Air Quality Assessment

Plaistow Commuter Rail Extension Study

Haverhill, MA to Plaistow, NH

March 17, 2015

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1 Introduction

Ambient air quality can be affected by “mobile sources” and “stationary sources.” Mobile sources of air pollutants include vehicular traffic or other moving sources of emissions. Sources that are in a fixed location are considered stationary sources. Stationary sources include boiler stacks and process exhausts from manufacturing and industrial operations. When a project or action is proposed, both mobile and stationary sources are considered in determining the need for an air quality impact assessment.

The Plaistow Commuter Rail Extension is a proposed extension of the Massachusetts Bay Transportation Authority (MBTA) Haverhill Line commuter rail from Haverhill, MA to Plaistow, NH. The project would include locomotives traveling the rail extension, a new Plaistow station and a layover facility. As a result, the Proposed Action has the potential to affect air quality from several sources of air emissions including fuel combustion (e.g., locomotive diesel engines) and construction activities (e.g., fugitive dust). Therefore, an assessment of the potential for air quality impacts was performed for the Proposed Action.

1.1 Pollutants of Concern

The pollutants of concern for this assessment are those for which National Ambient Air Quality Standards (NAAQS) have been established. The Clean Air Act (CAA) required that the U.S. Environmental Protection Agency (EPA) establish NAAQS for six pollutants. These pollutants have both “primary” and “secondary” standards. The “primary” ambient air quality standards have been established to protect the public health, while the “secondary” standards have been established to protect the public welfare and account for air pollutant effects on soil, water, visibility, materials, vegetation, and other aspects of the general welfare. These six pollutants are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM) which includes particles smaller than 10 microns in diameter, referred to as PM_{10} and particles smaller than 2.5 microns in diameter, referred to as $PM_{2.5}$, lead (Pb), and sulfur dioxide (SO_2). The NAAQS for these pollutants are provided in Table 1-1. As shown, the NAAQS include short-term averaging times (i.e., 1-hour, 3-hour, 8-hour and 24-hour) and long-term averaging times (i.e., 3 month, annual) depending on the pollutant. A description of these air pollutants is provided below.

Table 1-1. National Ambient Air Quality Standards

Pollutant	Primary	Secondary
CO		
1-Hour Average[1]	35 ppm	
8-Hour Average[1]	9 ppm	
Pb		
3 Month Rolling Average[2]	0.15 µg/m^3	0.15 µg/m^3
NO_2		
Annual Average	53 ppb	53 ppb
1-hour Average[3]	100 ppb	
O_3[4]		
8-Hour Average	0.075 ppm	0.075 ppm
$PM_{2.5}$		
24-Hour Average[5]	35 µg/m^3	35 µg/m^3
Annual Average[6]	12 µg/m^3	15 µg/m^3
PM_{10}		
24-Hour Average[7]	150 µg/m^3	150 µg/m^3
SO_2		
3-Hour Average[1]		0.5 ppm
1-Hour Average[8]	75 ppb	

Source: EPA National Ambient Air Quality Standards**.**

Notes:

(1) Not to be exceeded more than once per year.

(2) Not to be exceeded.

(3) 98th percentile of one-hour daily maximum concentrations averaged over 3 years.

(4) Annual fourth highest daily maximum of the 8-hour average concentration, averaged over three years. EPA has proposed lowering the primary standard to within the range of 0.060 – 0.070 ppm.

(5) 98th percentile, averaged over 3 years.

(6) Annual mean, averaged over 3 years.

(7) Not to be exceeded more than once per year on average over 3 years.

(8) 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.

1.1.1 CO

CO is produced in the urban environment primarily by the incomplete combustion of gasoline and other fossil fuels. In urban areas, most CO emissions are from motor vehicles. Since CO is a reactive gas which does not persist in the atmosphere, CO concentrations can vary greatly over relatively short distances; elevated concentrations are usually limited to locations near crowded intersections, heavily traveled and congested roadways, parking lots, and garages. Consequently, CO assessments are conducted on a local, or micro-scale, basis.

The Proposed Action would result in a decrease in vehicular traffic volumes in the study area which would effectively reduce CO emissions from passenger vehicles. However, the Proposed Action would also increase CO emissions associated with rail sources (e.g., locomotives). Therefore, this analysis provides a quantified assessment of CO emission levels for the Proposed Action.

1.1.2 Ozone, NO_x, and VOCs

Nitrogen oxides (NO_x), composed of NO_2 and nitrogen monoxide (NO), together with volatile organic compounds (VOCs), are precursor pollutants in the formation of ozone. Ozone is formed through a series of photochemical reactions that take place in the atmosphere in the presence of sunlight. Because the reactions are slow, and occur as the pollutants are carried downwind, elevated ozone levels are often found many miles from sources of the precursor pollutants. The effects of NO_x and VOC emissions are therefore, generally examined on a regional basis. Both NO_x and VOCs are products of fossil fuel combustion. VOCs are also common air pollutants released by industrial processes and commercial manufacturing sources.

In addition to its role in the formation of ozone, NO_2 is also a regulated pollutant. NO_2 is mostly formed from the transformation of NO after the release of NO_x emissions to the atmosphere. Similar to CO, NO_2 emissions are mostly the product of fossil fuel combustion.

The Proposed Action would result in a decrease in vehicular traffic volumes in the study area and would effectively reduce emissions from passenger vehicles for NO_x (including NO_2) and VOCs (VOCs are a subset of total hydrocarbons). However, the Proposed Action would also increase NO_x and VOC emissions associated with rail sources (e.g., locomotives). Therefore, this analysis provides a quantified assessment of NO_x and total hydrocarbons (HC) emission levels from the Proposed Action.

