Genomic insights into microbial processes in Permian Basin produced waters

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NETL - Pittsburgh
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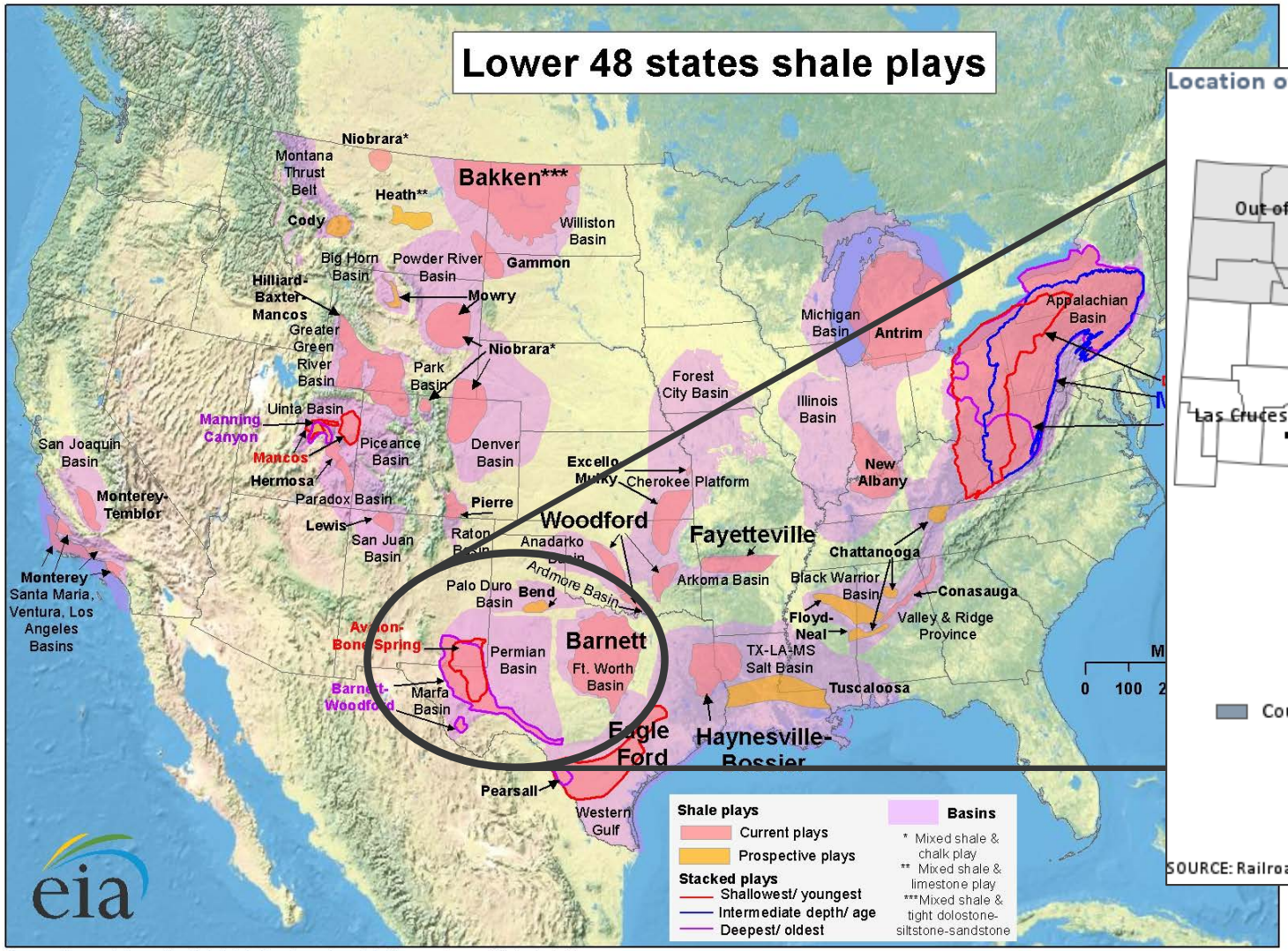
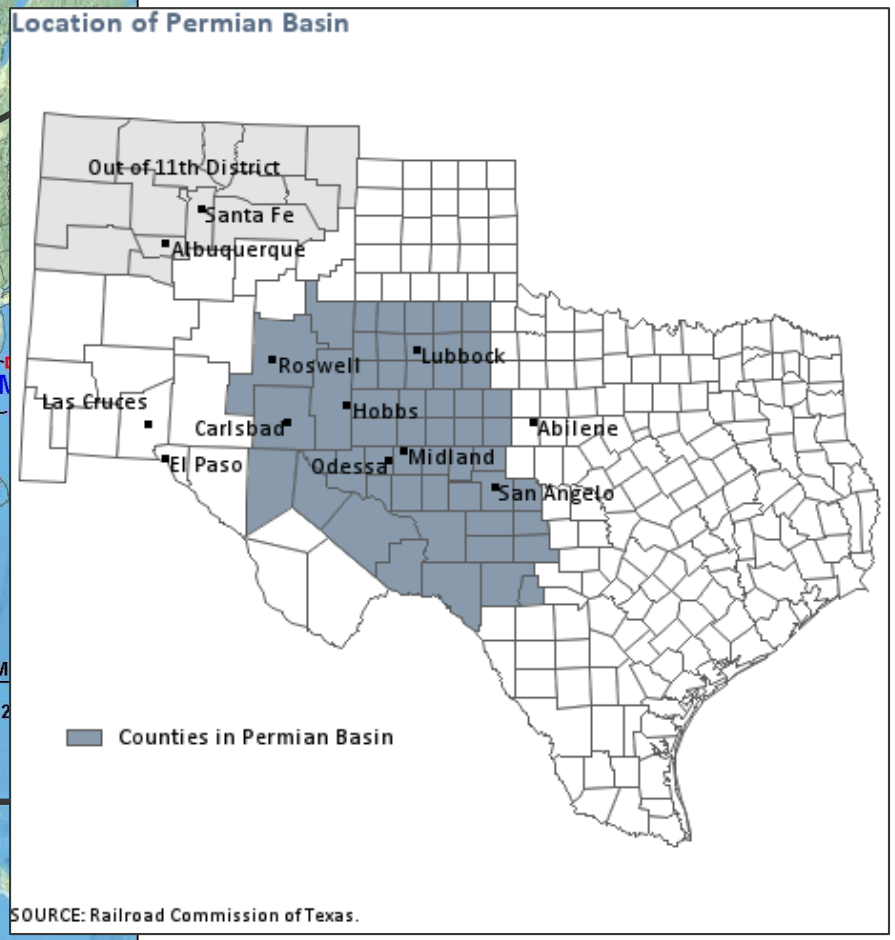
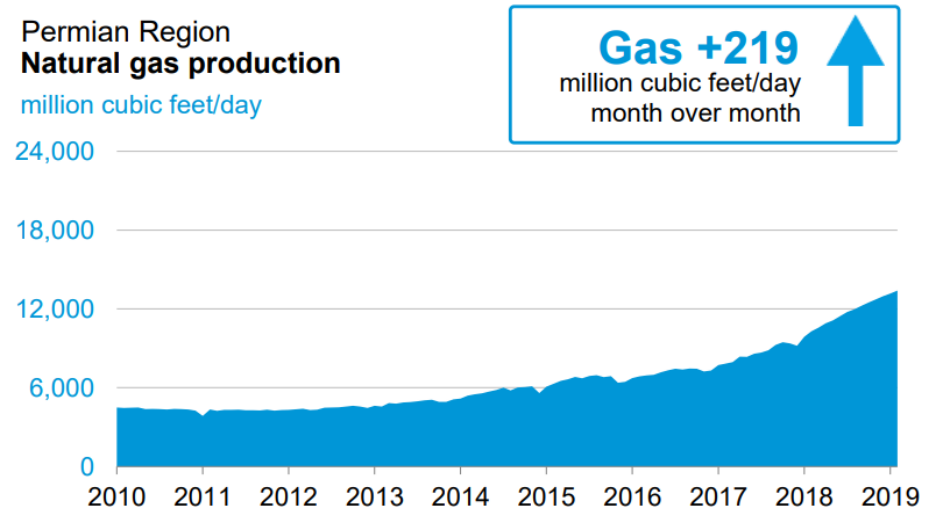
Permian Region

