APPENDIX B

TRAVEL DEMAND MODEL/TRAFFIC FORECASTING

Data Refresh Memos

MEMORANDUM

Date: December 20, 2018 (*FINAL VERSION*)

To: Brian St. John
From: Julie Woo
Subject: SCCCTS StreetLight O-D Analysis Tech Memo

CC: Robert Watts

Work Order Number: 35041-002
Contract Number: E03985
Project: SCCCTS – Route 322/144/45 Corridors Data Refresh

The purpose of this memorandum is to: (1) present the methodology for studying the origin-destination (O-D) patterns of traffic along US 322, PA 144 and PA 45, and (2) provide a comparison of truck and automobile travel patterns as noted in previous project work, including *Origin-Destination Survey Results, South Central Centre County Transportation Study, September 1999* (1999 O-D Study) and *South Central Centre County Transportation Study Needs Analysis, April 2001* (2001 Needs Analysis).

Project Background Information

The Traffic Analysis Zone (TAZ) structure from the latest Centre County Travel Demand Model (CCTDM) was used to initiate the zonal work for the StreetLight O-D analysis. Since the TAZ structure was based upon 2010 Census boundaries, further refinements were conducted. Zones were either modified or split to enhance the outcome of the data analysis. Once the zone structure revisions were completed, the zones were then grouped into StreetLight O-D regions to best match the 1999 O-D Study districts for comparison and analysis purposes. The O-D regions mapping was reviewed by McCormick Taylor, and a second iteration of zone splits and modifications was completed before the StreetLight O-D regions were finalized.

However, there are several methodological differences between the 1999 O-D Study and the current 2017 StreetLight O-D Analysis that should be noted (Table 1).

Table 1: Key Differences between 1999 O-D Study & 2017 StreetLight Analysis

Differences	1999 O-D Study	2017 StreetLight O-D Analysis
Data Capture Method	- Roadside study captured travelers through (5) five station locations - Provided postcards to fill out and return - Intercept survey ~ 28% responses	- Smartphone apps track locations of devices - Navigation-GPS data from devices that help people navigate (including connected vehicles & commercial fleet) - Typically captures ~23% for any given area
Truck Classification	- Tractor-trailers - Straight trucks	- Heavy trucks (>26,000 lbs) - Medium trucks (14,000 to 26,000 lbs)
Data Collection Time Frame	- Apr 21 and 30, 1999 (6:00 am to 6:00 pm) - Apr 22, 1999 (7:30 am to 6:00 pm)	- Jan to May 2016, Sept to Oct 2016 (all hours) - Calculated weekday average for Mon to Thurs - Sampled larger time span for more consistent outcome & averaged longer time period
Mechanics	- Direct # of trips for autos & trucks	- Index value (due to privacy concerns & use of different data providers) - Trips analyzed in terms of % between or through regions and stations

StreetLight Data Background Information

As a brief background into StreetLight Data and its sources, the company was established in 2011 and provides an on-demand mobility analytics platform to perform a variety of transportation related analyses using "Big Data". Data sources include information from navigation analytics firm INRIX, fitness trackers, weather apps, and any other apps that have location components (approximately 300 total). Some analyses use location-based services data, while others use navigation-GPS data. For the O-D analysis, navigation-GPS data was used, which is collected from smart phones with navigation guidance apps. The data capture rate has improved to approximately 23% for any given area (compared to the 10-15% capture rate from April 2018). To protect user privacy, all personal information is removed, and only a randomized device number is provided as the reference. Using this data, a series of metrics is made available to the user, depending on the agreement type and the level of detailed analyses that is needed.

Regarding accuracy and precision, StreetLight provides a series of case studies on their website from both private and public sectors. In one particular case study related to trucks at the Port of Virginia, StreetLight results were compared to VDOT truck counts for model validation purposes. It was determined that the truck data was fairly similar, and the StreetLight platform was able to provide the tools and insights for a better understanding of truck travel behavior patterns. The agency recognized that the traditional data collection method of truck driver surveys usually resulted in lower response rates and reporting errors, so the option was not considered for the project.

It should also be noted that "Big Data" sources are now being used by all states to monitor system performance. FHWA designated National Performance Management Research Data Set (NPMRDS) as the preferred baseline dataset to help establish basement performance targets. The detailed travel time data used is also sourced by INRIX.

StreetLight Parameters Setup

The StreetLight O-D Analysis was set up in an enhanced manner to capture extensive data. Data setup was customized to fit the needs of the analysis, with specific parameters including data period, trip type, day type, and time of day. StreetLight is a "Big Data" resource with records dating back to 2014, enabling a larger time span sampling for all hours of the day. The intercept survey methodology is typically limited by the data collection time frames, which is usually only a few days of the year for a 12-14 hour time span. With access to data during all months of the year using StreetLight, it provided a more consistent outcome due to the larger sample size. Analysis included the use of data for all non-seasonal months (January-May, September, & October) for average weekday trips (Monday-Thursday) during a full 24-hour time period for each day. For StreetLight data extraction, the following parameters were used to compile project specific data (Table 2*).*

Table 2: StreetLight Data Parameters

StreetLight Parameters	Parameter Details
Project Type	O-D Analysis with Middle Filter (GPS Data)
Premium Add-On Metrics	Premium Trip Attributes
Date Period	2016: [1,2,3,4,5,9,10] *[Jan to May, Sept to Oct]*
Trip Type	Locked to Route
Day Type	0: Average Day (M-Su) 1: Average Weekday (M-Th) 2: Average Weekend Day (Sa-Su)
Day Part	0: All Day (12am-12am) 1: Early AM (12am-6am) 2: Peak AM (6am-9am) 3: Mid-Day (9am-3pm) 4: Peak PM (3pm-6pm) 5: Late PM (6pm-12am)
Commercial Vehicle Weight Classes	Medium Trucks, Heavy Trucks

StreetLight O-D Analysis Set Up

Site Station Locations

Site stations were approximated based on the data collection locations noted in the 1999 O-D Study. Figure 1 shows the StreetLight O-D collection locations, which match the sites where postcards were distributed in the previous study. A shape file was developed and used to assemble project related data, resulting in a precise location analysis.

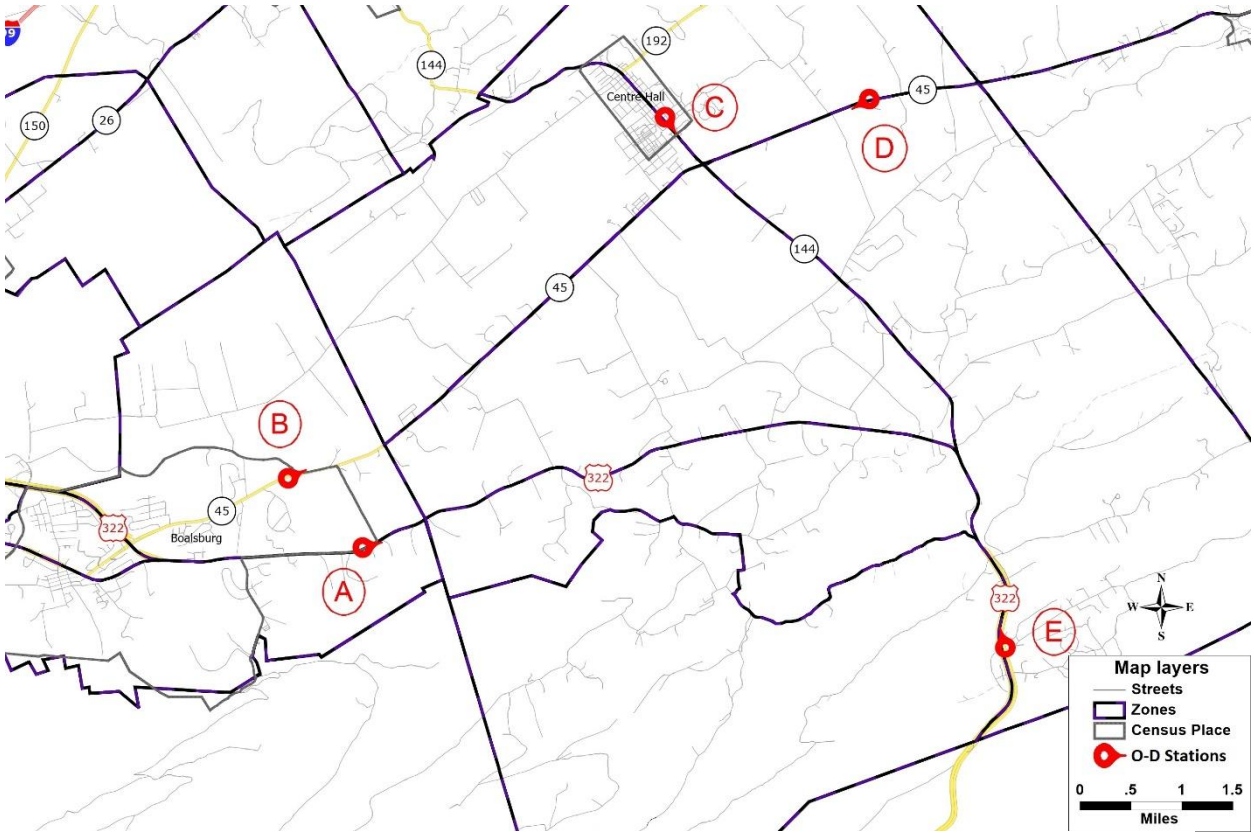


Figure 1: Site Station Locations

StreetLight O-D Analysis Regions

The refined zones from the CCTDM were used as the starting point for the O-D analysis. The zones were aggregated into StreetLight O-D regions to best match the 1999 O-D Study districts for comparison and analysis purposes. In the previous study, the O-D districts were categorized as follows:

- Zones in SCCCTS Study Area (Zones 1-4)
- Zones Outside of SCCCTS Study Area in Pennsylvania (Zones 5-14)
- Zones Outside of Pennsylvania (Zones 21-24, 71-73)

Also carried over from the 1999 O-D Study, "local" trips were defined as those who have an origin and/or destination within the study area, while "through" trips were defined as those that have neither an origin nor destination within the defined study area. Initially, the defined study area included the following districts: (1) Pleasant Gap Area, (2) Centre Hall Area, (3) Potters Mills Area, and (4) Boalsburg Area. Further analysis showed that the State College Area was the most popular origin and destination for automobiles traveling on US 322, PA 144, and PA 45 in the county. As a result, the State College Area was later included as part of the O-D study area.

A side-by-side comparison of the 1999 O-D districts and 2017 StreetLight O-D regions is shown in the next series of figures. Figure 2 shows the O-D study area used for both studies (internal zones highlighted in blue for StreetLight setup). Figure 3 shows the immediate "Zones Outside Study Area in Pennsylvania" within Centre County. The distinction for the two separate 2017 maps in Figure 3 is illustrating how the zones used for the StreetLight analysis were aggregated to reflect the combined local areas that were used in the original 1999 O-D Study. Figures 4 and 5 also show "Zones Outside Study Area in Pennsylvania", with closer and zoomed out statewide views to show the correlation between area names, zone numbers, and study areas.

For the purposes of this analysis, two things should be noted:

- The StreetLight O-D regions in the defined study area were identified as Internal Capture Zones (local traffic) and External Zones (through traffic) to correspond with the previous O-D study area boundaries, which also includes the State College Area.
- The StreetLight O-D analysis only extends to the Pennsylvania state boundaries. To capture trips from outside Pennsylvania regions, pass through gates were created at various locations along the state boundary. These pass through gates are also shown in Figure 5.

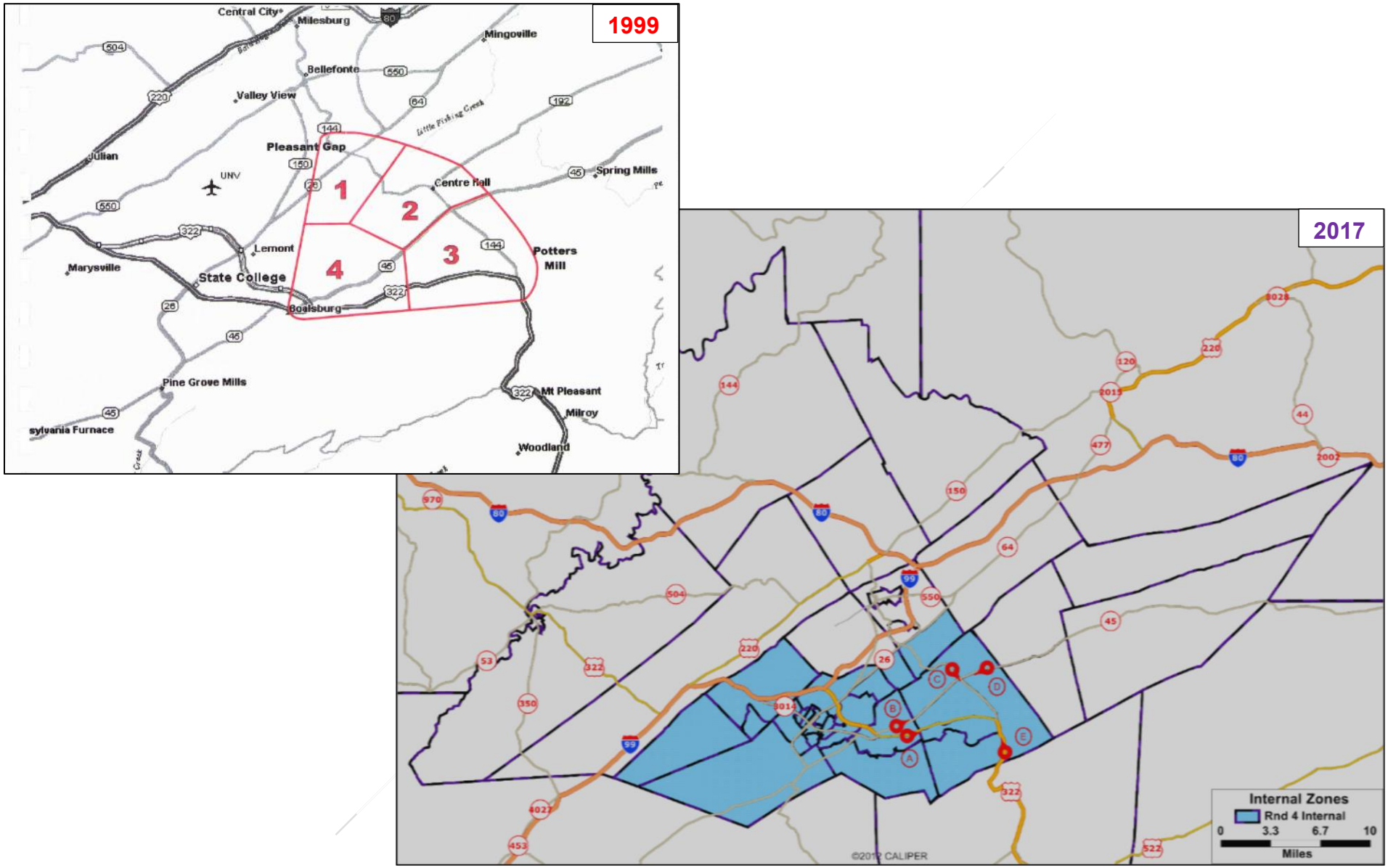


Figure 2: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones in Study Area

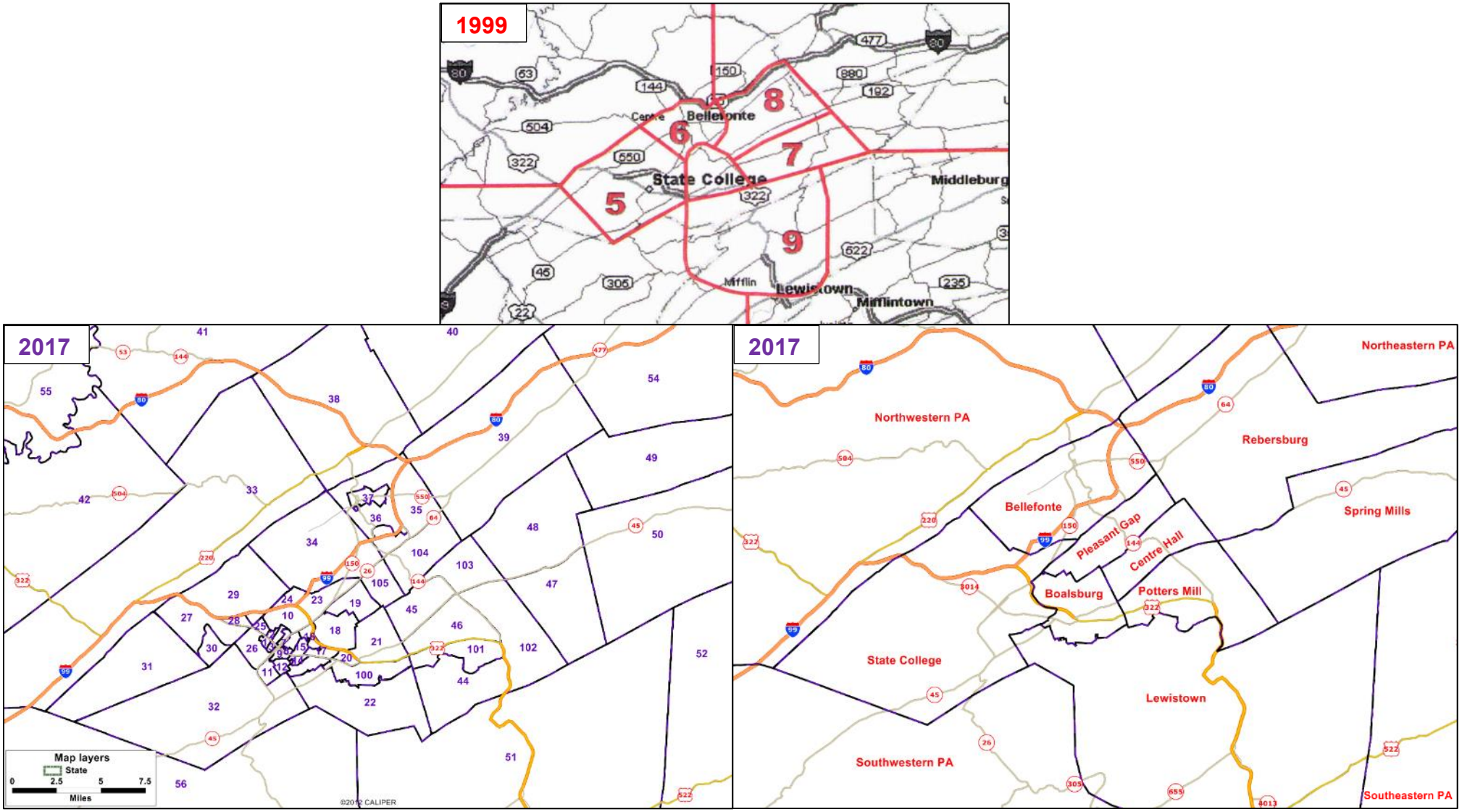


Figure 3: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Centre County)

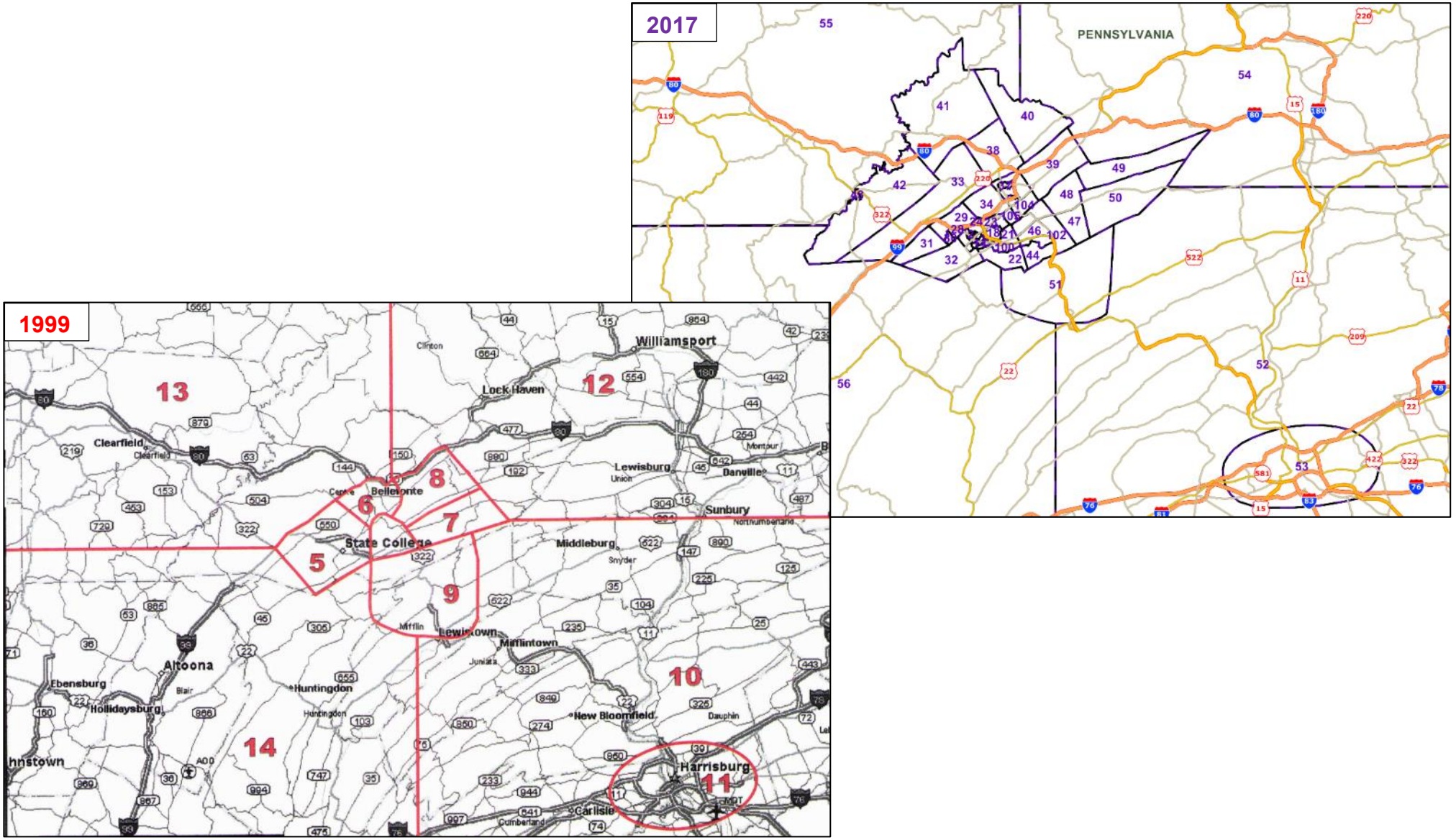


Figure 4: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Statewide Close-Up)

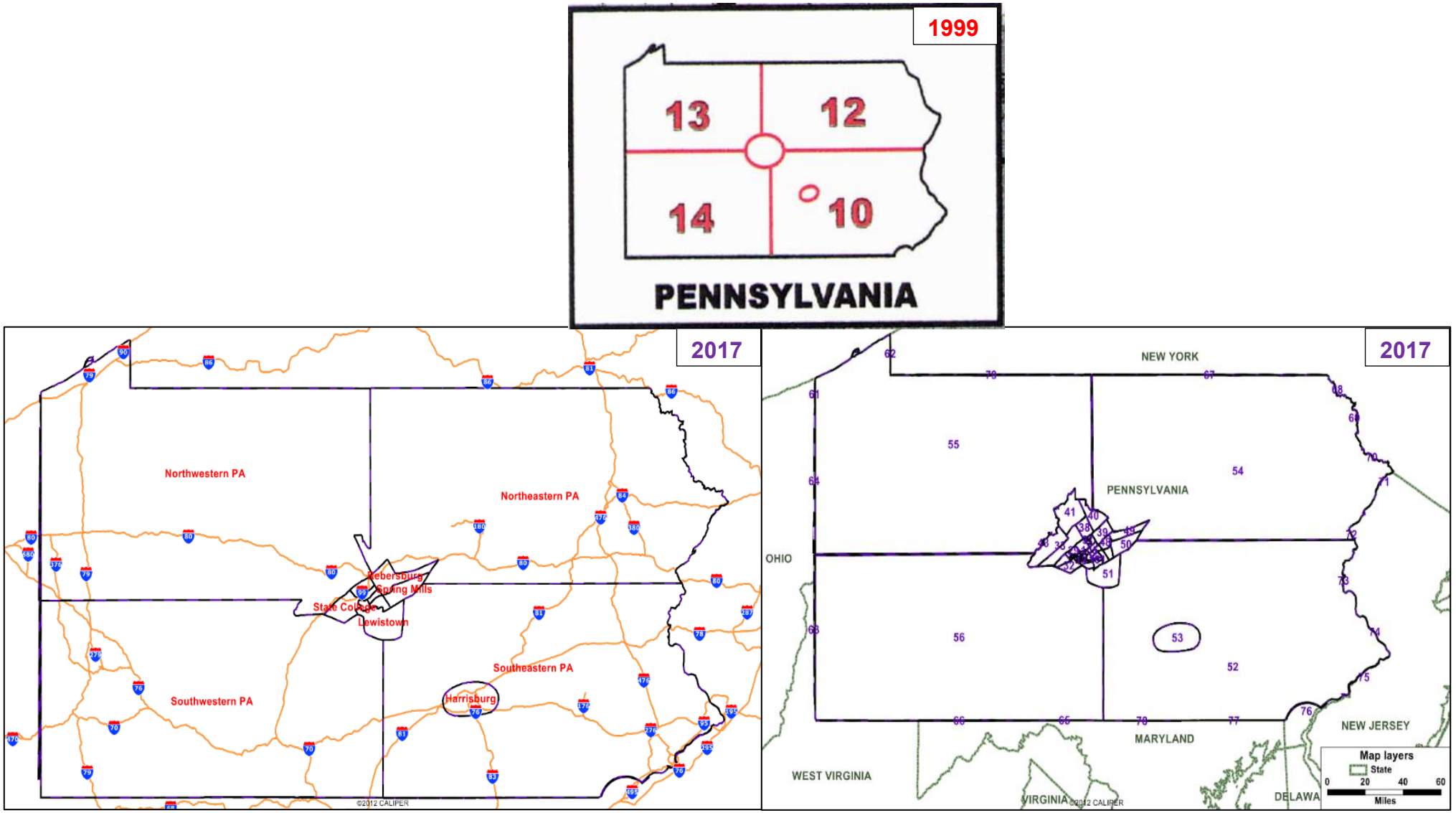


Figure 5: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Complete Statewide View)

To provide further clarification regarding the naming convention and related details between the 1999-O-D Study and the 2017 StreetLight O-D Analysis, Table 3 shows the following:

- The origin-destination areas used for both studies
- The zone numbers that correspond with the O-D districts / regions from both studies
- How zones were grouped to form StreetLight O-D regions and best match 1999 O-D Study district boundaries
- The naming convention for each O-D district / region

Table 3: Origin-Destination Areas Comparison

Origin / Destination Areas (1999 O-D Districts and StreetLight O-D Regions)	1999 OD-Study		StreetLight O-D Analysis	
	O-D Study Area (Local vs Through Traffic)	Zone #	O-D Study Area (Local vs Through Traffic)	Zone #
Pleasant Gap	Zones in Study Area (Local Traffic)	1	Internal Capture Zones (Local Traffic)	19, 104, 105
Centre Hall		2		45, 103
Potters Mills		3		46, 101, 102
Boalsburg		4		18, 20, 21, 100
State College		5		1-17, 23-32
Lewistown	Zones Outside of Study Area (Through Traffic)	9	External (w/ small portion Internal)*	22, 44, 51
Bellefonte		6	External Zones (Through Traffic)	34-37
Spring Mills		7		47, 50
Rebersburg		8		39, 48, 49
Southeastern PA		10		52
Harrisburg		11		53
Northeastern PA		12		40, 54
Northwestern PA		13		33, 38, 41-43, 55
Southwestern PA		14		56

**Note: For the StreetLight O-D Analysis, the northern portion of the Lewistown Area just south of US 322 was included in the O-D study area as local traffic.*

Data Analysis & Findings

Several iterations of zone groupings were performed and analyzed to best correlate with the 1999 O-D Study district boundaries. As the StreetLight O-D regions were adjusted and refined each time, StreetLight model test runs were conducted to ensure that the distribution of local and through traffic made sense. By the end of the process, the final StreetLight O-D regions were set up in a manner to measure the same routes at the same locations, which provides a comparable evaluation of results between both studies. A small portion of Lewistown Area just south of US 322 was also included as part of the study area to be analyzed as a local traffic component.

A comparative evaluation of results can be conducted. However, the differences in data capture methods, data collection time frames, and the mechanics of the data (see Table 1) should be taken into consideration as part of the comparison between studies and the interpretation of results.