1.1.3 PM_{10} and $PM_{2.5}$

As described above, PM is separated by aerodynamic size into two categories, PM_{10} and $PM_{2.5}$ particles. Particles in the PM_{10} size range are generated by a variety of industrial and construction activities, including exhaust from fuel combustion sources, aggregate processing, and construction activities that disturb soil. PM_{10} particles are small enough that they can penetrate into breathing airways. Particles in the $PM_{2.5}$ size range are generated primarily by fuel combustion sources (particularly diesel fuel and heavy fuel oils), and often form in the atmosphere from pollutants emitted in gaseous form, such as NO_x and SO_2. Conversion of gaseous pollutants to these fine particles can take place many of miles from the point of emission. $PM_{2.5}$ particles are small enough that they can penetrate deep into the lungs.

The Proposed Action would result in a decrease in vehicular traffic volumes in the study area which would effectively reduce PM emissions from passenger vehicles. However, the Proposed Action would also increase PM emissions associated with rail sources (e.g., locomotives). Therefore, this analysis provides a quantified assessment of PM emission levels from the Proposed Action.

1.1.4 SO_2

SO_2 is a lung irritant and is known to increase airway resistance, thereby making breathing more difficult, especially among more sensitive portions of the population, including asthmatics. Sources of SO_2 emissions are primarily metal smelters processing sulfur-bearing ores, and combustion processes burning sulfur-bearing fuels. On-road and non-road engine fuels are currently regulated at much lower levels of sulfur content than in the past, to the extent that current emissions of SO_2 from fuel combustion can be considered almost negligible.

No significant sources of SO_2 are associated with the Proposed Action, therefore analysis was not warranted.

1.1.5 Lead

Airborne lead emissions are principally associated with industrial sources and motor vehicles that use gasoline containing lead additives. Most U.S. vehicles produced since 1975, and all produced after 1980, are designed to use unleaded fuel. Effective January 1, 1996, the CAA banned the use of leaded fuel in on-road vehicles, concluding the 25-year effort to phase out lead in gasoline. Due to the CAA regulations, ambient lead emissions nationwide in urban areas have decreased by 97 percent since the 1970s.

No significant sources of lead are associated with the Proposed Actions and, therefore, analysis was not warranted.

1.2 NAAQS Attainment Status and State Implementation Plans

The CAA, as amended in 1990, defines non-attainment areas (NAA) as geographic regions that have been designated as not meeting one or more of the NAAQS. NAAs also have are classifications based on level of non-attainment (e.g., marginal, moderate, serious, etc.). When an area is designated as non-attainment by EPA, the state is required to develop and implement a State Implementation Plan (SIP), which delineates how a state proposes to achieve air quality that meets the NAAQS under the deadlines established by the CAA. When a non-attainment area is re-designated (i.e. reclassified) as in attainment, the CAA requires that a maintenance plan be developed and implemented to ensure continued compliance with the NAAQS for the former non-attainment area.

The geographic region for the Proposed Action includes the counties of Essex County, MA and Rockingham County, NH. Both counties were previously classified as moderate non-attainment for the 8-hour ozone standard but were recently reclassified by EPA as “unclassifiable/attainment” for the 2008 standard. Reclassification occurred on May 21, 2012 for Essex County and on March 4, 2013 for Rockingham County. In addition to the ozone standard, Rockingham Country is in partial non-attainment for SO_2. However, this status only covers the towns of Candia, Deerfield and Northwood, which are outside the project area.

Although the project area for the Proposed Action is otherwise in attainment for the NAAQS, the CAA has defined an Ozone Transport Region (OTR) in the northeastern US. For northeastern states that make up the OTR (including Massachusetts and New Hampshire), the CAA mandates them to submit a SIP with specific requirements on levels of control for precursor pollutants that form ozone, even if they meet the ozone standard.

1.3 Clean Air Act Conformity

The CAA contains legislation mandating that projects involving a federal agency ensure that actions occurring in non-attainment and maintenance areas do not interfere with a state’s timely attainment of the NAAQS. The legislation has two parts; General Conformity and Transportation Conformity. The Transportation Conformity rule would apply when project funding and/or approval would be through the Federal Highway Administration (FHA) or the Federal Transit Administration (FTA), both agencies of the U.S. Department of Transportation; otherwise, General Conformity would apply to the process which includes a conformity applicability analysis and a conformity determination, if necessary.

Because the Proposed Action involves funding and/or approval by the FTA, the project would be reviewed under Transportation Conformity rules. Conformity would be determined through the State's Transportation Improvement Program (TIP) for the region, whereby the appropriate state agency would certify that the proposed project has been considered in its regional emissions budget for the TIP. The project has been included in the Long Range Transportation Plan (LRTP) and TIP for the project area, and therefore the emissions associated with the project are in conformance with regional emissions budgets.

2 Methodology

In order to determine the potential effects on air quality, an analysis was performed to estimate air emissions associated with operational and construction sources related to the project. Operational sources include mobile emissions from locomotives and commuter vehicles traveling in the project area, and stationary emissions from locomotives idling at the layover facility. Construction sources include emissions from diesel engines and fugitive dust during this phase of the project. The analysis conducted assumed a build year of 2020.

