PHILADELPHIA ZOO PASSENGER RAIL:

Concept Development and Ridership Analysis

May 2017

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

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DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

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Source: Philadelphia Zoo. 2017

ACKNOWLEDGMENTS

Special thanks to the individuals and organizations who participated in the Advisory Committee and contributed data, input, and feedback throughout the project.

Byron Comati, Director of Strategic Planning, SEPTA
Victoria Harris, Long-Range Rail Planner, SEPTA
Kevin Jurgelewicz, SEPTA
Anita Davidson, Operations Planner, SEPTA
Vikram Dewan, President and Chief Executive Officer, Philadelphia Zoo
Andrew Baker, Chief Operating Officer, Philadelphia Zoo
Amy Shearer, Chief Marketing Officer, Philadelphia Zoo
Kenneth Woodson, Vice President of Community and Government Affairs, Philadelphia Zoo
Karl Fritz, Director of Business Operations, Philadelphia Zoo
Charles Marshall, Board Member, Philadelphia Zoo
Barry Schoch, McCormick Taylor
John Haak, Director of Planning Policy and Analysis, Philadelphia City Planning Commission
Brian Wenrich, City Planner, Philadelphia City Planning Commission
Robert Thomas, Partner, Campbell Thomas & Co.

Source: Philadelphia Zoo, 2017

EXECUTIVE SUMMARY

In the last 20 years, numerous planning studies have explored the feasibility and potential of a Southeastern Pennsylvania Transportation Authority (SEPTA) Regional Rail station serving the Philadelphia Zoo and adjacent neighborhoods. Most of the Zoo's periphery is bounded by Zoo Junction, a complex rail junction traversed by SEPTA and Amtrak passenger rail as well as the CSX freight "high line." As a result, direct passenger rail access to one of the region's premier tourist destinations has been close in proximity, but difficult to achieve.

The purpose of this study, conducted on behalf of SEPTA, was threefold:

- Synthesize prior Philadelphia Zoo station and rail access work, and summarize opportunities and challenges for the Zoo's preferred 34th and Mantua station location.
- Gather and analyze Zoo visitor and travel pattern data to understand the potential passenger market for Zoo rail access.
- Prepare ridership forecasts for five Philadelphia Zoo rail scenarios.

The first task in forecasting ridership potential for transit service to the Philadelphia Zoo was to understand the overlapping markets and factors that could contribute to ridership demand. A variety of data was examined to paint the picture of existing conditions, including Zoo attendance data and member visits by zip code of residence. Findings from this analysis were presented to the project Advisory Committee and used to inform the development of the five forecast scenarios.

Delaware Valley Regional Planning Commission (DVRPC) staff worked closely with the Advisory Committee members to develop the necessary inputs for travel demand forecasting. Each partner was asked to consider the "best realistic" future scenario in their area of expertise. In this case, "best realistic" was defined as a practical, achievable projection of future conditions based on knowledge of historic change and existing plans for the future. Universally, Advisory Committee members had the goal of creating an attractive transit option, enticing the highest number of future Zoo visitors to use transit.

The "best realistic" inputs were developed to estimate future study area population and employment, Zoo attendance and employment, and base operating patterns for a Regional Rail station and a monorail connecting 30th Street Station and the Zoo. The results of these "best realistic" scenarios were then analyzed to inform the development of three additional scenarios for which Advisory Committee members had the opportunity to revise inputs to answer "what if" questions about potential rail service. Table ES1 outlines the transit service modeled in each of the five scenarios.

Table ES1: Forecast Scenarios Summary

Phase	Scenario	Modeled Service
"Best Realistic" Scenarios	Base Regional Rail 	Paoli/Thorndale Line 3 platforms 30-minute or better headways 7 days a week, full day of service
	Base Monorail 	Connects Zoo to 30th Street Station 5 stops 10-minute headways 7 days a week, full day of service
"What If" Scenarios	Free Regional Rail 	Based on Base Regional Rail Scenario Free for Zoo visitors
	Full Regional Rail 	Full Build-out of Zoo Station from Campbell Thomas & Co. Study (2013) Paoli/Thorndale, Trenton, Chestnut Hill West, Cynwyd Lines Technical feasibility not endorsed by SEPTA
	Free Monorail 	Based on Base Monorail Free for all riders

Source: DVRPC, 2017

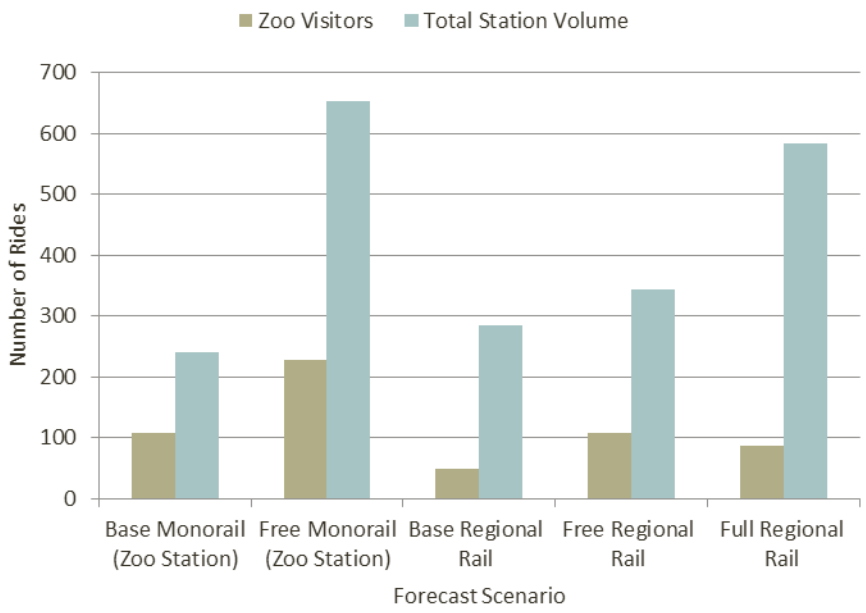
Table ES2 and Figure ES1 show the total station volume and number of Zoo visitors forecast to use the Zoo station in each of the five forecast scenarios. Station volume is the average of projected boards and alights. The Zoo station in the Free Monorail and Full Regional Rail scenarios is forecast to have the highest total station volume. The Base Monorail and Free Regional Rail scenarios are forecast to serve a similar number of Zoo visitors. The Free Monorail is forecast to serve the highest number of Zoo visitors: twice that of the next highest forecast. The Free Monorail and Full Regional Rail build options are forecast to serve the most non-Zoo visitors.

Table ES2: Daily Ridership Forecast Results Comparison for Zoo Station

Scenario	Non-Zoo Visitors	Zoo Visitors	Total Station Volume
Base Monorail	132	108	**240**
Free Monorail	426	227	**653**
Base Regional Rail	237	48	**285**
Free Regional Rail	236	108	**344**
Full Regional Rail	497	86	**583**

Source: DVRPC, 2017

Figure ES1: Daily Ridership Forecast Results Comparison



Source: DVRPC, 2017

CHAPTER 1: INTRODUCTION AND BACKGROUND

Over the past two decades, numerous studies have been conducted to assess the feasibility of a rail station serving the Philadelphia Zoo. SEPTA and the Zoo have asked DVRPC to conduct a concept development and ridership analysis study using DVRPC's regional travel demand model. The results of this study will help identify transit options worth pursuing further.

The first task in forecasting ridership potential for transit service to the Philadelphia Zoo was to understand the overlapping markets and factors that could contribute to ridership demand. A variety of data was examined to paint the picture of existing conditions. The following elements were analyzed in detail:

- Zoo attendance from Fiscal Year (FY) 2010 through FY 2015;
- member visits by zip code of residence;
- Zoo staff and volunteers by zip codes of residence;
- existing transit connections and ridership; and
- Commuting patterns of workers in surrounding neighborhoods.

Findings from this analysis were presented to the project Advisory Committee, which consisted of representatives from SEPTA, the Zoo, the Philadelphia City Planning Commission (PCPC), McCormick Taylor, and Campbell Thomas & Co. The Advisory Committee used the findings to inform the development of the five forecast scenarios modeled using DVRPC's Travel Improvement Model 2.2 (TIM 2.2). Additional information about TIM 2.2 is found in Appendix A.

This chapter summarizes the analysis and findings of the data collection and background research efforts.

Literature Review

Since 1994, five studies have been completed to examine the possibility of passenger rail service at the Philadelphia Zoo. These studies were reviewed to provide insight into the challenges related to providing this service. This section summarizes these five studies.

Proposed Improvement of Rail Passenger Transportation Access to the Philadelphia Zoo and the Parkside Neighborhood
Campbell Thomas & Co., May 1994

- Noted historic context of Zoo passenger rail service as the reason the Philadelphia Zoo was developed where it is.
- Identified Regional Rail service as the only meaningful option for improving access, given a (then-believed) inability to expand Zoo parking.
- Viewed New Jersey Transit's "new direct service to 30th Street Station from Atlantic City" as a key opportunity.
- Indicated that Amtrak had no interest in an additional local stop, and that all operators were concerned with an additional station slowing through rail movements.
- Suggested that a private partner for station operation would be desirable, since operation by SEPTA/NJ Transit alone would likely lead to an unstaffed, "lonely" station due to relatively low passenger volumes.

Campbell Thomas & Co., May 1994 (continued)

- Recommended a 34th/Girard Avenue station over a 34th/Mantua station (which would "require a complex, expensive station with multiple elevators"), with the only drawback being that Paoli/Thorndale service would not be available. A supplemental Paoli/Thorndale Line-only station at 35th/Mantua was noted as an option.
- Estimated construction costs of two million dollars for a Girard Avenue station, seven million dollars for supportive structured parking (1,100 vehicles), and $740,000 for a supplemental Paoli/Thorndale Line station at Mantua Avenue.

Ridership Potential/Market Assessment – Proposed Zoo Station and Rail Access

Campbell Thomas & Co., June 1995

- Anticipated a one-seat ride for the R7 (Trenton/CH East), R8 (Fox Chase/CH West), and Atlantic City lines.
- Noted that City Transit Division Transpass coverage of Zone 1 Regional Rail fares would ease use by neighborhood residents, but also that the primary modal competitor for many one-seat-ride trips is the City Transit system, with more frequent service.
- Further noted that "transferring has a far more negative impact on rail use for recreational travel than more work trips…This is especially the case where families are traveling to the Zoo."
- Estimated that the proposed station would have 94,050 boardings annually (325 on an annual average daily basis). Of these:
    - 56,100 (60 percent) would be neighborhood residents.
    - 13,500 (14 percent) would be Zoo employees.
    - 24,450 (26 percent) would be Zoo visitors.
- Boardings by Zoo visitors were projected to vary widely, ranging from a daily low of 22 on a February weekday to a high of 273 on an August Sunday.

Philadelphia Zoo Parking Access Study

Campbell Thomas & Co. (in association with Abrams-Cherwony & Associates, Orth-Rodgers Associates, Inc., Powell-Harpstead Inc., Promatech, Inc., Synterram Ltd., Urban Engineers, Inc., Urban Partners), January 2003

- Recommended a phased approach for improving public transit access to the Zoo (complementing parking and access recommendations for drivers):
    - Short-term: Establish a Zoo bus shuttle to 30th Street Station.
    - Mid-term: Pursue an expansion of the Route 15 trolley "along existing trackage to create a near loop connecting Center City, 30th Street Station, West Philadelphia, the Zoo, and North Philadelphia."
    - Long-term: Pursue the Zoo Regional Transportation Center (including the 34th/Girard Regional Rail station).

Feasibility Study for a Regional Rail Station and Transit-Oriented Development at the Zoo

Campbell Thomas & Co. (with Urban Partners and Jacobs Engineering), March 2013

- Took a new look at all potentially-viable options for a Zoo Regional Rail station (34th Street/Girard Avenue, 34th Street/Mantua Avenue, and 40th Street along the Paoli/Thorndale Line).
- Found that the 34th Street/Girard Avenue location would be best able to accommodate true Transit-Oriented Development (TOD) within a 2,000-foot walking distance.
- Found that a 34th Street/Mantua Avenue location, while challenging and complex, would have lower cost/complexity than 34th Street/Girard Avenue, and the ability to serve more SEPTA lines (although not NJ Transit Atlantic City Line trains, which follow Amtrak's tracks to the lower level of 30th Street Station). Constructability is better in part due to "more construction room, construction access from Mantua Avenue and the 34th Street Bridge, and the ability to phase construction."
- Proposed a four-platform, three-elevator station concept at 34th/Mantua.

Campbell Thomas & Co., March 2013 (continued)

- Proposed a complementary Cynwyd Line shuttle between the Zoo and 30th Street Station to enhance connectivity between the Zoo and Center City (and connectivity with SEPTA lines for which a one-seat-ride would not be available). This included the possibility of increasing Cynwyd service levels to 20- to 30-minute all-day frequencies.
- Estimated (with a preliminary/sketch methodology) that the proposed station would have 150,000 boardings annually (400/day):
    - o 100,000 by Zoo visitors;
    - o 25,000 by Zoo employees; and
    - o 25,000 by Zoo-area residents.

Centennial District Regional Rail Station and Transit-Oriented Development Planning Charrette

Lotus Partners, May 2014

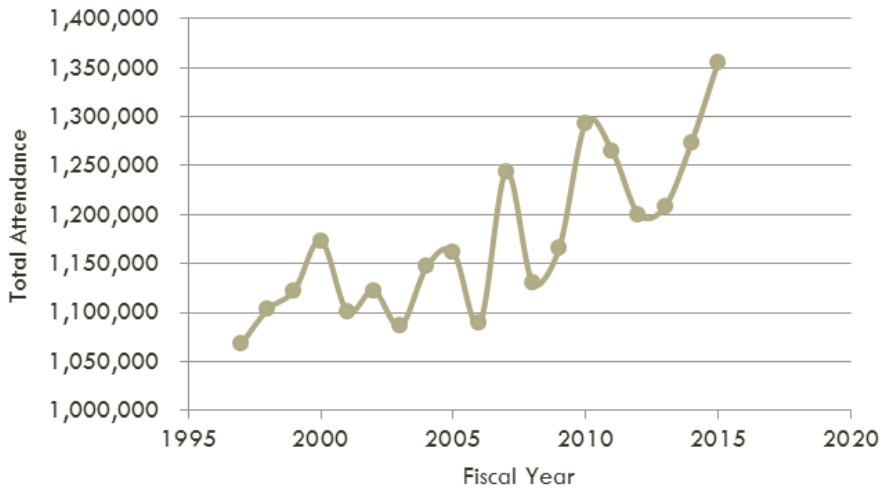
- Reinforced and built upon preferred 34th Street/Mantua Avenue station location.
- Identified two TOD "Opportunity Sites" in the vicinity of the proposed station (at 34th Street/Mantua Avenue, to the south of the proposed station; and at 38th Street/Mantua Avenue).
- Recommended a series of next steps, including the present DVRPC study.

Zoo Attendance

The Zoo provided detailed attendance data for FY 2010 through FY 2015. This data was used to visualize historic growth in attendance and to analyze the timing of peak visitation and the distribution of admission type. Figure 1 shows total Zoo attendance from FY 1997 through FY 2015. While there has been some noticeable fluctuation over the past 18 years, the overall trend is that annual attendance has increased. Annual attendance in FY 2015 was almost 300,000 visits higher than in FY 1997.

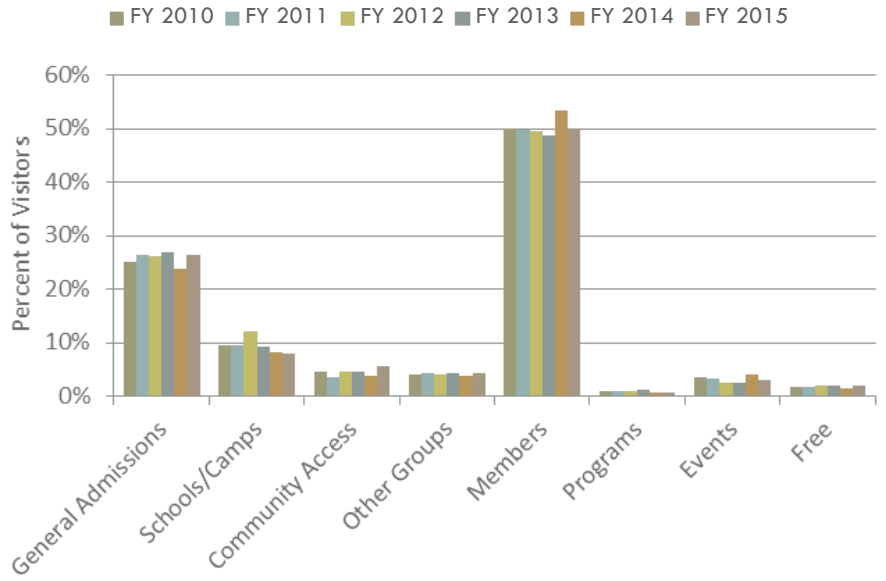
As portrayed in Figure 2, approximately 50 percent of visits to the Zoo are made by members. Another 25 percent of the visits are made by those in the general admissions category and the final 25 percent is comprised of visits from a variety of groups, schools, and events. This trend has been largely consistent over the past six years.

Figure 1: Historical Total Attendance



Source: Philadelphia Zoo, 1997-2015

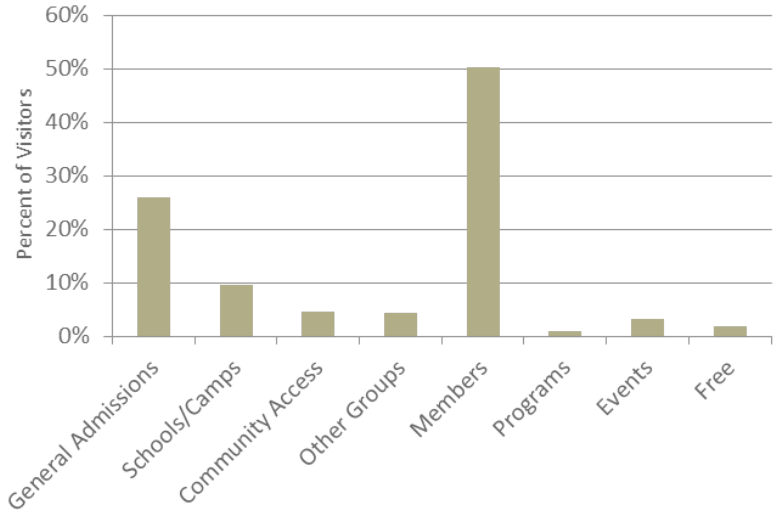
Figure 2: Attendance by Admission Type



Source: Philadelphia Zoo, 2010-2015

The highest daily attendance in the data provided, which goes back to March 1, 2009, occurred on Saturday, April 18, 2009, with 17,129 visits. This day happened to be the Saturday after the Easter holiday. The admission type for attendees on this day shows a similar distribution to the average annual admission type in Figure 2. However, as seen in Figure 3, general admissions and members made up a slightly higher than average share of visitors, while various groups and other admission types made up a smaller portion. This is not uncommon on the weekends since school field trips and other group events typically take place during the week.

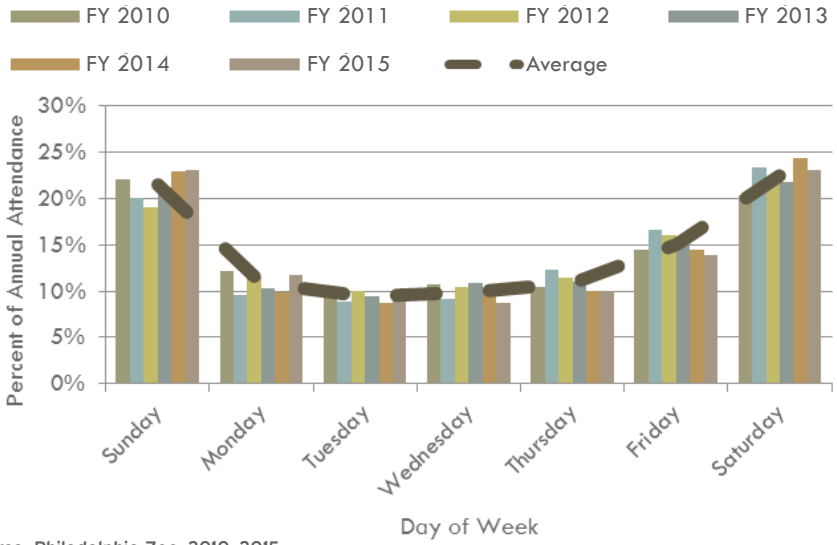
Figure 3: Admission Type Distribution - April 18, 2009



Source: Philadelphia Zoo, 2010-2015

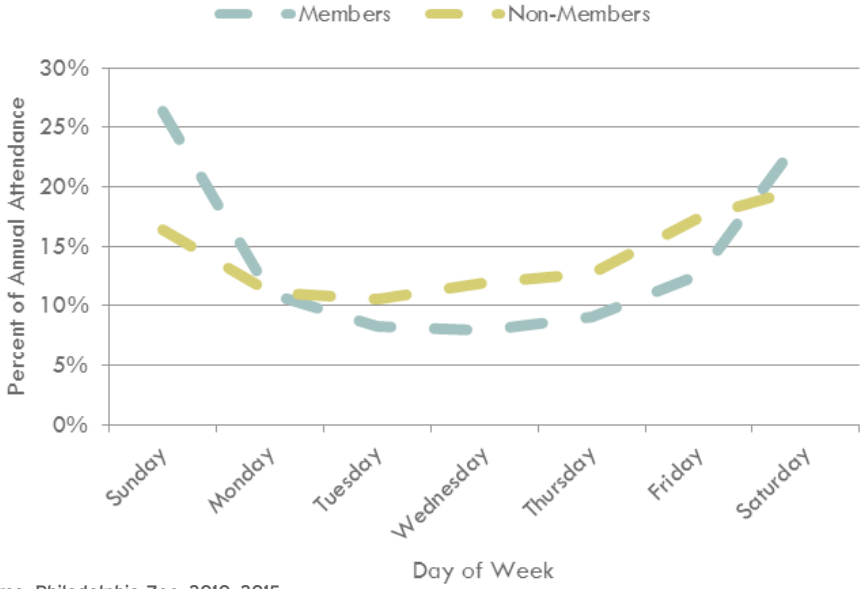
Figure 4 shows a clear weekend peak in Zoo visitation, with Friday falling between average weekday and average weekend attendance. However, as shown in Figure 5, the weekend peak is less prominent among non-member visitors.

Figure 4: Total Annual Attendance by Day of Week



Source: Philadelphia Zoo, 2010-2015

Figure 5: Average Annual Attendance by Day of Week

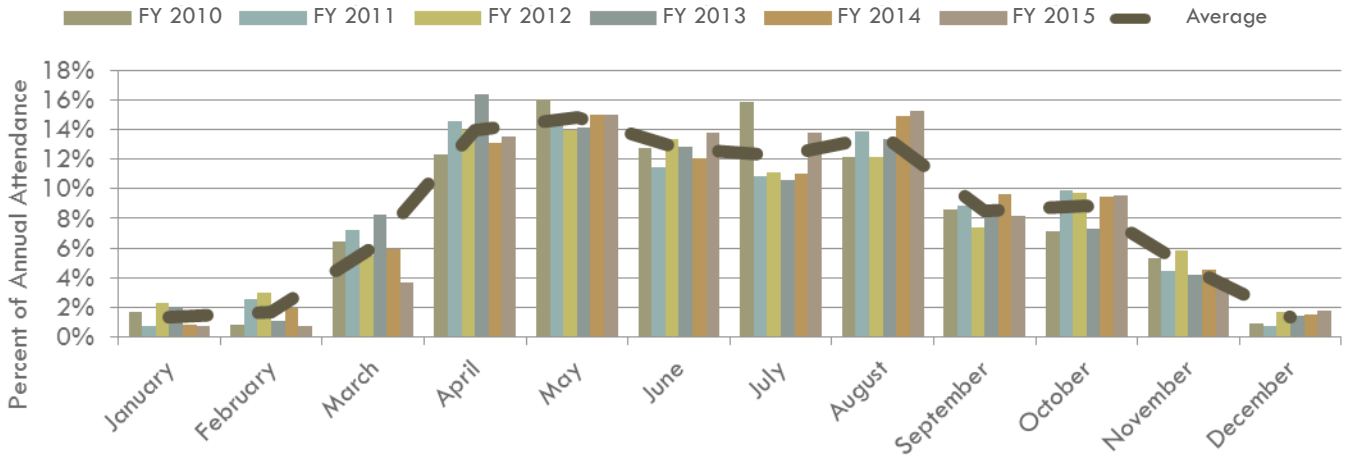


Source: Philadelphia Zoo, 2010-2015

Figure 6 shows an obvious seasonal peak in visitation during the warmer months, from March through October. However, Figure 7 shows that members tend to visit the Zoo more consistently throughout the warmer months. Non-members seem to prefer the spring to the fall.

