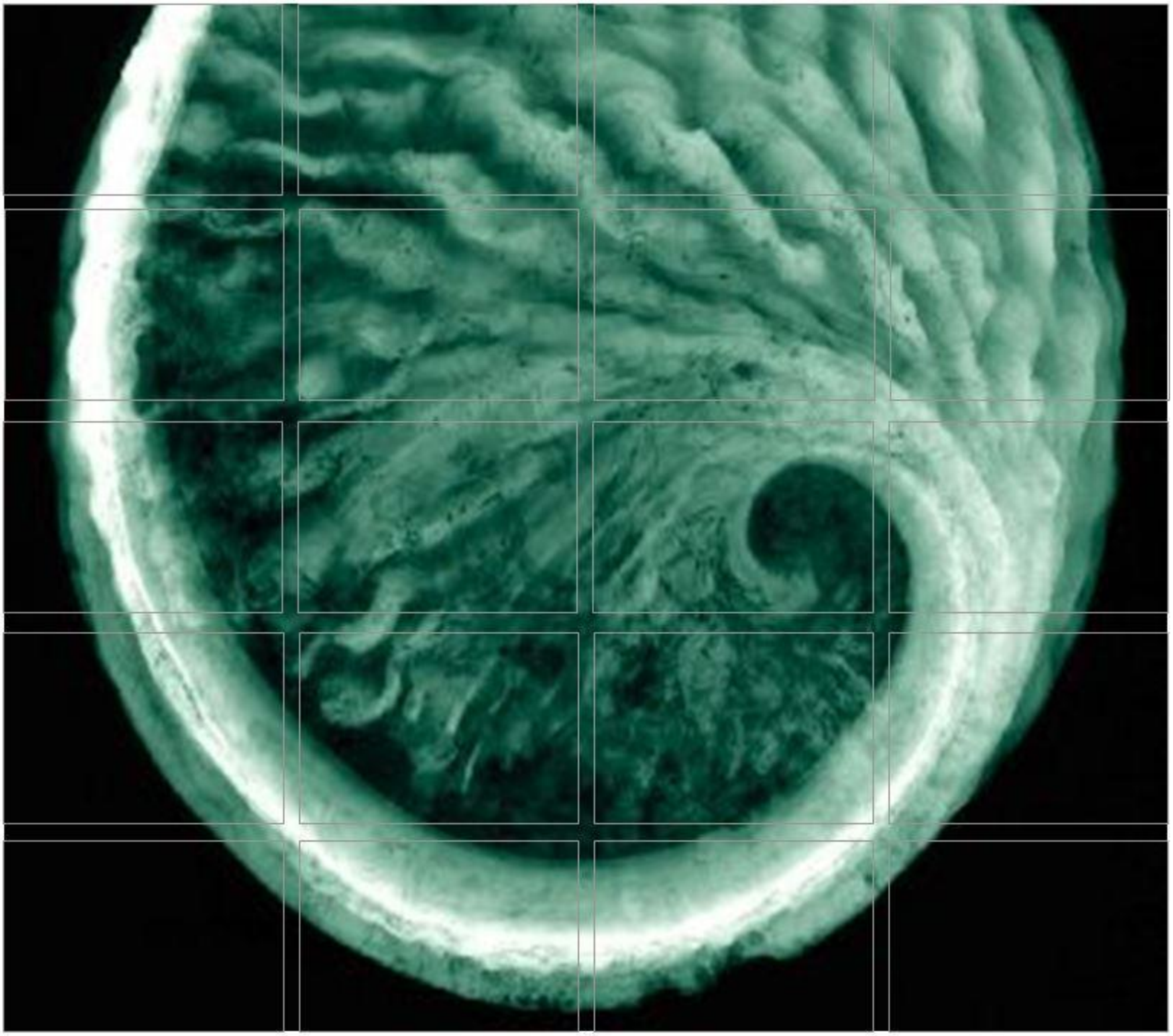

Analysis of GHG Emissions from the Proposed Pilgrim Pipeline

For Pilgrim Pipeline Holdings, LLP

Prepared by Environmental Resources Management

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ERM

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1.0 INTRODUCTION

Pilgrim Pipeline Holdings, LLC plans to develop a pipeline system that consists of two parallel pipelines. Crude oil will be transported on one pipeline from Albany, New York to Linden, New Jersey. After the crude is processed at refineries located in PADD 1[1], the refined petroleum products will be transported via a separate pipeline from Linden, New Jersey back to Albany, New York.

Pilgrim Pipeline Holdings, LLC requested that Environmental Resources Management, Inc. (ERM) perform a comparison of the operational greenhouse gas (GHG) air emissions from transporting the crude and refined products on the proposed Pilgrim pipeline project versus the current method of transporting the same volumes of crude and refined products along the Hudson River using barges.

This report is structured as follows:

- *Section 2* provides an overview of the scope of work for the assessment and the boundary conditions applied to the assessment.

- *Section 3* provides a description of the proposed pipeline project, as well as the assumptions used to calculate the emissions from this option.

- *Section 4* provides the a description of the assumptions used to determine the GHG emissions associated with transporting the same volumes of crude and refined products using barges as would be transported by the proposed pipeline project and an assessment of those emissions.

- *Section 5* provides a comparison of the emissions from both options.

[1] The Petroleum Administration for Defense Districts (PADDs) are geographic aggregations of the US States (and the District of Columbia) into five districts: PADD 1 represents the East Coast.

2.0 *SCOPE OF WORK AND BOUNDARY CONDITIONS*

This study's objective is to define and assess the anticipated operational air emissions of GHGs of the proposed pipelines, and barges transporting the same volumes, so as to enable a like-for-like analysis. The boundary conditions applied associated with the transportation activities are summarized as follows in *Table 1*:

Table 1: Boundary Conditions

Stage	Pipeline	Barge
