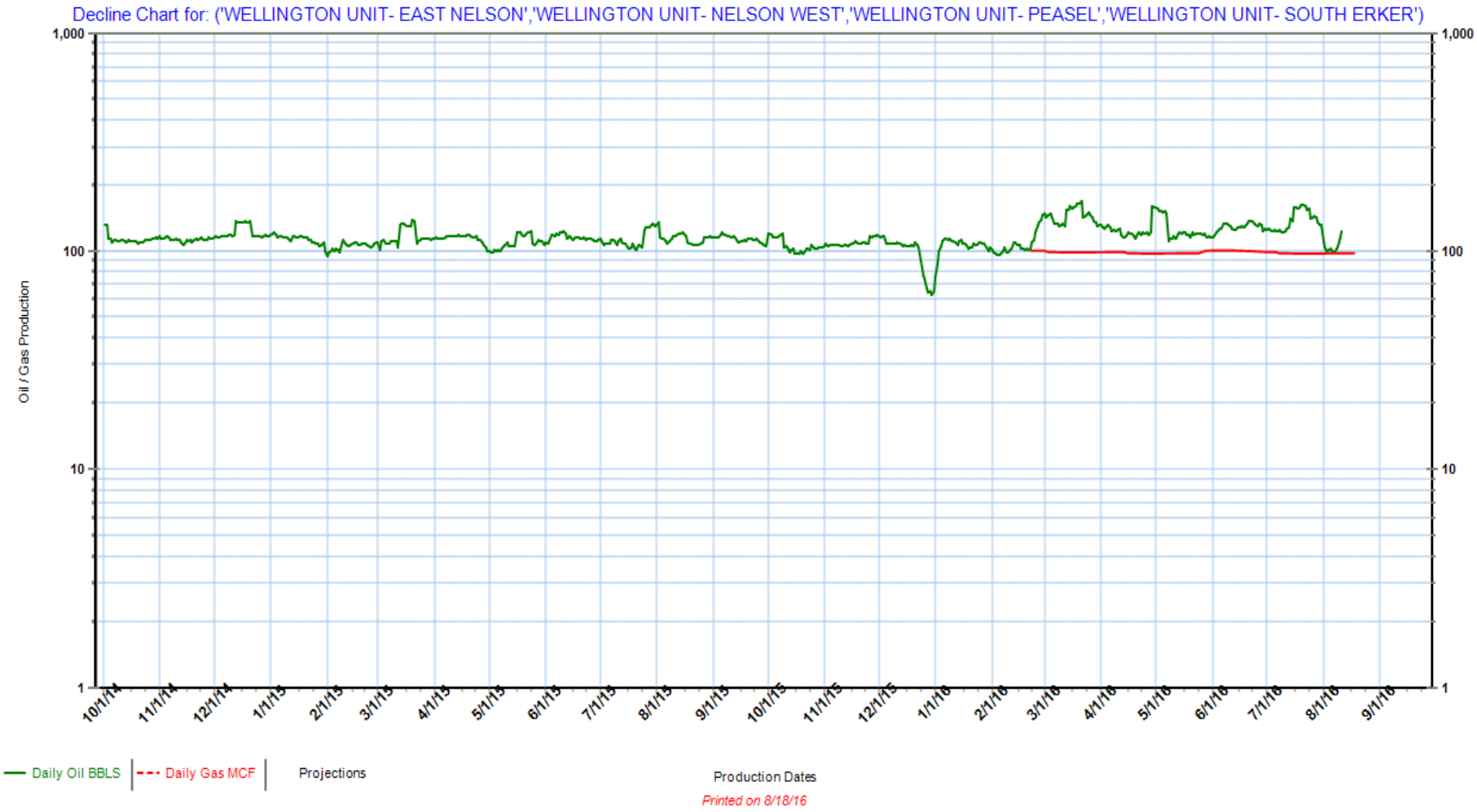
- CO2 Accounting
- Total 374,461 MCF Injected (21,784 US tons)
- Required 1,101 Truckloads, each about 20 US tons.
- Incremental Oil Production about 4,200 bbls as of 7/31/2016.
- Approximately 11% of CO2 injected has been produced (vented) as of 7/31/2016