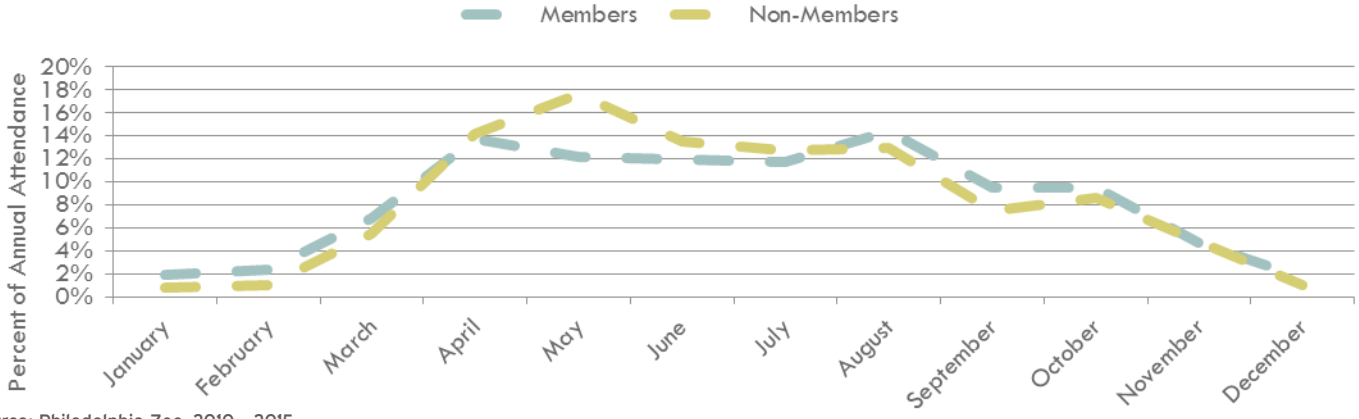
These figures clarify the fact that if transit service were added for Zoo access, demand patterns would be quite different from traditional, commuter-focused transit demand. They also highlight the fact that members and non-members have slightly different visitation patterns. Since the Zoo has far more data on its members than on non-members, demand analysis was based on member data. It is important to consider these slight differences between members and non-members when making generalizations about forecast results.

Figure 6: Total Attendance by Month



Source: Philadelphia Zoo, 2010 - 2015

Figure 7: Average Annual Attendance by Month



Source: Philadelphia Zoo, 2010 - 2015

Member Visits by Zip Code of Residence

The Zoo's database of member information was used to identify where trips to the Zoo originate. In Calendar Year (CY) 2014, members made 688,070 visits to the Zoo from 1,185 different zip codes within 100 miles of Philadelphia. The Zoo provided zip codes of residence for members who made over 99 percent of these visits. This data was used to visualize the general trend of Zoo visitors' origins.

The maps on the next two pages show the geographical distribution of where member visits originated in 2014. Figure 8 shows the total number of visits originating in each zip code. The darkest purple represents the zip codes with the highest number of member visits in CY 2014. As expected, the farther members live from the Zoo, the fewer visits they make.

However, since the population in each zip code varies significantly, an additional measure was used to visualize visitor origins. The number of visits in each zip code was divided by the population in that zip code to determine the number of member visits per capita. This is reflected in Figure 9. The light green color represents the lowest number of member visits per capita, while the dark blue represents the highest number of member visits per capita. This map paints a clearer picture of general interest in the Zoo among the population of each zip code. However, it could be skewed by the enthusiasm of a few members in a given zip code.

Both sets of maps show that the largest concentrations of member visits originate from zip codes either within the city or in the close-in western suburbs, such as Bala Cynwyd, Havertown, and Wynnewood.

Zoo Staff and Volunteers by Zip Code of Residence

The Philadelphia Zoo is a 24/7 operation with a staff of over 450 working in shifts to support visitors, provide animal care, maintain facilities, conduct business operations, plan and run events, and secure the property. Most employees work in shifts between 8 AM and 6 PM which roughly coincides with public operating hours from 9:30 AM through 5 PM from March through October, and from 9:30 AM through 4 PM from November through February. The Zoo also hosts numerous evening events throughout the year, which require additional staff.

Additionally, the Zoo has over 450 active volunteers who support their operations. Volunteers also typically work shifts between 8 AM and 6 PM throughout the week, depending on their individual schedule and time commitment.

The Zoo provided zip code information for both staff and volunteers to verify employment inputs to the regional model and to help determine if transit service to the Zoo would benefit those commuting there. As expected, employees and volunteers who travel to the Zoo on a regular basis live closer to the Zoo than do members, who are far more dispersed. The maps in Appendix C show where staff and volunteer commutes to the Zoo originate.

Existing Connections

In assessing the feasibility of additional transit service to the Zoo, it is important to examine all existing connections and how they are used. Given the Zoo's location adjacent to I-76, driving and parking is a popular option for many visitors. Surface lots, street parking, and the recently added parking garage offer a total of 1,806 parking spaces within walking distance to the Zoo's main entrance, as shown in Table 1. An additional 35 spaces for buses are located along 34th Street on the Zoo's eastern border.

Surface Transit

Existing surface transit options, shown in the maps in Appendix C, include SEPTA's Route 38 bus, connecting the Zoo to Center City; and the Route 15 trolley, traveling east–west along Girard Avenue. Route 38 stops at 34th Street and Mantua Avenue approximately every 20 minutes during the week and every 30 minutes on the weekends. Route 15 runs more frequently, with 10-minute peak-hour headways on weekdays, 20-minute morning and evening headways on weekends, and 15-minute headways during the mid-day throughout the week.

Figure 8: Zoo Member Visits by Zip Code of Residence

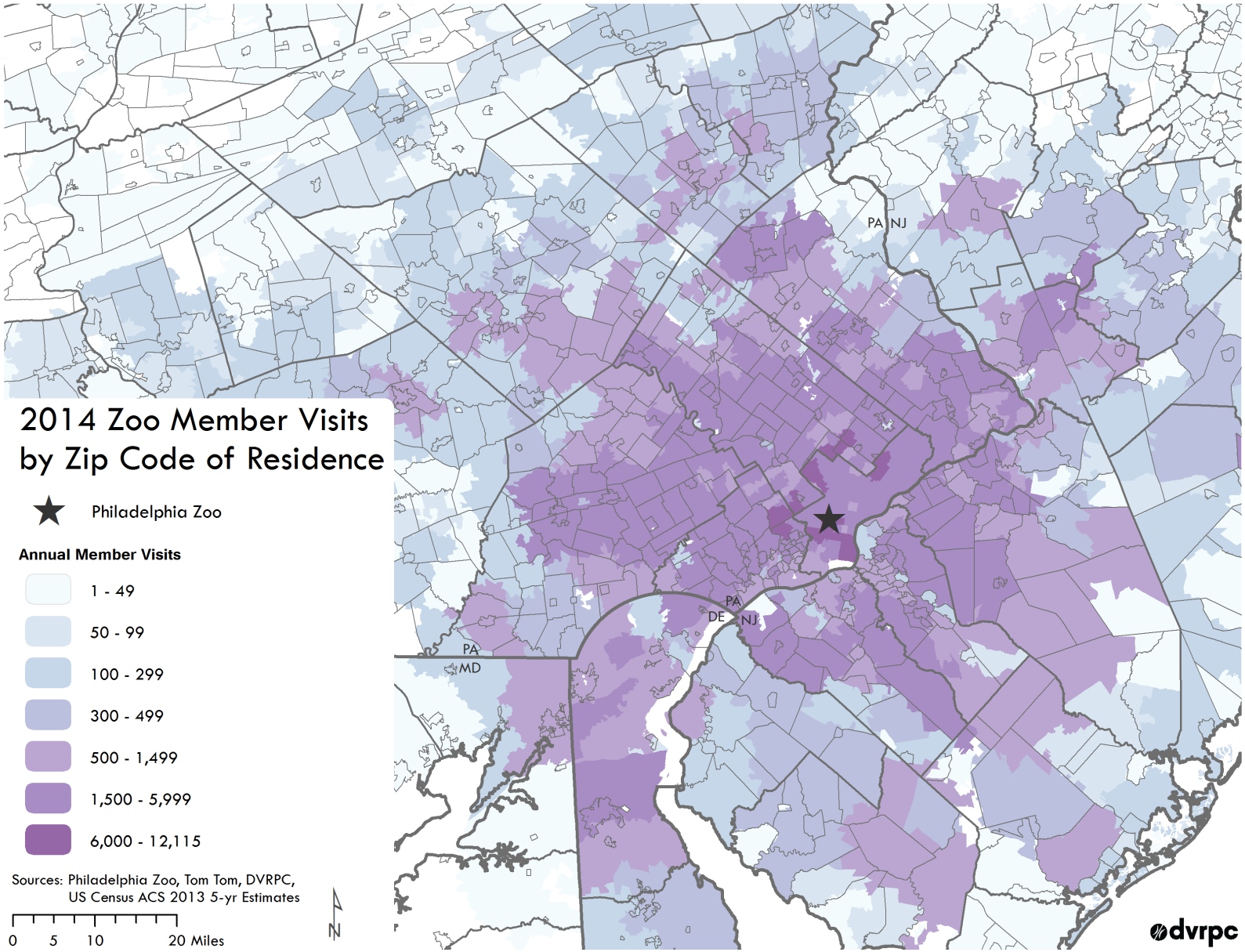


Figure 9: Zoo Member Visits per Capita by Zip Code of Residence

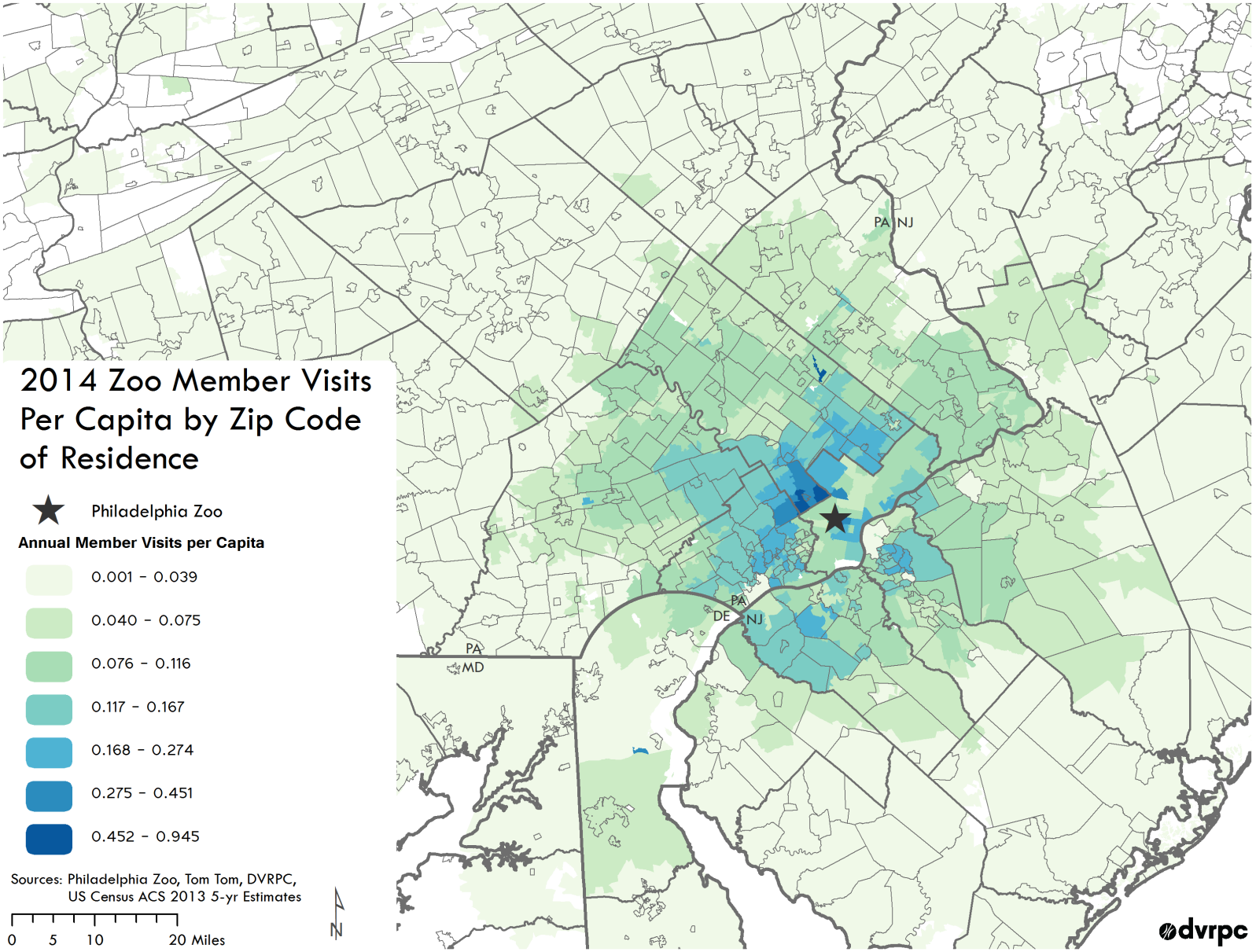


Table 1: Available Parking at the Zoo

Parking Lot	Number of Spaces
Sedgely Dr.	80
Frog	82
Tiger	121
P Sedgely Lot	140
Zoological Dr.	250
Giraffe	450
P Garage	683
Total	**1,806**
34th Street	*35 Buses*

Source: Philadelphia Zoo, 2016

The PHLASH, a tourist shuttle operated by Krapf's Coaches, also provides access to the Zoo. However, riders who board the PHLASH at one of the many stops in Center City are required to make a transfer to get to the Zoo.

The total weekday ridership (boarding plus alighting) along the SEPTA and PHLASH routes, as shown in Figures 10 and 11, as well as in the maps in Appendix C, highlight the fact that the stops closest to the Zoo are among the least-used stops along all three routes examined. Total weekend ridership paints a similar picture, except for the Route 15 trolley. The trolley stops adjacent to the Zoo at 34th Street and Girard Avenue have a noticeable increase in ridership on the weekends. There are 366 total boardings and alightings at 34th Street and Girard Avenue (both directions included). Given the average daily weekend attendance at the Zoo of 5,324 visitors, and assuming each rider using this stop is a Zoo visitor, the trolley weekend ridership represents about 3 percent of visitors.

Rail

Passenger rail was also examined, given its critical role in all proposed options for providing transit service to the Zoo. Figure 12 shows the 19 area passenger rail lines, including SEPTA's Regional Rail and subway lines, NJ Transit's River LINE and Atlantic City Line, as well as the Port Authority Transit Corporation (PATCO) high-speed line.

The rail lines are colored based on their one-seat service to 30th Street Station and to a potential Zoo station. These were identified using route maps, schedules, and Google transit trip tools. The red lines (four) require a transfer to reach 30th Street Station today. The yellow lines (nine) represent those that currently offer a one-seat ride to 30th Street Station. If a monorail were constructed, connecting 30th Street Station to the Zoo, access would be a relatively easy transfer. The green lines (six) currently offer a one-seat ride to 30th Street Station and if a train station were built at the Zoo, could potentially offer a direct, one-seat ride to the Zoo. However, the ability to fulfill this potential could vary considerably, with the Atlantic City Line presenting unique challenges. The lines are categorized as follows:

Transfer required to reach 30th Street Station today (red):

- Norristown High Speed Line;
- Broad Street Line;
- NJ Transit River LINE; and
- PATCO.

Figure 10: SEPTA Route 15 Weekday Ridership

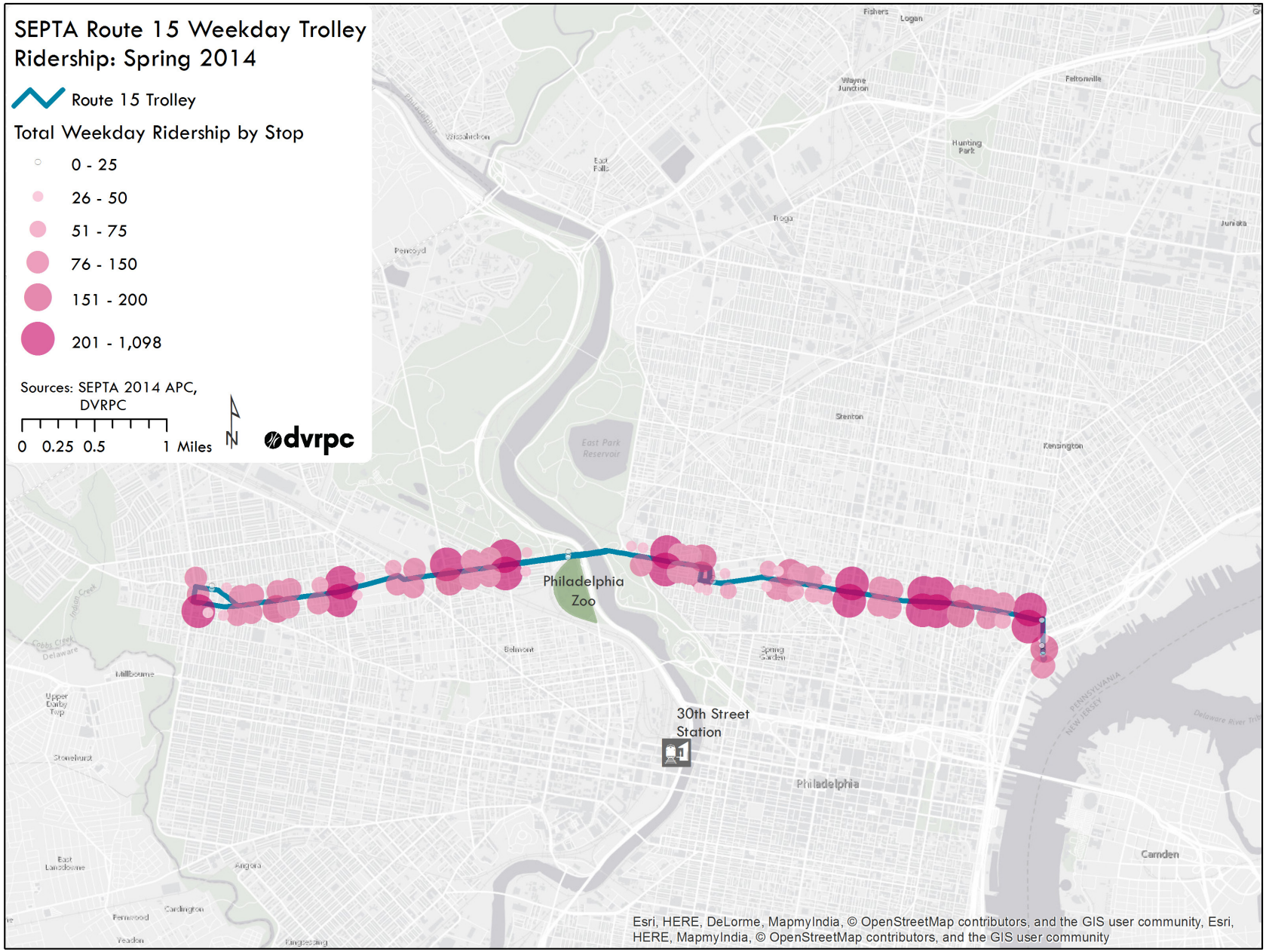
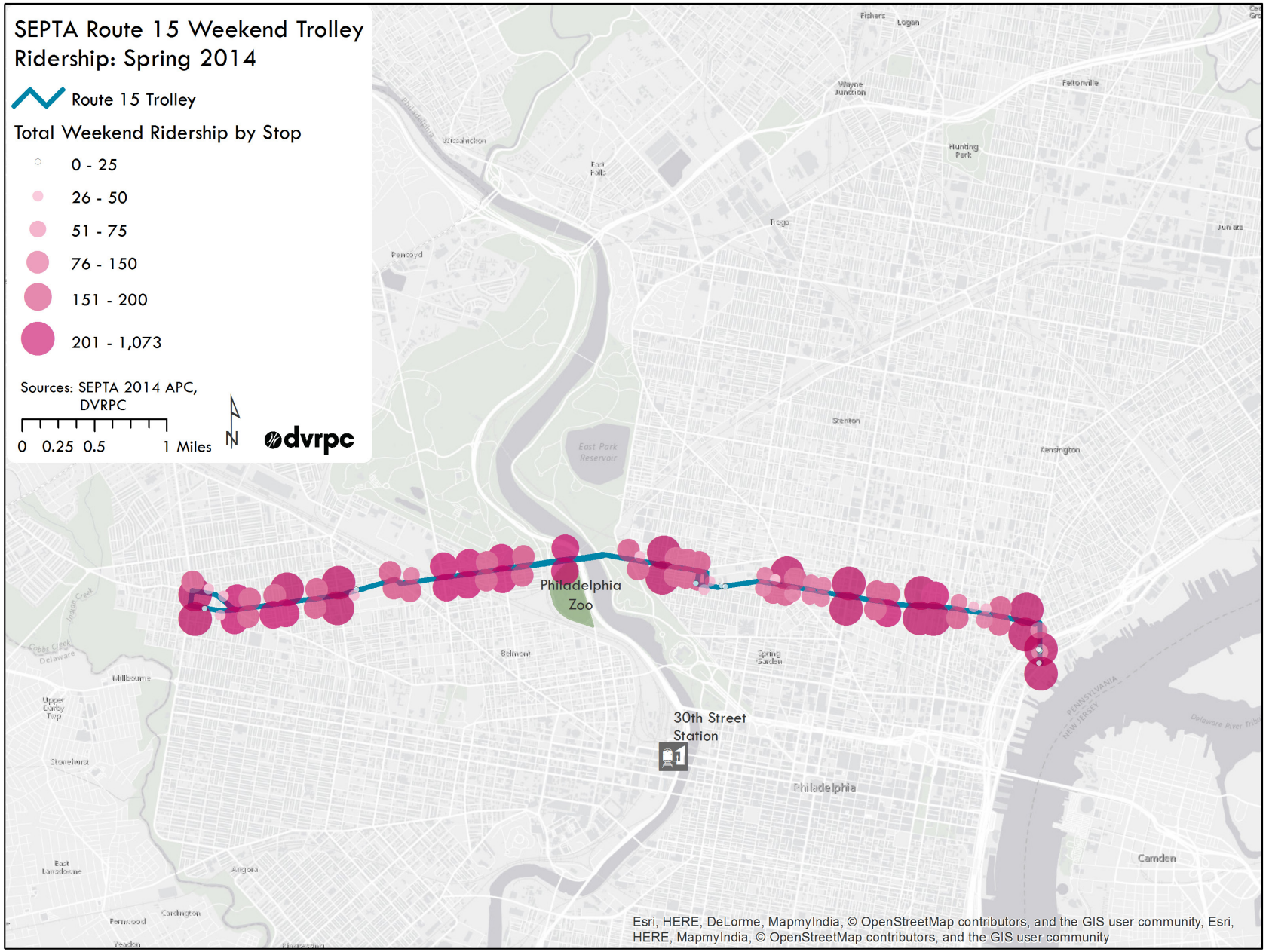


Figure 11: SEPTA Route 15 Weekend Ridership



Offers one-seat ride to 30th Street Station today (yellow):

- Market-Frankford Line;
- Fox Chase Line;
- West Trenton Line;
- Warminster Line;
- Chestnut Hill East Line;
- Manayunk/Norristown Line;
- Media/Elwyn Line;
- Wilmington/Newark Line; and
- Airport Line.

Offers one-seat ride to 30th Street Station today and could offer one-seat ride to potential Zoo station (green):

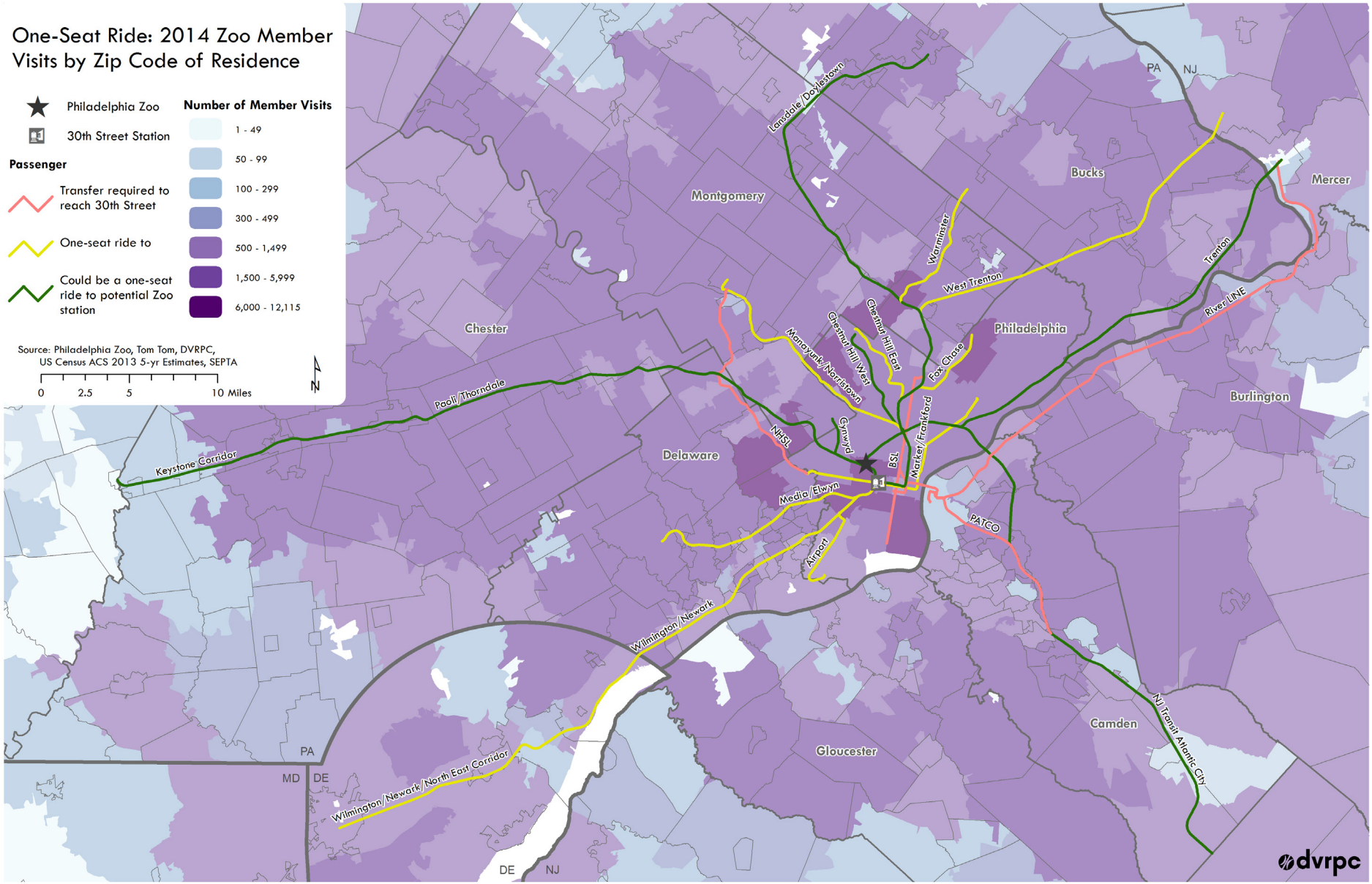
- Paoli/Thorndale Line;
- Cynwyd Line;
- Chestnut Hill West Line;
- Lansdale/Doylestown Line;
- Trenton Line; and
- NJ Transit Atlantic City Line.

