APPENDIX G: EMISSIONS CALCULATIONS AND FUEL CONSUMPTION INFORMATION

Table G-1. Total Diverted Vehicle, Bus and Plane Trips (passenger-miles/year)

Build Alternate 2035						
State	Additional Train Passenger-miles	Number of Diverted Passenger-miles			Total Diverted Trips	Net Change
		Vehicles	Buses	Planes		
Illinois	33,661,152	22,047,000	2,445,120	4,319,712	28,811,832	4,849,320
Indiana	102,853,520	67,365,000	7,471,200	13,199,120	88,035,320	14,818,200
Michigan	575,979,712	377,246,000	41,838,720	73,915,072	492,999,792	82,979,920
TOTAL	**712,494,384**	**466,658,000**	**51,755,040**	**91,433,904**	**609,846,944**	**102,647,440**

Table G-2. Estimated Changes in Fuel Use from Diversion of Vehicle, Bus and Plane Trips (Gallons)

Build Alternate 2035						
State	Additional Train Fuel Consumption	Reduction in Fuel Consumption			Total reduction	Net Change
		Vehicles	Buses	Planes		
Illinois	598,284	608,423	75,709	90,426	774,559	-176,275
Indiana	1,828,090	1,859,062	231,335	276,302	2,366,698	-538,608
Michigan	10,237,304	10,410,785	1,295,473	1,547,289	13,253,547	-3,016,243
TOTAL	**12,663,678**	**12,878,269**	**1,602,517**	**1,914,016**	**16,394,803**	**-3,731,125**

Note: A negative net change indicates that the implementation of the Build Alternative will result in an overall decrease in fuel consumption as the additional rail service is replacing passenger vehicle, bus, and plane trips along a similar route, and uses less fuel per passenger then other modes of transportation.

Table G-3. Estimated Changes in Air Pollutants from Diversion of Vehicle, Bus and Plane Trips (Tons per Year)

Build Alternate 2035						
Polluntant	Additional Train Emissions	Reduction in Emissions			Total Reduction	Net Change
		Vehicles	Buses	Planes		
HC	80.89	131.86	9.01	4.43	145.29	-64.40
CO	531.37	1,033.01	72.42	27.82	1,133.25	-601.88
NO_X	1,827.03	1,063.93	73.97	89.15	1,227.06	599.97
PM-10	47.42	52.42	3.67	0.00	56.08	-8.67
PM-2.5	46.00	43.56	3.11	0.00	46.67	-0.67
SO_2	1.34	2.20	0.14	2.53	4.86	-3.52
CO_2	141,687.56	113,850.34	17,929.77	20,190.96	151,971.06	-10,823.51

Note: A negative net change indicates that the implementation of the Build Alternative will result in an overall decrease in emissions as the additional rail service is replacing passenger vehicle, bus, and plane trips along a similar route, and produces fewer emissions per passenger then other modes of transportation.

Table G-4. Estimate of Diverted Trips- Illinois

Chicago to Detroit Intercity Passenger Rail Service - Illinois		
Build Alternative	**Quantity**	**Source:**
Total Annual Ridership	**2,830,000**	TEMS Study (June 2014)
Existing Rail Trips	495,250	TEMS Study (June 2014)
Total New Rail Trips	**2,337,580**	TEMS Study (June 2014)
New Trips from natural growth & induced demand	336,770	TEMS Study (June 2014)
Breakdown of Diverted Trips		
Auto Diverted Trips	1,531,030	TEMS Study (June 2014)
Bus Diverted Trips	169,800	TEMS Study (June 2014)
Air Diverted Trips	299,980	TEMS Study (June 2014)

