APPENDIX: AIR QUALITY

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GUIDELINES FOR EVALUATING AIR QUALITY IMPACTS FROM PARKING GARAGES

For air quality purposes, a parking garage is defined as a parking facility that would be totally (or almost totally) enclosed. This type of facility would require mechanical ventilation to limit the carbon monoxide (CO) concentrations within the garage to levels less than those mandated by the New York City Building Code. Table 1 displays the estimated hourly average ins and outs over a 24-hour period for a proposed auto parking garage. A sample air quality analysis is also provided for potential air quality impacts from ventilated exhaust CO emissions for an auto parking garage. This analysis does not use the most up-to-date MOBILE program or related emission factors, but the methodology used is still applicable. A spreadsheet is available here that could be used for the garage analysis.

Page 3 of the Appendix displays all input parameters that are required to estimate the maximum CO emission rates and concentrations within the parking garage. CO emission factors and background values are reported at the top of the page. In almost all cases, maximum hourly CO emission rates within the facility will be calculated for the time period with the maximum number of departing autos in an hour, since departing autos should be assumed to be "cold" and arriving cars should usually be assumed to be "hot" as part of the recommended procedures for estimating CO emissions for parking facilities. ("Cold" autos emit CO at considerably higher rates than "hot" autos as shown by the CO emission factors listed). Likewise, maximum hourly CO emission rates over a consecutive 8-hour period will normally be computed for the 8-hour time period that averages the largest number of departing autos per hour. Maximum hourly and 8-hour average CO emission rates should be determined based on the ins/outs (for the respective time averaging periods) and the mean traveling distance within the garage. The analysis should also assume that all departing autos would idle for one minute before travelling to the exits of the garage, and all arriving and departing autos would travel at 5 mph within the garage. The equations and definitions of the parameters used to determine the emission rates exhausted through the vents and the maximum CO concentrations within the garage are also presented on page 1.

Page 4 of the Appendix displays the calculations involved in determining the off-site impacts from the CO exhausted through the garage vent(s). These estimates of off-site CO impacts are based on equations pertaining to the dispersion of pollutants from a stack (EPA's Workbook of Atmospheric Dispersion Estimates, AP-26, pg. 6, equations 3.3 and 3.4). The initial horizontal and vertical distributions, $\sigma_y(0)$ and $\sigma_2(0)$, respectively, should be assumed to be equal and calculated by setting the CO concentration at the exit of the vent equal to the CO level within the facility. The sample analysis displays the recommended procedures for estimating 8-hor CO impacts at a receptor near the vent (5 feet from the vent, 6 feet below the midpoint height of the vent) and at a receptor across a street on the far sidewalk from the vent (50 feet away, also 6 feet below the vent midpoint). Page 3 displays contributions from on-street CO emissions to the far sidewalk receptor in this example that were calculated conservatively with a factor (307.7) that yields the maximum predicted impacts (which could be calculated by refined mathematical modeling), when multiplied by the on-street CO emission rate in grams/meter-second. Cumulative CO concentrations at the far sidewalk should be calculated by adding together the contributions from the garage exhaust vent, on-street sources, and background levels. An acceptable alternative method to the procedures detailed above would be to use only the peak hourly CO emissions to calculate the CO emission rates and concentrations at the vent outlet. This alternative procedure would yield very conservative estimates of off-site CO impacts.

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Air Quality Appendix Table 1
Garage Ins/Outs

HOUR	IN	OUT
12-1	1	1
1-2	1	0
2-3	0	0
3-4	0	0
4-5	0	1
5-6	1	5
6-7	5	8
7-8	7	9
8-9	14	31
9-10	17	8
10-11	18	11
11-12	15	12
12-1	31	32
1-2	14	11
2-3	10	10
3-4	10	11
4-5	13	16
5-6	35	30
6-7	17	20
7-8	13	10
8-9	9	6
9-10	1	2
10-11	1	0
11-12	1	0
Total	**234**	**234**

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File: GARAGE.WQ1

Sample Mechanically Ventilated Parking Garage Analyses:

1997 Mobile 4.1 CO Emission Factors:			1997 CO background
Cold Idle @ 45F	(CI):	[illegible].01 G/HR	1-HR 5.7 PPM
5mph Cold Auto @ 45F	(CA):	14[illegible] G/MI	8-HR 2.8 PPM
5mph Hot Auto @ 45F	(HA):	25.7[illegible] G/MI	

1997 INS/OUTS MAXIMUM HOUR PERIOD	INS	OUTS	MAXIMUM 8-HOUR PERIOD	INS	OUTS	GARAGE GSF	MEAN TRAV.DIS. (FEET)	PEAK HOURLY (G/SEC)	8-HR AVG. ER (G/SEC)	MAX 1-HR CONC.W/O BKGD (PPM)	PEAK 8-HR CONC.W/O BKGD (PPM)	MAX 1HR CONC.W/ BKGD (PPM)	MAX 8HR CONC.W/ BKGD (PPM)
12AM-1PM	31	32	11AM-[illegible]PM	16.1	17.8	4[illegible]0	300	0.200	0.112	7.60	4.20	13.30	7.10

where: maximum hour is 1-hour period with largest number of autos departing

maximum 8-hour period is usually the 8-hour period with largest average number of departing autos over 8 hours

garage GSF - total gross square feet of garage area where garage area does not include mechanical areas

mean travel distance - conservative estimate (about two-thirds of the longest travel distance within the facility) of average travel distance for a typical vehicle entering/exiting the facility

Max 1-hour & 8-hour average ER - maximum hourly average CO emission rates within the facility for these respective time averaging periods

Max hour ER:

(max hr autos out)*((CI/60) + (CA)*(mean travel distance/5280))/3600 + (max hr autos ins)*(HA)*(mean travel distance)/(5280*3600)

8-hour average ER

(max 8-hr autos out)*((CI/60) + (CA)*(mean travel distance/5280))/3600 + (max 8 hr autos ins)*(HA)*(mean travel distance)/(5280*3600)

Max 1-hour & 8-hour concentration without background - CO concentrations calculated within the facility based on respective emission rates and New York City building code minimum ventilation rate of 1 cubic foot per minute per gross square foot of garage area for the respective time averaging periods

peak hour conc w/o bkgrd:

0.873*(peak hour ER)*1000/(GSF*0.000472)

8-hour average conc w/o bkgrd:

0.873*(8-hour ave ER)*1000/(GSF*0.000472)

Max 1-hour & 8-hour concentration - maximum 1 and 8-hour concentrations within garage when backgrounds are added to concentrations without backgrounds

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Calculation of Cumulative Carbon Monoxide Impacts from Garage and Adjacent Street Emissions

ASSUMPTIONS: 2 Vents (since it is a relatively large garage, smaller garages may only warrant 1 vent)

Middle of Vent is 12' above local grade

Receptor height is 6', at a distance of 5' from vent

$\chi(0) = Q / \pi * \sigma_y(0) * \sigma_z(0)$

<u>1997</u>

8-HOUR CO ER PER VENT = 0.112/2 = 0.056 g/sec = Q
8-HOUR CO CONCENTRATION = 4.29 PPM = 0.0049 g/m^3
8-HOUR CO BKGD = 2.9 PPM
8-HOUR PERSISTENCE FACTOR - 8-HR PF = 0.70

Solve for initial horizontal + vertical distributions:

Let $\sigma_z(0) = \sigma_y(0)$

$0.0049 = 0.056 / \pi * (\sigma_y(0))^2$

Therefore $\sigma_y(0) = 1.9m$

at 5' (1.52m) from vent, 6'(H = 1.83m) below vent height:

$\sigma_y(1.52) = 0.16 * 1.52 + 1.9 = 2.14m$
$\sigma_z(1.52) = 0.14 * 1.52 + 1.9 = 2.11m$

8-hr $\chi(1.52) = (8\text{-hr PF})*Q*(\exp(-0.5*(H/\sigma_z(1.52))^2)) / \pi * \sigma_y(1.52) * \sigma_z(1.52)$

Therefore, $\chi(1.52) = 0.00190\ g/m^3 = 1.7$ PPM

at 50' (15.24m) from vent, 6'(H = 1.83m) below vent height:

$\sigma_y(15.24) = 0.16 * 15.24 + 1.9 = 4.3m$
$\sigma_z(15.24) = 0.14 * 15.24 + 1.9 = 4.0m$

8-hr $\chi(15.24) = (8\text{-hr PF})*Q*(\exp(-0.5*(H/\sigma_z(15.24))^2))/\pi * \sigma_y(15.24) * \sigma_z(15.24)$

Therefore, $\chi(15.24) = 0.000653\ g/m^3 = 0.6$ PPM

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Highest On-Street Emissions

		g/mi-hr	g/m-sec
WB adjacent street		6423	0.00111
EB adjacent street		3272	0.00056
	Total	9695	0.00167

Maximum Impacts from line source:

307.7 * (8-hr Persistence Factor) * 0.00167 = 0.36 PPM

Total 8-hr CO Concentration
@ receptor on opposite sidewalk = 0.6 + 0.36 + 2.9 = 3.8 PPM

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GUIDELINES FOR EVALUATING AIR QUALITY IMPACTS FROM PARKING LOTS

For air quality purposes, a parking lot is defined as a parking facility that would be an at-grade lot, exposed to the ambient air. Table 1 displays the estimated hourly average ins and outs over a 24-hour period for a proposed auto parking lot. A sample air quality analysis is also provided in the attachment for potential air quality impacts from CO emissions emitted by an auto parking lot. This analysis does not use the most up-to-date MOBILE program or related emission factors, but the methodology used is still applicable.