2.1 Operational Sources

As described above, emissions levels were calculated for both locomotives and automobiles. The pollutants quantified in the analyses include CO, NO_x, HC, and PM. The sections below provide a discussion of the air emissions calculation approach for both locomotives and automobiles.

2.1.1 Locomotive Emissions

For the operational scenario, the net change in air emissions were calculated using increased emissions from locomotives traveling the rail extension line between Haverhill, MA and Plaistow, NH and decreases in emissions associated with the lessening of commuter miles traveled by passenger car for persons using the proposed Plaistow Train Station.

Air emissions from locomotive engines were calculated based on a MBTA projected fleet mix of Tier 2, 3, & 4 engine types anticipated to be in service for the year 2020 and EPA locomotive exhaust emission standards[1]. The EPA standards are emission factors in grams per brake horsepower-hour (g/bhp-hr) and were converted to grams per gallon (g/gal) of diesel fuel using a conversion factor of 20.8 bhp-hr/gal for passenger trains. Fuel usage for trains traveling on the proposed extension (i.e., between Plaistow & Haverhill) were developed using default fuel consumption rates and computations of run time by throttle (notch) position (includes idling) from the Berkeley Simulation Software, LLC Rail Traffic Controller (RTC) Model (2015), Total Performance Calculations (TPC). A weighted average of the converted g/gal EPA emission factors for the Tier 2, 3 & 4 engine types was then multiplied by the daily gallons of fuel consumed to determine the mass of emitted pollutants. Total emissions for the Proposed Action were based on an expected 13 southbound and 13 northbound (26 total) train movements per day.

Stationary air emissions for the operational scenario were also computed for idling of locomotives. Three station and layover alternatives are associated with the Proposed Action. Alternative 1 would place a layover facility east of the tracks and to the south of New Hampshire Route 121 in Haverhill,

[1] Emission Factors for Locomotives (EPA-420-F-09-025), April 2009

MA. The station for this alternative is southeast of the tracks and adjacent to an existing park and ride lot near Westville Road in Plaistow, NH. Under Alternative 2 the station and layover facility are located together northwest of the tracks in the area of Joanne Drive in Plaistow, NH. Under Alternative 3 the station and layover facility are together, northwest of the tracks and southwest of New Hampshire Route 121A in Plaistow, NH. Emissions from locomotives idling at the new Plaistow station are already covered using EPA standard emission factors discussed above, therefore the estimated stationary emissions accounted for are related to locomotives idling at the layover facility. Because these operations would take place at another location along the rail line if the Proposed Action was not implemented, a net increase of zero emissions is anticipated with five trains expected to use the facility.

2.1.2 Automobile Emissions

To evaluate the effects of air emissions reductions resulting from the reduction in miles travelled by passenger cars, the EPA MOVES2014 mobile source emissions model was used to obtain estimates of emissions from these vehicles. The model output provided an average emission factor for passenger cars in grams per mile (g/mi) based on road type, speed range and seasonal conditions. The estimate of miles travelled was conservatively assumed to be the round trip distance between Plaistow and Haverhill train stations; the analysis is considered conservative because no credit was taken for potentially longer commutes to the Boston Metro Area for those commuters who would otherwise have driven to their destination (e.g., work) had it not been for the Proposed Action. The number of vehicles included in the analysis is based on data provided in the ridership analysis for the Proposed Action (see Appendix D).

The potential effects on air quality from mobiles sources (i.e., passenger cars) on nearby intersections due to increased traffic were considered but not analyzed since the maximum vehicle trips generated for the peak hour was only 100 vehicles and because the traffic analysis for the Proposed Action (see Appendix G) determined that there would be minimal delays at the affected intersections. Air emissions from passenger vehicles using the proposed Plaistow Train Station also did not warrant an analysis based on the peak hour usage of the parking lot (90 vehicles per hour) and station pick-up/drop-off area (10 vehicles per hour).

2.2 Construction Sources

In order to determine the potential effects on air quality from construction activities, an inventory of air emissions associated with construction of the proposed facilities at Plaistow was performed. For the construction scenario, temporary emissions increases were computed for the expected source types to be present onsite and the anticipated duration of the construction activities. Construction activities for the Proposed Action would be limited to the Plaistow train station and the layover facility as the new commuter train activity would occur on existing rail. Construction is expected to occur only during the daytime for a temporary 12-month period (of which, an estimated 3-month period would include heavy construction operations such as excavation). Provided below is a discussion of the air emissions calculation approach for construction sources.

2.2.1 Construction Emissions

Construction of the project will result in temporary increases in emissions of combustion-related pollutants and fugitive particulate matter due to the use of construction equipment and associated earth moving activities. A list of heavy equipment expected to operate during construction includes a

bulldozer, an excavator, a loader, and a crane. This equipment is expected to be powered by diesel engines and will be sources of CO, NOx, HC, and PM emissions from engine exhausts. Delivery trucks and dump trucks were considered to be insignificant as it is expected that their idling times would be very limited. Earth moving activities (e.g., excavation) during construction and onsite travel over unpaved areas will also be a source of air emissions. These activities are expected to generate fugitive dust (i.e., PM).

