APPENDIX G

AIR QUALITY

G.1 REGIONAL EMISSIONS ANALYSIS

Mobile source emission factors for the regional analysis, presented in Table 1, were calculated using EPA's MOBILE6.2 model, based on the approach and the data used to model NO_x and VOCs in New York County for the 2003 update to the New York ozone SIP, as submitted by NYSDEC to EPA and described below in Section G.2. This procedure includes the speed/VMT breakdown for each roadway and vehicle type in New York County. CO concentrations followed that same procedure, but employed a temperature of 52.3° F (for a description of the process for determining winter CO model temperature see the methodology for mobile sources in Chapter 14, "Air Quality".). PM emissions calculations were performed in the same manner, but an additional factor of 0.75 g/VMT was added for fugitive road dust, calculated based on EPA's AP-42 and the procedures specified for New York City in the *CEQR Technical Manual*, as described in Chapter 14, "Air Quality." It was assumed that regional trips to the site would 80 percent on urban principal arterial, 10 percent on minor arterial and 10 percent collector roadways.

Table G-1
Average Regional Vehicle Emission Factors by Year and Vehicle Type

Pollutant	Vehicle Type	2009	2010	2011	2012	2013	2014	2015	2020
NOx	Car	0.74	0.67	0.61	0.56	0.52	0.48	0.43	0.30
	Bus	12.48	11.61	10.72	10.53	9.72	8.40	7.47	4.73
	Truck	6.09	5.15	4.43	3.72	3.08	2.67	2.31	1.21
CO	Car	12.51	11.95	11.56	11.11	10.80	10.47	10.14	9.10
	Bus	5.98	5.33	4.96	4.06	3.89	3.65	3.07	1.92
	Truck	15.56	14.40	13.31	12.50	12.11	11.64	11.29	10.45
VOC	Car	1.07	0.94	0.83	0.73	0.66	0.60	0.55	0.44
	Bus	1.34	1.23	1.18	1.17	1.13	1.03	0.94	0.75
	Truck	1.74	1.58	1.38	1.28	1.18	1.08	1.00	0.76
PM_{10}	Car	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775
	Bus	0.973	0.931	0.917	0.897	0.885	0.870	0.859	0.842
	Truck	0.973	0.931	0.917	0.897	0.885	0.870	0.859	0.842

Notes: Calculated using NYSDEC MOBILE6 files and data, and CEQR procedures for fugitive dust.
Sources: MOBILE6; AP-42 (for PM_{10} only)

G.2 MOBILE SOURCE ANALYSIS

G.2.1 EMISSIONS MODEL

Aside from the change in direction of Liberty Street due to the Proposed Action, all roadway parameters for Proposed Action were the same as those for the future without the Proposed Action, in both the Pre-September 11 and the Current Conditions Scenarios.

Since the greatest traffic volumes were predicted for the evening peak, and since CO analyses were performed using the CAL3QHC screening model which does not utilize time-sensitive meteorological data, CO analyses were performed for that period. Particulate matter models were all CAL3QHCR analyses utilizing five years of hourly meteorological data over the entire day.

MOBILE6 SIP preparation input files were obtained DEC; all settings regarding vehicle registration, inspection and maintenance programs, diesel fractions, mile accumulation fuels and fuel programs were taken from those files. Additionally, specific taxi registration data obtained from NYCDEP were used for taxis. Since SUVs have similar emissions to LDGT, but have registration and start-per-day similar to cars, a separate file was prepared for SUVs accordingly. For VOCs and NO_x summertime conditions were used, as in the SIP. For CO, worst case winter conditions were used. Since CO emissions are for short-term calculations, no hourly distribution of any variables were used (the SIP calculations utilize a daily profile). When in doubt, CO analyses assumed all trucks to be HDGT, which emit more CO. Detailed breakdown of vehicle types to sub categories (which are not detailed in field counts or other specific data) was performed by utilizing the fraction of each sub category from the broader category as in the New York State registration data (e.g., MOBILE6 utilizes four categories of LDGT). All construction trucks were assumed to be the heaviest category of HDDV.