Regarding the differences in data capture methods and data collection time frames, the previous study collected data in the form of an intercept survey and the current analysis uses navigation-GPS data. The intercept survey was conducted at (5) five different site locations within the defined study area, where travelers were provided forms to fill out and return regarding their travel information. The survey period was conducted over the course of three days for a 12-hour span, which included AM, MIDDAY and PM peak hour periods. The navigation-GPS data used in StreetLight is processed into trips & activities to help provide an understanding of trip types from data collected by navigation applications. More than 28 billion data points are collected per month, which is an added benefit of using a “Big Data” resource. For the purposes of the O-D analysis, the study period was for all non-seasonal months (January-May, September, & October) for average weekday trips (Monday-Thursday) during a full 24-hour time period for each day.

The intercept survey had an approximate response rate of 28%, while the StreetLight data generally captures between 10-15% for any given area. While the percentage rate is lower than the previous study, the data used for the analysis consisted of a much larger sample size - the difference being three partial days versus (7) seven months of data covering a full 24-hour period over multiple weekdays. Larger sampling sets of this nature provide a higher level of confidence by smoothing out non-typical trips that are inevitably captured and included as part of the data collection process.

Regarding the mechanics of the data, the previous study was able to summarize truck and automobile trips as direct counts, and also were reported as percentages between origin and destination districts. Due to privacy regulations and the use of different data providers, the StreetLight data is typically reported as an index value. This index value is the aggregation of the readings, or hits, from BlueTooth or related devices that travel across the site location and can then be traced to the origin and destination of that device. Therefore, trips for the StreetLight O-D analysis were analyzed in terms of percentages between regions or stations. So although not exact data methodologies, the results can be viewed as reasonable approximations for comparable study areas, with a focus on the relative percentages between origin and destination regions.

After a series of zone aggregation iterations, data extraction, and comparisons to previous project work, this memorandum will present the following findings:

- Comparison of Traffic Counts for Site Station Locations
- Comparison to 2001 Needs Analysis Key Findings (Section XIII: Regional Travel Patterns)
- Comparison to 2001 Needs Analysis O-D Results Overview (Section VIII: Traffic Studies)

Comparison of Traffic Counts for Site Station Locations

In addition to the O-D analysis, a comparison of traffic counts for the key sites was compiled to help determine any changes in traffic volumes (and potentially travel patterns) over the years. The traffic counts comparison for routes along the O-D collection sites are shown in Table 4.

Table 4: Traffic Counts Comparison for Routes Along O-D Collection Sites

Route	O-D Collection Site	Year							
		2000	2005	2008	2009	2010	2015	2016	2017*
US 322	A	10000	12000	12000	12000	12000	10000	10000	15,359
PA 144	Between PA 45 & US 322	4100	5400	4200	4200	4200	4900	4800	6,499
PA 144	C	9300	14000	14000	11000	11000	10000	9900	9,858
PA 45	B	7600	7500	7400	6100	7000	6400	6200	7,689
PA 45	D	4900	5800	5200	5200	5200	5400	6400	6,673
US 322	E	13000	14000	13000	14000	14000	15000	17000	19,748
I-99					16000	29000	31000	33000	

**Note: Reflects seasonally adjusted ADT volumes from SCCCTS Data Refresh data collection efforts in 2017*

The bi-directional traffic count data for years 2000 to 2016 were obtained from the Historical Statewide Traffic Volume Maps on the PennDOT website. The seasonally adjusted 2017 ADT volumes that were collected for the SCCCTS Data Refresh project were also included for comparison purposes. Most of the corridors along the O-D collection sites are showing positive traffic growth. The only location that appears to have either nominal or decreasing trends is PA 144 (Site C). Traffic patterns also show steady growth along the I-99 corridor after construction was completed. The growth on reflects the increase of through trips through Centre County and a shift in traffic from PA 45 and PA 144 to the I-99 corridor.

Comparison to 2001 Needs Analysis Key Findings (Section XIII: Regional Travel Patterns)

In the 2001 Needs Analysis, key findings for regional travel patterns were noted in Section XIII of the report. The following figures are excerpts from the 2001 Needs Analysis showing the key movements for tractor trailers (Figures 6 - 7), straight trucks (Figures 8 -9), and automobiles (Figures 10-13). For comparison purposes, the 2017 StreetLight O-D percentages for heavy trucks, medium trucks, and autos were added (shown in red) to the corresponding figures.

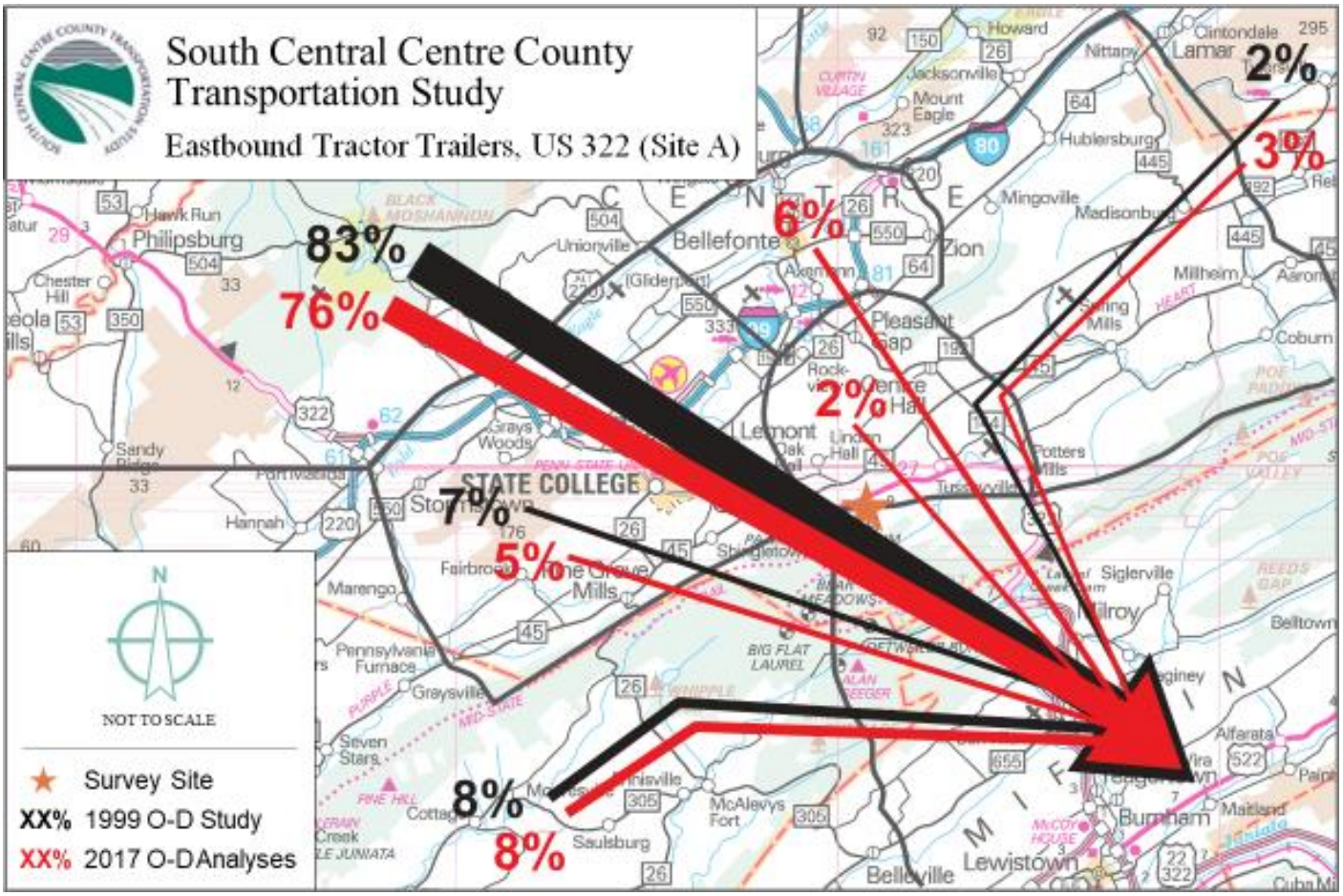


Figure 6: Eastbound Tractor Trailers, US 322 (Site A) Comparison

For tractor trailers on US 322 EB (Site A), heavy truck travel patterns are very similar between the two studies, with a majority of traffic coming from the Northwestern PA region. For 2017, additional truck traffic from the Bellefonte and Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas were noted, as well.

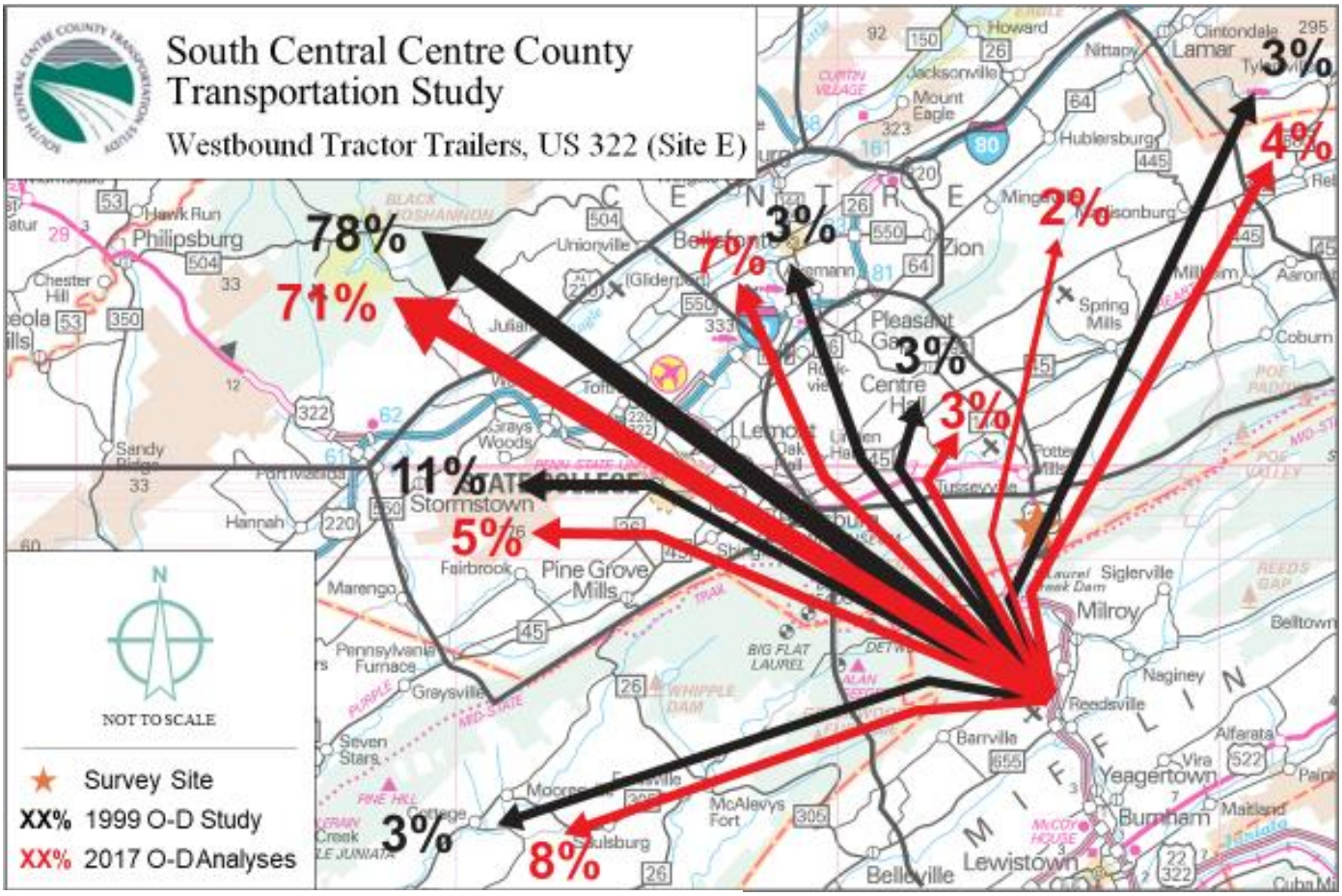


Figure 8: Westbound Tractor Trailers, US 322 (Site E) Comparison

For tractor trailers on US 322 WB (Site E), heavy truck travel patterns are very similar between the two studies, with the majority of traffic traveling towards the Northwestern PA region. For 2017, additional truck traffic is headed towards the Rebersburg area.

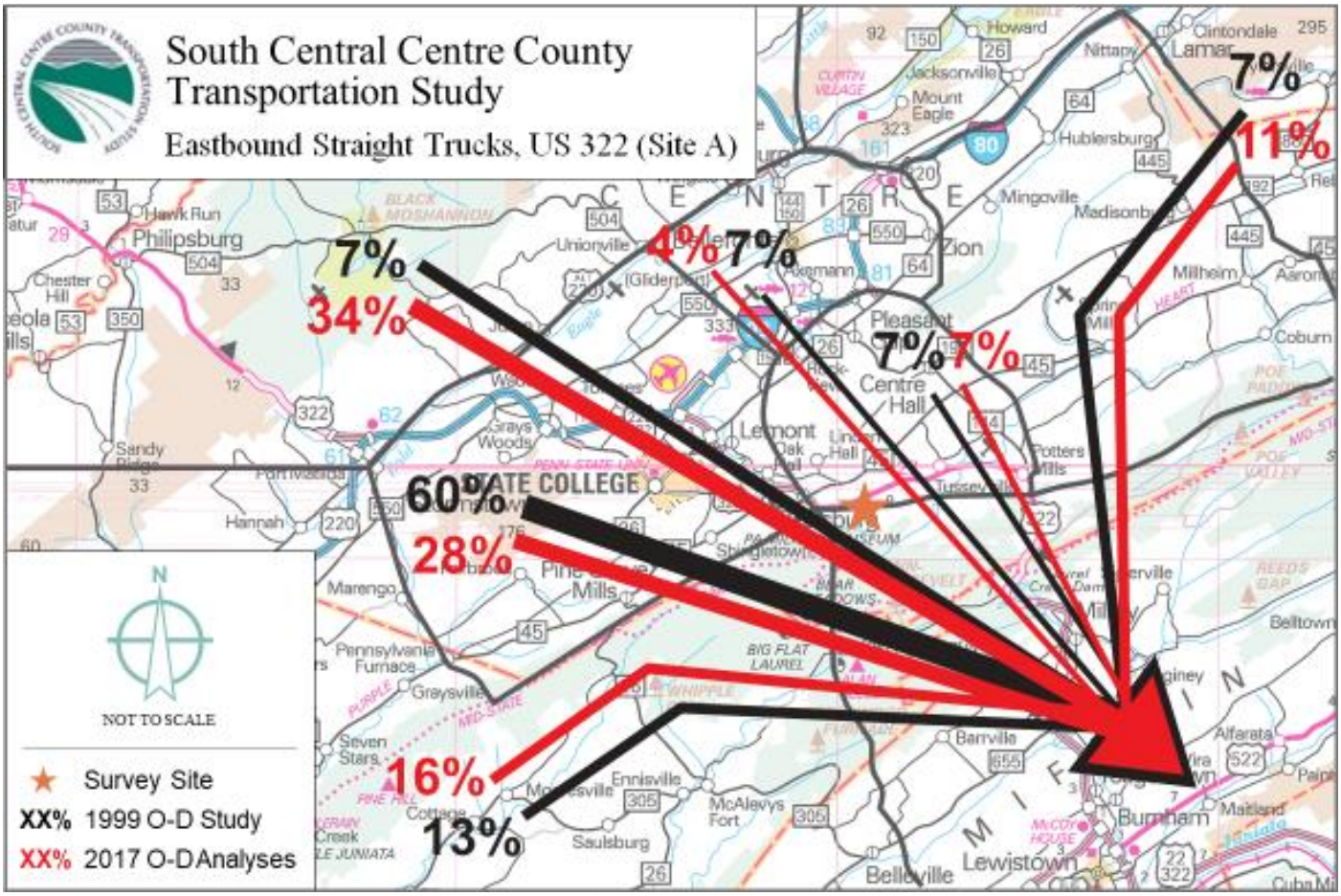


Figure 9: Eastbound Straight Trucks, US 322 (Site A) Comparison

For straight trucks on US 322 EB (Site A), key changes noted for medium truck travel patterns in 2017:

- 32% fewer trucks traveling from State College area and 28% more traveling from Northwestern PA region.
- All other areas noted from the 2001 Needs Analysis are showing nominal changes.

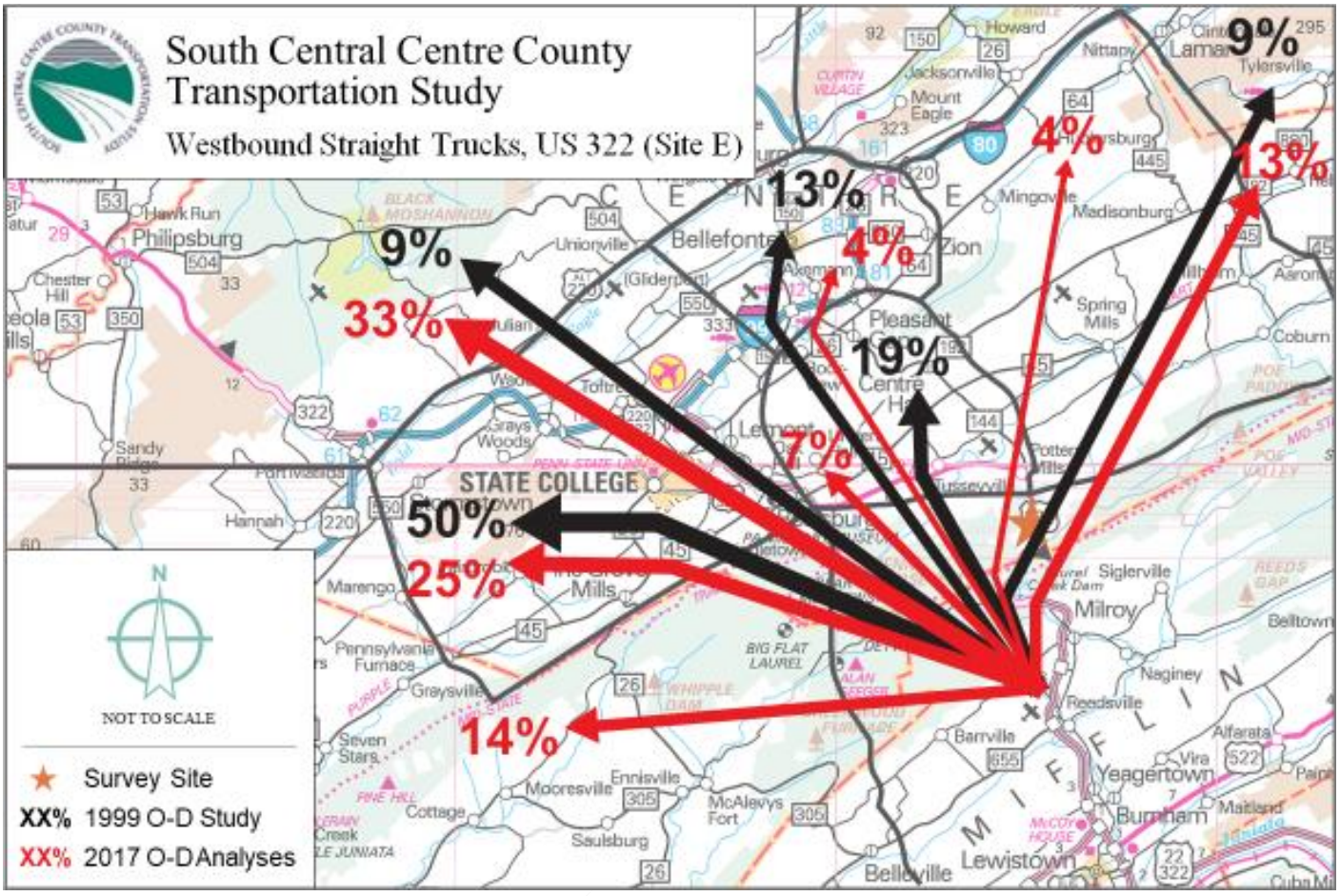


Figure 10: Westbound Straight Trucks, US 322 (Site E) Comparison

For straight trucks on US 322 WB (Site E), the following key changes are noted for medium truck travel patterns in 2017:

- 25% fewer trucks traveling to State College area and 26% more traveling to Northwestern PA region.
- All other areas noted from the 2001 Needs Analysis are showing smaller changes.
- Additional truck traffic is headed to the Southwestern PA region and the Rebersburg area.

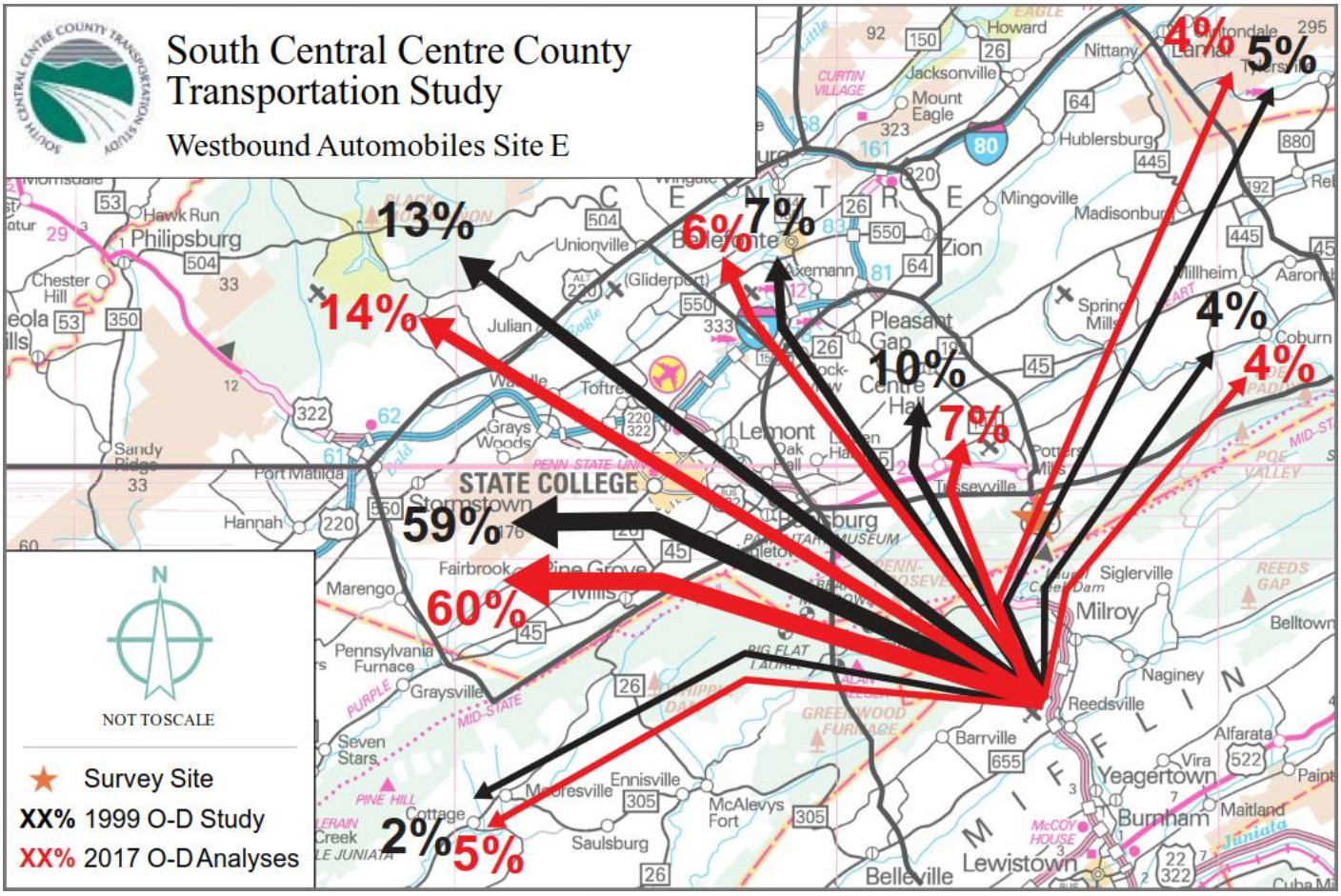


Figure 11: Westbound Automobiles, US 322 (Site E) Comparison

For automobiles on US 322 WB (Site E), travel patterns are very similar between the two studies.

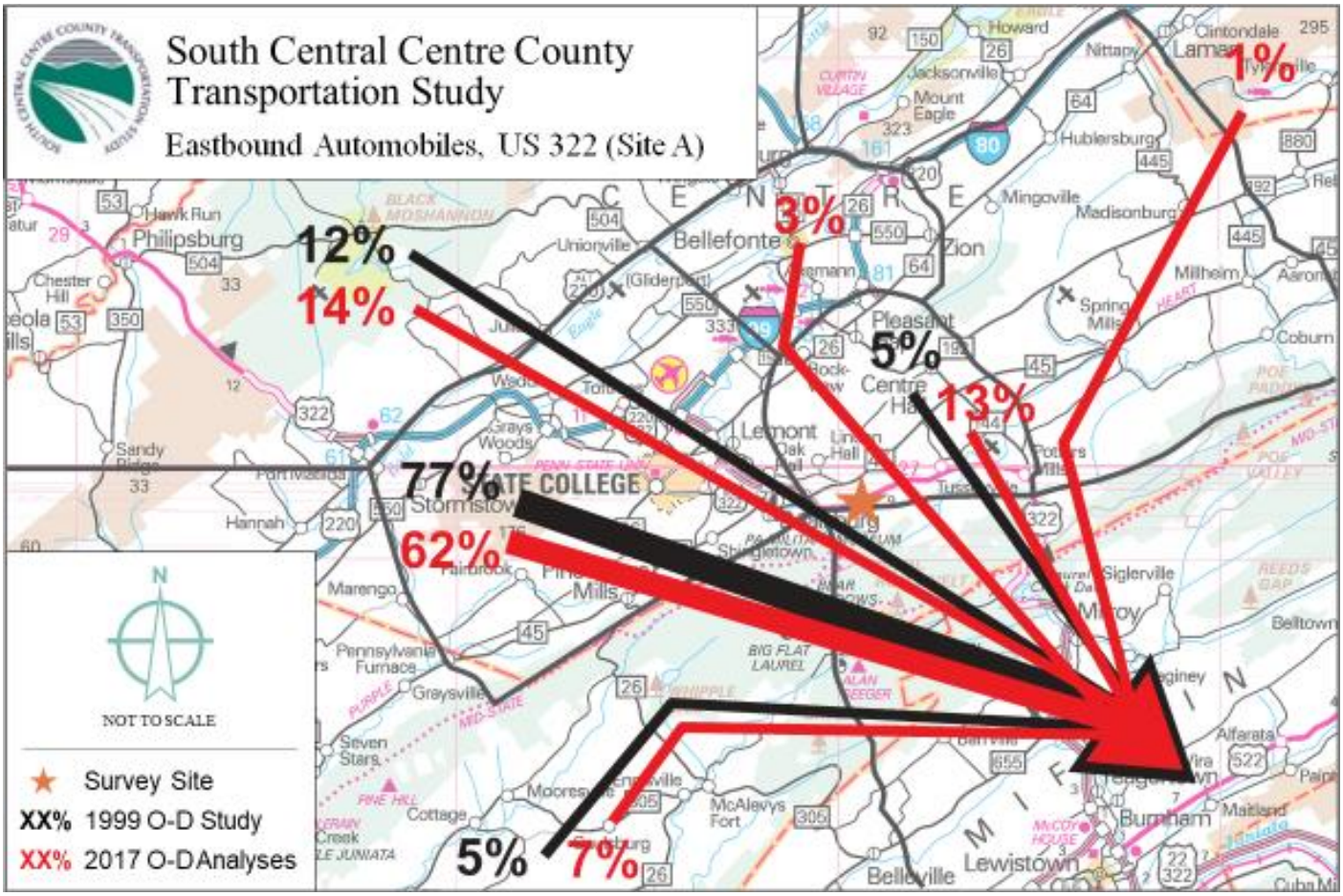


Figure 12: Eastbound Automobiles, US 322 (Site A) Comparison

For automobiles on US 322 EB (Site A), the following changes are noted for travel patterns in 2017:

- 15% fewer cars traveling from State College area.
- 2% more cars traveling from Northwestern PA region and 8% more from Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- Additional auto traffic is traveling from Bellefonte area and Northeastern PA region.

