The Kern River Reservoir of the Kern River Field: A Closed System*

Matthew Van Grinsven[1]

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[1]Division of Oil, Gas, and Geothermal Resources (matthew.vangrinsven@conservation.ca.gov)

Abstract

This study expands on the work of Coburn and Gillespie (2002), whose results suggest that a water management program to remove of excess water from the producing zones will increase steamflood efficiency. The current management plan bolsters the inward pressure gradient allowing fluids to be more efficiently produced and ensuring they remain in the bounds of the oil field. The previous work is limited to an up-dip section of the Field near the Kern River. To understand if the closed system assumption holds true for deeper western areas where there may be questions over the hydraulic connection to the SJ Basin or and Upper Chanac Formation below, a similar study was performed. There a correlation was found between increased production from interdiction wells and oil production and it is likely a result of a more efficient steam chest. Two causes for increased oil production may include greater accommodation space for the steam chest to expand caused by the reduction of reservoir fluids and/or a lower reservoir pressure required to maintain the steaming operations. Furthermore, in mature fields with a bottom water drive, it is common for the percentage of produced water to increase as oil production decreases with depletion. This is not the case for the Kern River Oil Field as the water-oil ratio has decreased over time. The decreasing water-oil ratio is strong evidence that the region acts as a closed system and maintains the economic viability of the oil field.

References Cited

Baumann, C.E., W.T. Osterloh, R.C. Temple, and C.S. Lolley, 2002, Full Field Simulation of Aquifer Interdiction in the Kern River Field, California: SPE/DOE Improved Oil Recovery Symposium, 13-17 April, Tulsa, Oklahoma, SPE 75151, 10 p.

Coburn, M.G., and J.M. Gillespie, 2002, A Hydrogeologic Study to Optimize Streaflood Performance in a Giant Oilfield: Kern River Field, California: American Association of Petroleum Geologists Bulletin, v. 86/8, p. 1489-1505.

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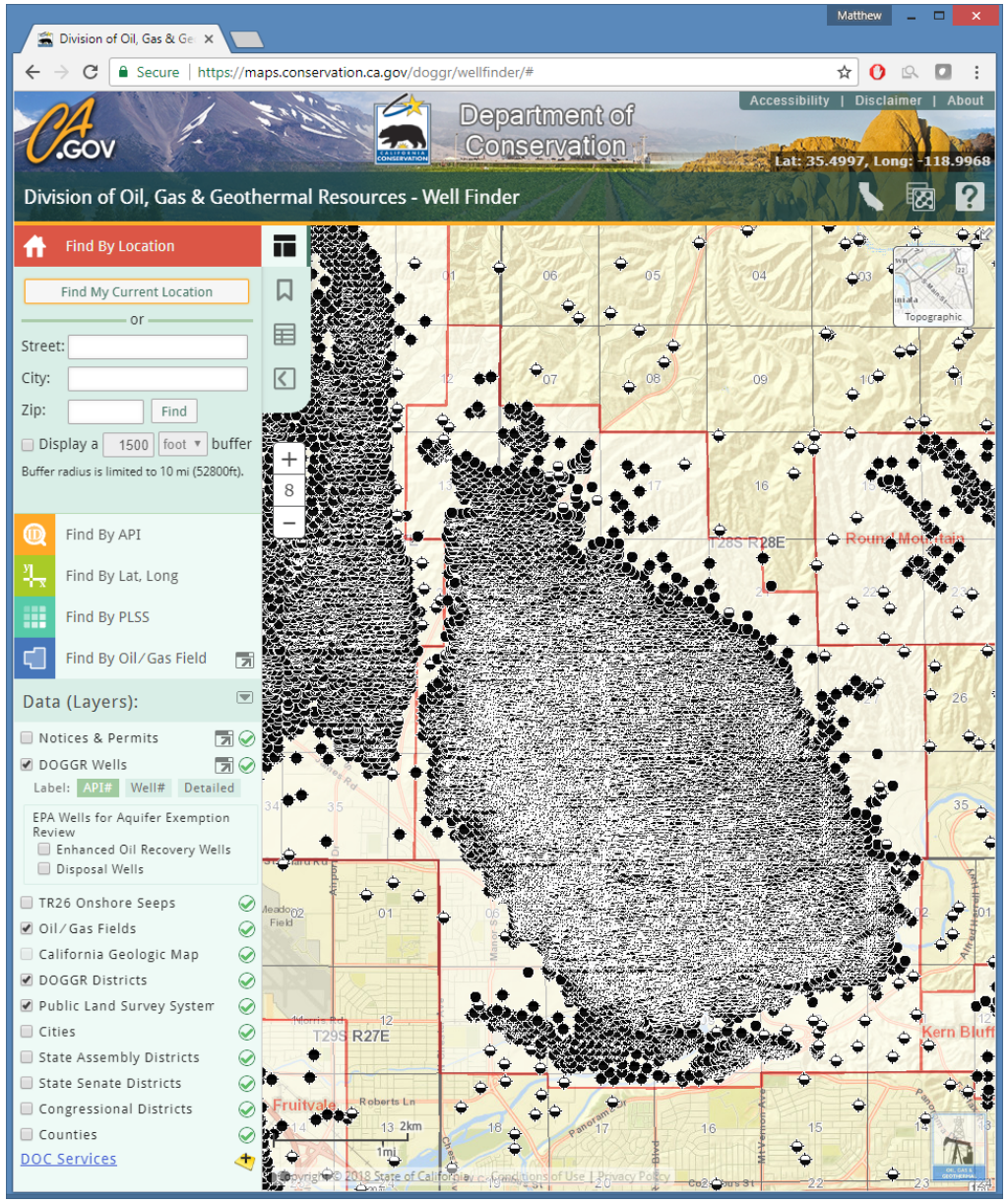
https://commons.wikimedia.org/wiki/File:Kern_River_Oil_Field_aerial.jpg