As shown in Figure 12, the zip codes from which the highest number of member visits originate are well served by one-seat rides to 30th Street station and could be somewhat well served by a one-seat ride to a potential Zoo station. In Appendix C, Figure C5 paints a similar picture, in which the zip codes with the highest number of member visits per capita have easy access to 30th Street Station and would have easy access to the Zoo if a new station were built.

Commuting Patterns

Commuting patterns for residents of the six census tracts south and west of the Zoo were analyzed using Census Transportation Planning Products (CTPP) commuter flow data from 2006 through 2010. According to the Census, 6,770 commuters reside in these tracts. The map in Appendix D shows the destinations of these commuters. One-quarter (25 percent) of commuters living in these tracts commute to Center City. An additional 11 percent of commuters travel to University City for work. The next largest group is comprised of those commuting to the Airport area. The remaining commuters travel in smaller concentrations to tracts dispersed throughout and beyond the city. The tracts these commuters are traveling to are not very well served by existing passenger rail service, nor would they be well served by a new Zoo station.

Figure 12: One-Seat Rides for Zoo Members by Zip Code



CHAPTER 2: SCENARIO DEVELOPMENT

DVRPC worked closely with the Advisory Committee to develop the necessary inputs for travel demand forecasting and to define the five future scenarios to be modeled. Each partner was asked to consider the "best realistic" future scenario in their area of expertise. In this case, "best realistic" is defined as a **practical, achievable projection of future conditions based on knowledge of historic change and existing plans for the future**. Advisory Committee members also shared the goal of creating an attractive transit option, enticing the highest number of future Zoo visitors to use transit. Grounded by the idea of a "best realistic" future scenario, planning partners provided the following inputs:

- PCPC estimated 2040 population and employment in the study area based on district plans and expected future developments.
- Philadelphia Zoo Advisory Committee members approved 2040 Zoo attendance and employment projections.
- SEPTA developed a plan of operations for a Zoo Regional Rail station, which included a conceptual review of potential station configurations to inform available service and schedule development.
- With SEPTA's input, DVRPC developed a similar plan of operations for a conceptual monorail connecting 30th Street Station and the Zoo.

These inputs, and the five scenarios they define, are discussed in detail in this chapter.

Model Phasing

Based on discussion at early Advisory Committee meetings, in order to make the best use of the five scenarios scoped for this project, the forecast modeling effort was divided into three phases. Phase 1 included the existing conditions model and the no-build future scenario model. The no-build scenario attempted to capture the future conditions based on population, employment, and Zoo attendance changes, but did not include changes in transit service to the Zoo. The Phase 1 models were used for comparison and did not count towards the five scenarios in the project scope.

Advisory Committee members from the Zoo and PCPC were consulted for feedback on the best realistic estimates for the critical Phase 1 model inputs shown in Table 2.

Phase 2 included two baseline build scenarios (specifically, the best realistic operating scenarios for a Zoo passenger rail station and a monorail between 30th Street Station and the Zoo), as shown in Table 3. With the exception of the new transit elements, the scenario inputs for these two build options remained the same as in the no-build scenario. Keeping variables such as population and Zoo attendance consistent in the Phase 2 scenarios allows for direct comparison and prevents background changes from masking the influence of the Zoo station or the monorail on travel demand.

Phase 3 included three additional scenarios based on the results of the Phase 2 scenarios. The goal of the Phase 3 scenarios was to give the Advisory Committee the opportunity to revise the model inputs to see which conditions generate the most ridership on the Phase 2 build options.

Phase 1 Model Inputs: No-Build Future Scenario

Population and employment projections used in the model were based on the DVRPC Board-adopted forecasts for most of the DVRPC region, specifically beyond the study area. However, given recent development plans in and around the study area conceptualized after these projections were completed in 2013— namely, the 30th Street Station District Plan—PCPC was asked to review the population and employment forecasts to ensure these plans are reflected in the future model.

Additionally, based on their knowledge of changes expected at the Zoo between now and 2040, the Zoo Advisory Committee members reviewed projections of annual attendance and the average daily number of working staff and volunteers.

Table 2: Phase 1 Scenario Modeling Inputs

Scenario Modeling Inputs	2013 Base	2040 No-Build	Data Partner	Description
Regional Population and Employment	Historic	DVRPC Board adopted forecasts	DVRPC	Fixed
Regional Road and Transit Network	Historic	DVRPC Board adopted planned improvements		
Study Area Population	Historic	2040 Population	PCPC	Based on the 2040 DVRPC Board-adopted forecasts and additional impactful development plans
Study Area Employment	Historic	2040 Employment		
Annual Zoo Attendance	1,355,759	1,700,000	Zoo	Projected annual attendance and staff/ volunteers
Average Daily Zoo Employment	356	447		

Source: DVRPC, 2017

Table 3: Phase 2 Scenario Modeling Inputs

Scenario Modeling Inputs	2013	2040		
Variable	Base	No-Build	Base Zoo Regional Rail	Base Monorail
Base Inputs				
Regional Population and Employment	Historic	DVRPC Board adopted forecasts		
Regional Road and Transit Network	Historic	DVRPC Board adopted planned improvements		
Study Area Population	Historic	2040 Population		
Study Area Employment	Historic	2040 Employment		
Annual Zoo Attendance	1,355,759	1,700,000		
Average Daily Zoo Employment	356	447		
Build Options				
Service Frequency	-	-	60 minutes (weekend) 30 minutes (mid-weekday)	10 minutes
Fare	-	-	Existing SEPTA fare structure	Existing SEPTA fare structure
Station Location	-	-	34th Street and Mantua Avenue	30th Street Race Street Spring Garden Street 34th Street and Mantua Avenue Philadelphia Zoo
Number of Stops	-	-	1	5
Speed	-	-	Existing rail speeds	15 mph

Source: DVRPC, 2017

Population and Employment

Population and employment are expected to grow throughout the city and within the study area, which includes the West, West Park, and University/ Southwest PCPC planning districts. With consideration for PCPC district plans, the potential development and transit connections included in the 30th Street Station District Plan, and transit network plans, PCPC developed "substantial absorption" population and employment estimates for the study area districts, as shown in Table 4.

The estimates for the West and West Park districts remain unchanged from the DVRPC Board-adopted forecasts. The estimates for the University/ Southwest district include rough estimates of the actual changes since 2010 and the assumption of at least partial completion of major projects being planned in University City. Table 4 served as the best realistic estimate of 2040 study area population and employment.

Table 4: PCPC "Substantial Absorption" Population and Employment Conceptual Forecast

	2010	2015	2020	2025	2030	2035	2040	Absolute Change 10–40
University/Southwest								
Population	81,746	87,361	92,111	92,841	95,191	96,416	97,304	15,558
Household Population	*67,535*	*70,650*	*72,900*	*72,380*	*73,480*	*74,030*	*74,580*	*7,045*
Households	*29,400*	*31,400*	*32,400*	*32,900*	*33,400*	*33,650*	*33,900*	*4,500*
Group Quarters	*14,211*	*16,711*	*19,211*	*20,461*	*21,711*	*22,386*	*22,724*	*8,513*
Employment	75,141	82,750	86,000	89,250	92,500	95,750	99,000	23,859
University City	*67,641*	*75,000*	*78,000*	*81,000*	*84,000*	*87,000*	*90,000*	*22,359*
Southwest	*7,500*	*7,750*	*8,000*	*8,250*	*8,500*	*8,750*	*9,000*	*1,500*
West								
Population	105,642	102,995	101,999	104,001	106,996	109,002	109,998	4,356
Household Population	*103,779*	*101,026*	*99,924*	*101,820*	*104,709*	*106,608*	*107,498*	*3,719*
Households	*41,579*	*40,410*	*39,970*	*40,728*	*41,884*	*42,643*	*42,999*	*1,420*
Group Quarters	*1,863*	*1,969*	*2,075*	*2,181*	*2,287*	*2,394*	*2,500*	*637*
Employment	14,257	14,201	14,200	14,403	14,603	14,803	14,901	644
West Park								
Population	43,454	43,001	43,495	43,997	44,494	44,499	44,994	1,540
Household Population	*40,452*	*39,916*	*40,327*	*40,745*	*41,159*	*41,081*	*41,492*	*1,040*
Households	*18,512*	*18,144*	*18,330*	*18,520*	*18,709*	*18,673*	*18,860*	*348*
Group Quarters	*3,002*	*3,085*	*3,168*	*3,252*	*3,335*	*3,418*	*3,502*	*500*
Employment	15,472	15,400	15,501	15,601	15,803	16,003	16,101	629

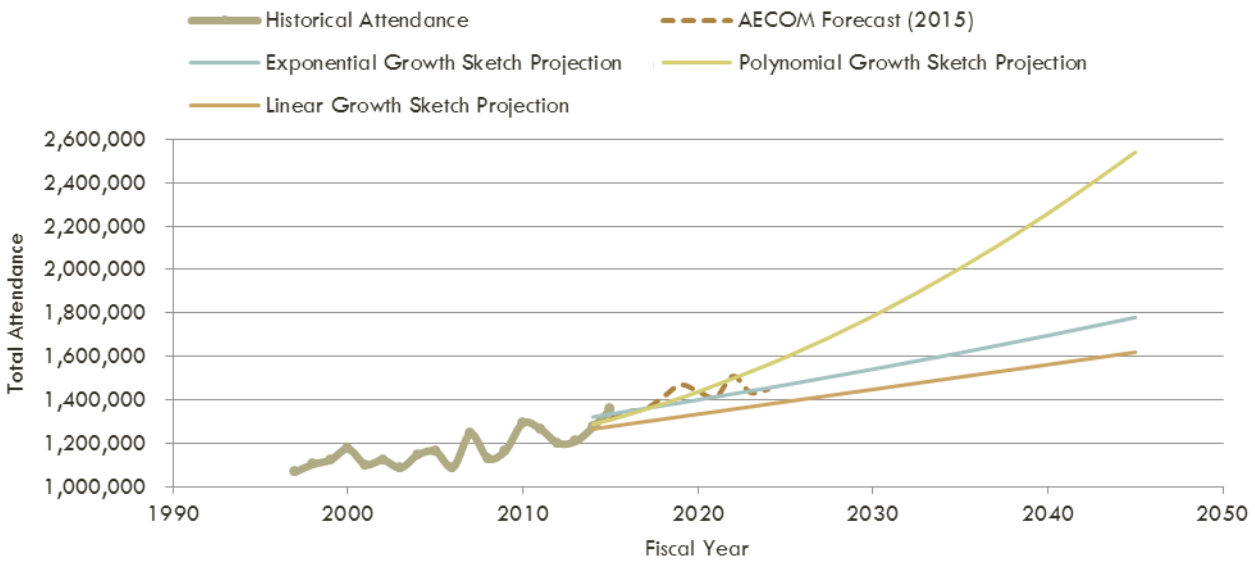
Source: PCPC, 2016

Zoo Attendance

The Zoo contracted with a private consulting firm, AECOM, to conduct a market analysis in early 2015 to forecast Zoo attendance through 2024. Their study predicted an increase of over 130,000 visitors from 2015 through 2024, with total annual attendance reaching approximately 1,448,000 visits. Since the ridership potential for transit service to the Zoo was modeled using the DVRPC 2040 road and highway networks, as well as 2040 population and employment estimates, historical attendance was analyzed to forecast total annual Zoo attendance in 2040. The chart in Figure 13 shows the results of the equations used to project Zoo attendance. Although these equations do not include the fluctuations seen in the historic visitation rates or in the detailed short-term AECOM predictions, they do provide an average estimate of potential growth.

The exponential growth model falls between the conservative linear growth model and the optimistic polynomial growth model and predicts 2024 attendance similar to the AECOM study. Given its alignment with the AECOM predictions, the exponential growth model projection of around 1,700,000 visitors in 2040 was used as the input to forecast scenarios in Phase 2.

Figure 13: Zoo Attendance Projections



Sources: DVRPC, AECOM, Philadelphia Zoo, 2017

Zoo Staff and Volunteers

While the Zoo has over 900 active staff and volunteers, necessary shift work and differences in employment types and schedules lead to variation in the number of staff and volunteers working on an average day. The number of Zoo staff and volunteers working on a given day is proportional to average daily visitor attendance. Therefore, it is logical that more staff and volunteers would be scheduled to work on weekends and in warmer months (March–October) than on weekdays and during the winter.

Table 5 shows the average daily attendance for both in-season and off-season weekdays and weekends for 2015. A similar distribution of average daily annual attendance was projected proportionally for 2040.

For example, in 2015, the average daily in-season weekend attendance was 8,260, which is 0.61 percent of the total annual attendance. That proportion was used to determine the projected 2040 average in-season weekend attendance based on the total annual projection of 1,700,00 visits. The result was a 2040 average daily in-season weekend attendance of 10,357 visitors.

Similarly, the average daily number of staff/volunteers was projected to remain proportional to attendance. On an average in-season weekend day, the average staff/volunteer total was 410, which is equal to 5 percentage of average attendance. The projected 2040 average daily staff/volunteer total was assigned to ensure that the number of Zoo staff/volunteers remained proportional to the increased number of visitors.

Table 5: 2015 and Projected 2040 Zoo Staff and Attendance Breakdown

	Average Daily Attendance	Percentage of Total Annual Attendance	Average Daily Staff/ Volunteers	Proportion of Average Daily Attendance
2015				
In-Season Weekday	3,881	0.29%	430	11%
In-Season Weekend Day	8,260	0.61%	410	5%
Off-Season Weekday	736	0.05%	229	31%
Off-Season Weekend Day	1,496	0.11%	191	13%
Annual Total	1,355,759			
Projected 2040				
In-Season Weekday	4,866	0.29%	539	11%
In-Season Weekend Day	10,357	0.61%	514	5%
Off-Season Weekday	923	0.05%	287	31%
Off-Season Weekend Day	1,876	0.11%	239	13%
Annual Total	1,700,000			

Sources: Philadelphia Zoo, DVRPC, 2017

Phase 2 Model Inputs: Build Scenarios

Base Regional Rail (best realistic)

Stop Location

Based on the previous rail feasibility studies conducted by Campbell Thomas & Co. and Lotus Partners, SEPTA developed the best realistic plan for operation of a Zoo passenger rail station. The most recent Campbell Thomas & Co. study, published in 2013, recommended the placement of a Zoo station at 34th Street and Mantua Avenue, near the southern end of the Zoo property. This location was preferred over stations at 34th Street and Girard Avenue, and 40th Street (along the Paoli/Thorndale Line), because it would have a lower construction cost, it would serve the greatest number of SEPTA lines, and it would be best suited to accommodate TOD.

Figure 14 is from the 2013 Campbell Thomas & Co. study and shows the proposed platform configuration for the Zoo station at 34th Street and Mantua Avenue. Platforms 1 and 3 would serve inbound and outbound Paoli/Thorndale and Cynwyd trains. Platform 4 would serve the occasional trains from these two lines using "K-Ladder," a critical part of one of the interlockings (Kay) that allows trains to cross over other tracks along this busy rail corridor when the normal tracks cannot be used. Platform 2, under the 34th Street Bridge, would serve the Trenton and Chestnut Hill West lines. These four platforms would serve as an additional stop on the lines passing through. The study proposed that the Cynwyd Line could also be used as a mid-day shuttle, offering service every 20–30 minutes between 30th Street Station and the Zoo station.

SEPTA Review of Station Configuration Options and Resulting Service Patterns

In an effort to develop the best realistic operating schedule, SEPTA took a deeper look at the technical feasibility of the platforms recommended in the 2013 Campbell Thomas & Co. study, the impact of the additional stops on existing service, and how the infrastructure changes could fit into their long-range planning efforts.

The goal was to develop a conceptual schedule for the most attractive rail service option possible, with respect to the existing conditions and best practices in rail operations. Their findings are as follows:

Paoli/Thorndale Line:

- Track speeds would allow for an additional Zoo station stop along the Paoli/Thorndale Line while adding minimal delay (between <1 and 2 minutes). Scheduled train times would likely not need to change.

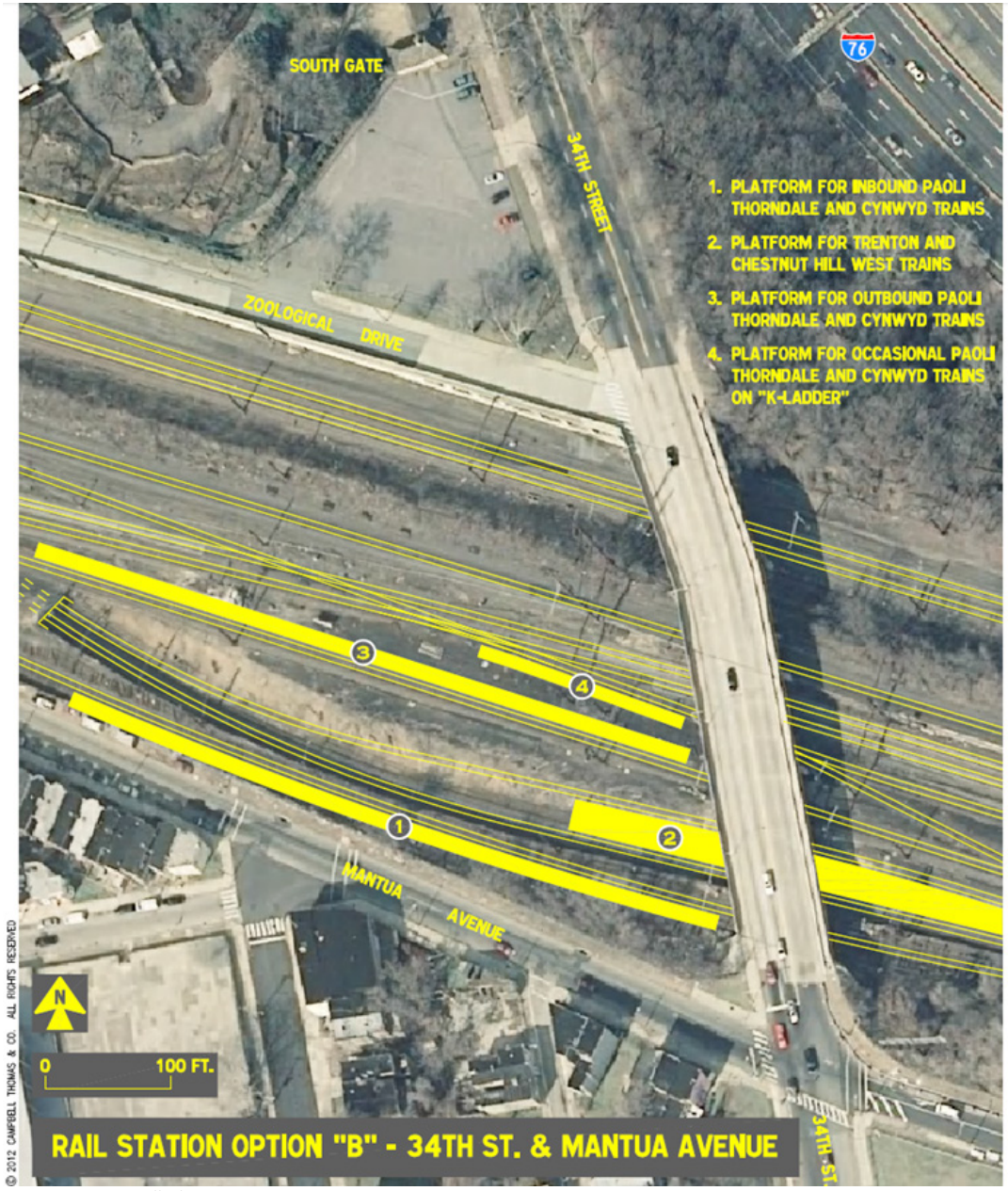
Chestnut Hill West and Trenton lines:

- Platform 2, required to serve the Chestnut Hill West and Trenton lines, may not be physically possible due to the location of the supports for the 34th Street Bridge and wayside equipment. Although only a detailed engineering feasibility study can provide a definitive conclusion, it appears that the construction of Platform 2 would be more technically challenging and expensive than initially estimated.
- These lines already experience delays and/or have scheduled delay time related to Amtrak's Northeast Corridor service. Increasing travel time, or even the perception of increased delay, by adding another stop would increase rider frustration and could negatively impact ridership.
- Adding Platform 2 requires moving track laterally, which would increase the complexity of the project significantly and would have major impacts on operations during construction.
- A construction operating schedule on these lines would require track closures and create detours that would generate conflicts between SEPTA's Northeast Corridor-bound trains, Amtrak's Keystone Line, and SEPTA's Paoli/Thorndale and Cynwyd line trains. This would result in significant delays and might require a reduction in service during construction.

Cynwyd Line:

- The benefit of a supplemental Cynwyd shuttle between 30th Street and the Zoo station is unclear since the Paoli/Thorndale Line is proposed to offer hourly service between those two locations in the mid-day.
- Providing the recommended level of service on the proposed Cynwyd Line shuttle would require major investments in infrastructure.

Figure 14: Proposed Platform Configuration



Source: Campbell Thomas & Co. 2013

SEPTA must be extremely cautious about infrastructure changes that may inhibit the proper or necessary placement of high-speed rail infrastructure in the future.

Therefore, SEPTA's best realistic operating concept for a Zoo station is a more limited option than proposed in the Campbell Thomas & Co. study, serving only the Paoli/Thorndale Line on Platforms 1, 3 and 4. The Paoli/Thorndale Line would offer half-hourly service on the weekends and during the mid-day, with trains stopping more frequently during the morning and evening peaks on weekdays. With half-hourly (or more frequent) service, the Paoli/Thorndale Line would serve as a shuttle, connecting passengers transferring from other rail lines at 30th Street Station to the Zoo.

While passengers coming from the west along the Paoli/Thorndale line would always have a one-seat ride to the Zoo, train line pairings would allow for additional one-seat rides throughout the Regional Rail system. For efficiency, train lines are often paired together to prevent long layovers or the need to turn around in the city. Paired trains have coordinated schedules that allow trains from one line to pass through Center City Philadelphia and become a different line on the opposite side. The pairings are listed on schedules.

In the current schedule configuration, the Paoli/Thorndale trains are paired with the West Trenton Line on the weekends. As an example, in a conceptual Saturday schedule, train number 5342 from Malvern at 1:47pm continues through Center City and becomes the West Trenton Line. Therefore, passengers boarding at the Zoo station at 2:30 PM are not required to make a transfer to reach any of the stations along West Trenton Line. Train pairings vary throughout the day during the week, with Paoli/Thorndale Line trains coming from or continuing to Doylestown, Lansdale, Chestnut Hill East, Warminster, Link Belt, West Trenton, Fox Chase, Colmar, and Norristown, which would allow for further distribution of one-seat rides to and from the Zoo station. One may envision special branding of such through services ("the Zoo flyer") for paired lines in the future.

Base Monorail (best realistic)

As an alternative to the potentially difficult and expensive addition of a Regional Rail station at the Zoo, the Advisory Committee elected to examine a separate fixed-guideway service between 30th Street Station and the Zoo. A similar connection is referenced in the 30th Street Station District Plan.

The monorail operating concept outlined in this section represents a realistic selection from a wide variety of options, including the monorail mode itself. This operating approach is conceptual and is designed as a starting point to forecast ridership along a technology-neutral fixed-guideway connection between 30th Street Station to the Zoo.