Figure 1 displays the overall dimensions of a proposed parking lot. Page 1 of the attachment displays all input parameters that are required to estimate the maximum CO emission rates within the parking lots. In almost all cases, maximum hourly CO emission rates within the facility will be calculated for the time period with the maximum number of departing autos in an hour, since departing autos should be assumed to be "cold" and arriving cars should usually be assumed to be "hot" as part of the recommended procedures for estimating CO emissions for parking lots. ("Cold" autos emit CO at considerably higher rates than "hot" autos as shown by the CO emission factors listed). Likewise, maximum hourly CO emission rates over a consecutive 8-hour period will normally be computed for the 8-hour time period that averages the largest number of departing autos per hour. Maximum hourly and 8-hour average CO emission rates should be determined based on the ins/outs (for the respective time averaging periods) and the mean traveling distance within the facility. The analysis should also assume that all departing autos would idle for one minute before travelling to the exits of the lot, and all arriving and departing autos would travel at 5 mph within the parking lot. The equations and definitions of the parameters used to determine the emission rates within the parking areas are identical to those found in the "Guidelines for Evaluating Air Quality Impacts from Parking Garages."

Equations 1, 2, and 3 display the calculations involved in determining the off-site impacts from CO emitted within the parking lot. These estimates of off-site CO impacts are based on EPA's guidelines pertaining to the dispersion of pollutants from a parking lot (*Guidelines for Air Quality Maintenance Planning and Analysis Volume 9 (Revised): Evaluating Indirect Sources*, pg.92, equations 35 and 36). Definitions of the various parameters in the equations area also provided on page 1 of the attachment. The sample analysis displays the recommended procedures for estimating 8-hour CO impacts at a pedestrian-height sidewalk receptor 6 feet from the lot and at a receptor across a street on the far sidewalk from the vent (62 feet away). On-street CO emissions contributions to the far sidewalk receptor in this example that were calculated conservatively with a factor (307.7) that yields the maximum predicted impacts (which could be calculated by refined mathematical modeling), when multiplied by the on-street CO emission rate in grams/meter-second. Cumulative CO concentrations at the far sidewalk should be calculated by adding together the contributions from the garage exhaust vent, on-street sources, and background levels. An acceptable alternative method to the procedures detailed above would be to use only the peak hourly CO emissions to calculate the CO emission rates within the facility and off-site 8-hour CO impacts. This alternative procedure would yield very conservative estimates of off-site CO impacts.

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Air Quality Appendix Table 2
Garage Ins/Outs

HOUR	IN	OUT
12-1	1	1
1-2	1	0
2-3	0	0
3-4	0	0
4-5	0	1
5-6	1	5
6-7	3	8
7-8	26	10
8-9	69	20
9-10	16	3
10-11	10	5
11-12	10	5
12-1	13	20
1-2	7	8
2-3	16	19
3-4	28	24
4-5	30	81
5-6	36	40
6-7	24	29
7-8	16	19
8-9	9	7
9-10	1	3
10-11	1	1
11-12	1	0
Total	**319**	**319**

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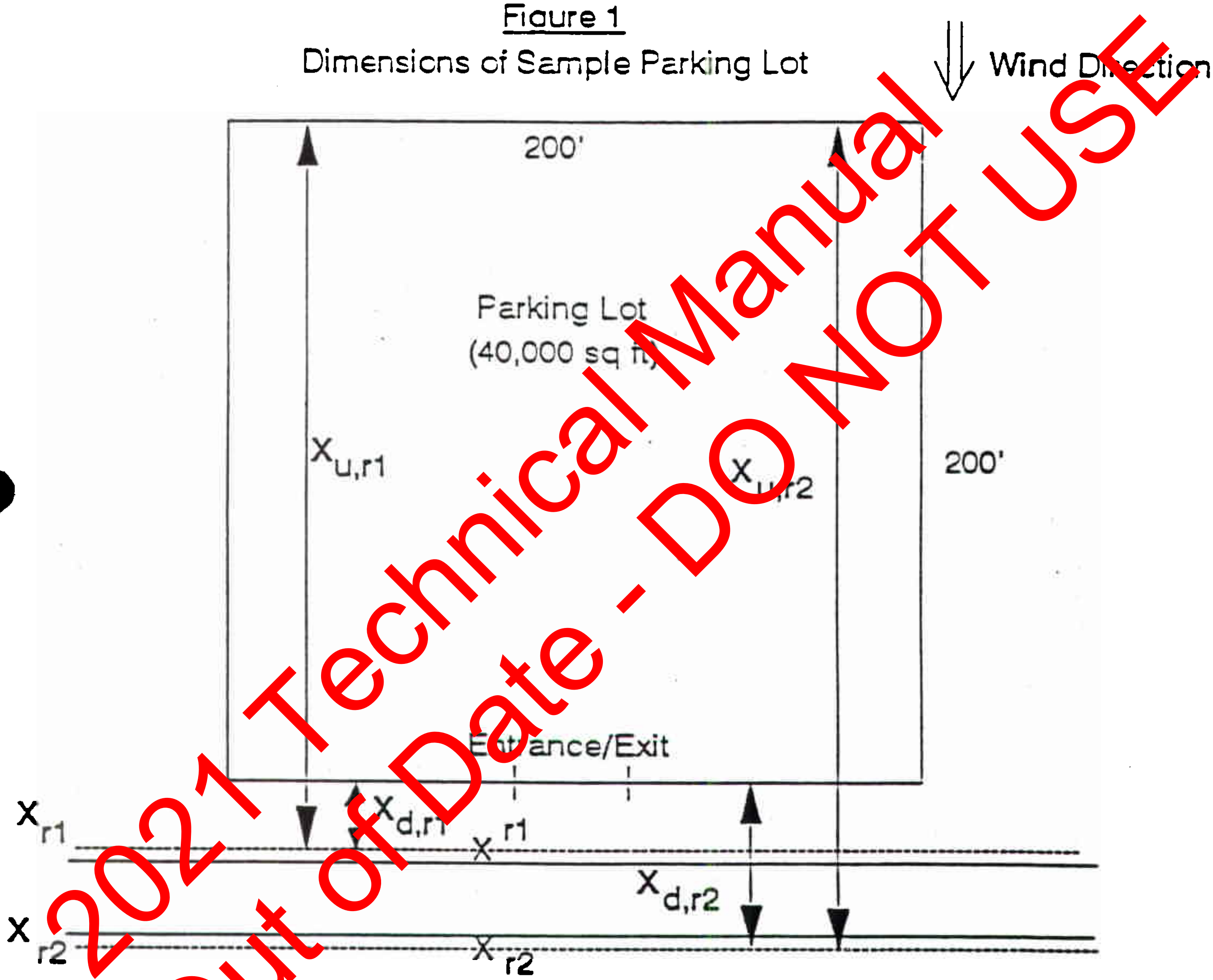
Figure 1
Dimensions of Sample Parking Lot



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Sample Parking Lot Analyses:

1997 Mobile 4.1 CO Emission Factors:

Cold Idle @ 30F	[CI]:	1028.61 G/HR
5mph Cold Auto @ 30F	[CA]:	188.17 G/MI
5mph Hot Auto @ 30F	[HA]:	32.13 G/MI

1997 CO background
1-HR 5.7 PPM
8-HR 2.9 PPM

1997 INS/OUTS MAXIMUM HOUR PERIOD	INS	OUTS	MAXIMUM 8-HOUR PERIOD	INS	OUTS	PARKING LOT GSF	MEAN TRAV.DIS. (FEET)	PEAK HOURLY ER (G/SEC)	8-HR AVG. ER (G/SEC)	Qa, 8-hr
4-5PM	30	81	12-8PM	21.3	31.3	40,000	201	0.557	0.219	0.000059

$$\chi u/Q_a = \frac{0.8}{a(1-b)}(r_u^{1-b} - r_d^{1-b}) * PF \quad (1)$$

$$r_u = x_u + x_o \quad (2)$$

$$r_d = x_d + x_o \quad (3)$$

where:

χ = 8-hour CO concentration from parking lot emissions (g/m^3)

u = wind speed (= 1 meter/sec)

Q_a = CO emissions in parking lot per unit area of lot (g/m^2-sec)

a,b = empirical constants (for almost all applications, a = 0.50, b = 0.7[illegible])

r_u = effective distance from the receptor to the upwind edge of the parking lot (meters)

r_d = effective distance from the receptor to the downwind edge of the parking lot (meters)

x_u = measured distance from the receptor to upwind edge of the parking lot (meters)

x_d = measured distance from the receptor to downwind edge of the parking lot (meters)

x_o = virtual distance used to affect an initial vertical mixing of CO emissions (x_o = 19.9m)

PF = 8-hour meteorological persistence factor (= 0.7)

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Since $x_{u,r1} = 62.8m$ (206 ft) & $x_{d,r1} = 1.8m$ (6 ft)
$x_{u,r2} = 79.9m$ (262 ft) & $x_{d,r2} = 18.9m$ (62 ft)

Therefore $\chi_{r1} = 0.00021\ g/m^3 = 0.18$ PPM
$\chi_{r2} = 0.00016\ g/m^3 = 0.14$ PPM

8-hr Total CO Conc @ r1 = χ_{r1} + bkgrd = 0.18 + 2.9 = 3.08 PPM

		ER	
		g/mi-hr	g/m-sec
WB adjacent street		6423	0.00111
EB adjacent street		3272	0.00056
	Total	9695	0.00167

On-street = 307.7 * PF * ER = 0.36 PPM

8-hr Total CO Conc @ r2 = χ_{r2} + On-street + bkgrd = 0.14 + 0.36 + 2.9 = 3.4 PPM

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GUIDELINES FOR EVALUATING AIR QUALITY IMPACTS FROM MULTILEVEL NATURALLY VENTILATED PARKING FACILITIES

A multi-level parking facility with at least 3 partially open sides is naturally ventilated by the ambient air. A sample air quality analysis is also provided in the Appendix for potential air quality impacts from CO emissions emitted by an auto parking lot. In this example, maximum hourly CO emissions will be used to conservatively estimate 8-hour CO impacts adjacent to the facility. The 5:00 p.m. to 6:00 p.m. period would have the largest number of departing autos and the largest hourly estimate of CO emissions in this sample analysis for a proposed 7-level naturally ventilated auto parking facility. This analysis does not use the most up-to-date MOBILE program or related emission factors, but the methodology used is still applicable.

