Appendix A

Emission Factor Derivations

The following physical constants and standard conditions were utilized to derive the criteria-pollutant emission factors used to calculate criteria pollutant and toxic air contaminant emissions.

standard temperature[a]:	70^{o}F
standard pressure[a]:	14.7 psia
molar volume:	386.8 dscf/lbmol
ambient oxygen concentration:	20.95%
dry flue gas factor[b]:	8743 dscf/MM BTU
natural gas higher heating value:	1030 BTU/dscf

[a] Standard conditions per BAAQMD Regulation 1, Section 228.

[b] F-factor is based upon the assumption of complete stoichiometric combustion of natural gas. In effect, it is assumed that all excess air present before combustion is emitted in the exhaust gas stream. Value shown reflects the typical composition and heat content of utility-grade natural gas in San Francisco Bay Area. The f-factor at 68 ^{o}F and 1 atm. is 8710 dscf/MMBTU (40CFR, Pt. 60, App. A). At 70 ^{o}F and 1 atm., the f-factor is approximately 8743 dscf/MMBTU.

Table A-1 summarizes the regulated air pollutant emission factors that were used to calculate mass emission rates for each source in the AQMD application and CEC AFC. All units are pounds per million BTU of natural gas fired based upon the high heating value (HHV). All emission factors reflect abatement by applicable control equipment. These values are based upon data supplied by the turbine/HRSG manufacturer, as such they may differ slightly from the calculated values which follow Table A-1.

Table A-1
Controlled Regulated Air Pollutant Emission Factors for Gas Turbines and HRSGs

Pollutant	Source			
	Gas Turbine		Gas Turbine & HRSG Combined	
	lb/MM BTU	lb/hr	lb/MM BTU	lb/hr
Nitrogen Oxides (as NO_2)	0.00735 [a]	3.48	0.00735 [a]	4.49
Carbon Monoxide	0.00896 [b]	4.24	0.00896 [b]	5.47
Precursor Organic Compounds	0.00255 [c]	1.2	0.00255 [c]	1.56
Particulate Matter (PM_{10})	0.00704	3.33	0.00704	4.3
Sulfur Dioxide	0.000676	0.32	0.000676	0.41

[a] Based upon the permit condition stack gas emission limit of 2.0 ppmvd NO_x @ 15% O_2 that reflects the use of water injection at the CTGs, low emission duct burners at the HRSGs, and abatement by the proposed A-1 and A-3 Selective Catalytic Reduction systems with ammonia injection.

[b] Based upon the permit condition stack gas emission limit of 4 ppmvd CO @ 15% O_2 with abatement provided by the oxidation catalyst A-2 and A-4on each power train.
[c] Based upon the permit condition stack gas emission limit of 2 ppmvd POC @ 15% O_2 with additional abatement provided by the oxidation catalyst A-2 and A-4on each power train.

Regulated Air Pollutants

NITROGEN OXIDE EMISSION FACTORS

Gas Turbine and Heat Recovery Steam Generator Combined

The combined NO_x emissions from the GT and HRSG will be limited to 2.0 ppmv, dry @ 15% O_2. This emission limit will also apply when the HRSG duct burners are in operation. This concentration is converted to a mass emission factor as follows:

(2.0 ppmvd)(20.95 - 0)/(20.95 - 15) = 7.042 ppmv NO_x, dry @ 0% O_2

($7.042/10^6$)(1 lbmol/386.8 dscf)(46.01 lb NO_2/lbmol)(8743 dscf/MMBTU)

= **0.00732 lb NO_2/MMBTU vs. mfg data in Table A-1 which shows 0.00735 lb/MMBTU**

The NO_x (as NO_2) mass emission rate based upon the maximum firing rate of the gas turbine alone is calculated as follows:

(0.00732 lb (NO_2)/MMBTU)(473.7 MMBTU/hr) = **3.47 lb NO_2/hr vs. mfg data in Table A-1 which shows 3.48 lb/hr**

The NO_x (as NO_2) mass emission rate when duct burner firing occurs is based upon the maximum combined firing rate of the gas turbine and HRSG and is calculated as follows:

(0.00732 lb NO_2/MMBTU)(610.6 MM BTU/hr) = **4.47 lb NO_x/hr vs. mfg data in Table A-1 which shows 4.49 lb/hr**

CARBON MONOXIDE EMISSION FACTORS

Gas Turbine and Heat Recovery Steam Generator Combined

The combined CO emissions from the GT and HRSG duct burner will be limited by permit condition to a maximum controlled CO emission concentration of 4 ppmv, dry @ 15% O_2 during all operating modes except gas turbine start-up and shutdown. The emission factor corresponding to this emission concentration is calculated as follows:

(4 ppmv)(20.95 - 0)/(20.95 - 15) = 14.084 ppmv, dry @ 0% O_2

($14.084/10^6$)(lbmol/386.8 dscf)(28 lb CO/lbmol)(8743 dscf/MM BTU)

= **0.00891 lb CO/MMBTU vs. mfg data in Table A-1 which shows 0.00896 lb/MMBTU**

The CO mass emission rate based upon the maximum firing rate of the gas turbine alone is calculated as follows:

(0.00891 lb/MM BTU)(473.7 MM BTU/hr) = **4.22 lb CO/hr vs. mfg data in Table A-1 which shows 4.24 lbs/hr**

The CO mass emission rate when duct burner firing occurs is based upon the maximum combined firing rate of each gas turbine and HRSG and is calculated as follows:

(0.00891 lb/MM BTU)(610.6 MM BTU/hr) = **5.44 lb CO/hr vs. mfg data in Table A-1 which shows 5.47 lbs/hr**

PRECURSOR ORGANIC COMPOUND (POC) EMISSION FACTORS

Gas Turbine

Silcon Valley Power estimates a maximum POC (non-methane, non-ethane hydrocarbon) emission rate of 1.2 lb/hour for full load operation of the gas turbine alone.