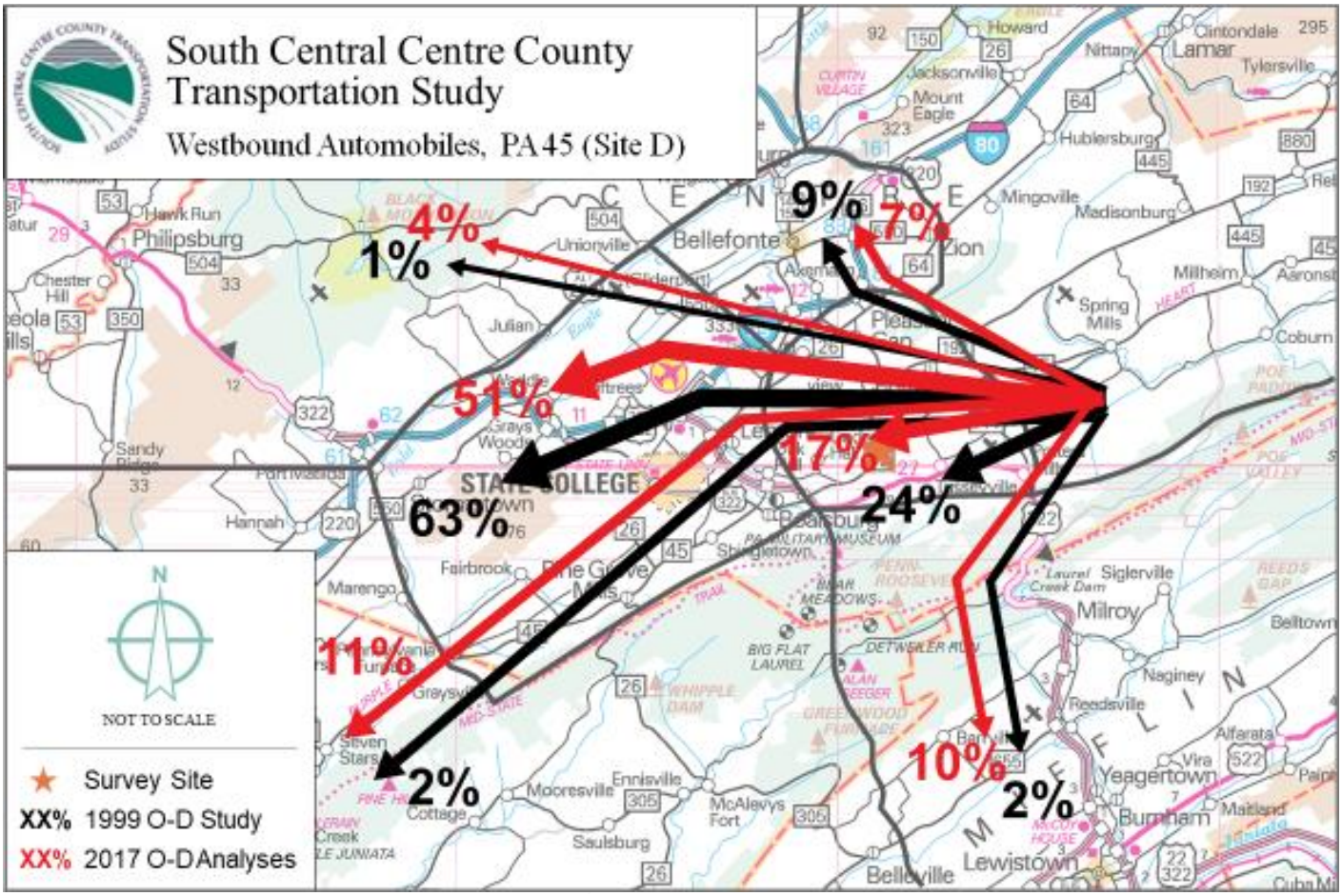


Figure 13: Westbound Automobiles, PA 45 (Site D) Comparison

For automobiles on PA 45 WB (Site D), the following changes are noted for travel patterns in 2017:

- 12% less cars traveling to State College area and 7% less to Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- 9% more cars traveling to Southwestern PA region and 8% more to Southeastern PA region.
- All other areas noted from the 2001 Needs Analysis are showing nominal changes.

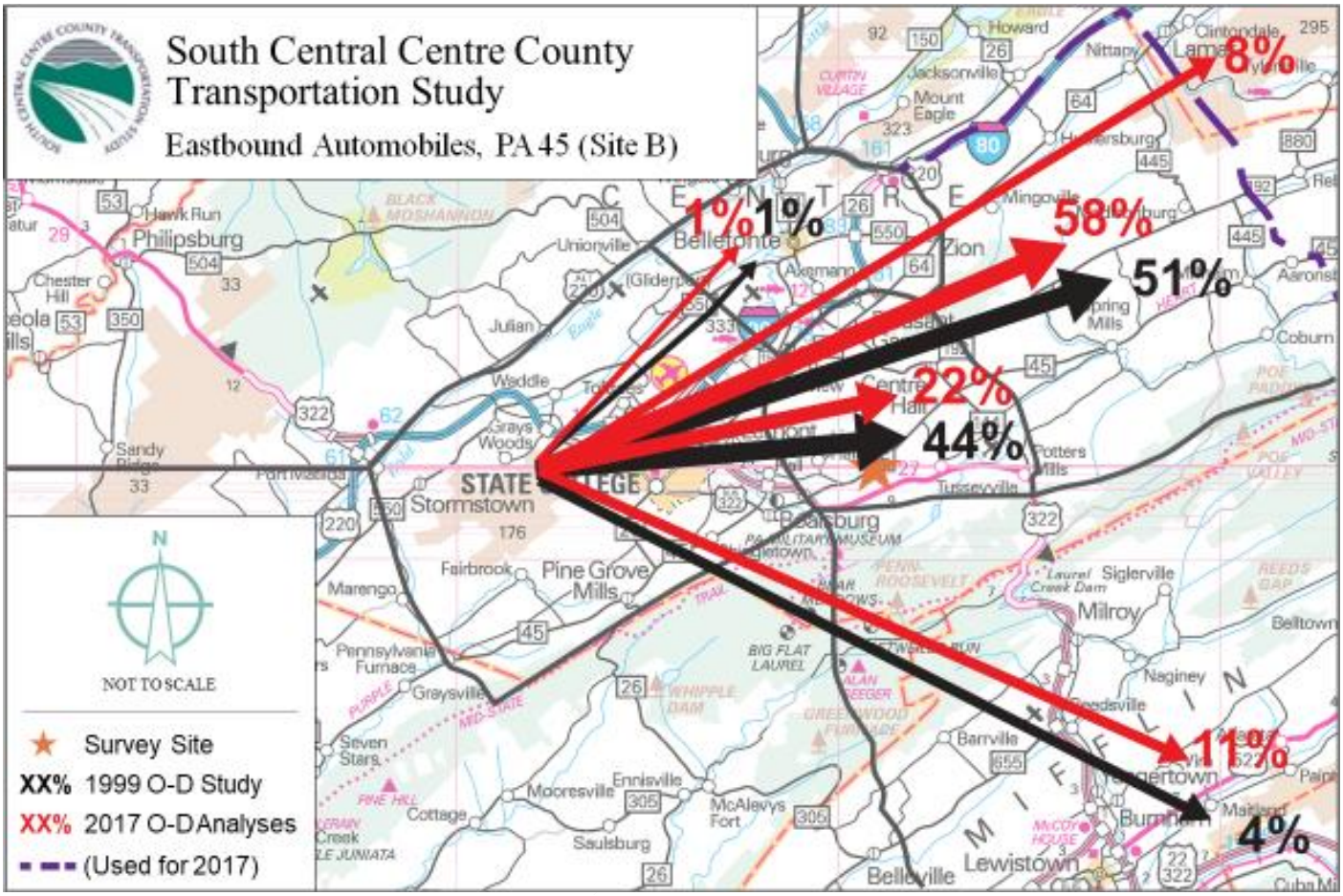


Figure 14: Eastbound Automobiles, PA 45 (Site B) Comparison

For automobiles on PA 45 EB (Site B), the following changes are noted for travel patterns in 2017:

- 22% fewer cars traveling to the Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- 7% more cars traveling to Spring Mills and Rebersburg areas and 7% more to the Southeastern PA region.
- Additional car traffic is traveling to Northeastern PA region.

Comparison to 2001 Needs Analysis O-D Results Overview (Section VIII: Traffic Studies)

An overview of O-D results shown in Section VIII of the 2001 Needs Report was summarized from the 1999 O-D Study. A comparison between these results and 2017 StreetLight O-D analysis is shown in Table 5 for trucks and Table 6 for autos. The tables show the traffic percentages and differences at Stations A through E for the following trip types:

- External to External (E-E) trips – Through traffic
- Internal to Internal (I-I) trips – Local traffic traveling within the study area
- External to Internal (E-I) or Internal to External (I-E) trips – Local traffic traveling to / from the study area

Table 5: Truck O-D Summary & Comparison

1999 O-D Survey								2017 StreetLight Analysis (includes refined zones)[1]								Difference (2017 StreetLight O-D Analysis vs 1999 O-D Survey)							
Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips	
US 322	Site A (EB) + Site E (WB)	TT	65%	90%	1%	12%		US 322	Site A (EB) + Site E (WB)	H	74%	89%	0%	11%		US 322	Site A (EB) + Site E (WB)	H	9%	-1%	-1%	-1%	
		ST	35%	36%	4%	59%				M	26%	64%	1%	35%				M	-9%	**28%**	-3%	**-24%**	
PA 144	Site C	TT	9%					PA 144	Site C	H	14%	59%	1%	40%		PA 144	Site C	H	5%	**59%**	1%	**40%**	
		ST	88%	59%	12%	29%				M	86%	50%	18%	32%				M	-2%	-9%	6%	3%	
PA 45	Site B (EB)	TT	65%					PA 45	Site B (EB)	H	24%					PA 45	Site B (EB)	H	**-41%**				
		ST	35%							M	76%							M	**41%**				
	Site D (WB)	TT	28%						Site D (WB)	H	21%						Site D (WB)	H	-7%				
		ST	72%							M	79%							M	7%				
	Total B + D	TT		53%	14%	40%			Total B + D	H		50%	12%	37%			Total B + D	H		-3%	-2%	-3%	
		ST		43%	9%	48%				M		46%	12%	42%				M		3%	3%	-6%	

Note1: Selected zones to match O-D Zones 1-5 for comparison to Scenario 2 from original study.
Abbreviations: Directions [EB = Eastbound, WB = Westbound]
Truck Types [TT=Tractor Trailer, ST=Straight Truck, H=Heavy Truck (>26,000 lbs), M=Medium Truck (14,000 to 26,000 lbs)]
Trip Types [E-E Trips = External to External Trips, I-I Trips = Internal to Internal Trips, E-I or I-E Trips = External to Internal or Internal to External Trips]

In general, the percentage breakdown of all trip types compares well for most stations between both studies, indicating similar travel patterns over the last 18 years. The biggest changes are along PA 45 EB (Site B), where heavy truck traffic has decreased, and medium truck traffic has taken its place over time. Another new truck trend for 2017 is that more medium truck traffic is using US 322 as a through route, rather than making a stop within the study area.

Key findings and specific details for truck travel patterns are noted below:

- US 322 EB (Site A) & US 322 WB (Sites E) show the most significant change for medium trucks. Through traffic has increased by 28% while local traffic traveling to / from the study area has decreased by 24%.
- PA 144 (Site C) shows a large variance for E-E and E-I or I-E trips, however the original survey did not breakdown data by truck type. Comparing those trips to the medium trucks splits, these percentages match relatively well.
- PA 45 EB (Site B) truck percentage differences should be noted. The percentages for heavy and medium trucks have essentially flipped. The most likely cause of this shift can be attributed to the opening of I-99 and heavy truck traffic re-routing to take advantage of the new facility.

Table 6: Auto O-D Summary & Comparison

1999 O-D Survey						2017 StreetLight Analysis (includes refined zones)[1]						Difference (2017 StreetLight O-D Analysis vs 1999 O-D Survey)					
	Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips
	US 322	Site A (EB) + Site E (WB)	26%	7%	68%		US 322	Site A (EB) + Site E (WB)	26%	4%	70%		US 322	Site A (EB) + Site E (WB)	0%	-3%	2%
	PA 144	Site C	34%	23%	48%		PA 144	Site C	35%	20%	45%		PA 144	Site C	1%	-3%	-3%
	PA 45	Site B (EB)	15%	35%	55%		PA 45	Site B (EB)	12%	43%	53%		PA 45	Site B (EB)	-3%	8%	-2%
		Site D (WB)		4%	77%			Site D (WB)		1%	71%			Site D (WB)		-3%	-6%

Note1: Selected zones to match O-D Zones 1-5 for comparison to Scenario 2 from original study.
Abbreviations: Directions [EB = Eastbound, WB = Westbound]
Truck Types [TT=Tractor Trailer, ST=Straight Truck, H=Heavy Truck (>26,000 lbs), M=Medium Truck (14,000 to 26,000 lbs)]
Trip Types [E-E Trips = External to External Trips, I-I Trips = Internal to Internal Trips, E-I or I-E Trips = External to Internal or Internal to External Trips]

The percentages for automobile trip types are showing nominal differences since 1999. So even through general traffic volumes have increased over time and truck volumes have doubled on certain portions of US 322, the comparison indicates little to no changes for automobile traffic patterns.

Key findings and specific details for automobile travel patterns are noted below:

- Local traffic traveling within the study area has decreased by 3% for US 322 EB (Site A), US 322 WB (Site E), and PA 45 WB (Site D)
- Local traffic traveling to / from the study area have:
  - Increased on US 322 (Site E) by 2%
  - Decreased on PA 144 (Site C) and PA 45 EB (Site B) by 3% and 2%, respectively
- Through traffic patterns show that changes are within (+/-) 3% for all O-D sites
- Relatively speaking, locations with the largest changes in automobile travel patterns are:
  - PA 45 EB (Site B), with an 8% increase for local travel within the study area
  - PA 45 WB (Site D) with a 6% decrease for local travel to / from the study area

Conclusions

After completing the current O-D analysis and making comparisons to the previous O-D study, findings reveal that many O-D patterns are either similar or have nominally changed over the last 18 years. The key travel patterns that are similar between the two studies include:

- US 322 continues to serve as the main travel route within the Centre Country project area.
- Consistent travel patterns are seen in the following percentage comparisons (shown as 1999 & 2017, respectively):
    - US 322 EB (Site A) Heavy Truck Origins from Northwestern PA region (83% & 76%)
    - US 322 EB (Site A) Auto Origins from State College area (77% & 62%)
    - US 322 WB (Site E) Heavy Truck Origins from Northwestern PA region (78% & 71%)
    - US 322 WB (Site E) Auto Origins from State College area (59% vs. 60%)
    - PA 45 EB (Site B) Auto Destinations to Spring Mills region (51% & 58%)
    - PA 45 WB (Site D) Auto Destinations to State College area (63% & 51%)
- The percentage comparison for automobile trip types are showing minimal differences with +/- 3% in changes for most of the O-D stations, which indicates automobile traffic patterns have experienced little to no change in recent years

The findings of this study also indicate the following notable travel pattern changes that have occurred since the 1999 study:

- More traffic is traveling to or from the Northwestern PA and Southeastern PA regions through the study area. Both regions are within the top 5 origins and destinations for automobiles & truck for most stations.
- PA 45 EB (Site B) traffic patterns reveal fewer heavy trucks and more medium trucks in 2017. The most likely cause of this shift can be attributed to the opening of I-99 and heavy trucks rerouting to use a higher tier facility for long distance travel.
- US 322 WB (Site A) and US 322 WB (Site E) show the most significant change for medium trucks. Through traffic has increased by 28% while local traffic traveling to / from the study area has decreased by 24%. This indicates more trucks are using US 322 as a through route for regional travel purposes.

Overall, travel patterns appear to correlate well with the previous study, where US 322 continues to serve as the main travel corridor and the State College area continues to be the main origin / destination for the local market. As for trip purpose (local traffic versus regional through traffic), the comparison results are revealing some shifts. An increase in traffic from the Northwestern PA and Southeastern PA regions adds additional traffic to US 322. More medium trucks are using US 322 as a regional through route, which also contributes to the growing traffic along this corridor. It should be noted that automobile travel patterns have remained consistent. So even through general traffic volumes have increased over time and truck volumes have doubled on certain portions of US 322, the comparison indicates little to no changes for automobiles. When planning for future transportation projects in the area, truck traffic needs and impacts should be taken into consideration.

MEMORANDUM

Date: December 20, 2018 (*FINAL VERSION*)

To: Brian St. John

From: Julie Woo

Subject: SCCCTS Calibration / Validation & Forecasting Tech Memo

CC: Robert Watts

Work Order Number: 35041-002

Contract Number: E03985

Project: SCCCTS Data Refresh

Introduction

The purpose of this memorandum is to document the travel demand model (TDM) calibration/validation and forecasting related efforts for the South Central Centre County Transportation Study (SCCCTS) Data Refresh project. Specifically, this memo will discuss the TDM model calibration/validation process & results and development of 2050 Future Year No-Build forecasts. Future year traffic forecasts include both daily traffic volumes and AM and PM peak hour turning movement volumes.

Model Input Data

The Centre County Regional TDM was utilized to perform the forecasting. The model study area is shown in **Figure 1,** which includes the SCCCTS project area and the surrounding area of influence. Due to the amount of time since the base year 2010 model was developed, a 2017 scenario was prepared to serve as the updated base year model.

As noted previously in the *SCCCTS Traffic Modeling Methodology Tech Memo*, Centre County Regional Planning Agency and Centre County Planning Office provided demographic updates to the study team for TAZ's within the SCCCTS Data Refresh study area. These demographic updates included changes that have occurred between 2010 and 2017. For the portions of the model outside of this area, demographic data was interpolated from the original 2010 and 2040 socioeconomic and land use data to calculate the remaining 2017 data. The roadway network was also updated to reflect transportation improvements between 2010 and 2017.

Using the 2040 demographic details provided by Centre County for Potter & Benner Townships, and Centre Region for Harris and College Townships, the 2050 model input data was generated by the extrapolation method. Growth rates between base year and future year for each TAZ were calculated at the parcel level and applied to the 2040 data. This methodology helped maintain the consistencies of growth patterns based on the most recent demographic updates and were carried through for the remaining forecast years. The 2050 demographic allocations were reviewed and modified as needed to ensure reasonable growth for all TAZs, accounting for developable land within these zones.

Between 2017 and 2050, most of the traffic analysis zones (TAZ) within the model study area are expected to have nominal growth. A few are expected to have slight declines and high growth was observed for TAZ's 103, 206, 294, 335, 364, 400, and 413. The overall growth trends for the model study area zones are shown in **Table 1**. Population and households have annual linear growth rates of 0.6% and 0.7%, respectively. Employment is expected to grow at a higher rate of 2.0% per year, with over 10,000 additional employment trips by 2050.

Figure 1: Model Study Area

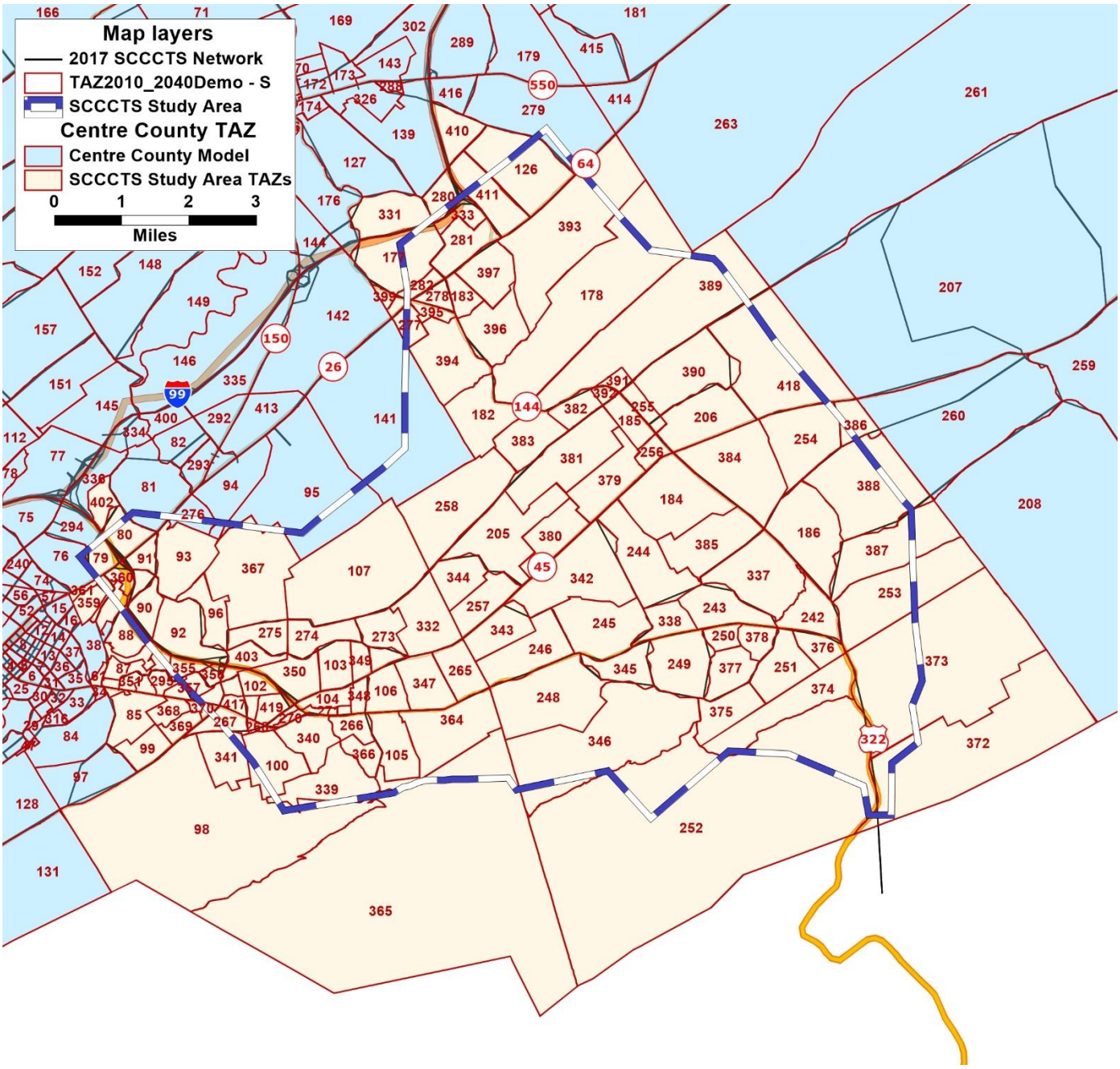


Table 1: Model Study Area Socio-Economic Data

	2017 Base Year	2050 Future Year	Total Growth	Total Growth %	Annual Linear Growth %
Population	24,083	29,240	5,157	21.4%	0.6%
Households	10,222	12,462	2,240	21.9%	0.7%
Employment	15,876	26,385	10,509	66.2%	2.0%

Base Year Model Validation and Refinement

The base year 2017 model area was refined and validated within the study area to match existing daily traffic volumes. During fall of 2017, daily traffic counts were collected for 28 locations within the SCCCTS project area. For external station locations, daily traffic count data was compiled from the PennDOT Traffic Count Publications.

The validation consisted of a series of refinements, which included centroid connector modifications, link additions, junction node updates, TAZ splits, updates to facility types, and adjustments within the trip generation, trip distribution, and highway assignment processes of the model. The following work was conducted to help update the base year model from 2010 to 2017 and refine the model for calibration purposes:

- Demographic updates per details in previous section
- Zones splits within and around the study area to refine zonal loading of the network
- Network updates to complement added zonal coverage
- Functional classification and lane reviews using Google Earth
- Adjustments and improvements to model processes:
    - StreetLight Data was used to update external thru and external local movements
    - Assignment process was updated to provide consistent feedback values
    - Truck factor was added to reduce truck speeds and help differentiate from auto speeds
    - Heavy truck trips were prohibited on PA 144 passing over the mountain
    - Unique speed adjustment was added on PA 144 passing over the mountain
    - Average trip lengths were adjusted based on StreetLight Data

Figure 2 shows the network related refinements noted above.

For validation purposes, the base year 2017 daily volumes before and after network refinements were compared to 2017 daily traffic counts. The segment calibration check results are shown in **Table 2**. The cutline calibration check results are shown in **Table 3**. The cutline locations are shown in **Figure 3**. The validation targets follow standards documented in the *NCHRP Report 765*[1]*.*

As shown in **Tables 2 and 3**, the calibration comparison checks show benefits after refinements. The addition of missing roadways and centroid connector modifications improved the traffic loading at the TAZ level, while the adjustments within the trip generation, trip lengths and assignment processes helped improve the traffic overloading issue on various corridors, such as PA 144.

After the validation checks were performed, it was determined that the model validation was reasonable for most of the study segments and acceptable for study area forecasts.

