

APPENDIX K:

Climate

Climate

Prepared by:

KB Environmental Sciences, Inc.

December 2017

**Western Land Area
Programmatic Environmental Assessment**

This page is left intentionally blank.

Table of Contents

	<u>Page</u>
1 Introduction	1
2 Construction.....	1
2.1 On-Road Construction Vehicles	1
2.2 Off-Road Construction Equipment	2
2.3 Estimated GHG Construction Emissions.....	4
3 Project-Related Traffic.....	5
3.1 On-Road Vehicles.....	5
3.2 Estimated Traffic-Related GHG Emissions.....	6
4 Conclusions and Findings	10

LIST OF TABLES

	<u>Page</u>
Table 1 On-Road Construction Vehicle Emission Factors (grams/mile).....	2
Table 2 Construction Equipment Emission Factors (grams/mile).....	3
Table 3 Current Market Alternative Construction Emissions (MT CO ₂ e/year).....	4
Table 4 Medium-Density Alternative Construction Emissions (MT CO ₂ e/year).....	4
Table 5 High-Density Alternative Construction Emissions (MT CO ₂ e/year)	4
Table 6 2016 Emission Factors.....	5
Table 7 2020 Emission Factors.....	5
Table 8 2025 Emission Factors.....	6
Table 9 Carbon Dioxide (CO ₂) Emissions.....	7
Table 10 Methane (CH ₄) Emissions	8
Table 11 Nitrous Oxide (N ₂ O) Emissions.....	9
Table 12 CO ₂ e Emissions (MT per year) – Proposed Action Alternatives.....	10

APPENDIX K

Climate

1 Introduction

This Appendix presents the data, assumptions, approach, and methodology for preparing the greenhouse gas (GHG) emissions inventories for the Western Land Area (WLA). As was prepared for the criteria air pollutants/precursors inventories (**Appendix J, Air Quality**), the GHG inventories for project-related motor vehicle traffic were estimated for the future years 2020 and 2025 for the three Proposed Action Alternatives (e.g., Current Market, Medium-Density, and High-Density) as well as the construction years of 2020-2025 for three alternatives.

The GHG inventoried were carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). As is customary for GHG emissions inventories, the results are reported in units of metric tons (MT) of carbon dioxide equivalents (CO₂e), by source, and on an annual basis. The GHG emission results were converted to CO₂e values using the Global Warming Potential (GWP) values of 1 for CO₂, 28 for CH₄, and 265 for nitrous oxide (N₂O), based on a 100-year period. GWP values are relative measures of how much heat a GHG traps in the atmosphere when compared to carbon dioxide (e.g., CH₄ is 25 times as potent a GHG than CO₂). For this purpose, estimates of CH₄ and N₂O emissions are multiplied by their respective GWP values (28 for CH₄ and 265 for N₂O) to determine the CO₂e.

2 Construction

GHG emissions were estimated for construction activities categorized as off-road (e.g., graders, excavators, forklifts, paving equipment) and for the on-road vehicles associated with construction (e.g., laborers/commuters) trips commuting to and from the worksite, material delivery/haul trucks and tractor trailers.

2.1 On-Road Construction Vehicles

Table 1 provides the GHG emission factors for on-road vehicles for each year during which construction activities would be scheduled. These emissions factors (grams/mile) were multiplied by the vehicle-miles-traveled (VMT) presented in Table 2 of *Appendix I, Air Quality* to derive the estimated GHG emissions and the CO₂e.

**Western Land Area
Programmatic Environmental Assessment**

Table 1
On-Road Construction Vehicle Emission Factors (grams/mile)

Vehicles	MOVES On-road	Pollutant	2020	2021	2022	2023	2024	2025
Laborers/Commuters	Passenger Car/Truck	CO ₂	467	454	441	427	414	401
		CH ₄	0.04	0.04	0.03	0.03	0.03	0.03
		N ₂ O	0.01	0.01	0.01	0.01	0.01	0.01
Material Delivery & Dirt Haul Trucks	Short-haul Single Unit Truck	CO ₂	1,372	1,361	1,351	1,343	1,335	1,328
		CH ₄	0.2	0.2	0.2	0.2	0.2	0.2
		N ₂ O	0.01	0.01	0.01	0.01	0.01	0.01
Tractor Trailers	Combination Short-haul Truck	CO ₂	2,127	2,113	2,102	2,091	2,082	2,076
		CH ₄	0.1	0.2	0.2	0.2	0.2	0.2
		N ₂ O	0.005	0.005	0.005	0.005	0.005	0.004

Source: MOVES2014a

Note: CO₂ – Carbon Dioxide, CH₄ – Methane, N₂O – Nitrous Oxide

2.2 Off-Road Construction Equipment

Table 2 provides the GHG emission factors for off-road equipment for all construction years. The emission factors (grams per horsepower) for each equipment type were applied to the anticipated equipment work output (horsepower-hour) of expected equipment use.