The mass emission rate converts to an emission factor as follows:

POC = (1.2 lb/hr)/(473.7 MMBTU/hr) = **0.002533 lb/MMBTU**

Converting to a concentration yields:

[(0.002533 lb/MMBTU)(10^6)(386.8 dscf/lbmol)]/[(16 lb CH_4/lb-mol)(8743 dscf/MMBTU)]

= 6.99 ppmvd @ 0% O_2

Converting to 15% O_2:

(6.99 ppmvd)(20.95 – 15)/(20.95) = 2.0 ppmvd @ 15% O_2

Gas Turbine and Heat Recovery Steam Generator Combined

Silcon Valley Power estimates a maximum POC (non-methane, non-ethane hydrocarbon) emission rate of 1.56 lb/hr based on mfg. Data for full load operation of the gas turbine with duct burner firing and water injection power augmentation.

This converts to an emission factor of:

(1.56 lb/hr)/(610.6 MMBTU/hr) = **0.00255 lb/MMBTU**

Converting to a concentration yields:

[(0.00255 lb/MMBTU)(10^6)(386.8 dscf/lbmol)]/[(16 lb CH_4/lb-mol)(8743 dscf/MMBTU)]

= 7.05 ppmvd @ 0% O_2

Converting to 15% 0_2: (7.05 ppmvd)(20.95 – 15)/(20.95) = 2.0 ppmvd @ 15% O_2

PARTICULATE MATTER (PM_{10}) EMISSION FACTORS

Gas Turbine

Silcon Valley Power has proposed a maximum PM_{10} emission rate of 3.33 lb/hr based on mfg. data at maximum load for each gas turbine without duct burner operation.

The corresponding PM_{10} emission factor is therefore:

(3.33 lb PM_{10}/hr)/(473.7 MMBTU/hr) = **0.00704 lb PM_{10}/MMBTU**

The following stack data will be used to calculate the grain loading at standard conditions for full load gas turbine operation without duct burner firing to determine compliance with BAAQMD Regulation 6-310.3.
The following worst-case stack gas characteristics (with respect to grain loading) during full load operation w/o duct burner firing occur at the lowest expected typical ambient temperature of 45°F.

PM_{10} mass emission rate:	3.33 lb/hr
Exhaust gas flow rate:	1,100 Klb/hr exhaust @ 13.064% O_2 and 228^oF ~= 318,121 acfm
moisture content:	10.095% by volume

Converting flow rate to standard conditions:

(318,121 acfm)(70 + 460 ^{o}R/228 + 460 ^{o}R)(1 – 0.10095) = 220,311 dscfm

Converting to grains/dscf:

(3.33 lb PM_{10}/hr)(1 hr/60 min)(7000 gr/lb)/(220,311 dscfm) = 0.00176 gr/dscf

Converting to 6% O_2 basis:

(0.00176 gr/dscf)[(20.95 - 6)/(20.95 – 10.095)] = 0.0024 gr/dscf @ 6% O_2

Gas Turbine and HRSG Combined

Silcon Valley Power has proposed a maximum PM_{10} emission rate of 4.3 lb/hr based on mfg. data at the maximum combined firing rate of 610.6 MM BTU/hr during duct burner firing and water injection power augmentation based upon data supplied by the manufacturer.

The corresponding PM_{10} emission factor is therefore:

(4.3 lb PM_{10}/hr)/(610.6 MMBTU/hr) = **0.00704 lb PM_{10}/MMBTU**

It is assumed that this PM_{10} emission factor includes the potential formation of secondary PM_{10} such as particulate sulfates.

The following stack data will be used to calculate the grain loading for full load turbine operation with duct burner firing at standard conditions to determine compliance with BAAQMD Regulation 6-310.3.

The following worst-case stack gas characteristics (with respect to grain loading) during full load with duct burner firing occur at the highest expected “typical” ambient temperature of 98^{o}F.

PM_{10} mass emission rate:	4.3 lb/hr
typical flow rate:	1.092 Klb/hr exhaust flow @ 10.98% O_2 and 229^{o}F ~= 315,835 acfm
typical moisture content:	12.29% by volume

Converting flow rate to standard conditions:

(315,835 acfm)(70 + 460 ^{o}R/229 + 460 ^{o}R)(1 - 0.1229) = 213,083 dscfm

Converting to grains/dscf:

(4.3 lb PM_{10}/hr)(1 hr/60 min)(7000 gr/lb)/(213,083 dscfm) = 0.00235 gr/dscf

Converting to 6% O_2 basis:

(0.00235 gr/dscf)[(20.95 - 6)/(20.95 – 10.98)] = 0.0035 gr/dscf @ 6% O_2

SULFUR DIOXIDE EMISSION FACTORS

Gas Turbine & Heat Recovery Steam Generator

The SO_2 emission factor is based upon an expected maximum natural gas sulfur content of 4 ppm and a higher heating value of 1005 BTU/scf.