Loading	Assumed no GHG emissions are produced because the pipeline is gravity loaded	Assumed no GHG emissions are produced because is the barges are gravity loaded
Transportation	Indirect emissions[2] from electricity to power pumps to allow pipeline transportation and direct[3] fugitive emissions from valves. No back-up generators will be provided along the pipeline	Direct emissions[4] from combustion engines for barge movement. Fugitive emissions were not included in the calculations because they are *de minimis* (see *Section 4*)
Unloading	Assumed no GHG emissions associated with unloading because the pipeline is unloaded by gravity	Direct emissions from operation of pumps on barges to unload crude oil/products
Maintenance, inspections and other support activities	Not included in the calculations because the contribution is expected to be *de minimis*	Not included in the calculations because the contribution is expected to be *de minimis*

Considering that both options will transport the same volumes of crude oil and refined petroleum products per year, the broader associated lifecycle emissions (such as from end combustion of the products and crude oil refining) have not been assessed as these emissions would be the same in both options.

This desktop study was based on research conducted by ERM.

[2] For the purposes of this assessment, indirect emissions from the pipeline are from the generation and distribution of purchased electricity.

[3] For the purposes of this assessment, direct emissions refer to GHG emissions that are from sources that are part of the pipeline or barge transportation system, such as combustion engines.

[4] *See* n.3 above.

3.0 PIPELINE TRANSPORT GHG EMISSIONS

3.1 Approach and Assumptions

The Pilgrim Pipeline project is designed to transport 73 million barrels of crude oil per year from Albany, New York to Linden, New Jersey and 73 million barrels of refined petroleum products per year from Linden, New Jersey to Albany, New York (total annual capacity of 146 million barrels). The project has been designed to utilize a total pump capacity of 18,000 horsepower (hp) to transport crude oil approximately 169 miles from Albany to Linden (utilizing three pump stations). In addition, 15,000 hp of pump capacity will be required to transport the refined petroleum products approximately 169 miles from Linden to Albany (also using three pump stations). Twenty mainline valves will be located on each of the pipelines.

