ms consultants, inc.
engineers, architects, planners

RSG
the science of insight

FINAL REPORT

US 30 FEASIBILITY STUDY

PID 98905

PREPARED FOR:
COLUMBIANA COUNTY TRANSPORTATION IMPROVEMENT DISTRICT

SUBMITTED BY:
RSG

IN COOPERATION WITH:
MS CONSULTANTS, INC

REVISED:
OCTOBER 2015

2709 Washington Ave., Suite 9
Evansville, IN 47714
802.295.4999
www.rsginc.com

CONTENTS

1.0 EXECUTIVE SUMMARY 1

1.1 | Economic Forecasting 1

1.2 | Truck GPS Analysis 2

1.3 | Pennsylvania Turnpike Toll Rate Analysis 3

1.4 | Travel Demand Forecasting 4

1.5 | Benefit Cost Analysis 5

2.0 ECONOMIC IMPACT OF UNCONVENTIONAL GAS AND OIL EXTRACTION 6

2.1 | Oil & GAS Data 6

2.2 | Methodology 8

2.3 | Reference Class Analysis 10

2.4 | Exponential Decay Projections 15

2.5 | Production Estimates Validation and Selection 18

2.6 | Production values 20

2.7 | Economic Input-Output Analysis 22

2.8 | Demographic Impacts 22

3.0 ALLOCATION OF GROWTH WITHIN THE STUDY AREA 25

4.0 ANALYSIS OF TRUCK GPS DATA 30

4.1 | Background 30

4.2 | Truck GPS Data Processing 31

4.3 | Final US 30 Truck GPS Data 34

5.0 PENNSYLVANIA TURNPIKE TOLL RATE ANALYSIS 39

6.0 TRAVEL DEMAND FORECASTING ... 42
6.1 | Model Framework ... 43
6.2 | Model Calibration ... 47
6.3 | Alternative Alignments ... 49
6.4 | Traffic Projections ... 50
6.5 | Travel Time Savings ... 56
6.6 | High Growth Scenario ... 57
7.0 BENEFIT-COST ANALYSIS ... 59
8.0 CONCLUSIONS ... 61
9.0 NOTE ON SUBSEQUENT DEVELOPMENTS ... 62
10.0 REFERENCES ... 64

Table of Figures

FIGURE 1: POTENTIAL 2030 IMPACT (IN EMPLOYEES) FOR SELECTED PRODUCTION AND PRICE SCENARIOS ... 1
FIGURE 2 TRUCKS USING THE US 30 CORRIDOR – AFTER 7 DAYS ... 2
FIGURE 3 PENNSYLVANIA TURNPIKE TOLL RATES PER MILE, HISTORIC AND FORECAST ... 3
FIGURE 4 FORECAST AVERAGE DAILY TRAFFIC AND TRUCK PERCENTAGE FOR FOUR ALIGNMENTS ... 4
FIGURE 5 AVERAGE DAILY TRAFFIC (ADT) - PRESENT AND 2030 MEDIUM GROWTH SCENARIO ... 4
FIGURE 6 TRAVEL TIMES FOR SELECT TRIPS (IN MINUTES) ... 5
FIGURE 7 BENEFIT COST ANALYSIS RESULTS ... 5
FIGURE 8: PENNSYLVANIA ANNUAL UNCONVENTIONAL PRODUCTION FIGURES BY COUNTY (DATA: PA DEP 2014) ... 7
FIGURE 9: OHIO STUDY COUNTIES ANNUAL UNCONVENTIONAL PRODUCTION FIGURES BY COUNTY (DATA: ODNR 2013) ... 8
FIGURE 10: OHIO STUDY COUNTIES' UNCONVENTIONAL OIL AND GAS PRODUCTION VALUES 2011-2013 (DATA: ODNR 2013) ... 10
FIGURE 11: PENNSYLVANIA COUNTIES' UNCONVENTIONAL GAS PRODUCTION VALUES 2007-2013 (DATA: PA DEP 2014) ... 11
FIGURE 12: NUMBER OF PENNSYLVANIA REFERENCE COUNTIES' FOR EACH OHIO STUDY COUNTY ... 12
FIGURE 13: CARROLL REFERENCE CLASS DATA ... 12
FIGURE 14: COLUMBIANA REFERENCE CLASS DATA ... 13
FIGURE 15: STARK REFERENCE CLASS DATA ... 14
FIGURE 16: REFERENCE CLASS ANALYSIS RESULTS, BY STUDY COUNTY ... 15
FIGURE 17: ANNUAL GROWTH RATES, FOR ALL PENNSYLVANIA COUNTIES AND SELECTED REFERENCE COUNTIES 15
FIGURE 18: EXPONENTIAL DECAY CURVES, FOR PENNSYLVANIA STATE AND SELECTED REFERENCE COUNTIES ... 16
FIGURE 19: RESULTING EXPONENTIAL DECAY PARAMETERS AND CORRELATION VALUES, FOR PENNSYLVANIA STATE AND SELECTED REFERENCE COUNTIES ... 17
FIGURE 20: 2030 PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES, BASED ON EXPONENTIAL CURVE PROJECTIONS ... 18

FIGURE 21: 2030 NATURAL GAS PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (IN MILLION CUBIC FEET) 18
FIGURE 22: NATURAL GAS PRODUCTION FOR LEADING PRODUCERS (IN MILLION CUBIC FEET) (SOURCE: EIA 2015).. 19
FIGURE 23: SELECTED 2030 NATURAL GAS PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (IN MILLION CUBIC FEET) 19
FIGURE 24: SELECTED 2030 OIL PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (BARRELS OF OIL).... 19
FIGURE 25: ANNUAL GROWTH RATES IN OIL AND GAS PRODUCTION IN TOP NORTH DAKOTA COUNTIES FROM 2006-2011 20
FIGURE 26: ANNUAL GROWTH RATES ASSUMED IN STUDY AREA COUNTIES THROUGH 2030 20
FIGURE 27: RESULTING POTENTIAL 2030 PRODUCTION VALUES (IN DOLLARS) FOR VARIOUS PRODUCTION AND PRICE SCENARIOS 21
FIGURE 28: SELECTED PRODUCTION AND PRICE SCENARIOS (IN DOLLARS) 21
FIGURE 29: POTENTIAL 2030 IMPACT (IN EMPLOYEES) FOR SELECTED PRODUCTION AND PRICE SCENARIOS 22
FIGURE 30 POPULATION GROWTH BY COUNTY 23
FIGURE 31 GROWTH IN HOUSEHOLDS BY COUNTY 24
FIGURE 32 NEW WORKERS BY RESIDENCE LOCATION 24
FIGURE 33 NEXUS GAS TRANSMISSION LINE WITH EXTENSIONS 26
FIGURE 34 ALLOCATION OF GROWTH FOR LOW GROWTH SCENARIO, 2030 28
FIGURE 35 ALLOCATION OF GROWTH FOR MEDIUM GROWTH SCENARIO, 2030 29
FIGURE 36 ALLOCATION OF GROWTH FOR HIGH GROWTH SCENARIO, 2030 29
FIGURE 37 ONE DAY OF ATRI'S TRUCK GPS DATA POINTS 30
FIGURE 38 CATCHMENT AREA FOR TRUCK GPS DATA FOR US 30 32
FIGURE 39 IDENTIFYING STOPS FROM GPS TRACE DATA 33
FIGURE 40 BRIEF RE-POSTITIONING MOVEMENTS TO BE DISTINGUISHED FROM TRIPS 33
FIGURE 41 EXISTING US 30 CORRIDOR 35
FIGURE 42 TRUCKS USING THE US 30 CORRIDOR – AFTER 1 DAY 36
FIGURE 43 TRUCKS USING THE US 30 CORRIDOR – AFTER 2 DAYS 36
FIGURE 44 TRUCKS USING THE US 30 CORRIDOR – AFTER 3 DAYS 37
FIGURE 45 TRUCKS USING THE US 30 CORRIDOR – AFTER 5 DAYS 37
FIGURE 46 TRUCKS USING THE US 30 CORRIDOR – AFTER 7 DAYS 38
FIGURE 47: PENNSYLVANIA TURNPIKE IN RELATION TO US 30 39
FIGURE 48 PENNSYLVANIA TURNPIKE TOLL RATES PER MILE, HISTORIC AND FORECAST 40
FIGURE 49 CONCEPTUAL DIAGRAM OF THE MAJOR COMPONENTS OF THE OHIO STATEWIDE MODEL 42
FIGURE 50 GENERAL SCHEME OF AN ACTIVITY-BASED MODEL SIMILAR TO THE OHIO STATEWIDE MODEL'S PASSENGER COMPONENTS 44
FIGURE 51 TRANSIT LINES, AIRPORTS, BUS AND RAIL STATIONS AND FREIGHT RAIL AND INTERMODAL FACILITY NETWORK IN THE OSM 45
FIGURE 52 US 30 FOCUS AREA ZONES 46
FIGURE 53 US 30 FOCUS AREA NETWORK 46
FIGURE 54 COMMUTE FLOW CALIBRATION 47
FIGURE 55 EXAMPLE OF ONLINE TRAVEL TIMES AND ROUTING USED FOR CALIBRATION 48
FIGURE 56 MODEL NETWORK WITH LOADING ERRORS SHOWING PATTERN OF RANDOM ERRORS 48
FIGURE 57 ALTERNATIVE ALIGNMENTS 49

FIGURE 58 PRELIMINARY ESTIMATED PROJECT COSTS BY ALIGNMENT 50
FIGURE 59 AVERAGE DAILY TRAFFIC (ADT) - PRESENT AND 2030 MEDIUM GROWTH SCENARIO 51
FIGURE 60 AVERAGE DAILY TRAFFIC (ADT) AND TRUCK PERCENTAGE BY SEGMENT 51
FIGURE 61: DIVERSION TO ALTERNATIVE 1 53
FIGURE 62: DIVERSION TO ALTERNATIVE 2 54
FIGURE 63: DIVERSION TO ALTERNATIVE 3 55
FIGURE 64: DIVERSION TO ALTERNATIVE 4 56
FIGURE 65 TRAVEL TIMES BETWEEN SELECT ORIGINS AND DESTINATIONS 57
FIGURE 66 AVERAGE DAILY TRAFFIC UNDER HIGH VERSUS MEDIUM GROWTH 58
FIGURE 67 DAILY TRAFFIC CONGESTION IN THE CORRIDOR UNDER HIGH GROWTH, NO BUILD 58
FIGURE 68 USER COST SAVINGS IN 2030 FROM UCOST 59
FIGURE 69 ANNUAL CRASHES AVERTED 59
FIGURE 70 BENEFIT COST ANALYSIS RESULTS 60

1.0 EXECUTIVE SUMMARY

In support of the Stark-Columbiana Route 30 Feasibility Study, RSG is tasked with forecasting the 2030 opening year traffic volumes for a potential new US 30 facility under future conditions associated with increased development of unconventional oil and gas production in three core counties: Stark, Columbiana, and Carroll. This effort included several supporting analyses including economic forecasts of the impact of unconventional oil and gas production and the allocation of predicted growth within the study area, the development and analysis of truck GPS data and Pennsylvania Turnpike toll rates and ultimately traffic forecasts for alternative alignments of an upgraded US 30 facility.

1.1 | ECONOMIC FORECASTING

Understanding potential oil and natural gas production which would drive regional economic growth involved a detailed evaluation of the growth in this industry that has occurred and is projected to occur in similar counties in neighboring Pennsylvania. Based on observed and projected production patterns in Pennsylvania, future projections were developed for the three study area counties.

Together with assumed oil and gas prices, an IMPLAN economic input-output model analysis was conducted for a range of scenarios. This model tracks spending through a region's economy, modeling the direct, indirect and induced impacts of economic changes. These analyses developed a range of potential county-level employment numbers for 2030, which are shown in **FIGURE 1**.

FIGURE 1: POTENTIAL 2030 IMPACT (IN EMPLOYEES) FOR SELECTED PRODUCTION AND PRICE SCENARIOS

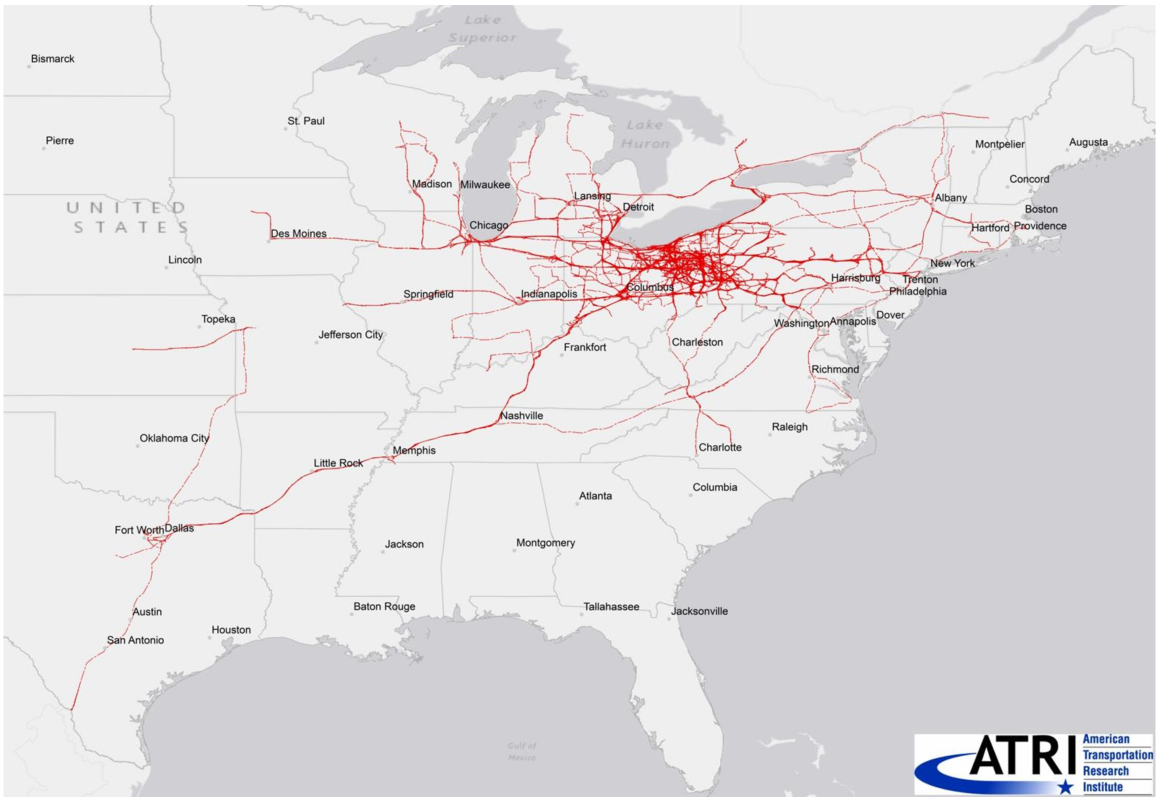
	LOW GROWTH SCENARIO	MEDIUM GROWTH SCENARIO	HIGH GROWTH SCENARIO
CARROLL	16,165	42,116	64,975
COLUMBIANA	9,031	24,520	45,947
STARK	736	1,779	2,148
STUDY AREA TOTAL	**25,932**	**68,415**	**113,071**

This level of job creation represents a significant impact on regional growth and should be expected to impact future traffic conditions in the region.

1.2 | TRUCK GPS ANALYSIS

An eight week sample of trucks passing through a catchment area around the US 30 corridor was obtained drawing two weeks of data from each of the four quarters of 2014. After processing the dataset included over 40 million movement records by roughly 70,000 individual trucks making over 2.6 million trips. This data was used to understand current trucking patterns in and nearby the US 30 corridor, including on competing facilities such as the Pennsylvania Turnpike. The data revealed that even the existing US 30 truck traffic has interactions as far away as Canada and Mexico. Truck forecasts were produced by applying modeled growth to pivot off these observed trucking patterns.

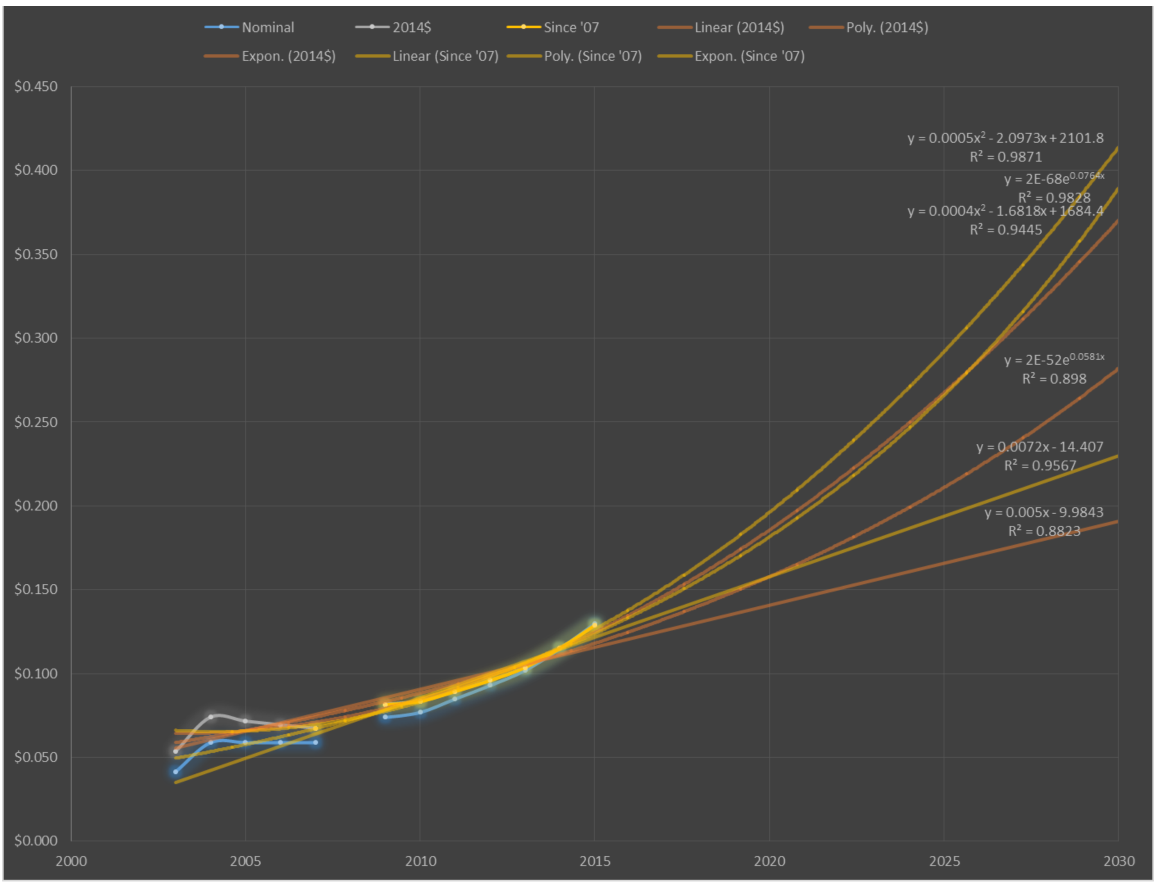
FIGURE 2 TRUCKS USING THE US 30 CORRIDOR – AFTER 7 DAYS



1.3 | PENNSYLVANIA TURNPIKE TOLL RATE ANALYSIS

Beyond trucking patterns, another of the key determinates of ultimate traffic on an improved US 30 corridor is the toll rate on the Pennsylvania Turnpike. Although previously turnpike tolls had remained fairly constant for many years, since 2004, passenger car toll rates have increased from \$0.04/mile to \$0.13/mile, over a 240% increase in 11 years or an average annual escalation of over 8%, even after adjusting for inflation. Since enabling state legislation in 2009, the turnpike has increased toll rates every year. It is reasonable to assume that the turnpike toll rates will continue to increase for at least some time into the future. An analysis of historic toll rates produced a range of likely future tolls. Toll rates of \$0.15/mi, \$0.23/mi and \$0.36/mi in 2014 dollars were assumed for forecasting.

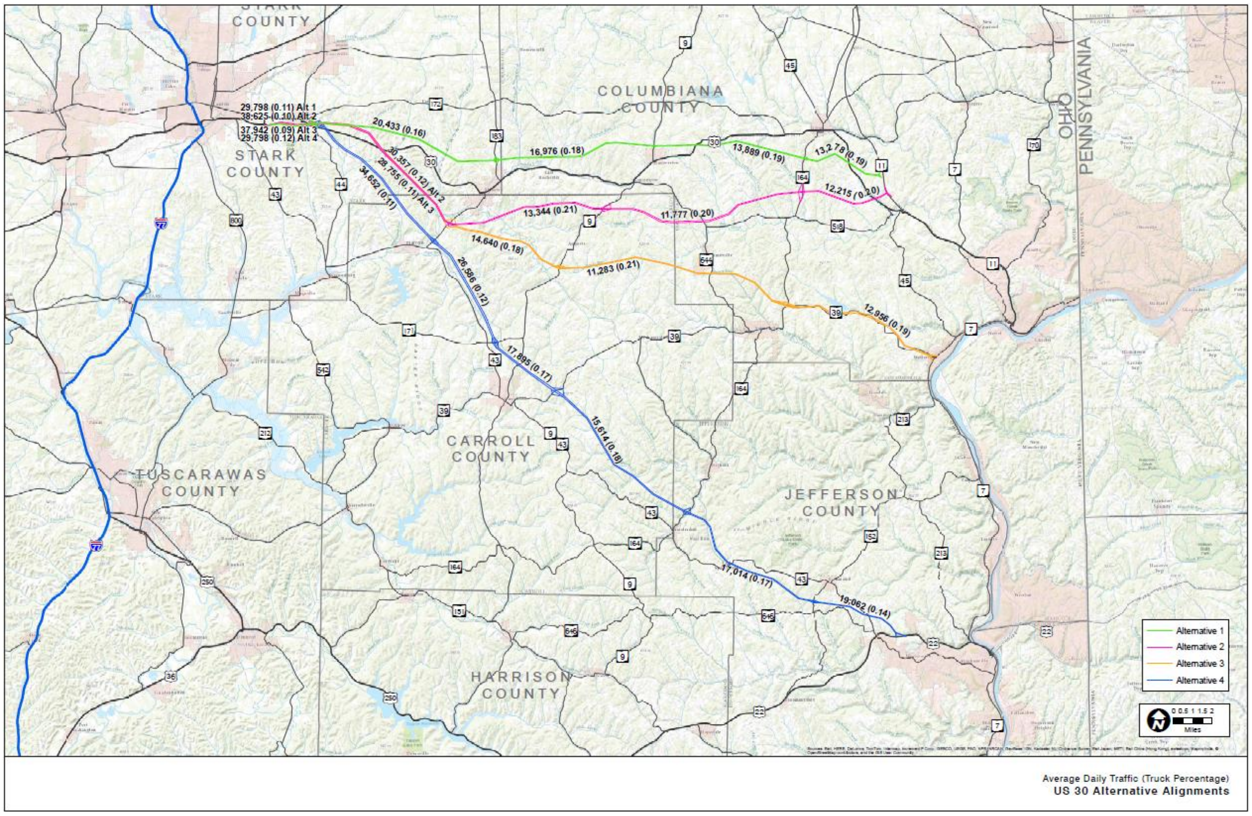
FIGURE 3 PENNSYLVANIA TURNPIKE TOLL RATES PER MILE, HISTORIC AND FORECAST



1.4 | TRAVEL DEMAND FORECASTING

To ensure the utmost defensibility of forecasts, ODOT models and procedures were used as much as possible. ODOT's statewide model was the primary tool for forecasting and it were calibrated to Census data on commute flows and observed travel time and traffic count data.

FIGURE 4 FORECAST AVERAGE DAILY TRAFFIC AND TRUCK PERCENTAGE FOR FOUR ALIGNMENTS



Forecasts were generated for four conceptual alignments under the Medium Growth assumption and a sensitivity test was done to examine the No Build and one alignment under the High Growth scenario. All of the alignments would carry three to four times as much traffic as US 30 today, with volumes similar to I-77 south of New Philadelphia, more than the capacity of a two-lane highway.

FIGURE 5 AVERAGE DAILY TRAFFIC (ADT) - PRESENT AND 2030 MEDIUM GROWTH SCENARIO

Medium Growth	Present ADT	2030 ADT				
		No Build	Alignment 1 (31 miles)	Alignment 2 (33 miles)	Alignment 3 (37 miles)	Alignment 4 (42 miles)
Maximum	7,850	13,463	20,431	30,357	25,537	34,652
Average	5,053	7,176	16,768	18,496	15,575	22,098
Minimum	3,040	3,513	13,278	11,775	8,911	15,614

All of the alternative alignments also offered significant travel time savings, but different alignments would best serve different locations. Alignment 4 carries the most traffic because it serves Carrollton and growing areas of Carrol County from both Canton and Steubenville as well as longer distance traffic between Canton and Steubenville and beyond. However, Alignment 4 is the longest and most costly alignment, and Alignment 2 also attracts considerable traffic, serving the Canton to Carrollton commuters as well as trips between Canton and Lisbon and East Liverpool.

FIGURE 6 TRAVEL TIMES FOR SELECT TRIPS (IN MINUTES)

	Present	2030				
		No Build	Alignment 1	Alignment 2	Alignment 3	Alignment 4
Cleveland – Pittsburgh (toll)	136	141	141	141	141	141
Cleveland – Pittsburgh (free)	165	172	169	171	172	169
Canton – Carrolton	36	40	37	32	32	29
Canton – Lisbon	51	53	39	44	49	49
Canton – E. Liverpool	69	71	52	53	61	67
Canton – Wellsville	70	71	56	58	49	63
Canton – Pittsburgh Airport	96	98	79	81	89	84
Canton – Steubenville	85	89	77	78	67	60
Carrolton – Steubenville	50	51	51	51	51	38

1.5 | BENEFIT COST ANALYSIS

A benefit-cost analysis was conducted on Alignment 2 as a representative alternative using ODOT's UCOST user benefit tool. The tool considers the value of travel time savings and improvements in travel time reliability as well as changes in vehicle operating costs, and safety impacts. Even with conservative assumptions, holding benefits constant beyond the project opening year of 2030, the analysis shows that the upgrade of US 30 would produce benefits far outweighing its costs as well as averting many crashes and saving an average of one life each year.