The sulfur emission data supplied by the manufacturer for the turbine and turbine with duct burner scenarios are:
:

Turbine only: 0.32 lb SO_2/hr
Turbine w/duct burner: 0.41 lb SO_2/hr

The corresponding mass SO_2 emission rate at the maximum combined firing rate of 473.7 MM BTU/hr is:

(0.32 lb SO_2/hr)(473.7 MMBTU/hr) = 0.000676 lb/MMBTU

The corresponding SO_2 mass emission rate at the maximum gas turbine firing rate of 610.6 MM BTU/hr is:

(0.41 lb SO_2/hr)(610.6 MMBTU/hr) = 0.000671 lb/MMBTU

This is converted to an emission concentration as follows for the combined turbine/HRSG firing scenario:

(0.000671 lb SO_2/MMBTU)(386.8 dscf/lb-mol)(lb-mol/64.06 lb SO_2)(10^6 BTU/8743 dscf)

= 0.463 ppmvd SO_2 @ 0% O_2

which is equivalent to:

(0.463 ppmvd)(20.95 - 15)/20.95 = 0.13 ppmv SO_2, dry @ 15% O_2

The emission concentration for the turbine only firing scenario is calculated as follows:

(0.000676 lb SO_2/MM BTU)(386.8 dscf/lb-mol)(lb-mol/64.06 lb SO_2)(10^6 BTU/8743 dscf)

= 0.467 ppmvd SO_2 @ 0% O_2

which is equivalent to:

(0.467 ppmvd)(20.95 - 15)/20.95 = 0.13 ppmv SO_2, dry @ 15% O_2

Toxic Air Contaminants

The following toxic air contaminant emission factors were used to calculate worst-case emissions rates used for air pollutant dispersion models that estimate the resulting increased health risk to the maximally exposed population. To ensure that the risk is properly assessed, the emission factors are conservative and may overestimate actual emissions.

Table A-2

TAC Emission Factors[a] for Gas Turbines and HRSG Duct Burners

Contaminant	Emission Factor (lb/MM scf)
Acetaldehyde[c]	1.37E-01
Acrolein	1.89E-02
Ammonia[b]	14.09
Benzene[c]	1.33E-02
1,3-Butadiene[c]	1.27E-04
Ethylbenzene	1.79E-02
Formaldehyde[c]	9.17E-01
Hexane	2.59E-01
Naphthalene	1.66E-03
Total PAHs[d]	1.79E-04
Propylene	7.71E-01
Propylene Oxide[c]	4.78E-02
Toluene	7.10E-02
Xylene	2.61E-02

[a] California Air Toxics Emission Factors (CATEF II) Database as compiled by California Air Resources Board under the Air Toxics Hotspot Program.

[b] Based upon maximum allowable ammonia slip of 10 ppmv, dry @ 15% O_2 for A-1and A-3 SCR Systems

[c]carcinogenic compound

[d] Total PAH species from Table B-5

Table A-3 TAC Emission Factors for 3-Cell Cooling Tower

Toxic Air Contaminant	Maximum Concentration in Cooling Tower Return Water (ppm)	Emission Factor[a] (lb/hr)
Ammonia	7	6.12E-04
Arsenic[b]	0.0082	7.20E-07
Cadmium[b]	0.0035	3.06E-07
Trivalent chromium	0.007	6.12E-07
Copper	0.021	1.84E-06
Lead[b]	0.007	6.12E-07
Mercury	0.000018	1.57E-09
Nickel	0.049	4.28E-06
Silver	0.007	6.12E-07
Zinc	0.363	3.17E-05

[a] Based upon maximum drift rate of 0.0005% and operation of cooling tower at maximum water circulation rate of 34,980 gallons per minute.

[b] Carcinogenic compound

AMMONIA SLIP EMISSION FACTORS

Combustion Gas Turbine & Heat Recovery Steam Generator

Each Gas Turbine/HRSG power train will exhaust through a common stack and be subject to a maximum ammonia exhaust concentration limit of 10 ppmvd @ 15% O_2.

NH_3 emission concentration limit:	10 ppmvd @ 15% O_2
Dry gas flow rate (w/o duct burner):	220,311 dscfm @ 13.064% O_2 by volume
Dry gas flow rate (w/duct burner):	213,083 dscfm @ 10.98% O_2 by volume

Correcting ammonia concentration to actual oxygen content at full load with duct burner firing:

(10 ppmvd)(20.95 – 10.98)/(20.95 – 15) = 16.76 ppmvd @ 10.98% O_2

The ammonia mass emission rate at full load with duct burner firing is therefore:

(16.76 ppmvd/10^6)(213,083 dscfm)(60 min/hr)(lb-mol/385.3 dscf)(17 lb NH_3/lb-mol) = **9.45 lb NH_3/hr vs. 8.3 lbs/hr as supplied by the manufacturer and used in the AQMD application and CEC AFC.**

Based upon the maximum combined heat input for a gas turbine/HRSG of 610.6 MM BTU/hr, this mass emission rate converts to the following emission factor:

(9.45 lb NH_3/hr)/(610.6 MM BTU/hr) = **0.0155 lb NH_3/MM BTU**
= **15.94 lb NH_3/MM scf**

Correcting ammonia concentration to actual oxygen content at full load without duct burner firing:

(10 ppmvd)(20.95 – 13.064)/(20.95 – 15) = 15.93 ppmvd @ 13.064% O_2

The ammonia mass emission rate at full load without duct burner firing is therefore:

(15.92 ppmvd/10^6)(220,311 dscfm)(60 min/hr)(lb-mol/385.3 dscf)(17 lb NH_3/lbmol) = **9.28lb NH_3/hr vs. 6.5 lbs/hr as supplied by the manufacturer and used in the AQMD application and CEC AFC.**

Based upon the maximum heat input for a gas turbine of 473.7 MM BTU/hr, this mass emission rate converts to the following emission factor:

(9.28 lb NH_3/hr)/(473.7 MM BTU/hr) = **0.0196 lb NH_3/MM BTU**
= **15.65 lb NH_3/MM scf**

Appendix B

Emission Calculations

Individual and combined heat input rate limits for the Gas turbines, HRSGs, and auxiliary boilers are given below in **Table B-1**. These are the basis of permit conditions limiting heat input rates.

