2007

Feasibility Analysis of West Chester Pike Busway

69th Street Terminal to I-476

DELAWARE VALLEY
REGIONAL PLANNING
COMMISSION

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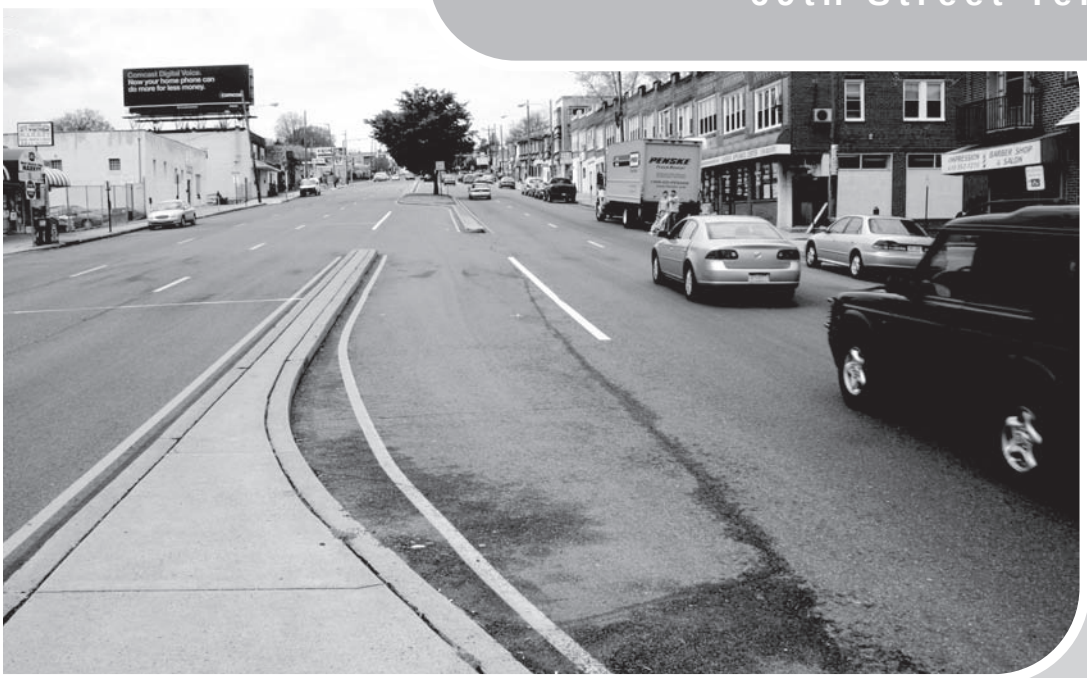

DELAWARE VALLEY
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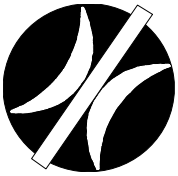
Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency that provides continuing, comprehensive and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties, as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester and Mercer counties in New Jersey. DVRPC provides technical assistance and services; conducts high priority studies that respond to the requests and demands of member state and local governments; fosters cooperation among various constituents to forge a consensus on diverse regional issues; determines and meets the needs of the private sector; and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the Commission.



Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole, while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. (A sentence regarding special sources of funding may be inserted here.) The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

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EXECUTIVE SUMMARY

The *Delaware County Long-Range Bus Service Study*, June 2001, prepared by a consultant for the Delaware County Planning Department and the Delaware Valley Regional Planning Commission, recommended several new transit service initiatives, one of which was a single-lane express busway in the median of West Chester Pike (PA 3). The busway would operate from 69th Street Terminal to North Lawrence Road, approximately 4.5 miles to the west. Its primary purpose would be to permit operation of Route 104 express bus service. From an operations perspective, it would operate eastbound in the morning, and westbound in the afternoon. According to the study, West Chester Pike is one of the few important corridors radiating from Center City that is not served by a rail line.

A cursory evaluation of the West Chester Pike median, conducted by the consultant, revealed for the most part, there is adequate right-of-way for a single-lane busway. However, there appeared to be four locations with insufficient width. Conflict with trolley operations in the vicinity of Garrett Road was another issued raise in the bus study. The purpose of this study is to conduct a more detailed feasibility analysis. It takes a "fatal flaw" approach, trying to identify potential issues that would prevent conversion of the median to a busway. It does not recommend a specific busway design.

Four areas were investigated:

- Transit operations – Does the number of buses on West Chester Pike meet minimum warrants for a busway; is there sufficient demand for additional bus service; should it be used for express or local service?

- Physical obstructions in the median – Are there obstructions in the median – such as traffic signals, signs, buildings, or drainage structures – that would prevent construction of a busway?

- Design issues – Is there adequate median width for a busway; how will left turns be treated along West Chester Pike; and can median openings remain unsignalized?

- Impact on traffic operations – How will the busway and left-turn treatment impact traffic flow?

This study identified the following critical issues:

- Insufficient transit demand – According to national standards (*Guide for High-*

Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials, November 2004) at least 50 buses per hour are required to warrant a median busway. Based upon experiences in other regions of the country, a lower level of bus service would make the busway appear to the public as an underutilized facility, resulting in demands to open it up to general purpose traffic. West Chester Pike bus levels vary from approximately 20 buses per hour at 69th Street Terminal to 9 buses per hour at the Blue Route.

A sketch planning analysis was conducted to estimate the annual ridership required to generate an additional 30 to 50 buses per hour, the number of buses required to bring current service up to the minimum threshold, and the number of new buses for exclusive express service respectively. Based on SEPTA's 2005 Route Operating Ratio Report, and standard fare recovery factors, it would take at least 1.5 million to well over 2 million annual riders to support an additional 30-50 additional buses. Other alternatives, such as implementing park-and-ride lots or diverting King of Prussia transit service from I-76 to I-476, would generate additional buses, but the net result would still fall short of the minimum bus threshold requirement.

- Insufficient right-of-way between State Road and North Keystone Avenue – From the eastbound State Road approach to North Keystone Avenue, the median is either two feet wide where turn lanes are present (i.e., a concrete median divider), or 14 feet wide when there is a grass median.

  Three options to increase the median width were examined. Reducing travel lane widths to 11 feet will not produce sufficient right-of-way in the two-foot sections for a busway. Removal of on-street parking will negatively impact local residents and stores lining the westbound lanes, and, in the eastbound direction, impact parking in front of police department offices. Removal of the third eastbound lane will make the State Road intersection fail (level of service F) from current acceptable conditions.

- Negative impact on traffic flow – A major consideration is how to maintain left turns for general purpose traffic. Reference materials recommend three approaches to this problem: forcing drivers to make the left through a series of right turns, permitting vehicles to enter the busway to make the left, or placing left-turn lanes outside the busway. The first option is not viable because local streets can not handle additional traffic due to their residential nature, narrow width, and on-street parking. The second option does not work for a median reversible lane. The outside left-turn option was evaluated using traffic signal timing software. It showed considerable degradation of level of service at 10 signalized intersections.

Other significant issues identified by the analysis include:

- SEPTA facilities in the right-of-way – SEPTA has several facilities located in the median at Garrett Road including a power substation, spur tracks to store maintenance vehicles and trains entering service, and a catenary support to power the trolleys through the Garrett Road intersection. Discussions with SEPTA indicate no plans to relocate any of these facilities.

- PennDOT signal equipment – Approximately five years ago, PennDOT constructed a closed-loop traffic signal system on West Chester Pike. At 19 intersections, signal controllers and other associated traffic signal equipment located in the median will have to be relocated.

- Unsignalized median openings – There are 17 unsignalized median openings in the corridor, two of which serve firehouses. All unsignalized median openings, other than those associated with the firehouses, will either have to be closed or signalized. Under either scenario, community opposition is expected unless an acceptable alternative is provided.

Given the difficulties of implementing a busway, this does not preclude implementation of other strategies to improve bus service in the corridor. Transit ridership levels in the corridor, combined with the fact that many of the passengers are taking a two-seat ride – bus and the Market-Frankford Line – clearly demonstrate the propensity to take transit. Improvement options include:

- Construct park-and-ride lots – Based upon a cursory look, this effort identified two possible park-and-ride locations with up to 450 spaces. A more rigorous examination of the corridor could potentially identify additional park-and-ride opportunities. The Delaware County Planning Department should organize a task force composed of SEPTA, PennDOT, Delaware County TMA, the municipalities, and DVRPC to identify and implement park-and-ride lots in the corridor.

- Limited bus priority treatment – Almost all intersections in the corridor currently operate with a very satisfactory level of service, therefore implementing bus priority treatment will have little or no impact since the time savings will be minimal. However, there are two locations where bus priority treatment may prove beneficial to transit, Glendale Road to Eagle Road and State Road to Garrett Road. To create these conditions would require reconfiguring the roadway and traffic signal timings to create congestion, and then construct a busway to offer travel time savings for bus passengers. This is a policy decision, and therefore, is outside the scope of this technical study. From a Transit First

policy perspective, there may be some merit to this approach; however, there could be considerable risk of motorist backlash.

1. INTRODUCTION

The *Delaware County Long-Range Bus Service Study*, June 2001, prepared by a consultant for the Delaware County Planning Department and the Delaware Valley Regional Planning Commission, recommended several new transit service initiatives, including a single-lane express busway in the median of West Chester Pike (PA 3). The busway would operate from 69th Street Terminal to North Lawrence Road, approximately 4.5 miles to the west. From an operations perspective, it would run eastbound in the morning, and westbound in the afternoon.

According to the study, West Chester Pike is one of the few important corridors radiating from Center City that is not served by a rail line. Traffic volumes and congestion are constantly increasing, impeding bus traffic into 69th Street Terminal. The principal purpose of the reversible busway would be to permit the operation of Route 104 express bus service. Provision of express bus service would then enable several new transit services:

- Special Route 104 service between a park-and-ride lot located at the I-476/West Chester Pike Interchange and 69th Street Terminal.

- Buses destined to West Chester, Newtown Square, and Cheyney University could take advantage of express service for all or part of their trips.

- Bus service between King of Prussia and 69th Street Terminal could be rerouted to take advantage of the express busway.

- Passengers using future bus services along I-476 can transfer at West Chester Pike and take Route 104 to 69th Street Terminal.

A cursory evaluation of the West Chester Pike median, conducted by the consultant, revealed for the most part, there is adequate right-of-way for a single-lane busway. However, there appeared to be four locations with insufficient width. Conflict with trolley operations at Garrett Road was another issued raised in the bus study.

The purpose of this study is to conduct a more detailed feasibility analysis of using the West Chester Pike median for a reversible busway. It takes a “fatal flaw” approach, trying to identify potential problems that would prevent conversion of the median. It does not recommend a specific busway design, but rather answers the following:

- Transit operations – Does the number of buses on West Chester Pike meet minimum warrants for a busway; is there sufficient demand for additional transit

service in the West Chester Pike corridor; should the busway offer express service, limited express service, or local service; and what happens to existing bus service along West Chester Pike?

- Physical obstructions in the median – Are there obstructions in the median, such as traffic signals, signs, buildings, or drainage structures, which would prevent construction of a busway?

- Design issues – What design elements are needed to configure a busway, and is there adequate width for a busway and turn lanes in the median?

- Impact on traffic operations – Left-turn lanes and median openings for cross traffic are located in the median. If some of them have to be removed, how would that impact traffic operations? From a safety perspective, how would left turns and the busway operate concurrently?

2. WEST CHESTER PIKE MEDIAN RIGHT-OF-WAY

The West Chester Pike median right-of-way is a legacy of trolley service from 69th Street Terminal to West Chester. In 1966, the last trolley service using the West Chester Pike median right-of-way, from Darby Road to 69th Street Terminal, was abandoned. The former was replaced by Route 104 bus service and the latter by Route 103 bus service. This chapter describes the physical characteristics of the median and any physical issues that may prevent its conversion to a reversible busway.

The median is a curbed grass strip lined with trees and other shrubbery. In Upper Darby Township, bushes are planted at the intersections for decorative purposes, with mature trees positioned along the length of West Chester Pike. In Haverford Township, the density of foliage is less dense, with more shrubbery than trees. Its cross section is either relatively flat or U-shaped for drainage purposes.

Concrete sidewalks are located in the median at all intersections and at median openings with crosswalks; their purpose is to give pedestrians a paved walkway across the median. All sidewalks are ADA accessible. Both Upper Darby and Haverford have placed formal welcoming signs in the median. Signs are located east of Township Line Road (Upper Darby), west of Township Line Road (Haverford), and east of Lawrence Road (Haverford).

The absence of utility poles in the median is a big plus in terms of constructing a busway. There is no need to relocate utility poles, an expensive item. Drainage, however, is a major issue. There are drainage structures located in the median (in the U-shape areas) and numerous inlets along the outside of the median. Generally, the purpose of the outside inlets are to capture storm water channeled by the median curb, feeding it to laterals that cross West Chester Pike. A stream passes under West Chester Pike just west of Gilmore Road. Whether the structure the median is built on can carry bus traffic is unknown.

Based upon the above observations, potential obstacles to constructing a reversible busway are:

- Impact on the appearance of the median will be substantial; however, this can be somewhat mitigated through context-sensitive design.

- Provision for pedestrians must be incorporated into the busway design. This includes a clearly marked pedestrian crosswalk and adequate room for a refuge for pedestrians who are unable to fully cross West Chester Pike before the signal changes. Pedestrian islands will be discussed in more detail under design

issues later in this report.

- Removing the median will necessitate substituting another mechanism to channel storm water. Options include: 1) Retaining curbing, but this will make it difficult to remove stalled buses from the busway; 2) Reconfiguring the busway cross section into a U-shape cross section and placing Type M drains in the busway; or 3) A combination of the two. Unlike most typical drains, Type M drains require no curbing and are flush to the pavement. Lateral piping along the entire length of the corridor will need to be reconstructed.

Median Width

This analysis will take two different approaches in describing the median width. First, the basic median width, exclusive of turn lanes, will be documented. This represents the gross median width that can be used for both a busway and turn lanes. The analysis then focuses on the most restricted median widths where turn lanes have reduced the median to a point where it will be very difficult to fit in a busway without some form of remedial treatment.

