CAPSTONE PROJECT REPORT

UCLA Institute of Transportation Studies

# Need for Speed:

## Opportunities for Peak Hour Bus Lanes Along Parking Corridors in Los Angeles

Project Lead: Mark Hansen
Faculty Advisor: Brian D. Taylor
Client: Los Angeles Metro

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**16. Abstract**

Expanding the network of bus lanes in Los Angeles can alleviate slow bus speeds, which are caused by the fact that most buses share a lane with general traffic. Many corridors in the city feature curb lanes that allow traffic during peak hours, but restrict access to allow parking in the off-peak. Introducing a bus lane on these corridors during peak periods, instead of a travel lane, offers an opportunity to improve bus service while preserving parking outside of peak hours. This report examines bus performance along 75 miles of peak-hour parking restriction (PHPR) corridors to determine whether bus lanes could improve travel times for riders and increase net person throughput. I developed a novel methodology to scrape the real-time position of LA Metro buses from a publicly accessible application programming interface (API) and convert collected coordinates into accurate representations of bus speeds on PHPR lanes. Using two months of data, I describe the speed of buses on PHPR lanes and calculate the potential travel time savings provided by bus lanes. With these findings in hand, I draw on historical traffic counts and the planned person capacity of LA Metro bus service to weigh the potential benefits of bus lanes. I find that bus speeds and travel times on PHPR lanes will likely universally benefit from bus lanes. However, only one-half of studied corridors will see an increase in net person throughput with the addition of a bus lane, typically on corridors with more frequent bus service.

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# Disclaimer

# Need for Speed:

## Opportunities for Peak Hour Bus Lanes Along Parking Corridors in Los Angeles


By Mark Hansen

University of California, Los Angeles
Meyer and Renee Luskin School of Public Affairs
Department of Urban Planning


Faculty Advisor: Brian D. Taylor
Client: LA Metro
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Master of Urban and Regional Planning

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# Executive Summary

As traffic congestion worsens in Los Angeles, public transit riders lose countless hours riding buses stuck in traffic. Despite carrying many more people than the average passenger car, buses must share space on equal terms with cars and trucks on most of Los Angeles' major boulevards. Bus service, and the experience of individuals riding public transit, inevitably suffers as a result. Falling transit ridership in the region has been directly linked to a decline in the quality of transit service (Manville et al., 2018). Increasingly, individuals who rely on transit spend more of their time locked in traffic and those with a choice are choosing other options. Those who remain on slow-moving buses can feel stuck, as 85 percent of LA Metro bus riders have no other option to reach their destinations (LACMTA, 2019).

In order to build on recent success with the Flower Street Tactical Transit Lane, LA Metro managers hope to identify opportunities for more flexible, peak period bus lanes in Los Angeles. With the release of the Los Angeles Metro NextGen bus plan, the most vital Los Angeles bus routes will benefit from better frequency all day with headways between five and 10 minutes. This effort is meant to counteract falling ridership and improve the core experience for Metro bus riders (LACMTA, 2020). While frequency is an important part of attracting and retaining riders, reliability plays an equally important role (Walker, 2011). To support this improvement in frequency and to ensure reliability, new bus lanes will be essential, and the city's network of Peak Hour Parking Restriction (PHPR) lanes offer a promising place to start. Accordingly, this report details the current performance of bus service in Los Angeles and explores opportunities for new bus lane investments, specifically along the city's network of Peak Hour Parking Restriction (PHPR) lanes.

I start by reviewing the existing literature on bus lanes and their effect on travel. Next, I summarize the existing bus speeds on PHPR segments in a large sample of collected bus data. With these speeds, I then estimate travel time savings based on the demonstrated effects of bus lanes in congested environments. Next, to weigh the travel efficiency benefits of bus lanes, I approximate person capacity advantages if bus lanes were present based on traffic volume counts and the capacity of buses in LA Metro's upcoming bus plan. Finally, with these findings in mind, I offer recommendations for how LA Metro should pursue new investments in bus lanes along PHPR corridors.

In this report, I introduce a novel method to achieve this goal. Over the course of two months, I collected bus location coordinates from LA Metro's free and publicly accessible API (application programming interface) to assemble a large volume of bus data with which to perform this analysis. I cleaned and processed these data to determine bus speeds and spatially combined them all known PHPR lanes in the city of Los Angeles. After adjusting for the time that buses spend at stops (i.e. dwell times), the result was a unique inventory of LA Metro bus speeds on all PHPR lanes. These data show that bus speeds across the city are slow (on the order of six to 17 mph), but especially slow in the dense center of Los Angeles (six to 12 mph). With these speeds in hand, I estimated how bus lanes could affect the travel times along PHPR corridors. As expected, bus lanes are likely to improve bus travel times, but when buses run both fast and frequently, improved travel times have the greatest effect. On PHPR corridors with the most frequent buses (and shortest headways), I predict that transit travel times improve the most.

The peak period Flower Street Tactical Transit Lane improved bus speeds and, as a result, travel times for passengers riding the bus. Yet its greatest success was increasing the total flow of transit travelers traversing that segment of Flower Street during the peak period. To conclude my analysis, I model the effects of peak period bus lanes on net person throughput (across all traffic modes) along PHPR corridors. PHPR corridors are already limited to two travel lanes outside of peak hours, so with this approach I determine if a bus lane might justify the removal of the third peak period traffic lane for cars (in the off-peak these lanes are designated for parking). In this straightforward analysis, I combined Los Angeles Department of Transportation peak period traffic counts with the planned LA Metro bus schedule. With some assumptions (described in detail in the report), I calculated changes in capacity to produce estimated peak period net person throughput effects for every PHPR corridor. In places where vehicle traffic volumes are high and bus service sparse, converting peak period traffic lanes to bus lanes would not increase net person throughput. However, in about one-half of the lanes, where bus service is frequent, I project a net increase in person throughput with a conversion to peak period bus lanes.

I conclude by recommending that planners primarily consider bus service frequency when evaluating bus lane projects. Overall, bus speeds in Los Angeles are slow, and bus lanes offer substantial travel time savings for transit travelers, but the most important element in a well-performing bus lane is the presence of lots of buses. The PHPR lanes I identify in this report as top performers are a good place to start.

As more and more transit agencies publish and increase the accessibility of transit data, subsequent improvements and expansions on this work can open the possibility for more detailed analysis. This project provides a set of findings to illustrate hotspots on PHPR corridors where bus lanes might move more people during peak periods, and further research can fully illustrate the benefits of bus lanes outside the peak period in Los Angeles by expanding on and refining this analysis. By combining historic data with a flexible, data-oriented lens for analysis, planners can quickly plan and implement bus lane successes like that of Flower Street.

# Introduction

As traffic congestion worsens in Los Angeles, public transit riders lose countless hours riding buses stuck in traffic. Despite carrying many more people than the average passenger car, buses must share space on equal terms with cars and trucks on most of Los Angeles' major boulevards. Bus service, and the experience of individuals riding public transit, inevitably suffers as a result. Falling transit ridership in the region has been directly linked to a decline in the quality of transit service (Manville et al., 2018). Increasingly, individuals who rely on transit spend more of their time locked in traffic and those with a choice are choosing other options. Those who remain on slow-moving buses can feel stuck, as 85 percent of LA Metro bus riders have no other option to reach their destinations (LACMTA, 2019).

To improve service for those who need it most, and to reverse trends of falling ridership, Los Angeles needs better bus performance. Dedicated lanes reserved only for buses offer a chance to achieve this goal. Accordingly, this report details the current performance of bus service in Los Angeles and explores opportunities for new bus lane investments, specifically along the city's network of Peak Hour Parking Restriction (PHPR) lanes.

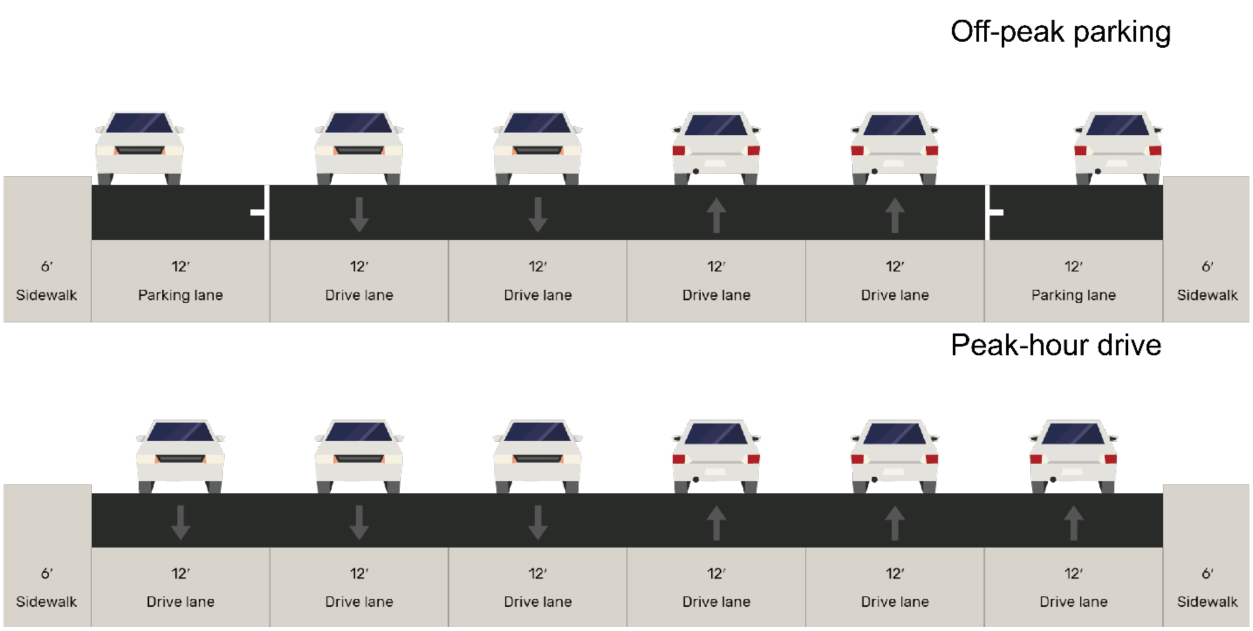
## Background

Dedicated bus lanes are clearly marked lanes limited to use by public transit and emergency vehicles only to reduce the delays of such vehicles in congested areas. These lanes have been shown to increase bus speeds, improve reliability, and promote growth in ridership along urban corridors (Litman, 2016; Kittleson, 2013; Pauley et al., 2006). While dedicated bus lanes may in some cases worsen congestion for automobiles in adjacent lanes, reserving lanes for buses can increase the overall person throughput of roads because the average bus carries many more people than the average car (Agrawal, 2012). To seize on this efficiency advantage, and to make wise decisions about where to invest (financially and politically) in bus lanes, cities across the country are increasingly turning to Tactical Transit Lanes (TTLs). TTLs are bus lanes strategically added to dense, congested environments to improve the speed and reliability of urban bus service. They can be quickly built, and adapted to the conditions of individual streets, operating all day or only during peak hours (Gahbauer and Matute, 2019). Locally, the recent Flower Street TTL in downtown Los Angeles met its performance objective and is being continued beyond its pilot test period. Implemented as a pilot, this bus lane embraced the TTL framework, and avoided a lengthy planning process, creating a new bus lane with just paint and cones. Quickly implemented, the project decreased overall bus travel times by 20 percent and kept buses on schedule by reducing the variability of bus travel times on the segment (LACMTA, 2020). This faster and more predictable service demonstrates the potential of strategically planned bus lanes in Los Angeles.

In order to build on recent success with the Flower Street TTL, LA Metro managers hope to identify opportunities for more flexible, peak period bus lanes in Los Angeles. With the release of the Los Angeles Metro NextGen Bus Plan, the most vital Los Angeles bus routes will benefit from better frequency all day with headways between five and 10 minutes.[1] This effort is meant to counteract falling ridership and improve the core experience for Metro bus riders (LACMTA, 2020). While frequency is an important part of attracting and retaining riders, reliability plays an equally important role (Walker, 2011). To support this improvement in frequency and to ensure reliability, new bus lanes will be essential, and the city's network of Peak Hour Parking Restriction (PHPR) lanes offer a promising place to start.

Peak Hour Parking Restriction (PHPR) lanes, which alternate between parking in the off-peak and vehicle travel in peak periods, aim to increase vehicle throughput during the periods of heaviest traffic congestion. Sometimes referred to as "Anti-Gridlock Zones," they run along major boulevards and restrict parking in the curb lane during certain periods of the day. This restriction generally occurs during peak travel periods in the morning, afternoon, or both. Codified under section 80.70 of the Los Angeles City Municipal Code (Los Angeles City Municipal Code, SEC. 80.70.), they often differ in form. Some lanes function exclusively as a parking lane during off-peak periods and only allow travel during rush hour. Others are wide lanes that narrowly accommodate both parked cars and moving vehicles. Both types of lanes restrict parking during peak periods, but only the PHPR lanes that alternate between vehicle travel and parking reduce vehicle capacity during off-peak periods. This study focuses exclusively on the peak-travel, off-peak parking lanes, shown in **Figure 1** below.

**Figure 1.** Diagram of a PHPR Lane




Source: Made with Streetmix

[1] The NextGen Bus Plan is a reworking of the LA Metro bus system to simplify routes and schedules while prioritizing the frequency and reliability of bus service. As planned, it will double the number of frequent (15 minutes between buses or less) buses and improve off-peak service (LACMTA, 2020).

These lanes, which alternate between parking and general travel, were justified in Los Angeles because an expansion in road capacity during peak periods can provide minor improvements to the flow of vehicle traffic (LADOT, 2008). Alternately, dedicating these peak-period-only traffic lanes to buses can greatly increase the person capacity of a given corridor by maximizing the throughput of people by improving bus service (NACTO, 2016). Still, removing a lane once accessible to general purpose traffic can be challenging. Besides political backlash, these bus lanes are subject to operational challenges because motorists unused to them violate the restrictions by driving in them. However, drivers in Los Angeles are already used to shifting traffic conditions on PHPR corridors and might be more tolerable of ceding a lane to buses. The network of PHPR lanes in Los Angeles, shown in **Figure 2** on the next page, follow some of the city's most heavily patronized transit routes, and opening a lane to buses could benefit the overall person throughput of these corridors, even at the expense of some vehicle capacity.

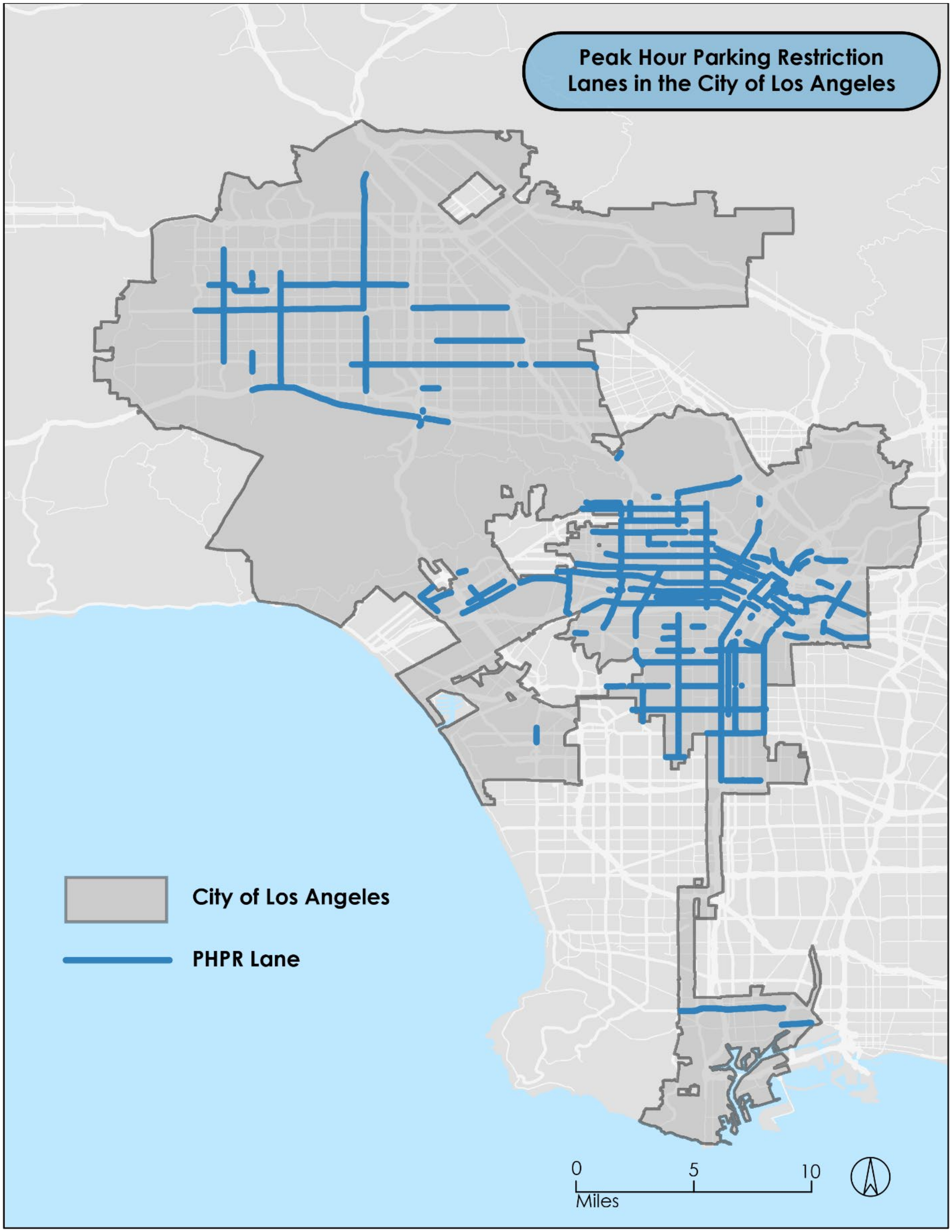
# Approach

Since most PHPR lanes run along corridors with three peak period travel lanes in each direction, introducing a bus lane only reduces general traffic vehicle capacity by one lane in each direction during the peak period. This can potentially improve bus travel times and increase overall person throughput significantly. Coupling this change with the flexible Tactical Transit Lane framework allows for fast and effective bus lane implementation. However, several roadway factors can influence the effectiveness of bus lanes. For example, bus frequencies, bus stop placement, traffic signal placement, and traffic volumes all influence the performance of a bus lane (Kittleson, 2013). A detailed examination should consider these factors. However, since PHPR lanes with bus service comprise nearly 80 miles of roadway in Los Angeles, this report instead takes a broad look at bus performance on PHPR lanes to highlight corridors where bus lanes are likely to be successful, warranting further analysis.

This project presents a comprehensive overview of bus performance in PHPR lanes by using real-time, publicly available LA Metro bus data. Rather than choosing individual PHPR corridors for study, I collected and assembled data on buses along every known PHPR corridor in the city of Los Angeles. This approach naturally highlights the PHPR lanes with the slowest bus speeds, which will allow LA Metro planners to objectively target corridors for further study.

I start by reviewing the existing literature on bus lanes and their effect on travel. Next, I summarize the existing bus speeds on PHPR segments found in my sample of collected bus data. With these speeds, I then estimate travel time savings based on the demonstrated effects of bus lanes in congested environments. Next, to weigh the travel efficiency benefits of bus lanes, I approximate person capacity advantages if bus lanes were present based on traffic volume counts and the capacity of buses in LA Metro's upcoming bus plan. Finally, with these findings in mind, I offer recommendations for how LA Metro should pursue new investments in bus lanes along PHPR corridors.