Table B-1 Maximum Allowable Heat Input Rates

Operational Scenario	Heat Rate
Single Turbine w/o HRSG-Duct Burners	473.7 MMBTU/HR
Single Turbine w/ HRSG-Duct Burners	610.6 MMBTU/HR
Two Turbines w/o HRSG-Duct Burners	947.4 MMBTU/HR
Two Turbines w/ HRSG-Duct Burners	1,221.2 MMBTU/HR
Single Turbine (16 hrs duct firing, 8 hrs no duct firing)	13,559.2 MMBTU/DAY
Two Turbines (16 hrs duct firing, 8 hrs no duct firing)	27,118.4 MMBTU/DAY
Single Turbine (1400 hrs duct firing, 7360 hours no duct firing)	4,341,272 MMBTU/YR
Two Turbines (1400 hrs duct firing, 7360 hours no duct firing)	8,682,544 MMBTU/YR

B-1.0 Gas Turbine Start-Up and Shutdown Emission Rate Calculations

The maximum nitrogen oxide, carbon monoxide, and precursor organic compound mass emission rates from a gas turbine occur during start-up periods. The PM_{10}, sulfur dioxide, ammonia, and toxic compound emissions are a function of fuel use rate only and do not exceed typical full load emission rates during start-up. The NO_x, CO, and UHC (POC) emission rates shown in Table B-3 are Silcon Valley Power estimates as supplied by the turbine manufacturer.

Table B-2 Gas Turbine Start-Up Emission Rates (lb/startup)

Pollutant	Cold Start-Up [a,c]	Hot Start-Up [b,c]
NO_x (as NO_2)	41	41
CO	35	35
POC (as CH_4)	3	3
PM_{10}	3	3
SO_x (as SO_2)	0.31	0.31

[a] Cold start not to exceed one hours

[b] Hot start not to exceed one hour

[c] Manufacturer's data supplied by Silicon Valley Power to BAAQMD.

Table B-4 is a comparison of baseload emission rates and shutdown emission rates based upon data supplied by the manaufacturer.

Table B-3 Gas Turbine Shutdown Emission Rates (lb/shutdown)

Pollutant	Shutdown Emission Rate[a]
NO_x	8
CO	10
POC (as CH_4)	3
PM10	3.33
SO_2	0.31

[a] Manufacturer's data supplied by Silcon Valley Power to BAAQMD.

B-2.0 Operating Scenarios and Regulated Air Pollutant Emissions for Gas Turbines and HRSGs

The Gas Turbine/HRSG air pollutant emission rates (except for NO_x) shown in **Table B-4** are the basis of permit condition limits and emission offset requirements and were also used as inputs for the ambient air quality impact analysis. To provide maximum operational flexibility, no limitations will be imposed on the type or quantity of turbine start-ups. Instead, the facility must comply with rolling consecutive twelve month mass emission limits at all times. The mass emission limits are based upon the emission estimates calculated for the following power plant operating envelope:

- 8256 hours of baseload (100% load) operation per year for each gas turbine
- 1400 hours of duct burner firing per HRSG per year with water/steam injection power augmentation at gas turbine combustors
- 200 one-hour hot startups per gas turbine per year
- 52 one-hour cold startups per gas turbine per year
- 252 shutdowns per gas turbine per year

Table B-4 Maximum Annual Regulated Air Pollutant Emissions for Gas Turbines and HRSGs

Source	NO_2[a]	CO	POC	PM_{10}	SO_2
Two Turbines/HRSGs	90,000 lbs/yr	99,000 lbs/yr	23,000 lbs/yr	56,000 lbs/yr	5,800 lbs/yr
Two Turbines/HRSGs	45 tpy	49.5 tpy	11.5 tpy	28 tpy	2.9 tpy

[a] Annual limit based upon average NOx emission rate of 2.0 ppmvd @ 15% O_2 for gas turbines and HRSGs; includes startup and shutdown emissions. Includes possible short term transient excursions of NO_x, up to a maximum of 0.54 ton/yr.

B-4.0 Cooling Tower PM_{10} Emissions

It is conservatively assumed that all particulate matter emissions are PM_{10}.

Cooling tower circulation rate:	34,980 gpm
maximum total dissolved solids:	5880 ppm
Drift Rate:	0.0005 %

Water mass flow rate:

(34980 gal/min)(60 min/hr)(8.337 lb/gal) = 17,497,696 lb/hr

Cooling Tower Drift:

(17,497,696 lb/hr)(0.000005) = 87.49 lb/hr

PM_{10} = (5880 ppm)(87.49 lb/hr)/(10^6)
= 0.5144 lb/hr
= 12.35 lb/day (24 hr/day operation)
= 4,506 lb/yr (8,760 operating hours per year)
= **2.25 ton/yr**

B-5.0 Worst-Case Toxic Air Contaminant (TAC) Emissions

The maximum toxic air contaminant emissions resulting from the combustion of natural gas at the S-1, S-3Gas Turbines and S-2, S-4 HRSGs are summarized in **Table B-5**. These emission rates were used as input data for the health risk assessment modeling and are based upon a maximum annual heat input rates for each gas turbine/HRSG power train. The derivation of the emission factors is detailed in Appendix A.

