Figure 32. Percent of decile having equipment

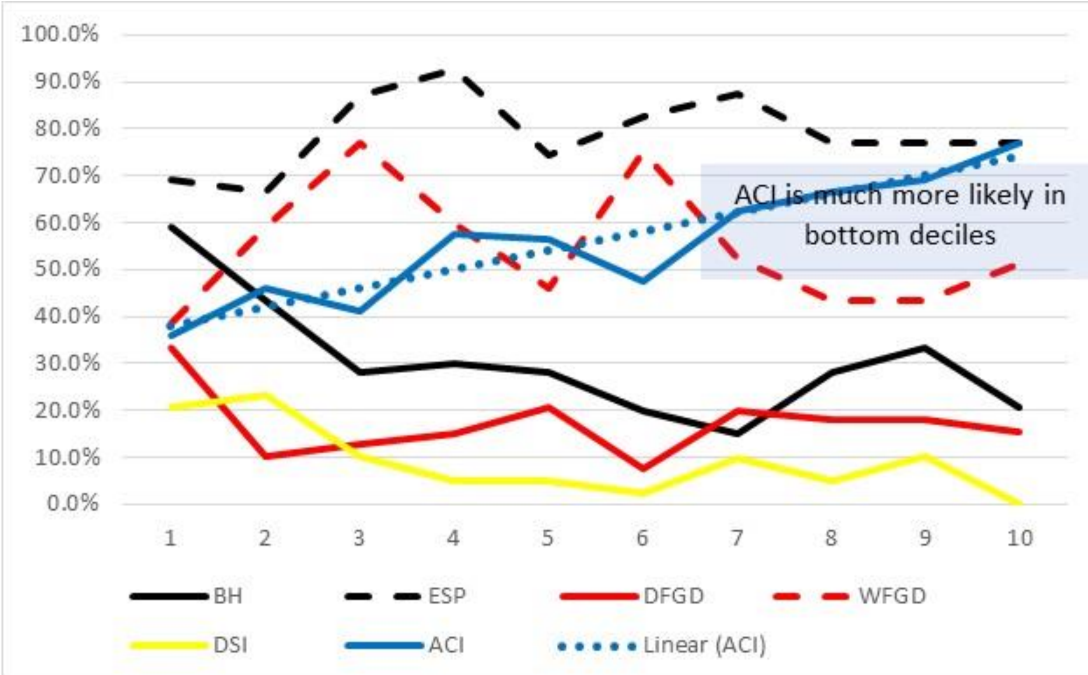
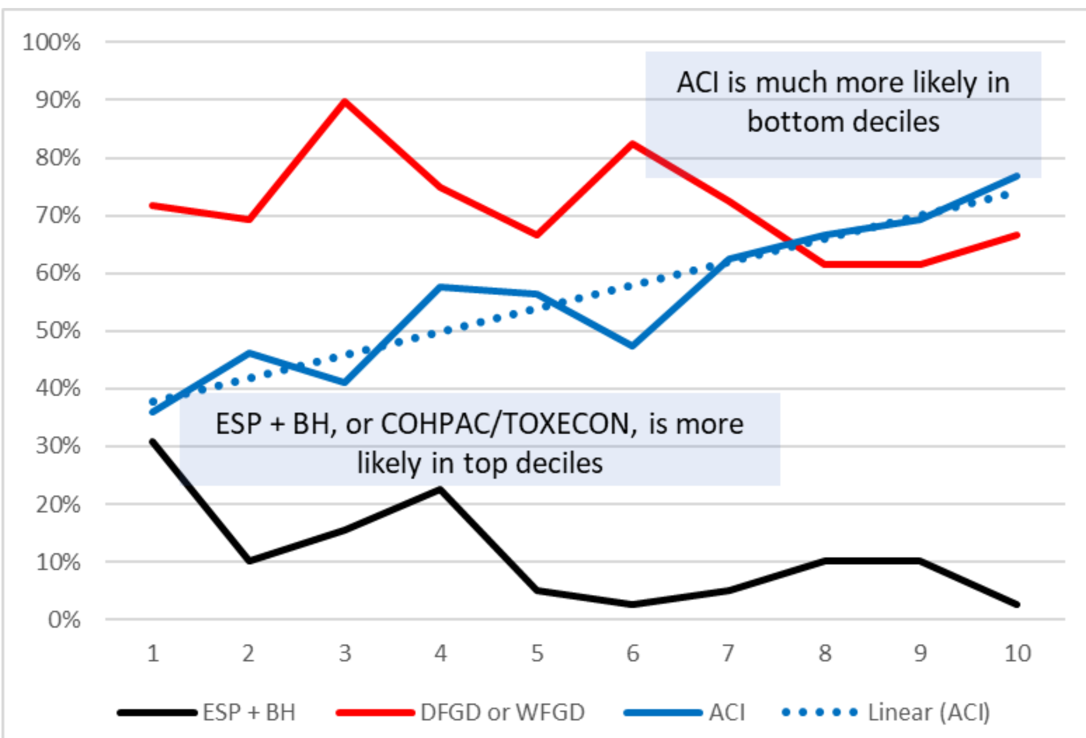


