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Memo

Date: July 10, 2017 Memo 6-14

To: Ron Jordan and Brian Schnitker, EPA

From: Yan Zhuang, John Rogers, and David Marker

Subject: Alternative effluent limitations for gasification wastewater at the Edwardsport IGCC Station
[EPD 12-050 WA4-03 (Steam Electric)]

1. Introduction

In April 2016, Duke Energy submitted an application for a fundamentally different factors (FDF) variance from the BAT[1] effluent guidelines that otherwise would be applicable for gasification wastewater discharged from the Edwardsport IGCC Station. Duke Energy also submitted influent and effluent arsenic, mercury, selenium, and total dissolved solids (TDS) concentration measurements from the Edwardsport plant that provide a basis for evaluating the application for a variance and establishing alternative effluent limitations for the plant. Duke Energy requested alternative effluent limits for arsenic, mercury, and TDS. Based on its review of the variance application and associated data, EPA is establishing alternative effluent limitations for mercury and TDS for the Edwardsport plant. EPA is not establishing alternative effluent limitations for arsenic or selenium; instead, the BAT effluent limitations at 40 CFR 423.13(j)(1) will continue to apply for these parameters. In addition, the BPT[2] effluent limitations for total suspended solids (TSS) and oil and grease at 40 CFR 423.12(b)(11) continue to apply to Edwardsport's discharges of gasification wastewater.

This memo presents the results of the statistical analyses performed on the data from the Edwardsport plant, including: 1) descriptive statistics for the influent and effluent data for arsenic, mercury, selenium, and TDS; and 2) for mercury and TDS, the resulting long-term average, variability factors, and effluent limitations based on the Edwardsport data. This memo also describes the data used to calculate the alternative limitations, and compares the Edwardsport data to the limitations.

EPA developed these alternative effluent limitations following the same procedures and statistical methodologies used to develop the BAT effluent limitations established for the steam electric power generating effluent limitations guidelines at 40 CFR 423. See the *Statistical Support Document: Effluent Limitations for FGD Wastewater, Gasification Wastewater, and Combustion Residual Leachate for the*

[1] Best available technology economically achievable, promulgated under authority of Section 301(b)(2)(A) of the Clean Water Act.

[2] Best practicable control technology currently available, promulgated under authority of Section 304(b)(1)(B) of the Clean Water Act.

Final Steam Electric Power Generating Effluent Limitations Guidelines and Standards (hereafter referred to in this memo as Statistical Support Document) for a detailed description of data selection, exclusions, baseline substitutions, data editing and statistical methodologies. Also see Section 13 and Appendix B of the *Technical Development Document for the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category* (EPA-821-R-15-007; September 2015. Hereafter referred to in this memo as Technical Development Document.).

The data analysis was performed by Westat under contract to EPA.

2. Description of Data Used to Calculate Long-Term Averages, Variability Factors, and Effluent Limits

This section provides an overview of the available data selected as the basis for the effluent limits for Edwardsport, the analytical methods used to analyze each of the pollutants, and the rationale for combining sampling data from multiple sources (i.e., sample locations) at the plant into a single dataset. See Section 2 of the Statistical Support Document for additional details.

2.1 Overview of the Data

The BAT effluent limitations for gasification wastewater in the ELGs were developed using data from two power plants: Polk and Wabash River. (See the Statistical Support Document for a discussion of how the ELG limits were developed.) In its application for a variance and supplemental documentation, Duke Energy provided self-monitoring data for gasification wastewater that Edwardsport IGCC Station collected at the influent and effluent of the grey water treatment system.

Duke Energy collected influent and effluent data at four sampling locations: influent samples at "LP Grey Water Feed Pumps" and "Grey Water Feed Pumps," and effluent samples at "RO Permeate Pumps" and "Outfall 501 - Cyanide Destruct Pumps." These data were collected between 5/9/2013 and 10/1/2016, and EPA used the data to evaluate treatment system performance and establish alternative effluent limitations, as appropriate. As explained in Section 3.1 and Appendix 1, EPA excluded certain data from the final analyses because the data are not representative of normal operations of Edwardsport's gasification process and grey water treatment system. The data from Duke Energy were transferred to an Excel spreadsheet that illustrates whether the data were used or excluded for calculating alternative effluent limitations or associated and whether any effluent values were adjusted when considering baseline substitution described below in Section 3.2.

2.2 Analytical Methods

EPA reviewed the self-monitoring data for assess whether the analytical methods used were appropriate, were sufficiently sensitive[3] to measure pollutant concentrations, and that the reported

[3] For data used to calculate the alternative effluent limitations, a sufficiently sensitive reporting limit (or a sufficiently sensitive analytical method) means that the analytical method is capable of and was used in a manner that most analytical results were above the level of quantitation. In instances where most analytical results were below the level of quantitation, sufficiently sensitive means that EPA is not aware of any other method approved in 40 CFR Part 136 that can produce substantially lower reporting limits for analyses of gasification wastewater.

results reflect proper sampling and analytical practices and that the effluent data appear to be valid for use in calculating effluent limits. Table 1 summarizes the analytical methods used by Duke Energy to analyze the regulated pollutants. The analytical methods used by Duke Energy methods are approved in 40 CFR 136 for NPDES purposes and are consistent with the analytical methods used to measure pollutant concentrations in wastewater samples for the ELG rulemaking. In addition to this initial data assessment, consistent with the methodology used for the ELG rulemaking, EPA thoroughly evaluated the available data to identify any data that should not be used when deriving effluent limits due to: (1) the samples being collected during periods that do not represent normal operation; (2) the analytical results being identified as questionable due to quality control issues, abnormal conditions or treatment upsets, or analytical anomalies; or (3) other relevant factors. This additional review is described below in Section 3 and Appendix 1.

Table 1. Summary of the analytical lab methods used by Duke Energy to analyze the regulated pollutants

Analytical method	Pollutant
200.8	Arsenic
1631E	Mercury
SM 2540C	Total Dissolved Solids
200.8	Selenium

3. Data Exclusions, Baseline Substitutions, and Aggregation

This section describes the rules applied to exclude certain data, and how multiple observations for a day were aggregated into daily values before developing summary statistics, data plots, and the effluent limits for each pollutant. Even though the arsenic and selenium data were not used to calculate alternative limits for gasification wastewater, (for the reasons described in Section 6), data exclusions, baseline substitutions, and aggregation were performed for these data, as appropriate.

3.1 Data Exclusions and Rationale for the Exclusions

Prior to calculating the effluent limits, EPA thoroughly evaluated the available data to confirm the data are valid and represent normal operation of the plant and its grey water treatment system. Refer to section 3.2 of the Statistical Support Document for detailed rules of this evaluation. Based on the evaluations, EPA identified certain data that warranted exclusion from the calculations of the limits because:

(i) samples were collected during a period that does not represent the normal operation of the gasification wastewater treatment system process; or
(ii) samples were collected during a period of possible system upset, samples were contaminated, or there were some errors in analyzing the samples in the laboratory.

Appendix 1 of this document provides a listing of each of the data points that were excluded, along with the reasons for their exclusion.

3.2 Baseline Substitutions

In general, EPA used detected values or the sample-specific detection limits[4] for non-detected values in calculating the effluent limits. However, there were some instances in which, as an alternative approach for calculating effluent limits, EPA substituted a baseline value for a detected value or a sample-specific detection limit (i.e., non-detect) that were lower than the baseline value. Baseline substitution accounts for the possibility that certain detected or non-detected results in the dataset may be at a lower concentration than generally can be reliably quantified by well-operated laboratories. Refer to Section 3.3 of the Statistical Support Document for more information about baseline substitution.

Table 2 presents the baseline values that were used for each pollutant in calculating the effluent limits in this memo. EPA prepared an Excel data file, Edwardsport 20170602.xlsx, that provides a listing of all the data considered, as well as showing whether and how each observation would be adjusted when performing baseline substitution.

Table 2. Summary of the baseline values used for each pollutant

Pollutant	Baseline Value (unit)
Arsenic	2 µg/L
Mercury	0.5 ng/L
Selenium	5 µg/L
Total Dissolved Solids	10 mg/L

For all observations at Edwardsport, concentrations of mercury and TDS were all at or above the baseline values listed in Table 2. Therefore, no baseline substitutions were made for these two parameters. Some effluent observations for arsenic and selenium were below the baseline values and were adjusted upward for evaluations that take baseline substitution into account.

3.3 Data Aggregation

EPA used daily values in developing the effluent limits. In cases with two or more samples per day, EPA calculated the arithmetic mean to obtain a single value for that day. For the sampling data used in this memo, there are instances when two sample results are available for a given day. This occurred with field samples collected from different sampling locations of the gasification treatment influent/effluent.

Duke Energy collected treatment system influent samples from two locations: "LP Grey Water Feed Pumps" and "Grey Water Feed Pumps." Samples from these two locations are considered equivalent for characterizing the untreated grey water since the locations are merely upstream and downstream of the grey water feed tanks, and no chemical addition or treatment occurs in the feed tanks. Duke Energy also collected Edwardsport's treatment system effluent from two locations: "RO Permeate Pumps" and "Outfall 501 – Cyanide Destruct Pumps." Samples from these two locations are considered equivalent for characterizing the treatment system effluent since the locations are merely upstream and downstream of a series of tanks in which no chemical addition or treatment occurs. In a January 24, 2017 email to EPA, Duke Energy stated:

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[4] The term "detection limit" is used in this memo to refer to the quantitation limit, not to the method detection limit.

"The grey water treatment process receives wastewater from the gasification process as grey water blowdown, which is transferred via the LP Grey Water Feed Pumps into the Grey Water Feed Tanks ("Tanks"). Water from these Tanks is then transferred via the (rather similarly named) Grey Water Feed Pumps into the grey water treatment system. The Grey Water Feed Pumps are therefore the actual "influent" point for the grey water treatment system, though the gasification wastewater is considered to be substantially unchanged between the LP Grey Water Feed Pumps (just upstream of the Tanks) and the Grey Water Feed Pumps (just downstream of the Tanks). In practice, Edwardsport lab technicians have collected samples from either or both of these pump locations to represent the grey water treatment system "influent." We believe the data from both sampling locations are valid for this purpose." Consequently, we have revised the summary table to retain all available "influent" data while also identifying the corresponding sample collection points.

In a similar fashion, the grey water effluent is represented by data obtained from two related sets of pumps. Water from the grey water treatment process discharges from the Second Pass RO (the final step in treatment) into the RO Permeate Tank, from which it is transferred via the RO Permeate Pumps through a series of three reaction tanks. These reaction tanks were installed for a cyanide destruction step that proved unnecessary for IGCC plant operations. Nevertheless, the tanks remain in place, and water from the RO Permeate Tank flows through them, without further treatment of change, en route to the final discharge point from the grey water treatment system (internal outfall 501 at the Cyanide Destruct Product Pumps). Edwardsport lab technicians have collected samples from either or both the RO Permeate Pumps and Cyanide Destruct Product Pumps (just upstream and just downstream of the reaction tanks) to represent the grey water treatment "effluent." We have revised the summary table to identify the corresponding sample collection points."

Refer to section 3.4 of the Statistical Support Document for additional discussion of data aggregation rules.

Table 3 below summarizes the procedure for aggregating the sample measurements.

Table 3. Aggregation of samples from the same day

If the field duplicates are:	Censoring type of average is:	Value of the aggregate is:	Formulas for aggregate values of duplicates
Both detected	D	Arithmetic average of measured values	$(D_1 + D_2)/2$
Both non-detected	ND	Arithmetic average of sample-specific detected limits (or baseline)	$(DL_1 + DL_2)/2$
One detected and one non-detected	D	Arithmetic average of measured value and sample-specific detection limit (or baseline)	$(D + DL)/2$

D: detected.

ND: non-detected.

DL: sample-specific detection limit.