Table B-5 Worst Case TAC Emissions for Gas Turbines and HRSGs

Toxic Air Contaminant	Emission Factor (lb/MM scf)	lb/yr-power train[a]	lb/yr-both power trains	g/sec per power train
Acetaldehyde[c]	1.37E-01	577.4	1154.8	.0083
Acrolein	1.89E-02	79.66	159.3	.00114
Ammonia[b]	14.09	59400	118800	.855
Benzene[c]	1.33E-02	56.05	112.1	.000807
1,3-Butadiene[c]	1.27E-04	.535	1.07	.0000077
Ethylbenzene	1.79E-02	75.45	150.9	.00109
Formaldehyde[c]	9.17E-01	3865	2706 [d]	.0556
Hexane	2.59E-01	1091.6	2183.2	.0157
Naphthalene	1.66E-03	7.0	14.0	.0001
PAHs[c]				
Anthracene	3.38E-05	.14	.28	.000002
Benzo (a) anthracene	2.26E-05	.095	.19	.00000136
Benzo (a) pyrene	1.39E-05	.059	.118	.00000085
Benzo (b) fluoranthene	1.13E-05	.048	.096	.00000069
Benzo (e) pyrene	5.44E-07	.0023	.0046	.000000033
Benzo (g,h,i) perylene	1.37E-05	.058	.116	.00000083
Benzo (k) fluoranthene	1.10E-05	.046	.092	.00000066
Chrysene	2.52E-05	.106	.212	.00000152
Dibenz (a,h) anthracene	2.35E-05	.099	.198	.00000143
Indeno (1,2,3-cd) pyrene	2.35E-05	.099	.198	.00000143
Propylene	7.71E-01	3245.4	6490.8	.0467
Propylene Oxide[c]	4.78E-02	201.5	403	.0029
Toluene	7.10E-02	299.3	598.6	.00431
Xylene	2.61E-02	110.0	220.0	.00158

[a] From each gas turbine/HRSG power train (S-1 & S-2, S-3 & S-4), assuming 1030 BTU/scf HHV

[b] Based upon the worst-case ammonia slip from the SCR system of 10 ppmvd @ 15% O_2

[c] Carcinogenic compounds

[d] Reflects 65% by weight formaldehyde emission reduction by oxidation catalyst.

The projected toxic air contaminant emissions from the exempt 3-cell cooling tower are summarized in **Table B-6**. The emissions are based upon a water circulation rate of 34,980 gpm and 8,760 hours of operation per year.

Table B-6 Worst Case TAC Emissions for 3-Cell Cooling Tower

Toxic Air Contaminant	Emission Factor (lb/hr)	Annual Emission Rate (lb/yr)	Risk Screening Trigger Level (lb/yr)
Ammonia	6.12E-04	5.36	19,300
Arsenic[a]	7.20E-07	0.0063	0.024
Cadmium[a]	3.06E-07	0.0027	0.046
Trivalent chromium	6.12E-07	0.0054	None specified
Copper	1.84E-06	0.016	463
Lead[a]	6.12E-07	0.0054	29
Mercury	1.57E-09	0.000014	57.9
Nickel	4.28E-06	0.038	0.73
Silver	6.12E-07	0.0054	N/S[b]
Zinc	3.17E-05	0.278	6,760

[a] Carcinogenic compound

B-6.0 Maximum Facility Emissions

The maximum annual facility regulated air pollutant emissions for the proposed gas turbines and HRSGs are shown in **Table B-7**. The total permitted emission rates shown below are the basis of permit condition limits and emission offset requirements, if applicable.

Table B-7 Maximum Annual Facility Regulated Air Pollutant Emissions (ton/yr)

Source	NO_2	CO	POC	PM_{10}	SO_2
S-1 Turbine and S-2 HRSG [a]	21.2	24.0	5.96	15.3	1.46
S-3 Turbine and S-4 HRSG [a]	21.2	24.0	5.96	15.3	1.46
Sub-Total	**43.0** [b]	**48.1**	**11.9**	**30.5**	**2.92**
S-8 Cooling Tower (exempt)	0	0	0	2.3	0
Total Facility Emissions	**43.0** [b]	**48.1**	**11.9**	**32.8**	**2.92**

[a] Includes gas turbine start-up and shutdown emissions.

[b] Includes possible short term transient excursions of NO_x, up to a maximum of 0.54 ton/yr.

Table B-8
Baseload Air Pollutant Emission Rates for Gas Turbines and HRSGs
(Excluding Gas Turbine Startup Emissions)

	NO_2	CO	POC	PM_{10}	SO_2
S-1, S-3 Gas Turbines [a]					
lb/hr-source	3.48	4.24	1.2	3.33	0.32
lb/day-source	83.52	101.8	28.8	79.92	7.68
S-1 & S-2, S-3 & S-4 Gas Turbine/HRSG Power Train					
lb/hr-power train	4.49	5.47	1.56	4.3	0.41
lb/day-power train[b]	99.7	121.4	34.6	95.4	9.12

[a] Based upon maximum heat input rate of 473.7 MM BTU/hr for each gas turbine.

[b] Based upon a maximum combined heat input rate for each gas turbine/HRSG power train of 610.6 MM BTU/hr and maximum 16 hours per day duct burner firing.

The maximum daily regulated air pollutant emissions per source including gas turbine start-up emissions are shown in **Table B-9**.

Table B-9
Maximum Daily Regulated Air Pollutant Emissions per Power Train (lb/day)[a]

Source (operating mode)	NO_2	CO	POC	PM_{10}	SO_2
Gas Turbine (1-hr Cold Start-up)	41	35	3	3.33	0.31
Gas Turbine & HRSG (16 hours Full load w/Duct Burner Firing and water injection power augmentation, 5 hrs w/o duct burners)	89.24	108.72	30.96	85.45	8.16
Gas Turbine (1-hr Hot Start-up)	41	35	3	3.33	0.31
Gas Turbine (shutdown)	8	10	3	3.33	0.31
Total	**179.24** [c]	**188.72**	**39.96**	**95.44**[b]	**9.09**[b]

[a]based upon one 1-hour hot start-up, one 1-hour cold start-up, and 16 hours of full load operation with duct burner firing @ 610.6 MM BTU/hr with water injection power augmentation.
[b] Maximum daily emissions of PM10 and SO2 under full load operations (8 hours w/o duct firing, and 16 hrs with duct firing) are 95.4 lbs/day and 9.12 lbs/day respectively.
[C] An additional maximum of 6.73 lb NO2 possible for a short term transient excursion upt to 5 ppmvd for up to one hour (limited to 160 hours between the two turbines annually; < 1 % of annual operating hours).