Geologic Applications in a Changing Regulatory Environment

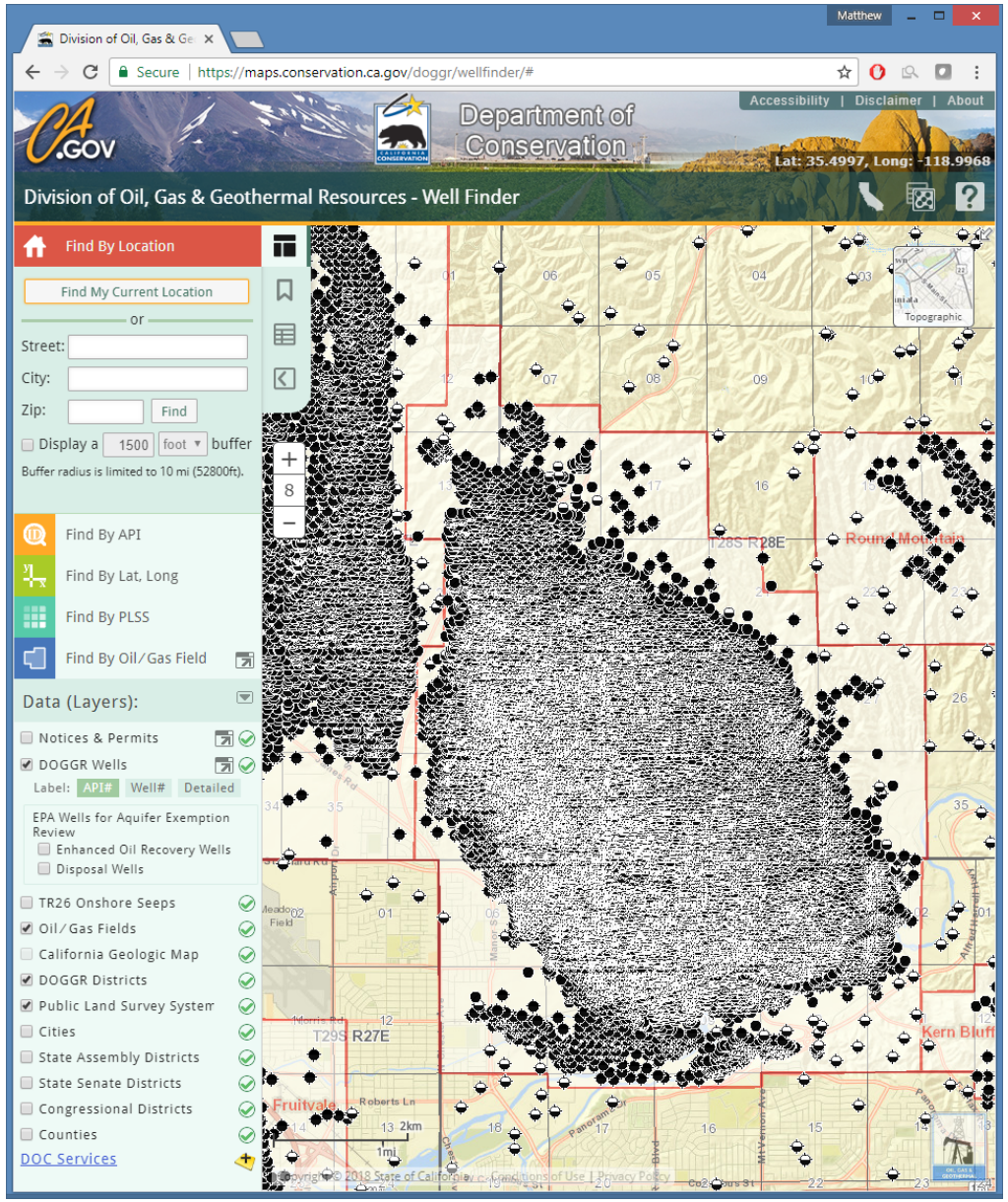
Questions and results of this study were brought about through discussions between the DOGGR and the Water Boards during the aquifer exemption process.

All data for this analysis is publically available on the DOGGR website.