4. Data Editing Criteria

After excluding and aggregating the data, EPA applied data editing criteria on a pollutant-by-pollutant basis to select the datasets to be used for developing the effluent limits. These criteria are referred to as the long-term average test (or LTA test). EPA often uses the LTA test to confirm that the pollutants for which limits are being set were present in the influent at sufficient concentrations to evaluate treatment effectiveness at the plant. The results of the LTA test for the Edwardsport data are presented in Appendix 3. Refer to Section 4 of the Statistical Support Document for more information about the LTA test.

The Edwardsport data for mercury and TDS passed the LTA test. See Appendix 4 for the results of the LTA test.

5. Statistical Methodology

The calculations for this memo follow the procedures described in the Statistical Support Document (see Section 5, in particular) and the Technical Development Document (see Section 13 and Appendix B) for the final steam electric effluent guidelines. These documents provide detailed information about the statistical model used, analysis of autocorrelation, dataset requirements, and the calculation of effluent limits.

The data provided by Duke Energy were not sufficient for obtaining a reliable estimate of autocorrelation. Thus, consistent with the methodology used when establishing the BAT effluent limitations in 40 CFR 423.13(j)(1), EPA set the autocorrelation to zero in the calculation of the limits. EPA did so because in addition to there being insufficient data to reliably evaluate the autocorrelation, EPA did not have a valid correlation estimate available that could be transferred from a similar technology and waste stream.

6. Treatment System Data and Alternative Effluent Limitations for Edwardsport Gasification Wastewater

The sections below provide longitudinal plots and summary statistics of Edwardsport data for each of the pollutants regulated by BAT limitations for gasification wastewater at 40 CFR 423.13(j)(1): arsenic, mercury, selenium, and TDS. The calculated long-term average, variability factors, and alternative effluent limitations for mercury and TDS are also presented below. EPA used data from the Edwardsport plant to develop the alternative effluent limitations.

Information is presented for untreated gasification wastewater (i.e., grey water treatment system influent) and treated gasification wastewater (i.e., effluent from the grey water treatment system). As described above in Section 3.3, the influent data provided by Duke Energy were collected from two locations upstream of the treatment system. The data from these two sample locations were combined into a single dataset because the sample locations are considered equivalent for characterizing the pollutants in treatment system influent. Duke Energy also collected effluent data from two sample locations; data from these two locations downstream of treatment are considered valid for characterizing treatment system effluent and were combined. When samples

were collected from both effluent locations on the same day, the concentrations were aggregated based on the rules described in Section 3.3 so that there was one effluent concentration per day for each pollutant. Similarly, multiple influent samples from the same day were aggregated as well.

Duke Energy collected sampling data for gasification wastewater at Edwardsport between 5/9/2013 and 10/1/2016. These data were used to evaluate treatment system performance and establish alternative effluent limitations, as appropriate. As explained in Section 3.1 and Appendix 1, certain data were excluded from the final analyses because the data are not representative of normal operations of Edwardsport's gasification process and grey water treatment system. Specifically, data collected during the period 5/9/2013 – 10/17/2013 and on 10/13/2015 were excluded for the reasons stated in Appendix 1.

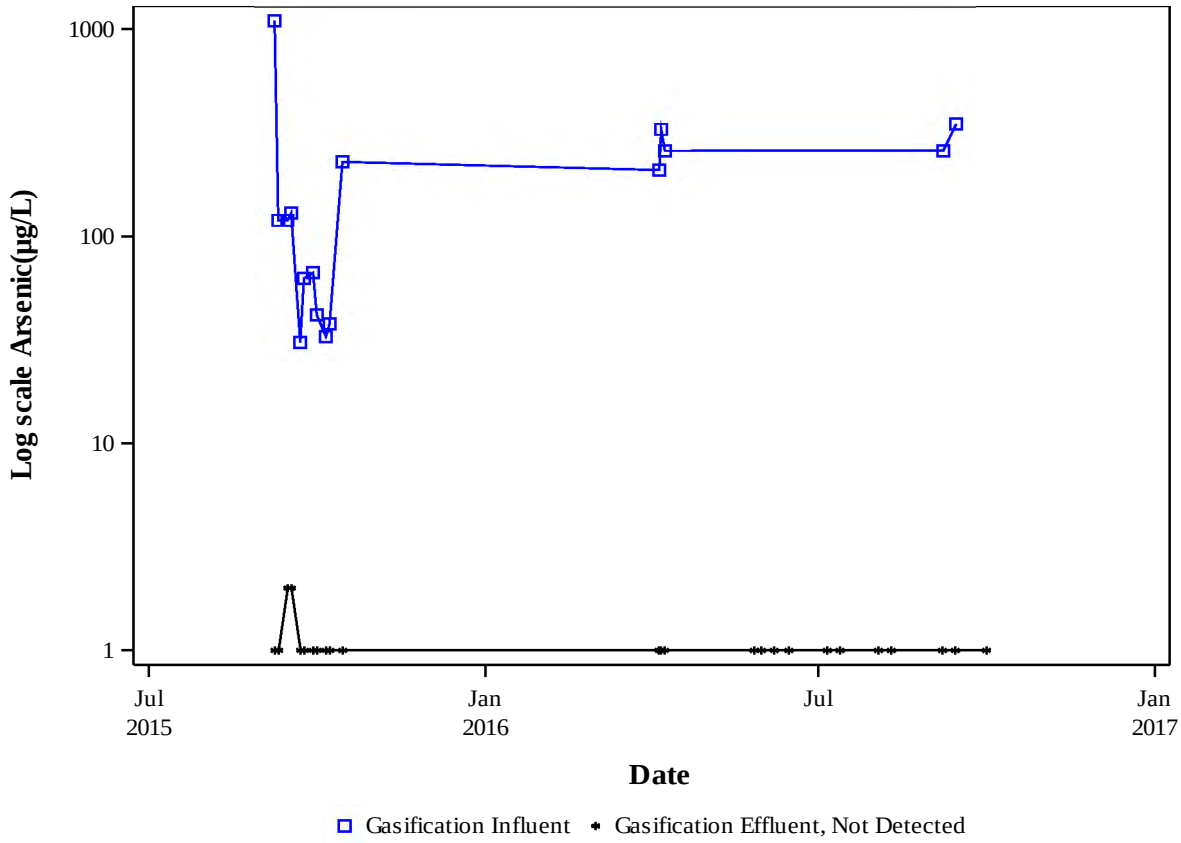
EPA attempted to use the available data to estimate autocorrelation. However, EPA was not able to perform an evaluation of the autocorrelation because there were not sufficient observations available. Thus, EPA set that the autocorrelation value is zero in the calculation of the limits of mercury and TDS as described in Section 5 of the Statistical Support Document.

6.1 Edwardsport Gasification Wastewater: Arsenic

6.1.1 Longitudinal Plots of the Data for Arsenic (µg/L)

Figure 1 shows a longitudinal plot of the arsenic concentrations (on a logarithmic scale) for Edwardsport.

Figure 1. Plot of arsenic (µg/L) data on a logarithmic scale for Edwardsport



6.1.2 Summary Statistics for Arsenic (µg/L)

Table 4 provides summary statistics for the numbers of detected and non-detected observations together with the sample-specific detection limits by sample location.

Table 4. Numbers of detected and non-detected observations and sample-specific detection limits for arsenic (µg/L) by sampling location

Sampling Location (Total Observations[1])	Baseline[2]	Indicator (n)[3]	Sample Specific Detection Limits for Arsenic (µg/L)	
			1	2
Influent (N = 16)	0 or 2	D (n = 16)		
Effluent (N = 25)	0	D (n = 0)		
		ND (n = 25)	23	2
	2	D (n = 0)		
		ND (n = 25)		25

[1]: Detected and non-detected observations combined.

[2]: Baseline value of 0 indicates no adjustment for baseline.

[3]: D = detected and ND = non-detected.

Table 5 provides summary statistics for gasification wastewater influent and effluent (detected and non-detected) at Edwardsport.

Table 5. Summary statistics of arsenic concentration (µg/L) for all detected and non-detected samples combined, by sampling location

Sampling Location	Baseline[1]	Summary Statistics for Arsenic (µg/L)					
		N[2]	Minimum	Mean	Median	Maximum	Std
Influent	0 or 2	16	31	211.5	125.0	1,100.0	260.4
Effluent	0	25	1.0	1.1	1.0	2.0	0.3
	2	25	2.0	2.0	2.0	2.0	0.0

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: Detected and non-detected observations combined.

6.1.3 Effluent Limits for Arsenic

In its application for a variance providing alternative effluent limitations, Duke Energy seeks a daily maximum limit of 8 ug/L for arsenic, claiming that the 4 ug/L limit in the ELGs "is unduly restrictive." (See Section 7.2 of Duke Energy's variance request.) The ELGs do not include a monthly average limit for arsenic. Based on a thorough evaluation of Duke Energy's application and effluent data collected by Edwardsport since commencing operation, EPA determined that alternative effluent limitations for arsenic are not warranted because all applicable data reflecting normal operation of the gasification system demonstrate compliance with the ELG limitations at 40 CFR 423.13. Furthermore, EPA disagrees with the methodology Duke Energy suggests should be used to establish alternative effluent limitation for arsenic, on the basis that it is arbitrary and can be easily manipulated to produce a biased outcome.

Duke Energy submitted effluent data for arsenic collected on 38 days (40 total measurements) during the period 5/9/2013 through 10/1/2016. As explained in Section 3.1 and Appendix 1, EPA excluded certain data from its final analyses because they do not represent normal operation of the gasification process and associated wastewater treatment system, due to abnormal operational variability and laboratory results that do not reflect sufficiently sensitive quantitation levels to adequately characterize effluent quality and treatment system performance. The resulting dataset for the treatment system effluent provides observations for 25 days. As shown by Table 4 above, each of these effluent observations for arsenic were reported as non-detect with a quantitation limit of either 1 ug/L or 2 ug/L – *i.e.*, either one-quarter or half of the daily limit of 4.0 ug/L. Detection limits for more than 90 percent of the effluent observations are equal to 1.0 ug/L. These effluent data show that the concentration of arsenic in Edwardsport treatment system effluent is much lower than the ELG daily maximum limit of 4.0 ug/L and alternative effluent limitations for the parameter are not warranted. Furthermore, 40 CFR 125.31(b) states, in part, that a request for establishment of effluent limitations less stringent than those required by national limits guidelines shall be approved only if the alternative effluent limitations is no less stringent than justified by the fundamental difference. The arsenic data for Edwardsport demonstrates that a less stringent effluent limit is not justified.

In Section 7 of its FDF variance request, Duke Energy explains that it attempted to follow EPA's statistical methodology for the ELG limitations while developing Duke Energy's proposed alternative effluent limitations for mercury and TDS. However, in proposing an alternative limitation for arsenic, Duke Energy put forth a new approach that is not consistent with the methodology EPA used to establish the BAT limitation. For arsenic, Duke Energy ignored the effluent data for Edwardsport. Instead of using the actual data for arsenic, Duke Energy arbitrarily selected four values lower than the ELG limitation of 4 ug/L, and proposed an alternative daily maximum limit of 8 ug/L based on its statistical analysis of these four values.[5]

As EPA described in Section 5.6 of the Statistical Support Document, in situations where there are too few detected results, the statistical models are not appropriate for use in obtaining the effluent limits since reliable estimates could not be calculated from the model. In such instances, EPA established the daily maximum ELG limits based on a detection limit (or more precisely, the quantitation limit) relevant to the observed data. Also, the monthly average ELG limit is not established when the daily maximum limit is based on the detection limit. This is reflected in the arsenic limits for gasification wastewater in the ELGs.

