Bridgewater Power Company
Emissions Calculations
Application # FY07-0091

Emergency Generator
1.77 mmBru/hr, limited to 13.0 gal/hr Diesel fuel with sulfur less than 0.4% by weight
195 kilowatts at 263 Hp
137,000 Btu/gal Diesel fuel
Use of USEPA AP-42 emission factors, Chapter 3.3, Gasoline and Diesel
Industrial Engines, Table 3.3-1, Updated October 1996 for SO2, VOC, and PM10.
The stack from the Emergency Generator is tied into the Boiler stack.

Potential Emissions

Pollutant	Efactor lb/mmBtu	Max Heat Input mmBtu/hr	Potential Emissions lb/hr	Potential Emissions 8760 hr/yr tons/yr	Potential Emissions 500 hr/yr tons/yr
PM10 (F+C)	0.31	1.77	**0.55**	2.40	**0.14**
SO2	0.29	1.77	**0.51**	2.25	**0.13**
NOx	3.56	1.77	**6.30**	27.60	**1.58**
CO	0.95	1.77	**1.68**	7.36	**0.42**
VOC	0.35	1.77	**0.62**	2.71	**0.15**

Actual Emissions

To make calculations easy, use the total number hours of operation.
For example in 2006 the total hours of operation was 25 hours.

Pollutant	Efactor lb/mmBtu	Max Heat Input mmBtu/hr	Actual Emissions lb/hr	Total Hours Operation for the year hr/yr	Actual Emissions tons/yr
PM10 (F+C)	0.31	1.77	0.55	25	0.01
SO2	0.29	1.77	0.51	25	0.01
NOx	3.56	1.77	6.30	25	0.08
CO	0.95	1.77	1.68	25	0.02
VOC	0.35	1.77	0.62	25	0.01

Emission Calculations
Bridgewater Power Company

Boiler

250 MMBtu/hr maximum firing wood
25 MMBtu/hr maximum firing #2 fuel oil or on-spec used oil
This is due to the 10% annual capacity limitation to stay out of 40 CFR 60 Subpart Db Sections 60.44b(j) and (k) for NOx emissions limits.

Potential uncontrolled emissions from combusting wood only at 250 MMBtu/hr

Pollutant	Uncontrolled Efactor lb/mmBtu	Max Heat Input mmBtu/hr	Potential Emissions lb/hr	Potential Emissions 8760 hr/yr tons/yr
PM10 (F+C)	**0.307**	250	**76.75**	**336.17**
SO2	0.025	250	6.25	27.38
NOx	0.22	250	55	240.90
CO	0.6	250	150	657.00
VOC	0.017	250	4.25	18.62

Emissions factors from USEPA AP-42 5th Edition 09/98, Chapter 1.6, Wood Residue Combustion, Updated 09/03, Tables 1.6-1, 1.6-2, and 1.6-3

Potential uncontrolled emissions from combusting wood only at 225 MMBtu/hr

Pollutant	Uncontrolled Efactor lb/mmBtu	Max Heat Input mmBtu/hr	Potential Emissions lb/hr	Potential Emissions 8760 hr/yr tons/yr
PM10 (F+C)	**0.307**	225	**69.08**	**302.55**
SO2	0.025	225	5.63	24.64
NOx	0.22	225	49.50	216.81
CO	0.6	225	135.00	591.30
VOC	0.017	225	3.83	16.75

Emissions factors from USEPA AP-42 5th Edition 09/98, Chapter 1.6, Wood Residue Combustion, Updated 09/03, Tables 1.6-1, 1.6-2, and 1.6-3

Actual controlled emissions from combusting wood only

226,000 tons wood combusted in 2006 at a heating value of 4250 Btu/lb
1,921,000 MMBtu/yr
Boiler is equipped with a multiclone and electrified gravel filter bed

Pollutant	Controlled Efactor lb/mmBtu	Actual Heat Input mmBtu/yr	Actual Emissions ton/yr
PM10 (F+C)	0.04	1921000	38.42
SO2	0.025	1921000	24.01
NOx	0.217	1921000	208.43
CO	0.224	1921000	215.15
VOC	0.017	1921000	16.33

PM10 emissions factors are from stack testing conducted on June 10, 2004.
SO2 and VOC emissions factors are from USEPA AP-42 5th Edition 09/98, Chapter 1.6, Wood Residue Combustion, Updated 09/03, Tables 1.6-2 and 1.6-3.
CO and NOx emissions factors are from the plant CEM data systems.

