ARBUCKLE HYDROSTATIC LEVELS

(ARE WE RUNNING OUT OF ROOM?)

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Consortium to Study Trends in Seismicity

July 18, 2018, Wichita, KS
POTENTIOMETRIC SURFACE
HYDROSTATIC SURFACE
PIEZOMETRIC SURFACE
(inference of subsurface flow patterns)

Well #1

Well #2

Well #3

Well #4

“freeboard”

flow direction

confined aquifer

Potentiometric Surface

cross-sectional view
ELEVATION of HYDROSTATIC SURFACE of CAMBRIAN-ORDOVICIAN ARBUCKLE GROUP (earlier versions)

(from Carr and others (1986))
ELEVATION of HYDROSTATIC SURFACE of ARBUCKLE (earlier versions)

Elevation of Hydrostatic Surface

Elevation of Land Surface

(from Jorgensen and others (1993))

Newell: July 2018
AN EASY SCENARIO when water salinity (i.e., density) is constant
ELEVATION of FLUID LEVEL in a WELL depends on brine density (dense brines lay low in a well)

DEPRESSION OF A STATIC FLUID LEVEL as a function of brine density

- 1500 ft
- 1232 ft SFL in 2016
- 1000 ft
- 500 ft
- sea level
- -500 ft
- -1000 ft
- -1500 ft
- -2000 ft
- -2500 ft

Salinity vs. Density
Kansas Brines

approximate salinity & density of City of Hutchinson #1 disposal water
approximate salinity & density of a dense brine (250,000 ppm TDS)

Both columns of water weigh the same, but the SFL is depressed 512 ft if the injected water is a dense brine

Newell, May 2018
DENSITY of DISPOSAL WATER CAUSING STRANGE DIFFERENCES in STATIC FLUID LEVELS

RENO COUNTY CLASS I & II DISPOSAL WELLS
ELEVATION of FLUID LEVEL in a WELL depends on brine density (dense brines lay low in a well)

DEPRESSION OF A STATIC FLUID LEVEL as a function of brine density

1500 ft
1232 ft SFL in 2016
1000 ft
500 ft
sea level
-500 ft
-1000 ft
-1500 ft
-2000 ft
-2500 ft
top Arbuckle (-2512')

approximate salinity & density of City of Hutchinson #1 disposal water
approximate salinity & density of a dense brine (250,000 ppm TDS)

Both columns of water weigh the same, but the SFL is depressed 512 ft if the injected water is a dense brine.

Newell, May 2018
SALINITY of ARBUCKLE (westward movement of fresh water off Ozark Dome into southeastern Kansas)

(from Carr et al., 2005)
ELEVATION of ARBUCKLE HYDROSTATIC SURFACE
(regardless of salinity)

Newell: May 2018
~717 ft separation between land surface and hydrostatic level for fresh water
<300 ft separation between land surface and hydrostatic level for fresh water
<100 ft separation between land surface and hydrostatic level for fresh water
0 ft separation between land surface and hydrostatic level for fresh water (fresh water will not enter Arbuckle by gravity feed)
(50,000 ppm TDS minimum necessary for brine to enter Arbuckle by gravity feed from surface)
ARBUCKLE DISPOSAL VOLUMES (by township) with fresh-water hydrostatic surface superimposed

SEVEN-YEAR DISPOSAL VOLUMES INTO THE ARBUCKLE (2010-2016; Total Volume per Township)

CLASS-I WELLS
CLASS-II WELLS

BBLS WASTE-WATER DISPOSED INTO ARBUCKLE, 2010-2016
- <1,000,000
- 1,000,000 to <5,000,000
- 5,000,000 to <10,000,000
- 10,000,000 to <20,000,000
- 20,000,000 to <40,000,000
- 40,000,000 to <80,000,000
- 80,000,000 or greater
DISPOSAL VOLUMES (per township) of CLASS-I & CLASS-II WELLS

SEVEN-YEAR DISPOSAL VOLUMES INTO THE ARBUCKLE
(2010-2016)

CLASS-I vs. CLASS-II WELLS
(Total Volume per Township)

CLASS-II DISPOSAL WELLS
1650 wells, 534 townships, 3,027.5 million bbls*

*excluding Class-II SWD wells in 120 townships on Central Kansas Uplift

CLASS-I DISPOSAL WELLS
49 wells, 25 townships; 620.9 million bbls

MILLION BARRELS (7 years disposal volume)