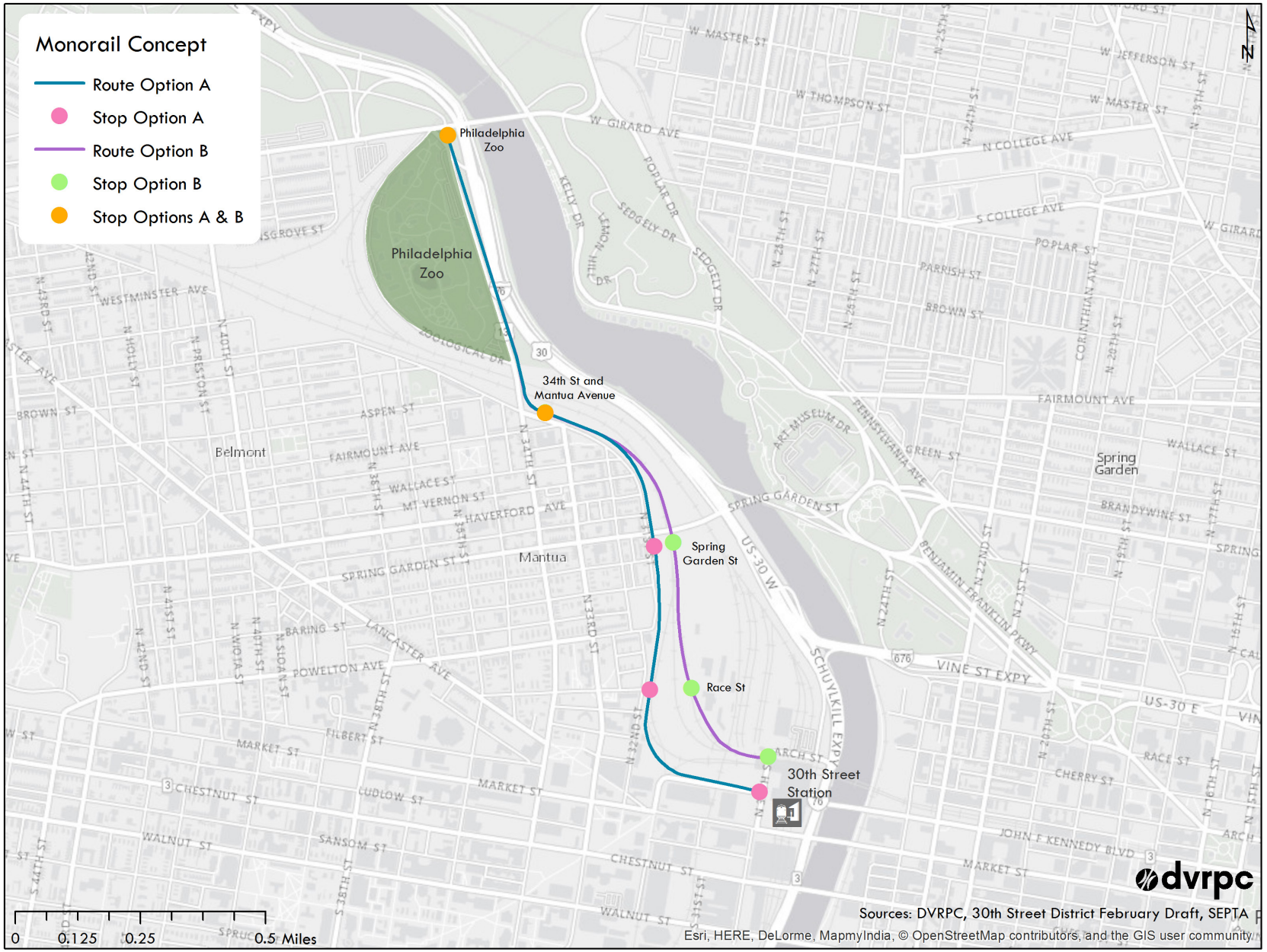
Based on information and preliminary concepts provided by SEPTA, DVRPC developed a conceptual plan of operations for a monorail serving 30th Street Station, the Zoo, and the area in between. Similar to the Regional Rail service concept developed by SEPTA staff, this concept is intended to simulate a "best realistic" monorail operating concept. Since the monorail would be a completely new service type in the model, additional inputs were required. The following model inputs were considered:

- route and stop locations;
- speed and resulting travel time;
- service frequency;
- hours of operation; and
- fare.

Route and Stop Locations

SEPTA's initial monorail idea included a conceptual alignment map situating the monorail along the western edge of Powelton Yard (route option A), the maintenance and storage facility for Regional Rail trains west of 30th Street Station. Conversely, the 30th Street Station District Plan includes reference to a right-of-way for fixed-guideway transit service on the eastern edge of Powelton Yard. Figure 15 shows both route options and their corresponding stops. The route locations on the map are approximate and are used only for rough distance estimates.

Figure 15: Monorail Concept Map



The eastern alignment (route option B) hugs the inside of a curve, shortening the end-to-end distance of the line by approximately 0.12 miles. For the purposes of ridership forecast modeling, this minor difference in total distance is not expected to have a significant impact on the number of riders the service attracts. The population and employment estimates provided by PCPC incorporate a substantial amount of the development presented in the 30th Street Station District Plan. Therefore, for consistency, route option B was modeled in the initial build forecast.

The stop locations shown in Figure 15 reflect those included in SEPTA's initial thinking, with the exception of the Philadelphia Zoo stop, which was moved from the southern to the northern end of the Zoo property. The stop locations, below, would serve Regional Rail passengers headed to the Zoo and residents of the surrounding neighborhoods.

- 30th Street Station;
- Race Street;
- Spring Garden Street;
- 34th Street and Mantua Avenue; and
- Philadelphia Zoo.

The 30th Street station location assumes that it is logistically and physically possible to create a monorail terminus close enough to Regional Rail lines so that transferring to the monorail is about as easy as transferring to another Regional Rail line. On the map, the Zoo terminus is located near the northern end of the Zoo property.

Speed and Travel Time

Research shows that existing monorail services travel at maximum speeds that vary widely: between 7 and 56 miles per hour. Since both route options contain significant curves, and many potential Zoo passengers will be traveling with strollers or small children, for purposes of travel time calculations in the initial forecast, the assumed average speed was 15 miles per hour.

Given the route, stop locations, and speed discussed above, Table 6 shows the calculations used to estimate total travel time. The total travel time is not the same as end-to-end travel time. Instead, it represents the time between when the vehicle leaves one terminus to the time it leaves the opposite terminus for a return trip. The calculation includes dwell time assumptions: 45 seconds for intermediate stations and 1 minute 15 seconds for terminus stations, which is where most Zoo visitors will be boarding and alighting.

Service Frequency

The short end-to-end distance and travel time allow for frequent service. In an attempt to keep operations simple, realistic, and easy to understand, the base monorail was scheduled to operate on 10-minute headways. This headway assumes that there will be two vehicles and two tracks (or at least sufficient room for the vehicles to pass each other in the middle).

Table 6: Travel TIme Calculations

Origin	Destination	Distance (miles)	Speed (mph)	Travel Time (minutes)	Dwell Time (minutes)	Total Time (minutes)
30th St.	Race St.	0.223	15	0.892	0.75	1.642
Race St.	Spring Gardern St.	0.297	15	1.188	0.75	1.938
Spring Garden St.	34th and Mantua	0.391	15	1.564	0.75	2.314
34th and Mantua	Philadelphia Zoo	0.601	15	2.404	1.25	3.654
Total		1.512				9.548

Sources: Philadelphia Zoo, DVRPC, 2017

Hours of Operation
The Philadelphia Zoo opens at 9:30 AM every day. The Zoo closes at 5:00 PM in season (March through October) and 4:00 PM out of season (November through February). In order to primarily serve Zoo visitors, staff, and volunteers, while also providing some service to residents of the surrounding neighborhoods, the monorail is modeled to operate from 7:00 AM to 10:00 PM, 7 days per week. It is not intended to be a late-night service. The Route 15 trolley and Route 38 bus will continue to serve the area beyond monorail operating hours.

Fare
Existing monorail fares vary widely. The base monorail was modeled to cost the same as a ride on one of SEPTA's subway lines.

Free Regional Rail

SEPTA offers a wide variety of fare options to their transit passengers, including, but not limited to, tokens, monthly passes, and transfer tickets. The total cost of a trip on SEPTA's system depends on the fare option used. To account for this complex variety of fare options, DVRPC's travel demand model uses a weighted average fare based on the most commonly used fares. Since Regional Rail uses a zone-based fare structure, an average fare was calculated for each origin-destination pair in the model. In the Base Regional Rail scenario, the Zoo Regional Rail station was considered part of SEPTA's Zone 1. For the Free Regional Rail scenario, Zoo visitors accessed the Zoo with no fare.

If this scenario were implemented (rather than modeled), a free trip to a Zoo Regional Rail station for Zoo visitors could take a variety of forms. One possible method is for the Zoo to provide a discount on admission fees to visitors who prove they used the station. The Zoo and SEPTA could also partner to provide a special pass for Zoo members. Additional coordination between the Zoo and SEPTA would be required to determine the details.

Full Regional Rail

The 2013 Campbell Thomas & Co. study recommended a station consisting of four platforms at 34th Street and Mantua Avenue served by the Paoli/Thorndale, Chestnut Hill West, Trenton, and Cynwyd lines. Base Regional Rail, the agreed-upon "best realistic" operating scenario for a Zoo station, simplified this station concept to include only three of the four proposed platforms. Therefore, the station could only be served by the Paoli/Thorndale Line. SEPTA believes that the additional platform required to serve the other three lines is unlikely to be technically feasible.

The Full Regional Rail scenario is a theoretical forecast examining the potential ridership if the additional platform was constructed allowing three additional lines to serve the Zoo station. SEPTA provided conceptual operating schedules for all lines impacted by this change.

Free Monorail

The free monorail scenario was based on the parameters described in the Base Monorail scenario. The only change was that the monorail fare was removed, making it free for all riders.

Table 7 summarizes the key modeled elements for each of the five forecast scenarios.

Table 7: Forecast Scenario Summary

Phase	Scenario	Modeled Service
"Best realistic" Scenarios	Base Regional Rail 	Paoli/Thorndale Line 3 platforms 30-minute or better headways 7 days a week, full day of service
	Base Monorail 	Connects Zoo to 30th Street Station 5 stops 10-minute headways 7 days a week, full day of service
"What if" Scenarios	Free Regional Rail 	Based on Base Regional Rail Free for Zoo visitors
	Full Regional Rail 	Full buildout of Zoo station based on Campbell Thomas & Co Study Paoli/Thorndale, Trenton, Chestnut Hill West, and Cynwyd lines Technical feasibility and constructability not endorsed by SEPTA
	Free Monorail 	Based on Base Monorail Free for all riders

Source: DVRPC, 2017

Travel Demand Model Considerations

The ridership forecasts in this study were specifically focused on the trips of Zoo visitors. However, DVRPC's TIM 2.2 does not explicitly capture the unique characteristics of Zoo trips in its standard procedures. Trips to the Zoo tend to have different peak hours, vehicle occupancy, and trip length frequency distributions than any of the standard trip purposes in the model. Therefore, additional assumptions and procedures were required to forecast the travel patterns of Zoo visitors.

Based on the available data, it was assumed that all visitor trips originated at the person's home location. Since the member zip code data provided the trip origins and their destination was the Zoo, the model only needed to determine the mode and path of each Zoo visitor to forecast transit ridership.

In the model, Zoo visitors accessed the Zoo on a loaded mid-day network, meaning that the full regional model was run first, to load passengers onto the trains and volume onto the highways, so that the Zoo visitors' mode choice would account for traffic already on the network. Only trips **to** the Zoo were modeled, and symmetry was assumed for the return trip. Calculating the mode choice and assignment separately for Zoo visitors allowed for a closer look into their travel patterns.

Trips to the Zoo occur most often on the weekends. However, DVRPC does not have a weekend model. Therefore, the mid-day (10 AM to 3 PM) network was selected to model Zoo visitor trips since congestion levels and transit schedules are analogous to weekend service levels.

Additional information about the travel demand modeling process is found in Appendix A.

CHAPTER 3: RIDERSHIP FORECAST RESULTS

After obtaining Advisory Committee agreement for the inputs to the five forecast scenarios, DVRPC completed the ridership forecasts. This chapter presents the forecast results in the form of station volume. Station volume is the average of projected boards and alights at a station.

Base Regional Rail

Table 8, below, shows the number of riders forecast to use the Zoo Regional Rail station in 24 hours. Station volume was calculated by averaging the number of passengers predicted to board and alight at the station. In the model, Zoo visitors were sent directly to the Zoo from their zip code of residence. The number of Zoo visitors in the table refers to those who used the Zoo Regional Rail station to access the Zoo. Non-Zoo visitors includes residents and workers using the station to access homes and jobs in the neighborhoods surrounding the Zoo, as well as Zoo employees using the station to get to and from work.

Table 8: Base Regional Rail Ridership Forecast Results

Station	Non-Zoo Visitors	Zoo Visitors	Total 24-Hour Station Volume
Zoo Regional Rail Station	237	48	285

Source: DVRPC, 2017

The map in Figure 16 shows the distribution of passengers predicted to use rail or subway to reach the Zoo via the Zoo Regional Rail station. The station is located next to the yellow star representing the Zoo. The thicker the orange line, the more passengers are predicted to use that line. Since the Paoli/Thorndale Line is the only line directly serving the Zoo station in this scenario, the highest number of passengers access the station via the Paoli/ Thorndale Line.

Base Monorail

Table 9, below, shows the number of riders forecast to use each Monorail station in 24 hours. Using the same methodology as the Base Regional Rail scenario, Zoo visitors include those who accessed the Zoo directly. Non-Zoo visitors include those using the Zoo monorail station to access homes and jobs in the surrounding area, as well as Zoo employees using the station to get to and from work.

Overall, the monorail is expected to serve almost 1,400 passengers per day. The 30th Street Station, and 34th Street and Mantua Avenue, monorail stations are forecast to have the highest station volume, while the Race Street and Spring Garden Street Stations are forecast to have the lowest station volume. All Zoo visitors accessing the Zoo via the Zoo monorail station are predicted to board or alight the monorail at the 30th Street monorail station, depending on their direction.

Table 9: Base Monorail Ridership Forecast Results

Station	Non-Zoo Visitors	Zoo Visitors	Total 24-Hour Station Volume
30th Street Station	566	108	**674**
Race Street	10	0	**10**
Spring Garden Street	57	0	**57**
34th and Mantua	409	0	**409**
Zoo Station	132	108	**240**
Line Total	1,174	216	**1,390**

Source: DVRPC, 2017

Figure 16: Base Regional Rail Scenario Ridership Forecast Passenger Distribution

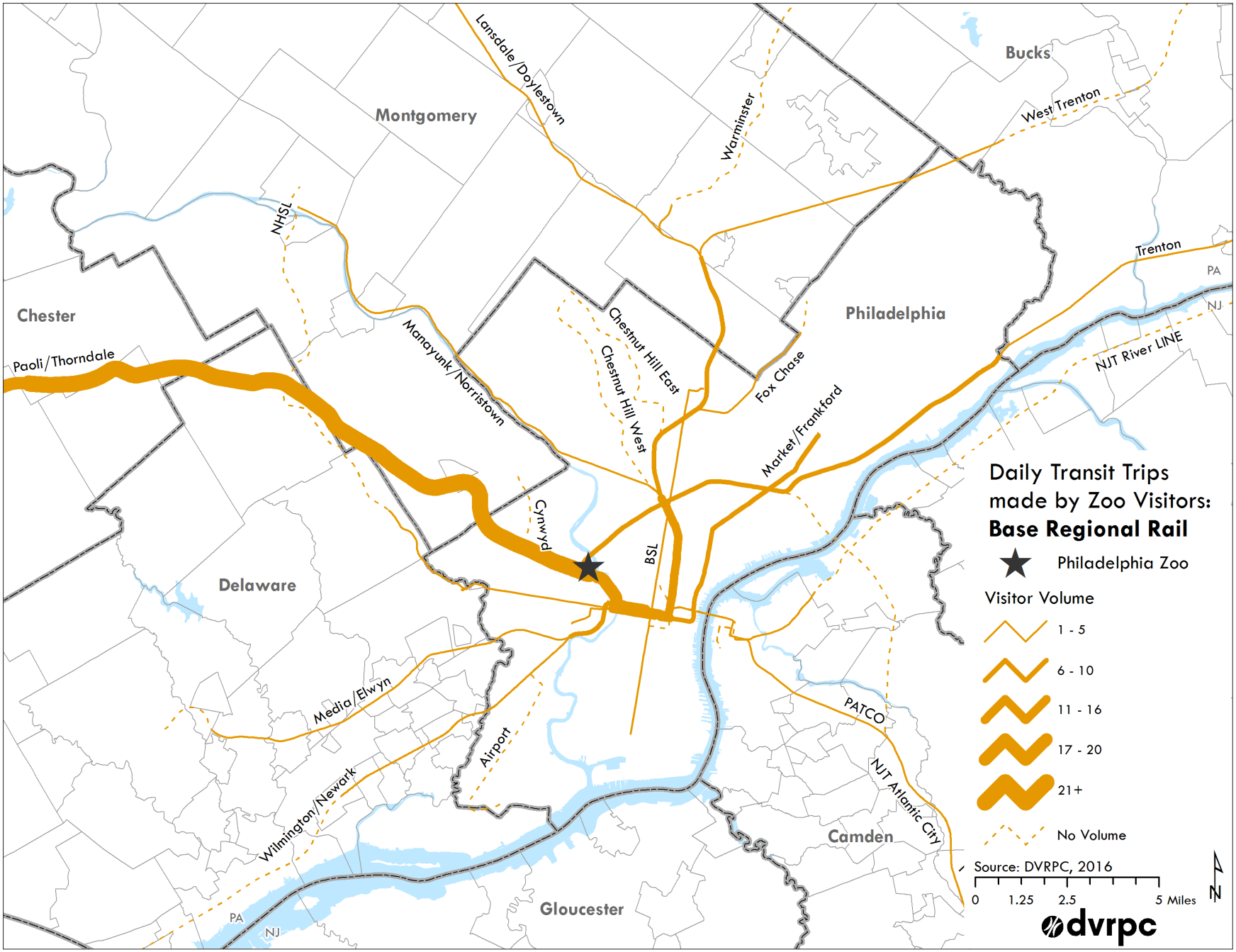
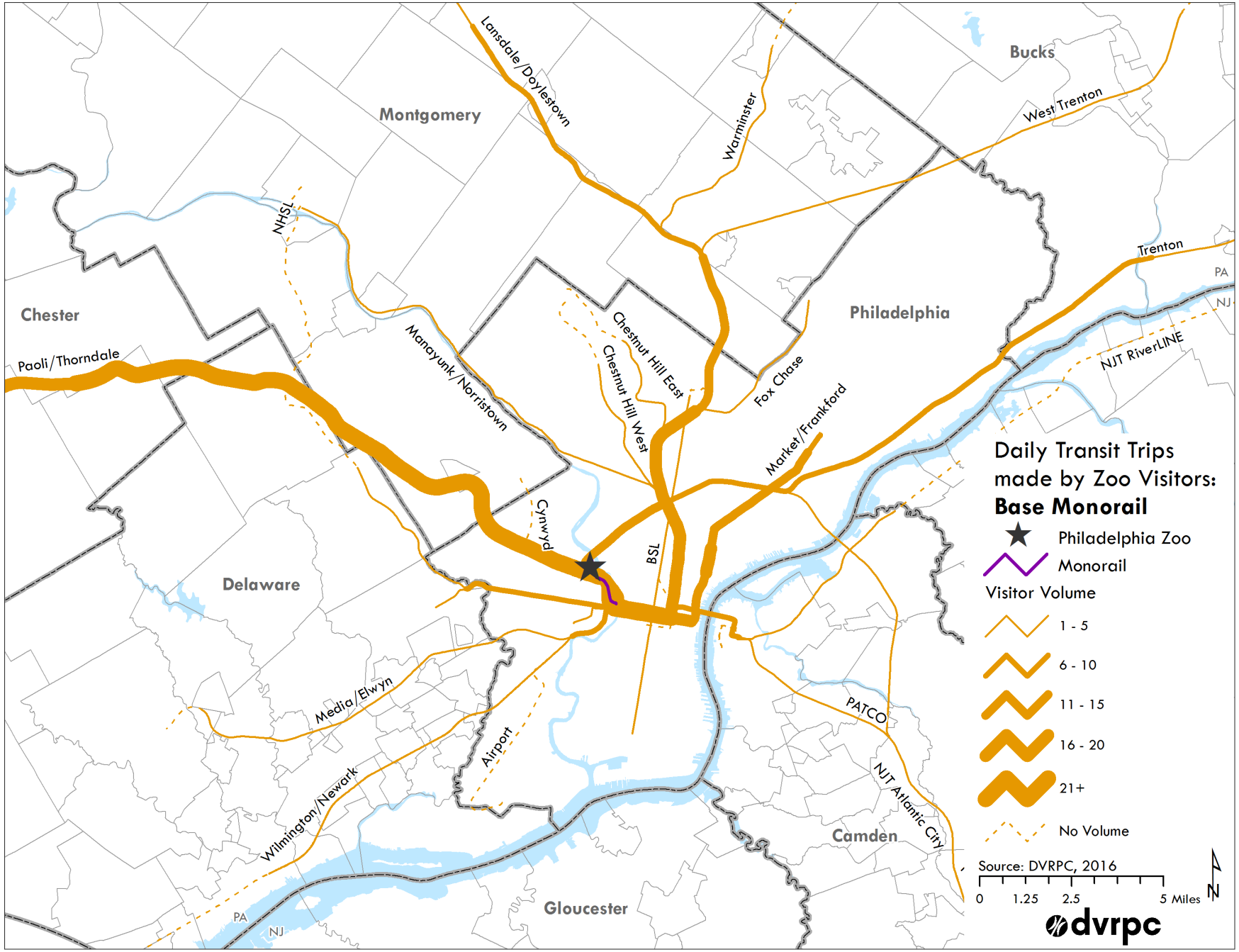


Figure 17: Base Monorail Scenario Ridership Forecast Passenger Distribution



Base Monorail *(continued)*

The map in Figure 17 shows the distribution of passengers predicted to use rail or subway to reach the Zoo via the monorail. The monorail is outlined in purple and the Zoo monorail station is located next to the yellow star representing the Zoo. The thicker the orange line, the more passengers are predicted to use that line. Compared to the Base Regional Rail passenger distribution, there are more thick orange lines on the map. This is due to the fact that the monorail is predicted to attract a higher number of passengers and that frequent monorail service, as well as the relative ease of transferring to the monorail at 30th Street Station, is expected to distribute passenger access across more rail and subway lines.

Free Regional Rail

Table 10 shows the forecast 24-hour station volume for a Zoo Regional Rail station where Zoo visitors are permitted to ride for free. Similar to the other scenarios, Zoo visitors include those who accessed the Zoo directly. Non-Zoo visitors include those using the Zoo monorail station to access homes and jobs in the surrounding area, as well as Zoo employees using the station to get to and from work.

The number of Zoo visitors forecast to use the station in a Free Regional Rail scenario is double the forecast for the Base Regional Rail scenario. As expected, since there was no change in service for non-Zoo visitors, there was no change in the number of non-Zoo visitors using the Zoo station. The increase in Zoo visitors accounts for the entire increase in the total 24-hour station volume.

Table 10: Free Regional Rail Ridership Forecast Results

Station	Non-Zoo Visitors	Zoo Visitors	Total 24-Hour Station Volume
Zoo Regional Rail Station	236	108	344

Source: DVRPC, 2017

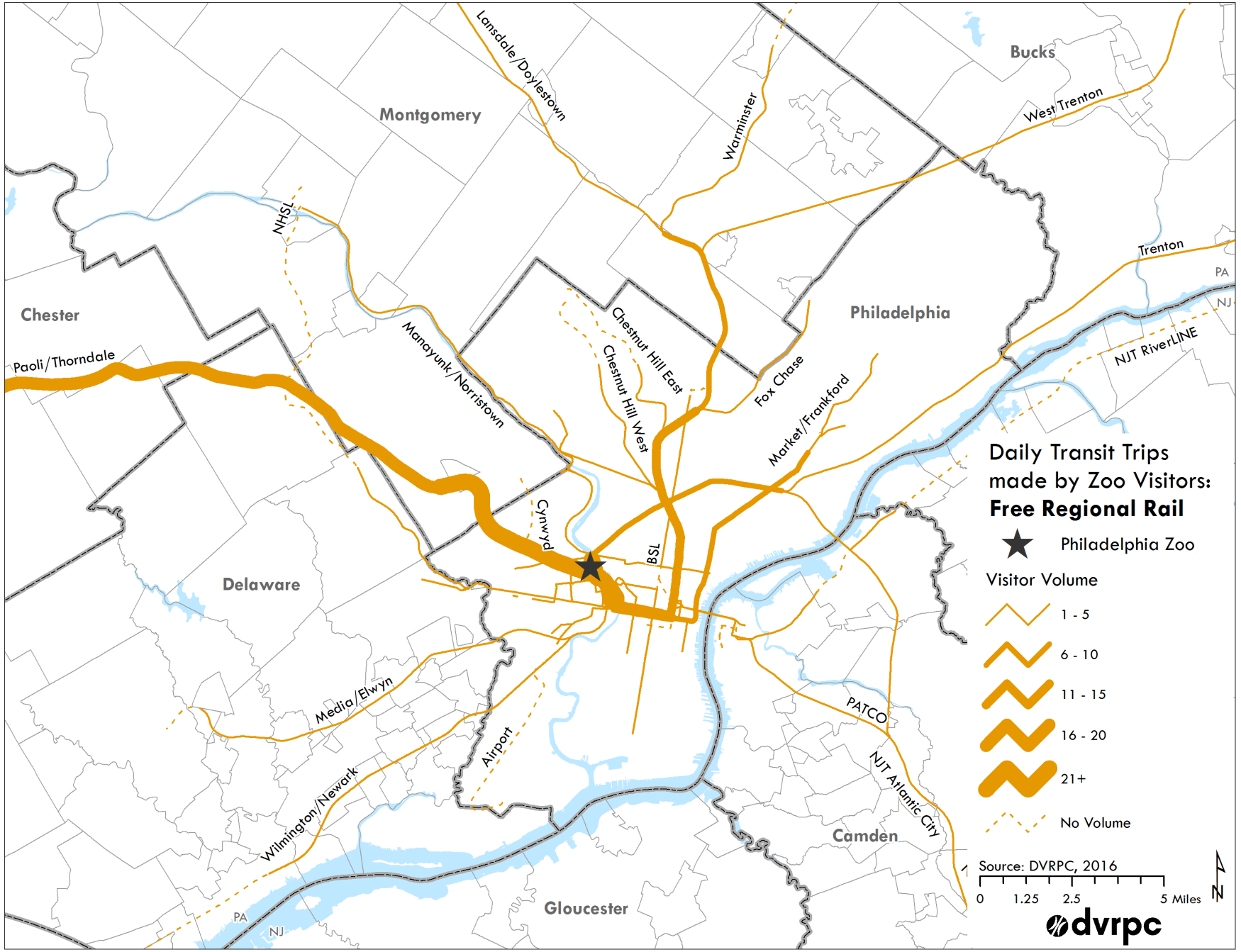
The Figure 18 map shows the distribution of passengers predicted to use rail or subway to reach the Zoo via the Zoo Regional Rail station. Overall, the lines are somewhat thicker than those on the map for the Base Regional Rail scenario due to the increase in Zoo visitors forecast to use transit. However, the distribution of passengers has not changed. Since the Paoli/Thorndale Line is the only line directly serving the Zoo station in this scenario, it is logical that the highest number of passengers access the station via the Paoli/Thorndale Line.

