

Oil and Gas Land Use in Osage County, Oklahoma

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Background

Use of the surface of Osage County to exploit Osage minerals is provided for by federal law. Federal regulations, 25 CFR § 226, outline “reasonable use” limitations. Oil and Gas (O&G) leases are usually granted by the Osage Minerals Council in quarter section units or in multiples of quarter section units. The surface used for O&G activates varies widely, lease to lease, and is rarely more than two percent of the lease area. The surface used is limited by the reasonable use criteria and may conflict with surface owner uses and environmental impacts such as plant and animal habitat. O&G surface use also competes with other uses, urbanization, water impoundments, highways, wind farms, etc., which have changed Osage County dramatically over the last 100 years.

The pending “Osage County Oil and Gas Draft Environmental Impact Statement” must anticipate the consequences of the Osage Agency’s continued management which requires knowledge of the current status as well as how surface use will change over a to be defined time period. The forecast period for the pending Environmental Impact Statement is expected to be 20 years.

Determining O&G Land Use

O&G land use includes; well sites, roads, tank batteries, support facilities, pipelines (including flow lines), and legacy damages (scars). We have determined O&G land use by measuring area used and lease road distance in randomly selected quarter sections selected from the 9,228 which make up Osage County.

Tools

After creating the random quarter section list, Earth Point © (<http://www.earthpoint.us/Townships.aspx>) was used to locate the sample quarter sections. Google Earth Pro © (https://www.google.com/work/earthmaps/earth_pro.html) was used to examine selected quarter sections for evidence of oil and gas activity. It was usually necessary to view each quarter section in parts from an eye elevation of about 500 feet.

Method

Pipelines and flow lines (produced liquids and brine disposal) were not measured because they are not always visible by satellite imagery and do not usually interfere with other surface uses. Also, no attempt was made to measure the many interstate and intrastate pipelines which

cross Osage County. Other than interference with mineral exploitation, these pipelines are not relevant to O&G activities and the Osage Agency's responsibilities.

We have measured well pads, turning areas, tank batteries, and denuded areas related to O&G using the Polygon feature in Google Earth Pro ©. An example of a Polygon feature measured by Google Earth Pro © is shown in Figure 1.



Areas were recorded to the nearest 0.1 acre and all identified isolated O&G features measured as zero by Google Earth Pro © were recorded as 0.1 acre. These were generally isolated pump jacks where vegetation had reclaimed the former well pad. An example is provided in Figure 2.



Figure 2. Pump Jack, Shannon No. 8, SE NE NW Sec. 13 T22N R8E

Picture is the view from the north (7/29/2016), Google Earth Pro © image is from the south viewed at 280 ft. (2/25/2014)

Roads which could be associated with O&G were measured using Google Earth Pro © path to the nearest 0.1 mile. The area used by roads was then calculated based on a width of 14 feet. Figure 3 shows a typical O&G road viewed from 1,300 ft. In some cases, the sample quarter section may only contain a road which passes through connecting O&G surface use on other quarter sections. In those cases, the length of the road inside the sample quarter section was measured and recorded. Ranch roads which did not connect O&G activities were not measured. Some ranch roads without a O&G nexus may have originally been established for O&G purposes and found sufficient utility to assure their survival.



Selection of Samples

Townships were placed in random order for 20 North through 29 North. Range was placed in random order for 2 East through 12 East. Sections were randomized, 1 through 36, and quarter sections NW, NE, SE, and SW. Random order lists were repeated to generate sample quarter sections from 15,840 possible alternatives. When a sample quarter section was found outside Osage County it was excluded from the sample list, 40 percent were outside Osage County.

Other Osage O&G land use estimates

The 1979 “Environmental Assessment for the Oil and Gas Leasing Program of the Osage Indian Tribe, Osage County, Oklahoma” made the following estimates:

	1978	1979 EA Forecast for year 2000
Oil Waste Land (1)	2,000(1)	2,544(5)
Wells, tank batteries, etc.	7,000(2)	10,254(6)
Lease Roads	<u>7,273(3)</u>	<u>10,657(6)</u>
Total	16,273(4)	23,455(4)

(1) 2,000 acres was a “horseback” estimate furnished by the Soil Conservation Service

(2) Based on an estimate of 14,000 active wells at 0.5 acres per well

- (3) Based on 0.2 miles per well and 20 ft. road width
- (4) Found on page 111 of the 1979 EA
- (5) Based on an assumption of spills per year and average associated damage and zero recovery of damaged land
- (6) 6,508 net additional wells (back calculated), page 112 is missing from the available copy of the 1979 EA that may contain this information

The USDA Natural Resources Conservation Service now provides soil classification maps on line, <http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm> . “Oil Waste Land” is a soil type classification, #44, used in the “Web Soil Survey “. In October, 2015 Hydration Engineering used the “Web Soil Survey” to determine acres classified as Oil Waste Land in Osage County. In October, 2015 the total surface designated as Oil Waste Land in Osage County was 1,628 acres.

