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I, Andrew J Knee, hereby submit this original work as part of the requirements for the degree of Master of Community Planning in Community Planning.

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Cincinnati Westside Busway
by
Andrew J Knee

A Thesis Submitted to the Graduate
Faculty of the University of Cincinnati School of DAAP
in Partial Fulfillment of the
Requirements for the degree of
Master of Community Planning

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ABSTRACT

The purpose of this thesis was to assess the complexity of a portion of Cincinnati, Ohio that is currently underserved by transit. This study outlines potential mode types that could be used to improve service, and then determines the best mode to be a busway.

This study then looked to Pittsburgh, Pennsylvania as a case study. The Port Authority of Allegheny County built out their three busways at different times, experimenting in different ways to build and use a busway. Pittsburgh’s three busways serve as a guide for determining the necessary factors to use in determining a proper alignment.

The thesis then used Pittsburgh’s example as a guide for determining the most suitable corridor for development. Population density, station placement, land acquisition and build-out costs were all used as factors in determining the most suitable alignment.

The thesis finds the former Chesapeake & Ohio of Indiana corridor to be the most suitable for development due to its relative cost to build per potential ridership.
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Lastly, this thesis is dedicated to the Westside. An area filled with endless potential and solid roots. The people of the Westside continue to inspire me with their passion and pride.
**CONTENTS**

Cincinnati Westside Busway ........................................................................................................... i
ABSTRACT ...................................................................................................................................... ii
ACKNOWLEDGMENTS ................................................................................................................ iv
LIST OF TABLES .......................................................................................................................... vii
LIST OF FIGURES ........................................................................................................................ viii
1. Introduction ................................................................................................................................. 1  
   1.1 What is the Westside? ........................................................................................................... 1
2. Need for transit improvement on Cincinnati’s Westside ......................................................... 4  
   2.1 How is the Westside currently served by transit? .............................................................. 4
   2.2 What are Westsiders primary destinations? ...................................................................... 4
   2.3 What are the needs for improvement on Cincinnati’s Westside? ...................................... 5
3. Potential Technical Solutions ..................................................................................................... 7
   3.1 Types of Solutions ............................................................................................................... 7
   3.2 Streetcar ............................................................................................................................. 7
   3.3 Light Rail ............................................................................................................................ 9
   3.4 Bus Rapid Transit ............................................................................................................... 10
   3.5 Busway ............................................................................................................................... 11
   3.6 Limited Stop Service ......................................................................................................... 12
   3.7 Mode Selection .................................................................................................................. 14
4. Case Study – Pittsburgh ............................................................................................................. 16
   4.1 Why Pittsburgh? .................................................................................................................. 16
   4.2 History of Port Authority busways .................................................................................. 16
   4.3 Direct Service Model ........................................................................................................ 16
   4.4 Station Design ................................................................................................................. 20
   4.5 Connections to other Modes ............................................................................................ 23
5. Potential Alignments ................................................................................................................ 24
5.1 Potential busway alignments ................................................................. 24
  5.1.1 Description of factors in determining route selection and station
  locations ........................................................................................................... 25
  5.1.2 Population within 1/2 mile of line ....................................................... 26
  5.1.3 Number of available connections to major cross streets .................. 26
  5.1.4 Number of potential station locations ................................................. 27
  5.1.5 Estimated cost of construction ............................................................ 27

5.2 C & W Corridor ....................................................................................... 30
  5.2.1 Population within 1/2 mile of line ....................................................... 30
  5.2.2 Number of available connections to major cross streets ................. 31
  5.2.3 Number of potential station locations ................................................. 32
  5.2.4 Estimated cost of construction ............................................................ 33

5.3 C & W Extended Corridor ................................................................. 34
  5.3.1 Population within 1/2 mile of line ....................................................... 34
  5.3.2 Number of available connections to major cross streets ................. 35
  5.3.3 Number of potential station locations ................................................. 36
  5.3.4 Estimated cost of construction ............................................................ 37

5.4 C & O of Indiana Corridor ................................................................. 38
  5.4.1 Population within 1/2 mile of line ....................................................... 38
  5.4.2 Number of available connections to major cross streets ................. 39
  5.4.3 Number of potential station locations ................................................. 40
  5.4.4 Estimated cost of construction ............................................................ 41

5.5 Alignment Selection ............................................................................. 42

6. Conclusion .............................................................................................. 44

7. Works Cited ............................................................................................ 45
LIST OF TABLES

Table 1: Sample table for cost calculation.................................................................28
Table 2: Estimated construction costs for C & W Corridor. ........................................33
Table 3: Estimated construction costs for C & W Extended Corridor .......................37
Table 4: Estimated Construction Costs for C & O of Indiana Corridor ......................41
Table 5: Overview of Data Observed in Corridor Analysis .......................................42
Table 6: Estimated Cost of Construction per Potential Daily Rider ............................43
LIST OF FIGURES

Figure 1-1: Cincinnati's West Side. (Photo courtesy of Bing Maps) ............................................ 1
Figure 1-2: Price Hill Incline. (Image courtesy of The Public Library of Cincinnati and Hamilton County) ........................................................................................................... 2
Figure 2-1: Circuitous routing is required to access the Westside's pocket neighborhoods ........................................................................................................................................ 6
Figure 3-1: Streetcar in Portland, Oregon. (Photo courtesy of John Smatlak) ......................... 8
Figure 3-2: Minneapolis Light Rail. (Photo courtesy of Metro Transit) ...................................... 9
Figure 3-3: Bus Rapid Transit in Nantes. (Photo courtesy of Yonah Freemark) .............. 10
Figure 3-4: Auckland's Northern Busway. (Photo courtesy of Transportblog.co.nz) .... 12
Figure 3-5: Cincinnati's Metro*Plus Limited Stop Service. (Photo courtesy of Randy Simes) ........................................................................................................................................ 13
Figure 4-1: Pittsburgh's West Busway (Courtesy of The Port Authority of Allegheny County) ........................................................................................................................................ 17
Figure 4-2: East Busway Service (Courtesy of The Port Authority of Allegheny County) ........................................................................................................................................ 18
Figure 4-9: Negley Busway Station with connection to local service via ramp. (Photo by author) ........................................................................................................................................ 23
Figure 5-1: Historic rail lines in Cincinnati. The corridors being analyzed are shown in Orange and labeled Cincinnati & Westwood and C & O of Indiana. (Map courtesy of Jeffrey B. Jakucyk) ........................................................................................................... 25
Figure 5-2: Three busways alignments. C & W Corridor in Orange. C & W Extended Corridor in Blue. C & O of Indiana Corridor in Red ........................................................................................................... 29
Figure 5-3: Property within 1/2 mile of the C & W Corridor .......................................................... 30
Figure 5-4: C & W Corridor connections to major cross streets (shown in green) .............. 31
Figure 5-5: Potential station locations along the C & W Corridor .............................................. 32
Figure 5-6: Property within 1/2 mile of C & W Extended Corridor ........................................... 34
Figure 5-7: Potential connections to major cross streets on the C & W Extended Corridor ........................................................................................................................................ 35
Figure 5-8: Potential station locations along the C & W Extended Corridor ......................... 36
Figure 5-9: Property within 1/2 mile of C & O of Indiana Corridor. ............................. 38
Figure 5-10: Potential connections to major streets on the C & O of Indiana Corridor. 39
Figure 5-11: Potential station locations on the C & O of Indiana Corridor. .................. 40
1. Introduction

