Estimating Future Oilfield Site Restoration Costs & Methane Emissions from Orphaned and Idle Wells in Louisiana

All numbers preliminary. Please do not cite or distribute.

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Outline

Work Plan Schematic

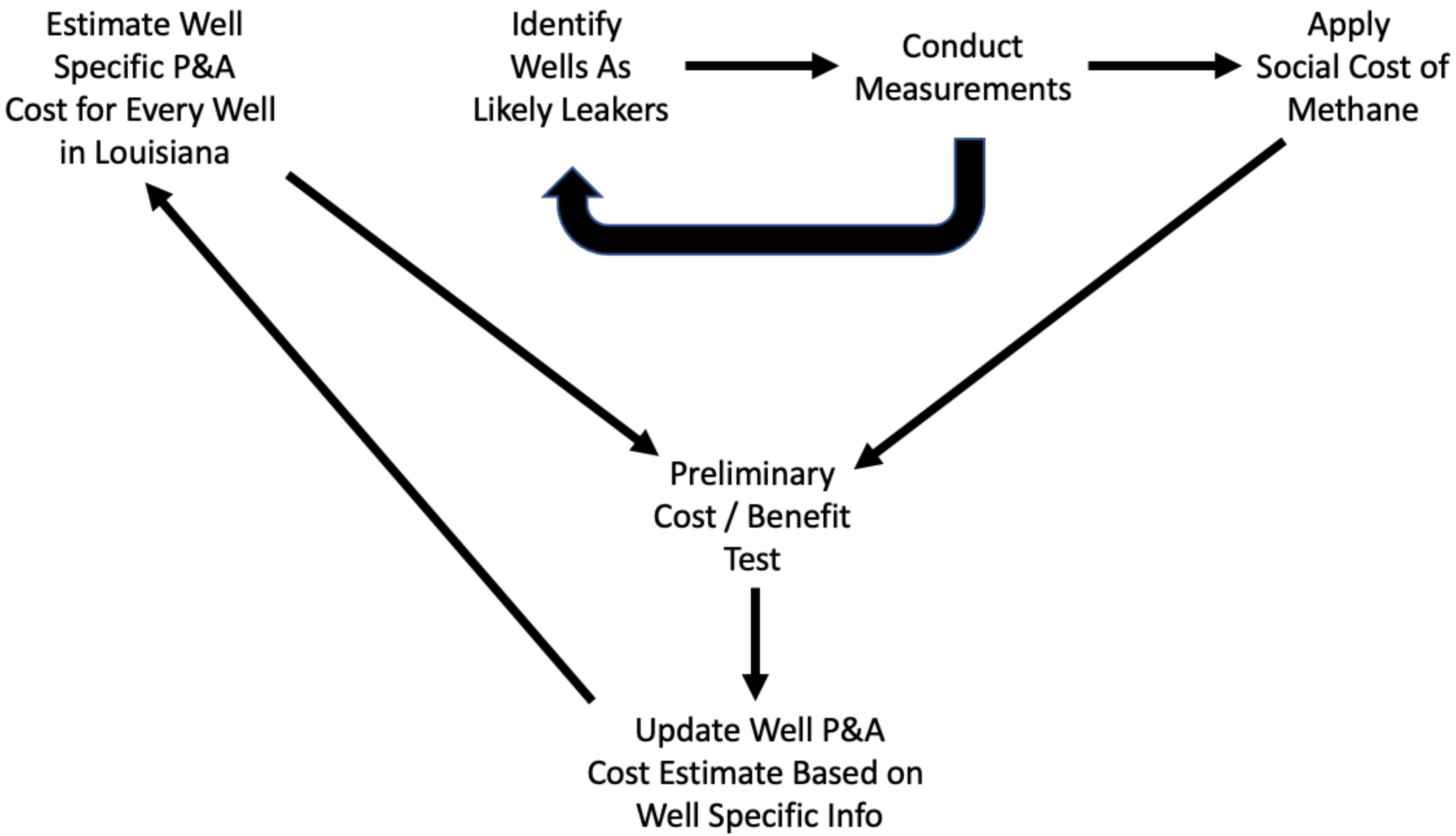

Table 1: Orphan & Idle Well Status	
Orphan Well Counts in January 2023 (A)	4,610
Orphan Wells Plugged through September (B)	530
Change in Orphan Well Counts Since January (other factors) (C)	670
Current Orphan Well Count (A) + (C) - (B)	4,750
Total Idle Wells in Louisiana	16,100

Note: All numbers rounded to nearest 10 wells based on current estimates.

Outline

Calculating the Social Cost

- One ton of CO_2 emitted today will increase CO_2 concentration in the atmosphere around the world for centuries.
- The social cost of carbon (SCC) is essentially an accounting exercise that quantifies these changes and converts them into common units through valuation and discounting.
- Human costs can include:
  - Costs of adapting to sea level rise.
  - Costs of adapting to changes in agricultural productivity.
  - Costs of weather events that might be more frequent with higher temperatures (i.e. forest fires and hurricanes).
- Discounting is needed to value damages to future generations in present dollars.

Emission Year	SC-CO_2 (2020 dollars per metric ton of CO_2) Near-term rate 2.5%	2.0%	1.5%	SC-CH_4 (2020 dollars per metric ton of CH_4) Near-term rate 2.5%	2.0%	1.5%
2020	120	190	340	1,300	1,600	2,300
2030	140	230	380	1,900	2,400	3,200
2040	170	270	430	2,700	3,300	4,200
2050	200	310	480	3,500	4,200	5,300
2060	230	350	530	4,300	5,100	6,300
2070	260	380	570	5,000	5,900	7,200
2080	280	410	600	5,800	6,800	8,200

For perspective, the "social cost" ~1.69¢/gallon of gasoline.
Venting = $37/MCF of Methane

Social Cost of Flaring and Venting

Converting gas densities to social cost per mscf

	Density (kg/m³)	Density (t/mscf)	100 yr GWP	CH_4e	SC Venting ($/mscf)
CO_2	1.873	0.0530	1		$2.70
CH_4	0.680	0.0193		1	$28.89
C_2H_6	1.283	0.0363	10.2		$18.90
C_3H_8	1.900	0.0538	9.5		$26.06
Iso C_4H_{10}	2.534	0.0718	6.5		$23.79
Normal C_4H_{10}	2.545	0.0721	6.5		$23.89

↓

Table 1: Climate costs from flaring ($/mcf)

Flare Efficiency	Bakken Mix	Pure methane
100%	$5.00	$2.70
98%	$5.38	$3.23
93%	$6.31	$4.54
0%	$23.76	$28.89

See Appendix D for calculations.

*"We perform a back-of-the-envelope calculation that reported U.S. upstream flaring in 2019, a peak year, generated **$1.7 to $3.4 billion** in climate costs, about **half to one percent of the value of U.S. oil & gas production.***

Note: Utilizes upstream F&M estimates from Alvarez et al, 2018. Science.

But this does not take into account the potential leakage from these wells once they are **no longer active**. Thus, there is significantly more work to be done to understand the **lifecycle social costs of oil and gas operations**.

Agerton, Gilbert & Upton. 2023. The Economics of Natural Gas Flaring in US Shale: An Agenda for Research and Policy. With Mark Agerton and Ben Gilbert. *Review of Environmental Economics and Policy. Volume 17, Issue 2.*

Outline

Table 2: Well P&A Costs		
Orphan Wells Plugged with Cost Data Reported		518
Cost of Completed P&Aed Wells (millions)	$	21.7
Cost per Completed Well	$	41,900

Note: Costs as of approximately the end of September 2023.