Estimated Osage O&G Land Use

407 random quarter sections were selected. 155 showed evidence of O&G activity. Other than roads, surface use was measured by Google Earth Pro © polygon. 151 quarter sections showed O&G related nonpublic roads and measured by Google Earth Pro © pathway, images were from the winter of 2014 and 2015, accessed in July 2016

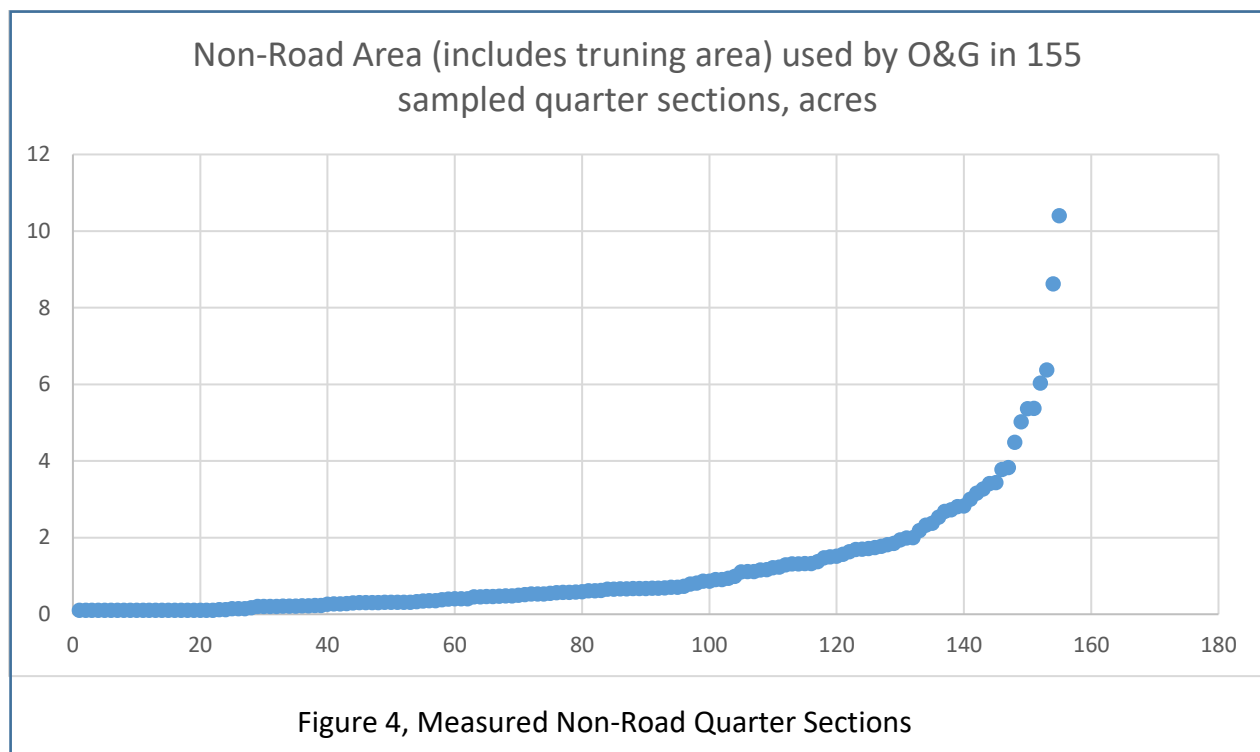
Per Quarter Section Results

	With O&G Activity	All Qt. Sections Combined
Average Measured Acres/Qt. Sec.	1.146	0.436
95 % Confidence Measured Acres/Qt. Sec.	1.398	0.549
99% Confidence Measured Acres/Qt. Sec.	1.477	<u>0.579</u>
Average Measured Roads, miles/Qt. Sec.	0.731	0.271
95% Confidence Measured miles/Qt. Sec.	0.815	0.318
99% Confidence Measured miles/Qt. Sec.	0.842	<u>0.332</u>