[1] *National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design (Chapter 4, pages 77-78)*

Figure 2: Base Year Model Network Refinements

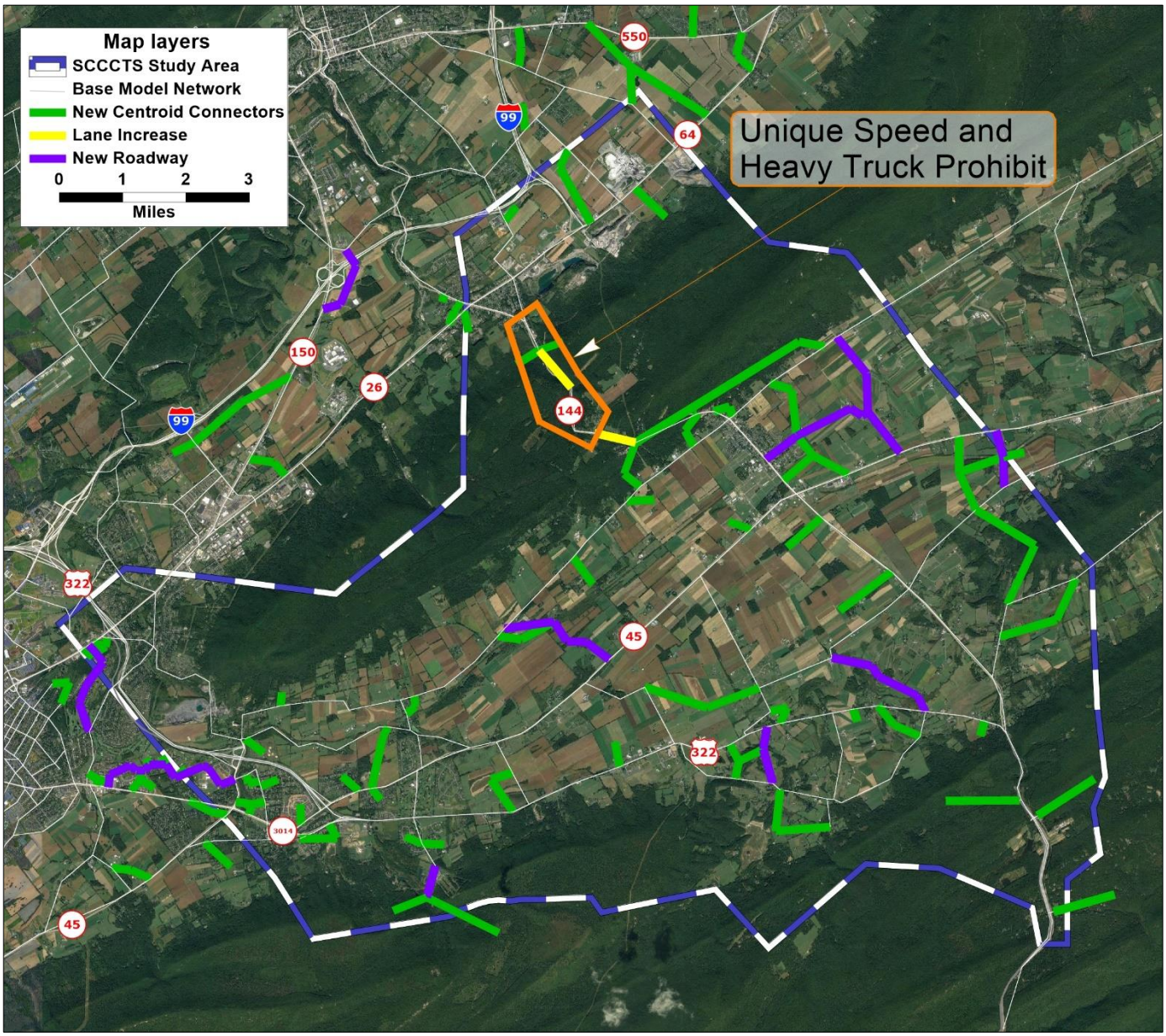


Table 2: Segment Calibration Check

Count ID	Roadway Segment	Description	Direction	2017 Base Year Traffic Count	2017 Base Year Model Volume	% Deviation	Allowable Deviation[2] (+/-)
A	PA 45	East of PA 144	WB+EB	6673	9241	38.5%	46.2%
B	Brush Valley Rd	West of Smith Road	WB+EB	629	1039	65.1%	67.2%
C	PA 144	North of East Wilson St.	SB+NB	9858	8108	-17.8%	38.4%
D	PA 192	East of Emery Rd.	WB+EB	2292	1880	-18.0%	60.5%
E	PA 144	South of Harrison Rd.	SB+NB	8798	8618	-2.0%	40.8%
F	US 322	East of PA 144	WB+EB	17157	18307	6.7%	26.2%
G	US 322	West of Mountainback Rd	WB+EB	12793	14551	13.7%	32.7%
H	US 322	West of Oak Hall Interchange	WB+EB	21886	23813	8.8%	21.2%
I	PA 45	East of Elks Club Rd	EB+WB	7689	9658	25.6%	43.6%
J	US 322	East of Laurel Meadow Rd	EB+WB	14411	15364	6.6%	30.1%
K	PA 45	West of PA 144	WB+EB	7502	9893	31.9%	44.0%
L	US 322	East of US 322 Bypass	WB+EB	16311	16341	0.2%	27.3%
M	PA 45	East of Willowbrook Dr	WB+EB	7831	10350	32.2%	43.2%
N	Brush Valley Rd	North of Linden Hall Rd	SB+NB	793	873	10.0%	66.5%
O	US 322 (BUS)	East of Church St	WB+EB	11593	10922	-5.8%	34.9%
P	PA 45	East of Woodside Dr	WB+EB	5041	2651	-47.4%	51.0%
Q	PA 144	North of Bible Rd	SB+NB	6499	4067	-37.4%	46.7%
R1	US 322	Off Ramp to Boal Avenue (US 322 Bus)	WB	3334	2444	-26.7%	56.7%
R2	US 323	On Ramp from Boal Avenue (US 322 Bus)	EB	3327	2168	-34.8%	56.7%
S1	Old Fort Interchange (US 322 at PA 45)	EB Off Ramp (from US 322 to PA 45)	EB	3123	3325	6.5%	57.4%
S2	Old Fort Interchange (US 322 at PA 45)	WB On Ramp (from PA 45 to US 322)	WB	3609	4003	10.9%	55.7%
T	PA 45	Between Old Fort Interchange & US 322 (Bus)	WB+EB	6857	5784	-15.7%	45.7%
U1	Oak Hall Interchange	WB On Ramp	WB	3170	1916	-39.5%	57.2%
U2	Oak Hall Interchange	WB Off Ramp	WB	250	67	-73.0%	68.9%
U3	Oak Hall Interchange	EB On Ramp	EB	203	126	-37.7%	69.1%
U4	Oak Hall Interchange	EB Off Ramp	EB	3540	2502	-29.3%	55.9%
V	Warner Blvd	Between Oak Hall Interchange & Boal Ave (US 322 (Bus)/PA 45)	SB+NB	7596	2891	-61.9%	43.8%
W	US 322 (BUS) (Atherton St)	West of Warner Boulevard	EB+WB	13903	11893	-14.5%	30.9%

Within Allowable Deviation

Not Within Allowable Deviation

[2]*National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design (Chapter 4, page 78, Figure 4-13)*

Table 3: Cutline Calibration Check

Cutline	Location	Roadway Segment	Description	Direction	2017 Traffic Count	Before Calibration		After Calibration		Allowable Deviation[3] (+/-)
						2017 Model Volume	% Deviation	2017 Model Volume	% Deviation	
101	P	PA 45	East of Woodside Dr	WB+EB	5,041	3,114	-38.2%	2,651	-47.4%	51.0%
102	-	US 322 BUS	East of State College	WB	13,000	13,491	3.8%	10,531	-19.0%	32.4%
103	H	US 322	West of Oak Hall Interchange	WB+EB	21,886	26,178	19.6%	23,813	8.8%	21.2%
201	E	PA 144	South of Harrison Rd.	SB+NB	8,798	15,421	75.3%	8,618	-2.0%	40.8%
202	D	PA 192	East of Emery Rd.	WB+EB	2,292	2,550	11.3%	1,880	-18.0%	60.5%
203	A	PA 45	East of PA 144	WB+EB	6,673	11,054	65.7%	9,241	38.5%	46.2%
301	Q	PA 144	North of Bible Rd	SB+NB	6,499	5,724	-11.9%	4,067	-37.4%	46.7%
302	G	US 322	West of Mountainback Rd	WB+EB	12,793	13,508	5.6%	14,551	13.7%	32.7%
401	L	US 322	East of US 322 Bypass	WB+EB	16,311	15,763	-3.4%	16,341	0.2%	27.3%
402	-	SR 2004	North of PA 45	WB+EB	100	21	-79.0%	32	-68.0%	69.5%
403	I	PA 45	East of Elks Club Rd	WB+EB	7,689	9,926	29.1%	9,658	25.6%	43.6%
404	B	Brush Valley Rd	West of Smith Road	WB+EB	629	1,379	119.2%	1,039	65.1%	67.2%

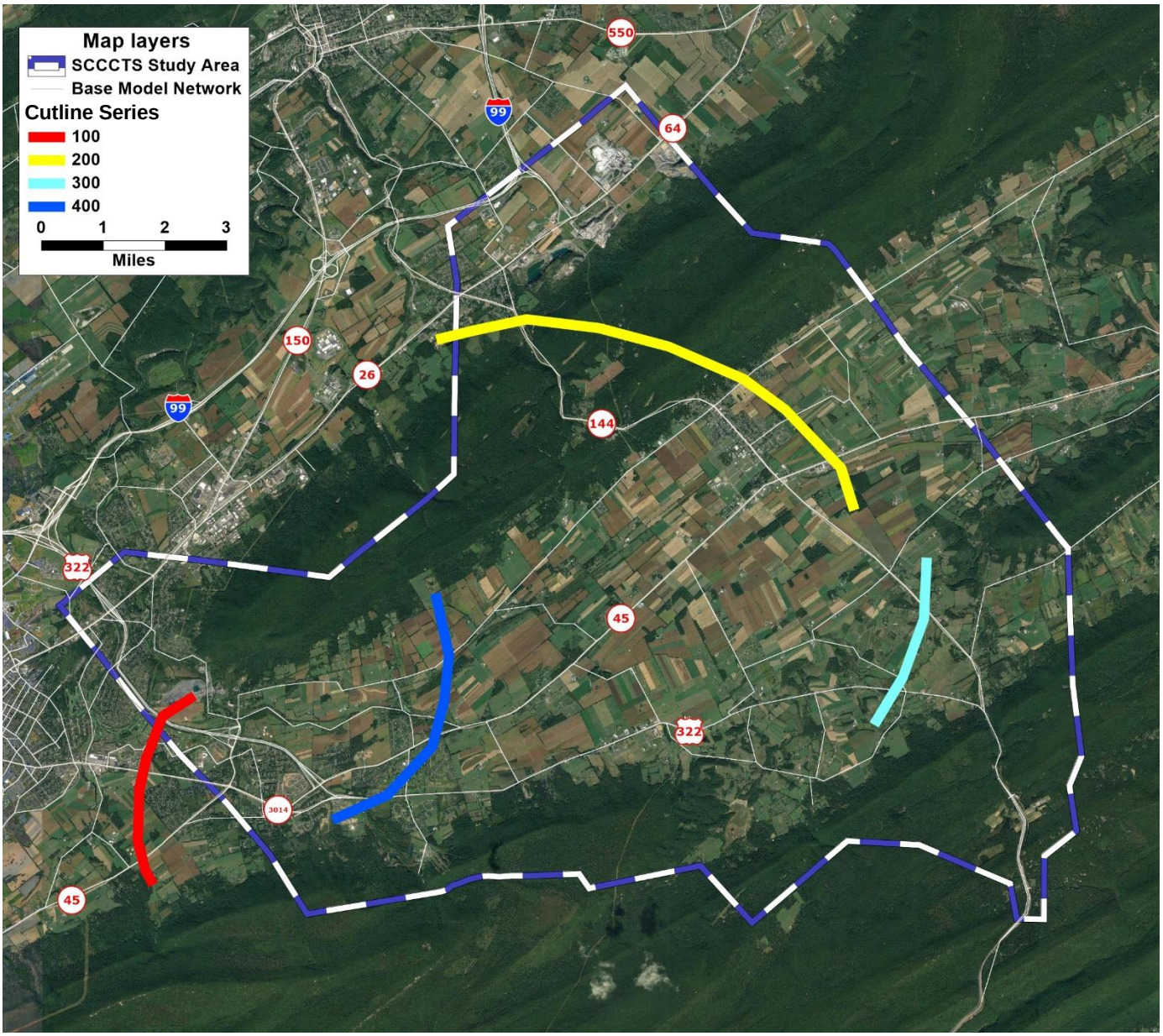
	Cutline Series	2017 Traffic Count	2017 Model Volume	Cutline % Deviation	2017 Model Volume	Cutline % Deviation	Allowable Deviation[3] (+/-)
Red	**100**	39,927	42,783	7.2%	36,995	-7.3%	12.2%
Yellow	**200**	17,763	29,026	63.4%	19,739	11.1%	25.5%
Light Blue	**300**	19,292	19,232	-0.3%	18,618	-3.5%	23.7%
Dark Blue	**400**	24,729	27,089	9.5%	27,069	9.5%	18.9%
	OVERALL	101,711	118,130	16.1%	102,421	0.7%	8.0%

Within Allowable Deviation

Not Within Allowable Deviation

[3] *National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design (Chapter 4, page 78, Figure 4-13)*

Figure 3: Cutline Locations



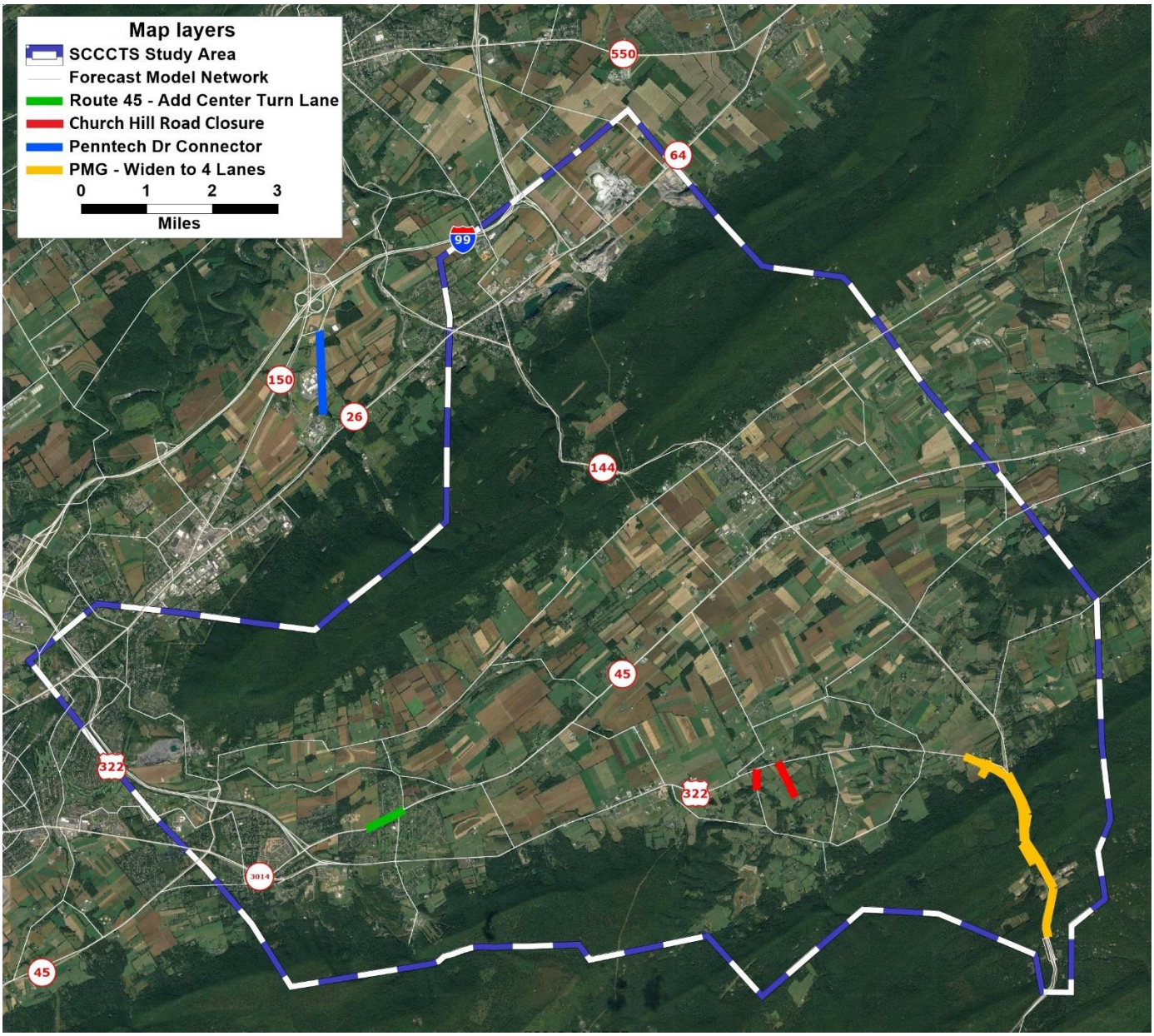
2050 Future Year No-Build Network

The model improvements performed for 2017 Base Year conditions were replicated in 2050 Future Year No-Build modeling efforts. The same network refinements and adjustments to model processes were applied to ensure consistent assumptions for base and future year conditions. Also, the future year transportation project list was reviewed with the Centre County Regional Planning Agency to ensure that all relevant projects were accurately coded in the 2050 Future Year No-Build network. The future year projects within the immediate study area, as well as the surrounding area of influence, are listed in **Table 4** and shown in **Figure 4**. It should be noted that the I-99/I-80 Interchange Project was also included in the future year network, located just outside of the model study area.

Table 4: Future Year Projects (Between 2017 and 2050)

Project ID	Name	Type of Improvement	Location
H-28	Route 45 Earlystown Rd	Add center turn lane	From Estate Dr to Linden Hall Rd
H-23	Church Hill Rd	Closure of Church Hill Rd	At Route 322
108	New Zone Connector	New access road	Access to Penntech Dr
B06	US-322 Potters Mill Gap	Widen to 4 lanes	West of PA 144 to Sand Mountain Rd

Figure 4: Future Projects for 2050 Future Year No-Build Network



Methodology for Development of 2050 Future Year No-Build Daily & Peak Hour Forecasts

Using refinement procedures in the *NCHRP 765 Report*[4]*,* 2050 Future Year No-Build raw model volumes were post processed to account for various assignment deviations in the base model. The underlying assumption is that deviations that occur in the base year assignment will continue to occur proportionally in any future year forecasts. The adjustment methods were based on the relationship between base year traffic counts and base year traffic assignments. One of four adjustment methods were applied:

1) Ratio Method – Ratio of base year traffic count and base year traffic assignment, multiplied by the future year traffic assignment.
2) Difference Method – Difference between base year traffic count and base year traffic assignment, added to the future year traffic assignment.
3) MRatio (Modified Ratio) Method – Modified version of the "ratio method" to weight towards the difference method for large model increases, specifically when the model ratio is greater than 1. If the model ratio is less than 1, then the MRatio method is simply the ratio method
4) Average Method – The average of the modified ratio and difference methods.

Using 2017 base year traffic counts and 2050 Future Year No-Build post processed volumes, annual linear growth rates were calculated for each project segment. **Table 5** shows a comparison of base year counts to future year post processed volumes, along with growth rates for both total vehicles and trucks only. Traffic growth rates from the previous SCCCTS 2001 Needs Report were also included in the table for reference purposes.

Future year AM and PM turning movement forecasts were developed for 15 intersections. The 2050 Future Year No-Build post-processed daily growth rates were applied to the existing AM and PM peak hour turning movement volumes. After calculations were completed, the turning movement volumes were further adjusted, as necessary, to account for corridor level balancing at adjacent intersections. After future year volumes were calculated, checks were conducted to ensure that model trends were reflected correctly in the forecasted daily and peak hour turning movement volumes. Based on overall model trends, all study segments are expected to increase in volume over time.

The future year daily and peak hour forecasts will be submitted in conjunction with this technical memorandum as separate volume diagrams.

US 322 Capacity Expansion Test Scenario

During this phase of the project, only the future year no-build scenario was analyzed. However, a US 322 expansion modeling scenario was conducted to analyze the effects of adding capacity along US 322. For this test scenario, the two-lane section between PA 45 and Crowfield Rd/Decker Valley Rd was upgraded so that US 322 operates as a continuous four-lane highway. Results show that the continuity makes US 322 a more attractive route, drawing approximately 16% more combined traffic and approximately 8% more truck traffic. Based on model trends, US 322 is pulling in traffic, which in turn, decreases traffic on adjacent routes such as Brush Valley Rd, PA 45, and PA 144 as traffic shifts over to US 322/I-99. The additional traffic is due to various shifts within the study area. The scenario does not appear to create any latent demand or cause major regional diversions.

[4] *National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design (Chapter 6, pages 106-111)*

Table 5: 2050 Future Year No-Build Daily Traffic Volumes and Growth Rates Comparison

					2017 Base Year (Seasonally Adjusted)			2050 Future Year No-Build (Post Processed per NCHRP 765)			2017 to 2050 Annual Linear Growth Rate (All)	2017 to 2050 Annual Linear Growth Rate (Trucks)	SCCCTS 2001 Needs Report
Site	Location	Roadway Segment	Description	Direction	All	Trucks	Truck %	All	Trucks	Truck %			1999 to 2025 Total Traffic % Increase Per Year (page 84)
Site 1 & 2	A	PA 45	East of PA 144	WB+EB	6,673	778	11.7%	9,050	1,250	13.8%	1.08%	1.84%	4.10%
Site 3	B	Brush Valley Rd	West of Smith Road	WB+EB	629	93	14.8%	1,500	150	10.0%	4.20%	1.86%	
Site 4 & 5	C	PA 144	North of East Wilson St.	SB+NB	9,858	1,528	15.5%	12,650	1,950	15.4%	0.86%	0.84%	1.40%
Site 6	D	PA 192	East of Emery Rd.	WB+EB	2,292	292	12.7%	3,400	350	10.3%	1.46%	0.60%	
Site 7	E	PA 144	South of Harrison Rd.	SB+NB	8,798	1,305	14.8%	12,450	1,700	13.7%	1.26%	0.92%	
Site 8 & 9	F	US 322	East of PA 144	WB+EB	17,157	4,375	25.5%	22,250	5,800	26.1%	0.90%	0.99%	3.40%
Site 10	G	US 322	West of Mountainback Rd	WB+EB	12,793	4,061	31.7%	16,000	5,300	33.1%	0.76%	0.92%	3.60%
Site 11 & 12	H	US 322	West of Oak Hall Interchange	WB+EB	21,886	7,088	32.4%	31,300	8,550	27.3%	1.30%	0.63%	2.60%
Site 13 & 14	I	PA 45	East of Elks Club Rd	EB+WB	7,689	744	9.7%	10,300	1,250	12.1%	1.03%	2.06%	2.70%
Site 15 & 16	J	US 322	East of Laurel Meadow Rd	EB+WB	14,411	2,946	20.4%	17,350	3,900	22.5%	0.62%	0.98%	
Site 17	K	PA 45	West of PA 144	WB+EB	7,502	1,277	17.0%	9,250	1,650	17.8%	0.71%	0.89%	
Site 18	L	US 322	East of US 322 Bypass	WB+EB	16,311	4,768	29.2%	19,550	6,050	30.9%	0.60%	0.81%	
Site 19	M	PA 45	East of Willowbrook Dr	WB+EB	7,831	941	12.0%	10,450	1,450	13.9%	1.01%	1.64%	
Site 20	N	Brush Valley Rd	North of Linden Hall Rd	SB+NB	793	69	8.7%	1,750	150	8.6%	3.66%	3.56%	
Site 21 & 22	O	US 322 (BUS)	East of Church St	WB+EB	11,593	1,642	14.2%	13,350	1,800	13.5%	0.46%	0.29%	3.30%
Site 23	P	PA 45	East of Woodside Dr	WB+EB	5,041	475	9.4%	7,050	550	7.8%	1.21%	0.48%	
Site 24	Q	PA 144	North of Bible Rd	SB+NB	6,499	895	13.8%	9,250	1,300	14.1%	1.28%	1.37%	0.00%
Site 25	R1	US 322	Off Ramp to Boal Avenue (US 322 Bus)	WB	3,334	270	8.1%	3,900	300	7.7%	0.51%	0.34%	
Site 26	R2	US 323	On Ramp from Boal Avenue (US 322 Bus)	EB	3,327	399	12.0%	3,950	450	11.4%	0.57%	0.39%	
Site 27	S1	Old Fort Interchange (US 322 at PA 45)	EB Off Ramp (from US 322 to PA 45)	EB	3,123	224	7.2%	5,050	450	8.9%	1.87%	3.06%	
Site 28	S2	Old Fort Interchange (US 322 at PA 45)	WB On Ramp (from PA 45 to US 322)	WB	3,609	335	9.3%	5,850	650	11.1%	1.88%	2.85%	
Site 29	T	PA 45	Between Old Fort Interchange & US 322 (Bus)	WB+EB	6,857	835	12.2%	8,400	950	11.3%	0.68%	0.42%	
Site 30	U1	Oak Hall Interchange	WB On Ramp	WB	3,170	225	7.1%	5,150	300	5.8%	1.89%	1.01%	
Site 31	U2	Oak Hall Interchange	WB Off Ramp	WB	250	26	10.4%	250	50	20.0%	0.00%	2.80%	
Site 32	U3	Oak Hall Interchange	EB On Ramp	EB	203	31	15.3%	250	50	20.0%	0.70%	1.86%	
Site 33	U4	Oak Hall Interchange	EB Off Ramp	EB	3,540	152	4.3%	5,300	250	4.7%	1.51%	1.95%	
Site 34	V	Warner Blvd	Between Oak Hall Interchange & Boal Ave (US 322 (Bus) / PA 45)	SB+NB	7,596	480	6.3%	9,150	600	6.6%	0.62%	0.76%	
Site 35	W	US 322 (BUS) (Atherton St)	West of Warner Boulevard	EB+WB	13,903	1,054	7.6%	14,900	1,200	8.1%	0.22%	0.42%	

MEMORANDUM

Date: December 20, 2018 (*FINAL VERSION*)

To: Brian St. John
From: Julie Woo
Subject: SCCCTS StreetLight O-D Analysis Tech Memo

CC: Robert Watts

Work Order Number: 35041-002
Contract Number: E03985
Project: SCCCTS – Route 322/144/45 Corridors Data Refresh

The purpose of this memorandum is to: (1) present the methodology for studying the origin-destination (O-D) patterns of traffic along US 322, PA 144 and PA 45, and (2) provide a comparison of truck and automobile travel patterns as noted in previous project work, including *Origin-Destination Survey Results, South Central Centre County Transportation Study, September 1999* (1999 O-D Study) and *South Central Centre County Transportation Study Needs Analysis, April 2001* (2001 Needs Analysis).

Project Background Information

The Traffic Analysis Zone (TAZ) structure from the latest Centre County Travel Demand Model (CCTDM) was used to initiate the zonal work for the StreetLight O-D analysis. Since the TAZ structure was based upon 2010 Census boundaries, further refinements were conducted. Zones were either modified or split to enhance the outcome of the data analysis. Once the zone structure revisions were completed, the zones were then grouped into StreetLight O-D regions to best match the 1999 O-D Study districts for comparison and analysis purposes. The O-D regions mapping was reviewed by McCormick Taylor, and a second iteration of zone splits and modifications was completed before the StreetLight O-D regions were finalized.

However, there are several methodological differences between the 1999 O-D Study and the current 2017 StreetLight O-D Analysis that should be noted (Table 1).

Table 1: Key Differences between 1999 O-D Study & 2017 StreetLight Analysis

Differences	1999 O-D Study	2017 StreetLight O-D Analysis
Data Capture Method	- Roadside study captured travelers through (5) five station locations - Provided postcards to fill out and return - Intercept survey ~ 28% responses	- Smartphone apps track locations of devices - Navigation-GPS data from devices that help people navigate (including connected vehicles & commercial fleet) - Typically captures ~23% for any given area
Truck Classification	- Tractor-trailers - Straight trucks	- Heavy trucks (>26,000 lbs) - Medium trucks (14,000 to 26,000 lbs)
Data Collection Time Frame	- Apr 21 and 30, 1999 (6:00 am to 6:00 pm) - Apr 22, 1999 (7:30 am to 6:00 pm)	- Jan to May 2016, Sept to Oct 2016 (all hours) - Calculated weekday average for Mon to Thurs - Sampled larger time span for more consistent outcome & averaged longer time period
Mechanics	- Direct # of trips for autos & trucks	- Index value (due to privacy concerns & use of different data providers) - Trips analyzed in terms of % between or through regions and stations

StreetLight Data Background Information

As a brief background into StreetLight Data and its sources, the company was established in 2011 and provides an on-demand mobility analytics platform to perform a variety of transportation related analyses using "Big Data". Data sources include information from navigation analytics firm INRIX, fitness trackers, weather apps, and any other apps that have location components (approximately 300 total). Some analyses use location-based services data, while others use navigation-GPS data. For the O-D analysis, navigation-GPS data was used, which is collected from smart phones with navigation guidance apps. The data capture rate has improved to approximately 23% for any given area (compared to the 10-15% capture rate from April 2018). To protect user privacy, all personal information is removed, and only a randomized device number is provided as the reference. Using this data, a series of metrics is made available to the user, depending on the agreement type and the level of detailed analyses that is needed.

Regarding accuracy and precision, StreetLight provides a series of case studies on their website from both private and public sectors. In one particular case study related to trucks at the Port of Virginia, StreetLight results were compared to VDOT truck counts for model validation purposes. It was determined that the truck data was fairly similar, and the StreetLight platform was able to provide the tools and insights for a better understanding of truck travel behavior patterns. The agency recognized that the traditional data collection method of truck driver surveys usually resulted in lower response rates and reporting errors, so the option was not considered for the project.

It should also be noted that "Big Data" sources are now being used by all states to monitor system performance. FHWA designated National Performance Management Research Data Set (NPMRDS) as the preferred baseline dataset to help establish basement performance targets. The detailed travel time data used is also sourced by INRIX.

StreetLight Parameters Setup

The StreetLight O-D Analysis was set up in an enhanced manner to capture extensive data. Data setup was customized to fit the needs of the analysis, with specific parameters including data period, trip type, day type, and time of day. StreetLight is a "Big Data" resource with records dating back to 2014, enabling a larger time span sampling for all hours of the day. The intercept survey methodology is typically limited by the data collection time frames, which is usually only a few days of the year for a 12-14 hour time span. With access to data during all months of the year using StreetLight, it provided a more consistent outcome due to the larger sample size. Analysis included the use of data for all non-seasonal months (January-May, September, & October) for average weekday trips (Monday-Thursday) during a full 24-hour time period for each day. For StreetLight data extraction, the following parameters were used to compile project specific data (Table 2*).*

Table 2: StreetLight Data Parameters

StreetLight Parameters	Parameter Details
Project Type	O-D Analysis with Middle Filter (GPS Data)
Premium Add-On Metrics	Premium Trip Attributes
Date Period	2016: [1,2,3,4,5,9,10] *[Jan to May, Sept to Oct]*
Trip Type	Locked to Route
Day Type	0: Average Day (M-Su) 1: Average Weekday (M-Th) 2: Average Weekend Day (Sa-Su)
Day Part	0: All Day (12am-12am) 1: Early AM (12am-6am) 2: Peak AM (6am-9am) 3: Mid-Day (9am-3pm) 4: Peak PM (3pm-6pm) 5: Late PM (6pm-12am)
Commercial Vehicle Weight Classes	Medium Trucks, Heavy Trucks

StreetLight O-D Analysis Set Up

Site Station Locations

Site stations were approximated based on the data collection locations noted in the 1999 O-D Study. Figure 1 shows the StreetLight O-D collection locations, which match the sites where postcards were distributed in the previous study. A shape file was developed and used to assemble project related data, resulting in a precise location analysis.