G.2.2 SPECIAL APPLICATION OF DISPERSION MODELS

TUNNEL EMISSIONS

The dispersion of pollutants from the proposed short bypass tunnel alternative for Route 9A was modeled within the same traffic modeling framework, with a special procedure applied to the tunnel emissions. The tunnel would consist of two separate tubes, one for each traffic direction. Vehicle engine missions within the tunnel would be mixed within the tunnel air and emitted via the exit portals. Air flow in the tunnel would be induced by a longitudinal, portal to portal jet fan ventilation system assisted by the traffic induced piston air flow.

This type of emission, known as turbulent horizontal jet flow, has similar dispersion to vertical point source emissions in that the concentrations are highest at the source, in this case the portal, and decrease as the pollutants disperse from the source. However, the CAL3 model does not provide for initial horizontal momentum due to the exit velocity; in the model emissions are dispersed downwind only. Since the initial jet is confined within the exit depressed section, this situation can be simulated by placing a line source along a small section starting out from the exit portal, and emitting the entire mass that would be emitted inside the tunnel. The estimated link length of 60 meters (roughly 197 feet) was based on the low end of measured jet length estimates in a physical road tunnel study performed by RWDI (Nadel C. *et al*, Physical Modeling of Dispersion of a Tunnel Portal Exhaust Plume, *8th International Conference on Aerodynamics and Ventilation of Vehicle Tunnels*, Vol. 12, 1994), producing a conservatively

high estimate of concentrations. This simulation produces higher concentrations further downwind due to the emission all along the line (rather that from the portal only), and is still conservatively high near the portal due to the concentrated mass emission from the line source (rather than a well mixed volume actually produced by tunnel ventilation).

In the model, in order to achieve the correct total mass emission rate, the jet links included the correct traffic volumes flowing through the tunnel, with the per–mile emission rate multiplied by the ratio between the actual tunnel length (where the emission actually occurs) and the 60 meter length used for the jet (e.g. the tunnel length was 325 meters, emissions were multiplied by 325/60=5.42).

Both the jet links, described above, and the tunnel approach and exit links were modeled as depressed links.

BUS LOADING AND UNLOADING AREA

The Greenwich Street area from Liberty to Vesey Street would function as a loading and unloading area for tour busses bringing visitors to the site. These buses would idle for up to three minutes while passengers embark or disembark. Since particulate matter is the main pollutant of concern in regard to diesel bus emissions, $PM_{2.5}$ and PM_{10} were analyzed for this location. The CAL3 model does not provide for stationary emissions such as this one; the model does have a provision for idle emissions from queuing at traffic lights, but since neither the timing of this case, nor the physical layout of the buses can be emulated as a traffic light, the use of queuing links was deemed inappropriate for this model. (The buses are expected to line up starting at the intersection of Fulton Street, with the line extending south as necessary.)

The bus idle emissions were modeled as a free flow link. Total average emissions were calculated, as presented in Table G-2, on an hourly basis by multiplying the idle emission rate by three minutes per arrival/departure, and divided by 60 minutes and by the length of the link to produce a pseudo per mile emission rate needed for CAL3; the link length was calculated as the minimum bus parking length, 12.2 meter, multiplied by the number of berths needed in any given hour. These calculations were performed for the annual average, used to model annual concentrations, and peak, used to model peak 24-hour concentrations.

Links were then placed accordingly, one for each hour of bus activity. Since this would not be a moving lane, and since the exhaust of standing busses are actually point sources, emissions would have less vertical and horizontal dispersion; to simulate this, a very narrow mixing width of one meter was employed (vertical dispersion in CAL3 is based on the horizontal, so this would limit both.)