Auto		
Auto miles (Illinois) one way	14.4	miles
Nationwide % passenger cars	60.3%	Percent[a]
Nationwide % passenger trucks	39.7%	Percent[a]
Average passenger car energy intensity	3,538	Btu/passenger mile
Average passenger truck energy intensity	3,663	Btu/passenger mile
Average passengers per car	1.55	passengers/vehicle[a]
Average passengers per truck	1.84	passengers/vehicle[a]
Total diverted auto passenger miles per year	**22,047,000**	passenger-miles/year
Annual diverted auto fuel consumption	79,095	MMBtu/yr
Gasoline heating value	130,000	Btu/gal - USEPA AP-42 Appendix A
Annual auto fuel consumption diverted	608,423	gallons per year
Annual auto miles diverted	13,241,143	miles per year
Bus		
Intercity passenger bus energy intensity[a]	4,242	Btu/passenger mile
One-way distance	14.4	miles
Total diverted bus passenger miles per year	**2,445,120**	passenger-miles/year
Annual diverted bus fuel consumption	10,372	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual diverted bus fuel consumption	75,709	gallons per year
Train		
Intercity passenger train energy intensity[a]	2,435	Btu/passenger mile
One-way distance	14	miles
Total new train passenger miles per year	**33,661,152**	passenger-miles/year
Annual new passenger train fuel consumption	81,965	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual new passenger train fuel consumption	598,284	gallons per year
Air		
Air transportation energy intensity[a]	2,826	Btu/passenger mile

One-way distance	14	miles
Total diverted air passenger miles per year	**4,319,712**	passenger-miles/year
Jet fuel heating value	135,000	Btu/gal[a]
Jet fuel density	7	lb/gal
Annual air fuel consumption diverted	12,208	MMBtu/yr
Annual air fuel consumption diverted	90,426	gal/yr
Annual air fuel consumption diverted	270,952	kg/yr

[a] US Department of Energy Transportation Energy Data Book: Edition 30-2011.

Table G-5. Emissions Calculations- Illinois

Pollutant	Additional Passenger Train Emissions			Automobile Emissions Diverted			Airline Emissions Diverted			Bus Emissions Diverted			Net Change (ton/yr)	Total Emissions Diverted (ton/yr)
	Emission Factor[1],[4] (g/gal) (lb/gal) CO2	Emissions Added (lb/yr)	Emissions Added (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[3],[4] (g/kg) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)		
Hydrocarbons	5.8	7,643	3.82	0.4272	12,459	6.23	0.7	418	0.2	0	851	0.43	-3.04	6.86
Carbon monoxide (CO)	38.1	50,208	25.10	3.3467	97,608	48.80	4.4	2,629	1.3	1	6,843	3.42	-28.44	53.54
Nitrogen oxides (NO_x)	131	172,633	86.32	3.4469	100,530	50.26	14	8,424	4	1	6,990	3.49	28.34	57.97
PM_{10}	3.4	4,481	2.24	0.1698	4,953	2.48				0	347	0.17	-0.41	2.65
$PM_{2.5}$	3.298	4,346	2.17	0.1411	4,116	2.06				0	294	0.15	-0.03	2.20
SO_2[5]	0.096	127	0.06	0.0071	207	0.10	0.4	239	0.119	0	13	0.01	-0.17	0.23
Carbon dioxide[4] (CO_2)	22.377	13,387,801	6,693.90	17.681	10,757,528	5,378.76	21.098	1,907,807	953.9	22	1,694,151	847.08	-485.84	7,179.74

[1] Except CO2, emission factors from EPA document EPA420-F-09-025; Emission Factors for Locomotives; Dated April 2009. Emission factors are projected calendar year 2015 emission factors for passenger/commuter locomotives (Tier 4).

[2] Emission factors from data output from EPA Moves2010b model run for 2015.

[3] Except CO2, emission factors from US Department of Transportation Federal Highway Administration document "Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level; Final Report; April 2005". Emission factors are projected for 2015.

[4] CO2 Emission factors from US Department of Transportation Energy Information Administration Voluntary Reporting of Greenhouse Gases Program - Coefficients webpage. Emission factors are in units of lb/gal.