Emission Calculations
Bridgewater Power Company

Potential uncontrolled emissions from combusting #2 Fuel Oil at 25 MMBtu/hr for the year

Permit limit of 25,000,000 Btu/hr/140,000 Btu/gal = 178.57 gal/hr

Pollutant	Efactor lb/gal	Max #2 FO Firing Rate gal/hr	Maximum Potential Emissions lb/hr	Potential Emissions 8760 hr/yr tons/yr
PM10 (F+C)	**0.0033**	**178.57**	0.59	2.58
SO2	**0.0568**	**178.57**	10.14	44.43
NOx	**0.024**	**178.57**	**4.29**	**18.77**
CO	0.005	**178.57**	0.89	3.91
VOC	0.0002	**178.57**	0.04	0.16

Emissions factors from USEPA AP-42 5th Edition 09/98, Chapter 1.3, Fuel Oil
Tables 1.3-1, 1.3-2, and 1.3-3

Acutal emissions from combusting #2 Fuel Oil During 2006

Facility burned 118,160 gallons of No. 2 fuel oil in 2006

Pollutant	Efactor lb/gal	Actual #2 FO Combusted gal/yr	Actual Emissions tons/yr
PM10 (F+C)	**0.0033**	118160	**0.19**
SO2	**0.0568**	118160	**3.36**
NOx	**0.024**	118160	**1.42**
CO	0.005	118160	0.30
VOC	0.0002	118160	0.01

Emissions factors from USEPA AP-42 5th Edition 09/98, Chapter 1.3, Fuel Oil
Tables 1.3-1, 1.3-2, and 1.3-3

Potential uncontrolled emissions from combusting 17 gal/hr No. 2 fuel oil in 2 burners
for the RSCR System

Pollutant	Efactor lb/gal	Max #2 FO Firing Rate gal/hr	Maximum Potential Emissions lb/hr	Potential Emissions 8760 hr/yr tons/yr
PM10 (F+C)	**0.0033**	17	0.06	0.25
SO2	**0.0568**	17	0.97	4.23
NOx	**0.024**	17	0.41	1.79
CO	0.005	17	0.09	0.37
VOC	0.0002	17	0.00	0.01

Potential Uncontrolled Emissions for the Wood-Fired Boiler at 250 MMBtu/hr
Combined with the two No. 2 Fuel Oil Fired Burners on the RSCR
Assuming 225 MMBtu/hr from wood, 25 MMBtu/hr from No. 2 fuel oil to the Boiler and
2.38 MMBtu/hr from the No. 2 Fuel Oil fired Burners on the RSCR

Pollutant	Wood firing (lb/hr)	Oil firing (lb/hr)	RSCR No.2FO (lb/hr)	Total (lb/hr)	Potential tons/yr
PM10 (F+C)	**69.08**	0.59	0.06	69.73	**305.4174**
SO2	5.63	10.14	0.97	16.74	73.3212
NOx	49.5	4.29	0.41	54.2	237.396
CO	135	0.89	0.09	135.98	**595.5924**
VOC	3.83	0.04	0	3.87	16.9506

Potential Controlled Emissions for the Wood-Fired Boiler at 250 MMBtu/hr
and RSCR Burners at 2.38 MMBtu/hr
Assuming 225 MMBtu/hr from wood, 25 MMBtu/hr from No. 2 fuel oil to the Boiler
Assuming RSCR burners on at maximum flow of 17 gal/hr or 2.38 MMBtu/hr
Assuming a NOx emission rate of 0.075 lb/MMBtu with the RSCR in operation
This would include all NOx from wood & oil to the Boiler plus oil to the RSCR burners.
Assuming a CO emission rate of 0.224 lb/MMBtu based on plant CEM data
Assuming a PM10 (F+C) emission rate of 0.04 lb/MMBtu based on stack testing
For VOC use the above lb/hr numbers combined for each of these fuels based on AP-42 in that there is no pollution control in place for VOC emissions.
For SO2 use the above lb/hr numbers combined for each of the fuels based on AP-42 in that there is no pollution control in place for SO2 emissions.