The following assumptions and methodologies were used to estimate the total GHG emissions associated with the pipeline transport:

- The electricity used to power these pumps will be taken off the grid and, therefore, the indirect GHG emissions associated with producing this power is assumed to be based on the mixture of multiple energy/fuel sources such as coal, fuel oil, natural gas, hydropower, wind power, etc. that makes up the grid mix for the location of electricity consumption.
- Pump efficiency of 97% motor and drive efficiency (ABB Group, 2009).
- Continuous operation of the pumps at the pump stations for 8,760 hours per year.
- 2.23 horsepower-hours (hp-hr) of work would be required to pump one barrel of crude oil from Albany, NY to Linden, NJ (calculated based on the crude oil pipeline pump power, annual throughput, and annual hours of operation).
- 1.86 hp-hr of work would be required to pump one barrel of refined petroleum products from Linden, NJ to Albany, NY (calculated based on the refined petroleum product pipeline pump power, annual throughput, and annual hours of operation).
- Annual indirect electricity usage in megawatt-hour (MWh) per year was estimated based on the amount of work required to pump one barrel of crude oil and one barrel of refined petroleum products, the annual pipeline throughput, and the annual hours of operation.
- Emission factors for carbon dioxide (CO_2) and CO_2 equivalent (CO_2e) emissions associated with electricity generation were obtained from the U.S. Environmental

Protection Agency Emissions & Generation Resource Integrated Database (eGRID), 9th Ed. (USEPA, 2014) (using Year 2010 data, Version 1.0 for upstate New York).

- The annual U.S. electricity transmission and distribution losses are approximately 6 percent (EIA, 2014).

- GHG emissions associated with the construction of the Pilgrim Pipeline, decommissioning, maintenance, or backup generators were not included in this analysis.

- Both pipelines were assumed be unheated.

3.2 Results

Based on the foregoing information and assumptions, the calculated total annual GHG emissions associated with transporting 73 million barrels of crude oil per year from Albany, New York to Linden, New Jersey, and then transporting 73 million barrels of refined petroleum products per year from Linden, New Jersey to Albany, New York are 58,642 metric tons carbon dioxide equivalent (CO_2e) /year. *Table 2* shows the breakdown of these emissions, and *Appendix 1* provides further details of the calculations used to derive these values.

Table 2: Pilgrim Pipeline Annual Operational GHG Emissions

GHG Source	Annual Emissions (metric ton CO_2e per year)
Fugitive emissions from valves	0.011
Electricity consumption for pumps (generation emissions)	55,323
Electricity consumption for pumps (transmission and distribution losses)	3,319
Total	**58,642**

The direct emissions associated with the pipelines from leaks from the mainline valves along the pipeline are *de minimis* (0.011 metric tons CO_2e/year).

4.0 BARGE TRANSPORT GHG EMISSIONS

4.1 Approach and Assumptions

After analyzing the GHG emissions associated with the pipeline option, ERM assessed the GHG emissions associated with transporting the same volumes via barge on the Hudson River (73 million barrels of crude oil per year and 73 million barrels of refined petroleum products per year).

The following assumptions and methodologies were used to estimate emissions from barge transport along the Hudson River:

- Barges are variable in terms of capacity; however, for these calculations the capacity of a typical barge was assumed to be 100,000 barrels (MTU America Inc., 2012).

- Emissions were calculated for round trips, with the barges full on the initial trip and empty on the return leg.

- The number of barge trips per day (for loaded and empty barges) were calculated based on the volumes transported per day (bbls/day) and average barge capacity.

- A one-way transport distance along the Hudson River from the Port of Albany in NY to Arthur Kill, NJ is approximately 160 miles (as measured by ERM using Google Earth).