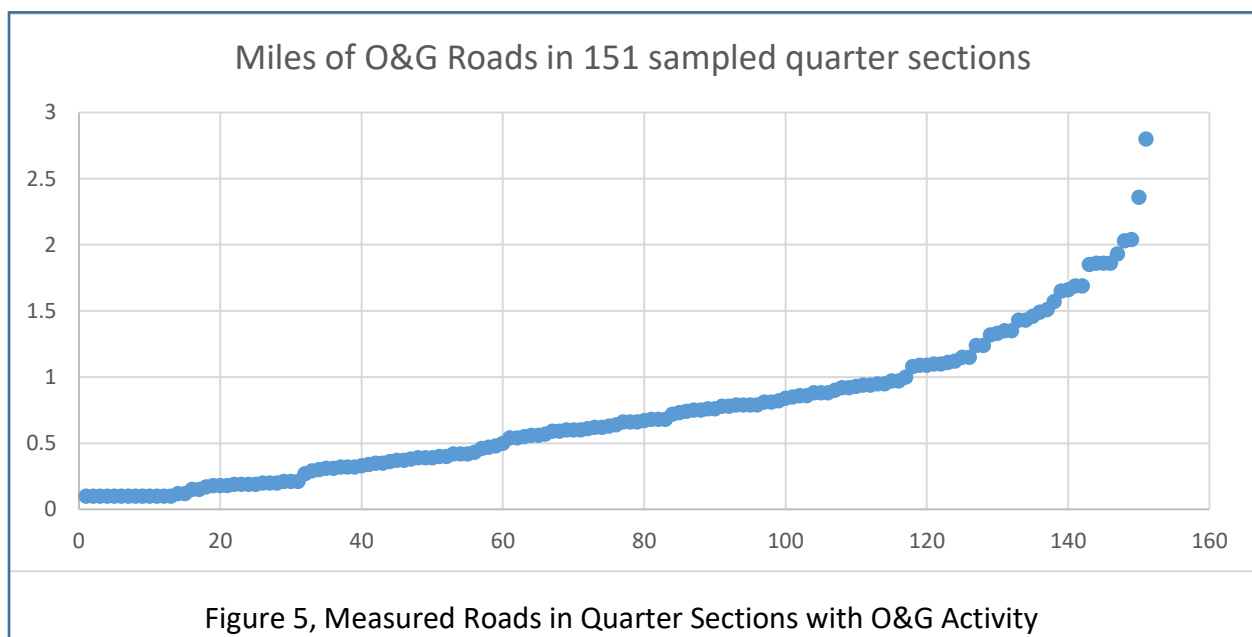
Used as the basis for the total O&G land use estimate.

In computing total land use we have chosen to use the 99% result from the entire 417 quarter section sample which gives slightly higher land use than the 155 quarter section alternative.

The distribution of the polygon measured surface use is shown in Figure 4.



The distribution of measured road miles is shown in Figure 5.



(A spread sheet is available by request from Hydration Engineering (www.hydrationengineering.com) which identifies each quarter section and the associated measurements.)

Road distance was measured in miles to the nearest 0.1 miles and a road width of 14 feet was used to calculate road area.

99% Confidence Osage O&G Land Use

<i>Measured Surface, Acres</i>	5,344
<i>O&G Roads, Miles</i>	3,064
<i>Road Area, Acres</i>	5,204

	1979 EA Forecast for 2000	New Estimate for 2016
Oil Waste Land	2,544	1,628(1)
Wells, tank batteries, etc.	10,254	5,344
Lease Roads	<u>10,657</u>	<u>5,204</u>
Total	23,455	12,176

- (1) From a 2015 Hydration Engineering township by township count of oil waste land, Web Soil Survey, Natural Resources Conservation Service, USDA, <http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>

There is an undetermined double count in the new estimate pertaining to Oil Waste Land. All land that appeared to be denuded was included in the new measured data. The 1979 Oil Waste Land was based on a “horseback” estimate of 2,000 acres for 1977 provided by the Soil Conservation Service and an additional 544 acres was added by the BIA for future damage. The natural and assisted recovery of brine damaged surface was not considered in 1979. Unassisted recovery of brine damage is slow but does occur. Based on the 1977 Soil Conservation Service estimate and the current count of Oil Waste land from the NRCS oil waste land has decreased 472 acres, approximately 12 acres per year.

