Appendix B Monmouth County Greenhouse Gas Emissions Inventory Protocols

Study Focus and Boundaries

The Monmouth County Transportation Audit and Sustainable Transportation Plan focuses specifically on transportation related facilities. For the purpose of this study, transportation facilities are defined as “mobile sources” of emissions. "Mobile sources" is a term used to describe a wide variety of vehicles, engines, and equipment that generate air pollution and that move, or can be moved, from place to place.

Mobile sources are broken down into two categories: on road and non-road sources. "On-road" or highway sources include vehicles used on roads for transportation of passengers or freight. This category of mobile sources includes light-duty vehicles, light-duty trucks, heavy-duty vehicles, buses, and motorcycles, used for transportation on the road. On-road vehicles may be fueled with gasoline, diesel fuel, or alternative fuels such as alcohol or natural gas. The other category, non-road mobile sources, includes non-road gasoline equipment and vehicles, non-road diesel equipment and vehicles, aircraft, marine vessels, locomotives, and assorted other engines and vehicles. These categories of mobile sources include equipment and vehicles fueled with diesel fuel, gasoline, propane, or natural gas in the following sectors: recreational, construction, lawn and garden, farm, commercial, railway, and passenger marine ferries. "Non-road" sources include vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. Within these two broad categories, on-road and non-road sources are further distinguished by size, weight, use, and/or horsepower.

This study will include both types of mobiles sources that are used in Monmouth County. However, the mobile emissions will be broken down into two distinct user categories for further analysis: Monmouth County Government Operations and the County Wide (General Public). County Government Operations is defined as the vehicles owned and operated by the County. This includes public transportation such as S.C.A.T. and similar services. All other transportation related emissions would be accounted for in the County Wide analysis.

In terms of government operations the study will focus only on the transportation sector owned and operated by the County such as the vehicle fleet, transit fleet and County’s employees. The study will not include buildings that house cars and trucks, and other transportation related

emissions such as traffic lights and street lighting. The study will only account for emission within Monmouth County's Boundaries.

Data Sources

County Operations Data

The County operations data for their vehicle fleet comes from two sources: The Monmouth County Public Work Department and the Parks Department.

The Monmouth County Public Work (PW) Division of Fleet Services provides service for county vehicles and equipment which includes county owned cars, light and heavy trucks, heavy and light equipment, buses, and other specialized equipment used throughout the county. The main point of contact has been the Superintendent of Fleet Services. The on road data collected from the PW includes the vehicle, its annual mileage, the annual amount of fuel it used, the department or division that uses the vehicle, the vehicle's make, model, and year, the type of fuel the vehicle uses, and the equipment type (type of vehicle: small truck, passage car, so on). Table 1 illustrates a sample of the data provided.

Table 1 Example of On Road Source Data

MONMOUTH COUNTY
DIVISION OF FLEET SERVICES
TRANSPORTATION AUDIT AND SUSTAINABLE PLAN
FOR YEAR 2009
COUNTY ON-ROAD MOBILE EQUIPMENT

DEPARTMENT	MAKE	MODEL	YEAR	EQUIPMENT TYPE	FUEL TYPE	HOURS	MILEAGE	FUEL USED (GALLONS)
AGING:OFFICE OF AGING	FORD	FOCUS	2002	1:PASSENGER CARS	U		1062	54.000
AGING:OFFICE OF AGING	FORD	E250 ECONOLINE VAN	2003	2:LIGHT TRUCKS,VANS,MASON DUMPS,UTILITY BODY,	U		1502	134.550
AGING:OFFICE OF AGING	FORD	ECONOLINE 150 VAN	2003	2:LIGHT TRUCKS,VANS,MASON DUMPS,UTILITY BODY,	U		3149	237.050
AVA:AUDIO VISUAL AIDE	CHEVY	G10 VAN	2008	2:LIGHT TRUCKS,VANS,MASON DUMPS,UTILITY BODY,	U		13593	1024.150
B&G:BUILDINGS AND GROUNDS	FORD	ESCORT STATION WAGON	1996	1:PASSENGER CARS	U		121	7.500

The non-road data collected by PW is provided in terms of both gas can fill ups and larger mobile off-road equipment such as mowers. Since much of the non-road equipment is transportable engines such as lawn equipment, generators, and so on, the amount of gas put into the cans equates to the total fuel used by the equipment. The data provided includes the type of dispenser used, the amount and type of fuel used by various County departments. Table 2 is an example of the type of non-road gas can source data provided.