Full Regional Rail

Table 11 shows the number of riders forecast to use the Zoo Regional Rail station in 24 hours when the station is served by the Paoli/Thorndale, Chestnut Hill West, Trenton, and Cynwyd lines. Using the same methodology as the other scenarios, Zoo visitors include those who were sent directly to the Zoo. Non-Zoo visitors include those using the Zoo station to access homes and jobs in the surrounding area, as well as Zoo employees using the station to get to and from work.

The number of Zoo visitors forecast to use the station falls between the numbers forecast for the Base Regional Rail (48) and Free Regional Rail (108) scenarios. However, since the station in the Full Regional Rail scenario provides access to a wider geographic area via the Chestnut Hill West, Trenton, and Cynwyd lines, the number of non-Zoo visitors is forecast to double.

Figure 18: Free Regional Scenario Rail Ridership Forecast Passenger Distribution



Full Regional Rail *(continued)*

Table 11: Full Regional Rail Ridership Forecast Results

Station	Non-Zoo Visitors	Zoo Visitors	Total 24-Hour Station Volume
Zoo Regional Rail Station	497	86	583

Source: DVRPC, 2017

In the Base Regional Rail and Free Regional Rail scenarios, no transfers were predicted to occur at the Zoo since the Zoo station was only served by a single line. However, in the Full Regional Rail scenario, even with a 1-minute 30-second transfer penalty, almost 450 transfers are forecast to occur at the Zoo station. This is due to the train paths, as shown in Figure 19. The Trenton and Chestnut Hill West lines travel north of the Zoo and would pass through the Zoo station before reaching 30th Street Station. If a passenger was traveling from Paoli to Trenton via Regional Rail, depending on the timing, it could be faster for them to transfer at the Zoo station than to ride for an additional stop in each direction to transfer at 30th Street Station.

Figure 19: Zoo Station Location

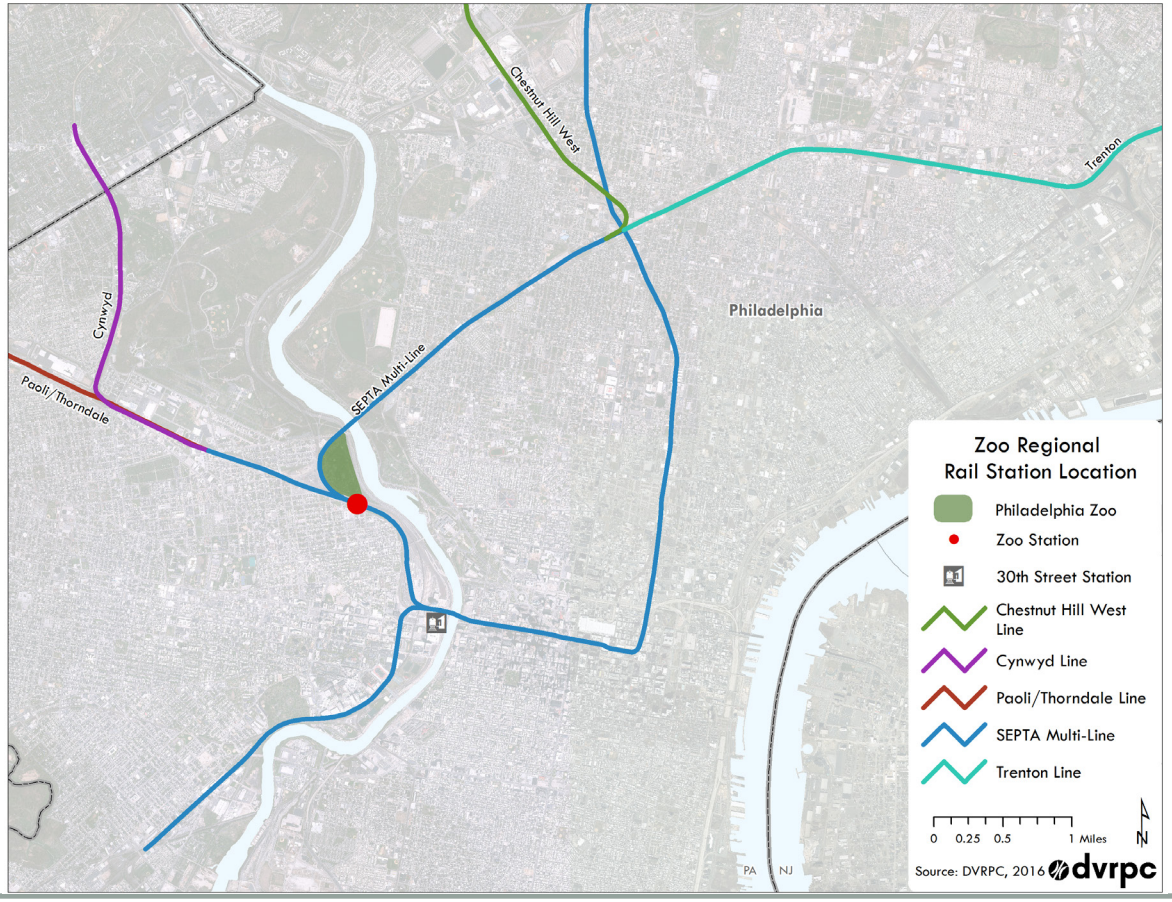
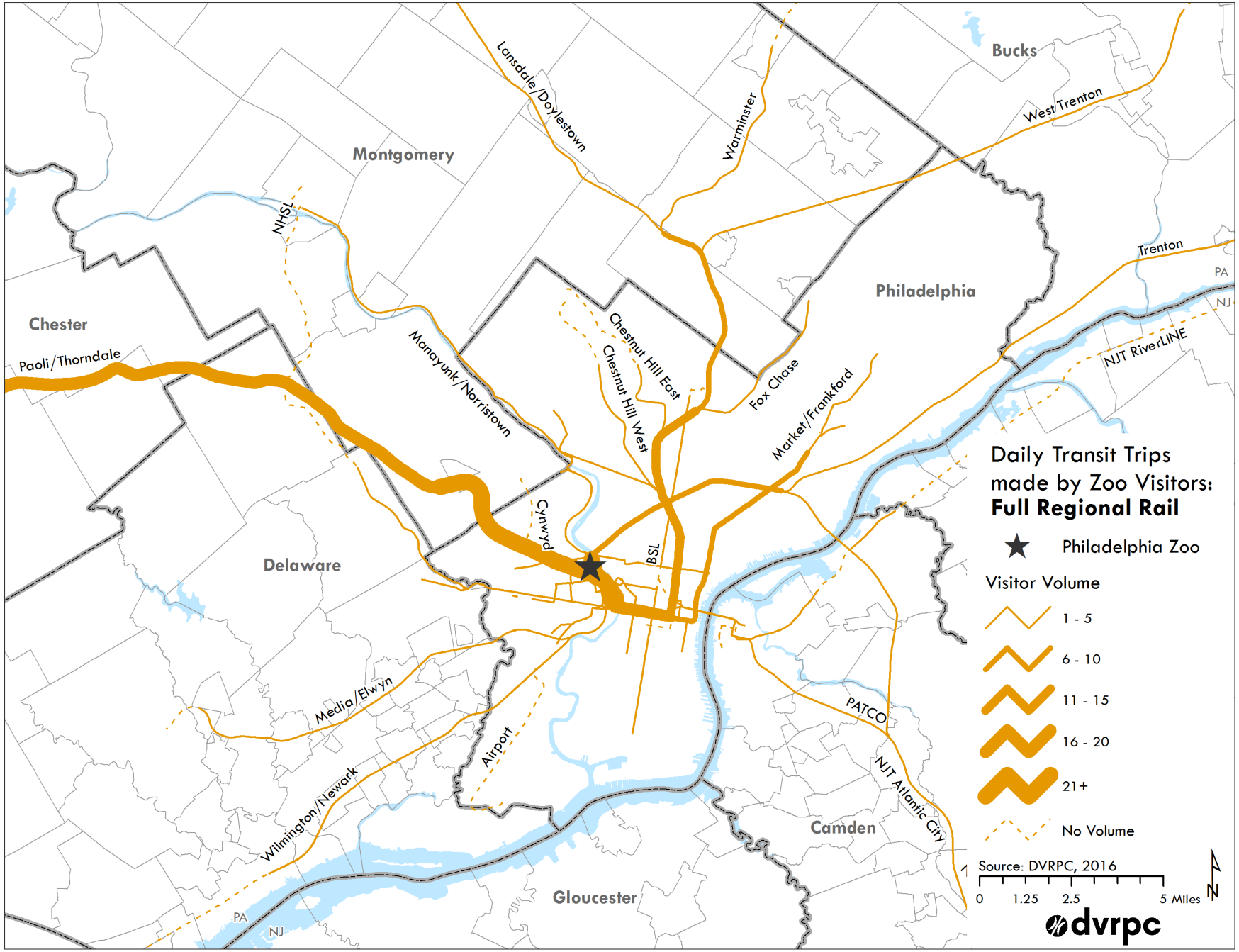


Figure 20: Full Regional Rail Scenario Ridership Forecast Passenger Distribution



Full Regional Rail *(continued)*

The map in Figure 20 shows the distribution of passengers predicted to use rail or subway to reach the Zoo via the full-buildout Zoo Regional Rail station. Since the station is served by more lines in this scenario, it is logical that passengers are slightly more dispersed throughout the system. However, very few visitors are predicted to use the Chestnut Hill West and Cynwyd lines.

The map in Figure 21 shows the distribution of non-Zoo visitors predicted to transfer at the Zoo Regional Rail station. The thicker the purple line, the more passengers are predicted to use that line either before or after transferring at the Zoo station. The majority of transfer passengers are forecast to use the Paoli/Thorndale Line or the Trenton Line. Fewer transfer passengers are expected to use the Chestnut Hill West and Cynwyd lines.

Free Monorail

Table 12 shows the number of riders forecast to use each monorail station in 24 hours when monorail rides are free for all passengers. Using the same methodology as the other scenarios, Zoo visitors include those who were sent directly to the Zoo. Non-Zoo visitors include those using the Zoo monorail station to access homes and jobs in the surrounding area, as well as Zoo employees using the station to get to and from work.

Overall, the free monorail is expected to serve over 6,000 passengers per day. This is more than four times the ridership forecast for the Base Monorail scenario, in which the monorail was modeled using the same fare structure as the subway. Similar to the Base Monorail scenario, the 30th Street Station, and 34th Street and Mantua Avenue, monorail stations are forecast to have the highest station volumes while the Race Street and Spring Garden Street stations are forecast to have the lowest station volumes. All Zoo Visitors accessing the Zoo via the Zoo monorail station are predicted to board or alight the monorail at the 30th Street monorail station, depending on their direction.

Table 12: Free Monorail Ridership Forecast Results

Station	Non-Zoo Visitors	Zoo Visitors	Total 24-Hour Station Volume
30th St Station	2,760	227	**2,987**
Race St	72	0	**72**
Spring Garden St	421	0	**421**
34th and Mantua	1,931	0	**1,931**
Zoo Station	426	227	**653**
Line Total	5,610	454	**6,064**

Source: DVRPC, 2017

The map in Figure 22 shows the distribution of passengers predicted to use rail or subway to reach the Zoo via the monorail. The monorail is outlined in purple and the Zoo monorail station is located next to the yellow star representing the Zoo. Compared to all other scenarios, there are more thick orange lines, or more Zoo passengers, on this map. This is due to the fact that the free monorail is predicted to attract the largest number of passengers and that frequent monorail service, as well as the relative ease of transferring to the monorail at 30th Street Station, is expected to distribute passenger access across more rail and subway lines.

Figure 21: Transfer Passenger Distribution

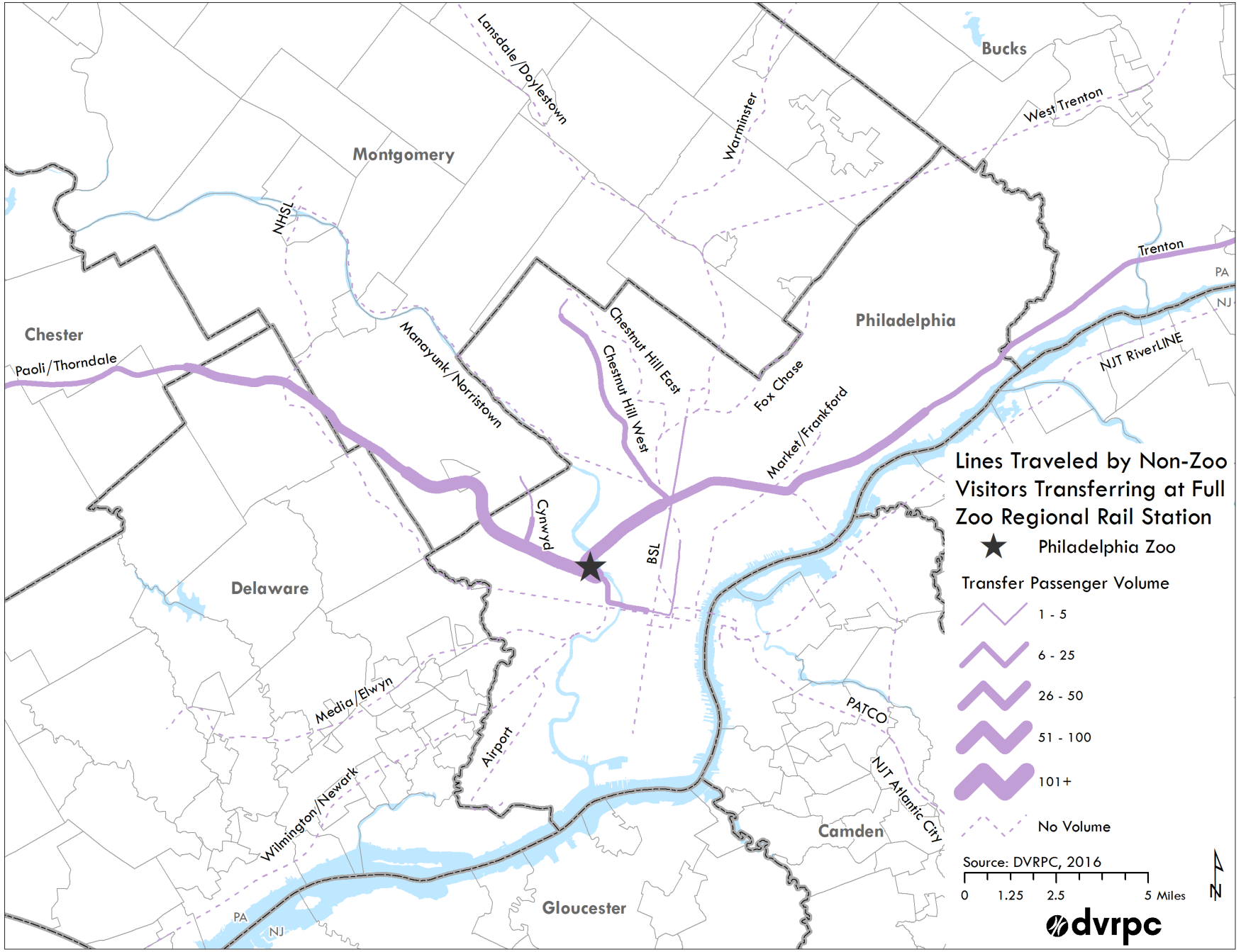
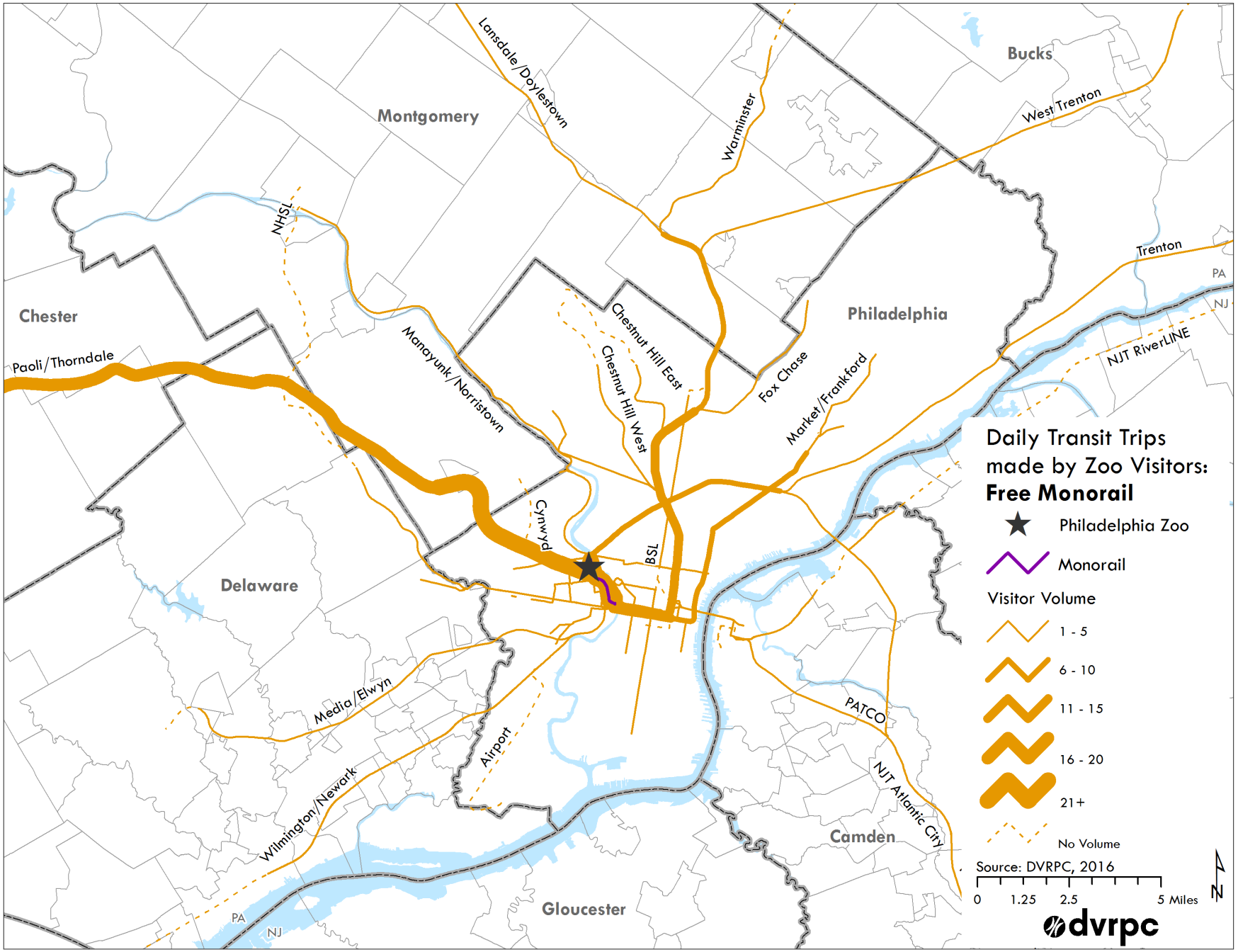


Figure 22: Free Monorail Scenario Ridership Forecast Passenger Distribution



CHAPTER 4: FORECAST ANALYSIS

Chapter 4 compares the results of the ridership forecasts, not only among the five forecast scenarios, but also to other ridership data and previous forecast results. A visual analysis is presented to compare the change in transit travel time across build options. Finally, Chapter 4 presents a discussion of alternative future scenarios.

Modeled Scenario Comparison

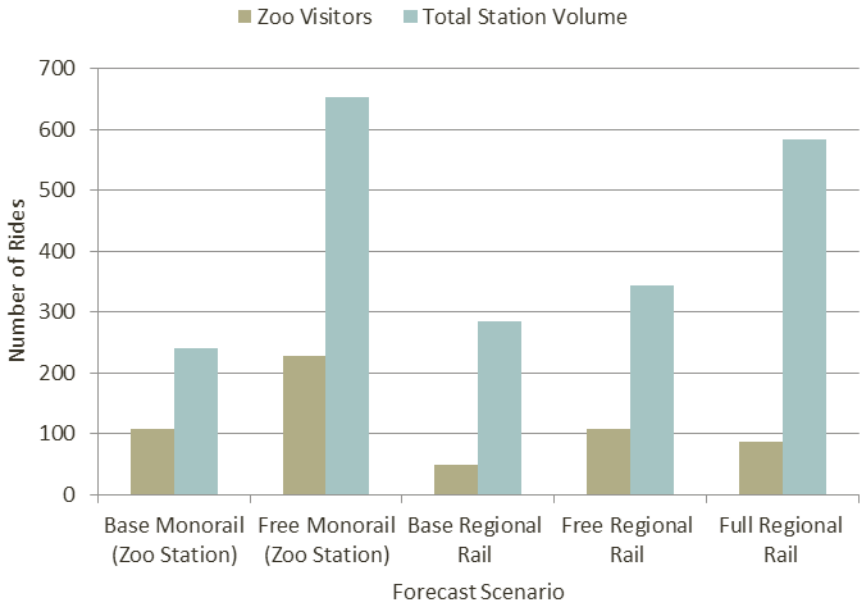
This section provides a comparison between all five forecast scenarios. Table 13 and Figure 23 show the total station volume and number of Zoo visitors forecast to use the Zoo station in each of the five forecast scenarios. The Zoo station in the Free Monorail and Full Regional Rail scenarios is forecast to have the highest total station volume. The Base Monorail and Free Regional Rail scenarios are forecast to serve a similar number of Zoo visitors. The Free Monorail is forecast to serve the highest number of Zoo visitors – twice the next highest forecast. The Free Monorail and Full Regional Rail build options are forecast to serve the most non-Zoo visitors.

Table 13: Zoo Station Results Comparison

Scenario	Non-Zoo Visitors	Zoo Visitors	Total Daily Station Volume
Base Monorail	132	108	**240**
Free Monorail	426	227	**653**
Base Regional Rail	237	48	**285**
Free Regional Rail	236	108	**344**
Full Regional Rail	497	86	**583**

Source: DVRPC, 2017

Figure 23: Zoo Station Results Comparison



Source: DVRPC, 2017

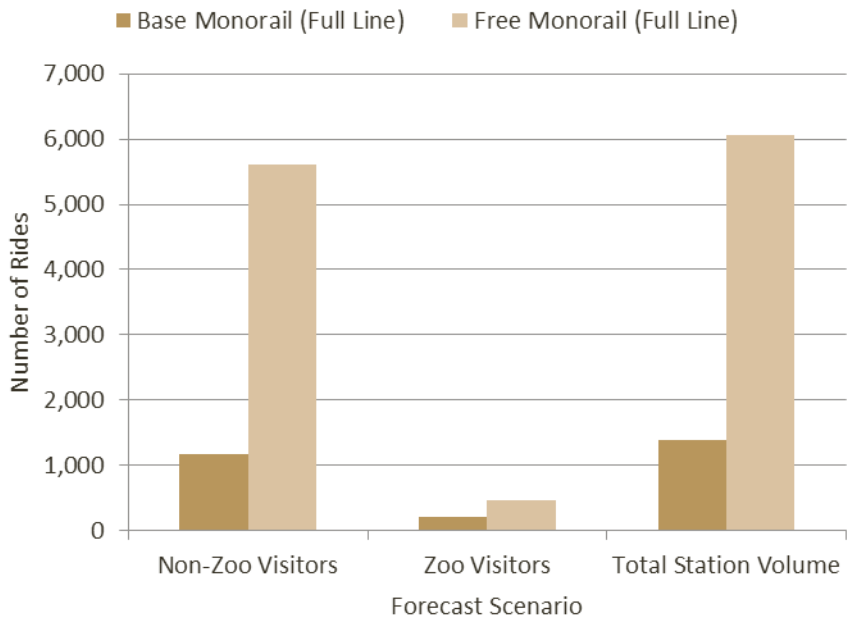
While there are differences among forecast station volume at the Zoo station in each of the five scenarios, only 400 rides separate the highest and lowest station level ridership estimates. However, the difference between line level ridership in the Monorail scenarios is significantly greater. Table 14 and Figure 24 show the total line volume forecast in each monorail scenario. The Free Monorail is forecast to serve over four times as many passengers as the Base Monorail and twice the amount of Zoo visitors.

Table 14: Monorail Line Results Comparison

Scenario	Non-Zoo Visitors	Zoo Visitors	Total Station Volume
Base Monorail	1,172	216	**1,388**
Free Monorail	5,608	454	**6,062**

Source: DVRPC, 2017

Figure 24: Monorail Line Results Comparison



Source: DVRPC, 2017

Table 15 shows statistics about the Zoo visitors forecast to use the Zoo station in each of the five scenarios. The average number of projected weekend visitors in 2040, just under 7,000, were sent to the Zoo in the model. Based on the number of visitors projected to use the station to access the Zoo, the table shows the share of Zoo visitors projected to use the Zoo station per day, per month, and per year. The results are similar to the share of Zoo visitors currently using the Route 15 trolley on the weekends.