Figure 1 provides a side view of a sample 7-level open-side facility, which would be built above a retail use. Figure 2 displays a top view applicable to each parking level. The proposed facility would have several entrances and exits. Page 15 of this Appendix displays all input parameters that are required to estimate the maximum CO emission rates within the parking lots. CO emission factors and background values are reported at the top of the page. The analysis should also assume that all departing autos would idle for one minute before travelling to the exits of the lot, and all arriving and departing autos would travel at 5 mph within the parking lot. The equations and definitions of the parameters used to determine the emission rates within the parking areas are identical to those found in the "Guidelines for Evaluating Air Quality Impacts from Parking Garages."

Estimates of CO emissions rates for each level should consist of two components: vehicles arriving/departing the level, and "excess" vehicles that are passing through a level, destined toward a higher or lower parking level within the facility. In this example, the total number of autos traveling in and out of the structure in the 5:00 p.m. to 6:00 p.m. hour have been divided by the number of parking levels (*i.e.*, 7) to determine the average number of vehicles parking or leaving each level in this hour (*e.g.*, a total of 679 departure averages out to 97 departures per level). $Q_{a,\, lvl}$ represents the CO emissions estimates per unit area for vehicles originating from or destined for each level. Excess CO emissions for each level should be calculated based on the number of excess autos traversing through the parking level and the distance traveled by such vehicles. As shown in the example, the number of excess vehicles increases to a maximum at level 1. Q_{exc} represents the excess emissions per level, and $Q_{\text{a exc}}$ is Q_{exc} divided by the floor area of the respective parking level. Q is defined as the total emission per unit area per level, and is the sum of $Q_{\text{a exc}}$ and $Q_{a,\, lvl}$ for each parking level.

The sample analysis displays the recommended procedures for estimating 8-hour CO impacts at a pedestrian height sidewalk receptor 70 feet from the facility. Equations 1, 2, and 3 are the calculations involved in determining the off-site impacts from CO emitted from an at-grade parking lot. Equation 4 is the recommended correction factor to adjust CO impacts calculated with $Q_{a,\, lvl}$ and equation 1 (i.e., χ center line) for each parking level to a pedestrian height receptor. The equation for this height correction factor is based on the correction term for elevated point sources in EPA's *Workbook of Atmospheric Dispersion Estimates*, AP-26 (pg. 6, equation 3.3.). Height corrections factors for each level should be based on the difference between pedestrian height (6 feet) and the respective parking level elevation, and should be multiplied to the χ centerline calculated for each level. The table at the bottom of page 16 shows the result of these products for each level of the parking facility in this example. Page 3 displays on-street CO emissions contributions to the receptor in this example, which were calculated with a factor (307.7) that yields the maximum predicted impacts (which could be calculated by refined mathematical modeling), when multiplied by the on-street CO emission rate in grams/meter/second. Cumulative CO concentrations at this receptor should be calculated by adding together the contributions from the parking facility, on-street sources, and background levels.

An acceptable alternative method to the procedures detailed above would be to use the hourly average CO emissions over the continuous 8-hour period with the largest CO emissions to calculate the CO emission rates within the facility and off-site 8-hour CO impacts. This alternative procedure should consider whether or not a larger proportion of vehicles would use the lower levels over an 8-hour average, as opposed to the equal averaging procedure used with the

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peak hourly emissions. The procedure employed in this sample analysis did not have to take this into account, since maximum hourly emissions were conservatively applied to estimate CO emission rates of an 8-hour period.

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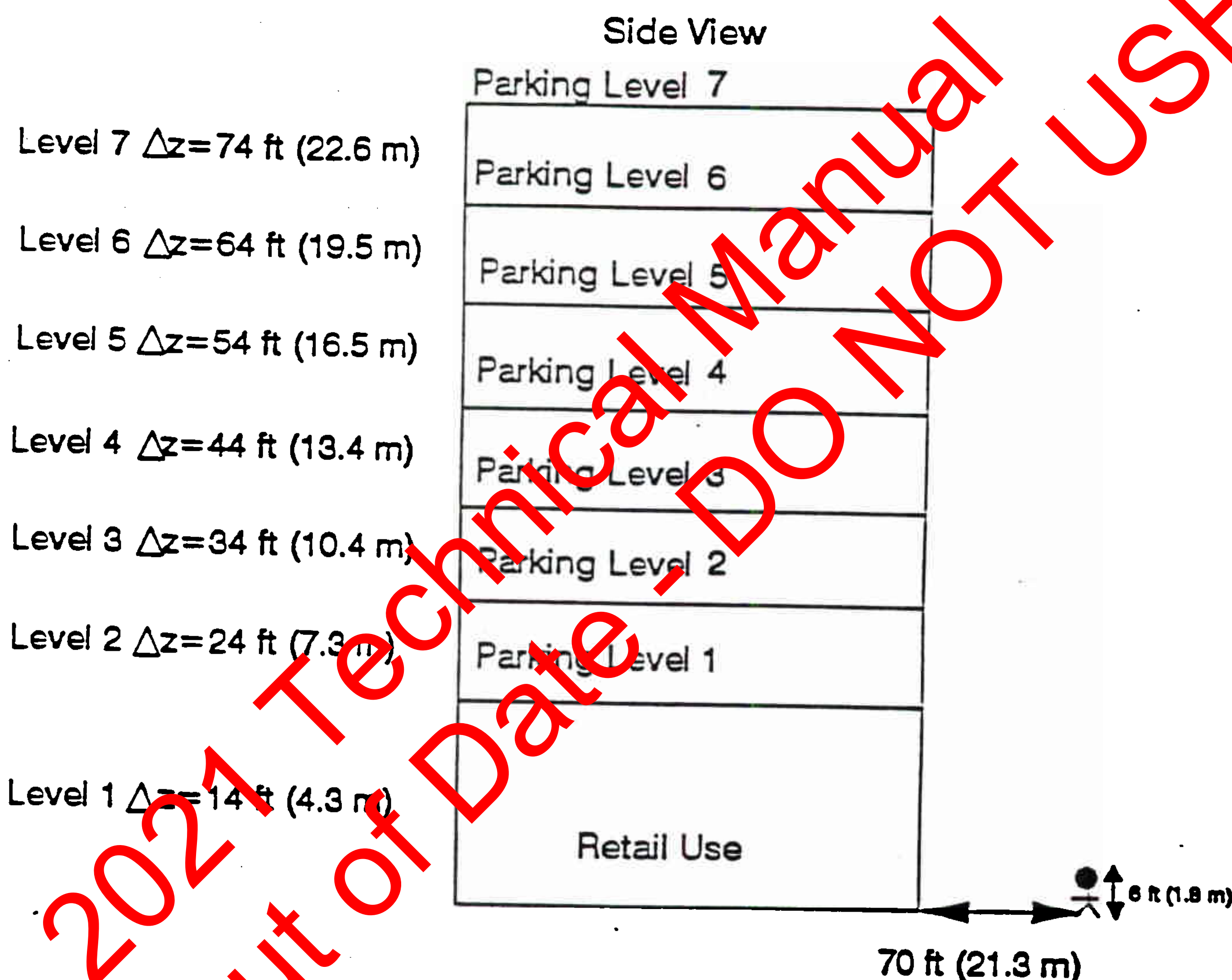
Figure 1



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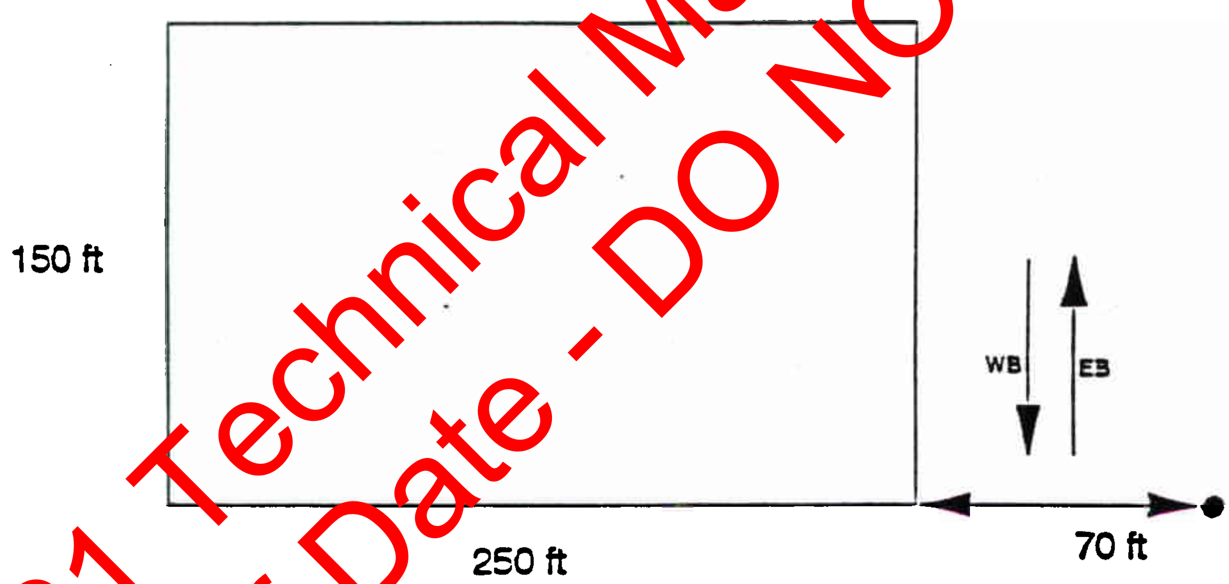
<u>Figure 2</u>

Top View



Sample Multi-Level Naturally Ventilated Parking Facility Analysis:

1997 Mobile 4.1 CO Emission Factors:

Cold Idle @ 30F	[CI]:	1028.61	g/hr
5mph Cold Auto @ 30F	[CA]:	188.17	g/mi
5mph Hot Auto @ 30F	[HA]:	32.13	g/mi

1997 CO background
1-HR 5.7 PPM
8-HR 2.9 PPM

1997 INS/OUTS

MAXIMUM HOUR PERIOD	INS	OUTS	MAXIMUM HOUR PER LEVEL PERIOD	INS	OUTS	PARKING LOT GSF	MEAN TRAV.DIS. (FEET)	PEAK HOURLY PER LEVEL (G/SEC)	$Q_{a,lvl}$ (g/m^2-sec)
5-6PM	301	679	5-6PM	43	97	37,500	270	0.741	0.000213