West Chester Pike's median width is plotted on Figure 2A-2E. Median width measurements include curbing. As a rule, the wider median widths generally indicate segments where no turn lanes are present; the narrower widths are the consequence of the presence of turn lanes.

From Lawrence Road to Township Line Road, the basic median width – where no turn lanes are present – is 31 feet wide. From Township Line Road to Park Avenue, the median width increases to 34 feet wide. From Park Avenue to Harvin Road it reverts back to 31 feet wide. Between State Road and New Street it is approximately 14 feet wide. From New Street to where it approaches Garrett Road, the median begins to widen; at Brief Avenue it is 27 feet wide.

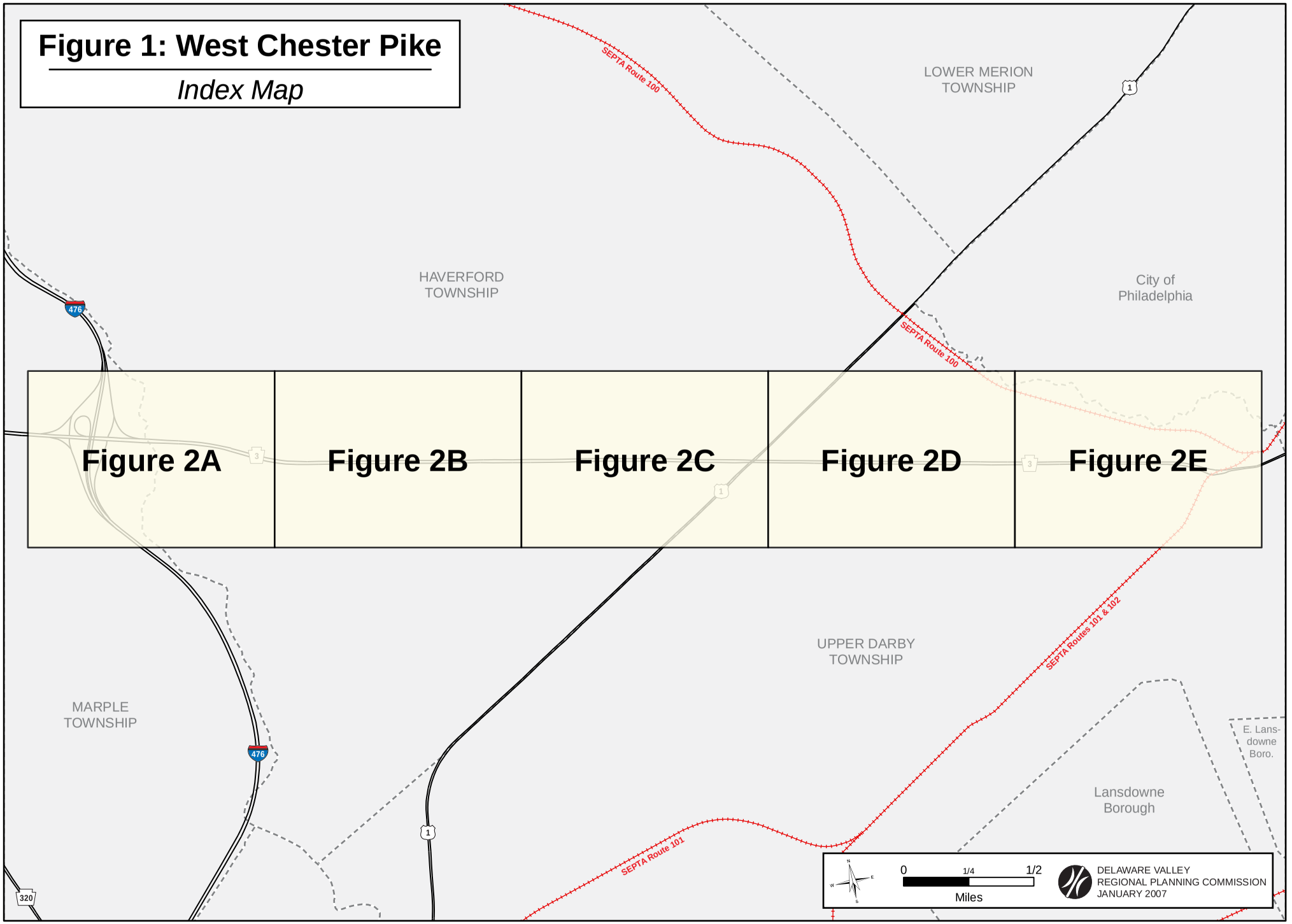
From a design perspective the most critical areas are colored yellow and light blue on Figure 2A-2E, where the median width is less than 10 feet wide or between 11-15 feet wide respectively. The most critical section is centered around State Road, where for 1,000 feet from east of Harvin Road to east of Golf Road the median is essentially just 2 feet wide (a concrete divider). Just east of this segment, for another 600 feet to New Street, the median is only 14 feet wide.

Three other critical segments have median widths of less that 10 feet:

- Township Line Road – From Llandaff Road to Township Line Road there is a six-foot grass median. Even though the section between Darby Road and Llandaff

Figure 1: West Chester Pike

Index Map



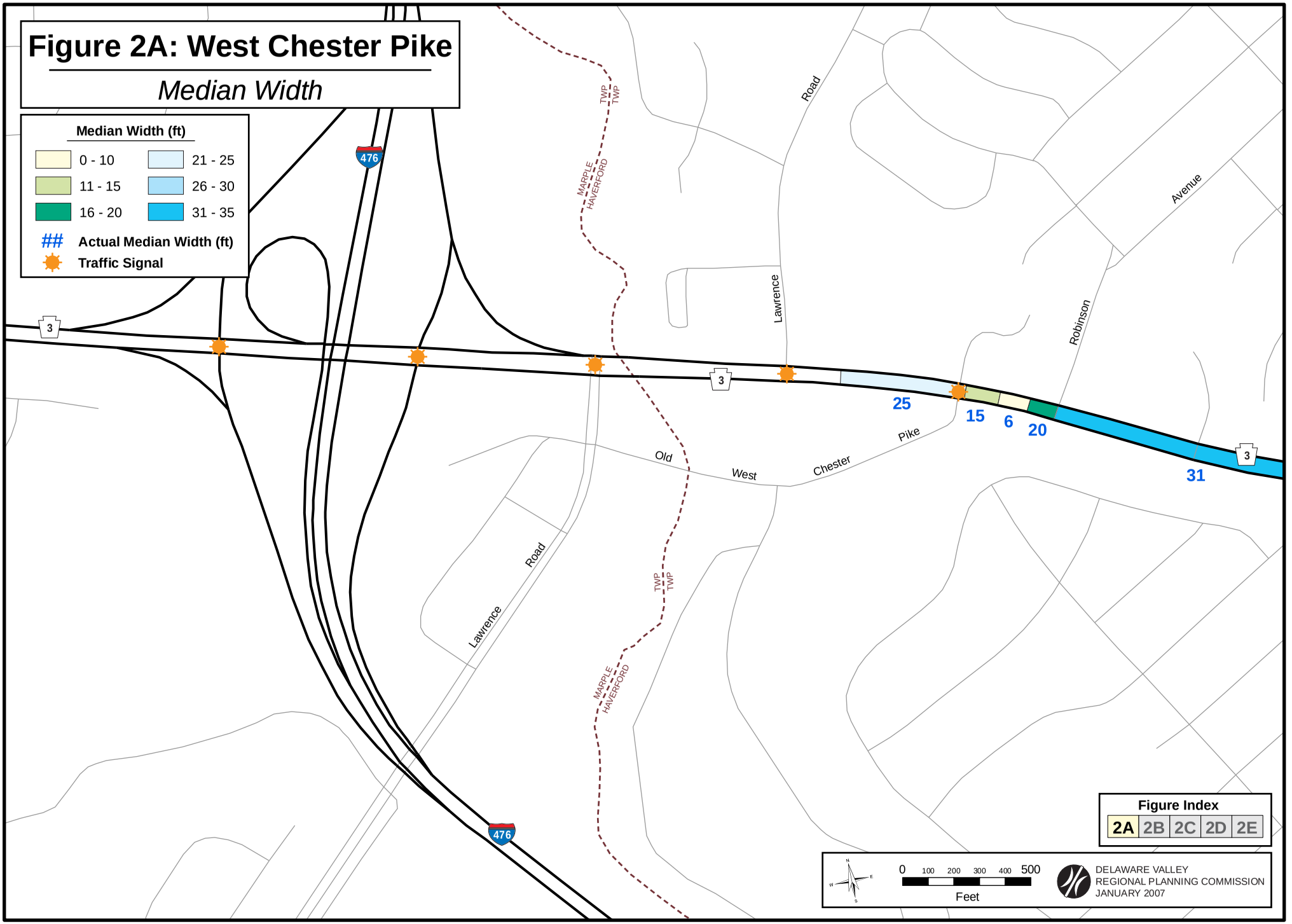


Figure 2A: West Chester Pike
Median Width
Median Width (ft)
0 - 10
11 - 15
16 - 20
21 - 25
26 - 30
31 - 35
Actual Median Width (ft)
Traffic Signal
476
3
TWP
TWP
MARPLE
HAVERFORD
Road
Avenue
Lawrence
Robinson
25
15
6
20
31
Pike
Old
West
Chester
Road
Lawrence
TWP
TWP
MARPLE
HAVERFORD
476
Figure Index
2A
2B
2C
2D
2E
0
100
200
300
400
500
Feet
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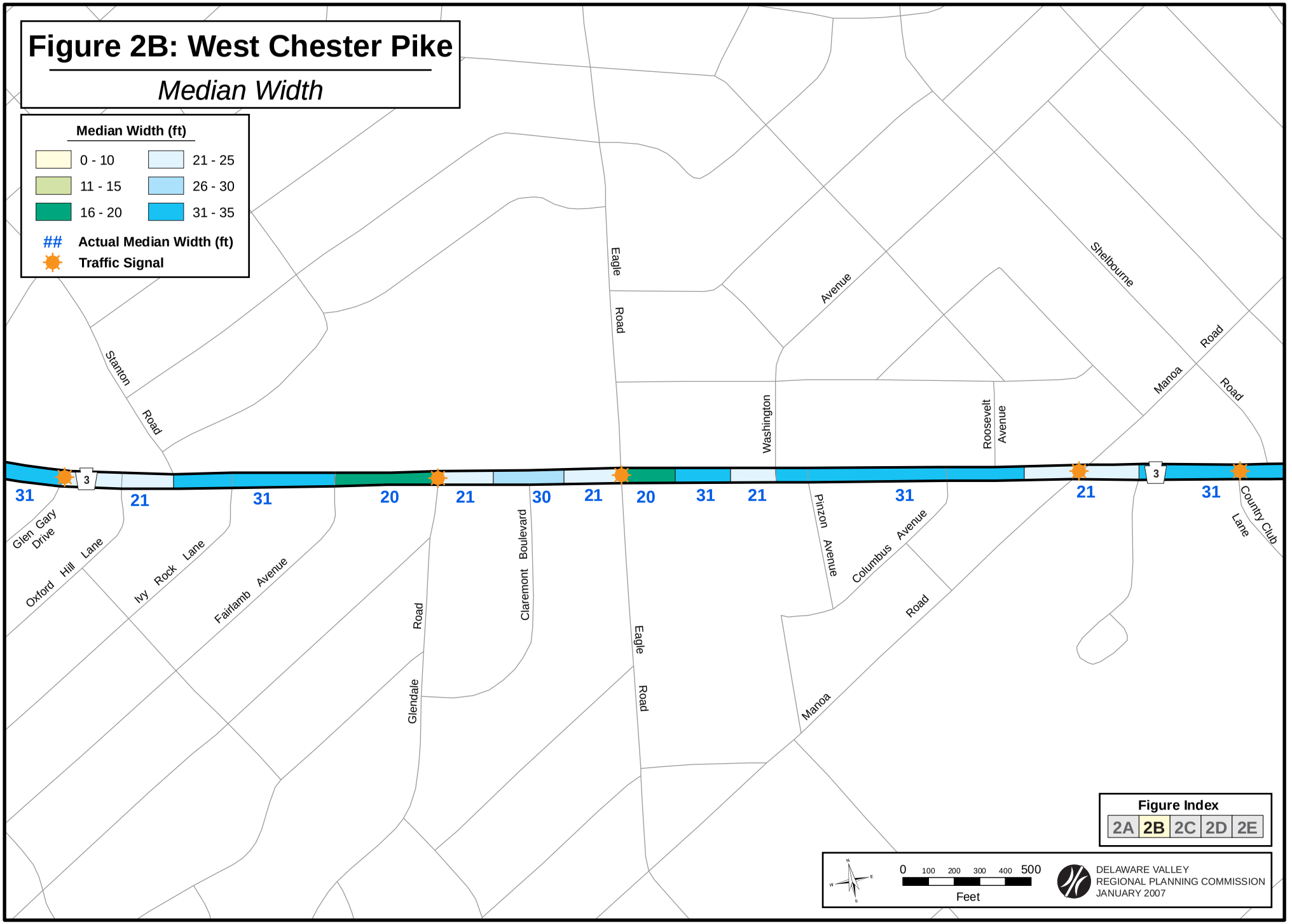
Figure 2B: West Chester Pike
Median Width
Median Width (ft)
0 - 10
11 - 15
16 - 20
21 - 25
26 - 30
31 - 35
Actual Median Width (ft)
Traffic Signal
Stanton Road
Eagle Road
Avenue
Washington
Roosevelt Avenue
Shellbourne
Manoa Road
Road
3
31
21
31
20
21
30
21
20
31
21
31
21
31
Glen Gary Drive
Oxford Hill Lane
Ivy Rock Lane
Fairlamb Avenue
Glendale Road
Claremont Boulevard
Eagle Road
Pinzon Avenue
Columbus Avenue
Road
Manoa
Country Club Lane
Figure Index
2A
2B
2C
2D
2E
0
100
200
300
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500
Feet
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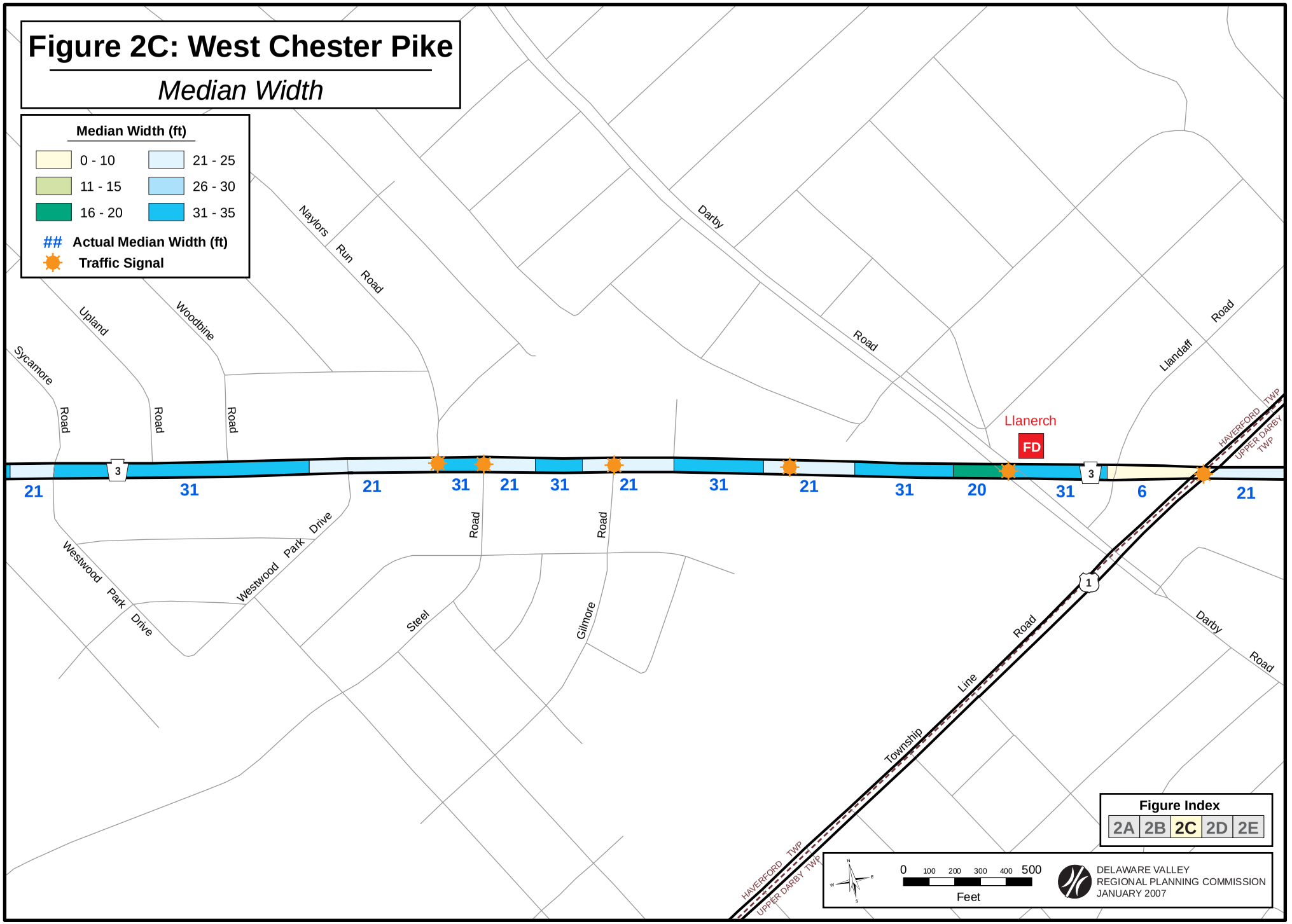
Figure 2C: West Chester Pike