The current O&G land use of 12,176 acres is a starting point for estimating future O&G land use.

Estimating Future O&G Land Use

The 1979 EA forecast was based on the assumption that once a well site is established, it is, forevermore, counted as O&G surface use. Observation of actual wells via Google Earth © and in the field demonstrates that this is not the case. Most well sites recover and “go native” over time. Many wells counted in the current work are hardly visible at an observation altitude of 500 ft. Other wells show significant activity in the form of turn around areas and vegetation differences. Wells without a pump jack and no road connection or visible activity were not

usually discovered in this effort. They may reappear as the resulting of plugging activity only to subsequently return to the background.

The surface life cycle is a dynamic process of well development, production, abandonment, plugging, and diminishment, if not disappearance.

Chaparral Energy experienced the rediscovery of several old wells in their CO₂ flood of the North Burbank Unit. Recently, a 1925 gas well reappeared near the Skiatook Airport. (Osage News, August 8, 2016.

<http://www.osagenews.org/en/article/2016/08/08/emergency-skiatook-brought-tribal-federal-and-local-agencies-together/>) These old wells do not compromise surface use until they manifest as a problem.

Approximately 45,000 wells have been drilled in the Osage since 1897. The most recent count provided by the Osage Agency is 19,755 (producing wells plus disposal wells). 25,245 wells have, therefore, come and gone over the last 119 years, an average of 212 wells per year. Extrapolating this experience, without additions, **Osage O&G land use will decrease 57.2 acres per year due to natural and assisted attrition.** (Current non-road use of 5,344 acres/current active wells of 19,755 times 212 wells per year.)

However, roads have an indefinite life due to their continued use for ranching after O&G activities are complete. (To facilitate recovery, primitive roads should be constructed whenever suitable for purpose. The reader is referred to the Bureau of Land Management's, Primitive Roads Manual – 9115.)

In this study non-public roads were only counted when there was evidence of O&G activity. Public roads were not counted. Many miles of ranch roads were not counted and are clearly visible in the 62 percent of the quarter sections where there is no current evidence of O&G activity.

Determining Land Use for New O&G Activity

We measured the disturbed area and lease road distance for 200 oil wells completed in the year 2010. All disturbed surface detectable via Google Earth © was measured, including vehicle turning areas, to the nearest 0.1 acres. If a tank battery was located abutting a new well its area was included. Most new wells are served by existing tank batteries, however, it is possible that some new tank batteries were not counted. Google Earth © images were from the winter of 2014 or 2015. A typical measured well area is shown in Figure 6. Lease roads necessary to connect new wells to existing roads were measured to the nearest 0.1 miles. In many cases new lease roads were not required when the wells are located next to existing roads.

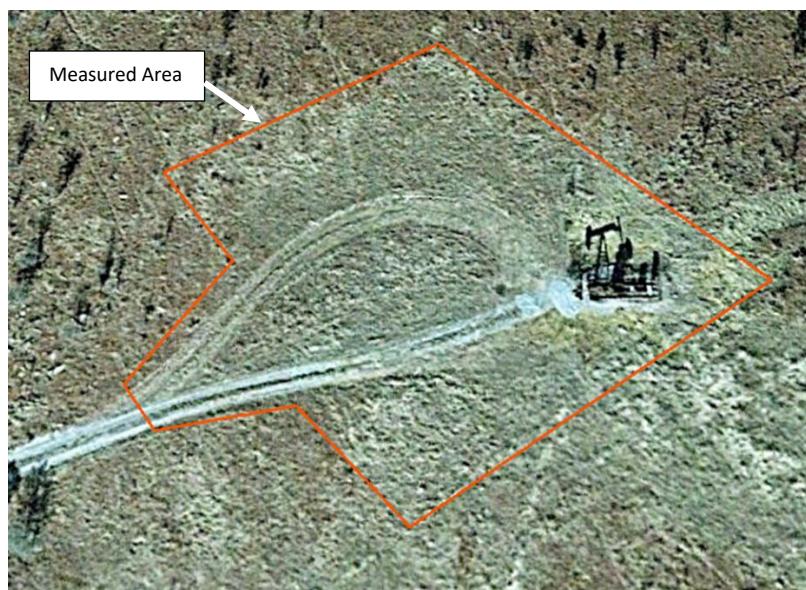
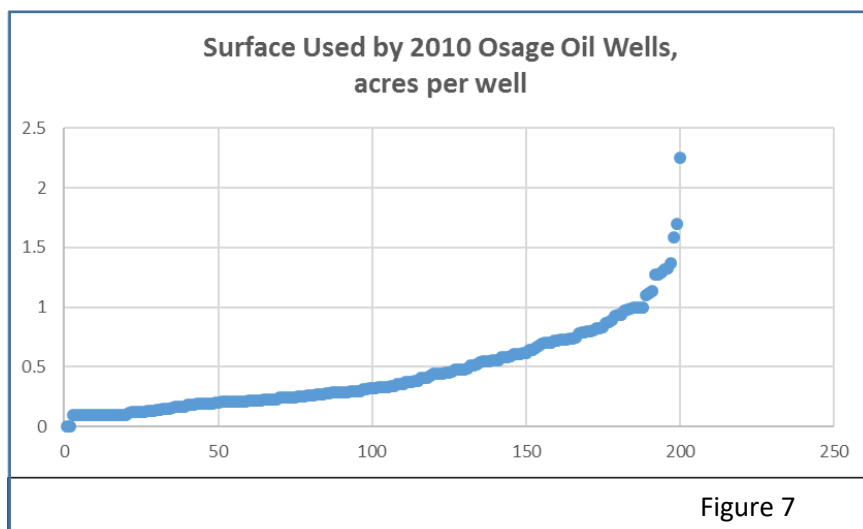