Figure 33. Percent of decile with equipment. Any type of FGD, ESP plus BH, ACI



The ability to control Hg while equipped with only an ESP and ACI was examined. As demonstrated in Figure 34, when there was only an ESP (no baghouse or scrubber), most units were estimated to have greater than 90% capture efficiency, and some well over 95%. ACI is the method of control. As a result, high capture efficiencies of 95% or better are possible when simply using ACI with an ESP.

Note that only units reporting unit level Hg emissions rate data are included. Excluded from this evaluation are those units where only plant level Hg emissions data was available.

Figure 34. Emission rate and estimated capture efficiency for not low-rank coal, unscrubbed units, with only an ESP and ACI.

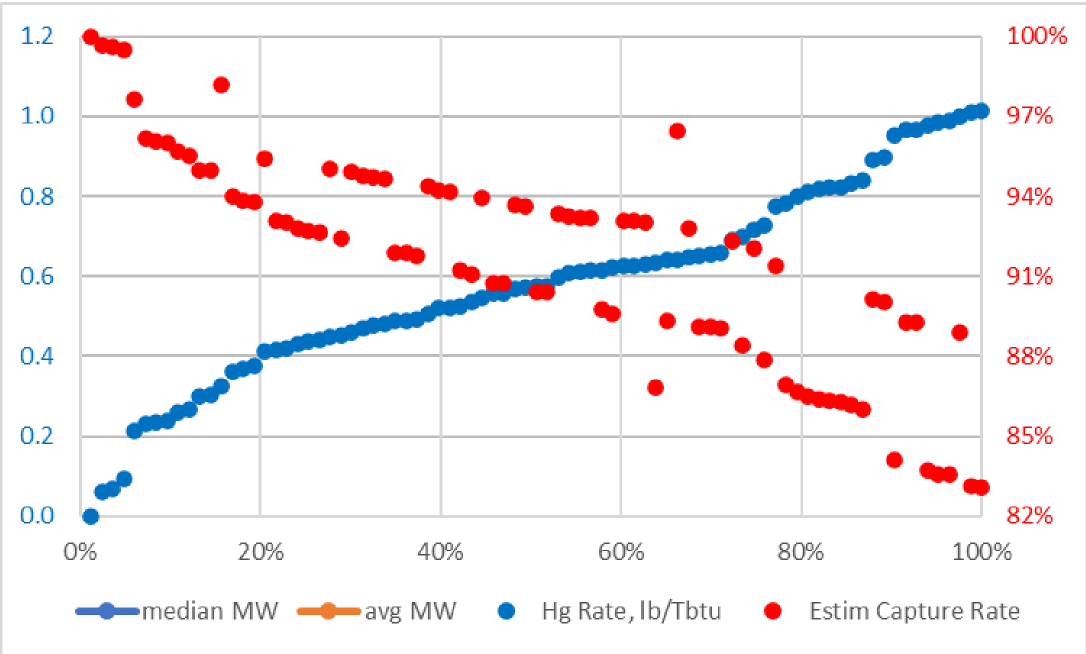


Table 11 shows a summary of the equipment for the top and bottom deciles. Top units are much more likely to:

- Have a baghouse
- Use bituminous coal
- Not rely upon ACI

Top decile units are also:

- Somewhat more likely to have a dry scrubber
- Somewhat less likely to have a wet scrubber

Table 11. Summary of equipment for top and bottom decile

Top Decile						
Row Labels	**Count of Coal Units**	**Sum of BH**	**Sum of ESP**	**Sum of DFGD**	**Sum of WFGD**	**Sum of ACI**
BIT	19	11	17	6	8	4
OTH	8	4	7	2	6	5
SUB	12	8	3	5	1	5
Grand Total	**39**	**23**	**27**	**13**	**15**	**14**

Bottom Decile						
Row Labels	**Count of Coal Units**	**Sum of BH**	**Sum of ESP**	**Sum of DFGD**	**Sum of WFGD**	**Sum of ACI**
BIT	11	1	10	0	11	3
OTH	9	0	9	1	3	9
SUB	20	8	11	5	7	19
Grand Total	**40**	**9**	**30**	**6**	**21**	**31**

The following are some caveats and summary of data on not low-rank coal.

- The data doesn't include use of oxidizing agents or scrubber re-emission additives
- The analysis only examined unit-level emissions data – not common stack data
- Top deciles have highest use of baghouses and combination of baghouses and ESPs
- Wet FGD units are most likely to be in mid-deciles
- Bottom deciles have the highest use of ACI and lowest use of baghouses
    - Consistent with "dial up" nature of ACI
- Even units equipped only with ESPs and ACI can achieve very high mercury capture

2. Low-rank coals

Table 12 shows the overall emission rates for the 23 low-rank units from the NRDC database. The emission rates, in some cases, were well under the limit of 4 lbs/TBtu. As shown in Table 13, the lowest emitter was an unscrubbed unit with a BH and ACI, and the highest emitter was scrubbed. Of the 23 units, all but four were listed as using ACI. The four without ACI were scrubbed units that were able to achieve Hg capture in the scrubber. One unit had a venturi scrubber and ACI. The scrubber's capture may have been aided by the addition of chemicals; however, this information is not available because it is not reported. Table 14 shows the coal types were primarily lignite and refined coal (mostly, lignite that has been modified to be refined coal).

Table 12. Overall Hg emission rates of low-rank coal units

No. of Units	Emission Rates (lb/TBtu)		
	Min	Max	Avg
23	1.04	3.81	2.34

Table 13. Control technologies and associated Hg emission rates for low-rank coal units