**Figure 2.** Peak Hour Parking Restriction Lanes in the City of Los Angeles




Source: Caswell 2014

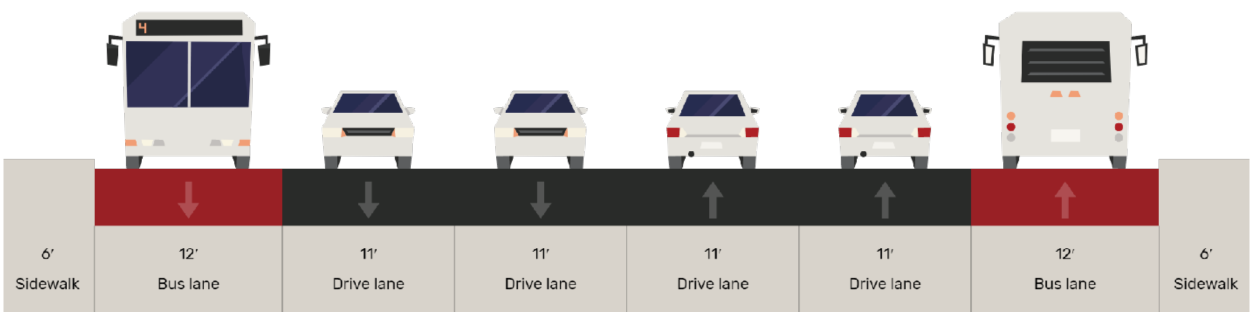
# Review of Previous Studies of Bus Lanes

A substantial body of literature details the advantages and disadvantages of bus lanes. This section summarizes this literature by discussing the primary effects of bus lanes on traffic operations and introduces several key adjacent topics. Specifically, I first define bus lanes and describe their effect on travel performance. I then discuss the importance of bus lane enforcement strategies, the time of day bus lanes are active, potential safety benefits, and the loss of parking incurred with some bus lanes.

## What is a Bus Lane?

Bus lanes provide dedicated road space to buses, allowing transit service to operate without competing for space with private automobiles. In many urban settings, the most common type of bus lane is a curbside lane, often painted red to set it apart. These lanes typically allow taxis, rideshare vehicles, and bicyclists to share the lane, and may permit high occupancy vehicle use as well. The most common bus lane type in the United States, the semi-exclusive curb running bus lane,[2] replaces the rightmost lane of traffic or parking, at least temporarily (NACTO, 2016). **Figure 3** below shows an example roadway configuration with curb running bus lanes in both travel directions.

**Figure 3**. Diagram of Curb Running Bus Lane




Source: Made with Streetmix

## Travel Effects

When implemented correctly, bus lanes can significantly improve bus travel speeds and reduce passenger travel times. In congested conditions, a curbside bus lane may increase bus speeds by as much as 75 percent, resulting in a reduction of overall travel times (Kittleson, 2013). A study of the effects of red-painted bus lanes in downtown San Francisco found that, while total congestion trends worsened city wide year-over-year, bus lanes reduced the

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[2] Other common bus lane types include: center-running bus lanes that replace the innermost traffic lanes or the roadway median, contraflow bus lanes that run against the direction of travel on a one-way street, and exclusive busways that are completely separated from general traffic (NACTO, 2016).

negative impact of congestion on bus travel times over the same period of time (SFMTA, 2017). Faster bus speeds and improved travel times subsequently allow transit managers to reduce delays and offer better service, through improved bus frequencies and reliability (Boyle 2013). A study of two bus routes in Montreal, both with exclusive bus lanes, revealed that the presence of a bus lane reduced variability of bus travel times and decreased delays, ultimately increasing the odds of a bus being on time by 65 percent (Surprenant-Legault and El-Geneidy, 2011).

This improvement in service quality, whether in speed or reliability, often affects transit ridership. In fact, better travel times are positively correlated with increased transit ridership in many instances. Currie and Sarvi (2012) model the benefits of transit travel time savings and show that modest travel time savings as low as five minutes per trip can encourage travelers to try transit and increase ridership. In one study on the effect of transit quality on ridership elasticity, a ten percent travel time improvement led to ridership increases by five percent or more (Paulley et al., 2006). While recent research shows that ridership is on the decline in most American cities (Manville et al., 2018), travelers dislike long waits. Therefore, changes that improve reliability and frequency can positively affect transit use (Taylor et al., 2009).

However, despite benefits to transit speed, travel time, and ridership, dedicating limited road space to the exclusive use of buses affects the performance of automobile travel in adjacent lanes. In a simulation of average delays, travel times, and speeds with the presence of bus lanes, Shalaby (1999) found that bus lanes improved the performance of buses but decreased the relative performance of automobile traffic on the same road. The study of bus lane effects in San Francisco found that, despite improvements to person throughput, vehicle travel times along bus lanes worsened (SFMTA, 2017). The travel disadvantages for automobiles caused by the addition of bus lanes means that, in cities where transit service is limited or use is low and automobile use is high, bus lanes are difficult to justify on the grounds of efficiency (Currie et al., 2007).

Limiting road space for automobiles may have a negative impact on vehicle travel performance, but bus lanes, when deployed skillfully in the right location, improve overall roadway travel effectiveness, not just transit speed and reliability. The capacity advantages of transit vehicles mean that negative effects on vehicle volumes due to the addition of a bus lane are disproportionate to the overall increase in person throughput when buses are full (NACTO, 2016). Furthermore, roadway vehicle volumes are typically measured on a per-vehicle basis, known as level of service (LOS) (Wolshon and Pande, 2016). LOS rates the conditions of a roadway based on speed, travel times, maneuverability, delays, and safety for individual automobiles, but an assigned LOS rating, from A to F, only describes the convenience of driving a vehicle and does not account for the number of passengers. By focusing on automobile traffic flow, this standard is biased against higher capacity vehicles, such as buses. On a vehicle-by-vehicle basis, one person driving alone in a car is given the same weight as a bus with 60 riders. The findings by Shalaby (1999) above showed that automobile performance suffered with the addition of bus lanes, but also that net person throughput improved. This demonstrates that analyzing LOS alone does not fully describe the travel effects of bus lanes. Instead, by considering the net person throughput of a road, planners and engineers can effectively weigh the impact of a bus lane.

# Enforcement

Bus lane enforcement, while not the focus of this project, is an important component to good bus lane implementation. Without it, the benefits of a dedicated bus lane are eroded, but transit managers have a choice between conventional or automated enforcement strategies. Conventional enforcement, via uniformed police officers stopping and citing violators, is costly and time consuming (Troy, 2004). Instead, enforcement can be automated with cameras mounted on the front of a bus or on the side of the road. This automated enforcement is more cost-effective, especially on corridors where bus lane access varies by time of day (Agrawal et al., 2013). However, barriers such as legislative permission, motorist education, and the time required to monitor camera footage can also be expensive for transit managers to overcome (NCRTPB, 2017). For example, automated camera-based enforcement in California requires special laws for use at the city level. San Francisco currently operates this technology, but the results on buses in San Francisco to date have been mixed, with some planners citing the long footage review time as a prohibitive process (Gahbauer and Matute, 2019). Still, a comprehensive review of bus lane enforcement strategies in seven cities revealed that conventional enforcement is financially difficult to sustain as bus lane networks grow, and that automated enforcement, while presenting some initial hurdles, is the most cost-effective way to enforce bus lanes in the long term (NCRTPB, 2017).

# Hours of Operation

Bus lanes can operate continuously, or for limited periods during the day. The hours of operation for bus lanes in cities across the globe vary significantly, with many only operating during peak periods (Agrawal, 2013). **Table 1** below shows several examples. In Los Angeles, bus lanes have historically been enforced only during peak periods, when transit service increases to meet the demands of commuters. This style of bus lane escapes many of the political challenges by not removing parking for part of the day. Since buses typically run more frequently during peak periods, transportation officials in many cities have chosen this approach (Agrawal, 2013). In Los Angeles, the Wilshire Boulevard bus lane and the new Spring Street lane are both curb adjacent peak period lanes. Intuitively, one would think that all day bus lanes would favor bus riders. However, recent research suggests that peak period bus lanes can operate efficiently and offer significant travel time savings when implemented properly (Chiabaut and Barcet, 2019). Likewise, the Tactical Transit Lane framework of quick implementation of pilot studies suggests that choices around operational periods should be made in the context of local planning issues and the specific circumstances of the project in question (Gahbauer and Matute, 2019).

**Table 1.** Example Bus Lane Hours of Operation

| Hours of Operation | London | Los Angeles | NYC | Paris | San Francisco | Seoul | Sydney |
|---|---|---|---|---|---|---|---|
| 24/7 | 29% | — | <2% | 100% | 66% | 44% | 12% |
| Daytime/Weekdays | 25% | — | 40% | — | 11% | 32% | 18% |
| Peak periods only | 46% | 100% | 58% | — | 23% | 24% | 70% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

Source: Agrawal, 2013

## Parking

The typical curbside bus lane requires the removal of parking, at least while in operation. All day bus lanes remove parking permanently while bus lanes that are active only during the peak periods and preserve parking outside of those hours. This loss of parking, even just during the peak period, is a common source of opposition to new bus lanes and a notable tradeoff. Many business owners feel that the loss of parking directly in front of their businesses will contribute to a loss of customers, due to the large share of their customers who rely on a car to frequent their business (Ward, 2006). However, research suggests that business owners often overestimate the number of customers who rely on this specific storefront parking (Shoup, 2017).

## Road Safety

The presence of a curbside bus lane may improve the overall safety of a road. In one study on the impact of bus priority treatments on road safety, bus lanes were shown to act as a buffer between the curb and other lanes of travel, reducing the number of fatal collisions. In total, this study demonstrated a 14 percent reduction in collisions on studied corridors (Goh et al., 2013). Furthermore, one study on bus priority systems in South America shows that improvements to bus infrastructure increased the safety of roadways by as much as 50 percent (Duduta et al., 2015). Streets featuring PHPR lanes in Los Angeles see more than twice as many fatalities and injuries per-mile than streets without (Caswell, 2014). With the addition of a bus lane, safety on these corridors can improve.

## Summary

Bus lanes present a promising solution to improve transit service in congested areas. There is a broad base of research demonstrating the substantial travel benefits of bus lanes, such as increased ridership, better speeds, and improved person throughput on congested corridors. These benefits are balanced by some costs. Reserving space for buses on the road inevitably removes space for automobiles, and in many cases adjacent lanes experience delays and a loss of vehicle capacity. Despite this tradeoff, the literature demonstrates that correctly implemented bus lanes can improve travel efficiency on busy roadways. In tandem with effective enforcement strategies, well-designed bus lanes could increase ridership and remarkably improve bus service for transit-dependent residents in Los Angeles.

# Data and Methods

This report investigates current bus performance along Peak Hour Parking Restriction (PHPR) lanes in the city of Los Angeles to understand the potential impact of new investments in bus lanes. To do this, I assembled a large sample of LA Metro bus speeds from a publicly accessible data feed and drew on several secondary data sources. These sources allow me to understand and compare the performance of buses on PHPR lanes while modelling the effects of bus lanes on passenger travel times and roadway person capacity. PHPR lanes are local policy, and as such this study is centered only on the city of Los Angeles. Within city limits, I constructed an inventory of the subset of PHPR lanes that feature LA Metro bus service and alternate between parking and travel and present observed bus speeds. With these data, in combination with bus stop dwell time data from LA Metro and traffic volumes from the Los Angeles Department of Transportation, I answer the following research questions:[3]

*1. What does LA Metro bus performance currently look like on PHPR lanes in Los Angeles?*

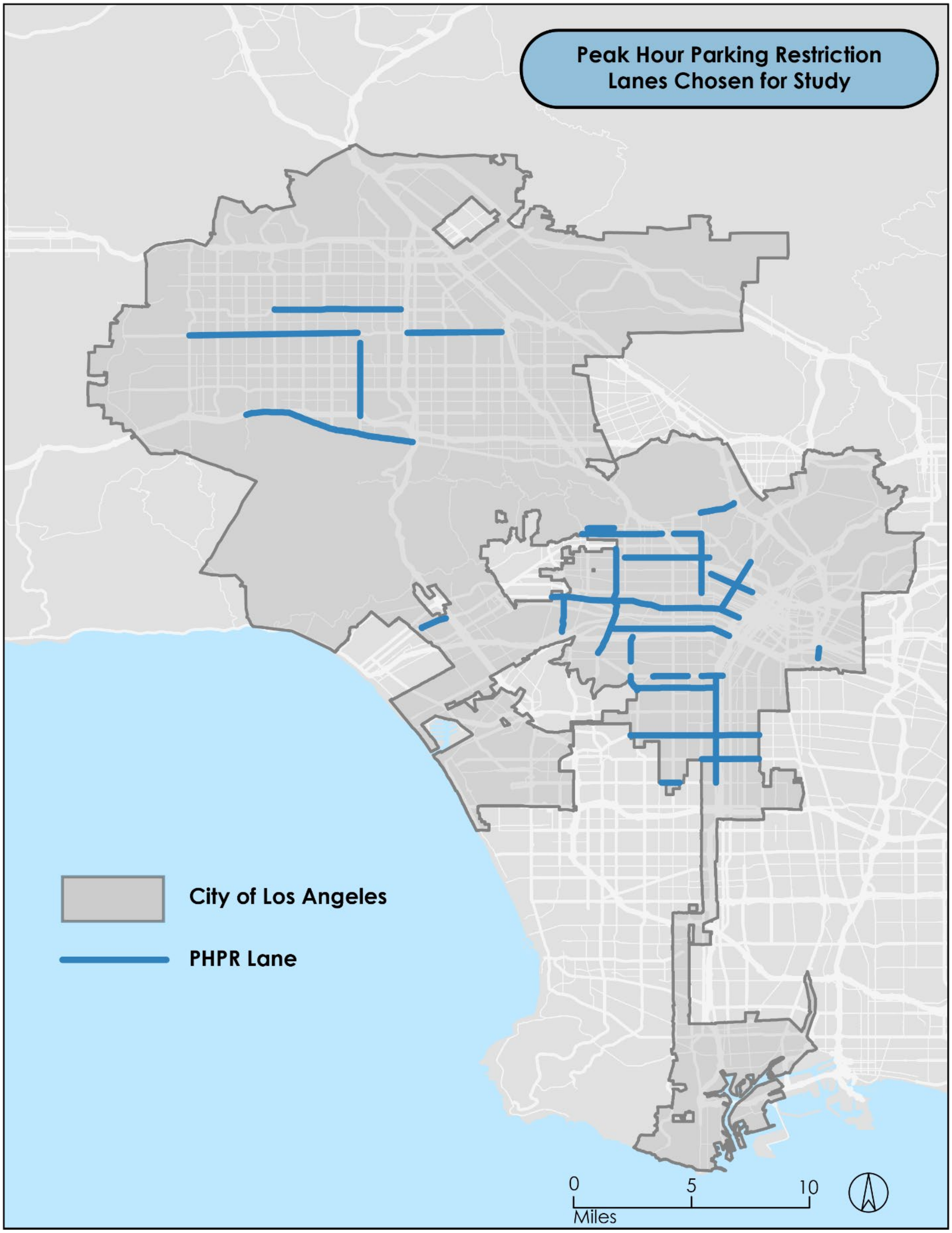
*2. Where can bus lanes along Peak Hour Parking Restriction corridors improve travel times and what might the effect be on person throughput in the peak period?*

## Data Source Overview

This report studies a specific subset of roads in Los Angeles, Peak Hour Parking Restriction (PHPR) lanes. To spatially aggregate bus speeds with this unit of analysis, I created a digital representation of PHPR lanes using geographic information system (GIS) software. No official inventory of PHPR lanes exists, so I relied on data provided by Caswell to start, which he created for an earlier UCLA Urban Planning study of traffic collision rates along PHPR lanes (Caswell, 2014). The file provided included all street segments deemed “Anti-Gridlock Zones,” so I digitally walked each corridor on Google Streetview to find and identify the PHPR lanes that convert between parking and vehicular travel over the course of a day. I digitally recorded all PHPR lanes that met these criteria with GIS software and constructed my own dataset for this analysis. The results of this process, all PHPR lanes that alternate between parking and travel, are mapped in **Figure 4** below.

[3] Dwell time refers to the time a bus spends at a bus stop with its doors open, waiting for passengers to board and alight (KIttleson, 2013).

**Figure 4.** PHPR Lanes Chosen for Study



Though several secondary data sources were used, I primarily rely on a novel sample of bus data collected specifically for this report. First, to determine current bus speeds on PHPR lanes, I conducted a nearly two-month long web scrape of real-time bus location data. LA Metro hosts an application programming interface (API) that lets those outside the agency access and manipulate transit data in real-time. APIs allow for the rapid and successive interaction between a user's local computer and a third-party source of information online using computer code; in this case, I gathered real-time bus position data from LA Metro's bus data feed. I then processed and spatially aggregated these observations with PHPR lanes. Afterwards, I combined these data with bus dwell times provided by LA Metro. This dwell data averages dwell times at the stop level for the peak (7am-10am, 4pm-7pm) and off-peak (10am-4pm) time periods. Next, to estimate changes in person throughput, I referenced bus scheduling data and publicly available traffic volumes to approximate the capacity benefits of bus lanes. Scheduling data were taken from the LA Metro NextGen Bus Plan to account for anticipated future changes to bus frequencies in Los Angeles. For traffic volumes, I accessed the Los Angeles Department of Transportation's online database of roadway traffic count summaries. These reports provide manual or automatic counts of passenger vehicle traffic at intersections throughout the city and allow for the estimation of person capacity in cars along PHPR corridors. Traffic counts were taken at the midpoint of each segment, and available data ranged between 2011 and 2019. The most recent count possible was used in each case. Lastly, to facilitate the spatial portion of my analyses, I used publicly available data from LA Metro's data portal website. I downloaded spatial files to create representations of bus stops and route lines for analysis within GIS software. Except for the bus dwell times, these data are all available publicly and listed fully in **Table 2** below.

**Table 2.** Data Inventory

| DATA | SOURCE | FORM |
|---|---|---|
| LA Metro bus GPS locations | LA Metro API | Tabular data |
| LA Metro selected route dwell times | LA Metro Service Planning | Tabular data |
| Los Angeles traffic counts | LADOT Navigate LA database | PDF reference |
| LA Metro routes and stops | LA Metro data portal | Shapefile |
| Los Angeles PHPR corridors | Marc Caswell | Shapefile |
| LA Metro planned bus schedule | LA Metro NextGen Bus Plan | PDF reference |

## Real-Time Bus Data Collection

To assess bus speeds on PHPR lanes in Los Angeles at the system-level, I collected data over a period of several weeks from January 21st, 2020 to March 6th, 2020 using LA Metro's open data API service. On this platform, Metro provides real-time bus locations gathered from their onboard vehicle monitoring systems. These data are free to access and open to anyone with an internet connection. I collected data for one Metro route per corridor studied. In some cases, multiple routes follow a PHPR corridor, but for the purposes of determining bus speeds, one LA Metro line was used per corridor. Additional routes are accounted for when determining transit capacity later in my analysis. The list of routes in each study corridor is in **Table 3** below.

