Appendix D: Emissions Analyses

Emissions Analyses Narrative for the Midwest City Water Infrastructure Improvements Project

The two scenarios that were assessed are Future without Project (FWOP) and Future with Project (FWP). For the FWP scenario, the primary source of pollutant emissions associated with this project are from emissions generated during construction of the project. The total emissions for the FWP scenario include the emissions from the 2-year construction project, operations and maintenance (O&M) required for structure maintenance and annual landscaping based on a 50-year lifespan, and embodied carbon in cement. The emissions from combustion engines for construction and O&M were incorporated into the Net Emissions Analysis Tool (NEAT) model, where the effect of cement needed for construction equipment was also included in the FWP scenario. The FWOP alternative does not include these emission sources and, for purposes of this study, the emissions over the 50-year lifespan for FWOP are negligible. Details on these inputs are described below.

Estimated equipment hours of operation, horsepower and crew size were used to compute the pollutant emissions for the duration of the construction period, while estimated monthly maintenance visits and annual landscaping were used to compute the pollutant emissions of the 50-year lifespan. These are conservative estimates meant to serve as high overestimates that are resulting in worst-case scenario of emissions. The estimates were obtained from the design contractor, Garver, since there is no guarantee that the construction contractor will use the same equipment. For a conservative estimate, the highest load factor between diesel and gasoline engines for off-road equipment was used. Emission factors were estimated for off-road equipment and on-road vehicles based on equipment with similar horsepower. Emission factors for on-road equipment were estimated based on similar equipment and were assumed to contain a full load for analysis purposes. Crew sizes are assumed to consist of passenger vehicles and light-duty trucks for commuting, and crew is assumed to work 5 days per week with an assumed travel distance of 30 miles roundtrip given that the project is in an urban area. Ratio of cement volume to mass of embodied carbon dioxide emissions generated is an average estimate based off the different proportions for concrete mixture. To simplify analysis, the total of embodied carbon emissions from cement were incorporated into the Eastside EST site analysis. Note that lead emissions were not included in the analysis due to load and emission factors being unavailable.

Although overall construction duration of the project is 2 years, the construction is divided between the 4 project sites. The construction periods for the 4 project sites do not fully overlap each other. Each project site has a different construction duration, but the longest duration is one year. Because of these factors, pollutant emissions were calculated individually for each project site. Table 1 presents the estimated annual pollutant emissions for each project site during the construction year. Estimated O&M activities of monthly maintenance and annual landscaping is anticipated only for the Eastside EST site; Table 2 presents the estimated projection of pollutant emissions from O&M throughout the 50-year lifespan. Per the NEAT analysis, net carbon dioxide emissions for the FWP are estimated at 1,953.00 MT, a sum of carbon dioxide emissions from all four project sites during construction and O&M at the Eastside EST. This figure does not include carbon dioxide equivalents of other pollutant emission estimates. Table 3 presents the estimated total pollutant emissions for the FWP. See Attachment to this Emissions Analyses for additional information on the emissions analytical results.

Emissions Summary Tables

Table 1: Annual pollutant emissions estimates during construction for each project site in FWP.

Project Site Name	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	ROG/ VOC (MT)	CO (MT)	SO_x (MT)	NO_x (MT)	PM 2.5 (MT)	PM 10 (MT)
Eastside EST Site	771.56	4.12	17.09	0.39	2.10	0.01	4.62	0.31	0.32
WTP and HSPS Site	989.79	6.18	25.63	0.59	3.15	0.02	6.94	0.47	0.49
Titan Tower Site	91.88	0.57	2.54	0.06	0.33	0.002	0.67	0.05	0.05
SE 15th and Westminster Site	91.88	0.57	2.54	0.06	0.33	0.002	0.67	0.05	0.05
TOTAL	**1,945.11**	**11.44**	**47.80**	**1.10**	**5.91**	**0.034**	**12.90**	**0.88**	**0.91**

Notes:

CH_4 = methane
CO = carbon monoxide
CO_2 = carbon dioxide
FWP = Future with Project
MT = metric ton
N_2O = nitrous oxide
NO_x = nitrogen oxides
PM 2.5 = Particulate Matter 2.5 microns
PM 10 = Particulate Matter 10 microns
SO_x = sulfur oxides
ROG = Reactive Organic Gases
VOC = Volatile Organic Compounds

Table 2: Annual pollutant emissions projection estimates from O&M at Eastside EST site throughout the 50-year lifespan.