Outline

1	Introduction
2	Economics 101
3	Cost Estimation
4	Methane Emissions ←
5	Benefit / Cost Analysis & J40
6	Next Steps

Measurement Techniques

- Satellite based measurements: detection limit ~100 kg/hr.
  - Social cost per year: $1.1 million.
  - Too high!
- Aircraft survey: detection limit ~10 kg/hr.
  - Social cost per year: $114 thousand
  - Also too high!
- Boots-on-ground chamber measurements: detection limit ~0.01 g/hr.
  - Social cost per year: $0.11
  - Now we're talking!

Recall the average cost to plug a well is ~42k.

Based on $1,300 / tonne social cost of methane. This is equivalent to ~$28.89 social cost per MCF (Agerton, Gilbert, Upton; 2023).

Table 3: Methane Measurement

	Contractors	LSU
Wells Measured	842	59
Methane Detected	189	51
Share with Methane Detected	22%	86%
Methane Detected (mscf/day)		
Total Methane	27.8	4.53
Average Methane per Well	0.03	0.08

Note: Methane measurements as of approximately the end of November 2023.

Table 4: Largest Leakers

	Methane	Share of Total
Serial Number 170615	3.60	13%
Serial Number 176135	2.16	8%
Serial Number 36679*	2.12	8%
Serial Number 212286	2.09	7%
Serial Number 87492	0.95	3%
Serial Number 204963	0.89	3%
Serial Number 154325	0.76	3%
Serial Number 150156	0.73	3%
Serial Number 195237	0.71	3%
Serial Number 59710	0.56	2%
All other wells	13.27	48%
Total Methane(mscf/day)	27.85	100.0%

Note: From contractor measurements

Table 4: Largest Leakers

	Methane	Share of Total
Serial Number 152434	1.74	38%
Serial Number 54602	0.36	8%
Serial Number 62164	0.30	7%
Serial Number 54601	0.29	6%
Serial Number 36679*	0.24	5%
Serial Number 150664	0.24	5%
Serial Number 54603	0.18	4%
Serial Number 112516	0.16	3%
Serial Number 205103	0.16	3%
Serial Number 70992	0.14	3%
All other wells	0.72	16%
Total Methane(mscf/day)	4.53	100.0%

Note: From LSU measurements

Table 1: Leak model parameter estimates

	Is leaking (0/1)		Log leak	
	(1)	(2)	(3)	(4)
main				
Constant	-3.935***	-3.386***	-1.982	-3.985***
	(-3.97)	(-5.27)	(-0.52)	(-24.82)
log_md	0.0400		-0.0547	
	(0.32)		(-0.12)	
log(well_age)	0.581**	0.577***	0.451	
	(3.09)	(3.63)	(-0.69)	
BOE Quartile				
min-25%	0.551**	0.594***	-0.411	
	(3.06)	(4.69)	(-0.65)	
26-50%	0.577**	0.652***	-0.121	
	(2.87)	(4.84)	(-0.18)	
51-75%	-0.0771		-1.357*	
	(-0.35)		(-2.06)	
76%-max	0.477		2.491	
	(0.84)		(1.63)	
Product type				
OIL	0.264		0.665	
	(1.10)		(0.67)	
GAS	0.315		0.380	
	(1.28)		(0.38)	
Observations	826	826	186	186
sigma			2.182	2.190
Rsq			0.0497	0
adj Rsq			0.00679	0

t statistics in parentheses

Huber/White standard errors.

Omitted categories are BOE:missing and product type:missing.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Older wells that were below average producers are more likely to leak.

Wells with more gas are not (statistically) more likely to leak.

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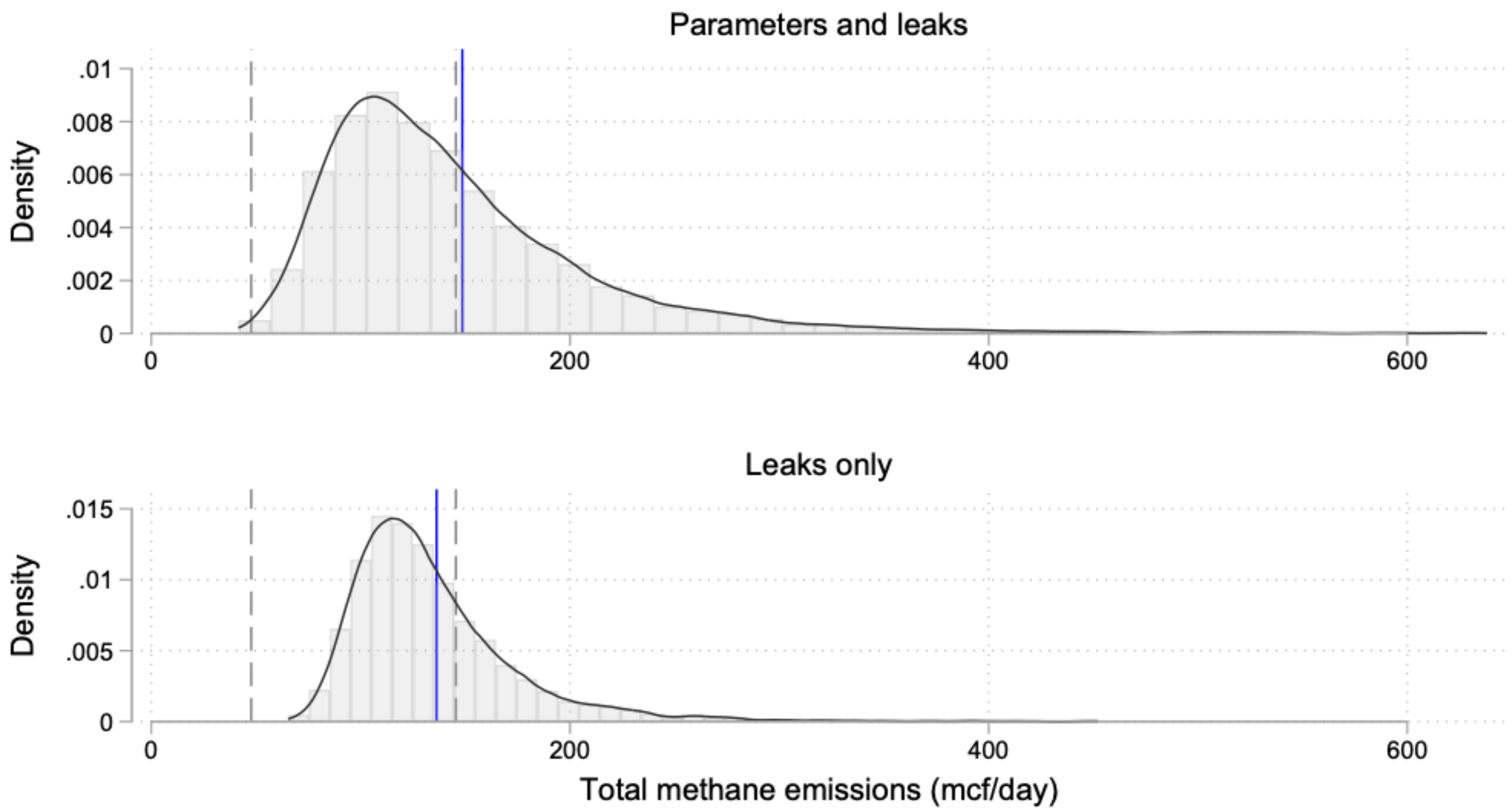
Conditional on leaking,
the size of the leak is not correlated with
any observables.