**Table 3.** PHPR Study Corridor Lengths and Boundaries

| CORRIDOR | BOUNDARY | METRO LINE | LENGTH (MILES) |
|---|---|---|---|
| Nordhoff St | Tampa Ave to I-405 | 166 | 4.4 |
| Balboa Blvd | Roscoe Blvd to Hwy-101 | 236 | 3.1 |
| Roscoe Blvd | Topanga Canyon Blvd to Balboa Blvd | 152 | 5.9 |
| Roscoe Blvd | I-405 to Hwy-170 | 152 | 3.3 |
| Ventura Blvd | Winnetka Ave to I-405 | 150 | 6.1 |
| Santa Monica Blvd | Bundy Dr to I-405 | 704 | 0.9 |
| Los Feliz Blvd | Vermont Ave to I-405 | 780 | 1.3 |
| Hollywood Blvd | Fairfax Ave to N La Brea Ave | 217 | 0.9 |
| S La Brea Ave | Santa Monica Blvd to Jefferson Blvd | 212 | 4.6 |
| Melrose Ave | Highland Ave to Virgil Ave | 10 | 3.0 |
| Sunset Blvd | Laurel Canyon Blvd to Hwy-101 | 2 | 2.8 |
| Vermont Ave | Sunset Blvd to Wilshire Blvd | 754 | 2.5 |
| Olympic Blvd | Robertson Blvd to Hwy-110 | 28 | 6.7 |
| S Alvarado St | Glendale Blvd to Olympic Blvd | 200 | 2.3 |
| Beverly Blvd | Commonwealth Ave to Lucas Ave | 14 | 1.6 |
| Crenshaw Blvd | Hwy-10 to Obama Blvd | 210 | 1.1 |
| Washington Blvd | S La Brea Ave to Hwy-110 | 35 | 4.3 |
| La Cienega Blvd | Olympic Blvd to Hwy-10 | 105 | 1.5 |
| Figueroa St | MLK Blvd to Century Blvd | 81 | 4.5 |
| MLK Blvd | 4th Ave to Normandie Ave | 40 | 1.2 |
| MLK Blvd | Vermont Ave to Broadway | 40 | 0.7 |
| Vernon Ave | Crenshaw Blvd to Figueroa St | 105 | 2.8 |
| Crenshaw Blvd | MLK Blvd to Vernon Ave | 210 | 0.7 |
| Florence Ave | West Blvd to Central Ave | 111 | 4.5 |
| Manchester Ave | Vermont Ave to Central Ave | 115 | 2.0 |
| Soto St | 8th St to 12th St | 66 | 0.4 |
| Century Blvd | Van Ness Ave to Denker Ave | 117 | 0.6 |
| Pico Blvd | Beverwil Dr to Beverly Dr | 14 | 0.2 |
| Sunset Blvd | Western Ave to Vermont Ave | 2 | 1.0 |

To collect speed data from these routes uninterrupted over the course of the study, I deployed several cloud computing servers on the Amazon Web Services (AWS) platform. AWS lets users access remote computer servers that can run software without interruption. Using code written in the programming language Python, I programmed four web servers to remotely access LA Metro's API and save the collected data to a cloud storage server on the AWS platform every 30 seconds for a period of 12 hours daily: 7am to 7pm. Reported data account for the time difference between bus reports to LA Metro's server and when the data were accessed by the API user. Real-time differences in observations ranged from between 30 seconds and two minutes. Given the limitations of GPS technology, sometimes bus pings did not match up to road networks. To account for this, I discarded unrealistic speed observations and time differences between bus pings greater than two minutes and less than 30 seconds. Observations outside this range either were too far apart to realistically be representative of a segment, or unreasonably close together, likely the result of duplicate data from the same bus. At the end of this study period, I collected a dataset of 4.5 million unique bus speed observations across the routes specified.

## Data Assembly

Bus data collected from Metro's API come in the form of coordinates over time. In order to translate these raw data into bus speeds, additional processing was required. Speed is a function of distance over time; with timestamps and coordinate data I was able to convert individual bus observations into speed measurements to estimate bus speeds between observations. Still, given that buses do not always travel in a straight line, simple linear speed calculations are not sufficient. To construct an accurate model of the movement of bus observations along the street grid, I calculated distances using the real Los Angeles city street network.

I performed these calculations using an open-source routing machine. A routing machine is a computer program that calculates the distance between two coordinate points on a given street network. Open Source Routing Machine (OSRM) publishes this software for personal and academic use, and I relied on their source code to set up a routing machine to perform this process (Luxen et al, 2011). A routing machine requires a digital geographic street network to function, and I used data downloaded from OpenStreetMap to meet this requirement. I sorted all collected data by unique bus trips and used the routing machine code to calculate the distance between each successive point in a trip. I then divided this distance by the elapsed time between each bus observation to determine the rate of travel, or speed, for each bus observation. I spatially associated these processed bus speed observations with my inventory of PHPR lane corridors, broken into segments ranging from 0.5 to two miles, controlling for dwell times. These segments, with lengths and boundaries, can be seen in **Appendix 1.** A flow chart detailing the data collection, assembly, and analysis methodology can be found in **Appendix 2**.

## Limitations

This method has several limitations. Due to the real-time nature of the project, data received from the Metro API occasionally contained inaccurate or inconsistent information that had to be discarded. Furthermore, location data collected from GPS technology will inevitably feature some inaccuracies when matching bus observations to the road network. The routing machine software used matches all bus pings to the closest road to eliminate as much error as possible, but there is a chance a small number of bus observations matched to roads other than the one on which they were travelling. Still, the robust size and comprehensiveness of the dataset helps eliminate error and provides a clear picture of bus speeds along measured segments.

Finally, my analysis relies on a few key assumptions that could be replaced with more robust data. Due to the geographic scope, I was forced to rely on a universal speed modifier to estimate travel time improvements, otherwise only accounting for dwell times. When narrowing in on a specific segment for a project, more accurate speed improvement estimations can be derived by incorporating factors just as stop placement, stop physical design, boarding procedures, and the use of the lane by other agencies (Kittleson, 2013). Likewise, when estimating the net person throughput effect of peak period bus lanes, I relied on official LA Metro bus load guidelines and made estimations as to how many people were going to ride the bus. These assumptions are generous to transit in that they predict good ridership, though I assume regular 40-foot buses in all cases despite the use of higher-capacity articulated buses on some LA Metro lines. Overall, this process was a straightforward calculation to demonstrate the potential of bus lanes on PHPR corridors. More detailed analyses with a less limited scope should incorporate past ridership trends and predict passenger volumes, while modelling vehicle travel in a more sophisticated way.

# Findings

My results show the speed of buses on PHPR corridors in Los Angeles and estimate the potential travel time savings were they converted to bus lanes. To contextualize the impact of bus lanes on these corridors, I approximate how a peak period conversion to a bus lane might affect the overall person capacity of these roads. I report collected bus speeds over the course of the study period (January 21st, 2020 to March 6th, 2020), and then estimate the potential travel time savings by assuming a standard speed benefit from bus lanes. Then, to weigh the potential tradeoffs of dedicating road space to bus lanes, I approximate changes in net person throughput based on current vehicle traffic counts and the scheduled frequency of buses.

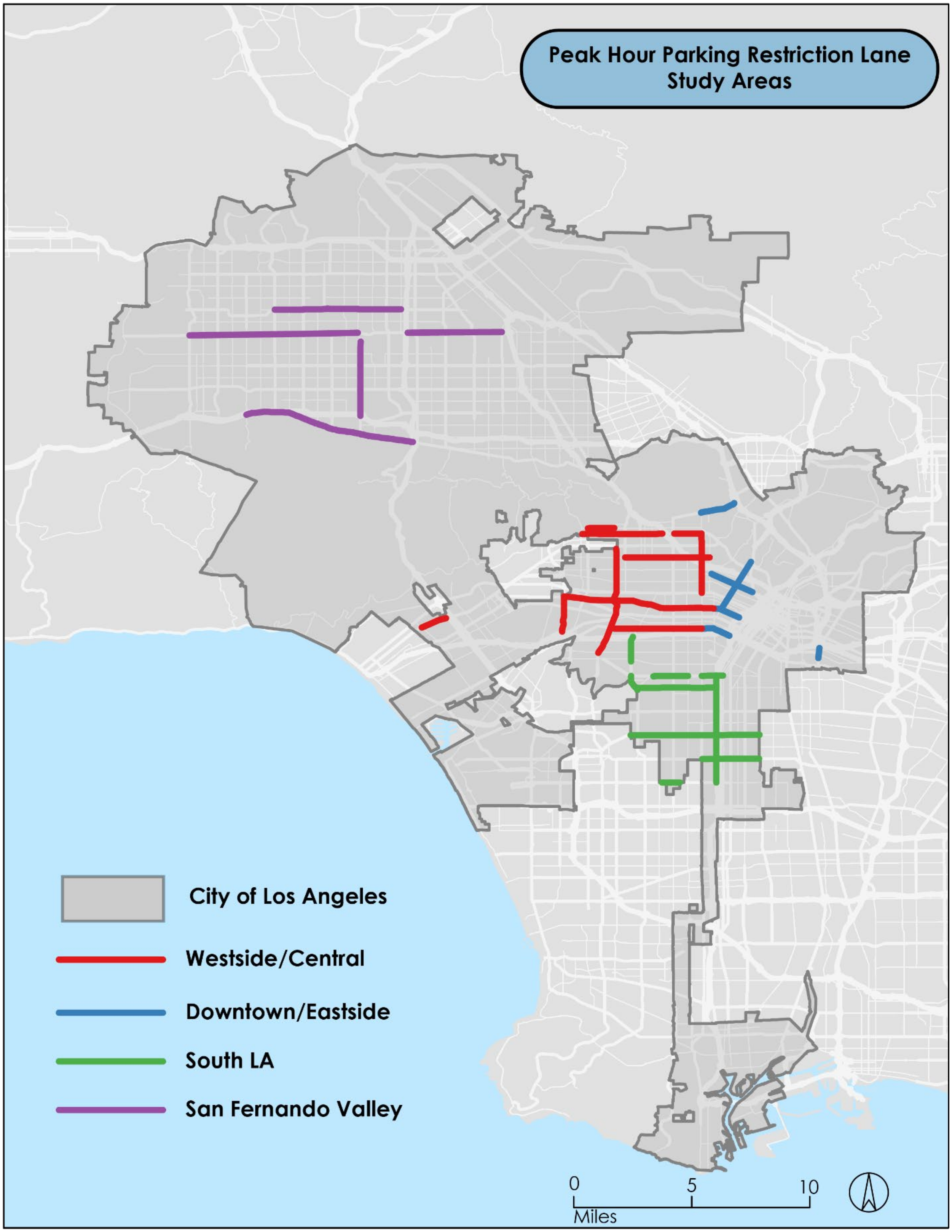
First, I find that bus speeds are slow on routes with PHPR lanes in Los Angeles, as expected. Second, I find that converting these PHPR lanes to peak period bus lanes would significantly increase bus speeds and therefore offer substantial passenger travel time savings where bus service is frequent. Lastly, I find that just one-half of PHPR corridors would benefit from better person throughput with the addition of a bus lane in the peak period.

I chose to summarize my findings speed and travel time findings within four distinct geographic areas:

- *Westside/Central Los Angeles*
- *Downtown/Eastside Los Angeles*
- *South Los Angeles*
- *San Fernando Valley*

**Figure 5** below maps the PHPR corridors within these four locations. There are 30 PHPR corridors across these four portions of Los Angeles. I split these 30 corridors into 57 segments, and calculated speed, travel time savings, and net person throughput effects by direction for the off-peak (10am-4pm) and peak (7am-10am, 4pm-7pm) periods. As described in the previous section, I chose to divide continuous PHPR corridors into shorter segments to capture differing transit performance and traffic conditions along longer corridors. Full results for the subsequent sections, which detail speeds, travel time savings, and overall road capacity changes by direction are provided in **Appendices 3** and **4**. For the purposes of describing my findings, I average the directional observations for each corridor, on the assumption that most bus lane treatments will occur in both directions.

**Figure 5.** PHPR Study Areas



## Current Bus Speeds

All PHPR corridors studied operate bus lines exclusively in mixed traffic conditions, and the calculated bus speeds reflect this. In this section, I summarize bus speeds along PHPR lanes, during the peak and off-peak periods. To do this, I spatially attributed bus speed observations to each PHPR segment. Since the results of my data collection are individual bus observation GPS coordinates, these data needed to be aggregated to the appropriate PHPR segment. To account for GPS drift,[4] a bus observation point was matched to a PHPR segment if it fell within 75 meters. I repeated this process for each travel direction and created two representations of each segment, one with data only from the peak periods and one with data from the off-peak period. I then combined my processed line segments with the stop level dwell data provided by Metro. I accounted for these dwell times when approximating speed. Dwell time represents the total time the bus spends with its doors open at a stop, while riders board and alight (Kittleson, 2013). The time between each bus observation in my collected data includes time spent at stops, while any potential speed improvements from bus lanes cannot account for differing dwell times between routes[5] (Kittleson, 2013). I controlled for this discrepancy by calculating the average travel times for each segment from the observed speed and length, subtracting the summed average dwell times, and estimating a dwell-controlled speed for each segment. As a result, these data show the average running speed by direction for each PHPR lane segment over the period studied. This control method can be seen in **Equation 1** below.

**Equation 1.** Calculation to Account for PHPR Dwell Times

$$Dwell\ Controlled\ Speed(mph) = Length(miles)/(Travel\ Time(min) - Dwell\ Time(min))$$

These summaries are meant to provide a broad sense of how buses currently perform on PHPR lanes in Los Angeles. To start, I graphed the average bus speed along PHPR lanes for each portion of the city in **Figure 6**. Travel speeds along these corridors mostly hovered at one-half to one-third the posted speed limit. However, buses were not universally slow along these lanes. Speeds, when accounting for dwell time, were much better in some areas of the city than others.

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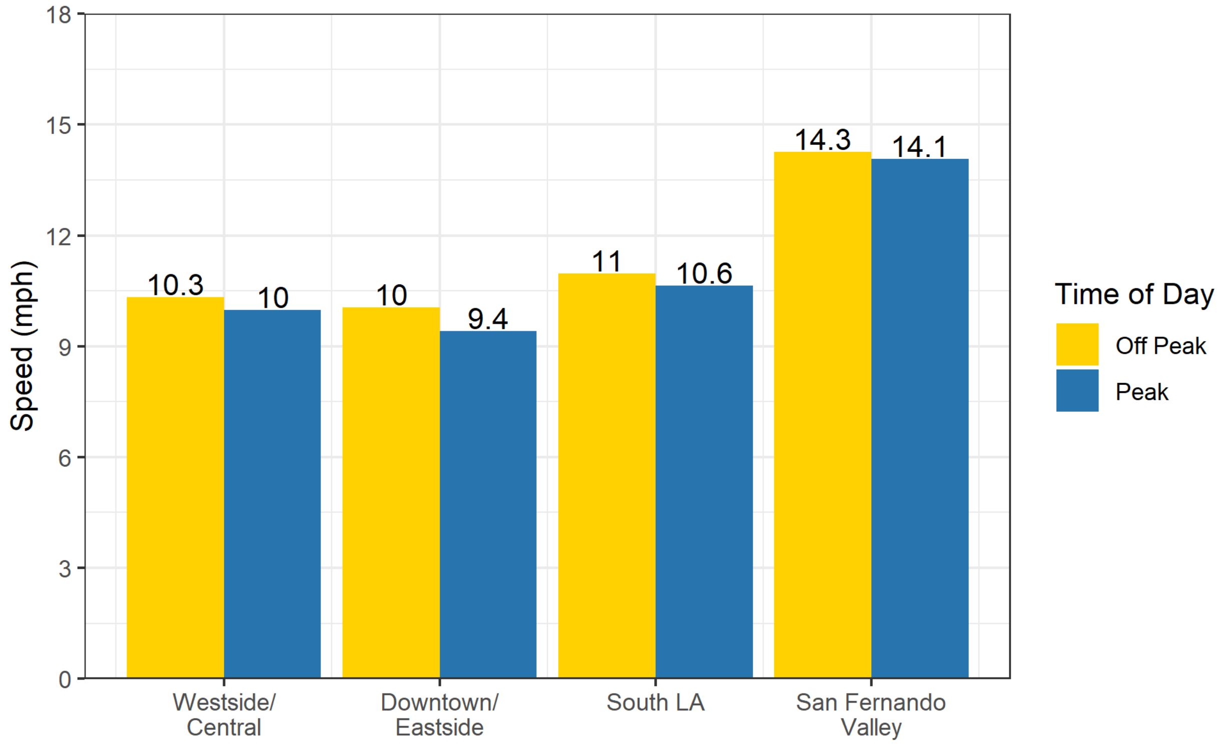
[4] GPS drift is the difference between the coordinates reported by a GPS system and the actual location of the object. GPS drift is affected by the accuracy of the GPS sensor and the strength of the GPS signal to the network of satellites communicating with the device.

[5] The main determinant of bus dwell time is the number of passengers boarding and alighting, but other factors may influence it, including fare payment systems, bus design, and crowding (Shockley et al., 2016; Milkovits, 2008)

**Figure 6.** Study Area Mean Bus Speeds




As shown above, buses in the San Fernando Valley ran the fastest, with off-peak and peak period mean speeds exceeding 14.3 mph and 14.1 mph respectively over the course of the study. The three remaining regions, Westside/Central, Downtown/Eastside, and South LA all had mean speeds between 9.7 mph and 11 mph, and all performed noticeably worse than the San Fernando Valley. Notably, while peak period speeds generally were slower, there was little difference in mean bus speeds between the off-peak (10am - 4pm) and peak periods (7am - 10am, 4pm - 7pm) in all four areas.