Duke Energy's selection of four hypothetical observations below the quantitation limit and calculating the daily maximum limit from those observations is arbitrary. Depending on the values chosen, hypothetical observations could be selected to obtain a daily limit that is greater than the quantitation limit or less than the quantitation limit. Using the values selected by Duke Energy, and rounding the limit upward to the nearest integer, would result in a limit of 8 ug/L.[6] However, there is no valid basis for using the values selected by Duke Energy and substituting different values would produce different effluent limits. Furthermore, it would be more appropriate to select values that more closely reflect the actual sampling data for Edwardsport. Since all valid observations for the treatment system effluent are lower than 2 ug/L, and more than 90 percent of these observations are in fact are lower than 1 ug/L, Duke Energy's approach whereby 75 percent of the hypothetical values are *higher* than the actual monitoring data lacks technical merit.

The BAT limit for arsenic at 40 CFR 423.13(j)(1) continues to apply for gasification wastewater discharges at Edwardsport. The data submitted by Duke Energy confirms that a variance is not needed for the arsenic, with all valid observations providing non-detect results at quantitation levels lower than the ELG limit. For comparison to the ELG limit of 4 ug/L, see Tables 4 and 5 above.

6.2 Edwardsport Gasification Wastewater: Mercury

6.2.1 Longitudinal Plots of the Data for Mercury (ng/L)

Figure 2 shows longitudinal plots of the mercury concentrations (on a logarithmic scale) for Edwardsport.

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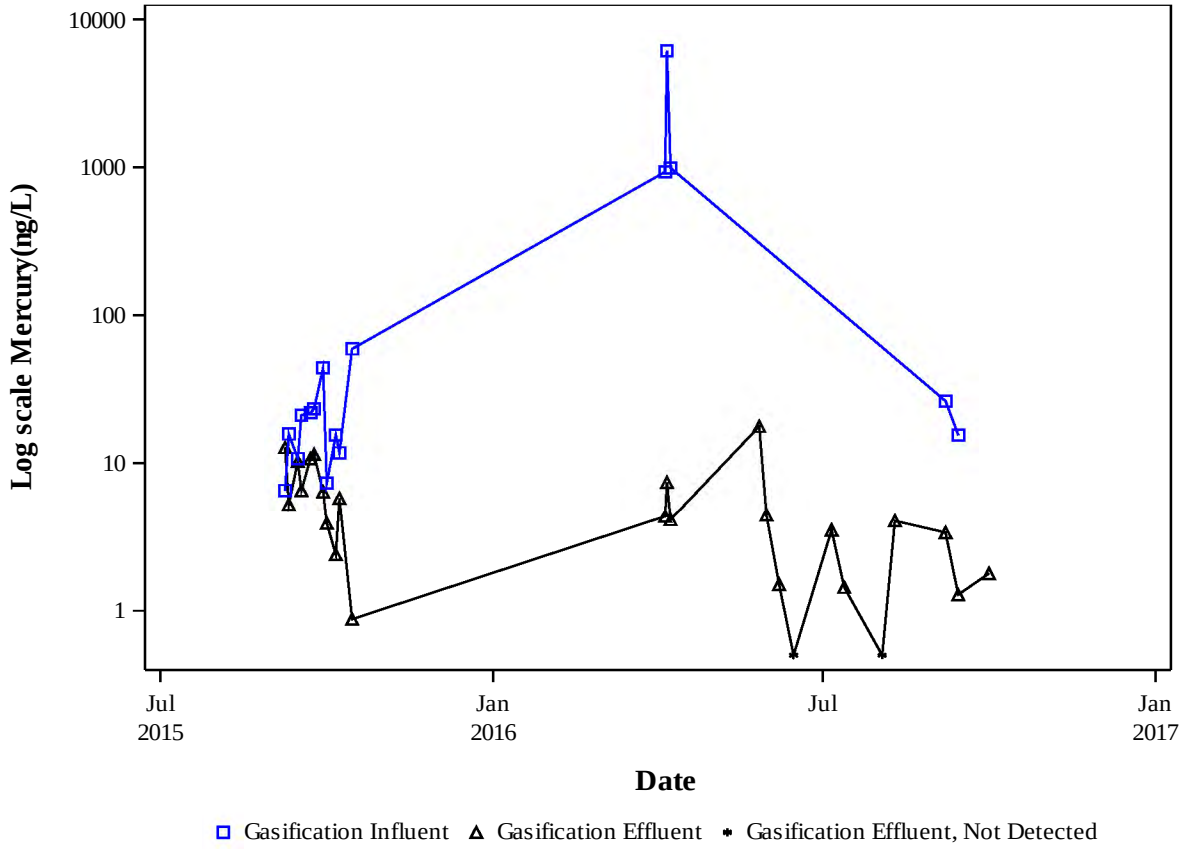
[5] For its analysis, Duke Energy used the following values: 1 ug/L, 2 ug/L, 3 ug/L, and 3.5 ug/L.

[6] Arguably, using these arbitrarily selected values in EPA's statistical model would also produce a monthly average effluent limitation of 4 ug/L.

Figure 2. Plot of mercury (ng/L) data on a logarithmic scale for Edwardsport



6.2.2 Summary Statistics for Mercury (ng/L)

Table 6 provides summary statistics for the numbers of detected and non-detected observations together with the sample-specific detection limits by sample location.

Table 6. Numbers of detected and non-detected observations and sample-specific detection limits for mercury (ng/L) by plant and sampling location

Sampling Location (Total Observations[1])	Baseline[2]	Indicator (n)[3]	Sample Specific Detection Limits for Mercury (ng/L)
			0.5
Influent (N = 16)	0 or 0.5	D (n = 16)	
Effluent (N = 25)	0 or 0.5	D (n = 23)	
		ND (n = 2)	2

[1]: Detected and non-detected observations combined.

[2]: Baseline value of 0 indicates no adjustment for baseline.

[3]: D = detected and ND = non-detected.

Table 7 provides summary statistics for gasification wastewater influent and effluent (detected and non-detected) at Edwardsport.

Table 7. Summary statistics of mercury concentration (ng/L) for all detected and non-detected samples combined, by plant and sampling location

Sampling Location	Baseline[1]	Summary Statistics for Mercury (ng/L)					
		N[2]	Minimum	Mean	Median	Maximum	Std
Influent	0 or 0.5	16	6.6	526.1	21.6	6,200.2	1,547.0
Effluent	0 or 0.5	25	0.5	5.3	4.1	17.8	4.4

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: Detected and non-detected observations combined.

6.2.3 Long-term Average, Variability Factors, and Alternative Effluent Limits for Mercury (ng/L)

Table 8 provides the LTA, variability factors, and alternative effluent limits for mercury at Edwardsport. Duke Energy requested alternative effluent limits for mercury (30.0 ng/L daily maximum; 12.4 ng/L monthly average) based on observations for 15 days collected during the period 7/22/2013 through 10/15/2015. The dataset used by EPA to establish alternative effluent limitations for Edwardsport differs from Duke Energy's dataset in the following ways: (1) EPA's limits are based on observations for 25 days rather than 15 days; (2) EPA's dataset includes additional data collected by Edwardsport for the period 4/5/2016 – 10/1/2016; and (3) EPA excluded data collected on 3 days in 2013 and 1 day in 2015, for reasons explained in Section 3.1 and Appendix 1.

Table 8. Long-term average, variability factors, and unrounded limits for mercury (ng/L)

Baseline Adjusted[1]	Sampling Location	N[2]	LTA	Daily Variability Factor	Monthly Variability Factor	Limits (prior to rounding)	
						Daily Maximum	Monthly Average
0 or 0.5	Effluent	25 (D=23, ND=2)	5.528	4.906	1.959	27.123	10.831

[1]: Baseline value of 0 indicates no adjustment for baseline.

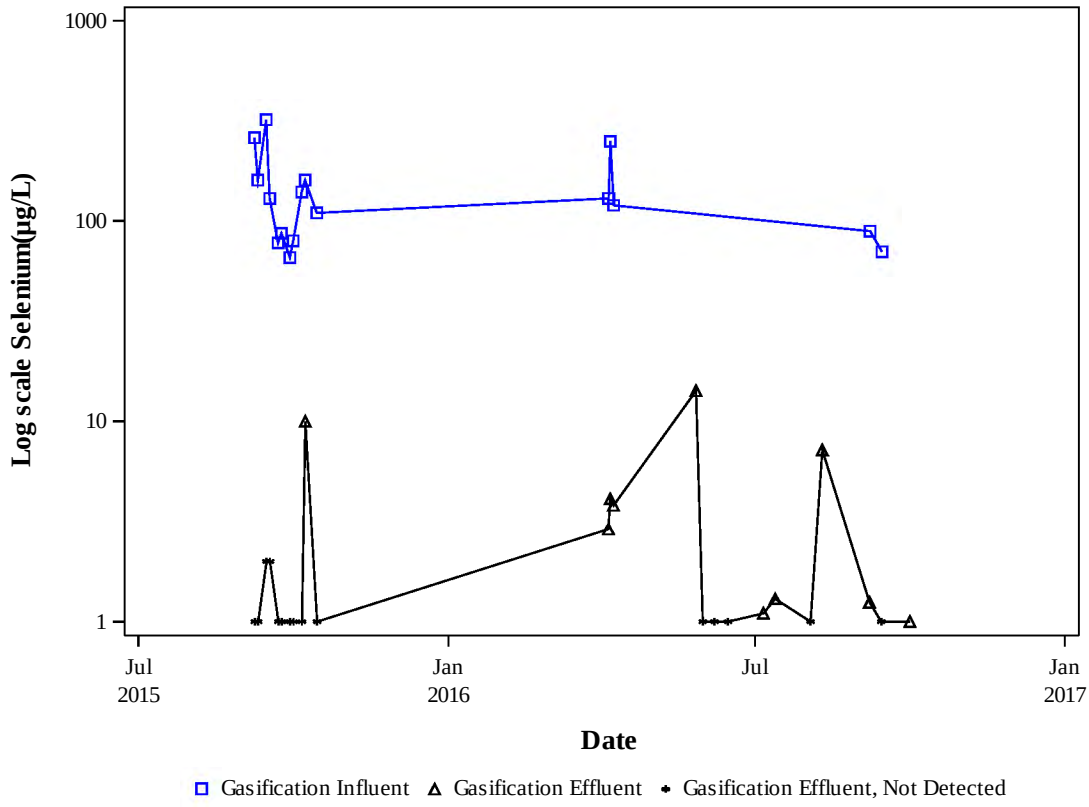
[2]: D = detected and ND = non-detected.

6.3 Edwardsport Gasification Wastewater: Selenium

6.3.1 Longitudinal Plots of the Data for Selenium (µg/L)

Figure 3 shows longitudinal plots of the selenium concentrations (on a logarithmic scale) for Edwardsport.

Figure 3. Plot of selenium (µg/L) data on a logarithmic scale for Edwardsport



6.3.2 Summary Statistics for Selenium (µg/L)

Table 9 provides summary statistics for the numbers of detected and non-detected observations together with the sample-specific detection limits by sample location.

Table 9. Numbers of detected and non-detected observations and sample-specific detection limits for selenium (µg/L) by sampling location

Sampling Location (Total Observations[1])	Baseline[2]	Indicator[3]	Sample-Specific Detection Limits for Selenium (µg/L)		
			1	2	5
Influent (N = 16)	0 or 5	D (n = 16)			
Effluent (N = 25)	0	D (n = 10)			
		ND (n = 15)	13	2	
	5	D (n = 3)			
		ND (n = 22)			22

[1]: Detected and non-detected observations combined.

[2]: Baseline value of 0 indicates no adjustment for baseline.

[3]: D = detected and ND = non-detected.

Table 10 provides summary statistics for gasification wastewater influent and effluent (detected and non-detected) at Edwardsport.

Table 10. Summary statistics of selenium concentration (µg/L) for all detected and non-detected samples combined, by sampling location

Sampling Location	Baseline[1]	Summary Statistics for Selenium (µg/L)					
		N[2]	Minimum	Mean	Median	Maximum	Std
Influent	0 or 5	16	66.0	140.7	125.0	320.0	75.0
Effluent	0	25	1.0	2.6	1.0	14.2	3.3
	5	25	5.0	5.7	5.0	14.2	2.1

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: Detected and non-detected observations combined (all were detected).