Total predicted emissions for unmeasured wells

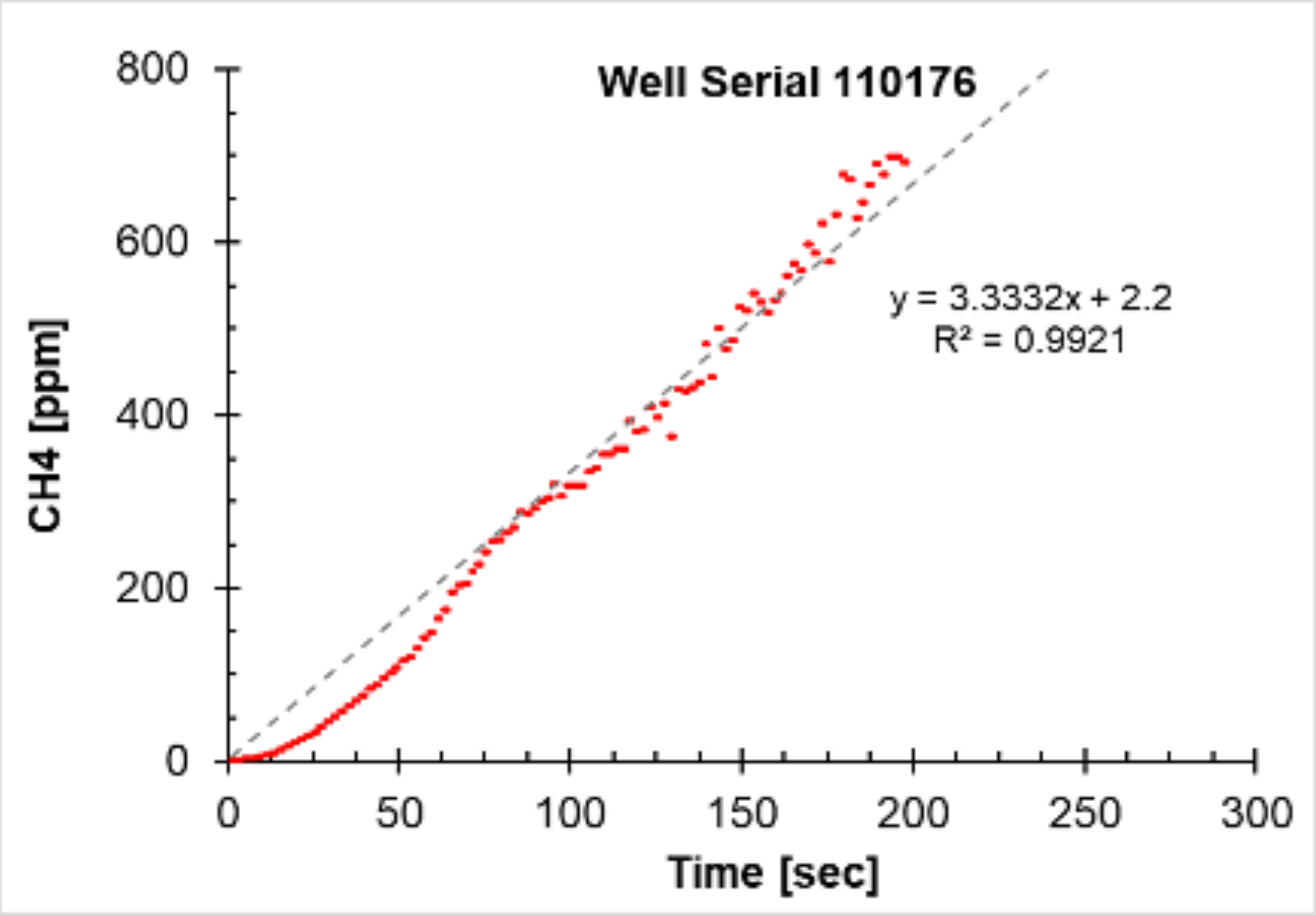


We estimate there is between ~78-296 mcf/d leaking from non-measured orphans.

($85k-$324k in market value / year using $3/MCF)

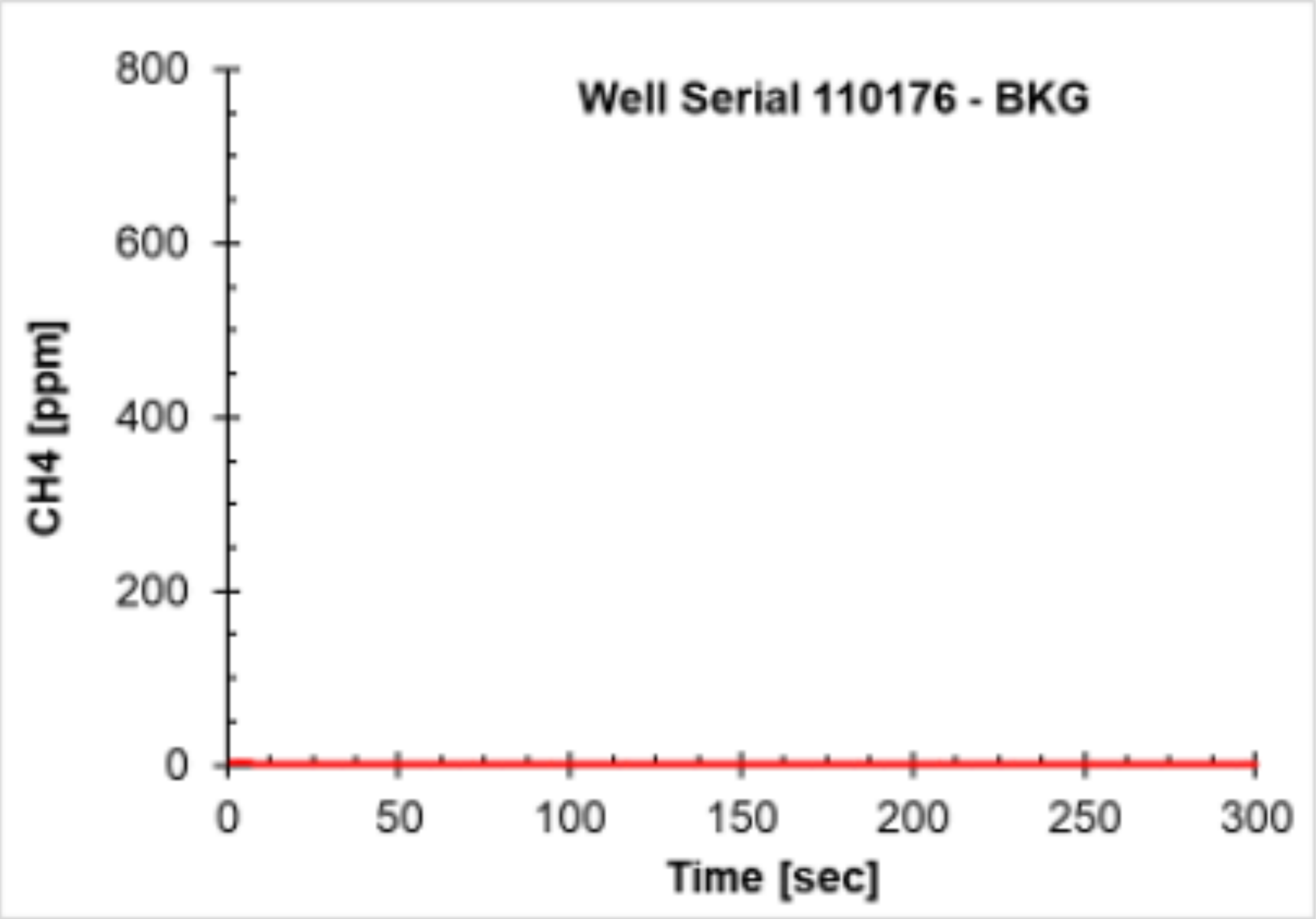
Monte Carlo simulation uses 10000 simulations over 3819 unmeasured wells based on data from 826 wells.
Parameters and emissions (top) takes draws from parameter and leak distributions, whereas
Realizations only (bottom) only draws leaks conditional on estimated parameters.
Mean marked by vertical blue line. X-axis truncated at 1.5 times 99th percentile.
Dashed gray, vertical lines are estimates using EPA emissions factors for non-Appalachia and Appalachia wel