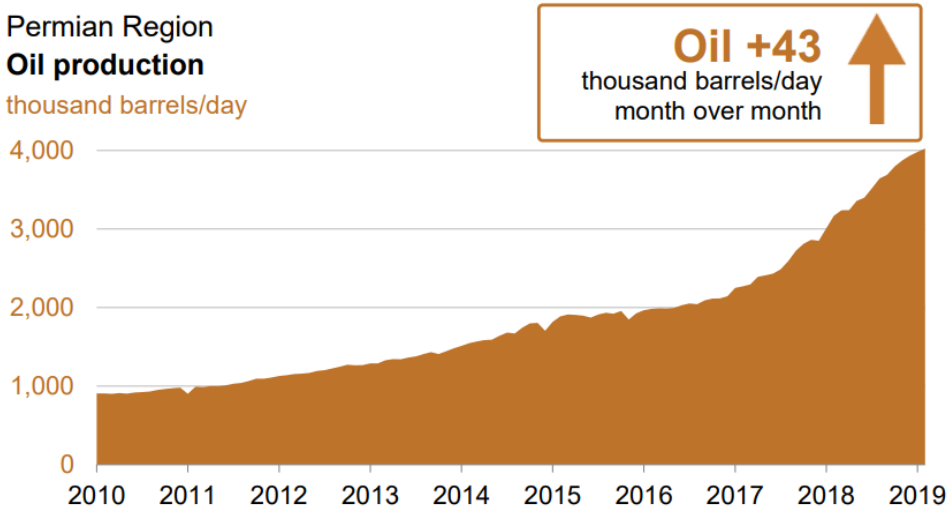


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011



Oil & Gas Production in the Permian Region



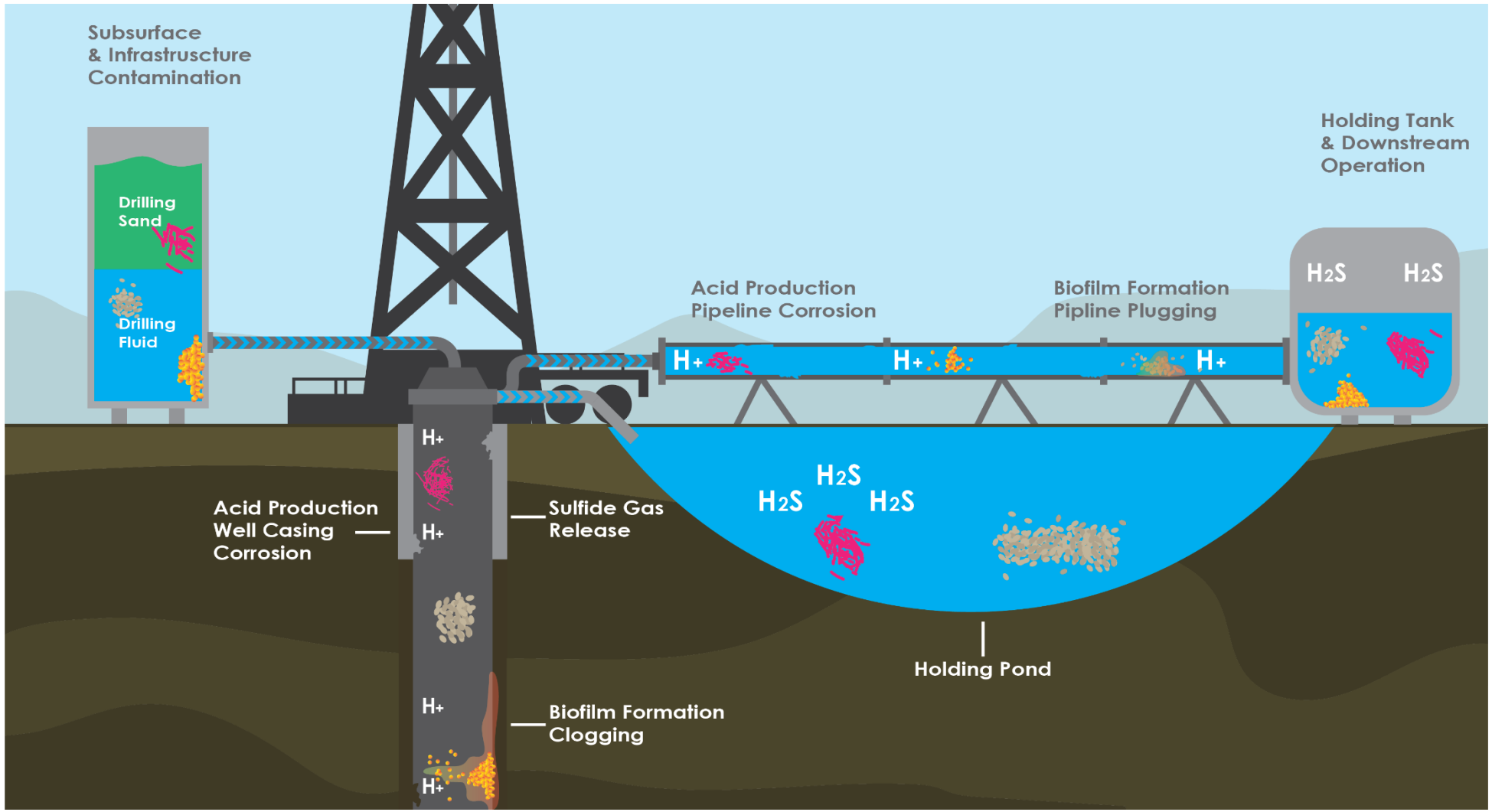


February 2019 EIA Permian Region Drilling Productivity Report

Oil production
thousand barrels/day

Region	February 2019	March 2019	change
Anadarko	587	587	-
Appalachia	138	141	3
Bakken	1,439	1,452	13
Eagle Ford	1,429	1,438	9
Haynesville	43	43	-
Niobrara	697	713	16
Permian	3,981	4,024	43
Total	8,314	8,398	84