Median Width



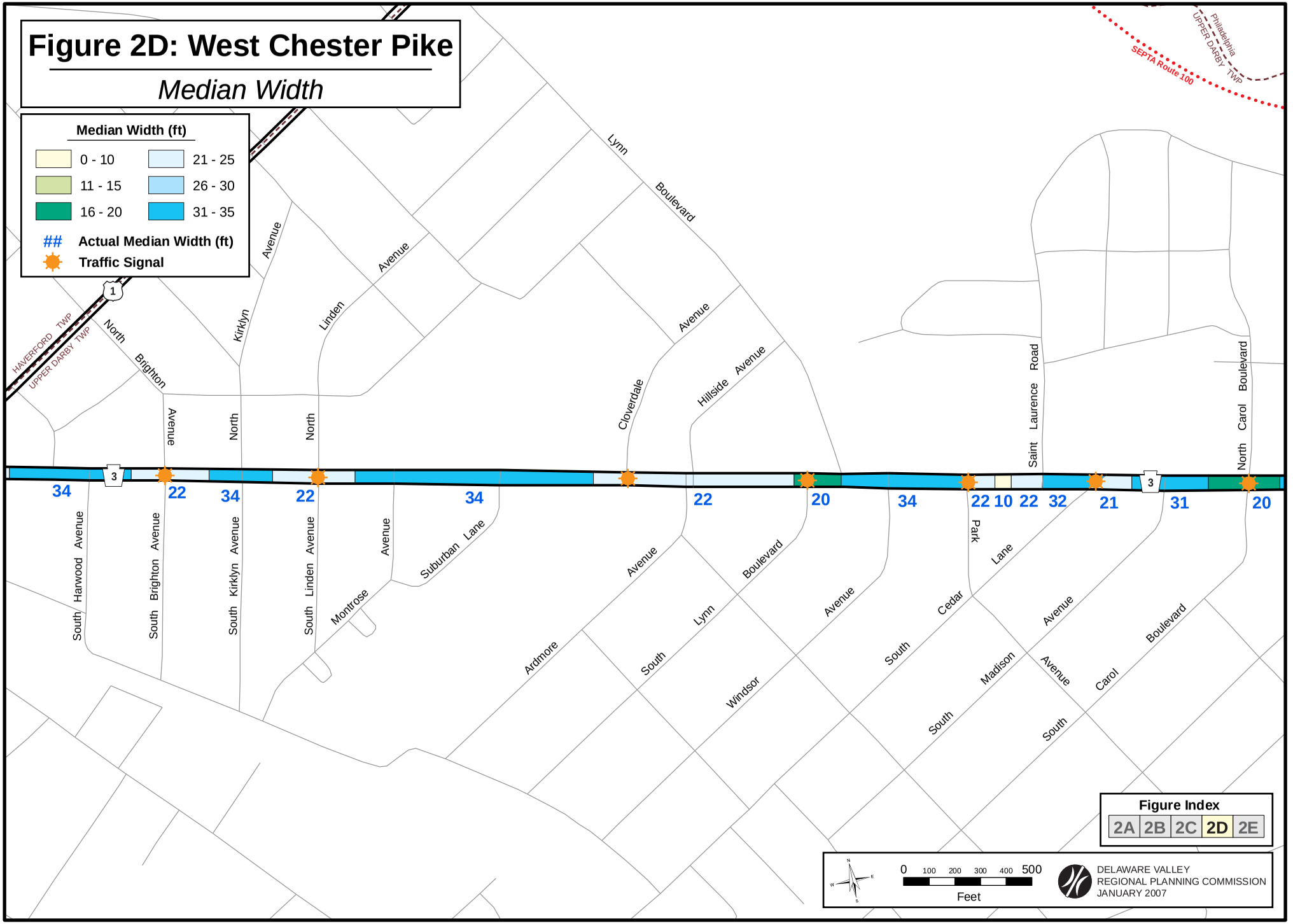


Figure 2D: West Chester Pike
Median Width
Median Width (ft)
0 - 10
11 - 15
16 - 20
21 - 25
26 - 30
31 - 35
Actual Median Width (ft)
Traffic Signal
HAVERFORD TWP
UPPER DARBY TWP
North Brighton Avenue
Kirklyn Avenue
Linden Avenue
Lynn Boulevard
Cloverdale Avenue
Hillside Avenue
Saint Laurence Road
North Carol Boulevard
SEPTA Route 100
Philadelphia
UPPER DARBY TWP
34 22 34 22 34 22 20 34 22 10 22 32 21 31 20
South Harwood Avenue
South Brighton Avenue
South Kirklyn Avenue
South Linden Avenue
Montrose Avenue
Suburban Lane
Ardmore Avenue
South Lynn Boulevard
Windsor Avenue
South Cedar Park Lane
South Madison Avenue
Carol Boulevard
Figure Index
2A 2B 2C 2D 2E
0 100 200 300 400 500
Feet
DELAWARE VALLEY
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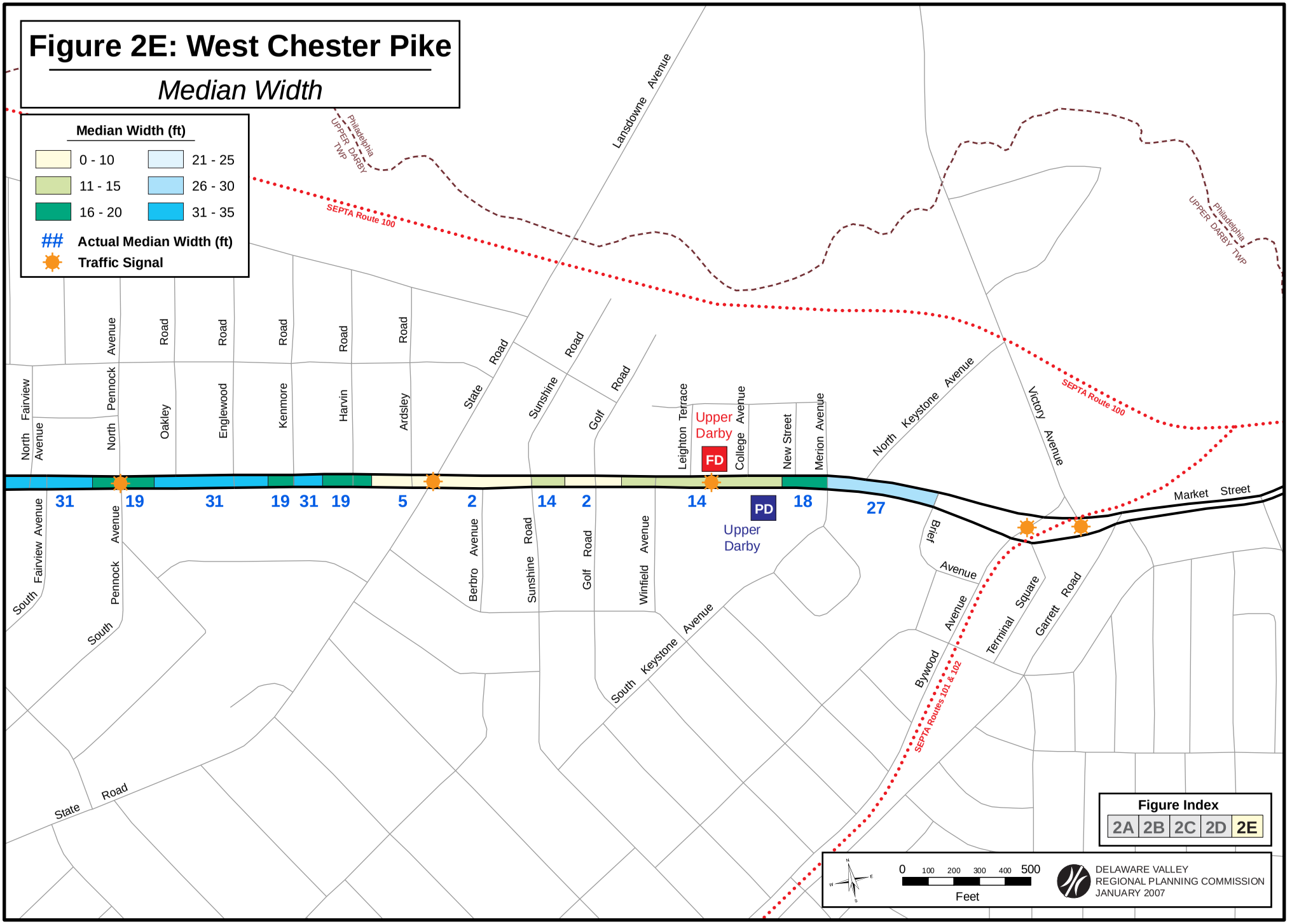
Figure 2E: West Chester Pike

Median Width



Road is depicted on Figure 1 as having a 31-foot median, in actuality it is largely a median opening for the Llanerch Volunteer Fire Company.

- Old West Chester Pike to Robinson Avenue – At the western end of the corridor the median narrows due to concurrent left-turn lanes for Old West Chester Pike and Robinson Road. At the narrowest section, where both left-turn lanes coexist, the median width is six feet. Where one turn lane exists, and the other turn lane has just a taper, the median width can be up to 15 or 20 feet wide.

- Park Avenue to Saint Laurence Road – Like Old West Chester Pike to Robinson Avenue above, this section has concurrent left-turn lanes.

The feasibility of constructing a left-turn lane at each of these locations will be examined in more detail later in the report. Other narrow sections, in the 16- to 22-foot range, also pose potential problems, but they are more manageable.

In general, the curb-to-curb width of West Chester Pike is approximately 100 feet wide from North Lawrence Road to Pennock Avenue, and approximately 80-90 feet wide from Pennock Avenue to Brief Avenue (by 69th Street Terminal). The widest width is between Stanton Road to Fairlamb Avenue, 108 feet wide. The narrowest width is located between Pennock Avenue and State Road, 78-79 feet wide.

Turn Lanes and Median Openings

Among the 22 traffic signals in the corridor (Garrett Road was excluded from the analysis), all but two, Country Club Lane and Brief Avenue, have at least one median turn lane associated with it, see Table 1. Eleven of the signalized intersections have both eastbound and westbound turn lanes, and nine signalized intersections have either a eastbound or westbound median turn lane. At two intersections, Lawrence Road and Township Line Road, there are dual eastbound turn lanes.