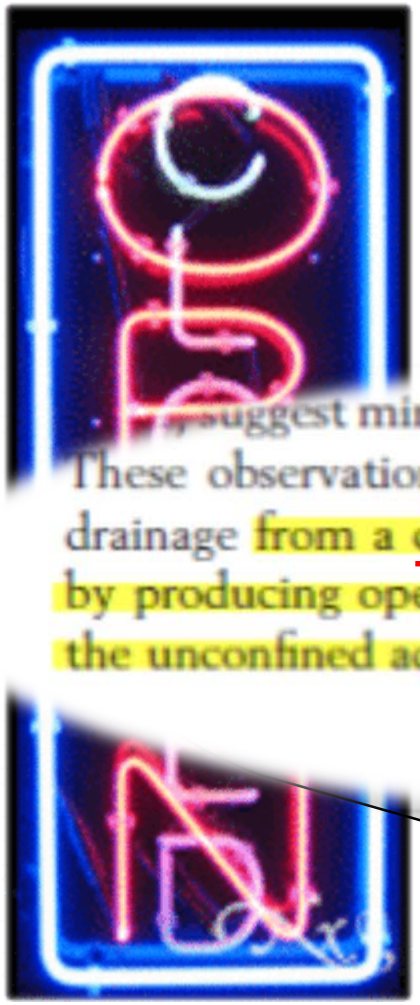
Geologic Applications in a Changing Regulatory Environment

- 16th Largest
- 13,000 active wells
- Producing since 1898
- >2.3 Billion Barrels of Oil Produced
- 247 million barrels of water produced in 2017
- 8-13% Water cut
- Within and surrounding Bakersfield City limits



The Safe Drinking Water Act (SDWA)

- Defaults to protecting all water (unless exempt or >10k mg/L).
- The US EPA is agency that makes the decision for whether an exemption is appropriate.
- The Division follows PRC 3131 (a) that mandates further scrutiny prior to proposing to the EPA
- My study was borne from the criteria that:
    - The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.
    - The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.



SPE 75151

Full Field Simulation of Aquifer Interdiction in the Kern River Field, California

C.E. Baumann, SPE-Altair Engineering, W.T. Osterloh, R.C. Temple and C.S. Lolley, SPE-ChevronTexaco Corp.

Abstract

suggest minimal groundwater recharge from natural sources. These observations suggest that fluids move downdip by gravity drainage from a closed volume, with significant removal of fluids by producing operations causing an overall decline in pressure in the unconfined aquifer. These findings are highly favorable for the

(Bauman et al 2002)

(Coburn and Gillespie 2002)

A hydrogeologic study to optimize steamflood performance in a giant oilfield: Kern River field, California

Michael G. Coburn and Janice M. Gillespie

AUTHORS

Michael G. Coburn — *Department of Geology, California State University Bakersfield, 9001 Stockdale Highway, Bakersfield, California, 93311; geomike@ncinternet.net*

Mike Coburn received his B.S. and M.S. degrees in geology in 1987 and 1996 from California State University in Bakersfield, California. He has been employed as a scout/development geologist for Getty and Texaco Oil from 1981 to 2002. He is currently entering the education field.

Janice M. Gillespie — *Department of Geology, California State University ...field, 9001 Stockdale Highway, ...ld, California, 93311; ...k.edu*

...eived her B.S. (1981) degree ...University, Minnesota, and ...degree in geology from the ...chool of Mines. She joined ...'s Pacific Coast Division as a ...al engineer in 1985 and received her ...in geology from the University of Wyoming in 1992. She is currently a professor of geology at California State University in Bakersfield, California.

...How ...mation and from ...disposal may provide un- ...for the steamed intervals, resulting in ...steamflood performance. Results of our study suggest that a water management program designed to remove and dispose of excess water from the producing zones will increase steamflood efficiency.

The overall dip of the potentiometric surface in the regional unconfined aquifer and the smaller perched aquifers is westward and parallels the structural dip of the beds. Widespread fluid depletion in zones along the updip edge of the field, and the absence of a potentiometric gradient showing flow outward from the Kern River ...suggest minimal groundwater recharge from natural sources. These observations suggest that fluids move downdip by gravity drainage from a closed volume, with significant removal of fluids by producing operations causing an overall decline in pressure in the unconfined aquifer. These findings are highly favorable for the