Emissions from excess vehicles:

$$Q_{exc} = (N_{veh,dep} * [CA] * \Delta L + N_{veh,arr} * [HA] * \Delta L) / 3600$$

$$Q_{a,exc} = Q_{exc} / GSF$$

where:

$N_{veh,dep}$ = number of excess departing autos from upper levels at each floor

$N_{veh,arr}$ = number of excess arriving autos from lower levels at each floor

ΔL = travel distance between floors (= 120 ft)

Level	Excess Vehicles Ins	Excess Vehicles Outs	Q_{exc}	$Q_{a,exc}$	$Q_{a,lvl}$	$Q_{a,tot}$
7	-	-	-	-	2.13×10^{-4}	2.13×10^{-4}
6	43	97	0.12	3.56×10^{-5}	2.13×10^{-4}	2.48×10^{-4}
5	86	194	0.25	7.12×10^{-5}	2.13×10^{-4}	2.84×10^{-4}
4	129	291	0.37	1.07×10^{-4}	2.13×10^{-4}	3.19×10^{-4}
3	172	388	0.50	1.42×10^{-4}	2.13×10^{-4}	3.55×10^{-4}
2	215	485	0.62	1.78×10^{-4}	2.13×10^{-4}	3.91×10^{-4}
1	258	582	0.74	2.13×10^{-4}	2.13×10^{-4}	4.26×10^{-4}

$$\chi u/Q_a = \frac{0.8}{a(1-b)}(r_u^{1-b} - r_d^{1-b}) * PF \quad (1)$$

$$r_u = x_u + x_o \quad (2)$$

$$r_d = x_d + x_o \quad (3)$$

with variables and constants as defined previously

Since x_u = 97.5m (320 ft) & x_d = 21.3m (70 ft),

Therefore $\chi u/Q_{a,tot} = 3.099$

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Vertical Diffusion Correction:

$$\bar{x} = \exp(-0.5 * (\Delta z / \sigma_z)^2) \qquad (4)$$

where: $\bar{x}$ = correction factor for difference between height of each parking level and pedestrian height

σ_z = urban vertical dispersion coefficient for Pooler-McElroy stability class D

σ_z = 0.14 * x, where x is the distance between the edge of the parking area and the receptor site (in meters)

Δz = difference in height between parking lot level and pedestrian height (≈ 6 ft)

since x = 70 ft = 21.3 m,

therefore σ_z = 2.98 and

$$\bar{x} = \exp(-0.5 * (\Delta z / 2.98)^2)$$

Level	Δz (ft)	Δz (m)	$\bar{x}$
1	14	4.3	0.35
2	24	7.3	0.050
3	34	10.4	0.0023
4	44	13.4	0.000041
5	54	16.5	≈ 0
6	64	19.5	≈ 0
7	74	22.6	≈ 0

Level	$Q_{a,tot}$	χ Center Line	$\bar{x}$	g/m3 @ receptor	PPM	PF*PPM
7	2.13×10^{-4}	0.00066	≈ 0	≈ 0	0.000	0.000
6	2.48×10^{-4}	0.00077	≈ 0	≈ 0	0.000	0.000
5	2.8[illegible] $\times 10^{-4}$	0.00089	≈ 0	≈ 0	0.000	0.000
4	3.1[illegible] $\times 10^{-4}$	0.00100	0.000041	$4.08E \times 10^{-8}$	0.000	0.000
3	3.55×10^{-4}	0.00111	0.0023	$2.55E \times 10^{-6}$	0.002	0.001
2	3.91×10^{-4}	0.00122	0.05	$6.09E \times 10^{-5}$	0.053	0.037
1	4.26×10^{-4}	0.00133	0.35	$4.65E \times 10^{-4}$	0.407	0.285
					total	0.32 = χ_{tot}

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		ER	
		g/mi-hr	g/m-sec
WB adjacent street		6423	0.00111
EB adjacent street		3272	0.00056
	Total	9695	0.00167

On-street = 307.7 * PF * ER = 0.36 PPM

8-hr Total CO Conc = χ_{tot} + On-street + bkgrd = 0.32 + 0.36 + 2.9 = 3.6 PPM

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GUIDELINES FOR PERFORMING VEHICLE CLASSIFICATION SURVEYS FOR AIR QUALITY ANALYSES

Collection of vehicle classification data for use in an air quality analysis should be performed according to the following general guidelines, to provide accurate and adequate descriptions of the vehicle classes required by the United States Environmental Protection Agency (EPA) **MO**tor **V**ehicle **E**mission **S**imulator (MOVES) model.

MOVES is a state-of-the-science emission modeling system used for estimating emissions from cars, trucks, motorcycles and buses, based on analyses of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions. Emissions estimated by the model include: criteria pollutants CO, NO_2, PM_{10}, $PM_{2.5}$, SO_2, along with NO_x, VOCs, mobile source air toxics (MSATS), and greenhouse gases (methane, nitrous oxide, CO_2 and CO_{2e}).

An important part of this analysis is the determination of vehicle classification pertinent to the project site. The following steps provide general guidelines for performing such surveys for use in the air quality analysis for mobile sources.

1. Vehicle classification data should be taken concurrently with other traffic data collection efforts in order to get the most accurate estimate of traffic conditions in the project area.
2. Vehicle classification surveys should be performed at or near any sites where mobile source air quality analyses are performed, and should include three (3) good days of surveys for the midweek AM, midday (if necessary), and PM peak periods. Determination of the peak hours for air quality analyses should be consistent with the project specific traffic study.
3. If the project includes potential weekend activity, and a weekend air quality analysis is required, the traffic survey should be performed for at least one day for the weekend peak hour.
4. If the project includes nighttime or overnight activity, and a refined air quality analysis is required, 24-hour traffic counts should be collected for analysis purposes (e.g., Tier II dispersion modeling).
5. Manual traffic counts should be conducted for the current five vehicle classes characterized by the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS) - Motorcycles, Light Duty Vehicles, Buses, Single Unit Trucks, and Combination Trucks. Field observers should use the following criteria to distinguish among these five vehicle classes:
   a. Motorcycles: Includes all two or three-wheeled motorized vehicles. Typically these vehicles have saddle-type seats and are steered by handlebars.
   b. Light Duty Vehicles: Includes two-axle, four-tire vehicles. This includes, but is not limited to: passenger cars, taxis and limos, pick-up trucks, vans, SUVs, ambulances, and minibuses.
   c. Buses: Includes passenger-carrying buses with two axles and six tires or three or more axles. This includes school buses, church buses, coach buses, transit buses, and multi-unit buses, etc.
   d. Single Unit Trucks: Includes single frame trucks that have 2-axles and at least 6 tires or a gross vehicle weight rating exceeding 10,000 lbs, such as moving trucks, courier trucks, dump trucks, cement mixers, garbage trucks, transport trucks without trailers or with small rigid trailers, large flatbed trucks, or motor homes.
   e. Combination Trucks: Includes tractor-trailers with full-length trailers or multiple trailers.
6. The EPA MOVES model includes a default database that defines the fuel type for each vehicle type and model year within the model (i.e., diesel, gasoline, E-85, CNG and electricity).[1] For example, it assumes that all motorcycles are gasoline powered, all intercity buses are diesel-powered over all model years in line with the US Energy Information Administration (EIA) assumptions[2]. This default input data should only be modified if local data are available; therefore, field surveys need not distinguish fuel type.
7. Raw survey counts should be summed by the five HPMS vehicle classes listed above. The average vehicle classification for the street corridor during the respective peak period should be based upon the summed values and the relative percentages among the vehicle classes.

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[1] As of December 11, 2020, MOVES2014 is currently the latest version of MOVES in use. However, EPA will publish a Federal Register notice to announce the availability of MOVES3 for official purposes. EPA intends to include in the Federal Register notice a two-year grace period. After the grace period, MOVES3 will need to be used to estimate vehicular emissions for CEQR projects. Please check the EPA website, https://epa.gov/moves, for the latest information.

[2] US Energy Information Administration (EIA) assumptions, "Transportation Sector Energy Use by Fuel Type within A Mode," reference case, Annual Energy Outlook 2016. http://www.eia.gov/oiaf/aeo/tablebrowser

8. Vehicle Classifications from alternative commonly used sources, such as FHWA vehicle categories, NYSDOT's video-based vehicle classification, Automatic Traffic Recorder (ATR) and Miovision, can be adjusted to the aforementioned five HPMS vehicle classes based on Table 1 below.

Table 1. Correlation of Alternative Vehicle Classifications with HPMS Vehicle Classes

HPMS Vehicle Classes	FHWA Vehicle Categories	NYSDOT Video-Based Vehicle Classification	ATRs and Miovision Vehicle Classes	MOVES Source Types
Motorcycles	F1	Motorcycles (MC)	Motorcycles	11
Light Duty Vehicles	F2, F3	Passenger Vehicles (PV), Light Trucks (LT)	Cars, Light-Goods Vehicles	21, 22, 23
Buses	F4	Buses (BS)	Buses	41, 42, 43
Single Unit Trucks	F5, F6, F7	Single-Unit Vehicles (SU)	Single-Unit Truck	51, 52, 53, 54
Combination Trucks	F8, F9, F10, F11, F12, F13	Combination Unit (CU)	Articulated Truck	61, 62

9. In the current version of the EPA MOVES model - the five HPMS vehicle classes are divided into subsets comprised of 13 source types (see Table 1), which are assumed to have unique activity patterns. Project-level analyses in MOVES re-quires hourly traffic volume fractions by the 13 source types. The following example explains how to convert field classifi-cation data into MOVES source type fractions based on county-level registration data obtained from New York State De-partment of Environmental Conservation (NYSDEC).

EXAMPLE: Conversion of Field Classification Data into MOVES Source Type Fractions

Traffic counts were conducted for the AM peak-hour at a hypothetical intersection in New York County in 2014. There are 1000 vehicles in total observed during the peak hour for a user-defined roadway link. The vehicle volumes are characterized by the five HPMS vehicle classes as shown in Table 2 column (1) and column (2). Column (3) and column (4) represent the 2014 annual registered vehicle population by each MOVES source type in New York County, and column (5) indicates the population fraction of each MOVES source type within relevant HPMS vehicle class. The fractions must sum to one for all source types within the same vehicle class.