Table 15: Zoo Visitor Comparison

Scenario	Share of Zoo Visitors Using Zoo Station (daily)	Average Number of Zoo Visitors Using Zoo Station per Month	Average Number of Zoo Visitors Using Zoo Station per Year	Percentage of Station Volume Comprised of Zoo Visitors
Base Monorail	2%	2,200	26,398	44%
Free Monorail	3%	4,624	55,485	35%
Base Regional Rail	1%	978	11,733	17%
Free Regional Rail	2%	2,200	26,398	31%
Full Regional Rail	1%	1,752	21,021	15%

Source: DVRPC, 2017

The model was also used to project the number of employees that will use the Zoo station in each scenario. Since the Zoo is isolated in the model, it is assumed that all non-Zoo visitors using the Zoo station to access the Zoo are all Zoo employees. Table 16 shows the number of Zoo employees projected to use the Zoo station per day.

Table 16: Zoo Employee Comparison

Scenario	Number of Zoo Employees Using Zoo Station	Percentage of Station Volume Comprised of Zoo Employees
Base Monorail	49	20%
Free Monorail	121	19%
Base Regional Rail	19	7%
Free Regional Rail	19	6%
Full Regional Rail	36	6%

Source: DVRPC, 2017

Outside Comparison

The results of the build option scenarios were compared with other ridership data and previous forecast results to check for reasonableness. The comparable data is discussed in this section. Based on these comparisons, the forecast results seem plausible.

Zoo Link Shuttle

The Zoo Link was a shuttle operated by SEPTA in 2007. The shuttle ran every half hour on peak season weekends between 30th Street Station and the Zoo. Zoo members, staff, and volunteers were able to ride the shuttle for free. Based on passenger data from 41 days during the summer of 2007, the Zoo Link had an average station volume of 49 passengers. Since the shuttle only stopped at 30th Street Station and the Zoo, it is assumed that all passengers were Zoo visitors.

Previous Forecast Results

The 1995 Campbell Thomas & Co. study conducted ridership forecasts for a Zoo Regional Rail station served by the Trenton, Chestnut Hill East, Chestnut Hill West, Fox Chase, and Atlantic City lines. The Zoo station in this study was predicted to serve 325 passengers on an average day, including 26 percent (or 84) Zoo visitors and 14 percent (or 45) Zoo employees. Zoo visitor ridership was expected to vary widely, from a daily low of 22 to a daily high of 273 passengers.

Typical Regional Rail Ridership

Based on 2015 average weekday ridership, the total station volume predicted for the Base Zoo Regional Rail station, would rank 99th out of 157 stations. The station volumes forecast in the Free Regional Rail and Full Regional Rail scenarios would rank 88th and 48th, respectively.

Change in Transit Access: Visual Analysis

So far, this analysis has focused on the impact of additional transit service on ridership estimates. However, changes in transit service and coverage also impact the ability of people to travel throughout the region via transit and the time it takes them to reach their destination. Regardless of fare, adding transit service to the Zoo will not only change how quickly people traveling from the Zoo can reach their destination, but will also change transit access for neighboring Mantua and Powelton Village residents. The software used to run the travel demand model includes tools to help visualize changes in transit travel time. This visualization is referred to as isochrones: a way of displaying travel time from an origin to all possible destinations. Isochrone maps can be found in Appendix E.

Isochrone maps, which depict access, are essentially pictures of an individual's ability to travel via transit, based solely on travel time. They are impacted by the availability and frequency of transit service. In terms of access, adding a new transit service is similar to adding a new road to a road network. The existence of the road makes connections possible, but does not necessarily mean it will be used. An isochrone map will show an area as accessible by transit whether or not it is a useful or desirable destination. It only cares about if one **can** get somewhere; not if one would **want or need** to go there.

Interpreting isochrone maps is different than reading ridership estimates. Ridership estimates account for a wide variety of factors, including, but not limited to, transit demand, trip purposes, vehicle ownership, fare, and travel time. Ridership estimates are impacted by changes in any of the travel model inputs, such as population, employment, or service patterns. These changes are reflected in the scenario forecast results.

Differences between the isochrone maps for each scenario (found in Appendix E) were very subtle and difficult to see. Therefore, additional maps were produced to highlight those differences. The maps in Figures 25–28 show the change in forecast travel time between different scenarios for comparison. The darker the color, the larger the forecast travel time savings between the two scenarios being compared.

- **No Build versus Base Regional Rail:** Adding the Regional Rail station shortens the time it takes people to travel from the Zoo. Since the station is only served by the Paoli/Thorndale Line in this scenario, it is logical that the largest travel time savings to the Zoo are seen along that line. However, as noted, adding a Zoo station along this line will slightly lengthen the travel time for those traveling into Center City.
- **No Build versus Base Monorail:** Forecast travel time savings are less, but are more dispersed throughout the region than in the Base Regional Rail scenario.
- **Base Regional Rail versus Full Regional Rail:** Since the Full Regional Rail scenario includes more service, it is forecast to save more travel time than the Base Regional Rail scenario. The largest travel time savings are along the Chestnut Hill West and Cynwyd lines.
- **Base Regional Rail versus Base Monorail:** The blue color highlights areas that are accessed more quickly from the Zoo via the monorail. The brown areas are accessed more quickly in the Base Regional Rail scenario.

Figure 25: Change in Forecast Transit Travel Time between No Build and Base Regional Rail Scenarios

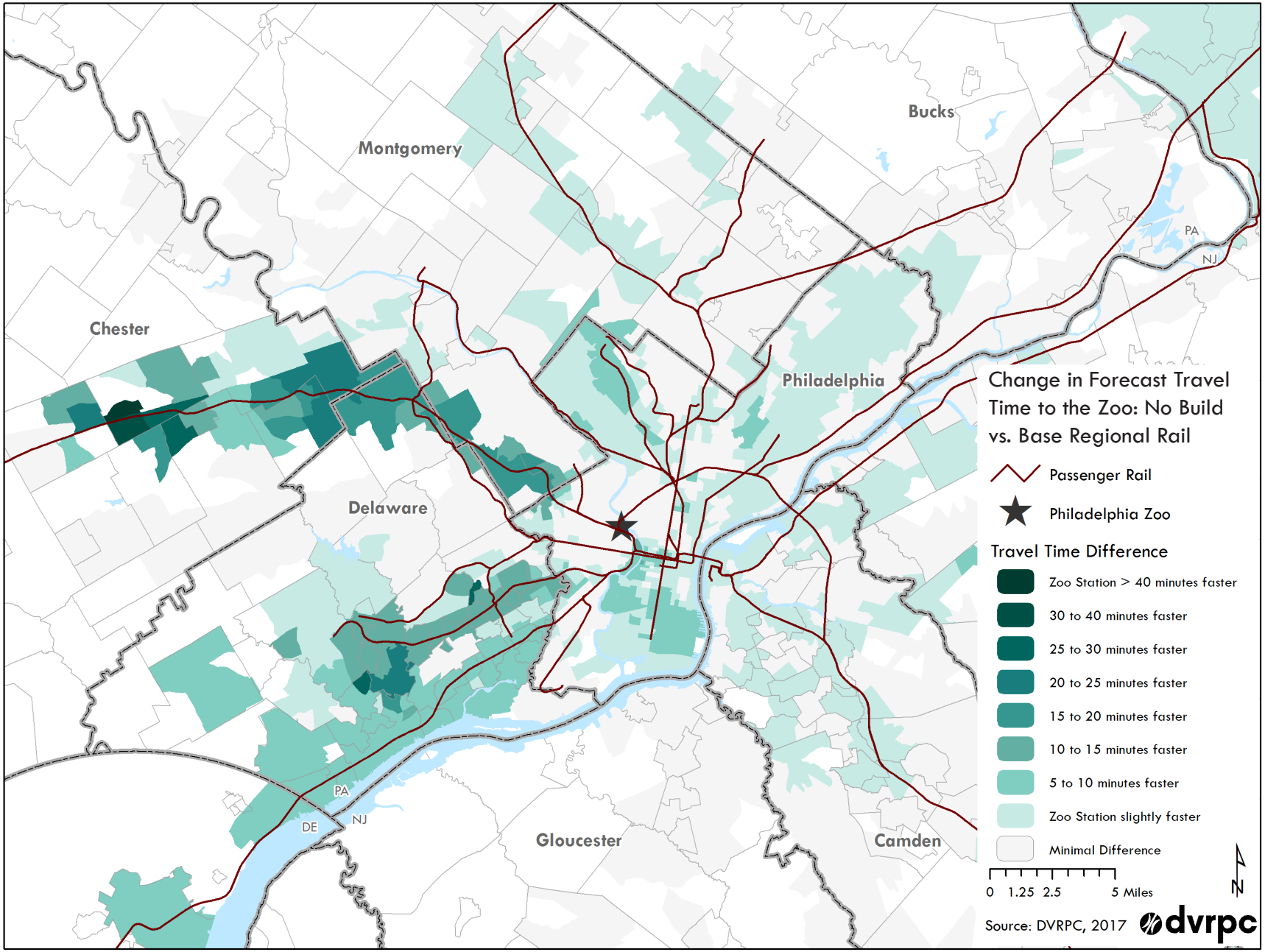


Figure 26: Change in Forecast Transit Travel Time Between No Build and Base Monorail Scenarios

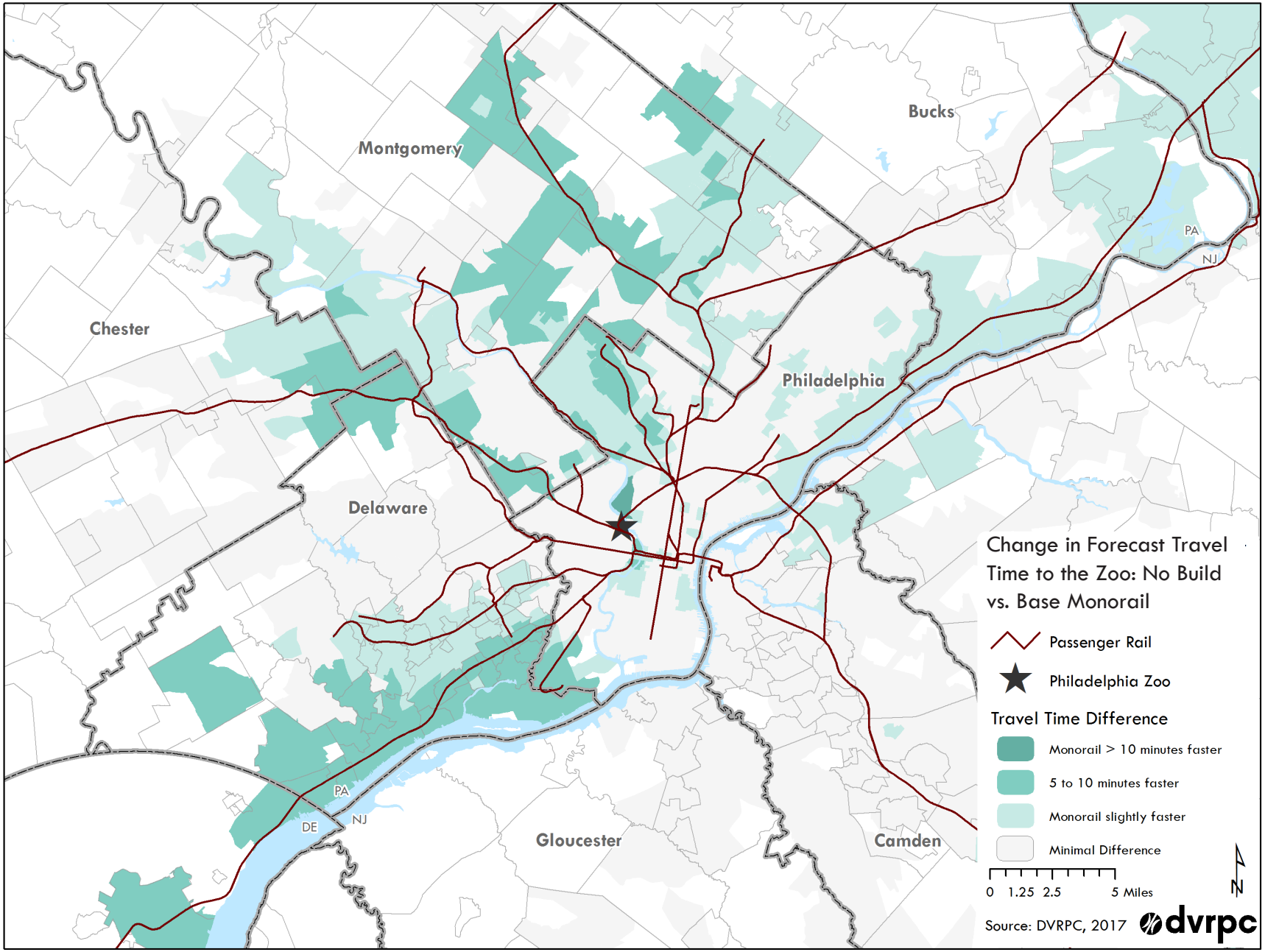


Figure 27: Change in Forecast Travel Time Between Base Regional Rail and Full Regional Rail Scenarios

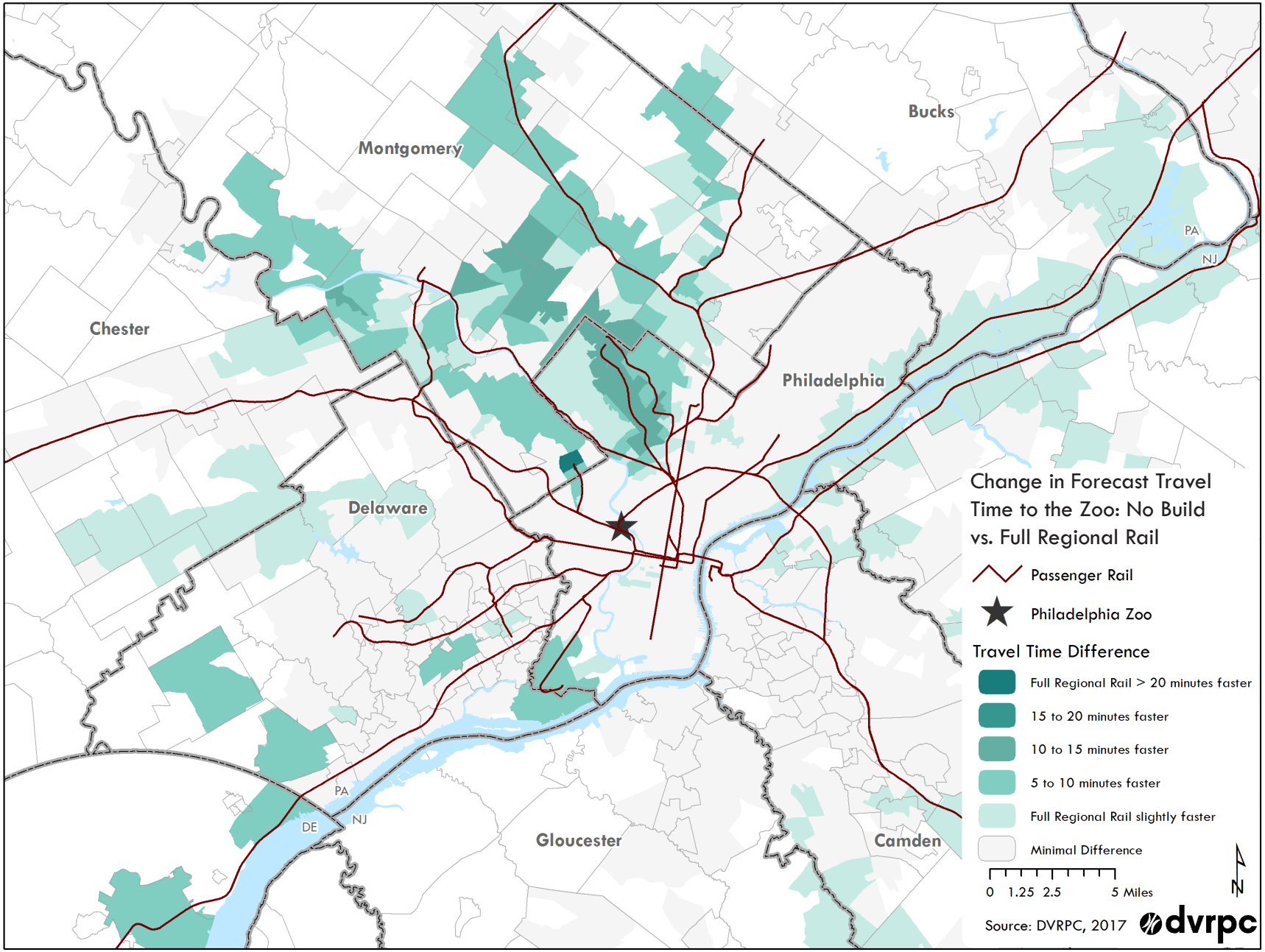
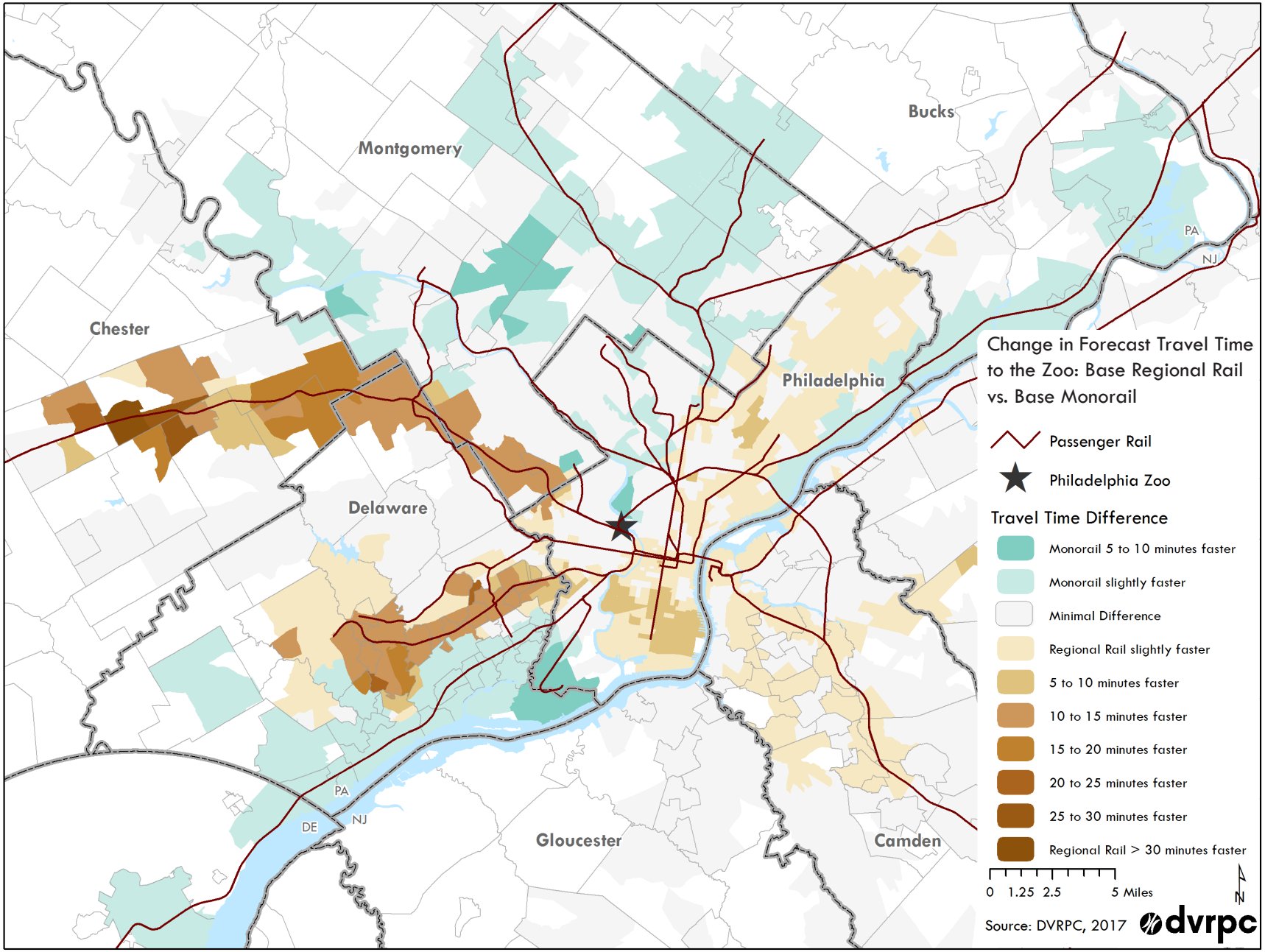


Figure 28: Change in Forecast Travel Time Between Base Regional Rail and Base Monorail Scenarios



Alternative Scenarios: Sketch Calculations

Since this project was scoped to model five future scenarios, not all questions about alternative futures could be analyzed using the full modeling process. However, some of the alternative future scenarios discussed at the Advisory Committee meeting in July 2016 can be estimated based on the results and travel patterns revealed in the five modeled scenarios. Sketch estimates are provided below for two alternative future considerations: upper-bound Zoo visitation and redistribution of Zoo visitor origins.

Upper-Bound Zoo Visitation

The agreed-upon projected annual number of Zoo visitors used in all five scenarios was 1.7 million. One question raised at the Advisory Committee meeting was: What if the actual number of visitors were significantly greater than 1.7 million? Instead of using one of the five modeled scenarios to answer this question, the committee decided that sketch calculations could be used to examine the impact of more Zoo visitors on projected ridership.

According to Zoo attendance data, on an average weekday, the Zoo can expect to see approximately 0.4 percent of their annual visitors, or around 7,000 visitors. Based on the transit option in the modeled scenarios, as shown in Table 17, between 1 percent and 3 percent of these visitors were forecast to use the Zoo station.

Table 17: Percentage of Zoo Visitors Forecast to Use the Modeled Zoo Station

Scenario	Zoo Visitors	Percentage of Zoo Visitors
Base Monorail	108	2%
Free Monorail	227	3%
Base Regional Rail	48	1%
Free Regional Rail	108	2%
Full Regional Rail	86	1%

Source: DVRPC, 2017

Based on the following assumptions, the number of visitors projected to use a Zoo station is estimated to grow proportionately with Zoo attendance.

- Assumption 1: The percentage of annual visits occurring on an average weekend day remains the same.
- Assumption 2: The percentage of Zoo visitors using the Zoo station in each of the five build options also remains consistent.

Table 18 shows the estimated number of Zoo visitors projected to use the Zoo station in each of the five modeled scenarios if the 2040 annual visitation increases to two million, 2.5 million, or three million. Given the low percentage of visitors forecast to use the station, the projected increase in station volume is relatively small. With three million annual visitors, the Base Regional Rail scenario is estimated to serve 85 visitors per day, while the Free Monorail Zoo station is estimated to serve around 400 visitors per day.

Table 18: Upper-Bound Visitation Estimates

Upper-Bound Option	Modeled	A	B	C
Annual Projected Visitation	1,700,000	2,000,000	2,500,000	3,000,000
Average Weekend Daily Visitors	6,955	8,182	10,228	12,274
Scenario	***Estimated Visitors Using Zoo Station***			
Base Monorail	108	127	159	191
Free Monorail	227	267	334	401
Base Regional Rail	48	56	71	85
Free Regional Rail	108	127	159	191
Full Regional Rail	86	101	126	152

Source: DVRPC, 2017

Redistribution of Zoo Visitors

For the forecast scenarios, Zoo visitor trip origins were distributed based on the zip codes of Zoo members. Since no data was available on the location of non-member trip origins, it was assumed that non-members were distributed throughout the region similarly to Zoo members. In reality, and in the model, some of these origin locations are considered transit accessible while others are not. Typically, a place is considered transit accessible if it is within walking distance of transit. Another question raised at the Advisory Committee meeting was: What if all Zoo visitors lived in transit-accessible places? This can also be thought of as a rough proxy for additional latent demand for a transit-accessible Zoo from transit-served places.

For the purposes of this analysis, a place was considered transit accessible in the model if it had walk access to a transit stop. Based on zip code data, 80 percent of Zoo visitors were coming from transit-accessible places, while 20 percent were coming from places with no transit access. However, in all five modeled scenarios, as shown in Table 19, the overwhelming majority of Zoo visitors coming from transit-accessible places were forecast to drive to the Zoo. Across all five scenarios, an average of 97 percent of trips to the Zoo from transit accessible places were made by auto, while only 3 percent used transit. This is only slightly more transit trips than the average of 1 percent made by those not coming from transit-accessible places *(transit trips from non-transit-accessible places are made by driving to a park-and-ride station)*.

Table 19: Mode Split for Zoo Visitors Based on Transit Access

	Coming from Transit-Accessible Places		NOT Coming from Transit-Accessible Places	
Scenario	*Auto*	*Transit*	*Auto*	*Transit*
Base Monorail	97%	3%	99%	1%
Free Monorail	95%	5%	98%	2%
Base Regional Rail	98%	2%	99%	1%
Free Regional Rail	97%	3%	99%	1%

Source: DVRPC, 2017

The percentage of people from transit-accessible places projected to use the Zoo station in each scenario was calculated to estimate the ridership impact if 100 percent of visitors came from transit-accessible zones. Assuming these percentages would remain constant as the distribution of visitors shifted, Table 20 shows the estimated increase and resulting total number of visitors projected to use the Zoo station for each build option. Since so many visitors living in transit-accessible places are forecast to drive to the Zoo, the estimated increases in Zoo station volume are all relatively small.