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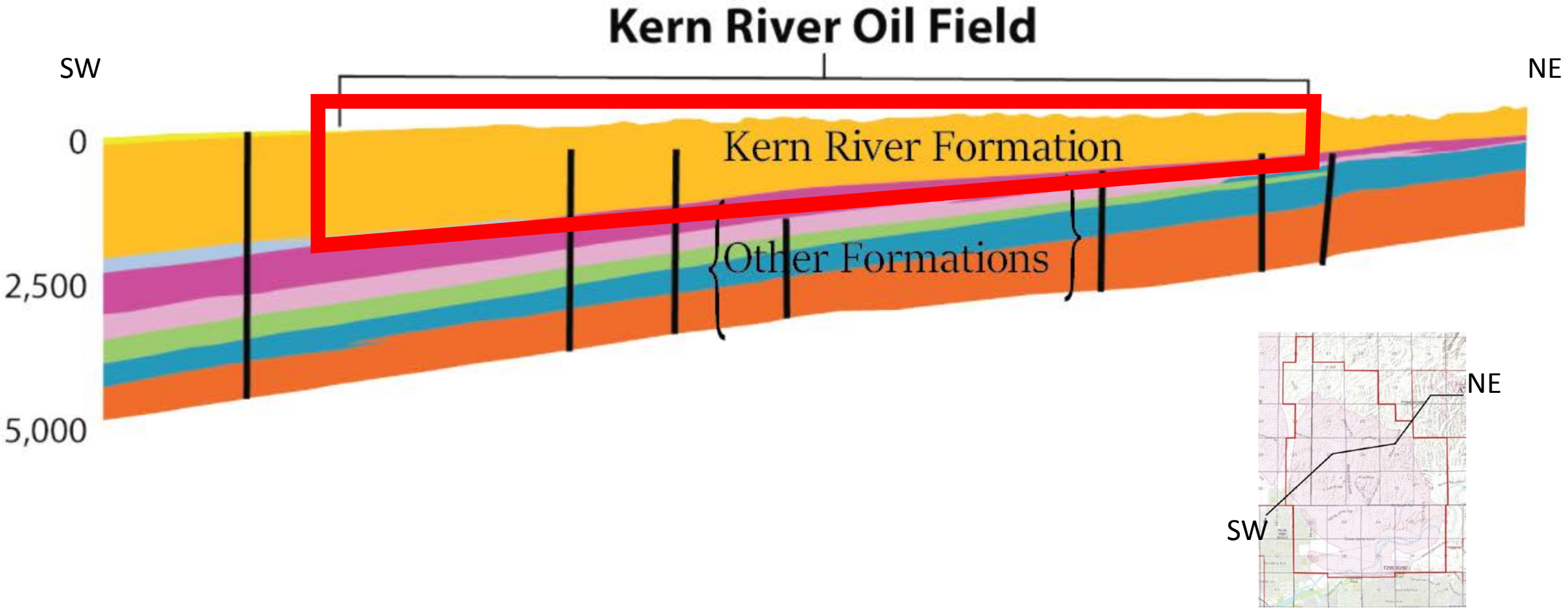