For example, the fraction of MOVES source type ID 21 is calculated as follows:

$$\frac{population\ of\ MOVES\ source\ type\ ID\ 21}{population\ of\ Light\ Duty\ Vehicles} = \frac{124{,}763}{(124{,}763 + 124{,}642 + 8{,}960)} = 0.4829$$

The peak hour traffic volume by each MOVES source type (column (6) in Table 2) for the user-defined roadway link can be calculated by multiplying each MOVES source type fraction (column (5) in Table 2) by the field counts (column (2) in Table 2) for each HPMS vehicle class. The last column (7) in Table 2 represents the peak hour traffic volume fraction of each MOVES source type that should be entered into EPA MOVES model for analysis purpose. The fractions are calculated by dividing the volume of each MOVES source type (column (6) in Table 2) by the total link volume (1000). Note that the "Source Type Hour Fractions" must sum to one across all source types.

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Table 2. Utilization of Vehicle Classification Surveys for Project-Level Analyses in MOVES

Field Survey		County-Level Registration Data			Project-Level MOVES Input	
1	**2**	**3**	**4**	**5**	**6**	**7**
HPMS Vehicle Classes	**Peak Hour Traffic Volumes**	**MOVES Source Type ID**	**Annual Vehicle Population by MOVES Source Type**	**MOVES Source Type Fractions within Each HPMS Vehicle Class**	**Roadway Link Volumes by MOVES Source Type**	**Roadway Link "Source Type Hour Fractions" as MOVES input**
Motorcycles	20	11	7,889	1.0000	20	0.020
Light Duty Vehicles	800	21	124,763	0.4829	386	0.386
		31	124,642	0.4824	386	0.386
		32	8,960	0.0347	28	0.028
Buses	60	41	325	0.0716	4	0.004
		42	4,136	0.9110	55	0.055
		43	79	0.0174	1	0.001
Single Unit Trucks	100	51	674	0.0671	7	0.007
		52	8,849	0.8802	88	0.088
		53	369	0.0367	4	0.004
		54	161	0.0160	2	0.002
Combination Trucks	20	61	324	0.4800	10	0.010
		62	352	0.5200	10	0.010
Total	**1000**	**N/A**	**281,523**	**N/A**	**1000**	**1.000**

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GUIDELINES FOR CALCULATING RECIRCULATION FOR CHEMICAL SPILLS

To assess impacts from accidental chemical spills under a laboratory fume hood, effects from recirculation must be addressed. If an exhaust vent is located near operable windows or air intake vents, there is potential for recirculation of the pollutant back into the building.

The potential for recirculation is assessed using the method described by D.J. Wilson in *A Design Procedures for Estimating Air Intake Contamination from Nearby Exhaust Vents*, ASHRAE TRAS 89, Part 2A, p. 136-152 (1983). This procedures takes into account such factors as plume momentum, stack-tip downwash, and cavity recirculation effects. This recirculation analysis determines worst-case minimum dilution between exhaust and air intake.

Three separate effects produce the available dilution: internal system dilution (mixing in plenum chamber of multiple exhaust streams and fresh air); wind dilution, dependent on the distance from the vent to intake and the exit velocity; and dilution from stack, caused by stack height and plume rise from vertical exhaust velocity. The critical wind speed is dependent on exit velocity, distance from vent to intake, and the cross-sectional area of the exhaust stack.

The following information about the pollutant and exhaust system must be known: stack height (m), stack diameter (m), stack exit velocity (m/s), mass flow rate of pollutant (g/sec), molecular weight of pollutant (g/mol), and the stretched string distance from the stack to the nearest receptor.

An example recirculation for carbon tetrachloride is included in the attachment. The inputs are: molecular weight of carbon tetracholoride, assumed mass flow rate, assumed stack diameter, height and exit velocity, and assumed string distance between stack and nearby receptor.

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ASHRAE Dilution Calculations for Potential Spill

Carbon Tetrachloride

DTOTAL = DSYSTEM *DWIND *DSTACK

Diameter = 3.26 ft

Actual Stack Height = 11 ft

Exit Velocity = 24.38 m/s

DILUTION OF SYSTEM (DSYSTEM): CALCULATED AS TOTAL CONCENTRATION EXITING STACK

DSYSTEM= (flowrate/(velocity per stack) x 1000 x 24.45/mol wt)

flowrate of carbon tetrachloride = 0.9635 g/sec

molecular wt of carbon tetrachloride = 154

DSYSTEM = 6.3 PPM

DILUTION OF WIND (DWIND) = ((1+1.48 (S/@SQRT Ae^.5)^2) **(from ASHRAE)**

WHERE S = STRING DISTANCE FROM STACK TO NEAREST RECEPTOR = 189 FT

AE = X-SECTIONAL AREA OF EXHAUST STACK (PI*D^2/4) = 8.35 FT^2

THEREFORE DWIND = 168.2

DILUTION FROM STACK (DSTACK) (BETA = 1 FOR UNCAPPED, VERTICAL EXHAUST) **(from ASHRAE)**

Ucrit/Ve = 20 x (sqrtAe)/S = 0.31

Therefore, Ve/Ucrit = 3.27 > 1.5 so Hd = 0

Hd = 2*diameter*(1.5-Ve/Ucrit) = 0.00 FT

Hs = actual stack height – Hd = 11.00 FT

DSTACK= exp ((4.23*hs/s+.707*beta)^2) = 2.5

THUS, DTOTAL = 0.015 PPM

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GUIDELINES FOR CALCULATING EVAPORATION RATE FOR CHEMICAL SPILLS

In order to calculate evaporation rate from an accidental chemical spill, the following physical properties must be known: boiling point (deg C), molecular weight (g/mol), density (g/cm^3), and vapor pressure (mm Hg).

The recommended procedures to determine the evaporation rate are displayed in the sample calculations provided in the attachment. Equations 1 and 3 are based on the Shell Model (Fleischer, M.T., *An Evaporation/Air Dispersion Model for Chemical Spills on Land*, Shell Development Company (Dec. 1980). Equations 2, 4, and 5 are based on *Mass Transfer Operations, 3rd Edition*, by R.E. Treybal, p. 31-33.

The evaporation rate, E, is dependent on the diffusivity of the component through air and saturated vapor density, among other factors. The diffusivity, D (equation 2), is based on several factors including a collision function that must be obtained from Figure 2.5 in *Mass Transfer Operations*, p. 32. The saturation vapor density, ρ*, is calculated from the ideal gas law: PV = nRT. Room temperature (20 C) and an air flow rate of 0.5 m/s are assumed for calculation of evaporation rate.

An example evaporation rate calculation for acetone is included in the attachment. Note that this example is limited by the size of the lab. A spill area of 0.25 m^2 is assumed.

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LAB SPILL ANALYSIS - EVAPORATION RATE

Sample Calculation for Acetone

Evaporation Rate

$E = D_{c\text{-}a} * Sh_L * (1/L) * (\rho^*)$ eq. (1)

where Dc-a is the diffusivity of component "c" through air, and defined as:

$$D_{c\text{-}a} = \frac{10^{-4} * (1.084 - 0.249\ \mathrm{sqrt}(1/M_c + 1/M_a)) * T^{3/2} * \mathrm{sqrt}(1/M_c + 1/M_a)}{P_t * (r_{ca})^2 * f(kT/E_{ca})}$$ eq. (2)

M_c, M_a are molecular weights of compound "c" and air, respectively [kg/kmol]

T = room temperature = 293 K

P_t = 1 std atm = 101.3×10^3 N/m^2

E_{ca} = energy of molecular attraction

r_{ca} = molecular separation at collision [nm]

$r_A = 1.18\ v^{1/3}$ (r in nm)

v = MW / Density (v in m^3/kmol)

$r_{AB} = (1.3711 + r_A) / 2$ (r_{AB} in nm)

$$v \rightarrow \frac{(g/mol) * (1000\ mol / 1\ kmol)}{(g/cm^3) * (100\ cm / 1\ m)^3} \rightarrow m^3/kmol$$

$E_A / k = 1.21 * T_b$

$E_{AB} / k = \mathrm{sqrt}\,(78.6 * (E_A / k))$

$f(kT/E_{AB})$ ---> estimate from Figure 2.5 on page 32 of *Mass Transfer Operations*

$$D_{acetone-air} = \frac{10^{-4} * (1.084 - 0.249\ \mathrm{sqrt}(1/58 + 1/29)) * (293)^{3/2} * \mathrm{sqrt}(1/58 + 1/29)}{(101.3 \times 10^3)\ (0.[illegible]33[illegible])\ (0.5[illegible])}$$

$= 1.10 \times 10^{-5}$ m^2/sec

ρ^* = saturated vapor density

$\rho^* = n/V = P/RT$

Ideal Gas Law: PV = nRT

R = Gas Constant = 0.082 L atm / mol K

$$\rho^* = \frac{180\ mmHg\ (1\ atm / 760\ mmHg)}{(0.082\ L\ atm / mol\ K)(293\ K)}$$ (vapor pressure of acetone = 180 mmHg)

$= 9.86 \times 10^{-3}$ mol/L or 9.86×10^{-6} mol/cm^3

$(9.86 \times 10^{-3}$ mol/L) * (1000 L / 1 m^3) * (58 g/mol acetone)

ρ^* = $= 572$ g/m^3

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Sh_L = Sherwood # = $0.664\ S_c^{1/3}\ Re_L^{1/2}$ eq. (3)

where S_c = Schmidt # = $\mu / (\rho * D_{c\text{-}a}) = \upsilon_{air} / D_{c\text{-}a}$ eq. (4)

[μ = viscosity, ρ = density, $D_{c\text{-}a}$ = diffusivity, υ = kinematic viscosity (at 21 degrees C and std atm)]

$Re_L = vL/\upsilon$ eq. (5)

[L = length, v = velocity of wind = 0.5 m/sec]