The Westside of Cincinnati is currently underserved by transit. With a mixed income population settled in hilly enclaves, the area provides some unique challenges to improving transit access. In this study, we will look at multiple transit options to determine a mode most suitable for the area. We will then look at a case study in a similarly topographically rich city and use that case study to determine the best route alignment to select for further development.

This thesis serves as a basic guide to assessing a route alignment for a given mode in a unique environment. Further development will be required to build out an appropriate system for Cincinnati’s Westside.

1.1 What is the Westside?

![Cincinnati's West Side](image)

**Figure 1-1: Cincinnati's West Side. (Photo courtesy of Bing Maps)**

The Westside of Cincinnati is a loose term that is commonly used in the Greater Cincinnati area to describe the neighborhoods generally west of the Queensgate railroad
yard and south of Interstate 74. (See Figure 1-1) Some residents argue that areas north of I-74 are also part of the Westside, however for the purpose of this thesis, we will be exploring only the region to the south. The area contains roughly 66,000 people within city limits. (City of Cincinnati, 2012)

Within the City of Cincinnati, most of the Westside neighborhoods settled in the first half of the 19th Century following the Symmes Purchase of 1788 that opened up the land for development. (Goss, 1912) While there was sporadic development throughout the 19th century, the first major boom in construction happened in the 1890s following the construction of the Price Hill Incline in 1894. (Figure 1-2) This brought the city of Cincinnati’s streetcar system to the hilltop establishing high-density streetcar suburbs. (McKay, 1984)

Figure 1-2: Price Hill Incline. (Image courtesy of The Public Library of Cincinnati and Hamilton County)
The population of the Westside is largely impoverished. According to a report by the United Way and the University of Cincinnati Community Research Collaborative, the Westside contains approximately half of the population of Cincinnati in the highest quartile of need for social services, and is also the fastest growing area of need. (Maloney & Auffrey, 2013) The report also notes that the Westside contains the majority of the city’s predominantly impoverished Appalachian population. The neighborhoods below the poverty line are clustered in the hillside areas where steep ravines isolate communities from one another.
2. Need for transit improvement on Cincinnati’s Westside

2.1 How is the Westside currently served by transit?

The Southwest Ohio Regional Transit Authority, or Cincinnati Metro currently serves the Westside. Seven local service bus routes and three express routes during weekday rush hour operate in the area. Six of the seven local routes serve Downtown Cincinnati while one route (Rt. 51) is crosstown service that passes through Uptown. Two of the express routes go directly downtown while the third offers direct service to Uptown. (Southwest Ohio Regional Transit Authority, 2014) Cincinnati Metro also offers school service called Xtra Service to many Cincinnati Public Schools including four schools on the Westside. These routes offer one trip to and from the schools to neighborhoods across the City on school days. While this service is open to public use, it’s generally discouraged and relatively inconvenient for regular transit commuters. (Cincinnati Public Schools, 2014)

2.2 What are Westsiders primary destinations?

The Cincinnati-Northern Kentucky Metropolitan Statistical Area (Greater Cincinnati) is dominated by two large employment centers, called Downtown and Uptown. In addition, there are large employment centers along the Interstate 275 corridor circling the city, including the Cincinnati and Northern Kentucky International Airport in Erlanger, KY.

Downtown is the leading employment center with 64,000 jobs. (Downtown Cincinnati, Inc., 2014) It is home to many of Cincinnati’s large corporations including Procter & Gamble, Macy’s and Kroger. Many of the city’s top rated restaurants are in the area, as well as a sizable share of the city’s shopping destinations including two department stores. The Public Library of Cincinnati and Hamilton County’s Main Branch is located there and boasts the largest circulation of any library in the country. It is also the
location of the Government Square Transit Center, which carries over 12,000 buses daily including service for Cincinnati Metro, Clermont Transit Connection, and the Transit Authority of Northern Kentucky. This is the main transfer point for Cincinnati Metro and the only transfer point to make trips to Northern Kentucky. (Southwest Ohio Regional Transit Authority, 2014)

Uptown is home the University of Cincinnati with 42,000 students, the Cincinnati Zoo with over 1 million per year, seven hospitals, and a number of additional office complexes, restaurants and shops. (Uptown Consortium, 2014) It is Greater Cincinnati’s second largest employer with 40,000 employees. (Uptown Consortium, 2010)

2.3 What are the needs for improvement on Cincinnati’s Westside?

Currently, the only destination easily accessible by the residents of the West Side is Downtown. Of the eight local routes and three express routes that go to the Westside, 6 local and 2 express routes go to Downtown while only one local and one express route go to Uptown. (Southwest Ohio Regional Transit Authority, 2014) In addition, poor access to many of the Westside’s neighborhood enclaves is credited to the area’s steep hills and valleys. An aerial view of Cincinnati (Figure 1-1) clearly shows the undevelopable hillsides that separate the central areas of the City from the Westside neighborhoods. The topography has historically left the Westside out of citywide transportation improvement plans. (Mecklenborg, 2010)

The largest residential and commercial districts on the Westside (Westwood, Cheviot, and West Price Hill) are west of the ravines. Traveling between these neighborhoods and the rest of the city requires navigating on a few select trunk roads. These roads can become congested and can slow down transit service during peak hours. (OKI Regional Council of Governments, 2011)
Currently, the 6.5-mile journey from the Glenway Crossing Transit Center to Government Square in downtown Cincinnati takes 1 hour 7 minutes on Metro’s Route 64 (Southwest Ohio Regional Transit Authority, 2014). This route takes a circuitous path on this journey due to the topography. (Figure 2-1)

As mentioned in Section 1.1 the Westside has quite a few pocket neighborhoods, tucked into the hillsides. Access to these neighborhoods is difficult to achieve as many of them only have one or two access points. The small populations in these neighborhoods require Metro to connect to all of them in a circuitous manner in order to be financially efficient.