Figure 6, Measured Use Area, 2010 well, 0.48 acres

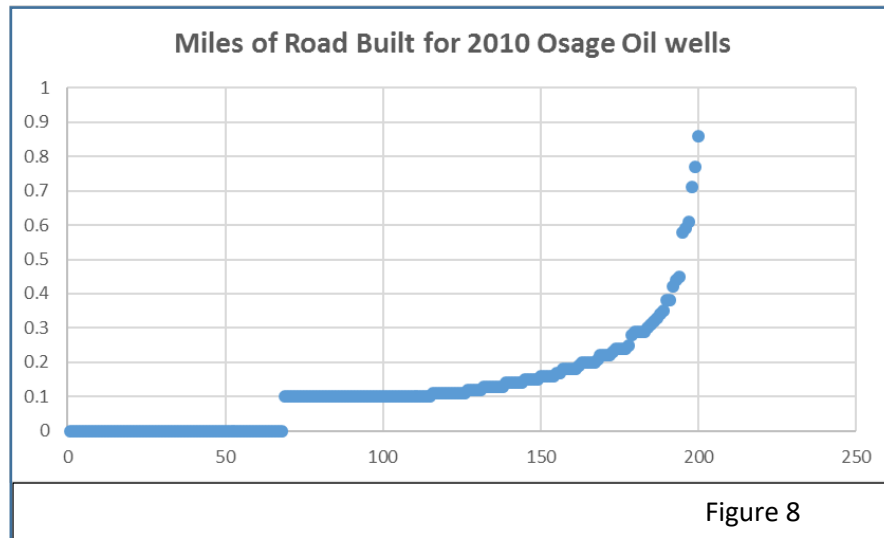
The distribution of measured area for the 200 well sample is shown in Figure 7.

About selection of 2010 as the basis for this estimate: 2010 was the recent peak in Osage Oil well completions, 212 completions. (The HIS Inc. US well data base listed coordinates of 12 wells which could not be found via Google Earth ©, presumably these coordinates are in error.) Images available are from the winter of 2014 and 2015, selection of wells at least three years old allows for recovery of incidental surface use, vehicle tracks, vegetation removal, etc. From the three year point long term encroachment will be slow, moving in and out so long as the well remains productive. All of the wells in the sample were vertical with one exception, a single horizontal by Nadel & Gussman (surface location NE/4 S25 T28N R7E). This well had the highest measured surface use of 2.25 acres and included a tank battery and other wells not in the 2010 completion sample.



Note: Only three wells exceeded the 1.5-acre area requiring the approval of the Osage Agency Superintendent.

The distribution of measured distance of new lease roads for the 200 well sample is shown in Figure 8.



Note: 58 percent of the wells required 0.1 miles or less of new road.

(A spread sheet is available by request from Hydration Engineering (www.hydrationengineering.com) which identifies each well location and measurements.)