FIGURE 7 BENEFIT COST ANALYSIS RESULTS

REAL DISCOUNT RATE	DISCOUNTED BENEFITS	DISCOUNTED COSTS	BENEFIT COST RATIO	NET PRESENT VALUE	ECONOMIC RATE OF RETURN
3%	$2,686,687,708	$614,576,909	4.4	$2,072,110,799	16%
5%	$1,499,602,451	$478,869,678	3.1	$1,020,732,773	16%
7%	$883,516,490	$374,979,056	2.4	$508,537,434	16%

2.0 ECONOMIC IMPACT OF UNCONVENTIONAL GAS AND OIL EXTRACTION

Traffic levels in the US 30 corridor will in some significant degree be a function of development in the region. Thus, the first step in exploring the feasibility of an upgrade of US 30 in Eastern Ohio is to understand the impact of the on-going development of unconventional gas and oil extraction on the local economy and produce a reasonable forecast of expected growth in the region.

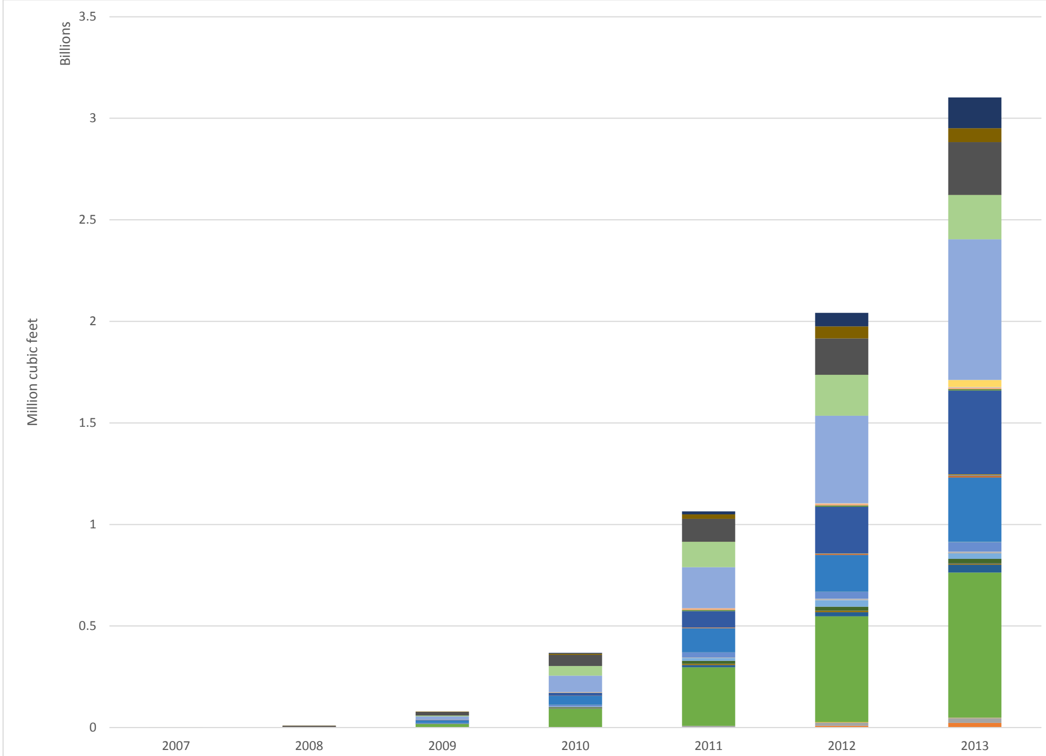
2.1 | OIL & GAS DATA

Unbiased data on unconventional oil and gas production futures is limited. Projections of reserves vary considerably and are affected by economic data that influences what is cost-effectively recoverable. Reserve data is also not readily available at the county-scale. For these reasons, we developed projections based on the most factual data available: statewide production reports (ODNR 2013 and PA DEP 2014).

Reviewing the production rate of change in Pennsylvania, it appears that the rate of production is still increasing significantly for unconventional gas extraction, but production has varied considerably from year to year for unconventional oil. (**FIGURE 8**). The same experience has not been true in the Ohio counties under review (**FIGURE 9**); both unconventional oil and gas production numbers have grown considerably. Notably, one county dominates the oil production values in both Ohio and Pennsylvania. This inconsistency between the two locations' annual oil production patterns indicates the reserves in the two locations have different characteristics. However, given the reference data is the best available information and a desire to produce analytically based projections, production projections for oil and gas in Ohio were both made using the Pennsylvania unconventional gas values. The oil forecasts were checked for reasonableness against county level oil and gas production data from 2006 to 2011 from the U.S. Department of Agriculture (USDA) Economic Research Service. (See Figure 25 and Figure 26). Data from North Dakota shows that oil production actually has tended to growth faster than gas production, so the use of gas production growth rates to forecast oil production in the study area may actually be conservative.

FIGURE 8: PENNSYLVANIA ANNUAL UNCONVENTIONAL PRODUCTION FIGURES BY COUNTY (DATA: PA DEP 2014)

PA Unconventional Gas Production



PA Unconventional Oil Production

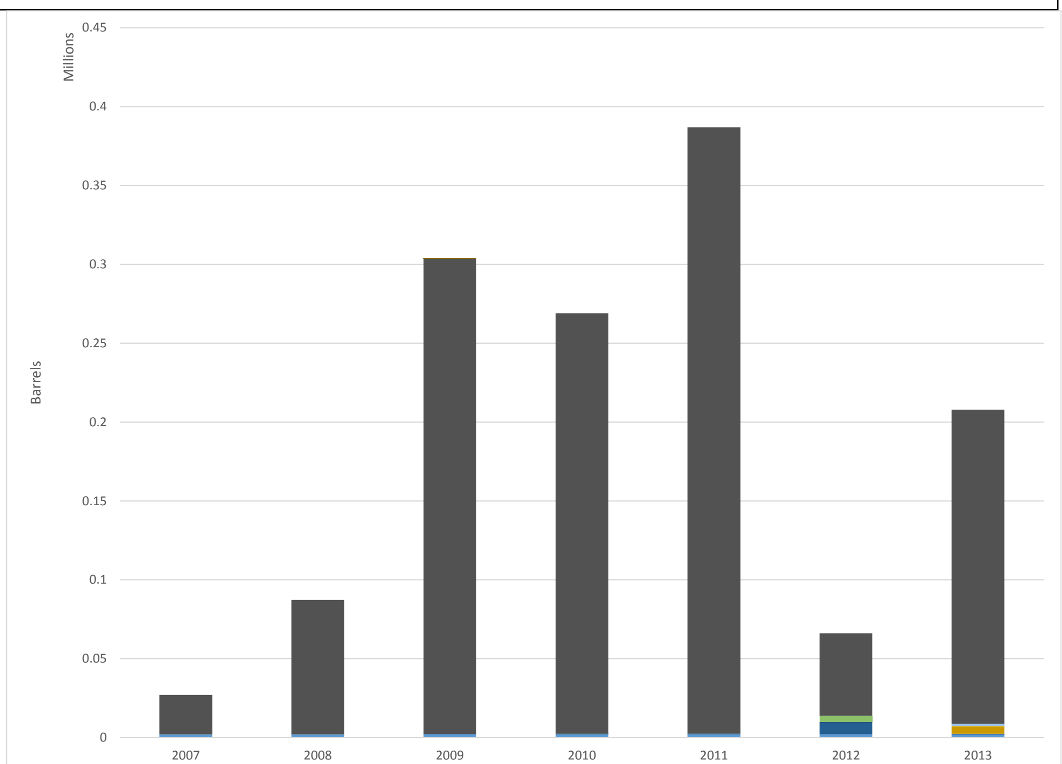
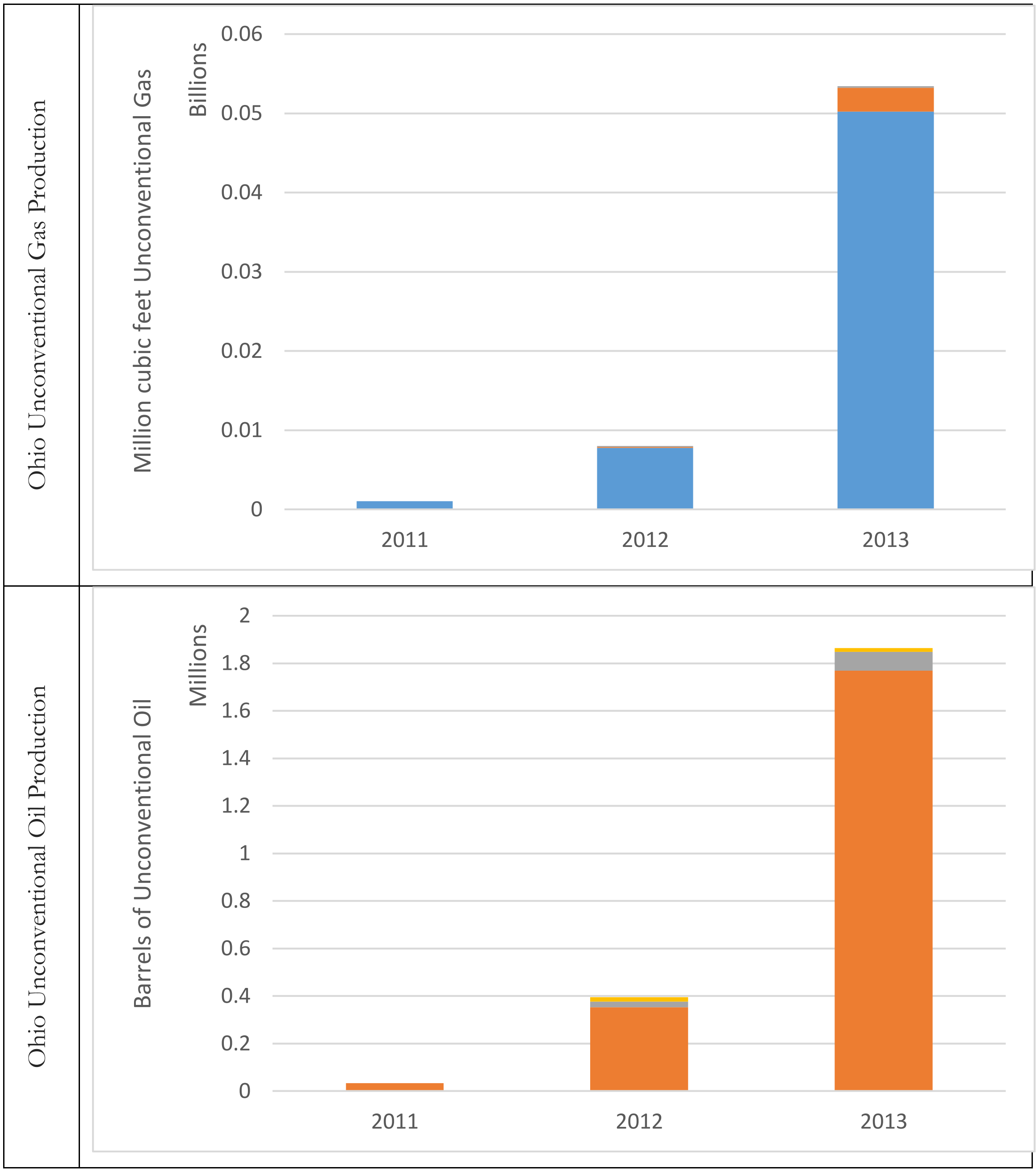


FIGURE 9: OHIO STUDY COUNTIES ANNUAL UNCONVENTIONAL PRODUCTION FIGURES BY COUNTY (DATA: ODNR 2013)



Additional reference data from other U.S. states and counties was used for order of magnitude reasonableness checking of forecasts.

2.2 | METHODOLOGY

Economic impact assessments of unconventional drilling are fairly common. They tend to estimate the amount of tax revenue local governments may anticipate under various scenarios, or the employment gains suggested by the development of drilling capacity. It is common for economic impact analyses of this sort to account for direct, indirect and induced impacts (or multiplier effects) by making use of IMPLAN (or similar Leontif input-output modeling) as was used for this analysis.

However, most of these impact assessments have been focused on the short term impacts of current oil and gas development. In this case, existing data on current oil and gas production levels and prices can be used as the inputs for the input-output modeling. One of the distinguishing features of this analysis is that it is concerned with projections of longer term impacts over the course of up to twenty years. Since future oil and gas production levels are not known, this requires that projections of these values be estimated first and then used as inputs in the IMPLAN model.

A review of the literature identified only one similar study (Considine et al., 2009) which included future forecasts. This study employed a different methodology than employed here and therefore served as a valuable validation check on this study's forecasts.

Projections of oil and gas production within the region were developed from the most factual data available: statewide production reports. Reference data from Pennsylvania, which has a more-established industry, was used as an indication of Carroll, Columbiana, and Stark counties' potential futures. Based on this data, a range of reference class forecasts were developed for each study area county using two methods. The first method used the reference counties actual production directly to provide a fairly conservative baseline scenario while the second method considered further growth in production, albeit at a decreasing rate modeled using exponential decay curves.

Both methods relied on the identification of reference counties for each of the study area counties. Based on levels of production, Ohio's development appears to lag Pennsylvania's by four years, so that 2012 production levels in Ohio mirror 2008 production levels in Pennsylvania. Given this, reference counties were identified by comparing 2012-2013 production levels in the Ohio counties to 2008-2009 production levels in Pennsylvania counties. See Figures 8-10 in the following section.

The first method simply then assumed that by 2030 production in each of the Ohio counties could grow to match production levels actually observed in the highest producing of its Pennsylvania reference counties in 2013.

The second method assumed further growth in production. Observing that the rate of growth appeared to have exponential decay, delay curves were fit to the growth rates for the state of Pennsylvania. These were then applied to the actual Ohio production values. Because of the limitations on the available data, three different numbers were used as seeds for the exponential decay curves. First, because the data is reported annually, the first year of reported data does not necessarily reflect a full year of data. The second year of available Ohio data was used as the seed. Second, the last year of available Ohio data was used as the seed. For Columbiana and Stark counties, this number is the same as that used in the previous approach. For Carroll County, an additional year of data was available. The third seed value relied on the last year of available data from the reference county data for each of the counties.

The results from the production estimates were then monetized using a range of anticipated producer prices. These values were used as inputs to an economic input-output analysis, reflecting purchases to the local economies. The IMPLAN system was chosen to provide the economic input-output analysis. It is a tool that models linkages between different economic sectors for a particular region and follows the resulting economic outputs through the economy. For this analysis, the value of the drilled oil and natural gas was treated as the input, reflecting local purchases. Those purchases have both direct and indirect impacts in the economy, which are estimated. For the purposes of modeling transportation impacts, the number of new employees can be leveraged as an input to travel models and used to estimate in-migration and was therefore the chosen output metric from the IMPLAN analysis, reflecting the direct, indirect and induced increases in employment for each county associated with the projected drilling sales.

2.3 | REFERENCE CLASS ANALYSIS

Annual unconventional oil and gas production by county was obtained for the study counties (ODNR 2013). **FIGURE 10** illustrated the annual MCF of gas and barrels of oil produced by unconventional wells for 2011, 2012, and 2013 (the only years for which unconventional production values are available in Ohio).

FIGURE 10: OHIO STUDY COUNTIES' UNCONVENTIONAL OIL AND GAS PRODUCTION VALUES 2011-2013 (DATA: ODNR 2013)

	2011		2012		2013	
	Oil	Gas	Oil	Gas	Oil	Gas
Carroll	32,854	1,038,059	352,958	7,751,602	1,768,635	50,224,172
Columbiana	-	-	24,085	132,599	80,411	3,000,276
Stark	-	-	17,714	106,941	15,382	196,005

Annual unconventional oil and gas production by county was obtained for Pennsylvania (PA DEP 2014); gas production values are shown in **FIGURE 11**.

FIGURE 11: PENNSYLVANIA COUNTIES' UNCONVENTIONAL GAS PRODUCTION VALUES 2007-2013 (DATA: PA DEP 2014)

	2007	2008	2009	2010	2011	2012	2013
	Unconventional Gas (MCF)						
Allegheny	0	0	248	1,643,033	2,480,604	8,340,837	23,041,626
Armstrong	2,800	29,536	196,384	1,569,308	6,230,295	17,707,185	23,292,446
Beaver	0	0	0	0	0	1,694,178	1,727,849
Blair	0	0	0	0	0	63,478	1,507,775
Bradford	0	176,494	17,123,700	89,643,911	287,676,292	520,251,181	713,571,482
Butler	53,130	304,076	950,025	2,655,997	11,644,920	20,941,254	38,240,789
Cambria	0	0	0	14,307	20,146	4,436	4,007
Cameron	0	0	65,065	284,589	309,713	190,996	1,426,728
Centre	2,555	84,996	160,685	984,126	5,165,727	5,749,462	4,232,605
Clarion	13,008	24,212	22,399	230,052	542,677	1,491,799	1,771,336
Clearfield	4,973	26,178	95,809	3,696,278	15,084,786	18,969,602	21,716,841
Clinton	0	1,918	484,591	1,690,791	13,646,072	32,171,889	27,532,455
Crawford	0	0	0	0	0	0	49,809
Elk	2,109	20,329	359,905	1,269,169	2,050,299	7,263,791	7,997,761
Erie	0	0	0	0	0	0	0
Fayette	305,100	788,977	3,760,034	8,306,219	25,577,405	34,434,673	47,884,589
Forest	0	0	122,823	192,153	138,658	196,927	664,530
Greene	52,746	1,793,856	11,722,979	43,915,132	118,919,305	180,505,447	317,111,680
Indiana	6,664	87,874	261,920	1,156,976	2,658,839	4,112,247	6,268,099
Jefferson	0	0	0	37,549	471,047	2,381,025	5,748,006
Lawrence	0	0	0	0	0	428,812	3,108,080
Lycoming	0	83,471	2,522,954	13,184,280	80,674,850	230,127,710	413,056,577
McKean	13,513	10,257	9,505	948,726	5,475,264	6,878,193	5,790,342
Mercer	0	0	0	0	0	0	465,780
Potter	9,181	68,682	311,349	2,908,092	9,235,784	8,823,163	7,336,766
Somerset	22,132	7,599	13,609	312,850	363,672	611,280	2,975,943
Sullivan	0	0	0	0	0	1,376,765	35,105,589
Susquehanna	0	716,118	16,459,132	81,361,594	201,472,607	430,717,148	692,309,558
Tioga	0	0	4,495,027	47,299,174	125,724,317	201,463,714	219,164,408
Venango	0	0	0	0	33,709	153,609	121,427
Warren	3,042	17,572	35,169	0	30,804	24,997	48,692
Washington	1,370,737	4,920,335	17,531,237	54,421,884	112,275,071	179,027,550	259,653,296
Westmoreland	39,531	608,295	1,712,858	6,870,518	21,768,192	59,230,652	68,599,977
Wyoming	0	0	0	3,287,372	14,467,473	66,232,755	151,068,806

A set of reference counties was developed for each of the three study counties based on the two or three years of data available for the Ohio counties matched to the relevant production data from Pennsylvania. For each reference comparison, Pennsylvania data was processed to match production years. The number of reference counties used for each study county is shown in **FIGURE 12**. The resulting comparison tables for each county are shown in **FIGURE 13** through **FIGURE 15** with the reference counties highlighted in green.

FIGURE 12: NUMBER OF PENNSYLVANIA REFERENCE COUNTIES' FOR EACH OHIO STUDY COUNTY

Study County	Number of Reference Counties
Carroll	6
Columbiana	7
Stark	9

FIGURE 13: CARROLL REFERENCE CLASS DATA

Carroll	Reference Year						
	1	2	3	4	5	6	7
Allegheny	1,643,033	2,480,604	8,340,837	23,041,626			
Armstrong	1,569,308	6,230,295	17,707,185	23,292,446			
Beaver	1,694,178	1,727,849					
Blair	1,507,775						
Bradford	176,494	17,123,700	89,643,911	287,676,292	520,251,181	713,571,482	
Butler	950,025	2,655,997	11,644,920	20,941,254	38,240,789		
Cambria							
Cameron	1,426,728						
Centre	984,126	5,165,727	5,749,462	4,232,605			
Clarion	1,491,799	1,771,336					
Clearfield	3,696,278	15,084,786	18,969,602	21,716,841			
Clinton	1,690,791	13,646,072	32,171,889	27,532,455			
Crawford							
Elk	1,269,169	2,050,299	7,263,791	7,997,761			
Erie							
Fayette	788,977	3,760,034	8,306,219	25,577,405	34,434,673	47,884,589	
Forest	664,530						
Greene	1,793,856	11,722,979	43,915,132	118,919,305	180,505,447	317,111,680	
Indiana	1,156,976	2,658,839	4,112,247	6,268,099			
Jefferson	471,047	2,381,025	5,748,006				
Lawrence	428,812	3,108,080					
Lycoming	2,522,954	13,184,280	80,674,850	230,127,710	413,056,577		
McKean	948,726	5,475,264	6,878,193	5,790,342			
Mercer	465,780						
Potter	311,349	2,908,092	9,235,784	8,823,163	7,336,766		
Somerset	312,850	363,672	611,280	2,975,943			
Sullivan	1,376,765	35,105,589					
Susquehanna	716,118	16,459,132	81,361,594	201,472,607	430,717,148	692,309,558	
Tioga	0	4,495,027	47,299,174	125,724,317	201,463,714	219,164,408	
Venango							
Warren							
Washington	1,370,737	4,920,335	17,531,237	54,421,884	112,275,071	179,027,550	259,653,296
Westmoreland	1,712,858	6,870,518	21,768,192	59,230,652	68,599,977		
Wyoming	3,287,372	14,467,473	66,232,755	151,068,806			

FIGURE 14: COLUMBIANA REFERENCE CLASS DATA

Columbiana	Reference Year						
	1	2	3	4	5	6	7
Allegheny	1,643,033	2,480,604	8,340,837	23,041,626			
Armstrong	196,384	1,569,308	6,230,295	17,707,185	23,292,446		
Beaver	1,694,178	1,727,849					
Blair	63,478	1,507,775					
Bradford	176,494	17,123,700	89,643,911	287,676,292	520,251,181	713,571,482	
Butler	53,130	304,076	950,025	2,655,997	11,644,920	20,941,254	38,240,789
Cambria							
Cameron	65,065	284,589	309,713	190,996	1,426,728		
Centre	84,996	160,685	984,126	5,165,727	5,749,462	4,232,605	
Clarion	230,052	542,677	1,491,799	1,771,336			
Clearfield	95,809	3,696,278	15,084,786	18,969,602	21,716,841		
Clinton	484,591	1,690,791	13,646,072	32,171,889	27,532,455		
Crawford							
Elk	359,905	1,269,169	2,050,299	7,263,791	7,997,761		
Erie							
Fayette	305,100	788,977	3,760,034	8,306,219	25,577,405	34,434,673	47,884,589
Forest	122,823	192,153	138,658	196,927	664,530		
Greene	52,746	1,793,856	11,722,979	43,915,132	118,919,305	180,505,447	317,111,680
Indiana	87,874	261,920	1,156,976	2,658,839	4,112,247	6,268,099	
Jefferson	471,047	2,381,025	5,748,006				
Lawrence	428,812	3,108,080					
Lycoming	83,471	2,522,954	13,184,280	80,674,850	230,127,710	413,056,577	
McKean	948,726	5,475,264	6,878,193	5,790,342			
Mercer	465,780						
Potter	311,349	2,908,092	9,235,784	8,823,163	7,336,766		
Somerset	312,850	363,672	611,280	2,975,943			
Sullivan	1,376,765	35,105,589					
Susquehanna	716,118	16,459,132	81,361,594	201,472,607	430,717,148	692,309,558	
Tioga	4,495,027	47,299,174	125,724,317	201,463,714	219,164,408		
Venango	153,609	121,427					
Warren							
Washington	1,370,737	4,920,335	17,531,237	54,421,884	112,275,071	179,027,550	259,653,296
Westmoreland	608,295	1,712,858	6,870,518	21,768,192	59,230,652	68,599,977	
Wyoming	3,287,372	14,467,473	66,232,755	151,068,806			

FIGURE 15: STARK REFERENCE CLASS DATA

Stark	Reference Year						
	1	2	3	4	5	6	7
Allegheny	1,643,033	2,480,604	8,340,837	23,041,626			
Armstrong	196,384	1,569,308	6,230,295	17,707,185	23,292,446		
Beaver	1,694,178	1,727,849					
Blair	63,478	1,507,775					
Bradford	176,494	17,123,700	89,643,911	287,676,292	520,251,181	713,571,482	
Butler	53,130	304,076	950,025	2,655,997	11,644,920	20,941,254	38,240,789
Cambria							
Cameron	65,065	284,589	309,713	190,996	1,426,728		
Centre	84,996	160,685	984,126	5,165,727	5,749,462	4,232,605	
Clarion	230,052	542,677	1,491,799	1,771,336			
Clearfield	95,809	3,696,278	15,084,786	18,969,602	21,716,841		
Clinton	484,591	1,690,791	13,646,072	32,171,889	27,532,455		
Crawford	49,809						
Elk	359,905	1,269,169	2,050,299	7,263,791	7,997,761		
Erie							
Fayette	305,100	788,977	3,760,034	8,306,219	25,577,405	34,434,673	47,884,589
Forest	122,823	192,153	138,658	196,927	664,530		
Greene	52,746	1,793,856	11,722,979	43,915,132	118,919,305	180,505,447	317,111,680
Indiana	87,874	261,920	1,156,976	2,658,839	4,112,247	6,268,099	
Jefferson	37,549	471,047	2,381,025	5,748,006			
Lawrence	428,812	3,108,080					
Lycoming	83,471	2,522,954	13,184,280	80,674,850	230,127,710	413,056,577	
McKean	948,726	5,475,264	6,878,193	5,790,342			
Mercer	465,780						
Potter	68,682	311,349	2,908,092	9,235,784	8,823,163	7,336,766	
Somerset	312,850	363,672	611,280	2,975,943			
Sullivan	1,376,765	35,105,589					
Susquehanna	716,118	16,459,132	81,361,594	201,472,607	430,717,148	692,309,558	
Tioga	4,495,027	47,299,174	125,724,317	201,463,714	219,164,408		
Venango	153,609	121,427					
Warren	48,692						
Washington	1,370,737	4,920,335	17,531,237	54,421,884	112,275,071	179,027,550	259,653,296
Westmoreland	608,295	1,712,858	6,870,518	21,768,192	59,230,652	68,599,977	
Wyoming	3,287,372	14,467,473	66,232,755	151,068,806			

From these reference class data sets, average, maximum, and minimum projected production values were developed for each study county for the available future years. These values are shown in **FIGURE 16**.