Figure 2-1: Circuitous routing is required to access the Westside's pocket neighborhoods
3. Potential Technical Solutions

3.1 Types of Solutions

To increase operating efficiency to the Westside, there are five different mode types that can be reasonably considered in this region. These were chosen based on their feasibility, working models in peer cities, and proven returns on investment. They include: Streetcar, Light Rail, Bus Rapid Transit, Busway, and Limited Stop Service. These are all systems currently operating in other United States cities, which have established the legal framework to facilitate construction established by the Federal Transit Administration. (Federal Transit Administration)

3.2 Streetcar

A streetcar is high-capacity light rail vehicle that generally runs within mixed-traffic right-of-way. Cars are usually not connected to one another and operated as individual vehicles. Stations are usually placed every 1/4-mile to 1/2-mile and are often incorporated with existing bus infrastructure. (APTA, 2013)

Streetcars generally function as supplemental bus service. High-capacity vehicles allow for more passengers to utilize a route while maintaining frequency. Some streetcar systems use high-level platforms at stations, which does not allow for shared station use with buses. Some stations may be built to accommodate both types of vehicles such as Kansas City’s Downtown Streetcar currently under construction (2015).

Streetcars work very well in dense, urban environments. They are most commonly placed in the historic city centers to maintain a level of service that meets pedestrians’ needs.
Large capital costs for this mode make extensions beyond the most heavily used pedestrian corridors unfeasible. Direct access to job centers outside of Downtown would require expensive extensions that may prove to be cost-ineffective. Streetcars generally run in mixed traffic along active roadways. (APTA Streetcar Subcommittee, 2011)

Streetcars have shown to have high returns on investment due to their popularity and staying power. Economic development potential along the corridor could be high.
3.3 Light Rail

Light Rail is a high capacity vehicle that runs on rails generally in exclusive rights-of-way. Vehicle gauges and specifications tend to be very similar to Streetcars, however trains often consist of multiple vehicles linked together. Light Rail systems generally have stops placed every mile along their lines. Light Rail stations rarely share their stations with any other mode. (TCRP, 2012)

Figure 3-2: Minneapolis Light Rail. (Photo courtesy of Metro Transit)

Light Rail systems generally act as a trunk line for transit users in a metropolitan area. They serve the neighborhood centers along the busiest commuter corridors. Light Rail stations often act as transit centers. Bus service can run parallel with light rail service to offer more localized service or it can run perpendicular to act as a feeder into the system.

Light Rail can be built within an urban environment at grade, below grade, or elevated. It is often placed in former freight rail corridors. Tunneling is often used in light rail corridors to increase efficiency and safety.
Light Rail has the highest capital cost of any mode being considered in this essay. With longer distances between stations, this mode is often poor at afford accessibility to smaller pocket neighborhoods in hilly terrains. (Litman, 2015)

3.4 Bus Rapid Transit

Bus Rapid Transit (BRT) is a high capacity bus that typically runs in exclusive right of way. BRT is most commonly built along existing high capacity traffic corridors. BRT stations are built to Light Rail standards, offering ticket vending machines for off-board fare payment, high platform loading, and typically connections to other modes at stations spaced approximately every mile. (APTA, 2010)

Figure 3-3: Bus Rapid Transit in Nantes. (Photo courtesy of Yonah Freemark)
BRT systems are used for trunk service along high capacity corridors, similar to light rail. BRT systems use unique buses that typically remain on the BRT corridor creating a closed system. BRT systems are treated in every way the same as light rail systems. They are often seen by policymakers as a cost-effective way to offer trunk service without light rail’s cost. BRT works well in freeway corridors or in dedicated lanes on wide arterial streets. Stations are often placed at major cross streets.

BRT offers light rail service potential, however it falls short in a couple key areas. Light rail vehicles (LRV) offer much higher capacity. BRT systems often use articulated buses, which come close to matching the capacity of one light rail vehicle, however articulated buses cannot be linked together like LRVs. In addition, BRT vehicles have a much shorter longevity than LRVs. (Litman, 2015)

### 3.5 Busway

A busway is a dedicated roadway for use by standard urban transit buses. The roadway generally follows a dedicated right-of-way and has stations every ½ mile to one mile. Busways are also built with a number of entrances and exits that offer direct service to transit vehicles. (APTA, 2010)

A busway is usually placed parallel to a major trunk road and is used by local service transit vehicles to offer express service. The entrances and exits allow for local vehicles to service smaller pocket neighborhoods just off the corridor. As an open system, often many routes will run the entire length of a busway and then spread out on local streets after the busway ends. This is referred to as a “direct service” model.
Busways are effective in any areas that have difficult terrain or urban congestion that needs to be bypassed. Busways are often built along former freight rail corridors in hilly terrain or in tunnels underneath large business districts.

The system offers many of the assets of BRT and is often included in the same category, but has a few different features that create their distinction. A dedicated right of way speeds up service to levels that conventional BRT cannot reach. The direct service model allows for more flexibility in service.

3.6 **Limited Stop Service**

Limited stop service utilizes standard urban transit buses, running service along high capacity local streets with limited stop placement. (APTA, 2010)

Limited stop service generally runs along the same corridor as local service. Riders of both local and limited stop service may use improved shelters at limited stop stations. Local routes are often woven into the limited stop route, offering service to only a
portion of a route. Limited stops allow for vehicles to move at much faster speeds than standard local service.

Limited stop service works very well in high volume local arterials that do not have space for dedicated lanes.

Figure 3-5: Cincinnati's Metro*Plus Limited Stop Service. (Photo courtesy of Randy Simes)

Limited stop service does not improve boarding speeds, as there is generally not off-board fare payment. This creates the potential to slow down traffic if stations become too popular. Limited stop service also has a very low potential to create transit-oriented development.
There are very few physical barriers to construction. In some locations, the ability to add an improved shelter could require removal of parking spaces.

Limited stop service is a low-cost solution to speeding up transit times and improving accessibility.