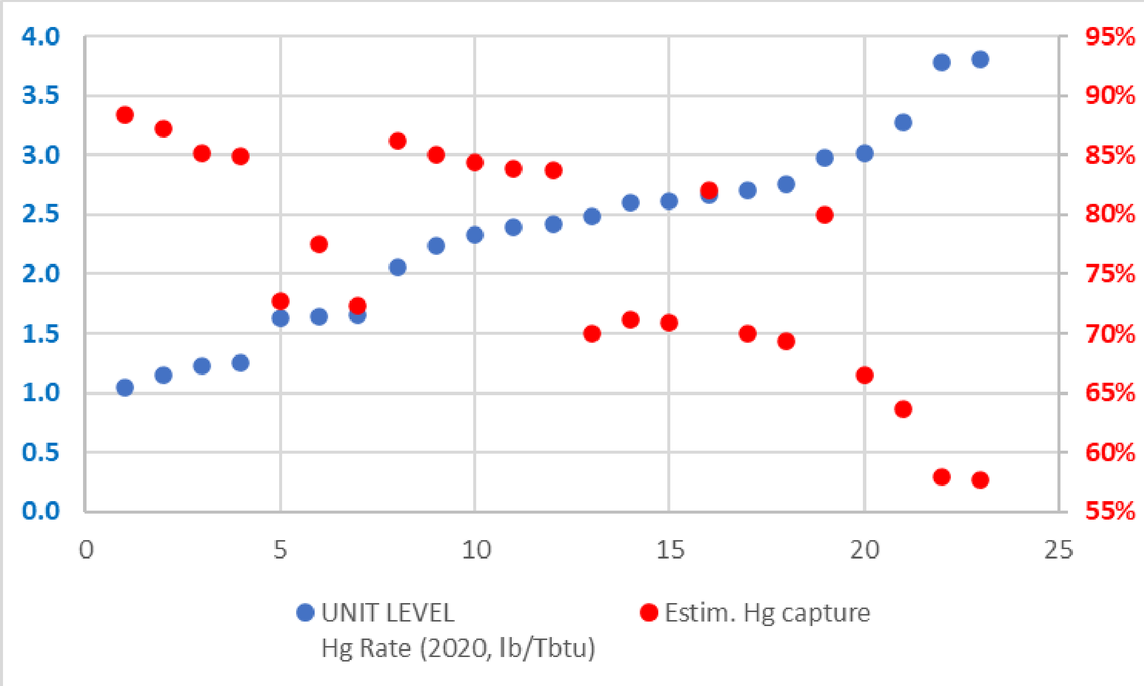
Row Labels	number	Average of Hg Rate, lb/TBtu	Max of Hg Rate, lb/TBtu	Min of Hg Rate, lb/TBtu
BH + FGD	2	2.69	2.76	2.62
BH + FGD+ACI	4	2.03	2.49	1.23
BH + ESP + FGD+ACI	1	1.65	1.65	1.65
BH no FGD+ACI	2	1.09	1.15	1.04
ESP + FGD	2	3.80	3.81	3.79
ESP + FGD+ACI	11	2.51	3.28	1.64
Only FGD+ACI	1	1.25	1.25	1.25

Table 14. Coal type and associated emission rates for low-rank coal units

	SUB	LIG	OTH
Avg Emission Rate, lb/TBtu	1.65	2.15	2.68
No. of units	2	11	10

The 23 units were ranked from lowest emission rate to the highest emission rate and the estimated capture efficiency was calculated for each unit. The results are shown in Figure 35. As this shows, capture efficiencies were estimated to be below 90% in all cases, with some only about 60% capture.

Figure 35. Hg emission rate and estimated capture efficiency for low-rank coal.



E. Summary and conclusions for Hg control

Because there were only a few state rules for Hg control prior to MATS, there was far less experience with Hg control in 2011 than there is today. MATS motivated a nationwide effort to control Hg emitted by power plants. As a result, MATS also motivated extensive research and development by industry to find ways to economically control Hg to the required levels.

Advances in technology included advances in means to enhance Hg capture by scrubbers and means to enhance Hg capture by PM control equipment. ACI, the technology that was most commonly used to increase Hg capture in the PM control devices, saw extensive advances. Applications that had been very challenging in the past, such as when SO_3 was present or when sodium-based DSI was being used, were later more easily addressed thanks to advances in technology – specifically, through the development of specialized activated carbons to address these difficult situations. Such carbons were not available in 2011, but they are available now. Much higher removal rates with lower carbon injection rates are possible because of these advances. In addition, new chemicals and operating methods were developed to address some of the challenges with capture in wet scrubbers, especially, re-emission of Hg. These chemicals and operating methods kept Hg from being reduced to elemental Hg, assuring high Hg removal rates in the scrubbers.