- The tugs used to tow or push the barges have variable engine horsepower and the transport of these barges are also influenced by seasonal variations in river flow volume, tide stage, cargo volume, degree of ice, and other environmental variables. For the purposes of these calculations, the following assumptions were made:

    - Propulsion engine power ratings for self-propelled tugboats that tow or push the barges were based on a Twin MTU 16V 4000 engine (i.e., two engines) with each twin engine delivering 1,760 kilowatts (2,360 hp) at 1,800 revolutions per minute (rpm)[5] (MTU America Inc., 2012).

    - Auxiliary engine power ratings for tugboats that tow or push the barges were based on two auxiliary engines per tugboat, each with a power rating of 100 kilowatts (ICF International, 2009).

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[5] Make and model number for tug-barge configurations on the Hudson River were not available so typical tugboat make and models used in the East Coast region of the United States were used in the analysis (MTU America Inc., 2012).

- The main propulsion engines and auxiliary engines for the tugboats pushing loaded barges were assumed to run at 90 percent load (MTU America Inc., 2012) and 31 percent load (ICF 2009), respectively.

- The auxiliary engine load factors for the tugboats towing or pushing empty barges were assumed to be the same as for moving the loaded barges (0.31 or 31 percent). The main propulsion engine load factors for the tugboats were assumed to be 2 percent (0.02) (ICF 2009).

- The tugboats are expected to travel at an average speed of 10.5 knots for both loaded and empty barges, pushing 500-foot 100,000-barrel barges. Knots (nautical miles per hour) were converted to miles per hour by multiplying by a factor of 1.15 miles per nautical mile (MTU America Inc., 2012).

- River barge transportation variations due to river flow volume, tidal influence, ice, idling, and other transportation variables were not analyzed.

- Greenhouse gas emissions were calculated using factors obtained from Chapter 2 and 3 of the ICF 2009 document.

- The barges were assumed to be unheated.

- The emissions associated with on-barge pumps used for unloading were determined using the following assumptions:

  - A full trip includes both loading and unloading a barge; therefore, the pumps used for unloading are only used during half of a full trip.

  - Reasonable time to unload would be about half a day (12 hours).

  - To unload within half a day at least 7 x 1629 gpm pumps would be needed.

- No allowances were made for Hudson River barge air emission exemptions.

3.2 *Results*

Table 3 shows that the annual GHG emissions associated with transporting the same volume of crude and refined products via barge are 72,888 metric tons CO_2e /year. *Appendix 2* provides further details of the calculations applied.

Table 3: Barge Transportation Annual GHG Emissions

GHG Source	Annual Emissions (metric ton CO_2e per year)
Combustion engine for barge transportation	71,418
Combustion of fuel to power unloading pumps	1,469
Total	**72,888**

The emissions from the barge option are produced by the combustion of hydrocarbons in the main propulsion engines and the auxiliary engines of the tugboats used to move the barges.

5.0 *COMPARISON OF BARGE AND PIPELINE GHG EMISSIONS*

A comparison of the GHG emissions from the pipeline and barge options is presented in *Table 4*.

Table 4: Comparison of GHG Air Emissions

Transport Option	Annual Emissions (metric ton CO_2e per year)
Proposed pipeline	58,642
Hudson River barges	72,888
Percent Difference Between Pipeline to Barge Emissions Total	19.5% reduction using the pipeline

As *Table 4* shows, the estimated annual total emissions of GHGs (in CO_2e) for transporting the crude and refined products via pipeline are approximately 20% lower than transporting the same volume of crude and refined products by barge.

Overall, the pipeline option does not represent a significant source of GHG emissions. To put the total GHG emissions from the pipeline option in context, if a major source (i.e., a power plant) makes a modification that caused its GHG emissions to increase by 75,000 tons CO_2e/year,[6] that source must obtain a Prevention of Significant Deterioration (PSD) permit that includes a GHG limit. The total emissions from the pipeline project are below this threshold. The emissions from the pipeline are also significantly lower than the overall GHG emissions produced by large power plants, which can exceed 2 million metric tons CO_2e / year (USEPA GHGRP).