[5] Train SO_2 emission factor calculated based on 15 ppm (weight basis) diesel fuel sulfur content:

Note: A negative net change indicates that the implementation of the Build Alternative will result in an overall decrease in emissions as the additional rail service is replacing passenger vehicle, bus, and plane trips along a similar route, and produces fewer emissions per passenger then other modes of transportation.

Table G-6. Estimate of Diverted Trips- Indiana

Chicago to Detroit Intercity Passenger Rail Service - Indiana		
Build Alternative	**Quantity**	**Source:**
Total Annual Ridership	**2,830,000**	TEMS Study (June 2014)
Exisiting Rail Trips	495,250	TEMS Study (June 2014)
Total New Rail Trips	**2,337,580**	TEMS Study (June 2014)
New Trips from natural growth & induced demand	336,770	TEMS Study (June 2014)
Breakdown of Diverted Trips		
Auto Diverted Trips	1,531,030	TEMS Study (June 2014)
Bus Diverted Trips	169,800	TEMS Study (June 2014)
Air Diverted Trips	299,980	TEMS Study (June 2014)

Auto		
Auto miles one way	44	miles
Nationwide % passenger cars	60.3%	Percent[a]
Nationwide % passenger trucks	39.7%	Percent[a]
Average passenger car energy intensity	3,538	Btu/passenger mile
Average passenger truck energy intensity	3,663	Btu/passenger mile
Average passengers per car	1.55	passengers/vehicle[a]
Average passengers per truck	1.84	passengers/vehicle[a]
Total diverted auto passenger miles per year	**67,365,000**	passenger-miles/year
Annual diverted auto fuel consumption	241,678	MMBtu/yr
Gasoline heating value	130,000	Btu/gal - USEPA AP-42 Appendix A
Annual auto fuel consumption diverted	1,859,062	gallons per year
Annual auto miles diverted	40,458,547	miles per year
Bus		
Intercity passenger bus energy intensity[a]	4,242	Btu/passenger mile
One-way distance	44	miles
Total diverted bus passenger miles per year	**7,471,200**	passenger-miles/year
Annual diverted bus fuel consumption	31,693	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual diverted bus fuel consumption	231,335	gallons per year
Train		
Intercity passenger train energy intensity[a]	2,435	Btu/passenger mile
One-way distance	44	miles
Total new train passenger miles per year	**102,853,520**	passenger-miles/year
Annual new passenger train fuel consumption	250,448	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual new passenger train fuel consumption	1,828,090	gallons per year
Air		
Air transportation energy intensity[a]	2,826	Btu/passenger mile

One-way distance	44	miles
Total diverted air passenger miles per year	**13,199,120**	passenger-miles/year
Jet fuel heating value	135,000	Btu/gal[a]
Jet fuel density	6.60	lb/gal
Annual air fuel consumption diverted	37,301	MMBtu/yr
Annual air fuel consumption diverted	276,302	gal/yr
Annual air fuel consumption diverted	827,910	kg/yr

[a] US Department of Energy Transportation Energy Data Book: Edition 30-2011.

Table G-7. Emissions Calculations- Indiana

Pollutant	Additional Passenger Train Emissions			Automobile Emissions Diverted			Airline Emissions Diverted			Bus Emissions Diverted			Net Change (ton/yr)	Total Emissions Diverted (ton/yr)
	Emission Factor[1],[4] (g/gal) (lb/gal) CO2	Emissions Added (lb/yr)	Emissions Added (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[3],[4] (g/kg) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)		
Hydrocarbons	5.8	23,354	11.68	0.4272	38,069	19.03	0.7	1,278	0.6	0.1581	2,601	1.30	-9.30	20.97
Carbon monoxide (CO)	38.1	153,415	76.71	3.3467	298,244	149.12	4.4	8,032	4.02	1.2706	20,909	10.45	-86.89	163.59
Nitrogen oxides (NO_x)	131	527,489	263.74	3.4469	307,171	153.59	14.1	25,740	12.87	1.2978	21,357	10.68	86.61	177.13
PM_{10}	3.4	13,691	6.85	0.1698	15,133	7.57		0		0.0644	1,059	0.53	-1.25	8.10
$PM_{2.5}$	3.298	13,280	6.64	0.1411	12,576	6.29		0		0.0545	898	0.45	-0.10	6.74
SO_2[5]	0.096	387	0.19	0.0071	634	0.32	0.4	730	0.4	0.0024	39	0.02	-0.51	0.70
Carbon dioxide[4] (CO_2)	22.377	40,907,168	20,453.58	17.681	32,870,067	16,435.03	21.098	5,829,411	2,915	22.377	5,176,573	2,588.29	9,571.83	21,938.03