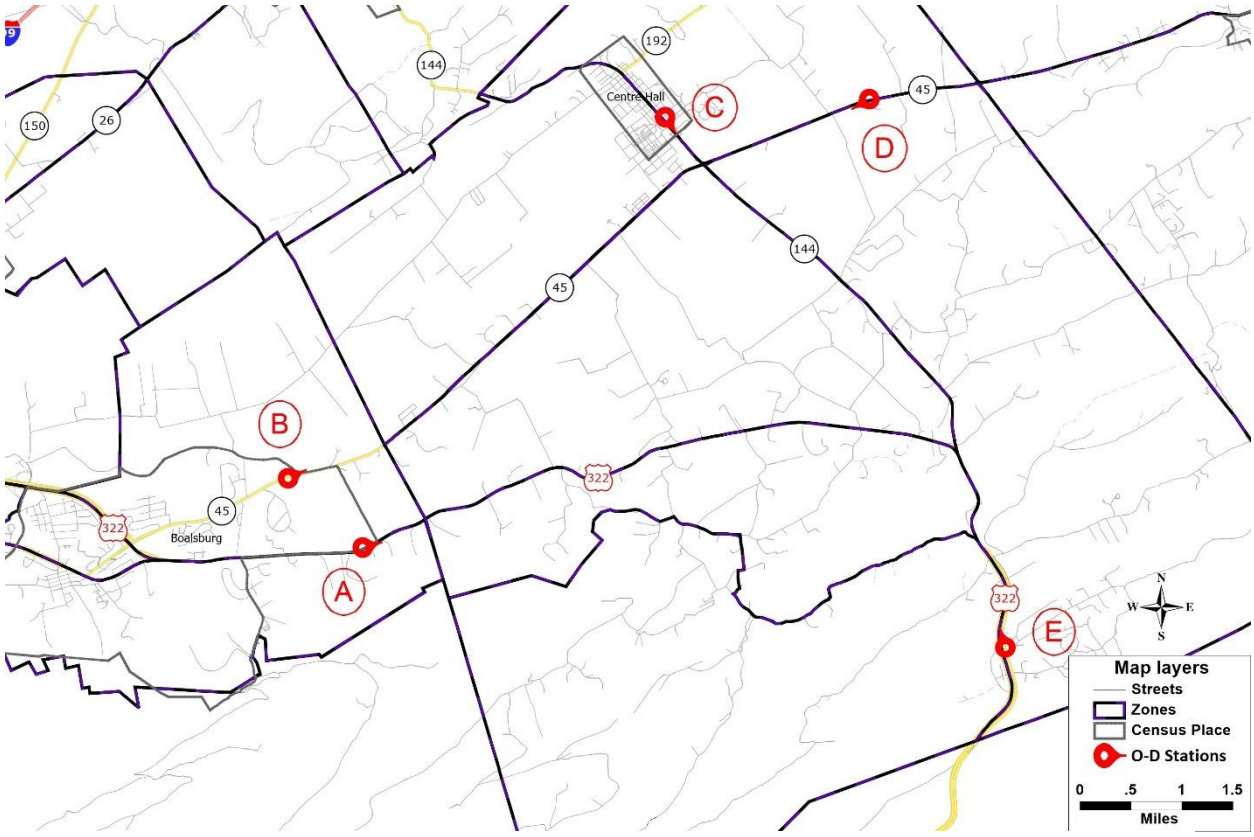


Figure 1: Site Station Locations

StreetLight O-D Analysis Regions

The refined zones from the CCTDM were used as the starting point for the O-D analysis. The zones were aggregated into StreetLight O-D regions to best match the 1999 O-D Study districts for comparison and analysis purposes. In the previous study, the O-D districts were categorized as follows:

- Zones in SCCCTS Study Area (Zones 1-4)
- Zones Outside of SCCCTS Study Area in Pennsylvania (Zones 5-14)
- Zones Outside of Pennsylvania (Zones 21-24, 71-73)

Also carried over from the 1999 O-D Study, "local" trips were defined as those who have an origin and/or destination within the study area, while "through" trips were defined as those that have neither an origin nor destination within the defined study area. Initially, the defined study area included the following districts: (1) Pleasant Gap Area, (2) Centre Hall Area, (3) Potters Mills Area, and (4) Boalsburg Area. Further analysis showed that the State College Area was the most popular origin and destination for automobiles traveling on US 322, PA 144, and PA 45 in the county. As a result, the State College Area was later included as part of the O-D study area.

A side-by-side comparison of the 1999 O-D districts and 2017 StreetLight O-D regions is shown in the next series of figures. Figure 2 shows the O-D study area used for both studies (internal zones highlighted in blue for StreetLight setup). Figure 3 shows the immediate "Zones Outside Study Area in Pennsylvania" within Centre County. The distinction for the two separate 2017 maps in Figure 3 is illustrating how the zones used for the StreetLight analysis were aggregated to reflect the combined local areas that were used in the original 1999 O-D Study. Figures 4 and 5 also show "Zones Outside Study Area in Pennsylvania", with closer and zoomed out statewide views to show the correlation between area names, zone numbers, and study areas.

For the purposes of this analysis, two things should be noted:

- The StreetLight O-D regions in the defined study area were identified as Internal Capture Zones (local traffic) and External Zones (through traffic) to correspond with the previous O-D study area boundaries, which also includes the State College Area.
- The StreetLight O-D analysis only extends to the Pennsylvania state boundaries. To capture trips from outside Pennsylvania regions, pass through gates were created at various locations along the state boundary. These pass through gates are also shown in Figure 5.

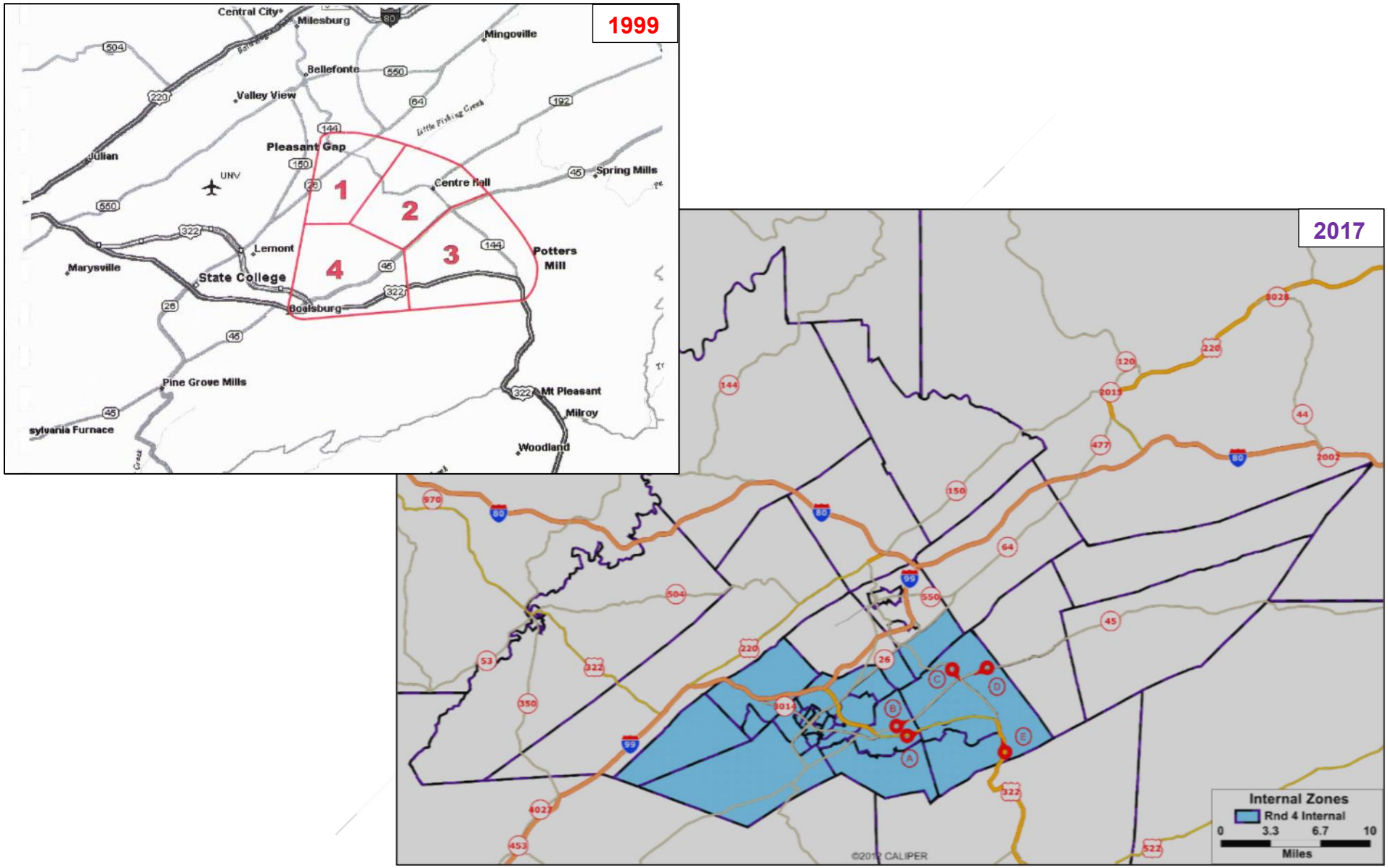


Figure 2: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones in Study Area

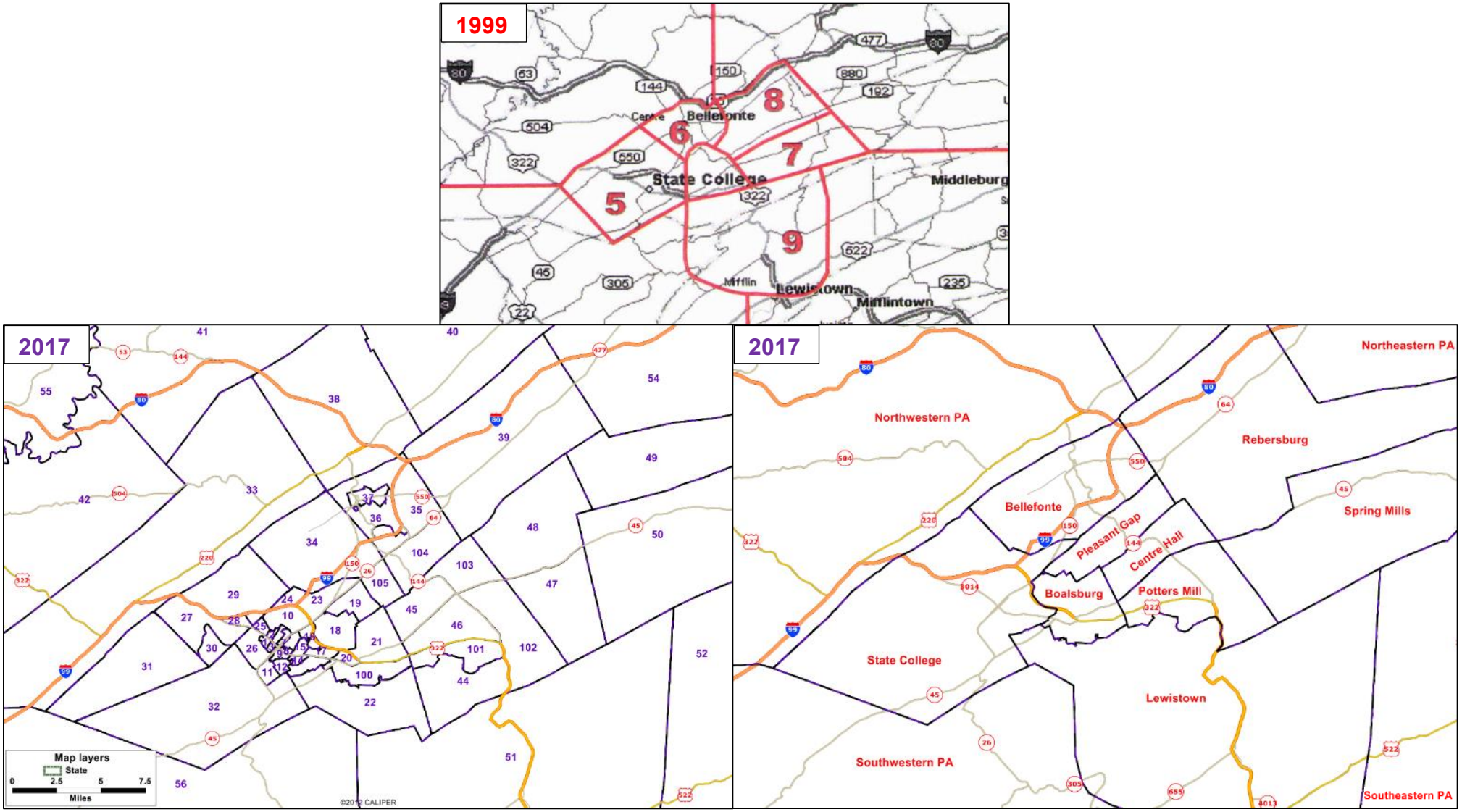


Figure 3: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Centre County)

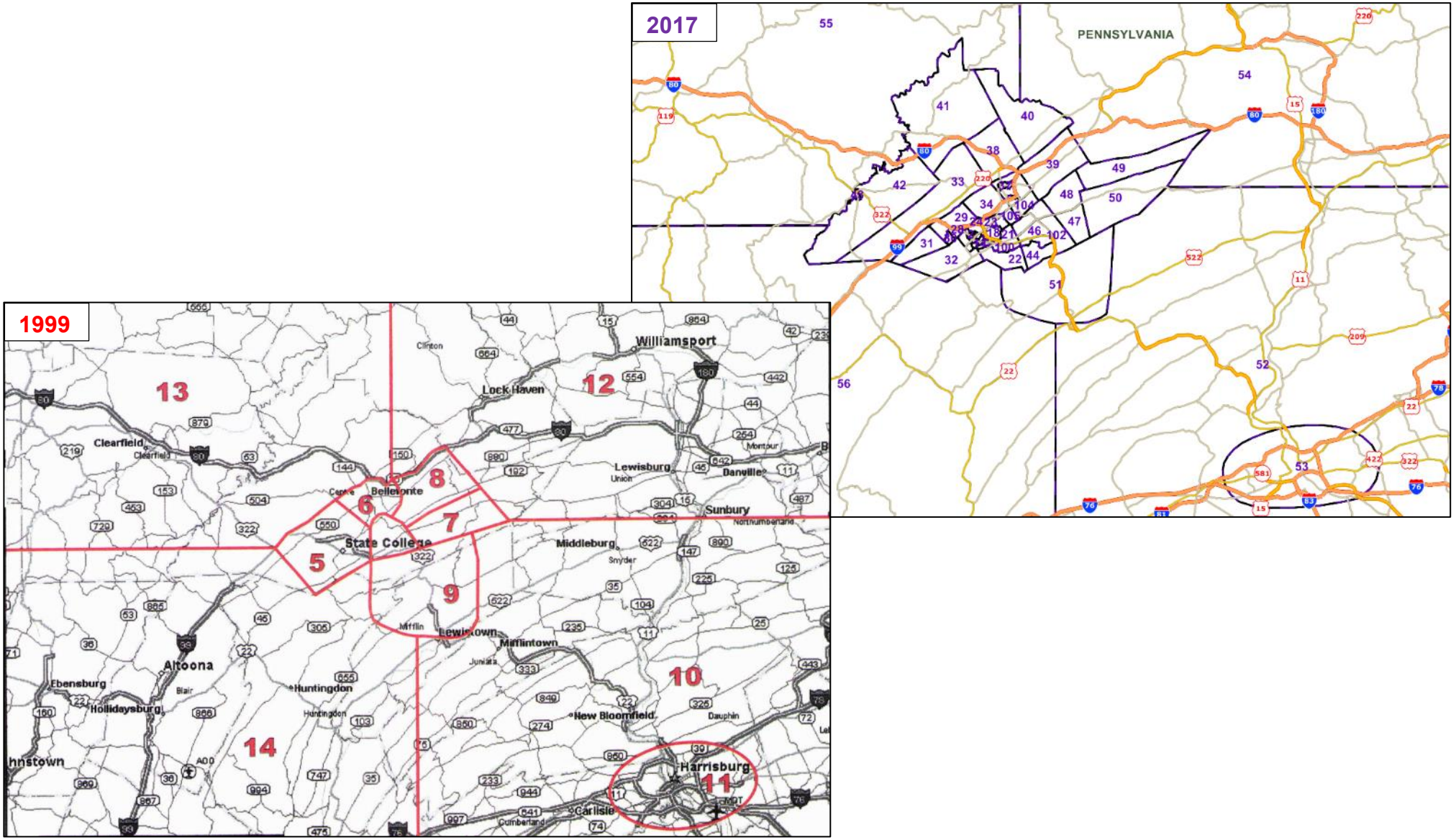


Figure 4: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Statewide Close-Up)

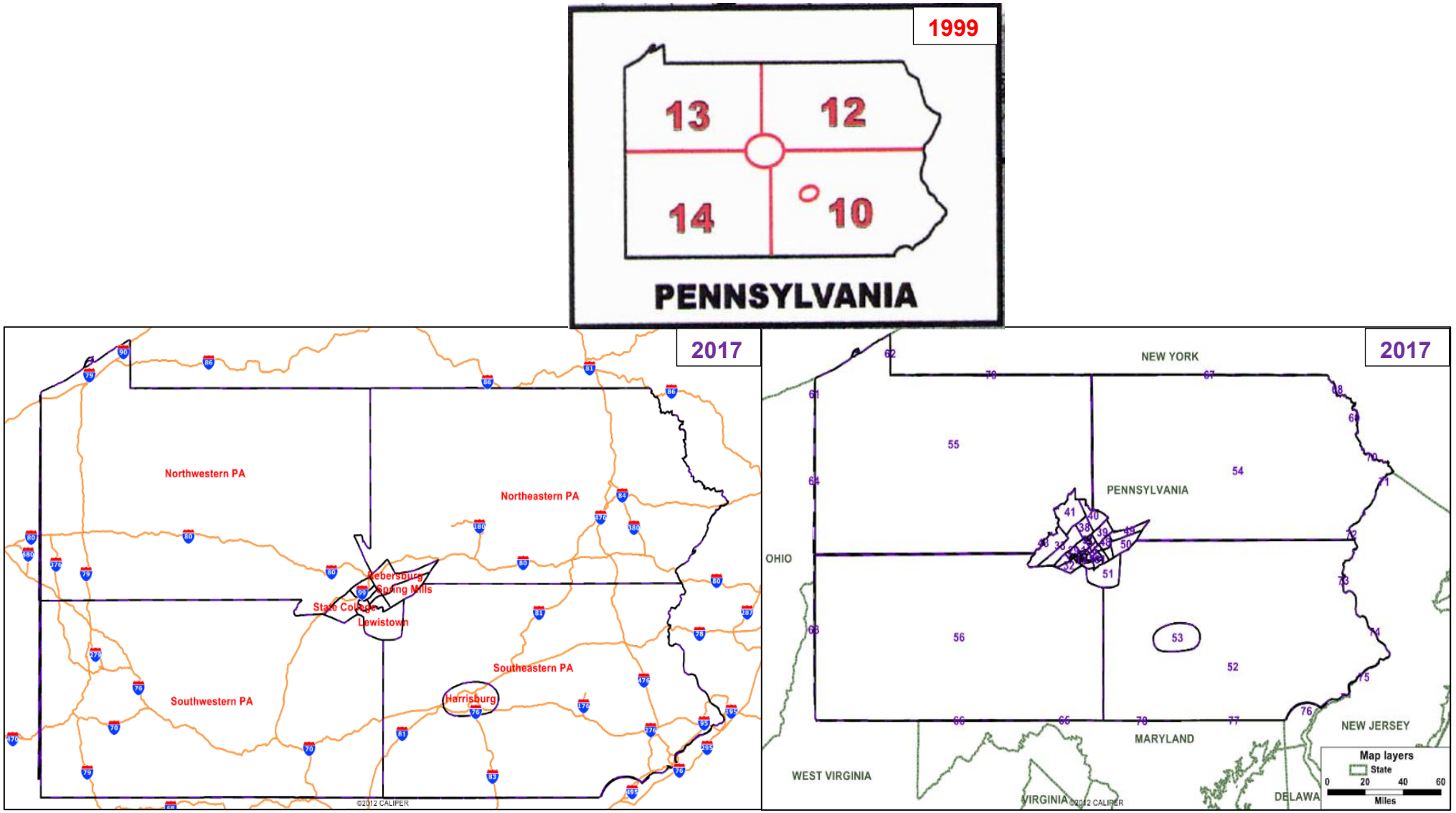


Figure 5: 1999 O-D Study Districts & 2017 StreetLight O-D Analysis Regions – Zones Outside of Study Area in Pennsylvania (Complete Statewide View)

To provide further clarification regarding the naming convention and related details between the 1999-O-D Study and the 2017 StreetLight O-D Analysis, Table 3 shows the following:

- The origin-destination areas used for both studies
- The zone numbers that correspond with the O-D districts / regions from both studies
- How zones were grouped to form StreetLight O-D regions and best match 1999 O-D Study district boundaries
- The naming convention for each O-D district / region

Table 3: Origin-Destination Areas Comparison

Origin / Destination Areas (1999 O-D Districts and StreetLight O-D Regions)	1999 OD-Study		StreetLight O-D Analysis	
	O-D Study Area (Local vs Through Traffic)	Zone #	O-D Study Area (Local vs Through Traffic)	Zone #
Pleasant Gap	Zones in Study Area (Local Traffic)	1	Internal Capture Zones (Local Traffic)	19, 104, 105
Centre Hall		2		45, 103
Potters Mills		3		46, 101, 102
Boalsburg		4		18, 20, 21, 100
State College		5		1-17, 23-32
Lewistown	Zones Outside of Study Area (Through Traffic)	9	External (w/ small portion Internal)*	22, 44, 51
Bellefonte		6	External Zones (Through Traffic)	34-37
Spring Mills		7		47, 50
Rebersburg		8		39, 48, 49
Southeastern PA		10		52
Harrisburg		11		53
Northeastern PA		12		40, 54
Northwestern PA		13		33, 38, 41-43, 55
Southwestern PA		14		56

**Note: For the StreetLight O-D Analysis, the northern portion of the Lewistown Area just south of US 322 was included in the O-D study area as local traffic.*

Data Analysis & Findings

Several iterations of zone groupings were performed and analyzed to best correlate with the 1999 O-D Study district boundaries. As the StreetLight O-D regions were adjusted and refined each time, StreetLight model test runs were conducted to ensure that the distribution of local and through traffic made sense. By the end of the process, the final StreetLight O-D regions were set up in a manner to measure the same routes at the same locations, which provides a comparable evaluation of results between both studies. A small portion of Lewistown Area just south of US 322 was also included as part of the study area to be analyzed as a local traffic component.

A comparative evaluation of results can be conducted. However, the differences in data capture methods, data collection time frames, and the mechanics of the data (see Table 1) should be taken into consideration as part of the comparison between studies and the interpretation of results.

Regarding the differences in data capture methods and data collection time frames, the previous study collected data in the form of an intercept survey and the current analysis uses navigation-GPS data. The intercept survey was conducted at (5) five different site locations within the defined study area, where travelers were provided forms to fill out and return regarding their travel information. The survey period was conducted over the course of three days for a 12-hour span, which included AM, MIDDAY and PM peak hour periods. The navigation-GPS data used in StreetLight is processed into trips & activities to help provide an understanding of trip types from data collected by navigation applications. More than 28 billion data points are collected per month, which is an added benefit of using a “Big Data” resource. For the purposes of the O-D analysis, the study period was for all non-seasonal months (January-May, September, & October) for average weekday trips (Monday-Thursday) during a full 24-hour time period for each day.

The intercept survey had an approximate response rate of 28%, while the StreetLight data generally captures between 10-15% for any given area. While the percentage rate is lower than the previous study, the data used for the analysis consisted of a much larger sample size - the difference being three partial days versus (7) seven months of data covering a full 24-hour period over multiple weekdays. Larger sampling sets of this nature provide a higher level of confidence by smoothing out non-typical trips that are inevitably captured and included as part of the data collection process.

Regarding the mechanics of the data, the previous study was able to summarize truck and automobile trips as direct counts, and also were reported as percentages between origin and destination districts. Due to privacy regulations and the use of different data providers, the StreetLight data is typically reported as an index value. This index value is the aggregation of the readings, or hits, from BlueTooth or related devices that travel across the site location and can then be traced to the origin and destination of that device. Therefore, trips for the StreetLight O-D analysis were analyzed in terms of percentages between regions or stations. So although not exact data methodologies, the results can be viewed as reasonable approximations for comparable study areas, with a focus on the relative percentages between origin and destination regions.

After a series of zone aggregation iterations, data extraction, and comparisons to previous project work, this memorandum will present the following findings:

- Comparison of Traffic Counts for Site Station Locations
- Comparison to 2001 Needs Analysis Key Findings (Section XIII: Regional Travel Patterns)
- Comparison to 2001 Needs Analysis O-D Results Overview (Section VIII: Traffic Studies)

Comparison of Traffic Counts for Site Station Locations

In addition to the O-D analysis, a comparison of traffic counts for the key sites was compiled to help determine any changes in traffic volumes (and potentially travel patterns) over the years. The traffic counts comparison for routes along the O-D collection sites are shown in Table 4.

Table 4: Traffic Counts Comparison for Routes Along O-D Collection Sites

Route	O-D Collection Site	Year							
		2000	2005	2008	2009	2010	2015	2016	2017*
US 322	A	10000	12000	12000	12000	12000	10000	10000	15,359
PA 144	Between PA 45 & US 322	4100	5400	4200	4200	4200	4900	4800	6,499
PA 144	C	9300	14000	14000	11000	11000	10000	9900	9,858
PA 45	B	7600	7500	7400	6100	7000	6400	6200	7,689
PA 45	D	4900	5800	5200	5200	5200	5400	6400	6,673
US 322	E	13000	14000	13000	14000	14000	15000	17000	19,748
I-99					16000	29000	31000	33000	

**Note: Reflects seasonally adjusted ADT volumes from SCCCTS Data Refresh data collection efforts in 2017*

The bi-directional traffic count data for years 2000 to 2016 were obtained from the Historical Statewide Traffic Volume Maps on the PennDOT website. The seasonally adjusted 2017 ADT volumes that were collected for the SCCCTS Data Refresh project were also included for comparison purposes. Most of the corridors along the O-D collection sites are showing positive traffic growth. The only location that appears to have either nominal or decreasing trends is PA 144 (Site C). Traffic patterns also show steady growth along the I-99 corridor after construction was completed. The growth on reflects the increase of through trips through Centre County and a shift in traffic from PA 45 and PA 144 to the I-99 corridor.

Comparison to 2001 Needs Analysis Key Findings (Section XIII: Regional Travel Patterns)

In the 2001 Needs Analysis, key findings for regional travel patterns were noted in Section XIII of the report. The following figures are excerpts from the 2001 Needs Analysis showing the key movements for tractor trailers (Figures 6 - 7), straight trucks (Figures 8 -9), and automobiles (Figures 10-13). For comparison purposes, the 2017 StreetLight O-D percentages for heavy trucks, medium trucks, and autos were added (shown in red) to the corresponding figures.