Like the PM emission data, it is apparent from the data that some units are controlling Hg to much lower levels than others. Setting aside low-rank virgin coal for the moment, this was not found to be the result of the coal type, although bituminous units were the majority of the top decile, while subbituminous units were the majority of the bottom decile. This is an unexpected result because the challenges with controlling Hg in bituminous units have generally been greater than for subbituminous units due to the relative sulfur content of the two types of coals. The difference was found to be the result of the equipment installed at the facility.

The bottom deciles tended to be smaller, although not universally. They were also much more likely to be controlled with ACI, and less likely to have a baghouse. There is little incentive for controlling far below the emissions limit with ACI because additional Hg reductions come at an increased cost. Therefore, it is not surprising that, although ACI has been shown to achieve very high Hg reductions, in practice many units only use it to achieve just below the emission rate limit.

The cost of added Hg control and the impact of lower Hg emission rates

The data indicates that higher removal rates are definitely achievable for many units, and at a modest incremental cost. Using the data from Figure 25, an increase in capture efficiency from 80% to 90% requires about 50% increase in treatment rate. An increase from 90% to 95% requires roughly a 15% increase in treatment rate. Conservatively increasing that to 25% and assuming that 90% capture costs roughly 1 mill/kWh or less, this means that an increase in cost of 0.25 mill/kWh or less would result from increasing capture efficiency from 90% to 95% capture. Using the same graph, an increase of capture from 90% to 97.5% requires roughly 30% more carbon injected. Conservatively increasing that to 50% means that an increase of capture from 90% to 97.5% will cost 0.50 mill/kWh or less.

If the majority of the not low-rank coals have a Hg content of about 6 lbs/TBtu, 90% capture results in 0.60 lb/TBtu. Controlling to exactly the limit represents roughly 80% control. More than half of the units are already controlling to this level. For not low-rank coals, a lower Hg standard of 0.7 lb/TBtu could be achieved at a modest cost to some units, and no cost for most units. Reducing emissions to 0.3 lb/TBtu would be, on average, 95% capture, and about 25% of all units are already at or below this level. Therefore, in this case 75% of the units would incur additional control costs. An increase in Hg capture from 80% to 95% would likely result in a doubling of carbon injection rate. From the data in Table **9**, 80% capture is likely achieved at well below 1.0 mill/kWh – probably in the range of 0.25 mill/kWh to around 0.60 mill/kWh, depending upon the specific circumstances. An assumption of an increase of 1.0 mill/kWh would constitute an absolute worst-case situation. 95% capture from the average coal Hg content would result in an emission rate of about 0.3 lb/TBtu. For not low-rank coals a Hg standard of 0.3 lb/TBtu could be complied with at a modest cost to most units, and no cost for some units. The cost would not exceed 1 mill/kWh, and would likely be much less. Units with fabric filters would have very little, if any, cost increase.

For low-rank coals, estimated Hg capture is low and could be increased. Nearly all of the low-rank virgin coal units use ACI and could increase their treatment rate to achieve higher capture rates. The low estimated capture efficiency of these units suggests that the ACI treatment could be improved. Assuming typical coal Hg content of about 10 lb/TBtu for virgin low-rank coal, an emission rate of 0.3 lb/TBtu is about 97% capture. Figure 26 demonstrates that this capture efficiency is being achieved for not low-rank units. The cost would also likely be at or below 1.0 mill/kWh. The highest estimated coal Hg content is 14.9 lb/TBtu. These seven units are all units burning Texas Lignite, and they are equipped with scrubbers. Two have baghouses, and five have ESPs. Therefore, as scrubbed units, they are all capable of achieving higher capture rates (current capture rates for low-rank coal units are estimated at 80%-85% based upon 2019 data). About a third of all low-rank coal units are already controlling to below 2 lb/TBtu, and five of the seven Texas Lignite units are controlling to below 2.4 lb/TBtu. A standard of 2 lb/TBtu would necessitate modest increased cost that would likely be well below 1 mill/kWh as this is consistent with under 90% removal in all cases. A control level of 1 lb/TBtu might also be justified, as this would require less than 95% capture in every case, and in most cases much less. Units with fabric filters would experience very little cost increase because of the high efficiency of ACI in this configuration. Wet scrubbed units could enhance capture using scrubber chemicals at a modest cost, likely well below 1 mill/kWh.