6 PSD applicability calculations are based on short tons (2,000 lbs), not metric tons (USEPA Mar. 2011).

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APPENDIX 1: Calculation Tables and Results for the Proposed Pilgrim Pipeline

Table A1-1 Direct Greenhouse Gas Emissions from Pipeline Transport

Location	Number of Mainline Valves along Pipeline[a]	TOC Emission Factor [b, c]	TOC Emissions[b]		CH_4 Emissions[c]		CO_2e Emissions[d]
	#	(lb/hr) / component	lb/hr	ton/year	lb/hr	ton/year	ton/year
Pipeline transport of Bakken light crude from Albany, NY to Linden, NJ	20	1.85E-05	0.00037	0.0016	0.000056	0.00024	0.0061
Pipeline transport of petroleum products from Linden, NJ to Albany, NY	20	1.85E-05	0.00037	0.0016	0.000056	0.00024	0.0061
Total:			**0.00074**	**0.0032**	**0.00011**	**0.00049**	**0.012**

Note:

[a] Number of mainline valves (MLVs) to be operated on the crude and product pipelines were provided by project design.

[b] Total organic carbon (TOC) emission factors for valves taken from USEPA's Equipment Leak Emission Estimates (USEPA, 1995). Emission factors pertaining to Oil and Gas Production Operations for Heavy Oil were used.

[c] Methane (CH_4) emissions were estimated from the TOC emission rates based on typical weight fraction of 0.15 for CH_4. (USEPA AP-42, Section 5.2, Transportation and Marketing of Petroleum Liquids, June 2006).

[d] CO_2e emissions were estimated based on a 100-year global warming potential of 25 for CH_4.

Table A1-2 Indirect Greenhouse Gas Emissions from Electricity Use by the Pipeline Transport

Pipeline Transport Location	e-Grid Region [a]	Annual Through-put (bbl/yr)[b]	Pipeline Pump Power (hp)[c]	Annual Hours of Operation (hr/yr)[d]	Work Required to Pump Crude or Petroleum Product (hp-hr/bbl)[e]	Annual Indirect Electricity Usage (MWh/yr)[f]	Greenhouse Gas Emission Factors for Electric Motor-Driven Pumps Powered from Grid (lb/MWh)[a]			Greenhouse Gas Annual Emissions (tons/year)[g]			Total GHG Emissions (ton/year)	Greenhouse Gas Annual Emissions (metric tons/year)[i]
							CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2e[h]	CO_2e
Bakken light crude from Albany, NY to Linden, NJ	NYUP	73,000,000	18,557	8,760	2.23	121,221	545.79	0.0163	0.00724	33,080	0.99	0.44	33,236	30,151
Petroleum products from Linden, NJ to Albany, NY	NYUP	73,000,000	15,464	8,760	1.86	101,017	546.79	0.0163	0.00724	27,618	0.82	0.37	27,747	25,172
						Electricity Generation Emissions:				**60,698**	**1.81**	**0.80**	**60,983**	**55,323**
						Transmission Loss Emissions [j]				**3,642**	**0.11**	**0.048**	**3,659**	**3,319**
						Total:				**64,340**	**1.92**	**0.85**	**64,642**	**58,642**

Note:

[a] The e-Grid (Emissions and Generation Resource Integrated Database) region for Upstate New York as well as electricity generation emission factors for each greenhouse gas (GHG) were taken from US EPA's eGRID2012 version 1 database, Year 2010 (USEPA, 2014).

[b] Based on 0.2 million barrels per day each of crude oil and refined petroleum products, 365 days per year.