### 3.7 Mode Selection

Cincinnati is currently building a 2.4-mile long streetcar system in Downtown Cincinnati that could be extended to the Westside. Vehicle selection, branding and maintenance operations are already established with the current system, however the Westside contains some of Cincinnati’s steepest hillsides. As a result of this topography, there are numerous pocket neighborhoods tucked into valleys and along ridges. To provide access to these neighborhoods, a flexible service model is necessary. Busses provide the flexibility to access these pocket neighborhoods. Building rail into neighborhoods with limited populations would prove to be cost prohibitive.

BRT would be a cost effective way to open up transit access from the neighborhoods of Westwood and Price Hill to Downtown Cincinnati. It would decrease travel times dramatically over current service. Economic development potential exists along the corridor. BRT requires a major arterial in which to run. The three main arterials on the Westside (Glenway Avenue, Queen City Avenue, Harrison Avenue) are all too narrow to accommodate BRT service.

A busway on the Westside would have to run along a right-of-way that is not currently established. This would require some eminent domain along the corridor route.

Limited Stop Service and Busways are both viable service models on the Westside. The Limited Stop Service model could be implemented for relatively low costs and would increase travel times and efficiency of transit in the area. There is already a limited stop
service line in operation in Cincinnati named Metro*Plus. Branding, shelter design and vehicle selection can be easily selected using the current system’s design.

Busways have a far higher capital cost, but they also have a higher return on investment. The Westside neighborhoods contain many parcels that are ready for development. Stimulating economic development along the corridor is could justify the higher capital cost and in the long term would bolster transit access to the area for many years. Considering the benefits and limitations of these modes, the most responsible mode choice for increasing transit access to the Westside is a busway.

To properly implement a busway system on the Westside we will need to first analyze a case study from a peer city. We can then use this information to determine the how to best place this service within the framework of Cincinnati’s current transit system.
4. Case Study – Pittsburgh

4.1 Why Pittsburgh?

There are currently five North American cities with functioning busways, Los Angeles, Seattle, Miami, Ottawa, and Pittsburgh. In addition there is one busway under development in Connecticut. Of those systems, Pittsburgh has the most similar topography, demographics and as Cincinnati. The hillsides of Cincinnati’s Westside are similar in many ways to the hillsides that Pittsburgh’s South and West busways are built into.

4.2 History of Port Authority busways

The Port Authority of Allegheny County is the owner and operator of the busways and transit system in Pittsburgh. They currently operate three busways called the South Busway, West Busway and Dr. Martin Luther King Jr. (MLK) East Busway.

The 4.3mile South Busway opened in 1977. The system was implemented as a low-cost and flexible alternative to rehabilitating the city’s aging streetcar lines. (Federal Transit Administration, 2003) The 6.8mile MLK East Busway opened six years later in 1983. The 5.6mile West Busway opened in 2000 adding a connection to the Penn Lincoln Parkway offering express service from Pittsburgh International Airport to Downtown Pittsburgh.

4.3 Direct Service Model

Pittsburgh’s busways are designed as open systems using a direct service model. While there is regular service that uses the corridor only, the busways are designed with access ramps that allow local service to access the busways for various reasons. This increases the frequency of service and expands the service destinations at any given stop. Pittsburgh offers regular, high frequency service in different ways along the three busways.
Figure 4-1: Pittsburgh’s West Busway (Courtesy of The Port Authority of Allegheny County)

The West Busway has two routes that operate at regular frequencies all day. G2- West Busway All Stops travels from Downtown Pittsburgh to the high-density suburb of Carnegie every 30 minutes all day. 28X- Airport Flyer is the express bus from Pittsburgh International Airport to Downtown Pittsburgh and Oakland. Special ramps from the West Busway to Interstate 376 between the two stops farthest from Downtown Pittsburgh, Carnegie and Bell, allow this route to service the majority of the West Busway and then express service to the airport. This route runs every half hour on a schedule opposite G2, giving 15-minute frequencies to all stations except Carnegie.
The MLK East Busway has three busway specific routes that run at high frequencies maintaining 15 minute or better headways along the entire route. The P1- East Busway All Stops travels the entire length of the busway from the suburban enclave of Swissvale to Downtown Pittsburgh. P2- East Busway Short travels from Downtown Pittsburgh two thirds of the way through the busway and then diverts onto local streets in the high-density and low income suburb of Wilkinsburg. P3- East Busway Oakland offers service from suburban Swissvale two thirds of the way toward Downtown and then diverts onto local streets to service the high-density college neighborhood of Oakland. These three routes alternate creating frequent service at every stop. In addition, a number of express bus routes running flyer service to Downtown and Oakland during rush hour use the busway for faster access into the city center. Some of these express routes stop at select stops along the busway and some bypass all stops to make travel times from the farthest suburbs as short as possible. The combination of these services creates frequencies as high as one bus every 35 seconds during peak service hours. (Federal Transit Administration, 2009, pp. 3-36)
The South Busway does not offer busway specific service. Instead it is used exclusively by rush hour flyer service offering quick service to and from Downtown Pittsburgh during peak hours. The lack of local and off-peak service is due to there being light rail service along the same corridor. The two modes run parallel for the majority of the corridor and actually share roadway in certain segments. Note in Figure 4-3, the South Busway extends from Station Square to Glenbury Station, where the exclusive right-of-way terminates and express services extends onto local streets. Parallel running light rail service is shown in light blue.

Figure 4-3: South Busway Service (Courtesy of The Port Authority of Allegheny County)
4.4 Station Design

The three busways in Pittsburgh have different station designs that reflect their age and uses. This is a listing of design features in chronological order.

The South Busway has the simplest and most inexpensive stations. This is because it was not only the first, but designed specifically for rush hour commuting. Along the roadway, platform areas have standard bus shelters with signage. Standard sidewalks connect stations to sidewalks along local streets. A standard double-line crosswalk crosses the roadway to provide access to both directions.

The MLK East Busway was built with more substantial, custom designed stations. Signage, platforms and access ramps reflect more typical light rail station design. Wider sidewalks, more seating, brighter lighting and safety feature such as police call stations were the major additions to this busway.

Figure 4-4: South Busway Inglewood Station. (Photo by author)

Figure 4-5: MLK East Busway Negley Station. (Photo by author)
The West Busway features more substantial shelter designs, however they are not custom designed as the East Busway stations are. These stations are built to light rail standards with large signage, lighting and station ramps. Police call stations and route maps are featured in every shelter. A major addition to these stations is a concrete barrier down the centerline of the roadway preventing pedestrians from crossing the roadway outside the crosswalk.