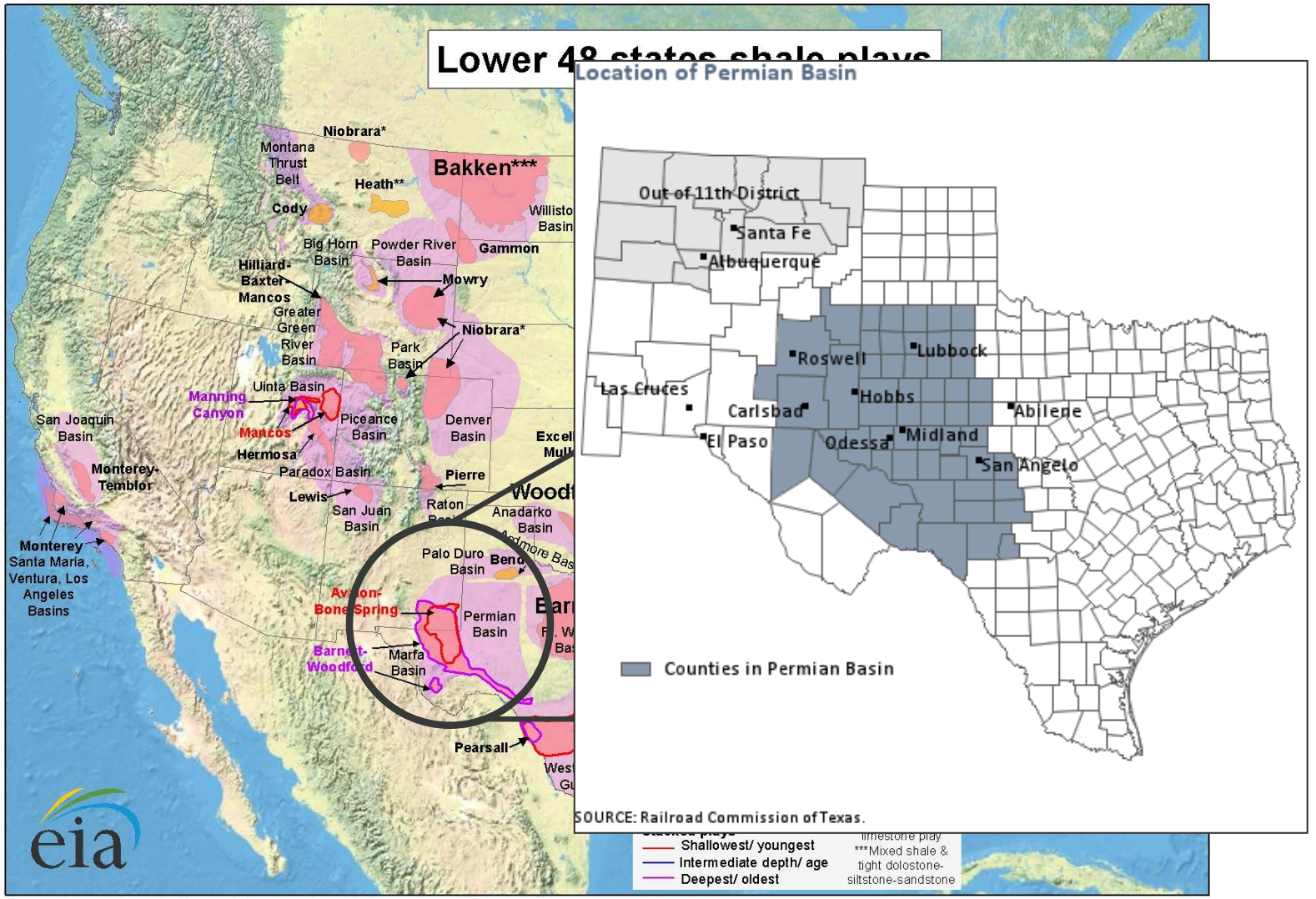
Hydraulic Fracturing



Objective:

Assess the geochemistry and microbiology of the reservoir for biogeochemical reactions that will indicate or impact oil productivity and/or reservoir and infrastructure failure

2018 Sampling Trip: Permian Region

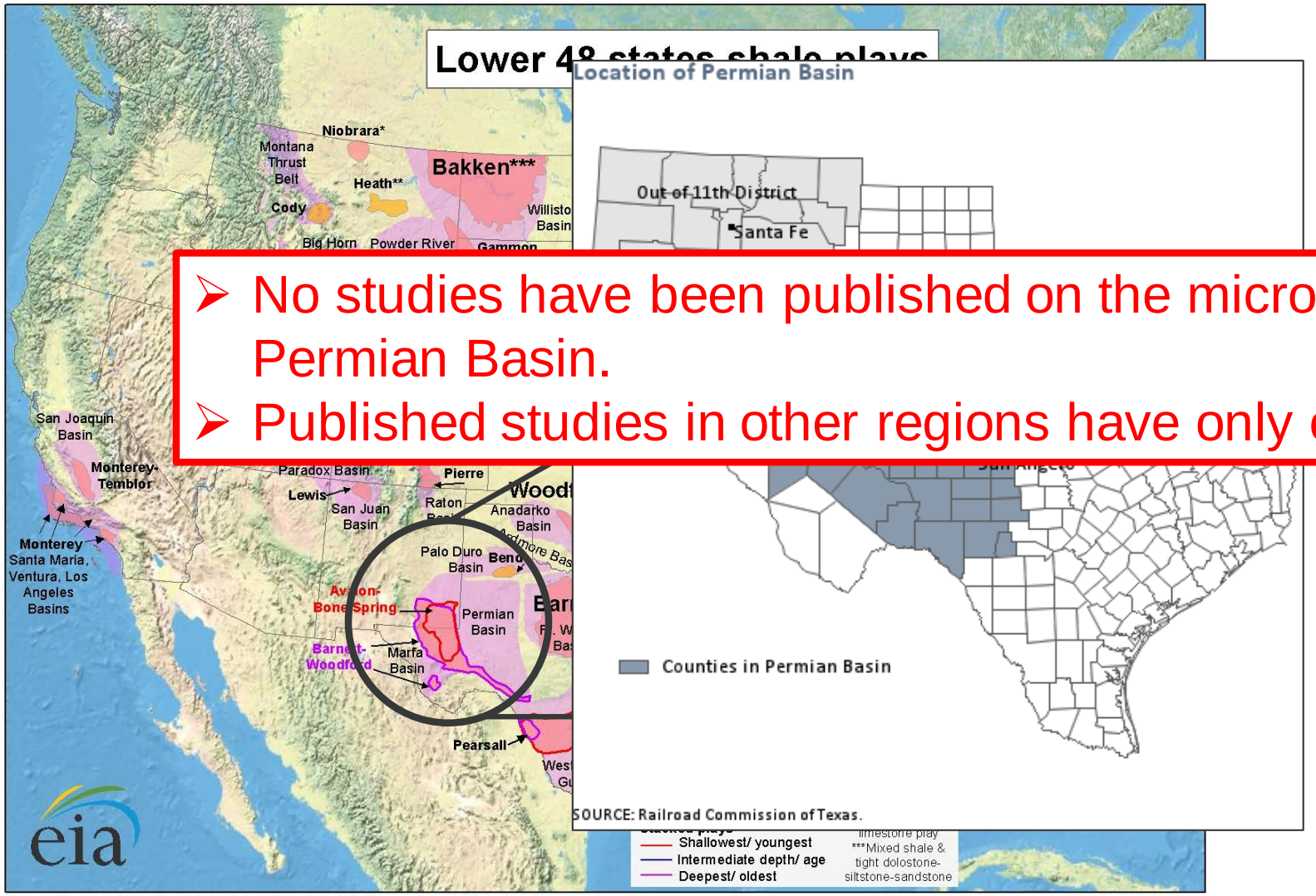


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

14 Produced Water Samples:

- 9 Separators, 5 Wellheads
- 10 “unique” wells
- 4 Wells with both separator + wellheads
- 1 Groundwater Sample

2018 Sampling Trip: Permian Region



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- No studies have been published on the microbial ecology of the Permian Basin.
- Published studies in other regions have only examined separator data

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- 4 Wells with both separator + wellheads
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2018 Sampling Trip: Permian Region