Table 15 shows the estimated impact of reducing Hg emission rate standards.

Table 15. Estimated impact of reduction in Hg emission rate standards

Hg limit for not-low rank coal units (current standard 1.2 lb/TBtu)	**Units with Electrostatic Precipitators**	**Units with Baghouses**	**Overall**
0.7 lb/TBtu (equivalent to 90% Hg removal)	▪ Majority of units would have little to no additional cost ▪ Roughly 25% of units would need to increase ACI treatment at additional cost of 1 mill/kWh or less	▪ Virtually all units can control to this level with little to no incremental cost	▪ Less than 50% of units are above 0.7 lbs/TBtu
0.3 lb/TBtu (equivalent to 95% Hg removal)	▪ 75% of units with ESPs would need to increase ACI treatment at cost of 1 mill/kWh *or less* ▪ If a unit installs a baghouse to meet the PM standard, it would not need any additional ACI	▪ Most units can control to this level with little or no incremental cost ▪ A few units would incur 0.25 mill/kWh cost or less	▪ Roughly 50% of units are above 0.3 lbs/Tbtu

Hg limit for low-rank units (current standard is 4 lb/TBtu)	**Scrubbed units**	**Unscrubbed units**
2 lbs/TBtu (< 90% Hg removal)	Low-Modest cost for most units, no cost for about a third of units	No cost for one unit; modest cost well under 1 mill/kWh for other two
1 lb/Tbtu (< 95% Hg removal)	Low-Modest cost of up to 1 mill/kWh for most units	No cost for one unit; cost of up to 1 mill/kWh for other two

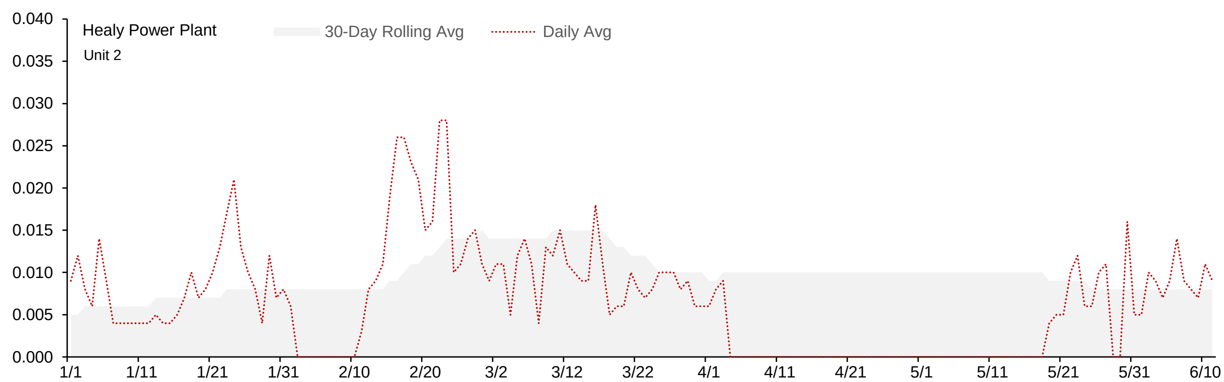
IV. Appendix

A. One-Day PM emissions v. 30-day average

A comparison of one-day PM emissions rates to 30-day average rates was made for some units. Not all companies report daily PM rates in Webfire reports, so that analysis of daily emissions is not possible for all units. For these units PM emissions dropped (or there may have even been a shutdown) after a spike, suggesting some corrective action. Notably, what is shown here are daily averages, not hourly averages, along with 30-day averages. Hourly averages would show greater variability. One would not expect significant peaks in daily averages lasting for days before or after a shutdown. So, there would have to be other factors that would cause such peaks. It was not possible in this effort to examine what other factors might have contributed to the PM variability. Data is taken from US EPA Webfire reports.