The range of observed speeds differed within each region as well. The bulk of the lane segments studied are in the west and central portions of Los Angeles, west of Hoover Street and north of Interstate 10. While individual segments differed, **Figure 7** below shows the speed of buses on PHPR segments within this area grouped by corridor. Buses generally did not exceed 11 mph over the course of the day on most segments, however, Hollywood Boulevard stands out from the others with an off-peak speed greater than 15mph.[6] Altogether, differences

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[6] Despite the anomalous findings on Hollywood Boulevard, the data on this PHPR corridor are confirmed correct and this analysis lacks an obvious explanation for higher than average bus speeds on this segment.

between off-peak and peak period mean speeds were small within the Westside/Central region. Next, **Figure 8** shows average bus speeds along the PHPR corridors located east of Hoover Street in Downtown Los Angeles and areas east. Again, there were few differences in the average speeds between the off-peak and peak periods. Speeds on Alvarado Street, Soto Street, and Olympic Boulevard fared the worst, with speeds at 10 mph or below off-peak and during the peak period. Next, looking towards corridors south of Interstate 10 in **Figure 9**, speeds in South LA mostly wavered between 9 mph and 12 mph, with Century Boulevard being the only segment to stand out with average speeds exceeding 14 mph. Buses on Crenshaw Boulevard and Manchester Boulevard recorded the worst average speeds, hovering around 9 mph during the peak and all day periods. Lastly, PHPR corridors in the San Fernando Valley can be seen in **Figure 10**. Average corridor speeds in this region generally exceeded all other areas, with all corridors measuring between 12 mph and 16 mph in both the peak and off-peak periods. These figures are aggregated to the corridor level and average the speeds in both directions, for a full accounting of observed corridor segment speeds by direction, refer to **Appendix 3.**

**Figure 7.** Westside/Central Los Angeles Mean Corridor Bus Speeds

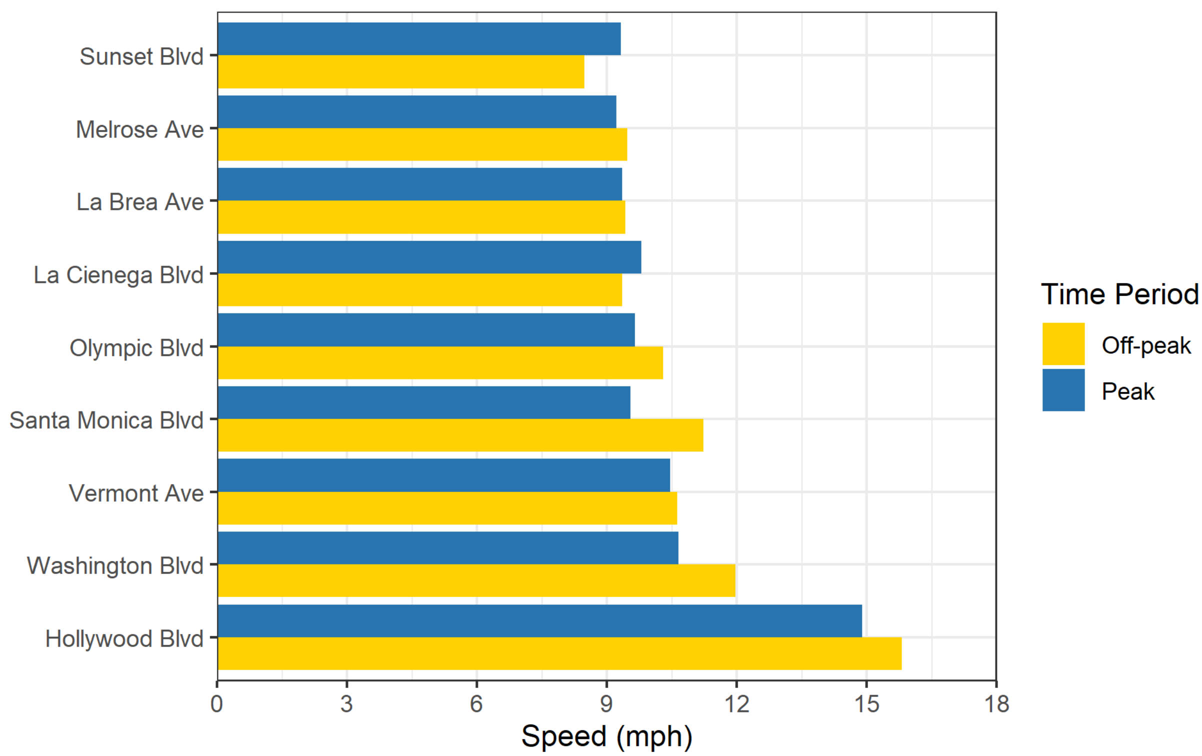


**Figure 8.** Downtown/Eastside Los Angeles Mean Corridor Bus Speeds

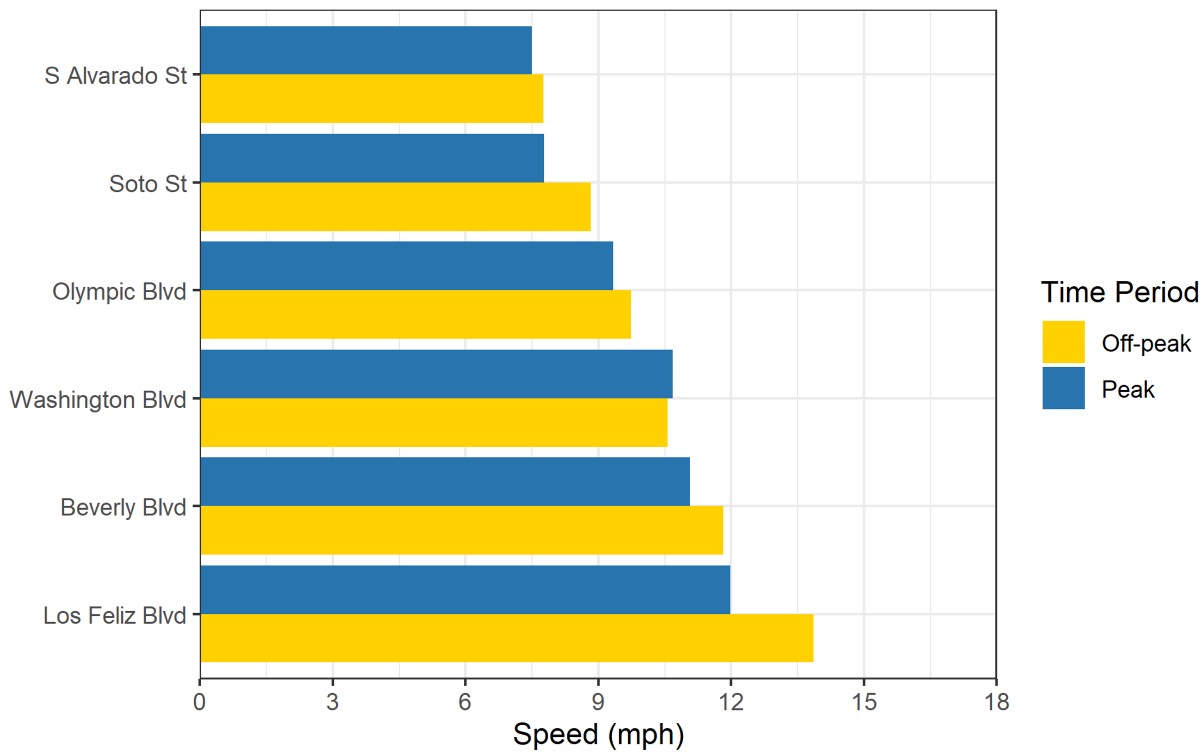



**Figure 9.** South Los Angeles Mean Corridor Bus Speeds

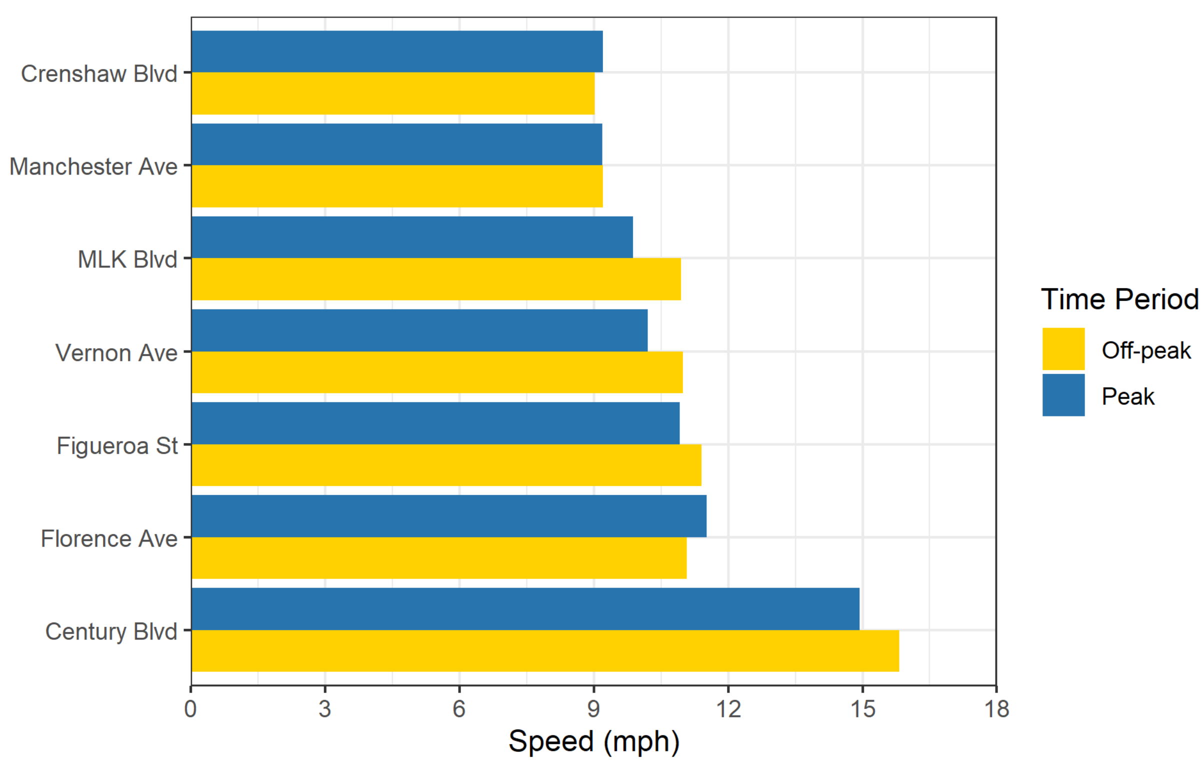
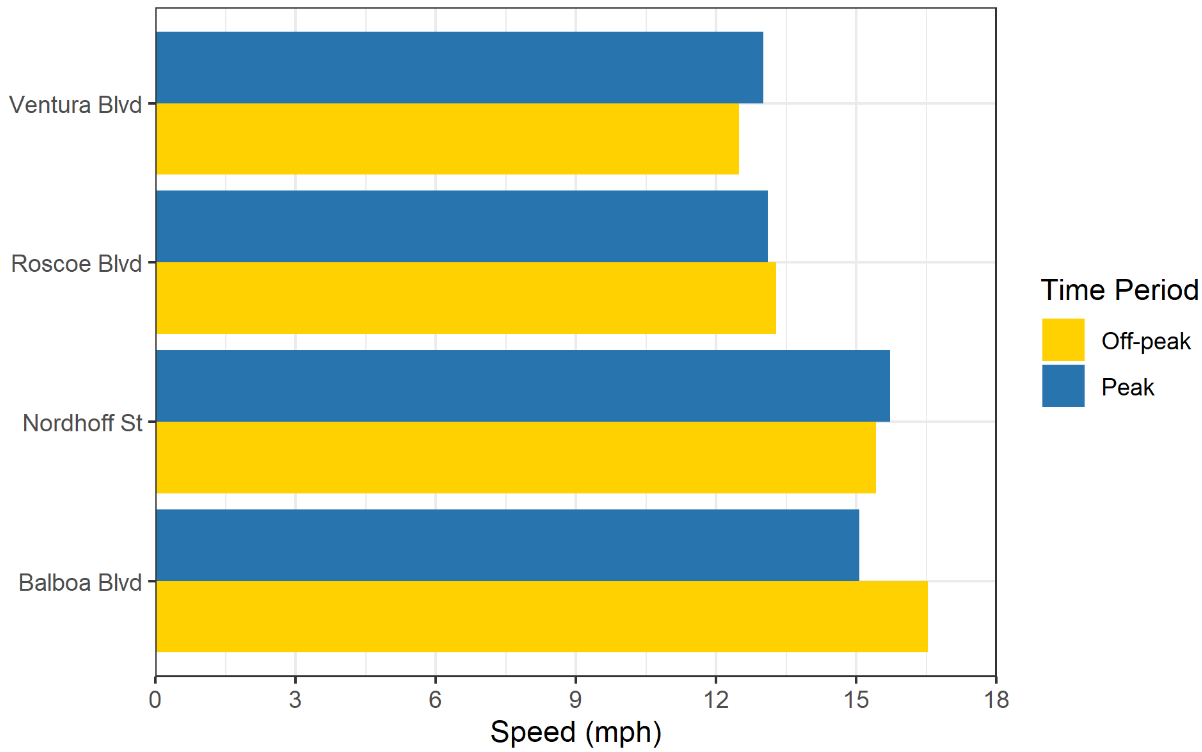


**Figure 10**. San Fernando Valley Mean Corridor Bus Speeds




These speed summaries give a general sense as to how buses perform on PHPR corridors in four distinct portions of Los Angeles, adjusted for dwell times. While most corridors had similar bus speeds across all individual segments, some had significant hotspots of relatively low or high speeds. As such, **Figures 11** and **12** below map PHPR corridor segments for the off-peak and peak periods to show where speeds are concentrated across the full network of PHPR lanes and to highlight low bus speed hot spots along certain corridors. Additionally, average speeds were generally only slightly better in the off-peak periods and these maps provide a side-by-side comparison. In the next section, I use these speed results to estimate the travel time savings that implementing bus lanes on PHPR lanes could produce.

**Figure 11**. Peak Period PHPR Average Speeds

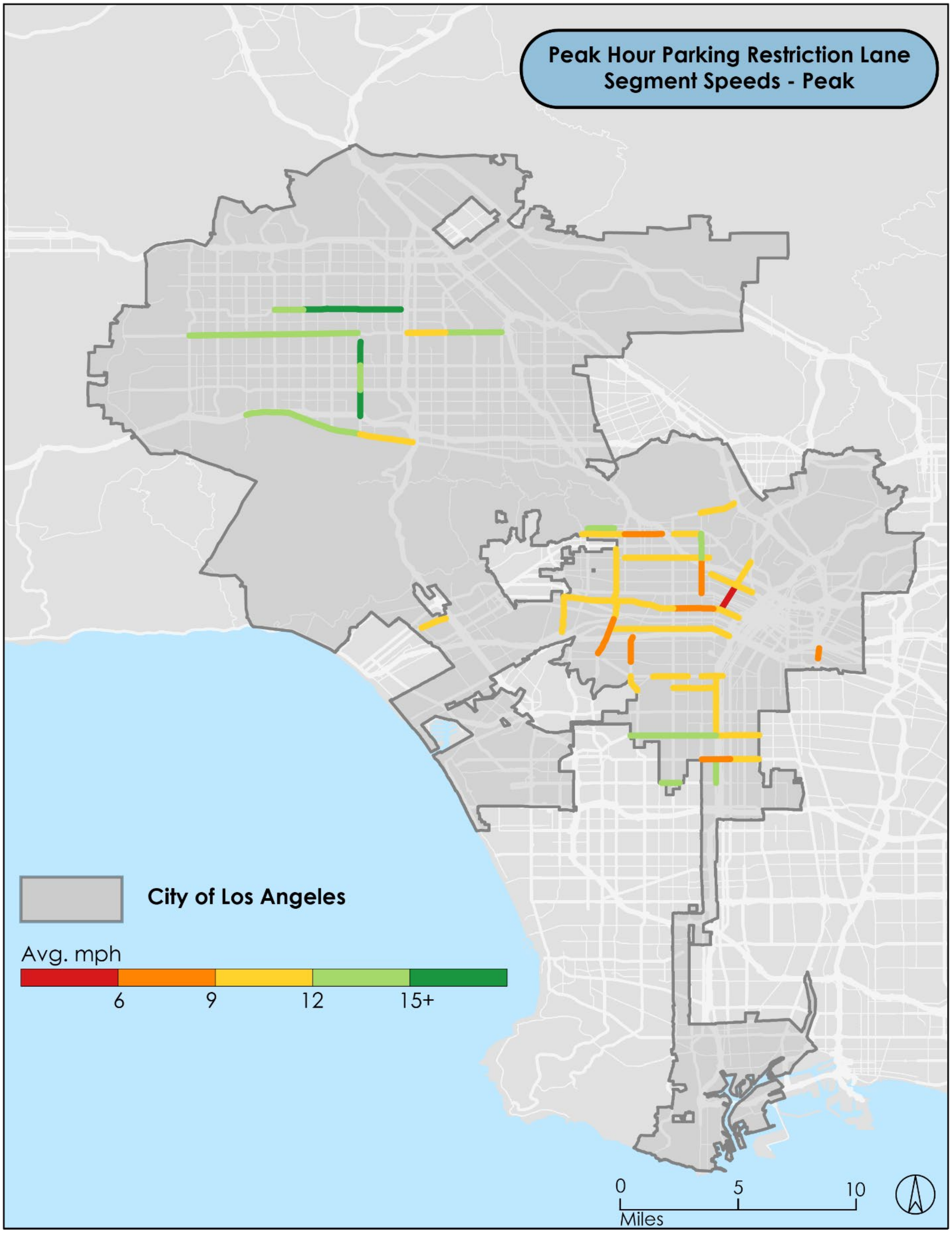
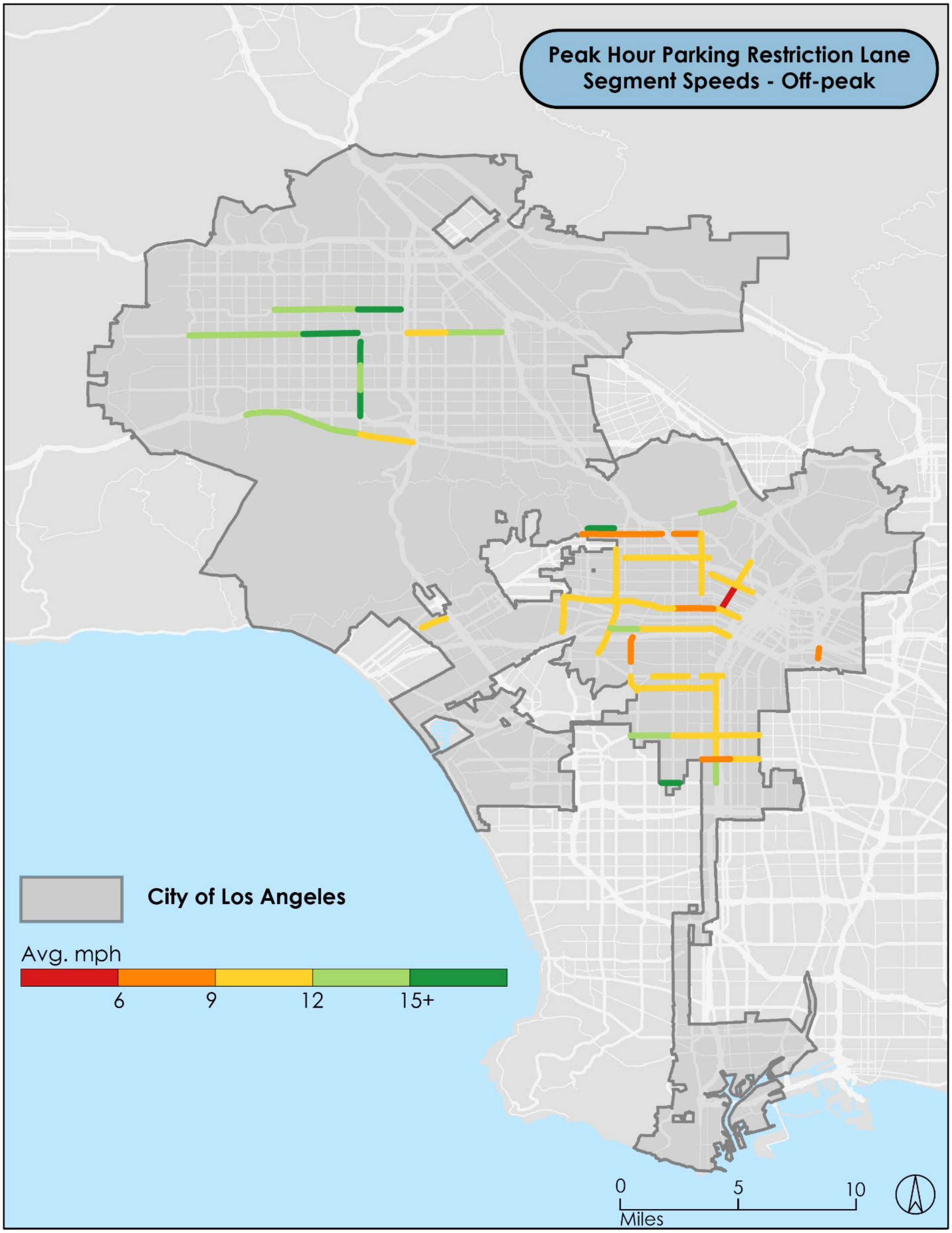


**Figure 12.** Off-peak Period PHPR Average Speeds



## Travel Time Savings

I calculated the estimated transit traveler time savings on PHPR segments assuming the implementation of an exclusive bus lane. This analysis relies on the speeds observed in the first portion of the study. The main benefit of any exclusive lane treatment for buses is a decrease in overall travel times, and by extension, the time passengers spend riding the bus, but travel time savings can provide many secondary benefits. Reduced and predictable travel times allow better operations scheduling to reduce bus headways, allow for more predictable frequencies, encourage mode shift, and improve the quality of transit for bus riders (Currie and Sarvi, 2012). Travel time improvements due to increased speeds improve bus frequencies without the need for additional service. As discussed earlier, bus speed efficiency is partially determined by the type of lane treatment provided, and exclusive bus lanes can grant a 75 percent increase in bus speeds when properly enforced (Kittleson, 2013). This increase in efficiency cannot account for the many circumstances affecting the performance of urban bus service but, in general, if buses are separated from mixed traffic, research suggests that they will drive 75 percent faster.