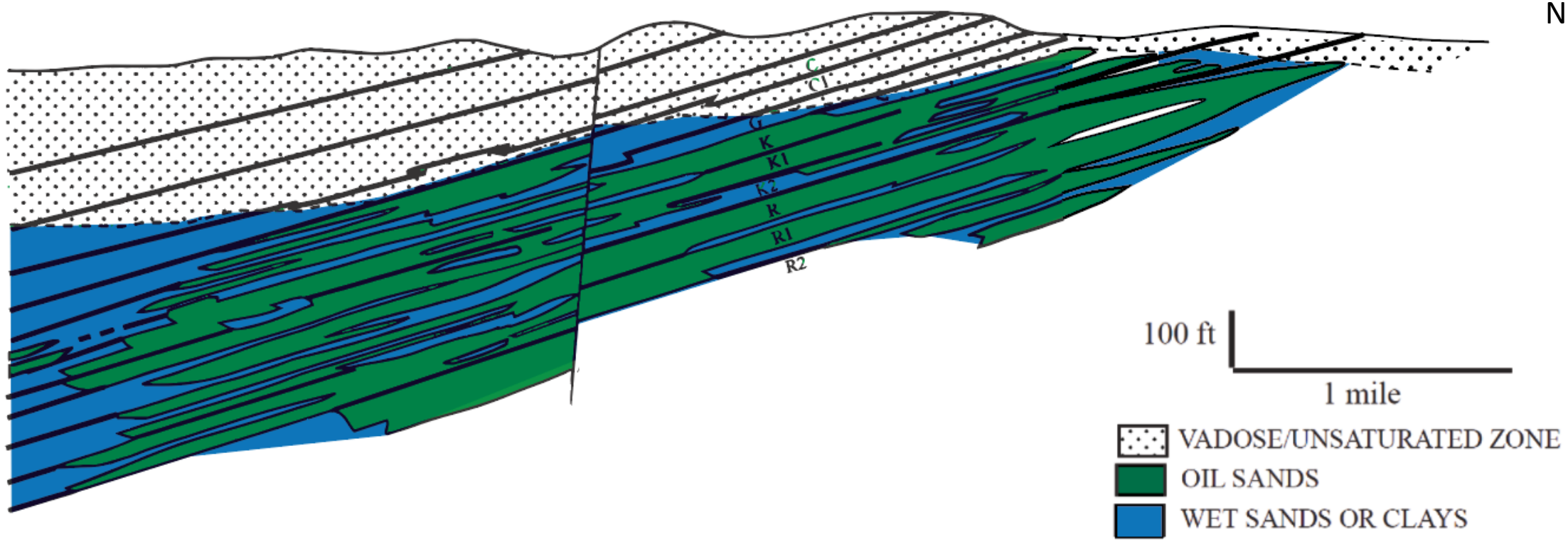
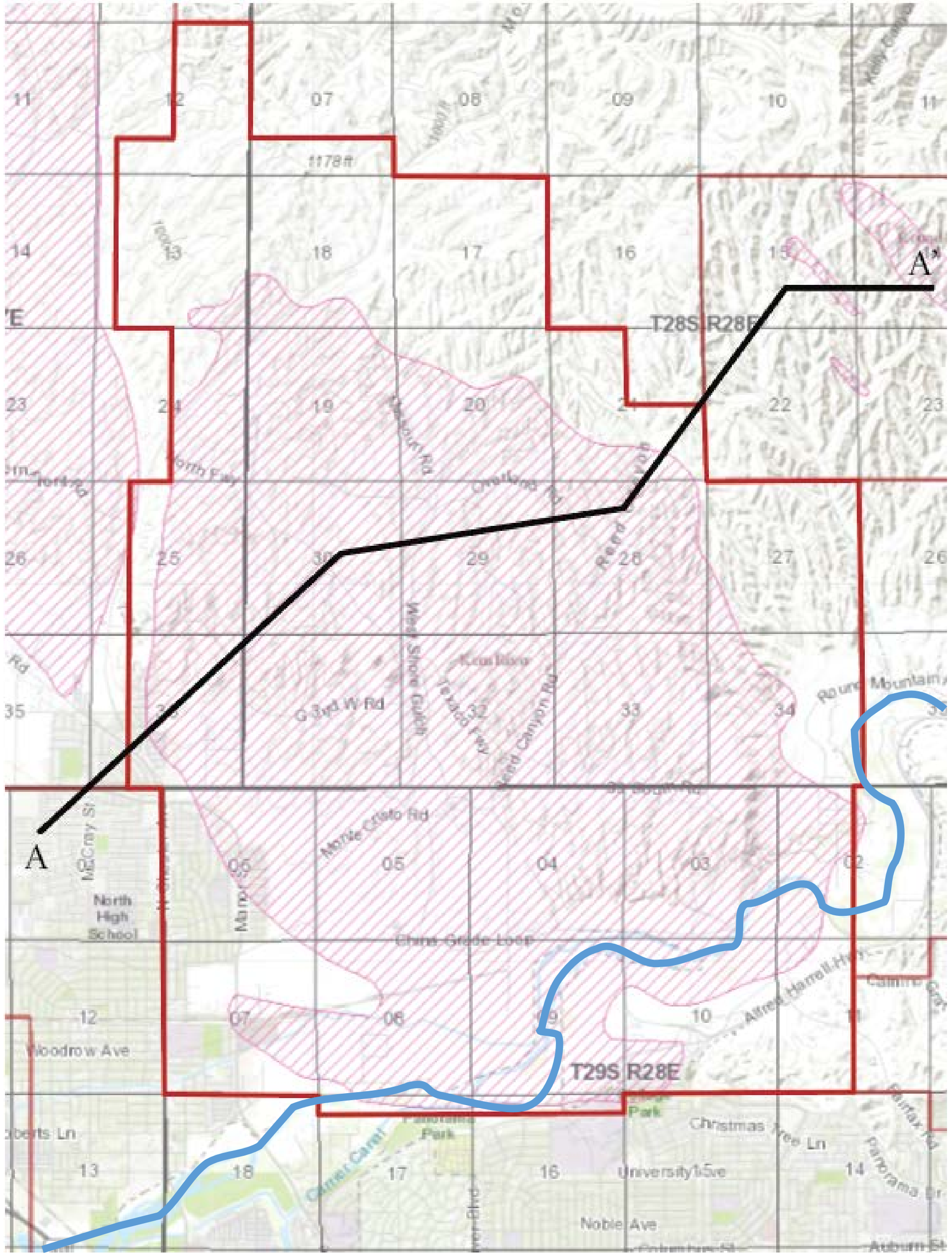
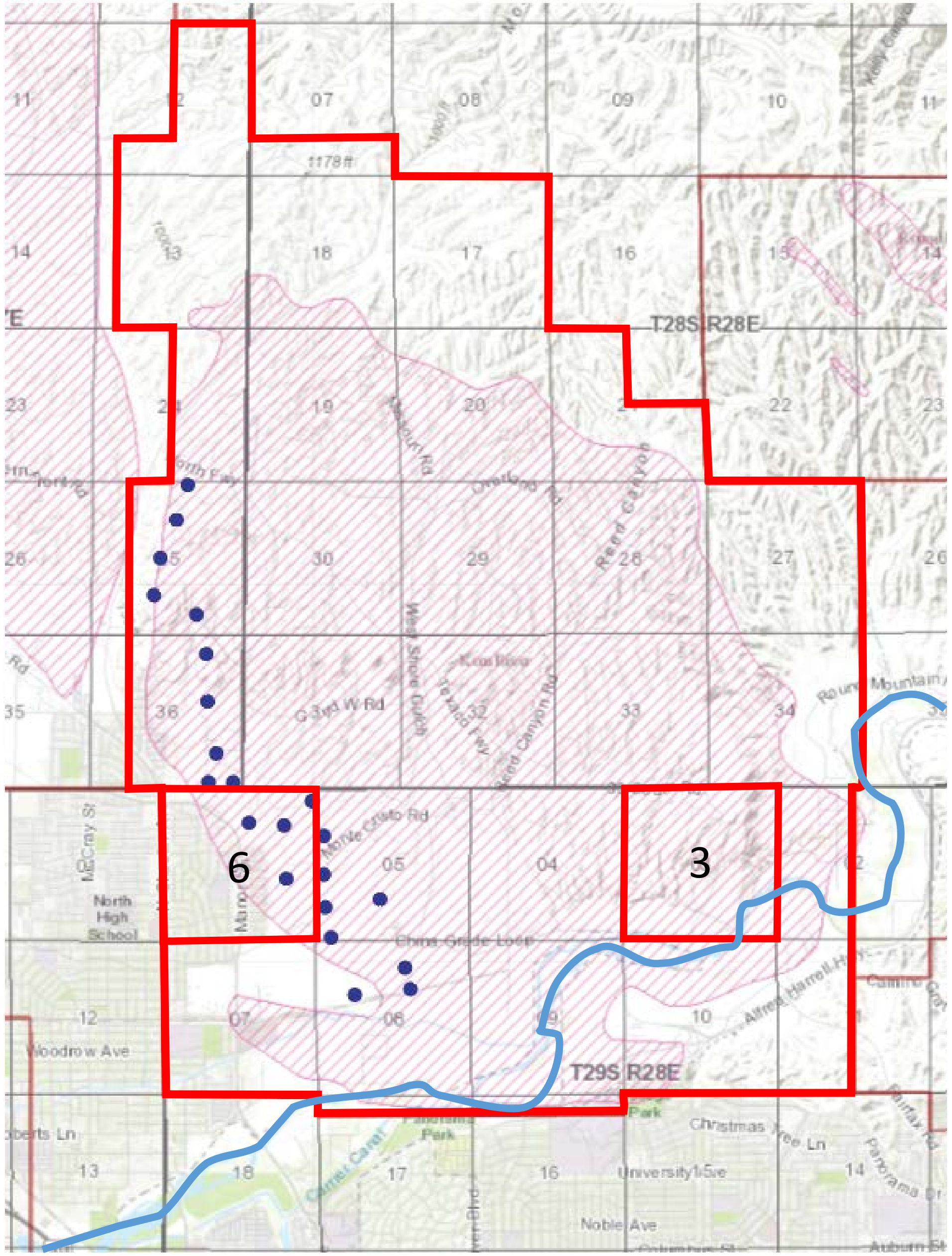