FIGURE 16: REFERENCE CLASS ANALYSIS RESULTS, BY STUDY COUNTY

Reference Year	1	2	3	4	5	6	
Carroll Actual	1038	7752	50224				
Reference Counties	1,669	12,329	58,609	142,474	306,436	409,529	Average
	3,287	16,459	81,362	230,128	430,717	692,310	High
	0	4,495	32,172	27,532	180,505	219,164	Low

Reference Year	1	2	3	4	5	6	7	
Columbiana	0	133	3,000					
Reference Counties	na	234	2,569	10,201	34,018	80,279	296,781	Average
	0	471	3,696	15,085	80,675	230,128	413,057	High
	0	53	1,569	5,748	8,823	7,337	180,505	Low

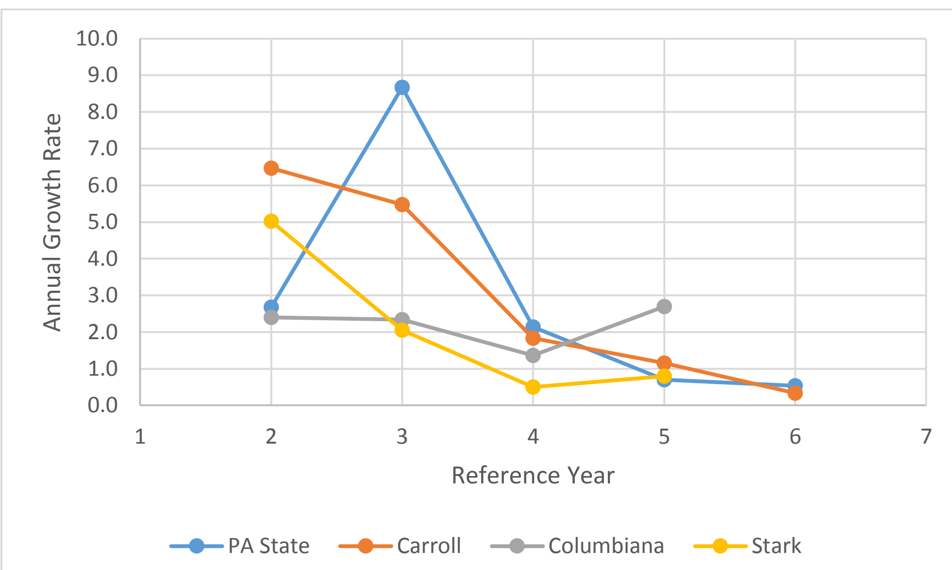
Reference Year	1	2	3	4	5	6	7	
Stark Actual	-	107	196					
Reference Counties	na	110	275	1,180	3,604	5,404	9,695	Average
	0	313	471	2,908	9,236	11,645	20,941	High
	0	38	121	139	191	665	4,233	Low

The reference class forecast resulted in the set of values in the far right columns of **FIGURE 16**. The Low, Average and High values for years 6 and 7 were assumed equivalent to the amount of production expected in 2030 to produce conservative scenarios.

2.4 | EXPONENTIAL DECAY PROJECTIONS

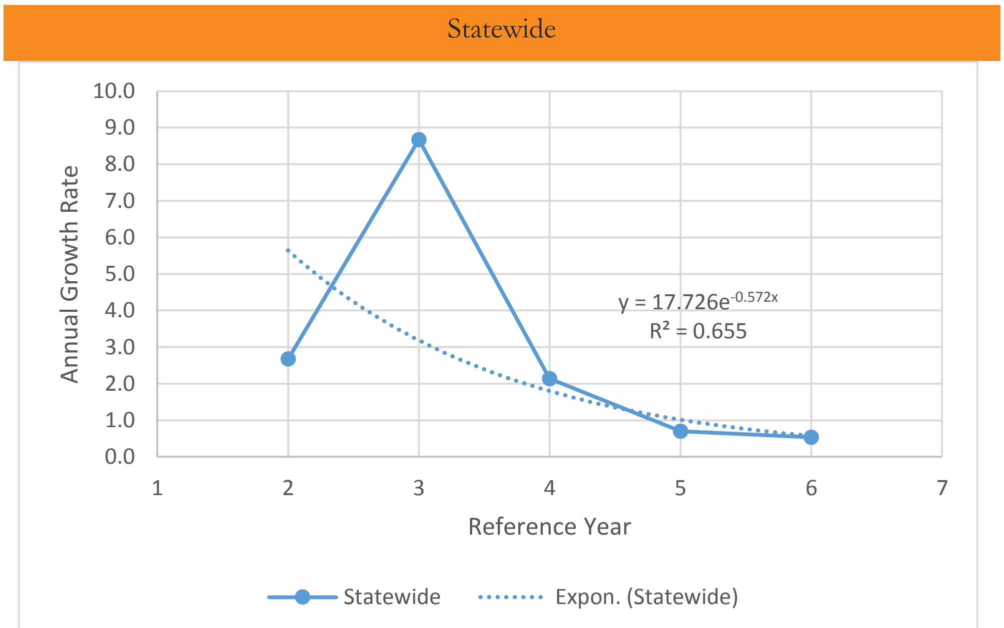
Taking the results from **FIGURE 16** and the Pennsylvania statewide data, various growth rates can be developed. The first year's data was not used for growth rate analysis since the first year's production values might only include part of the year. Because production would be expected to decline over time, annual rates were examined as opposed to compound growth rates. **FIGURE 17** illustrates the annual growth rates for the state and the reference counties.

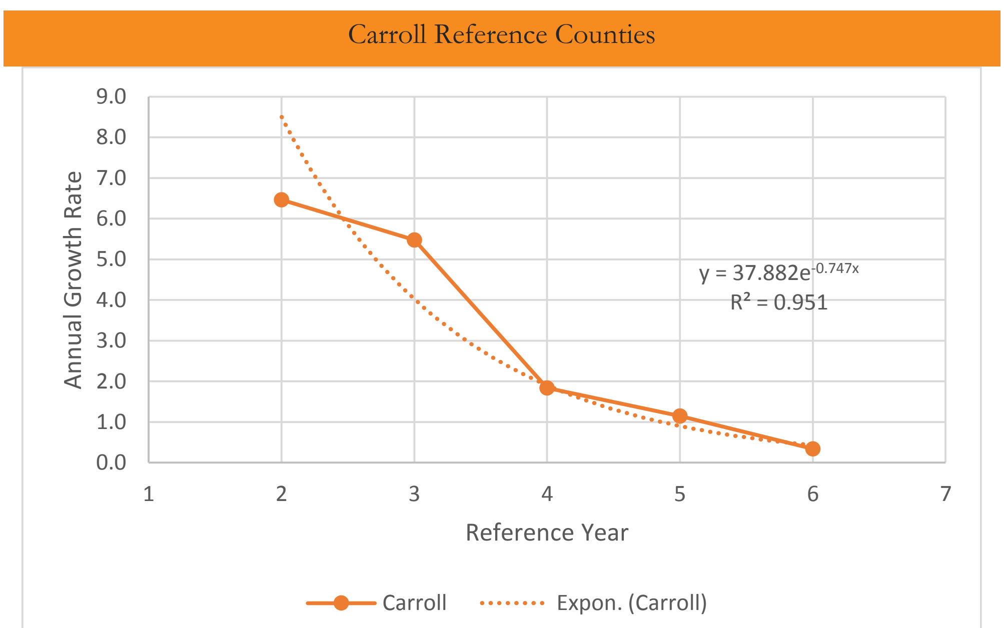
FIGURE 17: ANNUAL GROWTH RATES, FOR ALL PENNSYLVANIA COUNTIES AND SELECTED REFERENCE COUNTIES

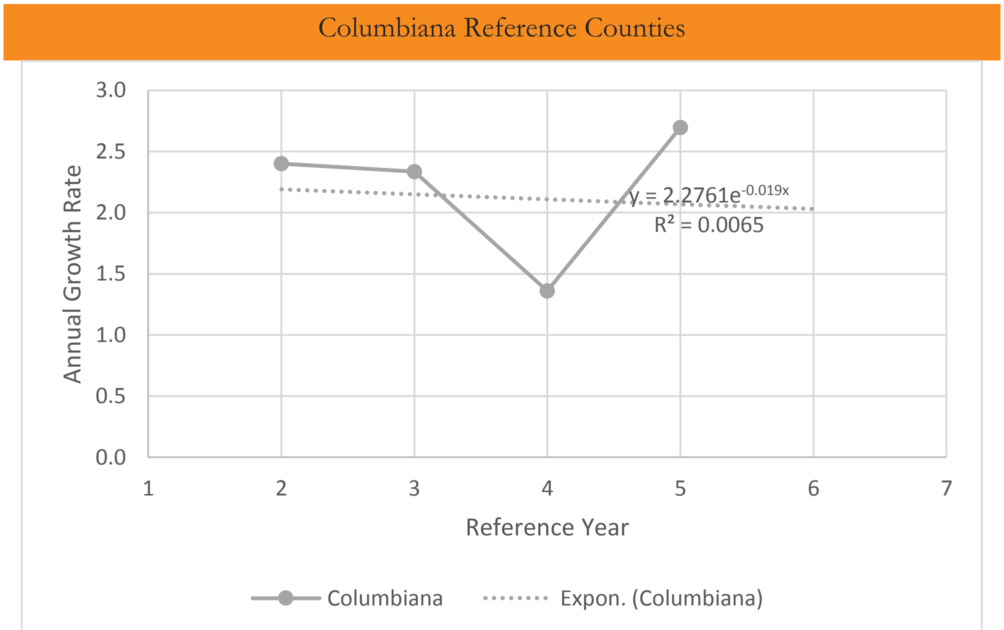


There is a notable peak in the state growth rates in year 3, and Columbiana's reference counties have relatively flat rates of change. Stark and Carroll counties' growth rates decline over the 5 observation years, as does the statewide data except for year 3. Fitting exponential curves to those data (**FIGURE 18**), results in the equations and correlation values listed in **FIGURE 19**.

FIGURE 18: EXPONENTIAL DECAY CURVES, FOR PENNSYLVANIA STATE AND SELECTED REFERENCE COUNTIES







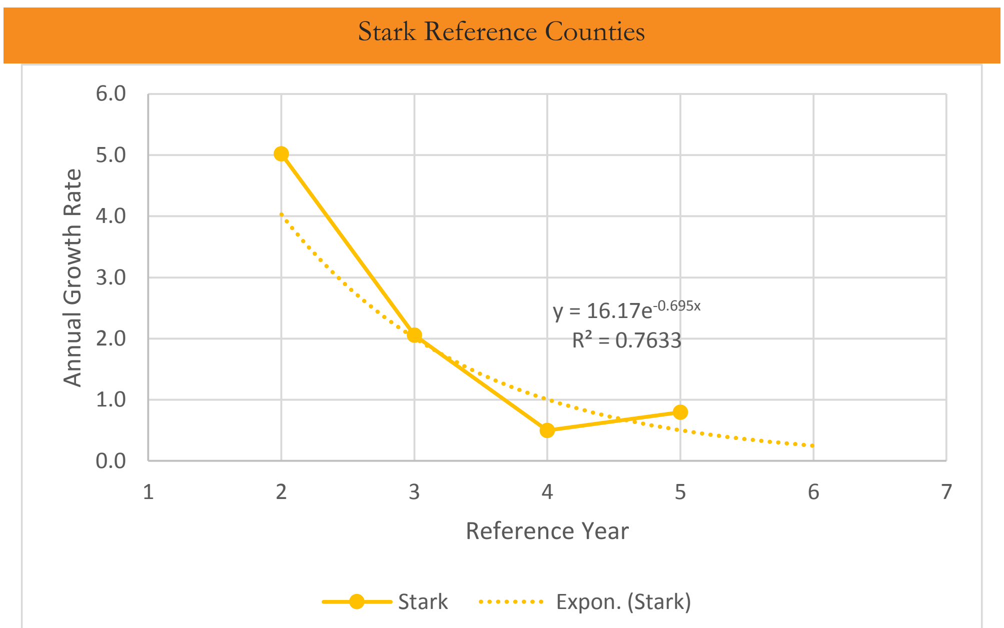


FIGURE 19: RESULTING EXPONENTIAL DECAY PARAMETERS AND CORRELATION VALUES, FOR PENNSYLVANIA STATE AND SELECTED REFERENCE COUNTIES

		m	x	R2
	Statewide	17.726	-0.527	0.655
Reference County	Carroll	37.882	-0.747	0.951
	Columbiana	2.276	-0.019	0.0065
	Stark	16.17	-0.695	0.7633
	All	13.559	-0.534	0.6059

Because there was a desire to apply a consistent methodology to all of the counties, and because Columbiana's curve had minimal explanatory power, just the statewide exponential curve was used to develop the future production estimates shown in **FIGURE 20**.

FIGURE 20: 2030 PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES, BASED ON EXPONENTIAL CURVE PROJECTIONS

	Carroll	Columbiana	Stark
Using second Ohio production year data	8,455,908	3,272,879	213,814
Using last Ohio production year data	7,632,450	3,272,879	213,814
Using last year of reference class average	1,068,073	774,021	25,284

2.5 | PRODUCTION ESTIMATES VALIDATION AND SELECTION

The results from Sections 2.3 | and 2.4 | are gathered together in **FIGURE 21**.

FIGURE 21: 2030 NATURAL GAS PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (IN MILLION CUBIC FEET)

			Carroll	Columbiana	Stark
	Reference Class	Low	219,164	180,505	4,233
		Averag	409,529	296,781	9,695
		High	692,310	413,057	20,941
Exponential Decay	Using last year of reference class		1,068,073	774,021	25,284
	Using last Ohio production year data		7,632,450	3,272,879	213,814
	Using second Ohio production year data		8,455,908	3,272,879	213,814

The values produced using these methods was compared to annual production values for a handful of states and counties that are current leading producers of natural gas (shown in **FIGURE 22**).

FIGURE 22: NATURAL GAS PRODUCTION FOR LEADING PRODUCERS (IN MILLION CUBIC FEET) (SOURCE: EIA 2015)

	2008	2009	2010	2011	2012	2013	2014
North Dakota	87,188	92,489	113,867	157,025	258,568	345,787	
Ohio	84,858	88,824	78,122	78,858	84,482	186,181	
Pennsylvania	198,295	273,869	572,902	1,310,592	2,256,696	3,259,042	
Texas	7,800,655	7,653,647	7,593,697	7,934,689	8,143,510	8,211,255	
North Dakota Counties							
Billings				4,134	5,452	5,809	6,039
Burke				3,238	5,449	6,805	7,660
Divide				6,031	10,795	14,888	16,138
Dunn				15,363	27,238	38,922	49,478
Golden Valley				499	654	688	885
McKenzie				43,897	85,021	129,897	188,486
Mountrail				34,213	51,190	61,610	77,948
Stark				1,776	4,511	8,043	8,702
Williams				32,724	55,515	67,258	77,260

Based on the values in **FIGURE 22** used for comparison, upper and lower bound future production levels were selected from the production estimates for each county along with their 2013 production levels. Those are shown below in **FIGURE 23**.

FIGURE 23: SELECTED 2030 NATURAL GAS PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (IN MILLION CUBIC FEET)

	Carroll	Columbiana	Stark
2013	50,224	3,000	196
Low	692,310	413,057	20,941
High	1,068,073	774,021	25,284

Since the Pennsylvania oil production patterns did not parallel the Ohio oil production patterns, but the Pennsylvania gas production did, the future projections for Ohio oil production was based on the Pennsylvania natural gas–sourced projections. The ratios of 2013 production to the selected Low and High scenarios listed in **FIGURE 23** were used to develop Low and High projections for the three study counties' oil production. Those values are listed below in **FIGURE 24**.

FIGURE 24: SELECTED 2030 OIL PRODUCTION ESTIMATES FOR THREE OHIO STUDY COUNTIES (BARRELS OF OIL)

	Carroll	Columbiana	Stark
2013	1,768,635	80,411	15,382
Low	24,379,554	11,070,412	1,643,419
High	37,611,999	20,744,701	1,984,248

Forecast oil growth rates for the Ohio study area counties based on this method using gas growth rates were validated against observed growth rates from high producing counties in North Dakota, using data on county level oil and gas production from 2006 to 2011 from the U.S. Department of Agriculture (USDA) Economic Research Service.

FIGURE 25: ANNUAL GROWTH RATES IN OIL AND GAS PRODUCTION IN TOP NORTH DAKOTA COUNTIES FROM 2006-2011

	Oil	Gas
Mountrail County	159%	85%
McKenzie County	40%	29%
Dunn County	87%	63%
Williams County	41%	8%

FIGURE 26: ANNUAL GROWTH RATES ASSUMED IN STUDY AREA COUNTIES THROUGH 2030

	Low Growth		High Growth	
	Oil	Gas	Oil	Gas
Carroll	17%	17%	20%	20%
Columbiana	34%	34%	39%	39%
Stark	32%	20%	23%	23%

Historic data shows that in North Dakota, growth rates for oil production have been consistently higher than growth rates for gas production with high producing counties experiencing annual growth rates of 40% to over 150% over a period of at least five years with absolute production values from 20 to 50 million barrels of oil annually by 2011 (the latest year for which data was available). In contrast, the forecast annual oil growth rates for the study area are limited to the gas growth rates in the range of 17-39% resulting in absolute 2030 production levels of 11 to 38 million barrels of oil in Carroll and Columbiana Counties, well within the range of observed 2011 values in North Dakota. Thus, the absolute oil production levels are within a reasonable range and the growth rates are probably conservative.

2.6 | PRODUCTION VALUES

The IMPLAN tool requires information provided in economic terms. Therefore, the 2030 production values had to be converted to monetary values. To do this conversion, producer prices were identified using US Energy Information Administration historical data using wellhead prices for natural gas (USEIA 2015b) and Brent crude prices for oil (USEIA 2015c). The minimum, average, and maximum monthly average price for the last ten years were identified (summarized in **FIGURE 27**). In conjunction with the Low and High production estimates, a range of total future economic generation scenarios was developed.

FIGURE 27: RESULTING POTENTIAL 2030 PRODUCTION VALUES (IN DOLLARS) FOR VARIOUS PRODUCTION AND PRICE SCENARIOS

		Wellhead price		
	MMCF Gas	2.66	5.34	7.98
Carroll	692,310	**1,838,081,876**	3,696,067,652	**5,523,476,422**
	1,068,073	2,835,734,171	5,702,175,444	**8,521,443,487**
Columbiana	413,057	**1,096,665,212**	2,205,205,800	**3,295,503,056**
	774,021	2,055,026,591	4,132,306,295	**6,175,400,057**
Stark	20,941	**55,599,030**	111,800,121	**167,076,307**
	25,284	67,129,724	134,986,371	**201,726,297**

		Brent crude		
	Bbl Oil	54.42	86.38	111.65
Carroll	24,379,554	**1,326,694,698**	2,105,883,160	**2,722,017,840**
	37,611,999	2,046,782,321	3,248,889,461	**4,199,442,420**
Columbiana	11,070,412	**602,433,388**	956,251,901	**1,236,029,987**
	20,744,701	1,128,892,043	1,791,907,925	**2,316,180,419**
Stark	1,643,419	**89,432,132**	141,957,016	**183,490,489**
	1,984,248	107,979,480	171,397,511	**221,544,619**

Data from the Considine et al. (2009) report were used to identify a range of realistic future monetary value scenarios. Three scenarios were selected as more likely future scenarios: the low production-low price, the low production-high price, and the high production-high price.

FIGURE 28: SELECTED PRODUCTION AND PRICE SCENARIOS (IN DOLLARS)

	Low Production Low Price	Low Production High Price	High Production High Price
Carroll	3,164,776,574	8,245,494,262	12,720,885,907
Columbiana	1,699,098,600	4,531,533,043	8,491,580,477
Stark	145,031,162	350,566,795	423,270,916

2.7 | ECONOMIC INPUT-OUTPUT ANALYSIS

The producer prices from **FIGURE 28** were entered into the IMPLAN tool under sector 20 (Extraction of oil and natural gas) as local purchases. The effects of this spending were traced through the economy, considering both direct and indirect impacts. The results can be summarized in terms of income creation, added value, or job creation – all different ways of examining the impact of this economic development. As transportation impacts are frequently linked to employment, the number of new employees associated with the investment was selected as the most useful metric. Following completion of the input-output analysis, a range of economic outputs in terms of employees for each county was developed (**FIGURE 29**).

FIGURE 29: POTENTIAL 2030 IMPACT (IN EMPLOYEES) FOR SELECTED PRODUCTION AND PRICE SCENARIOS

	LOW GROWTH SCENARIO	MEDIUM GROWTH SCENARIO	HIGH GROWTH SCENARIO
CARROLL	16,165	42,116	64,975
COLUMBIANA	9,031	24,520	45,947
STARK	736	1,779	2,148
STUDY AREA TOTAL	**25,932**	**68,415**	**113,071**

This level of job creation represents a significant impact on regional growth and should be expected to impact future traffic conditions in the region. The results of this analysis, together with further analysis to determine in-migration and the pattern of growth within the region define scenario assumptions for travel demand forecasting using the Ohio statewide model with special detail added in the study area.

2.8 | DEMOGRAPHIC IMPACTS

In order to forecast future traffic, in addition to job creation, it is important to understand associated increases in the number of workers by their residence locations, associated increases in household income and number and location of new population and households which migrate into the study area in response to the economic opportunity.

It is important to understand that new jobs may be filled in one of several ways.

- First, these jobs may be filled by those currently seeking jobs in the local area, decreasing unemployment and increasing household income and number of workers in the study area or neighboring areas but not adding new population or households.
- Second and similarly, these jobs may be filled by other local residents who were not previously seeking a job but who are enticed to enter the workforce in response to the new opportunities. This second case represents an increase in the local labor force participation

rate and also increases household income and number of workers in the study area or neighboring areas without adding any new population or households.

- In the third case, new workers may be associated with new households which re-locate to the region in response to the new economic opportunities. These workers increase the population and number of households in the study area but may or may not change the average number of workers per household or average income per household.

For the purposes of this study, the increase in population and households corresponding to the third case described above was estimated based on a second reference class analysis with the remainder of jobs assumed to be met through the first two methods.

The reference counties already identified for each of the study area counties for oil and gas production were re-examined and further filtered depending on whether they were also grossly comparable in terms of labor force. All of Carroll County's peer counties were retained for this analysis except for Lycoming County, PA, since it is significantly larger. The same group of counties was also used for Columbiana County, since several of its original peer counties were of inappropriate size or exhibited unusual growth patterns unlikely to be explained by oil and gas development. For Stark County, Butler and Centre counties appeared to be the only two reasonable peers in terms of both oil and gas production and labor force, but these two counties did seem to present a reasonable reference point.

The relationship between demographic and economic growth was examined in the refined reference class counties to estimate the amount of in-migration per new job created. For the smaller counties, roughly one in five new jobs corresponded to a new resident. For large counties like Stark, on the other hand each new job corresponded to roughly 1.1 new residents. This is not unreasonable, both because smaller areas have less housing stock and have limited ability to accommodate new residents quickly and because migrants into the region are often attracted to slightly larger areas more than small towns. The result is that Stark County has a larger increase per new job than the other counties, but still the strong majority of the growth in population and households occurs in Carroll and Columbiana counties, as with the job creation.

FIGURE 30 POPULATION GROWTH BY COUNTY

	LOW GROWTH SCENARIO	MEDIUM GROWTH SCENARIO	HIGH GROWTH SCENARIO
CARROLL	3,164	16,846	38,985
COLUMBIANA	1,791	9,808	27,568
STARK	827	2,000	2,414
STUDY AREA TOTAL	**5,783**	**28,654**	**68,968**

FIGURE 31 GROWTH IN HOUSEHOLDS BY COUNTY

	LOW GROWTH SCENARIO	MEDIUM GROWTH SCENARIO	HIGH GROWTH SCENARIO
CARROLL	1,261	6,712	15,533
COLUMBIANA	715	3,915	11,004
STARK	336	811	980
STUDY AREA TOTAL	**2,311**	**11,439**	**27,517**

The total increase in workers to meet the new job creation including those residing in both new and existing households must also be understood in terms of workers' residence locations in order to produce the right commuting patterns in the travel model. In order to estimate residence locations of workers, it was assumed that with rising labor force participation and decreasing unemployment, there would be roughly a 10% increase in the average number of workers per household within the three county study area. In this way, the study area counties will supply more workers than just those associated with new households, and in particular, Stark County will supply many of the workers for the new jobs in Carroll and Columbiana counties. Even so, there will be some in-commuting from beyond the study area. These new workers commuting into the area were assumed to reside in the same general locations as workers who currently commute to work in Carroll and Columbiana counties. The resulting number of new workers by residence location is presented below in Figure 32.

FIGURE 32 NEW WORKERS BY RESIDENCE LOCATION

County	Low Growth	Medium Growth	High Growth
Carroll	2,709	9,250	19,835
Columbiana	5,249	9,089	17,596
Hancock	70	1,129	2,242
Harrison	205	2,299	3,649
Jefferson	299	3,652	6,184
Mahoning	390	6,876	14,177
Stark	16,531	30,509	40,155
Tuscarawas	358	4,022	6,400
Summit	96	1,227	2,148
Portage	25	363	686

The result of these socioeconomic forecasts is significant daily commuting by workers residing in Stark County and working in Carroll and Columbiana counties.

3.0 ALLOCATION OF GROWTH WITHIN THE STUDY AREA

Economic analysis is typically conducted at the geographic level of counties, but traffic forecasting requires socioeconomic data at a much more geographically detailed level, called traffic analysis zones (TAZ). It was therefore necessary to allocate county level growth developed from the economic forecasts to the travel model's TAZs in order to produce traffic forecasts.

Given the inherent uncertainties in growth due to a variety of factors such as gas/oil prices, it is best to provide several representative scenarios or a range of possible growth and employment futures for the three target counties in the focus area – Stark, Columbiana and Carroll Counties. A variety of information was reviewed and input gained to allocate the numbers to areas anticipated to experience growth and development based on the employment types: agricultural, metal production and offices, light and heavy industrial production and office, wholesale and retail production and office, hotels, construction, health care, transportation handling, utility services, education, government and other services. The following is a summary of information obtained to allocate the projected high, medium and low growth for Stark, Columbiana and Carroll Counties:

Stark County

Land use and zoning maps for Canton, East Canton, Massillon, Louisville and the county were the basis for allocation of growth in Stark County. The Nexus gas transmission line planned alignment goes through the north part of Stark County near Louisville and North Canton and potential development due to the proximity of this line was also taken into account.