To determine potential travel time savings on PHPR corridors, I calculated the average observed running times for buses on individual segments accounting for bus stop dwell times. I then calculated a new running time based on the benefits of a bus lane. I assumed the described 75 percent increase in speed gained from exclusive bus lanes and subtracted this calculated value from the original dwell-controlled running time. I took this time difference and produced an estimated travel time savings for each PHPR segment assuming the presence of exclusive bus lanes. These calculations are described in **Equations 2** and **3** below. This process isolates the time the bus spent moving, rather than dwelling at stops, and provides a more accurate estimate of travel time savings, one that accounts for the difference in dwell times on each segment, by direction, for the peak and all day periods on every PHPR lane measured. The results of this process, and the estimated travel time savings for each segment, are fully listed in **Appendix 3**.

**Equation 2.** PHPR Segment Bus Running Time Calculation Method

$$Running\ Time(min) = \left(\frac{Length(miles)}{Dwell\ Controlled\ Speed(mph)}\right) * 60$$

**Equation 3.** PHPR Segment Time Savings Calculation Method

$$Time\ Savings(\mathrm{min}) = Running\ Time(min) - \left(\frac{Length(miles)}{Dwell\ Controlled\ Speed(mph) * 1.75}\right) * 60$$

As with my speed findings above, the following figures illustrate the estimated travel time savings effects of bus lanes broadly, by summarizing the average segment time savings on each PHPR corridor in the study, aggregated across both directions. **Figure 13** shows a somewhat even distribution of time savings across segments in the western and central portions of Los Angeles, with the most substantial time savings on Santa Monica Boulevard during the peak period. Likewise, the distribution of time savings in the eastern portion of the study shown in **Figure 14** is mostly evenly distributed, except for noticeably greater estimated time savings on the segments along Alvarado Street. Again, South LA and the San Fernando Valley represented in **Figures 15** and **16** show relatively even distributions of estimated time savings, expect for Century Boulevard in South LA, which has noticeably less. In the previous section, speeds varied across different corridors in the four sections, sometimes quite substantially. Here, assuming the addition of a bus lane, nearly all corridors will benefit relatively equally. However, between the four regions, the San Fernando Valley again stands out, with average travel time savings hovering between one and two minutes, showing that bus lanes will have the least effect here than in any other region. In most cases, across all four areas, peak period travel time savings are predicted to be larger than the savings in the off-peak period.

**Figure 13.** Estimated Westside/Central Los Angeles Mean Corridor Travel Time Savings

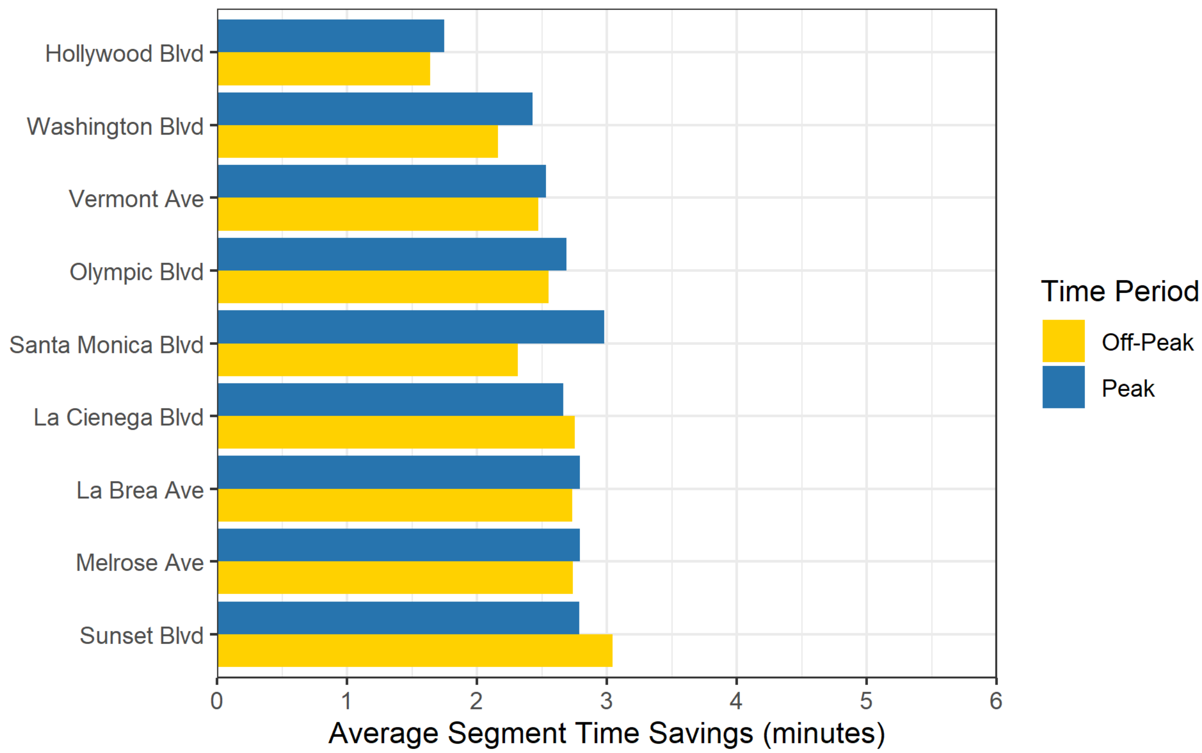


**Figure 14.** Estimated Downtown/Eastside Los Angeles Mean Corridor Travel Time Savings

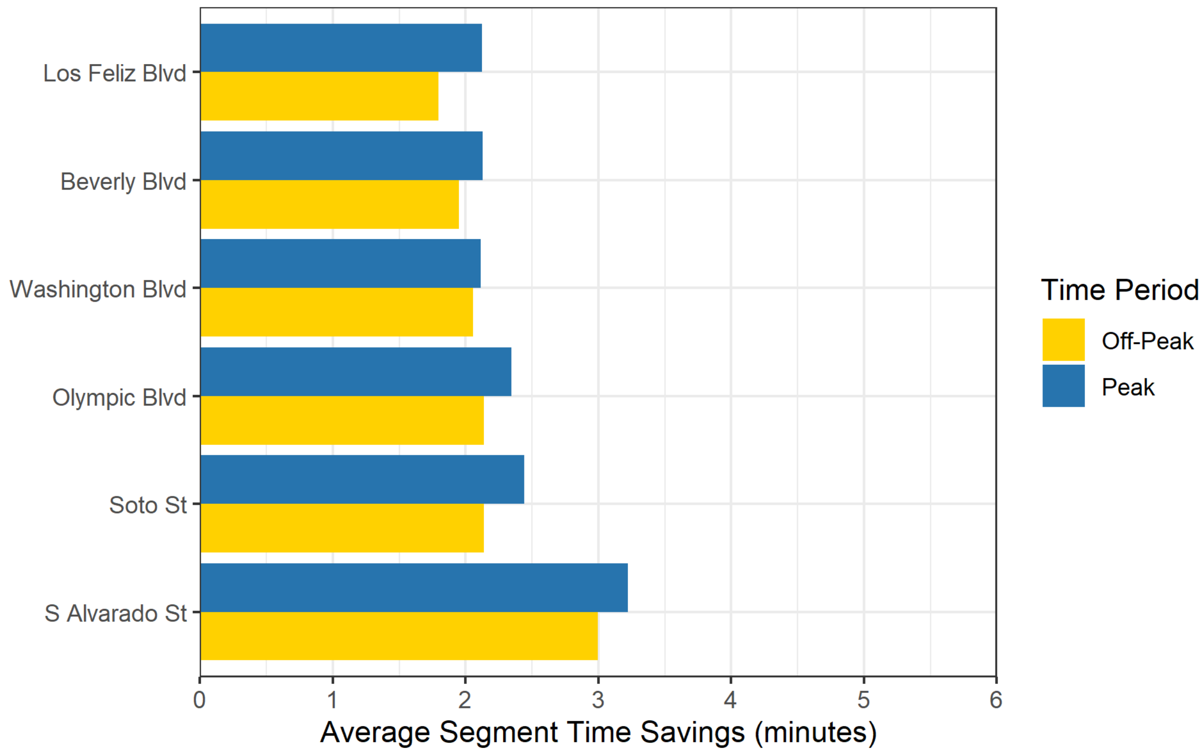



**Figure 15.** Estimated South Los Angeles Mean Corridor Travel Time Savings

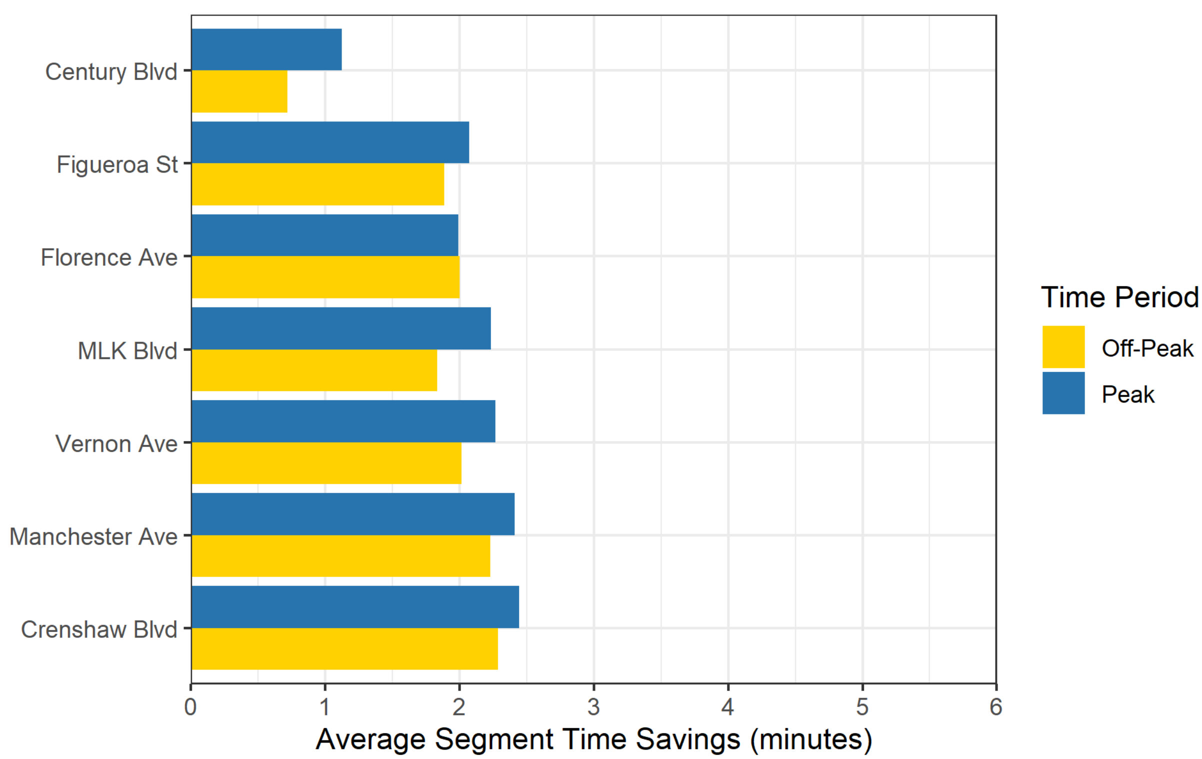
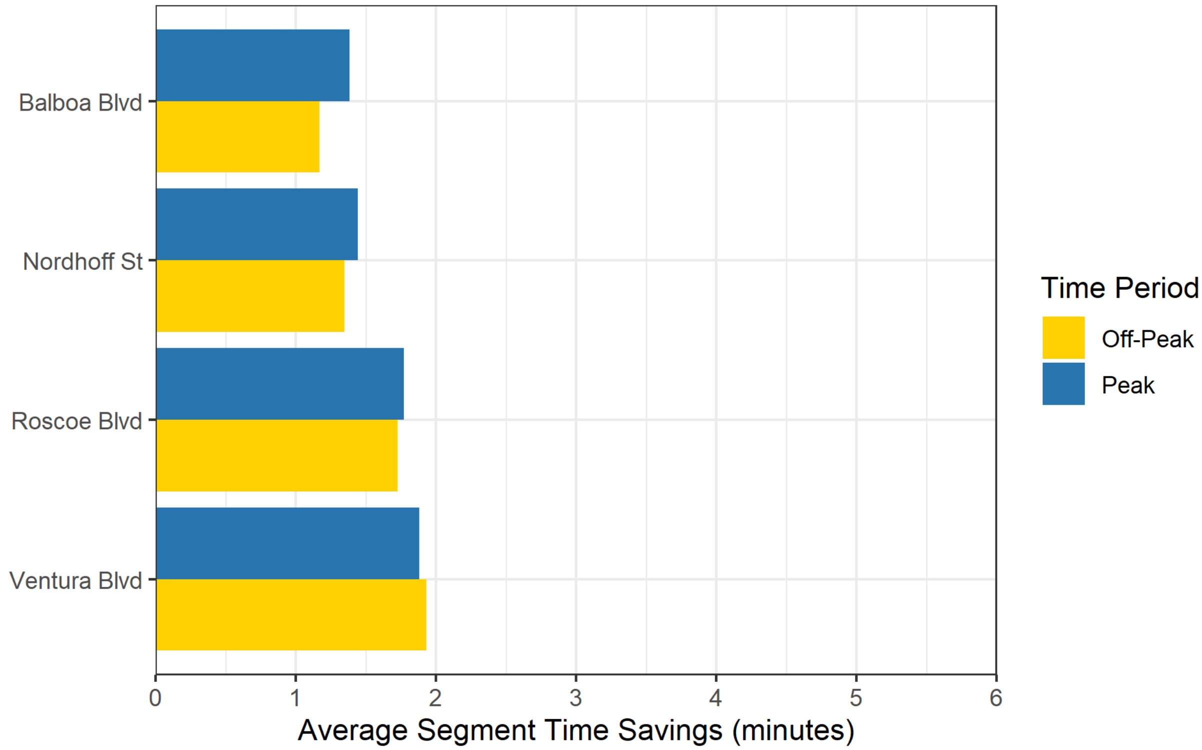


**Figure 16.** Estimated San Fernando Valley Mean Corridor Travel Time Savings




As expected, the estimated transit traveler time savings with a shift to exclusive bus lanes are significant, and not just during peak periods. At first pass, the time savings of individual bus runs appear small, ranging from 48 seconds to 5 minutes across all segments. However, this time saved adds up, with frequent and full buses shaving hours and days off the time riders spend commuting. **Figures 17** and **18** below describe this concept broadly, by mapping the total minutes saved per bus run in both directions for each PHPR segment in Los Angeles.