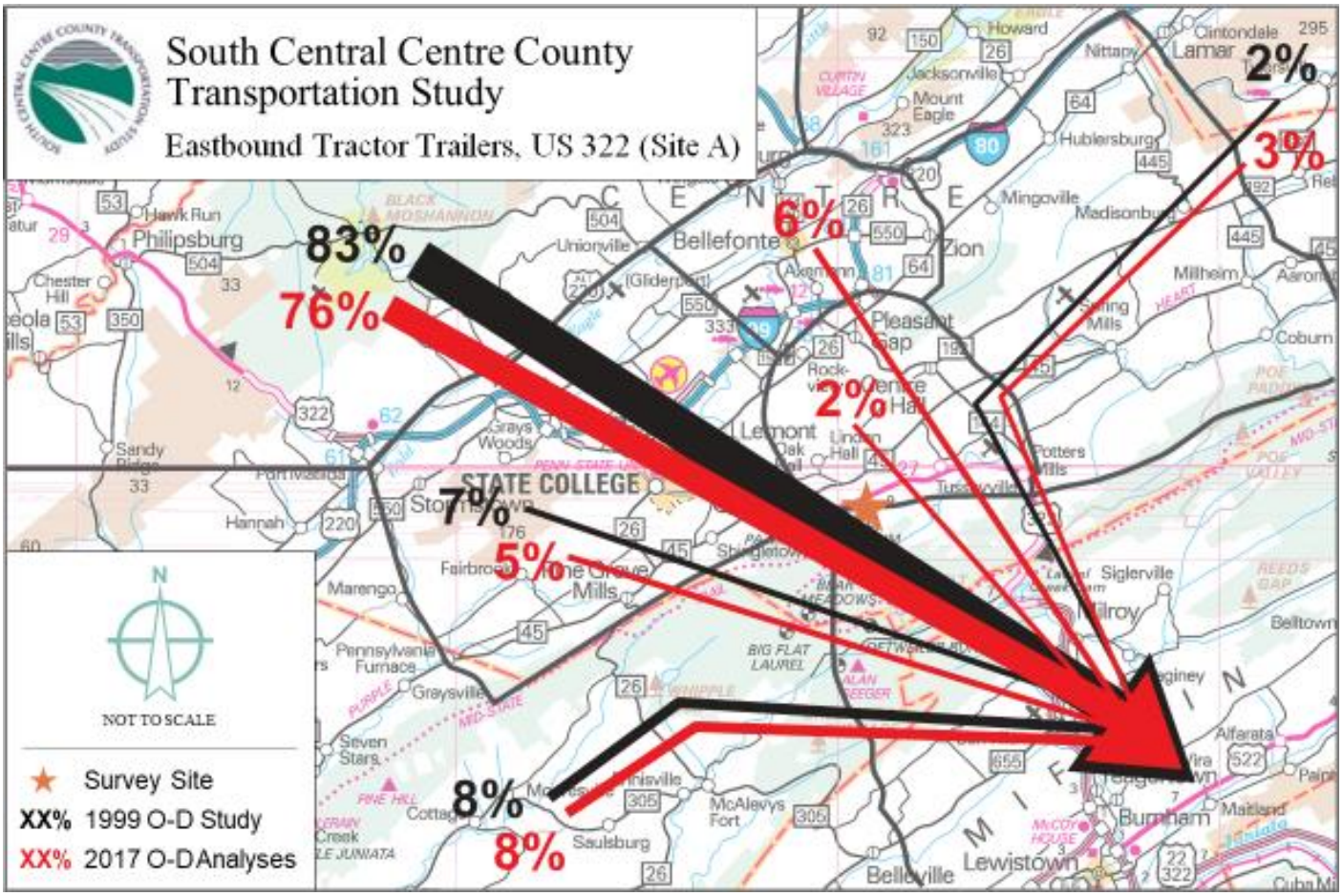


Figure 6: Eastbound Tractor Trailers, US 322 (Site A) Comparison

For tractor trailers on US 322 EB (Site A), heavy truck travel patterns are very similar between the two studies, with a majority of traffic coming from the Northwestern PA region. For 2017, additional truck traffic from the Bellefonte and Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas were noted, as well.

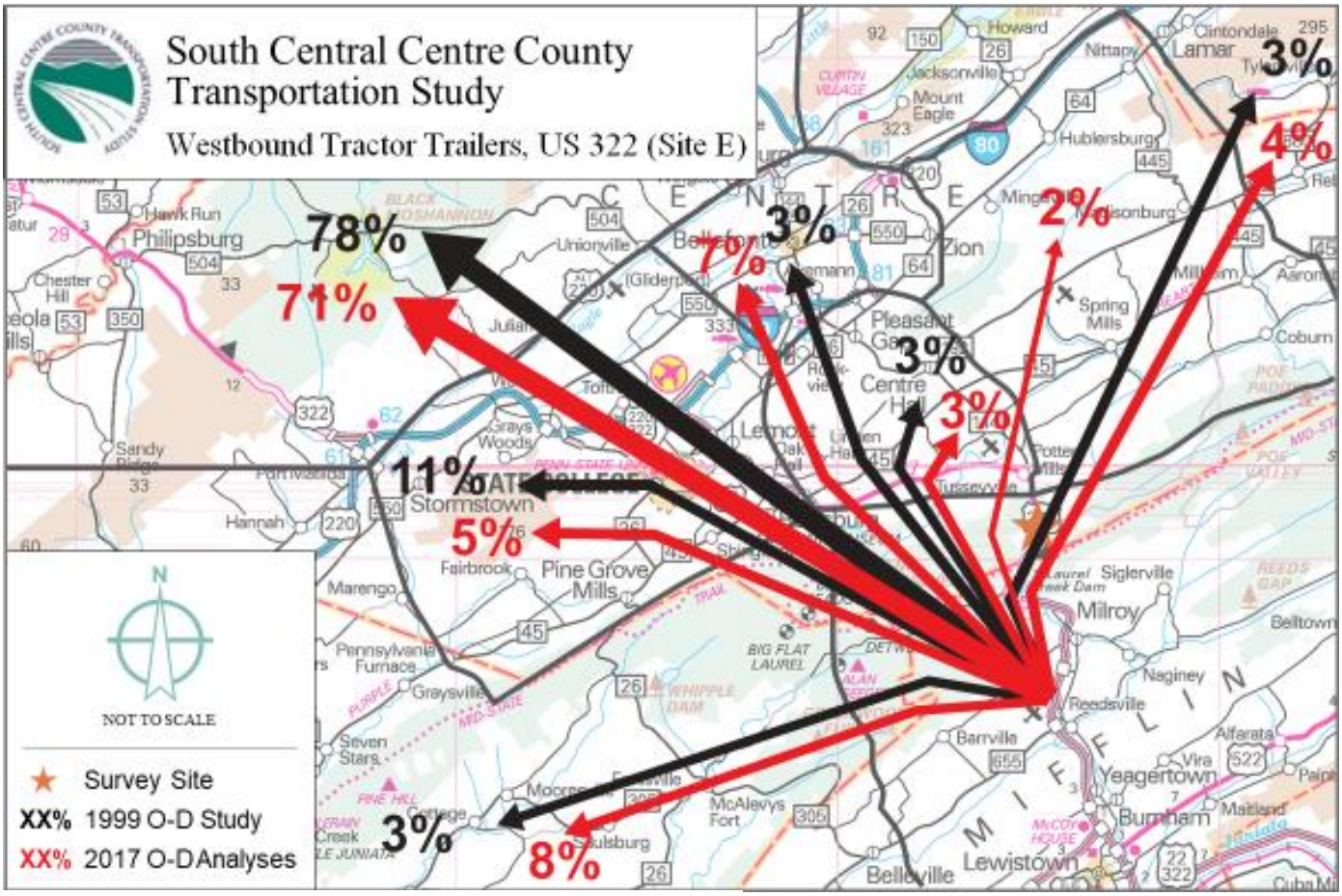


Figure 8: Westbound Tractor Trailers, US 322 (Site E) Comparison

For tractor trailers on US 322 WB (Site E), heavy truck travel patterns are very similar between the two studies, with the majority of traffic traveling towards the Northwestern PA region. For 2017, additional truck traffic is headed towards the Rebersburg area.

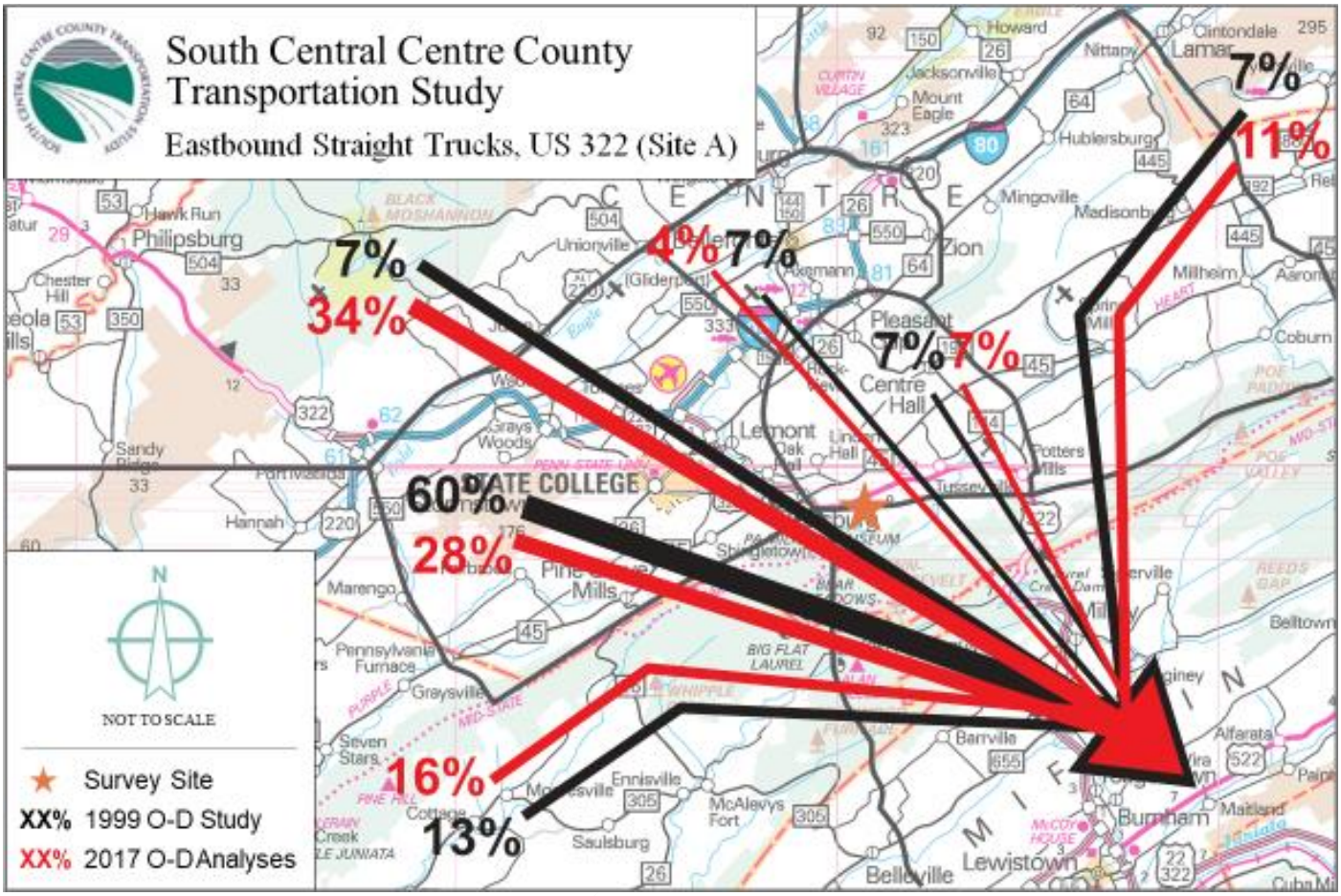


Figure 9: Eastbound Straight Trucks, US 322 (Site A) Comparison

For straight trucks on US 322 EB (Site A), key changes noted for medium truck travel patterns in 2017:

- 32% fewer trucks traveling from State College area and 28% more traveling from Northwestern PA region.
- All other areas noted from the 2001 Needs Analysis are showing nominal changes.

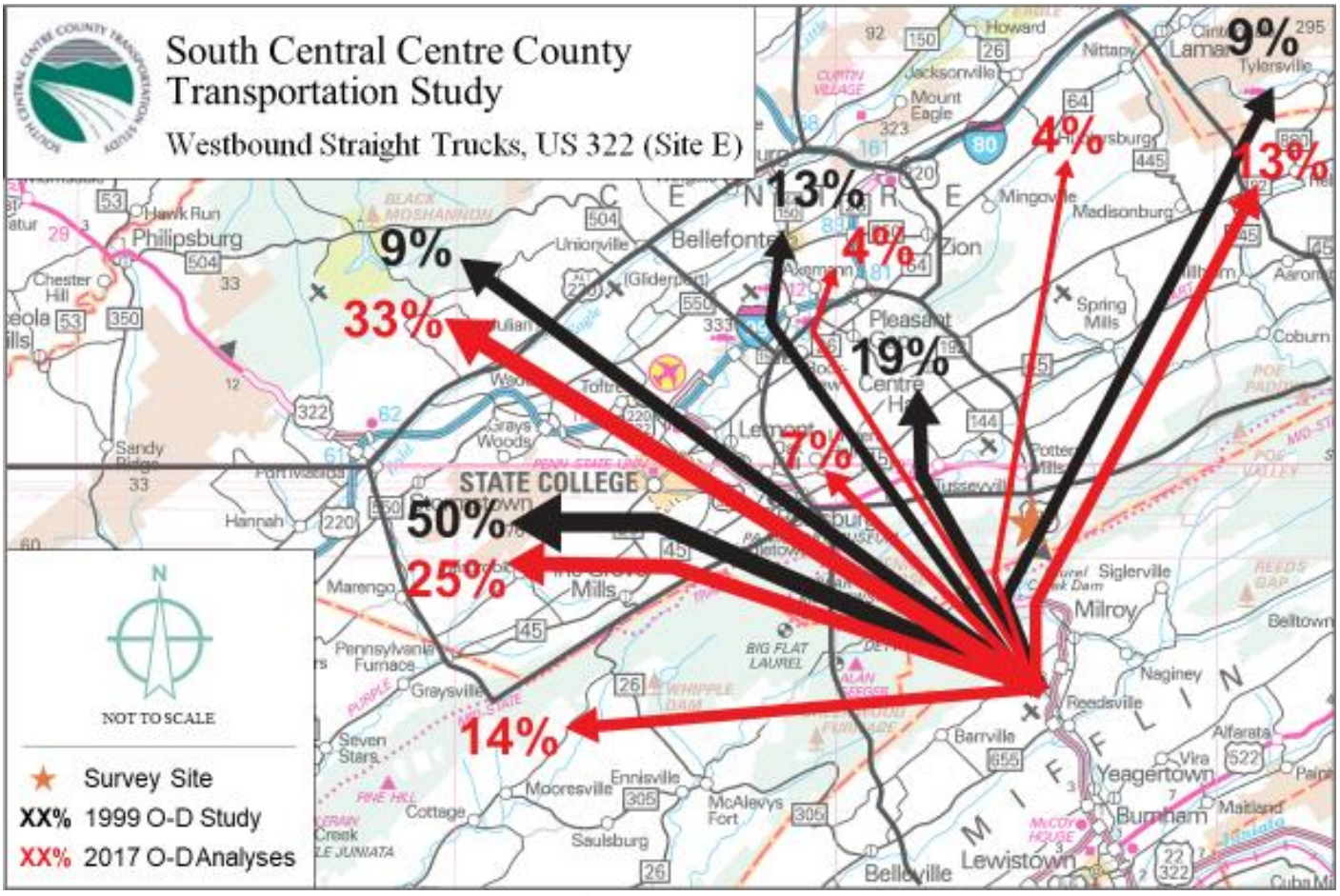


Figure 10: Westbound Straight Trucks, US 322 (Site E) Comparison

For straight trucks on US 322 WB (Site E), the following key changes are noted for medium truck travel patterns in 2017:

- 25% fewer trucks traveling to State College area and 26% more traveling to Northwestern PA region.
- All other areas noted from the 2001 Needs Analysis are showing smaller changes.
- Additional truck traffic is headed to the Southwestern PA region and the Rebersburg area.

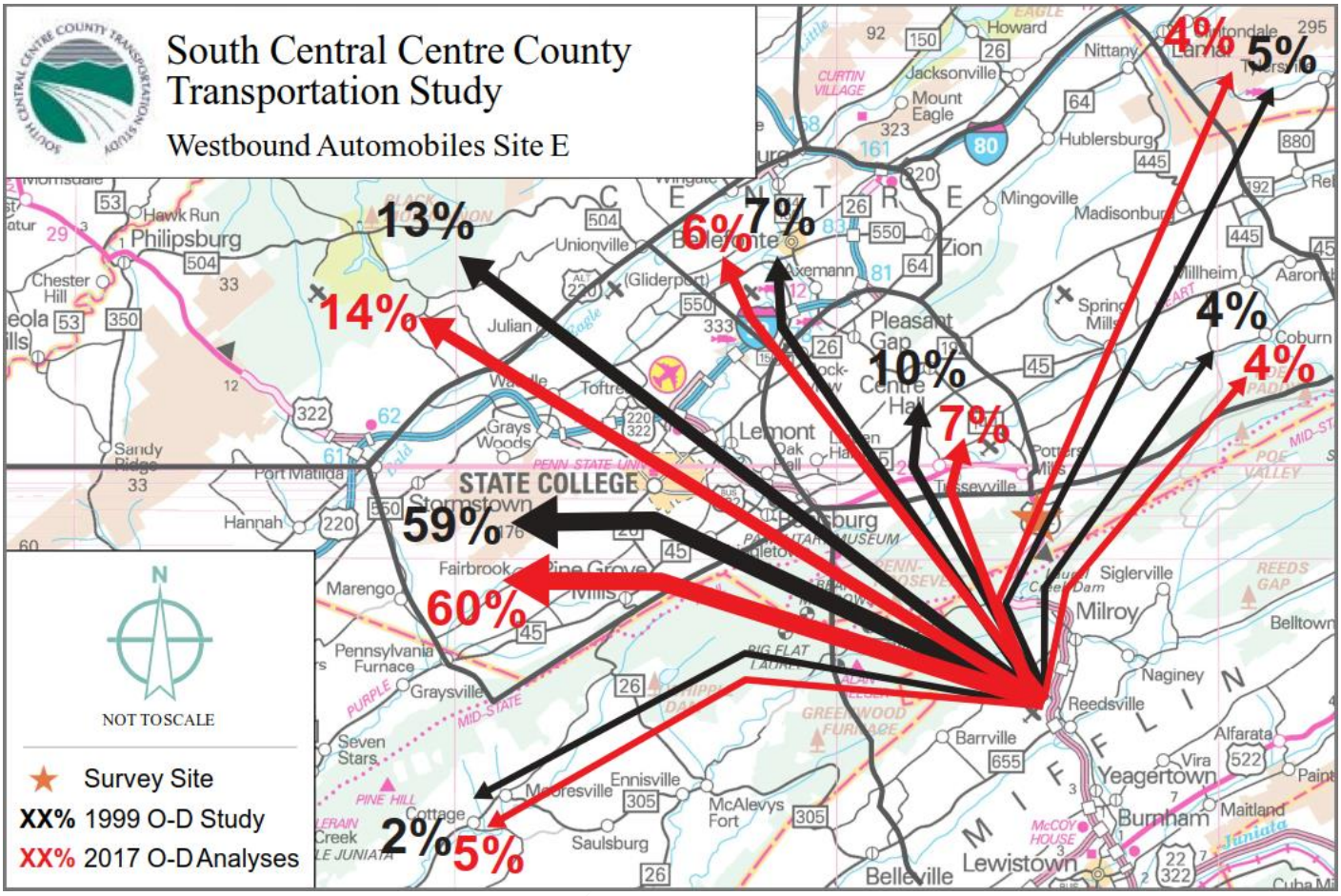


Figure 11: Westbound Automobiles, US 322 (Site E) Comparison

For automobiles on US 322 WB (Site E), travel patterns are very similar between the two studies.

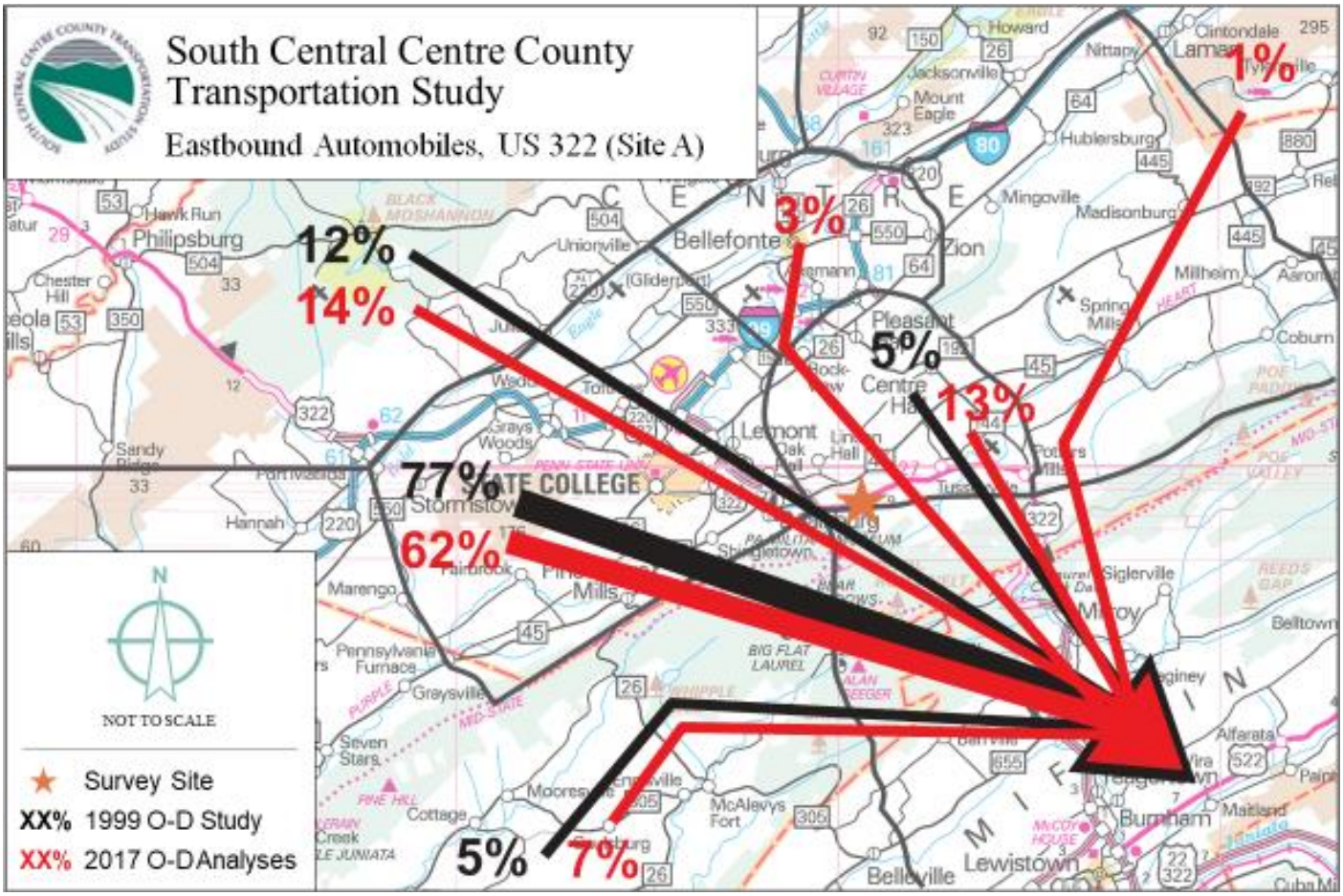


Figure 12: Eastbound Automobiles, US 322 (Site A) Comparison

For automobiles on US 322 EB (Site A), the following changes are noted for travel patterns in 2017:

- 15% fewer cars traveling from State College area.
- 2% more cars traveling from Northwestern PA region and 8% more from Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- Additional auto traffic is traveling from Bellefonte area and Northeastern PA region.

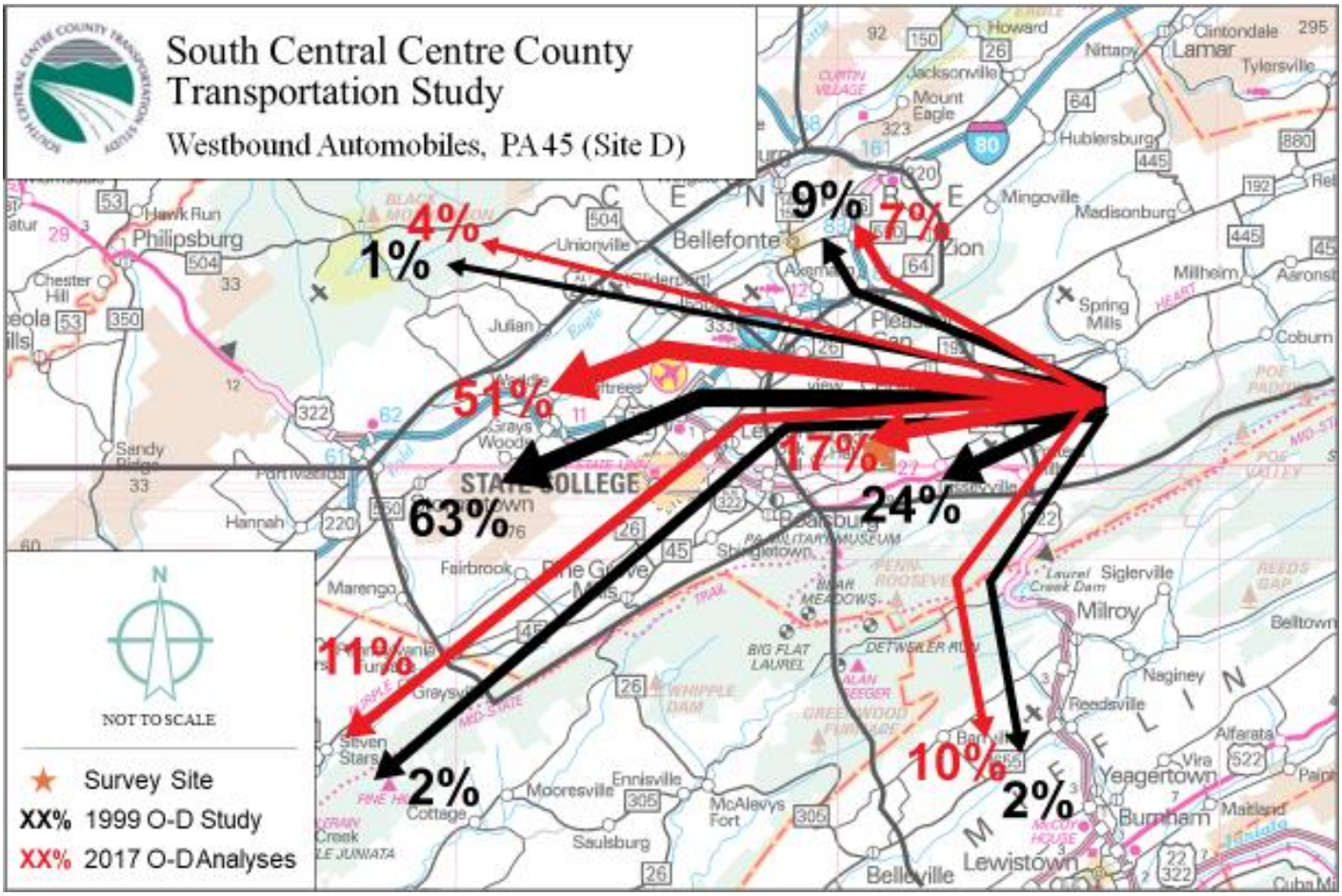


Figure 13: Westbound Automobiles, PA 45 (Site D) Comparison

For automobiles on PA 45 WB (Site D), the following changes are noted for travel patterns in 2017:

- 12% less cars traveling to State College area and 7% less to Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- 9% more cars traveling to Southwestern PA region and 8% more to Southeastern PA region.
- All other areas noted from the 2001 Needs Analysis are showing nominal changes.

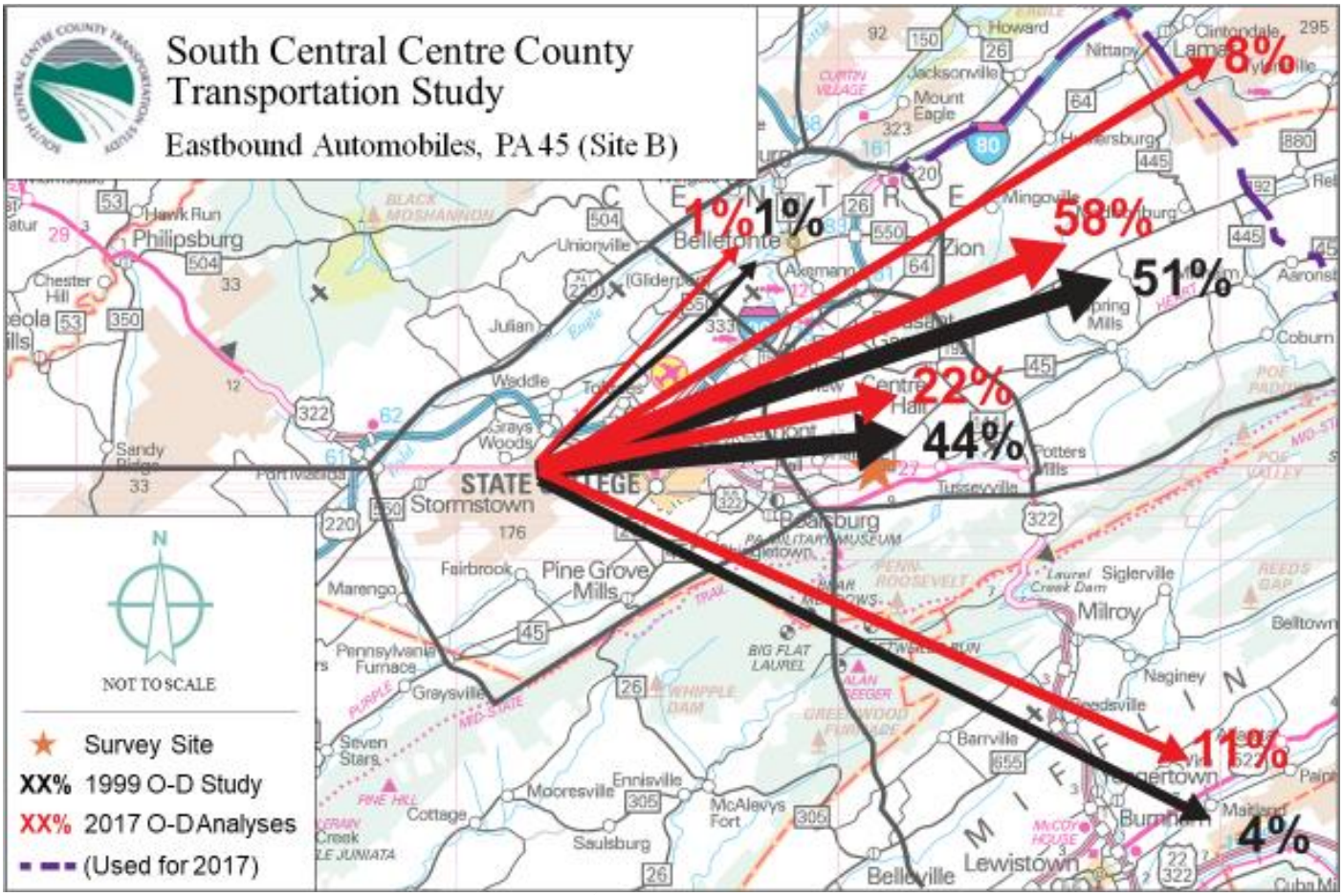


Figure 14: Eastbound Automobiles, PA 45 (Site B) Comparison

For automobiles on PA 45 EB (Site B), the following changes are noted for travel patterns in 2017:

- 22% fewer cars traveling to the Pleasant Gap / Centre Hall / Potters Mills / Boalsburg areas.
- 7% more cars traveling to Spring Mills and Rebersburg areas and 7% more to the Southeastern PA region.
- Additional car traffic is traveling to Northeastern PA region.