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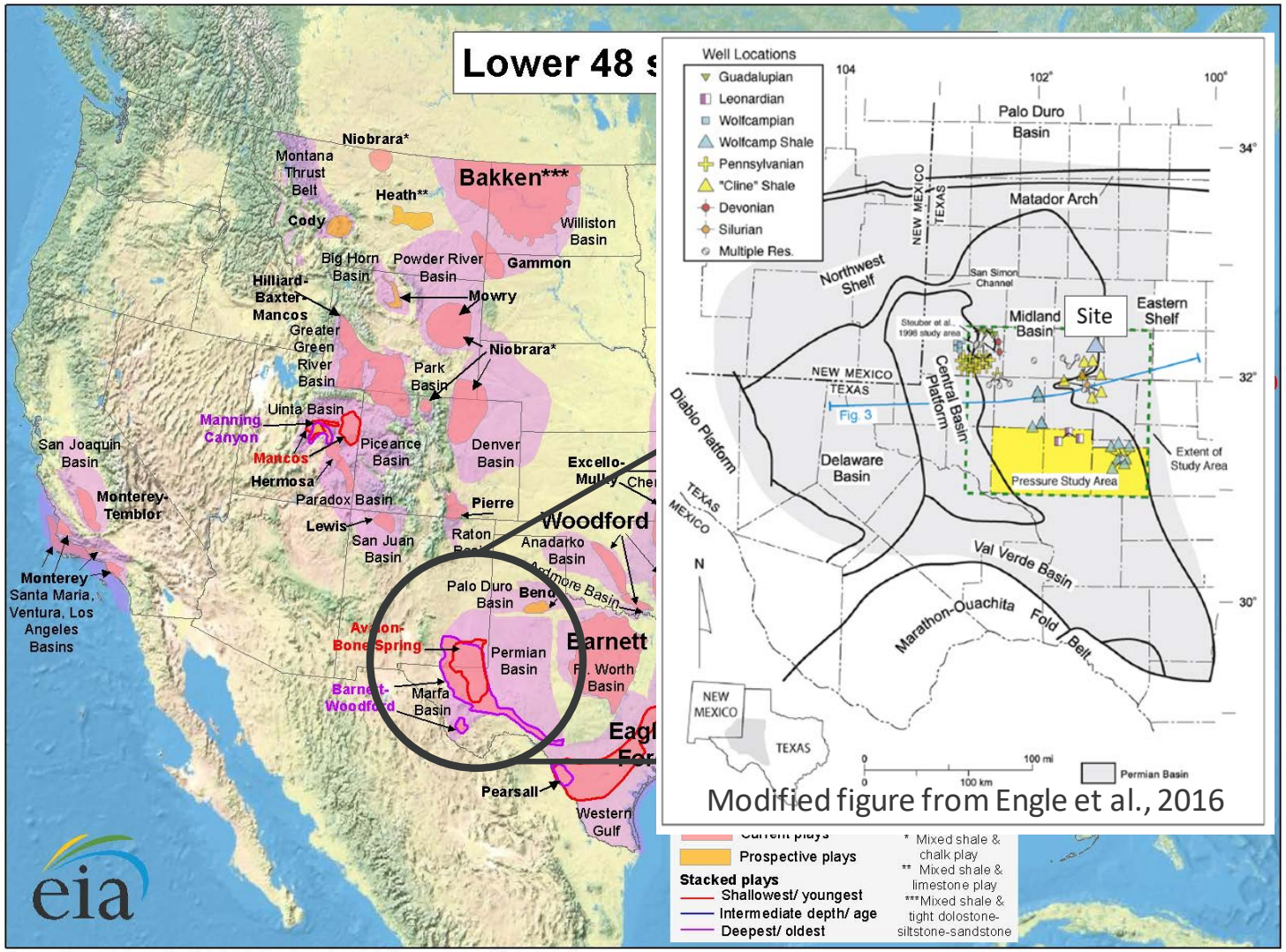
- **Take onsite measurements**
  - pH, conductivity, temperature
  - O_2, CO_2, CO, H_2S
  - Alkalinity
- **Prep samples onsite**
  - Ion Chromatography (16 analytes)
  - ICP-OES (17 analytes)
  - Ferric Iron
  - Genomics

2018 Sampling Trip: Permian Region



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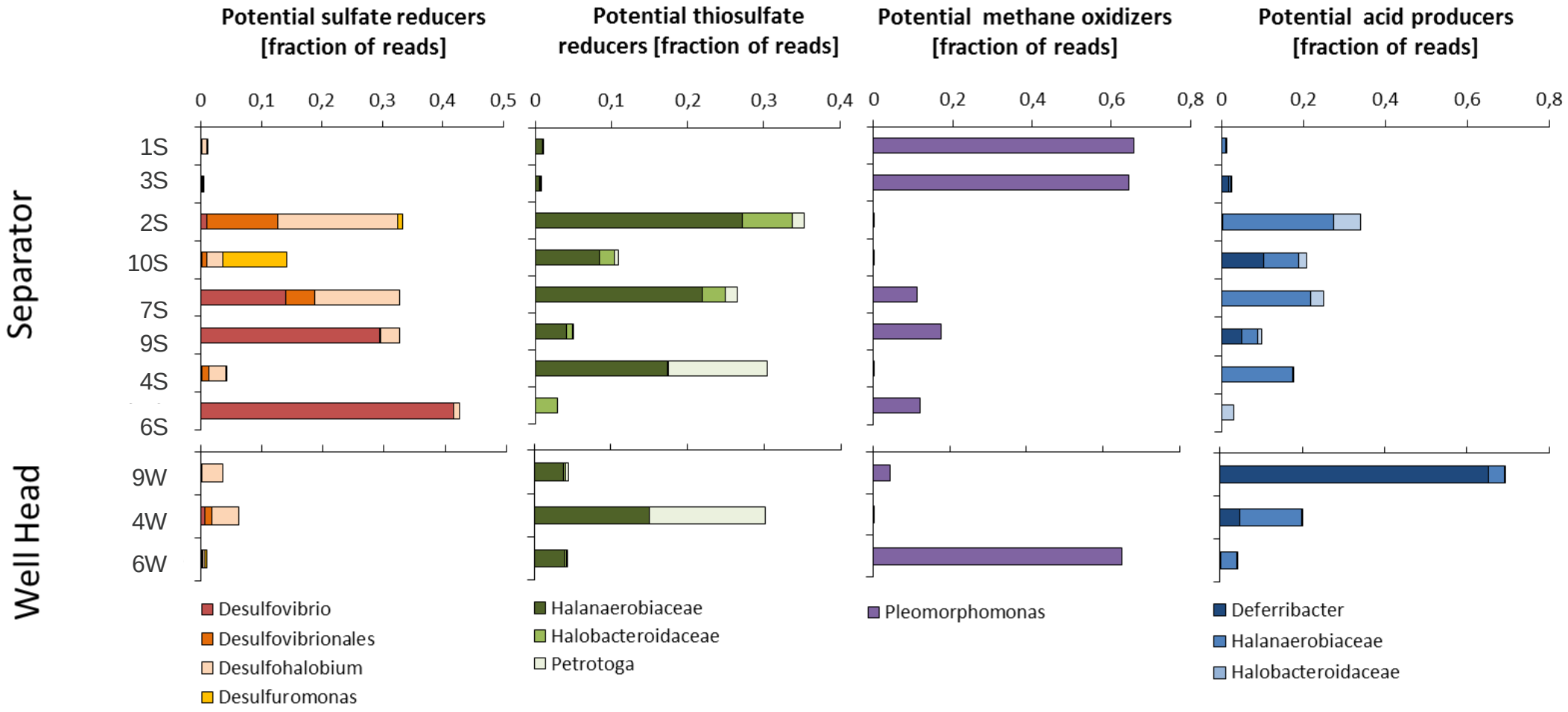
Sample ID	16S	Metagenomics
1S	duplicated	
2S		duplicated
3S		duplicated
4S		
5W		
6W		
6S		
7W		
7S		
8W		
8S		
9W		
9S		
10S	duplicated	