[1] Except CO2, emission factors from EPA document EPA420-F-09-025; Emission Factors for Locomotives; Dated April 2009. Emission factors are projected calendar year 2015 emission factors for passenger/commuter locomotives (Tier 4).

[2] Emission factors from data output from EPA Moves2010b model run for 2015.

[3] Except CO2, emission factors from US Department of Transportation Federal Highway Administration document "Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level; Final Report; April 2005". Emission factors are projected for 2015.

[4] CO2 Emission factors from US Department of Transportation Energy Information Administration Voluntary Reporting of Greenhouse Gases Program - Coefficients webpage. Emission factors are in units of lb/gal.

[5] Train SO_2 emission factor calculated based on 15 ppm (weight basis) diesel fuel sulfur content:

Note: A negative net change indicates that the implementation of the Build Alternative will result in an overall decrease in emissions as the additional rail service is replacing passenger vehicle, bus, and plane trips along a similar route, and produces fewer emissions per passenger then other modes of transportation.

Table G-8. Estimate of Diverted Trips- Michigan

Chicago to Detroit Intercity Passenger Rail Service - Michigan		
Build Alternative	**Quantity**	**Source:**
Total Annual Ridership	**2,830,000**	TEMS Study (June 2014)
Existing Rail Trips	495,250	TEMS Study (June 2014)
Total New Rail Trips	**2,337,580**	TEMS Study (June 2014)
New Trips from natural growth & induced demand	336,770	TEMS Study (June 2014)
Breakdown of Diverted Trips		
Auto Diverted Trips	1,531,030	TEMS Study (June 2014)
Bus Diverted Trips	169,800	TEMS Study (June 2014)
Air Diverted Trips	299,980	TEMS Study (June 2014)

Auto		
Auto miles one way	246.4	miles
Nationwide % passenger cars	60.3%	Percent[a]
Nationwide % passenger trucks	39.7%	Percent[a]
Average passenger car energy intensity	3,538	Btu/passenger mile
Average passenger truck energy intensity	3,663	Btu/passenger mile
Average passengers per car	1.55	passengers/vehicle[a]
Average passengers per truck	1.84	passengers/vehicle[a]
Total diverted auto passenger miles per year	**377,246,000**	passenger-miles/year
Annual diverted auto fuel consumption	1,353,402	MMBtu/yr
Gasoline heating value	130,000	Btu/gal - USEPA AP-42 Appendix A
Annual auto fuel consumption diverted	10,410,785	gallons per year
Annual auto miles diverted	226,569,064	miles per year
Bus		
Intercity passenger bus energy intensity[a]	4,242	Btu/passenger mile
One-way distance	246.4	miles
Total diverted bus passenger miles per year	**41,838,720**	passenger-miles/year
Annual diverted bus fuel consumption	177,480	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual diverted bus fuel consumption	1,295,473	gallons per year
Train		
Intercity passenger train energy intensity[a]	2,435	Btu/passenger mile
One-way distance	246.4	miles
Total new train passenger miles per year	**575,979,712**	passenger-miles/year
Annual new passenger train fuel consumption	1,402,511	MMBtu/yr
Diesel fuel heating value	137,000	Btu/gal - USEPA AP-42 Appendix A
Annual new passenger train fuel consumption	10,237,304	gallons per year
Air		
Air transportation energy intensity[a]	2,826	Btu/passenger mile