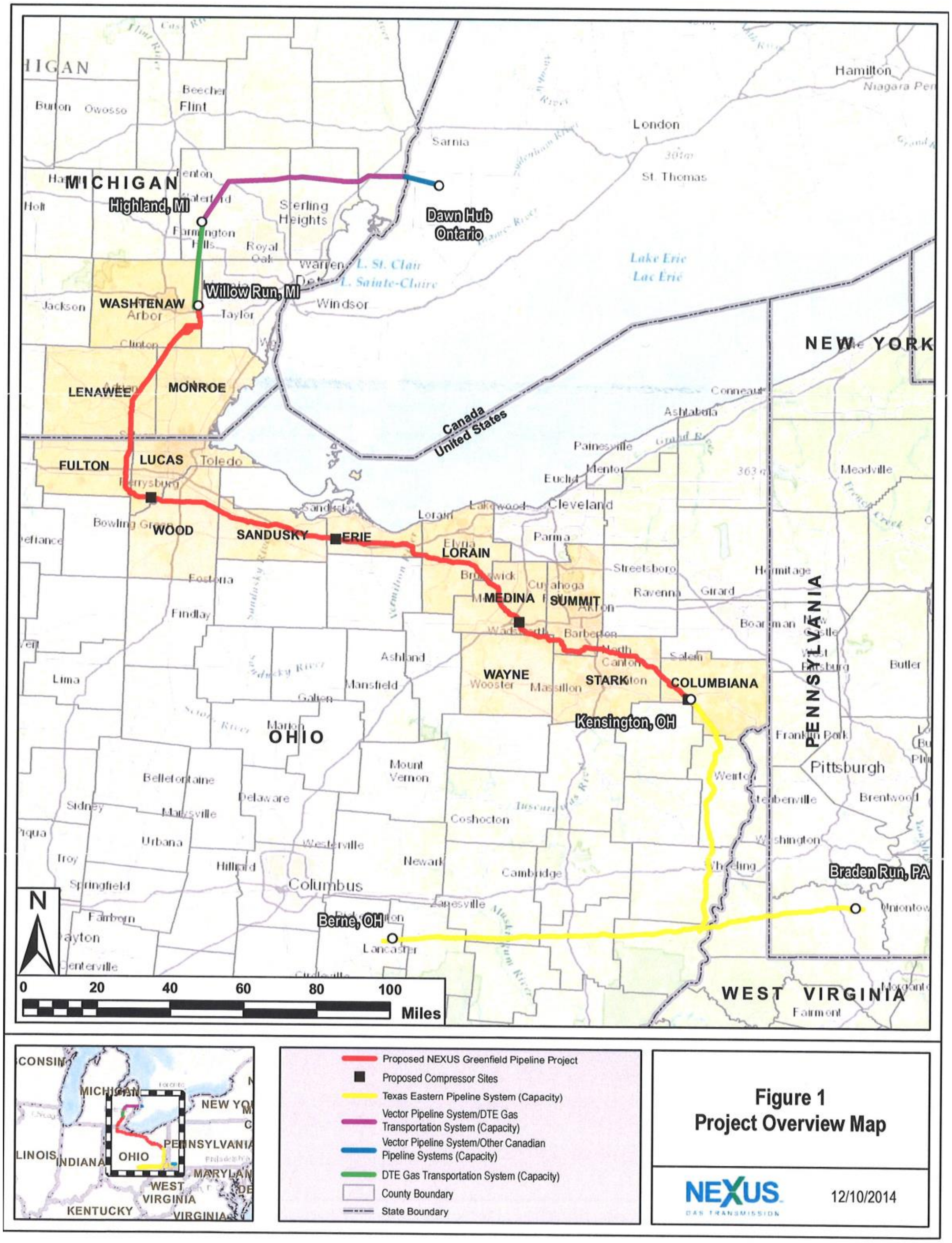
Carroll and Columbiana Counties

Zoning maps were not available for rural Carroll and Columbiana Counties. The Ohio Mid-Eastern Governments Association (OMEGA) provided existing land use and land cover maps which included oil well, power plant, pipeline and industrial center locations. Contact was made and information gained from the following resources to further understand the economy and future area growth in these two counties:

- Columbiana County Engineer
- Columbiana County Development Department
- Carroll County Development Department
- Columbiana County Port Authority
- Spectra Energy
- OMEGA

Information was also obtained on the Panama Canal Expansion project from the Panama Canal Authority and the Pittsburgh Post Gazette provided information on the Monaca Cracker Plant across the Ohio River from East Liverpool in Monaca Pennsylvania. A map of the overall Nexus gas transmission line is included for reference in Figure 33.

FIGURE 33 NEXUS GAS TRANSMISSION LINE WITH EXTENSIONS



Potential Growth Areas in Carroll County

Carroll County has already experience the most gas/oil growth of the three counties in the focus area for this study. Water and sewer is limited in Carroll County so the potential for additional growth is seen to be primarily around the existing cities and villages of Malvern, Carrollton, Mechanicstown, Leesville, and some at Sherrodsville. A rover pipeline runs south of Leesville and east of Sherrodsville and a processing plant, a joint effort by M3 Midstream, Access Midstream and EV Energy, exists east of Leesville. A power plant is under construction northeast of Carrollton. There are plans by Carrollton to extend water and sewer between Carrollton and Malvern along SR 43 for industrial and retail uses. Fairmont Tools, currently located halfway between Carrollton and Malvern is planning to expand and possibly add an intermodal facility to serve the shale/gas industry. All of these areas are seen as locations for future growth.

A new school is planned for Carroll County, funded in part by the new power plant. Carrollton has medical offices but no hospital yet and does have schools.

Potential Growth Areas in Columbiana County

Columbiana County is continuing to experience growth due to the oil/gas industry, primarily on the southwest side of the county. Pipelines are on west side and northeast part of the county. There is currently a cryogenic gas processing plant at Kensington. The Nexus gas transmission line is planned to run from east of Kensington, west just north of Hanoverton, and northwest into Stark County north of North Canton. The Columbiana County Engineer and Columbiana County Development Department have identified three locations along this route attractive to industrial development. A wastewater treatment plant is planned for north of Kensington to service and planned industrial center.

The Columbiana County Port Authority owns property between Leetonia and Columbiana. The 126 acre World Trade Park is located here and development is planned in this area. SR 11 corner of Leetonia and Columbiana is particularly attractive to industry. There is also current activity and potential future activity along the SR 11 corridor between Lisbon and Leetonia. Lisbon is currently home to downtown retail, government buildings, fairgrounds, schools and some industrial uses and some expansion will be expected.

The Port Authority also has property in East Liverpool and both Wellsville and East Liverpool benefit from their location along the Ohio River and proximity to bridges connecting to Pennsylvania. Barge traffic is expected to increase due to the Panama Canal Expansion and river frontage for warehouses and industries is expected to be in high demand. Ground is breaking on two new industrial sites in the Wellsville and East Liverpool area. Other areas in Columbiana County with expected growth are Salem and St. Clair Township. East Palestine has capacity for industrial growth but the site in not as attractive as others in the county. Salineville used to be the headquarters for Citizens bank and there are a few office buildings available which have been attractive to the oil and gas industries and there are buildings that could house a small corporate center.

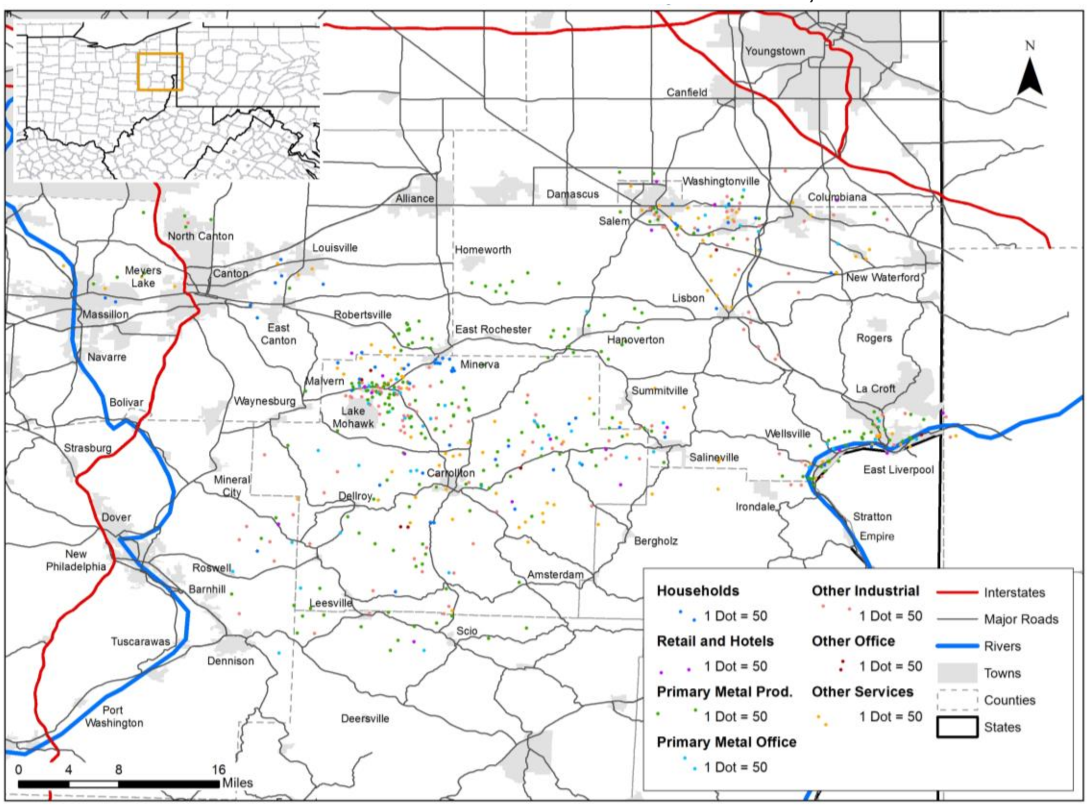
In regards to education, there are post secondary schools such as the New Castle school of Trade at East Liverpool. The Columbiana County joint vocational school is located outside of Lisbon.

Salineville has program for welding in southwest part of town for the oil/gas industry. Columbiana City Schools plans to starting programs for oil/gas industry training.

Healthcare is currently available primarily in Salem and Lisbon. Salem has a hospital and Prima Health Care recently announced a large expansion at the SR 7 and SR 14 intersection just outside Salem. Lisbon has County Clinics on the north side of town and there is a clinic in Salineville.

Figure 34 through Figure 36 use dot density maps to show the approximate distribution of growth as allocated to the model's TAZs.[1]

FIGURE 34 ALLOCATION OF GROWTH FOR LOW GROWTH SCENARIO, 2030



[1] Fuzzy boundaries were used to produce slightly more realistic looking distributions, but in some cases this allowed dots outside the zone where the growth was actually allocated in the model.

FIGURE 35 ALLOCATION OF GROWTH FOR MEDIUM GROWTH SCENARIO, 2030

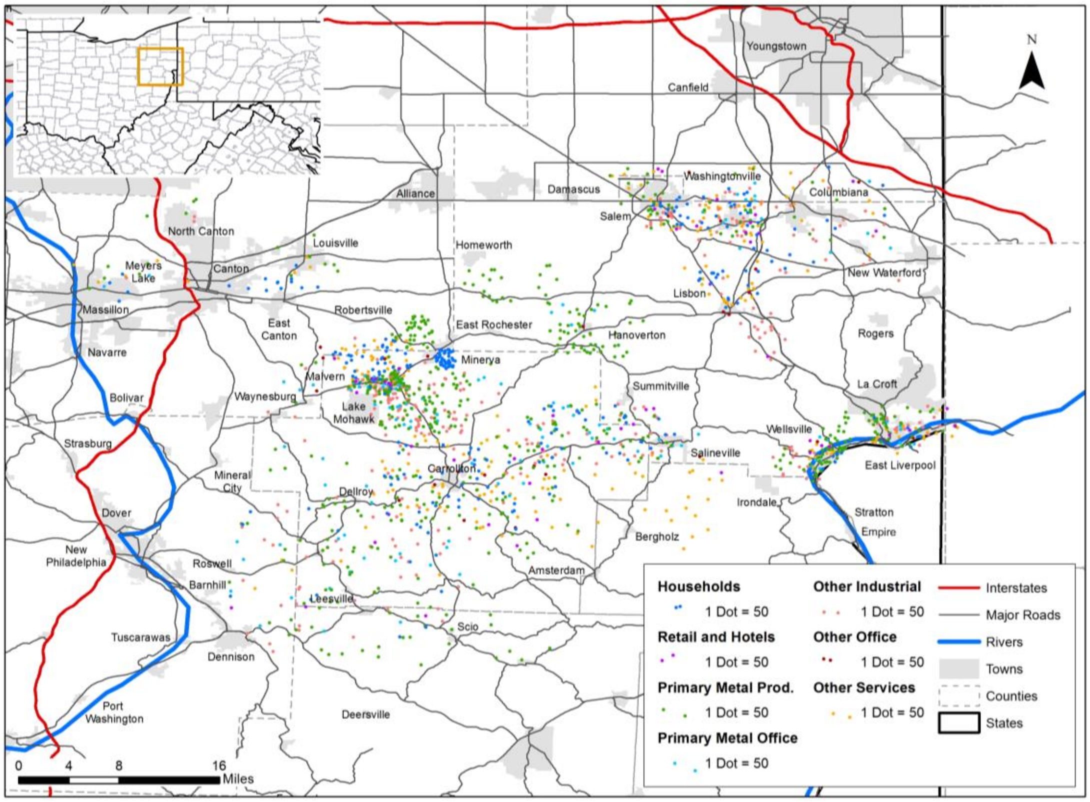
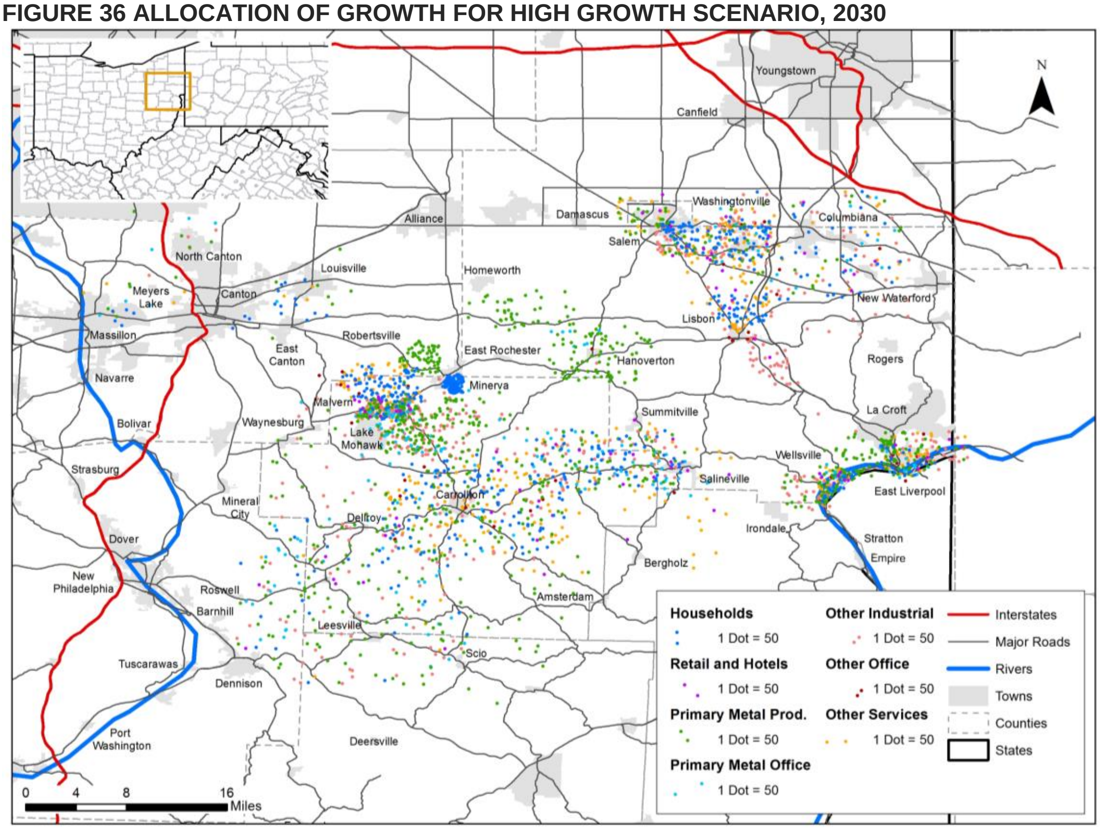


FIGURE 36 ALLOCATION OF GROWTH FOR HIGH GROWTH SCENARIO, 2030



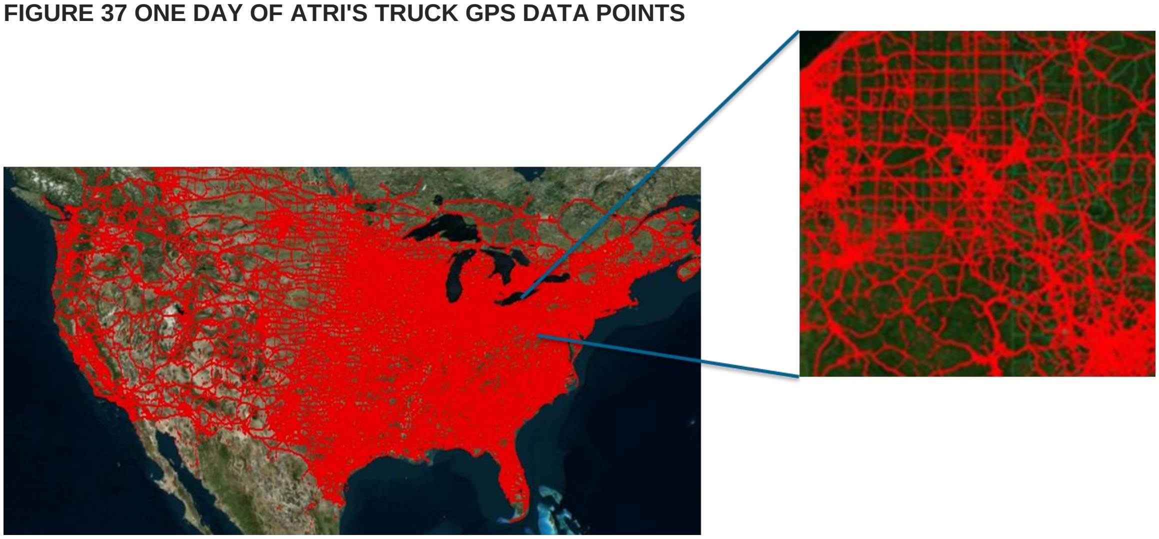
4.0 ANALYSIS OF TRUCK GPS DATA

The availability of large samples of truck GPS data has presented a new, unprecedented source of information for understanding truck travel patterns and forecasting truck demand. Therefore, although the traffic forecasts for US 30 are primarily derived using the Ohio Department of Transportation (ODOT)'s Ohio Statewide Model (OSM), the truck forecasts are also informed by an analysis of truck GPS data from the American Transportation Research Institute (ATRI) which was not available when the OSM was developed.

4.1 | BACKGROUND

The American Transportation Research Institute (ATRI) is a 501(c)3 not-for-profit research organization. As an independent part of the American Trucking Associations (ATA) Federation, it receives truck GPS position data from many of its members. The primary source of the data is on-board communications and navigation equipment installed on commercial trucks. The resulting dataset is extremely large and growing, containing over 50 billion truck positions annually, representing several hundred thousand individual trucks out of the total 2.4 million trucks registered in the US. ATRI compiles the data as part of the Freight Performance Measures Initiative, an effort sponsored in part by the Federal Highway Administration to support a variety of initiatives including their Freight Performance Measures Webtool.

FIGURE 37 ONE DAY OF ATRI'S TRUCK GPS DATA POINTS



ATRI's truck data has been used for nearly a dozen years in many analyses to identify truck bottlenecks, congestion and speeds on major highway freight corridors such as I-95 across the country. More recently it was used to better understand truck origin-destination patterns as part of a feasibility study of dedicated truck lanes on an 800-mile section of I-70 through Missouri, Illinois, Indiana and Ohio with funding from FHWA's Corridors of the Future program. The GPS data proved to be extremely useful in understanding the patterns of truck movements utilizing the corridor as well as "ground-truthing" and improving travel demand forecasts. However, the data was not formally incorporated in any models.

The Indiana Statewide Travel Demand Model was the first travel forecasting model to formally incorporate the data when it was updated in 2011-2012. The Indiana Department of Transportation obtained an eight week sample of ATRI's truck GPS data drawn from each of the four quarters of 2010. The resulting sample contained over 16 million records representing over 2 million trips by over 300,000 trucks. The data was analyzed and while it was determined that the ATRI data clearly includes short-haul movements, it was determined that the preponderance of the data related to medium- and longer-haul truck trips and it was therefore used to improve the commodity-flow based truck movements in the model. The incorporation of the ATRI data into the model resulted in substantial improvements in the truck model validation, decreasing the root mean squared error (RMSE) against roughly 6,000 truck counts from 69.3% to 60.6% and decreasing the mean absolute percentage error (MAPE) for trucks from 74% to 42%. Despite the very positive results on the truck model performance, it was recognized that further improvement was likely possible if the representativeness of the ATRI data was better understood so that it could be expanded more realistically.

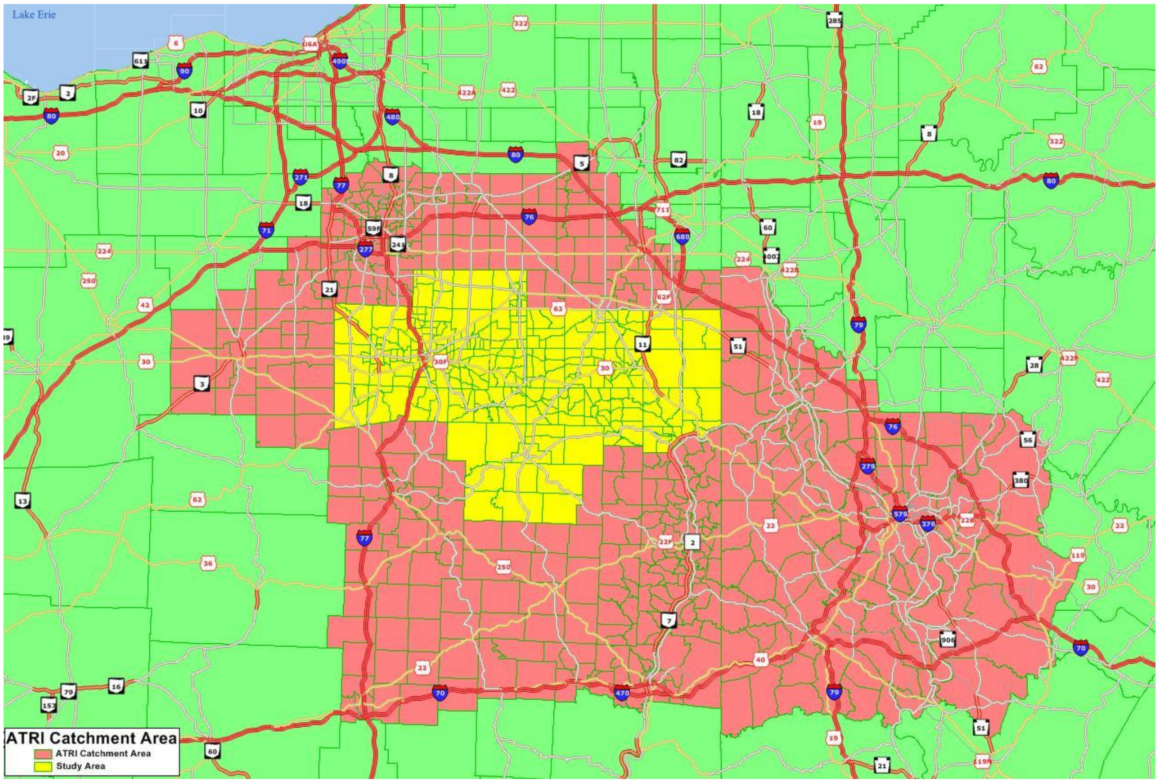
More recent work incorporating ATRI's truck GPS data in statewide models for the Iowa and Tennessee departments of transportation has therefore focused effort on understanding the representativeness of the data and how best to expand it. In particular, this work has developed methods for expanding ATRI data based on truck counts in such a way as to correct for biases against short-haul movements in ATRI's raw sample data.

Truck GPS data was obtained from ATRI for the US 30 feasibility study and used to support the study in several ways. First, it was analyzed to understand and establish actual truck travel patterns in and through the US 30 corridor and competing facilities such as the Pennsylvania Turnpike. Second, it was used in producing truck forecasts by serving as a pivot point, with modeled truck growth applied to the present patterns observed in the data. Third, it was also used to analyze current bottlenecks in the existing US 30 corridor to help understand the benefits of shorter term improvements to the existing corridor.

4.2 | TRUCK GPS DATA PROCESSING

An eight week sample of trucks passing through a catchment area around the US 30 corridor was obtained drawing two weeks of data from each of the four quarters of 2014. A GIS file based on TAZs was provided to ATRI. ATRI selected all truck GPS traces entering, exiting, traveling within or passing through the catchment area for each of the sampled weeks. The catchment area is shown in Figure 38 and was specifically designed to include the Pennsylvania Turnpike as well as I-77 and I-70 so that all truck trips between Pittsburgh and Cleveland should be captured.

FIGURE 38 CATCHMENT AREA FOR TRUCK GPS DATA FOR US 30



A data management and analysis software package was used to further prepare the dataset for integration into the truck trip table. Truck positions for each unique vehicle were sorted into a time series, and within each series each truck position was matched with the subsequent truck position to produce a set of truck position pairs. The geodetic distance between the first and second truck positions for each of the truck position pairs was then calculated. ATRI then replaces the precise GPS location data in its records with the TAZ. In addition to supporting the ultimate development of a trip table, this process also offers some benefit of further ensuring the anonymity of the data by associating truck positions with geographic areas far more generalized than a discrete latitude/longitude position – which could allow for the development of an address-specific customer list. The dataset is then reformatted so that each record represents the movement of a truck between GSP 'pings'. ATRI then delivers a dataset containing an anonymous truck identifier, the distance between pings, the TAZ position of the beginning and ending ping and the timestamp of the beginning and ending ping (see Figure 39).

FIGURE 39 IDENTIFYING STOPS FROM GPS TRACE DATA

from TAZ	to TAZ	distance	time	elapsed time	speed	status1	status2
10	101032	66.0	57.7	57.7	68.6	moving	moving
101032	101033	16.3	14.3	72.0	68.6	moving	moving
101033	101015	26.8	27.9	99.9	57.5	moving	moving
101015	101015	0.0	5.0	5.0	0.0	stopped	stopped
101015	101015	0.2	2.7	7.7	5.2	stopped	stopped
101015	101015	0.3	9.8	17.5	2.0	stopped	stopped
101015	101015	0.1	0.3	0.3	28.2	moving	*stopped?*
101015	2035	37.1	60.0	60.3	37.1	moving	moving
2035	18099	67.8	65.4	125.7	62.2	moving	moving
18099	27006	5.9	5.4	131.1	65.3	moving	moving
27006	18023	10.0	15.9	147.0	37.8	moving	moving
18023	18023	0.0	5.0	5.0	0.0	stopped	stopped

Trip	O	D
1	10	101015
2	101015	18023

This dataset must then be processed and further reduced to represent trips between origin-destination pairs. This is done in two steps, first identifying for each pair of GPS pings or movement record, whether the truck was in motion or stopped. This determination is made based on complex criteria of a minimum travel speed and a minimum elapsed time and/or distance. The complex criteria are necessary to avoid including brief stops at traffic signals or brief repositioning movements within a single site (see Figure 40 for an illustration).