Table B-10 summarizes the worst case daily regulated air pollutant emissions from permitted sources. These are the basis of permit condition daily mass emission limits.

Table B-10 Worst Case Daily Regulated Air Pollutant Facility Emissions from Permitted Sources (lb/day)

Source (Operating Mode)	NO_2	CO	POC	PM_{10}	SO_2
S-1 Gas Turbine (Cold Start-up)	41	35	3	3.33	0.31
S-1 Gas Turbine & S-2 HRSG (16 hours @ Full load w/Duct Burner Firing and water injection power augmentation)	89.24	108.72	30.96	85.45	8.16
S-1 Gas Turbine (Hot Start-up)	41	35	3	3.33	0.31
S-1 Gas Turbine (Shutdown)	8	10	3	3.33	0.31
S-3 Gas Turbine (Cold Start-up[a])	41	35	3	3.33	0.31
S-3 Gas Turbine & S-4 HRSG (16 hours @ Full load w/Duct Burner Firing and water injection power augmentation)	89.24	108.72	30.96	85.45	8.16
S-3 Gas Turbine (Hot Start-up)	41	35	3	3.33	0.31
S-3 Gas Turbine (shutdown)	8	10	3	3.33	0.31
S-8 Cooling Tower (exempt)	0	0	0	(12.3)	0
Total	**358** [b]	**377**	**79.9**	**191** [c]	**18.2**

[a] Both turbines may start in the same hour.

[b] An additional maximum 6.73 lb NO_2 possible for an infrequent, short term, transient excursion up to 5 ppmvd @ 15 % O_2 for up to one hour (limited to 160 hours between the two power trains annually; < 1% of annual operating hours).

[c] PM_{10} emissions from the exempt cooling tower not included in the total.

Appendix C

Health Risk Assessment

As a result of the combustion of natural gas at the proposed Gas Turbines and HRSGs and the presence of dissolved solids (heavy metals) in the cooling tower water, the proposed Pico Power Plant will emit the toxic air contaminants summarized in Table 3, "Maximum Facility Toxic Air Contaminant (TAC) Emissions". In accordance with the requirements of CEQA, the BAAQMD Risk Management Policy, and CAPCOA guidelines, the impact on public health due to the emission of these compounds was assessed utilizing the air pollutant dispersion model ISCST3 and the CARB multi-pathway cancer risk and hazard index model (Version 2.0e).

The public health impact of the carcinogenic compound emissions is quantified through the increased carcinogenic risk to the maximally exposed individual (MEI) over a 70-year exposure period. A multi-pathway risk assessment was conducted that included both inhalation and noninhalation pathways of exposure, including the mother's milk pathway. Pursuant to the BAAQMD Risk Management Policy, a project which results in an increased cancer risk to the MEI of less than one in one million over a 70 year exposure period is considered to be not significant and is therefore acceptable.

The public health impact of the noncarcinogenic compound emissions is quantified through the chronic hazard index, which is the ratio of the expected concentration of a compound to the acceptable concentration of the compound. When more than one toxic compound is emitted, the hazard indices of the compounds are summed to give the total hazard index. The acute hazard index quantifies the magnitude of the adverse health affects caused by a brief (no more than 24 hours) exposure to a chemical or group of chemicals. The chronic hazard index quantifies the magnitude of the adverse health affects from prolonged exposure to a chemical caused by the accumulation of the chemical in the human body. The worst-case assumption is made that the exposure occurs over a 70-year period. Per the BAAQMD Toxic Risk Management Policy, a project with a total hazard index of 1.0 or less is considered to be not significant and the resulting impact on public health is deemed acceptable.

As shown in Table C-1, the increased carcinogenic risk was found to be less than one in one million and is therefore considered to be not significant.

The results of the risk screening analysis performed by District Toxics Evaluation Section staff are summarized in **Table C-1**.

Table C-1
Health Risk Assessment Results

Source	Multi-pathway Carcinogenic Risk (risk in one million)	Chronic Hazard Index	Acute Hazard Index[a]
Gas Turbines, HRSGs, and Cooling Tower[b]	0.2	0.2	0.4
Maximum Facility Risk:	0.2	0.2	0.4

[a] Included for informational purposes only; the BAAQMD TRMP does not require an assessment of the impact due to short-term (< 24 hour) exposure to non-carcinogenic toxic air contaminants.

[b] Numbers represent combined risk from all sources.

In accordance with the BAAQMD Toxic Risk Management Policy (TRMP), the increased carcinogenic risk and chronic hazard index attributed to this project are each considered to be not significant since they are less than one in a million and less than 1.0, respectively. The BAAQMD TRMP does not require an assessment the impact due to short-term (< 24 hour) exposure to non-carcinogenic toxic air contaminants, which is expressed as the acute hazard index.

Based upon the results given in Table C1, the Pico Power Plant project is deemed to be in compliance with the BAAQMD Toxic Risk Management Policy.

Interoffice Memorandum
May 7, 2003

To: Ken Lim
From: Jane Lundquist Via: Brian Bateman

Subject: Risk Analysis for Pico Power Plant, P# 14991, A# 6481,
Two Power Trains (gas turbine with duct burner) and Three-celled Cooling Tower

At your request, a risk analysis for the Pico Power Plant, two gas turbines with duct burners and cooling tower, has been performed. The health risk results are summarized in the table below. The operation of these sources results in a maximum increased cancer risk of less than one in a million and a chronic hazard index of less than one. These levels of risk are considered acceptable under the District's Risk Management Policy. The acute hazard index is provided for information only.