G.2.3 RECEPTOR LOCATIONS

Standard receptor locations, used for CO, PM_{10} and local $PM_{2.5}$ analyses, were located on sidewalks just outside of the roadway mixing zone. The NYCDEP procedure for neighborhood scale corridor $PM_{2.5}$ modeling is based on the procedure for placement of ambient air quality monitoring stations, defined in Part 58 Appendix E. The procedure calls for the placement of PM_{10} monitors at a minimum distance of 15 meters from the roadway or 1 meter for every 1,000 vehicles average daily traffic—the greater of the two distances. Receptors in the annual $PM_{2.5}$ neighborhood scale models were placed at a minimum distance of 15 meters from the nearest moving lane; in cases where the average daily traffic (ADT) exceeds 15,000, the receptor

distance was calculated as 1 meter per 1,000 daily vehicles based on the lowest ADT from all of the scenarios run.

Table G-2
Bus Idle Emissions Calculation—2009

Hour	Arrivals	No. of Berths	Departures	No. Berths	Total Trips	Idle Time (hrs per hr)	Total Berths	Link Length (meters)	PM_{10} EF (g/mile)	$PM_{2.5}$ EF (g/mile)
Average Month Tour Bus Volumes (annual)										
24-9	0	0	0	0	0	0	0	-	-	-
9-10	8	1	3	1	11	0.53	3	32	67.9	62.5
10-11	12	3	7	3	19	0.93	5	65	59.4	54.7
11-12	13	3	13	4	27	1.33	7	81	67.9	62.5
12-13	33	7	16	4	49	2.46	11	130	78.5	72.2
13-14	21	4	19	5	40	2.00	9	114	72.8	66.9
14-15	17	4	40	11	57	2.86	15	178	66.4	61.1
15-16	15	3	20	5	35	1.73	8	97	73.6	67.7
16-17	9	3	13	4	23	1.13	7	81	57.7	53.1
17-18	4	1	3	1	7	0.33	3	32	42.4	39.0
18-24	0	0	0	0	0	0	0	-	-	-
Peak Tour Bus Volumes (24-hour)										
24-9	0	0	0	0	0	0	0	-	-	-
9-10	12	3	4	1	16	0.80	4	49	67.9	62.5
10-11	17	4	9	3	27	1.33	7	81	67.9	62.5
11-12	20	4	20	5	40	2.00	9	114	72.8	66.9
12-13	49	9	24	7	73	3.66	16	195	77.8	71.6
13-14	32	5	28	8	60	2.99	13	162	76.4	70.3
14-15	25	5	60	16	85	4.26	21	260	67.9	62.5
15-16	21	4	29	8	51	2.53	12	146	71.7	65.9
16-17	13	3	20	5	33	1.66	8	97	70.7	65.1
17-18	5	1	4	1	9	0.47	3	32	59.4	54.7
18-24	0	0	0	0	0	0	0	-	-	-

Notes: Mobile 6.2 Idle emission factors (g/hr): 2.5739 PM_{10} ; 2.368 $PM_{2.5}$
Sources: PANYNJ Traffic Engineering

G.3 BELOW GRADE VEHICLE FACILITIES

The hourly number of busses, trucks and cars entering and exiting the garage were based on the same data used for the mobile source PM_{10} analysis. Peak hour movements were calculated for hypothetical ventilation zones as presented in Table G-3 below. VMT by vehicle type and zone were calculated based on those movements, as presented in Table G-4. Based on the daily traffic

profile, presented in Table G-6, the average daily emission rate would be 24%, and the peak 8-hour emissions would be 35% of the sum of the three peak emissions (AM + mid day + PM). Total calculated emissions by zone are presented in Table G-7. All exiting cars were assumed to be cold, and all entering and exiting vehicles were assumed to idle for 3 minutes.