Kern River Oil Field
SW
NE
0
2,500
5,000
Kern River Formation
Other Formations
NE
SW

SW

NE

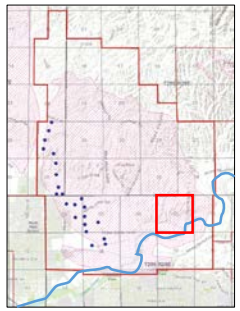

C
C1
K
K1
K2
R
R1
R2
100 ft
1 mile
VADOSE/UNSATURATED ZONE
OIL SANDS
WET SANDS OR CLAYS


A
A'
T28S R28E
T29S R28E
North High School
Woodrow Ave
Monte Cristo Rd
China Grade Loop
Alfred Harrell Hwy
West Shore Gulch
G 3rd W Rd
Overland Rd
Reed Canyon Rd
Christmas Tree Ln
Noble Ave
Panorama Park
1178 ft

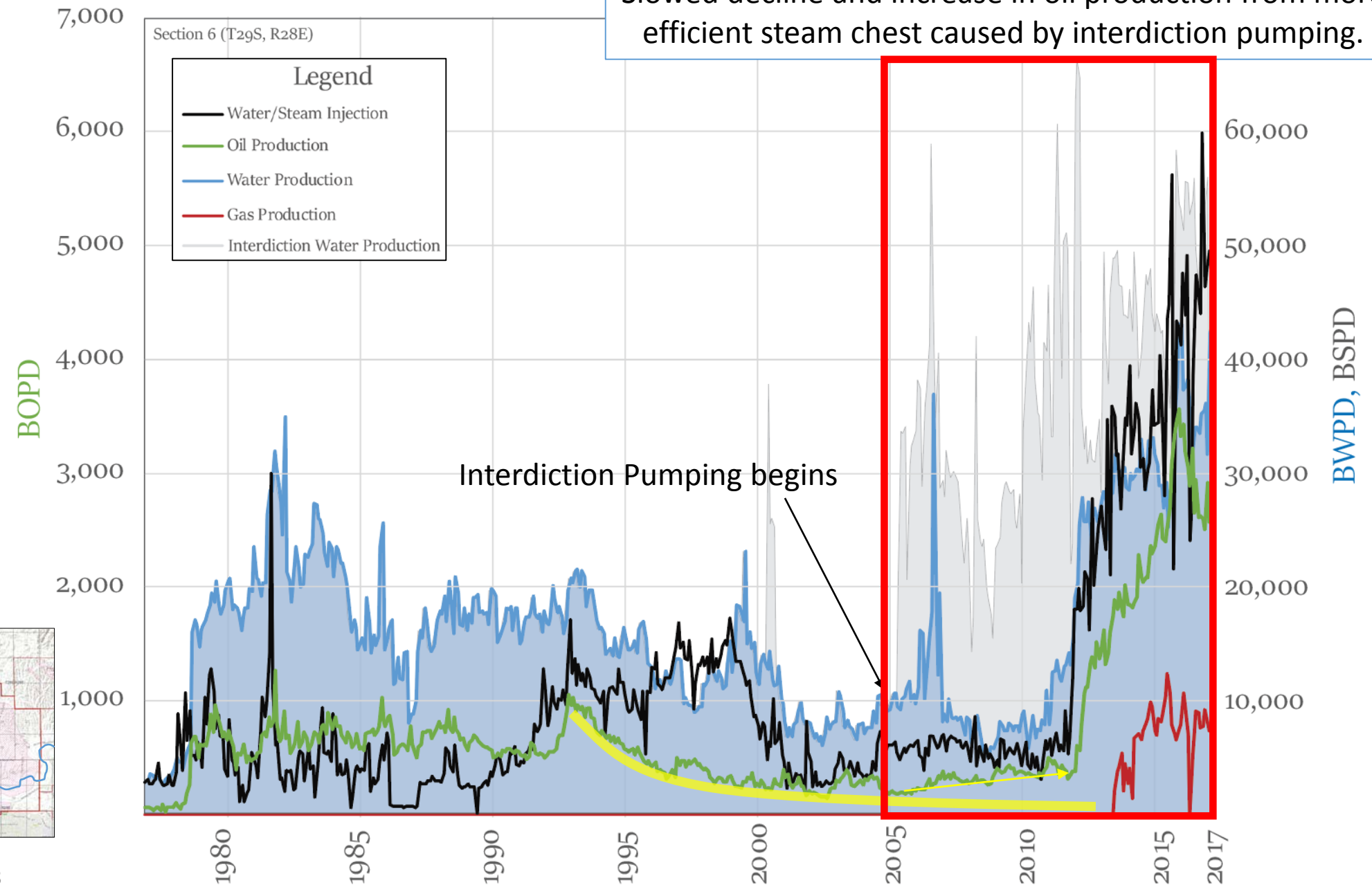


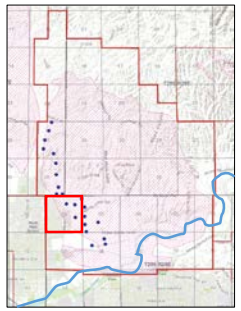
6
3
T28S R28E
T29S R28E
07
08
09
10
11
13
14
16
17
18
19
20
22
23
26
27
28
29
30
32
33
34
36
04
05
12
North High School
Woodrow Ave
Overland Rd
Reed Canyon
West Shore Gulch
Monte Cristo Rd
China Grade Loop
Alfred Harrell Hwy
Round Mountain
Christmas Tree Ln
Noble Ave
1178 ft

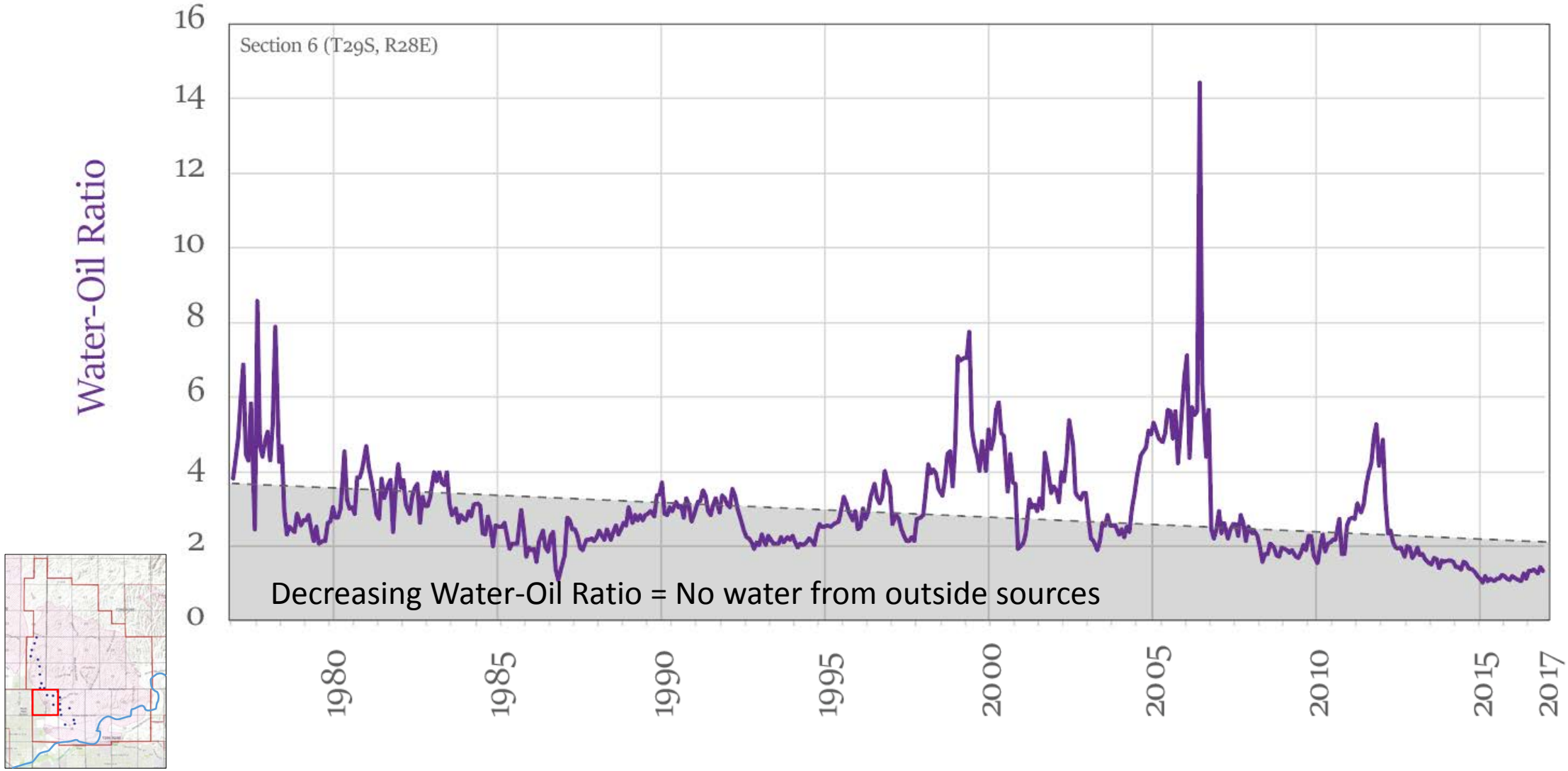
Total water production drops but oil production rises.