Year	CO_2 (kg/yr)	CH_4 (kg/yr)	N_2O (kg/yr)	ROG/ VOC (kg/yr)	CO (kg/yr)	SO_x (kg/yr)	NO_x (kg/yr)	PM 2.5 (kg/yr)	PM 10 (kg/yr)
2026	157.950	0.004	0.004	0.074	0.582	0.002	0.048	0.011	0.017
…	…	…	…	…	…	…	…	…	…
2076	157.950	0.004	0.004	0.074	0.582	0.002	0.048	0.011	0.017
O&M TOTAL (kg)	**7,897.50**	**0.215**	**0.195**	**3.719**	**29.081**	**0.095**	**2.401**	**0.567**	**0.857**

Notes:

Since emissions from O&M are considerably low, this table uses kilograms as units instead of metric tons.

CH_4 = methane
CO = carbon monoxide
CO_2 = carbon dioxide
kg = kilograms
kg/yr = kilograms per year
N_2O = nitrous oxide
NO_x = nitrogen oxides
O&M = operations and maintenance
PM 2.5 = Particulate Matter 2.5 microns
PM 10 = Particulate Matter 10 microns
SO_x = sulfur oxides
ROG = Reactive Organic Gases
VOC = Volatile Organic Compounds

Table 3: Net pollutant emissions estimates for FWP for each of the project sites.

Project Site Name	CO_2 (MT)	CH_4 (MT)	N_2O (MT)	ROG/ VOC (MT)	CO (MT)	SO_x (MT)	NO_x (MT)	PM 2.5 (MT)	PM 10 (MT)
Eastside EST Site	779.45	4.12	17.09	0.40	2.12	0.01	4.62	0.31	0.32
WTP and HSPS Site	989.79	6.18	25.63	0.59	3.15	0.02	6.94	0.47	0.49
Titan Tower Site	91.88	0.57	2.54	0.06	0.33	0.002	0.67	0.05	0.05
SE 15th and Westminster Site	91.88	0.57	2.54	0.06	0.33	0.002	0.67	0.05	0.05
TOTAL	**1,953.00**	**11.44**	**47.80**	**1.11**	**5.93**	**0.034**	**12.90**	**0.88**	**0.91**

Notes:

CH_4 = methane
CO = carbon monoxide
CO_2 = carbon dioxide
FWP = Future with Project
MT = metric ton
N_2O = nitrous oxide
NO_x = nitrogen oxides
PM 2.5 = Particulate Matter 2.5 microns
PM 10 = Particulate Matter 10 microns
SO_x = sulfur oxides
ROG = Reactive Organic Gases
VOC = Volatile Organic Compounds

Emissions Calculation Tables for EST Eastside Site

Duration – 8 months

Crew size – 6

Construction Emissions from off-road equipment

Carbon Dioxide						
Equipment Type	**Equipment Amount**	**Horsepower (HP)**	**Hours**	**Load Factor (LF)**	**Emission Factor (EF) (g of CO2 per HP per hour)**	**Total Emissions (g)**
Excavator	2	315	640	0.59	536.17951	127550671.3
Crane	2	270	640	0.47	530.29401	86136716.63
Construction Trucks	2	400	1280	0.59	535.9032139	323771285.7
Frontend loader	2	191	640	0.48	623.80773	73204086.64

Note: Load factors and emission factors for "Other Construction Equipment" was used for Construction Truck estimates. This applies through all sites.

Methane						
Equipment Type	**Equipment Amount**	**Horsepower (HP)**	**Hours**	**Load Factor (LF)**	**Emission Factor (EF) (g of CH4 per HP per hour)**	**Total Emissions (g)**
Excavator	2	315	640	0.59	2.6308336	625843.7434
Crane	2	270	640	0.47	2.2226008	361021.4931
Construction Trucks	2	400	1280	0.59	4.8534344	2932250.927
Frontend loader	2	191	640	0.48	1.7236496	202270.97

Nitrous Oxide						
Equipment Type	**Equipment Amount**	**Horsepower (HP)**	**Hours**	**Load Factor (LF)**	**Emission Factor (EF) (g of N2O per HP per hour)**	**Total Emissions (g)**
Excavator	2	315	640	0.59	15.0002601	3568381.875
Crane	2	270	640	0.47	14.83560623	2409777.191
Construction Trucks	2	400	1280	0.59	14.99253039	9057887.16
Frontend loader	2	191	640	0.48	17.45176388	2047971.471

Note: Emission factors for nitrous oxide from off-road equipment were derived from the ratio between emission factors for the on-road equipment (cement truck and semi-truck in grams/short ton-mile) due to limitations in availability of emission factors for nitrous oxide from the off-road equipment.