Table 2 Example of Non-Road Gas Can Source Data

MONMOUTH COUNTY
DIVISION OF FLEET SERVICES
TRANSPORTATION AUDIT AND SUSTAINABLE PLAN
FOR YEAR 2009
COUNTY GAS CANS AND MOBILE FUEL DISPENSERS

DEPARTMENT	MODEL	QUANTITY IN GALLONS	FUEL TYPE
B&G:BUILDINGS AND GROUNDS	28 GALLONS	63.400	D
B&G:BUILDINGS AND GROUNDS	5 GALLON	35.700	D
B&G:BUILDINGS AND GROUNDS	50 GALLONS	668.400	D
BRIDG:BRIDGE DEPT	5 GALLONS	19.000	D
FLEET:FLEET SERVICES	5 GALLON	8.600	D

Larger off-road vehicle data is also provided by PW. Much like the on road vehicle data, the off road data includes the department or division that uses the vehicle, the vehicle's make, model, and year, the type of fuel the vehicle uses, and the equipment type (type of vehicle: small truck, passage car, so on). However, instead of providing the amount of fuel used and mileage, the data provides the amount of hours used. This information is more useful since many of the off road equipment such as back hoes and pavers do not travel long distances but work harder than most engines just standing still. Table 3 provides an example of the off road data provided by the PW.

Table 3 Example of Off Road Source Data

MONMOUTH COUNTY
DIVISION OF FLEET SERVICES
TRANSPORTATION AUDIT AND SUSTAINABLE PLAN
FOR YEAR 2009
COUNTY OFF-ROAD MOBILE EQUIPMENT FUELED AT PUMPS

DEPARTMENT	MAKE	MODEL	YEAR	EQUIPMENT TYPE	FUEL TYPE	HOURS
B&G:BUILDINGS AND GROUNDS	INTERNATIONAL	MOWER-RIDING	1986	4:LT EQUIPMENT,MOWERS,TRACTORS-OPERATOR DRIVEN	D	20
B&G:BUILDINGS AND GROUNDS	JOHN DEERE	LOADER-UTILITY	2002	5:HEAVY EQUIPMENT-LOADERS,BACKHOES,GRADERS,SWEEPERS	D	943
B&G:BUILDINGS AND GROUNDS	BOBCAT	SKIDSTEER-LOADER-TRACK TYPE	2005	5:HEAVY EQUIPMENT-LOADERS,BACKHOES,GRADERS,SWEEPERS	D	43
B&G:BUILDINGS AND GROUNDS	MAGNUM	LIGHT TOWER	2005	7:OTHER SPECIALIZED EQUIPMENT-SMALL-ENGINE,TRAILERS	D	528
B&G:BUILDINGS AND GROUNDS	EX-MARK	MOWER-RIDING		7:OTHER SPECIALIZED EQUIPMENT-SMALL-ENGINE,TRAILERS	U	244
BRIDG:BRIDGE DEPT	CASE	680K BACKHOE	1986	5:HEAVY EQUIPMENT-LOADERS,BACKHOES,GRADERS,SWEEPERS	D	48

In addition to the vehicle fleet and other non-road equipment the government operations includes a County employee commuter emissions analysis. This data was compiled using a survey of County employees and their average weekly commuting patterns created, distributed, and collected by the County's Planning Board. The survey includes question pertaining to the origin (zip code where an employee resides) and destination (which County office does the employee work in), the type of vehicle used in the commute, the type of fuel the vehicle uses, types of alternatives to single car transportation used, why they make their commuting choice, and possible reasons that would make them use alternative commute modes other than single occupancy vehicles.