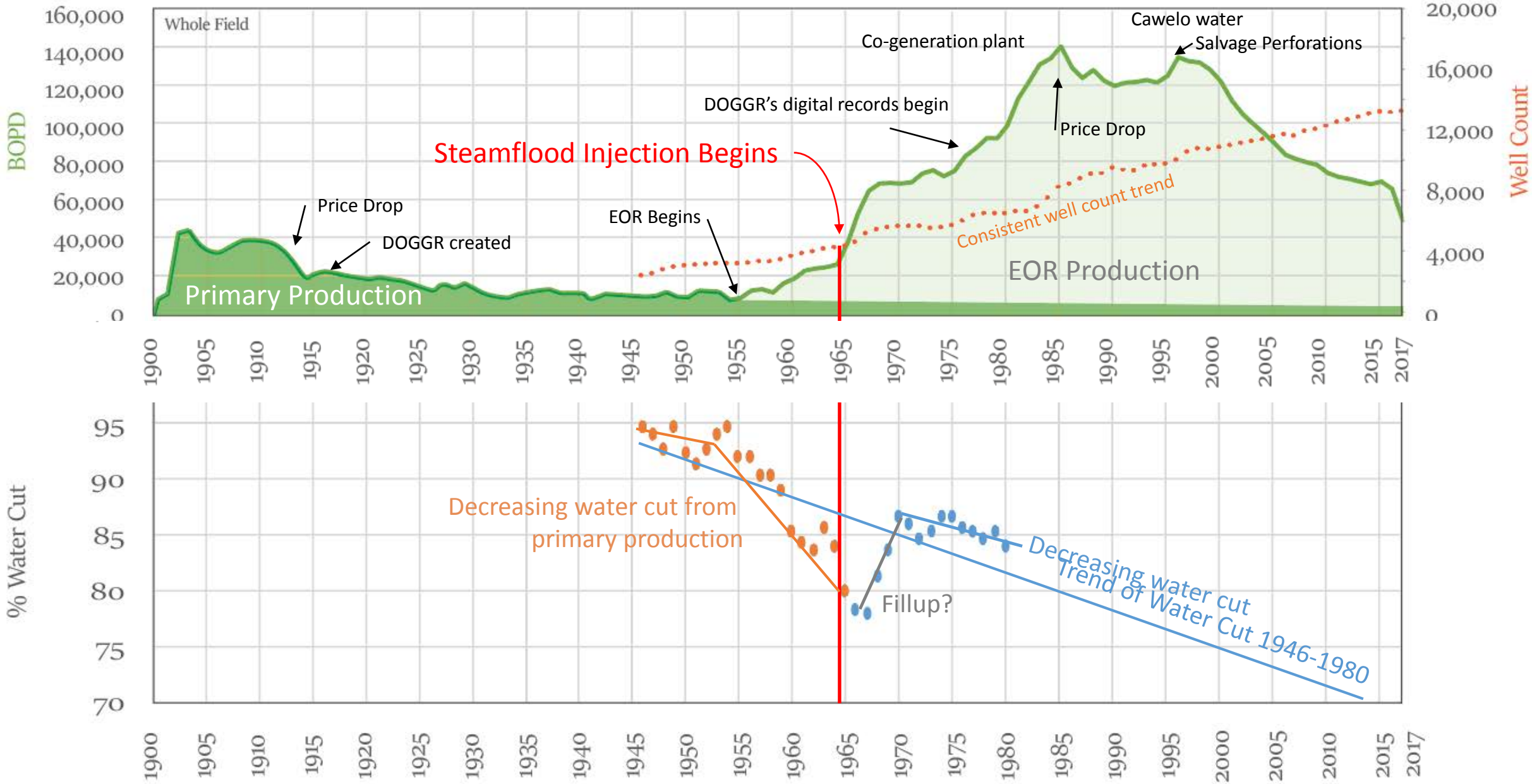


Slowed decline and increase in oil production from more efficient steam chest caused by interdiction pumping.






Section 6 (T29S, R28E)
Water-Oil Ratio
16
14
12
10
8
6
4
2
0
1980
1985
1990
1995
2000
2005
2010
2015
2017
Decreasing Water-Oil Ratio = No water from outside sources


Whole Field
BOPD
Well Count
Co-generation plant
Cawelo water
Salvage Perforations
DOGGR's digital records begin
Price Drop
Steamflood Injection Begins
Price Drop
DOGGR created
EOR Begins
Consistent well count trend
Primary Production
EOR Production
% Water Cut
Decreasing water cut from primary production
Fillup?
Decreasing water cut
Trend of Water Cut 1946-1980

Conclusion

- The field acts as an **operationally controlled closed system** as the water from the field is being removed faster than the oil. This fluid is not replaced save for injection to maintain and grow the steam chest.
- The results agree with Coburn and Gillespie who found that produced water is not replaced by natural sources over the time periods required for oilfield operations

Lastly, I challenge you to go and explore DOGGR's well finder, with a little digging you may just see that the field wide WOR ratio has been decreasing save for vigorous periods of field dewatering which has been ongoing since ~1996.