**Figure 17.** Peak Period PHPR Lane Estimated Time Savings

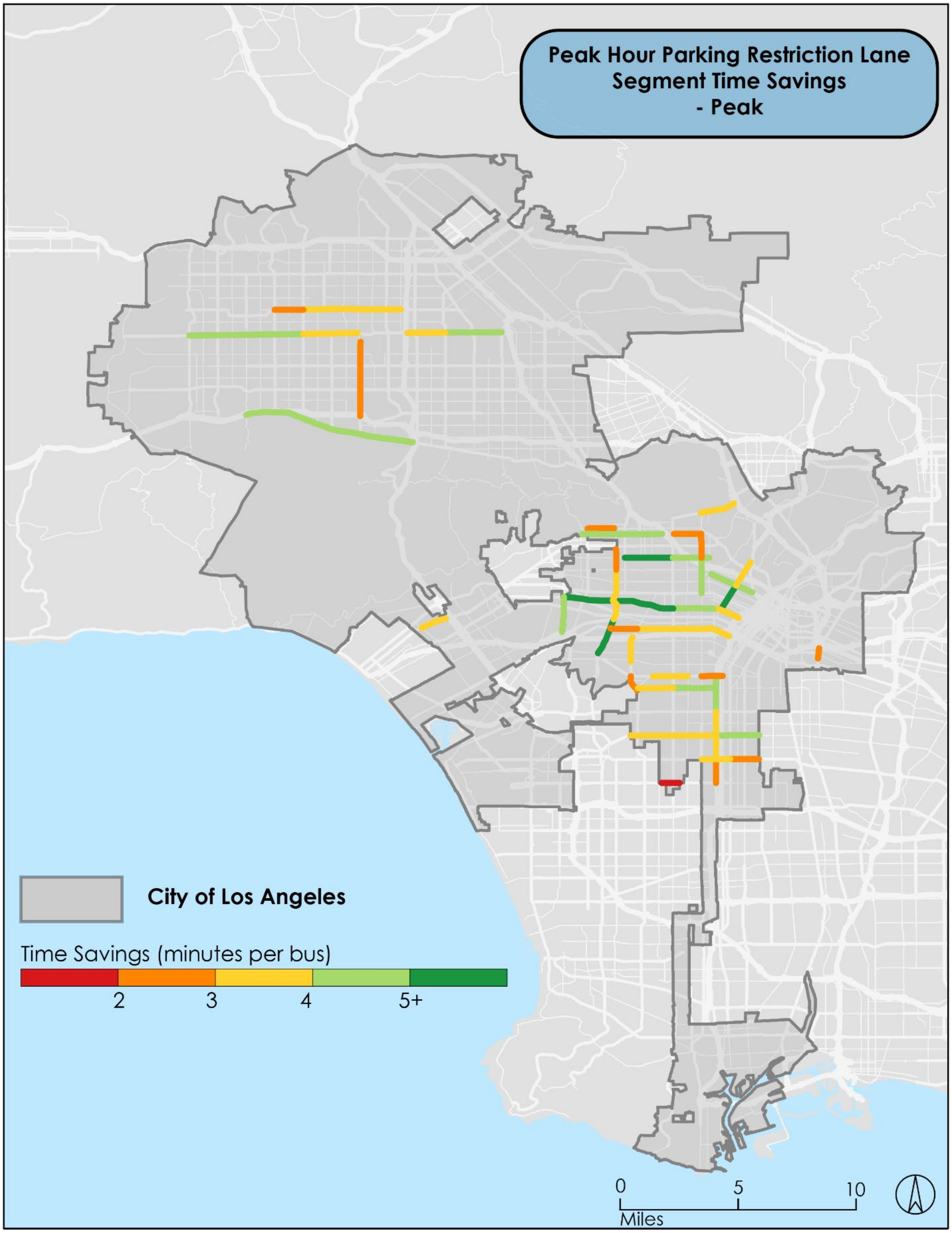
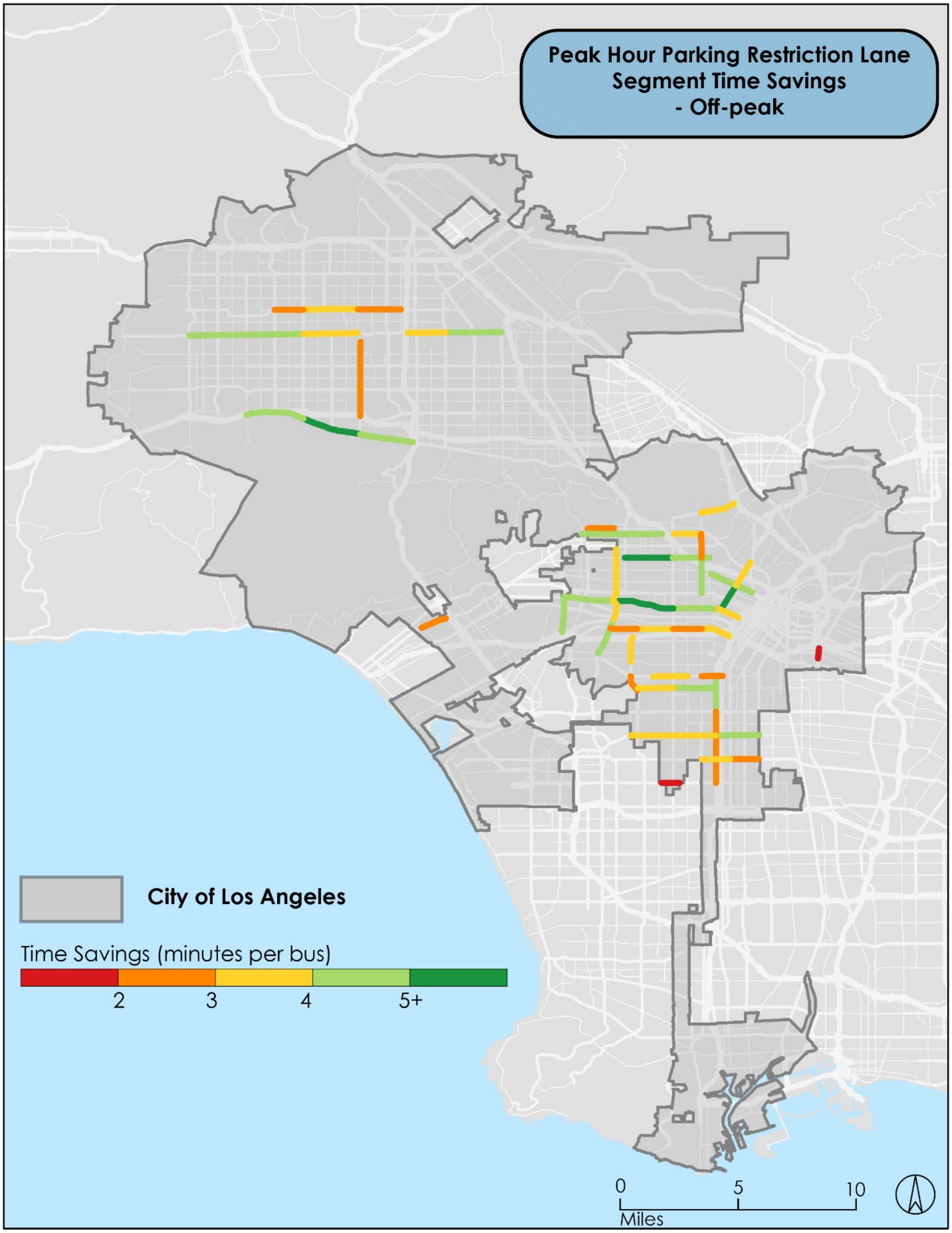


**Figure 18.** Off-peak PHPR Lane Estimated Time Savings



As the maps above show, the greatest opportunity for time savings improvements generally matches the distribution of bus speeds across the city. However, while every bus would benefit from its own lane in a densely developed, traffic congested city like Los Angeles, some PHPR segments offer more potential transit passenger time savings based on the amount of bus service provided. **Table 4** illustrates this concept by comparing two lane segments with differing levels of frequency, Vermont Avenue and Roscoe Boulevard, assuming full buses.[7] Vermont Avenue is planned to boast the best frequency in the city, with a bus every five minutes, while Roscoe Boulevard has a more typical 15-minute headway between buses. While time savings add up in both cases, the lane with more frequent bus service saves more time despite worse travel time savings per bus, because of the increased frequency.

**Table 4.** Travel Time Savings Comparison between Vermont Avenue and Roscoe Boulevard

| CORRIDOR | BOUNDARY | WEEKDAY BUS TRIPS | | TIME SAVINGS PER TRIP (MINS) | | TIME SAVINGS PER DAY (MINS) | | PASSENGER TIME SAVINGS PER DAY WITH FULL BUSES (HOURS) | |
|---|---|---|---|---|---|---|---|---|---|
| | | North | South | North | South | North | South | North | South |
| Vermont Ave | Sunset Blvd to Melrose Ave | 144 | 144 | 1.6 | 1.8 | 230 | 259 | 172.5 | 194.3 |
| | | East | West | East | West | East | West | East | West |
| Roscoe Blvd | Topanga Canyon to Winnetka Ave | 48 | 48 | 3.2 | 3.1 | 153.6 | 149 | 115.2 | 111.7 |

Travel times are important to bus riders and adding bus lanes to PHPR corridors could significantly improve travel time savings across the city. There are many reasons to prioritize bus travel, whether to further goals of transportation equity or promote healthier cities, but simply considering travel time savings for bus riders will often justify a bus lane. Still though,

[7] This calculation assumes a full bus to be fully seated but with no standees, which is 45 riders on a typical 40-foot bus.

adding bus lanes removes lanes for cars, and the next section demonstrates the potential traffic impacts of bus lanes on PHPR segments.

# Traffic Analysis

The final portion of my analysis approximates the peak period changes in person throughput when bus lanes are present on PHPR corridors using publicly available traffic data. As noted above, bus lanes have the potential to move far more people in a lane than passenger automobiles under optimal conditions (NACTO, 2016). In Los Angeles, where major corridors sometimes only have one bus line, a bus lane is not always justifiable, but where transit service is fast and frequent enough, net person throughput on a corridor can improve, even if private vehicle traffic slows. The addition of a bus lane on PHPR corridors means that the curb running lane is no longer accessible to automobile traffic during the peak period. To approximate the person throughput effects of a bus lane, I used peak-hour vehicle volumes captured by LADOT traffic counts and then estimated passenger loads of buses on the same segments. This analysis is straightforward, only considering traffic counts and the capacity of transit on PHPR corridors, but it shows where bus lanes might have the most effect, allowing planners to apply the speed and time savings improvements shown in this report.

My findings rely on a few assumptions. First, since traffic volumes are provided by LADOT in the form of peak period hourly counts, I derived typical peak period volumes by recording the largest hourly count in the AM and PM peaks, then multiplied that value across both 3-hour peak periods resulting in a total peak period (6-hour) traffic volume estimate. Then, I use a standard estimate for vehicle passenger load factors, 1.2 persons per car, to approximate the amount of people driving along these corridors during the peak hour (Wolshone and Pande, 2016). Because I multiply the largest hourly count across the entire peak period, and apply a universal load factor, my counts might over-estimate the amount of people driving in some instances, but this conservative approach demonstrates the full potential of exclusive bus lanes. For bus capacity, I relied on established LA Metro service policy. LA Metro plans for bus load factors of 1.2 across the whole day (LACMTA, 2018), meaning that a bus with 45 seats should spend most of the day operating at 120 percent of seated capacity with 45 seated riders and nine standing. As noted previously, research shows a positive relationship between travel time savings and ridership growth (Currie and Sarvi, 2012). As such, I combine LA Metro's service policy with the assumption that bus ridership is higher during the peak period and will continue to improve, applying a bus load factor of 1.2 to my calculations. This load factor is meant to represent the increased ridership demand stemming from more reliable service despite recent trends in falling ridership (Manville et al., 2018). My final person throughput calculations take the difference between the corridor operating at full vehicle capacity and the corridor operating with one less travel lane but with the addition of optimal bus service. I assume a decrease in vehicle volumes because of the change, from 100 percent with three lanes to 75 percent with two lanes. The full capacity results are available for each segment, by direction, in **Appendix 4**.

**Equation 4**. Estimation Method for Net Person Throughput

$$Vehicle\ Estimated\ Persons\ = \left((AM\ Peak\ Hour\ Count + PM\ Peak\ Hour\ Count) * 3\right) * 1.2$$

$$Bus\ Estimated\ Persons = \left((Buses\ per\ Peak\ Hour) * 6\right) * (Seated\ Capacity * 1.2)$$

$$Net\ Person\ Throughput = (Vehicle\ Estimated\ Persons * .75 + Bus\ Estimated\ Persons) - Vehicle\ Estimated\ Persons$$

**Figure 19** below shows the average net person throughput change during the peak period on each PHPR corridor. These results are strikingly different from the mostly positive changes shown in the previous sections. Only one-half of the studied corridors show a net increase in person throughput with the addition of a bus lane during the peak period. Where the increase was positive, bus service is the most frequent, capitalizing on the capacity benefits of buses. Hollywood Boulevard and Santa Monica Boulevard, with the largest net positive changes, have 6-minute peak hour bus headways. Conversely, the largest negative changes are where bus service is low. Balboa Boulevard, a PHPR corridor with high vehicle volumes and an adjacent freeway onramp, will have bus service only every half hour. In this circumstance, a bus lane does not justify the removal of a vehicle travel lane. However, in some corridors the sheer volume of vehicles outweighs the advantages of planned bus capacity. Los Feliz Boulevard has planned headways of 7.5 minutes during the peak hour, but incredibly high vehicle volumes entering and exiting the adjacent Interstate 5 predict a negative net change with the addition of a bus lane.

**Figure 19.** Estimated Peak Period PHPR Bus Lane Person Throughput Changes

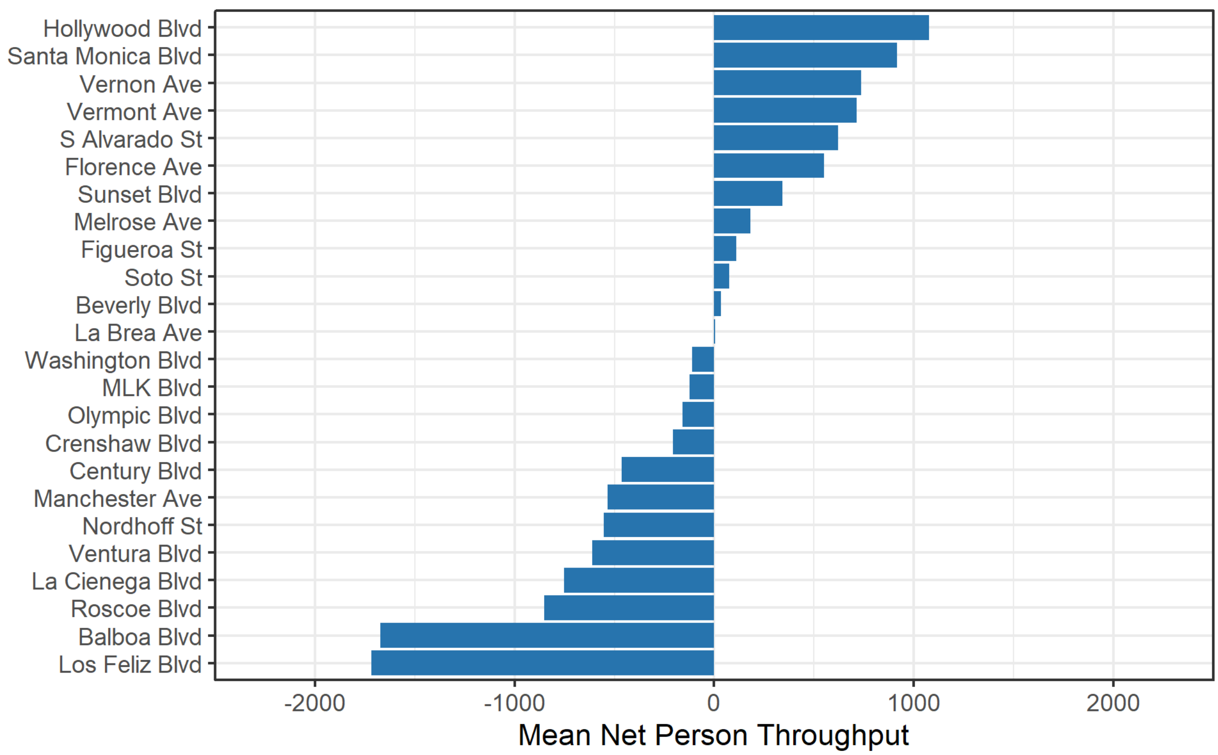



**Table 5** below outlines the estimated effects in more detail, showing the frequency of scheduled buses, the peak period bus person capacity, the approximated loss of person capacity in vehicles, and the net change in person throughput on the corridor. Notably, both

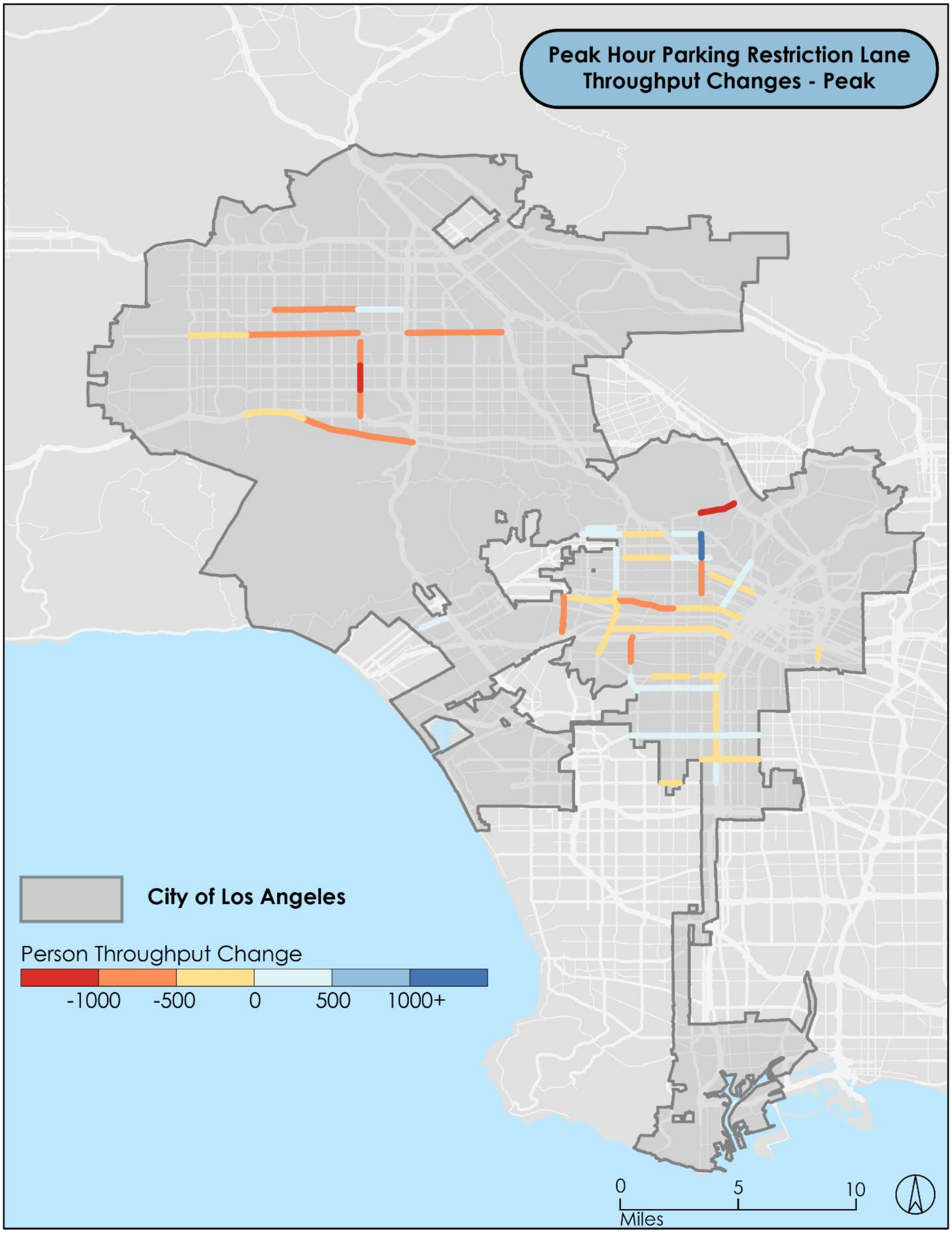
corridors have frequent buses, but differing traffic volumes allow a bus lane to increase the person throughput on Santa Monica Boulevard while severely decreasing the person throughput of Los Feliz Boulevard.

**Table 5.** Estimated Peak Period Person Throughput Changes between Santa Monica Boulevard and Los Feliz Boulevard

| CORRIDOR | BOUNDARY | PEAK PERIOD HEADWAY (MINS) | | PEAK PERIOD BUS PERSON CAPACITY | | PEAK PERIOD VEHICLE PERSON CAPACITY LOSS | | CHANGE IN PERSON THROUGHPUT | |
|---|---|---|---|---|---|---|---|---|---|
| | | East | West | East | South | East | West | East | West |
| Santa Monica Blvd | Bundy Dr to I-405 | 6 | 6 | 3240 | 3240 | 2271 | 2374 | 969 | 866 |
| | | East | West | East | West | East | West | East | West |
| Los Feliz Blvd | Vermont Ave to I-405 | 7.5 | 7.5 | 2592 | 2592 | 3992 | 4629 | -1400 | -2037 |

Changes in estimated total corridor person throughput (in buses and private vehicles combined) vary even more between corridor segments with the addition of bus lanes. **Figure 20** below maps these differences and shows the net person throughput changes across all PHPR lanes on a more granular level. There are several examples of corridors that have an entirely positive or negative aggregated value in the above charts yet show differing circumstances along different segments on the corridor. This justifies a more granular approach to implementing bus lanes.

**Figure 20.** Estimated Peak Period PHPR Bus Lane Person Throughput Changes



## Summary

This report analyzes estimated bus speeds across the city of Los Angeles, estimated transit traveler time savings with the installation of dedicated bus lanes in current PHPR lanes, and the estimated peak period person throughput effect in corridors where these lanes might be installed. Two months of bus GPS observations provided a comprehensive picture of speed on PHPR lanes, finding that bus speeds were slow across the city, but especially in areas outside the San Fernando Valley, with speeds slowing the most in the congested center of Los Angeles. Furthermore, estimated bus travel time improvements from exclusive bus lanes, while positive for all segments, will likely yield the greatest benefits on routes with frequent bus service. Transit passenger travel time savings are estimated to have the most effect on routes moving more people per hour and per day, even if the estimated individual travel time savings per person is relatively modest. Finally, I compared peak hour traffic volumes with the person capacity of LA Metro buses to predict changes in person throughput with the implementation of peak period bus lanes. My analysis found that the peak period corridor person throughput benefits of bus lanes vary; the most benefits are realized in corridors offering the most frequent bus service. This comparison likely overcounts traffic volumes, and only considers LA Metro buses, and still one half of PHPR corridors show a net positive increase in person throughput with peak period bus lanes. With the addition of other transit agencies, like LADOT's DASH, that share these corridors, I anticipate even greater improvements with the addition of bus lanes.