Pollutant	**Emission Factor lb/MMBtu**	**Total Heat Input MMBtu/hr**	**Controlled Potential Emissions lb/hr**	**Controlled Potential Emissions tons/yr**
PM10 (F+C)	0.04	252.38	10.10	44.22
SO2	NA	NA	16.74	73.32
NOx	0.075	252.38	18.93	82.91
CO	0.224	252.38	56.53	247.62
VOC	NA	NA	3.87	16.95

Potential Controlled Emissions for the Wood-Fired Boiler at 250 MMBtu/hr
and RSCR Burners at 2.38 MMBtu/hr
Assuming 250 MMBtu/hr from wood and NO No. 2 fuel oil
Assuming RSCR burners on at maximum flow of 17 gal/hr or 2.38 MMBtu/hr
Assuming a NOx emission rate of 0.075 lb/MMBtu with the RSCR in operation
This would include all NOx to the Boiler from wood and the fuel oil to the burners
Assuming a CO emission rate of 0.224 lb/MMBtu based on plant CEM data
Assuming a PM10 (F+C) emission rate of 0.04 lb/MMBtu based on stack testing
For VOC use the above lb/hr numbers combined for each of these fuels based on AP-42 in that there is no pollution control in place for VOC emissions.
For SO2 use the above lb/hr numbers combined for each of the fuels based on AP-42 in that there is no pollution control in place for SO2 emissions.

Pollutant	**Emission Factor lb/MMBtu**	**Total Heat Input MMBtu/hr**	**Controlled Potential Emissions lb/hr**	**Controlled Potential Emissions tons/yr**
PM10 (F+C)	0.04	252.38	10.10	44.24
SO2	NA	NA	7.22	31.60
NOx	0.075	252.38	18.93	82.91
CO	0.224	252.38	56.53	247.62
VOC	NA	NA	4.25	18.63

Boiler Ammonia Slip Emissions Compliance with Env-A 1400

Bridgewater has proposed meeting a 20 ppmdv at 6% oxygen ammonia slip emissions limit.
In order to demonstrate compliance with Env-A 1400, the adjusted in-stack concentration method in Env-A 1405.04 will be used to demonstrate compliance for the proposed emission limit of 20 ppmdv at 6% oxygen.
First, you need to use either the stack flow method or F Factor method to convert 20 ppm ammonia to lb/hr ammonia. Below is the stack flow method.
(20 ft3 NH3/1000000 ft3 stack flow dry) X (1 lb mole NH3/385.3 ft3 NH3) X (17 lb NH3/1 lb mole NH3) X (dry ft3 stack flow/min) X (60 min/hr) = lb NH3/hr
Using the maximum stack flow of 120,000 dry ft3 stack flow/min = 3.05 lb NH3/hr
X = emission rate of ammonia in lb/hr = 3.05 lb/hr
Y = grams.second of ammonia = X/7.94 = 3.05/7.94 = 0.3841 grams/second
Z = micrograms/second ammonia = Y X 1,000,000 = 0.3841 X 1,000,000 = 384,100 micrograms/second
A = stack volume flow in actual cubic feet/minute (ACFM)
A = 120,000 ACFM
B = stack volume flow in actual cubic meters/second = A/2,119 = 120,000/2,119
B = 56.63 actual cubic meters/second
In-stack concentration (micrograms/cubic meter) = Z/B
In-stack concentration = 384,100/56.63 = 6782.6
Adjusted In-stack concentration = In-stack concentration/400 = 6782.6/400
Adjusted In-stack concentration = 16.95 micrograms/cubic meter
24-hr AAL for ammonia = 100 micrograms/cubic meter
Annual AAL for ammonia = 100 micrograms/cubic meter
Therefore, 20 ppmvd NH3 at 6% oxygen is below the 24-hr and annual ambient air limits for NH3 and the Boiler will be in compliance with the state air toxics program for its ammonia slip emissions.

As a further check of this proposed emission limit,
Bridgewater plans on a maximum feed rate of 143 lb/hr ammonia (19% by weight, aqueous solution) and a slip of 20% of the feed rate.
X = emission rate of ammonia in lb/hr = 143 X 0.19 X 0.2 = 5.434 lb/hr
Y = grams/second ammonia = X/7.94 = 5.434/7.94 = 0.6843 grams/second
Z = micrograms/second ammonia = Y X 1,000,000 = 0.6843 X 1,000,000 = 684,300 micrograms/second
A = stack volume flow in actual cubic feet/minute (ACFM)
A = 120,000 ACFM
B = stack volume flow in actual cubic meters/second = A/2,119 = 120,000/2,119
B = 56.63 actual cubic meters/second
In-stack concentration (micrograms/cubic meter) = Z/B
In-stack concentration = 684,300/56.63 = 12,083.7
Adjusted In-stack concentration = In-stack concentration/400 = 12,083.7/400
Adjusted In-stack concentration = 30.2 micrograms/cubic meter
24-hr AAL for ammonia = 100 micrograms/cubic meter
Annual AAL for ammonia = 100 micrograms/cubic meter
Therefore, a maximum feed rate of 143 lb/hr of aqueous ammonia at 19% ammonia by weight with a slip of 20% will meet the ambient air limits for ammonia and the ammonia slip emissions from the Boiler will be in compliance with the state air toxics program for ammonia emissions.