[c] Based on a total pump size of 18,000 HP for moving crude oil over 169 miles (three pump stations) and a total pump size of 15,000 HP for moving refined petroleum products, respectively over 169 miles (three pump stations). Also accounted for a 97% motor and drive efficiency (ABB Group, 2009)

[d] Assumes the pumps (in pump stations) would be operating continuously for 8,760 hours per year.

[e] The work required to pump one barrel of crude oil or refined petroleum products between Albany, NY and Linden, NJ was calculated based on the pipeline pump power, annual throughput, and annual hours of operation.

[f] Annual indirect electricity usage was estimated based on the amount of work required to pump one barrel each of crude oil and refined petroleum products, annual throughput, and annual hours of operation.

[g] GHG emissions in tons per year were calculated based on the GHG emission factors and annual indirect electricity usage.

[h] Total GHGs were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298); see 40 CFR 98 Subpart A Table A-1.

[i] GHG emissions in metric tons per year were calculated using the conversion factor: 1 metric ton = 1.10231 tons.

[j] The US Energy Information Administration estimates that national electricity transmission and distribution losses average about 6% of the electricity that is transmitted and distributed in the United States each year (EIA, 2014).

APPENDIX 2: Calculation Tables and Results for the Barge Transportation Option

Table A2-3 Direct Greenhouse Gas Emissions from Barge Transport

Transport Mode	Volume Transported Per Day, Throughput (bbls/ day)[a]	Number of Calls Per Day[b]	Transport Distance, One Way (miles)[c]	Fuel Type[d]	Propulsion Engine[e]		Auxiliary Engines[f]		Speed (miles/ hr)[g]	Activity (hours/ trip)[h]	Propulsion Engine Emission Factors (g/kWh)			Auxiliary Engine Emission Factors (g/kWh)			Greenhouse Gas Annual Emissions (ton/year)[i]			Total GHG Emissions (ton/year)	Greenhouse Gas Annual Emissions (metric ton/year)
					Total Max. Power Rating (kW)	Engine Load Factor	Total Max. Power Rating (kW)	Engine Load Factor			CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2e	CO_2e
Loaded barges with towboats transporting refined petroleum northbound from Arthur Kill, NJ to Port of Albany, NY	200,000	2.0	160	ULSD	3,520	0.90	200	0.31	12.1	13.3	690	0.090	0.020	690	0.090	0.020	23,764	3.10	0.69	24,046	21,814
Empty barges with towboats going southbound from Albany, NY to Arthur Kill, NJ	0	2.0	160	ULSD	3,520	0.02	200	0.31	12.1	13.3	2854	23.97	54.82	690	0.090	0.020	2,598	18.05	41.16	15,316	13,895
Loaded barges with towboats transporting crude oil southbound from Port of Albany, NY to Arthur Kill, NJ	200,000	2.0	160	ULSD	3,520	0.90	200	0.31	12.1	13.3	690	0.090	0.020	690	0.090	0.020	23,764	3.10	0.69	24,046	21,814
Empty barges with towboats going northbound from Arthur Kill, NJ to Port of Albany, NY	0	2.0	160	ULSD	3,520	0.02	200	0.31	12.1	13.3	2854	23.97	54.82	690	0.090	0.020	2,598	18.05	41.16	15,316	13,895
																Total:	**52,723**	**42.3**	**83.7**	**78,725**	**71,418**

Notes:

[a]Based on 73 million barrels of crude oil and 73 million barrels of refined petroleum products transported annually (365 days), and 100,000 barrels per call.

[b]Number of barge trips per day (for loaded and empty barges) were calculated based on volume of crude transported per day (bbls/day) and assuming the capacity of a typical barge would be 100,000 barrels.

[c]Based on a round trip distance of 320 miles along the Hudson River from The Port of Albany in NY to Arthur Kill, NJ. This results to a one-way transport distance of 160 miles.

[d]The tugboat engines were assumed to fire ultra low sulfur diesel (ULSD) with a fuel sulfur content of 0.0015 percent or 15 parts per million (ppm).