As described in Chapter 14, "Air Quality", ISC was run for a generic elevated source. No additional plume rise was assumed, and the emissions were simulated from a vent of 1 meter in diameter with a zero velocity. Results of that run, presented in Table G-8, were applied as a factor to calculate the resulting maximum concentrations for each pollutant and averaging time (presented in Chapter 14, "Air Quality"), by multiplying the result from the 1 g/s model, by the predicted g/s emission from the source (note the difference in time scale g/s v. g/hr). It was assumed that all of the emissions would be from two vents only, one with the northern entrance and half of other parking levels, the other with the southern entrance, security area and half of other levels. Data for 2015 is presented in Tables G-9 through G-12.

Table G-3
Distances Traveled and Vehicle Volumes per Area—2009

Ventilation Zone	Description	Distance [ft]	am Peak Volume				mid-day Peak Volume				pm Peak Volume			
			Car in	Car out	Truck	Bus	Car in	Car out	Truck	Bus	Car in	Car out	Truck	Bus
1	Level -1 Vesey entrance/exit way via security	1775.0	83	1	13	0	43	8	16	18	4	16	6	27
2	Level -1 West@Liberty entrance/exit way via security	1104.0		1	76	9		11	85	41		23	30	15
2	Level -1 9a tunnel exit way	228.0		1	57			16	63			32	24	
3	Level -2 ramp to truck delivery bay	1233.0			146				164				60	
3	Level -2 bus to site 26	1896.0				9				59				42
3	Level -2 car to ramp down	874.0	83	3			43	35			4	71		
4	Level -3 car to parking or drop off	681.0	83	3			43	35			4	71		

Notes:
Sources:

Table G-4
VMT per Peak Hour by zone and vehicle type—2009

Ventilation Zone	Description	VMT am peak hour				VMT mid-day peak hour				VMT pm peak hour			
		Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus
1	Level -1 Vesey entrance/exit ramp	27.9	0.3	4.4	0.0	14.5	2.7	5.4	6.1	1.3	5.4	2.0	9.1
2	Level -1 9a entrances and security	0.0	0.3	18.4	1.9	0.0	3.0	20.5	8.6	0.0	6.2	7.3	3.1
3	Level -2	0.0	0.0	34.1	3.2	0.0	0.0	38.3	21.2	0.0	0.0	14.0	15.1
4	Level -3	10.7	0.4	0.0	0.0	5.5	4.5	0.0	0.0	0.5	9.2	0.0	0.0
Notes:													
Sources:													

Table G-5
Emission Factors by Vehicle Type and Pollutant—2009

Vehicle Type	$PM_{2.5}$				CO			
	Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus
g/vmt @ 5mph	0.0119	0.0119	0.1724	1.2067	19.97	26.44	34.59	34.59
g/min	negligible	negligible	0.0171	0.0395	1.3433	1.6130	1.7513	1.7513
Notes: Assumes trucks are diesel for $PM_{2.5}$ and Gas for CO								
Sources: Mobile6								

Table G-6
Hourly Traffic Profile

Hour	Fraction of 3 Peak Hours
1	0.126
2	0.066
3	0.044
4	0.031
5	0.033
6	0.068
7	0.174
8	0.258
9	**0.376**
10	0.303
11	0.29
12	0.286
13	**0.407**
14	0.306
15	0.336
16	0.395
17	0.401
18	**0.217**
19	0.393
20	0.326
21	0.296
22	0.266
23	0.230
24	0.182
24-h avg	0.24
8-hour peak	0.35

Notes: Peak Hours are in **bold.** Peak 8-hour is 13:00-18:00

Table G-7
Total Emission Rate by Ventilation Zone—2009

Ventilation Zone	Total Average $PM_{2.5}$ Emissions (g/hr)				Total Average CO Emissions (g/hr)				
	am	mid-day	pm	avg 24-h	am	mid-day	pm	avg 8-h	avg 24-h
1	1.8	11.4	14.9	6.8	1124.9	1145.8	819.7	1074.5	748.2
2	13.3	26.3	9.7	11.9	1462.3	2208.2	1153.7	1677.3	1167.9
3	18.3	47.6	28.7	22.9	2454.5	3571.9	1847.8	2737.7	1906.2
4	0.1	0.1	0.1	0.1	573.0	572.8	612.1	611.2	425.6