Cooling Pond Particulate Matter Emissions

Assumptions for the Cooling Pond
15,800 gal/min circulation rate X 1,440 min/day = 22,752,000 gal/day
15,800 gal/min circulation rate X 60 min/hr = 948,000 gal/hr
DR = Drift Rate = drift rate for the pond (based on manufacturer's data for the facility pond),
B + W = (E)/(C - 1) is an equation from the Drew Principles of Industrial Water Treatment book on page 166 which is used to figure out drift losses
E = Evaporation rate as a % of feed rate = (Temp. drop across system (deg F)/1000)
For Bridgewater 18 degrees F is the average temp. drop across the system,
so E = 18/1000 = 0.018 or 1.8% Evaporation
B = Water loss by bleedoff, as a percentage of circulation rate, and assumed to be zero for Bridgewater.
W = Wind and drift water losses, as a percent of circulation rate.
C = Cycles of concentration, which is the ratio between the total dissolved solids (TDS) in the cooling pond water and the TDS in the system's makeup supply. Determining optimum cycles of concentration for a cooling pond system is determined by its design, water characteristics, operating parameters and treatement program. For Bridgewater, this varies from 12 cycles in the winter to about 20 cycles in summer. So, now we can calculate drift losses or W for varying cycles of circulation.
Back to the original equation above and assuming B = 0, we have:
(E/(C-1))/100 = W
For 12 cycles of concentration:
(1.8/(12-1))/100 = 0.001636% Wind and drift losses = 0.00001636 gal drift/gal circulation
For 20 cycles of concentration:
(1.8/(20-1))/100 = 0.000947% Wind and drift losses = 0.00000947 gal drift/gal circulation
Let's assume an average of 16 cycles of concentration:
(1.8/(16-1))/100 = 0.0012% Wind and drift losses = 0.000012 gal drift/gal circulation

For Bridgewater, wind and drift losses in gal/day are:
22,752,000 gal/day X 0.0012% = 273 gal/day

Total Dissolved Solids (TDS) lost in drift from the cooling pond
Bridgewater periodically tests their cooling pond water for TDS, with a range from 1,700 to 3,600 mg/liter or ppmw. For determining worst case TDS emissions, use 3600 ppmw.
TDS loss in lb/min = (TDS ppmw/1,000,000)X(drift loss (gal/gal))X(circ. rate (gal/min))X(8.34 lb/gal)
TDS loss in lb/min = (3600/1,000,000)*(0.000012)*(15,800)*(8.34) = 0.00569 lb/min
0.00569 lb/min X 60 min/hr = 0.3416 lb/hr
0.3416 lb/hr X 24 hr/day = 8.20 lb/day TDS
8.20 lb/day X 365 days/yr = 2,993 lb TDS/yr
2,993 lb TDS/yr X ton/2,000 lb = 1.50 tons/yr TDS emissions

Cooling Pond Water Treatment Chemical RTAP Emissions

Bridgewater uses approximately 7 different biocide, corrosion inhibitors, and anti-scalants in its circulating water cooling pond to treat the water for reuse as feedwater in the Boiler.
Below is a summary Table of Maximum Daily Chemical Usage for the Cooling Pond.

Product	Ingredients	Max Daily Feed Rate gal/day	Density lb/gal	Max Daily Feed Rate lb/day	Ingredient Feed Rate in lb/day	RTAP - ? Yes/No
Sodium Hypochlorite	15% NaOCl	55	10.24	563.2	84.5	N
	0.2-2.0% NaOH				11.3	YES
	72.0% Water				405.5	N
	12.0% NaCl				67.6	N
Sulfuric Acid	70% H2SO4	4	15.28	61.12	42.8	YES
	30% H2O				18.3	N
WPD	45-55% Sodium Tolytriazole	1.5	9.9	14.85	8.2	N
Drewsperse	10-25% Propylene Glycol	1.5	8.41	12.61	3.1	YES
	1-10% Surfactant					N
	1-10% Trade Secret					N
	1-10% Trade Secret					N
	1-10% Polyethylene Glycol				1.3	YES
Adjunct	100% NaOH	0.25	12.67	3.167	3.2	YES
Amercor	10-20% Morpholine	0.25	8.24	2.06	0.41	YES
	10-20% Cyclohexylamine				0.41	YES
Amersite	8-18% Sodium Erythorbate	1	8.82	8.82	1.6	N