**Western Land Area
Programmatic Environmental Assessment**

Table 2
Construction Equipment Emission Factors (grams/mile)

Description	2020		2021		2022		2023		2024		2025	
	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂	CH ₄
40 Ton Crane	533	0.01	533	0.01	533	0.01	533	0.01	533	0.01	533	0.01
90 Ton Crane	533	0.01	533	0.01	533	0.01	533	0.01	533	0.01	533	0.01
Auger Drill	540	0.01	540	0.01	540	0.01	540	0.01	540	0.01	540	0.01
Backhoe	664	0.03	665	0.03	665	0.03	665	0.03	665	0.02	665	0.02
Bob Cat	664	0.03	665	0.03	665	0.03	665	0.03	665	0.02	665	0.02
Bulldozer	539	0.01	539	0.01	539	0.01	539	0.01	539	0.01	539	0.01
Chain Saws (gasoline)	1062	2.04	1062	2.04	1062	2.04	1062	2.04	1062	2.04	1062	2.04
Compacting Equipment	559	0.02	559	0.01	559	0.01	559	0.01	559	0.01	559	0.01
Concrete Pump	537	0.01	537	0.01	537	0.01	537	0.01	537	0.01	537	0.01
Concrete Ready Mix Trucks	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Flat Bed or Dump Trucks	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Fork Truck	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Front Loader	664	0.03	665	0.03	665	0.03	665	0.03	665	0.02	665	0.02
Grout Mixer for Mortar	564	0.02	564	0.02	564	0.02	564	0.02	564	0.02	564	0.02
High Lift	569	0.02	569	0.01	569	0.01	569	0.01	569	0.01	569	0.01
Line Painting Truck and Sprayer	546	0.01	546	0.01	546	0.01	569	0.01	546	0.01	546	0.01
Log Chipper	586	0.02	586	0.02	586	0.02	546	0.01	586	0.02	586	0.02
Man Lift	693	0.03	693	0.03	693	0.03	586	0.02	694	0.03	694	0.02
Masonry Saw	591	0.02	591	0.02	592	0.02	694	0.03	592	0.02	592	0.02
Mulcher	586	0.02	586	0.02	586	0.02	592	0.02	586	0.02	586	0.02
Paving Machine	556	0.02	556	0.02	556	0.02	586	0.02	556	0.02	556	0.02
Roller	559	0.02	559	0.01	559	0.01	556	0.02	559	0.01	559	0.01
Seed Truck Spreader	546	0.01	546	0.01	546	0.01	559	0.01	546	0.01	546	0.01
Small Dozer	539	0.01	539	0.01	539	0.01	546	0.01	539	0.01	539	0.01
Survey Crew Trucks	546	0.01	546	0.01	546	0.01	539	0.01	546	0.01	546	0.01
Ten Wheelers	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Tool Truck	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Tractor	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01	546	0.01
Trowel Machine	555	0.02	555	0.02	555	0.02	546	0.01	555	0.02	555	0.02

Source: MOVES2014a

Note: N₂O emission factors for off-road construction equipment not available on MOVES2014a.

2.3 Estimated GHG Construction Emissions

The estimated GHG emissions to occur during year 2020 through 2025 with the construction of the three Proposed Action Alternatives (e.g., Current Market, Medium-Density, and High-Density) are presented in **Tables 3 through 5**. As shown, emissions vary by alternative. The greatest annual emissions of CO₂, CH₄, and N₂O are estimated to occur in the year 2020 with the High-Density alternative.

Table 3
Current Market Alternative Construction Emissions (MT CO₂e/year)

Year	CO ₂	CH ₄	N ₂ O	Total
2020	17,033	15	4	17,051
2021	17,020	15	3	17,038
2022	17,007	15	3	17,025
2023	16,994	14	3	17,012
2024	16,981	14	3	16,998
2025	16,968	14	3	16,985

Source: KBE, 2017.

Note: Results subject to rounding.

Table 4
Medium-Density Alternative Construction Emissions (MT CO₂e/year)

Year	CO ₂	CH ₄	N ₂ O	Total
2020	19,644	17	4	19,665
2021	19,632	17	3	19,652
2022	19,619	17	3	19,639
2023	19,607	16	3	19,626
2024	19,594	16	3	19,613
2025	19,581	16	3	19,600

Source: KBE, 2017.

Note: Results subject to rounding.