More recently, the MLK East Busway was extended to include the Hamnett, Roslyn, and Swissvale stations. These stations once again feature custom designed waiting areas,
light rail standard signage, and ramps with the addition of the centerline barrier. These stations were designed to incorporate the Port Authority’s new ConnectCard Ticket Vending Machines (TVMs). Since then, TVMs have been added to most MLK East Busway and West Busway stations. The South Busway does not feature any TVMs partially because it only serves peak hour commuter traffic but also because TVMs are located at most nearby light rail stations.

Figure 4-8: MLK East Busway East Liberty Station with TOD (Photos by author)

The most recent addition to the busway system is the East Liberty Station. This station was originally built as part of the initial construction of the MLK East Busway, however it’s high usage allowed for the Port Authority to experiment with Transit Oriented Development. The station is currently being rebuilt with Architect designed waiting areas, plaza areas, and a large parking garage with apartments built on top. This station has also spurred the development of a nearby urban format Target store, Whole Foods, and new urban art installations.
4.5 Connections to other Modes

According to a 2009 FTA report, 91% of riders indicated the West Busway was Very Important or Fairly Important in their decision to start using the bus. (Federal Transit Administration, 2009) The busway acts as a high frequency, high capacity transit network very similar to light rail systems in other cities. Typically, light rail stations serve as transfer points from local bus routes running generally perpendicular to the light rail alignment. While Pittsburgh’s busway system features a number of local routes that end or cross the busways, most bus routes feed into the busway, running along the alignments and adding service capacity to the busway spine.

Busway stations often have direct connections to other transit service with signage directing riders.

![Negley Busway Station with connection to local service via ramp. (Photo by author)](image-url)
5. Potential Alignments

5.1 Potential busway alignments

Busways require exclusive rights-of-way with connections to cross streets for direct service. Using the Pittsburgh model of abandoned freight corridors for alignments, there are currently two corridors that will be considered for conversion to a busway; the former Cincinnati & Westwood line and the former Chesapeake & Ohio of Indiana line. In Figure 5-1, we can see that these two options are the only freight corridors that have ever existed on Cincinnati’s Westside. Both are East-West alignments that would carry service through the hillsides directly to the northern edge of Downtown Cincinnati and the southern edge of Uptown Cincinnati. The majority of the right-of-way exists for the Chesapeake & Ohio of Indiana corridor between State Avenue to the east and Ferguson Avenue to the west. For this study this alignment will be shown on maps with a Red line and will be referred to as the C & O Corridor. The Cincinnati & Westwood Line maintains much of its right-of-way between Beekman Street to the east and Werk Rd to the west. This alignment will be shown on maps using an Orange line and will be referred to as the C & W Corridor. The Cincinnati & Westwood line originally extended beyond Werk Rd to end just west of Glenmore Avenue. This segment has since been subdivided into residential neighborhoods however the end of this line is significantly close to the Cheviot and Western Hills business districts. This study will also analyze the feasibility of an extension of the C & W Corridor beyond Werk Road to Glenway Avenue. This alignment will be shown on maps using a Blue line and will be referred to as the C & W Extended Corridor. It is important to note that the study area for the C & W Extended Corridor includes the entire C & W Corridor east to Beekman Street.
5.1.1 Description of factors in determining route selection and station locations

To compare the feasibility of multiple corridors, there are a myriad of categories we can use as benchmarks. There is no set standard for selecting benchmarks and as a result, the process of choosing benchmarks can become endlessly complex. We could study everything from soil textures, to affects on migratory patterns, to density of low income housing, etc. Selecting which benchmarks to use must be determined by the intent of the project. If we were intending to choose an alignment based on environmental impact, the displacement of migratory patterns could be a useful benchmark. In this project, we’re intending to build a large-scale capital improvement project with the express intent to increase speed of service through a low-density corridor. Cost, ridership, and speed are the most important and impartial factors.

To determine the best corridor to build this busway in, we will need to estimate potential ridership and weigh it with corridor construction costs. We will be determining potential

Figure 5-1: Historic rail lines in Cincinnati. The corridors being analyzed are shown in Orange and labeled Cincinnati & Westwood and C & O of Indiana. (Map courtesy of Jeffrey B. Jakucyk)
ridership by determining the potential riders within walking distance, then adding potential riders by determining potential connecting bus service and then adjusting that ridership based on corridor speed increases. The details of these steps are outlined in the following sections.

5.1.2 Population within 1/2 mile of line

Transit lines need a nearby population base to obtain ridership from. The standard walking distance to high frequency transit services used by most transit planners and Departments of Transportation is ½ mile. We will analyze the population within ½ mile of the line to determine the potential for ridership. This section will look at current population density, populations potentially displaced by construction and potential new population on current parcels. According to the US Census Bureau, in 2010 there were an average of 2.58 people per single-family house. That number will be used to estimate the potential number of new residents within vacant housing units. In the analysis, the total estimated population would be used as a base for potential ridership.

5.1.3 Number of available connections to major cross streets

In this section, we will determine the eligibility of cross streets to allow for a connecting local bus service. We will do this using historic transit lines, current transit service and Ohio Department of Transportation specifications for truck routes allowing bus service. We will then address the grade separation and availability of adjacent land to build an access ramp between the busway and the cross street. All street along an alignment will be classified as Major (allowing bus traffic), Minor (public streets allowing local traffic only), and Private Drives (improved roadways connecting to apartment complexes, businesses, and alleyways.) Connections to additional bus service on connecting street can improve ridership. Pittsburgh saw a 135% increase in ridership along the West Busway corridor by incorporating seven bus routes into the corridor, a 19% increase per line. (Federal Transit Administration, 2003) In the analysis, we will use this figure to
weigh the potential ridership increase by having connecting service by adding a 19% increase in potential riders per route.

5.1.4 Number of potential station locations

This section will determine all of the potential station locations. This will be decided based on access to a major cross streets, adjacent business districts and neighborhood populations and potential for park and ride development. Station locations provide the potential to increase ridership, but also slow down service speeds. In an evaluation of Pittsburgh’s West Busway, a passenger survey found that 44% of new riders chose to use the service because of increased travel speeds. A study by McGill University found that every stop increases travel time by 12.9 seconds. (El-Geneidy & Tetreault, 2008) Busway corridors can have speeds of 50 miles per hour with no obstructions. (Federal Transit Administration, 2003) Using this information we can estimate that for every stop added there is an approximately 2.4% reduction in service. We will use this number to reduce our potential ridership by 2.4% per stop.