$Sh_{acetone} = (0.664) * (1.482 \times 10^{-5}\ m^2/sec / 1.10 \times 10^{-5}\ m^2/sec)^{1/3} * [(0.5\ m/sec)(0.5\ m) / (1.482 \times 10^{-5}\ m^2/sec)]^{1/2}$

= 95.2

$E_{acetone} = (1.10 \times 10^{-5}\ m^2/sec)\ (95.2)\ (1 / 0.5\ m)\ (572)$

= 1.1980 g/m^2.sec = evaporation rate for acetone

Emission Rate

Based on a spill area of 0.25 m^2, Q = Emission Rate

E x A = 1.1980 g/m^2.sec x 0.25 m^2 = 0.299 g/sec

<u>References</u>

Eq (1), (3) from Shell Model
Eq (2), (4), (5) from *Mass Transfer Operations*, 3rd Ed., by Treybal

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Calculation of Evaporation Rate from Chemical Spill

23-Oct-01

Name	Container Size (liters)	Tb (C)	MW (g/mol)	d (g/cm^3)	r (nm)	E/(kT)	<r> (nm)	<E/(kT)>	<(kT)/E>	f(<>)	D (m^2/s)	P at 20C (mm Hg)	ro (g/m^3)	Evaporation Rate (g/m^2-s)
Example														
Acetone		56.2	58	0.[illegible]857	0.4950	1.3603	0.4331	0.6041	1.6554	0.56	1.10E-05	180	572	0.8[illegible]

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REFINED SCREENING ANALYSES FOR HEAT AND HOT WATER SYSTEMS

Section 322.1 in Chapter 17, "Air Quality," provides a discussion which identifies that impacts from boiler emissions are a function of fuel type, stack height, minimum distance from the source to the nearest receptor (building), and square footage of development resulting from the project. The preliminary screening analysis outlined in Section 322.1 to determine a project's potential for significant impacts (Figure 17-3) is based on use of No. 2 fuel oil in a residential building, which is the most conservative, 'worst case' scenario. If more detailed information regarding the boiler characteristics is available, then a more accurate screen can be performed.

These screens in the manual and appendices are based on emission factors obtained from EPA's, Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources (http://www.epa.gov/ttn/chief/ap42) and fuel consumption data obtained from the Department of Energy (www.eia.gov/consumption/residential/ and www.eia.gov/consumption/commercial/index.cfm).

Appendix Figures 17-1 to 17-3 were specifically developed through detailed mathematical modeling to predict the threshold of development size below which a project would not likely have a significant impact based on the type of fuel, use of the proposed building(s), and distance to nearest building of a height similar to or greater than the stack height of the proposed building(s). The screen for commercial building using No. 2 fuel oil, and residential and commercial building using natural gas are provided. The step-by-step methodology outlined below explains how to use these figures. Similar to the screen described in 322.1, this methodology is only appropriate for single building or emission source. It is also only appropriate for boiler stack located at least 10 meters (approximately 33 feet) from the nearest building of similar or greater height and is applicable to all stack heights greater than or equal to 30 feet.

1. Consider the type of fuel that would be used to provide heat/hot water as well as the proposed use of the building. If the type of fuel is unknown, generally assume No. 2 fuel oil (a conservative assumption for air quality purposes). If the proposed use is residential and fuel type is undetermined, use the screen provided in 322.1.
2. Determine the maximum size and type of development that would use the boiler stack. For residential or mixed-use commercial and residential projects, refer to the figures indicating "residential development." For non-residential uses, refer to the "commercial and other non-residential development" figures.
3. Using Geographic Information Systems (GIS), a Borough President's map, Sanborn atlas, or equivalent, determine the minimum distance (in feet) between the building(s) resulting from or facilitated by the proposed project and the nearest building of similar or greater height.
4. If this distance is less than 33 feet, more detailed analyses than this step-by-step screen are required. If the distance is greater than 400 feet, assume 400 feet.
5. Determine the stack height of the building resulting from the proposed project, in feet above the local ground level. If unknown, assume 3 feet above the roof height of the building. If the stack height is less than 30 feet, more detailed analyses are required.
6. Based on steps 1 through 5 above, select the appropriate Appendix Figure for the proposed project:
   a. Appendix Figure 17-1: Commercial and Other Non-Residential Development, Fuel Oil #2
   b. Appendix Figure 17-2: Residential Development, Natural Gas
   c. Appendix Figure 17-3: Commercial and Other Non-Residential Development, Natural Gas

Locate a point on the appropriate chart by plotting the size of the development against the distance in feet to the edge of the nearest building of height similar to or greater than the stack of the proposed project.

If the plotted point is on or above the curve, there is the potential for a significant air quality impact from the project's boiler(s), and detailed analyses may need to be conducted. If the plotted point is below the relevant curve, a potential significant impact due to boiler stack emissions is unlikely, and no further analysis is needed.

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In some cases, it may be possible to pass this screening analysis by restricting the type of fuel that could be used to supply heat and hot water. As illustrated in figures 17-1 through 17-3, No. 2 oil has greater emissions than natural gas. Limiting the fuel used by the proposed project to natural gas may eliminate the potential for significant adverse impacts and also the need for further analyses. This can be determined using steps 1 through 5 above. The project, however, would have to include the restriction on the boiler fuel type (and indicate the mechanism that would ensure the use of a specific fuel type) if this option is selected.

Figure 17-4 can alternatively be used to determine the potential for significant impacts from any HVAC source. If the quantity of fuel consumption is known for a combustion source, the maximum emissions can be calculated using EPA's AP-42 emission tables. For example, if the daily quantity of #2 fuel oil to be used is 100 gallons, the grams per second emissions can be calculated as follows:

$$\frac{100\ gallons}{day} \times \left(\frac{0.0013\ lbs_{\ condensable}}{gallon} + \frac{0.002\ lbs_{\ filterable}}{gallon}\right) x \frac{454\ grams}{lb}\ x \frac{1\ day}{86{,}400\ secs} = \frac{0.0017\ gram}{second}$$

The emission factor for $PM_{2.5}$ for #2 fuel oil was obtained from EPA's AP-42 and represents the total of filterable plus condensable PM. If the plotted point corresponding to the project size and the distance to the nearest building of height similar to or greater height is on or above the curve, there is the potential for a significant air quality impact from the project's boiler(s), and detailed analyses may need to be conducted. If the plotted point is below the curve, a potential significant impact due to boiler stack emissions is unlikely, and no further analysis is needed. For the above example, figure 17-4 indicates that for a proposed project that burns 100 gallons of #2 fuel oil daily and has a minimum stack height of 30 feet, further analysis is necessary if there are any buildings within a distance of 180 feet.