6.3.3 Effluent Limits for Selenium

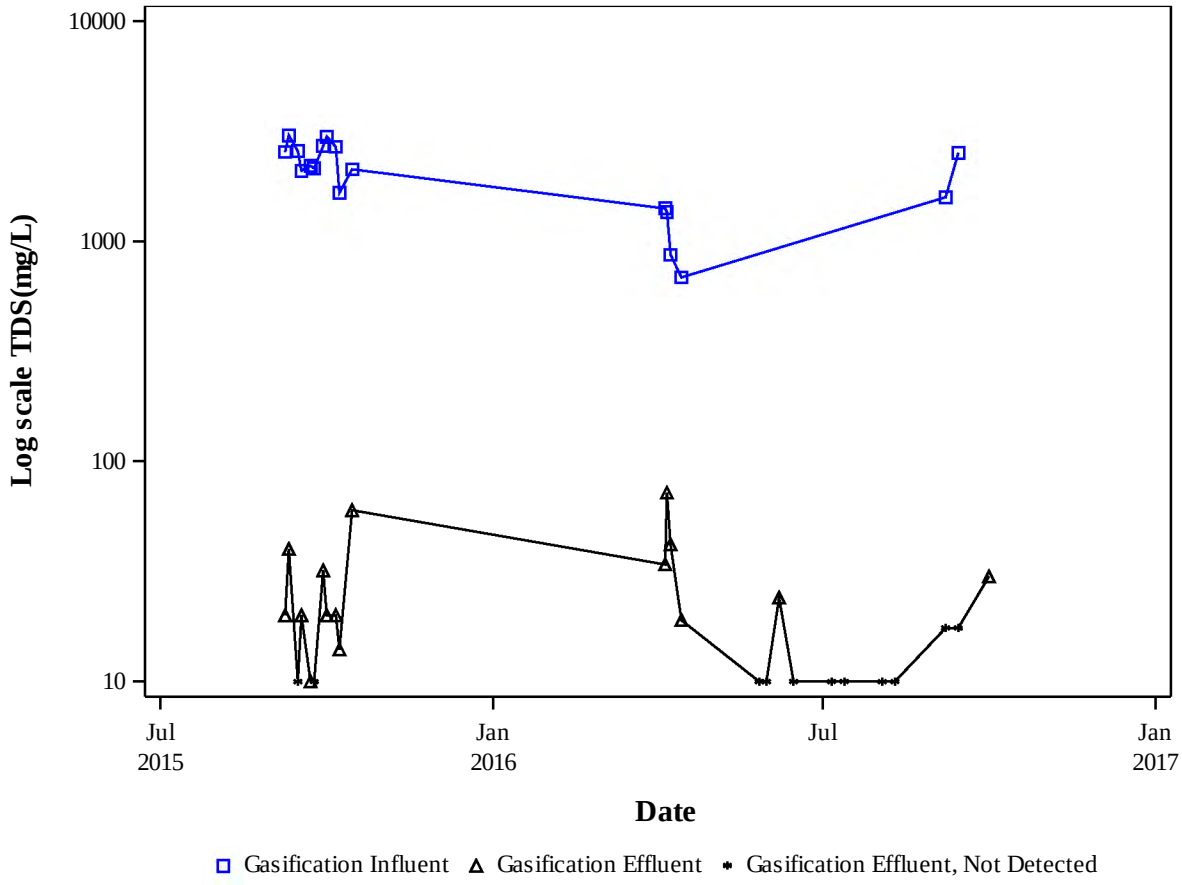
Duke Energy did not request alternative effluent limitations for selenium. Because of this, the BAT limits for selenium at 40 CFR 423.13(j)(1) continue to apply for gasification wastewater discharges at Edwardsport. The data submitted by Duke Energy confirms that a variance is not needed for the selenium, with all observations substantially lower than the both the daily maximum and monthly average ELG limits (453 ug/L and 227 ug/L, respectively). The mean concentration for selenium at Edwardsport is also much lower than the long-term average (147 ug/L) upon which the ELG limits are based. For comparison, see Table 10 above and the Statistical Support Document.

6.4 Edwardsport Gasification Wastewater: Total Dissolved Solids (TDS)

6.4.1 Longitudinal Plots of the Data for TDS (mg/L)

Figure 4 shows longitudinal plots of the TDS concentrations (on a logarithmic scale) for Edwardsport.

Figure 4. Plot of TDS (mg/L) data on a logarithmic scale for Edwardsport.



6.4.2 Summary Statistics for TDS (mg/L)

Table 11 provides summary statistics for the numbers of detected and non-detected observations together with the sample-specific detection limits by sample location.

Table 11. Numbers of detected and non-detected observations and sample-specific detection limits for TDS (mg/L) by plant and sampling location

Sampling Location (Total Observations[1])	Baseline[2]	Indicator (n)[3]	Sample-Specific Detection Limits for TDS (mg/L)	
			10	17.5
Influent (N = 17)	0 or 10	D (n = 17)		
Effluent (N = 26)	0 or 10	D (n = 15)		
		ND (n = 11)	9	2

[1]: Detected and non-detected observations combined.

[2]: Baseline value of 0 indicates no adjustment for baseline.

[3]: D =detected and ND = non-detected.

Table 12 provides summary statistics for gasification wastewater influent and effluent (detected and non-detected) at Edwardsport.

Table 12. Summary statistics of TDS concentration (mg/L) for all detected and non-detected samples combined, by plant and sampling location

Sampling Location	Baseline[1]	Summary Statistics for TDS (mg/L)					
		N[2]	Minimum	Mean	Median	Maximum	Std
Influent	0 or 10	17	688.0	2,065.8	2,140.0	3,020.0	701.6
Effluent	0 or 10	26	10.0	22.4	18.3	72.0	16.2

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: Detected and non-detected observations combined.

6.4.3 Long-term Average, Variability Factors, and Alternative Effluent Limits for TDS (mg/L)

Table 13 provides the LTA, variability factors, and effluent limits for TDS at Edwardsport. Duke Energy requested alternative effluent limits for TDS (78 mg/L daily maximum; 36 mg/L monthly average) based on observations for 11 days collected during the period 9/8/2015 through 10/15/2015.[7] The dataset used by EPA to establish alternative effluent limitations for Edwardsport differs from Duke Energy's dataset in the following ways: (1) EPA's limits are based on observations for 26 days rather than 11 days; and (2) EPA's dataset includes additional data collected by Edwardsport for the period 4/5/2016 – 10/1/2016.

[7] Duke Energy excluded a 12th daily observation, collected on 10/13/2015, stating that it was an outlier due to "likely treatment system upset or lab error." EPA similarly excluded the observation for 10/13/2015.

Table 13. Long-term average, variability factors, and unrounded limits for TDS (mg/L)

Baseline Adjusted[1]	Sampling Location	N[2]	LTA	Daily Variability Factor	Monthly Variability Factor	Limits (prior to rounding)	
						Daily Maximum	Monthly Average
0 or 10	Effluent	26 (D=15, ND=11)	22.511	3.637	1.679	81.879	37.789

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: D = detected and ND = non-detected.

6.5 Gasification Wastewater: Summary of the Long-term Averages, Variability Factors, and Alternative Effluent Limits for Edwardsport

Table 14 summarizes the long-term averages, variability factors, and alternative effluent limitations for mercury and TDS in discharges of gasification wastewater at Edwardsport. In addition, the existing BAT effluent limitations for arsenic and selenium at 40 CFR 423.13(j)(1), and the BPT effluent limitations for total suspended solids (TSS) and oil and grease at 40 CFR 423.12(b)(11) continue to apply to Edwardsport's discharges of gasification wastewater.

Table 14. Summary of long-term averages, variability factors, and alternative effluent limits for mercury and TDS at Edwardsport

Pollutant	Baseline[1]	Autocorrelation Value[2]	LTA	Daily Variability Factor	Monthly Variability Factor	Daily Maximum Limit[3]	Monthly Average Limit[3]
Mercury (ng/L)	0 or 0.5	0	5.528	4.906	1.959	28	11
TDS (mg/L)	0 or 10	0	22.511	3.637	1.679	82	38

[1]: Baseline value of 0 indicates no adjustment for baseline.

[2]: Correlation ranges from -1 to 1, with a value of 0 indicating that EPA assumed no correlation in the data.

[3]: Effluent limitations have been rounded upward to the next highest integer.

7. Engineering Review of the Effluent Limits

EPA performed an engineering review to verify that the alternative effluent limits for mercury and TDS are reasonable based upon the design and expected operation of the control technologies. (See Section 11 of the Statistical Support Document for additional information about EPA's engineering review of effluent limitations and associated data.) As part of this review, EPA evaluated whether the data demonstrate that the plant can comply with the alternative limitations being established. EPA performed two types of comparisons. First, EPA compared the effluent limits for each pollutant against the effluent data used to develop the limits. This type of comparison helps to evaluate how reasonable the limits are from an engineering perspective. Second, EPA compared the limits for each pollutant to the influent data for Edwardsport. This

second comparison helps evaluate whether the influent concentrations were generally well-controlled by the treatment system.

Section 7.1 compares the limits and all effluent data that were used to calculate the limits for mercury and TDS. Section 7.2 compares the effluent limits to the influent data. See Appendix 4 for plots comparing the effluent data to the daily maximum limitations.

7.1 Comparison of the Limits to Effluent Data Used as the Basis for the Limits

First, EPA compared the daily effluent concentrations to the daily limits to identify any observations that were above the daily limit. The plots (Figures A4.1 and A4.2) prepared for this first comparison also provide insight on how other data (i.e., daily values below the daily limit) compare to the limit. Next, EPA compared the daily concentrations to the monthly average limits, particularly for those periods where there are sufficient data to represent weekly monitoring.

After evaluating the results of the comparison between the limits and the effluent values used to calculate the limits, EPA determined that the statistical distributional assumptions used to develop the limits are appropriate for the data (that is, they provide a reasonable fit to the actual effluent data) and the limits for each waste stream are reasonable and achievable. If the plant properly operates its wastewater treatment system to achieve the long-term average for the model technology[8] (rather than targeting performance at the effluent limits themselves), it will be able to comply with the limits.

EPA is establishing alternative effluent limitations for mercury, with a daily maximum limit of 28 ng/L and a monthly average limit of 11 ng/L. The valid effluent data for Edwardsport includes 25 daily observations collected 9/8/2015 – 10/1/2016. Each of these daily observations are below the maximum daily limit being established. The effluent data range from 0.5 ng/L to 17.8 ng/L, and the dataset has a mean value of 5.3 ng/L and a median value of 4.1 ng/L. See Section 6.2.2 and Appendix 4, Figure A4.1.

The mercury data collected by Edwardsport generally were not collected at sufficient frequency to represent weekly sampling; however, only 3 of the 25 daily observations were at concentrations higher than the monthly average limit. In fact, 2 of those 3 observations above the monthly average limit were collected during September 2015. Edwardsport collected a total 7 samples for mercury during that month, and the average of all 7 values is 9.1 ng/L, which is lower than the monthly average limit. The only other mercury sample that was higher than the monthly average limit was collected 5/27/2016. Only two samples for mercury were collected during May 2016; the average of those two values is 11.1 ng/L, only slightly higher than the monthly average limit. When viewed in context of samples collected in the months preceding and following May 2016, which are all substantially lower than the 5/27/2016 observation, it is likely that if Edwardsport had collected additional samples during May the overall average for the month would be lower than the monthly average limit.

For TDS, EPA is establishing alternative effluent limitations with a daily maximum limit of 82 mg/L and a monthly average limit of 38 mg/L. The valid effluent data for Edwardsport includes

[8] For the alternative effluent limitations for mercury and TDS being established for Edwardsport, the model treatment technology is comprised of thermal evaporation followed by reverse osmosis filtration.