The Parks Department provided fuel consumption instead of vehicle and equipment specific information. The emissions will be calculated based on total fuel consumption by road and non-road consumption.

County Wide Emissions

The County Wide emissions data will be provided by the NJTPA who is completing a regional GHG emissions inventory which includes Monmouth County. Additional information on non road sources such as railways, ferries, and air transportation that originate in Monmouth County will also be provided by NJTPA.

Methods of Calculation of Emissions for Government Operations

The study will utilize ICLEI's CACP worksheet to calculate the GHG emissions for the government operations component of the study. All of the data gathered on government mobile source data, both on road and non-road, will be inputted into the CAPC for calculation.

Tables 4-8 are the emission factors used by the CACP software when calculating GHG emission from all mobile sources including on road, non-road, and any mobile emission created by alternative fuel.

Table 4 ICLEI Default CO^2 Emission Factors for Transport Fuels

Fuel Type	Carbon Content	Heat Content	Fraction Oxidized	CO_2 Emission Factor (Per Unit Volume)
Fuels Measured in Gallons	kg C / MMBtu	MMBtu / barrel		kg CO2 / gallon
Gasoline	19.15	5.25	1	8.78
Diesel Fuel (Distillate No. 2)	20.17	5.80	1	10.21
Aviation Gasoline	18.89	5.04	1	8.31
Jet Fuel (Jet A or A-1)	19.33	5.67	1	9.57
Kerosene	20.51	5.67	1	10.15
Residual Fuel Oil (#5,6)	21.49	6.29	1	11.80
Crude Oil*	20.32	5.38	1	10.28
Biodiesel (B100)*	20.14	5.38	1	9.45
Ethanol (E100)*	18.67	3.53	1	5.75
Methanol**	NA	NA	1	4.10
Liquefied Natural Gas (LNG)*	NA	NA	1	4.46
Liquefied Petroleum Gas (LPG)*	17.18	3.86	1	5.79
Propane	16.76	3.82	1	5.59
Ethane	17.08	4.03	1	6.01
Isobutane	17.70	4.16	1	6.30
n-Butane	17.77	4.24	1	6.58
Fuels Measured in Standard Cubic Feet	kg C / MMBtu	Btu / Standard cubic foot		kg CO2 / Standard cubic foot
Compressed Natural Gas (CNG)	14.47	1,028	1	0.054

Source: U.S. EPA, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2007 (2009), Annex Table A-34, A-39, A-42. Except those marked * EPA Climate Leaders, Mobile Combustion Guidance, Table B-3, B-4, B-5, B-6, B-7(2008) and ** from California Climate Action Registry General Reporting Protocol Version 2.2, 2007, Table C.3. A fraction oxidized value of 1.00 is from the IPCC, *Guidelines for National Greenhouse Gas Inventories* (2006).

Note: Default CO_2 emission factors are calculated using Equation 12d: Heat Content × Carbon Content × Fraction Oxidized × 44/12 × Conversion Factor. Heat content factors are based on higher heating values (HHV).). NA = data not available.

Table 5 Default CH^4 and N^2O Emission Factors for Highway Vehicles by Model Year