Cancer Risk	Chronic Hazard Index	Acute Hazard Index
0.2 in a million	0.2	0.4

The maximum health risk values presented above occur in non-residential locations. When residential and non-residential exposure is taken into consideration the maximum cancer risk and chronic hazard index values would be lower than those presented above.

POLLUTANT EMISSIONS: The pollutant emissions used in the analysis are those you supplied that also have health values adopted by the Office of Environmental Health Hazard Assessment (OEHHA). As you have requested, the formaldehyde value has been adjusted (down by 65%) to reflect the abatement by the CO catalyst. These values are summarized on the attached spreadsheets.

HEALTH VALUES: The cancer potency values, chronic and acute reference exposure levels adopted by OEHHA for use in the Air Toxics "Hot Spots" Program are used in this analysis. The PAH cancer potency value for multipathway exposures (inhalation, soil ingestion, dermal absorption, and mother's milk ingestion) is from CARB's HRA Program version 2.0e using the March 4, 2002 database. The six PAHs that we are currently including in our analysis are Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene and Indeno(1,2,3-cd)pyrene. The cancer unit risk factors for these PAHs, evaluated as Benzo(a)pyrene equivalents, are listed below.

	Multi-Pathway Cancer Unit Risk Factors				
Pollutant	air	soil	skin	mother's milk	Total
Arsenic	3.30E-03	3.90E-03	8.26E-05		7.3E-03
Lead	1.20E-05	2.21E-05	4.68E-07		3.5E-05
PAHs	1.10E-03	1.65E-03	1.05E-03	2.73E-03	6.5E-03

The chronic hazard index addresses the inhalation, soil ingestion, dermal absorption and mothers milk ingestion pathways. The non-inhalation Hazard Index per unit X/Q ((ug/m^3)(g/s)) were derived CARB'S Health Risk Assessment (HRA) Program, version 2.0e with the March 4, 2002 database. The uptake factor for Nickel is assumed to be similar to that for Arsenic.

Pollutant	Non-inhalation Chronic Hazard Index per ($\mu g/m^3$) (g/s)
Arsenic	8.9E+00
Cadmium	5.4E+00
Mercury	1.1E+01
Nickel	5.3E-02

MODELING: The ISCST3 model was run with San Jose Airport meteorological data to determine the cancer risk, the chronic hazard index and the acute hazard index. The emission rate input into the model for the cancer risk incorporates the cancer potency factor and a 1,000,000 multiplier so that the resulting output from the model would be the increased cancer risk in a million. The emission rate input into the model for the chronic hazard index incorporates the inhalation chronic reference exposure level and the non-inhalation hazard index per ($\mu g/m^3$) (g/s) so that the resulting output from the model would be the chronic hazard index. The emission rate input into the model for acute hazard index incorporates the acute reference exposure level so that the resulting output from the model would be the acute hazard index. The attached spreadsheets show the model emission rate inputs.

The model was run twice for each health risk value: once with the urban land use option and once with the rural land use option. The urban land use option yielded the more conservative results, which are reported above. Stack parameters, building dimensions and locations were obtained from the applicant's input files "97NORM.IN" and "Bpip3.inp". Elevations for complex terrain modeling were obtained from the USGS DEM files for Milpitas and San Jose-West.

HEALTH RISK: The cancer risk and chronic hazard index results are based on continuous exposure to annual average pollutant concentrations. The acute hazard index result is based on exposure to the maximum one-hour average concentrations.

Appendix D

TOP-DOWN BACT ANALYSIS

A “top-down” BACT analysis for NO_x has been previously prepared by the BAAQMD for power plants and is summarized here. The analysis is applicable to the present proposed Pico plant because the energy, economic, and environmental impacts would be expected to be even less than those for the larger power plants which were the focus of the top-down BACT study. Furthermore, cost-effectiveness and technical feasibility are not issues because of the demonstrated performance or achieved in practice status shown by the Valero plant, with the same class and category of combustion turbine as that in the Pico proposal.

Top-Down BACT Analysis

The following “top-down” BACT analysis for NO_x has been prepared in accordance with EPA’s 1990 Draft New Source Review Workshop Manual. A “top-down” BACT analysis takes into account energy, environmental, economic, and other costs associated with each alternative technology, and the benefit of reduced emissions that the technology would bring.

Available Control Options and Technical Feasibility

In a March 24, 2000 letter sent to local air pollution control districts, EPA Region 9 stated that the SCONOX Catalytic Adsorption System should be included in any BACT/LAER analysis for combined cycle gas turbine power plant projects since it can achieve the BACT/LAER emission specification for NO_x of 2.5 ppmvd @ 15% O_2, averaged over one hour or 2.0 ppmvd @ 15% O_2, averaged over three hours. In this letter, EPA stated that ABB Alstom Power, the exclusive licensee for SCONOX applications, has conducted “full-scale damper testing” that demonstrates that SCONOX is technically feasible for gas turbines of the size proposed for the East Altamont Energy Center. Stone & Webster Management Consultants, Inc. of Denver, Colorado was subsequently hired by ABB to conduct an independent technical review of the SCONOX technology as well as the full-scale damper testing program. According to the report by Stone & Webster, modifications to the actuators, fiberglass seals, and louver shaft-seal interface are being incorporated to resolve unacceptable reliability and leakage problems. However, no subsequent testing of the redesigned components has occurred to determine if the problems have been solved. Because the feasibility of the “scale-up” of the SCONOX system for large turbines has not been demonstrated, we do not consider SCONOX to be a demonstrated NO_x control technology for projects of the size of the Pico Power Plant.