26 daily observations collected 9/8/2015 – 10/1/2016. Each of these daily observations are below the maximum daily limit being established. For nearly half of the observations, the concentration of TDS was below the quantitation level. The effluent data range from 10 mg/L to 72 mg/L, and the dataset has a mean value of 22.4 mg/L and a median value of 18.3 mg/L. See Section 6.4.2 and Appendix 4, Figure A4.2.

As was the case for mercury, the TDS data collected by Edwardsport generally were not collected at sufficient frequency to represent weekly sampling. However, only 4 of the 26 daily observations were at concentrations higher than the monthly average limit. In September 2015 and October 2015 only one of the TDS samples for each month was higher than the monthly average, and in both cases the average of all observations for the month was lower than the monthly average limit being established. April 2016 is the only month in the dataset where the average of all observations was higher than the monthly average limit. Since all 4 observations for April 2016 were collected within a 10-day period and the 2 samples higher than the monthly average limit were collected only 2 days apart (4/6/2016 and 4/8/2016), the samples for the month may not sufficiently reflect the variability present in the effluent and it is possible that additional sampling reflective of the remainder of the month would have resulted in an overall monthly average lower than the monthly average limit.[9] Weekly sampling is a better indicator and more representative of treatment system performance than less frequent periodicity such as monthly sampling. Using less frequent monitoring may more closely reflect the daily variability than the monthly variability in effluent data. This has been well-demonstrated by other data evaluated by EPA for effluent guidelines rulemakings. In the Statistical Support Document for the steam electric ELGs, EPA presented information showing how relying on single-day sampling for compliance monitoring may not accurately reflect whether the monthly limit would have been met. See Section 11.1 of the Statistical Support Document for more information.

7.2 Comparison of the Effluent Limits to Influent Data

In addition to comparing the limits to effluent data, EPA also compared the daily maximum limits to the pollutant concentrations in the treatment system influent. This comparison helps evaluate whether the limits are set at a level that ensures that treatment of the wastewater and that the influent concentrations were generally well-controlled by the treatment system. See Appendix 4 for a detailed listing of the summary statistics for the influent data for mercury and TDS (Table A4.1).

For gasification wastewater at Edwardsport, the minimum, average, median, and maximum influent concentration values were much higher (one to two orders of magnitude) than the long-term average and daily maximum limit for TDS. The influent data for mercury were right-skewed, with the minimum and median less than the limit and the average and maximum much higher (one to two orders of magnitude) than the limit. EPA found that influent concentrations, including pollutant concentrations at the extreme upper end of the concentration range, were well-controlled by the treatment technology used at Edwardsport. This is illustrated by the longitudinal plots in Sections 6.2.1 and 6.4.1.

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[9] This is illustrated by the 4/14/2016 observation of 19 mg/L, as well as the observations for May 2016 (both 5/27/2016 and 5/31/2016 were non-detects at 10 mg/L) and subsequent months.

Appendix 1 List of All Observations that Were Excluded Before Calculating Alternative Effluent Limits for Edwardsport

This appendix contains listing of all observations that were excluded prior to calculating the alternative effluent limits for Edwardsport. In addition to the exclusions for mercury and TDS, this appendix also identifies arsenic and selenium data that were excluded from the summary statistics and longitudinal plots presented in Section 6.

Table A1.1 List of excluded plant self-monitoring data at Edwardsport

Pollutant (unit)	Date	Sampling Location	Exclusion Rationale
Arsenic, Mercury, Selenium (there are no TDS data for this period)	5/9/2013 to 10/17/2013	All Locations	All data collected during this period were excluded because they do not represent normal operation of the gasification process and associated wastewater treatment system, due to abnormal operational variability and laboratory results that do not reflect sufficiently sensitive quantitation levels to adequately characterize effluent quality and treatment system performance. In Section 2.2.2 of the variance application, Duke Energy stated that "the Edwardsport IGCC experienced substantial operational variability during the first year of operation. Duke Energy's focus during this period was on eliminating operational interruptions." The operational variability experienced by Edwardsport is reflected in the data the plant collected in 2013. For example, the only detected observation for arsenic (15 ug/L on 8/21/2013) was identified by Duke Energy's contractor AECOM as an outlier and not valid for calculating the alternative limits proposed by Duke Energy. Three other arsenic observations in 2013 were reported as non-detects with unacceptably high quantitation levels (ND at 10 ug/L on 9/5/2013, 9/25/2013, & 10/8/2013). All other observations for arsenic at Edwardsport were reported as non-detect with a quantitation limit of either 1 ug/L or 2 ug/L. The selenium observations for Edwardsport exhibited similar characteristics. Five selenium observations in 2013 were reported as non-detects with unacceptably high quantitation levels (ND at 10 ug/L on 8/21/2013, 9/5/2013, 9/25/2013, 10/8/2013, & 10/17/2013); in contrast, Duke Energy's data shows that a more appropriate limit of quantitation for gasification wastewater at Edwardsport is much lower (e.g., 1 ug/L or 2 ug/L). Because of the concerns articulated above regarding operational abnormalities and the data quality issues evident for arsenic and selenium, EPA excluded all data for the period 5/9/2013 to 10/17/2013.
Arsenic, Mercury, Selenium, TDS	10/13/2015	All locations	EPA excluded all data collected on 10/13/2013 because the observation for effluent TDS indicates an abnormality likely due to treatment system upset, contamination of the sample during sample collection, or laboratory error. Similarly, Duke Energy's

			consultant AECOM identified the TDS observation (222 mg/L) as an outlier and did not use the value when calculating the alternative limits proposed by Duke Energy, citing "likely treatment upset or lab error." Since it is unknown whether the abnormality is limited to the TDS observation, all data for that day were excluded.

[1] D=Detected, ND=Non-detected.

Appendix 2 Plots of Available Data Prior to Any Exclusions

This Appendix contains plots of all available Edwardsport data for arsenic, mercury, selenium and TDS in gasification wastewater influent and effluent, prior to any exclusion (described in Section 3.1). Data are plotted on two different scales, linear and logarithmic.

Figure A2.1 Influent and effluent data for arsenic at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

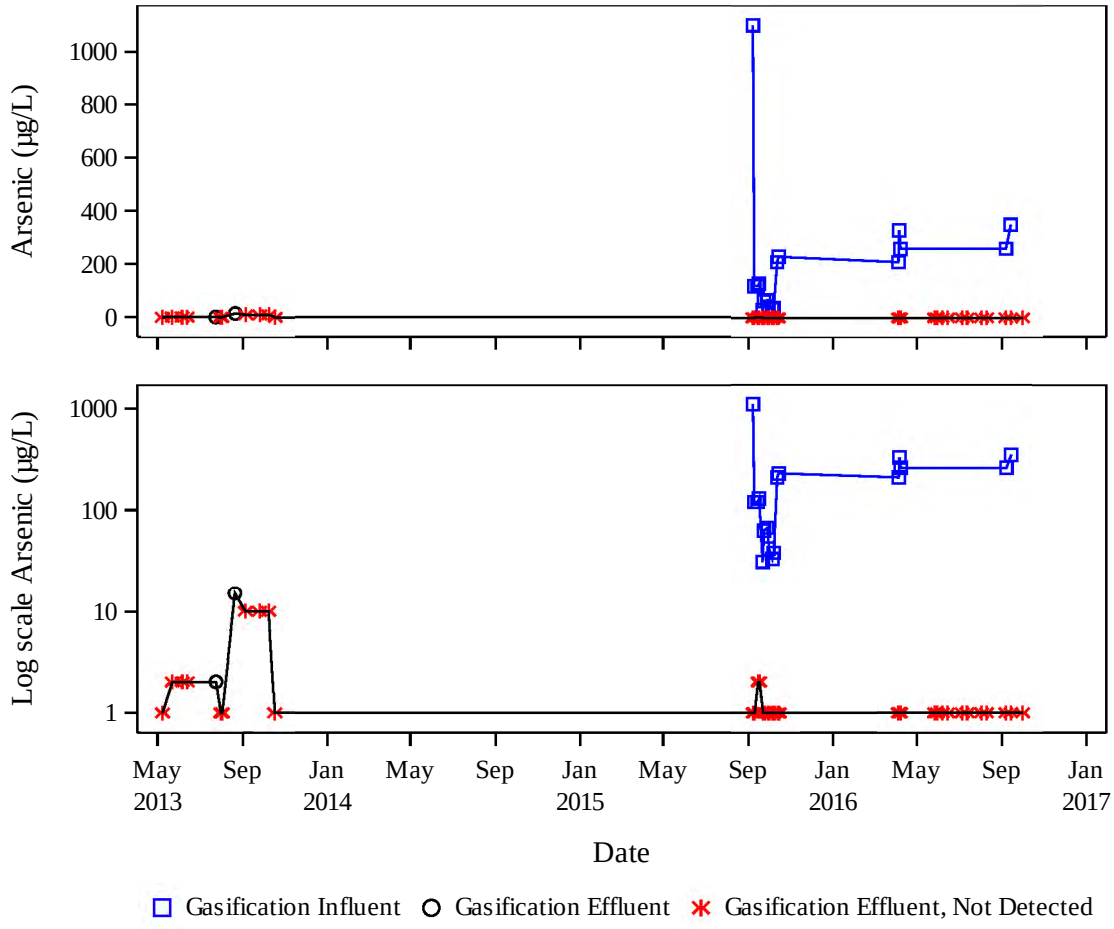


Figure A2.2 Effluent data for arsenic at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

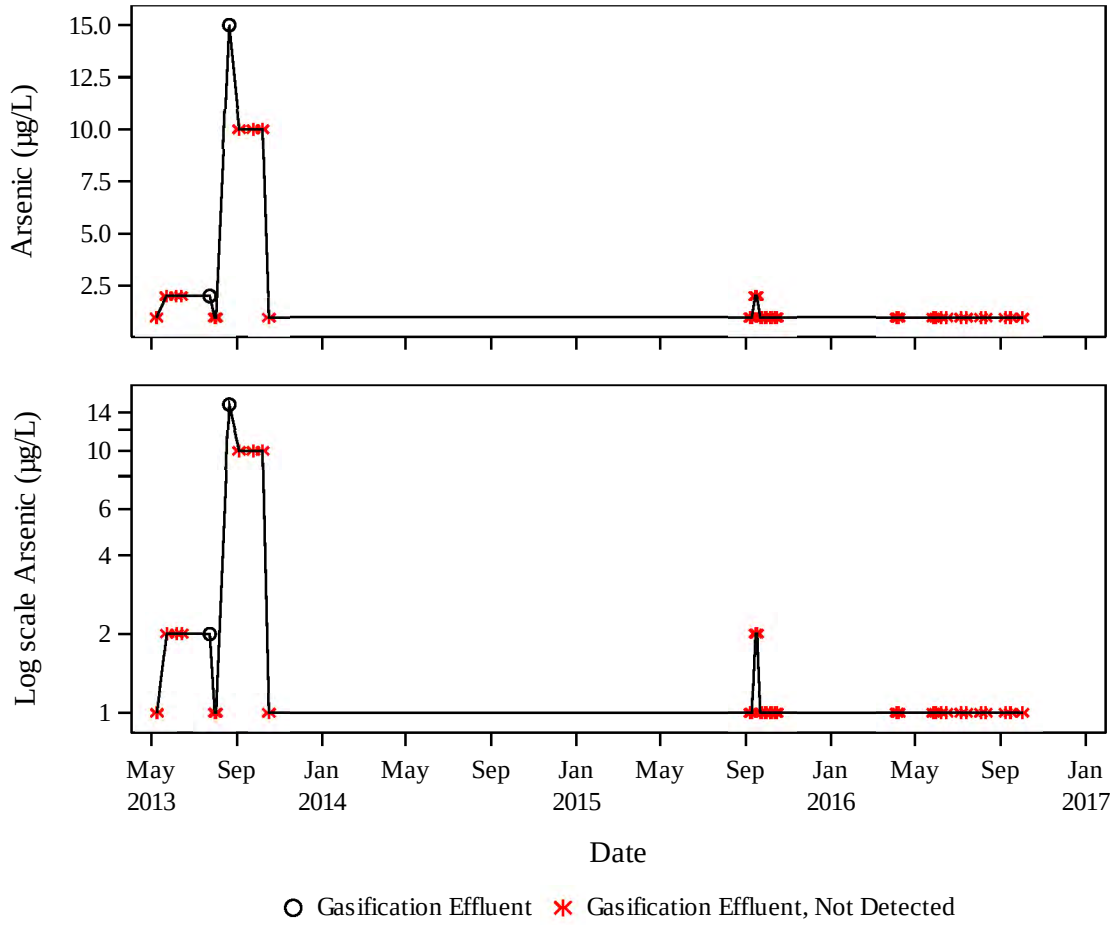


Figure A2.3 Influent and effluent data for mercury at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