Comparison to 2001 Needs Analysis O-D Results Overview (Section VIII: Traffic Studies)

An overview of O-D results shown in Section VIII of the 2001 Needs Report was summarized from the 1999 O-D Study. A comparison between these results and 2017 StreetLight O-D analysis is shown in Table 5 for trucks and Table 6 for autos. The tables show the traffic percentages and differences at Stations A through E for the following trip types:

- External to External (E-E) trips – Through traffic
- Internal to Internal (I-I) trips – Local traffic traveling within the study area
- External to Internal (E-I) or Internal to External (I-E) trips – Local traffic traveling to / from the study area

Table 5: Truck O-D Summary & Comparison

1999 O-D Survey								2017 StreetLight Analysis (includes refined zones)[1]								Difference (2017 StreetLight O-D Analysis vs 1999 O-D Survey)							
Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	Truck Type	% of Truck Traffic	E-E Trips	I-I Trips	E-I or I-E Trips	
US 322	Site A (EB) + Site E (WB)	TT	65%	90%	1%	12%		US 322	Site A (EB) + Site E (WB)	H	74%	89%	0%	11%		US 322	Site A (EB) + Site E (WB)	H	9%	-1%	-1%	-1%	
		ST	35%	36%	4%	59%				M	26%	64%	1%	35%				M	-9%	**28%**	-3%	**-24%**	
PA 144	Site C	TT	9%					PA 144	Site C	H	14%	59%	1%	40%		PA 144	Site C	H	5%	**59%**	1%	**40%**	
		ST	88%	59%	12%	29%				M	86%	50%	18%	32%				M	-2%	-9%	6%	3%	
PA 45	Site B (EB)	TT	65%					PA 45	Site B (EB)	H	24%					PA 45	Site B (EB)	H	**-41%**				
		ST	35%							M	76%							M	**41%**				
	Site D (WB)	TT	28%						Site D (WB)	H	21%						Site D (WB)	H	-7%				
		ST	72%							M	79%							M	7%				
	Total B + D	TT		53%	14%	40%			Total B + D	H		50%	12%	37%			Total B + D	H		-3%	-2%	-3%	
		ST		43%	9%	48%				M		46%	12%	42%				M		3%	3%	-6%	

Note1: Selected zones to match O-D Zones 1-5 for comparison to Scenario 2 from original study.
Abbreviations: Directions [EB = Eastbound, WB = Westbound]
Truck Types [TT=Tractor Trailer, ST=Straight Truck, H=Heavy Truck (>26,000 lbs), M=Medium Truck (14,000 to 26,000 lbs)]
Trip Types [E-E Trips = External to External Trips, I-I Trips = Internal to Internal Trips, E-I or I-E Trips = External to Internal or Internal to External Trips]

In general, the percentage breakdown of all trip types compares well for most stations between both studies, indicating similar travel patterns over the last 18 years. The biggest changes are along PA 45 EB (Site B), where heavy truck traffic has decreased, and medium truck traffic has taken its place over time. Another new truck trend for 2017 is that more medium truck traffic is using US 322 as a through route, rather than making a stop within the study area.

Key findings and specific details for truck travel patterns are noted below:

- US 322 EB (Site A) & US 322 WB (Sites E) show the most significant change for medium trucks. Through traffic has increased by 28% while local traffic traveling to / from the study area has decreased by 24%.
- PA 144 (Site C) shows a large variance for E-E and E-I or I-E trips, however the original survey did not breakdown data by truck type. Comparing those trips to the medium trucks splits, these percentages match relatively well.
- PA 45 EB (Site B) truck percentage differences should be noted. The percentages for heavy and medium trucks have essentially flipped. The most likely cause of this shift can be attributed to the opening of I-99 and heavy truck traffic re-routing to take advantage of the new facility.

Table 6: Auto O-D Summary & Comparison

1999 O-D Survey						2017 StreetLight Analysis (includes refined zones)[1]						Difference (2017 StreetLight O-D Analysis vs 1999 O-D Survey)					
	Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips		Route	Site	E-E Trips	I-I Trips	E-I or I-E Trips
	US 322	Site A (EB) + Site E (WB)	26%	7%	68%		US 322	Site A (EB) + Site E (WB)	26%	4%	70%		US 322	Site A (EB) + Site E (WB)	0%	-3%	2%
	PA 144	Site C	34%	23%	48%		PA 144	Site C	35%	20%	45%		PA 144	Site C	1%	-3%	-3%
	PA 45	Site B (EB)	15%	35%	55%		PA 45	Site B (EB)	12%	43%	53%		PA 45	Site B (EB)	-3%	8%	-2%
		Site D (WB)		4%	77%			Site D (WB)		1%	71%			Site D (WB)		-3%	-6%

Note1: Selected zones to match O-D Zones 1-5 for comparison to Scenario 2 from original study.
Abbreviations: Directions [EB = Eastbound, WB = Westbound]
Truck Types [TT=Tractor Trailer, ST=Straight Truck, H=Heavy Truck (>26,000 lbs), M=Medium Truck (14,000 to 26,000 lbs)]
Trip Types [E-E Trips = External to External Trips, I-I Trips = Internal to Internal Trips, E-I or I-E Trips = External to Internal or Internal to External Trips]

The percentages for automobile trip types are showing nominal differences since 1999. So even through general traffic volumes have increased over time and truck volumes have doubled on certain portions of US 322, the comparison indicates little to no changes for automobile traffic patterns.

Key findings and specific details for automobile travel patterns are noted below:

- Local traffic traveling within the study area has decreased by 3% for US 322 EB (Site A), US 322 WB (Site E), and PA 45 WB (Site D)
- Local traffic traveling to / from the study area have:
  - Increased on US 322 (Site E) by 2%
  - Decreased on PA 144 (Site C) and PA 45 EB (Site B) by 3% and 2%, respectively
- Through traffic patterns show that changes are within (+/-) 3% for all O-D sites
- Relatively speaking, locations with the largest changes in automobile travel patterns are:
  - PA 45 EB (Site B), with an 8% increase for local travel within the study area
  - PA 45 WB (Site D) with a 6% decrease for local travel to / from the study area

Conclusions

After completing the current O-D analysis and making comparisons to the previous O-D study, findings reveal that many O-D patterns are either similar or have nominally changed over the last 18 years. The key travel patterns that are similar between the two studies include:

- US 322 continues to serve as the main travel route within the Centre Country project area.
- Consistent travel patterns are seen in the following percentage comparisons (shown as 1999 & 2017, respectively):
    - US 322 EB (Site A) Heavy Truck Origins from Northwestern PA region (83% & 76%)
    - US 322 EB (Site A) Auto Origins from State College area (77% & 62%)
    - US 322 WB (Site E) Heavy Truck Origins from Northwestern PA region (78% & 71%)
    - US 322 WB (Site E) Auto Origins from State College area (59% vs. 60%)
    - PA 45 EB (Site B) Auto Destinations to Spring Mills region (51% & 58%)
    - PA 45 WB (Site D) Auto Destinations to State College area (63% & 51%)
- The percentage comparison for automobile trip types are showing minimal differences with +/- 3% in changes for most of the O-D stations, which indicates automobile traffic patterns have experienced little to no change in recent years

The findings of this study also indicate the following notable travel pattern changes that have occurred since the 1999 study:

- More traffic is traveling to or from the Northwestern PA and Southeastern PA regions through the study area. Both regions are within the top 5 origins and destinations for automobiles & truck for most stations.
- PA 45 EB (Site B) traffic patterns reveal fewer heavy trucks and more medium trucks in 2017. The most likely cause of this shift can be attributed to the opening of I-99 and heavy trucks rerouting to use a higher tier facility for long distance travel.
- US 322 WB (Site A) and US 322 WB (Site E) show the most significant change for medium trucks. Through traffic has increased by 28% while local traffic traveling to / from the study area has decreased by 24%. This indicates more trucks are using US 322 as a through route for regional travel purposes.

Overall, travel patterns appear to correlate well with the previous study, where US 322 continues to serve as the main travel corridor and the State College area continues to be the main origin / destination for the local market. As for trip purpose (local traffic versus regional through traffic), the comparison results are revealing some shifts. An increase in traffic from the Northwestern PA and Southeastern PA regions adds additional traffic to US 322. More medium trucks are using US 322 as a regional through route, which also contributes to the growing traffic along this corridor. It should be noted that automobile travel patterns have remained consistent. So even through general traffic volumes have increased over time and truck volumes have doubled on certain portions of US 322, the comparison indicates little to no changes for automobiles. When planning for future transportation projects in the area, truck traffic needs and impacts should be taken into consideration.

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

MEMORANDUM

Date: December 20, 2018 (*FINAL VERSION*)

To: Brian St. John
From: Julie Woo
Subject: SCCCTS Traffic Modeling Methodology Tech Memo

CC: Robert Watts, Tom Zilla

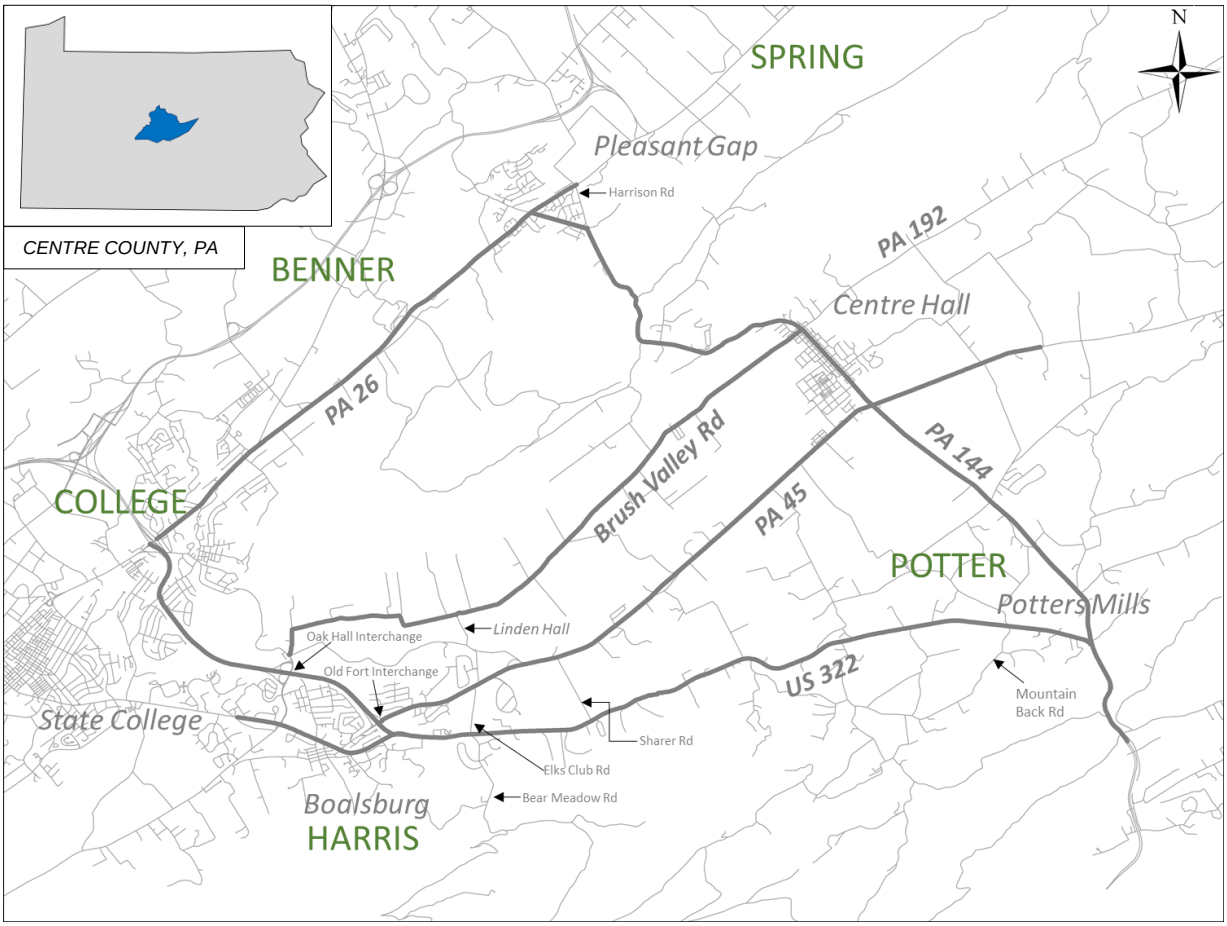
Work Order Number: 35041-002
Contract Number: E03985
Project: SCCCTS - Route 322/144/45 Corridors Data Refresh

The purpose of this memorandum is to: (1) present the methodology for modeling truck travel patterns to support the South Central Centre County Transportation Study (SCCCTS) Data Refresh project base and future year no-build scenarios, and (2) present the methodology for future year 2050 forecasting.

Project Background

Figure 1 shows the SCCCTS study area, noting the key transportation facilities for the project, and local roadways that were included as part of the analysis.

Figure 1: SCCCTS Project Study Area



The SCCCTS project area is comprised of the following major transportation facilities: US 322, PA 144, and PA 45. The US 322 corridor carries both local and regional through traffic, and a mix of all vehicle types (automobiles, medium trucks, and heavy trucks). It is classified as a principal arterial, and due to substantial roadside land development and the sparse local street network, US 322 also operates as a collector route. On a local level, US 322 serves as a key connection to the State College area, providing access to the borough's economic hub and to Penn State University's main campus. On a regional level, the corridor serves as the prime connection between many cities to the east of Centre County to locations to the Midwest and West. Based on the origin-destination (O-D) analysis conducted using StreetLight data, the results confirmed that US 322 continues to serve as the main travel route within the Centre County project area.

As one of the key findings noted in the *South Central Centre County Transportation Study Needs Analysis – April 2001*:

> *Increased traffic volumes are anticipated for US 322 as more development occurs within the study area and regional commuter traffic volumes increase. By year 2025, the volumes of total traffic are anticipated to at least double, while the truck volumes will increase to approximately 4,000 trucks per day.*

Table 1 shows a comparison of daily volumes between 1999 and 2017 along the US 322 corridor. When comparing the 2017 traffic count data to previous data collection efforts along the same study segments, the results show growth in truck volumes, which have more than doubled on some portions of the US 322 corridor. This growth can be attributed to several factors, including general growth in the region and ongoing improvements to the corridor. With regional through traffic rising in the area, improvements will help support anticipated growth and future increases in traffic use, as well as complement alternative routes as system-wide demands are expected to increase over time. As part of this project, the anticipated truck growth and their related travel patterns were evaluated for future year conditions.

Table 1: SCCCTS 1999 and 2017 Daily Volumes Comparison*

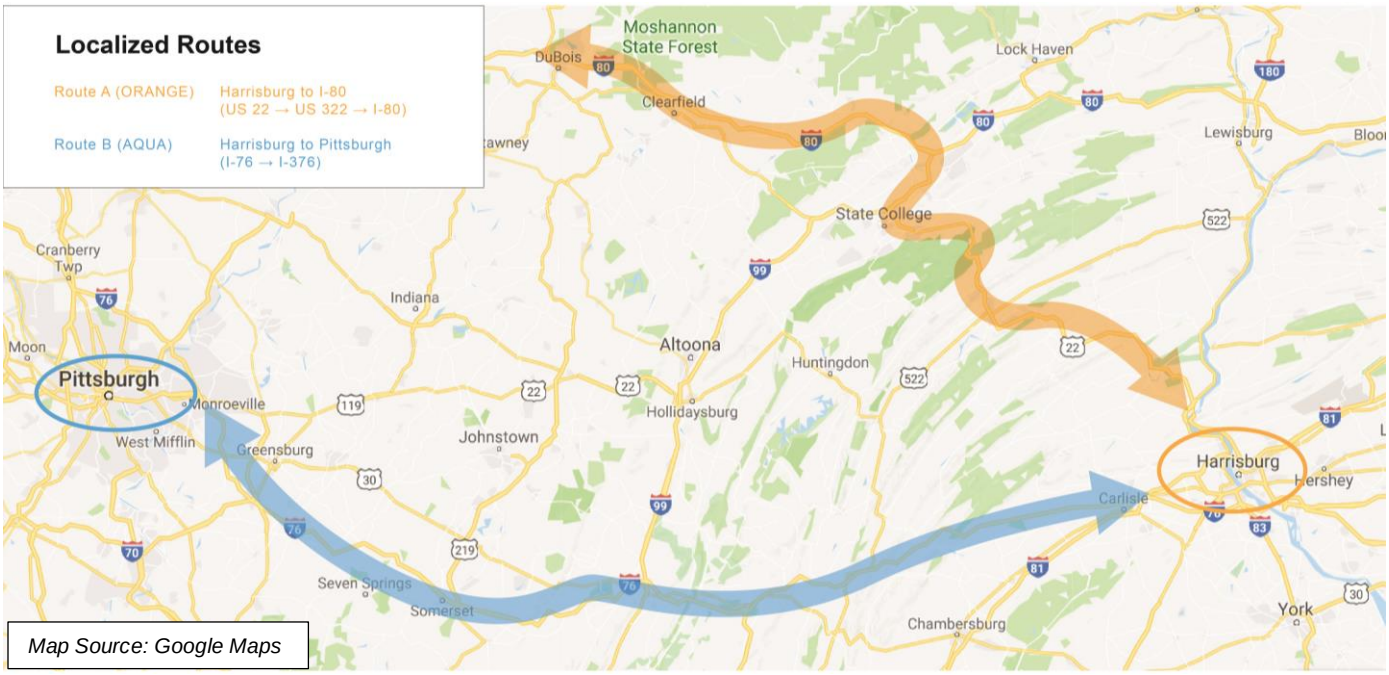
Roadway	Description	1999 ADT		2017 ADT Unadjusted		2017 ADT Seasonally Adjusted	
		All	Heavy Vehicles	All	Heavy Vehicles	All	Heavy Vehicles
US 322	east of PA 144	12,396	1,982	18,689	4,972	17,157	4,375
	west of Mountain Back Rd	10,378	-	14,019	4,344	12,793	4,061
	west of Oak Hall Interchange	18,597	2,572	24,849	6,090	21,886	7,088
	east of Laurel Meadow Rd	10,864	2,113	16,404	3,877	14,411	2,946
	east of US 322 Bypass	11,722	-	16,980	4,484	16,311	4,768

**Note: Bi-directional eastbound and westbound volumes are shown.*

Regional Perspectives

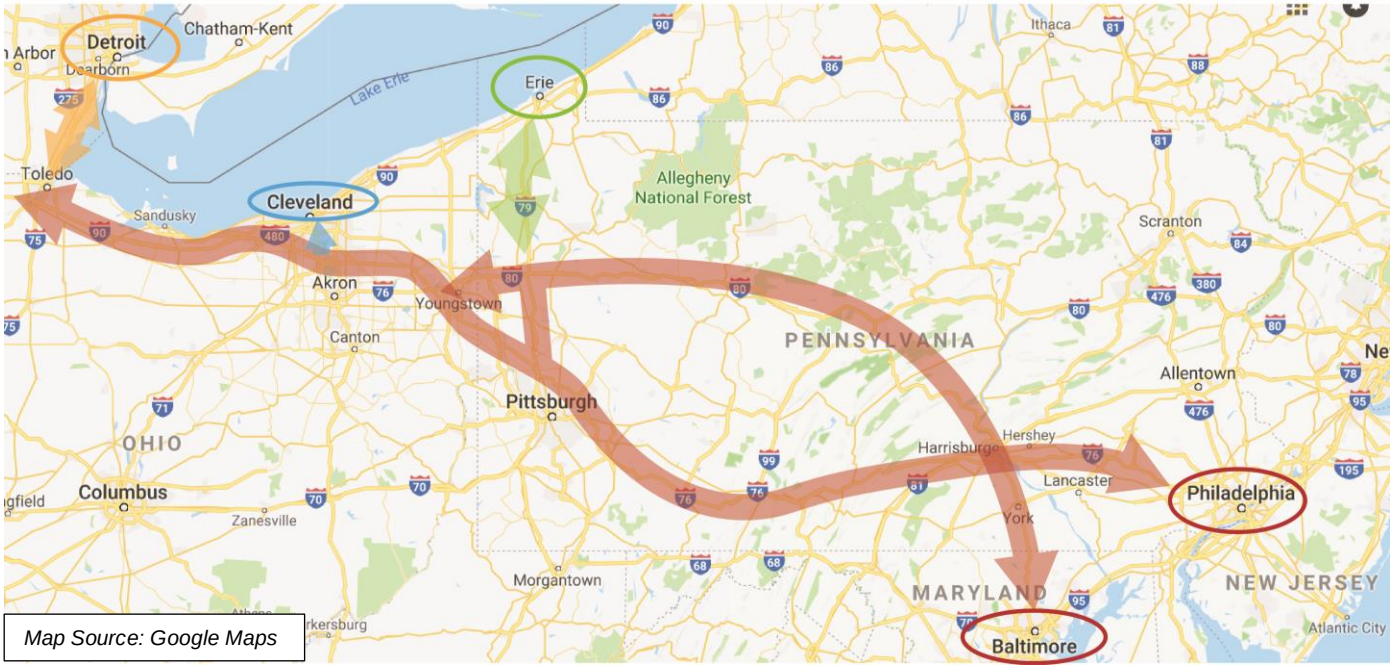
When traveling between cities to the east of Centre County to I-80 and other locations to the Midwest and West, US 322 serves as an important connection. Using Harrisburg as an example, there are currently several alternate routes for travel to I-80 and I-76 from the Harrisburg area. One of these options utilizes US 322 as a regional through route. The first route option includes travel along US 22 from Harrisburg to US 322 to access cities along I-80 (Route A), and the second involves traveling east on I-76 towards Pittsburgh and beyond (Route B) (*Figure 2*).

Figure 2: Localized Route Options



From a regional perspective, future improvements to US 322 will help serve alternative routes for long distance traffic moving through the region. Broader origins and destinations as identified by the Streetlight O-D analysis, includes travel to / from / between major cities outside of Pennsylvania. Examples include travel between Baltimore and Philadelphia to locations such as Erie, Cleveland, Detroit, and Chicago (*Figure 3*).

Figure 3: Regional Route Options



For automobile trips traveling to or from the study area, commuter travel patterns are an important component as they contribute to the AM and PM peak travel conditions. Recent analysis shows substantial commute activity along the US 322 and PA 45 corridors from areas including Mifflin, Juniata, and Union Counties. The commute patterns are external to Centre County, and are based on demographics, housing costs, and transportation costs. These commute patterns were evaluated as part of the forecast model development.

Truck Model Data Sources

The development of base and future year forecast truck demands for External to External (E-E), External to Internal (E-I), and Internal to External (I-E) movements were based on several traditional and non-traditional sources (*Table 2*). E-E trips are those movements that pass through the model area while E-I / I-E trips are those movements with one end of the trip inside the study area and the other outside or external to the region.

Table 2: Truck Demand Data Sources

Data Source	Base Year Demand	Future Year Demand	Notes
Freight Analysis Framework (FAF)	2012	2045	- FAF zone structure - Commodity movements by mode
StreetLight GPS Origin Destination Data – Commercial Movements	2017	N/A	- Custom zone structure (based on 1999 O-D Study boundaries) to capture external sources, entries and internal trip ends - Unadjusted sample (challenge to expand)
Pennsylvania Statewide Model (PSM)	2012	2040	- CARGO based truck trip table - Validated to 2012 AADT - Statewide Network
Global Insight Transearch Data (Pennsylvania Statewide Model)	2012	2040	- Used by PennDOT Consultant for calibration of the PSM Cargo Model
Truck Counts	2017		- Observed truck counts by single and multi-unit vehicle types. Used to validate model and understand existing traffic patterns.
Truck Generators	2017		- Major truck activity centers in the region based upon employment type and observations of the region. Includes warehousing and distribution centers, industrial areas, and major truck stops.
TAZ Employment	2017	2040	- TAZ employment by sector will be used to assign truck trips to TAZs with appropriate activities in the zone.

Each of the above datasets differ in the type of information provided and whether it is based on observed information or predictions / output from a model.

Below are some additional details regarding the truck demand data sources.

Models:

- Pennsylvania Statewide Model (PSM): Travel demand model that covers the entire state and can account for shifts in the network impacting trips well outside the Centre County region.

- Freight Analysis Framework (FAF): Provides national movements of freight by mode at a coarse level of resolution thus providing a high-level understanding of the growth in movements. Existing year patterns are based on observed data from the Commodity Flow Survey and future year patterns are based on predictive models.

Observed Data:

- StreetLight GPS OD Data: Based on GPS data collected from vehicles and summarized at a defined zone structure. This dataset was used to establish the base year travel patterns for through movements.

- Counts: Data collected to support the project, and available from PennDOT for various locations.

In the modeling of truck movements, it is necessary to consider the interim stops that are typically made by trucks that may impact the model forecasts. Interim truck stops are typical, either to stay within required hours of service guidelines or due to multiple stops during the same trip. In terms of freight commodity flows, these interim stops are often referred to as secondary traffic, which involves freight flows to and from distribution centers or through intermodal facilities. When freight data is compiled, no commodities are assigned to this intermediate step in the transportation process

Within the context of the Centre County Travel Demand Model (TDM), the truck model is a trip-based model and thus each movement is an independent trip between either an external or internal zone to either another external or internal zone. Where the potential for interim stops occur, the model will account for this by creating trips from the destination zone. This may include major truck stops in the region or warehousing / distribution centers.

For base year truck demand, the StreetLight data was used to help determine top flows on a region to region basis. With this information, high level growth trends along key freight routes were determined to help identify the impact of interim stops on truck flows that may be using US 322. For future year truck demand, the PSM was used to establish growth rates for the external auto and truck patterns destined for Centre County or passing through the region.

Methodology

To develop the truck external demand for the updated TDM, a pivot model approach was used to establish an accurate 2017 base year trip table and develop appropriate adjustments based upon the forecast year and network assumptions within the study area.

Base Year Demand

Using the GPS O-D data from StreetLight, a base year trip table was developed that includes the travel patterns through the Centre County area based on defined external stations. In addition to understanding the through movements, StreetLight provided insights on the relationship of trips traveling to and from locations within the study area.

To develop the base year demand, StreetLight data was expanded to replicate the observed traffic counts on the local network. The expansion was completed by first adjusting the external volumes from the extracted StreetLight data to counts at the external stations. This was done using a Fratar process in CUBE by adjusting the trip table to match the E-E movements. The internal trip ends for the E-I / I-E movements was reviewed based on identification of known truck generators and truck activity. The overall quality of the expansion process was assessed by comparing the assigned volumes from the base demand to the observed truck counts.

Future Year Scenarios & Forecast Growth

Using the TDM, future year conditions were modeled and analyzed. Due to the use of the corridor from trips outside the Centre County region, the model design must be sensitive to potential diversions or increases in traffic beyond the expected growth patterns. If the modeling identifies these types of shifts in travel patterns, the projected traffic patterns can be adjusted accordingly.

The model can be sensitive to patterns and impacts outside its typical influence area. For this analysis, it will require a methodology that will develop alternative forecasts of the through truck trips based upon improvements within the region that may draw additional traffic to the corridor.