Table 20: Estimated Ridership Impact of All Zoo Visits Originating in Transit-Accessible Zones

Scenario	Estimated Increase Expected	Estimated Total Visitors Using Zoo Station
Base Monorail	27	135
Free Monorail	58	285
Base Regional Rail	12	60
Free Regional Rail	27	135
Full Regional Rail	22	108

Source: DVRPC, 2017

Conclusions

This purpose of this study was to develop concepts and conduct a ridership forecast analysis using DVRPC's regional travel demand model. The goal was to help identify transit options worth pursuing further, but this report does not provide an analysis of the costs or detailed design challenges of the options. The Advisory Committee will need to continue to work together to weigh the trade-offs of each scenario and determine which, if any, of the build options are worth a closer look.

APPENDIX A: RIDERSHIP FORECAST METHODOLOGY

DVRPC's regional travel demand model, TIM 2.2, is used to simulate travel behavior to answer "what if" questions, both broad policy questions and also detailed questions about specific facilities. TIM 2.2 is a traditional four-step model built around the following steps:

1. Trip Generation: determines the total number of trips made by an individual, a household, or the entire region;
2. Trip Distribution: determines the origins and destinations for each of those trips;
3. Mode Choice: determines which trips will be made by car, transit, or a non-motorized mode; and
4. Traffic Assignment: determines the route or path that each trip will take.

The outcomes of these four steps are based on the wide variety of input data built into the model. Input data includes land use variables, such as area type, intersection density, and employment density, socioeconomic data, such as household income and number of employees, and network data, detailing the street and transit networks.

This Appendix highlights key steps taken to develop input data and to prepare the TIM 2.2 model to provide the best possible ridership estimates.

Model Validation

During model development, the regional model is calibrated to ensure that it represents existing conditions throughout the nine-county region. Since the model covers such a large geographic area, even if it is able to replicate regional benchmarks, it is expected that a detailed look at a particular location may not provide the best representation of reality. Therefore, at the start of every forecasting project, DVRPC focuses the regional model on the study area through a detailed validation process.

The validation process involves comparing base year model estimates, such as transit ridership and traffic volume, to observed data from the same year. If the model's estimates are considerably different from the observed data, incremental adjustments are made to bring the model closer to reality. A variety of techniques are employed to adjust model parameters during validation. The primary techniques used for this study were: K-factor adjustments, link type and capacity changes, and walk connector modifications.

K-factors are used to shift travel flows throughout the modeled network. Model estimated travel flows between counties (or smaller areas) are compared to survey data, specifically from the Census Transportation Planning Products (CTPP) and Household Travel Survey. K-factors exist in a matrix with origins on the side and destinations on the top. If a K-factor between an origin and destination is high, it acts as a penalty for trips between those locations. If the K-factor is low, it acts as a bonus for trips between those locations. Since K-factors change the number of trips produced from and attracted to certain areas, their impact is felt throughout the model results. Therefore, they are usually adjusted early in the process, followed by smaller, narrower-impact adjustments.

At the start of the validation process, the K-factor between Chester County and Philadelphia was found to be low, which led to a high number of trips occurring from Chester County to Philadelphia. This was creating an overestimation of both highway and rail volumes between these locations. This and other K-factors were adjusted to bring the model's estimated travel flows closer to the CTPP travel flows.

Next, traffic counts were collected on roads around the Zoo. These counts were compared to the model's estimated volumes along these roads. At the start of the validation process, forecast volume along 34th Street was high compared to the traffic counts. The "link type," or road segment type, was changed to reduce the capacity of the road and deter traffic from using the road. These changes, and a few other similar adjustments, brought the estimated volume on the roads surrounding the Zoo much closer to the traffic counts.

Finally, a considerable amount of time was spent making adjustments to the modeled estimates of Regional Rail ridership. Compared to the observed data, the model estimated ridership at 30th Street Station was low, line-level ridership along a few of the lines that could potentially serve the Zoo station were off, and a number of stations on those lines were also off.

In the base TIM 2.2 regional model, transit connector times are determined using a formula accounting for the length of the connector and an assumed walk speed of 3.1 miles per hour. This formula generally provides reasonable walk times in urban areas but is not always as accurate in suburban areas where passengers may need to go farther out of their way to reach a transit stop. To address the low ridership at 30th Street Station, additional walk connectors were added to the zones around the station to allow for more walk access. The area type of some of the zones was changed to Central Business District, the most dense and most likely to produce transit trips. Throughout the rest of the Regional Rail system, walk connectors were added and times were manually adjusted to better reflect the relative ease or difficulty of accessing the transit stop.

The final Regional Rail validation differences are shown in Table A1. Ridership on key lines is close to the observed data. One noticeable anomaly is the Cynwyd Line. While the percentage difference seems high, the difference between the ridership estimate and the observed ridership is under 200 passengers. The percentage difference is exaggerated because the total line ridership is extremely low compared to other lines.

Table A1: Model Validation Results for Regional Rail Ridership

Key Regional Rail Line	Percentage Difference (Model Estimate minus Observed Count)
Trunk Lines	–2%
Thorndale	–4%
Cynwyd	–48%
Trenton	–3%
Chestnut Hill West	3%

Source: DVRPC, 2017

Future Scenarios

Demographics

During scenario development, the Philadelphia City Planning Commission provided updated estimates of population and employment for the University Southwest district, where substantial development has recently occurred and legitimate plans for additional growth are in progress. The "substantial absorption" estimates, assuming at least partial completion of major projects being planned for University City, were added to the 2040 model using a two-part process.

First, the growth needed to be distributed throughout the zones within the district. The three zones included in the 30th Street Station District Plan area received 80 percent of the growth, while the remaining 20 percent was distributed across the remaining zones in the University Southwest district within 1.5 miles of the three main zones. The farther the zone was from the three main growth zones, the smaller proportion of the 20 percent growth it received. Within the three main growth zones, population and employment were distributed differently, with zone 1040 receiving the most growth in both sectors of population and employment.

Once growth was distributed across the zones, it had to be distributed within the zones across variables such as vehicles, income, number of workers, number of persons, and university/K–12 students. For the extended growth zones (20 percent), the internal distribution was held constant. For the three main growth zones, the distribution was averaged for the surrounding zones within 0.5 miles. The population assigned to those zones was distributed according to that average. Number of household vehicles and number of employed residents were calculated based on the other distribution variables.

Demographics

In all future scenarios, it was assumed that the additions to the road network in the Draft 30th Street Station District Plan are built and operating by 2040. These roads were coded into the no-build 2040 network and were carried over into the five build scenarios.

For the three Regional Rail build scenarios, SEPTA provided conceptual schedules for the impacted Regional Rail lines. These schedules were based on the 2016 schedules and included the addition of a stop—a Zoo station—on certain runs. The calibrated and validated model was based on 2010 Regional Rail schedules. Instead of rebuilding the entire schedule for each affected line, the Zoo stop was slotted into the 2010 schedules following the same patterns as the conceptual schedules SEPTA provided, such as the time between trains leaving the station and the number of stops at the station per day.

Off-Model Estimates for Zoo Visitors

Data Preparation

The Zoo provided the annual number of member visits by zip code for 2013. To use this data in the model, it needed to be converted to the daily weekend average number of visits by Transportation Analysis Zone (TAZ). To convert from annual to daily weekend average, the following process was used:

- Add annual average Saturday and Sunday attendance to get annual average weekend member attendance.
- Divide by number of weekend days in year (104 for 2013) to get annual daily weekend member attendance.
- On weekends, members make up approximately 58 percent of visitors. It is safer to assume that non-members cluster in patterns similar to members than to assume they do not cluster at all. Divide annual daily weekend member attendance by 0.58 to get the total average weekend daily attendance.

To disaggregate the attendance data from zip code to TAZ, the following process was implemented:

- In ArcGIS, break zip codes and TAZs into census blocks.
- Spatial join census block centroids (with population attribute), to ZIP code file with visitor numbers.
- In Excel, disaggregate visits proportional to population distribution.
- Spatial join census block centroids to TAZs.
    - Where census block centroids fall within the same TAZ, sum the total attendance to get the number of visits by TAZ.

This process does not work for visits coming from outside the region because there are no TAZs beyond the extended region, which includes the counties in PA, NJ, and DE that share a border with any of the nine counties in the DVRPC region. To account for these visits, the total daily weekend average visits were manually assigned to enter the extended region at specific locations (cordons) to be loaded onto the network.

Special Generator

The ridership forecasts in this study were specifically focused on the trips of Zoo visitors. However, DVRPC's TIM 2.2 does not explicitly capture the unique characteristics of Zoo trips in its standard procedures. Trips to the Zoo tend to have different peak hours, vehicle occupancy, and trip length frequency distributions than any of the standard trip purposes in the model. Zoo employees are accounted for in the model's home-based-work and non-home-based-work trip procedures, but the home-based-other trip purpose underestimates visitor trips.

Based on the available data, it was assumed that all visitor trips originated at the person's home location. Since the member zip code data provided the trip origins and their destination was the Zoo, the first two steps of the model (trip generation and trip distribution) were fixed. To determine how visitors traveled from home to the Zoo, only the final two steps (mode choice and assignment) were needed.

A "special generator" process was developed to run Zoo visitors through the last two steps of the model. The special generator was run on a loaded mid-day network, meaning that the full regional model was run first, to load passengers onto the trains and volume onto the highways, so that the Zoo visitors' mode choice would account for traffic already on the network. Only trips **to** the Zoo were modeled, and symmetry was assumed for the return trip. Calculating the mode choice and assignment separately for Zoo visitors allowed for a closer look into their travel patterns.

This study was focused on trips by Zoo visitors, which occur most often on the weekends. However, DVRPC does not have a weekend model. Therefore, the mid-day (10 AM to 3 PM) network was selected to model Zoo visitor trips since congestion levels and transit schedules are analogous to weekend service levels.

The purpose of a trip to the Zoo was determined to match most closely with that of a home-based-other (HBO) trip. TIM 2.2 divides HBO trips into those made by people in low-income households and those made by people in high-income households. Since the Zoo is visited by people from all income levels, Zoo visitors were sent to the Zoo twice, using the parameters for each HBO income level separately. The results were then averaged to determine the number of visitors using the Zoo station in each scenario.

In the Free Regional Rail scenario, since the Zoo station was only free for Zoo visitors, modifications were made between the completion of the regional model run and the running of the special generator. The Zoo station was removed from the fare zone, and Transit Walk (matrix 460) /Transit Auto (matrix 660) fares were recalculated. When the special generator was run, Zoo visitors' mode choice was affected by a different fare than experienced by the rest of the trips traveling through the system.

APPENDIX B: ZOO STAFF/VOLUNTEER ZIP CODES OF RESIDENCE

Figure B1: Zoo Staff by Zip Code of Residence

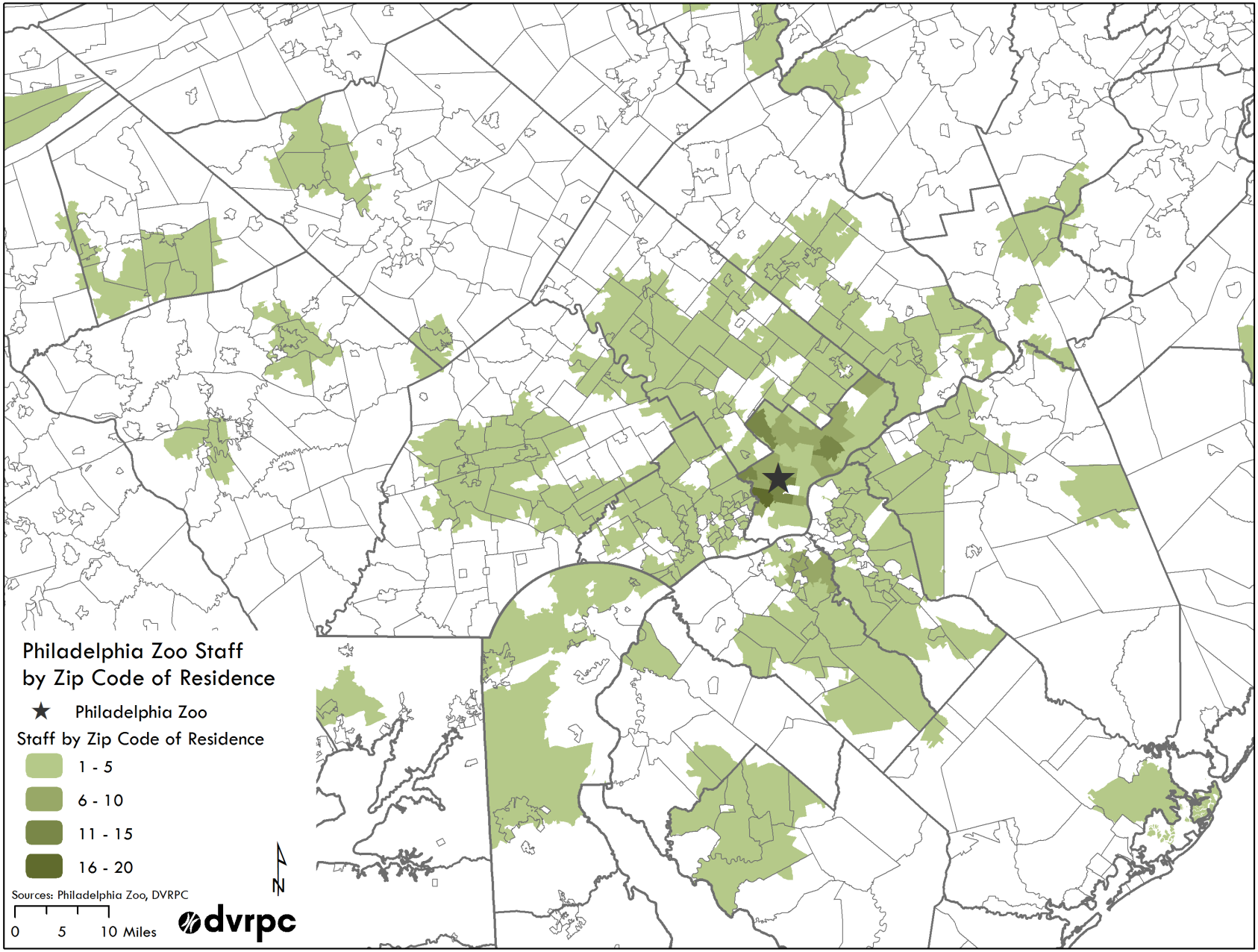
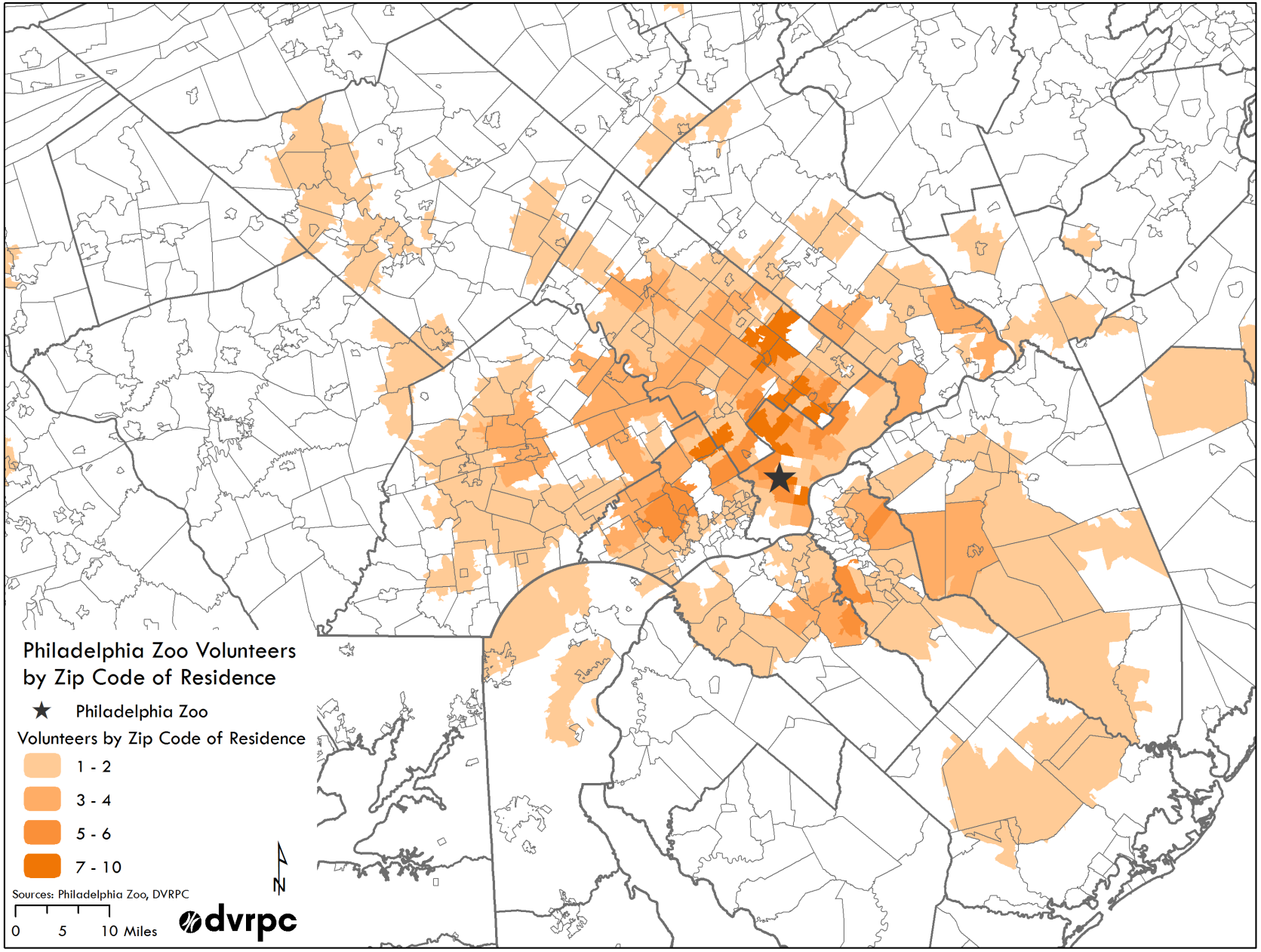