Air emissions from construction equipment engines were calculated based on the anticipated types and utilization of non-road equipment. Emission factors for diesel equipment engines were obtained using USEPA's NONROAD model documentation[2]. Emission factor development conservatively assumed the exclusive use of EPA Tier 2 diesel engine standards since specifications on projected engine types for the Proposed Action are not readily available and Tier 2 engines would be considered older models in the 2020 build year. These standards were applied to construction equipment engines for the 2020 build year and do not reflect the phasing-in of more stringent emissions standards (e.g., Tiers 3 & 4) already occurring. In addition, the use of ultra-low sulfur diesel (ULSD) fuel was assumed for non-road diesel vehicles, since ULSD is required per 40CFR 80.510. Emission factors from EPA AP-42[3] were used to determine emission rates for PM from construction activities that generate fugitive dust. These emission factors are conservative, but were used because site specific details for construction tasks (e.g., excavation rates) are not readily available.

3 Existing Conditions

Applicable air quality data are shown in Table 3-1. The values shown are the highest reported during the calendar year by all monitoring sites in the county. The table also includes the corresponding NAAQS for each of these criteria pollutants. As indicated in the table, monitored concentrations of each pollutant are below the NAAQS.

[2] EPA 420-R-10-018, NR-009d, July 2010

[3] EPA AP-42, Compilation of Air Pollutant Emission Factors, Section 13.2.3 (January 1995)

Table 3-1. Representative Monitored Ambient Air Quality Data

Pollutant	Monitor	Averaging Time	Value	NAAQS
CO[1]	Rockingham County, NH	8-Hour	0.6 ppm	9 ppm
		1-Hour	0.7 ppm	35 ppm
NO_2[2]	Essex County, MA	1-Hour	43 ppb	100 ppb
		Annual	7 ppb	53 ppb
$PM_{2.5}$[3]	Rockingham County, NH	24-Hour	24 µg/m^3	35 µg/m^3
		Annual	9 µg/m^3	12 µg/m^3
PM_{10}[4]	Rockingham County, NH	24-Hour	27 µg/m^3	150 µg/m^3
SO_2[5]	Rockingham County, NH	1-Hour	30 ppb	75 ppb

Sources:

EPA AirData, (2011-2013) http://www.epa.gov/airquality/airdata/

Massachusetts Air Quality Report, (2011-2013) http://www.mass.gov/eea/agencies/massdep/air/quality/air-monitoring-reports-and-studies.html

Notes:

1 CO monitored concentrations are the highest 2nd max values from the latest year of available monitoring data from EPA AirData (2013).

2 The 1-hour NO2 monitored concentration is the three-year average (2011-2013) of the 98th percentile of daily maximum 1-hour concentrations. Annual NO2 monitored concentration is the maximum annual average from the latest year of available monitoring data from MassDEP and AAB (2013).

3 24-hour PM2.5 background concentration is the average of the 98th percentile for the latest three years of available monitoring data from EPA AirData (2011-2013). Annual PM2.5 monitored concentration is the maximum annual average from the latest year of available monitoring data from EPA AirData (2013).

4 24-hour PM10 monitored concentration is the highest 2nd max values from the latest year of available monitoring data from EPA AirData (2013).

5 The 1-hour SO2 monitored concentration is the three-year average (2011-2013) of the 99th percentile of daily maximum 1-hour average concentrations EPA AirData (2013).

4 Future Conditions without the Proposed Action

The primarily suburban nature of the air quality study area is not expected to change by the future year of the Proposed Action (i.e., 2020 analysis year). In addition, air quality regulations associated with mobile and stationary related sources mandated by the CAA are anticipated to maintain or improve air quality in the region. As such, with no major changes in land use or traffic conditions, it can be expected that air quality conditions in the future without the Proposed Action would be no worse than those that presently exist.

5 Potential Impacts with the Proposed Action

As detailed above in Section 2 Methodology, a quantified inventory of air emissions was developed for operational and construction sources associated with the Proposed Action. These air emissions are presented in tons per year (tpy) for CO, NOx, HC, and PM. The significance of quantified emissions levels for these air pollutants was determined based on the magnitude of the net change in emissions and, in the case of idling locomotives at the rail yard layover facility, proximity to nearby sensitive receptors. In the case of construction activities, the permanent versus temporary nature of the emissions load was also considered in the analysis.

5.1 Operational Sources

As indicated in Table 5-1, there is a minor net increase of CO, NO_x, HC and PM (presented as PM_{10}) associated with the Proposed Action in regards to locomotive emissions for projected trips on the rail line extension versus emissions reductions due to lesser commuter miles traveled by passenger cars. Although the Proposed Action is not subject to CAA General Conformity rules (it is a conforming project under Transportation conformity rules – see above), applicability thresholds from General Conformity are used to demonstrate the level of significance for air emissions presented in Table 5-1. Based on threshold values for moderate non-attainment inside an ozone transport region (100 tpy for CO, NO_x, and PM; and 50 tpy for VOC), net emission changes associated with locomotive trips would fall between one and seven percent of the applicability thresholds (substituting HC for VOC). As such, the project would be considered de minimis. In addition, the analysis is assumed to be conservative since it did not consider longer commuting distances by car (e.g., Boston Metro Area commutes) when calculating emissions reduction levels or the projected increases in ridership for years beyond the 2020 build year. Therefore, no significant impacts would be expected from locomotive trips associated with the Proposed Action.

Table 5-1 also provides air emission estimates for idling trains at the rail yard layover facility. These emissions could be considered a stationary area source that may potentially affect nearby sensitive receptors. However, at the levels presented in the table, emissions of CO, NO_x, HC and PM would be considered insignificant by stationary source permitting standards. In addition, the closest nearby receptor for the Recommended Alternative is greater than 300 feet from the rail yard layover facility. Therefore, no significant impacts would be expected from the idling of five trains in the rail yard, due to the small level of emissions and significant distance to the nearest receptors.