Unless there are protected left turns, motorists who make left turns on West Chester Pike use the median openings as a refuge to wait for gaps in opposing traffic. At some intersections, it appeared motorists were partially obstructed by objects in the median and/or vehicles making an opposing left turn. Placing a bus lane in the median will further exacerbate this sight-distance issue. Due to the median, many motorists were also observed making U-turns to backtrack to their destination. U-turns require a larger gap in the traffic stream for vehicles to complete the maneuver. As will be discussed in the design section, converting the median to a reversible busway requires more positive guidance over left-turning vehicles to ensure they do not conduct their turns while buses are approaching. Consequently, all permitted left-turns – 11 intersections (see Table 1) – will need to be converted to protected phasing, impacting traffic flow. Impact of the

Table 1: Location of Turn Lanes at Signalized Intersections

Location	Direction of Turn Lane		Left Turn Lane Phasing	
	Eastbound	Westbound	Protected	Permitted
Lawrence Rd	X*		X	
Old West Chester Pk		X	X	
Glen Gary Dr		X	X	
Glendale Rd	X	X	X	
Eagle Rd	X	X	X	
Manoa Rd	X	X	X	
Naylors Run Rd	X			X
Steel Rd		X	X	
Gilmore Rd	X	X		X
Kohl Driveway	X	X		X
Darby Rd	X			X
Township Line Rd	X*	X	X	
Brighton Ave	X	X		X
Linden Ave	X	X		X
North Lynn Blvd	X			X
Park Ave		X		X
Cedar Ln		X		X
Carol Blvd	X	X		X
Pennock Ave	X	X		X
State Rd	X	X	X	

* Dual left-turn lane

Source: PennDOT

busway on traffic will be discussed later in this report.

There are 17 unsignalized median openings, see Table 2. Two of them, Llanerch Volunteer Fire Company and Upper Darby Fire Company, serve firehouses fronting them. The latter location has an emergency-vehicle traffic signal that normally operates in flash mode. Clovedale Avenue and Elm Avenue/Golf Road have both eastbound and westbound turn lanes; Robinson Avenue, Washington Avenue, and Saint Laurence Road have just eastbound turn lanes. The Cloverdale Avenue median opening serves the Montrose Cemetery; the Saint Laurence opening serves Saint Lawrence Church and its school. Several unsignalized median openings have restrictions placed on them, see Table 2; some median openings are restricted to emergency and authorized vehicles only, at others U-turns are prohibited. Regardless of the signing, nonemergency vehicles were observed using the median openings, and there appears to be no restrictions on cross-street traffic using the medians.

Constructing a reversible busway will have a detrimental impact on the unsignalized median openings. There are three major issues associated with unsignalized median openings: 1) Potential conflict between free-flowing buses and left-turning vehicles, 2) Vehicles making left turns will no longer have an opportunity to sit in the median until there is a gap in opposing traffic, and 3) There are safety concerns that cross street traffic will not look for buses approaching in the median. Ultimately, the unsignalized median openings will either have to be closed or signalized. Closing the medians without an acceptable alternative will generate community opposition, overload adjacent signalized intersections, and increase the number of U-turns taking place. Therefore, signalizing the unsignalized intersections and constructing left-turn lanes are the only viable solutions.

Traffic Control Equipment

The most predominate physical entity in the West Chester Pike median is traffic control equipment – pedestrian pushbuttons, traffic signals, controller boxes, and signs. About five years ago, PennDOT constructed a new closed-loop traffic signal system on West Chester Pike. An inventory was conducted of the traffic control equipment located in the median, based on PennDOT traffic signal diagrams and field views (see Table 3.)

Among the 22 traffic signals in the corridor (Garrett Road was excluded from the analysis), all but three have their controller cabinets located in the median. From PennDOT's perspective, installing controller cabinets in the median minimizes conduit costs and wire runs. Placing controller cabinets in the median also avoids cluttering sideways and obstructing pedestrian crosswalks.

Each approach on West Chester Pike has two far side overhead signals directly over

Table 2: Location of Unsignalized Median Openings

Location	Function/Restrictions	Turn Lanes	
		Eastbound	Westbound
Robinson Ave	No U-turn	X	
Stanton Rd	No U-turn		
Washington Ave		X	
Pinzon Ave			
Westwood Park Dr			
Sycamore Rd			
Llanerch Vol Fire Co	Authorized vehicles only		
Harwood Ave	Authorized vehicles only		
Cloverdale Ave	Cemetery	X	X
St Laurence Rd	Church, school	X	
Englewood Rd			
Kenmore Rd	Authorized vehicles only		
Harvin Rd	Authorized vehicles only		
Elm Ave/Golf Rd		X	X
Upper Darby Fire Co	Flashing signal, authorized vehicles only		
New St	Authorized vehicles only		
Marion/S. Keystone Ave			

Source: DVRPC

Table 3: Median Traffic Control Equipment Inventory

Intersection	Controller Cabinet	Pedestrian Push Buttons	Pedestrian Signals	Traffic Signals	Loop Detector Equipment	Signs
Lawrence Rd					X	X
Old West Chester Pk	X	X	X		X	X
Glen Gary Rd	X	X	X	X	X	X
Glendale Rd	X	X	X	X	X	X
Eagle Rd	X	X	X	X	X	X
Manoa Rd	X	X	X		X	X
Country Club Ln	X	X	X			X
Naylors Run Rd	X	X	X			X
Steel Rd	X	X	X	X	X	X
Gilmore Rd	X	X	X			X
Kohl Driveway	X	X	X		X	X
Darby Rd	X		X	X	X	X
Township Line	X	X	X		X	X
Brighton Ave	X	X				X
Linden Ave	X	X				X
N. Lynn Blvd	X	X	X			X
Park Ave	X	X	X	X	X	X
Cedar Ln	X	X		X	X	X
Carol Blvd	X	X				X
Pennock Ave	X	X				X
State Rd						X
Brief Ave						X

Source: PennDOT

the center of each through-travel lane. A number of intersections have supplemental left-turn signals to facilitate protected left-turn movements. Seven intersections have traffic signals positioned in the median; in most instances they are used to control cross street traffic whose approach is at an angle to West Chester Pike.

Because the signal timing programs provide the bare minimum time for pedestrians to cross West Chester Pike, nearly all the intersections have post-mounted pedestrian push buttons located in the median to activate a pedestrian phase that will extend red time on West Chester Pike. Fourteen of the intersections also have pedestrian Walk/Do Not Walk heads mounted on the same poles. Pedestrian push buttons and heads are located in both the eastern and western median approaches to the intersections, behind the sidewalks.

Every intersection has at least one sign posted in the median. The most frequent signs are “Left Lane Must Turn Left” (R3-7L) posted at almost all left-turn lanes, and “No Left Turn” (R3-2) signs posted where left-turn lanes are absent.

PennDOT traffic signal diagrams indicate that more that half the intersections have loop detectors installed at the intersection to detect vehicles present in the left-turn lane. They are connected to either a junction box or the controller located in the median.

PennDOT’s signal interconnection is maintained through a combination of existing two-inch conduit, interconnect conduit, and aerial interconnect wires using utility poles. All conduit (two-inch or interconnect) are located in the median right-of-way. From State Road to Brighton Avenue, the interconnect is via existing two-inch conduit located in the median. From Brighton to Gilmore Road, the signals are interconnected via an interconnect conduit in the median. From Gilmore to Glen Gary Drive, the interconnect is via aerial wire. From Glen Gary Drive to Lawrence Road, it is via interconnect conduit in the median.

Traffic control equipment located in the median does not necessarily render the proposed busway infeasible; high-cost solutions can be found to relocate equipment.

- The most problematic concern is finding adequate right-of-way for pedestrian islands and pedestrian push buttons/signal heads. In some sections of West Chester Pike, right-of-way may not be available. Without pedestrian islands, pedestrians will be unable to safely cross West Chester Pike. Relocating pedestrian push buttons/signal heads requires constructing new foundations, installing new poles and Walk/Do Not Walk heads, and rewiring.

- Retaining traffic signal heads in the median is also an important concern. Because they must properly align with the traffic approach they are facing, this

will dictate where the pedestrian poles they are mounted on are located.

- There is a lot more flexibility with respect to controller cabinets. They can be relocated to another location in the median or an adjoining sidewalk. Choice of location is dependent upon the availability of median right-of-way. Like pedestrian signals, it will require installation of additional foundations, conduit and wiring. Signal interconnect wiring would need to be relocated from the median to existing utility poles.

- Left-turn-only signs and no-left-turn signs can be either ground mounted in the remaining median, if room is available; or mounted overhead on the mast arm.

SEPTA Facilities in Right-of-Way

SEPTA still has facilities located in the West Chester Pike median, between Garrett Road to just west of Keystone Avenue, which support operation of the Media and Sharon Hill trolley lines. Facilities include:

- Two buildings are located in the median near the Garrett Road intersection (see photo). According to SEPTA engineering staff, one of the buildings functions as a substation for the Media and Sharon Hill lines. The other building appears to house an auto driving school; SEPTA staff had no information about it.

Buildings and catenary support located in West Chester Pike median at Garrett Road

Source: DVRPC

- A catenary support used to power the trolley lines is located in the median at Garrett Road. Structures on either side of Garrett Road support overhead catenary lines over the West Chester Pike/Garrett Road intersection. The structure can be observed in the photo.

- A single track rail spur extends from the trolley main line, along the West Chester Pike median to North Keystone Avenue. Initially, three tracks depart from the main line, two from the direction of 69th Street Terminal and one from the direction of Media; they cross Garrett Road and quickly merge into a single track spur line in the median (see photo). According to SEPTA engineering staff, the track is to store trolleys waiting to enter service at 69th Street Terminal. The track is occasionally used to store maintenance vehicles for the trolley line.

SEPTA spur line in median at Garrett Road

Source: DVRPC

- Poles for power lines – There are 14 utility/power line poles located in the median. Some are associated with overhead catenary for the spur line, others have unknown ownership. A visual observation of the other poles did not clarify their ownership or usage. SEPTA engineering did not have any information about the unidentified poles.

- Trolley interlocking – In the median at the junction of West Chester Pike and Garrett Road is an interlocking, permitting trolleys to move between the main line and the spur line. Any realignment of the spur track to facilitate the busway will have an adverse impact on the interlocking's tracks, switches, and signal equipment. Reconstruction of the interlocking is both expensive and disruptive to trolley operations.

Discussions with SEPTA engineering staff revealed the substation can not be removed unless a replacement substation is constructed. They were unsure how removal of the spur line would impact trolley operations and whether an alternative operations plan was feasible. A review of SEPTA's Fiscal Year 2006 Capital Budget, Fiscal Years 2006-2017 Capital Program and Comprehensive Plan, and the proposed 2007-2019 Capital Program did not reveal any plans to relocate the substation. Conversations with SEPTA Capital Programming confirmed there are no plans to replace the substation.

There appears to be adequate room in the median to support a busway and either the substation or the spur line. A detailed analysis of relocating the substation or reconfiguring trolley operations in and out of 69th Street Terminal requires expertise beyond the scope of this effort. Another potential option is paving between the tracks to permit joint bus and trolley usage. Under this scenario buses will use the spur line as an eastbound bypass during peak hours and trolleys using it the rest of the day. Unless this issue can be satisfactorily resolved, the busway will have to terminate west of Keystone Avenue and buses will have to merge back into general purpose traffic and be delayed in traffic approaching Garrett Road.

SEPTA facilities pose a major quandary for the busway. It is not quite a fatal flaw because the busway can be terminated at Keystone Avenue, with buses using West Chester Pike to reach 69th Street Terminal. However, from an operational and marketing perspective this is not a highly desirable option. On the other hand, to relocate either the substation or spur line so the busway can extend to Garrett Road is, at a minimum, a multimillion dollar expense and, at the worst case, is infeasible.

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3. IMPACT ON TRANSIT OPERATIONS

This section will document the existing transit service on West Chester Pike; the bus volume threshold needed to warrant implementation of a busway; and, lastly investigate – through various sketch planning techniques – the probability of SEPTA operating sufficient bus service to justify a reversible busway. The issue of what is the most appropriate type of service for the busway – express service, limited stop service or local service – will also be examined.

Existing Bus Service

Seven bus routes currently serve West Chester Pike. The following is a description of each bus route including coverage area, service frequency, annual ridership, and any other unique characteristics of the service. Ridership information published by SEPTA does not break down annual ridership in finer detail than by bus route; therefore, there is no information on the number of passengers boarding or alighting at 69th Street Terminal or at any specific bus stop along the route. In examining annual ridership information, the reader must be cognizant that for some routes serving major generators, for example Route 103 to Ardmore or Route 123 to King of Prussia, the majority of the stated ridership may actually take place outside the West Chester Pike busway corridor.

- Route 103, 69th Terminal to Ardmore – This route uses West Chester Pike between 69th Street Terminal and Lynn Boulevard. After buses turn onto Lynn Boulevard, they follow Earlington Road and Darby Road on the way to Suburban Square in Ardmore. Weekdays, buses operate at 30-minute headways between 5:30 a.m. to 9 p.m. In 2005, Route 103 carried 176,330 passengers.

- Route 104, 69th Street Terminal to West Chester – Route 104 is the primary bus service along West Chester Pike. It operates along West Chester Pike from 69th Street Terminal to West Chester, and then continues to West Chester University where it terminates. Weekdays, there is a 30-minute headway in service to/from West Chester from 5 a.m. to about 12 a.m. Supplemental service operates to/from 69th Street Terminal and Sproul Road in Broomall during peak periods. In 2005, Route 104 carried 1,030,420 passengers.

- Route 110, 69th Street Terminal to Granite Run Mall/Penn State – This route proceeds from 69th Street Terminal to State Road, and then runs along State Road, Lansdowne Avenue to Township Line Road, State Road, and Sproul Road to Baltimore Pike, ultimately terminating at Penn State by Lima. Between 69th Street and Penn State, Route 110 operates on hourly headways; there is half-

hour weekday service on the route between 69th Street and Springfield Mall. During peak hours, there is additional supplemental service between 69th Street Terminal and Pilgrim Gardens (on Township Line Road). In 2005, Route 110 carried 508,760 passengers.