Wellington Scale Comparisons

- Average CO2 injection rate: 2,500 MCFD
- A 45 MMGPY ethanol plant emits about 7,500 MCFD CO2. CO2 volume is linear to MMGPY.
- Wellington project injected about 22,000 US tons of CO2 (Approx 20,000 Metric Tons).
- EPA.GOV states “A typical passenger vehicle emits about 4.7 metric tons of CO2 per year” https://www.epa.gov/sites/production/files/2016-02/documents/420f14040a.pdf
- 20,000/4.7 = 4,255 cars (for one year)


CO_2 Injected and Recovered; Oil Produced Through 7/31/16
CO_2 Injection Begins 1-09-16
Pause in CO_2 Injection
CO_2 Injection Ends
Sustained High Volume Water Injection Begins 7-14-16
Oil Recovery Starts 2-26-16
Legend
CO2 Purchased Daily (MCF)
CO2 Produced Daily (MCF)
Cumulative CO2 Produced (MCF)
Incremental Oil Daily (bbls)
Cumulative Incremental Oil (bbls)
Cum. Ratio Produced/Purchased CO2
Daily Ratio Produced/Purchased CO2
Daily Water Injection (bbls)
100,000.000
10,000.000
1,000.000
100.000
10.000
1.000
0.100
0.010
0.001
1/1/2016
1/31/2016
3/1/2016
3/31/2016
4/30/2016
5/30/2016
6/29/2016
7/29/2016
8/28/2016

Wellington Unit Oil Production



CO2 Produced Gas Measurement

- Cameron MC-III EXP Flow Measurement
- Installed at wellhead vent, or 2 phase separator at well.
- Separators needed to stop liquids flowing up annulus making a mess as gas volumes increase.
- CO2 Content Sensors for low volume gas venting.

CAMERON
A Schlumberger Company

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NUFLO Gas Turbine Meters

Overview Specifications

Overview

NUFLO GT gas turbine flowmeters feature a transducer that utilizes a lightweight, low-inertia rotor to sense gas velocity. It offers an output frequency that has a linear relationship to gas velocity over a wide flow range.

The meter tracks the flow rate continuously, offers little resistance to flow, and has a unique cartridge design that allows removal of all internal parts as one assembly. The meter also exhibits little sensitivity to gas density above two atmospheres pressure. The low inertia of the rotor and vee bearings allows overranging of the meter to twice its rated capacity without damage for intermittent flow variations.