Preliminary data from wells in Shreveport area

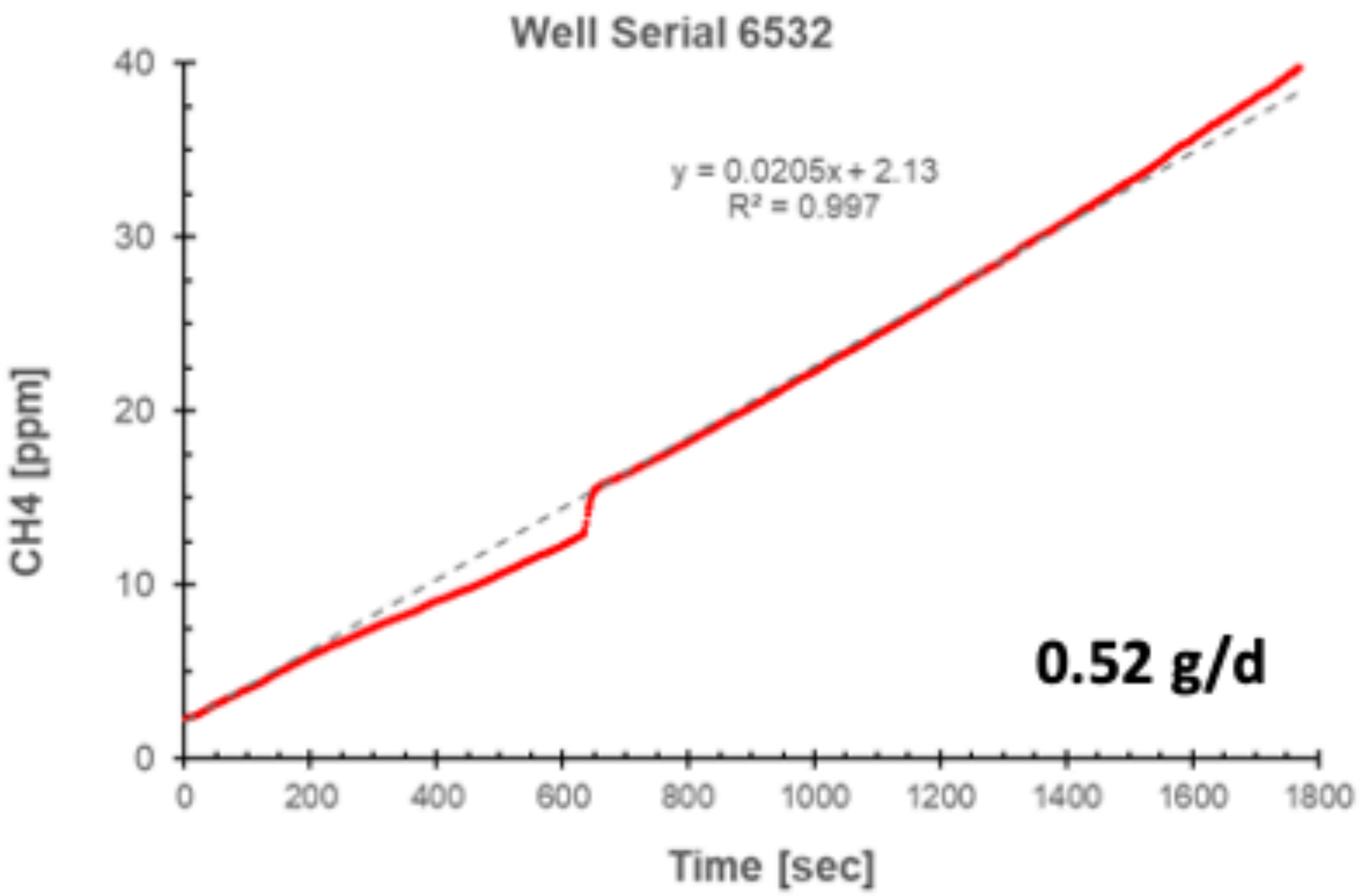


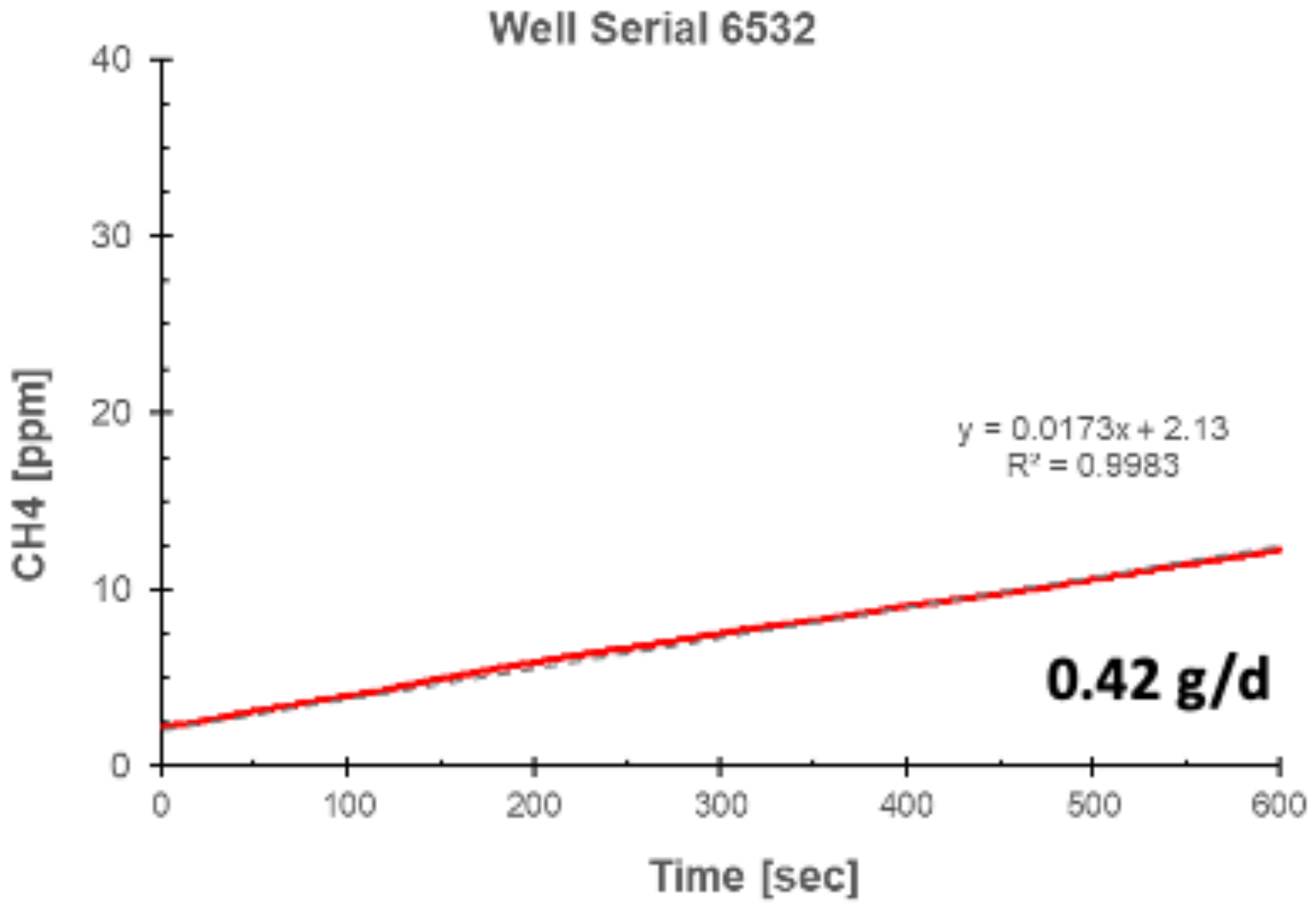
Chamber based emission = 74.55 g/d

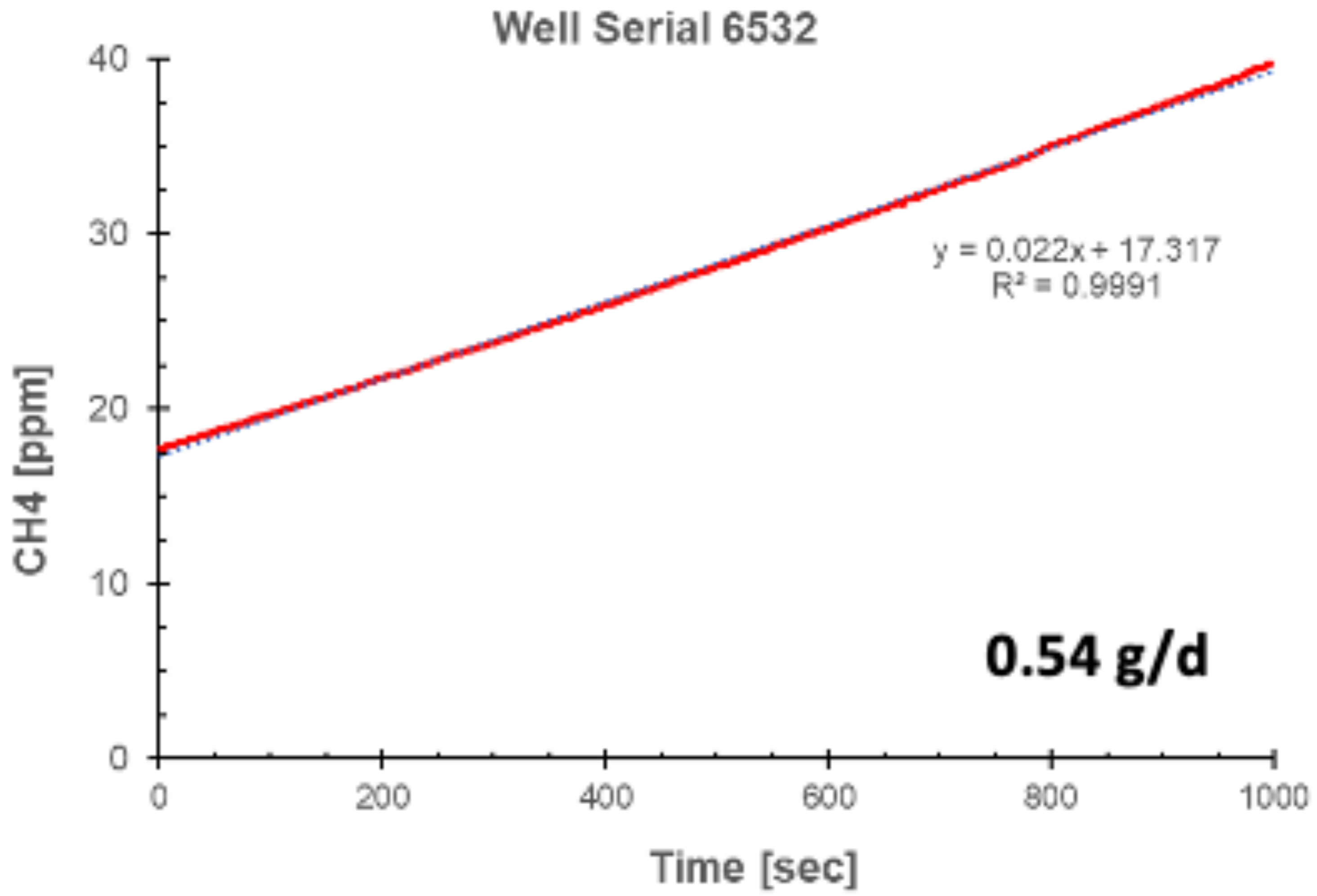
Chamber based emission for background = 0.0



Hint of fluctuating emission rates?







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4. Methane Emissions
5. Benefit / Cost Analysis & J40
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Table 4: Social Costs vs PA Estimates	
Well Counts by Methane Measurement Status	
Pre and Postplug Measurement	582
Only Preplug Measurement	260
No Measurement	3,768
Total Orphan Wells in Louisiana	4,610
Avoided Social Costs (From Plugging)	
At 0% decline	5,750,114
At 2.5% decline	4,210,522
At 5% decline	3,187,288
Social Costs (Estimated from Only Preplug Measurements)	
At 0% decline	2,652,661
At 2.5% decline	1,942,411
At 5% decline	1,470,370
Orphan Well PA Estimates (at $21.2/ft MD) - Preliminary	
Pre and Postplug Measurement	25,465,694
Only Preplug Measurement	12,020,845
No Measurement	467,345,011
Total PA Estimates	504,831,550

$25.5 million of costs incurred to abate $5.8 million in social cost of methane.

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Pre and Postplug Measurement	582
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Only Preplug Measurement	12,020,845
No Measurement	467,345,011
Total PA Estimates	504,831,550

$12.0 million of costs estimated to abate $2.7 million of social cost for measured wells not yet plugged.

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Largest leaker social cost ~$39/year!

Table 4: Largest Leakers

	Methane	Share of Total
Serial Number 152434	1.74	38%
Serial Number 54602	0.36	8%
Serial Number 62164	0.30	7%
Serial Number 54601	0.29	6%
Serial Number 36679*	0.24	5%
Serial Number 150664	0.24	5%
Serial Number 54603	0.18	4%
Serial Number 112516	0.16	3%
Serial Number 205103	0.16	3%
Serial Number 70992	0.14	3%
All other wells	0.72	16%
Total Methane(mscf/day)	4.53	100.0%

Note: From LSU measurements

Recall the average cost to plug a well is ~41k.