Table 5
High-Density Alternative Construction Emissions (MT CO₂e/year)

Year	CO ₂	CH ₄	N ₂ O	Total
2020	25,373	22	4	25,399
2021	25,361	22	3	25,386
2022	25,349	21	3	25,373
2023	25,337	21	3	25,360
2024	25,324	20	3	25,347
2025	25,312	20	3	25,334

Source: KBE, 2017.

Note: Results subject to rounding.

3 Project-Related Traffic

GHG emissions were also estimated for motor vehicle traffic-related activities with and without the associated development of the Western Lands parcels. The detailed methodology can be found in **Attachment A**.

3.1 On-Road Vehicles

On-road vehicles emission factors (g/mile) for the given vehicle fleet (i.e., passenger cars and trucks, motorcycles, busses, light commercial truck, single unit short-haul trucks, combination short-haul trucks) were derived from MOVES2014a. **Tables 6 through 8** provide the GHG emission factors for on-road vehicles. These emissions factors (grams/mile) were multiplied by the traffic volume and vehicle distance to estimate traffic-related emissions.

Table 6
2016 Emission Factors

Vehicle Description	MOVES Vehicle Type	Emission Rate (g/mile)		
		CO ₂	CH ₄	N ₂ O
Motorcycles, Passenger Cars and Vans	Motorcycles, Passenger Cars/Trucks	368.60	0.01	0.0002
Busses	Transit Bus	1448.41	0.03	0.0002
2-Axle Single Unit Trucks (not including pickups and vans)	Light Commercial Truck	590.80	0.02	0.0003
3-Axle Single Unit Trucks	Short-haul Single Unit Truck	839.51	0.03	0.0003
Trucks with Single Trailer	Combination Short-haul Single Unit Truck	1623.85	0.02	0.0003

Source: MOVES2014a

Table 7
2020 Emission Factors

Vehicle Description	MOVES Vehicle Type	Emission Rate (g/mile)		
		CO ₂	CH ₄	N ₂ O
Motorcycles, Passenger Cars and Vans	Motorcycles, Passenger Cars/Trucks	345.38	0.01	0.0002
Busses	Transit Bus	1022.39	0.02	0.0002
2-Axle Single Unit Trucks (not including pickups and vans)	Light Commercial Truck	953.36	0.03	0.0004
3-Axle Single Unit Trucks	Short-haul Single Unit Truck	826.86	0.03	0.0004
Trucks with Single Trailer	Combination Short-haul Single Unit Truck	1607.02	0.03	0.0003

Source: MOVES2014a

**Western Land Area
Programmatic Environmental Assessment**

Table 8
2025 Emission Factors

Vehicle Description	MOVES Vehicle Type	Emission Rate (g/mile)		
		CO ₂	CH ₄	N ₂ O
Motorcycles, Passenger Cars and Vans	Motorcycles, Passenger Cars/Trucks	315.68	0.01	0.0001
Busses	Transit Bus	489.87	0.02	0.0003
2-Axle Single Unit Trucks (not including pickups and vans)	Light Commercial Truck	1406.57	0.04	0.0005
3-Axle Single Unit Trucks	Short-haul Single Unit Truck	811.06	0.04	0.0005
Trucks with Single Trailer	Combination Short-haul Single Unit Truck	1586.00	0.03	0.0004

Source: MOVES2014a

3.2 Estimated Traffic-Related GHG Emissions

Motor vehicle traffic-related emissions were calculated by multiplying the traffic volume of each vehicle type by the appropriate emission factor and vehicle travel distance. Potential traffic-related emissions are presented in **Tables 9 through 11**.

**Western Land Area
Programmatic Environmental Assessment**

Table 9
Carbon Dioxide (CO₂) Emissions

Road Segment	Distance (Miles)	Description	CO ₂ Maximum Potential Emissions (tons)								
			Existing Condition 2016	2020 No Action	2025 No Action	2020 Current Market	2020 Medium Density	2020 High Density	2025 Current Market	2025 Medium Density	2025 High Density
1	2.24	North of Freeport/Trade Center to Dulles Greenway	4,125	4,586	5,204	5,136	5,215	5,429	6,151	6,269	6,666
2	0.33	Between Freeport/Trade Center and Beaver Meadow	570	644	745	721	734	768	883	899	955
3	0.18	Between Beaver Meadow and Overland	329	367	423	409	416	435	492	500	531
4	0.21	Between Overland and School Rd	174	197	228	450	459	484	559	570	609
5	0.17	Between School Rd and Pebble Run	139	157	182	358	365	384	442	451	481
6	2.64	South of Pebble Run to John S. Mosby Hwy	4,647	5,234	6,039	5,926	6,037	6,331	7,254	7,395	7,869
Total:			9,983	11,184	12,822	12,999	13,226	13,831	15,780	16,083	17,111

Source: KBE, 2017.