Calculations for operational source emissions are provided in Appendix A and Appendix B.

Table 5-1. Air Emissions Inventory for Operational Sources

Annual Emissions in Tons per Year				
Source	**CO**	**NOx**	**HC**	**PM_{10}[1]**
CAA General Conformity Applicability Thresholds	100	100	100	100
Locomotive Trips (+)	3.22	6.90	0.46	0.13
Passenger Cars (-)	-1.15	-0.09	-0.02	-0.03
Net Emission Change	2.07	6.81	0.44	0.10
Percent of CAA Applicable Threshold	**2.07%**	**6.81%**	**0.44%**	**0.10%**
Rail Yard Idling	0.10	0.22	0.015	0.0043
Percent of CAA Applicable Threshold	**0.10%**	**0.22%**	**0.015%**	**0.0043%**

Notes:
[1] $PM_{2.5}$ emissions contribute 97 percent of the PM_{10} emissions.

5.2 Construction Sources

As indicated in Table 5-2, emissions of CO, NO_x, HC and PM (presented as PM_{10}) from heavy equipment engine exhausts during the construction period would be insignificant. Likewise, fugitive emissions from dust generating activities would be relatively minor and likely less than those presented in Table 5-2 since the analysis did not consider the use of dust suppression techniques often used by contractors at construction sites. Furthermore, the construction activities would be temporary. Therefore, no significant impacts would be expected from construction associated with the Proposed Action.

Calculations for construction source emissions are provided in Appendix C.

Table 5-2. Air Emissions Inventory for Construction Sources

Annual Emissions in Tons per Year				
Source	**CO**	**NOx**	**HC**	**PM_{10}**
Diesel Engines	0.32	1.06	0.08	0.038
Fugitive Dust	N/A	N/A	N/A	8.1[1]

Notes:
[1] $PM_{2.5}$ emissions contribute 15 percent of the PM_{10} emissions.

Appendix A. Locomotive Air Emissions Calculations

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Appendix A - Locomotive Air Emissions Calculations

TABLE A-1
Plaistow to Haverhill - Fuel Use by Notch

Throttle Position (Notch)	Total Time in Notch[a] (hours)	Total Fuel Rate by Notch[b] (gal/hr)	Total Fuel Use by Notch (gal)
0 or Idle	2.58E-02	3.3	0.085
1	3.36E-02	11.1	0.373
2	2.44E-02	22.7	0.555
3	1.72E-02	47.3	0.815
4	1.83E-02	72.1	1.322
5	4.72E-03	99.7	0.471
6	2.50E-03	129.4	0.324
7	4.17E-03	162	0.675
8	1.72E-02	193.2	3.327
		Total Fuel Use for One Trip	7.95
		Total Daily Fuel Use for 13 Southbound Trips per Day	103.30

Notes:
a. Computed using RTC Total Performance Calculations (TPC)
b. RTC default fuel rates for TPC

TABLE A-2
Haverhill to Plaistow - Fuel Use by Notch

Throttle Position (Notch)	Total Time in Notch[a] (hours)	Total Fuel Rate by Notch[b] (gal/hr)	Total Fuel Use by Notch (gal)
0 or Idle	2.39E-02	3.3	0.08
1	2.11E-02	11.1	0.23
2	1.61E-02	22.7	0.37
3	2.06E-02	47.3	0.97
4	1.81E-02	72.1	1.30
5	8.89E-03	99.7	0.89
6	4.17E-03	129.4	0.54
7	2.50E-03	162	0.41
8	3.61E-02	193.2	6.98
		Total Fuel Use for One Trip	11.76
		Total Daily Fuel Use for 13 Northbound Trips per Day	152.88

Notes:
a. Computed using RTC Total Performance Calculations (TPC)
b. RTC default fuel rates for TPC

TABLE A-3
EPA Air Emission Standards

Locomotives - NOx Emission Standards[a]		
Tier 2 Emission Factor (g/bhp-hr)	Tier 3 Emission Factor (g/bhp-hr)	Tier 4 Emission Factor (g/bhp-hr)
5.5	5.5	1.3
(g/gal)	(g/gal)	(g/gal)[b]
114.4	114.4	27.04
Locomotives - CO Emission Standards[a]		
Tier 2 Emission Factor (g/bhp-hr)	Tier 3 Emission Factor (g/bhp-hr)	Tier 4 Emission Factor (g/bhp-hr)
1.5	1.5	1.5
(g/gal)	(g/gal)	(g/gal)[b]
31.2	31.2	31.2
Locomotives - PM Emission Standards[a]		
Tier 2 Emission Factor (g/bhp-hr)	Tier 3 Emission Factor (g/bhp-hr)	Tier 4 Emission Factor (g/bhp-hr)
0.1	0.1	0.03
(g/gal)	(g/gal)	(g/gal)[b]
2.08	2.08	0.624
Locomotives - HC Emission Standards[a]		
Tier 2 Emission Factor (g/bhp-hr)	Tier 3 Emission Factor (g/bhp-hr)	Tier 4 Emission Factor (g/bhp-hr)
0.3	0.3	0.14
(g/gal)	(g/gal)	(g/gal)[b]
6.24	6.24	2.912

Notes:
a. g/bhp-hr standards obtained from http://www.epa.gov/otaq/standards/nonroad/locomotives.htm
b. Converted using 20.8 bhp-hr per gal (for large line haul and passenger trains) from http://www.epa.gov/otaq/regs/nonroad/locomotv/420f09025.pdf

TABLE A-4
Air Emissions Estimation From SB/NB Locomotives

Weighted Average Emission Factors in g/gal[a]			
NOx	CO	PM	HC
66.92	31.20	1.29	4.43
Annual Emissions in tons/yr for 26 Train Movements[b]			
NOx	CO	PM	HC
6.90	3.22	0.13	0.46

Notes:
a. Based on a projected fleet mix of MBTA Locomotives for 2020.
Fifty Tier 4 Engines
Forty Tier 3 Engines
Two Tier 2 Engines
b. Based on projected train schedule for Proposed Action. Assumes 365 days per year.