Produced water contains functionally relevant microbiota



19 Bins Recovered

	Organisms	Sample ID	Completeness	Contamination	Quality
1	Orenia	3S-D	98.33	9.83	high
2	Geoglobus	4S	97.39	6.87	high
3	Orenia	1S	96.03	5.42	high
4	Methanohalophilus	4S	95.22	8.47	high
5	Methanothermococcus	4S	95.1	2.68	high
6	Desulfohalobium	2S	95.03	1.97	high
7	Methanohalophilus	7S	93.95	4.3	high
8	Desulfohalobium	7S-D	90.67	1.45	high
9	Marinobacter	4S	83.82	9.4	high

	Organisms	Sample ID	Completeness	Contamination	Quality
10	Archaeoglobus	4S	97.71	14.71	medium
11	Halomonas	3S-D	83.65	9.45	medium
12	Methanohalophilus	2S	76.2	5.89	medium
13	Pseudomonas	3S	72.57	5.56	medium
14	Pelobacter	3S	67.54	10.17	medium
15	Clostridium	3S	65.22	9.25	medium
16	Marinobacter	1S	76.67	22.21	low
17	Halanaerobium	3S	75.5	15.2	low
18	Pelobacter	3S-D	69.33	9.69	low
19	Alcanivorax	10S-D	51.03	4.89	low
20	Archaeoglobus	3S-D	50.25	6.66	low
21	Ralstonia	1S	41.08	6.78	low

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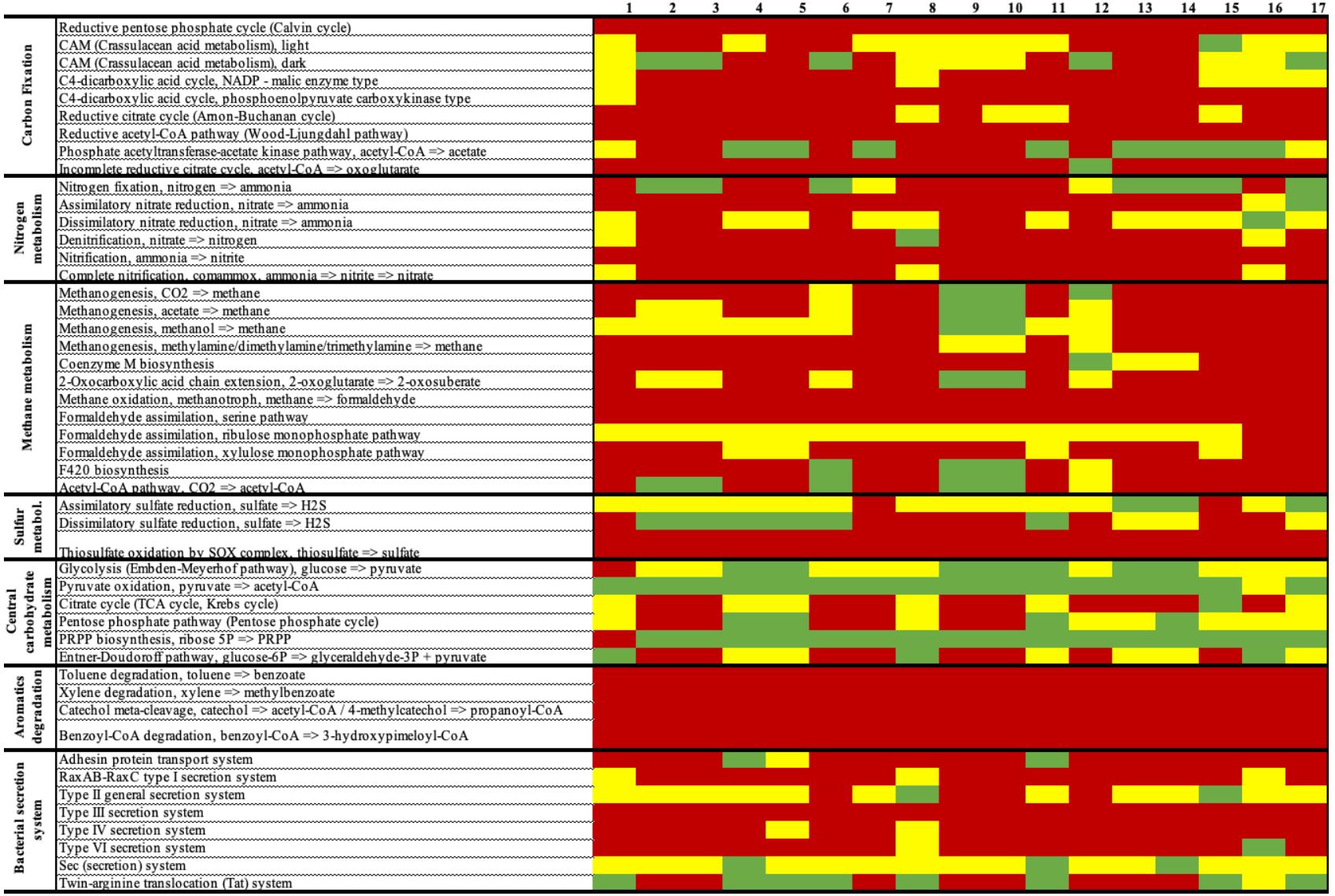

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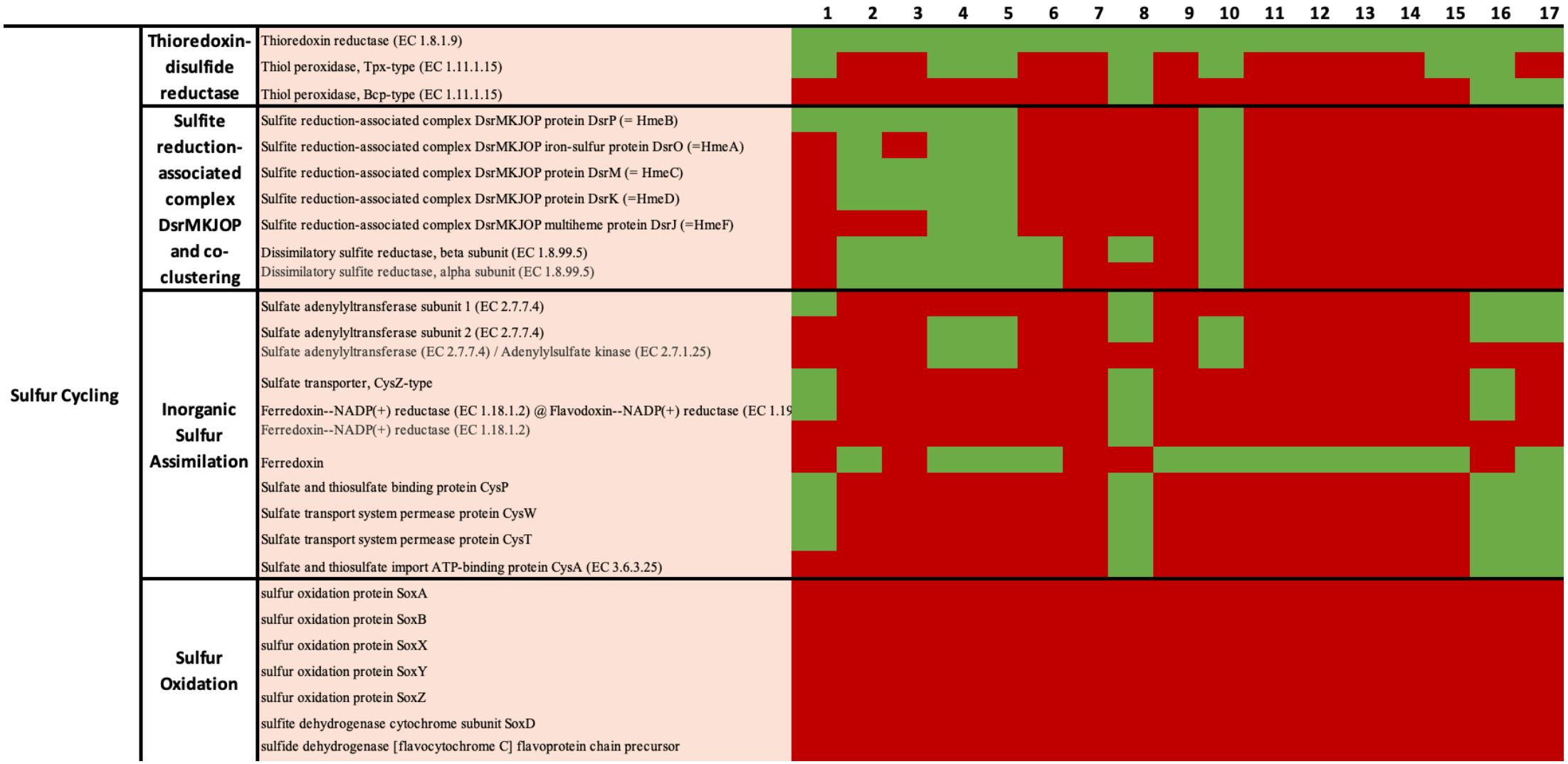