- Route 111, 69th Street Terminal to Penn State/Chadds Ford – Route 111 only transverses West Chester Pike between 69th Street Terminal and State Road. It then proceeds along US 1 to Penn State; with limited service to Chadds Ford. Inbound, service originates at Chadd Ford, Penn State, and in the morning at Drexeline Shopping Center (Township Line Road/State Road). The net result is a 20-25 minute headway for buses arriving at 69th Street. Outbound, there is a 30-minute headway for most of the day, with a 15-minute headway during the peak hour. In actuality, headways can be much longer depending upon where the passenger is destined. In 2005, 315,990 passengers used this route.

- Route 112, 69th Street Terminal to Delaware County Community College – Except for a small diversion along Darby Road and Manoa Road, Route 112 travels along the entire length of West Chester Pike within the study area. At Lawrence Road, Route 112 deviates from West Chester Pike, loops through the Lawrence Industrial Park, and then heads to Delaware County Community College via Sproul Road/Springfield Road and Media Line Road. Inbound, there is hourly service from Delaware County Community College throughout the day, and half-hour service during the AM and PM peak hours. Additional inbound service is offered from the Lawrence Park Shopping Center throughout the day. In the outbound direction, there are 30-minute headways, with some service terminating at Lawrence Park Shopping Center, some at the industrial park, and some at the community college. In 2005, 182,246 passenger used this route.

- Route 120, 69th Street Terminal to Cheyney University – Route 120 travels along West Chester Pike to Street Road in Willistown Township, which it then takes to Cheyney University. There are 11 inbound buses that arrive at 69th Street Terminal each weekday; 7 outbound buses depart the terminal. Supplemental bus service operates between Newtown Square and Cheyney University. In 2005, only 167,670 passengers used this route.

- Route 123, 69th Street Terminal to King of Prussia – The route follows West Chester Pike to the Blue Route, the Schuylkill Expressway, and ultimately terminating at King of Prussia Mall. There is half-hour service in both directions from 5 a.m. (inbound only) to 11 p.m. at night. In 2005, Route 123 carried 336,530 passengers.

Based on SEPTA schedules, it takes eastbound buses approximately 13 to19 minutes

to travel from the Blue Route to 69th Street Terminal in the morning peak. In the afternoon, the outbound travel time is approximately 16 to 19 minutes.

Busway Volume Threshold Standards

Busways are intended to increase bus speeds, making buses more competitive with autos. Too many buses in a busway will slow travel times, negating its benefits. On the other hand, an underutilized busway will be perceived by the public as a failure; ultimately there will be pressure to open it to general traffic.

A number of studies have been conducted to determine minimum and maximum volume thresholds for busway and high occupancy vehicle (HOV) lanes. The studies balance busway/HOV lane speeds versus general traffic lane speeds, and the person per hour throughput of a reserved lane versus the general traffic lanes. According to the definitive study conducted by the Texas Transportation Institute (TTI) for the Transportation Research Board (TRB), Table 4 presents threshold volumes for different types of arterial bus lanes.

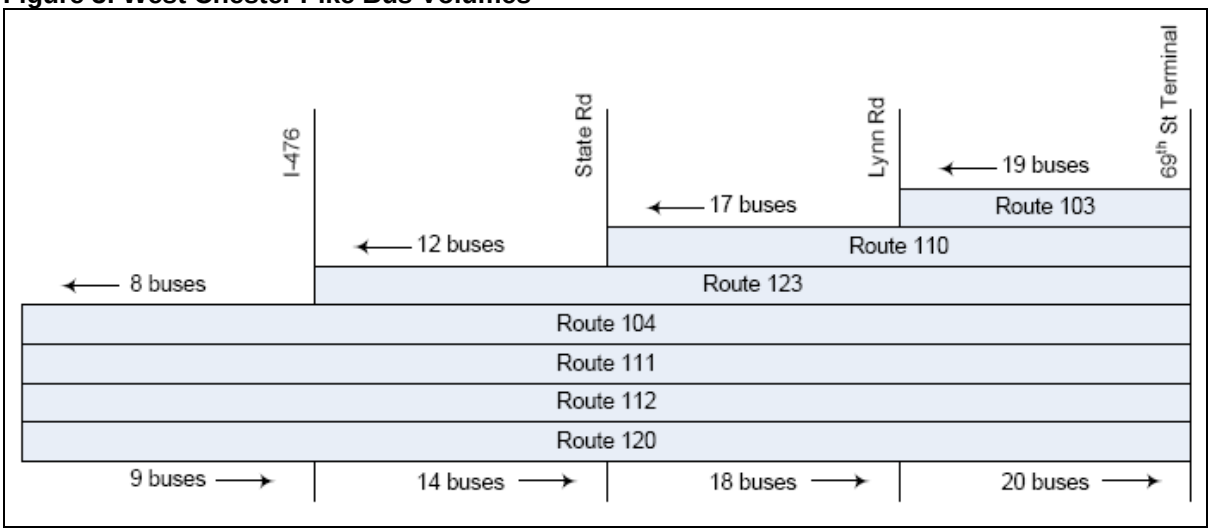
Table 4: Volume Operating Thresholds for Arterial Bus Lanes Versus Existing PA 3 Bus Volumes

Facility Type	Bus Volume Threshold (Volume per hour, per lane)		Existing West Chester Pike Bus Volumes per Hour	
	Minimum	Maximum	AM Peak	PM Peak
Right-side bus only	50	200	20	19
Left-side bus only	50	200	20	19
Center reversible	80	600	20	19
Contraflow bus only on one-way street	50	200	20	19

Source: Guide For High-Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials, November 2004

As shown in Table 4, the existing AM and PM peak-hour bus volumes are substantially below the threshold required to justify a bus lane. The bus volumes shown in the table are based on buses entering and leaving 69th Street Terminal. Because half of the routes turn off West Chester Pike prior to the Blue Route, bus volumes at the western end of the corridor are considerably lower. Figure 3 summarizes the number of buses using West Chester Pike during peak hours when a reversible busway would be in operation. The number of buses at the top of the figure represents the total afternoon outbound buses; morning inbound buses are totaled at the bottom of the figure. Without a significant increase in bus service and ridership, a reversible busway is not warranted.

Figure 3: West Chester Pike Bus Volumes



Source: SEPTA

Examination of Potential for Additional Bus Service

Using sketch planning techniques, DVRPC estimated the ridership required to operate additional bus service to meet the minimum bus warrants identified in Table 4. Since most bus lane configurations call for 50 buses per hour, this was selected as our target threshold. Two scenarios were examined, one with express service and the other with local service. In the first scenario, 50 additional peak-hour buses, representing a new express bus service from I-476/Lawrence Road area was examined. Existing local buses would operate concurrent with traffic. In the local bus scenario, 30 new peak-hour local buses, representing the additional buses needed to meet the 50 bus threshold at 69th Street Terminal, were examined. Because of the drop off of local buses west of State Road, the actual increase in buses required to meet the threshold falls somewhere within this range.

Assumptions for this analysis were derived from SEPTA's 2005 Route Operating Ratio Report upon which SEPTA's annual service plans are based. SEPTA operations is predicated upon meeting minimal thresholds of fare recovery. As such, the concept of peak-hour bus service or ridership is irrelevant; rather, SEPTA looks at the annual ridership required to support "X" amount of buses. In this manner, capital and personnel costs are spread out over the entire day, and weekends, not just a peak hour. Unfortunately, this cost model discriminates against a busway with limited hours of operation, and no weekend service, to support the annual ridership criteria.

This analysis assumes a "straight line" estimate derived from the three routes traversing

the length of the corridor (routes 104, 112, and 120). It also assumes no changes in operations, other than increased frequency; and it assumes appropriate capital improvements would be in place to permit optimal operations. The provided figures generally portray changes in magnitude and together demonstrate a range of required passenger boardings. Any significant changes to these assumptions will significantly alter the cost/benefit analysis.

The assumption is that the busway would run along West Chester Pike from Lawrence Road to 69th Street Terminal. The three routes examined extend well beyond the Lawrence Road limit. Consequently, there are limits on scaled comparisons using these routes as proxies for busway service. As stated previously, variable costs can only reliably be tied to the existing route designs. Because a shorter length than any existing route is proposed, these estimates are "high numbers" and the tendency would be to halve or quarter them to replicate the mileage of the corridor limits. However, that action would ripple through the other operation numbers, progressively diluting the accuracy of the estimates.

Conversely, by implementing a busway, SEPTA will incur capital and operating expenses beyond those factored in the cost assumptions. This includes costs associated with expanding 69th Street Terminal to handle additional buses, maintenance of busway right-of-way (including snow removal), operation of park-and ride-lots to serve the new service, and possibly increased service on the Market-Frankford Line to serve the influx of additional riders. Costs associated with construction of the busway are one-time capital costs that do not affect the analysis.

The general methodology is as follows: first, current vehicle hours and vehicle miles for each of the three routes are multiplied by their respective costs ($43.38 per vehicle hour and $1.50 per vehicle mile), added together and multiplied by a factor equaling an additional 30 and 50 peak buses. Peak vehicles are the number of buses required in the peak hours by a route to complete its operations; this number is determined by a combination of frequency, route length, etc. The resulting number is an estimate of the variable expense of each route.

Next, the estimated variable expense is then divided by 69 percent, the Victory Division's average ratio of variable costs to total costs, approximating the amount of fully allocated route expenses in the Victory Division. The fully allocated expenses for each line estimated for an additional 30 and 50 peak vehicles is then multiplied by 20 percent to yield the minimum acceptable operating ratio (fare box recovery) for the Suburban Transit Division. This number is the minimum acceptable income collected from fares for the routes described. Finally, when this fare box number is divided by the average Victory Division fare of $1.205, the total number of required fare paying passengers is the result.

Table 5 shows the estimated annual passenger ridership required using this methodology for an additional 30 and 50 peak-period buses. In addition, the Victory Division's average fare box recovery of 32 percent is also figured for each route, which yields a greater number of annual passengers. It should be emphasized the 20 percent and 32 percent columns in the table refers to fare box recovery rates, not increased levels of bus service.

Table 5: Required Ridership for Increase in Bus Service

					30 Add. Buses		50 Add. Buses	
					Fare Box Recovery Rates			
Route	**Vehicle Hours**	**Vehicle Miles**	**Existing Peak Vehicles**	**FY 2005 Annual Pass.**	**20% Req. Annual Pass.**	**32% Req. Annual Pass.**	**20% Req. Annual Pass**	**32% Req. Annual Pass.**
104	42,088	686,889	10	1,030,420	2,950,557	4,720,891	4,425,836	7,081,337
112	15,194	182,246	8	411,640	1,152,242	1,843,588	1,819,330	2,910,928
120	6,400	167,670	1	103,860	4,049,338	6,478,941	6,748,897	10,798,234

Source: DVRPC

The numbers shown for the three routes should be regarded as scaled up versions of the currently operating routes' "straight line" trend estimates. Since all of these routes exceed the geographic limits of the corridor, these vehicle miles and vehicle hours are large relative to the study segment (meaning that required ridership to cover costs are also likely overstated). On the other hand, additional costs to maintain the busway and expand 69th Street Terminal partially compensate for the overestimation.

Based on Table 5, at least 1.5 million annual riders will be required to sustain a sufficient level of buses to warrant a busway. It is the best case scenario, based on 30 additional buses for Route 112 and an average of the two fare box recovery rates. That is as many riders as routes 104, 112, and 120 currently carry combined – and a fair portion of their ridership originates beyond the busway corridor. For a new express service, more than 2 million annual riders are needed. To place the ridership issue in perspective, the Victory Division currently operates 102 buses. Implementing a new express bus service – with limited hours of service at the service level to warrant a busway – would necessitate a 50 percent increase in bus service over current levels for the entire division. A new express bus service with this frequency of service is not feasible.

Local bus operation in the busway appears to be the best option from a ridership perspective, but even this is unlikely to generate sufficient ridership. Assuming conservatively an annual ridership increase of 1.5 million additional passengers, 30

additional buses – distributed over 250 work days, and six hours of service (three hours inbound and three hours outbound) – this would require 33 passengers per bus every hour of busway operation throughout the year. Given the extensive service in the corridor, it will be difficult to sustain this level of additional ridership without a structural change in service.

Other Considerations

In addition to increasing service on the three routes studied in the previous analysis, the *Delaware County Long-Range Bus Service Study* predicated its busway recommendation on the following changes in transit service:

- Passengers using future bus service along I-476 can transfer at West Chester Pike and take Route 104 to 69th Street.

- Bus service between King of Prussia and 69th Street Terminal could be rerouted to take advantage of the express lanes.

- Special Route 104 service could be offered between a park-and-ride lot located at the I-476/West Chester Pike Interchange and 69th Street Terminal.

This section will evaluate each of these assumptions.

The court agreement that permitted construction of I-476 contained several stipulations, one of which required PennDOT to construct park-and-ride lots along the Blue Route. As per the stipulation, PennDOT and its consultant team attempted to construct park-and-ride lots and/or transit stations at the locations listed below:

- Radnor – PennDOT proposed a new station to serve both the Route 100 Trolley and the R-5 Line. A new ramp from I-476 was to provide access to the station.

- Marple – PennDOT proposed constructing a park-and-ride lot at the West Chester Pike interchange.

- Wallingford – PennDOT proposed a new station on the R-3 Line. New ramps would serve the station.

- Eddystone – PennDOT proposed a new station on the R-2 Line in the vicinity of the Baldwin site.

In most instances, local opposition prevented PennDOT from implementing any of the projects (Eddystone is the exception). Residents were opposed to “outside traffic” from

adjoining municipalities using their streets to reach the parking lots, even when PennDOT was proposing direct ramps from I-476. If PennDOT could not overcome the opposition when they were under court order to construct park-and-ride lots, the feasibility of constructing park-and-ride lots for a Blue Route bus service is problematic.