One-way distance	246	miles
Total diverted air passenger miles per year	**73,915,072**	passenger-miles/year
Jet fuel heating value	135,000	Btu/gal[a]
Jet fuel density	6.60	lb/gal
Annual air fuel consumption diverted	208,884	MMBtu/yr
Annual air fuel consumption diverted	1,547,289	gal/yr
Annual air fuel consumption diverted	4,636,296	kg/yr

[a] US Department of Energy Transportation Energy Data Book: Edition 30-2011.

Table G-9. Emission Calculations- Michigan

Pollutant	Additional Passenger Train Emissions			Automobile Emissions Diverted			Airline Emissions Diverted			Bus Emissions Diverted			Net Change (ton/yr)	Total Emissions Diverted (ton/yr)
	Emission Factor[1],[4] (g/gal) (lb/gal) CO2	Emissions Added (lb/yr)	Emissions Added (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[3],[4] (g/kg) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)	Emission Factor[2] (g/mile) (lb/gal) CO2	Emissions Diverted (lb/yr)	Emissions Diverted (ton/yr)		
Hydrocarbons	5.8	130,785	65.39	0.4272	213,188	106.59	0.7	7,156	3.58	0.1581	14,566	7.28	-52.06	117.45
Carbon monoxide (CO)	38.1	859,122	429.56	3.3467	1,670,173	835.09	4.4	44,981	22.49	1.2706	117,090	58.54	-486.56	916.12
Nitrogen oxides (NO_x)	131	2,953,936	1,476.97	3.4469	1,720,165	860.08	14.1	144,145	72.07	1.2978	119,601	59.80	485.01	991.96
PM_{10}	3.4	76,667	38.33	0.1698	84,746	42.37		0		0.0644	5,932	2.97	-7.01	45.34
$PM_{2.5}$	3.298	74,367	37.18	0.1411	70,423	35.21		0		0.0545	5,027	2.51	-0.54	37.73
SO_2[5]	0.096	2,165	1.08	0.0071	3,550	1.78	0.4	4,089	2.04	0.0024	220	0.11	-2.85	3.93
Carbon dioxide[4] (CO_2)	22.377	229,080,144	114,540.07	17.681	184,073,083	92,036.54	21.098	32,644,700	16,322	22.377	28,988,807	14,494.40	-8,313.22	122,853.30

[1] Except CO2, emission factors from EPA document EPA420-F-09-025; Emission Factors for Locomotives; Dated April 2009. Emission factors are projected calendar year 2015 emission factors for passenger/commuter locomotives (Tier 4).

[2] Emission factors from data output from EPA Moves2010b model run for 2015.

[3] Except CO2, emission factors from US Department of Transportation Federal Highway Administration document "Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level; Final Report; April 2005". Emission factors are projected for 2015.

[4] CO2 Emission factors from US Department of Transportation Energy Information Administration Voluntary Reporting of Greenhouse Gases Program - Coefficients webpage. Emission factors are in units of lb/gal.

[5] Train SO_2 emission factor calculated based on 15 ppm (weight basis) diesel fuel sulfur content:

Note: A negative net change indicates that the implementation of the Build Alternative will result in an overall decrease in emissions as the additional rail service is replacing passenger vehicle, bus, and plane trips along a similar route, and produces fewer emissions per passenger then other modes of transportation.

Table G-10. Chicago to Detroit Rail Trips; 2035 Sources of Rail Trips

Rail Trips	Existing	Natural Growth	Induced Demand	Air Diversion	Bus Diversion	Car Diversion
100%	17.50%	5.70%	6.20%	10.60%	6.00%	54.10%
2,830,000	495,250	161,310	175,460	299,980	169,800	1,531,030