FIGURE 40 BRIEF RE-POSTITIONING MOVEMENTS TO BE DISTINGUISHED FROM TRIPS

Once the moving records and stopped records are identified, the records are processed to identify the origin and destination for each sequence of moving records. When a stop record was found in the list, it signified the destination of the trip and the origin for the subsequent trip (see Figure 39). The result is a list of trips by origin-destination pair, which can be aggregated by origin-destination pair to produce a trip-table in flat/list format, which, in turn, can be read into a matrix format file by most travel modeling software.

The resulting trip table still must be cleaned for several reasons discussed in turn below. The largest issue was GPS positional errors, or "blips," where the GPS location jumps from one location to another in a way that could not possibly represent a real movement (e.g., a change in position of 50 miles in a span of 30 seconds). Given the large size of the sample data (with over 3 million trips for Iowa), it was not necessary to invest large effort to correct these blips; rather, trips with such errors were simply identified and removed from the dataset. Moreover, a very conservative test of what qualified as a good trip or a very liberal identification of blips was used, again given the luxury of the abundant data. Although it may be ideal to attempt to correct and recover some of these trips with blips, simply removing them is safest course of action and was deemed reasonable given the very large sample size.

Some trips at the very beginning and end of each two week period were removed in order to avoid capturing trip fragments or partial trips in progress at the beginning or end of the period. If a truck is initially moving (no starting records of a stop) within the first hour of the global start time (Mar 01 @ 00:00:00) then those records were flagged. This time was determined to be a reasonable buffer by looking at the starting time distribution of all initial trips. Similarly, trucks that did not display a final stop and had movement within 3 hours of the global end time (Mar 15 @ 00:00:00) were flagged. After a look at ping length and ending trip distribution, it was assumed that if a truck displayed no pings for over 3 hours that it's trip had ended. Less than 1% of the total trips were affected by either the stop time or end time filters.

For each trip, its GPS calculated length was also compared to a centroid-to-centroid geodetic distance. Trips were flagged if the ratio was outside the bounds of 0.7 & 2.25. This was used to catch both blips that slipped through the initial filter as well as undetected stops and helped to confirm "clean" probable trips. This filter also resulted in the removal of less than 1% of the total trips.

A small number of trips appeared to start and end in the same zone (an intrazonal trip), but with unreasonable VMT. Looking into individual pings, it appears that these trips went through several zones and made a large circular trip. This seemed be from either a brief trip outside the model or in many cases an undetected stop. Intrazonal trips greater than 30 miles were generally removed.

The final effort is on the expansion of this resulting raw trip table. The approach taken in this effort begins by simply scaling the raw ATRI trip table to represent the proper amount of truck VMT. Then, origin-destination matrix estimation algorithms are applied using truck counts on the network and the scaled trip table as a seed. While ODME algorithms are an imprecise method, they provide a consistent, structured and logical framework for relating the information contained in truck count data to origin-destination patterns. Truck counts, while also imperfect, are widely available and believed to be the best source of unbiased data on total truck traffic.

4.3 | FINAL US 30 TRUCK GPS DATA

After processing the dataset included over 40 million movement records by roughly 70,000 individual trucks making over 2.6 million trips. Due to quality issues with GPS signals, it was necessary to remove about 304,000 trips with suspect GPS data. It was judged better to be conservative and throw out a few possible good trips than to include a few very bad ones. The resulting final dataset contained over 2.3 million trips, including over 140 million truck miles of travel observed over the 56 days in the sample.

FIGURE 41 EXISTING US 30 CORRIDOR

FIGURE 42 TRUCKS USING THE US 30 CORRIDOR – AFTER 1 DAY

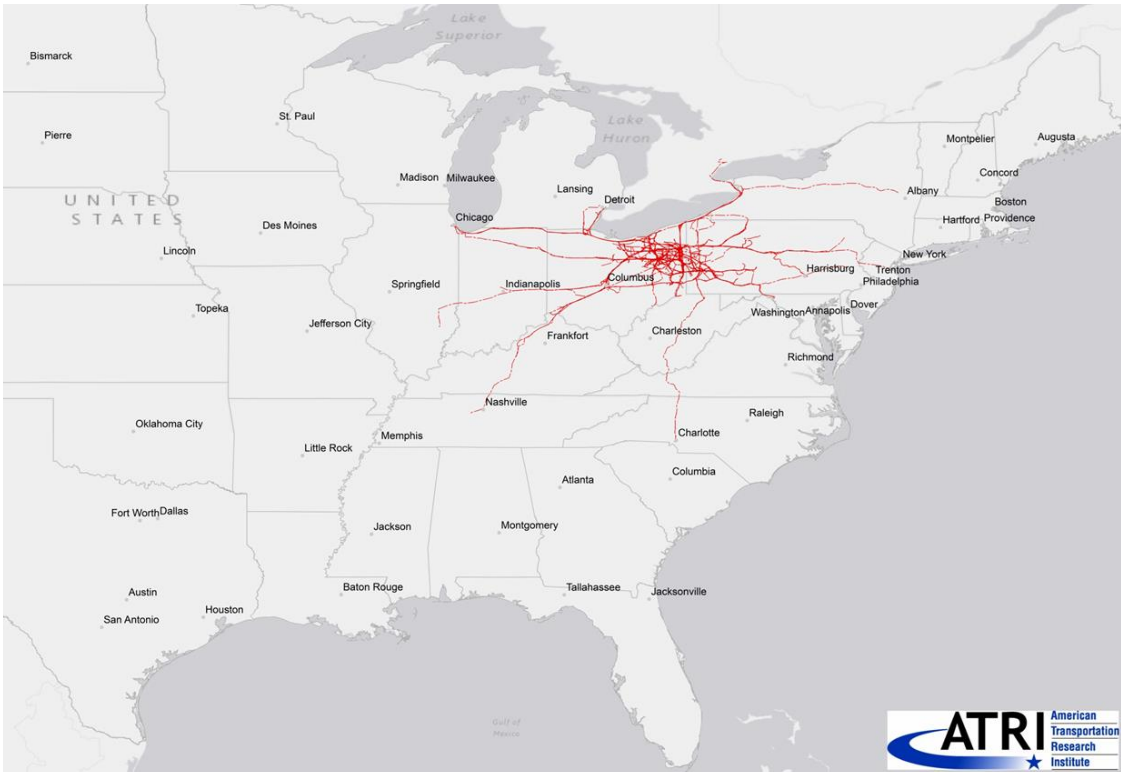


FIGURE 43 TRUCKS USING THE US 30 CORRIDOR – AFTER 2 DAYS

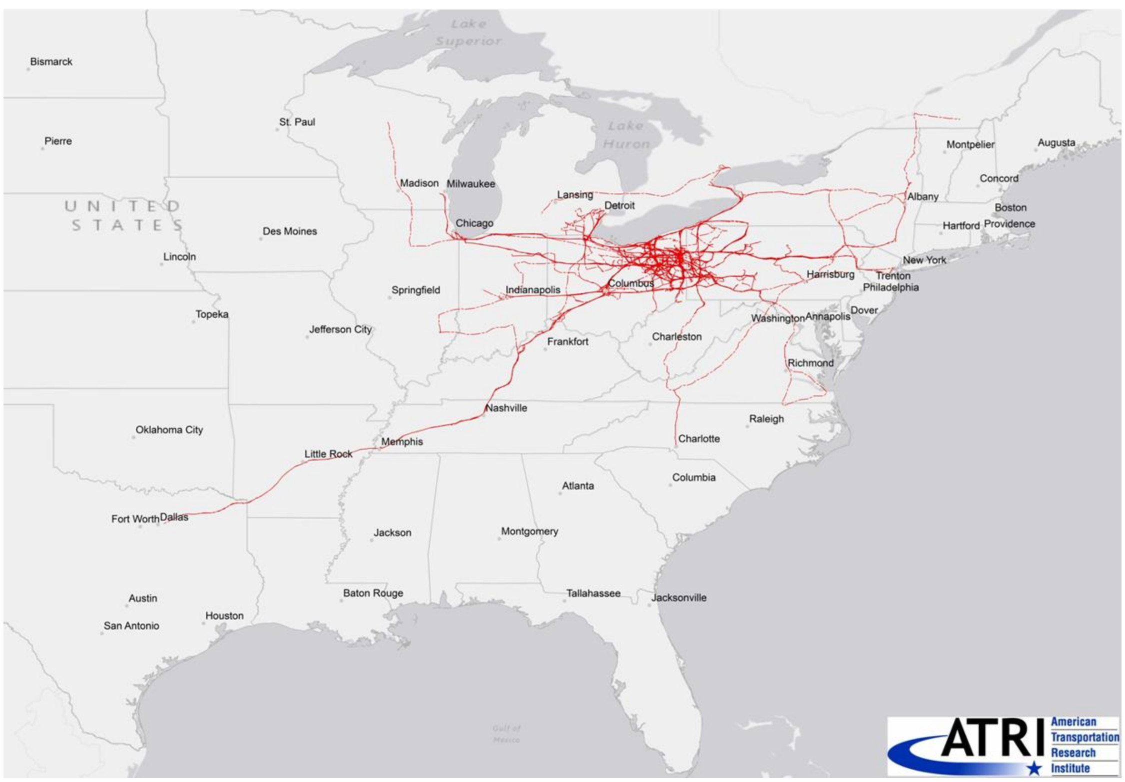


FIGURE 44 TRUCKS USING THE US 30 CORRIDOR – AFTER 3 DAYS

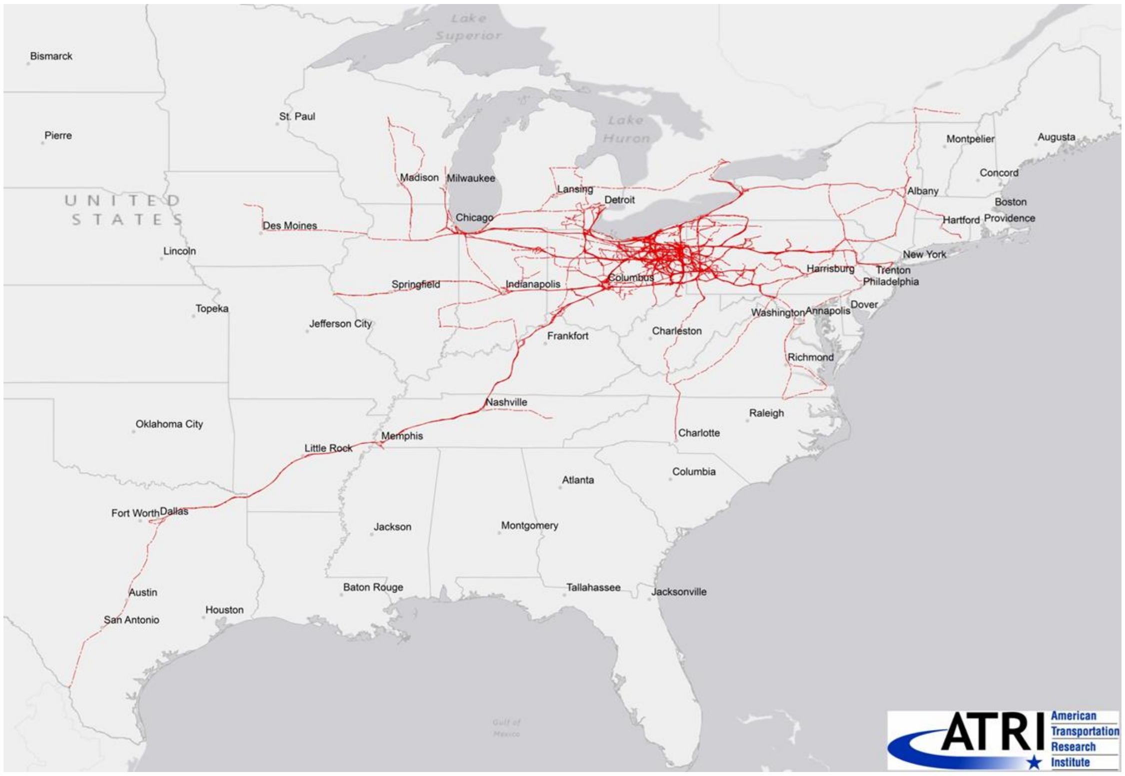


FIGURE 45 TRUCKS USING THE US 30 CORRIDOR – AFTER 5 DAYS

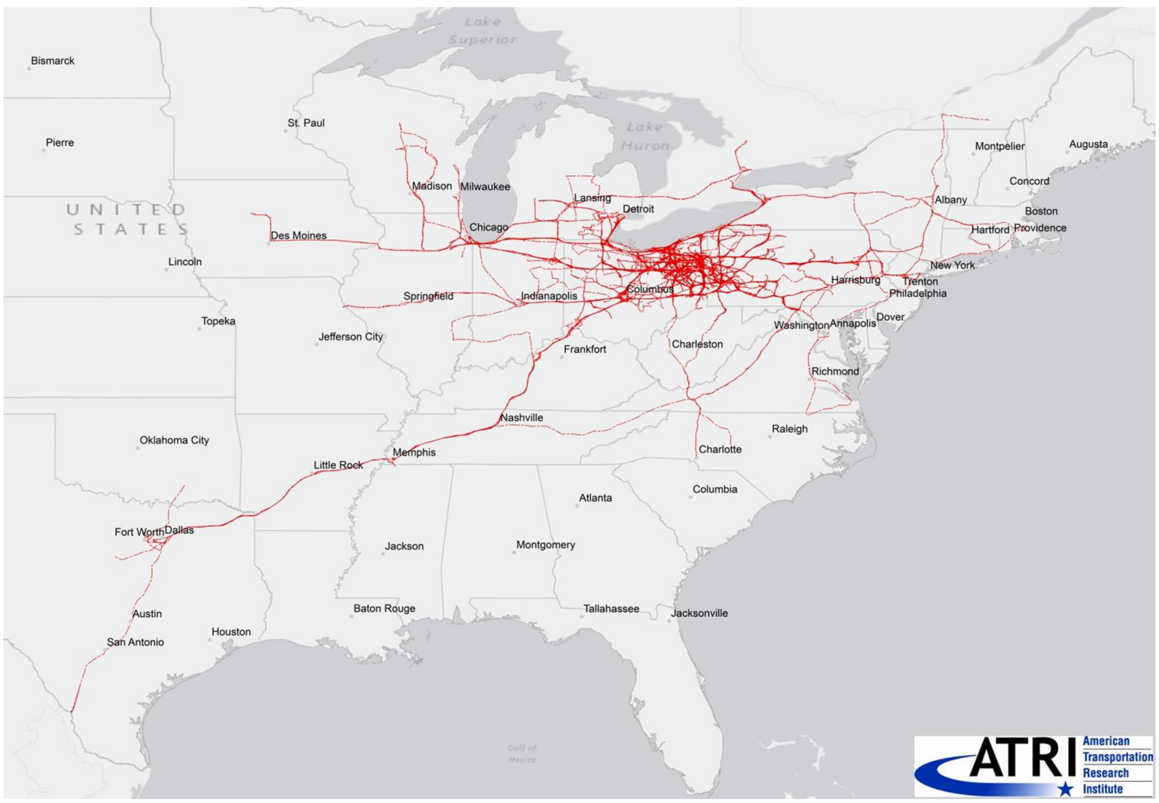


FIGURE 46 TRUCKS USING THE US 30 CORRIDOR – AFTER 7 DAYS

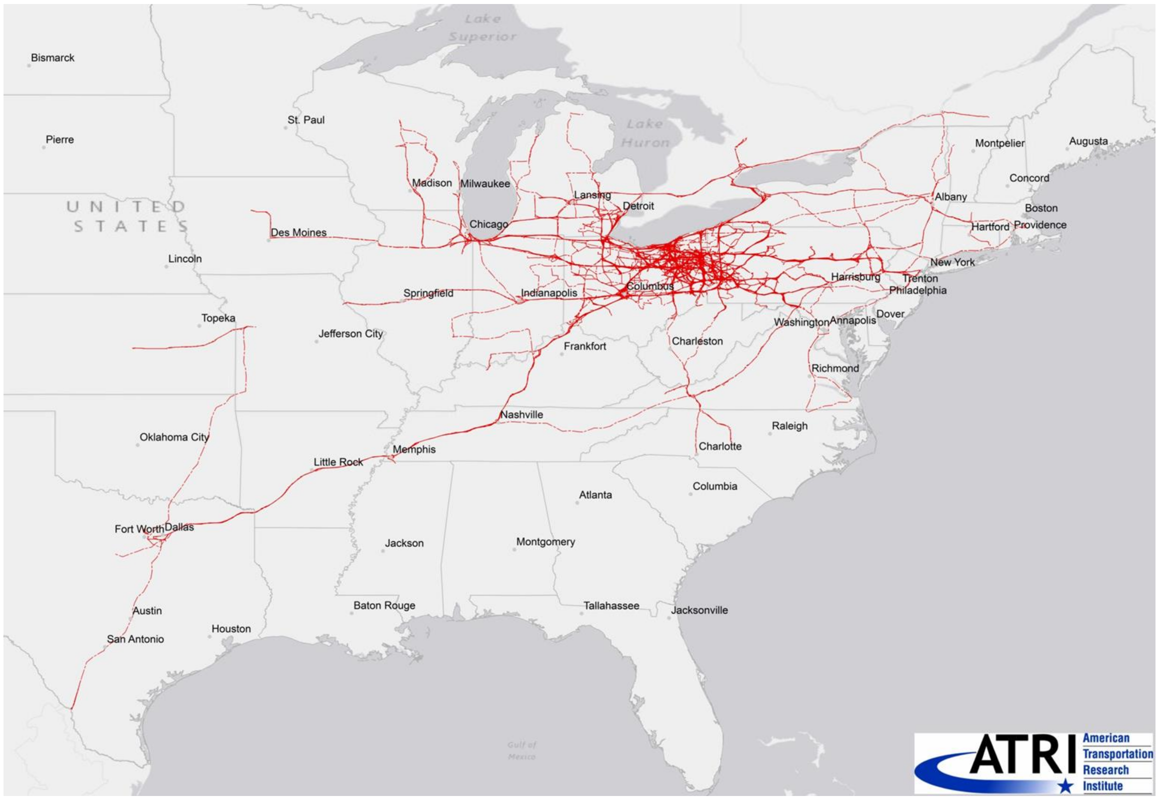


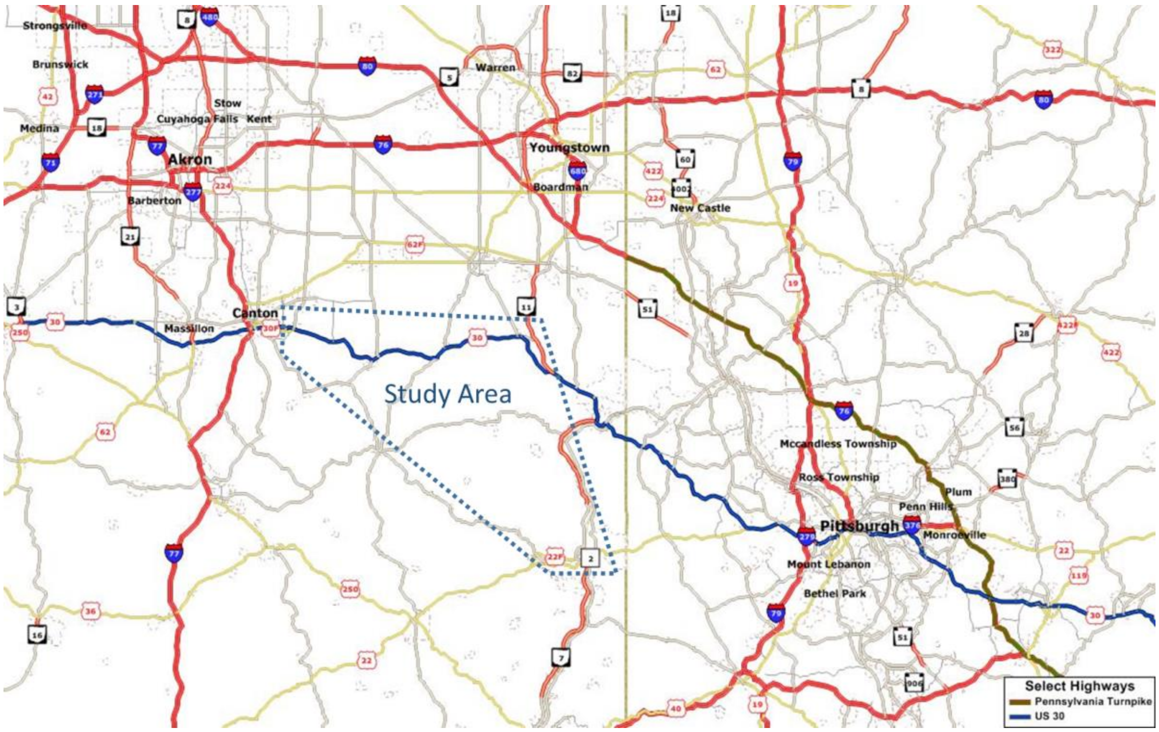
Figure 41 through Figure 46 illustrate the power of the data, tracking trucks that used the existing US 30 (including SR 172) between Lisbon and East Canton for one week. This simple analysis demonstrates the significance of even the existing US 30 corridor. While the majority of the trucks traffic using US 30 is serving destinations the larger general corridor between Cleveland and Pittsburgh, existing US 30 truck traffic is interacting with Canada and Mexico.

The final dataset truck GPS dataset expanded through matrix estimation from truck counts is used as a pivot point for truck forecasting. In other words, predicted growth and changes in truck traffic from the Ohio Statewide Model (OSM) are applied to the observed truck origin-destination patterns in the ATRI data. This process should produce a more accurate forecast than the OSM could achieve alone in the absence of this data.

5.0 PENNSYLVANIA TURNPIKE TOLL RATE ANALYSIS

The Pennsylvania Turnpike parallels a long section of US 30 immediately to the east of the study area (See) and both facilities could potentially serve similar long distance demand between Pittsburgh and points east and Canton, Akron, and ultimately Cleveland.

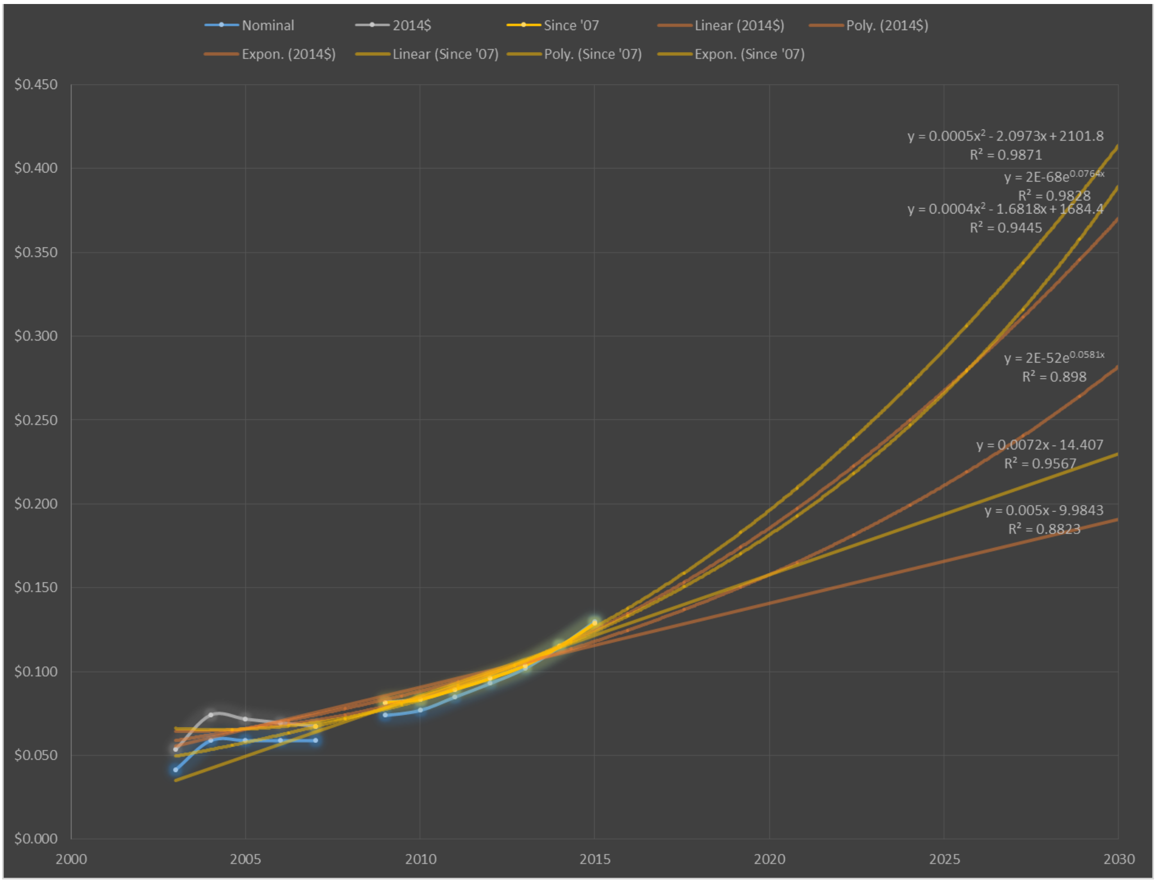
FIGURE 47: PENNSYLVANIA TURNPIKE IN RELATION TO US 30



For this reason, one of the key determinates of ultimate traffic on an improved US 30 corridor will be the toll rate on the Pennsylvania Turnpike. Depending on the toll, a new freeway facility in the US 30 corridor could attract travelers wishing to avoid tolls on the turnpike. For this reason, toll rates on the turnpike were studied to produce a range of estimates of likely future toll rates.

Although previously turnpike tolls had remained fairly constant for many years, since 2004, passenger car toll rates have increased from $0.04/mile to $0.13/mile. Rates for trucks have increased by the same margin. Rates have increased even more dramatically for travelers without an E-ZPass. This represents a staggering, over 240% increase in 11 years or an average annual (compound) escalation of over 8%, even after adjusting for inflation. Since enabling state legislation (Act 44) in 2009, the turnpike has increased toll rates every year.