TABLE A-5
Plaistow Layover Facility - Fuel Use by Idling Time

Number of Idling Trains in Yard	Amount of Idle Time per Train[a] (hours)	Total Fuel Rate Idle (gal/hr)	Total Fuel Use by Idle Time (gal)
5	2.5	3.3	8.25

Notes:
a. Five trains would layover in the Plaistow Yard and idle as follows:
Each train would idle 90 minutes in Plaistow Yard at morning start-up
Each train would idle 30 minutes in morning once moved to Plaistow Station Platform for scheduled departure
Each train would idle 10 minutes at Plaistow Station Platform at end of day
Each train would idle 20 minutes in Plaistow Yard at end of day

TABLE A-6
Air Emissions Estimation From Locomotives at Layover Facility

Weighted Average Emission Factors in g/gal[a]			
NOx	CO	PM	HC
66.92	31.20	1.29	4.43
Annual Emissions in tons/yr for Idling Trains[b]			
NOx	CO	PM	HC
0.22	0.10	0.0043	0.015

Notes:
a. Based on a projected fleet mix of MBTA Locomotives for 2020.
Fifty Tier 4 Engines
Forty Tier 3 Engines
Two Tier 2 Engines
b. Based on projected idling times presented in Table 5. Assumes
365 days per year.

Appendix B. Passenger Car Air Emissions Calculations

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Appendix B - Passenger Car Air Emissions Calculations

Table B-1: NOx Average Yearly Rate for Gasoline Passenger Cars in MA and NH

		Average Emission Rate (g/mile) [Model Year: 2020]			
Speed Range (mph)	Speed Bin	Road Type 2 (Rural Restricted Access)	Road Type 3 (Rural Unrestricted Access)	Road Type 4 (Urban Restricted Access)	Road Type 5 (Urban Unrestricted Access)
<2.5	1	0.19	0.18	0.19	0.18
2.5-7.5	2	0.14	0.14	0.14	0.14
7.5-12.5	3	0.11	0.12	0.11	0.12
12.5-17.5	4	0.09	0.12	0.09	0.12
17.5-22.5	5	0.08	0.11	0.08	0.11
22.5-27.5	6	0.09	0.11	0.09	0.11
27.5-32.5	7	0.09	0.10	0.09	0.10
32.5-37.5	8	0.10	0.10	0.10	0.09
37.5-42.5	9	0.10	0.10	0.10	0.09
42.5-47.5	10	0.11	0.10	0.11	0.09
47.5-52.5	11	0.11	0.10	0.11	0.09
52.5-57.5	12	0.11	0.10	0.11	0.10
57.5-62.5	13	0.11	0.10	0.11	0.10
62.5-67.5	14	0.12	0.11	0.12	0.11
67.5-72.5	15	0.13	0.12	0.13	0.12
>72.5	16	0.14	0.14	0.14	0.14

Table B-2: PM10 Average Yearly Rate for Gasoline Passenger Cars in MA and NH

		Average Emission Rate (g/mile) [Model Year: 2020]			
Speed Range (mph)	Speed Bin	Road Type 2 (Rural Restricted Access)	Road Type 3 (Rural Unrestricted Access)	Road Type 4 (Urban Restricted Access)	Road Type 5 (Urban Unrestricted Access)
<2.5	1	0.40	0.41	0.40	0.41
2.5-7.5	2	0.24	0.24	0.24	0.24
7.5-12.5	3	0.15	0.15	0.15	0.15
12.5-17.5	4	0.12	0.12	0.12	0.12
17.5-22.5	5	0.10	0.10	0.10	0.10
22.5-27.5	6	0.08	0.09	0.08	0.09
27.5-32.5	7	0.07	0.07	0.07	0.07
32.5-37.5	8	0.06	0.06	0.06	0.06
37.5-42.5	9	0.05	0.05	0.05	0.05
42.5-47.5	10	0.05	0.04	0.05	0.04
47.5-52.5	11	0.04	0.03	0.04	0.03
52.5-57.5	12	0.04	0.03	0.04	0.03
57.5-62.5	13	0.03	0.03	0.03	0.03
62.5-67.5	14	0.03	0.02	0.03	0.02
67.5-72.5	15	0.03	0.02	0.03	0.02
>72.5	16	0.03	0.02	0.03	0.02