Figure B2: Zoo Volunteers by Zip Code of Residence



APPENDIX C: EXISTING CONNECTIONS

Figure C1: SEPTA Route 38 Weekday Ridership

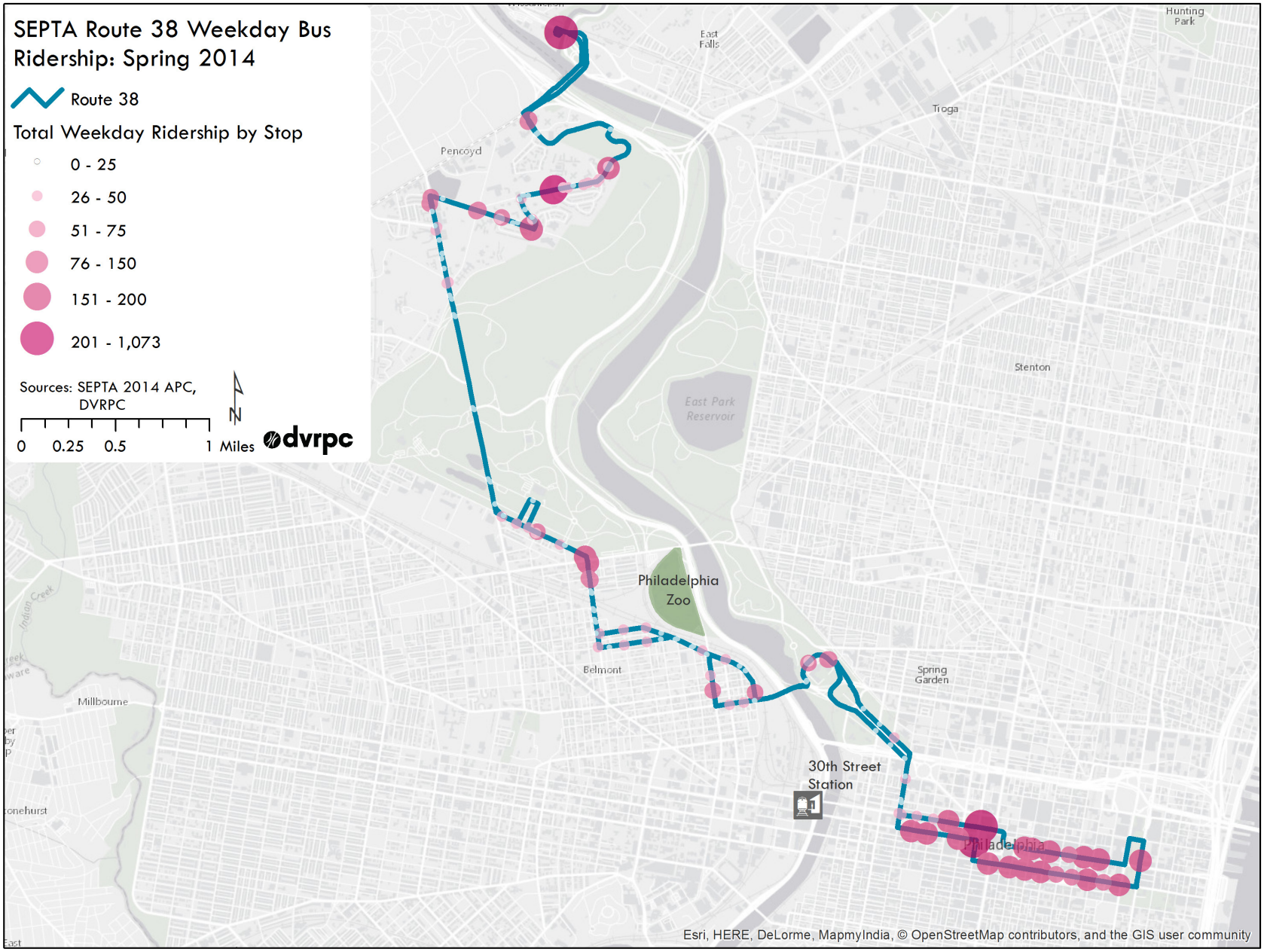


Figure C2: SEPTA Route 38 Weekend Ridership

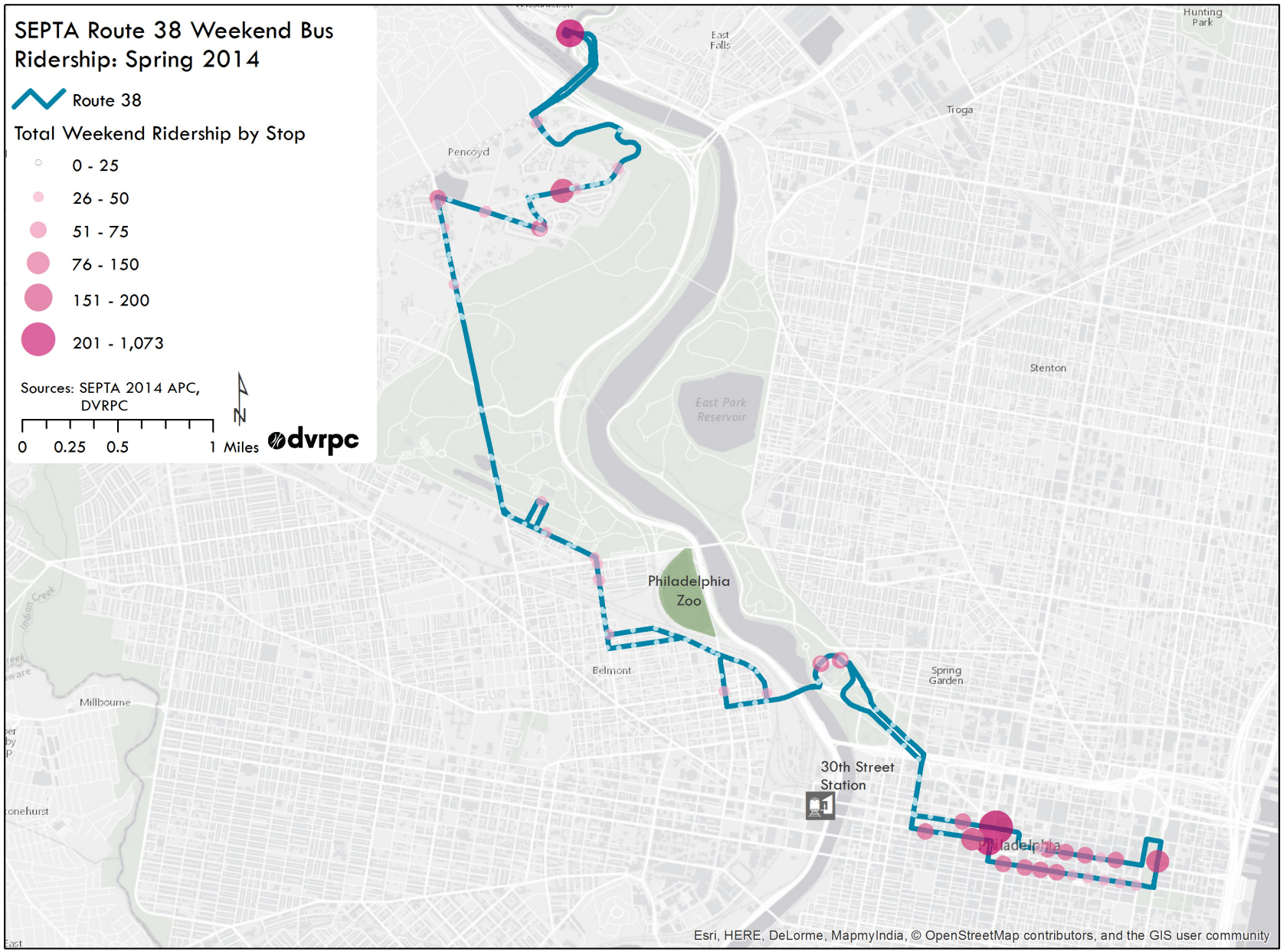


Figure C3: PHLASH Weekday Ridership

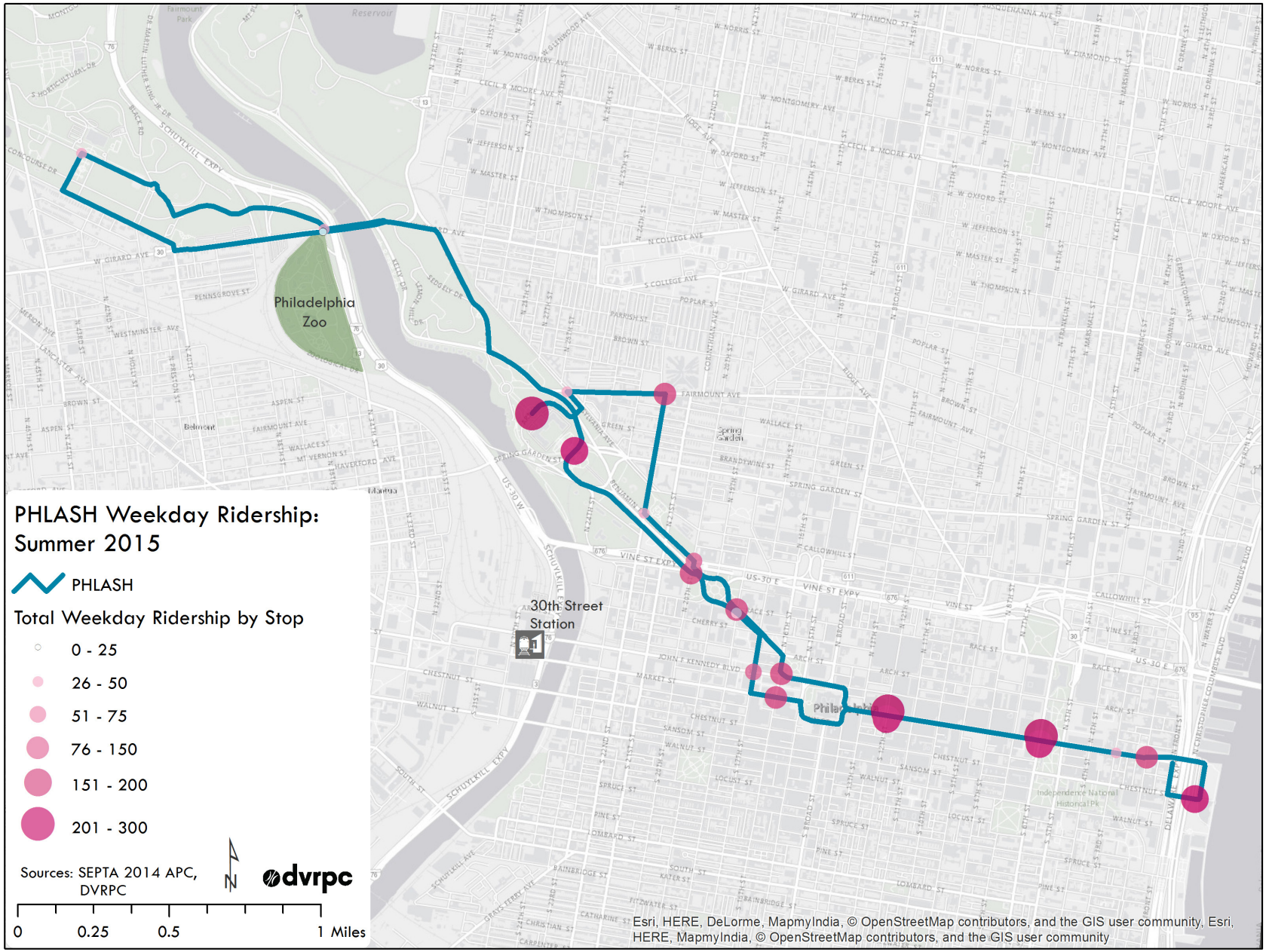


Figure C4: PHLASH Weekend Ridership

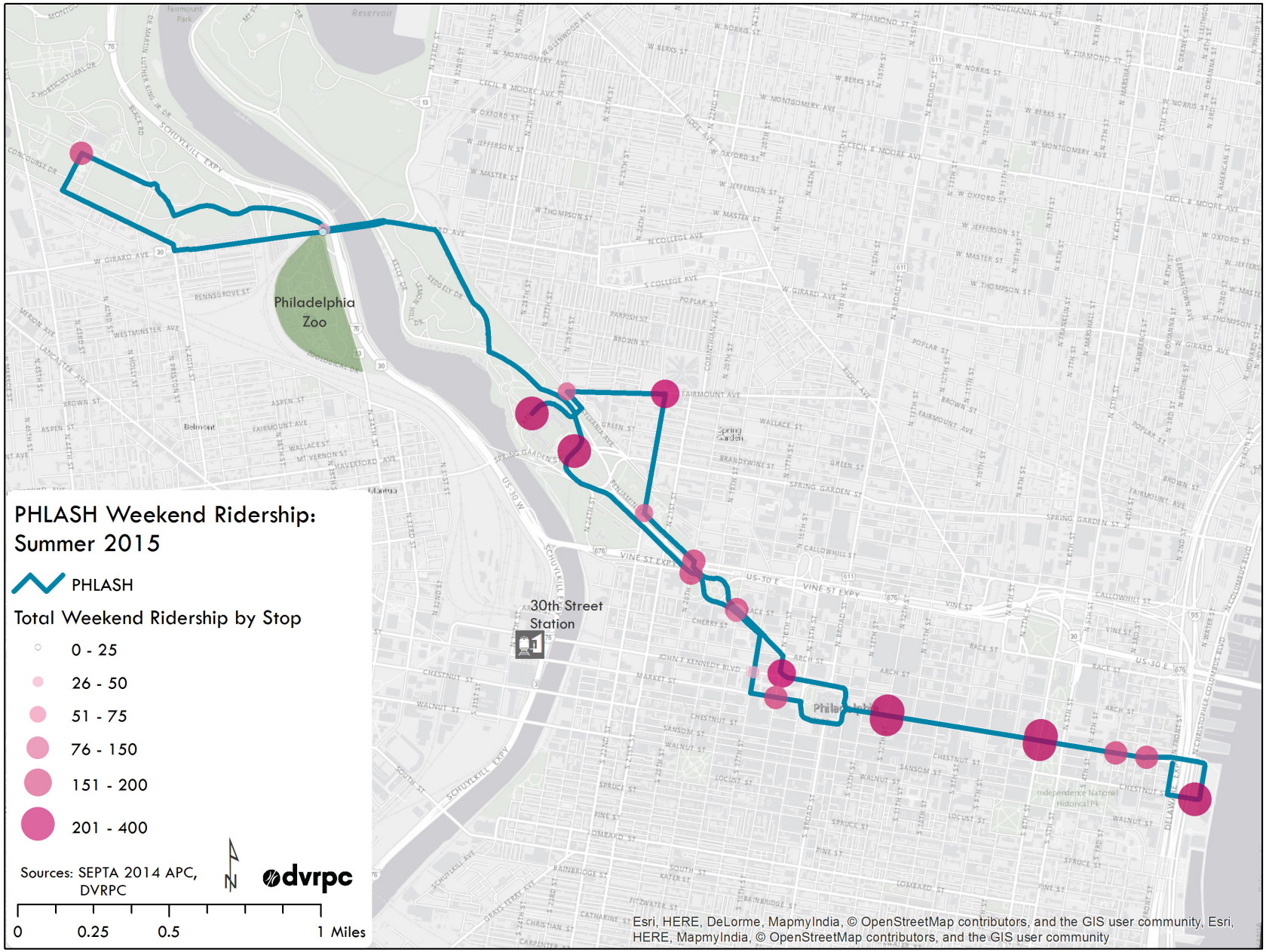
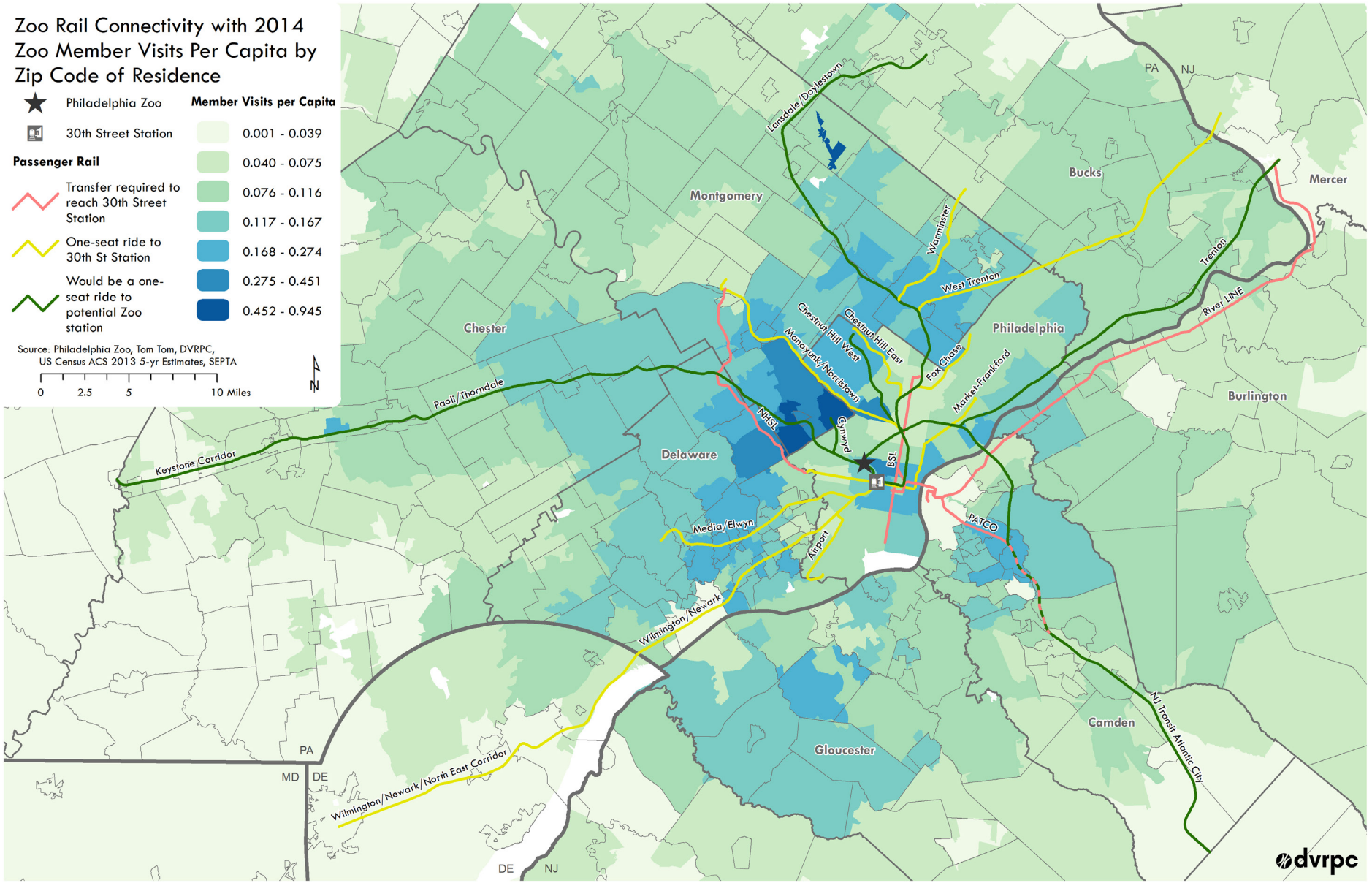
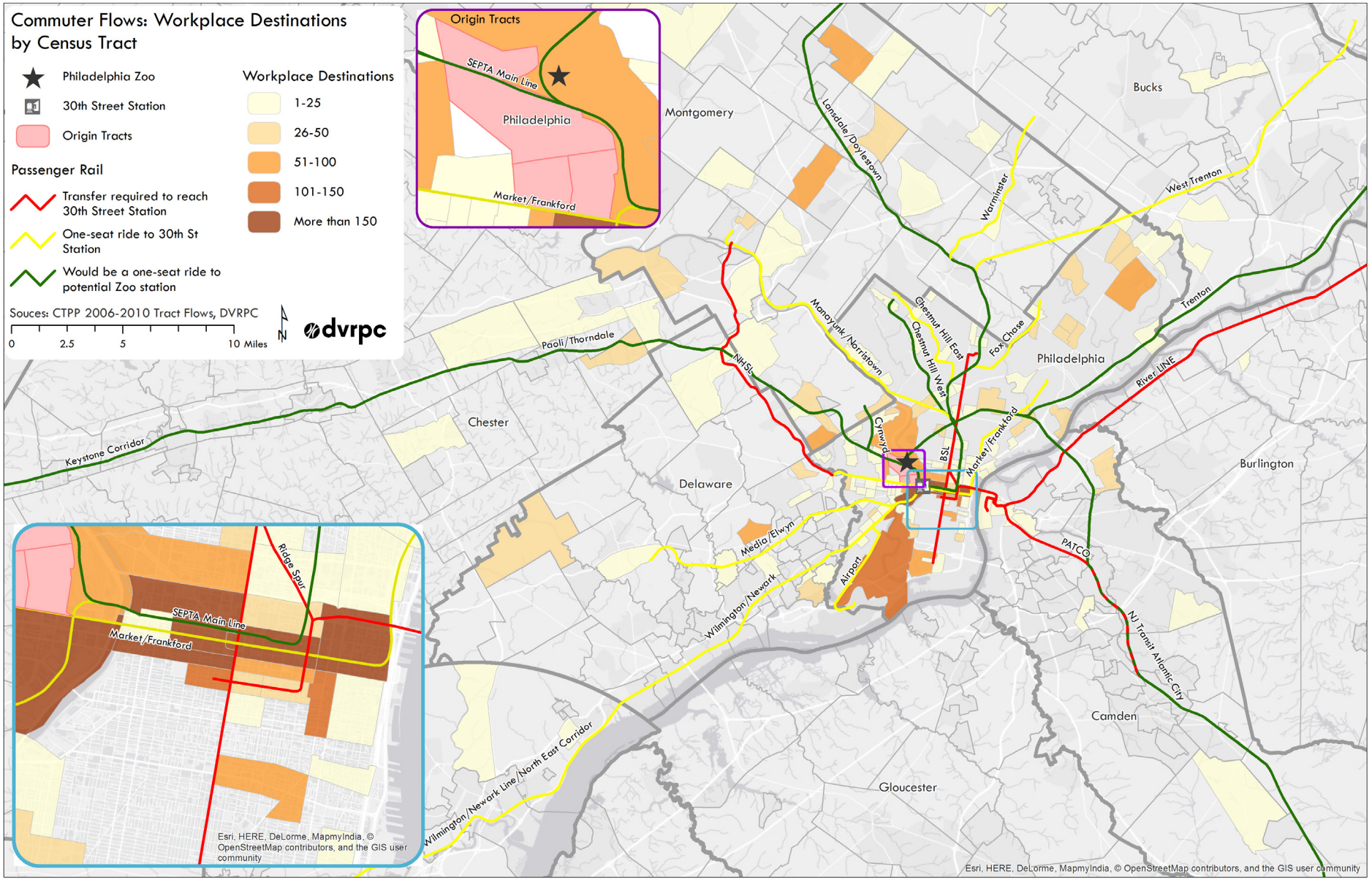


Figure C5: One-Seat Rides for Zoo Members per Capita by Zip Code



APPENDIX D: COMMUTING PATTERNS

Figure D1: Workplace Destinations by Census Tract



APPENDIX E: ISOCHRONE MAPS

The isochrones maps in Figure E1 are based on the travel time to transit stops from the Zoo itself, while the isochrones in Figure E2 are based on the travel time to transit stops from Mantua and Powelton Village. Both sets of isochrones show similar patterns of access with subtle differences between the build options:

- **No Build** (upper left) shows transit access based on the current transit system with no additional service to the Zoo.
- **Monorail** (lower left) shows a slightly larger beige area near the Zoo and 30th Street Station. This indicates that a larger area is accessible within five or 10 minutes of the Zoo via transit.
- **Base Regional Rail** (upper right) shows a noticeable decrease in the time it takes to travel farther out into the suburbs along the Regional Rail lines. The most noticeable increase is along the Paoli/Thorndale Line, which is logical given the fact that the Zoo station is only served by the Paoli/Thorndale Line in that scenario.
- **Full Regional Rail** (lower right) shows the largest geographic area accessible in less than one hour. The most noticeable increase in accessibility is in the area of the Chestnut Hill East and West lines and the Airport Line.

Figure E1: Places Accessible via Transit from the Zoo

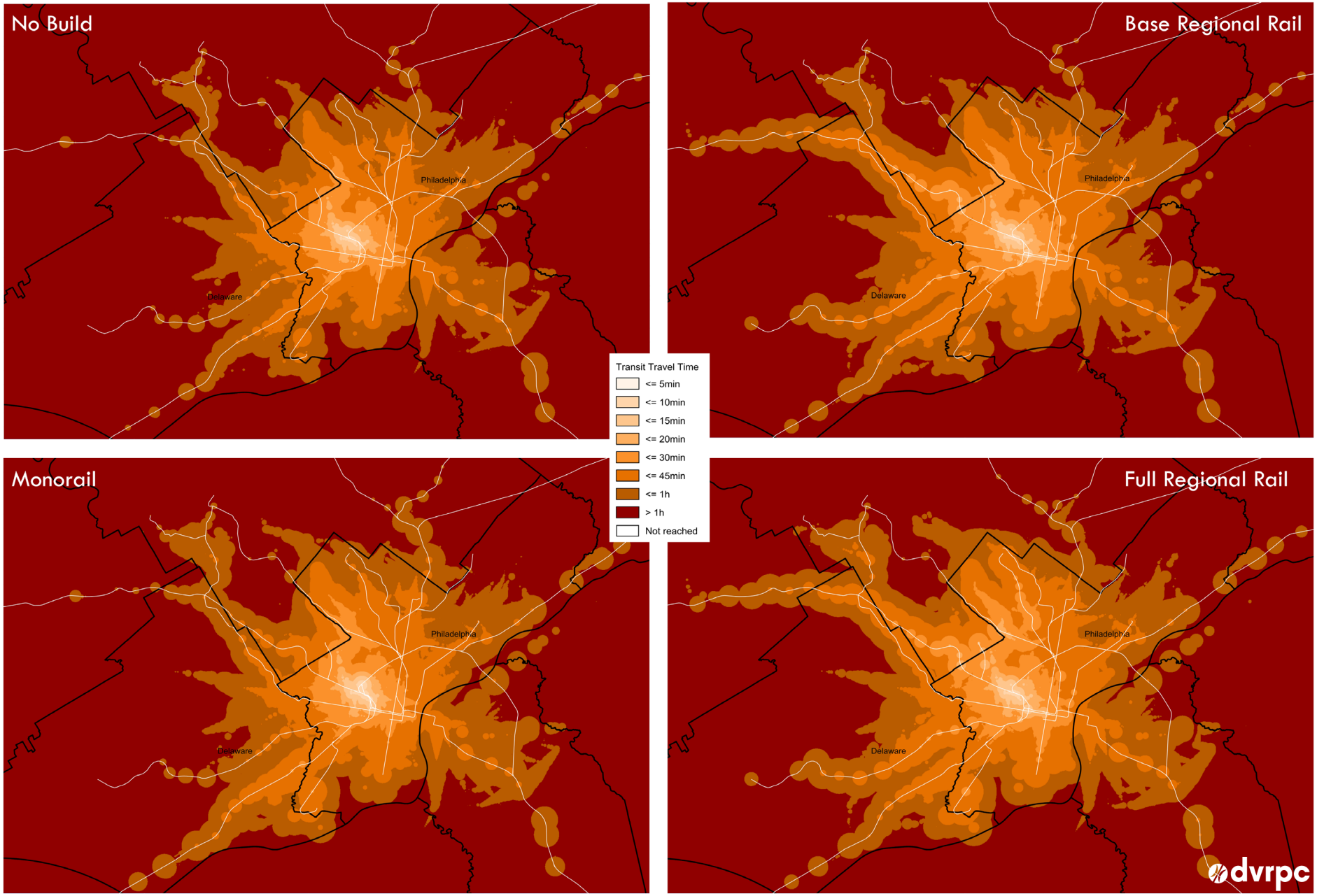
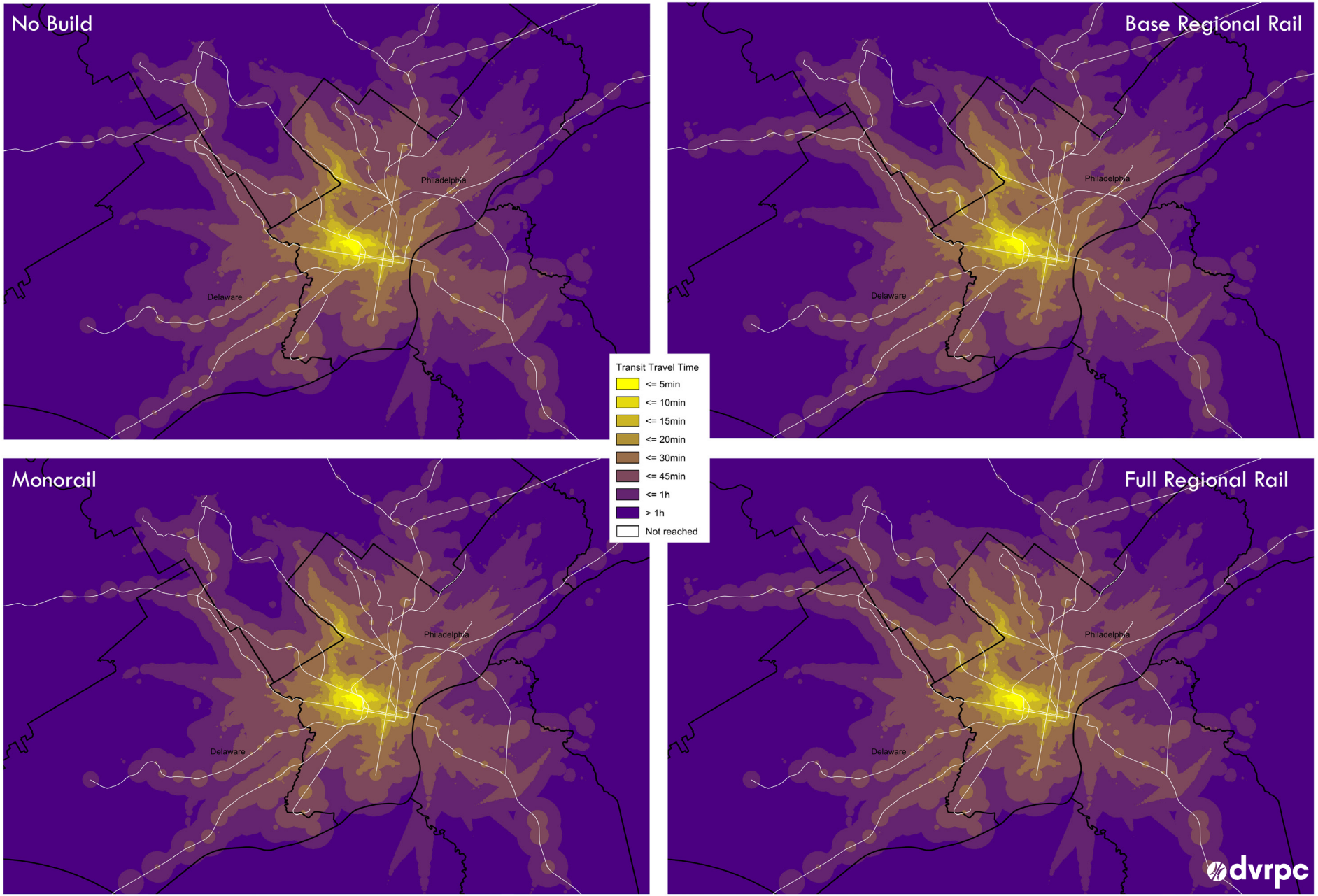


Figure E2: Places Accessible via Transit from Mantua and Powelton Village



PHILADELPHIA ZOO PASSENGER RAIL:
Concept Development and Ridership Analysis

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Geographic Area Covered: Philadelphia's West and University Southwest districts; specifically the Philadelphia Zoo, Mantua, Powelton Village, University City, and the 30th Street District.

Keywords: Zoo, Regional Rail, SEPTA, Monorail, 30th Street Station, University City, Mantua, Regional Model, TIM 2.2

Abstract:
This study examines the potential for passenger rail service at the Philadelphia Zoo. The report includes a synthesis of previous planning studies, concepts for five future scenarios, and ridership forecasts using the Delaware Valley Regional Planning Commission's Regional Travel Demand Model.

Staff Contact:
Sarah Moran
Transportation Planner
(215) 238-2875
smoran@dvrpc.org

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

190 N. Independence Mall, West
8th Floor
Philadelphia, PA 19106
www.dvrpc.org

DELAWARE VALLEY
dvrpc
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190 N. Independence Mall, West
8th Floor
Philadelphia, PA 19106
www.dvrpc.org