FIGURE 48 PENNSYLVANIA TURNPIKE TOLL RATES PER MILE, HISTORIC AND FORECAST



Traffic counts reveal that truck traffic has declined on the western portion of the turnpike from 2008 to 2012 from 3% to 14%, varying by segment. Some of this decrease may be attributable to the economic downturn, but there is anecdotal evidence of trucks using local routes to avoid the turnpike tolls. It is likely that at least some of the recent decrease in truck traffic on the turnpike is due to toll diversion, and more diversion should be anticipated if tolls increase.

Moreover, it is reasonable to assume that the turnpike toll rates will continue to increase for at least some time into the future. An analysis of historic toll rates shown in Figure 48 produced a range of likely future tolls. Exponential or polynomial growth curves best fit the historic trend and would predict toll rates as high $0.40/mi by 2030. However, it does seem easy to question whether this trend is sustainable and whether such high tolls would be accepted by the public. On the other hand, it seems highly unlikely that the turnpike will suddenly stop raising toll rates after more than a decade of consistent hikes.

Ultimately, for the purposes of the US 30 analysis, recognizing the uncertainty in future turnpike toll rates as in future economic growth, three toll rates were carried forward for scenario forecasting. A passenger car toll rate of $0.15/mi (in constant 2014 dollars) was assumed for a very conservative assumption to be used together with the low growth scenario. A mid-range forecast rate of $0.23/mi based on linear growth was used together with the medium growth scenario to represent a reasonable mid-range forecast, and a rate of $0.36/mi was used together with the high growth scenario to represent a higher, but still plausible forecast. For all scenarios, toll rates for trucks were assumed to escalate at the same rate as passenger cars.

Results of the traffic forecasts do suggest that higher toll rates on the Pennsylvania Turnpike would divert some traffic to an improved US 30 facility in the medium and high growth scenarios. However, the traffic forecasting results suggest that this diversion would actually be fairly limited as free routes using I-79 would still remain slightly faster than an improved US 30 alternative in Ohio. All forecasts assume no improvements to US in Pennsylvania. If improvements were also made to US 30 in Pennsylvania, then the long distance diversion from the turnpike to the US 30 corridor would likely be much greater.

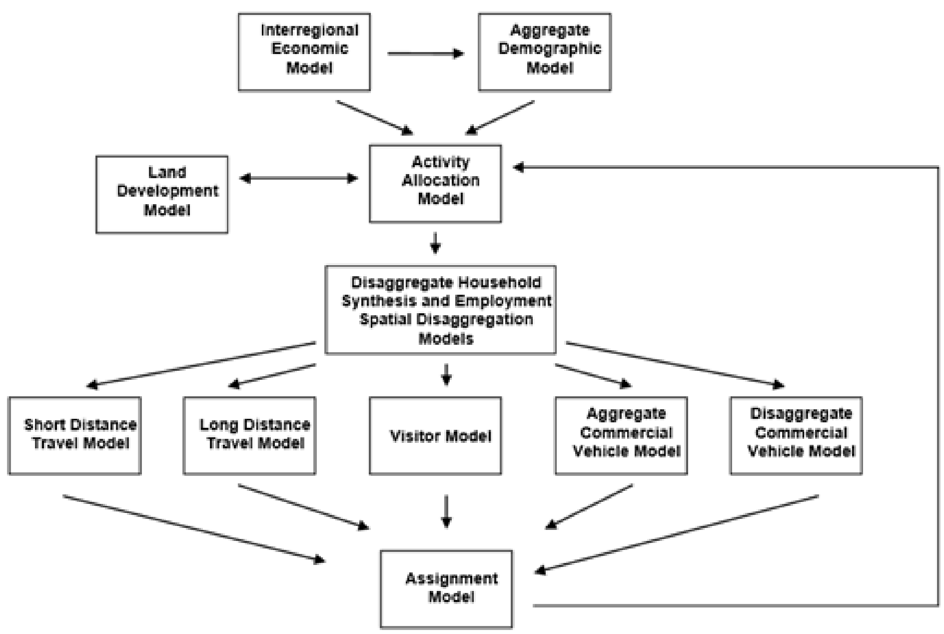
6.0 TRAVEL DEMAND FORECASTING

To ensure the utmost defensibility of forecasts, ODOT models and procedures have been used as much as possible. ODOT's statewide model and its Focus model tool have been the primary tools for forecasting. The US 30 Feasibility Study's traffic forecasts fall in the category of Class 3, Refined Alternative Level Traffic, according to ODOT's Guidelines for the Use of Models for Project Traffic Forecasting appropriate for large, complex Path 4 and 5 projects as defined in ODOT's Project Development Process Manual in coordination with ODOT's Modeling and Forecasting Unit in the Division of Planning under the assumption that US 30 would be a Path 4 project. ODOT's Guidelines for the Use of Models for Project Traffic Forecasting describes this level of traffic forecasting in the following way:

> "Refined alternative level traffic only occurs in certain rare cases where additional model work beyond the TDF model has occurred for certain types of projects. This model work typically involves using matrix estimation techniques (other techniques are possible as well) to refine travel demand to more precisely match study area traffic counts so that the results are accurate enough for use in operational level traffic models. Since this is extremely labor intensive, this level of traffic is generally only produced for very complex model projects… This traffic is suitable for making more detailed decisions on alternatives in a Feasibility Study…"

The current modeling effort has made use of matrix estimation techniques for trucks using the ATRI truck GPS data, but not for passenger cars, although that might still be considered to support more detailed alternatives analysis.

FIGURE 49 CONCEPTUAL DIAGRAM OF THE MAJOR COMPONENTS OF THE OHIO STATEWIDE MODEL



6.1 | MODEL FRAMEWORK

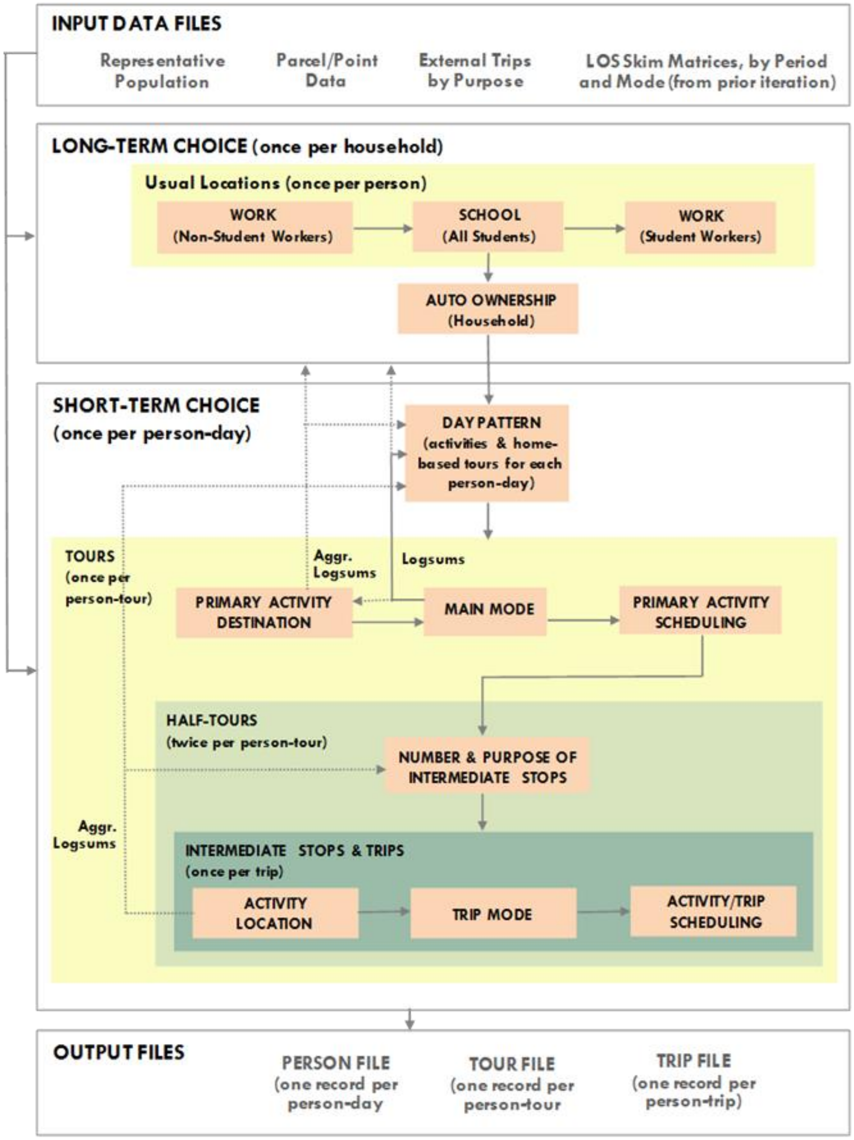
The changes in traffic are still fundamentally derived from those of ODOT's Ohio Statewide Model (OSM). The OSM is an integrated travel, economic and land use forecasting system designed to support transportation planning and analysis in the state, particularly in areas not fully or adequately covered by MPO models as is the case for the US 30 corridor. The conceptual diagram of the whole model is shown in Figure 49.

Referring to Figure 49, the interregional economic model, the aggregate demographic model, the activity allocation model and land development components are all being partially overridden based on the economic analysis presented earlier in this report since the statewide model does not 'see' or 'understand' the development of unconventional oil and gas extraction or its impact in eastern Ohio. Specifically, the outputs of the SEAM component are being overwritten with the forecast new jobs and a distribution of households that accounts for the increased earnings and labor force participation rate and decreased unemployment predicted.

The Short Distance Travel Model, Long Distance Travel Model and Visitor Model are all being run unaltered from their standard OSM form. The Aggregate Commercial Vehicle Model of long haul freight and the Disaggregate Commercial Vehicle Model of short-haul trucks are also both being run unaltered, but their results are being applied to pivot off of a base year truck matrix estimated from ATRI truck GPS data and observed truck counts. The seven-class or "economic" assignment option is being used in order to allow subsequent economic analysis with the benefit cost and economic impact modules (not depicted in the figure).

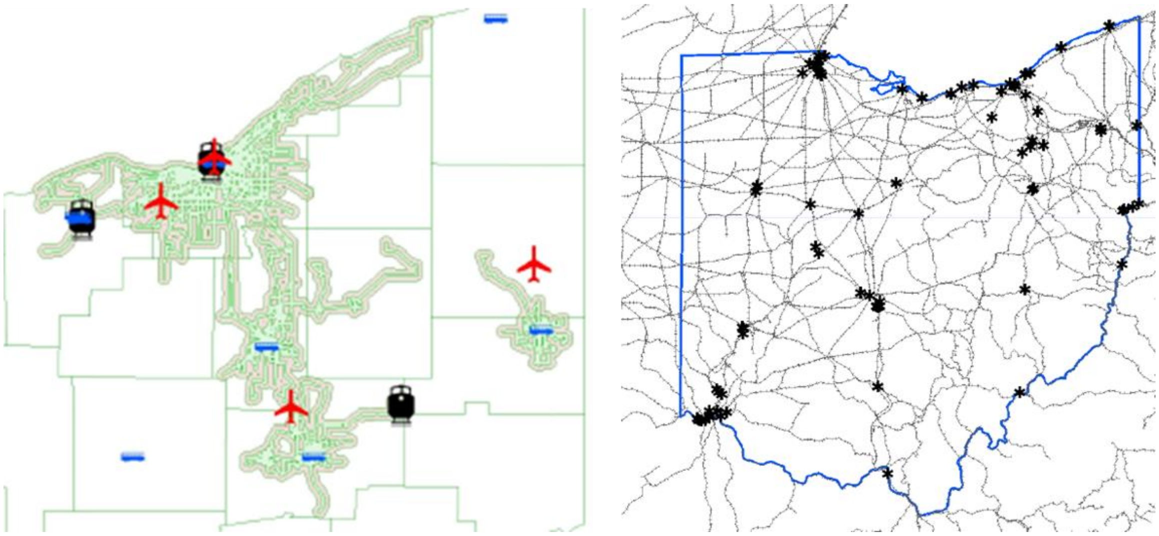
The passenger components of the OSM constitute a state-of-the-art activity-based travel model. See Figure 50. The model begins by creating a synthetic population of households, individuals, hotel rooms and occupants and produces synthetic diaries of each of their day detailing where they went and when as well as how they got there and who they went with just as if the entire population had been surveyed on a typical day. The model is thus fully disaggregate, representing each individual traveler in the entire state and every travel-related decision they make throughout a day or even in longer time frames. The model starts with long term choices such as where people live, work and go to school. Next the model simulates the overall pattern for each person's day (whether they go to work, go shopping, etc.). Then the model simulates each tour or round-trip from home determining the primary destination, whether a car is taken and whether other stops are made on the way to/from the primary destination. The model then determines each trip in the tour including its location, mode and timing. Finally, the trips are routed over the network. Except for the final routing, the component models are mostly loosely nested logit discrete choice models realized by Monte Carlo simulation.

FIGURE 50 GENERAL SCHEME OF AN ACTIVITY-BASED MODEL SIMILAR TO THE OHIO STATEWIDE MODEL'S PASSENGER COMPONENTS



The OSM is intermodal in nature. The model includes representation of transit lines, airports and intercity rail and bus stations for passenger travel in addition to its highway network. (See Figure 51.) The model also represents freight, with detailed representation of rail and intermodal rail/truck facilities in addition to simple truck freight over the highway network.

FIGURE 51 TRANSIT LINES, AIRPORTS, BUS AND RAIL STATIONS AND FREIGHT RAIL AND INTERMODAL FACILITY NETWORK IN THE OSM



Truck trips are modeled in two stages in the OSM. First, commodity flows by all freight modes are modeled by disaggregating the FHWA's Freight Analysis Framework (FAF) data. The portion of these freight flows carried by trucks is estimated and the tonnage converted to long haul truck trips. Short haul / distribution truck trips are then produced using a set of disaggregate simulation models (similar to the passenger models) based on commercial vehicle surveys.

The OSM is limited in its geographic detail by the computational implications of matrix math. The model's roughly 5,000 zones translate into roughly 25,000,000 cell matrices of trips from origin zone to destination zone. At this resolution, a single 5-year time step of the model runs for more than half a day on ODOT's dedicated, high end servers. For this reason, the Focus tool was created to allow more detailed analysis of individual corridors by just adding resolution in the study area. ODOT maintains a more detailed network covering much of the state and a default zone system, but these are rough outside MPO areas and can require considerable refinement. A new detailed zone system was developed for US 30 study area and the detailed network was refined and enhanced. The focus area zones and network are shown in Figure 52 and Figure 53, respectively.

The existing or standard focus tool for the OSM was developed during the same period of time as the economic analysis tools and unfortunately as a result was not compatible with them, supporting only the OSM's original two-class assignment option. Therefore, to support the use of the economic analysis tools with the focusing tool for US 30, several changes had to be made to the focusing tool most notably including the number of vehicle classes assigned from the original two (autos, trucks) to the seven classes for economic analysis (low income autos, medium income autos, high income autos, commercial service autos, commercial freight autos, single unit trucks and multi-unit trucks).

FIGURE 52 US 30 FOCUS AREA ZONES

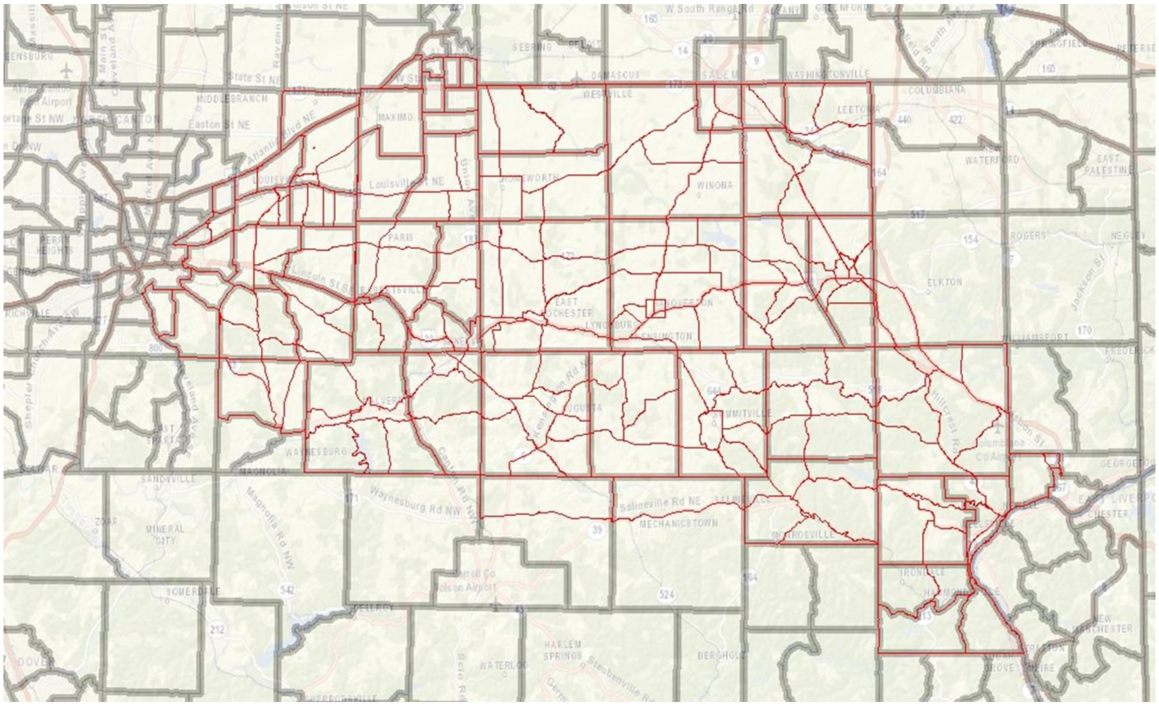
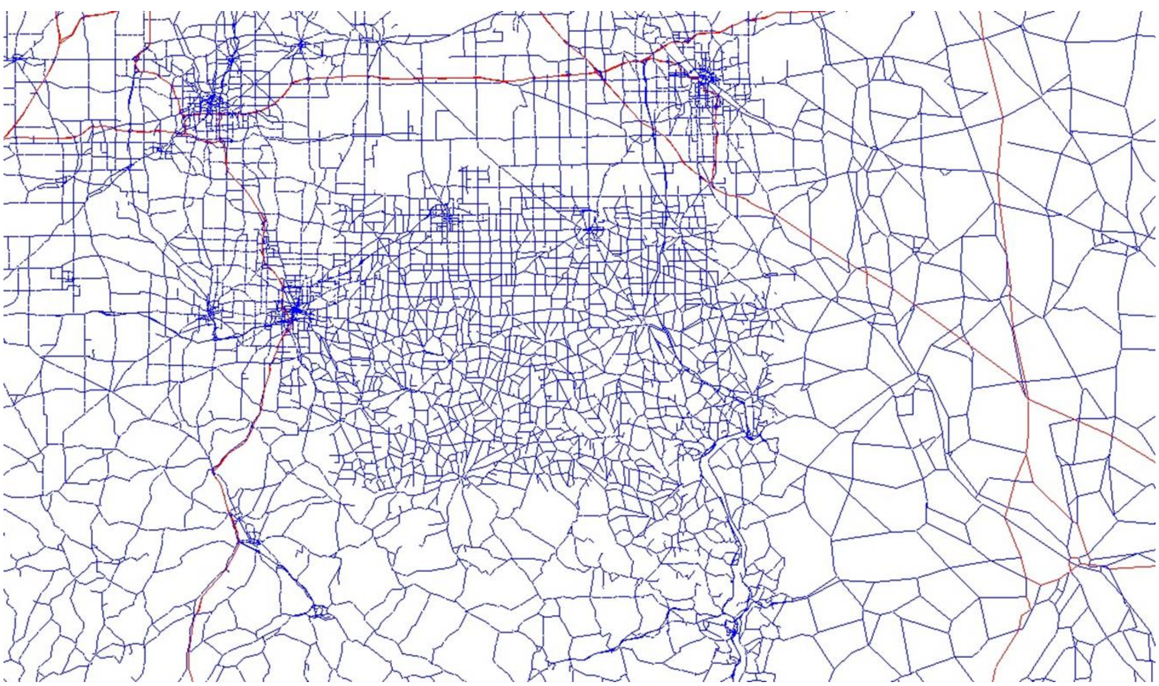


FIGURE 53 US 30 FOCUS AREA NETWORK



6.2 | MODEL CALIBRATION

The model was validated against commute flow data, travel time data and online routing information as well as traffic counts. Commute flows predicted by the model were compared to data from the Census Transportation Planning Package (CTPP) and Longitudinal Household-Employment Dynamics (LEHD). Both of these Census data products were combined to produce a county-level target commute flow matrix and the model was calibrated by adjusting the seed matrix in SEAM to provide a reasonable match to these patterns. Figure 54 shows both target flows in black and model flows in orange.

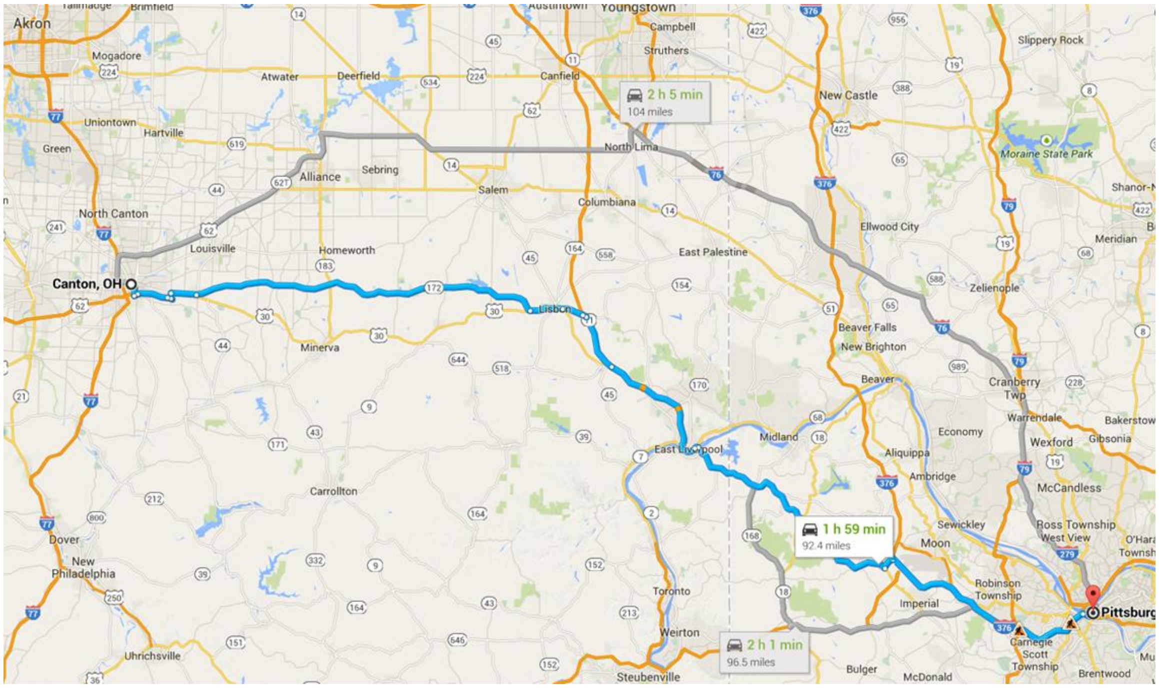
FIGURE 54 COMMUTE FLOW CALIBRATION

County	Carroll	Columbiana	Hancock	Harrison	Jefferson	Mahoning	Stark	Tuscarawas	Total
Carroll County, OH	3,946 3,711	359 317	12 1	141 124	202 198	119 0	4,415 3,726	975 868	**10,168 8,944**
Columbiana County, OH	334 314	21,321 18,844	1,774 1,635	36 0	865 876	7,135 5,982	3,247 2,758	105 0	**34,816 30,409**
Hancock County, WV	17 0	506 457	5,114 4,798	23 0	977 963	61 0	21 0	29 0	**6,747 6,219**
Harrison County, OH	154 155	38 5	52 19	2,171 2,040	925 937	29 0	341 2	999 951	**4,708 4,109**
Jefferson County, OH	194 194	481 444	1,115 1,069	369 345	15,495 15,237	150 0	245 0	134 0	**18,181 17,288**
Mahoning County, OH	36 35	3,645 3,669	65 3	14 0	148 8	63,830 61,846	2,672 2,604	124 0	**70,531 68,166**
Stark County, OH	872 904	1,154 1,124	8 0	31 0	228 31	1,900 1,763	112,854 105,897	2,342 2,311	**119,387 112,031**
Tuscarawas County, OH	267 246	86 1	13 0	266 229	148 2	155 0	6,086 5,039	25,369 22,122	**32,389 27,640**
Total	**5,818 5,559**	**27,589 24,860**	**8,152 7,526**	**3,050 2,738**	**18,986 18,252**	**73,377 69,592**	**129,879 120,026**	**30,076 26,251**	**296,926 274,805**

Model travel times and routing were compared both to INRIX (GPS/cell-phone based) commercial travel time data and to freely available online routing and travel time information. Almost all modeled speeds where within 5 mph of INRIX but a few were between 5-10 mph off. In general, the OSM runs just a couple miles an hour faster than observed INRIX speeds. However, adjustments had to be made to SR-172 and US 62 to increase their speeds to agree more closely with the speeds observed from INRIX. Modeled travel times between major origins and destinations were within 5 minutes of Google and other online estimates.

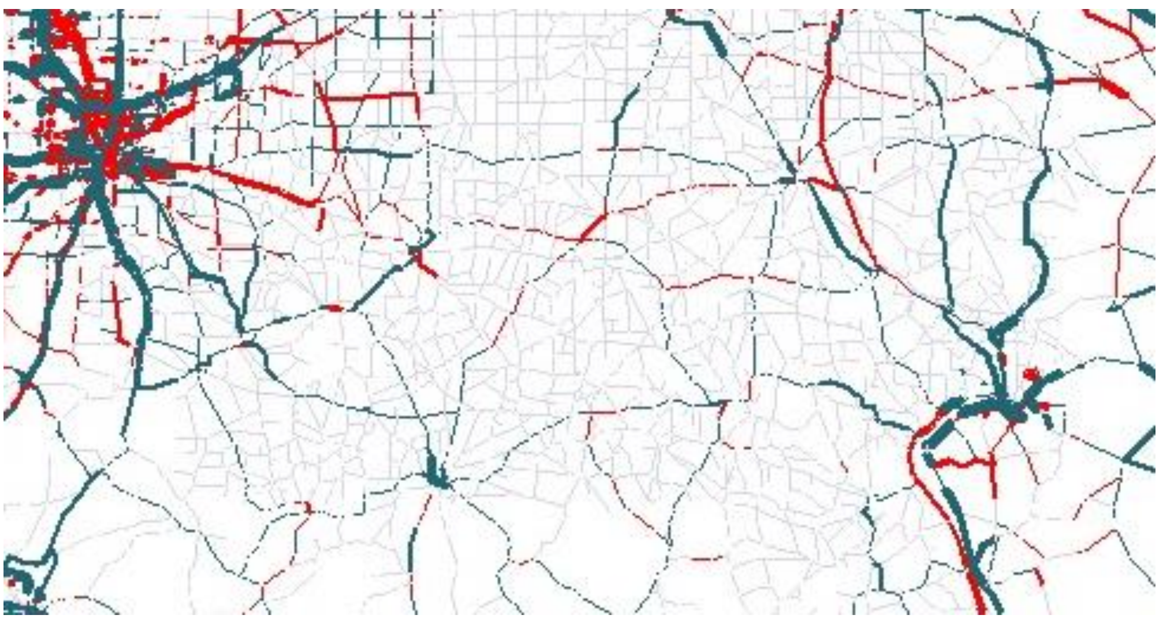
Both online mapping and local anecdotes agree with the model that multiple routes are used through the corridor and for longer distance trips such as between Canton and Pittsburgh (see Figure 55). There is no dominant route in the corridor and some travelers detour to avoid US 30 while others do not. Online routing is similarly variable with Google and other services recommending significantly different routes depending on precise origin and destination locations. Similarly, in the model, different assignment classes showed different routing.