The second premise is predicated on rerouting King of Prussia bus service from the Schuylkill Expressway to the busway via I-476. Even though King of Prussia - Philadelphia bus service is principally used by city residents reverse commuting to King of Prussia, the analysis of rerouting bus service from the Schuylkill Expressway is based upon the in-bound direction concurrent with usage of the busway. Transit passengers are very sensitive to travel times, whether it is in-vehicle or in-station waiting times. Based upon current schedules, it takes routes 124 and 125 in the range of 51-63 minutes to travel from the King of Prussia Transportation Center to 15th and Market streets in Center City via the Schuylkill Expressway during the AM peak period. Comparable travel times by means of Route 123 to 69th Street Terminal and then via the Market Street El to 15th Street is 52-54 minutes. When transfer time at 69th Street is accounted for, there is no significant difference in travel times between the two routes. Making passengers transfer from bus to subway service could somewhat negatively impact ridership. While it appears feasible to reroute routes 124 and 125, the net result on the busway is only an additional four buses per hour, still well below the required threshold.

If express bus service is to operate on the busway, it is critical to construct a park-and-ride lot in the vicinity of the I-476 interchange as suggested by the *Delaware County Long-Range Bus Service Study*. Park-and-ride expands the market shed for transit beyond residents living within walking distance of a bus stop. A I-476 interchange site would offer the widest market shed, not only attract riders west of the Blue Route but also from areas lining the Blue Route. The potential for such a facility(s) was investigated.

As shown in the aerial photo, Figure 4, four potential sites were identified. The wooded parcel in the northeast quadrant of the interchange, just north of the South Lawrence Road intersection was not included in the analysis because Darby Creek passes through it making it totally unsuitable for development. Below is an analysis of each of the four sites:

- Site 1, Northwest Quadrant – This site consists of four separate parcels. The strip of land bordering West Chester Pike, where the accident investigation lot is located, is owned by PennDOT, and is a remnant of the I-476 right-of-way. Immediately behind it is a road owned by the Gamma Swim Club, functioning as its driveway. About 80 percent of the remainder belongs to Delco Mather Associates; a strip running from the swim club to where the driveway bulges out

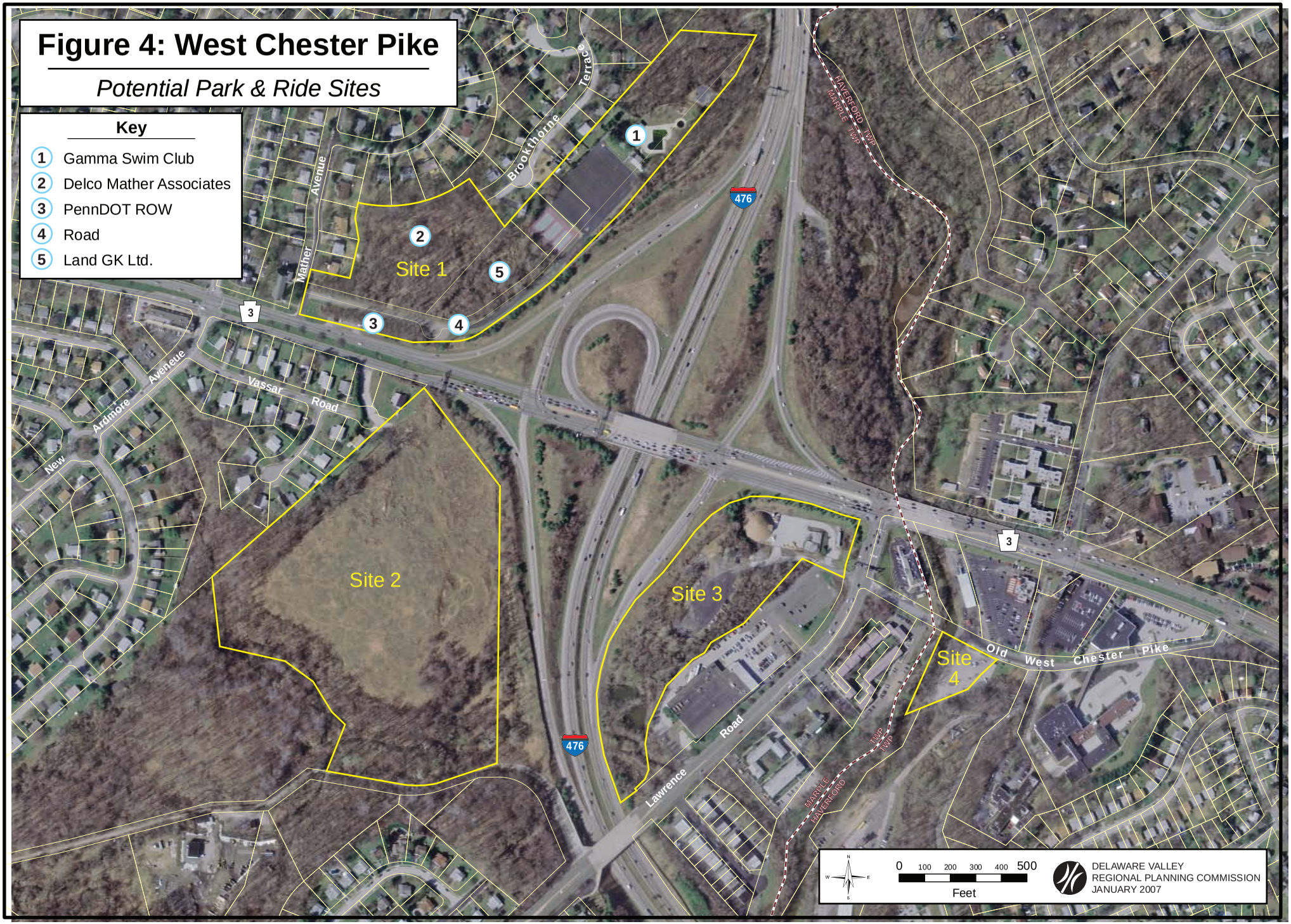


Figure 4: West Chester Pike
Potential Park & Ride Sites
Key
1 Gamma Swim Club
2 Delco Mather Associates
3 PennDOT ROW
4 Road
5 Land GK Ltd.
Site 1
Site 2
Site 3
Site 4
Brookthorne Terrace
Mather Avenue
Vassar Road
Ardmore Avenue
New
Lawrence Road
Old West Chester Pike
HAVERFORD TWP
MARPLE TWP
476
3
0 100 200 300 400 500
Feet
DELAWARE VALLEY
REGIONAL PLANNING COMMISSION
JANUARY 2007

belongs to Land GK LTD.

This site was rejected as a potential park-and-ride lot due to recent development and access issues. The Delco Mather Associates parcel is under development and renders most of the site unavailable. The developer extended Brookthorne Terrace to Gamma Swim Club driveway, constructing houses on both sides of the road. Access to the Land GK LTD property is also an issue. First, PennDOT or SEPTA would have either to purchase a part of the Gamma Swim Club driveway or gain an easement to it. Second, there is no direct access between the parcel and West Chester Pike. The site is too close to the I-476 interchange to construct a new signalized intersection at the accident investigation site. Access via Mather Avenue will likely generate opposition from local residents.

- Site 2, Southwest Quadrant – This site is unusable because of access and topography issues. The parcel is situated on the I-476 southbound on-ramp with no West Chester Pike frontage. The road that appears to extend from West Chester Pike toward the site is a private driveway serving a business it encircles. Its intersection with West Chester Pike is inaccessible to southbound Blue Route off-ramp traffic, one of the primary markets to be served by the park-and-ride lot. The other option to gain access to the site involves using the New Ardmore Avenue signalized intersection (at the left border of the aerial) and Vassar Road. Neither option is very desirable given community opposition they would generate. In addition to access issues, there is a steep grade at the rear of the parcel as the topography drops toward Langfod Run. The net acreage available for development is considerably smaller than the clear area shown on the aerial.

- Site 3, Southeast Quadrant – This is an ideal location for a park-and-ride lot. PennDOT's Maintenance Facility and the property adjacent to it are I-476 right-of-way remnants. Access is available via a signalized intersection on South Lawrence Road. A sizeable portion of the site is already cleared, which should expedite environmental clearance. There are approximately 1.7 acres available, which should yield about 300 parking spaces. The two negatives about this site involve potential easement issues related to use of the driveway and a steep drop between the site and I-476.

- Site 4, Southeast Quadrant - This site is an overflow parking lot for the abandoned Mercy Hospital. It contains approximately 140 spaces. There is easy access into and out of the site via the signalized West Chester Pike/Old West Chester Pike intersection. If the Old West Chester Pike Bridge over Darby Creek is replaced, motorists would have direct access from South Lawrence Road; it would also enable using this site in tandem with the PennDOT site. Other than requiring a resurfacing, the site is available for use; no environmental

clearance is required.

Even if 450 parking spaces were constructed (sites 3 and 4), making it one of SEPTA's largest parking facilities, it would still not provide sufficient parking to generate a level of ridership to sustain an additional 30 buses per hour. In summary, the increase in ridership required to warrant a reversible busway would practically require doubling the existing ridership. Assumptions expressed in the *Delaware County Long-Range Bus Service Study* about constructing park-and-ride lots and diverting bus service from King of Prussia would only generate a minor increase in bus levels.

Given the difficulties of increasing bus ridership sufficiently for a busway, this does not preclude implementation of other strategies to improve bus service in the corridor. Transit ridership levels in the corridor, combined with the fact that many of the passengers are taking a two-seat ride – bus and the Market-Frankford Line – clearly demonstrate the propensity to take transit. Improvement options include:

- Construct park-and-ride lots – Based upon a very cursory look, this effort identified two potential park-and-ride locations with up to 450 spaces. A more rigorous examination of the corridor could potentially identify additional park-and-ride opportunities. The Delaware County Planning Department should organize a task force composed of SEPTA, PennDOT, Delaware County TMA, Chester County, Transportation Management Association of Chester County, the municipalities, and DVRPC to identify and implement park-and-ride lots in the corridor.

- Bus priority treatment – As will be discussed in the next chapter, almost all intersections in the corridor currently operate with a very satisfactory level of service, therefore implementing bus priority treatment will have little or no impact since there is no incentive in terms of time savings. However, there are two locations where bus priority treatment may prove beneficial to transit.

    1. Glendale Road to Eagle Road – These intersections currently operate satisfactorily in the morning, but are congested in the afternoon. The delays largely occur on the approach roads, not on West Chester Pike. One option is for PennDOT to retime the traffic signals, giving more green time to Glendale and Eagle roads, thus transferring the congestion onto West Chester Pike. Employing traffic signal preemption technology, buses can avoid delays and give themselves a travel time advantage over general purpose traffic. Implementing a limited busway in the median at this location will worsen overall traffic congestion, but will make the travel time advantage of the buses more pronounced. Retiming traffic signals and employing transit preemption will require the approval of PennDOT and the municipality.

2. State Road to Garrett Road – Ideally, as the buses approach 69th Street Terminal, some form of bus treatment should be implemented to increase the visibility of buses in the corridor. As previously discussed, the spur line at Garrett Road could be paved to allow dual use with buses using it in the morning as a bypass, and trolleys using it in the afternoon as a storage facility. As will be discussed in the next section, just to the west of the spur line there is insufficient median right-of-way for a busway, and various options were investigated to solve this issue. One of the options studied was removing the third eastbound lane and combining it with the median to form a busway. This option was rejected on technical merits due to its impact on traffic. From a policy perspective, if the county is willing to trade off congestion for bus priority treatment, and can somehow obtain concurrence from PennDOT and Upper Darby, this may be an option.

4. DESIGN ISSUES

Converting the West Chester Pike median to a reversible busway is not a simple matter of paving a 12 foot travel lane. There are design issues relating to delineating and signing the busway, separating it from other travel lanes, facilitating left-turning traffic, treatment of surplus median areas, and creating safety areas for pedestrians crossing West Chester Pike. To address design issues, this section will identify critical design elements from various design standards and busway efforts in other regions. The primary output will be a determination of the adequacy of the West Chester Pike median to support a busway. If bus rapid transit (BRT) service is considered, as some have suggested, the design standards that would be employed are much more robust than those used in this analysis.

A recurring theme that must be addressed is the need for a proactive approach to ensure unauthorized vehicles do not enter the busway. This region has extremely aggressive drivers who routinely disobey basic traffic regulations. If motorists perceive the busway is underutilized, some of them will be tempted to use it, creating a safety hazard, and endangering the busway's existence. To avoid potential liability issues, and assuage the concerns of PennDOT and SEPTA lawyers, the design must include both active and passive design elements to prevent intrusion by unauthorized vehicles.

Another basic assumption, as discussed in the previous chapter, is that the busway will be for local bus service. Even if express bus service is warranted, and bus stops are not required, there would still be a need for some form of pedestrian refuge treatment to assist pedestrians crossing West Chester Pike. Thus the inclusion of bus stops, which impacts right-of-way requirements, does not alter the basic conclusions of this analysis.

Design Elements

To identify busway design elements and standards, a literature review was conducted. Some of the more pertinent design standards and reference materials include:

- *Geometric Design of Highways and Streets, 2004*, American Association of State Highway and Transportation Officials (AASHTO)
- *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*, 2003 Edition, Federal Highway Administration (FHWA)
- *Guide for High-Occupancy Vehicle Facilities*, November 2004, AASHTO

- *Bus Rapid Transit*, 2003, Transportation Cooperative Research Program (TCRP) Report 90

- *Characteristics of Bus Rapid Transit for Decision Making*, August 2004, Federal Transit Administration (FTA)

Based upon the previously listed reference materials, the following design elements are integral to designing a busway:

- Busway width – The width of the busway travel lane should be 12 feet wide; if sufficient right-of-way is unavailable, a minimum width of 11 feet is acceptable.

- Separator – A traffic separator is required to separate the busway from the general-purpose travel lanes. Three separator options are possible: raised medians, painted separators, and physical devices.

    1. Raised medians – This option includes retaining a portion of the grass median, or constructing mountable or unmountable curbs. Pedestrian refuge islands and/or bus stops can also function as a raised median when they are closely spaced. Raised medians provide the most positive restriction on general-purpose traffic in entering the busway. However, raised medians make it more difficult to manage snow removal and vehicle breakdowns; they make it more difficult for snow plows and tow trucks to enter the busway.

    2. Painted separators – Painted neutral areas is another method to separate busways from general purpose lanes. There is little information as to how wide the painted neutral area should be and what form it should take. If the separator is too wide, it can be used by vehicles as a breakdown lane. If it is too narrow, it essentially becomes a lane edge line. The MUTCD suggests if it exceeds four feet wide, painted chevron markings should be placed in the neutral area.