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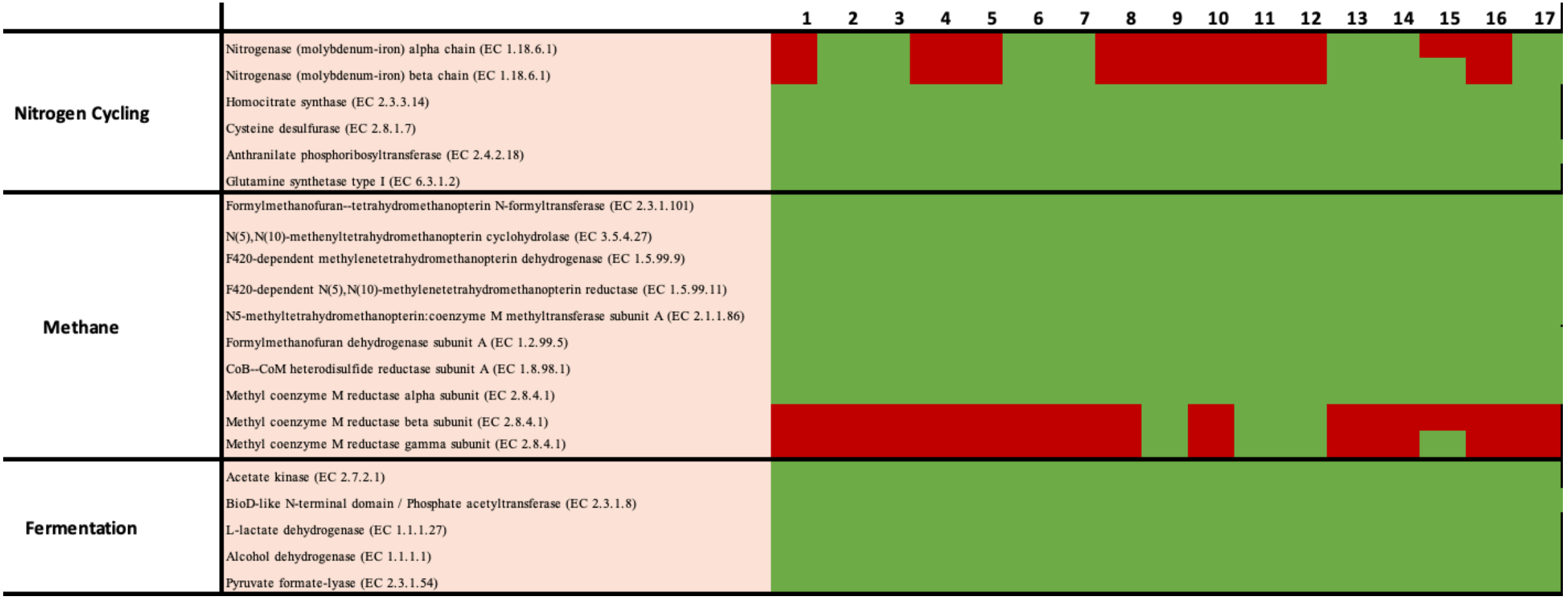

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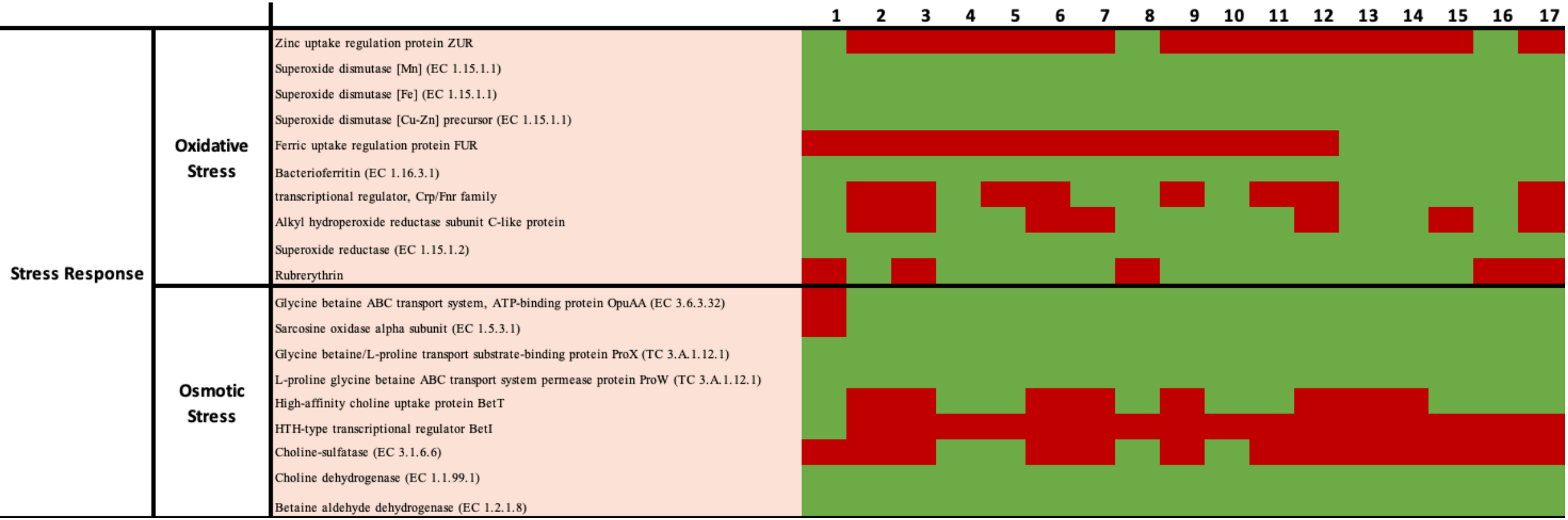