# Conclusion

## Recommendations

This report uses big data drawn from multiple sources to develop and test a new analytical tool to identify where bus lanes may be warranted. I aggregated large volumes of bus data open to the public over the course of two months and focus on the peak period feasibility of bus lanes along Peak Hour Parking Restriction (PHPR) corridors in Los Angeles. While this analysis is limited in scope, accessing bus data through free and publicly accessible data points, and processing with this methodology, could be the beginnings of a new way for transit managers and researchers to quickly assess bus systems, requiring only a computer and some knowledge of programming. Future researchers can replicate this methodology and measure the effects of transit investments across the entire LA Metro system, and search for more opportunities to improve bus service in Los Angeles. As more and more transit agencies publish and increase the accessibility of transit data, subsequent improvements and expansions on this work can open up the possibility for more detailed analysis, like incorporating ridership numbers to accurately model bus loads by time of day, estimating changes in non-busway vehicle speeds, and improving the granularity of person throughput estimations. By combining historic data with a flexible lens for analysis, planners can quickly plan and implement bus lane successes like that of Flower Street.[8] For planners investigating opportunities for bus lanes along these PHPR corridors, I offer the following three recommendations for future action.

1. **Prioritize bus lane projects on the most frequent routes**

   I conclude that bus lanes would have a positive peak period net person throughput effect on some, but not all, PHPR lanes in Los Angeles. Bus lanes will improve travel times for transit riders but also cause reduced vehicle capacity, and likely throughput, in adjacent lanes. However, on some PHPR corridors this reduction in vehicle capacity is offset by an overall increase in the amount of people able to travel the corridor. Improving the speed of buses naturally leads to a positive travel time savings in all cases, but prioritizing transit makes the most sense on corridors where buses can be both fast and frequent, and where the effect on adjacent motor vehicle traffic is offset by better transit performance. There are some corridors included in this study where the volumes of traffic suggest that even optimistic ridership numbers would not offset the loss of person throughput from removing a travel lane available to cars. Despite greater time savings on some corridors with less frequent service, PHPR segments with better headways will save more time for more people.

[8] Due to COVID-19, transit managers expect significant short-term effects on transit. Data for this report were collected prior to the announcement of the pandemic and my analysis makes no assumptions regarding the effect of the virus on ridership.

2. **Consider the peak period addition of bus lanes carefully, with more data**

In this study, I modelled the effect of bus lanes only during the peak period. This is when speeds are typically slowest and travel time savings are likely going to be higher with the addition of bus lanes, but also when transit competes most with large volumes of vehicle traffic. Peak hour traffic volumes are high in Los Angeles, and the current policy of opening the curbside lane during peak periods increases vehicle capacity. In my analysis of traffic effects, the amount of people driving often surpassed the amount of people I estimated buses could carry. Still, I predicted that in many instances bus lanes will have a positive effect and my analysis often overestimates vehicle counts and underestimates the amount of buses using a corridor. The removal of a lane for vehicle traffic during peak hours will have a large impact on person throughput, so any proposed bus lanes must have enough frequency and demand to justify the loss of a general travel lane. The best analysis will include current ridership numbers, vehicle traffic speeds, predict the demand elasticity based on established methods, and compare these results to the loss of vehicle capacity (Kittleson, 2013).

3. **Collect more data; consider bus lanes outside of peak period**

The primary weakness of my analysis is that a lack of data prevents me from considering bus lane options outside of the peak period. More sophisticated traffic engineering models can improve on my assumption by estimating the effect of bus lanes on the volume-to-capacity ratio in adjacent travel lanes, predicting more accurate volumes, and the subsequent effect on person throughput (USDOT, 2018). I stopped short of modelling the effects of off-peak bus lane additions because my analysis does not account for the effects of adding a bus lane in the place of parking. Despite no loss in capacity, the presence of a bus lane may cause delays in the two adjacent vehicle travel lanes. This project provides a set of findings to illustrate hotspots on PHPR corridors where bus lanes might move more people during peak periods, and further research can fully illustrate the benefits of bus lanes outside the peak period in Los Angeles.

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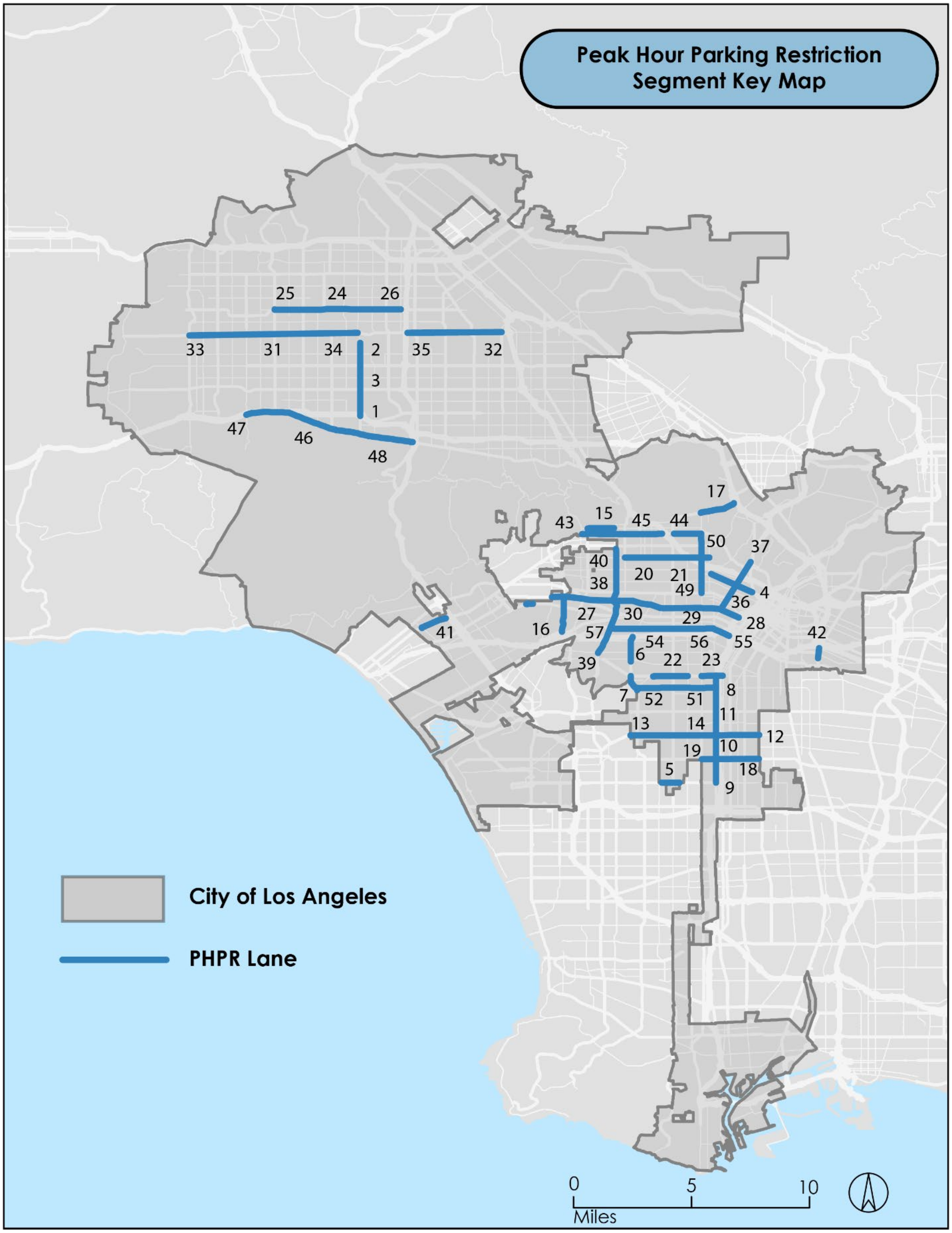
# Appendices

## Appendix 1. PHPR Segment List and Keymap

| CORRIDOR | BOUNDARY | LENGTH | MAP KEY |
|---|---|---|---|
| Balboa Blvd | Victory Blvd to Hwy 101 | 1.1 | 1 |
| | Strathern St to Sherman Way | 1 | 2 |
| | Sherman Way to Victory Blvd | 1 | 3 |
| Beverly Blvd | Commonwealth Ave to Glendale Blvd | 1.6 | 4 |
| Century Blvd | Haas Ave to La Salle Ave | .6 | 5 |
| Crenshaw Blvd | I-10 to Rodeo Rd | 1.1 | 6 |
| | MLK Blvd to Vernon Ave | .7 | 7 |
| Figueroa St | MLK Blvd to Slauson Ave | 1.5 | 8 |
| | Manchester Ave to Century Blvd | 1 | 9 |
| | Florence Ave to Manchester Ave | 1 | 10 |
| | Slauson Ave to Florence Ave | 1 | 11 |
| Florence Ave | Figueroa St to Central Ave | 1.5 | 12 |
| | West Blvd to Western Ave | 1.5 | 13 |
| | Western Ave to Figueroa St | 1.5 | 14 |
| Hollywood Blvd | Fairfax Ave to La Brea Ave | .9 | 15 |
| La Cienega Blvd | Olympic Blvd to Cadillac Ave | 1.5 | 16 |
| Los Feliz Blvd | Vermont Ave to Riverside Dr | 1.3 | 17 |
| Manchester Ave | Main St to Central Ave | 1 | 18 |
| | Vermont Ave to Main St | 1 | 19 |
| Melrose Ave | Highland Ave to Western Ave | 1.7 | 20 |

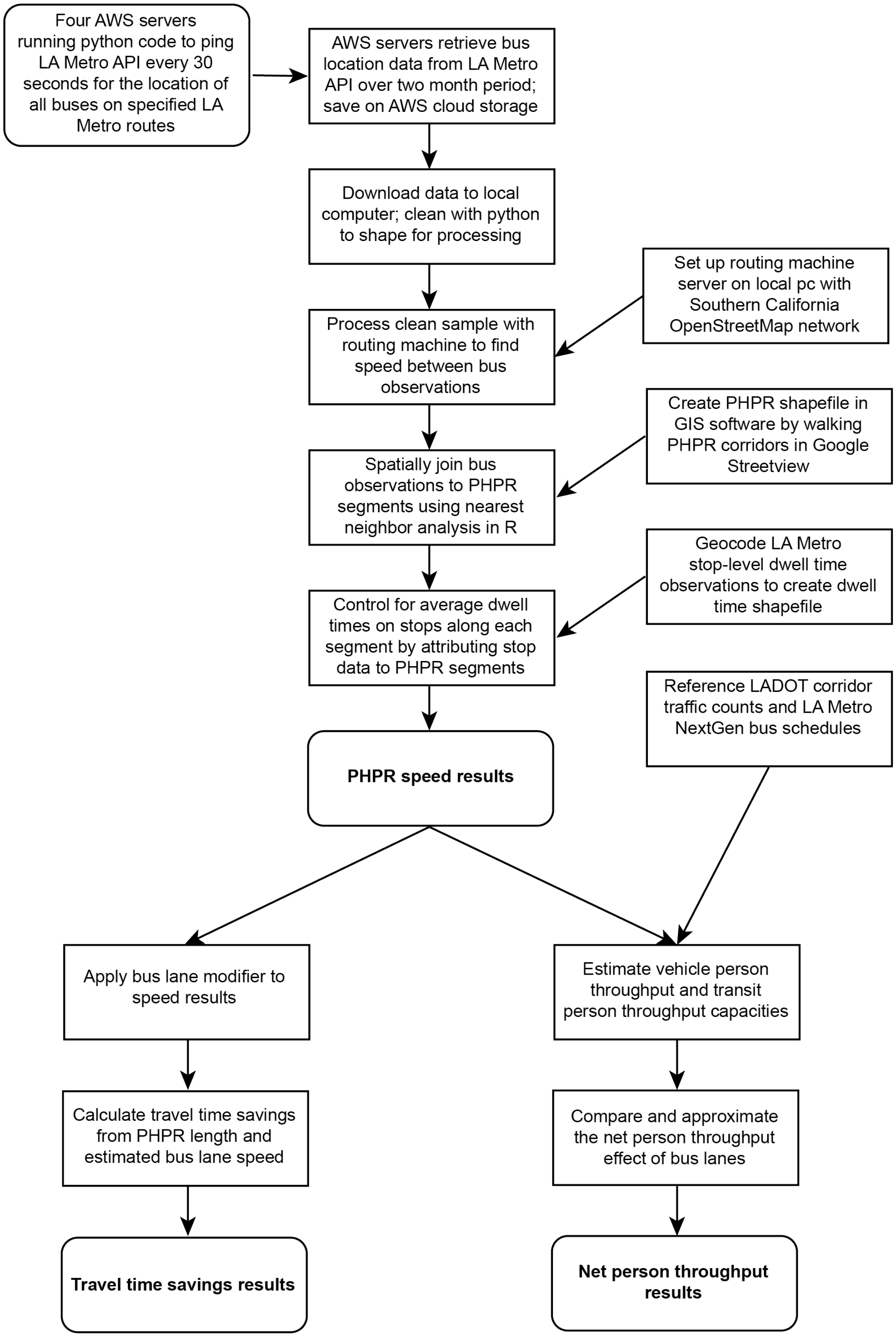
| CORRIDOR | BOUNDARY | LENGTH | MAP KEY |
|---|---|---|---|
| | Western Ave to Virgil Ave | 1.3 | 21 |
| Martin Luther King Jr. Blvd | 4th Ave to Normandie Ave | 1.2 | 22 |
| | Vermont Ave to Broadway | .7 | 23 |
| Nordhoff St | Reseda Blvd to Balboa Blvd | 1.9 | 24 |
| | Tampa Ave to Reseda Blvd | 1 | 25 |
| | Balboa Blvd to Haskell Ave | 1.5 | 26 |
| Olympic Blvd | La Cienega Blvd to La Brea Ave | 1.7 | 27 |
| | Hoover St to Hwy-110 | 1 | 28 |
| | Western Ave to Hoover St | 1.4 | 29 |
| | La Brea Ave to Western Ave | 2.2 | 30 |
| Roscoe Blvd | Winnetka Ave to Reseda Blvd | 2 | 31 |
| | Van Nuys Blvd to Coldwater Canyon Ave | 2 | 32 |
| | Topanga Canyon Blvd to Winnetka Ave | 2 | 33 |
| | Reseda Blvd to Balboa Blvd | 1.9 | 34 |
| | I-405 to Van Nuys Blvd | 1.3 | 35 |
| S Alvarado St | Beverly Blvd to Olympic Blvd | 1.2 | 36 |
| | Montana St to Beverly Blvd | 1.1 | 37 |
| S La Brea St | Beverly Blvd to Wilshire Blvd | 1 | 38 |
| | Venice Blvd to Jefferson Blvd | 1.5 | 39 |
| | Wilshire Blvd to Venice Blvd | 1.2 | 40 |
| | Romaine St to Beverly Blvd | .9 | 41 |
| Santa Monica Blvd | Bundy Dr to I-405 | .9 | 42 |
| Soto St | 8th St to 12th St | .4 | 43 |

| CORRIDOR | BOUNDARY | LENGTH | MAP KEY |
|---|---|---|---|
| Sunset Blvd | Laurel Canyon Blvd to Highland Ave | 1.5 | 44 |
| | Western Ave to Vermont Ave | 1 | 45 |
| | Highland Ave to Van Ness Ave | 1.3 | 46 |
| Ventura Blvd | Reseda Blvd to Balboa Blvd | 2.1 | 47 |
| | Winnetka Ave to Reseda Blvd | 2.1 | 48 |
| | Balboa Blvd to I-405 | 1.9 | 49 |
| Vermont Ave | Melrose Ave to Wilshire Blvd | 1.5 | 50 |
| | Sunset Blvd to Melrose Ave | 1 | 51 |
| Vernon Ave | Western Ave to Figueroa St | 1.5 | 52 |
| | Leimert Blvd to Western Ave | 1.3 | 53 |
| Washington Blvd | Crenshaw Blvd to Western Ave | 1.3 | 54 |
| | Vermont Ave to I-110 | 1 | 55 |
| | Western Ave to Vermont Ave | 1 | 56 |
| | La Brea Ave to Crenshaw Blvd | .9 | 57 |



Peak Hour Parking Restriction
Segment Key Map
25
24
26
33
31
34
2
35
32
3
1
47
46
48
17
15
45
44
43
50
37
40
20
21
38
49
4
36
27
30
29
28
16
57
55
41
42
54
56
6
22
23
39
8
7
52
51
11
13
14
12
10
19
18
5
9
City of Los Angeles
PHPR Lane
0
5
10
Miles