    3. Physical devices – Physical devices such as traffic cones or flexible posts placed in drill holes can be employed to separate the busway from general traffic lanes. While they have excellent visibility and can be removed to facilitate snow removal, they are temporary devices that need to be continuously replaced. Without a strong maintenance program they will eventually become ineffective.

    Given the aggressive nature of drivers in the region and the need to minimize SEPTA maintenance costs, a raised median is the most appropriate approach for West Chester Pike. Where at least eight feet is available on either side of the

busway, a grass strip with curbing is appropriate. Where there is less than eight feet available for a separator, a mountable concrete curb is acceptable. It is difficult to mow grass when the grass strip is less than six feet wide (eight feet with curbing).

- Passenger loading platform – Passenger loading areas should not be less than five feet wide, and preferably 6 to 10 feet wide. If bus shelters are located in the passenger loading area, the upper end of the range becomes the desirable minimum width. For the purposes of this analysis, a six-foot width is assumed (i.e., no bus shelter). Loading areas should be raised to allow passengers to board and exit buses more easily. Protection is required to ensure passengers do not inadvertently step into a general purpose travel lane. This can be in the form of a railing or a wall. Protection is also needed to ensure that vehicles that lose control do not hit passengers waiting on the loading platform. The photo below shows an example of a SEPTA median passenger loading-platform on Girard Avenue, which includes many of the design elements just discussed.

Example of a passenger loading platform on Girard Avenue

Source: DVRPC

Because the busway will be reversible and in operation for limited hours, passengers may be confused as to which bus stop to use. A traveler information program will be needed to inform passengers which bus stop to use.

- Pedestrian considerations – There are three separate pedestrian issues that must be addressed.

  1. Pedestrian expectations – Contraflow and reversible bus lanes pose significant concerns for pedestrian safety because they violate pedestrian expectations. Pedestrians are not accustomed to looking in both directions

when crossing a busway. Signing will be required to warn pedestrians of this hazard.

2. Need for pedestrian refuge islands – The width of West Chester Pike generally varies between 80 to 100 feet curb-to-curb. Based upon a pedestrian speed of four feet per second (MUTCD design standard), it will take a pedestrian between 20 and 25 seconds to cross West Chester Pike. A review of the PennDOT signal diagrams indicate when pedestrian signals are actuated, or when pedestrians cross West Chester Pike concurrent with cross traffic – only the bare minimum time is provided. Therefore, some form of pedestrian refuge treatment is required. Bus stops, if properly designed, can also function as pedestrian refuge islands.

3. Crosswalks – ADA provisions must be built into the median treatment and platform area. Most of the signalized intersections have striped crosswalks consisting of two four-inch white lines. Relocating bus stops to the median will increase pedestrian activity, consequently the crosswalks should be enhanced with some form of supplemental longitudinal or diagonal lines for added visibility.

- Left-turn vehicle treatment – One of the major issues associated with arterial street HOV or bus lane treatments is how to accommodate turning movements for general-purpose traffic. There are three general approaches to address this problem:

  1. Prohibit left turns at intersections for all or part of the day – If this were to happen, provisions must either be made for periodic left turns at other intersections or, alternately, the left turns will have to be routed via a series of right turns to complete the left turn maneuver. These options are contrary to normal driver expectations and would lead to confusion and increased accidents. Most side streets are residential in nature and can not handle additional traffic, especially trucks.

  2. Permit general-purpose traffic to enter the busway or HOV lane to make a left turn – Generally this is the most common approach to address the left turn issue. However, this is not an option for West Chester Pike for a number of reasons. A reversible median busway is incompatible with letting vehicles enter the busway. Buses going straight through an intersection will be obstructed by opposing traffic occupying the busway waiting to make a left turn. Given the aggressive nature of drivers in the region, and their disrespect of traffic regulations, permitting vehicles to enter the busway to make left turns will only encourage unauthorized vehicles to use it. Lastly,

any congestion at the intersection will only slow down buses.

3. Place left-turn lanes outside the busway – This option allows general-purpose traffic to cross the busway. Protected signal phasing will be required to prevent conflicts between the buses and left-turning traffic. However, adding an additional protected phase for buses will negatively impact traffic flow and requires additional right-of-way.

The last option, separate turn lanes outside the busway, is the only viable option for the West Chester Pike corridor.

- Transition treatment – Transition treatment refers to how buses can enter and exit the busway. The two options are 1) crossovers where buses can enter and exit from the left general-purpose travel lane or 2) buses can directly enter the busway at an intersection. For West Chester Pike, both treatments have merit. Terminating the busway at the Garrett Road intersection (if SEPTA facilities can be relocated from the median) would in effect create a queue jumper, allowing the buses to bypass vehicles waiting in the general purpose travel lanes. At the other end of the corridor by Lawrence Road there is no natural transition and cross overs are the only option. At intermediate points where buses enter and exit West Chester Pike, the choice is a function of the configuration of the intersection and its immediate area. Gates will be required to prevent unauthorized access during hours when the busway is inoperative.

- Pavement Markings – The diamond shape symbol with the word message "Buses Only" is required at the busway's approaches to each intersection. For physically separated reversible lanes, the MUTCD calls for the use of single normal solid white lines along the busway's left and right edge lines.

- Pavement color – AASHTO recommends using contrasting color and texture at bus turnouts to discourage through traffic from encroaching. Contrasting color and texture may also be appropriate for the busway to reinforce that it is not open to general-purpose traffic.

- Signs – As both a preferential lane and a reversible lane, proper signing of the busway is critical. The MUTCD recommends overhead preferential-only lane signs be used at the initial entry point, and at intermediate access points where vehicles are legally allowed to access a buffer-separated preferential lane (e.g., busway). Ground mounted signs are required periodically along the preferential lane; supplemental ground mounted signs can also be employed at all legal entry points. At a minimum, "Bus Only" signs should be ground mounted at each intersection. In terms of reversible lane signs, because the busway will have a

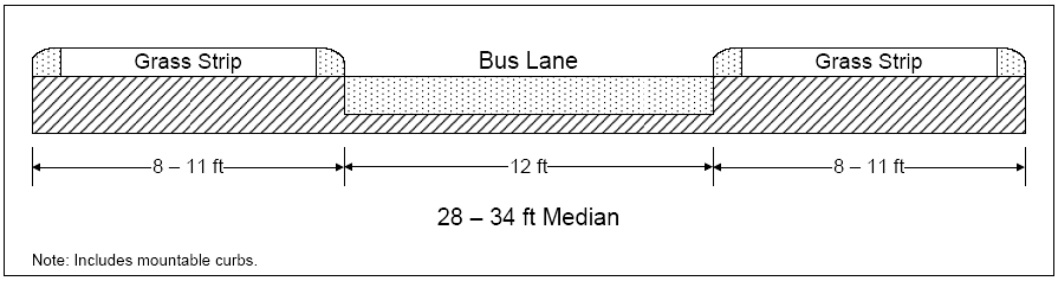
buffer separating it from general-purpose traffic, and it is limited exclusively to buses, ground mounted signs indicating hours of operation and direction of traffic should meet MUTCD signing requirements. Based upon standard sign dimensions, and the pedestal dimensions for cantilever overhead signs, at least four feet are required on each side of the busway to support required signing.

- Enforcement – Many other regions have struggled with the issue of enforcement when dealing with busways and other forms of high occupancy vehicle (HOV) lanes. Typical solutions call for dedicating law enforcement personnel to monitor where vehicles enter the HOV lane or constructing a pullout area where law enforcement can periodically monitor the lane for unauthorized vehicles. For West Chester Pike neither option is feasible, which reinforces the need for a proactive design to restrict its use.

- Median remnants – West of State Road where the mid-block median width is 31-34 feet wide, there will be between 19-22 feet of median remaining, available for grass, and other decorative planting. Even when the median narrows and there is only 4-8 feet of median available on either side of the busway, decorative elements such as mosaic tiles can be employed to mitigate the median's appearance.

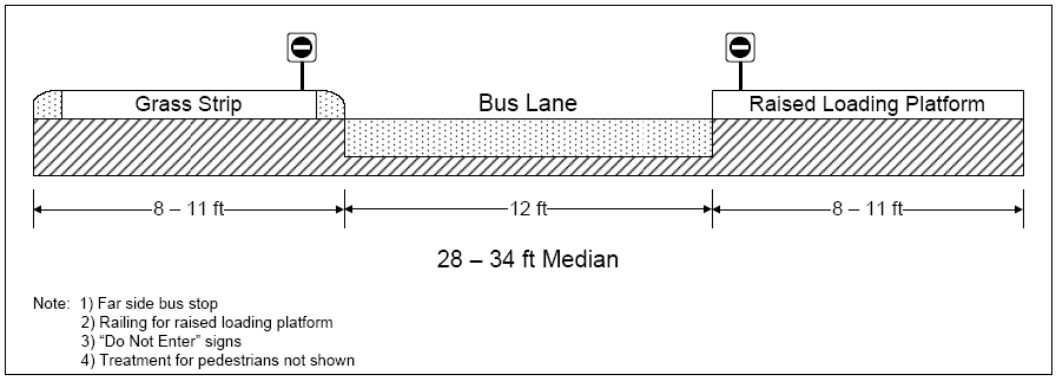
Based on the preceding design elements and standards, the busway should ideally be configured as shown in Figures 5 and 6. Figure 5 shows an ideal mid-block configuration, and Figure 6 shows the desirable configuration at intersections. The next section focuses on those areas that do not meet these conditions.

Figure 5: Ideal Mid-block Busway Configuration



Source: DVRPC

Figure 6: Ideal Busway Configuration at Intersections



Source: DVRPC

Analysis of Adequacy of Median

This section will apply the above design standards to the West Chester Pike median to determine if there is adequate width for a busway. The focus will be on those sections that do not match the ideal configuration described above. Special consideration will be given to the section between Harvin Road and Merion where the median width varies between 2-14 feet wide, well below the required width; and at Township Line Road where there is a 6 foot wide median coupled with a wide median opening for the Llanerch Volunteer Fire Company. Except for a few isolated sections, the remainder of the median has adequate width for a busway.

Harvin to Merion

State Road represents a transitional area where the West Chester Pike right-of-way narrows from 120 feet west of State Road to 103 feet east of State Road. As a result of the 17 foot reduction in right-of-way, the basic median width goes from 31 feet wide in the western section of the corridor to 14 feet wide east of State Road. When left-turn lanes are present, at State Road and Elm Avenue, the median is reduced another 12 feet to a 2 foot concrete median. Since the median alone clearly can not support a busway, three alternative options were investigated: narrow the travel lanes to increase the median width, removal of on-street parking and reconfigure the travel lanes, and eliminate the third eastbound travel lane.

The first option involved narrowing travel lanes to bare minimum standards; reducing 12 or 13 foot lanes to 11 feet wide. This action could potentially yield an additional seven feet for the busway (based on PennDOT traffic signal diagrams). While this would produce sufficient right-of-way where the median is currently 14 feet wide (less than ideal busway configuration but still meeting minimum standards), it will still not solve the problem at State Road or Elm Avenue where the right-of-way is currently two feet wide.

State Road intersection

Source: DVRPC

The second option examined removal of on-street parking and then reconfiguring the travel lanes to increase the median. In the westbound direction, there are two travel lanes and a parking lane. Metered parking is available in Upper Darby via an unstriped parking lane. In Haverford, painted markings delineate the parking lane. In the eastbound direction, limited on-street parking is available in Upper Darby.

Removal of on-street parking is not a very desirable option. Properties abutting the westbound lanes can be characterized as almost continuous two-story buildings. East of Leighton Terrace it is exclusively residential. Between Leighton and Township Line Road, the first floor is generally retail and the second floor is residential. As a consequence, there is a fair amount of on-street parking. Based on field views, analysis of aerial photos, and review of PennDOT video logs, between 18-25 vehicles park at any given time over this quarter-mile stretch of road. Between opposition from local residents and retail establishments who have no alternative parking choices, and loss of parking revenue from more than 40 parking spaces, it is highly unlikely that Upper Darby would be supportive of this option. Removal of on-street parking would also negatively impact pedestrians because relatively fast moving traffic would be directly adjacent to sidewalks, creating unpleasant conditions.

In the eastbound direction, the land use is more commercial in nature with most commercial establishments having off-street parking. Thus, there is less frequent on-street parking. The primary location where on-street parking was observed is in front of the Upper Darby Police Department offices. It is assumed Upper Darby would not be supportive of removing on-street parking used by police officers and borough residents

having police business.

The last option involves eliminating the third eastbound travel lane and combining it with the median to provide right-of-way for the busway. Just to the west of State Road, the eastbound lane configuration goes from two travel lanes to three travel lanes; it continues as three lanes to Garrett Road. The net result of eliminating the third lane would be increasing the two-foot median width cross section to 15 feet wide and the 14-foot section to 27 feet wide. Theoretically this will provide right-of-way for a busway. However, it would still entail eliminating bus stops in the 15-foot section. A level of service analysis of the West Chester Pike/State Road intersection was conducted to evaluate its impact on congestion levels. The methodology used in this analysis will be described in more detail in the next chapter. Results indicate increased congestion, creating level of service F conditions from current level of service D. Today, all approaches operate at level of service D or better. Under this option, three of the intersection approaches will experience level of service F.

Due to lack of sufficient right-of-way in the median for a busway, and no viable scenario to rectify this deficiency, constructing a busway in this section of West Chester Pike represents a fatal flaw. This half-mile section is located in the most critical section of the corridor, the approach to 69th Street Terminal, where any form of bus treatment would be both highly visible to motorists and beneficial to buses. It may be possible that policy concerns will override this technical analysis and Delaware County, PennDOT, and Upper Darby will all agree that promoting transit service outweighs increased congestion in the corridor and are willing to assume the risk of angering motorists. Promotion of Transit First policies of this magnitude is a policy decision outside the scope of this study.