Produced Water Chemistry

ID	pH	HCO_3 (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Br (mg/L)	TDS (mg/L)	Water type
Produced Waters, likely Wolfcamp origin												
1S	6.6	522	1680	601	18500	338	42.6	3650	32800	229	58300	Na-Cl
2S	6.9	737	1830	506	23500	383	14.7	2680	39800	308	69700	Na-Cl
3S	6.4	366	1350	517	18200	299	24.4	3490	30100	238	54500	Na-Cl
4S	6.7	337	2150	509	28400	436	52.8	2500	49300	388	84000	Na-Cl
5	7.3	378	3210	593	37900	520	48.7	1300	66700	524	111000	Na-Cl
6	7.2	512	3300	578	36400	410	66.9	1110	63800	469	107000	Na-Cl
6D	7.2	512	3320	584	36200	408	67.0	1120	63500	471	106000	Na-Cl
6S	7.0	368	3180	565	36600	415	BDL (<1.00)	1090	64300	469	107000	Na-Cl
7	6.7	388	3610	615	42000	613	52.1	856	74500	604	123000	Na-Cl
7S	6.6	290	3600	611	41700	610	57.6	817	74100	614	122000	Na-Cl
8	6.7	381	3420	599	40300	540	52.1	827	71300	554	118000	Na-Cl
8S	6.5	425	3430	602	40400	542	64.2	864	73300	555	120000	Na-Cl
9	6.6	464	3790	617	39900	423	79.8	630	71300	524	118000	Na-Cl
9S	6.6	398	3830	623	40400	428	86.8	626	73100	530	120000	Na-Cl
10	6.9	95.2	1320	504	18000	302	24.4	3420	29300	229	53200	Na-Cl
min	6.4	95.2	1320	504	18000	299	14.7	626	29300	229	53200	
max	7.3	737	3830	623	42000	613	86.8	3650	74500	614	123000	
median	6.7	388	3300	593	36600	423	52.5	1110	64300	471	107000	
average	6.8	412	2868	575	33227	444	52.4	1665	58480	447	98113	
Groundwater used for mixing frac water												
GW	7.1	427	92.9	48.5	2830	11.0	ND	2070	2960	6.23	8432	Na-Cl

Two distinct groups of produced water

ID	pH	HCO_3 (mg/L)	Ca (mg/L)	Mg (m	/L)	Cl (mg/L)	Br (mg/L)	TDS (mg/L)	Water type
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9S	6.6	398	3830	623		73100	530	120000	Na-Cl
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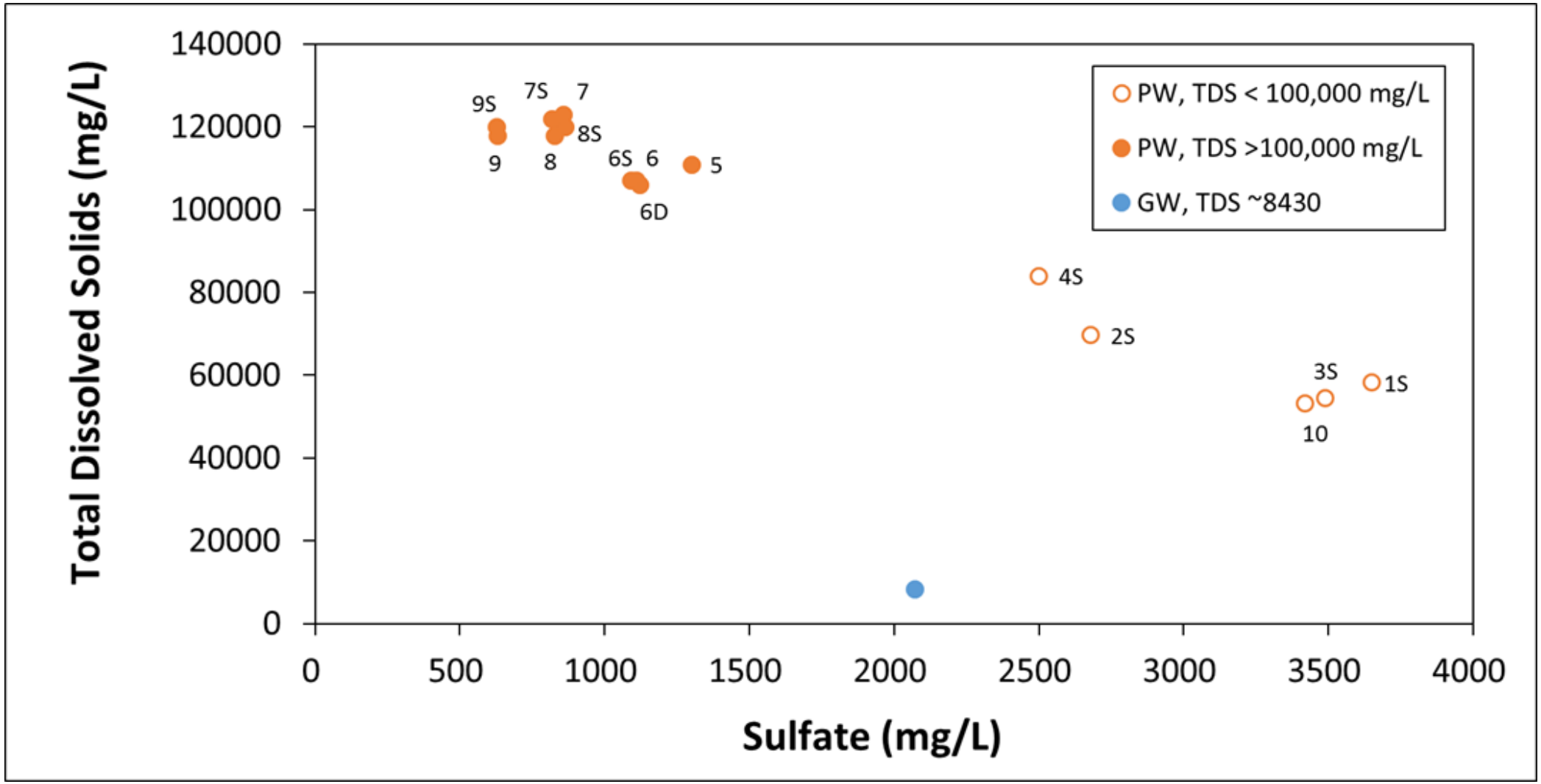
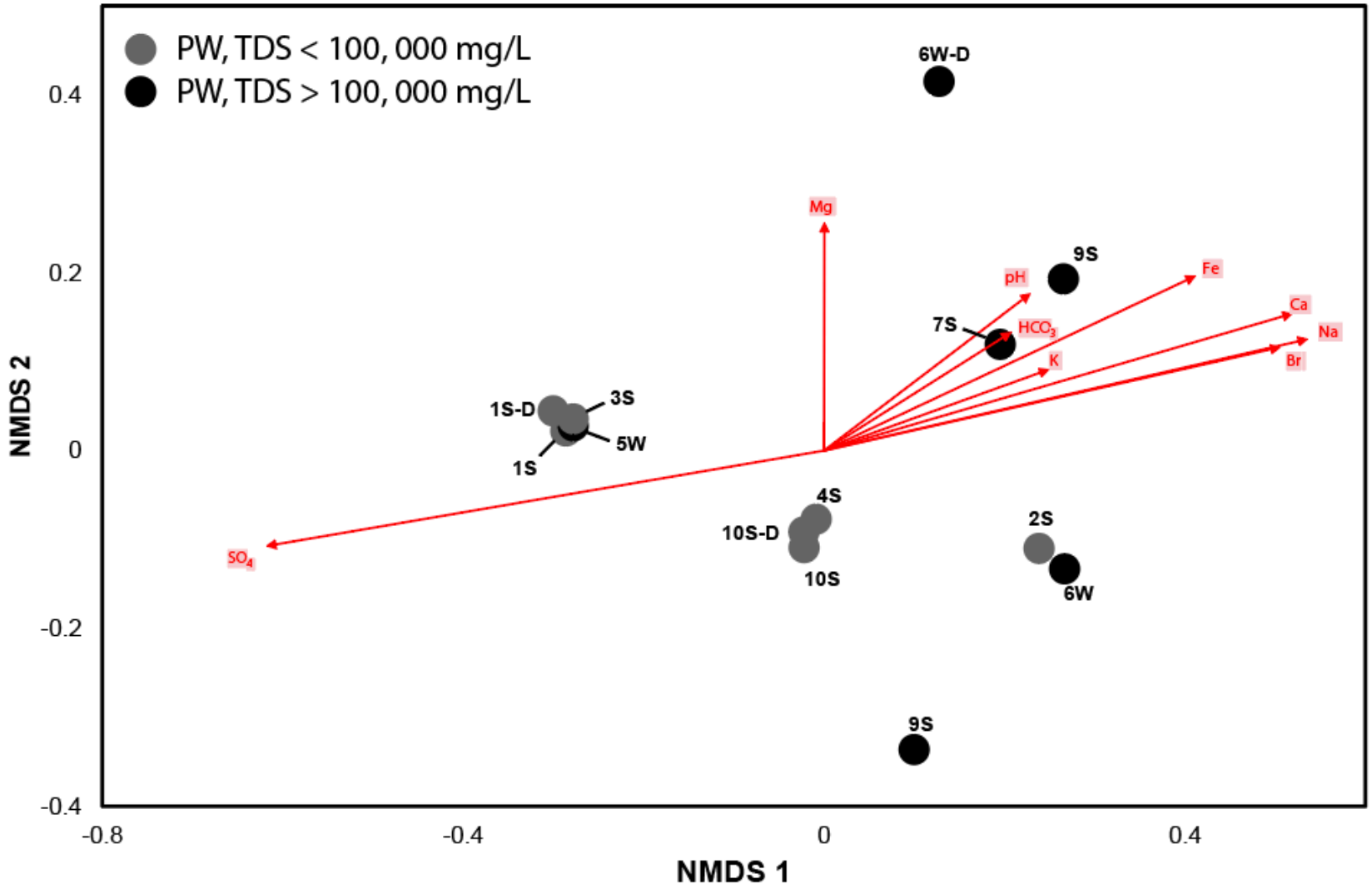
median	6.7	388	3300	593		64300	471	107000	
average	6.8	412	2868	575		58480	447	98113	
Groundwater used for mixing frac water									
GW	7.1	427	92.9	48.5		2960	6.23	8432	Na-Cl