Vehicle Type and Year	N_2O (g/mi)	CH_4 (g/mi)
Gasoline Passenger Cars		
Model Years 1984-1993	0.0647	0.0704
Model Year 1994	0.0560	0.0531
Model Year 1995	0.0473	0.0358
Model Year 1996	0.0426	0.0272
Model Year 1997	0.0422	0.0268
Model Year 1998	0.0393	0.0249
Model Year 1999	0.0337	0.0216
Model Year 2000	0.0273	0.0178
Model Year 2001	0.0158	0.0110
Model Year 2002	0.0153	0.0107
Model Year 2003	0.0135	0.0114
Model Year 2004	0.0083	0.0145
Model Year 2005	0.0079	0.0147
Model Year 2006	0.0057	0.0161
Model Year 2007	0.0041	0.0170
Model Year 2008	0.0038	0.0172
Gasoline Light Trucks (Vans, Pickup Trucks, SUVs)		
Model Years 1987-1993	0.1035	0.0813
Model Year 1994	0.0982	0.0646
Model Year 1995	0.0908	0.0517
Model Year 1996	0.0871	0.0452
Model Year 1997	0.0871	0.0452
Model Year 1998	0.0728	0.0391
Model Year 1999	0.0564	0.0321
Model Year 2000	0.0621	0.0346
Model Year 2001	0.0164	0.0151
Model Year 2002	0.0228	0.0178
Model Year 2003	0.0114	0.0155
Model Year 2004	0.0132	0.0152
Model Year 2005	0.0101	0.0157
Model Year 2006	0.0089	0.0159
Model Year 2007	0.0079	0.0161
Model Year 2008	0.0066	0.0163
Gasoline Heavy-Duty Vehicles		
Model Years 1985-1986	0.0515	0.4090
Model Year 1987	0.0849	0.3675
Model Years 1988-1989	0.0933	0.3492
Model Years 1990-1995	0.1142	0.3246
Model Year 1996	0.1680	0.1278
Model Year 1997	0.1726	0.0924
Model Year 1998	0.1693	0.0641
Model Year 1999	0.1435	0.0578
Model Year 2000	0.1092	0.0493
Model Year 2001	0.1235	0.0528
Model Year 2002	0.1307	0.0546
Model Year 2003	0.1240	0.0533
Model Year 2004	0.0285	0.0341
Model Year 2005	0.0177	0.0326
Model Year 2006	0.0175	0.0326
Model Year 2007	0.0173	0.0327
Model Year 2008	0.0171	0.0327

Vehicle Type and Year	N_2O (g/mi)	CH_4 (g/mi)
Diesel Passenger Cars		
Model Years 1960-1982	0.0012	0.0006
Model Years 1983-1995	0.0010	0.0005
Model Years 1996-2007	0.0010	0.0005
Diesel Light Duty Trucks		
Model Years 1960-1982	0.0017	0.0011
Model Years 1983-1995	0.0014	0.0009
Model Years 1996-2007	0.0015	0.0010
Diesel Heavy-Duty Vehicles		
All Model Years	0.0048	0.0051

Source: Based on U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008 (2010).

Table 6 Default CH^4 and N^2O Emission Factors for Alternative Fuel Vehicles

Vehicle Type*	N_2O (g/mi)	CH_4 (g/mi)
Light Duty Vehicles		
Methanol	0.067	0.018
CNG	0.050	0.737
LPG	0.067	0.037
Ethanol	0.067	0.055
Biodiesel (BD20)	0.001	0.001
Heavy Duty Vehicles		
Methanol	0.175	0.066
CNG	0.175	1.966
LNG	0.175	1.966
LPG	0.175	0.066
Ethanol	0.175	0.197
Biodiesel (BD20)	0.005	0.005
Buses		
Methanol	0.175	0.066
CNG	0.175	1.966
Ethanol	0.175	0.197
Biodiesel (BD20)	0.005	0.005

Source: U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 (2009), Annex 3.2, Table A-91.