1. Healy Unit 2

Healy unit 2 is a 60 MW circulating fluid bed plant with limestone injection and a dry scrubber with fabric filter. One-day averages of PM appeared to be high under some conditions, even approaching the MATS emission limit in the days near February 20. Subsequently, PM emissions fell, which may have been a result of some corrective measures.



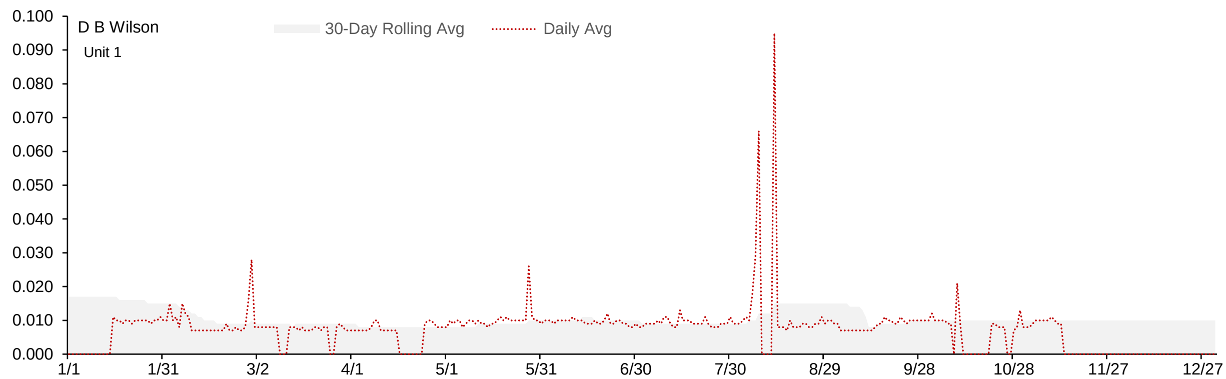
2. D.B Wilson, Unit 1

DB Wilson unit 1 is a 500 MW unit with an ESP, SCR and FGD. Looking at the 2019 data, from 2/25 to 2/28, emissions increased from 0.007 lb/MMBtu to 0.016 lb/MMBtu on 2/27, and to 0.028 lb/MMBtu on 2/28. Emissions then dropped to 0.008 lb/MMBtu. This was followed by a shutdown from 3/9 through 3/11. There was an emissions spike on 8/8 to 0.066 lb/ MMBtu (daily avg; 14 valid hours). The unit went offline from 8/9 to 8/12. Two "valid hours" were on 8/13. There was an emission spike again on 8/13 to 0.095 lb/ MMBtu (daily avg). By 8/14, emissions were back down to 0.008 lb/ MMBtu and the unit was reporting 24 valid hours each day. Monitoring issues were reported. The spike in reported PM may have been related to that. But, 2018 data appears more compelling that there was work being done on this unit relating to PM emissions control.

Looking back to the second half of 2018, after months of fairly consistent daily average emissions rates between about 0.015 and 0.020 lb/MMBtu, in mid-September daily average emissions climbed up to as high as 0.028 lb/MMBtu on 9/28, after which the unit shut down until the end of December for two days

(12/29 and 12/30, where emissions were still high). The unit shut down again until 1/15/19 where the emissions were well controlled to about 0.010 lb/MMBtu for a daily average rate. In this case it appears very likely that shut downs may have been taken to address PM emission issues.

DB Wilson 2019 PM Emissions control data – full year



DB Wilson 2018 PM Emissions control data – July through December