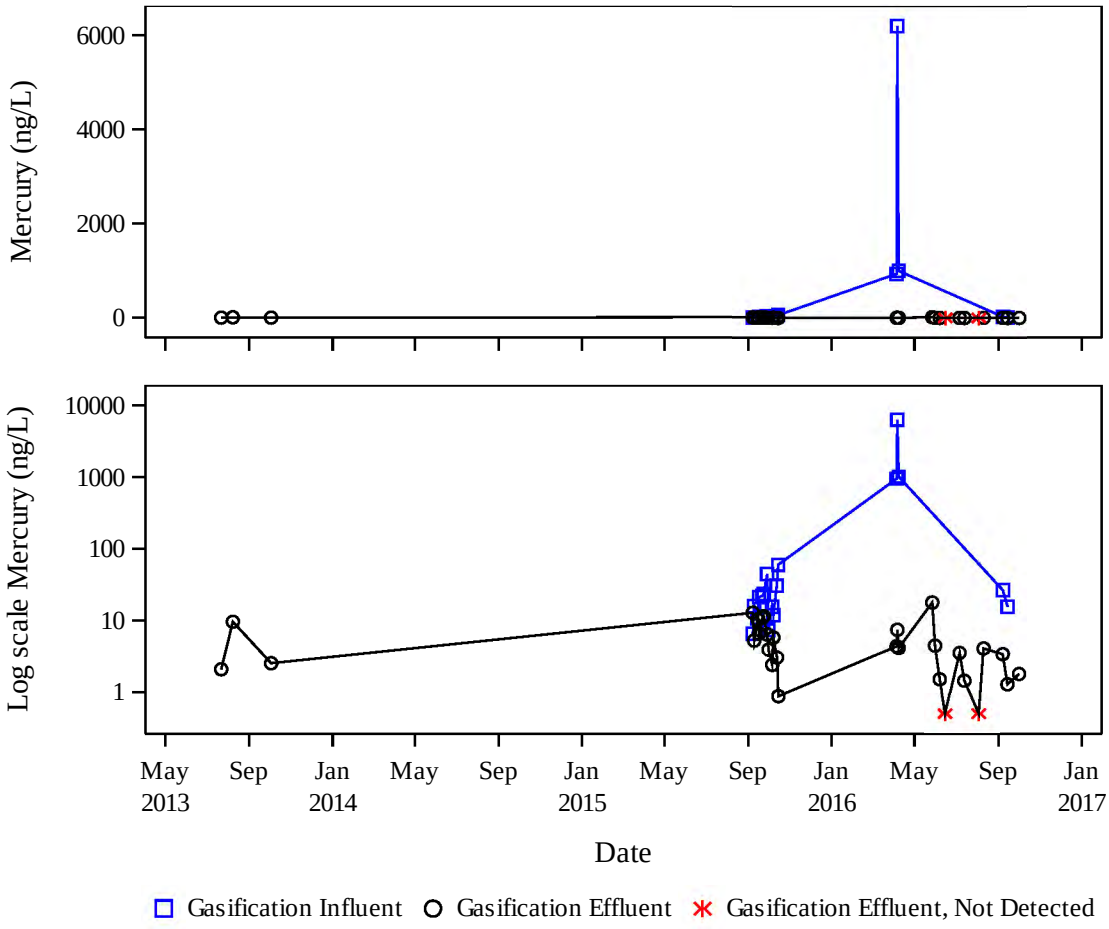


Figure A2.4 Effluent data for mercury at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

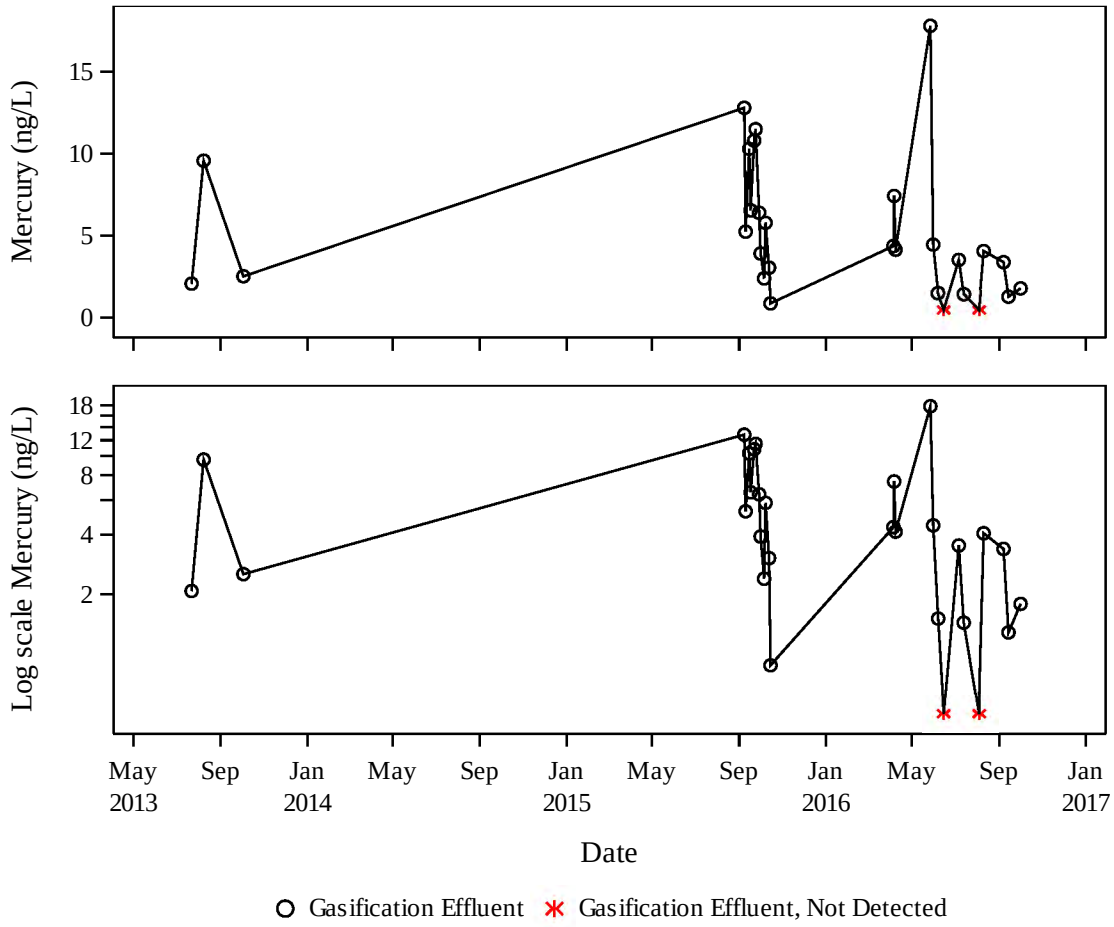


Figure A2.5 Influent and effluent data for selenium at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

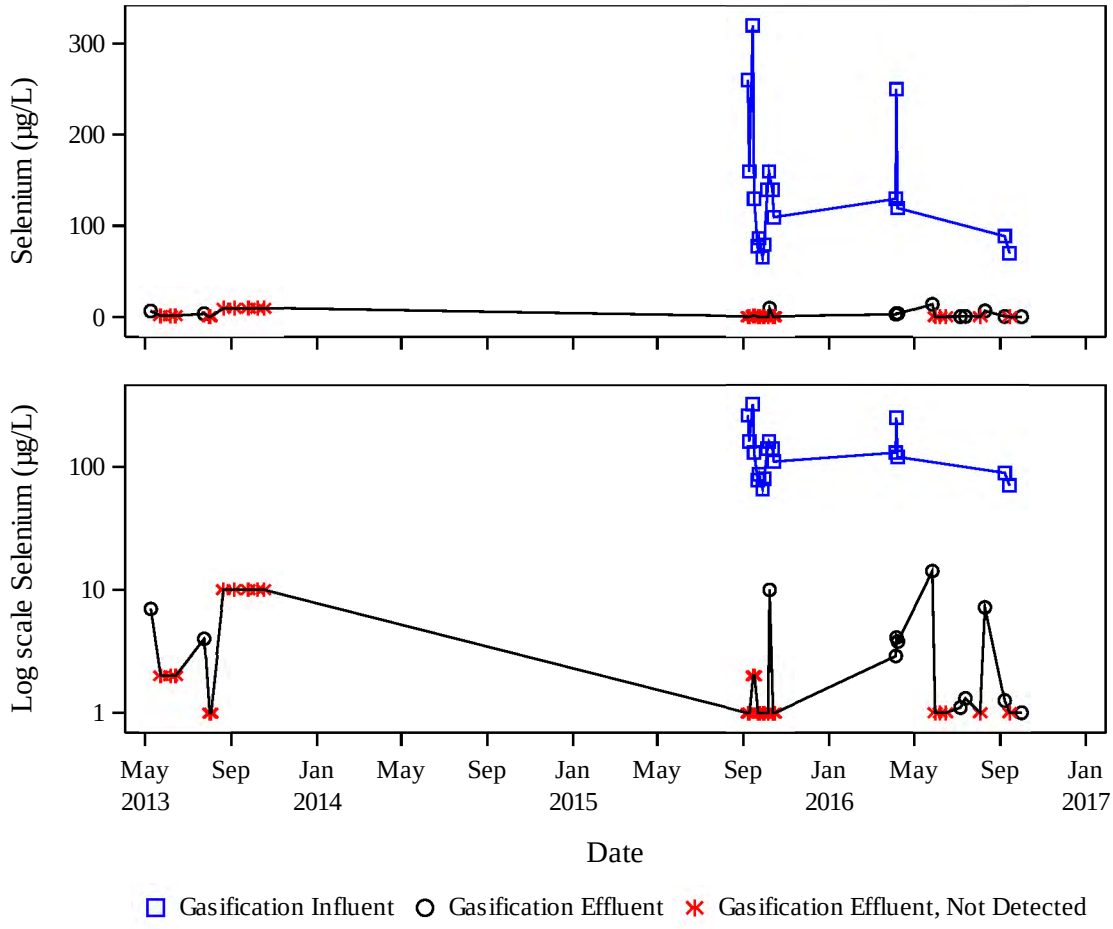


Figure A2.6 Effluent data for selenium at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