5.1.5 Estimated cost of construction

This section will tally up the estimated pre-engineering and design costs for the construction of each corridor. We will use industry metrics to determine general two-lane arterial construction costs accounting for roadway, bridge and station construction. Additionally, we will estimate the cost of right-of-way acquisition based on the total market value of all parcels affected by corridor construction using 2009 figures provided by the Cincinnati Area Geographic Information System (CAGIS). A 2009 report by the Arkansas State Highway and Transportation Departments breaks down construction costs per lane mile per road type. (AHTD, 2009) The report estimates the cost per mile of a 2-lane arterial roadway in an urban area as $3,750,000. Roadway costs will be estimated by multiplying the length (in miles) of planned at-grade roadway (including access ramps) for each line by $3,750,000. Bridge construction is estimated at $125 per square foot according to the same source. The Ohio Department of transportation
recommends 32’ width for bridges on two lane arterial streets. (ODOT, 2012) Bridge costs will be estimated by multiplying the linear feet by $4000 ($125/sq ft x 32ft). Station construction costs can vary greatly. A generic bus shelter on a concrete pad can cost as little as $15,000. (MTC, 2014) An architect-designed station can cost several million dollars per shelter. In 2013 Cincinnati’s Metro transit agency constructed 13 new architect designed shelters in the Uptown area at a cost of $530,000 per shelter. (Cincinnati Business Courier, 2012) For this study we assume a cost of $500,000 per shelter for comparative purposes, as the Uptown Transit District shelters are similar in scope to what would probably be most desirable in this busway. Bridge placement and lengths are based on historic railroad bridge placements found using GIS parcel boundaries provided by the City of Cincinnati unless otherwise noted. In our corridor selection analysis, we will take the total estimate cost of construction and divide it by the total estimate ridership to determine an approximate cost per potential rider.

These equations will be calculated for each alignment by completing Table 1.

<table>
<thead>
<tr>
<th>Corridor Name</th>
<th>Roadway length (mi)</th>
<th>Bridge length (ft)</th>
<th>Stations (# of locations)</th>
<th>Right-of-Way Costs ($)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per unit (USD)</td>
<td>$ 3,750,000</td>
<td>$ 4,000</td>
<td>$ 500,000</td>
<td>$</td>
<td>1</td>
</tr>
<tr>
<td>Total cost (USD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To study the potential alignments, property data from the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) and the Cincinnati Area Geographic Information System (CAGIS) was used in the program ArcMap by ESRI. Graphics in Chapter 5 are all produced by the author using ArcMap unless otherwise noted.

The alignments (shown in figure 5-2) were drawn using the parcel boundary lines remaining along each corridor. Paths were traced by hand using the parcels as a guide. Alignment placements are within one foot of historic placements.

On all ArcMap produced maps cross streets usable by bus are shown in green, ramps connections between alignments and public streets are shown in yellow and all stations are represented by grey circles.
5.2 C & W Corridor

5.2.1 Population within 1/2 mile of line

Within a half-mile of the 3.1-mile corridor there are currently (2010 Census) 10,798 residents. This population is spread among 416 multifamily buildings, 3606 single-family houses. The residential density is currently 3,456 residents per square mile within this area. The alignment will result in the displacement of 334 residents within a 30 foot zone around the corridor. There are currently 22 vacant single-family houses within the corridor that can be rehabilitated, which have the potential to add 57 new residents. The total population served is 10,521.

Figure 5-3: Property within 1/2 mile of the C & W Corridor.
5.2.2 Number of available connections to major cross streets

The C & W Corridor crosses ten streets between its western terminus at Werk Road and its eastern Terminus at Beekman Street, both Major streets with potential local bus service connections. These streets are Lafeuille Avenue, Lafeuille Circle (twice), LaFeuille Drive, Lisa Ridge Apartment Drive, Bluffcrest Lane, Saffin Avenue, White Street, Harrison Avenue and Pinetree Street. The alignment will also use Montrose Street and Horton Street as part of the corridor alignment. These two streets will need to be removed if this corridor is expanded. Two of these cross streets are Major cross streets with potential pedestrian connections to local bus service; Lafeuille Avenue and Harrison Avenue. In addition, there are two potential connections to major cross streets via ramps at the intersections of Queen City Avenue & Lafeuille Avenue and Queen City Avenue & Sunset Avenue. Three streets are Minor streets that will be largely unaffected by service; Saffin Avenue, White Street and Pinetree Street. The minor streets of Lefeuille Circle, La Feuille Drive, Lisa Ridge Apartment Drive and Bluffcrest Drive are attached to apartment communities, which would likely be removed in order to implement service. Total, there are six potential connections to Major streets, three unaffected Minor streets and four Private Drives that would need to be removed.

Figure 5-4: C & W Corridor connections to major cross streets (shown in green).
5.2.3 Number of potential station locations

There are seven potential station locations along this corridor. Werk Road, Lafeuille Avenue, Harrison Avenue and Beekman Street are station locations at major cross streets where potential pedestrian connections to local service could be made. A fifth station could be placed on the site of the current Lisa Ridge Apartment complex. This station has the potential for a large park and ride and/or transit oriented development. A hillside station could be placed just uphill from the small business district at Wyoming and Queen City Avenues. This station could also provide a pedestrian connection to Homestead Place. The seventh potential station location is at the Minor street crossing at White Street. This station has pedestrian connections to the dense residential and commercial area at the western edge of the South Fairmount neighborhood.

![Figure 5-5: Potential station locations along the C & W Corridor.](image)
5.2.4 Estimated cost of construction

This corridor has a total length of 16,497 feet. Connector ramps at Sunset Avenue, the intersection of Queen City and Lafeuille Avenues and at Lafeuille Avenue total 1,347 feet. The total at grade roadway length is 17,845 feet, or 3.38 miles. Historically, the Cincinnati & Westwood Line did not contain any bridges. The entire right-of-way was at-grade. For the construction of a busway in this corridor, a bridge was added across Lafeuille Avenue to prevent congestion on both roadways during rush hour. The standard length of a two-lane overpass outlined by the Ohio Department of Transportation was used to determine the length. (ODOT, 2012) There are seven potential station locations as described in section 5.2.3. There are 296 parcels that need to be acquired for construction. The fair market value of these parcels according to CAGIS 2009 parcel data is $35,548,850. Using the equations described in section 5.1.5, a preliminary cost of construction is estimated at $48,974,642 as shown in Table 1.