Sample ID	TDS (mg/L)
Produced water, likely Wolfcamp origin	
1S	58300
2S	69700
3S	54500
4S	84000
5W	111000
6W	107000
6W-D	106000
6S	107000
7W	123000
7S	122000
8W	118000
8S	120000
9W	118000
9S	120000
10S	53200
Groundwater used for mixing frac water	
Proximal Groundwater	8432

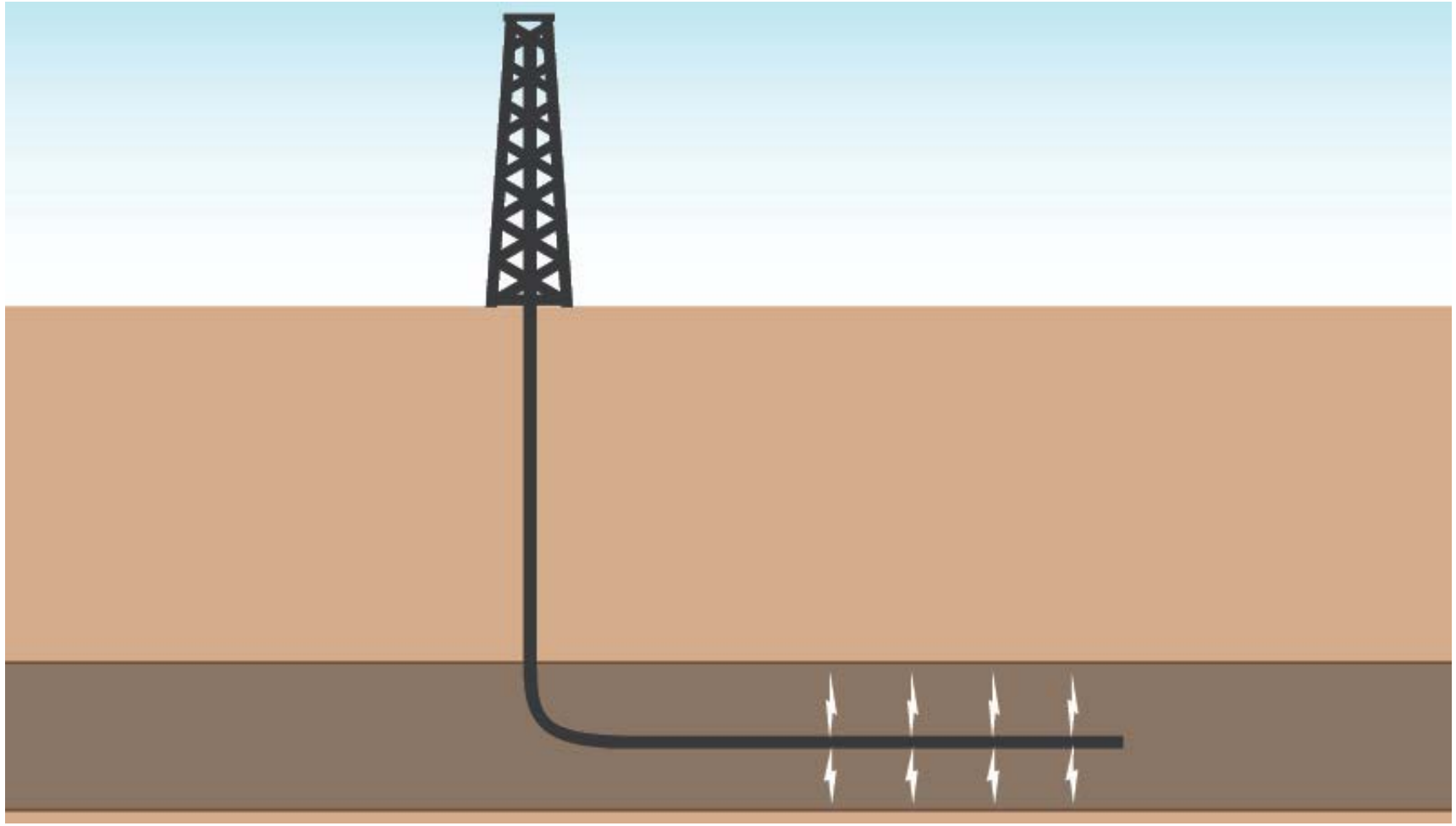
Two distinct groups of produced water



Microbiota cluster by produced water group



Are some sites affected by nearby injections?



Future Work

- Finish Permian Data Analysis
- Process & analyze Bakken Data
- Continue sampling efforts

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- Establish internal metatranscriptomic protocols
- Review protocols for low biomass samples
- Review protocols industry biocide practices

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NETL – Albany

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