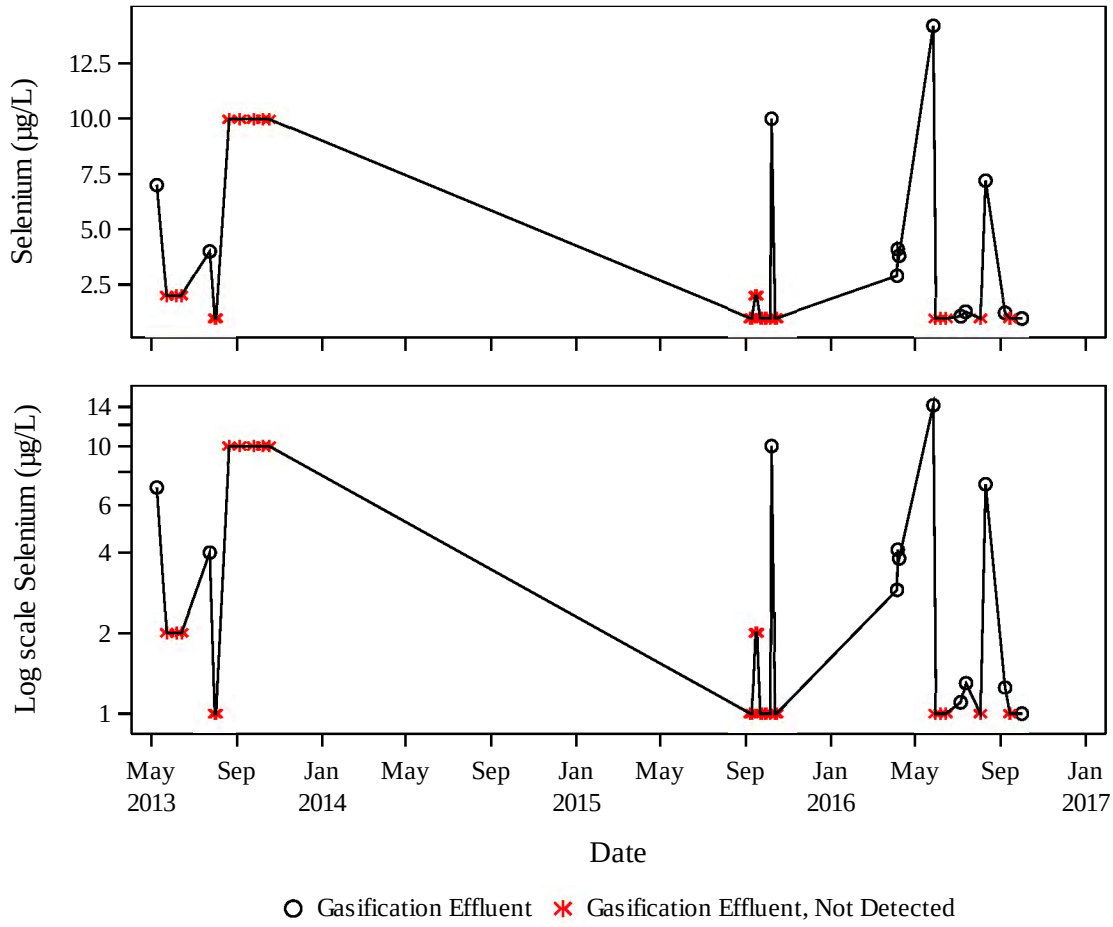


Figure A2.7 Influent and effluent data for TDS at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.

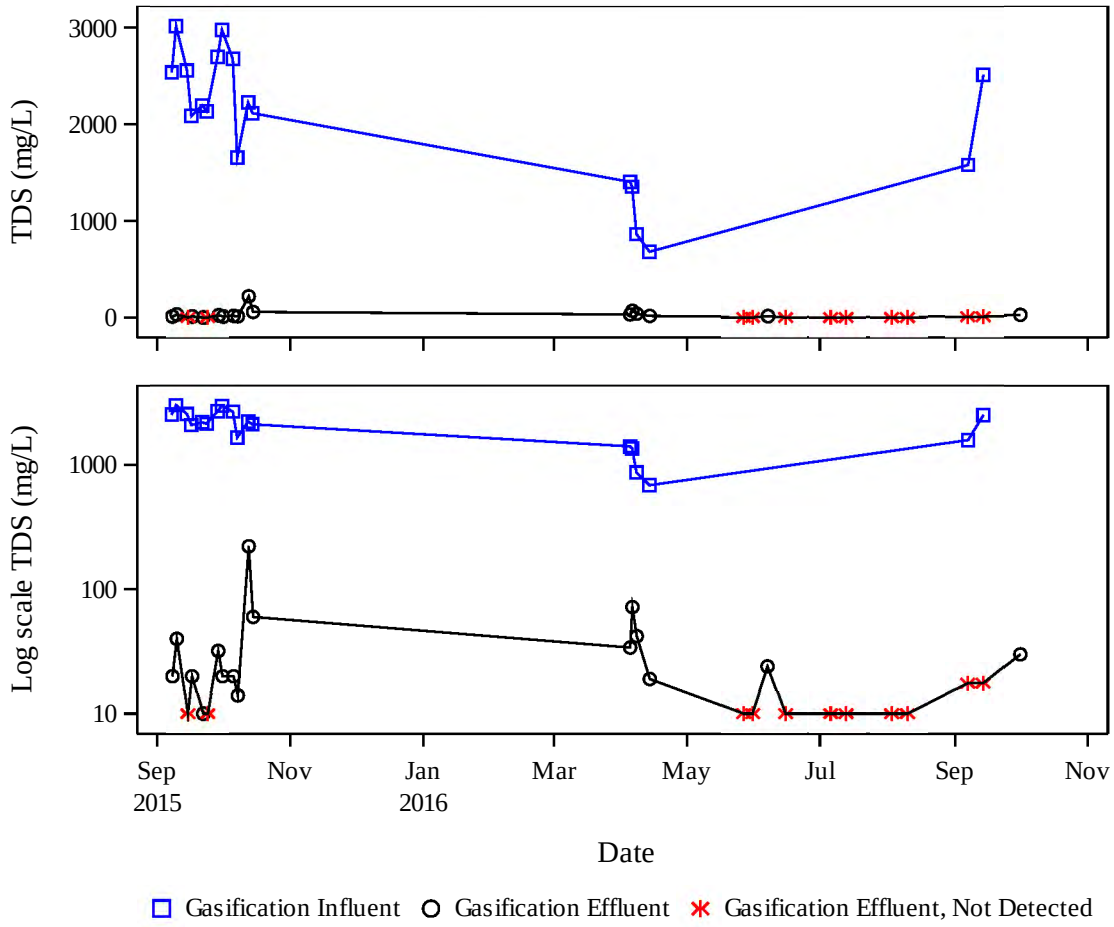
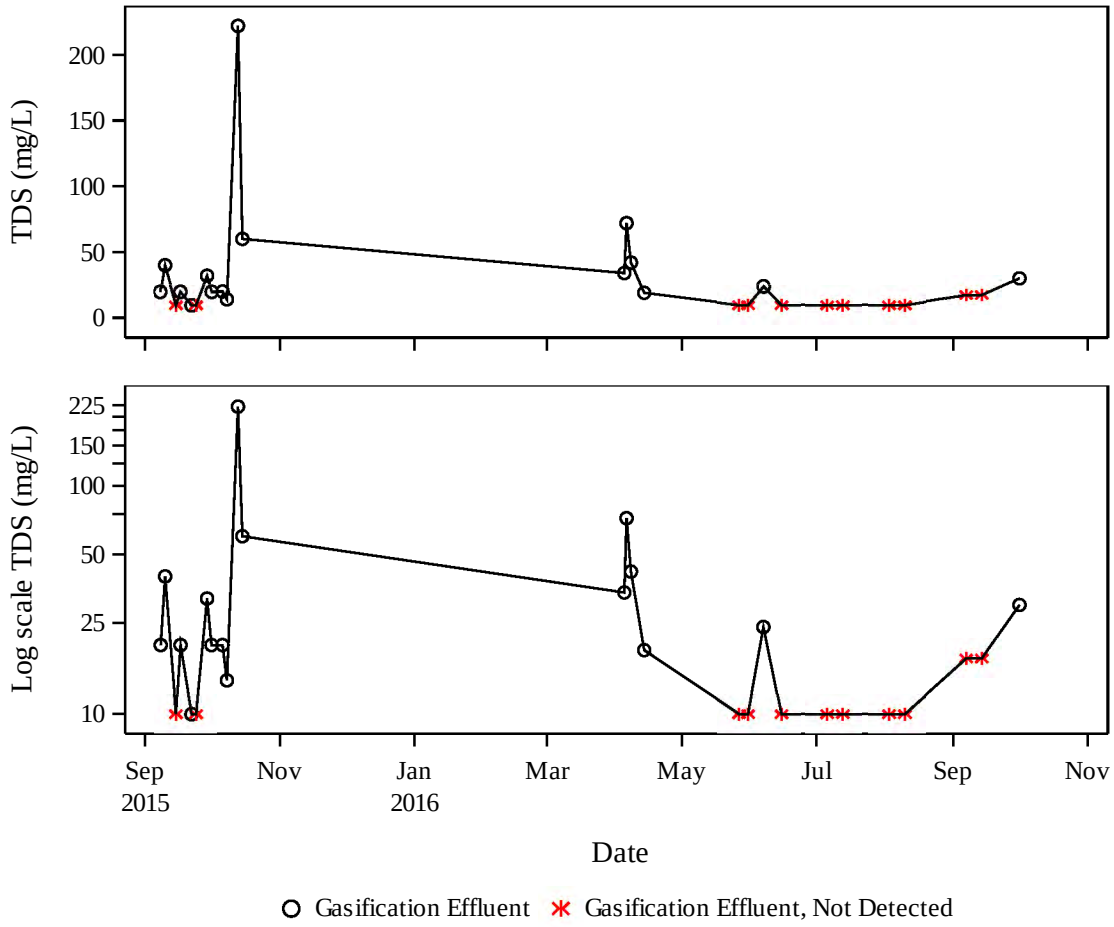


Figure A2.8 Effluent data for TDS at Edwardsport, prior to excluding any data for reasons described in Section 3.1. Pollutant concentrations are shown on a linear scale in the upper plot, log scale in the lower plot.



Appendix 3 Data Editing Criteria Results

This appendix contains a summary of the results of the data editing criteria on a pollutant-by-pollutant basis to select the dataset for calculating effluent limits (described in Section 4 of the Statistical Support Document). These criteria are referred to as the long-term average test (or LTA test). EPA established the LTA test to ensure that the pollutants for which limits are being set were present in the influent at sufficient concentrations to evaluate treatment effectiveness at the plant. The data editing procedure is specified as follows: first, the influent had to pass a basic requirement that 50% of the influent measurements for the pollutant had to be detected at any concentration. If the dataset for a pollutant at a plant passed the basic requirement, it then had to pass one of the following two criteria to pass the LTA test:

> Criterion 1. At least 50% of the influent measurements in a dataset at a plant are detected at levels equal to or greater than 10 times the baseline value (shown in Section 3.2).
>
> Criterion 2. At least 50% of the influent measurements in a dataset at a plant are detected at any concentration and the influent arithmetic average equal to or greater than 10 times the baseline value (shown in Section 3.2).

If the dataset for a parameter failed the basic requirement, then EPA automatically set both Criteria 1 and 2 to "fail." If the dataset for a plant failed the basic requirement, or passed the basic requirement but failed both criteria, EPA would exclude effluent data for that pollutant when calculating the limits. Through the application of the LTA test, EPA ensures that the limits result from treatment of the wastewater and not simply the absence or substantial dilution of that pollutant in the waste stream.

Table A3.1 shows how each pollutant at Edwardsport fared with respect to the basic requirement and the two criteria of the LTA test. The bullets below provide a brief description for the important columns in the table:

- Column "N" presents the total number of influent observations (detected and non-detected combined)
- Column "Percent Detected for Influent (%)" shows the percent of influent observations that are detected.
- Column "Basic Requirement" contains an indicator of whether the dataset passed (or failed) the basic requirement in the data editing criteria.
- Column "Baseline Value" shows the baseline value for each pollutant.
- Column "% Influent values ≥10*baseline value" contains the percent of influent observations that are at least 10 times the baseline values.
- Column "Criterion 1" contains an indicator of whether the dataset passed (or failed) criterion 1 of the LTA test.
- Column "Mean Influent" shows the mean of the influent concentrations.

- Column "Criterion 2" contains an indicator of whether the dataset passed (or failed) criterion 2 of the LTA test.