Reactive Organic Gases aka Volatile Organic Compounds						
Equipment Type	**Equipment Amount**	**Horsepower (HP)**	**Hours**	**Load Factor (LF)**	**Emission Factor (EF) (g of N2O per HP per hour)**	**Total Emissions (g)**
Excavator	2	315	640	0.59	0.218660636	52016.74138
Crane	2	270	640	0.47	0.2516986	40883.907
Construction Trucks	2	400	1280	0.59	0.306230491	185012.2134
Frontend loader	2	191	640	0.48	0.92114671	108096.9349

Carbon Monoxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	640	0.59	0.94443	224668.5638
Crane	2	270	640	0.47	0.706243	114716.463
Construction Trucks	2	400	1280	0.59	2.13603394	1290506.265
Frontend loader	2	191	640	0.48	3.5191138	412969.4121

Sulfur Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	640	0.59	0.009084	2160.974592
Crane	2	270	640	0.47	0.0092126	1496.421043
Construction Trucks	2	400	1280	0.59	0.009513511	5747.682806
Frontend loader	2	191	640	0.48	0.0112681	1322.316042

Nitrogen Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	640	0.59	2.6731554	635911.5918
Crane	2	270	640	0.47	3.3541777	544825.7922
Construction Trucks	2	400	1280	0.59	4.572203408	2762342.411
Frontend loader	2	191	640	0.48	5.564499	652996.1834

Particulate Matter – 2.5 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	640	0.59	0.18113	43088.65344
Crane	2	270	640	0.47	0.1478959	24023.02683
Construction Trucks	2	400	1280	0.59	0.284915615	172134.618
Frontend loader	2	191	640	0.48	0.6176165	72477.54332

Particulate Matter – 10 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	640	0.59	0.1867319	44421.27823
Crane	2	270	640	0.47	0.15247	24766.00704
Construction Trucks	2	400	1280	0.59	0.293727438	177458.3689
Frontend loader	2	191	640	0.48	0.636718	74719.11199

Construction Emissions from on-road equipment

Equipment	number of vehicles	Estimate weight (short ton)	estimate miles for round trip	CO2 factor (kg CO2/short ton-mile)	CH4 factor (g CH4/short ton-mile)	N2O factor (g N2O/short ton-mile)	CO2 emissions (g)	CH4 emissions (g)	N2O emissions (g)
Cement truck	2	33	2000	0.168	0.0015	0.0047	22176	198	620.4
Semi - Equipment Dropoff	2	40	500	0.168	0.0015	0.0047	6720	60	188

Equipment	number of vehicles	Estimate weight (short ton)	estimate miles for round trip	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
Cement truck	2	33	2000	0.350073371	1.906432285	0.017897412	4.077746263	0.156781326	0.211905354	1400.293	7625.729	71.58965	16310.99	627.1253	847.6214
Semi - Equipment Dropoff	2	40	500	0.350073371	1.906432285	0.017897412	4.077746263	0.156781326	0.211905354	350.0734	1906.432	17.89741	4077.746	156.7813	211.9054

Construction Emissions from on-road crew vehicles

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	CO2 factor (kg CO2/vehicle-mile)	CH4 factor (g CH4/vehicle-mile)	N2O factor (g N2O/vehicle-mile)	CO2 emissions (kg)	CH4 emissions (g)	N2O emissions (g)
passenger car for commuting	3	30	160	0.306	0.009	0.006	4406.4	129.6	86.4
light-duty truck for commuting	3	30	160	0.405	0.011	0.01	5832	158.4	144

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
passenger car for commuting	3	30	160	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	2746.752627	21474.94	70.27033	1772.773	419.0072	632.7598
light-duty truck for commuting	3	30	160	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	2746.752627	21474.94	70.27033	1772.773	419.0072	632.7598

Embodied carbon emissions from cement during construction

Cement needed for construction (cubic yards)	Cement (cubic meters)	CO2 conversion factor (CO2 kg/cement cubic meters)	CO2 emissions from embodied carbon in cement (kg)	CO2 emissions from embodied carbon in cement (lbs)
455	347.875608	350	121756.4628	268426.733

Note: This calculation includes cement projections for the entirety of the project. Calculations were included under the EST Eastside calculations due to most of the cement being used at this site.