Note: Results for existing condition are provided for informational purposes.

**Western Land Area
Programmatic Environmental Assessment**

Table 10
Methane (CH₄) Emissions

Road Segment	Distance (Miles)	Description	CH ₄ Maximum Potential Emissions (tons)								
			Existing Condition 2016	2020 No Action	2025 No Action	2020 Current Market	2020 Medium Density	2020 High Density	2025 Current Market	2025 Medium Density	2025 High Density
1	2.24	North of Freeport/Trade Center to Dulles Greenway	0.13	0.15	0.18	0.17	0.17	0.18	0.21	0.21	0.23
2	0.33	Between Freeport/Trade Center and Beaver Meadow	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03
3	0.18	Between Beaver Meadow and Overland	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
4	0.21	Between Overland and School Rd	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
5	0.17	Between School Rd and Pebble Run	0.004	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
6	2.64	South of Pebble Run to John S. Mosby Hwy	0.15	0.17	0.21	0.19	0.20	0.21	0.25	0.25	0.27
Total:			0.31	0.36	0.44	0.42	0.43	0.45	0.54	0.55	0.59

Source: KBE, 2017.

Note: Results for existing condition are provided for informational purposes.

**Western Land Area
Programmatic Environmental Assessment**

Table 11
Nitrous Oxide (N₂O) Emissions

Road Segment	Distance (Miles)	Description	N ₂ O Maximum Potential Emissions (tons)								
			Existing Condition 2016	2020 No Action	2025 No Action	2020 Current Market	2020 Medium Density	2020 High Density	2025 Current Market	2025 Medium Density	2025 High Density
1	2.24	North of Freeport/Trade Center to Dulles Greenway	0.0016	0.0019	0.0023	0.0021	0.0022	0.0023	0.0027	0.0028	0.0030
2	0.33	Between Freeport/Trade Center and Beaver Meadow	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004
3	0.18	Between Beaver Meadow and Overland	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
4	0.21	Between Overland and School Rd	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003
5	0.17	Between School Rd and Pebble Run	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002
6	2.64	South of Pebble Run to John S. Mosby Hwy	0.0018	0.0022	0.0027	0.0025	0.0025	0.0026	0.0032	0.0033	0.0035
Total:			0.0040	0.0047	0.0057	0.0054	0.0055	0.0058	0.0070	0.0072	0.0076

Source: KBE, 2017.

Note: Results for existing condition are provided for informational purposes.

**Western Land Area
Programmatic Environmental Assessment**

4 Conclusions and Findings

The GHG inventories for project-related motor vehicle traffic were estimated for the future years 2020 and 2025 for the three Proposed Action Alternatives (e.g., Current Market, Medium-Density, and High-Density) as well as the construction years of 2020-2025 for three alternatives. Over the long term, CO₂e emissions are largely attributable to project-related motor vehicle exhaust. Presently, there are no federal, state or local thresholds for GHG emissions associated with mixed-use developments, however the estimated annual CO₂e project-related construction and traffic emissions associated with the Proposed Action Alternatives are shown in **Table 12**.

Table 12
CO₂e Emissions (MT per year) – Proposed Action Alternatives

Year	Alternative	Construction/ Traffic	CO ₂ e Emissions (MT per year)		
			Current Market Density	Medium Density Alternative	High Density Alternative
2020	No Action	Traffic	10,157	10,157	10,157
	Action	Traffic	11,805	12,010	12,560
	<i>Difference (Project-Related)</i>		<i>1,648</i>	<i>1,854</i>	<i>2,403</i>
	Action	Construction	17,051	19,665	25,399
	<i>Total Project-Related</i>		<i>18,699</i>	<i>21,519</i>	<i>27,802</i>
2021	Action	Construction	17,038	19,652	25,386
2022	Action	Construction	17,025	19,639	25,373
2023	Action	Construction	17,012	19,626	25,360
2024	Action	Construction	16,998	19,613	25,347
2025	No Action	Traffic	12,822	12,822	12,822
	Action	Traffic	14,331	14,606	15,540
	<i>Difference (Project-Related)</i>		<i>1,508</i>	<i>1,784</i>	<i>2,718</i>
	Action	Construction	16,985	19,600	25,334
	<i>Total Project-Related</i>		<i>18,493</i>	<i>21,384</i>	<i>28,052</i>

Note: Totals are subject to rounding; MT = metric ton; and CO₂e = carbon dioxide equivalent.