The influent sampling locations at Edwardsport are grey water feed pumps and LP grey water feed pumps. If samples were collected from both influent locations on the same day, the concentrations were aggregated based on the rules described in section 3.3 so that there was one effluent concentration per day for each pollutant. As shown in Table A3.1, the data for each pollutant at Edwardsport all passed the LTA test.

Table A3.1 Summary of the results for data editing procedure performed to select a dataset for pollutant at Edwardsport in calculating the limits

Pollutant (unit)	N[1]	Percent Detected for Influent (%)	Basic Requirement[2]	Baseline Value	% Influent values ≥ 10*baseline (%)	Criterion[1]	Mean Influent	Criterion[2]
Arsenic (µg/L)	16	100	Passed	2	100	Passed	211.5	Passed
Mercury (ng/L)	16	100	Passed	0.5	100	Passed	526.2	Passed
Selenium (µg/L)	16	100	Passed	5	100	Passed	140.7	Passed
TDS (mg/L)	17	100	Passed	10	100	Passed	2,065.8	Passed

[1]Total number of observations (detected and non-detected combined).

[2]if a dataset fails the basic requirement, EPA automatically set both Criteria 1 and 2 to Failed.

Appendix 4 Summary of the Results for the Engineering Review of the Limits

As described in Section 7, to evaluate whether the limits are reasonable, EPA performed an engineering review to verify that the limits are reasonable based upon the design and expected operation of the control technologies. EPA performed two types of comparisons for this evaluation. First, EPA compared the limits to the effluent data used to develop the limits. Second, EPA compared the limits to the influent data.

Section 1 of this appendix presents the results of the comparisons between the limits and all effluent data that were used to calculate the limits for each technology option. A plot is presented for each pollutant, showing how each of the daily observations compare to the daily limit. All daily concentrations for these pollutants were equal to or below the daily limits. Comparisons between effluent values and the monthly average limits were performed for those periods where there were sufficient data to represent weekly monitoring. All monthly averages were equal to or below the monthly limits.

Section 2 of this appendix contains the results of the comparisons between the limits and influent data for each technology option.

1. Comparison of the Limits to the Effluent Data Used as the Basis for the Limits

A plot is presented for each regulated parameter (for example, see Figures A4.1 and A4.2) showing how each of the daily observations compare to the daily limit. The dashed line shows the option LTA. The solid line shows the limitation established for the parameter and technology option.

For each analyte, monthly averages for calendar months were calculated using all daily effluent values within the calendar month. As described in Section 7, this comparison to the monthly limit requires that the observations are representative of weekly monitoring. EPA accounted for this by calculating monthly averages for all time periods where there were at least four daily values with the sample dates spread across a period of at least several weeks (i.e., that spanned a range of at least 21 days and for which the maximum number of days between sequential samples was 10 days or less). Data not representative of weekly (or more frequent) monitoring generally were not valid for this evaluation. As a result, samples collected in a short time frame, or samples that were not spread across the month were not used when comparing the monthly averages to the monthly limits. For data collected from Edwardsport, only one monthly average can be calculated for mercury and total dissolved solid respectively during the sampling period.

Limits for Edwardsport Gasification Wastewater (Mercury and TDS)

The limitations for Edwardsport were calculated using baseline adjusted data. As a result, the effluent limits were compared to the reported concentrations after baseline adjustment.

Figures A4.1 and A4.2 show the daily limitation and daily concentrations from Edwardsport for mercury and total dissolved solid, respectively. All observations for these pollutants were below the daily limits.

There is only one monthly average available based on the requirements described above. The monthly average concentrations for mercury (9.1 ng/L) and total dissolved solids (20.3 mg/L) were both below the monthly average limits.

Figure A4.1 Mercury daily limitation and daily concentrations (µg/L) at Edwardsport used to calculate the limitations for gasification wastewater

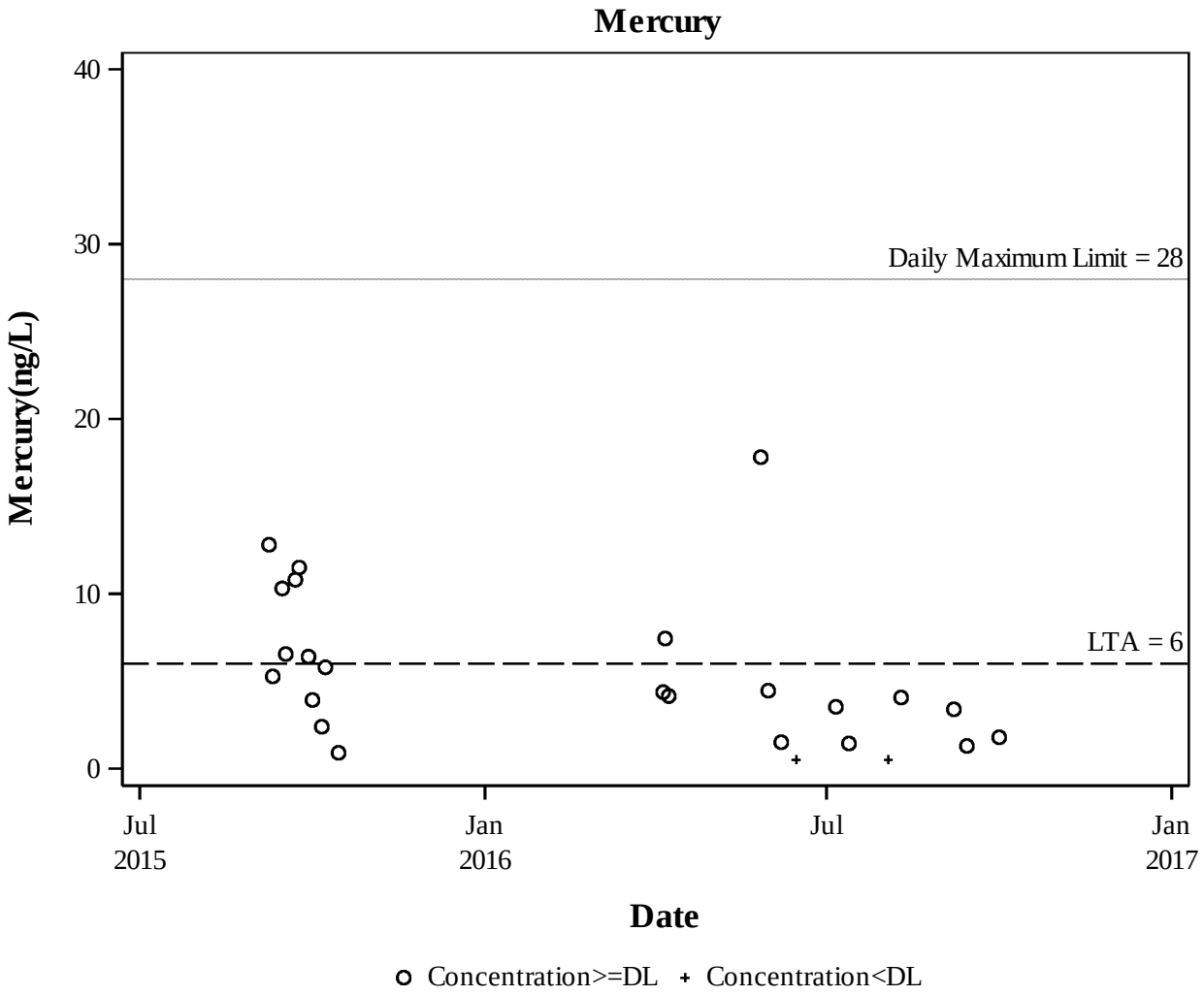
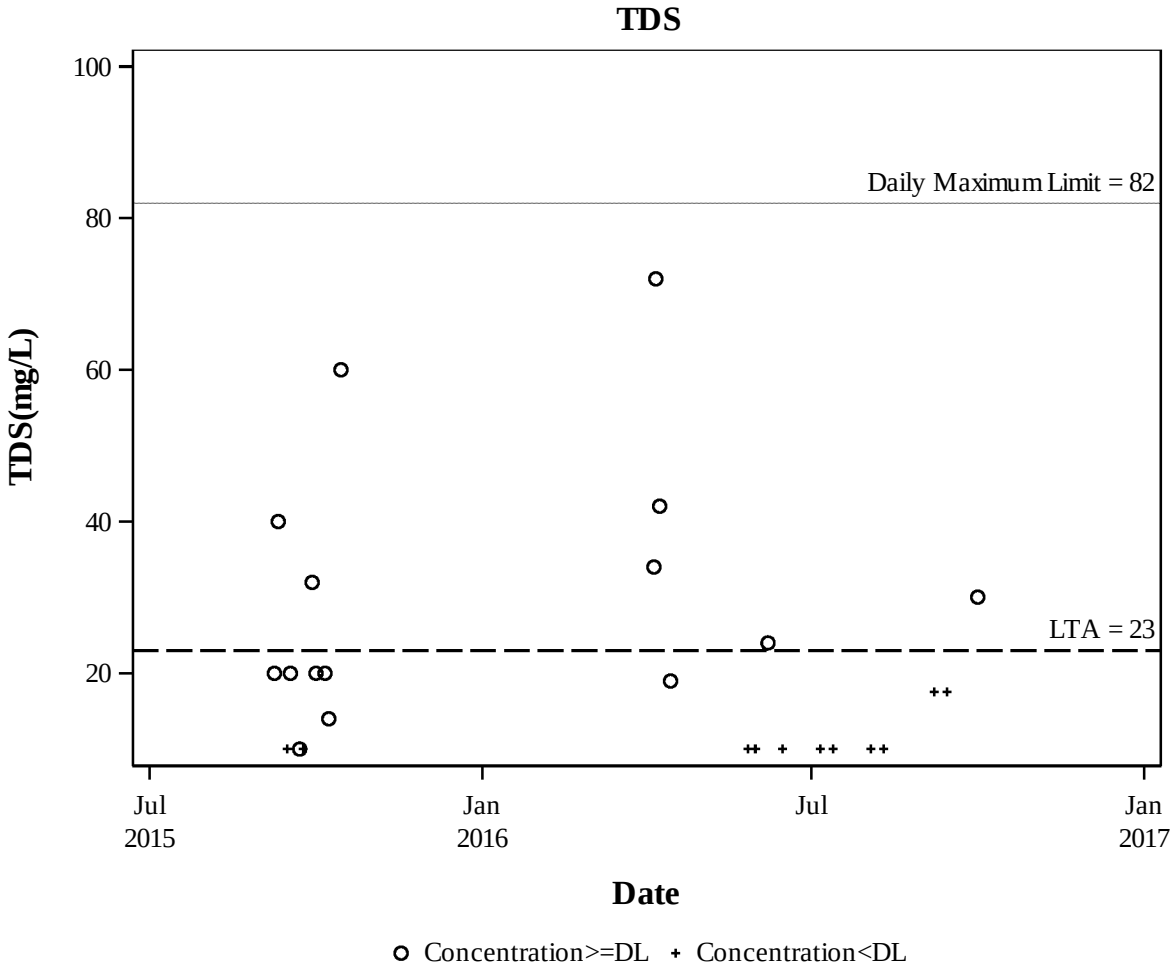


Figure A4.2 Total dissolved solid daily limitation and daily concentrations (mg/L) at Edwardsport used to calculate the limitations for gasification wastewater



2. Comparison of the Alternative Effluent Limits to Influent Data

Table A4.1 Summary statistics for the influent concentrations for data used as the basis for calculating the limits for gasification wastewater

Pollutant (daily limits)	Grey Water Treatment System Influent				
	N	Minimum	Median	Mean	Maximum
Mercury (Daily Maximum Limit = 28 ng/L)	16	6.6	21.6	526.1	6,200.0
Total Dissolved Solids (Daily Maximum Limit = 82 mg/L)	17	688.0	2,140.0	2065.8	3,020.0