Table B-3: CO Average Yearly Rate for Gasoline Passenger Cars in MA and NH

		Average Emission Rate (g/mile) [Model Year: 2020]			
Speed Range (mph)	Speed Bin	Road Type 2 (Rural Restricted Access)	Road Type 3 (Rural Unrestricted Access)	Road Type 4 (Urban Restricted Access)	Road Type 5 (Urban Unrestricted Access)
<2.5	1	5.58	5.25	5.41	5.25
2.5-7.5	2	3.25	3.44	3.35	3.44
7.5-12.5	3	2.06	2.54	2.30	2.54
12.5-17.5	4	1.70	2.24	1.97	2.24
17.5-22.5	5	1.55	1.98	1.77	1.98
22.5-27.5	6	1.44	1.61	1.52	1.61
27.5-32.5	7	1.45	1.55	1.50	1.55
32.5-37.5	8	1.66	1.41	1.53	1.39
37.5-42.5	9	1.81	1.27	1.53	1.25
42.5-47.5	10	1.91	1.17	1.54	1.17
47.5-52.5	11	1.90	1.11	1.52	1.14
52.5-57.5	12	1.81	1.15	1.48	1.15
57.5-62.5	13	1.77	1.18	1.47	1.18
62.5-67.5	14	1.76	1.26	1.51	1.26
67.5-72.5	15	1.93	1.44	1.69	1.44
>72.5	16	2.34	1.93	2.14	1.93

Table B-4: HC Average Yearly Rate for Gasoline Passenger Cars in MA and NH

		Average Emission Rate (g/mile) [Model Year: 2020]			
Speed Range (mph)	Speed Bin	Road Type 2 (Rural Restricted Access)	Road Type 3 (Rural Unrestricted Access)	Road Type 4 (Urban Restricted Access)	Road Type 5 (Urban Unrestricted Access)
<2.5	1	0.10	0.10	0.10	0.10
2.5-7.5	2	0.06	0.06	0.06	0.06
7.5-12.5	3	0.03	0.04	0.03	0.04
12.5-17.5	4	0.03	0.03	0.03	0.03
17.5-22.5	5	0.02	0.03	0.02	0.03
22.5-27.5	6	0.02	0.02	0.02	0.02
27.5-32.5	7	0.02	0.02	0.02	0.02
32.5-37.5	8	0.02	0.02	0.02	0.02
37.5-42.5	9	0.02	0.02	0.02	0.02
42.5-47.5	10	0.02	0.02	0.02	0.02
47.5-52.5	11	0.02	0.02	0.02	0.01
52.5-57.5	12	0.02	0.02	0.02	0.01
57.5-62.5	13	0.02	0.02	0.02	0.02
62.5-67.5	14	0.02	0.02	0.02	0.02
67.5-72.5	15	0.02	0.02	0.02	0.02
>72.5	16	0.03	0.02	0.02	0.02

Table B-5: Tons/Year Calculations						
Pollutant	g/miles	estimated roundtrip miles/veh	veh/day	day/year	Tons/g	tons/year
NOx	0.10	13.8	170	365	1.10E-06	**0.09**
PM10	0.04	13.8	170	365	1.10E-06	**0.03**
CO	1.22	13.8	170	365	1.10E-06	**1.15**
HC	0.02	13.8	170	365	1.10E-06	**0.02**

Appendix C. Construction Activity Air Emissions Calculations

Plaistow Commuter Rail Extension Study
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Appendix C - Construction Activity Emissions Calculations

Table C-1
NONROAD Model Tier 2 Diesel Fuel Emission Factor Calculations for PM, NOx, CO and HC

Construction Equipment	NONROAD Equipment Classification	Site Eqp Rated HP	Emission Factor Calculations - PM					Emission Factor Calculations - NOx				Emission Factor Calculations - CO				Emission Factor Calculations - HC			
			Efss[1]	TAF[2]	DF[3]	Spm-adj[4]	Ef - PM[5]	Efss[1]	TAF[2]	DF[3]	Ef - NOx[5]	Efss[1]	TAF[2]	DF[3]	Ef - CO[5]	Efss[1]	TAF[2]	DF[3]	Ef - HC[5]
Bull Dozer	Rubber Tire Dozers	325	0.1316	1.23	1.473	0.0860	0.152	4.335	0.95	1.009	4.155	0.8425	1.53	1.101	1.419	0.1669	1.05	1.034	0.181
Excavator	Excavators	250	0.1316	1.23	1.473	0.0860	0.152	4.000	0.95	1.009	3.834	0.7475	1.53	1.101	1.259	0.3085	1.05	1.034	0.335
Loader	Rubber Tire Loaders	300	0.1316	1.23	1.473	0.0860	0.152	4.000	0.95	1.009	3.834	0.7475	1.53	1.101	1.259	0.3085	1.05	1.034	0.335
Crane	Cranes	275	0.1316	1	1.473	0.0860	0.108	4.000	1	1.009	4.036	0.7475	1	1.101	0.823	0.3085	1	1.034	0.319

Notes

[1] Steady state emission factors (Efss) were obtained from Table A.4 of EPA 420-R-10-018, NR-009d, July 2010.

[2] Transient adjustment factors (TAF) were obtained from Table A.5 of EPA 420-R-10-018, NR-009d, July 2010.

[3] See Deterioration Factor calculations below

[4] See Sulfur PM Adjustment Factor calculations below

[5] Equation for adjusted emission factor (Ef_{adj}) from Eqn 1 (Eqn 2 for PM) on page 6 of EPA NR-009d, July 2010 is as follows:

Ef_{adj} (g/hp-hr) = [steady state emission factor (Efss) x transient adjustment factor (TAF) x deterioration factor (DF)] minus sulfur PM adjustment factor (Spm-adj for PM calculations only).