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Figure App 17-1

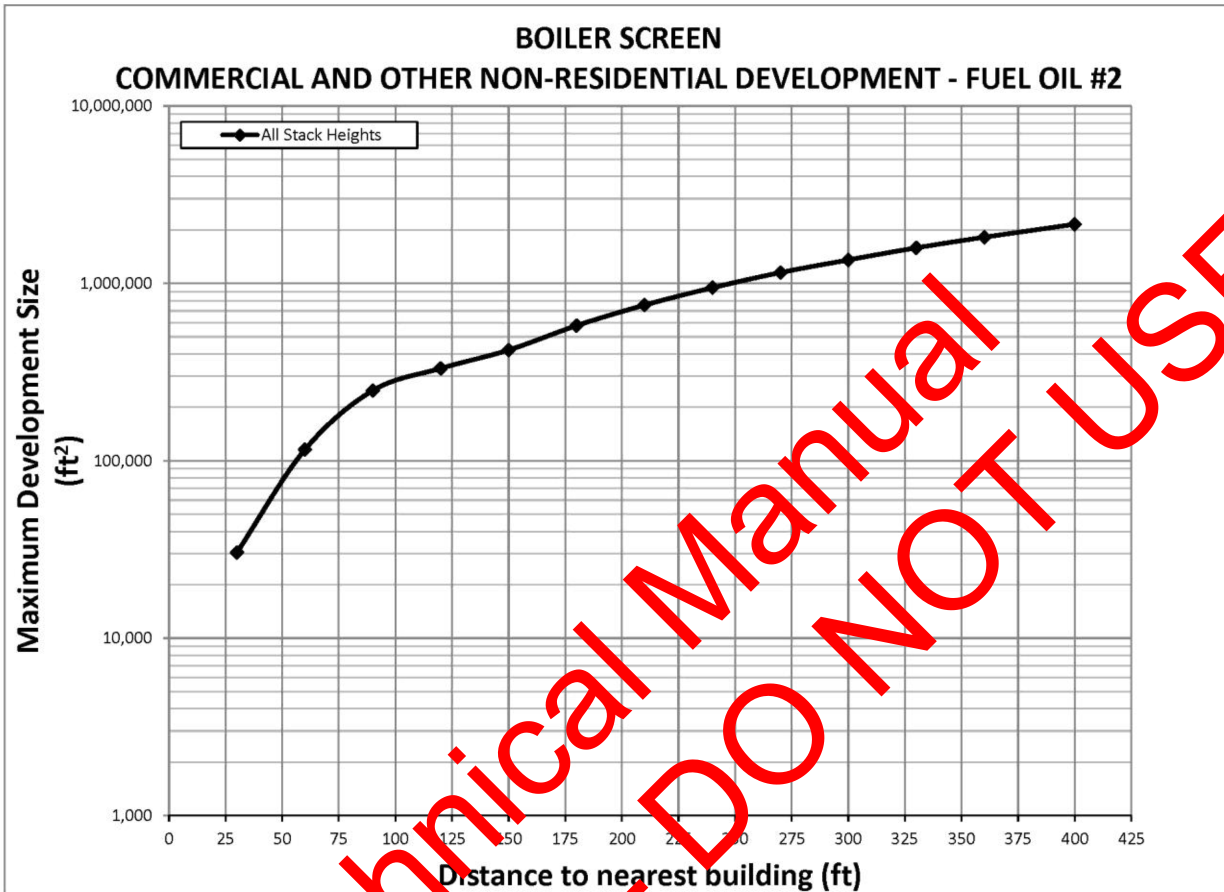

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Figure App 17-2

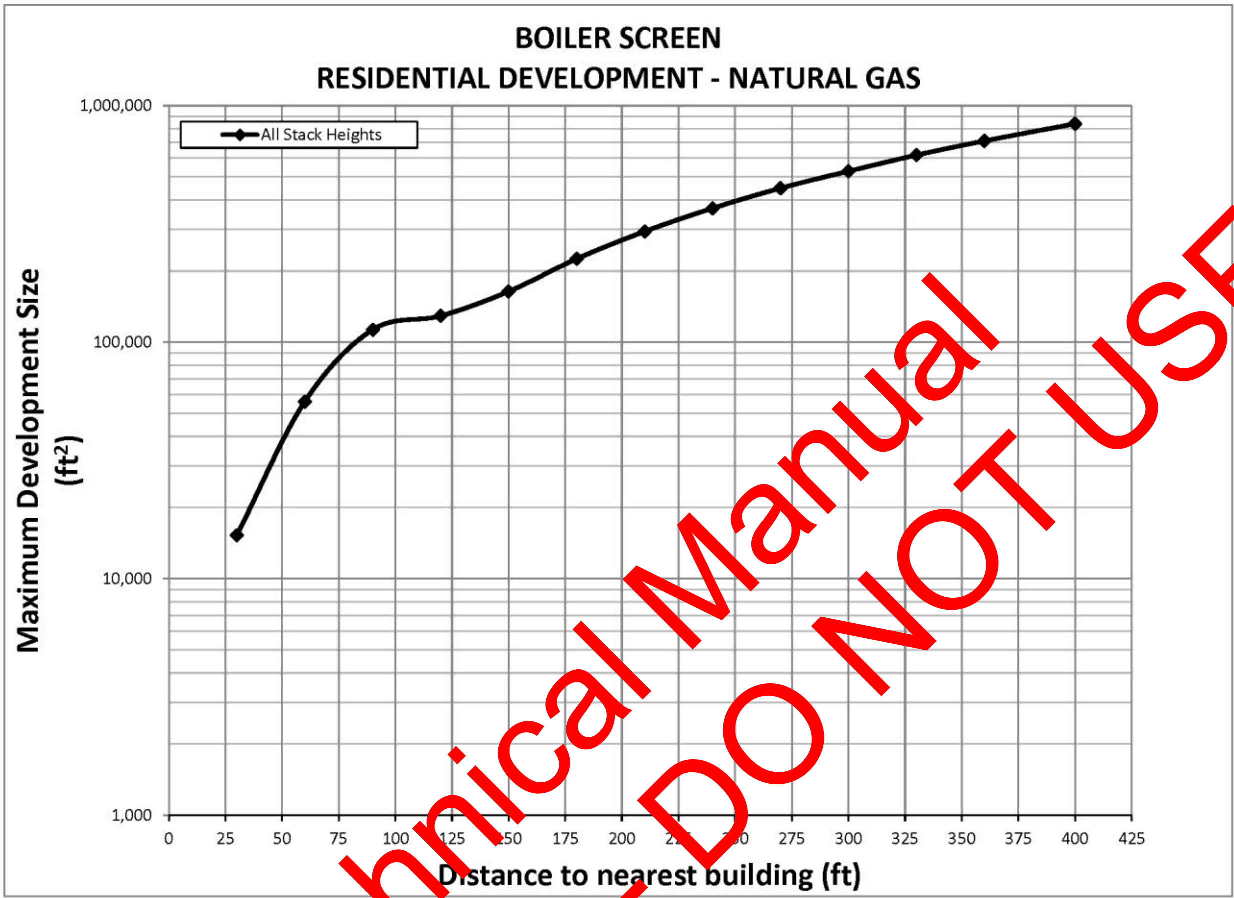

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Figure App 17-3

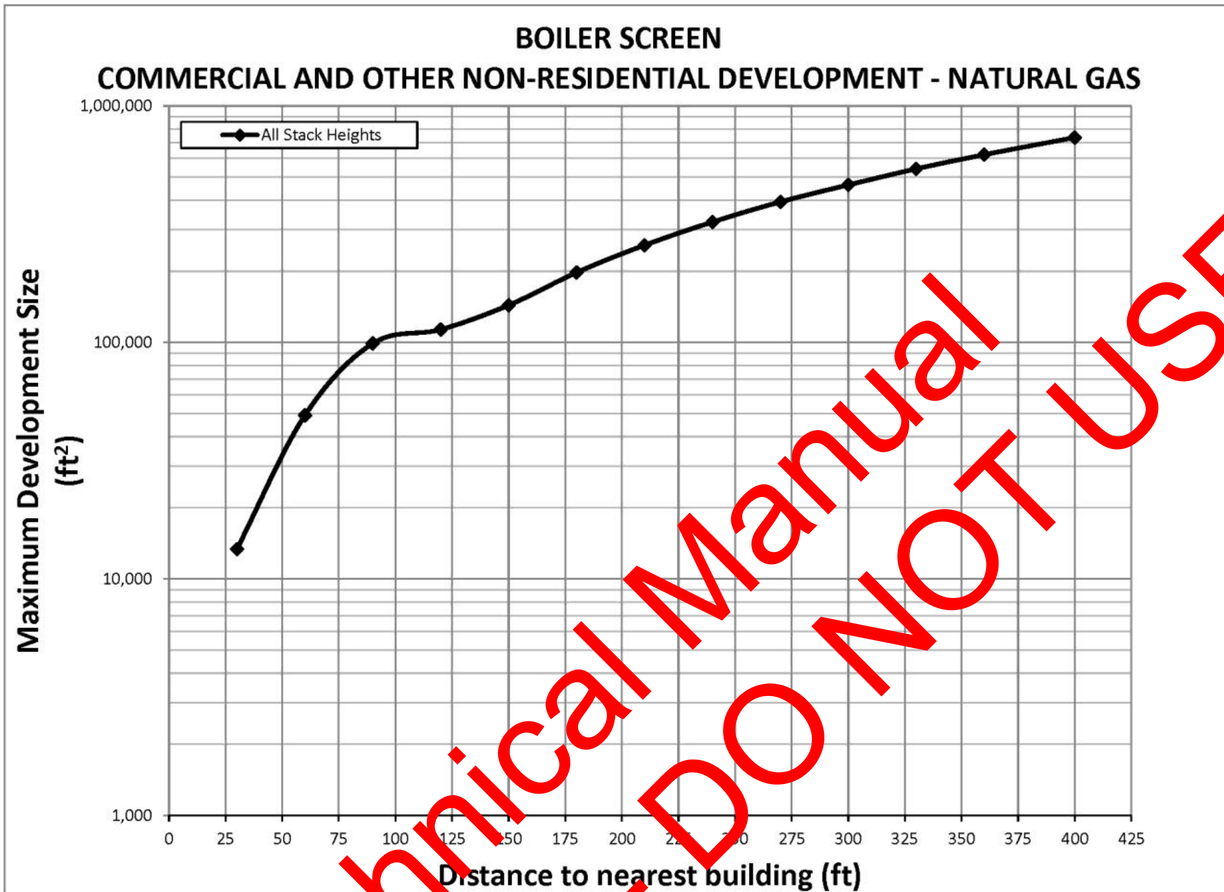

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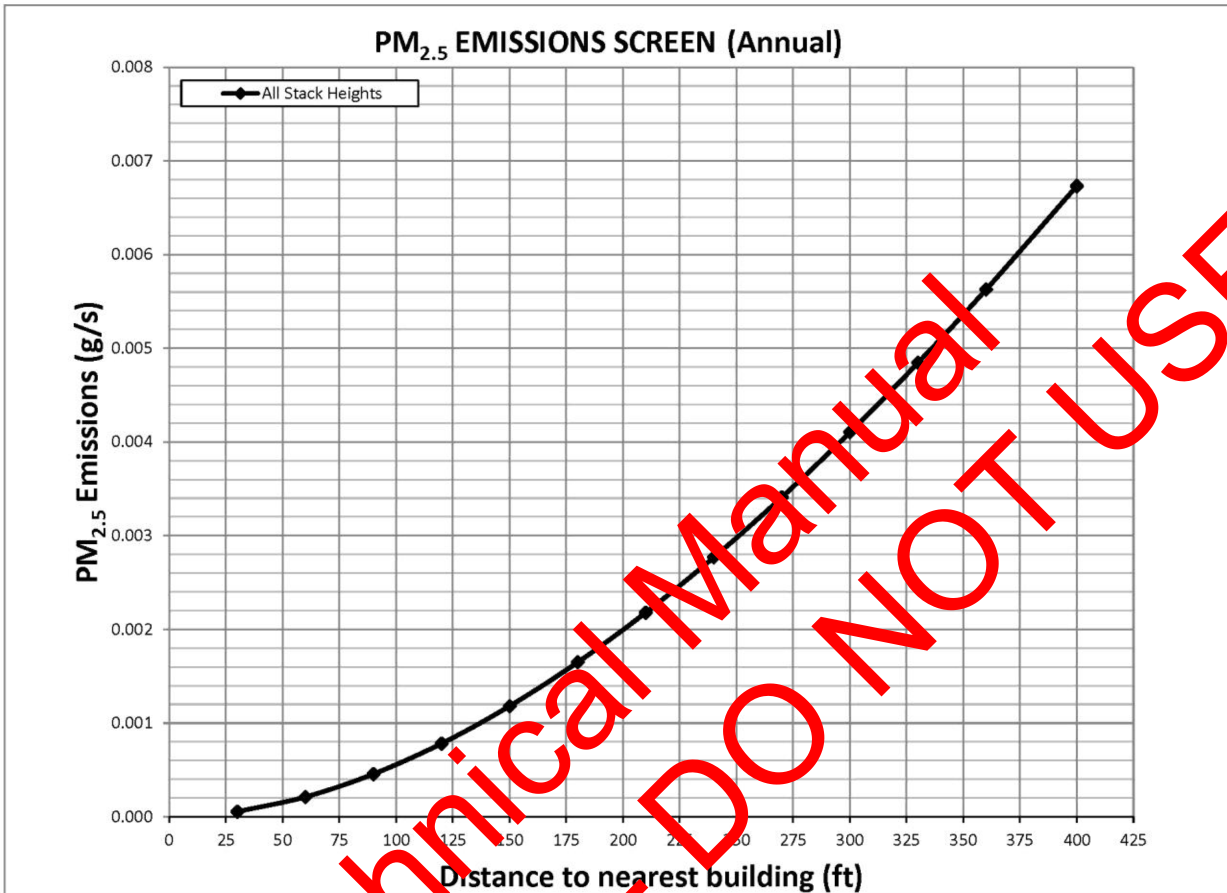
Figure App 17-4