Table 3: Estimated construction costs for C & W Corridor.

<table>
<thead>
<tr>
<th>C &amp; W Corridor</th>
<th>Roadway length (mi)</th>
<th>Bridge length (ft)</th>
<th>Stations (# of locations)</th>
<th>Right-of-Way Costs ($)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total units</td>
<td>3.38</td>
<td>414</td>
<td>7</td>
<td>$35,548,850</td>
<td></td>
</tr>
<tr>
<td>Cost per unit (USD)</td>
<td>$ 3,750,000</td>
<td>$ 4,000</td>
<td>$ 500,000</td>
<td>$ 1</td>
<td></td>
</tr>
<tr>
<td>Total cost (USD)</td>
<td>$12,675,000</td>
<td>$1,656,000</td>
<td>$3,500,000</td>
<td>$35,548,850</td>
<td>$53,379,850</td>
</tr>
</tbody>
</table>
5.3 C & W Extended Corridor

5.3.1 Population within 1/2 mile of line

Within a half-mile of the 5.49-mile corridor there are currently (2010 Census) 17,344 residents. This population is spread among 798 multifamily buildings, 6679 single-family houses. The residential density is currently 3,593 residents per square mile within this area. The alignment will result in the displacement of 430 residents within a 30-foot zone around the corridor. There are currently 24 vacant single-family houses within the corridor that can be rehabilitated adding 62 residents. The total population served by this corridor is 16,976.

Figure 5-6: Property within 1/2 mile of C & W Extended Corridor.
5.3.2 Number of available connections to major cross streets

The C & W Extended Corridor contains all six Major streets, three Minor streets and four Private Drives of the C & W Corridor described in section 5.1.1. The extension beyond Werk Road to Glenway Avenue travels through a heavily residential neighborhood that has since built many local cross streets that would need to be dead-ended to build out the corridor. These streets will be counted as Private Drives in the ranking as they will be negatively impacted by construction. Eight streets (McKinley Avenue, Lischer Avenue, Daytona Avenue, Statem Avenue, Cheviot Avenue, Dartmouth Drive, Stanhope Avenue and Buell Street) would need to be dead-ended as part of the project. Additionally four streets (Broadwell Avenue, Hope Lane, Koenig Avenue and Fieldcrest Drive) would need to be removed. Epworth Avenue is a minor street without bus service that must remain intact to serve as an important local connection. A bridge over this street would need to be constructed to keep the street intact. Lastly there are three major streets that could be accessed to provide a connection to local bus service, (Boudinot Avenue, Glenmore Avenue, and Parkcrest Lane.) Total, this corridor contains nine Major streets that can be accessed, four Minor streets that will remain unaffected and 15 Private Drives that would be negatively impacted.

Figure 5-7: Potential connections to major cross streets on the C & W Extended Corridor.
5.3.3 Number of potential station locations

This corridor contains all seven potential station locations as the C & W Corridor described in section 5.2.3. Within the extension, there are four potential station locations. Stations with can be placed at the Major streets of Boudinot Avenue, Glenmore Avenue and Parkcrest Lane. A fourth station could be added at the end of the alignment utilizing a park and ride at West Town Centre. In total, this alignment has the potential for eleven stations.

Figure 5-8: Potential station locations along the C & W Extended Corridor.
5.3.4 Estimated cost of construction

This corridor has a total length of 27,615 feet. Connector ramps at Sunset Avenue, the intersection of Queen City and Lafeuille Avenues and at Lafeuille Avenue total 1,347 feet. The total at grade roadway length is 28,962 feet, or 5.49 miles. Historically, the Cincinnati & Westwood Line did not contain any bridges. The entire right-of-way was at-grade. For the construction of a busway in this corridor, two bridges were added across Lafeuille and Epworth Avenues to prevent congestion on both roadways during rush hour. The standard length of a two-lane overpass outlined by the Ohio Department of Transportation was used to determine the length. (ODOT, 2012) There are eleven potential station locations as described in section 5.3.3. There are 510 parcels that need to be acquired for construction. The fair market value of these parcels according to CAGIS 2009 parcel data is $68,521,247. Using the equations described in section 5.1.5, a preliminary cost of construction is estimated at $90,521,248 as shown in Table 2.

Table 4: Estimated construction costs for C & W Extended Corridor

<table>
<thead>
<tr>
<th>C &amp; W Extended Corridor</th>
<th>Roadway length (mi)</th>
<th>Bridge length (ft)</th>
<th>Stations (# of locations)</th>
<th>Right-of-Way Costs ($)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total units</td>
<td>5.49</td>
<td>598</td>
<td>11</td>
<td>$68,521,247</td>
<td></td>
</tr>
<tr>
<td>Cost per unit (USD)</td>
<td>$3,750,000</td>
<td>$4,000</td>
<td>$500,000</td>
<td>$1</td>
<td></td>
</tr>
<tr>
<td>Total cost (USD)</td>
<td>$20,587,500</td>
<td>$2,392,000</td>
<td>$5,500,000</td>
<td>$68,521,247</td>
<td>$97,000,747</td>
</tr>
</tbody>
</table>
5.4 C & O of Indiana Corridor

5.4.1 Population within 1/2 mile of line

Within a half-mile of the 3.1-mile corridor there are currently (2010 Census) 10,440 residents. This population is spread among 357 multifamily buildings, 7536 single-family houses. The residential density is currently 3,367 residents per square mile within this area. The alignment will result in the displacement of 430 residents within a 30-foot zone around the corridor. There are currently 52 vacant single-family houses within the corridor that can be rehabilitated adding 135 residents. The total residents served by this corridor are 10,145.

Figure 5-9: Property within 1/2 mile of C & O of Indiana Corridor.
5.4.2 Number of available connections to major cross streets

The C & O of Indiana Corridor crosses over four Major cross streets (Guerley Road, Sunset Avenue, Quebec Road and Grand Avenue) with potential connections to local bus service using ramps and has two additional connections to the Major cross streets of Ferguson Road and State Avenue at the ends of the alignment. This corridor has four Minor streets (Sunset Lane, Wyoming Avenue, Selim Avenue and Amor Place) that will remain unaffected by corridor construction due to their locations within ravines. One street with two names (Forbus Street and Esmonde Street) will need to be removed for this alignment. In total this corridor has six Major streets with potential connections, four Minor streets, and one Private Drive that will need to be removed.