Emissions from on-road crew vehicles to complete O&M

Crew	number of vehicles	estimate miles for round trip	days in one year	CO2 factor (kg CO2/vehicle-mile)	CH4 factor (g CH4/vehicle-mile)	N2O factor (g N2O/vehicle-mile)	CO2 emissions (kg)	CH4 emissions (g)	N2O emissions (g)
light-duty truck for commuting (monthly maintenance)	1	30	12	0.405	0.011	0.01	145.8	3.96	3.6
light-duty truck for commuting (annual landscaping)	1	30	1	0.405	0.011	0.01	12.15	0.33	0.3

Crew	number of vehicles	estimate miles for round trip	days in one year	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
light-duty truck for commuting (monthly maintenance)	1	30	12	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	68.66881568	536.87346	1.756758136	44.31933083	10.47518107	15.81899419
light-duty truck for commuting (annual landscaping)	1	30	1	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	5.722401307	44.739455	0.146396511	3.693277569	0.872931756	1.318249516

Emissions Calculation Tables for WTP and HSPS Site

Duration – 12 months

Crew size – 6

Construction Emissions from off-road equipment

Carbon Dioxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CO2 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	536.17951	191326006.9
Crane	2	270	960	0.47	530.29401	129205074.9
Construction Trucks	2	400	1920	0.59	535.9032139	485656928.6
Frontend loader	2	191	960	0.48	623.80773	109806130

Methane						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	2.6308336	938765.6152
Crane	2	270	960	0.47	2.2226008	541532.2397
Construction Trucks	2	400	1920	0.59	4.8534344	4398376.391
Frontend loader	2	191	960	0.48	1.7236496	303406.455

Nitrous Oxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	15.0002601	5352572.812
Crane	2	270	960	0.47	14.83560623	3614665.787
Construction Trucks	2	400	1920	0.59	14.99253039	13586830.74
Frontend loader	2	191	960	0.48	17.45176388	3071957.207

Note: Emission factors for nitrous oxide from off-road equipment were derived from the ratio between emission factors for the on-road equipment (cement truck and semi-truck in grams/short ton-mile) due to limitations in availability of emission factors for nitrous oxide from the off-road equipment.

Reactive Organic Gases aka Volatile Organic Compounds						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	0.218660636	78025.11207
Crane	2	270	960	0.47	0.2516986	61325.86049
Construction Trucks	2	400	1920	0.59	0.306230491	277518.3202
Frontend loader	2	191	960	0.48	0.92114671	162145.4023

Carbon Monoxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	0.94443	337002.8458
Crane	2	270	960	0.47	0.706243	172074.6945
Construction Trucks	2	400	1920	0.59	2.13603394	1935759.398
Frontend loader	2	191	960	0.48	3.5191138	619454.1181

Sulfur Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	0.009084	3241.461888
Crane	2	270	960	0.47	0.0092126	2244.631565
Construction Trucks	2	400	1920	0.59	0.009513511	8621.524209
Frontend loader	2	191	960	0.48	0.0112681	1983.474063

Nitrogen Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	2.6731554	953867.3877
Crane	2	270	960	0.47	3.3541777	817238.6882
Construction Trucks	2	400	1920	0.59	4.572203408	4143513.616
Frontend loader	2	191	960	0.48	5.564499	979494.2752

Particulate Matter – 2.5 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	0.18113	64632.98016
Crane	2	270	960	0.47	0.1478959	36034.54024
Construction Trucks	2	400	1920	0.59	0.284915615	258201.9269
Frontend loader	2	191	960	0.48	0.6176165	108716.315

Particulate Matter – 10 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	2	315	960	0.59	0.1867319	66631.91734
Crane	2	270	960	0.47	0.15247	37149.01056
Construction Trucks	2	400	1920	0.59	0.293727438	266187.5534
Frontend loader	2	191	960	0.48	0.636718	112078.668