Table G-8
Factors for Ambient Concentration Based on ISC Model Results

Period	factor (µg/m^3 per 1 g/s emission)	met date	X	Y
1-hour	566	01-04-15-10	45.96	-38.57
8-hour	174	02-10-24-16	23.94	-65.78
24-hour	65.1	02-06-19-24	10.42	-59.09
Annual	6.48	1999	-76.6	-64.28
Notes: Results from generic 1 g/s source ISC model, single 1m stack at 40', 1998-2002 met data from LaGuardia station.				

Table G-9
Distances Traveled and Vehicle Volumes per Area—2015

Ventilation Zone	Description	Distance [ft]	am Peak Volume				mid-day Peak Volume				pm Peak Volume			
			Car in	Car out	Truck	Bus	Car in	Car out	Truck	Bus	Car in	Car out	Truck	Bus
1	Level -1 Vesey entrance/exit way via security	1775.0	318	3	36	0	196		42	16	78		8	24
2	Level -1 West@Liberty entrance/exit way via security	1104.0		4	193	8		44	218	36		89	42	14
2	Level -1 9a tunnel exit way	228.0		6	143			60	160			123	32	
3	Level -2 ramp to truck delivery bay	1233.0			372				420				82	
3	Level -2 bus to site 26	1896.0				8				52				38
3	Level -2 car to ramp down	874.0	318	13			196	104			78	212		
4	Level -3 car to parking or drop off	681.0	318	13			196	104			78	212		

Table G-10
VMT per Peak Hour by zone and vehicle type—2015

Ventilation Zone	Description	VMT am peak hour				VMT mid-day peak hour				VMT pm peak hour			
		Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus
1	Level -1 Vesey entrance/exit ramp	106.9	1.0	12.1	0.0	65.9	0.0	14.1	5.4	26.2	0.0	2.7	8.1
2	Level -1 9a entrances and security	0.0	1.1	46.5	1.7	0.0	11.8	52.5	7.5	0.0	23.9	10.2	2.9
3	Level -2	0.0	0.0	86.9	2.9	0.0	0.0	98.1	18.7	0.0	0.0	19.1	13.6
4	Level -3	41.0	1.7	0.0	0.0	25.3	13.4	0.0	0.0	10.1	27.3	0.0	0.0

Table G-11
Emission Factors by Vehicle Type and Pollutant—2015

Vehicle Type	$PM_{2.5}$				CO			
	Car	Cold Car	Truck	Bus	Car	Cold Car	Truck	Bus
g/vmt @ 5mph	0.0115	0.0115	0.0666	0.6555	16.02	22.04	27.71	2.51
g/min	negligible	negligible	0.0156	0.0197	1.0417	1.2930	1.3967	0.1280

Notes: Assumes trucks are diesel for $PM_{2.5}$ and Gas for CO
Sources: Mobile6

Table G-12
Total Emission Rate by Ventilation Zone—2015

Ventilation Zone	Total Average $PM_{2.5}$ Emissions (g/hr)				Total Average CO Emissions (g/hr)				
	am	mid-day	pm	avg 24-h	am	mid-day	pm	avg 8-h	avg 24-h
1	3.7	8.1	7.6	4.7	3226.5	2255.0	801.3	2184.4	1521.0
2	20.4	28.3	7.2	13.5	2767.4	3734.4	1954.0	2939.9	2047.0
3	25.5	41.5	16.3	20.2	5020.4	5560.4	1888.1	4335.1	3018.5
4	0.5	0.4	0.4	0.3	1738.2	1716.6	1829.9	1837.4	1279.3

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