5th largest leaker social cost ~$9.7k/year.

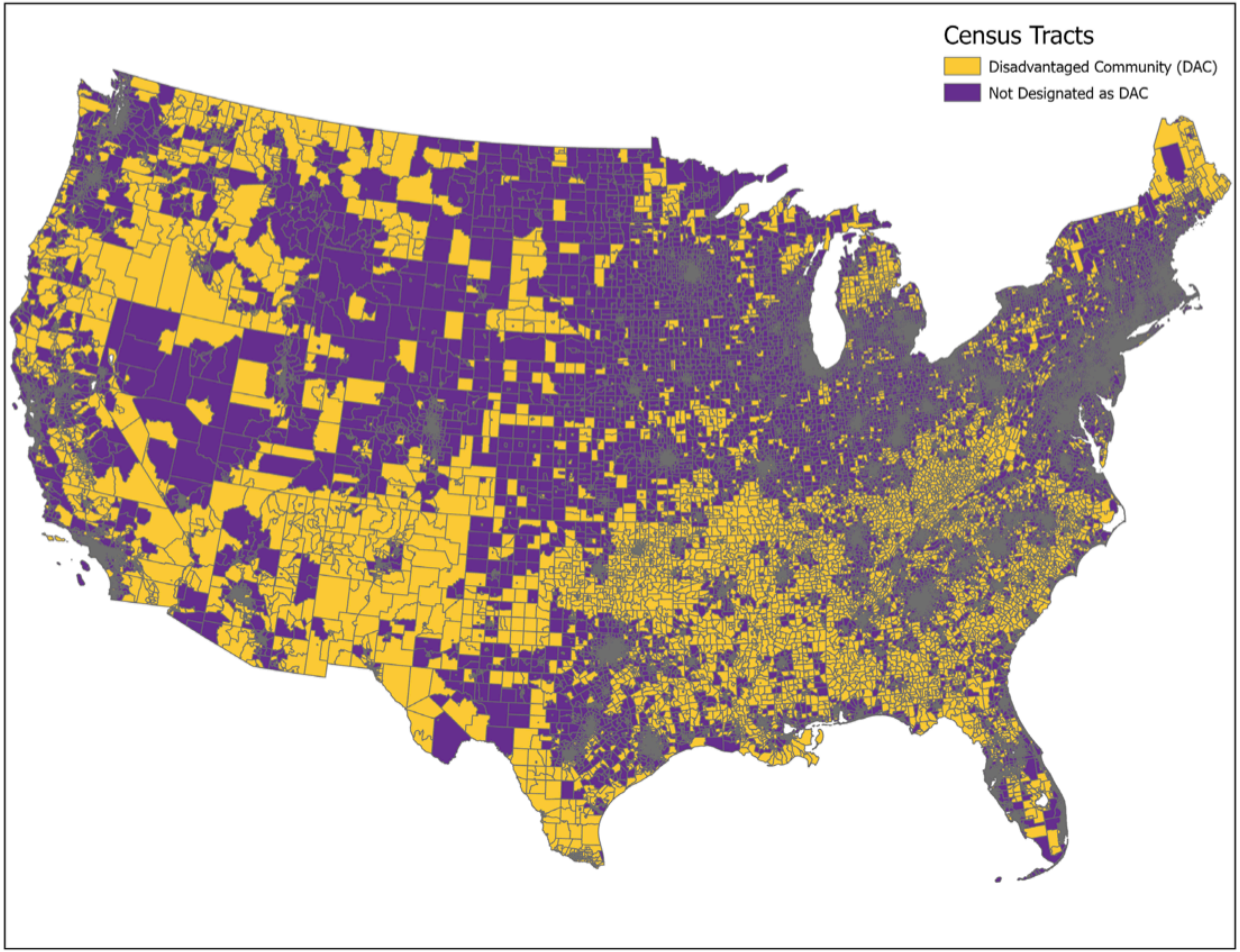
Table 4: Largest Leakers

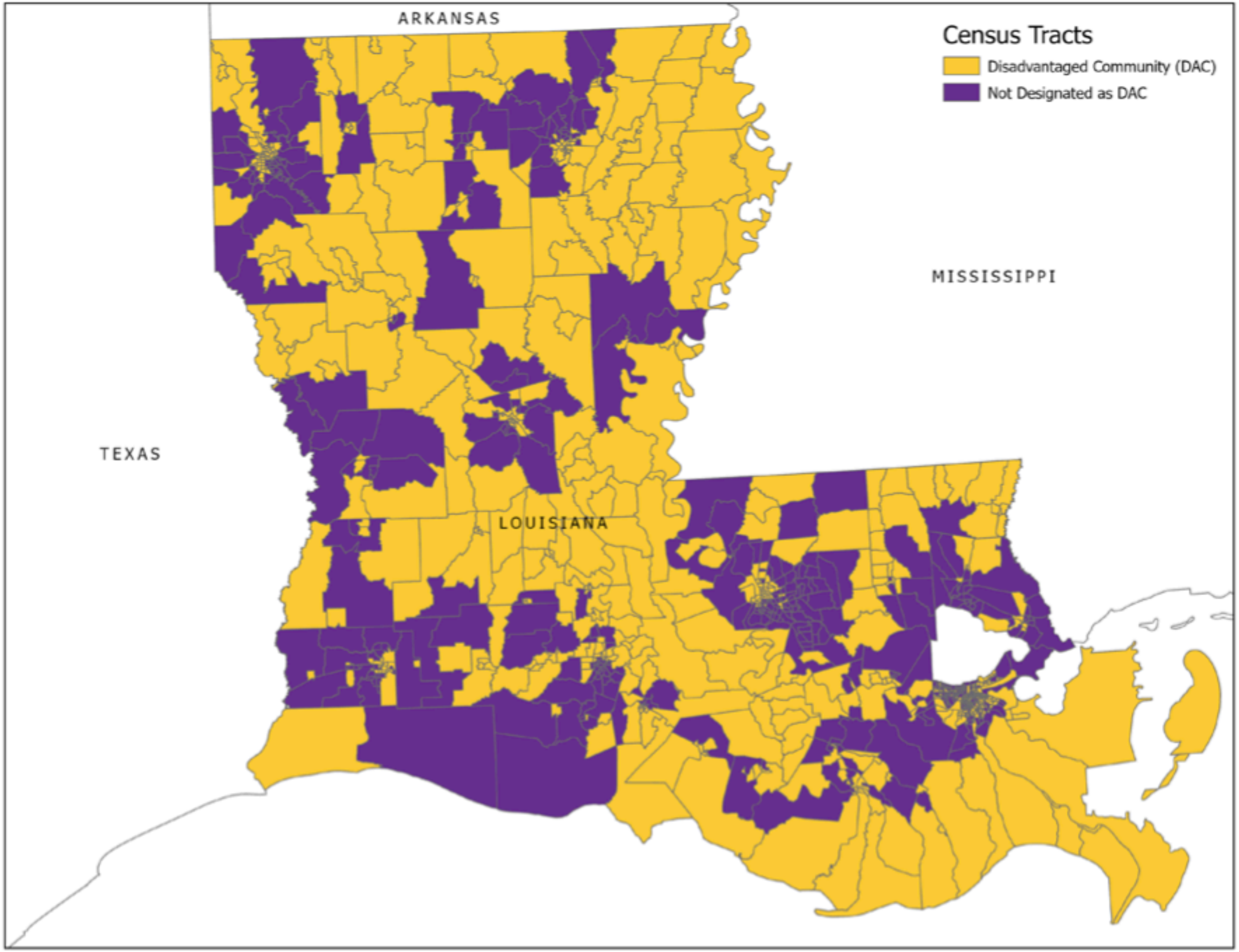
	Methane	Share of Total
Serial Number 176135	2.16	10%
Serial Number 36679	2.12	9%
Serial Number 212286	2.09	9%
Serial Number 87492	0.95	4%
Serial Number 204963	0.89	4%
Serial Number 154325	0.76	3%
Serial Number 150156	0.73	3%
Serial Number 195237	0.71	3%
Serial Number 59710	0.56	2%
Serial Number 186667	0.50	2%
All other wells	11.02	49%
Total Methane(mscf/day)	22.50	100.0%