Construction Emissions from on-road equipment

Equipment	number of vehicles	Estimate weight (short ton)	estimate miles for round trip	CO2 factor (kg CO2/short ton-mile)	CH4 factor (g CH4/short ton-mile)	N2O factor (g N2O/short ton-mile)	CO2 emissions (g)	CH4 emissions (g)	N2O emissions (g)
Cement truck	2	33	4000	0.168	0.0015	0.0047	44352	396	1240.8
Semi - Equipment Dropoff	2	40	1000	0.168	0.0015	0.0047	13440	120	376

Equipment	number of vehicles	Estimate weight (short ton)	estimate miles for round trip	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
Cement truck	2	33	4000	0.350073371	1.906432285	0.017897412	4.077746263	0.156781326	0.211905354	2800.58697	15251.458	143.1792929	32621.9701	1254.250606	1695.242828
Semi - Equipment Dropoff	2	40	1000	0.350073371	1.906432285	0.017897412	4.077746263	0.156781326	0.211905354	700.1467424	3812.8646	35.79482323	8155.492525	313.5626515	423.8107071

Construction Emissions from on-road crew vehicles

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	CO2 factor (kg CO2/vehicle-mile)	CH4 factor (g CH4/vehicle-mile)	N2O factor (g N2O/vehicle-mile)	CO2 emissions (kg)	CH4 emissions (g)	N2O emissions (g)
passenger car for commuting	3	30	250	0.306	0.009	0.006	6885	202.5	135
light-duty truck for commuting	3	30	250	0.405	0.011	0.01	9112.5	247.5	225

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
passenger car for commuting	3	30	250	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	4291.80098	33554.591	109.7973835	2769.958177	654.6988168	988.6871368
light-duty truck for commuting	3	30	250	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	4291.80098	33554.591	109.7973835	2769.958177	654.6988168	988.6871368

Emissions Calculation Tables for Titan Tower Site

Duration – 2 months

Crew size – 3

Construction Emissions from off-road equipment

Carbon Dioxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CO2 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	536.17951	31887667.82
Construction Trucks	1	400	320	0.59	535.9032139	40471410.71
Frontend loader	1	191	320	0.48	623.80773	18301021.66

Methane						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	2.6308336	156460.9359
Construction Trucks	1	400	320	0.59	4.8534344	366531.3659
Frontend loader	1	191	320	0.48	1.7236496	50567.7425

Nitrous Oxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	15.0002601	892095.4687
Construction Trucks	1	400	320	0.59	14.99253039	1132235.895
Frontend loader	1	191	320	0.48	17.45176388	511992.8679

Note: Emission factors for nitrous oxide from off-road equipment were derived from the ratio between emission factors for the on-road equipment (cement truck and semi-truck in grams/short ton-mile) due to limitations in availability of emission factors for nitrous oxide from the off-road equipment.

Reactive Organic Gases aka Volatile Organic Compounds						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.218660636	13004.18534
Construction Trucks	1	400	320	0.59	0.306230491	23126.52668
Frontend loader	1	191	320	0.48	0.92114671	27024.23372

Carbon Monoxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.94443	56167.14096
Construction Trucks	1	400	320	0.59	2.13603394	161313.2831
Frontend loader	1	191	320	0.48	3.5191138	103242.353

Sulfur Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.009084	540.243648
Construction Trucks	1	400	320	0.59	0.009513511	718.4603507
Frontend loader	1	191	320	0.48	0.0112681	330.5790106

Nitrogen Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	2.6731554	158977.8979
Construction Trucks	1	400	320	0.59	4.572203408	345292.8014
Frontend loader	1	191	320	0.48	5.564499	163249.0459

Particulate Matter – 2.5 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.18113	10772.16336
Construction Trucks	1	400	320	0.59	0.284915615	21516.82724
Frontend loader	1	191	320	0.48	0.6176165	18119.38583

Particulate Matter – 10 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.1867319	11105.31956
Construction Trucks	1	400	320	0.59	0.293727438	22182.29612
Frontend loader	1	191	320	0.48	0.636718	18679.778