Table C-2
NONROAD Model Tier 2 Diesel Fuel Deterioration Factor Calculations

Construction Equipment	NONROAD Equipment Classification	Site Eqp Rated HP	Deterioration Factor - PM			Deterioration Factor - NOx			Deterioration Factor - CO			Deterioration Factor - HC		
			RD[1]	Age Fctr[2]	DF[3]	RD[1]	Age Fctr[2]	DF[3]	RD[1]	Age Fctr[2]	DF[3]	RD[1]	Age Fctr[2]	DF[3]
Bull Dozer	Rubber Tire Dozers	325	0.473	1	1.473	0.009	1	1.009	0.101	1	1.101	0.034	1	1.034
Excavator	Excavators	250	0.473	1	1.473	0.009	1	1.009	0.101	1	1.101	0.034	1	1.034
Loader	Rubber Tire Loaders	300	0.473	1	1.473	0.009	1	1.009	0.101	1	1.101	0.034	1	1.034
Crane	Cranes	275	0.473	1	1.473	0.009	1	1.009	0.101	1	1.101	0.034	1	1.034

Notes:

[1] Relative deterioration obtained from Table A.6 of EPA 420-R-10-018, NR-009d, July 2010

[2] Age factor was not calculated (per NONROAD model calculations for "fraction of median life expended") but was instead conservatively assumed to be equal to 1 (i.e., maximum deterioration).

[3] Equation for deterioration factor (DF) from Eqn 4, on page 21 of EPA NR-009d, July 2010 is as follows:

DF = 1 + (relative deterioration x age factor)

Table C-3
NONROAD Model Tier 2 Diesel Fuel Sulfur PM Adjustment Factor Calculations

Construction Equipment	NONROAD Equipment Classification	Site Eqp Rated HP	Sulfur PM Adjustment Factor		
			BSFC[1]	FSWt%[2]	Spm-adj[3]
Bull Dozer	Rubber Tire Dozers	325	0.367	0.0015	0.0860
Excavator	Excavators	250	0.367	0.0015	0.0860
Loader	Rubber Tire Loaders	300	0.367	0.0015	0.0860
Crane	Cranes	275	0.367	0.0015	0.0860

Notes:

[1] Brake specific fuel consumption (BSFC) obtained from Table A.4 of EPA 420-R-10-018, NR-009d, July 2010

[2] A fuel sulfur content of 15 ppm or 0.0015% was used as input (as required per 40 CFR 80.510 for nonroad diesel).

[3] Equation for sulfur PM adjustment factor (Spm-adj) from Eqn 5, on page 22 of EPA NR-009d, July 2010 is as follows:

Spm-adj = brake specific fuel consumption (BSFC) x 453.6 x 7 x soxcnv default value of 0.02247 x 0.01 x (soxbas default value of 0.33 - user defined fuel sulfur weight percent, FSWt%)

where: soxcnv is the fraction of fuel sulfur converted to direct PM and soxbas is the default certification fuel weight percent.

Table C-4
Total Project Emissions for Criteria Pollutants from Nonroad Engines

Construction Equipment	NONROAD Equipment Classification	Site Eqp Rated HP	Load Factor[1]	# of Eqp	Work Days[2]	Hours per Day[2]	Operating Hours[2]	PM10 (tons)[3]	PM2.5 (tons)[3]	NOx (tons)[3]	CO (tons)[3]	HC (tons)[3]
Bull Dozer	Rubber Tire Dozers	325	0.59	1	60	6	360	0.012	0.011	0.316	0.108	0.014
Excavator	Excavators	250	0.59	1	60	6	360	0.009	0.009	0.224	0.074	0.020
Loader	Rubber Tire Loaders	300	0.59	1	60	6	360	0.011	0.010	0.269	0.088	0.024
Crane	Cranes	275	0.43	1	120	4	480	0.007	0.007	0.253	0.051	0.020
							Totals Emissions by Pollutant (tons per year)	0.038	0.037	1.06	0.32	0.08

Notes:

[1] Load factor obtained from Appendix A of EPA 420-R-10-016, NR-005d, July 2010

[2] This construction schedule is based on an expected duration of 12 months at average intensity (i.e., not every piece of heavy equipment operates simultaneously for all eight hours of a work day). Heavy equipment associated with excavation activities are expected to be present onsite for a duration of three months; the duration of activities associated with cranes (i.e., hoisting) were expected to last six months.

[3] Equation for annual emissions is as follows: Pollutant Emissions (tons) = (Ef (g/hp-hr) * HP * load factor * operating hours) / (2000 lb/ton * 453.6 g/lb); See Table A.3-1A for the derivation of pollutant emission factors.

Table C-5
Total Project Emissions for Fugitive Dust from Land Disturbance due to Construction Activities

Parameter	Surface Area Disturbed by Construction Activities (acres)	PM Emissions (tons)[2]		
		TSP	PM10[3]	PM2.5[4]
Fugitive Dust Emissions from Land Disturbance (tons per year)[1]	4.5	16	8.1	1.22

Notes:

[1] Fugitive emissions from land disturbances due to construction activities were calculated using a total suspended particulate (TSP) emission factor of 1.2 tons/acre/month (from EPA AP-42, Section 13.2.3) and 3 months of expected heavy construction (e.g., excavation activities).

[2] Fugitive dust control measures will be determined at the site upon commencement of construction activities (likely to be water spray applications) but are not accounted for in this emissions estimate since it expected to be applied at the discretion of the onsite contractor.

[3] PM10 emissions were calculated by multiplying the calculated value for TSP by a particle size multiplier of 0.5 (from EPA AP-42, Section 13.2.5).

[4] PM2.5 emissions were calculated by multiplying the calculated value for TSP by a particle size multiplier of 0.075 (from EPA AP-42, Section 13.2.5).