NUFLO™

MC-III™ EXP Flow Analyzer

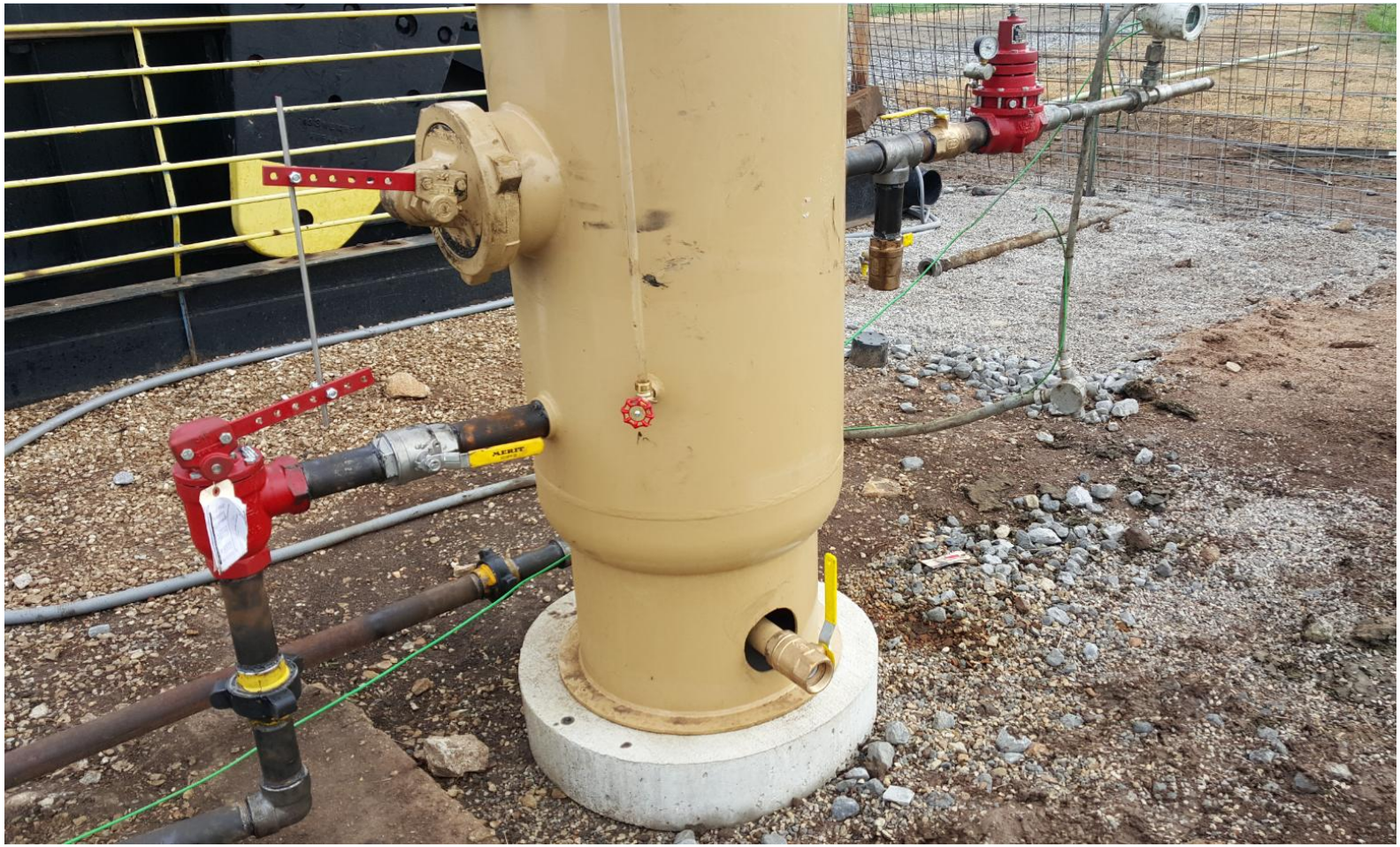
User Manual

CO2 Measurement Data

	A	B	C	D	E	F	G	H
1	KGS MCF/D and % CO2 venting		TOTAL			TOTAL		
2	Well	Date	MCF	% CO2	Date	MCF	% CO2	
3	Red Circle							
4	53	1-Aug	9163	100	2-Aug	9223	100	
5	61	1-Aug	12415	100	2-Aug	12497	100	
6	62	1-Aug	5355	100	2-Aug	5504	100	
7	Green Circle							
8	45	1-Aug	0	2.2	2-Aug	0	2.2	
9	47							
10	60	1-Aug	6901	100	2-Aug	6995	100	
11	63	1-Aug	3024	100	2-Aug	3025	100	
12	69							
13	Orange Circle							
14	35							
15	36							
16	41							
17	44							
18	73							
19	82							
20	136A							
21								
22	Other							
23	6							
24	E Nelson TB	1-Aug	6715	100	2-Aug	6747	100	
25	S. Erker TB							
26								
27								
28	**TOTAL**		**43573**			**43991**		
29								
30								

Wellington Oil Well Configuration

2 Phase Separator



CO2 Measurement at Tank Battery

Conclusions

- EOR projects with Class 2 permitting can accurately measure CO2 injected, recovered and stored in the reservoir
- EOR projects WILL produce CO2, including after CO2 injection ceases
- Need to differentiate between reinjected and vented CO2 from producers and tank batteries

- Thanks and Credits to DOE/NETL, Kansas Geological Survey, Berexco LLC.