The methodology assumed a baseline forecast of external movements, for both passenger and truck movements to be developed based upon the no-build scenario. Build alternatives should consider the diversion of forecasted traffic to the corridor and corresponding externals.

No Build Scenario

To establish the future year no-build truck trip table, growth rates were developed for each external station using traffic count historical trends and observed growth from the PSM. The growth rates were refined based on PSM trends, economic factors both within and outside the region, and major changes in policy and technologies.

After the forecast growth rates were applied to the base demand (established from StreetLight data), the internal ends of the E-I / I-E trips were adjusted based on changes in employment and known new truck generators. The internal adjustments were made based on application of a simplified truck model that was calibrated using observed trip ends from the base demand and base year employment.

Build Scenario

During this phase of the project, only the future year no-build scenario was analyzed. To analyze future year travel patterns for the build scenario, the following procedures can be used:

- Using the data processed from StreetLight, truck flows that are not entering Centre County can be identified as candidate trips for diversion. The zone structure used for the StreetLight analysis includes dividing the state outside of Centre County to major regions and the major entry / exit routes for long distance trucks that would could potentially use the corridor. Figure 4 shows the zone structure that was used for the StreetLight analysis.

- Using the statewide model trip tables, a matrix-based analysis will help identify the trips currently originating or destined to Centre County and identify the through trips for the county. Additional zone pairs can be identified by identifying potential catchment areas for the corridor using shortest time paths between major zone pairs with and without the project improvements. The results of the analysis can be compared with StreetLight and an evaluation of the FAF dataset to help identify how the base trip tables should be adjusted for the build scenario.

- The truck demand for the build scenario must take into account the diversion of trucks to the facility after the improvements are complete. This new demand should be added to the existing Forecast Growth – No Build trip table using information gleaned from the StreetLight Data and the PSM. The external station forecasts can be updated based on the increment of new demand as well as adding additional fixed interchanges to the through movements. The allocation of the E-I / I-E trip ends should be consistent with the future year no-build scenario as the methodology assumes consistent land use between the two scenarios.

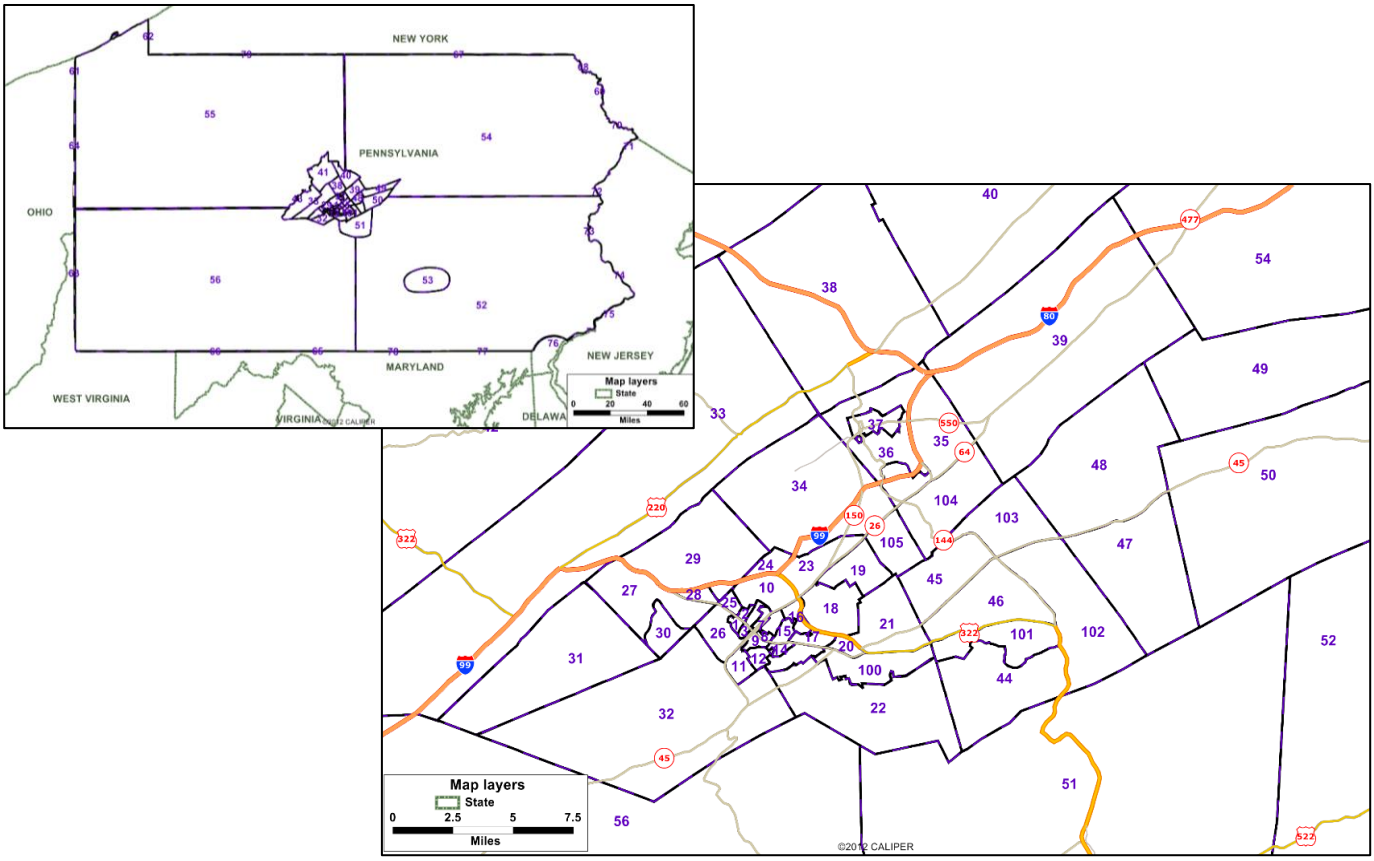


Figure 4: StreetLight Zone Structure

2050 Model Input Data Forecasts

Centre County Regional Planning Agency and Centre County Planning Office provided demographic updates to the study team for the TAZ's that intersect the US 322 (SCCCTS) Data Refresh Study Area. These demographic updates included changes that have occurred between 2010 and 2017 and reflect the most recent land use assumptions from 2017 to 2040. These updates were applied accordingly to both 2017 base year and 2040 future year model runs.

Using the 2040 demographic details provided by Centre County for Potter & Benner Townships, and Centre Region for Harris and College Townships, the model input data for 2050 forecasts were generated by the extrapolation method. Growth rates between base year and future year for each TAZ were calculated at the parcel level and applied to the 2040 forecasts. This methodology helped maintain the consistencies of growth patterns based on the most recent demographic updates and are carried through for the remaining forecast years. The 2050 demographic allocations were reviewed and modified as needed to ensure reasonable growth for all TAZs, accounting for developable land within these zones.

US 322
Origin-Destination
Tables

SCAC PROJECT - PEL STUDY BJM

Origin-Destination Data 1/31/2022

ESTIMATED ADT				ORIGINS (EB) AND DESTINATIONS (WB)			
2017 Base		2050 No Build		PASSENGER VEHICLES - US 322 EB & WB			
EB	WB	EB	WB	LOCATION	EB	WB	
3,985	3,730	5,560	5,205	State College	63%	59%	Includes Lemont/Houserville/Nittany Mall
125	380	175	530	Bellefonte	2%	6%	
760	380	1,060	530	Boalsburg	12%	6%	
65	65	90	90	Pleasant Gap	1%	1%	
0	255	0	355	Centre Hall	0%	4%	Includes Potters Mills
0	125	0	175	Spring Mills	0%	2%	PA 45/PA 192
65	125	90	175	NE	1%	2%	I-80 E
885	950	1,235	1,325	NW	14%	15%	I-80 W/US 322 W
440	315	615	440	SW	7%	5%	I-99 S
6,325	**6,325**	**8,825**	**8,825**	**TOTAL**	**100%**	**100%**	

ESTIMATED ADT				ORIGINS (EB) AND DESTINATIONS (WB)			
2017 Base		2050 No Build		MEDIUM TRUCKS - US 322 EB & WB			
EB	WB	EB	WB	LOCATION	EB	WB	
155	140	230	205	State College	28%	25%	Includes Lemont/Houserville/Nittany Mall
20	20	30	30	Bellefonte	4%	4%	
10	5	15	10	Boalsburg	2%	1%	
30	30	40	40	Pleasant Gap	5%	5%	
0	20	0	30	Centre Hall	0%	4%	Includes Potters Mills
0	10	0	15	Spring Mills	0%	2%	PA 45/PA 192
65	70	90	95	NE	11%	12%	I-80 E
190	185	275	270	NW	34%	33%	I-80 W/US 322 W
90	80	130	115	SW	16%	14%	I-99 S
560	**560**	**810**	**810**	**TOTAL**	**100%**	**100%**	

ESTIMATED ADT				ORIGINS (EB) AND DESTINATIONS (WB)			
2017 Base		2050 No Build		HEAVY TRUCKS - US 322 EB & WB			
EB	WB	EB	WB	LOCATION	EB	WB	
80	80	115	115	State College	5%	5%	Includes Lemont/Houserville/Nittany Mall
95	115	135	160	Bellefonte	6%	7%	
15	30	25	45	Boalsburg	1%	2%	
15	15	25	25	Pleasant Gap	1%	1%	
0	30	0	45	Centre Hall	0%	2%	Includes Potters Mills
0	15	0	25	Spring Mills	0%	1%	PA 45/PA 192
50	50	70	70	NE	3%	3%	I-80 E
1,230	1,150	1,760	1,645	NW	76%	71%	I-80 W/US 322 W
130	130	185	185	SW	8%	8%	I-99 S
1,615	**1,615**	**2,315**	**2,315**	**TOTAL**	**100%**	**100%**	

SCAC PROJECT - PEL STUDY BJM

Origin-Destination Data 1/31/2022

ESTIMATED ADT			
2017 Base		2050 No Build	
EB	WB	EB	WB
4,220	3,950	5,905	5,525
240	515	340	720
785	415	1,100	585
110	110	155	155
0	305	0	430
0	150	0	215
180	245	250	340
2,305	2,285	3,270	3,240
660	525	930	740
8,500	**8,500**	**11,950**	**11,950**

ORIGINS (EB) AND DESTINATIONS (WB)			
ALL VEHICLES - US 322 EB & WB			
LOCATION	EB	WB	
State College	50%	47%	Includes Lemont/Houserville/Nittany Mall
Bellefonte	3%	6%	
Boalsburg	9%	5%	
Pleasant Gap	1%	1%	
Centre Hall	0%	3%	Includes Potters Mills
Spring Mills	0%	2%	PA 45/PA 192
NE	2%	3%	I-80 E
NW	27%	27%	I-80 W/US 322 W
SW	8%	6%	I-99 S
TOTAL	**100%**	**100%**	

ESTIMATED ADT			
2017 Base		2050 No Build	
EB	WB	EB	WB
235	220	345	320
115	135	165	190
25	35	40	55
45	45	65	65
0	50	0	75
0	25	0	40
115	120	160	165
1,420	1,335	2,035	1,915
220	210	315	300
2,175	**2,175**	**3,125**	**3,125**

ORIGINS (EB) AND DESTINATIONS (WB)			
ALL TRUCKS - US 322 EB & WB			
LOCATION	EB	WB	
State College	12%	10%	Includes Lemont/Houserville/Nittany Mall
Bellefonte	5%	6%	
Boalsburg	1%	2%	
Pleasant Gap	2%	1%	
Centre Hall	0%	3%	Includes Potters Mills
Spring Mills	0%	1%	PA 45/PA 192
NE	5%	5%	I-80 E
NW	65%	62%	I-80 W/US 322 W
SW	10%	10%	I-99 S
TOTAL	**100%**	**100%**	

Centre County Regional Travel Demand Model

Traffic Volume Forecasting

SCAC Project (PEL Study Phase)
Level 2B Screening Evaluation of ADT Volumes

Note: ***Projections below include hand adjustment of additional volume shift for Alternative 2 from US 322 Corridor to New Rdwy & I-99.***

			2050 Traffic Volume Projections								Percent Change Compared to No Build					
			No Build		Upgrade Existing		Build Alt 1 (US 322)		Build Alt 2 (PA 144)		Upgrade Existing		Build Alt 1 (US 322)		Build Alt 2 (PA 144)	
ROADWAY	SEGMENT		AADT	AADTT	AADT	AADTT	AADT	AADTT	AADT	AADTT	AADT	AADTT	AADT	AADTT	AADT	AADTT
PA 45																
	Warner Blvd/Boalsburg Rd	Boal Ave	13,500	1,800	13,000	1,800	12,400	1,600	14,400	2,000	-4%	0%	-8%	-11%	7%	11%
	US 322	Elks Club Rd	10,900	1,500	9,100	1,150	3,200	450	6,100	700	-17%	-23%	-71%	-70%	-44%	-53%
	Elks Club Rd[1]	Williams Rd[1]	9,200	1,100	7,500	850	2,400	350	5,200	550	-18%	-23%	-74%	-68%	-43%	-50%
	Williams Rd[2]	PA 144[2]	9,600	1,700	8,600	1,450	9,300	1,450	6,100	1,000	-10%	-15%	-3%	-15%	-36%	-41%
	PA 144	East of	9,900	1,350	9,800	1,350	9,400	1,350	12,400	1,600	-1%	0%	-5%	0%	25%	19%
PA 144																
	US 322	PA 45	8,500	1,200	4,400	800	2,200	200	1,400	50	-48%	-33%	-74%	-83%	-84%	-96%
	PA 45	PA 192	14,100	2,150	9,300	1,800	7,600	400	3,000	150	-34%	-16%	-46%	-81%	-79%	-93%
	PA 192	PA 26	13,400	1,850	10,000	800	8,000	500	600	100	-25%	-57%	-40%	-73%	-96%	-95%
US 322																
	PA 45	Elks Club Rd	15,700	4,850	23,400	6,500	1,400	100	9,100	1,600	49%	34%	-91%	-98%	-42%	-67%
	Elks Club Rd	Neff Rd	18,600	4,200	26,000	6,500	700	50	8,000	1,350	40%	55%	-96%	-99%	-57%	-68%
	Neff Rd	Red Mill Rd	17,900	5,950	23,000	5,400	500	200	8,500	1,950	28%	-9%	-97%	-97%	-53%	-67%
College Ave (PA 26) / PA 64	**From**	**To**														
	South of	PA 144	9,200	600	9,200	600	8,700	600	7,200	800	0%	0%	-5%	0%	-22%	33%
	I-99 Ramps	North of	7,700	900	7,700	900	8,100	900	8,200	1,000	0%	0%	5%	0%	6%	11%
Brush Valley Rd (SR 2006)																
	South of	PA 144	1,900	200	1,200	100	700	100	1,000	100	-37%	-50%	-63%	-50%	-47%	-50%
	PA 144	North of	2,900	300	2,600	200	2,300	200	900	50	-10%	-33%	-21%	-33%	-69%	-83%
Study Area Roadways Volumes Total			163,000	29,650	92,400	11,800	76,900	8,450	92,100	13,000	-17%	-19%	-53%	-72%	-43%	-56%

Notes:

[1] For Build Alternative 1, this segment extends from Elks Club Rd to the New Connector Road.

[2] For Build Alternative 1, this segment extends from the New Connector Road to PA 144.

SCAC PEL Study

Future Year Build Traffic Volume Projections

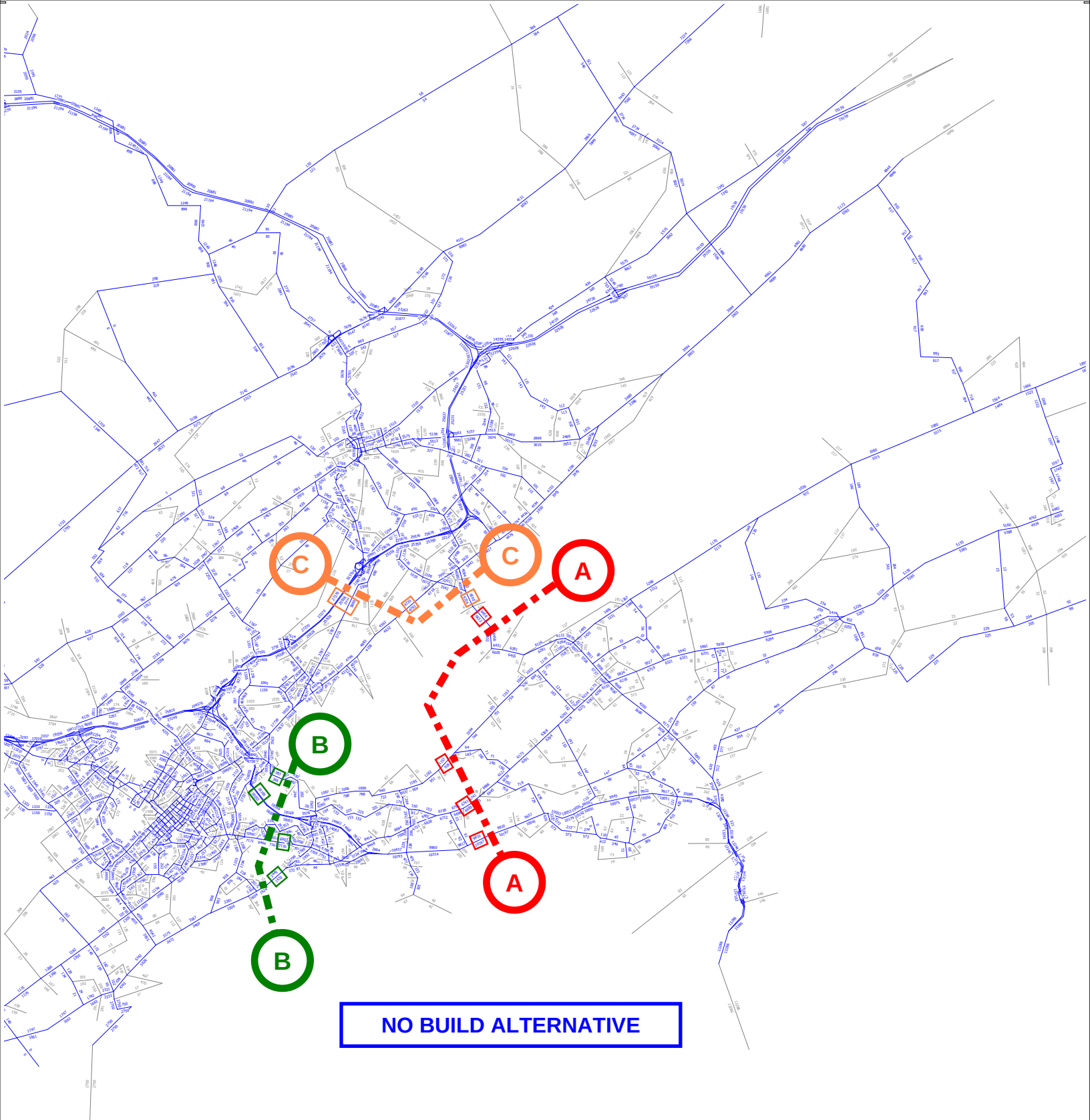
Future year traffic volume projections were developed utilizing the Centre County Regional Travel Demand Model (CCRTDM). This model was updated as part of the Data Refresh efforts associated with the previous South Central Centre County Transportation Study (SCCCTS) project. This work included updates to incorporate the Streetlight Data origin-destination (OD) data and model calibration and validation. Details associated with this model update efforts are contained in the SCCCTS Data Refresh memos.

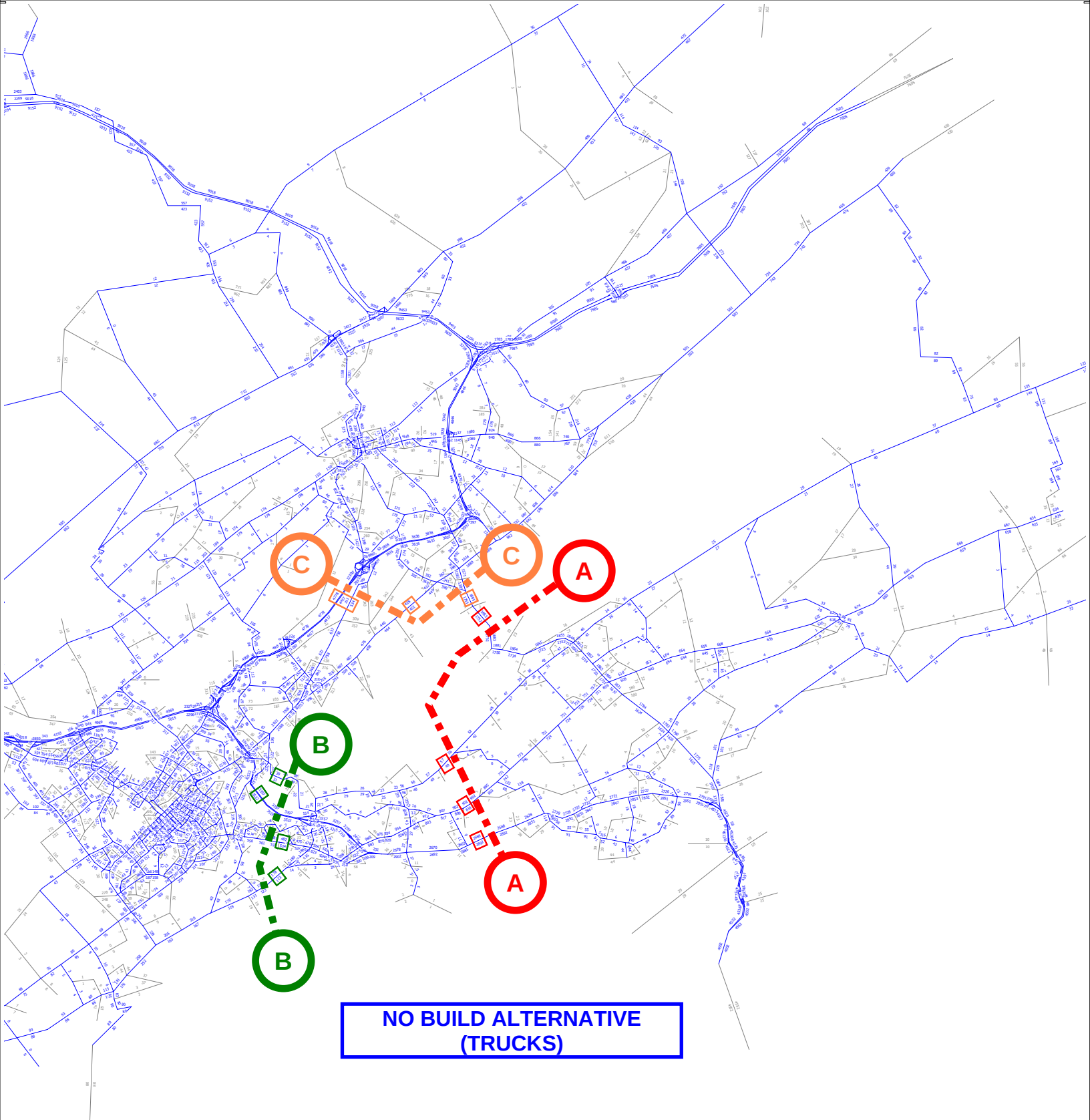
The CCRTDM model is a Cube model comprised of four modules; AM peak period, Midday period, PM peak period, and off-peak period. ADT volumes are a summation of the model output data for all four of the modules. AM and PM peak hour volumes were developed from the corresponding module by applying a study area peak hour factor. (It should be noted that this peak hour factor is not the typical PHF used in traffic capacity analyses.)

The peak hour factor used for estimating the PEL Study peak hour traffic volumes from the CCRTDM is a factor that represents the portion of the peak period volume that occurs in the peak hour (systemwide for the study area). To compute the factors for each peak hour, existing available traffic volume data was used. Separate AM and PM peak hour factors were determined by dividing a systemwide peak hour volume by the cumulative systemwide total of hourly volumes comprising the peak period. This factor was then applied to the corresponding peak period module output data to compute estimated peak hour link volumes.

Intersection turning movements were then developed for each study intersection in accordance with NCHRP 765 procedures.

Year 2050 No Build


C
C
A
B
A
B
NO BUILD ALTERNATIVE



NO BUILD ALTERNATIVE (TRUCKS)

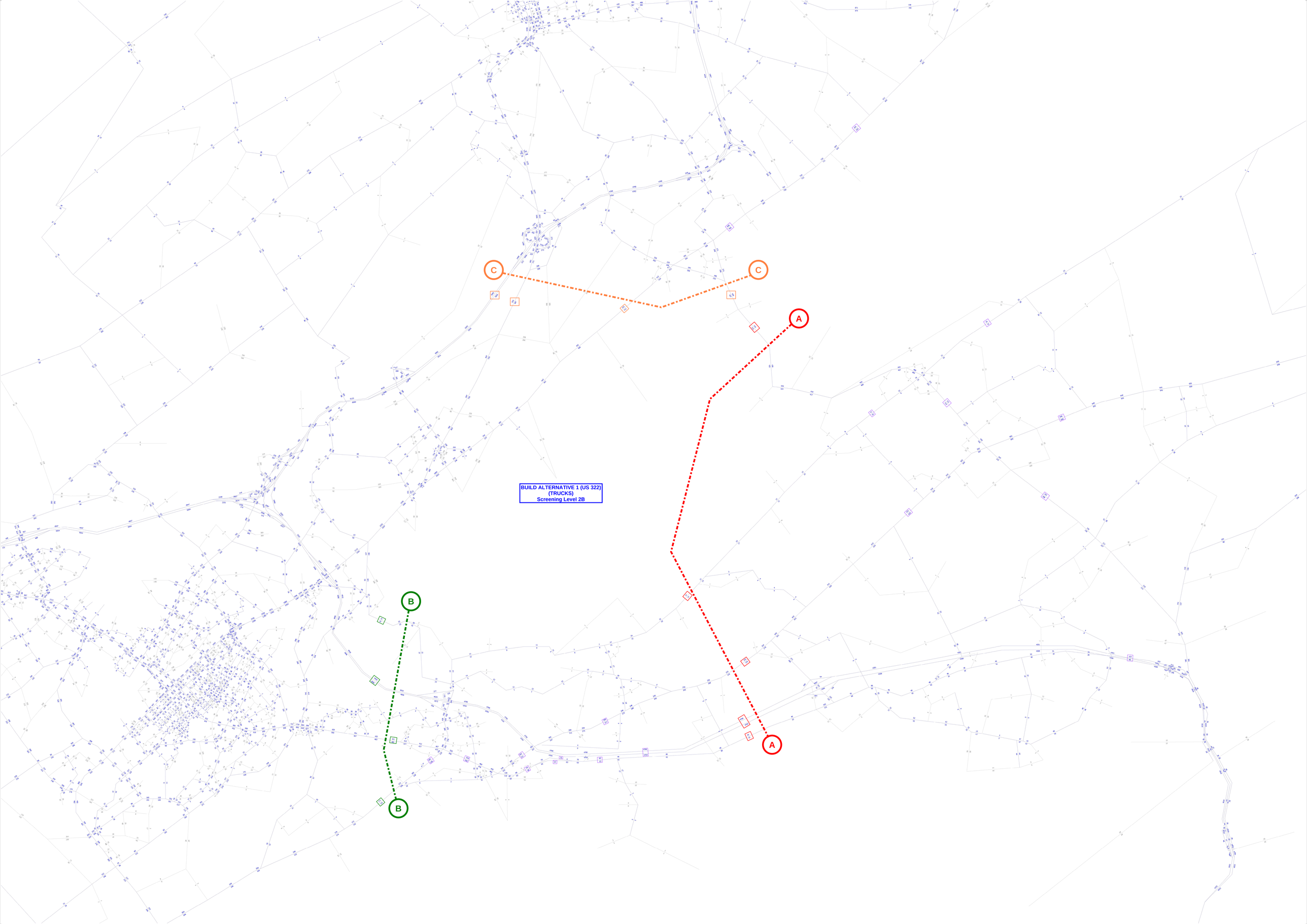
Year 2050 Build

Upgrade Existing US 322 Alternative

Year 2050 Build
Build Alternative 1
(US 322 Corridor)

BUILD ALTERNATIVE 1 (US 322)
Sceening Level 2B

48,673
52,991
8,318
C
C
55,860
8,976
8,218
A
8,037
57,792
7,080
11,454
11,985
56,929
35,439
12,206
50,333
578
12,015
B
3,476
28,170
43,574
3,424
1,032
1,067
564
317
215
26,569
692
43,574
5415
37,424
5,844
10,398
6,715
11,588
13,343
2,385
870
4,162
B
A



Year 2050 Build
Build Alternative 2
(PA 144 Corridor)