Wells Sampled	200
Avg. Acres per Well	0.45
95 % Confidence Acres per Well	0.50
99 % Confidence Acres per Well	0.52
Avg. Road Miles per Well	0.12
95 % Confidence Miles per Well	0.14
99 % Confidence Miles per Well	0.15
99% Confidence Road Area Acres @ 14' width	0.25

Area Required for new Osage Oil Wells, 0.77 acres per well (99% confidence value)

O&G Fee and Leased Land

No attempt was made here to account for surface owned by O&G operators. In some areas of concentrated use this is significant (Chaparral Energy LLC owns in fee over 7,000 acres in the North Burbank Unit.). In these cases, the BIA's responsibilities to protect the interests of the surface owner are moot. In some cases, operators have formal and informal lease arrangements with surface owners.

Duration and Long-term effects

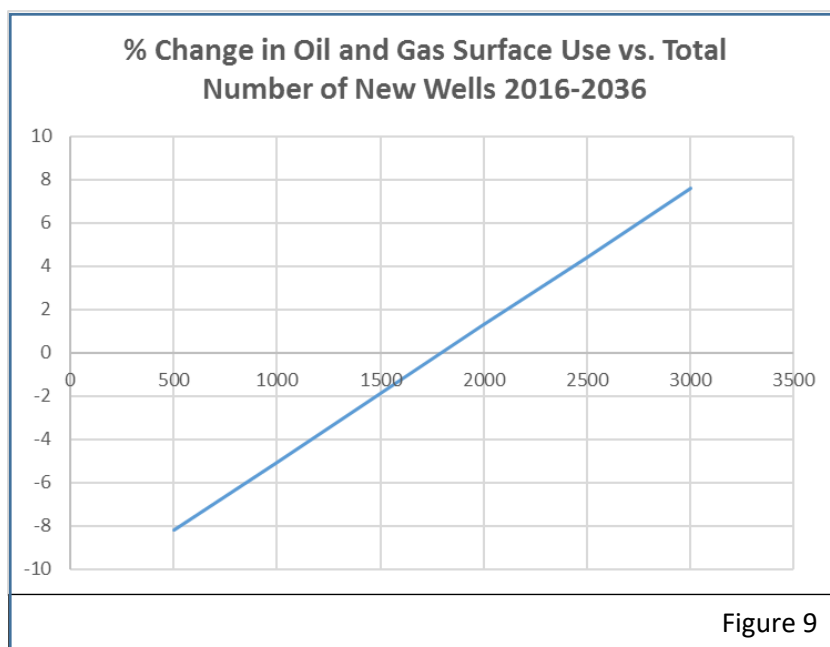
The instructions provided the Osage Agency (*Indian Affairs National Environmental Policy Act (NEPA) Guidebook IAM 3-H, August 2012*) state: "... the long-term and short-term effects must be defined as well as the duration of the effects.". "Long-term effects" and "duration" are not defined terms in the Guidebook or in the Council on Environmental Quality regulations (*40 CFR Parts 1500–1508*).

We assume the "duration" premise be the same as the 1979 Environmental Assessment, 20 years. Had the BIA been following NEPA procedures there is little doubt that the 1979 EA would have been amended or replaced around 2000.

Sample Calculation

Number of New wells over 20 years	1800
Current Land Use	12,176 acres
New Surface Use for Wells and Roads (0.77 acres/well)	1,386 acres
Well Abandonment (57.2 acres/year)	- 1,144 acres
Legacy Scar Recovery (12 acres/year)	- <u>240 acres</u>
2036 Estimated O&G Land use	12,178 acres
Change in O&G land use as a % of 2016	zero

The relationship between the change in O&G surface use and the number of new wells completed between 2016 and 2036 is illustrated in Figure 9.



Conclusion

O&G land use in Osage County, 12,000 acres, is about half previous estimates. Declining surface use for O&G is likely if the total number of new wells completed between 2016 and 2036 is less than 1800. Enhanced efforts to reduce Oil Waste Land, complete abandonment of roads when no longer needed for O&G, and active plugging and abandonment of unproductive wells would accommodate additional wells without increasing the O&G footprint. Given the conservative assumptions made in this work it is highly likely that more than 100 new wells per year could be accommodated without increasing total O&G surface use in Osage County.

Acknowledgement

This work was sponsored by the Osage Producers Association and the contribution of numerous OPA members is acknowledged and appreciated.

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Robin Phillips, Osage Agency Superintendent to Everett Waller, Chairman, Osage Minerals Council, May 11, 2016. (The attachment to this letter contains the current count of producing and disposal wells.)

Well data, IHS Inc., <https://www.ihs.com/products/us-well-data.html>