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INDUSTRIAL SOURCE SCREEN FOR POTENTIAL CUMULATIVE IMPACTS

Section 322.1 in Chapter 17, "Air Quality," outlines the methodology for analysis of an additional screen for industrial sources from a single point pollutant source. This appendix describes how to determine potential cumulative impact from multiple sources. Table 17-3 depicts maximum concentration values for various time periods (1-hour, 8-hour, 24-hour and annual) for the distances from 10 meters to 120 meters (33 feet to 394 feet) and the shortest stack and receptor height (10 meters). This table is based on the generic emission rate of 1 gram per second of pollutant from a point source and the latest five years of available meteorological data (2003-2007) from La Guardia airport. Default values from the CEQR manual were used: stack exit velocity employed was 0.001 m/s, stack diameter was assumed to be 0 meters and stack exit temperature was set at 293K. Step-by-step methodology outlined below explains how to accurately use the values in this table to determine the potential cumulative impact from industrial emissions on a new proposed project:

1. Identify all sources with potential impact on the proposed project.
2. Convert the estimated emissions of each pollutant from the industrial sources of concern into grams/second.
3. Determine distance to each point pollution source.
4. Using the look up table, find the corresponding concentration for distance between each industrial source and the new use of concern for desired averaging time.
5. For each point, multiply the emission rates from step 2 with the value from the table (step 4).
6. Combine these values to determine potential cumulative impact.

Table 17-3
Industrial Source Screen

20 Foot Source Height

Distance from Source	1-Hour Averaging Period (ug/m3)	8-Hour Averaging Period (ug/m3)	24-Hour Averaging Period (ug/m3)	Annual Averaging Period (ug/m3)
30 ft	126,[illegible]70	64,035	38,289	6,160
65 ft	2[illegible],787	15,197	8,841	1,368
100 ft	[illegible]2,[illegible]51	7,037	4,011	598
130 ft	7,345	4,469	2,511	367
165 ft	4,702	2,967	1,643	236
200 ft	3,335	2,153	1,174	167
230 ft	2,657	1,720	924	131
265 ft	2,175	1,377	727	103
300 ft	1,891	1,142	594	84
330 ft	1,703	991	509	73
365 ft	1,528	857	434	62
400 ft	1,388	755	377	54

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Table 1.3-1. (cont.)

Firing Configuration (SCC)[a]	SO_2[b] Emission Factor (lb/10^3 gal)	SO_2[b] EMISSION FACTOR RATING	SO_3[c] Emission Factor (lb/10^3 gal)	SO_3[c] EMISSION FACTOR RATING	NO_x[d] Emission Factor (lb/10^3 gal)	NO_x[d] EMISSION FACTOR RATING	CO[e] Emission Factor (lb/10^3 gal)	CO[e] EMISSION FACTOR RATING	Filterable PM[f] Emission Factor (lb/10^3 gal)	Filterable PM[f] EMISSION FACTOR RATING
Boilers < 100 Million Btu/hr										
No. 6 oil fired (1-02-004-02/03) (1-03-004-02/03)	157S	A	2S	A	55	A	5	A	9.19(S)+3.22[i]	B
No. 5 oil fired (1-03-004-04)	157S	A	2S	A	55	A	5	A	10[i]	A
No. 4 oil fired (1-03-005-04)	150S	A	2S	A	20	A	5	A	7	B
Distillate oil fired (1-02-005-02/03) (1-03-005-02/03)	142S	A	2S	A	20	A	5	A	2	A
Residential furnace (A2104004/A2104011)	142S	A	2S	A	18	A	5	A	0.4[g]	B

a To convert from lb/103 gal to kg/103 L, multiply by 0.120. SCC = Source Classification Code.

b References 1-2,6-9,14,56-60. S indicates that the weight % of sulfur in the oil should be multiplied by the value given. For example, if the fuel is 1% sulfur, then S = 1.

c References 1-2,6-8,16,57-60. S indicates that the weight % of sulfur in the oil should be multiplied by the value given. For example, if the fuel is 1% sulfur, then S = 1.

d References 6-7,15,19,22,56-62. Expressed as NO2. Test results indicate that at least 95% by weight of NOx is NO for all boiler types except residential furnaces, where about 75% is NO. For utility vertical fired boilers use 105 lb/103 gal at full load and normal (>15%) excess air. Nitrogen oxides emissions from residual oil combustion in industrial and commercial boilers are related to fuel nitrogen content, estimated by the following empirical relationship: lb NO2 /103 gal = 20.54 + 104.39(N), where N is the weight % of nitrogen in the oil. For example, if the fuel is 1% nitrogen, then N = 1.

e References 6-8,14,17-19,56-61. CO emissions may increase by factors of 10 to 100 if the unit is improperly operated or not well maintained.

f References 6-8,10,13-15,56-60,62-63. Filterable PM is that particulate collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. Particulate emission factors for residual oil combustion are, on average, a function of fuel oil sulfur content where S is the weight % of sulfur in oil. For example, if fuel oil is 1% sulfur, then S = 1.

g Based on data from new burner designs. Pre-1970's burner designs may emit filterable PM as high as 3.0 1b/103 gal.

h The SO2 emission factor for both no. 2 oil fired and for no. 2 oil fired with LNB/FGR, is 142S, not 157S. Errata dated April 28, 2000. Section corrected May 2010.

i The PM factors for No.6 and No. 5 fuel were reversed. Errata dated April 28, 2000. Section corrected May 2010.

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Fuel Consumption 1993
Residential

	sq ft million	Total Btu (tril)	Btu/sq ft (thousand)	Electricity	minus Elec (tril Btu)	heating Btu/sq ft (thou)	cubic ft/sq ft NG	gallons/sq ft #2 fuel oil	gallons/sq ft #4 & 6 fuel oil
average	181200	9966	55.0	3280	6686	36.9	36.2	0.26	[illegible]
Year Constructed									
before 1939	40600	2639	65.0	510	2129	52.4	[illegible]	0.37	0.35
1940-1949	11600	777.2	67.0	200	577.2	49.8	48.8	0.36	0.33
1950-1959	24700	1482	60.0	420	1062	43.0	42.2	0.31	0.29
1960-1969	27200	1550.4	57.0	490	1060.4	39.0	38.2	0.28	0.26
1970-1979	31700	1585	50.0	710	875	27.6	27.1	0.20	0.18
1980-1984	14700	676.2	46.0	350	326.2	[illegible]	21.8	0.16	0.15
1985-1987	10800	475.2	44.0	230	245.2	22.7	22.3	0.16	0.15
1988-1990	10000	430	43.0	210	220	22.0	[illegible]	0.16	0.15
1991-1993	10000	400	40.0	160	240	24.0	[illegible]	0.17	0.16
Northeast	40100	2406	60	470	[illegible]	[illegible]	47.3	0.34	0.32
New York	12800.0	819.2	64.0	130	[illegible]	[illegible]	52.8	0.38	0.36
Type of Housing Unit									
Single Family	152200	7914.4	52	2580	5334.4	35.0	34.4	0.25	0.23
Detached	139100	7233.2	52	2340	4893.2	35.2	34.5	0.25	0.23
Attached	13100	694.3	53	240	[illegible]	34.7	34.0	0.25	0.23
Mobile Home	5400	453.6	[illegible]	210	[illegible]	45.1	44.2	0.32	0.30
Multifamily	23600	1628.4	[illegible]	490	1138.4	48.2	47.3	0.34	0.32
2 -4 units	9600	796.8	83	170	626.8	65.3	64.0	0.47	0.44
5 or more units	14000	840	60	[illegible]	520	37.1	36.4	0.27	0.25

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Fuel Consumption - 1995
Commercial Use

	sq ft (million)	Total Btu (tril)	Btu/sq ft (thousand)	Electricity	minus Elec (tril Btu)	heating Btu/sq ft (thou)	cubic ft/sq ft NG	gallons/sq ft #2 fuel oil	gallons/sq ft #4 & 6 fuel oil
average	58772	5321	90.5	2608	2713	46.2	45.3	0.33	[illegible]
Year Constructed									
before 1919									
1900-1919	3673	292	79.5	99	193	52.5	51.5	0.38	0.35
1920-1945	6710	508	75.7	173	335	49.9	[illegible]	0.36	0.33
1946-1959	9298	826	88.8	325	501	53.9	52.8	0.38	0.36
1960-1969	10858	1024	94.3	472	552	50.8	49.8	0.36	0.34
1970-1979	11333	1125	99.3	615	510	[illegible]	44.1	0.32	0.30
1980-1989	12252	1059	86.4	648	411	33.5	32.9	0.24	0.22
1990-1992	2590	297	114.7	163	134	[illegible]	[illegible]	0.37	0.34
1993-1995	2059	190	92.3	113	77	37.4	36.7	0.27	0.25
size (sq. ft)									
1001-5000	6338.0	708	111.7	380	[illegible]	[illegible]	50.7	0.37	0.35
5001-10000	7530.0	624	82.9	238	[illegible]	[illegible]	50.3	0.37	0.34
10001-25000	11617.0	824	70.9	384	440	37.9	37.1	0.27	0.25
25001-50000	7676.0	630	82.1	316	314	[illegible]	40.1	0.29	0.27
50001-100000	7968.0	698	87.6	[illegible]	335	42.0	41.2	0.30	0.28
100001-200000	6776.0	687	101.4	337	350	51.7	50.6	0.37	0.34
200001-500000	5553.0	636	114.5	307	[illegible]	59.2	58.1	0.42	0.39
over 500000	5313.0	514	96.7	282	232	43.7	42.8	0.31	0.29
Northeast	11883.0	1035	87.1	436	599	50.4	49.4	0.36	0.34

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