In reviewing RTAP emissions, DES first looks to see if the usage is 50% below deminimus values in lb/day and lb/yr and if a chemical constituent is less than 50% of the deminimus values it needs no further evaluation and has passed the RTAP evaluation. DES has constructed a Table below summarizing the RTAPs emitted and listed the Env-A 1400 deminimus values from Table 1450-1 for each of the chemical constituents from above.

Chemical	CAS #	Deminimus lb/day	Deminimus lb/yr	24-hr AAL ug/m3	Annual AAL ug/m3	Max Usage lb/day
Sodium Hydroxide	1310-73-2	0.26	96	33	20	**14.5**
Sulfuric Acid	7664-93-9	0.028	10	3.6	2.4	**42.8**
Propylene Glycol	107-98-2	16	5741	2,000	2,000	3.1
Polyethylene Glycol	25322-68-3	1.6	597	208	99	**1.3**
Morpholine	110-91-8	2.8	1025	357	238	0.41
Cyclohexylamine	108-91-8	1.2	420	146	98	0.41

Based on the above maximum usages of Propylene Glycol, Morpholine, and Cyclohexylamine, these three chemicals if they were used 24 hours/day are less than the deminimus emissions numbers even before you perform calculations to determine how much is emitted in the drift from the cooling pond. Calculations must be performed for sodium hydroxide, sulfuric acid, and polyethylene glycol to determine how much of the chemical is lost in drift emissions to the air from the cooling pond, since their usage rate in lb/day are above the deminimus emissions levels.

Sulfuric Acid Drift Losses
H_2SO_4 feed rate = 61.12 lb/day
% by weight H_2SO_4 = 70.0%
H_2SO_4 concentration in ppmw = Daily consumption/Daily circulation rate
= (61.12 lb/day*0.70)/(22,752,000 gal/day*8.34 lb/gal) = 2.25474E-07
= 0.225 ppmw
Daily Drift = Drift factor as fraction*Daily circulation rate in gal/day
(0.000012)*22,752,000 gal/day
= 273 gal/day
H_2SO_4 in Daily Drift Losses = 273 gal/day*8.34 lb/gal*0.225 ppmw/1,000,000 = 5.12X10-4 lb/day
0.000512 lb/day X 365 day/yr = 0.19 lb/yr
Both of these values of 0.000512 lb/day and 0.19 lb/yr are below deminimus values and in compliance with Env-A 1400.

Sodium Hydroxide Drift Losses
NaOH feed rate = 563.2 + 3.167 lb/day
% by weight NaOH = 2% and 100%
NaOH concentration in ppmw = Daily consumption/Daily circulation rate
= ((563.2*0.02)+(3.167*1))/(22,752,000 gal/day*8.34 lb/gal) = 14.5/189,751,680
= 7.64E-08
= 0.076 ppmw
Daily Drift = Drift factor as fraction*Daily circulation rate in gal/day
(0.000012)*22,752,000 gal/day
= 273 gal/day
NaOH in Daily Drift Losses = 273 gal/day*8.34 lb/gal*0.076 ppmw/1,000,000 = 1.73E-04 lb/day
0.000173 lb/day X 365 day/yr = 0.063 lb/yr
Both of these values of 0.000173 lb/day and 0.063 lb/yr are below deminimus values and in compliance with Env-A 1400.

Polyethylene Glycol Drift Losses
PEG feed rate = 12.61 lb/day
% by weight PEG = 10%
PEG concentration in ppmw = Daily consumption/Daily circulation rate
= (12.61 lb/day*0.10)/(22,752,000 gal/day*8.34 lb/gal) = 1.26/189,751,680
= 6.64E-09
= 0.0066 ppmw
Daily Drift = Drift factor as fraction*Daily circulation rate in gal/day
(0.000012)*22,752,000 gal/day
= 273 gal/day
PEG in Daily Drift Losses = 273 gal/day*8.34 lb/gal*0.0066 ppmw/1,000,000 = 1.5E-05 lb/day
0.000015 lb/day X 365 day/yr = 0.0055 lb/yr
Both of these values of 0.000015 lb/day and 0.0055 lb/yr are below deminimus values and in compliance with Env-A 1400.