Figure 5-10: Potential connections to major streets on the C & O of Indiana Corridor.
5.4.3 Number of potential station locations

This corridor contains seven potential station locations. A station at the western end of the alignment just east of Ferguson Ave could have room for a large park and ride location as well as potential for transit oriented development. A station at the Dunham Recreation Area could also be used as a park and ride location. A station at Guerley Road, Gilsey Avenue and Sunset Avenue provides access to the residential neighborhood of West Price Hill. Stations at Wyoming Avenue, Quebec Road and Grand Avenue provide access to residential pockets and business districts within the South Fairmount neighborhood. Lastly a station at State Avenue serves as a gateway for connecting service heading west.

Figure 5-11: Potential station locations on the C & O of Indiana Corridor.
5.4.4 Estimated cost of construction

This corridor has a total length of 16,403 feet. Connector ramps at Guerley Road, Sunset Avenue and Grand Avenue total 1,347 feet. The total at grade roadway length is 17,661 feet, or 3.34 miles. Historically, the Chesapeake & Ohio of Indiana Railroad had nine bridges in this corridor crossing Guerley Road (twice), Sunset Lane (twice), Sunset Avenue, Wyoming Avenue, an unnamed ravine, Quebec Road and Grand Avenue. All bridges would be rebuilt in this corridor except for Quebec Road. Quebec Road has since had its hillside regarded to allow for an at-grade crossing. There are seven potential station locations as described in section 5.4.3. There are 111 parcels that need to be acquired for construction. The fair market value of these parcels according to CAGIS 2009 parcel data is $10,578,115. Using the equations described in section 5.1.5, a preliminary cost of construction is estimated at $24,071,115 as shown in Table 3.

Table 5: Estimated Construction Costs for C & O of Indiana Corridor.

<table>
<thead>
<tr>
<th>C &amp; O of Indiana Corridor</th>
<th>Roadway length (mi)</th>
<th>Bridge length (ft)</th>
<th>Stations (# of locations)</th>
<th>Right-of-Way Costs ($)</th>
<th>Total Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total units</td>
<td>3.34</td>
<td>1,998</td>
<td>7</td>
<td>$10,578,114</td>
<td></td>
</tr>
<tr>
<td>Cost per unit (USD)</td>
<td>$3,750,000</td>
<td>$4,000</td>
<td>$500,000</td>
<td>$1</td>
<td></td>
</tr>
<tr>
<td>Total cost (USD)</td>
<td>$12,525,000</td>
<td>$7,992,000</td>
<td>$3,500,000</td>
<td>$10,578,114</td>
<td>$34,595,114</td>
</tr>
</tbody>
</table>
5.5 Alignment Selection

Compiling all of the data (Table 4) we can see that the C & W Corridor and the C & O of Indiana Corridor serve similar populations with similar stations number and connections, however the cost to build the C & W Corridor is nearly double. The majority of the cost savings were in right-of-way acquisition. The C & W Extended Corridor captures higher ridership and allows for more connections but comes at a high cost.

Table 6: Overview of Data Observed in Corridor Analysis

<table>
<thead>
<tr>
<th></th>
<th>C &amp; W Corridor</th>
<th>C &amp; W Extended Corridor</th>
<th>C &amp; O of Indiana Corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population served within 1/2 mile</td>
<td>10,521</td>
<td>16,976</td>
<td>10,145</td>
</tr>
<tr>
<td>Available connections via cross streets</td>
<td>6</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Number of potential stations</td>
<td>7</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Estimated construction cost</td>
<td>$53,379,850</td>
<td>$97,000,747</td>
<td>$34,595,114</td>
</tr>
</tbody>
</table>
To determine the cost effectiveness of each corridor (outlined in sections 5.1.2 – 5.1.5) take the Estimated Cost of Construction and divide it by the Population Served within ½ Mile adjusted for estimated ridership increases of 19% per Available Connection via Cross Street and adjusted for ridership decreases of 2.4% per Potential Station placement.

The equation for calculating the ratio of cost to potential ridership is as follows:

\[
\frac{d}{a(1 + 0.19b)(1 - 0.024c)}
\]

Where
- \(a\) = Population served within ½ mile
- \(b\) = Number of available connections via cross streets
- \(c\) = Number of potential stations
- \(d\) = Estimated construction cost

Calculating the cost to potential daily ridership ratio for the three alignments (Table 5) we can see that the C & O of Indiana Corridor has the best potential return on investment of the three corridors studied.

**Table 7: Estimated Cost of Construction per Potential Daily Rider**

<table>
<thead>
<tr>
<th></th>
<th>C &amp; W Corridor</th>
<th>C &amp; W Extended Corridor</th>
<th>C &amp; O of Indiana Corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Cost / Potential Daily Rider</td>
<td>$2,850</td>
<td>$2,865</td>
<td>$1,915</td>
</tr>
</tbody>
</table>
6. Conclusion

Cincinnati’s Westside offers a unique set of circumstances that exist nowhere else on the globe, however there are parallels that can be found in peer cities. In the case of the Westside, the topography is a defining feature that has historically prevented it from receiving the same level of transit service as the rest of the city. Looking at a peer city with similar problematic conditions can offer new ideas for problem solving.

Even with those new tools, the mechanisms for determining the best location for transportation improvements are not always the same. In this instance, when initially looking at these possible corridors, I had assumed that the C & W Corridor would be the most cost effective, as there were more houses along the line and the line was entirely at grade eliminating the expensive task of building bridges. Instead, the cost of right-of-way acquisition far outweighed the cost of bridge construction.

This thesis was a starting point for developing a more comprehensive transit system on the Westside of Cincinnati. The very next step must include community outreach. There is an important legal obligation to discuss capital improvements such as this with the community. Further development and engineering is required to get a more accurate cost estimate and full set of construction documents. An Environmental Impact Assessment must be completed to ensure that full build out will not negatively affect the surrounding environment. Funding must be secured. A Title VI Compliancy must be obtained by assessing the affects of transit improvements on all demographics as required by the Civil Rights Act of 1964. Lastly, a Comprehensive Operational Analysis must be done on current transit service in Greater Cincinnati to insure that the busway is used to its full potential, connecting as many neighborhoods as possible with high frequency service.

No two transit systems are alike. Every city, every neighborhood, every street has a different set of circumstances that determine what types of transit solutions will work and how effectively they meet the needs of a populous.
7. Works Cited