Construction Emissions from on-road crew vehicles

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	CO2 factor (kg CO2/vehicle-mile)	CH4 factor (g CH4/vehicle-mile)	N2O factor (g N2O/vehicle-mile)	CO2 emissions (kg)	CH4 emissions (g)	N2O emissions (g)
passenger car for commuting	2	30	40	0.306	0.009	0.006	734.4	21.6	14.4
light-duty truck for commuting	1	30	40	0.405	0.011	0.01	486	13.2	12

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
passenger car for commuting	2	30	40	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	457.7921046	3579.1564	11.7117209	295.4622055	69.83454046	105.4599613
light-duty truck for commuting	1	30	40	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	228.8960523	1789.5782	5.855860452	147.7311028	34.91727023	52.72998063

Emissions Calculation Tables for 15TH and Westminster Site

Duration – 2 months

Crew size – 3

Construction Emissions from off-road equipment

Carbon Dioxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CO2 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	536.17951	31887667.82
Construction Trucks	1	400	320	0.59	535.9032139	40471410.71
Frontend loader	1	191	320	0.48	623.80773	18301021.66

Methane						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	2.6308336	156460.9359
Construction Trucks	1	400	320	0.59	4.8534344	366531.3659
Frontend loader	1	191	320	0.48	1.7236496	50567.7425

Nitrous Oxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	15.0002601	892095.4687
Construction Trucks	1	400	320	0.59	14.99253039	1132235.895
Frontend loader	1	191	320	0.48	17.45176388	511992.8679

Note: Emission factors for nitrous oxide from off-road equipment were derived from the ratio between emission factors for the on-road equipment (cement truck and semi-truck in grams/short ton-mile) due to limitations in availability of emission factors for nitrous oxide from the off-road equipment.

Reactive Organic Gases aka Volatile Organic Compounds						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of N2O per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.218660636	13004.18534
Construction Trucks	1	400	320	0.59	0.306230491	23126.52668
Frontend loader	1	191	320	0.48	0.92114671	27024.23372

Carbon Monoxide						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.94443	56167.14096
Construction Trucks	1	400	320	0.59	2.13603394	161313.2831
Frontend loader	1	191	320	0.48	3.5191138	103242.353

Sulfur Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.009084	540.243648
Construction Trucks	1	400	320	0.59	0.009513511	718.4603507
Frontend loader	1	191	320	0.48	0.0112681	330.5790106

Nitrogen Oxides						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	2.6731554	158977.8979
Construction Trucks	1	400	320	0.59	4.572203408	345292.8014
Frontend loader	1	191	320	0.48	5.564499	163249.0459

Particulate Matter – 2.5 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.18113	10772.16336
Construction Trucks	1	400	320	0.59	0.284915615	21516.82724
Frontend loader	1	191	320	0.48	0.6176165	18119.38583

Particulate Matter – 10 microns						
Equipment Type	Equipment Amount	Horsepower (HP)	Hours	Load Factor (LF)	Emission Factor (EF) (g of CH4 per HP per hour)	Total Emissions (g)
Excavator	1	315	320	0.59	0.1867319	11105.31956
Construction Trucks	1	400	320	0.59	0.293727438	22182.29612
Frontend loader	1	191	320	0.48	0.636718	18679.778

Construction Emissions from on-road crew vehicles

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	CO2 factor (kg CO2/vehicle-mile)	CH4 factor (g CH4/vehicle-mile)	N2O factor (g N2O/vehicle-mile)	CO2 emissions (kg)	CH4 emissions (g)	N2O emissions (g)
passenger car for commuting	2	30	40	0.306	0.009	0.006	734.4	21.6	14.4
light-duty truck for commuting	1	30	40	0.405	0.011	0.01	486	13.2	12

Crew Vehicle	number of vehicles	estimate miles for round trip	days in one year	VOC (g/mile)	CO (g/mile)	SOx (g/mile)	NOx (g/mile)	PM2.5 (g/mile)	PM10 (g/mile)	VOC emissions (g)	CO emissions (g)	SOx emissions (g)	NOx emissions (g)	PM2.5 emissions (g)	PM10 emissions (g)
passenger car for commuting	2	30	40	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	457.7921046	3579.1564	11.7117209	295.4622055	69.83454046	105.4599613
light-duty truck for commuting	1	30	40	0.190747	1.491315159	0.004879884	0.123109252	0.029097725	0.043941651	228.8960523	1789.5782	5.855860452	147.7311028	34.91727023	52.72998063

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