AVERAGE BARRELS PER DAY PER TOWNSHIP
RELATIVE DISPOSAL VOLUMES (per year) of CLASS-I & CLASS-II WELLS

SEVEN-YEAR DISPOSAL VOLUMES INTO THE ARBUCKLE (2010-2016)
CLASS-I vs. CLASS-II WELLS
(excluding Class-II SWD wells on Central Kansas Uplift)
FLUID RISES and DISPOSAL VOLUME ARE NOT REGIONALLY CORRELATIVE

KANSAS CLASS I ARBUCKLE DISPOSAL WELLS

FLUID VOLUME VS. FLUID RISE
in FIVE-YEAR PERIOD (2011-2015)


Rise (or fall) of hydrostatic level in Arbuckle disposal well from early 2011 to early 2016
CHANGES in STATIC FLUID LEVEL (color-coded) with fresh-water-equivalent hydrostatic surface superimposed

2011-2016 Change in Fluid Level (color coded) >>>>

Static Fluid Level average yearly change 2011-2016 (feet)

individual well

0

Static Fluid Level rising

SFL falling

+50

+40

+30

+20

+10

0

-10

-20

-30

-40

-50

Newell: May 2018
Hydrostatic Level of Arbuckle Water, Arbuckle Depth, and Land Surface (central Kansas)

- ONEOK Well #3, sec. 31-T17S.-R.09W.
- Compass Minerals Well #004, sec. 29-T20S.-R.07W.
- City of Hutchinson Well #1, sec. 21-T23S.-R.05W.
- Air Products & Chemical Injection Well #1, sec. 33-T28S.-R.01W.

- Arbuckle DSTs in oil wells (water-level inferred from P)
  sec. 31-T10S.-R.20W.

- Arbuckle water hydrostatic level in 2016
- Arbuckle water hydrostatic level in 2006

Central Kansas Uplift

Sedgwick Embayment of Anadarko Basin

V.E. = 113.5

Arbuckle water level changes over time in central Kansas.
ARBUCKLE FREEBOARD and projected years before loss of freeboard

FREEBOARD (depth of static fluid level from surface as of Jan 2016)


Newell: May 2018
SOURCES OF ADDITIONAL DATA for ARBUCKLE FLUID LEVELS other than Class-I wells (so we can better understand water levels and fluid movement)

- IDLE CLASS-II DISPOSAL WELLS -- energy industry cooperation urgently needed
- MECHANICAL INTEGRITY TESTS -- disposal wells in eastern Kansas
- DRILL-STEM TESTS (imprecise, only general)
- TOWN WATER SUPPLIERS’ ARBUCKLE WELLS -- SE Kansas only
HYDROSTATIC MEASUREMENTS from MECHANICAL INTEGRITY TESTS help in eastern Kansas

MISSISSIPPIAN DISPOSAL WELLS

A Richard Oil Co.
Austin-Rush #1-SWD
sec 11-T28S-R18E

B R&B Oil
Kepley Farms #10-SWD
sec 20-T28S-R18E

C Joe & Jeff Kephart
Hudson #4
sec 21-T28S-R20E

D Brecheisen & Cook
Kite #1-SWD
sec 32-T30S-R19E

ARBUCKLE DISPOSAL WELLS

1 Richard T. Falkin
Cooney #1
sec 22-T28S-R20E

2 Quest Cherokee, LLC
Strange SWD ‘A’ #1-30
sec 30-T28S-R20E

3 John M. Magee
Graham #4-A
sec 14-T30S-R18E

4 Quest Energy Service
Bailey #1-SWD
sec 18-T30S-R18E

5 A.W. Brecheisen et al.
Vogel #3
sec 23-T30S-R19E

6 Kephart Gas Production
Allen Kephart #2-SWD
sec 27-30S-R18E

MISSISSIPPIAN & ARBUCKLE STATIC FLUID LEVELS vs. TIME
9-township area, Neosho County

YEAR

STATIC FLUID LEVEL (feet relative to Sea Level) from mechanical integrity test

-100 0 (S.L.) 100 200 300 400 500 600 700 800 900 1000 1100 1200
STATIC FLUID LEVELS derived from DSTs vary

ARBUCKLE GROUP
HYDROSTATIC LEVEL vs. TIME
(freshwater equivalent)

Elev. (ft above S.L.)

DATE (year)

1990  2000  2010  2018

4-townships investigated

Graham Co.  Rooks Co.
Trego Co.  Ellis Co.

hydrostatic level from P
hydrostatic level from nearly equilibrated DST
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