Table 7 Default CH^4 and N^2O Emission Factors for Non-Highway Vehicles

Vehicle Type / Fuel Type	N_2O (g / gallon fuel)	CH_4 (g / gallon fuel)
Ships and Boats		
Residual Fuel Oil	0.30	0.86
Diesel Fuel	0.26	0.74
Gasoline	0.22	0.64
Locomotives		
Diesel Fuel	0.26	0.80
Agricultural Equipment		
Gasoline	0.22	1.26
Diesel Fuel	0.26	1.44
Construction		
Gasoline	0.22	0.50
Diesel Fuel	0.26	0.58
Other Non-Highway		
Snowmobiles (Gasoline)	0.22	0.50
Other Recreational (Gasoline)	0.22	0.50
Other Small Utility (Gasoline)	0.22	0.50
Other Large Utility (Gasoline)	0.22	0.50
Other Large Utility (Diesel)	0.26	0.58
Aircraft		
Jet Fuel	0.31	0.27
Aviation Gasoline	0.11	7.04

Source: U.S. EPA Climate Leaders, Mobile Combustion Guidance (2008) based on U.S. EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005* (2007), Annex 3.2, Table A-101.

Table 8 Alternate Methodology CH^4 and N^2O Emission Factors for Highway Vehicles by Inventory Year

Vehicle Type and Year	N_2O (g/mi)	CH_4 (g/mi)
Gasoline Passenger Cars		
Inventory Year 1999	0.05372	0.05035
Inventory Year 2000	0.05080	0.04648
Inventory Year 2001	0.04711	0.04248
Inventory Year 2002	0.04364	0.03886
Inventory Year 2003	0.04011	0.03542
Inventory Year 2004	0.03630	0.03251
Inventory Year 2005	0.03413	0.02990
Inventory Year 2006	0.02940	0.02780
Gasoline Light Trucks (Vans, Pickup Trucks, SUVs)		
Inventory Year 1999	0.09029	0.06059
Inventory Year 2000	0.08665	0.05701
Inventory Year 2001	0.07795	0.05158
Inventory Year 2002	.07095	0.04700
Inventory Year 2003	0.06295	0.04236
Inventory Year 2004	0.05593	0.03811
Inventory Year 2005	0.04935	0.03451
Inventory Year 2006	0.04331	0.03146
Gasoline Heavy-Duty Vehicles		
Inventory Year 1999	0.12126	0.26243
Inventory Year 2000	0.12262	0.23709
Inventory Year 2001	0.12546	0.21149
Inventory Year 2002	0.12721	0.19053
Inventory Year 2003	0.12685	0.17253
Inventory Year 2004	0.11780	0.15537
Inventory Year 2005	0.10984	0.13826
Inventory Year 2006	0.10310	0.12351

Vehicle Type and Year	N_2O (g/mi)	CH_4 (g/mi)
Diesel Passenger Cars		
Inventory Year 1999	0.001	0.0005
Inventory Year 2000	0.001	0.0005
Inventory Year 2001	0.001	0.0005
Inventory Year 2002	0.001	0.0005
Inventory Year 2003	0.001	0.0005
Inventory Year 2004	0.001	0.0005
Inventory Year 2005	0.001	0.0005
Inventory Year 2006	0.001	0.0005
Diesel Light Trucks (Vans, Pickup Trucks, SUVs)		
Inventory Year 1999	0.00144	0.00094
Inventory Year 2000	0.00145	0.00095
Inventory Year 2001	0.00146	0.00096
Inventory Year 2002	0.00147	0.00097
Inventory Year 2003	0.00147	0.00097
Inventory Year 2004	0.00148	0.00098
Inventory Year 2005	0.00148	0.00098
Inventory Year 2006	0.00149	0.00099
Diesel Heavy-Duty Vehicles		
Inventory Year 1999	0.0048	0.0051
Inventory Year 2000	0.0048	0.0051
Inventory Year 2001	0.0048	0.0051
Inventory Year 2002	0.0048	0.0051
Inventory Year 2003	0.0048	0.0051
Inventory Year 2004	0.0048	0.0051
Inventory Year 2005	0.0048	0.0051
Inventory Year 2006	0.0048	0.0051

Sources: Derived from US EPA Climate Leaders, Mobile Emissions Guidance (May 2008), US EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2004* (April 2006) and US EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2006* (April 2008).