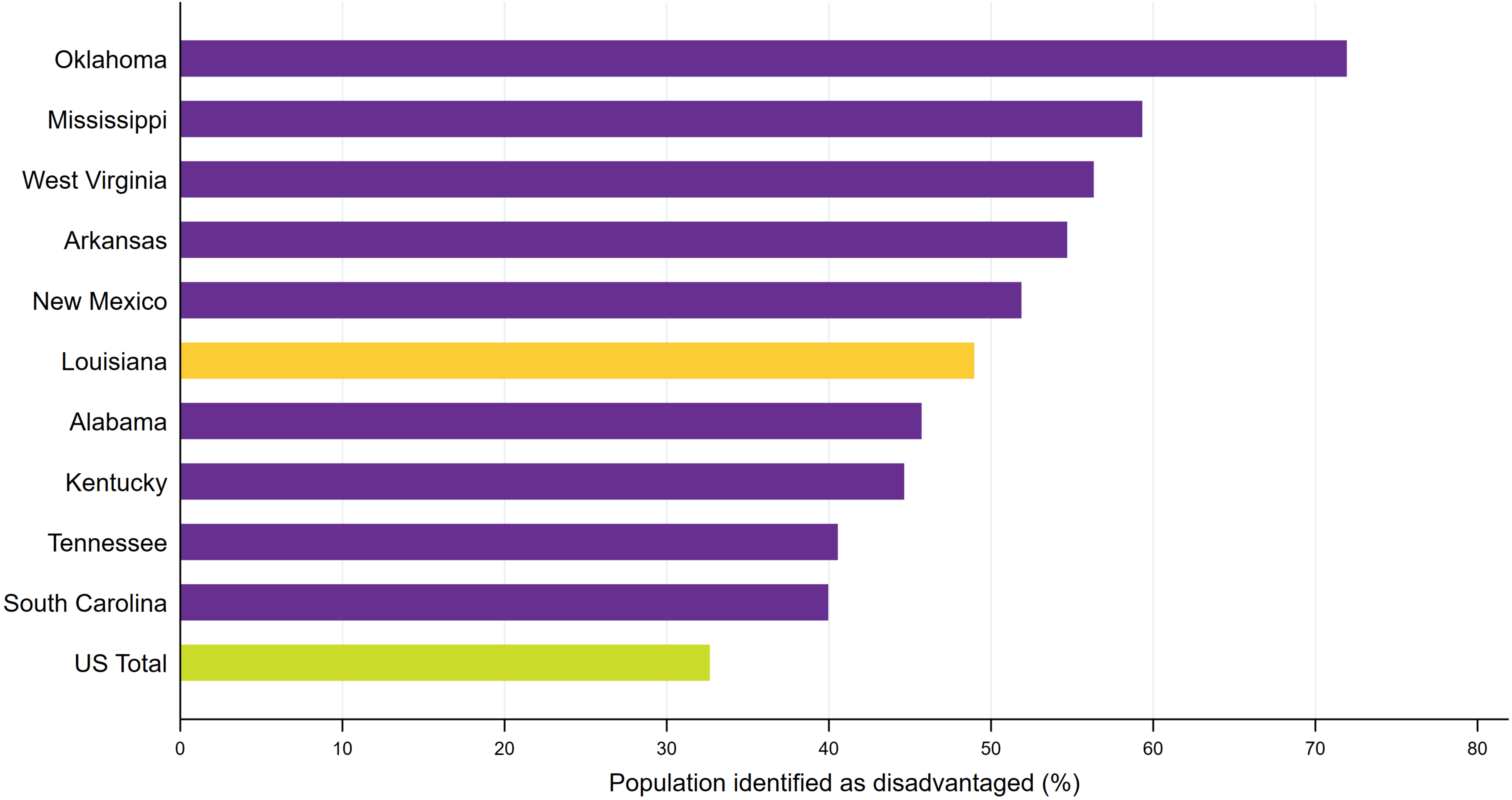
Recall the average cost to plug a well is ~41k.

Justice 40

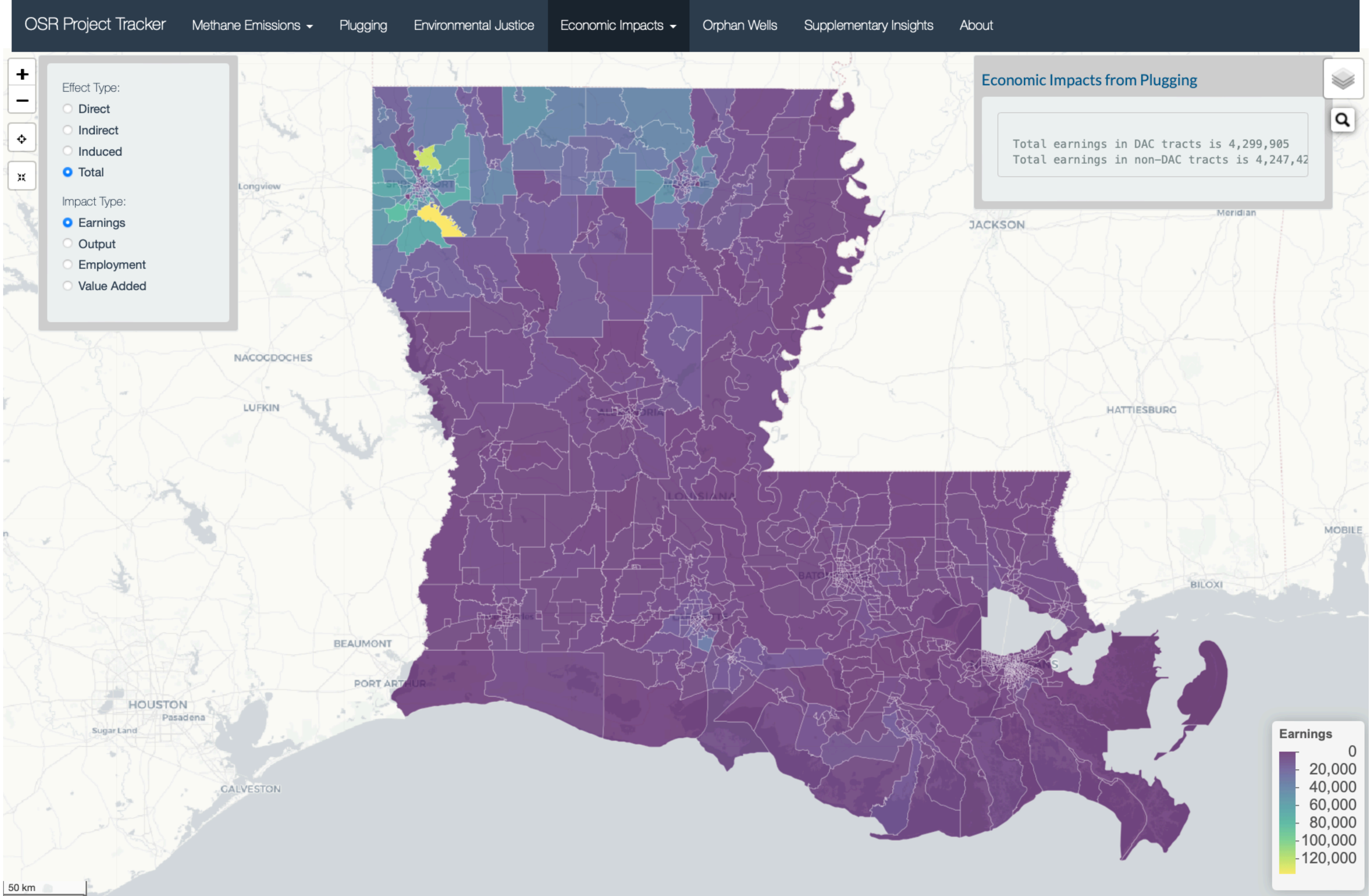
- In 2021, President Biden signed Executive Order 14008, *Tacking the Climate Crisis at Home and Abroad.*
- Although the E's focus was global climate change, one notably component is the Justice40 Initiative (J40).
  - J40 is a goal that 40 percent of the overall benefits from certain federal investments flow to disadvantaged communities (DACs).
- Federal government released a screening tool called the Climate and Economic Justice Screening Tool (CEJST) to help stakeholders identify census tracts that are eligible.