# Appendix 2: Data Collection and Analysis Process



# Appendix 3. Detailed Results of PHPR Speed and Travel Time Findings

| | | | PEAK PERIOD | | OFF-PEAK PERIOD | |
|---|---|---|---|---|---|---|
| CORRIDOR | BOUNDARY | DIRECTION | SPEED (MPH) | TIME SAVINGS (MINS) | SPEED (MPH) | TIME SAVINGS (MINS) |
| Balboa Blvd | Victory Blvd to Hwy 101 | North | 16.9 | 1.0 | 17.4 | 0.9 |
| | | South | 14.5 | 1.7 | 17.0 | 1.2 |
| | Strathern St to Sherman Way | North | 15.2 | 1.4 | 16.9 | 1.2 |
| | | South | 18.6 | 1.1 | 20.0 | 1.1 |
| | Sherman Way to Victory Blvd | North | 12.3 | 1.7 | 12.2 | 1.6 |
| | | South | 12.9 | 1.8 | 15.7 | 1.4 |
| Beverly Blvd | Commonwealth Ave to Glendale Blvd | East | 12.5 | 3.0 | 13.0 | 2.8 |
| | | West | 9.7 | 3.9 | 10.7 | 3.5 |
| Century Blvd | Haas Ave to La Salle Ave | East | 15.7 | 0.6 | 16.5 | 0.4 |
| | | West | 14.2 | 0.8 | 15.1 | 0.5 |
| Crenshaw Blvd | I-10 to Rodeo Rd | North | 7.8 | 3.1 | 8.8 | 2.7 |
| | | South | 8.1 | 2.9 | 7.6 | 3.0 |
| | MLK Blvd to Vernon Ave | North | 10.8 | 1.3 | 9.9 | 1.2 |
| | | South | 10.1 | 1.4 | 9.8 | 1.3 |
| Figueroa St | MLK Blvd to Slauson Ave | North | 9.5 | 3.8 | 10.4 | 3.4 |
| | | South | 10.5 | 3.4 | 10.5 | 3.4 |
| | Manchester Ave to Century Blvd | North | 12.0 | 1.8 | 12.7 | 1.7 |
| | | South | 13.7 | 1.6 | 13.4 | 1.6 |
| | Florence Ave to Manchester Ave | North | 10.3 | 2.1 | 11.0 | 1.9 |
| | | South | 11.6 | 1.9 | 11.8 | 1.8 |
| | Slauson Ave to Florence Ave | North | 10.0 | 2.2 | 11.2 | 1.9 |
| | | South | 10.0 | 2.2 | 10.9 | 1.9 |
| Florence Ave | Figueroa St to Central Ave | East | 10.0 | 3.5 | 8.8 | 3.8 |
| | | West | 10.6 | 3.3 | 9.9 | 3.3 |

| | | | PEAK PERIOD | | OFF-PEAK PERIOD | |
|---|---|---|---|---|---|---|
| **CORRIDOR** | **BOUNDARY** | **DIRECTION** | **SPEED (MPH)** | **TIME SAVINGS (MINS)** | **SPEED (MPH)** | **TIME SAVINGS (MINS)** |
| | West Blvd to Western Ave | East | 11.9 | 3.0 | 11.6 | 2.9 |
| | | West | 12.6 | 2.7 | 13.1 | 2.5 |
| | Western Ave to Figueroa St | East | 11.5 | 3.0 | 10.5 | 3.1 |
| | | West | 12.6 | 2.7 | 12.5 | 2.6 |
| Hollywood Blvd | Fairfax Ave to La Brea Ave | East | 16.4 | 1.3 | 17.1 | 1.1 |
| | | West | 13.3 | 1.5 | 14.5 | 1.3 |
| La Cienega Blvd | Olympic Blvd to Cadillac Ave | North | 11.0 | 3.2 | 9.6 | 3.6 |
| | | South | 8.6 | 4.1 | 9.1 | 3.9 |
| Los Feliz Blvd | Vermont Ave to Riverside Dr | North | 9.8 | 3.1 | 11.8 | 2.5 |
| | | South | 14.2 | 2.3 | 15.9 | 2.0 |
| Manchester Ave | Main St to Central Ave | East | 11.5 | 1.8 | 10.5 | 2.0 |
| | | West | 10.1 | 2.1 | 10.6 | 1.9 |
| | Vermont Ave to Main St | East | 7.1 | 3.1 | 7.3 | 2.7 |
| | | West | 8.1 | 2.7 | 8.3 | 2.4 |
| Melrose Ave | Highland Ave to Western Ave | East | 8.9 | 4.6 | 8.2 | 4.6 |
| | | West | 9.5 | 4.3 | 10.4 | 3.8 |
| | Western Ave to Virgil Ave | East | 9.0 | 3.3 | 9.5 | 3.0 |
| | | West | 9.5 | 3.1 | 9.8 | 3.0 |
| Martin Luther King Jr. Blvd | 4th Ave to Normandie Ave | East | 10.6 | 2.6 | 11.7 | 2.2 |
| | | West | 10.6 | 2.6 | 11.3 | 2.3 |
| | Vermont Ave to Broadway | East | 8.1 | 2.0 | 8.9 | 1.7 |
| | | West | 10.2 | 1.5 | 11.8 | 1.0 |
| Nordhoff St | Reseda Blvd to Balboa Blvd | East | 14.7 | 3.1 | 13.8 | 3.1 |
| | | West | 16.6 | 2.7 | 15.4 | 2.8 |
| | Tampa Ave to Reseda Blvd | East | 13.6 | 1.6 | 13.6 | 1.3 |
| | | West | 15.6 | 1.3 | 14.9 | 1.2 |
| | Balboa Blvd to Haskell Ave | East | 16.4 | 2.2 | 17.7 | 1.8 |

| | | | PEAK PERIOD | | OFF-PEAK PERIOD | |
|---|---|---|---|---|---|---|
| CORRIDOR | BOUNDARY | DIRECTION | SPEED (MPH) | TIME SAVINGS (MINS) | SPEED (MPH) | TIME SAVINGS (MINS) |
| | | West | 17.6 | 1.9 | 17.1 | 1.9 |
| Olympic Blvd | La Cienega Blvd to La Brea Ave | East | 9.2 | 4.5 | 9.8 | 4.1 |
| | | West | 9.8 | 4.2 | 11.7 | 3.4 |
| | Hoover St to Hwy-110 | East | 8.8 | 2.5 | 9.1 | 2.3 |
| | | West | 9.9 | 2.1 | 10.4 | 1.9 |
| | Western Ave to Hoover St | East | 8.5 | 3.9 | 8.1 | 4.0 |
| | | West | 9.1 | 3.6 | 8.9 | 3.6 |
| | La Brea Ave to Western Ave | East | 11.0 | 4.7 | 11.7 | 4.3 |
| | | West | 10.3 | 5.0 | 11.5 | 4.5 |
| Roscoe Blvd | Winnetka Ave to Reseda Blvd | East | 13.7 | 3.3 | 14.5 | 3.1 |
| | | West | 14.8 | 3.2 | 15.2 | 3.0 |
| | Van Nuys Blvd to Coldwater Canyon Ave | East | 12.7 | 3.6 | 12.5 | 3.6 |
| | | West | 14.0 | 3.3 | 14.4 | 3.0 |
| | Topanga Canyon Blvd to Winnetka Ave | East | 12.8 | 3.6 | 13.5 | 3.4 |
| | | West | 13.3 | 3.6 | 13.1 | 3.6 |
| | Reseda Blvd to Balboa Blvd | East | 14.3 | 3.1 | 14.9 | 2.9 |
| | | West | 15.4 | 2.8 | 15.9 | 2.7 |
| | I-405 to Van Nuys Blvd | East | 9.5 | 3.0 | 9.3 | 3.0 |
| | | West | 10.5 | 2.7 | 9.6 | 2.9 |
| S Alvarado St | Beverly Blvd to Olympic Blvd | North | 5.3 | 5.1 | 5.4 | 4.8 |
| | | South | 6.3 | 4.3 | 6.3 | 4.1 |
| | Montana St to Beverly Blvd | North | 9.1 | 2.8 | 9.7 | 2.5 |
| | | South | 9.3 | 2.6 | 9.7 | 2.3 |
| S La Brea St | Beverly Blvd to Wilshire Blvd | North | 10.2 | 2.0 | 9.4 | 2.2 |
| | | South | 9.6 | 2.2 | 8.6 | 2.4 |
| | Venice Blvd to Jefferson Blvd | North | 8.6 | 4.1 | 10.0 | 3.5 |
| | | South | 7.1 | 5.2 | 9.8 | 3.6 |

| | | | PEAK PERIOD | | OFF-PEAK PERIOD | |
|---|---|---|---|---|---|---|
| CORRIDOR | BOUNDARY | DIRECTION | SPEED (MPH) | TIME SAVINGS (MINS) | SPEED (MPH) | TIME SAVINGS (MINS) |
| | Wilshire Blvd to Venice Blvd | North | 10.0 | 2.6 | 9.9 | 2.7 |
| | | South | 8.6 | 3.2 | 9.1 | 2.9 |
| | Romaine St to Beverly Blvd | North | 10.4 | 1.9 | 9.7 | 1.9 |
| | | South | 10.1 | 1.9 | 8.9 | 2.1 |
| Santa Monica Blvd | Bundy Dr to I-405 | East | 6.6 | 3.2 | 10.1 | 2.0 |
| | | West | 12.5 | 1.7 | 12.3 | 1.7 |
| Soto St | 8th St to 12th St | North | 8.2 | 1.0 | 7.0 | 1.1 |
| | | South | 7.4 | 1.1 | 10.7 | 0.7 |
| Sunset Blvd | Laurel Canyon Blvd to Highland Ave | East | 9.7 | 3.7 | 8.8 | 3.9 |
| | | West | 9.4 | 3.8 | 8.8 | 4.0 |
| | Western Ave to Vermont Ave | East | 10.1 | 2.1 | 8.6 | 2.3 |
| | | West | 10.2 | 1.9 | 8.9 | 2.2 |
| | Highland Ave to Van Ness Ave | East | 7.7 | 4.1 | 7.6 | 4.0 |
| | | West | 8.8 | 3.4 | 8.2 | 3.7 |
| Ventura Blvd | Reseda Blvd to Balboa Blvd | East | 13.2 | 3.9 | 12.8 | 4.0 |
| | | West | 13.1 | 3.9 | 12.4 | 4.1 |
| | Winnetka Ave to Reseda Blvd | East | 15.3 | 3.3 | 14.7 | 3.3 |
| | | West | 12.7 | 3.9 | 11.7 | 4.2 |
| | Balboa Blvd to I-405 | East | 11.5 | 4.0 | 12.0 | 3.8 |
| | | West | 12.2 | 3.7 | 11.3 | 4.0 |
| Vermont Ave | Melrose Ave to Wilshire Blvd | North | 8.4 | 4.1 | 9.0 | 3.7 |
| | | South | 9.2 | 3.6 | 9.6 | 3.2 |
| | Sunset Blvd to Melrose Ave | North | 12.8 | 1.7 | 12.9 | 1.6 |
| | | South | 11.4 | 1.8 | 10.9 | 1.7 |
| Vernon Ave | Western Ave to Figueroa St | East | 9.5 | 3.7 | 10.4 | 3.2 |
| | | West | 9.3 | 3.8 | 10.4 | 3.2 |
| | Leimert Blvd to Western Ave | East | 11.4 | 2.5 | 11.5 | 2.4 |

| | | | PEAK PERIOD | | OFF-PEAK PERIOD | |
|---|---|---|---|---|---|---|
| **CORRIDOR** | **BOUNDARY** | **DIRECTION** | **SPEED (MPH)** | **TIME SAVINGS (MINS)** | **SPEED (MPH)** | **TIME SAVINGS (MINS)** |
| | | West | 10.6 | 2.7 | 11.6 | 2.3 |
| Washington Blvd | Crenshaw Blvd to Western Ave | East | 10.5 | 2.7 | 12.1 | 2.3 |
| | | West | 10.2 | 2.9 | 11.2 | 2.5 |
| | Vermont Ave to I-110 | East | 11.7 | 2.0 | 10.7 | 2.1 |
| | | West | 9.6 | 2.5 | 10.4 | 2.2 |
| | Western Ave to Vermont Ave | East | 11.5 | 1.8 | 12.1 | 1.7 |
| | | West | 9.3 | 2.4 | 10.5 | 2.1 |
| | La Brea Ave to Crenshaw Blvd | East | 11.0 | 1.8 | 13.2 | 1.5 |
| | | West | 11.3 | 1.8 | 12.8 | 1.5 |

# Appendix 4. Detailed Results of Person Throughput Findings

| CORRIDOR | BOUNDARY | DIRECTION | PEAK BUS HEADWAY (MINS) | PEAK AUTO PERSON COUNT | PERSON THROUGHPUT CHANGE |
|---|---|---|---|---|---|
| Balboa Blvd | Victory Blvd to Hwy 101 | North | 30 | 3056 | -116 |
| | | South | 30 | 8687 | -1524 |
| | Strathern St to Sherman Way | North | 30 | 7168 | -1144 |
| | | South | 30 | 8320 | -1432 |
| | Sherman Way to Victory Blvd | North | 30 | 13810 | -2804 |
| | | South | 30 | 14681 | -3022 |
| Beverly Blvd | Commonwealth Ave to Glendale Blvd | East | 10 | 7153 | 156 |
| | | West | 10 | 8140 | -91 |
| Century Blvd | Haas Ave to La Salle Ave | East | 15 | 6682 | -374 |
| | | West | 15 | 7405 | -555 |
| Crenshaw Blvd | I-10 to Rodeo Rd | North | 10 | 12485 | -1177 |
| | | South | 10 | 8075 | -75 |
| | MLK Blvd to Vernon Ave | North | 10 | 6772 | 251 |
| | | South | 10 | 7060 | 179 |
| Figueroa St | MLK Blvd to Slauson Ave | North | 10 | 6764 | 253 |
| | | South | 10 | 7974 | -50 |
| | Manchester Ave to Century Blvd | North | 10 | 7355 | 105 |
| | | South | 10 | 6228 | 387 |
| | Florence Ave to Manchester Ave | North | 10 | 7772 | 1 |
| | | South | 10 | 6829 | 237 |
| | Slauson Ave to Florence Ave | North | 10 | 8086 | -77 |
| | | South | 10 | 7135 | 160 |
| Florence Ave | Figueroa St to Central Ave | East | 7.5 | 7668 | 675 |
| | | West | 7.5 | 7708 | 665 |
| | West Blvd to Western Ave | East | 7.5 | 8838 | 383 |

| CORRIDOR | BOUNDARY | DIRECTION | PEAK BUS HEADWAY (MINS) | PEAK AUTO PERSON COUNT | PERSON THROUGHPUT CHANGE |
|---|---|---|---|---|---|
| | | West | 7.5 | 8388 | 495 |
| | Western Ave to Figueroa St | East | 7.5 | 8194 | 544 |
| | | West | 7.5 | 8208 | 540 |
| Hollywood Blvd | Fairfax Ave to La Brea Ave | East | 6 | 8467 | 1123 |
| | | West | 6 | 8842 | 1029 |
| La Cienega Blvd | Olympic Blvd to Cadillac Ave | North | 10 | 11873 | -1024 |
| | | South | 10 | 9695 | -480 |
| Los Feliz Blvd | Vermont Ave to Riverside Dr | North | 7.5 | 15966 | -1400 |
| | | South | 7.5 | 18515 | -2037 |
| Manchester Ave | Main St to Central Ave | East | 12 | 9097 | -654 |
| | | West | 12 | 8500 | -505 |
| | Vermont Ave to Main St | East | 12 | 8078 | -400 |
| | | West | 12 | 8816 | -584 |
| Melrose Ave | Highland Ave to Western Ave | East | 10 | 7416 | 90 |
| | | West | 10 | 8071 | -74 |
| | Western Ave to Virgil Ave | East | 10 | 8147 | -93 |
| | | West | 10 | 4572 | 801 |
| Martin Luther King Jr. Blvd | 4th Ave to Normandie Ave | East | 10 | 9241 | -366 |
| | | West | 10 | 9518 | -436 |
| | Vermont Ave to Broadway | East | 10 | 8125 | -87 |
| | | West | 10 | 6199 | 394 |
| Nordhoff St | Reseda Blvd to Balboa Blvd | East | 15 | 10033 | -1212 |
| | | West | 15 | 10231 | -1262 |
| | Tampa Ave to Reseda Blvd | East | 15 | 7729 | -636 |
| | | West | 15 | 8309 | -781 |
| | Balboa Blvd to Haskell Ave | East | 15 | 4180 | 251 |
| | | West | 15 | 3924 | 315 |
| Olympic Blvd | La Cienega Blvd to La Brea Ave | East | 7.5 | 10062 | 77 |

| CORRIDOR | BOUNDARY | DIRECTION | PEAK BUS HEADWAY (MINS) | PEAK AUTO PERSON COUNT | PERSON THROUGHPUT CHANGE |
|---|---|---|---|---|---|
| | | West | 7.5 | 9601 | 192 |
| | Hoover St to Hwy-110 | East | 7.5 | 13324 | -739 |
| | | West | 7.5 | 7751 | 654 |
| | Western Ave to Hoover St | East | 7.5 | 10955 | -147 |
| | | West | 7.5 | 9799 | 142 |
| | La Brea Ave to Western Ave | East | 7.5 | 12798 | -608 |
| | | West | 7.5 | 13770 | -851 |
| Roscoe Blvd | Winnetka Ave to Reseda Blvd | East | 15 | 9209 | -1006 |
| | | West | 15 | 9076 | -973 |
| | Van Nuys Blvd to Coldwater Canyon Ave | East | 15 | 10051 | -1217 |
| | | West | 15 | 10897 | -1428 |
| | Topanga Canyon Blvd to Winnetka Ave | East | 15 | 8107 | -731 |
| | | West | 15 | 6239 | -264 |
| | Reseda Blvd to Balboa Blvd | East | 15 | 6228 | -261 |
| | | West | 15 | 9641 | -1114 |
| | I-405 to Van Nuys Blvd | East | 15 | 8687 | -876 |
| | | West | 15 | 7841 | -664 |
| S Alvarado St | Beverly Blvd to Olympic Blvd | North | 7.5 | 7765 | 651 |
| | | South | 7.5 | 7362 | 752 |
| | Montana St to Beverly Blvd | North | 7.5 | 7387 | 745 |
| | | South | 7.5 | 9047 | 330 |
| S La Brea St | Beverly Blvd to Wilshire Blvd | North | 7.5 | 8777 | 398 |
| | | South | 7.5 | 8233 | 534 |
| | Venice Blvd to Jefferson Blvd | North | 7.5 | 12845 | -619 |
| | | South | 7.5 | 10174 | 49 |
| | Wilshire Blvd to Venice Blvd | North | 7.5 | 13579 | -803 |
| | | South | 7.5 | 11171 | -201 |
| | Romaine St to Beverly Blvd | North | 7.5 | 9104 | 316 |

| CORRIDOR | BOUNDARY | DIRECTION | PEAK BUS HEADWAY (MINS) | PEAK AUTO PERSON COUNT | PERSON THROUGHPUT CHANGE |
|---|---|---|---|---|---|
| | | South | 7.5 | 8910 | 365 |
| Santa Monica Blvd | Bundy Dr to I-405 | East | 6 | 9083 | 969 |
| | | West | 6 | 9497 | 866 |
| Soto St | 8th St to 12th St | North | 10 | 7528 | 62 |
| | | South | 10 | 7430 | 86 |
| Sunset Blvd | Laurel Canyon Blvd to Highland Ave | East | 7.5 | 8831 | 384 |
| | | West | 7.5 | 9022 | 337 |
| | Western Ave to Vermont Ave | East | 7.5 | 8089 | 570 |
| | | West | 7.5 | 5875 | 1123 |
| | Highland Ave to Van Ness Ave | East | 7.5 | 13054 | -671 |
| | | West | 7.5 | 9115 | 313 |
| Ventura Blvd | Reseda Blvd to Balboa Blvd | East | 10 | 12312 | -1134 |
| | | West | 10 | 8942 | -292 |
| | Winnetka Ave to Reseda Blvd | East | 10 | 9497 | -430 |
| | | West | 10 | 7250 | 131 |
| | Balboa Blvd to I-405 | East | 10 | 14000 | -1556 |
| | | West | 10 | 9284 | -377 |
| Vermont Ave | Melrose Ave to Wilshire Blvd | North | 5 | 17856 | -576 |
| | | South | 5 | 16823 | -318 |
| | Sunset Blvd to Melrose Ave | North | 5 | 8244 | 1827 |
| | | South | 5 | 7884 | 1917 |
| Vernon Ave | Western Ave to Figueroa St | East | 10 | 5548 | 557 |
| | | West | 10 | 4806 | 743 |
| | Leimert Blvd to Western Ave | East | 10 | 4406 | 842 |
| | | West | 10 | 4565 | 803 |
| Washington Blvd | Crenshaw Blvd to Western Ave | East | 12 | 7621 | -285 |
| | | West | 12 | 8482 | -500 |
| | Vermont Ave to I-110 | East | 12 | 6790 | -77 |

| CORRIDOR | BOUNDARY | DIRECTION | PEAK BUS HEADWAY (MINS) | PEAK AUTO PERSON COUNT | PERSON THROUGHPUT CHANGE |
|---|---|---|---|---|---|
| | | West | 12 | 6448 | 8 |
| | Western Ave to Vermont Ave | East | 12 | 7063 | -146 |
| | | West | 12 | 5764 | 179 |
| | La Brea Ave to Crenshaw Blvd | East | 12 | 5555 | 231 |
| | | West | 12 | 7679 | -300 |