Darby Road to Township Line Road

This segment is characterized by a short 31-foot median between Darby Road and Llanerch Volunteer Fire Company, a median opening in front of the fire company building, and then a median taper to a 6-foot grass median between Llandaff Road and Township Line Road. The photo on Page 46 shows this segment in more detail.

There are two issues associated with this section: 1) the narrow 6-foot median, and 2) the discontinuous median.

The easier of the two issues to address is the narrow median width. There are 10-13 on-street metered parking spaces in the eastbound direction between Darby Road and Township Line Road. Field observations and a review of aerial photographs reveal only limited on-street parking, usually only two or three vehicles. A municipal parking lot, with metered parking, is located on the eastbound roadway minimizing the need for on-

street parking. Removal of the on-street parking and reconfiguring the lane configurations should provide adequate right-of-way for a busway.

Darby Road intersection, Llanerch Volunteer Fire Company

Source: DVRPC

The second issue involving the discontinuous median opening is more complex and potentially a fatal flaw. Darby Road intersects West Chester Pike at an oblique angle. Having Route 112 buses execute left turns into a busway that is less than 50 feet long followed by the 100-foot median opening is a very difficult maneuver for buses. Visual observation of the intersection revealed trucks and buses had difficulty making the left turn from Darby Road to West Chester Pike, frequently straying beyond their lanes. A short 50 foot median would more act as a channelization island, which based upon observations, would probably be constantly driven over by buses. If emergency equipment is parked in the median (which frequently happens), it would compound the complexity of the maneuver, because bus drivers would be unaware the busway is obstructed, creating a hazardous situation. Removal of the median would create a 150-foot undelineated opening, confusing motorists. There are no obvious solutions to this problem.

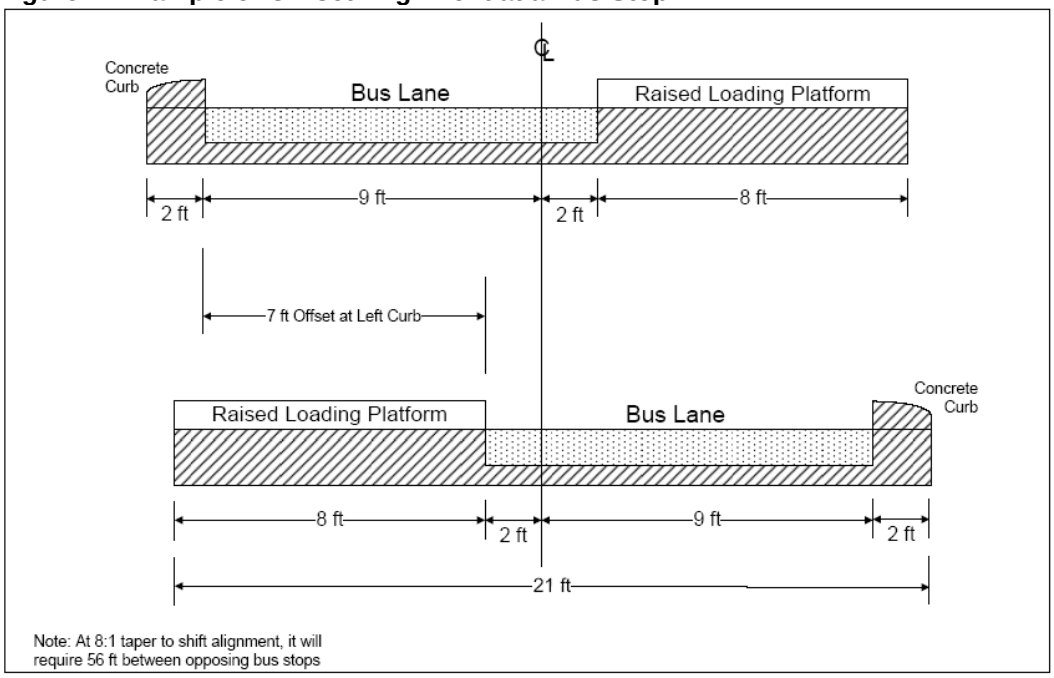
Old West Chester Pike to Robinson Avenue

In this segment there are two concurrent left-turn lanes, an eastbound left-turn lane for Robinson Road, and a westbound left-turn lane for Old West Chester Pike. As a result, the median varies from 6 feet wide when the two lanes are present to 20 feet wide when only one lane is present. A combination of narrowing the shoulders and reducing travel lane widths should produce sufficient right-of-way for a busway.

Other Substandard Locations

There are many locations, where due to the presence of a left-turn lane or other circumstances, the median is only moderately substandard. Generally, these locations have a median width of the magnitude of 19-22 feet wide; wide enough for a midblock busway, but inadequate at intersections when bus stops are present. As shown in Figure 5, the minimal ideal median width when a bus stop is present is 28 feet. The situation can be corrected by first reducing the width of travel lanes, turn lanes, shoulders, and/or parking lanes. If this is inadequate, the busway alignment can be slightly off-set from the true centerline of the median, shifting it in the opposing direction from the bus stop, thus reducing the required width (see Figure 7). Buses will be required to slightly veer to their right or left as they pass through the intersection. While not an ideal situation, due to the slow bus speeds, the minimal offset, and the distance to effect it, it will have a minimal impact on the buses.

Figure 7: Example of Off-set Alignment at a Bus Stop



Source: DVRPC

Below is a list of areas where this problem occurs and its approximate median width:

- Glen Gary Drive to Stanton Road – 21 feet wide
- Fairlamb Avenue to Glendale Road – 20-21 feet wide
- Eagle Road – 20-21 feet wide

- West of Washington Avenue – 21 feet wide
- Manoa Road – 21 feet wide
- West of Sycamore Road – 21 feet wide
- Westwood Park Drive to Naylors Run Road – 21 feet wide
- East of Steele Road – 21 feet wide
- Gilmore Road – 21 feet wide
- West of Kohl's – 21 feet wide
- West of Darby Road – 20 feet wide
- East of Township Line Road – 21 feet wide
- Brighton Avenue – 22 feet wide
- Linden Avenue – 22 feet wide
- Cloverdale Avenue to Lynn Boulevard – 20-22 feet wide
- Park Avenue to Saint Laurence Road – 22 feet wide
- South Cedar Lane – 21 feet wide
- Carol Boulevard – 20 feet wide
- Pennock Avenue – 19 feet wide
- West of Kenmore Road – 19 feet wide
- Harvin Road – 19 feet wide

5. IMPACT ON TRAFFIC

To study the traffic impact of the proposed busway, DVRPC used Synchro as a sketch planning tool to analyze traffic flow in the corridor. Synchro software is used by PennDOT to optimize arterial traffic signal interconnects. For a given set of traffic volumes, signal phasing, and distance between signalized intersections, Synchro will optimize signal splits and offsets. As a byproduct of the optimization runs, Synchro produces a number of measures of effectiveness including travel times, delays, queue lengths, and, most importantly, level of service (in accordance with Highway Capacity Manual methodology). Synchro also produces visual simulations that graphically show vehicles flowing through the network to help professionals observe the impact of alternative signal timing scenarios.

Synchro is not designed to evaluate the impact of a reversible busway on traffic flow. It is essentially traffic signal optimization software. In discussions with experts who teach Synchro training courses, they indicated the only way to accurately evaluate the busway is to employ micro simulation modeling techniques, which is beyond the scope of the study. Given these constraints, Synchro was employed with the realization it will only very loosely emulate field conditions.

Methodology and Assumptions

DVRPC obtained Synchro data sets (traffic volumes, turn movements, roadway configuration, and signal timings) from PennDOT. Information is based on traffic studies conducted around 2001-2002 when closed loop traffic signal systems were constructed on West Chester Pike. The data set has three major limitations. First, turning movement information for unsignalized intersections is missing, consequently unsignalized intersections are not modeled. Second, traffic volumes are a few years old; but in this section of Delaware County traffic is fairly stable and no significant deviations are anticipated. Lastly, traffic information for Garrett Road is missing and thus not modeled.

To simulate busway conditions, the following assumptions were made:

- Buses in the busway will have their own exclusive phase – Since left-turn lanes will be placed outside the busway, the busway must have its own exclusive phase to avoid conflict with turning vehicles. Since Synchro can not model a busway, we attempted to emulate the busway phase by increasing the all red interval equivalent to the green time and change interval needed for the busway. Based upon the minimum warrant of 50 buses per hour, and existing cycle lengths, it is reasonable to assume two buses per cycle will pass through an

intersection. Therefore, an additional 13 seconds was added to the all red interval based on two buses per cycle (with slower start-up time and headways than standard vehicles) and a 6-second yellow/all red change interval.

- Convert all left turns to protected phasing – Eliminating permitted phasing is required to avoid the situation where vehicles are sitting in the median opening trying to observe a gap in opposing traffic, but are obstructed by a bus in the busway.

- Two lane eastbound configuration at State Road – The only change to the current roadway configuration was to eliminate the third eastbound through-lane at State Road. As previously discussed, this is required to provide right-of-way for the busway.

Level of Service Analysis

Level of service (LOS) for all signalized intersections, under current conditions and with a busway, is presented in Table 6. Both AM and PM peak conditions are displayed.

As shown in Table 6, all intersections in the study area currently operate with level of service D or better with the exceptions of Eagle Road and Township Line Road, which operate at level of service E in the afternoon, and Glendale Road, which operates at level of service F in the afternoon. Of the 21 intersections analyzed, over half operate with level of service A during at least one of the peak periods.

Low cross street volumes are the primary reason why the corridor operates with such an excellent level of service. Many cross streets have fewer than 100 vehicles on each approach, allowing green time to be apportioned to West Chester Pike. With detectors placed on most cross streets and left-turn lanes, controllers can terminate phases on minimum green for these movements without having to max out.

Provision of a busway will severely impact the following intersections:

- North Lawrence Road – This intersection currently operates at level of service D; with a busway it will operate at level of service F in the morning and level of service E in the afternoon. Congestion is attributable to backups on North Lawrence Road approaching the intersection. West Chester Pike will operate with minimal congestion.

- Old Westchester Pike – In the afternoon, level of service will go to E from existing C conditions. Like North Lawrence Road, congestion will occur on the cross street approach to the intersection.

- Glendale Road and Eagle Road –These intersections are currently operating satisfactorily in the morning, but are failing in the afternoon peak period. With a busway, the intersections will fail in the morning, and congestion levels will worsen in the afternoon. Failures will occur on both approaches of Eagle Road, northbound Glendale Road, and the westbound left-turn traffic on West Chester will extend into one of the through lanes in the afternoon (through traffic will be unaffected).

- Steel Road – With a busway, there will be a backup in the eastbound direction from Steel Road to Naylors Run Road in the afternoon.

- Darby Road and Township Line Road – The two intersections currently operate at level of service C in the morning; it is anticipated they will operate at service level D with a busway. In the afternoon, the Darby Road intersection will go to level of service E from level of service D; Township Line Road will experience service level F conditions from current E conditions. In the afternoon, both the northbound and southbound approaches on Darby Road and Township Line Road will be backed up with the queue much worse than existing conditions. On the northbound Darby Road approach and the northbound Township Line approach, the queue will extend past the Darby Road/Township Line Road intersection. On West Chester Pike, eastbound left-turns at Township Line Road will extend into the through lanes, even though there are dual left turn lanes. In the westbound direction, the left turns will also extend into through lanes.

- North Lynn Boulevard/Park Avenue – North Lynn Boulevard goes from level of service C to service level E in the morning, and Park Avenue goes to level of service F from service level D during both peak periods. The Park Avenue intersection eastbound and northbound approaches currently operate at or beyond capacity; the other approaches operate with acceptable level of service. Giving green time to the busway pushes the eastbound movement beyond capacity in both peak periods; the westbound approach operates at capacity in the morning. A visual observation of Synchro shows traffic between North Lynn Boulevard and Park Avenue will not clear the intersections, causing spillback conditions. Consequently, southbound traffic on North Lynn Boulevard becomes congested because traffic on that approach will be unable to enter the intersection.

- State Road – All approaches to State Road currently operate at level of service D or better during both peak periods. The combination of removing the third eastbound lane and adding a phase for the busway will result in three of the four approaches operating at service level E or F.

Table 6: Level of Service With and Without a Busway

Intersection	Peak AM LOS		Peak PM LOS	
	Existing	Busway	Existing	Busway
South Lawrence Rd	B	C	C	C
North Lawrence Rd	D	F	D	E
Old West Chester Pk	A	B	C	E
Glen Gary Dr	B	C	A	C
Glendale Rd	D	F	F	F
Eagle Rd	D	E	E	E
Manoa Rd	C	C	C	D
Country Club Ln	A	A	A	A
Naylors Run Rd	A	A	A	A
Steel Rd	A	B	A	F
Gilmore Rd	A	B	A	B
Kohl Driveway	A	B	A	C
Darby Rd	C	D	D	E
Township Line Rd	C	D	E	F
Brighton Ave	A	B	A	B
Linden Ave	A	A	A	B
North Lynn Blvd	C	E	C	D
Park Ave	D	F	D	F
Cedar La	A	A	A	A
Carol Blvd	A	B	A	C
Pennock Ave	A	C	A	B
State Rd	C	D	D	F

Source: DVRPC

For the remainder of the corridor, the impact of a busway on traffic flow is minimal. In most instances, the level of service is either unchanged or mildly degraded, and will still operate with acceptable level of service. As stated earlier, the low-volume side streets can easily absorb green time diverted to the bus phase.

Title of Report: Feasibility Analysis of West Chester Pike Busway: 69th Terminal to I-476

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Geographic Area Covered: This study consists of the area in Delaware County surrounding West Chester Pike. It includes Upper Darby and Haverford Township.

Key Words:
transit, busway, bus volumes, bus ridership, park-and-ride lots, traffic control, traffic impacts, level of service, medians, median elements, traffic control equipment, design

ABSTRACT
The purpose of this study is to conduct a feasibility analysis of using the West Chester Pike median between 69th Terminal and I-476 for a reversible busway. It takes a "fatal flaw" approach, trying to identify potential problems that would prevent conversion of the median. Areas examined included identification of physical obstructions in the median, transit ridership and the impact on transit operations, design issues related to a busway, and impact on traffic flow.

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