FIGURE 55 EXAMPLE OF ONLINE TRAVEL TIMES AND ROUTING USED FOR CALIBRATION



Modeled traffic volumes were also validated against traffic counts throughout the study area but with a particular focus on US 30 and SR 172. Following calibration, both the statewide and Focus model assignment error was less than 5% for US 30 and SR 172 and remaining errors appeared random in nature and not critical to the analysis (see Figure 56).

FIGURE 56 MODEL NETWORK WITH LOADING ERRORS SHOWING PATTERN OF RANDOM ERRORS

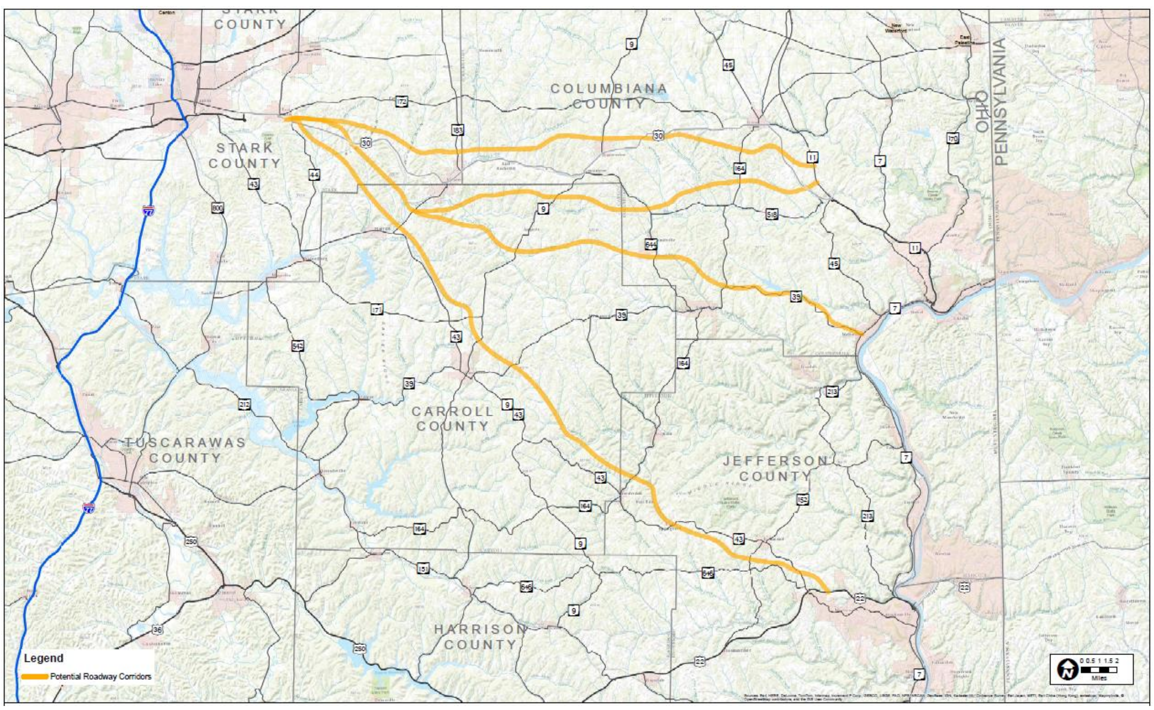


6.3 | ALTERNATIVE ALIGNMENTS

A US 30 Implementation Study and a Major Investment Study (MIS) were completed in the 1990's as support documents for a new alignment for US 30 from Trump Avenue in Canton to SR 11 in Lisbon, Ohio. Subsequently, a DRAFT Environmental Impact Statement (EIS) was prepared in 2003. Ten (10) initial alignment alternatives were developed in 1995 as part of the preliminary engineering study and EIS. Two (2) alignments moved forward for further consideration based on an evaluation of cost vs benefits and public input, one alignment to the north of existing Route 30 and one alignment to the south of Route 30. These alignments remained as the alternatives selected for further analysis in determining a Preferred Alignment and a preferred alternative was not selected and approved when the study was halted in 2006. As an added note, a first section of US 30 from Trump Avenue to SR 44 in Canton is currently under design. This study is evaluating alternative alignment options for the existing US 30 corridor from SR 44 east to SR 11.

The two alignments which were identified in the 2003 EIS as moving forward for consideration were chosen as the starting point for alignment evaluation as part of this study. These two alignments are shown as Alignment 1 and Alignment 2 on Figure 57.

FIGURE 57 ALTERNATIVE ALIGNMENTS



Alignment 1 parallels existing US 30 on a northerly alignment, passing just north of Hanoverton and Kensington where development has been projected due to the oil/gas extraction and due to the Spectra gas pipeline planned alignment. This alignment also provides connections from Salem, Leetonia which has been identified for future development in particular due to the Columbiana Port Authority property and allows for connection to the development projected along the Route 11 corridor north and south of Lisbon.

Alignment 2 parallels US 30 to the south of the existing route, allowing for connections just north of Malvern and the development planned along the SR 43 corridor by Carroll County between Malvern and Carrollton.

Alignment 3, also shown on Figure 57, was chosen as a more southerly alignment through both Columbiana and Carroll Counties based on input on existing and projected development patterns due to development in the area between Malvern and Carrollton along the Route 42 corridor and to freight and barge traffic along the Ohio River at Wellsville and East Liverpool. This alignment provides a connection across the Ohio River to gas/oil development in Pennsylvania and to Pittsburgh via the nearby SR 39/US 30 interchange and bridge over the Ohio River.

A fourth alignment is shown connecting East Canton south through Columbiana, Carroll and Jefferson Counties to connect with US 22 just east of Steubenville. This is a lengthier, more costly alignment and does not necessarily track the existing US 30 corridor, but it is being examined to answer questions on travel demand from destinations to the west, along existing interstates such as Akron, Cleveland, Toledo, south to the Ohio River and east to Pittsburgh via US 22, an existing four lane divided, freeway corridor.

FIGURE 58 PRELIMINARY ESTIMATED PROJECT COSTS BY ALIGNMENT

Alignment	Estimated Cost
Alignment 1 (30.95 Miles):	$783,800,000
Alignment 2 (old Alignment 5) (33.08 Miles):	$902,300,000
Alignment 3 (36.92 Miles):	$963,600,000
Alignment 4 (42.14 Miles):	$1,103,800,000

The costs for each of the alignments are shown in Figure 58. Costs for Alignment 1 and 2 were estimated in a previous study and simply updated to account for the inflation in producer prices. Preliminary estimates of the cost for Alignments 3 and 4 were produced by applying the cost per mile for Alignment 2 to the length of these new alignments. Since the number of interchanges is expected to be the same for Alignments 3 or 4 as for Alignment 2, this method should produce fairly liberal cost estimates for the new alignments, depending on the need for other structures, the costs for these new alignments may be slightly high. More detailed, engineering based cost estimates should be produced if the project is carried forward for further study.

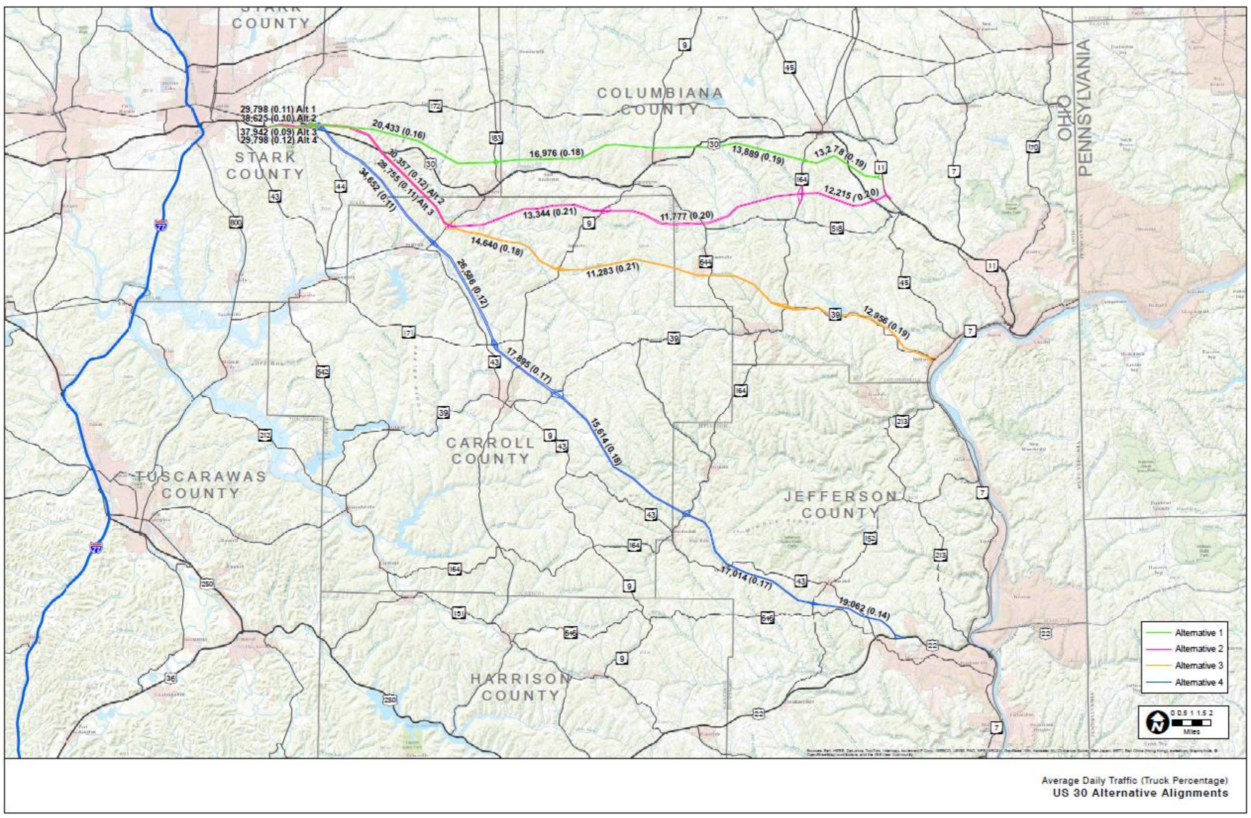
6.4 | TRAFFIC PROJECTIONS

Using the Ohio statewide model and making assignments in TransCAD in order to reach convergence and produce results that could support economic analysis, traffic was projected for the year 2030 for the NO BUILD condition - - existing two lane facility – and for the four alignment alternatives described in above. As described in Chapter 3, future growth was allocated in the focus area for a range of possible growth due to uncertainties in factors such as gas/oil prices. The medium growth scenario was run in the model to produce traffic projections under a likely, representative scenario. The Average Daily Traffic (ADT) results are shown in Figure 59. The maximum ADT in the future was, in all cases, at the western end of the corridor nearest Canton. The average ADT was calculated weighting by distance (i.e., dividing VMT on the whole facility by the road miles of the facility). The minimum ADT was generally nearer the eastern end of the corridor.

FIGURE 59 AVERAGE DAILY TRAFFIC (ADT) - PRESENT AND 2030 MEDIUM GROWTH SCENARIO

Medium Growth	Present ADT	2030 ADT				
		No Build	Alignment 1 (31 miles)	Alignment 2 (33 miles)	Alignment 3 (37 miles)	Alignment 4 (42 miles)
Maximum	7,850	13,463	20,431	30,357	25,537	34,652
Average	5,053	7,176	16,768	18,496	15,575	22,098
Minimum	3,040	3,513	13,278	11,775	8,911	15,614

FIGURE 60 AVERAGE DAILY TRAFFIC (ADT) AND TRUCK PERCENTAGE BY SEGMENT



The ADT's and truck percentages (in parenthesis) for each segment of each alternative alignment are shown in Figure 60 for comparison purposes.

The ADT by 2030 for the US 30 No Build condition under the Medium Growth assumption shows an increase in traffic due to the area growth but still does not show an issue with congestion. This is largely attributable to the dispersion of the traffic growth across the many rural roads in the network in the areas of growth. The existing US 30 facility is not significantly more attractive than more direct local routes in many cases (as well as SR 172 which also absorbs growth), so while there is notable growth in VMT in the area, the growth on the existing US 30 facility is only modest.

Somewhat in contrast, the new, higher speed, four lane alignments draw trips from many competing facilities and as a result all carry significantly more than the existing US 30 would. Even the lowest performing alignment (3) carries more than double the traffic that US 30 would in the future and generally triple the traffic US 30 carries today. The most utilized alignment (4) in the Medium Growth scenario would carry more than four times as much traffic as US 30 does today; it would carry notably more under higher growth assumptions. The ADT numbers are in the majority above the capacity for a two-lane facility and in that sense show justification for a four-lane facility.

Alignment 4 attracts the most traffic, serving commuting to Carroll County's growing job base from both Steubenville as well as Canton as well as longer trips between them and beyond. However, Alignment 4 is also the longest and most expensive alternative and would represent a significant re-routing of US 30. Alignment 2 remains more in the existing US 30 corridor and is one of the alignments actually carried forward from previous studies of US 30. With an average daily traffic volume of roughly 18,500 Alignment 2 carries more than 10,000 vehicles per day (vpd) more than the existing US 30 facility either today or in the future. Both Alignments 2 and 4 are predicted to carry similar volumes to I-77 south of New Philadelphia (presently and in the future).

Overall or on average, Alignments 1 and 3 attract a similar amount of traffic, but the traffic they serve is somewhat different. Alignment 3 performs better in the western part of the corridor where it turns south toward Carroll County like Alignments 2 and 4, but carries comparatively less traffic at the eastern end of the corridor near Wellsville. In contrast, Alignment 1 performs worst of all alignments in the western part of the corridor since it is furthest north and serves the least number of commuters between Canton and Carroll County. However, it performs comparatively well on the eastern end of the corridor, with a higher minimum traffic than either Alignments 2 or 3.

Although there may not be horrible congestion in the future (assuming Medium Growth), there would be substantial demand for a new freeway corridor if it were provided. Figure 61 to Figure 64 show facilities with increased traffic in red and facilities with decreased traffic in blue. The pattern shows that an improved US 30 facility would draw traffic from a large number of facilities.

FIGURE 61: DIVERSION TO ALTERNATIVE 1

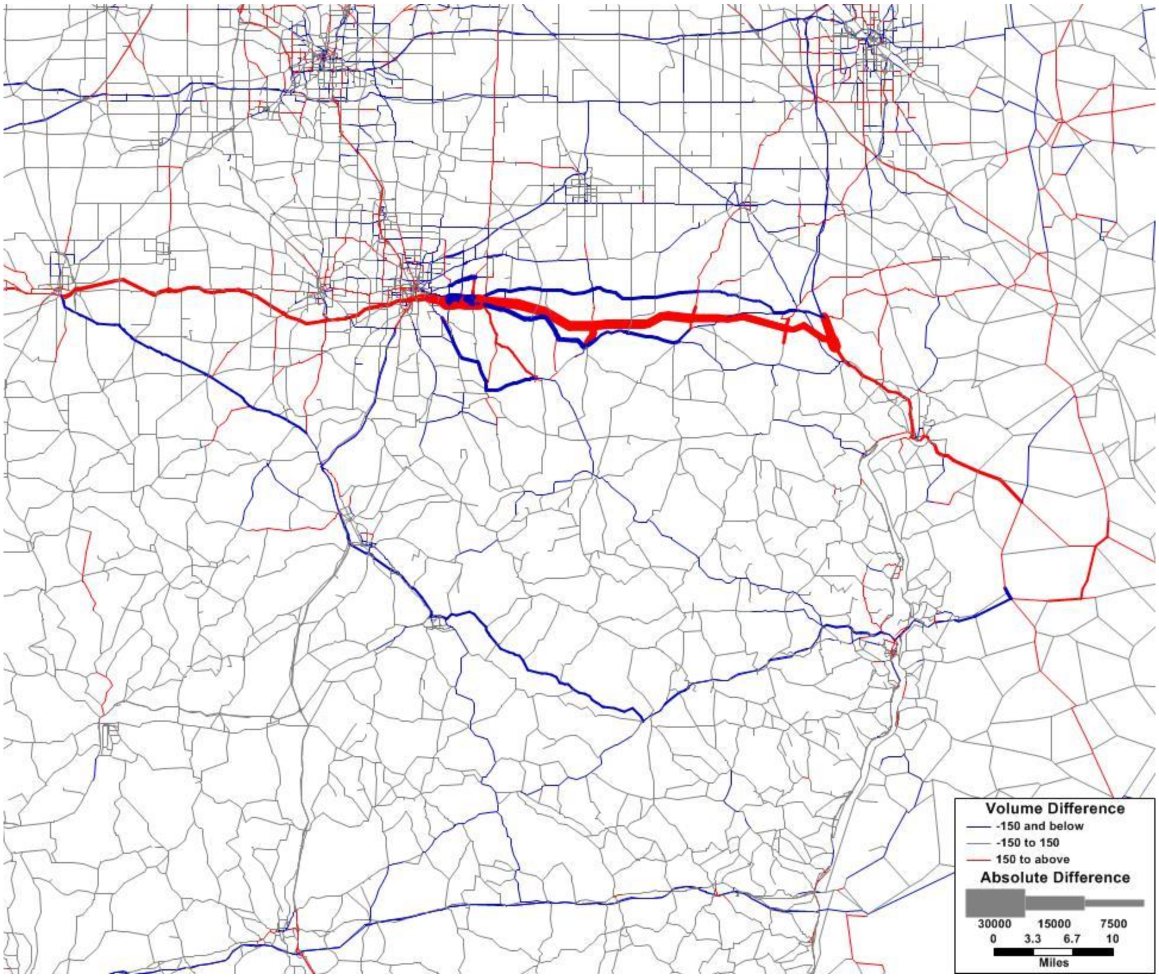


FIGURE 62: DIVERSION TO ALTERNATIVE 2

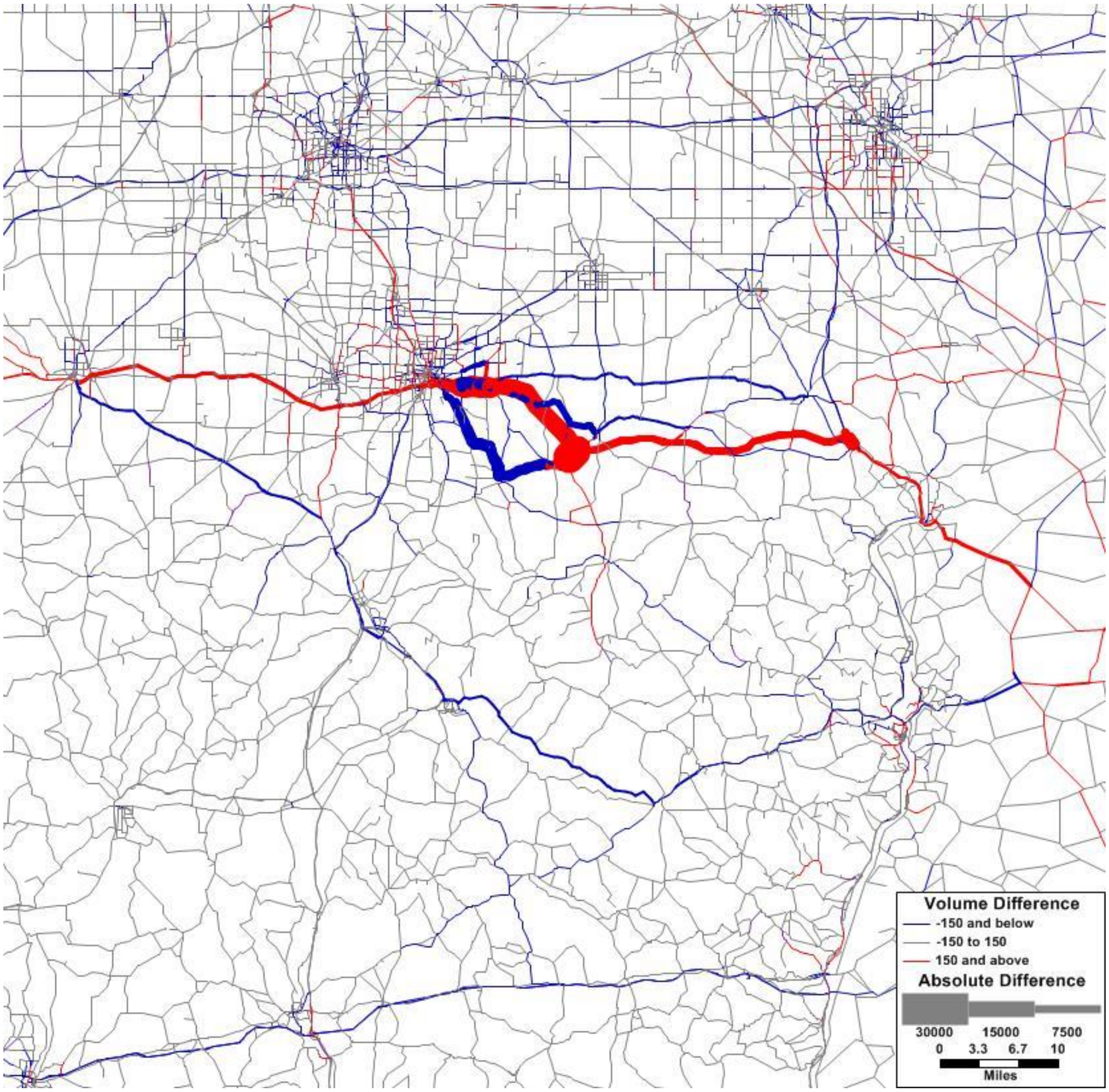


FIGURE 63: DIVERSION TO ALTERNATIVE 3

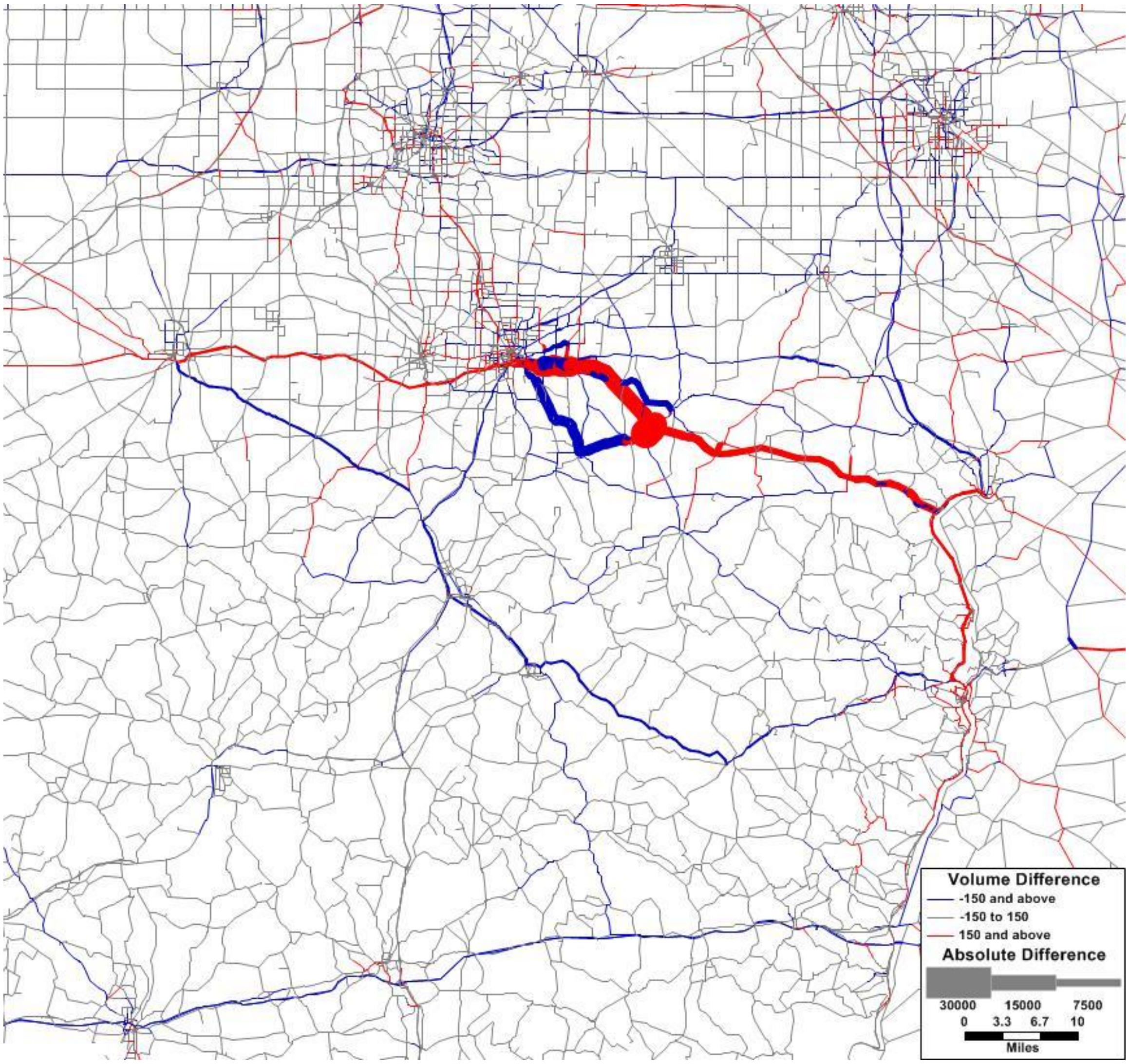
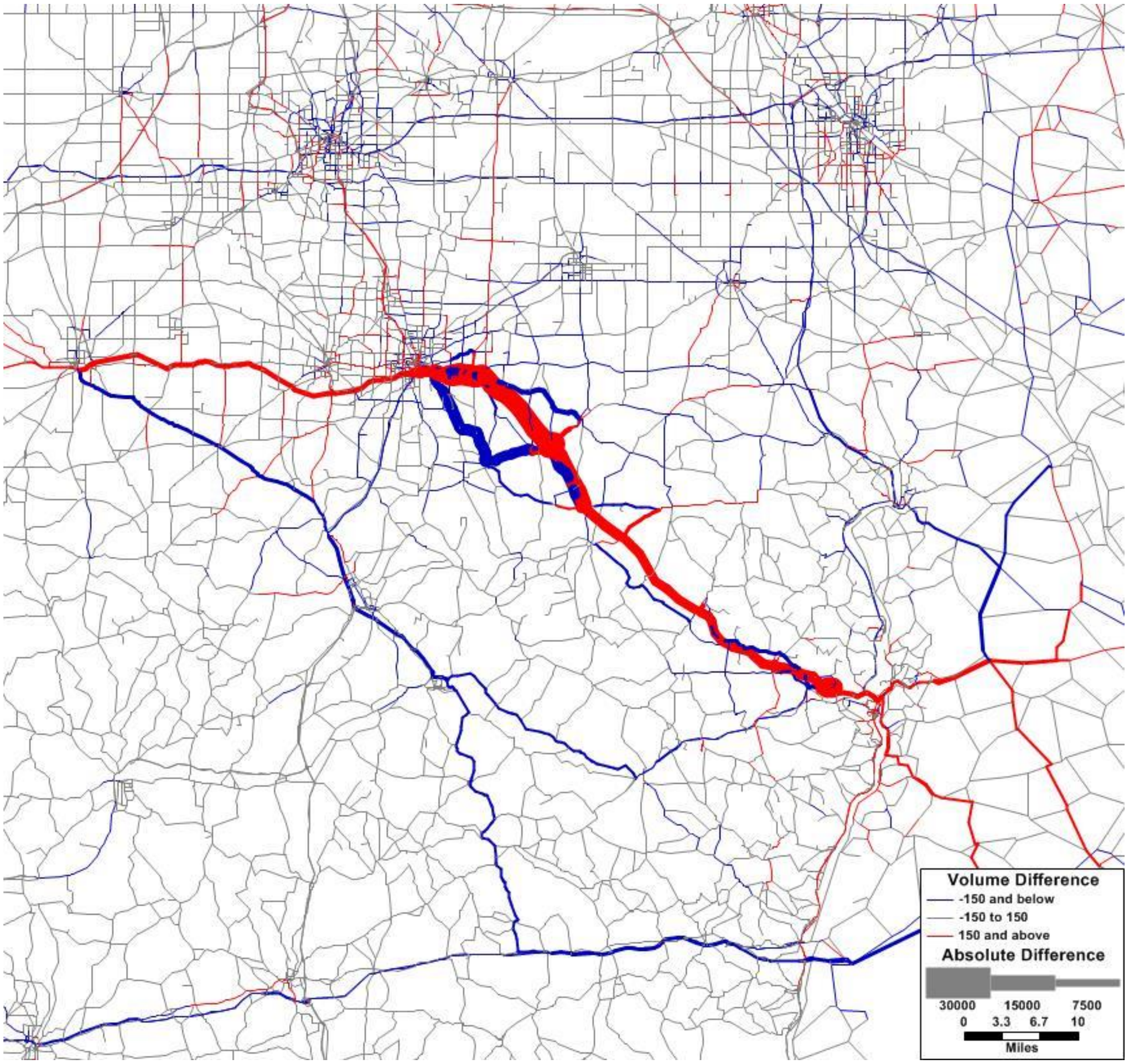


FIGURE 64: DIVERSION TO ALTERNATIVE 4



6.5 | TRAVEL TIME SAVINGS

All of the potential alignments would result in significant travel time savings, but different alignments would best serve different locations. Figure 65 shows predicted travel time savings in 2030, under the Medium Growth assumption, for each alignment for various origins and destinations.