Although we do not consider SCONOX to be a demonstrated control alternative for this project, it is likely to be a technically feasible technology, and thus we have analyzed the collateral impacts of both SCR and SCONOX. We are providing the following analysis for informational purposes only. The analysis shown in Table D-5 applies to a single GE Frame 7FA or 7FB Gas Turbine equipped with DLN combustors and an unabated NO_x emission rate of 25 ppmvd @ 15% O_2.

Table D-1 Top-Down BACT Analysis Summary for NO_x

Control Alternative	Emissions[a] (ton/yr)	Emission Reduction[b] (ton/yr)	Total Annualized Cost[c] ($/yr)	Average Cost-Effectiveness ($/ton)	Incremental Cost-Effectiveness ($/ton)	Toxic Impacts	Adverse Environmental Impacts	Incremental Energy Impact (MM BTU/yr)
SCONOX	788	709	4,122,889	5,815	N/A[d]	No	No	122,000[e]
SCR	788	709	1,557,125	2,196	-	Yes	No	67,900[e]

[a]based upon unabated NO_x emission rate of 25 ppmvd @ 15% O_2, and annual firing rate of 17,436,780 MM BTU/yr

[b]based upon NO_x emission rate after abatement of 2.5 ppmvd @ 15% O_2, and annual firing rate of 17,436,780 MM BTU/yr

[c]"Cost Analysis for NO_x Control Alternatives for Stationary Gas Turbines", ONSITE SYCOM Energy Corporation, October 15, 1999

[d]does not apply since there is no difference in emission reduction quantity between alternatives

[e]"Towantic Energy Project Revised BACT Analysis", RW Beck, February 18, 2000; based upon increased fuel use to overcome catalyst bed back pressure

Energy Impacts

As shown in Table D-1, the use of SCR does not result in any significant or unusual energy penalties or benefits when compared to SCONOX. Although the operation and maintenance of SCONOX does result in a greater energy penalty when compared to that of SCR, this is not considered significant enough to eliminate SCONOX as a control alternative.

Economic Impacts

According to EPA's 1990 Draft New Source Review Workshop Manual, "Average and incremental cost effectiveness are the two economic criteria that are considered in the BACT analysis."

As shown in Table D-1, the average cost-effectiveness of both SCR and SCONOX meet the current District cost-effectiveness guideline of $17,500 per ton of NO_x abated. However, the average cost-effectiveness of SCR is approximately 40% of the average cost-effectiveness of SCONOX. These figures are based upon total annualized cost figures from a cost analysis conducted by ONSITE SYCOM Energy Corporation. Although SCONOX will result in greater economic impact as quantified by average cost-effectiveness, this impact is not considered adverse enough to eliminate SCONOX as a control alternative.

Incremental cost-effectiveness does not apply since SCR and SCONOX both achieve the former BACT/LAER standard for NO_x of 2.5 ppmvd @ 15% O_2, averaged over one hour and therefore achieve the same NO_x emission reduction in tons per year.

Environmental Impacts

The use of SCR will result in ammonia emissions due to an allowable ammonia slip limit of 10 ppmvd @ 15% O_2. A BAAQMD health risk screening analysis of the proposed Pico project using air dispersion modeling showed an acute hazard index and a chronic hazard index to be each much less than 1 (0.02 and 0.03, respectively), resulting from an ammonia slip limit of 10 ppmv @ 15% O_2. In accordance with the District Toxic Risk Management Policy and currently accepted practice, a hazard index of less than 1.0 or above is considered not significant. Therefore, the toxic impact of the ammonia slip resulting from the use of SCR is deemed to be not significant and is not a sufficient reason to eliminate SCR as a control alternative.

The ammonia emissions resulting from the use of SCR may have another environmental impact through its potential to form secondary particulate matter such as ammonium nitrate. Because of the complex nature of the chemical reactions and dynamics involved in the formation of secondary particulates, it is difficult to estimate the amount of secondary particulate matter that will be formed from the emission of a given amount of ammonia. However, it is the opinion of the Research and Modeling section of the BAAQMD Planning Division that the formation of ammonium nitrate in the Bay Area air basin is limited by the formation of nitric acid and not driven by the amount of ammonia in the atmosphere. Therefore, ammonia emissions from the proposed SCR system are not expected to contribute significantly to the formation of secondary particulate matter within the BAAQMD.

A second potential environmental impact that may result from the use of SCR involves the storage and transport of aqueous ammonia. Although ammonia is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose, or throat, it is a commonly used material that is typically handled safely and without incident. The Pico Power Plant will be required to maintain a Risk Management Plan (RMP) and implement a Risk Management Program to prevent accidental releases. The RMP provides information on the hazards of the substance handled at the facility and the programs in place to prevent and respond to accidental releases. The accident prevention and emergency response requirements reflect existing safety regulations and sound industry safety codes and standards. In addition, a number of previous modeling analyses of the health impacts arising from a catastrophic release of ammonia due to spontaneous storage tank failure at proposed power plant facilities have shown that the impact would not be significant. Thus the potential environmental impact due to aqueous ammonia storage at the Pico Plant does not justify the elimination of SCR as a control alternative.

Conclusion

Because both SCR and SCONOX can achieve the NO_x emission limit of 2.0 ppmvd @ 15% O_2, averaged over one hour and neither will cause significant energy, economic, or environmental impacts, neither can be eliminated as viable control alternatives. The only aspect of this analysis affected by the current NOx standard of 2.0 ppmvd @ 15% O_2, averaged over one hour is the cost of compliance. The increased cost is not expected to affect the conclusion of this analysis. Therefore, the applicant's proposed use of SCR to meet the NO_x BACT specification is acceptable.