[e]Propulsion engine power ratings for self-propelled tugboats that tow or push the barges were based on a Twin MTU 16V 4000 engine (i.e. two engines), with each twin engine delivering 1,760 kilowatts (2,360 horsepower) at 1,800 revolutions per minute (rpm). The tug locks into the bow of a barge and from a dead stop takes the engines to 100 percent load to get the barge moving. From that point and through the entire voyage, the engines run at 80-to 90-percent load (MTU America Inc., 2012). For the purpose of this assessment, the main propulsion engines for the tugboats pushing loaded barges are assumed to run at 90 percent load. For empty barges during the return trips, the main propulsion engine load factors for the tugboats were assumed to be the same as for the loaded trip (i.e., 0.90 or 90 percent).

[f]Auxiliary engine power ratings for tugboats that tow or push the barges were taken from ICF International, 2009, Table 3-10 (i.e., approximately two auxiliary engines per tugboat, each with a power rating of 100 kilowatts). The auxiliary engines for the tugboats pushing loaded barges are assumed to run at 31 percent load (ICF International, 2009, Table 3-4). For empty barges during the return trips, the auxiliary engine load factors for the tugboats were assumed to be the same as for the loaded trip (i.e., 0.31 or 31 percent).

[g]The tugboats are expected to travel at an average speed of 10.5 knots pushing a 500-foot 100,000-barrel barges. Knots (nautical miles per hour) converted to miles/hour by multiplying by a factor of 1.15 miles/nautical mile.

[h]Activity (duration) calculated using tugboat speed and distance traveled per trip.

[i]Greenhouse gas emissions in tons per year were calculated calculated using emission factors for Category 1 Tier 2 main propulsion engines (minimum power of 1000 kW) and Category 1 Tier 2 auxiliary engines (mininum power of 130 kW) (ICF 2009, Table 3-8). The tugboats were assumed to have Category 1 main and auxiliary engines since about 90 percent of all tug, tow, push, and assist tugs are Category 1 and 10 percent are Category 2 (ICF International, 2009, Section 3.4.2). Total greenhouse gases were estimated as CO_2 equivalents (CO_2e), accounting for 100-year global warming potentials of CO_2 (1), CH_4 (25) and N_2O (298).At reduced load (i.e. loads less than 20 percent), emission factors for the integrated tug-barge propulsion engines were calculated using equation 5 and 6 of the ICF 2009 document. CH_4 propulsion emission factors are multiplied by hydrocarbon (HC) low load adjustment factors for load factors below 20 percent based upon the premise that CH_4 emissions are tied to HC emissions. N_2O propulsion emission factors are multiplied by NOx low load adjustment factors on the premise that N_2O is linked to NOx (see pg 2-18 and 2-19 of the ICF 2009 document). According to the ICF 2009 document (pg 2-19), there is no need for a low load adjustment factor for auxiliary engines because they are generally operated in banks.

Table A2-4 Direct Greenhouse Gas Emissions from Barge Unloading

Barge Pump Engine Emissions factors (lb/hp-hr)					Pump Engine Power (hp)	Number of pumps	Pump Size (gpm)	Unloading time for 1 pump (hrs)	Unloading time for 7 pumps (hrs)	Number of trips per year	Criteria Pollutant Emissions (tons/year)				
CO	NOx	SO_2	PM_{10}	CO_2							CO	NOx	SO_2	PM_{10}	CO_2
6.68E-03	0.031	2.05E-03	2.20E-03	1.15	180	7	1629	85.9	12.3	182.5	8.535	39.610	2.619	2.811	1,469

The source for the greenhouse gas emissions factors was US EPA AP-42 Section 3.3 http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf

Conversion Factors

1 Gallon [Fluid]	0.023809524 bbls Oil
1 lb	0.00045359 metric tons

Assumptions

A full trip considered to include both loading and unloading a barge; therefore, the pumps used for unloading are only used during half of a full trip