Alignment 1 provides the biggest time savings for Lisbon and East Liverpool to Canton, saving 14 minutes between Canton and Lisbon and 19 minutes between Canton and East Liverpool. The 19 minutes saved between Canton and Lisbon is also saved for those who travel from Canton and continue on to the Pittsburgh Airport, making Alignment 1 the best for this trip as well. However, Alignment 1 provides the least benefit to Carrollton and other high growth areas in Carroll County saving only three minutes between Canton and Carrollton. For longer trips between Canton and Steubenville, Alignment 1 only saves 12 minutes.

Alignment 2 is not the fastest alternative for any of the trips represented, but it is something of a compromise, offering a more even distribution of benefits across a wider range of destinations. For instance, it saves 8 minutes between Canton and Carrollton (better than 3 minutes for Alignment 1 but not as good as 11 minutes for Alignment 4) and saves 9 minutes between Canton and Lisbon (better than 4 minutes for Alignment 4 but not as good as 14 minutes for Alignment 1). For trips between Canton and East Liverpool, Alignment 2 performs almost as well as Alignment 1, saving 18 minutes (as opposed to 19). It similarly does well connecting Canton with the Pittsburgh Airport, but only offers 11 minutes of savings between Steubenville and Carrollton.

FIGURE 65 TRAVEL TIMES BETWEEN SELECT ORIGINS AND DESTINATIONS

	Present	2030				
		No Build	Alignment 1	Alignment 2	Alignment 3	Alignment 4
Cleveland – Pittsburgh (toll)	136	141	141	141	141	141
Cleveland – Pittsburgh (free)	165	172	169	171	172	169
Canton – Carrolton	36	40	37	32	32	29
Canton – Lisbon	51	53	39	44	49	49
Canton – E. Liverpool	69	71	52	53	61	67
Canton – Wellsville	70	71	56	58	49	63
Canton – Pittsburgh Airport	96	98	79	81	89	84
Canton – Steubenville	85	89	77	78	67	60
Carrolton – Steubenville	50	51	51	51	51	38

Alignment 3 saves the most time (22 minutes) between Canton and Wellsville, but somewhat surprisingly still only saves 10 minutes between Canton and East Liverpool due to distance and delays between Wellsville and East Liverpool. These same delays make it save less to the Pittsburgh Airport as well. It offers only 4 minutes of savings between Canton and Lisbon.

Alignment 4 saves the most time (11 minutes) between Canton and Carrollton and between Canton and Steubenville (29 minutes) as well as between Carrollton and Steubenville (13 minutes). It is the only alignment to improve travel times between Steubenville and Carrollton. Given the high growth in Carroll County, this makes Alignment 4 the alternative with the highest demand. However, Alignment 4 saves the least time between Canton and Lisbon (4 minutes) or East Liverpool (4 minutes).

6.6 | HIGH GROWTH SCENARIO

Throughout the course of the development of the socioeconomic growth forecasts a range of scenarios was developed both to respect the real inherent uncertainty in future development of the region and to allow an understanding of the range of possible outcomes. Under ideal circumstances, traffic and user benefits might be forecast and examined for all the alternatives under the high, low and medium scenarios, but given the limited time and resources available for this study this was not possible. However, in addition to the Medium Growth forecasts, traffic was also forecast for both the No Build condition and for one representative alternative (Alignment 2) under the High Growth scenario to gain a fuller understanding of the potential need for the new highway, keeping in mind that the High Growth scenario was not designed to represent the maximum possible growth but rather a truly realistic but higher end possible growth scenario.

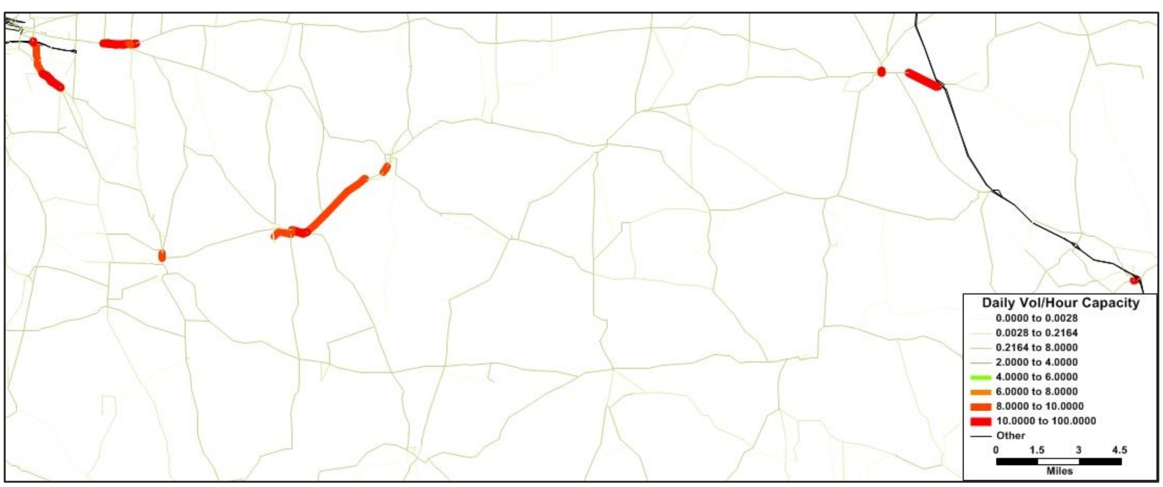
FIGURE 66 AVERAGE DAILY TRAFFIC UNDER HIGH VERSUS MEDIUM GROWTH

	Present ADT	2030 Medium Growth		2030 High Growth	
		No Build	Alignment 2	No Build	Alignment 2
Maximum	7,850	13,463	30,357	18,362	35,934
Average	5,053	7,176	18,496	9,564	20,169
Minimum	3,040	3,513	11,775	4,720	12,823

Figure 66 shows the range of volumes on the existing US 30 facility and potential Alignment 2 under both the Medium and High Growth scenarios. Two things are notable. First, while Alignment 2 carries more traffic in the High Growth scenario than the Medium Growth scenario, particularly in the western part of the corridor where volumes are highest, its overall average daily traffic across the corridor is only modestly higher. This suggests that its volumes are largely a function of diversion to the new facility and not overly sensitive or driven by the growth scenario. For this reason, it is reasonable to think that the low growth scenario traffic numbers would not be much lower than the medium growth and a four lane facility would be justified in that scenario, too, but an actual low growth model run may ultimately be desirable to confirm this.

Second, although there is relatively small change in the Alignment 2 numbers between the Medium and High Growth scenarios, there is a notable increase in the traffic on the existing US 30 facility in the No Build scenario. Although congestion does not appear to be a motivating issue based on the Medium Growth scenario, in the High Growth scenario congestion on the existing US 30 could be an important issue. Figure 67 shows locations with significant congestion in the High Growth, No Build scenario. Congestion is significant on US 30 on both ends of the corridor near East Canton and in Lisbon as well as on portions of SR 43, SR 154 and SR 183.

FIGURE 67 DAILY TRAFFIC CONGESTION IN THE CORRIDOR UNDER HIGH GROWTH, NO BUILD



7.0 BENEFIT-COST ANALYSIS

Benefit cost analysis was performed on Alignment 2, as a representative alternative, in order to demonstrate the feasibility of a US 30 upgrade on an economic basis. Ohio DOT's UCOST software for benefit cost analysis was applied to model results. For purposes of the benefit cost analysis, some conservative assumptions were made including that the project would begin construction in 2027 with construction over three years, opening to traffic 2030. While the project may well be constructed sooner than this, assuming later construction is more conservative as benefits are more deeply discounted. User cost savings were based only on 2030 and were not inflated into the future. This is another very conservative assumption; more realistically, it is likely that user costs would increase to some degree over time with further growth in the future.

FIGURE 68 USER COST SAVINGS IN 2030 FROM UCOST

User Cost Category	Savings
Time	$11,868,302
Reliability	$8,592,273
Work Zone Delays	$22,572,888
Crash Delays	-$5,496,104
Crash Costs	$26,613,930
Vehicle Operating Costs	$98,466,570

Analysis with ODOT's UCOST tool reveal annual user cost savings of over $160 million dollars in 2030 (before discounting, after accounting for increase in value of time per FHWA guidance). The largest benefit came from decreased vehicle operating costs primarily associated with better fuel efficiency on the new freeway facility compared to many more and larger acceleration-deceleration cycles on the existing roads with traffic signals, etc. The analysis also revealed significant safety benefits from decreased crashes (See Figure 69) as traffic shifts from two-lane roads to a much safer freeway facility. UCOST predicts that the US 30 upgrade would save one life a year on average, and prevent more than 175 injury involved crashes as well as nearly 450 property damage only crashes.

FIGURE 69 ANNUAL CRASHES AVERTED

Crash Type	Averted
Fatal	1
Injury	179
Property Damage Only	449
Total	629

However, despite the significant decrease in the number of crashes, UCOST predicts some increase in delays associated with crashes owing to the fact that crashes on freeways typically cause more delays than crashes on two-lane roads in part simply because they delay more vehicles because of higher volumes on freeways even if the delay per vehicle is the same. Decreased delays associated with work zones for maintenance activities would also provide a significant benefit, owing to the ability to avoid detours or flagmen and one lane operations required on two lane roads.

Normal travel time savings and reliability improvements also contribute importantly to the projects benefits. Benefits related to improvements in travel time reliability are accounted for in UCOST and in the case of US 30 account for a benefit over 70% as much as direct travel time savings. This stands to reason and is easily understandable in terms of the common phenomenon of being stuck behind a truck or other slower moving vehicle on two lane roads such as US 30 versus the ability to pass easily on a rural freeway facility.

FIGURE 70 BENEFIT COST ANALYSIS RESULTS

REAL DISCOUNT RATE	DISCOUNTED BENEFITS	DISCOUNTED COSTS	BENEFIT COST RATIO	NET PRESENT VALUE	ECONOMIC RATE OF RETURN
3%	$2,686,687,708	$614,576,909	4.4	$2,072,110,799	16%
5%	$1,499,602,451	$478,869,678	3.1	$1,020,732,773	16%
7%	$883,516,490	$374,979,056	2.4	$508,537,434	16%

Depending on the assumed discount rate, the benefit-cost ratio ranges from 2.4 to 4.4 and the net present value varies between $509 million and $2.07 billion. Since the funding for the project is likely to be primarily from general tax revenues that will be used for other transportation improvements if US 30 is not built, a discount rate of 3% is most appropriate, which would result in the higher benefit cost ratio (4.4) and net present value ($2.1 billion). Even if an aggressive discount rate of 7% were assumed the benefit cost ratio at 2.4 would remain far above the 1.0 break-even point and the net present value would remain very positive at $509 million.

In conclusion, benefit cost analysis of a representative alternative under the Medium Growth scenario shows that the upgrade of US 30 would produce benefits far outweighing its costs. (See Figure 70 discounted benefits and discounted costs.)

8.0 CONCLUSIONS

This study examined the feasibility of an upgraded US 30 facility east of Canton. The study attempted to consider on-going and likely growth in the study area related to unconventional oil and gas developments and forecasting production level scenarios and their economic and demographic impacts on the study area. The Pennsylvania Turn Pike toll rates were also analyzed, and various toll rate forecasts were combined with growth forecasts to create high, medium, and low traffic forecasts. Traffic forecasts were developed using the Ohio Department of Transportation's (ODOT) statewide travel model, augmented with truck GPS data from the American Transportation Research institute, and calibrated to observed traffic counts and travel time data within the study area. Finally, a benefit cost analysis was conducted using ODOT's UCOST2 benefit-cost analysis tool.

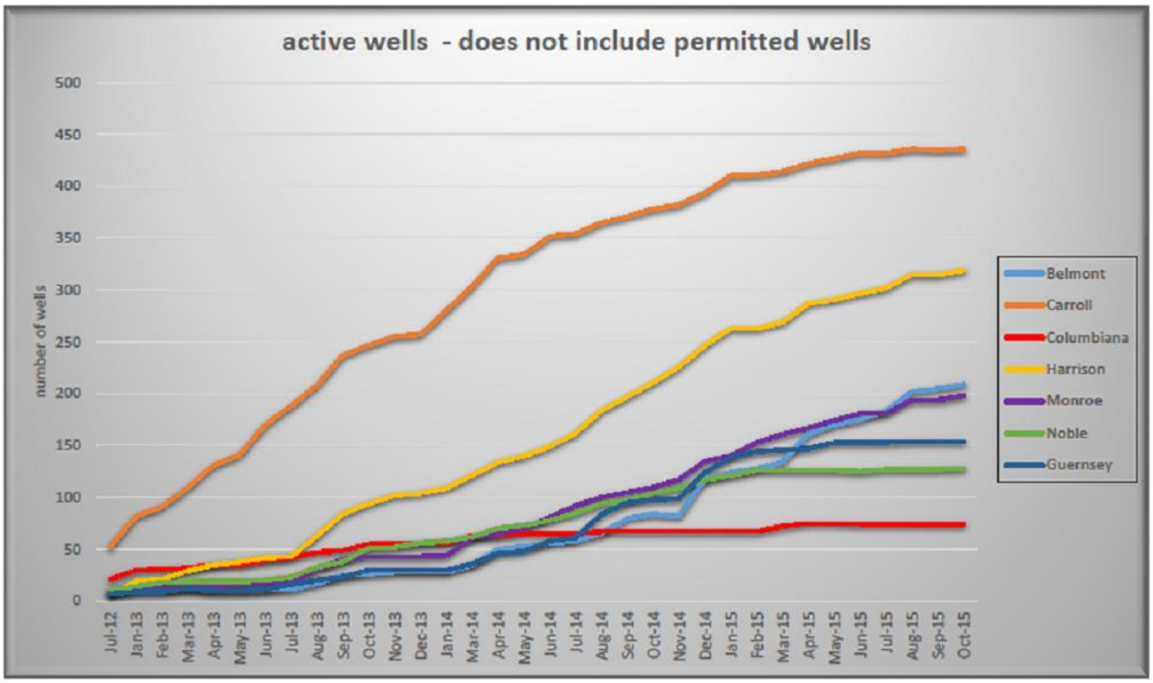
The results of the traffic forecasts suggest the general feasibility of the proposed project. All improved alignments carry traffic that would require a four-lane facility. An upgraded US 30 facility east of Canton would generally carry more traffic than sections of US 30 west of Canton, with traffic levels similar to I-77 south of New Philadelphia. Traffic on existing US 30 in the no build scenario is not severe and does not provide a rationale for the project because as mild to moderate congestion develops on US 30, local travelers shift to a myriad of alternative two-lane country roads. Conversely, upgraded facilities attract significant traffic volumes not only from the existing US 30 facility and SR 72 but also from many alternative routes because they provide significant travel time savings and safety benefits owing to their higher design standards and speeds. Alternative conceptual alignments would provide travel time savings to different local areas and further study is recommended to support the development of a clear purpose and need statement and eventual alternatives analysis. It is clear from this analysis, however, that all of the proposed alternatives upgrading US 30 would significantly improve mobility in the corridor despite the fact that they provide little congestion relief.

The benefit cost analysis further underscores the feasibility of the project. User cost savings provide substantial motivation for the project. The new version of ODOT's UCOST2 tool, captures significant benefits from improvements in travel time reliability and work zone time savings offered by a four lane facility in which users could pass trucks more easily and flagmen would not be needed for work zones. The project also offers important safety benefits. Despite the lack of major safety hot spots in the existing corridor, an upgraded facility would be far safer than the existing network of rural two lane roads and as a result is projected to save one life per year on average and avert over 150 injury accidents. The monetization of these benefits reveals a strong economic justification for the project, showing total benefits which outweigh costs by a factor of between 2 and 5 times and yielding an attractive 16% return on the investment of taxpayers' dollars.

9.0 NOTE ON SUBSEQUENT DEVELOPMENTS

After the original version of this report was submitted, ODOT District 11 noted some concerns about the forecasts contained in this report in light of more recent trends in oil and gas development. The forecasts developed for this study were developed in late 2014 and early 2015 based on the latest data available at that time. It is possible that more recent data could support some revision of these forecasts if the project is carried forward for further study.

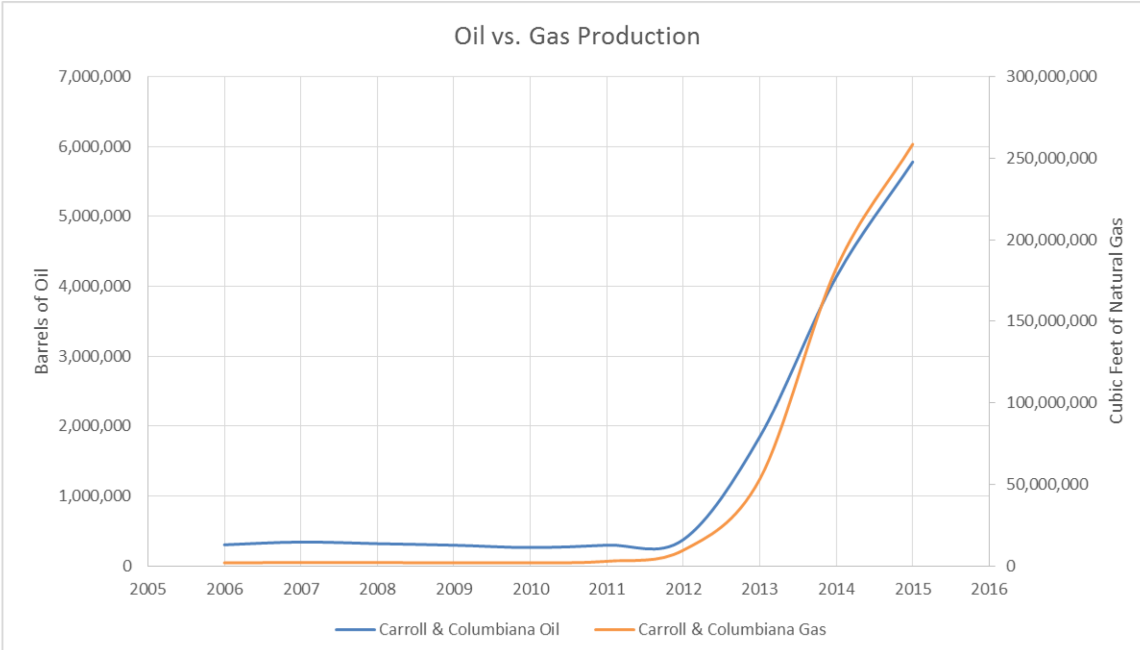
A graph showing the number of active wells by county provided by ODOT District 11 is provided below:



Data on oil and gas production through the first half of 2015 (2015 numbers based on doubling the first half of the year) from the Ohio Department of Natural Resources, accessed in November 2015, is provided in the table below:

	Oil			Gas		
	Carroll Oil	Columbiana Oil	Combined Oil	Carroll Gas	Columbiana Gas	Combined Gas
2006	245,729	57,937	303,666	848606	1136117	1,984,723
2007	278,163	64,358	342,521	918745	1195715	2,114,460
2008	253,792	65,642	319,434	893686	1205855	2,099,541
2009	231,528	65,987	297,515	778675	1194153	1,972,828
2010	204,045	60,167	264,212	750044	1227087	1,977,131
2011	245,582	52,507	298,089	1789786	1116859	2,906,645
2012	352,958	24,085	377,043	8442316	1230919	9,673,235
2013	1,768,635	80,411	1,849,046	50224172	3000276	53,224,448
2014	3,962,654	172,387	4,135,041	161137566	21272751	182,410,317
2015	5,510,438	269,076	5,779,514	221300992	37213938	258,514,930

The same data is illustrated in the table below:



While new drilling has slowed, oil and gas production have continued to grow quite significantly, although slightly slower than previously. The assumption that oil development grows at the same rate as gas development seems largely supported but could be slightly optimistic on oil based on this data which shows that Carrol County oil production has slightly more than tripled between 2013 and the first half of 2015 versus more than quadrupling of gas production.

Given the current decrease in lease offers and some modest slowing in new drilling in the study area, it is easy to understand why there may be some local skepticism for the forecasts. However, the current downturn seems to be a function primarily of lower energy prices and secondarily of higher than expected prices to extract oil from Utica deposits – not from decreased estimates of Utica oil reserves. Essentially, lease prices have fallen and new drilling slowed because the expected time to production has grown, not because the expected yield has fallen. Oil companies that a few year ago thought they would be extracting oil by the end of this decade now think extraction may not be likely for some additional years, depending on when / how sharply fuel prices rebound and if any further technology improvements decrease the cost of extracting Utica oil. It is the opinion of the report authors that the timing and the time value of money are the key to the change, not the long-term outlook. However, at the same time, the forecasts produced by this study and the assumptions upon which they are based should be reviewed based on the latest data should the project be carried forward for further study.

10.0 REFERENCES

Considine, Watson, Entler, and Sparks. 2009. An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play. http://s3.amazonaws.com/propublica/assets/monongahela/EconomicImpactsMarcellus.pdf Visited 17 November 2014.

Expanding Truck GPS-based Passive Origin-Destination Data in Iowa and Tennessee. Bernardin, V., S. Trevino and J. Short. Presented at the 94th Annual Meeting of the Transportation Research Board of the National Academies, Washington, D.C., January 2015.

Highway Statistics 2011, Table MV-9, Federal Highway Administration, accessed online at http://www.fhwa.dot.gov/policyinformation/statistics/2011/ on 11/27/2013.

Indiana Statewide Travel Demand Model (ISTDM6v3) Truck Model Update. Final Report. CDM Smith. Indiana Department of Transportation. December 3, 2012.

Ohio Department of Natural Resources (ODNR) Division of Oil & Gas Resources. 2013. Oil & Gas Well Production. http://oilandgas.ohiodnr.gov/production . Visited 8 October 2014.

Pennsylvania Department of Environmental Protection (PA DEP). 2014 Oil & Gas Reporting Website- Statewide Data Downloads by Reporting Period. https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/DataExports.aspx. Visited 9 October 2014.

Pittsburgh Tribune-Review. "PA. Turnpike Truck Traffic Drops as Tolls Increase" Tom Fontaine. Jan. 3, 2013 http://triblive.com/news/allegheny/3075051-74/traffic-turnpike-tolls#ixzz3bTBpcUCV

United State Energy Information Administration (EIA). 2015a. Natural Gas Gross Withdrawals and Production. http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm Visited 20 January 2015.

United State Energy Information Administration (EIA). 2015b. Natural Gas Wellhead Price. http://www.eia.gov/dnav/ng/hist/n9190us3A.htm. Visited 20 January 2015.

United State Energy Information Administration (EIA). 2015c. Europe Brent Spot Price FOB. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rbrte&f=m. Visited 20 January 2015.

Using Large Sample GPS Data to Develop an Improved Truck Trip Table for the Indiana Statewide Model. Bernardin, V. and L. Amar. Presented at the 4th TRB Conference on Innovations in Travel Modeling, Tampa, Florida, May 2012.