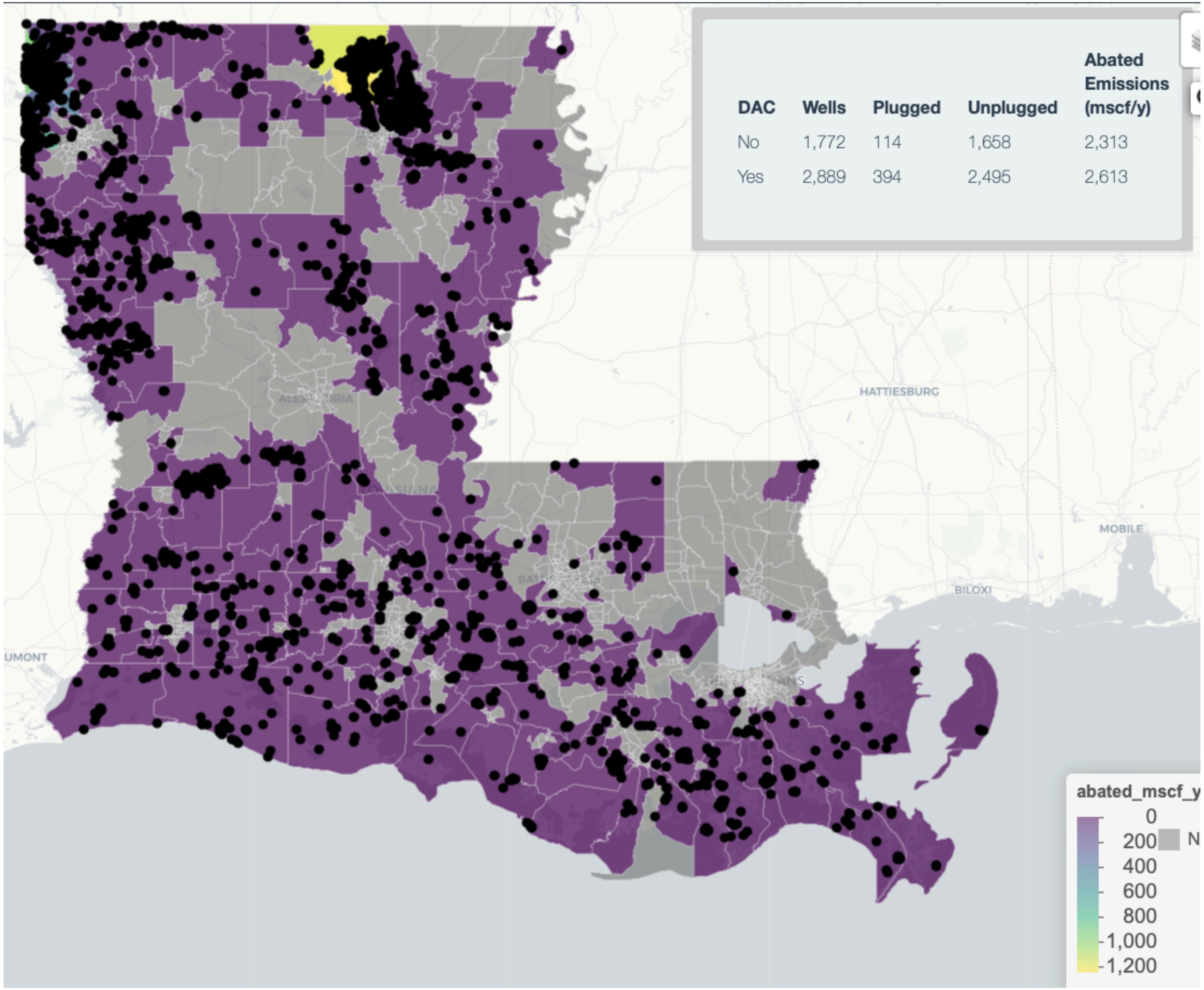

Census Tracts
Disadvantaged Community (DAC)
Not Designated as DAC


Census Tracts
Disadvantaged Community (DAC)
Not Designated as DAC
ARKANSAS
MISSISSIPPI
TEXAS
LOUISIANA



Source: Community and Environmental Justice Screening Tool Version 1.0


OSR Project Tracker
Methane Emissions
Plugging
Environmental Justice
Economic Impacts
Orphan Wells
Supplementary Insights
About
Effect Type:
Direct
Indirect
Induced
Total
Impact Type:
Earnings
Output
Employment
Value Added
Economic Impacts from Plugging
Total earnings in DAC tracts is 4,299,905
Total earnings in non-DAC tracts is 4,247,42
Longview
NACOGDOCHES
LUFKIN
BEAUMONT
PORT ARTHUR
HOUSTON
Pasadena
Sugar Land
GALVESTON
JACKSON
Meridian
HATTIESBURG
MOBILE
BILOXI
Earnings
0
20,000
40,000
60,000
80,000
100,000
120,000
50 km



DAC	Wells	Plugged	Unplugged	Abated Emissions (mscf/y)
No	1,772	114	1,658	2,313
Yes	2,889	394	2,495	2,613

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Next Steps / Discussion

- Preliminary estimates suggest that methane emissions from orphan wells are **highly right skewed** (~half the leaks from ~1% of wells), and thus more funding for finding leakers (and less for actual OSR work) is likely to abate the most emissions for a given budget.
- As detailed measurements come in, we will compare with contractor measurements.
- Continue modeling predictors of leaking.
- Cost modeling continually incorporates new information.

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Questions/Comments

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